Impact of the integration of energy-saving strategies on the demand profile of residential buildings in a tropical climate: a case study

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I. Introduction

Building impacts

- Energy
- Water
- Others

Needs met

Impacts

- Consumption of natural resources (30-50%)
- Waste generation (45-65%)
- 25% Global water consumption
- 1/3 polluting gas emissions
- 40% of global energy consumption
I. Introduction

Building’s energy consumption

Figure 1. Global share of buildings and construction final energy and emissions 2019. Source: 2020 Global Status Report for Buildings and Construction.

The buildings and construction sector is a key player in the fight against the climate crisis. This sector represents 35% of final energy use and 38% of emissions.
I. Introduction
Building’s energy consumption in Colombia

Figure 2. Distribution of the final electricity consumption of the SIN for 2020. Source: Adapted from BECO – UPME 2021.
I. Introduction
Reduction of energy consumption in buildings

The massive integration of energy saving strategies in buildings is being promoted locally through energy standards and / or regulations.
I. Introduction
RES. 0549 of 2015

Minimum energy saving requirements

<table>
<thead>
<tr>
<th>Energy</th>
<th>Fijo</th>
<th>Templo</th>
<th>Cálido</th>
<th>Cálido número</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hogar</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Hospitales</td>
<td>35</td>
<td>25</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Oficinas</td>
<td>30</td>
<td>30</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Centros comerciales</td>
<td>25</td>
<td>40</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Escuelas</td>
<td>45</td>
<td>40</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Vivienda en VIVS</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>Vivienda VTS</td>
<td>30</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Vivienda VIP</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

Climate zoning
Savings strategies recommendation
I. Introduction
RES. 0549 of 2015

MANDATORY SAVINGS PERCENTAGES

Prescriptive method

Performance Method

Baseline indicator

Indicator calculated by simulation

What is the impact of integrating these measures?
I. Introduction
Findings from the literature review

01 Impact on energy consumption of EEM integration

02 Impact on thermal comfort of EEM integration

03 Impact on reducing emissions

04 At the Colombian level, prospective studies of the impact of Res. 0549, and some sectorial ones.

The impact of integrating the recommended EEM in the network has not been studied in detail.

Lack of studies evaluating the impact of EEM on the demand curve

Study the impact of a group of energy-saving strategies on the demand curve of a residential building located in tropical climate.
II. Proposed methodology

1. Description of the building under study
   - Building characteristics:
     - Materials
     - Operation
     - Loads
   - Measured energy consumption data

2. Energy modeling
   - Calibrated energy model of the building (real building)
   - Reference energy model
     - Energy model with horizontal shading
   - Energy model with natural ventilation
   - Energy model with WWR 30%

3. Comparative analysis
   - Evaluation of the impact of strategies
## II. Proposed methodology

### Description of the building under study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value / Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction system</td>
<td>Industrialized with a structure of plates and concrete walls.</td>
</tr>
<tr>
<td>Approximate WWR</td>
<td>19</td>
</tr>
<tr>
<td>Exterior walls configuration</td>
<td>Wall in concrete, putty, and paint inside, plastic stucco outside. Overall thickness: 13 cm</td>
</tr>
<tr>
<td>Exterior walls U value [W/m²-K]</td>
<td>3.25</td>
</tr>
<tr>
<td>Roof configuration</td>
<td>Solid concrete plate, stucco, and lower face paint. Mortar, asphalt layer, and reflective paint on the upper face. Overall thickness: 16 cm</td>
</tr>
<tr>
<td>Cover U value [W/m²-K]</td>
<td>2.76</td>
</tr>
<tr>
<td>Lighting power density - LPD [W/m²]</td>
<td>2.22</td>
</tr>
<tr>
<td>Power Density of plug-in charges [W/m²]</td>
<td>31.49</td>
</tr>
<tr>
<td>Average power consumption [kWh/m²]</td>
<td>130</td>
</tr>
<tr>
<td>Air conditioning system</td>
<td>The main room of some of the apartment typologies (9000 BTU)</td>
</tr>
<tr>
<td>Elevators</td>
<td>1 x 7.5 HP</td>
</tr>
<tr>
<td>Apartment area [m²]</td>
<td>4145.0</td>
</tr>
<tr>
<td>General services area [m²]</td>
<td>456.6</td>
</tr>
</tbody>
</table>
II. Proposed methodology

Energy modeling

1. Geometric modeling

2. Model data definition
   - Data in categories: activity, enclosures, openings, HVAC, equipment.

3. Model calibration
   - Measured energy consumption data
   - Differences of less than 10% between measured and simulated data in 90% of the thermal zones
   - Error < 1%
II. Proposed methodology
Evaluation of the impact of strategies

Simulation scenarios

Real setting (1)
This scenario corresponds to the simulation of the energy model of the building under study as it is built.

Reference scenario (1)
A building with conventional characteristics, without any type of savings strategy

Strategy integration scenario (3)
Real building + horizontal shading (1)
Real building + Natural ventilation (1)
Real building + WWR 30% (1)

Analysis of energy consumption.
Results of the real scenario.
Comparison of the demand curve obtained for the proposed scenarios.
III. Results

Annual energy consumption

Fig. 3. Annual energy consumption of the different simulation scenarios. Source: Authors.
III. Results

Real Scenario

Fig. 4. The hourly curve of the energy demanded the real scenario. Source: Authors.
III. Results

Comparison of the demand curve for scenarios

Fig. 5. Hourly energy consumption curves for the different simulation scenarios. Source: Authors.
III. Results

Comparison of the demand curve for scenarios

Fig. 6. Hourly curves of energy consumption for the use of air conditioning in the different simulation scenarios considered. Source: Authors.
III. Results

Comparison of the demand curve for scenarios

Fig. 7. Comparison of hourly consumption concerning the reference scenario. Source: Authors.
III. Results
Comparison of the demand curve for scenarios

![Graph showing transformer chargeability analysis for different scenarios.](image)

**Fig. 8.** Transformer chargeability analysis. Source: Authors.
### III. Results

Comparison of energy use intensity indicators

<table>
<thead>
<tr>
<th>Scen.</th>
<th>kWh/m²/year</th>
<th>Baseline kWh/m²/year</th>
<th>Savings Hot-Dry [%]</th>
<th>Savings Tempered [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hot-Dry</td>
<td>Tempered</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>30.50</td>
<td>36.9</td>
<td>48.3</td>
<td>17%</td>
</tr>
<tr>
<td>1</td>
<td>38.06</td>
<td></td>
<td></td>
<td>-3%</td>
</tr>
<tr>
<td>2</td>
<td>30.33</td>
<td></td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>3</td>
<td>26.60</td>
<td></td>
<td></td>
<td>28%</td>
</tr>
<tr>
<td>4</td>
<td>30.52</td>
<td></td>
<td></td>
<td>17%</td>
</tr>
</tbody>
</table>
IV. Conclusions

• The main determinants of energy consumption in the scenarios analyzed are plug-in equipment. These represent around 75% of total consumption.

• The presence of efficient elevators and LED lighting in the real configuration (Scenario 0) produces a saving percentage of 17%. concerning the baseline of Resolution 0549. However, under a temperate climate, the savings are close to 37%.

• Most of the scenarios that include strategies do not present significant changes in energy demand. Compliance with local regulations requires the integration of additional strategies. The opposite case occurs with the natural ventilation scenario. This is the only one that allows minimum savings to be achieved under hot-dry weather conditions.
IV. Conclusions

- The results allow appreciating that energy-saving strategies can influence the chargeability of the transformer. For this study, the integration of natural ventilation reduces the energy demand and makes that chargeability is near 25% most of the time.
IV. QUESTIONS