Digital human-building avatar for energy-efficient building design and operation with advanced thermal occupant model

The occupant's thermal comfort is the most influential aspect to be considered in building design since it impacts the building's energy consumption and occupants' well-being. Building performance simulations (BPS) are used to optimize building parameters. Nonetheless, the projected energy consumption differs significantly from its real-life values due to inadequate consideration of human factors.

So far, only global thermal sensation models (predicted mean value and adaptive comfort model) have been coupled with BPS to evaluate occupant thermal comfort. Nonetheless, it is known that local discomfort overrides global comfort – the fact not considered by global thermal sensation models but frequently occurs in spaces exposed to solar radiation or large temperature gradients and locally increased air speed. Therefore, an adequate analysis of the occupants' comfort can only be done using a human thermoregulation model with an integrated clothing model and a local thermal sensation model. Integrating a sequence of well-validated and coupled models in BPS is a challenge in terms of the availability of such models and the computational time needed for the simulation of occupants in a building simulation over a year. Secondly, thermal building models typically represent idealized zones with environmental parameters expressed as a single value for the entire zone. This is insufficient to consider any local discomfort. On the other hand, computational fluid dynamic modelling (CFD) could offer greater parameter resolution but are too time- and computational-resources-consuming to be considered for the simulation of the entire building throughout the year. Thus, a new tool is necessary to address local room parameters based on node parameters provided by BPS and known building configuration.

The main project aim to develop and measurement validation a human-building avatar for precise prediction of human comfort and energy demand in building under conditions of variable internal and external loads during the year. Such an avatar shall consist of an advanced thermal model coupled with the physical representation of the building structure and associated heating, ventilation and air conditioning systems developed in EnergyPlus. In addition, a data-driven model of individual rooms or spatial zones will be derived to translate single-value node data provided by EnergyPlus to local physical parameter distribution (e.g., temperature, solar radiation, and air speed) essential for evaluating spatial and temporal comfort distribution. Secondly, an advanced occupant model will provide a realistic estimation of the thermal load in the building due to the occupants' presence and activity.

The research carried out in the project includes experimental work and computer modelling. Project expected impact includes increased simulation accuracy of the thermal state of the occupants and their heat load contribution to the energy balance of the building, and hence, improved accuracy of the calculation of the building energy consumption.