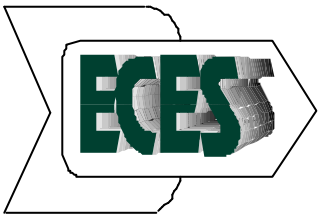
OECD/IEA
COMMITTEE ON ENERGY RESEARCH AND TECHNOLOGY
END-USE WORKING PARTY

Implementing Agreement on Energy Conservation through Energy Storage

Annual Report 2001



April 2002

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CHAIRMAN'S REPORT

Halime Paksoy
Çukurova University, Turkey

In 2001, IEA ECES IA continued its activities to develop and deploy more efficient and environmentally friendly energy storage technologies. This is necessary to achieve its objectives of energy security, environmental protection, and economic and social development. Introduction of correct economic and environmental instruments is the single most important factor in controlling the sustainable growth of renewable technologies. Effective international collaboration has become increasingly important. Increasing the number of participating countries enhances ECES's strength and motivation. Norway has notified the IEA that it will sign the Agreement and is expected to become member next year. Poland is continuing its efforts to become signatory. Currently, there is interest from Australia, Bulgaria, China, France, Korea, Malaysia, Portugal, Switzerland and Slovenia on experts level. ECES hopes to see these countries among its members.

IEA ECES IA is one of six Building Related Implementing Agreements (BRIAs). ECES has been actively involved in collaborative activities with BRIAs. One such activity is participation in Building Coordination Group for co-ordination and enhancement of BRIAs' work. An International Symposium on "Heat and Cold Storage" was organised in Munich on October 4-5, 2002in collaboration with the Solar Heating and Cooling (SHC) Implementing Agreement. Another workshop, on "Advanced Storage Concepts for Solar Thermal Domestic Applications", was held in Rapperswil, Switzerland in conjunction with a workshop of SHC Task 26 (Solar Combisystems) experts. There is also interest in having a Joint Executive Committee Meeting with Solar Heating and Cooling IA in 2002.

Annex 10 "Phase Change Materials and Thermochemical Reactions in Thermal Energy Storage" commenced its activities in 2001 and gave birth to Annex 17**"**Advanced Thermal Energy Storage Techniques – Feasibility Studies and Demonstration Project". Fuel cells and thermal energy storage and marketing are new annex ideas that have been brought up and will be further studied. Collaborative activities in Annex 12 and Annex 13 introduced the Thermal Response Test to Underground Thermal Energy Storage market. Annex 14 is forming an information network for reaching out to different countries around the world.

Workshops are our main tools for disseminating information. Annex 10 started the tradition of having a workshop accompanied by Experts Meetings. Annex 14 and 17, now follow this tradition. These workshops bring together experts from different groups of interest and provide a very productive platform for the annex. In some cases, the workshops are organized in non-member countries in order to initiate or enhance interest in energy storage in that new country. Annex 14 realized one such workshop in China. The Executive Committee had two workshops in parallel to its meetings in Spring 2001 in Canada and Fall 2001 in Paris: "The Role of Energy Storage in Future Energy Systems" and "Legal Issues, Opportunities and Barriers in Marketing" These workshops look at two important issues: future and marketing of energy storage were only introductory and should be emphasized even more in the coming year.

I look forward to a more productive year with new motivation to shift to energy storage techniques of the millennium. This report will summarize what we have accomplished in the year 2001.

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 (2000) 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 Norway is expected to become signatory member in 2002. Australia, Bulgaria, China, France, India, Israel, Korea, Malaysia, Poland, South Africa and Switzerland have expressed interest to participate in the activities of the Implementing Agreement.

According to the Strategy Plan (1998 – 2003) 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 50th meeting was held in Hull, Canada on May 16-17 and 51st in Paris, France on October 16-17.

<u>The Hull Meeting, May 2001</u>

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

- Chairman and secretary were re-elected unanimously
- ExCo gave comments on guidelines for end-of-term-report preparation.
- Comments on guidelines for evaluating IA's
- Approval of annual report 2000
- Approval of the budget of the year 2001-2002.
- Annex 10 final report presented. Approval of the final report will be done through internet after including the ExCo comments.
- Approval of all progress reports of ongoing Annexes (12, 13,14)
- Annex 17 approved.
- Annex preparation guidelines approved.
- Mirror-site of the homepage will be formed in Canada.

<u>The Paris Meeting, October 2001</u>

The most important discussions and decisions are outlined below.

- OpA's are asked to contact the experts from China interested in their annexes and inform them about the framework for energy technology cooperation between IEA and China.
- Op.A's are encouraged to take part in the Workshop on Lessons learned and best practices in technology deployment policies on 28-29 November, 2001 in Paris.
- New countries of interest, Poland was an observer at this meeting and XC decided to invite Norway, China and Portugal to join ECES IA.
- Approval of all annex progress reports (12,13,14, 17) and the extension of Annex 13.
- Task definition phase of the Annex 16 is approved. Bo Nordell will be asked to investigate the possibility of EC funding, GM will provide information on the EC funding possibilities and contacts
- FS will develop the idea on TES and fuel cells further and present it to the next XC meeting.
- OA will develop the idea on marketing UTES further based on the results of the IEA ECES workshop on marketing issues in Paris and present it to the next meeting.
- EM will contact Retscreen and bring us detailed information on how to proceed.
- The name of Information policy Committee is changed to Information Committee. E-group will continue to work, bringing up issues on information activities to the XC.
- An electronic version of the ECES Brochure will be available on the home page. Cost for printing the brochure at Cukurova University will be determined. NL will provide the brochure with the layout.
- Mirror site in Canada will be formed. "ECES Treasures" prepared by EM and the electronic version of brochure will be put on the homepage. Two way links between homepages of BRIA's will be established. XC delegates will send information on upcoming meetings to be put on homepage.
- FS will represent ECES in the formation of a possible joint working group with SHC. A joint XC meeting possibility will be decided after being discussed at SHC XC
- Report on preparation status of Futurestock'2003, 9th International Conference on Thermal Energy Storage in Warsaw, Poland

ACTIVITIES

Workshops 2001

Annex 17, April 2001, Leida, Spain

Annex 17 "Heat and Cold Storage Workshop" , October 4-5, 2001, Munich, Germany

IEA ECES workshop on Role of Energy Storage in Future Energy Systems, May 15, 2001, Canada

IEA ECES workshop on Legal Issues, Opportunities and Barriers in Marketing, October 15, 2001, Paris

Annex 14 "Cooling in All Climates with Thermal Energy Storage" 3rd Workshop, April 19, 2001, Istanbul, Turkey

Annex 14 "Cooling in All Climates with Thermal Energy Storage" 2nd Workshop, September 26, 2001 Beijing, China

Conferences 2001

EESAT 2001, Electrical Energy Storage Systems Applications and Technologies, September 2001, Florida, USA

Planned Conferences and Workshops

Annex 17, April 2002, Lublijiana, Slovenia

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

Scope and objectives

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.

Workplan

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 in June 2002.

The participating countries and their status of participation at the end of 2001 is shown below.

Belgium		Formal
Canada		Formal
Germany		Formal
Japan	Formal	
Netherlands	Formal	
Norway		Observer
Sweden		Formal
Turkey		Formal
USA	Formal	

Activities in 2001

During the year 2001 there has been two organised activities. These are

- The 7th Expert Meeting that was held in Nijmegen, Netherlands, May 26-27, 2001 with all countries represented. At this meeting three draft state of the art reports were presented and discussed. Furthermore group works for guidelines and items for further research and development were executed giving the first results for the guidelines.

- The 8th Expert Meeting that was held in Adana, Turkey, November 28-30, 2001 with all countries but Japan represented. A major part of the meeting was scheduled for group work where proposals for guidelines were worked out, covering all subtasks but subtask C.

For the coming year 2002, one more Expert Meeting is planned to finalise the work of the Annex.

Contacts

Country co-ordinators are

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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 Center 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 2002

Collaboration with other Cooling Activities in IEA

- Presentation at SHC Task 25 "IEA Solar Heating and Cooling Programme " 4th Experts' Meeting in Nice on January 29-30, 2001
- Information exchange with IEA ECBCS Annex 37 "Low Exergy Systems for Heating and Cooling in Buildings"

- **Activities in 2001**

- Fifth Experts' Meeting and Fourth Workshop were held on April 19-20, 2001 in Istanbul, hosted by Cukurova University. There were 75 participants joining the workshop from Canada, Denmark, Germany, Japan, Malaysia, Sweden, and Turkey. 15 papers were presented during the workshop.
- Sixth Experts' Meeting of Annex 14 could not held in Shanghai as planned, because of global crisis. This meeting was held in November 26-27 2001 Adana, Turkey in conjunction with Annex 13 experts meeting. Japanese member of Annex 14 could not participate the meeting. But 5th workshop was held in Shanghai China as planned before.

Information Network of Annex 14

The purpose of the network is to facilitate information exchange between all interested parties around the world on the subject of cooling with thermal energy storage (TES). The network aims to provide a list of experts, projects, and on-going and planned activities in this field and also to form a platform for discussion and initiation of new activities.

There is an online link being create in Annex 14 home-page under (http://cevre.cu.edu.tr/annex14/information.htm) for network membership. Visitors can find a short description about Annex 14 network membership and also they can find an application form at the same page.

At the moment experts from Annex 14 member countries (Canada, Japan, Sweden, Turkey) and China, Germany, Malaysia and USA are interested in information network..

Status of Subtasks in 2001

Subtask 1

- Final country-specific state-of-the-art reports - completed except for Canada.
- General state-of-the-art report - on-going,
- Final reports are available on CD-ROM and also on Annex 14 web-page.

Subtask 2

- List of boundary conditions – on-going
- Cold sources – on going
- System configurations – on going

Subtask 3

- Ice storage early decision tool program translated from Japanese to English - Completed
- Survey on existing models - on-going
- Guidelines - not started yet

Subtask 4

- Potential application scenarios - start activities in June 2001

Publications in 2001

- 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
- Draft general state-of-the-art report
- Annex 14 Workshop April 19, 2001 in Istanbul, Turkey, Proceedings on CD-ROM

Experts' Meetings in 2001

- April 20, 2001 in Istanbul, Turkey
- November 26-27, 2001 in Adana, Turkey

Upcoming Meetings

- May 6-9 2002, Kuala-Lumpur, Malaysia

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ON-GOING ANNEXES

Annex 17. Advanced thermal energy storage through phase change materials and chemical reactions - feasibility studies and demonstration projects

Operating Agent: Frederik Setterval, Royal Institute of Technology, Sweden

Annex 17 "Advanced Thermal Energy Storage trough Application of Phase Change Materials and Chemical Reactions – Feasibility Studies and Demonstration Projects" was approved at the meeting of the Executive Committee of the Implementing Agreement on Energy Conservation through Energy Storage in Hull, Canada, 2001-05-16—18. Officially the Annex has three members, Germany, Japan and Sweden. Strong interest in participation has been shown by Australia, Canada, the Netherlands and Spain. Further countries that have been interested in the work of the annex are Finland, .France, New Zealand, Poland, Slovenia, Switzerland, United Kingdom, United States The first Expert Meeting was held in Benediktbeuern, Germany on the 3 rd of October 2001 followed by a symposium jointly arranged with ZAE – Bayern. 20 presentations were made during this symposium. The expert meeting was attended by three member countries (Germany, Japan and Sweden) and four observing countries (Australia, the Netherlands, Spain and Turkey). According to the work plan the first phase was intended to be a project definition and finanziation phase. More than 15 projects have been defined to be part of the Annex. The projects fall into three categories (responsible countries and persons in bracket):

- Heating and cooling of buildings (Germany and Japan)
  - "Energy storage in the CREA building (Lleida)"
  - "PCM module to improve stratified water tanks"
  - o Building materials:(Harald Mehling)
    - "PCM wallboard containing PCM penetrated with cross-linked polyethylene"
    - "Encapsulated PCM in building technology"
    - "PCM in composite bridge decks"
    - "Mixture of wood, PCM and concrete"
    - "PCM wallboards"
  - o Sorption systems: (Andreas Hauer)
    - "Air conditioning and cold storage in open sorption systems",
  - o Peak shaving:(Motoi Yamaha)
    - "HVAC with PCM storage in it"
    - "Simulation of PCM storage system",
    - "Cityhall with PCM heater"
- Temperature sensitive materials :(Spain, Luisa Cabeza)
  - "Blod transportation",
- Waste heat utilization: (Sweden, Fredrik Setterwall)
  - "Absortion chillers and energy storage"
  - "Cold transportation in liquid dessicants"

"PCM applications in industry"
"Thermal management of solid oxide fuel cell systems"
"PCM slurry systems"

In order to facilitate the cooperation between industry and research institutes, two experts from each country will participate in experts meetings, one industrial and one from the research world.

A home page for the annex will be constructed. Companies will be invited to sponsor the updating of the home page. When sponsoring they will be listed in the data base on companies active in the field and their products together with properties of said products will be published in a data base updated once every three month. In order to attract new countries the experts meetings and work shop will be located tocountries that either have difficulties to attract enough attention on thermal energy storage within the country or are not members of IEA. In this way the cooperation and collection of information will be spread outside the members of the annex.

Upcoming meetings

- Slovenia, April 2002, provided they agree. The backup country being Australia.
- Japan, 30 Sept to 2 Oct 2002, after the International Sorption Heat Pump
- Conference, that will take place in Shanghai.
- India, spring 2003, provided they agree. The backup country being Turkey.
- Poland, autumn 2003, after the Futurestock Conference.
- Swden Spring 200

PROPOSED ANNEXES

Annex 15. Electrical Energy Storage and the Integration of Renewables

Operating Agent: Alan Collinson, EA Technology, UK

Introduction

Electrical energy storage is widely recognised as a key emerging technology, likely to find widespread use within electricity generation, transmission, distribution and supply networks as well as other major industrial and commercial end user applications. The benefits of bulk energy storage applied to the increasing levels of embedded generation, especially from new and renewable sources, are being increasingly recognised. The Annex 15 proposal is focusing specifically on the issues of electrical energy storage and how it can be used to assist in the successful conservation of energy by the integration of new and renewable energy sources into existing electrical networks.

Key issues which will be addressed by Annex 15 include:

- 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

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. Key elements of this strategy include the modelling of the interaction between the electricity network and the energy source as well as producing targeted educational and promotional material to increase awareness of the growing potential of energy storage-based solutions.

Discussions with the ECES Executive Committee

The UK government believes it is inappropriate for the role of XC delegate and Annex OA to be held by the same person, since this results in a potential conflict of interest. It has been agreed in principle that a new UK XC delegate will be chosen, most likely from the UK DTI, although this is taking longer than expected to resolve. If this issue is not resolved by the next XC meeting, an alternative approach would be to allow another country to take over the lead in developing Annex 15.

There is a complementary EU project entitled 'INVESTIRE' and synergies between this project and Annex 15 are being investigated.

Current support within the XC for development of the proposal can be summarised as:

UK: Need to resolve the XC delegate/OA conflict-of-interest before proceeding further.

Sweden: Yes, there is still interest from utility companies in Sweden. Therefore, the US should take over the lead if UK is unable to continue.

Germany: Recognise the need for a new leading country, if UK cannot continue. Also, difference between Annex 15 and the INVESTIRE project is not clear to potential German participants

US: Supportive, but the work programme needs developing

Netherlands: Dutch utilities are participating in INVESTIRE project and will wait to see the results of this project before considering joining.

Japan: There is some interest, but it will be difficult to find funding.

Canada: Quebec Hydro will be the best potential. Interest should be there, since the importance of green power is increasing and encouraged.

Turkey: No interest at the moment.

Progress Since Last Exec Co Meeting and Current Status

The "Annex 15" internet discussion group continues to expand, with a current membership of 112 people from over 19 countries. These countries include: Australia, Belgium, Canada, Denmark, Finland, Germany, Ireland, Italy, Japan, Jordan, Netherlands, New Zealand, Portugal, Sweden, Thailand, Turkey, United Kingdom, United States.

The egroup provides a record of the group members' email discussions on the development of the Annex 15 proposal. In addition to the email archive, the web site contains a "files" section, where relevant documents can be accessed and downloaded over the internet. Document sections include:

- Selected Annex 9 reports and documents
- The Annex 15 workplan (Version E, December 2000)
- Powerpoint presentations on the subject of electrical energy storage
- General documents of interest which have been submitted by members of the egroup

Most interested parties preferred to use private one-to-one communication with the operating agent rather than enter into an open debate and so the egroup proved to be most useful in providing a framework for disseminating the results of individual discussions to the rest of the group.

It is increasingly likely that the participants in Annex 15 are going to be significantly different from the participants in Annex 9, in terms of participating agents, national participants and in terms of countries participating. Given the large number of new individuals involved, the development of the proposal is taking longer than anticipated.

For further information on Annex 15 is available from the project manager,
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http://groups.yahoo.com/group/electricalenergystorage

PROPOSED ANNEXES

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

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

1. General information

One of the conclusions of Annex 8, **Implementing** Underground Thermal Energy Storage Systems (UTES) of ECES IA, was that an engineering textbook was needed for the wide spread utilization of UTES system. This textbook on Thermal Energy Storage (TES) would be used for technology transfer to engineers and consulting companies but also for teaching at engineering educations. The project should preferably be carried out within the framework of IEA.

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.

The idea is to start from an existing Swedish textbook, which has been used at Luleå University of Technology for more than 15 years. The textbook was preliminary translated into English in 1998 as a subject of discussion for the Annex 8 experts. Environment Canada made additions and changes to the text while brushing up the language in 2001.

Bo Nordell (BN) presented a draft annex proposal at XC47 in Berlin, Nov 1999. The plan was to write the TES textbook during a three-year period to collect available data and knowledge from experts in participating countries.

The Executive Committee showed interest but the project was not approved because of different opinions in the funding of the annex. Since then Annex 16 has been brought up at several XC meeting.

2. Activities for 2001

At XC51 in Paris, Oct 2001, the Executive Committee suggested that BN should take leadership, contact EU and look for the possibilities and deadlines etc. Some EU contacts had already been taken by some of the XC delegates, indicating that this project should have a good chance to get funding. One advantage was that Energy Storage was now defined in the EU program as target action K.

The suggested EU programs involved were; Thematic Networks (for travelling costs and small additional financial support) and Accompanying Measures (for studies etc.). The plan was to use both possibilities. After contacts with EU we were suggested to submit a pre-proposal of the

project. This is a standard procedure to enable EU officials to define the project idea and suitable program for funding.
The result of the pre-proposal was that Mr. Günter Israel, EU, informed that the TES Textbook project did not fit within the 5th Energy Framework Program. Furthermore, target action K (energy storage) only included medium to long-term actions, i.e. 5-10 years' projects.

Mr Israel suggested that we should try the ALTENER Program but underlined that our project would have a very low priority in that program. Since a EU proposal means a lot of work and we would have small chances for approval, no further work has been carried out for funding within the EU programs.

3. Upcoming activities

Today, it is even more urgent to write an up-to-date UTES Textbook. My strategy is now to get national (Swedish) funding for the main part of the project, i.e. 12 to 15 man-months per year during three years. With this base funding it would still be possible and desirable to carry out the project within the IEA framework, provided that interested countries would support their experts to participate in the annex.

4. National contacts

After contacts with the Swedish Energy Agency (SEA) to explain the problem and necessity of having a UTES textbook, we were informed that they could possibly fund the project. Our project would fit into two SEA programs; Technology transfer and Information.

Transfer of a new technology from research to industry would fit into their Technology Transfer Program. Since part of the textbook and future websites should include general information part of our project would fit into the Technical Information Program. International collaboration would improve the chances of approval. We were however recommended not to underline that the textbook was aimed for teaching.

5. Next step

During the first half of 2002 a project proposal will be submitted to the Swedish Energy Agency. It will cover 12 – 15 man-months per year for the Swedish part of the UTES textbook project. The proposal will include possible IEA collaboration with ECES participants and other countries. This three-year project is planned to start in Jan 2003.

Completed Annexes

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

Operating Agent: Frederik Setterval, Royal Institute of Technology, Sweden

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

1. the demonstration of thermal energy storage with phase change materials in building materials
2. the demonstration of thermal energy storage with phase change materials or chemical reactions for cold and heat storage for comfort cooling
3. the demonstration of thermal energy storage with phase change materials or chemical reactions for long and short term storage in the food sector
4. the demonstration of thermal energy storage with phase change materials or chemical reactions for applications in industrial processes.

Means

The participants shall share the coordinated work necessary to carry out this Task. The objectives shall be achieved by:

1. Collecting, in their countries, data relevant for the use of energy storage with phase change materials or chemical reactions in the building, the agricultural and the industrial sector.
2. Collecting, in their countries, data on ongoing projects on energy storage with phase change materials or chemical reactions in the building, the agricultural and the industrial sector.
3. Performing case studies and initiating demonstration projects on thermal energy storage with phase change materials or chemical reactions in the building, the agricultural and the industrial sector.

Subtasks

I. Heating of buildings (Germany)
II. Air-conditioning and other cold storage (Japan)
III. Building material (Canada)
IV. Warm industrial processes (Sweden)
V. Material databases (Sweden)
VI. Bibliography (Sweden)

VII. Simulation Programs (Japan)
VIII. Test and measurement methods (Finland)

Deliveries

- Subtask reports
- Homepage : http://www.ket.kth.se/avdelningar/ts/annex10
- Proceedings from workshops
- Material physical properties data base (320 components)
- Bibliography (500 references)
- Fact sheets (100 projects presented)

Soft outcome

- Sweden – Japan Post.doc. from Japan in Stockholm for one year
- Germany – Japan Researcher from Germany cooperates with Japanese company
- Germany – Sweden Cooperation between Swedish and German companies

New annex suggestion

- Feasibility studies
- Demonstration projects
- Basic research
- Advanced Thermal Energy Storage Techniques – Feasibility Studies and Demonstration Projects

Collaborative Groups, Workshops and Meetings

- Annex 14 presentation at SHC Task 25 "IEA Solar Heating and Cooling Programme " 4th Experts' Meeting in Nice on January 29-30, 2001
- Future Buildings Forum Think Tank 2001 Oslo, Norway
- Participation in Future Buildings Forum, Building Coordination Group(BCG) and Building Related Implementing Agreements

Planned Activities

- BCG Meeting, January 2002, Frascati, Italy
- BCG Meeting, October 2002, Oslo, Norway
- Joint Executive Committee Meeting with IEA Solar Heating and Cooling Programm, November 2002, Belgium

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
2. Motivation
3. Mission
4. Vision
5. Objectives and Strategies
6. Market Opportunities and Barriers to Market Deployment
7. Collaboration with other Executive Committee´s
8. Achievements
9. Scope and Workplan
10. Proposed Future Activities
11. Participation
12. References

Appendix: Current Annexes

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, Norway 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. Cost-sharing: 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. Task-sharing: 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
12	High Temperature UTES
13	Design, Construction and Maintenance of UTES Wells and Boreholes
14	Cooling in All Climates with Thermal Energy Storage
17	Advanced Thermal Energy Storage Techniques Feasibility Studies and Demonstration Projects
	Planned Annexes
15	Electrical Energy Storage and the Integration of Renewables
16	Engineering textbook on thermal energy storage and renewable energy

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.

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.

Ongoing Annexes

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.

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.

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.

APPENDIX 3 -LIST OF PUBLICATIONS

Strategy Plan 1999-2003

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

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
Final 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 ,Third and Fourth 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