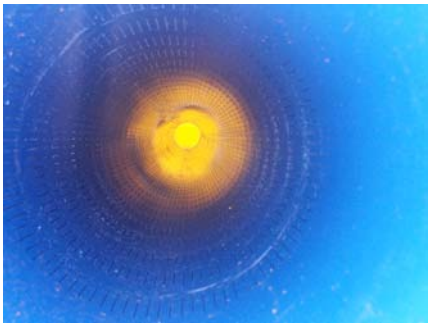
International Energy Agency

Energy Conservation through Energy Storage Programme



Annual Report 2007

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Preface

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, Finland, France, Germany, Italy, Japan, Korea, Norway, 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 Switzerland. New Zealand, Slovenia, Australia, Brazil, Bulgaria, India, Israel, Malaysia, South Africa are also interested. 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:

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.

Introduction

We need energy – electrical or thermal – but in most cases not where or when it is available. Enjoying the sound of music while you are jogging, you can not stand beside the socket: electrical energy storages – batteries – make you mobile. The energy you need is stored for a short while and over the distance you like to run. Having a cold beer on a summers evening was possible even before cooling machines were invented. At that time people were cutting ice from the lakes in winter, transported the ice to the brewery and stored it in deep cellars. The cold was stored form the winter to the summer: An example for long term thermal energy storage and the utilization of renewable energies. In cold climates surplus solar heat from summer can be used in winter for heating of buildings by seasonal storage.

Waste heat from industrial processes, steam from solar thermal power plants or electricity from photovoltaic panels are examples for energy sources, which can not be used more extensively without energy storages. A huge potential of energy sources substituting fossil fuels can only be exploited by energy storage systems, utilizing renewables like solar thermal, PV and wind energy. Thermal and electrical energy storage systems enable greater and more efficient use of these fluctuating energy sources by matching the energy supply with the demand. This can finally lead to a substantial energy conservation and reduction of CO_2 emissions. The growing peak demand of today's energy consumption, essentially caused by electrical air conditioning, leads more often to black-outs all over the world. Such a problem – the shifting of a peak demand for only a few hours or minutes – can be solved by cold storage technologies. In this context energy storages can be the best solution not only from the technical point of view, but also for economical reasons.

The energy to be stored can be either electrical or thermal. Both energies require completely different storage technologies. However in the actual application both technologies can meet: The peak demand of electricity for example is in most cases caused by air conditioning, which is a thermal task. The cooling demand can be covered by a cold store (ice or chilled water) which is charged at off peak hours by electric chillers. Energy storages can be described by their storage capacity (stored energy per mass or volume), power (energy output per time), storage period (how long the energy should be stored) and size. All these parameters can vary over a huge scale: From latent heat storage to prevent laptops from getting too hot (stored energy in the range of a few Wh) to the heat and cold thermal underground storage system underneath the German Reichstag in Berlin (stored energy in the range of some 2 GWh).

Many governments have committed to reduce CO_2 emissions into the atmosphere. They have decided to strengthen their national efforts and the international co-operation for research and development (R&D) in the International Energy Agency (IEA) and to increase the deployment of energy conservation technologies and utilization of renewable energy sources. So far in most industrialized countries, renewable energy sources contribute only marginally to satisfy energy demand. Energy storage technologies can help to solve problems caused by the intermittent energy supply of these sources. There is a huge potential for the application of energy storage systems. The fact that energy storage systems are not as widely used as they could, is due to several reasons, in particular because most new storage systems are not yet economically competitive with fossil fuels and their long term reliability and performance is not yet proven. There are still some regulatory and market barriers which have to be overcome. Therefore, further attempts are being made to resolve these issues.

The IEA Implementing Agreement on Energy Conservation through Energy Storage provides the platform for international co-operation (www.iea.org) in R&D, D. After almost 3 decades of R&D the emphasis of the co-operative RD&D efforts has shifted towards to implementation and optimal integration of new storage technologies for an efficient use of energy and renewable energy sources. In the future more application oriented topics like thermal energy storage for cooling and industrial processes or mobile thermal storage systems for the utilization of waste heat will be investigated. The issue of implementation and deployment of new energy storage technologies has become a higher priority as the R&D phase is concluding.

Chairman´s Report

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. Today, energy use in residential and commercial /public buildings accounts for 35% of total global final energy consumption.

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.

Achievements in 2007

Annex 21 "Thermal Response Test" was approved in 2007 and ECES has now four active Annexes. 8 countries were participating at the Annex 21 kick off workshop. The participation from Argentina is showing that the test method has been spread to a new continent.
The ECES Secretary, Andreas Hauer, was invited to the IEA and G8's NEET Workshop in Brazil in November and gave a presentation on Energy storage.
Both our ExCo meetings were in Asia. The spring meeting was hosted by China Academy of Building Research in Beijing, China. The technical tour showed that there already are established some huge UTES and Ice Storage Systems in this part of China.
The fall meeting was hosted by Tubitak and Cukorova University in Ankara, Turkey. Experts from all over Turkey were participating in the Energy storage workshops arranged in connection with the ExCo meeting.

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).

Ongoing Activities

In 2007 4 Annexes were performed by the "Energy Conservation through Energy Storage" Implementing Agreement.

Annex-No.	Title	Time Schedule	Operating Agent
18	Transportation of Thermal Energy Utilizing Thermal Energy Storage Technology	2006 - 2009	KTH / Sweden
19	Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage	2006 - 2009	DLR / Germany
20	Sustainable Cooling with Thermal Energy Storage	2006 - 2009	Nagoya University
21	Thermal Response Test	2007 - 2009	ZAE Bayern / Germany

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 and will proceed until December 2009. Operating Agent is Royal Institute of Technology KTH / Sweden.
Participating Countries: Germany, Japan, Sweden

Activities 2007
The work in the annex is now organized into three subtasks:

1. Pumpable thermal energy storage technologies (slurries, emulsions, etc)
2. Thermal energy storage transportation using truck, train or boat.
3. Thermal energy storage in vehicles – vehicle waste heat recovery and transportation of temperature sensitive goods.

R&D activities within the annex has during the period of 2007 included:

- Drafting templates for organize state-of-the art updates in the three sub-tasks. Level of maturity for technologies assessed – from basic research to commercial status.
- Innovative collaboration and best practise project, using waste heat utilization in steel industry as a case.

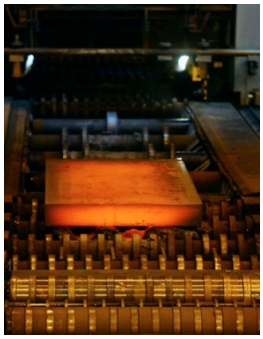
The second Workshop and Experts' Meeting was held in Bordeaux, France, in March 2007. This workshop included networking and exchange of information with representative experts from the IIR Working Party on Ice Slurries.

The third Expert's Meeting was held in conjunction with the KYOTO IMPRES conference (Materials in Energy Systems).

At the end of the year, two demonstration projects for the external utilization of industrial waste heat by means of advanced energy transportation was under way within the annex 18 partners. Also, an extensive R&D project on pumpable solutions like Phase Change Slurries using micro-encapsulated PCM or emulsions is in progress. An industrial interest and market survey for the technology has been completed for Japanese conditions. Several projects for using thermal energy storage in vehicles are being monitored.

Future Activities

- Two workshops and experts' meetings per year 2008, 2009.
- Joint workshops with other relevant annexes such as the Annex 19 Optimized industrial process heat and power generation with thermal energy storage.
- Continuation of demo-projects, market survey (extended to partners outside Japan) and analysis of the state-of-the art evolvement.



Annex 18 -- Mastering Challenges in Thermal Energy Transportation with Advanced Thermal Energy Storage Technology for Sustainable Energy Systems

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 and will continue until December 2009. Operating Agent is German Space Agency DLR /Germany.
Participating Countries: Germany, France

Activities 2007

The work in the annex has been focussed on three major subjects:

- to provide an overview and assessment of the available high temperature thermal energy storage (HTTES) technology as well as on previous and current activities and research projects in the HTTES field
- to compare and assess different HTTES concepts
- R&D activities which are directed to material development as well as to designing and testing of storage components in technical scale.

While the focus in France is directed to the development of improved composite phase change storage materials, the contribution from Germany covers the development and testing of a PCM storage for industrial process steam applications.

The first Workshop and Expert's Meeting was held in Stuttgart, Germany in April 2007. The Workshop was attended by 16 participants from Belgium, Bulgaria, Germany, France and Spain. 8 presentations covered current R&D projects dealing with sensible and PCM storage, material testing and modelling.

The 2nd Expert's meeting took place in Seville, Spain, in October 2007 with participants from France, Germany and Spain. The current situation of HTTES in Spain was discussed, which is strongly affected by the demand of concentrated solar power plants on cost effective HTTES technology. University of Lleida will actively contribute to the Annex 19 activities. The work program for the next 12 months was defined in more detail.

Since CNRS (France) and DLR (Germany) are involved in the European FP6 project DISTOR dealing with PCM storage development for CSP plants, the Annex 19 workshop was held together with the DISTOR dissemination workshop to present the status and latest results on high temperature (140-300 °C) PCM storage development. The workshop took place at the Plata Forma Solar near Almeria in Spain, and was hosted by CIEMAT. 35 Participants from Spain, Germany, France, and Bulgaria - 20 from industry and 15 from research institutes and universities - attended the WS.

Joint Annex 19 and DISTOR dissemination workshop
held at the Plata Forma Solar de Almeria

Future Activities

- Two workshops and experts' meetings per year in 2008.
- Joint workshop with Annex 18 Transportation of Thermal Energy Utilizing Thermal Energy Storage Technology.
- Delivery of the state-of –the art report on HTTES with contributions from Germany (HTTES for industrial heat applications), from France (HTTES Patent search), and from Spain (TES for concentrated solar power plants).
- Development of subsequent projects in Germany and France

Annex 20: Sustainable Cooling with Thermal Energy Storage

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 expec-tations 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 and will end in May 2009. Operating Agent is Nagoya University / Japan. Participating Countries: Japan, Canada, Germany, Turkey

Activities 2007

Annex 20 "Sustainable Cooling with Thermal Energy Storage" has been operated from January 2006 to December 2007. An extension of Annex 20 through December, 2009 was approved at the 63rd meeting of the Executive Committee of the Implementing Agreement on Energy Conservation through Energy Storage.

The work in the Annex was conducted at following three 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

The third experts meeting and fourth workshop was held in Beijing, China, in April 2007. There were fourteen presentations given at the workshop. The progress of work in 2006 and 2007 was summarized and a work plan for next two years was discussed.

The fourth experts meeting and fifth workshop was held in Ankara, Turkey in November 2007.

For subtask A, there were 22 projects to be demonstrated and evaluated (6 ATES, 4 BTES, 1 Ice, 3 Water, 5 Foundation, 1 BTES+Ice, 2 PCM). Projects from Korea and China are expected to be included. An index for system performance evaluation was discussed.

For subtask B, characteristics of the tools which can be used to simulate the system with TES were discussed.

Future Activities

- Two workshops and expert meetings will be held in 2008, 2009.
- Template for evaluation of TES system will be completed.
- Evaluation of actual system will start
- Comparison of simulation tools will be done
- Usability of tools will be discussed

Annex 21: Thermal Response Test

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. This is important for the design of Underground Thermal Energy Storages (UTES). 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 overall objectives 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.

Annex 21 was approved by the Executive Committee in April 2007 and will run until April 2010. Operating Agent is the Bavarian Center for Applied Energy Research ZAE Bayern / Germany. Participating Countries: Germany, Sweden, Canada, Finland, Japan, Norway, Turkey and The Netherlands. Several other countries have shown interest to join.

Activities 2007

The Annex started with a kick-off workshop in November hosted by ZAE Bayern in Garching, Germany. The work is divided into 5 subtasks chaired by a lead country:

- Subtask 1: State-of-the-Art-Study – Sweden
- Subtask 2: New Developments – The Netherlands
- Subtask 3: Evaluation Methods and Developments – Germany
- Subtask 4: Standard TRT Procedures – Canada
- Subtask 5: Dissemination activities – Finland

This Annex will particularly focus on quality improvement, international standardization and promotion of this technology. During the 1st workshop a detailed working programme for each subtask was discussed and agreed amongst the participants.

Future Activities

- Two expert's meetings and workshops will be held each year 2008 – 2010.
- At the Effstock 2009 Conference a special session on Thermal Response Test is planned.

Planned Activities

„Applying Energy Storage in Ultra-low Energy Buildings“

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 buildings1. 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.

Responsible for this proposal of a new Annex is Ed Morofsky (MOROFSKE@PWGSC.GC.CA).

"Thermal Energy Storage Applications in Closed Greenhouses"

Increasing attention is being paid to thermal energy storage (TES) in greenhouse systems as a means of enhancing crop production while reducing primary energy (fossil fuel) use and operational impacts to soil, water and air. TES leads to the 'closed or nearly closed' greenhouse concept, which subsequently allows for active environmental control, avoiding the need to control of environmental variables by opening and closing windows – an act which also unintentionally releases CO2.

Thermal energy storage has an important contribution to make to the viability and sustainability of horticultural greenhouse systems because it allows for a renewable, continuous, and adaptable supply of heating, cooling, and dehumidification. The nature of this contribution is cardinal in light of concerns of increasing fossil fuel expenses and climate change.

The industries which provide us with food and plants (i.e. potted plants, flowers, sod, trees) strive to maximize the outputs of their greenhouse system while simultaneously minimizing their inputs. They do this to meet ever-increasing demands for competitive pricing as well as product quality and security assurances. There are three key ways in which the integration of TES simultaneously addresses the system's outputs and inputs:

- Energy savings
- Controlled CO2 and humidity
- Fewer chemicals

If you are interested in this new Annex activity please contact Frank Cruickshanks (Frank.Cruickhanks@ec.gc.ca).

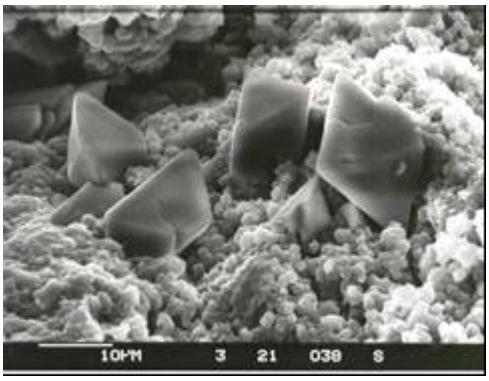
"Material Development for Thermal Energy Storages"

For the performance of thermal energy storage systems their thermal energy and power density are crucial. Both criteria are strongly depending on the materials used in the systems. After a number of thermal energy storage technologies have reached the state of prototypes or demonstration systems a further improvement is necessary to bring theses systems into the market. The development of improved materials for TES systems is an appropriate way to achieve this. The material solutions have to be cost effective at the same time. Otherwise the state of the existing technologies can not be brought closer to the market.

In Addition to that the more precise knowledge from pilot and demonstration projects concerning the real boundary conditions of the TES systems is necessary to put up a profile of requirements for the material properties. In a lot of cases these conditions are quiet different from the assumptions made in the beginning of the development.

Very important for many applications is a high number of charging and discharging cycles of the TES system. Therefore the stability of all materials in the systems is a very important property.

The world wide R&D activities on novel materials for TES applications could be better coordinated. A lot of projects are focusing on the material problems related to their special application and not towards a wider approach for TES in general.



The proposed Annex should help to bundle the ongoing R&D activities in the different TES technologies.
The proposed Annex should be operated as a joint activity with the Solar Heating and Cooling Implementing Agreement (SHC)

The picture shows sulphur crystals on the inner surface of Zeolite pellets after the exposition to combustion gases. Zeolite is used in sorption systems for thermal energy storage.

This new Annex activity was proposed by Andreas Hauer (hauer@muc.zae-bayern.de).

Further Activities

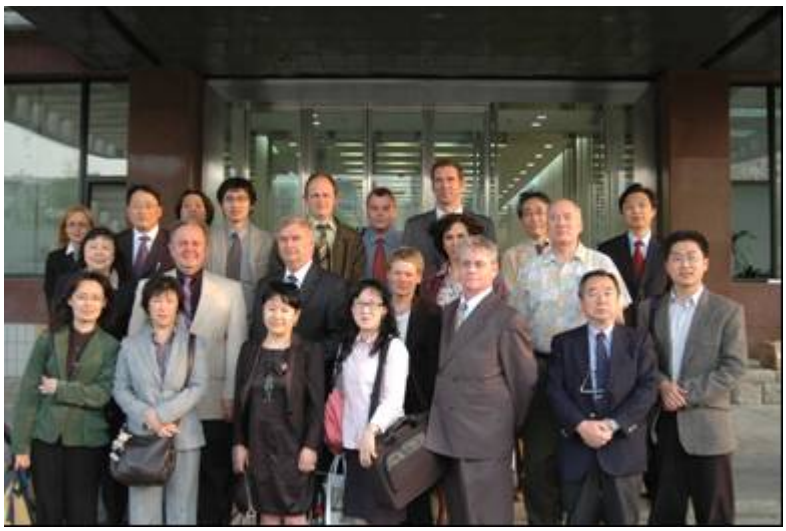
Executive Committee Meetings

The Executive Committee had two meetings during the year 2007. The 63rd Executive Committee Meeting in Beijing, China on April 26 – 27 and the 64th XC meeting in Ankara, Turkey on November 29 – 30 2007.

The most important items and decisions of the XC meetings in 2007 are outlined below.

The Beijing Meeting, April 26 – 27 2007

- Approval of the minutes of the 62nd XC meeting
- Kirsti Midtomme (Norway) was unanimously elected as the Chairman, Tadahiko Ibamoto (Japan) and Lynn Stiles (USA) were elected as Vice Chairs.
- Annual Report 2006 was approved
- Financial statement about the common fund of the secretariat was approved
- Approval of the progress reports of the ongoing Annexes 18, 19 and 20.
- Evaluation of new Annex proposals on " Energy Storage in Ultra-low Energy Buildings" and on "Thermal Energy Storage in Greenhouses".
- Approval of Annex 21 on "Thermal Response Test for UTES", Operating Agent Germany.



The Ankara Meeting, November 29 – 30, 2007

- Minutes of the 63rd XC meeting were adopted
- Financial statement about the common fund of the secretariat was approved
- Peter Cunz, chairman of the End-Use Working Party, reported about their activities
- Korea, represented by In-Hwan Oh, was welcomed as new participating country
- The ExCo approved a new format for the Annual Report to make it more attractive
- Approval of progress reports of the ongoing Annexes 18, 19, 20 and 21.
- Evaluation of new Annex proposals on "Applying Energy Storage in Ultra-low Energy Buildings" and on "Thermal Energy Storage in Closed Greenhouses".
- Evaluation of a new Annex proposal on "New Material Development for Thermal Energy Storage" in collaboration with the SHC IA.
- ExCo decided to support a Symposium on New material Development for TES in 2008 in Germany
- The progress of the organization of the "Effstock"-conference 2009 in Stockholm was presented

Other Activities

BCG Meeting in Paris

Andreas Hauer was at the last BCG Building Coordination Group meeting February 1st in Paris. Most of the Building Related Implementing Agreements BRIAS were present (DHC, SHC, HP, PV, DSM, ECBCS and EUWP). Interesting points on the agenda were a presentation from the IEA secretariat on the "International Collaborative on CHP", where energy storage should have its place, and the "Energy Technology Essentials", which are very small paper (less than one page) written for policy makers to get a more focused view on a certain topic. Andrea Hauer proposed to write such an ETE-brief about TES. The next meeting will be January 31st 2008 in Paris.

FBF in Helsinki

4th Think –Tank Meeting arranged by Future Buildings Forum (FBF) was held in Espoo Finland 21-22March 2007. Aart Snijders, Raili Alanen and Kirsti Midttomme was participating from ESES

The Future Buildings Forum has been established to identify long-term energy, environmental, economic, and technological issues, assess their potential effect on

future buildings, and encourage research projects on these issues that will help to ensure that buildings contribute to a sustainable society by the year 2025 and beyond. Originally a resource only for the Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS), the role and activities of FBF have expanded to take account of the areas of interest of all seven building related IEA Implementing Agreements.

Ministerial Meeting in Paris

The 14-15 May bi-annual IEA ministerial meeting in Paris concluded with a communiqué highlighting the need to accelerate development and deployment of new technologies. It listed steps that would be taken urgently to bring this about. The ministerial communiqué will provide guidelines for the IEA's future work in the energy technology domain.

The ministerial gathering was the occasion to present a rich array of publications and papers drawing attention on the work of the IEA Secretariat and its international energy technology network. The ministerial meeting featured a technology fair showcasing the work of the Implementing Agreements. The fair illustrates with stands the potential of different technologies and steps that governments, businesses and consumers need to take to realize them. The picture shows the ECES exhibit at the meeting, which was explaining a mobile sorption storage system for the utilization of industrial waste heat.

NEET workshop in Brazil

NEET - Networks of Expertise in Energy Technology - is part of the IEA's programme supporting the G8 Gleneagles Plan of Action. It works to foster broader, more effective international co-operation, in particular with non-IEA countries. Building on its existing "Implementing Agreement" programmes, the IEA is linking with the international business community, with policy makers, researchers and other stakeholders.

In this context a two-day Workshop was organized by the IEA and the Ministery of Mines and Energy MME of Brazil. 12 IAs were participating (DMS, Hydrogen, Hydro Power, Wind, SHC, Fossil Fuels, Bio Energy, ETSAP Modelling, Ocean, Hy-

brid Electric Vehicles, RETD Deployment and ECES). The ECES activities were presented and discussed.

Special topics of interest were

- Peak shaving: Avoiding electricity peak caused by air conditioning by the implementation of thermal energy storages (TES).
- Industrial Application: Utilization of „waste cold“at the re-gasification of liquefies natural gas (LNG) or after transportation in a pipeline.
- Cold storage in remote sites (in combination with solar cooling)
- Avoiding electricity peak caused by use of electric shower heads by TES

The next step would be an official invitation by the ECES ExCo for Brazil to participate in the Implementing Agreement.

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The Chairman from Norway, the Finish, Spanish and Turkish Delegate of the Executive Committee of the ECES at the Spring meeting in Beijing 2007

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