Grundfos iGRID temperature zones

Use Grundfos iGRID temperature zones to add digitaldemand-driven heating zones to your district heating network and reduce heat losses, deliver low-cost heating and open up for heat generation from renewable energy sources


Anders Nielsen
Application Manager


Charles Winther Hansen
Application Manager

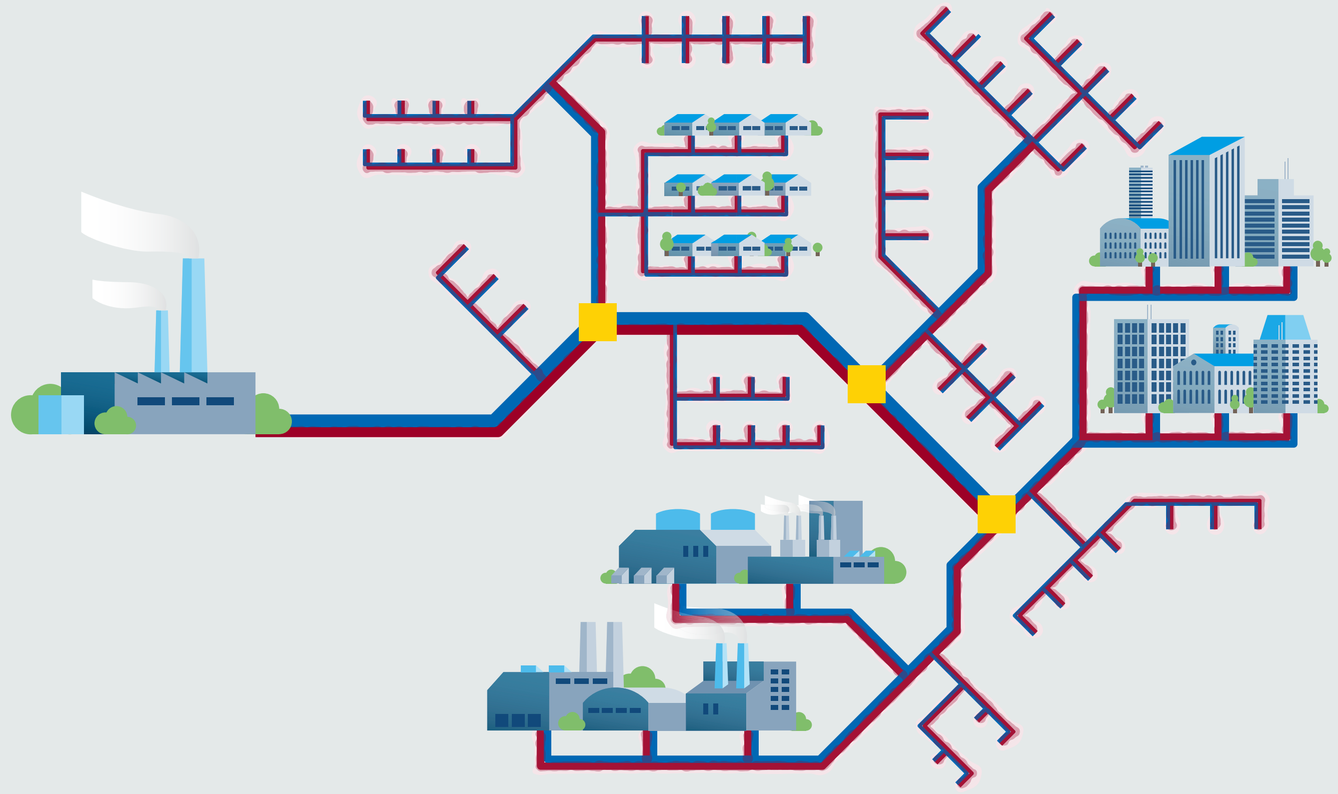
Executive summary

Installing Grundfos iGRID temperature zones into a district heating network add management and optimisation benefits from the digitalisation of the network. They also present the opportunity to deliver low-cost heating in a system future-proofed for the transition to renewable energy sources. As obvious as it is that district heating is here to stay, it is also vital that district heating systems change in order to increase their efficiency and utilise the benefits of digitalisation. One of the greatest challenges in today's district heating systems is heat losses between the plant and the final users. Installing prefabricated iGRID in the distribution network is a solution to solve this challenge in distribution networks. This turns the network into an intelligent heat grid that can reduce heat losses dramatically. How this is done will be described in detail in this white paper.

Contents

Introduction to district heating networks

District heating networks can normally be divided into two different parts, a transmission network and a distribution network.



The transmission line from the heating plant to the substations (▬) has the purpose of delivering energy to the entire system. Opportunities for optimising the system are in the distribution networks extending from the substations (■).

The main purpose with the transmission network is to deliver a sufficient amount of heating energy from the heat production plant into the connected distribution networks in the area where district heating is used.

The size of the transmission network can be very large – both in terms of pipe dimensions and pipe line length. The capacity of the transmission network must be sufficient to deliver enough energy to all the connected branches, from where heat is delivered to the distribution network.

When a district heating network grows, and the number of connected consumers rise, the capacity of the transmission network must be increased. This can only be done by expansion of the pipe dimensions or by increasing the temperature and pressure in the supply line.

Because replacing pipelines in urban areas to expand the dimensions of the main pipes is very expensive, it is more common to increase the temperature and the pressure in the supply line. In some cases, capacity problems can lead to a forward temperature in the supply line of 130 °C and pressure higher than 20 bar or more, close to the main pumps.

The interface between the transmission and the distribution network can be a substation placed in a separate engineering building or in a plant room placed in large buildings.

A substation is provided with equipment such as heat exchangers, pumps, valves, meters, pressure-holding systems, strainers and so on, usually assembled onsite or on a base frame. The purpose of the substation is to reduce temperature and pressure from the present values in the transmission network to the needs in the distribution network.

The distribution pipelines constitute a separate network and are connected to the transmission network through the substations. All consumers are connected to the distribution network. The ability to change pressure and flow temperature in the distribution system enables quick adaptation to actual needs. These can change under the influence of weather and match the needs consumers have for heating up houses, office buildings and public buildings, as well as for the production of hot tap water without any risk of pollution with legionella bacteria.

Defining the challenge

Two of the greatest challenges in district heating networks are:

- Access to data generated in the network provides detailed knowledge that opens up for a more informed approach to optimisation; and
- How to reduce heat loss caused by the widely-spread network and the high temperature difference between the water flowing in the pipelines and the ground in which the pipes are buried.

The digitalisation of the network consists often of a virtual network made for calculation and sizing, a SCADA plant to control pumps and sensors, and energy meters connected in a radio network to sample energy consumption at the consumer.

Heat loss is due to the widely-spread nature of the network. This is typical of district heating, and a large network therefore causes substantial loses, but is able to reach a lot of consumers. There is nothing that can be done about this to avoid heat loss – as consumers live where they live. However, it is important to optimise the network as much as possible and to try to get rid of unnecessarily long pipelines.

High temperature in the main pipelines or transmission network is unavoidable due to the capacity considerations. Therefore, it is very important to build the main pipelines with an effective and sufficiently thick layer of insulation material for the following reasons:

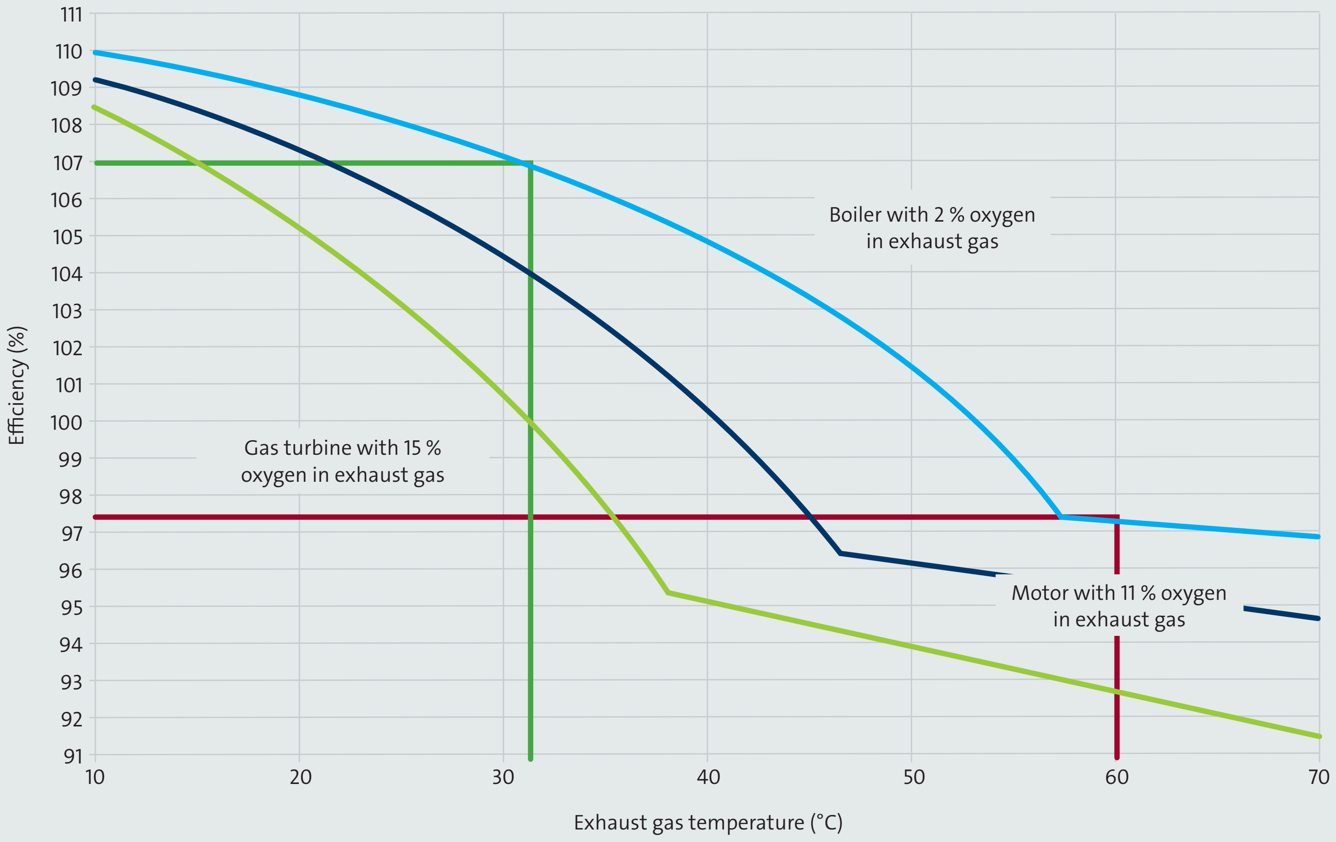
- Every lost energy unit costs money to reproduce
- CO_2 emissions need to be reduced
- Makes best use of current capacity in the pipes

The immediate and easiest way to improve pipeline capacity in the network is to increase the temperature difference between the supply and the return line. The forward temperature can in some cases become very high and cause problems. If utilities can manage to improve the temperature difference between the supply and the return line by lowering the temperature in the return pipe, several advantages are possible:

- Increased capacity in the pipelines
- Less energy loss in the network
- Much lower demand for circulated water in the system

Another very important advantage is that lower temperatures in the return pipeline will result in a more efficient exploitation of the fuel in the boiler plant or power plant, because the economiser in the exhaust gas system is capable of condensing more of the moisture from the fuel burning process, increasing the overall system efficiency dramatically.

Theoretical boiler efficiency using natural gas
(with 2, 11 and 15 % oxygen in dry exhaust gas, 0 °C combustion air, loss from boiler surfaces not included)



The example above shows how a reduction in return water temperature from 60 °C to 31 °C will increase boiler efficiency from 97.5 % to 107 % , resulting in a primary fuel reduction of approximately 10 %.

If energy is delivered from a heat pump or a solar plant, for example, a low return temperature is essential for the efficiency of the energy plant.

Towards an intelligent heat grid using Grundfos iGRID temperature zones

Grundfos iGRID temperature zones have the ability to dynamically adjust the flow temperature to any given consumer requirement, whether for industry, commercial buildings, or homeowners. Grundfos iGRID temperature zones is easy to install due to the compact design and the possibility to place the units under the surface of or beside a road, or similarly into pedestrian area or green park area with bushes or lawns.

Grundfos iGRID temperature zones can, in its most simple version, can operate as a standalone 100 % autonomous unit controlled by the intelligent digital controller built into the pump electronics. This adjusts the temperature in the distribution supply pipeline according to measured values from an internal temperature sensor and a setpoint chosen by the utility company.

In a more advanced solution, Grundfos iGRID temperature zones can adapt the temperature in the distribution supply line to the desired level, adjusted after weather data and load pattern. It can perform peak shaving and optimise the energy demand by increasing or decreasing the pressure and temperature, depending on sensors placed in the most critical parts of the network.

Grundfos iGRID temperature zones can be equipped with meters and engine valves as required and can also function as the main shutoff station for the distribution network, either manually or controlled automatically and remotely via SCADA.

A digitalised network ready for renewables
Installing Grundfos iGRID temperature zones to achieve an intelligent district heating network makes it easy to use alternative energy sources, for example surplus energy from industrial processes and renewables, such as geothermal energy and heat from a solar energy plant. This requires that the temperature is sufficiently low in the distribution network, and iGRID ensures that this is the case. The ability to adapt the temperature in the distribution network to needs of consumers for a lower temperature is expected of a modern district heating network.

In addition, Grundfos iGRID temperature zones can provide the utility with a lot of valuable digital information, which enables a precise and necessary overview of the network, making possible efficient and economic control of operations.

All use of fossil fuels needs to be reduced in the future, and perhaps in 20-30 years from now, District Energy will become 100 % fossil free. In fact, Copenhagen, Denmark, has already set a target of becoming CO_2 neutral by 2025.

A low-temperature district heating solution is one of the ways to reach that target. Many utilities are therefore already now planning to make low temperature district heating network. The GTO unit is a very important part in these plans, because many of the investments in energy systems we make today will still be running in 20-30 years from now and be a part of future CO_2 neutral low-energy solutions.

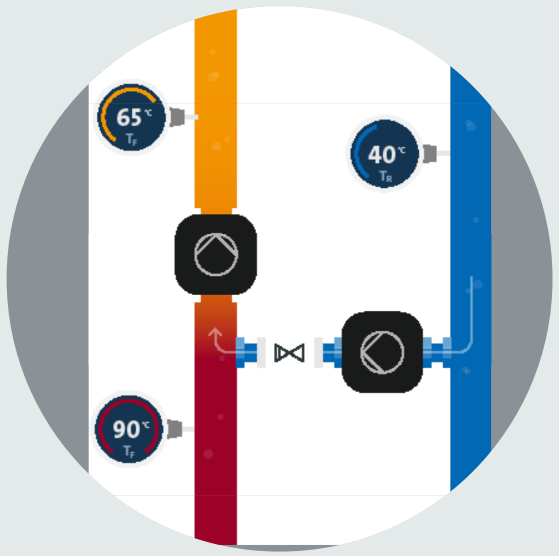
iGRID is a smart solution which allows the utility to take an important step into the future of district heating networks.

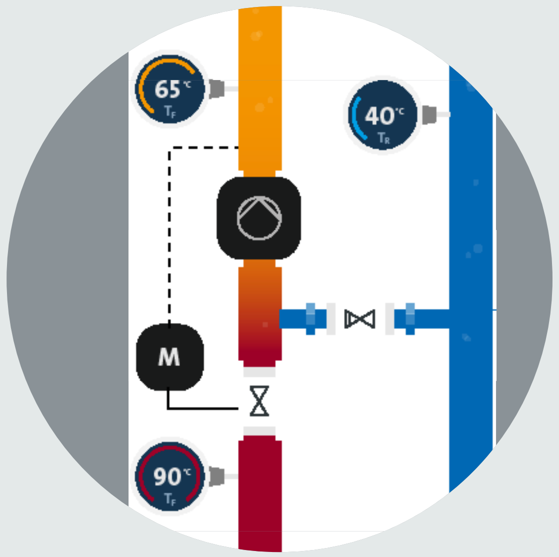
iGRID solves a lot of the problems that occur when converting from high temperature to low temperature district heating networks.

In Europe, approximately 40 % of all energy consumption is related to space heating in buildings. Clearly the exact use in buildings can be reduced by improving building construction and insulation, but it is also important to reduce the losses from the systems delivering heat to buildings.

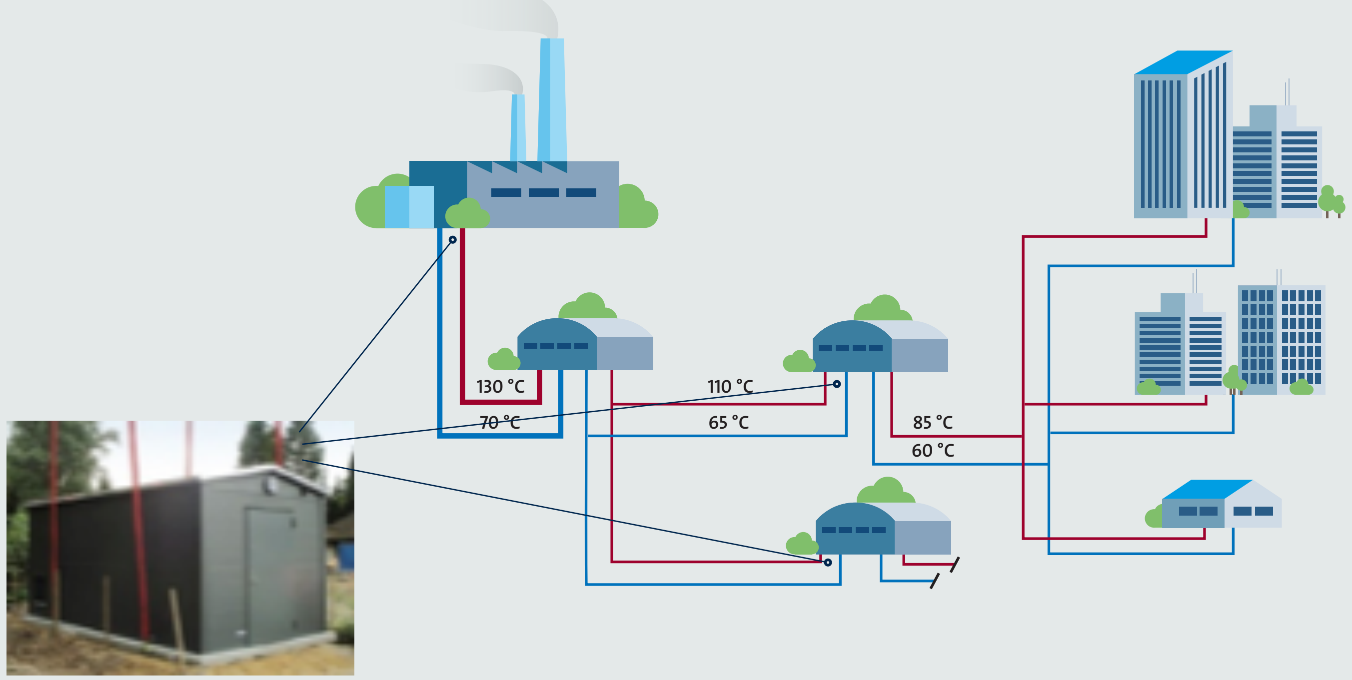
There are many reasons why we need to improve efficiency in district heating systems:

- Reduce temperature (energy) losses
- Deliver solutions that lower temperature now via loops and are prepared for the future of renewables (which require a lower delivery water temperature)
- Data is an enabler for low temperature networks, as it lets us zone the district heating network, and installed GTO units potentially provide insights from data points in local pits for:
  - T (temperature)
  - P (pressure)
  - ΔT (cooling)
  - ϕ (efficiency) delivered power





With an understanding of the need to reduce flow temperatures in already-existing district heating networks, let us look at the ways this can be done.



The traditional approach:
A building including heat exchangers, valves and all necessary components

PROS:
- Resilient solution
- Easy access
- Well known technology

CONS:
- Expensive
- Complicated implementation
- High operational cost, due to pressure loss across the Heat Exchanger

How we see the future of temperature-optimised networks:
Mixing loops (GTO units) placed directly in network

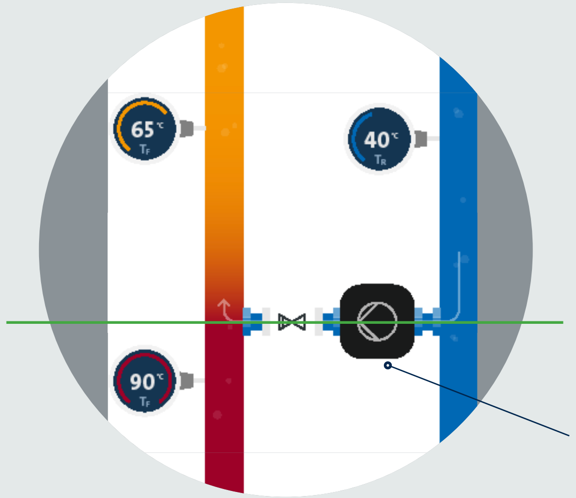
PROS:
- Easy implementation
- Low Return on Investment (ROI – payback time)
- Off-the-shelf communication/control
- Prefabricated solution

CONS:
- Needs detailed planning

How Grundfos iGRID temperature zones work

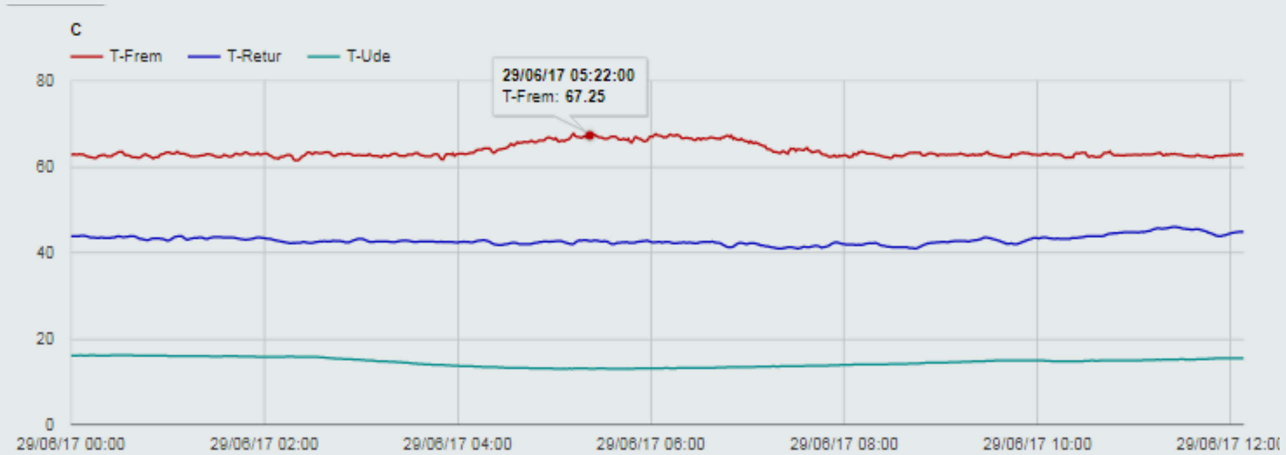
The Grundfos Temperature Optimisation (GTO) unit is a mixing loop with a pump placed in the bypass between the flow pipe from the supply side and the return line from the area which needs to be served with a lower temperature.

Primary side from the distribution network



Secondary side with reduced temperature

This is where the pump is placed to infuse water from the distribution return side to the supply side, thereby meeting the desired flow temperature. In this case the flow temperature is reduced from 90 °C to 65 °C.



An example showing how actual temperatures are adjusted and also a read-out of outdoor temperature.

Red: Flow temperature secondary (consumer) side
Blue: Return water temperature
Light blue: Outside air temperature.

Getting actionable data from your network
Grundfos iGRID temperature zones enables the manager of the district heating network to reduce the flow temperature to any given level and also to increase the flow temperature when this is needed. In the example shown in the graph above, the temperature is increased a few degrees around four in the morning, most likely to ensure sufficient production of hot tap water.

This shows how temperatures in a district heating network can be much more dynamic and adjusted according to actual load and/or need. A further and very important benefit is that every time you install Grundfos iGRID temperature zones, you get access to information on real time values for:

- Flow temperatures on the primary side and the secondary side
- Pressure and differential pressure
- If a heat meter is added, information on energy flow can be sent back to the district heating manager

These values can be stored and serve as input for trend curves which again allow the creation of plans for when temperatures can be reduced and needs increased. All with the end-goal of increasing the system performance and strengthening the value of the district heating system.

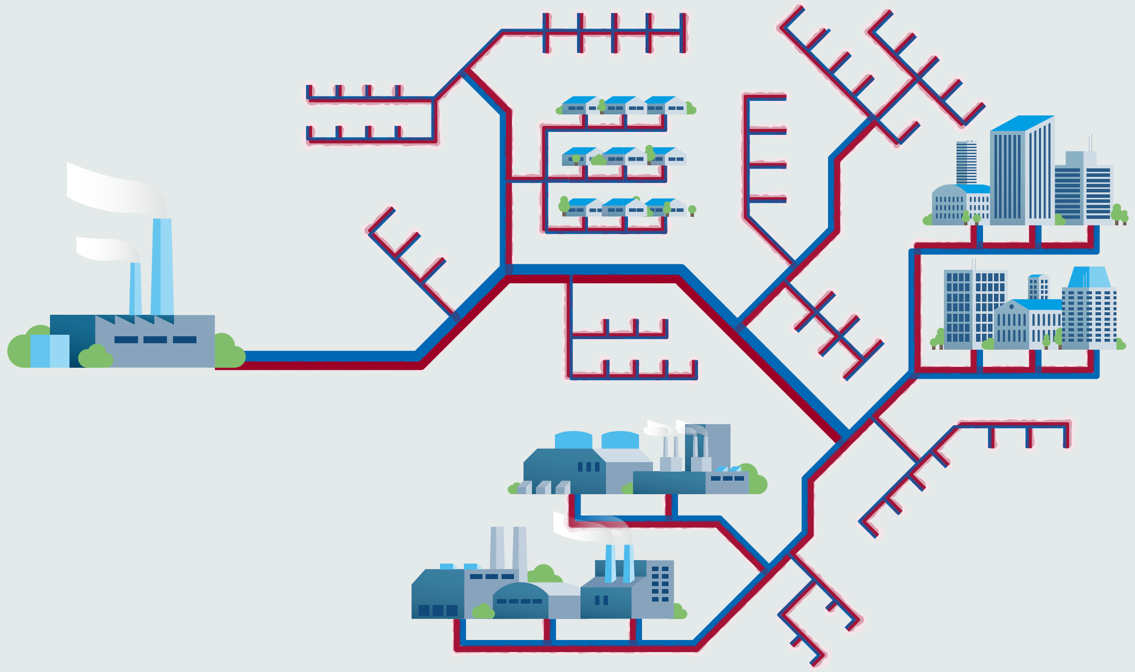
If a pit is equipped with flow meters on both the flow and return lines, this will allow for real-time leakage detection.

And if shut-off valves can be operated remotely (in the overall SCADA system), this will reduce the risk of damages and costly losses of water.

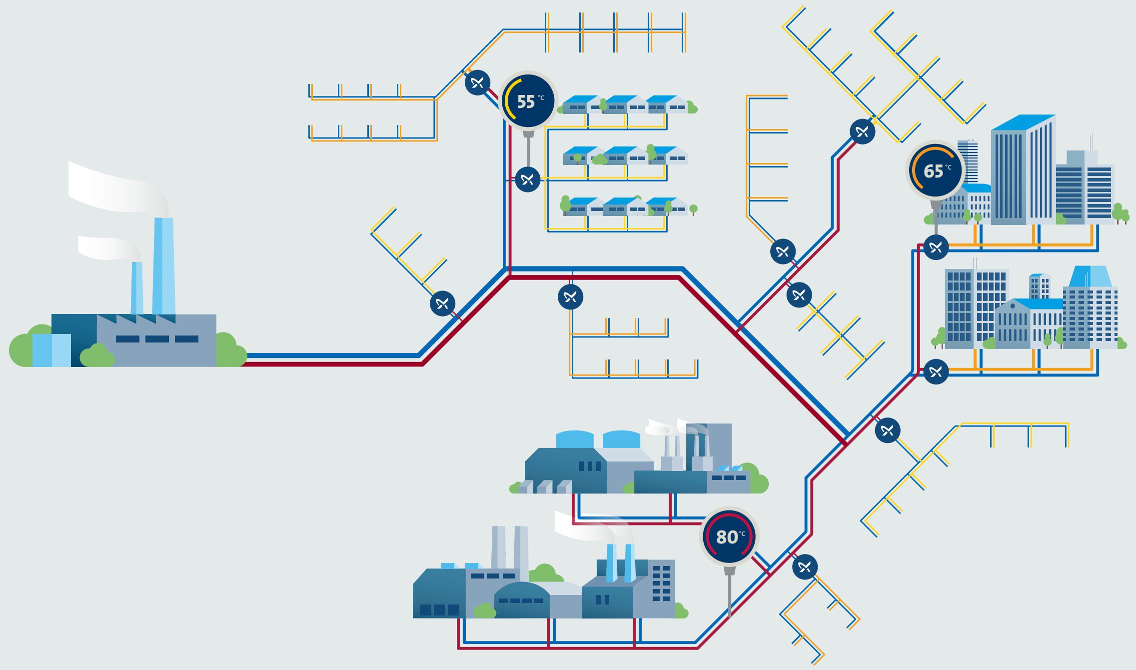
Zoning your network increases overview
When an entire network is divided into smaller sections (zones), the total overview is increased dramatically.

In the illustration below, the 'before' scenario can be described as having one flow temperature to the entire network with no ability to adjust according to load conditions. The only possibility to optimise is based on historical data from billing, typically a year old. Heat losses are high due to the high flow temperature to all consumers, perhaps because a hospital requires 95 °C.

Before



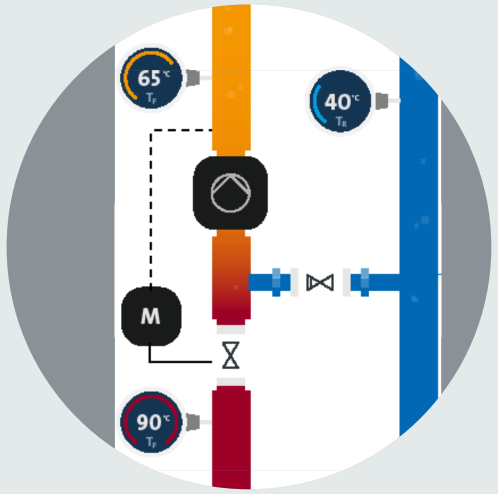
After



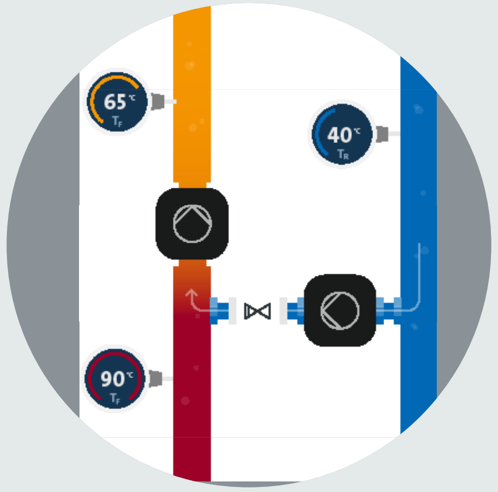
The 'after' scenario shows how the network looks when temperature is optimised. There are three different ways this can be implemented, and we will describe these solutions with GTO units now.

Solutions using Grundfos iGRID temperature zones

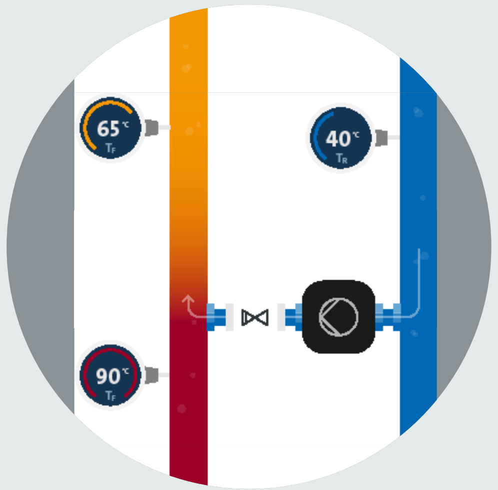
As we have seen, iGRID is a mixing loop that takes water from the return line and shunts it into the supply, to lower the temperature to the required level in any given network zones. They are produced in the following three different versions.



Classic solution



Free flow solution



Shunt pump solution

The Classic solution:
Here we have a decoupling between the primary and secondary side. Differential pressure from the primary side is only needed to cover flow requirements until the pump on the secondary side starts.

PROS:
- Well known solution
- Easy to calculate/design

CONS:
- Pressure loss in engine valve
- Differential pressure from primary side not utilised
- Higher cap and OPEX cost

Free-flow solution:
Here we utilise pumps to control temperature as well as differential pressure. The pump in the string between the flow and return pipes adjusts secondary flow temperature to the required level. The pump in the secondary flow line supplies differential pressure to overcome the pressure losses in the network it serves.

PROS:
- No losses in valves
- High reliability
- Low CAPEX and OPEX

CONS:
- Decoupling from primary side
- Limit utilisation of ΔT from primary side

Shunt solution:
Only one pump is needed to adjust the secondary flow temperature. You utilise the pressure provided from the main pumps in the existing network to draw on the efficiency gains from lower temperatures, although without the even-pressure benefits from a distributed pump solution.

PROS:
- No losses in valves
- High reliability
- Easy implementation
- Utilisation of ΔT from primary side

CONS:
- No control of secondary side ΔT

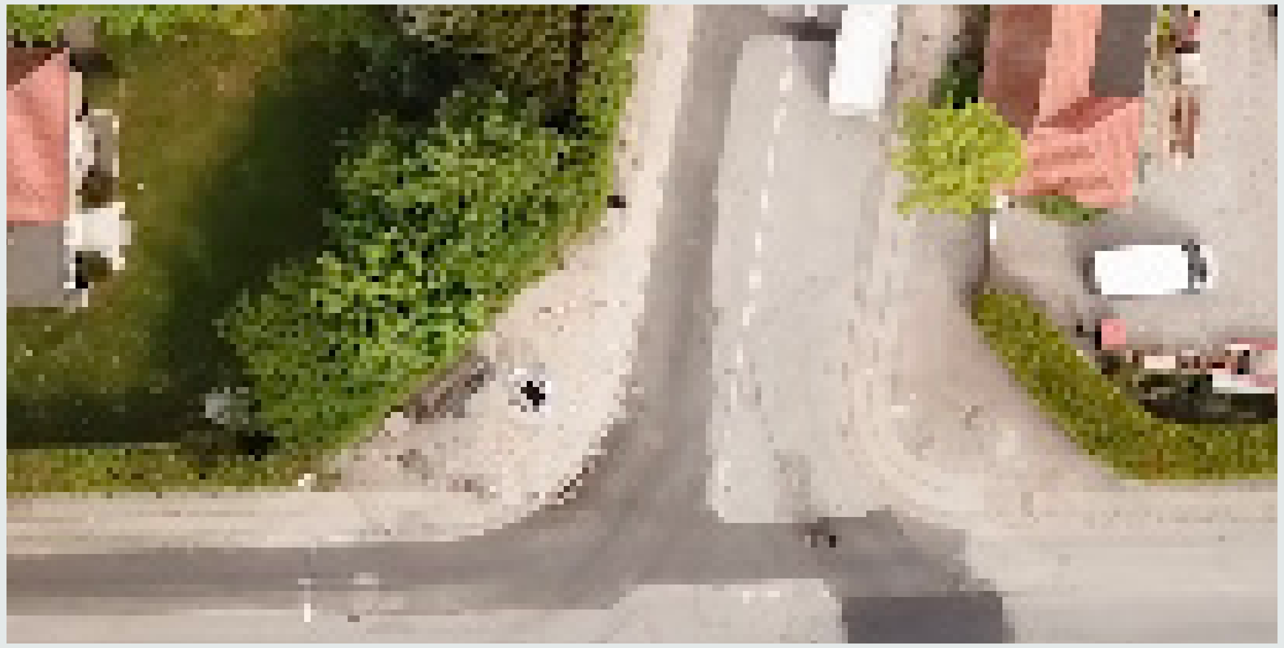
Savings in an extension area with a low temperature zone

Annual customer demand: 9,000 MWh	Usual design	Expected new temperature
Avg. temperatures (flow/return)	79 °C - 48 °C	60 °C - 38 °C
Heat loss in pipes per year	2,570 MWh	1,950 MWh
Pump energy per year	0 MWh	14 MWh
Carbon emission du to heat loss	195 tonnes	148 tonnes

Heat loss reduction
24 %

CO_2 reduction
47 tonnes

A specific case in the Copenhagen area in Denmark shows that by reducing supply temperatures from 79 °C in average (and 95 °C in peaks) down to 60 °C on average, then the heat loss reduction would be 25 %, corresponding to a saving of 620 MWh (the equivalent of heating 34 average houses on a yearly basis) in an area where the demand is 9000 MWh. This results in a payback time that is far less than what is usual in district heating.
To see a video from the actual case, please use this QR code:



These before and after photos show the small footprint from the mixing loop installation using Grundfos iGRID temperature zones.

"Temperature zones give us the possibility to reduce heat losses from our pipes quite significantly and this is done in an easy and neat solution"

Johan Sølvhøj Heinesen, Director, Gentofte District Heating

"Grundfos Pumps is easy to commission and allow for an easy solution. Everything is built into the pump and it works pretty well"

Magnus Justesen, Technical Manager

Adding Grundfos Temperature Optimisation units to the network provided:
- Significant reduction in overall heat losses and thus lover energy consumption
- Digital-enabled solution, with detailed information available from the network in real time values
- Reduced primary energy consumption due to increased flue gas condensation
- Preparing of the network for a future supply from renewable energy sources at lower temperature level

About Grundfos District Heating

Grundfos is one of the world's leading pump manufacturers and has been renowned for its innovative and reliable solutions since the humble beginnings in 1945.

Today, we produce more than 16 million pump units every year for a wide range of application areas – from circulators for heating and air conditioning to industrial pumps and solutions for water supply, wastewater and district heating.

Our vast experience with district heating dates back 50 years. Scandinavian district heating is the most efficient and reliable heating system in the world, and Grundfos technology is a proud part of that legacy.

Find out more on www.grundfos.com/market-areas/buildings/district-energy/district-heating

0219/BUILDING SERVICES/4010795-BrandBox

GRUNDFOS Holding A/S
Poul Due Jensens Vej 7
DK-8850 Bjerringbro
Tel: +45 87 50 14 00
www.grundfos.com