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7. Norddeutsche Geothermietagung

Danish experiences with operation of deep geothermal district heating plants

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Operating experiences, Abstract

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Denmark has three geothermal plants producing heat for district heating from sandstone aquifers. The heat is transferred using absorption heat pumps driven by heat from biomass. All of the driving heat is transferred to the heating net together with the heat from the geothermal water.

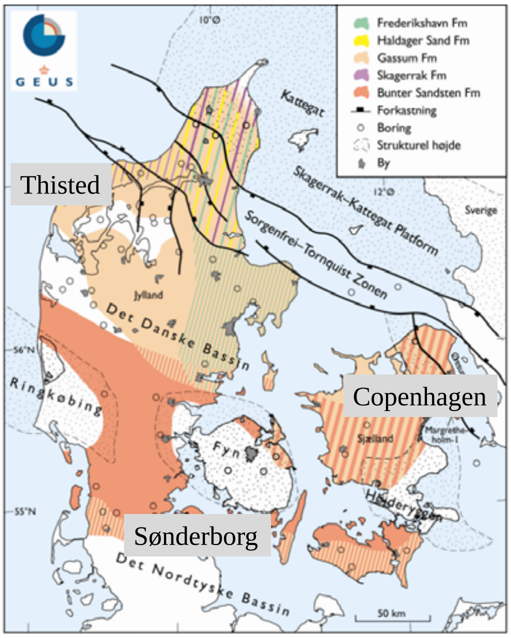
A concept has thereby been developed where biomass based district heating boilers when in operation can drive geothermal heat pumps for free, but two of the plants suffer from high injection pressures increasing pumping costs and reducing the plant capacity. However, the injection pressure at the first plant from 1984 is still low - and ongoing investigations and work at the two other plants are expected to improve their injectivity substantially.

The first plant located in Thisted was established as a pilot plant in 1984 and later expanded to extract up to 7 MW heat from 200 m3/h of 44 °C, 15 % saline geothermal water from 1,250 m depth.

The second plant situated in Copenhagen designed to extract up to 14 MW heat from 235 m3/h of 73 °C, 19 % saline geothermal water from 2,560 m depth started production in 2005.

The last plant located in Sønderborg was inaugurated 2013. It is designed to extract up to 12.5 MW heat from 350 m3/h of 48 °C, 15 % saline geothermal water at 1.2 km depth. Experience with operation of these three plants including recent work on the improvement of injectivity is presented.

Introduction



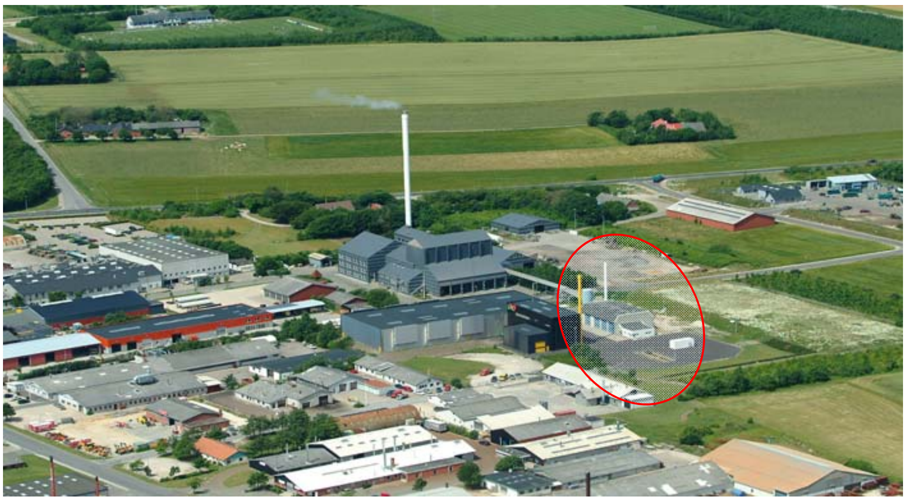
Denmark has three geothermal plants producing heat for district heating from deep sandstone aquifers.

The heat is transferred using absorption heat pumps often driven for free by biomass based boilers.

The first plant located in Thisted was established in 1984, the second in Copenhagen 2005 and the last in Sønderborg 2013.

Experience from the operation including work on the improvement of injectivity is presented.

Geothermal plant in Thisted. Production since 1984



Established as a pilot plant in 1984 and later expanded to extract up to 7 MW heat from 200 m3/h of 44 °C, 15 % saline geothermal water from Gassum sandstone at 1.25 km depth.

Electric replaced by larger absorption heat pump 1988

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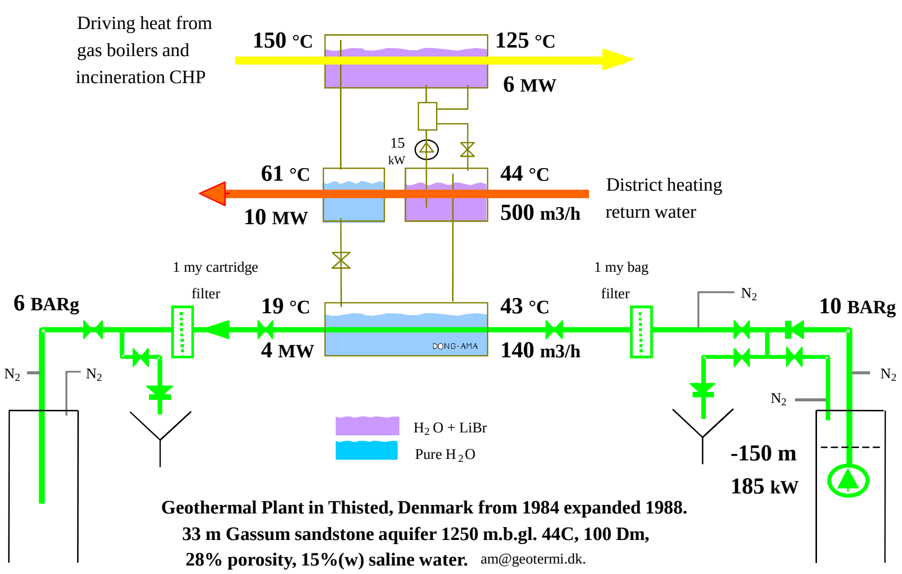

Geothermal Plant in Thisted, Denmark from 1984 expanded 1988.
33 m Gassum sandstone aquifer 1250 m.b.gl. 44C, 100 Dm,
28% porosity, 15%(w) saline water. am@geotermi.dk.

Increased flow and 2 absorption heat pumps 2001

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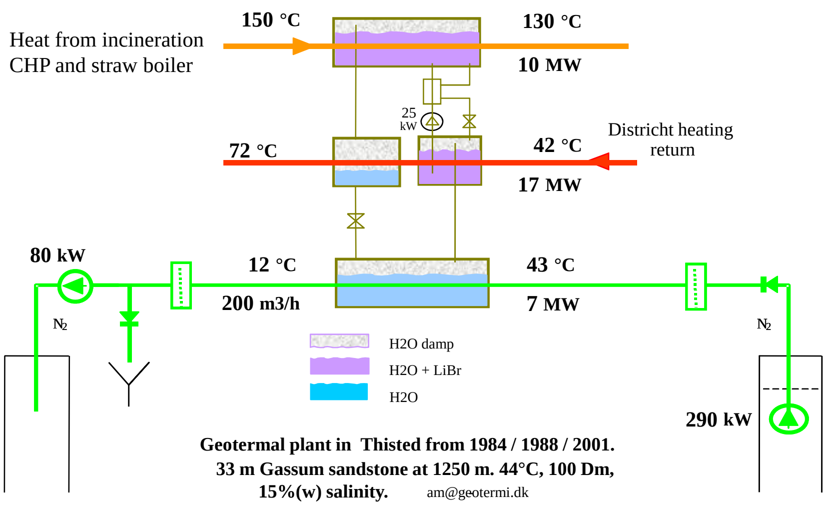

Geotermal plant in Thisted from 1984 / 1988 / 2001.
33 m Gassum sandstone at 1250 m. 44°C, 100 Dm,
15%(w) salinity. am@geotermi.dk

All of the driving heat is transferred to the heating net. Biomass based district heating boilers can thereby drive the geothermal heat pumps for free.

Free driving of absorption heat pumps

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When the heat pumps are not operating the straw boiler produces heat direct to the heating network.

When the heat pumps are started the boiler instead produces the same amount of heat to the heating network through the heat pumps at no additional costs.

The heat pumps are then driven for free (disregarding a circulation pump power consumption often at below 1% of the evaporator heat).

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Annual production in Thisted since 1988

(change from incineration CHP to straw boiler heat drive heat around 2006)

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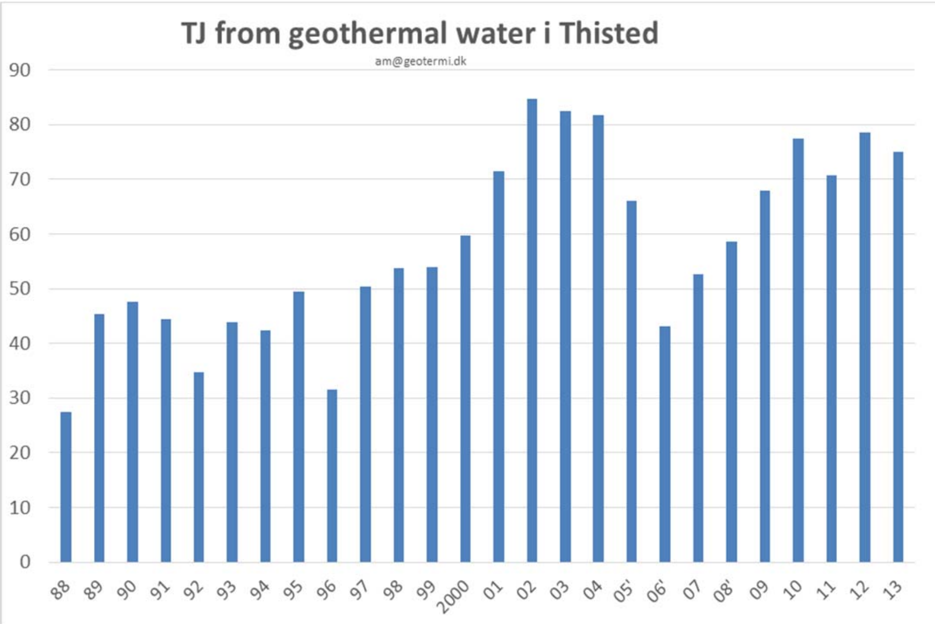

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Filters and sewage pipe buffer bassin

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When the submersible pump is started at least a well plus surface plant volume is pumped to the sea through a methane degassing and sedimentation sewage pipe buffer bassin

Injection at geothermal plant in Thisted

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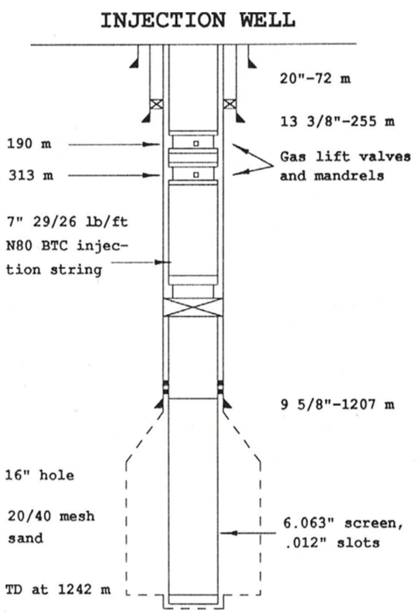

Low injektion pressure since first production at Pilot Plant 1984.

Long summer stops, but nitrogen protection system and ok water chemestry gives low corrosion rates (about 0.06 mm/year in carbon steel in the 15% saline geothermal water).

Designed with injection tubing ready for for gas lift, but not realy needed – what seem more important is the initial clean flowpath.

2014 Data: 25 BARo wellhead pressure at 175 m3/h, 13°C.

HGS plant in Copenhagen, production since 2005

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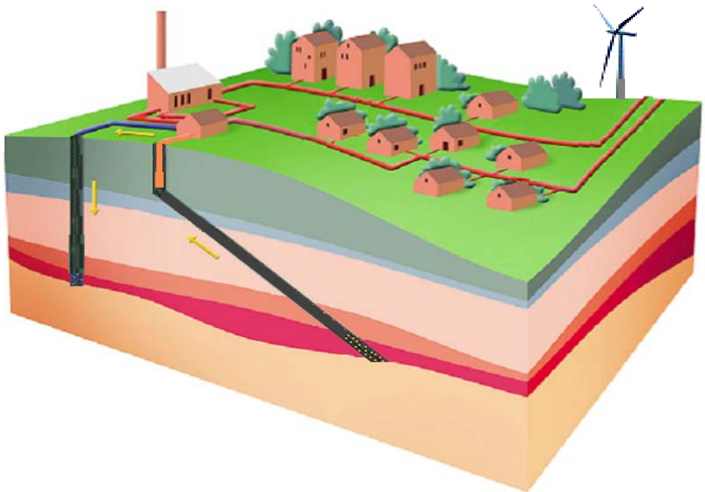

Op to 14 MW from 235 m3/h of 74°C, 19% saline geothermal water from Bunter sandstone through perforations at 2,6 km's depth

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HGS geothermal plant, design data

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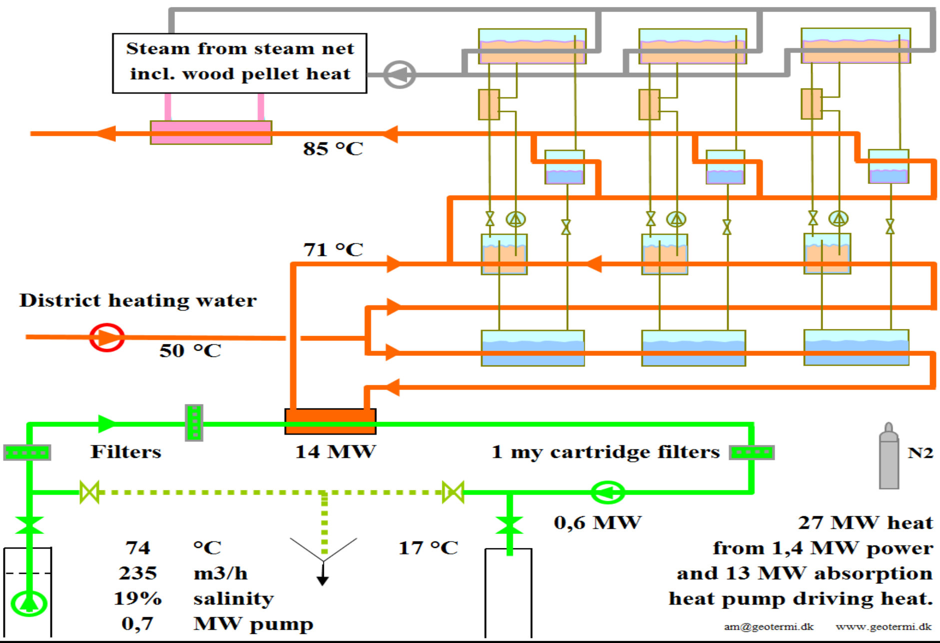

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270 m3/h clean up 18/4-2005 to reach design capacity

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TJ annual production 2005-2013

(Increasing injection pressure, injection pump problems 2010-2011)

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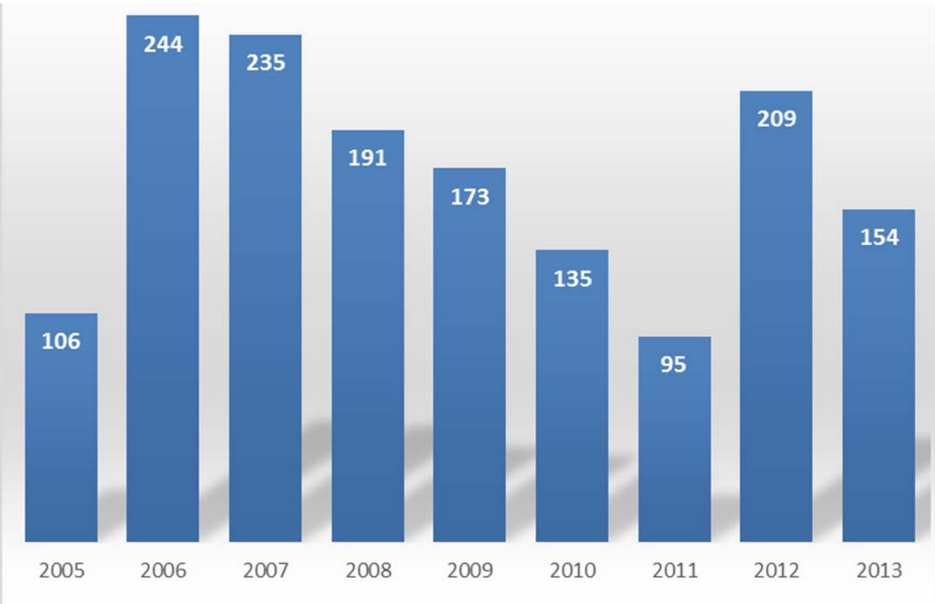
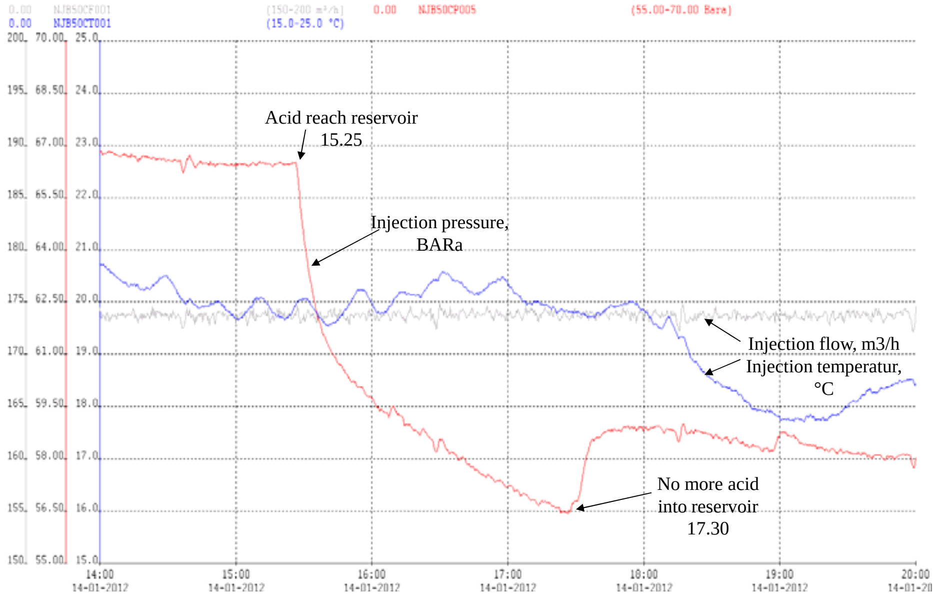


Soft acidizing injection well



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Clean up with pressure in injection well aquifer

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Well investigations 29/9-1/10-2014

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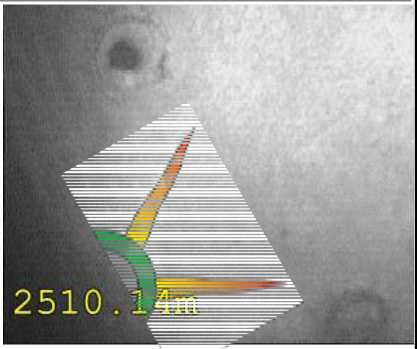
- Camera inspection
- Bailer sample
- Flowlog
- Filter cupons

Perforations may be 0.4-0.5 m deep and Ø 7-10 mm. Picture with open and plugged.



Object stopping camera - maybe cable holder or centralizer spring

HGS Well investigations 29/9-1/10-2014.

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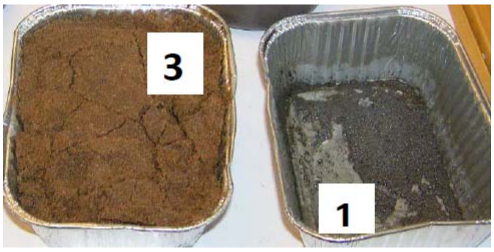
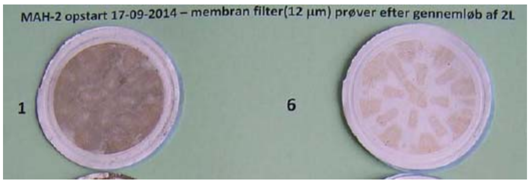
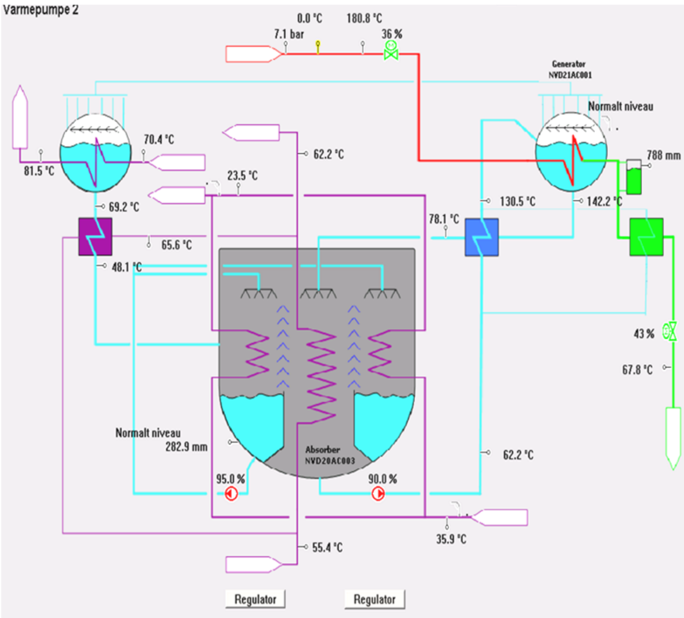


- Bailer sample
- Particles in geothermal water from production well at start up and later



Next step, e.g. well scrabing and clean up pumping or new perforations not yet decided

Absorption heat pumps



Increased vacuum pumping is often required and water in pump oil then often a problem

Old vacuum valve menbranes may leak and not open when tried opened.

Limited standard instrumentation is a problem

Can when correct used provide stable heating with low operating cost

HGS, 24 m submersible pump

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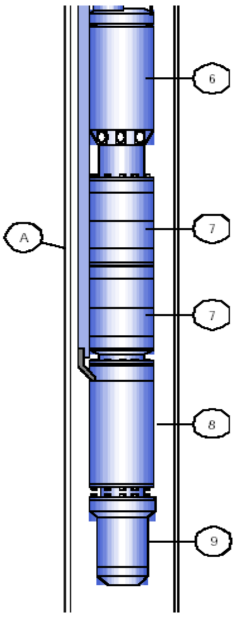
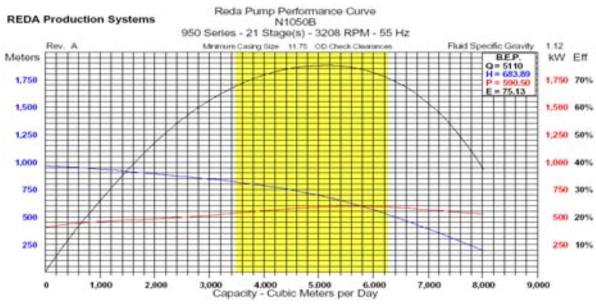


A higher bubble point than assessed from bottom hole samples required an increased pump motor capacity.

The pump motor HP was increased by removing a pump step to make the motor speed up and thereby get more HP



HGS, selfcleaning filter

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Prefiltering was needed and and added

The self cleaning filter is scrabed on the filter cylinders and backflushed at the same time when cleaned

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HGS, heat exchangers

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The pressure in the 19% saline water is higher than in the district heating water.

Leaks into the district heating water has been stopped by alarms from an district heating water electric conductivity masurement.

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HGS, injection pump

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Seal broke down at low barier fluid pressures. Fixed by pressured N2 blanket gas and better seal.

Long spare part delivery times

Geothermal plant in Sønderborg from 2013

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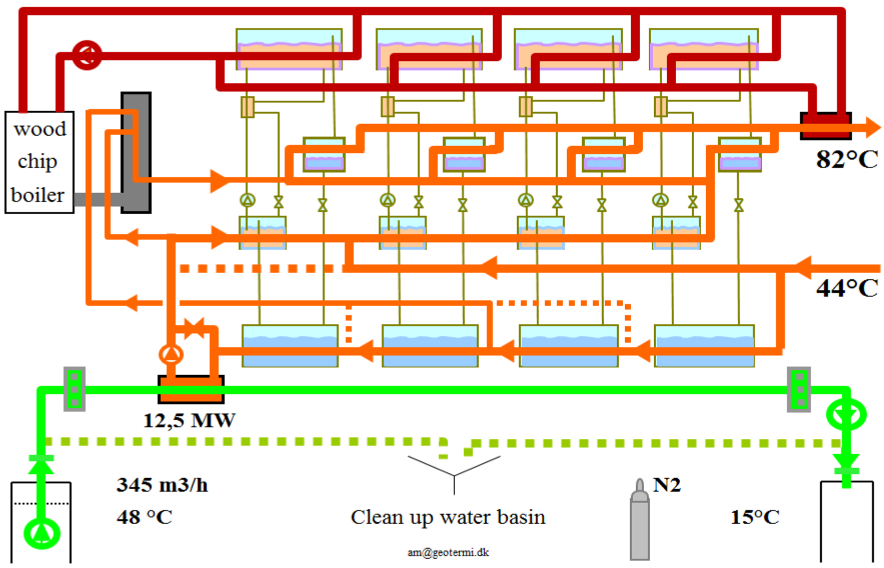

Designed to extract up to 12.5 MW heat from 350 m3/h of 48 °C, 15 % saline geothermal water from Gassum sandstone at 1.2 km depth.

Capacity problems

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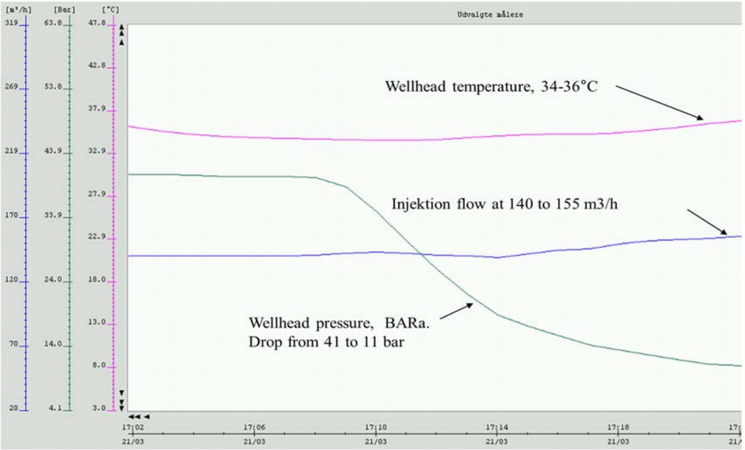
More adjustments on heat pumps and geotermal pump VSD's are still needed.

The plant has had problems with an increasing injection pressure. An example of a pressure reduction adding 0.38 m3 15% HCL to the injection water after an air ingress at a leaking wellhead gasket is shown below.



Injection well investigations

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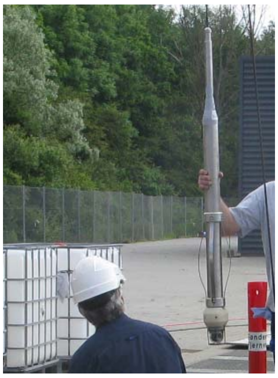
Soft acidizing has helped reducing the injektion pressure but not alone been able to maintain a satisfactirily inejction capacity. Very little "dirt" can plug up the 1,6 m² 0,152 mm slots in the gravel pack filter screen.

The injection problems has lead to an investigation programme: Camera inspection, bailer sample, flowlog, particle content in water.



Injection well clean up

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The well wall did not look clean and the screen openings seemed pluged up. It was concluded the well should be cleaned by scrabers and the gravel pack filter screen should be cleaned by high rate pumping.

The well was cleaned with rotating scrabers – in the gravel pack zone at the same time pumping water out of the well with gas lift at up to 72 m3/h.

Thereafter the production pump was moved to the injection well and a cleanup pumping was made 10-13. October at rates up to 350 m3/h. Drawdown indicates an injection capacity exceeding 350 m3/h at the injection temperature viscosity.

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