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**International Energy Agency  
Energy R&D Program  
Energy Conservation through Energy Storage IA (ECES  
IA)**

**ANNEX 8, Implementing Underground Thermal Energy  
Storage**

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**FINAL REPORT**

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**1. Background**

Annex 8 was initiated at a preparatory meeting in Stuttgart (Oct. 1993) where UTES was discussed. The main issue was; There are several storage technologies (ATES, BTES, CTES) which are mature and ready for the market. Then, why are not UTES widely applied? This was the starting point from which the objectives of the annex were defined.

## Objectives

The general objective of Annex 8 is to conserve energy and improve the environment by speeding the introduction of Underground Thermal Energy Storage Systems (UTES) into the building, industrial, agricultural and aqua-culture sectors. More specifically the Annex 8 group tried to speed-up the introduction of UTES in participating countries. We were also very active in attracting more countries in the Annex. The project description is given in the [Annex 8 Text](#).

At the start the annex had four participants CANADA, GERMANY, NETHERLANDS and SWEDEN. Later on BELGIUM, TURKEY, USA and JAPAN joined. Several more countries showed their interest by attending the experts meetings as observers (AUSTRALIA, DENMARK, FINLAND, POLAND, SPAIN, and UK).

The idea of this annex has been spread to other IAs and IEA Working Parties. Thus, the Solar Heating and Cooling IA has started a task on Technical Procurement and plans for Solar Cities and the HP IA on Deployment. Also the Working Party arranged a Conference on Deployment.

## Subtasks

Originally the annex consisted of five sub-tasks, with different countries as lead countries:

- 1 Evaluation of Feasible UTESS Boundary Conditions (The Netherlands)
- 2 Environmental Screening and Community-Based Development (Canada)
- 3 Demonstration Projects (Germany)
- 4 Design and Analysis Tools (Sweden)
- 5 Technology Transfer to Appropriate Groups (Sweden)

Participants that joined the annex after the start in May 1994 participated in the original sub-tasks but were also given their own specific tasks. New participants with little experience of UTES (Turkey, Belgium, Japan) performed national potential of UTES (economy, geology etc.) of their countries:

- 6 UTES Potential in Turkey
- 7 UTES Potential in Belgium
- 8 UTES Potential in Japan

The USA, which had no specific subtask of its own, contributed considerably to the subtask Technology Transfer by sharing experience from the Geothermal Heat Pump Consortium (GHPC) work. The GHPC also added a category of membership that included non American scientists and engineers to be members at no cost. The numerous technical reports were thus made available to the experts and several others who were told of this opportunity at the various seminars we conducted.

## Time Schedule

The first Experts' Meeting was held in Uppsala, Sweden (May 1994). Initially Annex 8 was planned for five years (May 1994 - May 1999). This time schedule was later changed to three

years to comply with the time schedule of ECES IA. When the IA later was extended Annex 8 went back to its original time schedule.

The Final Annex 8 Experts' Meeting was held in Sweden in June 1999. At that occasion a workshop was arranged on the Future of Annex 8. After that a Final Annex 8 Report would be completed before the termination of Annex 8. This report has been delayed and for that reason also the time schedule of the annex was prolonged. The present plan is that 8 will be terminated at the ECES 49<sup>th</sup> Executive Committee Meeting, in Tokyo November 2000.

## Experts

During some of the Experts' Meetings experts were replaced by an other delegate but most of these delegates were attending the meetings:

- Bo Nordell, Luleå University of Technology, SWEDEN (Operating Agent)
- Göran Hellström, Lund University of Technology, SWEDEN (Secretary)
- Olof Andersson, VBB VIAK AB, Malmö, SWEDEN
- Burkhard Sanner, University of Giessen, Giessen, GERMANY
- Manfred Reuss, Technische Universität München, Freising, GERMANY
- Frank Cruickshanks, Environment Canada, Dartmouth, Nova Scotia, CANADA
- Guido Bakema, IF Technology b.v., Arnhem, NETHERLANDS
- Halime Paksoy, Çukurova University, Adana, TURKEY
- Kiyoshi Ochifuji, Hokkaido University, Sapporo, JAPAN
- Lynn F. Stiles, Richard Stockton College of New Jersey, Pomona, New Jersey, USA
- Paul Dirven, Vlaamse Instelling voor Technologisch Onderzoek, Mol, BELGIUM

The address to all delegates are found in the [Address List](#).

A list of all experts, observers, guests, etc that were attending the meeting is found in [List of all Attendees](#).

## 2. Brief History of Annex 8

The Annex 8 work was mainly performed between (or rather just before) the experts' meetings. These meetings were important for the work-task itself but also for the extensive exchange of information that took place at these occasions. The atmosphere of the meetings was informal and easy.

At several occasions we also had international seminars in connection with the experts meetings. The seminars were organised by the national expert, which meant that the national expert decided which target groups the seminar should aim at to best fulfil the objectives of Annex 8. These groups varied in different countries. In some countries, where UTES was used to some extent, the target group was mainly consulting engineering companies. In

countries with less or no experience of UTES the target group would be politicians, scientist or students.

During the path of Annex 8 the Operating Agent prepared and presented seven reports to the ECES Executive Committee. [Annex 8 Reports to the Executive Committee](#). Other articles and papers are listed in [References](#).

Annex 8 held ten Expert's Meetings (XM) during its lifetime, Table 1 ([Typcial XM Agenda](#)). The possibility of inviting observers was of great importance for the development of Annex 8. The four participants that joined after the annex was already started (Belgium, Turkey, USA and Japan) all began as observers. Some of the observers never joined (Finland, UK, Australia, Poland, Denmark and Spain) but were able to collect information that helped them join other annexes. In some cases the observers had some help to initiate UTES in their countries even if they never joined the annex. All together 67 persons from 14 countries attended the meetings ([List of all attendees](#)). The minutes from all meetings are gathered in [Pro Memoria of all Experts' Meetings](#).

Table 1. Annex 8 Experts' Meetings.

	<i>Location</i>	<i>Date</i>	<i>No. Experts</i>	<i>Participants</i>	<i>Observers</i>
I.	Uppsala, Sweden	May 94	13	Swe, Ger, Can, NL	Fin, Bel
II.	Arnhem, Netherlands	Nov 94	11	Swe, Ger, Can, NL	UK, Bel
III.	Freising, Germany	Apr 95	10	Swe, Ger, Can, NL	Bel, Tur
IV. *	Adana, Turkey	Nov 95	10	Swe, Ger, Can, NL, Bel, Tur	USA
V. *	Halifax, Canada	Jun 96	12	Swe, Ger, Can, NL, Bel, Tur, USA	Jap
VI. *	Leuven, Belgium	Nov 96	15	Swe, Ger, Can, NL, Bel, Tur, USA	Jap, Fin
VII. *	Sapporo, Japan	Jun 97	18	Swe, Ger, Can, NL, Bel, Tur, USA, Jap	A, Pol
VIII. *	Pomona, USA	Mar 98	13	Swe, Ger, Can, NL, Bel, Tur, USA, Jap	Pol
IX. *	Warsaw, Poland	Nov 98	14	Swe, Ger, Can, NL, Bel, Tur, USA, Jap	Pol, Den
X. *	Luleå, Sweden	Jun 99	18	Swe, Ger, Can, NL, Bel, Tur, Jap	Spa

\*/ The expert meeting was arranged in connection with a conference or a seminar

## Seminars

The Annex 8 experts gave international UTES seminars, organised by the national expert, at the location of the several meetings. The experts have also arranged a number of national seminars.

[The Adana Seminar](#): 16 November 16, 1995. The UTES technology was explained and good applications in different countries were described. Proceedings of the Adana Seminar have been published - 60 participants.

[The Halifax Seminar](#): 17 June 1996. The seminar, similar to that in Adana, was given to Atlantic Canada industry. Resulted in good discussions and interaction with the audience - 90 participants from universities, government departments, architects/engineering firms, utilities etc.

[The Leuven Seminar](#): 13 November 1996. The seminar was devoted exclusively to ATES since this technology is currently being promoted and developed in Belgium. Consequently, only the Dutch-speaking experts of our group participated. The meeting, which was given in Dutch, was supported by VITO, CERA, ENERGIK, EC and the Flemish Government. About 300 registered participants.

[The Second Stockton International Geothermal Conference held at the Richard Stockton College of New Jersey, Pomona, New Jersey, USA, on March 16 - 17, 1998](#). This conference was not an Annex 8 seminar though the US Expert of Annex 8 arranged it. The Annex 8 experts were engaged in half of the presentations. About 250 registered participants for a two full days. The conference papers are freely available on the website and it is also possible to get paper copies and CD copies of the proceedings.

[The Stockton Computer Workshop](#): 18-20 March 1998. This workshop followed the 2<sup>nd</sup> International Stockton Geothermal Conference in which the Annex 8 experts were involved. The workshop was on computer models for simulation of different UTES systems.

[The Warsaw Seminar](#): 16 November 1998. Ministry of Environmental Protection, Natural Resources and Forestry. 25 participants.

[The Future Annex 8 Workshop](#). June 1999. Hotell Storforsen, Sweden. This seminar was different from the others because here the experiences of Annex 8 were discussed. What was good or bad? What should we do in the future to support UTES? The minutes of the workshop is found at the end of the [Pro Memoria of the 10<sup>th</sup> and Final Experts Meeting](#) and also in [Chapter 6](#) of this report.

### **3. Annex 8 Experts' Meetings (XM)**

#### **3.1 XM1: Uppsala, Sweden, May 94** (Repr: Swe, Ger, Can, NL, Fin, Bel)

The background of Annex 8 was described, based on the preparatory meeting October 1993 in Stuttgart, and the role of this annex in ECES IA. There were no participants from France though France was the lead-country of one of the sub-tasks. Belgium and Finland were also represented. At this stage very few of the attendees knew if they would get funding to participate in the Annex.

The work on the State-of-the-Art Report 1994 on Seasonal Thermal Energy Storage had already started and a first outline was presented. Some 20 projects were presented and discussed in the state-of-the-art report. Completion of the report Oct.1994.

It was decided that ATES, BTES, CTES, and DTES should be the storage technologies that would be included in Annex 8. Other storage technologies, e.g. horizontal pipes in soil, artificial rock caverns would only be briefly included. It was also decided that we should: 1/ Move the implementation of solar energy towards the future 2/ Need of better integration of STES into energy systems 3/ More implementation of high temperature storage.

### **3.2 XM2: Arnhem, Netherlands, Nov 94**

(Repr: Swe, Ger, Can, NL, UK, Bel)

Subtask 1. Synopsis, work-plan, time-plan and engaged persons were presented. 1. State-of-the-art survey. Draft version by June 1994. 2. Identification and characterisation of feasible applications. 3. Determination of boundary conditions for feasible applications.

Subtask 2. Not yet a synopsis and a plan for this sub-task. Financial situation still unclear.

Subtask 3. The plan was defined as: 1/ Identification of demonstration projects (existing and new). 2/ Monitoring Programme. 3/ Evaluation of the projects.

Subtask 4. Sweden became the lead-country (since France never joined). The synopsis, work and time plan was presented. 1/ Perform an inventory of existing analysis and design tools. 2/ Evaluation of the inventory to judge the state-of-the-art of the tools. 3/ Development and documentation of validated tools.

Subtask 5. Synopsis and workplan was presented. 1/ Identify target groups 2/ Identify necessary information for the different target groups 3/ Develop procedures for lobbying, information, education etc. 4/ Prepare information for the specific target groups.

New Subtasks. It was suggested that new participating countries, which have not performed research on heat storage, focus on national studies of their potential for heat storage (energy, economy) and energy geological studies i.e. the geological conditions for UTESS in their country. The new participants are also invited to take part in the ongoing sub-tasks. For Finland, a special mini-task was suggested, "Development of Drilling Equipment" for BTES and ATES.

### **3.3 XM3: Freising, Germany, Apr 95**

(Repr: Swe, Ger, Can, NL, Bel, Tur)

The Annex 8 text has been rewritten by the IEA Legal Office. The time schedule of the annex was changed since the ECES IA is so far only decided until 31 December 1997. If the ECES IA is extended it is also possible that Annex 8 is extended in accordance with the original time schedule.

Invitations of participation have been sent out to a number of countries: Belgium and Turkey hope to become participants in the near future. Experts from Finland, Poland, Switzerland, and UK are trying hard to convince their authorities to fund participation. USA: No answer so far.

Subtask 1. The State-of-the-art Report was approved by the Executive Committee, with some minor editorial comments. The workplan for the next phase, evaluation of feasible boundary

conditions presented. 1/ The Netherlands; 2/ Other countries; 3/ Comparison with other countries. So, it was decided that only the most promising technology in the Netherlands, ATEs, would be considered as a first step. Type of application versus pay-back for different sectors, storage and energy sources. Description of 5 to 10 most promising applications.

Subtask 2. Not yet a synopsis and a plan for this sub-task. Suggestion to combine UTESS models with GIS. Plans to cooperate with Turkey. Financial situation still unclear.

Subtask 3. The demonstration project sheet, previously sent out to all of us for us to fill in, was discussed.

Subtask 4. An inventory reporting format was sent out to the experts' group in the beginning of Jan 1995. Totally 25 models at the moment.

Subtask 5. This subtask will start May, 1995. Before next XM a synopsis and a workplan will be sent out.

### **3.4 XM4: Adana, Turkey, Nov 95** (Repr: Swe, Ger, Can, NL, Bel, Tur, USA)

Turkey and Belgium are now participants of Annex 8 and the USA and Japan are interested to join. Finland has decided not to join.

The previously defined for Finland "UTES Drilling Equipment Development" was discussed. Annex 8 sees three ways to initiate such work:

1/ A mini-subtask within Annex 8. 2/ Under Subtask 1 in the new annex for geothermal energy. 3/ As a new annex.

Subtask 1: Continued work on Phase I. Distribution of report at beginning of the next 1996. Phase II: Other countries. The only other country that can perform a similar investigation is Sweden and it should be done for both ATEs and BTEs. It was recommended to use the same format.

Subtask 2: Outline of document concerning the environmental impact assessment of UTES was presented. The document needs to be reviewed by the experts. Ideas of GIS maps for UTESS were presented. From these maps possible projects and potentials in a community may be identified.

Subtask 3: First presentation of how the folders summarising the demonstration projects would look. Data are still missing. These folders could be used directly for distribution but should also be used as a basis to create a WWW site on Internet.

Subtask 4: Review of the inventory performed. It was decided to give priority to tools for pre-study, pre-design, detailed design and evaluation. The evaluation, modification and development of these design tools are ongoing processes. The databases in the Earth Energy Designer (EED) for ground thermal properties, geothermal heat flux, ground surface temperature, properties of heat carrier fluid were updated in October 1995.

Subtask 5: Workplan, timeplan and synopsis were presented. Discussion about presenting the Annex 8 work on homepage.

May 1995 - Dec 1995	Identify Target Groups
Jan 1996 - Sep 1996	Identify Necessary Information
Oct 1996 - Dec 1997	Prepare Information

The technology transfer must consider the different levels of information for different target groups. Information at any level should also include information at higher levels.

1/ General Information (Philosophy, UTES Potential, benefits, system)

Target Group: Politicians, Decision makers

2/ Engineering Information (Demonstration projects, Systems and applications, Design Tools)

Target Group: Architects, Consulting Engineers, Public Works on community level

3/ Scientific Information (Theory, Teaching, Courses, Books, Detailed modelling)

Target Group: Scientist, students, post graduate students)

Subtask 6: (UTES Potential in Turkey). Primary energy consumption increases much faster than production. Need for energy conservation and new energy sources. Energy conservation systems do not exist in any form. Environmental considerations and energy conservation are part of the present five-year plan in Turkey. Discussion of how to perform the study.

Subtask 7: (UTES Potential in Belgium). A potential survey for Belgium was presented. Suitable aquifers in Flanders. Consultants, decision makers, private, public, and HVAC companies have been contacted. Experience from the projects in the Netherlands have been used. Three projects have been started based on these efforts.

### **3.5 XM5: Halifax, Canada, Jun 96** (Repr: Swe, Ger, Can, NL, Bel, Tur, USA, Jap)

USA is now formally a participating in Annex 8.

Subtask 1: The evaluation of feasible ATES boundary conditions in the Netherlands has been published and distributed. Phase 1 is completed as soon as the comments from the experts have been considered. Phase II: Other countries. Only Sweden can do a similar investigation, preferably for both ATES and BTES. Phase III. Comparison with Other countries might be cancelled due to lack of money.

Subtask 2: Paper document on TES guidelines is available and have been sent out for comments. These guidelines will be included in the Toolbook Application. However, the guidelines were found to have too much Canadian bias. A revised version will be prepared. Workplan 1/ paper copy 15 August 1996 2/ Electronic copy 3/ No formal funding for GIS-application.

Subtask 3: Information sheets of the collected project data (20 projects) were distributed. Data is still missing.

Subtask 4: It was again stressed that the evaluation, modification and development of these design tools are ongoing processes. The progress depends on the feedback from the users. Preliminary report of the "Inventory of UTESS Design and Analysis Tools" was presented. This report summarises the information received from participants in Annex 8, and from non-participating countries, about 25 design models.

Subtask 5: The Annex 8 Home Page has been opened. (This address is now changed to <http://cevre.cu.edu.tr/eces/>). The homepage contains information about IEA, ECES IA; Annex 8 and also a list of ATES and DTES literature. There is also an option to suggest email new references to the lists. Project information (from subtask 3) will be added to the information.

#### Thermal Response Test

Two students at Luleå University of Technology, Sweden, presented their diploma work on the thermal response test. They had constructed a mobile equipment (TED), for in situ measurements of thermal capacity of a borehole, to determine the thermal properties of the entire borehole system. The equipment consists of a pump, a heater and temperature sensors for measuring the inlet and outlet temperatures of the borehole. In order to make the equipment easily transportable it is set up on a small trailer. The results from the response test include thermal properties of the ground and the borehole but also properties that are difficult to estimate, e.g. natural convection in the boreholes, asymmetry in the construction etc. Since the response test takes about one week to execute, the test is fully automated including the recording of measured data.

Subtask 6: The Turkish UTES potential study was presented. It was divided into different sectors: Residential, special buildings (e.g. hospitals), industry and agriculture. Related topics were; population densities, climates, industrial areas, agricultural production, legislation, geological condition, economics, and environmental aspects. The workplan includes the continued work on the geological description, environmental aspects and emissions. GIS will be used. It was suggested that lakes and rivers should be included since they give important information to ATES locations.

Subtask 7: The UTES potential of Belgium has not yet been studied. A (hydro)geological map on C/H ATES will be completed in December 1996. The potential sectors of Turkey is probably the same for Belgium. Great interest in hospitals and office buildings. No effort in the agricultural sectors. This has a low priority with the experience of the Netherlands. They, the farmers, try do it themselves because they can drill (and they make mistakes). Boundaries important. The influence of neighbours. Aquifers in 65 % of Flanders. Today no real legislation that restricts ATES in Belgium.

### **3.6 XM6: Leuven, Belgium, Nov 96**

(Repr: Swe, Ger, Can, NL, Bel, Tur, USA, Jap, Fin)

Japan is expected to sign the ECES IA next week. Australia, Switzerland and Poland (now a member of OECD) still show some interest. This work will continue. Based on the discussions within Annex 8 the experts are working on new annex proposals: 1/ High Temperature UTES. 2/ Low Temperature UTES. 3/ Drilling and Well/Hole Technology.

Subtask 1: Phase I: Study for the Netherlands, completed 1996. Phase II: Other countries. Sweden performs a similar study for both aquifers and ducts. Other countries performs a table summary of pay-back time. Phase III: Comparison with Other countries (after the Swedish study)

Subtask 2: TES Guidelines and the Tool-book delayed but will come within 6 month. GIS funding not clear. Prototype the design of the UTES spatial support system. The following steps are planned: 1/ Identification and compilation of critical parameters. 2/ Parameter selection. 3/ Database creation. 4/ Spatial analysis.

Subtask 3: The experts' group has decided on 20 demonstration projects but Very little information have been received. These demonstration project will later be added to our homepage.

Subtask 4: The Inventory of UTESS Design and Analysis Tools is now completed. This report will also be added to our homepage. The EED model has been improved, manuals in English and in German. EED was previously suitable for heat extraction systems only - now borehole storage systems can also be managed by the model.

Subtask 5: This subtask results from all other subtasks. Also teaching, seminars, courses and the WWW information are part of the technology transfer. So, technology transfer happens all the time. The final report of Annex 8 should include and summarise all our activities for the purpose of promoting UTES.

The Annex 8 homepage was discussed and some revisions were suggested.

Subtask 6: The project plan includes all aspects necessary to evaluate the UTES potential in Turkey. It should become a model for other countries where UTES is not yet introduced. GIS will be used to present and calculate the potential.

Energy situation	Environmental aspects	Economics	Marketing
Population density	Agricultural production	Legislation	Availability of technology
Climate	Industrial areas	National energy policy	Geology and hydro-geology

Subtask 7: Maps showing the ATES potential in Belgium was presented. The maps indicate the very good locations as well as locations where you should not even try to build an ATES.

#### UTES Potential and Technology Transfer in USA

The Geothermal Heat Pump Consortium (GHPC) has established eight regional UTES training centres. They are looking for students, borers and people who are maintaining and repairing the equipment. A few more training centres will be started soon. They have a fast track program - training of trainers at the same time. The idea is to develop a market to reduce the cost. A non-profit organisation acts as contractor - with certified authority. The training centres are usually located at colleges.

Electronic journal: The UTES journal will be started soon. The journal will have peer-review of articles

### **3.7 XM7: Sapporo, Japan, Jun 97**

(Repr: Swe, Ger, Can, NL, Bel, Tur, USA, Jap, A, Pol)

Japan was welcomed as a new participant of our annex.

We tend to save the annex work until the last weeks before the meeting. This is a big problem for subtasks that require extensive input from all participants. It was decided that all participants must submit an informal monthly report on work related to the Annex, even if no activity has occurred. The participants shall submit their report during the last week of the month. The operating agent compiles, comments and distributes the monthly Annex 8 Update during the first week of the following month.

It was decided that HP Newsletter should be contacted for a special issue on UTES. The IEA Heat Pump Centre later decided to have special UTES issue of the Heat Pump Newsletter in mid 1998.

Subtask 1: The report "Applications and Cost-Effectiveness of Energy Storage in Aquifers in the Netherlands" was approved. It was decided that Sweden prepares a similar report for Swedish conditions. When this study is completed the realisation of phase III will be discussed. A one-sheet decision model (Quickscan) for ATES feasibility was demonstrated. A catalogue containing ten basic schemes of ATES applications (Energie-opslag in aquifers by Novem) was also shown.

Subtask 2: The Environmental Impact Assessment document is evolving and a draft version (90 pp) was distributed on diskette to BN and it will be further distributed to group members. GIS for UTES localisation was demonstrated. In order to make it possible for the group members to interact in the development of the GIS UTES tool the first priority must be to make the logical decision scheme available for discussion. 1/ Identification and compilation of critical parameters. 2/ Parameter selection. 3/ Database creation. 4/ Spatial analysis.

Subtask 3: Difficulties of obtaining a complete set of data for the demonstration projects.

Subtask 4: New version of the EED is available.

Subtask 5: Technology transfer is ongoing through new projects and pre-studies, and national seminars in different countries. New changes suggested to our homepage.

Subtask 6: The Turkish UTES potential study is further developed and a draft report was handed out. Comments from the participants are requested. GB proposed that a duration graph of the air temperature should be added. Very good example of how to perform such studies and should also be distributed to potential new participating countries.

Subtask 7: Improved maps of the UTES potential in Belgium was presented. So far the potential is evaluated for ATES only. The maps indicate the very good locations as well as locations where you should not even try to build an ATES.

### **3.8 XM8: Pomona, USA, Mar 98**

(Repr: Swe, Ger, Can, NL, Bel, Tur, USA, Jap, Pol)

Japan is now a participant of Annex 8. A new or extended Annex 8 was discussed for the first time.

Subtask 1: Final version of report was sent out. Dutch version will be sent out (Energie-opslag).

Subtask 2: Environmental Assessment procedure - still waiting for input from the group.

Subtask 3: 23 demo project are now included. Examples of how the demonstration projects would be presented in our brochure was shown. US and Canada have so far only one project. Time schedule: final corrections and all missing information by end of April. Revised demo projects, estimated printing cost and a request of how many copies we need in different countries. Demo projects should be included on our homepage.

Subtask 4: Documentation of simulation tools? It is difficult to understand what version/documentation you have.

Subtask 5: Technology transfer is ongoing through new projects and pre-studies, and national seminars in different countries. New changes suggested to our homepage. Technology transfer to developing countries was discussed. New annexes - Electronic journal - Future of UTES - where do we expect the future development and areas. We should have a final report on our work - history of our annex and progress of our work.

Subtask 6: The work and conclusion of the Turkish potential study was summarised: Start: Nov 95 - Why do we need UTES potential study? - Draft report in Sapporo - Comments from experts - Dec. 98 final version. Temperature duration chart for Adana - Include both dry bulb and wet bulb - The Degree Days Method is something that we should look into.

Subtask 7: The Belgium UTES Potential Study does not yet include BTES.

Subtask 8: (UTES Potential of Japan). The Heat Pump Thermal Storage Committee of Japan (HPTSCJ) has a working group of 25 people who come from power companies and municipalities, researchers etc. Frequent seminars on TES including UTES. So far this type of UTES projects have been investigated: 1/ snow melting system 2/ hybrid system (both short and long term storage). A preliminary UTES Potential map of the Sapporo region - geology, hydrology etc.- was presented.

UTES Potential in Poland: The Polish energy situation was presented. Electrical power plants are oversized. The need of heat reduces the electricity production during the winter. So, seasonal heat storage would be of great need. DH temp 90/70°C - heat loss in DH ca 33% New DH system - 1.5% heat loss. Waste heat resources and geological conditions have not yet been investigated.?

### **3.9 XM9: Warsaw, Poland, Nov 98**

(Repr: Swe, Ger, Can, NL, Bel, Tur, USA, Jap, Pol, Den)

Several new potential participants in the ECES IA, Bulgaria, China, Poland, Korea, Spain and India. The future of the Swedish Council of Building Research (BFR) is not yet decided. (Today we know that BFR is closed down Dec 2000). As a consequence Björn Sellberg (ECES Chair) and Bo Nordell (ECES Secretary) will have to resign from these commissions.

Subtask 1: The major part of the task has been completed. Remaining work requires Swedish data on ATES and BTES applications.

Subtask 2: The Environmental Impact Assessment was presented. It is now available for peer review among the annex 8 experts.

Subtask 3: No news at this meeting.

Subtask 4: Nothing to report at this meeting. Final report to be prepared (GH).

Subtask 5: "Underground Thermal Storage and Utilization – A Peer Review International Journal on Energy Conservation" is now available on Internet (<http://www.geo-journal.stockton.edu/>). Vol. 1 contains papers from the 2nd Stockton Conference and Vol.2 now accepts submissions. It was decided that all of the Annex 8 experts are available as reviewers for the UTSU Journal. For this purpose we need instructions or a checklist for the review. The technology transfer continues. Final report on our work - a history of our annex and progress of our work will be prepared by the Operating Agent before terminating the annex.

Subtask 6: The final report is almost finished. Some additional work on co-generation plants and cost-benefit analysis will be performed. The final report will be published in both Turkish and English.

Subtask 7: Belgium was not represented at this meeting.

Subtask 8: Very interesting presentation on the UTES potential in Hokkaido. Snow storage systems in Japan and also snow melting systems used at 22 locations in Japan.

UTES Potential Study and Promotion in Poland: KAPE educates Polish engineers in Energy Conservation, Heat Pumps and Renewables. UTES is included in the lectures. Polish installed capacity 33000 MW, national consumption 220000 MW. Central district heating common. Poland has 70 years experience of co-generation. Possible HT UTES application - to store waste heat produced by electricity production during the summer. Coal Peak boilers in winter. 75% space heating 25% for hot water.

Discussion on a future Annex 8. When Annex 8 is finished, we would need a similar annex. Based on the experiences of Annex 8, it shows that the main content of the work has been dissemination of information. One possibility new way is to initiate an "umbrella" annex within ECES IA that would co-ordinate the dissemination of information from all annexes, somewhat similar to the IEA HP centre. This would require all countries signing the ECES IA to member of this annex. Most participants preferred to have a more active annex with workshops on special topics.

What do we expect of the New Annex 8?: So far the Annex 8 work has: 1/ Made UTES known 2/ Helped in Implementation. 3/ Disseminated information. 4/ Collected and evaluated models, systems etc.

A New UTES Centre "Thermal Energy Storage Documentation and Information Network" was suggested as the natural continuation of Annex 8. Part of the work should include: Education - Technology Transfer - Workshops on Specific Topics - Subtask to find sources for funds.

Names like TES for Agenda 21; TES Information and Outreach Program were discussed. It was decided that the a workshop will be arranged

"Workshop on the Future Annex 8" at the next (last) Annex 8 meeting. All Executive Committee members will be invited.

### **3.10 XM10: Storforsen, Sweden, Jun 99,** (Repr: Swe, Ger, Can, NL, Bel, Tur, Jap, Spa)

Subtask 1: The State-of-the-art Report was completed as part of subtask 1. Also a report on Feasible ATES applications was completed. The report on Feasible BTES Application was never done.

Subtask 2: Environmental Screening and Aquifer-Based Development (Canada)  
This subtask was summarised in the report "[UTES, Procedures of Environmental Impact Assessment](#)" May 1997.

Subtask 3: Some data missing - urgent need to finish. No data available for subtask 4. Final list of demonstration project must be completed before termination of the annex.

Subtask 4: Final reports will be completed before termination of the annex. 1/ Inventory of UTESS, Design and Analysis Tools, Final Report, May 1996. This report was finished already in 1996. It will be published on our homepage in PDF-format. 2/ There will also be a final report from

Subtask 5: Final report – History of Annex 8 - will be completed before termination of the annex. This report will be ended by new ideas for future work. A new annex proposal or a Draft Proposal for New Annex "[Engineering Textbook on Thermal Energy Storage and Renewable Energy](#)" will also be presented to the Executive Committee before the termination of Annex 8.

Subtask 6: UTES potential study for Turkey is completed.

Subtask 7: ATES potential study for Japan is completed. Tool for quick scan of projects. Grid of Flanders, complex geology in Flanders. Different colours: Yellow 25-50 m<sup>3</sup>/h, Green 50-75 m<sup>3</sup>/h, Blue 75- m<sup>3</sup>/h. Booklet only ATES restricted but not secret

Subtask 8: UTES potential study for Japan is completed.

#### The History of Annex 8

It was decided that the History of Annex 8 Report (this report) will be the end of the work.

## 4. Fulfilment of Subtasks

The Task of Annex 8 will encourage energy conservation and increased sustainability of the energy resource by stimulating the expanded use of UTESS in innovative, energy efficient and cost-effective projects in Participating Countries. The means employed to achieve the objectives of this Annex will be collaborative efforts based upon co-operation and task-sharing arrangements with Lead Countries for each Subtask.

The activities are grouped into five Subtasks: (1) Evaluation of Feasible UTESS Boundary Conditions; (2) Techniques for Environmental Screening and Community-based UTESS Development; (3) Standard Methods for Evaluating UTESS Applications; (4) Design and Analysis Tools; (5) Technology Transfer.

By looking at the specific sub-tasks of the annex it is clear that all of them were not fulfilled. To some extent this was a result of lacking resources.

### **Subtask 1: Evaluation of Feasible UTESS Boundary Conditions. Lead Country: The Netherlands**

#### Objectives:

- (a) Conduct a state-of-the-art survey covering all UTESS technologies based on existing and planned applications and dealing with technical, financial and environmental aspects.
- (b) Identify and characterise feasible applications of UTESS.
- (c) Develop and evaluate criteria for the determination of the boundary conditions of technically and financially feasible UTESS applications.

#### Fulfilment:

The UTESS state-of-the-art study (a) was published in 1995 ([BAKEMA et.al 1995](#)). The evaluation of feasible UTESS boundary conditions (b, c) was carried out for ATES only. ([BAKEMA 1996](#)). Sweden should have done a similar evaluation for BTES but this was never completed.

### **Subtask 2: Techniques for Environmental Screening and Community-based UTESS Development. Lead Country: Canada**

#### Objectives:

- (d) Develop environmental impact assessment procedures for use on UTESS projects and studies.
- (e) Perform an environmental evaluation.
- (f) Develop analytical and engineering tools to evaluate and design community-based UTESS developments (Geographic Information Systems, GIS).

#### Fulfilment:

The environmental impact assessment procedures (d, e) were developed, [Environmental Impact Assessment \(EIA\)](#). This document defines and discusses environmental impact assessment in respect to UTESS and also the steps required in a UTESS environmental assessment and overviews the components of an ecosystem approach. GIS based analytical and engineering tools to evaluate and design community-based UTESS developments were not

completed. However, some of this work was performed and tested at Dalhousie University. The Canadian expert assisted Turkey in its GIS based potential study, see subtask 6. The subtask was later summarised by ([CRUICKSHANKS 2000](#)).

### **Subtask 3: Standard Methods for Evaluating UTESS Applications. Lead Country: Germany**

#### Objectives:

- (g) Employ demonstration projects to develop standardised project evaluation methodologies for assessing the financial, environmental and energy efficiency benefits of UTESS projects.
- (h) Gather and disseminate the broader practical knowledge of UTESS based on experience.

#### Fulfilment:

The subtask was not completely fulfilled since the objectives were partly changed during the course of the annex. The main task was now to collect good examples of UTESS applications, demonstration projects, situated at "good locations" in the participating countries. Good location would mean a beautiful or remarkable place that attracted people for other reasons than UTESS. For each demonstration plant data were collected and gathered. Some 20 plants in seven of the participating countries were defined as demonstration plants and project information was collected. These [Demonstration Projects](#) are available via Internet and also as a few pages brochure on each project (end of 2000).

### **Subtask 4: UTESS Design and Analysis Tools. Lead Country: Sweden**

#### Objectives:

- (i) Evaluate and modify planning and engineering tools for the analysis, modelling and verification of UTESS and validate the tools against field data from Subtask 3.

#### Fulfilment:

Available Design and Analysis Tools were evaluated. A [list of models](#) (Inventory of UTESS, Design and Analysis Tools, Final Report) was prepared in a matrix format that showed the qualities and the use of the models ([HELLSTRÖM, 1996](#)).

The design tools selected for further evaluation and development are listed and discussed in the [Final Report of Subtask 4 \(Hellström, 2000\)](#). Information on development and use of these tools has been presented at the expert meetings. Some tools were distributed for evaluation to the Annex participants. Others have been available on request. Feasibility studies and actual designs of UTESS applications in the participating countries have, to a large extent, been performed based on these "common" tools. (Several other programs have been used in the USA and Japan. However, these countries were not participating in the Annex when the inventory was performed). Development of the tools has been stimulated by knowledgeable comments from the participating experts. The modifications and validations is discussed for each tool.

There is also a Final report from Subtask 4: UTESS Design and Analysis Tools, summarising the work.

## **Subtask 5: Technology Transfer to Appropriate Groups Lead Country: Sweden**

### Objectives:

(j) Develop model environmental guidelines, which promote UTESS utilisation while protecting the environment.

(k) Develop and implement a strategy for greater utilisation of UTESS by consultants, developers and building owners, municipalities and utilities.

### Fulfilment:

The first part of the objectives, ..environmental guidelines which promote UTESS utilisation .., has not been specifically done, though part of the work was carried out within Subtask 2, [Environmental Impact Assessment \(EIA\)](#). Environmental concern has also been one of the strongest incentives for many of realised UTES projects, mainly because companies want to have en "environmental image".

This subtask "technology transfer to appropriate groups" has been an ongoing process throughout the annex, with contribution from all subtasks and experts. The second part of the objective has been successfully achieved, though it is difficult to verify Annex 8 influence on the UTES development in participating countries. Annex 8 attracted many new participants and observers. The experts initiated many UTES project. The international seminars, see [Seminars](#), helped in several cases to speed up the introduction of UTES. The national seminars were maybe of even greater importance. Many new contacts resulted from the [ECES homepage](#) that was first created for Annex 8 information. The USA, which had no own subtask, was especially important to Subtask 5. The size of GHPC and the Stockton was impressed on many of those who were sceptics at the beginning. The US way of UTES promotion and UTES education programs were also of great value.

The mobile Thermal Response Test equipment (TED) was first developed at Luleå University ([GEHLIN et al, 1997](#)). It became very important for the BTES development. TED is in most cases not necessary but became a real door opener in Sweden, Norway, and Canada. Different types of TEDs are now available in USA, the Netherlands, Germany, and Turkey. The international use of TED measurements would not have happened without the Annex 8 group.

An other ongoing work, resulting from Annex 8, is the experts' intention to write a UTES Textbook for engineering students and consultants. At this stage it is just an other [annex proposal](#) (Annex 16?), that was not approved by the Executive Committee. However, the experts of Annex 8 will realise this task, one way or the other. This would be one of the most important achievements to fulfil the objectives of Annex 8.

## **Additional Subtasks – National Potential Studies**

### **Subtask 6: UTES Potential in Turkey**

The Turkish potential study was a model work for how to perform UTES potential studies. GIS was used as a tool to locate suitable UTES locations (ATES and BTES). This study considered many different parameters e.g. geological, geographical, meteorological, hydro-geological and demographic information ([PAKSOY et.al 1997, BEKIR, PAKSOY 1997,](#)

[PAKSOY, EVLIYA, 1999](#)).

### **Subtask 7: UTES Potential in Belgium**

The Belgian potential study focussed on ATES. This study used the same basic data to evaluate the potential but the results were presented on a map where different areas were coded in colours to show potential areas suitable for ATES, [DIRVEN \(1995\)](#), [DIRVEN, BAKEMA \(1996\)](#), [DIRVEN \(1997\)](#), [DIRVEN BAKEMA \(1997\)](#), [PATYN ET.AL \(1998\)](#), [DIRVEN, GYSEN \(1999\)](#).

### **Subtask 8: UTES Potential in Japan**

The Japanese potential study focussed on the UTES Potential at Hokkaido. This study followed the Turkish model and resulted in a useful tool for future UTES development, OCHIFUJI K (1998, 1999), SAKAI, K.(1998).

### **UTES Potential in Poland**

Poland also carried out a UTES potential study though Poland was never a formal participant. It seems to be one large HT UTES application in storing waste heat from electricity production during the summer. Such storage would be economically feasible since it would increase the electricity production during the winter.

## **5. Results of Annex 8**

### **General**

- UTES development. It is impossible to find out what influence Annex 8 has had on the UTES development in different countries but there has been strong UTES expansion in most of the participating countries and also in some of the observer countries.
- Five international UTES seminars were held in different countries and several national UTES seminars in each of the participating countries to promote the technology.
- A Peer Review International Journal on Energy Conservation, Underground Thermal Storage and Utilization (UTSU) was started after the Stockton meeting in March 1998. Annex 8 experts are available as reviewers for the UTSU Journal. UTSU is freely available at: <http://www.geo-journal.stockton.edu/>
- The ECES/Annex 8/ homepage at <http://cevre.cu.edu.tr/eces/> reached far outside the participating countries.
- The in-situ measurement method to determine thermal properties of BTES (TED - Thermal Response Test) was developed as a result of Annex 8. TED is now in use in several countries. (GEHLIN et.al. 1997).
- Several of the Annex 8 experts contributed to the special UTES issue of the IEA Heat Pump Newsletter (Vol. 16, No. 2/1998).
- The Annex 8 network was of invaluable help to all experts.

## New Annexes

As a result of Annex 8 discussions on necessary UTES R&D, three new Annexes were initiated within the ECES IA:

- Annex 12, High Temperature UTES (HT UTES)
- Annex 13, Design, Construction and Maintenance of UTES Wells and Boreholes
- Annex 14, Cooling in All Climates with TES

## 6. Workshop on the Future Annex 8

After the final Expert's Meeting the results of Annex 8 during its five years were discussed at a Workshop on the Future Annex 8, at Storforsen Sweden. Different scenarios for a continued Annex 8 were discussed and also new annex ideas emanating from discussions within the experts' group. Annex 6 – 7 resulted in Annex 8, which was a great network for information exchange. It was group for fruitful discussions on new applications and systems. This network was helpful for new countries in starting up new projects. The Annex group collaborated with other annexes within ECES IA but also with other IAs. Annex 8 initiated three new annexes:

- Annex 12, High Temperature UTES (HT UTES)
- Annex 13, Design, Construction and Maintenance of UTES Wells and Boreholes
- Annex 14, Cooling in All Climates with TES

Indirectly Annex 9 on Electrical Energy Storage and Annex 10 on Phase Change Materials were started because of Annex 8.

It was concluded that the main result of Annex 8 was that it:

- Made UTES known
- Helped in implementation
- Disseminated information
- Collected and evaluated models, systems etc.

It was also found that this work had been successful and important in speeding the UTES development in participating countries.

Several suggestions were discussed to organise continued work. A new UTES centre "Thermal Energy Storage Documentation and Information Network" was seen as the natural

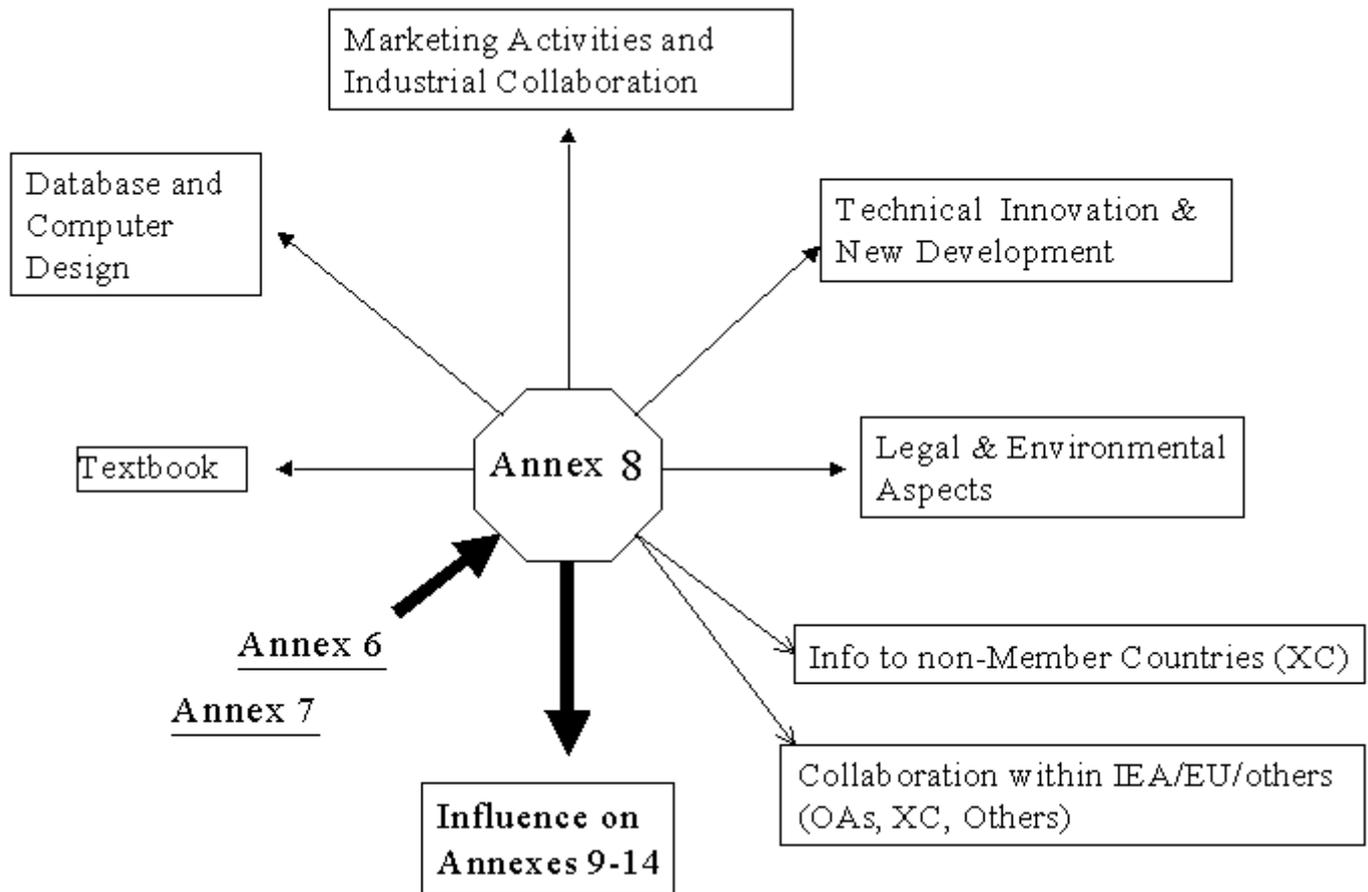
continuation of Annex 8. Other names were also suggested: "TES for Agenda 21" and "TES Information and Outreach Program". Part of the work should include:

- Education
- Technology Transfer
- Workshops on Specific Topics
- Subtask to find sources for funds

For the continued work five different areas were defined. It was also suggested that some of the experts would write annex proposals in these areas for future discussions within ECES IA. These areas and experts were:

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

The outcome of the discussion was summarised in graphic form as shown by Fig. 1. Some of these annex proposals were presented at the ECES Executive Committee Meeting in Berlin .



Figur 1. Annex 8 - influences and outcome.

## 7. Concluding Remarks

Annex 8, which was a result of Annex 6 - 7, was a great network for information exchange and resulted in fruitful discussions on new applications and systems. The Annex group also collaborated with other annexes within ECES IA but also with other IAs. This network was helpful for new countries in starting up new projects.

The structure of the annex was fragile, like a house of cards. Still the annex was of great help to all the experts and our mission because it looked solid and convincing from a distance. It became stronger with each new participant and each observer.

When promoting the idea of UTES it was often better to tell about projects in other countries though we in many cases had more and better projects at home. Our beautiful demonstration projects were of great help long before our brochures were completed. The most impressive projects were convincing by their location and size. In other cases comments like "- maybe it is feasible up north where you need a lot of heating -" could be met by informing about that our experts' group included participants from many different climates.

The experts also helped each other and other countries in speeding the introduction of UTES. As a university professor Annex 8 helped in many ways. The Annex 8 activities have resulted

in three PhD students at Luleå University of Technology, working on UTES in different applications.

For the continued work five different areas were defined (1/ UTES Textbook, 2/ Database and Computer Design 3/ Marketing Activities and Industrial Collaboration 4/ Technical Innovation and New Development 5/ Legal & Environmental Aspects). It is most likely that several of these annex proposals will be realised in the near future.

Finally, I would like to like thank all the experts of Annex 8, for all the hard and good work done in Implementing Underground Thermal Energy Storage.