Developing an end-use load profile tool for college campuses

Homeira Mirhosseini, Energy Engineer Intern at Ramboll, PhD Candidate in Architectural Engineering at Penn State
Supervisors: **Michael Kingsley**, Energy Services Technical Lead at Ramboll / **Mark McGuire**, Energy Services Manager at Ramboll

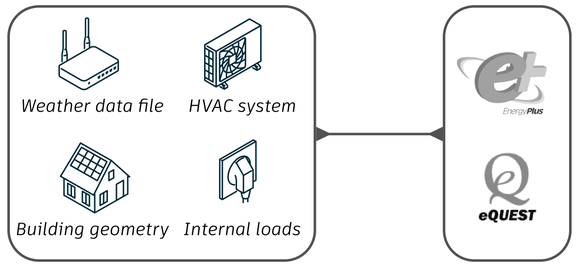
INTRODUCTION

End-use load profiles describe how and when energy is used in the building. They are needed in R&D efforts for prioritization, utility resources, and distribution system planning. Also, they are very critical for the widespread adoption of grid-interactive and efficient buildings, according to National Renewable Energy Laboratory (NREL).

End-use load profiles are foundational data sets that help different stakeholders such as grid operators, manufacturers, government entities, and research organizations in the decision-making process by helping them to understand the value of energy efficiency, demand response, and other distributed energy resources.

Load profiles fall into two categories: Load profiles that are measured using advanced metering infrastructure (AMI) or measurement and verification metering, and load profiles that are modeled using building energy modeling simulation. Both types of profiles are crucial in identifying end-use energy consumption across a region or segment of buildings.

To calculate the energy consumption of each end-use in a building on a sub-hourly basis, physics-based building energy modeling can be used. In this type of energy modeling, characteristics of the building such as insulation levels, lighting power, and HVAC equipment performance, as operational schedules and weather data are used as inputs to calculate time series results of the energy use of a building's systems and appliances using heat transfer, fluid flow, and other types of equations.



Physics-based building energy modeling simulation

NREL and its research partners (including Lawrence Berkeley National Laboratory and Argonne National Laboratory) are collaborating on a multiyear study to develop a database of end-use load profiles representing all major end uses, building types, and climate regions in the U.S. commercial and residential building stock. The project involves an innovative approach that benefits from the reach, cost-effectiveness, and granularity of data-driven and physics-based building stock modeling combined with submetering studies, statistical disaggregation of whole-building interval meter data, and other emerging data sources. The resulting public database will provide Validated end-use load profiles for the U.S. building stock at both aggregate and individual building scales, representing all major end uses, building types, and climate regions in the U.S. building stock.

METHODOLOGY

Ramboll uses hourly profiles of heating and cooling demand for campus buildings as data to analyze various methods of supplying these heating and cooling needs. Our scenario analyses examine the costs, carbon emissions, and other factors related to serving the campus building demands through individual building systems or centralized campus systems, including various low carbon supply and storage options. While the NREL profiles under development will be a great tool for this purpose, Ramboll has current projects that require load profiles now. This summer at Ramboll, we are developing our own load profile analysis tool based on datasets of end-use load profiles representing all major end uses in building types common on college campuses. We used three types of data sets to generate the required results for building load-profiles of typical college campus buildings. Datasets include the annual hourly energy use from multiple buildings for various loads such as heating, cooling, and electricity. The following datasets were used in this project:

1. **DOE Reference Building:** The U.S. Department of Energy (DOE), in conjunction with three of its national laboratories has developed a standard for building energy models for the most common commercial buildings. The reference acts as a starting point for energy efficiency research using realistic building characteristics and construction data. 16 types of buildings are determined by the DOE, the National Renewable Energy Laboratory (NREL), Pacific Northwest National Laboratory (PNNL), and Lawrence Berkeley National Laboratory (LBNL) in this guide. For the purposes of this study, we chose 6 building types that best resembled the buildings on a college campus. In addition to these building types, the DOE categorizes these buildings into 3 groups based on vintage. For this study, we assumed that the buildings were constructed after 1980. Using the commercial end uses in the chart below and the climate of Syracuse, NY, we ran building energy model simulations using the DOE reference buildings.
2. **Existing Ramboll Energy Models for previous projects:** For the second dataset, we used existing Ramboll energy models available in eQUEST to run similar simulations using the same end uses defined in the first dataset.
3. **Annual hourly measured data:** For the last dataset, we used the real-time monitored data of electric consumption from multiple buildings on a college campus.

RESULTS

Using the three datasets above, the goal was to develop a tool to estimate the load profile of a building based on given data and modifications. Load profiling is a valuable input to the scenario analysis models that Ramboll develops for campuses to provide cost optimized carbon reduction solutions.

The end result of this project was load-profiles developed from data sources (DOE reference building models, actual building models, and building interval data) to represent typical buildings on college campuses. The new load profiles provide a more precise basis for calculating energy and carbon impacts of supplying campus energy needs.

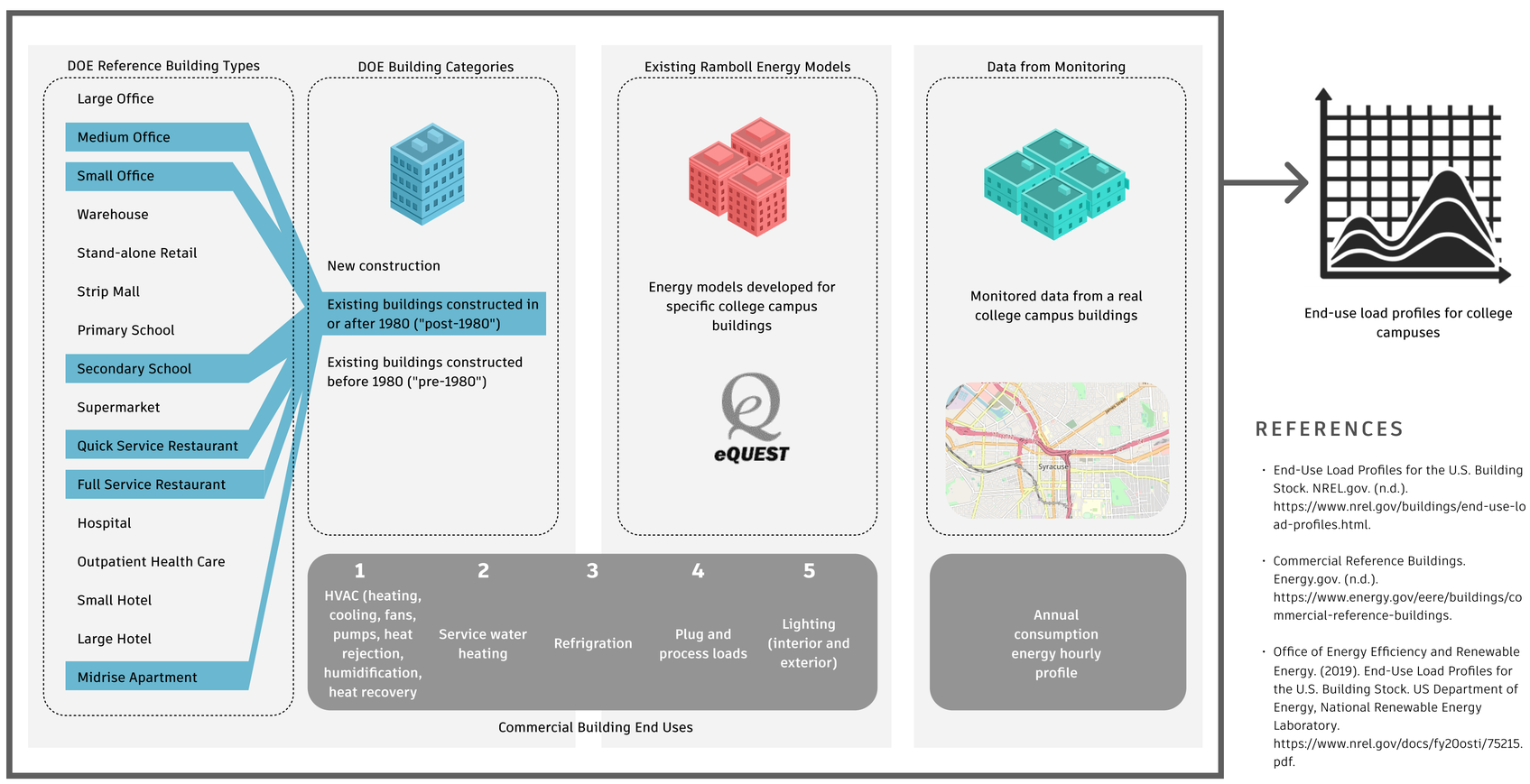


Diagram of the project methodology using three sets of data

REFERENCES

- End-Use Load Profiles for the U.S. Building Stock. NREL.gov. (n.d.). https://www.nrel.gov/buildings/end-use-load-profiles.html.
- Commercial Reference Buildings. Energy.gov. (n.d.). https://www.energy.gov/eere/buildings/commercial-reference-buildings.
- Office of Energy Efficiency and Renewable Energy. (2019). End-Use Load Profiles for the U.S. Building Stock. US Department of Energy, National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy20osti/75215.pdf.