Iceland
Liechtenstein
Norway grants

Norway
grants

Optimization of Shallow Geothermal Energy Resources for Green Transition OptiSGE

Analytical approach to energy supply for GSHP. Examples from Poland.

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Wrocław University of Science and Technology
Faculty of Environmental Engineering

mgr inż. Jarosław Ozimek

DPS Sp. z o.o. Boreholes for heat pumps.
Polish Heat Pump Technology Development Organisation

6th June 2024

POLISH GEOLOGICAL INSTITUTE
MENTE ET MALLEO
1919
NATIONAL RESEARCH INSTITUTE

NORCE

Ground heat pump source - the most important triad

- **DRILLING ASPECT**

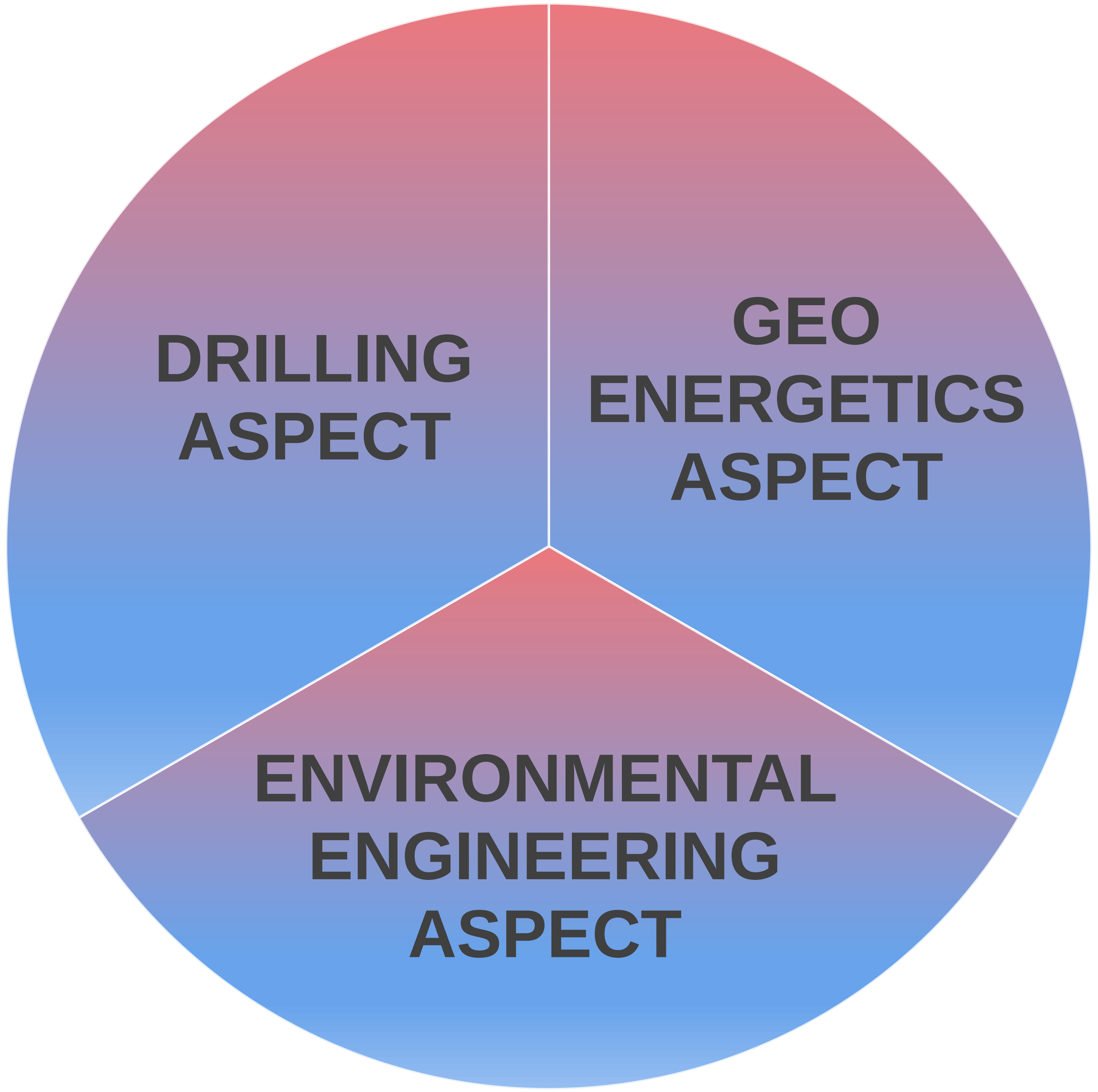
  Design and execution of boreholes

- **ENVIRONMENTAL ENGINEERING ASPECT**

  Design and implementation of horizontal connection network installation

- **GEOENERGETICS ASPECT**

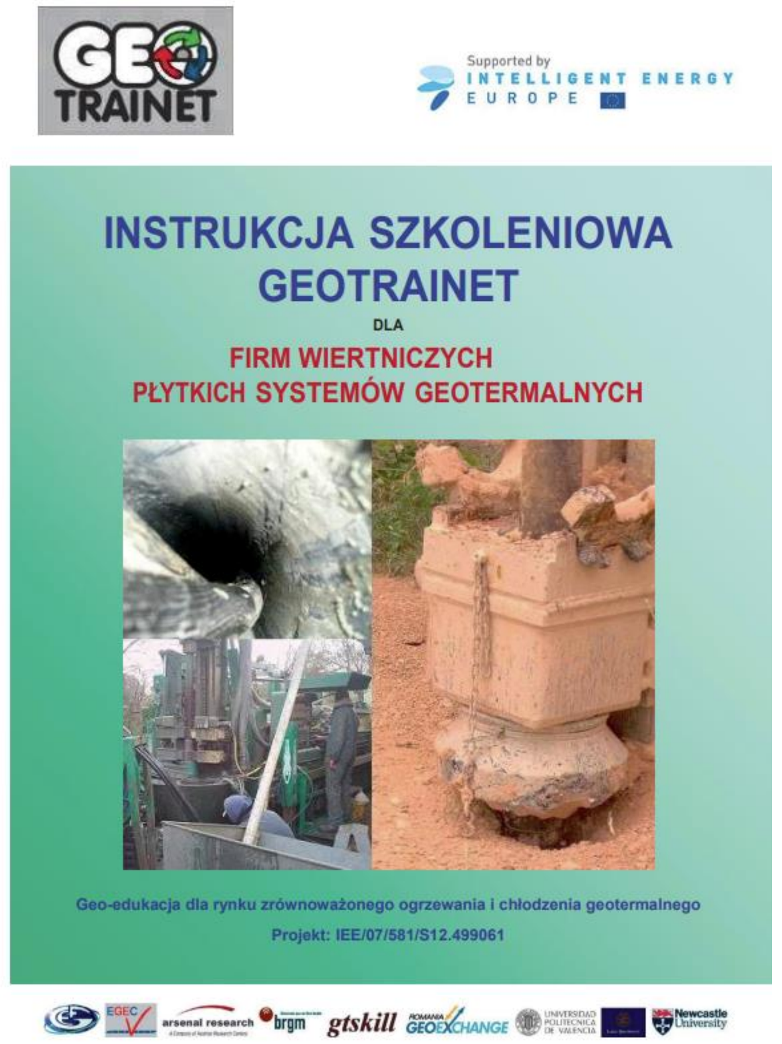
  Determination (confirmation) of number and depth of holes

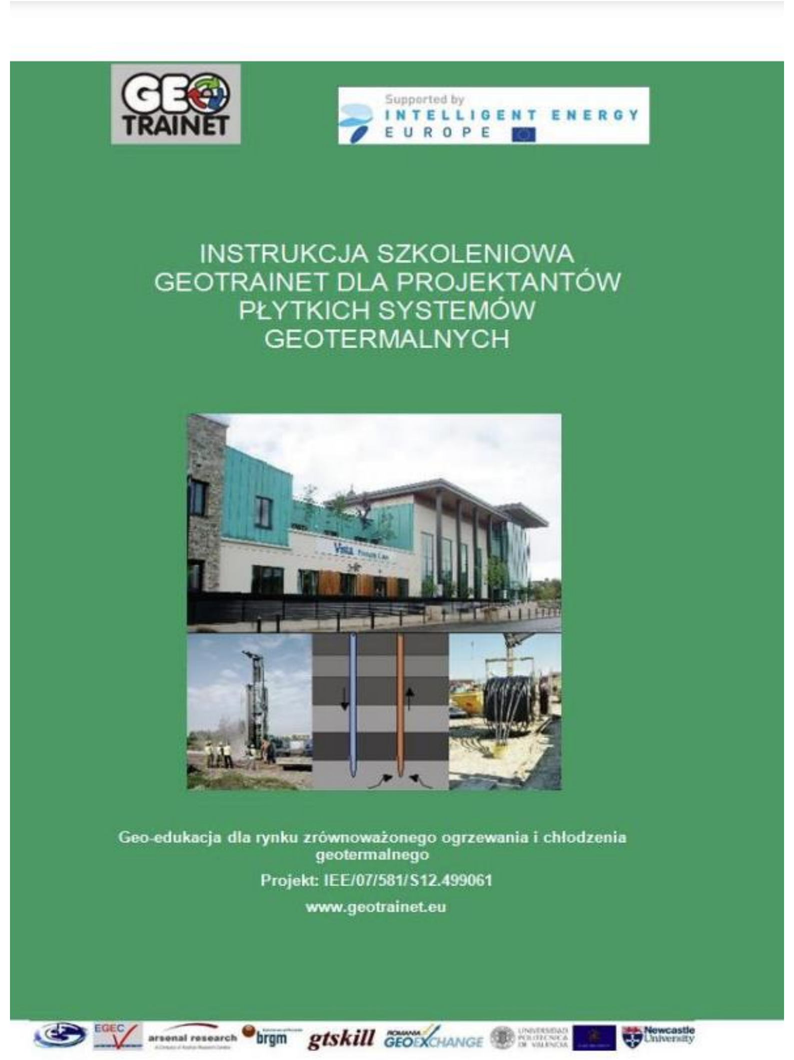


Drilling Aspect

From a market perspective in Poland

- Known formal rules (November 2005, last major revision for GHE in June 2011)
- Large contractor base up to 100 mbgl, small for over 250 mbgl,
- Access to equipment, knowledge, experience, training





Geo BOOST
Interreg CENTRAL EUROPE
GeoPLASMA-CE
GEODH
SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

Environmental Engineering Aspect

BOREHOLES CONNECTION AND MAINTAIN PLAN

- Preparation by formal designers.

- Support from manufacturers of GHE components.

- The main parts are repeatable

- But some parts should be calculated for each one separatly

Safety:

- Investor
- Designer
- Contractor

Environmental Engineering Aspect

DESIGN PLAN

- **Technical site plan**
- **Transmission depths and cross-sections**
- **Descriptive part**
- **Materials**
- **Designations**
- **Backfill / ballast**
- **Selection of diameters and manholes**
- **Flow resistance**

- **Environmental considerations**
- **Conservation elements**
- **Culverts and sealing**
- **Land restoration**
- **Soil compaction level**
- **Commissioning (venting)**
- **Acceptance recommendations**
- **Ongoing service**
- **Building law**
- **Acceptances**

Safety:

- Investor
- Designer
- Contractor

Geoenergetic Aspect

for heat pumps with a heating output ≤ 30 kW

- formula estimation method

when the prerequisites for design are met:

- heating power ≤ 30 kW (for B0W35)
- borehole depth 50-200m
- max. 5 vertical GHEs of the same length
- no interaction between GHEs
- 6 m minimum distance between vertical GHEs
- compressor operation 1200 - 2400 h/year at full heat load
- standard heat exchanger characteristics

for heat pumps with a heating output > 30 kW

- estimation method according to previous formulae as for pumps with a heating output ≤ 30 kW

<u>and recommendations for executive part:</u>

- drilling a test GHE, measuring λ by performing the TRT Thermal Response Test,
- performing numerical modelling of the temperature field of vertical GHEs for min. 50 years,
- modification of desing, if needed.

Source: Polish Organisation for Heat Pump Technology Development 'Guidelines for Designing, Executing and Accepting Heat Pump Installations. Part 1. Ground sources for heat pumps. Second Edition 09/2021"

Geoenergetic Aspect

For very large heat pumps – Analytical approach

Design part

- Theoretical average thermal conductivity of a single heat exchanger (virtual TRT)
- Heat exchanger layout
- Energy response of the hole network

Executive part

- Execution of test borehole to check the implementation on the drilling side
- Execution of the Thermal Response Test to check the implementation on the geoenergetic side
- Possible correction of the energy response of the borehole layout and the borehole network
- Execution of the whole

Safety:

- Investor
- Designer
- Contractor

Geoenergetic Aspect

For very large heat pumps – Analytical approach

Part 1 - Determination of estimated average thermal conductivity

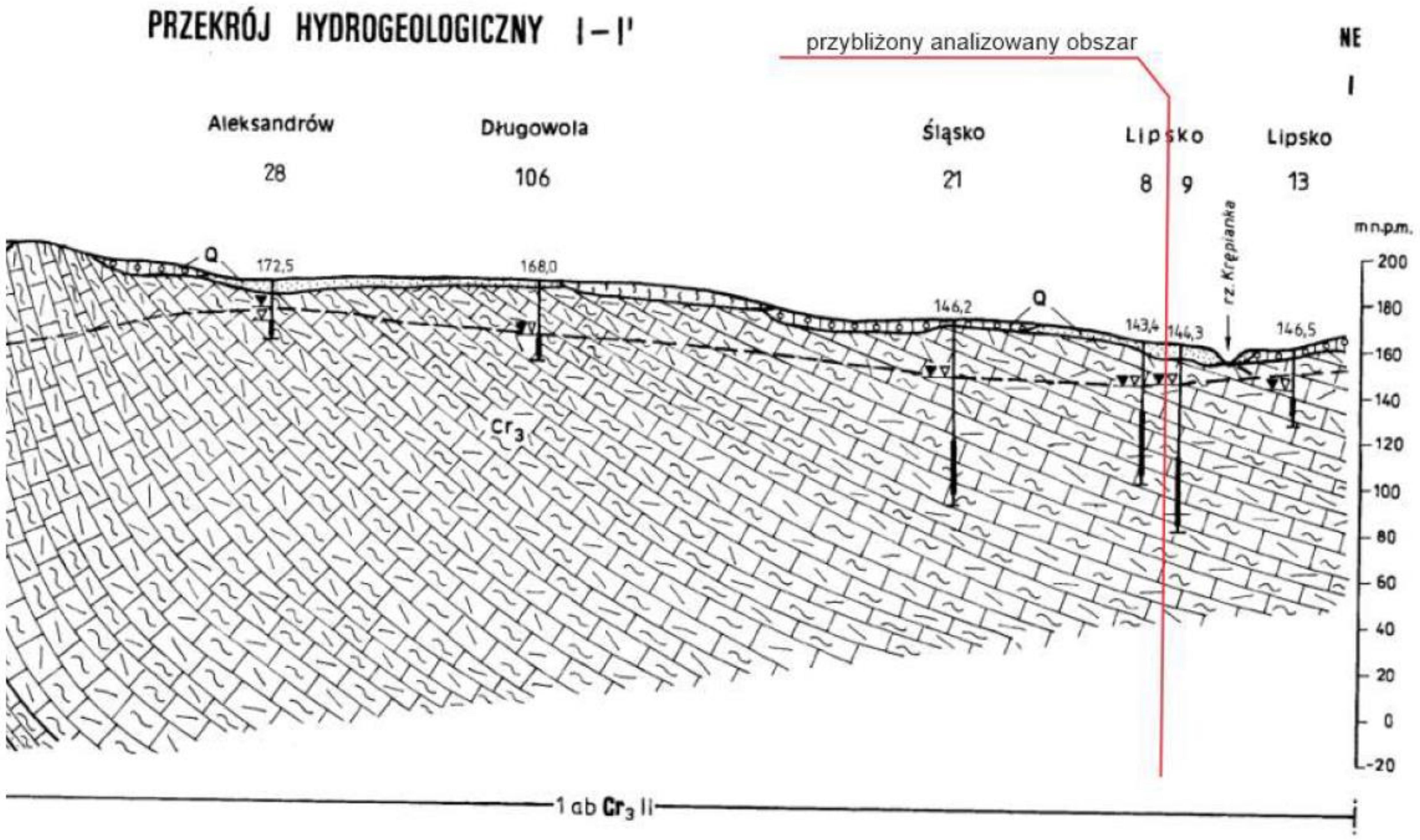
- **Geological and geoenergetic reconnaissance**

  - **Maps of Poland's low-temperature geothermal potential (geolog.pgi.gov.pl, geologia.pgi.gov.pl)**
  - **Geoplasma-CE web portal (portal.geoplasma-ce.eu)**
  - **Own analysis based on lithological layers and potential studies**

Geoenergetic Aspect

For very large heat pumps – Analytical approach

Part 1 - Determination of estimated average thermal conductivity



QUATERNARY:
 0,0 – 7,0 mbgl.: sands

CREDA:
 7,0 – 250,0 mbgl.: limestone, marls

According to the sources analysed, the water table is expected to be at a depth of approximately 15.0 mbgl.

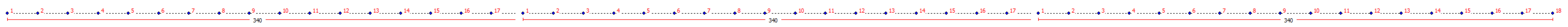
100, 150, 200 and 250 meter GHE λ estimation

Geoenergetic Aspect

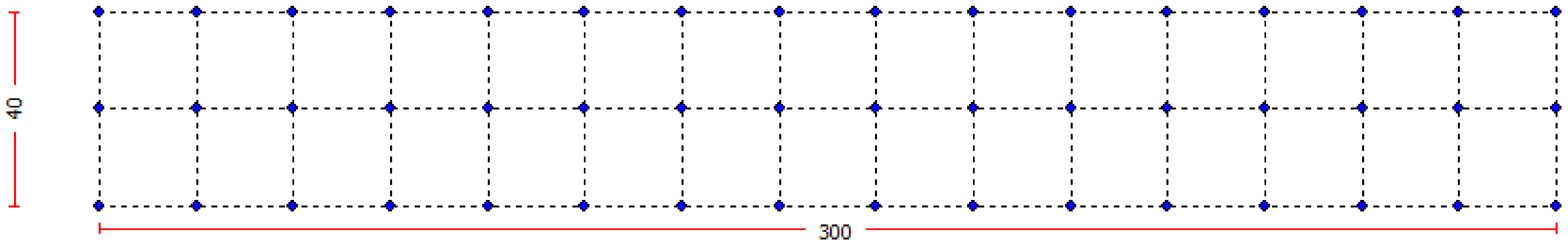
For very large heat pumps – Analytical approach

Part 2 - definition of the hole grid - GHE layout (system type)

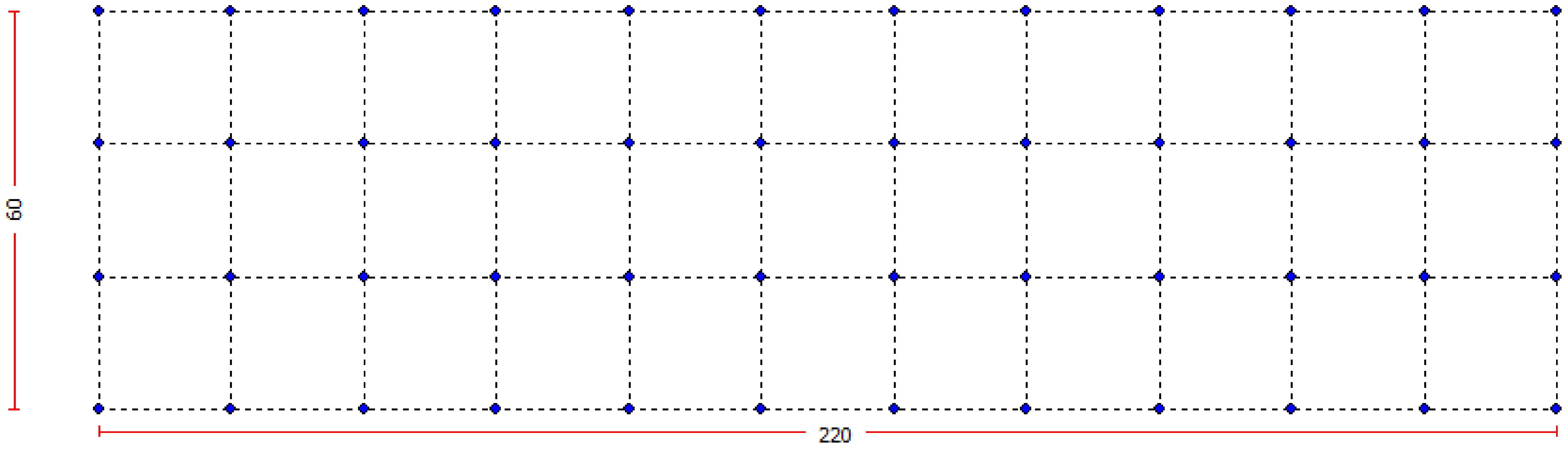
1 row x 48



2 rows x 24



3 rows x 12



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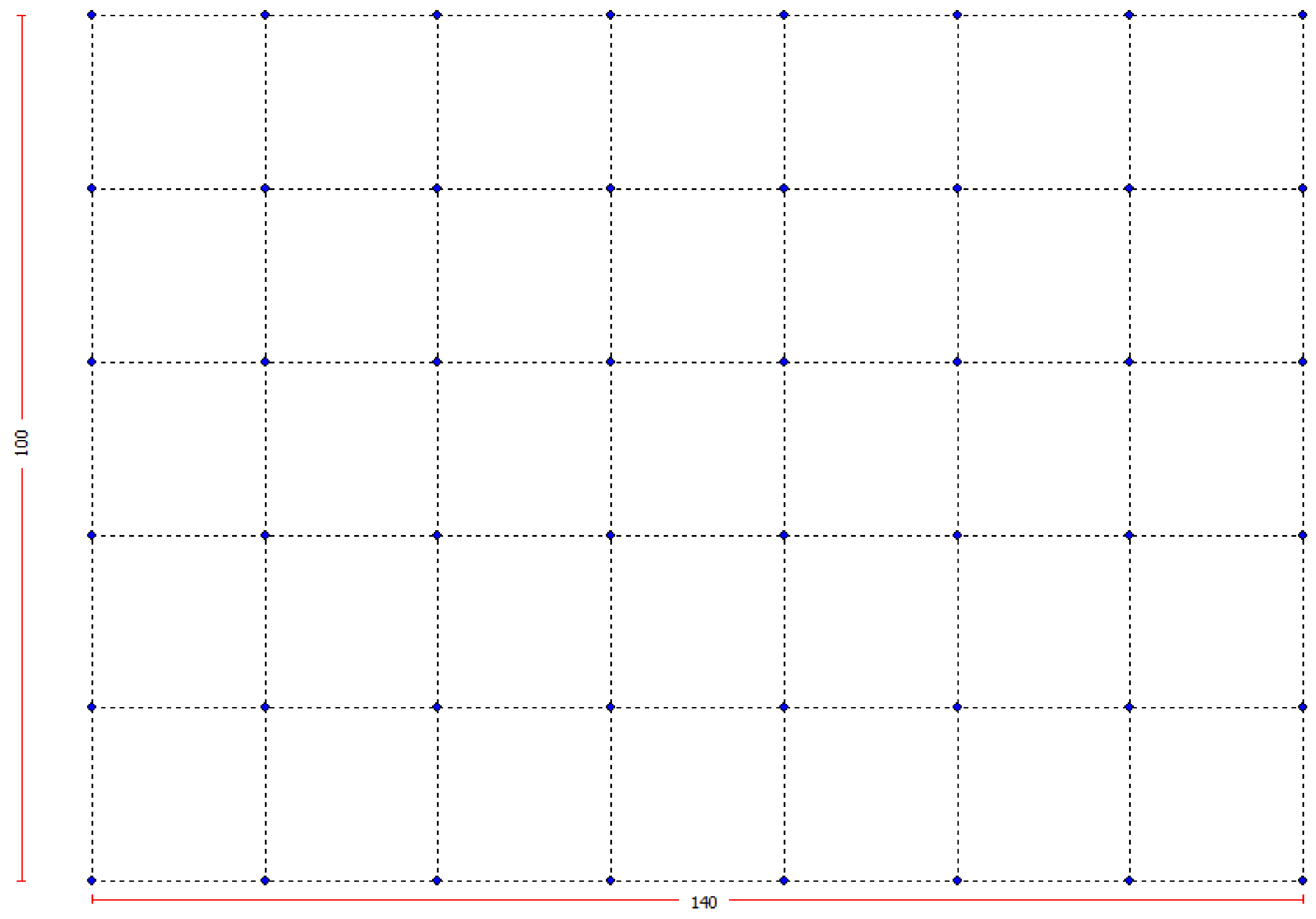


Geoenergetic Aspect

For very large heat pump

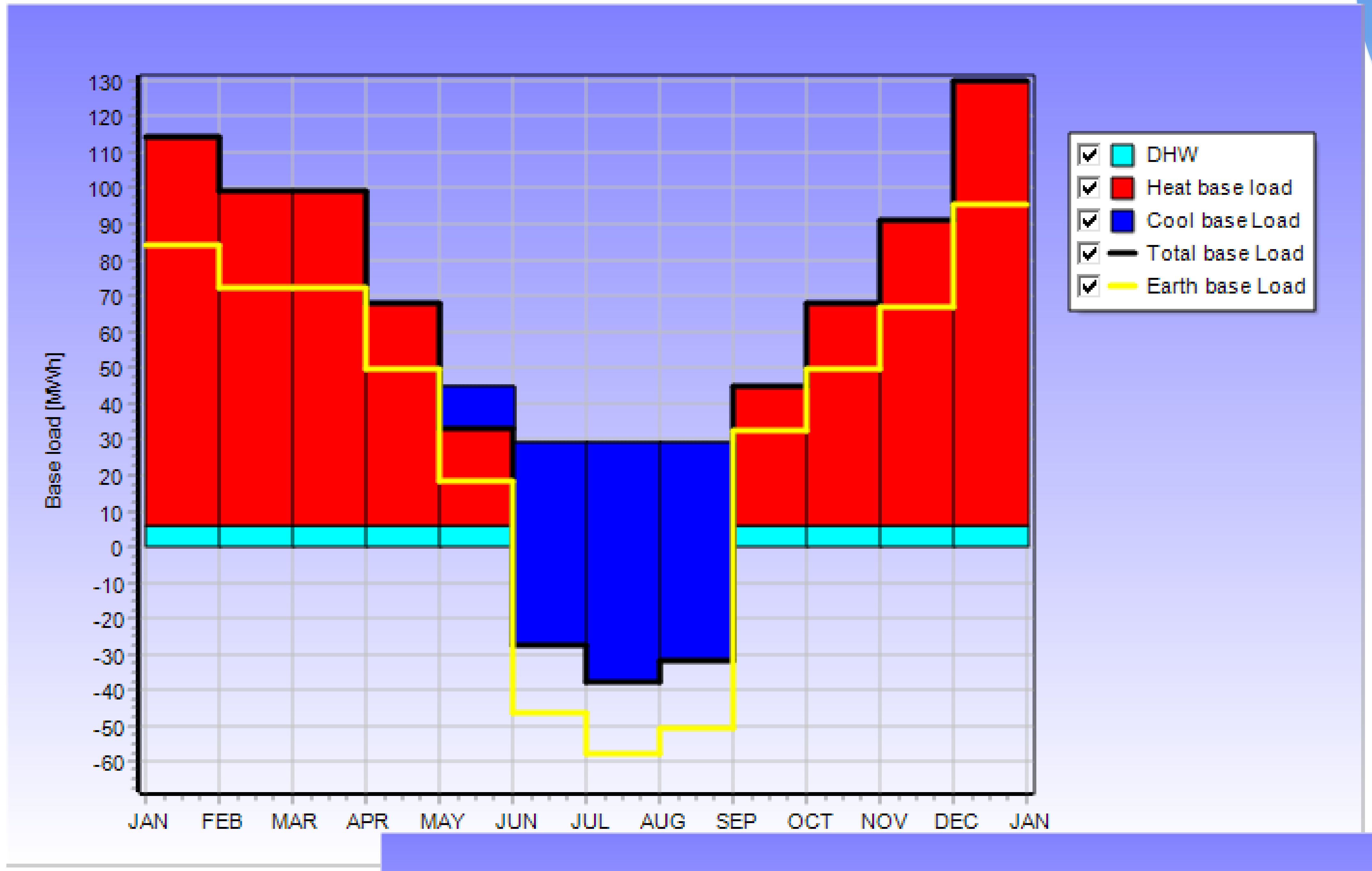
Analytical approach

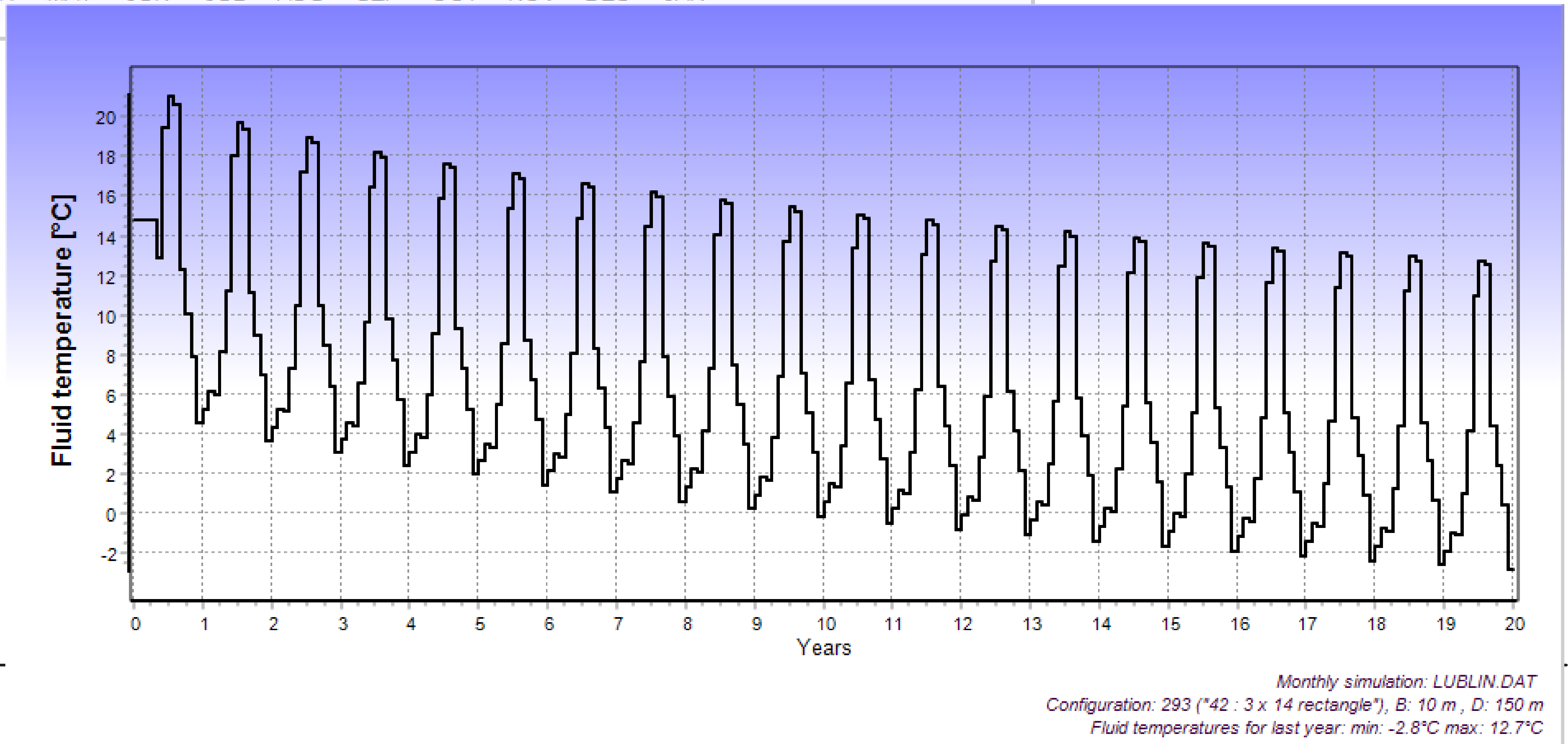
Based on:

1. Estimated average conductivity
2. Layout of GHEs
3. Heat and cooling requirements

Using modelling software, we determine the brine temperature on a schedule of, for example, 20 years.

1. Compatibility of lower source operation with assumptions
2. Fluid temperature in the HP operating window

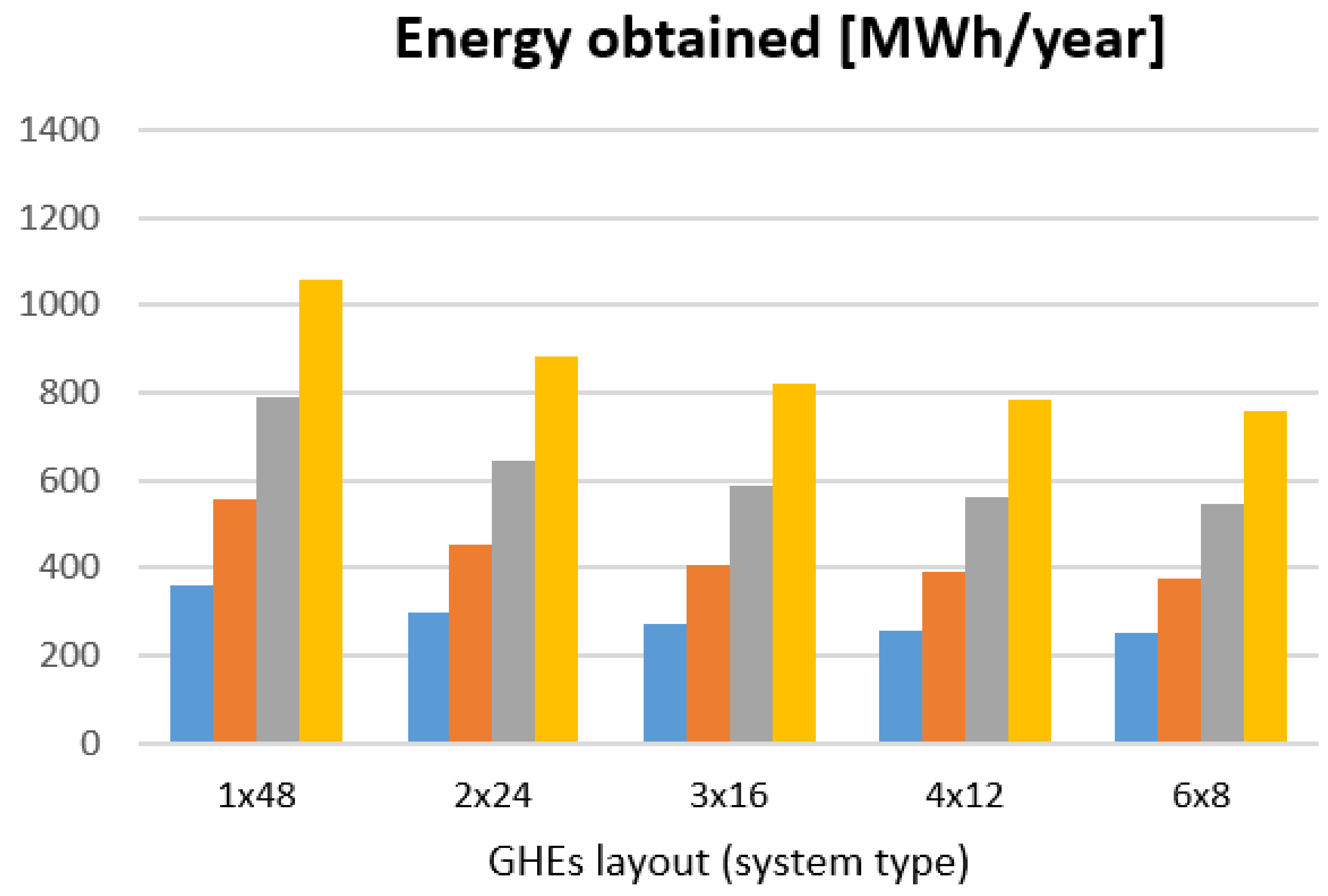


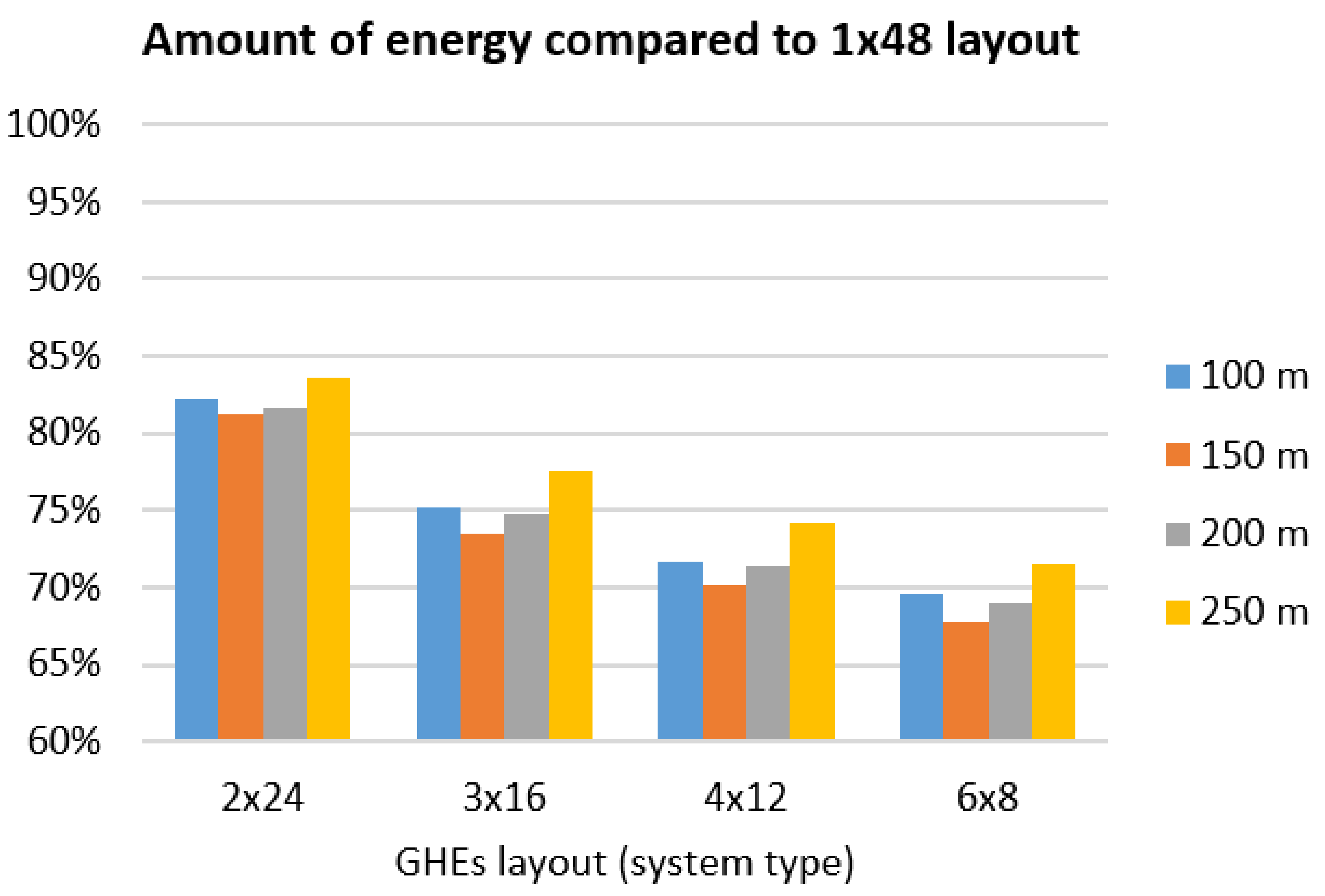


Geoenergetic Aspect

Heat only system (GHE fluid temperature: not less than 0°C)

Comparison of GHEs field performance

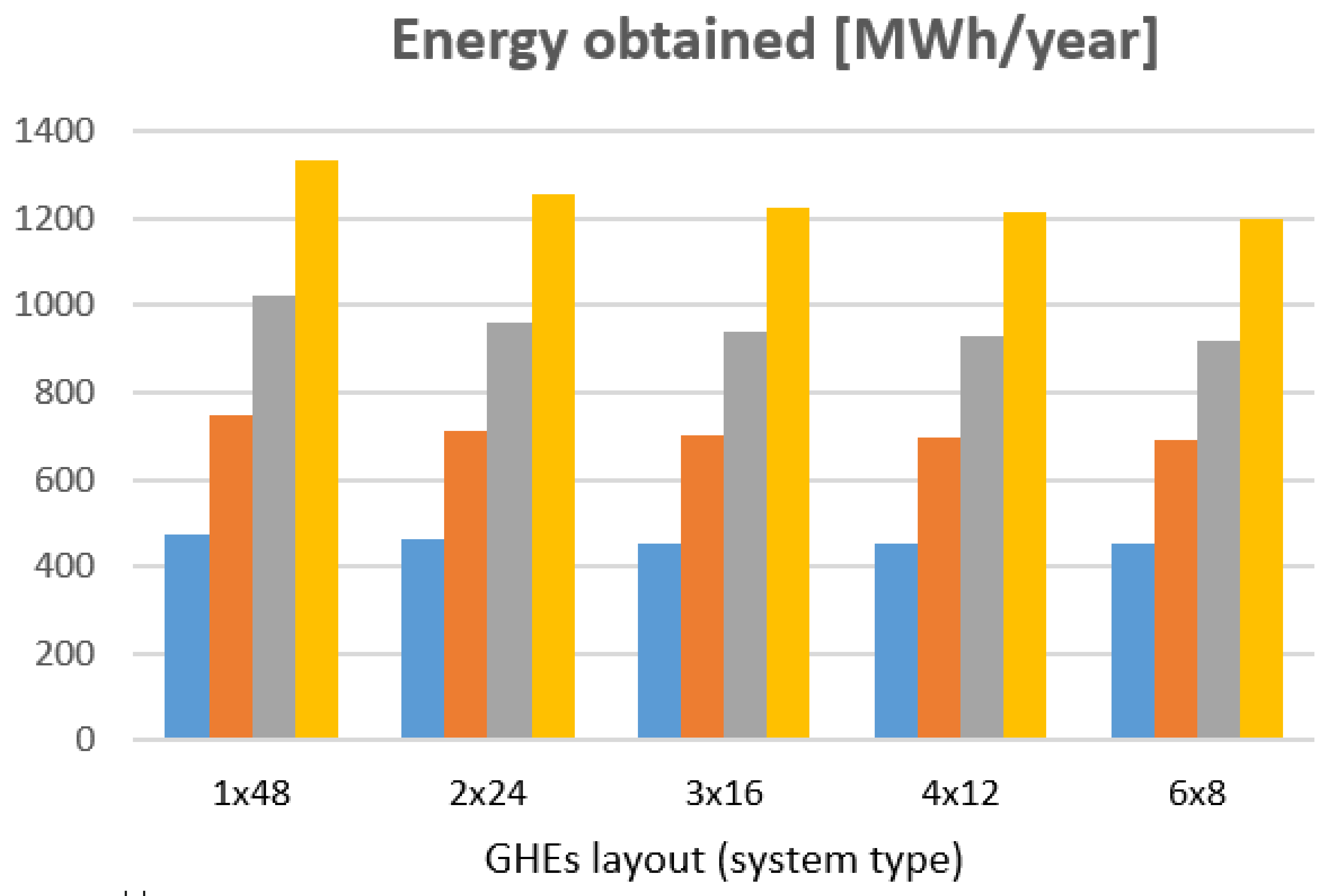


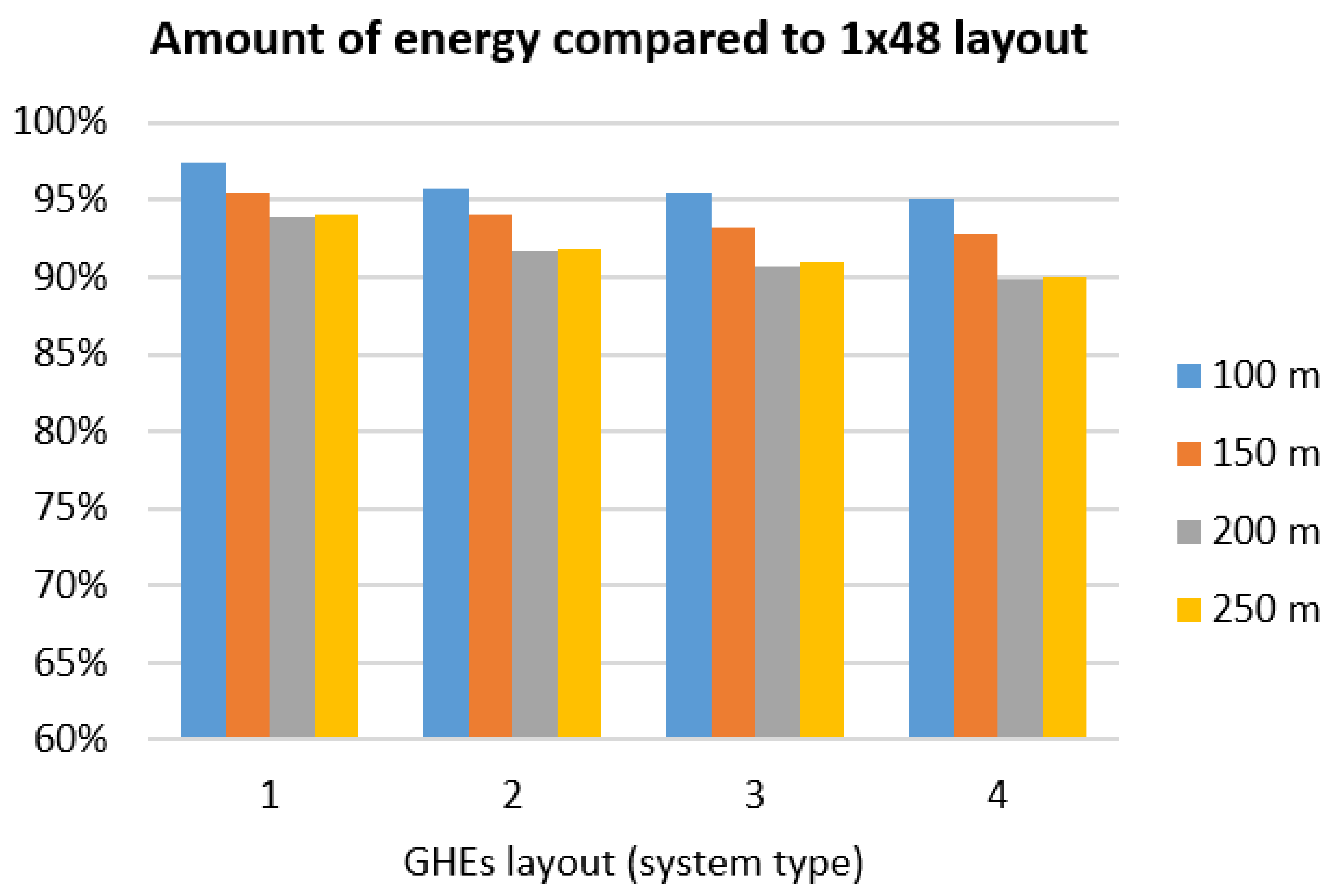


Geoenergetic Aspect

Heat and cold system (GHE fluid temperature: 0 °C - 25 °C)

Comparison of GHEs field performance

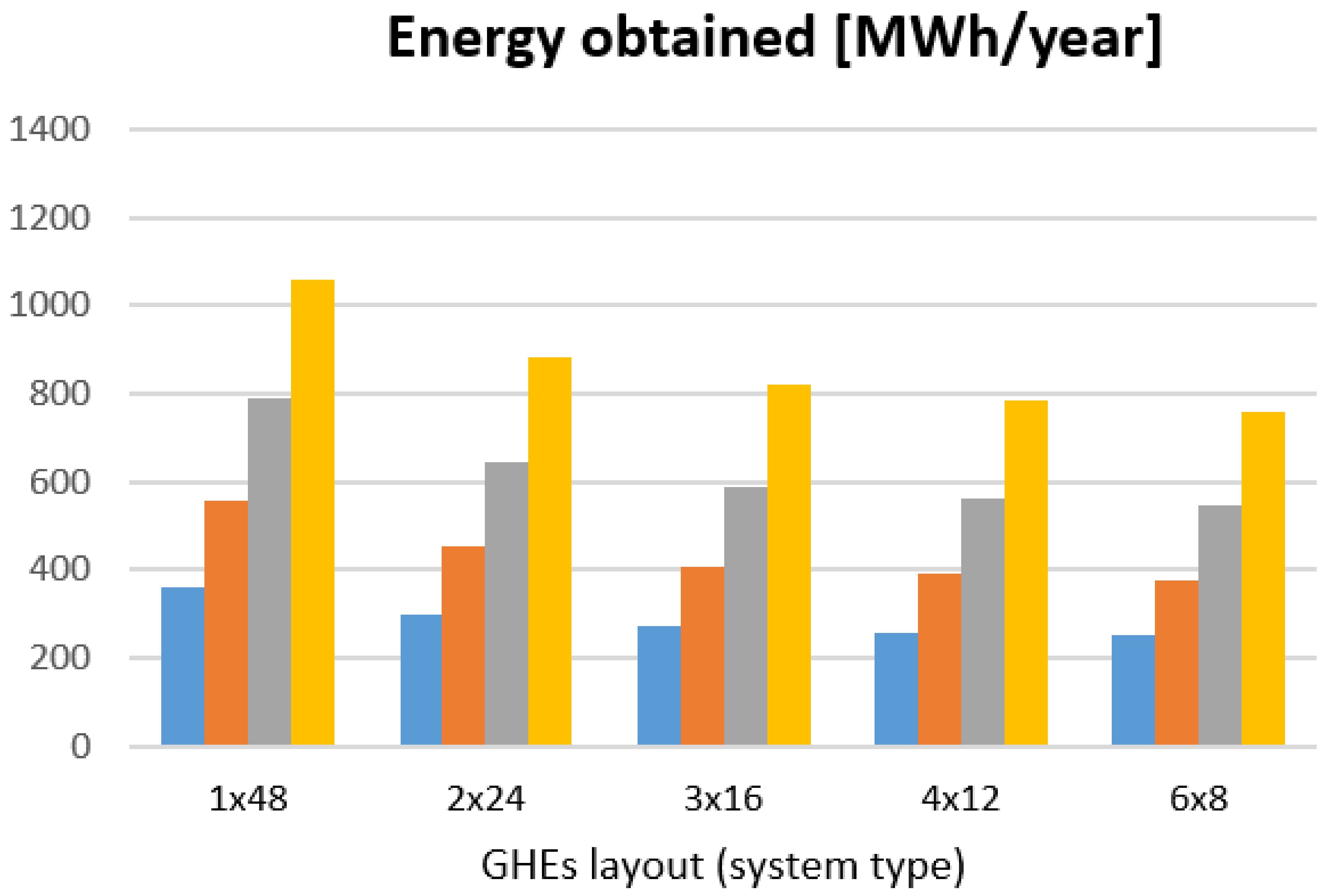


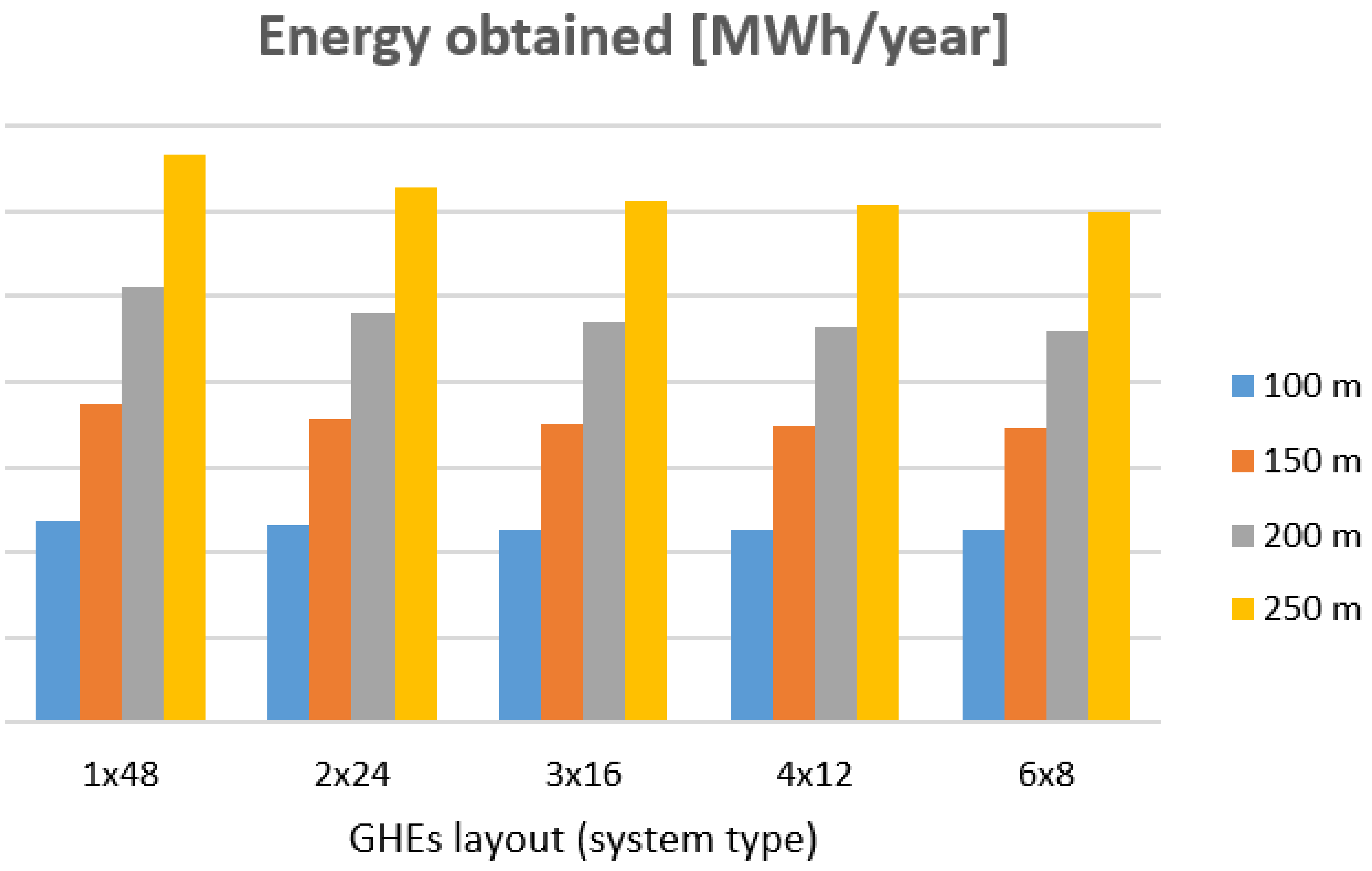


Geoenergetic Aspect

Heat only vs heat and cold system

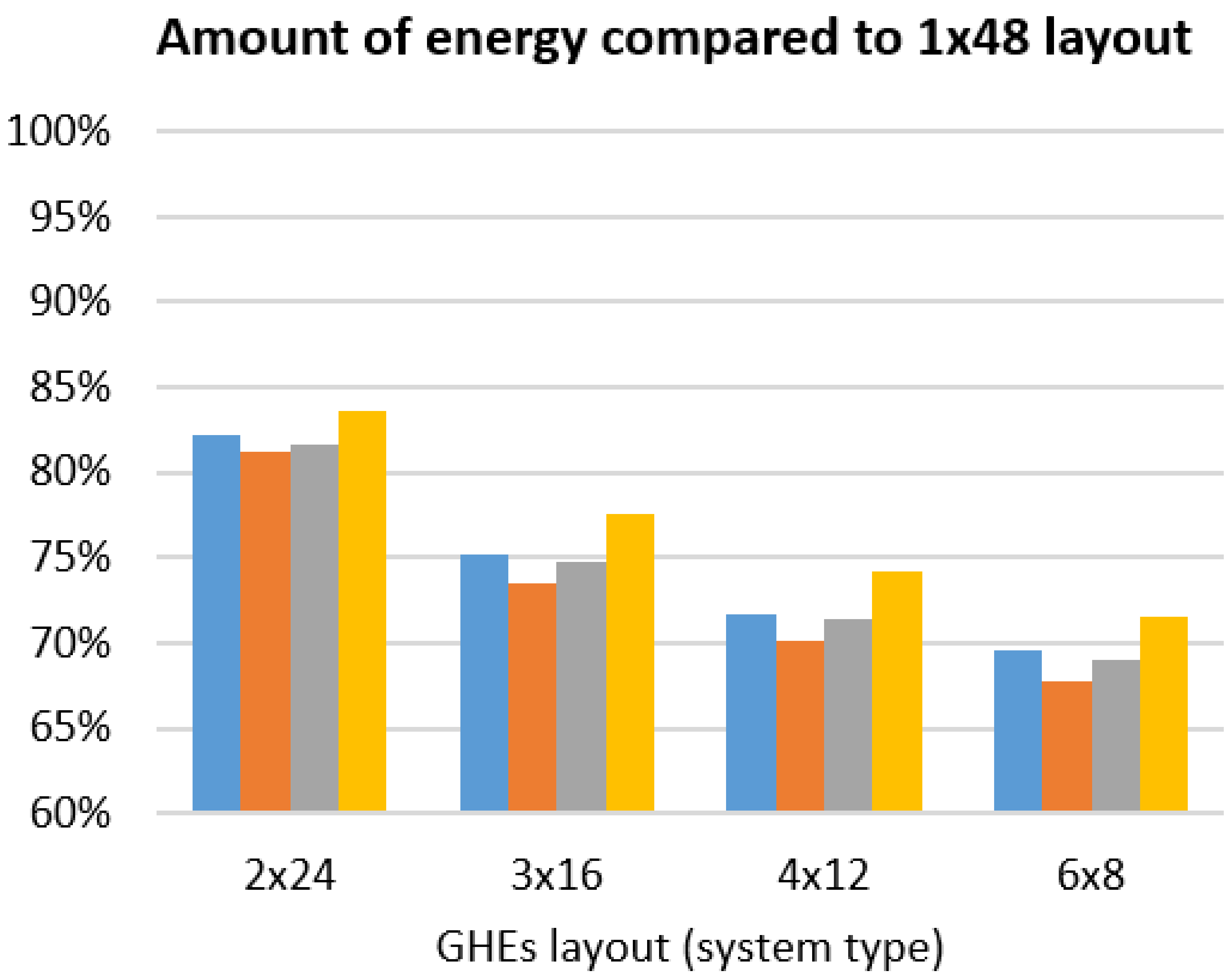
Comparison of GHEs field performance

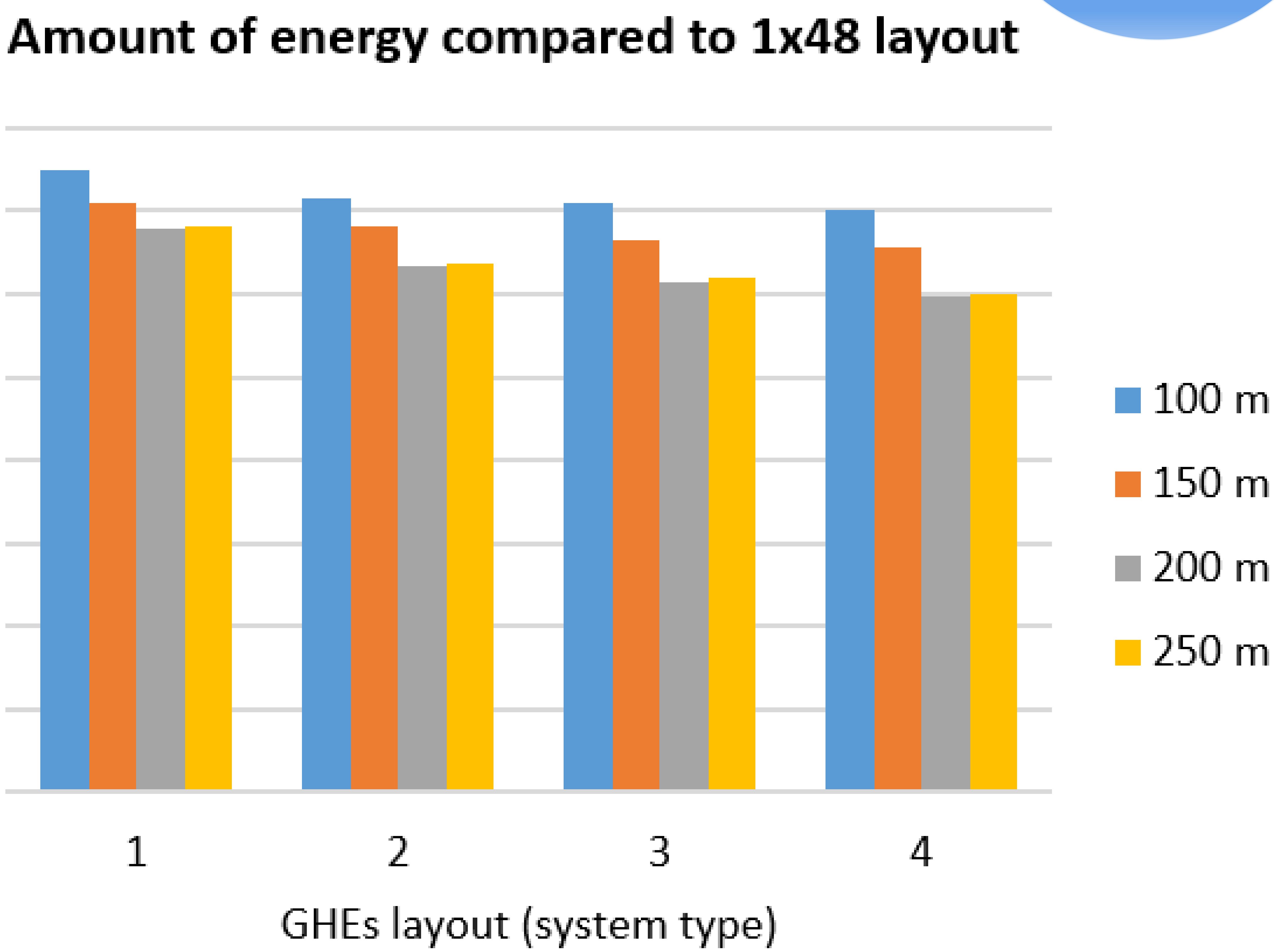




Geoenergetic Aspect

Heat only vs heat and cold system

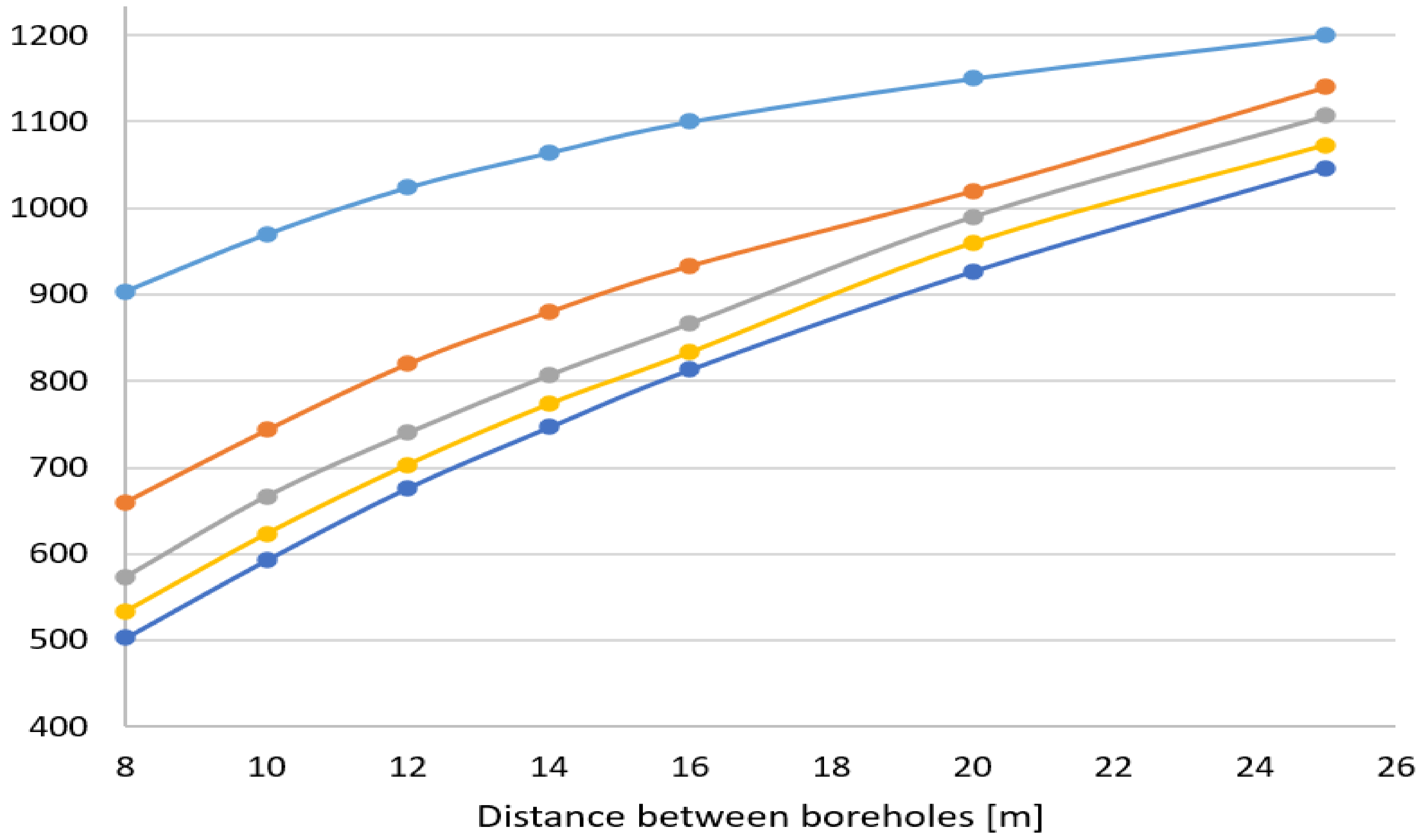


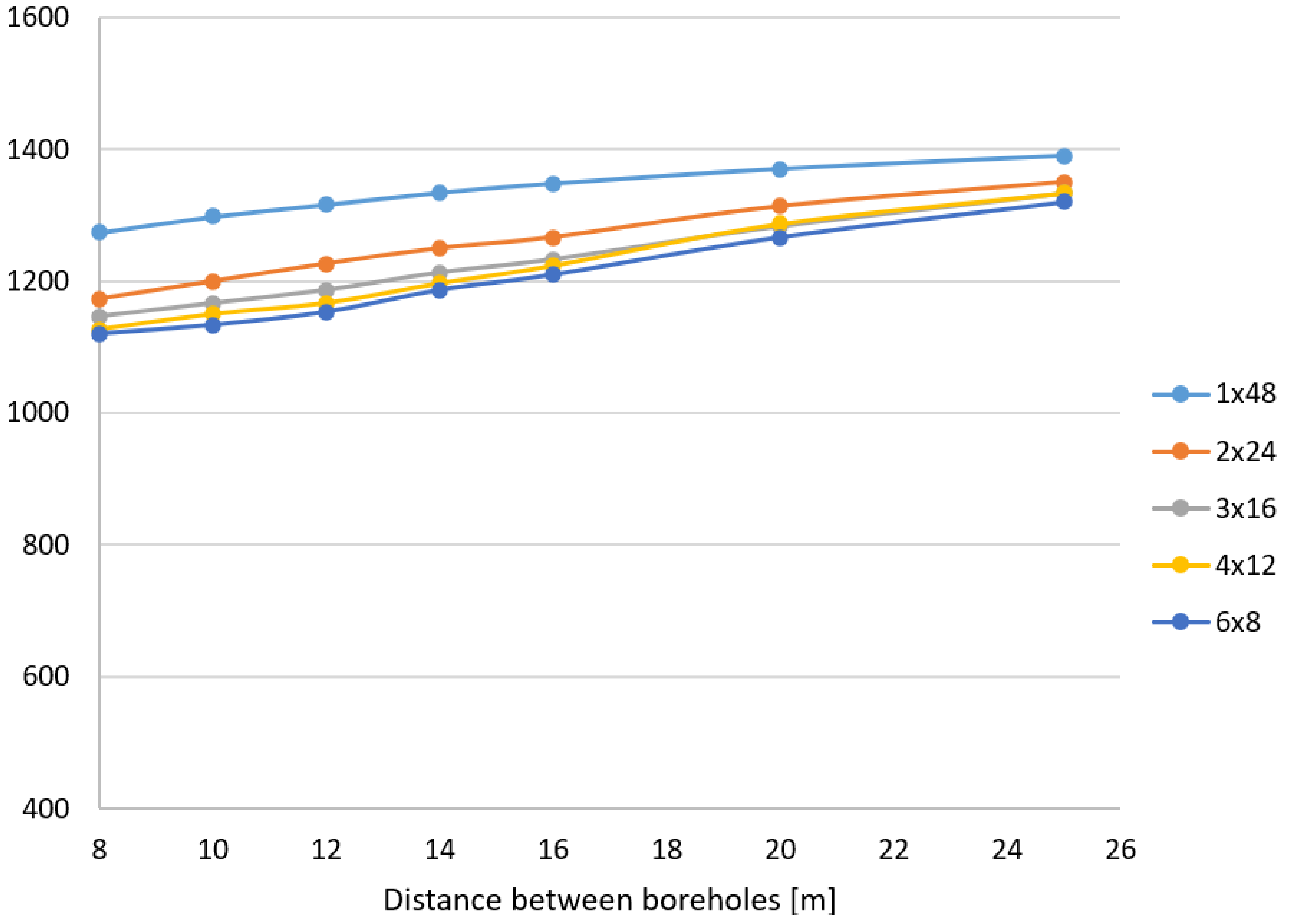


Geoenergetic Aspect

Dependence of the energy reservoir on the distance between the holes

Energy obtained (MWh/year) in heat-only and heat-and-cool systems





Geoenergetic Aspect

CONCLUSIONS

1. For heat only the heat capacity of the ground source depends on the configuration - the arrangement of the exchangers
2. The distance between wells in a system without regeneration is of great importance
3. In systems with ground source regeneration (heat and cold systems), the influence of exchanger configuration and distance between boreholes significantly decreases and the amount of possible energy obtain increases.

4. **The use of heat discharge (production heat, cooling heat or waste heat) makes it possible - on the basis of a geoenergetic analysis - to reduce the number of boreholes drilled and the distance between boreholes, and thus the cost of the necessary GHE source (15-40%).**

Geoenergetic Aspect – summing up

Numerical simulations can provide reliable estimations of the ground temperature evolution with time. This information is important to evaluate the influence of unbalanced loads in an early design stage of the project. **The safest approach from the point of view of the operation of the source over a multi-year period.**

With heat and cold system, it can also **reduce the cost of implementation from 15 per cent to as much as 40 per cent** in specific cases,

what can lead to major increase of GHE technology availability.

Selected projects

- Industry projects are often hidden behind NDA
- Two non-industry projects:
  - Heat only, good layout for GHE optimisation
  - Heat and cold, only possibility for a chess-like layout

Selected projects

Kraszewo-Czubaki (2018) Care and Treatment Facility

- 46 boreholes with a total depth of 10160 m.b.
- 2 directional boreholes under the street for the main downstream pipes
- heat and cold hub 250 metres from the well field


120


106/2
bud.G
107
120
23
23a
bet.
j.asf.
ch.k.
rz.Racl'Inica
(318,24 m)
318,24 m

Selected projects

Cistercian abbey complex in Henryków (2021)

- A post-Cistercian Baroque monastery complex located in Henryków, Lower Silesia, in the municipality of Ziębice.
- The ground source, with a total depth of 13,000 m, feeds 3 separate heat substations with an energy demand of over 780 kW.

Optimisation and cost-effectivness behind modeling software

Most widely known analytical software

- **Poland – own estimation:**

  1. **EED** – Earth Energy Designer, Sweden
  2. **EWS** – Huber Energietechnik AG, Switzerland

OWN ESTIMATION

- **World - according to MUSE output:**

  1. **TRNSYS** - Transient System Simulation Tool, USA – most popular
  2. **GLD** – Ground Loop Design, USA
  3. **Passive House Institute**, Germany
  4. **GLHEPRO** – Ground Loop Heat Exchange Design, OSU, USA (IGSHPA)
  5. **EED** – Earth Energy Designer, Sweden

MUSE
Managing Urban Shallow Geothermal Energy

Thank you!

Any questions?

Contact: Jarosław Ozimek, jaroslaw.ozimek@dps.net.pl