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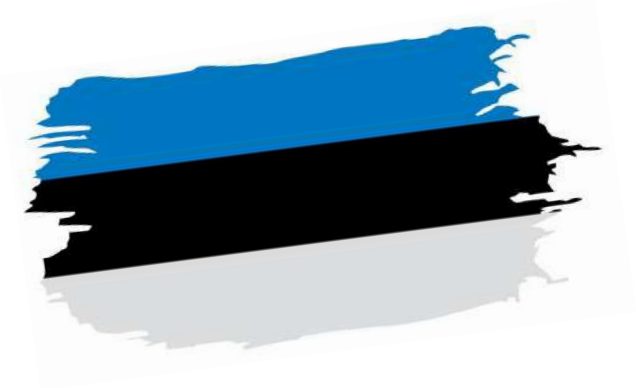

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The English version is the reference version. Translations were prepared with the support of AI-based translation tools.

Sustainable Heat Production

Outlines

- District Heating
- What Are The Advantages Of District Heating?
- What Are The Drawbacks Of District Heating?
- Key Components Of A District Heating Network
- Examples And Best Practices
- District Heating Alternatives; Local Heat Production

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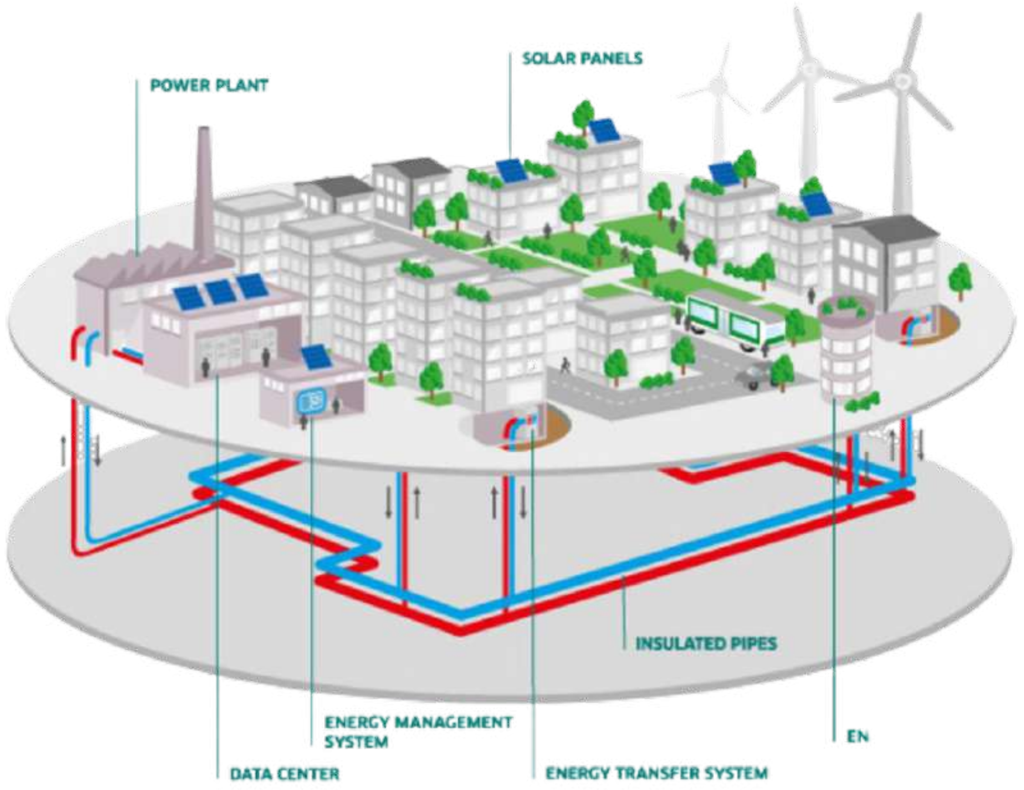
What Is District Heating?

Let’s start with the hot topic of today, District Heating.

District heating is a centralized system for distributing heat generated in a central location to meet the heating needs of residential, commercial, and industrial buildings. Any District Heating Network has 8 key components which we will discuss in more detail later: Heat Generation Plant, Distribution Network, Heat Exchangers, Control Systems, Pumping Stations, Thermal Storage, Monitoring and Metering Systems, and Substations.

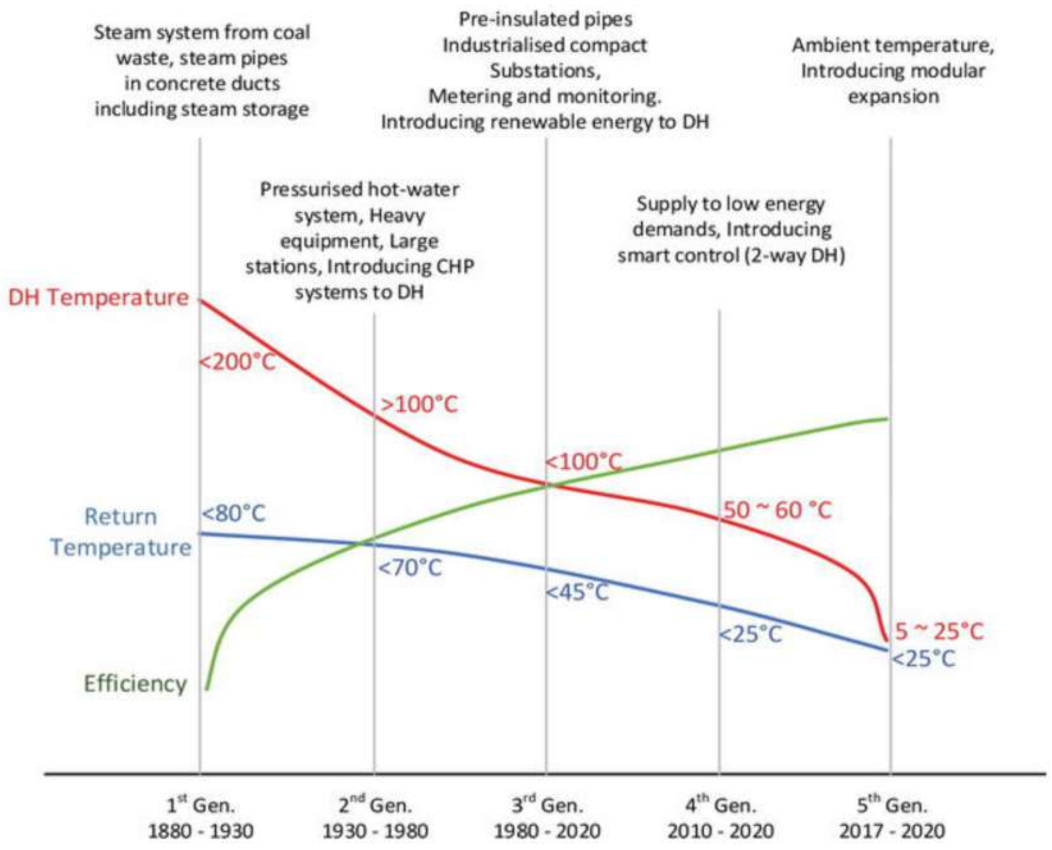


What Are The Advantages Of District Heating?

1. Energy Efficiency

Combined Heat and Power (CHP): District heating often utilizes CHP plants, which generate both electricity and heat from the same fuel source, achieving higher overall efficiency compared to separate heat and power generation (Technavio Newsroom).

Reduced Heat Loss: Modern district heating systems are designed with highly insulated pipes, minimizing heat loss during distribution .



https://www.intechopen.com/chapters/74667

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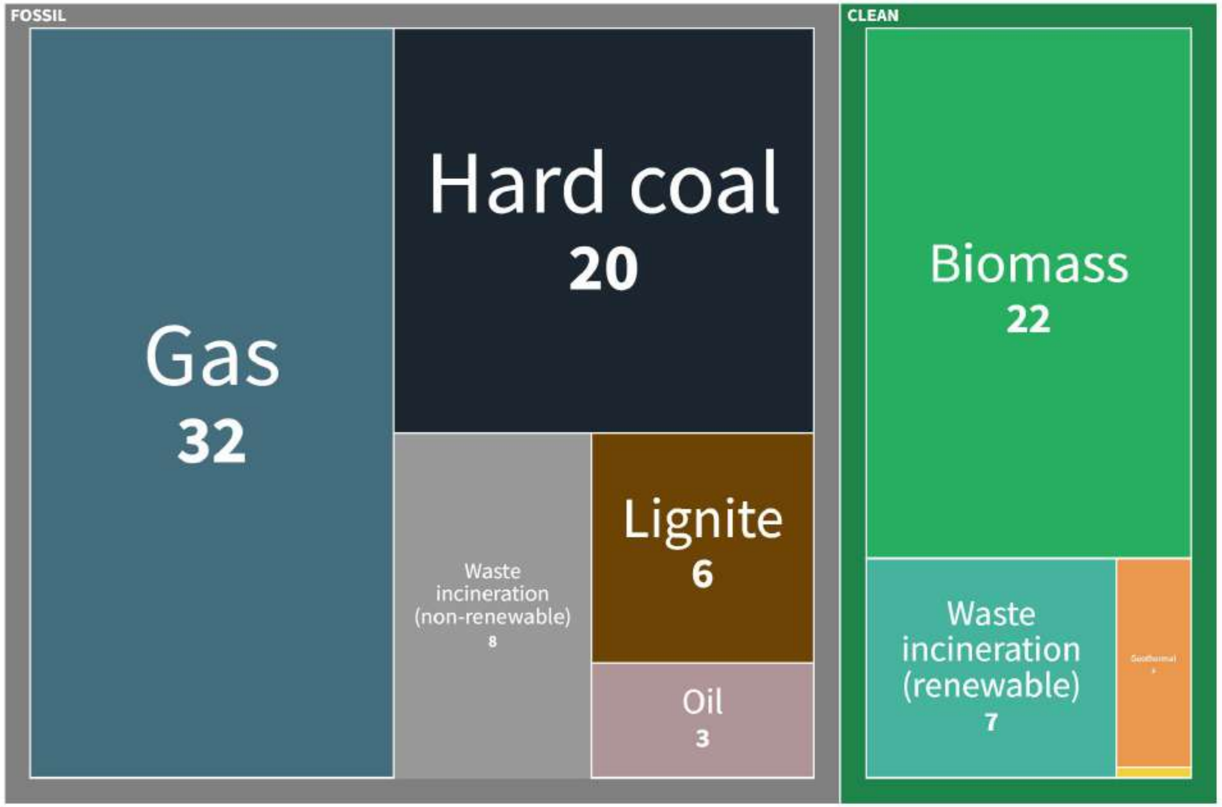
2. Environmental Benefits

Lower Emissions: Centralized heat production, particularly from renewable sources (biomass, geothermal, solar thermal), can significantly reduce greenhouse gas emissions compared to individual heating systems using fossil fuels.

Waste Heat Utilization: District heating can use waste heat from industrial processes, power plants, and waste incineration, effectively recycling energy that would otherwise be lost.



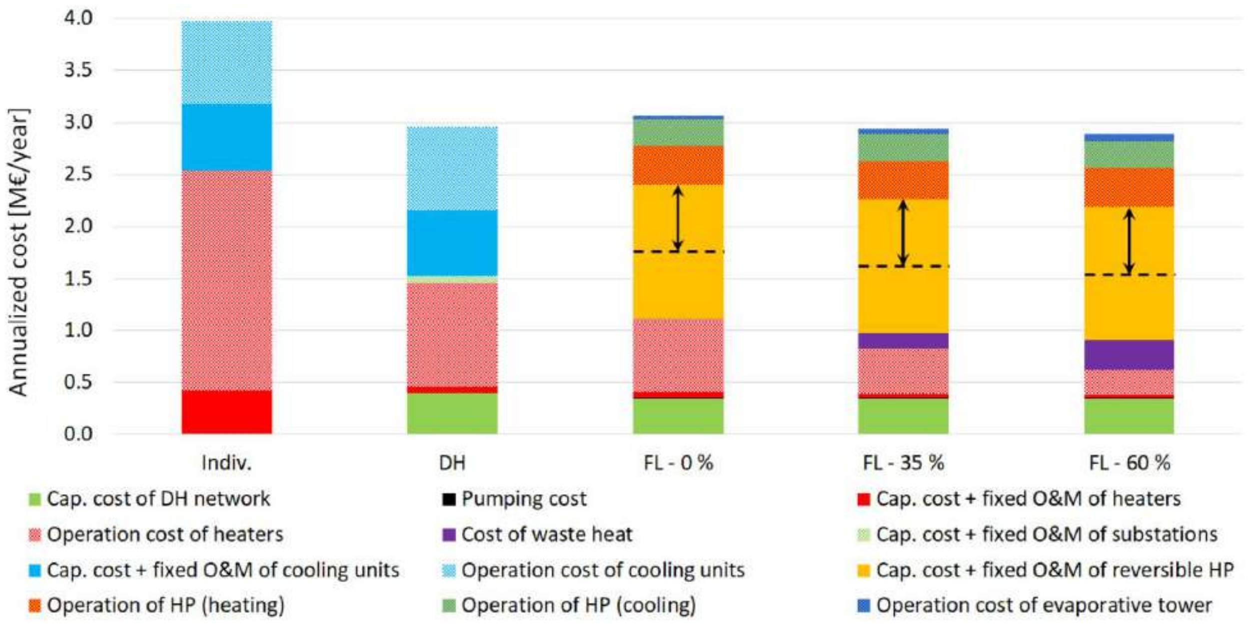
Based on: European Commission et al.- under creative commons licence

https://www.raponline.org/blog/how-clean-is-europes-district-heating/

3. Cost Efficiency

Economies of Scale: Large-scale heat production and distribution systems can reduce costs per unit of heat compared to smaller, decentralized systems.

Stable Energy Prices: District heating can provide more stable and predictable energy costs, particularly when utilizing locally available renewable energy sources.

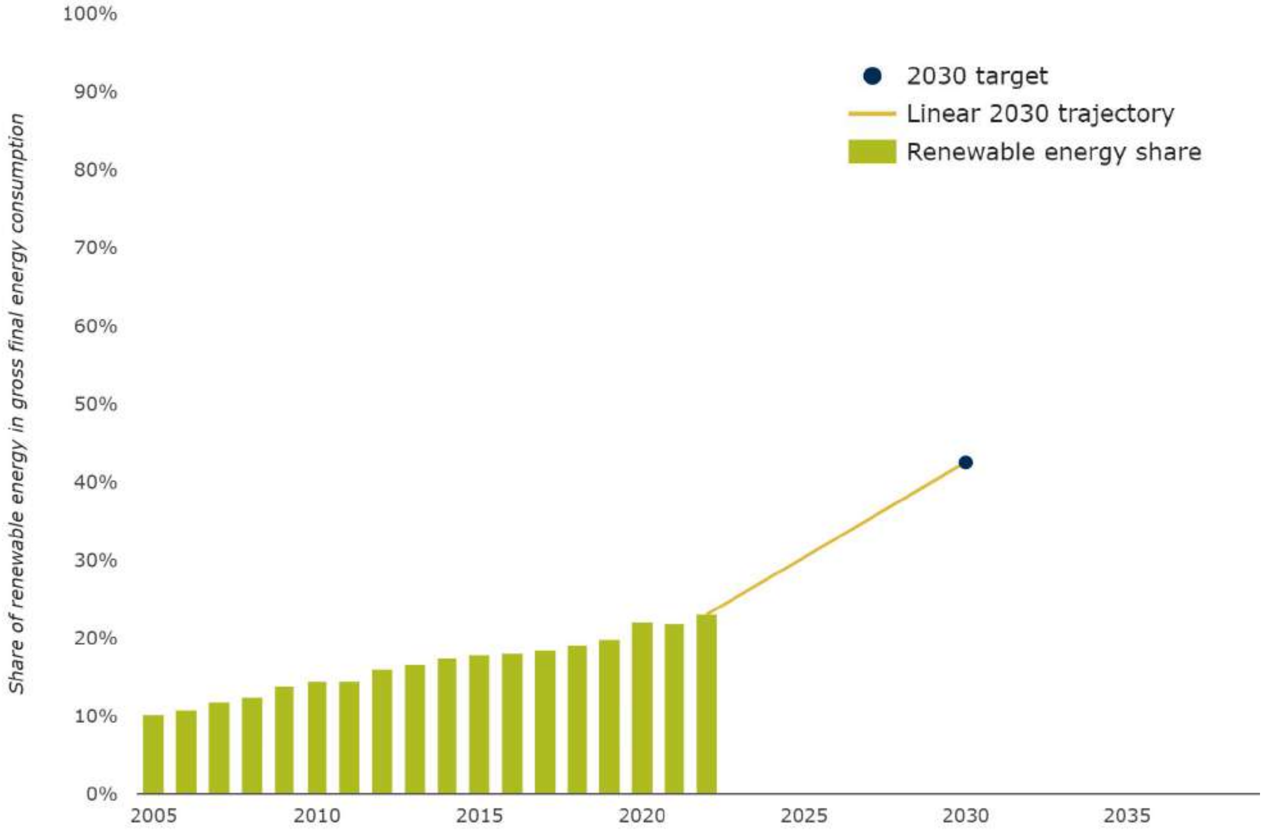


https://heatpumpingtechnologies.org/district-heating-and-cooling-networks-based-on-decentralized-heat-pumps-energy-efficiency-and-reversibility-at-affordable-costs/

4. Flexibility and Integration

Renewable Integration: District heating systems can integrate various renewable energy sources, adapting to changes in energy production and consumption patterns.

Future-Proofing: These systems can adapt to new technologies and energy sources over time, ensuring long-term sustainability and resilience.



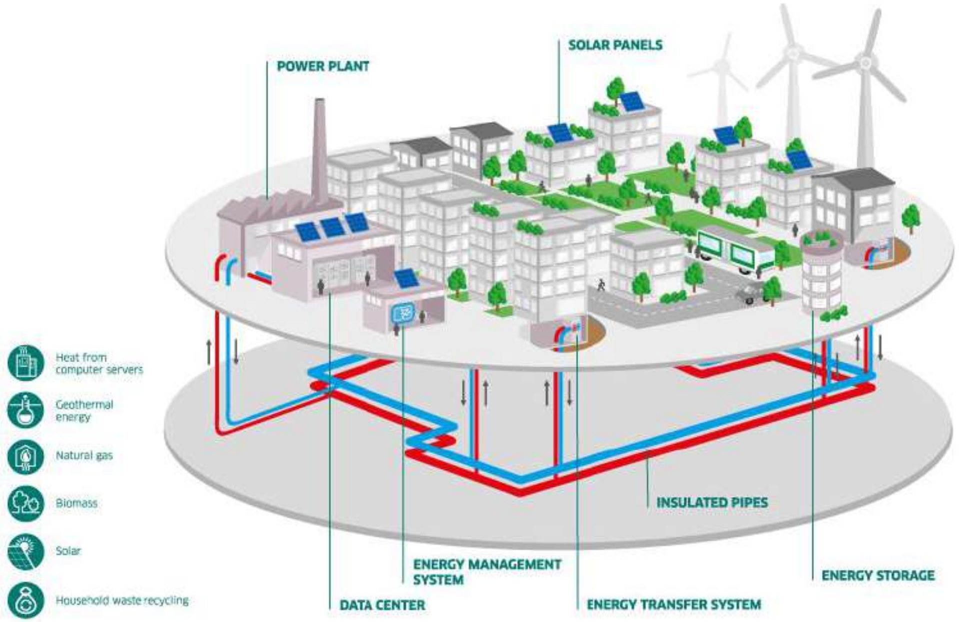
https://www.eea.europa.eu/en/analysis/indicators/share-of-energy-consumption-from

5. Enhanced Urban Planning

Reduced Pollution: Centralized heating reduces the need for individual boilers, decreasing urban air pollution and improving public health.

Efficient Land Use: District heating systems can be integrated into urban infrastructure, optimizing space and reducing the need for large fuel storage facilities within cities.

Let's visit this website to get the full picture of the current situation of district heating in Europe; https://www.wedistrict.eu/interactive-map-share-of-district-heating-and-cooling-across-europe/



What Are The Drawbacks Of District Heating?

1. High Initial Costs

Infrastructure Investment: Establishing a district heating network requires significant capital investment for the construction of central plants, distribution pipes, and building-level installations.

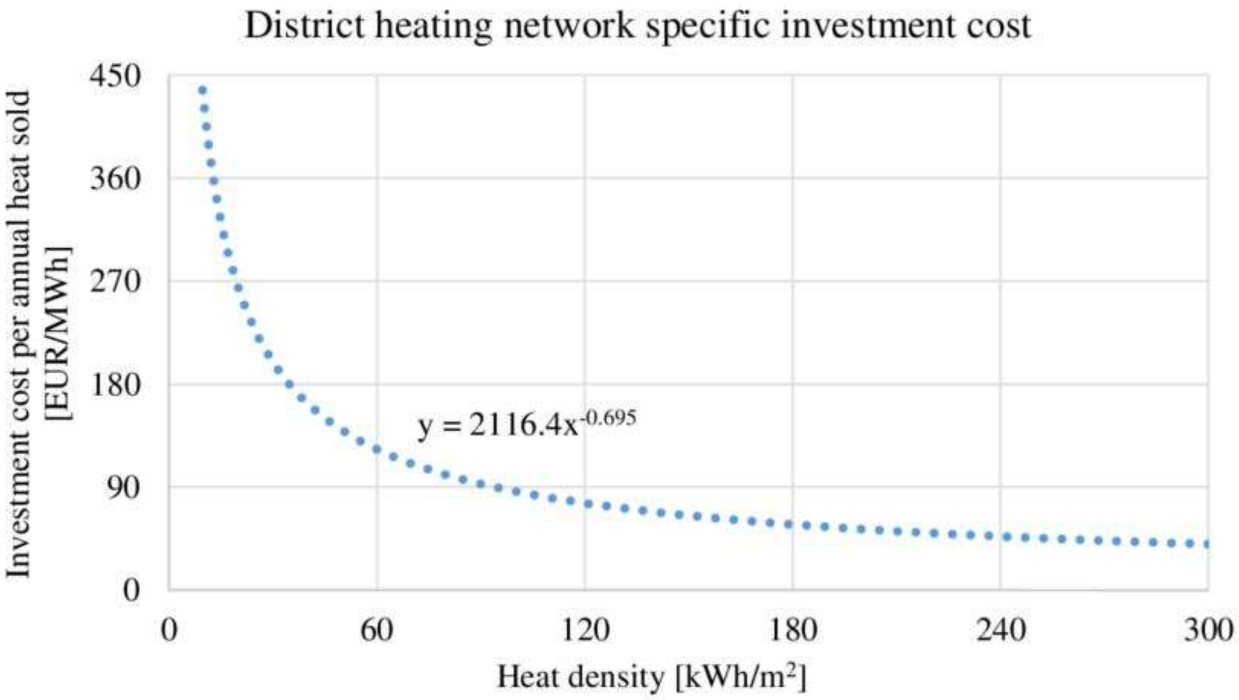
Financial Risk: The high upfront costs and long payback periods can be a financial risk, especially if the demand for heat does not meet projections.

According to a 2023 research, The typical payback period for district heating projects in Europe varies but is generally between 8 to 10 years. The average payback period based on various studies and surveys is around 9 years, with a median of 8.5 years (MDPI). This range can be influenced by several factors, including project scale, funding mechanisms, and local economic conditions.

1. High Initial Costs

The main criteria that usually make district heating suitable in an area include higher densities and waste heat from nearby industries. According to Danish municipalities, areas with a heat density greater than 150 TJ/km² are deemed technically and economically suitable for developing traditional district heating systems.

Generally, initial investment costs can range from €0.5 million to €2 million per kilometer of district heating network laid, depending on factors such as urban density, existing infrastructure, and heat demand density.



https://www.researchgate.net/publication/348623026_Evaluation_of_District_Heating_with_Regard_to_Individual_Systems_-_Importance_of_Carbon_and_Cost_Allocation_in_Cogeneration_Units

1. High Initial Costs

The operation and maintenance (O&M) costs for district heating systems in Europe vary depending on several factors, including the system's size, technology, and local conditions. Typically, these costs range from 1.5 to 3.5 EUR per MWh of heat produced. This variation is influenced by the efficiency of the system, the types of fuels used, and the level of integration with renewable energy sources.

2. Dependency on Centralized Systems

Vulnerability to Disruptions: Centralized systems can be vulnerable to operational disruptions, maintenance issues, or failures in the central plant, which can impact a large number of consumers simultaneously.
Lack of Competition: Monopolistic control by a single district heating provider can lead to less competitive pricing and potential inefficiencies in service provision.

3. Geographical Limitations

Urban Focus: District heating systems are more viable in densely populated urban areas. In rural or sparsely populated areas, the high costs of laying distribution pipes over long distances may not be justifiable.
Resource Availability: The feasibility of district heating depends on the local availability of heat sources, such as biomass, geothermal energy, or industrial waste heat.

4. Complex Implementation and Regulation

Planning and Coordination: Implementing a district heating system requires extensive planning, coordination among stakeholders, and adherence to regulatory standards, which can be complex and time-consuming.

Customer Transition: Convincing existing building owners and residents to switch from individual heating systems to district heating can be challenging and may require incentives or subsidies.

You can find and review the regulation and policy framework on the European Commission website; https://energy.ec.europa.eu/publications/district-heating-and-cooling-european-union_en

Key Components Of A District Heating Network

1. Heat Generation Plant

The system begins with a central plant where heat is produced. The heat can be generated from various sources such as combined heat and power (CHP) plants, waste incineration, biomass, geothermal, solar thermal, and industrial excess heat.

District heating networks in Europe utilize a diverse mix of heat production methods, focusing increasingly on renewable and sustainable sources. Combined heat and power plants, waste-to-energy facilities, geothermal energy, and biomass boilers are some of the most common and effective methods.

✔ Combined Heat and Power (CHP) Plants

Combined heat and power (CHP), also known as cogeneration, refers to an array of proven technologies that concurrently generate electricity and useful thermal energy from the same conventional or renewable fuel sources. CHP is a form of local or distributed generation as heat and power production take place at or near the point of consumption. CHP generally is more energy efficient than the separate generation of electricity and useful thermal energy. CHP can be used to either replace or supplement conventional heat or power. While the traditional method of producing separate heat and power has a typical combined efficiency of 45%, CHP systems can operate at 80% efficiency or higher.

Fuel Sources: Natural gas is the most common fuel for CHP plants, but biomass and biogas are increasingly used to reduce carbon emissions

✔ Combined Heat and Power (CHP) Plants

CHP applications have multiple benefits, including:

- **Increased energy efficiency;** The typical method of separate centralized electricity generation and on-site heat generation has a combined efficiency of about 45%. CHP systems typically achieve total system efficiencies ranging from 60 to 80% for producing electricity and thermal energy. Higher efficiency can translate into lower operating costs, reduced emissions of all pollutants, increased reliability and power quality, reduced grid congestion and avoided distribution losses.

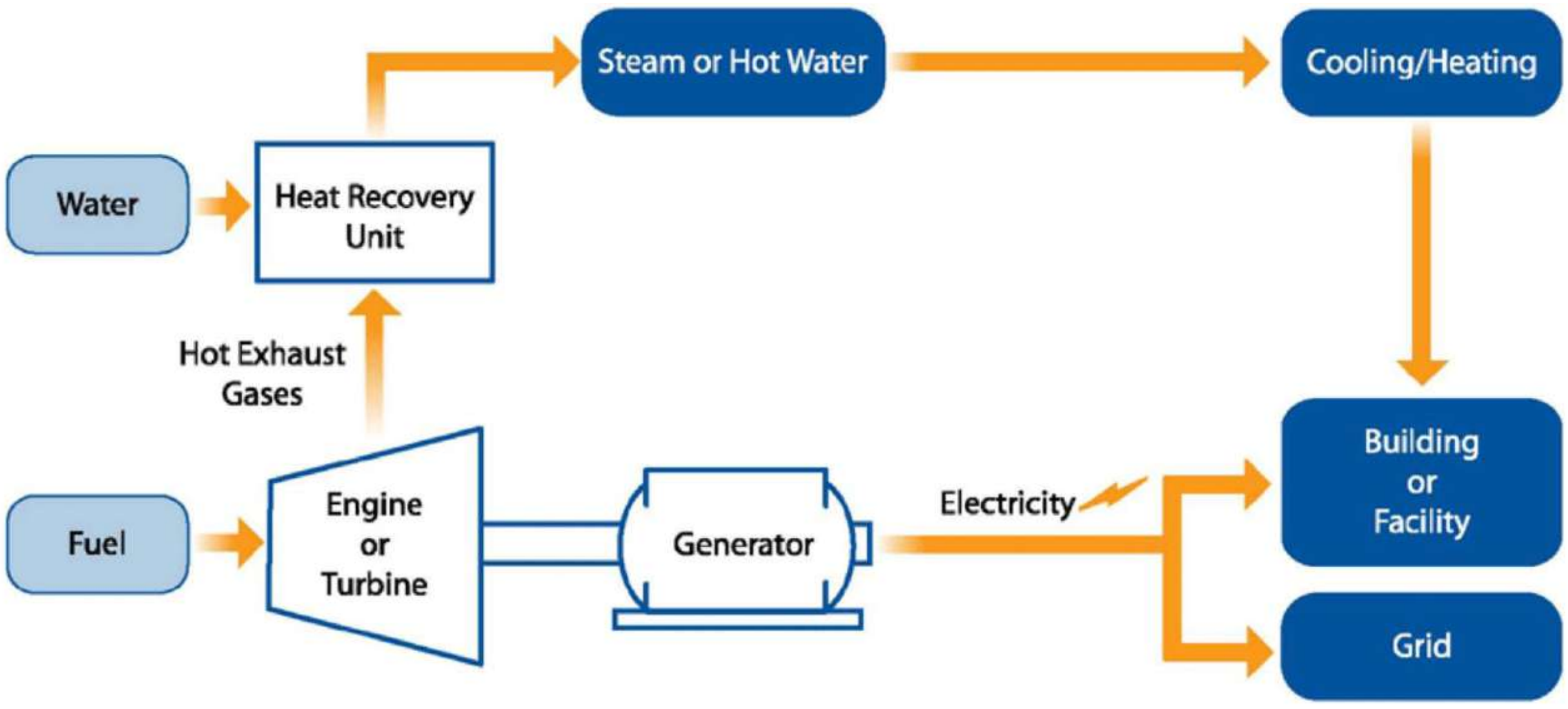
- **Reduced air emissions;** Since less fuel is consumed in CHP applications than equivalent separate heat and power systems to produce the same amount of energy, greenhouse gas emissions, such as carbon dioxide (CO_2), as well as pollutants like nitrogen oxides (NO_x) sulfur dioxide (SO_2) and mercury (Hg), are reduced (in some case by more than 40%).

✔ Combined Heat and Power (CHP) Plants

- **Enhanced grid reliability and resilience;** The properly designed CHP systems can provide critical power reliability for a variety of businesses and organizations. They can provide resilient power for critical services in the face of grid outages or emergencies.

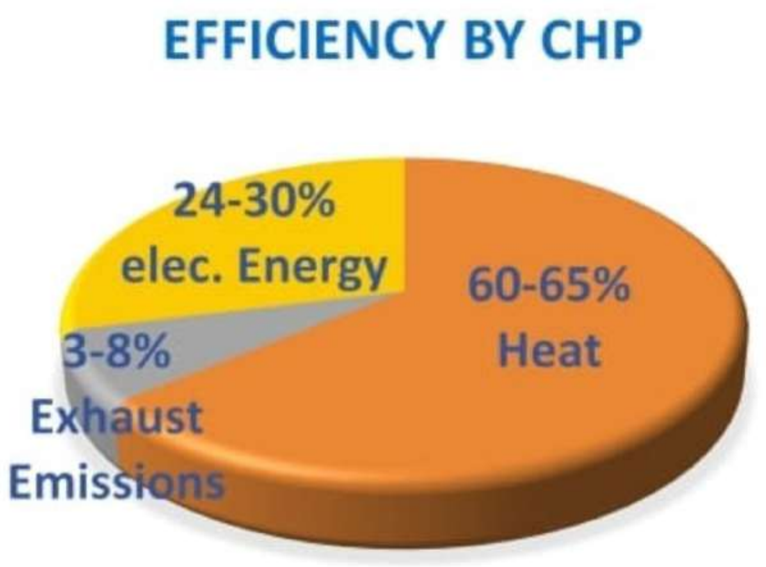
- **Reduced energy and infrastructure costs;** CHP applications offer a variety of economic benefits for large energy users, including lower energy costs, an offset to capital costs, protection of revenue streams, and a hedge against volatile energy prices. Additional investments in new electricity transmission and distribution infrastructure can be deferred or avoided.

✔ Combined Heat and Power (CHP) Plants



https://www.epa.gov/chp/what-chp

✔ Combined Heat and Power (CHP) Plants



http://pacific-int.com/trade/energy/renewable-energy/chp

✔ Combined Heat and Power (CHP) Plants

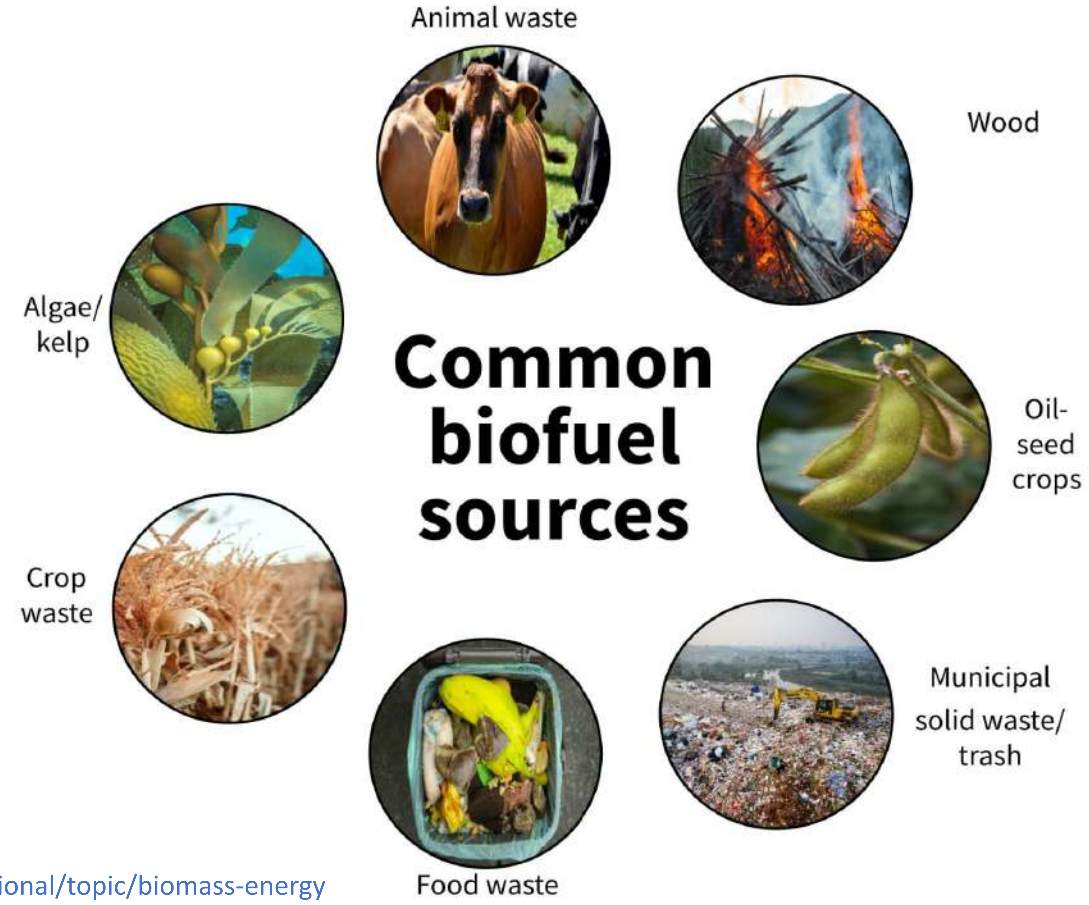
Biomass is a renewable organic material that comes from plants and animals. Biomass contains stored chemical energy from the sun that is produced by plants through photosynthesis. Biomass can be burned directly for heat or converted to liquid and gaseous fuels through various processes.

Biomass is converted to energy through various processes, including:

- Direct combustion (burning) to produce heat
- Thermochemical conversion to produce solid, gaseous, and liquid fuels
- Chemical conversion to produce liquid fuels
- Biological conversion to produce liquid and gaseous fuels

The following is an excellent article laying out the trend in Biomass usage in Europe;
https://energy.ec.europa.eu/news/bioenergy-report-outlines-progress-being-made-across-eu-2023-10-27_en#:~:text=As%20regards%20heating%20and%20cooling,%25)%20and%20biogases%20(5.0%25).

✔ Combined Heat and Power (CHP) Plants



https://www.climatehubs.usda.gov/hubs/international/topic/biomass-energy

✔ Waste-to-Energy Plants

Waste-to-energy uses trash as a fuel for generating power, just as other power plants use coal, oil, or natural gas. The burning fuel heats water into steam that drives a turbine to create electricity. The process can reduce a community's landfill volume by up to 90 percent, and prevent one ton of carbon dioxide release for every ton of waste burned.
Generating electricity in a mass-burn waste-to-energy plant is a seven-step process:

1. Waste is dumped from garbage trucks into a large pit.
2. A giant claw on a crane grabs waste and dumps it into a combustion chamber.
3. The waste (fuel) is burned, releasing heat.
4. The heat turns water into steam in a boiler.
5. The high-pressure steam turns the blades of a turbine generator to produce electricity.
6. An air-pollution control system removes pollutants from the combustion gas before it is released through a smoke stack.
7. Ash is collected from the boiler and the air-pollution control system.

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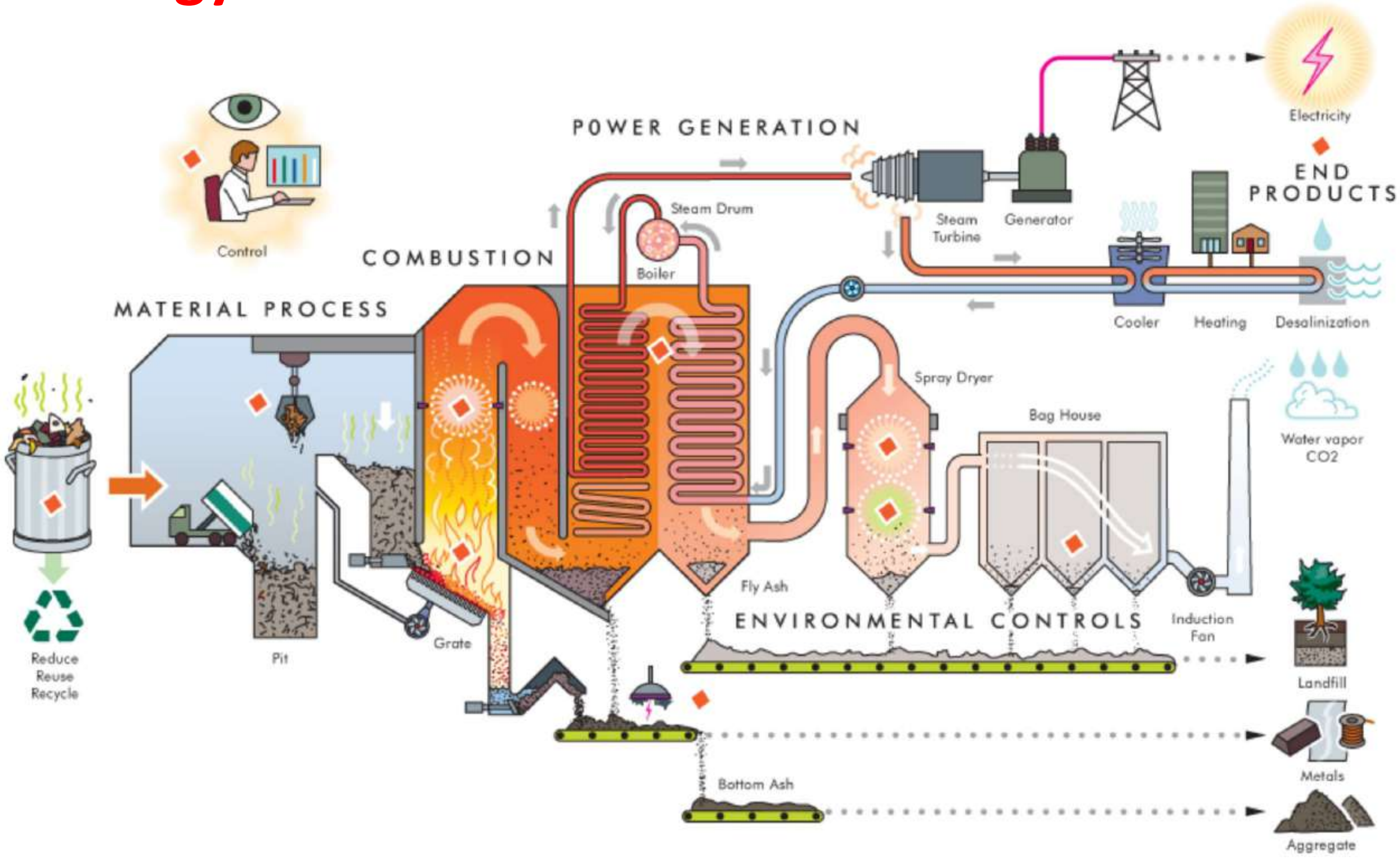
✔ Waste-to-Energy Plants



✔ Geothermal Energy

Geothermal power plants draw fluids from underground reservoirs to the surface to produce heated material. This steam or hot liquid then drives turbines that generate electricity before it is reinjected back into the reservoir.

There are three main types of geothermal power plant technologies: dry steam, flash steam, and binary cycle. The type of conversion is part of the power plant design and generally depends on the state of the subsurface fluid (steam or water) and its temperature.

Let's visit this amazing article to learn more about each type:
https://www.energy.gov/eere/geothermal/electricity-generation#:~:text=Small%20underground%20pathways%2C%20such%20as,drive%20turbines%20that%20produce%20electricity.

Key Components Of A District Heating Network

2. Distribution Network

Supply and Return Pipes: A network of insulated pipes that transport hot water or steam from the heat generation plant to the buildings and return cooler water back to the plant for reheating. The supply pipes carry the heated medium to the buildings, while the return pipes bring back the cooled medium (Technavio Newsroom).

Insulation: Ensures minimal heat loss during transportation, maintaining the efficiency of the system. Pipes are often buried underground to protect them and reduce heat loss.

This step requires extensive planning and optimization which can only be achieved by hiring an experienced contractor.

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2. Distribution Network

Here are some of the major players in District heating network design:

- EFENCO OU, Estonia; https://efenco.eu/
- Stockholm Exergi, Sweden; https://www.stockholmexergi.se/
- RIFT, Netherlands; https://www.ironfueltechnology.com/
- Skyfora, Finland; https://www.skyfora.com/

You can find more contractors using the links below;

- https://www.ventureradar.com/keyword/district%20heating
- https://www.marketsandmarkets.com/ResearchInsight/district-heating-market.asp

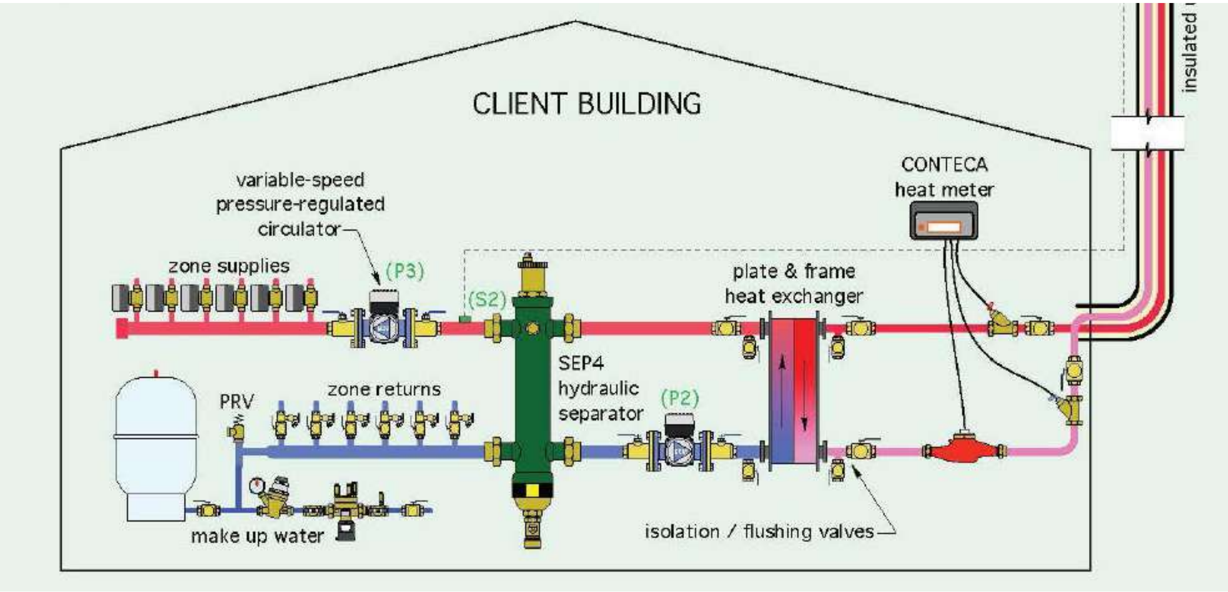
Key Components Of A District Heating Network

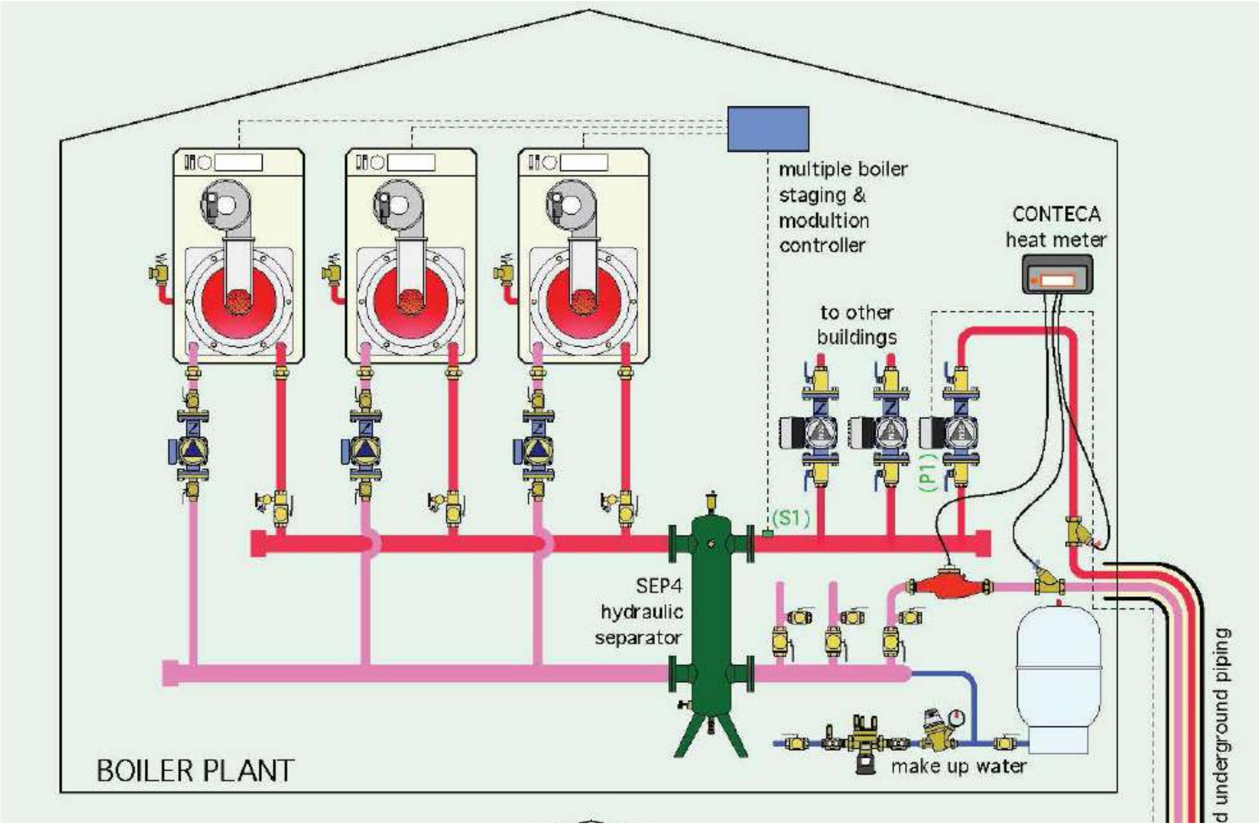
3. Heat Exchangers

Building-Level Heat Exchangers: Transfer heat from the district heating network to the building’s internal heating system. They separate the primary circuit (district heating network) from the secondary circuit (building’s heating system), preventing any direct mixing of water.

The heat from the boiler plant is distributed to multiple “client” buildings through insulated underground piping. The layout of this distribution piping depends on the locations of the client buildings. When the buildings are located along a street, a 2-pipe direct return piping system is typically used and installed parallel to the street. When the buildings form a cluster around the boiler plant, a homerun piping distribution system is appropriate.

3. Heat Exchangers





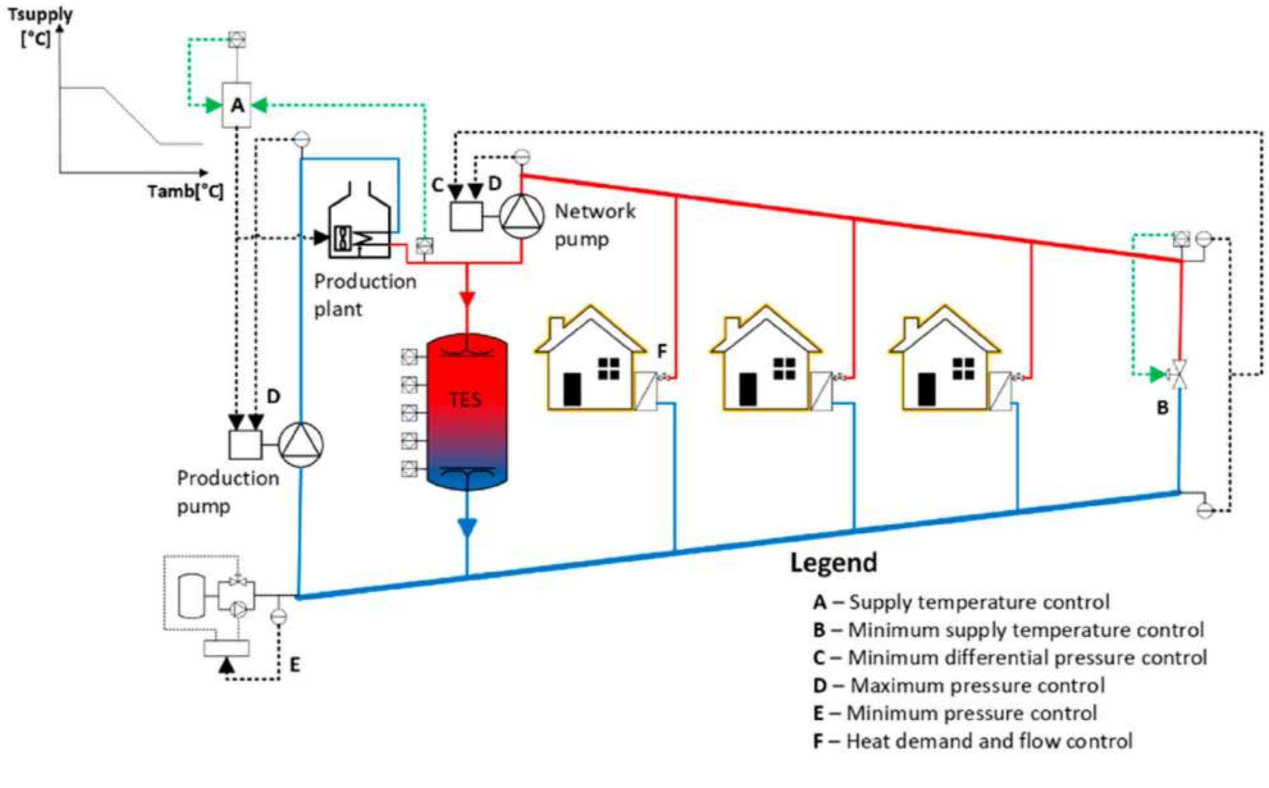
https://idronics.caleffi.com/article/6-heat-exchanger-applications

Key Components Of A District Heating Network

4. Control Systems

Central Control Systems: Monitor and control the temperature and flow of the hot water or steam throughout the network. These systems ensure efficient operation and respond to varying heat demands.

Building-Level Controls: Include thermostats and automated valves that regulate the heat output to meet the specific needs of each building.



Basic control strategies in traditional district heating (DH) systems.

https://www.mdpi.com/2076-3417/11/1/455

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Key Components Of A District Heating Network

5. Pumping Stations

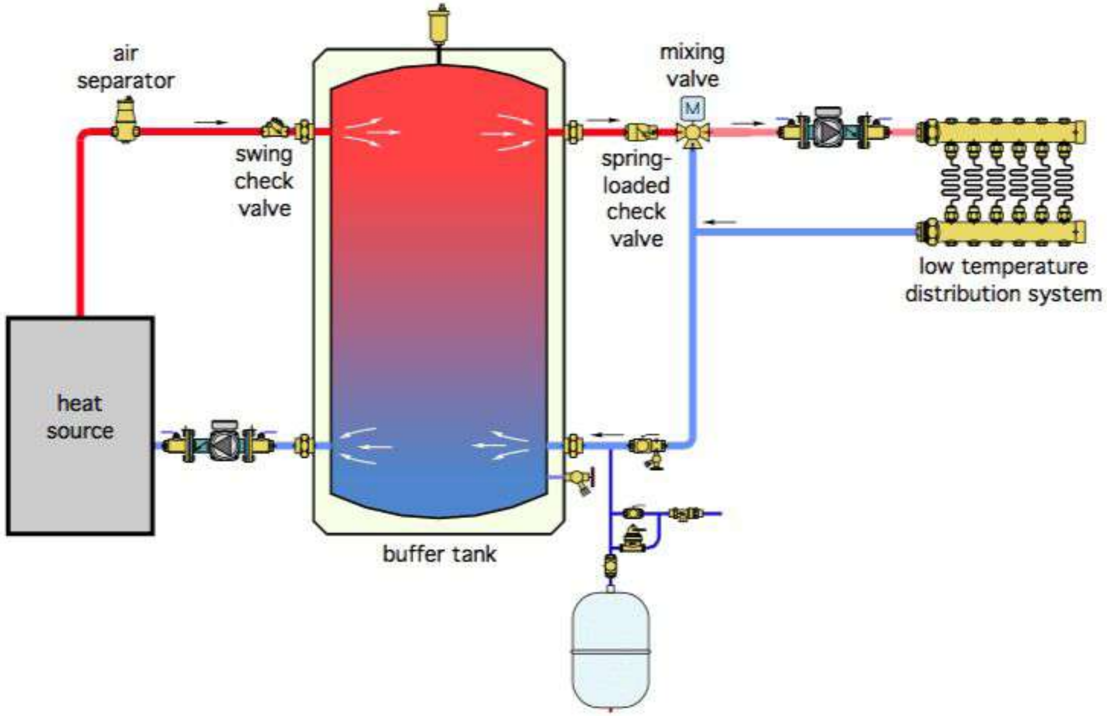
Primary Pumps: Located at the heat generation plant, these pumps move the heated medium through the supply pipes to the buildings.

Secondary Pumps: These can be located at various points in the distribution network to boost pressure and ensure efficient heat distribution over long distances or to higher elevations.

Key Components Of A District Heating Network

6. Thermal Storage

Buffer Tanks: Large insulated tanks that store excess heat produced during low-demand periods. This stored heat can be used during peak demand times, improving the stability and efficiency of the heating network.

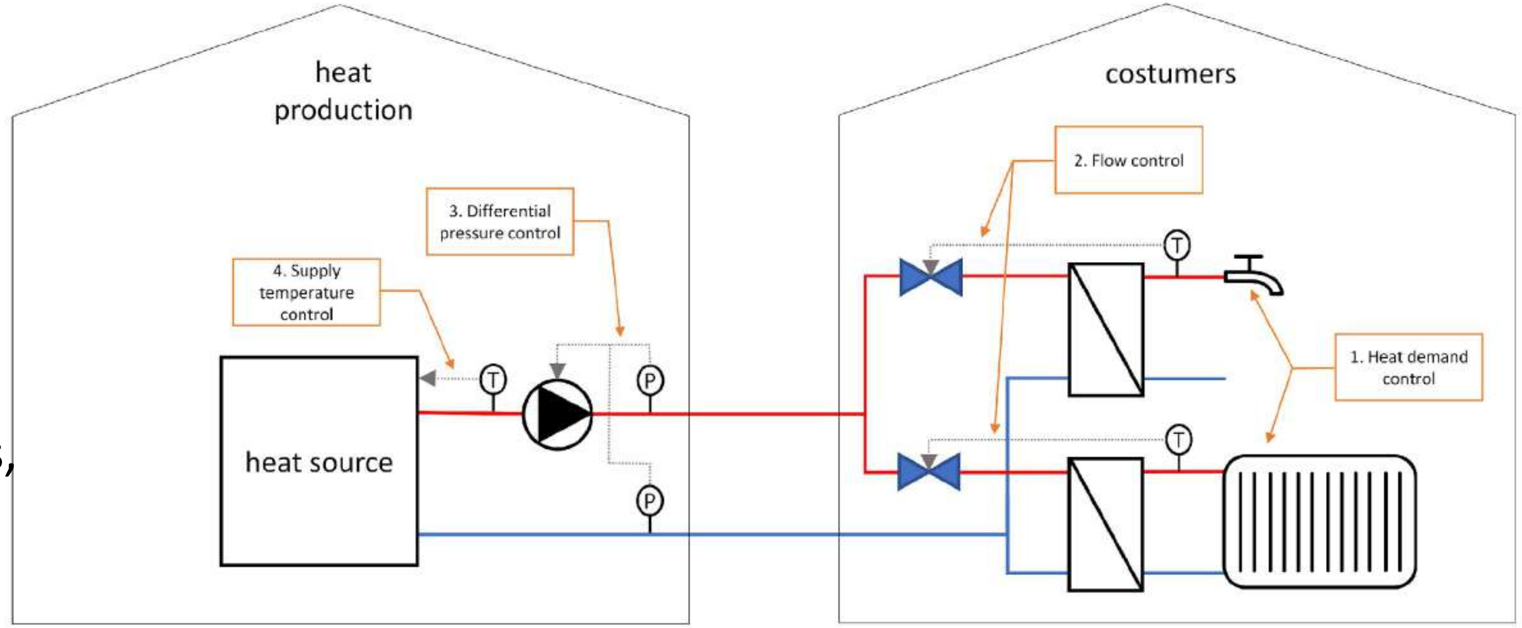


Key Components Of A District Heating Network

7. Monitoring and Metering Systems

Energy Meters: Installed in buildings to measure the amount of heat consumed. This data is used for billing purposes and to monitor system performance.

Sensors and Data Collection: Provide real-time data on temperature, flow rates, and system pressures, which are critical for efficient network management.

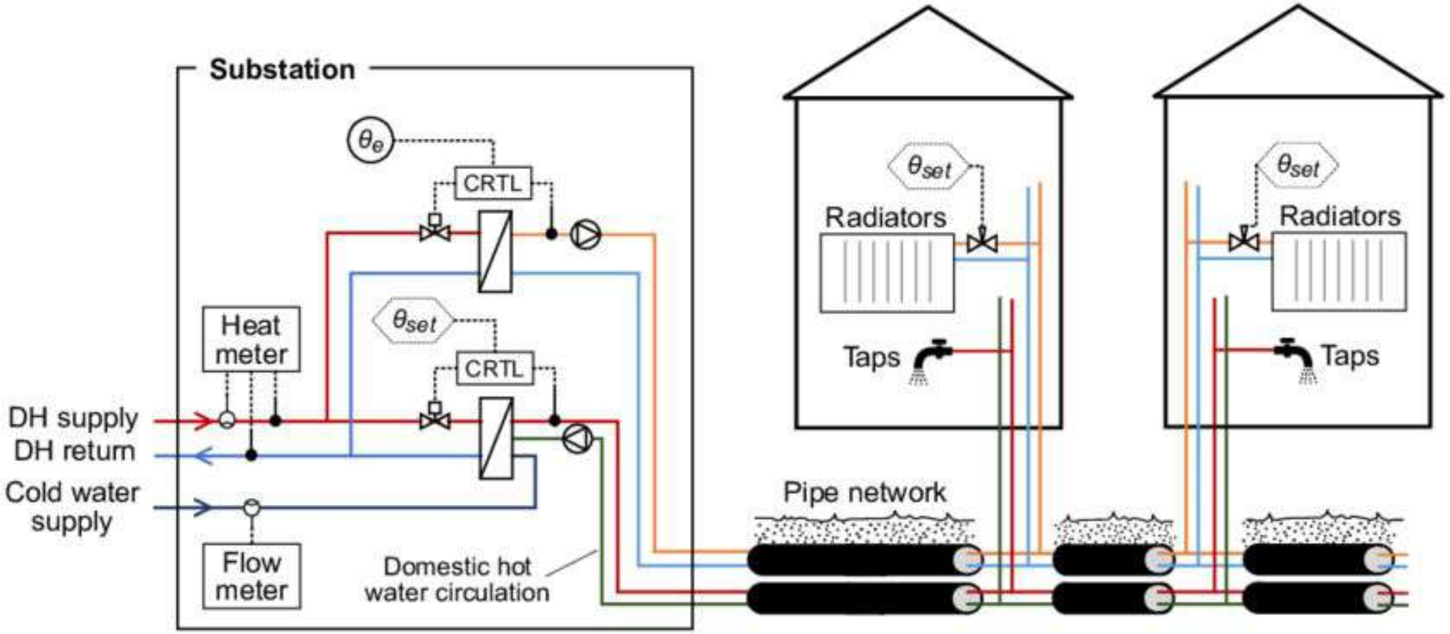


https://www.mdpi.com/2076-3417/11/13/6112

Key Components Of A District Heating Network

8. Substations

Intermediate Substations: In large or complex networks, substations are used to further distribute heat within specific areas or neighborhoods. They can also house additional pumps and heat exchangers to boost system performance.



https://www.researchgate.net/figure/A-district-heating-substation-serving-multiple-buildings_fig7_343760670

Examples And Best Practices

- **Jokkmokk Municipality, Sweden**

Jokkmokk Municipality, Sweden

Jokkmokk municipality has about 5000 inhabitants in an area of 19 334 km². Jokkmokk district heating company successfully works to increase the cooling performance in district heating sub-stations. A sub-station with poor cooling extracts less energy per unit volume of water. That means an overconsumption of flow to meet the consumers' heat demand. The positive effects of increased cooling are particularly reduced heat losses in the district heating network and efficiency increase for flue gas condensation. In Jokkmokk's case, the fuel demand has decreased by about 435 MWh due to an efficiency increase in flue gas condensation. About 570 MWh has reduced the pipeline losses70 MWh, but more energy for pumping was needed, approximately 6 MWh.

Jokkmokk's district heat plant sells about 34 GWh of heat annually. The heat is delivered to 522 customers, of which 332 are households. About 99% of the heat is produced with wood chips, bark and wood pellets. A 17 MW wood chip boiler is used during the main part of the year. A pellet boiler of 3 MW is used end of May to mid-September.

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Jokkmokk Municipality, Sweden

Investment costs for materials were about 1200 € and labor costs about 9000 €, while the cost saving is about 14 815 €/year. However, it is important to notice that most economic projects for maintenance of sub-stations have been done now, the next projects will most likely be less profitable.

Energy efficiency

Asset owner: Jokkmokk district heating, Sweden

Used assets: District heating network and its sub-station

Cost saving potential: 14 815 €/year

Environmental benefits: + 3,5% energy efficiency; - 210 kg NOx/yr; - 100 kg CO/yr

Investment costs: 10 200 €

Payback time: less than 1 years

Jokkmokk Municipality, Sweden

Points of success:

- New measuring units will allow for good control of flow for each customer
- Making efficiency a priority
- Educated staff
- Political commitment

Jokkmokk is a Swedish Eco-Municipality and a signatory of the EU Covenant of Mayors. It has developed its Sustainable Energy Action Plan and is committed to reducing its greenhouse gas emissions by at least 20% by 2020, compared to 2005. Another success factor for a district heating efficiency campaign is the lower cost both for the company and the customers.

Examples And Best Practices

- Kiruna Municipality, Sweden

Kiruna Municipality, Sweden

Kiruna aims for 100 percent waste heat.

Kiruna municipality plans to gradually change the fuel mix for the district heating system. Waste heat from LKAB mining company will in the long run be responsible for the entire district heating.
Around 2040, the goal is for Kiruna to be heated entirely with waste heat.

Today, 90 % of Kiruna's properties and 30 % of residential buildings are connected to district heating. The system is based on a mix of waste (55 %, mostly from Norway), biofuel (20 %) and waste heat (25 %).

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Kiruna Municipality, Sweden

It is the waste heat from LKAB's pellet plant that will eventually be the basis for all district heating in the city, according to an agreement that was concluded between the mining company and the municipality.

Energy storage in the mountain:
To meet the entire municipality's heating needs even during cold winter days, the waste heat from LKAB is not enough. That is why Kiruna has investigated the possibilities of energy storage in boreholes - storing LKAB's waste heat during the summer.

More Information on;
https://www.energi.se/artiklar/2024/januari-2024/kiruna-siktar-pa-100-procent-restvarme/

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District Heating Alternatives; Local Heat Production

Despite the numerous advantages of district heating, it is not always a feasible solution for every area. In certain regions, the load calculations may indicate that district heating would not be energy-efficient or cost-effective. This is particularly true in less densely populated areas or where the heat demand is too low to justify the infrastructure investment. In such cases, localized heat generation systems can offer a more practical alternative to meet energy needs while maintaining economic viability and sustainability.

“So, what is the alternative way?” you might ask!

Well, there are a couple! Let’s dive into them now.

Heat Pumps

A **heat pump** is a device that transfers heat from one place to another, rather than generating heat by burning fuel. It works like an air conditioner or refrigerator, but it can also work in reverse to heat your home.

In simple terms:

- In **heating mode**, the heat pump pulls heat from the outside air (or ground, depending on the type) and brings it inside your home, even when it's cold outside.

- In **cooling mode**, it reverses the process, removing heat from inside your home and releasing it outside, just like an air conditioner.

This process uses electricity to move heat, making it a very efficient and eco-friendly way to heat and cool a home because it uses less energy compared to traditional systems that burn fuel.

Air-source heat Pumps

The most commonly used type of heat pump is the **air-source heat pump** (ASHP). This is primarily due to its affordability, ease of installation, and versatility. Air-source heat pumps transfer heat between the outside air and your home, and they are widely popular because:

1. **Lower upfront costs**: Compared to other types like ground-source (geothermal) heat pumps, air-source systems have significantly lower installation costs, making them accessible to more homeowners.

2. **Ease of installation**: ASHPs are easier and faster to install than ground-source systems, which require extensive land excavation.

The outdoor unit of an Air-source heat pump

https://www.uswitch.com/gas-electricity/green-energy/air-heat-pump/

Air-source heat Pumps

3. Versatility: They can be used for both heating and cooling, making them an all-in-one solution for year-round comfort.

4. Technological advancements: Modern ASHPs are highly efficient, even in colder climates, making them viable in many regions that were previously unsuitable.

Due to these factors, air-source heat pumps are the most widely adopted for residential and commercial applications globally.

Common in residential and commercial settings due to their versatility and ease of installation.

The indoor unit of an Air-source heat pump

https://www.islandinstitute.org/working-waterfront/heat-pumps-harvest-warmth-from-cold-air/

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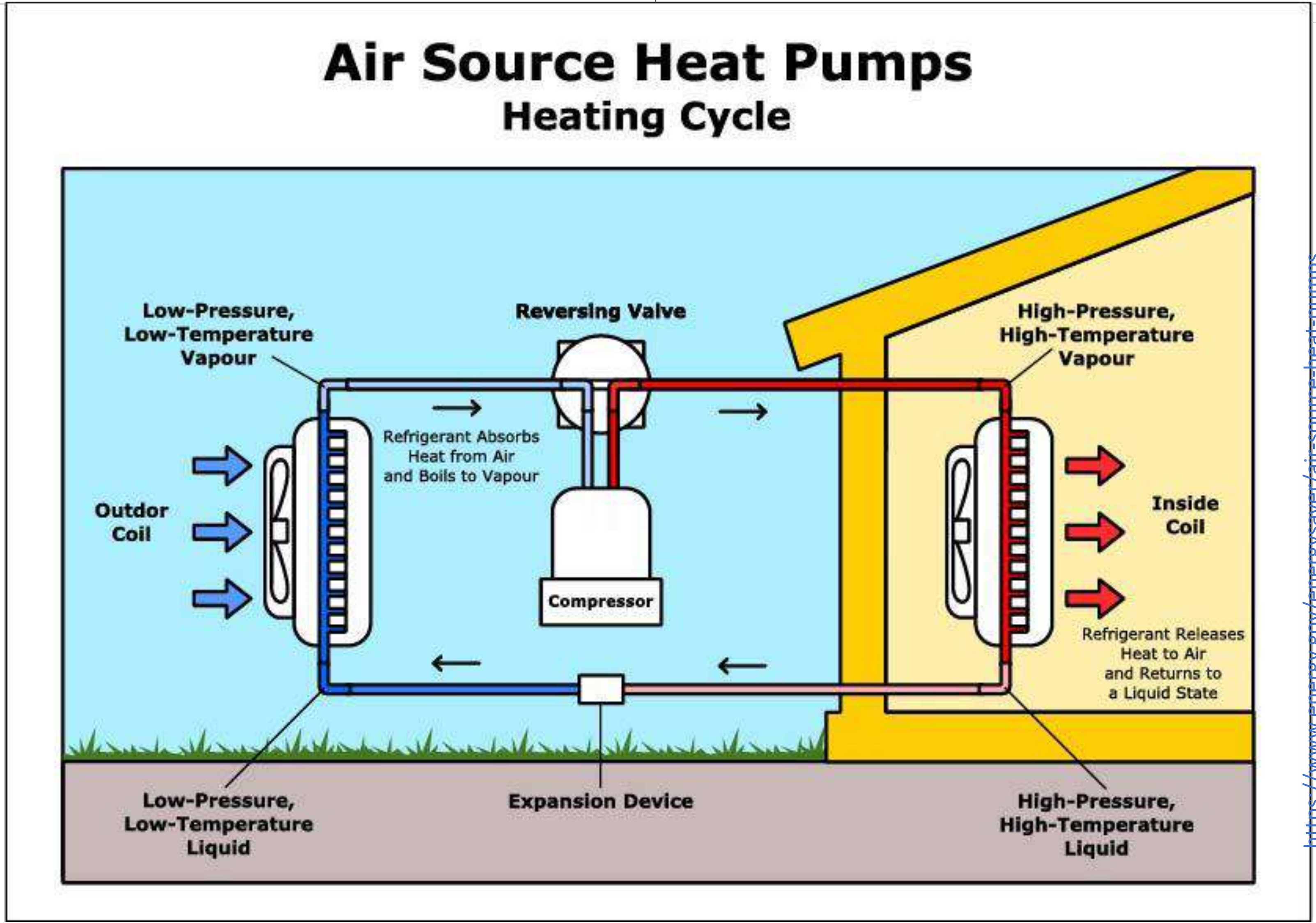


https://www.energy.gov/energysaver/air-source-heat-pumps

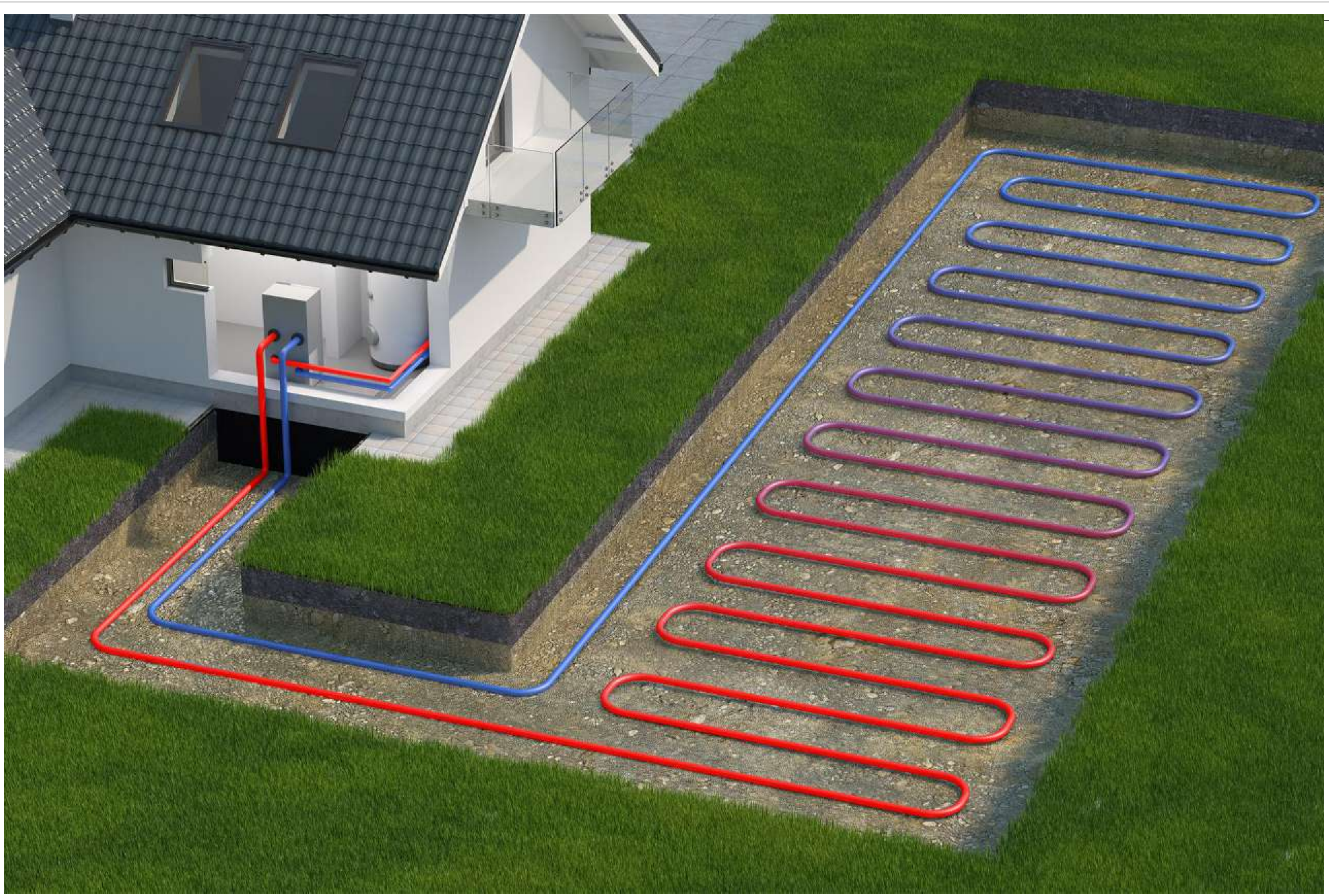
Ground-source (Geothermal) Heat Pumps

Configuration: Consist of an indoor unit connected to a ground loop system buried underground.

Function: The ground loop absorbs heat from the earth, which remains at a relatively constant temperature, providing efficient heating and cooling.

Usage: Best suited for new constructions or properties with sufficient land for installing the ground loops.

https://www.self-build.co.uk/ground-source-heat-pumps-guide/



https://www.checkatrade.com/blog/cost-guides/ground-source-heat-pump-cost/

Water-Source Heat Pumps

Configuration: Include an indoor unit and a separate component connected to a nearby water source, such as a lake, pond, or well.

Function: Utilize the stable temperature of the water source to transfer heat, offering efficient heating and cooling.

Usage: Applicable in areas where a reliable and accessible water source is available.

https://www.self-build.co.uk/water-source-heat-pumps-is-it-right-for-your-self-build/

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German company to build world's largest heat pump in Helsinki

By Nikolaus J. Kurmayer | Euractiv Est. 2min

28 Aug 2024 (updated: 3 Sept 2024)

https://www.euractiv.com/section/energy-environment/news/german-company-to-build-worlds-largest-heat-pump-in-helsinki/

Solar Thermal Systems

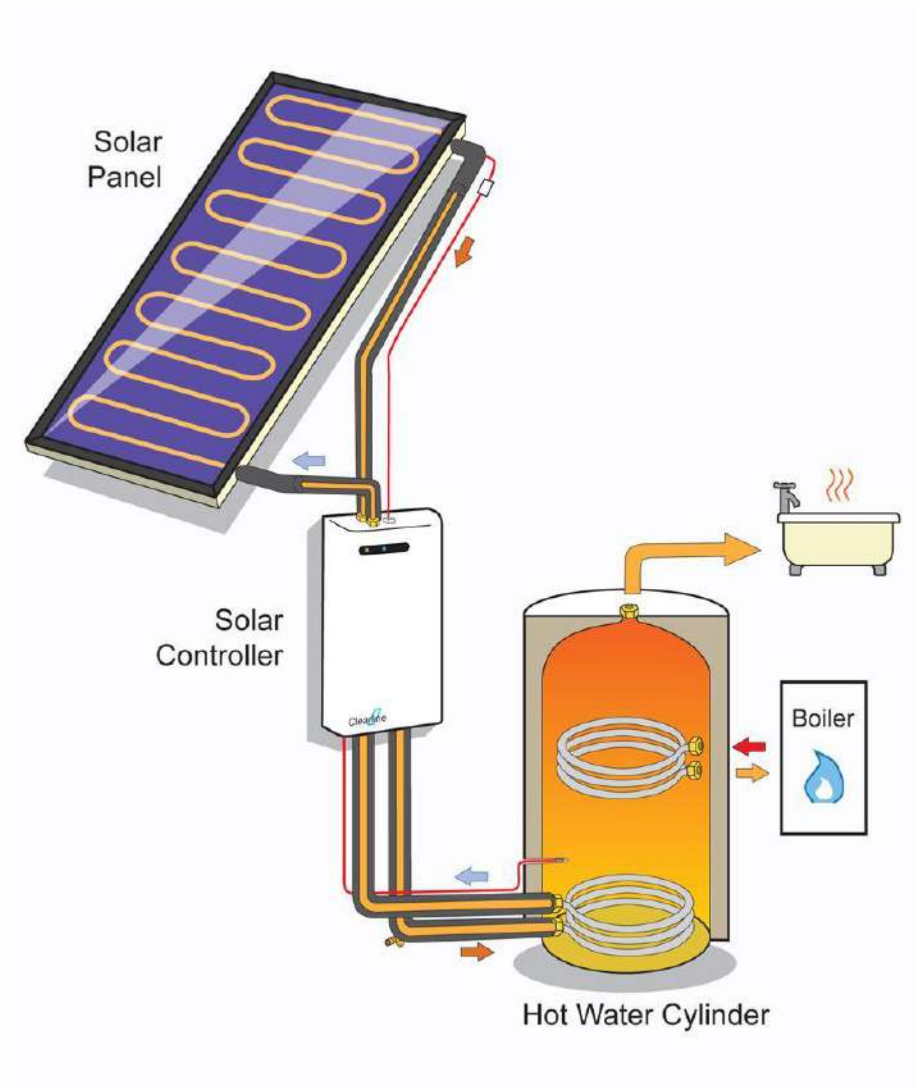
A **solar thermal system** uses the sun's energy to heat water or air, which can then be used to provide heating for your home or hot water.

In simple terms:

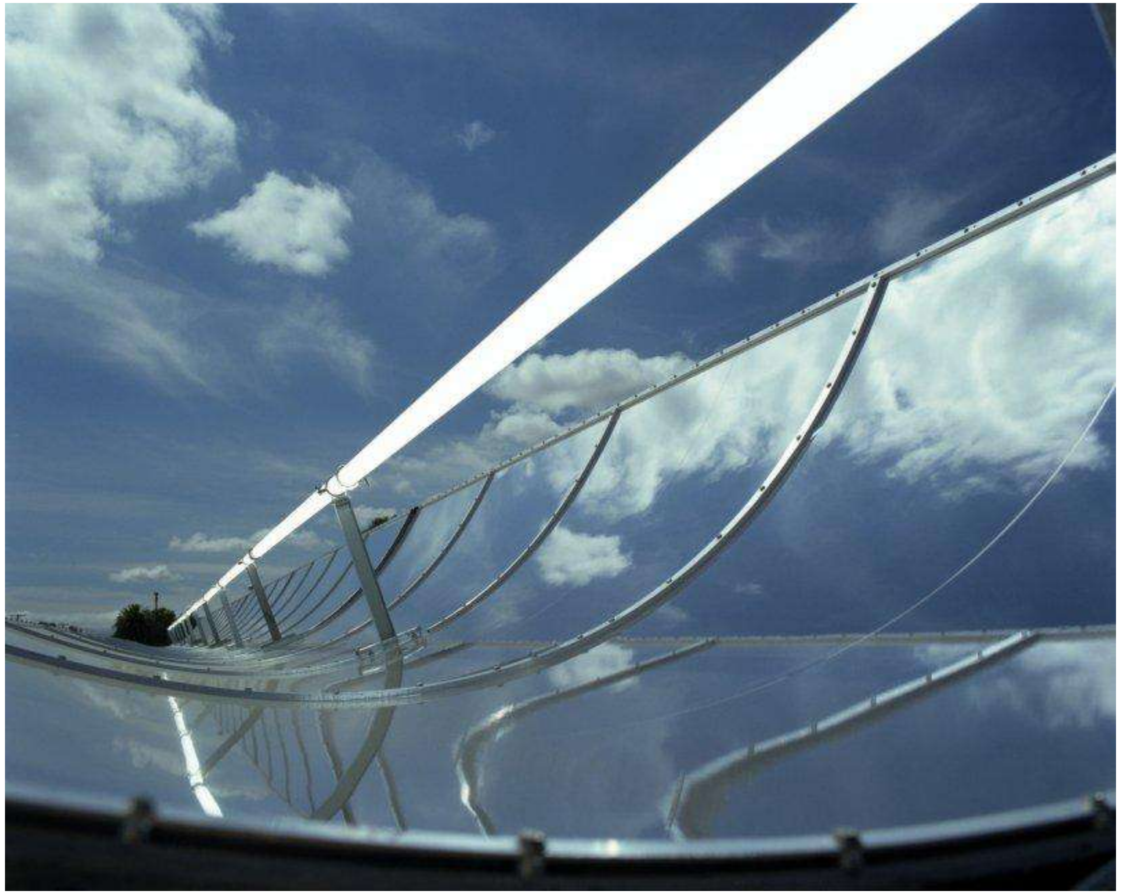
1. **Solar panels** on the roof absorb sunlight, which heats a fluid (usually water or an antifreeze solution) that flows through the panels.

2. The heated fluid is then transferred to a **storage tank** or directly into a system that distributes the heat, such as a radiator or underfloor heating.

3. The heated water or air can be used for **hot water** in the house or to heat rooms during colder months.



https://www.viridiansolar.co.uk/resources-3-0-solar-heating.html



https://energy.gov/eere/solar/articles/line-focus-solar-collector

Radiant Heating

Radiant heating is a system that warms up your home by directly heating surfaces, like floors, walls, or ceilings, rather than heating the air like traditional systems.

In simple terms:

1. **Heat is transferred** through a network of pipes or electric heating elements embedded in the floor or other surfaces.

2. These surfaces then **radiate heat**, warming objects and people in the room directly.

3. The result is a more comfortable and even warmth without the need for blowing air, as seen with conventional heating systems.

Radiant Heating

This system is very efficient because it eliminates heat loss through ducts and provides consistent warmth throughout the space. It's also quieter and can improve air quality by reducing the circulation of dust and allergens. Radiant heating is commonly used in floors, known as underfloor heating, but can also be applied to walls or ceilings.

https://orangecoastplumbing.net/2023/01/radiant-heating-system-pros-cons/

Biomass Heating

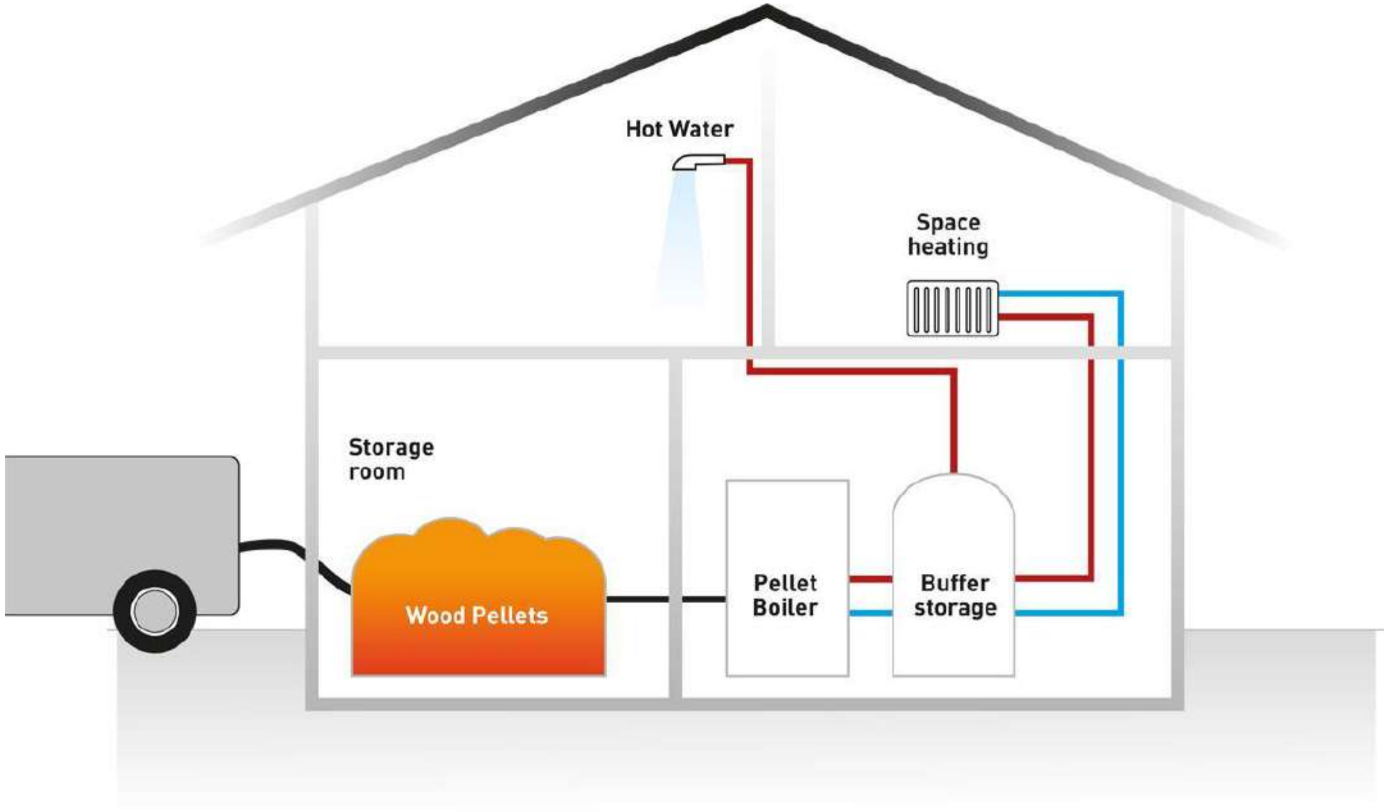
Biomass heating is a system that generates heat by burning organic materials, such as wood, wood pellets, or agricultural waste, instead of using fossil fuels like oil or gas.

In simple terms:

1. You **burn organic materials** like wood or plant matter in a boiler or stove.
2. The heat produced from burning these materials is used to **warm water or air**, which then heats your home.
3. Since the fuel comes from renewable sources, like wood from sustainably managed forests or agricultural leftovers, biomass heating is considered more environmentally friendly.

Radiant Heating

This system reduces reliance on fossil fuels and can help lower carbon emissions, as long as the organic materials are sustainably sourced. It’s commonly used in areas where wood or other biomass fuels are easily available.



https://www.espenergy.co.uk/products/biomass-boilers

Wrap Up!

In conclusion, district heating remains the preferred method for providing heat due to its numerous advantages, including lower operational costs and higher energy efficiency compared to local heat production solutions. However, district heating is only viable in areas where the heat demand is substantial enough to justify the initial infrastructure investment. In cases where district heating is not feasible, localized heat generation using the sustainable methods discussed in this presentation, such as heat pumps, biomass heating, and solar thermal systems, provides an effective and environmentally friendly alternative.

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Thank You for your attention!

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