**INTRO**

Energy consumption and indoor environment are two very fundamental yet conflicting objectives of building design. Finding a design that takes full advantage of a situation, while satisfying both of these objectives, is a challenge even for experienced engineers due to the number of parameters and strategies involved. In order to significantly reduce the energy consumption while maintaining a comfortable indoor environment, global optimization techniques such as genetic algorithms can be used. [Magnier2010]

The building sector has the highest share of operational energy consumption and greenhouse gas missions among all sectors. Environmental targets set by many countries impose the need to improve the environmental footprint of the existing building stock. Building retrofit is considered one of the most promising solutions towards this direction. According to the European Commission, operational energy involved in the building sector is responsible for nearly 40% and 36% of the total energy consumption and CO2 emissions, respectively. Thus, reducing the environmental footprint of the building sector is a big step towards a more sustainable environment. [Thrampoulidis2020]

Building retrofit, especially large-scale retrofit, is considered of highest importance to reduce the overall share of energy consumption and GHG emissions of the building sector. Building retrofit is the process of adjusting a building after it has been constructed and occupied to improve its environmental footprint. [Thrampoulidis2023]

More and more BESMs (building energy simulation models) are built to simulate existing buildings in operation, rather than buildings in design. Calibrating the models with building operation data is becoming an important issue. However, in the building operation phase, developing and calibrating a BESM becomes difficult because all operating parameters must be adjusted according to real-time data. Engineers must randomly adjust input parameters until the output energy use matches measured energy use. To solve the problem above, a new calibration approach with a detailed procedure is proposed in this paper. This approach relies on electricity submetering data and HVAC (Heating, Ventilation and Air Conditioning) cooling/heating loads. These data are becoming more vailable in commercial buildings [Ji2015]

High resolution data are getting increasingly used in BEMS. In comparison, measurements of the other outputs such as HVAC energy, equipment electricity, and indoor dry bulb temperature would involve installing sub-meters and/or accessing the building automation system where data is usually available at sub-hourly resolution. High-resolution data is prevalent in both automated and manual approaches possibly due to increasing sensing capabilities and data availability in the built environment. [Chong2021]

However, in order to have a robust prediction of the impact on energy consumption and comfort of the planned interventions, the simulation model has to be calibrated against measured data. Temperature and heat flow meter data are used for calibration. [Angelotti2018]

The European Commission presented the EGD to the EU institutions and the public on December 11, 2019. After a parliamentary debate in January 2020, the European Parliament decided to support the EGD, but pointed out that more needed to be done to achieve a just transition that would leave no one behind. [The main goals of the EGD are a net carbon neutral European Union by 2050 and a decoupling of economic growth and resource use. The EGD is not a law in itself, but a general policy strategy, outlining the ambitions and goals in different policy sectors. Buildings account for 40% of the energy consumed in the European Union. To reach the 2030 climate target of a 55% emissions reduction, greenhouse gas emissions from buildings need to be reduced by 60%, and energy consumption lowered by 14%.35 Energy consumption could be much lower if all buildings adhered to newest standards in energy efficiency and insulation. Old buildings need to be brought to the newest standards, especially with regards to energy efficiency and insulation. [Fetting2020]

**Literature**

[Gokhale2022] Implemented a physics-informed neural network to model the temporal evolution of room temperature, power consumptions and temperature of the building thermal mass. In particular, two different variants were proposed. The first configuration consisted of an encoder and dynamics modules, while the second was a simple fully connected network. To introduce physics in the network, a grey box approach with a two resistances and two capacitors (2R2C) model was used. The results showed that both the network architectures where able to accurately predict the room temperature. Additionally, the models proved to be data-efficient, hence requiring less training data.

[DiNatale2022] Proposed a Physically Consistent Neural Network (PCNN) for building zone thermal modelling. The model consisted of a simple neural network and a physics-informed module with prior physical knowledge. In particular, the thermal dynamics of the building was described by an ordinary differential equation (ODE) which represented a simple RC model. Even if the PCNN showed similar performance to the single neural network, the results proved that the temperature prediction could remain physically consistent.

[Xiao2023] This article proposes a novel physically consistent deep learning (PCDL) approach for building thermal modeling and assesses its potential for optimizing building energy efficiency and indoor thermal comfort through model predictive control (MPC). The PCDL model considers physical relationships between system inputs and outputs and is applied to predict the indoor thermal climate. the proposed PCDL model has better generalization ability than other machine learning approaches. Subsequently, the PCDL model is integrated into an MPC controller to optimize building energy consumption and indoor thermal comfort. The PCDL model demonstrate a much better generalization ability for yielding physically-feasible predictions compared to the long short-term memory (LSTM) model. he proposed PCDL-based MPC reduces by 5.8%, 4.5%, and 8.9% energy consumption and improves by 55%, 59%, and 64% indoor thermal comfort, respectively, and therefore enhances the building decarbonization progress. A two-layer RNN-LSTM model structure is used to construct the PCDL model that enforces positive constraints on the weighting parameters of the RNN cell to ensure physics consistencies.

[Chen2023] Thus, we propose a novel model based on a physics-informed neural network dubbed as PhysCon, which combines the interpretable ability of physical laws and the expressive power of neural networks for control-oriented demand response of grid-integrated buildings. Specifically, a Resistance-Capacitance (2R2C) thermal model is adopted to express the knowledge of building physics, and a full-connected neural network is developed to learn the information from actual data. The results show that PhysCon outperforms the purely data-driven model in predicting the room temperature and thermal load demand for both light and heavy buildings. for demand response (DR) control in grid-integrated buildings.

[Wang2023] Therefore, in this research study, we proposed a novel physics-informed input convex neural network (PINN) to predict indoor environmental dynamics with 6 h ahead. The model sanity check results showed that the proposed PINN had physically consistent behavior to different control inputs. Then, the PINN is used to design a hierarchical data-driven predictive control (HDDPC) strategy to minimize both the space cooling load and airside coil load. On average, the HDDPC strategy could reduce more than 35% of total cooling energy and 70% of total airside coil energy with the guarantee of indoor thermal comfort and air quality. The proposed neural network can not only guarantee the time correlation between inputs and outputs but also provide accurate, physics-consistent predictions for indoor temperature and CO2 dynamics. Incorporating both indoor temperature and air quality considerations into the predictive control strategy