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

Implementing Agreement on Energy Conservation Through Energy Storage

Annual Report 2005

May 2006

CONTENTS

CHAIRMAN'S REPORT

The Year 2005: Achievements and Challenges

In 2005 the Executive Committee finalized the new Strategy Plan and the application for the extension of the Programme for the new term 2006-2010. In October 2005 the Strategy Plan and End of Term Report were successfully presented at the EUWP and the subsequent CERT meeting. The 5year extension for the period 2006-2010 was approved by CERT. The extension is the basis for continuing the successful international co-operation in the R&D, D Programme "Energy Conservation Through Energy Storage (ECES)".

A high priority challenge for the Executive Committee is to expand the scope of the Programme and the participation by new member countries. Contacts have been established with experts in P.R. China and India, but also with France, Switzerland, The Netherlands and Austria to comply with the requirements to join the Implementing Agreement. There is good hope that new countries will participate and sign the Implementing Agreement in the new term. In 2005 we could welcome the Institute of Heat Engineering –Warsaw University of Technology ("ITC") as a SPONSOR in the Programme.

Challenges: The G8 Gleneagles Summit 2005:
After many years of cheap and abundant oil and gas supply energy has become again a high priority political and economical issue. In 2005 prices of fossils fuels increased drastically with a detrimental impact on the national economies worldwide. Moreover the political situation shows that the security of the energy supply is not stable at all. Meanwhile many Governments have signed the Kyoto Protocol and the Kyoto Protocol became effective in 2005. A common goal is to prevent the possible climate change due to the rapid increase of CO_2 concentration in the atmosphere. At the Gleneagles Summit in July 2005 the G8 heads of Government addressed the challenge of tackling climate change, promoting clean energy, and achieving sustainable development globally.

The Executive Committee ECES supports the proposed IEA Plan of Work (POW) which was developed and approved by the Governing Board to support the Gleneagles Plan of Action. The Executive Committee offers to contribute with its expertise to implement the POW. It has been recognized that the ECES Programme already fits very well to the scope and aims of the G8 Dialogue and Plan of Action. In particular:

- Energy storage is a key component in many energy efficient systems. Continued R&D, D in addition to short and medium term implementation programmes is a solid basis for the enhanced utilization of energy efficient technologies and the use of renewable energy sources in the long term. Great progress has already been achieved during the past 30 years in the ECES Programme.
- Co-operation with developing countries. Experts from developing countries already participate in the ECES activities as observers (Annexes, workshops, conferences).
- Implementation and deployment activities.

Achievements

In 2005 Annex 17: “Phase Change Materials (PCM) and Thermo-Chemical Reactions” was successfully completed. The final report is available on CD-ROM. In April 2005 the final Task expert meeting took place in Kizkalesi, Turkey with 36 experts participating from 10 countries. Results of the Annex 17 projects were presented and intensively discussed with representatives of the industry. It is obvious that market oriented activities including the deployment of new PCM products for different applications is vital for small companies marketing PCM materials and products.

After approval of Annex 20: “Sustainable Cooling with Thermal Energy Storage” by the Executive Committee in Krakow, May 10-11, 2005 the kick-off meeting was organized by the Operating Agent Prof. Masaya Okumiya at the Nagoya University, Japan in September 2005. More than 30 experts discussed the state of the art and elaborated a common work plan.

The kick-off meeting of Annex 18: “Transportation of Thermal Energy by Thermal Energy Storage” was held in Bad Tölz, Germany November 14-15, 2005. After a state of the art review the work plan was discussed by the participants. The expert meeting was attended also by experts from countries which have not yet signed the Implementing Agreement, including Austria, Switzerland and The Netherlands. The Task definition phase was extended for another half year to enable the designated Operating Agent, Prof. Victoria Martin of Sweden to acquire the necessary funds.

In spite of the great interest on the subject the start of proposed Annex 16: “Deployment of energy storage technologies” had to be postponed due to the lack of available funds. The participation of Annex 19 “Industrial process heat and power generation with thermal energy storage” still lacks the adequate interest of participating countries. In the meantime the new Implementing Agreement: “Industrial Related Technologies and Systems (IETS)” was addressed for co-operation in this area.

Sponsored by the Executive Committee the NATO Advanced Study Institute on “Thermal Energy Storage for Sustainable Energy Consumption (TESSEC)” was organized by Cukurova University (Prof. Halime Paksoy and Prof. Hunay Evlyia) in Cesme-Izmir, Turkey, June 6-17, 2005. Twenty five lecturers presented energy storage related topics to sixty five students from eighteen countries. Many of the lecturers were active in the ECES executive committee or in the Annex work of the ECES.

The Following topics on thermal energy storage were discussed during the Summerschool:

- Underground Thermal Energy Storage (UTES)
- Phase Change Materials (PCM)
- Thermochemical Reactions (TCR)
- Building Structure

Design, construction and operation of these systems were the issues that were addressed. Case studies from existing applications for buildings (residential, commercial and service) and dif-

ferent industries were given. In addition to energy savings, the effects of thermal energy storage on mitigating greenhouse gas emissions were also discussed. The lecturers were accompanied by problem sessions where practical design examples were solved. The proceedings of the School will be published as a textbook in the NATO Science Series by Kluwer Academic Publisher.

Technology Transfer and Participation

The ECES Executive Committee strongly supports the co-operation with other Implementing Agreements within the seven Building Related Implementing Agreements (BRIAS). In June 2005 another joint workshop was organized together with the IEA-Executive Committee on "District Heating and Cooling" in Berlin. The topic "Cool Storage in District Cooling Systems" is relevant for both Implementing Agreements. The presentations showed that by cold storage the energy efficiency can be improved considerably in a more flexible operation. Diurnal storage systems are also a strategic component for peak (power) leveling.

Technology transfer and information dissemination from the Annexes to the outside world is an important issue in the Programme. Therefore industrial workshops have been arranged in conjunction with the expert meetings. A highlight was the final workshop of Annex 17 and the kick-off meetings of Annex 18 and Annex 20. As in previous years the EcoStock 2006 Conference on Thermal Energy Storage at Richard Stockton College, NJ, USA will provide another excellent opportunity for international information dissemination for enhanced deployment.

Support by the IEA-Secretariat.

I would like to take the opportunity to thank all colleagues for their continuous efforts and engagement, in particular Ms Carrie Pottinger (IEA-desk officer) and Dr. Andreas Hauer (ECES scientific secretary).

ENERGY CONSERVATION THROUGH ENERGY STORAGE IMPLEMENTING AGREEMENT

The Implementing Agreement (IA) started in 1978. Its present term ends by the end of 2005. At present, Contracting Parties from the following countries have signed the Implementing Agreement: Belgium, Canada, CEC, Denmark, Finland, Germany, Italy, Japan, Norway, Spain, Sweden, Turkey, United Kingdom, USA and IF Technologies from The Netherlands and the Institute of Heat Engineering (ITC) of the University of Technology, Warsaw, Poland as sponsors. The Executive Committee is working intensively to attract more countries to join the activities and to sign the Implementing Agreement in particular China and France. New Zealand, Slovenia, Australia, Bulgaria, India, Israel, Korea, Malaysia, South Africa are also interested. Switzerland has indicated to reconsider the participation in the Implementing Agreement. Experts from several countries do already participate in the Annex work as observers.

According to the new Strategy Plan (2006 – 2010) approved 2005 the strategic objectives for the IA are as follows*:*

"Strategic Objectives

Technology: Maintain and develop international technical RD&D collaborations that further the environmental and market objectives.

Environment: Quantify and publicise the environmental and energy efficiency benefits of integrated energy storage systems.

Market and Deployment: Develop and deliver information to support appropriate market deployment and provide effective collaboration and information to stakeholders."

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.

List of annexes and participating countries:

Annex 12: High-Temperature Underground Thermal Energy Storage (HT UTES)
Objectives of this task 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-systems concerned shall be confined to Aquifer Storage (ATES) and Duct/Borehole Storage (DTES). This annex was started at the end 1997 with Germany as Operating Agent.

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

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 the ECES IA at the end of 1997 with Sweden as Operating Agent.

- Participating Countries: Belgium, Canada, Germany, Japan, Netherlands, Norway, Sweden, Turkey, USA

Annex 17: Advanced Thermal Energy Storage Techniques - Feasibility Studies and Demonstration Projects
The objectives of this Annex is 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. Operating Agent is Sweden.

- Participating Countries: Germany, Japan, Sweden

Annex 20: Sustainable Cooling with Thermal Energy Storage (Annex 20): Renewable and natural energy sources, main components of sustainable energy systems, can only be made continuously available to users through thermal energy storage (TES). In addition to heating TES provides several flexible alternatives for cooling systems. Recent discussions on topics like global warming and heat waves have brought attention once again to energy efficient cooling systems utilizing renewable energy sources. Cooling demand has already been increasing due to the evolving comfort expectations and technological development around the world. Climate change has brought additional challenges for cooling systems designers. New cooling systems must use less and less electricity generated by fossil fuel based systems and still be able to meet the ever increasing and varying demand. Annex 20 was approved by the Executive Committee at the meeting in May. Operating Agent is Japan.

- Participating Countries: Japan, Canada, Germany, Turkey

Executive Committee Meetings
The Executive Committee had two meetings during the year 2005. The 59th XC meeting was held in Krakow, Poland on May 10-11 and the 60th XC meeting in Bad Tölz, Germany on November 17-18.

The most important items and decisions of the XC meetings in 2005 are outlined below.

The Krakow Meeting, May 10-11, 2005
- Approval of the minutes of the 58th XC meeting
- The development of a new ECES brochure was decided. A budget for the secretary was approved.
- Volkmar Lottner was unanimously re-elected as Chairman, Kirsti Midtomme as Vice Chair.
- Annual Report 2004 was approved
- Financial statement about the common fund of the secretariat was approved
- Approval of the new strategy plan (2005-2010)
- Approval of the application for the extension of the ECES IA and the end-of-term-report for the EUWP and the CERT.
- Approval of the progress reports of ongoing Annexes (12, 13 and 17).
- Approval of the final report from Annex 17.
- Extension of Annex 13 was approved.
- Evaluation of new Annex proposals Annex 15, 16, 18 and 19.
- Approval of Annex 20.

The Bad Tölz Meeting, November 17-18 2004
- Minutes of the 59th XC meeting were adopted
- Andreas Hauer was re-elected as the secretary and the budget until the end of 2006 was unanimously approved.
- Financial statement about the common fund of the secretariat was approved
- First version of the new brochure of the ECES IA was approved.
- Lynn Stiles was unanimously elected as second Vice-Chairman.
- Approval of progress reports of the ongoing Annexes 13 and 20
- Approval of the extension of Annex 13.
- A new concept for the proposed annex 15 will be written
- The new Annexes 18 and 19 should continue in their task-definition-phase.
- The international conference on thermal energy storage “EcoStock 06” will take place in Stockton, USA, May 30 to June2

ACTIVITIES OF THE EXECUTIVE COMMITTEE

Executive Committee Meetings 2005

- **58th XC meeting, Krakow, Poland on May 10-11**
- **60th XC meeting, Bad Tölz, Germany on November 17-18**

Expert Meetings and Workshops 2005

Annex 17: Advanced Thermal Energy Storage through Application of Phase Change Materials and Chemical Reactions-Feasibility Studies and Demonstration Projects

- **8th and final Experts Meeting, April, Kizkalesi, Turkey on April 18**
- **Workshop, April, Kizkalesi, Turkey on April 19-20**

Annex 18: Transportation of Thermal Energy by Thermal Energy Storage

- **Task-definition workshop, November 14-15, Bad Tölz, Germany**

Annex 20: Cooling in All Climates With Thermal Energy Storage

- **Kick-off meeting and first workshop, September 14-15, Nagoya, Japan**

Joint Activities with Other Implementing Agreements

- **Joint workshop with the District Heating and Cooling IA "Cool Storage in District Cooling Systems", June 8, Berlin, Germany**

Other Activities

- **International Summer School "NATO Advanced Study Institute on Thermal Energy Storage for Sustainable Energy Consumption (TESSEC) - Fundamentals Case Studies and Design", June 6-17, Izmir-Cesme/Turkey**

ON-GOING ANNEXES

Annex 12. High Temperature Underground Thermal Energy Storage

The following text reflects the status of the Annex by the end 2004.

Operating Agent; Burkhard Sanner, Giessen University, Germany

Introduction
The Annex 12 "High Temperature Underground Thermal Energy Storage (HT UTES)" was approved at XC43, December 1997.

Participating Countries: Belgium, Canada, Germany, Netherlands, and 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.

Work plan
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 are a small number of HT-UTES plants in operation, where monitoring programs allow the evaluation of system performance, reliability, operational experiences, etc. within Phase 2. Monitoring is done within national programmes, and the results should be shared and compared within Annex 12:

Amorbach	Neckarsulm, D	BTES, residential area with solar heat (meanwhile enlarged to >500 BHE)
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

Two other projects became operational during 2002 with first operational results:

Attenkirchen	near Freising, D	BTES with water tank, residential area with solar heat	Spring 2002
TESSAS	Mol, B	BTES, test plant	Summer 2002

In Neckarsulm, the work for enlargement of the total system had an impact of the operation of the existing store and on the monitoring. For Annex 12, only the existing part as of late 2000 is considered. The full extent of the Reichstag ATES in Berlin has been reached in the year 2002, with the finalization of the surrounding building and the connections of the heating and cooling network. The full thermal capacity of the co-generation plants was available for loading of the store for the first time.

Some other HT-UTES projects have been discussed or planned in 2002:

Malmö, S	Huge system for 50 MW thermal output and about 100 °C, 2x19 wells 450-500 m deep, for the district heating system
Mahone Bay, NS, CAN	Hawthorn Village, HT-BTES with ca. 80 houses, medical center, etc., with solar thermal for loading; total system should have at least 50 % solar fraction
Halifax, NS, CAN	Quinpool Towers, residential complex, flats/apartments; 1100 m^3 pilot store, 4 holes, 3 m distance 120 m depth, storage operated at 50 °C. Planned to be enlarged to ca. 32 boreholes. Solar collectors and/or waste heat as heat source

Test methods for both BTES and ATES have been successfully demonstrated:

- Thermal Response Test (TRT), used in mobile equipment since ca. 1995, was used for design of the Attenkirchen BTES and also for the enlargement of Neckarsulm BTES. This technology meanwhile can be considered commercial for the low-temperature applications (mainly ground source heat pumps), and proved to be well adapted also for the higher temperature range. Because TRT does not determine the thermal conductivity of the solid ground only, but gives a value for apparent thermal conductivity comprising also other components like convection, the results are temperature-dependent and measurements have to be done at the desired operational temperature of the BTES.

- Test equipment for ATES to investigate groundwater behavior in situ (scaling, corrosion, etc.) has been improved and tested at several locations in 2002. A standard procedure to assess the suitable temperature range for ATES was developed, using step-wise increase of loading temperature with given flow and test duration. Tests at sites with different groundwater chemistry allowed studying the different behaviour, however, more tests are required to understand the processes better and to allow for the comparison with results obtained from computer models of groundwater chemical behaviour.

Status of work: preparation of the Final Report by the Operating Agent.

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

The following text reflects the status of the Annex by the end 2004.

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

Scope and objectives

Annex 13 cover aspects of test drilling, 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 test drilling (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.

Work plan

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

The work plan takes into consideration that a number of participating countries will contribute to the development of the Annex following the task shearing principle. The target was set to close the Annex during 2003. However, the Annex has been extended and will be finalized in 2005.

Participating countries

Over the years the following countries have formally or as observers participated in the development and progress of the Annex.

- Belgium Formal
- Canada Formal
- Germany Formal
- Japan Formal
- Netherlands Formal

- Norway Formal
- Switzerland Observer
- Sweden Formal
- Turkey Formal
- USA Formal

During 2003 Norway became a formal member. Japan has announced that they cannot participate at the finalization of the Annex due to financial problems.

Activities in 2004

During 2004 there have been no activities but further work on the Annex reports. There are seven reports to be written and approved by the ExCo. At the end of 2004 four reports were finalized. These are

- Subtask A:1. Test Drilling for UTES Applications, *by F.Michel, B.Andersson*
- Subtask A:2. Thermal Response Tests for BTES Applications, *by J.Spitler, S.Gehlin*
- Subtask B:2. Borehole Heat Exchangers Configurations and Thermal Efficiency, *by G.Hellström*
- Subtask D. Well and Borehole Failures and Cures in UTES Systems, *by G. Bakema*

These reports are to be found on the homepage of ECES and will later be published separately.

Work plan for 2005

For the year 2005, the Annex will be closed after submitting two subtask reports and a final report with guidelines.

Contacts

Country co-ordinators for countries still active in Annex 13 are:

– Belgium, Bert Gysen (gysenb@vito.be)
– Canada, Frank Cruickshanks (frank.cruickshanks@ec.gc.ca)
– Germany, Burkhard Sanner (burkhard.sanner@geo-uni-giessen.de)
– Japan, Xiaomei Li (li@host2.hptej-unet.ocn.ne.jp)
– Netherlands, Guido Bakema (office@if-tech.nl)
– Norway, Helge Skarphagen (helge.skarphagen@ngu.no)
– Sweden, Olof Andersson (olof.andersson@sweco.se)
– Turkey, Halime Paksoy (hopaksoy@mail.cu.edu.tr)
– USA, Jeff Spitler (spitler@osuunx.ucc.okstate.edu)

Annex 17. Advanced Thermal Energy Storage trough Application of Phase Change Materials and Chemical Reactions – Feasibility Studies and Demonstration Projects

Summary

Annex 17 "Advanced Thermal Energy Storage trough Application of Phase Change Materials and Chemical Reactions – Feasibility Studies and Demonstration Projects" was approved by the executive committee of the IEA Implementing Agreement on Energy Conservation through Energy Storage at their meeting in Hull, Canada on the 15th to 18th of June 2001. Three countries, Germany, Japan and Sweden participated in the annex.

Eight experts meetings and six workshops have been arranged during the course of the annex. The workshops have been arranged in Spain, Slovenia, Japan, India, Sweden, China and Turkey. Experts meetings have been arranged in connection to other events with implications on thermal energy storage in Germany ("ZAE Bayern Symposium") and Poland ("Futurestock"). Participants in the workshops also originated from countries not participating in the annex namely: Australia, Canada, China, India, the Netherlands, Slovenia, Spain, Switzerland, Turkey and the United Kingdoms. During the six workshops more than one hundred presentations on ongoing research, development and demonstrations have been presented. The work in the annex has been divided into three sub tasks: Heating and cooling of buildings, Temperature control and Natural and waste heat utilization.

During the course of the annex the use of phase change materials for thermal energy storage purpose has increased rapidly and many products based on PCM have been introduced into the market. In other areas demonstrations have shown the technical feasibility of the applications.

New materials, both phase change materials and new sorbents, with improved properties or with physical properties related to the need of specific applications are on or near to the market. Standardized procedures for measuring and presenting physical properties of phase change materials are under development.

In the field of Heating and cooling of buildings systems utilizing PCM for peak shaving and/or utilization of natural and waste heat have been introduced. Floor heating systems, passive cooling of offices are examples of this technique. Building materials and components with PCM for increasing of the thermal mass are introduced or are near to be introduced into the market. Sorption systems for heating and cooling of buildings utilizing waste heat as driving energy have been demonstrated. The demonstrations show both technical and economical feasibility. Temperature control utilizing PCM for transportation of pharmaceutical goods or other temperature sensitive goods has become a common technology. Utilization of PCM for cooling or heating of the human body has been demonstrated both for personal comfort and for medical therapy. Several applications in different field of application are on the market. Passive cooling of buildings and of telecom cabinets are examples of the widespread applications.

Natural or waste heat and cold utilization both for domestic and for industrial use have been discussed and presented during the work of the annex. The use of nighttime cold for daytime cooling is demonstrated in several countries as well as the use of the cold nights for cooling of telecom stations. Small-scale use of the solar heat of the day for night time heating or for cooking of meals after dark have also been presented during the workshops of the annex.

Annex work

Annex 17, "Advanced Thermal Energy Storage Through Application of Phase Change Materials and Chemical Reactions – Feasibility Studies and Demonstration Projects", was approved by the Executive Committee of the IEA Implementing Agreement on Energy Conservation through Energy Storage at the meeting in Hull, Canada on 2001-June-15—18. An extension of the annex from June 30th 2004 to June 30th 2005 was approved by the Executive Committee on a meeting in Bergen, Norway on 2003-May-12—14. The activities of this Annex officially started on July 1st 2001 and will end June 30th 2005.

2.1 Scope and objectives of annex 17

The objectives of Annex 17 are in general to solve technical and market problems for a better market opportunity for thermal energy storage systems utilizing PCM or chemical reactions in building systems and for temperature sensitive materials and waste heat utilization and to broaden the knowledgebase and disseminate information. In particular, research will be encouraged into system analysis in order to recognise market barriers for implementing the technology in residential, commercial, industrial and agricultural sectors. The action will be executed in close co-operation with manufacturers, utilities, users, governmental representatives and organizations involved in the dissemination of energy technologies. An important task is to execute case studies and commence demonstration projects so that various promising practical applications of PCM and thermochemical technology can be highlighted (e.g. highly energy – efficient).

The Annex 17 shall result in accomplished/initiated demonstration projects related to potential fields of application. Furthermore it should give general recommendations for the energy industry and more application oriented R&D activities with increased participation of industry, manufacturers, etc.

2.2 Participating countries

Participants in this annex have been Germany, Japan and Sweden. The Operating Agent has been professor (emeritus) Fredrik Setterwall, (fredrik.setterwall@comhem.se) (former KTH) on behalf of the Swedish Council for Building Research (later Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning). Viktoria Martin from KTH (vmartin@kth.se) was the Swedish expert. Experts from Japan and Germany were Motoi Yamaha from Chubu University (yamaha@isc.chubu.ac.jp) and Andreas Hauer from ZAE-Bayern (hauer@muc.zae-bayern.de) respectively.

The annex has been opened to co-operation from researchers and companies in countries not officially participating in the Annex. The 10 countries thus having participated in the work of

the Annex are Australia, Canada, China, India, Netherlands, Slovenia, Spain, Switzerland, Turkey and the United Kingdoms.

2.3 Reports to ExCo

8 progress reports have been presented, semi-annually, to the Executive Committee on the progress and the results of the work performed. These reports are found as appendixes.

2.4 Experts' Meetings and Workshops

Before the Annex was officially started, a kick-off Workshop was held in Lleida, Spain the 5 - 6 April 2001. At this event, the outcome of Annex 10 "Phase Change Materials and Chemical Reactions for Thermal Energy Storage" was presented, and a proposal for annex text and work program was discussed.

During the Annex, eight Experts' Meetings and seven Workshops were organized. Since many countries were interested in the work developed in the Annex, but they could not get official participation by their governments, the Experts'Meetings and Workshops were held alternatively in a member country and in a non-member country. Apart from the participating countries Work Shops and Expert Meetings therefore have been organized by entities in China, India, Poland and Turkey. Details of Experts' Meetings and Workshops are presented in Tables 1 and 2.

EM/WS	Location	Date	Number of Participants	Participating countries
Kick-off	Lleida Spain	2001-04-05--06	13	Germany Japan Netherlands Spain Switzerland Sweden
1	Benediktbeuern Germany	2001-10-03--04	1)	Australia Germany Japan Netherlands Spain Sweden Turkey
2	Ljubljana Slovenia	2002-04-03--05	16	China Germany Japan Slovenia Spain

				Sweden Switzerland
3	Tokyo Japan	2002-09-30—10-02	38	China Germany India Japan Spain Sweden Turkey
4	Indore India	2003-03-21--24	56	Germany India Japan Sweden
5	Warsaw Poland	2003-08-31	1)	Germany Japan Spain Sweden Switzerland Turkey
6	Arvika Sweden	2004-06-07--09	50	Germany India Japan Netherlands Slovenia Spain Sweden Turkey
7	Beijing China	2004-10-08--12	48	Canada China Germany Japan Netherlands Sweden
8	Kizkalesi Turkey	2005-04-18--20	36	Germany India Japan Netherlands Slovenia Spain Sweden Switzerland Turkey United Kingdom

1) In connection with other events

Table 1: Details on Experts' Meetings and Workshops organized during the annex

Table 2 Country participation in Workshops and Experts' Meetings

Tasks

From the beginning, it was decided to divide the work in the Annex in sub-tasks. For each of these sub-tasks, a responsible person was appointed. Since the work in the Annex was mainly project oriented, each of these projects was assigned to one sub-task, and the responsible person was responsible to get all the available information about those projects.

The work in the Annex has been divided into three subtasks:

- Heating and cooling of buildings
    - Building materials and components
    - Sorption processes
    - Peak shaving

- Temperature control
- Utilization of natural and waste energy sources

Information on the web

The work in the annex has been reported on www.fskab.com/Annex17. The web site contains information on the 25 projects that are included in the annex. The final results of these projects are found as appendices to this report. Further the six workshops and the eight experts meetings are reported. All presentations during (~125 presentations) the workshops are found on the web site.

Physical properties of commercial available PCMs as well as other tested substances are available on this site. Information on commercially available PCMs is found as appendix. This web site has been visited monthly by between 1500 and 2000 visitors originating from more than 70 different countries. More than 1 Gbytes of information have been downloaded every month. The CD-version of the final report contains also the content of the web site.

International Cooperation

Within the activities of Annex 17 some international cooperation has started. The exchange of ideas and experiences during the Annex 17 workshops has developed new partnerships and project collaboration between the participating companies, universities and research institutes. Some examples of this outcome of the Annex work will be documented in the following paragraphs.

International cooperation that was strengthened because of Annex 17 is cooperation between PCM producers, and the fact that because of this Annex these companies could expand their market to new countries. For example, Climator is now the representative of Rubitherm in Scandinavia, and they are working very close today. We should highlight that all the companies participating in one or another way to the Annex (Rubitherm, Climator, TEAP, SGL Technologies) have been giving away free samples to researchers to be tested in their applications and projects.

One example of industry and university collaboration has been the corrosion tests made by the University of Lleida for TEAP hydrated salts.

During the course of Annex 17 a strong need for more reliable thermal data was discovered. To find out the accuracy of the current way of doing measurements, and finally to improve this, a ring test between institutes, universities and companies from different countries is being performed.

Within a research project funded by the New Energy Development and industrial Technology Organization, NEDO in Japan interest in a mobile latent heat storage system developed in Germany was expressed by Japanese companies in 2002. The latent storage system was developed by the German company Alfred Schneider GmbH and was commercialized as a complete system by the company TransHeat. In early 2004 SANKI Inc., KURIMOTO Inc. have decided to introduce a Trans Heat Container from PROJECT MANAGEMENT CONSULTANTS, Co LTD (Germany). The system will be investigated in Japan.

In the sorption storage field two collaborations have been started during the Annex 17 workshops. The first one is dealing with the development of a new adsorbent. First ideas have been presented at the 3rd workshop in Tokyo in 2002 by Dr. Jänchen from ZeoSys GmbH in Berlin, Germany. Mitsibishi Chemical Corporation MCC has started to work in the same direction. During the following product development experiences with the new types of adsorbent have been exchanged. The new adsorbent was presented at the 7th workshop in Beijing, China in 2004 by MCC. The Bavarian Center for Applied Energy Research, ZAE Bayern and the Fraunhofer Institute for Solar Energy Systems, ISE were involved in the evaluation and integration of the new material into TES systems.

Collaboration between Mitsubishi Chemical Engineering Corporation, MEC, and the ZAE Bayern was initialized after the Tokyo workshop. An investigation of a liquid desiccant storage system using high concentrated lithium chloride was performed by the ZAE Bayern for MEC.

Another of the ways where this Annex has helped a lot to the researchers around the world is by networking. The best confirmation of this is the amount of exchange activities that have taken part during the length of the Annex. Scientists of the Annex 17 group from six countries (China, Germany, Japan, Slovenia, Spain and Turkey) visited institutes in Germany, Spain and Sweden in the course of Annex 17.

Final Report

The Final Annex 17 report was approved by the Executive Committee at the 59th XC meeting, which was held in Krakow, Poland on May 10-11 2005. It is not available on the web, but a CD containing the report and the presentations at the Annex 17 workshops can be ordered from Fredrik Setterwall (fredrik.setterwall@comhem.se).

National contacts

Germany	Andreas Hauer hauer@muc.zae-bayern.de
Japan	Motoi Yamaha yamaha@isc.chubu.ac.jp
Spain	Luisa Cabeza lcabeza@diei.udl.es
Sweden	Viktoria Martin vmartin@kth.se
	Fredrik Setterwall fredrik.setterwall@comhem.se

Annex20: Sustainable Cooling with Thermal Energy Storage

Introduction

ANNEX 20 has been started formally since January, 2006. Before that, the kickoff meeting was held in Nagoya, Japan on September, 2005. Heat Pump & Thermal Storage Technology Center of Japan acts as the Operating Agent.

Annex 20 will follow a project-oriented approach for optimized integration of TES in cooling systems by demonstrating and evaluating the sustainability (energy saving and CO_2 emission reduction) of cooling system with TES system.

Under the background described above, the objectives of Annex 20 are:

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

Subtasks

- Subtask A: Demonstration projects/System performance evaluation for an actual project
- Subtask B: Design Procedure and System Performance Evaluation Tools
- Subtask C: Information Dissemination and Technology Transfer

Planned Time schedule

Phase 1: January-Jun 2006

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

Phase 2: July – December 2006

- Evaluation of actual projects in participating countries
- Collecting information on the design manuals/tools and operating manuals

Phase 3: January – Jun 2007

- Evaluation of actual projects in participating countries (continuation)
- Collecting information on the design manuals/tools and operating manual (continuation)

- Define the application and condition for investigating the design manual and tools

Phase 4: July – December 2007

- Execution of several design tools for the defined application
- Making the summary for competition

Kick Off Meeting

Workshop was held on 14th Sep, 2005 and on 15th the Legal Text of Annex 20 was discussed. At work shop following presentations were made.

- Results of Annex 14"Cooling in all climates with thermal energy storage"
  Halime Paksoy / Cukurova University, Turkey
- IEA Annex 20 " Sustainable Cooling with Thermal Energy Storage "
  Masaya Okumiya / Nagoya University, Japan
- The Issue of Current Energy Supply & Demand in Japan and the Development of heat Pump and Thermal Storage Systems
  Fuminori Horiya / Heat Pump & Thermal Storage Technology Center of Japan
- Successful application of heat pumps to a DHC system in Tokyo bay area
  Ryuji Yanagihara / Tokyo Electric power Company, Japan
- Technologies of Ground Source Heat Pump Systems in Japan.
  Katsunori Nagano / Hokkaido University, Japan
- Cool-TES-project in Chemnitz (Germany) - State of the Project
  Thorsten Urbaneck / Chemnitz University of Technology, Germany
- Innovation and New Energy Technologies
  Volkmar Lottner / Forschungszentrum Jülich (FZJ), Germany
- Thermal energy storage in office building foundations
  Christian Sasse / TECHNICAL UNIVERSITY Carolo-Wilhemina of Braunschweig, Germany
- Ground Source Heating /Cooling and Thermal Energy Storage
  Bo He / Royal Institute of Technology, Sweden
- "Sustainable Cooling with Thermal Energy Storage in Canada: Current Situation and Potential Projects"
  Brian Coffey / Concordia University, Canada
- "Borehole cold storage with seawater from Halifax Harbour"
  By Frank Cruickshanks / Environment Canada, Meteorological service of Canada, Climate Change Division

PROPOSED ANNEXES

Annex 16. Market Deployment of Energy Storage Systems

The Executive Committee has decided to stop the activities on that proposal for one year. This text reflects the status of the Annex by the end 2004.

1. Background.

The IEA Implementing Agreement "Energy Conservation through Energy Storage" has contributed significantly to the development of energy storage technologies in the participating countries. These energy storage technologies are considered a strategic and necessary component for the efficient utilization of renewable energy sources and for energy conservation. The energy storage technologies developed and demonstrated involve underground thermal energy storage, thermal energy storage in phase change materials, and technologies for electrical energy storage.

To promote the implementation of thermal energy storage in building energy supply systems, the most energy and cost effective applications have been identified in the framework of Annex 8 to the Implementing Agreement. However, for the large scale deployment of new, energy efficient technologies in the energy market a greater effort is required from all stakeholders. This conclusion is not typical to energy storage technologies, but also holds for other energy efficient technologies like heat pumps, as well as renewables like solar and wind. This situation is recognized by the OECD/IEA and has resulted in the publication of two books:

- Enhancing the Market Deployment of Energy Technology - a survey of eight technologies (IEA, 1997);
- Creating Markets for Energy Technologies (IEA, 2002).

In both books it is concluded that the responsibility for market deployment cannot be left to private companies only, but is the responsibility of governments too.

"If new technologies are to deliver their potential, they must be commercially launched in a way that leads to effective penetration of the many and varied markets for energy equipment and services. The process of technology deployment can be long and complex and the rate at which it occurs is influenced by many variables, including government policies and programmes.…." (IEA ,1997).

"Deployment policy and programmes are critical for the rapid development of cleaner, more sustainable energy technologies and markets. While technology and market development is driven by the private sector, government has a key role to play in sending clear signals to the market about the public good outcomes it wishes to achieve" and *"In the end it is the combined effect of technology potential and customer acceptance that makes an impact on the market and hence on energy systems. Developing a deeper understanding of both, including how they are influenced by the actions of government, is an essential ingredient of effective deployment policy."* (IEA, 2002).

2. Objectives

The objectives of the work to be performed under this Annex are:

1. To assess the most prospective applications (market segments) for one or more energy storage technologies developed in this Implementing Agreement: Underground Thermal Energy Storage (UTES), Phase Change Material Storage (PCMS) and Electrical Energy Storage (EES)1.
2. To develop deployment strategies for these prospective market segments.

To achieve these objectives, it is considered essential that the activities in the framework of this Annex will be carried out by marketing experts, in close cooperation with specialists in energy storage, representatives of the private sector, and policy makers. As a minimum, each national team shall consist of one marketing expert and one specialist in energy storage.

Phase 1 Market segmentation

The major objectives of this phase are:

- Definition of the system concepts or products that include storage technologies that are already on the market or ready for the market;
- Assessment of the major market segments for these "embedded storage technologies". This will result in a number of Product-Market Combinations (PMC's).

The objective of this phase is not to complete a detailed market segmentation for each storage technology considered, but to focus on promising market segments. This implies that those market segments that are considered not interesting for the near future will be discarded (with reason) in an early stage. The promising market segments will be analysed into more detail. The analysis for these market segments includes the size of the market segment, existing technologies that will be replaced by the new technology, position of the storage technology, major stakeholders in this segment, as well as a preliminary SWOT analysis for the embedded storage technology.

Output Phase 1: A report on market segmentation for selected PMC's for (and by) each participating country.
Timeline: September 2005 - April 2006.

Phase 2 Selection of one or two PMC's per participating country

In this phase an Experts Meeting will be organized to select the most prospective PMC for each of the storage technologies. It is not expected that the most prospective market segments will coincide for the participating countries, so the PMC selection will be country specific.

Output Phase 2: The most prospective market segments for UTES, for PCMS, and for EES[1].
Timeline: May 2006.

1 It will be decided by the participation countries which storage technologies will be included in this Annex.

Phase 3 PMC analysis and development of deployment strategies.
In this phase the PMC's selected in Phase 2 will be further analysed and deployment strategies will be developed for these PMC's. The PMC selection, and thus the further analysis will be country specific and will be performed for one or two PMC's by each participant.

The analysis of each of the PMC's will result in the deployment strategy and includes the answers to the following questions:

- what is the product (embedded storage technology)? *"Most consumers have little interest in energy issues per se, but would gladly respond to energy efficiency measures or use renewable fuels as part of a package with features they do care about"* (IEA, 2002)
- what is the position of this product in this market segment? This includes both the position of the product in the technology adoption life cycle and the position as compared to existing technologies (incremental first cost, energy saving, operational cost saving, etc.).
- what are the opportunities and threats for this storage technology in this specific market segment?
- who are the first adopters in the specific market segment and which clients will be the early majority?
- how does the value chain look like in this market segment?
- what is the best route to approach the client?
- what type of documentation and promotion material is required?
- what is the role of the government (e.g. regulations, subsidies, early adoption, etc.) and the other stakeholders in the market deployment strategy?

An Experts Meeting will be held after completion of the PMC analyses to focus the next step: the development of the deployment strategies.

Output Phase 3: Country specific deployment strategies for the PMC's selected in Phase 2.
Timeline: June - December 2006.

Phase 4: Dissemination of results
The results of this Annex will be made available to stakeholders in the field of energy efficiency and renewables through:

- presentation of the (country specific) deployment strategies to the stakeholders in the participating countries.
- publication of the major results on the ECES website.
- preparation of a summary report and distribution of the summary report to EUWP members and EC members of Implementing Agreements in the fields of energy efficiency and renewable energy sources.
- presentation of the results at the next International Conference on Energy Storage.

Output phase 4: See above
Timeline: January - March 2007 (excl. Presentation Energy Storage Conference)

4. Costs involved.

To carry out the activities described in this Annex, the level of effort is estimated to be about six person months per participating country (four months marketing expert, two months energy storage specialist). In addition to this, about three person months are required for the specific tasks of the Operating Agent.

5. Operating Agent.

To be determined.

6. Participating countries.

To be determined.
An expression of interest was received from:
Belgium
Germany
The Netherlands
Norway
Turkey
Sweden.

Annex 18. Transportation of energy by utilization of Thermal Energy Storage Technology

Introduction

A key component in a sustainable energy system is to be able to use thermal energy from various sources at a consumer located at a distance from theses sources. For this purpose, the thermal energy has to be transported from one place to another. This could be achieved by using thermal energy storage technology. Depending on the distance, the storage medium could either be pumped through pipelines or for longer distances the TES itself could be transported on a truck or a train. The crucial properties of the TES for the technical and economical feasibility are the storage capacity per volume and weight, and the charging and discharging power, which affects the possible number of storage cycles per time, and material durability on cyclic operation.

Task Definition Workshop

In mid November 2005, more than 25 participants from seven countries participated in the kick-off event in Bad Tölz, Germany. Among these, we had representatives from industry (materials, as well as systems), research institutes, municipalities, as well as universities. The chairperson Dr. Lottner, the secretary, Dr. Hauer, and Canada's representative Ed Morofsky represented the IEA/ECES executive committee. The two-day event covered fifteen presentations, thus providing a nice jump-start to defining state-of-the-art for the task of energy transport through advanced energy storage technology. Examples of topics covered in the presentations are:

- National activities of relevance for Annex 18
- Feasibility study on thermochemical storage in Netherlands
- Feasibility study of mobile TES in Belgium coupled to CHP.
- Feasibility study of mobile TES in Germany
- Description of a pilot project in Germany
- Presentations from companies marketing mobile TES
- Update on slurry technologies
- Possibilities for mobile TES using chemical reaction

National activities

Japan

In Japan's preparation to participate in Annex 18, a pre-requisite questionnaire was prepared and sent out to about 110 companies. They were asked to indicate special focus areas, or areas of interest with regards to heat transfer conditions (source temperature and power, storage method, means, density, temperature), transportation (means, distance, container specification), usage (demand and scale), storage method (temperature, power, density, temperature, scale).

Some indication had so-far been obtained from this questionnaire although only a few companies answered.

In general in Japan, ice slurries are very popular one reason being the very nice heat transfer characteristics.

Germany

In Germany, two main projects are of relevance for the Annex 18 work: one regarding PCM slurries lead by Fraunhofer-Institut für Solare Energiesysteme ISE; and one regarding mobile TES conducted by ZAE Bayern. In addition, there are many companies working on technology issues and product development. Germany hope to form a national expert group around the work related to Annex 18.

Canada

Canada joined the workshop enthusiastically by representatives from the Halifax Regional Municipality, along with an engineering company specializing presently in underground thermal energy storage. An overview of the local energy situation was provided with the following issues highlighted:

- The present challenge of demand-shifting electricity consumption – Halifax area is greatly affected by the US east coast which has a large cooling load.
- There is a goal as a municipality to decrease the greenhouse gas emissions by 20%.
- Plans are under way for developing a district energy system for the downtown area (2 square miles) where there is a university, a large hospital, a naval base etc.

Sweden

Sweden is preparing to join the Annex 18, and in Bad Tölz a presentation was given on possibilities with *Energy Transportation using TES* in the Swedish District Energy System. Some examples were given of candidate systems that deserves further exploration:

1. The Stockholm, and Gothenburg district cooling systems where too low cooling capacity [$MW_{cooling}$] is threatening in the future due to steadily increasing demand for cooling. Shortage of space for storage make pumpable PCM slurries interesting, at least for local, small parts of the network. Then, the network will have a storage capacity in itself.
2. The Oxelösund steel making company (SSAB) where a large amount of heat is wasted every year due to lack of suitable heat demand in the nearby community. Could part of this waste heat be transported by railroad to the nearby city of Nyköping, utilizing mobile TES?

Sweden has participated in the now finished annex 10, annex 14, and annex 17 dealing with cooling through TES, as well as advanced TES concepts. Knowledge on material characteristics, heat transfer, and experience in design with efficiency monitoring will be of great use for the potential applications studies of TES systems in district energy systems and in industry.

Switzerland

Switzerland conducts research on PCS slurries, and also on advanced storage concepts for solar applications (IEA/Solar Heating and Cooling Task 32). Switzerland highlighted the importance of annex 18 to collaborate with that Task 32. Switzerland has, through Professor Egolf of Univ. of Applied Sciences of Western Switzerland, been extensively involved with the IIR working party on ice slurries. Collaboration with this working party is also of interest for annex18. Nowadays, activities with PCS are also included (see below).

Objectives

The general objectives of this Annex on Transportation of Energy by Utilization of Thermal Energy Storage Technology are to identify state-of-the-art for using different technologies for energy storage and transportation, to broaden and co-ordinate the knowledge within the field, and to disseminate information. In particular coordinated R&D activities will include the following:

- Development of high capacity storage materials and high thermal power charging and discharging technologies that are easy to implement in an energy transport system.
- Consideration of system aspects where heat sources are linked to the customer's need and where these links' impact on system design is assessed. Through system analysis, potential cost-effective applications shall be identified.

At the end of the Annex, present activities within the field are expected to be better co-ordinated, and initiatives for new activities have been taken. Demonstration activities in pilot plant scale shall be initiated, but may not yet have been taken into operation.

Work program – Main Activities and Time Schedule

Phase 0: June 2005 – June 2006

- Invitation to participate
- Kick-off workshop in Bad Tölz, November 2005 in Germany – establishing participants and their combined goal with the Annex
- Finalizing Financing Plans for participants (AP)
- Finalize Annex Objectives, Goals and Work Plan with ExCo (OA/AP)
- Collecting information on ongoing activities in the area (AP)
- Final Task Definition Meeting, Stockton, New Jersey, June 2006 (OA/AP)

Phase 1: July -- December 2006

- Establishing collaborative activities (AP/OA)
- Begin establishing State-of-the-Art high capacity TES technologies (AP/OA)
- First Workshop and Expert Meeting, Japan (preliminary suggestion), November 2006. (AP/OA)

Phase 2: January-June 2007

- Compile State-of-the-Art high capacity TES technologies (OA/AP)
- Identify potential applications, including heat/cold sources and "customers" (OA/AP)
- 2nd Workshop and Expert Meeting (provisionally participating country) (AP/OA)

Phase 3: July-December 2007

- Applications' evaluations (AP)
- Candidate technologies – special material's issues for PCS systems, system issues for sorption systems, design of mobile TES. (AP)
- 3rd Workshop and Expert Meeting (tentatively, Sweden) (OA/AP)

Phase 4: January-June 2008

- Establishing desired feasibility studies and demonstration projects – a plan for future IEA activities (OA/AP)
- 4th Workshop and Expert Meeting (provisionally participating country) (OA/AP)

Phase 5: June – December 2008

- Assessment of path to commercialization (AP)
- Commence final reporting activities (OA/AP)
- 5th Workshop and Expert Meeting (tentatively Germany) (OA/AP)

Phase 6: January -- June 2009

- Final Report Due in May (to be disseminated in June). (OA)
- Dissemination of Results (OA)
- 6th Workshop and Expert Meeting (if possible in conjunction with next "STOCK"-conference) (OA/AP)
- Closing the Annex

Activities

- Evaluation of presentations and findings
- Workshops and expert meetings
- Identify promising applications
- Identify design criteria for high capacity and high power mobile TES
    - Initiate demonstration projects and case studies.

Major outcomes

The major outcomes of the proposed Annex will be:

- increased awareness of the possibilities of efficient energy transportation using advanced thermal energy storage;
- increased activities in the area, e.g. initiation of feasibility studies and demonstration projects regarding energy transportation through TES.
- a solid workplan for continuing Annex regarding feasibility studies and demonstration projects

Participants in this Task

Participants in this task are:

Germany
Japan
Sweden
a number of provisional participants

Sweden will be the Operating Agent.

Annex 19. Optimized Industrial Process Heat and Power Generation with Thermal Energy Storage

1. Background.

Previous activities in the IEA Implementing Agreement "Energy Conservation through Energy Storage" has achieved significant progress in thermal energy storage technologies for energy savings and for reduction of peak demand of energy in buildings and in advancing the prospects of cooling with TES technologies.

The potential for thermal energy storage and regenerative heat transfer for the industrial process heat sector for efficient energy utilization, heat recovery and storage of high temperature waste heat as well as the need for energy storage for power generation based on new conversion techniques and renewable energy resources (RES) is a concern of several national and international research strategies. Both areas are directed to applications and processes at high temperature. In this context "High Temperature" is defined to be higher than 120 °C as required for comfort heating and where water cannot be applied as heat transfer fluid.

Nevertheless, no or very few examples of commercial high temperature thermal energy storage (HTTES) are realized. Main reasons are the still too high investment costs of the existing HTTES technology which leads to non economic systems. In order to achieve the required cost reduction the realization of long-term stable, low cost storage materials with superior thermo physical properties, the development of a high efficient and economically optimized heat exchanger configuration and innovative storage design are required. In the same way, the development of optimized integration and operation strategies for the specific application are essential.

Currently, international research activities in the field of HTTES are fragmented with respect to the investigated storage technique and TES material development as well as to the considered power level, range of thermal capacity and temperature range.

Important applications for high temperature heat storage can be found in the industrial process heat sector. Depending on the temperature range and the dominating heat transfer fluids, two different areas are identified. A huge amount of energy in the temperature range of 100-300°C is needed to generate process steam at low or intermediate pressure for application in food processing, manufacturing of construction materials, production of cardboard and paper, in the textile industry, manufacturing of rubber and other commodities. For such applications improved PCM/steam storage systems could lead to economic TES solutions. For elevated temperatures above 500/600 °C flue gas and process air are the dominating heat transfer fluids. Due to the poor heat transfer characteristics of gas/air the development and design of high efficient heat transfer technique represent an additional important task for the realization of economic HTTES technology.

With increasing amount of electricity generated by RES feeding into the interconnected grids, considerable grid stability problems come up. For solar thermal power plants the integration of thermal energy storage avoids such interconnection and frequency stability problems by stabilizing solar power generation within the fence of the solar thermal plant. For stand alone solar thermal plants in remote or island power parks, energy storage is the fundamental element to maximize capacity factor and to assure availability. In case of wind power, electricity

has to be stored to make up for the inherent variability of wind. As an alternative to storing electricity the "Advanced Adiabatic Compressed Air Energy Storage (CAES)" is being developed by a European consortium. The core component of the AA-CAES concept is an efficient high temperature heat storage device necessary to enable effective and economic adiabatic CAES technology. With respect to power generation with fuel cells there is considerable demand for thermal management and HTTES especially for the operation of high temperature solid oxide fuel cells.

2. Activities 2005

The definition of the scope and work program was further developed. Significant effort was made to distribute information and to raise interest of potential participants for participation.

The French research group "High Temperature and Power Materials" - HTP-stock expressed strong interest to collaborate with new annex 19. Funding of the HTP-stock project is provided by Ministry of Research. International cooperation in the IEA frame was approved by the Ministry of Industry. It is expected that the formal procedure will be completed during the first half of 2006.

The status of negotiations with interested parties can be summarised as follows:

- Germany – represented by DLR – agreed to participate and to provide the OA
- France – represented by the HTP stock group – will participate but needs first to enter the ECES IA
- Australia – represented by CSIRO – has shown significant interest to participate in the Annex but needs first to become an official member of the ECES IA.
- Finland – represented by VTT – has not yet defined a specific project which would fit to the Annex.
- Sweden - represented by KTH – needs industrial support for project funding, which is a requirement for active participation.

In addition there are request from interested parties from several other countries, but actually there is no official commitment available.

3. Objectives.

The general objectives of the proposed Annex" Optimized Industrial Process Heat and Power Generation with Thermal Energy Storage" are to overcome the fragmented research and to achieve synergies from existing and new future HTTES activities.

The objectives of the work to be performed under this Annex are:

- To conduct a general review and assessment study of existing and emerging HTTES technologies
- To develop a methodology to assess and to compare different storage technologies
- To identify efficient and economic storage materials and design concepts
- To identify possibilities for economic HTTES applications

- To define strategies for efficient storage integration and operation
- Technology transfer

4. Work Programme.

The work in the framework of this Annex is planned for a period of 3 years (with expected start after approval by the ExCo in late fall 2004) and subdivided in subsequent phases. For each phase an indication is given of the time required to carry out the activities.

Phase 0: Pre-definition Phase
January-October 2004

- Invitation to participate, clarification of interest and participation
- Kick-off workshop in June or July 2004 (organized by DLR) – establishing participants and their combined goal with the annex
- Collecting information on ongoing activities in this area, compiling State-of-the-Art of HTTES technologies

Phase 1: Start up and Task Definition Phase (time required 6 months)

- Finalizing Annex Objectives, Goals and Work Plan with ExCo
- Finalizing Financing Plans for participants
- Establishing collaboration activities
- State of the Art Reviews
- Workshop and Expert Meeting

Phase 2: Review and Assessment Phase (time required 15 months)

- State of the Art Reviews (continued)
- Technical and economic assessment of different HTTES concepts
- Identify of applications with high potential for economic HTTES integration
- Case Studies
- Evaluation of the concepts and applications
- Workshop and Expert Meetings

Phase 3: Development and Implementation Phase (time required 15 months)

- Case Studies and Pilot projects (continuation)
- Defining candidate technologies for power generation and process heat
- Establishing desired feasibility studies and demonstration projects – a plan for future IEA activities
- Initiation of energy storage projects related to industrial process and power generation

- Workshop and Expert Meetings
- Final Report and Dissemination of Results

5. Costs involved.

The work will be carried out on Task Sharing Basis.

To carry out the activities described in this Annex, the level of effort per participating country is estimated to be about 3 person months per year. In addition to this, about 4 person months per year is required for the specific tasks of the Operating Agent.

6. Operating Agent.

To be determined by the ExCo.

DLR has the experience and capability to take over the role of the OA.

7. Participating countries.

To be determined.

APPENDIX 1 - PARTICIPANTS OF ECES IA

Belgium, Ministry of Economical Affairs
Canada, Public Works and Government Services Canada
CEC, EC / Research Director-General, RTD Programme "Improvement of energy efficiency"
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
Norway, Geological Survey of Norway
Spain, IBERDROLA, Madrid
Sweden, The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, FORMAS
Turkey, Çukurova University, Adana
United Kingdom, Department of Trade and Industry (dti)
United States of America, Department of Energy
IF Technology (The Netherlands), as a Sponsor
Institute of Heat Engineering (ITC) of the University of Technology Warsaw (Poland), as a Sponsor

IEA-Secretariat:

Responsible desk officer: Carrie Pottinger

APPENDIX 2 -LIST OF PUBLICATIONS

Annex 12 / 13:

Final Reports and State of the Art Reports Annex 12 and Annex 13 are in preparation, will be published 2006

Annex 17:

Proceedings of Wokshops presented in internet of Annex 17 homepage:
http://www.fskab.com/Annex17

- **Workshop, April 19-20 , Kizkalesi, Turkey**

A CD containing the report and the presentations at the Annex 17 work shops can be ordered from Fredrik Setterwall (fredrik.setterwall@comhem.se).

Annex 18:

Presentations from the task-definition workshop in Bad Tölz, Germany November 14 – 15 can be downloaded from the preliminary Annex 18 homepage:
http://www.iea-eces.org/annexes/annex_home/annex18/a18_meeting_05.html

Joint workshop with the District Heating and Cooling IA "Cool Storage in District Cooling Systems"

Presentations from the joint workshop with the DHC IA in Berlin, Germany, June 8, Berlin, Germany can be downloaded from the ECES homepage:

International Summer School "NATO Advanced Study Institute on Thermal Energy Storage for Sustainable Energy Consumption (TESSEC) - Fundamentals Case Studies and Design"

A textbook from the international summer school TESSEC held in Izmir-Cesme/Turkey, June 6-17, will be published in 2006. Information about the publication will be on the ECES homepage: http://www.iea-eces.org/index.html