Value creation by use of smart city data

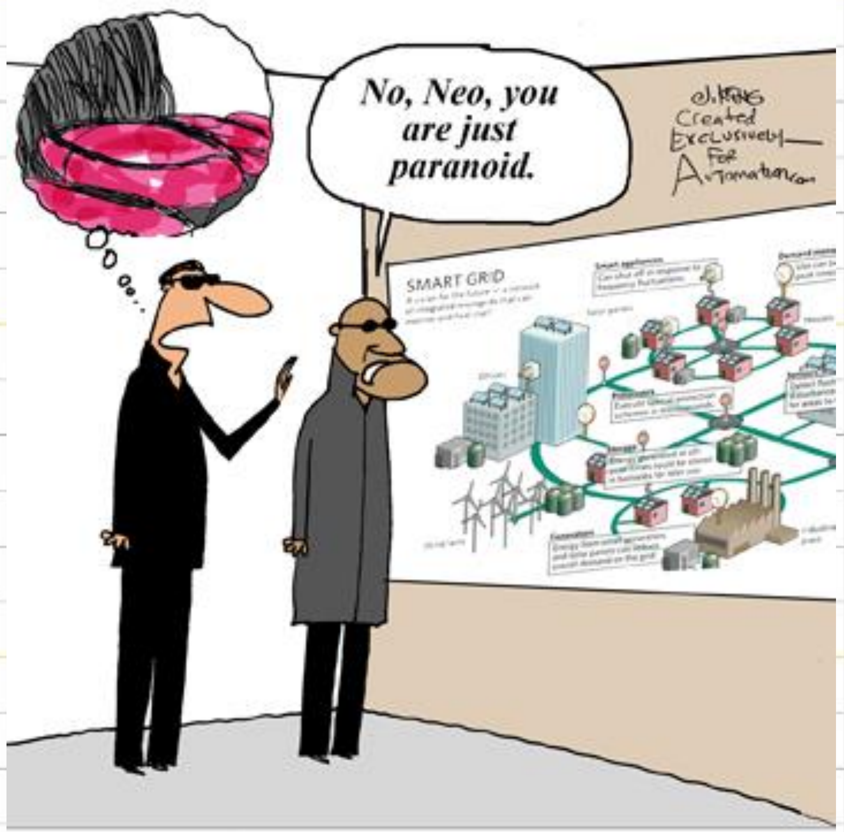
NEOGRID
TECHNOLOGIES

Neogrid Technologies ApS

Cities meeting, Aarhus, January 12th 2017

Outline

- Introduction
- Heat pump case
- District Heating case
- Green Houses case at Fjernvarme Fyn

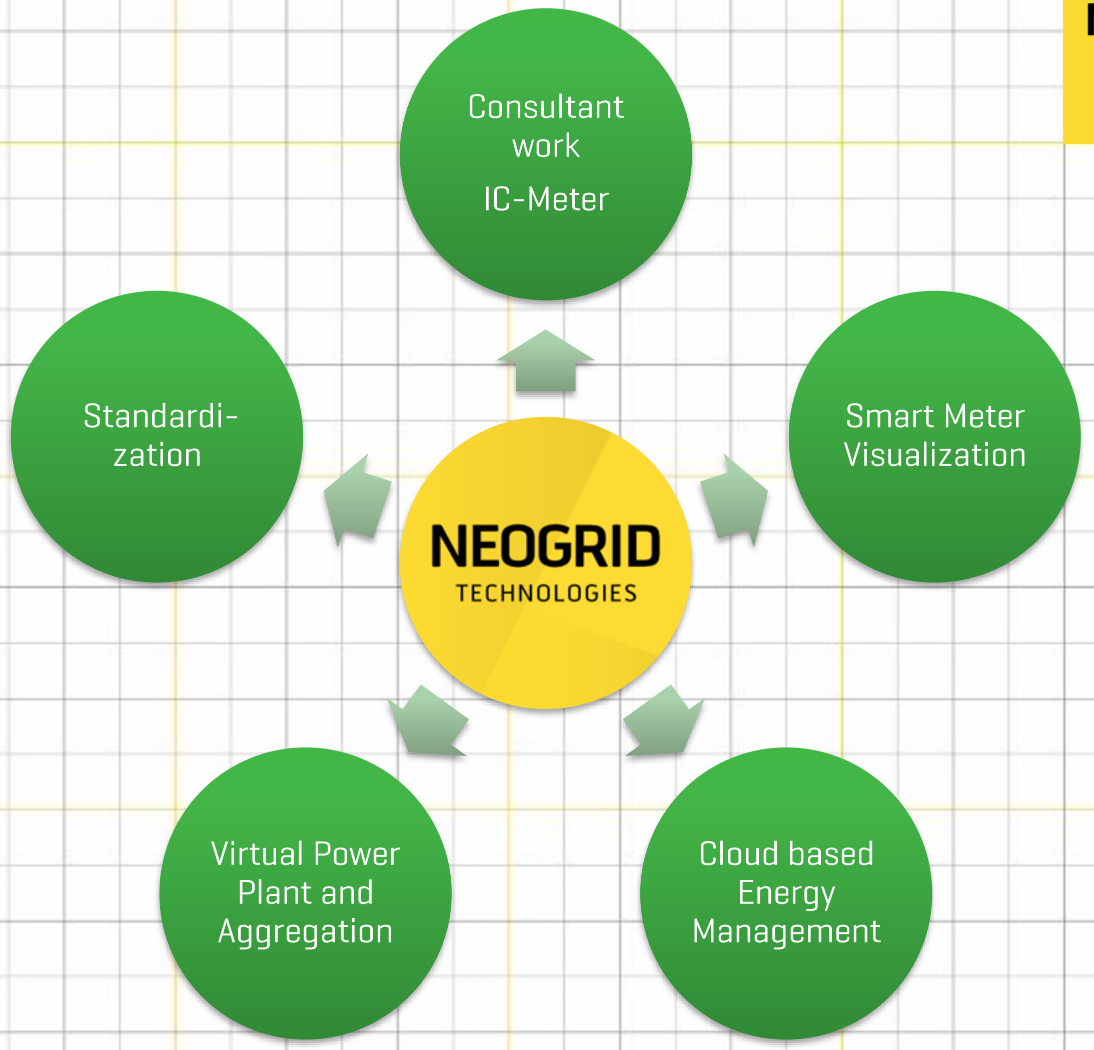


"Morpheus, I've heard this term, Smart Grid, before. It's what they called the Matrix before it took control of our lives."

Neogrid Technologies ApS

Background

- Founded in 2009
- +30 years experience from mobile communication
- Involved in 25+ national and international research projects within Smart Grid And Energy Optimization
- 8 employees



PreHEAT solution for Energy Management

Idea

- Forecast based direct control of heat supply to buildings equipped with
  - Heat pumps
  - District Heating

- Supports two different solutions
  - Individual modelling and control
  - Pool modelling and control

PreHeat – use of data

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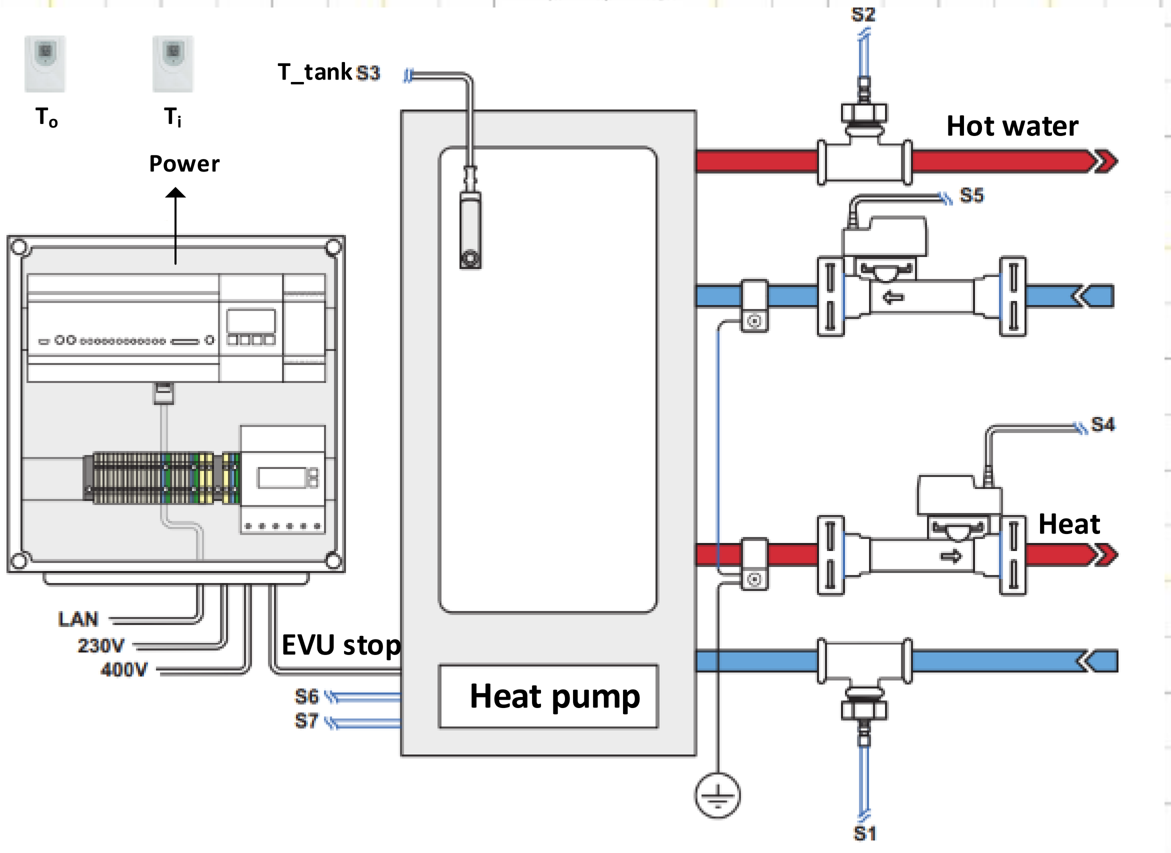
Weather forecast (yr.no) **1 hour resolution, 36 hours ahead**	**Heat pump/District heating** **5 min resolution**	**House** **5 min resolution**
Low/Med/High cloudiness (calculate direct/diffuse sunradiation)	Energy (domestic hot water)	Inside temperature
Outside temperature	Energy (heat)	User behaviour?
Wind (speed/direction)	(Electricity consumption)	Wood burner?
Humidity	Water temperatures	

Heat pump control

StyrDinVarmepumpe setup

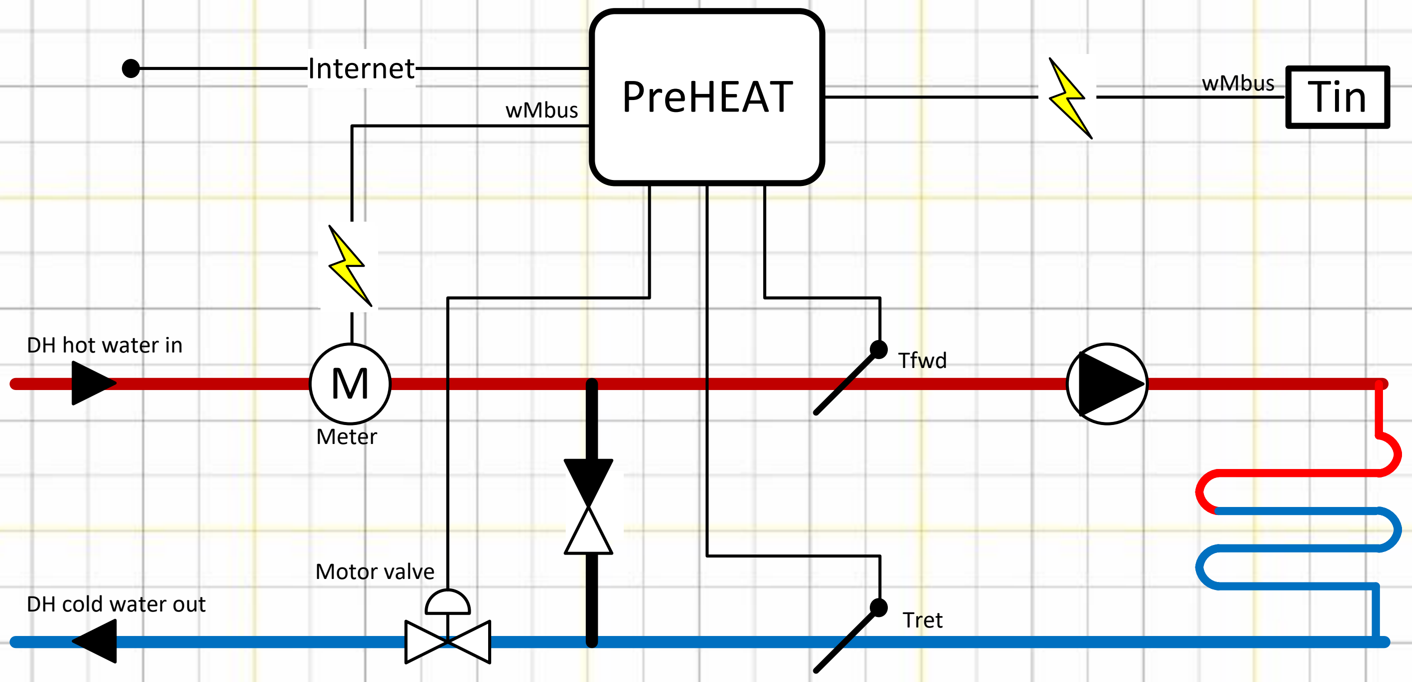


- 300 installations
- 5 minutes resolution

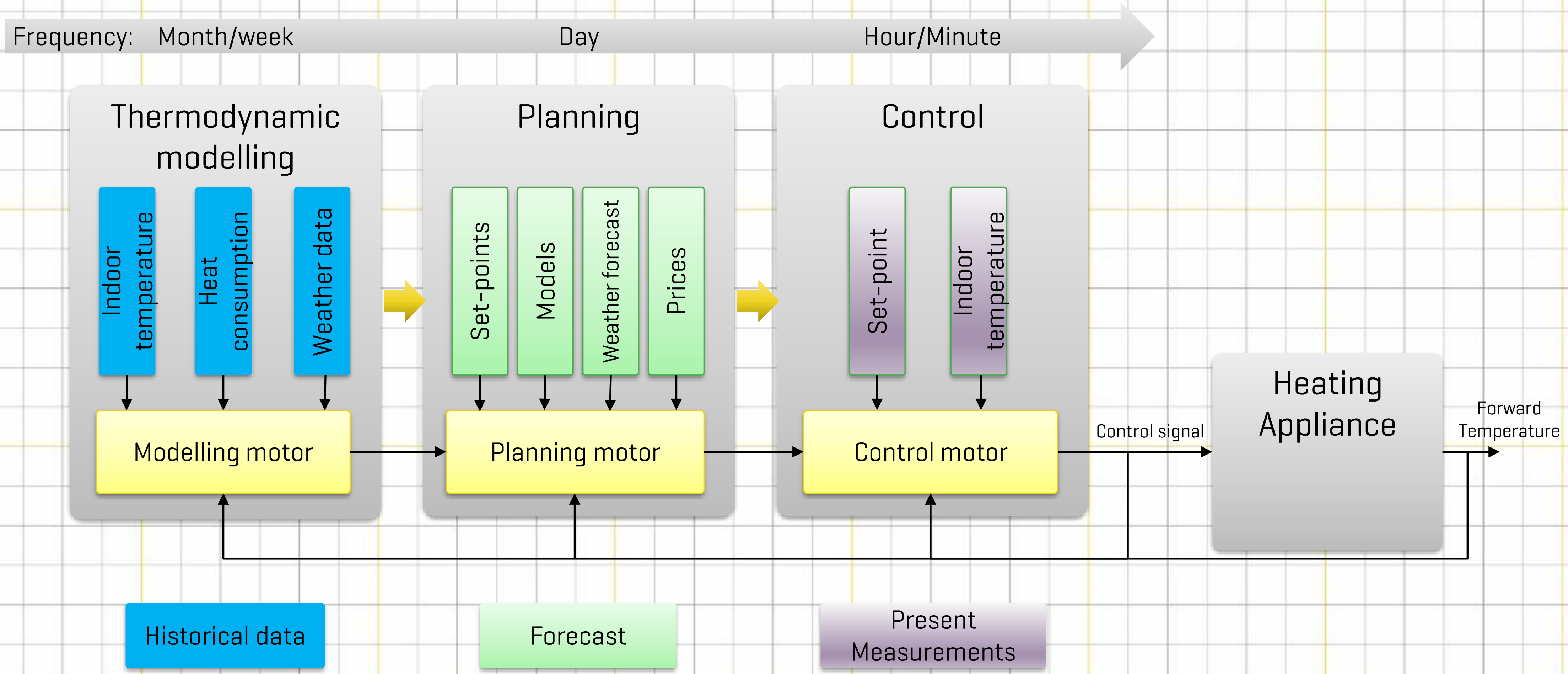
- Controlled via relay input
- Can stop heat pump
- Can not force start, but allow heat pump to run
- XMPP: online monitoring
- XMPP: online control

PreHEAT for district heating

PreHEAT architecture



PreHEAT Function diagram



Benefits – PreHeat

District Heating case

Area	Type
Reduce Heating Cost	Weather forecast based MPC control of forward temperature (reduces heat loss from pipes in/outside building envelope)
	Optimize operation due to sunlight
	Night setback and out of house setback
Improve Comfort	Reduce excess temperature due to sunlight App control and monitoring
Services for District Heating Companies	Load shifting
	Price optimization
	More accurate demand estimates
	Pool control and monitoring
Service	Monitoring and alarm
	Building envelope
	Remote diagnostic

PreHeat savings

District Heating case

Energy saving break down	Saving potential
Optimized control of forward temperature	5-20 %
Optimized operation based on sun modelling	2-10 %
Intelligent night and ”out-of-house” set back	10 %
Reduced loss in heating pipes outside building envelope	< 5 %
Reduced loss in heating pipes inside building envelope	< 5 %

- Significant parameters
  - Presence of room thermostats
  - Radiators vs. floor heating
  - House age and time constant
  - Presence of weather compensated heat curve (i.e. heat pumps & gas burners)
  - Disitrict Heating billing models: Volume or Energy settled
  - Fixed amount share of energy bill

Intelligent Energy Management

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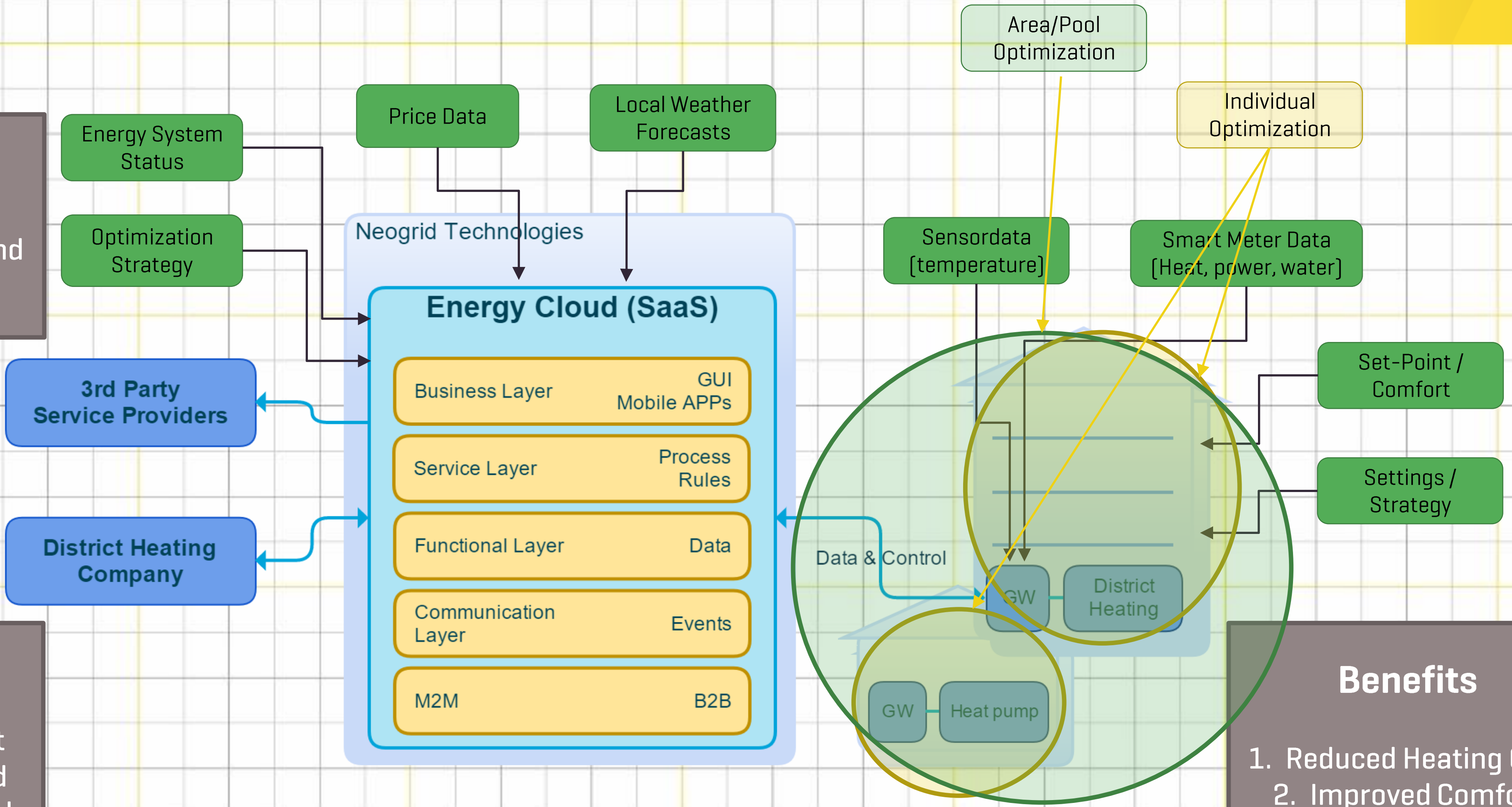
Benefits

1. Generalized Data
2. Building Envelope and Demands



Benefits

1. Load Shift / Market
2. More Acurrate Load Estimations for Pool

Benefits

1. Reduced Heating Cost
2. Improved Comfort

Online prediction of heat load

A case study of greenhouses in a district heating system

CITIES

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This research is a joint work within CITIES

Algorithms and investigation:

- DTU Compute *(Peder Bacher & Henrik Madsen)*
- Neogrid *(Pierre Vogler-Finck & Per Dahlgaard Pedersen)*

Heat load data and weather measurements:

- Fjernvarme Fyn A/S *(Lasse Elmelund Pedersen)*

Weather forecast data:

- ENFOR A/S *(Henrik Aalborg Nielsen)*

CITIES is supported by the Danish Strategic Research council

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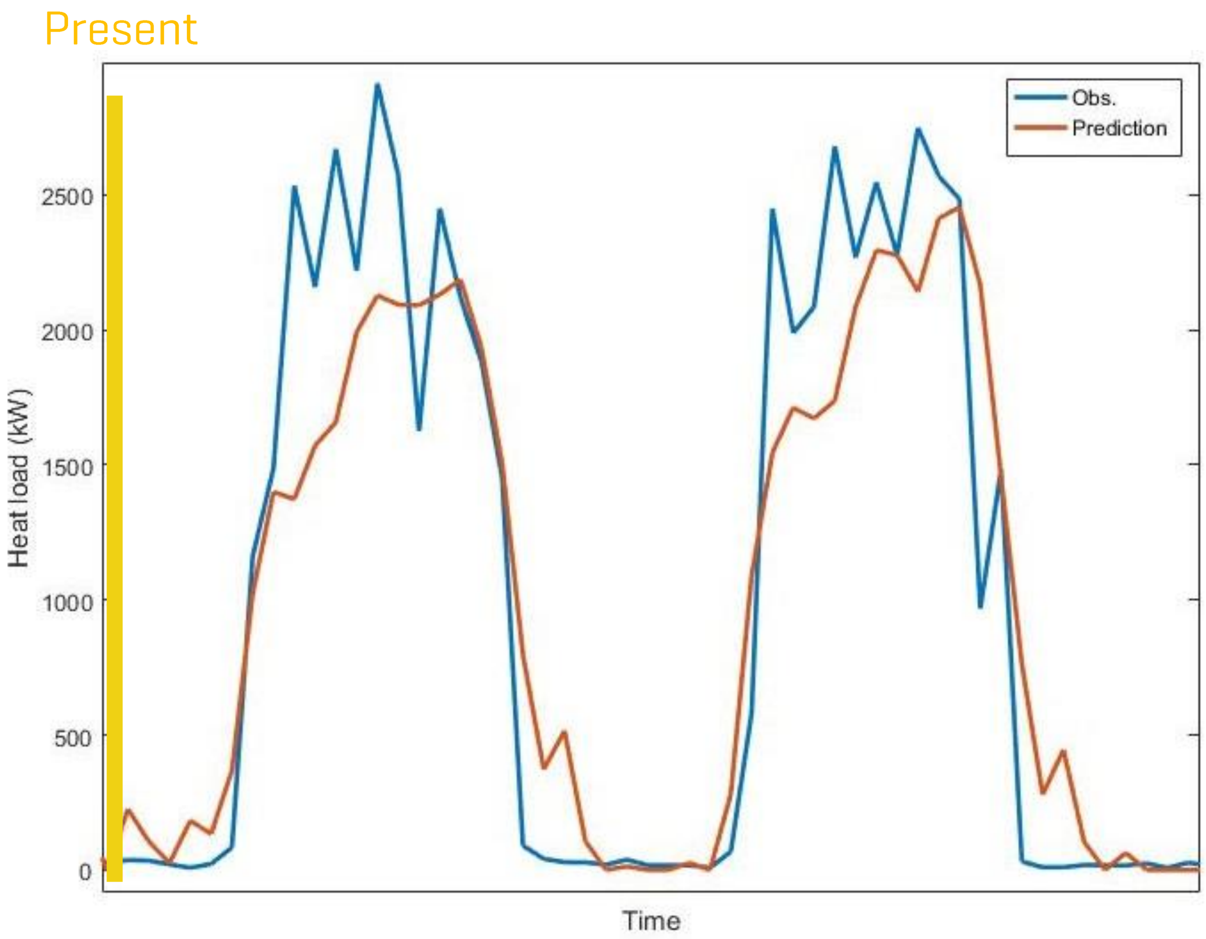
Outline

1. Problem description
2. Prediction method
3. Practical performance
4. Conclusion

Problem description

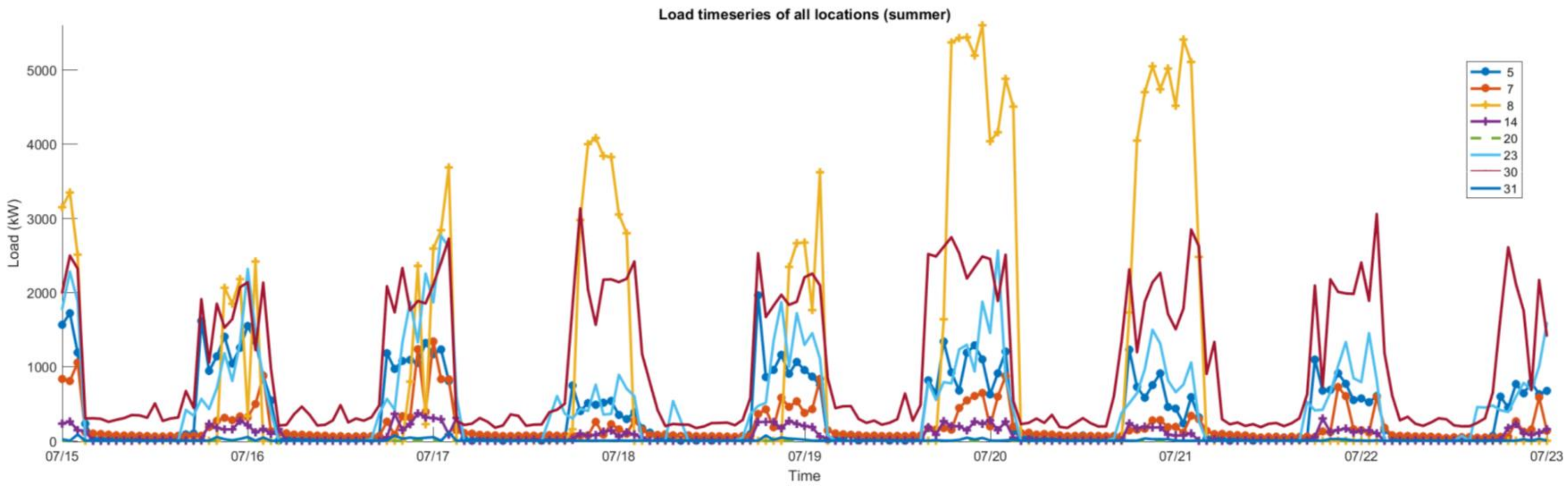
The aim is to predict short term future load

At a given time, predict the future heat load of a greenhouse in the next **48 h** :

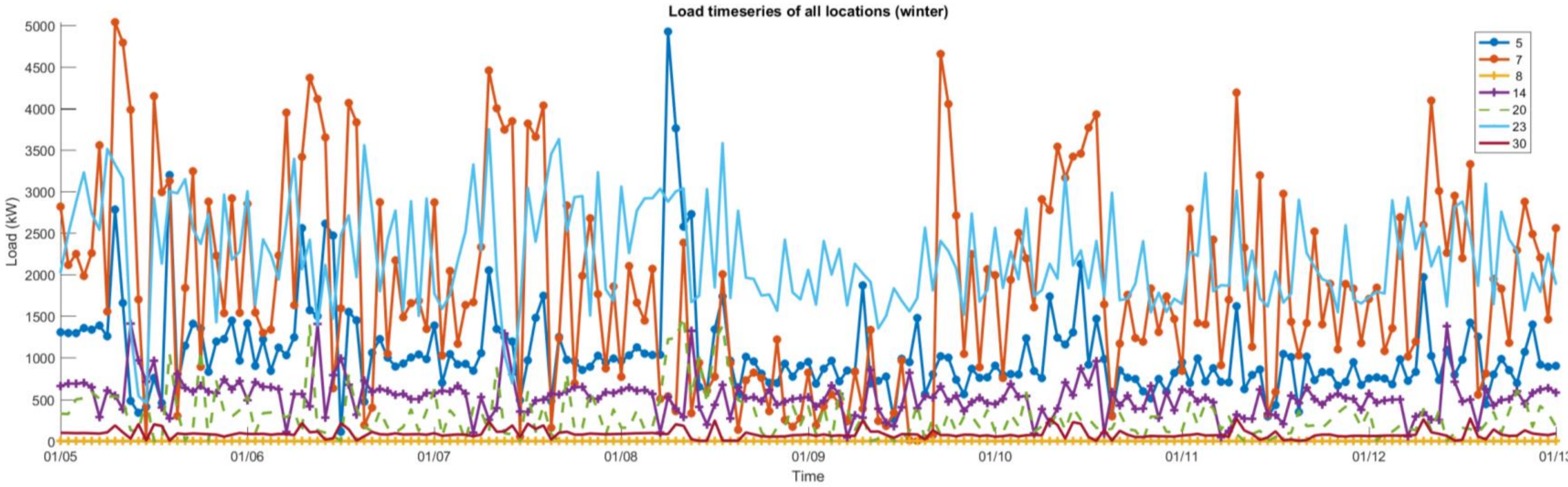


Greenhouse load undergoes large variations

Summer week



Winter week



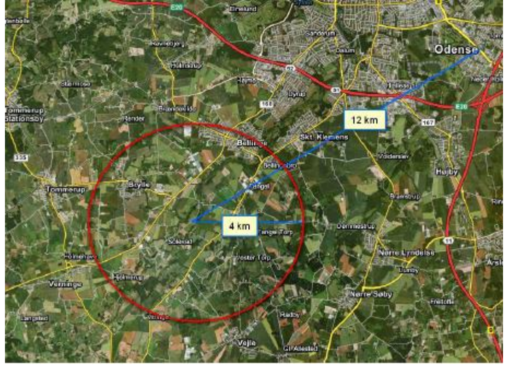
Detailed analysis of 8 greenhouses was made

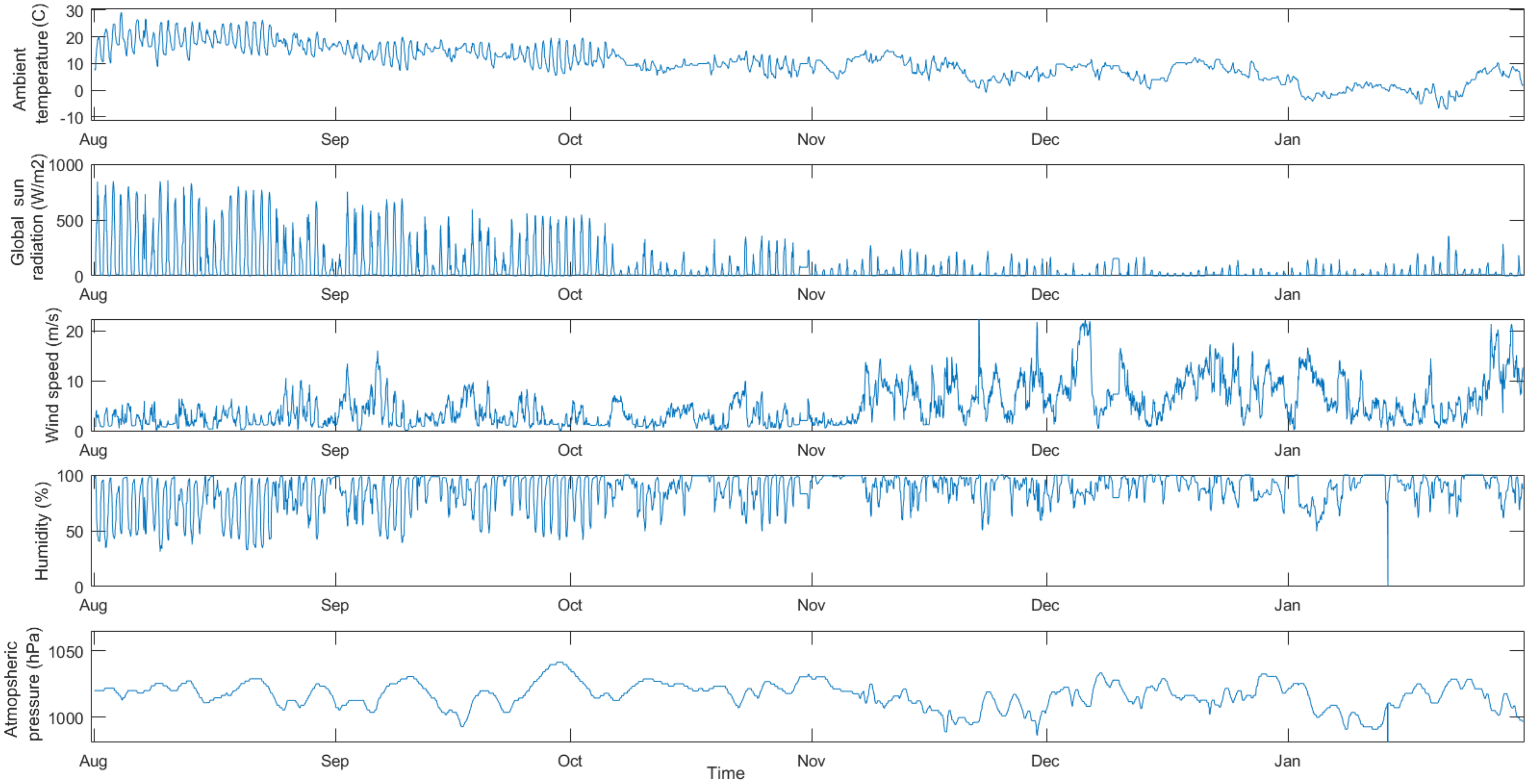
ID number	Data available	Period covered	Avg. heat load (MW)	Peak (MW)
5	t, q, H_s, T_f, T_r	08/06/2015-18/01/2016	0,69	5,2
7	t, q, H_s, T_f, T_r	08/06/2015-18/01/2016	0,93	5,2
8	t, q, H_s, T_f, T_r	08/06/2015-19/01/2016	1,18	6,2
14	t, q, H_s, T_f, T_r	08/06/2015-19/01/2016	0,22	1,6
20	t, q, H_s, T_f, T_r	09/06/2015-19/01/2016	0,11	2,0
23	t, H_s, T_f, T_r	09/06/2015-19/01/2016	0,90	4,6
30	t, q, H_s, T_f, T_r	08/06/2015-09/12/2016	1,06	4,0
31	t, q, H_s, T_f, T_r	08/06/2015-18/01/2016	0,03	0,2

- Timestamps (t, in UTC time)
- Flow (q in m^3/h)
- Thermal energy usage rate (H_s in kW)
- Forward temperature (T_f in °C)
- Return temperature (T_r in °C)

15 min data, resampled to 1h

Weather data was used in prediction





Prediction method

The predictor learns from past behaviour and adapts to changes

Recursive least squares with forgetting [1]

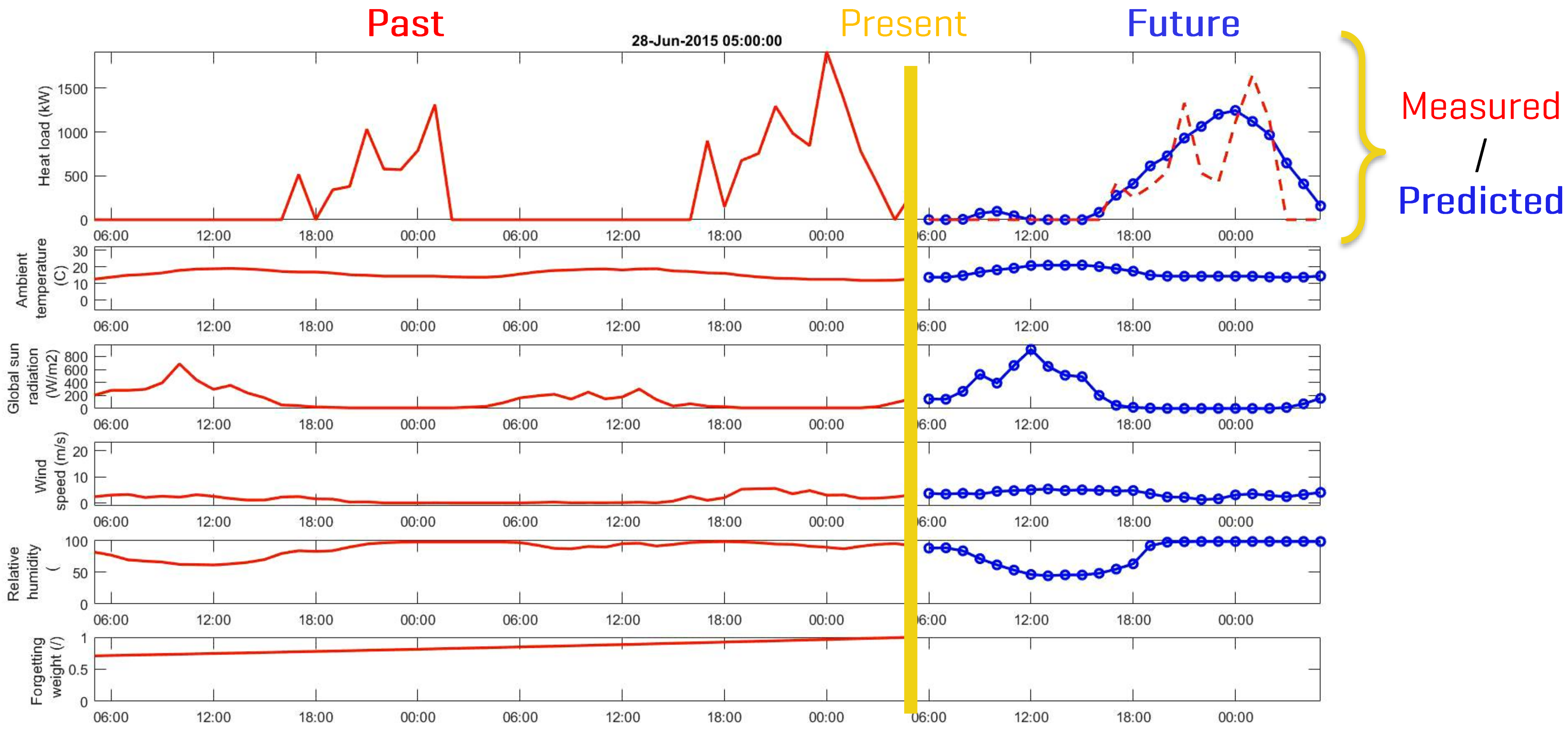
Forward selection of relevant inputs (diurnal curves terms and weather variables)

1 greenhouse = 1 predictor

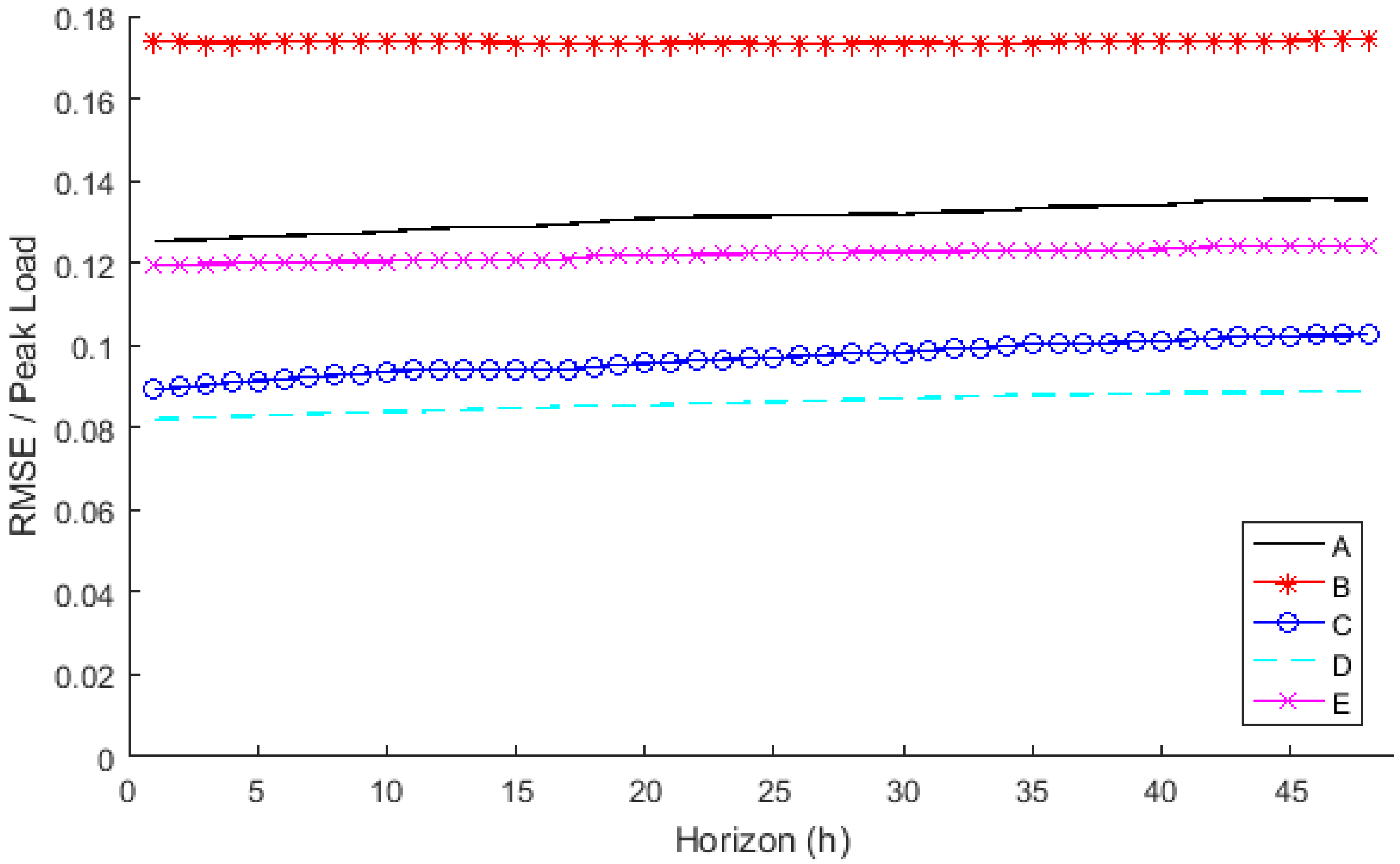
References:
[1] H. Madsen, "Timeseries analysis", Chapman & Hall, 2008

Practical performance

The predictor provides reasonable performance



Performance varies location by location



Conclusion

The method seems promising

- The method is computationally simple
- Weather forecast improves performance
- Results vary greenhouse by greenhouse, with differences in:
  - Relevant explanatory variables
  - Speed of changes in operation
  - Performance of forecast
- Much uncertainty still remains
- Fjernvarme Fyn has shown interest in deploying it
- A journal paper and report are expected to be published this year

Thank you for your time and attention!

Questions

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