Indoor environment prediction using climate correlation models

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PRELUDE is a H2020 project which aims to facilitate the transition to clean energy by combining innovative, smart, low-cost solutions into a proactive optimization service. The project is focused on assessing the right level of smartness necessary for any given household and then providing the optimal tools according to the needs of the user. A schematic of the approach is shown in Figure 1. The system is designed to be versatile and adapt to the engagement, monitoring, and automation level of the building. Passive solutions, such as natural ventilation and cooling, are prioritized through a free-running strategy. Predictive maintenance is implemented to reduce costs, emphasizing Renewable Energy Sources. Big data and advanced analytic tools are used to facilitate flexible building side demand and ease the integration into district heating and electricity grids. Proactive optimization is aimed to be achieved through data predictive control.

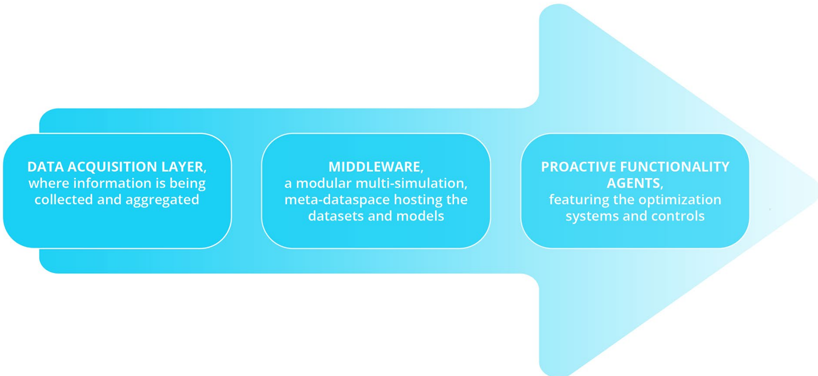

Figure 1: The PRELUDE approach

Within the PRELUDE project, a climate correlation model was developed to derive simple rules on how to operate the opening of windows in naturally ventilated residences so that thermal comfort and indoor air quality (IAQ) are provided as far as possible. This model builds on bioclimatic design principles which consider how a space can be conditioned if the external climate conditions are known. The proposed model is based on indoor/outdoor correlations, derived through simulations using EnergyPlus. Simulation test cases were defined considering factors that can statistically change correlations, including the effect of single-sided and cross-ventilation, trickle ventilators, different schedules for window opening, heating and occupancy, size of the space, and building orientation. The study found strong correlations between external and internal hourly temperatures, as well as between airflow and wind speed, and the inverse temperature differences between outdoor and indoor. The derived model consists of coefficients of determination (R^2) between the correlated parameters and a set of equations to calculate thermal comfort and pollutant concentrations in the space. The correlations are then used to predict internal operative temperature, ventilation rates and natural illuminance levels from forecasts of ambient conditions based on models developed within the PRELUDE project. Finally, thermal comfort can be evaluated (based on the adaptive thermal comfort model), and indoor concentrations of contaminants such as CO_2, VOC, PM2.5, and moisture using contaminant transient mass balance equations. The rate of contaminants is determined by the outside concentration and internal emissions from materials and household activities.

Figure 2 shows an example of the thermal comfort, metabolic CO_2 and natural illuminance predictions in one of the PRELUDE buildings. The correlation equations were derived through extensive simulations using EnergyPlus with data provided by the studied building. The derived correlations are implemented in an Excel spreadsheet and are used with external data sourced through weather forecasts for the required period. It is then straightforward to predict internal environmental conditions which are communicated to the occupants of the building to inform their behaviours for the next day.

The model is being tested in pilot buildings of the PRELUDE project (Figure 3) to compare its predictions with measured parameters. Once validated, it will be a useful tool for low-technology residential buildings in which automatic controls of windows and blinds are not available.

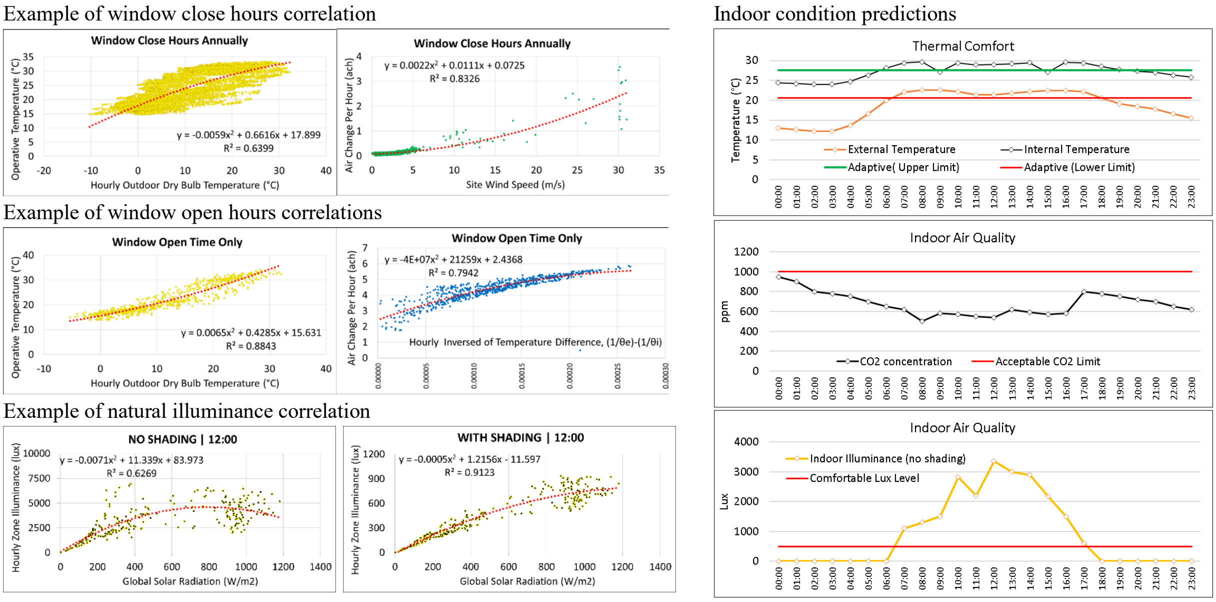

Figure 2: The climate correlation model that informs occupants on how to use windows and blinds

Figure 3. External photo of the case-study PRELUDE pilot building

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