Solar District Heating with Seasonal Storage in Attenkirchen

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Solar District Heating Attenkirchen

Reduction of CO₂ – emission by:
- energy conservation
- use of renewable energies

Solar district heating is one option to achieve significant reduction of CO₂ – emission at tolerable extra cost

Objectives:
- saving of primary energy by improved insulation
- use of solar energy
- use of heat pumps
- little extra costs for users

Total heat demand: 487 MWh/a
- 20 single family houses (260 m²)
- 5 semi-detached houses (175 m²)
Solar District Heating Attenkirchen
System layout
Combined Pit / Borehole Storage

The heat storage consists of a pit store made of concrete located in the center of a ring of ducts. The total storage surface is covered with an insulation layer and a ground layer.

- top insulation layer
- grass
- well for piping
- water pit
- concrete wall without insulation and liner
- duct storage ring

**typical size of pit:** $10^2 - 10^3 \text{ m}^3$;  
**size of duct:** $10^3 - 10^5 \text{ m}^3$
Combined Pit / BTE-Storage
Borehole Thermal Energy Storage

**CROSS SECTION**

- **Surface**
- **1.50m b. surf.**
- **300mm humus**
- **1000mm gravel**
- **200 mm thermal insulation**
- **100mm sand (0-5mm)**
- **Pipe in sand**
- **Heat exchanger tube (single U-pipe)**
- **Backfill (bentonite-cement-sand-water-grouting)**
- **Borehole 150 mm diameter (e.g. 30 m deep)**

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**Image**: A photograph of a borehole thermal energy storage system with pipes and cables arranged on a field.
Combined Pit / BTE-Storage

Advantages of the hybrid storage:
• thermal coupling of both storage types
• pit store allows easy adjustment of power fluctuations of the solar system
• pit store serves as short term storage
• horizontal temperature gradient
Solar Collectors

- Solar Roof Collector
- 836 m² gross area
- 764 m³ aperture
- Selective surface (Tinox)
Parameters of Components

Solar system
- Solar Roof: 836 m² gross area

Hybrid storage
- volume of the central water pit: 500 m³
  - 8.50 m deep, 9.00 m diameter, cylindrical concrete vessel
  - no liner for tightening
  - no insulation to the bottom and to the sides
- ring shaped BTES 9850 m³
  - 90 boreholes, 30.00 m deep
  - borehole diameter: 150 mm, borehole distance: 2.00 m
  - double-U-BHE (PB-pipe 25x2.3)
  - backfill: bentonit/cement/quartz sand/water-suspension, ThermoCem

Heat pumps
- 2 heat pumps (BTES – water pit)
- 2 heat pumps to the district heating

Heating system in the buildings
- Low temperature floor heating
# Cost Evaluation

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### Specific costs:

- **collector**: 231,100 €
  - gross area aperture
    - 836 m²
    - 764 m²
    - 276 €/m²
    - 302 €/m²

- **water pit**: 203,200 €
  - volume
    - 500 m³-H₂O
    - 406 €/m³-H₂O

- **BHE’s**: 124,100 €
  - total length
    - 2700 m
    - 46 €/m
  - ground volume
    - 10,500 m³
    - 12 €/m³
  - water equivalent
    - 6800 m³-H₂O
    - 18 €/m³-H₂O

- **total storage**: 327,300 €
  - water equivalent
    - 7300 m³-H₂O
    - 45 €/m³-H₂O
Energy Balance

Apr 2004 – Mar 2005
BTES => HP => pit => load (pit at ~ 50°C)
solar fraction (elec.) 73%

Apr 2005 – Feb 2006
all heat pumps in use
(pit at ~ 50°C in summer, ~10 - 25°C in winter)
solar fraction (elec.) 74%
Operating Experiences

- system concept is technically and economically promising
- the new storage type should be tested in real operational conditions
- interesting operational features – e.g. storage management
  - parallel charging
  - serial charging
- major mistakes in design, construction and control – new control program required
- small temperature drop in the district heating due to high flow rate
- improved performance by demand related variation of flow rate and floating of supply temperature of the district heating – 50 °C for domestic hot water reduction and 35 °C for space heating
- analysis of the construction costs was encouraging and shows still potential for cost reduction
- analysis of system performance shows potential
Conclusion

- Attenkirchen is a rather small solar district heating system
- objective was to demonstrate the feasibility of such small size plants
- the new storage type tested in real operational conditions showed encouraging results
- Long-term grouting materials for borehole heat exchangers
- analysis of the construction costs as very promising for the solar system and the storage
- major mistakes in the control program
- detailed analysis of system performance not yet possible because of control

**Intensive coaching of designers and construction companies is required**
Acknowledgement

- The construction of the solar district heating system in Attenkirchen was subsidized by the Bavarian Ministry of Economy, Traffic, Infrastructure and Technology.
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