Energy Flexible Buildings
IEA EBC Annex 67

Operating Agent
Søren Østergaard Jensen
Danish Technological Institute
sdj@teknologisk.dk

Meeting in CITIES,
Lyngby, April 23, 2018
Common understanding that we need to replace fossil fuels with renewable energy.
Example: Denmark
Goal: 50% wind in power grid by 2020 and only RES in the total energy system by 2050
Solutions to large share of RES in the energy systems

Large interconnectors - export/import
Heat pumps in district heating
Generation of hydrogen and upgrading of biogas
RES based fuel factories

Demand response - industry and buildings
Most buildings have the ability to become energy flexible.
Commercial buildings

ventilation systems

cooling systems

supermarkets

pumps
Electricity demand in households

heat pumps (aircondition)

heat pump

ground heat exchanger

EVs

ventilation systems

white goods
Example

Load profile for 0.4 kV feeder

- existing load
- max allowed load

Hours: 1 to 24

kW: 0 to 120
Example

Load profile for 0.4 kV feeder

- 40% homes with EV
- Heat pumps
- Existing load
- Max allowed load

KW

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Hours
Example

Load profile for 0.4 kV feeder

40% homes with EV
Heat pumps
Existing load
Max allowed load

kW

120
100
80
60
40
20
0

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

hours

Flexibility
Prosumers
Voltage problems

With PV

Without PV

max.

230 V

min.
European Union

Smartness Indicator in EBPD (Energy Performance in Buildings Directive)

- The introduction of a smartness indicator rating the readiness of the building to adapt its operation to the needs of the occupant and the grid, and to improve its performance

- The smartness indicator should be used to measure buildings’ capacity to use ICT and electronic systems to optimise operation and interact with the grid
Smart readiness indicator in EPBD

Annex 67 has written a Position paper

There is a need for an approach that takes into account the dynamic behavior of buildings rather than a static counting and rating of control devices. It is further important to minimize the CO₂ emission in the overall energy networks rather than optimize the energy efficiency of the single energy components in a building.

Characterization and labelling of Energy Flexibility in buildings

control signal, penalty signal, reward signal, disturbance signal
Characterization and labelling of Energy Flexibility in buildings

Daily load profiles divided on sectors

Temperasture set point

Set point and room temperatures - April 11

Base case
Demand response both excess heating and switch off
Characterization and labelling of Energy Flexibility in buildings

![Graphs showing temperature, CO₂ emission, and accumulated CO₂ over time for Flexible Controller and Conventional Controller.](chart.png)
What is the possible Energy Flexibility in buildings

It depends

- type of building and energy service systems
- use of the building
- climate
- time of the day and the year
- occupants
- control possibilities
- state of storage (constructions, tank, battery, ...)
- physical max vs. cost optimal energy flexibility
- surrounding grids
- energy tariffs
- ...

...
What is the possible Energy Flexibility in buildings

It depends

- type of building and energy service systems
- use of the building
- climate
- time of the day and the year
- occupants
- control possibilities
- state of storage (constructions, tank, battery, ...)
- physical max vs. cost optimal energy flexibility
- surrounding grids
- energy tariffs
- ...

...
Expected Flexibility Saving Index

Graphs showing demand change and penalty over time, and a table with wind, solar, and ramp penalties for different buildings.
Flexibility Index

![Graph showing demand change over time for Building 1, 2, and 3.]

![Graph showing penalty over time for Wind, Solar, and Ramp.]

<table>
<thead>
<tr>
<th></th>
<th>Wind (%)</th>
<th>Solar (%)</th>
<th>Ramp (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>36.9</td>
<td>10.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Building 2</td>
<td>14.4</td>
<td>47.9</td>
<td>22.3</td>
</tr>
<tr>
<td>Building 3</td>
<td>17.9</td>
<td>35.6</td>
<td>67.5</td>
</tr>
</tbody>
</table>
## Expected Flexibility Saving Index vs. Flexibility Index

<table>
<thead>
<tr>
<th></th>
<th>Wind (%)</th>
<th>Solar (%)</th>
<th>Ramp (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>11.8</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Building 2</td>
<td>4.4</td>
<td>14.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Building 3</td>
<td>6.0</td>
<td>10.0</td>
<td>18.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Wind (%)</th>
<th>Solar (%)</th>
<th>Ramp (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>36.9</td>
<td>10.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Building 2</td>
<td>14.4</td>
<td>47.9</td>
<td>22.3</td>
</tr>
<tr>
<td>Building 3</td>
<td>17.9</td>
<td>35.6</td>
<td>67.5</td>
</tr>
</tbody>
</table>

Characterizing the Energy Flexibility of Buildings and Clusters
Submitted to: Applied Energy
Currently there is, however, still little overview or insight into how much Energy Flexibility different building types and their usage may be able to offer to future energy systems.

There is thus a need for increasing knowledge on and demonstration of the services Energy Flexible Buildings can provide for the energy grids as well to identify critical aspects and possible solutions to manage this Energy Flexibility.
IEA EBC Annex 67
Energy Flexible Buildings

June 2014 – June 2015: Preparation phase: done
June 2018 – June 2019: Reporting phase

Sixth working meeting:
Montreal, 10-12 October 2018
Definition of Energy Flexibility in buildings

- The Energy Flexibility of a building is the ability to manage its demand and generation according to local climate conditions, user needs and grid requirements.
- Energy Flexibility of buildings will thus allow for demand side management/load control and thereby demand response based on the requirements of the surrounding grids.
Annex 67 work plan

Subtask A: Definitions and Context
- Common terminology and definition of Energy Flexibility in buildings
- Methodology for characterization of Energy Flexibility in buildings
- User needs, motivation and barriers for application of EF in building
- Market analysis

Subtask B: Analysis, Development and Testing
- Simulation of Energy Flexibility in single buildings and clusters of buildings
- Control strategies and algorithms
- Laboratory tests of components, systems and control strategies
- Example cases and design examples

Subtask C: Demonstration and User Perspectives
- Measurements in existing buildings
- Demonstration of Energy Flexibility in real buildings and clusters
- User motivation and acceptance
Participating countries

• Austria
• Belgium
• Canada
• China
• Denmark
• Finland
• France
• Germany
• Ireland
• Italy
• Norway
• Portugal
• Spain
• Switzerland
• The Netherlands
• UK
Currently there is no overview or insight into how much Energy Flexibility different building types and their usage may be able to offer to future energy systems. The aim of the Annex is thus to increase knowledge on and demonstrate the Energy Flexibility buildings can provide for the energy grids, and to identify critical aspects and possible solutions to manage this Energy Flexibility.

In-depth knowledge of the Energy Flexibility that buildings may provide is important for the design of future Smart Energy systems and buildings. The knowledge is, however, not only important for the utilities it is also necessary for companies when developing business cases for products and services supporting the roll out of Smart Energy networks. Furthermore, it is important information for policy makers and government entities involved in the shaping of future energy systems.

Read more about Annex 67, click here
Other related IEA activities

Demand Flexibility and RES Integration
Thank you for your attention