# Numerical benchmarks for the comparison of inverse modeling techniques to identify building wall thermal resistance

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## ABSTRACT

European countries set a significant goal to reduce the energy consumption by 30% and CO2 emissions before 2030. As the building sector represents in Europe about one third of energy consumption, it is a sector of particular interest. To reduce the energy consumption in existing buildings, three complementary actions can be planned: the building thermal refurbishment, the smart management of building equipments and the awareness of users. In the presentation, we address the first point. The objective, fixed in the French national research project "ResBati", is to identify bad insulated building envelope and to quantify its thermal resistance by inverse modeling techniques coupling sensor outputs and physical models. To accelerate the identification process, a part of the envelope is excited by an imposed flux on the inside face using lights. During the active excitation, temperature are recorded on both faces of the wall and integrated in inverse modeling techniques. Three different inverse modeling strategies, developed by IFSTTAR, CSTB and UPEC, are compared on numerical benchmarks. Two kinds of envelopes are considered: interior insulated walls and single-walls. Both IFSTTAR and UPEC strategies use 1D thermal PDE to represent the thermal behavior of the wall while CSTB considers 0D resistance-capacitance model. Concerning the inverse techniques, a maximum likelihood estimation method is applied by CSTB [1], UPEC implements a trust region algorithm and a Bayesian inference technique. Lastly, IFSTTAR performed a data misfit minimization using the adjoint state with Tikhonov regularization. In IFSTTAR strategy, the regularization parameter is chosen using Morozov principle considering both measurement and model errors. Herein, the model error comes from the simplification of 3D thermal problem to a 1D thermal problem. All the considered inverse approaches propose an estimation of the uncertainty on the identified wall building thermal resistance. First results show that thermal resistance of interior insulated walls is better identified by CSTB approach at a low computational cost whereas IFSTTAR inverse technique is more relevant for single-walls.

## REFERENCES

[1] Thébault, S. and Bouchié, R. Refinement of the ISABELE method regarding uncertainty quantification and thermal dynamics modelling, *Energ. & Build.*, Vol. **178**, pp. 182–205, (2018).