Energy flexibility by structural thermal storage in dwellings

IEA EBC Annex 67

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Energy Flexible Buildings

ANNEX 67

Smart Grid & other energy infrastructures

Built environment

Building

Floor

Room

Workingplace

User
Goal

“Define and quantify energy flexibility in buildings”

Activities

• Subtask A: Definitions and Context
• Subtask B: Analysis, Development and Testing
• Subtask C: Demonstration and User Perspectives

3rd Work meeting: Bolzano, Italy. October 17-19, 2016
Contact O.A.: Søren Østergaard Jensen <sdj@teknologisk.dk>
- What impact do buildings have on district energy system?
- What can buildings offer as flexibility to the grid?
grid perspective

- Size (kWh)
- Power (kW)
- Availability (s)
- Investment cost (€ + kWh)
- Current state (-)

building perspective

- Comfort
- Cost / Profit (€)
- Energy use (€ + kWh)

Flexibility indicators

- Available capacity
- Storage Efficiency
- State of Charge
- Power shifting capability
Generic Flexibility Characteristics

\[ C_{ADR} \] : Available storage capacity [kWh]
\[ \eta_{ADR} \] : Storage efficiency [%]

- Interpretation: ADR signature
- Interesting for: planning, design

![Diagram](https://via.placeholder.com/150)

- Reference (\( Q_{Ref} \))
- ADR heating (\( Q_{ADR} \))

Typical profile
- ADR profile

\[ l_{pulse} \]
Activation of structural thermal mass – The concept

Time

Temperature

ADR

No ADR

$T_A D R$

$T_{ADR}$

Time
“How do building design parameters of new and existing buildings influence the potential for active demand response using structural thermal storage?”
ADR potential of Belgian residential stock

I. REDUCED-ORDER BUILDING STOCK MODEL
ADR potential of Belgian residential stock

II. ADR CHARACTERISTICS
ADR potential of Belgian residential stock

III. INTEGRATED OPERATIONAL MODEL

Optimal control problem
ADR potential of Belgian residential stock

**GRID IMPACT**

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<tr>
<th>Floor heating ACHP</th>
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**Figure 1:**
- **Y-axis:** Increase peak load [kW/build]
- **X-axis:** Nominal power heat pump [kW_el]
  - case — no ADR ...
  - ADR
- **Legend:**
  - Renovation level
    - Ref. 1 △ Ref. 2
  - Building Type:
    - D • SD ▲ T

**Figure 2:**
- **Y-axis:** Increase HP electricity use [kWh/build]
- **X-axis:** Reduced curtailment [kWh/build]
Main conclusions

• Generic definition & dynamic quantification method
  o general comparison between buildings (and other storage technologies)
• Available capacity & storage efficiency
  o interpretable as building signature
  o mainly influenced by:
    - heat emission system
    - heat loss coefficient
    - heat loss coefficient / thermal mass
• Characteristics are coupled and not constant!
• Case study showed buildings have significant potential as short-term storage
  o 8-16 kWh (thermal) in 2h
  o 73-96 % efficiency
Thank you!

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