Unabhängige Unternehmensgruppe des DVGW

www.dbi-gruppe.de

Grid-based heat supply for buildings based on geothermal energy

- Possibilities of GIS-supported modelling -

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DBI Gas- und Umwelttechnik GmbH

Professional training on „geothermal energy"
11.05.2023, Freiberg

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Structure

1 Kurze Vorstellung DBI-Gruppe

2 Fundamentals of heat grids and benefits of grid-connected energy supply

3 Methods of potential and location analyses using geoinformation systems

4 Time for questions

1. Brief introduction DBI-Gruppe

DBI-Gruppe

Gas production
Gas storage

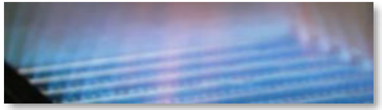
Gas networks
Gas plants

Gas application - Thermoprocessing

Gas Process Engineering

Gas chemistry
Gas processing

Energy supply systems / RE



Energy Test Laboratory

Freiberg Training Centre Natural Gas

2. Fundamentals of heat grids and benefits of grid-connected energy supply

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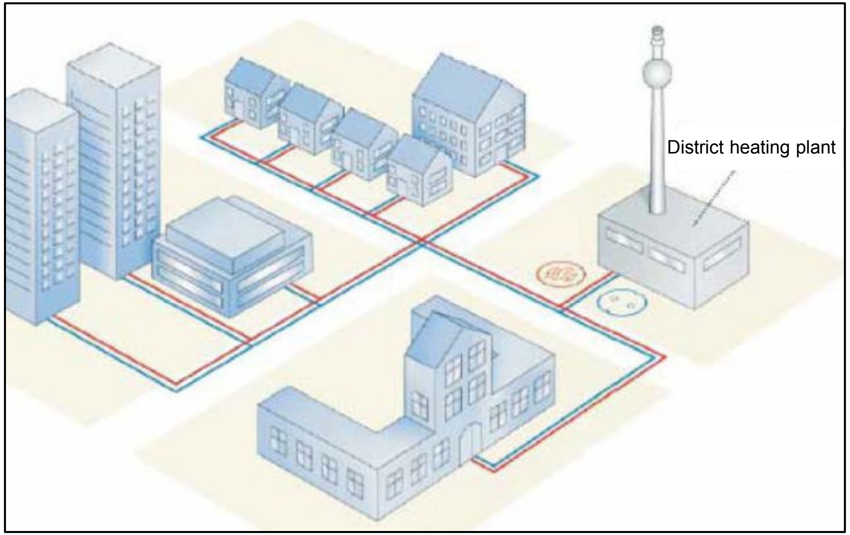
2. Fundamentals of heat grids and benefits of grid-connected energy supply

Heat grids:

Piped heat supply, connection of heat source(s) with consumers

- Distinction between local and district heating:
  - Smooth transition
  - Differentiation based on network length and flow temperature

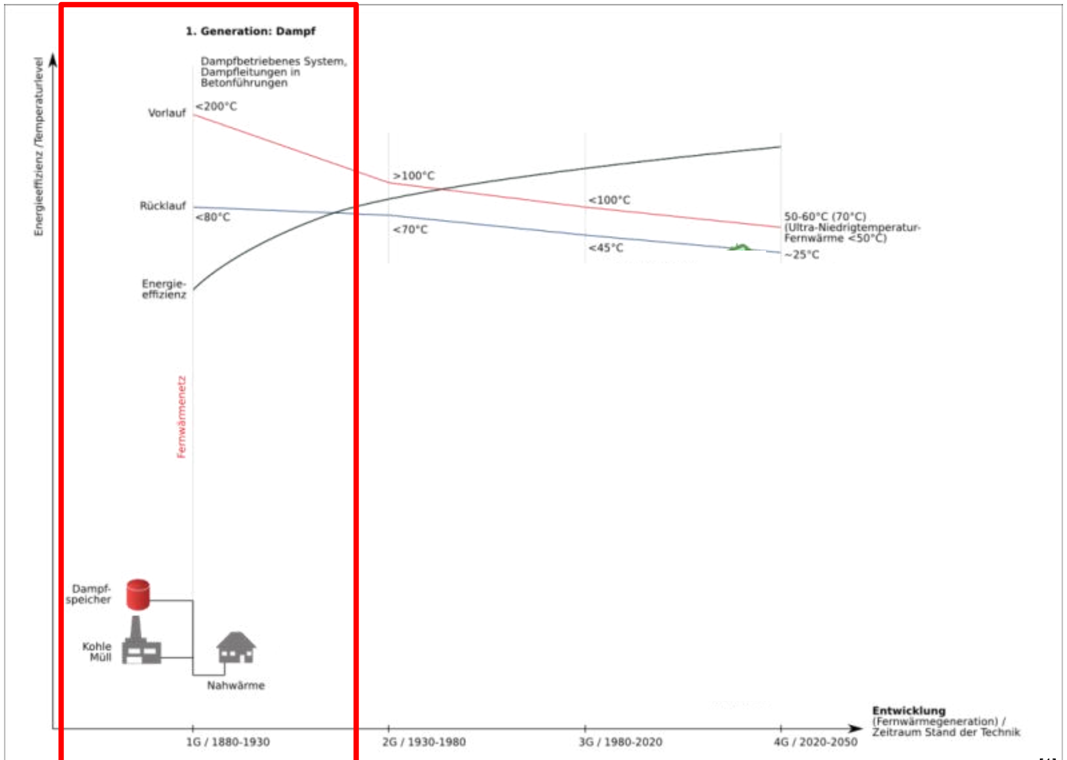
  → District heating: usually high flow temperatures (> 90°C)



➔ Grouping of heating networks into **technical generations**

➔ Depending on timeline and technical parameters / innovations

First technical generations :



[1]

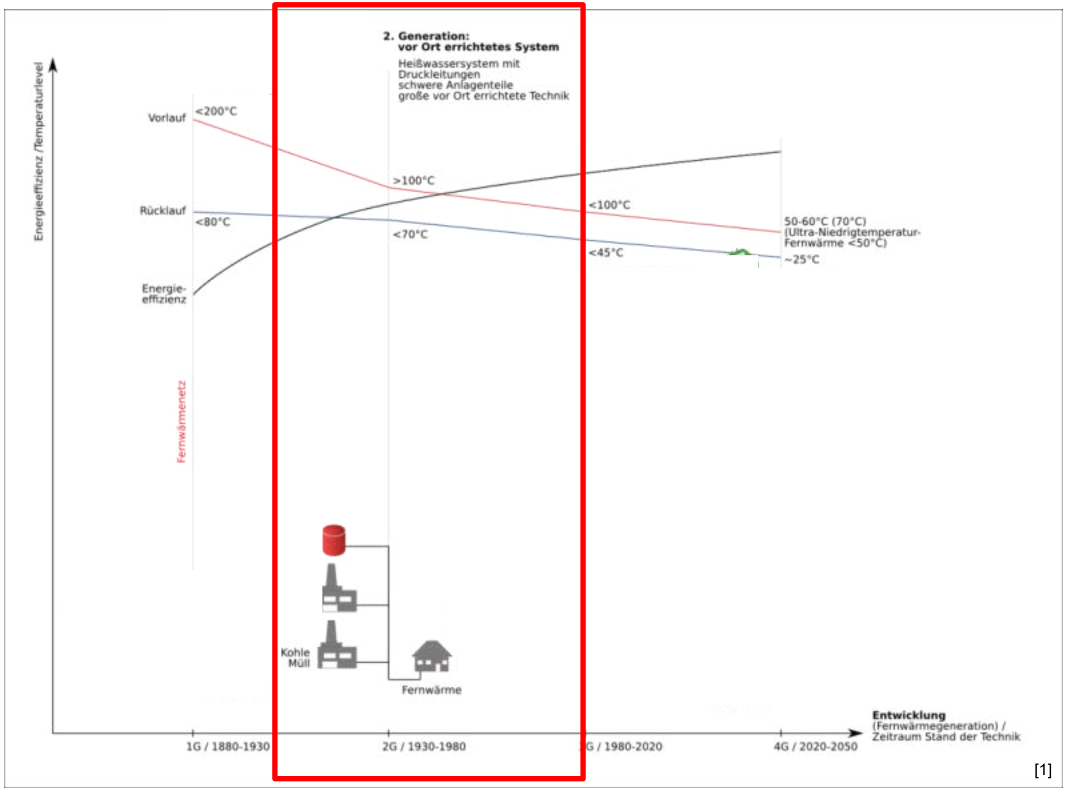
Steam networks

Characteristics of the network

- Inlet temperature:
  < 200 °C
- Return temperature:
  < 80 °C
- Energy efficiency:
  low
- Year of contrsuction:
  1880 - 1930

[1] H. Lund, S. Werner, R. Wiltshire, S. Svendsen, J. E. Thorsen, F. Hvelplund, B. V. Mathiesen, *4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems*, Vol. 68 **2014**.

Second technical generations :



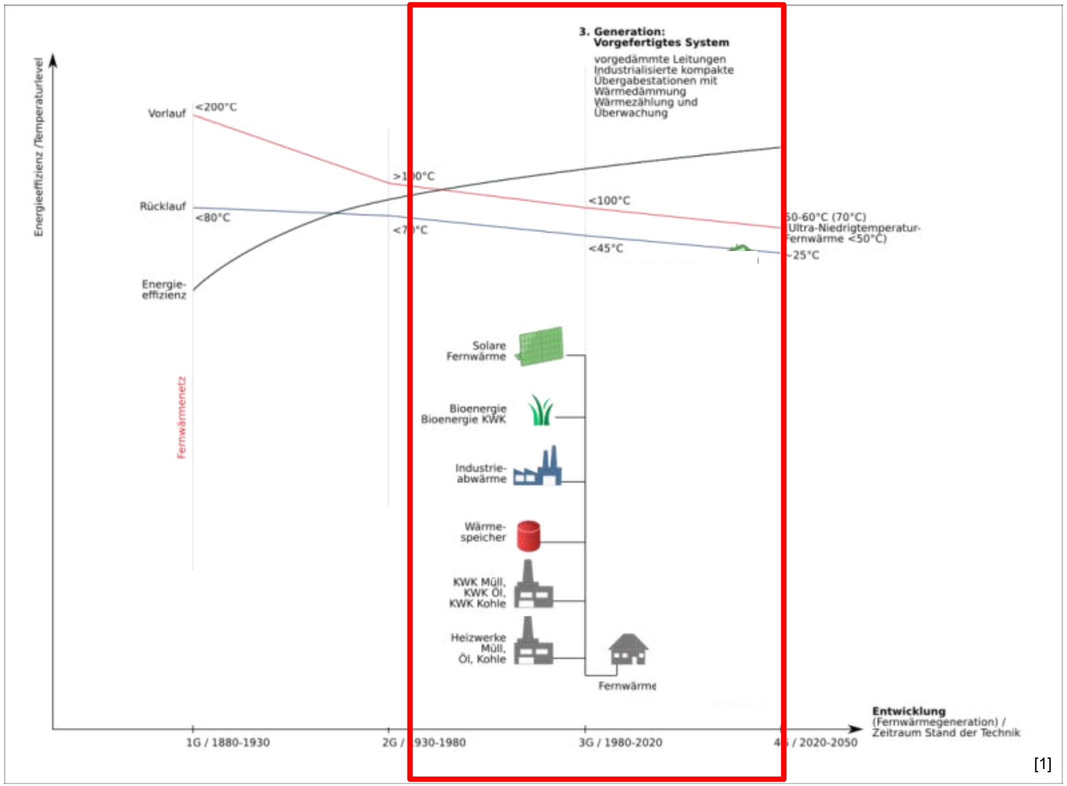
High temperature water network

Characteristics of the network

- Inlet temperature:
  > 100 °C
- Return temperature:
  < 70 °C
- Energy efficiency:
  low
- Year of contrsuction:
  1980 - 2020

[1] H. Lund, S. Werner, R. Wiltshire, S. Svendsen, J. E. Thorsen, F. Hvelplund, B. V. Mathiesen, *4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems*, Vol. 68 **2014**.

Third technical generations :



[1]

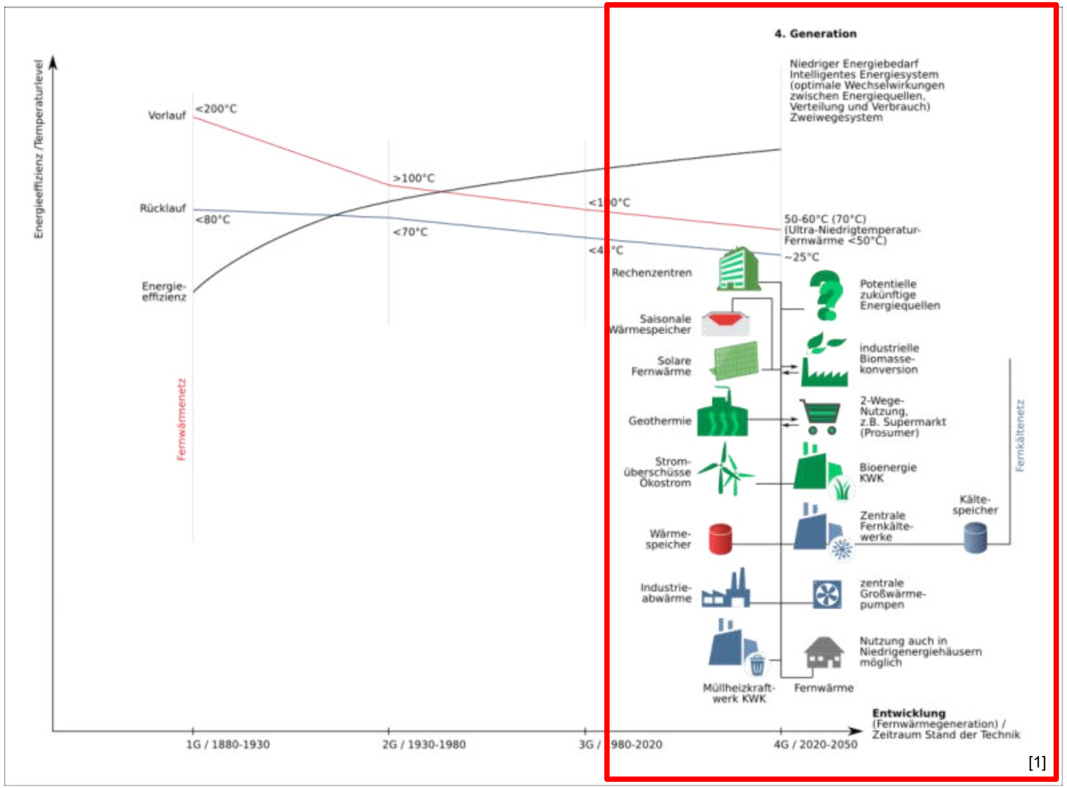
Optimised high temperature water network

Characteristics of the network

- Inlet temperature:
  > 100 °C
- Return temperature:
  < 45 °C
- Energy efficiency:
  Moderatly (insulation)
- Year of contrsuction:
  1980 - 2020

[1] H. Lund, S. Werner, R. Wiltshire, S. Svendsen, J. E. Thorsen, F. Hvelplund, B. V. Mathiesen, *4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems*, Vol. 68 **2014**.

Fourth technical generations :



[1]

District heating network 4.0

Characteristics of the network

- Inlet temperature:
  50 – 70 °C
- Return temperature:
  > 25 °C
- Energy efficiency:
  High
- Year of contrsuction:
  Since 2020

[1] H. Lund, S. Werner, R. Wiltshire, S. Svendsen, J. E. Thorsen, F. Hvelplund, B. V. Mathiesen, *4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems*, Vol. 68 **2014**.

2. Fundamentals of heat grids and benefits of grid-connected energy supply

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RawMaterials Connecting matters

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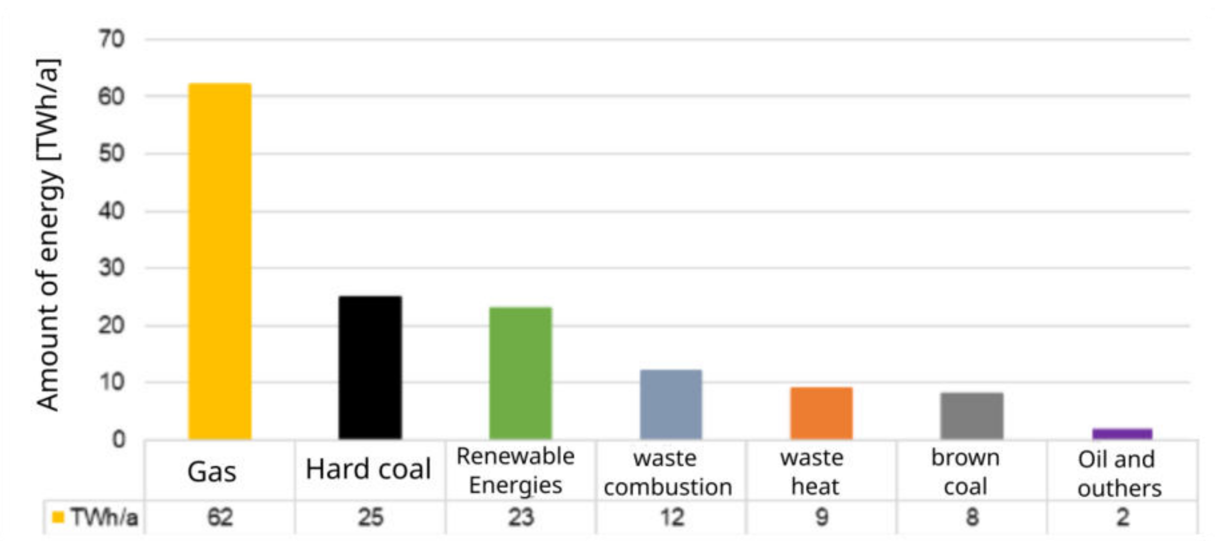
Subdivision of energy sources of district heating for heating purposes 2019 according to [10].



Current supply situation

- District heating in Germany mainly provided by fossil fuels (natural gas, coal)
- Future supply?
  - 5.6 million households are supplied by district heating
- Need to integrate renewable energy sources (coal phase-out) (supply security for natural gas)

[1] M. Petersen, B. Olzem, *Strategiepapier Zukunft Wärmenetzsysteme*, Berlin **2017**.

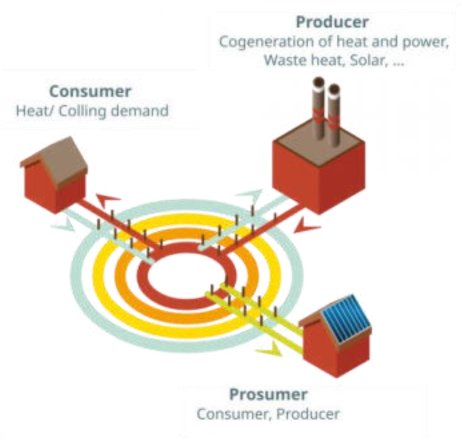
→ New opportunities by further developments of the heat grids (5th generation)

DBI Gruppe

Fifth technical generations : **Anergy networks („Cold district heating network “)**

- Characteristics:
  - Energy distribution at **low temperature levels** (5 - 35°C)
  - Significantly **lower heat losses** (reduction of ΔT → no insulation necessary)
  - Buildings need **decentralised heat pump** with heat network as source (especially for hot water supply)
  - Possible **heat sources**: Waste heat renewable energies (e.g. mine water).
  - Use of the **same infrastructure** for heating and cooling

  → Possibility for prosumers



[1]

[1] *Das Forschungsprojekt LowExTra*, http://lowextra.de/.

2. Fundamentals of heat grids and benefits of grid-connected energy supply

Anergy networks („Cold district heating network“)

Pros	Cons
- Simultaneous supply of heat and cooling via one network - Simple expansion - Low network losses - Integration of different renewable heat sources with thermal energy at a low temperature level → Decarbonisation of the heating network possible - Decentralised consumer-specific heat setting by means of heat pump →Heating and cooling operation with one unit	- Complex and demanding system control → Digital infrastructure required - Higher volumetric flows required due to low temperature differences between inlet and return flow → High pump energy & rising costs - More expensive transfer stations for customers due to additional heat pump - Conversion of existing buildings only possible to a limited extent → Energy refurbishment required beforehand

➔ Mine water geothermal energy/ cold brines are predestined for cold local heating networks

➔ Local potential analyses are the basis for future supply systems

2. Fundamentals of heat grids and benefits of grid-connected energy supply

Implementation of local potential analyses necessary

→**Goal:** Identification of regions/neighbourhoods etc. where a lucrative and medium-term feasible operation of cold heat networks is possible.

To achieve this, the following points must be analysed:

- Inventory analysis

→ e.g. localisation of heat consumers

- Potential analysis

→ e.g. analysis and location of renewable energy sources

- Development of target scenarios

→ e.g. geothermal coverage in the neighbourhood based on mine water of 50%

- Development of strategies and measures

→e.g. establishment of heating networks with mine water geothermal energy as a renewable energy source

→ These questions can only be answered with geoinformation systems.

3. Methods of potential and location analyses using geoinformation systems

DBI database for modelling building-specific heat requirements

→ Goal: Modelling of building-specific heat requirements as a basis for network simulations

Data basis::

Approx. **23 million geo-referenced geodata with location** accuracy in the DBIdata stock

Division into **four categories**:

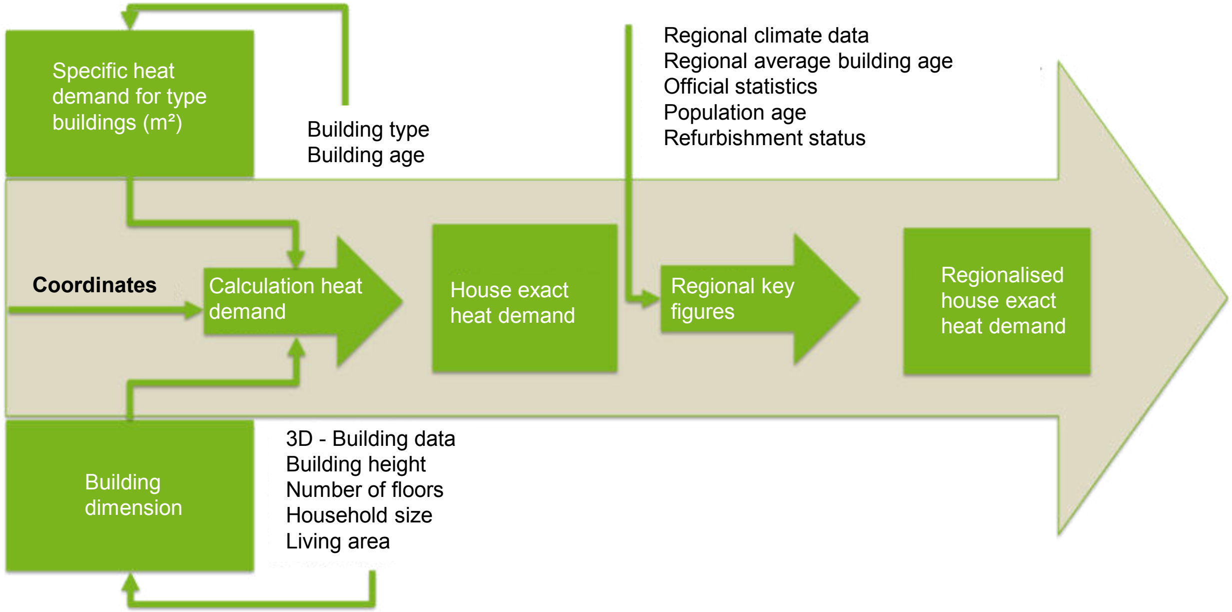
- Residential buildings
- Municipality
- Commercial (incl. trade and services)
- Industry

Enrichment of the geodata with parameters for energy demand calculations:

- Building-specific data per address based on official statistics and own research, including:
  - Geograpical location
  - Building characteristics (single/multi-family house, ...)
  - Year of construction
  - Number of households, …
- micro- and macro-climate data
- Specific energy parameters

Procedure for modelling building-specific heat requirements

Bottom-Up modelling of heat demand



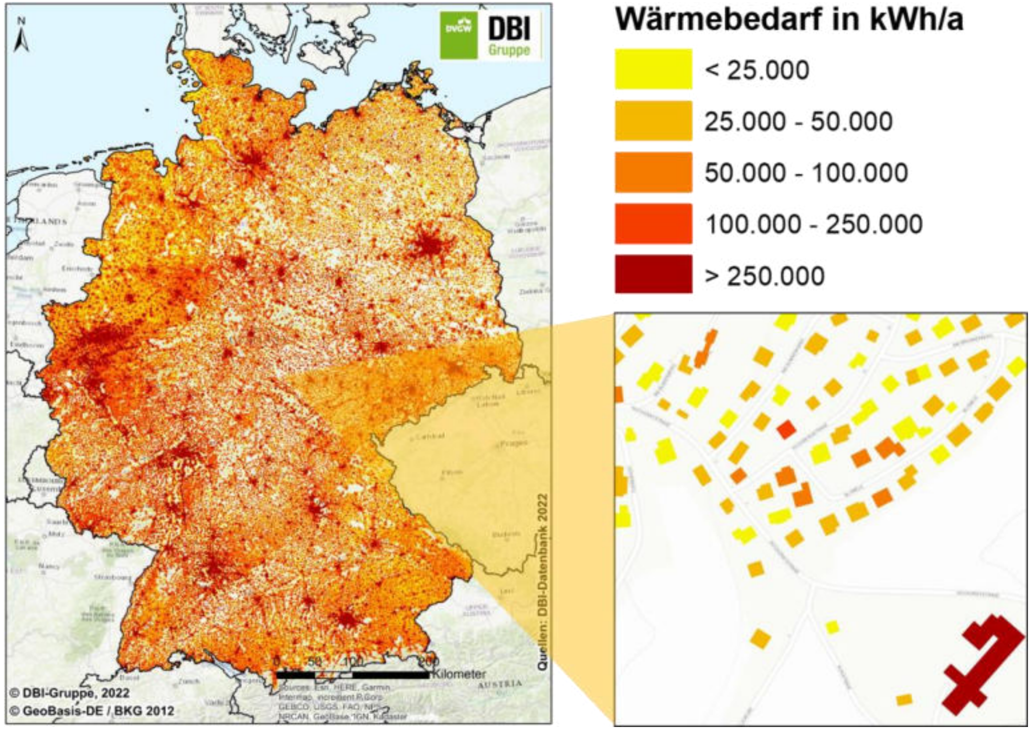
Algorithm:

1. Capture of addresses with geo-coordinates
2. Assignment of building dimensions in different quality
3. Assignment of specific heat demand parameters:
4. Determination of the site-specific heat demand
5. Regionalisation of heat demand with additional characteristic values

→ Result: a modelled heat demand in kWh/a is available for **each building**

DBI Gruppe

Representation of the modelled heat requirements in a map



Germany-wide representation of heat demand

Potentially possible evaluation levels:

- site / building level
- municipality / district level
- Any grid format

Heat requirements form the basis for further analyses:

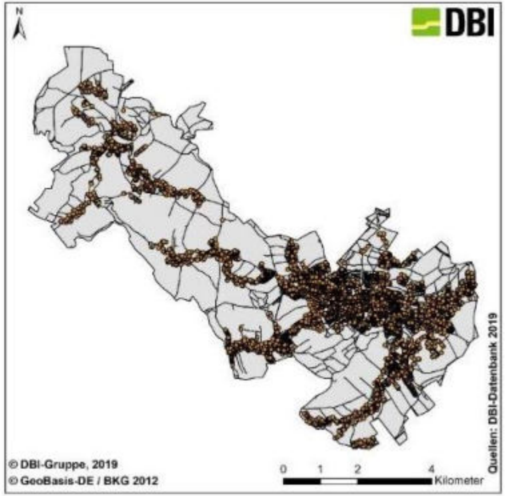
- possibilities for densification of existing grids
- New network construction: new supply concepts
- Heat demand forecast

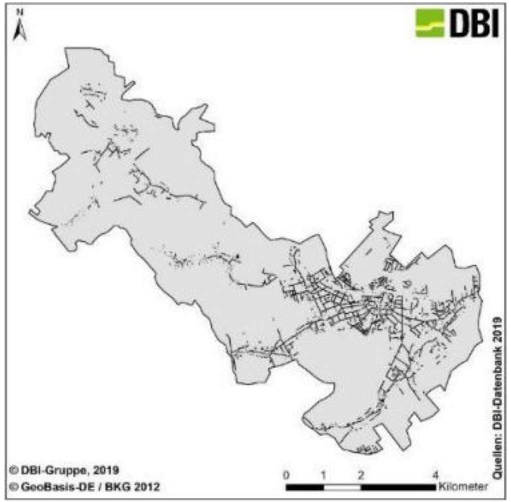
→ Result: a modelled heat demand in kWh/a is available for **every building**

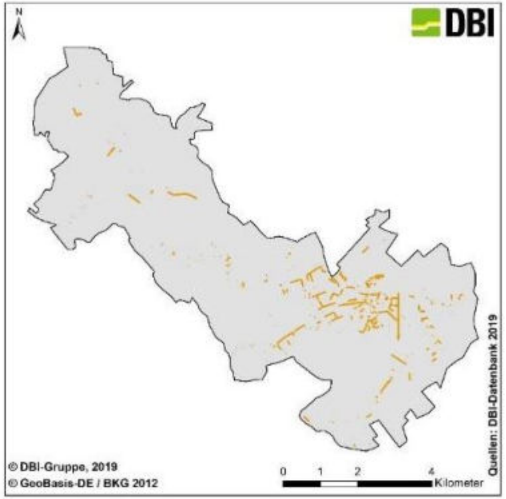
Heat network modelling based on the DBI-GridAnalyst

Allocation of heat consumers to nearby infrastructure → Selection of network sections with heat consumers → Identification of profitable network sections

Field of investigation | Road network | Heat consumers | Lucrative streets





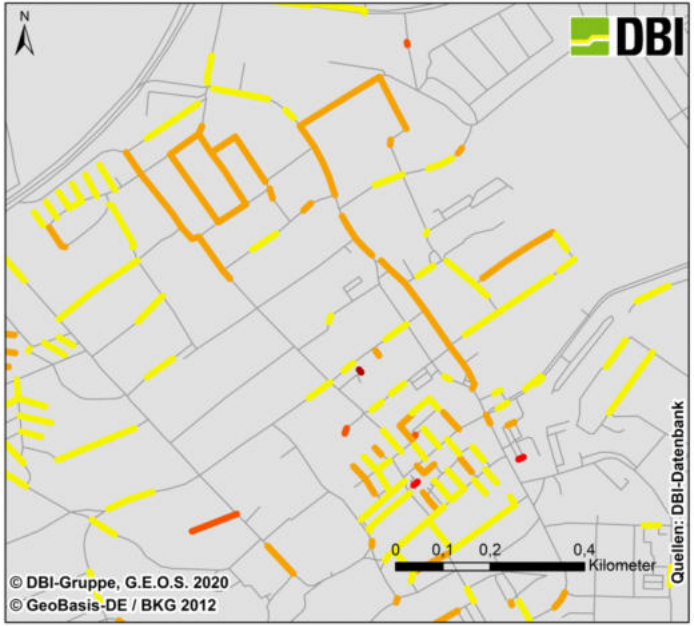


Heat network modelling based on the DBI-GridAnalyst

Modelling of the network for lucrative grid sections:

- Criteria for network routing:
  - along public infrastructures
  - no meshes / loops
  - avoidance of cost-intensive sections (e.g.: motorways)
  - Optimal course in terms of total length under the above conditions.
- Procedure:
  - Start with the highest heat consumption per network section (kWh/(m*a) heat energy)
  - Check surrounding network sections
  - iterative connection until all potentially lucrative network sections are connected

→ **Target:** most efficient distribution of the total amount of available energy to the consumers



Example of heat network calculation

DBI Gruppe

Characteristic values for the economic evaluation of heating networks

- **Specific network length:**
  - Ratio of network length to number of consumers

  → The smaller the specific network length, the more efficient the heating network.
  - Standard value for rural areas: < 50 m per connection user [1].

Average power density:
  - Ratio of total nominal connection power to number of connection users
  - Calculation by means of utilisation period of district heating general guideline = 1,800 h/a [2].
  - Reference value > 15 kW district heating capacity [1].
- **Heat occupancy density:**
  - Average annual heat consumption in relation to network length
  - Reference value: > 1,500 kWh/(m-a) [3,4] with a high share of RE > 500 kWh/(m-a) to 800 kWh/(m-a) [5,6].

[1] J. Kaspers, C. Maiworm, F. Hoppe, *Rahmenbedingungen für Nahwärmenetze* **2019**.
[2] M. Wolf, Fernwärme- Preisübersicht (Stichtag 01.10.2021), AGFW, **2021**
[3] P. Engelmann, B. Köhler, R. Meyer, J. Dengler, S. Herkel, V. Bürger, S. Braungardt, T. Hesse, M. Sandrock, C. Maaß, N. Strodel, *Systemische Herausforderung der Wärmewende: Abschlussbericht* **2021**.
[4] U. Dankert, *Sonnenenergie* **2015**, 37 – 39.
[5] Bayrisches Staatsministerium für Wirtschaft, Landentwicklung und Energie, *Richtlinien zur Förderung der Nutzung erneuerbarer Energien und der Vermeidung von Kohlendioxidemissionen durch Biomasseheizwerke (Förderprogramm BioKlima)* **2022**, *Bayrisches Ministerblatt (159)*.
[6] KfW, *Merkblatt Erneuerbare Energien "Premium"* **2022**.

Many Thanks!

Contact person

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