INTERACTION HEAT PUMPS AND THE ELECTRICITY GENERATION SYSTEM

System value of residential heat pump demand response
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Balance electric grid: now

SUPPLY = DEMAND
Balance electric grid: future

SUPPLY = DEMAND
Balance electric grid: future

SUPPLY \quad = \quad DEMAND

\[ \text{freq.} \]
Flexibility heat pump

Temperature vs. time:
- At 22°C for 6h, 8h, and 18h
- At 20°C for 23h

Temperature vs. time:
- At 60°C for 6h, 8h, and 18h
- At 50°C for 23h
Flexibility heat pump

“Demand response”

**Temperature and Time Graphs**

- **Temperature:** 22°C, 20°C
- **Time:** 6h, 8h, 18h, 23h

- **Temperature:** 60°C, 50°C
- **Time:** 6h, 8h, 18h, 23h

*Images of a thermostat and a water heater are also present.*
Balance electric grid: future

\[
\text{SUPPLY} = \text{DEMAND}
\]
Integrate operational model

SUPPLY = DEMAND

Cost savings

Effort Potential
req.
Integrated operational model
Example output.
2 days

(a) Electricity generation, no DR
(b) Mean temperatures, no DR
(c) Electricity generation, with DR
(d) Mean temperatures, with DR
Overview

• Context
• Integrated operational model
• Highlights research
• Conclusion
Belgian case study: model

- Scenario 2030
- Impact 250,000 heat pumps with/without demand response

30% wind
10% PV

CCGT
OCGT

Inflexible demand
Profile 2013

3 types
Air HP + rad
Air HP + fh
Ground HP + fh

6 periods
3 types
2 renovations
Belgian case study: peak load

![Graphs showing residual demand and day zone temperature with DR and No DR scenarios, along with additional peak demand per building vs heat pump nominal electric power demand.](image)
Belgian case study: CO$_2$

Lower CO$_2$ compared to a condensing gas boiler
Belgian case study: \( \text{CO}_2 \) How?

**Efficiency**
Gas -> CCGT -> Heat pump

\[
1 \times 0.5 \times 3 - 4
\]

**Demand response**
More efficient power plants
Belgian case study: \( \text{CO}_2 \) How?

Demand response:
less RES curtailment
Study: market effects

• Same mix as Belgian case study
• 1 million well-insulated buildings
  – 5 to 100% participation

• Results
  – Max. 150 EUR/a/part. operational
  – Max. 300 EUR/a/part. peak shaving
  – Unnecessary: Larger $\Delta T$, larger hot water tank
Study: market effects

Higher participation rates

-> Lower gains per participant
Study: market effects

- 30% solar
Study: market effects

- 30% wind
Overview

• Context

• Integrated operational model

• Highlights research

• Conclusion
Conclusion

• Exploration value demand response heat pumps
  – CO₂ reduction 10-20%
  – Reduce peak demand
  – Value 50-400 EUR/part/year
  – 1 to 10% higher electricity use

• PhD text
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