GEOTHERMAL UNDERGROUND STORAGE FOR SOLAR APPLICATIONS

Technology, research and business cases

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ISES Webinar

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BRIEFLY ABOUT ME

- 2008 MSc Mech. Engineering, *Sustainable Energy, KTH.*

  Characterization and Measurement Techniques in Energy wells for heat pumps

- 2010 Technology Licentiate, KTH.

  Improvements of U-pipe Borehole Heat Exchangers

- 2013 PhD, KTH

  Distributed Thermal Response Test: New insights in U-pipe and Coaxial BHEs in groundwater filled boreholes

- 2010-current

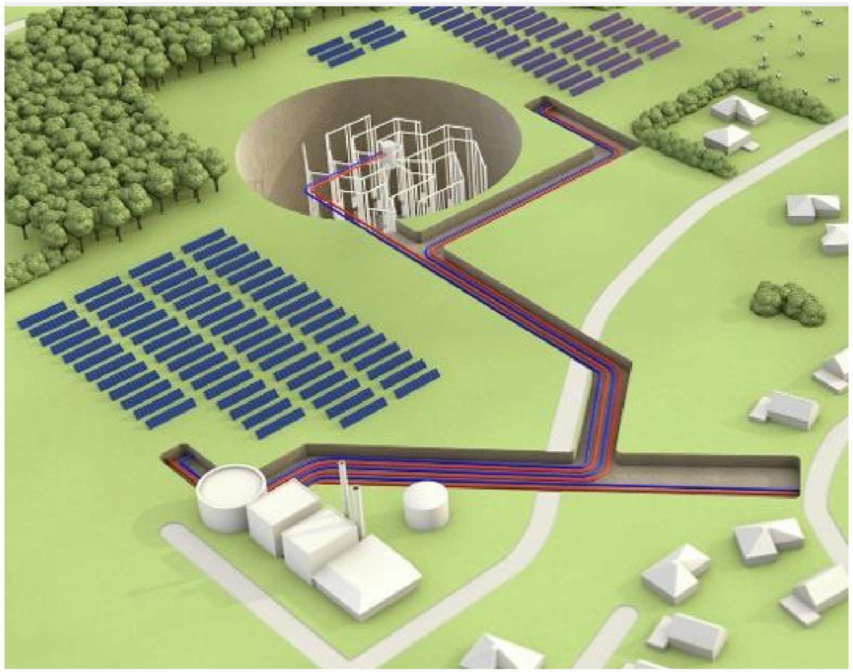
  GSHP energy consultant (at Bengt Dahlgren AB since 2014) and researcher on GSHPs at KTH Royal Institute of Technology.

- Private life

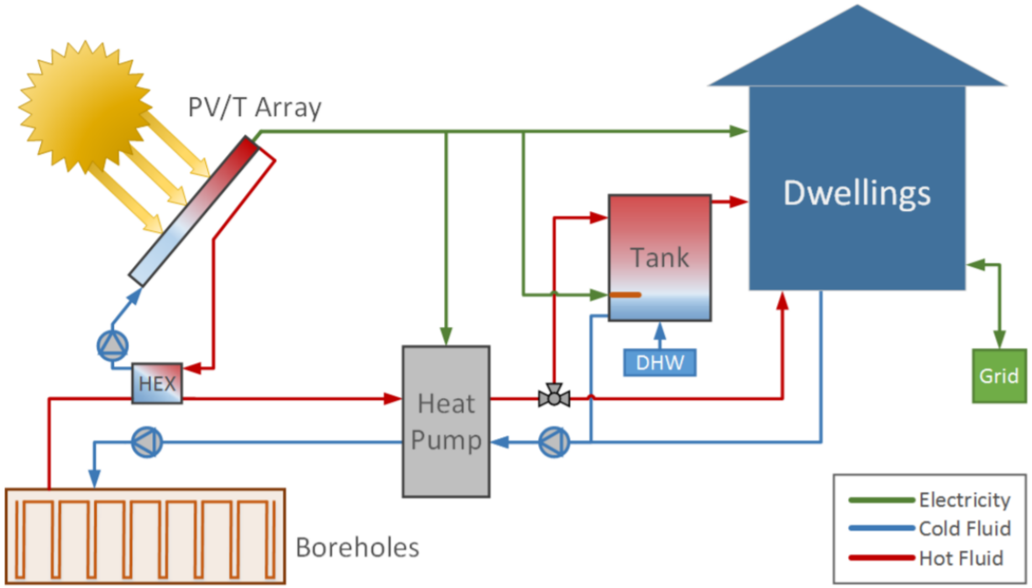
  Happily married, two daughters, play fotboll and a music instrument called Cuatro

STRUCTURE OF THE PRESENTATION

- Background
  - What is important to know in order to understand design of borehole thermal energy storage
- Study cases connected to solar (one low and one high temperature)



(Bjorn, 2018)

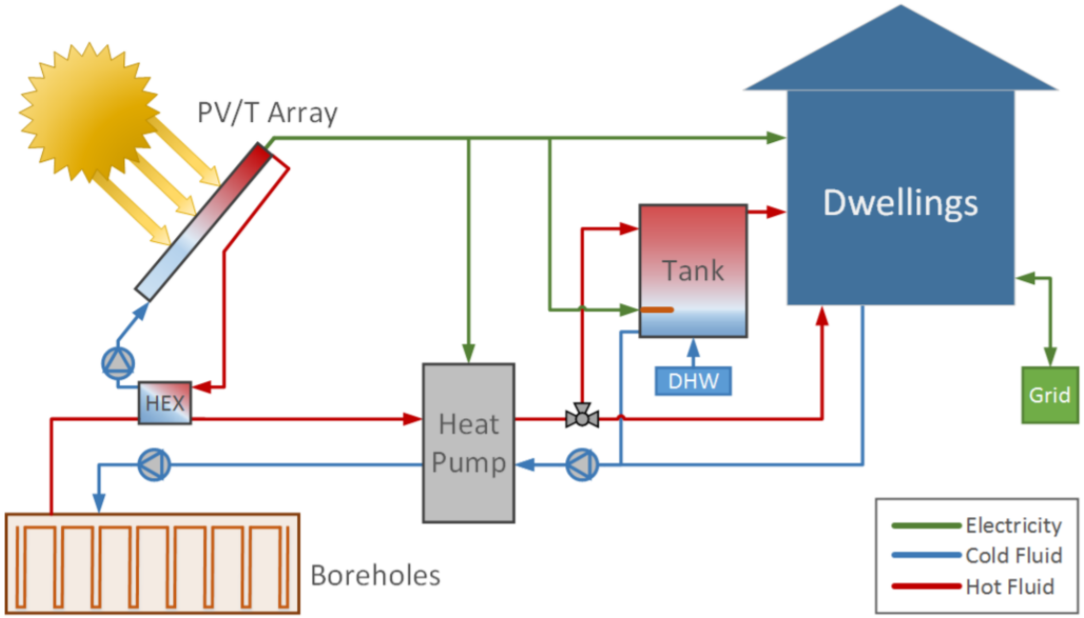


(Sommerfeldt, 2018)

GEO+SOLAR

OPPORTUNITIES

- Heat can be stored
  - Short and long term storage
  - **High and low temperature**
- PV can work more efficiently (low temp case)
- Higher ground source heat pump efficiency thanks to higher temperatures



(Sommerfeldt, 2018)

CHALLENGES

- System complexity
  - Controls, higher installation costs, some non existing products?
- Compromise temperature levels for different parts of the system
  - e.g. ground source cooling

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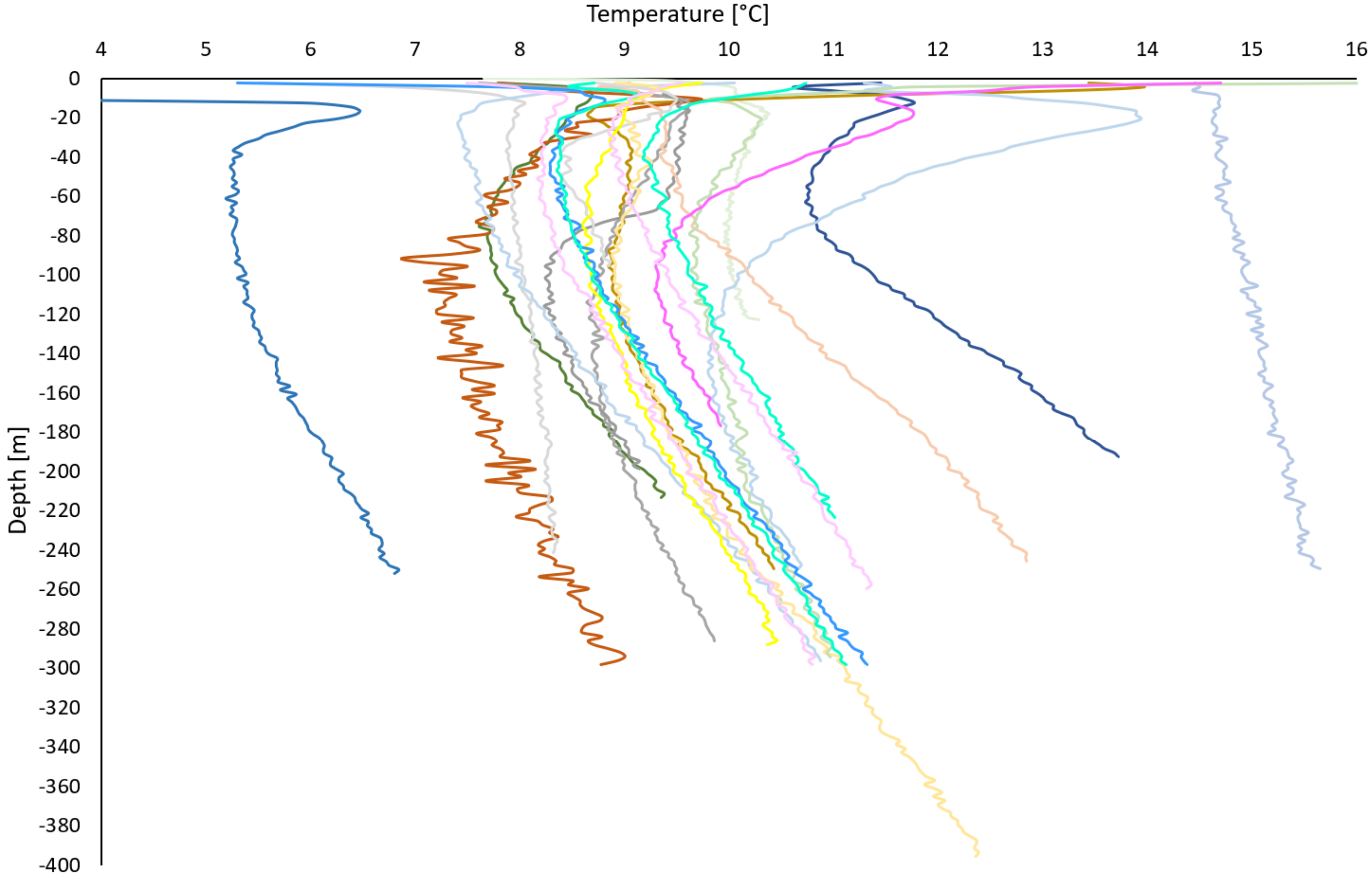
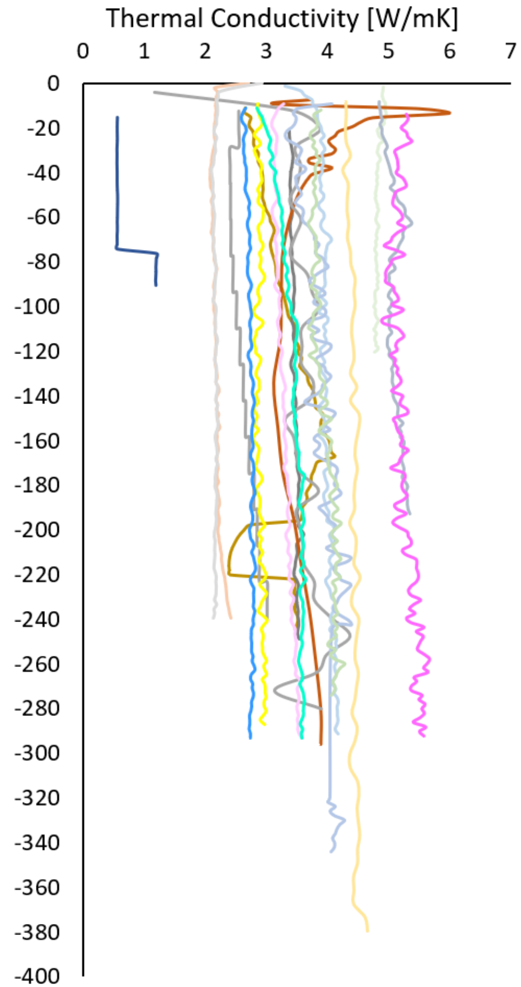
GROUND PROPERTIES

- The average ground temperature at shallow depths is close to the average yearly outdoor temperature. Increases thereafter with a geothermal gradient.
- Thermal properties differ from place to place. Each project can be unique.



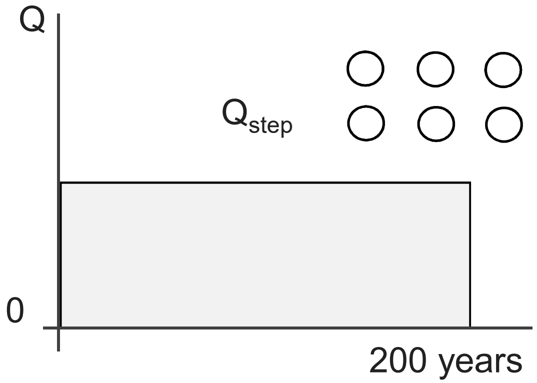


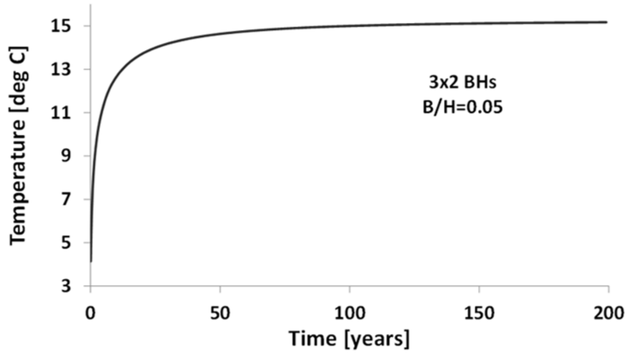
BOREFIELD DESIGN

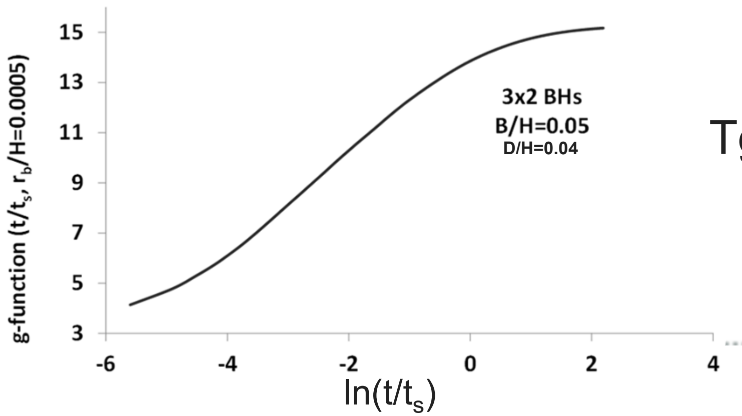
- The depth and number of boreholes as well as the distance between them is determined accounting for:
  - Available drilling area
  - Ground properties
  - Design temperature levels and limits set by the system and application
  - Expected energy and power coverage
    - How much heat will be injected from the solar collectors?
    - How much will be extracted for heating purposes?
    - How much will be injected while using the boreholes for cooling?

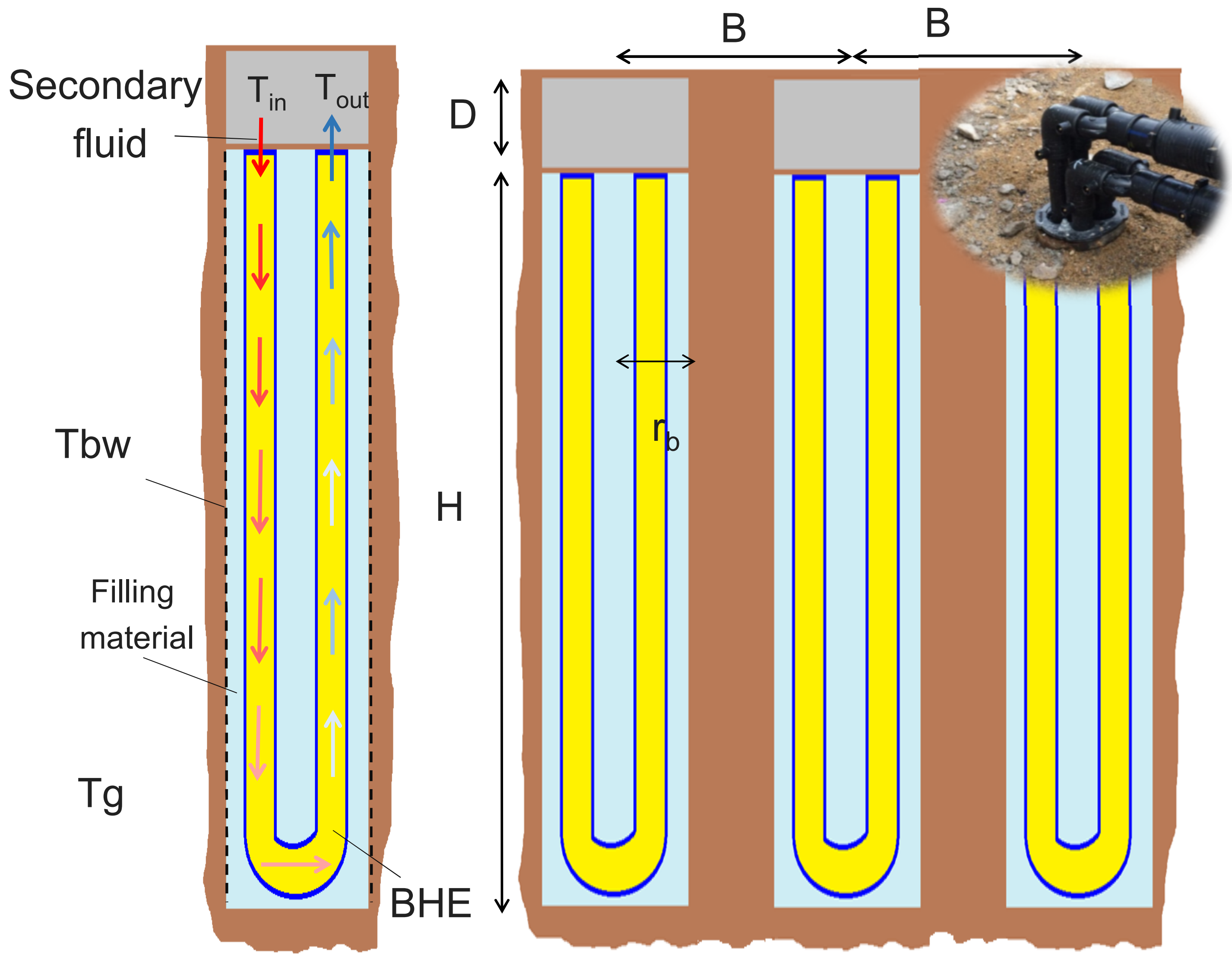
CHARACTERIZATION OF A BOREHOLE FIELD

$$T_{bw}-T_g=\frac{q}{2\pi k}g\left(\frac{t}{t_s},\frac{r_b}{H},\frac{B}{H},\frac{D}{H}\right)$$



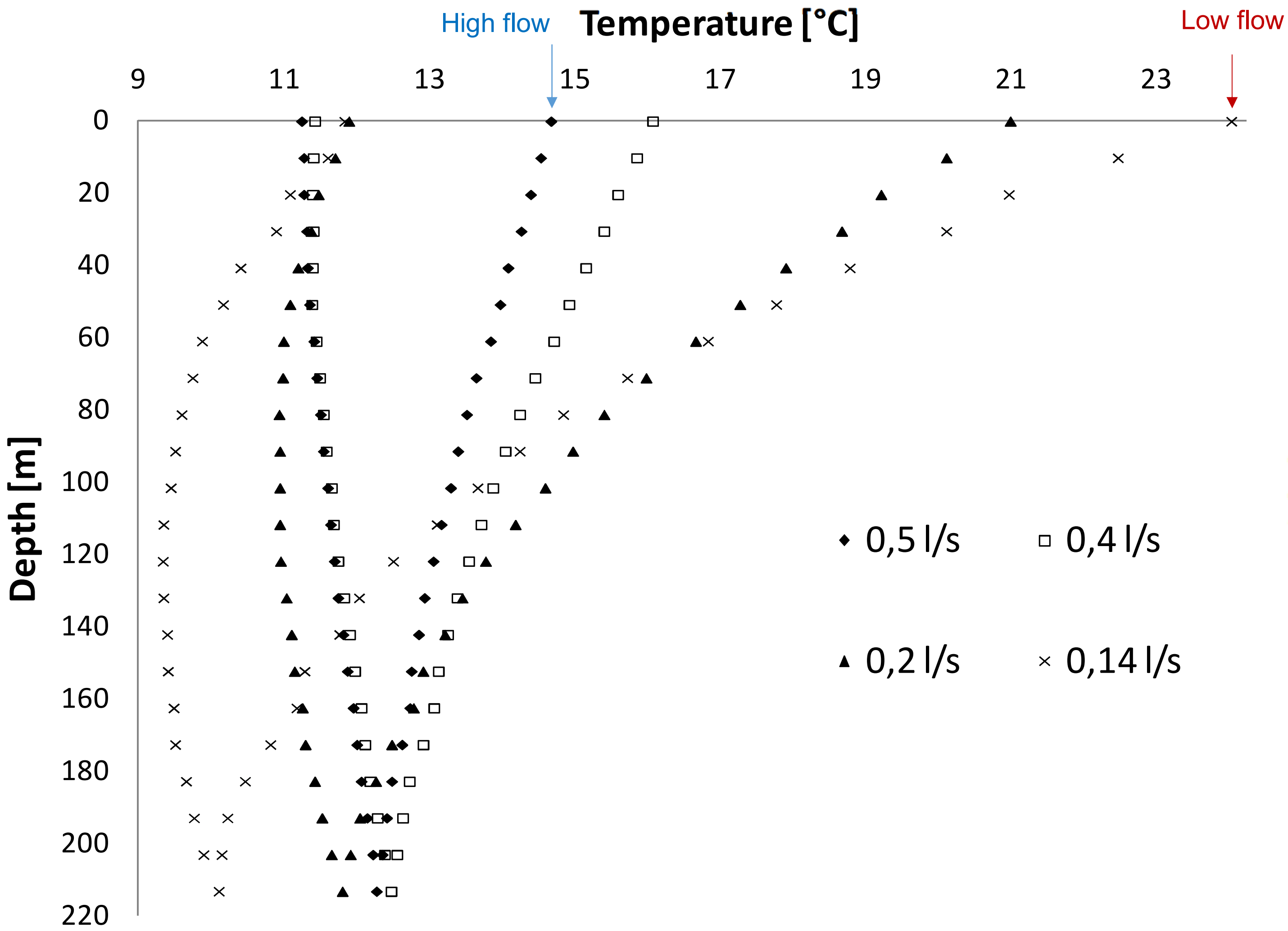


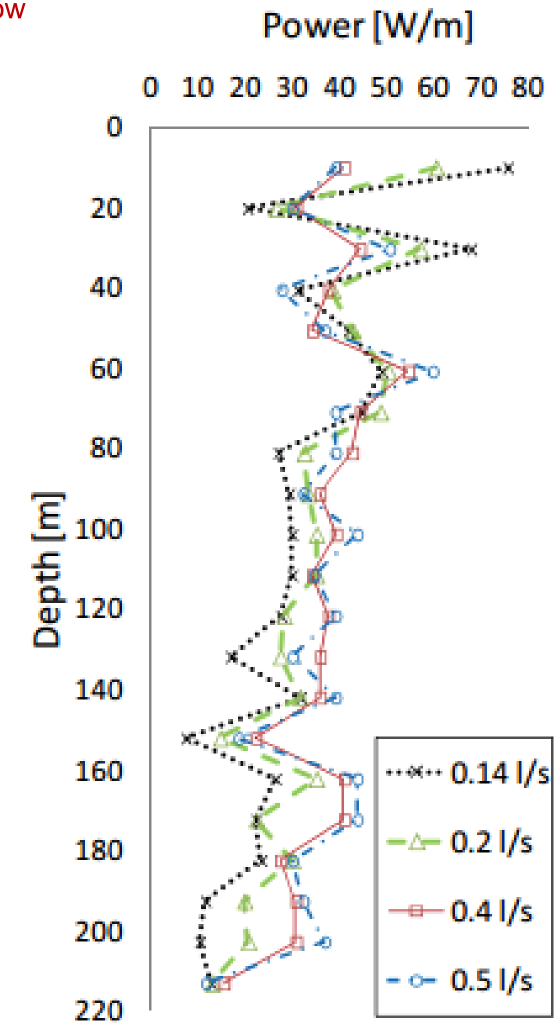




(Monzó, 2018)

INSIDE THE BOREHOLES DURING HEAT INJECTION

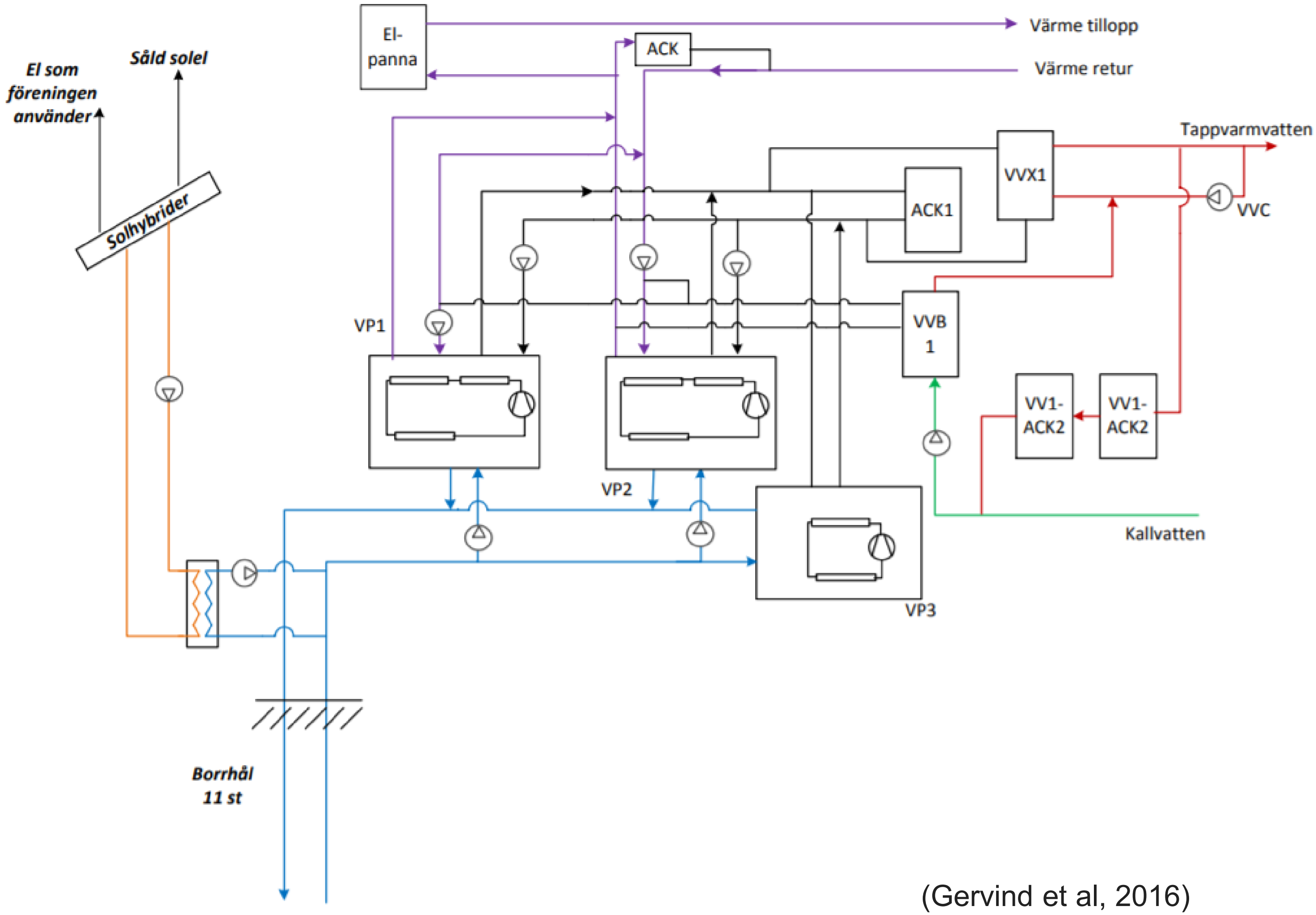




(Acuña, 2013)

STUDY CASE: HOUSING COOPERATIVE VÅRLÖKEN I KUNGÄLV

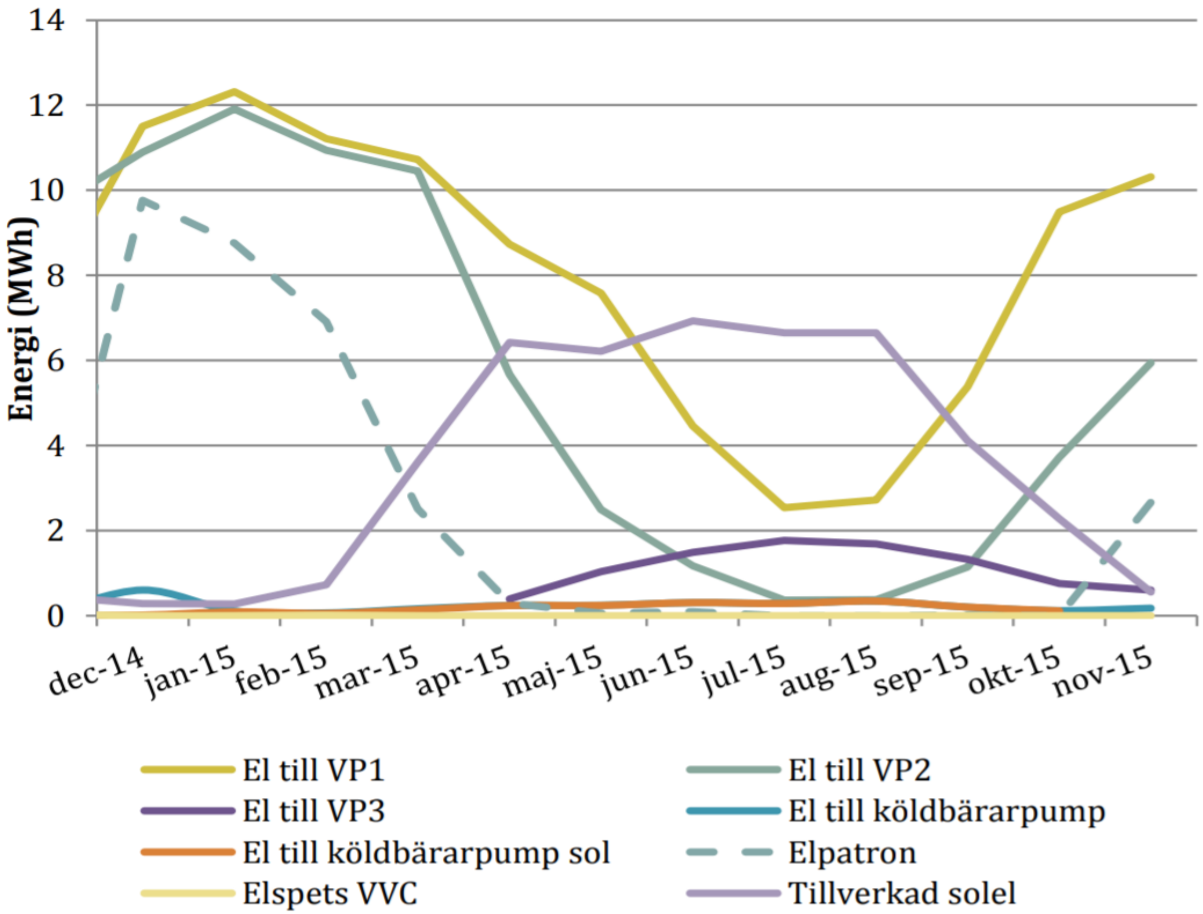
- Switch from district heating to PVT + geo
- 330 sqm PVT
- 11 boreholes
  - regtangular configuration
  - 15 m distance
  - Borehole field configuration **<u>not optimum</u>**



(Gervind et al, 2016)

HOUSING COOPERATIVE VÅRLÖKEN I KUNGÄLV

- PVT produces 22% of the electricity needed by the system

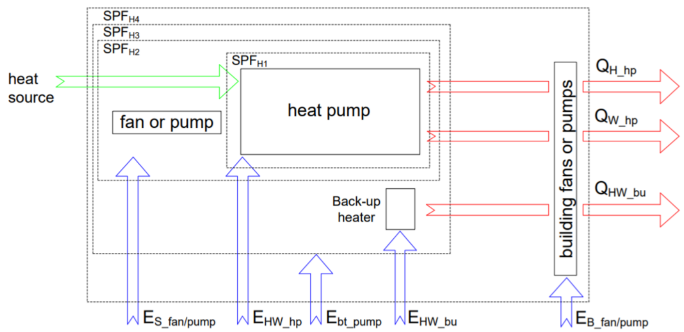


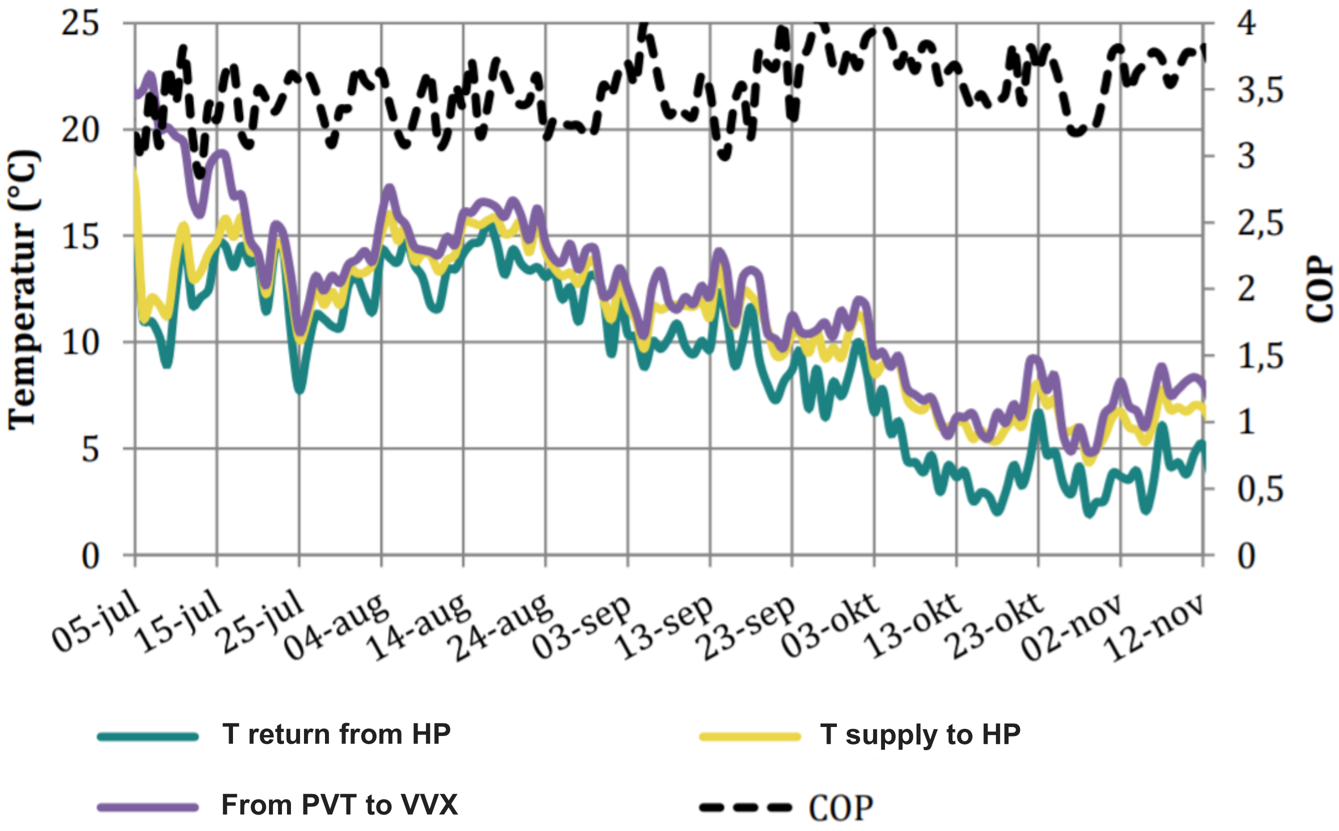
(Gervind et al, 2016)

TEMPERATURE LEVELS AND SYSTEM PERFORMANCE

SPF = 3,1 calculated for the heat pump compressor and circulation pumps

SPF = 2,7 if including peak supply electric heater





(Gervind et al, 2016)

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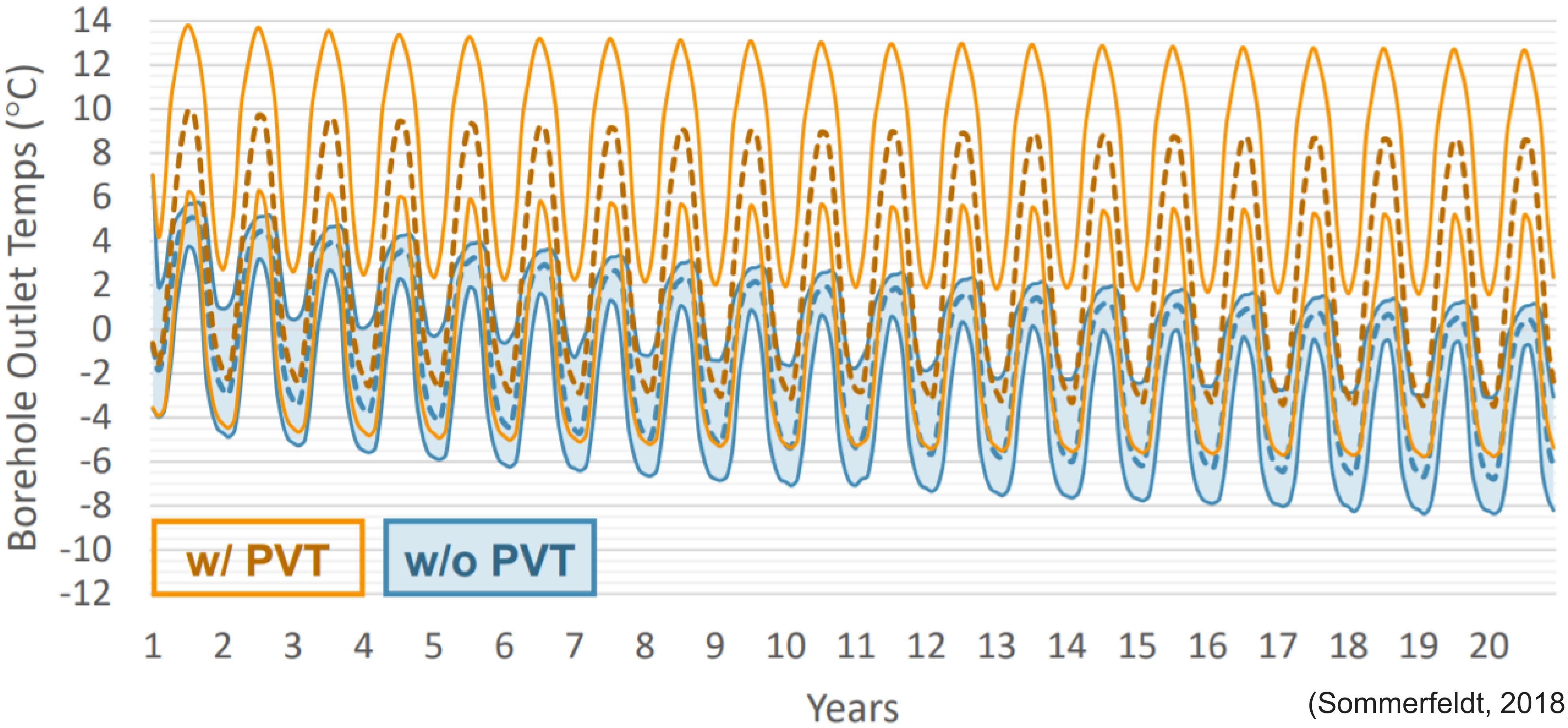
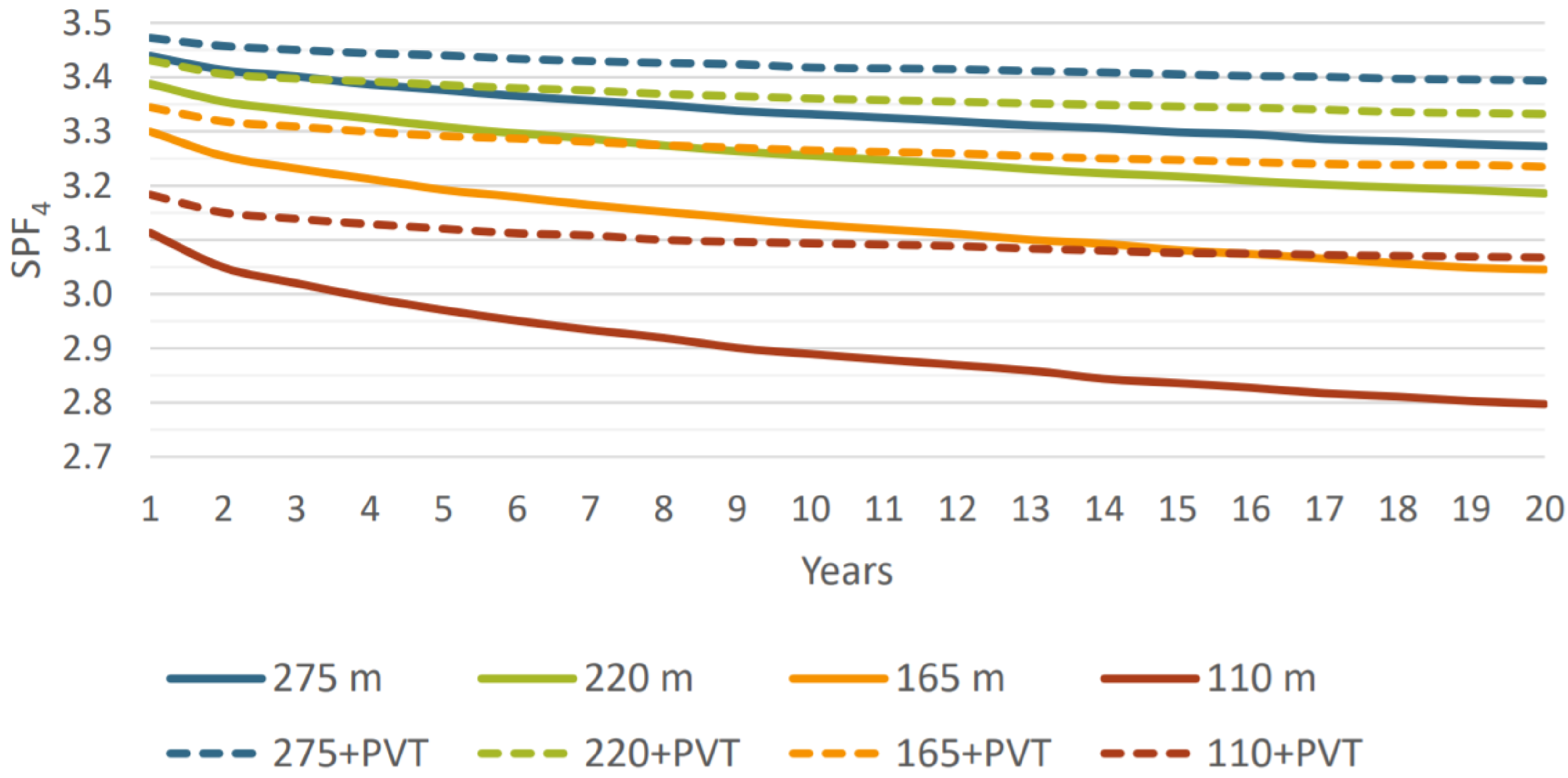
EXAMPLE OF BOREHOLE TEMPERATURES (SIMULATED LOW TEMPERATURE APPLICATION)



(Sommerfeldt, 2018)

SIMULATED LOW TEMPERATURE APPLICATION



(Sommerfeldt, 2018)

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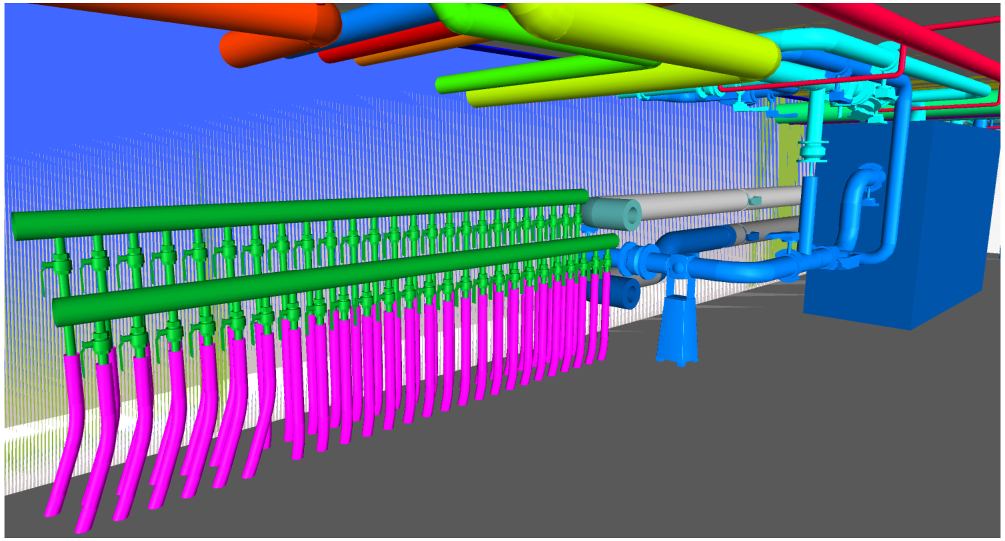
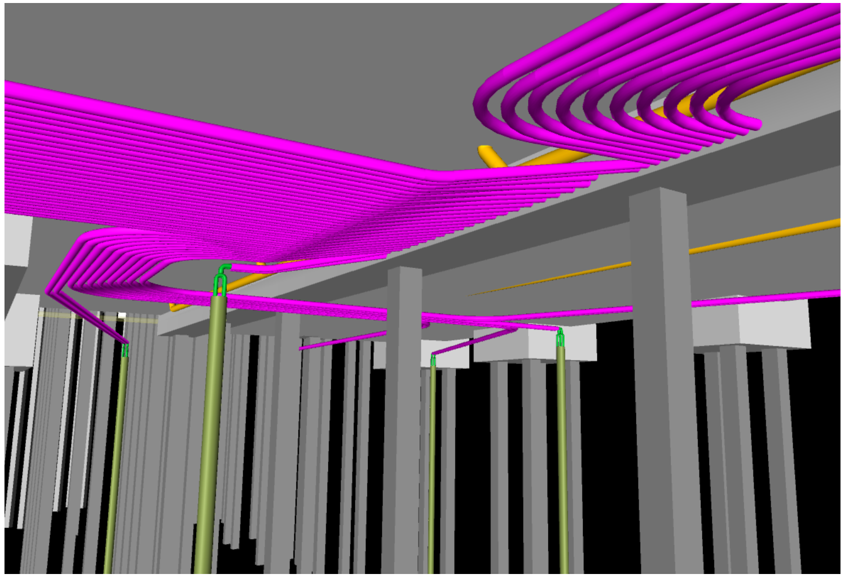
PLANNING AND PRODUCTION OF BOREHOLE FIELD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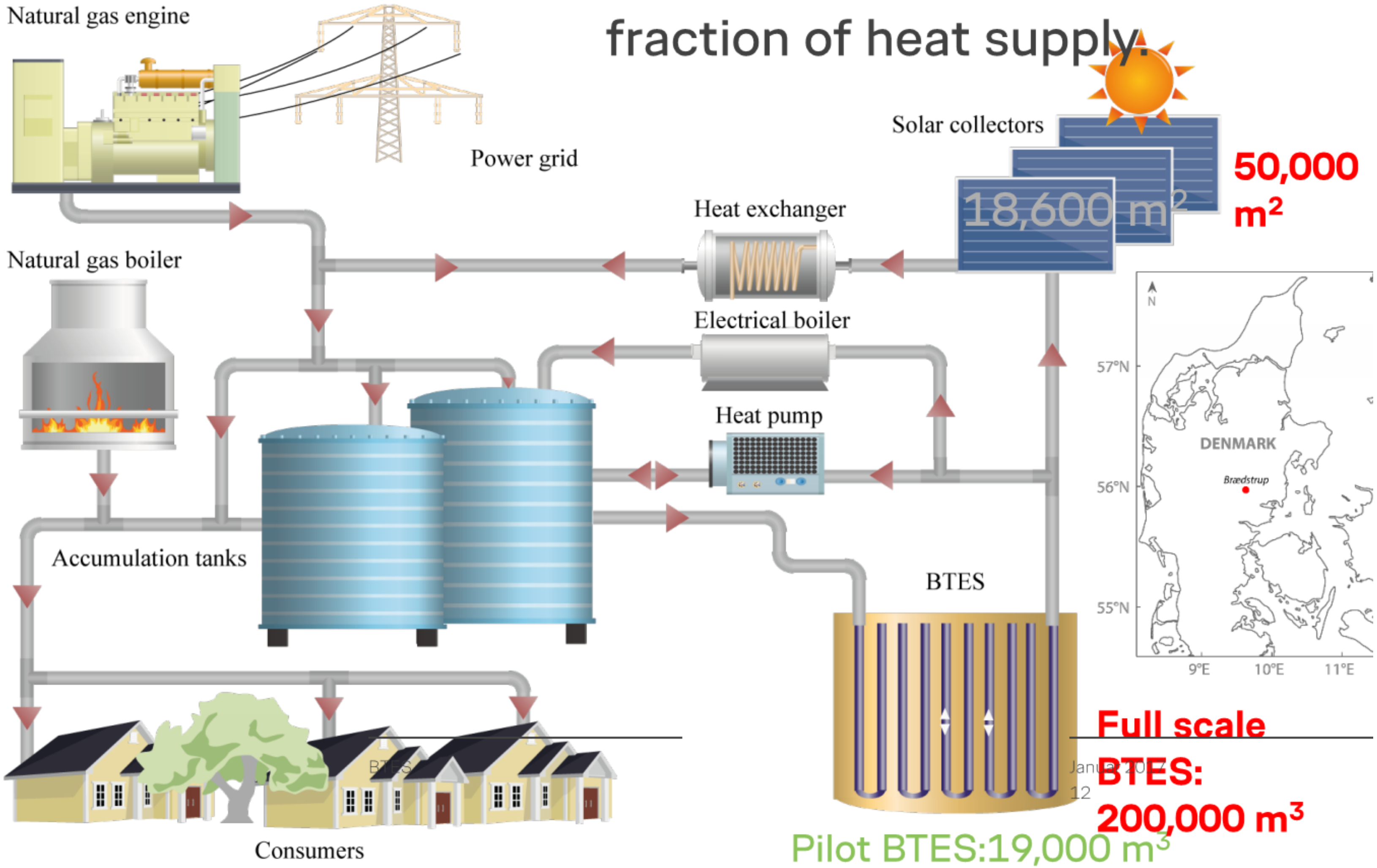
STUDY CASE: BRAEDSTRUP

Full scale: achieve 50% solar fraction of heat supply.



50,000 m²

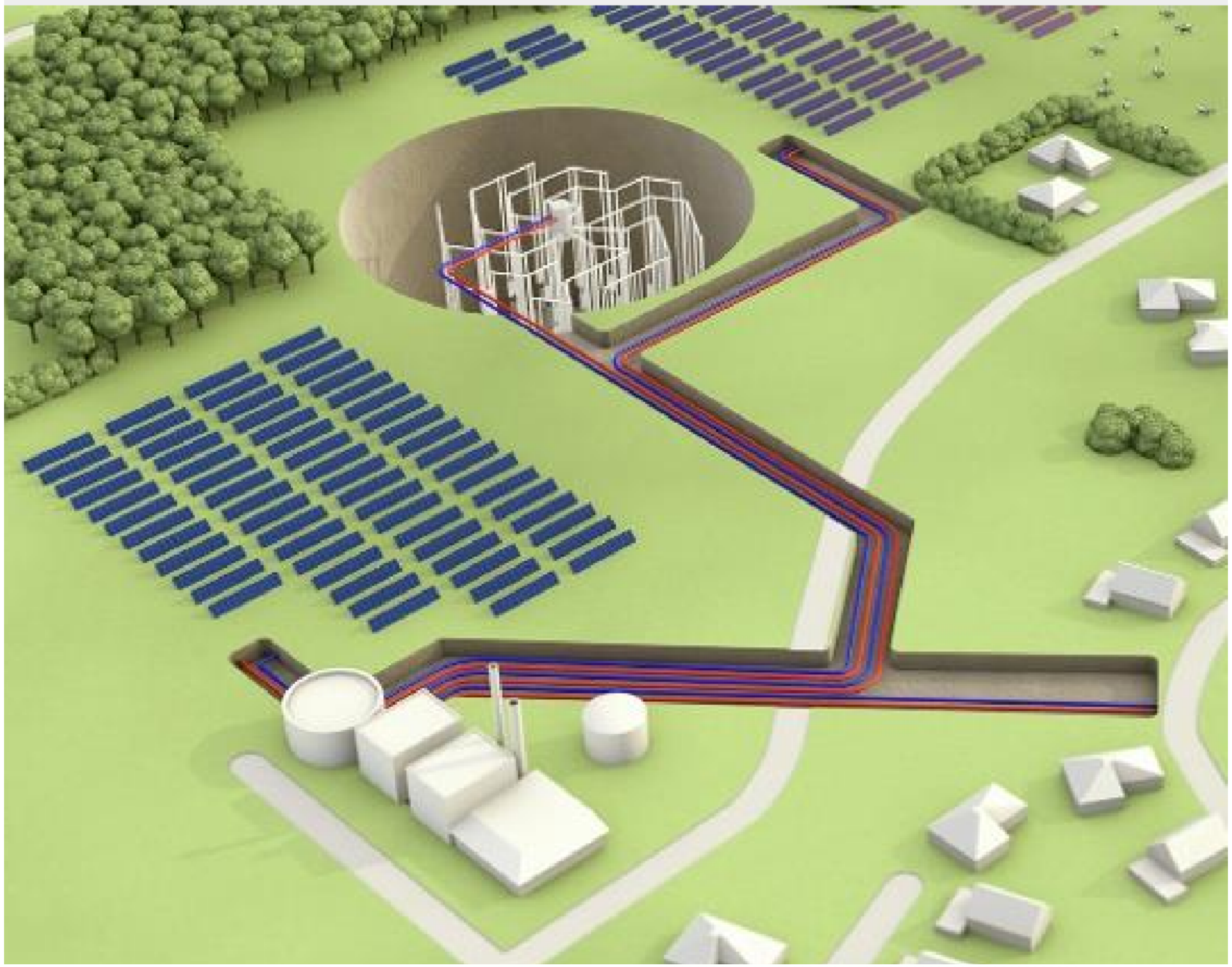
Full scale BTES: 200,000 m³

Pilot BTES:19,000 m³

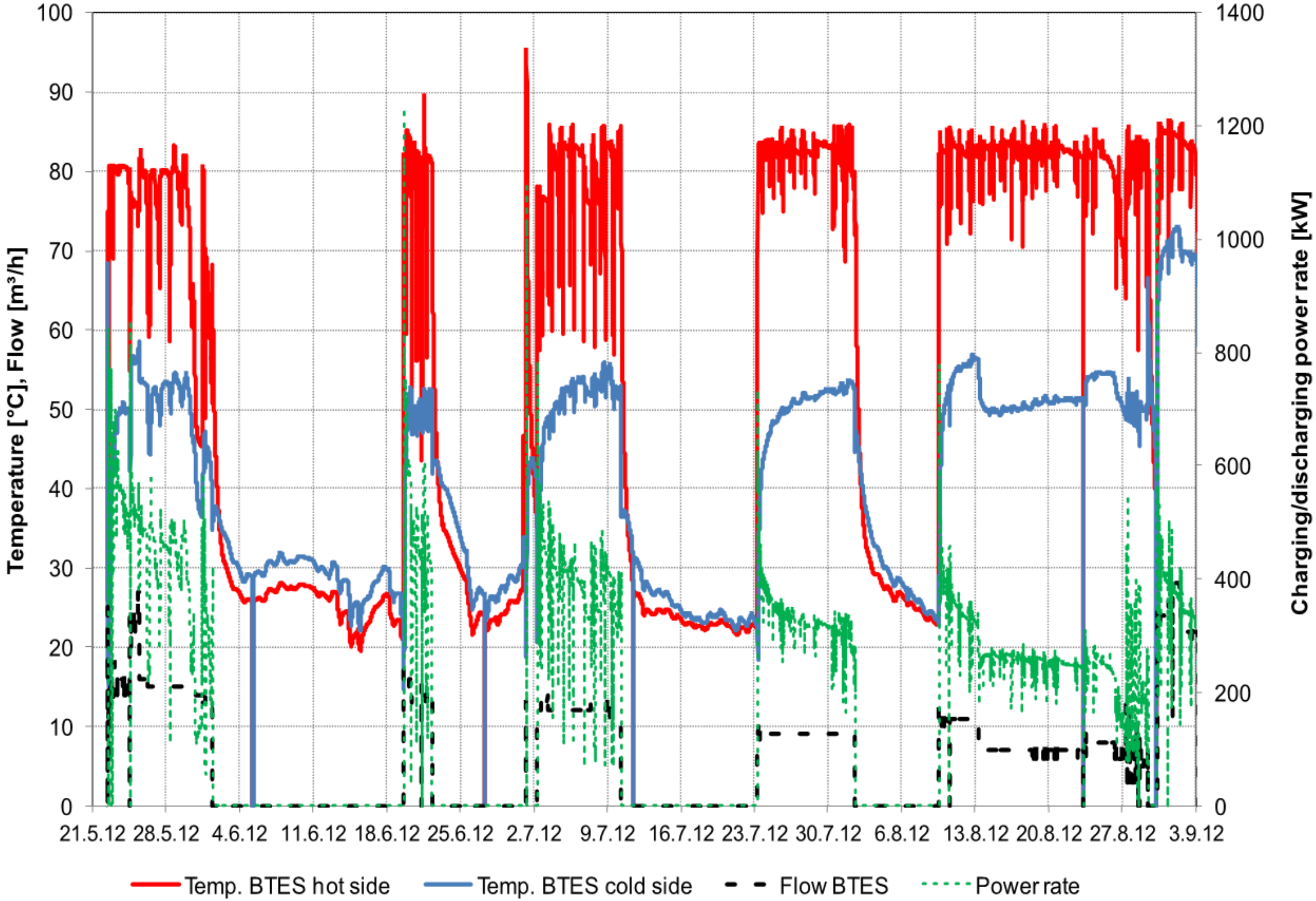
(Tordrup, 2017)

STUDY CASE: BRAEDSTRUP

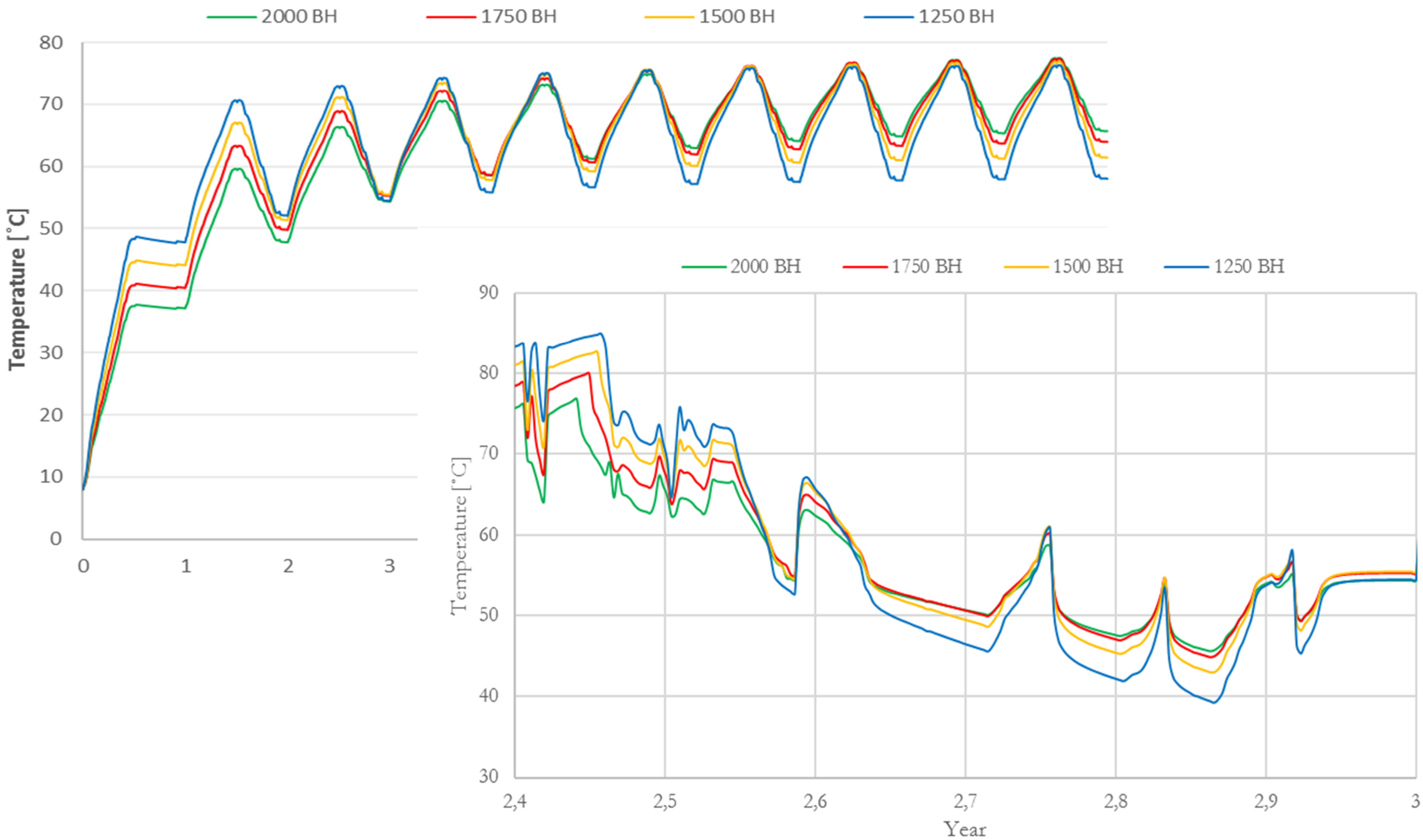
- High temperature



(Bjorn, 2018)


100
90
80
70
60
50
40
30
20
10
0
1400
1200
1000
800
600
400
200
0
Temperature [°C], Flow [m³/h]
Charging/discharging power rate [kW]
21.5.12 28.5.12 4.6.12 11.6.12 18.6.12 25.6.12 2.7.12 9.7.12 16.7.12 23.7.12 30.7.12 6.8.12 13.8.12 20.8.12 27.8.12 3.9.12
Temp. BTES hot side
Temp. BTES cold side
Flow BTES
Power rate

EXAMPLE OF SIMULATED BOREHOLE TEMPERATURE IN LARGE SCALE HIGH TEMPERATURE BOREHOLE FIELD



(Malmberg, 2017)

THANK YOU!

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