Module 1
Introduction to District Heating Systems

SHaKE – Sharing Heat and Knowledge on Energy Communities
Erasmus+ KA220-HED Cooperation Partnerships in Higher Education
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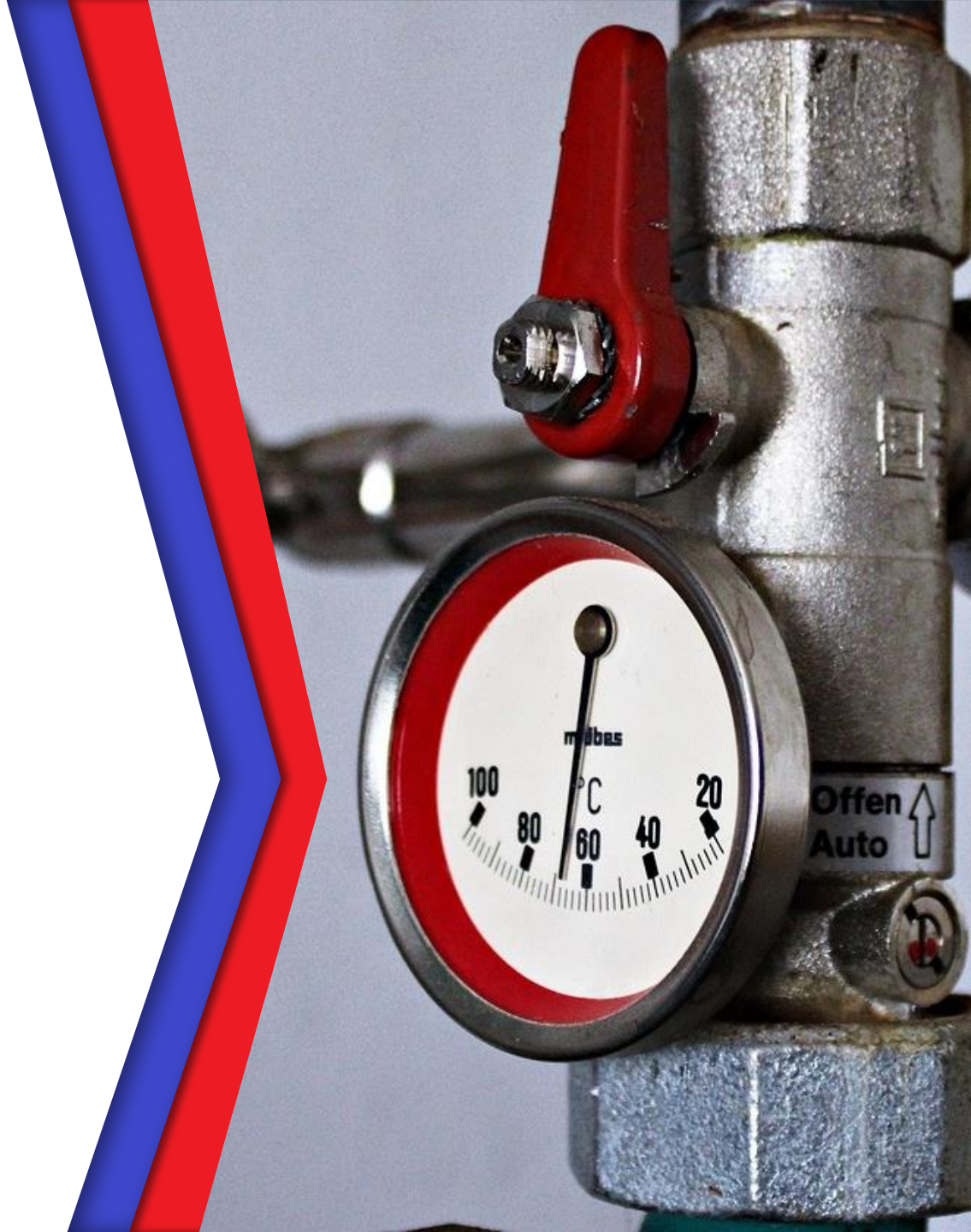
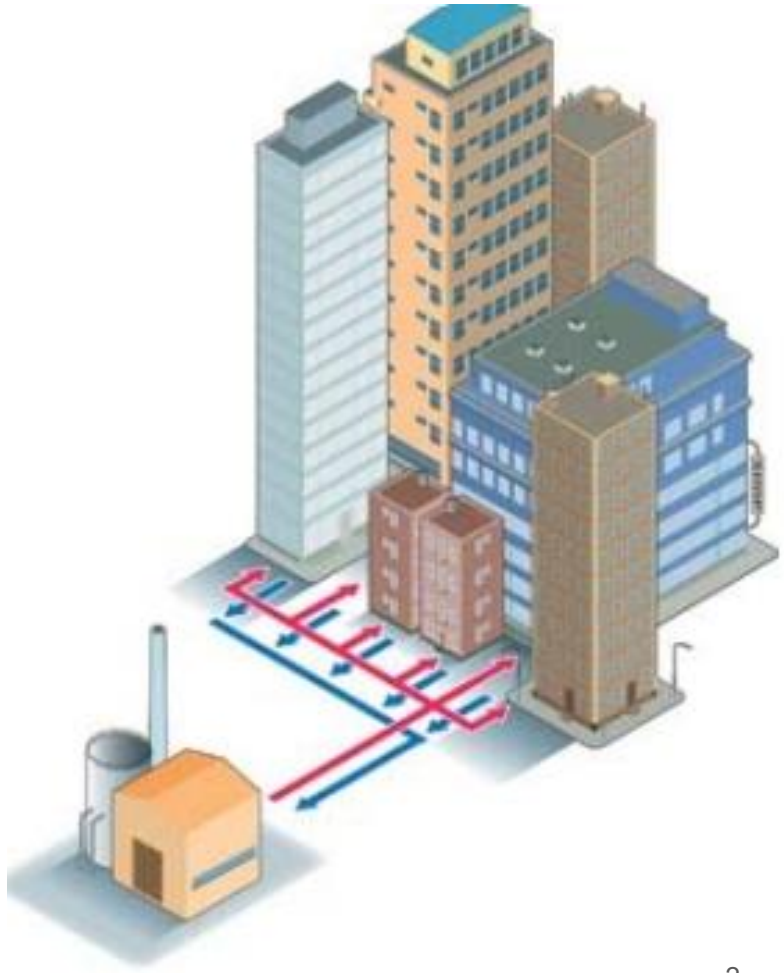
Sharing Knowledge on Energy Communities



ADVANTAGES OF DISTRICT HEATING

- Advantages:
  - *Economic, cheaper, low service cost*
  - *large use of renewable energy sources and waste heat.*
- Disadvantages:
  - *Energy loss in pipes*
  - *Big infrastructure*
  - *Problem on heat production affects entire district.*



Source: decentralized-energy.com

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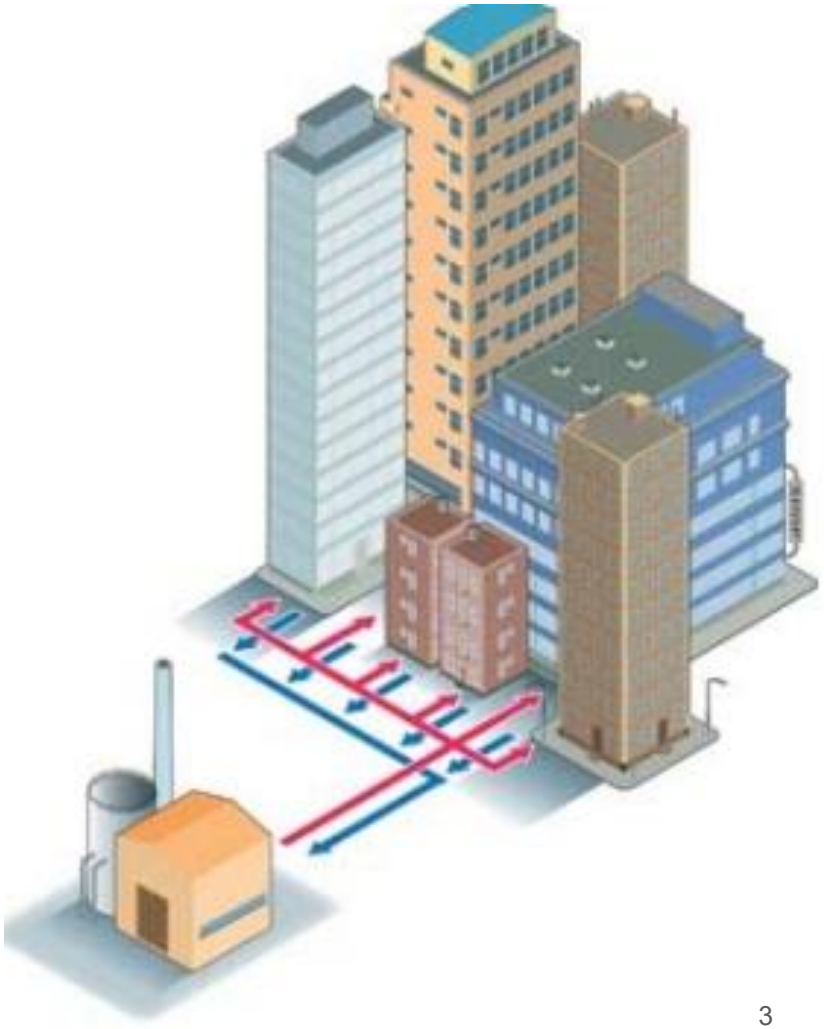
ADVANTAGES OF DISTRICT HEATING

- Heat is produced in the distance, far from the place of utilisation.
- The heat reaches the consumers through a district heating line.
- Heat production site:
  - Heating plant
  - CHP plant (combined heat and power plant)
  - Renewable energy sources (solar thermal, geothermal, etc.)
  - Waste heat utilisation
- Energy communities
- Better maintenance of facilities
- More precise power control can be implemented in the heating plant than in the case of heat generators installed at consumers.



Source: decentralized-energy.com

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ADVANTAGES OF DISTRICT HEATING

- Air quality of densely populated areas can be relieved from combustion products.
- The chimney of the North-Buda Power Plant is with 203 m the highest building of Budapest.

Source: http://m.cdn.blog.hu/

Centralised Heat Production and Control

- More precise performance control and maintenance can be implemented in the heating plant than in the case of heat generators installed at consumers.

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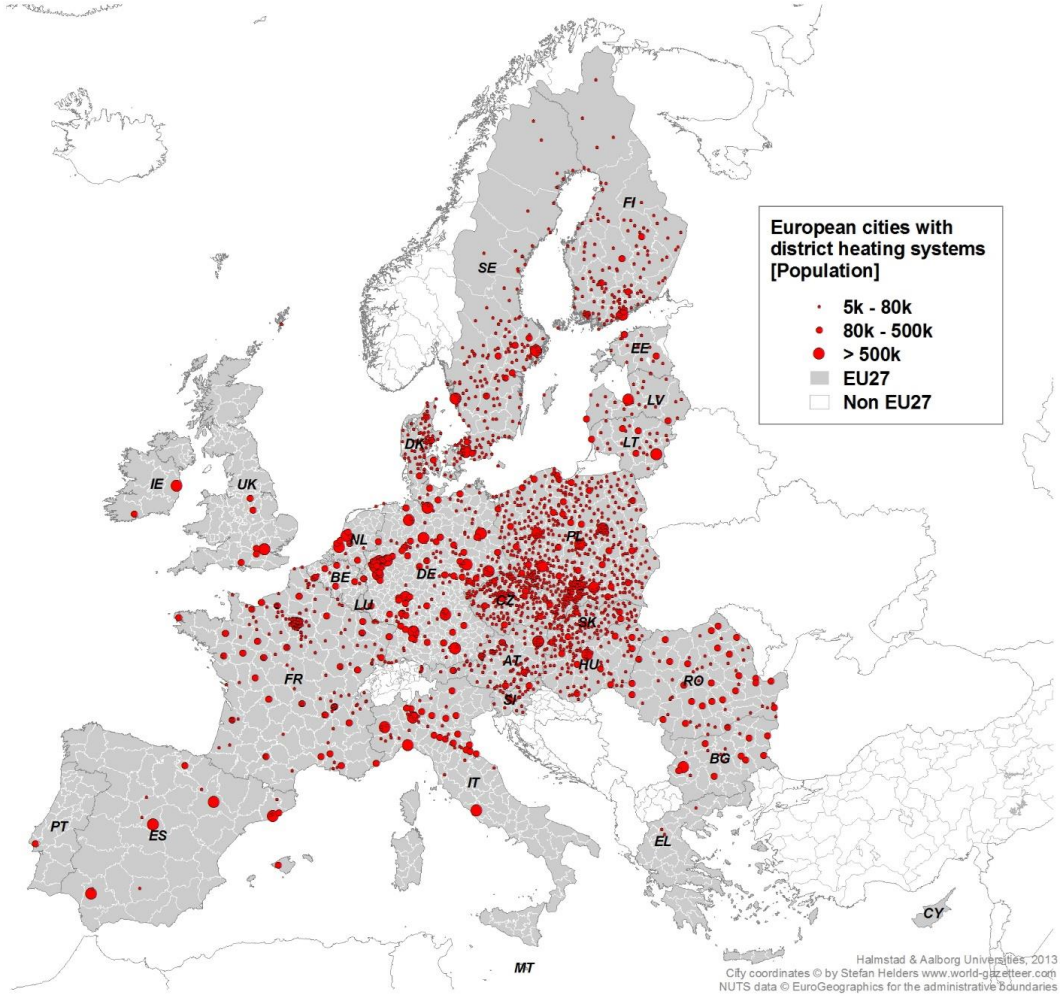
Source: vacholding.hu, wikimapia.org

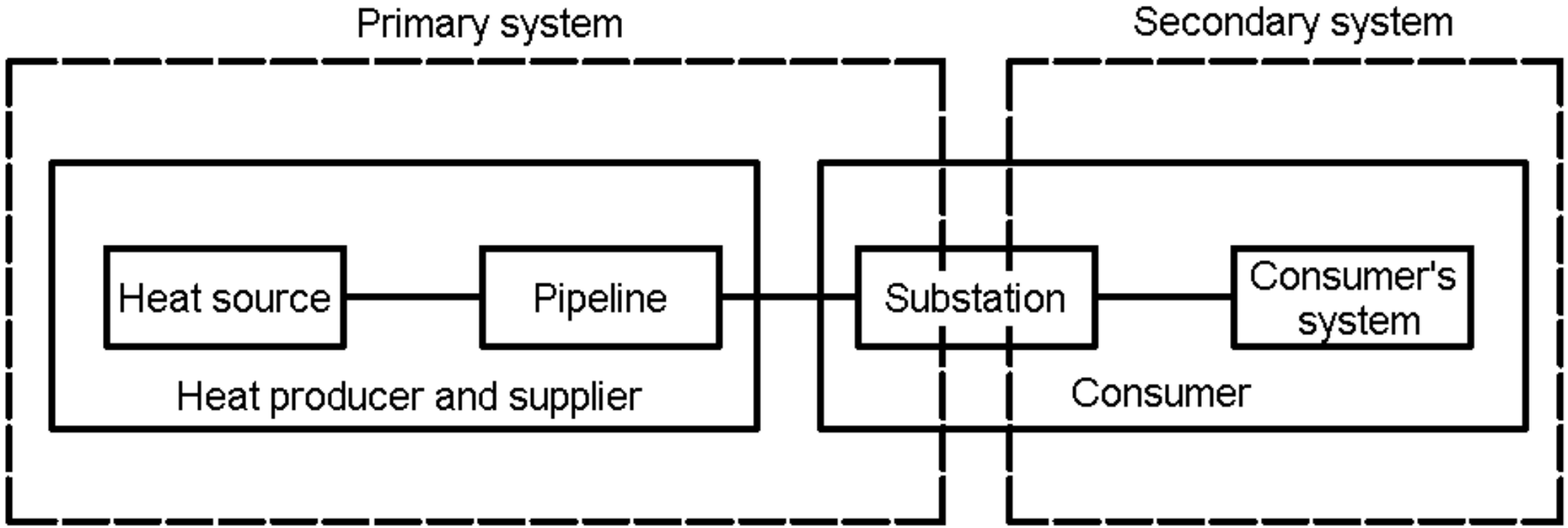
DISTRICT HEATING IN EUROPE

- Northern-Europe, Scandinavia
  - Widespread, long tradition of DH technology
- Western-Europe
  - Cities and larger towns, and DH technology is currently booming.
- Eastern-Europe
  - DH was prioritised in during socialist era, but misused for the heating of housing estates.



Source: Halmstad and Aalborg Universities, 2014, Halmstad University District Heating and Cooling Database, NUTS data, Euro Geographics for administrative boundaries

DISTRICT HEATING SUBSYSTEMS



- Heat production
- Heat division
- Heat transfer
- Heat consumption

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Source: Dr. Szánthó Zoltán: Heat Transport (Hőszállítás) - lecture slides. Budapest University of Technology and Economics

1ST GENERATION: STEAM DISTRIBUTION

- Flow: steam
- Return: condensate

Source: http://sfz-bellows.com

1ST GENERATION: STEAM DISTRIBUTION

- Birdsill Holly (1820-1894) american mechanical engineer
- Heat supply has to be equally available to the public as water, gas and electricity supply.
- In winter 1878/79 builds a prototype district heating system on his facility, supplying the neighbouring estated with steam.
- Later establishes district heating systems in several U.S. cities.

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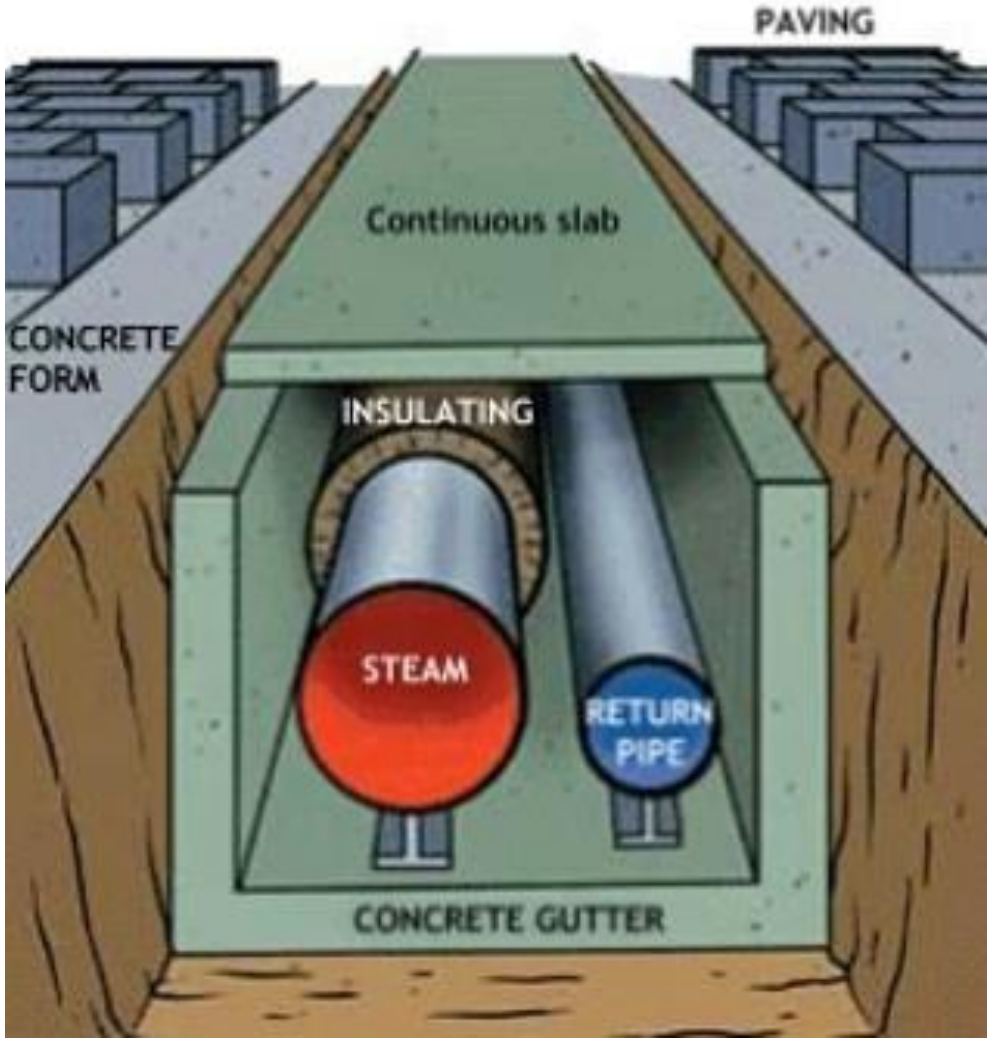
Source: https://www.invent.org/inductees/birdsill-holly-jr

1ST GENERATION: STEAM DISTRIBUTION

- It was introduced in the United States in the 1880s.
- The primary reason for its development is to reduce boiler accidents in residential buildings.
- Steam condenses during heat dissipation.
- In many cases, the condensate has leaked due to corrosion.



Source: https://sti.eduscol.education.fr/concours_examens/epreuve-e2-bac-pro-tisec-septembre-2012

1ST GENERATION: STEAM DISTRIBUTION

- A steam pipeline is still in use in Manhattan.
- In 2020, steam district heating systems are considered to be highly obsolete.
- They have been reconstructed in Salzburg, Hamburg, Munich and Copenhagen.
- In many cases, the steam pipeline network has proven to be dangerous. Explosions, pedestrian injuries, death cases.

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https://www.fanpage.it/esteri/paura-a-new-york-esplosione-in-strada-colonna-di-fumo-altissima-edifici-evacuati/

2ND GENERATION: HOT WATER DISTRIBUTION

- Hot water is a heat transfer medium with a temperature above 100 °C.
- It appeared in 1930 and dominated installations until 1970.
- Typically, a pair of pipelines conducted in a concrete gutter.
- Used primarily in the Soviet Union.
- In many cases, poor performance control was typical.
- High on-site labour requirements during installation.

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Source: https://minap.hu/miskolc/2019/08/02/tavhovezetek-csere-az-arpad-uton

2ND GENERATION: HOT WATER DISTRIBUTION

- Overground pipelines in Hungary

- U-bends compensate thermal expansion in the pipeline.

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Source: moksha.hu, de.wikipedia.org

2ND GENERATION: HOT WATER DISTRIBUTION

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Source: https://www.quora.com/What-type-of-home-heating-systems-did-they-use-in-the-Soviet-Union

2ND GENERATION: HOT WATER DISTRIBUTION

- DH substation
- Location of heat transfer between the primary (city) and secondary (building) heating circuits.
- Tubular heat exchangers.
- High demand for on-site installation.
- Non-prefabricated elements.
- Significant space requirements.

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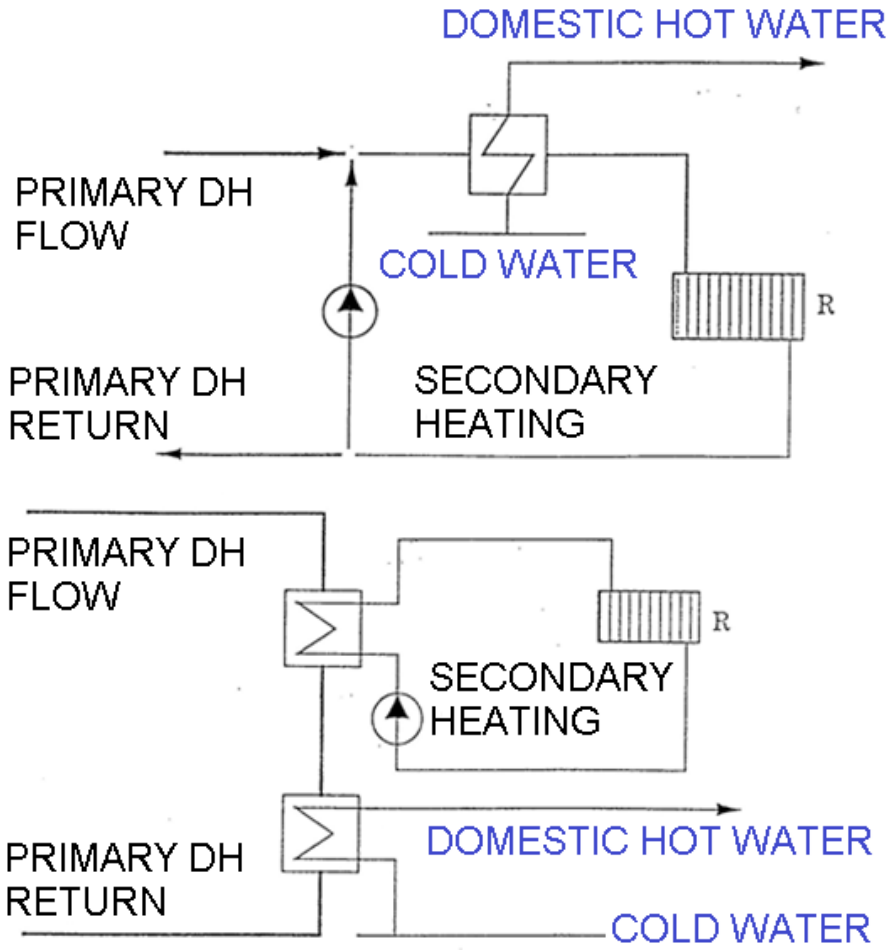
Source: Mohács város távhő rendszerének energetikai korszerűsítése

DISTRICT HEATING SUBSTATIONS

- **Hydraulic connection to the primary district heating network**
  - Direct: the district heating network and the heating system of the building form a hydraulically common system.
  - Indirect: the secondary heating (consumer) system of the building is separated from the primary district heating network by a heat exchanger.



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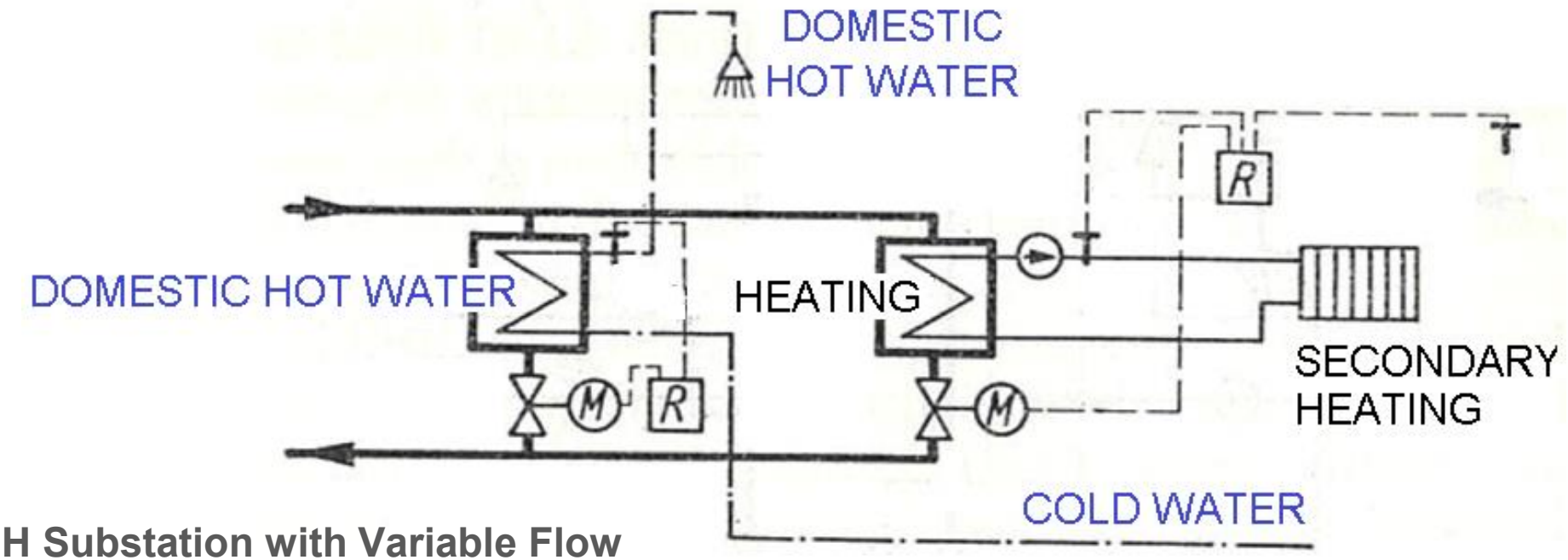
Source: Dr. Kiss Róbert szerk.: Távhőellátási zsebkönyv. Műszaki Könyvkiadó, Budapest, 1977

DISTRICT HEATING SUBSTATIONS



- **Indirect DH Substation with Variable Flow**
- Motoric valves help regulate the flow between DHW and heating heat exchanger.
- Motoric valves open and close based on measured temperatures in DHW, heating flow and outdoor.
- Usually DHW requires higher temperature than heating, therefore the first order in receiving hot water.

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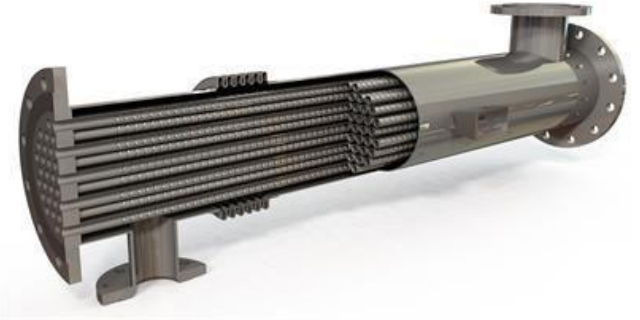
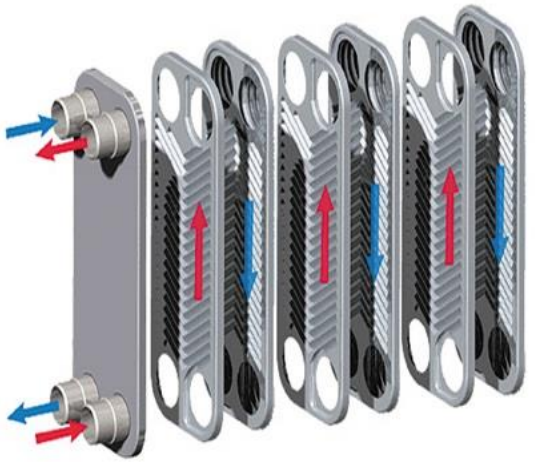
Source: Dr. Kiss Róbert szerk.: Távhőellátási zsebkönyv. Műszaki Könyvkiadó, Budapest, 1977

2ND GENERATION: HOT WATER DISTRIBUTION



- Tube bundle heat exchanger in a Budapest DH substation
- Plate heat exchangers



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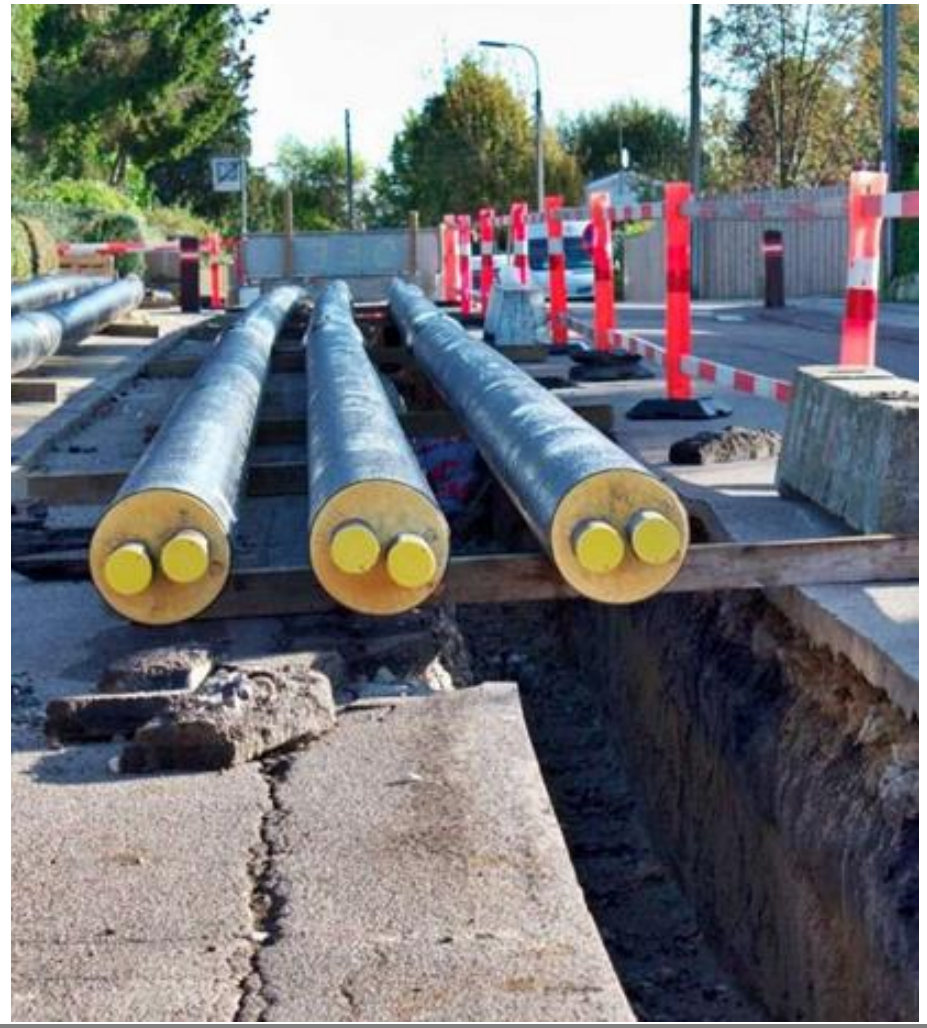
Source: Wikipédia, Hőközpont cikk, szerző: Intercity (IC), https://www.hullokft.hu/my-portfolio/hocserelo-javitas/

3RD GENERATION: WARM WATER DISTRIBUTION

- Water heat transfer medium with a temperature below 100 ° C.
- Prefabricated components, pre-insulated piping.
- Pipeline laid directly into the ground.
- Technology used for the renovation of old systems in the former Soviet Union and Eastern Europe.
- In some cases, the use of renewable heat producers (solar collectors, geothermal energy)



Source: http://www.magyarepitok.hu

3RD GENERATION: WARM WATER DISTRIBUTION

- Technology used for the renovation of old systems in the former Soviet Union and Eastern Europe.

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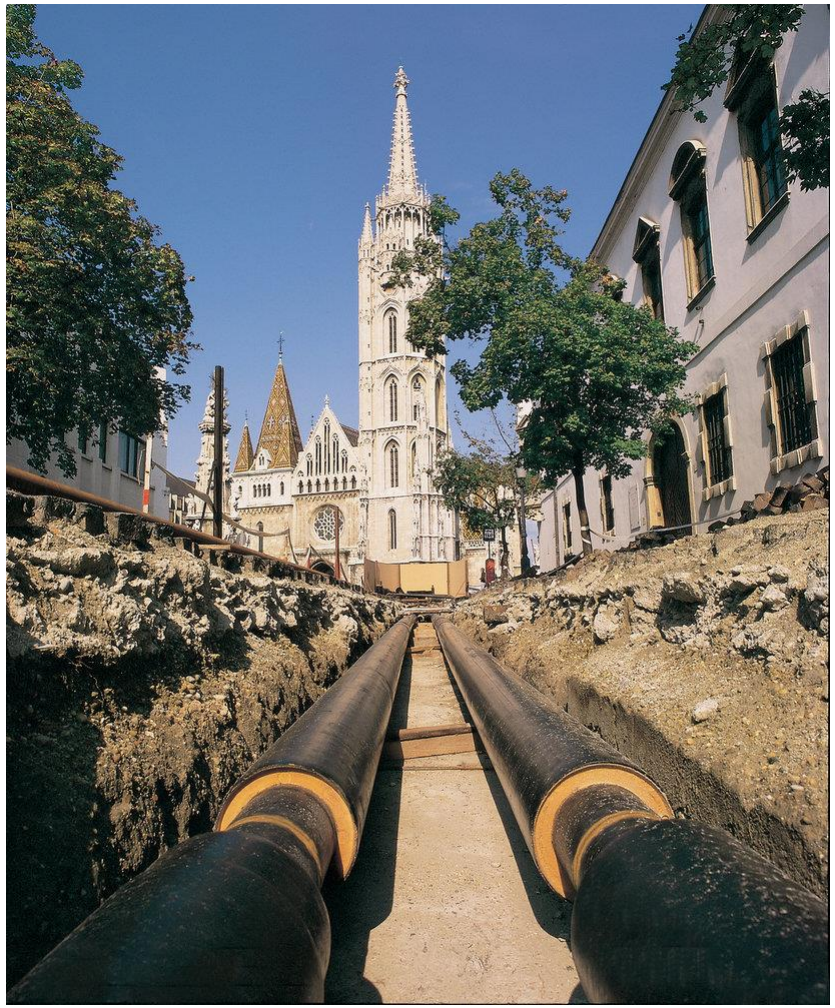
Source: https://minap.hu/miskolc/2019/08/02/tavhovezetek-csere-az-arpad-uton , petkomkft.hu

3RD GENERATION: WARM WATER DISTRIBUTION



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Source: https://cdn.portfolio.hu/files/r/res-2013-6-web.pdf, Jánya Gergely, Budapest régi képeken.

3RD GENERATION: WARM WATER DISTRIBUTION

- Prefabricated, compact, modular substations.
- Plate heat exchangers.
- Significantly less space required
- **Development direction of district heating generations:**
- Lower heat transfer temperature
- Prefabrication reduces labor requirements during installation.
- Better quality, more flexible use of materials.
- Reducing losses, increasing efficiency

Source: http://www.fotav.hu

RENEWABLE ENERGY IN DISTRICT HEATING

- Iceland geothermal power plant and district heating systems
- After circulating through a building, excess low-quality geothermal heat may be used for pavement heating in order to melt snow and ice.

Source: https://en.wikipedia.org/wiki/File:NesjavellirPowerPlant_edit2.jpg

WASTE INCINERATION IN VIENNA, SPITTELAU

- Heat supply for 60,000 homes
- Electricity supply for 50,000 homes
- **Annual performance**
- 250,000 tons of waste
- 120,000 MWh of electricity
- 500,000 MWh of heat
- 6000 t recyclable metal
- 60,000 tons of ash, soot and filter charge

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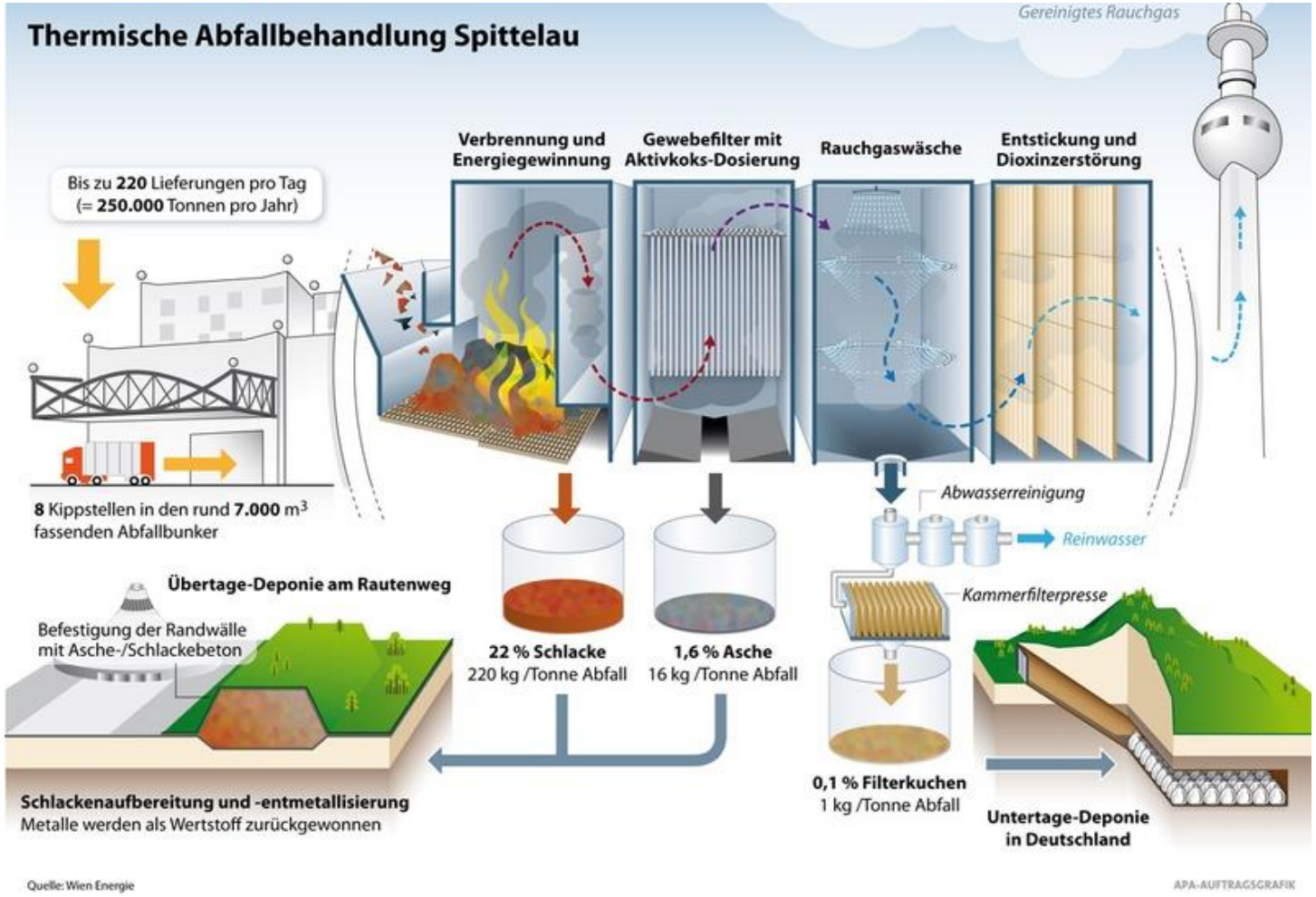
Source: https://24.hu/kultura/2017/06/27/a-napoleoni-haborukra-emlekeztet-a-vilag-legfurabb-betongyara/

WASTE INCINERATION IN VIENNA, SPITTELAU

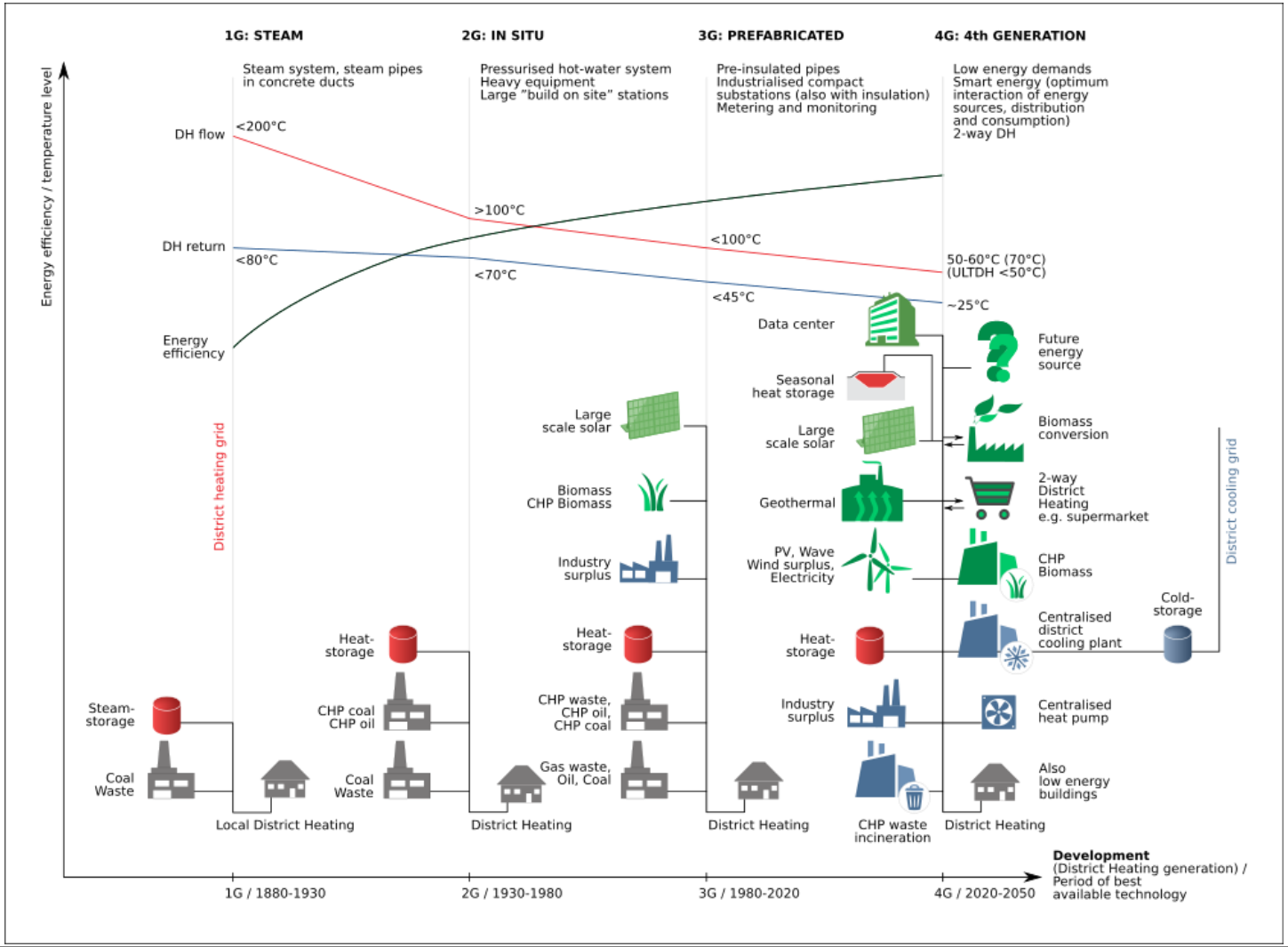


Source: Wien Energie

”HUHA” WASTE RECLAMATION PLANT IN BUDAPEST

- <u>Yearly capacity:</u>
- 400,000 tons of rubbish incineration
- 170,000 MWh electricity produced
- 139,000 MWh heat produced
- The cheapest heat source in Budapest with ¼ of the price of purchased heat

Source: https://www.bvh.budapest.hu/kozos-fejlesztesekkel-az-fkf-zrt-vel-az-olcsobb-tavhoert



Source: https://commons.wikimedia.org/wiki/File:Generations_of_district_heating_systems_EN.svg

SOURCES AND TECHNOLOGIES FOR HEAT GENERATION IN DISTRICT HEATING

Heat source	Technology	Energy conversion principle
Fossil fuels (coal, oil, gas)	Boilers Cogeneration	Chemical energy to thermal energy

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Basic idea of activity: Prof. Dr.-Ing. Stefan Holler, HAWK, DHC+ Summer School in Paris 2019

4TH GENERATION: WASTE HEAT REUSE, ENERGY COMMUNITIES

- Birdsill Holly (1820-1894) american mechanical engineer
- Heat supply has to be equally available to the public as water, gas and electricity supply.
- **Let's compare it with the electricity supply system of today.**

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Source: https://www.invent.org/inductees/birdsill-holly-jr

4TH GENERATION: LOW TEMPERATURE NETWORK, RENEWABLE ENERGY USE

- Construction of a low temperature primary network
- The energy demand of buildings is constantly decreasing
- They can also be equipped with low temperature heating systems
- Low distribution losses
- Densely populated settlements have advantages, shorter distribution network, lower losses
- Utilisation of local waste heat and use of locally produced (renewable) heat
- Operation as part of an intelligent power distribution system

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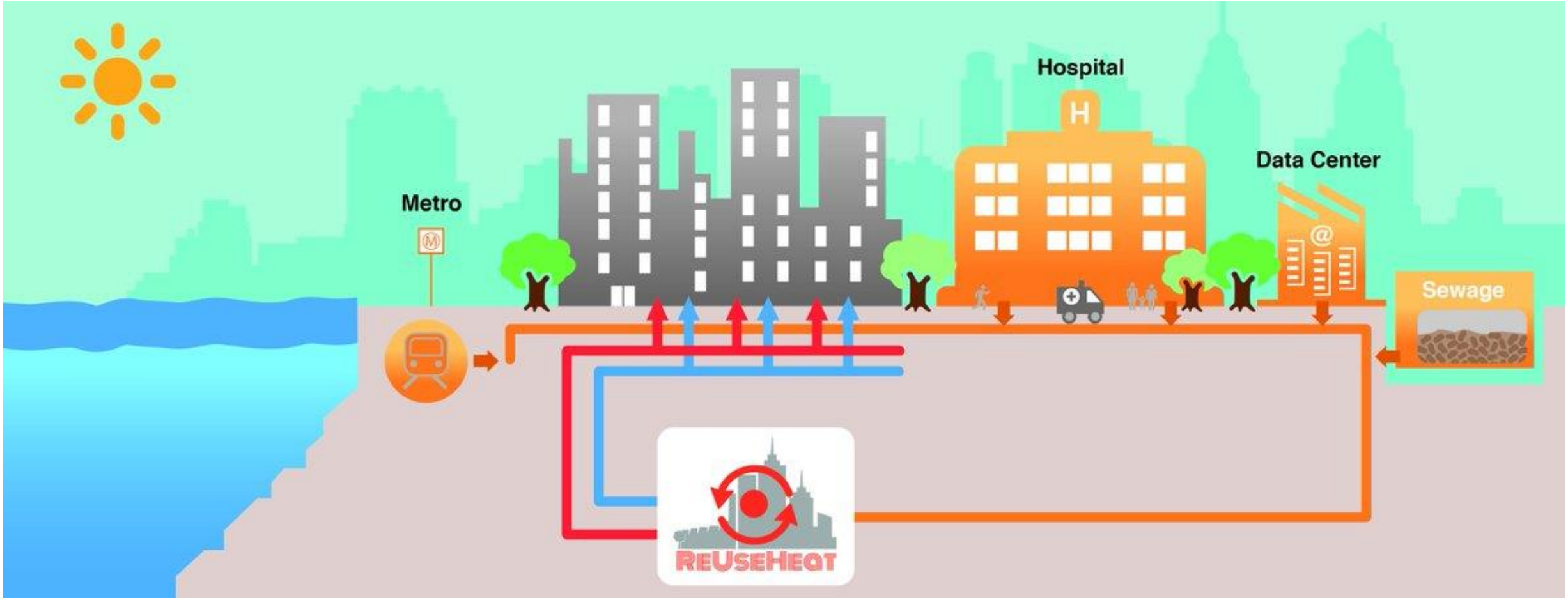
Energy Communities In District Heating

Waste Heat Utilization



Source: www.reuseheat.eu

Energy Communities In District Heating

Utilization of Waste Heat from Data Centers

- Electricity consumption worldwide in 2010: 350 TWh
- This represents >1% of the world's electricity consumption in 2010
- Cooling is necessary for the safe operation of equipment
- Medium-sized data center:
- 1 MW IT capacity
- Heat emission: 3700 MWh/year with cooling
- 0.46 MWh_{th} waste heat for every 1 MW_{el} electricity consumption

Source: www.reuseheat.eu

Energy Communities In District Heating

Utilization of Waste Heat from Data Centers

- Electric Energy Consumption Of Data Centers In Europe:
  - 2007: 56 TWh/year
  - 2020: Expected to reach 104 TWh/year
- Growing Trends: Streaming, IoT
- Cooling accounts for 40% of the total energy consumption of data centers.
- Performance of Data Centers:
  - 5 MW IT performance (in some locations in Europe)
  - 500 kW – 5 MW (many centers)
  - Below 500 kW (most centers)

Source: www.reuseheat.eu, https://www.constructionglobal.com/cloud-computing/apple-construct-second-data-centre-china

Energy Communities In District Heating

Utilization of Waste Heat from Subway Tunnels

- **Heat source**
- When braking trainsets
- Ventilation of subway cars
- **Worldwide**
- In 148 cities
- 11000 km line
- 151 million passengers/day
- **In the European Union**
- 50 medium and large cities
- 2800 km of lines
- 31 million passengers/day
- 6.7-11.2 TWh/a waste heat
- **Average 1 km between two stations**
- **In a densely populated area**

Source: www.reuseheat.eu

Energy Communities In District Heating

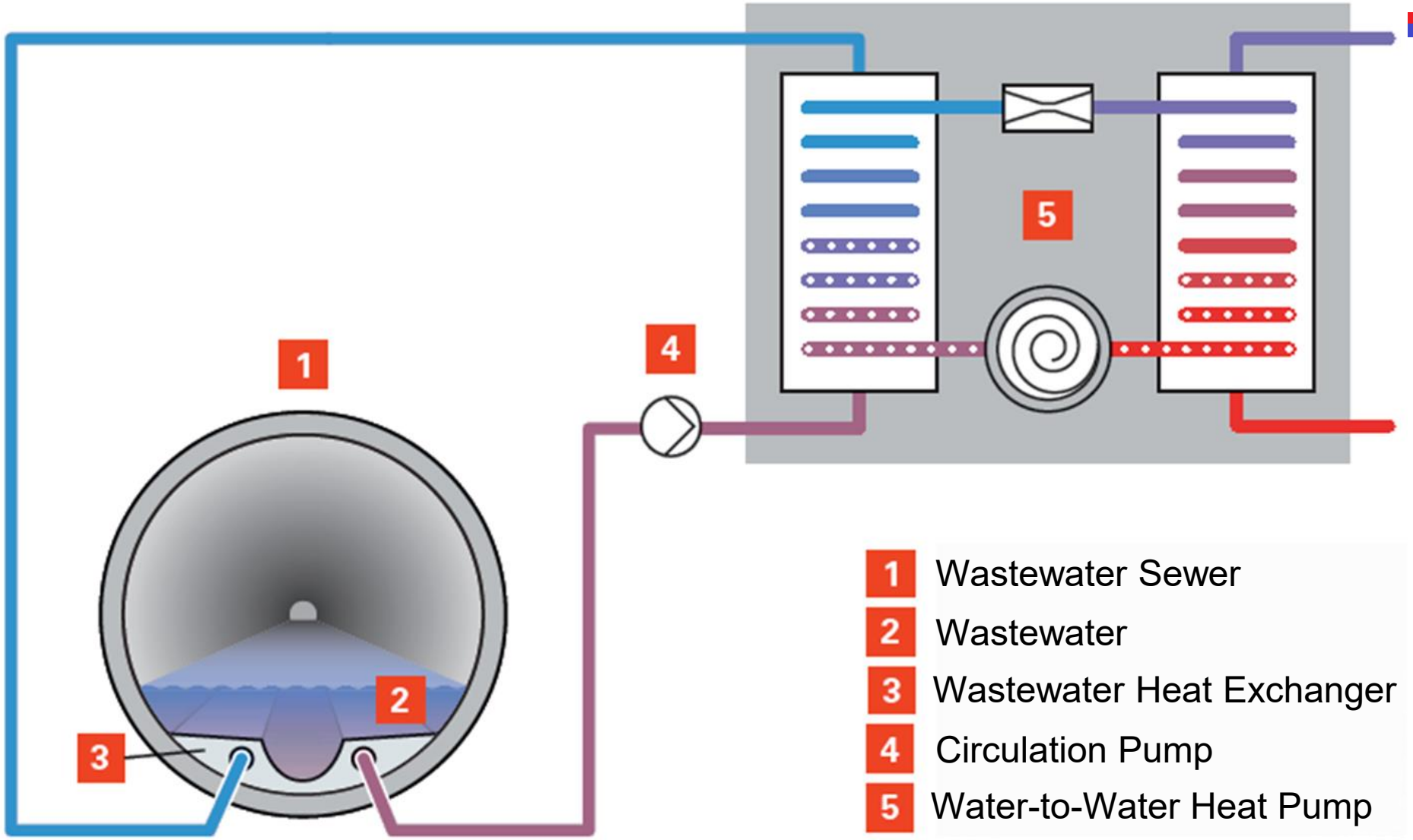
Utilization of Waste Heat from Sewer Networks Using Heat Pumps

- Heat source
  - Annual average 10-15 °C
  - In summer, it reaches 20 °C
- Application of heat pump technology:
  - In cities with more than 10,000 inhabitants
  - can cover 5% of total heat demand
  - 150 TWh/a
- In Germany
  - could supply 20% of the building stock
- Completed projects:
  - Cologne
  - Nice

Source: www.reuseheat.eu

Energy Communities In District Heating

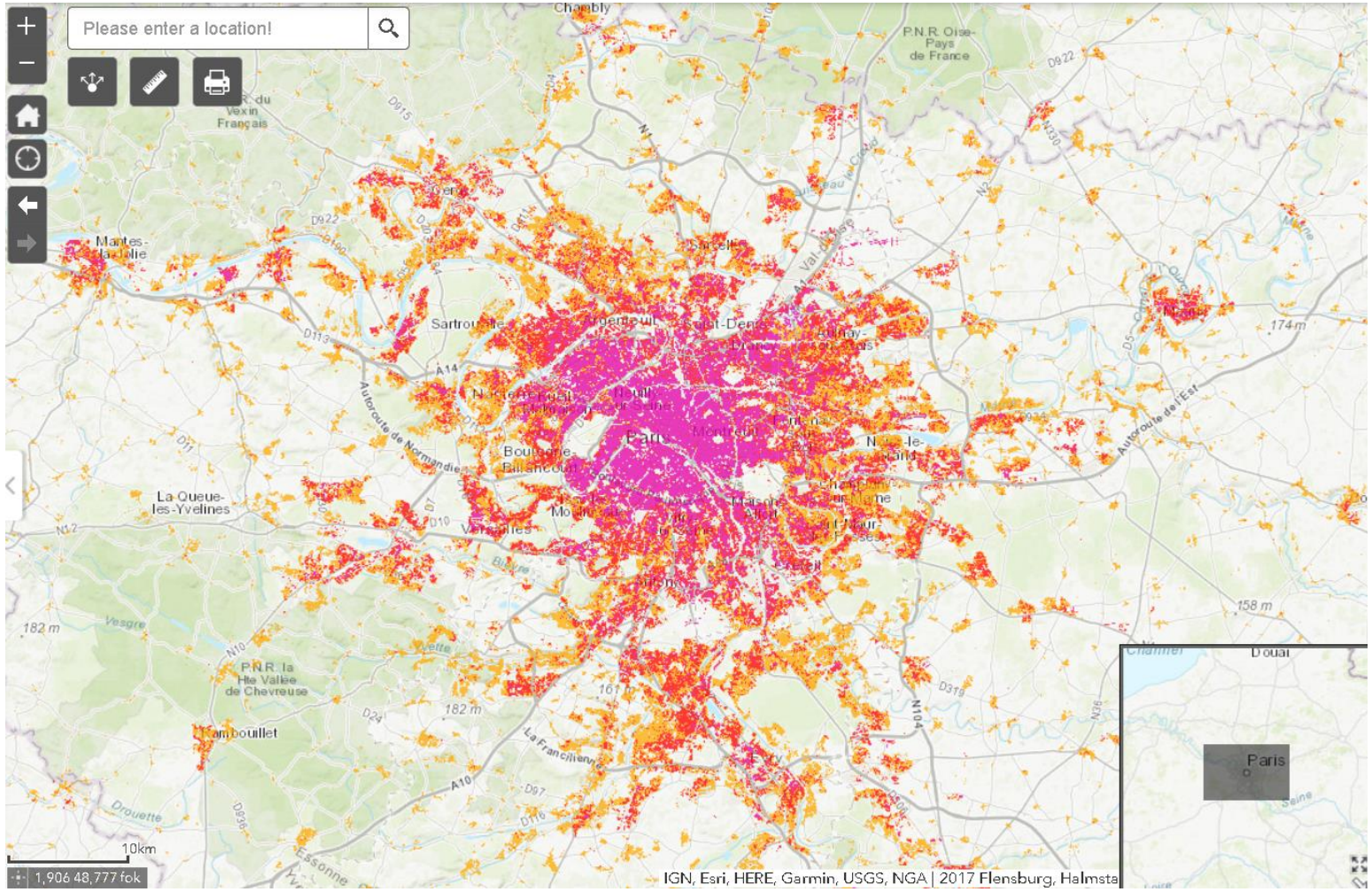
Utilization of Waste Heat from Sewer Networks Using Heat Pumps



1 Wastewater Sewer
2 Wastewater
3 Wastewater Heat Exchanger
4 Circulation Pump
5 Water-to-Water Heat Pump

Source: www.reuseheat.eu

5TH GENERATION: WASTE HEAT REUSE

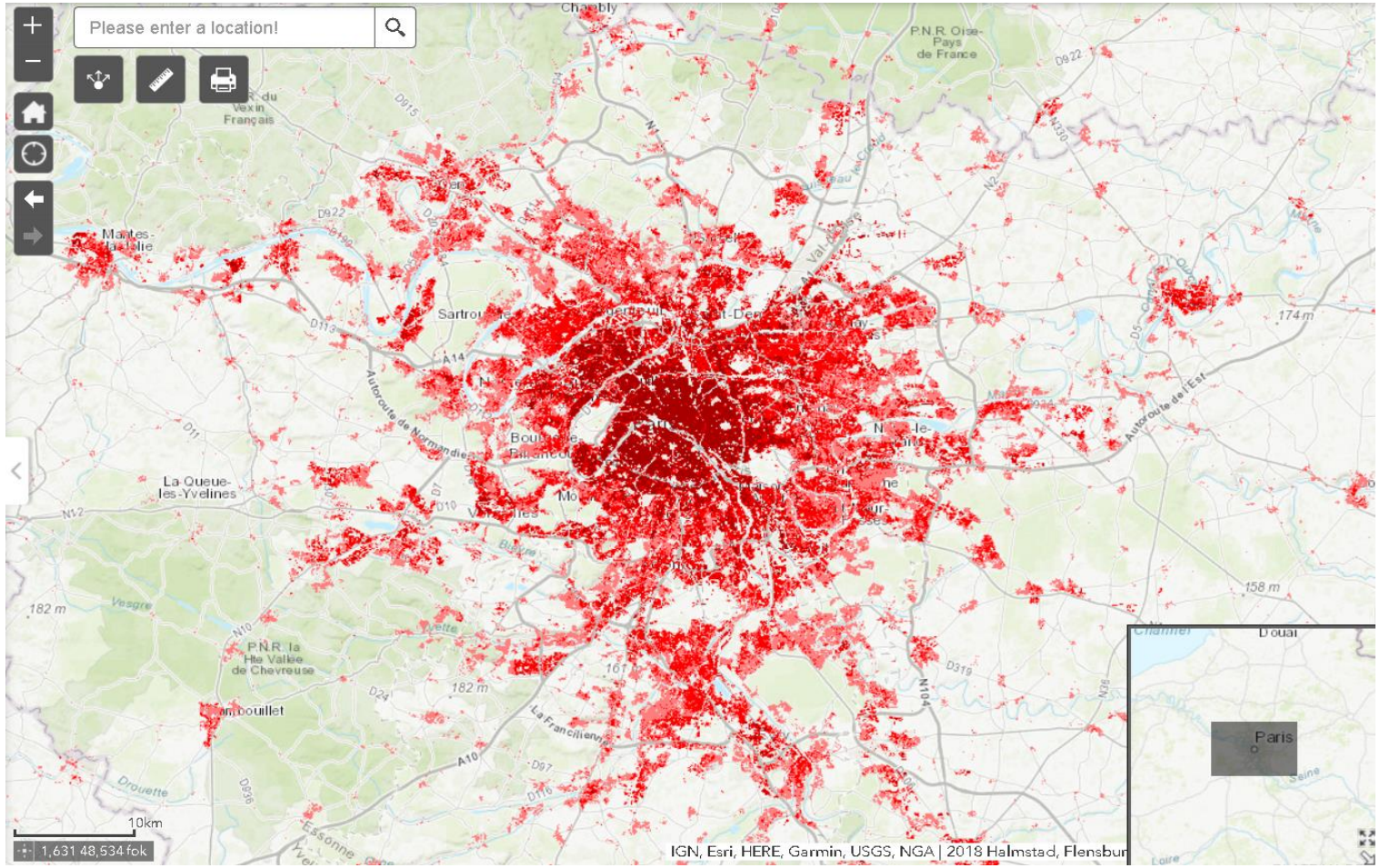


- Heating demand densities in Paris

Heat Roadmap Europe

Source: https://heatroadmap.eu/

5TH GENERATION: WASTE HEAT REUSE



- Cost of one unit of heating energy supplied by a waste-heat based district heating network.

Heat Roadmap Europe

Source: https://heatroadmap.eu/

5TH GENERATION: ENERGY COMMUNITIES WITH WASTE HEAT REUSE

- Campus buildings with a new district heating system.
- Instantaneous heating and cooling demand in buildings.
- Waste heat of cooled buildings is utilised as heat for heated ones.
- Circular pipeline serves as energy community basis.

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https://www.chooseparisregion.org/news/combine-environmental-excellence-rd-design-sustainable-city

THE FIRST DISTRICT HEATING SYSTEM IN HUNGARY

- The House of Parliament in Budapest
- Imre Steindl, architect of the building did not want to spoil the architecture with a chimney.
- Boiler house set up in the neighbouring residential building.
- There the chimney disturbs no-one.
- DH pipeline below the square.
- Building completed in 1896.

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Source: szatmar.ro

Thank you!

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

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