Cost-optimal assessment for energy efficient buildings

Integration of thermal comfort, productivity and health benefits

Sérgio Tadeu
tadeu.sergio@usp.br
Deciding to invest in energy retrofit of buildings can be a complex process since it involves multiple criteria and objectives that are sometimes conflicting.

This complexity can discourage building owners from investing. In the absence of data and guidelines, decisions tend to be postponed or taken at a subjective level.

Thus, there are advantages to performing a data analysis that can improve the consistency of decisions and also promote the social, environmental and economic sustainability of energy retrofit measures.
Cost-optimal assessment for energy efficient buildings
Cost-optimal assessment for energy efficient buildings

\[ PE = \left[ \sum_{k=1}^{K_h} \frac{f_{h,k} \cdot E_{h,k}}{\eta_{h,k}} P_{h,k} \right] + \left[ \sum_{k=1}^{K_w} \frac{f_{w,k} \cdot E_{w,k}}{\eta_{w,k}} P_{w,k} \right] - \left[ \sum_{k=1}^{K_r} E_{r,k} \cdot P_{r,k} \right] \]

\[ GC = \sum_{j=0}^{J} \left[ \sum_{i=0}^{\tau} IC_{i,j} \cdot D_i + EC_{i,j} \cdot D_i + GHG_{i,j} \right] \]

\[ AI(\tau) = \sum_{j=1}^{J} \left[ \sum_{i=0}^{\tau} IC_{i,j} \cdot D_i \right] - \left[ \sum_{i=0}^{\tau} IC_{BAU,i,0} \cdot D_i \right] \]
HEATING

HIGH EFFICIENCY - COP = 4.3
LOW EFFICIENCY - COP = 1.0

INSULATION

UPPER BOUND = 26.96 [€/R]
LOWER BOUND = 9.81 [€/R]
Cost optimality: Integration of thermal comfort, productivity and health benefits

1. The cost-optimal methodology involves a balance between costs and energy savings throughout the lifecycle of the building. There is a large level of flexibility when selecting the input data for calculation (reference buildings characteristics, discount rates, energy costs, investment costs, …). Currently, the first challenge that I wish to address is to develop a multidimensional approach focused on the owner perspective.

2. Buildings with low comfort levels are associated with health problems and can have a negative economic impact. It can imply direct medical costs or indirect costs related with lower productivity levels (reduction of the individual performance due to, for example, higher absenteeism). This fact justifies the major challenge which is to introduce the cost dimension associated with health on cost-optimal approaches.

3. Solving cost-optimal problems is a highly time-consuming process and there is a lack of experience among energy experts. As the objective is to contribute to the effective implementation of cost-optimal energy efficient solutions in buildings (including the comfort dimension), it is mandatory to provide tools contributing to the proficiency of energy experts, offering direct benefits to owners. The third challenge to address is the conversion of the multidimensional and complex problem into a user-friendly tool.
The problem is characterized by a large list of variables that need to be considered together: reference buildings, discount rates, energy costs, energy measures, inter alia. This multidimensional problem may be tackled using multi-objective optimization models.

The amount of possible combinations of efficiency measures hinders the selection of the cost-optimal ones by stakeholders: authorities (in policy making), experts (in the recommendation of corrective actions), suppliers of products and services (in their market positioning) and buildings owners (in the investment decision).
First, the selection of solutions on common cost bases considering the suitability for reference buildings.

Step 2 involves performing simulations of the energy performance of combinations of the most competitive solutions that had been previously selected.

The third step is to calculate the global cost for the combinations of improvement measures.

At the end, a sensitivity analysis is performed by comparing the profitability for different scenarios.