

# How to renovate residential buildings in Portugal so they become machines for planetary regeneration?

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## Introduction

The built environment has a significant share in global final energy use, greenhouse gases emission, and land-system change. In Europe, the biggest challenge is to regenerate existing building stock to create a positive impact on the planetary systems. In Portugal housing stock is old, 56% is more than 30 years old, and at the same time, it provides a low level of thermal comfort and is not energy efficient. To meet the EU decarbonisation goals, and improve energy efficiency and indoor thermal comfort most residential buildings need renovation.

This poster presents a workflow that tests renovation strategies based on vernacular architecture as complementary to common renovation strategies in Portugal. It employs digital simulation to verify whether they could be used for renovation/retrofitting, measuring their impact on human and planetary health. It assesses Energy, Materials and Comfort as the three most important areas of regenerative renovation. It shows that there is a broad spectrum of parameters that influence renovation processes and that it is possible to complement common renovation strategies to enhance building performance using vernacular knowledge.

## Methods

The research looks to develop a workflow (fig. 04) to test the performance of renovation strategies. Each test evaluates the previous one and later makes necessary improvements. An improved workflow model (eg. different input or output parameters) uses a new case study and tests it. Such an iterative process of a proposed workflow verifies if the initial assumptions are correct and if the simulation outcome brings relevant information for a designer. Multiple iteration must be performed to build a robust workflow(s).

To test the workflow one of the researched vernacular strategies is selected. Input parameters look to reflect a real-life setting. The output parameters that allow evaluation of the strategy are selected to reflect both impact on the human comfort and on the environment. Different options of one strategy are compared according to multiple criteria and therefore there is none one best solution.

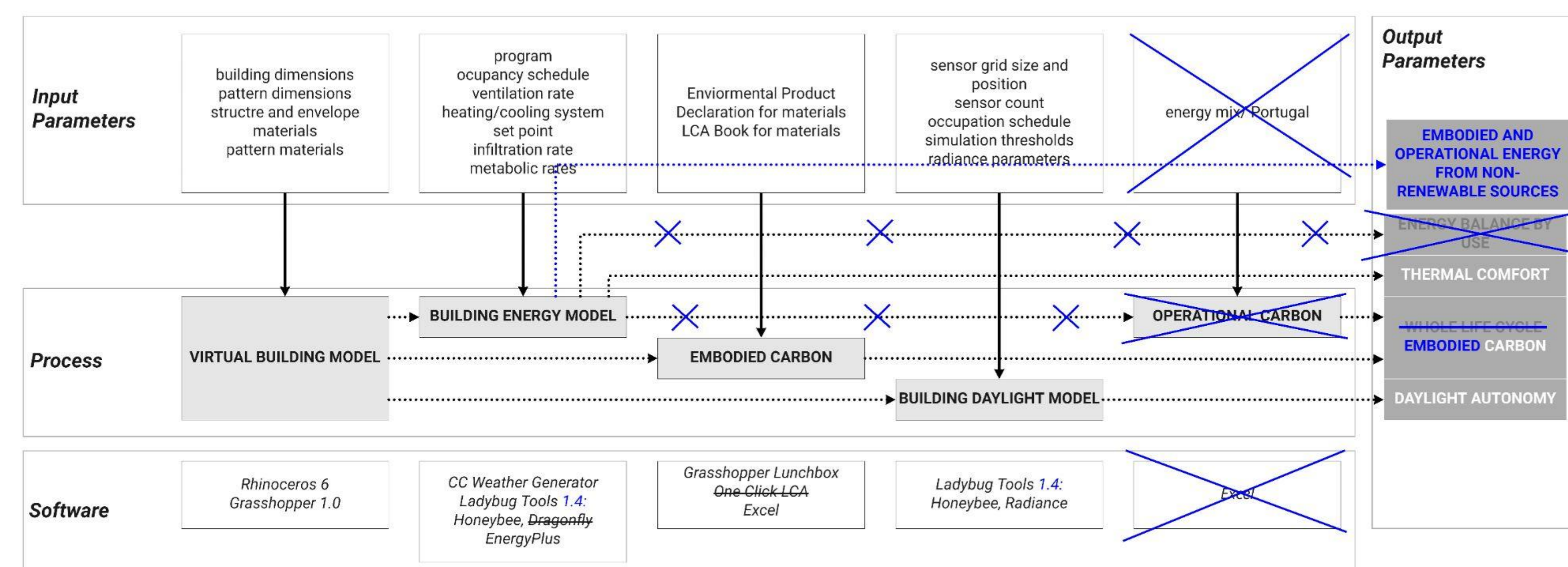
## Results

### Building as-it-is.

	observed	trend	future
Thermal Comfort [%]	61%	↗	73%
Daylight Autonomy	1	↔	1
Carbon Balance [CO2equiv/m2]	876	↘	561
Energy Balance [kWh/m2]	4735	↘	3037

The table (fig.01) shows simulation for observed and future climate for a south facing room of a test building as-it-is. According to the study thermal comfort will rise while energy and carbon balance will reduce, only because of outdoor temperature rise and decarbonization of energy sources. Any renovation will reduce operational impact, therefore embodied impact needs to be measured carefully. In the study four options are compared: baseline (no changes are made), typical renovation (insulation, new windows, new heating device), open and closed balcony (fig.02, fig.03).

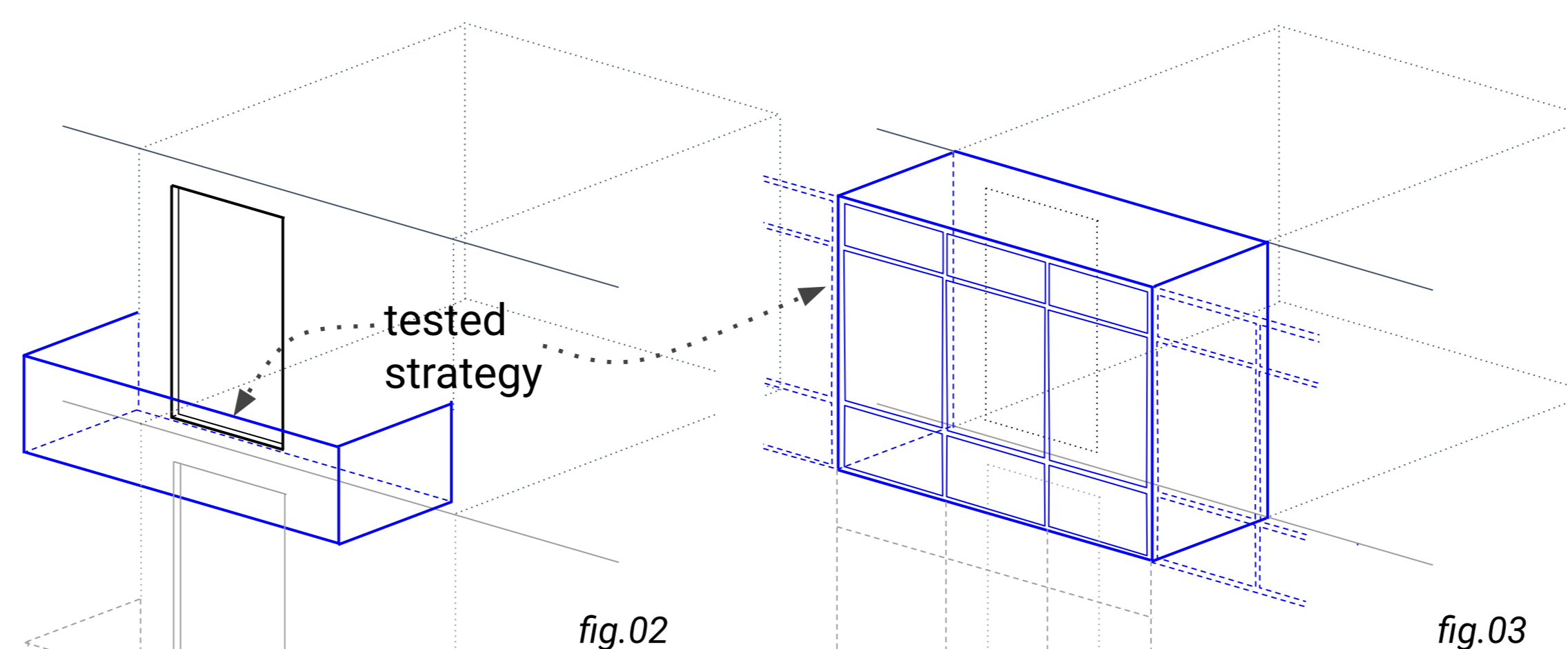
### Initial workflow with alternation



## Conclusions

- Climate change is the biggest factor that alternates building performance, it reduces building energy needs and improves thermal comfort. Adequate retrofitting strategies should be tested.
- The initial workflow needs to include embodied energy. Biobased materials used in the study accumulate carbon while growing, and therefore are carbon negative. But, their process of sourcing, manufacturing, and transporting might be energy expensive. Calculating both carbon and energy is equally important.
- From the point of view of comfort and energy consumption presented retrofitting strategies cannot replace popular on the market renovation strategies: thermal insulation, energy-efficient windows, new heating device. Although, the research shows that they can complement existent strategies. High energy balance is connected with addition of new building components and their embodied energy.
- From the point of view of carbon balance, mainly because of embodied carbon, the conventional strategy performs much worse (it consumes up to 600% more energy and emits 378% more of CO2 equiv). A careful selection of materials with low/negative embodied carbon will improve this balance.
- Architectural renovation strategies bring other, not quantifiable benefits, like an outdoor space of the balcony, which enlarges a flat with a comfortable living space.
- Further iteration of the test workflow allows to adjust input and output parameters, and find relation between key metrics and strategy.
- Relation between comfort and environmental impact needs to be evaluated more profound.

### Renovation strategy

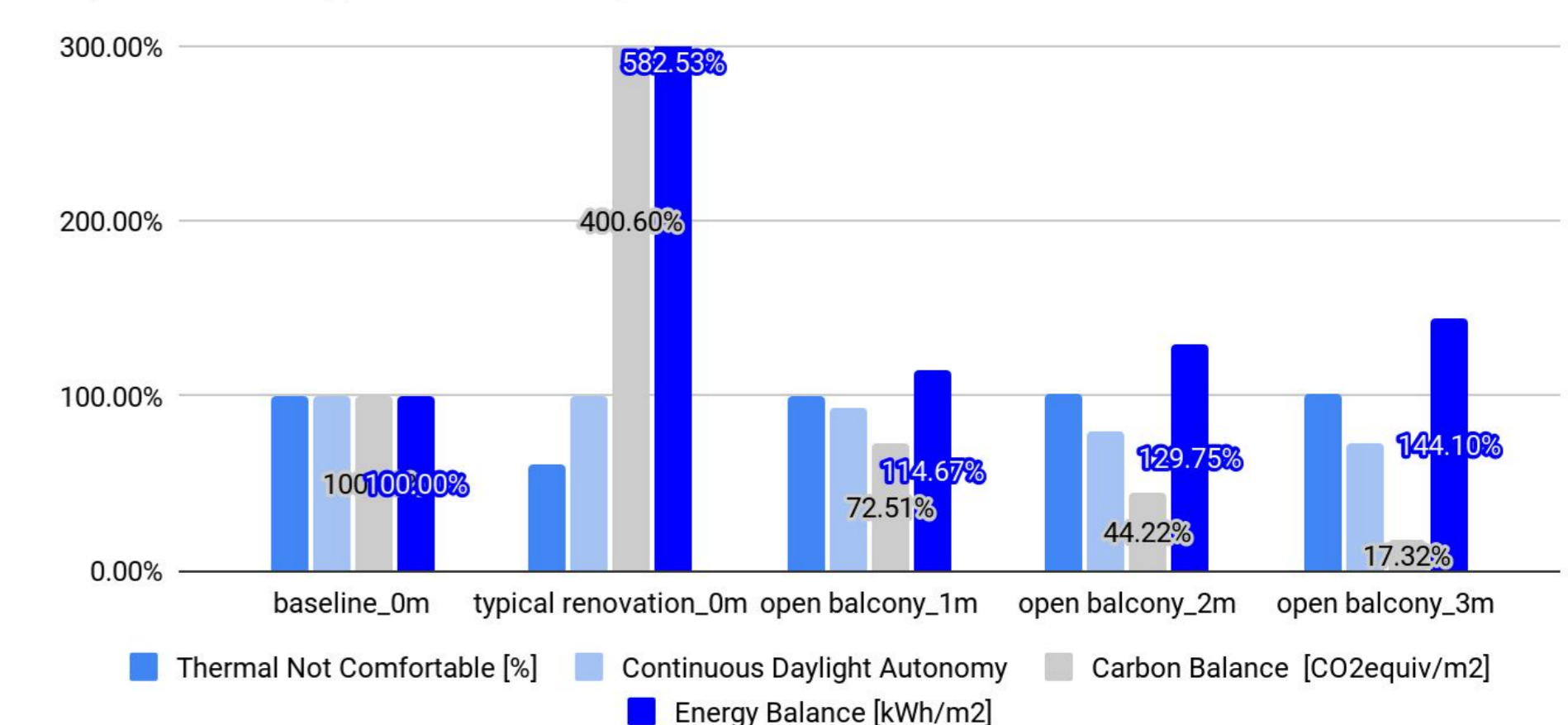


One of the climate-oriented solutions found in Portuguese vernacular architecture (more in the south than in the north) is an open balcony. It protects from the summer overheating and at the same time provides comfortable, shaded outdoor space. Balconies of 1m, 2m and 3m on the south and the north facade were evaluated to check their impact on the building performance.

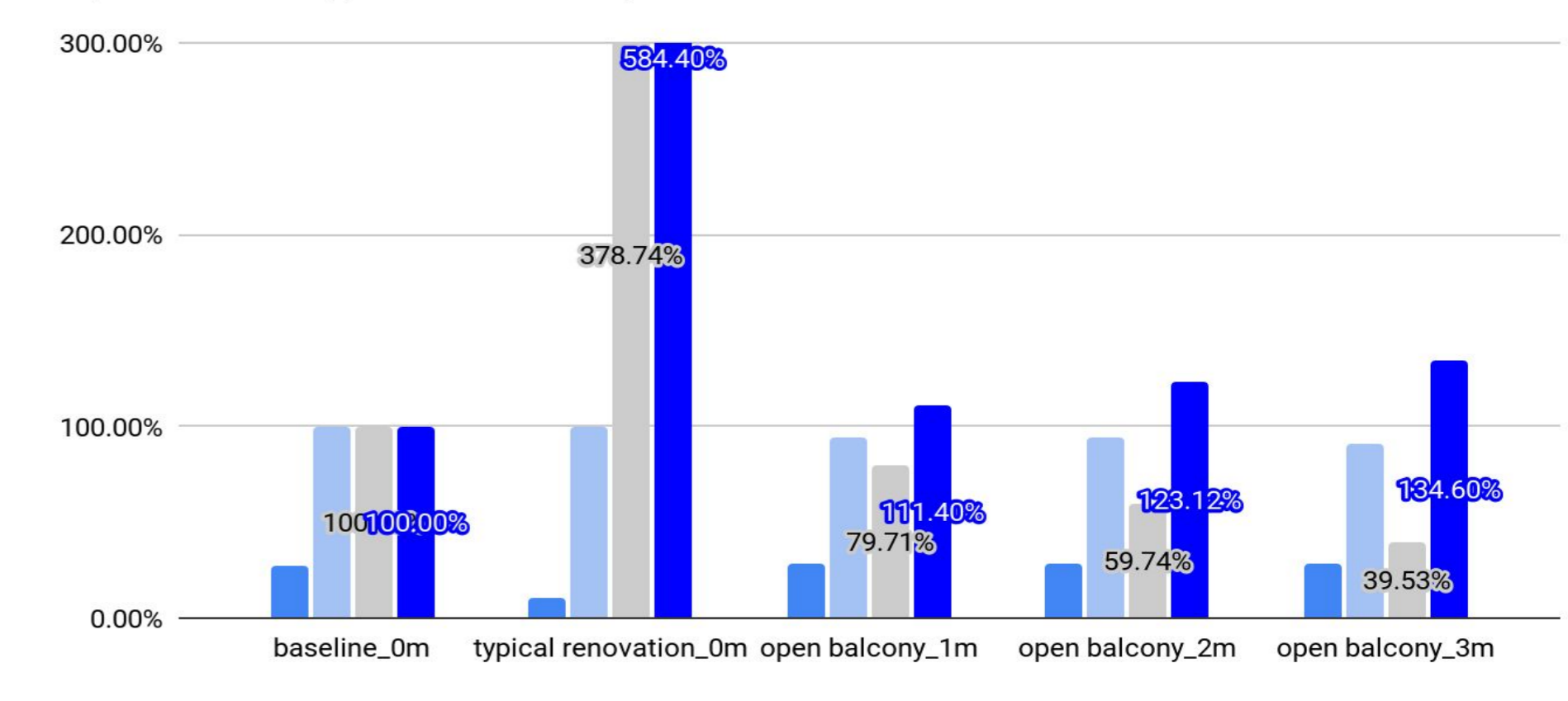
Another strategy is popular in the north of the Iberian Peninsula: a glazed, closed balcony in thick wooden frames. When closed in the winter time it creates greenhouse effect, in summer it is open allowing crossed ventilation. There is no division between the balcony space and the house interior. Balconies of 1m, 2m and 3m on the south and the north facade were evaluated.

### Comparison of different strategies

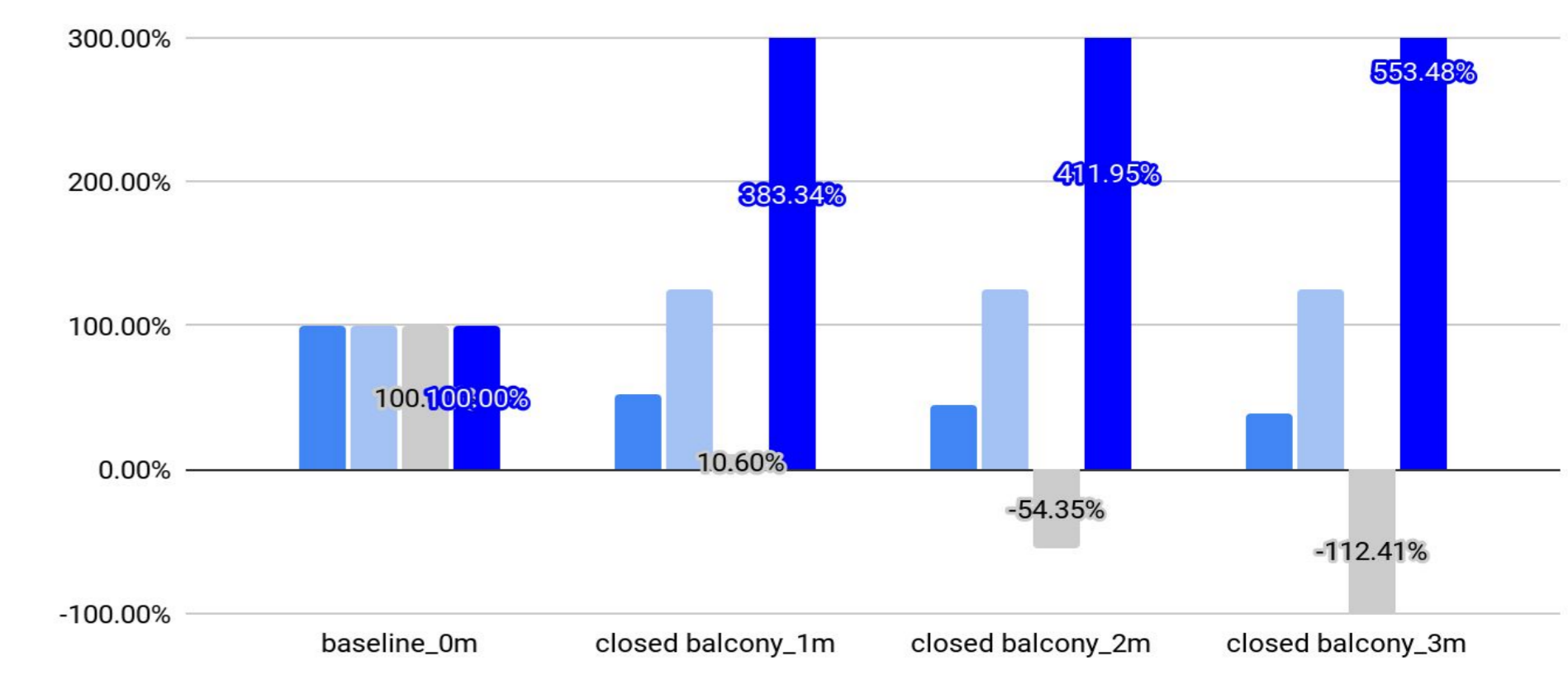
#### Open Balcony, North Room, 2050 RCP 8.5



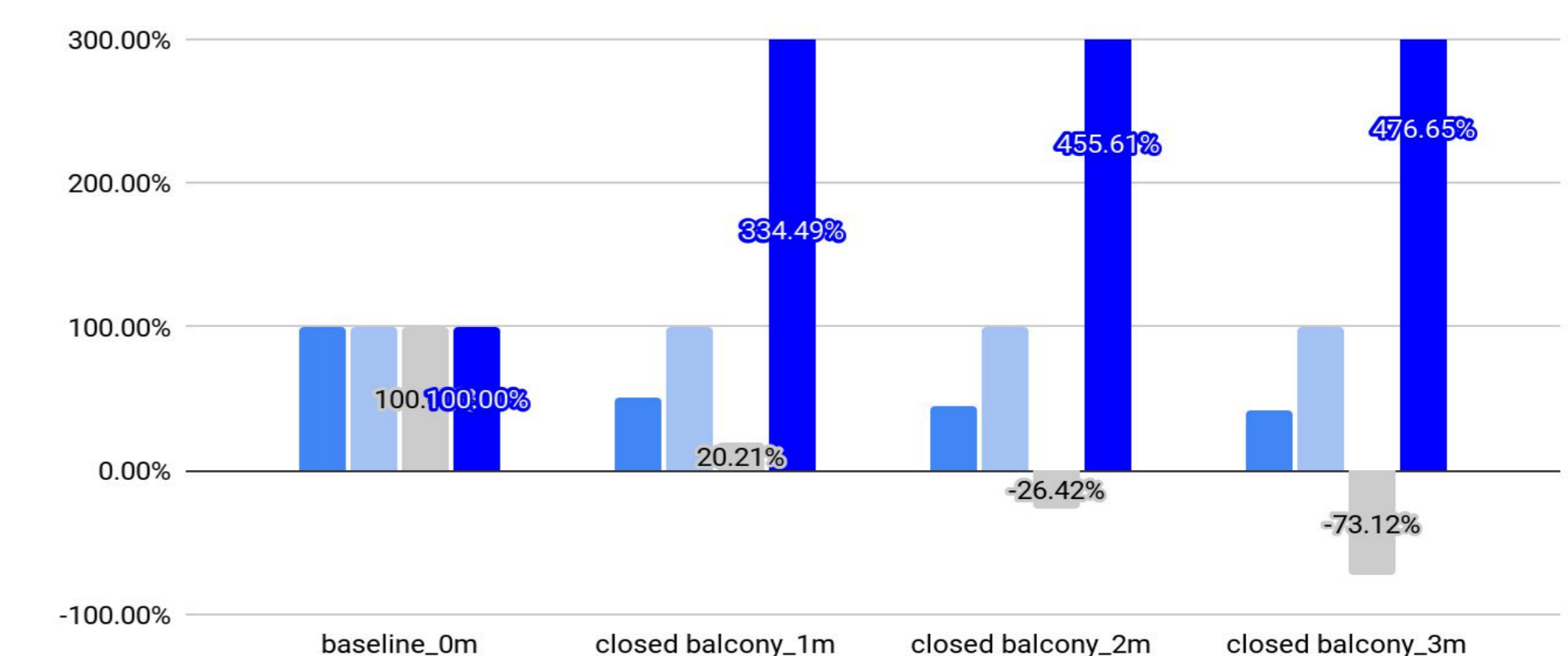
#### Open Balcony, South Room, 2050 RCP 8.5



#### Closed Balcony, North Room, 2050 RCP 8.5



#### Closed Balcony, South Room, 2050 RCP 8.5



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