Data Intelligent Temperature Optimization

(Temp. Opt. v.4.0)

Henrik Madsen

Dept. Appl. Mathematics and Computer Science, DTU

http://www.citiesinnovation.org

http://www.smart-cities-centre.org

http://www.henrikmadsen.org

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Software solutions

Software for combined physical and statistical modelling

Continuous Time Stochastic Modelling (CTSM) is a software package for modelling and simulation of combined physical and statistical models. You find a technical description and the software at CTSM.info.

Software for Model Predictive Control

HPMPC is a toolbox for High-Performance implementation of solvers for Model Predictive Control (MPC). It contains routines for fast solution of MPC and MHE (Moving Horizon Estimation) problems on embedded hardware. The software is available on GitHub.

MPCR is a toolbox for building Model Predictive Controllers written in R, the free statistical software. It contains several examples for different MPC problems and interfaces to opensource solvers in R . The software is available on GitHub.

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Latest news

- Summer School at DTU, Lyngby, Denmark – July 4th-8th 2016
- Summer School – Granada, Spain, June 19th-24th 2016
- Third general consortium meeting – DTU, May 24th-25th 2016
- Smart City Challenge in Copenhagen – April 20th 2016
- Guest lecture by Pierluigi Mancarella at DTU, April 6th

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Integrated energy systems powered by intelligent data

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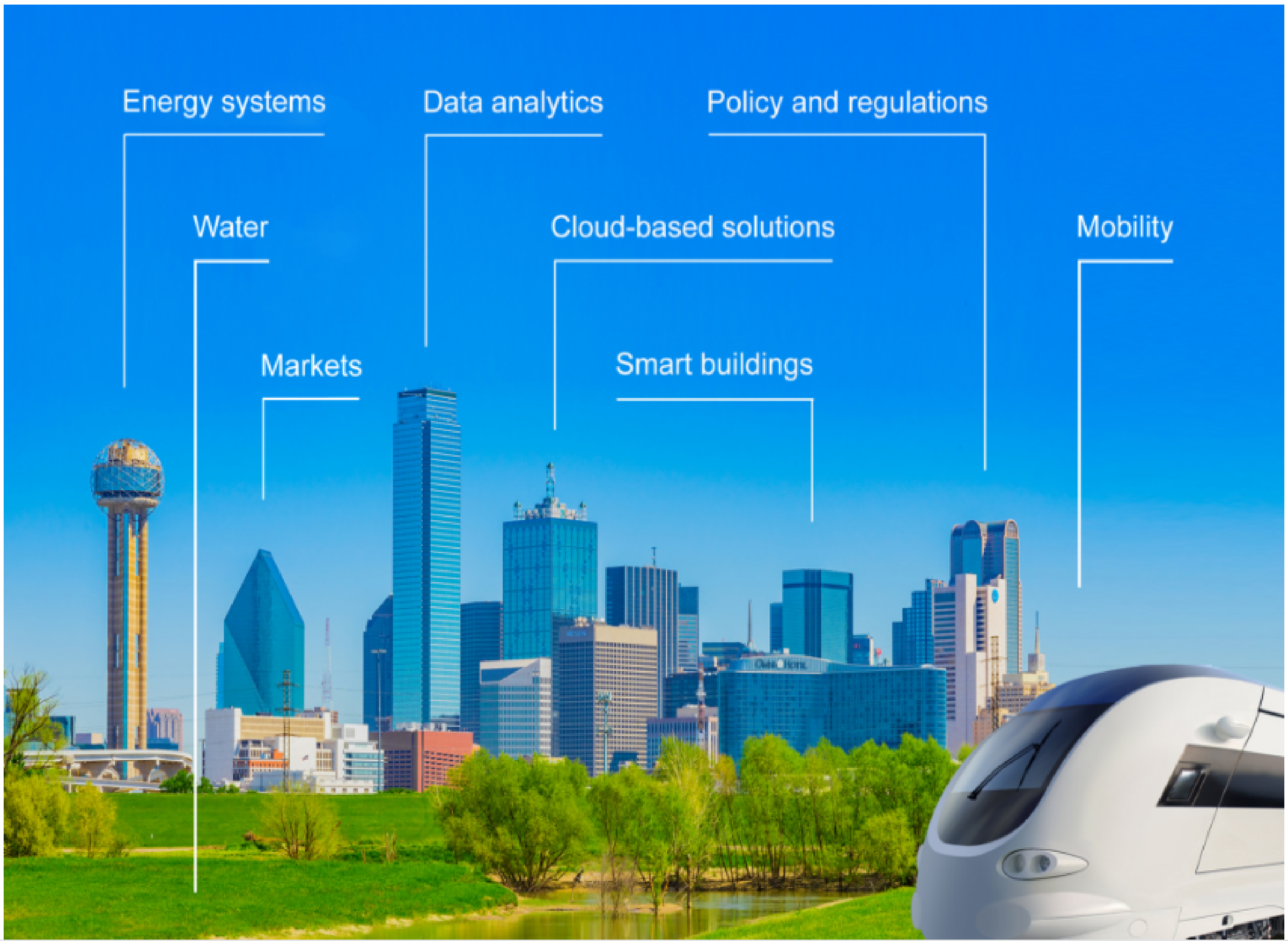

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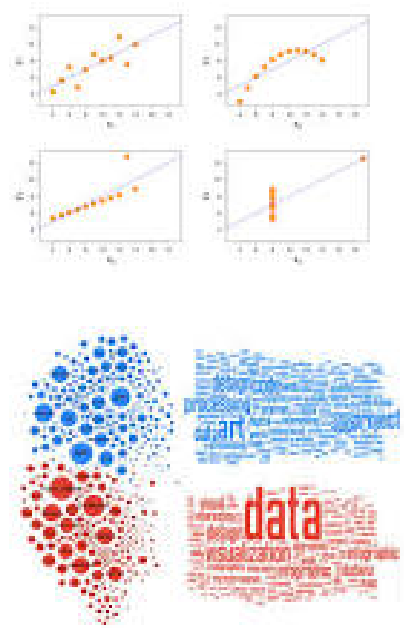
1. Datainfrastruktur for smarte byer og distrikter

Lead: LU
Co-lead DTU

Dette emne er et generisk komponent der kan indgå i alle ovenfor nævnte indsatsområder. Det skal sikres at der kan opnås en bedre og/eller større datatilgængelighed, så der gives bedre mulighed for prediction-/fremskrivningsmodeller, forudsigelse af forbrug og produktion, justering af forbrug til produktion, etc. Der skal derfor for hvert indsatsområde laves en definition af behovet for datatilgængelighed og analyse af mulige datakilder. Der udvikles videre på de eksisterende datainfrastrukturer som indbringes i Interreg-projektet fra de forskellige partnere. Målet er at disse kan samarbejde på en transparent måde, så anvenderne ikke mærker om de bruger deres egen infrastruktur eller låner sig til nogle services på andre partneres set-up eller cloud løsninger. Principielt består denne IT-tunge løsning af tre grundlæggende komponenter; dataindsamling, datahåndtering/-analytics og præsentation. Endelig vil der være en fjerde komponent der kan håndtere kommunikationen for styringen parallelt med dataindsamlingen.

Big Data value chain

Sense		Think		Act
Data Origins: The Internet, sensors, machines, etc.	**Data Collection** Web log, sensor data, images/audio, RFID and videos, etc.	**Data Storage** Technologies supporting data storage	**Analytics:** Predictive analytics, patterns in data, decision making	**Consumers:** Business processes, humans, and applications



CITIES Data Management System

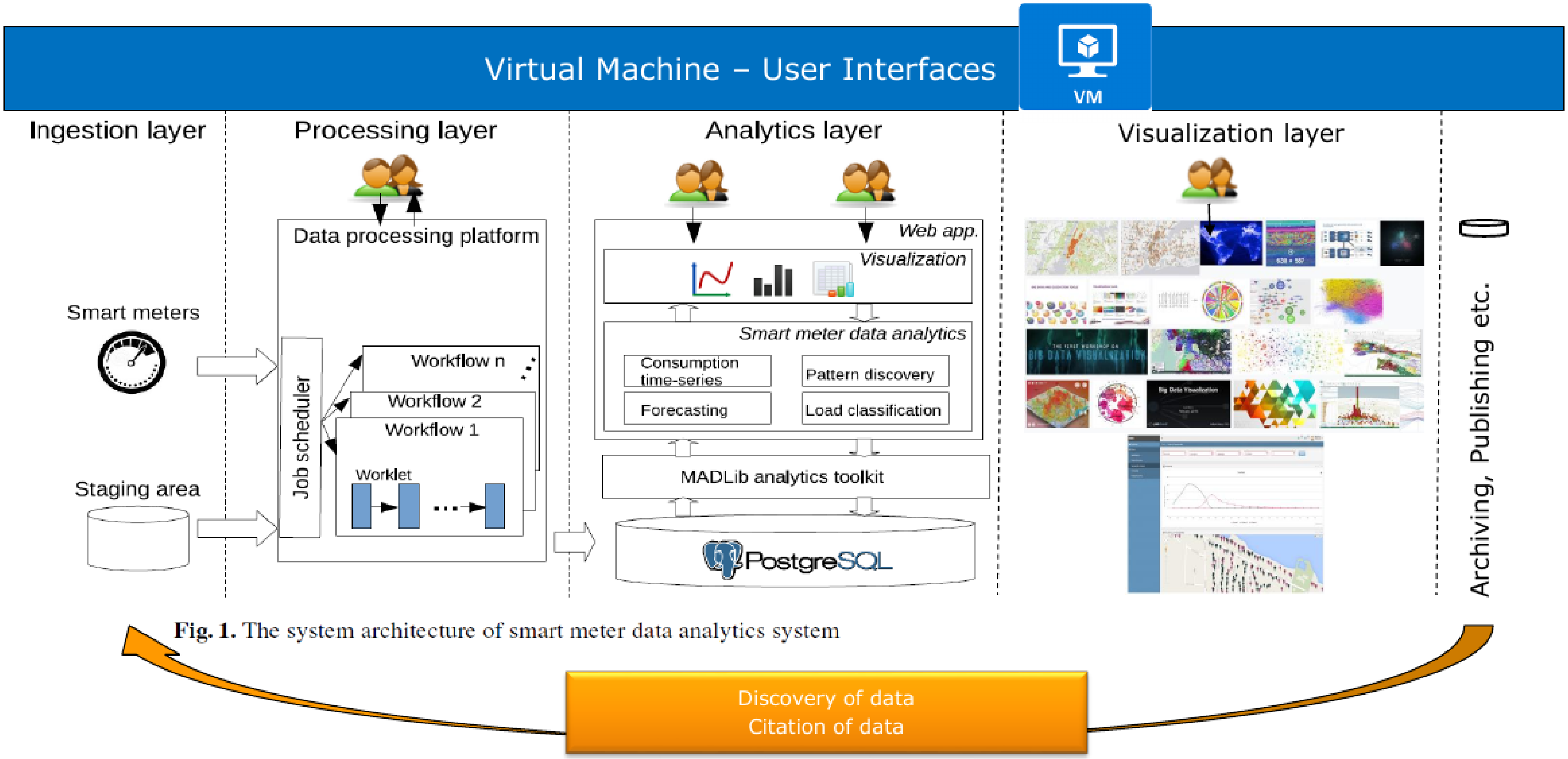
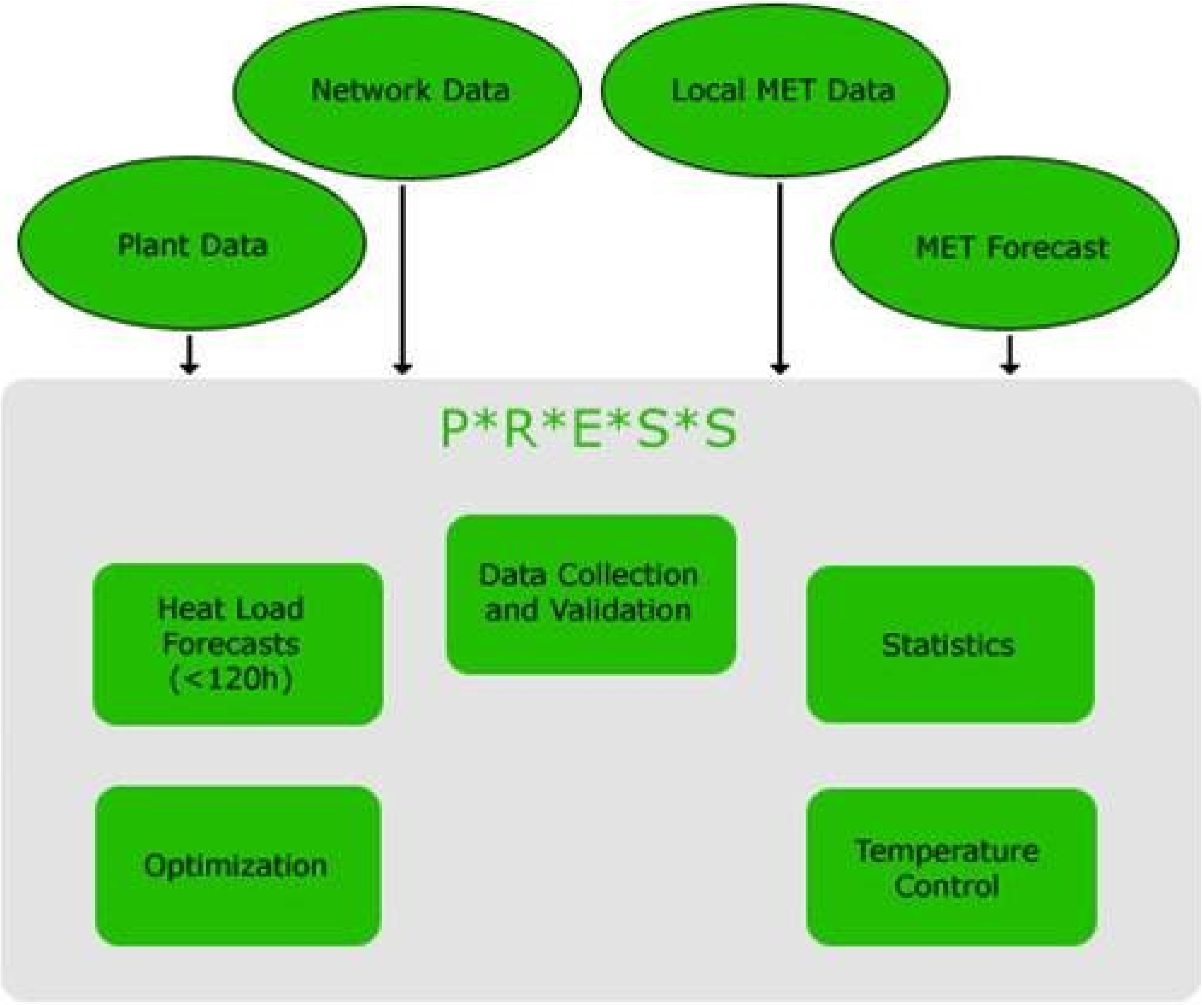


Fig. 1. The system architecture of smart meter data analytics system

PRESS Setup


Network Data
Local MET Data
Plant Data
MET Forecast
P*R*E*S*S
Data Collection and Validation
Heat Load Forecasts (<120h)
Statistics
Optimization
Temperature Control

Data Intelligent Temperature Optimization for DH Systems (incl. load forecasting)

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Kraftringen, Örtoftaverket, June 2017

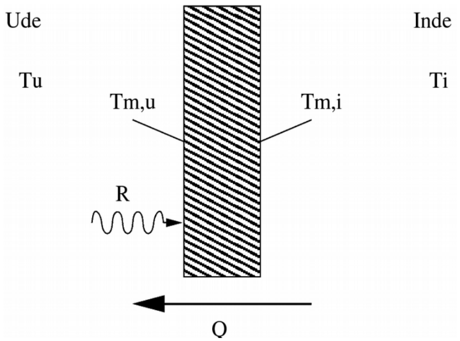
2. Integrering af lav-temperatur fjernvarme til eksisterende byområder

CITY lead: Høje Taastrup Fjernvarme - CITY co-lead: Malmö Stad
SCIENCE lead: DTU

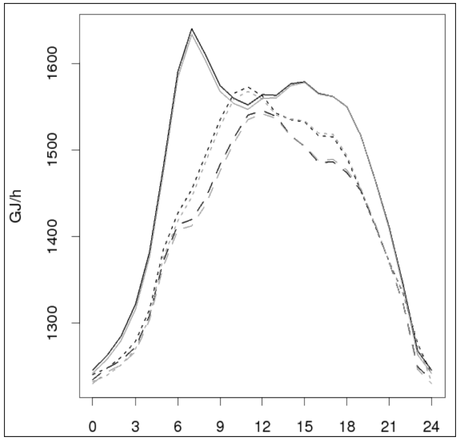
På begge sider af Øresund er der en stor andel af fjernvarmesystemer, men systemerne er ret forskellige. Samspillet mellem fjernvarme og el-systemer forventes at spille en stor rolle i forhold til mulighederne for at integrere store mængder af sol- og vindenergi. For nyere og velisolerede bygninger vil fokus være på lavtemperatur fjernvarme. Dels vil det lave temperaturniveau øge mulighederne for at opsamle spildvarme fra eksempelvis forretningscentre og kølehuse, og dels vil lave temperaturer være vigtige for at minimere det samlede nettab. I CITIES projektet er der udviklet nogle nye data- og prognosebaserede metoder til optimeret styring af fremløbstemperaturer, samt til optimeret brug af termiske energilagre i såvel ledningsnet som i akkumulatortanke i fjernvarmesystemer. Endelig er der også udviklet metoder til reduktion af f.eks. morgenspidsen i fjernvarmesystemerne, idet temperaturen ofte med fordel kan hæves lidt tidligere end ellers planlagt. I f.eks. dele af Københavnsområdet (VEKS) vil der blive undersøgt metoder til at sænke det nødvendige temperaturniveau i transmissionsnettet i forhold til kravet fra sekundær områderne. Der vil passende kunne undersøges potentialer for solvarmecentraler i disse lavtemperatur fjernvarme, hvormed VE-andelen kan øges betragteligt. I disse anlæg vil store lagre kunne naturlig integreres hvormed solandelen øges til meget store andele.

Model components in load forecasting

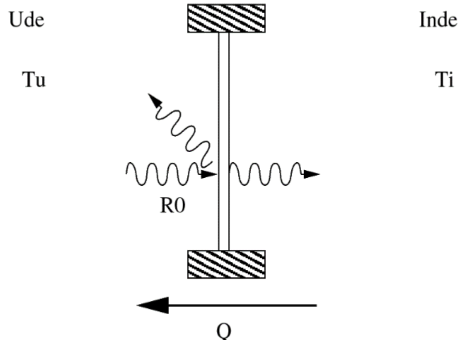
Wall: Slow reaction on climate



Occupant behaviorl



Windows + ventilation: Fast reaction



PRESS Load Forecast
(Model principles)

Load forecast for time t+k, Pp(t+k), is written:

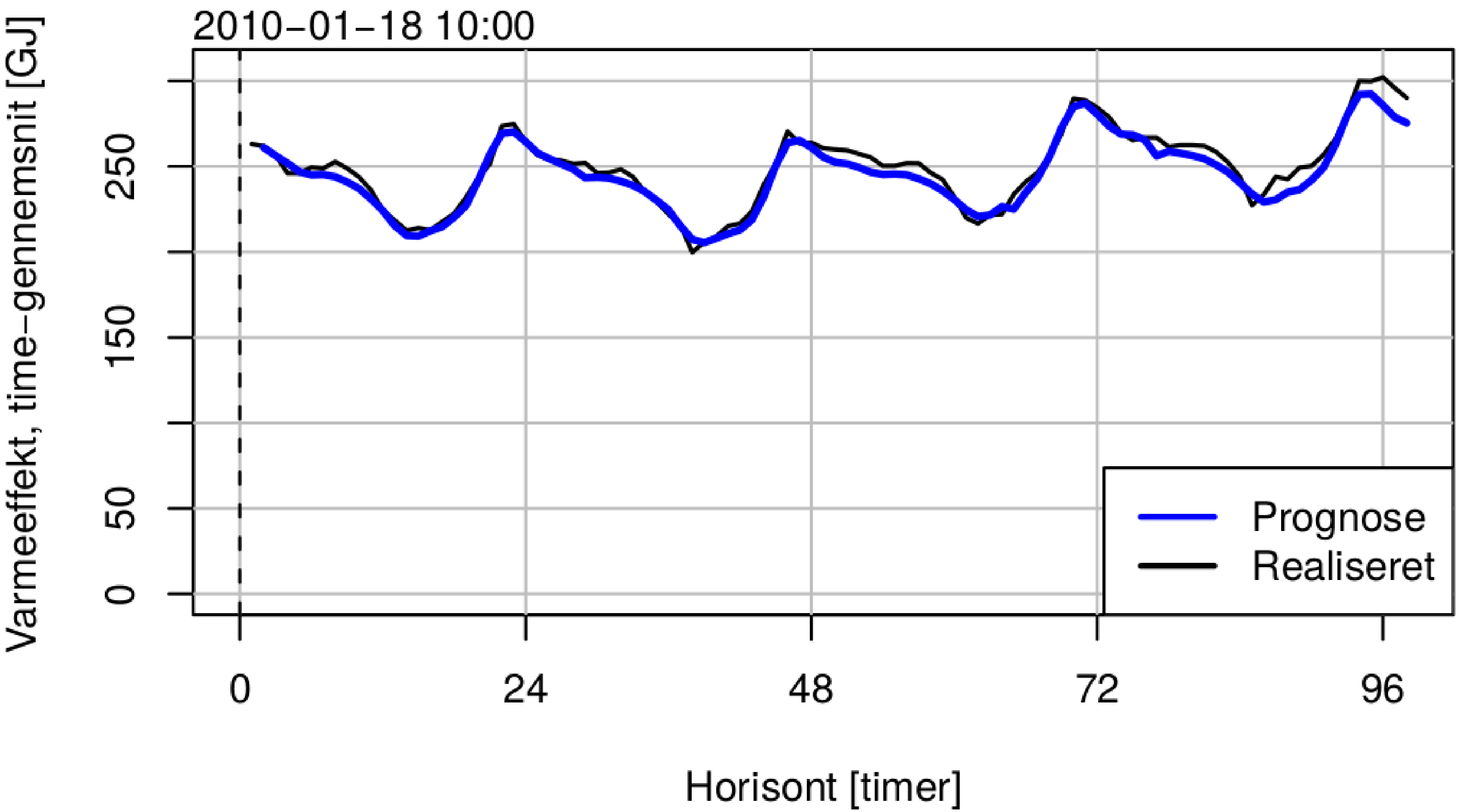
Pp(t+k) = Fmur(Vejr(t+k)) + Fvv(Vejr(t+k) +

Far(Pp(t) - P(t)) + DP(t+k)

where

- Fmur, Fvv, Far and DP are semi-parametric functions (estimated by PRESS)
- Vejr(t+k) is weather input (measured + forecasts) for time t+k.
- P(t) is measured heat load for time t.

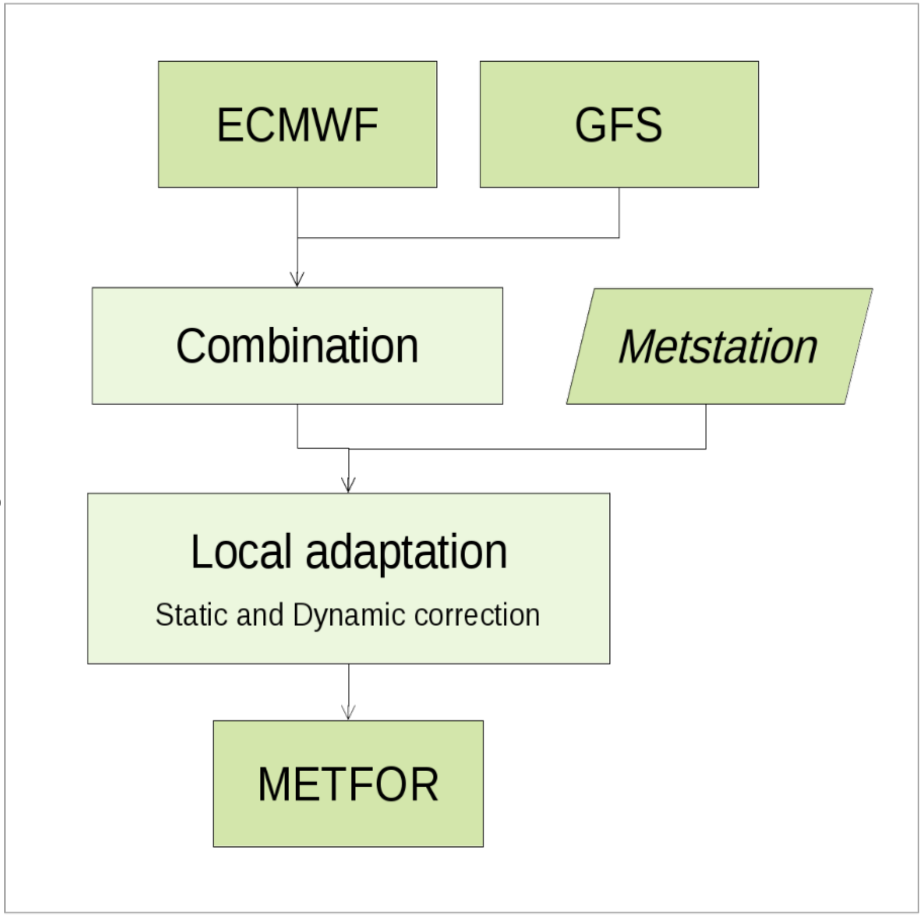
PRESS Load Forecast
(Example)



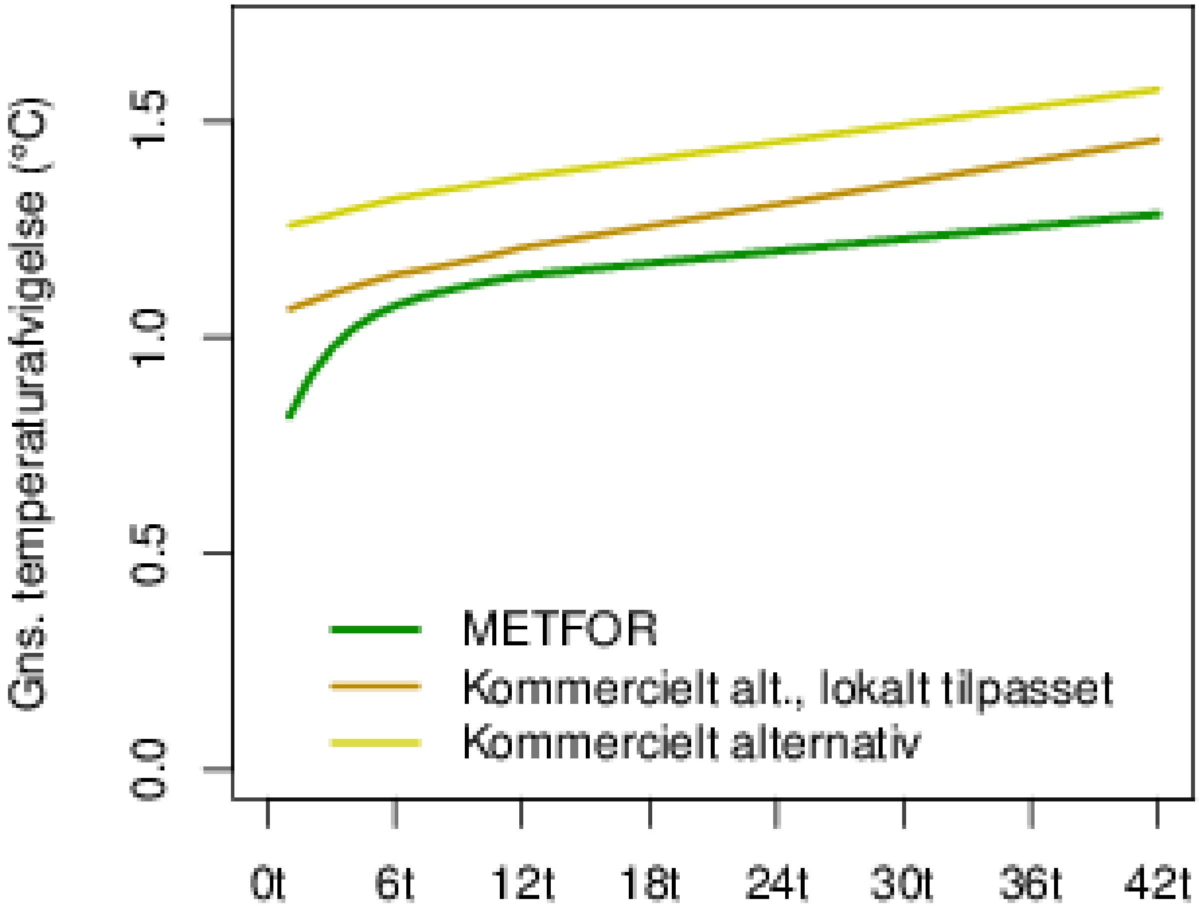
Weather data and forecasts

Optimize local weather forecast base on:

- Local climate data
- Several MET forecasts



MetFor performance



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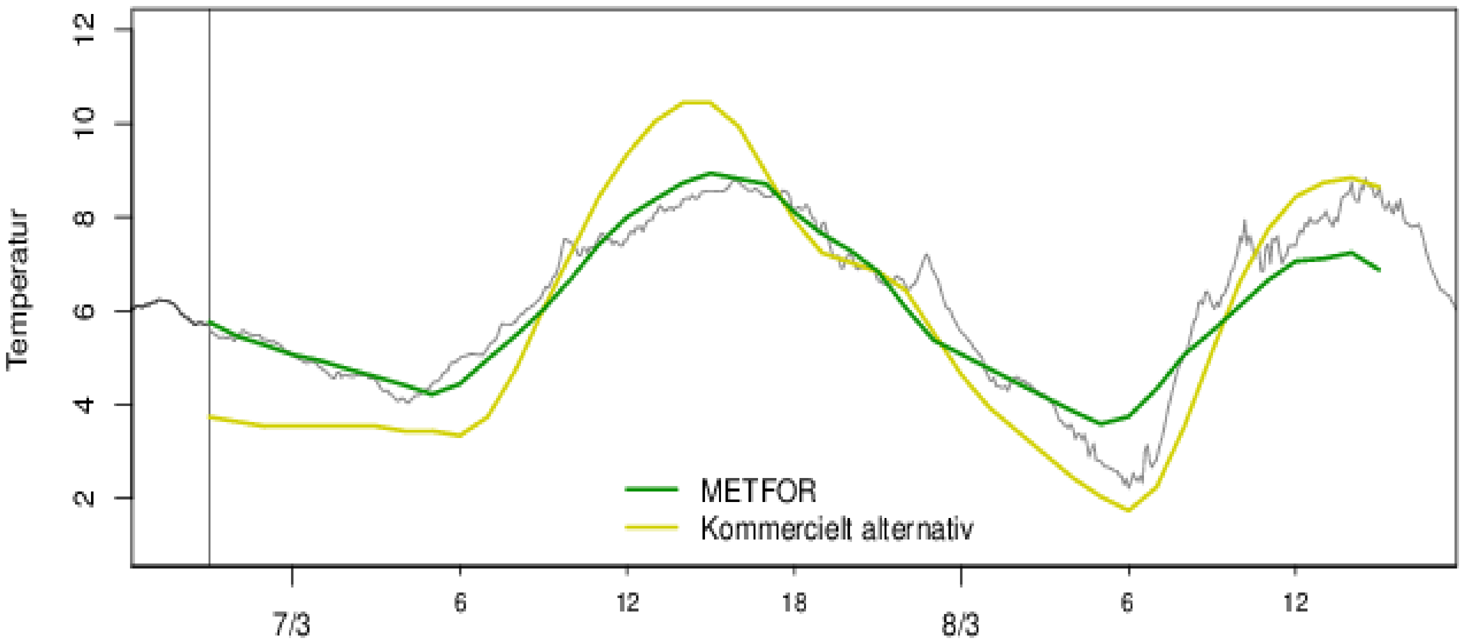
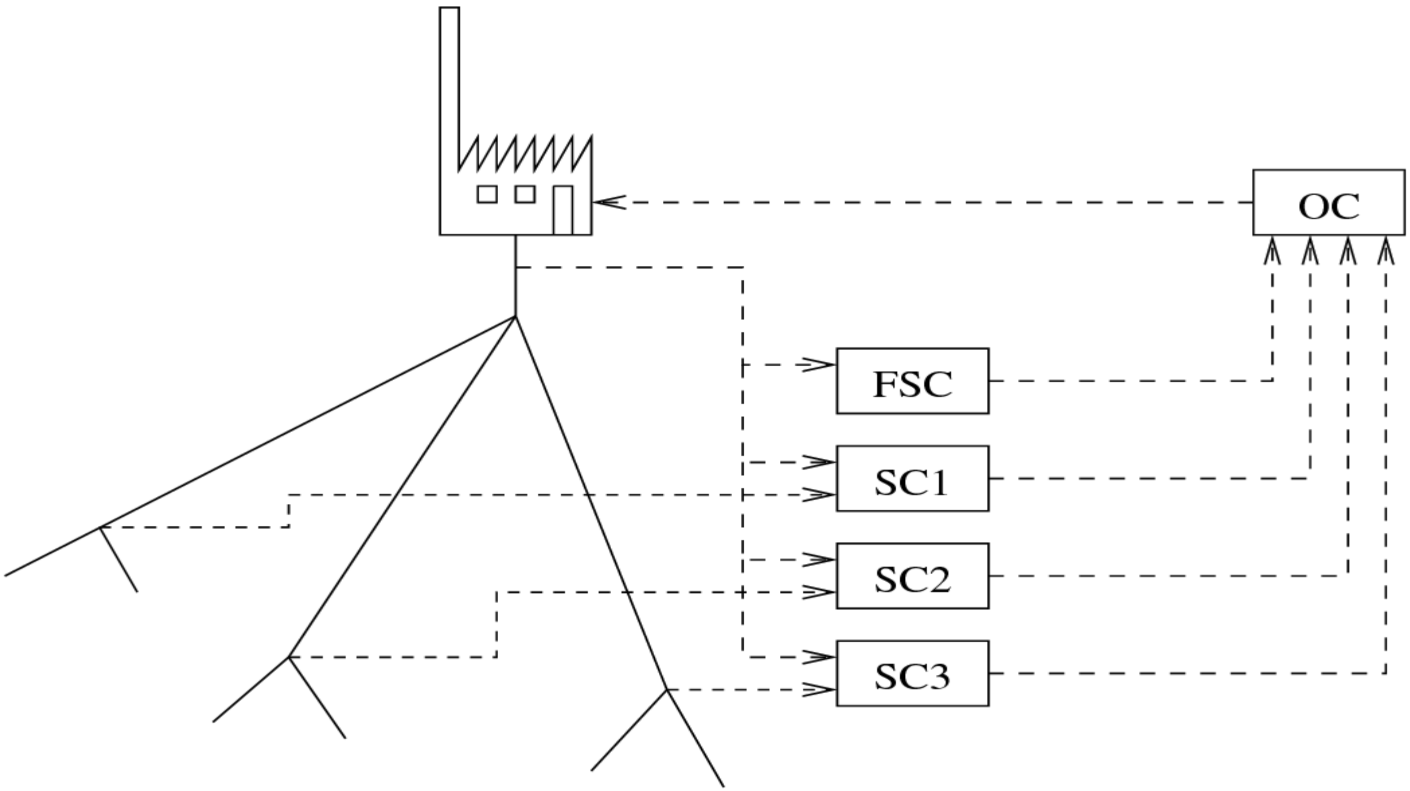
MetFor forecast example



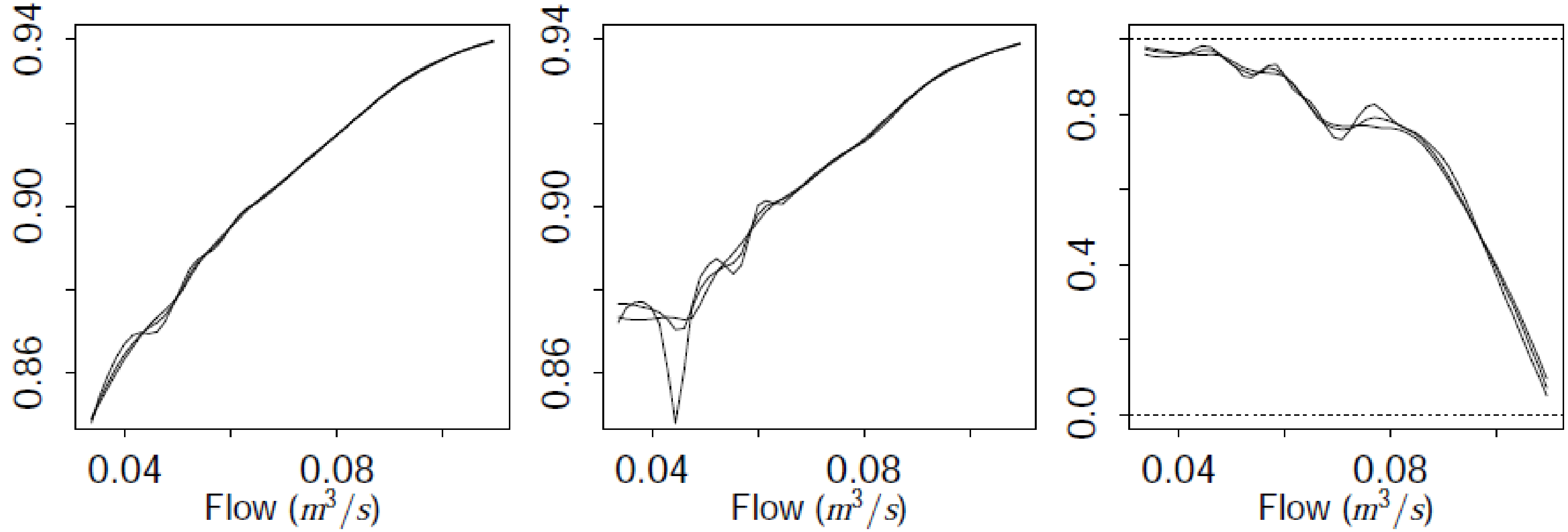
Models and Controllers
(Highly simplified!)



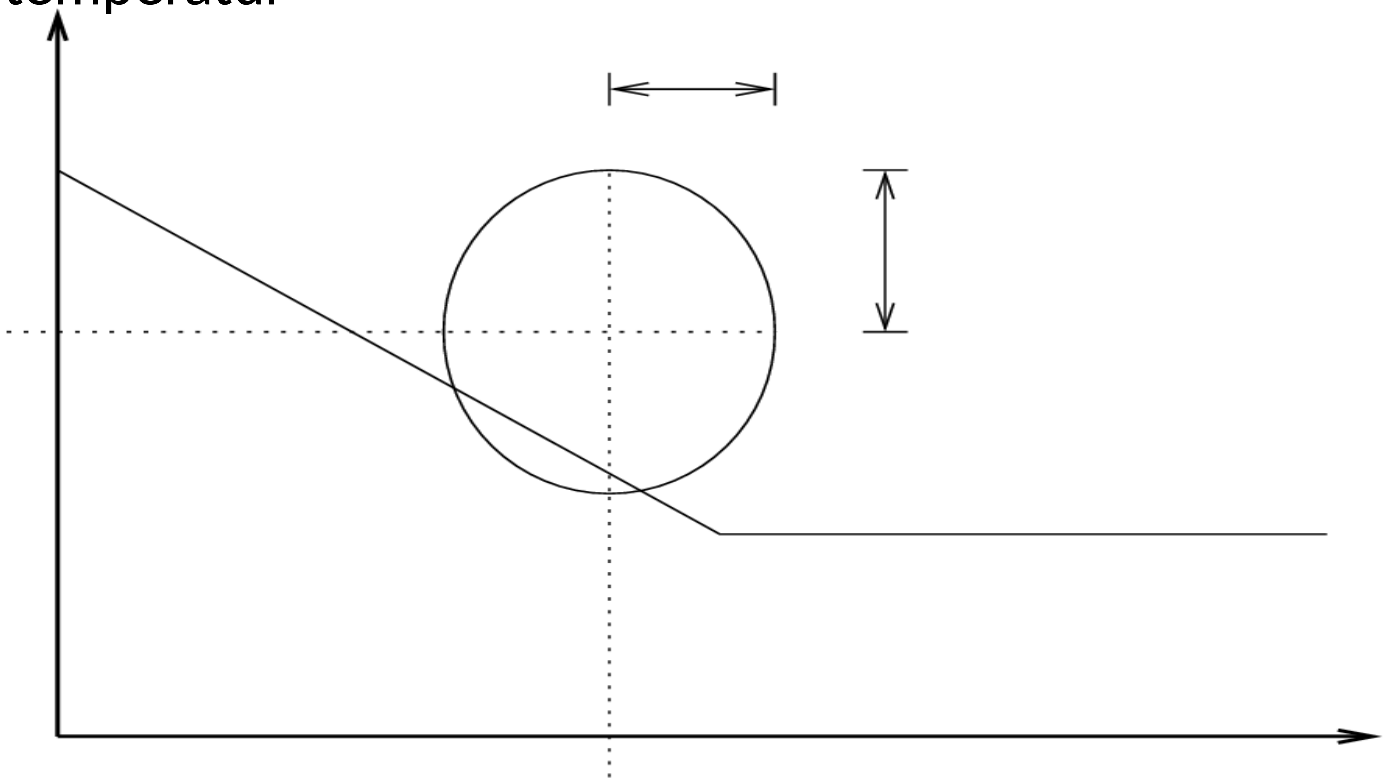
Characteristics

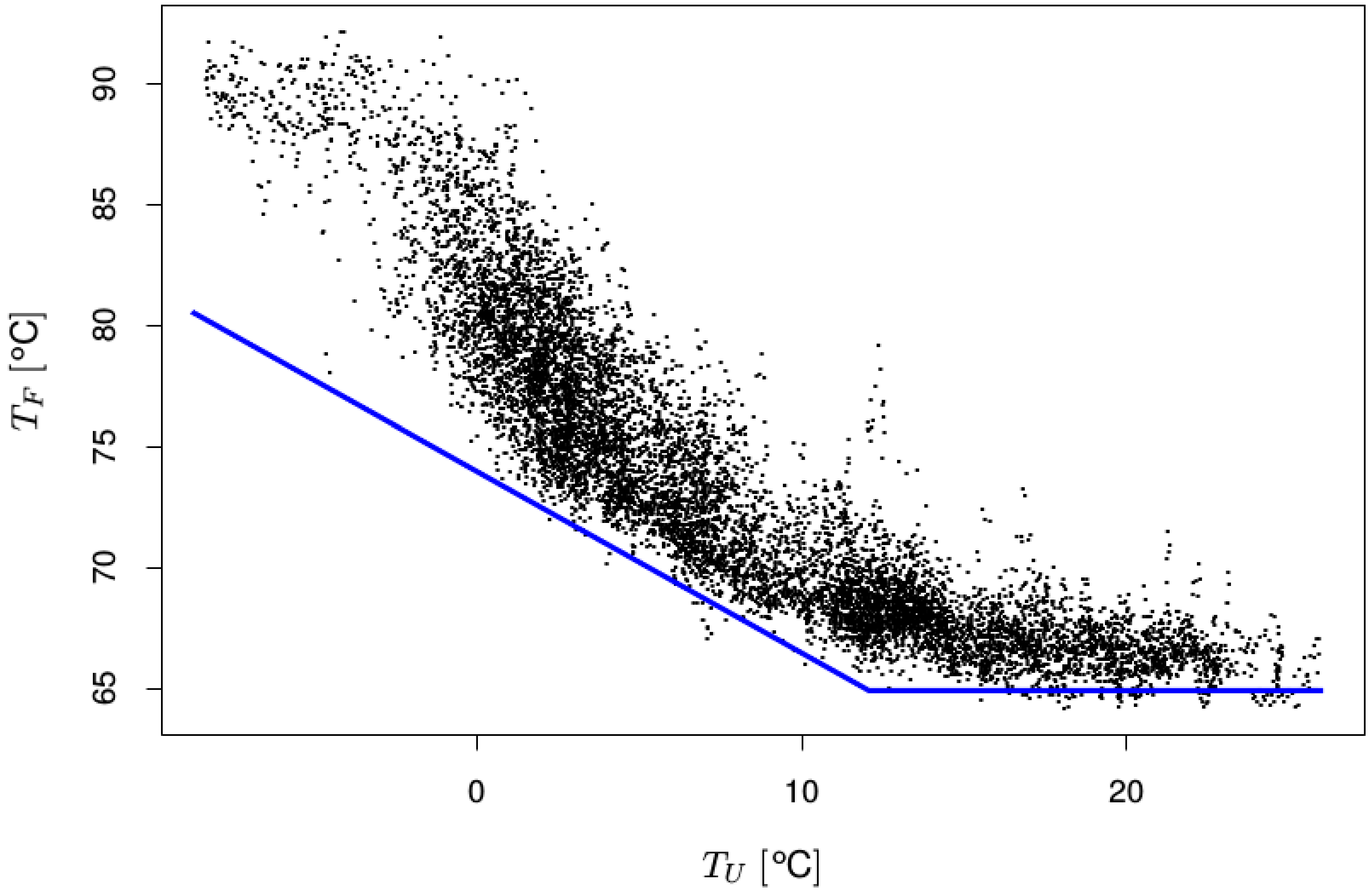
30%, 40%, 50%

Stationary gain of FIR | Stationary gain of ARX | Pole of ARX



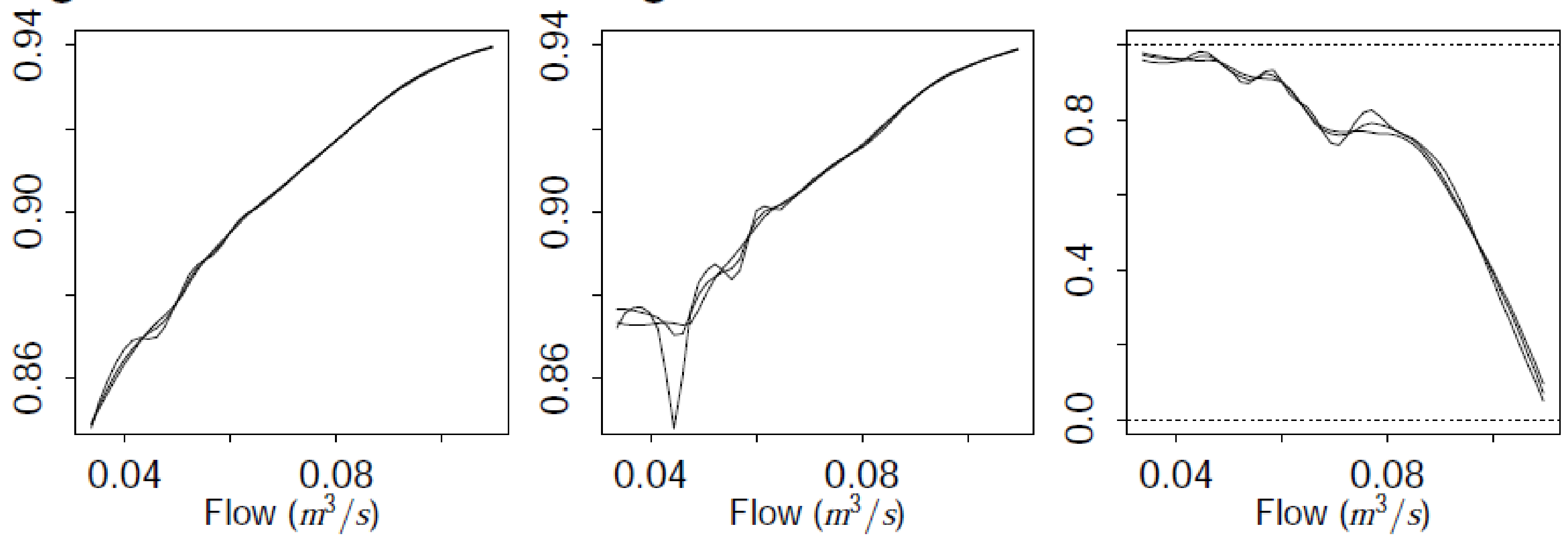
Optimal set-point taking uncertainty into account



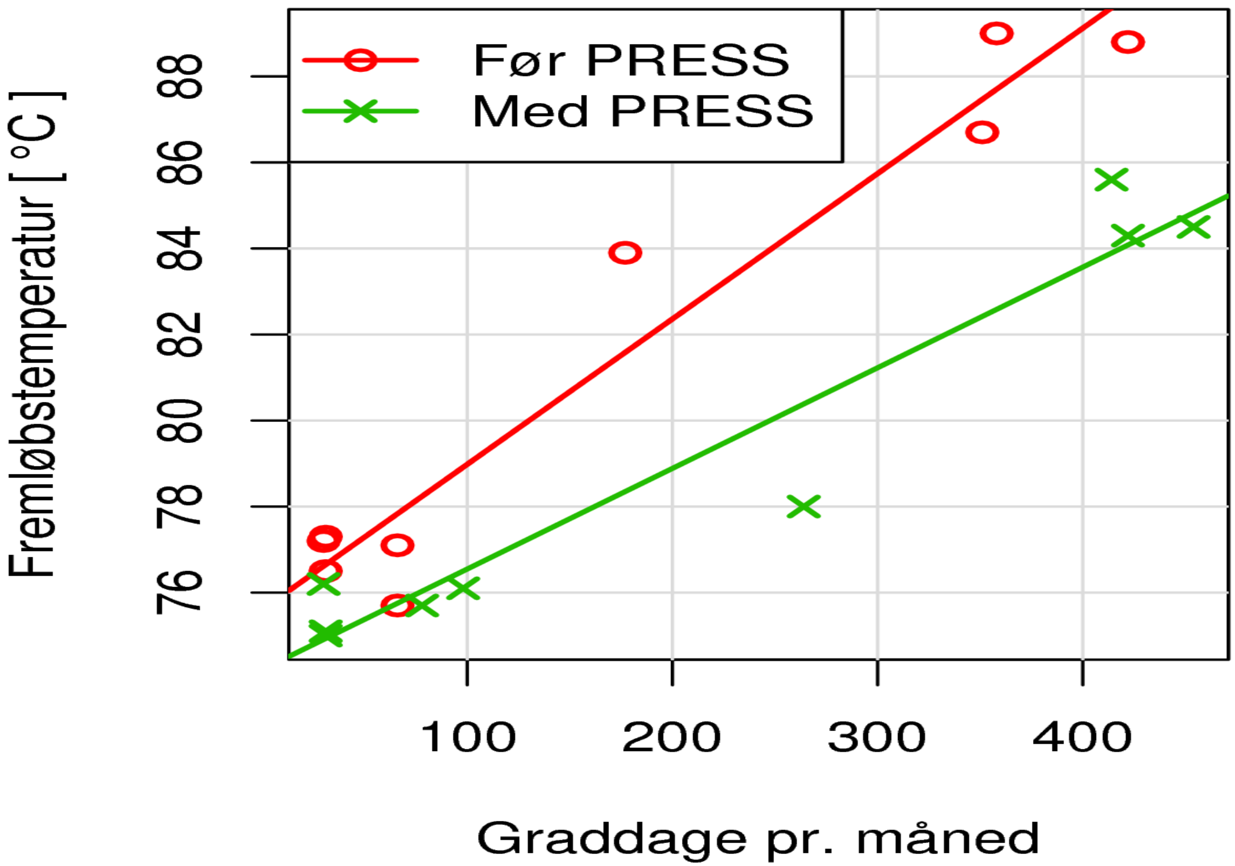

90
85
80
75
70
65
T_F [°C]
0
10
20
T_U [°C]

Characteristics

30%, 40%, 50%



Supply temperature with/without data intelligent control



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Savings
(Reduction of heat loss = 18.3 pct)

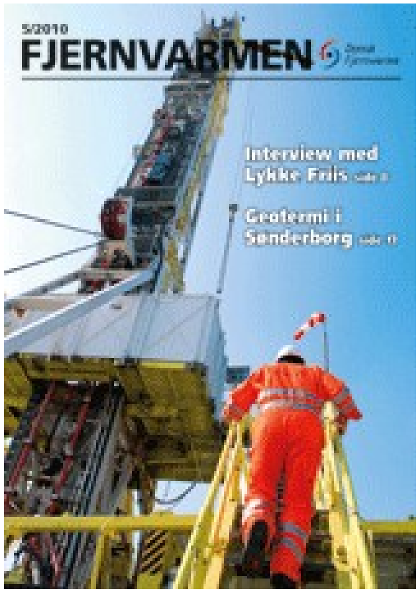
	Varmekøb		Elkøb	
	GJ	1000kr	kWh	1000kr
Før PRESS	653,000	30,750	499,000	648
Med PRESS	615,000	28,990	648,000	842
Forskel	37,400	1,760	-149,000	-194

Total besparelse (9 første måneder af normalår): **1,566,000kr**

Besparelse for et normalår:

- $12/9 \times$ 1,566,000kr $=$ **2.1 mill.**
- Imidlertid står jan.–sept. (75% af året) kun for ca. 65% af graddagen i er normalår.
- 1,566,000kr$/0.65 =$ **2.4 mill.**

Control of Temperatures in DH Systems



FJERNVARMEN | 5 2010

Styring af temperatur rummer kæmpe sparepotentiale

Lesson learned:

- Control using **simulation** of temperature gives **up to 10 pct reduction** of heat loss.
- Control using **data and predictions** gives **up to 20 pct. reduction** of heat loss.

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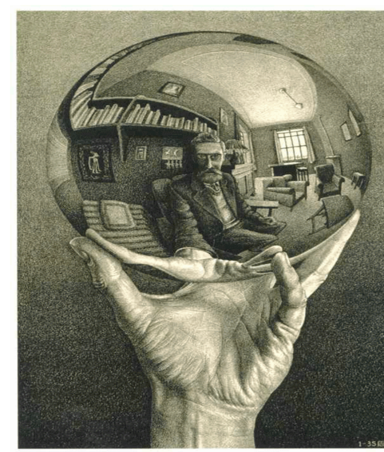
Which approach to use?

- Use **simulation based** control if:
  - No access to data from the DH network
  - Want an evaluation of new operational scenarios
- Use **prediction based** control if:
  - Access to network data online
  - Want to used meteorological forecasts automatically
  - Want to combine MET forecasts with local climate data
  - Want automated update of models

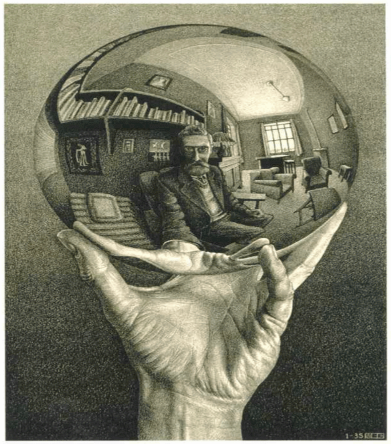
Data Intelligent Temperature Optimization for DH Systems

- Able to take advantage of information in data
- Self-calibrating models for the DH network
- Shows where to upgrade the DH network
- Fast (real time) calculations
- Use DH net for peak shaving and storage
- Able to use online MET forecasts etc.



Data Int. Temp. Opt (v.4.0)

- Big Data Analytics – more specificall:
- Take advantage of (smart) meter readings
- Use of all available MET forecast
- Combination of MET forecasts with data from local climate stations
- New grey-box models



For more information ...

See for instance

www.henrikmadsen.org

www.smart-cities-centre.org

www.citiesinnovation.org

...or contact

– Henrik Madsen (DTU Compute)

hmad@dtu.dk

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