Geothermal Energy Applications – Medium Deep Geothermal Systems and Heat Storage

Dr.-Ing. Sebastian Homuth
GANDOR Project, 2nd Workshop, 10. – 11.03.2015, Szeged, Hungary
Profile
Core competences

Specialist know how in Ground Engineering and all related works
Project management of complex infrastructure projects
International / cross border activities
High value chain due to own resources
Profile
Know How

Diaphragm / slurry walls
Piles
Retaining walls
Grouting
Quay walls
Ground anchors
Ground improvement
Dewatering
Deep drilling

Uplift systems
Soil freezing
Monitoring and Instrumentation
Turnkey excavation pits
Immersed tunnels
Planning, Design
Profile
Markets and Locations (Europe)

Area
Focus
Location
Profile
Management Structure

North + West: Germany, Poland, Benelux, Scandinavia
South + East: Austria, Switzerland, Czech Republic, Slovakia, Hungary, RANC, SEE
International + Special Divisions

Operational

Strong brands

STRABAG  ZUBLIN

Central Staff Units

LEGAL AFFAIRS  CONTRACT MANAGEMENT  AUDIT DEPARTMENT

Central Service Companies

1) BRVZ Bau- Rechen- und Verwaltungszentrum  2) BMTI Baumaschinentechnik International  3) TPA Gesellschaft für Qualitätssicherung und Innovation
Figures
Züblin Group Output

<table>
<thead>
<tr>
<th>Year</th>
<th>Germany (€ millions)</th>
<th>Abroad (€ millions)</th>
<th>Change</th>
<th>Planning 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>2,950 (71%)</td>
<td>856 (29%)</td>
<td>+5%</td>
<td>ca. 3,188</td>
</tr>
<tr>
<td>2009</td>
<td>2,524 (72%)</td>
<td>718 (28%)</td>
<td>-14%</td>
<td>ca. 2,297</td>
</tr>
<tr>
<td>2010</td>
<td>2,419 (68%)</td>
<td>774 (32%)</td>
<td>-4%</td>
<td>ca. 2,297</td>
</tr>
<tr>
<td>2011</td>
<td>2,714 (67%)</td>
<td>914 (33%)</td>
<td>+12%</td>
<td>ca. 2,297</td>
</tr>
<tr>
<td>2012</td>
<td>3,075 (67%)</td>
<td>1,017 (33%)</td>
<td>+13%</td>
<td>ca. 2,297</td>
</tr>
<tr>
<td>2013</td>
<td>3,086 (71%)</td>
<td>905 (29%)</td>
<td>+0.4%</td>
<td>ca. 2,297</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Change values in parentheses*
Figures
Züblin Group Employees

<table>
<thead>
<tr>
<th>Year</th>
<th>Germany</th>
<th>Abroad</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>7,793</td>
<td>7,026</td>
<td>+46.7%</td>
</tr>
<tr>
<td>2008</td>
<td>7,821</td>
<td>6,608</td>
<td>-2.0%</td>
</tr>
<tr>
<td>2009</td>
<td>5,881</td>
<td>6,398</td>
<td>-15.0%</td>
</tr>
<tr>
<td>2010</td>
<td>6,920</td>
<td>6,382</td>
<td>+8.3%</td>
</tr>
<tr>
<td>2011</td>
<td>6,721</td>
<td>6,690</td>
<td>+0.8%</td>
</tr>
<tr>
<td>2012</td>
<td>6,144</td>
<td>7,313</td>
<td>+0.3%</td>
</tr>
<tr>
<td>2013</td>
<td>6,460</td>
<td>7,410</td>
<td>+3.1%</td>
</tr>
</tbody>
</table>
Figures
STRABAG Group Output Volume (€M)
Definition of Geothermal Applications

Permeability of subsurface [log m²]

Surface near geothermal: closed systems
Medium deep geothermal: closed systems
depth borehole heat exchangers
Surface near geothermal: open systems
Medium deep Geothermal: ATE systems

Deep Geothermal: Petrothermal systems
Deep Geothermal: Hydrothermal systems

Subsurface temperature [°C]
Process temperature [°C]
Heat transport
Flow regime
predominantly conductive
predominantly convective
predominantly turbulent
predominantly laminar

modified, Bär 2011
Hydrothermal Systems

Shallow hydrothermal systems (800 to 3.000 m reservoir depth)

- High to medium high enthalpy regions (volcanic active areas, sedimentary basins)
- Reduced risk of insufficient permeability ("Fündigkeitsrisiko"): high natural permeability of the reservoir formation
- Open cycle system:
  - Production boreholes
  - Power plant
  - Injection boreholes
- Depending on reservoir type and fluid heat and/or power production (CHP) is possible

Mielke, 2010
Geothermal Markets in Europe

1 North German Basin (Germany, Netherlands, Denmark)
2 Paris Basin (France)
3 Upper Rhine Graben (Germany, France)
4 Molasse Basin (Germany, Austria)
5 Pannonian Basin (Austria, Hungary, Slovenia, Slovakia, Romania, Serbia)
6 Tuscany (Italy)
7 Mediterranean volcanic belt (Turkey)

Legend:
- High enthalpy (electrical power)
- High temperature basins (electrical power, district heating)
- Medium temperature basins (district heating)
- Everywhere (EGS, shallow geothermal)
Conventional seasonal thermal storage

Summer operation: cooling

Winter operation: heating

Underground Energy, LLC
High Temperature Borehole Heat Exchanger Storage

- A few, but medium deep boreholes (500 – 1500 m)
- High preflow/storage temperatures of 70 - 110°C
- Drilling depths of more than 1000 m gain higher underground temperatures ➔ decreasing temperature differences between reservoir and preflow temperature ➔ less heat losses compared to surface near storages
- High storage backflow temperatures (preflow for conventional heating system) can be obtained (45-65°C)
- Increase of efficiency (possibly abandonment of heat pumps) ➔ less primary energy use
- Energetic optimization of existing infrastructure
- Cost-saving drilling techniques applicable (down the hole (DTH) fluid hammer)

Bär et al. 2014
Borehole Design
(a) heat storage (b) heat extraction

(a)
- Inspection chamber
- Casing
- Thermally insulated grout
- Thermally insulated inner pipe
- Outer pipe (steel)
- Thermally enhanced grout

(b)
- Inlet
- Outlet

Bär et al. 2015
Medium deep open systems: Aquifer thermal energy storage (ATES)

- Seasonal changing operation of geothermal well doublet
- 100 to 200 m spacing in reservoir necessary
- Several doublets depending on pre- and backflow temperatures of heating and cooling systems possible
- Storage efficiency of 60 – 80 % (Sommer et al., 2013) with groundwater flow velocity of less than 20 m/a
- At groundwater flow velocities of more than 150 m/a not feasible
- Thermal underground influence is greater compared to closed systems
Thermal aquifer applications in urban areas

Master plan in the Netherlands:

- In urban areas an underground master plan enables the optimized planning of different thermal underground storage systems
- Increase of efficiency by 20-30% possible (Sommer et al. 2013)
Coupled systems

- Coupling of different renewable energies with existing infrastructure is only possible via storage technologies.

- Especially weather and climate depending technologies like solar thermal and wind power are rely on storage technologies.

- Coupling of geothermal potentials with industrial waste heat or process waste heat guarantees base load capability.

- Coupling with combined heat and power plants (CHP) enables a electricity based operation in summer.

Schmidt et al. 2003
Summer operation scenarios

Scenario 1:
CHP Plant / MDHTS / End User

Scenario 2:
CHP Plant + Solar Thermal / MDHTS / End User
Winter operation scenarios

**Scenario 1:**
CHP Plant / MDHTS / End User

**Scenario 2:**
CHP Plant + Solar Thermal / MDHTS / End User
Coupling of solarthermal, CHP und underground storage: *summer*

Storage phase
Coupling of solarthermal, CHP und underground storage: summer
Drilling technique: DTH fluid hammer

DTH (down to hole) fluid hammer:

- Hydraulically driven percussion drill technique
- High rate of penetration in hard formations
- Less primary energy use
- Good borehole stability and control of borehole deviation
- Improved cutting transport compared to pneumatic drilling

→ improved economic drilling technique

Comparison of energy and water consumption:
- DTH air hammer (compressor) requires 4 x more energy than DTH water hammer

Wittig 2010

Wittig 2012
Ausführung Bohrung

400 m HDPE double-U-borehole heat exchanger DN40
SDR 11 40 X 3,9 mm

Technical Data:
Nom. Hook Load: 45 mt
Max. Hook Load: 50 mt
Power: 440 (HP)

Drilling Depths:
up to 1200m /3940 ft
depending on the drill string weight

Tubulars: API CSG Range I
ATEX: No

Location: Austria (2014)

Special Features:
additional rotary table 419mm circular flushing pump
triplex plunger pump
Drilling experience

- Water driven DTH drilling technique is state of the art in horizontal and surface near drilling in hard rock formations (W100, W150 bits at Hallandsas tunnel project in Sweden)
- More than 25 Millionen meters have been drilled, 4.300 m vertical borehole in South Korea
- 1.000 m deep vertical drilling is common with conventional rotary drilling techniques
Decentralized and seasonal heat storage will gain importance in the near future ➔ smart heat grid technology

Implementation of innovative and energy efficient systems are necessary

A fast, economical and emission free drilling method (water powered DTH-hammer) is the base for the successful implementation of underground storage and/or geothermal energy applications in medium depths
Thank you very much for your attention!

Contact:
Dr.-Ing. Sebastian Homuth
Project Manager Geothermal Energy

Züblin Spezialtiefbau GmbH
Ground Engineering
Business Unit Direct Export
Europa-Allee 50
60327 Frankfurt a. M. / Germany

T: +49 (0) 69 6 06 08 32 05
M: +49 (0) 151 61 64 18 56
F: +49 (0) 69 6 06 08 32 02
E: sebastian.homuth@zueblin.de