Development of a decision-making model based on fuzzy logic for the optimization low-energy residential building design in Algeria

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The performance optimisation of low-energy buildings should always take place in the early design stages when most of the critical decisions affecting building energy performance are made by integrating the optimal values of different building parameters depending on the climatic conditions. This research aims to contribute to the implementation of energy-efficient housing buildings across the Algerian territory and under all Algerian climate zones through informed design decision making in the early design stages of low-energy building.

- Monitoring and calibration of residential building model which represents the mainstream building typology in Algeria using EnergyPlus,
- Using a mixed approach combing bioclimatic charts and building performance simulations to evaluate the bioclimatic potential of the Algerian climate zones,
- Using mixed approach that combine between building performance simulation (BPS) tool and building performance optimization (BPO) algorithm to define the optimal passive design solution for Algerian climate zones,
- Development of an Adaptive Neuro-Fuzzy Inference System (ANFIS) to estimate the cooling and the heating energy loads.

low-energy building, energy efficiency, thermal comfort, climatic zoning; design optimization, NSGA-II, ANFIS, decision-making model.

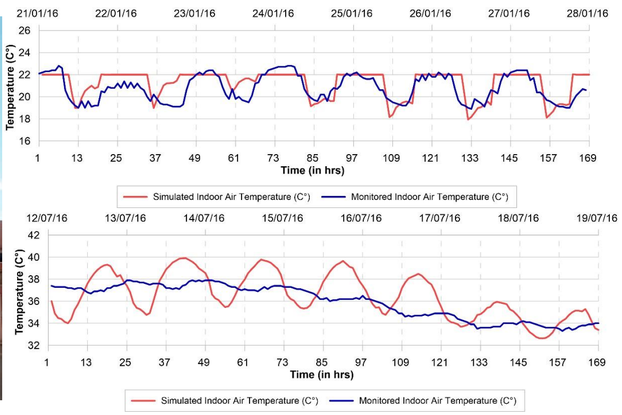
In Algeria, the final energy consumption remains dominated by the housing sector, which represents 36% of the total final consumption [1]. In 2019, the energy use increased more than 80 % from 2009. Thus, The prospects for developing the housing stock will lead to an exponential increase in this energy consumption. However, Buildings in the residential sector nevertheless have a significant potential for energy savings. In this context, the construction of energy-efficient housing is essential for controlling energy consumption in the residential sector.

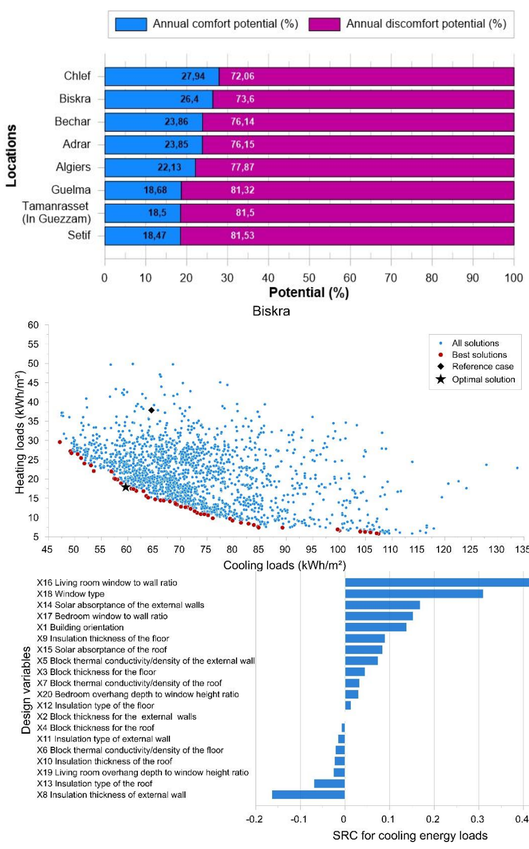
To design and construct low-energy buildings, it is essential to assure informed decision-making during the early design phases [2]. Therefore, there is a need for the development of decision support tools that can predict the building performance and support the design decision making of low-energy buildings.

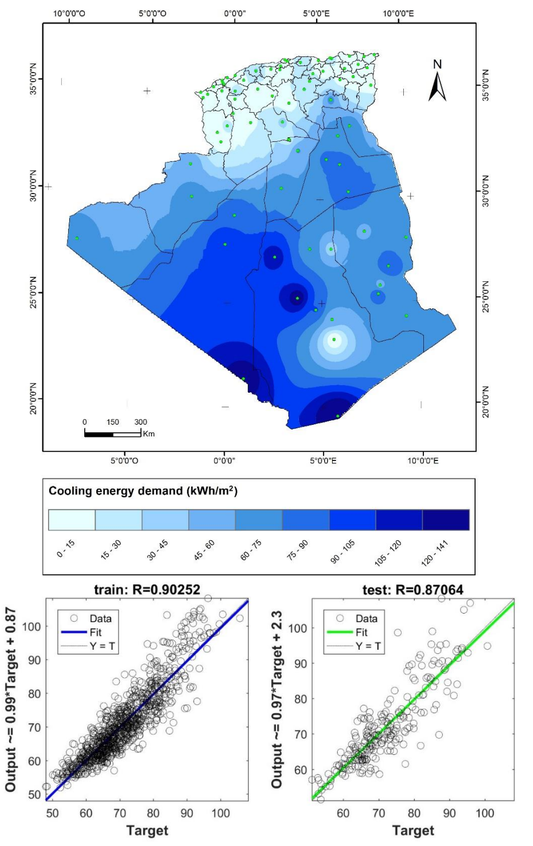
- Analyze the bioclimatic potential of the Algerian climate zones,
- Develop new zoning maps based on thermal energy demand and indoor-discomfort hours,
- Optimize the passive envelope design measures for multi-family apartment building,
- Forecast the building heating and cooling energy loads in their early design phases,

Architects, designers, building engineers, national and local authorities, researchers.

- What are the thermal comfort and passive design potential of the Algerian climate zones?
- What are the most influential passive design variables on the cooling and heating energy demand for Algerian climate zones?
- What are the optimal passive and energy efficiency solutions for Algerian climate zones?







- The study provided an accurate estimation of the bioclimatic potential for the whole country of Algeria,
- The study presented six new maps in high-resolution that show the spatial distribution of thermal comfort and energy demand in Algeria,
- The study used and applied for the first time, in the Algerian context, an advanced simulation approach involving automated optimization (NSGA-II),
- The study developed a design decision-making models using the adaptive neuro-fuzzy inference system (ANFIS) to estimate the building energy consumption based on the building passive design variables for a mainstream building typology.

- The percentage of average discomfort hours in Algerian households across all climatic zones is around 60% [3].
- Evaporative cooling is the most effective bioclimatic design strategy in Algeria, accounting for 60% of the hours annually in cooling-dominated cities due to their arid nature [3].
- The current base case that represents the most commonly constructed architectural type in Algeria is far away from the optimal design recommendations [4].
- Our optimization approach achieved energy saving ranging from around 21% to 51%.

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