



# **Data-driven control for efficient and flexible energy use at building level**

*Field investigations in Denmark*

Pierre J.C. Vogler-Finck, Henrik Lund Stærmose, Per Dahlgaard Pedersen

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# Outline

- 1- Presentation of Neogrid and its activities
- 2- PreHEAT: a heating control solution for buildings
- 3- Presentation of some use cases

# Neogrid Technologies ApS

The logo for Neogrid Technologies, featuring the company name in a bold, sans-serif font with 'NEOGRID' on the top line and 'TECHNOLOGIES' on the bottom line, set against a yellow square background with a subtle geometric pattern.

Founded in 2009 in Aalborg (Denmark), currently 8 employees

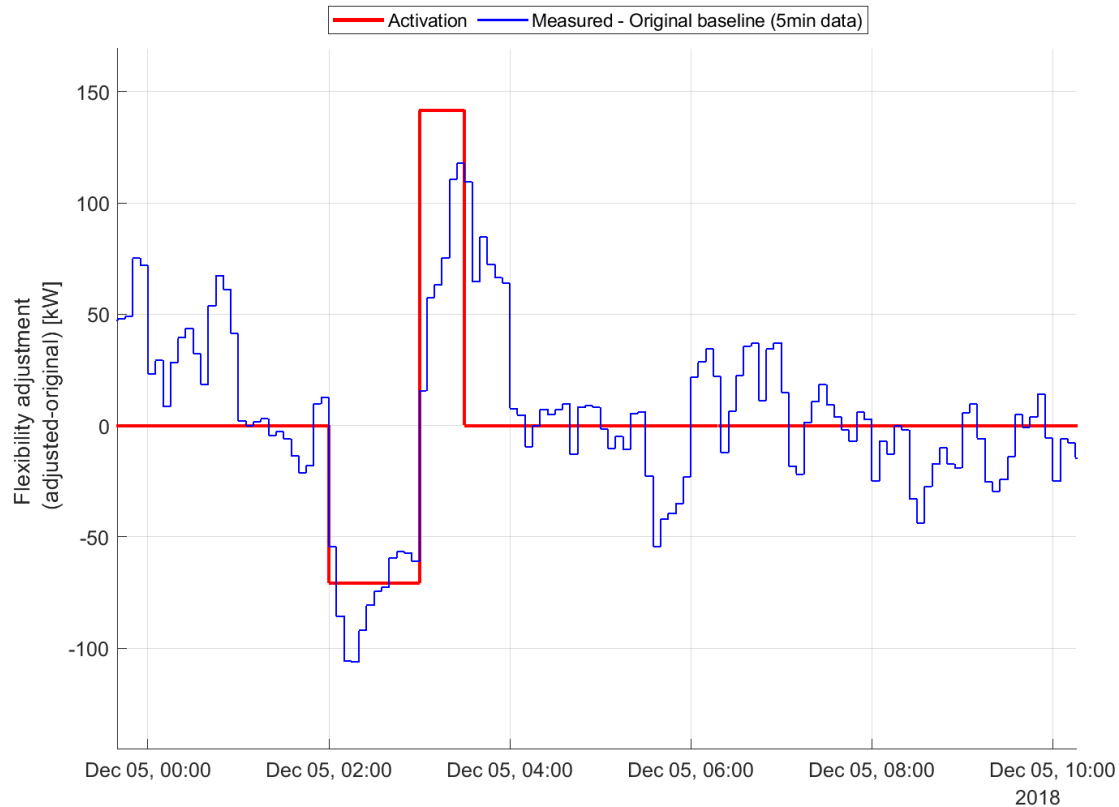
## **Collaboration-oriented**

- ✓ Extensive experience in research and demonstration projects in the energy sector
- ✓ Engaged in both national (Denmark) and international projects

## **Focus areas**

- ✓ Visualisation and monitoring technology for building heating
- ✓ Data collection from 'smart' meters and IoT sensors
- ✓ Energy-efficient and energy-flexible controllers

# Flexibility 'in the real world' in power systems



- ✓ Technology developed and demonstrated for heat-pump aggregated control.
  - ✓ Waiting for the flexibility market to take-off (still waiting...)
- > Business needed to look at another direction

# Commercial platform capability for research and demonstration

## Hardware

- ✓ Gateway supporting direct access for acquisition and control via:
  - ✓ BMS systems (Modbus, Bacnet)
  - ✓ Local wireless sensor network (Wireless Mbus)
  - ✓ Custom box for direct interaction with valves of substation
- ✓ Supporting online collection of large buildings
  - ✓ Demonstrated on >1,100 measurement points per gateway
  - ✓ Low latency communication for control (<1 minute)

## Software

- ✓ Online visualisation dashboard
- ✓ Web API for automated data exchange (<https://neogrid-technologies.gitlab.io/neogrid-api/>)
  - ✓ Reading historical data
  - ✓ Sending control setpoints
  - ✓ A toolbox for Matlab and Python is available
  - ✓ Demonstrated in research and demonstration environments

# Neogrid's activity in the DH sector



## Technology development:

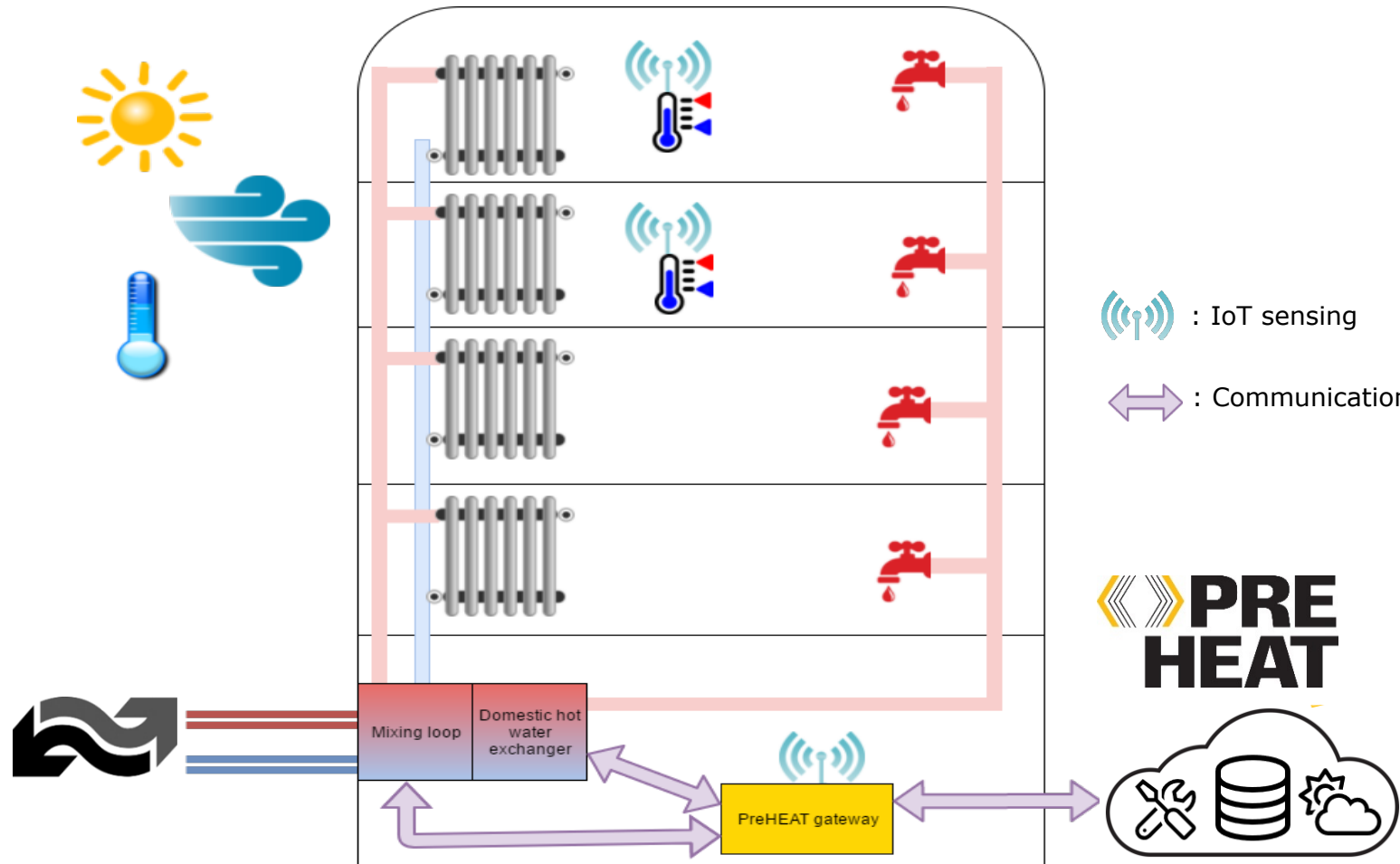
- Online data acquisition and monitoring
- Data-driven control technology
- Automated analytics

## Services:

- Data collection and management
- Optimised control of supply temperature at central level
- Monitoring and reporting on performance

Indicators		
Years of operation in Denmark	>3	years
Number of buildings in pool	>140	
Apartment blocks	104	
Single family houses	31*	
Others (schools, offices, institutions, ...)	7	
Heated area covered	>260,000	m <sup>2</sup>
Measurement points	>25,000	
Entries in timeseries database	2.2 billion	

# Control is made at central level with room feedback



- ❖ Predicts the heating demand
  - ✓ Using models from historical data
  - ✓ weather dependency and forecast
  - ✓ Accounts for temperatures in critical zones

- ❖ Dynamically optimises the supply temperature
  - ✓ Ensuring comfort in critical zones
  - ✓ Reducing pipe losses

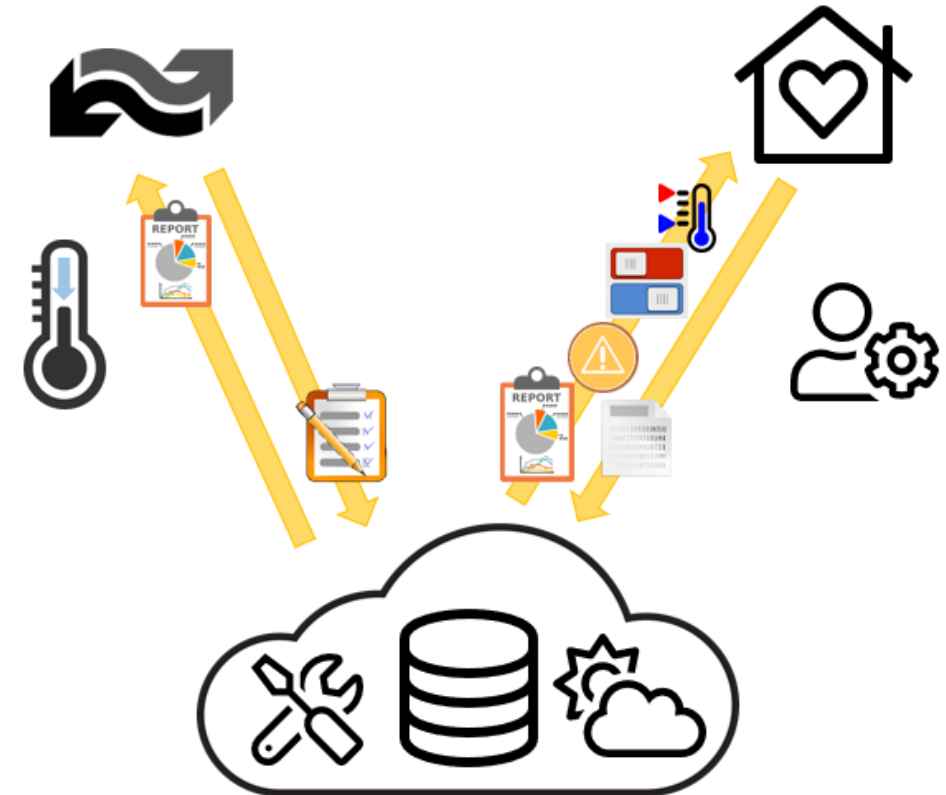
# Providing services to different stakeholders

## ❖ For building owner/occupants

- ❖ Condition monitoring (regular reporting and live view)
  - Energy usage
  - Indoor climate
  - State of the installation and substation
- ❖ Fault-detection (building operator is contacted)
  - Abnormally high consumption
  - Bad cooling in heat exchangers/loops
  - Defect valves and other components in technical rooms
  - Cost of fault (and ROI of fixing) can be quantified
- ❖ Remote tuning of controller settings

## ❖ For DH operators

- ❖ Delivering demand forecasts (at building and aggregate level)
- ❖ Unlocking demand response from buildings

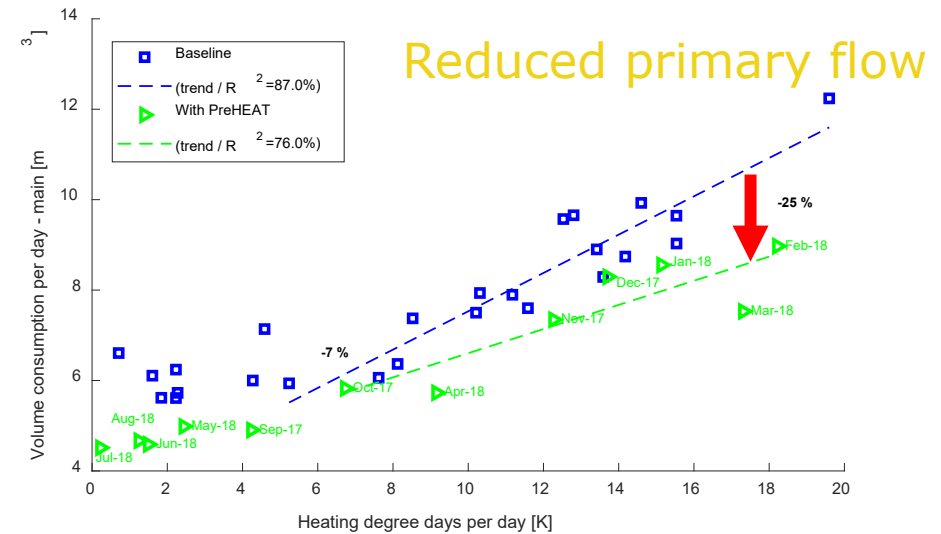
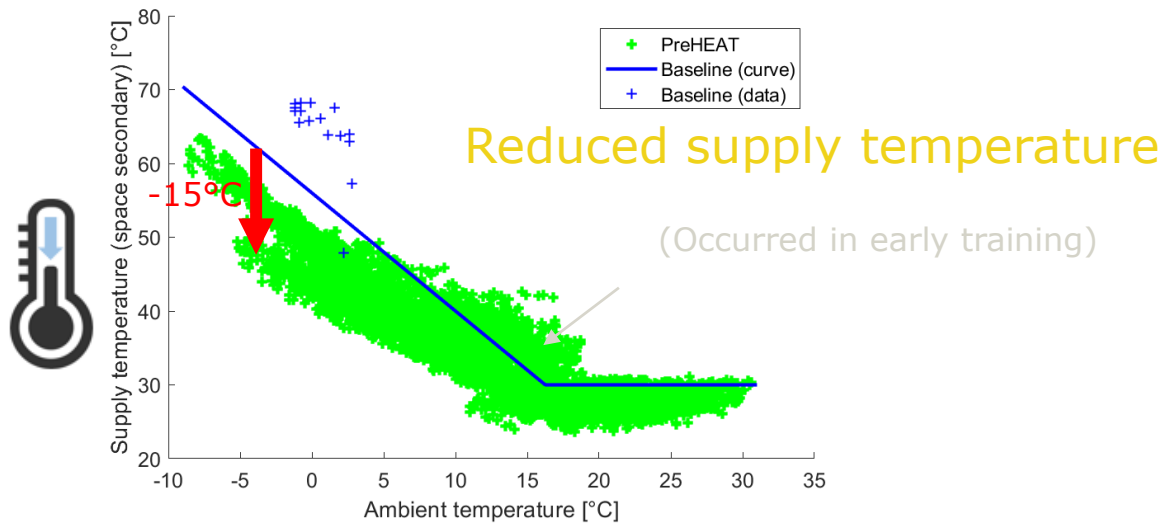
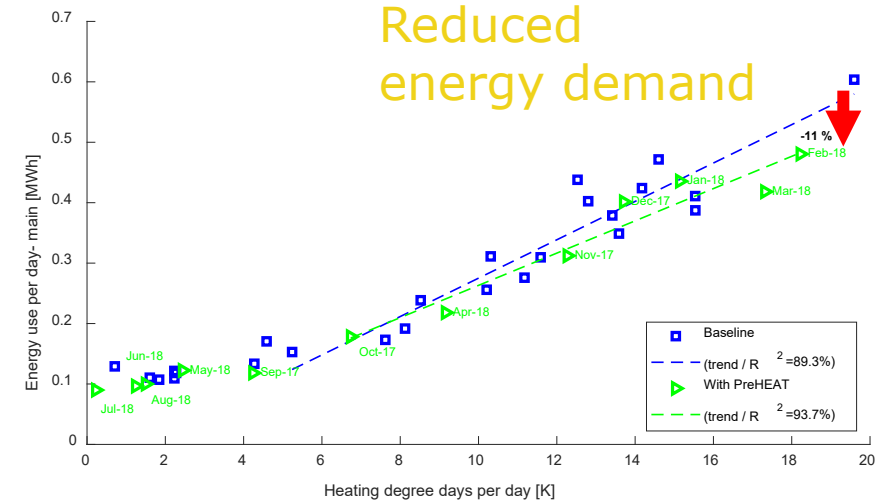




# Improved cooling and energy efficiency in a renovated apartment block



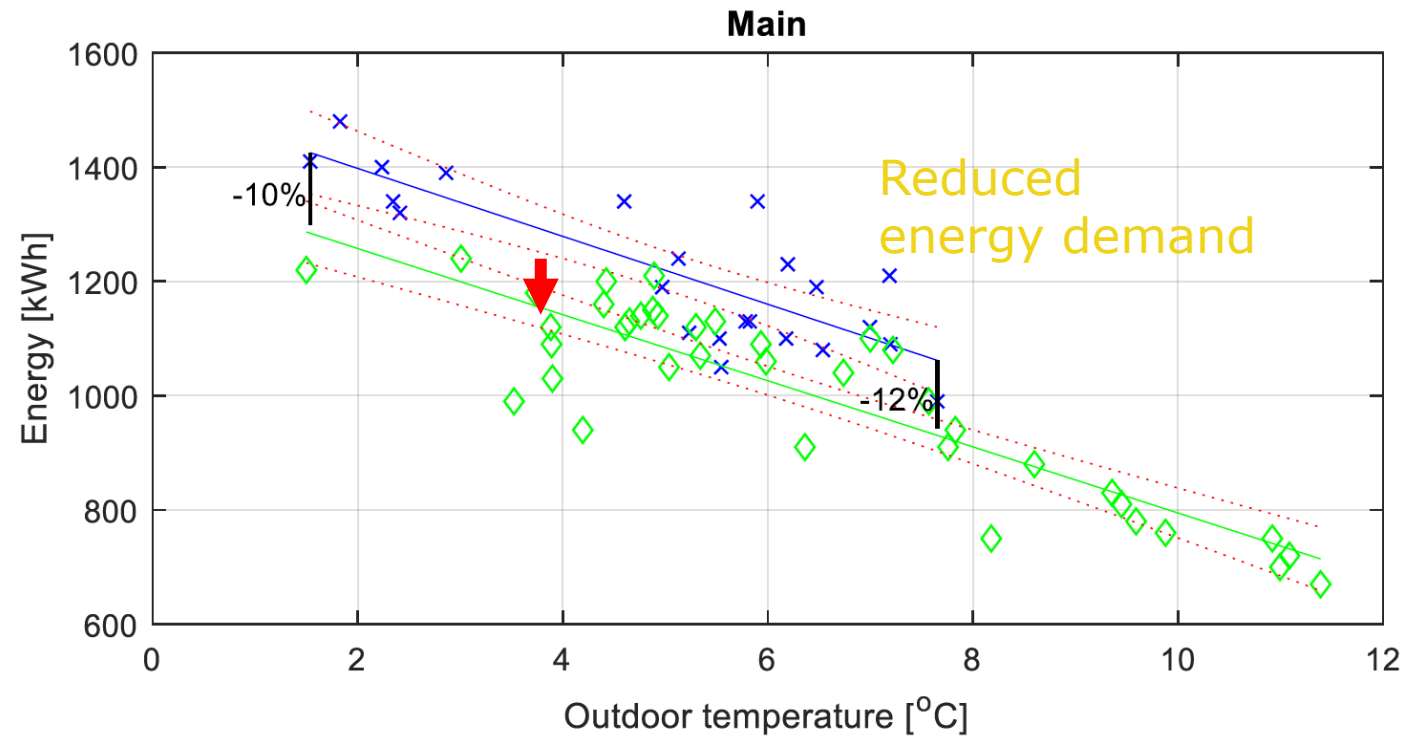
Example: [MA14 – Aalborg]	
Type	Apartment block
Construction	1960s (renovated)
Heated area	1 132 m <sup>2</sup>
Energy class	C
Total heat usage	90 MWh/yr. (80 kWh/m <sup>2</sup> /yr.)



# Improved energy efficiency in a pool of apartment blocks

## Example: [GD -Taastrup]

Type	Apartment blocks
Construction	1970-80s
Heated area	33 128 m <sup>2</sup>
Energy class	(?)
Total heat usage	(?)

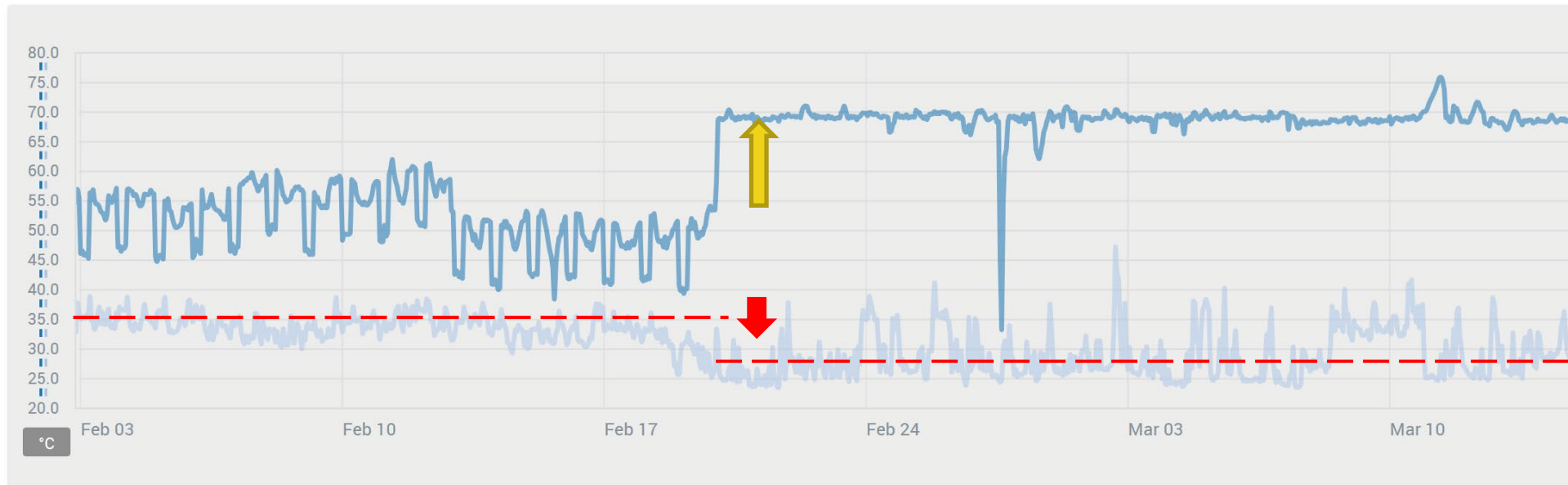


Cooling of DH water improved by 2-4 °C

Several malfunctions identified from the data and reported to building operator.

# Things aren't always that simple

Example: [NG19 – Aalborg]	
Type	Apartment block
Construction	1920s
Heated area	2 003 m <sup>2</sup>
Energy class	F
Total heat usage	152 MWh/yr. (76 kWh/m <sup>2</sup> /yr.)



# Control of heating in an office building with complex HVAC system

IntelByg project with Bravida, and financed by the Danish ministry of energy

## Example: [L21 – Aalborg]

Type	Office building
Construction	2005
Heated area	1 851 m <sup>2</sup>
Energy class	(?)
Total heat usage	~85 MWh/yr. (46 kWh/m <sup>2</sup> /yr.)
Ventilation systems	2 (with heat recovery, hydronic heating & cooling)
Heating loops	4 (2 to ventilation, 1 floor, 1 radiator, 1 fan coil)

### Gateway

- integrated in Bacnet-based BMS
- Collecting real time data from 792 points
- Updating setpoints in real time control

### Currently

- Controlling the radiator heating
- Investigating multizone control-oriented modelling
- Fault detection implemented

### Aim

- Integrated multizone model predictive controller of HVAC system
- Automated fault detection

# Conclusions

- Commercial technology for robust online cloud-based building data collection is available, including online control technology.
- Supply temperature in building heating can often be optimised for more efficiency.
- Documentation of savings is difficult, for ranges of  $\sim 10\%$  savings.
- Energy efficiency is a way to get into the buildings, and cloud-based controllers infrastructure can support demand response at low extra cost.
- Flexibility enabling technology is ready and waiting, but there are major barriers to commercial delivery :
  - lack of clear quantifications of value of flexibility for system operators
  - absence of functioning appropriate markets.



## **Neogrid Technologies ApS**

Niels Jernes vej 10, Aalborg Øst, Denmark / [www.neogrid.dk](http://www.neogrid.dk)

### **Contact:**

Pierre J.C. Vogler-Finck (R&D scientist)  
+45 4280 0898 / [pvf@neogrid.dk](mailto:pvf@neogrid.dk) / Skype: pvf.neogrid

# Selected current projects

## HEAT 4.0 – Digitally supported district heating (<https://energiforskning.dk/node/9356>)

- ✓ *Control to support integrated operation of DH systems*
- ✓ *Optimised heating control at central and zone level in houses and offices*

## FED – Flexible Energy Denmark (<https://energiforskning.dk/node/9406>)

- ✓ *Data-driven control to provide energy flexibility in Living Labs with a market environment*
- ✓ *Optimised control of residential building substations and local area supply in a DH system*

## SmartCE2H – Smart citizen-centered local electricity to heat systems (<https://energiforskning.dk/node/9297>)

- ✓ *Optimised control of large booster heat pumps to local areas in DH systems*
- ✓ *Collaborative control of building substations in local areas with booster heat pumps*
- ✓ *Optimised control of booster heat-pumps at building level for DHW production*