Machine Learning and Quick Energy Prediction!

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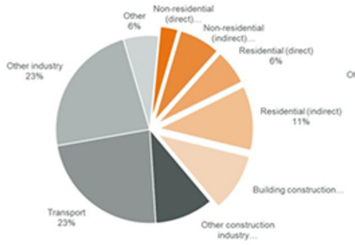
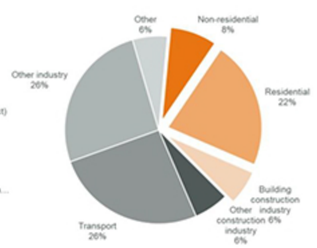
Abstract

Buildings contribution to Energy usage and environmental impacts

Co2 emission 37 %

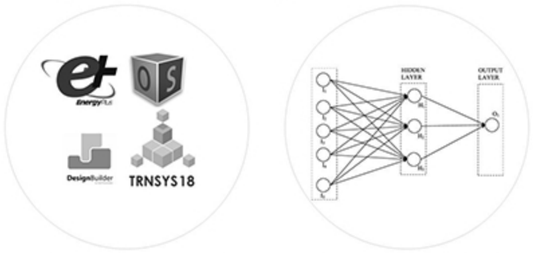


Energy usage 36 %



ML as a substitute for time-consuming and computationally expensive Energy simulation software

Energy simulation **vs** ML



Role of ML in Buildings life-cycle and using its prediction power based on different building characteristics

Introduction / background information

energy-saving strategies in building construction are still slow compared with the industry and have not kept pace with the need for change.

demanding process of working with energy simulation software discourages most architects from assessing and improving the energy demand of their design solutions

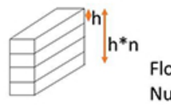
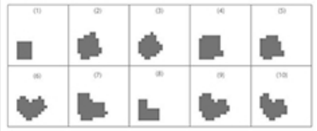
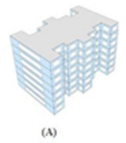
ML, as a powerful solution, enables the system to learn from previous experiences without being explicitly programmed and has a great capacity for solving multi-dimensional problems of interest.

In this study, we focus on a range of articles that have utilized ML to improve energy efficiency during different design stages based on different building characteristics.

Methods and data

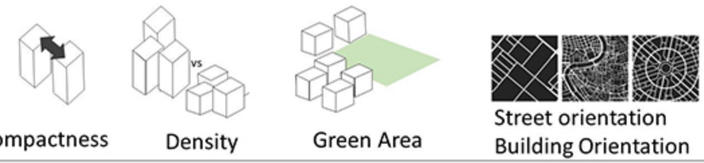
configuration

Individual

Simple	**Complex**
determining key simple geometrical factors influencing energy use developing reliable fast-computing statistical models using ML	ANN model is rarely used to predict the energy consumption of the complex building scheme at the early design stage generalization of ML for multiple building shapes for early-stage energy prediction
 Orientation  Aspect Ratio Building Scale  Floor-floor height Number of floors	   
- For heating energy, floor numbers and building scale show a non-linear yet monotonic trend. - total energy has positive correlations with the total building area + rooms' numbers. - testing different ANN structures is necessary to achieve high accuracy.	- ANN method can accelerate the optimization process -CNN model facilitates communication within the design team using graphical representations of the design options. - It is possible to simplify energy prediction of complex shapes by decomposing methods.

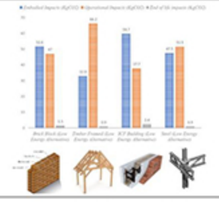
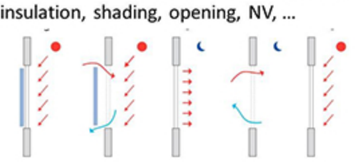
Urban

the effect of spatial structural urban form indices



- compactness, passivity, shading, and diversity among the most influential factors

Envelope

composition	**Control logics**
Predicting lifecycle impacts of different building typologies varying materials 	ML in controlling dynamic façade, movable, insulation, shading, opening, NV, ... 
- increasing R-value above a certain point does not improve energy performance. - lowest WWR => minimum Ozone depletion. - embodied energy contributes up to 60% of LC in buildings with min operational energy	- RL leads to the most optimum control strategies compared to rule-based and MPC.

Methods and data

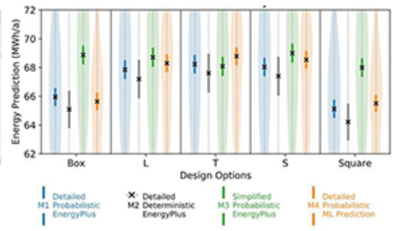
Integrated approaches

Combining parametric modeling and energy simulation process and offering a reliable model for energy prediction based on user inputs.
Comparing different ML prediction methods' errors with each other and with Energy simulation results and modeling and prediction time

Revit Plugin / BIM Plugin / MATLAB environment / user-interface developed by VB

Example of developed user interfaces

Comparing different prediction methods with detailed EnergyPlus simulation



- With training algorithms predict energy usage with No drawings or deep modeling expertise but only a few numbers, And more than 50 times faster than simulation!
- In order to reduce the computational time, we could rely on detailed ML and avoid simplifying zones and factor in the effect of uncertain parameters considering a threshold.

Summary of Findings

We witness less attention to the impact of design decisions on **cost** and **embodied** energy.

Current research lacks an adequate amount of **training data**, and also the trained algorithms could not be applied to new situations.

exploring the **design alternatives** more efficiently through integrating **human-computer interaction** with the **energy prediction** process.

providing a comprehensive approach for building energy prediction of **different climate zones**.

There is a huge gap in determining the **impact of building neighbors and site** conditions, and it has often been disregarded.