Large-scale modeling of building demand flexibility

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EBC Technical Day
Panel #3 Modeling Demand Flexibility
To represent demand flexibility, we need to model

1. Heterogeneity

2. Stochasticity
To represent demand flexibility, we need to model:

1. Heterogeneity
2. Stochasticity

Agenda

Why?
How?
Example applications
Why do heterogeneity and stochasticity matter?
Why does heterogeneity matter?

06:00
3 occupants
Why does heterogeneity matter?

06:00
3 occupants

16:00
0.5 occupants

What is the demand flexibility?
Why does heterogeneity matter?

06:00
3 occupants

16:00
0.5 occupants

0 occupants
2 occupants
Why does stochasticity matter?

Daily hot water draw profiles

Blended average of all households
Why does stochasticity matter?

Daily hot water draw profiles

Blended average of all households

An individual household

What is the demand flexibility?
Why does stochasticity matter?

Typical occupancy model

Office Misc. plug loads
Why does stochasticity matter?

**Typical occupancy model**

**With stochastic office occupancy model**

*What is the demand flexibility?*
Hourly vs. minutely resolution

1-hour resolution
self-consumption = 17 kWh
Hourly vs. minutely resolution

Overpredicts self-consumption by 30%

1-hour resolution
self-consumption = 17 kWh

1-minute resolution
self-consumption = 13 kWh
How are we modeling large-scale building stock demand flexibility?
Building Load Modeling

Top-down econometric models

Bottom-up engineering models

See forthcoming IEA-EBC Annex 70 paper:
“Developing a common approach for classifying building stock energy models”
Building Load Modeling

Top-down econometric models

Difficulty representing “what if” impact of new technologies

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Bottom-up engineering models

Traditionally do not to represent diversity of buildings and occupants

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“Developing a common approach for classifying building stock energy models”
Scaling-up building stock modeling

Bottom-up engineering models

Typical: detailed subhourly models of 10s of prototype building models

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Scaling-up building stock modeling

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100,000s of detailed subhourly models
Scaling-up building stock modeling

Bottom-up engineering models

Typical: detailed subhourly models of 10s of prototype building models

Traditionally do not represent diversity of buildings and occupants

Designed to represent full diversity of buildings and occupants

100,000s of detailed subhourly models

House icons by HAWRAF via autodraw.com
How do we scale up the models?

Building stock characteristics database + Physics-based computer modeling + High-performance computing
Diversity represented using 6000 probability distributions for 100 parameters structured in a dependency tree.

Building stock characteristics database

1 model for every 200 dwelling units
Two applications of large-scale building demand modeling
End-use load profiles for the U.S. Building Stock

End-use load/savings profiles are...

- **the most essential** data resource currently missing for Time-Sensitive Valuation of Energy Efficiency (TSV-EE)
- needed for **R&D prioritization**, utility resource and distribution system planning, state and local energy planning and regulation
- critical for widespread adoption of grid-interactive and efficient buildings.

Existing profiles are often **outdated, regionally limited, based on small sample size, and limited to a subset of the building stock** because of the high cost of the historical sub-metering approach.

Source: Navigant Massachusetts RES 1 Baseline Load Shape Study
End-use load profiles for the U.S. Building Stock

2019–2021 U.S. DOE project
NREL, Berkeley Lab, Argonne, EPRI, NEEP

Hybrid approach combines best-available ground-truth data with the reach, cost-effectiveness, and granularity of physics-based and data-driven building stock modeling capabilities

The novel approach delivers a nationally-comprehensive dataset at a fraction of the historical cost.
First-of-its-kind analysis

What role do energy efficiency, electrification, and demand flexibility play in achieving 100% renewable energy for a city AND utility?
First-of-its-kind analysis

What role do energy efficiency, electrification, and demand flexibility play in achieving 100% renewable energy for a city AND utility?

Key study considerations

- Necessary infrastructure upgrades
- Critical transmission investments
- Maintaining system reliability
- Impact on equity, jobs, and local economy

Application: Los Angeles 100% Renewable Energy Study

Building load modeling

Electricity system modeling

Projected to 2050

Growth + Electrification + Efficiency

ResStock ComStock
Thank you

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