



ECES Annex 12

"High Temperature Underground Thermal Energy Storage"

Sixth report to the Executive Committee

6.-7.11.2000

The number of participating countries is meanwhile steady, and comprises the locations of the most important HT-ATES plants:

- Belgium
- Canada
- Germany
- Netherlands
- Sweden

One experts meetings has been conducted since the last ExCom meeting:

XM 6, Mol, B, Oktober 2000

The minutes of this meeting are given as Appendix A.

With funding for the German project and the leading of Annex 12, work on monitoring and on the site test methods for aquifer chemistry and ground thermal parameters is continuing. Currently monitored are:

- Neckarsulm, BTES (D)
- Rostock, ATES (D)
- Berlin, ATES (D)
- Hooge Burch, ATES (NL)

New HT-UTES projects are under construction or in planning, and will be monitored:

- Anneberg, BTES (S) start of operation spring 2001
- Attenkirchen, BTES (D) start of operation summer 2001
- Mol, BTES (B) start of operation summer 2002

Activities are also resumed in Canada.

With the current end of phase 2 in June 2002, data from Anneberg and Atten

A specific focus in the last months was on thermal response test:

For borehole heat exchangers, knowledge of ground thermal parameters is a vital requirement for correct design. A very useful tool to determine these parameters is the thermal response test (partly developed within Annex 8). A

dedicated, joint workshop of Annex 12 and Annex 13 was organized on 14.10.2000 to bring together the people working with this test, for discussion and exchange of experiences. The workshop venue was Mol in Belgium, where both Annexes had there expert´s meetings.

The Mol site also offered the opportunity to have a comparison of tests with three mobile test rigs from Germany and the Netherlands. The test equipment use an electric heat pump (NL, Groenholland) or electric resistance heaters (D, UBeG Wetzlar and Weihenstephan), respectively, as thermal energy source. A forth mobile test device from Sweden was originally also invited, but finally could not come to Mol. Tests were made in 3 pilot boreholes drilled for the design of the TESSAS BTES, each equipped with a double-U-tube BHE, and all grouted with different material. The results are given below:

Evaluation with Line-Source-Method

	Mol-sand	calibrated sand	bentonite
Groenholland	$\lambda = 2.47 \text{ W/m/K}$ $r_b = 0.06 \text{ K/(W/m)}$	$\lambda = 2.40 \text{ W/m/K}$ $r_b = 0.1 \text{ K/(W/m)}$	$\lambda = 1.86 \text{ W/m/K}$ $r_b = 0.08 \text{ K/(W/m)}$
UBeG	-	-	$\lambda = 2.49 \text{ W/m/K}$ $r_b = 0.13 \text{ K/(W/m)}$
Weihenstephan	$\lambda = 2.47 \text{ W/m/K}$ $r_b = 0.05 \text{ K/(W/m)}$	no data yet	-

Evaluation with 2D-model, Groenholland

	Mol-sand	calibrated sand	bentonite
Soil	$\lambda = 2.56 \text{ W/m/K}$	$\lambda = 2.47 \text{ W/m/K}$	$\lambda = 2.26 \text{ W/m/K}$
Grout	$\lambda = 2.42 \text{ W/m/K}$	$\lambda = 2.52 \text{ W/m/K}$	$\lambda = 1.25 \text{ W/m/K}$

The workshop was attended by 20 participants from 9 countries (B, CH, D, J, NL, S, TR, UK, USA). Presentations from Sweden, Germany, the Netherlands and Switzerland informed about experiences in these countries. Discussion focussed on the results of the tests in Mol, accuracy of the test method, equipment, test duration, and vertical resolution (layers). The analogies of thermal testing to well tests in hydrogeology were discussed, and the applicability of hydrogeological methods for evaluation should be investigated. The following recommendations were given by the group:

- Test duration minimum ca. 50 h, up to 100 h
- Temperatur change minimum 10 K from start, up to desired temperature of operation
- Flowrate should be turbulent, or with flowrate desired for operation, if known at that stage

In Luleå a homepage for exchange of information on response test is planned. A workshop like that in Mol should be conducted about once a year. A documentation of the presentation and discussion of the Mol workshop is planned, input until end of November to the OA of Annex 12.

Report given by: Dr. Burkhard Sanner
Operating Agent Annex 12

Appendix A



Minutes of the 6th Expert's Meeting in IEA ECES Annex 12 High Temperature UTES

12.-13.10.2000, Mol, Belgium

Participants:

Olof Andersson, Sweco, S
Paul Dirven, VITO, Mol, B
Bert Gysen, VTO, Mol, B
Hans Hoes, VITO, Mol, B
Guido Knoche, ISWA, Univ. Stuttgart, D
Michael Koch, ISWA, Univ. Stuttgart, D
Manfred Reuß, Landtechnik Weißenstephan, Freising, D
Burkhard Sanner, IAG, Univ. Gießen, D
Thomas Schmidt, ITW, Univ. Stuttgart, D
Hiromichi Umemiya, Univ. Yamagata, J
Takao Yokoyama, Univ. Yamagata, J

Begin 12.10.2000, 10.30

Hubert van den Bergh of VITO welcomed the participants and gave a short introduction to VITO.

After the adoption of the agenda and a short introductory round, project updates were given.

Existing projects

Neckarsulm: Enlargement of the BTES to about the triple size is under way. While in the existing part a row comprises 6 BHE coupled in series, in the new addition 12 BHE are in one row. Connection here is in two alternating lines, to have again 6 BHE in series. Problems with the manifold shafts required optimization in the design, with connections more on the top. Monitoring of the existing part of the BTES shows:

- Temperatures in the store in late 1999 ca. 50-55 °C
- Return from district heating was about 50 °C (now optimized and reduced to 40 °C, as planned originally)
- In winter 1999/2000, no discharge was possible with the data stated above.

Rostock: In this ATES, a strong temperature increase was measured in the upper part of the aquifer (convection?). Well distance is 55 m, flowrate 14-15 m³/h. Monitoring started.

Berlin: For the ATES at the Reichstag site, monitoring started. Values are consistent since August 2000, the earlier flow and temperature history had to be reconstructed from sheets. Chemical analysis started also. Loading of the heat storage was done over most of the summer 2000 (with yet relatively low temperature), and will continue in summer 2001 with higher capacity and temperature, after the second heat-and-power cogeneration plant will be operational. In winter 2000/2001, no unloading of the store is planned.

New projects

Anneberg: Drilling is finished, BHE are single-U-tubes in water filled holes in granite, with home-made spacers to separate the shanks. Loading is planned to start in summer 2001.

Attenkirchen: District heating net is under construction, drilling planned for spring 2001, for 90 BHE each 30 m deep. Part of the holes will be grouted with a bentonite-graphite-mixture to enhance thermal conductivity. Start of the system is planned for summer 2001; temperatures and moisture movements will be monitored.

Mol: The BTES will consist of 144 BHE each 30 m deep (double-U-tube of polybuten), to comprise 16.000 m³. Storage capacity is 600 MWh with maximum 85 °C. Current status is 3 pilot holes, each grouted differently:

- sand of Mol
- sand of different grainsizes („calibrated sand“)
- bentonite/cement/sand

Groundwater is 2.7-2.8 m below ground. Construction will start in 2001, loading is planned from spring 2002 on.

Subtasks

Subtask B - Monitoring

Minimum monitoring is:

- Temperature in - out
- Energy in - out
- ATES: mass flow (water), pressure (groundwater level), chemical development
- BTES: temperature inside store
- Temperature outside of the store for environmental reasons
- Listing of failures, operational remarks

Current monitoring:

- Neckarsulm from early 1999 to at least end of May 2001
- Rostock May 2000 to at least end of March 2001

- Berlin from June 1999 to August 2000 only fundamental data, from August 2000 to at least end of March 2001 normal data
- Hooge Burch ?

New projects:

- Anneberg start spring 2001
- Attenkirchen start summer 2001
- Mol start summer 2002

Subtask C - ATES groundwater suitability and water treatment

Guido Knoche presented the design of the trailer and equipment, and the status of the work. The test rig should be operational in January 2001 and tested at a well on the ISWA Stuttgart site. Interest for use in design phase exists from Sweden (Malmö).

Subtask D - BTES ground parameter investigation and BHE optimization

Response Test discussion postponed to workshop on 14.10.2000.

Subtask F - System concepts and economy

Several concept to determine the economic data for the storage were discussed. The experts agreed on:

$$\text{storage cost} = \frac{\text{writing off} + \text{operation cost}}{\text{produced energy}}$$

In the same way, system energy cost could be determined:

$$\text{system cost} = \frac{\text{writing off} + \text{operation cost}}{\text{produced energy}}$$

Then the items are:

- writing off: incl. store, heat source, peak boiler, heat pump, etc.
- operating: pumps, maintenance, control, heat pump, peak fuel
- produced energy: at system output

The concept can be used for end user cost, if distribution cost until entrance of houses are included.

Bert Gysen will send a list of writing-off times to the experts.

Subtasks and subtask leaders:

Subtask	Leader
B, Monitoring	B. Sanner
C, ATES groundwater suitability and water treatment	M. Koch
D, BTES ground parameter invest. and BHE optimiz.	G.
Hellström	
E, Components, list of specifications	B. Sanner
F, System concepts and economy	P. Dirven

Status of participating countries:

- Germany participating, national project, OA
- Belgium participating, national project

Netherlands	participating (to be confirmed)
Sweden	participating
Canada	participation planned again

Next meeting will be 23./24.4.2001 in the Netherlands, again in conjunction with Annex 13. B. Sanner thanked P. Dirven and his staff very much for the meeting opportunities and organisation, and closed the meeting on 13.10.2000 ca. 13.00.

In the afternoon of 13.10.2000, a technical visit allowed the experts to visit the underground research facility „HADES“ on the Mol site, in ca. 220 m depth in clay.