Project Proposal

Exploratory Analysis of EnergyPlus Simulation Data with Database Management and Web-Based Visualization

Athul Jose P
Kunal Shankar

CptS 575 Data Science
Washington State University

Objective

This project analyzes data generated from numerous EnergyPlus simulations using Pacific Northwest National Laboratory (PNNL) Prototype Building Models and weather files. The goal is to perform an exploratory analysis to evaluate the richness of this data, uncover potential insights, and determine its usefulness for building performance modeling. We will also identify areas where the dataset could be improved for greater depth and diversity. Additionally, the project includes the development of a NoSQL database for efficient data storage and an upgrade to an existing web app for enhanced data analysis and visualization.

Scope

The analysis will focus on how building energy performance is affected by climate conditions, schedules, and other factors. The input data for the EnergyPlus simulations includes building models and weather files sourced from the PNNL Prototype Building Models and weather databases. We will assess the potential uses of this dataset for informing energy efficiency strategies and improving energy code compliance.

Methods

- **Exploratory Data Analysis (EDA)**: Conduct an in-depth analysis of the EnergyPlus simulation data, focusing on identifying trends in energy usage, HVAC performance, and building behavior across different climate zones. Visualizations and statistical techniques will be used to evaluate data richness and identify potential improvements.
- **Database Setup**: Implement a NoSQL database to efficiently store and query the large volume of data from simulations, ensuring easy access and management.
- **Web App Enhancement**: Extend the functionality of the existing web app to include tools for interactive data analysis, such as visualizing energy performance across different climate zones and schedules. Integrate the web app with the NoSQL database to provide real-time access to simulation data.

Data Source

The dataset was generated from EnergyPlus simulations, using the PNNL Prototype Building Models [1] that cover various building types like residential, manufactured, and commercial structures. Each building model was simulated across different U.S. climate zones using weather files specific to those zones. Key data points collected include energy consumption, HVAC performance, indoor temperatures, and operational schedules. This rich dataset allows for the exploration of energy behavior across climates and building types, with minor schedule variations introduced to simulate different occupancy and operational conditions.

The dataset's breadth provides an opportunity to evaluate both typical building performance and responses to changing operational patterns. The weather files incorporated reflect realistic climate conditions, giving a solid foundation for understanding the impact of environmental factors on energy

usage. This data serves as the backbone for the exploratory analysis, database development, and web app enhancements, and will be critical for identifying trends, gaps, and areas for improvement in building modeling.

Relevant Background Work

EnergyPlus is a leading simulation tool used for modeling building energy consumption and HVAC performance across various climates. The PNNL Prototype Building Models, along with associated weather files, are trusted sources of input for these simulations, allowing for highly detailed and realistic scenarios. In our lab, scripts were developed to automate the generation of extensive simulation data, and a web app was created to visualize these results. However, the dataset generated so far remains largely unanalyzed.

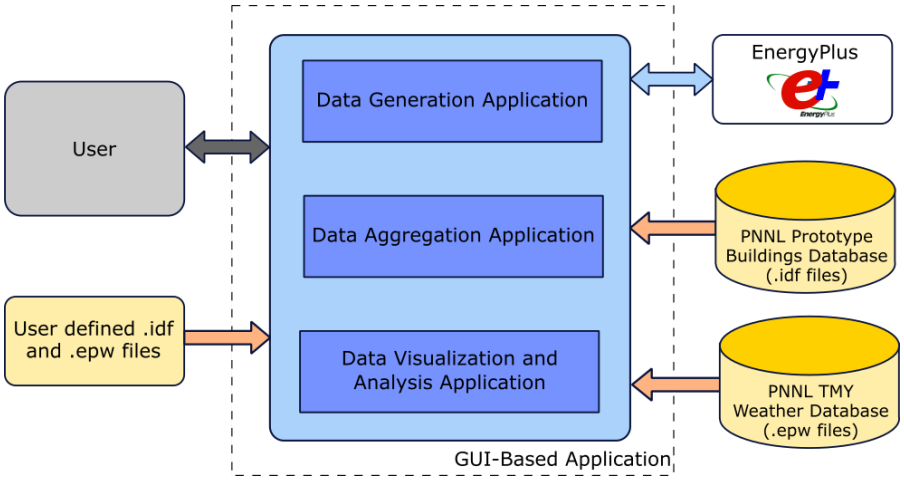

Figure 1: EnergyPlus Data Analysis GUI Tool schematic

We aim to thoroughly assess the richness and applicability of this data to determine its potential for deeper analysis, modeling, and energy optimization strategies. This analysis will help reveal gaps or areas where additional data might be needed to improve accuracy or diversity in future simulations, ensuring that the data can support a wide range of use cases in building performance modeling.

Tentative Plan

- **Weeks 1-2**: Perform an exploratory analysis to understand patterns in the dataset, including energy consumption, climate zone behavior, and operational variations. Identify initial use cases for the data.
- **Weeks 3-4**: Deepen the analysis by assessing the richness of the data and developing suggestions for improving data coverage or adding more variables. Explore how the dataset can support various building energy modeling use cases.

- **Weeks 5-6**: Enhance the web app with improved data analysis and visualization features, while integrating a NoSQL database for efficient storage and retrieval of simulation data.
- **Weeks 7-8**: Compile findings and finalize the project report with actionable insights and suggested improvements.

Second Project Choice

If the first project proposal is not feasible, a secondary project option could involve focusing on the development of the data visualization tool with enhanced interactivity and features for users to explore building energy data.

References

[1] U.S. Department of Energy, "Prototype building models," https://www.energycodes.gov/prototype-building-models, 2024, accessed: 2024-10-07.