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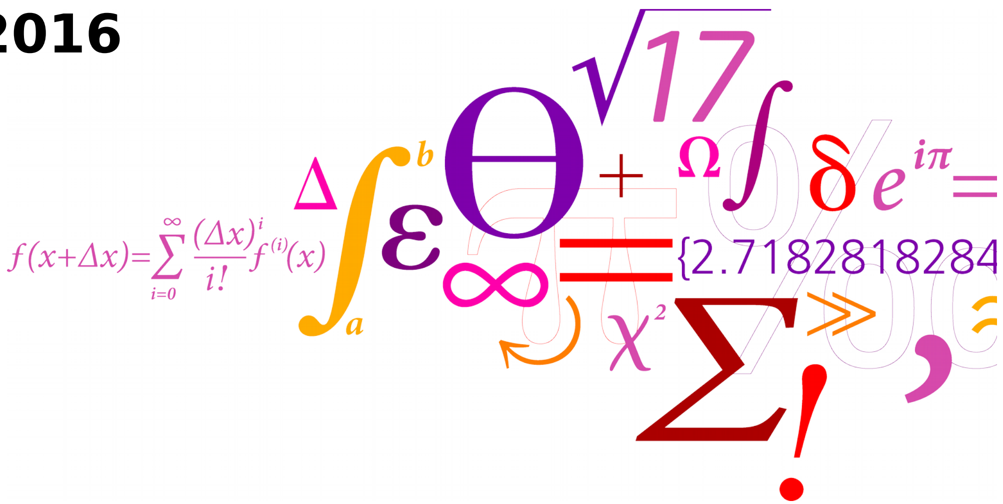
Præsentation af CITIES projektet - med fokus på SCA

Smart City Accelerator (SCA),
Kick-off seminar, Oktober 2016



Henrik Madsen,
www.henrikmadsen.org

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Oversigt:

DTU

- **CITIES**
- Energimærkning
- Bygningers termiske performance
- Anvisninger på (og verifikation af) energibesparelser
- Prognoser af energiforbrug
- Temperaturstyring i fjernvarmenet
- Smart styring af rensningsanlæg og afløbssystemer
- Energilagring og -fleksibilitet

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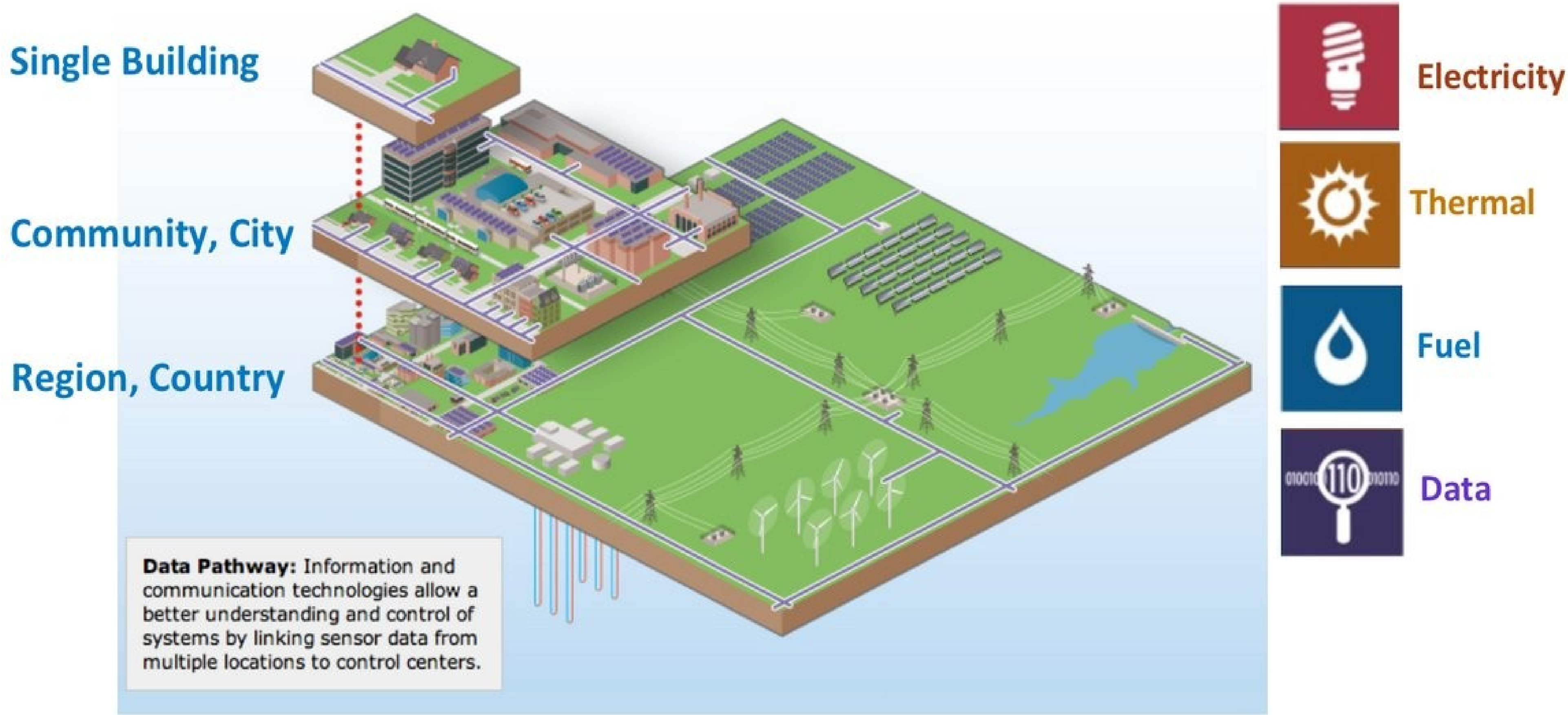
Energisystemer i Smarte Byer

Energy system integration (ESI) = the process of optimizing energy systems across multiple pathways and scales



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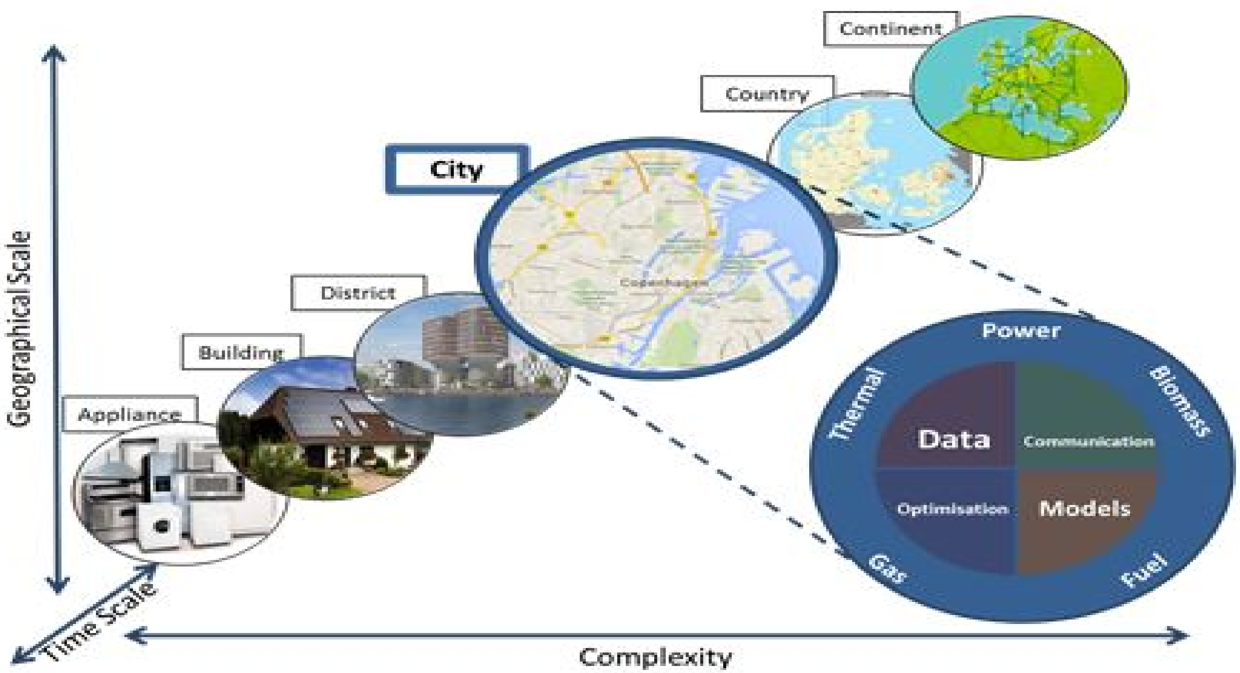
Center for IT-Intelligent Energy Systems in Cities **(CITIES – budget 75 mill. kr.) har til formål at etablere intelligente (data baserede) løsninger for design og optimering af integrerede energisystemer (el, fjernvarme, gas, biomasse, ..)**



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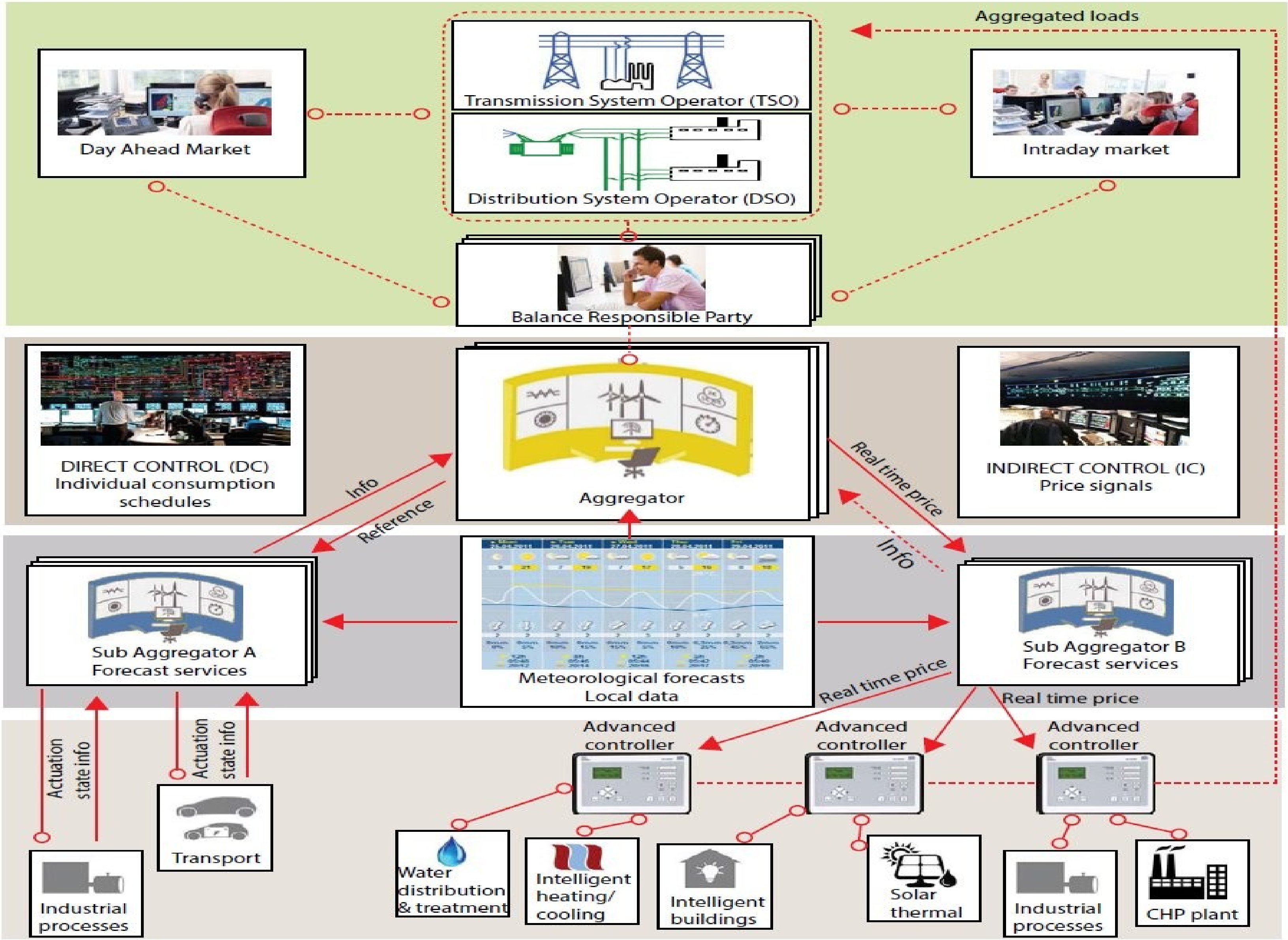
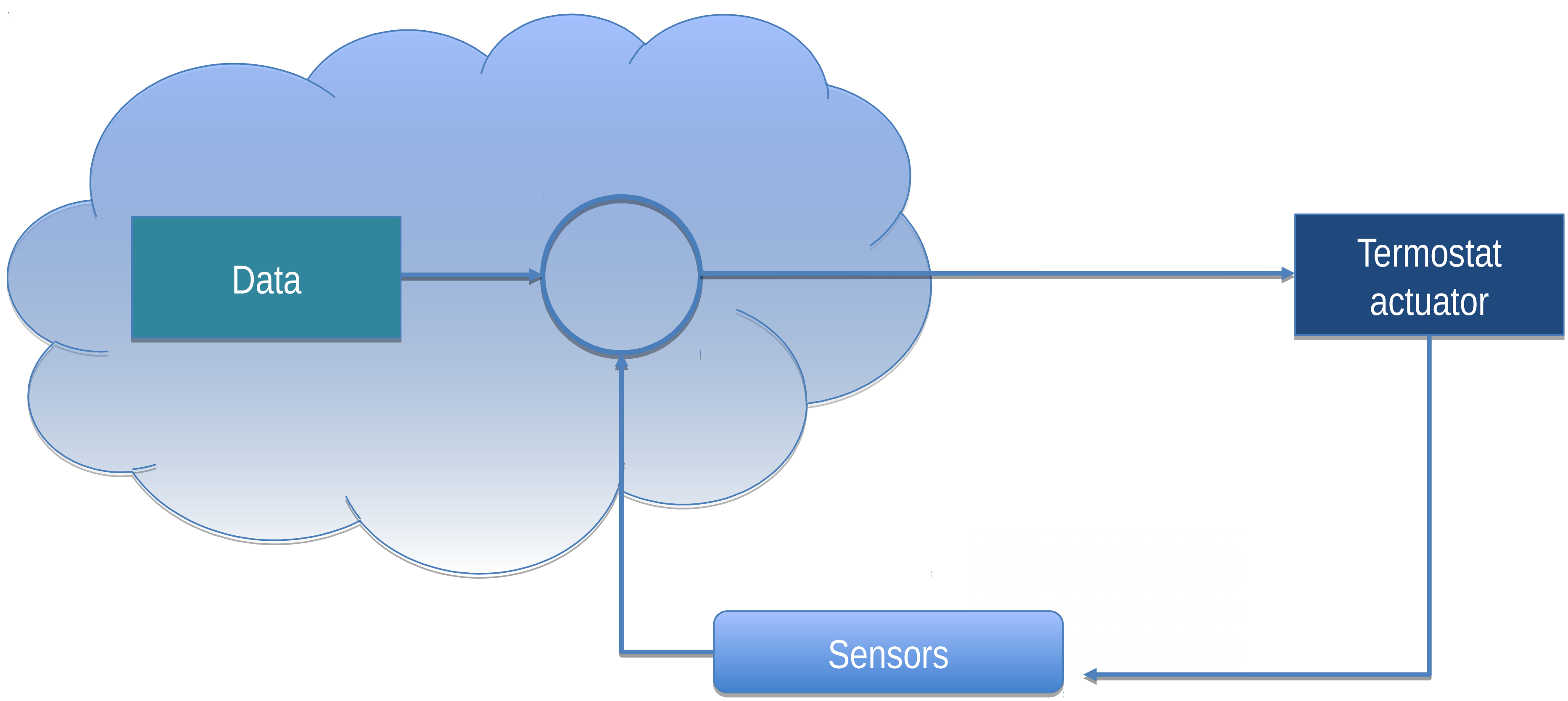
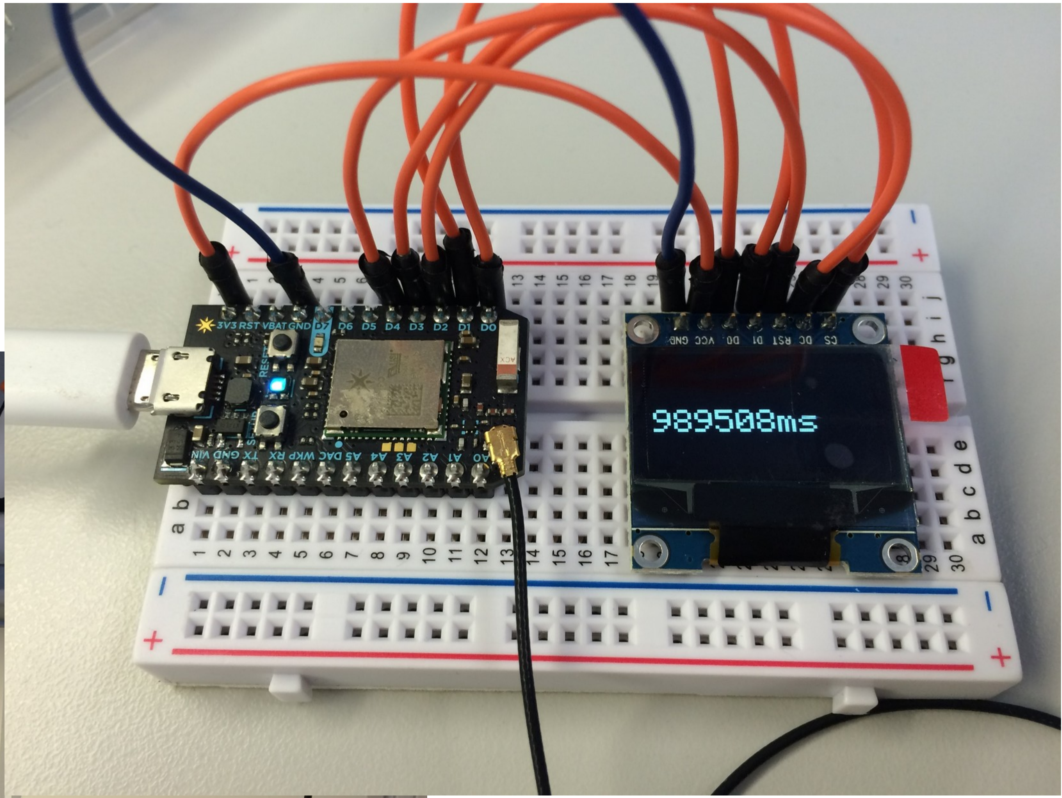
Smart-Energy OS



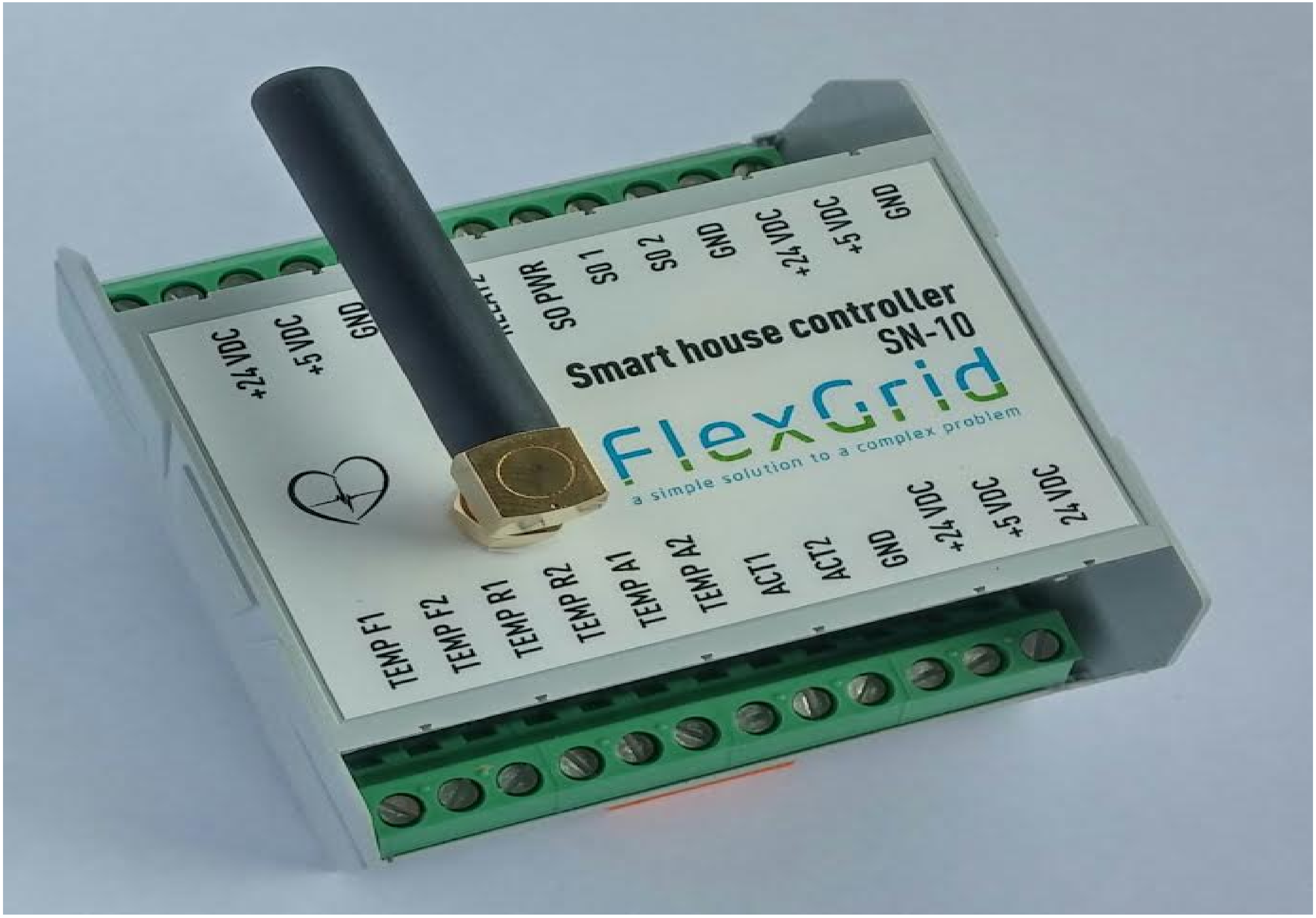
SE-OS
Control loop design – **logical drawing**



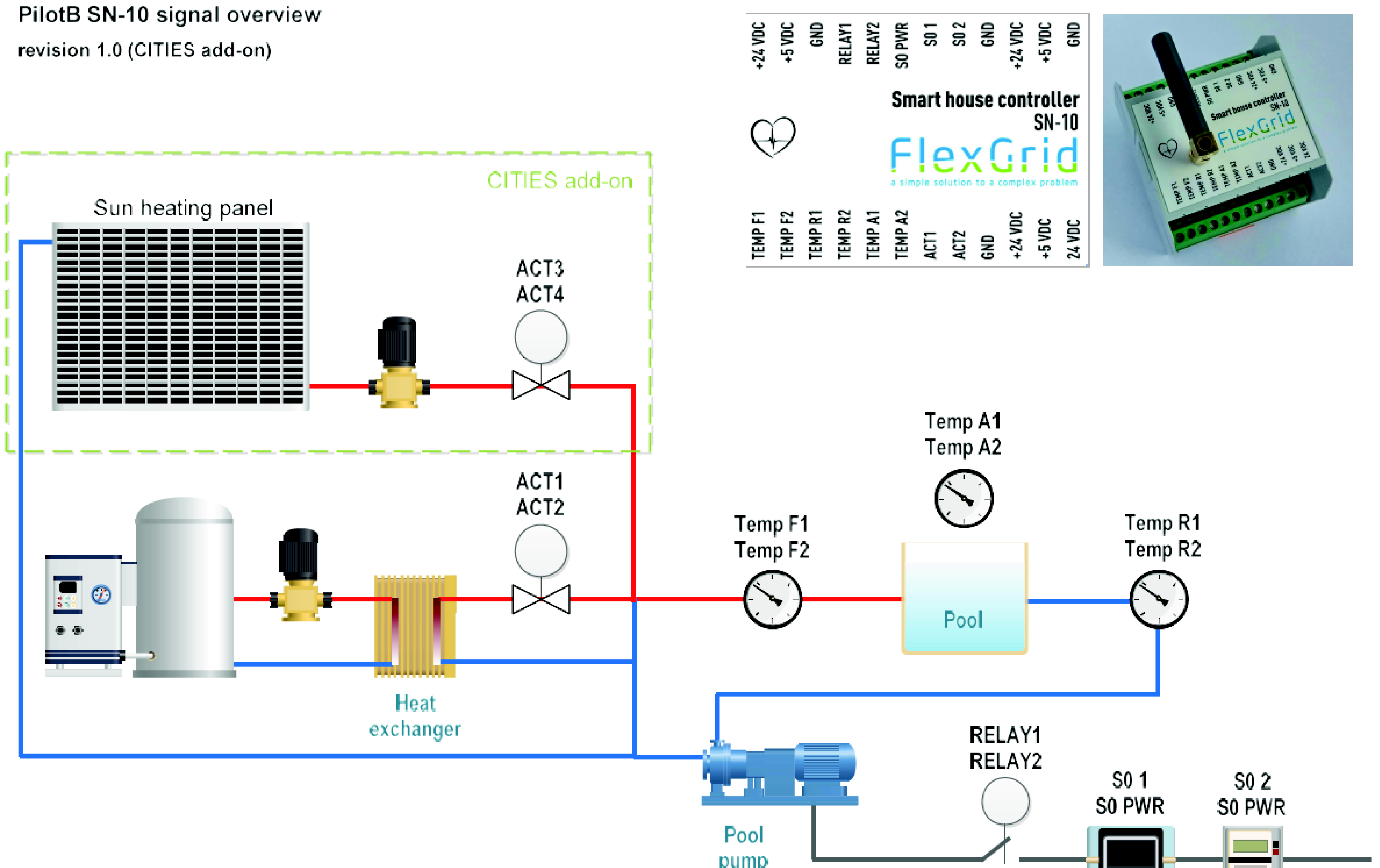
Lab testing ….



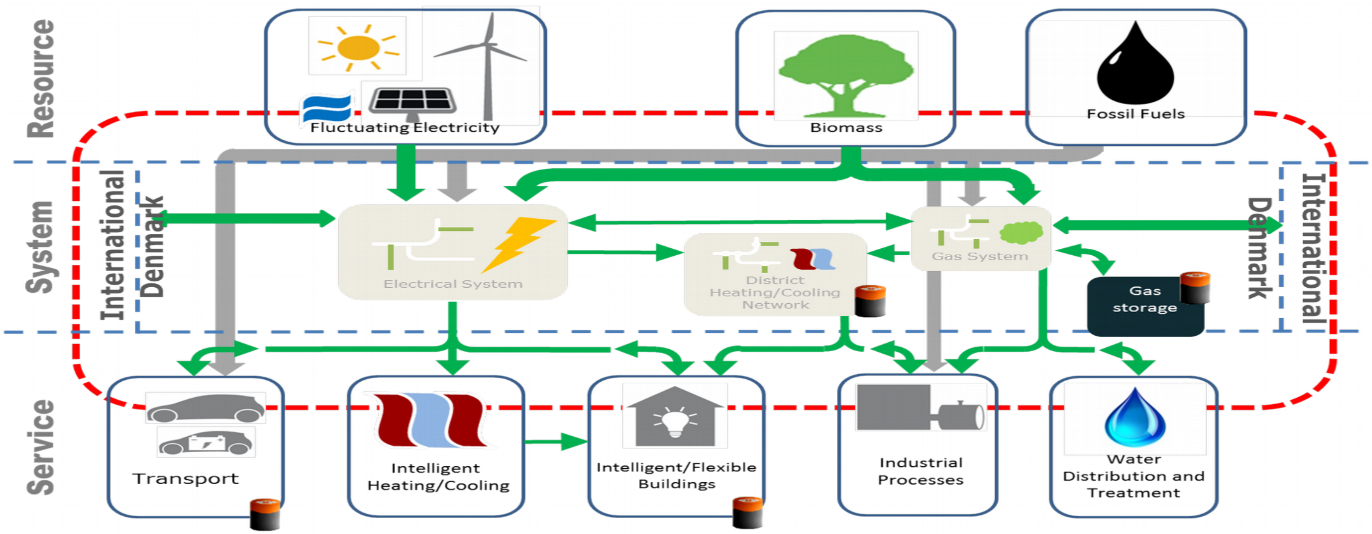
SN-10 Smart House Prototype



Smart control af hus med pool



Modeller – og (virtuel) Energilagring



- **Flexibility (or virtual storage) characteristics:**
  - Supermarket refrigeration can provide storage 0.5-2 hours ahead
  - Buildings thermal capacity can provide storage up to, say, 5-10 hours ahead
  - Buildings with local water storage can provide storage up to, say, 2-12 hours ahead
  - District heating/cooling systems can provide storage up to 1-3 days ahead
  - DH systems with thermal solar collectors can often provide monthly storage solutions
  - Gas systems can provide seasonal/long term storage solutions

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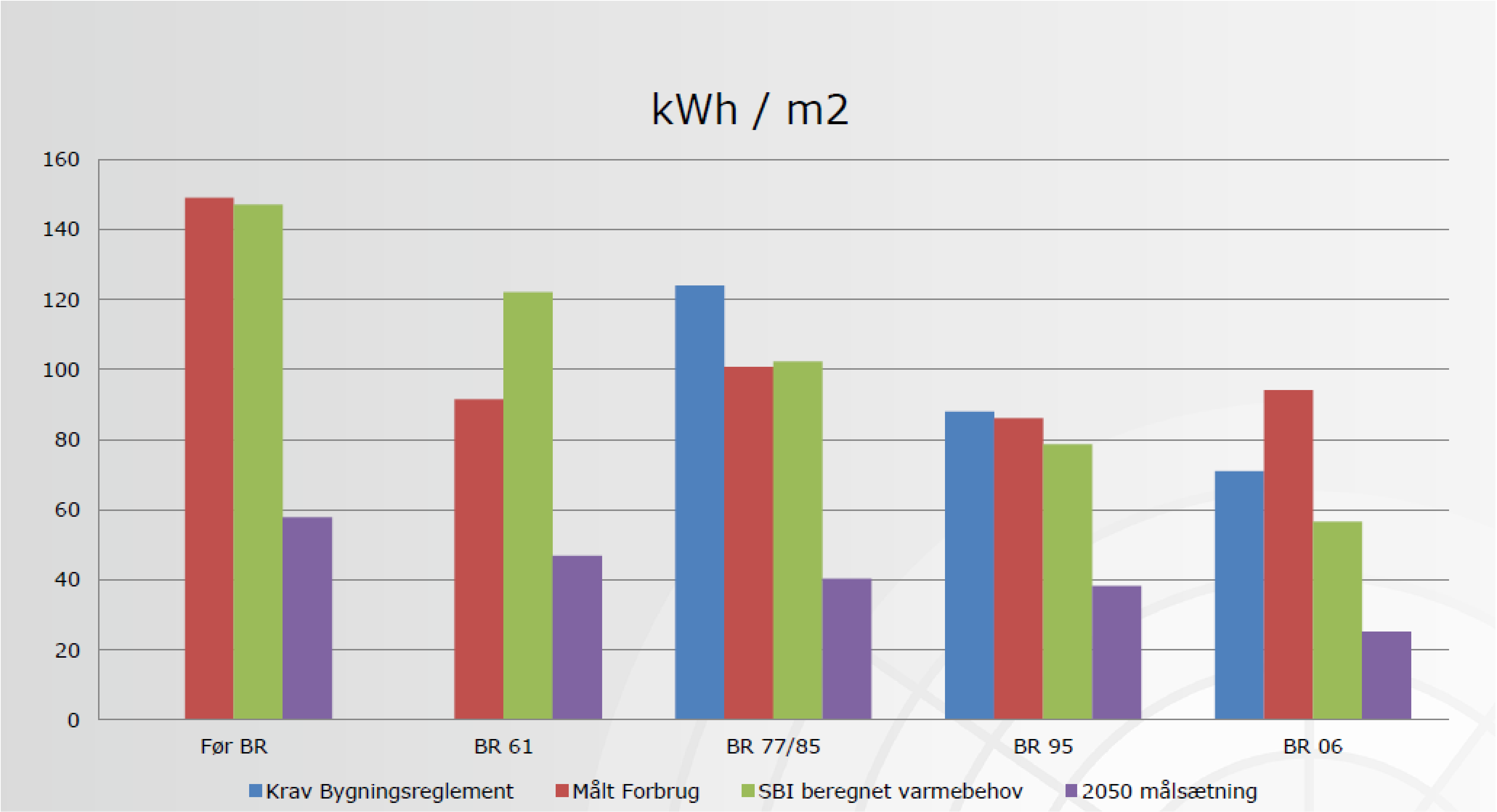
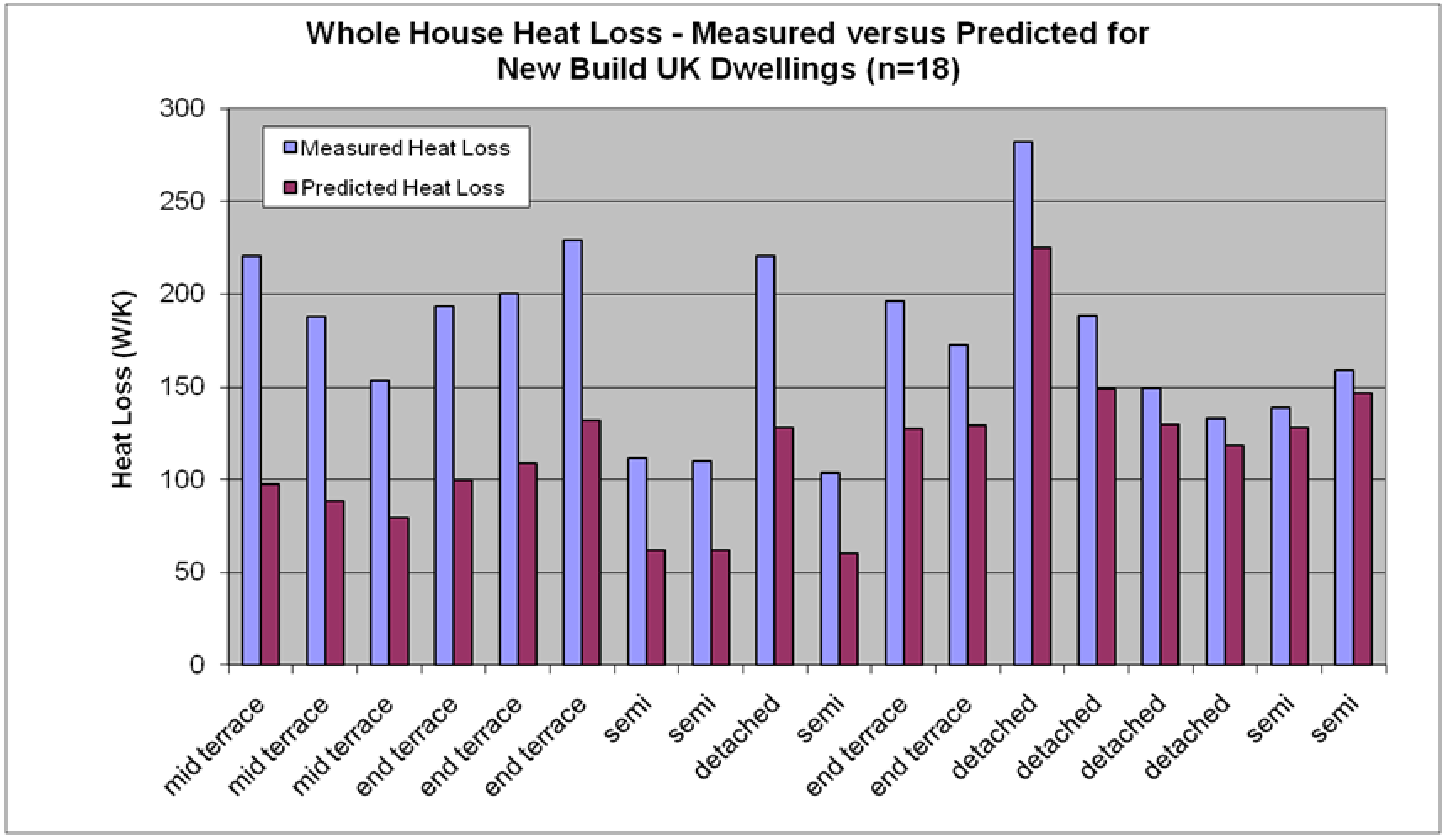
Case Study

Identifikation af den termiske profil af bygninger på grundlag af hyppige målerdata

Energiforbrug pr. m2 - DK

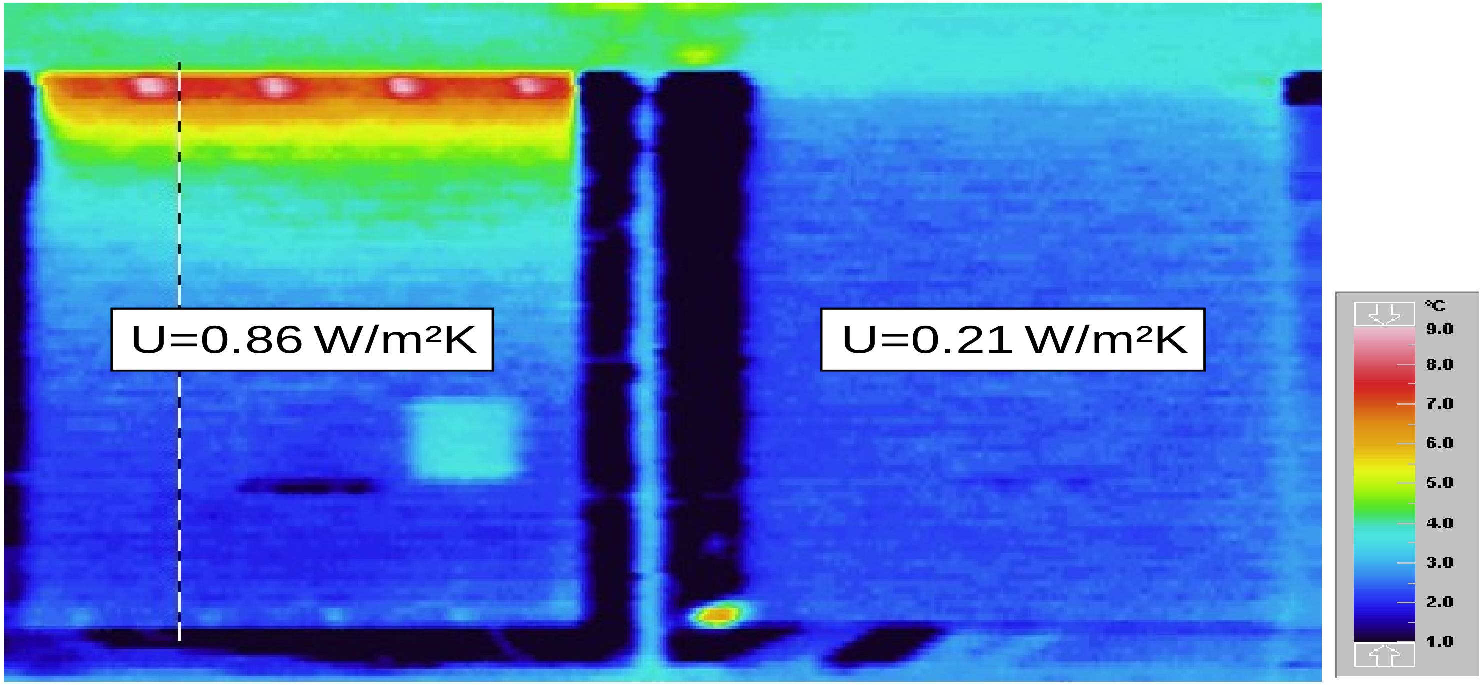


Beregnet og faktisk forbrug



Generelt dårlig overensstemmelse mellem beregnet og faktisk forbrug.
Derfor bør man bruge målinger (og ikke tegninger....)

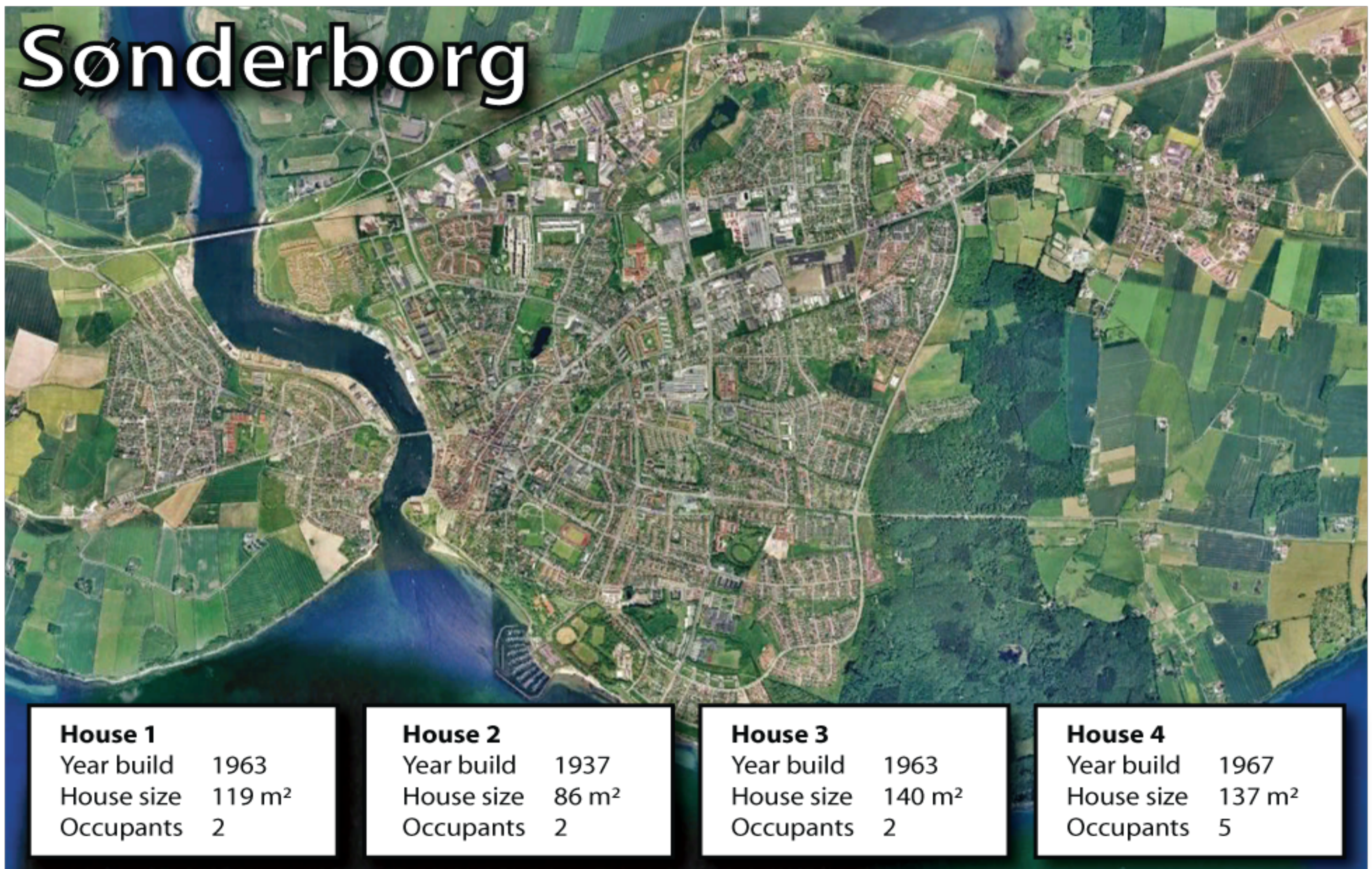
Eksempel



Konsekvens af dårlig og god udførelse (teoretisk værdi er U=0.16W/m2K)

Data

- 10 min averages from a number of houses



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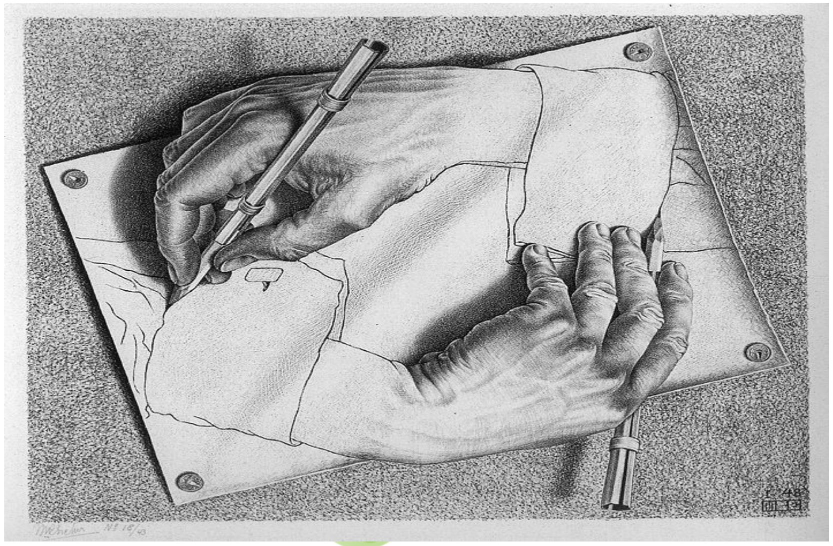
Nuværende energimærkning

- **Energimærkning:** Sker pt. på baggrund af tegninger, årsforbrug, og et besøg
- Det er velkendt at to energikonsulenter kan komme til ret forskellige resultater
- Der er ofte debat om kvalitet (og omkostninger) ifm energimærkning
- **Renovering:** Dokumentation af opnåede resultater



Energimærkning

- Energikonsulenten kan ikke foretage destruktive indgreb
- Der er brug for en ny objektiv metode, som yderligere kan 'se' de skjulte dele af bygningen.
- En ny energimærkning kan etableres helt automatisk pga måleraflæsningsdata!
- Metoden korrigerer automatisk for forskelle i forbrugsmønstre uden at kræve målinger af indetemperaturen (t.ex.)

Bygningers termiske karakteristika

Karakteristiske respons-værdier:

- UA-værdi: Respons ved udetemperatur (W/grad C)
- gA-værdi: Respons ved solstråling (W/lux)
- wA-værdi: Respons ved vindhastighed (W/(m/s))

Effekten af vindhastigheden afhænger af vindretningen

UA og wA siger noget om isolering og tæthed

gA siger noget om boligens evne til at opfange og udnytte solindfald

Results

	UA W/°C	σ_{UA}	gA^{max} W	wA_E^{max} W/°C	wA_S^{max} W/°C	wA_W^{max} W/°C	T_i °C	σ_{T_i}
4218598	211.8	10.4	597.0	11.0	3.3	8.9	23.6	1.1
4381449	228.2	12.6	1012.3	29.8	42.8	39.7	19.4	1.0
4711160	155.4	6.3	518.8	14.5	4.4	9.1	22.5	0.9
4836681	155.3	8.1	591.0	39.5	28.0	21.4	23.5	1.1
4836722	236.0	17.7	1578.3	4.3	3.3	18.9	23.5	1.6
4986050	159.6	10.7	715.7	10.2	7.5	7.2	20.8	1.4
5069878	144.8	10.4	87.6	3.7	1.6	17.3	21.8	1.5
5069913	207.8	9.0	962.5	3.7	8.6	10.6	22.6	0.9
5107720	189.4	15.4	657.7	41.4	29.4	16.5	21.0	1.6
.	.	.	.	.	.	.	.	.

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Based on measurements from the heating season **2009/2010** your typical indoor temperature during the heating season has been estimated to **24** ^oC. If this is not correct you can change it here [24] ^oC.

If your house has been left empty in longer periods with a partly reduced heat supply you have the possibility of specifying the periods in this [calendar].

According to BBR the area of your house is **155** m^2 and from **1971**.

Based on BBR information it is assumed that **you do not use any supplementary heat supply**. If this is not correct you can specify the type and frequency of use here:

- Wood burning stove used [0] times per week in cold periods.
- Solar heating [y/n], approximate size of solar panel [0] $\times$ [0] meters.

Based on the indoor temperature **24** ^oC, the use of a wood burning stove **0** times per week, and **no** solar heating installed, the response of your house to climate is estimated as:

- The response to outdoor temperature is estimated to **200** $W/^oC$ **which given the size and age of your house is expectable**[a].
- On a windy day the above value is estimated to increase with **60** $W/^oC$ **when the wind blows from easterly directions. This response to wind is relatively high and indicates a problem related to the air sealing on the eastern side of the house.**
- On a sunny day during the heating season the house is estimated to receive **800** W as an average over 24 hours. **This value is quite expectable.**

[a] Many kind of different recommendations can be given here.

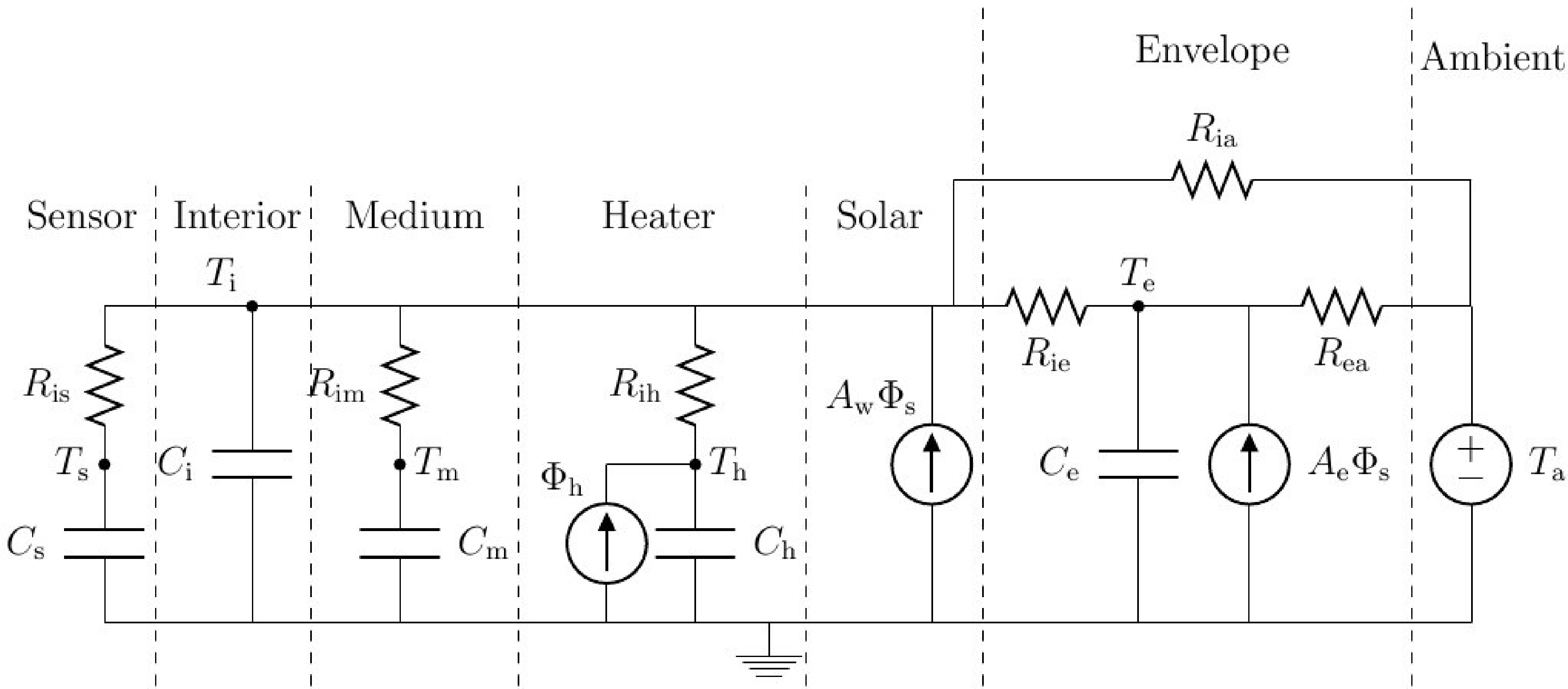
Perspektiver for brug af data fra energimålere

- Energisignatur (koefficienter)
- Energimærkning
- Tidskonstanter (t.ex. For bedre styring)
- Aut. Forslag til energibesparelser:
  - Udskiftning af vinduer?
  - Ekstra isolering på loftet?
  - Er huset utæt?
  - ......
- Optimeret styring
- Bedre integration af vind og sol – huset som energilager

Case study

Flere sensorer –>
detaljeret modellering af en bygning

Detaljeret modellering af bygninger
CTSM-R
(http://smart-cities-centre.org/software-solutions/)



Case study

Fjernvarmesystemer
Prognoser, styring og optimering

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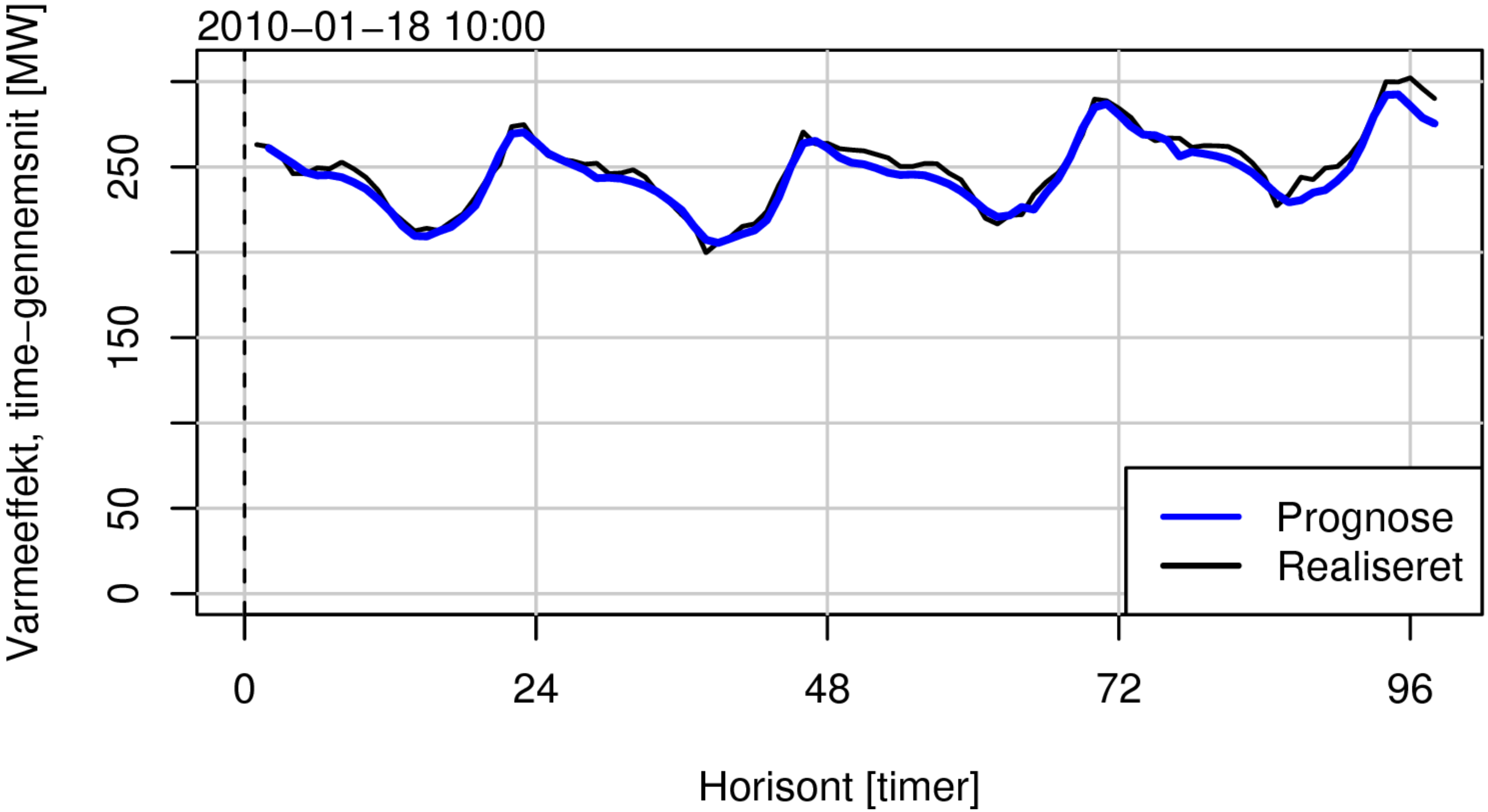
Fjernvarmenet

- Samme problematik som ved bygninger:
  - Udførelsen er ikke altid nøjagtig som på tegningerne
  - Isoleringsevnen kan afvige en del fra det teoretiske (eksempelvis grundet våd isolering)
  - Hydrodynamikken kan være vanskelig at udregne præcist
- Vi har udviklet løsninger til temperaturstyring

Forudsigelse af varmebehov



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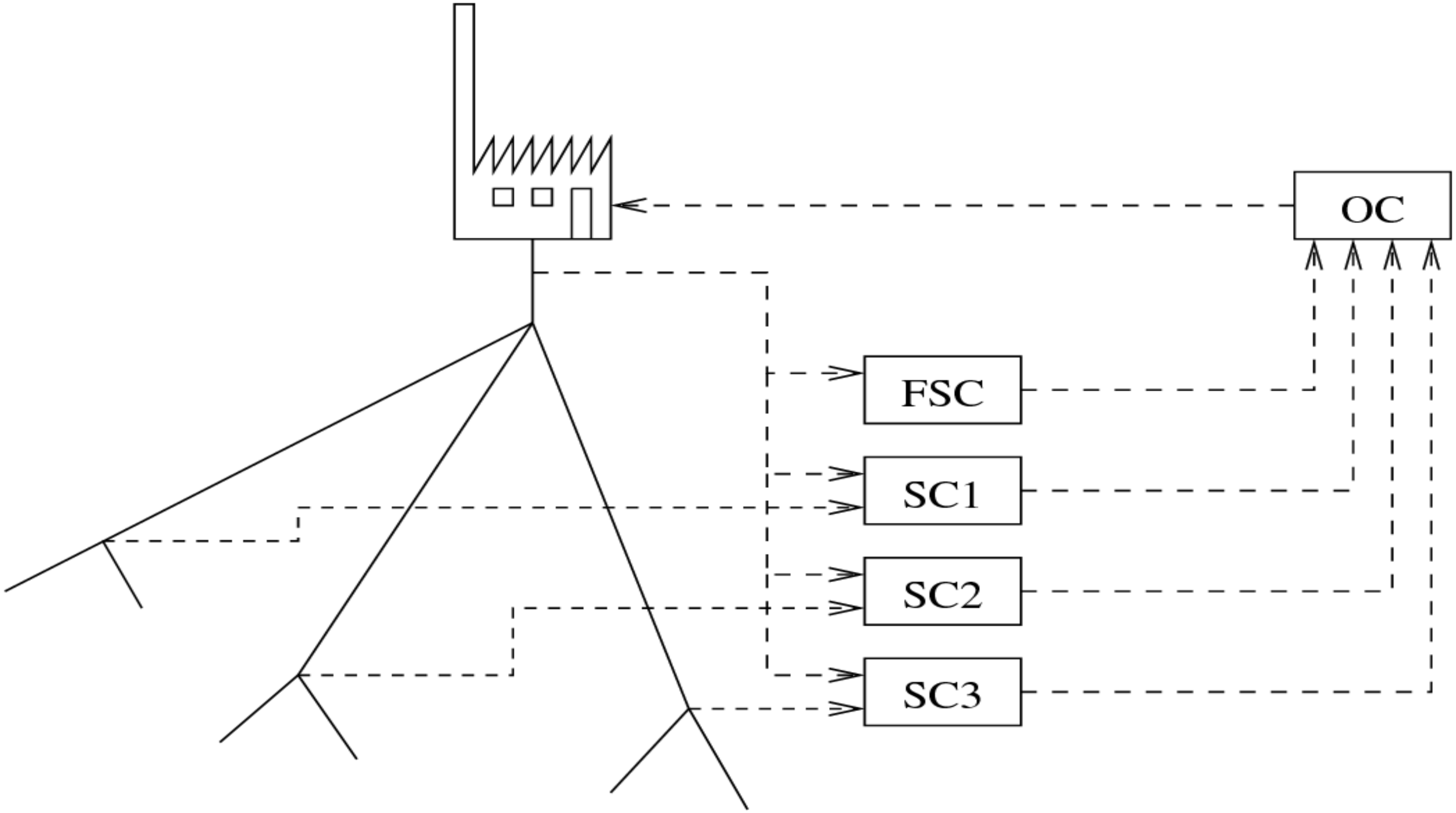
Modeller og Styring

(Simplificeret! - Reelt ca. 400 km rør)



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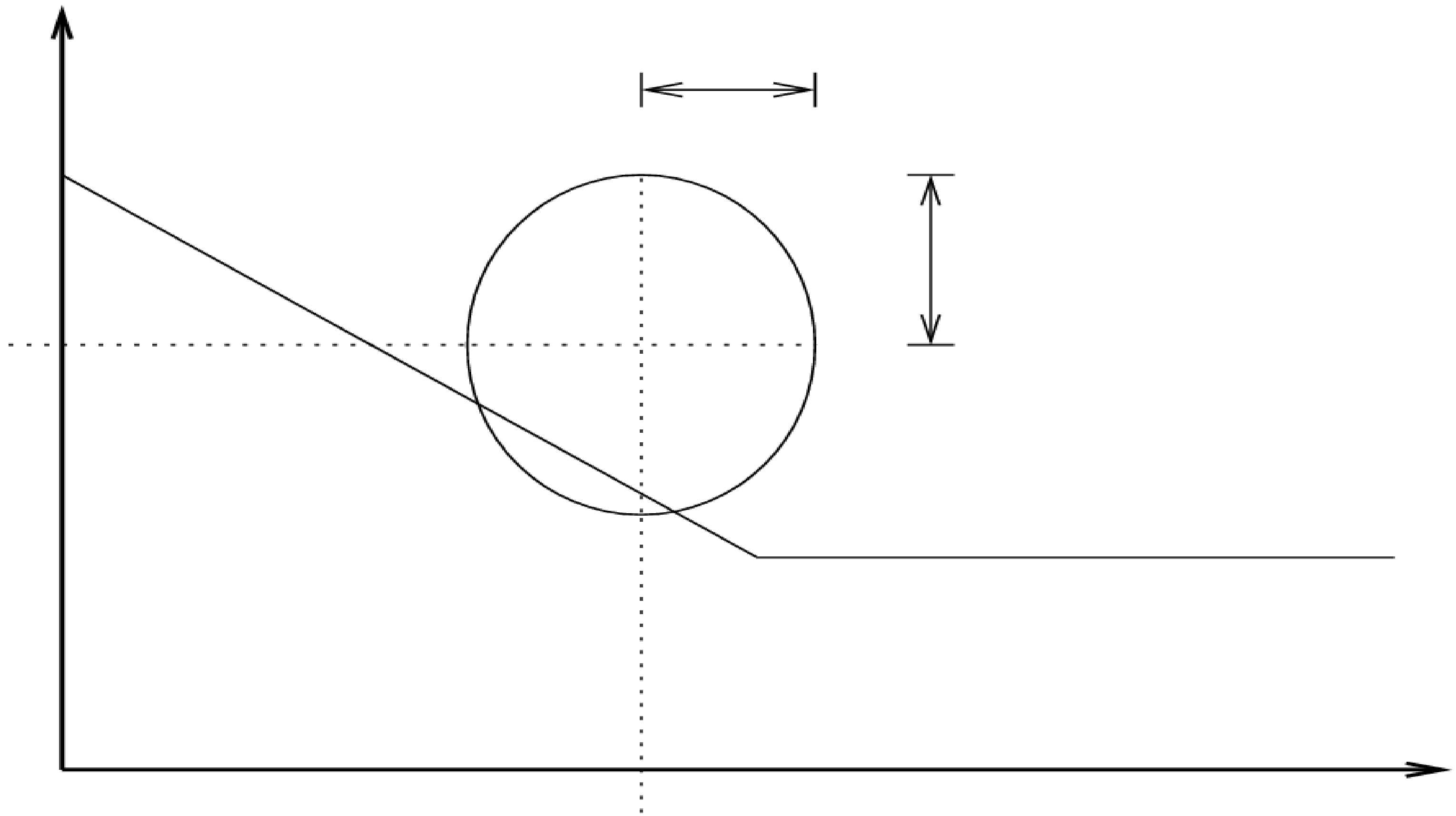
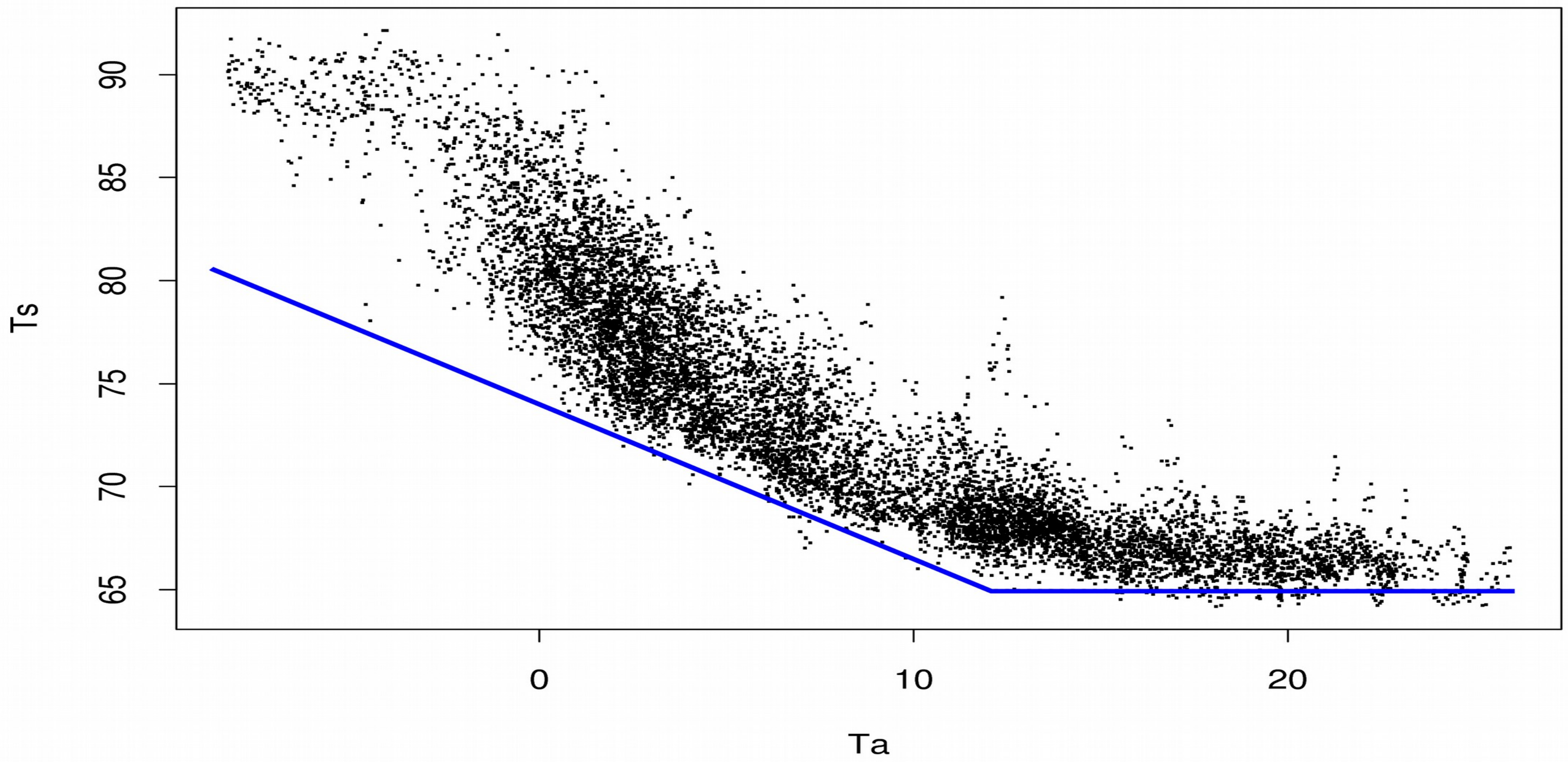
Setpunkt for styringen

Temp at User



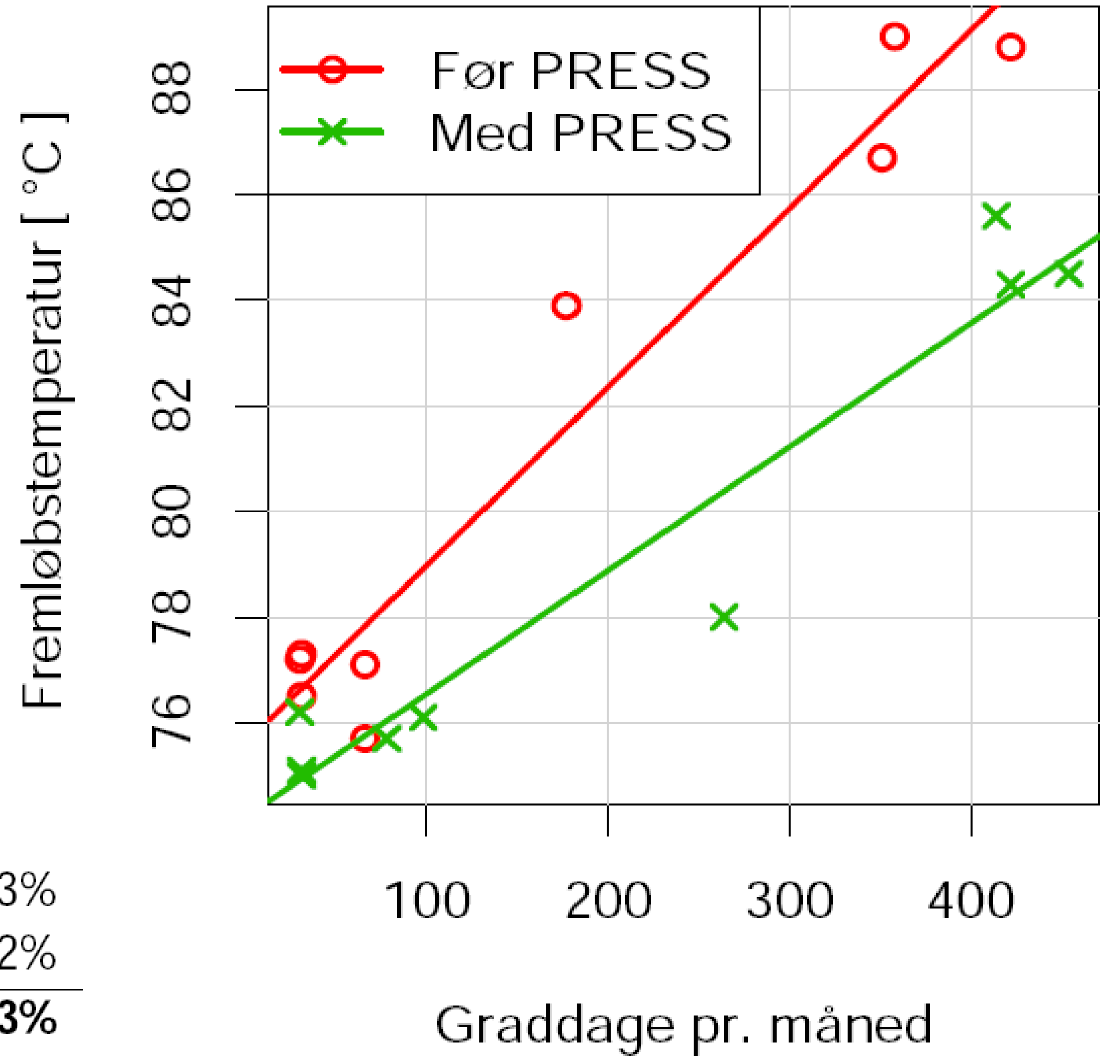
Ambient Air Temp.

Observeret brugertemp.



Temperatur optimering

Fremløbstemperatur mod graddage



Før PRESS:	22,3%
Med PRESS:	18,2%
Nettabsreduktion:	**18,3%**

Case study

Smart styring af spildevandssystemer

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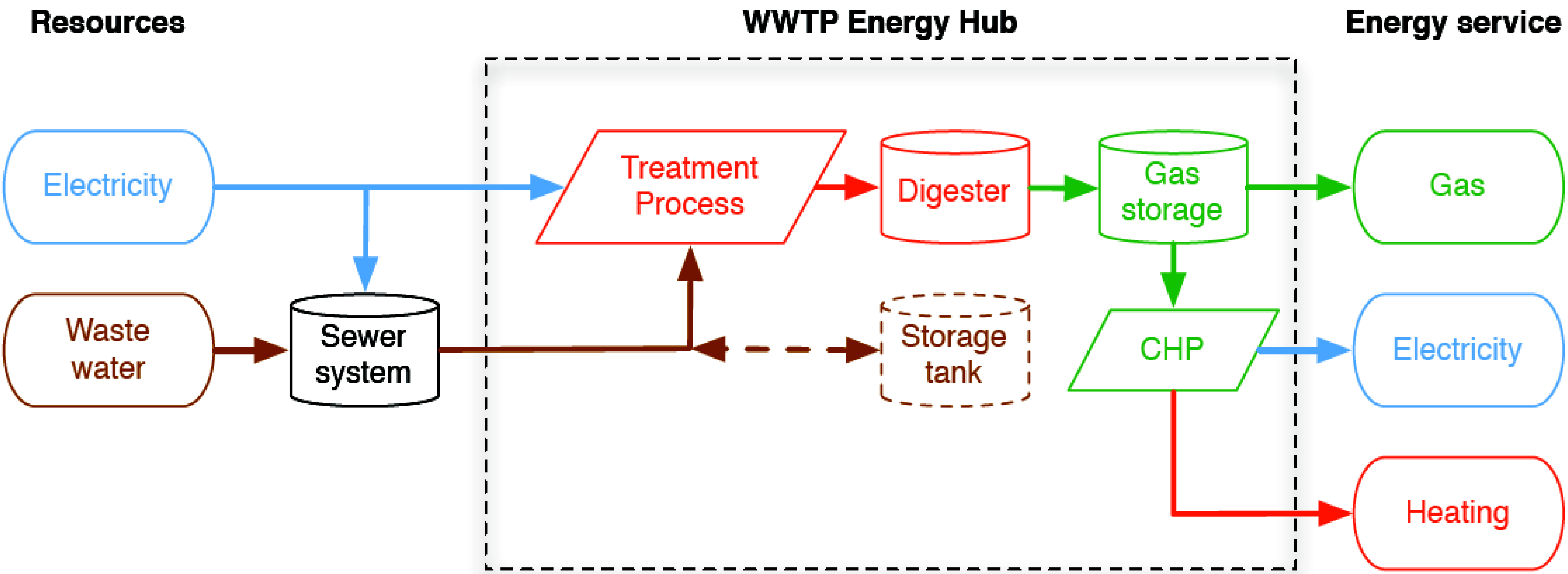
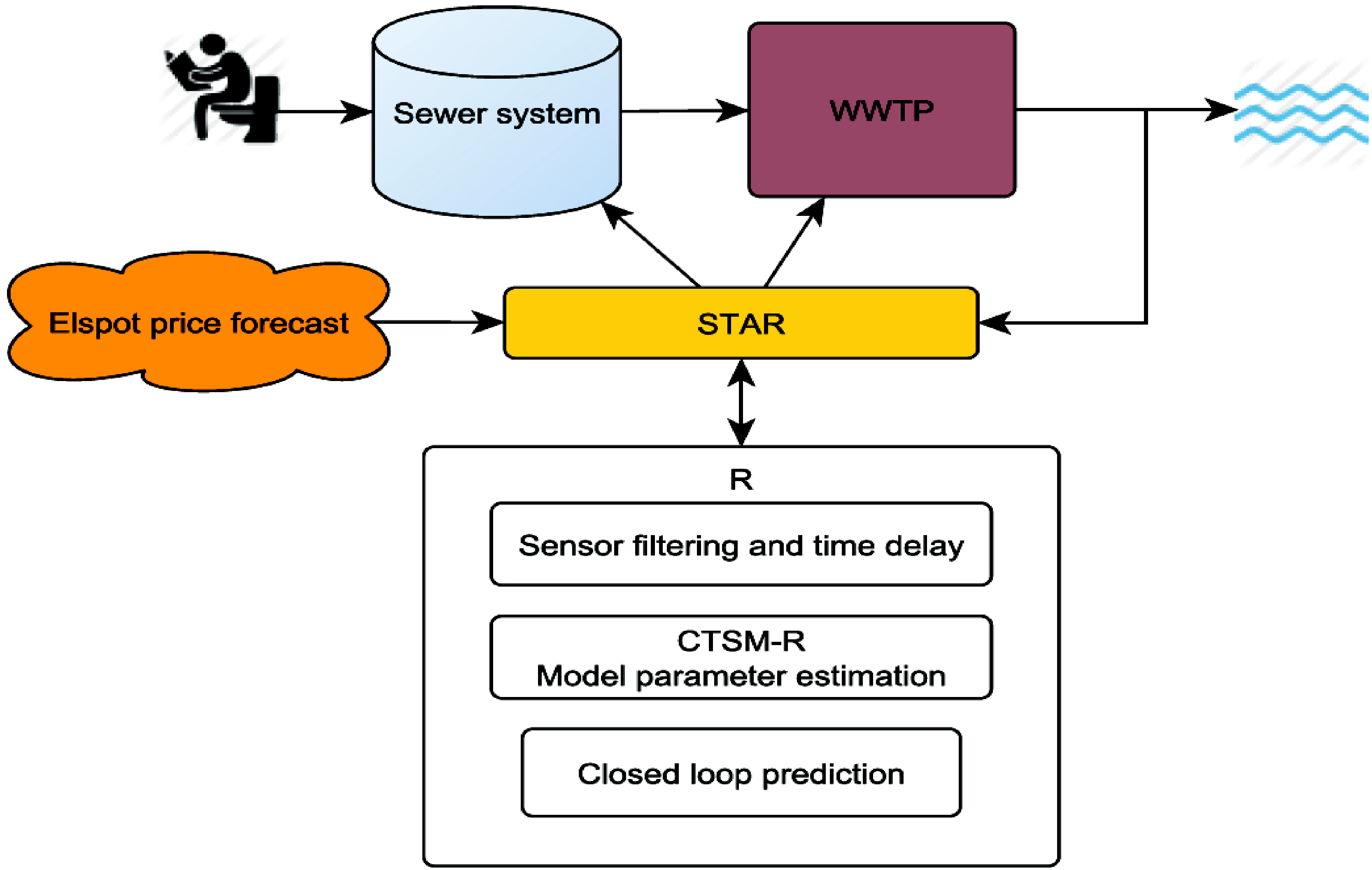
Waste-2-Energy

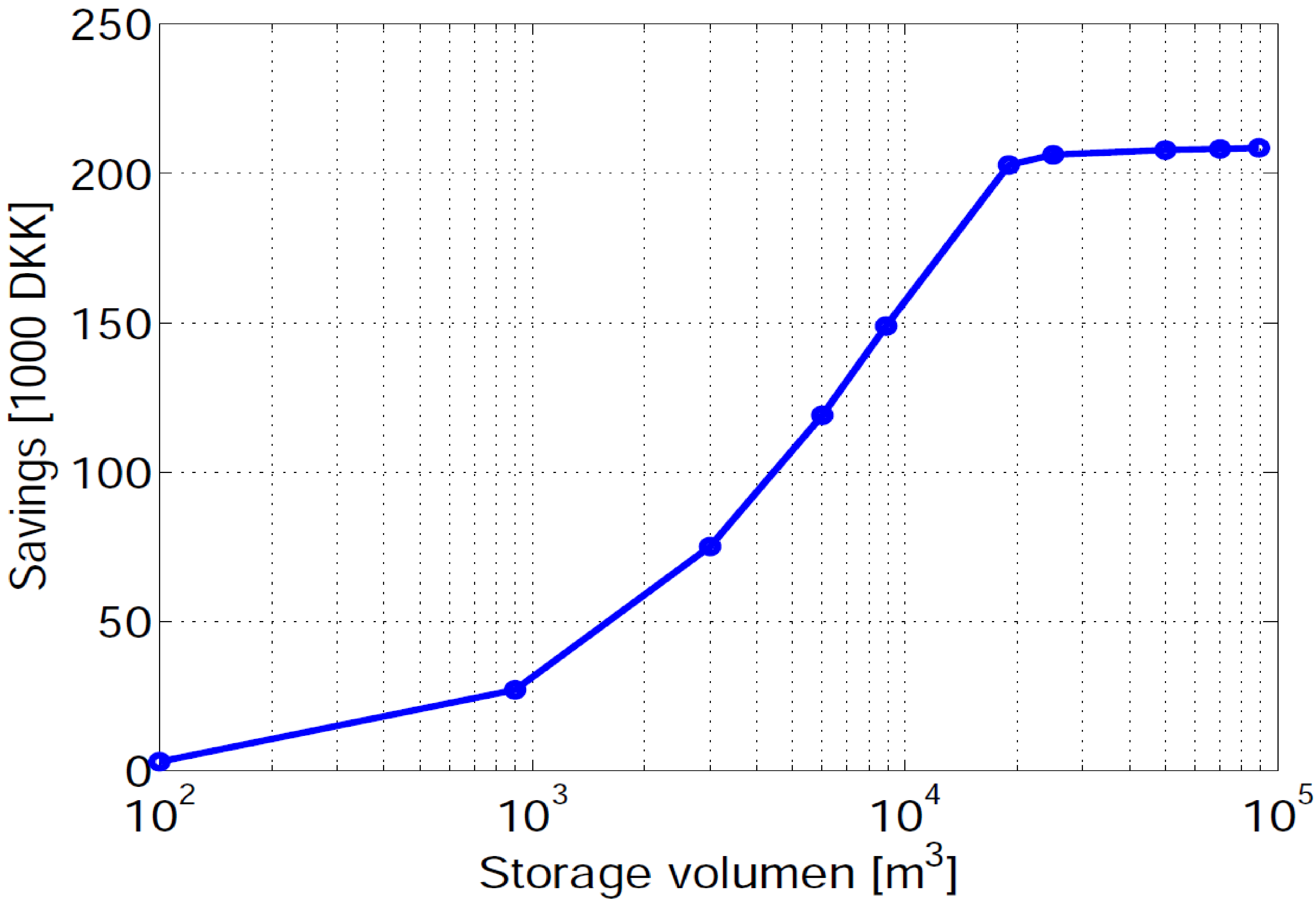


Kolding WWTP

Energifleksibilitet i Spildevandsbehandlingen



Besparelser – kun afløbssystemet



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Centre for IT-Intelligent Energy Systems in cities

Demo projects | Software solutions | Work Packages | Partners | Events | Communications | Publications | Vacant positions | Contacts

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 at GitHub.

Search ...

Latest news

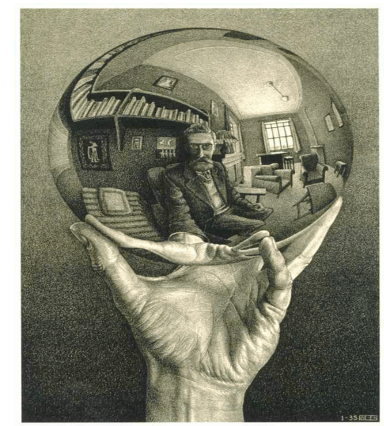
Ambassador Louise Bang Jespersen visited CITIES, October 29th 2015

CITIES Korean International Workshop – KIER, Daejeon, Korea, October 22nd 2015

Workshop on Mathematical Sciences Collaboration in Energy Systems Integration – DTU,

Nogle Demo-projekter i CITIES

- Control of WWTP (ED, Krüger, ..)
- Heat pumps (Grundfos, ENFOR, ..)
- Supermarket cooling (Danfoss, TI, ..)
- Summerhouses (DC, SE, Energinet.dk, ..)
- Green Houses (NeoGrid, Danfoss, F.Fyn, ...)
- CHP (Dong Energy, FjernvarmeFyn, HOFOR, NEAS, ...)
- Industrial production (DI, ...)
- EV (charging) (Eurisco, ED, ...)
- ....



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CITIES –> CTA
Opsummering

- **CITIES – Intelligent Energy Systems Powered by Data**
- Smart-Energy OS - for implementation af fleksible energisystemer i smarte byer er beskrevet
- Bygger på: Big Data Analytics, Cyber Physical systems, Stochastic opt./control, Forecasting, IoT, IoS, Cloud computing, ...
- Eksempler på (virtuel) lagring og fleksibilitet
- Eksempler på Demo-projekter fra CITIES som kandidater til SCA test og implementering
- **Modelling**: Toolbox – CTSM-R - for (grey-box) modellering af energisystemer
- **Control:** Toolbox – MPC-R - for Model Predictive Control
- **Big Data Management System** for Smart Cities: Senere ...

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