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Agent-based control of a neighborhood

A generic approach by coupling Modelica with Python

Agenda

1. Introduction

2. Methodology
    - Model predictive control with a MAS
    - Coupling Modelica & Python

3. Results

4. Conclusions and discussion

1. Introduction - Duality of research

Building physics

- Modeling
- Simulation

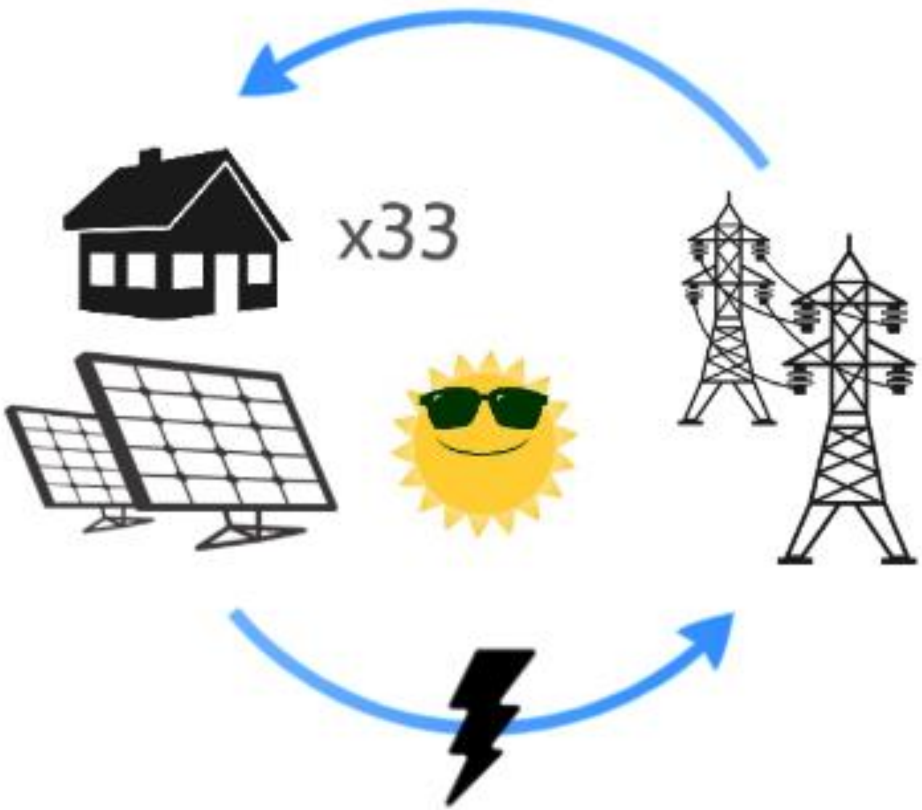
- Rule-based controls

Control

- Optimal control
- Frameworks

- Simple models

1. Introduction - Proof of Concept



Modelica model

- 33 houses
- PV panels
- Risk of over-voltages

- DSM with DHW tanks
- RBC-strategies
  - Clock
  - Voltage

↦ **Improve performance**

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- **Coupling Modelica & Python**
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2. Methodology - Modelica & Python

Modelica

- Modeling
- Simulation

Building physics

Python

- Control framework
- Optimisation

Control

FMI

- Tool for ME and CS
- Free

Dymosim.exe

- Commercial
- Made by Dymola

Other options

- BCVTB
- Dymola
- Modelica scripts

2. Methodology - Modelica & Python

ModelicaRes

Kevin Davies, Hawaii Natural Energy Institute and Georgia Tech Research Corporation

Annex 60 Activity 1.2

- Load, analyze and browse data
- Filter and sort groups of results
- Produce various plots and diagrams
- **Simulate models**

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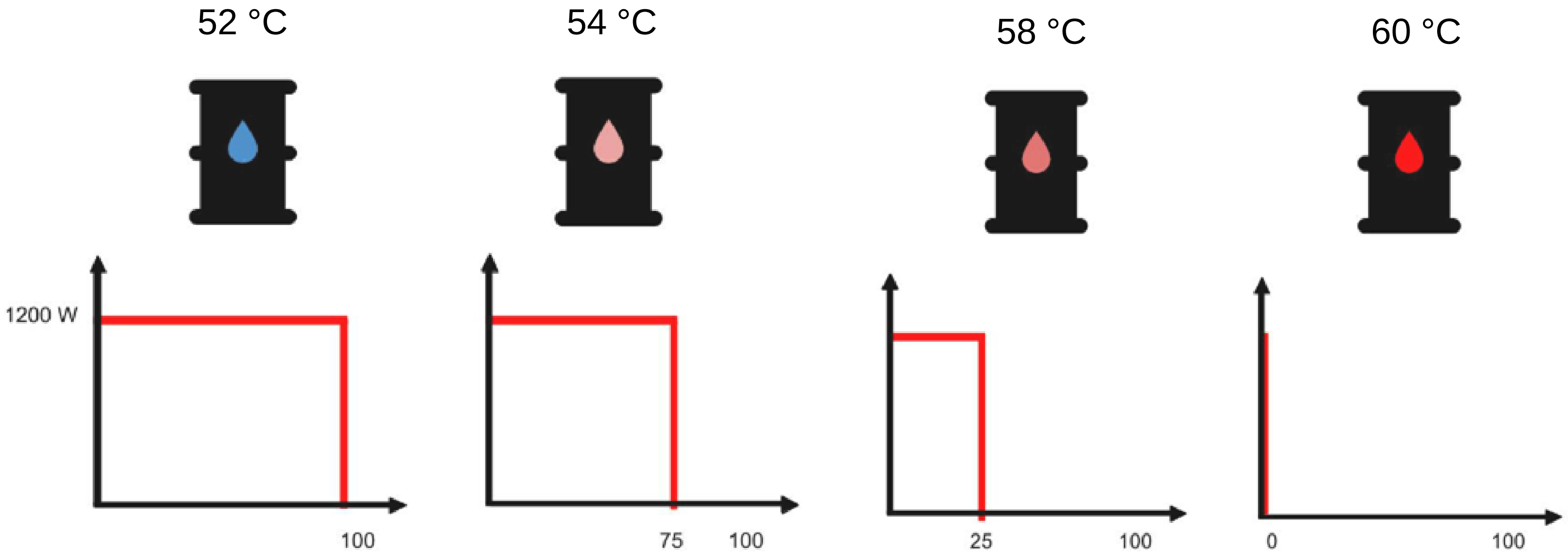
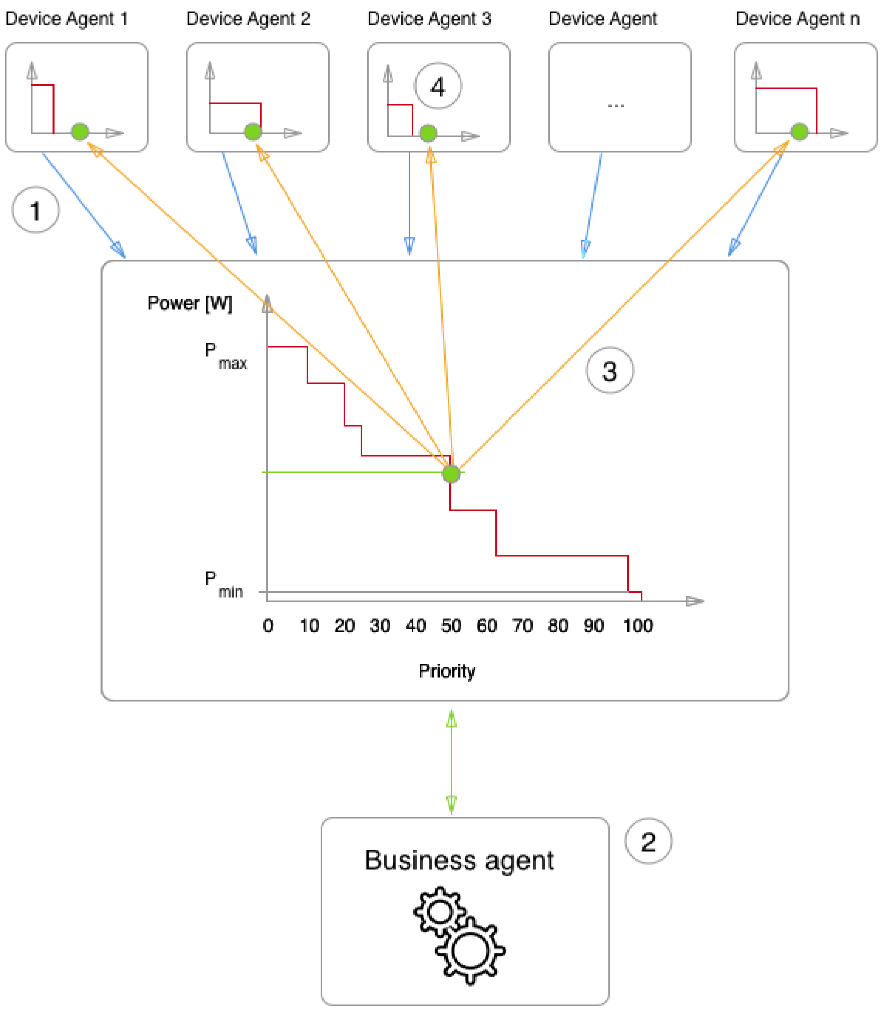
2. Methodology - Multi-Agent System

- Control of the DHW tanks heated by a HP
- 52-60 °C
- Represented by a **step bidding curve** based on comfort



2. Methodology - Multi-Agent System



1. Send bidding curves to the central control
1. Find the **optimal priority p***
1. Send **p*** to the devices
1. Act on **p***

2. Methodology - MPC in the BA

Very simple aggregated model for all storage tanks

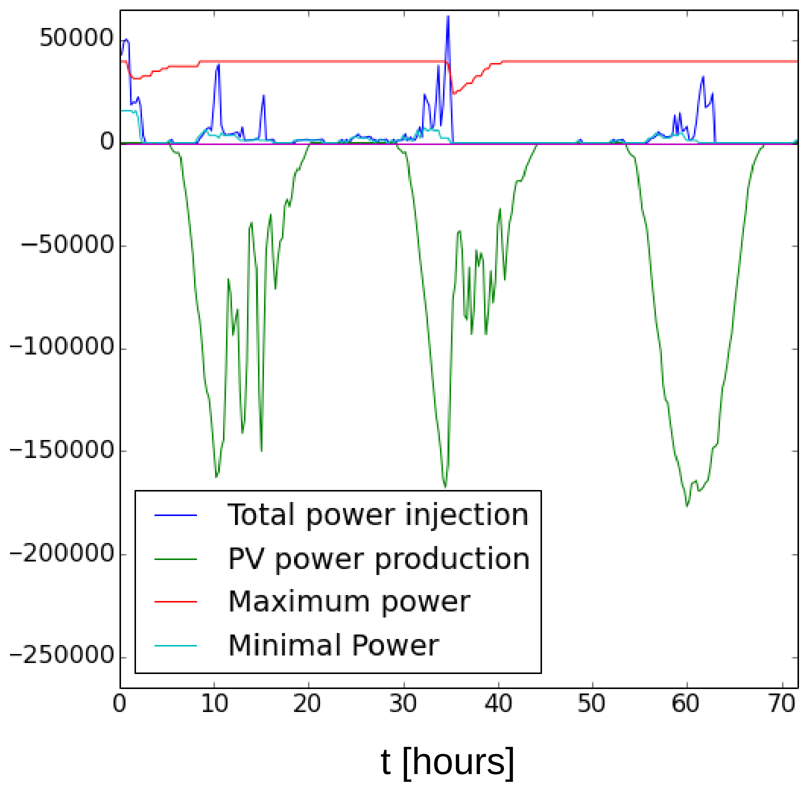
$$\theta_{i+1} = \theta_i + a \cdot (\theta_i - \theta_{out,i}) + b \cdot Q_i + c \cdot u_i$$

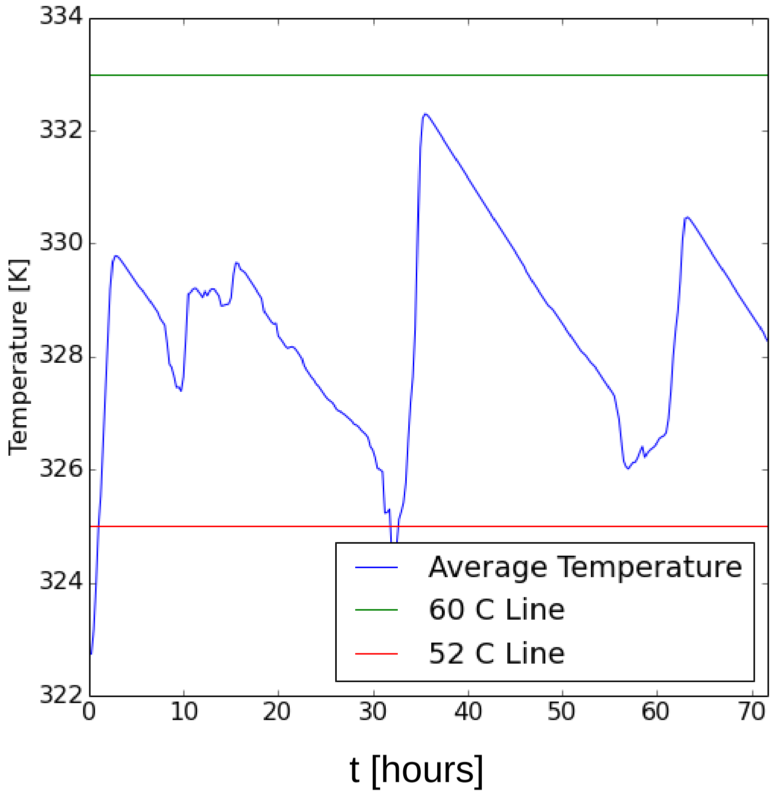
Optimization problem

$$J = \sum_{i=0}^{N-1} \underbrace{\boxed{(u_i + P_{occ,i} - P_{PV,i})^2}}_{\text{peak shaving}} + \underbrace{\boxed{W \cdot u_i}}_{\text{min E}}$$

$$\begin{aligned}
\min \quad & J(\mathbf{u}) \\
\text{s.t.} \quad & \theta_0 = \frac{\sum_{k=1}^{M} \theta_{k,dhw}}{M} \\
& P_{max} \geq u_0 \geq P_{min}, \\
& \forall i \in [0, N-1] : \theta_{i+1} = \theta_i + a(\theta_i - \theta_{out,i}) + b\, Q_i + c\, u_i, \\
& \forall i \in [0, N-1] : \theta_{out,i} = \theta_{out,i,\text{ predicted}}, \\
& \forall i \in [0, N-1] : Q_i = Q_{i,\text{ predicted}}. \\
& \forall i \in [1, N] : 333 \geq \theta_i \geq 325, \\
& \forall i \in [1, N-1] : 39600 \geq u_i \geq 0.
\end{aligned}$$

2. Methodology - MPC





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3. “Results”

4. Conclusions and discussion

3. “Results” - Modelica & Python

FMI

- Direct interface to C-code
- Intuïtive for developers

+ **Free**!
+ Small overhead
+ **Tool independent**

− Instable
− Speed f(general solver)

Dymosim / Dymola

- Indirect link via .txt files
- Not meant for Co-Sim

+ Very robust
+ Good and fast solvers

− Very expensive
− Large overhead
− Tool dependent

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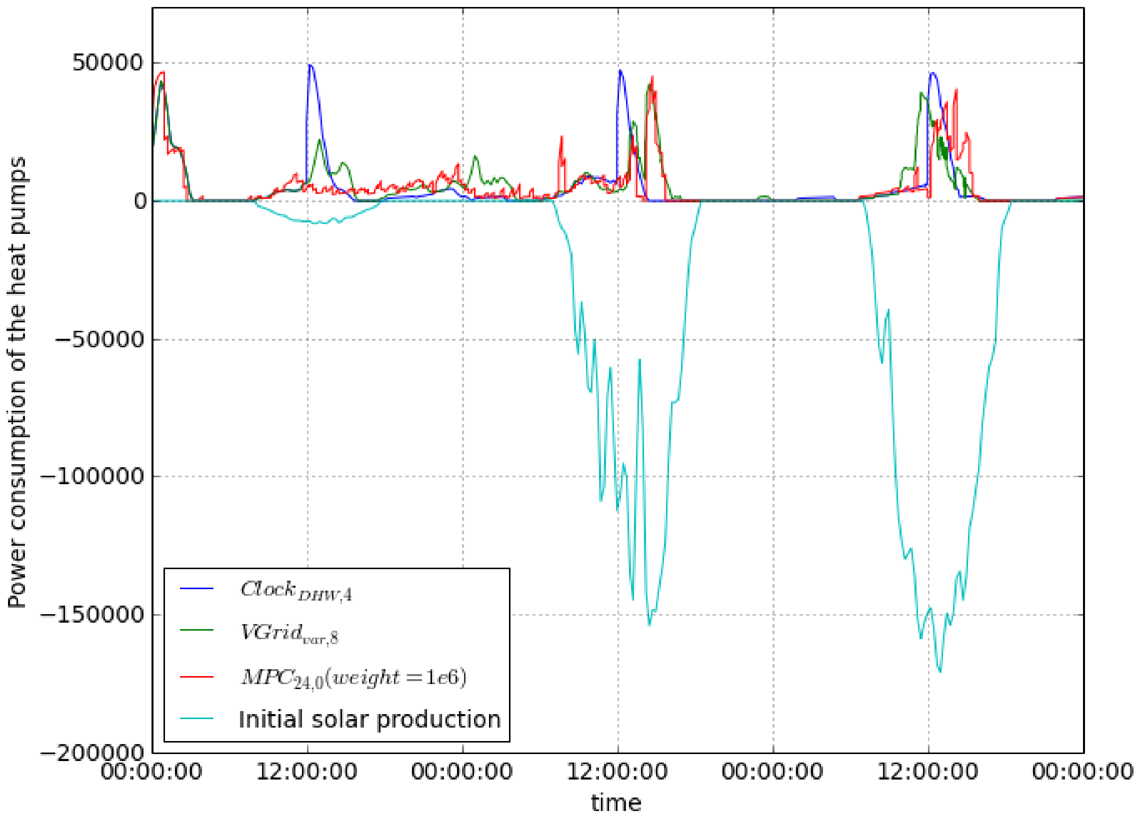
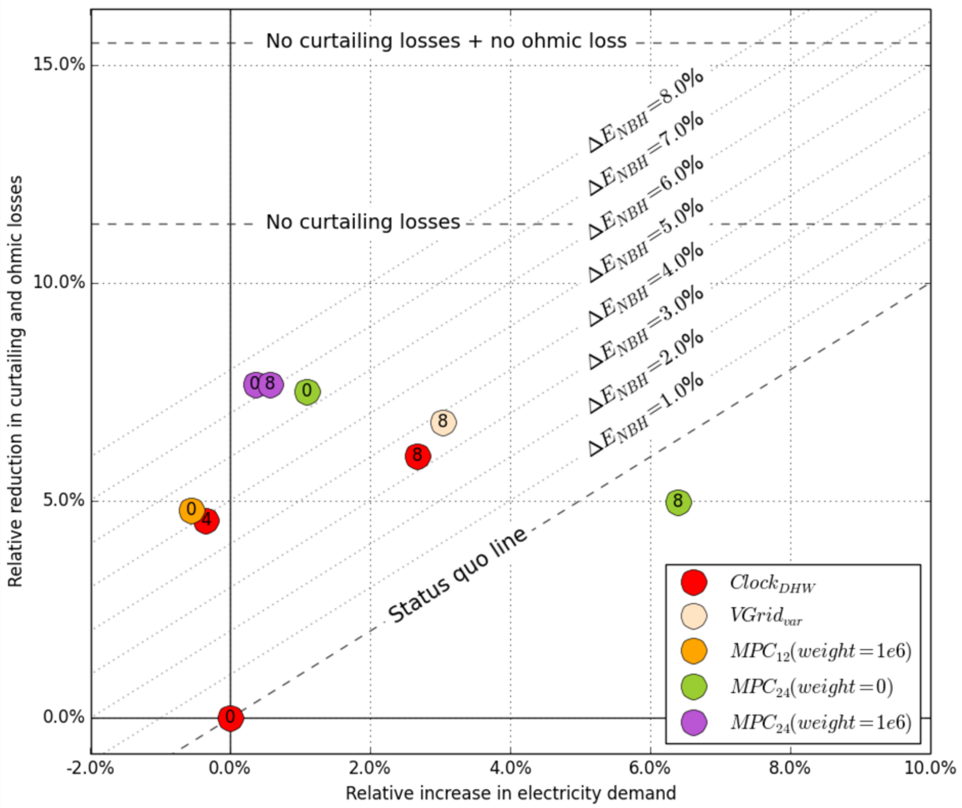
3. “Results” - MPC with a MAS

Comparison with RBC strategies



3. Results - MPC with a MAS

- Better performance
- Optimizes both goals
  - Maximize PV-output
  - Minimize E-demand



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4. D&C - Modelica Python coupling

- Good research environment
- Modelicares provides similar interface for both fmi and dymosim

- Potential to be totally free with FMI
  - Adjust models to solvers
  - QSS

4. D&C - Proof of concept

- Good performance for this case
  - Simple aggregated model
  - Central control

- MAS handles the distribution of the power well
- Flexible control framework

- Value of the results?
  - Short simulation periods
  - Homogeneous neighborhood

Thank you

Questions?