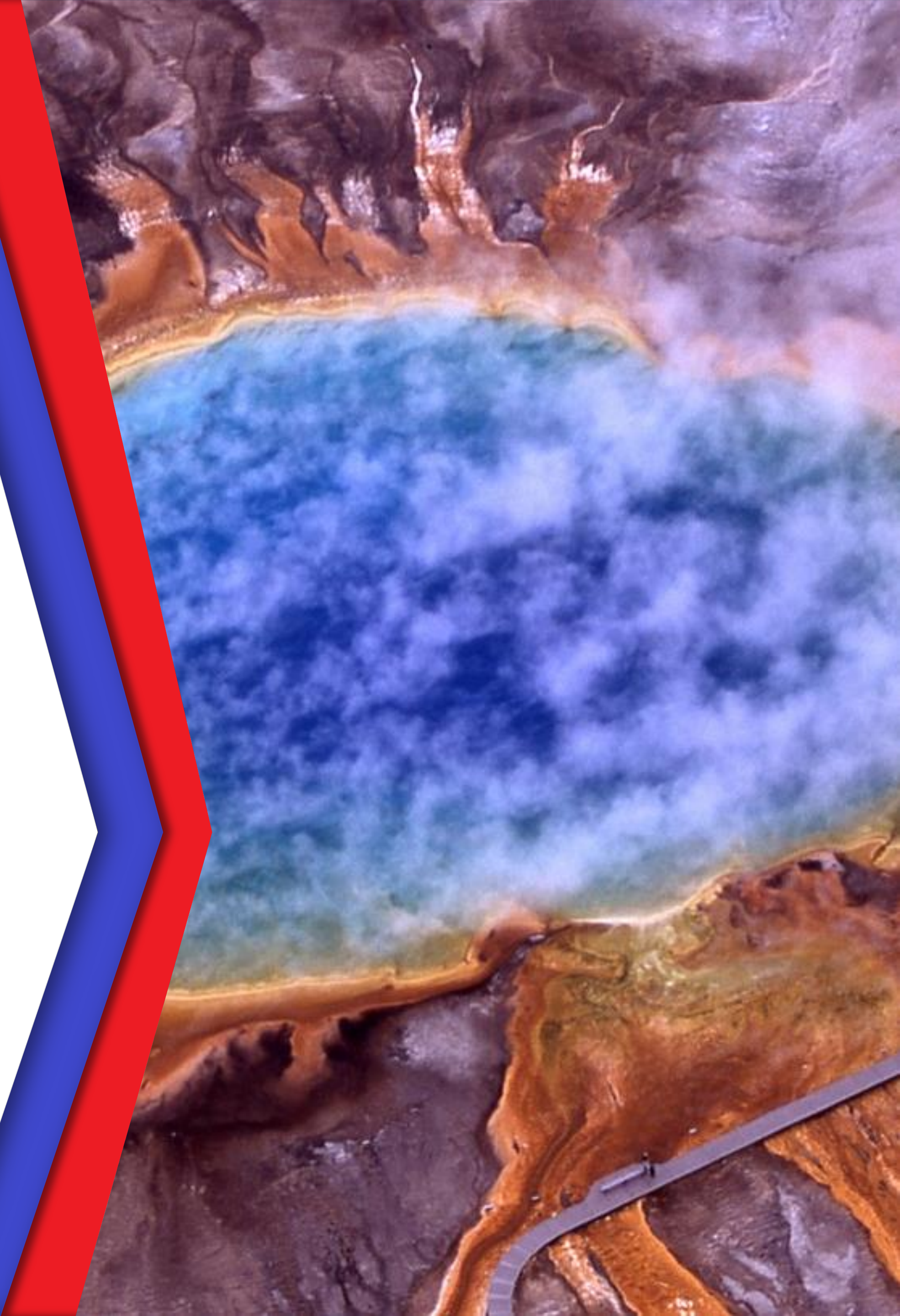
Module 3: Heat production

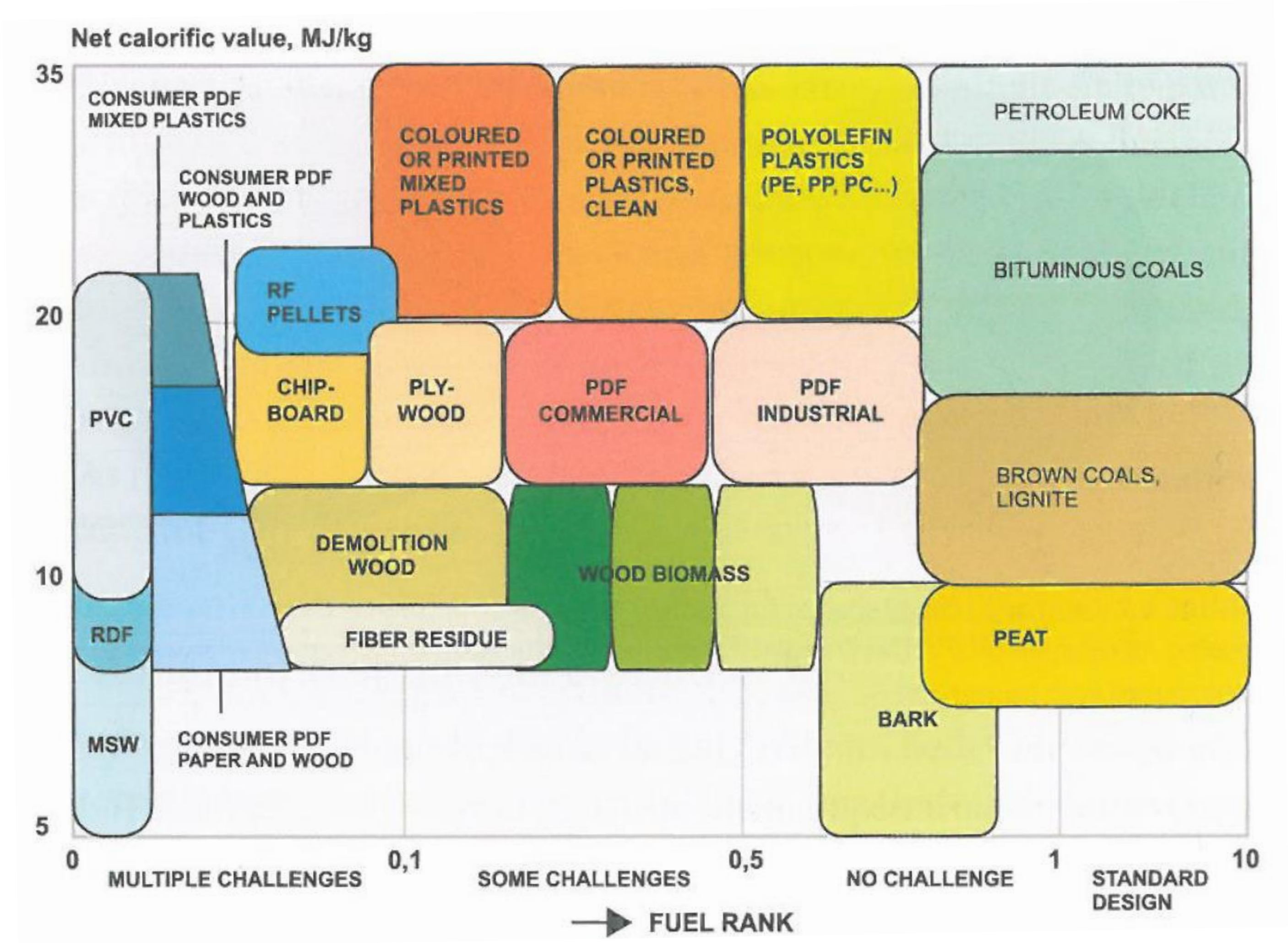
Module 3.1 Renewable heat production

SHaKE – Sharing Heat and Knowledge on Energy Communities
Erasmus+ KA220-HED Cooperation Partnerships in Higher Education
Developing institution: Budapest University of Technology and Economics
Author: Dr. Balázs Bokor
Date: May 2026
Version 1.1

SHaKE
Sharing Knowledge on Energy Communities



SOLID FUEL ASSESSMENT

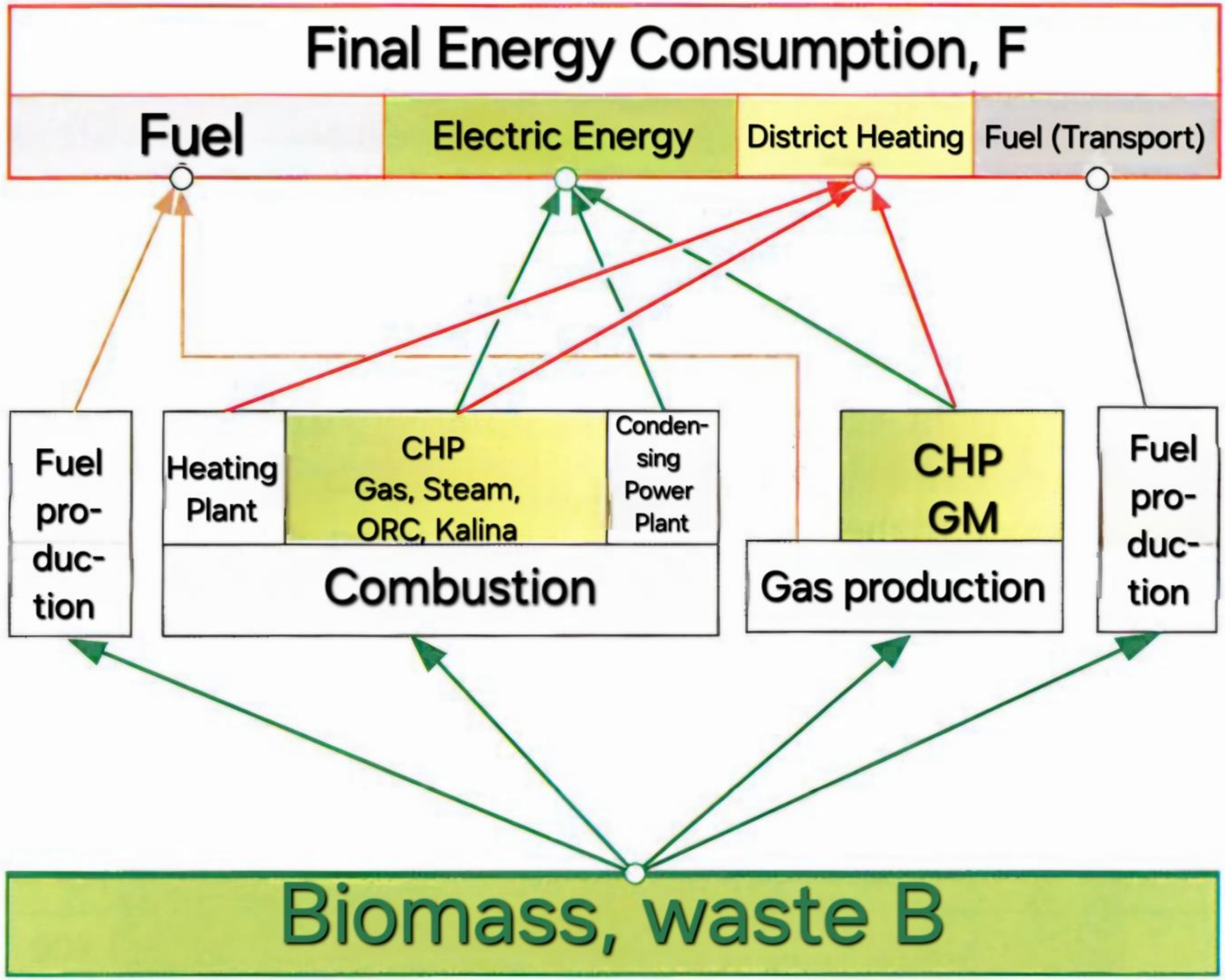


- Ordinate: calorific value
  - High moisture content
- PVC, RDF (refuse derived fuels), MSW (municipal solid waste)
  - HCl and dioxins, toxic even in small concentrations.
- Ash formation
  - Maybe highly corrosive
  - In other cases, it is harmless.

Source: Svend Fredriksen, Sven Werner: District Heating and Cooling. Studentlitteratur 2013

BIOMASS COMBUSTION

Uses of biomass and waste

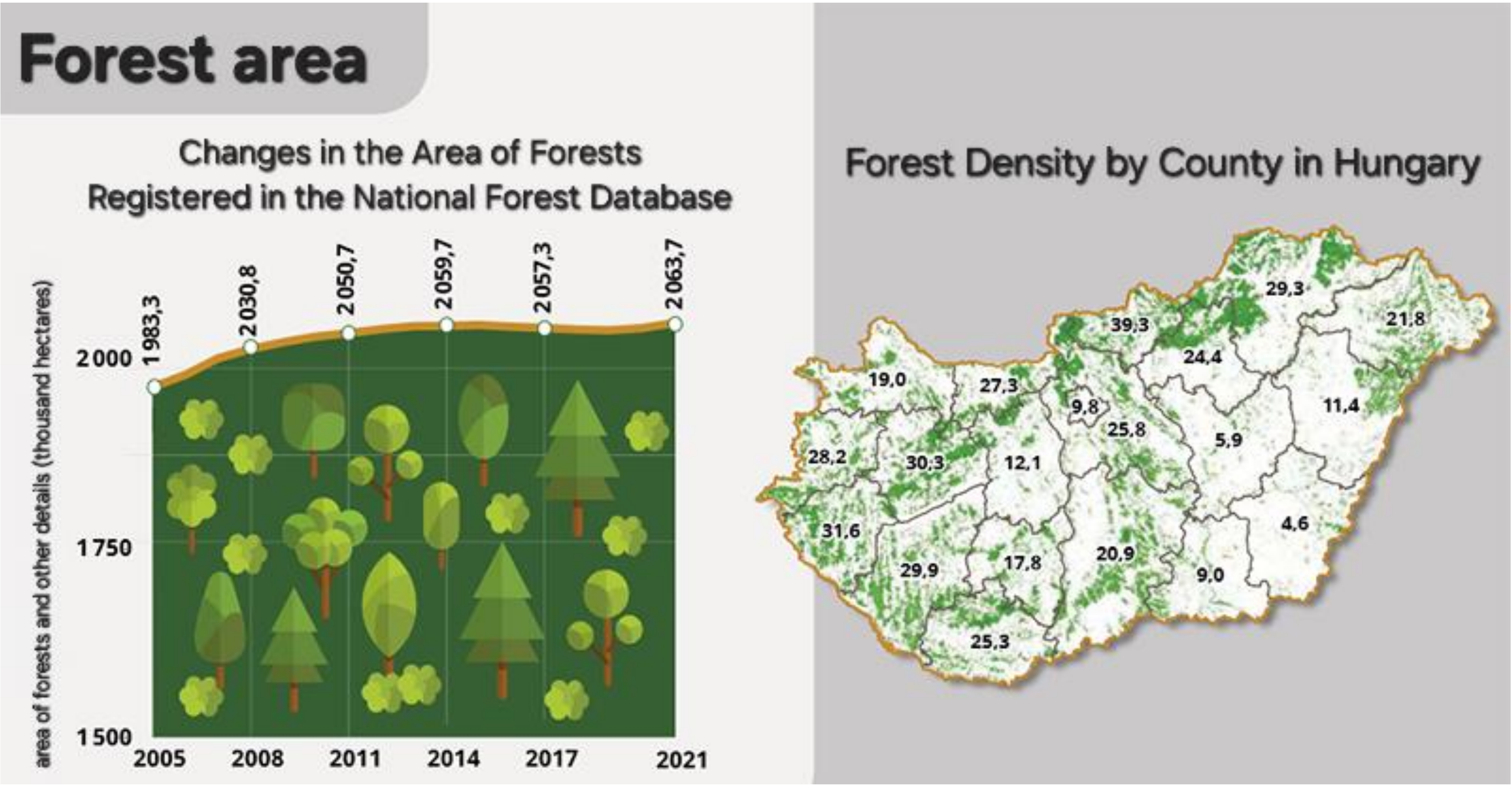


- Lower quality biomass and waste recovery in district heating supply. Energy recovery of biomass:
- Combustion
  - Solid and dry biomass
  - Direct or combined heat production
- Gasification
  - Wet biomass, sludge
  - Raw gas is the production of heat and power locally, combined with a gas engine.
  - Sale of biogas as fuel gas.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés.

BIOMASS COMBUSTION

Fibustible biomass



- Forestry, agricultural biomass
- Municipal Solid Waste (MSW)
- Hungary low forest cover:
  - 20% (half of the EU average)
- Estimated tree stock:
  - 360 million m^3
  - Gain: 13 million m^3/a
- If half of the gain is used energetically:
  - 60-70 PJ/a primary energy source

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1, https://fataj.hu/2022/11/erdok-erdogazdalkodas-magyarorszagon-2021/

BIOMASS COMBUSTION

Plant-based fuels

Firewood

- 40% of logging
- It is advisable to use it in individual heating systems
- Calorific value at 15% moisture: 15,000-16,000 kJ/kg

Wood Chips

- Fuel used in larger boilers
- Calorific value at 50% moisture: 8,000 kJ/kg
- Calorific value at 10% moisture: 16,000 kJ/kg
- Hungarian quantity: 1-1.4 million t/a
- Energy potential per year: 10-18 PJ/a

Wheat Straw

- Can be burned annually: 1.5 million t/a
- Calorific value at 18% moisture: 13,000 kJ/kg
- 20 PJ/a primary energy source

Total Fuels of Plant Origin

- 70-90 PJ/a renewable energy source

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1, https://ecocomfort.hu/biomassza/

BIOMASS COMBUSTION

Bio-briquette, bio-pellet

- More comfortable, higher efficiency combustion
- Binder-free compression
- Density: 1-1.3 t/m³
- Enables automatic operation in small equipment

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1, https://barkacsvilag.hu/, https://www.kemencemania.hu/

BIOMASS COMBUSTION

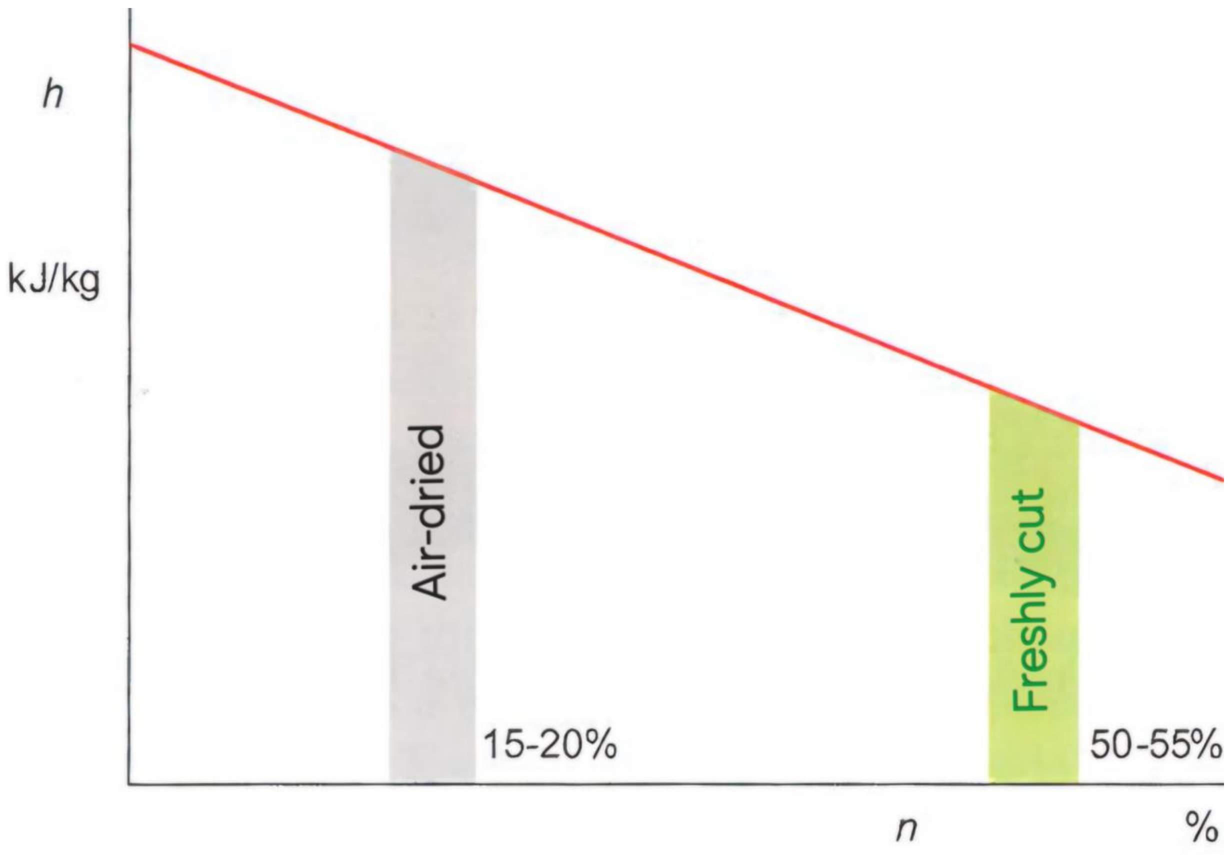
Energy plantation

- They grow quickly and large:
  up to 2-3 m in height
- During rapid growth, the plant binds aggressive compounds
- Corrosion in combustion plants, environmental pollution.
- Fast-growing species can also trigger dangerous processes in the soil.
- Their harvesting and drying are well mechanized.
- Energy plantation
  - 2-3 year cutting cycle
  - Canes 2-3 cm in diameter, 2-3 m long
  - A special reaper also shreds it right away.
  - After cutting, it resprouts from the root.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1, http://www.panenerg.hu/biomassza/

BIOMASS COMBUSTION

Biomass-combustion heating plants



- Remote utilization of lower quality, combustible biomass.
- Heating plants: 100 kW-more MW of power.
- During installation, planning and municipal tasks:
- Purchase of biomass, availability, determination of costs.
- Local woodworking waste, forest holdings.
- Freshly cut biomass with 50% moisture
- It can be reduced to 15-20% by drying.
- Possibility of drying between heating seasons in summer.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

BIOMASS COMBUSTION

- High performance heat production plants are covered with glass facade to minimise structural damage in case of an explosion.

BIOMASS COMBUSTION

- Lorry delivering the biomass is weighted at the entrance.

BIOMASS COMBUSTION

BIOMASS COMBUSTION

- Smaller wood chips are worse because the air blows them away during combustion.
- Sampling
- Quality-based payment to forestry

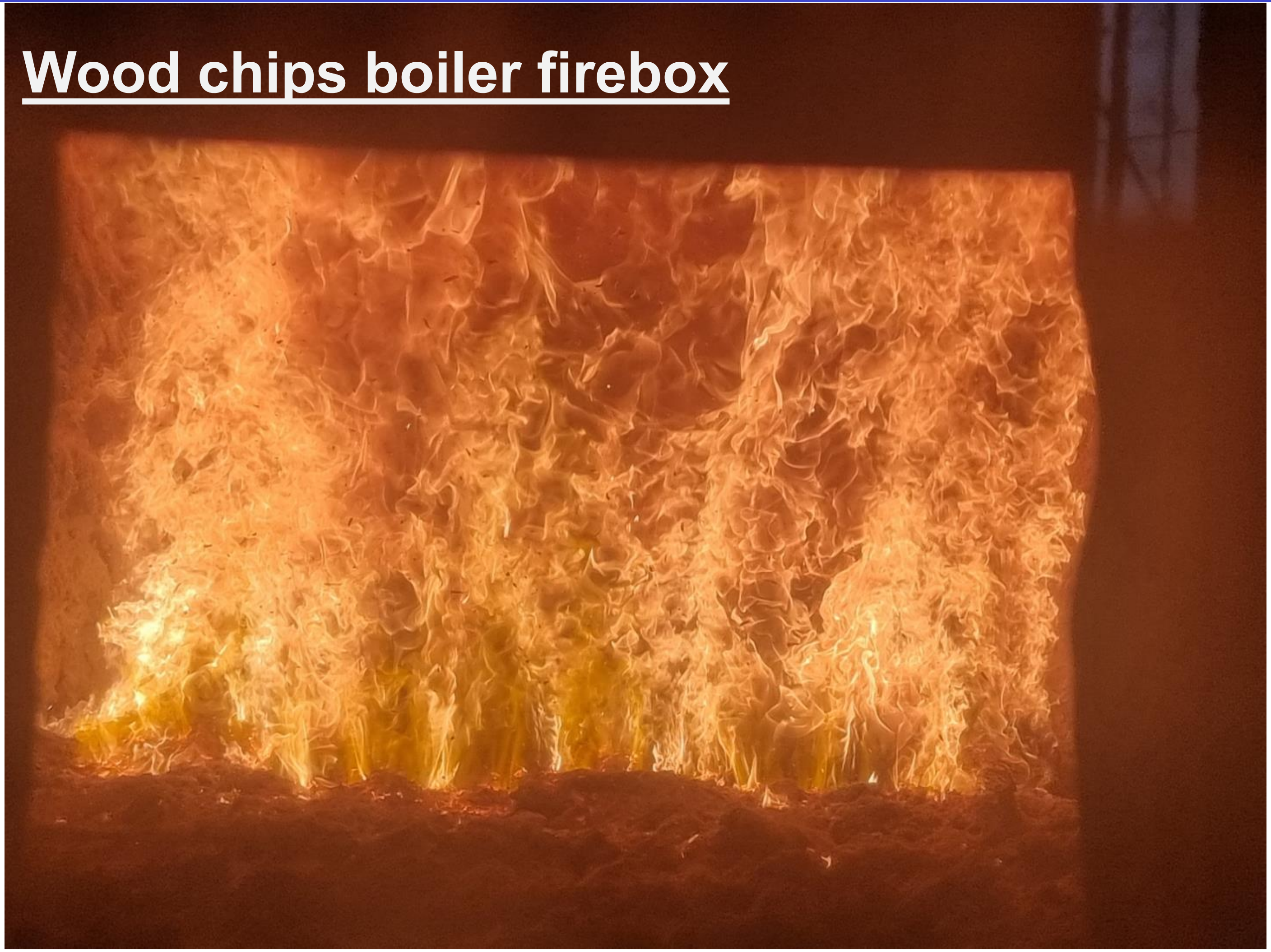
BIOMASS COMBUSTION

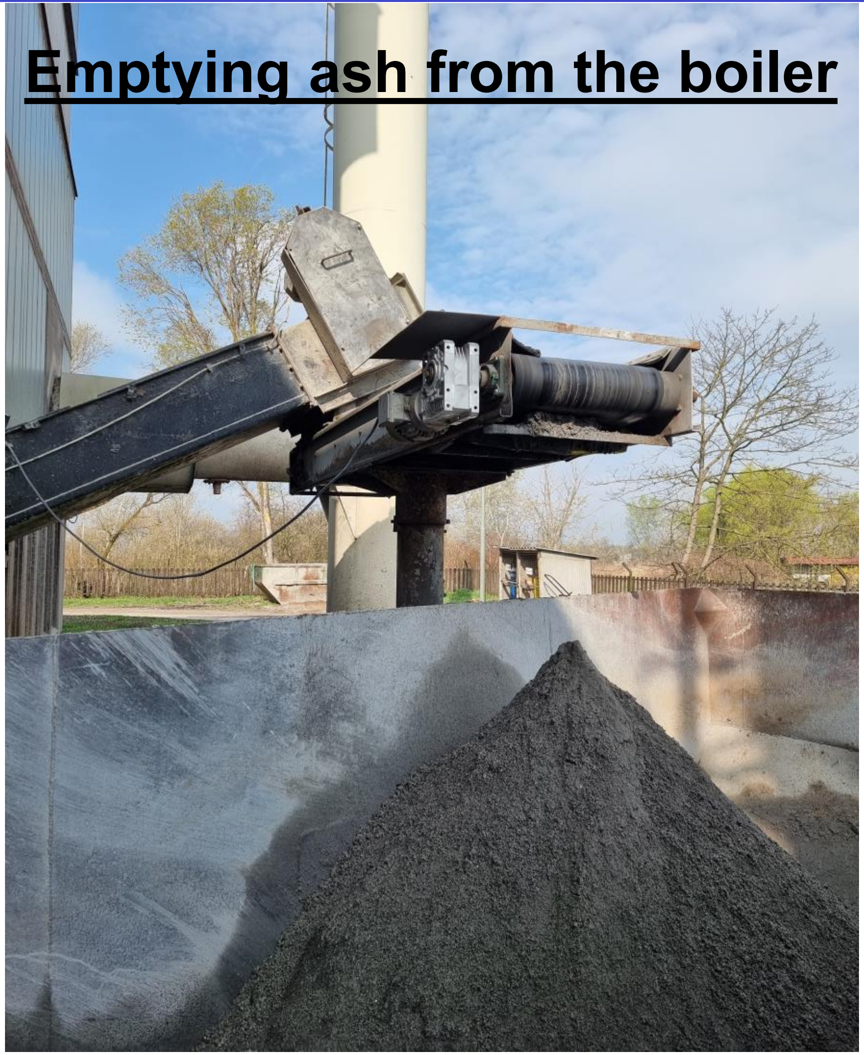
Transmission device

BIOMASS COMBUSTION

BIOMASS COMBUSTION

BIOMASS COMBUSTION





BIOMASS COMBUSTION

Boiler control panel

- Instantaneous performance
- Circulated volume flow
- Supply temperature
- Return temperature

BIOMASS COMBUSTION

- **District Heating Connection:**
- Primary Supply,
- Return

BIOMASS COMBUSTION

Primary circuit pumps in the heating plant

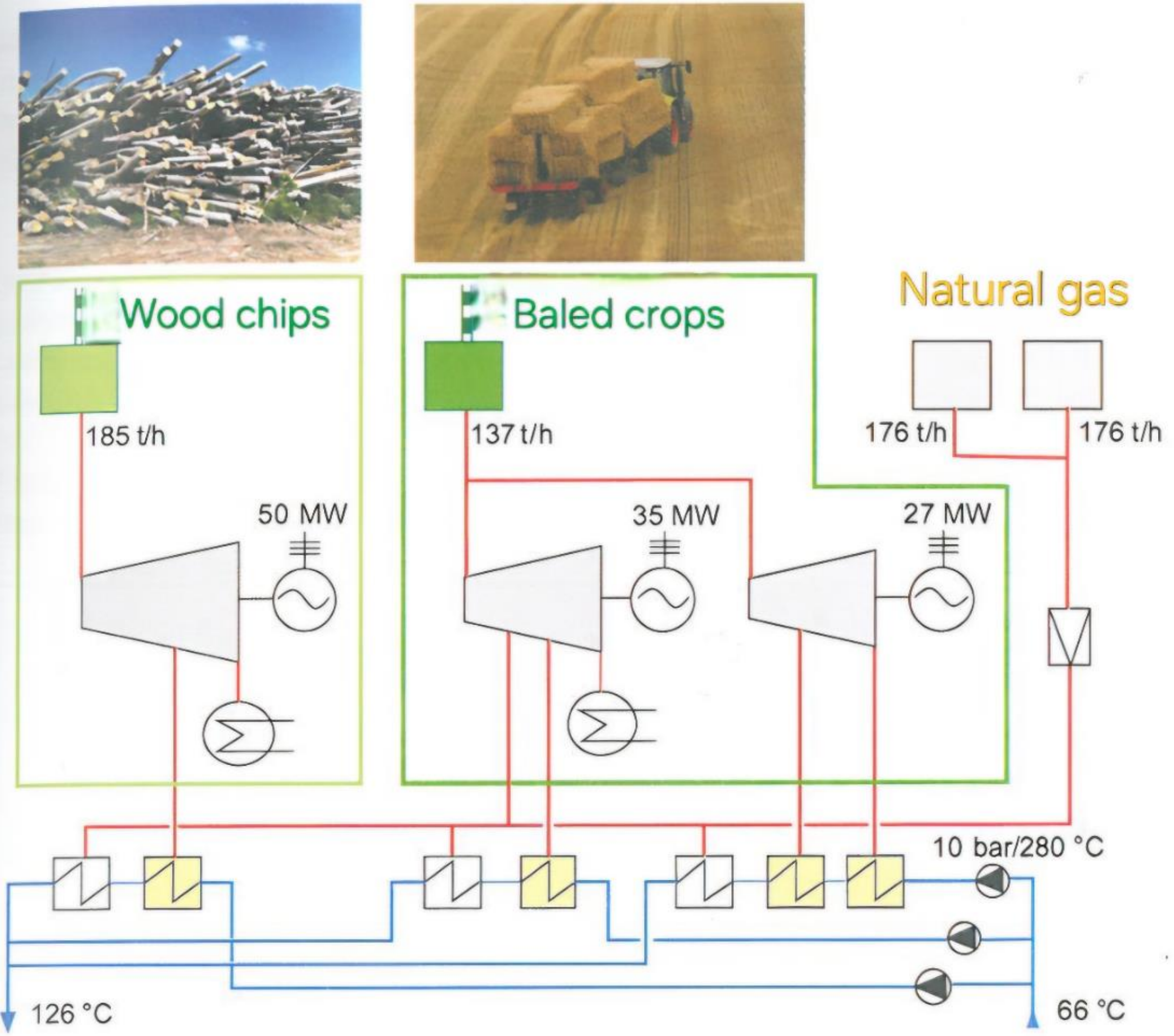
- Small pump for summer operation
- Large pump for winter operation.
- Ensuring Pressure Maintenance and Water Treatment

BIOMASS COMBUSTION

Backup Gas Boilers to Ensure Heat Supply in All Circumstances

BIOMASS COMBUSTION

Wood chip and straw-fired heating block at Pécs Power Plant

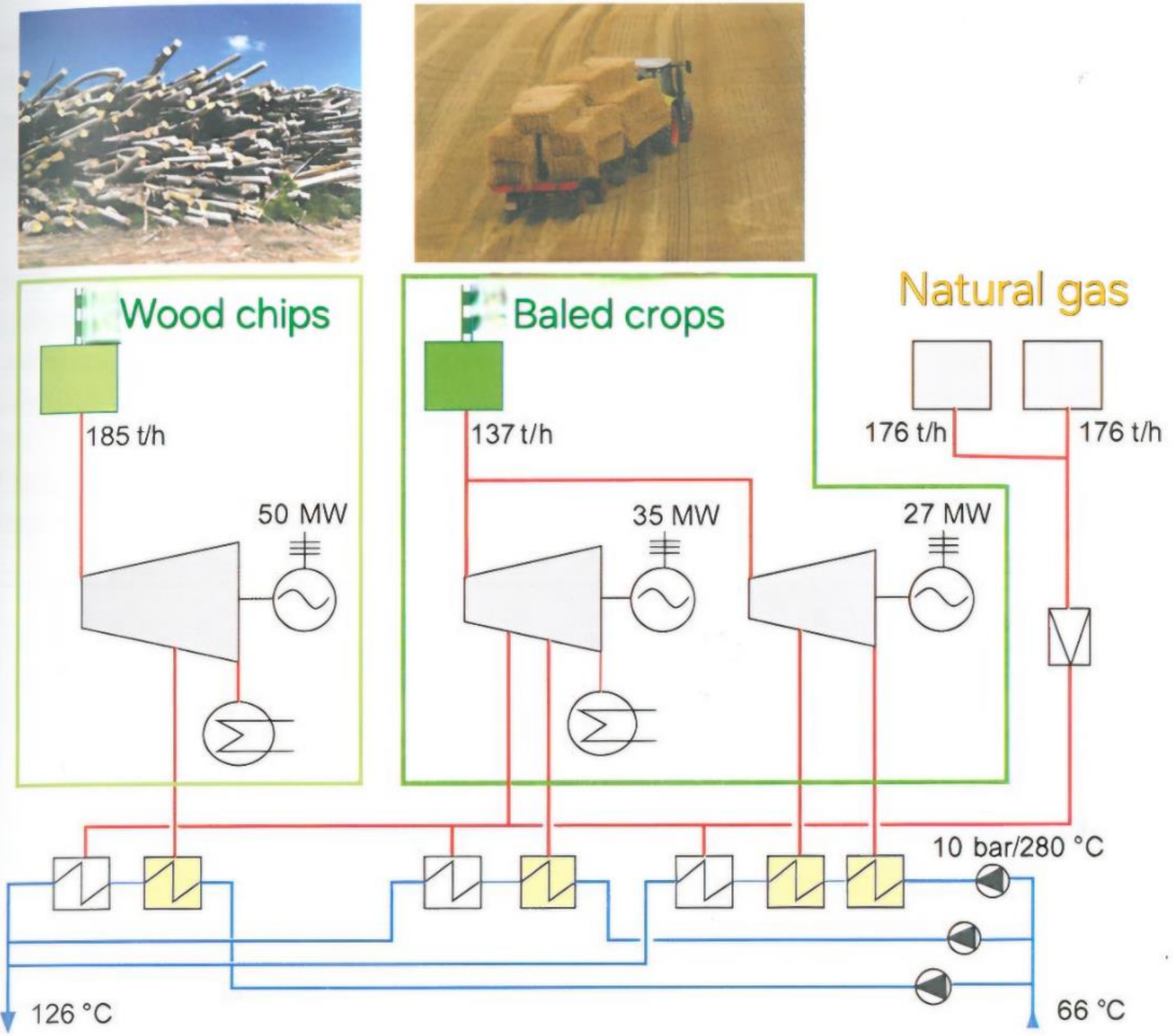


- Originally a coal-fired power plant, it was converted into a biomass power plant in two stages.
- Steam turbines and steam parameters of the old power plant have been preserved.
- Step 1: a wood chip-fired boiler was established. 185 t/h steam boiler.
  - It produces steam for its extraction-condensing steam turbine with an electrical capacity of 50 MW.
- Step 2: straw-fired boiler was installed
  - The boiler with a steam capacity of 137 t/h cooperates with a 35 MW extraction-condensing steam turbine outside the heating period. During the heating period, it works in conjunction with a 27 MW backpressure heating turbine.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

BIOMASS COMBUSTION

Wood chip and straw-fired heating block at Pécs Power Plant



- District heating supply of the city of Pécs:
- 31 thousand apartments
- 450 institutions
- Annual heat demand 1600 TJ/a
- 62% is supplied by straw-fired heating blocks
- 32% is supplied by the wood-fired heating unit.
- The biomass units provide 94% renewable heat and electricity to Pécs.
- Combustion of natural gas must cover around 6% of heat demand.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

THE POTENTIAL OF HUNGARIAN BIOGAS PRODUCTION

Organic Material	Amount (million $t/year$)	Biogas Production (billion $m^3/year$)	Natural Gas Equivalent (billion $m^3/year$)
Animal-origin Waste	43	1.6	1.1
Municipal Waste	10	0.7	0.5
Energy Crops (1000 thousand ha)	30	3.3	2.2
Total	**83**	**5.6**	**3.8**

- Soft biomass that cannot be utilized by combustion.
- For example, 700,000 t/a of sewage sludge is produced annually.
- In Hungarian agriculture, 7.5 million t/a of waste suitable for gasification is generated annually.
- Today, around 40 domestic biogas plants utilize approximately 3 million tons.

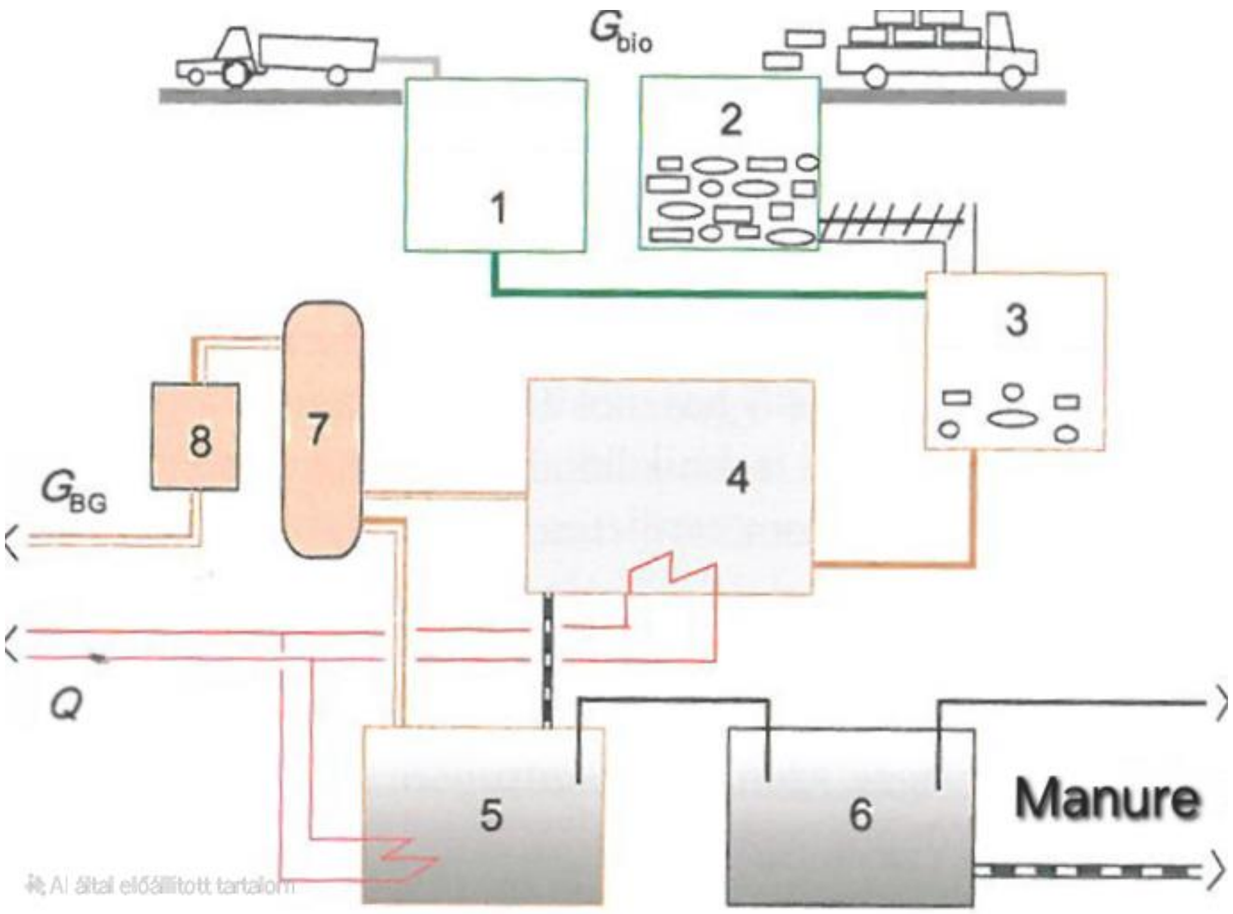
Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés.

THE POTENTIAL OF HUNGARIAN BIOGAS PRODUCTION

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1, https://www.mnnsz.hu/wp-content/uploads/2014/05/m7.2.jpg

- Anaerobic fermentation of organic matter (=fermentation in an oxygen-free environment).
- Wet breakdown of carbohydrates, fats, and proteins in a dark and oxygen-deficient environment.
- Microorganisms (fungi and bacteria) break down macromolecular organic matter (carbohydrates, fats and proteins) into small molecule products.
- These products are converted into acids (acetic acid, lactic acid), alcohols, aldehydes, hydrogen, carbon dioxide and other gases under the influence of acid-forming bacteria.

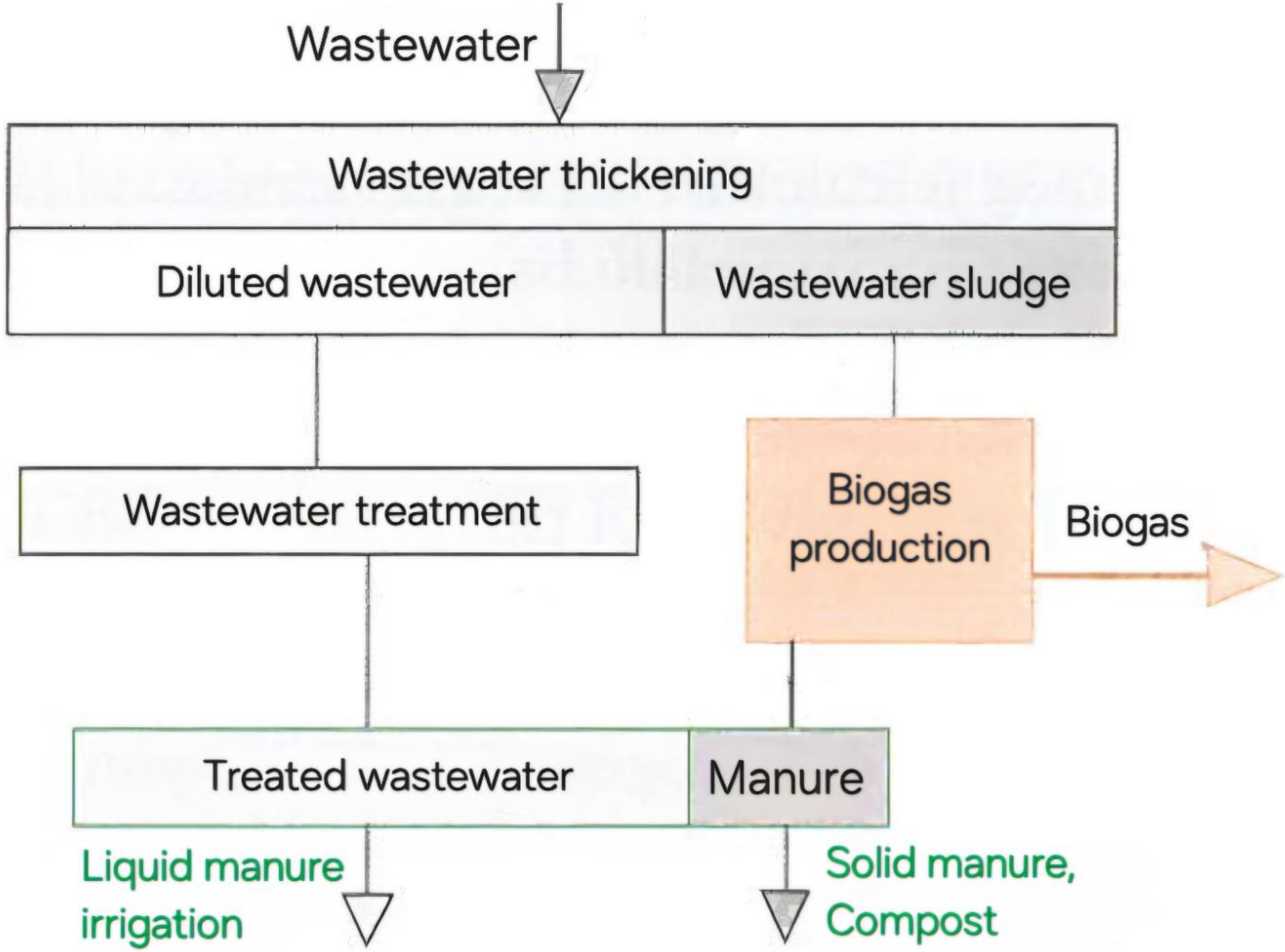
THE PROCESS OF BIOGAS PRODUCTION



Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

- 1: Receiving of liquid biomass
- 2: Receiving solid biomass
- 3: Pre-storage
- 4: Pre-fermentor
- 5: Post-fermentor
- 6: Final storage
- 7: Gas tank
- 8: Gas scrubber
- During fermentation, the number of pathogens in the biomass decreases, it becomes less smelly, and it becomes an excellent plant nutrient.

PROCESS OF WASTEWATER TREATMENT AND BIOGAS PRODUCTION



- Urban wastewater is thickened.
- The thick wastewater sludge is directed into an anaerobic gasification system.
    - Energetically valuable biogas and solid manure are produced.
- The diluted wastewater is made suitable for agricultural use after appropriate purification, deodorization, and disinfection.
- If this process is not fully comprehensive, it is used to irrigate energy crops.
- After drying, solid manure can be utilized as fuel.

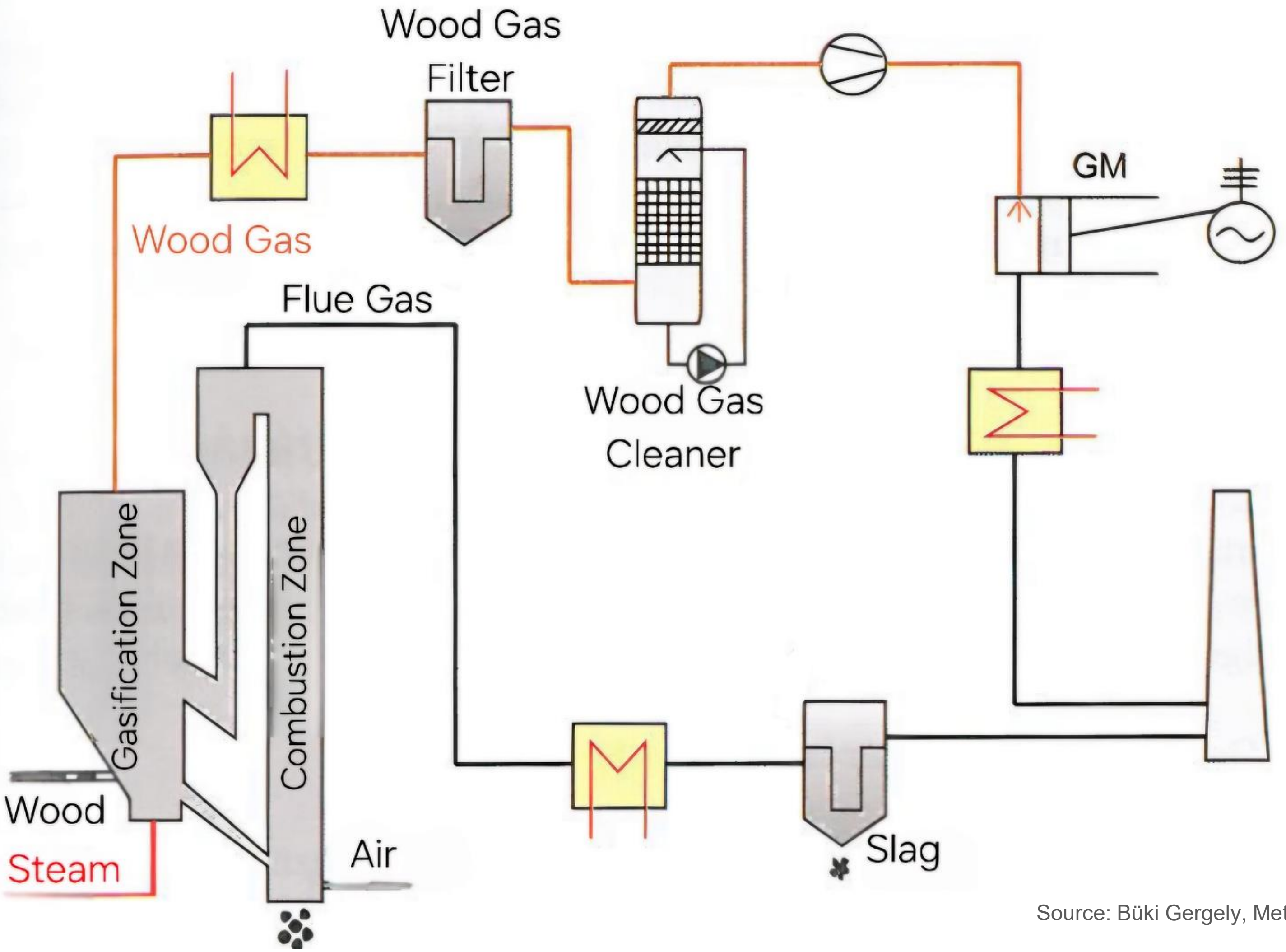
Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

THE GÜSSING BIOMASS POWER PLANT

- Thermal gasification of wood in an air or steam atmosphere.
- Production of synthesis gas.

Source: https://www.tuwien.at/tu-wien/aktuelles/news/news/biomasse-kraftwerk-in-guessing

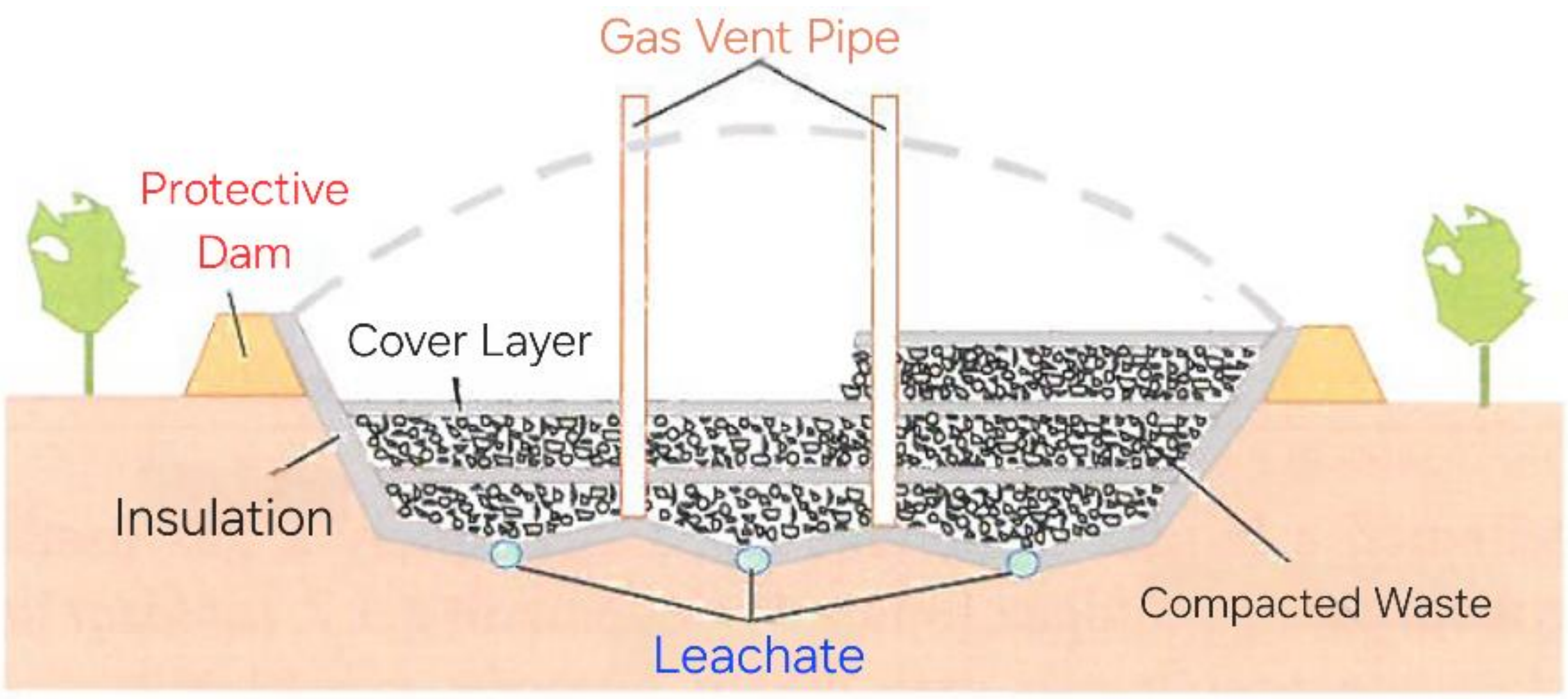
THE PROCESS FLOWCHART OF THE GÜSSING BIOMASS GASIFICATION POWER PLANT



- Fluidized bed wood gasifier has two zones.
- Burning zone:
  Bed material and air circulate and provide heat for gasification.
- Gasification zone:
  Wood material is introduced here. The superheated steam (850°C) generated by the heat fluidizes this zone.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

LANDFILLING OF MUNICIPAL SOLID WASTE, LANDFILL GAS PRODUCTION



- Aerobic, then anaerobic processes take place.
- Landfill gas:
  - 40-60% methane
  - 60-40% carbon dioxide
- Trace amounts of:
  - Carbon monoxide
  - Nitrogen
  - Hydrogen sulfide
  - Volatile fatty acids
  - Mercaptans,
  - Steam.
- Site closure takes 20-30 years.
- Extractable: 2-3 m³/t,a

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

BIOGAS YIELD FROM VARIOUS ORGANIC MATERIALS

Organic Material	Biogas Yield (m^3/t)	Organic Material	Biogas Yield (m^3/t)
Pig manure	340–550	Grass	280–550
Cattle manure	90–310	Reed	170
Poultry manure	310–620	Clover	430–490
Horse manure	200–300	Potato waste	280–490
Sheep manure	90–310	Sugar beet leaves	400–500
Stable manure	175–280	Sunflower leaves	300
Wheat straw	200–300	Agricultural waste	310–430
Corn stalks	380–460	Plant seeds	620
Rapeseed straw	200	Leaves	210–290
Rice straw	170–280	Algae	420–500
Flax	360	Sewage sludge	310–740
Hemp	360	Landfill waste	40–300

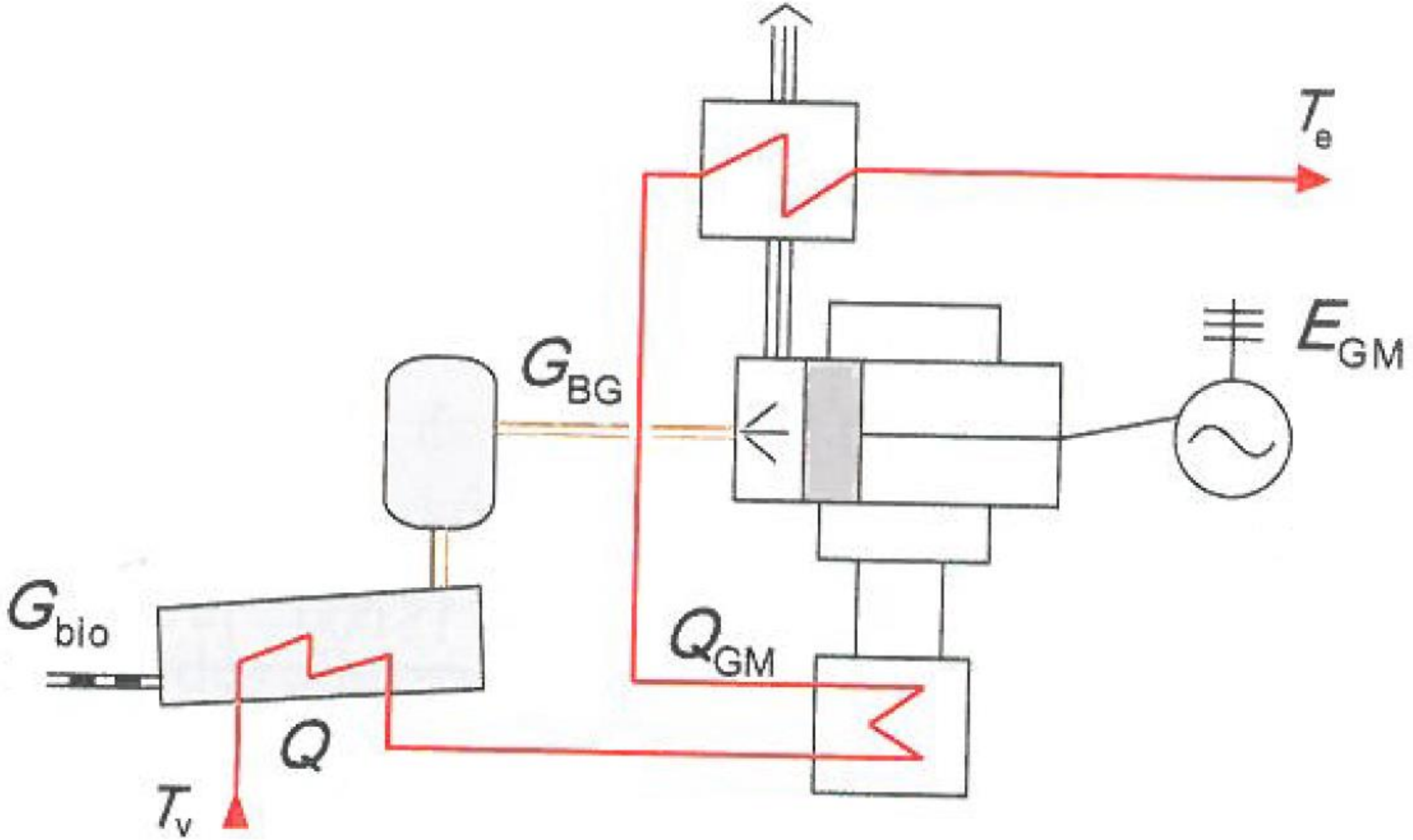
Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

COMPARISON OF BIOGAS, LANDFILL GAS, AND NATURAL GAS

Component	Biogas	Landfill Gas	Natural Gas
Methane (%)	50--70	45--55	94--98
Carbon Dioxide (%)	17--42	30--35	0.0--3
Nitrogen (%)	0--1	15--25	0.3--4
Density (kg/m³)	1.1--1.15	1.15--1.20	0.8--0.9
Calorific Value (kJ/m³)	18,000--25,000	15,000--17,000	32,000--40,000

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés.

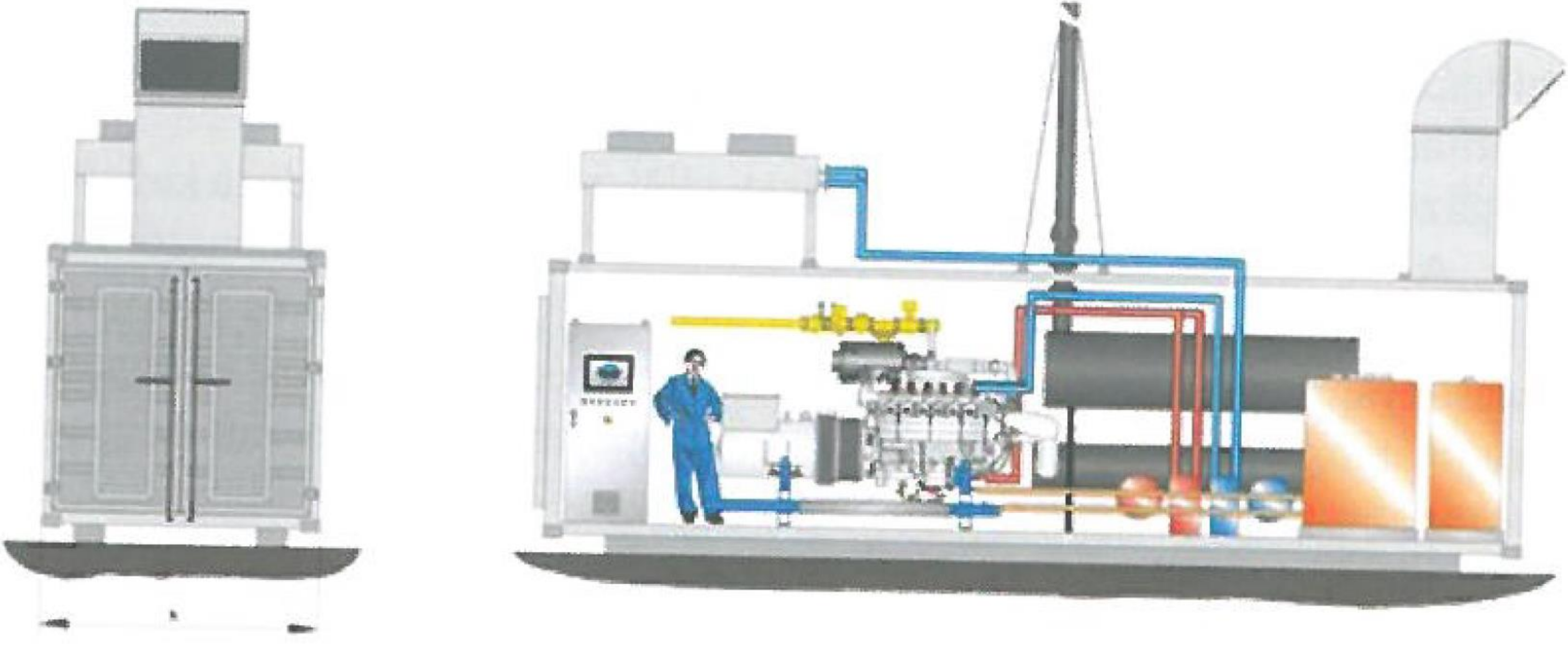
COMBINED HEAT AND POWER PRODUCTION WITH A BIOGAS-FUELED ENGINE



- Decentralized use in gas engines.
- Gas engines: range between a few kW and MW.
- Containerized biogas engines
- Easy installation
- Includes heating heat exchangers. The electric generator and connecting equipment.

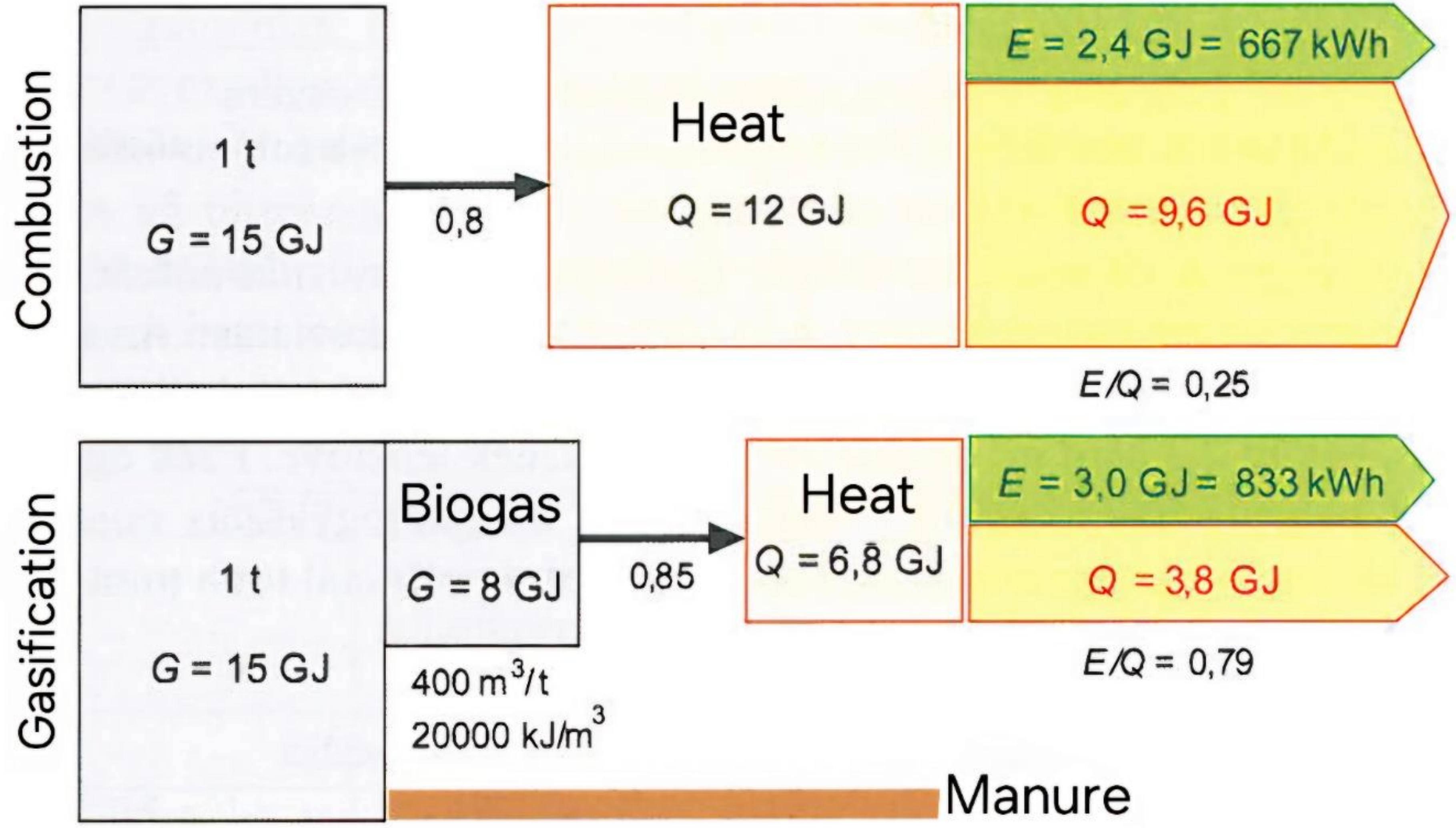
Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

CONTAINERIZED BIOGAS-POWERED GAS ENGINE



Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1

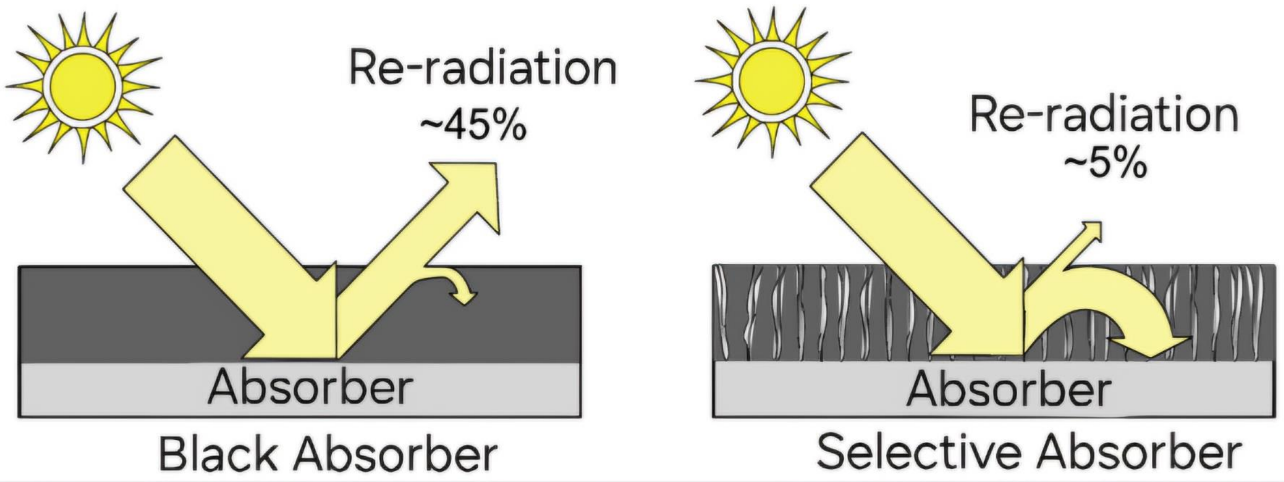
COMPARISON OF BIOMASS COMBUSTION AND GASIFICATION FOR ENERGY PRODUCTION

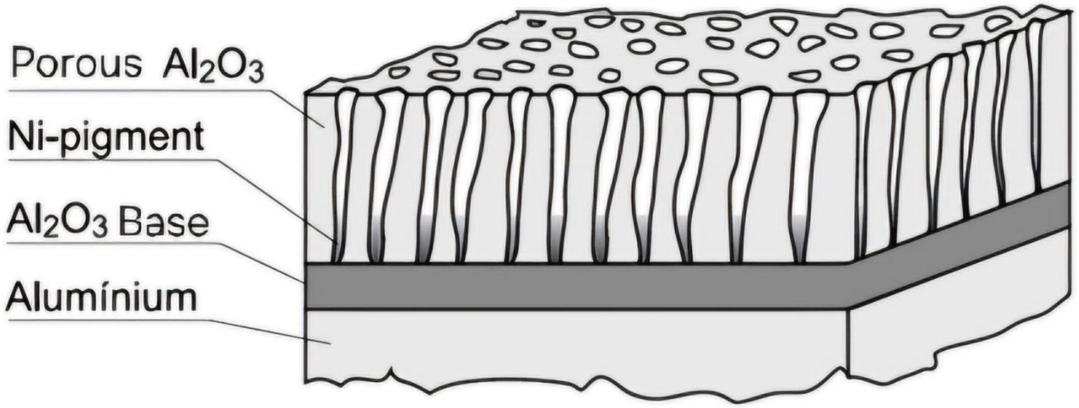


- Combustion or gasification?
- For high heat demands, it is advisable to choose combustion, while for low heat demands, gasification is recommended.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés.

SOLAR DISTRICT HEATING





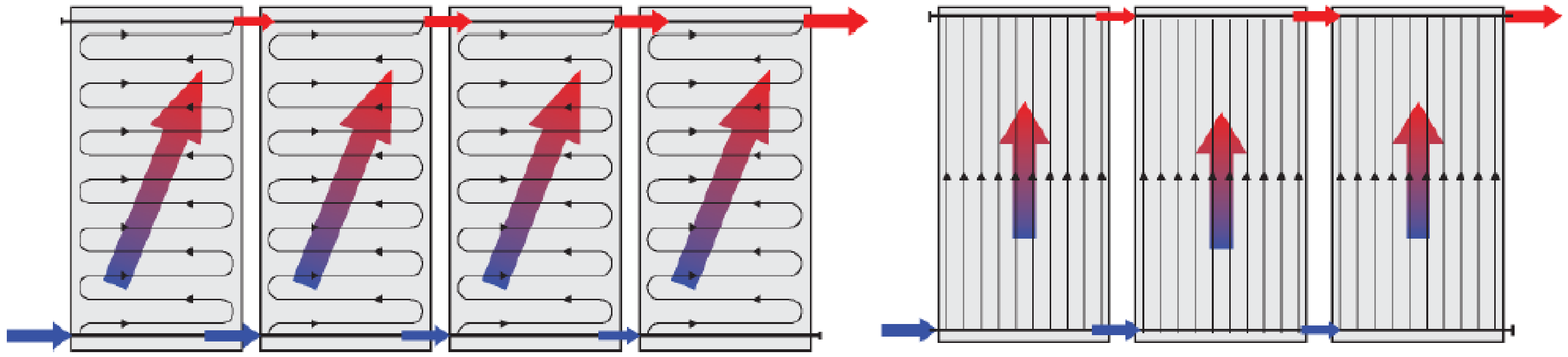
Flat-plate collector

Source: gazdasaghaza.hu, naplopo.hu

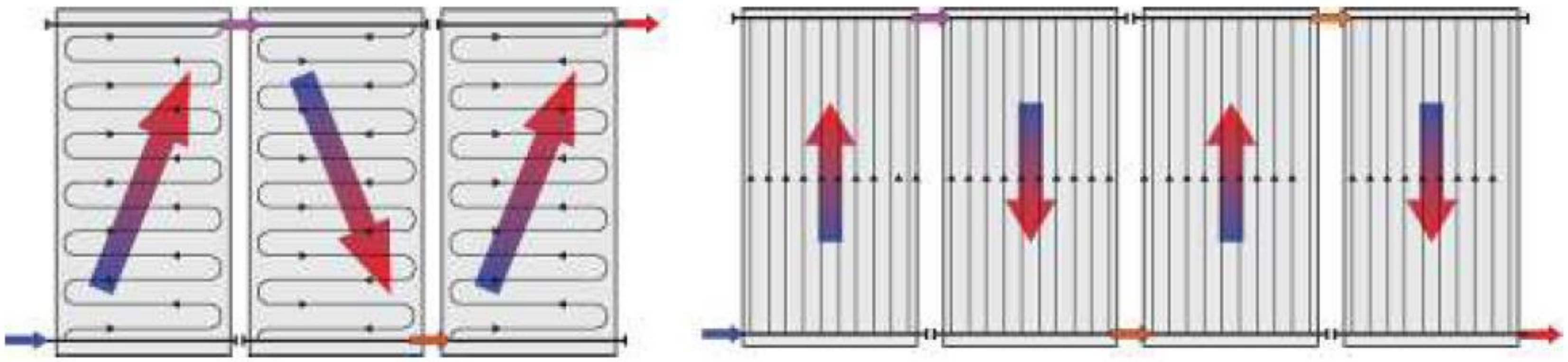
SOLAR DISTRICT HEATING

Connecting Collector Fields

- In parallel connection, there is less pressure drop, but a lower flow rate.
- In series connection, there is a greater pressure drop and a higher flow rate.
- Regulation?
- Are the collectors equivalent?



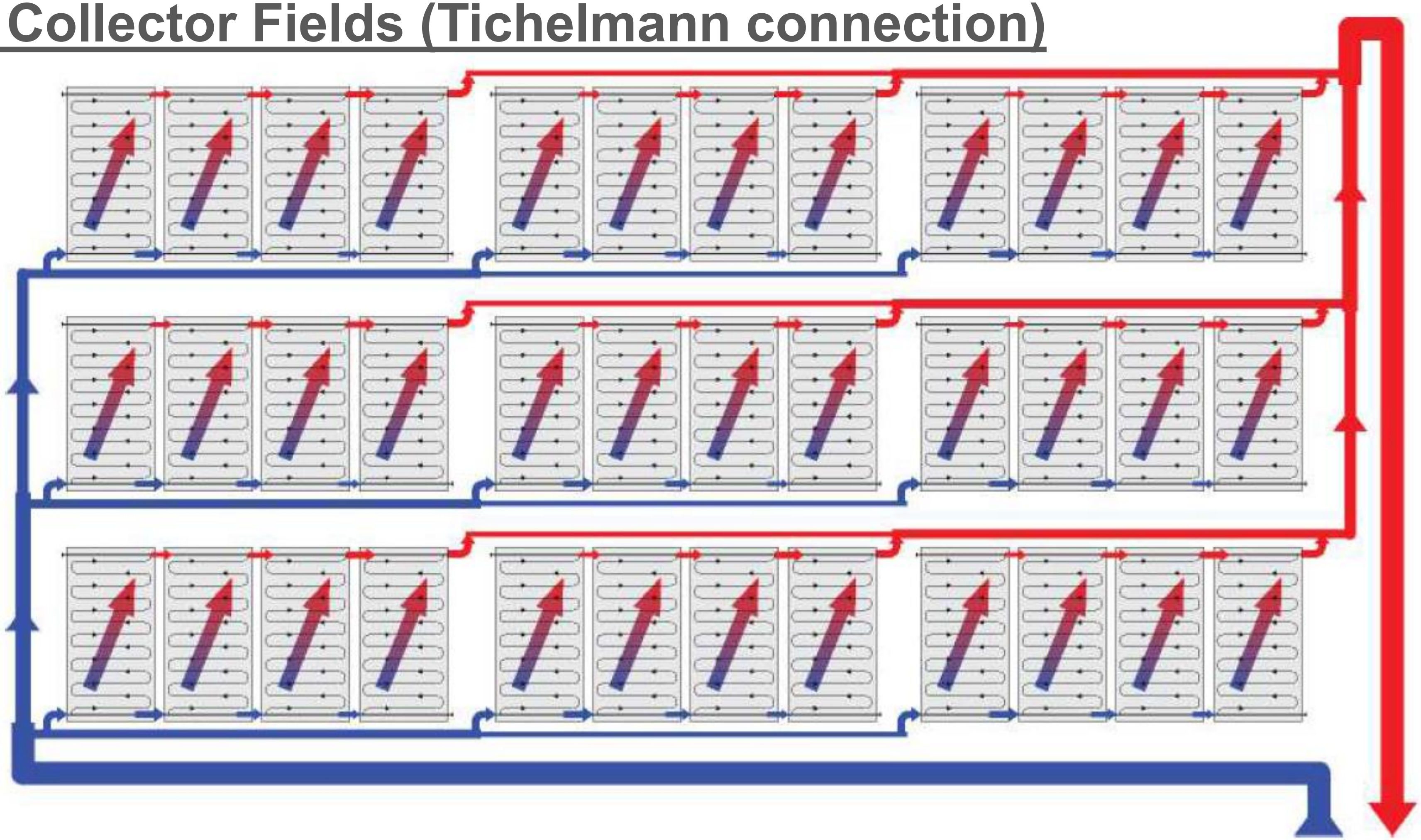
Parallel connection



Series connection

SOLAR DISTRICT HEATING

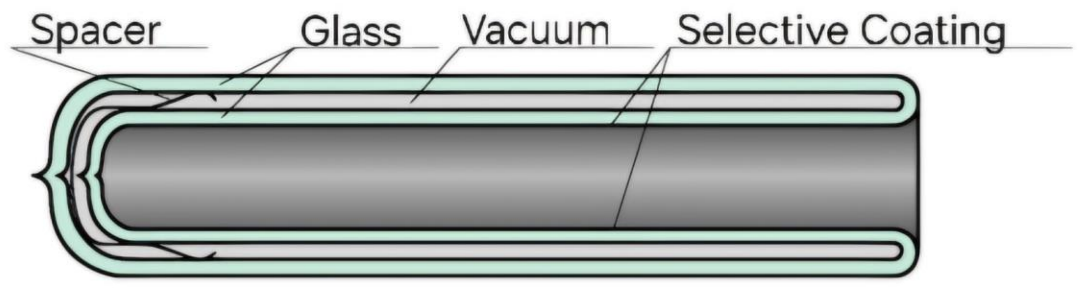
Connecting Collector Fields (Tichelmann connection)



Source: naplopo.hu

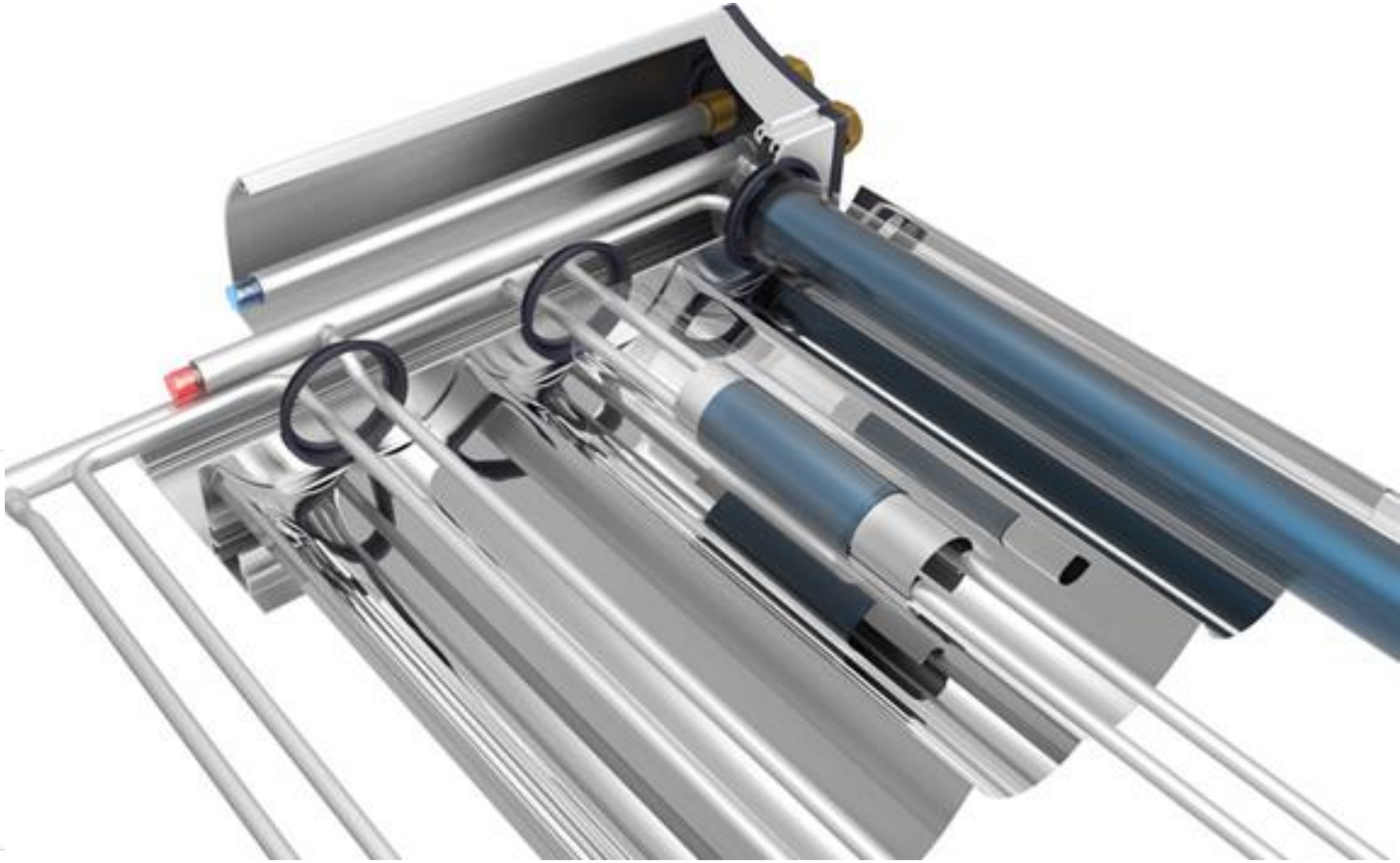
SOLAR DISTRICT HEATING

- Thermos-style double-walled vacuum tube
- Absorber adhered to the inner side of the inner glass wall
- Heat-conductive sheet required
- CPC mirror optional to maximize the utilized radiation



Double-Walled "Sydney" Type Vacuum Tube

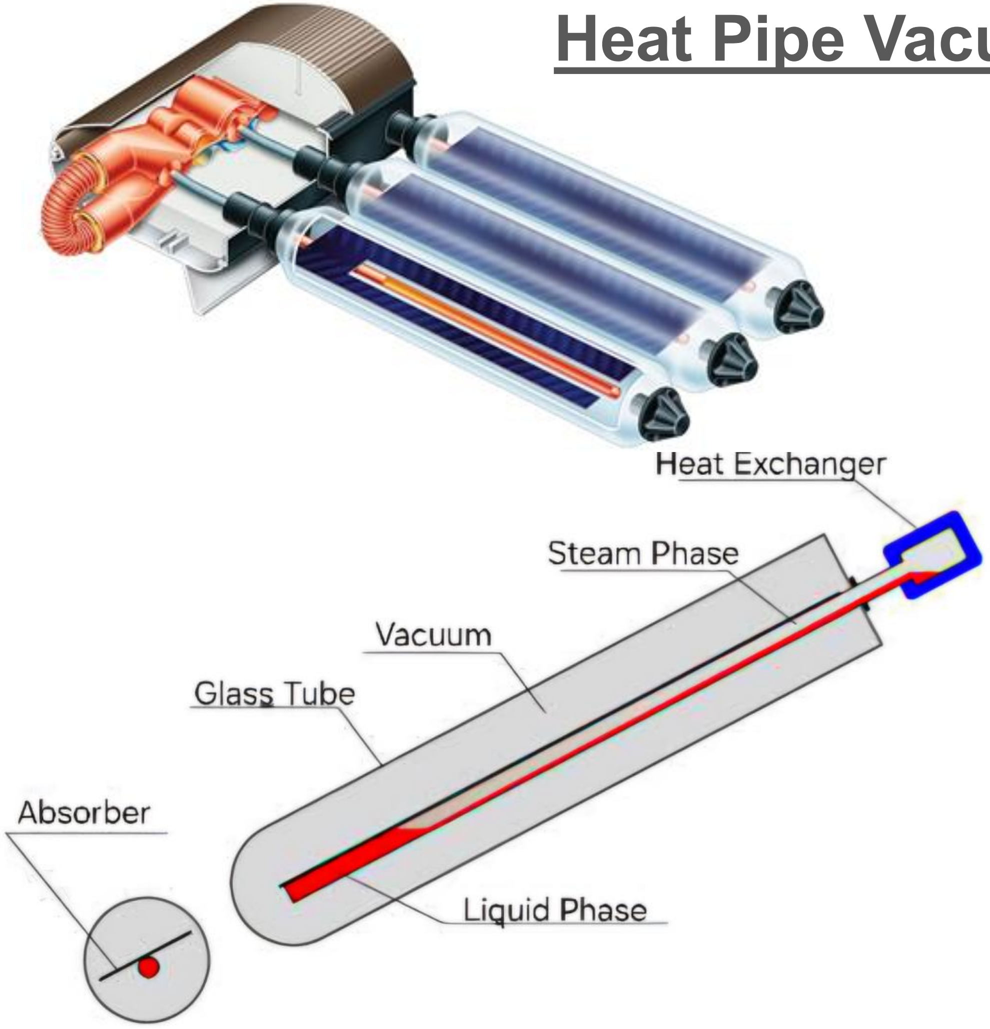
"Sydney tube" collector

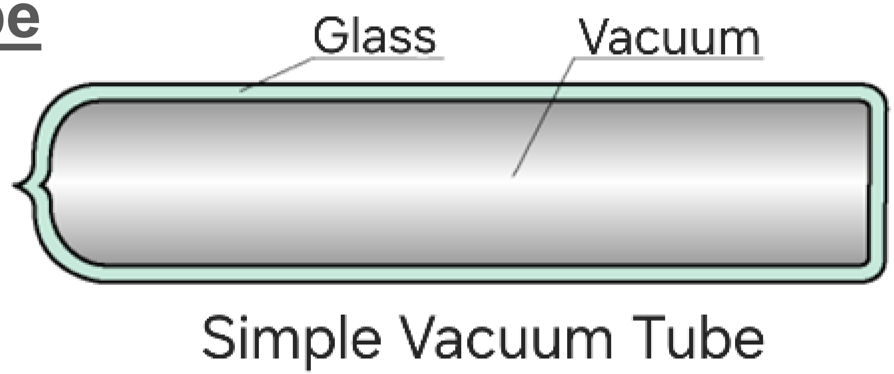


Source: naplopo.hu, paradigma.de

SOLAR DISTRICT HEATING

Heat Pipe Vacuum Tube



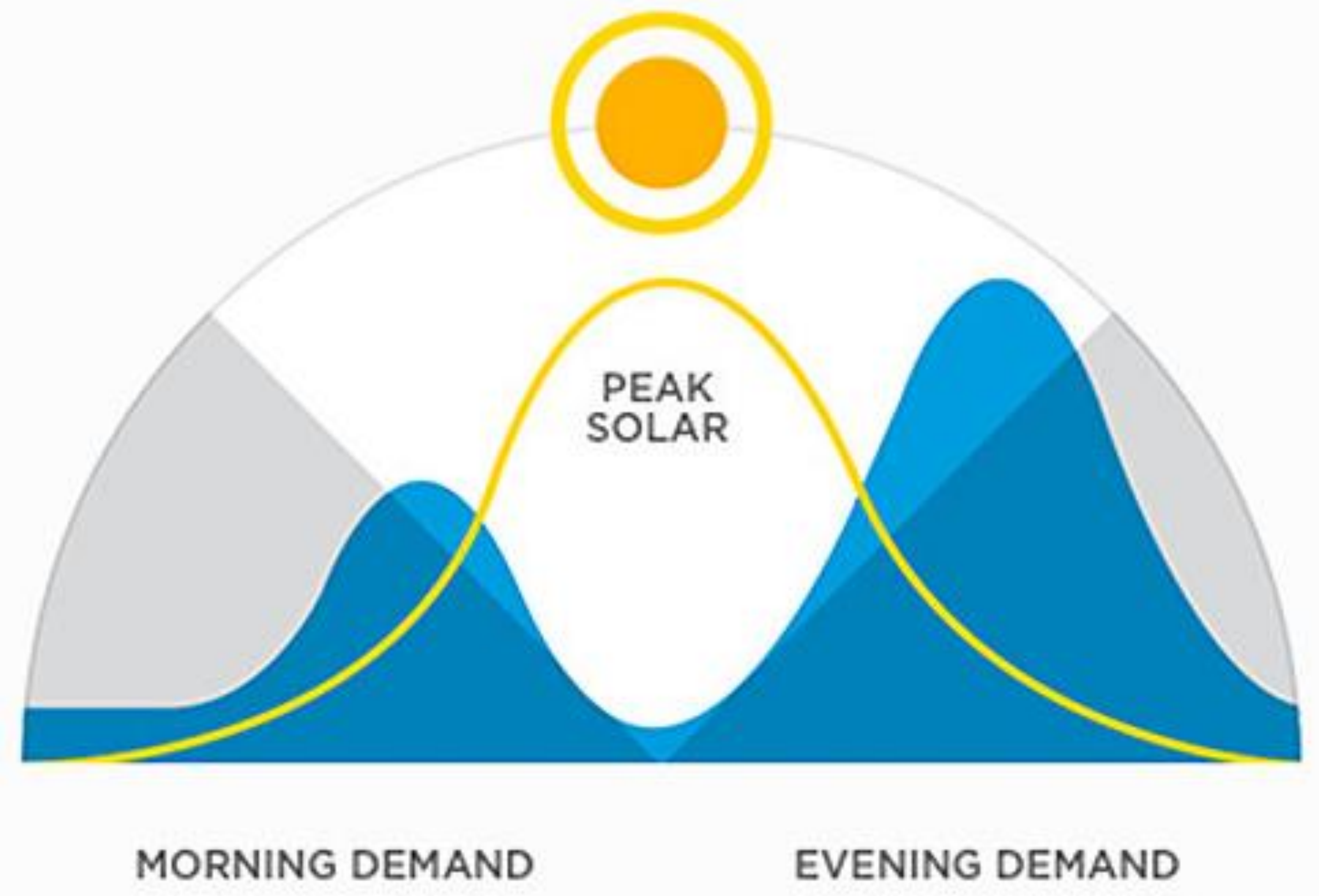


- Plate absorbers in the tubes
- Slightly adjustable absorber tilt angle within the vacuum tube
- Heat pipe design, which can only be installed at an angle
- Special attention required for thermal expansion at glass-metal connections

Source: naplopo.hu, viessmann.com

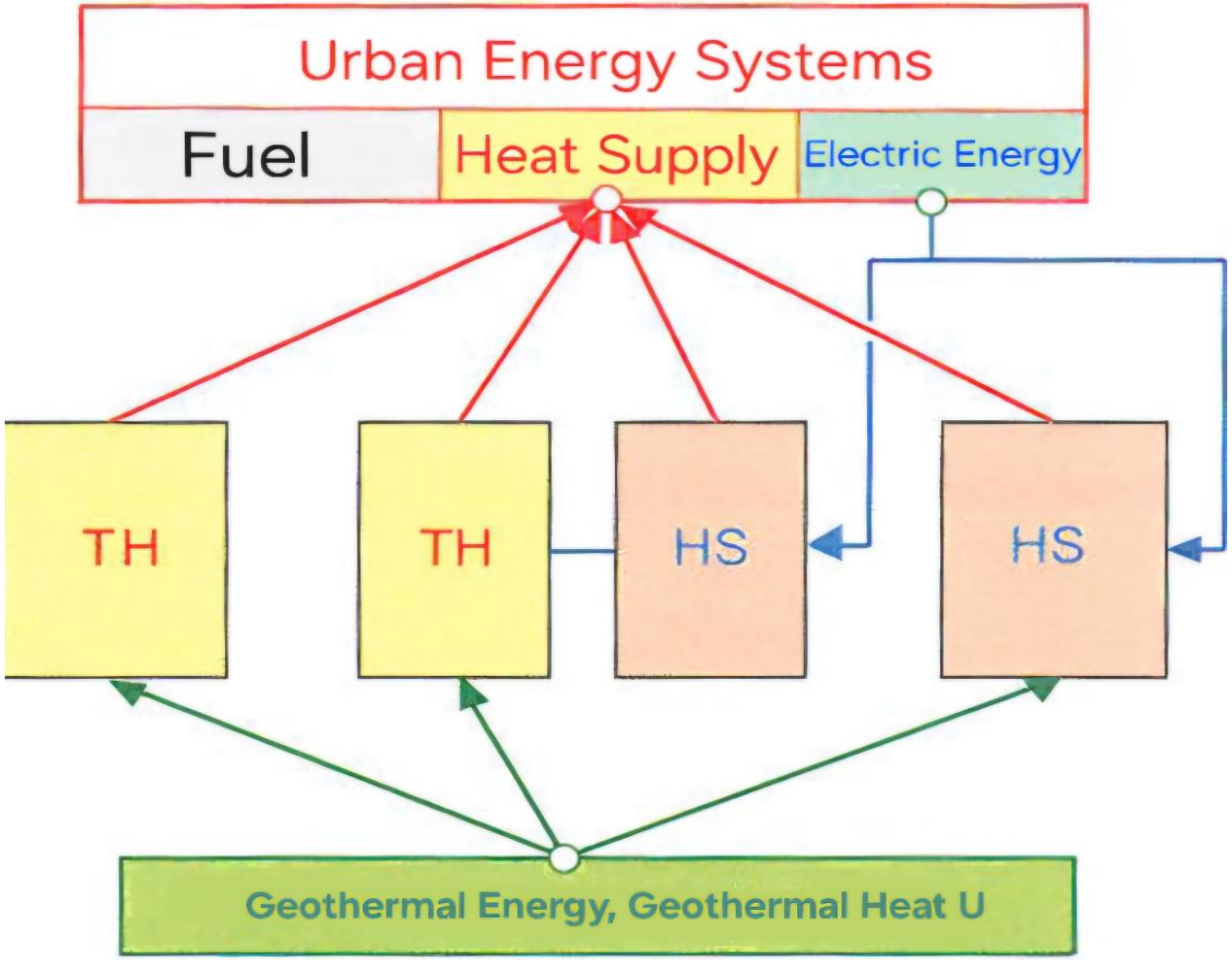
SOLAR DISTRICT HEATING

The Challenge of Large-Scale Solar Heat Production: Storing Performance Peaks



Source: www.teslamotors.com

Geothermal District Heating



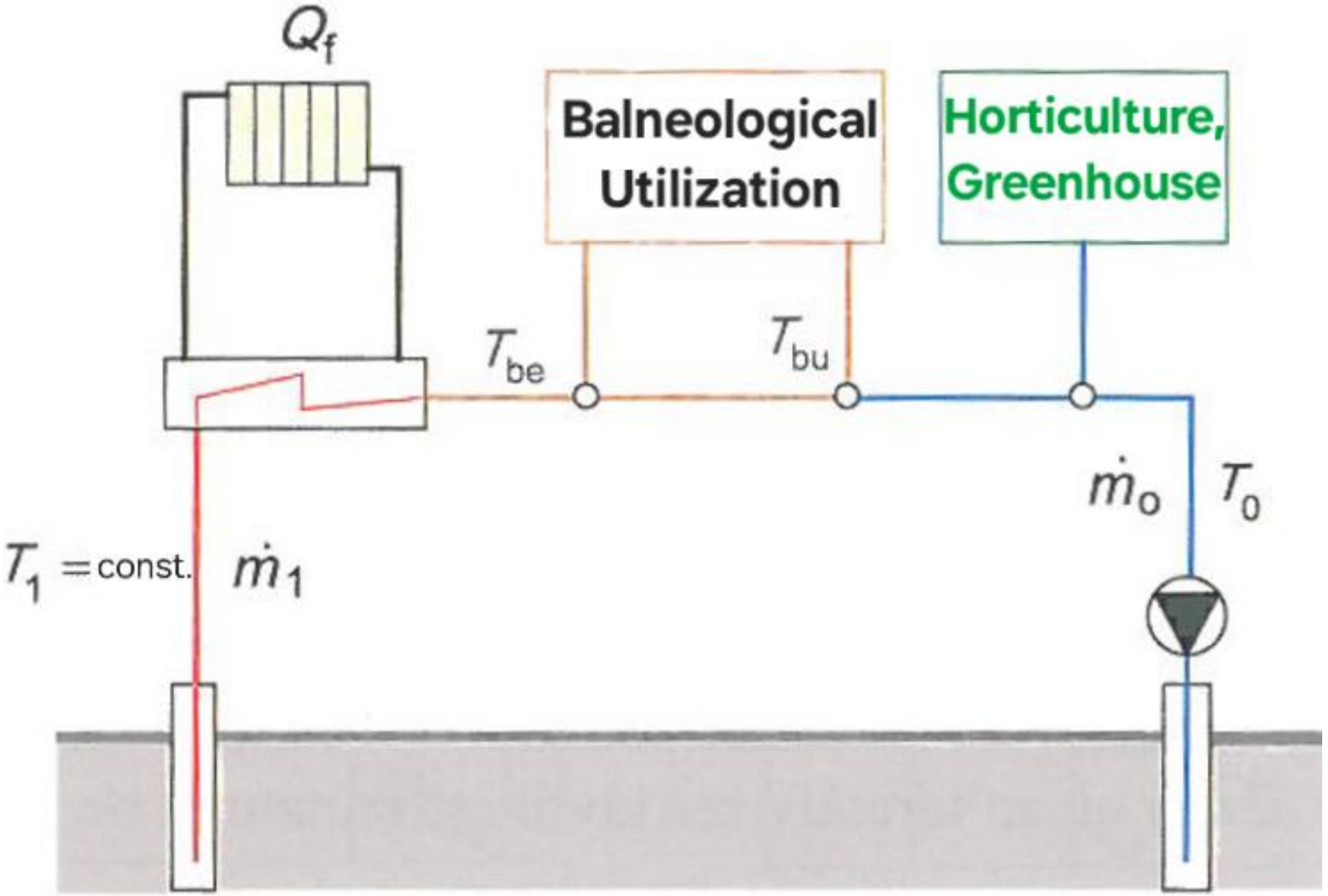
Utilization of Geothermal Energy in Urban Energy Systems

- High-temperature thermal water (>80°C) for direct heat supply.
- Medium-temperature thermal water (40-80°C)) for partial direct use and heat pump utilization
- Low-temperature thermal water (<30°C) heat pump utilization.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

Geothermal District Heating

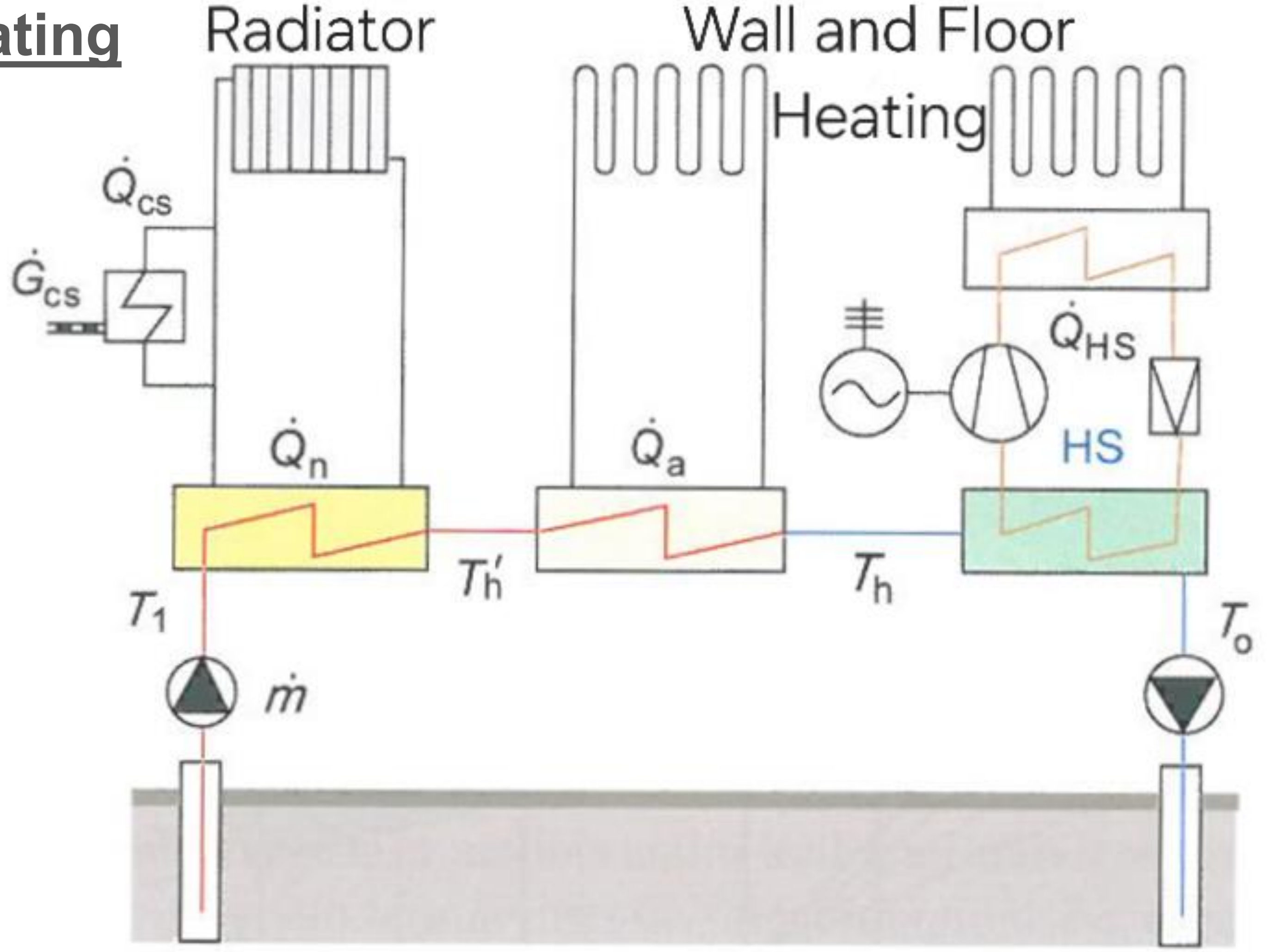
Multipurpose, Cascade Utilization of Thermal Water



Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

Geothermal District Heating

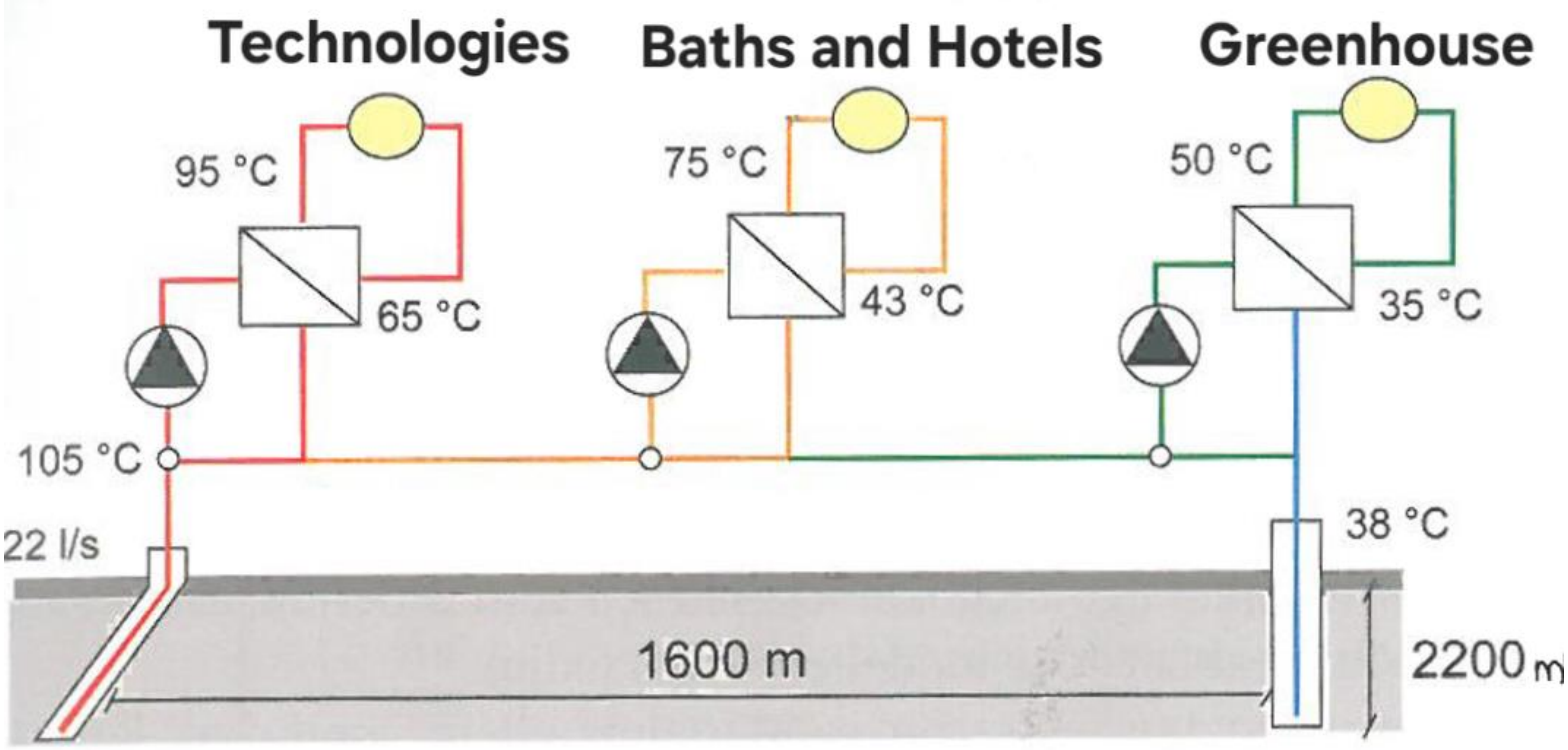
Thermal Water District Heating



Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

Geothermal District Heating

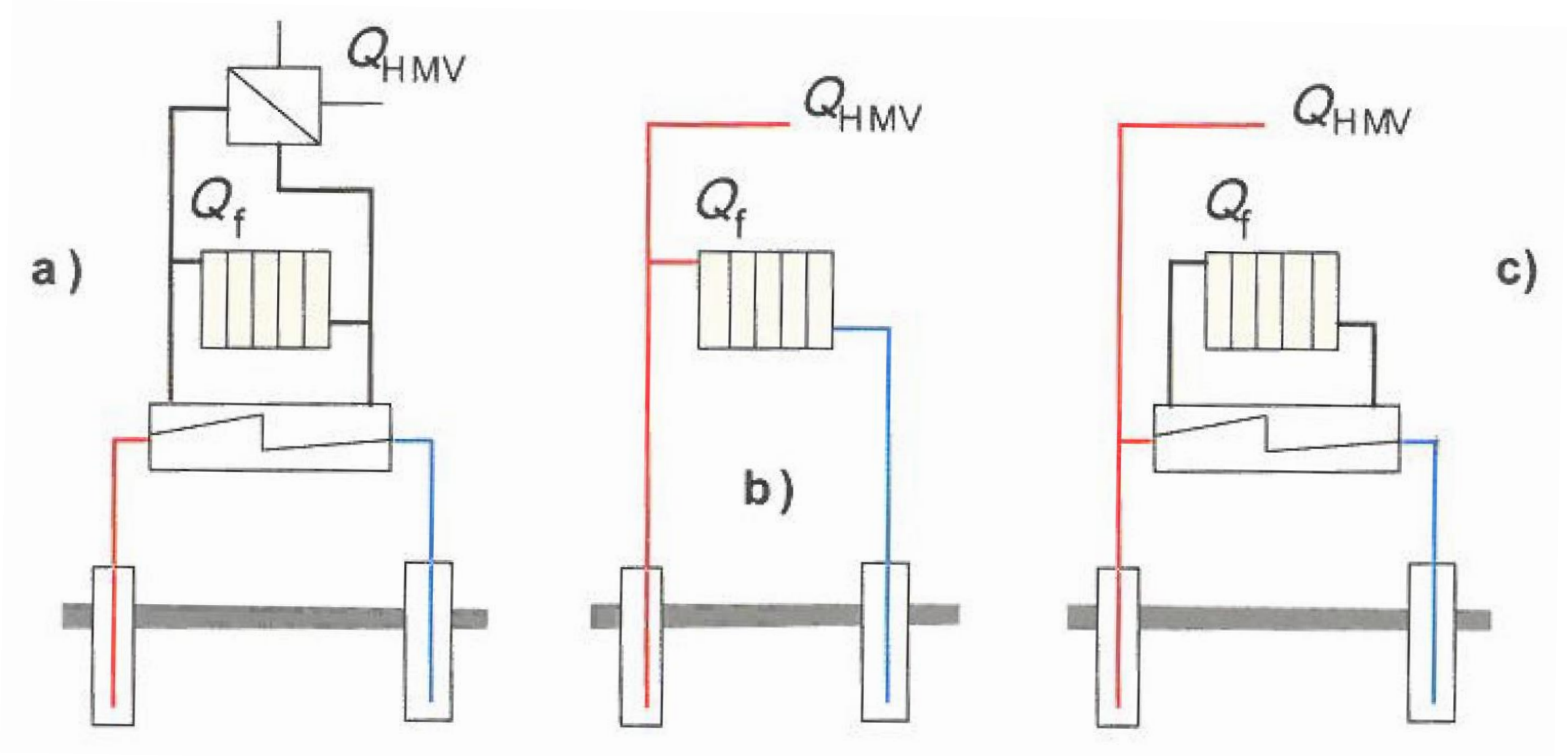
Cascade Connection of Thermal Water Utilization in Geinberg



Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

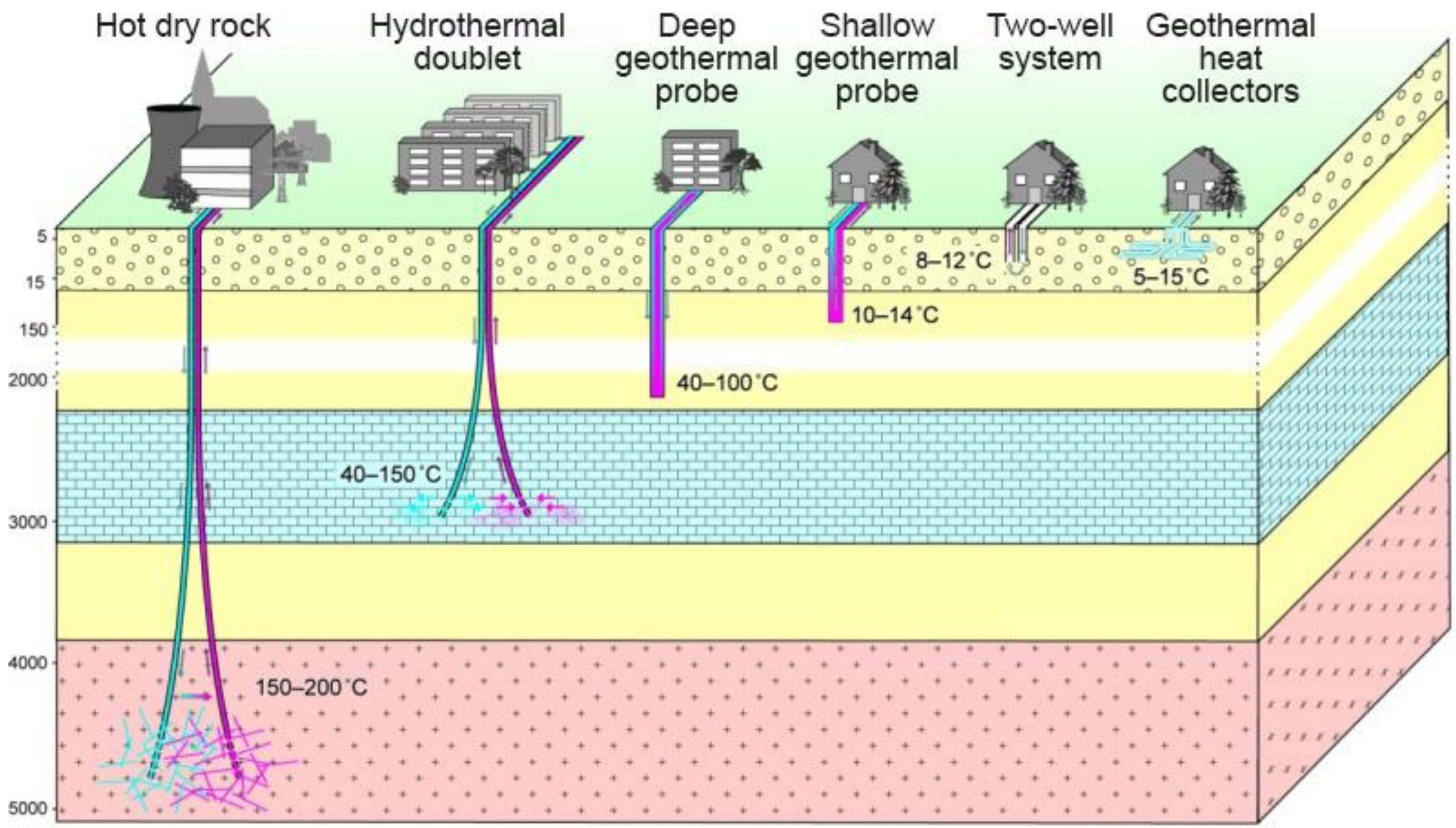
Geothermal District Heating

Connecting Consumers Directly, Indirectly to Geothermal District Heating



Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés

Geothermal District Heating



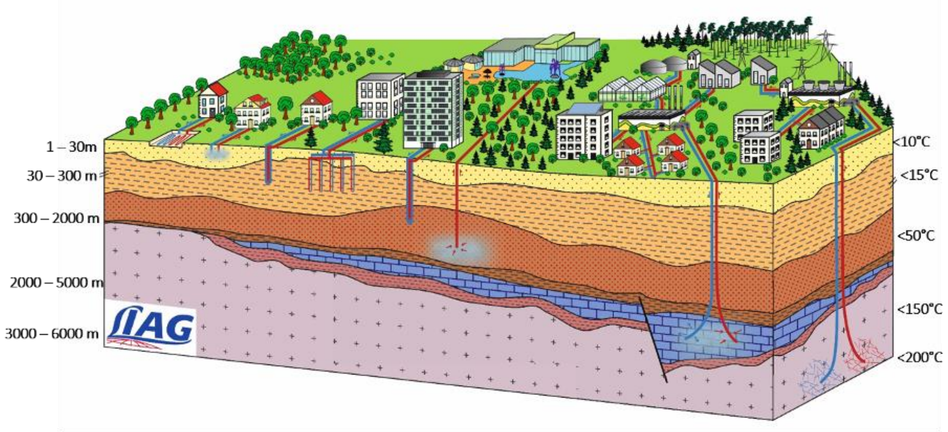
The possibilities of utilizing water depend on the quality and yield of the water

- Utilization as a medicinal product depends on the proven methods based on the mineral salt and gas content.
- Electricity generation using high-enthalpy fluids through production wells.
- Low-enthalpy thermal water wells for heating purposes.

Source: https://www.roedl.com/en-gb/de/media/publications/newsletters/renewable-energy/publishingimages/02-2018/geothermal%20heat.jpg

Geothermal District Heating

Establishing a Geothermal District Heating System



Top 7 countries (Heat energy production in GWh, 2015)

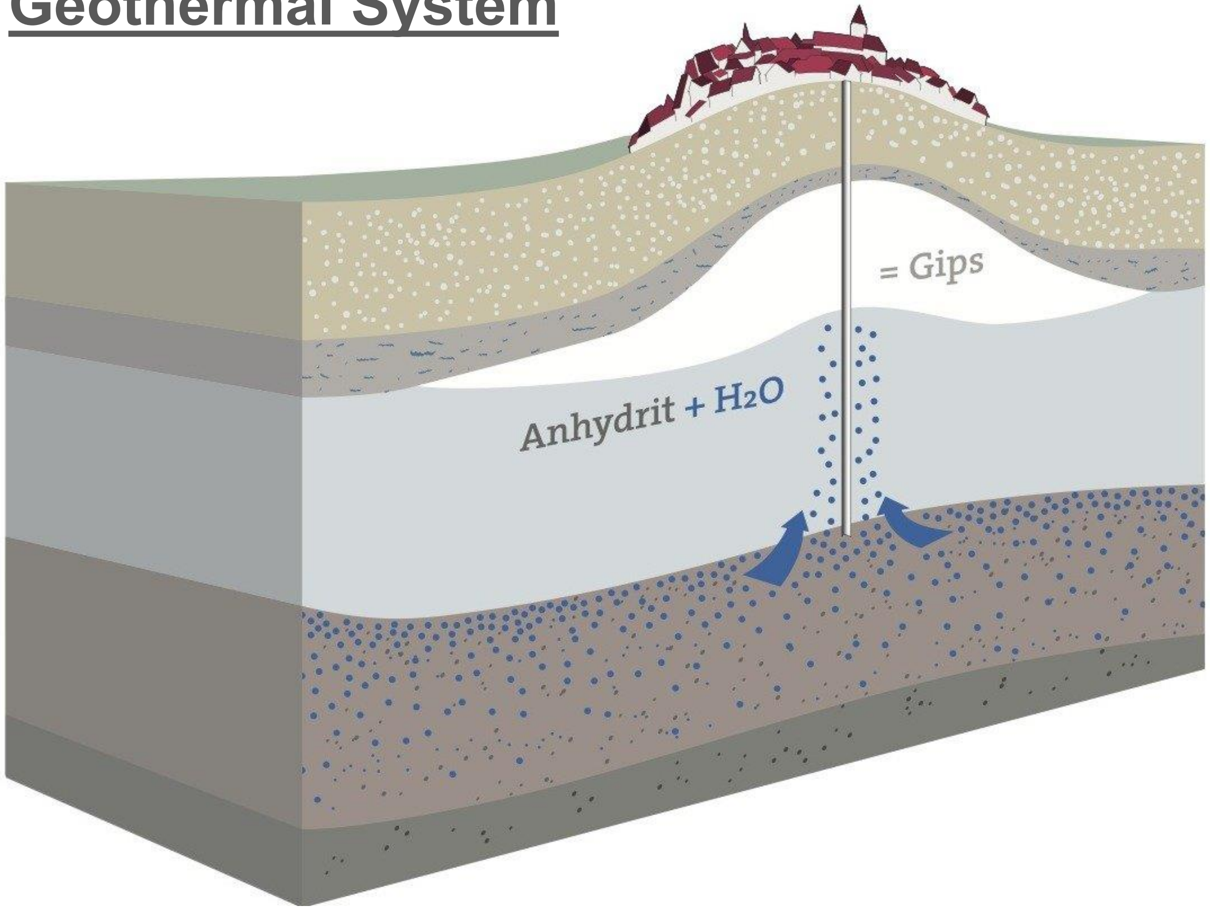
1		Iceland	6,421
2		France	1,335
3		Germany	662
4		Hungary	380
5		Austria	272
6		Italy	249
7		Serbia	243

- Alongside biomass, geothermal energy is the most accessible renewable energy source for district heating.
- High investment cost.
- Risk of partial or complete project failure:
  - Uncertainty of water yield estimation.
  - Accurate estimation of water temperature.
- Occurs in tectonically active areas:
  - Where there are earthquakes.
  - Where there are volcanic eruptions.

Source: https://www.roedl.com/insights/renewable-energy/2018-02/key-europes-district-heating-lies-deep-under-ground, https://www.europenowjournal.org/2021/05/10/geothermal-heating-and-cooling-networks-for-green-and-livable-urban-transformations-part-i/

Geothermal District Heating

Challenges During the Implementation of a Geothermal System



- Geothermal groundwater may contain toxic substances (e.g. arsenic).
- It can contaminate underground drinking water resources.
- Great care must be taken during reinjection.
- Human-induced earthquakes:
    - Basel (CH)
    - Stauffen (DE)
- “Anhydrite is a waterless calcium sulfate mineral, belonging to the sulfate group and categorized as an alkaline sulfate.” [Wikipedia]

Source: https://www.ingenieur.de/technik/fachbereiche/energie/geothermie-trotz-einzelner-schaeden-sicheres-verfahren/

Geothermal District Heating

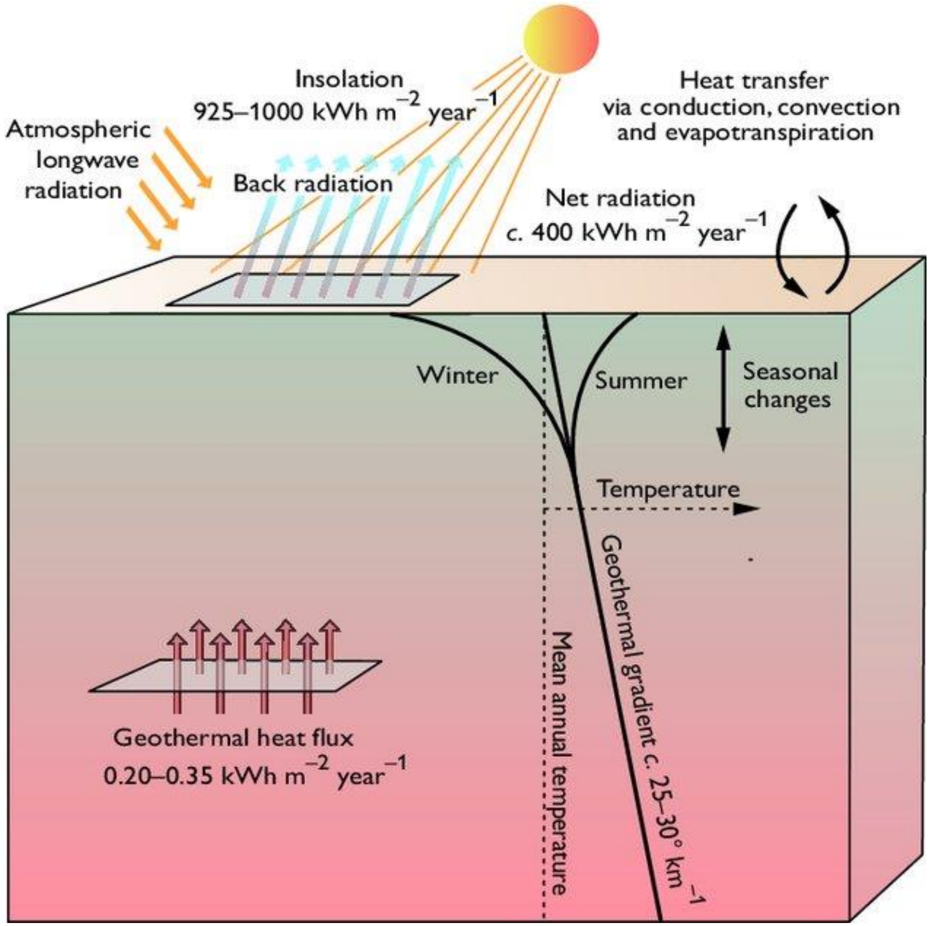
Staufen (DE)

- Ground level rises by 3 mm per year

Source: https://www.planet-wissen.de/technik/energie/erdwaerme/pwieproblemfallstaufen100.html

Geothermal District Heating

The geothermal gradient



- The Earth's temperature increases towards its center, proportional to the distance from the Earth's surface.
- The thinner the solid crust beneath a given area, the higher the geothermal gradient.
- In the upper layer (the lithosphere), it is approximately 30°C/km.
- An average well depth of 3 km is required for 90°C.
- 90°C is the lower limit for geothermal electricity production.
- The deepest wells currently reach 5 km.

Source: https://www.researchgate.net/publication/234094751_Shallow_geothermal_energy_in_Denmark/figures?lo=1

TEMPERATURE ABOVE 90°C AT 2000 M DEPTH

Source: http://geodh.eu/geodh-map/

Subsurface Water Layers in the Carpathian Basin

Source: http://geodh.eu/geodh-map/

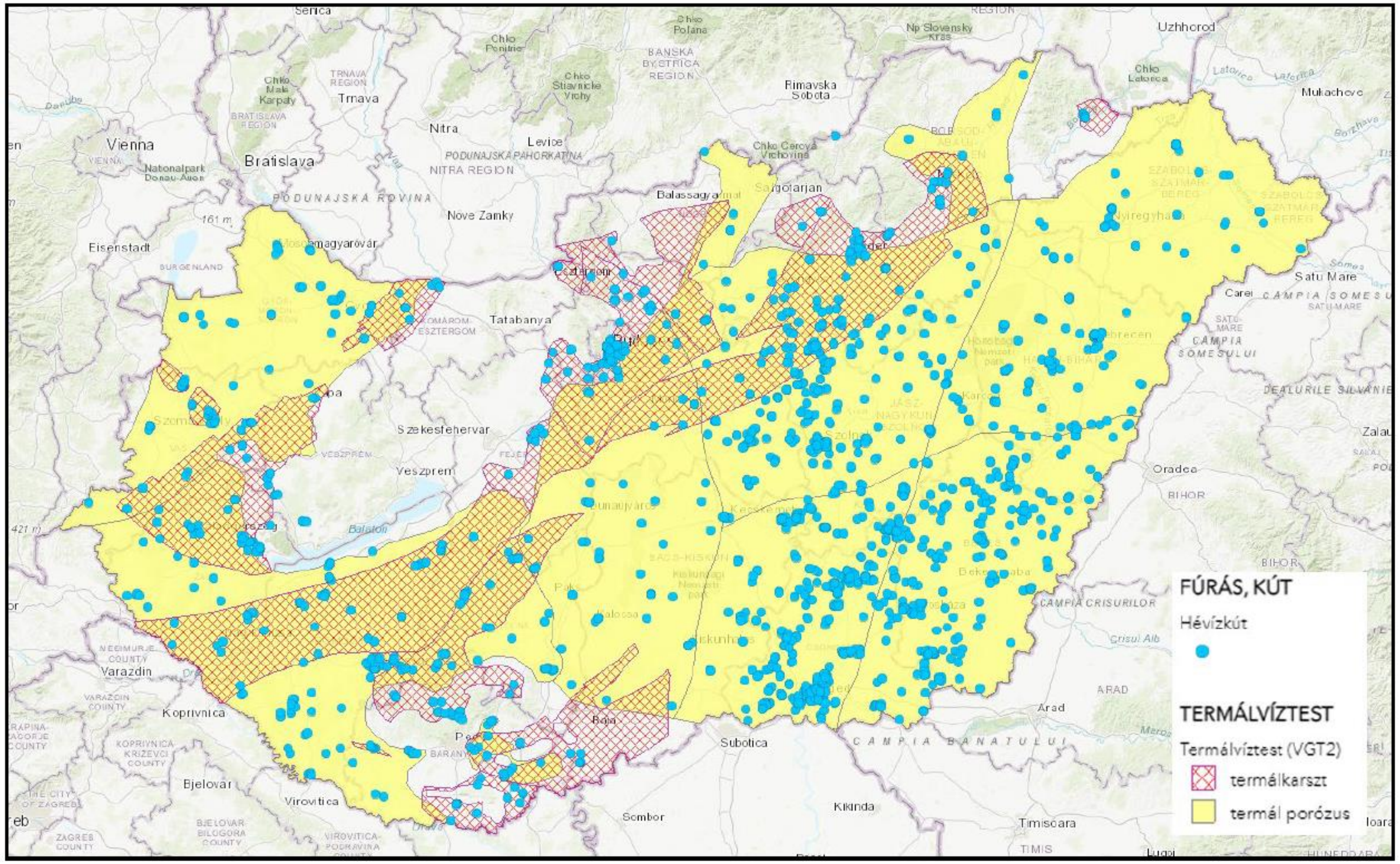
GeoDH Map

- http://geodh.eu/geodh-map/
- Estimation of geothermal heat sources
- Existing geothermal district heating
- Heat demand map
- For 14 project countries:
- Italy
- Germany
- France
- Netherlands
- Ireland
- United Kingdom
- Slovakia
- Slovenia
- Czech Republic
- Romania
- Bulgaria
- Poland
- Denmark
- Hungary

Source: http://geodh.eu/geodh-map/

Geothermal District Heating

Geothermal potential in Hungary

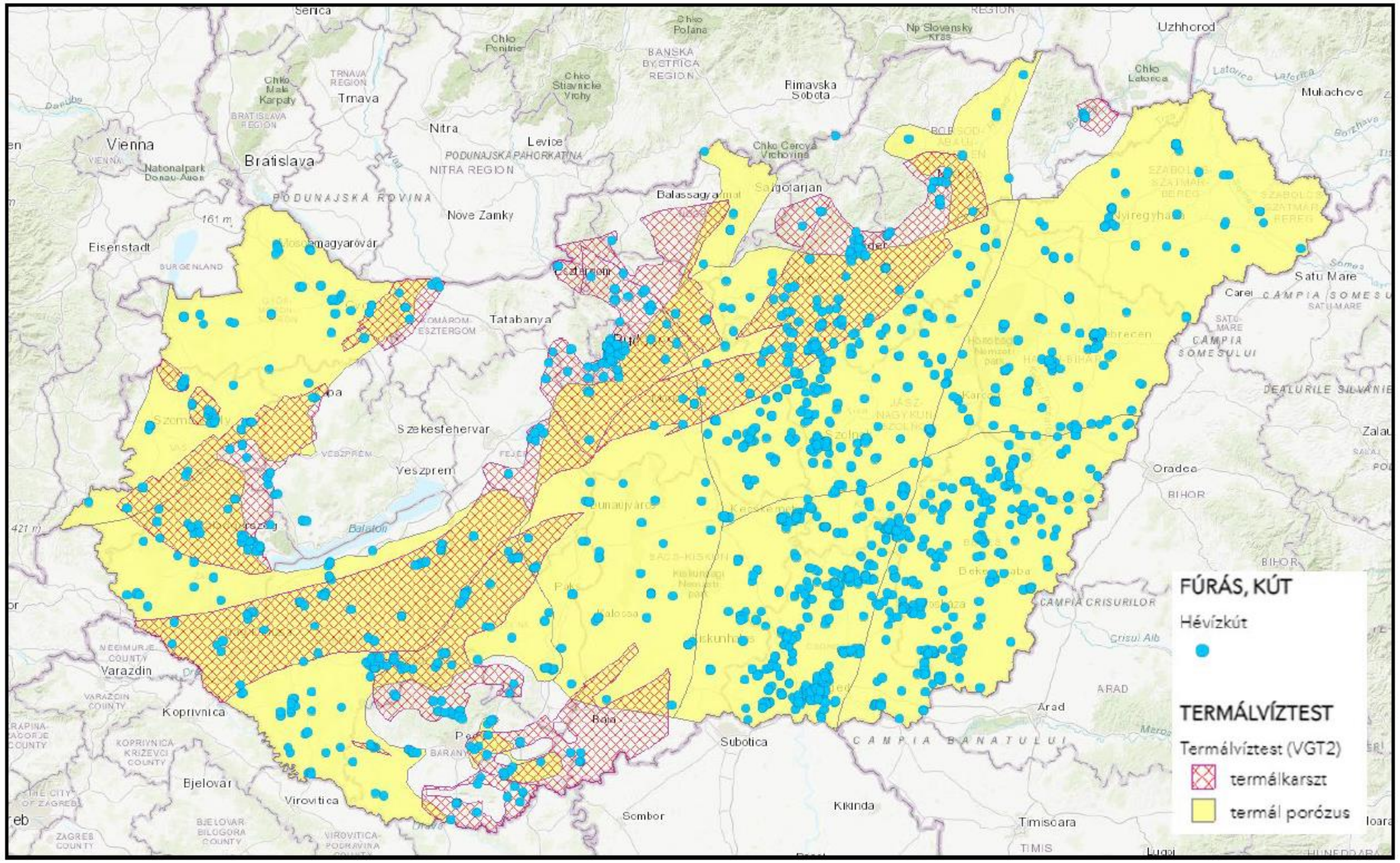


- Data from the Year 2000
- 1100 thermal water wells
- 286 wells with an outlet temperature of 30–40°C
- 179 wells with an outlet temperature of 41–60°C
- 121 wells with an outlet temperature of 61–90°C
- Assuming a final cooling temperature of 15 K, the annual extracted heat amount is 30.4 PJ
- This corresponds to the heating value of 740,000 tons of crude oil

Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó, [https://map.mbfsz.gov.hu/ogre/#], Graf Dárius: Termálvíz hasznosítása fürdőkomplexumokban. Szakdolgozat, Budapest 2023.

Geothermal District Heating

Geothermal potential in Hungary



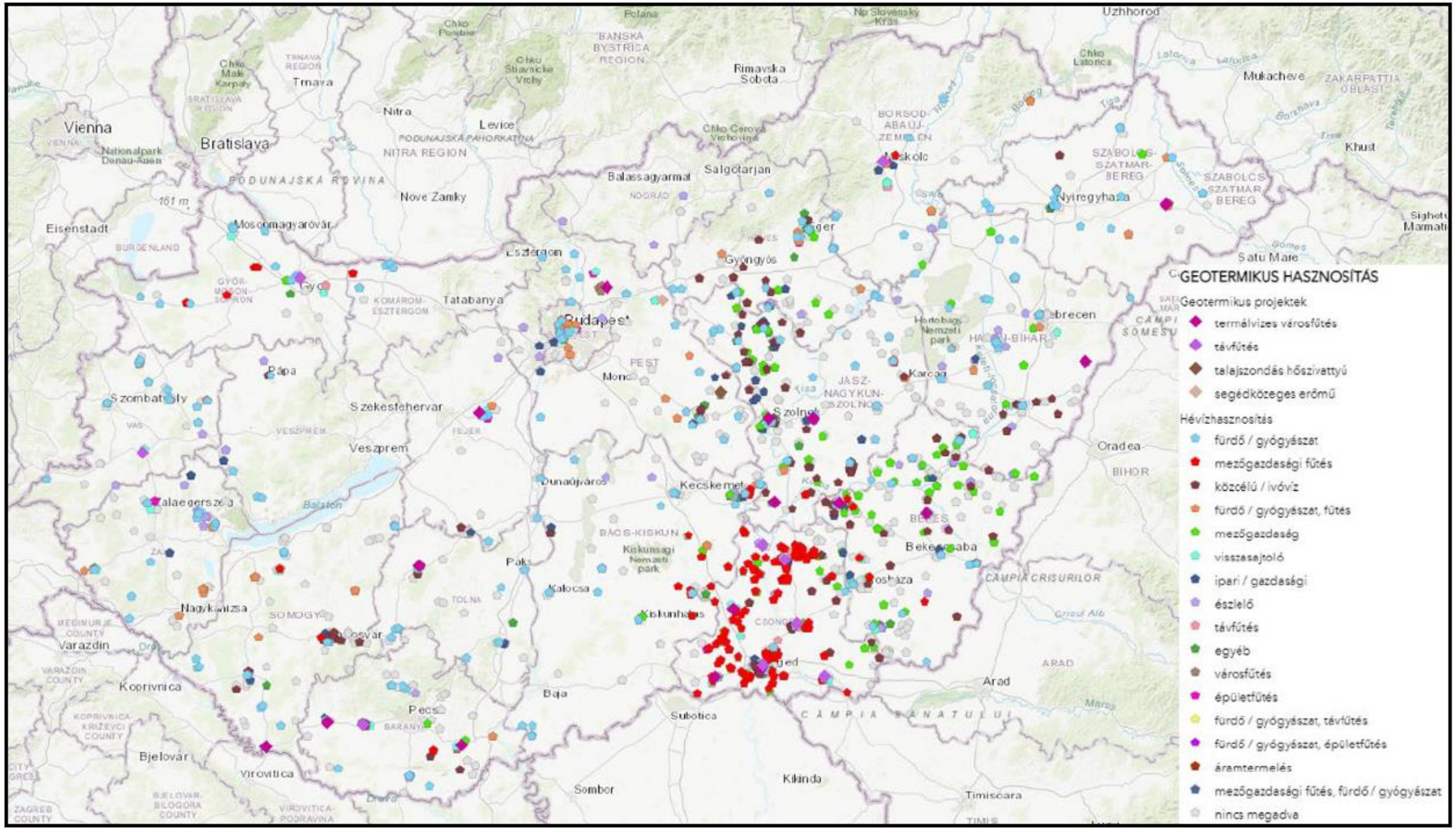
- 2015: 1622 wells. In 2015, the amount of thermal water extracted reached 24.608 million m³ per year, which corresponds to 2509 TJ of thermal energy.
- 2023: The number of wells is estimated to be between 1750 and 1800.
- National Geothermal System (OGRE)

  https://map.mbfsz.gov.hu/ogre/#

Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó, [https://map.mbfsz.gov.hu/ogre/#], Graf Dárius: Termálvíz hasznosítása fürdőkomplexumokban. Szakdolgozat, Budapest 2023.

Geothermal District Heating

Utilization of Thermal Wells in Hungary



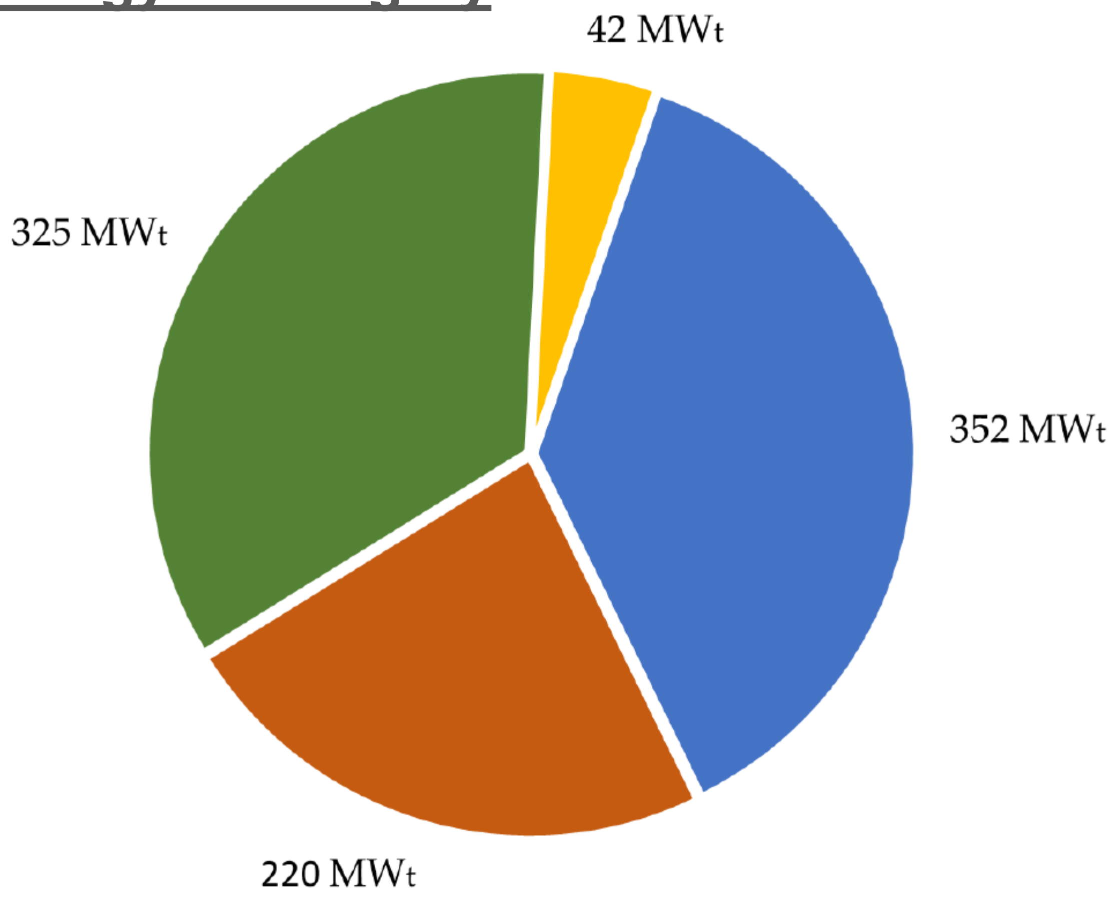
- Balneology
- Agriculture
- Urban Heating, District Heating
  - The construction of district heating networks began in the late 1960s in cities of Southern Hungary.
- Hódmezővásárhely
- Szeged
- Makó
- Szentes
- Kistelek

Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó, Graf Dárius: Termálvíz hasznosítása fürdőkomplexumokban. Szakdolgozat, Budapest 2023

Geothermal District Heating

Direct Heat Utilization Based on Geothermal Energy in Hungary

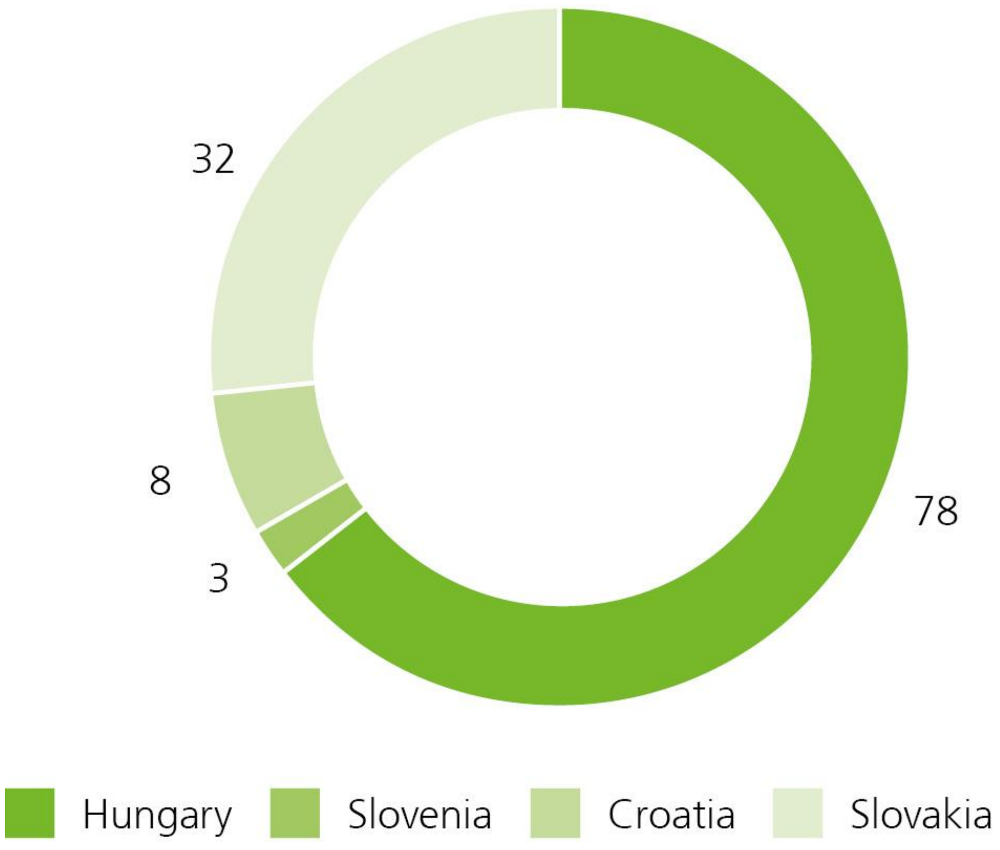
- Balneology
- Building Heating
- Agriculture and Industry
- Geothermal Heat Pumps



Source: Graf Dárius: Termálvíz hasznosítása fürdőkomplexumokban. Szakdolgozat, Budapest 2023.

Geothermal District Heating

Number of District Heating Systems Near Significant Geothermal Fields



- “The energy stored in the outer crust (10 km deep) can supply the world’s energy needs for 6 million years (based on current consumption).
- ”Source issue:
  The intensity of the source can decrease significantly over the years.
- Relocation of the source over time:
  Is it economically viable?

Source: https://www.roedl.com/insights/renewable-energy/2018-02/key-europes-district-heating-lies-deep-under-ground

Geothermal District Heating

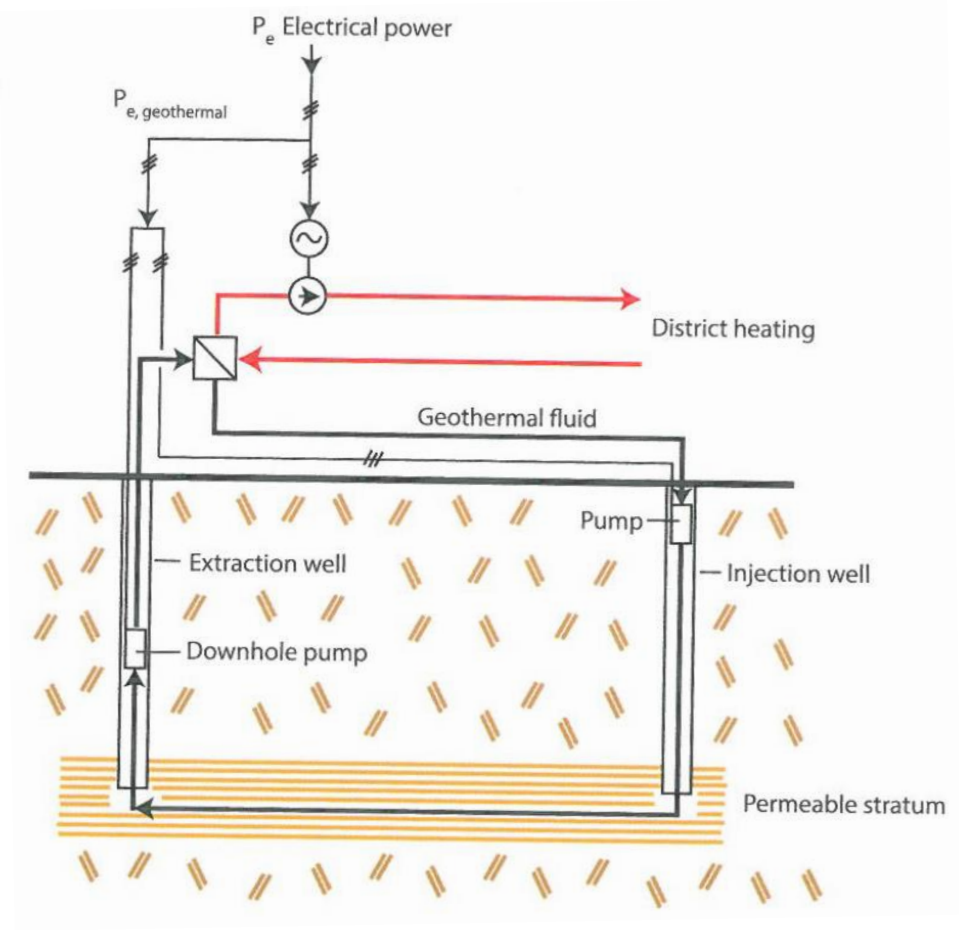
Practical Aspects of Utilizing Thermal Groundwater

- The heat from deep layers is brought to the surface by geothermal fluids, containing:
  - Water,
  - Dissolved salts,
  - Gases,
  - Suspended solids.
- Test Production
  - To determine production characteristics:
  - Cleaning pumping at 40, 60, then 80% of water yield is conducted for a minimum of 72 hours.
  - The resting water level is measured along with the height of the water column.
- After this, it can be determined whether the well operates in a positive or negative mode.
  - Positive mode: The well operates independently, allowing free flow.
  - Negative mode: The well requires artificial operation, e.g., with pumps, as the static and operational water levels do not reach the surface.

Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó

Geothermal District Heating

Artificial production



- Positive wells can supply the required amount of thermal water without the need for auxiliary equipment.
- Negative wells have their static water level below the surface and require assistance:
  - Auxiliary equipment is needed to lift the required water quantity to the surface.
  - For long-term use, most thermal water wells transition to a negative operational mode.
  - Only artificial methods can bring the water to the surface.
- Two types of artificial production:
  - Compressor operation
  - Pump operation

Source: Svend Fredriksen, Sven Werner: District Heating and Cooling. Studentlitteratur 2013, Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó

Geothermal District Heating

Artificial Production Methods

- **Pump-based production**
  - Multi-stage centrifugal pumps or submersible pumps can be installed in thermal water wells. These pumps often have radial or semi-axial impellers integrated with an electric motor.
  - Modern production always involves controlled thermal water extraction.
  - Submersible pump performance is regulated with speed control to maintain desired levels.
  - Today, submersible pumps are widely used due to their precise, automatic, and cost-effective performance regulation.
- **Compressor-based production**
  - Air introduction pipes are installed into the well.
  - Compressed air is injected into the well's water column.
  - This reduces the density of the water column in the well.
  - The disadvantage is that extracted thermal water contains more dissolved oxygen.
  - This method is not suitable for wells with high sediment content, such as sand-carrying water.

Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó

Geothermal District Heating

Increasing Water Flow

For higher flow demand, one of the following methods may be applied:

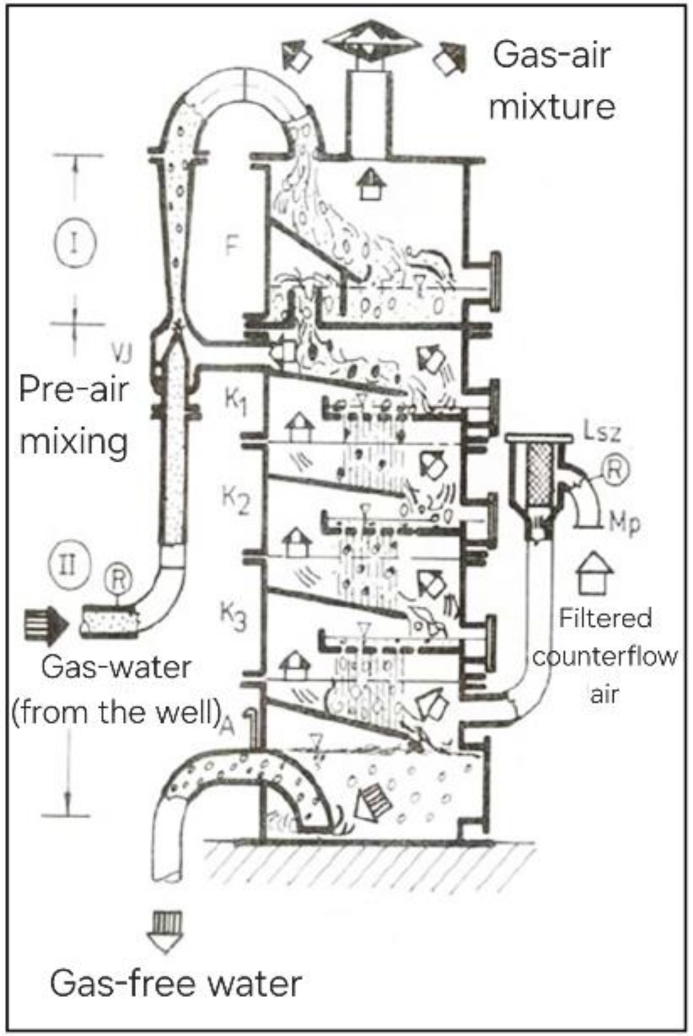
- Acidizing:
  - The water yield can be increased by acid treatment lasting at least 8 hours.
- Explosions:
  - Detonation of insoluble explosives at great depths within the well.
- Layered Fracturing:
  - High-pressure fluids are injected into the well to remove sand contamination.
- Hydrodynamic Testing
  - Capacity testing that examines the entire water supply system for detailed pressure-volume-temperature assessments.

Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó

Geothermal District Heating

Degassing of extracted thermal water

- The extracted thermal waters often contain separable gas content.
- Typically CO_2, CH_4, N_2
- For low methane content:. The gas is released into the environment or compressed and stored in tanks. It can also be injected into cooled thermal water before reinjection.
- In case of high methane content, the separated methane is used in gas engines.



Source: Kontra Jenő: Hévízhasznosítás. Műegyetemi Kiadó

Geothermal District Heating

Utilization of Thermal Wells in Hungary

- In Budapest, the palm house was already heated with hydrothermal energy after the First World War.
- The first geothermal heated residential buildings in Pest are located in the vicinity of the Budapest Zoo and Botanical Garden.

Source: https://pestbuda.hu/cikk/20200501_foldvary_gergely_az_allatkert_lakoit_csaknem_teljesen_megettek_a_budapestiek_az_1945_os_ostrom_utan_de_majus_1_jen_ujra_megnyilt_az_intezmeny

Geothermal District Heating

Veresegyház System in (the first well launched in 1987)

- In 1987, the first production well was drilled
- In 1992, the thermal bath was built, followed by the connection of the school, the community center, and later the new Mézesvölgy Primary School and the swimming pool to the geothermal heating system.

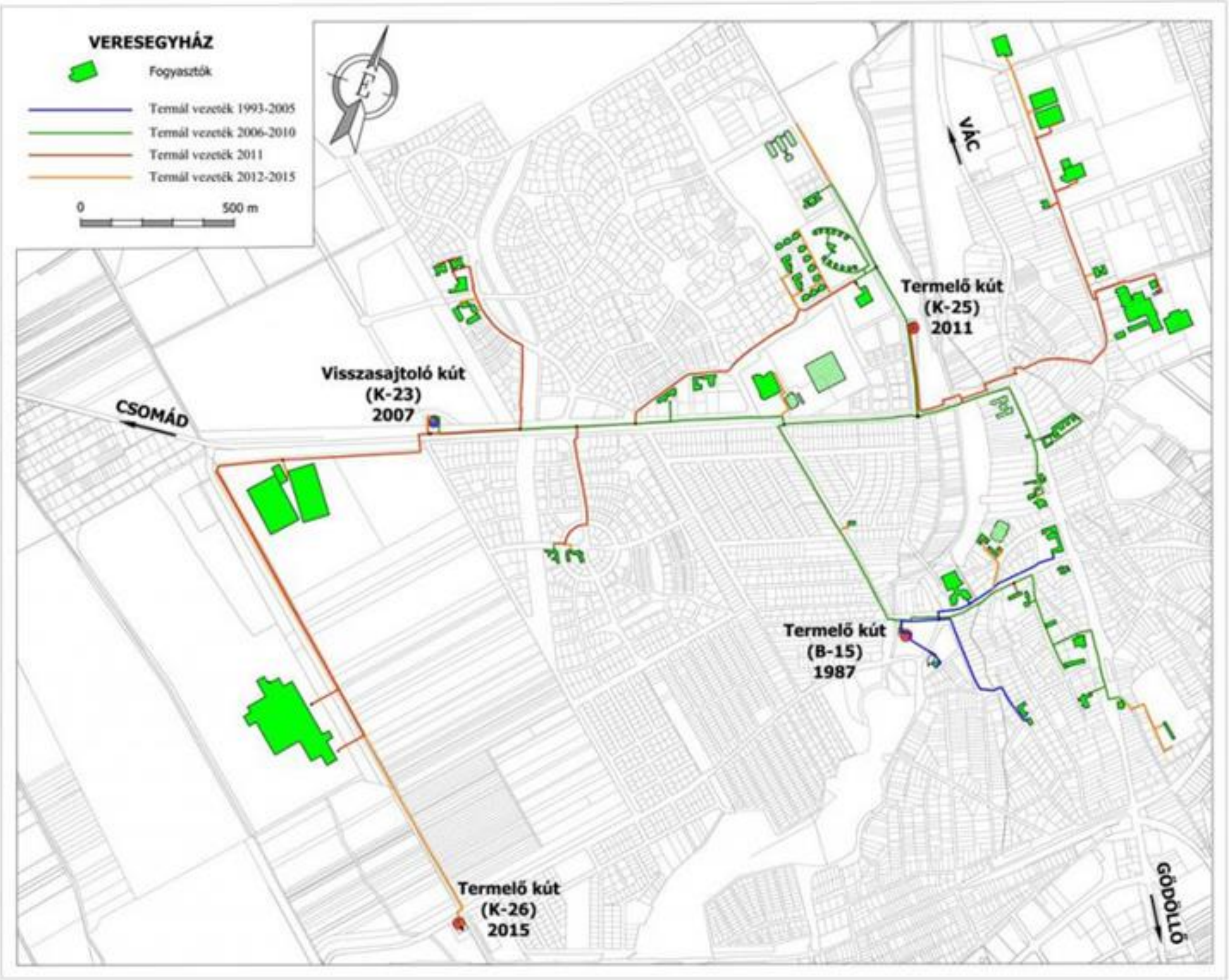
The construction of the reinjection well marked a significant step: by 2007–10, several public institutions were connected to the system, and from autumn 2011, with the drilling of new production wells and the construction of pipelines with a total length of nearly 1,500 meters, around 45 large consumers could benefit from the advantages of low-cost energy provided by geothermal resources.

Source: https://porcio.hu/veresegyhaz-38/

Geothermal District Heating

The Veresegyház System

- During winter, city residents can walk on snow-free and ice-free sidewalks.
- The forward pipes are insulated, but the return pipes are uninsulated and run 1.5 meters underground, allowing the used water's heat to melt snow and ice on the sidewalks. The system extends over 14.5 kilometers.
- Consumers: public institutions and industrial facilities.
- Annually replaces 2.2 million cubic meters of gas.



Source: https://porcio.hu/veresegyhaz-38/

Geothermal District Heating

The Geothermal District Heating System in Veresegyház

(Well K26 in 2016, one year after commissioning)

Without 60% support from the European Union and the government, the development could not have been realized. The project, costing approximately 650 million HUF, received 385 million HUF in funding, to which the municipality contributed with 40% co-financing.

Source: https://porcio.hu/veresegyhaz-38/

Geothermal District Heating

The District Heating System in Szeged

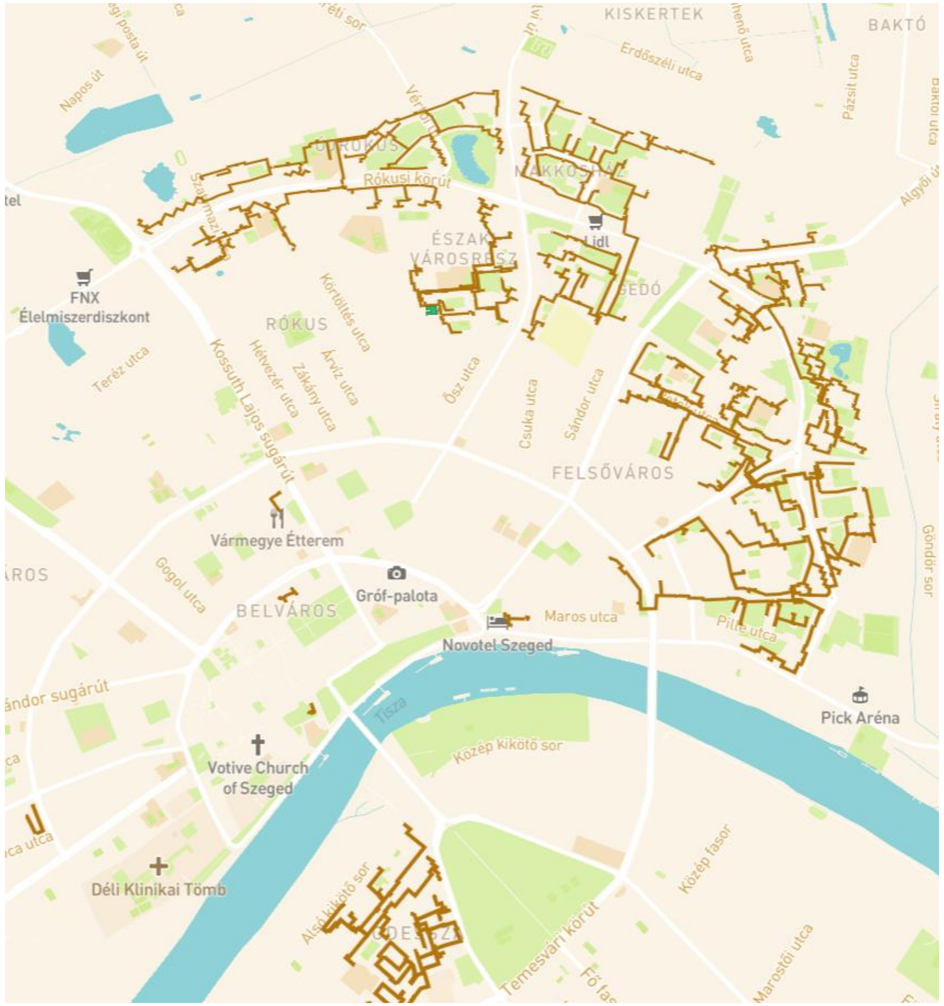
- The Szeged District Heating Company provides heating and domestic hot water to 27,256 apartments (mostly in 4-10 story residential buildings).
- 433 public buildings (schools, kindergartens, retail units).
- Since 2018, SZETAV and its partners have been carrying out Europe's largest geothermal district heating renovation.

Source: https://geotherm.szetav.hu/

Geothermal District Heating

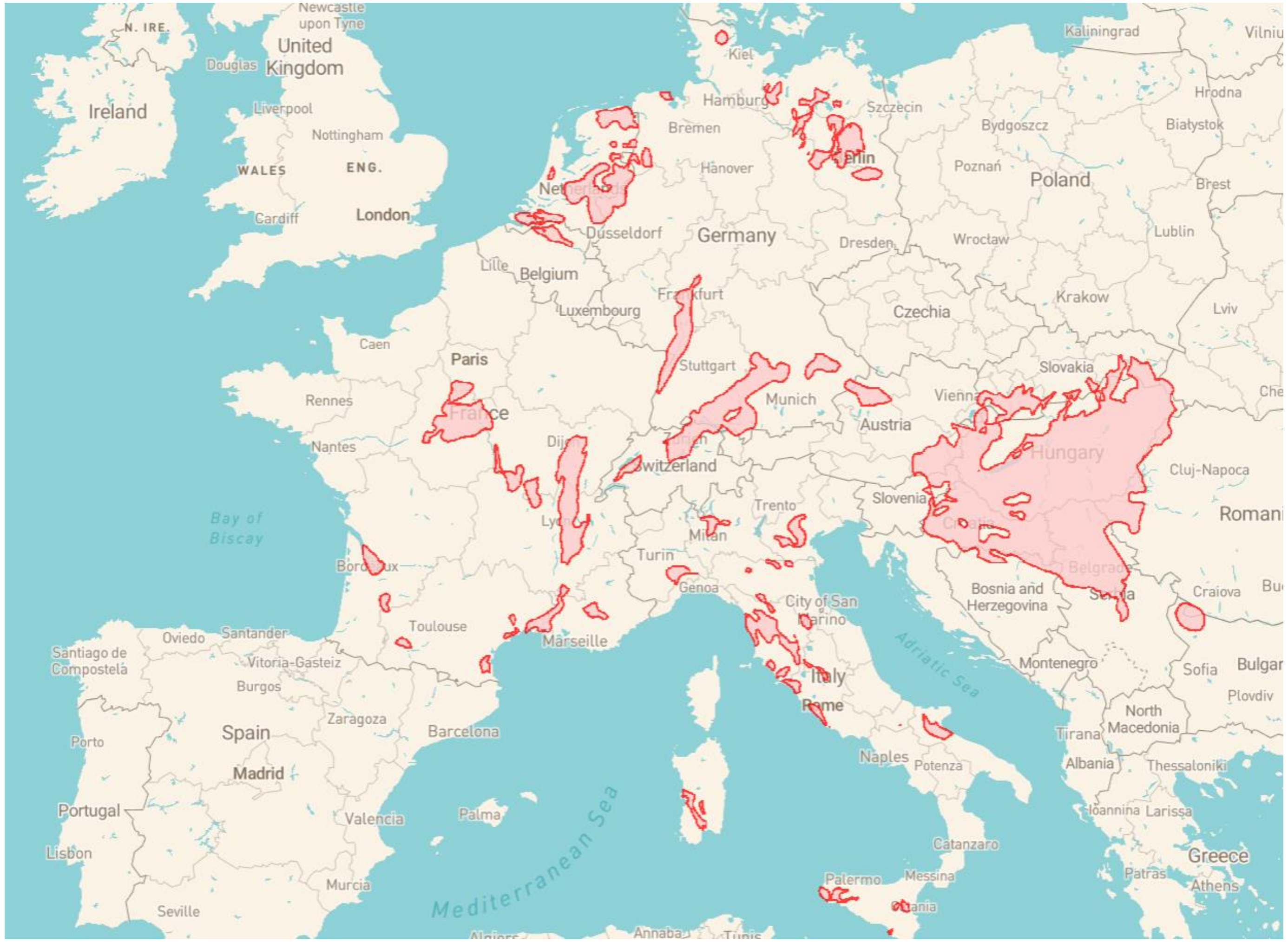
The District Heating System in Szeged

- The Szeged district heating system consists of 23 heating circuits.
- Boilers with a capacity of 1–12 MW provide a total installed capacity of 204.17 MW.
- A total energy production of 843,700 GJ/year is supplied to end users.
- 239 heat centers.
- 215 km of pipeline network.
- Until recently, the system relied entirely on imported natural gas as its sole energy source, making the company the largest local CO2 emitter.



Source: https://geotherm.szetav.hu/

Geothermal District Heating

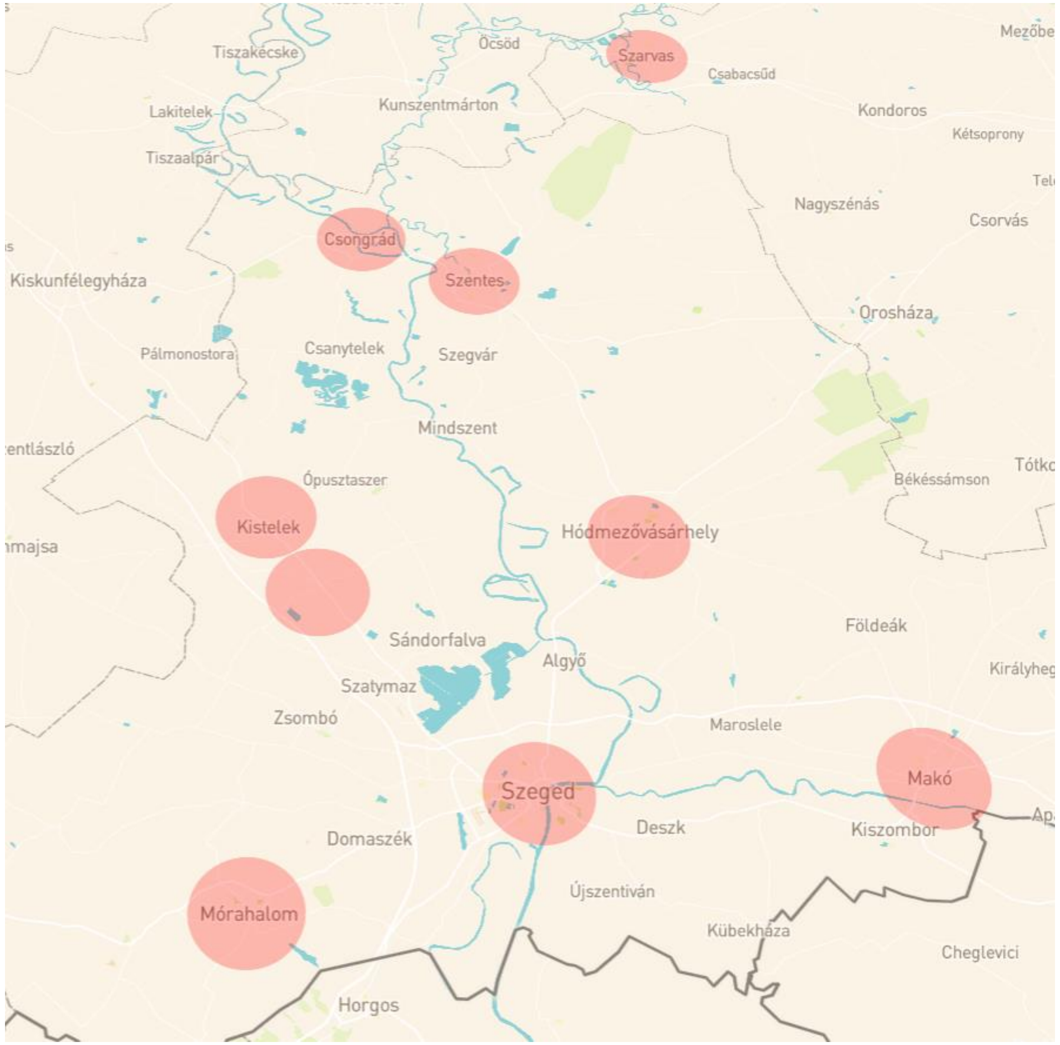


Source: https://geotherm.szetav.hu/

Geothermal District Heating

Szeged District Heating System

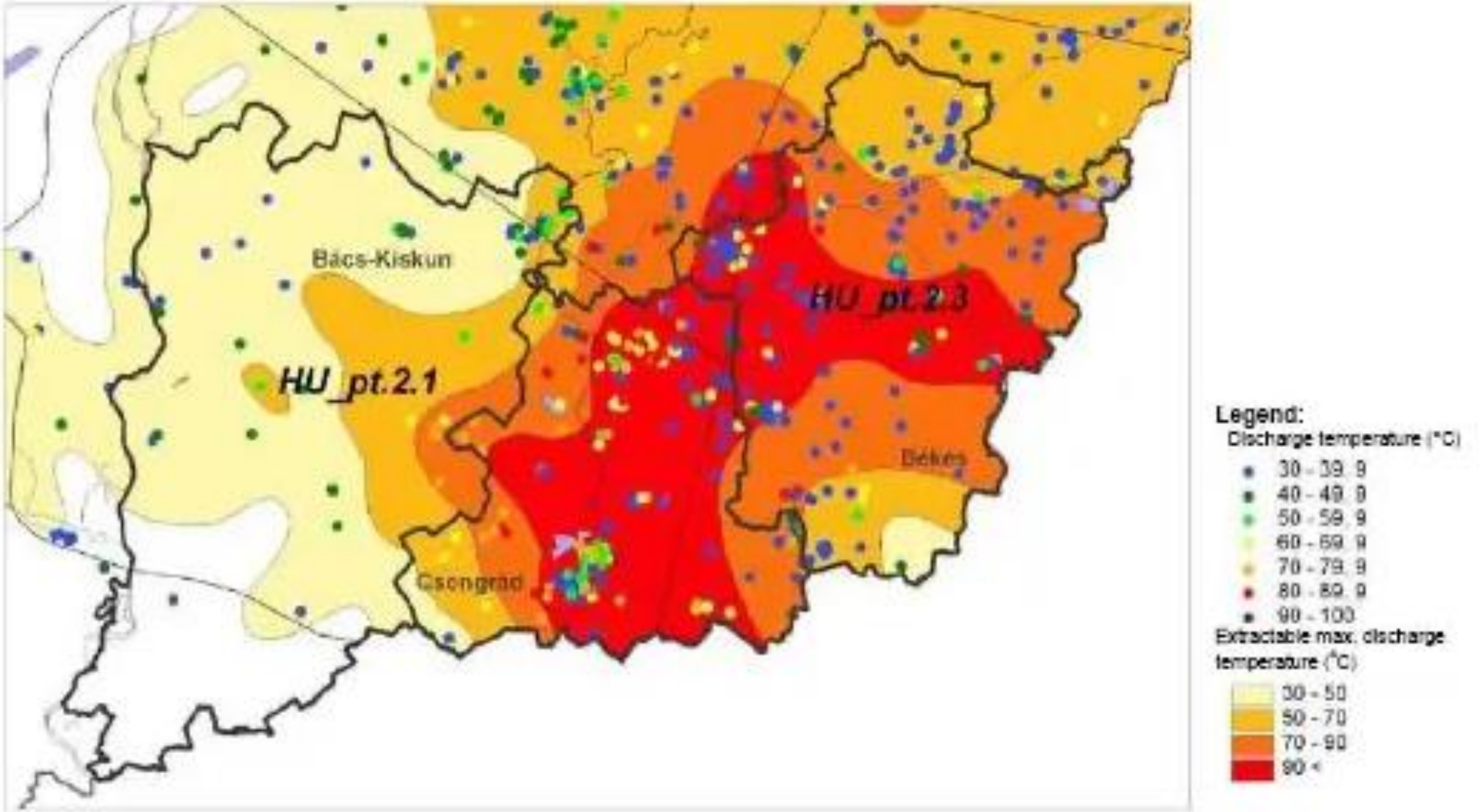
- Apart from balneological and agricultural uses, 9 settlements utilize geothermal energy for district heating within a 50 km radius.
- These systems are based on favorable medium enthalpy sources.
- Most systems rely on a design with 1 production well and 1 or 2 reinjection wells, with some also using the thermal water for heating and balneological purposes.



Source: https://geotherm.szetav.hu/

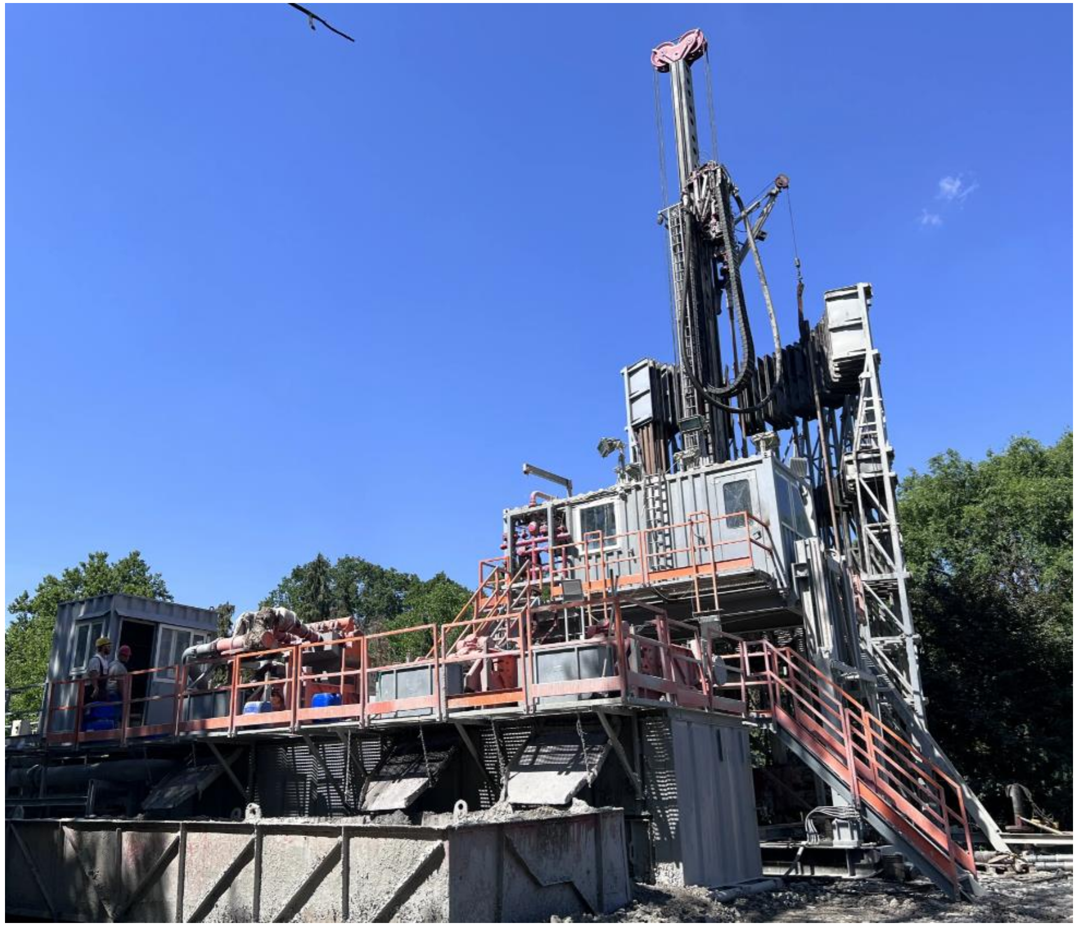
Geothermal District Heating

The temperature of the extractable thermal water



Source: https://geotherm.szetav.hu/

Geothermal District Heating



The District Heating System in Szeged

- In „Felsőváros”, at the Odessa housing estate, in the northern part of the city, in Tarján, in Rókus, and in the city center, thermal wells are being drilled to depths of 1700-2000 meters.
- These sources produce 70 m³/h of thermal water at 90°C.
- A total of 27 new wells are being drilled in the city, with two drilling rigs operating day and night.

Source: https://geotherm.szetav.hu/

Geothermal District Heating

The District Heating System in Szeged

- The thermal energy is utilized through heat exchangers.
- Geothermal water serves only as a heat source, so it does not enter the district heating network and is not used as domestic hot water.
- Annually, 606,958 GJ of geothermal energy can replace nearly 20 million m³ of natural gas.
- Geothermal heat in the Szeged district heating system results in savings of 595,887 GJ/year (82%) and 17,525,718 m³/year (68%) in natural gas consumption.
- 606,958 GJ/year of thermal energy ensures a saving of 39,299 t/year (65%) in CO_2 emissions in district heating.

Source: https://geotherm.szetav.hu/

Thank you!

Module 3.1 – Renewable heat production
SHaKE – Sharing Heat and Knowledge on Energy Communities

https://www.shakeproject-dhc.eu/

Developed by Budapest University of Tevhnology and Economics
Balázs Bokor | bokor.balazs@gpk.bme.hu

Co-funded by
the European Union