Centre for IT-Intelligent Energy Systems in Cities (CITIES)

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http://www.citiesinnovation.org

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

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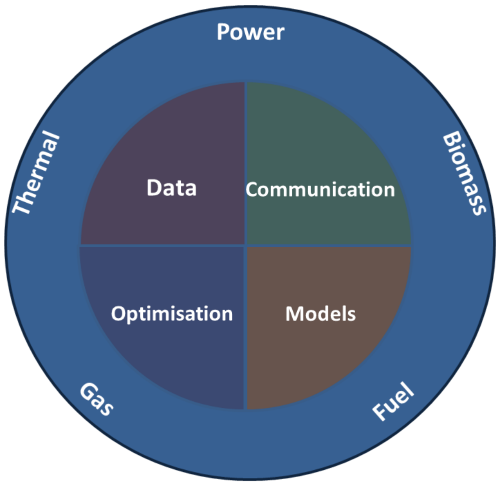
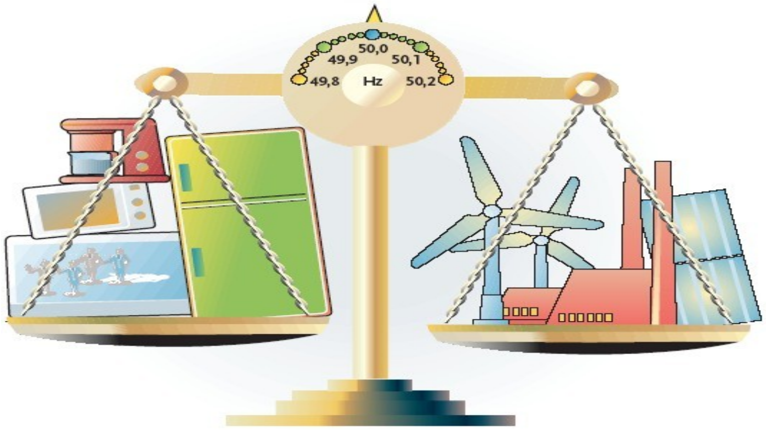
Energy Systems Integration



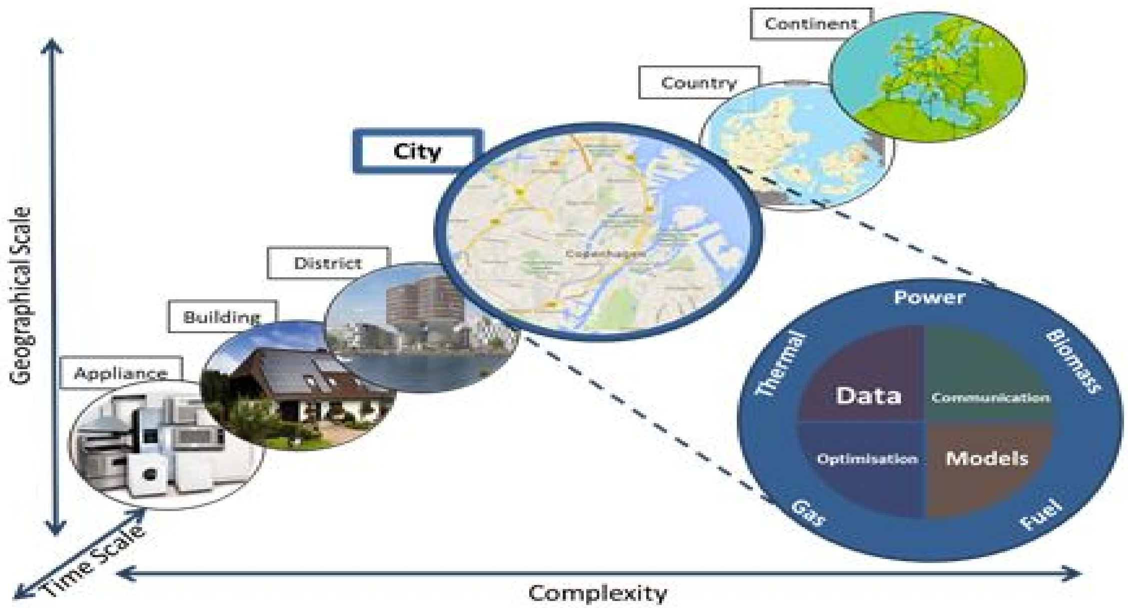


The **central hypothesis** is that by **intelligently integrating** currently distinct energy flows (heat, power, gas and biomass) using grey-box models we can balance very large shares of renewables, and consequently obtain substantial reductions in CO2 emissions. DH/C will play an important role.

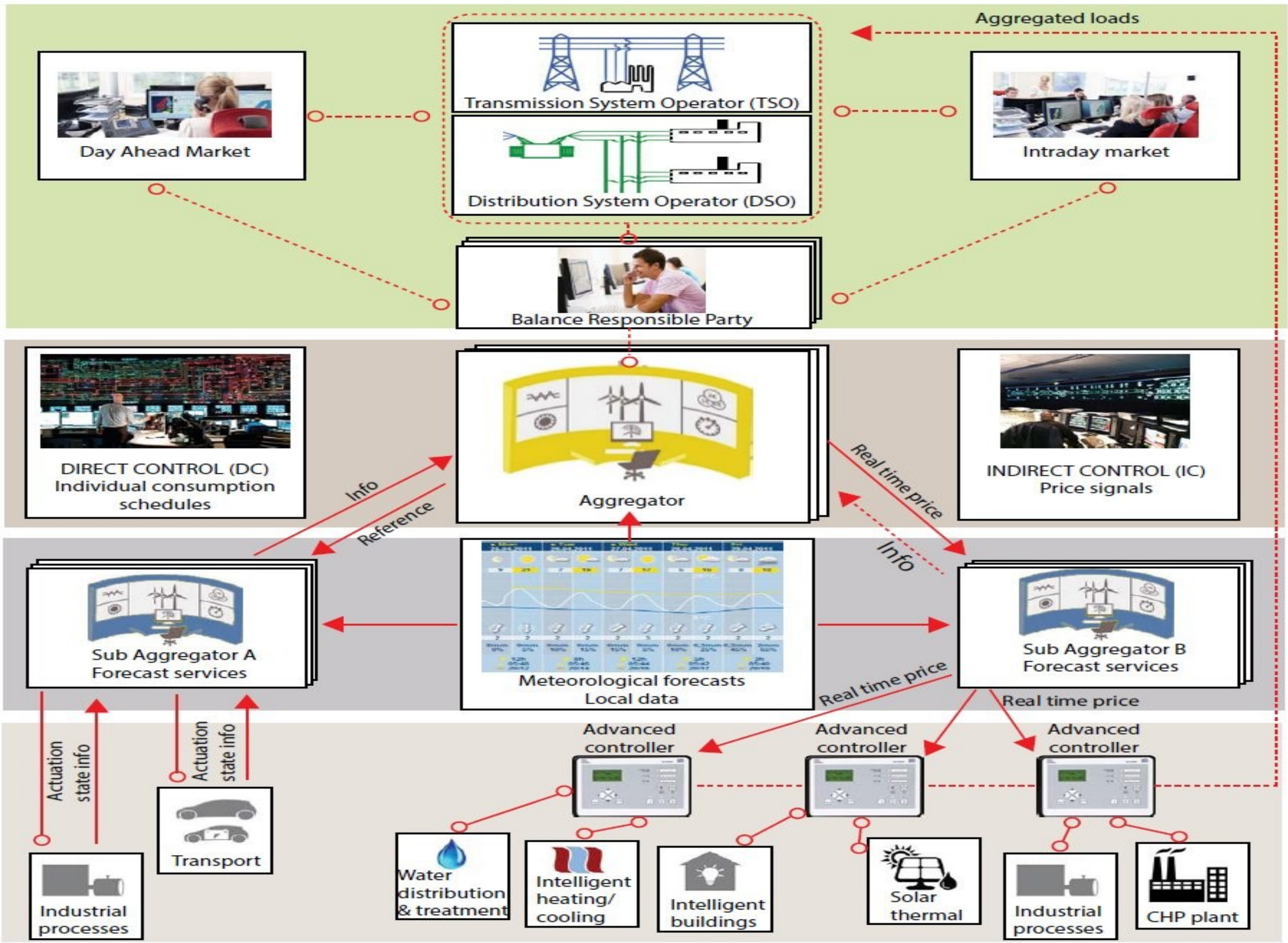
Intelligent integration will (for instance) enable lossless ‘virtual’ storage on a number of different time scales.

Temporal and Spatial Scales

The ***Smart-Energy Operating-System (SE-OS)*** is used to develop, implement and test of solutions (layers: data, models, optimization, control, communication) for ***operating flexible electrical energy systems*** at **all scales**.



Smart-Energy OS



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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.

Search ...

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

DTU

Case study

Control of Heat Pumps for Summer Houses with a Pool

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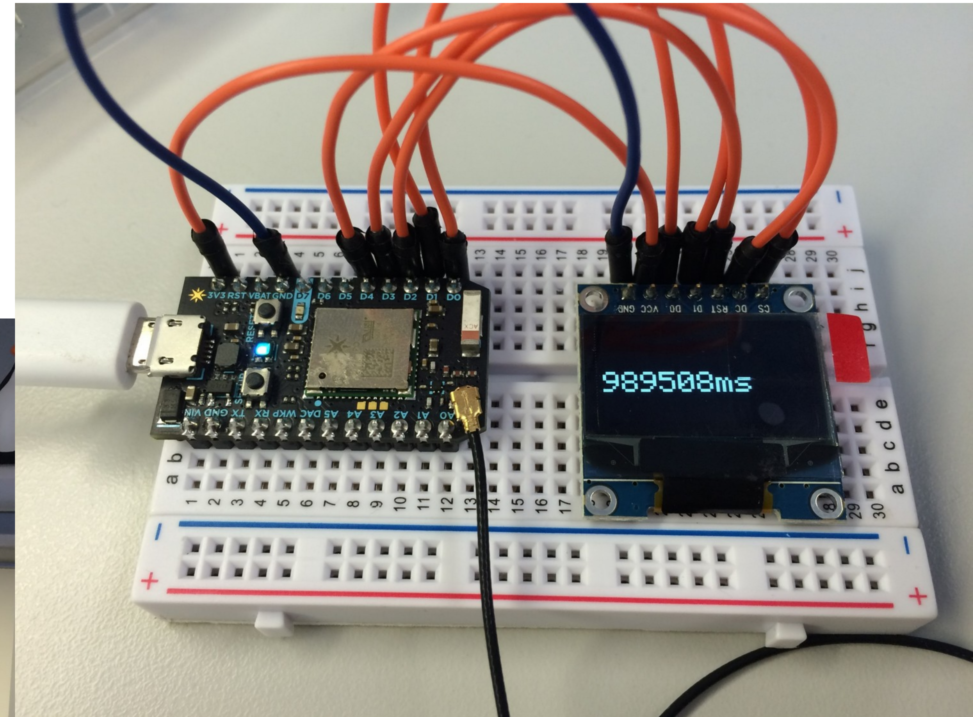
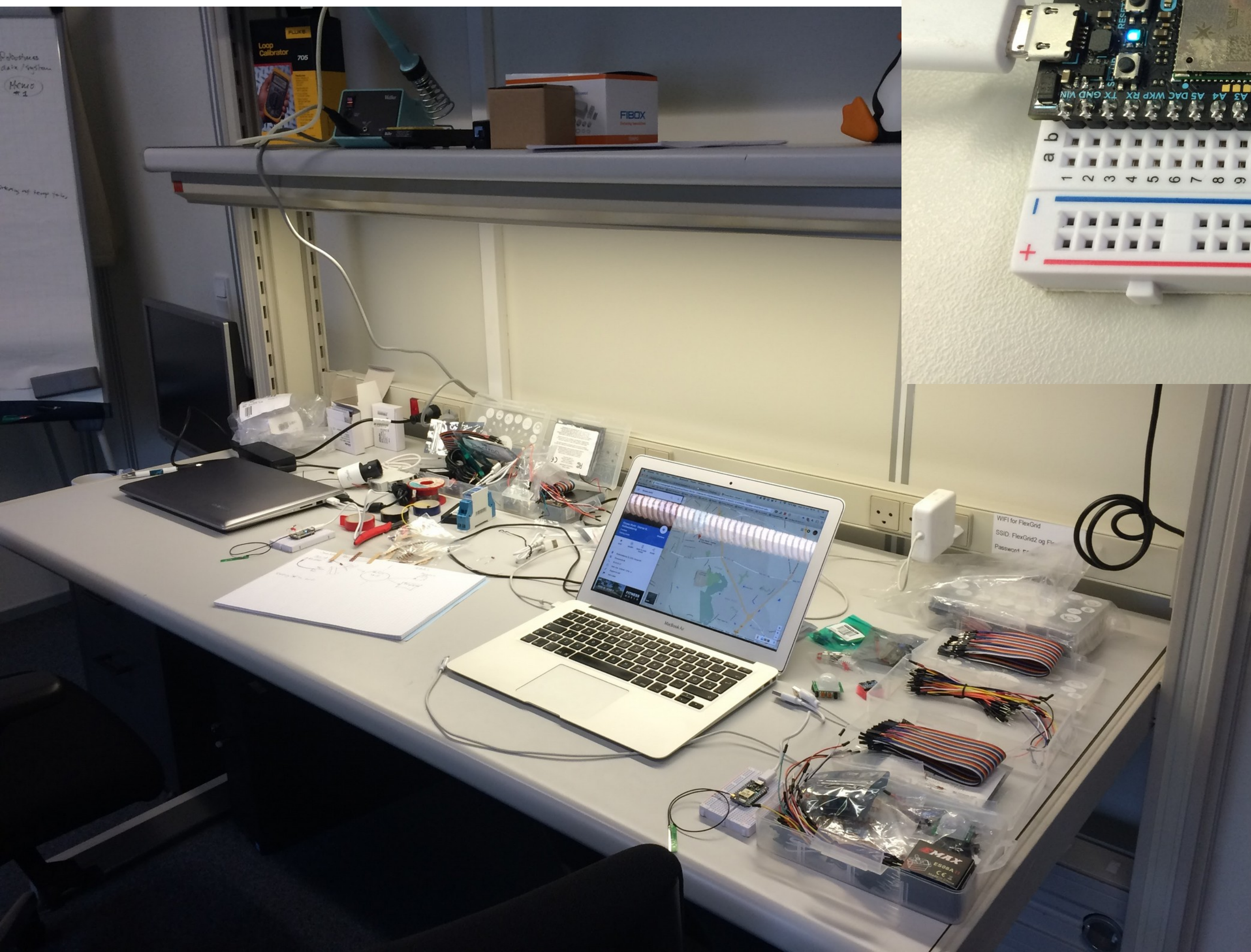
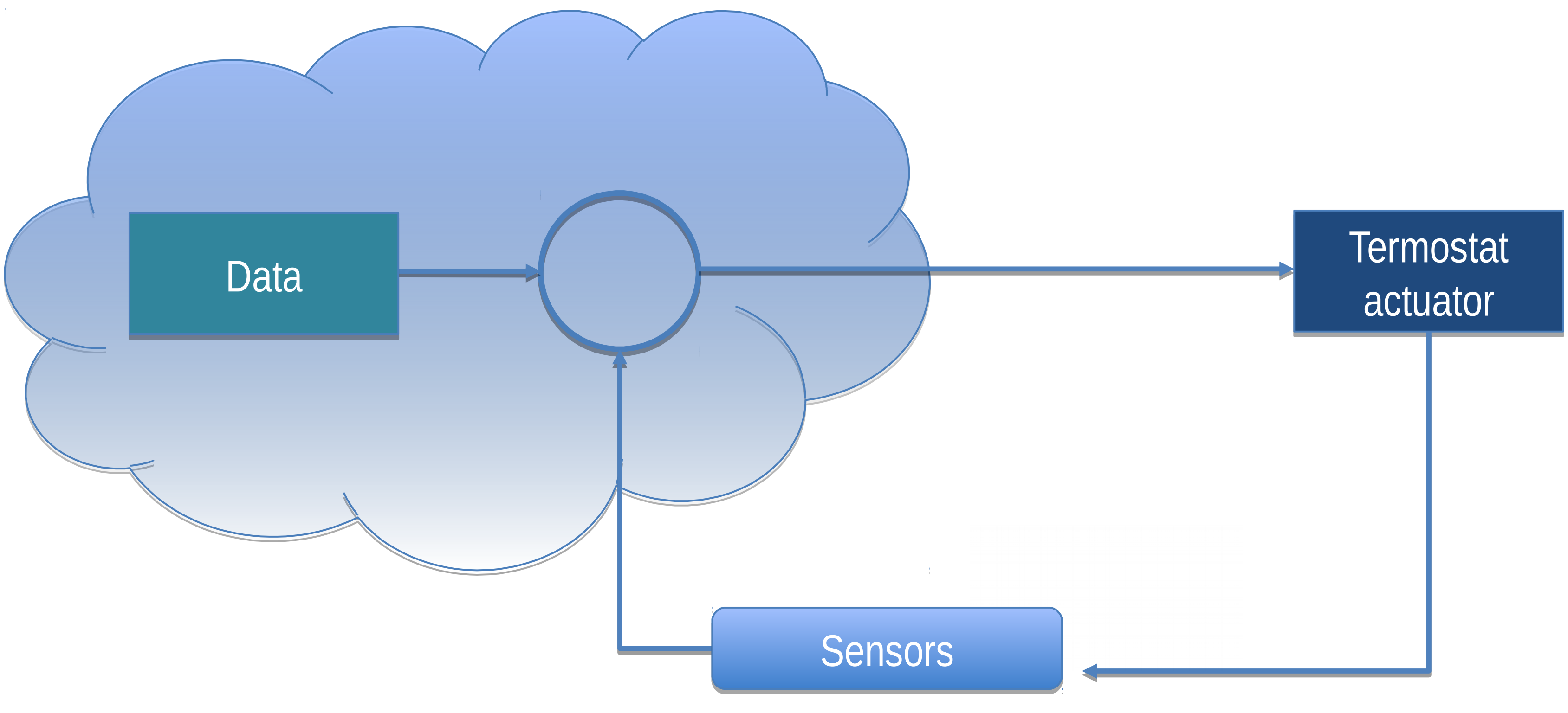
Lab testing ….

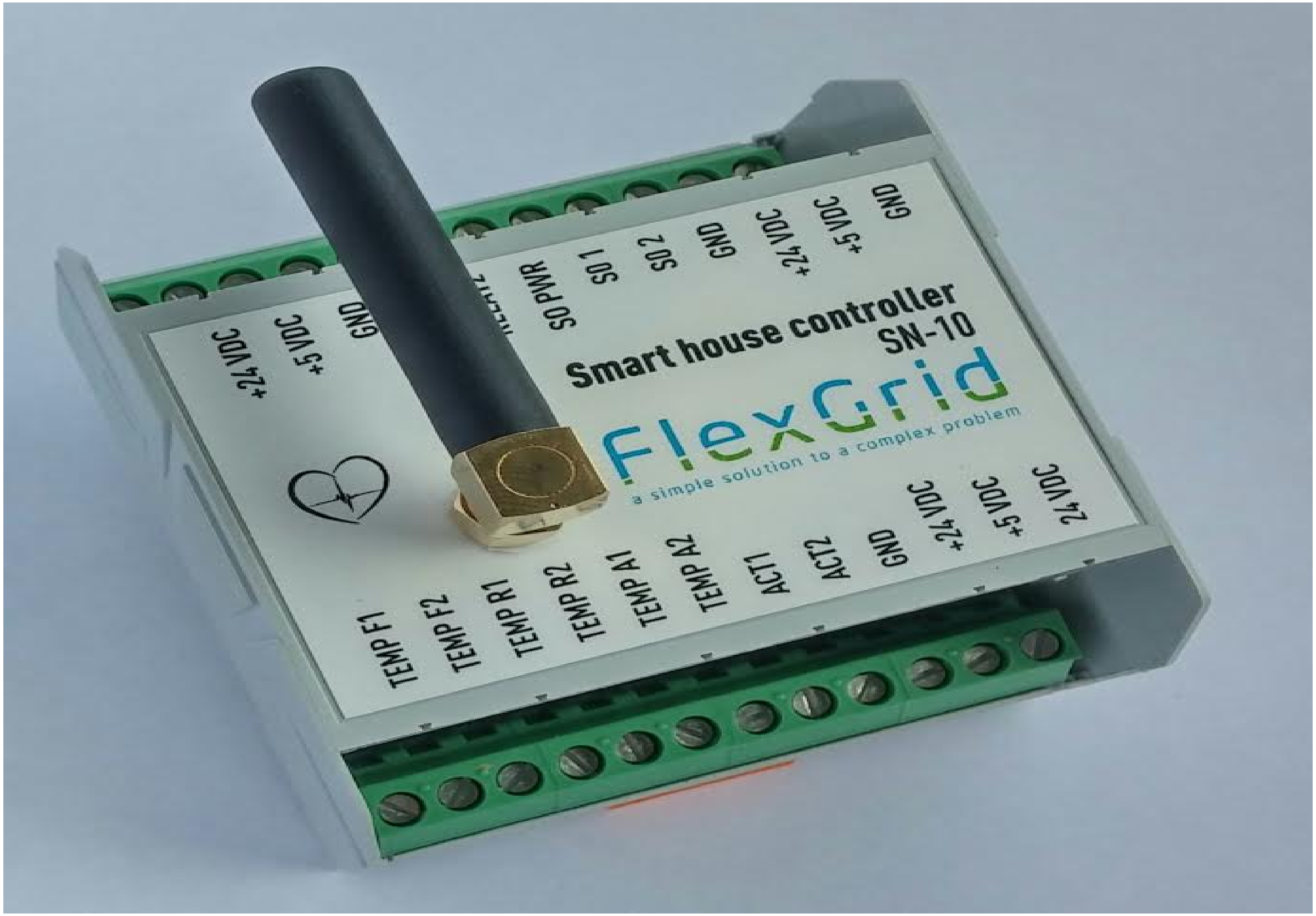




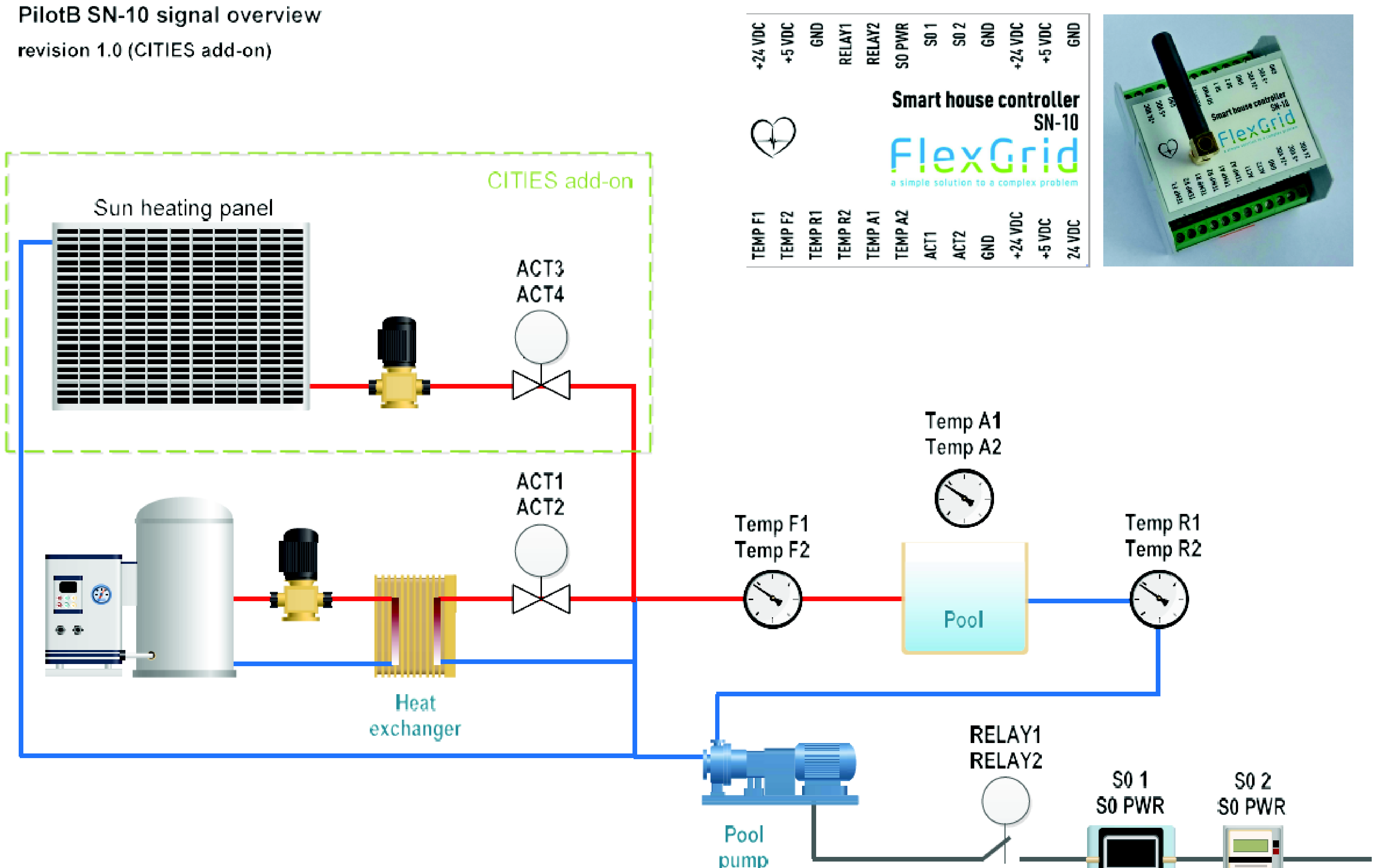
SE-OS
Control loop design – **logical drawing**



SN-10 Smart House Prototype



Smart Control of Houses with a Pool

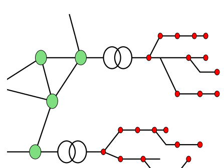


Services

Balancing

Voltage regulation (DSO)

Congestion management



- The large inertia of pools allows for shift of electricity consumption by several hours.
- Via active coordination of the flexibility below a critical node on the DSO grid.
- Active load management to help finding an optimal routing of the power.

Case study

Data Intelligent Temperature Optimization for DH Systems

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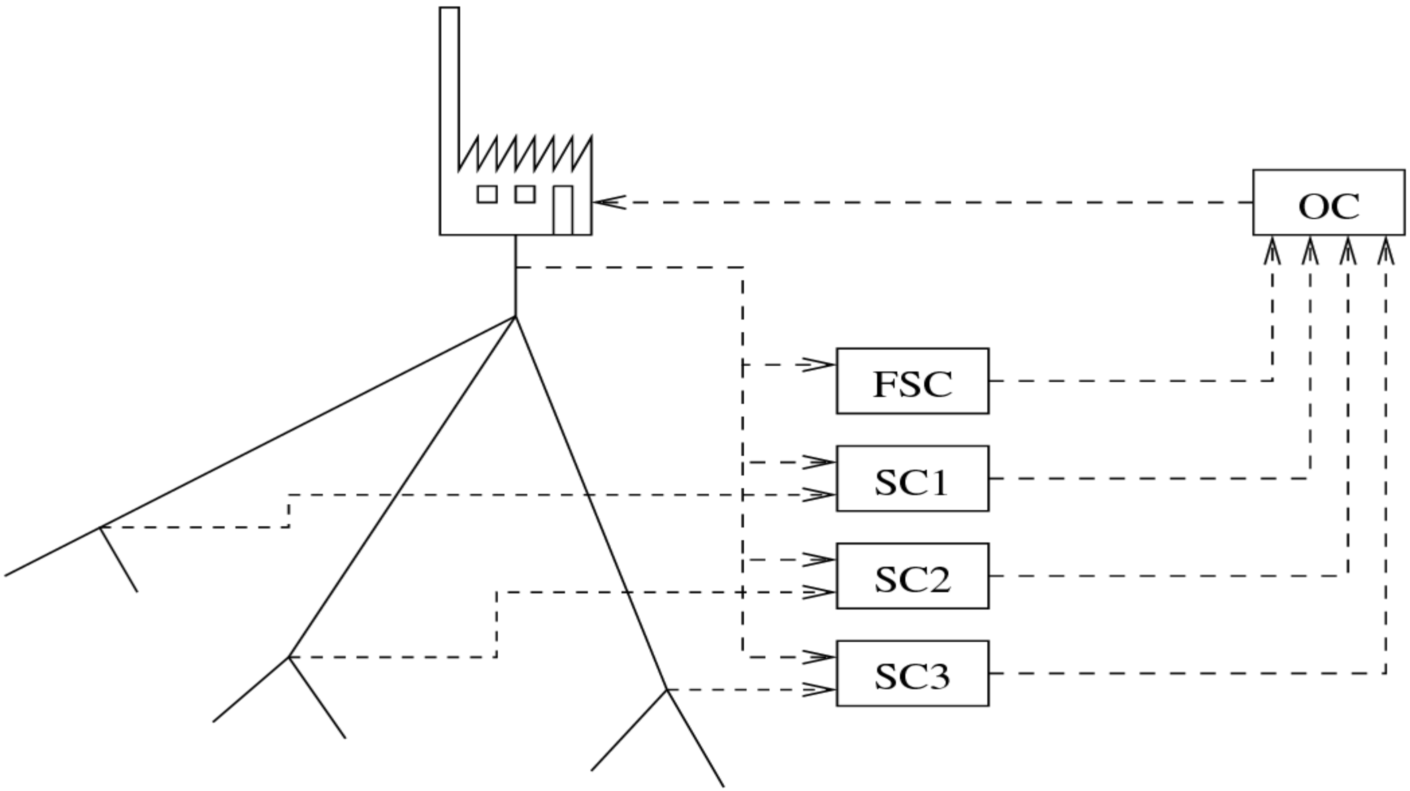
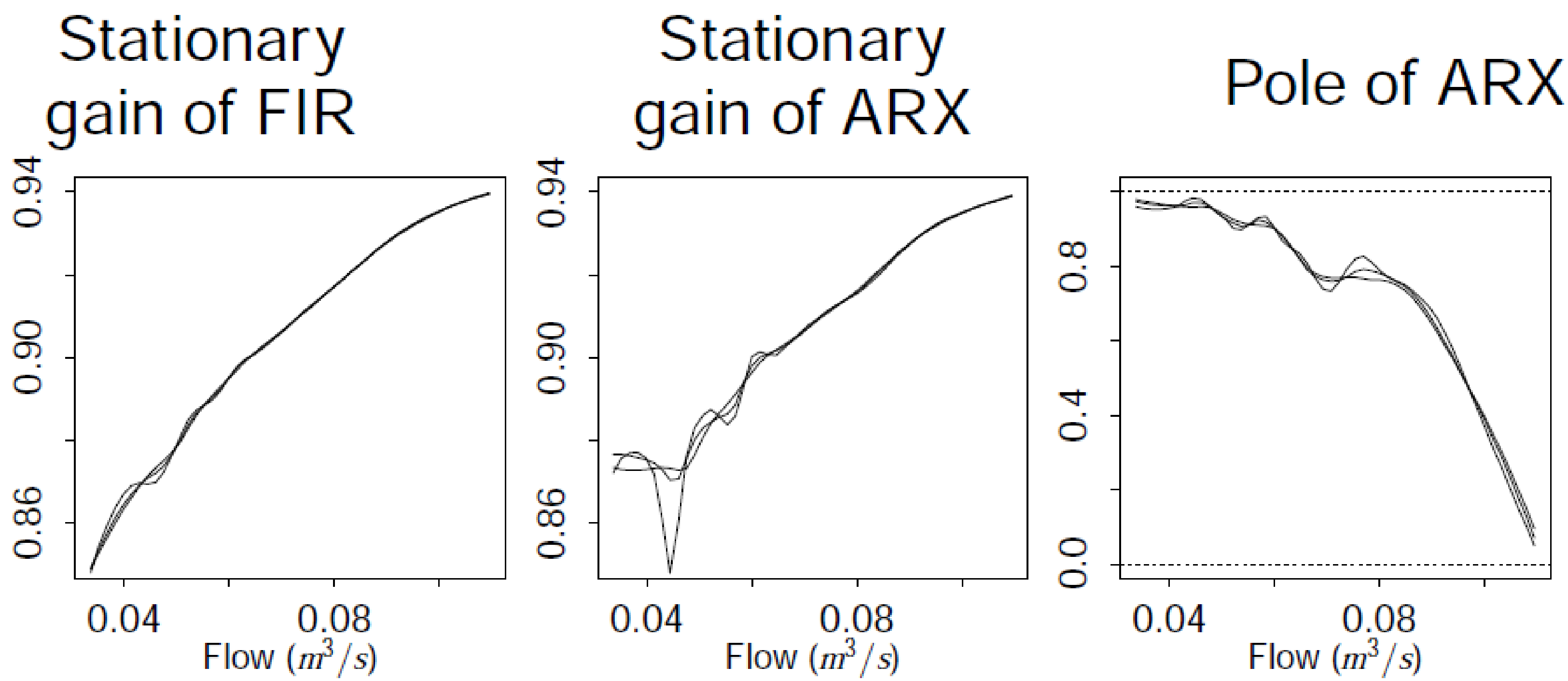
Models and Controllers
(Highly simplified!)

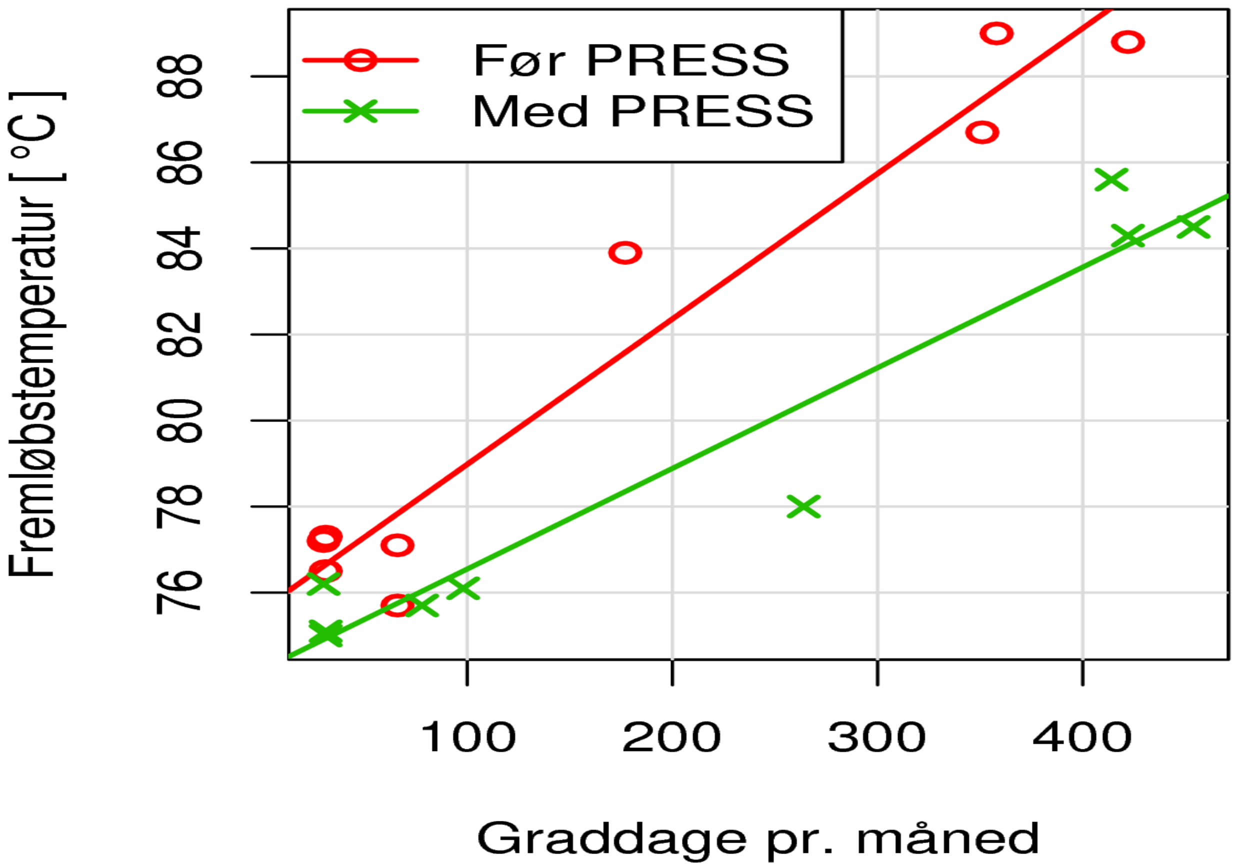


Characteristics

30%, 40%, 50%



Supply temperature with/without data intelligent control



Savings
(Reduction of heat loss = 18.3 pct)

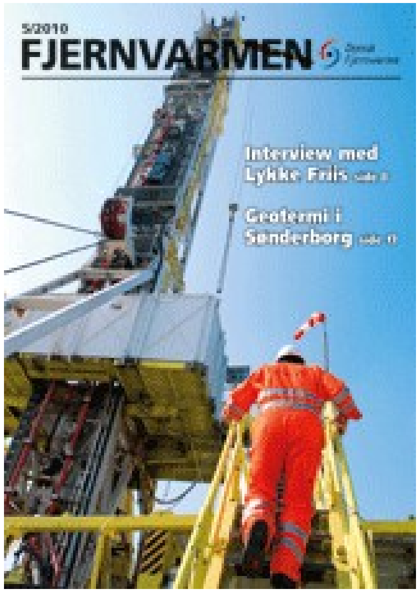
	Varmekøb		Elkøb	
	GJ	1000kr	kWh	1000kr
Før PRESS	653,000	30,750	499,000	648
Med PRESS	615,000	28,990	648,000	842
Forskel	37,400	1,760	-149,000	-194

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

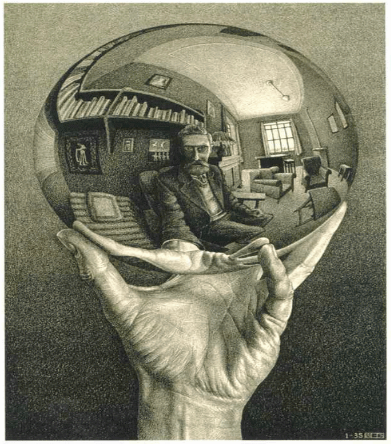
Styring af temperatur rummer kæmpe sparepotentiale

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.

Data Intelligent Temperature Optimization for DH Systems

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



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For more information ...

See for instance

www.smart-cities-centre.org

...or contact

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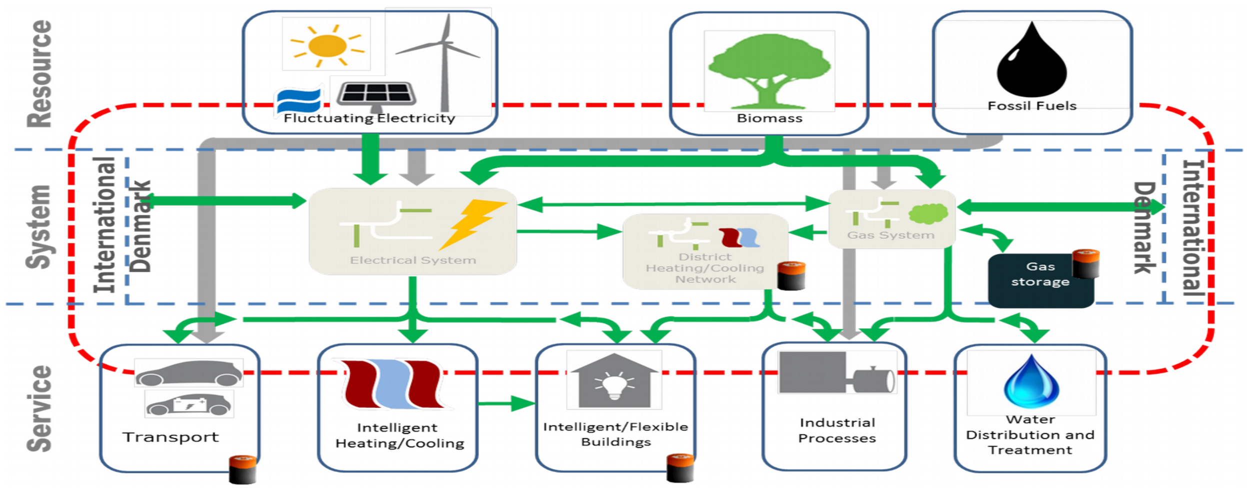
(Virtual) Storage Solutions

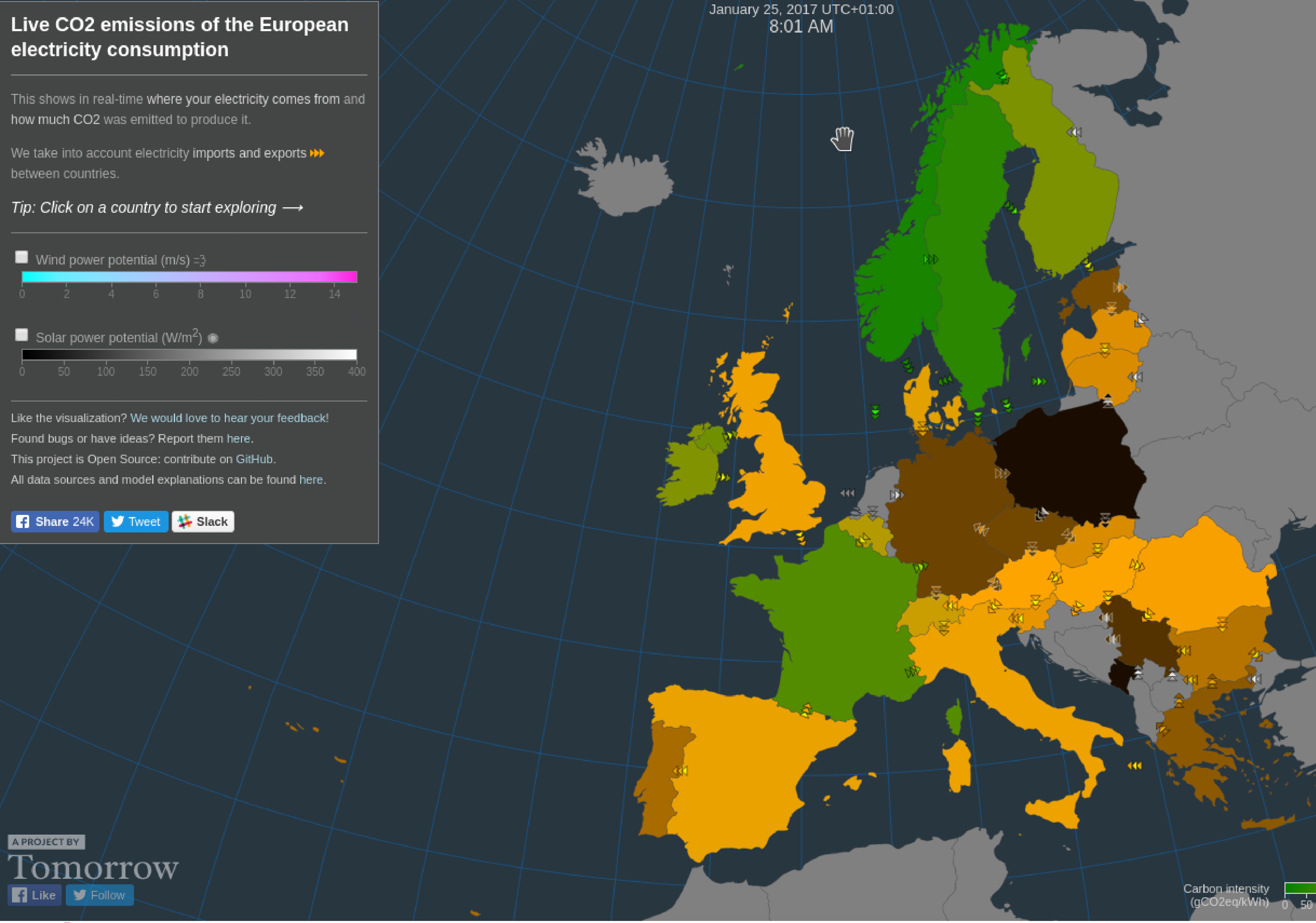


- **Flexibility (or virtual storage) characteristics:**
  - Supermarket refrigeration can provide storage 0.5-2 hours ahead
  - Buildings thermal capacity can provide storage up to, say, 5-10 hours ahead
  - Buildings with local water storage can provide storage up to, say, 2-12 hours ahead
  - District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

Further Aspects

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 automated update of models



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