IRENA
International Renewable Energy Agency

Renewable energy technology and infrastructure

19 April 2023

Designing modern municipal network systems with renewable energy to achieve district energy decarbonization in Southeastern Europe

Workshop on District Heating and Cooling - Sarajevo

Agenda

Introduction to modern district energy systems

Designing new DHC projects

Designing DHC refurbishment projects

Key takeaways/ Final considerations

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Key takeaways/ Final considerations

District Energy Systems - Introduction

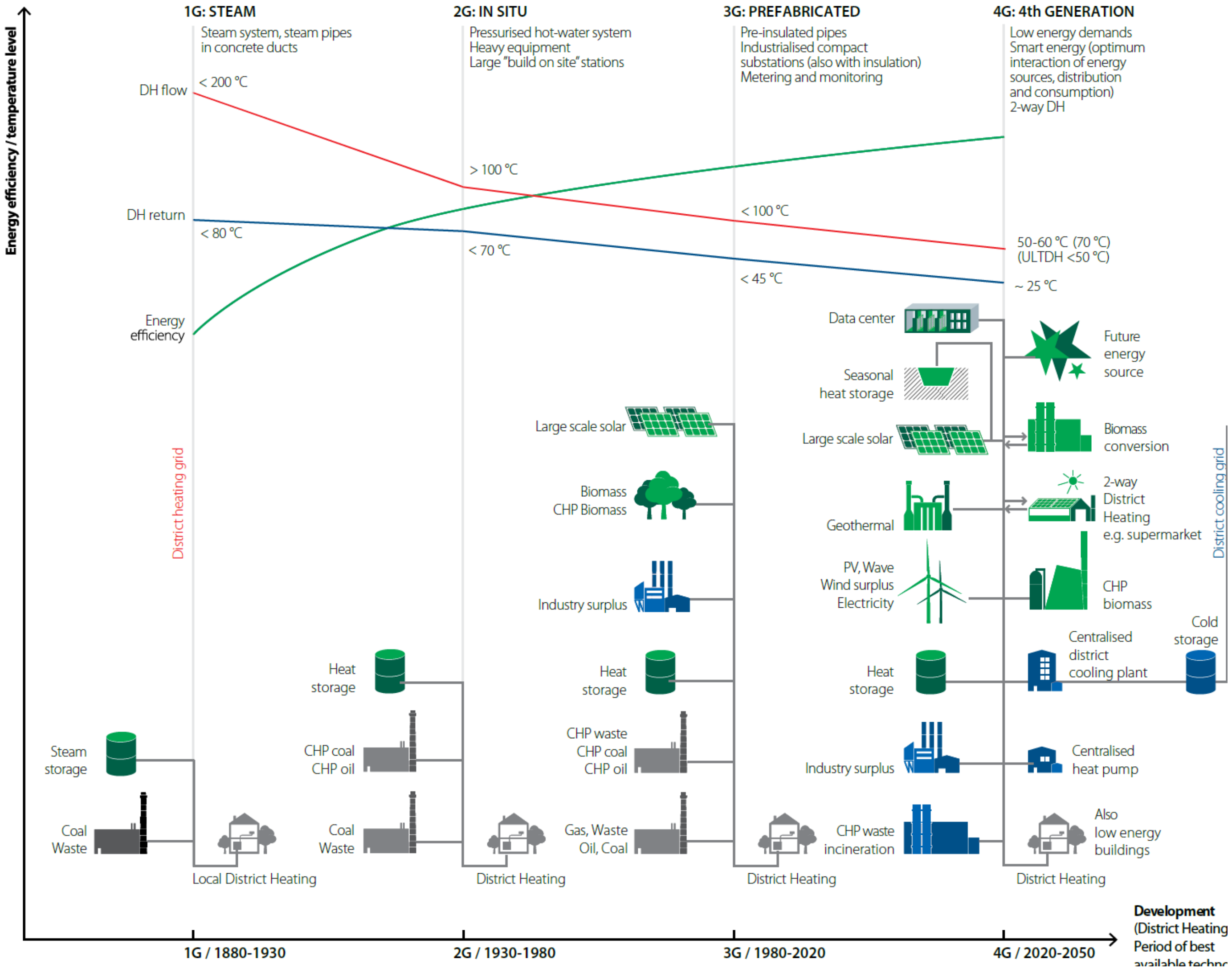
When should we consider District Energy Systems?

- High heat/cooling density areas
- The utilisation of fuel in centralised production units is higher than the associated heat losses across distribution networks

Benefits of district energy systems

- Economies of scale
- High level of security of supply
- Higher level of comfort at lower levels of effort than individual production
- Reduce carbon intensity in buildings sector, by enabling integration of RE sources
- Displacement of individual units

District Energy Systems – New generations



- Decreasing temperatures
- Bidirectional flows (heating and cooling)
- Integration of new sources and technologies
  - New storage technologies
  - Shifting away from fossil fuels

➢ Increased efficiency and higher decarbonization

Energy-efficient buildings also play an important role!

Source: Lund et. al (2018)

District heating

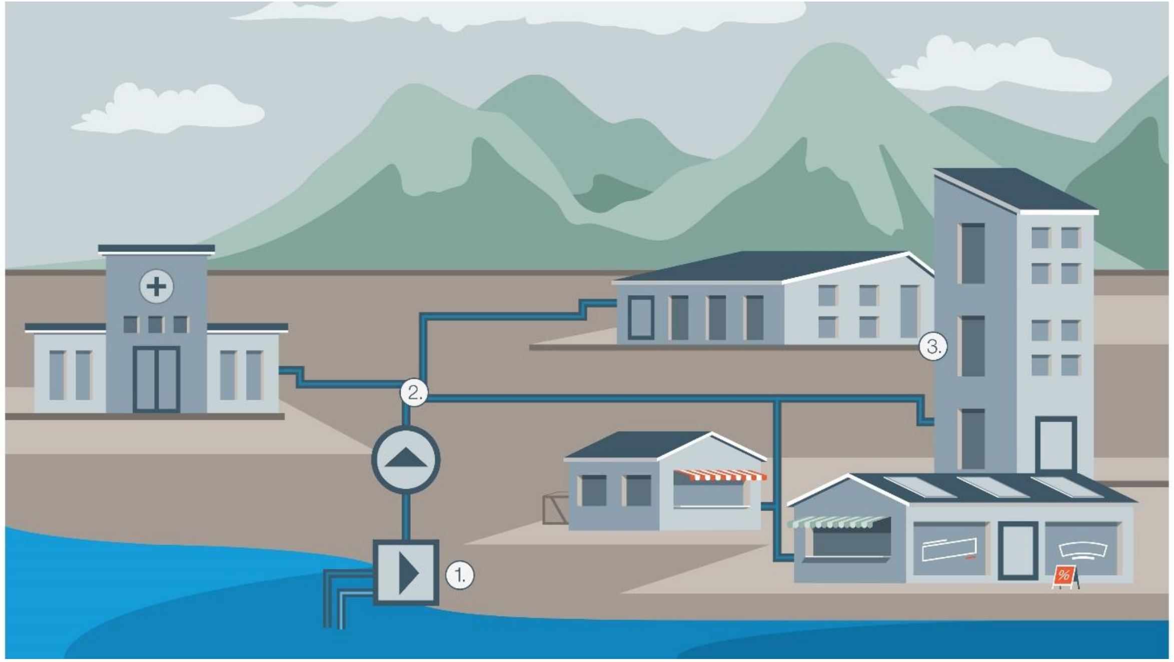
(1) District heating production, (2) Power supply, (3) transmission pipeline network, pump and distribution pipeline network, (4) Heat demand at consumers in residential or commercial buildings.

Common uses of DH are space heating and domestic hot water in households, public buildings, and service sector

DH is most often supplied by:

- Surplus heat from combined heat and power (CHP) production where district heat provides cooling for electricity production and replaces large cooling towers
- Surplus heat from industries, in some scenarios replacing cooling towers
- Surplus heat from cooling units
- Heat from electric boilers and heat pumps, using surplus power from RE sources (RES) such as wind power, solar, and others
- Heat from municipal waste incineration, both heat-only and CHP

District cooling

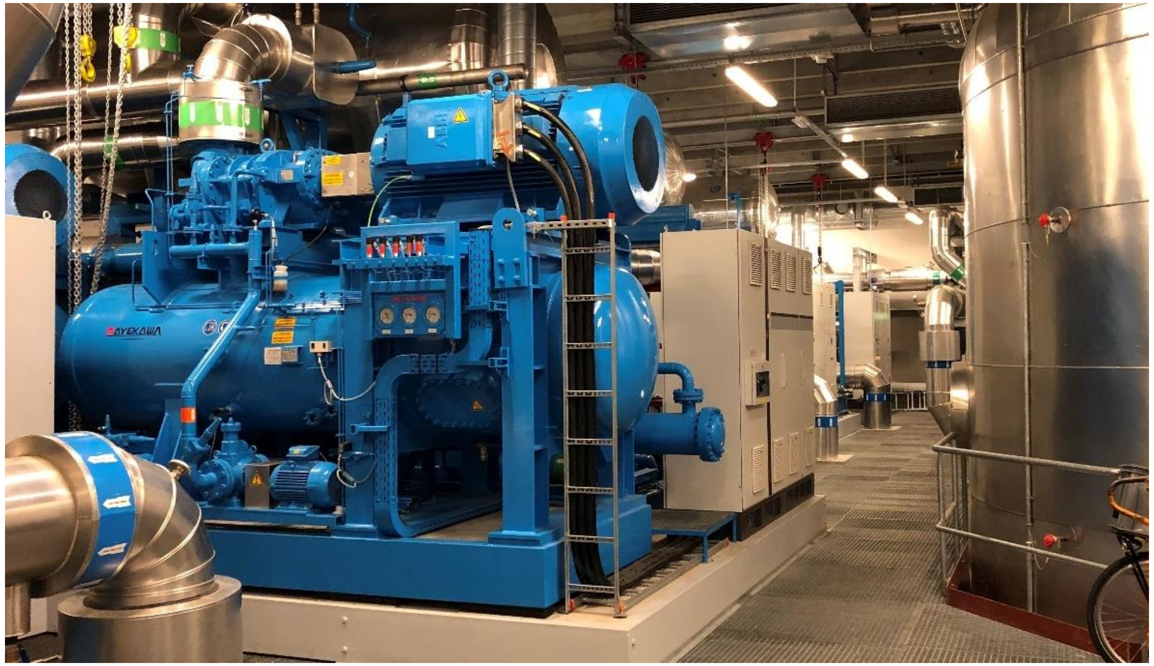


(1) District cooling production facility, (2) distribution pipeline network, (3) Cooling demand at consumers in residential or commercial buildings.

Centralised cooling is most often seen in large public and service buildings such as office buildings and large commercial centres.

DC is most often supplied by:

- Free cooling



Renewable and energy-efficient DHC systems

DHC systems, in order to fulfil their role in future (renewable) sustainable energy systems, need to:

- **utilise low-temperature resources** to supply heat and cold in existing, new and renovated buildings
- **have low thermal losses** in the distribution grid
- **integrate renewable heat sources** such as solar thermal and geothermal energy as well as low temperature waste heat
- be one of the **components of a smart energy system** that integrates variable renewable energy sources and promotes energy efficiency
- be developed **taking into account local energy planning**, policy schemes and system costs
- contribute to the development of sustainable energy systems of the future (Lund et al., 2018).

Source: IRENA and Aalborg University (2021).

Renewable and low-temperature sources – advantages and potentials

Sources	Advantages	Potentials
Geothermal	Continuously available and not dependent on weather conditions Very low O&M costs	Large, especially for shallow and low-temperature geothermal resources
Solar thermal	Sustainable Very low O&M Very long lifespan	Almost everywhere
Bioenergy	Abundant and sustainable source in some areas	Almost everywhere
Free cooling	Abundant Very low O&M costs	Large
Waste heat	Use of a resource that would otherwise be lost Advantageous cost	Industrial and commercial areas

Source: IRENA and Aalborg University (2021).

Barriers to utilization of low-temperature energy sources

The utilisation of low-temperature renewable energy sources and sustainable waste heat in district energy systems is often hampered by barriers, including the following:

- lack of data
- insufficient knowledge and awareness about the best available technologies
- disconnection with building renovation strategies
- unfair competition with individual fossil-based heating systems or electric cooling systems
- high upfront costs
- budgetary constraints at the municipal level
- inadequate regulation and lengthy authorization procedures.

Source: IRENA and Aalborg University (2021).

Modifications needed for system elements for new generations of DHC

<table>
<tr><th></th><th>Existing district heating system</th><th>New district heating system</th></tr>
<tr><td rowspan="2">Existing area</td><td colspan="2">Adaptation of consumers’ connections, substations, and in-house installations for space heating and DHW supply</td></tr>
<tr><td>Potential need for retrofitting the network, if it is oversized</td><td></td></tr>
<tr><td>New development area</td><td colspan="2">Low supply temperature is particularly suitable for new low-energy buildings with low-temperature heating installations, e.g. floor heating or low supply temperature radiators</td></tr>
</table>

Source: IRENA and Aalborg University (2021).

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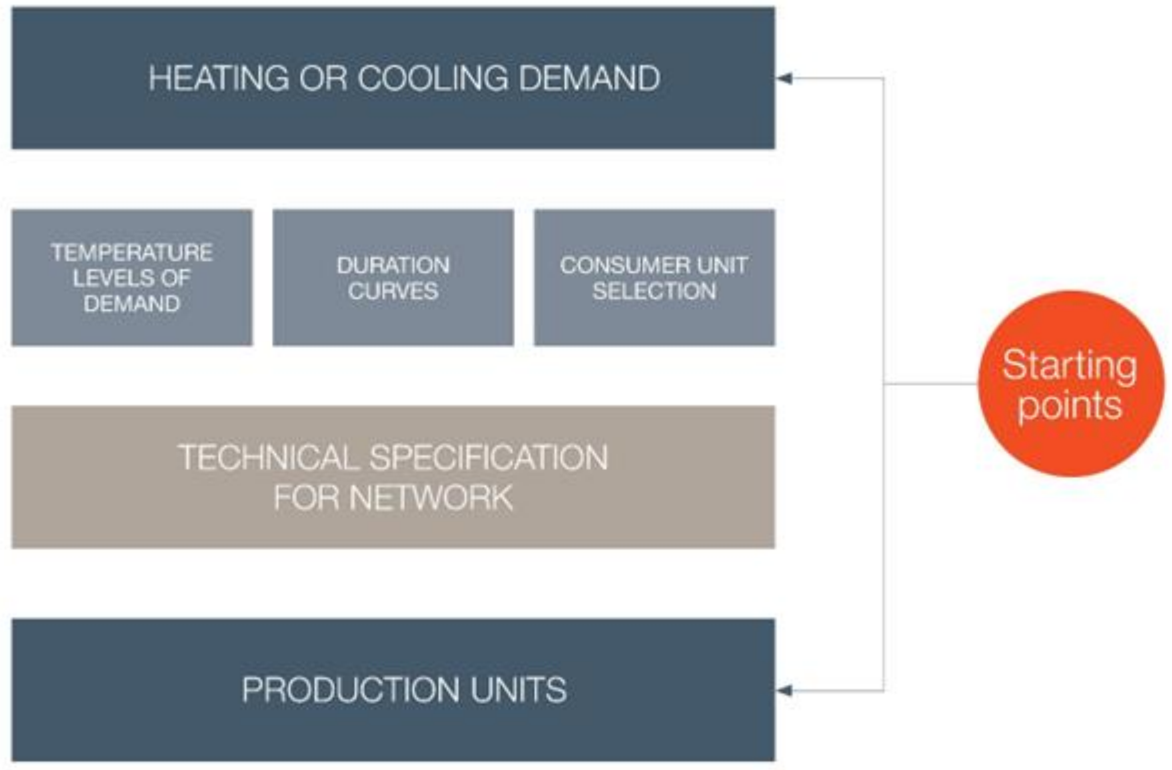
Typical implementation process

Identification

1) Review local plans (existing energy plans)
2) Identify DE suitability and system scale
3) Identify of heating and cooling supply and demand factors
4) Identify project barriers, risks and enablers
5) Identify stakeholders



Screening

Energy resource availability

- What RE sources are currently available in the area and at which amounts?
- What RE sources are unavailable or unfeasible? What peak load generation sources are available?

Demand, network size and utilization

- **Determine the maximum size of the network** of the districts that may be connected
- Reasonable **estimate of the distribution of the energy demand** across the year considering any seasonal variation

Technologies

- **Evaluate different technology possibilities** – production and storage
- Consider scale of production plants
- Individual supply technology should also be considered as alternative to DHC

Temperature levels

- **Identify heating and cooling temperatures** demanded by consumers
- Consider heat loss in distribution system

Main challenges and possible solutions to exploit low temperature heat sources in DHC

Source	Main challenges	Possible solutions
Geothermal	• High investment cost • Risk of drilling failure • **Risk of decreasing productivity over time** • Risk of scaling and corrosion	• Establishing geothermal resource risk and well productivity guarantee schemes • Conducting extensive geo-scientific studies • **Monitoring reservoirs and managing resources** • Maintaining temperature of geothermal fluid above the saturation temperature of the dissolved substances during heat exchange, regularly maintaining heat exchangers and other equipment, treating of geothermal fluids using chemical methods to reduce the rate of precipitation and scaling
Solar thermal	• **Offset between seasonal availability and demands** • High investment costs • Constraint temperature • Space constraint	• **Ensuring use in systems that have a DWH demand** • **Using solar thermal to provide cooling when the supply and demand for heating are mismatched** • Incorporating thermal storage to take care of surplus solar thermal • Using alternative spaces
Waste heat	• Sustainability of the resource • **Fluctuating conditions of supply**	• Developing contractual agreements to assure supply • **Incorporating thermal storage in the network** • Combining connections to deliver high-temperature to the supply line and lower temperature to the return line
Free cooling	• Preservation of water quality and aquatic life • Risk of fouling and corrosion	• Filtering • Antifouling processes

Source: IRENA and Aalborg University (2021).

Assessment

The assessment phase builds upon the screening step and uses the information obtained to systematically compare project design options and prepare for selection of specific options.

- Quantification of major assumptions for feasibility of the project
- Availability and cost estimate for energy resources
- Demand estimation and its variation across the year
- Assessment of network size, costs, and district inclusions
- Assessment of plant technologies and sizes, cost estimates, and main technical parameters
- Assessment of other technologies (e.g. storage), cost estimates, and main technical parameters
- Assessment of the costs and environmental effects of existing individual heating/cooling solutions to be potentially replaced by DHC
- Risk assessment

Assessment
Risk Assessment - Example

Risk	Description	Severity
Local demand for DHC insufficient	DE systems are constantly competing with individual heating/cooling solutions. In some cases, customers may choose to disconnect from the system.	High
Feedstock supply	Bio-based fuels which depend on waste streams from wood industry and other agribusiness may, at some point, become unavailable due to weather, seasons, competition with food production, etc.	High
Feedstock and energy price variability	For both bio-based and fossil fuels, energy prices can vary drastically throughout the year.	High
Environmental criteria for fuels	Climate mitigation policies can affect the supply, demand, and, thereby, the price of fuels to increase.	Medium
Leaks of pipes (minor)	It is not rare for DE networks to leak distribution water. However, even minor leaks, can be expensive over time.	Small
Leaks of pipes (major)	Some local construction work can, by accident, damage DE pipes. This should be dealt with immediately, not only due to heat and water loss but also due to safety issues such as the undermining of the roads and pavement.	High
Fire at plant	Despite high safety standards for production plants, fires can occur. These should be handled immediately, especially fires initiating at fuel storage is complicated since the fire will quickly intensify.	High

Selection and Pre-development phases


Source: Luis Sánchez-García

Selection

- Selecting the project that best suits the needs and opportunities available, based on all the prior analysis in previous steps.
- This phase compares and ranks each project alternative by potential and priority.

Pre-development

- This phase constitutes the complete final design, from detailed feasibility study to permitting, licencing and other authorisations
- Decisions on type of production plants and energy source for both base load and peak load, the size of production plants, etc.
- Environmental Impact Assessment and risk management plans

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Typical implementation development process

Energy Audit/ Feasibility study

- Assess the current situation of the district heating system with regard to its energy consumption and production needs
- Elaborate energy efficiency and renewable energy refurbishment measures
- Cost-effectiveness analysis of the proposed improvement interventions

Identify refurbishment measures

- Select which refurbishment measures will be further developed (limited to available budget)

Project design

- Detailed investment and operational costs for each measure
- Energy savings and operational costs savings for each measure

Final selection of refurbishment measures

- Final selection of refurbishment measures based project design findings and available budget

Source: Covenant of Mayors (2018).

Integrating low-temperature supply into existing buildings and DH networks

Assess compatibility with existing building stock (also applicable for new district energy systems)

- Renovate the building envelope of existing buildings
- Redesign and change installed heating equipment that is not scalable for low-temperature usage
- New heating substations
- Adapt user behaviour to best practices for management of heating operations

Assess compatibility with existing heating network

- Ensure lowered return temperature from the building
- Incorporate heat pumps to increase temperature from supply source or in certain points in the grid
- Reduce heat loss in the network (e.g. insulation of pipes)

Source: IRENA and Aalborg University (2021).

Other considerations

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Integrate building renovation and change of supply and modernisation of the network plans so as to achieve an optimum performance level and avoid lock-in effects and disconnections.

- Establish cooperation between strategies to achieve district energy and energy efficiency in buildings.
- Prioritise poorly insulated buildings and the largest consumers that require more energy for implementing renovation policies.
- Move towards consumption-based billing for all consumers to encourage more energy-efficient practices.

Build local capacity to address technical challenges for integrating low-temperature heat sources into existing networks and building stock.

- Develop a critical mass of experts, incl. public authorities, in renewable energy
- Invest in enhancing the expertise of the workforce to ensure the smooth operation of district energy networks.

Source: IRENA and Aalborg University (2021).

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Final considerations

- Develop strategic heating and cooling plans based on clear political drivers and identify the main stakeholders to engage in the process.
- Integrate change of supply, modernisation of the network and building renovation plans to achieve an optimum performance level.
- Promote the utilisation of locally available renewable energy sources for heating and cooling by addressing intrinsic challenges and building local capacity.
- Ensure enabling regulatory conditions, supportive financing options and business models are put in place.

Local energy and climate plans must align with national goals and consider integration of all the energy systems in a city.

Source: IRENA and Aalborg University (2021).

Thank you!

19 April 2023