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Heating demand peak shaving in smart homes
Motivation

• In order to address and mitigate the most damaging aspects of anthropomorphic climate change, **climate action is needed**

  • Transition towards clean renewable energy sources
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    • Increased need for flexibility in energy systems
      – Storage
      – Production side (Curtailment)
      – Demand Side Management
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      » ICT, increased automation
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- Copenhagen aims to be the first carbon neutral capital by 2025
  - Make the District Heating carbon neutral
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  • Heating demand flexibility
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EnergyLab Nordhavn Project
• Full-scale smart city energy laboratory located in Copenhagen, Nordhavn
• Demonstrates how electricity and heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimized energy system
• Develop and demonstrate future energy solutions
Experiment

- Demand side management (DSM) - Peak Shaving
- Field tests in 16 smart apartments (heating season of 2018/19)
- Schedule control of the temperature setpoint of thermostats
- Focus on the learning process of the methodology
ICT System

Partners

Monitoring side
ICT System

Control side  Monitoring side

Partners

营利有限公司 ABB BALSLEV DTU Center for Electric Power and Energy Department of Electrical Engineering DTU Civil Engineering Department of Civil Engineering
Project timeline

Testing
Dec 2018

Algorithm 1
Jan 2019

Algorithm 2
Feb 2019

Algorithm 3
Mar 2019
Testing phase – December 2018

• Making sure that the all systems was working correctly
• Fixing issues in the ICT system
• Single living room → Multiple living rooms
• Response of the heating system (indoor temperature) to simple control signals

• Outcome
  • Data available + monitoring/visualization tools → Detect issues in the system
Algorithm 1 – January 2019

• Definition of reference temperature setpoint:
  ▪ Offline calculation using historical data of indoor temperature

• Pre-heating between 2:00 and 6:00:
  ▪ Only living rooms
  ▪ Offset of +1°C

• Peak shaving between 6:00 and 9:00:
  ▪ All rooms
  ▪ Offset of -1°C
Algorithm 1 – January 2019

• Outcomes
  - Historic setpoint was not OK
  - Pre-heating time of 4 hours was too long
  - Delay of 15 minutes was observed in the system response
Algorithm 2 – February 2019

• Definition of reference temperature setpoint:
  ▪ Defined as the current setpoint at 2:30

• Pre-heating between 4:00 and 5:45:
  ▪ Only living rooms
  ▪ Offset of +1°C

• Peak shaving between 5:45 and 9:00:
  ▪ All rooms
  ▪ Setpoints fixed in 20°C
Algorithm 2 – February 2019

• Outcomes

  ▪ Users feedback: bathrooms and toilets removed from experiments (warm floor)
  ▪ Rebound effect observed when temperatures were increased back to reference
  ▪ No pre-heating was needed (building’s thermal inertia was enough)
  ▪ It was possible to increase the heat cut-off period
Algorithm 3 – March 2019

- Bathrooms and toilets were excluded from our control loop

- Definition of reference temperature setpoint:
  - Defined as the current setpoint at 3:30
  - No pre-heating
  - Peak shaving between 5:45 and 12:00:
    - Offset of -1.5°C
    - Extra step at 12:00 to set back the setpoint
      - Delay of 1 minute between rooms
Results – Algorithm 3

1. Read of setpoint reference (3:30)
2. Beginning of DSM experiment (3:40)
3. Heat cut-off (5:45)
4. Setpoint back to reference (12:40)
Conclusion

• Significant reductions compared to non-experimental days with similar weather conditions

• Little impact on indoor temperature

• These methods can be applied to other smart homes where heating supply is controlled using room thermostats
Thank you

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