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

Implementing Agreement on Energy Conservation through Energy Storage

Annual Report 2006

August 2007

CONTENTS

CHAIRMAN’S REPORT

The Year 2006: Achievements and Challenges

The world is not on course for a sustainable energy future. Improved energy efficiency is one of the cheapest, fastest and most sustainable way for the world's environment. Energy storage is a key component in many energy efficient systems. Energy storage technologies are already fully competitive in some countries, but more government and private funded R & D is needed to research, develop and integrate energy storage technologies. Deployment programmes will also be important for technology and market development.

Achievements in 2006

An important event for the Implementing Agreement “Energy Conservation through Energy Storage” was Ecostock 2006, the 10th International Conference on Thermal Energy Storage. The Conference was organized and hosted by the Richard Stockton College of New Jersey. About 200 participants from 31 countries participated in the conference. The “Stock” Conference has never had so many countries represented.

Two new annexes were approved in 2006. Annex 18 “Transportation of Thermal Energy by Thermal Energy Storage”, with Victoria Martin from the Royal Institute of Technology in Stockholm, Sweden as operating agent, held the first expert meeting and workshop in Tokyo in November. After three years with patient work by Rainer Tamme from the DLR in Stuttgart, Germany, Annex 19 “Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage” was approved by the XC at the fall meeting in Stockholm.

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 the P.R. China and Republic of Korea, but also with 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 2006 we could welcome France as the seventeenth participating country in the Programme. The contracting party is Ministère de l’Economie, des Finances et de l’Industrie, France. The new french delegate in the executive committee, Prof. Elena Paloma del Barrio from the university of Bordeaux was already present at the fall meeting 2006.

IEA and G8 countries are cooperating through the Gleneagles programme. Within the collaboration, particular emphasis is focussed on the "plus five countries” - China, India, South Africa, Brazil, Mexico and Russia. Fast–growing developing countries offer opportunities to accelerate technology learning. Therefore, we welcome very much China, hosting the ECES meetings, and the Republic of Korea as observers at the executive committee meeting in Beijing in April 2007.

Support by the IEA-Secretariat.

I would like to take the opportunity to thank all colleagues for their continuous efforts and engagement, in particular Jeppe Bjerg (IEA-desk officer) and Dr. Andreas Hauer (ECES scientific secretary). A special thank you we want to express to Ms Carrie Pottinger, the former desk officer, for the intensive collaboration and for her engagement with the ECES Executive committee over the last several years.

ECOSTOCK 2006 10th International Conference on Thermal Energy Storage

Prof. Lynn Stiles from the Richard Stockton College summarized the conference as a very successful one. About 180 participants from 31 different countries participated and 110 presentations were given (oral and as posters). A very positive aspect from the organizers point of view was the participation of many young scientists from a number of countries. Prof. Stiles said it was a pleasure to host that conference and to organize it. The proceedings are now available on CD and the printing is on the way (contact see page 32).

Figure 1: The ECES Executive Committee at the Ecostock conference 2006 in New Jersey, USA

ENERGY CONSERVATION THROUGH ENERGY STORAGE IMPLEMENTING AGREEMENT

The Implementing Agreement (IA) started in 1978. Its present term ends by the end of 2010. At present, Contracting Parties from the following countries have signed the Implementing Agreement: Belgium, Canada, CEC, Denmark, Finland, France 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. 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 18: Transportation of Thermal Energy Utilizing Thermal Energy Storage Technology

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 possible charging and discharging power, which affects the possible number of storage cycles per time.

Annex 18 was approved by the Executive Committee at the meeting in June 2006. Operating Agent is Sweden.

- Participating Countries: Germany, Japan, Sweden

Annex 19: Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage

The potential for thermal energy storage and regenerative heat transfer for the industrial process heat sector for efficient energy utilisation, 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.

Annex 19 was approved by the Executive Committee at the meeting in November 2006. Operating Agent is Germany.

- Participating Countries: Germany, France

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 2005. Operating Agent is Japan.

- Participating Countries: Japan, Canada, Germany, Turkey, USA and Sweden.

Executive Committee Meetings

The Executive Committee had two meetings during the year 2006. The 61st XC meeting was held at the Richard Stockton College, NJ, USA June 3-4 and the 62nd XC meeting in Stockholm, Sweden November 30 – December 1.

The most important items and decisions of the XC meetings in 2006 are outlined below.

The New Jersey Meeting, June 3-4, 2006

- The first printed version of the new ECES brochure was presented.
- Kirsti Midttomme (Geoligical Survey of Norway) was unanimously elected as the new Chairman, as Vice Chair Tadahiko Ibamoto (Tokyo Denki University) was elected.
- Annual Report 2005 was approved
- Financial statement about the common fund of the secretariat was approved
- The next Stock-conference was decided to take place in 2009 in Stockholm, Sweden.
- Annex 13 was concluded.
- Approval of the progress reports of the ongoing Annex 20.
- Evaluation of new Annex proposals Annex 19 and an Annex about TES and green houses.
- Approval of Annex 18.

The Stockholm Meeting, November 30 – December 1, 2006

- 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
- The election period for the secretary was extended to two years.
- Mashahiro Kawaji (Canada) from the International Institute of Refrigeration was present and expressed his interest in future collaboration
- France, represented by Elena Paloma, was welcomed as new participating country
- Approval of progress reports of the ongoing Annexes 18 and 20
- Evaluation of new Annex proposals on “Applying Energy Storage in Ultra-low Energy Buildings” and on “Thermal Response Test”.
- Approval of Annex 19.
- The progress of the organization of the “Effstock”-conference 2009 in Stockholm was presented

Executive Committee Meetings 2005

- **61st XC meeting, June 3-4, 2006 Richard Stockton College, New Jersey, USA,**
- **62nd XC meeting, November 30 – December** 1, **2006, Stockholm, Sweden,**

Expert Meetings and Workshops 2006

Annex 18: Transportation of Thermal Energy by Thermal Energy Storage

- **"Final" Task-definition workshop, June 3, 2006, Richard Stockton College, New Jersey, USA**
- **Annex 18 1st Workshop and Expert's Meeting, "State-of-the-Art and Collaborative Activities in Energy Transportation through Advanced Thermal Energy Storage Technology" November 13-15, Tokyo, Japan.**

Annex 20: Cooling in All Climates With Thermal Energy Storage

- **2nd Annex 20 expert meeting, June 3, 2006, Richard Stockton College, New Jersey, USA**
- **3rd Annex 20 expert meeting and workshop, November 28-29, Stockholm, Sweden**

Other Activities

- 10th International Conference on Thermal Energy Storage, ECOSTOCK 2006

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. Annex 18 started in June 2006 with the aim of 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.

Objectives

Coordinated R&D activities will include the following:

- Development of high capacity storage materials and high thermal power charging and discharging technologies, which 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.

Participating Countries

Presently, Sweden, Japan and Germany are formal partners of the Annex. A strong interest to join has been expressed by many other countries including France, Belgium and Finland. It is desirable that the number of formal participating countries increases during 2007.

Operating Agent

FORMAS, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, acting through KTH – the Royal Institute of Technology, Sweden, is designated as the Operating Agent.

Work outline

This Annex 18 will consider the following two subtasks for further studies:

1. Pumpable Systems for Energy Transportation
2. Mobile Thermal Energy Storage – Truck, Train or Boat

Subtask 1 includes the use of Phase Change Slurries (PCS), emulsions or chlatrates to work as multifunctional fluids for both energy transport and storage. Subtask 2 includes sorption technology, e.g. zeolite systems, and chemical reactions.

In addition to the two subtasks, it was decided at the Annex 18 1st workshop and expert's meeting (Tokyo, November, 2006) to also incorporate joint project efforts. The first initiative is focusing on waste heat transportation from the steel industry. Such a national project is under formation in Sweden, and discussions are ongoing in Germany and Japan. During the Expert Meeting in Tokyo, in addition to the experts, representatives from Nippon Steel, as well as JFE were present. They held presentations at the expert meeting. At the expert's meeting, Fredrik Setterwall, Fredrik Setterwall Konsult AB, SWEDEN, was chosen as the project manager for this joint effort. Goals are to:

- Involve many disciplines in addition to R&D competencies for TES, e.g logistics, chemistry, chemical engineering and system analysis.
- Establish national sub-projects for the transportation of waste heat from the steel industry.
- Acquiring joint funding as well, for example from the EU (with broadened partnerships outside the annex 18 possible) or if there is any international organization for the steel making industry.
- Work efficiently with the Annex 18 subtasks on technology specific issues.

Phase 0: (Preparation Phase) 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
- Finalize Annex Objectives, Goals and Work Plan with ExCo
- Collecting information on ongoing activities in the area
- Final Task Definition Meeting, Stockton, New Jersey, June 2006

Phase 1: July -- December 2006

- Establishing collaborative activities
- Begin establishing State-of-the-Art high capacity TES technologies
- First Workshop and Expert Meeting, Japan, October 2006.

Phase 2: January-June 2007

- Compile State-of-the-Art high capacity TES technologies
- Identify potential applications, including heat/cold sources and "customers"

- 2nd Workshop and Expert Meeting Bordeaux, France, March 2007

Phase 3: July-December 2007

- Applications' evaluations

- Candidate technologies – special material's issues for PCS systems, system issues for sorption systems, design of mobile TES.
- 3rd Workshop and Expert Meeting, Kyoto, Japan, November 2007

Phase 4: January-June 2008

- Establishing desired feasibility studies and demonstration projects – a plan for future IEA activities
- 4th Workshop and Expert Meeting (tentatively a joint workshop with Annex 19)

Phase 5: June – December 2008

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

Phase 6: January -- June 2009

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

Homepage of Annex 18:

www.webforum.com/**annex18**/home/index.asp

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

Annex 19 “Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage” was approved at the 62nd XC meeting in Stockholm, Sweden, December 1st, 2006.

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.

Activities 2006

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” from the Institute TREFLE / CNRS 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. The formal procedure of signing the Implementing agreement was completed in June 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 TREFLE / CNRS –participates in the Annex
- 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.

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

Work Programme.

The work in the framework of this Annex is planned for a period of 3 years (with expected start end of 2006 after approval by the ExCo) and is subdivided in subsequent phases. For each phase an indication is given of the time required to carry out the activities.

Phase 0: Preparation Phase

- Invitation to participate, clarification of interest and participation
- Workshop in June or July 2004 at CNRS – 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: Jan. to June 2007 Start up and Task Definition Phase

- Launch Meeting and Expert workshop establishing participants and their combined goal with the annex
- Finalizing Annex Objectives, Goals and Work Plan with ExCo
- Establishing collaboration activities
- State of the Art Reviews
- Workshop and Expert Meeting

Phase 2: July 2007 to Sept. 2008 Review and Assessment Phase

- 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: Oct. 2008 to Dec. 2009 Development and Implementation Phase

- 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

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.

Operating Agent.

The DLR was appointed as Operating Agent for this Annex..

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

Participating countries.

Currently the Annex has two members: France and Germany with Germany acting as the Operating Agent. Interest in participation has been shown by Spain, Belgium, and possibly Sweden, Finland, Japan, Australia and The Netherlands.

There is strong interest from the Spanish company Solucar – a subsidiary company of the ABENGOA group – to participate in Annex 19. Solucar will try to be nominated as the Spanish delegate and to replace Iberdrola, currently not active in the ECES IA.

Introduction

ANNEX 20 has been started formally since January, 2006. 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

Three expert meetings were held from January 2006. One was held with EcoStock Coneference in May 2006, one was held in Nov. 2006 at Stockholm and the other was held at Beijing in Apr. 2007.

Followings are the outline of results of each Subtasks.

Subtask A

Prof. Halime Paksoy and Prof. Lynn Stiles are undertaking the leadership of Subtask A. In the subtask A, the projects which will be evaluated were collected from the participating countries and the evaluation index was discussed.

Projects

The projects from the participating countries to be included in Subtask A are 16 projects with following storage technologies:

- ATES (6 projects)
- BTES (3 projects)
- Ice (2 projects)
- Water (1 project)
- Foundations (1 project)
- BTES and Ice (1 project)
- PCM (2 projects)

Project Template

The project template format for IEA ECES Annex 20 is prepared (see Table 2) based on the information gathered from previous annexes and input from Annex 20 experts.

Subtask B

Prof. Thorsten Urbaneck is the leader of Subtask B. In this subtask, the design procedure and system performance evaluation tools are discussed from following perspective.

- Theoretical background (mathematical model)
- What kind of calculation engine is used (from MatLab to Excel)
- For what kind storage technologies (ATES, BTES, Water, Shor-term, Long-term so on)
- On which stage, the tool can be used (Design stage, operating stage or other stage)
- What kind of performance index can be evaluated (Energy, CO2, Cost,...)

Workshop

Usually Annex 20 holds Expert Meeting and Workshop at the same time. However, expert meeting at Stockton was held just after EcoStock conference, workshop was not held that time. Therefore only one workshop was held in Nov. 2006. Followings are contents of workshop at Stockholm. Presentations are appeared in Website of ANNEX 20 (http://www.hptcj.or.jp/annex20/index.html).

Workshop in Nov. 2006 (Stockholm)

1. Introduction of progress status of Subtasks A
2. Introduction of progress status of Subtasks B
3. Introductionh of each country project

- ✓ Alderney 5 Energy Project - Halifax - Julian Boyle, Canada
- ✓ Seasonal thermal energy storage – concepts and demonstration project in Germany - Thomas Schmidt, Germany
- ✓ ATES and BTES applications in Sweden - Bo He, Sweden
- ✓ UTES projects for Annex20 in the US - Lynn Stiles, USA
- ✓ Storage research at the University of Zaragoza and the University of Lleida - Luisa F. Cabeza, Spain
- ✓ Brief introduction of The International Institute of Refrigeration (IIR) - Masahiro Kawaji, Canada
- ✓ Development of Thermal Storage Systems using Ice Slurry and Phase Change Material Slurries - Masahiro Kawaji, Canada
- ✓ Shallow geothermal heat and cold storage systems - monitoring results of three German office buildings - Christian Sasse, Germany
- ✓ Outline of Nakanoshima DHC Plant Using River Water for Heating and Cooling Source - Hideki Tanaka, Japan

Homepage of Annex 20:

http://www.hptcj.or.jp/annex20/index.html

PROPOSED ANNEXES

Annex 15. Applying Energy Storage in Ultra-low Energy Buildings

Introduction

Sustainable buildings will need to be energy efficient well beyond current levels of energy use. They will need to take advantage of renewable and waste energy to approach ultra-low energy buildings[1]. Such buildings will need to apply thermal and electrical energy storage techniques customized for smaller loads, more distributed electrical sources and community based thermal sources. Lower exergy heating and cooling sources will be more common. This will require that energy storage be intimately integrated into sustainable building design. Many past applications simply responded to conventional heating and cooling loads. Recent results from low energy demonstrations, distributed generation trials and results from other Annexes and IAs such as Annex 37 of the ECBCS IA, Low Exergy Systems for Heating and Cooling need to be evaluated. Although the ECES IA has treated energy storage in the earth, in groundwater, with and without heat pumps and storing waste and naturally occurring energy sources, it is still not clear how these can best be integrated into ultra-low energy buildings capable of being replicated generally in a variety of climates and technical capabilities.

Energy storage has often been applied in standard buildings that happened to be available. The objective was to demonstrate that the energy storage techniques could be successfully applied rather than to optimize the building performance. Indeed the design of the building and the design of the energy storage were often not coordinated and energy storage simply supplied the building demand whatever it might be.

Subtasks

This Task will consider the following four subtasks for study.

Subtask A: Coordinated national reviews of energy storage use in energy efficient buildings.

Subtask B: Collaborative evaluation of energy storage usage and proposed efficient systems based on Subtask A and other Annex results.

Subtask C: Development of Sustainable Energy Storage Designs for a variety of ultra-low energy buildings using thermal, phase change materials and electrical storage options. Energy storage designs for the following building types would be examined:

1. A distributed electrical generation multi-unit residential building that stores cogenerated heat energy for multiple uses.

[1] An ultra-low energy building should have dramatically lower energy requirements than the minimum requirements of the building or energy code applying in the jurisdiction under consideration. For example, in Canada a 90% reduction in the energy use compared to the reference built to the Model National Energy Code for Buildings would be an ultra-low energy building.

2. A renewable energy single family house
3. A small community that shares energy among various types of buildings and occupancies including residential, commercial and institutional.

Subtask D: Apply, monitor and evaluate demonstrations of these Designs in a number of countries and climates.

Schedule

Planning	July 2006	July 2007	
Subtask	Start	Finish	Result
A	July 2007	Dec 2007	National reviews
B	July 2007	Dec 2008	Proposed concepts
C	Jan 2008	July 2010	Sustainable designs
D	Jul 2008	July 2011	Monitored and evaluated applications

Objectives

The general objective of the Annex is to ensure that energy storage techniques are properly applied in ultra-low energy buildings and communities. Applications of these designs are foreseen in a post-Kyoto world where total CO_2 reduction is required. Proper application of energy storage is expected to increase the likelihood of sustainable building technologies.

Specific objectives include,

- assess the potential of harnessing natural energy sources to supply building heating and cooling through energy storage;
- assess the use of energy storage (electrical and thermal) to optimize the efficiency of distributed generation;
- develop and evaluate energy storage conceptual designs suitable for specific applications;

Results

Position energy storage techniques to respond to the needs of future buildings with very low energy and power requirements. This would include the use of natural energy from earth and water, waste energy from sources such as distributed generation and conventional storage technologies sized and modified to operate efficiently at customized temperatures and quantities.

Subtask A: Coordinated national reviews of energy storage use in energy efficient buildings.

- Standard reporting format
- National reviews of storage applications
- Design concepts used and practical results
- Database of National results

Subtask B: Collaborative evaluation of energy storage usage and proposed efficient systems based on Subtask A and other Annex results.

- Evaluation and inclusion of related findings from IAs on Buildings and Community Systems, Heat Pumps, District Heating and Cooling; Solar Heating and Cooling; and Energy Storage.
- Identification of obstacles to effective storage techniques.
- Recommendations for Subtask C designs.

Subtask C: Development of Sustainable Energy Storage Designs for a variety of ultra-low energy buildings using thermal, phase change materials and electrical storage options.

- Conceptual designs of ultra-low energy building types with energy storage recommendations.
- Case studies.

Subtask D: Apply, monitor and evaluate demonstrations of these Designs in a number of countries and climates.

- Design guidebook (electronic format)
- Collaborative designs and monitored results
- Web-site
- National Workshops

Scope

The Annex will cover:

- A variety of building types as selected by participants.
- New buildings.
- A variety of distributed electrical generation as selected by the participants from renewable technologies and fuel cells, Stirling engines, microturbines and engines.
- Small scale and distributed community energy systems.
- Various energy sources including natural energy sources and temperature ranges.
- A variety of climates as selected by participants
- Environmental impacts of systems

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.

1. Background and Scope

Thermal Response Test (TRT) is a measurement method to determine in situ ground thermal properties i.e. effective thermal conductivity of ground thermal resistance in boreholes. The TRT equipment is usually set up on a trailer for easy transportation between test sites. This method has been very important in the rapid spreading of BTES systems. It has been a door opener for introducing the technology in "new" countries.

The first paper suggesting the mobile TRT method was presented at the "Stock" Conference in Stockholm in 1983. It took until the mid 90ies until TRT was developed, independently in US and Sweden, and the first mobile TRT equipment was operated in 1996 in Sweden. The technology has since spread to about 20 countries in Europe, Asia, North America and South America and will soon be introduced in Africa. Since the TerraStock Conference in Stuttgart 2000, TRT has had a special session at the Stock Conferences.

There are basically two types of mobile TRT equipment; for heat injection or heat extraction in the tested borehole. There are also systems in which both modes are available. The design of such equipments varies from suitcase to caravan size and shape.

Before performing the test the undisturbed ground temperature has to be determined. This is usually made by temperature logging in the borehole, or by evaluating the fluid temperature before the heating/cooling is switched on. Sometimes, the general ground temperature of the area is used.

The measured thermal response is the temperature drop between inlet and outlet temperatures. Temperature fluctuations usually depend on the varying ambient air temperature or corresponding fluctuations in the power supply to the circulation pump. Air temperature and the power consumption are therefore often measured to separate such disturbances in the evaluation.

Used evaluation methods are: the Line Source Model, which is commonly used in Europe and Numerical Simulation Models which are more often used in North America.

2. Objectives

The overall objective of Annex 21 are to compile TRT experiences worldwide in order to identify problems, carry out further development, disseminate gained knowledge, and promote the technology. Based on the overview, a TRT State of the art, new developments and further work are studied.

The Specific Objectives of Annex 21 are:

Overview

- Worldwide use of TRT (country, type, number)
- Test application (design values, research & development, quality control / failure analysis).
- Applications (BHE, energy piles, heat pipe BHE's, etc.)
- TRT method (heating and / or cooling)
- Experimental setup (monitoring accuracy, etc.)
- Test procedure
- Evaluation models

New Developments and Further work

- Method to determine undisturbed ground temperature
- TRT while drilling
- Swiss TRT – swimming data acquisition 'Fisch', etc.
- Groundwater influence
- Software for automatic evaluations
- Comparison of equipment and evaluation
- Initiate a common quality standard of TRT worldwide
- Invitation to „new“ countries – workshop and courses on how to use TRT

3. Means

Countries participating in the IEA R&D Program perceive collective benefits from sharing R&D results from national programs and from collaborative international R&D. Therefore, the means employed to achieve Annex 21 objectives will be collaborative efforts based upon co-operation and task sharing arrangements with lead countries for each sub-task.

4. Activities

Figure 1 shows the flowchart for the activities that will be performed in the subtasks.

Sub-task 1. TRT state-of-the-art

- Conduct a state-of-the-art survey covering worldwide use including TRT types, applications, experimental setup, test procedure and evaluation models

Sub-task 2. New Developments

- Method to determine undisturbed ground temperature
- TRT while drilling
- Swiss TRT – swimming data acquisition 'Fisch', etc.

Sub-task 3. Evaluation methods and developments

- Comparison of equipment and evaluation
- Groundwater influence
- TRT for special geometries like energy piles

- Software for automatic evaluations

Sub-task 4. Standard TRT Procedures
- Initiate a worldwide TRT standard
- Invitation to ‘new‘ countries – workshop and courses on how to use TRT

Responsibilities for Sub-tasks

Table 1. Activity Plan – Thermal Response Test (TRT)	
SUB-TASKS	**LEAD COUNTRY**
1. TRT state-of-the-art	Sweden
2. New TRT Developments	Norway or Belgium?
3. TRT Evaluation methods and developments	Netherlands or US?
4. Standard TRT Procedures	Germany

Suggested lead countries are not yet decided

5. Responsibilities of Participants

Experts' Meetings will be rotated among the participating countries to the extent feasible. A Lead Country will be responsible for each sub-task.

Participants are expected to contribute equally to the completion of the Annex in terms of collaborative effort. The Executive Committee may decide that one or more Participants may contribute to the Annex in part with budgetary resources in lieu of collaborative effort on certain tasks.

Associate memberships in the Annex are encouraged under arrangements agreeable to by the participating countries and the consent of the Executive Committee.

6. Responsibilities of the Operating Agent

Sweden, represented by Luleå University, will provide the Operating Agent. The Operating Agent shall be responsible for overall management of the work under Annex 21 and for implementing the decisions of the Executive Committee. To that end, the Operating Agent shall

- initiate and plan Experts' Meetings to accomplish the objective of the Annex;
- prepare work plans for the Annex to accomplish its objectives;
- co-ordinate the publication and dissemination of intermediate reports as required;
- report to the Executive Committee on the results and progress of the work under this Annex, at least semi-annually, or as required;

- on completion of the Annex, compile and distribute to all participants a final report on the Annex.

7. Results

The results of this annex will be:

- A TRT state-of-the-art survey. This survey will help determine the need and direction of further R&D. The "State of the Art Report" will be published as an IEA technical document.
- Periodic documents and interim progress reports
- A final report describing the work carried out under this Annex.
- Information database on a www site on Internet.

8. Time Schedule

The Annex will run for 36 months from 2007 until 2010.

9. Level of Effort

Participants are expected to contribute equally to the completion of the Task in terms of work sharing. All activities need to be documented. The lead country for each phase will be responsible for the editing, printing and distribution of activity reports.

Expert Meetings will be called by the Operating Agent with the advice of Experts so as to accomplish the objectives of the Annex. Activity meetings may be called by lead countries with the agreement of the Operating Agent. The Operating Agent is urged to employ advanced communications techniques to enhance communications among participants between meetings. A rough guide to the number and frequency of full Experts' Meetings is on to two such meetings per year over the life of the Annex.

It is expected that the level of collaborative effort required to complete the work of this Annex is 3 person-months per country per year and 3 months per year for the Operating Agent.

10. Participants

According to the results of the Executive Committee meeting at Stockton, N.J. USA, 1 June 2006 the XC delegates from Canada, Netherlands, Norway, Turkey, Japan, Sweden, Belgium, and Germany showed interest to participate. The final decision of participating countries will be made at the Executive Committee Meeting.

11. Workplan

The Annex 21 Workplan and time schedule for the activity plan is shown in Table 1. Each activity will be carried out during a 12 month calendar period. It is assumed that the state-of-the-art report and also new TRT developments should be updated during the last year of the project.

Table 2. Workplan – Thermal Response Test (TRT)

ACTIVITY	2007	2008	2009	2010
Annex Meetings	X	X	X	X
Phone Meetings	X ?	X ?	X ?	X
1. State-of-the-art	X----------------	-----X	- - - - - -	- - - -
2. New TRT Developments	X---------	-----------X	- - - - - -	- - - -
3. TRT Evaluation methods and developments		X-----------------------	------X	
4. Standard TRT Procedures			X----------------	-----------X

APPENDIX 1 - PARTICIPANTS OF ECES IA

- **Belgium, Ministry of Economical Affairs**
- **Canada, Public Works and Government Services Canada**
- **Denmark, Ministry of Energy**
- **Finland, Technology Development Centre TEKES**
- **France, TREFLE/CNRS**
- **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, FORMAS**
- **Turkey, Çukurova University**
- **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 of the University of Technology Warsaw (Poland), as a sponsor**

IEA-Secretariat:

Responsible desk officer: Carrie Pottinger / Jeppe Bjerg (from 2006)

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 2007

Annex 18:

All contributions to the workshops of Annex 18 can be found on the homepage:
www.webforum.com/**annex18**/home/index

Ecostock

The content of the proceedings from the The 10th International Conference on Thermal Energy Storage ECOSTOCK 2006 can be found at the ecostock homepage:
http://intraweb.stockton.edu/eyos/page.cfm?siteID=82&pageID=3
To receive the proceedings, please contact the Conference Secretariat:

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