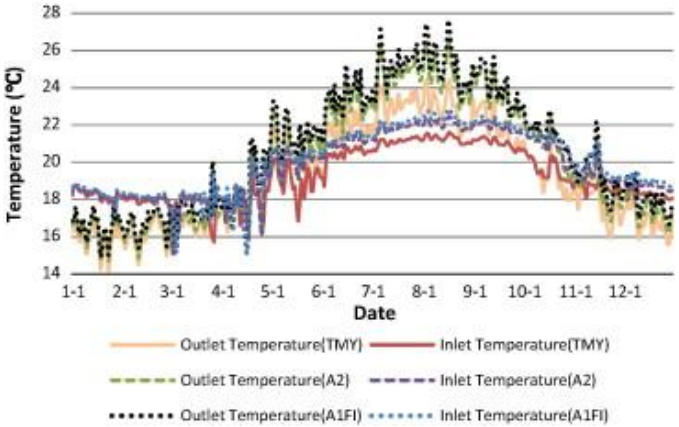
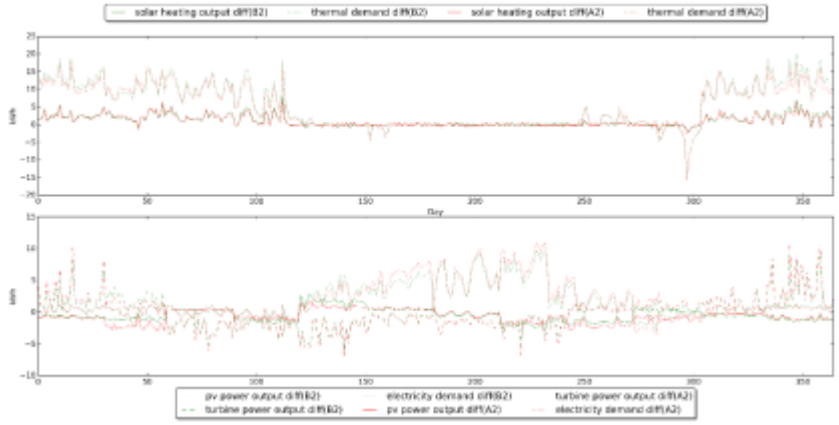
Pengyuan is a PhD candidate in Department of Architecture at PennDesign. He got his bachelor degree from School of Mechanical Engineering in Tongji University, with a focus on building environmental engineering. He finished his Master of Science in Architecture at PennDesign after two years' of working in Tongji University and Shanghai Research Institute of Building Science. His research interest during PhD mainly involves building energy simulation, data-driven models, optimization, and climate change impacts on buildings.

1. Climate Change

During the study of his master degree, he found his interest in researching how future climate change is going to influence building energy use and its forthcoming change in decision making process. Using EnergyPlus as the building simulation engine and future downscaled hourly weather data, the performance of ground source heat pump and onsite renewable energy sources are studied under the context of climate change and the role they would play in achieving net zero energy buildings in the future, and it is proposed that the design and decision making process regarding building's energy performance should be subject to climate change and its uncertainties.



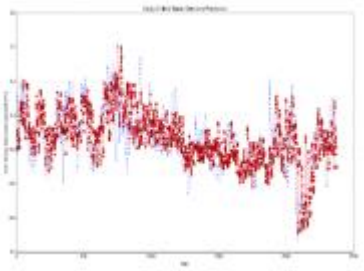
TRNSYS modeling of GSHP with ground temperature being coupled


Difference of daily building load and energy production of each sub system under B1 and A2 compared with TMY in Albuquerque's residential building

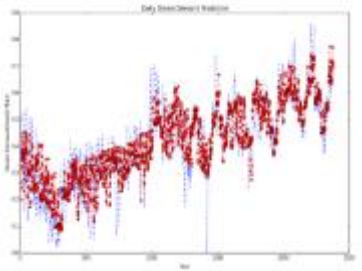
2. Data-driven & Simplified Modeling Method

He is also interested in adopting data-driven modeling methods and gray model in building energy modeling. Related researches involved using and comparing different machine learning algorithm to study the short-term pattern and behavior of on campus building at Penn. As appropriate

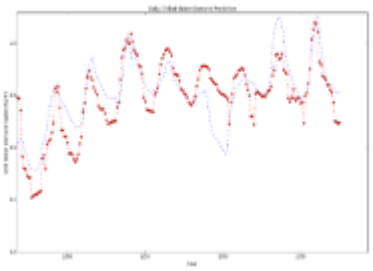
period of sliding window is selected as the training data, the data-driven model is able to predict near future building energy performance with good confidence.



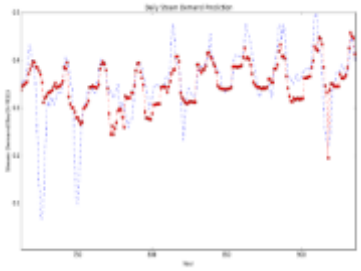
chilled water prediction (3 months granularity)



steam use prediction (3 months granularity)



chilled water prediction (10 days granularity)

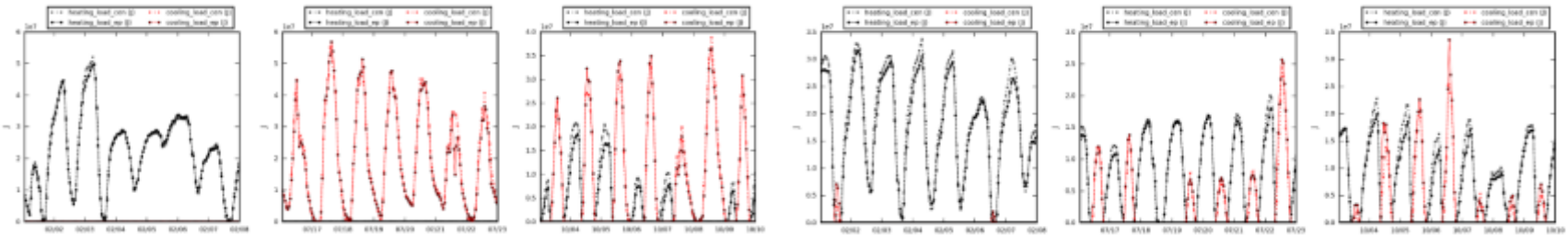


steam use prediction (10 days granularity)

In order to reduce computational resource of building simulation in dealing with large scale combinatorial problems, a building simulation tool based on ISO13790 standard called SimBldPy is also under the development using Python programming. The tool adopts simplified hourly method by means of resistantce & capacitance (RC) gray modeling to do hourly heating and cooling load and energy simulation with building zone thermal coupling. The user can specify the building's geometry, material properties of building facade, use schedules, and etc. through text based input file. This simulation tool is light-weighted compared with popular white modeling tools like EnergyPlus, making it less intense in computational efforts and comparatively reliable simulation results. The end of the development of this tools if for the fast parametric study and retrofit options screening and selection.

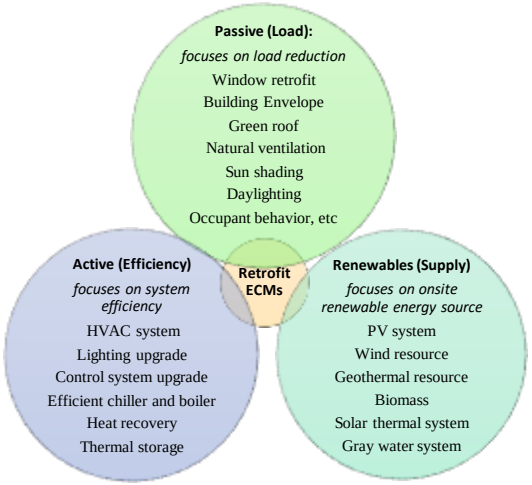
Houston

San Francisco



Validation of the simplified model with EenrgyPlus of an office building in different climate zones

3. Building Retrofit

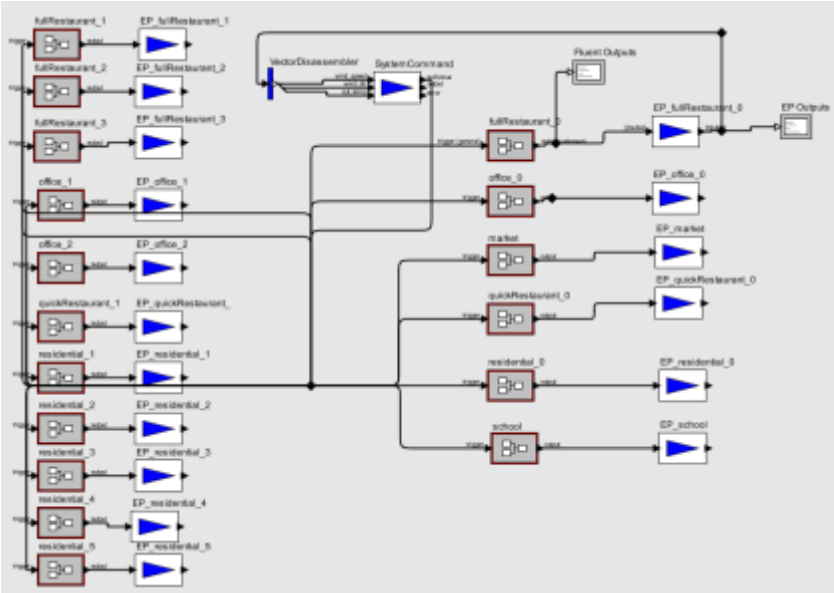


Building retrofit has always been an inevitable topic in achieving a future world with low energy using and carbon emission in building sector. With the help of data-driven and simplified gray model method, we see the light in solving multi-objective optimization problem regarding huge combinatorial design space regarding building thermal physical properties, mechanical systems, and schedules.

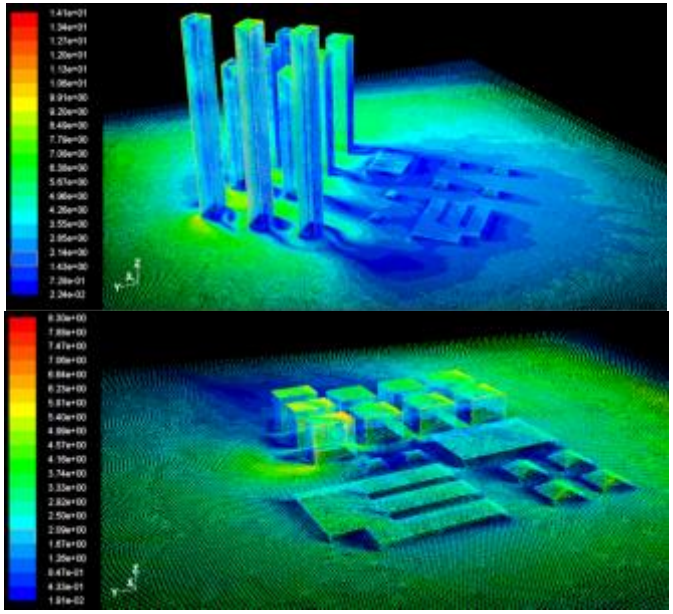
The optimization method being developed by Pengyuan will be applied to the campus buildings at Penn by providing non-dominated solutions to the decision making in retrofit for each building according to their respective goals in energy saving, type of use, and thermal comfort in the next thirty or forty years.

4. Regional scale modeling

What kind of geometrical form of a community can be the most energy efficient one for a particular climate zone? Here, the "geometrical form" involves floor area ratio (FAR), street setbacks, orientation of a community (or regional, urban scale). This research is about a regional building energy simulation method coupling with computational fluid dynamics (CFD) simulation. A tool is programmed to be able to take in these design variables for a CFD simulation with different types of buildings in the region (residential, commercial, school, and etc.). Each type of the building is represented by DOE's reference EnergyPlus model. The method then creates an urban environment for the buildings in the region with different combinations of FAR, setbacks, and orientation and CFD simulation will be coupled with EnergyPlus for each case of variable combination to find the best one with the help of building controls virtual test bed (BCVTB).



EnergyPlus simulation of buildings coupled with CFD using BCVTB in the region



Two exemplary regional “forms” with different orientation, FAR, and setbacks