Module 6 – REFURBISHMENT OF DISTRICT HEATING SYSTEMS

SHaKE – Sharing Heat and Knowledge on Energy Communities
Erasmus+ KA220-HED Cooperation Partnerships in Higher Education
Developing institution: BME
Author: Dr. Balázs Bokor
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SHaKE
Sharing Knowledge on Energy Communities

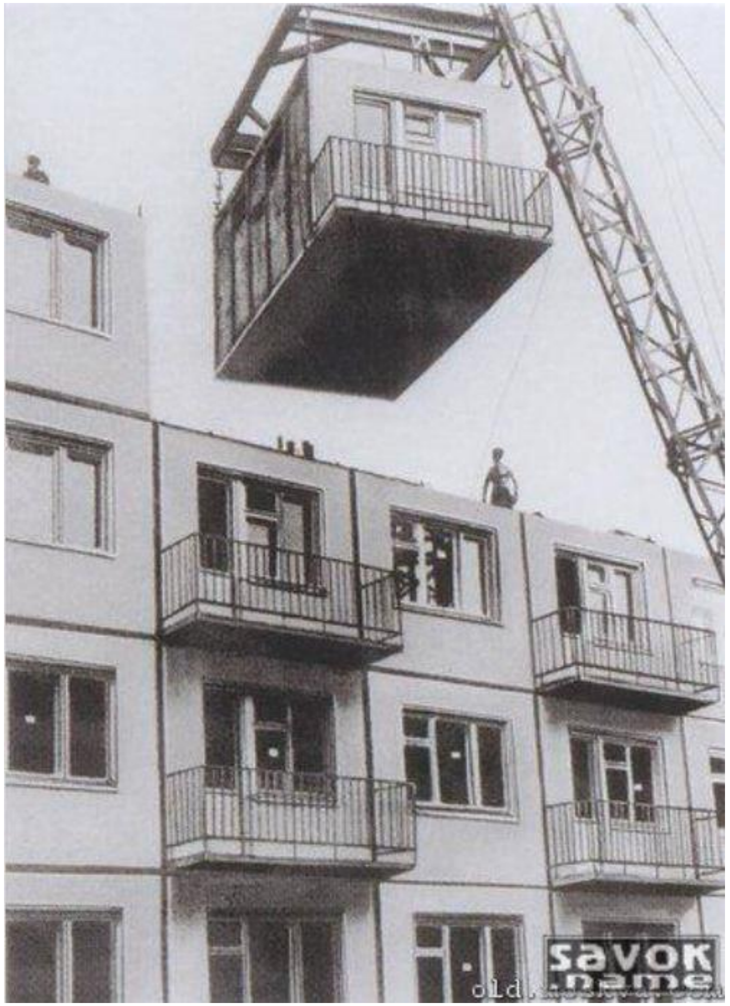
THE ROLE OF DISTRICT HEATING SYSTEMS

- District heating is meant to be an urban energy concept.
- It minimises emissions in the densely populated areas of cities.
- It can provide more efficient system control due to large scale.
- In some countries it was used for heat supply for housing estates.
- More efficient system control and maintenance
- It facilitates the integration of renewable energies such as geothermal that would be difficult at individual scale

Source: https://dunaujvarosmesel.hu/2023/02/03/vakolokanal-helyett-toronydaru/

HISTORICAL CONTEXT IN EASTERN EUROPE

- Several systems were installed in the age of very cheap energy.
- Efficiency did not play a significant role in the design process.
- Low-efficiency systems have been around for decades.
- Renovation is necessary in many cases. Conscious design is required, as large-scale renovations are carried out rarely.
- Hungary: Single-pipe heating was compulsory for dwellings built with insulated technologies.



https://dunaujvarosmesel.hu/2023/02/03/vakolokanal-helyett-toronydaru/

BACKGROUND: HIGH-TEMPERATURE SYSTEMS

Characteristics:

- **Supply temperatures**: Typically 100–130 °C
- **Return temperatures**: Around 60–70 °C
- **Energy sources**: Mostly fossil fuels (coal, natural gas, oil), large-scale combined heat and power (CHP) plants, and waste incineration
- **Pipe networks**: Large diameter, heavily insulated
- **Designed for**: Buildings with high heating demands and low envelope efficiency

Source: https://www.proidea.hu/termekalkalmazasok-5/oventrop-haromjaratu-szelep-futotestkotes-10582.shtml

BACKGROUND: HIGH-TEMPERATURE SYSTEMS

Challenges:

- **High heat losses** in distribution (especially in aging infrastructure)
- **Limited integration** of low-exergy heat sources (e.g., solar thermal, geothermal, heat pumps)
- **High maintenance costs** and pressure management requirements
- **Unsuitability for modern low-energy buildings**

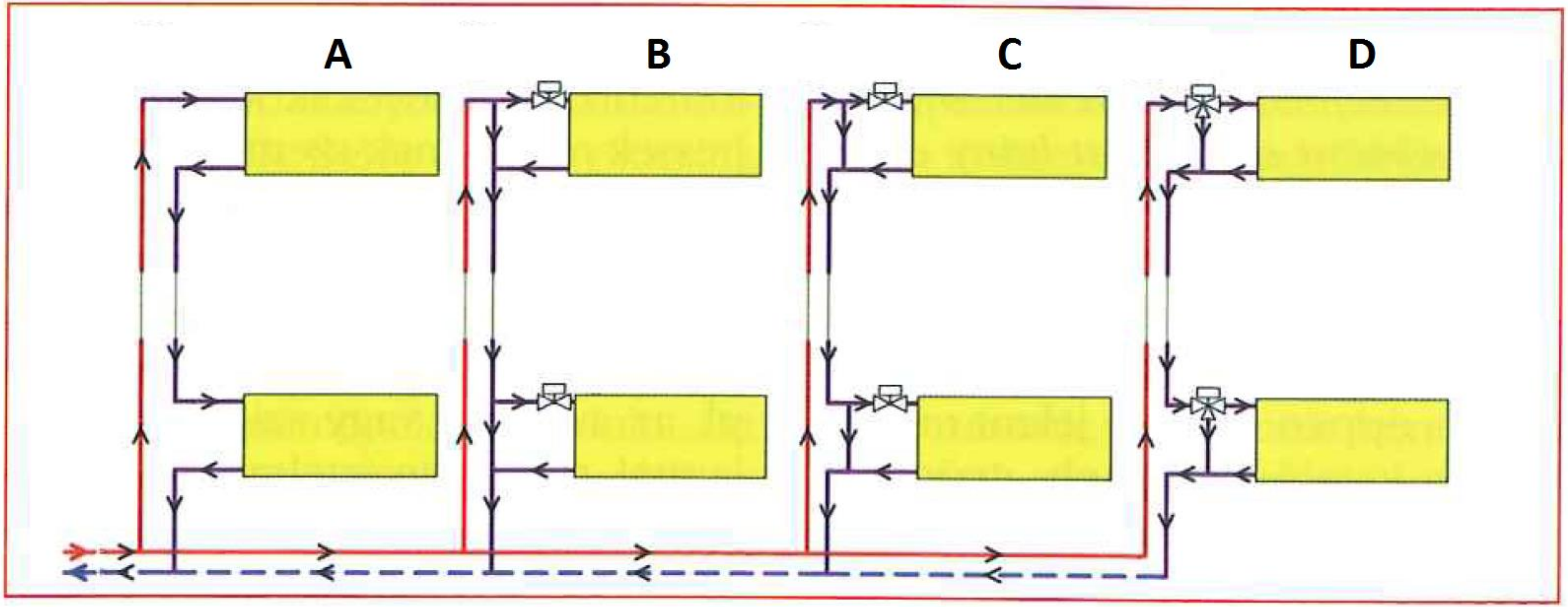
Source: https://www.proidea.hu/termekalkalmazasok-5/oventrop-haromjaratu-szelep-futotestkotes-10582.shtml

ENHANCING ENERGY EFFICIENCY IN SECONDARY DISTRICT HEATING SYSTEMS

- Strategies for improving building-level heating systems.
- Thermal insulation of buildings
- Reducing supply temperatures in secondary heating systems.
- Implementation of motivational tariffs to encourage efficiency.
- Impact on overall DH network performance.

Source: https://www.proidea.hu/termekalkalmazasok-5/oventrop-haromjaratu-szelep-futotestkotes-10582.shtml

SINGLE PIPE SYSTEM REFURBISHMENT



A. Single-pipe, flow-through heating

B. Single-pipe, bypassed radiator

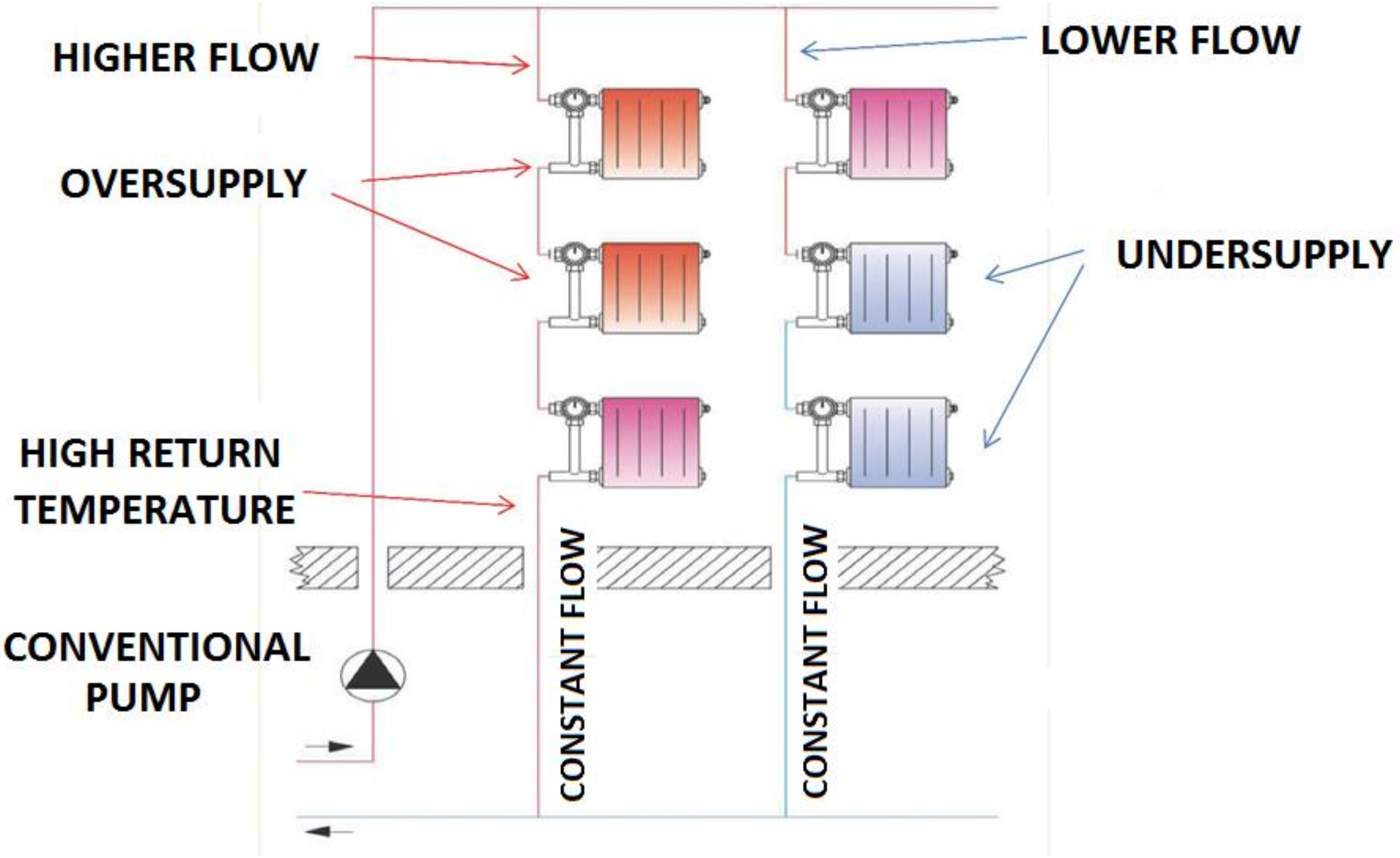
C. Single-pipe, shifted bypass with one-way valve

D. Single-pipe, shifted bypass with three-way valve

Source: Kepka György: Panelkorszerűsítés gyakorlati szemmel II., Magyar Installateur, 2014/10.

SINGLE PIPE SYSTEM REFURBISHMENT

- Hydraulic pressure equalisation of heating strings
- Strings closer to the circulation pump receive a higher mass-flow.
- Higher thermal performance on strings with higher flow.
- Proper use of variable frequency pumps.



Source: https://www.proidea.hu/termekalkalmazasok-5/oventrop-haromjaratu-szelep-futotestkotes-10582.shtml

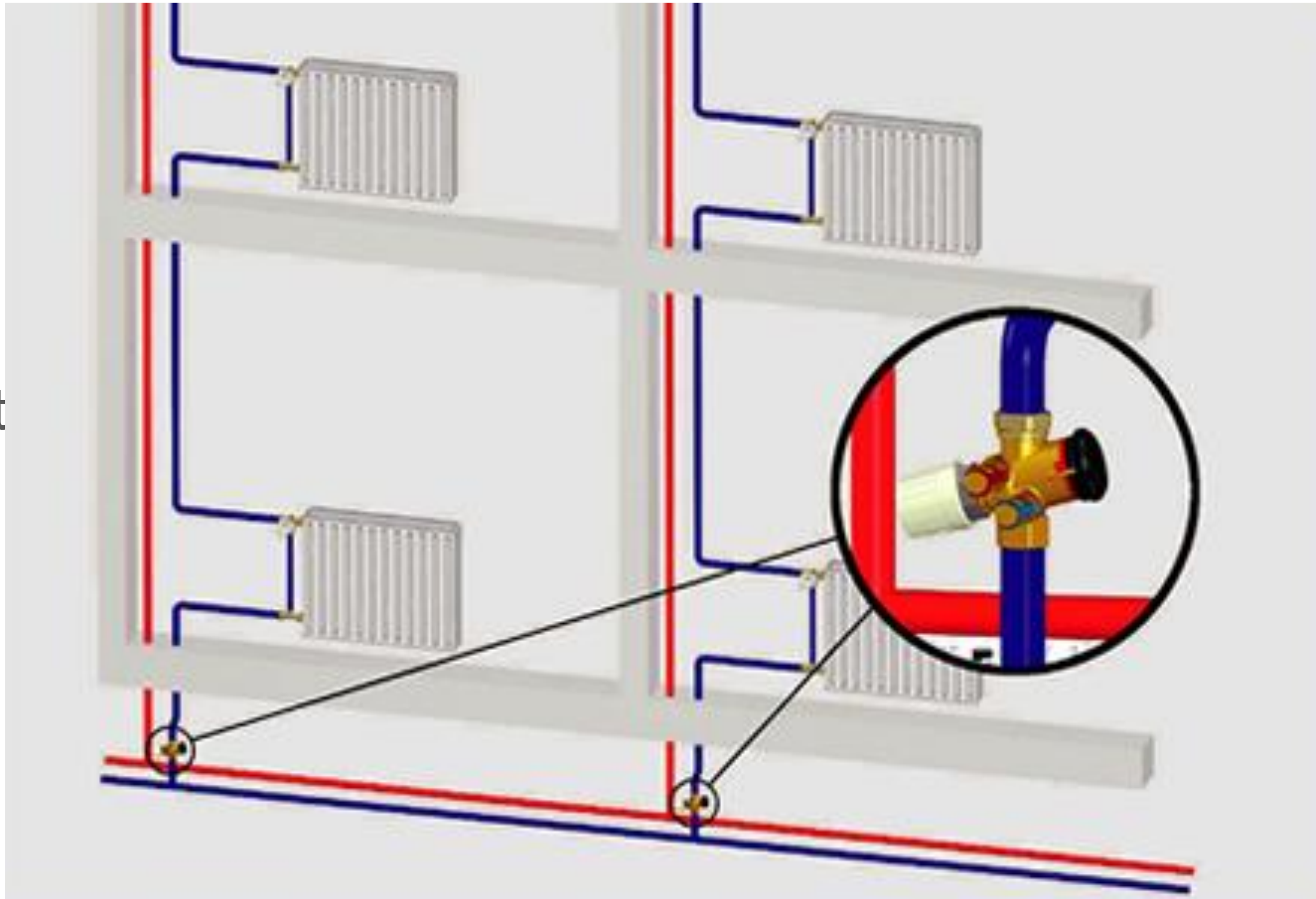
SINGLE PIPE SYSTEM REFURBISHMENT

Solution is the utilisation of balancing valves for each string.

Balancing valves compensate the pressure differences.

Pressure difference measurement opportunity at each valve.

Proper flow can be defined for each string.



Source: https://www.proidea.hu/termekalkalmazasok-5/oventrop-haromjaratu-szelep-futotestkotes-10582.shtml

REFURBISHMENT OF DHC IN HOUSING ESTATES

COMPACT, MODULAR SUBSTATIONS

- In 2nd generation district heating systems substation were installed in situ.
- In 3rd generation DH prefabricated components are used, also for substations.
- Substations are available in various performance levels prefabricated with all necessary elements equipped, sich as:
  - Flat-plate heat exchangers
  - Variable frequency pumps
  - Performance adjustment valves
  - Expansion vessels.

Source: www.szovaterm.hu

REFURBISHMENT OF DHC IN HOUSING ESTATES

Source: www.szovaterm.hu

APARTEMENT SUBSTATIONS

- Heating regulation and DHW production per flat.
- Substation can be installed in a wall recess (150 mm).
- Heat and water consumption metering per flat.
- Differential pressure control at each substation.
- DHW temperature can be adjusted per flat.
- Heating season can be started and stopped individually.
- No DHW circulation circuit required.
- Low risk of legionella contamination due to the lack of DHW storage.

https://designcenter.danfoss.com/products/climate-solutions-for-heating/stations/direct-heating-and-instantaneous-dhw/termix-vmtd-f-b

TRANSITION TO LOW-TEMPERATURE DISTRICT HEATING (LTDH)

Characteristics:

- **Supply temperatures**: 35–70 °C (sometimes as low as 30 °C)
- **Return temperatures**: 20–40 °C
- **Energy sources**: Emphasis on low-exergy and renewable sources (e.g., ambient heat, industrial waste heat, solar, geothermal, heat pumps)
- **Supports**: Energy-efficient buildings and retrofitted building stock

Design Principles:

- **Reduced temperature levels** to minimize thermal losses
- **Smaller pipe diameters** and decentralized network sections
- **Demand-side efficiency** (e.g., improved insulation, efficient radiators)
- **Smart controls and monitoring** to adjust heat delivery

TECHNICAL CONSIDERATIONS IN THE TRANSITION

- **Supply System Modifications**
- Lowering temperatures in existing networks progressively (pilot zones, secondary loops)
- Upgrading generation sources (e.g., adding low-temperature-compatible heat pumps)
- Using **4th or 5th generation** DH concepts

https://www.atamate.com/atamate-news/apartment-innovations-1-fifth-generation-heat-networks

TECHNICAL CONSIDERATIONS IN THE TRANSITION

Building-Level Adaptations

- Ensuring radiators or underfloor heating systems work efficiently at lower inlet temperatures
- Improving thermal envelopes (windows, walls, roofs)
- Installing substation heat exchangers that operate well at lower ΔT
- Domestic hot water (DHW) preparation:
  - Requires booster heaters (e.g., electric or heat pump-based)
  - Avoiding Legionella risk (use point-of-use or pasteurization strategies)

https://www.atamate.com/atamate-news/apartment-innovations-1-fifth-generation-heat-networks

TECHNICAL CONSIDERATIONS IN THE TRANSITION

Control and Optimization

- More precise control strategies due to lower temperature margins
- Real-time demand response integration
- Smart thermostats and weather compensation

Predictive Maintenance and Monitoring of District Heating Networks

- Importance of maintenance for system reliability and efficiency.
- Application of predictive maintenance techniques and technologies.
- Data analytics and sensor integration for fault detection.

INTEGRATION OF ELECTRIC BOILERS IN DHC

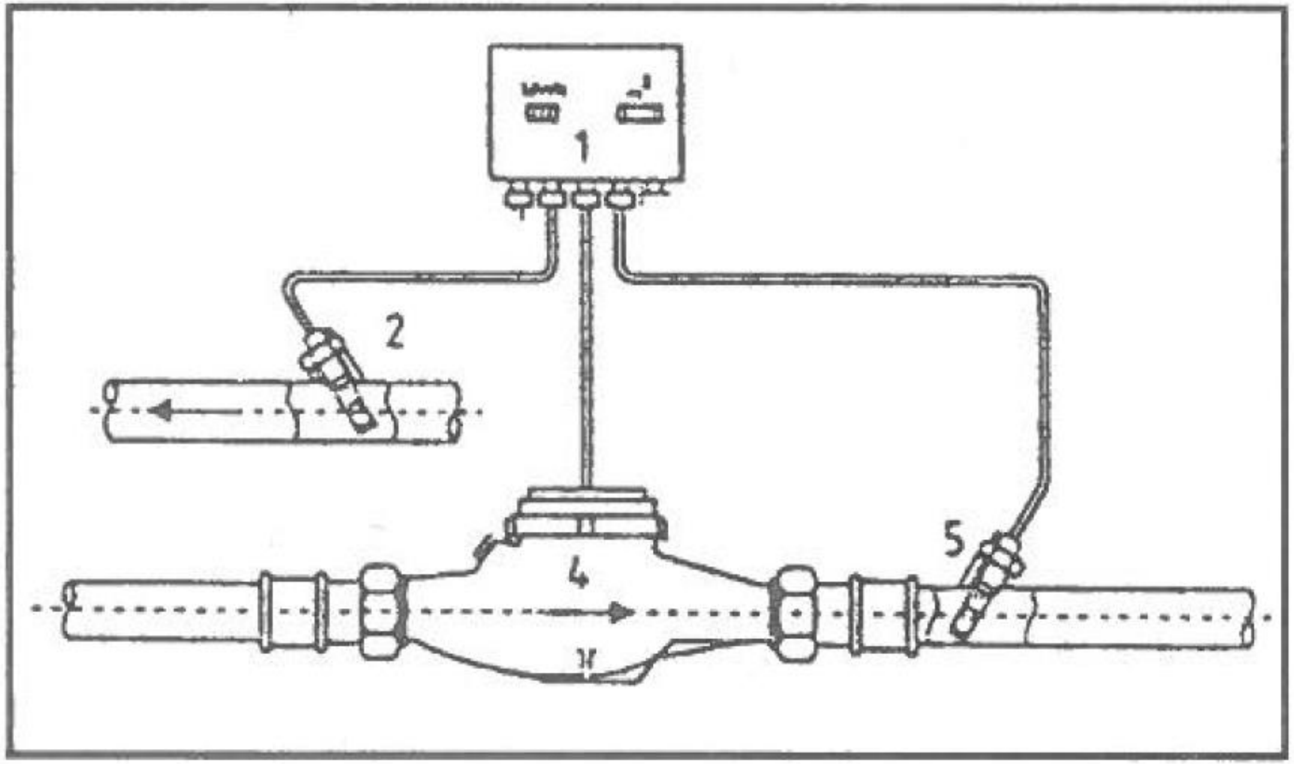
- Electric boilers are installed to provide frequency stablility for electric networks with increasing renewable source proportion.
- District heating systems provide large heat capacity, so they can absorb the heat stochastically provided by the boilers.
- Quick response required from the supplemetary heat providers.
- Real-time adjustment in response to grid frequency changes by electicity network opetator.

Source: Büki Gergely, Metzing József, Orbán Tibor: Településenergetika, távhőellátás, távhűtés. ISBN: 978-968-88358-7-1, https://www.kfw.de/stories/environment/energy-efficiency/aurubis-hamburg/

MEASURING AND BILLING HEAT CONSUMPTION

Heat consumption meters

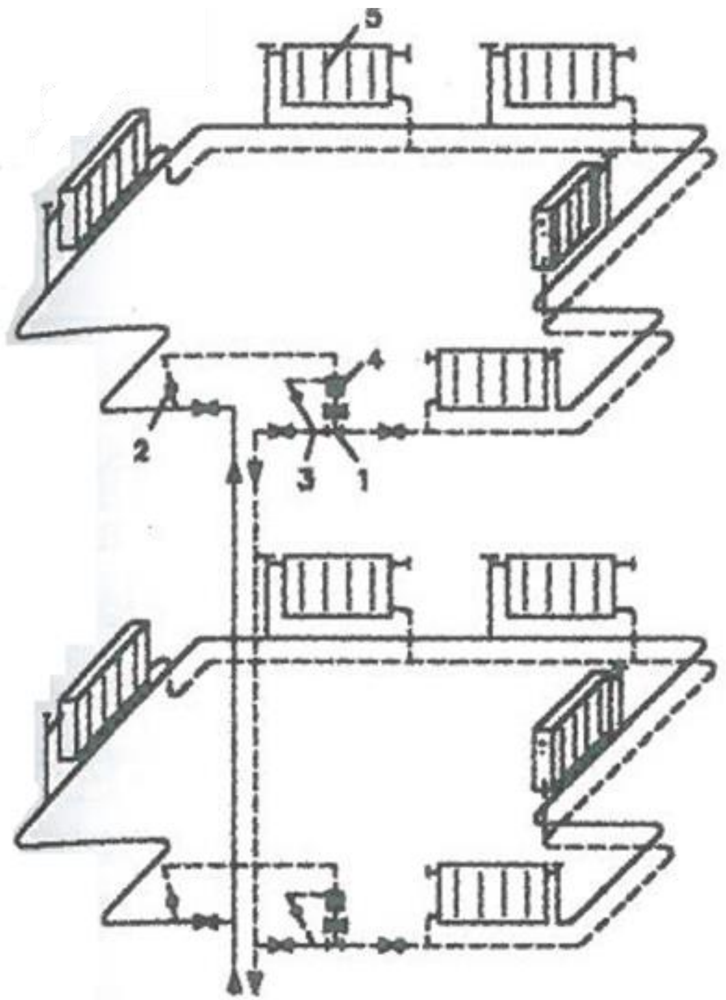
- Processing computer
- Supply thermometer
- Flow sensor
- Return thermometer



- Central heat consumption measurement for buildings
- Division of heating cost among consumers

Source: Forrás: Horváth Gábor: A hőfogyasztásmérés elmélete és gyakorlata. Sontex. Budapest, 2008.

MEASURING AND BILLING HEAT CONSUMPTION



Structuring measured building parts

- Entire building
- Building part
- Per flat (see figure)
- Per consumption site

- Easy realisation for double-pipe systems.
- Impossible for single-pipe systems.

Source: Forrás: Horváth Gábor: A hőfogyasztásmérés elmélete és gyakorlata. Sontex. Budapest, 2008.

BUSINESS MODELS AND ECONOMIC ASPECTS OF DISTRICT HEATING

- Analysis of current and future business models for DH.
- Economic considerations in system refurbishment and expansion.
- Policy and regulatory frameworks influencing DH economics.

- District heating involves **large capital investments** (CAPEX) in pipelines, heat generation plants, and substations, but relatively **low operating costs** (OPEX), especially when using waste heat or renewables. Thus, **long-term planning and stable financing** are essential.

Source: www.szovaterm.hu

COMMON BUSINESS MODELS FOR DH SYSTEMS

1. Public Utility Model

- Owned and operated by a **municipality or public authority**.
- Profits reinvested into infrastructure or used to reduce tariffs.
- Emphasizes **affordability, energy security**, and **climate goals**.
- Common in Nordic countries (e.g., Denmark, Sweden).

2. Private Utility Model

- Operated by **private companies**, either independently or under a concession.
- Focus on **profitability** and **efficiency**.
- Often used in **liberalized energy markets** (e.g., UK, parts of Eastern Europe).
- Risk of **less investment in decarbonization** unless incentivized.

Source: www.szovaterm.hu

COMMON BUSINESS MODELS FOR DH SYSTEMS

3. Public-Private Partnership (PPP)

- Shared ownership and responsibilities between **government and private firms**.
- Enables public goals with private investment and operational efficiency.
- Requires clear **risk-sharing** and **performance-based contracts**.

4. Cooperative Model

- Owned by **end-users or local communities**.
- Profits shared or reinvested.
- Enhances **local engagement and acceptance**.
- Common in **smaller municipalities** and **eco-villages**.

Source: www.szovaterm.hu

KEY ECONOMIC FACTORS IN DH

Capital Expenditure (CAPEX)

- Network infrastructure: 50–70% of total cost
- Heat generation plants (CHP, biomass, solar): 20–30%
- Customer substations and metering

Revenue Sources

- Heat sales to buildings
- Ancillary services (e.g., balancing the electricity grid)
- Government subsidies or feed-in tariffs
- Carbon credits in ETS (Emission Trading Schemes)

Operating Expenditure (OPEX)

- Fuel or energy cost
- Maintenance and labor
- Pumping electricity
- Administration

Heat Pricing and Tariffs

- Pricing models vary but generally aim to:
- **Recover costs** (cost-reflective)
- **Encourage energy efficiency**
- **Ensure affordability**

Source: www.szovaterm.hu

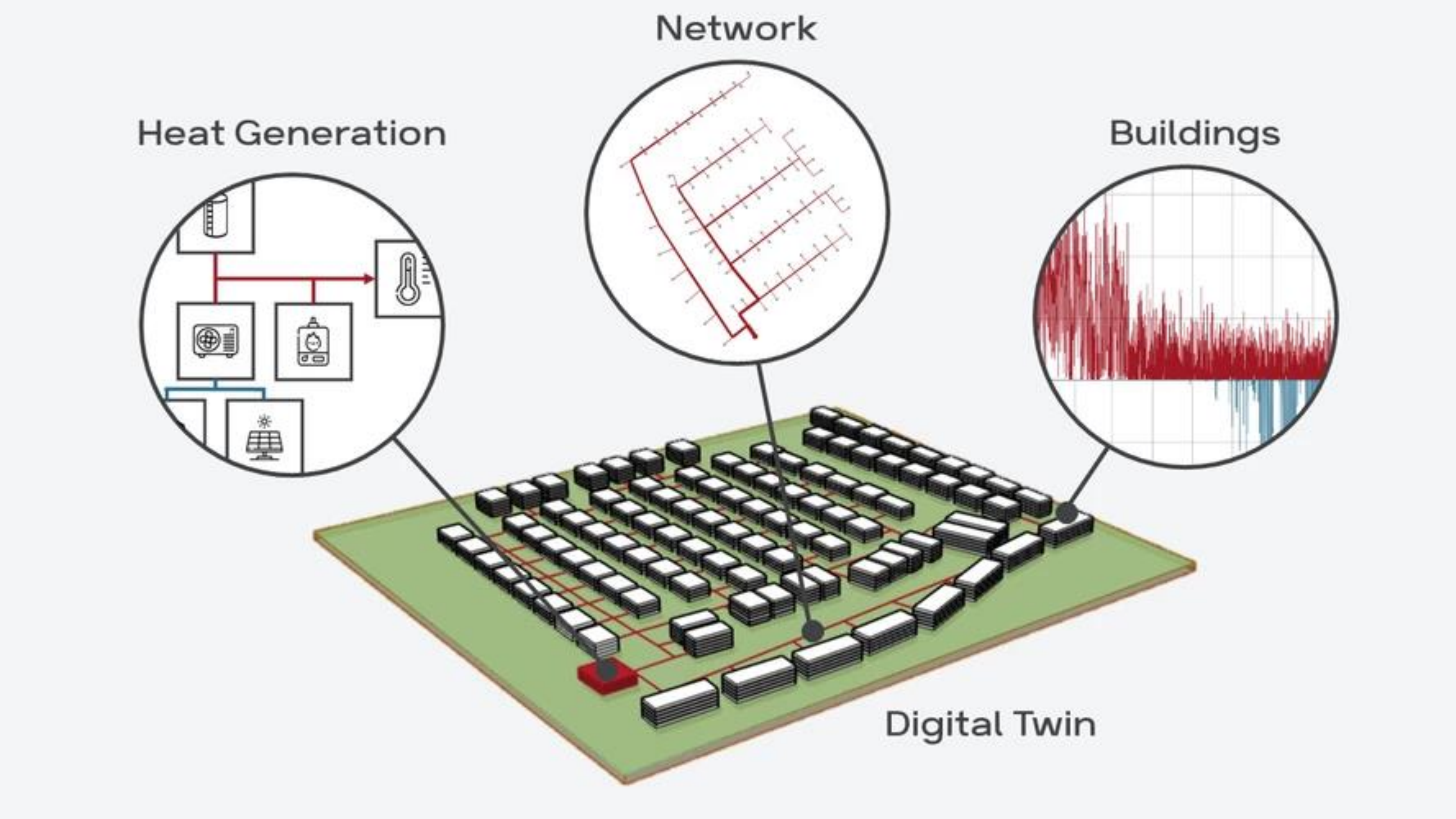
TRANSITIONING BUSINESS MODELS FOR MODERN DH

- **Performance-Based Contracts**
  - Operators are incentivized for energy efficiency, emissions reductions, and service quality.
- **Service-Based Business Models**
  - Heat-as-a-service: Customers pay for comfort (e.g., indoor temperature), not energy units.
  - Drives supplier innovation and system optimization.
- **Digital and Smart DH Integration**
  - Enables **dynamic pricing**, **remote monitoring**, and **demand response**.
  - Opens up **new revenue streams** through energy services.

Source: www.szovaterm.hu

DIGITAL TWINS IN DISTRICT HEATING

A digital twin is a continuously updated, dynamic virtual replica of real-world systems — such as district heating networks.



Forrás: https://heatbeat.de/en/services/

BUILDING A DIGITAL TWIN

Physical Model

Digital map of the heating network

- Pipe layouts, sizes, materials
- Valves, pumps, heat exchangers
- Consumer locations and heat demand
- **Data Connections**
- Sensors for temperature, pressure, flow
- - Real-time data transmission to the twin model

BUILDING A DIGITAL TWIN

- **Simulations and Maintenance**
- Simulates flow, heat loss, temperature changes
- - Detects anomalies
- **Predictive maintenance based on actual conditions**
- The system predits which section of the pipeline is going to get damaged due to age
- Maintenance team can work in a more structured way, not only based on time-based maintenance plan.

Forrás: www.engieheat.eu

BUILDING A DIGITAL TWIN

- **Energy optimization**
  - The digital twin analyses consumption patterns, e.g. higher heat demand in the morning and evening on weekdays.
  - Based on this, the output of the boilers is dynamically controlled to avoid unnecessary heat generation.
- **Simulation of "what if" scenarios**
  - For example: what would happen if a new housing estate was connected to the network?
  - The digital twin can be used to simulate whether the existing system can cope or whether upgrades would be needed.

Forrás: [illegible]

DIGITAL TWINS IN DISTRICT HEATING

- **Network modelling and optimization**
- Accurate, live updated models of the hydraulic and thermal behaviour of pipe networks.
- They help identify and minimise network losses (e.g. heat loss, pressure drop).
- They identify hydraulic resistances and refine system calibration to more realistically reflect real-world operation.

- **Operations and maintenance support**
- The digital twin helps you predict system failures and maintenance needs.
- In case of failure, simulations can be used to quickly analyse possible causes and solutions.
- It supports predictive maintenance, which reduces downtime.

DIGITAL TWINS IN DISTRICT HEATING

Design and development

- When designing new network sections or upgrades, simulations can be used to test the impact of new configurations before they are implemented in the real world.
- It helps you plan how to modernise existing infrastructure at minimum cost.
- Regulation and control
- The digital twin can interface with automated control systems (e.g. SCADA) to provide real-time recommendations or even automatically change control settings.

NOVELTY COMPARED TO SYSTEM MONITORING

	Data-based system monitoring	Digital twin
What is it?	Monitoring and basic analysis of real-time operational data.	A live, dynamic virtual replica of the system, which also performs simulations and forecasts.
Main objective	Quick detection of faults, status tracking.	Optimisation, forecasting, decision support, simulation.
How deep is the data processing?	Just an observation: if something deviates from the norm, it signals it.	It analyses data regularly, "understanding" the dynamics of the system.
Does it use prediction?	Very limited or none at all.	Yes, it uses machine learning or physical simulation to predict.
Response to errors	A human decision is required after an error has been reported.	It not only reports errors, but also suggests solutions or intervenes automatically.
Simulations	None or only rarely.	Run regular "what if" simulations (e.g. if a pump fails).
Examples	SCADA monitoring, dashboards, simple alarms.	Full network modelling, predictive maintenance, energy optimisation.

REFURBISHMENT OF DISTRICT HEATING SYSTEMS

CASE STUDIES

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Sharing Knowledge on Energy Communities

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

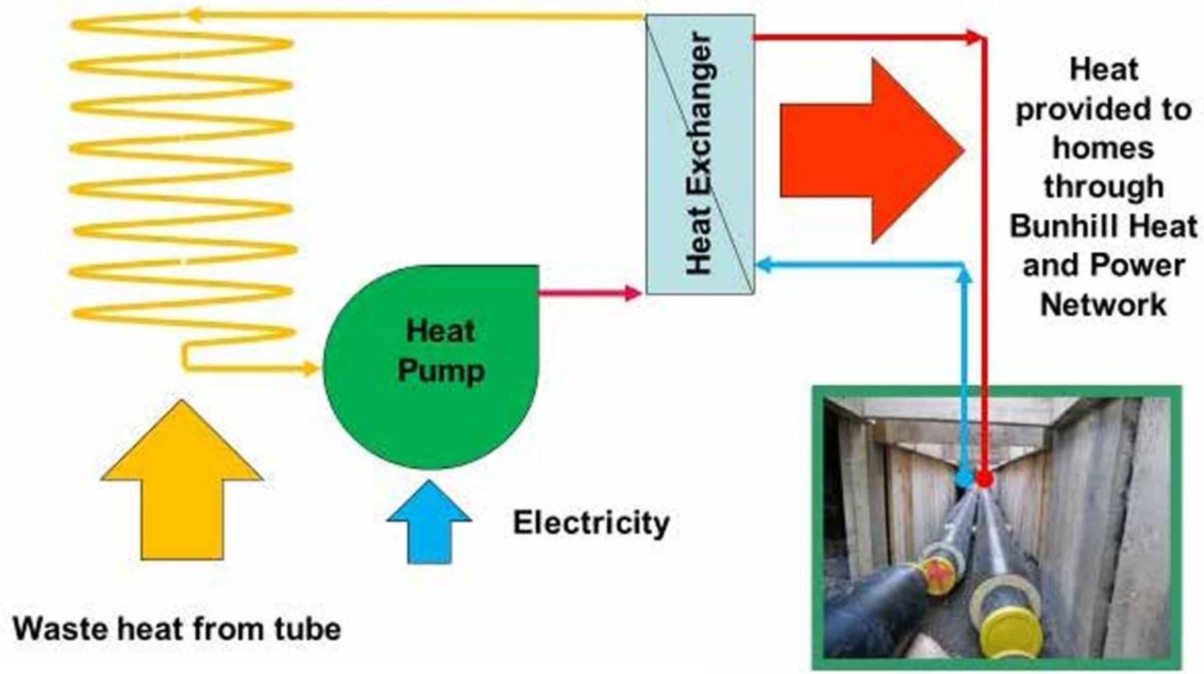
London: Bunhill Heat and Power Network

- The first project in the world to take waste heat from an underground train network (the London Underground) and use it to provide heat locally.
- Phase 1 was based on a gas-fired Combined Heat & Power (CHP) plant in Central Street; waste heat from electricity generation was captured for district heating.
- Phase 2 introduces a new energy centre located at a London Underground ventilation shaft (corner of Moreland Street & Central Street). It extracts waste heat from the Tube's ventilation system via a heat pump.

Source: www.islington.gov.uk, Bunhill Heat and Power Network.

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

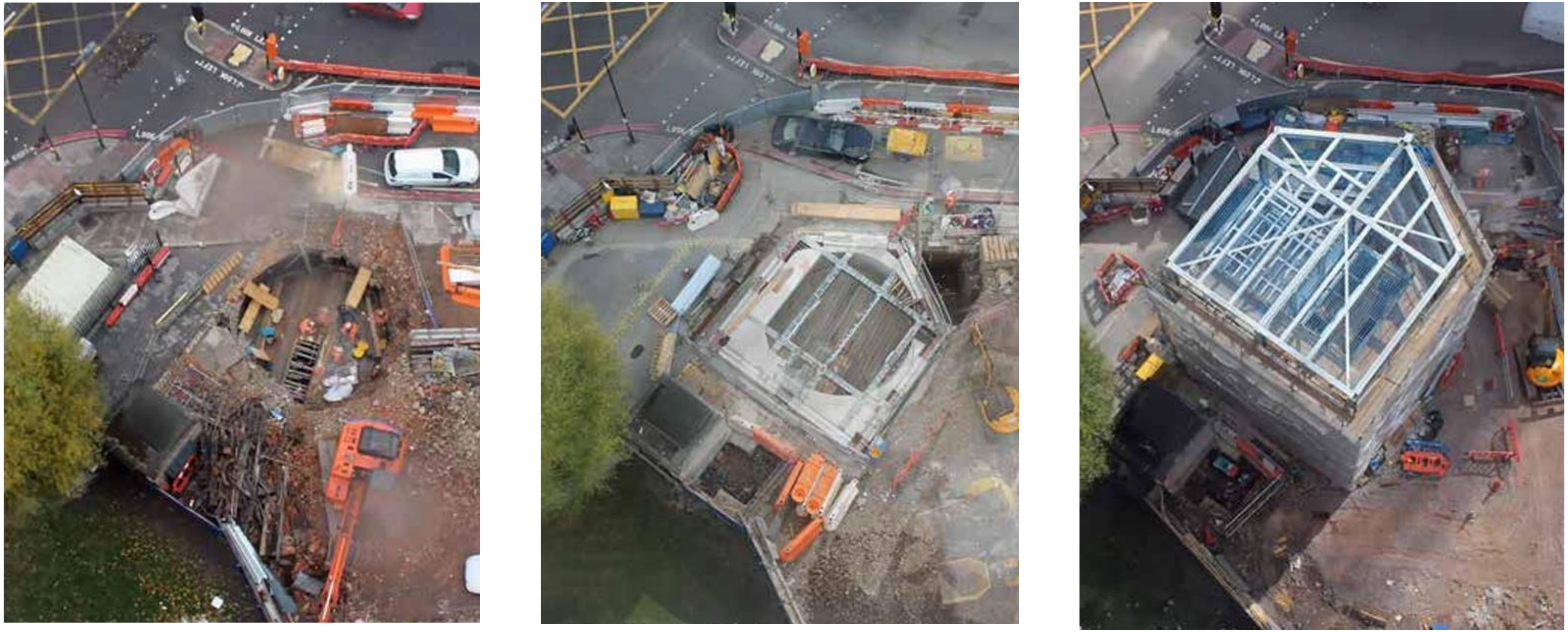
London: Bunhill Heat and Power Network



Source: www.islington.gov.uk, Bunhill Heat and Power Network.

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: Bunhill Heat and Power Network, Phases of Construction



Source: www.islington.gov.uk, Bunhill Heat and Power Network.

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: Bunhill Heat and Power Network


Ventilation shaft fan

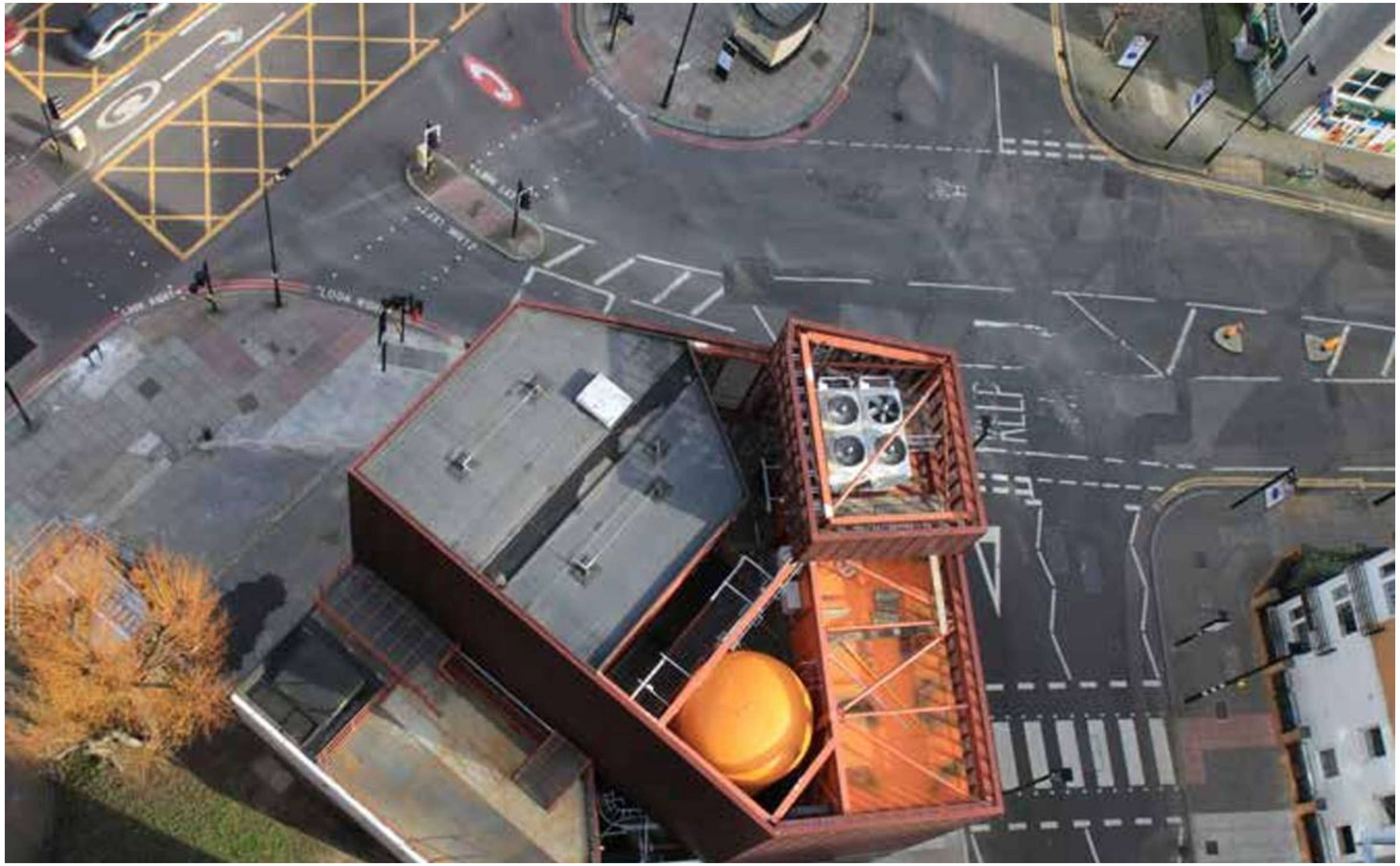

Thermal energy storage

Source: www.islington.gov.uk, Bunhill Heat and Power Network.

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: Bunhill Heat and Power Network

- The design also allows redundancy / resilience: the two energy centres (old + new) are interconnected, so one can take over if the other fails.
- The Phase 2 extension connects 550 additional properties (King Square Estate, Moreland School etc.) to the network.
- It supplements the ~800 homes and public buildings already served by Phase 1.
- Estimated carbon emissions reduction is ~ 500 tonnes of CO_2 per year from the extension.

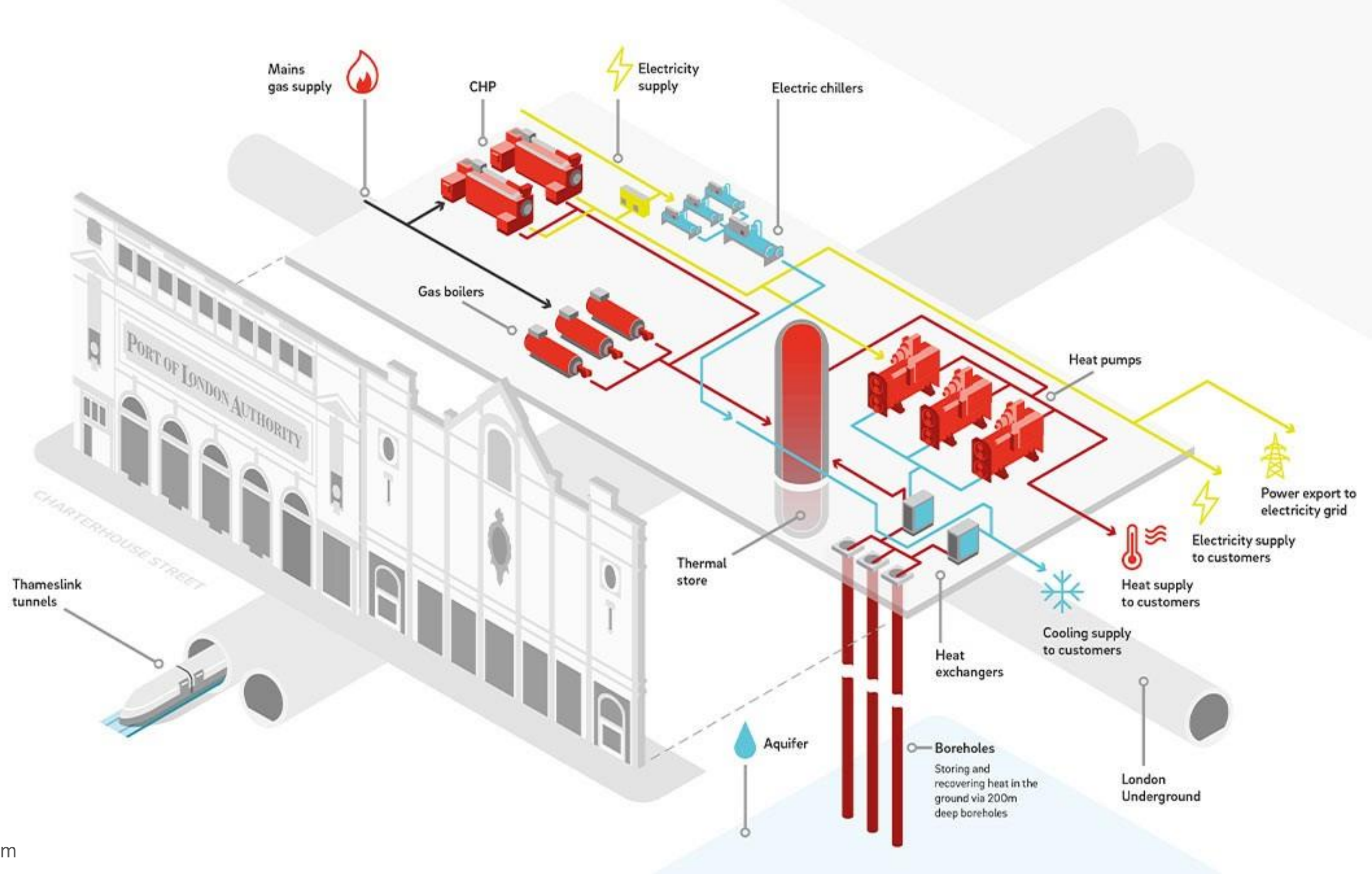


Source: www.islington.gov.uk, Bunhill Heat and Power Network.

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: CITIGEN Project

- 4 MW heat pump will draw the natural warmth from the London Aquifer (on average 14°C), via 3 boreholes 200m below the surface, as well as recycling waste heat from power and chill generation, which would otherwise vent into the atmosphere.
- The heat pump will be equal to the demand of 2,300 UK homes or businesses. This is complemented by a further 2.8MW of new cooling capacity for customers across the business district.
- 320,000 litres thermal storage tank for flexibility of heat generation - peak shaving, allowing Citigen to use excess renewable energy on the grid to store heat.

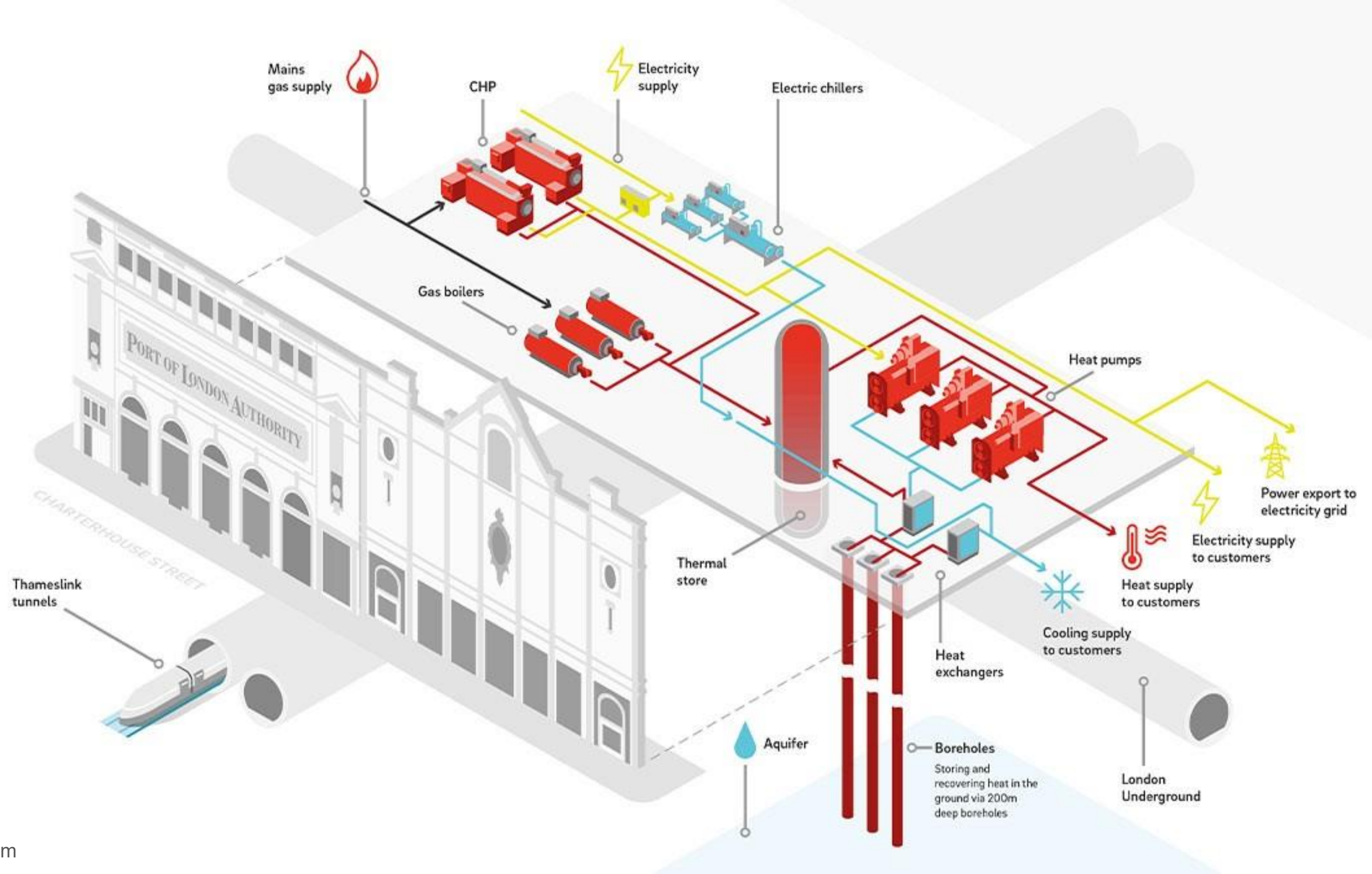


Source: https://www.eonenergy.com/business/why-eon/case-studies/citigen.html?utm

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: CITIGEN Project

- Citigen has a large thermal store with a capacity of 320,000 litres for hot water. This thermal store allows for flexibility of heat generation - peak shaving, allowing Citigen to use excess renewable energy on the grid to store heat.

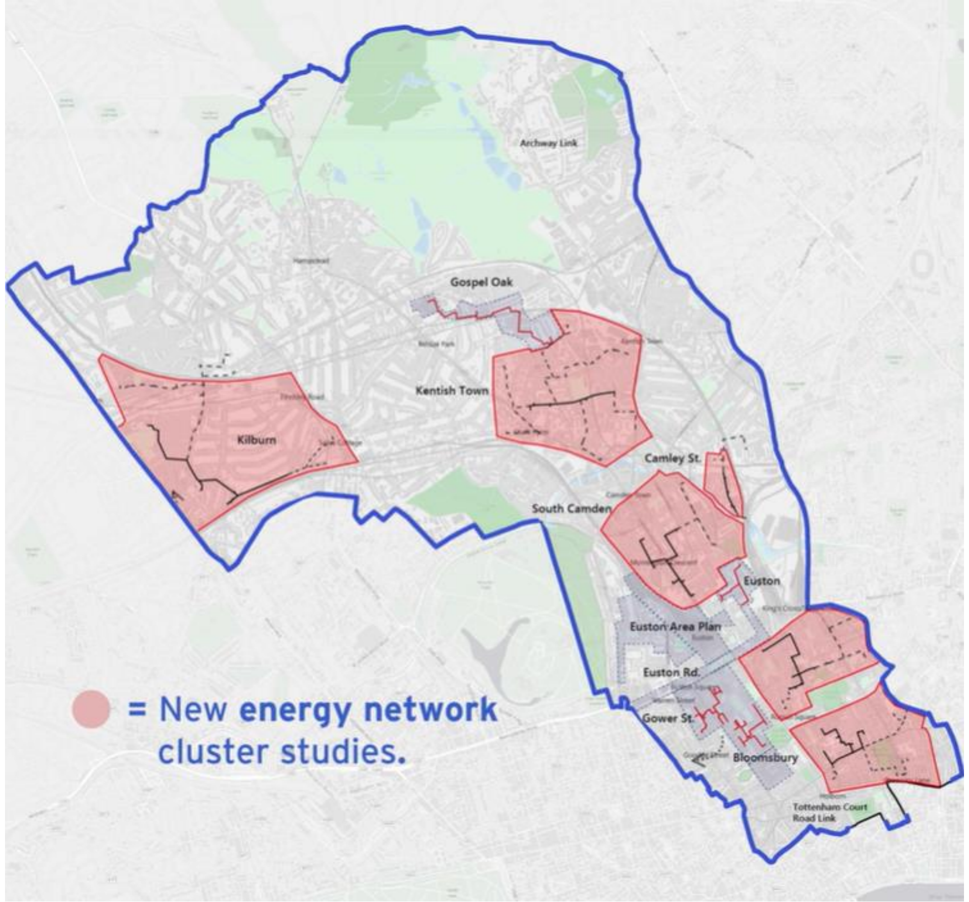


Source: https://www.eonenergy.com/business/why-eon/case-studies/citigen.html?utm

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: Somers Town Decentralised Energy Network

- Provides heat and hot water to five housing estates, a new community centre and the redesigned Edith Neville School, and provide electricity to The Francis Crick Institute via a private wire.
- A phased solution was decided upon as there was limited historical operational data to determine demand patterns and so the Council wanted a period of study following the connection of the first estates to understand the network's performance. This would allow us to analyse the operational data before deciding upon the best matched CHP engine size to provide an accurate solution.

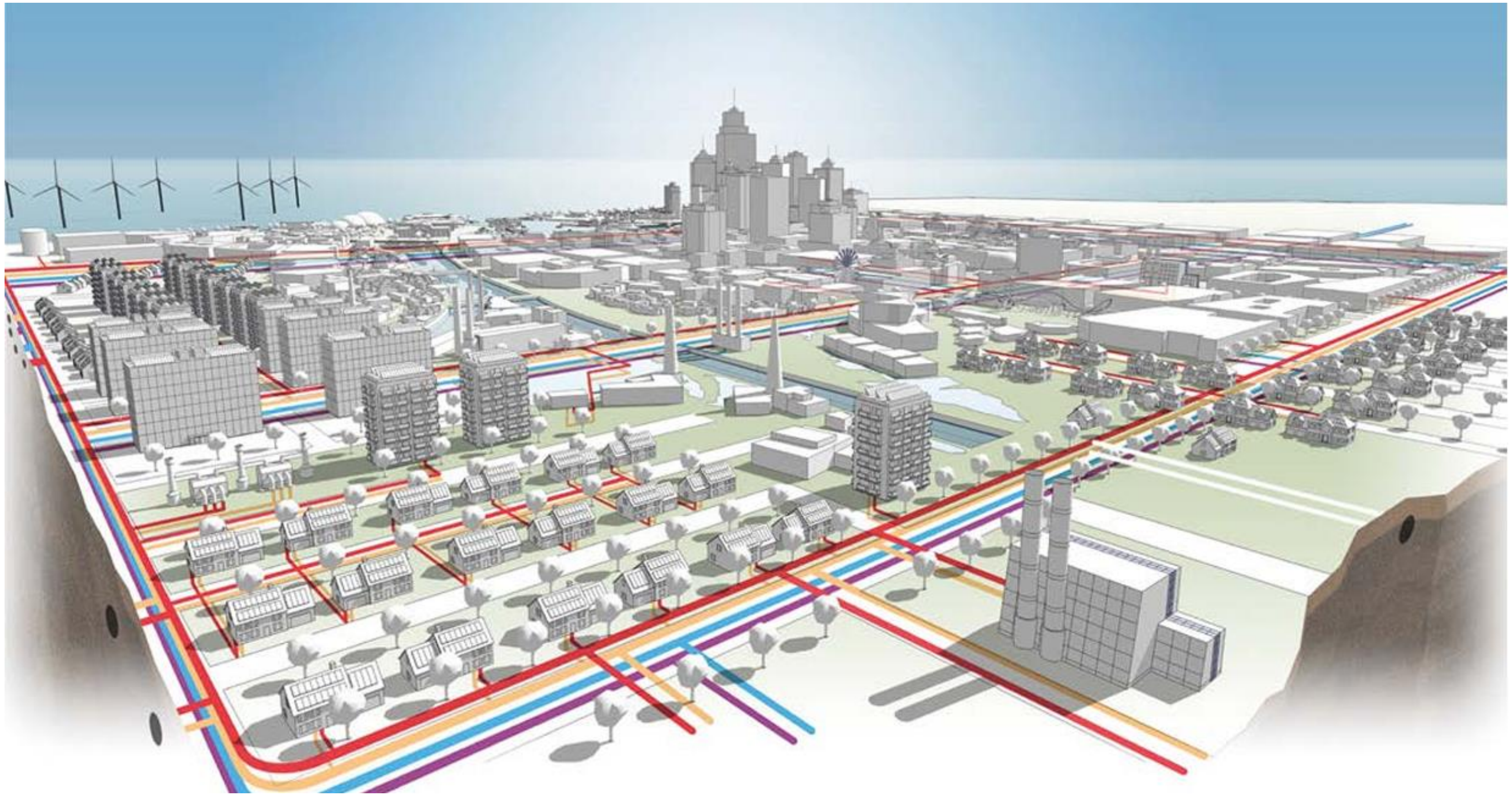


Source: https://www.vitalenergi.co.uk/case-studies/somers-town-decentralised-energy-network

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Paris District Heating Development

- CPCU district heating network: ~ 5,500 GWh/year heat produced; network length ~ 475 km.
- CPCU serves ~ 500,000 households equivalent, includes 100% of hospitals, ~50 % social housing, ~50 % publicly-owned buildings.



Source: https://urban-leds.org/wp-content/uploads/2019/resources/case_studies/ICLEI_cs_Paris-case-study.pdf

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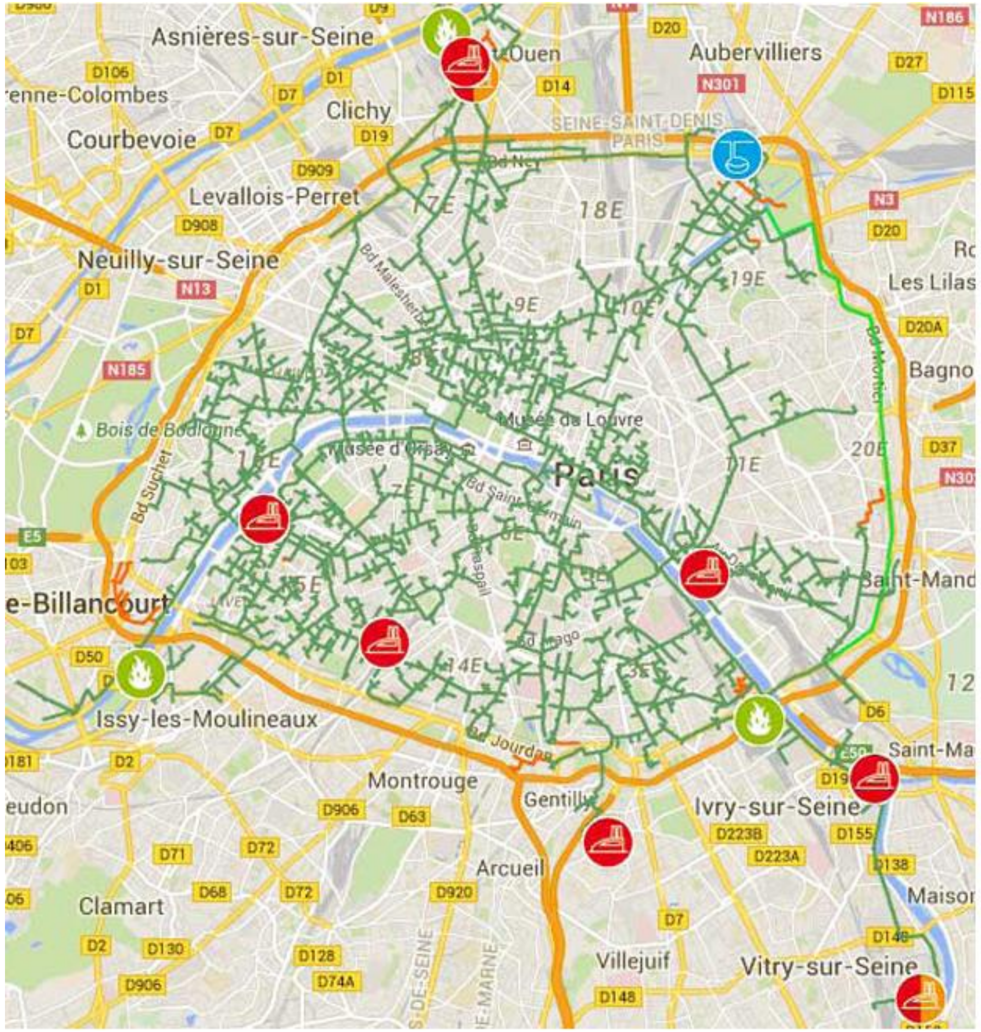


Source: CPCU, 2015

● CPCU owned Heat Plant

● CPCU owned Combined Heat and Power (CHP) plant

● CPCU owned Geothermal production plant

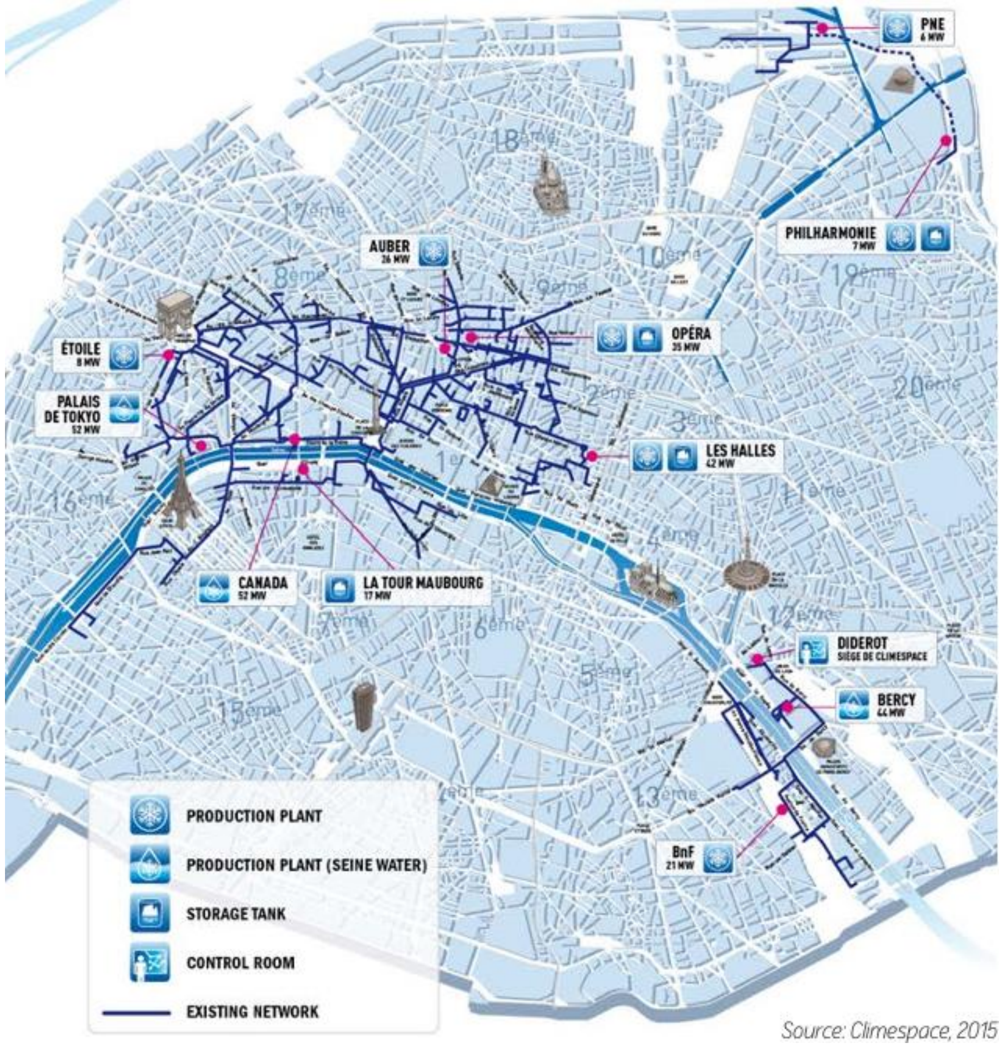
● SYCTOM owned Waste incinerator

Source: https://urban-leds.org/wp-content/uploads/2019/resources/case_studies/ICLEI_cs_Paris-case-study.pdf

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Paris: Climespace District Cooling

- Climespace district cooling: ~ 330 MW cooling capacity, ~ 412 GWh/year. ~ 71 km cooling network.



Source: Climespace, 2015

Source: https://urban-leds.org/wp-content/uploads/2019/resources/case_studies/ICLEI_cs_Paris-case-study.pdf

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

London: Somers Town Decentralised Energy Network

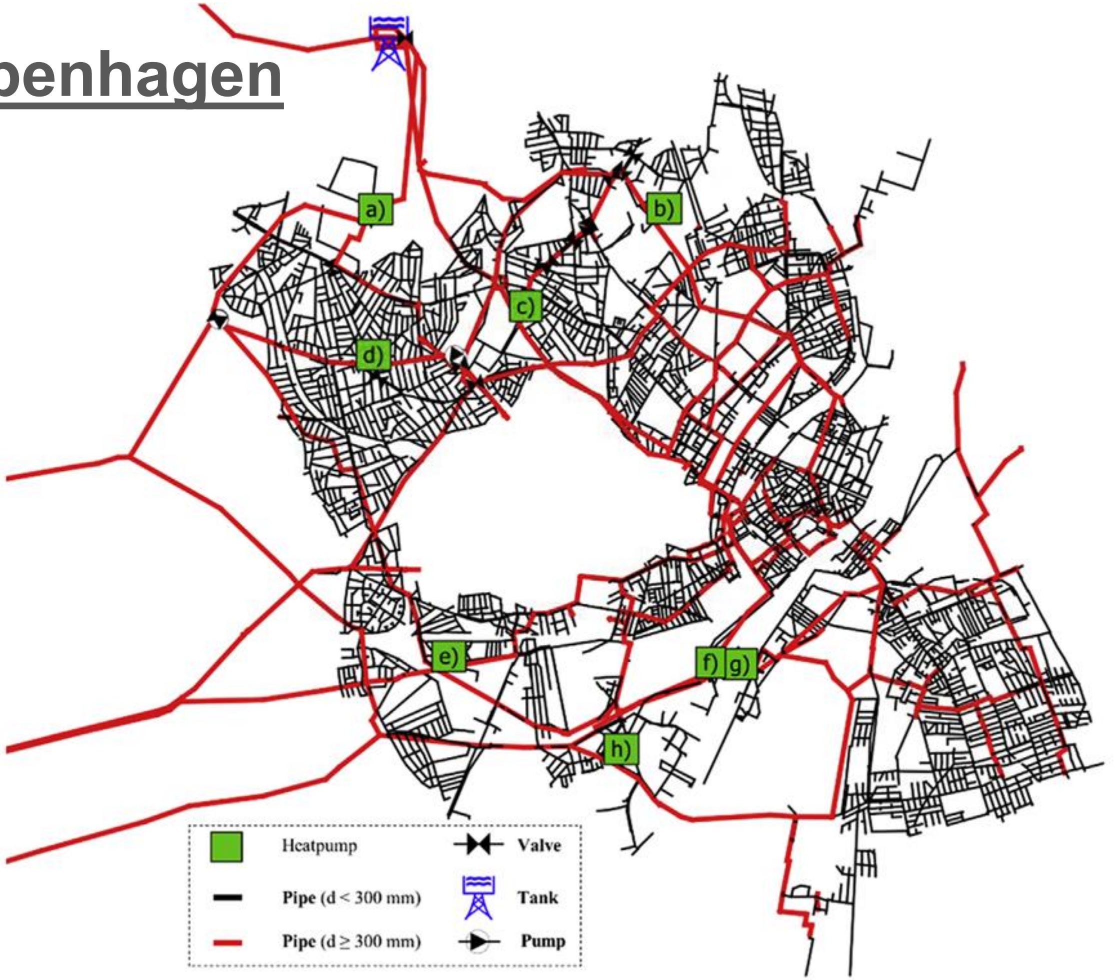
- First phase: seeing the installation of the district heating network connecting four estates and the retrofit energy centre into the basement of a 1960’s under-used car park.
- Second phase: the installation of the CHP engine and thermal stores, and connecting another housing block, community centre and school to the network.

Source: https://www.vitalenergi.co.uk/case-studies/somers-town-decentralised-energy-network

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Drinking Water Network as Heat Source in Copenhagen

- The drinking water distribution network (DWDN) can act as a low-temperature heat source via large heat pumps (HPs) to support district heating.
- Copenhagen: coupling the drinking water network with the city’s existing district heating system.
- The potential heat extraction from Copenhagen’s drinking water network amounts to about 21 MW.

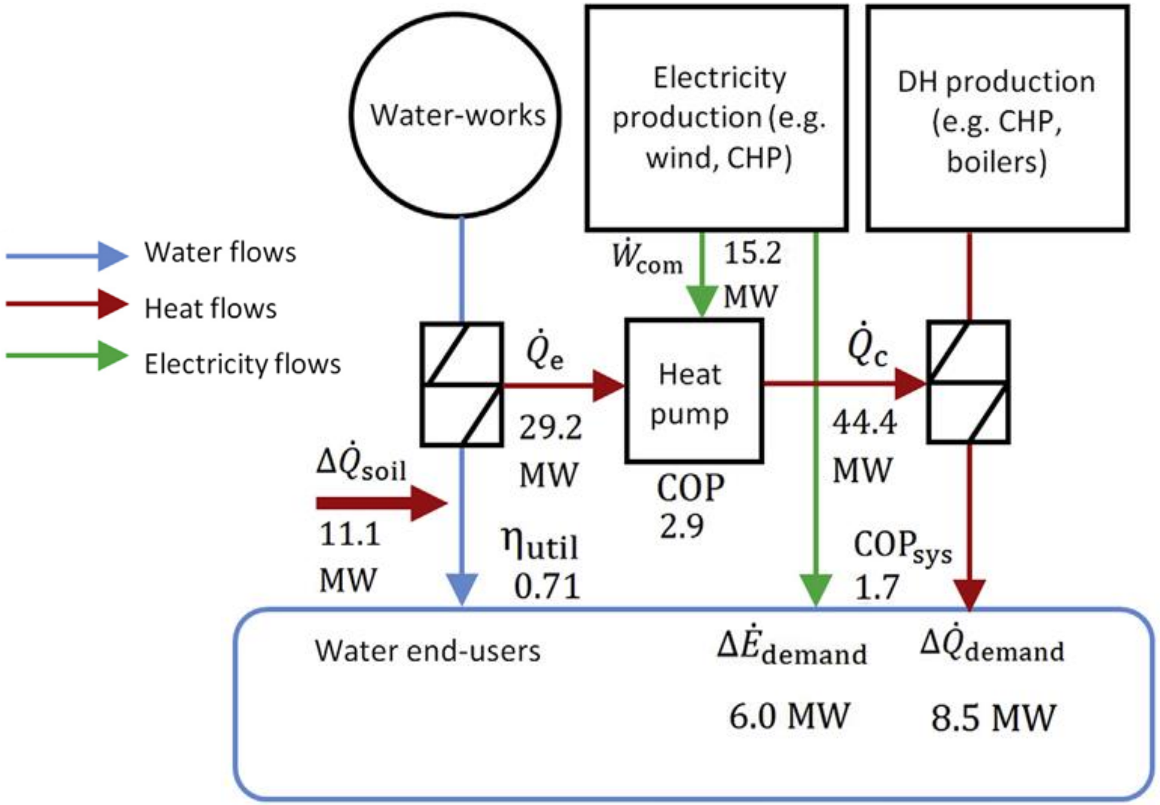


Source: Helga Hubeck-Graudal, Jonas Kjeld Kirstein, Torben Ommen, Martin Rygaard, Brian Elmegaard, Drinking water supply as low-temperature source in the district heating system: A case study for the city of Copenhagen, Energy, Volume 194, 2020, 116773, ISSN 0360-5442, https://doi.org/10.1016/j.energy.2019.116773.

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Drinking Water Network as Heat Source in Copenhagen

- Heat pump COP (coefficient of performance) between 2.8 and 3.2, but the system COP (accounting for network losses and reheat requirements) is only ~1.7.
- The relatively low system COP suggests that using drinking water as the source is not always advantageous.
- In summer, operating such a system could help keep drinking water temperatures lower.



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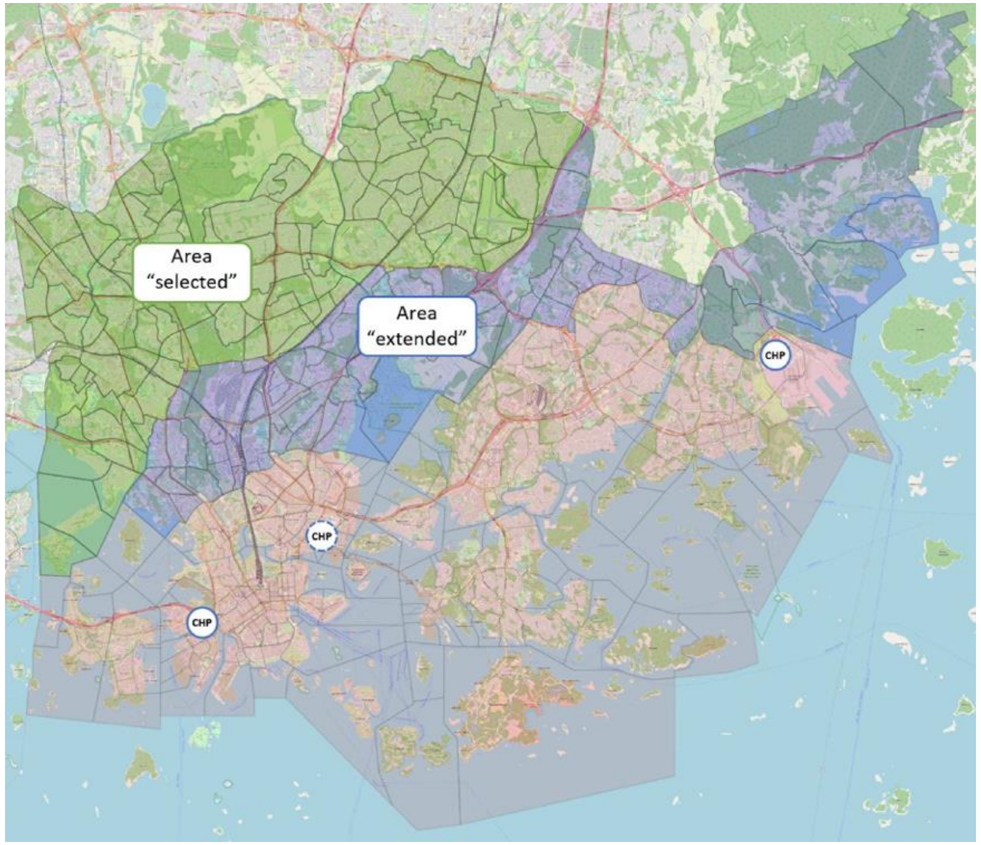
DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Helsinki: Dynamically Distributed District Heating

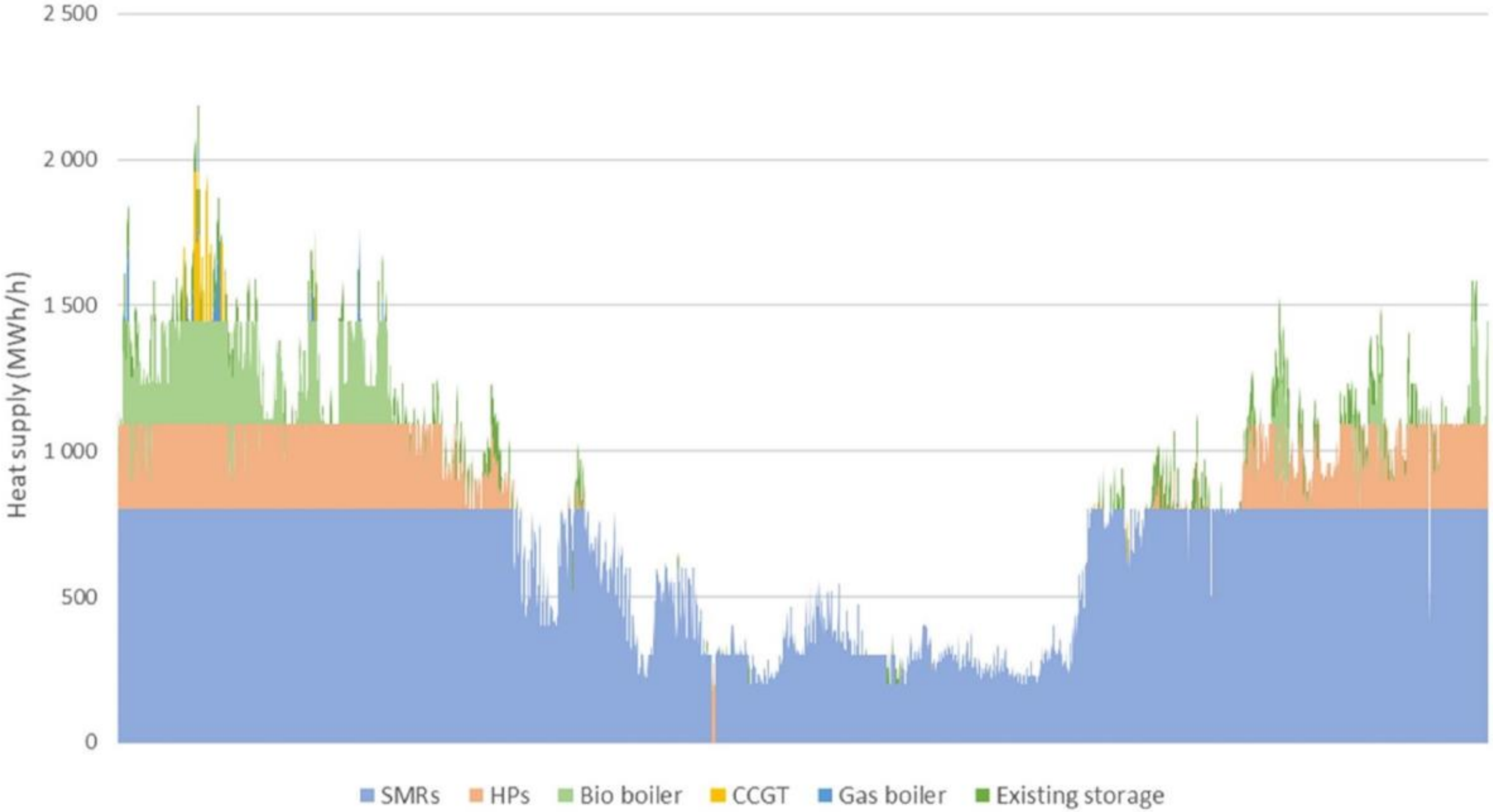
- Storage and islanding are key enablers for flexibility, resilience, and modular deployment in urban settings.
- A hybrid strategy to transition an existing (3rd generation) district heating (DH) system gradually toward 4th generation / low-temperature operation, area by area.
- Rather than converting the entire network at once, the approach allows localized “island” operation of sub-areas (i.e. disconnected from the main network during heating season) with their own distributed heat supply + local storage, yet still benefiting from the central network when needed.



Source: Miika Rämä, Esa Pursiheimo, Dennis Sundell, Rinat Abdurafikov,: Dynamically distributed district heating for an existing system, Renewable and Sustainable Energy Reviews, Volume 189, Part A, 2024, 113947, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2023.113947

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Helsinki: Heat supply of the existing system with three SMR units



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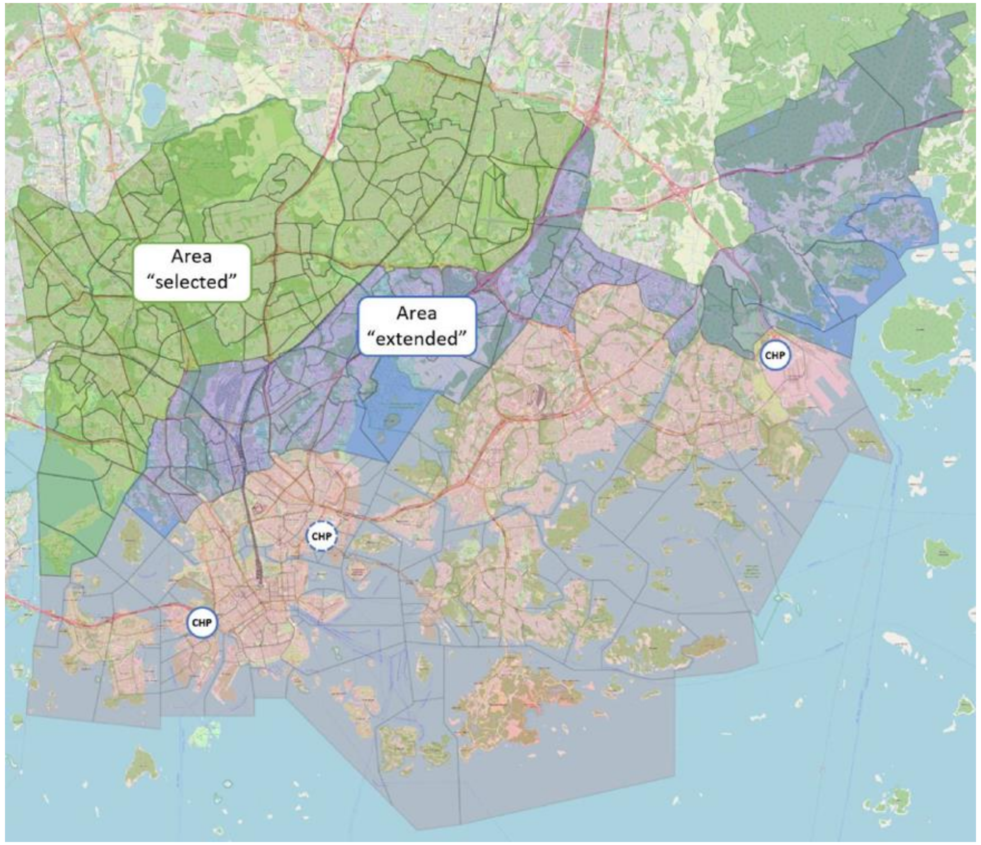
DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Helsinki: Dynamically Distributed District Heating

- Large seasonal heat storage (activated during summer when cheap or excess heat is available) is integral: these storages charge when demand is low and then supply heat during the colder months to the islanded sub-areas.
- Storage capacity is critical: the ability to stock heat during off-peak or summer periods underpins the viability of islanding approaches.
- Because islanded areas can operate independently in the heating season, they relieve stress or constraints on the central network under certain load situations.
- The performance depends heavily on local conditions (e.g. availability of cheap heat in summer, cost / efficiency of storage, distributed generation cost) — its success is context-sensitive.



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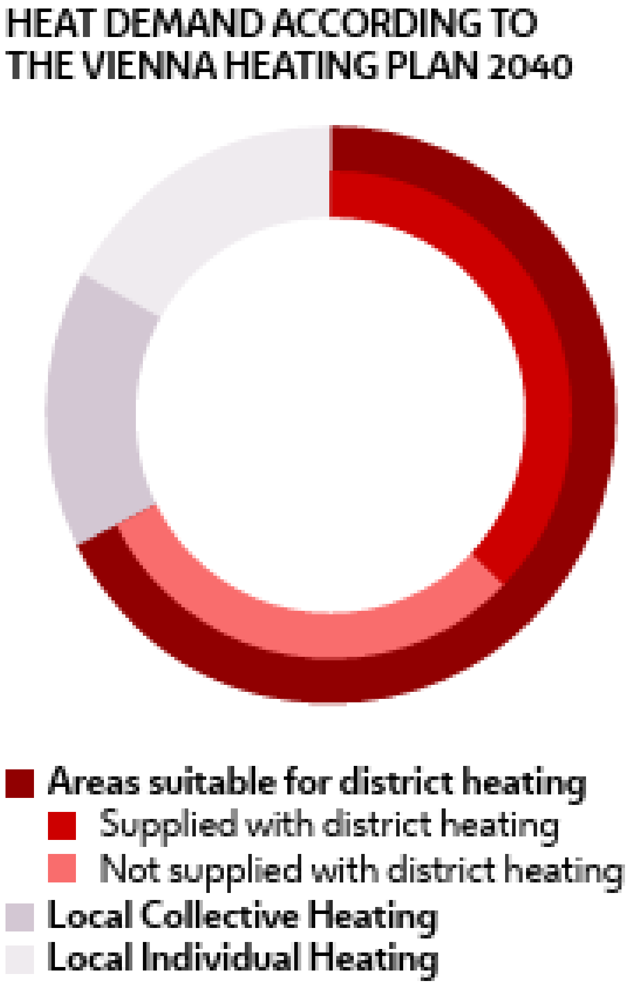
DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Vienna: Involvement of Downtown areas

- The transport/distribution network is extensive: by 2006, the Vienna DH network (“transport network”) had reached ~ 1,000 km in length. That indicates large coverage, including downtown / inner city.
- Over time, district heating came to serve many buildings in central / urban areas: homes, museums, government buildings, hotels, offices. Fernwärme Vienna is supplying large numbers of existing private residential buildings in addition to public / commercial ones.
- The network expanded by integrating multiple production plants (incineration, CHP), but also by transporting heat over distance through the transport ring and pipes so that heat generated in Spittelau, Flötzersteig etc. can reach central or densely built-up parts. Thus, downtown and inner districts were connected via the expanding distribution network.

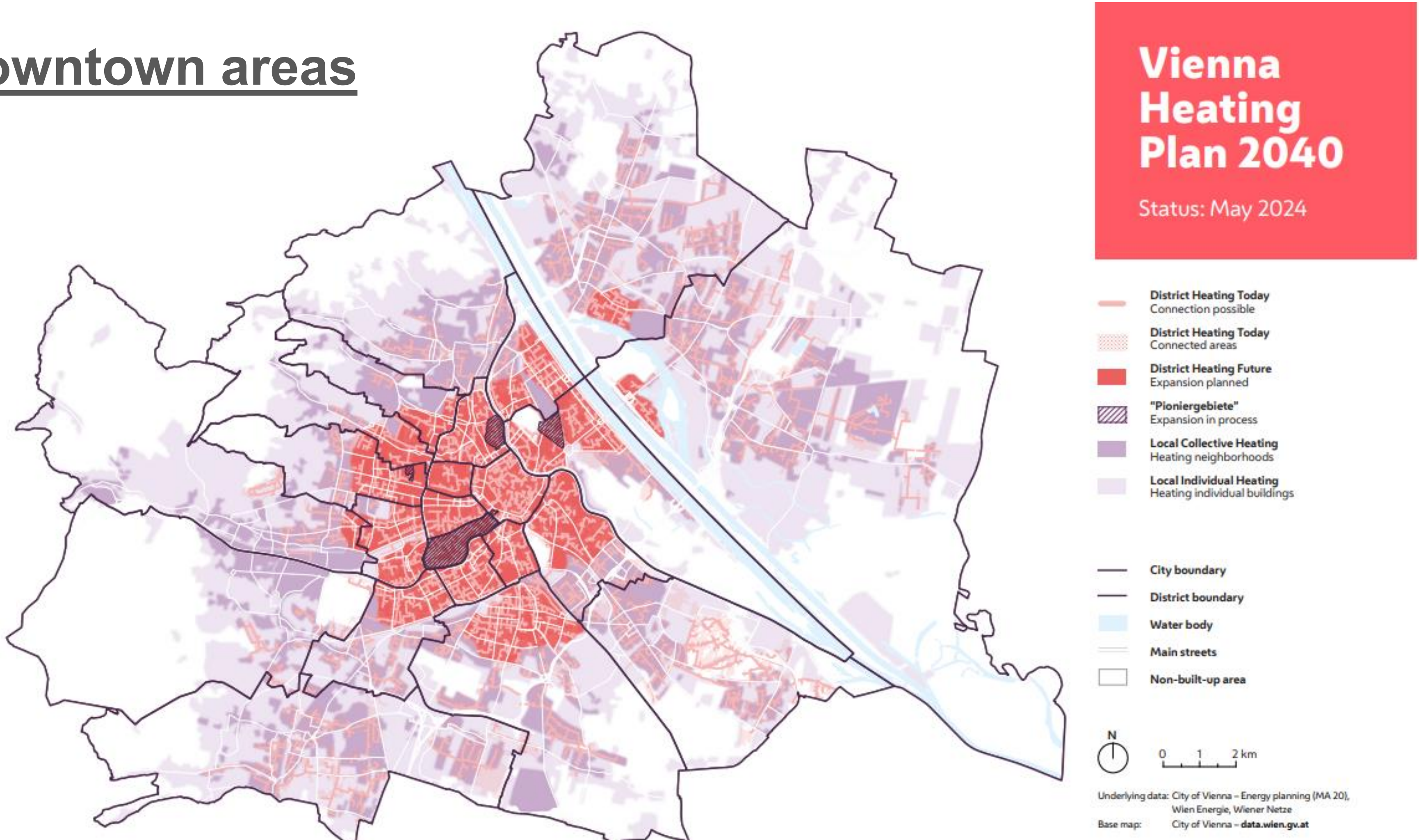


Source: https://www.districtenergyaward.org/wp-content/uploads/2012/10/Vienna_Austria-District_Energy_Climate_Award.pdf, https://www.wien.gv.at/pdf/ma20/vienna-heating-plan-2040.pdf

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Vienna: Involvement of Downtown areas

- Global District Energy Climate AwardsPlanned production capacity increases: a CHP repowering project adding ~100 MW (district heating capacity), and planning for a geothermal well (~50 MW) as additional future source.
- Global District Energy Climate AwardsContinued diversification: more waste heat sources yet to be exploited; more efficient plants; fuel diversification (biomass, waste, industrial sources)

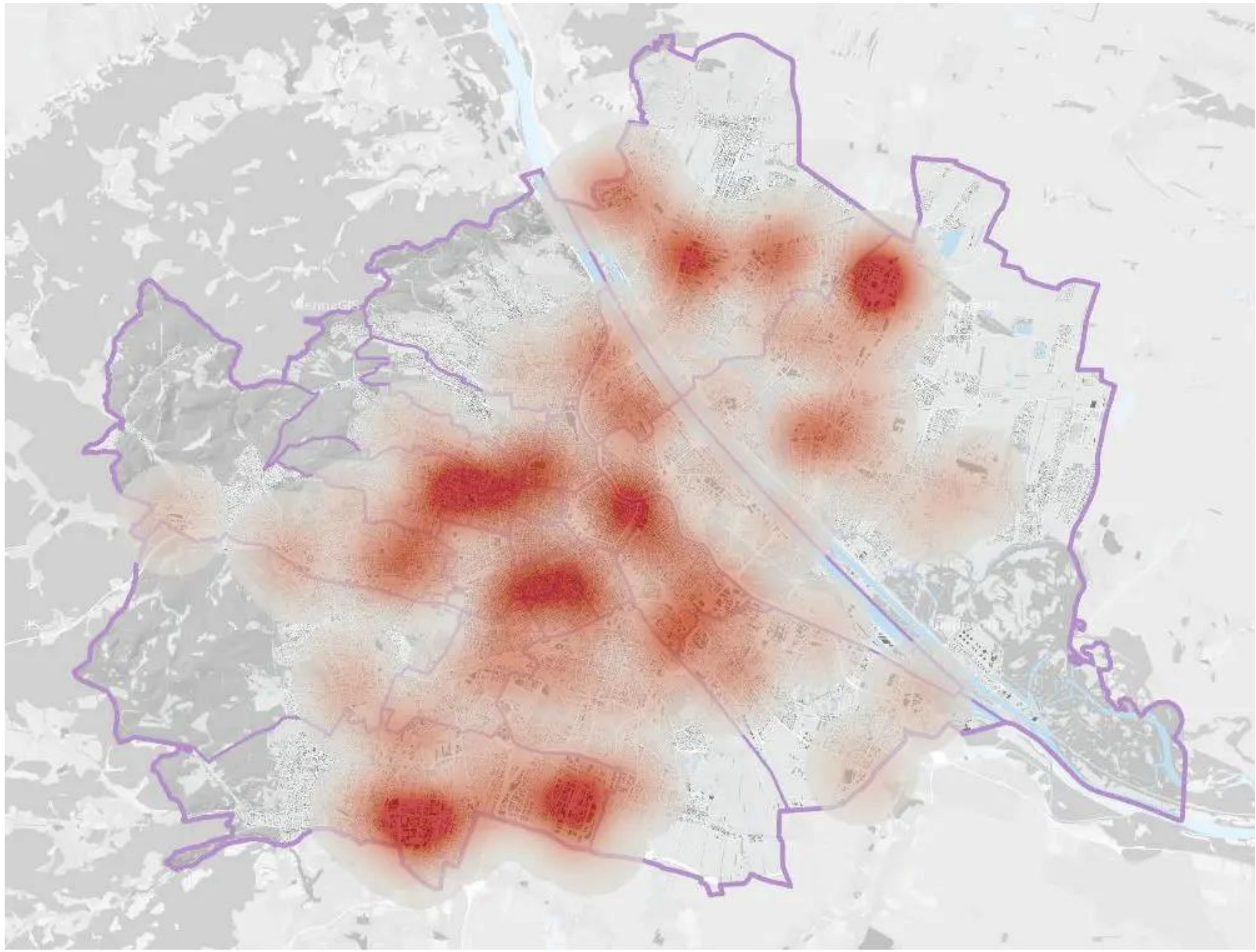


Source: https://eu-mayors.ec.europa.eu/en/vienna-s-heat-detox-for-an-even-happier-city

DH DEVELOPMENT: INVOLVING DOWNTOWN AREAS

Waste Heat Potential Map of Vienna

- Huge savings in primary energy: Vienna’s system (with waste heat etc.) has a primary energy factor of about 0.26 (i.e. 0.26 MWh of fuel needed for 1 MWh of district heat delivered), compared to ~1.4 MWh fuel for individual gas boiler heating.
- CO_2 emissions per MWh have fallen (e.g. from ~168 kg CO_2/MWh in 1990 to ~130 kg CO_2/MWh by ~2005), through fuel diversification, waste heat-use, modernization of plants etc.
- System losses (“network losses”) are monitored; the document shows evolution of network losses and compares with European averages, indicating Vienna’s network management is relatively efficient.



Source: https://smartcity.wien.gv.at/en/thematic-city-map-energy/

SHaKE
Sharing Knowledge on Energy Communities

Thank you!

Module 6 - REFURBISHMENT OF DISTRICT HEATING SYSTEMS
SHaKE – Sharing Heat and Knowledge on Energy Communities

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

Developed by BME
Balázs Bokor| bokor.balazs@gpk.bme.hu

MŰEGYETEM 1782
UNIVERSITAT JAUME I
MINES PARIS | PSL

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