



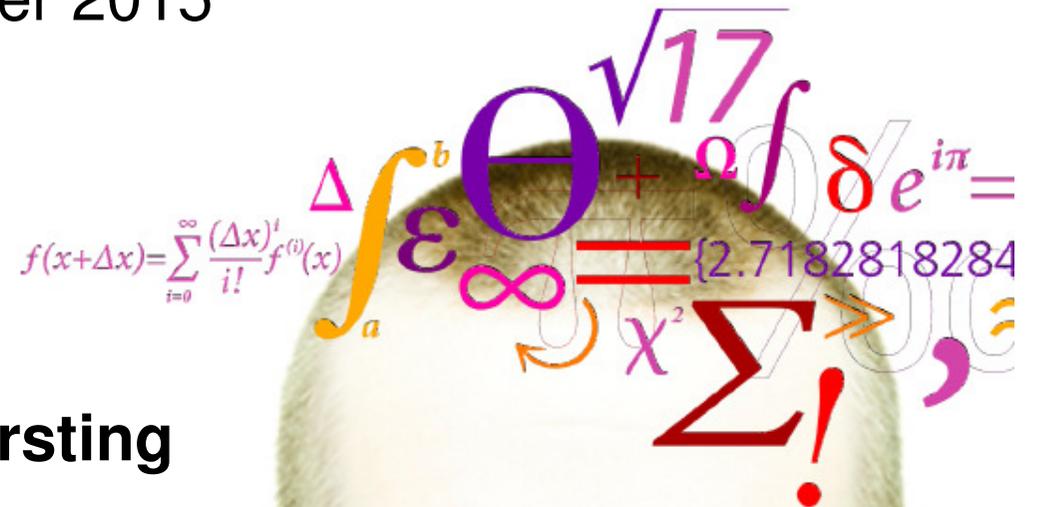
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Centre for IT Intelligent Energy Systems



# Price Responsive Predictive Control of heat pumps in a family house

Nordic Cities 1.-2. September 2015



**Jacopo Parvizi**

PhD Student  
DTU Compute

**Hakon Børsting**

Manager  
Control Technology  
Grundfos Holding A/S

DTU Compute

Department of Applied Mathematics and Computer Science

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## SUSTAINABLE

Grundfos runs its business in a responsible and ever more sustainable way. We make products and solutions that help our customers save natural resources and reduce climate impact. We take an active role in the society around us. Grundfos is a socially responsible company. We take care of our people - also those with special needs.

**Today pumps account for no less than 10% of the world's electricity consumption.**

# Building Services is a huge part of our business

## Installations in and around buildings:

- Air-conditioning
- Hot water recirculation
- Heating
- Wastewater
- Pressure boosting
- Fire protection
- District energy
- Drainage



**33%** of all energy in EU is used for transport

**26%** of all energy in EU is used by industry

**41%** of all energy in EU is used by buildings



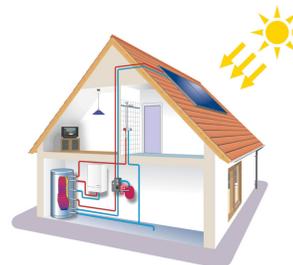
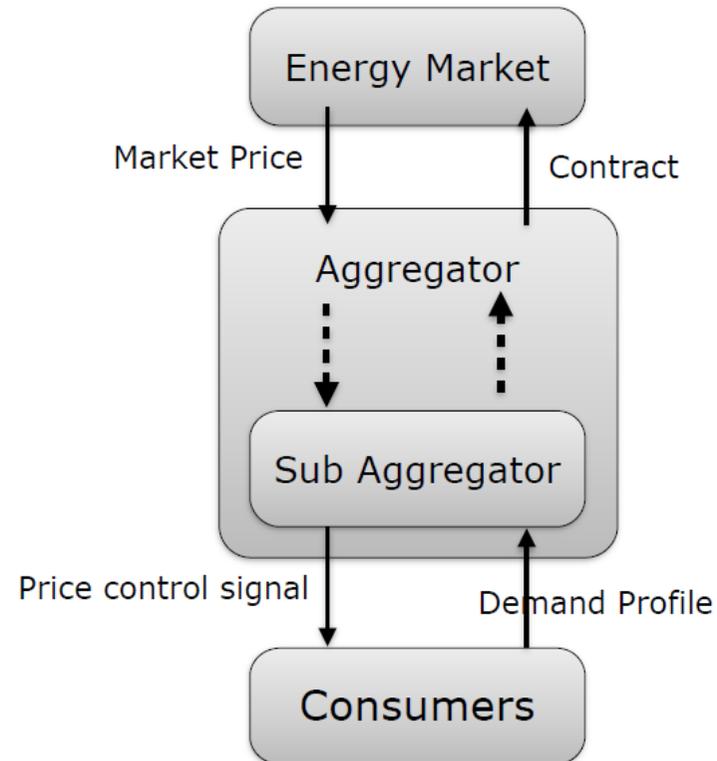
**2/3** of energy consumption in buildings is used for heating and cooling

**80%** of energy consumption is used in small buildings < 1000 m<sup>2</sup>

be  
think  
innovate

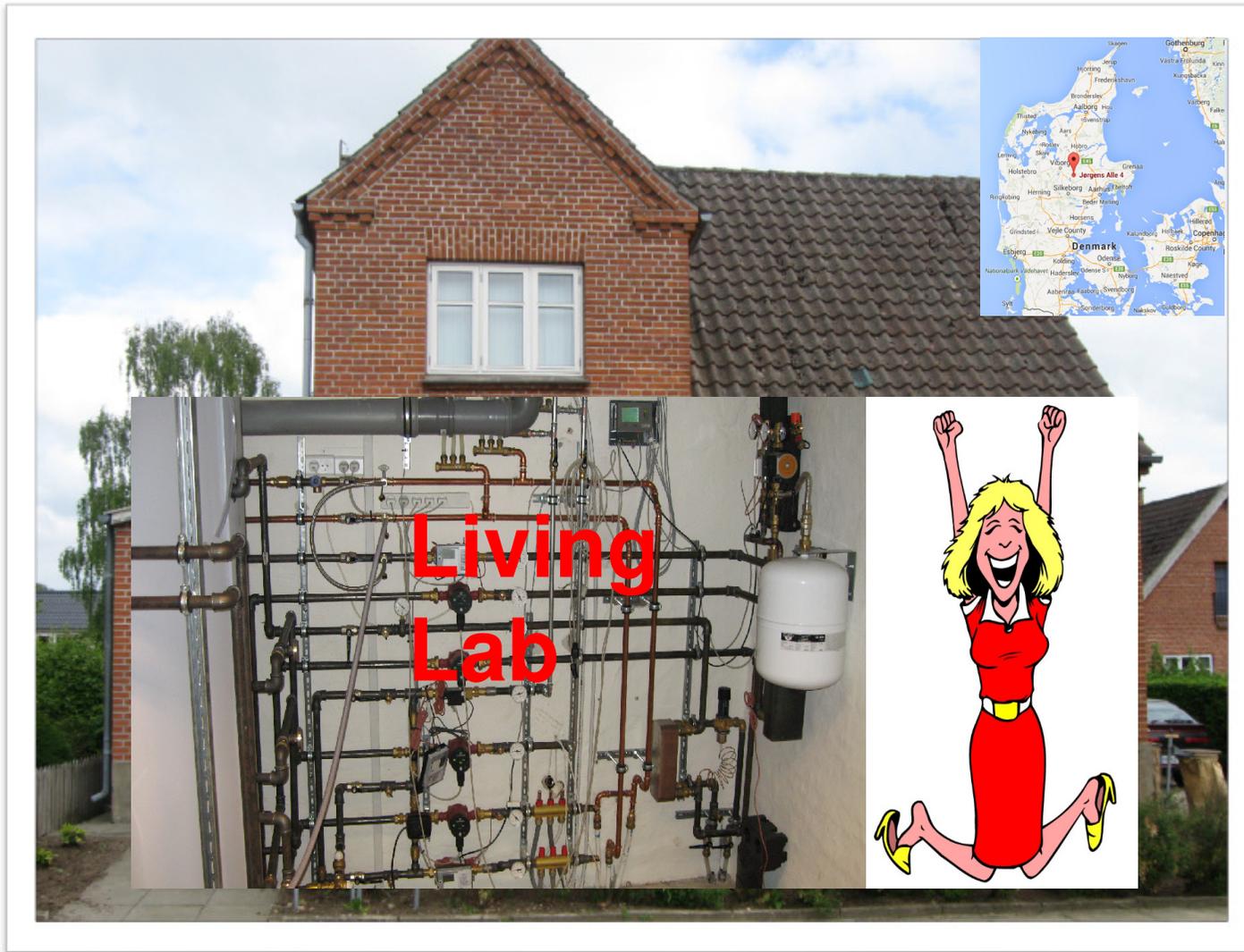
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# Energy Markets for Price Responsive Units

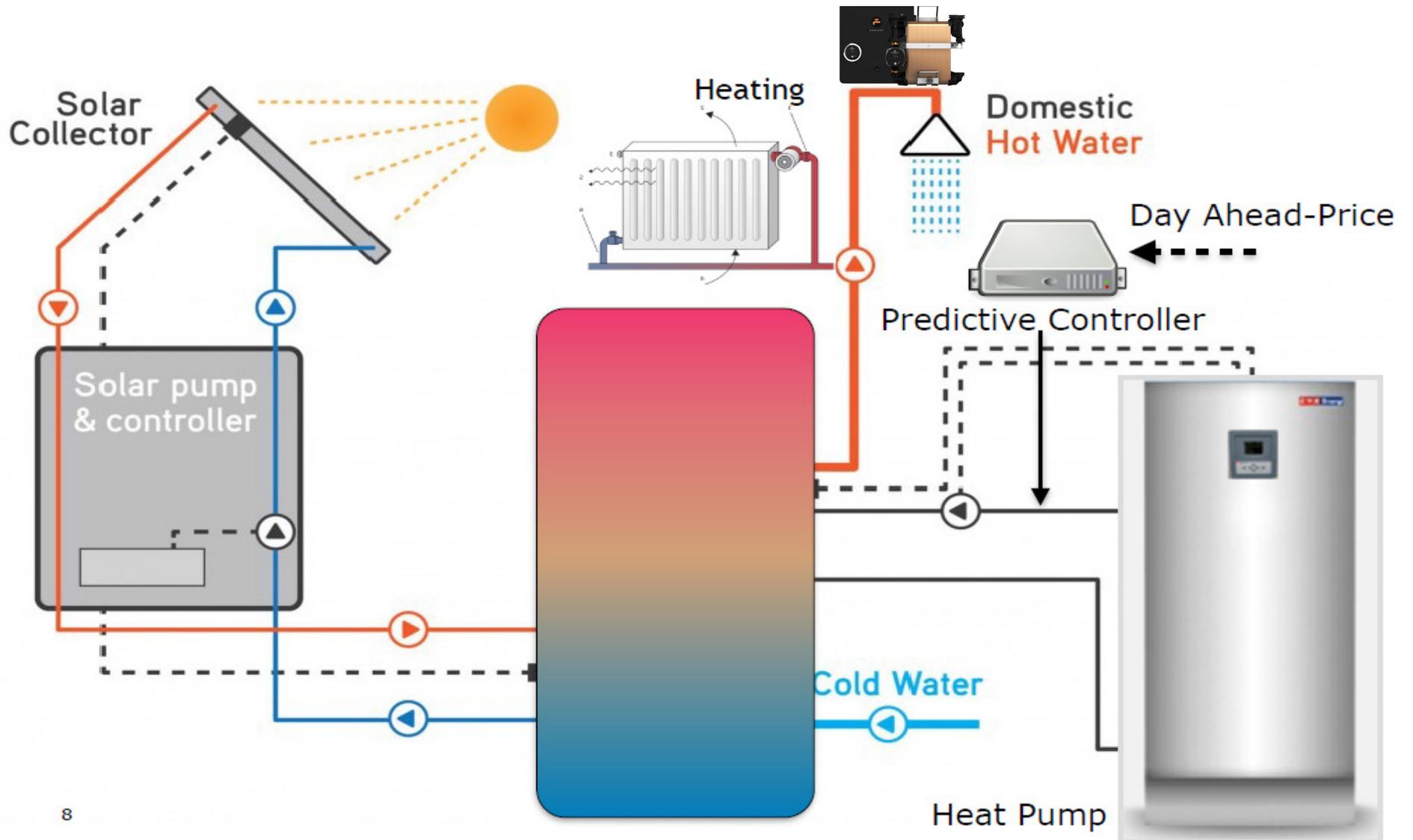




# Test Facility

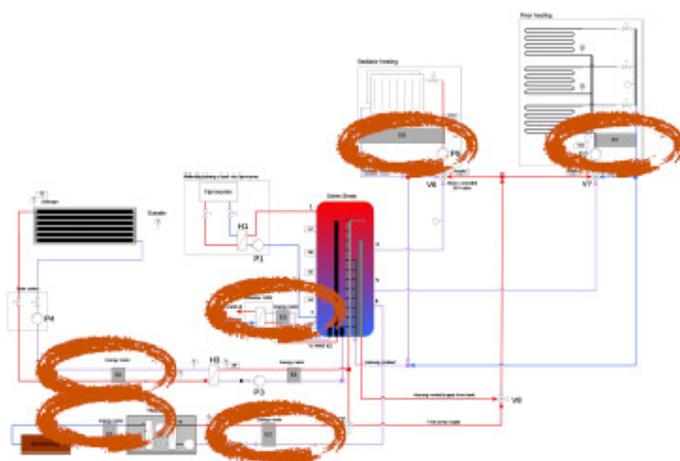
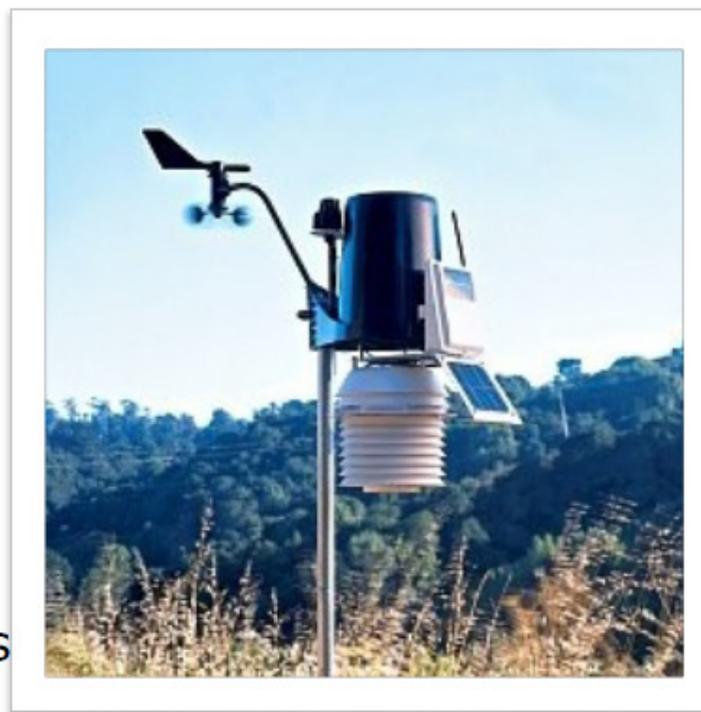


# Heating System

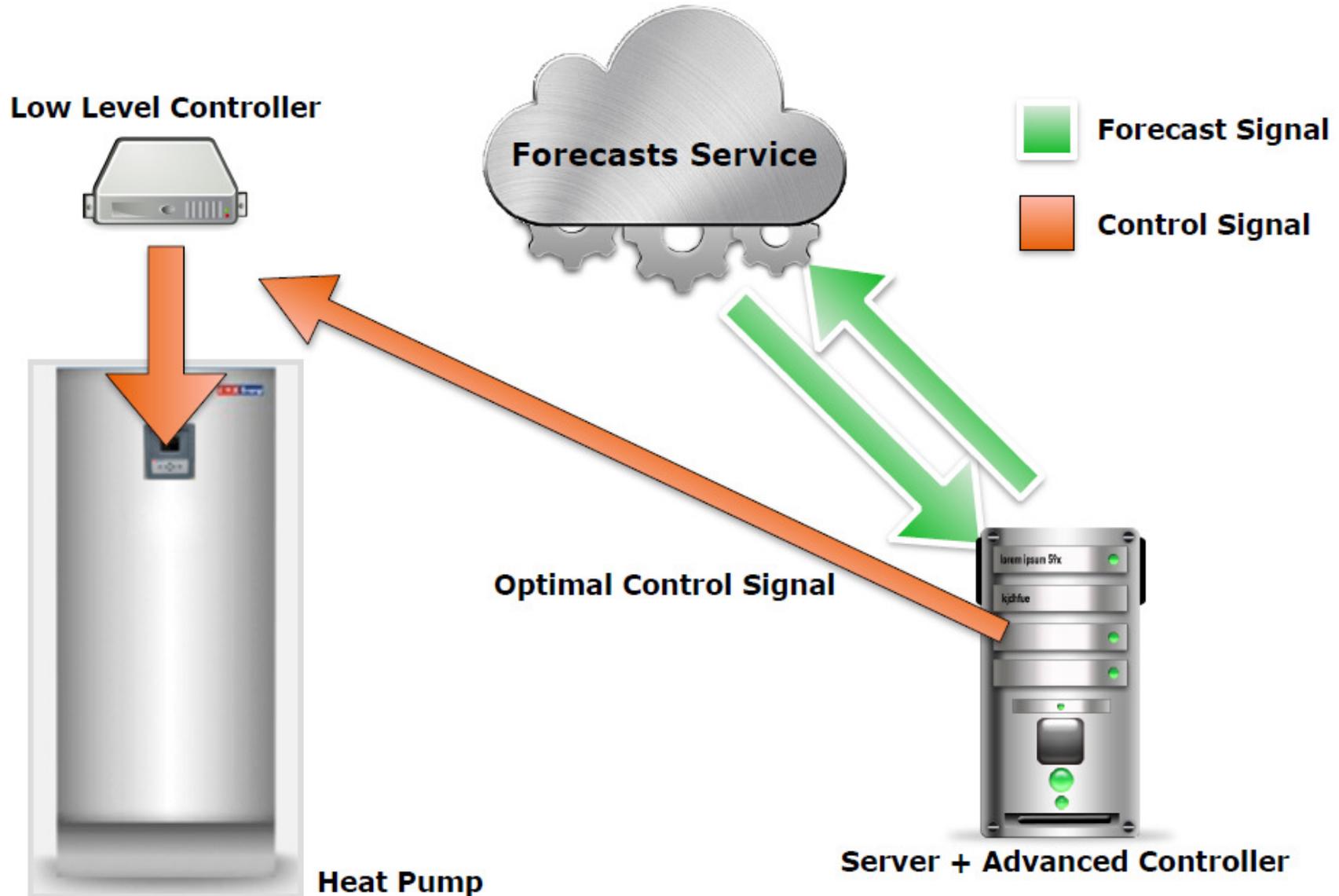


# Sensors

- Weather Station
  - Davis Vantage Pro2 Plus
- Heat Meters
  - Kamstrup Multical in water circuits
  - Sontex Multical in brine circuits
- Wireless temp. sensors
  - Room and floor Temps

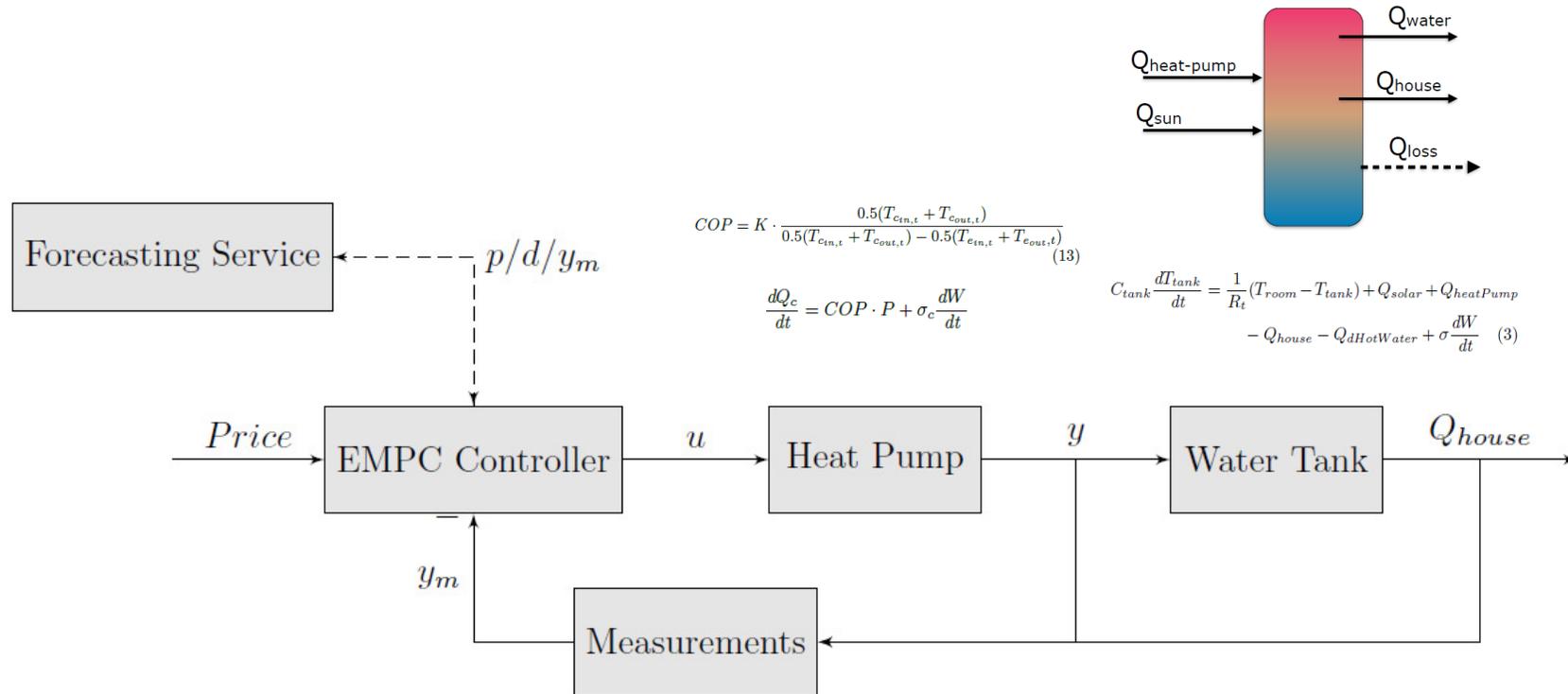


# Controller Communication

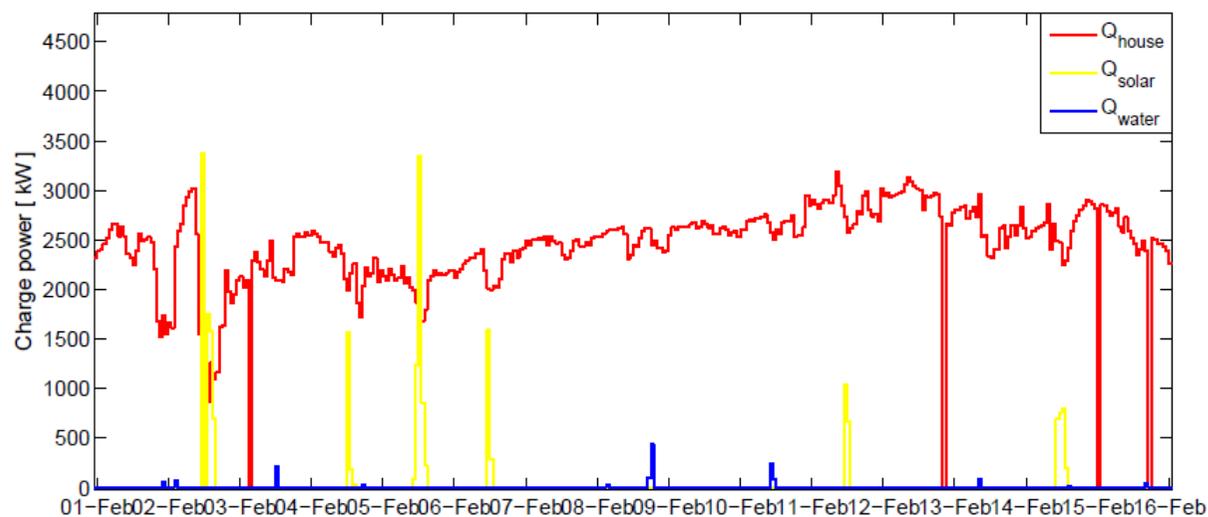
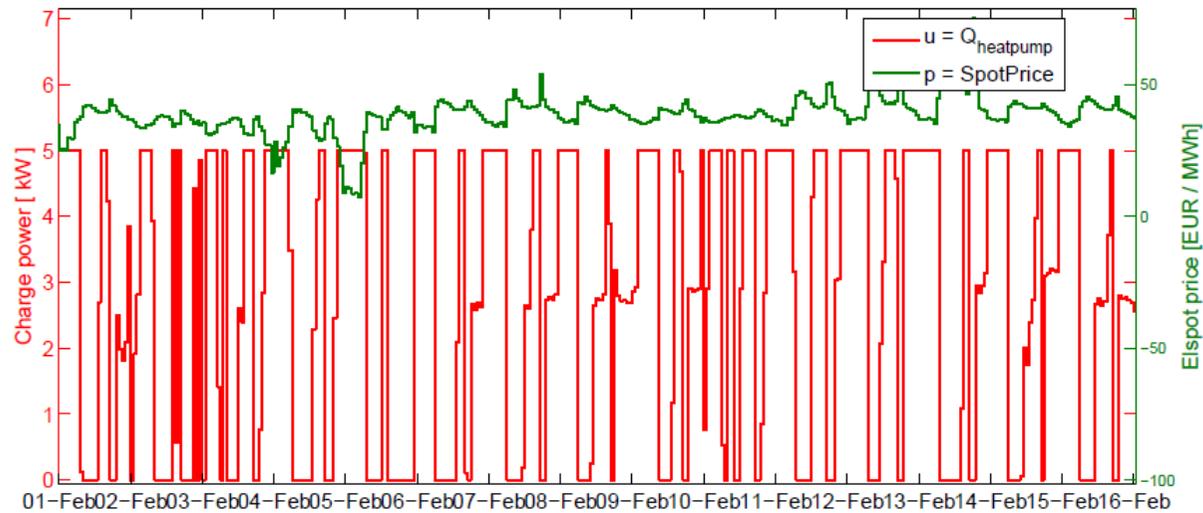


# High Level Controller

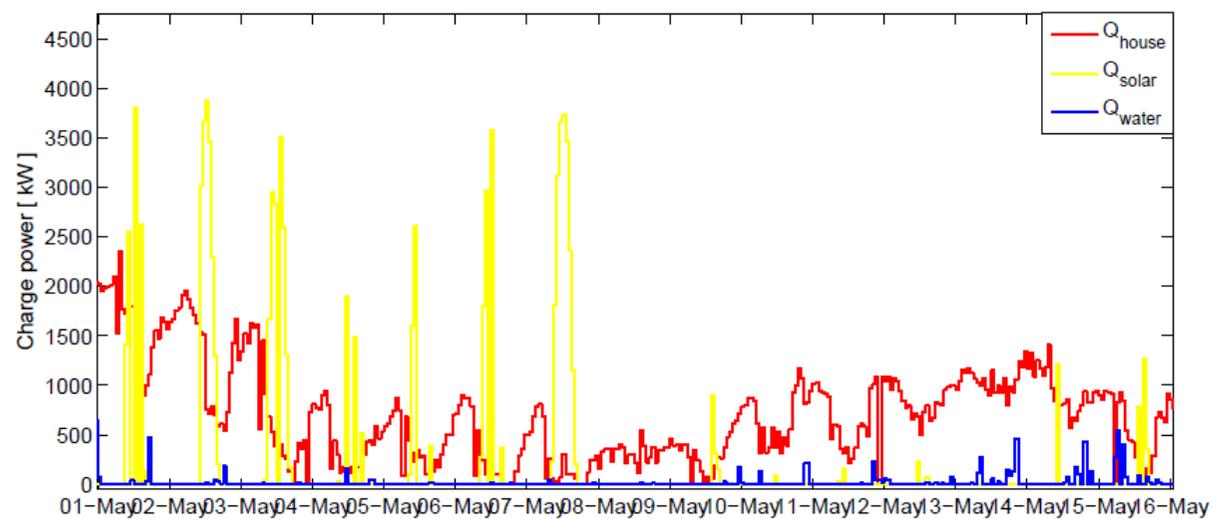
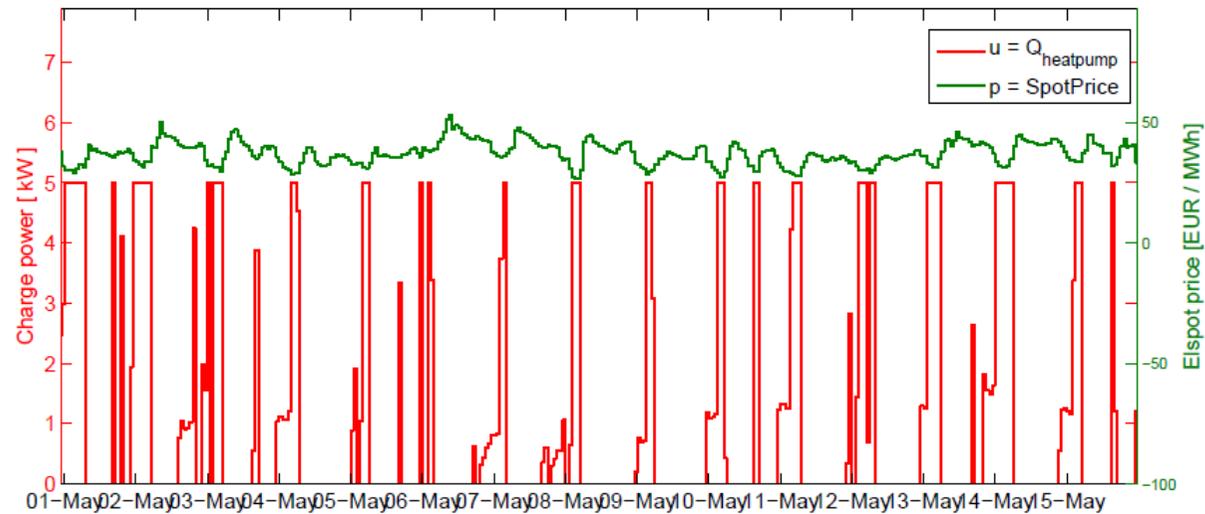
## Grey box models of heat pump and water tank



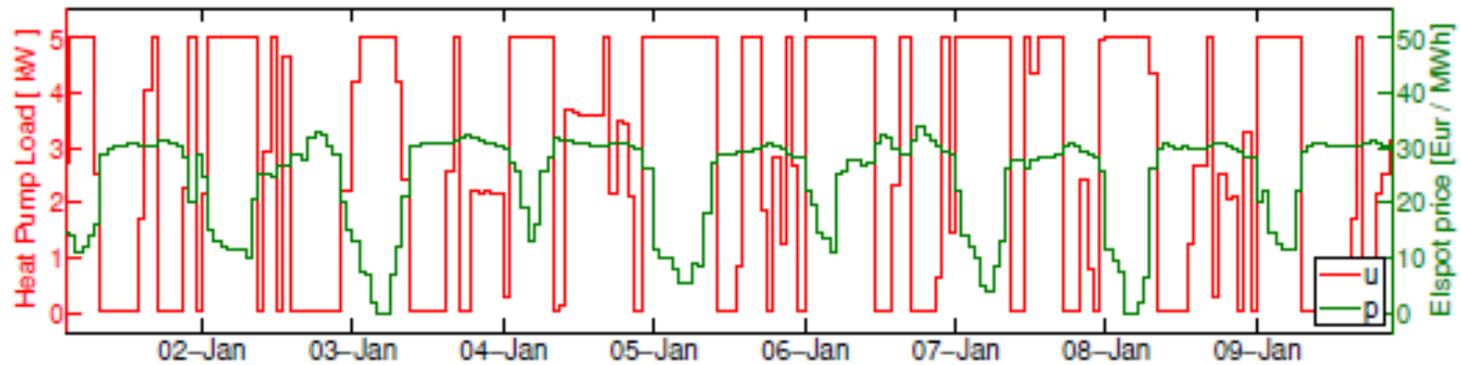
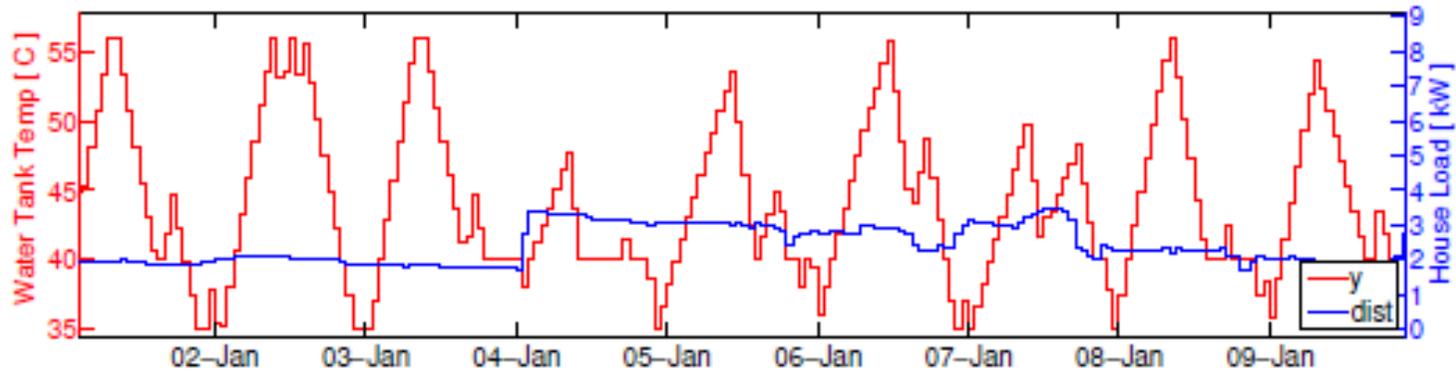
# Test results 2014



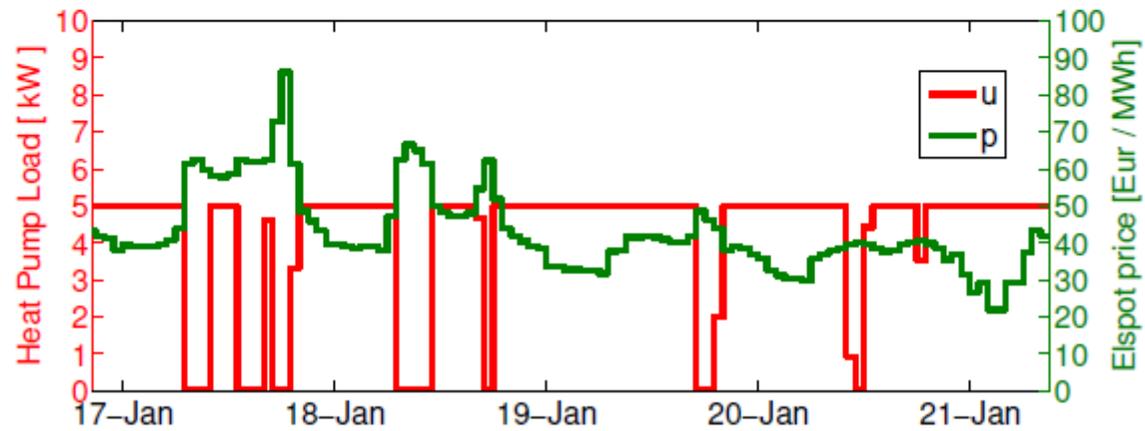
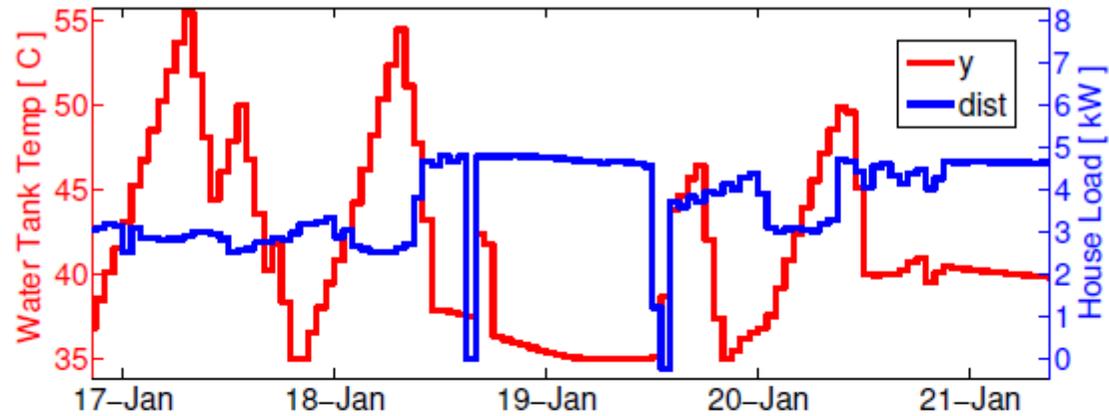
## Test results 2014



# Test results 2014



## Test results 2014



## Conclusions

- Savings of 16% with el. spot prices and 8% with el. flat tariff prices compared to standard heat pump controller
- Big investments in energy storage and control setup
- Houses with higher demand require additional heat sources (e.g. electric heater)
- Models and controller parameters need to be automated

THANK YOU FOR YOUR ATTENTION

**Jacopo Parvizi**

[jacop@dtu.dk](mailto:jacop@dtu.dk)

[www.imm.dtu.dk/~jacop](http://www.imm.dtu.dk/~jacop)

**Hakon Børsting**

Manager  
Control Technology  
Grundfos Holding A/S



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Forecasting and Optimization for the Energy Sector

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