Building Performance Simulation (BPS) Software for Planning of Energy Efficiency Retrofits

Mondrup, Thomas Fænø; Karlshøj, Jan; Vestergaard, Flemming

Publication date:
2015

Document Version
Peer reviewed version

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Citation (APA):
Building Performance Simulation (BPS) Software for Planning of Energy Efficiency Retrofits

Thomas Fænø Mondrup, Jan Karlshøj, and Flemming Vestergaard
Department of Civil Engineering, DTU, Denmark

Session: Retrofitting of Buildings II, Paper Nr: 152
10th Nordic Symposium on Building Physics (NSB 2014)
Lund, Sweden, 15-19 June 2014
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Study Background

**Selecting Retrofit Strategies**
- When planning a retrofit, multiple performance strategies and actions has to be considered.
- How to select the most appropriate retrofit strategy/actions?
- A decision support methodology is needed.
- Possible solution: Implementing Building Performance Simulation (BPS) software as a performance-based decision-making tool.

**Strategy 1: Building envelope and design aspects**
Actions: Insulation upgrades, air leakage reduction, improvement of doors and windows, control and exploitation of solar gain and daylight, etc.

**Strategy 2: Building systems and installations**
Actions: Installation of high-efficiency HVAC systems, improvement of electrical lighting systems, improvement of domestic appliances, installation of renewable energy, etc.

**Strategy 3: Building services and management tools**
Actions: Monitor and control of the building during operation, utilization of metering services, clock controls, sensors, etc.
Study Goals

• Multifaceted Study
  - The main purpose is to describe a methodology to facilitate BPS software as a performance-based decision-making tool.
  - The methodology is implemented and tested in a retrofit case study.
Case Study Framework

• **Gate 21 Pilot Project**
  - The case study is directed towards the Gate 21 pilot project ”Building Envelope Retrofits: Retrofitting of Danish Social Housing”.
  - The case study aims to develop multiple exemplar building envelope retrofit actions, which can be adopted into future projects.
  - The case study focuses on integrating BPSs as a performance-based decision-support tool.

• **Clients Requirements**
  - The client (Gate 21) wishes to develop building envelope retrofit actions optimized for solar radiation and daylight exploitation.
  - Retrofitting focus: Investigating different building envelope design variables, particularly, different window positions, sizes, and shapes.
Case Study Methodology

- **Simulation-based process**
  - The simulation-based retrofit design process consists of three phases:

  1. Analysis of existing conditions
  2. Development of retrofit strategies/actions (+ evaluation)
  3. Implementation of retrofit strategies/actions

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*Phase 1: First step is to understand existing conditions, current requirements, limitations, project site context, etc.*

*Phase 2: Based on existing conditions, multiple retrofit strategies/actions are developed and evaluated against predefined performance criteria.*

*Phase 3: The final step is to construct and implement the proposed retrofit strategies/actions, hereby improving the overall building performance.*
Case Study Investigations [1/4]

• Analysis of Existing Conditions
  - The dwelling used for the retrofit case study is a precast concrete construction, 1970s single storey house in Albertslund, Denmark.
  - Pre-retrofit buildings conditions: Aging window units, poor insulation, air leakage, and mould growth due to surface condensation.
Case Study Investigations [2/4]

- **Development of Retrofit Strategies/Actions**
  - Retrofit actions focus on investigating selected building envelope design variables: Alternative window positions, sizes, and shapes.
  - List of retrofit actions:

  **Action (0): Existing conditions**
  **Action (1): Energy efficient windows**
  Action (2): Energy efficient windows + increased window width
  Action (3): Energy efficient windows + increased window height
  Action (4): Energy efficient windows + extra window section at patio doors
  Action (5): Energy efficient windows + double patio doors
  Action (6): Energy efficient windows + small skylight in living room
  **Action (7): Energy efficient windows + large skylight in living room**
  Action (8): Energy efficient windows + extra window section in living room
  Action (9): Energy efficient windows + extra window section in master bedroom
Case Study Investigations [3/4]

- Development of Retrofit Strategies/Actions
  - BPS software is used to investigate the retrofit actions; simulation of interior solar gains and daylight distribution [performed in IESVE].

  HERE: Average annual solar gains and daylight distribution, mapped over existing conditions, Action 1, and Action 7, contour range 40-760 LUX.
EXISTING FIGURES, LIVING ROOM
SOLAR GAIN = 352 kWh/yr
EE WINDOWS
FIGURES, LIVING ROOM ●
SOLAR GAIN = 530 kWh/yr
SKYLIGHT
FIGURES, LIVING ROOM
SOLAR GAIN = 862 kWh/yr
Case Study Investigations [4/4]

- Implementation of Retrofit Strategies/Actions
  - The client should select specific retrofit actions within the developed solution space.

<table>
<thead>
<tr>
<th>Action 0</th>
<th>#Existing conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action 1</td>
<td>#Energy efficient windows</td>
</tr>
<tr>
<td>Action 2</td>
<td>#Window width</td>
</tr>
<tr>
<td>Action 3</td>
<td>#Window height</td>
</tr>
<tr>
<td>Action 4</td>
<td>#Windows at patio doors</td>
</tr>
<tr>
<td>Action 5</td>
<td>#Double patio doors</td>
</tr>
<tr>
<td>Action 6</td>
<td>#Small skylight, living room</td>
</tr>
<tr>
<td>Action 7</td>
<td>#Large skylight, living room</td>
</tr>
<tr>
<td>Action 8</td>
<td>#Window section, living room</td>
</tr>
<tr>
<td>Action 9</td>
<td>#Window section, master bedroom</td>
</tr>
</tbody>
</table>
Conclusions

• Implementation of Retrofit Strategies/Actions
  - In the decision-making process of selecting specific retrofit strategies, multiple actions are available.
  - Therefore, a decision support is needed.
  - BPS can be implemented as a performance-based decision-making methodology.