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Article | Danfoss Climate Solutions — District Energy

Unlock digital transformation in district energy networks with smart control solutions

Today's district energy networks are ripe with untapped potential. And digitalization is the fundamental lever to unlock the next generation of district energy—of new networks and network expansion that unlock unrealized end-to-end optimization and energy efficiency. The question, then, is 'How?'. In this article, we'll unpack why the complexity of district energy networks is an advantage that supports greater resilience and flexibility with actionable insights—when monitored and regulated by intelligent control solutions.

Embracing the maze: The untapped potential of complex district energy networks

Complex networks are akin to mazes, marked by complexity and loops. While traditional mazes have just one starting point and one endpoint, today's district energy networks are a new kind of maze with multiple starting points for heat or cold production and thousands of endpoints at the consumer level.

As the complexity of the system increases, the more important it becomes to apply effective control logic to ensure stable and optimized operation. In a modern system with multiple thermal plants that use a variety of fuels, it's increasingly important to control when, where, and how the energy is produced, distributed, and consumed.

With advanced control logic throughout the supply system—based on intelligent digital solutions—you can gain more cost-effective energy production while reducing CO_2 emissions and maintaining comfort for end users.

How digitalized district energy networks improve resilience through flexibility and efficiency

District energy offers unique opportunities to deliver sustainable heating and cooling from a large variety of renewable sources—which might not be accessible at an individual building level—reinforcing the idea of a complex heat or cold maze. Using minimal primary energy inputs, however, district energy enables heat and cold generation from production to distribution and consumption—with intelligent control systems being the foundation to realize the full potential of the system.

Leveraging renewable energy sources—such as heat pumps that capture excess heat from a data center or supermarket, biomass materials like wood chips, or even geothermal energy—enables the flexibility to select an energy source based on availability. Thus, making it easier to absorb cost fluctuations in the network. And shifting from fossil fuels to renewables ensures greener operations: historically, district energy has reduced CO_2 emissions by 3–4%[1], and with digitalization, you can enable an ever-faster transition by lowering energy consumption and increasing full transparency in the district energy maze.

This union of flexibility, efficiency, and exceptional openness to new energy sources make the district energy infrastructure ideal for expanding or building more sources into the system while increasing the system's resilience.

Fundamentally, a domain hardware knowledge of how the "heat or cold thermal maze" is built—down to each valve, controller, or heat exchanger—is essential to create smart components upgraded with advanced AI-based software and digital twin solutions. This ultimately maximizes the value of available information and data while helping utilities and building owners make better decisions empowered by digital tools.

[1] Source: IEA, District Heating and Cooling: Environmental Technology for the 21st Century

Key parameters for district energy resilience

Multiple heat sources:
In 2021, renewables represented less than 8% of global district energy supplies[2]. It's imperative that we move toward renewable sources such as waste heat, large heat pumps, geothermal, and biomass to enable fuel flexibility and support the long road to decarbonization. A network based on multiple sources and digital controls also enables operators to leverage different economic parameters—for example, using heat pumps when electricity costs less or biomass when wood chips cost less—to optimize the network and offer the operational flexibility to balance the power grid.

Meshed distribution layout:
There are two main structures for a heat network. A "branch layout" has one main line with branches extending into the city based on a single heat or cold source—a configuration that is the least resistant to pipe failures and, thus, less resilient. A "mesh layout," on the other hand, is based on the branch layout with additional connections between the branches—an advanced layout with multiple heat or cold sources—enabling greater resilience by isolating disruptions within parts of the system and ensuring heat delivery to end users through alternative paths.

Simple design and operation:
While the complexity of a heat or cold network is what ultimately enables greater resilience, simplicity based on advanced knowledge should be the guiding principle in terms of design and operation. The larger a network grows, the greater the need for intuitive operational control and controls becomes. That's why digital tools that support around-the-clock monitoring and control is essential to managing complex heat networks.

Low temperatures:
The biggest obstacle for introducing energy efficient, low-temperature renewable energy and waste heat sources is the high operating temperature of district heating systems. Thus, it's of paramount importance to reduce the temperature requirements of existing systems and design new systems for low temperature operation. Most of today's water-based district heating systems operate with peak temperatures around 100°C and have the goal to reduce that number to 70°C–75°C. Digital tools will provide insights to identify the critical pain points for reducing the supply temperatures—and maximize the period of the year when low temperature operations can be achieved—thus improving operational costs.

[2] Source: https://www.iea.org/reports/district-heating

Solving the district energy maze automatically:

The journey to **resilient, data-optimized district energy networks**

Digital tools are a key part of planning, monitoring, and controlling the complexities of a heat network—in other words, they help navigate the heat or cold maze.

And whether you're expanding an existing network or building a new network from the ground up, the journey to resilient, data-optimized district energy networks can be divided into four focus areas.

1. Network planning

Whether you're starting by renovating one part of the network with a plan for expansion or establishing a completely new network, it's critical that the network is designed with the endpoint in mind—only then can the system costs be minimized while optimizing for long-term resilience. Plus, it's important to ensure that the heat production is adjusted to the new heat load required for the additional buildings.

2. Network operation

When operating a heat network, planning the operation of the heat source to ensure enough heat for end users is a priority. However, it's increasingly important to optimize between the different heat sources—i.e., a biomass plant and a large heat pump—so that utilities can optimize the cost of heat production depending on various economic parameters.

3. Heat distribution

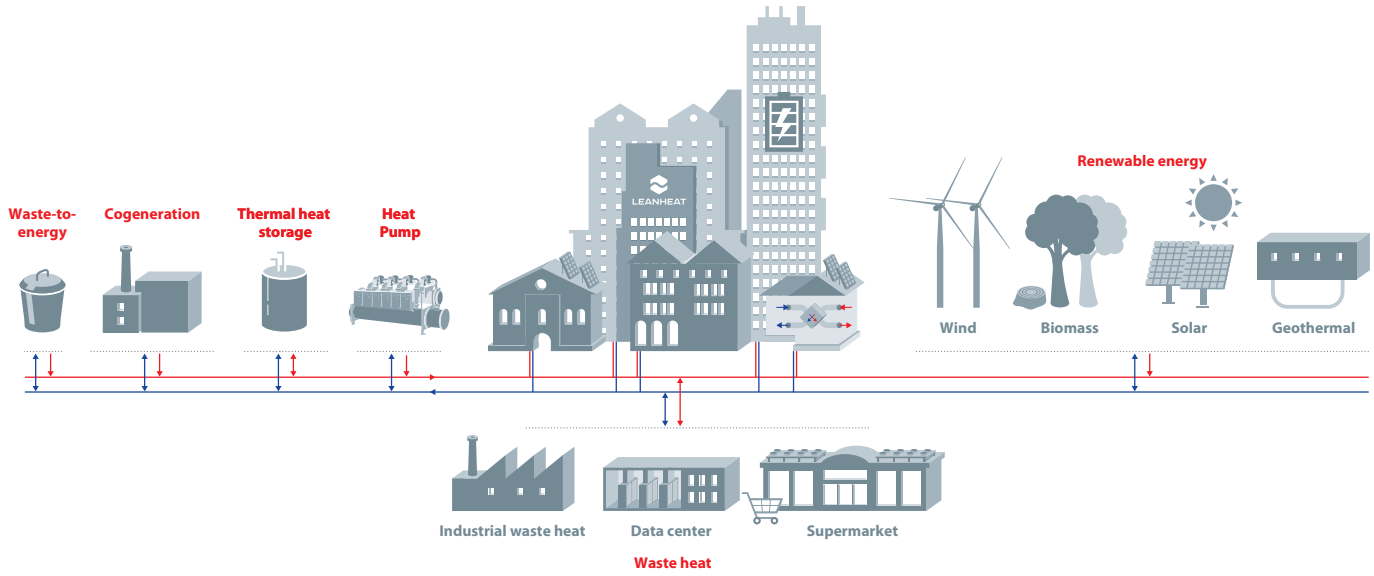
When it comes to heat distribution, transparency is essential to better understand, simulate, and evaluate different scenarios related to, for example, pressure, temperature, and demand. Software can be used at each step of this process—and as a support to better predict distribution throughout the entire system.

4. Heat consumption

As the system's complexity increases, it becomes increasingly important to accurately forecast thermal demands. This enables the system operator to adapt both the operational strategy of the distribution network and the thermal generation to ensure that thermal energy is consistently delivered—at the optimal cost. By integrating thermal management software for buildings with the utility's heat distribution and thermal generation software, the overall system can be optimized to ensure stable and affordable thermal supply.

Optimizing the heat network from production to consumption with digital tools

Planning and operating complex heat networks—which only continue to increase in complexity—is no easy feat. However, digital tools have the potential to transform a complex district energy maze into a highway of efficiency—from production to consumption.



Production can be optimized based on heat load forecasts, weather conditions, and other planning elements to allow you to produce heat when it costs less—and with the most sustainable sources. Danfoss Leanheat® Production, for example, leverages data to maximize energy efficiency with:

- Load forecasting that predicts exact in-network heat consumption
- Production optimization that saves 1–3% on fuel costs annually
- Temperature optimization that reduces heat losses by 5–10% annually with a low ROI between 0.5–2 years

The network can be designed down to the smallest detail—that is, the individual consumer of heat or network branch—allowing you to change and test any parameter before changing any hardware while ensuring better temperature and pressure optimization matched to the exact needs of individual consumers. Leanheat® Network helps to:

- Reduce annual supply temperature by 6°–8°C
- Reduce existing pipeline network loss by approx. 8–10%
- Reduce heat or cold production costs by up to 2%

Consumption can be transparently monitored and used to assess the performance of individual buildings—all while working dynamically with when heat is needed and when it is produced. Close cooperation benefits both the utility and the consumer with an information-driven understanding of demand to enable effective load forecasting—ultimately leading to significant cost savings while avoiding fossil fuel consumption. Danfoss offers several software solutions for supporting the control and monitoring of consumption:

- Leanheat® Monitor: Full transparency at low costs with alarms and commissioning reports
- Leanheat® Building: Up to 20% savings with smart heating control and up to 30% savings on technical maintenance costs
- Danfoss Titan: Reduces return temperatures up to 2°–5°C

The complexity of today's district energy networks is the future of decarbonization—it's one of the fastest routes toward energy systems of tomorrow. End-to-end transparency enabled by intelligent digital solutions—to reduce CO_2 emissions, optimize operations, and ensure better comfort all year round—is already here. We just have to use it.

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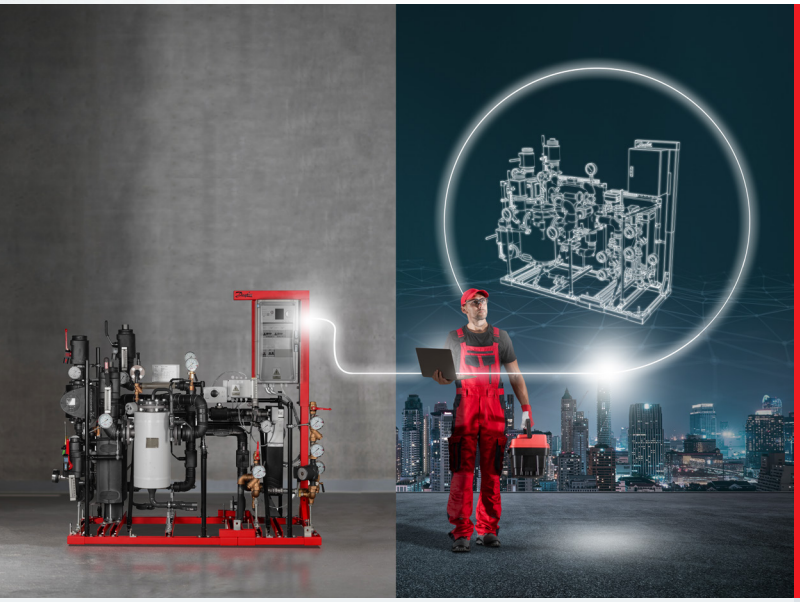
Let's unlock the grid

What does it take to unlock the grid's full potential?
As the complexity of today's district energy networks increases, so does the potential they hold for ensuring cost-effectiveness, energy efficiency, and ultimate resilience.

With the industry's only full product portfolio combined with our hardware domain knowledge, Danfoss' end-to-end solutions deliver actionable insights and optimization—from production to distribution, and consumption.

Learn more about Danfoss District Energy solutions >



Danfoss Titan
A new dimension of district energy

Danfoss Titan combines best-in-class substations with innovative digital twin technology to add a new and data-driven dimension to the district energy network.

Discover Titan >

Danfoss Leanheat®
Holistic heating optimization from production to people

Danfoss Leanheat® is an application-driven suite of end-to-end software and services that optimize energy production and consumption, increase operational efficiencies, and put building control and maintenance in your hands.

Discover Leanheat® >

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