POLITECNICO DI TORINO
SECOND SCHOOL OF ARCHITECTURE
Master of Science in Architecture
***Honors theses***

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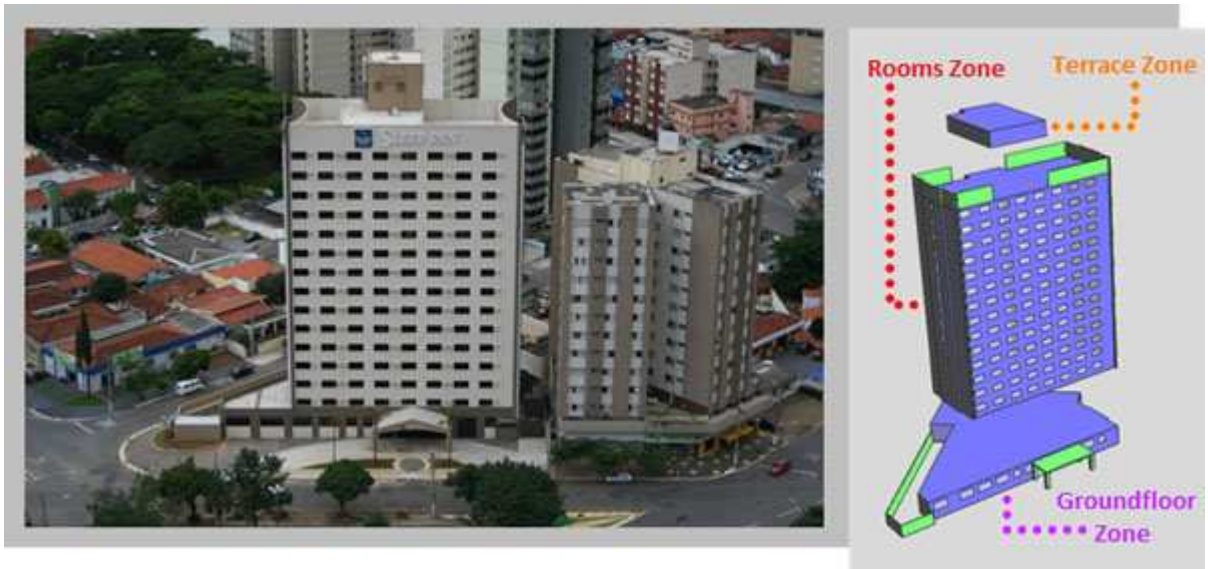
**Energy efficiency in the Brazilian built environment – retrofitting strategies for a hotel in Goiânia**

by Eduardo Cademartori
Tutor: Guglielmina Mutani
Co-tutors: Paolo Oliaro, Jan Hensen, Daniel Costola, Cláudia Amorim

Energy is an issue of extreme relevance to contemporary society, which is nowadays based on urban centers and buildings with high energy consumption. To have this changed in a critical way is one of the goals of sustainable development, a theme constantly in evidence in the last decades due to various political, economical and environmental issues. In Brazil, energy policy concerning sustainable buildings was primarily fostered by an important energy supply crisis followed by a long period of rationing that took place in 2001. Solutions for such a crisis could not accrue only from a supply expansion, but also from energy efficiency on its final uses.

Hotels characterize a building typology of significant savings potential through passive strategies for environmental comfort and local renewable energy generation. A broader awareness regarding energy efficiency in Brazilian hotels' design is being boosted by major international events, such as the 2014 World Cup and the 2016 Olympic Games, which will take place in Brazil. Furthermore, a specific governmental program has been conceived to support both construction and renovation of hotels with high energy performance. Whereas these projects should benefit from loans with low interest rates, hotels must reach A class according to the *Brazilian Protocol for Energy Evaluation in Buildings.*



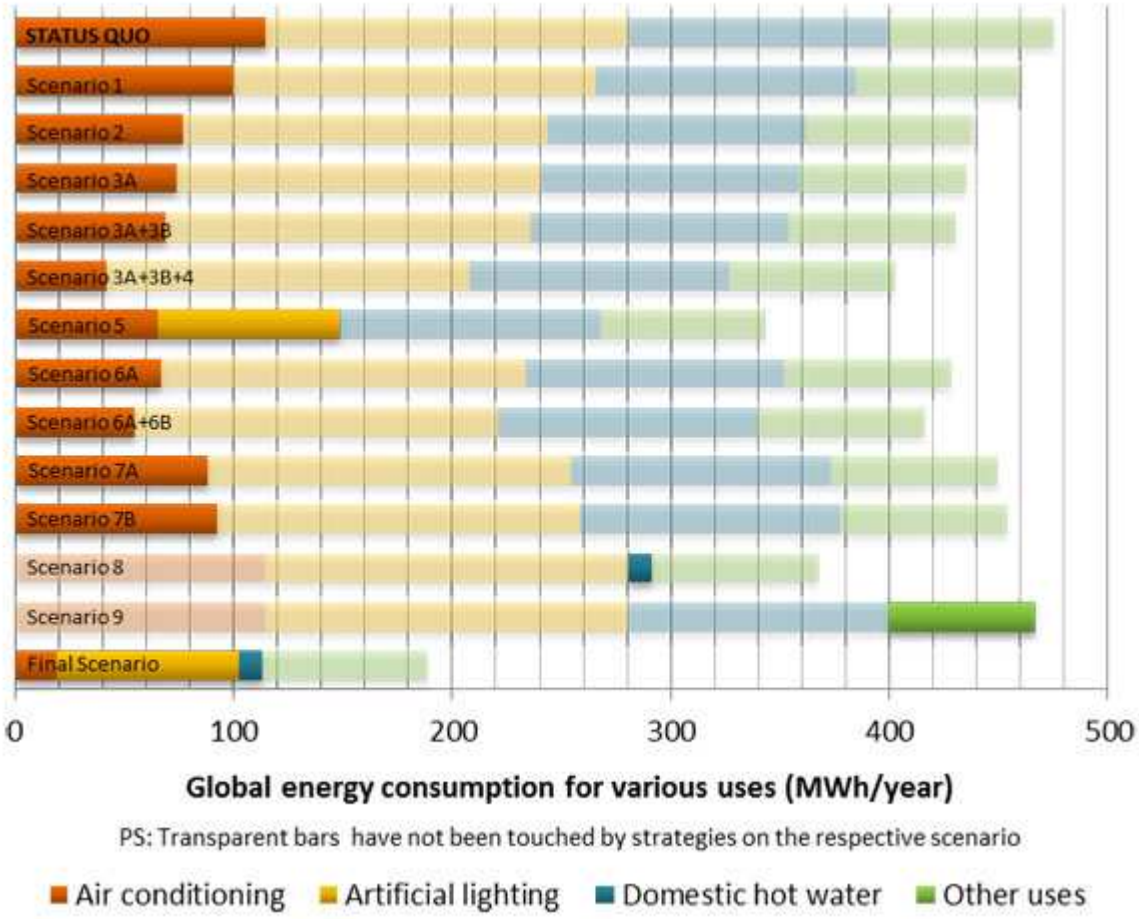

*Picture of the hotel's southeast façade and its scheme for zones division in the building*

A hotel in Goiânia – a Brazilian mid-western metropolis – was analyzed as a case study. The building is composed by 16 floors, comprised in 196 rooms and many common areas that amount to 8040 m². Taking into account the physical properties and components, as well as its operative and technical characteristics, it was possible to simulate its energy performance using the IES<VE > software. Along with hotel's real annual energy consumption, it was rendered possible to calibrate a model reproducing its real energy profile.

Simulation outcomes allowed the identification of hotel's energy critical points : thermal internal gains happen to be rather high, given the great occupation of the building and its artificial lighting system. Solar gains through envelope are also significant, and air conditioning activation setpoint, here taken as 24℃, overcharges individual cooling appliances. Furthermore, building's envelope reached C class in energy performance, due to high values of roofs' thermal transmittance and solar absorptance.

Several scenarios for the reduction of energy consumption were proposed. On glazed surfaces of first and second scenarios, shading was proposed in two different ways, whereas on the third scenario setpoint's redefinition for air conditioning and correction of air changes' rates within the hotel were suggested. When it comes to scenario 4, centralization of air conditioning system was proposed, leading to an increase of its coefficient of performance (COP) from 3,0 to 5,0. Scenario 5 resulted in a hypothetical reduction of the energy absorbed by an artificial illumination system, in order to reduce internal thermal gains in the building.

Scenario 6 concerns reductions on the opaque façades' solar absorptance and the glazed surfaces' solar factor. In order to reach an A class on energy performance, both roofs' insulation and color change were simulated on scenario 7. Scenarios 8 and 9 deal with integration of renewable energy sources in the building, respectively through solar thermal and photovoltaic panels. A final scenario was proposed in order to synthesize best performance strategies previously deployed.




Interventions, as shown by graphics, played a very heterogeneous role on building's energy consumption. By doing so, they have demonstrated savings' scale of each one of the strategies and their reflexes on the electric bill. Its current status considered the hotel pays around US$ 130.000,00/year to the power company, whereas the final scenario deals with savings that amount to almost US$ 80.000,00.

| Scenarios | Annual Consumption (MWh/year) | Annual Savings (MWh/year) | Annual Energy Savings | Cost Savings | Savings % |
|---|---|---|---|---|---|
| Status Quo | 475,04 | - | US$ 73.359,43 | - | - |
| Scenario 1 | 460,13 | 14,91 | US$ 71.056,92 | US$ 2.302,52 | 3,1% |
| Scenario 2 | 437,73 | 37,31 | US$ 67.597,73 | US$ 5.761,70 | 7,9% |
| Scenario 3A | 434,97 | 40,07 | US$ 67.171,51 | US$ 6.187,93 | 8,4% |
| Scenario 3A+3B | 429,88 | 45,16 | US$ 66.385,47 | US$ 6.973,97 | 9,5% |
| Scenario 3A+3B+4 | 402,34 | 72,7 | US$ 62.132,52 | US$ 11.226,92 | 15,3% |
| Scenario 5 | 343,22 | 131,82 | US$ 53.002,75 | US$ 20.356,68 | 27,7% |
| Scenario 6A | 427,9 | 47,14 | US$ 66.079,69 | US$ 7.279,73 | 9,9% |
| Scenario 6A+6B | 415,43 | 59,61 | US$ 64.153,99 | US$ 9.205,45 | 12,5% |
| Scenario 7A | 448,91 | 26,13 | US$ 69.324,24 | US$ 4.035,20 | 5,5% |
| Scenario 7B | 453,24 | 21,8 | US$ 69.992,90 | US$ 3.366,53 | 4,6% |
| Scenario 8 | 366,97 | 108,07 | US$ 56.670,41 | US$ 16.689,02 | 22,7% |
| Scenario 9 | 466,44 | 8,6 | US$ 72.031,35 | US$ 1.328,08 | 1,8% |
| Final Scenario | 188,66 | 286,38 | US$ 29.134,37 | US$ 44.225,07 | 60,3% |

*Proposed scenarios' resume (reduction of energy consumption and its costs)*

This work aims at fostering energy efficiency within the Brazilian built environment. In order to do so, it provides quantitative references of savings obtained through diverse retrofitting strategies applied to an existing building.

**Complete thesis on:**
Part 1:
https://docs.google.com/viewer?a=v&pid=explorer&chrome=true&srcid=0ByMtnMHtS5xTYjYyNTUyOTUtNmU0ZS00OTljLWI0ZTItNTQ5NzQ3ZWJhZjFi&hl=en_US
Part 2:
https://docs.google.com/viewer?a=v&pid=explorer&chrome=true&srcid=0ByMtnMHtS5xTODFkYTY4MTItZDNkZi00ODc3LWEyOWItZjVjOTVjNWZhYjEy&hl=en_US

For further information, e-mail:
Eduardo Cademartori: eduardo.cademartori@asp-poli.it