Present state, best practice and future developments of geothermal activities in Sweden

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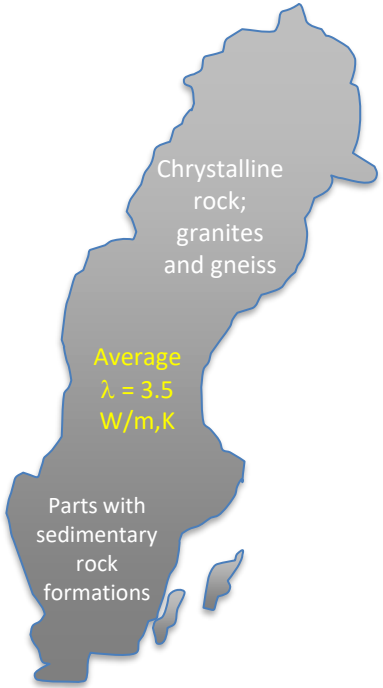
Geothermal energy: Present, Future and Development Strategies
Arbavere Field Research Station, Estonia – June 16th 2022

Eesti Geoloogiateenistus

Majandus- ja Kommunikatsiooniministeerium

Estonian Geothermal Association

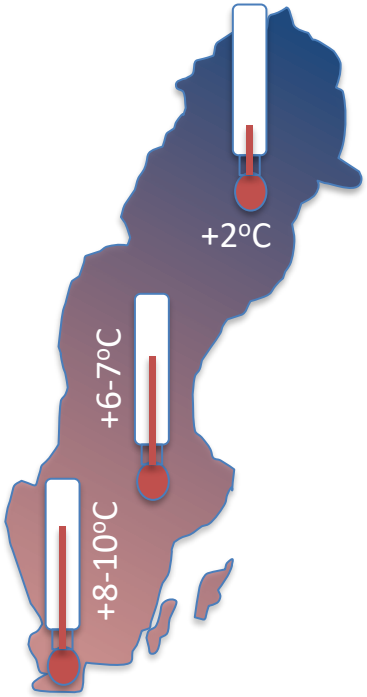
Sweden in a hydrogeological nutshell



Geology



Geothermal gradient



Ground temperature

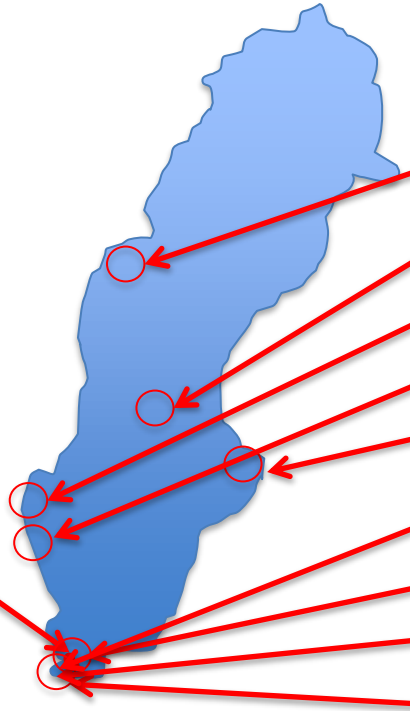


- Generally high groundwater levels
- Aquifers in eskers
- Sandstone aquifers in the south

Groundwater

Deep Geothermal in Sweden

Lund Deep Geothermal Plant
In operation from 1985
Depth 550-800 m
4 + 5 wells
Initially 22°C, now ~20°C
Production at peak in 1993:
~350 GWh
Production 2015-2020:
~100-140 GWh/y
Production in 2021:
~68 GWh



Exploration wells

Åre 2500 m, 2014-

Siljan Impact crater 500-600 m, 2010-2013

Fjällbacka, 500 m, 1984-1995

Göteborg, 1000 m + 1300 m, 2021-2022

Birka 1000 m, 2005

Ljunghusen 2270 m, 1955

Lund 3700 + 1930 m, 2002-2005

Höllviksnäs 2605 m, 1977-79

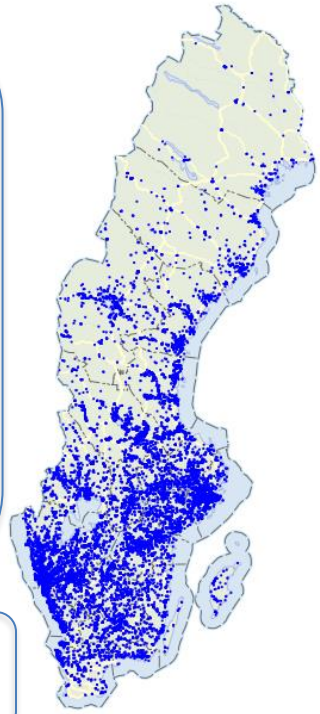
Malmö 2800 m, 2002-2003
2100 m, 2002-2003 => 3133 m, 2020

Shallow Geothermal in Sweden

~600 000 geothermal energy systems in Sweden:

>95% for small residential buildings

75-80% vertical boreholes with heat pump



~450 000 vertical borehole systems

~140 000 horizontal systems

~10 000 groundwater heat pumps

~700 large BTES systems (borehole storage)

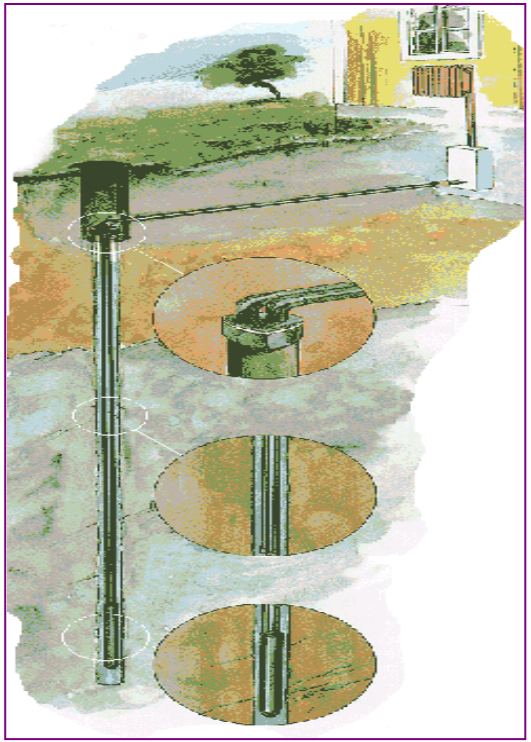
~200 large ATES systems (aquifer storage)

Every 2nd single family building in Sweden is heated by a heat pump (air, water, ground)

Every 4th single family building in Sweden is heated by a ground source heat pump of some sort

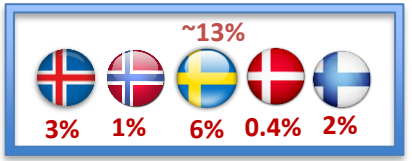
The typical Swedish ground heat exchanger

- Vertical borehole in crystalline rock
- 150-350 m depth
- 114 mm (4 ½'') diameter
- Single U-pipe, PE 40 mm SDR17
- Groundwater-filled (not grouted)
- At least 6 m steel casing through soil, sealed at 2 m depth in rock
- Best practice in guideline document ”Normbrunn-16”

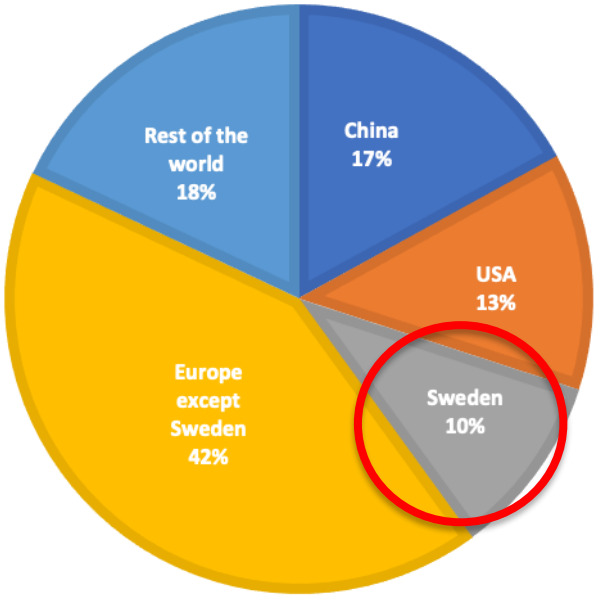


WGC 2010-2020:

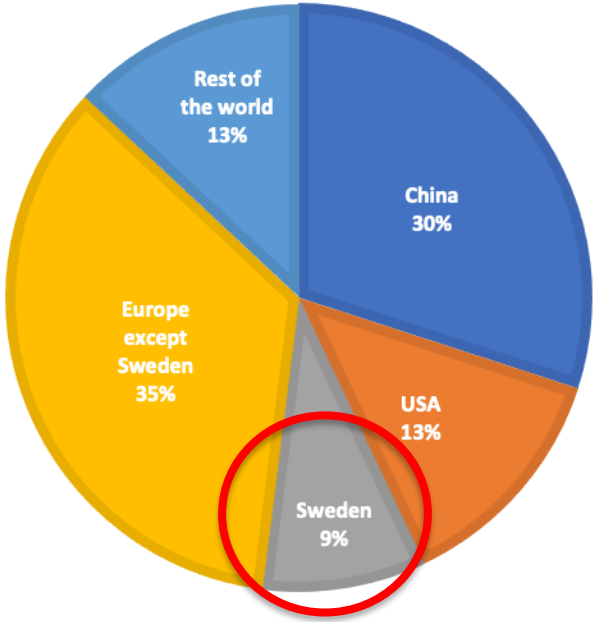
Total Geothermal Direct Energy Use Shares



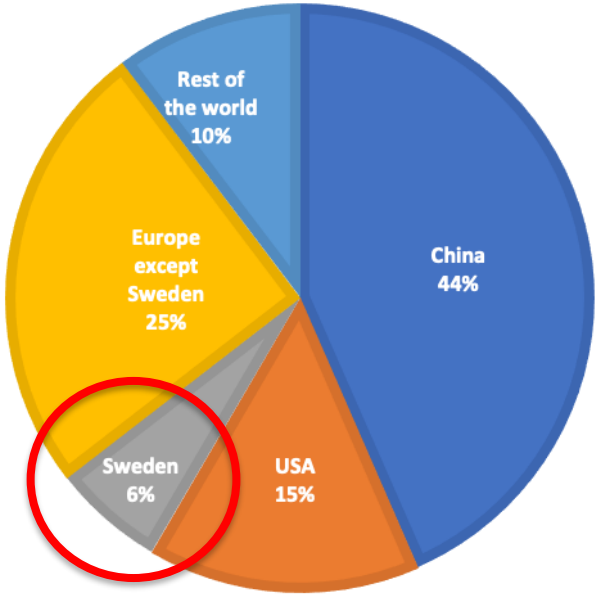
2010
122 TWh



2015
163 TWh

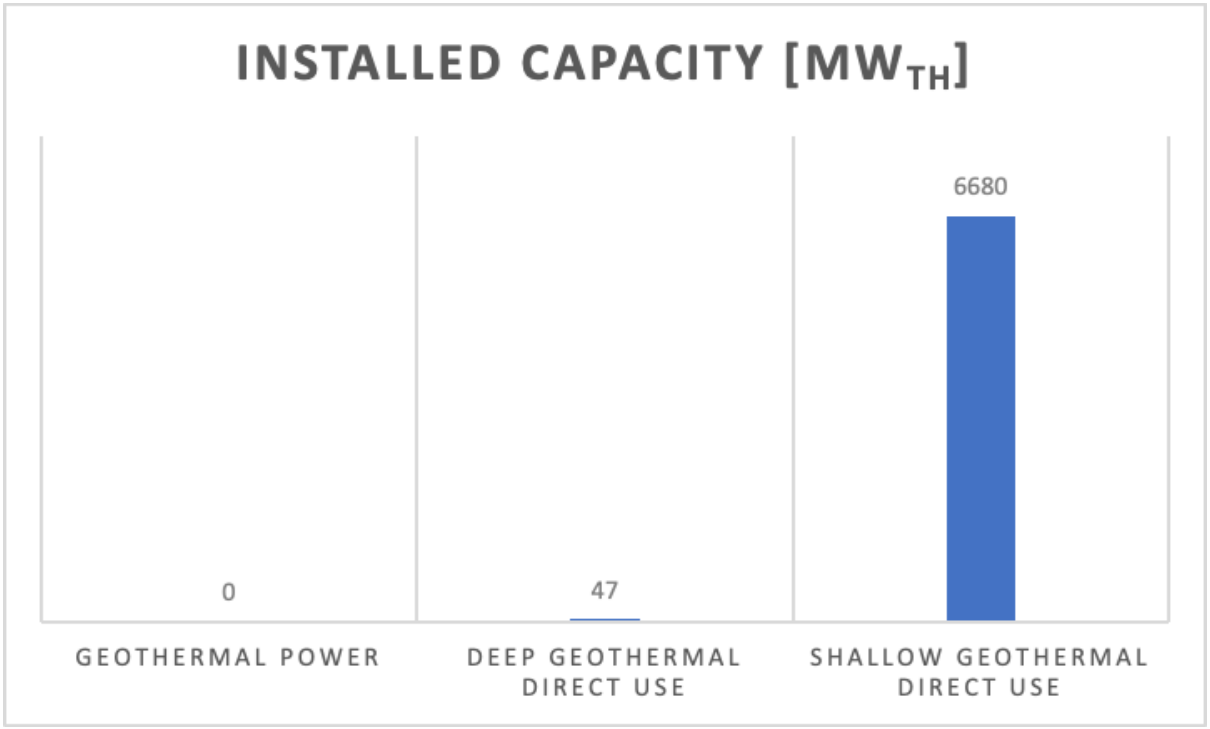


2020
284 TWh



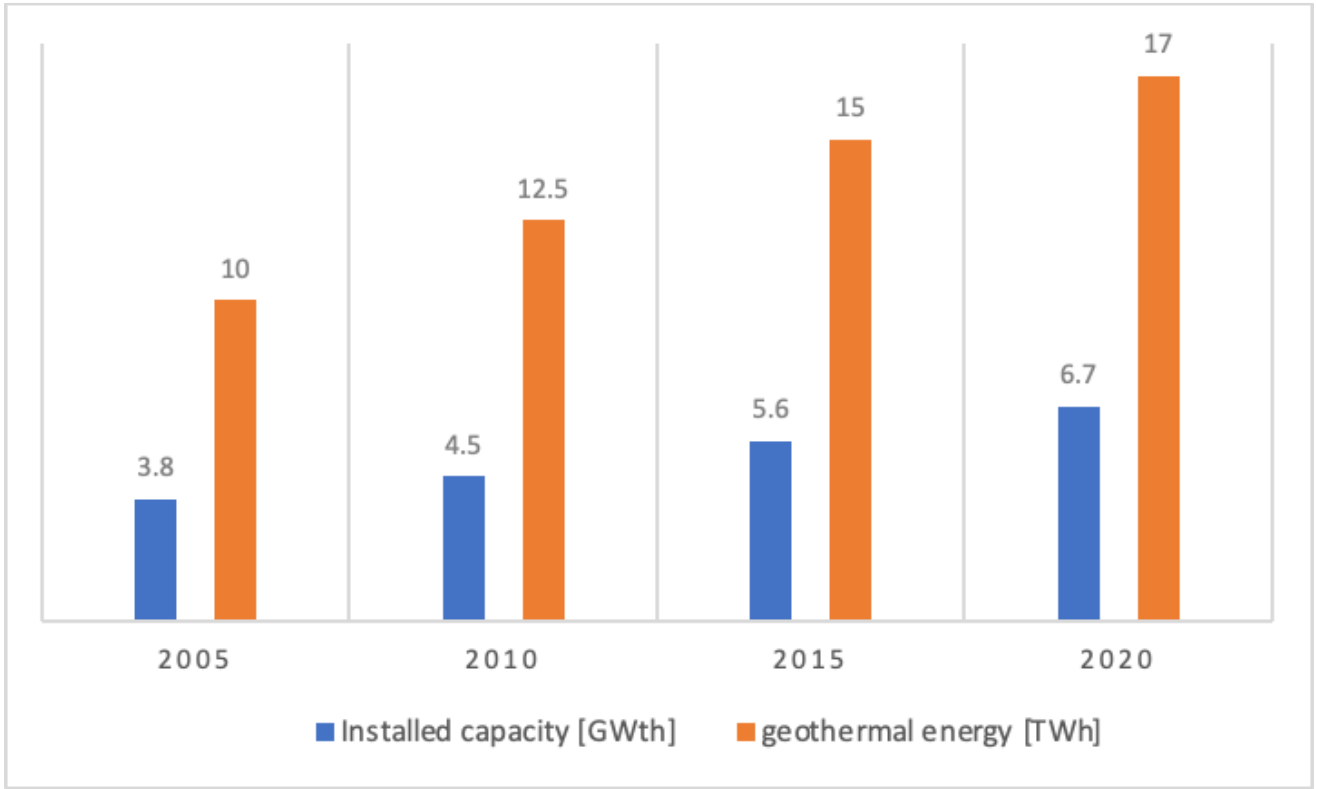
Based on figures from WGC 2010, WGC 2015 and WGC 2020+1 (Lund et al.)

Geothermal in Sweden 2020



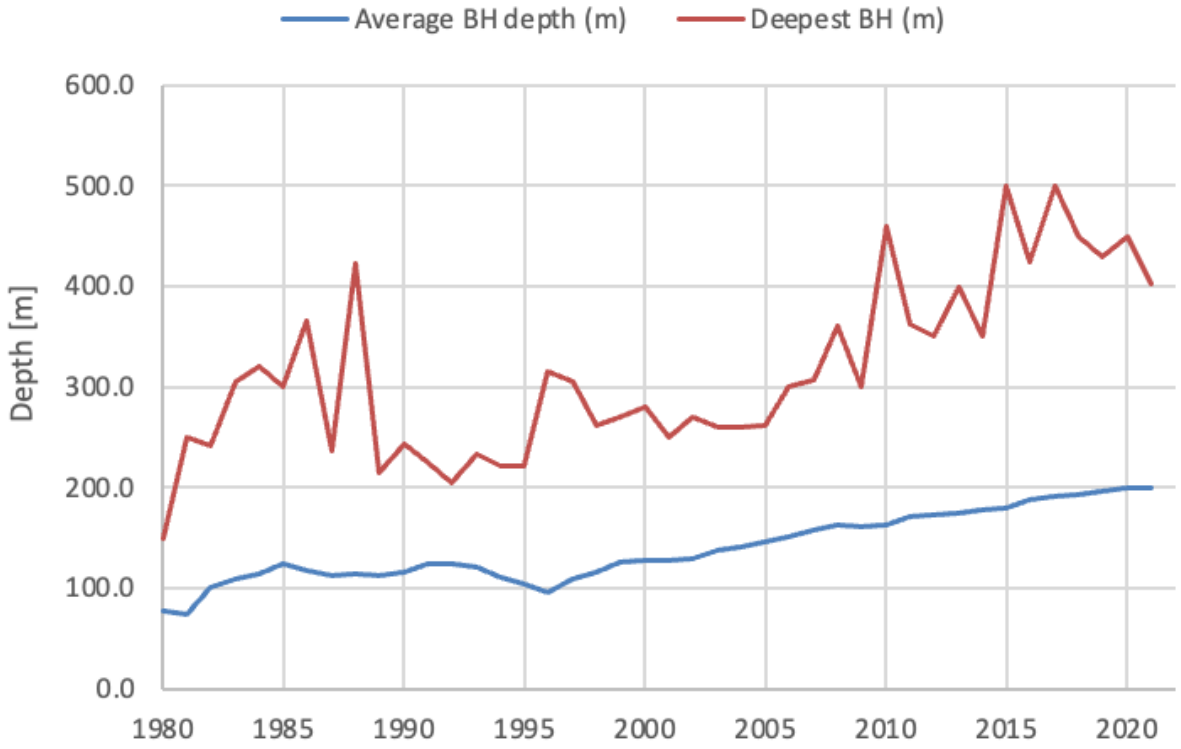
WGC 2020 (Gehlin et al)

Geothermal Energy in Sweden 2005-2020



Figures from WGC 2005 (Lund et al), WGC 2010 (Lund et al), WGC 2015 (Gehlin et al), and WGC 2020 (Gehlin et al)

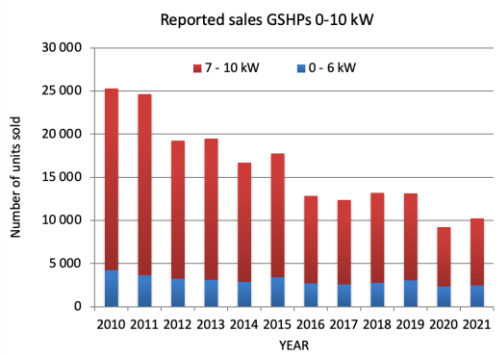
Continued trend towards deeper boreholes

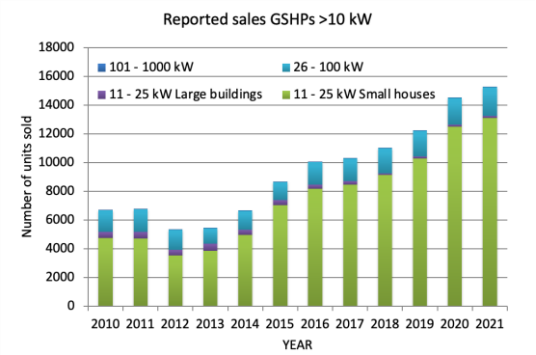


Graph based on data from the Swedish Geological Survey, 2022

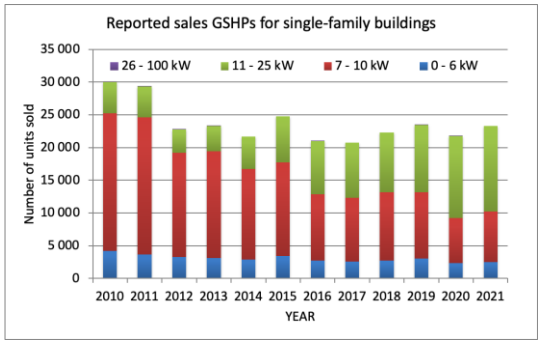
Heat Pump Sales in Sweden

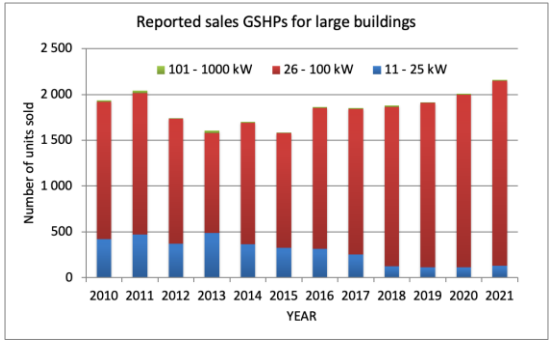
Small systems level out - Larger systems increase





Strong heat pump market 2021-2022, despite component shortage!

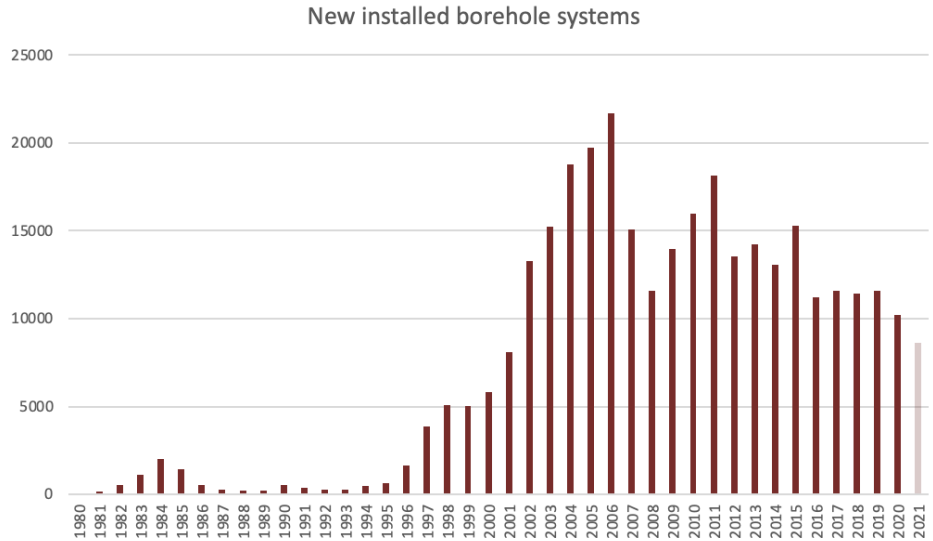


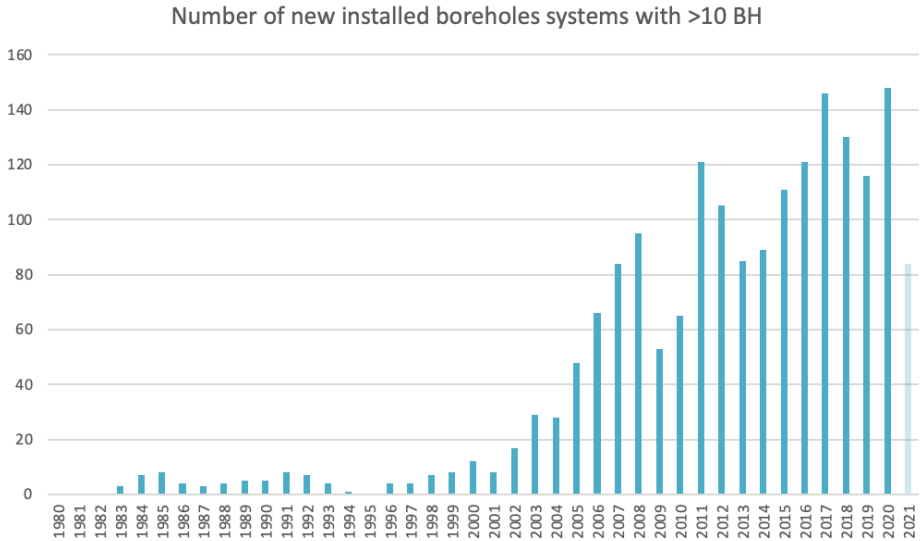


Based on data from The Swedish Heat Pump Association 2022

Shallow geothermal market in Sweden

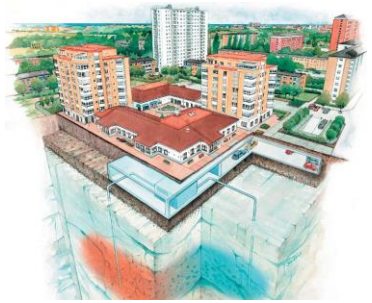
Small systems level out - Larger systems increase

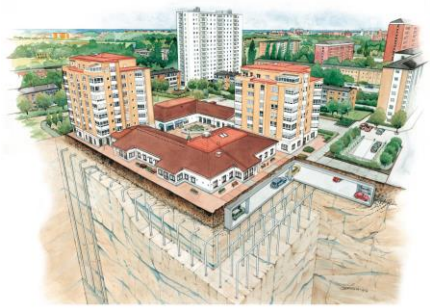




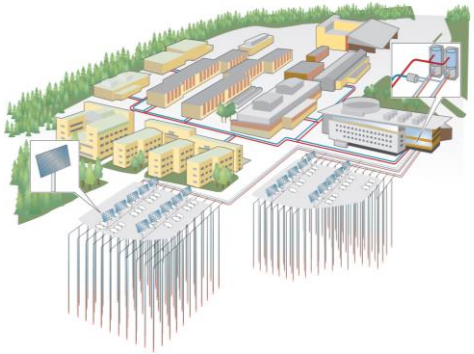
Based on data from Swedish Geological Survey 2022

Best practice and future development





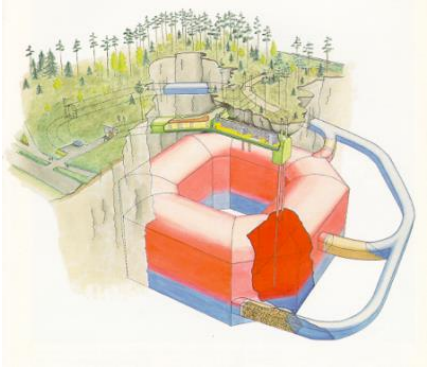
Larger systems mostly more or less balanced ATES and BTES for heating and cooling



Thermal grids/5GDHC



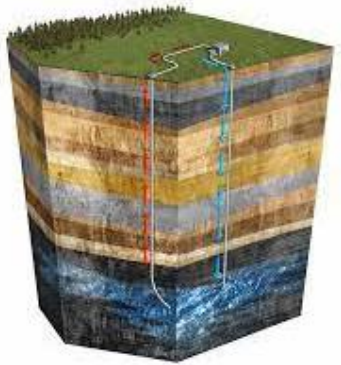
Increased interest in high temperature BTES



CTES



Direct heating/cooling (DGC)

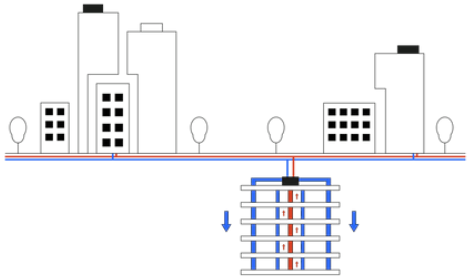


Deep geothermal

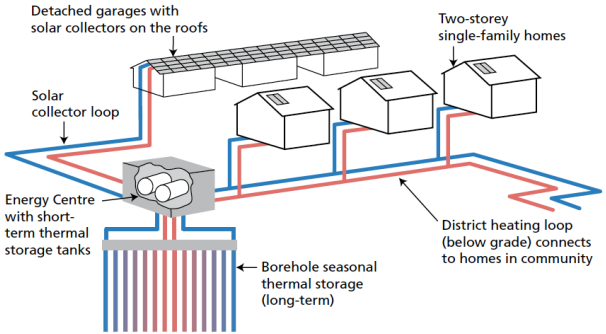
…and some more budding trends



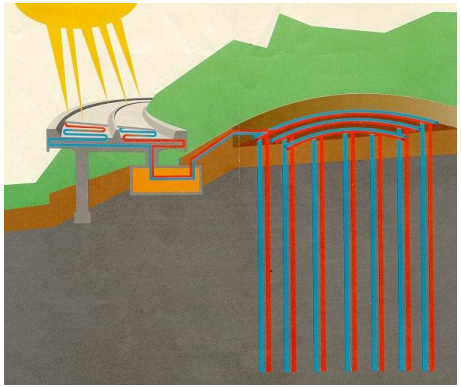
PV+GSHP



Experimental new storage types



Solar heat storage



De-icing of infrastructure

Summary

- Sweden is #3 geothermal country in the world after China and the USA
- Geothermal energy is well developed and is the 4th renewable energy source in Sweden
- Increasing interest in deep geothermal for direct heat
- Increasing average borehole depth (shallow geothermal)
- Increasing number of commercial building applications
- Stable or slightly decreasing trend for the small residental building market
- Several trends and newer applications
  - High temperature borehole thermal energy storage
  - Thermal networks
  - Direct borehole cooling/heating
  - De-icing of infrastructure



Geothermal energy in Sweden 2021:
~20 TWh renewable heating and cooling
=> saves ~42 million barrels of oil/year
~5.6 million tons of oil equivalents
=> Reduces ~17.8 million tons of CO_2 per year

Thanks for your attention!

Gehlin et al 2022 (EGC 2022)