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Independent company group of DVGW

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GIS-based development of anergy networks using mine water geothermal energy for cross-sectoral heating and cooling supply of municipal quarters

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TU Bergakademie Freiberg

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1. Our corporate structure – DBI group

02 min

Our corporate structure

Deutscher Verein des Gas- und Wasserfaches e.V.
Technisch-wissenschaftlicher Verein

DBI Gas- und Umwelttechnik GmbH

- 100% subsidiary of the DVGW e.V.
- Private-sector company
- Engineering, consulting and industry-oriented research and development
- Accredited chemical laboratory

DBI - Gastechnologisches Institut gGmbH Freiberg

- 100% subsidiary of DBI Gas- und Umwelttechnik GmbH
- Non-profit research institution
- Basic and applied research
- Accredited Test Laboratory and further training

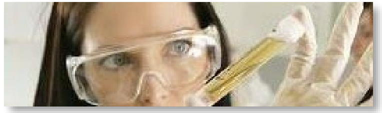
Our eight departments

Gas Production
Gas Storage

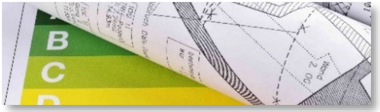
Gas Grids
Gas Facilities

Gas Utilization

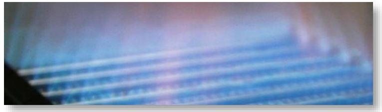
Gas Processing
Technology



Gas Chemistry
Gas Treatment



Energy Supply Systems



DVGW-Test Laboratory
Energy

Training Center Gas

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2. Project introduction GEoQart

05 min

2. Project introduction: GEoQart

What is the GEoQart project about?

- Topic: **Mine water** as a source of heating and cooling in urban districts
- Objective: Identification of regions / districs in which lucrative and feasible **grid-supply concepts** based on mine water geothermal energy are possible
- Output: Tool for **cost-effective pre-evaluation** of suitable locations

Executing project partners:

TUBAF – TU Bergakademie Freiberg – Die Ressourcenuniversität. Seit 1765.

DVGW – DBI GUT – Gas- und Umwelttechnik

Associated project partners: Geothermal Association, Municipal authorities, energy suppliers etc.

Bundesverband Geothermie | Bergstadt Brand-Erbisdorf | Berg- und Greifensteinstadt Ehrenfriedersdorf | Universitätsstadt Freiberg / Sachsen | eins energie in sachsen | TRANTER The heat transfer people | WISMUT

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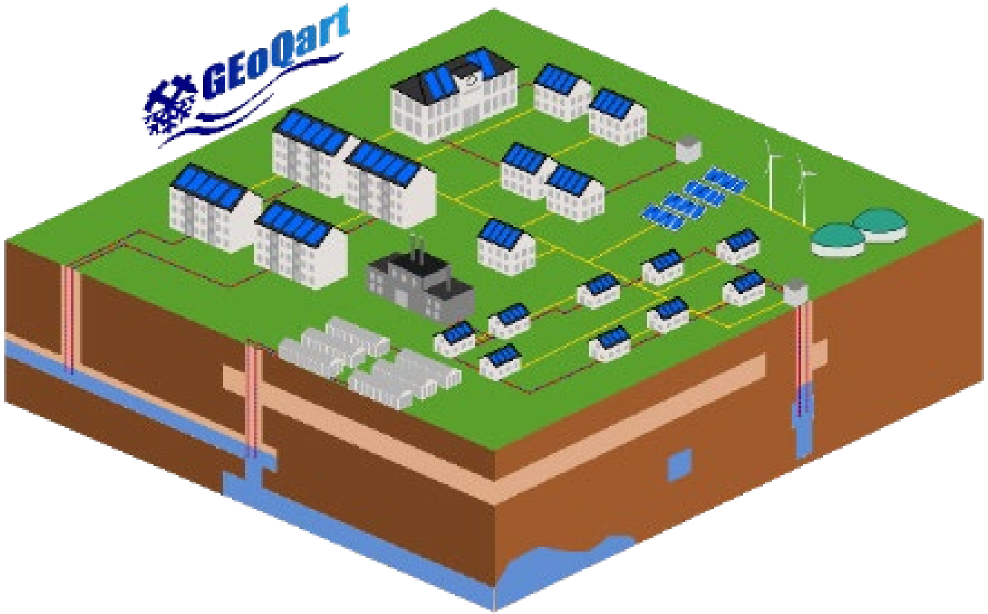
2. Project introduction: GEoQart

What are the work priorities in the project?



- **Mine water geothermal energy** as the **main source** of heating and cooling
- Combination with other renewable energies (e.g. photovoltaics)
- Investigation of cooling and heating distribution using **geospatial data** and **grid-based GIS-analysis**
- Development of technical and economical **feasible supply concepts**
- Acquisition of further locations and transfer of results

Objective: Calculation tool for the preliminary design of quarters / neighborhoods etc.

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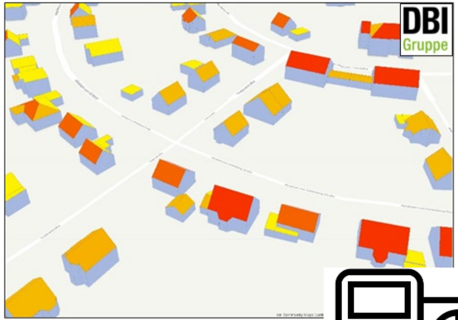
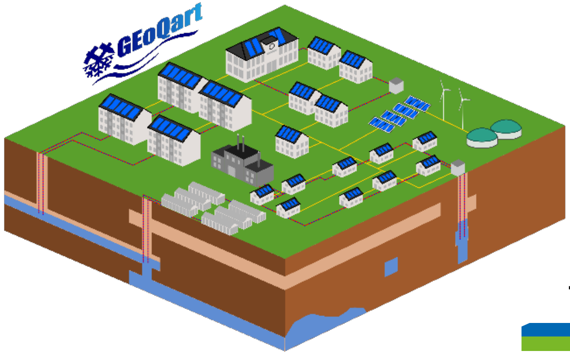
2. Project introduction: GEoQart

Project development





➡ TU Bergakademie Freiberg (blue)
➡ DBI Gas- und Umwelttechnik GmbH (green)

Development of **feasible supply concepts**

System design of quarters

GIS-supported **grid design**

Calculation of **sub-surface** heat potentials

Modeling of **above-ground** heat demand via GIS

2023 | 2024 | 2025

step I | step II | step III

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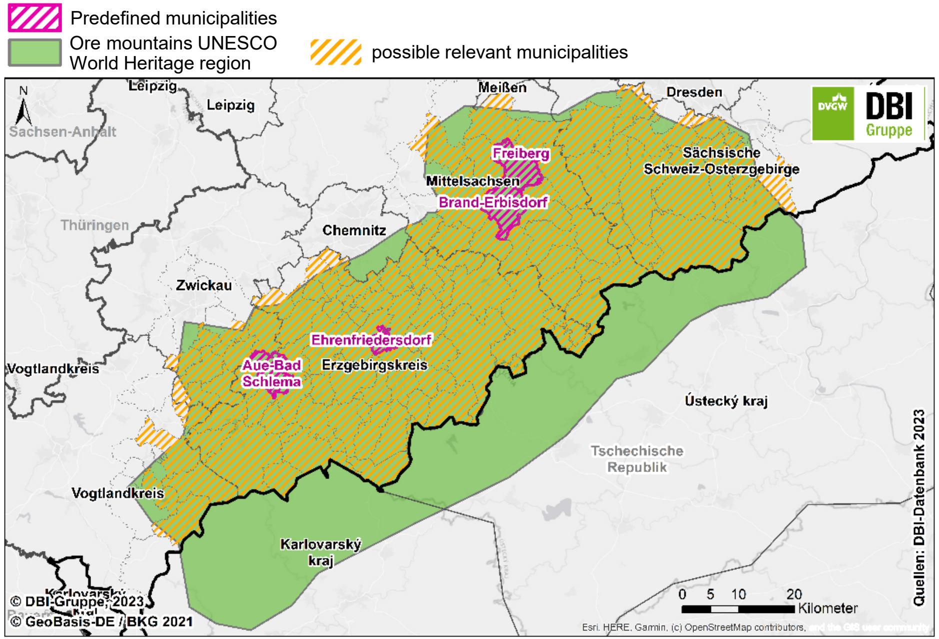
2. Project introduction: GEoQart

Delimitation of the study area
Ore mountains UNESCO World Heritage region:

- **four** predefined municipalities
  (see illustration on the right)
- addition of further relevant municipalities
  (selection from 102 municipalities in the study area)

➔ GIS-based selection using various parameters:

- **Settlement structure**
  ➔ municipalities in rural and urban areas
- **Sector-specific customer structures**
  ➔ municipalities with mainly residential, non-residential and/or mixed use
- **Size/extension of the mine / sub-surface structures**
  ➔ %-share of the municipality covered by former mining structures
- **Characteristic values of mine structures**
  ➔ mined raw material, time of mine closure



***Ore mountains** model region of the GEoQart project*

Objective: Pre-selection of suitable locations in the region for further analysis in the project

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3. First project results: Simulation of heating demands using 3D geospatial data

08 min

3. First **project results**: Simulation of heating demands using 3D geospatial data

GEoQart: Focus DBI Group → **Above-ground analysis**

- **Objective**: Analysis of the heat demand structures in the Ore mountains model region

- **Tasks**:
  - **Building-specific calculation of heating demands using 3D building models (LOD 2)**
  - Development of GIS-based methods for a routing of heating networks
  - Identification of grid-connected supply options in the study area using geothermal energy from mine water
  - Evaluation of the economic feasibility for technically suitable supply options and areas

- **Output**:
  1. feasible above-ground supply concepts and boundary conditions for mine water supply → input data for the tool
  2. Examination of transferability to other regions outside the study area

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3. First **project results**: Simulation of heating demands using 3D geospatial data

Methodology for heating demand modeling

→ Simulation based on german industry standards (DIN V 18599)

Balancing of heat sinks and heat sources for each building:

$$Q_{h,b} = Q_{sink} - \eta \cdot Q_{source} - \Delta Q_{c,b}$$

$Q_{h,b}$	**heat requirement** in the building zone [kWh]
Q_{sink}	summary of the **heat sinks** in the building zone considering the boundary conditions
Q_{source}	summary of the **heat sources** in the building zone considering the boundary conditions
$\Delta Q_{c,b}$	storage heat in the external building components
η	the monthly utilization rate of the heat sources (for heating purposes)

Objective: development of a GIS-based calculation based on 3D-geometric values

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3. First **project results**: Simulation of heating demands using 3D geospatial data

List of modeled individual energy values
(12 monthly values each, taking into account usage and non-usage times)

Heat sources:

- Heat input through **solar radiaton** on windows and opaque (intransparent) surfaces (wall/roof etc.)
- Heat input through **transmission** via building elements (wall/roof etc.)
- Heat input through **ventilation**

Heat sinks:

- **Heat radiation** of the building (wall/roof)
- Heat **dissipation through transmission** via building elements (wall/roof)
- Heat **dissipation through ventilation**
- Heat for **hot water generation** in the building zone

➔ Depending the season (summer/winter) all heat sources could be sinks, vice versa

Objective: development of a GIS-based calculation based on 3D-geometric values

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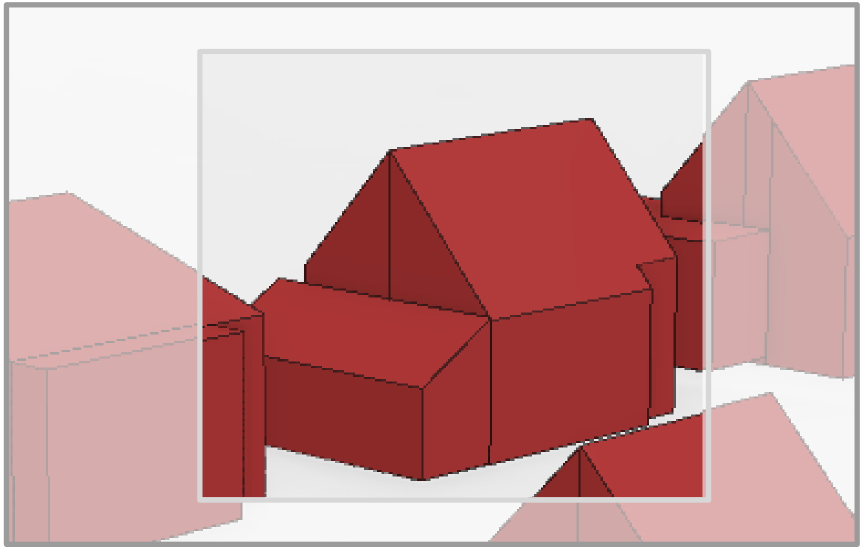
3. First **project results**: Simulation of heating demands using 3D geospatial data

3D-data used for the heat demand calculation (example):

- 2 building sections (garage + residential building)
  ➔ 11 areas / building polygons to consider
- Residential building with pitched roof and max. 3 floors
- **Roof orientation**: 126,5° (SE), roof pitch: 48,1°
- **Roof area**: 144,1 m^2
  (NW: 67,7 m^2 / SE: 76,4 m^2)
- **Wall area**: 261,0 m^2
  (NW: 62,6 m^2 / NE: 70,8 m^2 / SE: 56,3 m^2 / SW: 71,3 m^2)
  ➔ NW: 40,2 m^2 covered by another building nearby
- **Floor area**: 96,2 m^2
- Total lateral surface: 501,3 m^2, total building volume: 763,4 m^3



➔ Derivation of **net floor area**: 223,9 m^2
➔ Calculation of **net building volume**: 580,2 m^3

Objective: Creation of a database with structural characteristic values / geometrical information

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3. First **project results**: Simulation of heating demands using 3D geospatial data

Additional point-based data sets for the heat demand calculation (example):

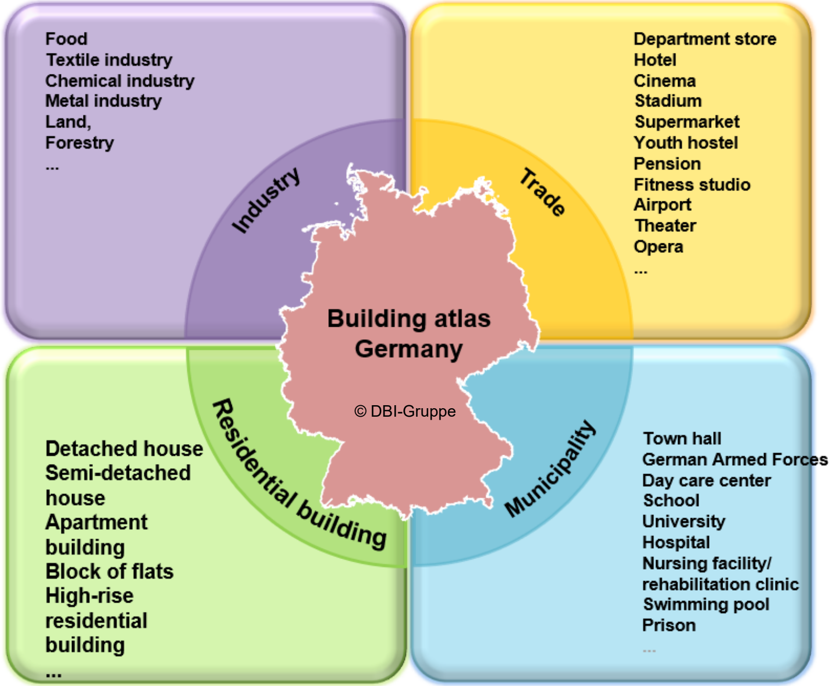
→ Information about building usage

approx. **23 million geo-referenced address data with geocoordinates** in the database for Germany

Classification into **four categories** (see illustration on the right):

- **Residential buildings**
- **Municipality buildings**
- **Trade / Commercial / Service buildings**
- **Industry**

➔ approx. 180 customer sections covered in the database



Sectors / Geodata covered in the DBI-database

Objective: Enrich the 3D-geodatabase with parameters of the building‘s usage

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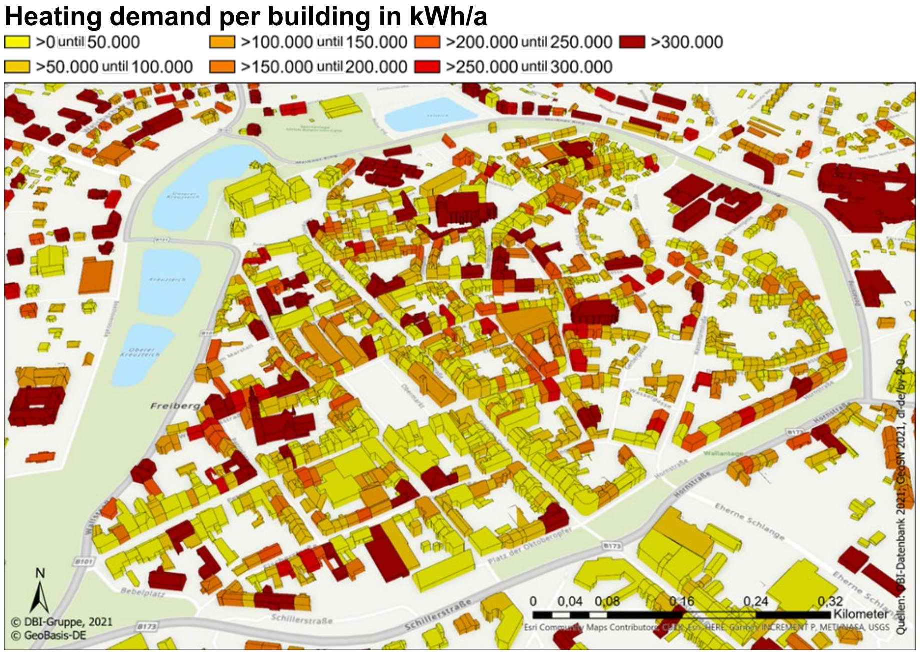
Heat demand modeling result (example):

1. structural parameters:
   ➔ Building dimensions, wall and roof alignment, thermal transmittance value

2. Climatic influences:
   ➔ Grid-based Temperature data and solar irradiation

3. Information about building usage:
   ➔ Derivation of usage profiles (load profile, temperature level etc.)



Objective: Creation of a methodology with freely customizable parameters without needs for specific consumption values → methodology only based on spatial (3D) and climate data

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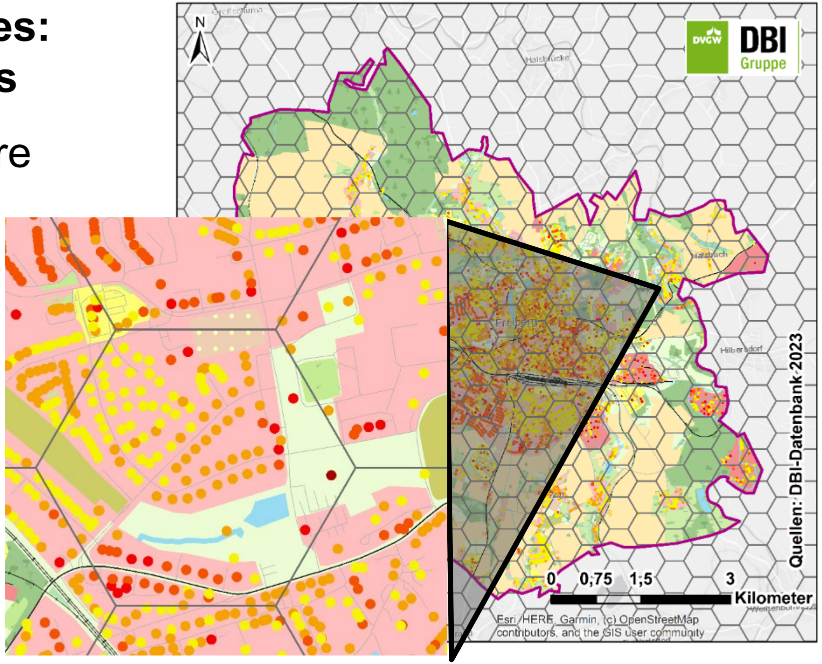
3. First **project results**: Simulation of heating demands using 3D geospatial data

Further analysis using the heating demand values: Detailed location assessment using grid analysis

Modeling of different characteristic values to compare different regions and municipalities

➔ **Intersection from grids and heat consumers (see illustration on the right)**

- **Heat occupancy density** (kWh/(a· m^2))
- **Specific consumer density** (consumers/km^2)
- **Average power density** (kW/a)
- **Average heat demand** (kWh/a)
- **Total energy demand** (kWh/a)



Intersection example for the city of Freiberg in a hexagonal grid (250.000 m^2)

Objective: Identification of regions / neighborhoods suitable for grid-connected heat supply using mine water geothermal energy as the base-load capable heat source

4. Project progress: GIS-Analysis of technical / economic feasibility supply concepts

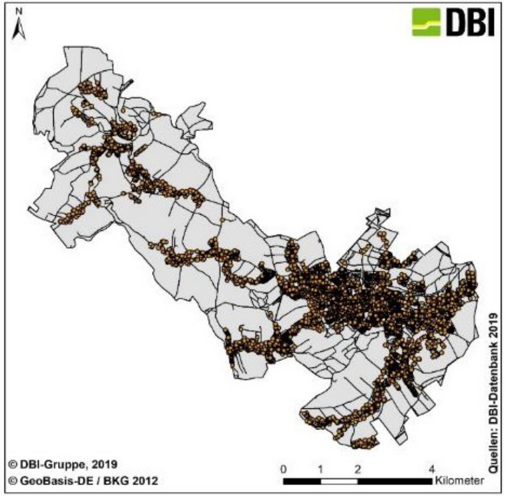
05 min

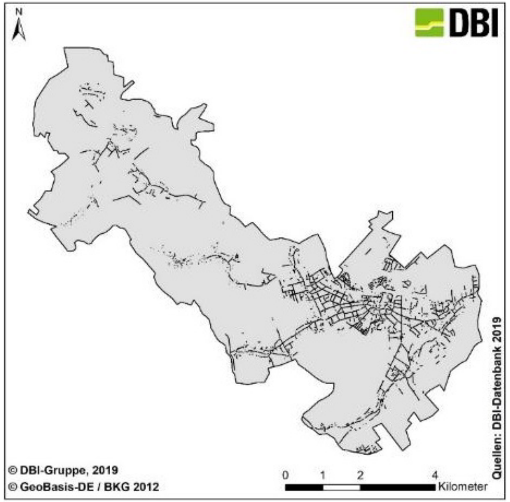
4. **Project progress**: GIS-based modelling of a heating network routing tool with GIS

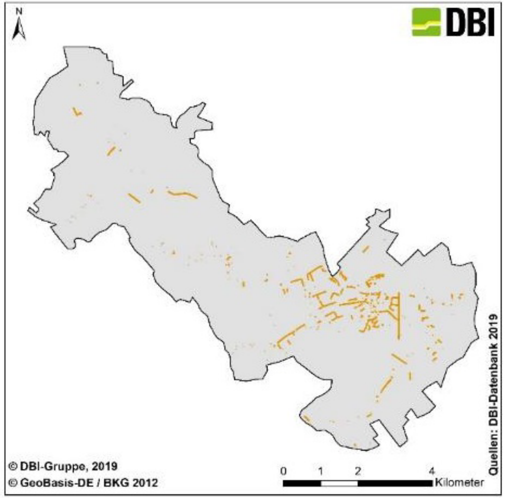
Example for the algorithm routing / heating network analysis – Step 1

Allocation of heat consumers to nearby suitable infrastructure → Selection of network sections with heat consumers nearby → Identification of lucrative network sections / streets

study area | road network | heat consumer | lucrative streets







Objective: Modeling of the spatial extension of heating networks and localizing suitable heat consumers

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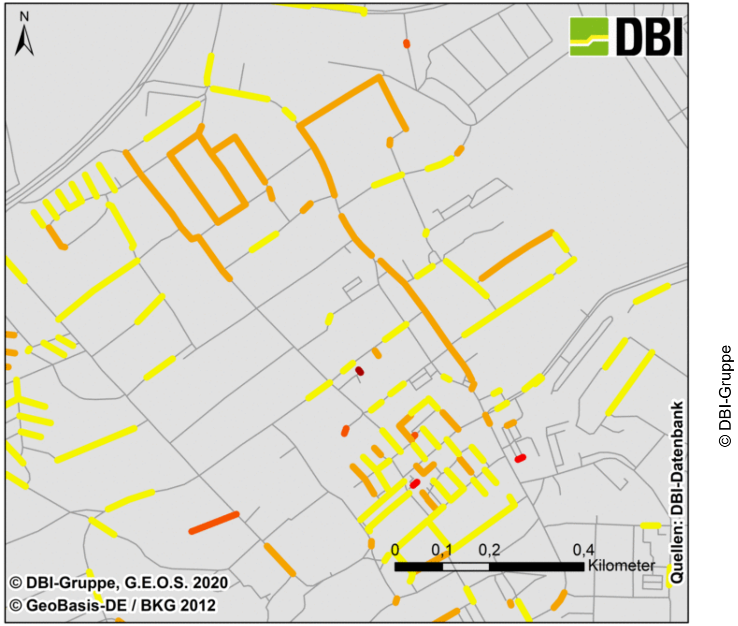
Example for the algorithm routing / heating network analysis – Step 2

- Criteria for network analysis:
  - Alongside public infrastructures
  - No meshes / loops etc.
  - Bypassing cost-intensive sections (e.g. highways)
- Iterative procedure **DBI GridAnalyst:**
  - Start with the most lucrative grid section (max. kWh/(m*a))
  - Connect the grid sections until all suitable consumers are connected to the grid
  - Connect until a termination criterion is fulfilled (e.g. heat occupancy, mine water energy availability, route length, number of consumers based etc.)

→ most efficient distribution of the available energy from customer to customer



Example of the algorithm execution

Objective: Derivation of site-specific network parameters for the district assessment
→ connection to the possible mine water extraction point and economical evaluation

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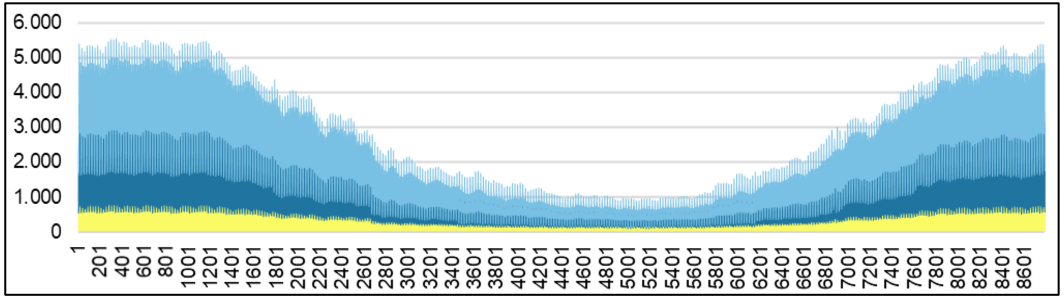
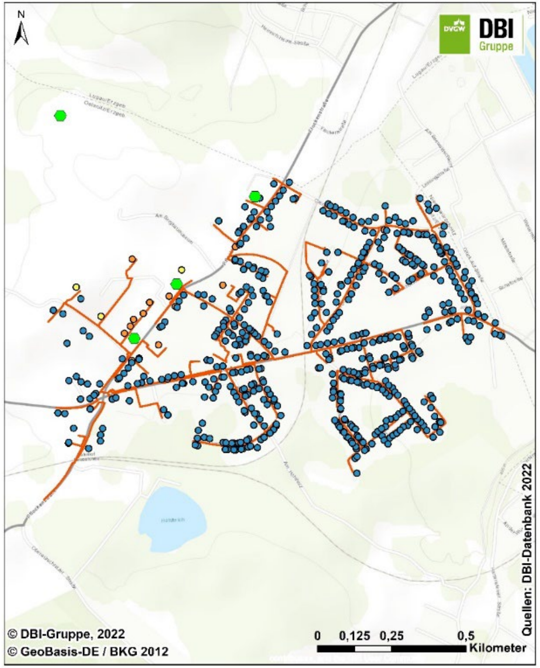
4. Project progress: GIS-based modelling of a heating network routing tool with GIS

Project stage II: development of specific neighborhood supply concepts

- **Validation of** modeled heat demands with real minicipal data
- Development of **district supply concepts** (see image on the right)
  ➔ Mine water geothermal energy as the main source of energy
- Investigation of cooling and heating distribution via **heating networks**
  ➔ Analysis of seasonal load behaviour / load profiles (see image below)
- Consideration of **heat storage systems** und more renewable energies (e.g. photovoltaics)





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Objective: Evaluation of the **technical** feasibility of district supply concepts

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4. <u>Project progress</u>: GIS-based modelling of a heating network routing tool with GIS

Project stage II: profitability and economical analysis for technical feasible concepts

Application of the **annuity methods** according to **german industry standards** (VDI 2067)
Taking into account the following costs**:**

- <u>Capital-related costs</u>
  → All system-related costs for investment / replacement investment / refurbishment (pipelines, heat pumps, heat exchangers etc.)
- <u>Operating costs</u>
  → Costs for maintenance, servicing, repairs and cleaning costs
- <u>Demand-related costs</u>
  → mainly electricity requirements
- <u>Other costs</u>
  → Insurance and management costs

Objective: Evaluation of the **economic** feasibility of district supply concepts

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Thank you for your attention!

geothermie.iwtt.tu-freiberg.de

dbi-gruppe.de/potential-und-gis-analysen.html

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Energy with Future. Environment and Responsibility.

5. Discussion and time for your questions

05 min