End Use Load Profiles for the U.S. Building Stock

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Project Overview

The U.S. Department of Energy's Building Technologies Office is funding a 3-year research effort to produce updated end-use load profiles for the entire U.S. residential and commercial building stock.

Methodology

Researchers from three national laboratories are collaborating with industry partners to collect and evaluate end-use and whole building load profile data from a wide range of existing sources. Critical gaps will be addressed with additional data collection and disaggregation techniques. Ultimately, the data will be used to calibrate building stock models and produce hourly end-use load profiles at both aggregate (average) and individual (typical) building scales, for regions and building types across the U.S. building stock.

The resulting end-use load profiles, along with the underlying calibrated models, will be publicly available as tools for the energy industry. The load shapes and models will be available to generate time-of-savings shapes for both existing and emerging energy efficiency and demand response technologies as well as for many other uses such as electricity resource planning, rate design, and program impact evaluation.

Progress to Date

The first year of the project is nearly complete, and the project team has successfully framed out the remainder of the project. Identification of use cases for resultant end use load profiles led to the identification of tentative data requirements: 15-minute time resolution real-power data at the utility territory level using stochastic occupant-driven loads. Armed with this context, the team tabulated the current sources used for each of the 657 current building stock model inputs and highlighted those that require updating. In addition to ensuring we are using the best available data from the U.S. Energy Information Administration, U.S. Census, and other nationally available surveys, we are pursuing a wide range of more specific data sources, including:

- utility advanced metering infrastructure (AMI) data,
- circuit-level submetering study data,
- connected thermostat data,
- Building Automation/Management Systems (BAS/BMS) data, and
- Evaluation, Measurement and Verification (EM&V) study data.

These data will be used to update modeling inputs, such as appliance and equipment schedules, as well as to calibrate models and validate the resulting end-use load profiles.

Our technical advisory group is made up of over 70 people from industry, government, non-profit, utility, and other sectors. They have been instrumental in our work thus far, providing guidance and recommendations at every step. They helped us understand how these load profiles will be used, and the data needs that accompany those use cases, and helped us locate appropriate data for our modeling and calibration needs.

We are now wrapping up work on our first-year report covering end use load profile market needs, use cases, and data gaps. The report should be available publicly by the end of 2019.

Next Steps

The first year of the project is nearly complete. Over the second project year the team will further its work on all aspects of the project including targeted acquisition of ground-truth data, statistical disaggregation of specific end uses from AMI data, stochastic modeling of occupancy and events, and calibration of building stock model results.

Poster Highlights

- Use cases for end use load profiles
- Data requirements for end use load profile use cases
- Data gaps we are still looking to fill (Note: we have funding available for certain types of high-priority data)
- An example of how we use data for calibration

Contact

If you are interested in hearing more about this project but can't make the poster session, or if you have data that might benefit the project, we'd love to hear from you. Have a look at our website or send an email to elaina.present@nrel.gov.

NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

End-Use Load Profiles for the U.S. Building Stock

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BUILDING SCIENCE AND INNOVATION

Research Vision

End-use load profiles describe *how* and *when* energy is used in buildings on an hourly or sub-hourly basis. These profiles…

- are the **most essential** data resource currently missing for time-sensitive valuation of energy efficiency (BTO survey)
- enable analysis of energy efficiency (EE) technologies for R&D prioritization, utility resource and distribution system planning, and state/local energy planning and regulation.
- are the foundation for understanding energy flexibility in the building stock, as well as the relationship between EE and DR measures.
- potentially influence $7.8B spent annually on ratepayer-funded EE and DR programs in the United States, as well as $20B in annual utility transmission infrastructure spending.

Challenge

Existing end-use load profiles

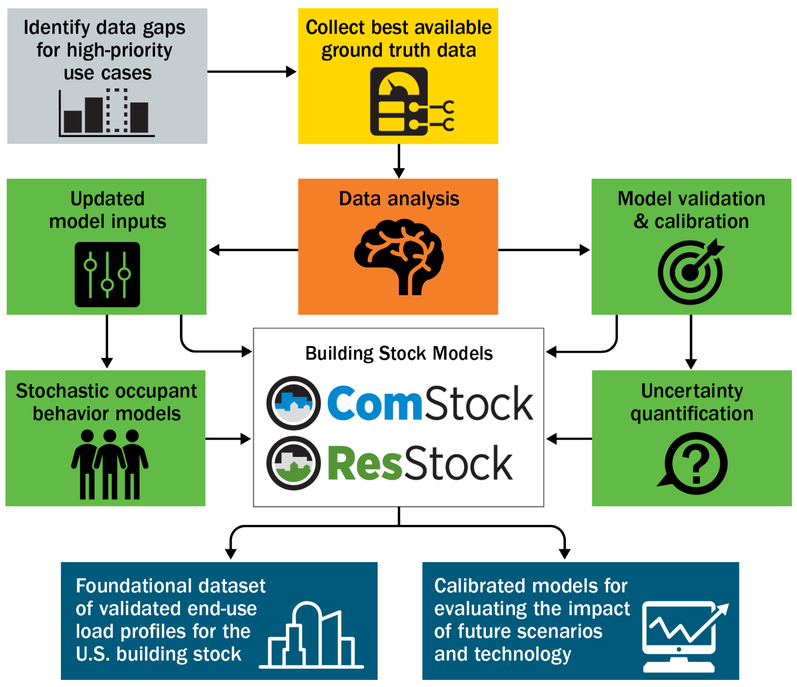
- are often outdated and limited to certain regions and building types because of the high cost of traditional end-use sub-metering
- are insufficient for accurate evaluation of numerous emerging use cases of grid-interactive and efficient buildings

Opportunity

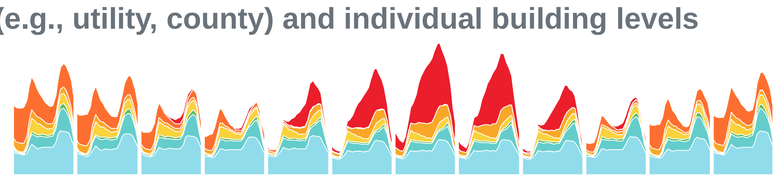
- New ResStock™ and ComStock™ models statistically represent energy use of U.S. buildings
- Models produce hourly end-use load profiles, but calibration efforts to date have focused on annual energy use

Project Objective

This project's hybrid approach combines best-available ground truth data, such as submetering studies and statistical disaggregation of whole-building interval meter data, with the reach, cost-effectiveness, and granularity of physics-based and data-driven building stock modeling to deliver a nationally-comprehensive dataset at a fraction of the historical cost.



The ultimate outcome of this project will be end-use load profiles for every location in the U.S., at both the aggregate (e.g., utility, county) and individual building levels



Research Results

In the first 6 months of the 3-year project, progress was made in the following areas:

Stakeholder Engagement

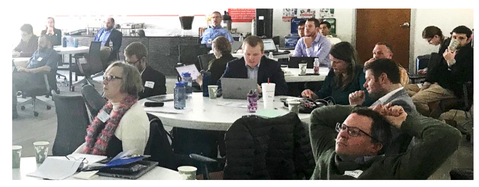
- Created technical advisory group with over 60 members representing utilities, regulators, experts and consultants, energy efficiency regional organizations and vendors
- First meeting in November 2018 (call)
- Second meeting in March 2019 (in-person); focused on identifying market needs, use cases, and data gaps for the project.

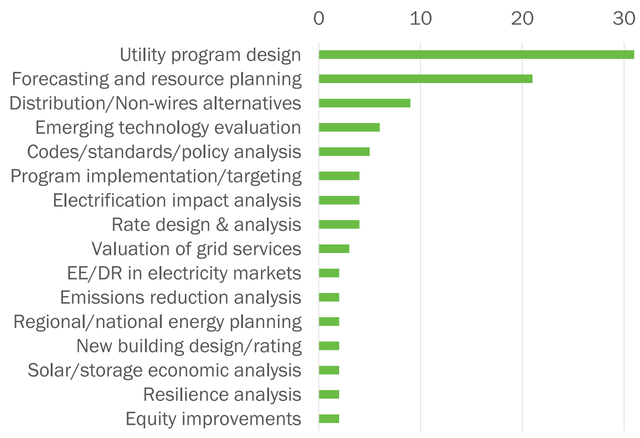
"This was as good as it gets for engaging people across different locations and disciplines."

Organizations represented by the advisory group

Use Case Understanding

- Identified approximately 75 use cases for end-use load profiles and load modeling
- Drafted descriptions of 10 novel use cases
- Collected input on highest-priority use cases





Technical advisory group members identified their highest-priority use cases of end-use load profiles, presented as a word cloud (left) and graph of use case categories (right).

Data Requirements Driven by Use Cases

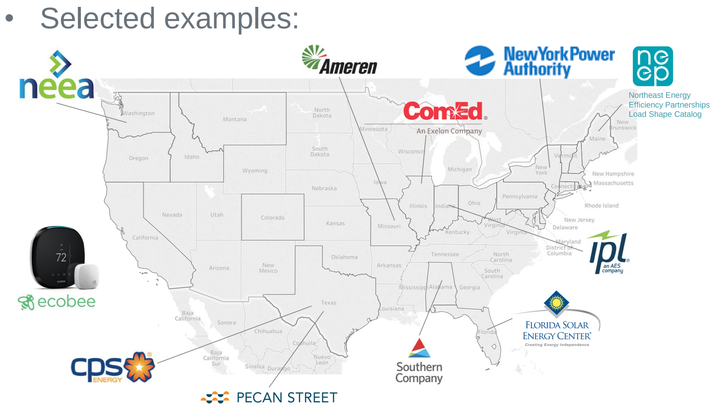
The team drafted a list of key attributes for the top priority load profile use cases.

Indicates requirement typically outside status quo

Use Case	Rank	Time resolution	Geographic resolution	End-uses	Stochastic Occupancy	Electrical Characteristics
Utility program design	1	Hourly or peak day	Service territory	Yes	No	Real power
Forecasting and resource planning	2	Hourly or peak day	Service territory	Yes	No	Real power
Distribution/Non-wires alternatives	3	15-min	Distribution feeder	Yes	Yes	Real, reactive power, voltage
Emerging technology evaluation	4	Depends on rates	Service territory or larger	Yes	Yes	Depends on application
Codes/standards/policy analysis	5	15-min to Hourly	State, climate zone	Yes	Yes	Real power
Program implementation/targeting	6	Hourly	Service territory or smaller	Yes	No	Real power
Electrification impact analysis	6	Hourly	Service territory or smaller	Yes	Yes	Real power
Rate design & analysis	6	15-min	Service territory or smaller	No	Yes	Real power
Valuation of grid services	9	Hourly	Feeders to markets	Yes	Yes	Depends on application
EE/DR in electricity markets	10	15-min to hourly	Service territory or larger	Yes	Yes	Real power
Emissions reduction analysis	10	Hourly	Service territory or larger	Yes	No	Real power
Regional/national energy planning	10	Hourly	Regional or national	Yes	No	Real power
New building design/rating	10	15-min to hourly	Weather station	Yes	Yes	Real power
Solar/storage economic analysis	10	1-min	Weather station	No	Yes	Real power
Resilience analysis	10	1-min to hourly	Distribution feeder or smaller	Yes	Yes	Depends on application
Equity improvements	10	Hourly	Service territory or smaller	Yes	Yes	Real power

Data Outreach

- Acquired or actively pursuing around 20 data sources from around the U.S.
- Selected examples:



Preparing for Next-Level Models

- Categorized approximately 500 high-level inputs for ResStock/ComStock
  - Documented current & potential future data sources for each input
  - Identified highest priority data gaps
- Completed initial literature review on residential stochastic occupant behavior models
- Progress developing commercial building stochastic occupant behavior

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