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Optimizing Residential Housing Renovation Strategies at Territorial Scale: A Data Driven Approach and Insights from the French Context

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Abstract : In a scenario of extensive residential housing renovation, stakeholders need models that support decision-making through a deep understanding of the existing building stock and accurate energy demand simulations. To address this need, we have modified an optimization model using open data that enables the study of renovation strategies at both territorial and national scales. This approach provides (1) a definition of a strategy to simplify decision trees from theoretical combinations, (2) input to decision makers on real-world renovation constraints, (3) more reliable identification of energy-saving measures (changes in technology or behaviour), and (4) discrepancies between currently planned and actually achieved strategies. The main contribution of the studies described in this document is the geographic scale: all residential buildings in the areas of interest were modeled and simulated using national data (geometries and attributes). These buildings were then renovated, when necessary, in accordance with the environmental objectives, taking into account the constraints applicable to each territory (number of renovations per year) or at the national level (renovation of thermal deficiencies (Energy Performance Certificates F&G)). This differs from traditional approaches that focus only on a few buildings or archetypes. This model can also be used to analyze the evolution of a building stock as a whole, as it can take into account both the construction of new buildings and their demolition or sale. Using specific case studies of French territories, this paper highlights a significant discrepancy between the strategies currently advocated by decision-makers and those proposed by our optimization model. This discrepancy is particularly evident in critical metrics such as the relationship between the number of renovations per year and achievable climate targets or the financial support currently available to households and the remaining costs. In addition, users are free to seek optimizations for their building stock across a range of different metrics (e.g., financial, energy, environmental, or life cycle analysis). These results are a clear call to re-evaluate existing renovation strategies and take a more nuanced and customized approach. As the climate crisis moves inexorably forward, harnessing the potential of advanced technologies and data-driven methodologies is imperative.

Keywords : residential housing renovation, MILP, energy demand simulations, data-driven methodology
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