Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

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Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

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Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

Introduction
Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

-Introduction-

Heating plant with auxiliary burner

Solar collectors 5263 m²

Borehole thermal energy store 63360 m³

Two buffer tanks each 100 m³

Heat distribution net

300 accommodation units & public buildings

5263 m²

100 m³

63360 m³

300
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- BTES -

1997: experimental store
1998: 1st extension
2001: 2nd extension
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-BTES-

Scheme of a borehole heat exchanger

- Polybutene Double-U-pipe 25 x 2.3 mm
- Borehole wall
- Grouting material (Suspension of bentonite-sand-cement)
- Thermal active depth (30 m)
- Connection pipe in sand layer
- Insulation (200 mm)
- Covering layer (appr. 2 - 3 m)
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**Insulation of the BTES**

- Styrodur moist with foil
- Styrodur dry with foil

- soil (2-3 m)
- liner
- drainage
- liner, non-vapor retarder
- insulation (0.2 m)
- drainage
- liner
- sand
- soil

Measurements by M. Benner, ITW
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-Charging & discharging heat amounts and temperatures in the BTES-

-heat in MWh per month
-temperature in °C

charging

discharging

construction work for 2nd extension

red: temperature first extension in 10 m depth
orange: temperature second extension in 10 m depth
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District heating system
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-District heating system-

Diagram showing the phases of construction and the complete construction area of the district heating system.
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-District heating system-

Temperatures and volume flows in the heat distribution net

(net supply temperature, net return temperature, net volume flow)

connection and supply of new buildings

supply of adjacent district heating net

connection and supply of new buildings

supply of adjacent district heating net
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-District heating system-

Heat balance for the district heating system (2005)

- $Q_{Gasboiler}$ 3311 MWh/a
- $Q_{Buildings}$ 3534.5 MWh/a
- $Q_{Solar, direct}$ 934.5 MWh/a
- $Q_{Storage}$ 155.5 MWh/a
- $Q_{Store, discharge}$ 321.5 MWh/a
- $Q_{Heat losses}$ 1032.5 MWh/a (heat distribution net, calc.)
- $Q_{Heat losses}$ 258 MWh/a (solar net, calc.)
- $Q_{Solar}$ 1669 MWh/a
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Simulations
Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

-Simulations-

Superposition Borehole Model (for TRNSYS)

* 528 Borehole Heat Exchangers (BHE)
* non-uniformly placement of BHE’s
* hydraulic coupling of BHE’s (seriell, parallel)
* ground layers
* implementation in TRNSYS for system simulations
Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

-Simulations-

<table>
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<tr>
<th>Date</th>
<th>Temperature at M17 (10 m)</th>
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- Thermal conductivity -
  - 1997-1998: 2.0 W/(m⋅K)
  - 1997-2002: 2.2 W/(m⋅K)
  - 2003-2005: 2.4 W/(m⋅K)

- Volumetric heat capacity: 2.85 MJ/(m³⋅K)
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Summary & conclusions
Monitoring results and operational experiences for a central solar district heating system with Borehole Thermal Energy Store in Neckarsulm (Germany)

-Summary & conclusion-

Solar fraction

2002-2005: 30-40% (measured)
design: 50%

Future: increasing heat demand?
installation of a heat pump?
further extension of the BTES?
Thank you for your attention!

more information:
www.itw.uni-stuttgart.de/sun
www.solarthermie2000plus.de
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-BTES-

Construction of the BTES
experimental store & 1st extension  2nd extension
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- BTES -

Construction of the BTES experimental store 2nd extension
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Temperatures in the BTES

![Graph showing temperatures in the BTES over time]
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Connection ducts

experimental store & 1st extension  2nd extension (pipes before insulation)
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Temperatures in the BTES

![Graph showing temperatures in the BTES with four different extensions and their temperatures over time from January 1999 to January 2005. The graph includes temperature values in °C, with extensions labeled as 1. extension (0 m), 1. extension (20 m), 1. extension (32 m), 2. extension (0 m), 2. extension (20 m), and 2. extension (32 m).]
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-District heating system-

Solar gross heat gain of the solar collectors (5263 m³)

-Graph showing solar gross heat gain in kWh/(m²·a) for different locations and years (1999-2004).

School, senior residence, shopping centre, terraced houses, carport, wall, senior care residence, and Eglob,coll are the locations.

Solar irradiation (collector plane, 15 °) in kWh/(m²·a) is also shown for each year.
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-Simulations-

<table>
<thead>
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<th>Month</th>
<th>Temperature</th>
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<td>01.12.04</td>
<td>Measured: 28°C</td>
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</tbody>
</table>

**Thermal Conductivity**
- 1997-1998: 2.0 W/(m·K)
- 1997-2002: 2.2 W/(m·K)
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**Volumetric Heat Capacity**
2.85 MJ/(m³·K)