NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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

Technical Advisory Group meeting #1
November 27, 2018

Eric Wilson, NREL
Andrew Parker, NREL
Natalie Mims Frick, LBNL

Agenda

- Meeting housekeeping items
- U.S. DOE Building Technologies Office
- Project background, overview, and team
- Project timeline and outcomes
- Technical Advisory Group responsibilities and benefits
- Overview of EPRI Utility Collaborative
- Overview of Northeast Energy Efficiency Partnerships (NEEP) regional research
- Q&A

Meeting housekeeping items

- We will post slides and recording of this webinar on the project web site (once created).
- Because of the large number of participants, everyone is in *listen-only* mode.
- Please use the chat box to send us your questions and comments any time during the webinar.
- Moderated Q&A will follow, with the presenters responding to questions typed in the chat box.

US Department of Energy Building Technologies Office

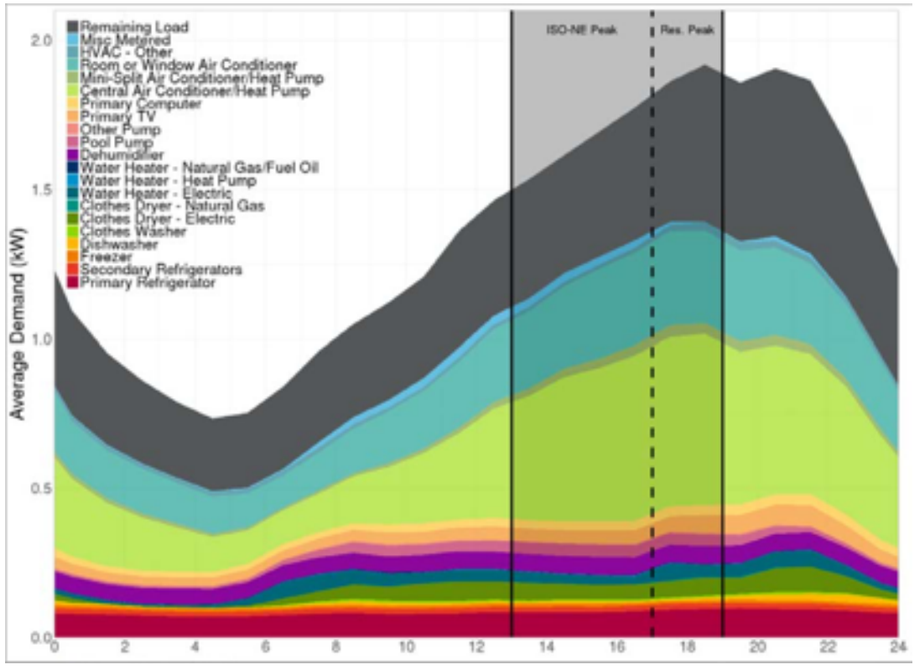
Monica Neukomm

Background

End-use load/savings profiles are…

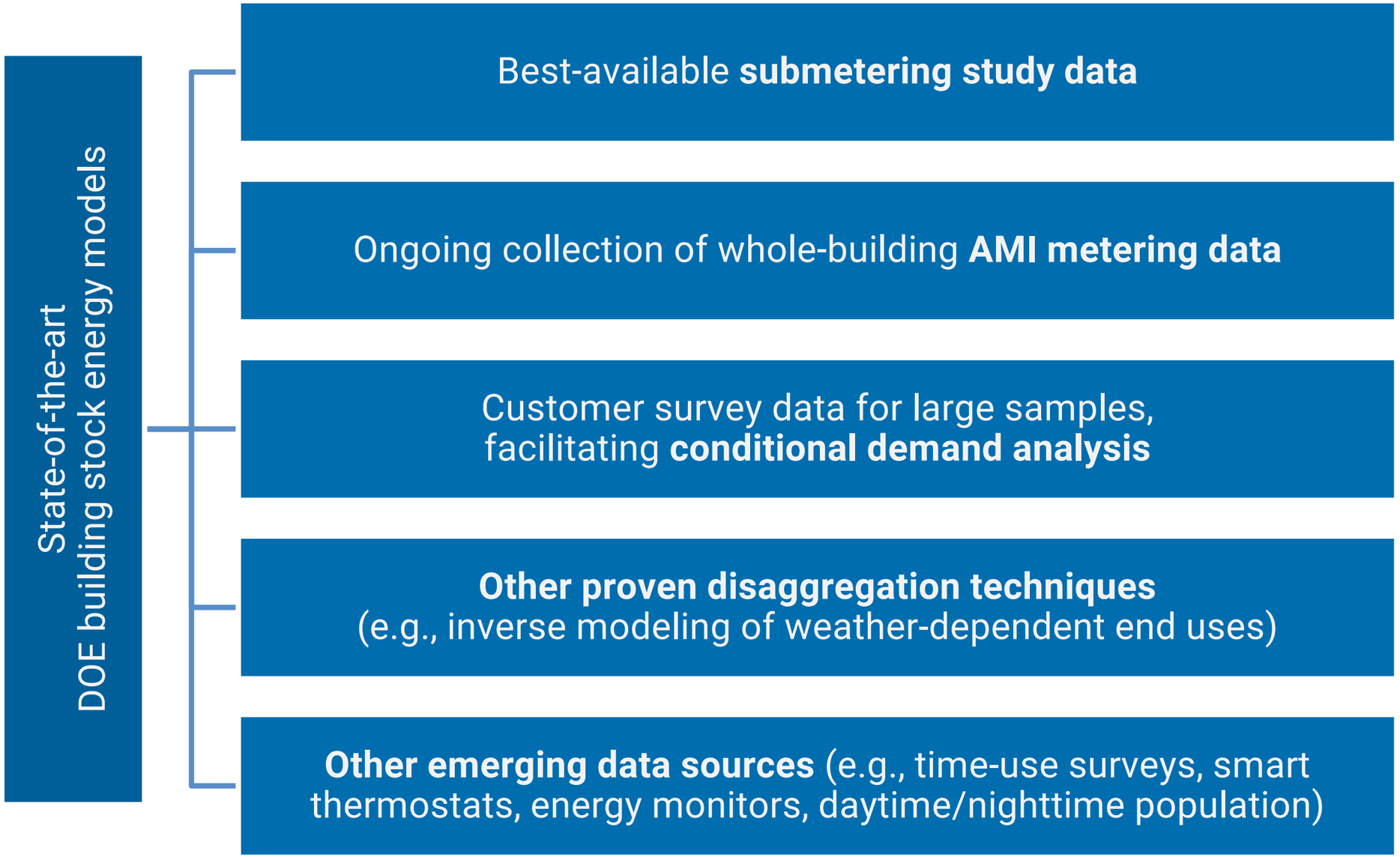
- the **most essential** data resource currently missing for Time-Sensitive Valuation of Energy Efficiency (TSV-EE)
- needed for **R&D prioritization, utility resource and distribution system planning, state and local energy planning and regulation**
- critical for widespread adoption of **grid-interactive 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Existing profiles are often **outdated, regionally limited, based on small sample size, and limited to a subset of the building stock** because of the high cost of the historical sub-metering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.



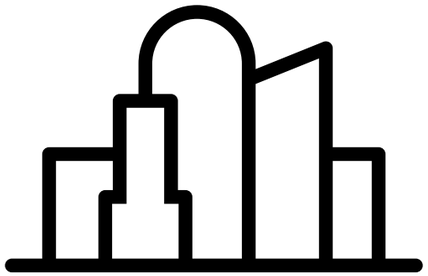
Source: Navigant Massachusetts RES 1 Baseline Load Shape Study

Solution: a hybrid approach



Background: DOE Building Stock Models

ComStock ResStock



Building stock characteristics database

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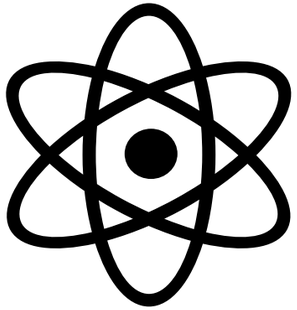

Physics-based computer modeling

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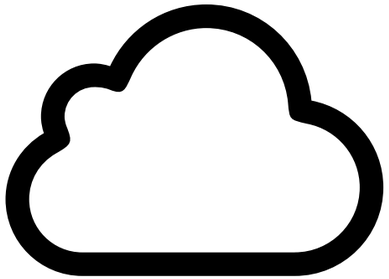
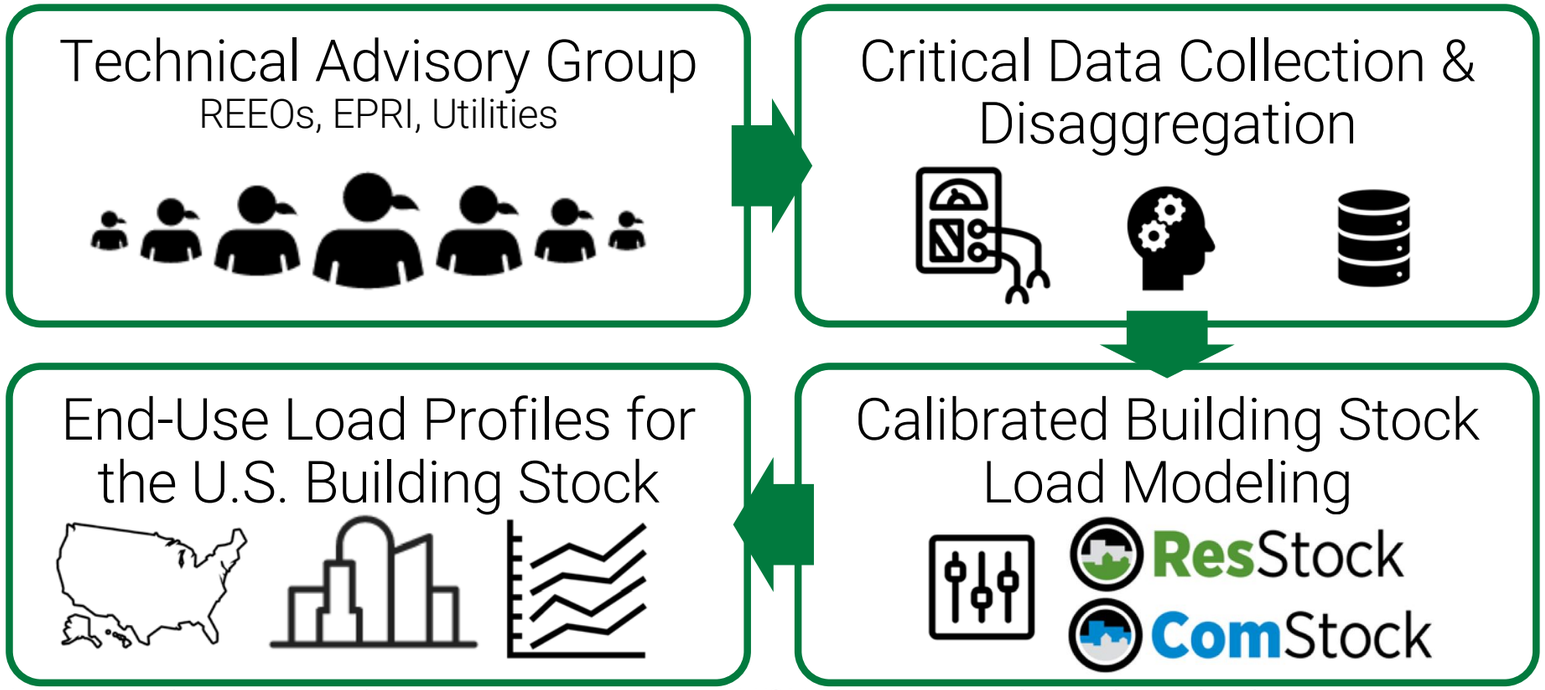


High-performance computing

- DOE-funded, NREL-developed models of the U.S. building stock
- 100,000s of statistically representative physics-based building energy models (BEM)
- Use DOE's flagship BEM tools OpenStudio and EnergyPlus
- Produce hourly load profiles, but calibration to-date has focused on annual energy consumption

Project Overview

1. Establish technical advisory group
2. Identify load profile use cases, data requirements, existing data sources, and critical gaps
3. Address data gaps with critical data collection and disaggregation techniques
4. Incorporate stochastic occupancy into ComStock/ResStock
5. Calibrate ComStock and ResStock statistical building stock models
6. Publish end-use load profiles and documentation



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Project Team – Labs

NREL

Eric Wilson (PI)

Andrew Parker (Co-PI)

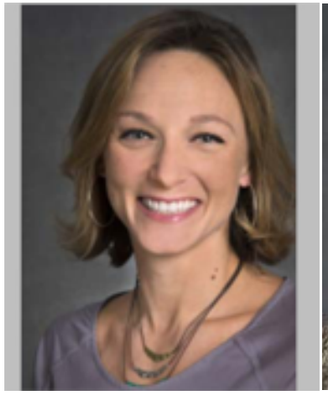
Dr. Lieko Earle

Henry Horsey

Dr. Anthony Fontanini

Noel Merket

LBNL



Natalie Mims Frick (Co-PI)

Lisa Schwartz

Dr. Tianzhen Hong

Argonne

Dr. Ralph Muehleisen

Project Team – Industry

Northeast Energy Efficiency Partnerships (NEEP)

Elizabeth Titus

Claire Miziolek

Electric Power Research Institute (EPRI)

Chris Holmes

Krish Gomatom

...and many others on the technical advisory group

Technical Advisory Group (TAG) Members (1)

Regional Energy Efficiency Organizations
- Midwest Energy Efficiency Alliance
- Northwest Energy Efficiency Alliance
- Northeast Energy Efficiency Partnerships
- Southeast Energy Efficiency Alliance

Regulators
- Georgia Public Service Commission
- Hawaii Public Service Commission
- Indiana Utility Regulatory Commission
- Michigan Public Service Commission

Utilities and RTOs
- Ameren
- Bonneville Power Administration
- Commonwealth Edison
- Consolidated Edison
- CPS Energy
- DTE Energy
- Duke Energy
- Indiana Power & Light
- PacifiCorp
- PJM
- Southern Company
- Xcel Energy

TAG Members (2)

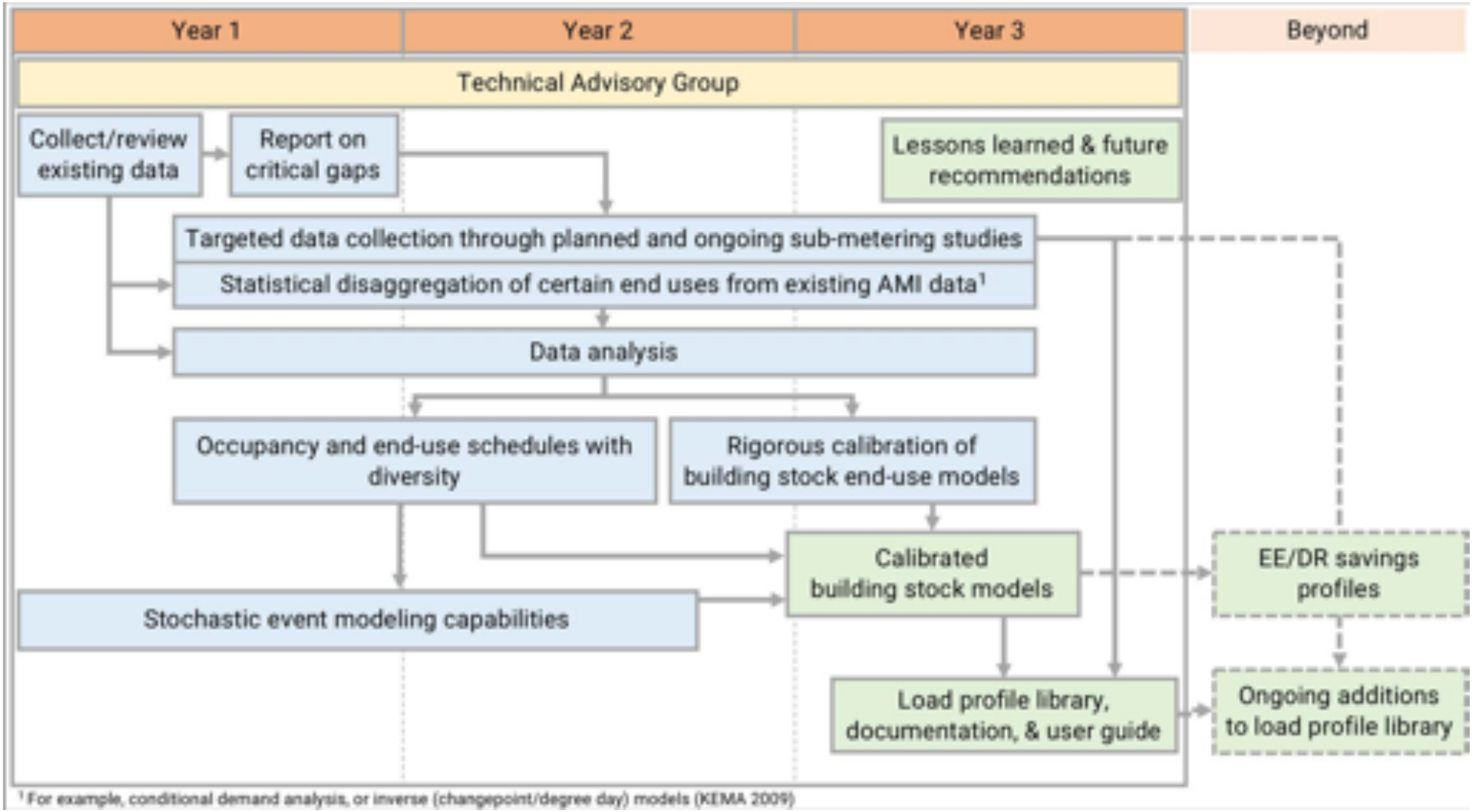
Consultants
- Cadmus
- Elevate Energy
- Energy Futures Group
- The Greenlink Group
- ICF
- Navigant
- Solar Investment, Inc
- Seventhwave
- Synapse Energy Economics
- TRC Solutions
- Tom Eckman

Research
- Electric Power Research Institute
- Clarkson University
- Pacific Northwest National Laboratory

NGOs
- ACEEE
- Environmental Defense Fund
- National Association of State Energy Officials (NASEO)

Government
- US Department of Energy
- New York State Energy Research and Development Authority (NYSERDA)
- City of New York
- City of Boulder

Project Timeline



Project Outcomes

The project will result in:

- **Validated end-use load profiles** for U.S. building stock at both aggregate and individual building scales
- Calibrated open source building stock end use **models with ability to estimate EE/DR savings profiles for existing and emerging technologies**
- **Documentation** of load profile use cases, critical gaps, model methodology, and user guide

ComStock

Building Types

- Small Office
- Medium Office
- Large Office
- Stand-alone Retail
- Strip Mall
- Primary School
- Secondary School
- Outpatient Healthcare
- Hospital
- Small Hotel
- Large Hotel
- Warehouse (non-ref.)
- Quick Service Restaurant
- Full Service Restaurant
- Mid-rise Apartment
- High-rise Apartment
- Supermarket

End-Uses

- Heating
- Cooling
- Interior Lighting
- Exterior Lighting
- Interior Equipment
- Exterior Equipment
- Fans
- Pumps
- Heat Rejection
- Humidification
- Heat Recovery
- Water Systems
- Refrigeration
- Generators

ResStock

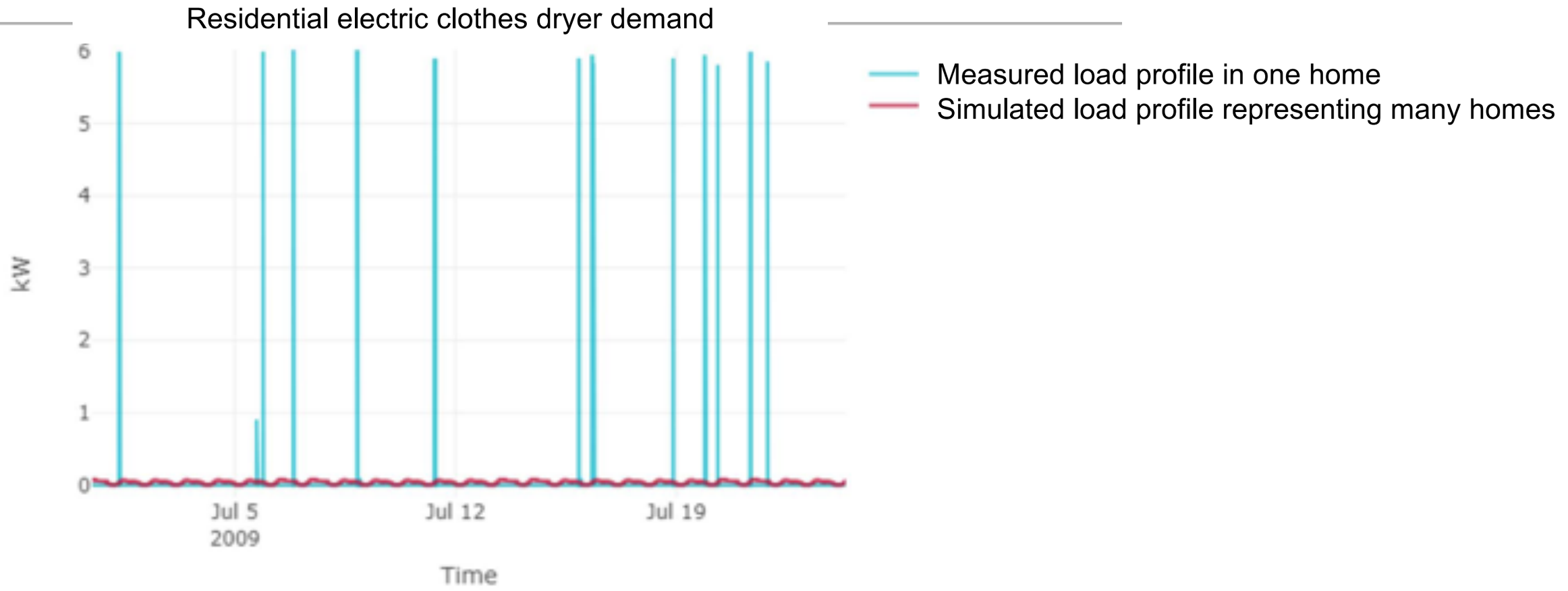
Building Types

- Single-Family Detached
- Multifamily (low-rise)
  - Single-Family Attached
  - 2 - 4 Units
  - 5+ Units

End-Uses:

- Heating
- Cooling
- Furnace/AC fan
- Boiler pumps
- Vent. fans
- Water heating
- Interior Lights
- Exterior Lights
- Misc. plug loads
- Refrigerator
- Clothes washer
- Clothes dryer
- Dishwasher
- Cooking Range

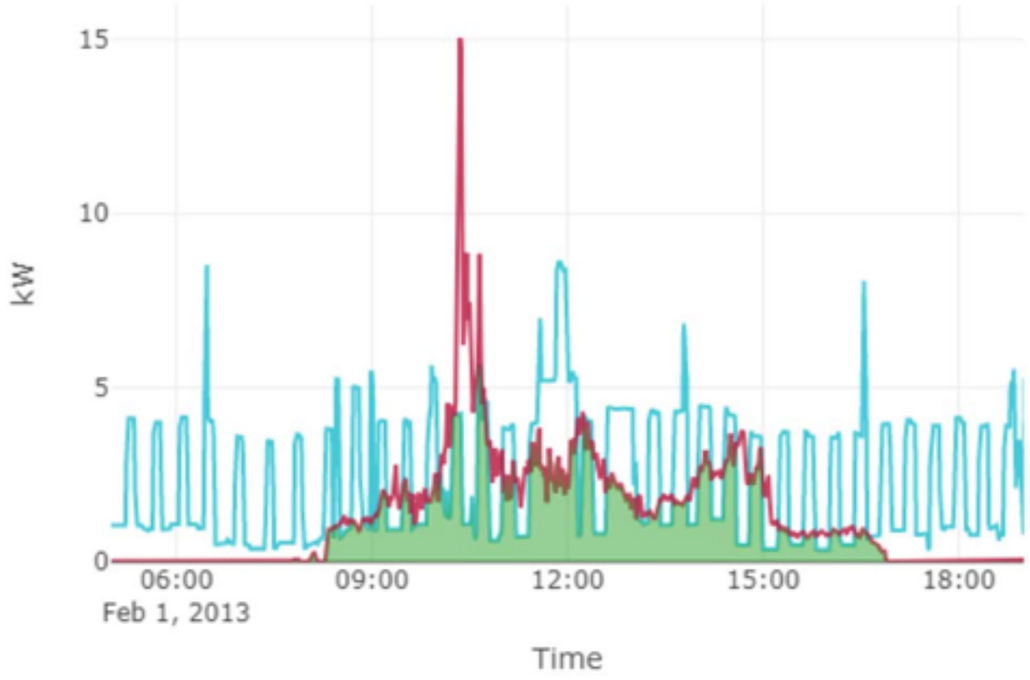
Project Outcomes:
Stochastic load profiles for individual buildings



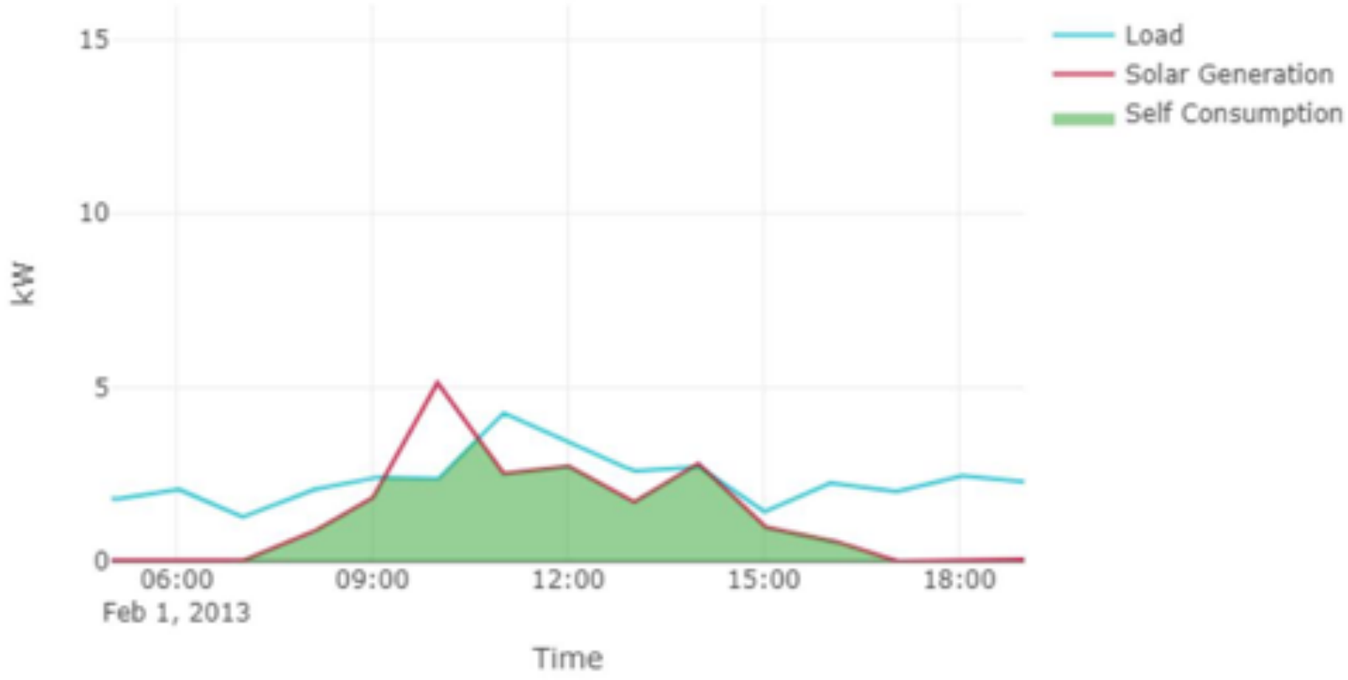
Why are stochastic load profiles important?

Overpredicts self-consumption by 30%

1-minute resolution
self-consumption = 13 kWh



1-hour resolution
self-consumption = 17 kWh



Key Milestones and Deliverables

Year 1 ~2019	• **Establish TAG** • **Publish Market Needs, Use Cases and Data Gaps report** that discusses applications of end-use load profiles, use cases and identify gaps in existing data
Year 2 ~2020	• **Produce working but uncalibrated model** of national residential and commercial building stocks that generates end-use load profiles • **Develop models to represent stochastic behavior** of discrete end-use events in building operation
Year 3 ~2021	• **Complete a calibrated model** of national residential and commercial building stocks that generates average and typical end-use load profiles • **Publish Technical Project Documentation** that describes technical details, assumptions and methodologies used to develop and calibrate the models and create end-use load profiles • **Publish User's Guide** describes approach, results, and applications (e.g., load forecasting, resource planning, program, and policy design)

TAG Responsibilities

- **Review materials provided in advance** of quarterly calls and annual meetings
- Be prepared to **contribute to thoughtful conversation** to guide review of technical choices and decision-making
- **Review three draft reports** and provide comments and feedback
- Help the project team produce **useful and industry-accepted** load profiles
- Help **disseminate results**

TAG Benefits

- Advance access to datasets and reports produced by the project
- Ensure that the project results are useful to your state/region
- Participant organizations will be recognized in each report and on project website
- Opportunity to visit Colorado and network with fellow TAG members
- Help address this important challenge facing our industry and county

In-person TAG Meeting
March 5–6
Golden, Colorado

Based on polled availability, meeting will be:

- 12–5 pm on March 5
- 9am–1pm on March 6

The TAG meeting will use facilitated work groups to:

- Identify use cases
- Identify data sources
- Identify data gaps

In-person TAG Meeting
March 5–6
Golden, Colorado

- Small meeting rooms will be available on morning of March 5 and afternoon of March 6 for side meetings, calls, etc.
- Call-in option will be available

Any **non-U.S. citizens**, contact Barbara.VanDyke@nrel.gov as soon as possible to complete paperwork (at least 30 days in advance)

Electric Power Research Institute (EPRI)

Chris Holmes
cholmes@epri.com

Baseline End-Use Profile Development for National Building Stock

Utility Collaborative Leveraging Whole Premise Interval Data

Chris Holmes

Technical Lead, Principal

Krish Gomatom

Technical Lead, Senior

End-use Load Profile Development for Baseline Loads

Scope

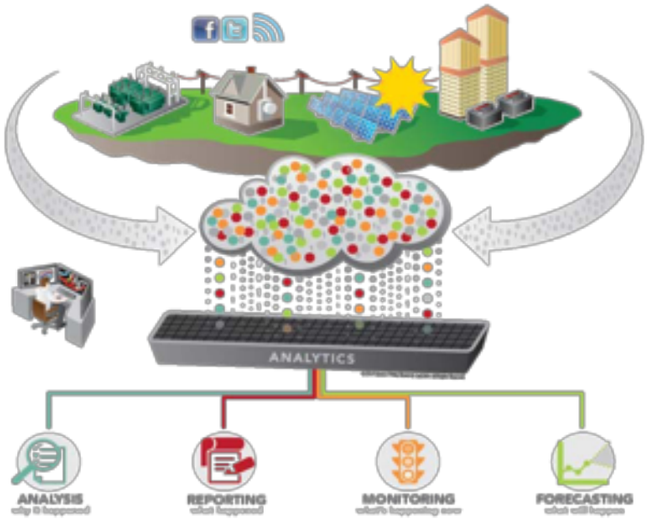
- Development of end-use load shapes for Residential & Commercial building stock
- Leverage utility meter data by region, to cover different types of buildings and climate zones.

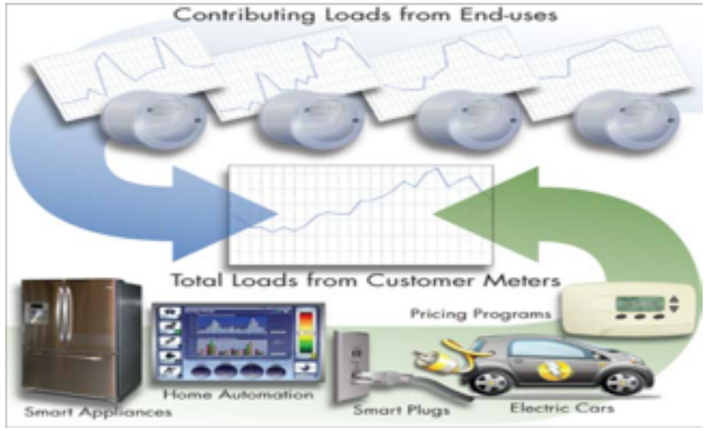
Leverage

- Knowledge base, expertise under EPRI Load Research and Market Analytics
- EPRI Public Product: Load Shape Library
  loadshape.epri.com

Value

- Statistically significant, empirical, baseline end-use profiles by building type and climate zone
- Web accessible data and visualization
- Utility representation across the U.S





Proposed Approach

- Residential & Commercial end-use load shapes by building type and climate zone
- Leverage customer AMI data with customer survey information, building characteristics and other public data
- Better accuracy by class-level, building type level
- Basic and enhanced data collection
  - Improved accuracy (optional)
  - Additional sampling domains such as age and size of structures, occupancy, income level, program participation, etc.
- Data made available through EPRI's web product
  Load Shape Library: public database, user interface

Load Shape Development Options

Statistical: AMI and Survey Information

- Whole premise data by class X, building type X, appliance saturation X climate zone
- Lowest cost & verifiable accuracy (function of data availability)
- Whole premise outputs that can still provide some end-use detail
- Currently being used in California

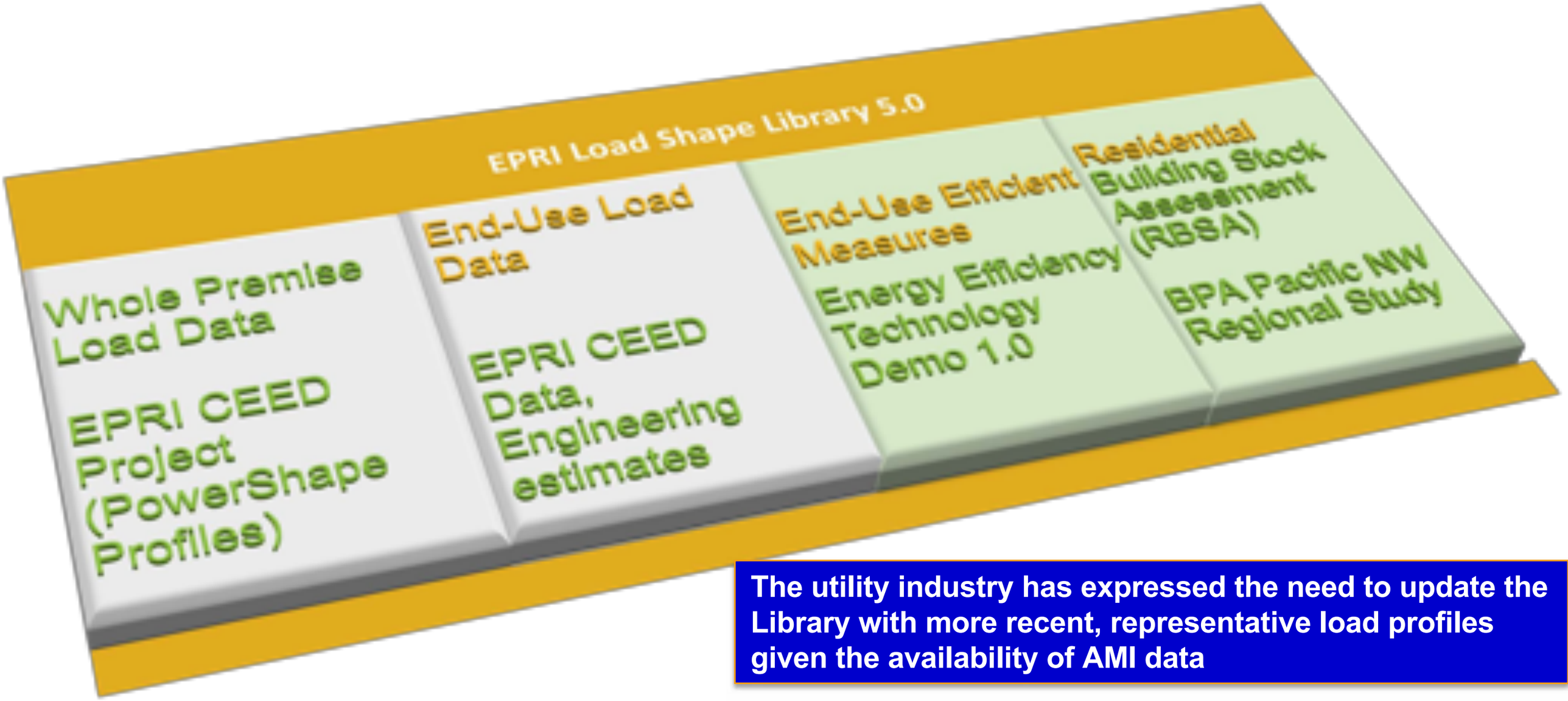
SAE: Statistically Adjusted Engineering Estimates, engineering estimates plus limited metering

- Specific for utilities without whole premise interval data
- Deploy select metering to calibrate site-specific engineering models
- Intermediate cost and moderate accuracy

Hourly CDA Approach: (Class) Diversified Load Shapes

- Relies on the *variation* of the presence of end-use appliance for statistically inferring the *components* of customers' hourly load profiles
- Modified Regression applied to hourly *load* data, using variables from *survey* information
- Conditioned on other causal variables to allocate total load to end uses
  - Comparing total loads of two identical houses, where only one has electric water heater; difference between loads is load of water heater
  - Regression analysis makes those comparisons across hundreds of customers & all included end uses
  - Result produces a "diversified end use load shape"
  - Cost to collect is far less than other methods
- Survey design will be important to ensure statistical stability and to allow for collection of other useful information such as reliability, resiliency, attitudes and data needed for adoption modeling of DER and EV
- Empirically validated through EPRI's end-use load data development research

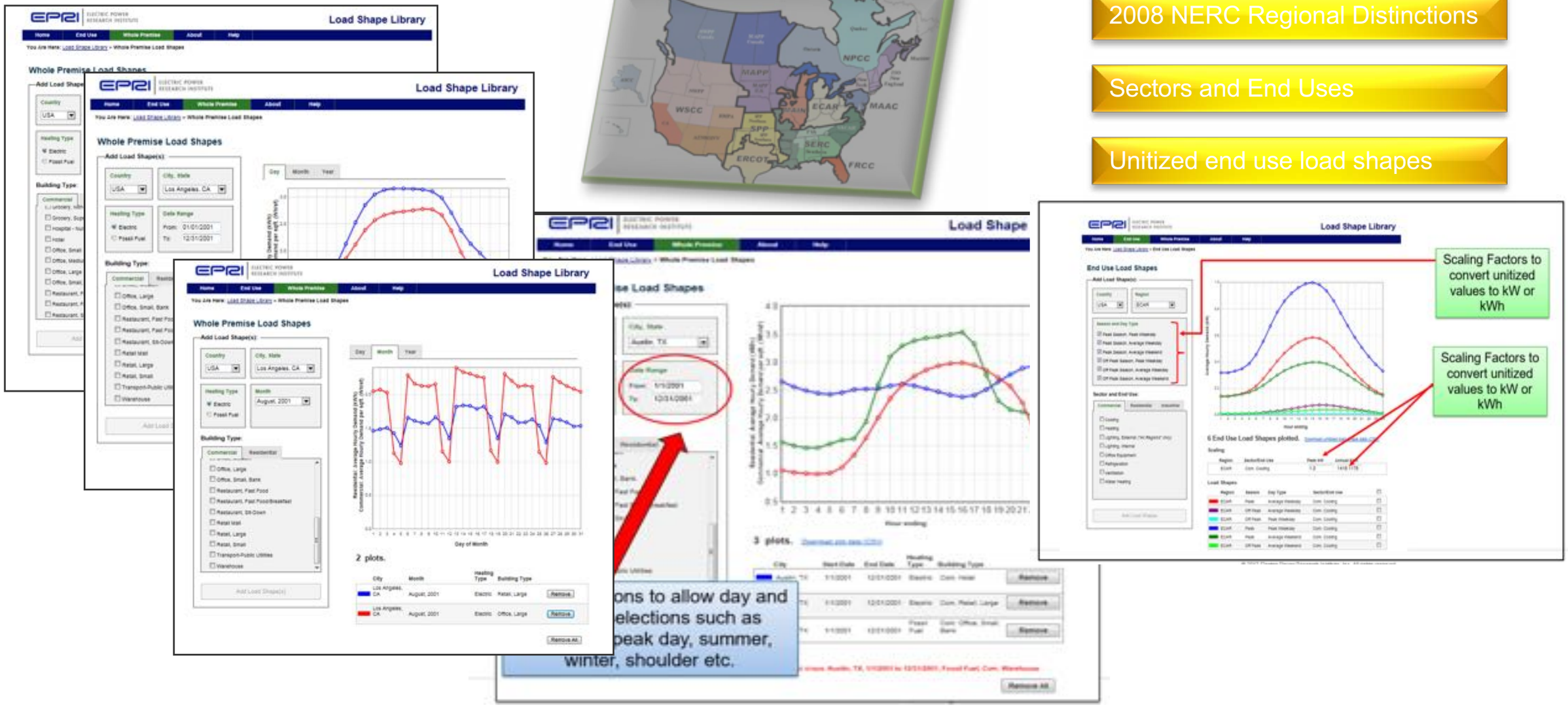
EPRI Public Product: Load Shape Library 5.0



The utility industry has expressed the need to update the Library with more recent, representative load profiles given the availability of AMI data

End-Use & Whole Premise Databases

(EPRI CEED PowerShape™, Model +Limited Field Validated)



Northeast Energy Efficiency Partnerships (NEEP)

Questions?

Please use the chat box to send us your questions and comments any time during the webinar. You may want to direct your question to a specific presenter.

Thank you

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