

Optimization of Shallow Geothermal Energy Resources for Green Transition OptiSGE

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

dr inż. Wojciech Mazurek

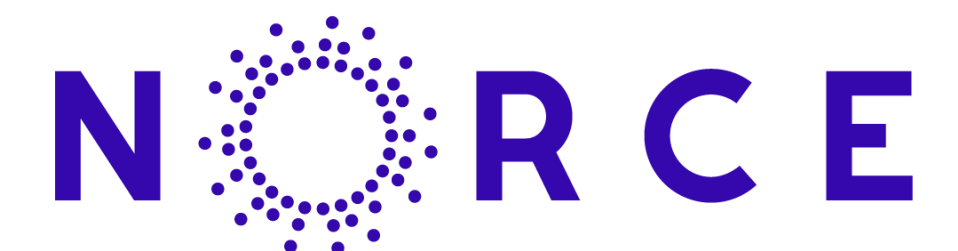
mgr inż. Jarosław Ozimek

Wrocław University of Science and Technology  
Faculty of Environmental Engineering

DPS Sp. z o.o. Boreholes for heat pumps.

Polish Heat Pump Technology Development Organisation

6th June 2024



# Ground heat pump source - the most important triad

- **DRILLING ASPECT**

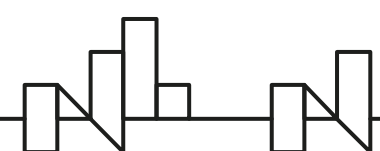
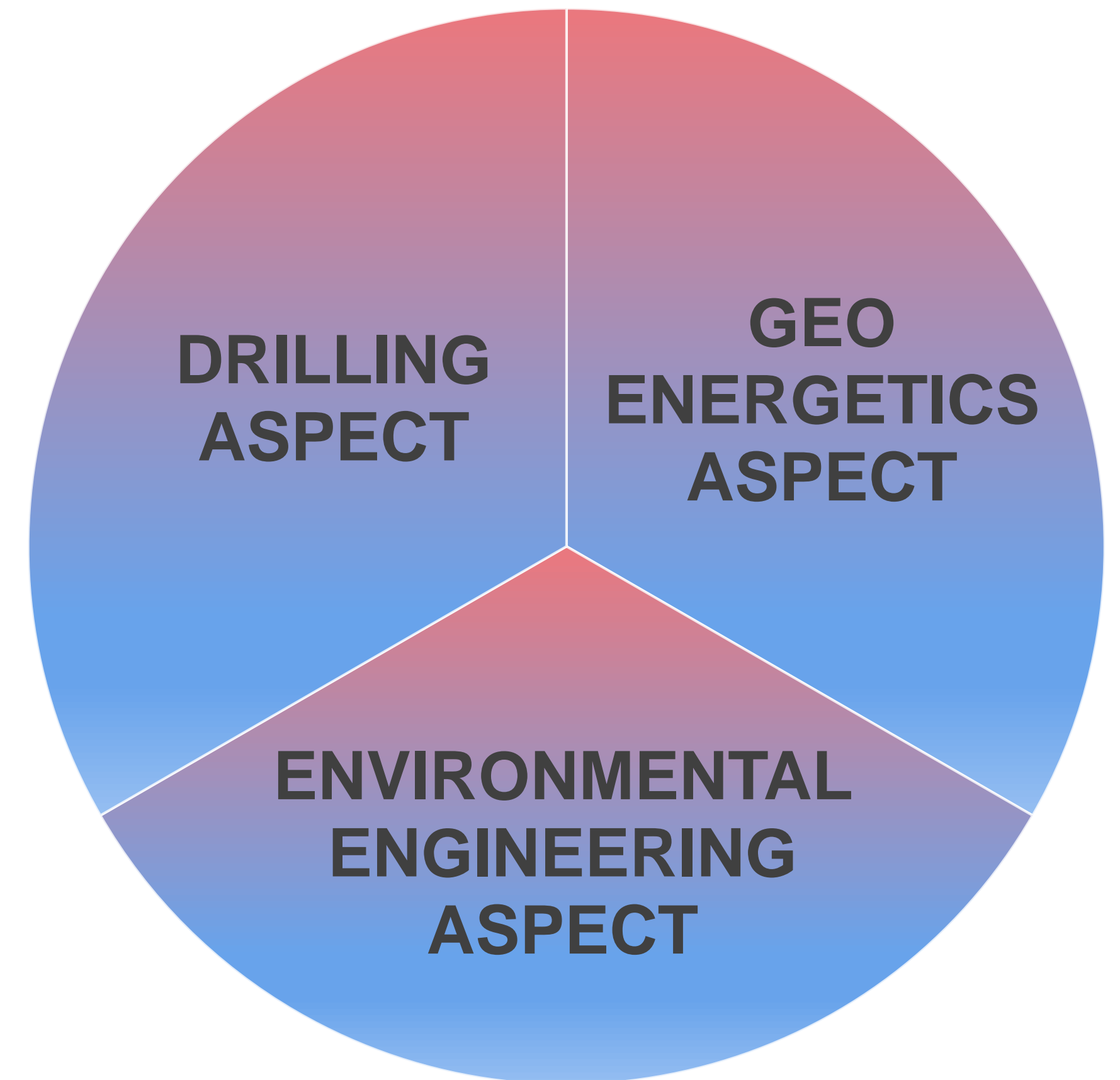
Design and execution of boreholes

- **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



POLSKA ORGANIZACJA ROZWOJU TECHNOLOGII POMP CIEPŁA  
WYDANIE DRUGIE  
09/2021

**WYTYCZNE PROJEKTOWANIA,  
WYKONANIA I ODBIORU  
INSTALACJI Z POMPAMI CIEPŁA**

**Część 1  
Dolne źródła do pomp ciepła**

- pionowe gruntowe wymienniki ciepła
- poziome gruntowe wymienniki ciepła
- koszowe gruntowe wymienniki ciepła
- pale energetyczne i inne betonowe konstrukcje wymienników ciepła

\*Wszelkie prawa autorskie zastrzeżone. Żadna część niniejszych wytycznych nie może być powielana bez pisemnej zgody Prezesa Polskiej Organizacji Rozwoju Technologii Pomp Ciepła

**INSTRUKCJA SZKOLENIOWA  
GEOTRAINET**  
DLA  
**FIRM WIERTNICZYCH  
PŁYTKICH SYSTEMÓW GEOTERMALNYCH**

Geo-edukacja dla rynku zrównoważonego ogrzewania i chłodzenia geotermalnego  
Projekt: IEE/07/581/S12.499061  
www.geotrainet.eu

**INSTRUKCJA SZKOLENIOWA  
GEOTRAINET DLA PROJEKTANTÓW  
PŁYTKICH SYSTEMÓW  
GEOTERMALNYCH**

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Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie  
Wydział Wiertnictwa, Nafty i Gazu

WYDANE W RZECZYPOSPOLITEJ POLSKIEJ

**ŚWIADECTWO**  
UKOŃCZENIA STUDIÓW PODYPLOMOWYCH

UKOŃCZYŁA W ROKU 2023  
DWUSEMESTRALNE STUDIJA PODYPLOMOWE:  
**Geotermia**  
z wynikiem bardzo dobrym

PROFESOR DR. KSZTAŁCENIA  
DR inż. Andrzej Węgrzyn  
EG

Numer Świadectwa:  
WNG/GE03/12/2023

Kraków, 14 lipca 2023 r.

Euro-Centrum  
Park Naukowo-Technologiczny

ehpa

PORT PC

**CERTYFIKAT**  
NR 76/PNT EC/2023

Pan

uczestniczył w szkoleniu pn.  
„INSTALATOR POMP CIEPŁA EUCERT”

w terminie:  
30 listopada do 1 grudnia oraz 13 do 15 grudnia 2023

Podpis trenera

WICEPRZEDSIĘDZIECZA  
Podpis organizatora

Planek Rozwojowa Technologiczna  
Instytut Technologiczny  
Instytut Technologiczny  
Instytut Technologiczny

INNOWACYJNA GOSPODARKA

Szkolenie współfinansowane ze środków Europejskiego Funduszu Rozwoju Regionalnego w ramach Programu Operacyjnego Innowacyjna Gospodarka

**Geo BOOST**

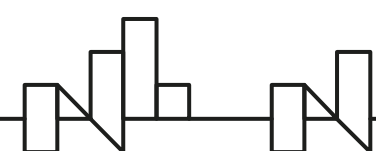
**Interreg**  
CENTRAL EUROPE  
European Union  
European Regional  
Development Fund

**GeoPLASMA-CE**

**GEODH**

**SAPHEA**

INTEGRATING GEOTHERMAL HEATING  
AND COOLING NETWORKS IN EUROPE





# Environmental Engineering Aspect

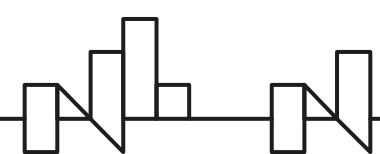
## BOREHOLES CONNECTION AND MAINTAIN PLAN

- Preparation by formal designers.
- Support from manufacturers of GHE components.
- The main parts are repeatable
- But some parts should be calculated for each one separately



### **Safety:**

- Investor
- Designer
- Contractor



# Environmental Engineering Aspect

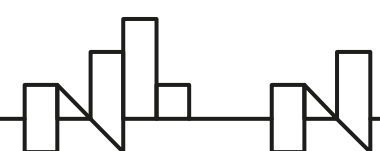
## DESIGN PLAN

- **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**

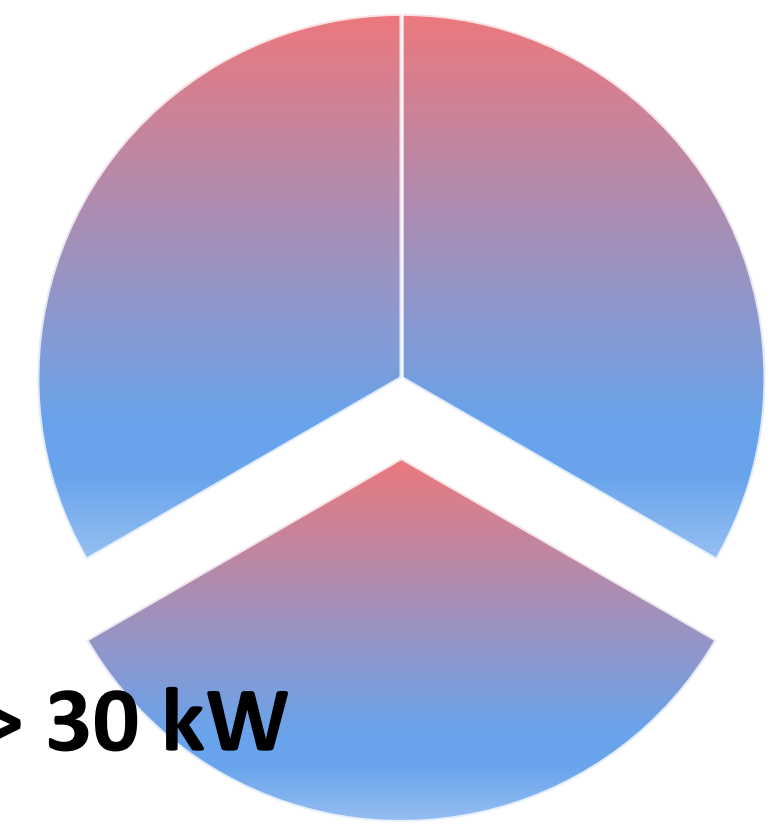


### **Safety:**

- Investor
- Designer
- Contractor



# Geoenergetic Aspect



## for heat pumps with a heating output $\leq 30$ kW

- formula estimation method

when the prerequisites for design are met:

- heating power  $\leq 30$  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

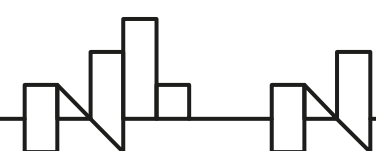
## for heat pumps with a heating output $> 30$ kW

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

and recommendations for executive part:

- drilling a test GHE, measuring  $\lambda$  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

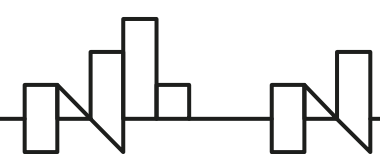
## Executive part

- 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

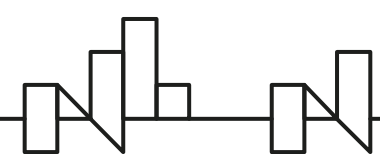


# Geoenergetic Aspect

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](http://geolog.pgi.gov.pl), [geologia.pgi.gov.pl](http://geologia.pgi.gov.pl))**
  - **Geoplasma-CE web portal ([portal.geoplasma-ce.eu](http://portal.geoplasma-ce.eu))**
  - **Own analysis based on lithological layers and potential studies**

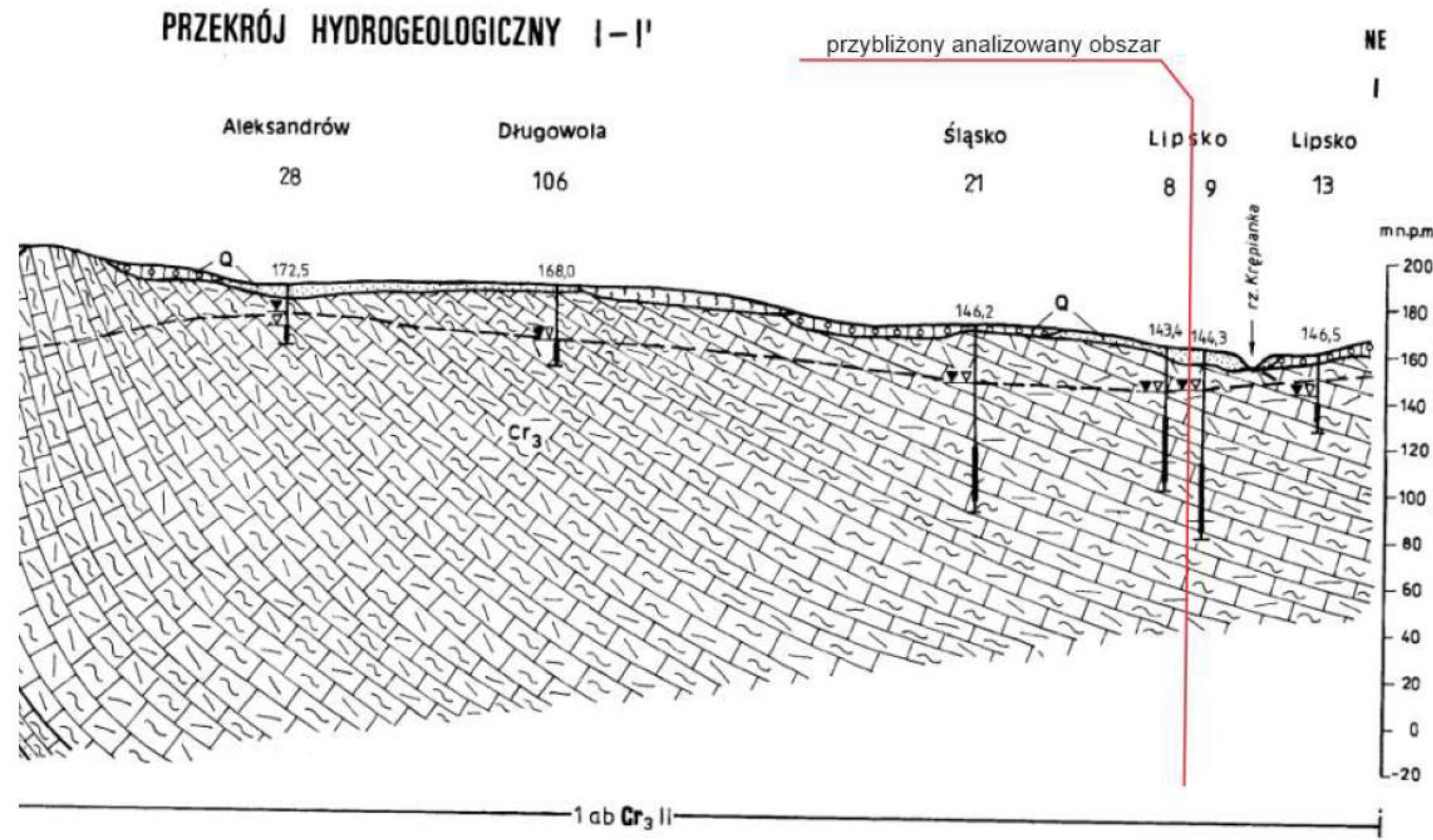




# Geoennergetic Aspect

For very large heat pumps – Analytical approach

Part 1 - Determination of estimated average thermal conductivity



QUATERNARY:

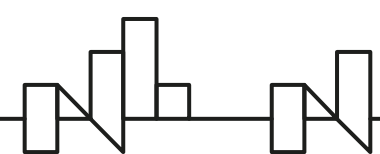
☐ 0,0 – 7,0 mbgl.: sands

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  $\lambda$  estimation**



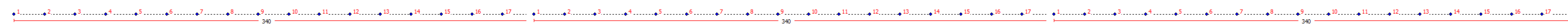
# Geoenergetic Aspect

For very large heat pumps – Analytical approach

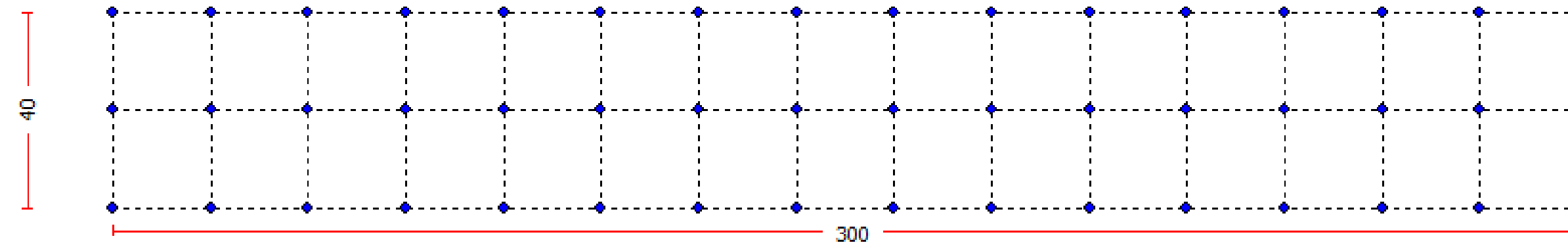
Part 2 - definition of the hole grid - GHE layout (system type)



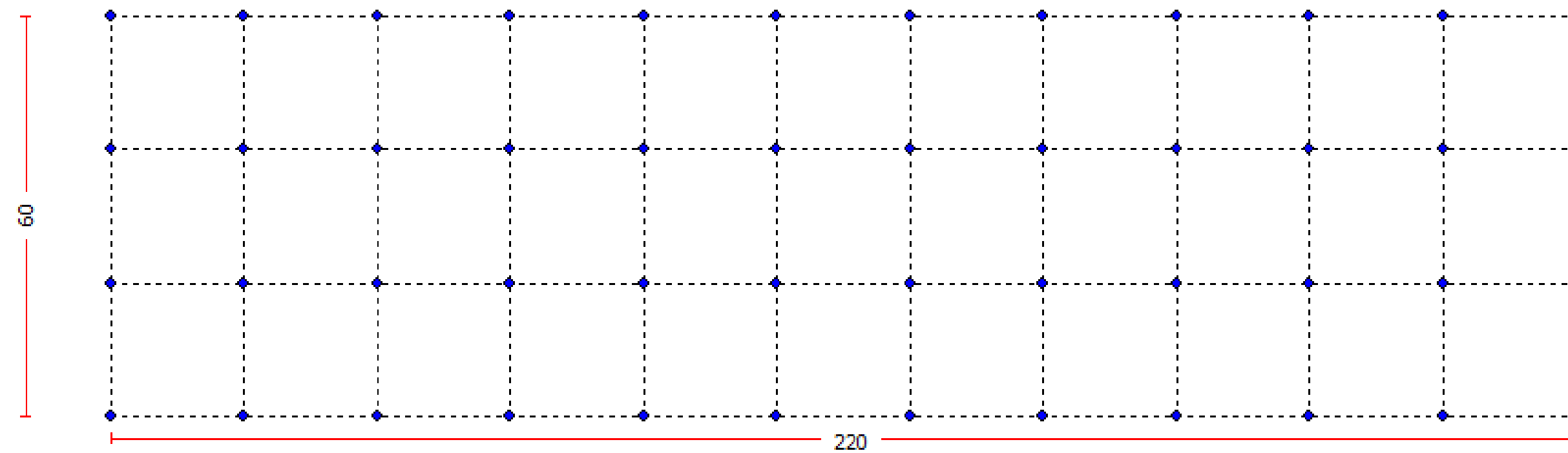
1 row x 48



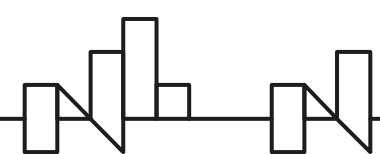
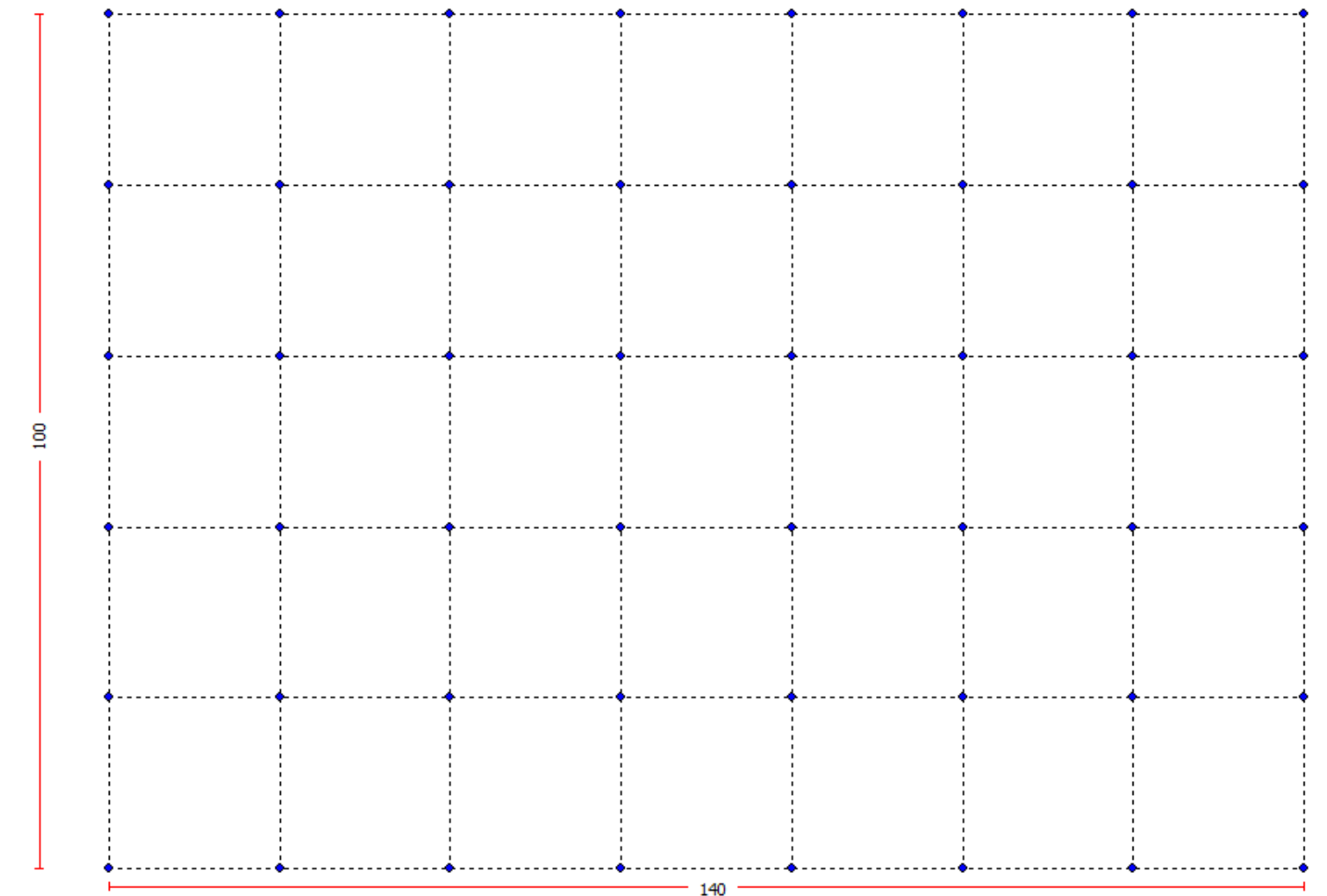
2 rows x 24



3 rows x 12



4 rows x 4



# Geoenergetic Aspect

For very large heat pump

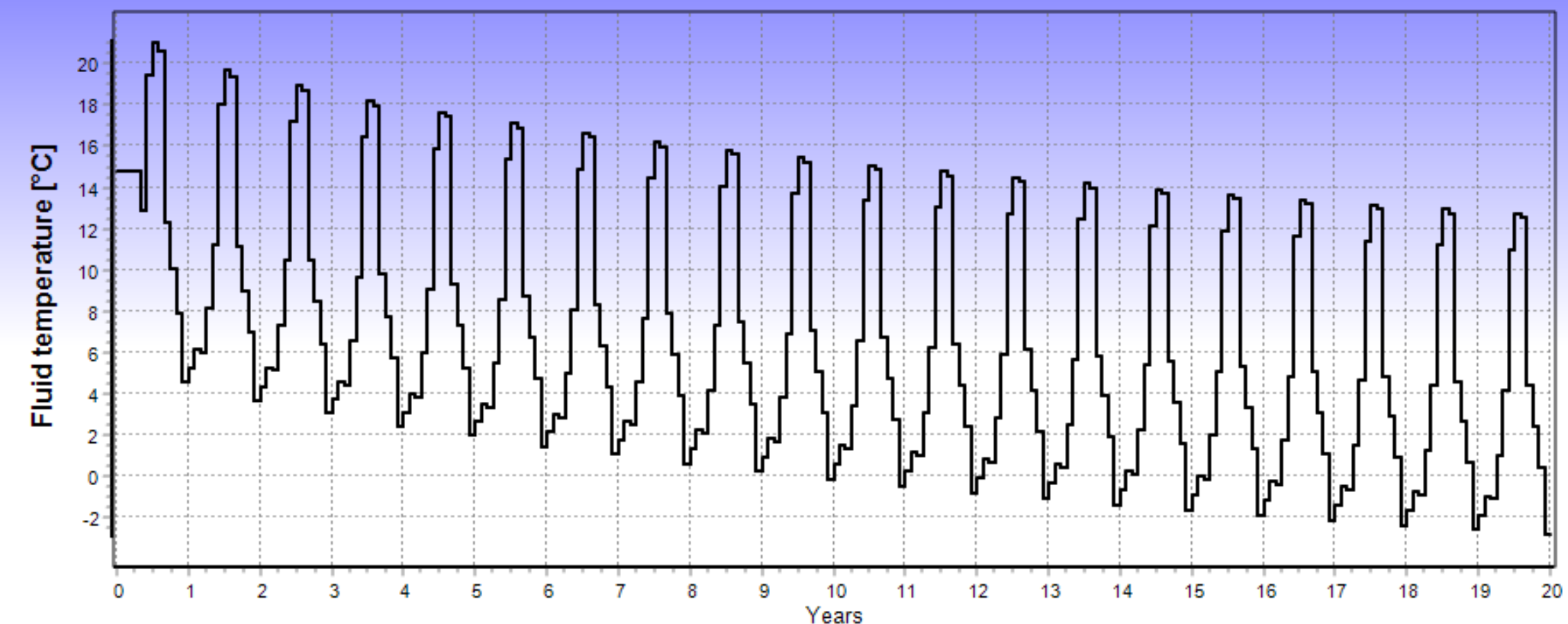
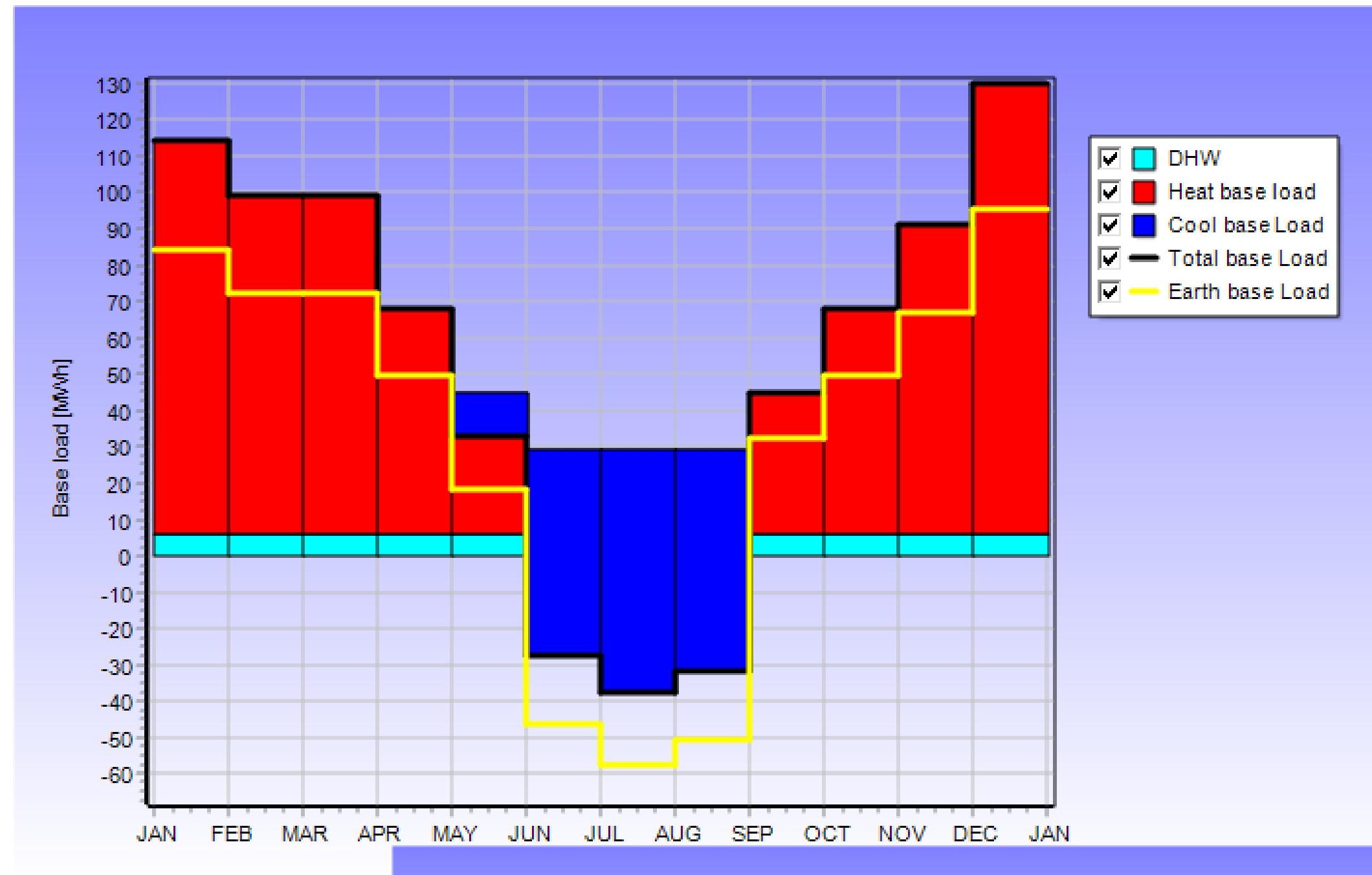
Analytical approach

Based on:

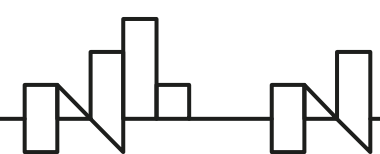
1. Estimated average conductivity
2. Layout of GHEs
3. Heat and cooling requirements

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



Monthly simulation: LUBLIN.DAT  
Configuration: 293 (\*42 : 3 x 14 rectangle\*), B: 10 m, D: 150 m  
Fluid temperatures for last year: min: -2.8°C max: 12.7°C





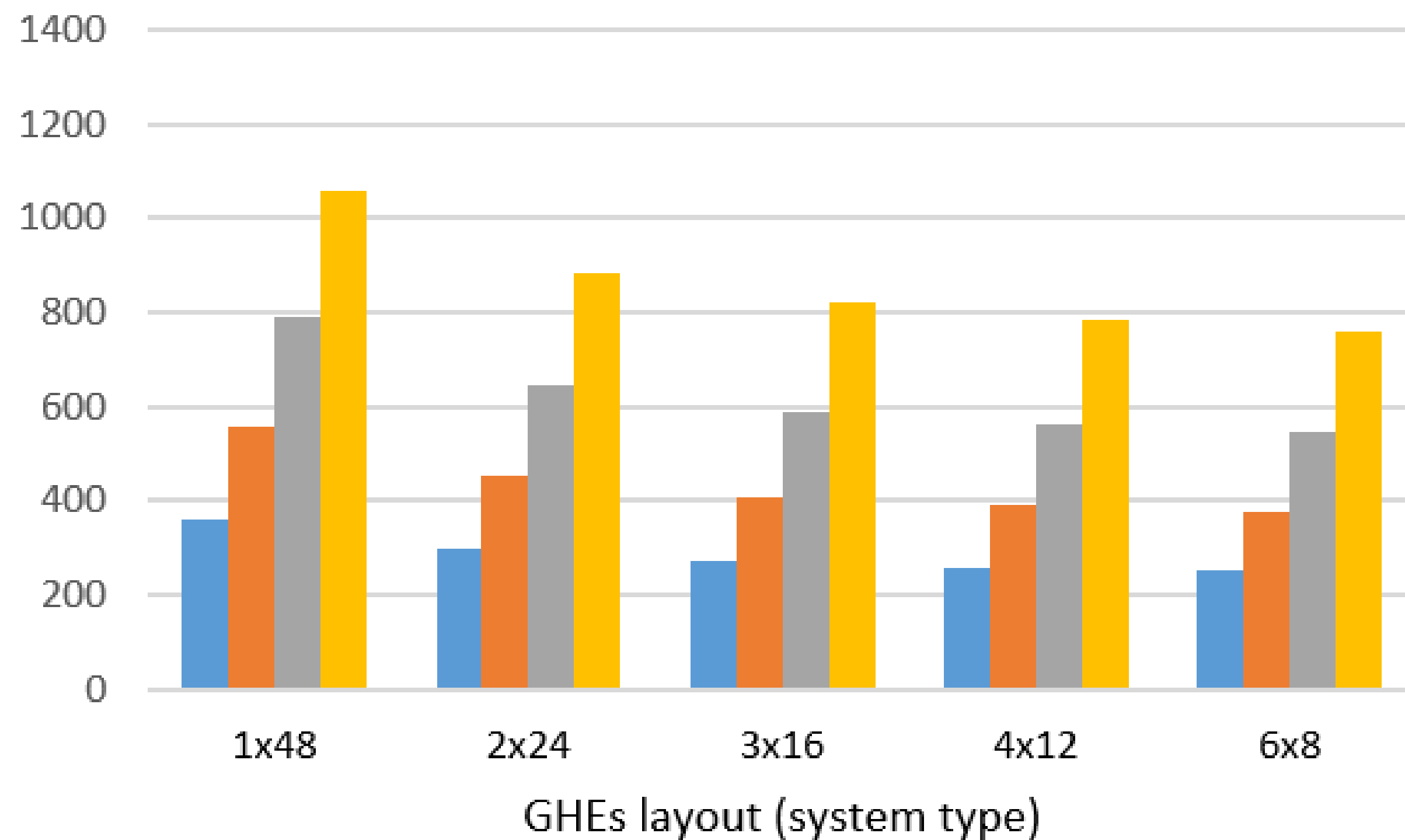
# Geoenergetic Aspect

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

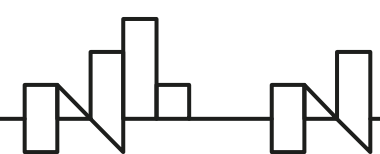
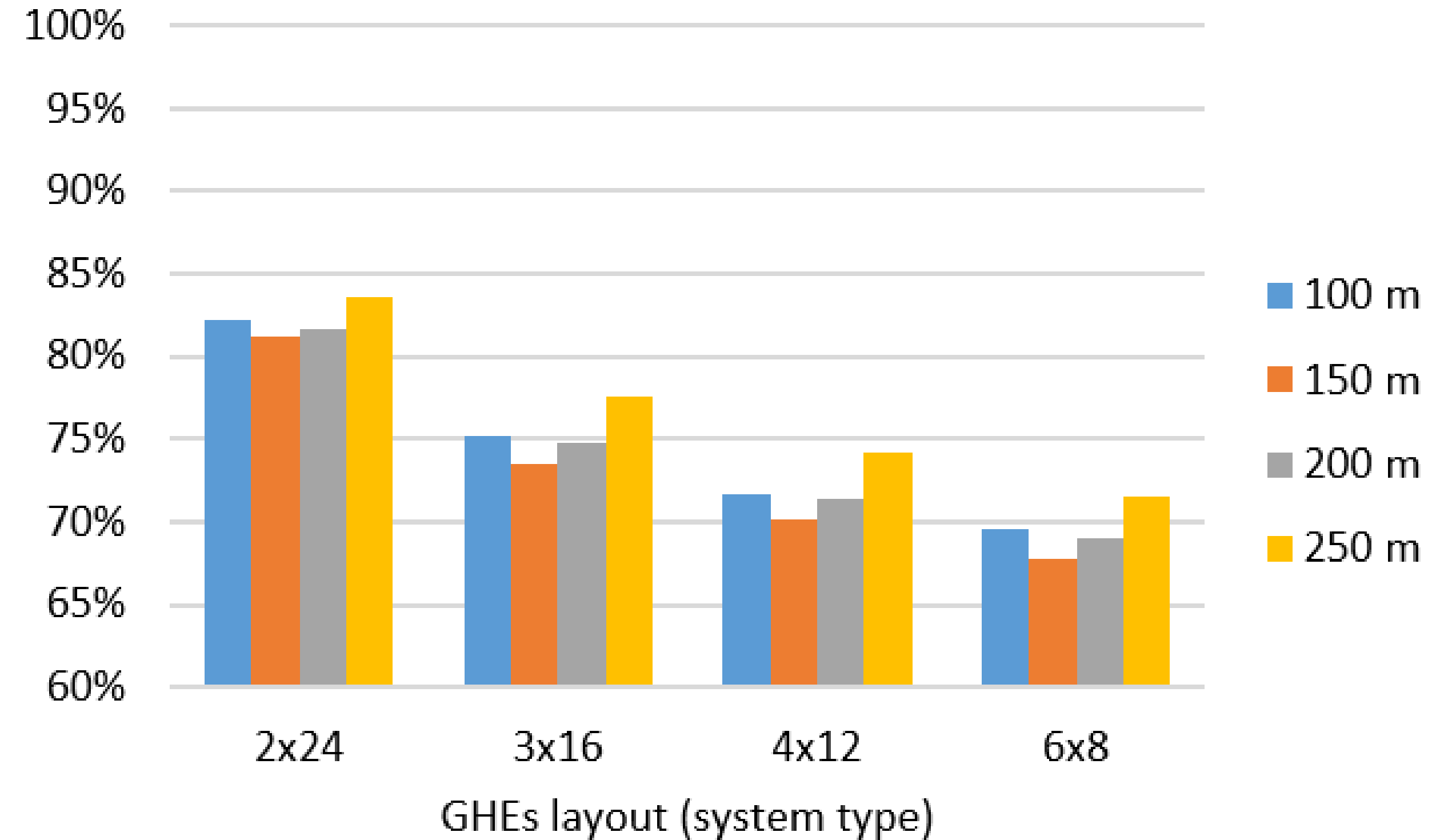
Comparison of GHEs field performance



### Energy obtained [MWh/year]



### Amount of energy compared to 1x48 layout





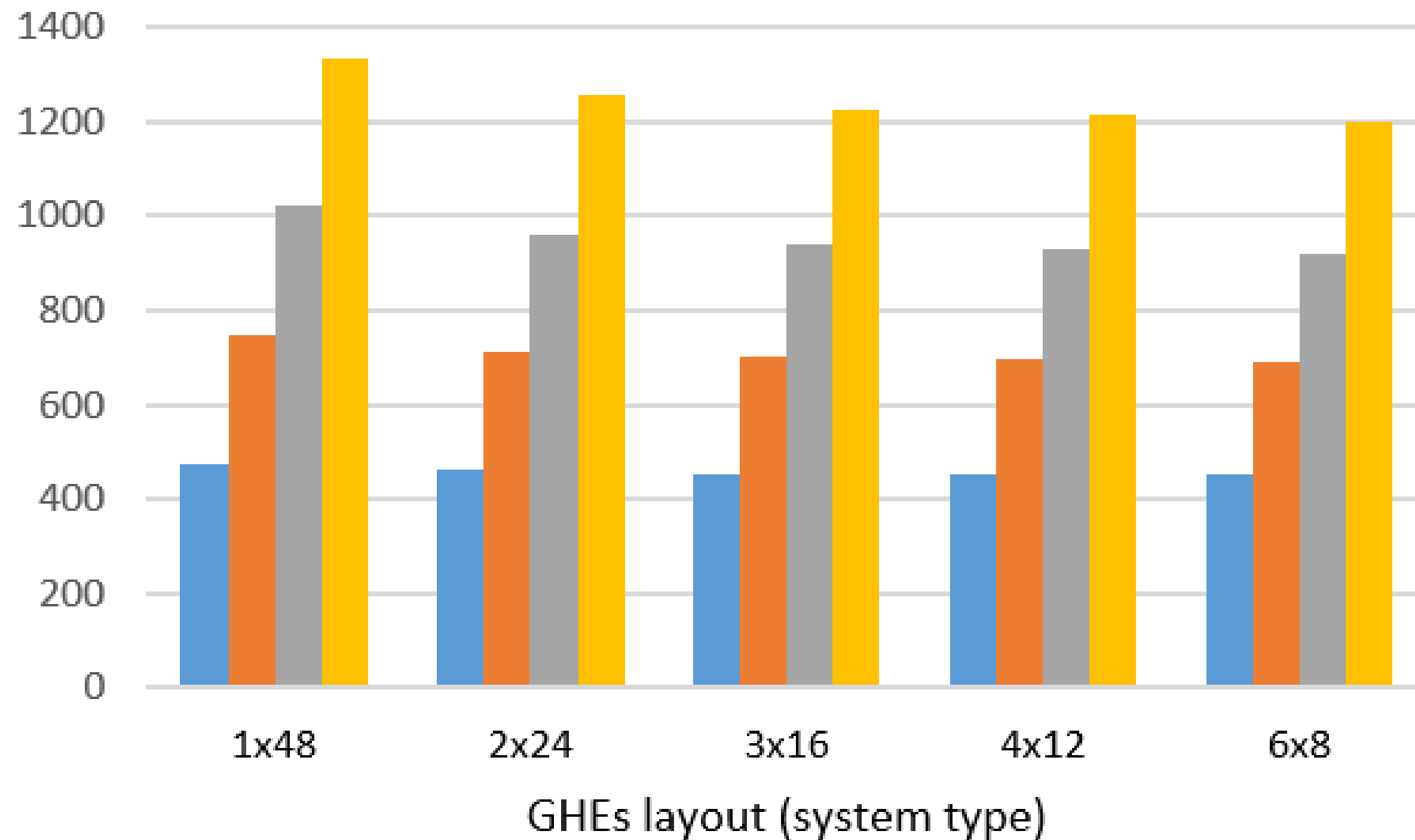
# Geoenergetic Aspect

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

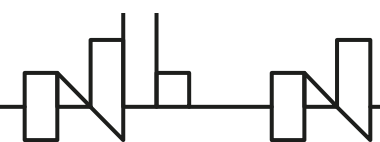
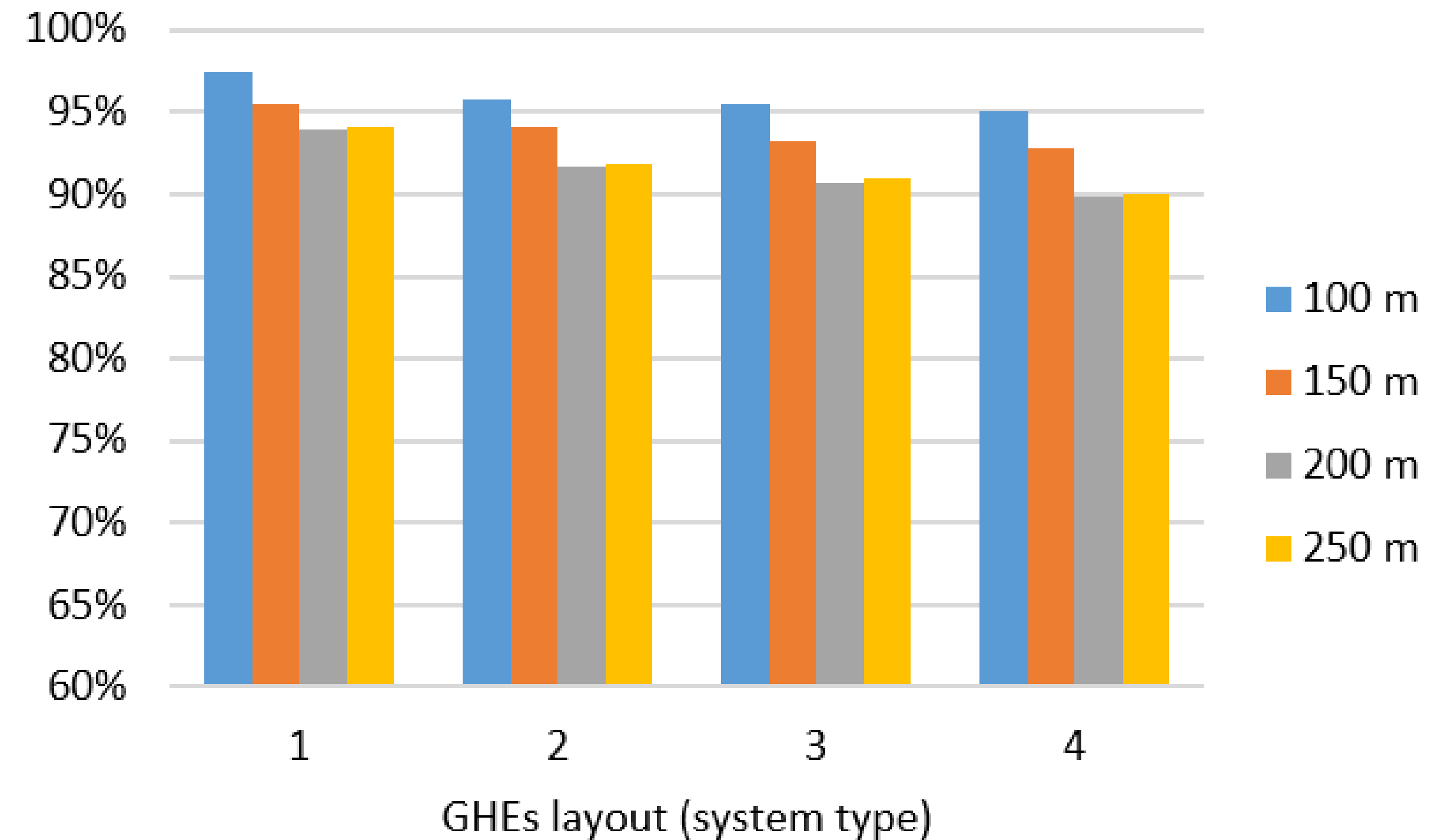
Comparison of GHEs field performance



### Energy obtained [MWh/year]



### Amount of energy compared to 1x48 layout



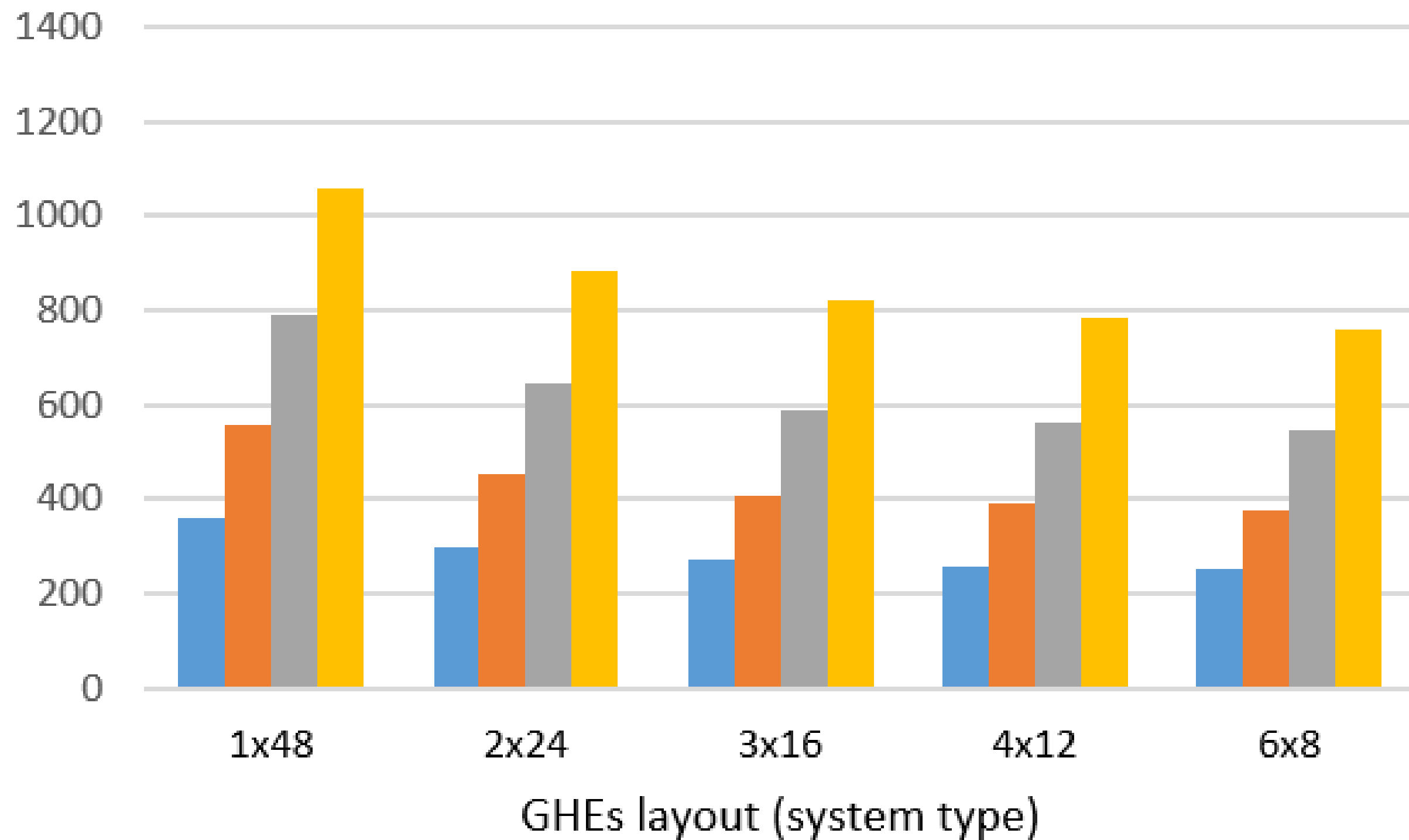
# Geothergetic Aspect

Heat only vs heat and cold system

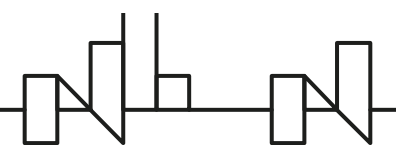
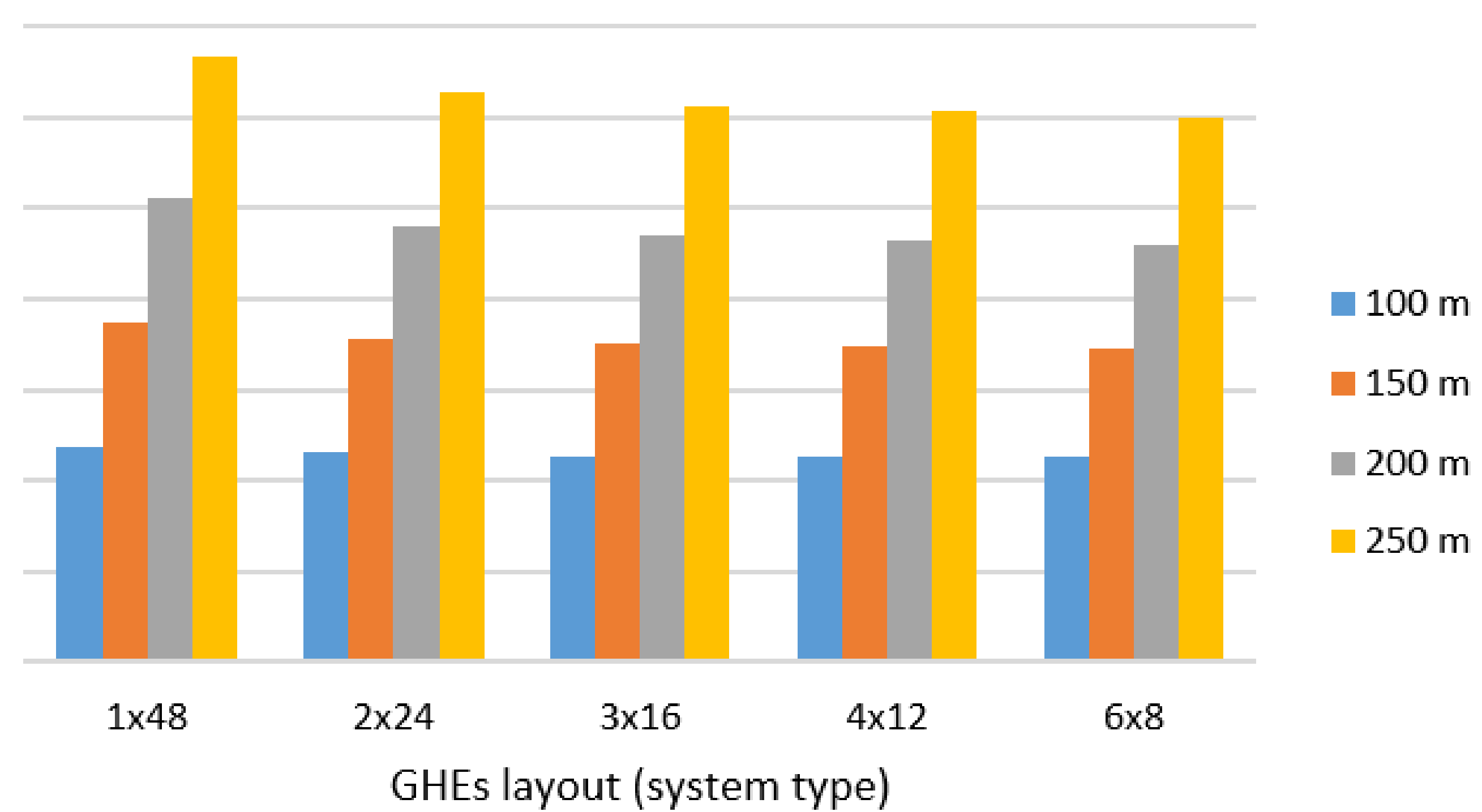
Comparison of GHEs field performance



## Energy obtained [MWh/year]



## Energy obtained [MWh/year]



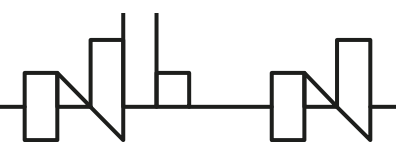
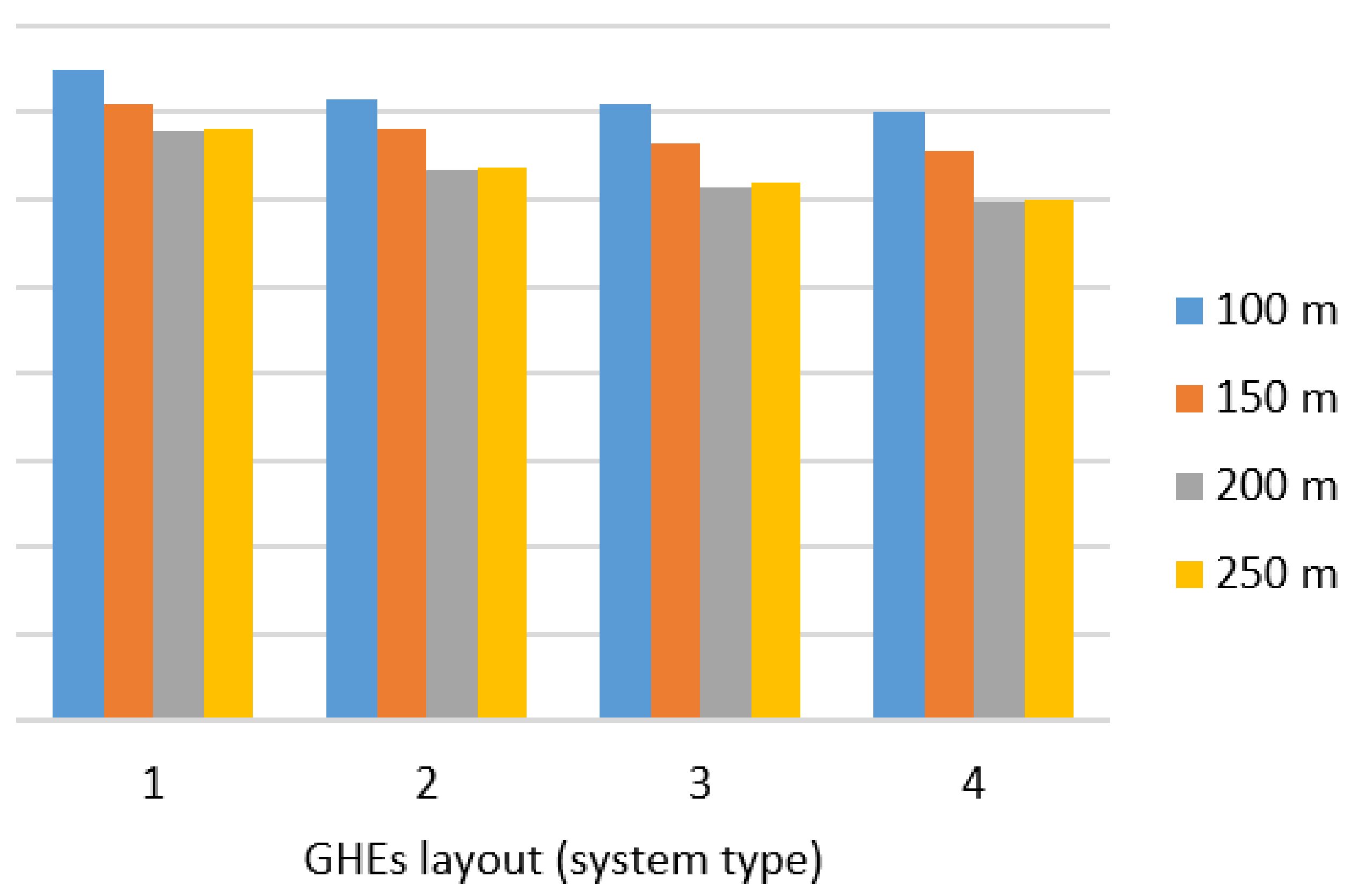
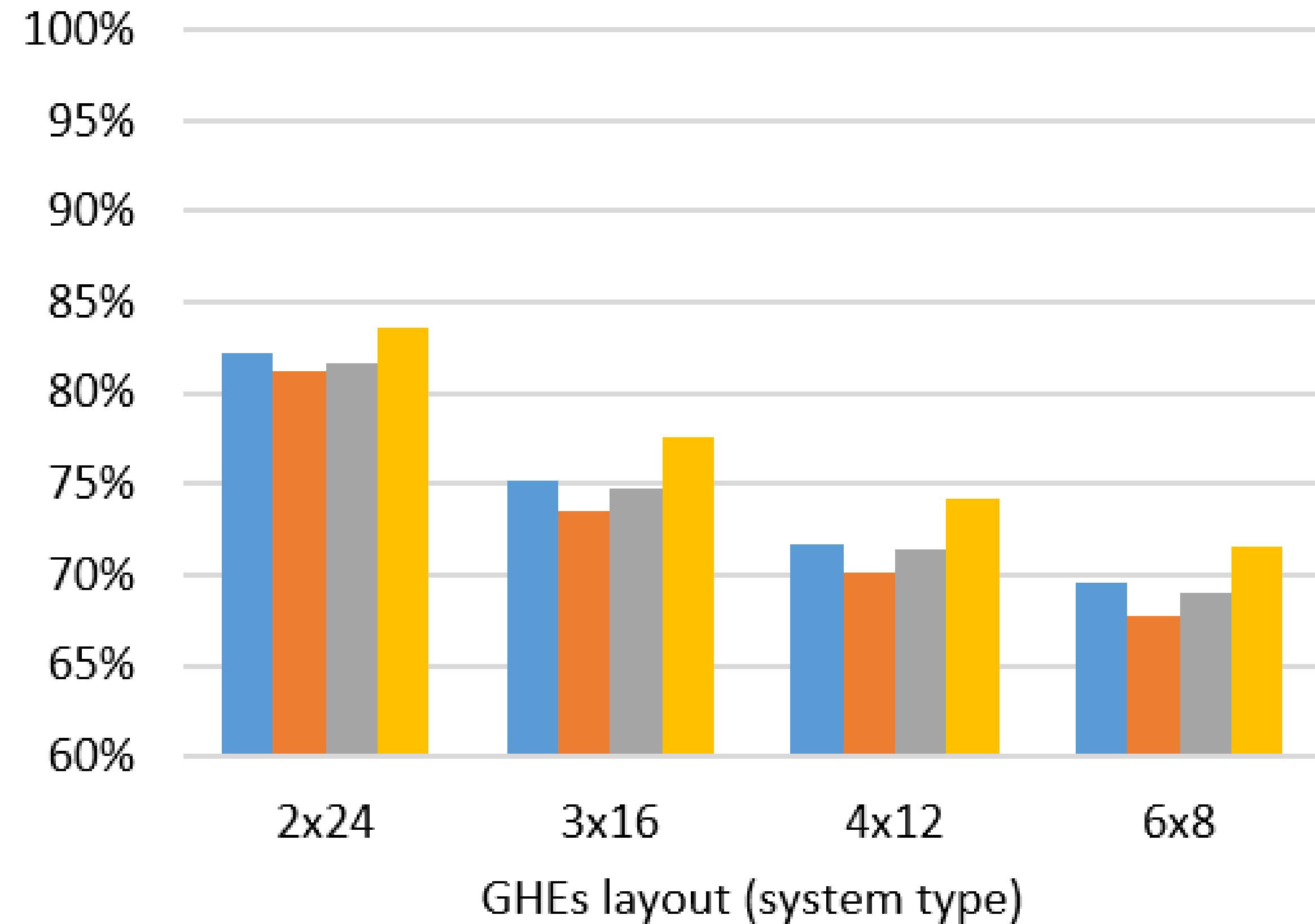
# Geoenergetic Aspect

Heat only vs heat and cold system



Amount of energy compared to 1x48 layout

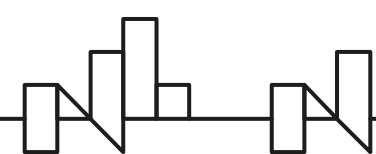
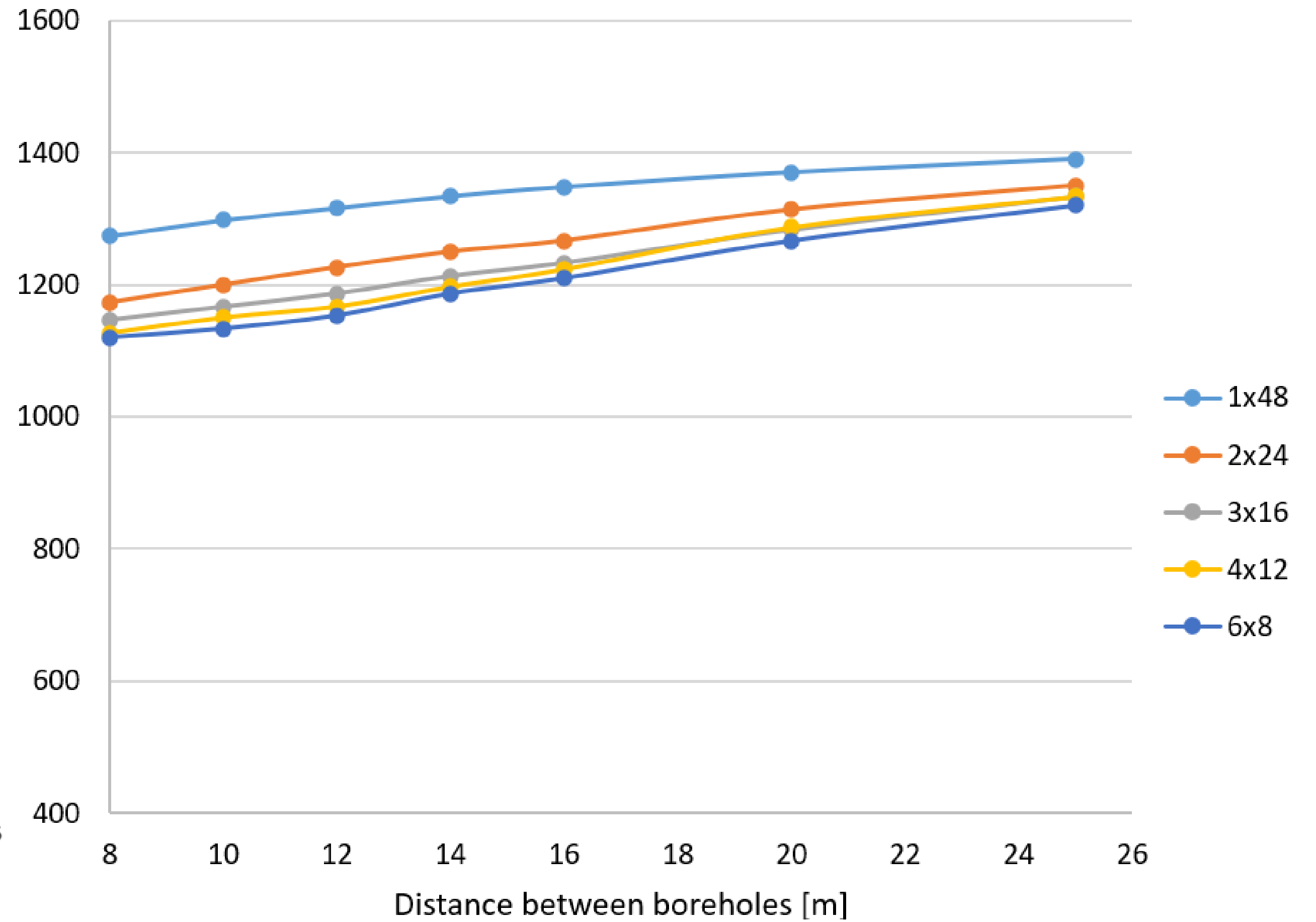
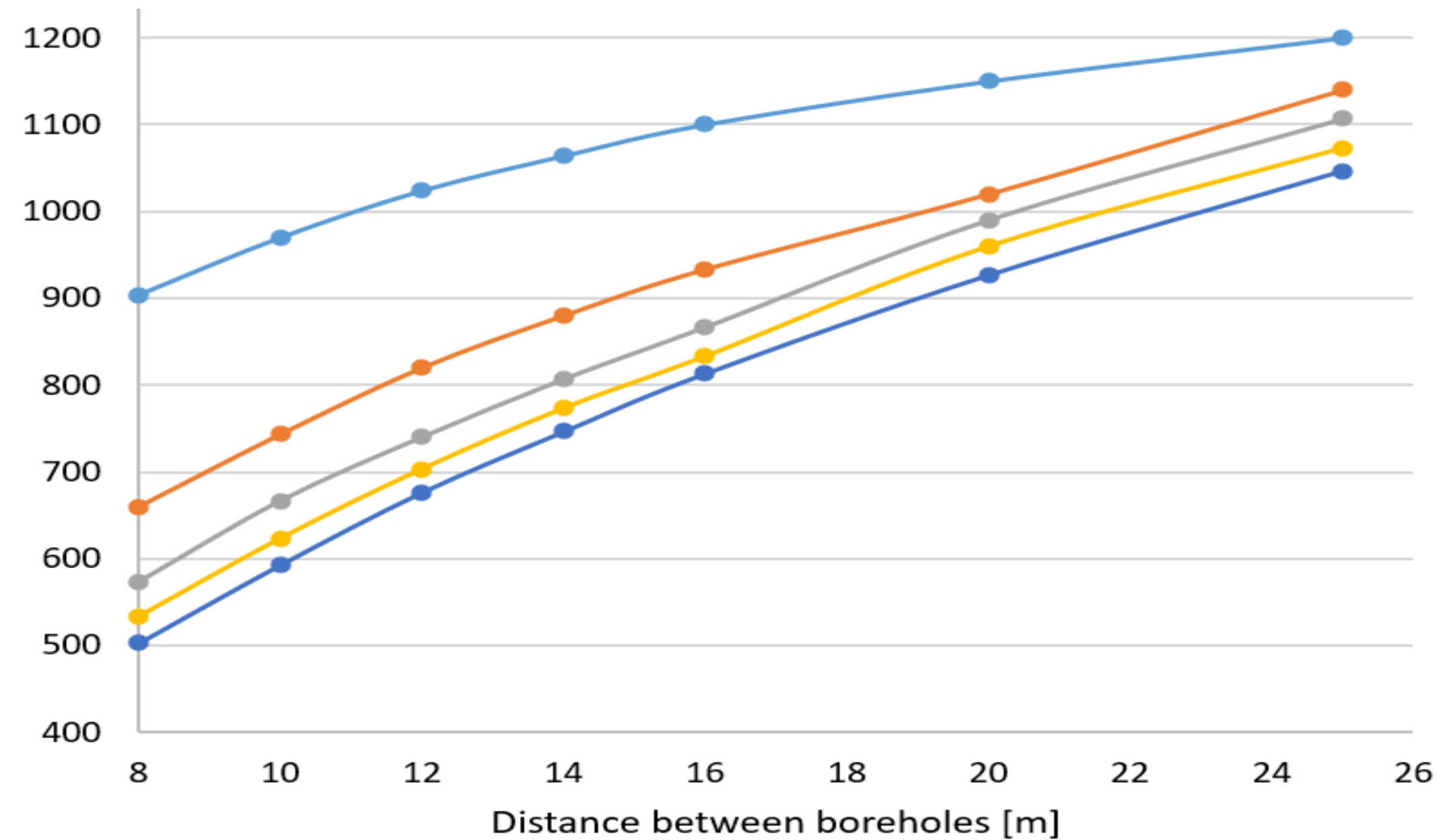
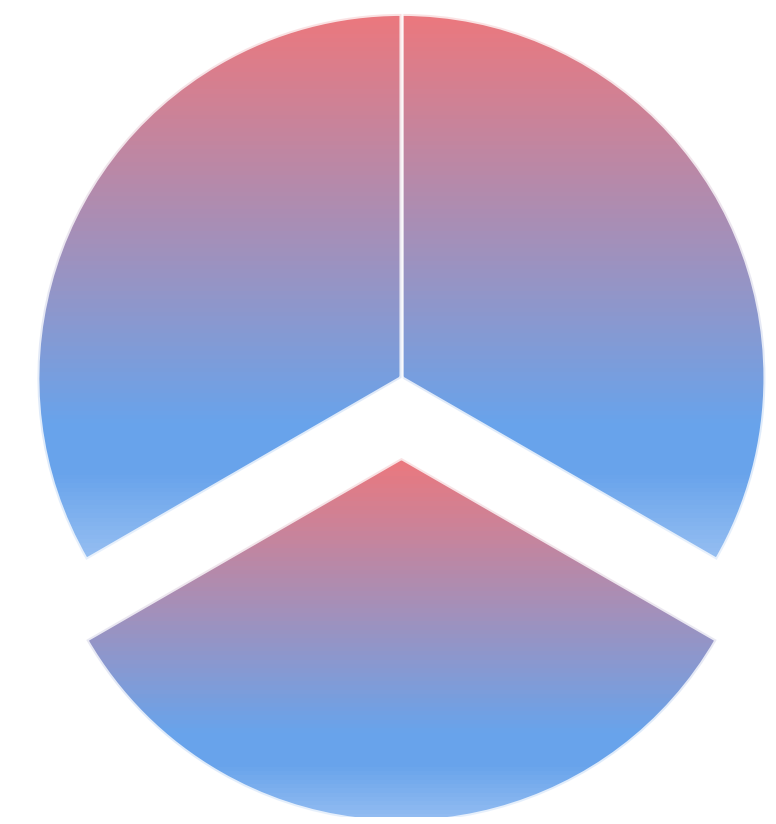
Amount of energy compared to 1x48 layout



# 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

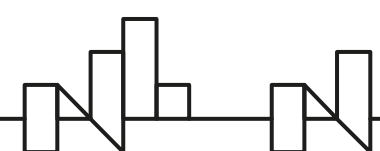




# Geoenergetic Aspect

## 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%).**



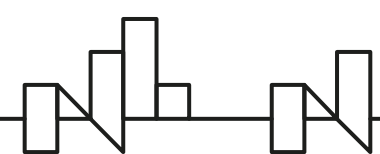
# Geoenergetic Aspect – summing up



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,

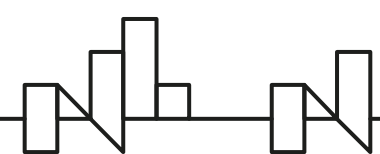
**what can lead to major increase of GHE technology availability.**





# 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

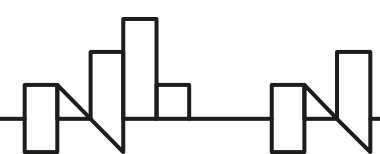




# Selected projects

## 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





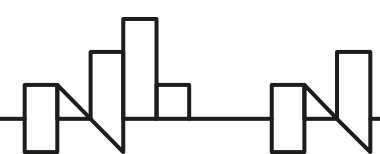
318,24 m



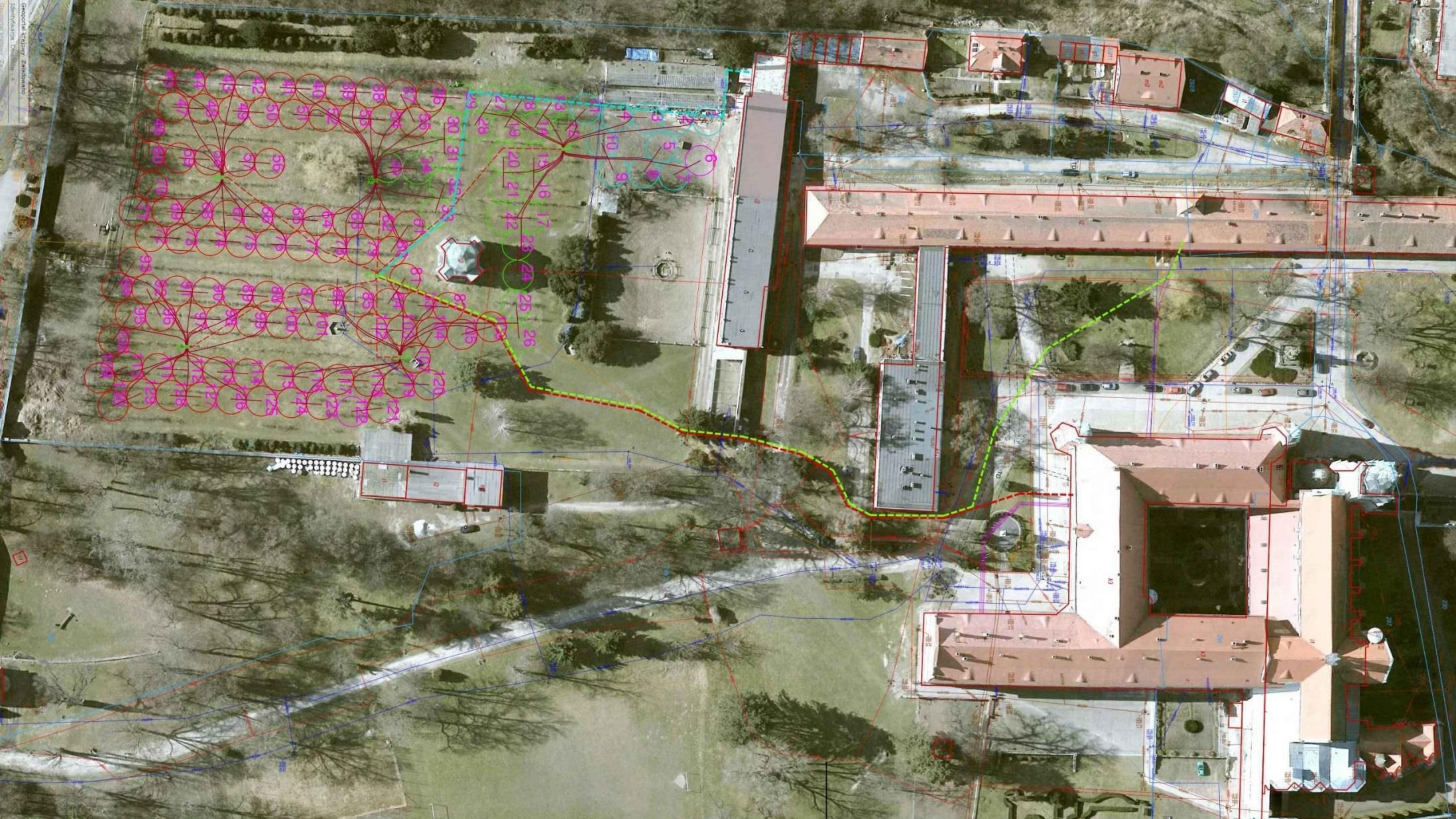
# Selected projects

## 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.









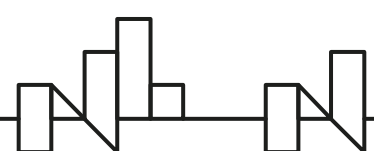
# Optimisation and cost-effectivness behind modeling software

## Most widely known analytical software



OWN ESTIMATION

- **Poland – own estimation:**
  1. **EED** – Earth Energy Designer, Sweden
  2. **EWS** – Huber Energietechnik AG, Switzerland
- **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



# Thank you!

## Any questions?

Contact: Jarosław Ozimek, [jaroslaw.ozimek@dps.net.pl](mailto:jaroslaw.ozimek@dps.net.pl)

