

The Danfoss logo is a red rectangle with the word "Danfoss" written in a white, cursive script font.

Danfoss

The title "Leanheat® Network" is displayed in a large, white, sans-serif font. The background is a futuristic cityscape with glowing blue and orange light trails and reflections on a dark surface.

Leanheat[®] Network

The word "Introduction" is written in a white, sans-serif font, positioned below the main title.

Introduction

Key Challenges in District Energy can be addressed by **End-to-end** energy optimization solutions



Optimal Network Design

With new connections and new buildings



Decentralization – Increased source complexity

In production: more heat sources including renewables



Decarbonization

Legislation and environmental care / energy efficiency



Peak energy demand

Drives up overall cost (OPEX as well CAPEX)



Legacy SCADA

Make data integration less difficult and time consuming



Danfoss Leanheat® is leading the green energy transformation

➤ A complete portfolio of products, components, and software for end-to-end optimization.

Leanheat® Production



Leanheat® Network



Leanheat® Monitor



Leanheat® Building



Heat exchangers, line components



Motorized valves



Self acting diff. pressure controls



Substations



Intelligent controllers



Heat meters



eTRV



ASV

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Leanheat® Home



Heat exchangers, line components



Motorized valves



Self acting diff. pressure controls



Substations



Intelligent controllers



Heat meters



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Danfoss Leanheat® software suite and services

End-to-end energy optimization solutions

Leanheat® Production



- > Future focused planning
- > AI powered predictions
- > Optimized production operation
- > AI powered temperature control

Leanheat® Network



- > Budget and investment planning
- > Online operation and visualization
- > AI powered predictions
- > Optimized temperature control

Leanheat® Monitor



- > Remote monitoring
- > Remote control
- > Online Reporting and alarming
- > Smart Weather compensation

Leanheat® Building



- > Heating Optimization
 - > Peak Load optimization
 - > Return temperature optimization
 - > Tariff optimization
 - > SCOP optimization
- > Heating Optimization
 - > Peak Load optimization
 - > Demand side management
 - > Return temperature optimization

Data API HUB

AI Engine

Primary Side

(Planning, Network operation, Production)

Secondary Side

(Buildings)

Leanheat® Network



Budget and investment planning



Network design >



Hydraulic Analysis >

Online operation and visualization



Online visualization of network >



Web dashboard >



Pressure optimization >

AI powered predictions



MetFor Weather Forecast >



HeatFor Load Forecast >

Optimized temperature control



Hydraulic temperature optimization >



HeatTO Data Driven Temperature Optimization >

Leanheat® Network

Plan, visualize, and optimize a sustainable network operation

Budget and investment planning



- › Optimize costs and target low-impact investments
- › Design network routing
- › Ensure accuracy by validating results
- › Comprehensive dimensioning of DH components
- › Accelerate decisions and save man-hours

Online operation and visualization



- › Get connected to real-time word and gain insights in network operation
- › Identify and minimize critical hotspots to improve efficiency and performance
- › Gain clarity and confidence in managing daily operational challenges
- › Plan interventions with effective execution and quality of service
- › Reduce pumping cost to minimum

AI powered predictions



- › Automatically and accurately forecasts energy demand
- › Forecasts local weather more accurately than global and regional weather models
- › Increases security of energy supply
- › Easy and inexpensive to install, maintain and operate
- › Reliable and stable with high availability
- › Low maintenance with minimal interference and interaction required

Optimized temperature control



- › Heat losses reduction by 3-10% leading to 1-3% fuel cost reduction
- › Highly flexible as can be configured to various network configurations
- › Minimizing pressure fluctuations
- › Considerable savings and reduction of carbon emissions

Leanheat® Network



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Leanheat® Network



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Leanheat® Network



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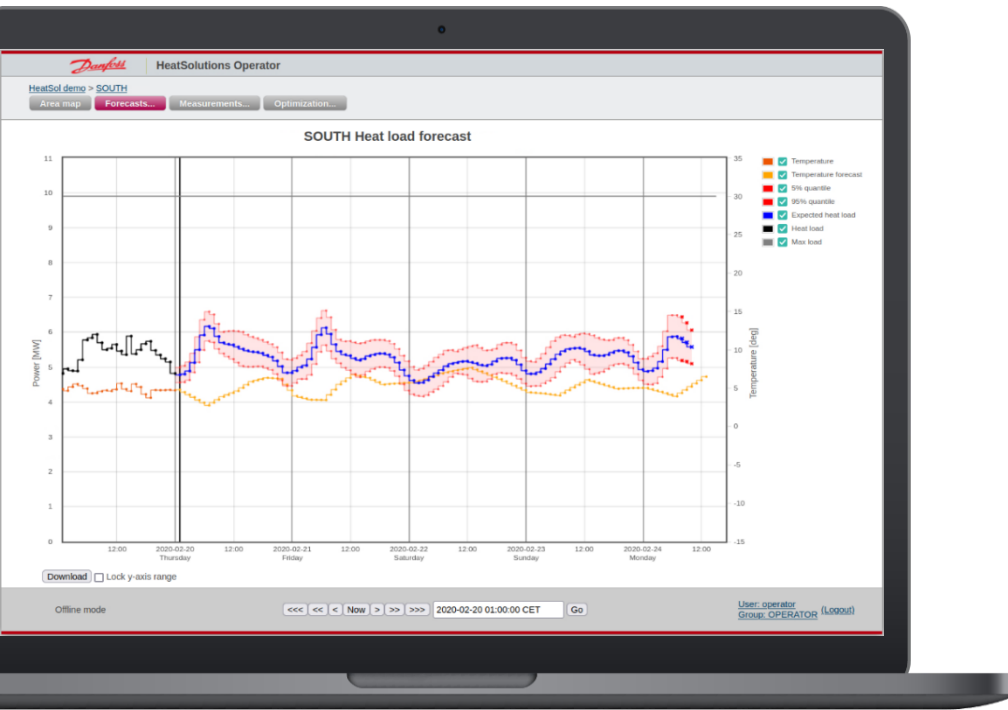
Optimized temperature control

 Hydraulic temperature optimization >

 HeatTO Data Driven Temperature Optimization >

Package 3: AI powered prediction

Automatic and accurate load forecast



- > Automatically and accurately forecasts energy demand in district energy systems
- > Forecasts local weather more accurately than global and regional weather models
 - > 5-8% more accurate on time horizons of 1-12 hours ahead
 - > 6-10% more accurate on time horizons of 13-36 hours ahead
- > Increases security of energy supply
- > Easy and inexpensive to install, maintain and operate
- > Reliable, stable and high availability with a proven operational track record of more than 20 years
- > Low maintenance with minimal interference and interaction required

Leanheat® Network



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Optimized temperature control

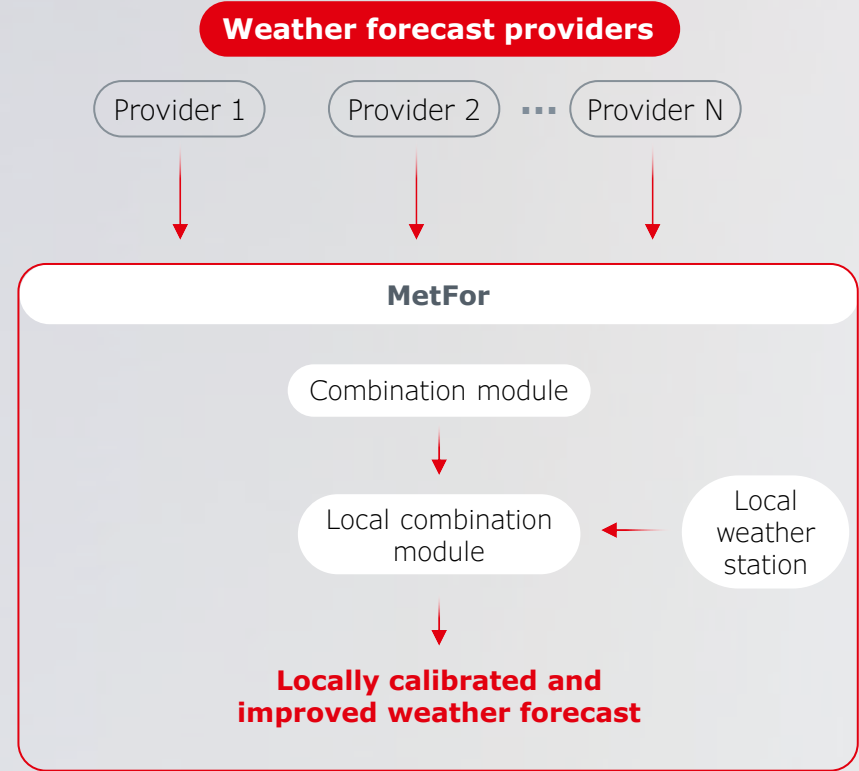
 Hydraulic temperature optimization >

 HeatTO Data Driven Temperature Optimization >

MetFor Weather Forecast

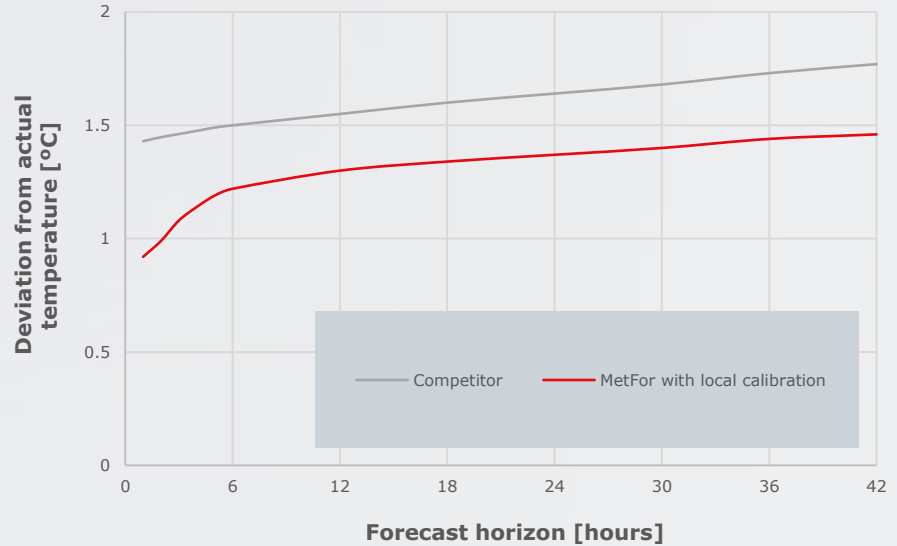
How it works

- > Based on self-calibrating and self-learning models (machine learning) to continuously update weather forecasts as more data becomes available
- > By combining and weighting a number of weather forecast providers (depending on location), accuracy is improved & reliability increased
- > Utilizes various weather models and optimizes their weights for specific locations to enhance forecast accuracy
- > Uses local online measurements (from a local weather station) to adjust forecasts, correcting systematic deviations specific to the location
- > Continuously updates forecasts based on real-time data, improving short-term predictions up to 12 hours ahead



MetFor Weather Forecast Performance

- › Forecasts local weather more accurately than global and regional weather models
 - › 5-8% more accurate on time horizons of 1-12 hours ahead
 - › 6-10% more accurate on time horizons of 13-36 hours ahead
- › Chart shows MetFor (red) and a reputable weather service (gray) mean absolute error (MAE) over a year across multiple sites
- › MetFor's improved accuracy at shorter lead times is due to online data usage
- › Using multiple weather forecast providers improves MetFor's accuracy at longer lead times



MetFor Weather Forecast

Highlights



- Forecast single or multiple locations up to 10 days ahead
- Forecast updated every hour
- Integrates seamlessly with:
 - Local weather measurements
 - Load forecaster
- Data integration interfaces based on FTP, SFTP or web-services supporting numerous formats and file types (CSV, XML, SOAP, JSON etc.)
- Delivered as a service solution
- Proven operational track record with redundant server setup provides very reliable data delivery

Leanheat® Network



Budget and investment planning

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 **Online visualization of network** >

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 **Pressure optimization** >

AI powered predictions

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Optimized temperature control

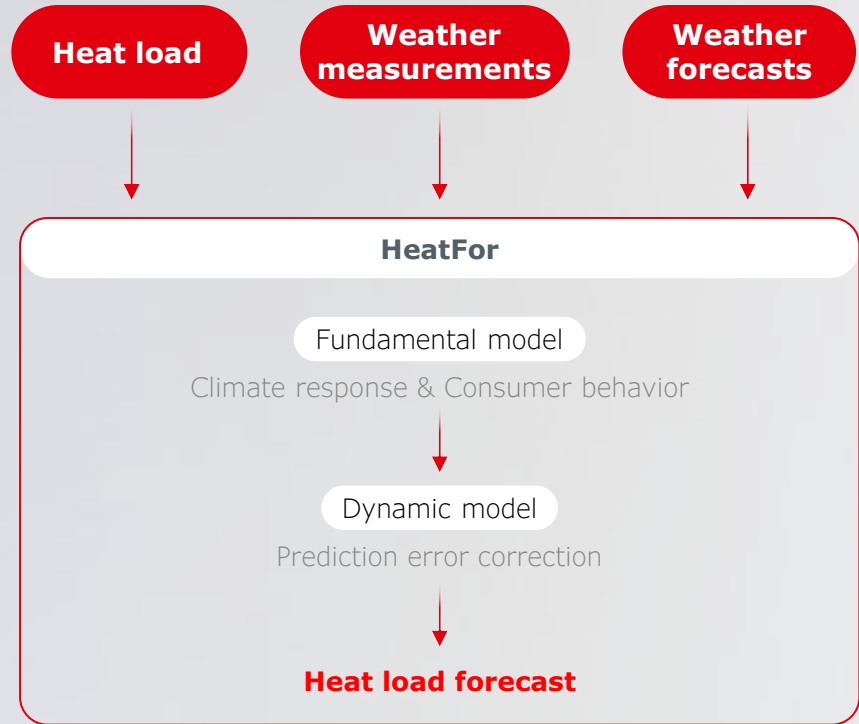
 **Hydraulic temperature optimization** >

 **HeatTO Data Driven Temperature Optimization** >

HeatFor Load Forecast

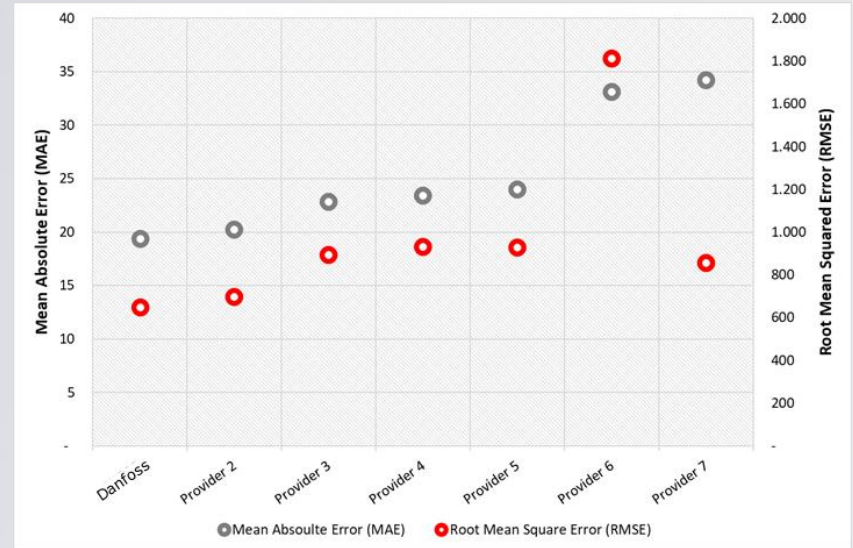
How it works

- > Based on self-calibrating and self-learning models (machine learning) which continuously update as new measurements & weather forecasts become available
- > It automatically adapt to changes in consumer behavior, consumer numbers, meteorological models, building thermal characteristics, and network changes
- > The system applies a smoothing effect to model the energy system's physical properties accurately.
- > It can use Weather Forecaster for improved local weather forecasts and better load predictions
- > A module collects, validates, and corrects data to ensure accurate forecasting
- > It integrates with SCADA systems and supports various data formats, installable locally or hosted by Danfoss.



HeatFor Load Forecast Performance

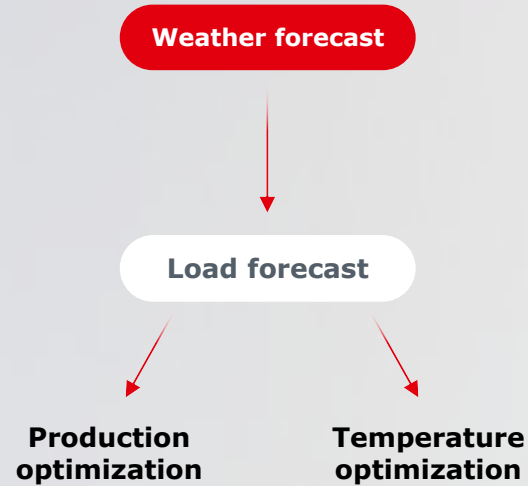
- > Solution was tested over a three-month period in a real-life commercial environment by an actual client
- > The performance was compared against seven other competing systems in the industry
- > The forecasts were evaluated over a 36-hour prediction horizon, ensuring a thorough and robust assessment of the system's capabilities
- > The accuracy of the forecasts was measured using two key performance indicators: mean absolute error (MAE) and root mean square error (RMSE).
- > Our solution outperformed all competitors, achieving the best results in both MAE and RMSE metrics.



HeatFor Load Forecast

Highlights

- > Integrates seamlessly with:
 - > SCADA systems for retrieval of heat production data
 - > Local weather measurements
 - > Locally optimized weather forecasts (ideally provided by Danfoss)
 - > Data driven temperature optimization for temperature optimization of district heating networks
 - > Leanheat Network online modules for optimizing operational parameter of district heating system
 - > Leanheat Production Operations for optimizing heat and electricity production
- > Data integration interfaces based on FTP, SFTP or web-services supporting numerous formats and file types (CSV, XML, SOAP, JSON etc.)
- > Runs on all common server platforms (Windows, Linux) or can be hosted on Danfoss cloud infrastructure



Leanheat® Network



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Package 4: Optimized temperature control

Reduces energy costs

- › Typically reducing heat losses by 3-10% leading to 1-3% fuel cost reduction
- › Highly flexible. Can be configured to various network configurations with and without dependencies between the networks
- › Minimizing pressure fluctuations hence extending the lifetime of the network
- › Considerable savings and reduction of carbon emissions

$$\text{Heat loss} = \text{Constant} (T_{media} - T_{soil})$$

where T is the temperature

Heat loss is reduced if average media temperature is reduced!

The basis for temperature optimization is a reduction of supply temperature.



Leanheat® Network



Budget and investment planning

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 **Web dashboard** >

 **Pressure optimization** >


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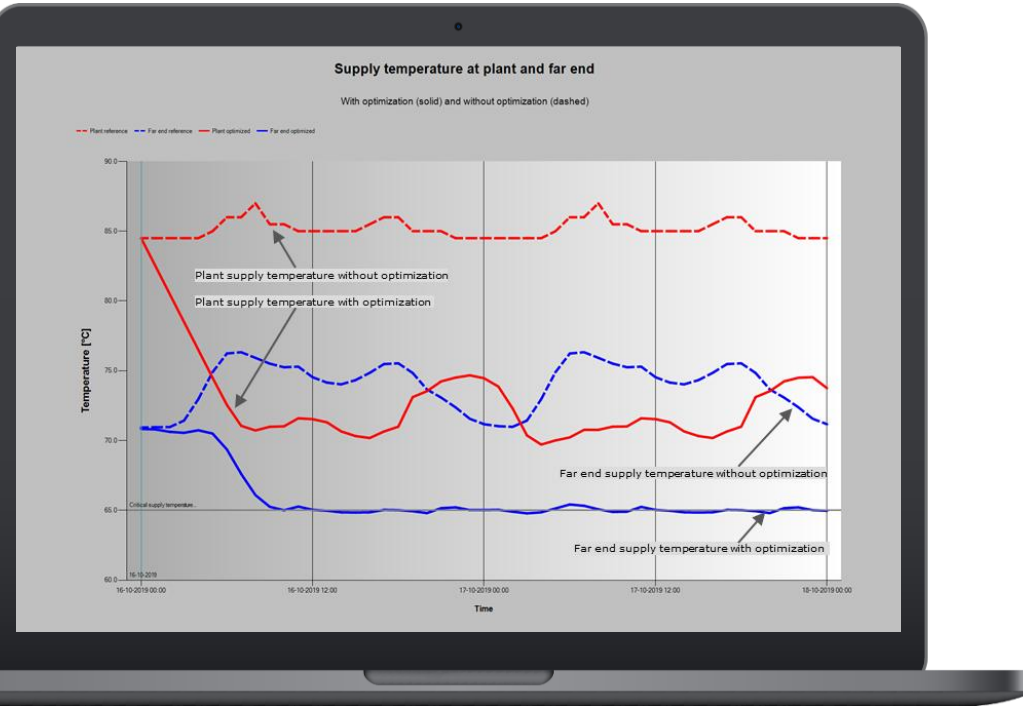
Optimized temperature control

 **Hydraulic temperature optimization** >

 **HeatTO Data Driven Temperature Optimization** >

Hydraulic Temperature optimization

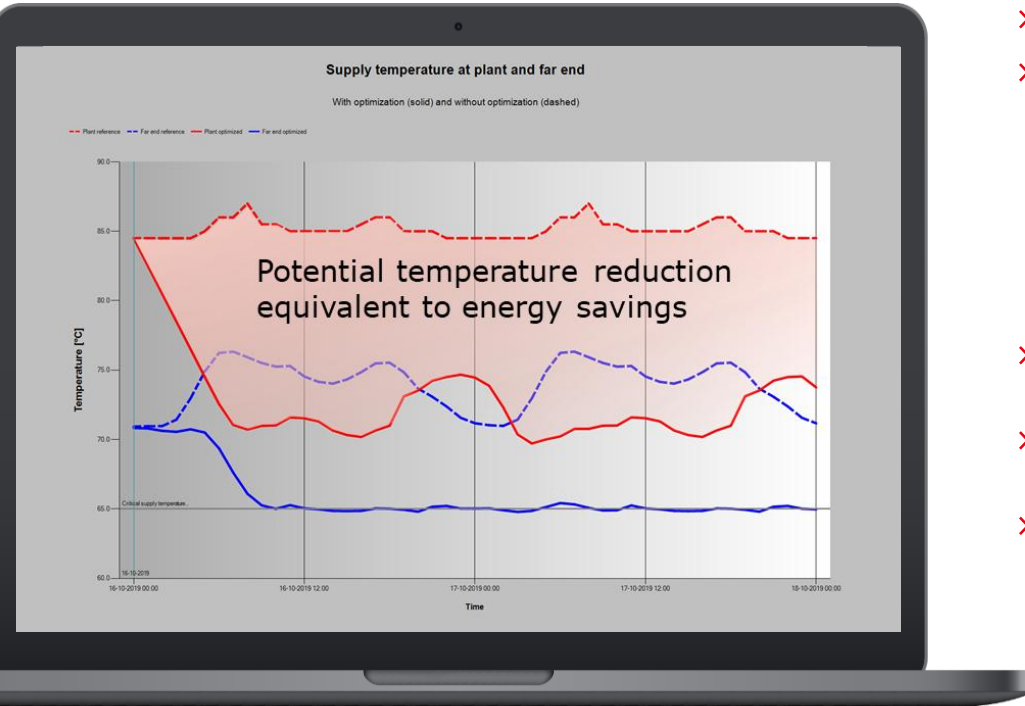
How it works



- Works on top of online thermo-hydraulic model
- Optimization uses load forecast, flow and temperature measurements combined with thermo-hydraulic optimization engine, while ensuring that:
 - the hydraulic capacity of the system is respected
 - the critical areas have sufficient supply temperature
 - combined costs for producing and distributing the energy to consumers are minimized
- Supply temperature is subject to:
 - min/max limits
 - restrictions in rate of change
 - diurnal change to reduce peak loads
- Automate continuous online simulations with a cyclic process that integrates real-time conditions and future load forecasts

MetFor Weather Forecast

Highlights



- › Runs with in-house developed thermo-hydraulic engine
- › Integrates seamlessly with:
 - › Any measurements from the district heating network
 - › Heat demand forecasts (ideally provided by Danfoss Load forecaster)
 - › Leanheat Production Operations
 - › Leanheat Monitor
- › Manages fluctuating baseload production from multiple locations for efficient operation
- › Optimizes large networks with looped connections and complex hydraulic behavior
- › Adapts to instantaneous network changes, ensuring reliable and efficient performance

Leanheat® Network



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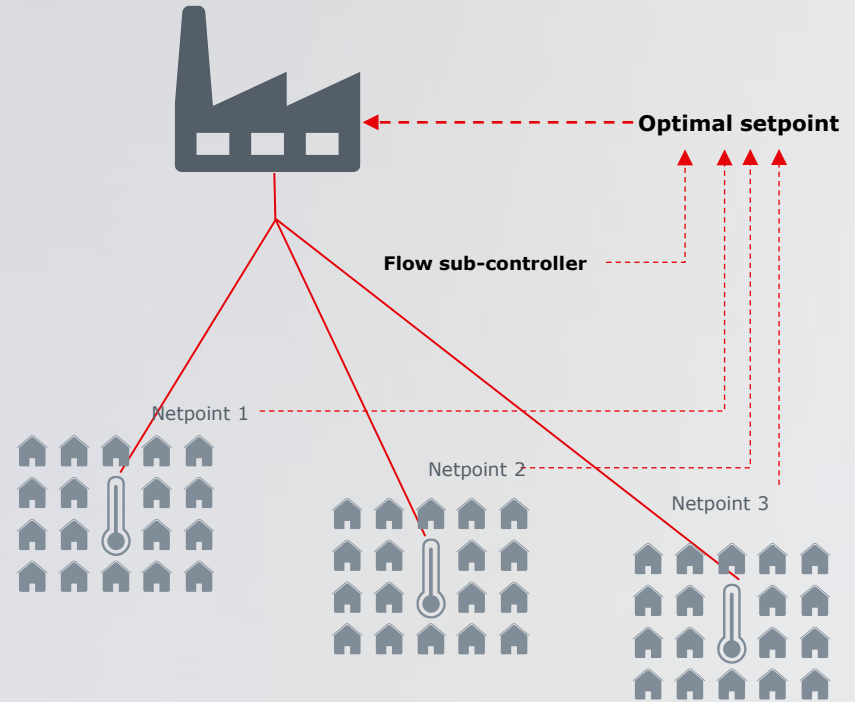
 **Hydraulic temperature optimization** >

 **HeatTO Data Driven Temperature Optimization** >

HeatTO Data Driven Temperature Optimization

How it works

- > Uses load forecast, flow and temperature measurements combined with data driven self-learning and self-calibrating algorithms, to optimize supply temperature in the heating network, while ensuring that:
 - > the hydraulic capacity of the system is respected
 - > the critical areas have sufficient supply temperature
- > Controller logic
 - > flow sub-controller (under a configurable max value)
 - > number of netpoint temperature sub-controllers (above a configurable control curve dependent on ambient temperature).
- > Supply temperature is the maximum of the sub-controller temperatures, and subject to:
 - > min/max limits
 - > restrictions in rate of change
 - > diurnal change to reduce peak loads

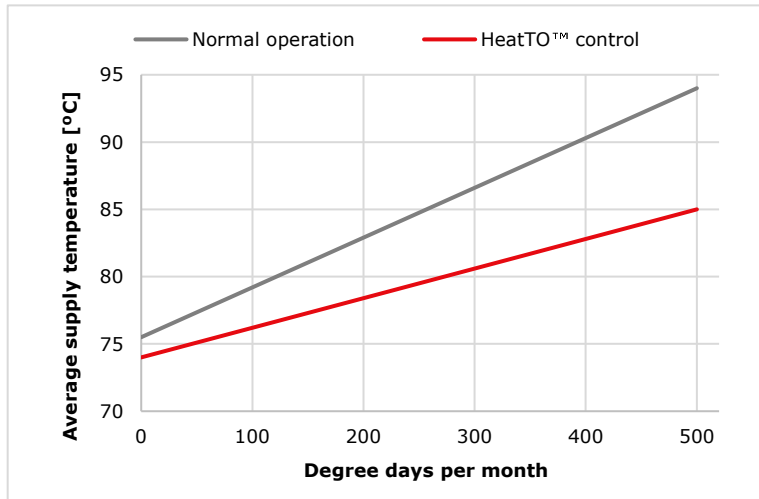


HeatTO Data Driven Temperature Optimization

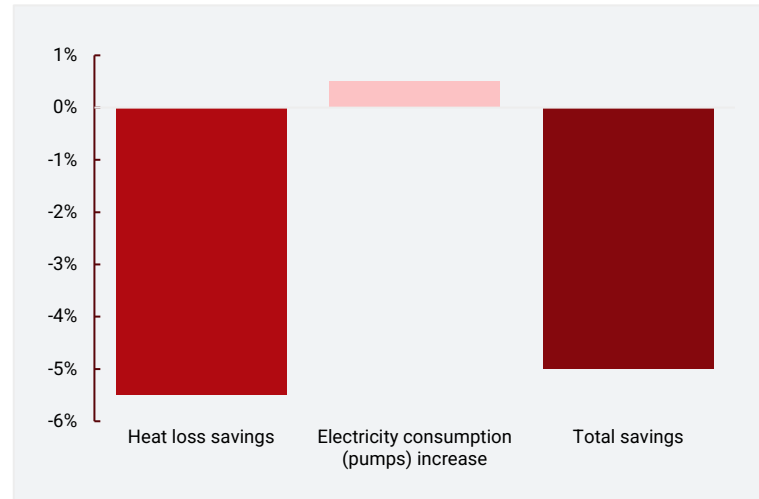
Performance

> Client cases results

Supply temperature reduction

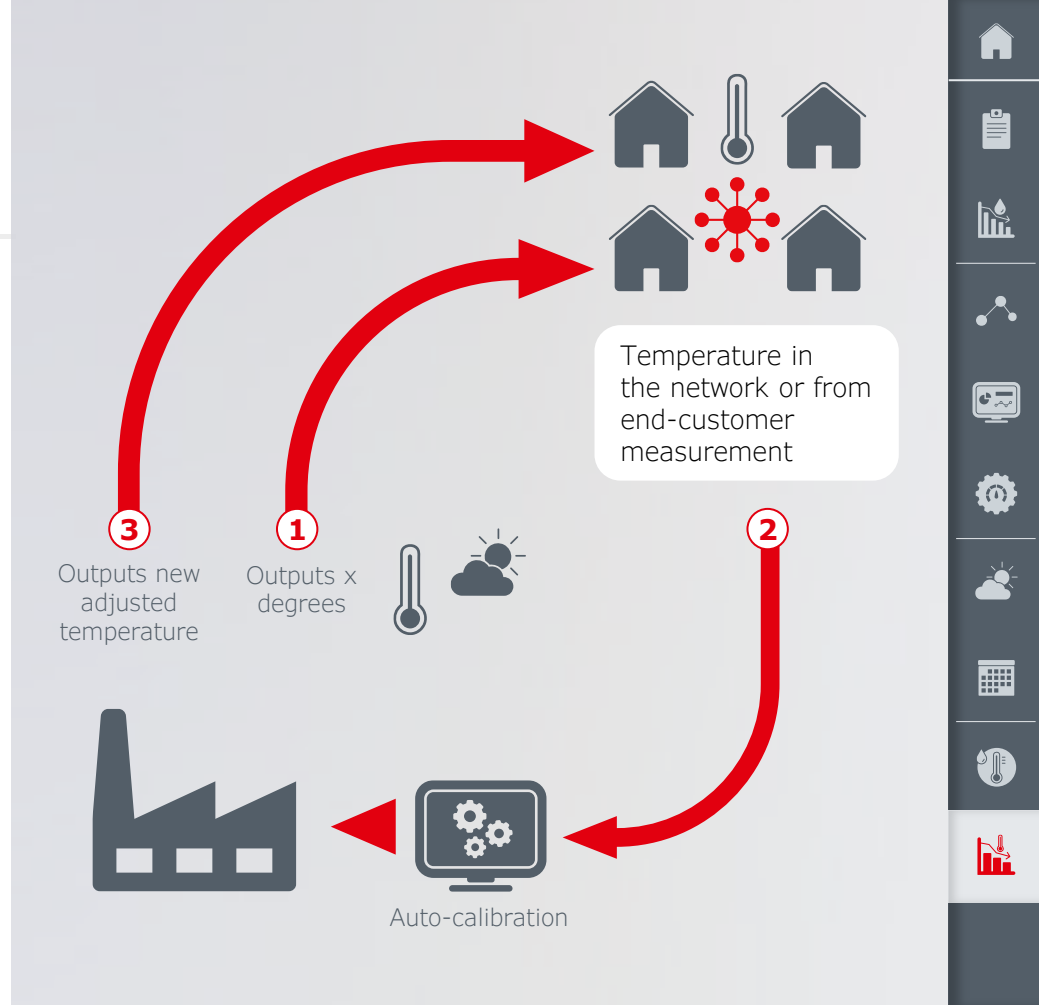


Savings



HeatTO Data Driven Temperature Optimization **Highlights**

- > Self-learning and self-calibrating algorithms for optimization of supply temperature of district heating network
- > Integrates seamlessly with:
 - > Temperature measurements from the district heating network
 - > Heat demand forecasts (ideally provided by Danfoss Load forecaster)
 - > Local weather measurements
 - > Locally optimized weather forecasts (ideally provided by Danfoss Weather forecaster)
- > Controls single network or multiple linked networks
- > Data integration interfaces based on FTP, SFTP or web-services supporting numerous formats and file types (CSV, XML, SOAP, JSON etc.)
- > Runs on all common server platforms (Windows, Linux) or can be hosted on Danfoss cloud infrastructure



HeatTO Temperature Optimization

Best suited for systems where...

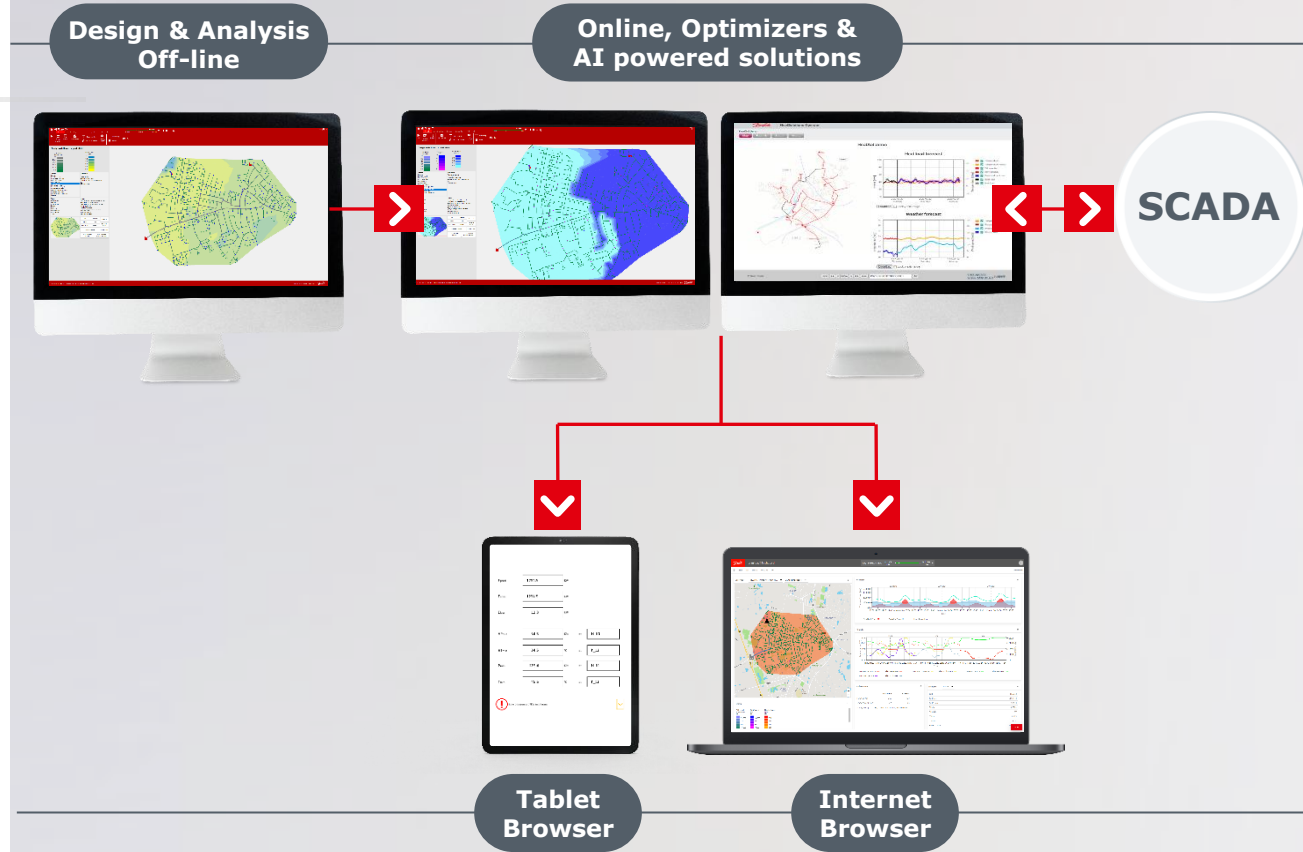


- › Networks are supplied from a maximum 1-3 sources operating under the same temperature regime
- › There are no sudden large network changes, allowing the model to adapt relatively quickly
- › Data available are reliable, frequent and of good quality
- › Network expansions are gradual, allowing the model to adapt to the new conditions

Leanheat® Network – System Overview

> Start and grow with your needs:

- > Offline design tool
- > Online module
- > Add optimizer modules
- > Interface to browsers





Danfoss Climate Solutions, your partner for district energy solutions.