Data-driven decision support for optimisation of heat installations

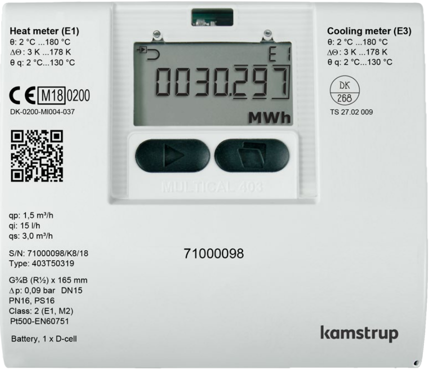
Smart Energy Systems, 11th September 2019, Copenhagen

Morten K. Rasmussen, Data Scientist, Kamstrup

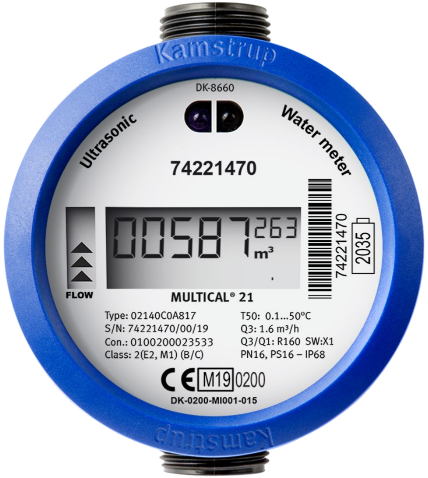
https://www.linkedin.com/in/mortenkrasmussen

All our products are electronic with built-in intelligence

MULTICAL®
Heat/cooling
meters



OMNIPOWER
Electricity meters



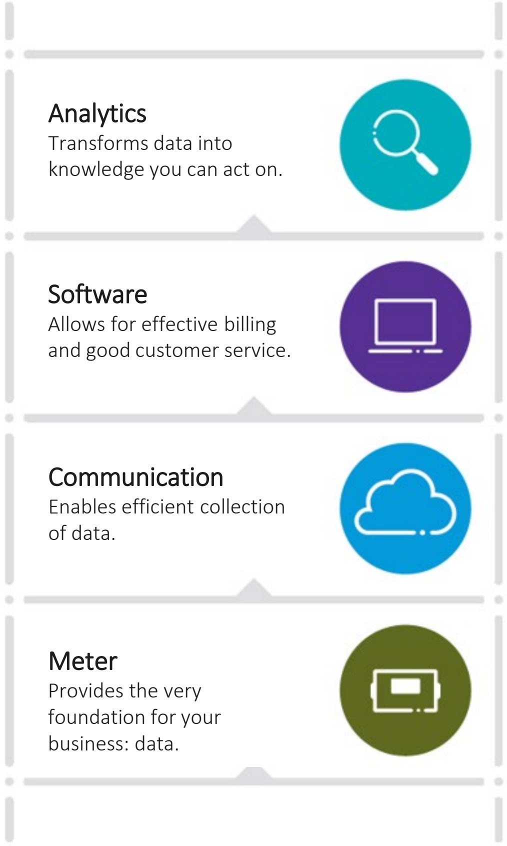
MULTICAL® and flowIQ
Water meters

The digital value chain

You cannot optimise what you do not measure, but…

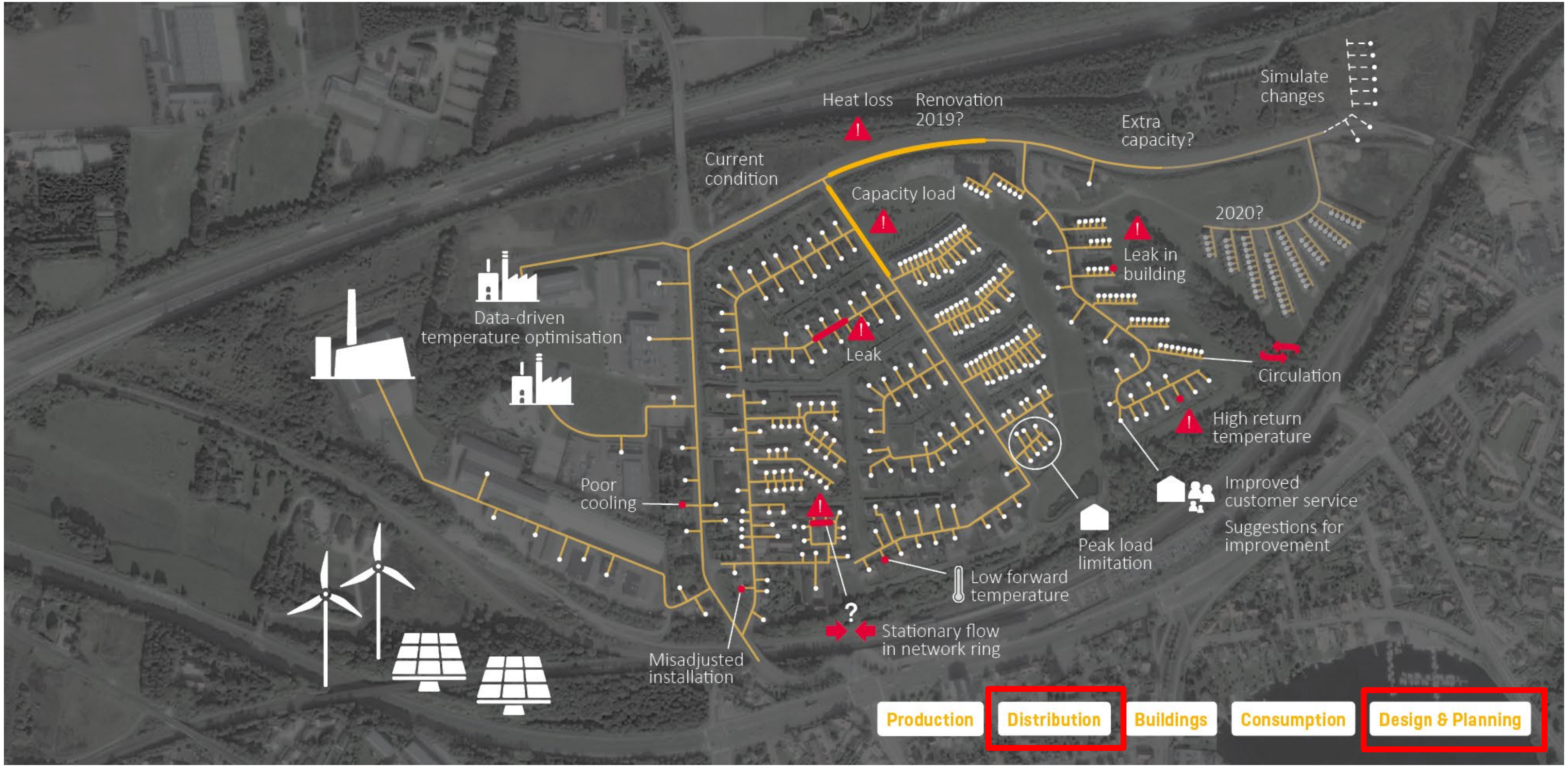
Unlocking the true potential in smart meter data requires the right tools to turn it into knowledge you can act on.

Kamstrup's value chain includes everything from the actual meter to the communication, software and analytics.



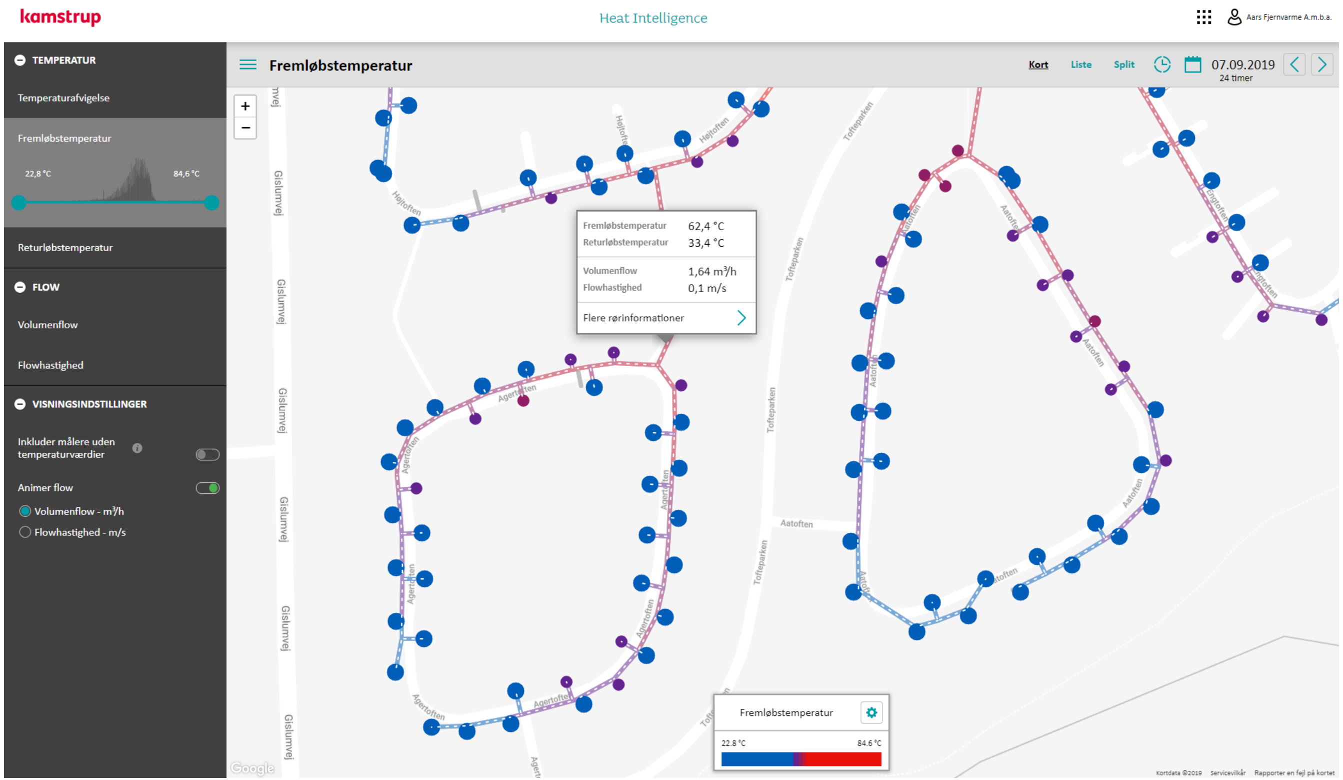
Digitalised District Heating

kamstrup



Heat Intelligence – transparency in the distribution network

Flow, temperature and pressure is estimated in the distribution network on the basis of meter data (network end nodes)



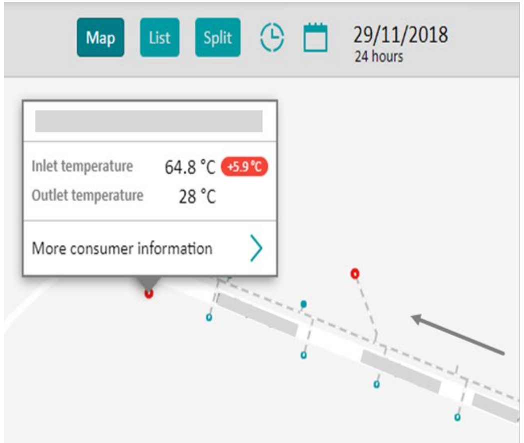
Heat Intelligence - identifying bad network performance

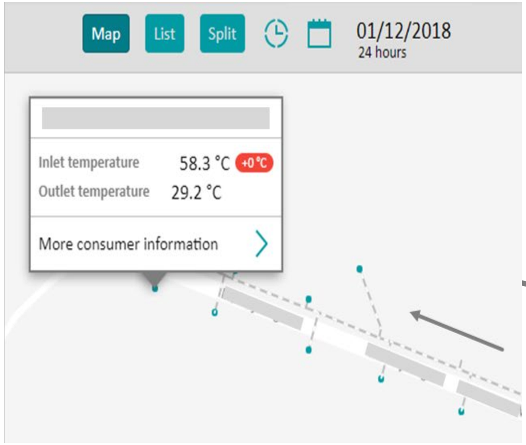
When the network flow, temperature and pressure is known,

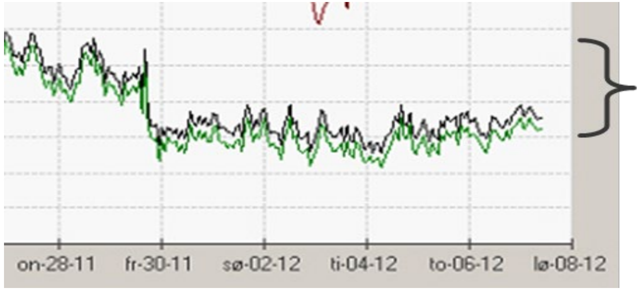
Model outliers consumers (meters) can be identified to gain various information converning the consumer installation and distribution network performance

Reduce return temperatures in distribution network

kamstrup







≈ 1.5 °C decrease in return temperature

Identify and close unnecessary bypasses

District heating network in small village with 300 connections, primarily 1-family houses

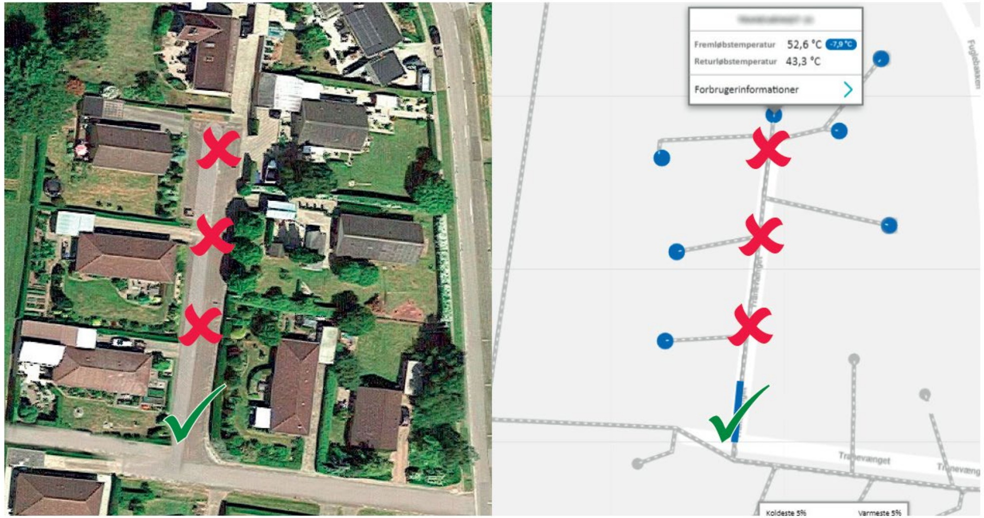
In this case, the bypass is resulting in a flow temperature deviation of 5.9 °C

After closing the bypass, the temperature dropped to the expected temperature

The average return temperature from the area dropped with 1,5 to 2 °C

https://www.kamstrup.com/en-en/blog/eliminate-bypasses-and-decrease-return-temperature

Locate leakages in the distribution network



Search for leakages with Heat Intelligence

In the area around the leakage, the temperature pattern changes significantly

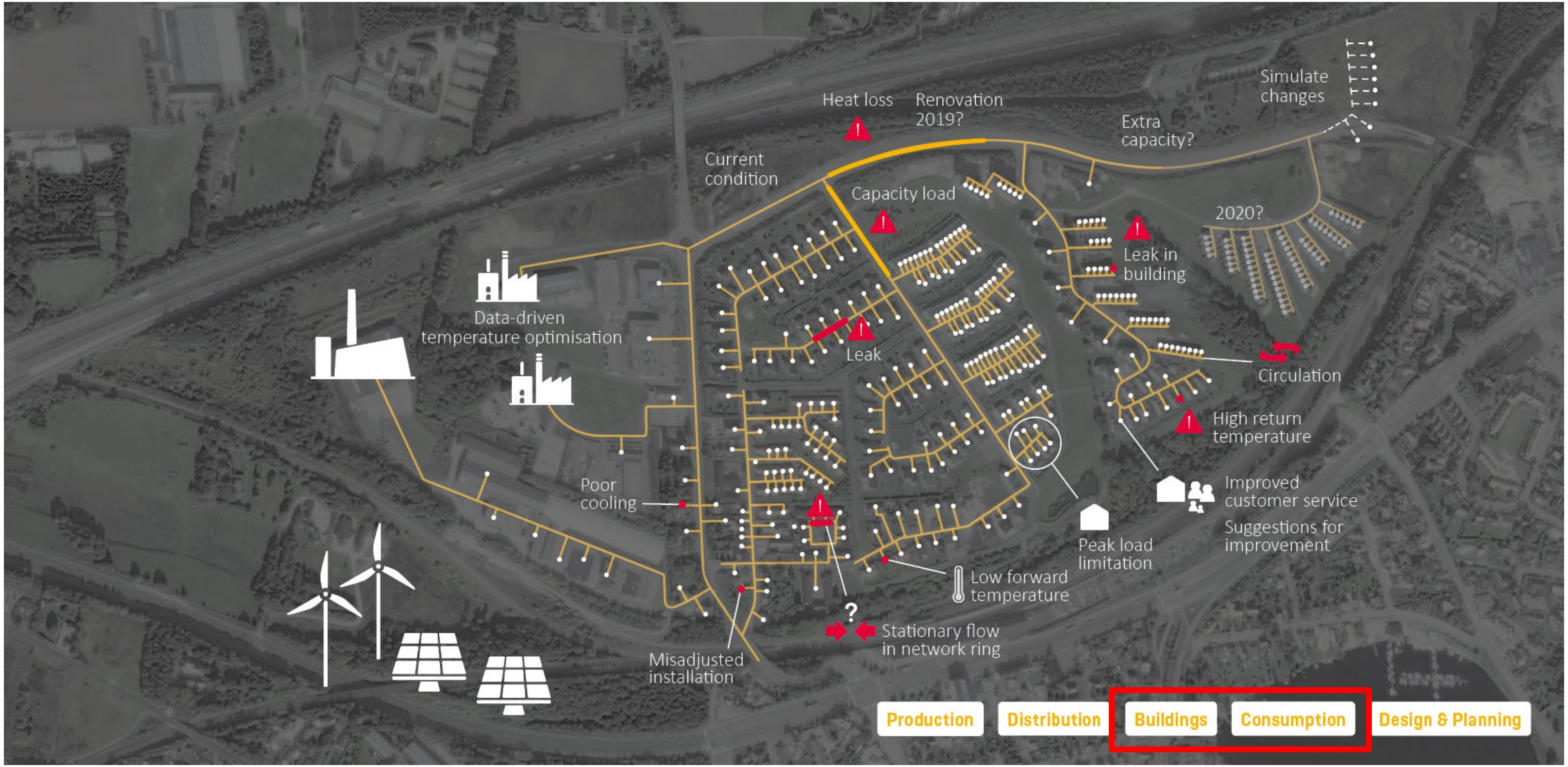
In this case, the consumers downstream from the leakage are marked blue due to temperatures lower than expected

Based on data from Heat Intelligence, the first dig would have been done between the blue consumers (with deviations) and the consumers without deviations

The concrete repair of the broken pipe demonstrated that instead of digging 4 places before finding the leakage, 1 dig would have been enough as the leakage was found exactly where Heat Intelligence indicated it should be!

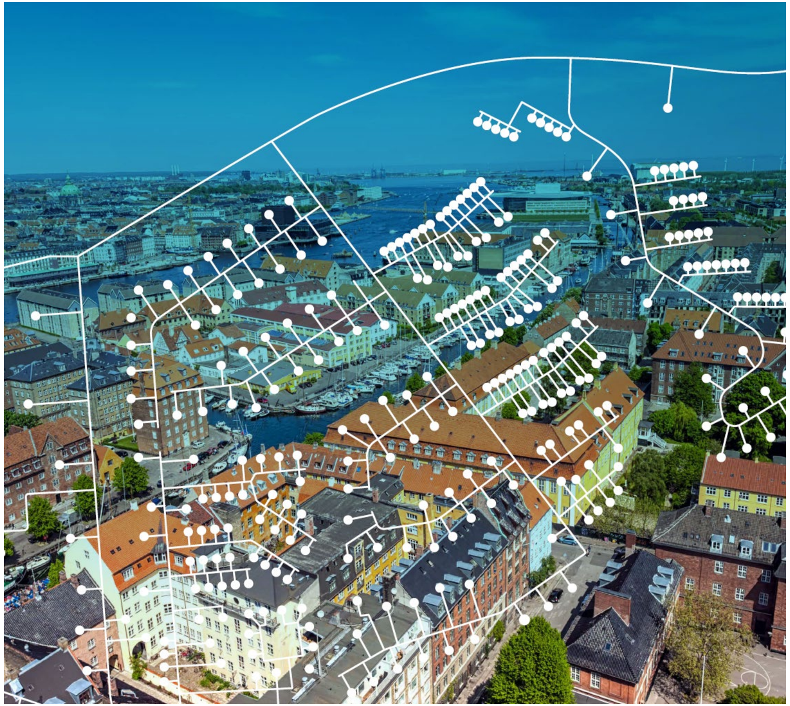
https://www.kamstrup.com/en-en/blog/how-data-could-have-reduced-the-number-of-diggings-for-a-leak-by-75

Digitalised District Heating, buildings and installations



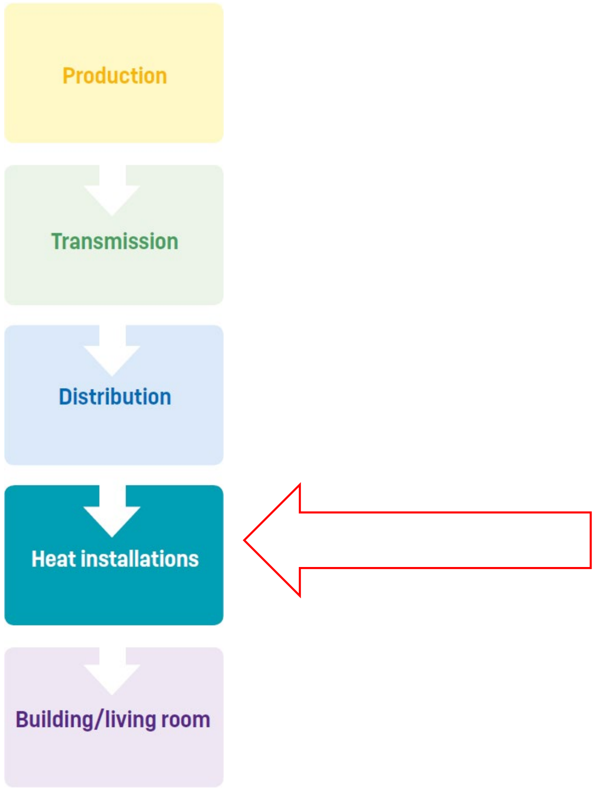
kamstrup

Developing integrated, scalable solutions with international potential that save energy and optimise the entire district
heating value chain through a strong collaboration of Danish partners, shared knowledge, data and intelligence.



HOFOR GRUNDFOS Danfoss kamstrup

Ongoing project with HOFOR (greater Copenhagen utility)



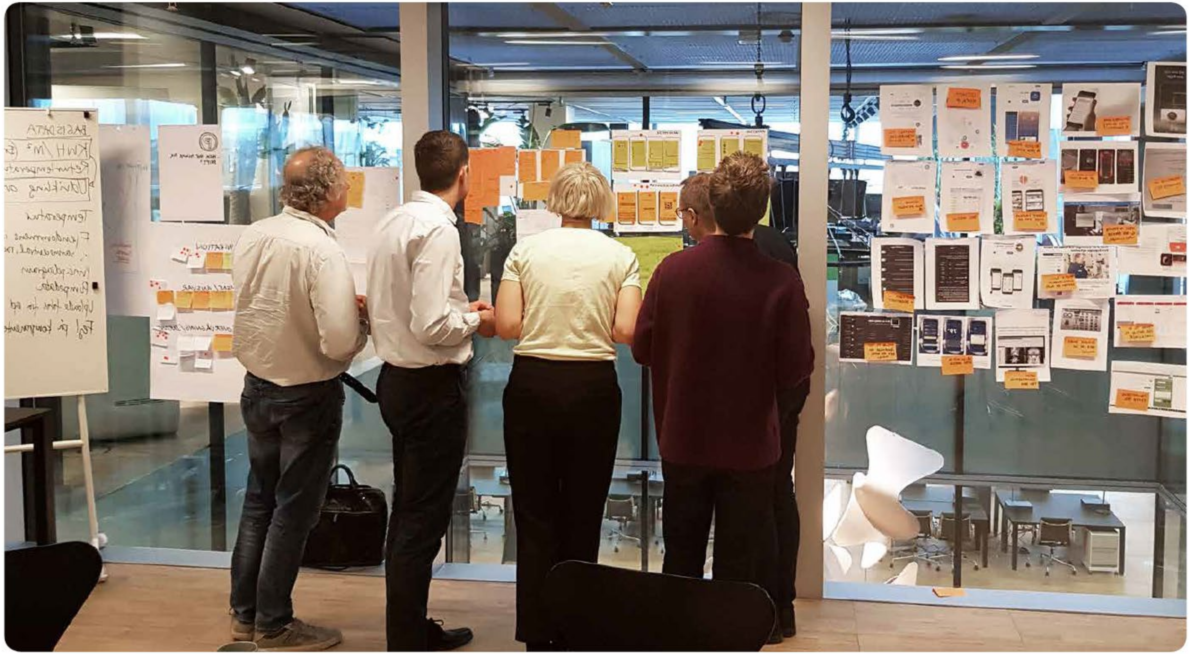
Our focus area is the optimisation of end-user heat installations. This is where we see the biggest and most immediate potential for value creation because buildings have such a big impact on return temperatures.

Also, optimising this link will directly impact the rest of the chain, such as a utility's production and distribution

HOFOR estimates that **50% of heat installations** in their supply area could be optimised in some way, and around **25% are outright faulty**.

As a result, they are not only inefficient, which has a negative effect on the utility's operations, but consumers are also paying too much for the heating of their homes.

Ongoing project with HOFOR – workshop with domain experts

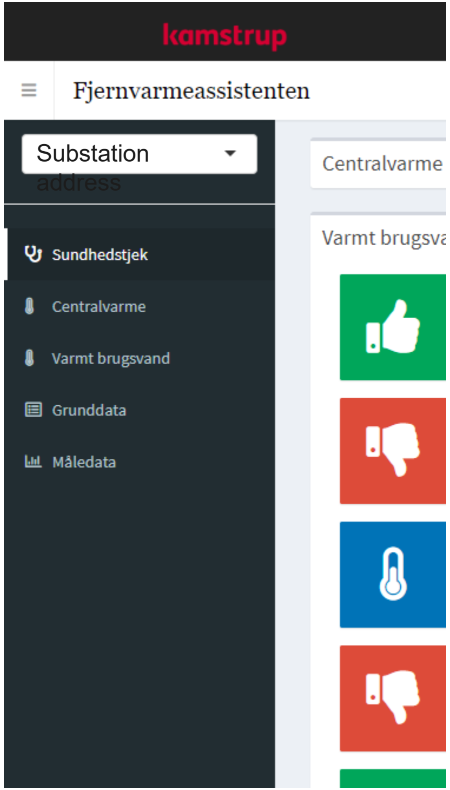


Design sprint workshop, where the Heat Assistant prototype was sketched on paper.

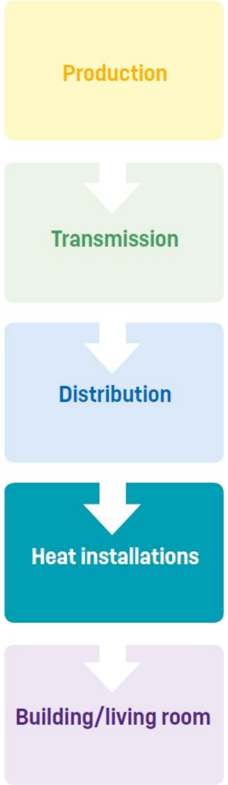
Heat Assistant

is a data-driven tool providing decision support for plumbers or other professionals optimizing heat installations.

The application shows the overall KPIs, information about the building, the heat installation and suggests possible diagnoses as well as corrective actions.



kamstrup



Expected results:

- Number of inefficient end-user heat installations to be reduced
- Lower heat prices for end users
- Lower forward and return temperatures
- Network losses to be reduced

Motivation:

- 3 degrees lower return temperatures on Average (DKK 100 million savings)
- 5% reduction of heat consumption in buildings on average
- Support goal of CO2 neutrality by 2025

Fault detection in substations

kamstrup

- Energy companies put significantly effort into improving the efficiency of the energy supply and distribution

- Substations and customer secondary systems are of less interest (regarded as the customers' problem)

- Reasons for not working with fault detection in substations
  - There are many substations… and significant work is required to see any results
  - Lack of knowledge, internal problems with handling a job in which a large part of the company must be involved, difficult customer relations

- Current 3 kinds of faults (2.6)
  - faults resulting in comfort problems such as lack of heat or domestic hot water and physical faults such as water leakage
  - Faults that are known but unsolved due to the need of too many man-hours to identify them
  - faults for which new fault detection methods must be developed.

- … "because new faults will appear in substations and secundary systems, work to decrease system temperatures must be an ongoing component of day-to-day work. Otherwise, system temperatures will slowly increase as new faults appear".

- … therefore we need to use a data driven approach (frequently read meter data) as the basis for automatically detection of hidden faults

75% of substation are found faulty, and have a optimization potential

Gadd, H., & Werner, S. (2015). Fault detection in district heating substations. *Applied Energy*, *157*, 51–59. https://doi.org/10.1016/j.apenergy.2015.07.061

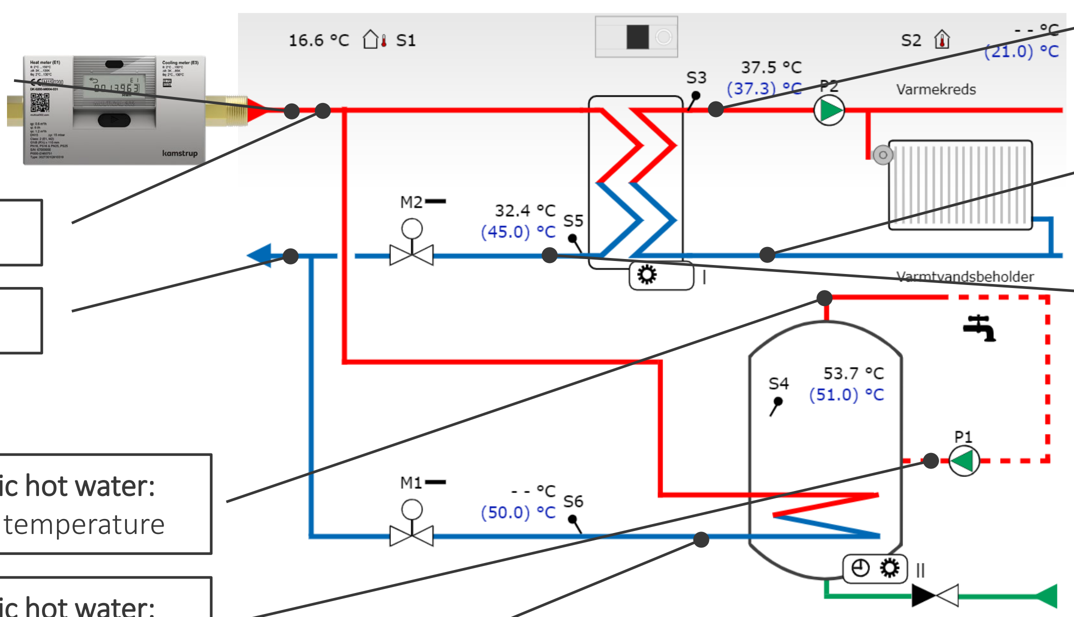
Typical installation, and the data used in the project

kamstrup

Primary side:
Flow
(energy)

Forward temp.

Return temp.



Space heating:
Forward temperature

Space heating:
Return temperature

Space heating:
Return temperature to primary side

Domestic hot water:
Forward temperature

Domestic hot water:
Circulation temperature

Domestic hot water:
Return to primary side

9 signals in total (8 temperature + 1 flow) …
… and in addition:

- Building data (type of installation, installation capacity, living space area)
- Weather data (degree days, outdoor temperature)

kamstrup

Algorithms are developed to:

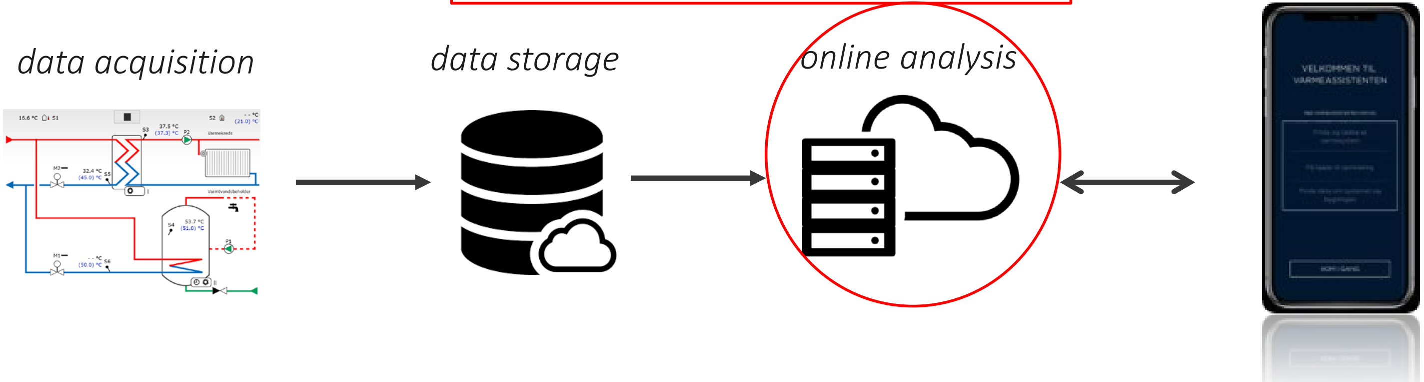
- ingest, clean, validate and align data from the relevant sources

1. Diagnosis of heat exchanger performance
2. Diagnosis of domestic hot water production performance
3. Diagnosis of district heating supply performance

Cloud based prototype application (mobile phone compatible) ingests data from all onboarded buildings / heat installations in the project

This part was developed in close collaboration with the utility (HOFOR)

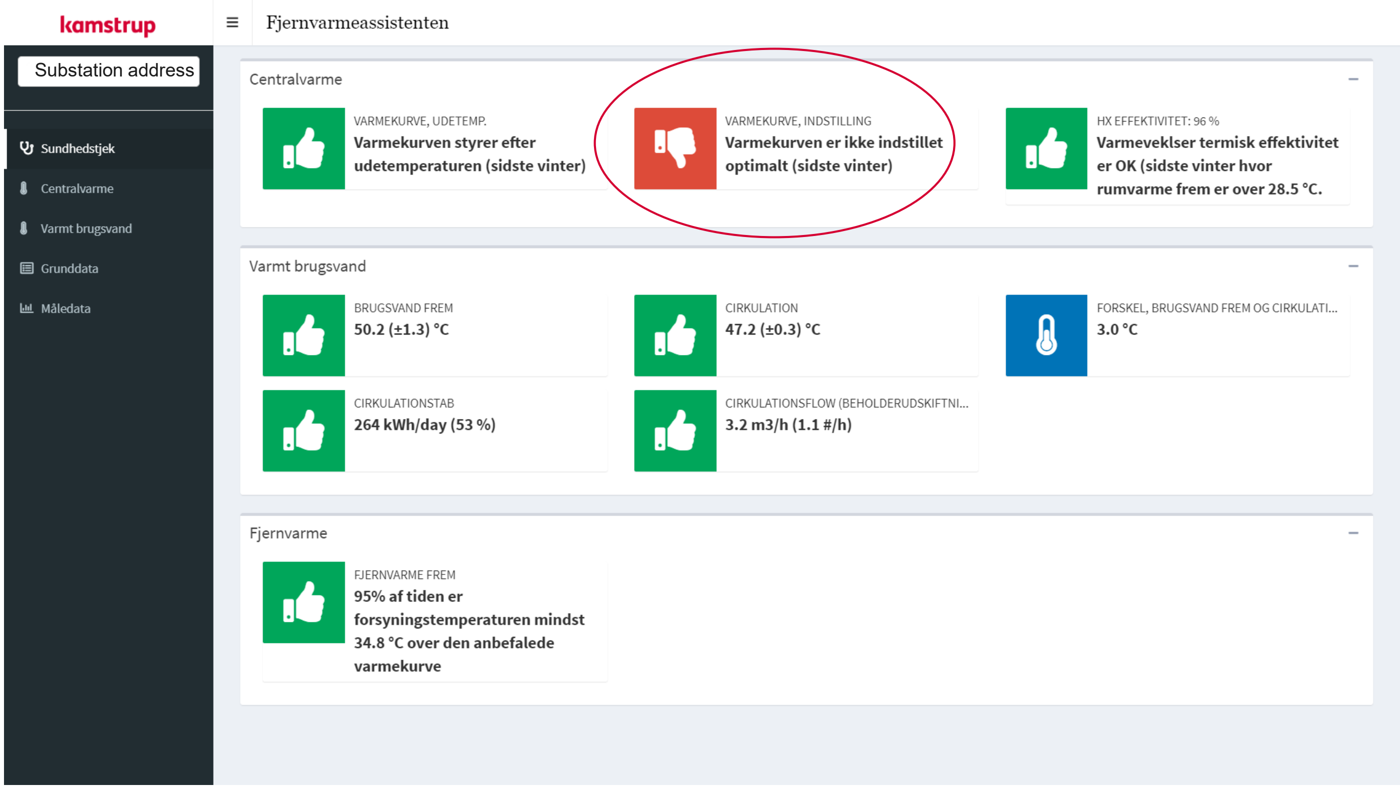
Front end - optimized for mobile devies



Heat Assistant – substation overview

kamstrup

overview KPI's

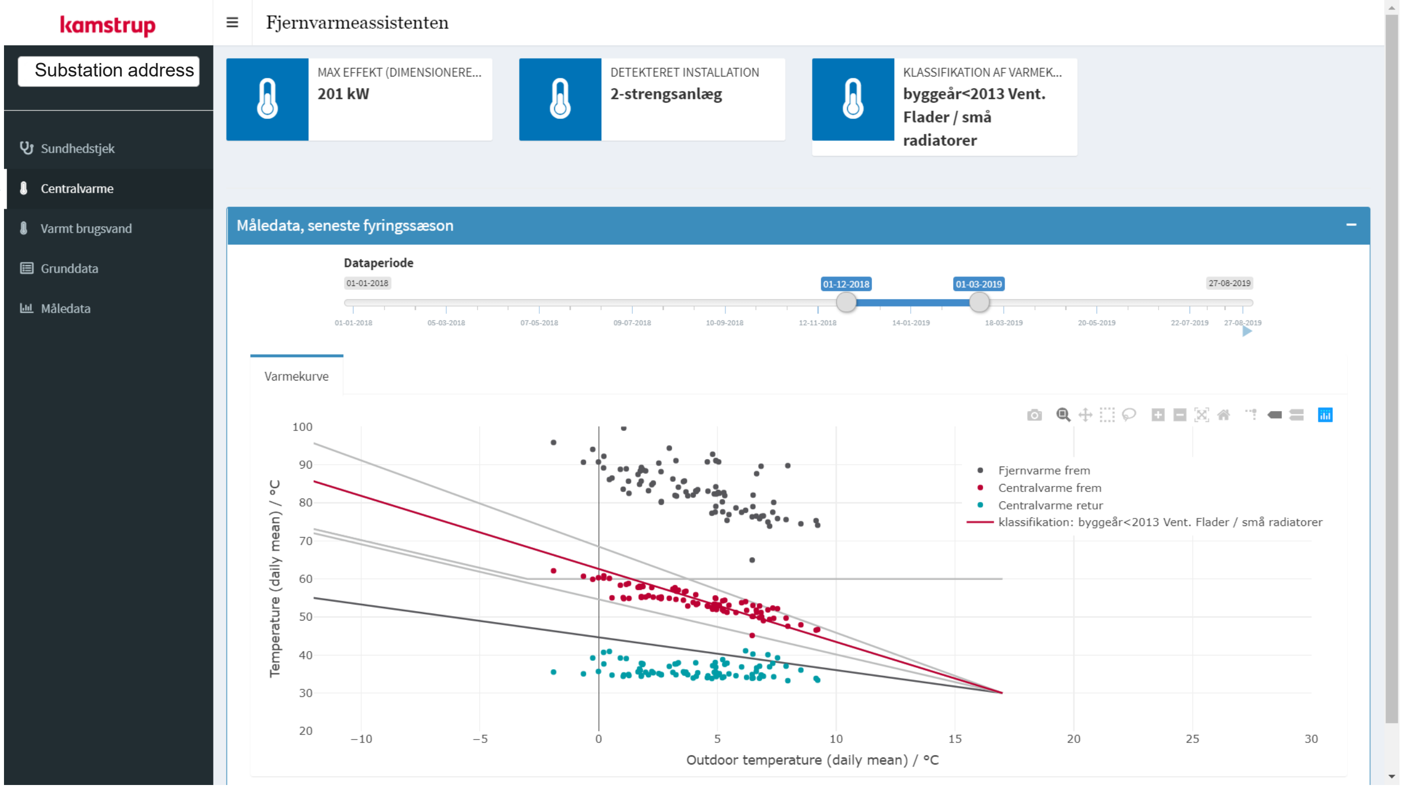


Space heating KPI's

Heat Assistant – central heating overview

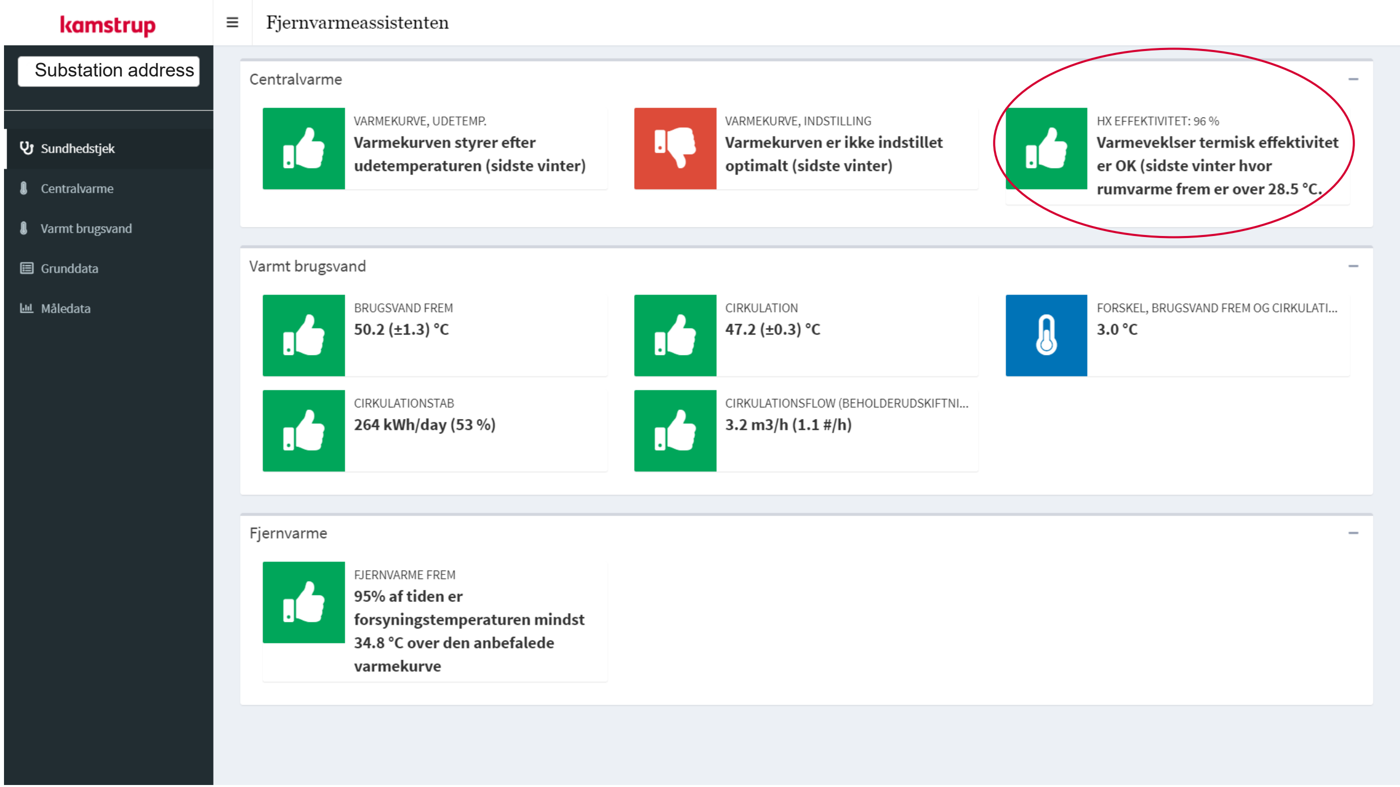
kamstrup

Space heating sub KPI’s



Heat Assistant – substation overview

overview KPI's



Space heating KPI's

Hot water KPI's

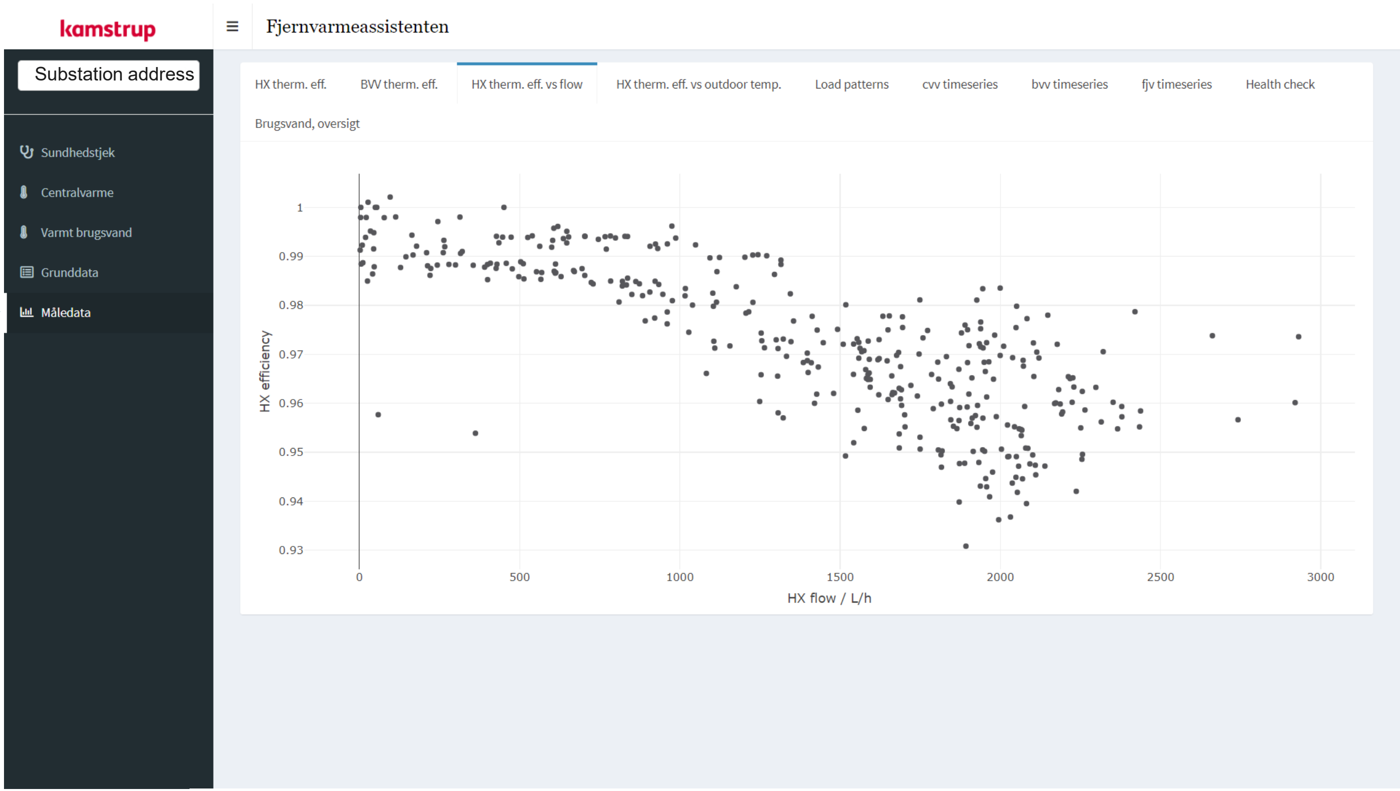
Heat supply KPI's

Heat Assistant – inspecting heat exhanger performance over time

Time series plots of various parameters

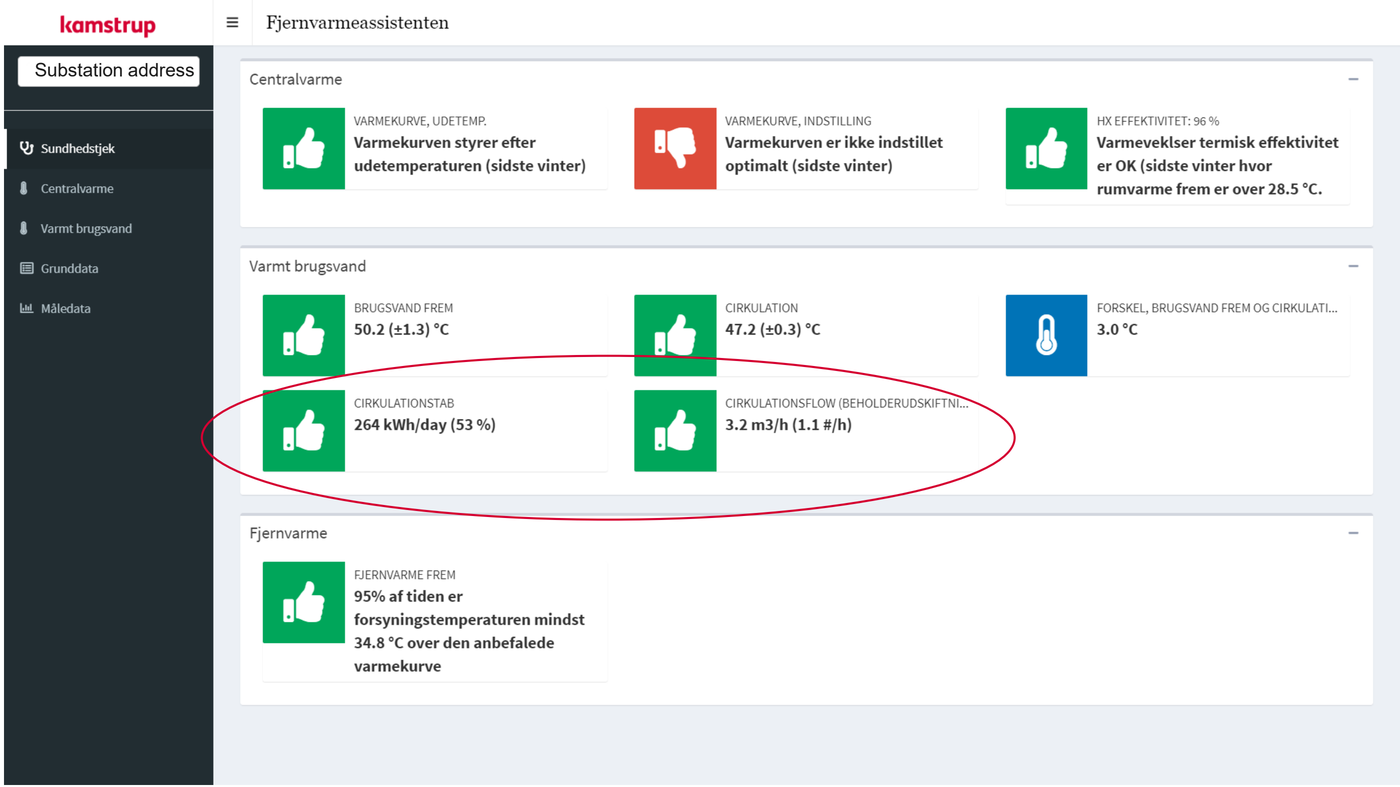
Heat Assistant – inspecting heat exhanger efficiency vs flow

more complicated visualizations of various paramters



Heat Assistant – substation overview

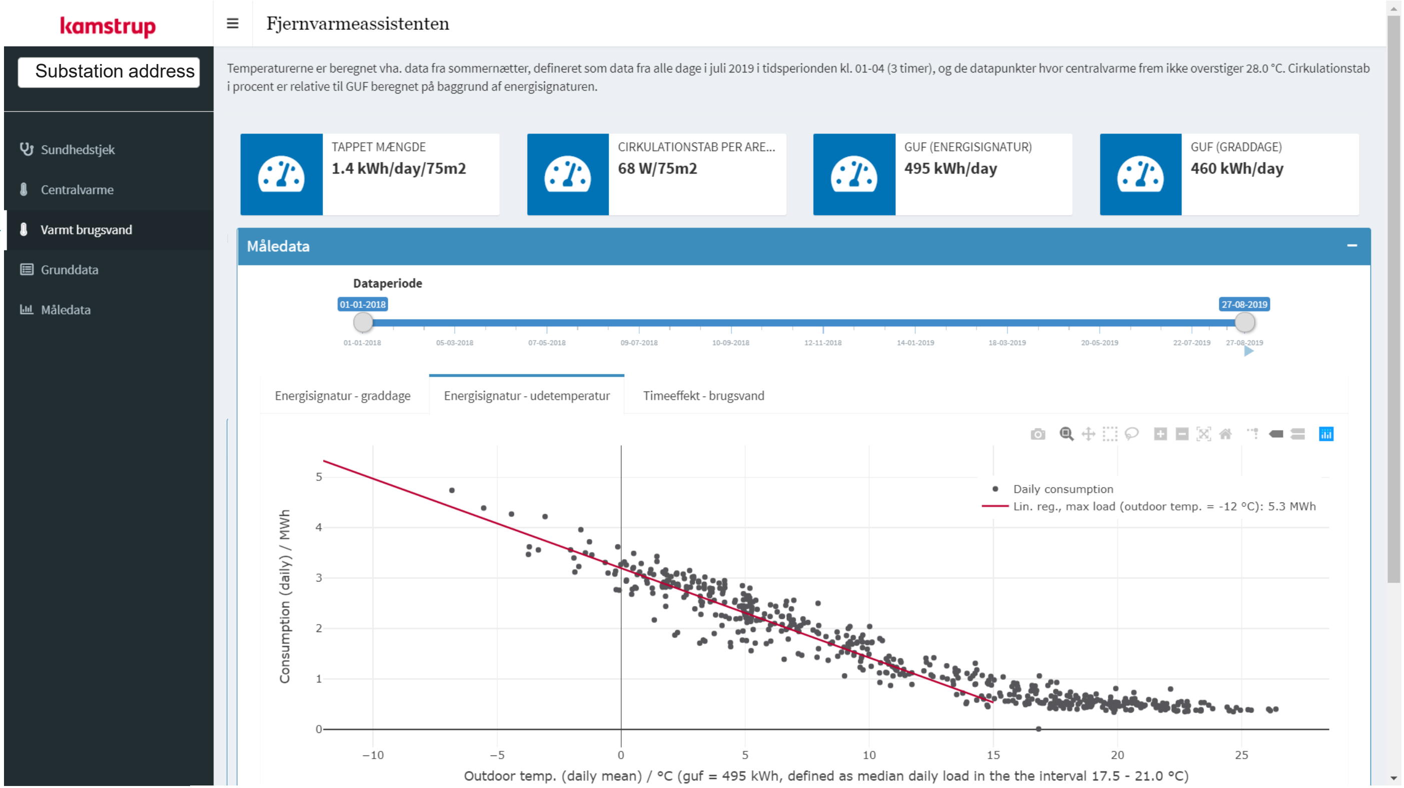
overview KPI's



Hot water KPI's

Heat Assistant – domestic hot water overview

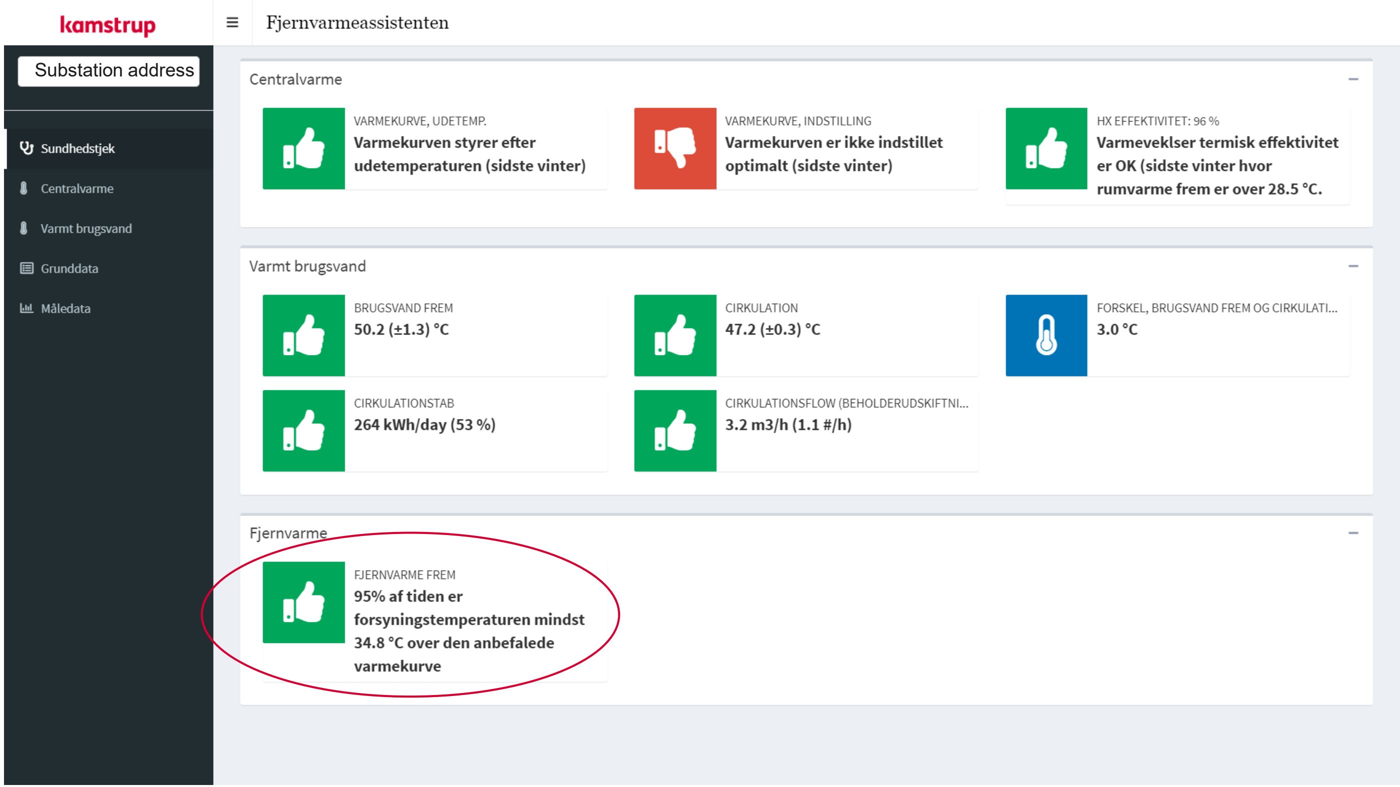
Hot water sub KPI's



Heat Assistant – substation overview

kamstrup

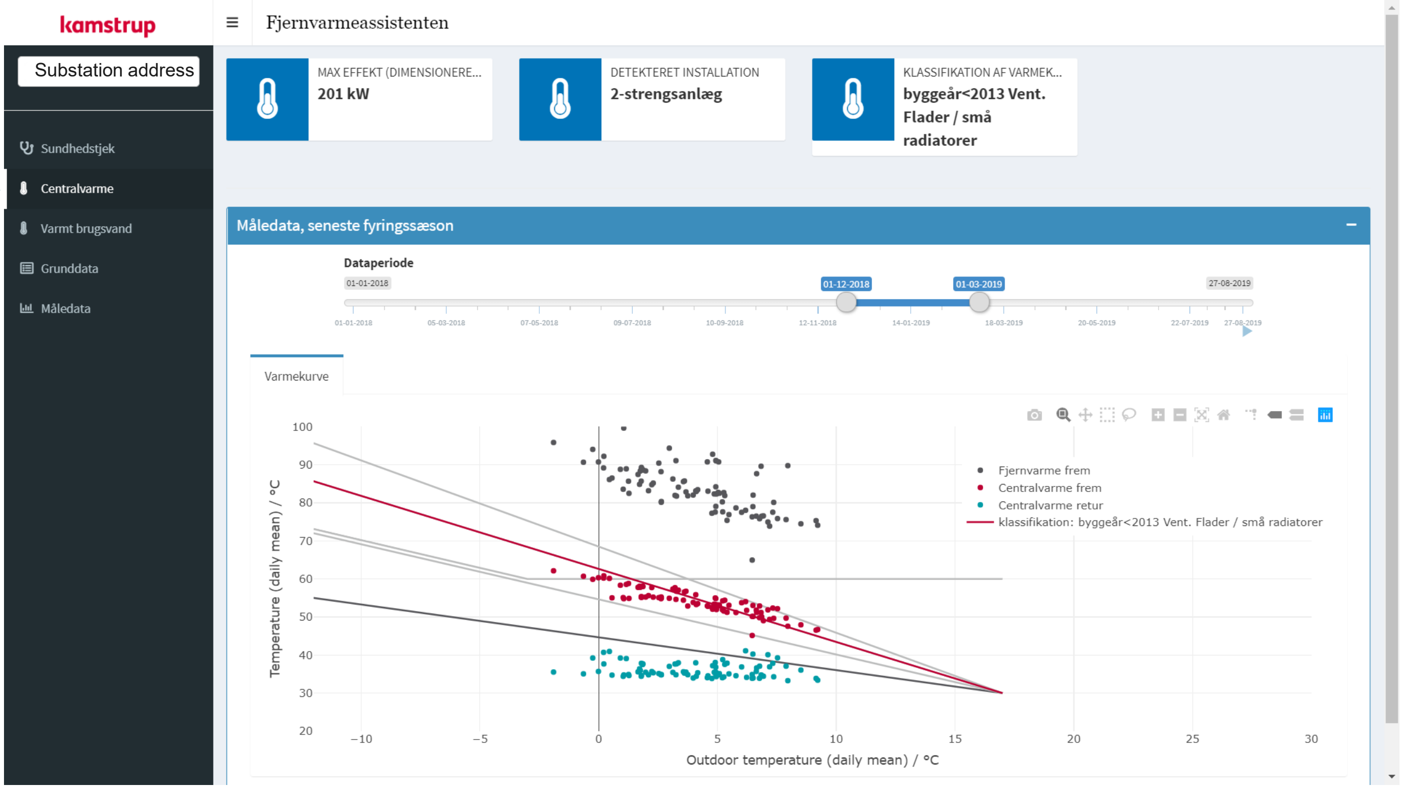
overview KPI's



Heat supply KPI's

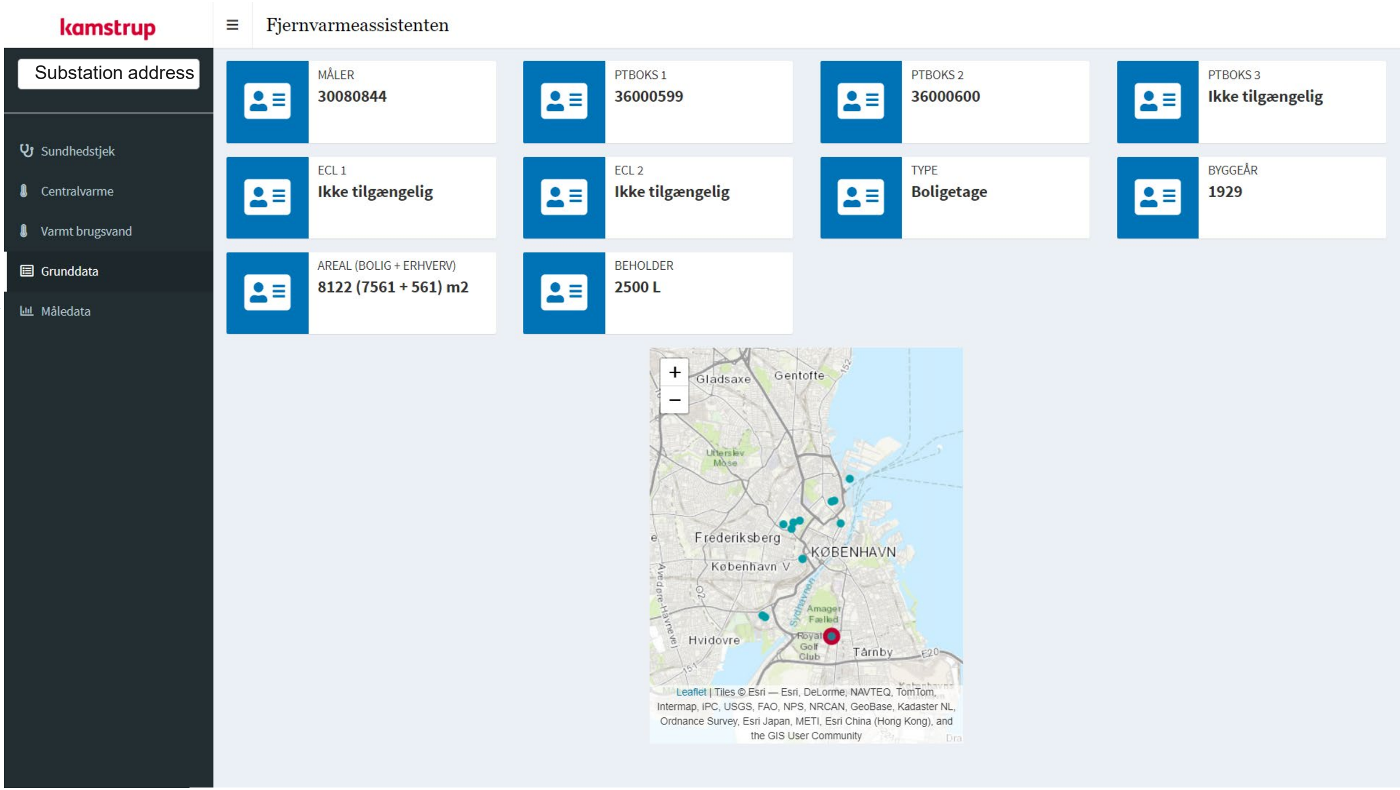
Heat Assistant – central heating overview

Space heating sub KPI's



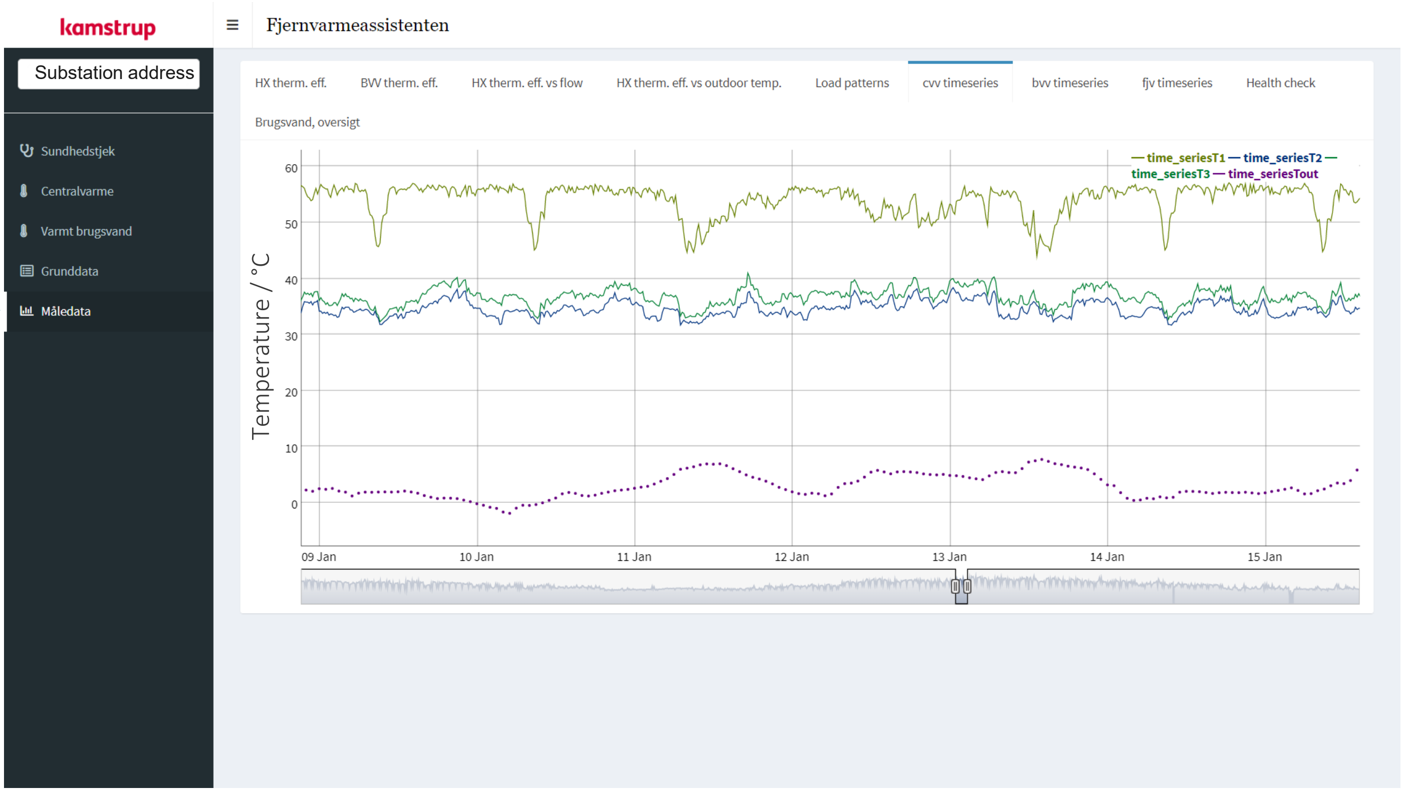
Heat Assistant – building information

Building / substation information



Heat Assistant – inspecting central heating temperatures time series

Time series plots of sensor data



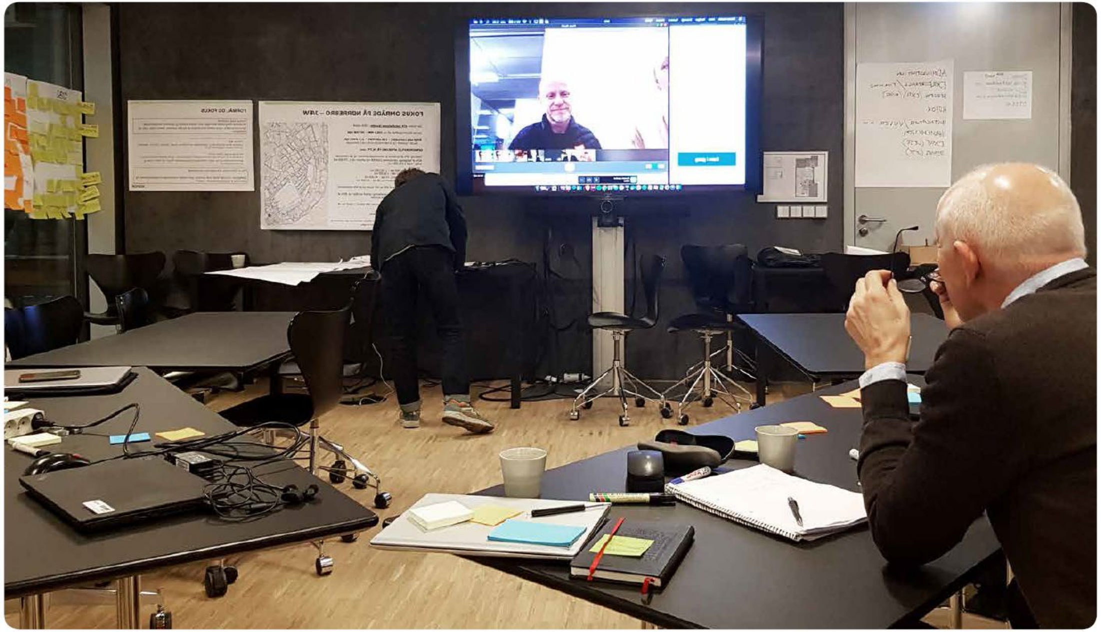
Heat Assistant – next step is user test ...

kamstrup

Prototype is developed in the project group...

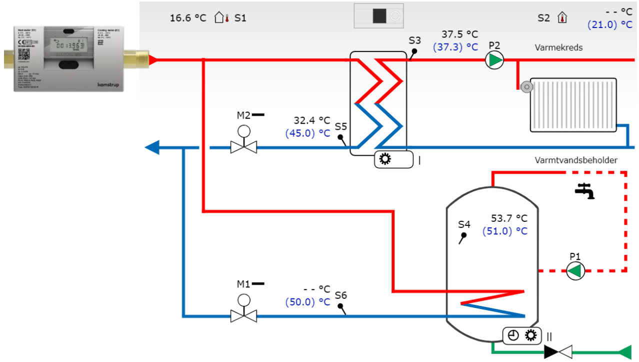
application target group is building managers, plumbers etc.

the prototype needs to be aligned in accordance with the test results of the real end users



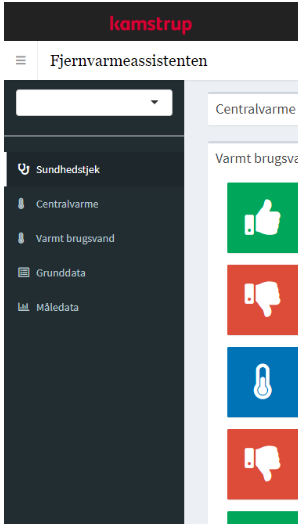
The digital prototype is tested by two plumbers. The project participants observe via video in order to not interfere or influence the test.

Heat assistant – … and scaling up the application



Energy meters are in all buildings → how many sensors are necessary on the secondary side?

Apply AI / machine learning to reduce the required amount of measuring points and amount of data (temporal resolution)



Solution needs to be developed to scales the concept to many utilities and many substations / installations

Proof of concept has been established through validated prototype application

Next step is, in the project group, to find out how to proceed and further develop the obtained knowledge and proof of concept.

Thank you for your attention

kamstrup

Think forward!

Morten K Rasmussen
Data scientist
mok@kamstrup.com

Describing state-of-art, objectives, recommendations and barriers with digitalisation

Now available in 2^{nd} version

https://www.euroheat.org/knowledge-hub/