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END-USE WORKING PARTY

Implementing Agreement on
Energy Conservation through Energy Storage

Annual Report 2000

May 2001

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CHAIRMAN'S REPORT

Halime Paksoy
Çukurova University, Turkey

The new millenium greeted us with urgent energy security concern. The increased emissions and depletion of critical resources threaten economic growth as well as our quality of life. By the year 2020, non-member countries are expected to double their energy demand and CO_2 emissions. In other words, the problem has spread beyond the borders of IEA member countries. The Implementing Agreements of different Working Groups within the International Energy Agency need to work hand-in-hand to meet these challenges.

The Committee of Energy Research and Technology (CERT), in its recent Implementing Agreement's review, is faced with a challenge to develop a new generation of technologies that are sustainable as well as innovative.

The aim of the Implementing Agreement on Energy Conservation Through Energy Storage (ECES) is to research, develop, and integrate energy storage technologies. Such technologies provide sustainable energy alternatives that in turn, decrease greenhouse gas emissions and conserve energy through enhanced efficiency.

Energy storage technologies are spreading through the efforts of ECES and have already become commercially viable in many countries. The pervading nature of energy storage technologies requires the collaboration of various IEA bodies. The first joint Executive Committee meeting with ECBCS took place in 2000 to provide this collaboration.

2000 has been a year in which cooperation with other implementing agreements and dissemination of information among countries were the important accomplishments of ECES. The Executive Committee of ECES has also formed an information policy committee. This committee's task is to enhance information services and in turn, increase the visibility of this Agreement.

Two conferences organised this year - TERRASTOCK'2000 6th International Thermal Energy Conference and EESAT'2000- provided a very good chance for information exchange.
Other two notable achievements in 2000 are: the completion of Annex 8 "Implementing Underground Thermal Energy Storage Systems" and of Annex 9 "Electrical Energy Storage". Annex 8 has become a source of the on-going Annexes 12,13 and 14. Annex 9 is a first on electrical storage and broadens the scope of the Implementing Agreement. A new Annex 15 is now proposed as an outcome of Annex 9.

The ECES aims to increase the number of participating countries and reactivate nonactive members. TERRASTOCK'2000 has been an excellent opportunity to accomplish this goal. Both China and Norway have shown interest in joining the Implementing Agreement following this very well organised conference.

I look forward to a productive year and a stronger ECES with new activities that broaden our horizons.

ENERGY CONSERVATION THROUGH ENERGY STORAGE IMPLEMENTING AGREEMENT

The Implementing Agreement (IA) started in 1978 and in the latest Executive Committee Meeting in Berlin it was decided to ask for an extension for another five years starting December 2000. It has now (1999) 14 members: Belgium, Canada, CEC, Denmark, Finland, Germany, Italy, Japan, The Netherlands, Spain, Sweden, Turkey, United Kingdom, USA. During the past year the Executive Committee has worked intensively to attract more countries to join the activities and to sign the Implementing Agreement. As a consequence Spain is the new member of the year and Australia, Bulgaria, China, France, India, Israel, Korea, Poland and South Africa have expressed interest to participate in the activities of the Implementing Agreement.

The Executive Committee has finished the work on preparation of the Strategy Plan for the period 1998 - 2003, which mainly will be an update of the present Strategy Plan (1994-1997).

According to the Strategy Plan the objectives for the IA are as follows*:*

'' The overall objective of the IA on ECES is to develop and demonstrate various energy storage technologies for applications within a variety of energy systems and to encourage their use as a standard design option. Energy storage technologies can improve the utilisation of renewable energies, in particular solar and wind and the greater utilisation of waste heat energy storage technologies should be implemented in all countries with significant energy storage market potential''

The Executive Committee co-ordinates and leads the collaborative work in the annexes and the Committee also takes an active part in various information activities such as workshops, seminars and conferences.

The Executive Committee had two meetings during the year. The first meeting was held in Adana, Turkey in May and second in Tokyo, Japan in November.

<u>The Adana Meeting, May 2000</u>

The most important items and decisions of the Adana meeting are outlined below.

- Chairman and secretary were re-elected unanimously
- Approval of the legal text of revised IEA ECES IA
- Approval of annual report 1999
- Approval of the budget of the year 2000-2001.
- EUWP approved the extension request of the ECES IA and chairman will give a presentation at the fall meeting of EUWP
- Approval of the extension for the final report of Annex 8.
- Approval of all progress reports of ongoing Annexes (9, 10, 12, 13,14)

- A joint meeting will be organised with ECBCS in Japan on November 8, 2000
- Two new annexes were proposed (continuation of Annex 10 and Information Centre)
- Çukurova University Centre for Environmental Research will continue to be the webmaster.

The Tokyo Meeting, November 2000

The most important discussions and decisions are outlined below.

- The chairman gave information about the EUWP strategies
- New countries of interest, Poland was an observer at this meeting and XC decided to invite Norway, China and Portugal to join ECES IA.
- Decision on task definition phase for two annexes: Annex 15. Electrical energy storage and integration of renewables, Annex 16. Engineering textbook on thermal energy storage and renewable energy
- Approval of all annex reports and the extension of Annex 8.
- A committee is formed to make a proposal about the information policy of ECES
- Draft of the ECES Brochure is completed
- Guidelines for Annex preparation

ACTIVITIES

Workshops 2000

Annex 10, PCM and Chemical Reactions for Thermal Energy Storage 5th Workshop, 12-14 April 2000 Tsu, Japan

Annex 10, PCM and Chemical Reactions for Thermal Energy Storage 6th Workshop November 2000, Stockholm, Sweden

Workshop on Thermal Response Test, , October 15, 2000, Mol, Belgium

Annex 13, Design, Construction and Maintenance of UTES Wells and Boreholes, April 11, 2000, Edmonton, Canada

Annex 14, Cooling in All Climates with Thermal Energy Storage 2nd Workshop April 6-7, 2000 Halifax, Canada

Annex 14, Cooling in All Climates with Thermal Energy Storage 3rd Workshop, November 10, 2000, Tokyo, Japan

Conferences 2000

TERRASTOCK'2000, 8TH Conference on Thermal Energy Storage, 28 Aug-Sept 1, 2000 Stuttgart, Germany

EESAT 2000, Electrical Energy Storage Systems Applications and Technologies, September 2000, Florida, USA

Planned Conferences and Workshops

IEA ECES Workshop on the Role of Energy Storage in the Future Energy Systems, May 16, 2001, Ottawa, Canada

Annex 10, PCM and Chemical Reactions for Thermal Energy Storage, November, 2000, Stockholm, Sweden

Annex 14, Cooling in All Climates with Thermal Energy Storage, April 19, 2001, Istanbul, Turkey

Annex 17, April 2001, Leida, Spain

Annex 13, 26-27 April 2001, Nijwegen,Niederlands

ON-GOING ANNEXES

Annex 10. Phase Change Materials and Chemical Reactions for Thermal Energy Storage.

Operating Agent: F. Setterwall, Royal Institute of Technology, Stockholm, Sweden.

Introduction

Annex 10 was approved during the Executive Committee meeting in Paris 4-5 of December 1997. It was decided that the Department of Chemical Engineering and Technology at the Royal Institute of Technology in Stockholm, Sweden should act as Operating Agent. The Annex will be finalised in spring 2001.

The general objective of Annex 10 is to solve technical and market problems for a better market opportunity for thermal energy storage systems utilising Phase Change Materials (PCM) or chemical reactions in the building, the agricultural and the industrial sector. The aim is to broaden the knowledgebase and disseminate information. The Annex 10 work will result in accomplished/initiated case studies and demonstration projects related to potential fields of application. This will be accomplished in close co-operation with manufacturers, utilities and users.

Participants in the annex are Canada, Finland, Germany, Japan, Sweden and Turkey. Several other countries have shown interest in Annex 10, mainly Bulgaria, China, India, Poland, United Kingdom and USA.

Activities during 2000

During the year three experts meetings have been held in conjunction with two of these have technical workshops been arranged.

The fifth workshop and experts meeting of the annex was held in Tsu, Japan the 12^{th} to 14^{th} of April 2000. Among the 36 participants were 31 from Japan, most of them from the Japanese Annex 10 group but also several other people. 22 participants were from different kind of companies like energy companies (gas and electrical), construction companies engineering companies and chemical companies. 11 presentations were made about the topics: chemical reactions for TES (3), PCM in heat/cold transportation systems (3), systems/applications (3) and new materials (2). After each group of presentations a discussion was held on the specific topic and certain conclusions were drawn and important features stressed out. In general it was stated that it is essential to use a systematic approach to find a solution to the problems that we are facing. More scientific and more strategic ways must be applied when doing experiments and presenting/analysing the data obtained. A technical tour was arranged. First, a high-rise building for offices and other commercial usage, including a railway station, was visited. In this building a large cold storage facility was situated for air-conditioning. Second, a school with a floor heating system combined with storage was visited.

The sixth Experts' Meeting was held in Stuttgart, Germany, in conjunction with the Terrastock Conference in September. At the meeting two major topics were on the agenda. First it was decided on how to make the final report, second the different possibilities of some sort of continuation of

Annex 10 were discussed. All experts were positive about an annex on “Information” and an annex based on case studies and demonstration projects. See further below.

The seventh experts meeting and the sixth workshop were held in Stockhom, Sweden in November 2000. The 29 participants came from Finland (1), Germany (7), Japan (2), the Poland (1), Sweden (14), Turkey (2) and UK (2). First the sub-task leaders presented the preliminary results of the annex. After this nine ordinary presentations followed, the content of the presentations well representing the broad scope of the annex, as they concerned cold and heat storage, system, heat transfer and material aspects, theoretical and experimental studies as well as commercial applications.

Initiatives to continuation after the finalisation of Annex 10

It is the opinion of the experts that the annex should have some kind of continuation. In conjunction with Terrastock an open meeting was held to discuss the matter where many countries showed their interest to participate. During the “continuation” annex should all activities be related to case studies (=feasibility studies) and demonstration projects. For example activities to initiate monitor and perform studies/projects and arranging workshops to spread information about the projects. All countries that want to take part in the annex should show that there would be resources available to perform demonstration projects and/or case studies. It should also be shown that some project would be started in the beginning of the annex period. This suggestion for a new annex has been looked upon positively by the ExCo and has been given the name, Annex 17.

It is also the view of the experts that a new annex on information should be initiated. The new annex should take care of databases and other outcomes as well as information activities. Possibly should this annex be for the whole ECES IA. This suggestion was not approved by the ExCo and will not be looked into further.

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ON-GOING ANNEXES

Annex 12. High Temperature Underground Thermal Energy Storage

Operating Agent; Burkhard Sanner, Giessen University, Germany

Introduction

The annex on " High Temperature Underground Thermal Energy Storage (HT UTES)" was approved at XC43, December 1997.

Participating Countries: Belgium, Canada, Germany, Netherlands, Sweden

Based upon the results from previous IEA activities and ongoing R&D, the objectives of Annex 12 are to demonstrate that HT-UTES can be attractive to achieve more efficient economical and environmentally benign energy systems, and to disclose requirements and find problem solutions for reliable long-term operation. The type of UTES-system concerned is confined to Aquifer Storage (ATES) and Duct/Borehole Storage (BTES). High temperature in this annex refers to a minimum storage loading temperature in the order of 50 °C.

Workplan

To achieve the objectives, several activities will be carried out in two Phases:

The work is divided into two phases:

Phase 1	Review of the state-of-the-art, investigations into system opportunities and further R&D-need; completed with report end of 1999
Phase 2	Monitoring of existing plants (demo projects), design tools, improvement in water treatment and development of test equipment, choice of materials suited for high temperatures, economic analysis, design guidelines. Phase 2 was approved at XM 47, November 1999; ongoing

The work is done on a task-sharing basis, with experts meetings twice a year.

Results

The state-of-the-art report within phase 1 was published as:

SANNER, B. (ed.) (1999): High Temperature Underground Thermal Energy Storage, State-of-the-art and Prospects. - Giessener Geologische Schriften 67, 158 p., Giessen

There is a small number of (new) HT-UTES plants in operation, where monitoring programs allow to evaluate system performance, reliability, operational experiences, etc. within Phase 2:

Amorbach	Neckarsulm, D	BTES, residential area with solar heat

Anneberg	Solna, S	BTES, residential area with solar heat
Brinckmannshöhe	Rostock, D	ATES, appartment houses with solar heat
Hooge Burch	near Gouda, NL	ATES with heat from heat-and-power-cogeneration
Reichstag building	Berlin, D	ATES with heat from heat-and-power-cogeneration

Some other projects under construction can be accompanied within the framework of the annex, and first operational results may be obtained:

Attenkirchen	near Freising, D	BTES with water tank, residential area with solar heat
TESSAS	Mol, B	BTES, test plant

Test methods for BTES and for ATES are under development:

- Thermal Response Test, used in mobile equipment since ca. 1995, will be further developed and used for higher temperature BTES applications
- Test equipment for ATES to investigate groundwater behaviour in situ (scaling, corrosion, etc.) is developed and will be tested.

In 2000, two experts meetings have been held;

- Arnhem, Netherlands, May 18/19, 2001
- Mol, Belgium, Oct. 12/13, 2001

A workshop dedicated to thermal response testing was organized jointly with annex 13, on Oct. 14, 2001. It was attended by 20 participants from 9 countries and allowed discussion of test operation and evaluation. At the Mol site, 3 different test rigs were used to investigate the thermal properties around 3 boreholes, and two of the rigs could be visited during the workshop. The comparison of the results showed a fair degree of consistence.

In 2000, main work and achievements were on monitoring, understanding system behaviour, using and optimizing thermal response test, and the construction of the test equipment for aquifer water chemical behaviour (to be operational early 2001).

ON-GOING ANNEXES

Annex 13. Design, Construction and Maintenance of UTES Wells and Boreholes

Operating Agent: Olof Andersson, Lund Institute of Technology, Sweden

Annex 13 cover aspects of testdrilling, well and borehole design, construction and maintenance of wells and boreholes for UTES applications especially concerning ATES and BTES systems.

The final goal of the Annex is to work out a set of guidelines covering the following subtasks.

- How to gain information of the underground properties by testdrilling (Subtask A)
- How to design well or borehole systems properly (Subtask B)
- How to construct wells or boreholes cost effective, safe and properly (Subtask C)
- How to keep the storage systems functional during operation (Subtask D)

A second goal is to identify items or areas that need further research and development.

The annex was planned during 1997 and eventually approved by the 43rd EXCO Meeting in Paris 4-5 of December 1997.

The workplan takes into consideration that a number of participating countries will contribute to the further development of the Annex following the task shearing principle. The target is set to finalise the work at the end of year 2001.

The participating countries and their status of participation at the end of 2000 is shown in the table below.

Country	Joinment	Financial support	Working team
Belgium	Formal	Limited	Develops
Canada	Formal	Limited	Develops
Germany	Formal	Fully	Develops
Japan	Formal	Fully	Formed
Netherlands	Formal	Fully	Formed
Norway	Observer	NA	NA
Sweden	Formal	Fully	Formed
Turkey	Formal	Fully	Formed
USA	Formal	Fully	Formed

During the year 2000 there has been two organised activities. These are

- The 5th Expert Meeting that was held in Edmonton, Canada, April 10-11, 2000 and the results were reported to the 48th EXCO Meeting in Adana, Turkey, May 24-25, 2000. At this meeting it was approved to extend the time schedule to finalise the work at the end of year

2001. It was also announced that Germany would formally join the Annex and take over the subtask C leadership after the withdrawal of Switzerland. At the expert meeting it was concluded that the future work would be focused on finalising the state of the art reports and to screen the information with respect to guidelines and items that need further research and development.

- The 6th Expert Meeting, that was held in Mol, Belgium, October 16-17, 2000 and the results were reported to the 49th ECXO Meeting in Tokyo, Japan. At this meeting Norway appeared as an observing country with a potential to become a formal member by signing the ECES implementing agreement. A general conclusion from the meeting was that country specific state of the art material now should be completed and that missing information will be covered by inputs to the draft reports during the review stage.

For the coming year 2001, two more Expert Meetings are planned to finalise the work of the Annex.

Country co-ordinators are

– Belgium, Bert Gysen (gysenb@vito.be)

– Canada, Frank Cruickshanks (frank.cruickshanks@ec.gc.ca)

– Germany, Burkhard Sanner (burkhard.sanner@geo-uni-giessen.de)

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– USA, Jeff Spitler (spitler@osuunx.ucc.okstate.edu)

Two more countries are involved as observers. Contact persons for these are

– Denmark, Stig Sørensen (emcon@post10.tele.dk)

– Switzerland, Stefan Berli (foralith@foralith.ch)

ON-GOING ANNEXES

Annex 14. Cooling in All Climates with Thermal Energy Storage.

Operating Agent: Halime Paksoy, Çukurova University, Adana, Turkey.

Introduction

Annex 14 has started operation after being approved by the Executive Committee at the 46th Executive Committee Meeting of ECES IA in Lulea, Sweden on June 14-16, 1999. Cukurova University Centre for Environmental Research Adana, Turkey acts as the Operating Agent.

The scope of the work is to improve the efficiency of energy usage (energy conservation) which is valuable for the global environment and economies in both developed and developing countries. Moreover, Thermal Energy Storage (TES), which provides the matching of energy supply and demand, has been shown to contribute significantly in improving energy efficiency when compared to conventional energy systems. Such systems can also increase the potential of utilizing renewable energy sources such as ambient cold air or waste heat.

The overall objective of Annex 14 is to employ research, development and feasibility studies to advance the prospects of cooling with TES technologies for applications within a variety of energy systems and climate conditions and to encourage their use as a standard design option. The Annex will rely heavily on the activities and results of Annexes 6, 7, 8, 10 and 13 to encourage energy efficiency and increased sustainability of the global energy resources by stimulating the expanded use of TES in innovative, energy efficient and cost-effective projects in participating countries.

Subtasks

- Sub-task 1. Conduct a general review of existing and emerging cooling with TES applications in different climates
- Sub-task 2. Evaluation of Feasible Boundary Conditions and System Configurations for Cooling with TES
- Sub-task 3. Design and Analysis User-friendly Tools
- Sub-task 4. Determining potential cooling with TES applications in different climates

Duration of Phase I

July 1999 – June 2001

Activities in 2000

- Second Experts' Meeting and Workshop were held on April 6-7, 2000 in Halifax, hosted by Environment Canada.
  There were 24 participants with 11 presentations joining the workshop from Canada, Japan, Sweden, USA and Turkey. The Proceedings of the Workshop is prepared on a CD-ROM and will be send to the workshop participants.

- Third Experts' Meeting of Annex 14 was held on September, 1 ,2000, in Stuttgart during Terrastock 2000 Conference hosted by Stuttgart University.
  There were 17 participants joining the Experts' Meeting from Canada Germany, Japan, New Zeland, Sweden and Turkey.

The following decisions and actions were taken during the Annex 14 Third Experts' Meeting

- Discussion of associate membership
- Decided to ask for an extension of 18 months to the ECES ExCo
- Discussion on Subtasks and subtask reports from subtask leaders

- Fourth Experts' Meeting and Workshop were held on 9-10 November in Tokyo, hosted by Heat Pump and Thermal Energy Storage Technology Centre of Japan (HPTCJ).
  There were 34 participants joining the workshop from Canada, China, Germany, Japan, Korea, Sweden, and Turkey. Table 1 summarises the evaluation of the papers in terms of input to Annex 14.

Table 1. Input from Annex 14 Third Workshop

	Subtask1	Subtask 2	Subtask 3	Subtask 4
Bo He et al.	*			
Bo Nordell	*			
Motoi Yamaha	*			
Xiao Mei Li et.al	*			
Xiping Wu et al	*			
Tadahiko Ibamoto		*		*
Olof Andersson et al.	*			
Yoshitaka Sakano				
Byoung-Youn Choi et al.	*			
Hiroo Sakai		*		
Makoto Nakamura				
H. Tanaka et al.				
W. Son et al.		*	*	*
Shigeru Aoyama et al.		*	*	
Masaki Shioya et al.		*		
Sadao Nishimura		*		
Minoru Kawashima		*		

3. Workplan for 2000

December 1999 – June 2000

- Develop and evaluate criteria for the determination of the boundary conditions of technically and financially feasible cooling with TES applications

- Evaluate possible sources of cold to determine which sources of cold are most applicable to cooling with TES in different climates
- Evaluate and modify existing planning and engineering tools for the analysis, modelling and verification of cooling with TES
- Draft state-of-the-art-report

June 2000 – December 2000

- Final state-of-the-art-report

4. Publications in 2000

- Draft state-of-the-art report for Canada
- Final state-of-the-art report for Japan
- Final state-of-the-art report for Sweden
- Final state-of-the-art report for Turkey
- Second Workshop Proceedings, April 6-7, 2000 Halifax, Canada (CD-ROM)
- Third Workshop Proceedings, November 10, 2000 Tokyo, Japan (CD-ROM)

5. Experts' Meeting in 2000

- April 6-7, in Halifax, Canada
- September 3 in Stuttgart, Germany
- November 9-10 in Tokyo, Japan

6. Upcoming Meetings

- September 28-29, 2001 Shanghei, China
- Spring 2002, Maleysia

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PROPOSED ANNEXES

Annex 15. Electrical Energy Storage and the Integration of Renewables

Alan Collinson, EA Technology, UK

The benefits of bulk energy storage applied to the increasing levels of embedded generation, especially from new and renewable energy sources, are beginning to be recognised. Annex 15 is a natural development borne out of Annex 9 and focussing specifically on the issues of electrical energy storage and how it can be used to assist in the successful integration of new and renewable energy sources into existing electrical networks.

Annex 15 aims to build upon the successful foundation of the previous work carried out within the Annex 9 work programme. The focus of the work will be to develop a firm understanding of the technical issues and commercial implications of applying electrical energy storage technologies to the integration of renewables and to develop awareness of the capabilities and uses of existing and developing energy storage systems as applied to renewables.

Benefits include identifying how energy storage can be used to increase the value of renewable generation. This has advantages for both owners of renewable generators and suppliers of energy storage systems. It also has direct benefit in helping Governments achieve their Kyoto emissions targets.

The details of the work programme are not defined as yet, but a basic framework will focus activities on:

- the need for storage from a renewables perspective
- modelling of network/renewables/storage interaction
- implementation strategies for storage-based solutions
- the costs of storage
- the benefits of storage
- alternatives to storage

An internet discussion group has been set up to help develop the details of the work programme definition. This group was set up about six months ago and currently has 65 members. This has proved to be an efficient and effective mechanism for communication across four continents.

Annex 15 is seen as a key enabling mechanism in moving the application of energy storage to the integration of new and renewable energy sources significantly closer to market realisation. It is intended that the participation base will be expanded from the existing Annex 9 participative organisations and so the new Annex welcomes participation from countries and organisations who have not previously been involved in the IEA Implementing Agreement's work on electrical energy storage.

PROPOSED ANNEXES

Annex 16. Engineering textbook on thermal energy storage and renewable energy

Operating Agent: B. Nordell, Luleå University of Technology, Sweden

Background

Thermal energy storage has, during the last few decades, grown from small-scale pilot tests to an important technology for the future. It is benign to the economy and the environment and it is the key technology for the large-scale utilisation of renewable energy sources. A number of countries are collaborating within the framework of IEA, in the Energy Storage Implementing Agreement (ECES IA), to develop and to speed-up the introduction of these technologies.

The status of the energy storage technologies varies in different countries. In most countries it is never considered but in some countries it is a natural option for space heating and space cooling. There are many reasons for this difference but one conclusion drawn by the experts of Annex 8 (ECES IA) was that lacking engineering education is one explanation.

Even in countries where energy storage technologies are commonly used only a few experts know how to design the systems. To speed-up the extended use of energy storage technologies the design procedures must be included in engineering education. There is a demand of a good textbook to disseminate the knowledge now concentrated at a few institutes and companies. We have only found one textbook – in Swedish and at Luleå University of Technology for 15 years now. The intention of this annex is to use this existing text as a basis for a new improved and extended textbook in English for engineering students and consulting engineers. As a second stage of this annex we have the vision to develop an Internet based course on energy storage.

Objectives

The overall objective of the annex is to write and disseminate an engineering textbook on Thermal Energy Storage and Renewable Energy. The target group should be engineering students and consulting engineers.

The vision for a second stage of this annex is to develop an Internet course based on the textbook. One suggestion is to present the course in three levels of education:
1/ General. 2/ Engineering. 3/ Scientific.

Means and Activities

The new textbook will be written in English. It will be based on an already existing textbook[1] originally written in Swedish and used at Luleå University of Technology (LTU) The LTU course has been given during the final (5th) year in civil engineering for almost 15 years.

[1]/ Nordell B, Söderlund M (1998). Natural Energy Sources and Energy Storage. 2nd revised edition. Department of Environmental Engineering, Luleå University of Technology. Sweden. pp. 132.

The Swedish textbook was translated into English during the spring of 1999. This was made to enable international collaboration in rewriting and updating the current book to meet requirements in different countries. Consequently, given examples must picture the situation in different countries and climates. Environmental benefits of the technology must be included.

In the new textbook different technologies should be described as part of a system. Simple design rules, detailed design calculations and modelling should be treated.

Definition of the potential reader groups
As a first step the potential readers must be defined. Should the content be divided into different levels of information? General, Engineering and Scientific information?

Detailed list of contents
During the second step the content or the scope of the textbook will be defined. What kind of renewable energy sources should be included? Thermal or/and other types of renewable energy?

At this stage we also have to decide which types of storage systems that should be treated. Seasonal storage and short-term storage? Thermal storage and PCM? Underground storage? Geothermal energy? ATES, BTES, CTES? Snow Storage?

Review of current literature
So far we have not found any other textbook covering our field of interest but there are of course many textbooks and papers with vital information for the annex, e.g. environmental aspects must be considered. For this we have to define keywords for a literature search, perform the search and also collect information from the participating group of experts.

Layout
The layout of the textbook should be decided before the actual work of writing starts. It is of great importance that everybody engaged has a vision of the final work.

Writing and Proof-reading
Most of the available project time will be spent on writing and proof reading. Here we should also find good pictures of current projects to be included in the text. This part requires electronic communication to speed-up the process.

During this stage of the annex we must make good design problems to be solved by the reader. These problems must be relevant in different countries and climates.

At the end of this task we also have to consider next stage of the annex, the development of an Internet course based on the textbook.

Project Management and Reporting

It is proposed that the work of the Annex is carried out on a task-share basis. The proposed organisation structure is shown in Figure 1. The Operating Agent will have a stronger position than what is normally the case in most other annexes. This is because of the very special project.

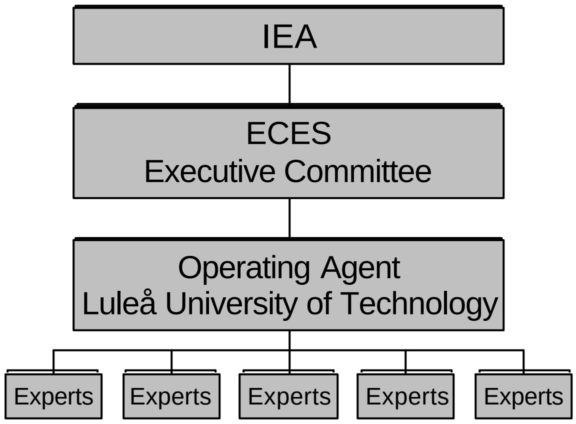

Figure 1. Proposed Organisation Structure.

A good textbook requires an all-pervading style. Nevertheless the experts are of utmost importance for the result of the annex.

Operating Agent

Luleå University as Operating Agent will supervise and co-ordinate the activities of the Annex. They will be responsible for the progress of work in order to fulfil the objectives within the time scales of the Annex.

The Operating Agent will report to the Executive Committee twice a year at the Committee meetings on the progress and results of the work performed.

On completion of the Annex, all participating experts will disseminate the textbook through suitable national activities (i.e. seminars, promotion, marketing etc)

Luleå University of Technology is familiar with IEA procedures and is therefore well suited to undertake the role of Operating Agent. Luleå University of Technology is also experienced in teaching the content of the textbook.

Participants

Each Participant shall contribute to the completion of task shared activities in terms of collaborative effort.

Each Participant shall make its best efforts to provide the Operating Agent with any information and data requested to fulfil the objectives of the Annex.

It is estimated that the level of collaborative effort required to complete the work of the Annex will be a total of 24 man months of which half is estimated for the Operating Agent.

Results

The deliverables of the Annex are:
- Engineering Textbook on Thermal Energy Storage and Renewable Energy.
- National activities for dissemination.

- A new annex proposal to establish an Internet based education on thermal energy storage.

Time Schedules

This Annex shall run for two years (June 2000 – June 2002). The Internet will be used for most of the information exchange but at some occasions there must be some time in Experts' Meetings, for round-table discussions and presentations of ideas.

	Meetings	Date
1	Kick-off Meeting Potential readers and scope	Jun 2000
2	1st Experts' Meeting Current literature, Layout	Dec 2000
3	2nd Experts' Meeting Writing and Proof-reading	Jun 2001
4	3rd Experts' Meeting Writing and Proof-reading	Dec 2001
5	4th Experts' Meeting Final Writing and Proof-reading National activities to promote the textbook 2nd Stage: Internetbased course	June 2002

Level of Effort

The level of collaborative effort required from the Participants to complete the task activities of the Annex is estimated to a total of about 24 man months. The major work must be in the hand one person, the Operating Agent. For that reason the Operating Agent is assumed to need 6 man months per year while the other experts are assumed to contribute with 1-2 man months per year.

Participants

During the Workshop on the future of Annex 8 (June 1999) several of the participants plus Spain showed great interest in the writing of this textbook. As a result of these discussions the experts of the following countries should to be interested: Belgium, Canada, Germany, Netherlands, Spain, Sweden, Turkey, and Japan. USA was not attending the meeting.

Information and Intellectual Property

It is of vital importance to have a mutual understanding and agreement upon the strategy for rights to intellectual property of the textbook

PROPOSED ANNEXES

Annex 17 Advanced Thermal Energy Storage Techniques Feasibility Studies and Demonstration Projects

1. Description of Technical Sector

Energy storage serves at least three different purposes.

- Energy conservation
- Natural energy sources
  - solar energy
  - utilization of differences in outdoor temperature between night and day
- Waste energy utilization
- Peak shift
- Shifting the energy peak from the more expensive daytime to the more cheap nighttime
- Power conservation
- Running energy conversion machines on full load instead of part load reduces the power demand and increases the efficiency of the machines.

Storage of thermal energy can be performed by sensible heat storage, e.g. heating a material to a high temperature at loading and cooling it down at deloading. Water is a common material for sensible heat storage at temperatures between 5 and 100 oC. The storage density is in the order of 0,01 MWh/m3

Another way of storing thermal energy is the utilization of the latent heat of phase change materials. Usually the heat of melting is utilized. The heat of melting is 80 to 100 times larger than the heat required for heating a material one degree. The energy density of the storage becomes in the order of 0,1 MWh/m3. The use of liquid -vapor phase change further increases the energy density.

The use of chemical reactions for thermal energy storage expands the temperature range for storage and also increases the potential energy density in the storage up to 1MWh/m3.

Chemical reactions for thermal energy storage are however combined with a heat pumping effect. Energy at a low temperature level has to be provided in order to discharge the storage. This energy is for instance used for vaporization of water. At the charging process energy is withdrawn from the process for instance by condensing water. The chemical contrary to phase change materials for thermal energy storage therefor has to be combined with utilization of energy and also requires energy for decharging.

The storage itself could be an underground thermal energy storage (UTES). The storage media is the groundwater (Aquifer Thermal Energy Storage) or the rock or soil itself (Borehole Thermal Energy Storage, Cavern Thermal Energy Storage). A cavern could be filled with snow or ice utilizing the latent heat of melting of the water.

The storage could alternatively be made in tanks or containers. A phase change material could also be included in materials for construction.

The scope of the work undertaken in this annex includes thermal energy storage by solid-solid, solid-liquid, liquid -vapor and solid-vapor phase transfer, for instance melting/solidification, crystallization/solubilization, vaporization/liquefaction as well as by solid sorption processes and by chemical reactions.

The difficulties in using phase change materials for energy storage are

(a) finding suitable materials for the required temperature range

(b) mass and heat transfer limitations
(c) phase separation, subcooling and other irreversabilities of the system
(d) system integration
The thermal energy that needs to be stored comes from different sources. Solar energy and district heating are just two possibilities. In these fields collaboration with the implementing agreements "Solar Heating and Cooling" and "District Heating and Cooling" is planned.
Three main areas of application will be covered in the annex:
Heating and cooling of buildings
Temperature sensitive materials
Waste heat utilization

1.1 Heating and Cooling of Buildings

The energy consumption for heating and cooling of buildings in Germany was about 3180 PJ for the year 1998. This is more than one third of the total energy consumption. The average household in Germany needs more that 75 % of its total energy consumption for space heating. The cooling demand in buildings increased rapidly over the last few years. The reason, beside general climatic and architectural boundary conditions, is an increase in the internal cooling load and higher comfort requirements. These aspects show the huge potential in this field for the implementation of advanced thermal energy storage technologies.

The heating and cooling of buildings can be identified as one of the most promising fields of application for thermal energy storage (TES) by phase change materials (PCM) and chemical reactions. Depending on the location and the use of the building, heating or cooling is the main application for the storage system. Due to high insulation standards and high internal heat production in many of today's buildings, cooling is necessary even in cold climates. Therefore many buildings in fact need heating **and** cooling. A demonstration project concerning the use of adsorption systems for cold and heat storage by the same system is planned.

PCM's and chemical reactions can be used for heating and cooling in active or passive systems. Active systems are defined by an actively supported charging or discharging process, for example, by ventilated air or a pumped heat transfer fluid. They are coupled to the building's heating or air conditioning system. The demonstration of active PCM storage with enhanced heat transfer mechanisms is planned. Passive storage systems (only PCM's) are an integral part of the building. They can level out temperature changes in the building by raising the thermal mass of the building. PCM's can be integrated into building materials. Demonstration projects for the implementation of these materials in old and new buildings will be carried out. The integration of PCM's in greenhouses in hot climates for the purpose of temperature control will be investigated as an additional application.

1.2 Handling of Temperature Sensitive Products

A tremendous amount of money is lost each year due to the damage of temperature sensitive products and materials when exposed to operating temperature extremes outside of their design specifications. The area of interest includes for example, keeping products within certain temperature limits during transport and protecting electronic equipment from overheating.

Both these application areas have seen a limited use of phase change materials (PCM’s) in combination with improved insulation techniques to achieve improved protection. The potential advantages that can be achieved by utilizing the benefits of PCM’s in numerous temperature sensitive applications is however, largely unknown. The objective of any demonstration projects in this area will be to optimize the bounds of application and to promote the suitability of incorporating PCM’s.

In the medical field there is a large demand to be able to transport for example, blood, vaccines, medication and transplant organs within very specific temperature ranges, no matter what the environmental conditions. A demonstration project in this area will highlight the effect on temperature control when incorporating PCM’s in the transport containers.

Another area of interest is the transportation of fresh foods and flowers. The temperatures to which they are subjected during transport tremendously affect the shelf life of these products. The water content of fresh foodstuffs should not freeze nor should they be exposed to higher than normal refrigerator temperatures. Today, either costly refrigerated transport equipment or the use of dry ice is common. The disadvantages of today using dry ice are well documented. A demonstration project will show how a passive system incorporating PCM’s is a viable and economically advantageous alternative.

Most electronic equipment is susceptible to permanent damage when exposed to high temperatures. A demonstration project will show how potential overheating can be limited by incorporating PCM’s within the system. Of special interest will be the problem of regeneration of the PCM back to its solid state so that it is available in cycles as a heat sink during normal operation.

These demonstration projects will focus on economic viability and the advantages of incorporating PCM’s over the alternatives of concentrating on expensive dynamic equipment such as air conditioning and refrigeration equipment or the limited improvement gained by improved insulation. This area of application is also realisable in a relatively short space of time, and as such will demonstrate the use of PCM's for applications in the building and waste heat management industries. The spin off should be increased understanding of the technical and financial benefits of incorporating PCM’s and therefore a faster track to commercialization.

1.3 Waste heat utilisation

Industrial processes often encompass a wide range of temperatures and different heat and cold fluxes in any one particular production site. If supply and demand exist simultaneously, heat exchangers can be used very efficiently. In many cases however supply and demand vary in time and quantity. Instead of using energy efficiently, electricity is often used to generate heat and cold on the spot, just where and when it is needed. This is convenient, but inefficient in economical and ecological terms. Heat and cold stores can fill this gap and match supply and demand with respect to availability in time and power.

A wide range of methods for heat storage with different properties is available. Latent heat storage by a solid / liquid phase change, for example, can be used to store heat or cold in a narrow temperature range but with a large storage density. If appropriate heat transfer mechanisms are applied, latent heat storage can also be used to supply large heat or cold fluxes, while equipment to generate the heat or cold is minimised in size, while operating continuously. The functional principle of latent heat storage has already been demonstrated in several fields. Waste heat utilisation however, has mostly remained on the technological level of hot water heat stores, with all their inherent limitations. Due to the existence of commercial storage materials with phase change temperatures from –33°C to +120°C the potential of latent heat storage however, is large, especially for waste heat utilisation. This temperature range can even be extended to higher temperatures if chemical reactions are included.

Several demonstration projects for waste heat utilisation are planned. In co-generation systems for example, heat is produced in parallel with electricity, but can often not be used at the same rate. Presently, hot water heat stores are used to store the heat, but are not suitable as the temperature of the waste heat is very close to the boiling point of water. Another option are drying processes, where heat has to be supplied for a long time, but might be available as waste heat in a short time process. Further, all batch processes such as in chem. engineering and food processing are potential applications for heat stores. Suitable ones have yet to be identified.

2. Objectives

The objectives of this Task are to overcome technical and market barriers for introduction of long- (seasonal) or short-term phase change and chemical reaction thermal energy storage for energy savings and for reduction of peak demand of energy in buildings, agricultural and industrial applications. Specifically this will be achieved by the demonstration of thermal energy storage with phase change materials or chemical reactions

- in building materials
- for cold and heat storage for comfort purposes
- for long and short term storage in the food sector including the transportation of food and other temperature sensitive goods
- for applications in industrial processes.

3. Means

The Participants shall share the coordinated work necessary to carry out this Task. The objectives shall be achieved by performing case studies and demonstration projects on thermal energy storage with phase change materials or chemical reactions in the building, the agricultural and the industrial sector. The result of the projects should be distributed to the participating member countries in the annex. If possible the 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. Observers from non-member countries are encouraged to participate in the workshops and to take part in the information exchange except for what is stated in Article 10.

4. Results

The results of this Task shall be

- periodic documents and interim progress reports on the results achieved under the Program 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

5. Time schedule

This Annex shall commence 1st of July 2001 and remain in force until 30st of June 2004. 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.

Completed Annexes

Annex 8 Implementing Underground Thermal Energy Storage Systems

Operating Agent: B. Nordell, Luleå University of Technology, Sweden

The final Annex 8 experts' meeting was held already in June 1999 at Storforsen, Sweden. After that the completion of the annex meant to write a final report, to the ECES Executive Committee, summarizing all work performed during the years 1994-1999. Most of this work was done during 2000.

A preliminary final report was prepared and available on the annex 8 homepage before the Executive Committee Meeting in Tokyo, Japan (November 2000). At that meeting the ECES Executive Committee decided to approve the Final Report, conditionally. The decision was that comments from delegates of the Executive Committee and also the Annex 8 Experts would be suggested to the Operating Agent before the 1st December 2000. Then the Operating Agent had two weeks to revise and correct the report. This was fulfilled and the Approved Final Annex 8 Report was completed on the 15th December 2000. [http://www.sb.luth.se/~bon/bon/IEA/ax8report.html]

As a result of Annex 8 some new activities are being planned. Some of these would possibly lead to new ECES annexes. The suggested new projects were:

- UTES Textbook (B Nordell, Sweden): The idea was to write a comprehensive textbook on UTES. The target group was engineering students and consulting engineers. This textbook would be based on a Swedish textbook that has been used at Luleå University of Technology during the last fifteen years.
- Database and Computer Design (G Hellström, Sweden). Continued work on evaluation and testing of available models. Databases for important UTES data should be made available via Internet or CD.
- Marketing Activities and Industrial Collaboration (G Bakema, Nehterlands).
- Technical Innovation and New Development (M Reuss, Germany).
- Legal & Environmental Aspects (O Andersson, Sweden).

Completed Annexes

Annex 9. Electical Energy Storage

Operating Agent: Alan Collinson, EA Technologies, UK

The final report has been prepared for the ECES Executive Committee as an executive overview of Annex 9. The Annex 9 (Phase 2) project is now successfully completed. The project has produced several useful reports, including a case study report of energy storage systems and a project definition report, which defines the framework for two potential demonstration projects (one for a power quality application and one for a utility-scale bulk storage project). A computer model for evaluating power quality applications has been developed and a requirement specification has been produced for the definition of a network applications model. General awareness of energy storage has been raised through the production of additional promotional material, including the Annex 9 publicity brochure, two Annex 9 newsletters and two "how-to" guides (one looking at the application of energy storage to power quality problems and the other looking at utility-scale energy storage). Use has also been made of the internet, with a dedicated Annex IX web site, operated by one of the annex participants. Annex 9 participants used the EESAT 2000 conference, which took place in September 2000, as a further opportunity to disseminate information related to electrical energy storage technologies and applications.

The participants in Annex 9 (Phase 2) included the following countries:

- Canada
- Finland
- Germany
- Netherlands
- Spain
- Sweden
- United Kingdom
- United States

The Annex 9 Work Programme consisted of the following subtasks:

- Subtask 1: Applications Case Studies
- Subtask 2: Project Definitions
- Subtask 3: Applications Modelling
- Subtask 4: Information Collation & Dissemination
- Subtask 5: Complementary R&D Programmes
- Subtask 6: Project Management

Project management for Annex 9 was achieved through several mechanisms. Regular experts/participating agent meetings were arranged and where a physical meeting of participating agents was not practical, then use was made of teleconferences. Electronic mail and one-to-one telephone communications were used for day-to-day project management issues. Progress was also reported to the ECES Executive Committee every six months.

The following experts/participating agents meetings and teleconferences took place during the course of the project:

• First Experts/PA Meeting	EA Technology Offices, UK	June 1998
• Second PA Meeting	Atlanta, USA	Oct. 1998
• First Teleconference	Europe, USA	Dec. 1998
• Second Teleconference	USA/Europe	Feb. 1999
• Third Teleconference	USA/Europe	Mar. 1999
• Third Experts/PA Meeting	Elforsk Offices, Sweden	June 1999

It was originally planned to carry out the project over an 18-month period, with completion in September 1999. The project overran slightly on those timescales, with final completion of all deliverables in November 1999. The project is now complete. The project budget overspent by approximately 20% (£155,000 total expenditure against an income of £127,000). The project overspend was borne by the Annex 9 Operating Agent.

The Annex 9 work programme was recently reviewed by the Renewable Energy Working Party (REWP). The REWP members found that the Annex IX focus was on near-term utility needs and did not undertake enough work on longer-term renewable-related energy storage needs. Indeed, the need for more work in the area of "integration with renewables" was also identified by the Annex 9 participants and the Operating Agent.Other Implementing Agreement representatives agreed to detail their needs and describe previous work carried out on storage in order to help define the next steps. The main needs for electrical energy storage come from the wind, photovoltaic and electric/hybrid vehicle implementing agreements. The feedback from other Implementing Agreements led to the development of the Annex 15 proposal, entitled "Electrical Energy Storage and the Integration of New and Renewable Energy

Collaborative Groups, Workshops and Meetings

IEA Energy End-Use Technologies Working Party Workshop, October 4, 2000, Vienna

Renewable Energy Technologies Working Party Workshop, October 11, 2000, Paris

Joint Executive Committee Meeting with ECBCS IA November 8, 2000, Tokyo, Japan

Participation in Future Buildings Forum, Building Coordination Group and Building Related Implementing Agreements

STRATEGIC PLAN 1999 - 2003

Preface

This strategic plan of the Executive Committee outlines the scope and goals of the IEA-Energy Storage Programme for the next 5 years (1999-2003). The paper has been compiled after intensive discussions at two workshops arranged in conjunction with the regular Executive Committee Meetings in 1998. The final document was approved by the Executive Committee in Spring 1999.

The strategy plan will serve as the basic working document to guide the future work of the Executive Committee and will also provide a comprehensive summary for other Committees of the IEA and for the IEA-secretariat. More detailed information on the Storage Programme, especially for a public audience is published in Conference Proceedings /1/, annual reports and Annex status reports of the Executive Committee, Annex brochures and on the Internet-Website of the IEA-Energy Storage Programme /2/.

Structure

1. Introduction

Energy storage technologies are a strategic and necessary component for the efficient utilization of renewable energy sources and energy conservation. There is a great technical potential to substitute for burning fossil fuels by using stored heat that would otherwise be wasted and by using renewable generation resources. These energy sources can be used more effectively through the addition of short and long term energy storage. Thermal and electrical energy storage systems enable greater and more efficient use of these fluctuating energy sources by matching the energy supply with demand. Thermal energy storage can also be used for cooling to reduce or eliminate the demand for electricity, including the most expensive electrical energy that is generated during periods of peak power demand.

The Implementing Agreement on Energy Conservation through Energy Storage was established in 1978 with the objective to facilitate international cooperation on research, development and demonstration (RD&D) of new, innovative energy storage technologies. Energy storage technologies are relevant in many IEAImplementing Agreements, especially in the building and transport sectors related to the Working Parties Renewable Energies and End Use Energy. Cooperation with these IEA Executive Committees is becoming more and more important in order to achieve the system integration and implementation of storage technologies.

2. Motivation

In 1973, after the first oil crisis, highest priority was given to improving the **energy security** of highly industrialized countries. At that time, many countries were completely dependent on imported oil. Today the situation has changed. The dependence on imported oil continues, but the rate of growth of petroleum products is slowing, and cheap fossil fuels are currently available. However, the further unlimited use of fossil fuels is causing a steady increase of energy-related CO_2-emissions into the earth`s atmosphere. This may lead to changes in the world climate in the medium and long term. Additionally, the use of conventional mechanical cooling utilizing ozone depleting substances (ODS), such as CFC and HCFC refrigerants, is also a major concern.

In December 1997, the Parties to the UN Framework **Convention on Climate Change** agreed to the terms of the **Kyoto Protocol**. This historic agreement sets legally-binding greenhouse gas emission objectives over the period 2008-2012 for industrialized countries. The energy sector, from supply to end use, is responsible for the majority of greenhouse gas emissions in the developed world, through the combustion of fossil fuels and the emissions of CO_2, N_2O and CH_4, three of the six gases covered by the Protocol.

Many governments have committed to reduce CO_2 emissions into the atmosphere. They have decided to strengthen their national efforts to increase the deployment of energy conservation technologies and utilization of renewable energy sources. So far in most industrialized countries, renewable energy sources contribute only marginally to satisfy energy demand. This is due to several reasons, in particular because new energy systems are not yet economically competitive with the combustion of fossil fuels, long term reliability is not yet proven, and there are still some regulatory and market barriers which have to be overcome. Therefore, further attempts have to be made to resolve these issues. This is especially true for many new energy storage technologies and concepts that have not yet been implemented on a large scale in the market.

The Executive Committee on Energy Storage has the following mission and vision for the Programme:

3. Mission

To research, develop, implement, and integrate energy storage technologies to optimize energy utilization by improving overall energy efficiency and economic growth while benefiting the local and global environments.

4. Vision

Energy storage technologies are able to contribute significantly to energy efficiency, the global environment, and economic growth. Therefore it is envisioned that over the next decade the IEAProgramme on Energy Storage will continually broaden the scope of its activities by undertaking research and technology development, technology transfer activities and the prototyping and deployment of near-market ready and market ready technologies. Moreover, the effective matching of energy supply with energy demand through systems integration will be emphasized, as will the expansion of collaborative actions with all interested countries and other Implementing Agreements.

5. Objectives and Strategies of the Programme

The Energy Storage Programme is technology, environment and market oriented. The main objectives are:

TECHNOLOGY: Advance the development of thermal energy storage technologies utilizing waste, renewable or ambient energy sources to supply space heating, space cooling and process cooling to achieve significantly improved energy efficiency and cost-effectiveness. Research and develop electrical energy storage technologies and systems that integrate batteries, flywheels, and other storage media with power electronics and controls to enhance energy security and facilitate increased use of renewable energy sources. We will provide a forum to facilitate the international exchange of information and experience on energy storage research, development, project applications, field trials and products. We will advocate that adequate design information on innovative energy storage technologies is made available to interested groups in industry, government, and academia.

ENVIRONMENT: Evaluate and document the many environmental benefits of energy storage and ensure that potential environmental problems are directly addressed and avoided by sound technical analysis and design techniques. We will involve national and regional environmental agencies in our work to ensure that energy storage meets the present and future requirements of these agencies. We will raise the level of awareness and understanding of energy storage technologies, especially their environmental benefits, and advocate that impartial technical information is made available to all stakeholders involved in the implementation of energy storage.

MARKET: Encourage the required steps be taken to achieve the proper application of proven energy storage technologies world-wide in the commercial, industrial and agricultural sectors. We will focus our communications efforts on the world market players including design engineers, architects, building owners, developers, governments, regulatory agencies, electric utilities, and community leaders. We will encourage the use of renewable energy sources to cool non-residential buildings in a post-CFC world; develop methods to integrate energy storage technologies into community-based systems; and develop effective residential cold storage techniques that avoid the use of conventional chillers in moderate climates. Heating and cooling applications are part of the market, but economic and technical limitations indicate that cooling is the first priority, followed by combined cooling and heating, and lastly heating. We will develop and encourage deployment of electrical storage with renewable generation technologies where market conditions favor off-grid implementation (many developing countries and remote locations world-wide). Short-term electrical storage will be investigated to improve power quality and reliability in all types of commercial endeavors. Longer duration electrical storage will be considered for peak shaving, system stability, and improved asset utilization in utility networks.

In general, we will establish and strengthen new and existing internal and external international networks that may result in increased implementation world-wide of many energy storage technologies.

6. Market Opportunities and Barriers to Deployment

As with many other renewable energy and energy saving technologies, energy storage technologies offer great market potential in the long term, but the present implementation is impeded by significant barriers.

The most important factors have been identified by the Executive Committee:

Market Opportunities

- Great energy saving and fossil fuel substitution potential.
- Opportunity to assist in meeting CO_2 emissions targets.
- Market deployment will create new jobs.
- Enhanced energy security through the use of storage technologies.

Threats and Challenges

- Energy storage technologies are not always cost-effective based on energy savings.
- High initial costs.
- Availability of cheap fossil fuels.
- National regulations of groundwater protection often impede the implementation of aquifer thermal energy storage.
- Perceived high technical and financial risks for the owner.
- Lack of knowledge and the need for education.

Strengths and Weaknesses

The most important factors are:

Strengths

- Direct and immediate technology transfer between the participating countries.
- Increased research capacity by combining research efforts.
- International network of experts.

Weaknesses

- Lack of sufficient funding for RD&D of thermal and electrical energy storage systems.
- Early demonstration plants had overly optimistic expectations and were not highly reliable.
- Cooperation is mainly research-oriented, there has been poor or insufficient involvement of industry.

7. Collaboration with other Executive Committees

Closer cooperation among the relevant Executive Committees is essential, especially for the Storage Programme. Storage technologies have to be integrated with the total system and have to meet the specific technical and economic requirements of the application. Integrated system concepts that include storage technologies have to be developed to achieve an optimal cost-effectiveness and energy saving potential. Therefore the Executive Committee will intensify the cooperation with other Executive Committees in the future. One way this will be done is by joint workshops to identify new cooperative joint activities. Close collaborations will be established in the Residential and Commercial Sectors especially with the following Programmes:

- Solar Heating and Cooling
- Energy Conservation in Buildings and Community Systems
- Heat Pumping Technologies
- District Heating and Cooling
- Demand Side Management (DSM)
- Photovoltaic Power Systems
- Superconductivity

8. Achievements of the Programme

So far, great progress has been made by the Programme to achieve its objectives. The main results are:

- A reliable data and information base on various energy storage technologies and concepts has been established by international reviews of the state of the art, assessment and market studies, and construction and monitoring of pilot and demonstration plants.
- The technical as well economic risks to implement new energy storage technologies have been reduced.
- National and international guidelines have been developed for the implementation of ground and aquifer storage systems to avoid environmental risks and to facilitate installation by local water authorities.
- Design tools and computer models have been developed and are being used now by engineers for the planning and design of new energy systems that include energy storage technologies.
- Technology transfer and information dissemination have continued with the sponsorship of workshops and international conferences, including the series of International Thermal Energy Storage Conferences (Enerstock'85, Jigastock´88, Thermastock´91, Calorstock´94, Megastock´97) and the Electrical Energy Storage Conference (EESAT´98).
- Deployment of low temperature aquifer storage facilities for heating and cooling on a large scale in various countries, e. g., Belgium, the Netherlands, Sweden, the United States of America, Switzerland and Germany.

- Close cooperation with other Implementing Agreements (e. g., Solar Heating and Cooling, Buildings and Community Systems, Heat Pumping Technologies) has been established to avoid duplication of effort and to align the Energy Storage Programme with the interest of other IEAProgrammes. Cooperation within the Future Building Forum has been initiated.
- Internet homepages of the IEA-Energy Storage Programme and various Tasks has been set up.
- New member countries (Japan, Spain, Turkey, UK) have been attracted. Other countries (Bulgaria, Poland, Switzerland) are interested in participating in the Programme.

9. Scope and Workplan

The Executive Committee constitutes a forum of Senior National Programme Managers and Experts. It fulfills the following tasks:

- Task Management (Appendix)
- Coordination of national activities among participating countries
- Information dissemination by electronic Journals and Internet Websites
- Organization of International Conferences and workshops
- Evaluation of the State-of-the-Art technologies.

Until recently, the Storage Programme was mainly focused on thermal energy storage technologies for the heating and cooling of buildings because this sector offers the largest energy saving and substitution potential in northern countries. However, electrical energy storage systems are also important for the stabilization and optimization of electrical energy systems as well as for the utilization of renewable energy sources, in particular in photovoltaic and wind energy systems. Therefore, the End Use Working Party recommended that the scope of the programme be broadened to include electrical and other energy storage technologies.

In January 1995 an IEAWorkshop on Energy Storage was held in Montreal to examine the opportunities and interest of cooperation in storage technologies that the IA had not previously covered in the Programme. As a result of the workshop, two new Annexes were initiated:

- Annex 9: Electrical Energy Storage Systems and Network Optimization.
- Annex 10: Phase Change Materials and Thermochemical Storage.

In 1998, the IA was extended by the Energy End-Use Working Party for 3 years until the end of the year 2000. So far twelve Annexes have been carried out, and seven of them have already been completed successfully (Appendix 1).
Special R&D activities on energy storage systems have been carried out in the context of other IEA programmes, e. g.,

- Solar PACES: (High temperature thermal storage systems for solar thermal power plants).
- Solar Heating and Cooling: Task 16 - Photovoltaics in Buildings (Survey: Battery Storage Systems), Task 14 and Task 26: Advanced Solar Heating Systems (hot water storage).
- Photovoltaic Power Systems.
- Heat Pumping Technologies.
- District Heating and Cooling.

10. Proposed Future Activities

The proposed future activities are largely extensions of the previous and present work of the Programme. Various topics and activities will be continued in order to achieve successful implementation of storage technologies. The following list includes the activities that will be examined by the Executive Committee.

- Follow-on to Annex 8: Implementation of underground thermal energy storage.
- Follow-on to Annex 9: Pilot and demonstration electrical storage plants. Develop consortia and explore funding mechanisms to realise demonstration schemes within a reasonable time scale.
- Evaluation of electrical storage systems for use with renewable resources and demonstration of the environmental benefits of reduced greenhouse gas emissions.
- Research electrical energy storage for competitive electricity supply markets and determine the economic advantages of storage for peak shaving, capital equipment deferral and frequency regulation applications.
- Annex 14: Cooling in all climates with thermal energy storage systems (Task Definition Phase).
- Short term cold storage for DSM (demand side management)
- Comprehensive evaluation of the environmental and indoor consequences of energy storage by reviewing present national efforts and development of a validated methodology.
- Role of thermal energy storage in increasing the energy efficiency of building HVAC systems such as combined with closed-loop building heat pump systems and desiccant-based cooling systems. Cooperation with the IEA Building and Community Systems, Heat Pumping Technologies and Solar Heating and Cooling IAs will be useful.
- Evaluation of the benefits of hot and cold storage with heat pumps, especially the advanced generation of heat pumps, in collaboration with the Heat Pump IA.
- Study the potential for water remediation efforts using energy storage through community or aquifer-based planning of large-scale energy supply systems with the objective of assisting the implementation of energy storage in a systematic manner.
- Organisation of International Conferences, workshops and symposia:
    - TERRASTOCK-2000 (August 2000, Stuttgart, Germany)
    - EESAT 2000 (September 2000, Orlando, Florida, USA)
    - Workshop on Advanced Solar Thermal Energy Storage (October 1999, Freiburg, Germany) in collaboration with the Solar Heating and Cooling Programme.
- Publication of the electronic journal: Underground Thermal Storage and Utilization /2/.
- Publication of Programme and Annex brochures and reports on Internet /2/.
- Continuous evaluation and preparation of state-of-the-art reviews.
- Joint efforts should be initiated to implement new energy storage technologies in all countries with an interest in storage or with a significant energy storage market potential.

11. Participation

The following countries and corresponding organizations have signed the IEA Energy Storage Implementing Agreement:

Belgium, Ministry of Economical Affairs
Canada, Public Works Canada
Commission of the European Communities
Denmark, The Ministry of Energy
Finland, Technology Development Centre TEKES
Germany, Forschungszentrum Jülich GmbH
Italy, Ente per le Nuove Tecnologie l `Energia e l`Ambiente (ENEA)
Japan, Heat Pump &Thermal Storage Technology Center of Japan.
Spain, IBERDROLA
Sweden, The Swedish Council for Building Research
The Netherlands, The Netherlands Agency for Energy and the Environment (NOVEM)
Turkey, Çukurova University, Adana

United Kingdom, EA Technology
United States of America, Department of Energy.
Bulgaria, Poland and Switzerland presently participate in various Tasks and have sent representatives to the Executive Commitee meetings. These countries are expected to become signatory countries of the Implementing Agreement on Energy Storage.

12. References

/1/ CALORSTOCK`94: 6th International Conference on Thermal Energy Storage, August 22-25, 1994 Espoo, Finland, Proceedings pp. 303-339.

MEGASTOCK`97: 7th International Conference on Thermal Energy Storage, June 18-21, 1997, Sapporo, Japan, Proceedings pp. 1003-1026.

EESAT 98, Electrical Energy Storage Systems Applications & Technologies, June 16-18, 1998, Chester, UK, Proceedings.

/2/ Internet Website addresses:

http://www. sb.luth.se/vatten/projects/iea/ (general information, task and annual reports)
http://www.eatl.co.uk/annexIX/home.htm and http://www. eus.de/energy-storage/ (Annex9)
http://www.chemeng.kth.se/avdelningar/ts/annex10/index.htm (Annex10)
http://www.geo-journal.stockton.edu (electronic journal)
http://www.itw.uni-stuttgart/TERRASTOCK

APPENDICES

APPENDIX 1 - IEA GENERAL INFORMATION

Framework of the International Energy Agency (IEA)

Established in 1974 with headquarters in Paris, the IEA is the energy forum for 24 industrial countries - Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Union also participates in the work.

The IEA is an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD). The IEA's main decision-making body is the Governing Board, composed of senior energy officials from each Member country. Under normal circumstances, the Governing Board holds regular meetings several times a year. Meetings at Ministerial level are held every two years.

The Governing Board directs the activities and makes the major policy decisions of the IEA. It regularly reviews the world energy situation as well as domestic energy policies to assess future energy supply and demand patterns and to determine policies to meet changing energy and economic conditions.

A Secretariat, with a staff of energy experts drawn from Member Countries, supports the work of the Governing Board, the Standing Groups and Committees. The IEA Secretariat collects and analyses energy data, assesses Member countries' domestic energy policies and programmes, makes projections based on differing scenarios and prepares studies and recommendations on specialised energy topics. An Executive Director appointed by the Governing Board heads the IEA Secretariat.

The countries participate in the IEA to safeguard the members' collective energy security, and thereby reduce the economic risks, associated with energy shortages. Steps to safeguarding from economic risks has included reducing dependency on oil imports, the sharing of oil supplies in emergencies, the promotion of more stable world oil markets and the initiation of collaborative research on new and efficient energy technologies.

The future promises fundamental changes in the global energy balance. Higher economic growth rates will result in non-industrialised nations accounting for more than 60% of the world energy demand by the end of the century. The growing concern for environmental issues also having a strong influence on the nature of national and global energy priorities. IT appears that the need for international collaboration in energy strategy continuing to increase in importance.

Objectives

- To maintain and improve systems for coping with oil supply disruptions;
- To promote rational energy policies in a global context through co-operative relations with

non-member countries, industry and international organisations;
- To operate a permanent information system on the international oil market;
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- To assist in the integration of environmental and energy policies.

Committee on Energy Research and Technology (CERT)
Fostering energy technology innovation is a central aspect of the IEA's work. Development of safer, more efficient technologies is imperative for energy security, environmental protection and economic growth. Equally essential is the widespread deployment of these more economical, environmentally benign technologies. But progress in energy technology research, development, demonstration and deployment implies investment. Two decades of IEA experience have shown that international collaboration on these activities avoids duplication of effort, cuts costs and speeds progress.

The IEA's Energy Technology Collaboration Programme operates under the guidance of the Agency's Committee on Energy Research and Technology (CERT) and its subsidiary bodies dealing with technologies for fossil fuels, renewable energy, efficient energy end-use and fusion power, as well as its expert groups on electric power technologies and technology assessment methodologies. The Programme enables experts from different countries to work collectively and share results, which are usually published. The Programme's objectives are
- improved energy efficiency and technology reliability;
- enhanced access to up-to-date assessments of energy technology performance;
- reduced environmental impact of energy-sector activities;
- Co-operation with non-member countries.

Practical elements of the Programme include:
- policy analysis through reviews of energy technology and R&D programmes in Member and selected non-member countries, thereby encouraging common approaches;
- sharing of practical experience and exchange of information through joint studies, conferences and workshops that monitor technological advances in key areas and enhance visibility for leading-edge techniques; and
- collaborative research projects. IEA Implementing Agreements offer the framework for these collaborative research projects.

The projects aim to:
- expand basic understanding of existing technical processes and reduce their costs;
- remove barriers to market deployment;
- foster sharing of operating experience and expand general awareness of technological capabilities.

The Implementing Agreements provide the legal mechanism for establishing participants' commitments and the project's management structure, and for ensuring distribution of benefits from the co-operative work while protecting participants' intellectual property. Activities are managed jointly by experts from IEA Member and non-member countries (representing government bodies, industry, academia and other international organisations). Resources come from participants. Benefits include not only pooled resources and shared costs, but also harmonisation of standards and hedging of technical risks. The IEA programme places emphasis on expanding co-operation with industry.

More than 30 countries are involved in Europe, America, Asia, Australia and Africa. Flexible and dynamic, the programme is expanding steadily as the advantages of international collaboration secure wider recognition. Some forty Agreements operate currently, involving a total of some US$100 million. They cover the full range of technologies used in the production, transformation, distribution and end-use of energy. Among the many areas covered by Agreements are bio-energy, solar heating and cooling, wind turbine systems, advanced fuel cells and electric vehicles. Energy technology information centres have also been set up under the programme. Concern for the protection of the environment is reflected strongly in the mandates of both long-standing and more recent Implementing Agreements.

Working Parties

The four Working Parties are the Working Party on **Energy end-Use Technologies**, the Working Party on **Fossil Fuels**, the Working Party on **Renewable Energy Technologies** and the **Fusion Power Co-ordinating Committee**. Working parties are composed of government officials from member countries who have a broad knowledge of their countries' activities in those particular areas. They help focus research and development initiatives and review the status of technology development and deployment. Working Parties identify areas of mutual interest among countries and, if warranted, initiate Implementing Agreements, which they then review and guide on a regular basis. Working Parties also exchange information on the status of national programs and on the development of technologies.

Working Party on Energy End Use Technologies

Infrastructure energy systems, buildings, industry, agriculture and food, electricity end-uses and crosscutting technologies are the current thrust areas of this Working Party. The following lists the active Implementing Agreements of the IEA which are guided by the Working Party on Energy End-Use Technologies.

Implementing Agreements

- Advanced Fuel Cells
- Alternative Motor Fuels
- Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET)
- District Heating and Cooling
- Electric Vehicle Technologies and Programs
- Energy Conservation and Emissions Reduction in Combustion
- Energy Conservation in Buildings and Community Systems
- Energy Conservation through Energy Storage
- Energy Technology Data Exchange (EITDE)
- Impacts of High-Temperature Superconductivity in the Electric Power
- Program of Energy Technology Systems Analysis (ETSAP)
- Pulp and Paper

An **Implementing Agreement**: is a framework, which facilitates the initiation, implementation monitoring and review of international collaborative efforts. Implementing Agreements can encompass any phase of the technology cycle research and development demonstration, validation of technical environmental and economic performance: market deployment or information: exchange:

Member countries choose to participate in those-Implementing Agreements which best meet their needs.

Implementing Agreements are flexible and are set up to meet the requirements of those countries that wish to take part. Participants can be member country government organisations, semi-private entities (including universities) and private organisations when formally designated by the national government. Non-member countries may also join a given Implementing Agreement under a mechanism termed **Associate Participation**, provided **they obtain prior consent** from the IEA Governing Board. Private organisations not formally designated by their government, and non-intergovernmental international entities may also join the Implementing Agreement under a special designation termed **Sponsor Participation** provided they obtain prior approval from the Committee on Energy Research and Technology.

The initiative for an Implementing Agreement is usually taken by interested countries, which work with the IEA Secretariat and the Working Parties to draft a program of work. The proposed Implementing Agreement is first considered by CERT and then by the IEA Governing Board. Once approved, an **Executive Committee**, made up of one representative from each country, which joins the Agreement, develops a strategy for carrying out the research and development. If an implementing Agreement involves sizeable or varied work, it may be broken down into Annexes. Interested countries may choose to join all the Annexes, or only those which fulfil their requirements. An **Operating Agent** is elected for each Annex to act as project manager;

The IEA has no central funds to finance the Implementing Agreements, thus all resources are supplied by the participating countries. Two methods exist for financing an Implementing Agreement:

1. <u>Cost-sharing</u>: the participating countries contributing monetary resources to a common fund for equipment purchase or the operation of test facilities or information processing centres, and

2. <u>Task-sharing</u>: each participating country undertakes to devote specific resources and personnel to carry out part of a common work program.

Implementing Agreements are legal documents signed at a senior level such as the ambassador to the OECD.

APPENDIX 2 - LIST OF ANNEXES

Annex No.	Annex Name
	Closed Annexes
1	Large Scale Thermal Storage Systems Evaluation
2	Lake Storage Demonstration Plant in Mannheim
3	Aquifer Storage Demonstration Plant in Lausanne-Dorigny
4	Short-term Water Heat Storage Systems
5	Full-scale Latent Heat Storage Installations
6	Environmental and Chemical aspects of Thermal Energy Storage in Aquifers and Research and Development of Water Treatment Methods
7	Innovative and Cost-effective Seasonal Cold Storage Applications
8	Implementing Underground Energy Storage Systems
9	Electrical Energy Storage Technologies for Utility Network Optimisation
	Ongoing Annexes
10	Phase Change Materials and Chemical Reactions for Thermal Energy Storage
12	High Temperature UTES
13	Design, Construction and Maintenance of UTES Wells and Boreholes
14	Cooling in All Climates with Thermal Energy Storage
	Planned Annexes
15	Electrical Energy Storage and the Integration of Renewables
16	Engineering textbook on thermal energy storage and renewable energy
17	Advanced Thermal Energy Storage Techniques Feasibility Studies and Demonstration Projects

Previous Annexes

Annex 1. Large Scale Thermal Storage Systems Evaluation
Annex 1 was a technical and economic evaluation of various storage concepts presented by the participating countries. The results of this work formed the basis for subsequent Annexes. The final report was published in October 1981.The Annex was formally closed at the Executive Committee Meeting in April 1983. Participating countries: Switzerland (OpA), Belgium, CEC, Denmark, Germany, Sweden, USA.

Annex 2. Lake Storage Demonstration Plant in Mannheim
Annex 2 had the objective of developing a seasonal lake storage and to demonstrate the feasibility by the construction of a large-scale pilot plant in Mannheim, Germany. Construction of the plant was cancelled after failing to achieve an economic design.

Annex 3. Aquifer Storage Demonstration Plant in Lausanne-Dorigny
Annex 3 involved the design, construction and operation of a high-temperature aquifer storage in Lausanne-Dorigny. The storage consisted of a vertical well with horizontal drains. The project was commonly called SPEOS. Waste heat from a municipal facility was stored in summer and used for space heating and domestic hot water of a gymnasium. Collaboration involved seven countries and terminated in 1989. Participating countries: Switzerland (OpA), Denmark, USA, Sweden.

Annex 4. Short-term Water Heat Storage Systems
Annex 4 reviewed the theory, techniques and application of hot water storage systems and produced a state-of-the-art report. It focused on various measures to maintain thermal stratification. The Annex was closed in 1988. Participating countries: The Netherlands (OpA), Germany, Sweden, USA

Annex 5. Full-scale Latent Heat Storage Installations

Annex 5 involved the installation and monitoring of latent energy storage installations with the objective of evaluating their technical and economic feasibility. The Executive Committee recommended reviewing the state-of-the-art of latent heat stores and a workshop was held in 1984 sponsored by the German Ministry for Research and Technology. As a result of the workshop recommendation to concentrate on monitoring pilot and demonstration plants to provide reliable performance data, an Annex on Full Scale Latent Heat Storage Installations was initiated in 1988. Germany has provided the Operating Agent. The Annex was terminated in 1992. Participating countries: Germany (Op. A), Sweden, USA.

Annex 6. Environmental and Chemical aspects of Thermal Energy Storage in Aquifers and Research and Development of Water Treatment Methods

Annex 6 dealt with the chemical and environmental aspects of thermal energy storage in aquifers. A major potential problem of aquifer energy storage is the scaling an clogging of wells and heat exchangers. To avoid these problems reliable and ecologically sound methods of water treatment are required. The development and testing of the chemical, micro-biological and environmental effects of ground-water treatment methods were the objectives of Annex 6. The work was initiated in 1987 and extended through twelve experts meetings into 1993. The Netherlands provided the Operating Agent and nine countries participated. The Annex was formally closed by the Executive Committee in 1996. Participating countries: The Netherlands (Op. A), Canada, Denmark, Finland, Germany, Sweden, Switzerland, USA.

Annex 7. Innovative and Cost-effective Seasonal Cold Storage Applications

Annex 7 aimed to demonstrate innovative, energy efficient and cost-effective cold storage design for a variety of building types and industrial applications to encourage the adoption of cold storage as a standard design option. More specifically, it evaluated effective storage control and operating strategies; evaluated combined hot and cold storage for increased energy efficiency and cost-effectiveness; and conducted national market studies for the developed technologies. A planning workshop in Sweden initiated the work in January 1989 and the activities extended through eight experts meeting into 1993. The Annex was formally closed by the Executive Committee in 1996. Participating countries: Canada (Op. A), Germany, Netherlands, Sweden.

Annex 8. Implementing Underground Thermal Energy Storage Systems

Annex 8 aims to speed the introduction of Underground Thermal Energy Storage in the building, industrial and agricultural sectors. It will encourage the adoption of energy storage in standard project designs by developing procedures and tools based upon documented applications in different energy efficient systems. Screening and decision tools will be provided to ensure ecologically sensitive applications. The first experts' meeting was held May 1994 in Sweden. Participating countries: Sweden (Op. A), Belgium, Canada, Germany, Netherlands, Turkey, USA, Japan. Final report can be reached at [http://www.sb.luth.se/~bon/bon/IEA/ax8report.html]

Annex 9. Electrical Energy Storage Technologies for Utility Network Optimisation

Annex 9 will examine the potential role of electrical storage technologies in optimising electricity supply and utilisation. It will identify and overcome barriers to widespread adoption of electrical energy storage technologies through successful demonstration projects. Annex 9 was proposed by

EA Technology Limited of the UK as a result of the recommendations of the Energy Storage Strategy Workshop held in Montreal during January 1995. The annex started in June 1996. Participating countries: Canada, Germany, Netherlands, Sweden, UK (OpA), and USA.

Ongoing Annexes

Annex 10. PCM and Chemical Reactions for Thermal Energy Storage.
Annex 10 will examine the role and accelerate the introduction of phase change materials into energy systems in residential, commercial, industrial and agricultural sectors. It has been proposed by the Concordia University, Centre of Building Studies in Montreal as a result of the recommendations of the Energy Storage Strategy Workshop held in Montreal during January 1995. The Annex was approved by XC43 on December 1997. Participating countries: Bulgaria, Canada, Finland, Germany, Japan, Poland, Sweden (OpA) and Turkey. China is preparing its participation and Australia, France, India, Italy, the Netherlands, United Kingdom, and USA have shown interest in participation.

Annex 12. High Temperature UTES
Germany initially suggested Annex 12. Phase 1 of the annex was approved by XC43. This stage starts with a State-of-the-art review of HT UTES applications. It will be followed by at study in which the most promising applications and system concepts for HT-UTES are evaluated. The results will allow assessing the expected benefit of HT-UTES and justify a decision on phase II. Participating countries are not yet clear but Canada, Germany (OpA), Belgium, Sweden and the Netherlands have shown interest in the annex.

Annex 13. Design, Construction and Maintenance of UTES Wells and Boreholes.
Annex 13 is a result of the Energy Storage Strategy Workshop held in Montreal during January 1995. The annex was approved by XC43, December 1997. The objectives are to: Describe UTES drilling and exchange experiences of different technologies. Identify related problems in order to establish areas for further R&D. Work out guidelines connected to test drilling, well design and construction. Investigate the occurrences and arts of operational failures related to the well or borehole system and to work out preventive guidelines for monitoring, maintenance and rehabilitation measures. The following countries have shown interest in participation: Australia, Belgium, Canada, Germany, Italy, the Netherlands, Sweden, Switzerland, Turkey, and the U.S.

Annex 14. Cooling in All Climates with TES
This annex has been approved by the ExCo at 46th meeting in Lulea, Sweden in June 1999. Participants are Canada, Japan, Sweden and Turkey. The overall objective of Annex 14 is to employ research, development and feasibility studies to advance the prospects of cooling with TES technologies for applications within a variety of energy systems and climate conditions and to encourage their use as a standard design option. The Operating Agent is Cukurova University, Center for Environmental Research from Turkey. Phase I of the annex is planned to end in June 2001.

Proposed Annexes

Annex 15. Electrical Energy Storage and Integration of Renewables

This annex has been proposed to the ExCo at the 48th meeting in Berlin in November, 1999. It is a stated objective of this work to move storage systems towards commercial market implementation, via the mechanism of technology and applications demonstrators. Whilst it is beyond the scope of Annex 15 to implement an actual demonstration project, it is fully intended that much of the necessary groundwork will be covered within the project to make a demonstration project the next logical step in electrical energy storage system market development. Such a move towards market uptake will represent a significant advance in the application of storage systems, permitting their very real benefits in terms of improved integration of renewables to be realised. A Programme Definition Workshop will be held in Spring 2000 which will provide the platform for pulling together the Annex 15 participants.

Annex 16. Engineering Textbook on Thermal Energy Storage and Renewable Energy
This annex has been proposed to the ExCo at the 48th meeting in Berlin in November, 1999. The overall objective of the annex is to write and disseminate an engineering textbook on Thermal Energy Storage and Renewable Energy. The target group should be engineering students and consulting engineers. The vision for a second stage of this annex is to develop an Internet course based on the textbook. One suggestion is to present the course in three levels of education: 1/ General. 2/ Engineering. 3/ Scientific.

Annex 17. Advanced Thermal Energy Storage Techniques Feasibility Studies and Demonstration Projects
The objectives of this Task are to overcome technical and market barriers for introduction of long- (seasonal) or short-term phase change and chemical reaction thermal energy storage for energy savings and for reduction of peak demand of energy in buildings, agricultural and industrial applications. Specifically this will be achieved by the demonstration of thermal energy storage with phase change materials or chemical reactions in building materials, for cold and heat storage for comfort purposes, for long and short term storage in the food sector including the transportation of food and other temperature sensitive goods, for applications in industrial processes.

APPENDIX 3 -LIST OF PUBLICATIONS

Strategy Plan 1999-2003

Internet site: http://cevre.cu.edu.tr/eces/

Annex 8
Final Report, [http://www.sb.luth.se/~bon/bon/IEA/ax8report.html]

Annex 9
Collinson, A., Stones, J.C.& Tyson, A. "Electrical Energy Storage:Network Application Case studies" EATL Report No. 4829, April 1999.
Collinson, A., Stones, J.C.& Tyson, A. "Electrical Energy Storage:Costed project definitions for selected applications" EATL Report No. 4825, May1999.
Collinson, A., Stones, J.C.& Tyson, A."Applications Modelling of energy storage", EATL Report No. 5029, November1999.
Stones, J.C. "Power Quality Applications model" Software model, September 1999.
Collinson, A., Stones, J.C.& Tyson, A. "Annex IX Phase 2 (Electrical Energy Storage) Final Report" EATL Report No. 4073, November1999.

Annex 10
Marketing brochure
Country state-of-the-art reports
Materials database
Fact sheets for case studies and demonstration projects
Internet site: http://www.ket.kth.se/Avdelningar/ts/annex10/

Annex 12
SANNER, B. (ed.) (1999): High Temperature Underground Thermal Energy Storage, State-of-the-art and Prospects. - Giessener Geologische Schriften 67, 158 S., Giessen

SANNER, B. & KNOBLICH, K. (2000): IEA ECES Annex 12 - High Temperature Underground Thermal Energy Storage. - Proc. TERRASTOCK 2000, S. 17-24, Stuttgart

SANNER, B., REUSS, M., MANDS, E. & MÜLLER, J. (2000): Thermal Response Test - Experiences in Germany. - Proc. TERRASTOCK 2000, S. 177-182, Stuttgart

Annex 14
Draft state-of-the-art report for Canada
Final state-of-the-art report for Japan
Draft state-of-the-art report for Sweden
Final state-of-the-art report for Turkey
CD-ROM's containing papers presented at the First, Second and Third Workshops
Internet site: http://cevre.cu.edu.tr/annex14/

APPENDIX 4 - PARTICIPANTS OF ECES IA

COUNTRY	CONTRACTING PARTY
Belgium	Ministry of Economical Affairs
Canada	Public Works Canada
CEC	Commission of the European Communities
Denmark	The Ministry of Energy
Finland	TEKES, Technology Development Centre of Finland
Germany	Forschungszentrum Jülich GmbH
Italy	ENEA , Governmental Energy Research Agency
Japan	The Heat Pump and Thermal Storage Centre of Japan
Spain	IBERDROLA, Madrid (Feb 1999)
Sweden	The Swedish Council for Building Research
The Netherlands	NOVEM, The Netherlands Agency for Energy and the Environment
Turkey	Cukurova University
UK	EA Technology
USA	US Department of Energy