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Fatima Harkouss, Farouk Fardoun, Pascal Henry Biwole

To cite this version:

HAL Id: hal-01660949
https://hal-mines-paristech.archives-ouvertes.fr/hal-01660949
Submitted on 11 Dec 2017

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Multi-Objective Decision Making Optimization of a Residential Net Zero Energy Building in Cold Climate

F. Harkouss a,b, F. Fardoun a, P-H. Biwolé c

a. University Institute of Technology, Department GIM, Lebanese University, Saida, Lebanon
b. University of Nice Sophia-Antipolis, J-A Dieudonné Laboratory, UMR CNRS 6621, 06108 Nice, France
c. Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont-Ferrand, France

Introduction-Objective

Net Zero Energy Buildings (NZEBs) are suggested to limit buildings energy consumption.

Investigate Cost-effective design options of a residential NZEB in Cedars, through a Multi-Objective Optimization, followed by a Decision Making

Case Study

- Three stories building in Cedars.
- Two apartments, each apartment 102 m².
- Heating loads covered by natural gas condensing boiler, η=98.3%, Heating set point = 20°C
- Flat plate active Solar Domestic Hot Water System + auxiliary Electric heater, to cover domestic hot water demands.
- Photovoltaic system on rooftop to generate electricity.
- Utility power grid for electricity.

Base Case Simulation Results

- Electrical loads= 37.78 MWh/y
- Thermal loads= 45.19 MWh/y
- Gains “Load-generated by PV” - 21.81 MWh “High amount “
- Life Cycle Cost, life period 20 years, is 181180 $

Optimization tool / Algorithm

TRNSYS + MOBO : “Multi-Objective Building Optimization Tool”.

The Non-Dominating Sorting Genetic Algorithm (NSGA-II), is adopted.

Parameters for NSGA-II:
1- Population size = 40
2- Generation number = 25

Optimization Results-Decision Making

Pareto Front

Four-objective optimization generates Four-dimensional (4D) problem space. Projecting 4D-Pareto-front on 2D-Graph.

Multi-Criteria Decision making (MCDM)

Elimination and Choice Expressing the Reality (ELECTRE III) method classifies Pareto front solutions.

Parameters for ELECTRE III:
1- Inference Threshold: 5%
2- Preference Threshold: 10%
3- Veto Threshold: 30%
4- Weights: 25% for each objective function

Decision making Results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>f1 (MWh) “SDHW electric consumption”</th>
<th>f2 (MWh) “Thermal Loads”</th>
<th>f3 (MWh) “Load-generation”</th>
<th>f4 (1000$) “LCC”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit (cm)</td>
<td>Roof insulation</td>
<td>Windows U-value</td>
<td>Cooling set point</td>
<td>Heating set point</td>
</tr>
<tr>
<td>Optimal</td>
<td>10</td>
<td>0.86</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>Solar collectors Pump flow Number PV Eastern WWR Western WWR</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal</td>
<td>8</td>
<td>115</td>
<td>72</td>
<td>21.87</td>
</tr>
</tbody>
</table>

Conclusions

- Significant potential to improve energy performance of residential NZEB in cold climate of Cedars by using proven passive strategies.
- The optimum design parameters decreases annual thermal load and LCC by 33.19% and 31.09% respectively, compared to the baseline model.
- Envelop high level of insulation is a key parameter to decrease the high heating demands.