DOE/BPA Load Composition Analysis

DOE Dynamic Load Modeling Workshop

23 March 2020

David Chassin (SLAC), Tony Faris (BPA), and Joe Eto (LBNL)

Overview

1. Update on data, methods, and preparation of CLM feeder models
2. Summary of next steps in support of NERC LMTF and WECC MVS

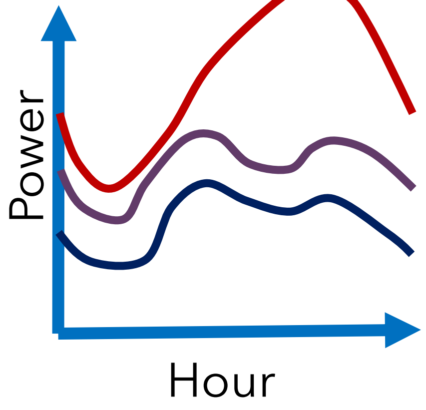
Load Composition Analysis

Support NERC LMTF

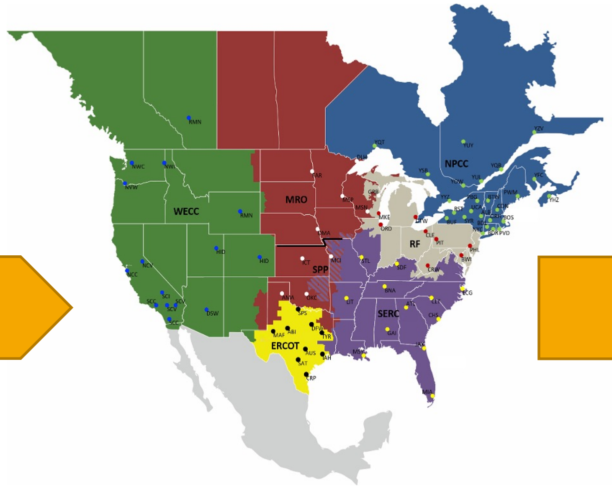
- Fields tests of Composite Load Model (CLM)
- Collaboration to prepare non-industrial feeder models
- Focus on Eastern Interconnection and Texas

Load Composition Analysis: 4-step process

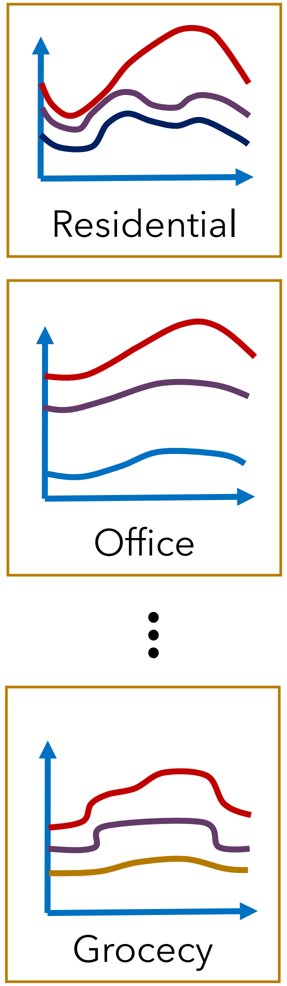
(1)
End-use Load Data



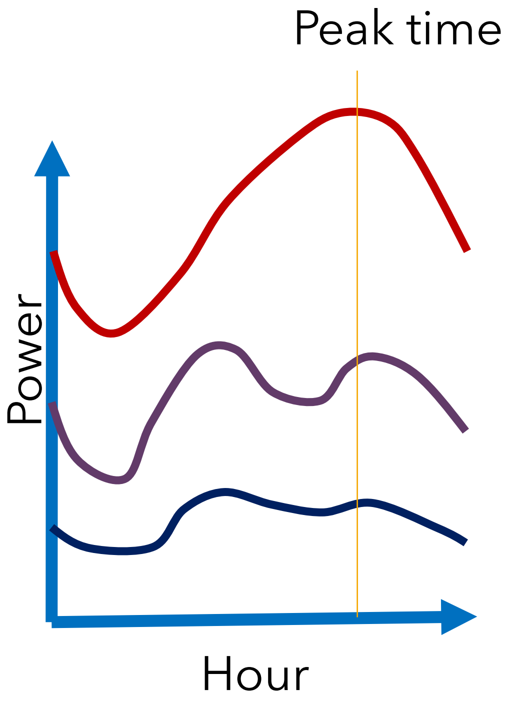
(2)
Regional Loadshapes



(3)
Economic Loadshapes

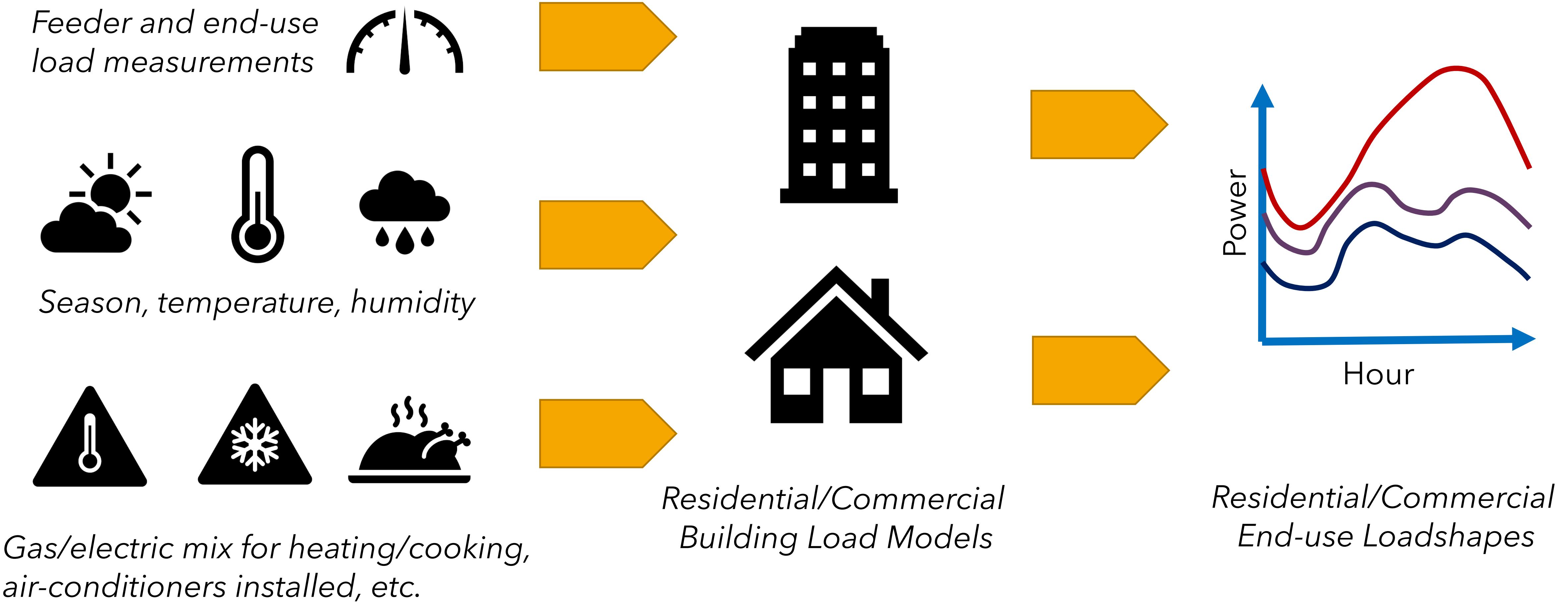


(4)
Load Components



Load Composition Analysis Step 1

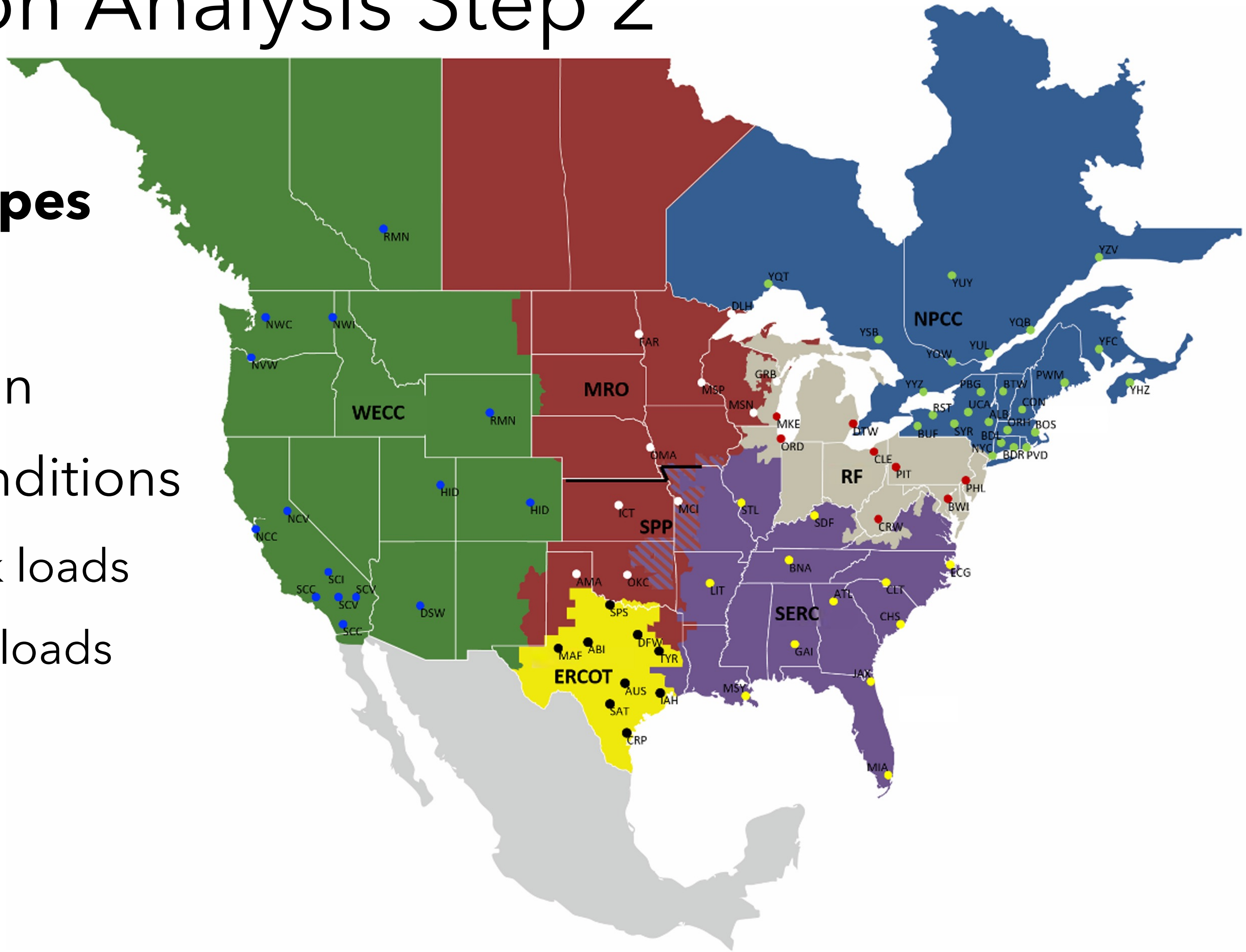
Identify end-use loadshapes for common building types



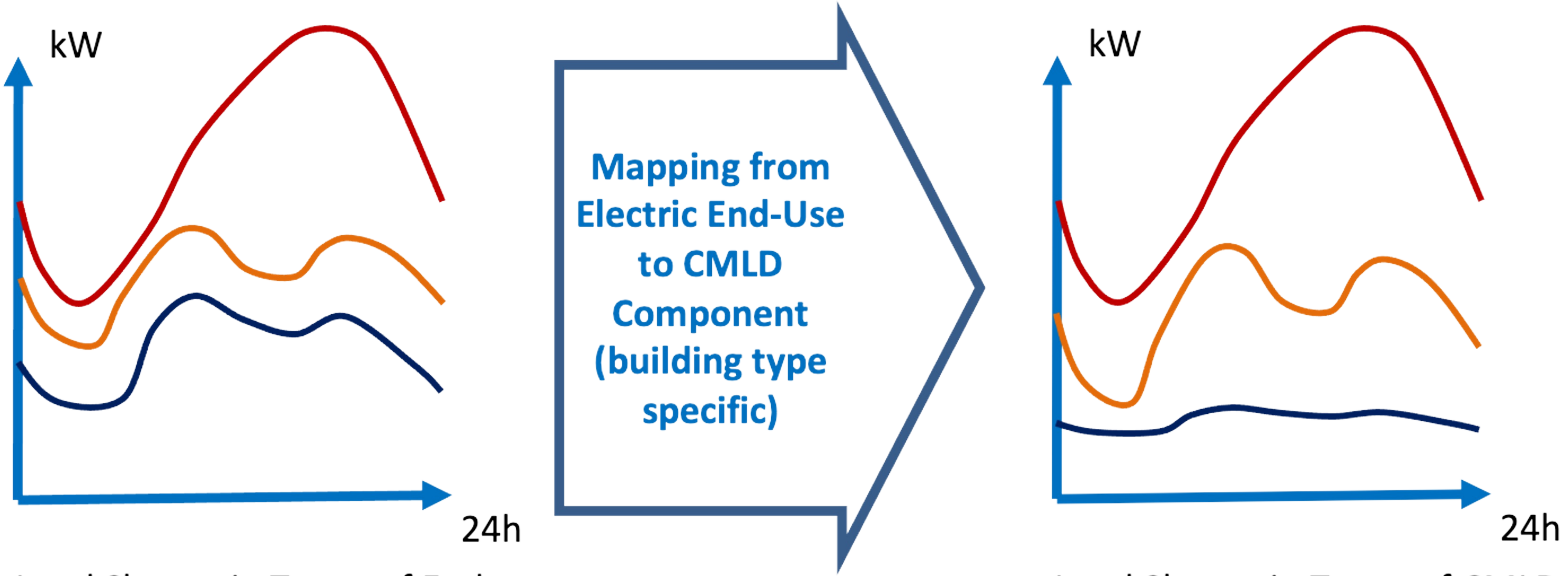
Load Composition Analysis Step 2

Project regional loadshapes

- Multiple weather sites
- Chosen by each region
- Generated for key conditions
  - Winter/summer peak loads
  - Spring/fall minimum loads



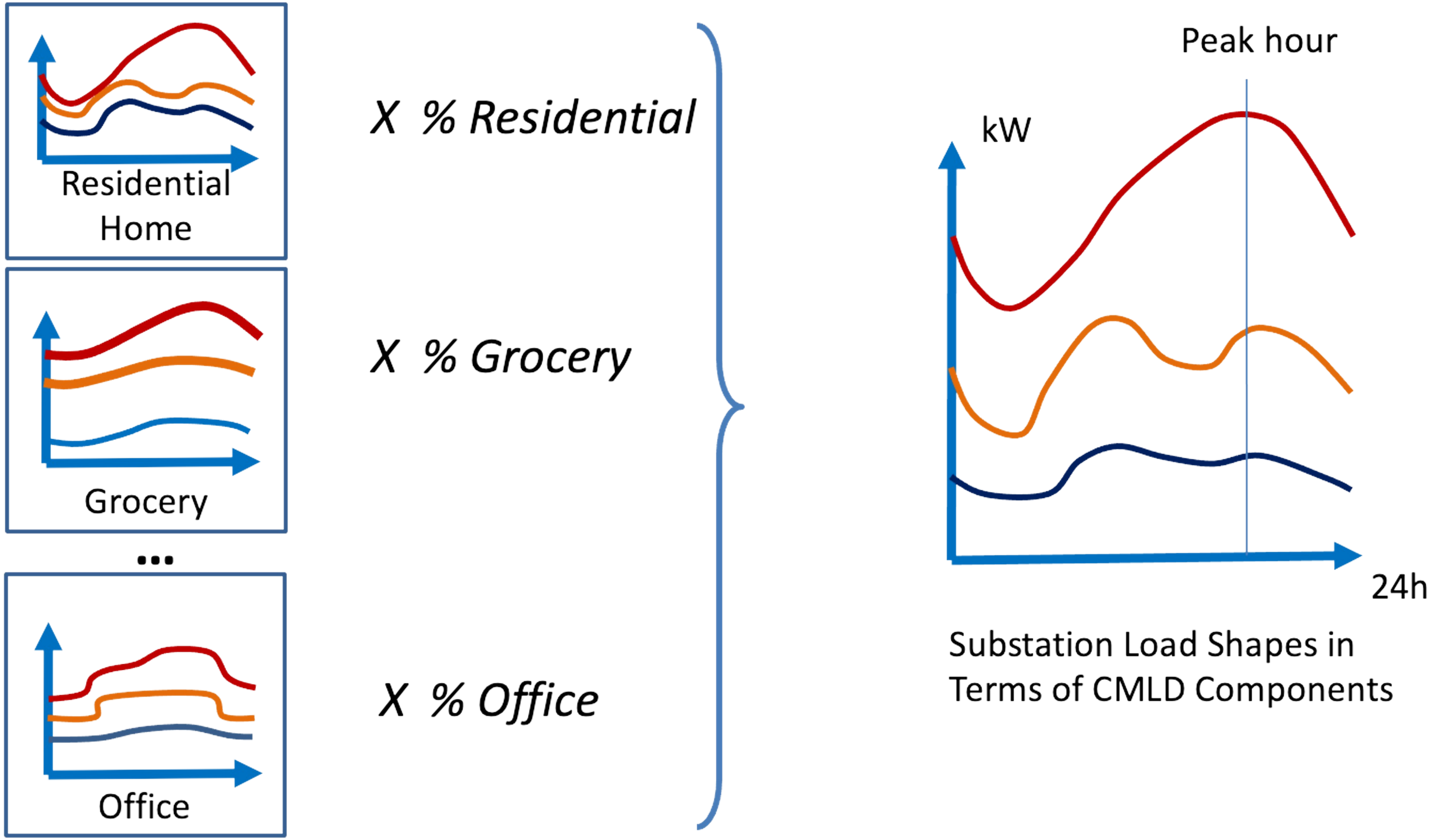
Load Composition Analysis Step 3



Load Shapes in Terms of End-Uses
(Air-Conditioning, Water Heating, Refrigeration, …)

Load Shapes in Terms of CMLD Components
(Motor A, Motor B, …, Power Electronic)

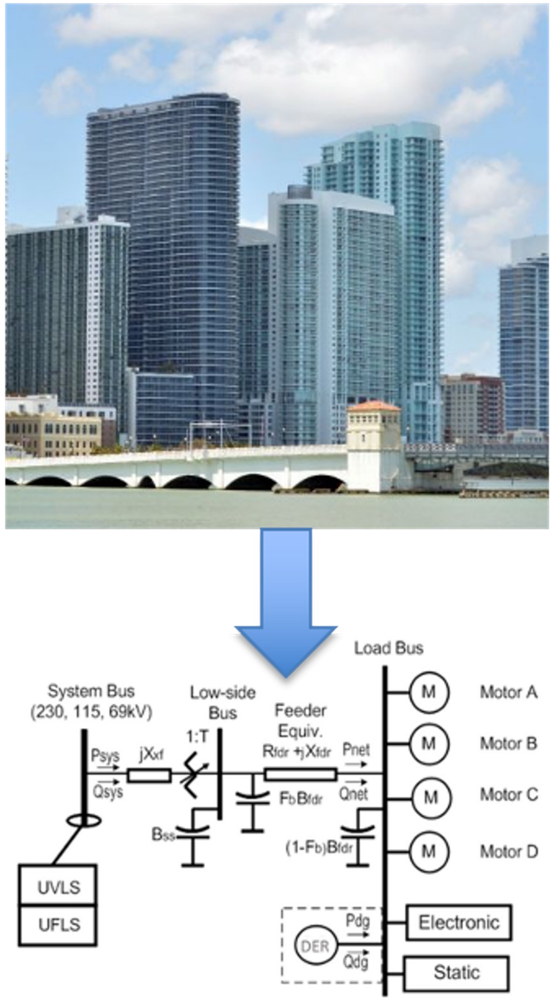
Load Composition Analysis Step 4



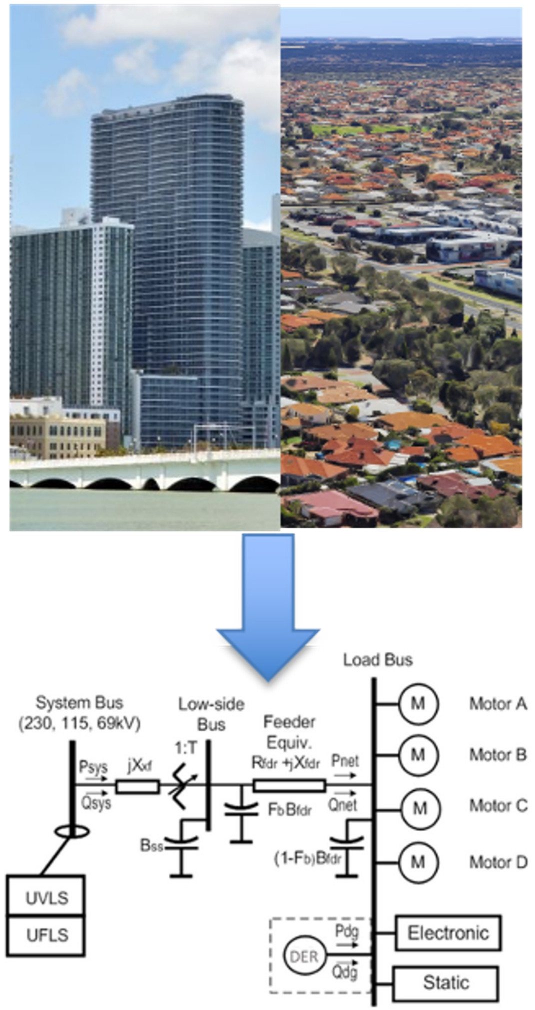
Four Standard "Economic" Feeder Types

RES - suburban

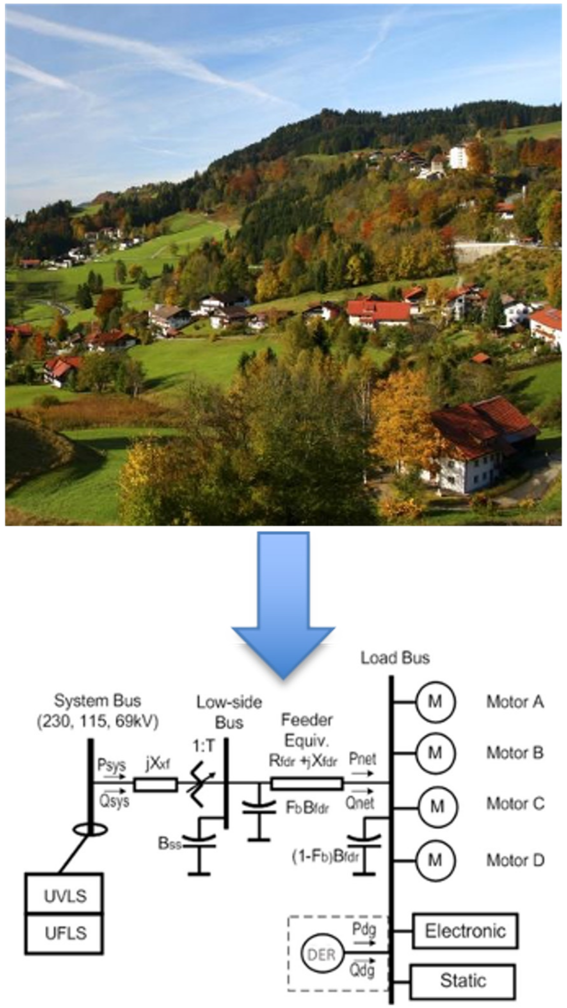
COM - urban



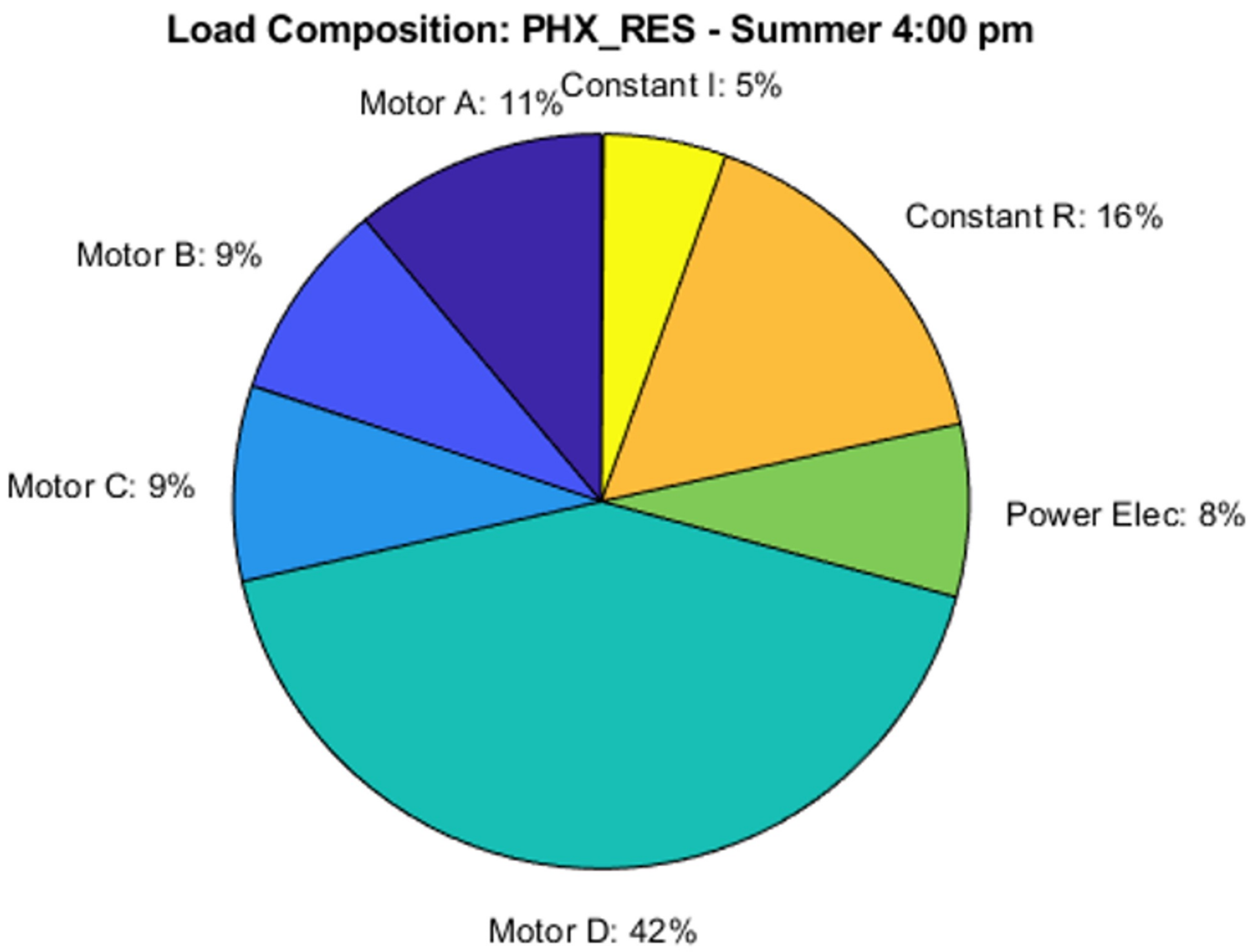
MIX

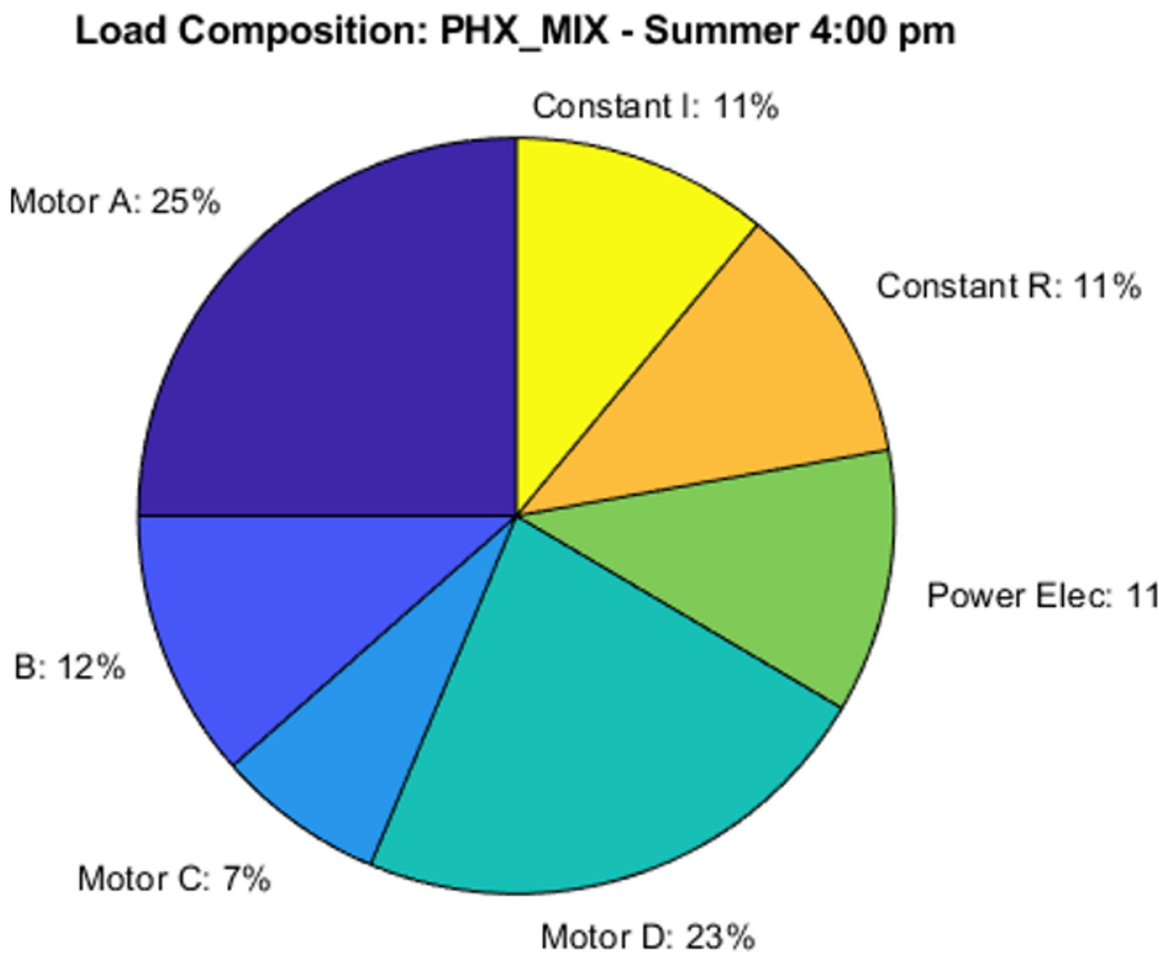


RAG - rural



Example Result - Phoenix AZ Summer Peak CLM





Technical Documentation

Provide technical support information

- Load composition analysis role in CLM
- Technical details on 4-step process
- Representative results of analysis

Electricity Markets & Policy
Energy Analysis & Environmental Impacts Division
Lawrence Berkeley National Laboratory

Load Composition Analysis in Support of the NERC Load Modeling Task Force 2019-2020 Field Test of the Composite Load Model

Anthony Faris and Dmitry Kosterev[1], Joseph H. Eto[2], and Dave Chassin[3]

[1]Bonneville Power Administration
[2] Lawrence Berkeley National Laboratory
[3] Stanford Linear Accelerator Center

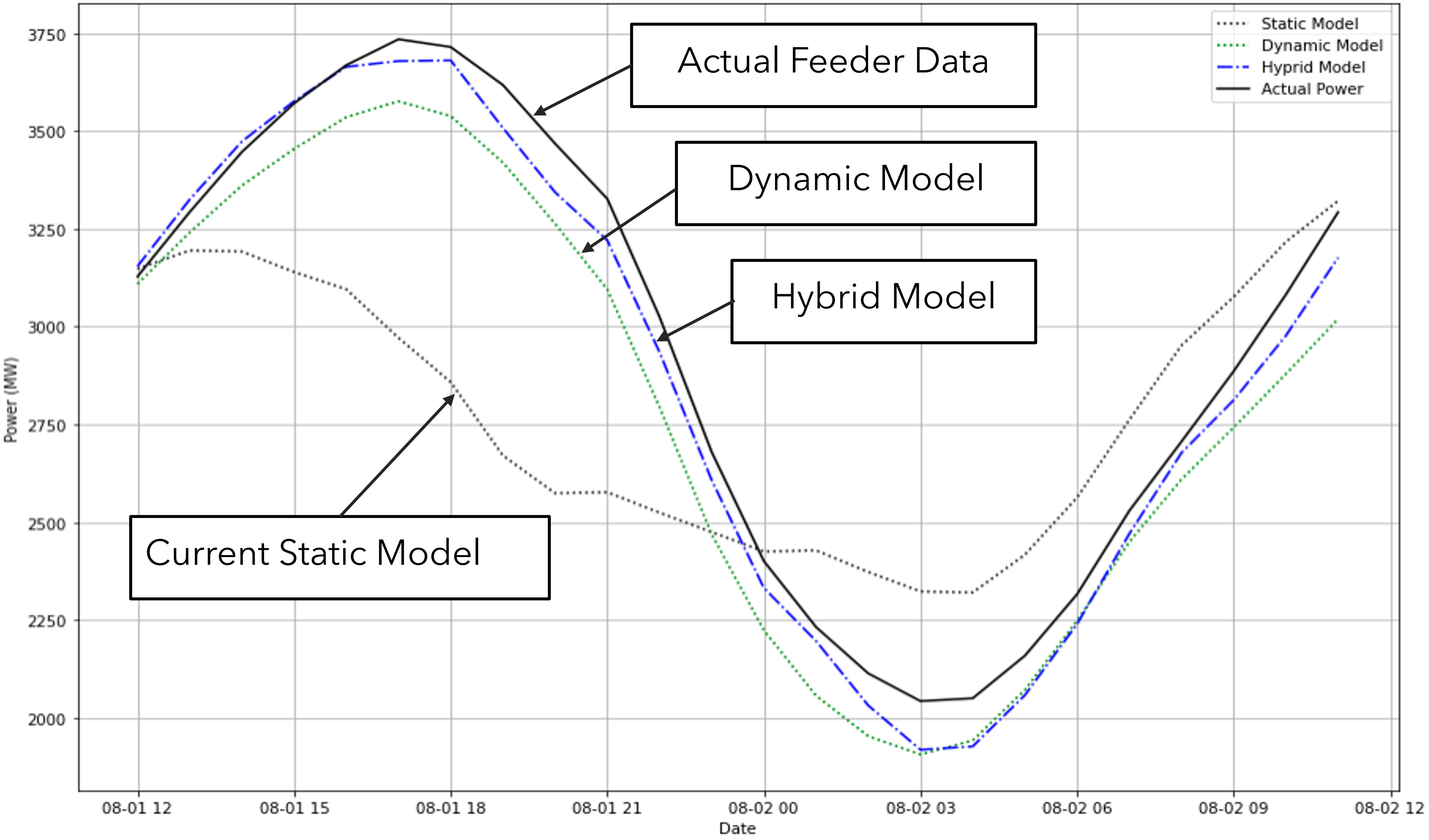
June 2020

This work was supported by the U.S. Department of Energy's Office of Electricity, under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

Next steps for Load Composition Team

Continue	**Continue maintenance/updates of CLM datasets** • Support of NERC LMTF and utilities in using CLM datasets • Update of technical documentation of methodology and performance results
Support	**Support WECC MVS with new/updated CLM datasets**
Coordinate	**Coordinate with utilities to explore specific needs, e.g.,** • Side-by-side comparisons of CLM datasets with in-house utility feeder models
Improve	**Improve default datasets** • Account for evolving residential heating mix (resistance vs. heat-pump loads) • Include feeder-specific customer information • Extend load model to include building thermal dynamics
Extend	**Extend modeling of changing loads (VFDs, EV, PV, ES, etc.)**
Incorporate	**Incorporate results/findings into future updates to CLM datasets**

Enhanced load model: Capture salient building dynamics



Thank you

Contact us:

David Chassin (dchassin@slac.stanford.edu)

Tony Faris (ajfaris@bpa.gov)

Joe Eto (jheto@lbl.gov)

Data-driven Building Load Modeling Methodology

Problem: Predict load based on date, time, and weather based on historical feeder data

Three approaches considered:

1. Static model (predict load based on current weather only)

   power = F (heat_index[0], solar[0])

2. Dynamic model (predict load based on recent weather and load)

   power = G (power[1:N], heat_index[0:N], solar[0:N])

3. Hybrid model (static model + dynamic residual model)

   power = F (heat_index[0], solar[0]) + G(power[1:N] - F (heat_index[0], solar[0]) , heat_index[0:N], solar[0:N])

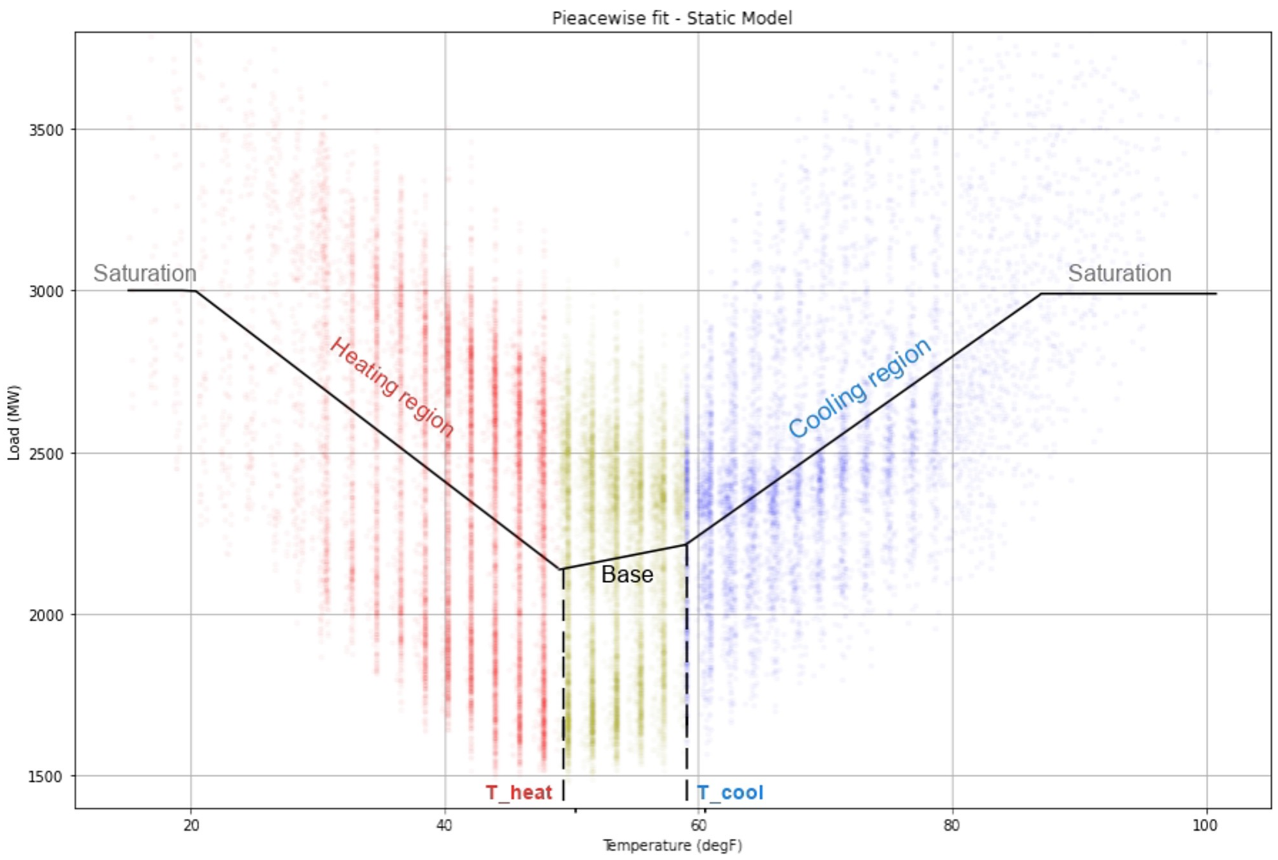
Static Load Model

Piecewise linear fit

- F = PWLF(heat_index,power)
- Five regimes
- Function of indoor temperature (heating, mixed, cooling)

Temperature bins must be chosen

- Minimize slope of mixed region
- Temperature difference of 10 °F



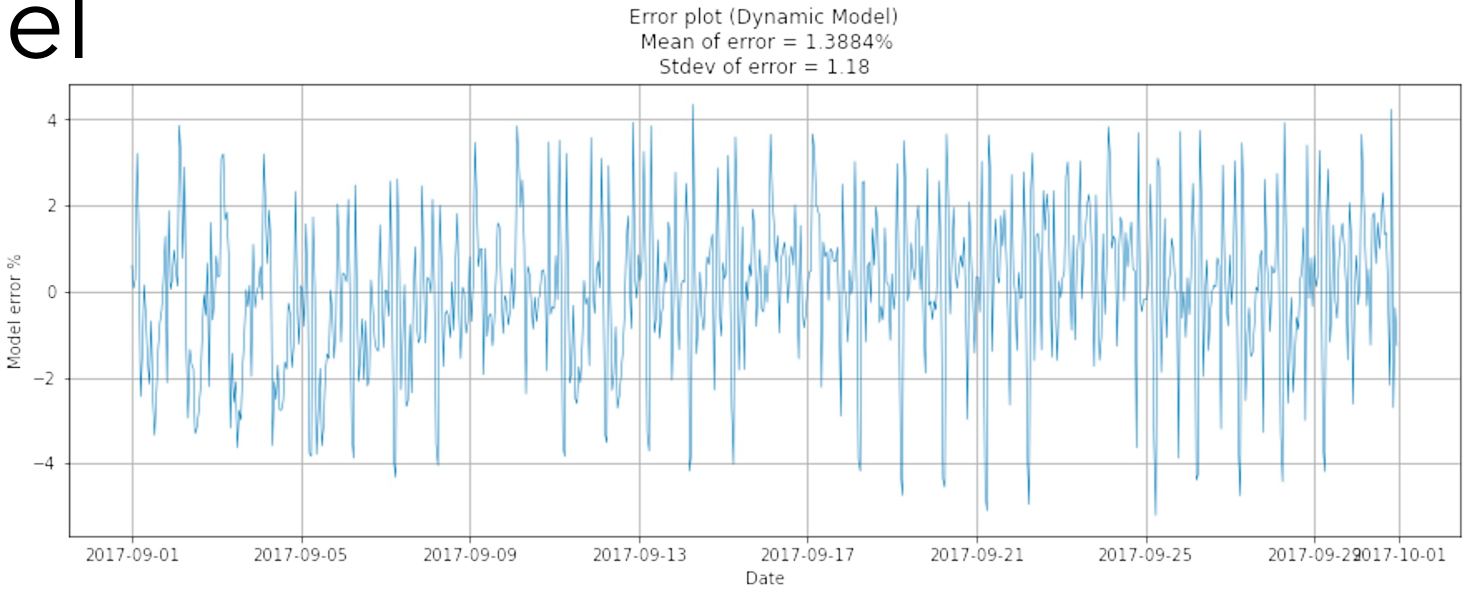
Dynamic Load Model

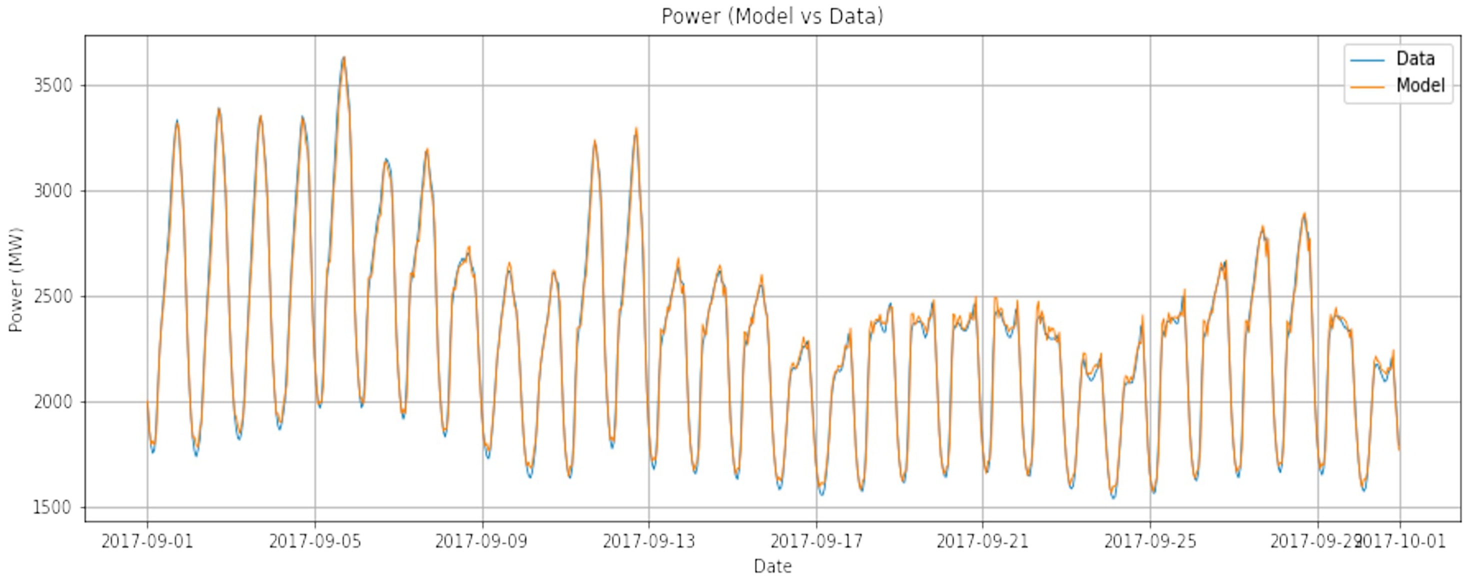
Discrete LTI transfer function

- G = LTIF(heat_index,power)
- Optionally add solar
- Features: hour, day, month

Model order N

- Minimizes RMSE
- Usually N ~ 24h





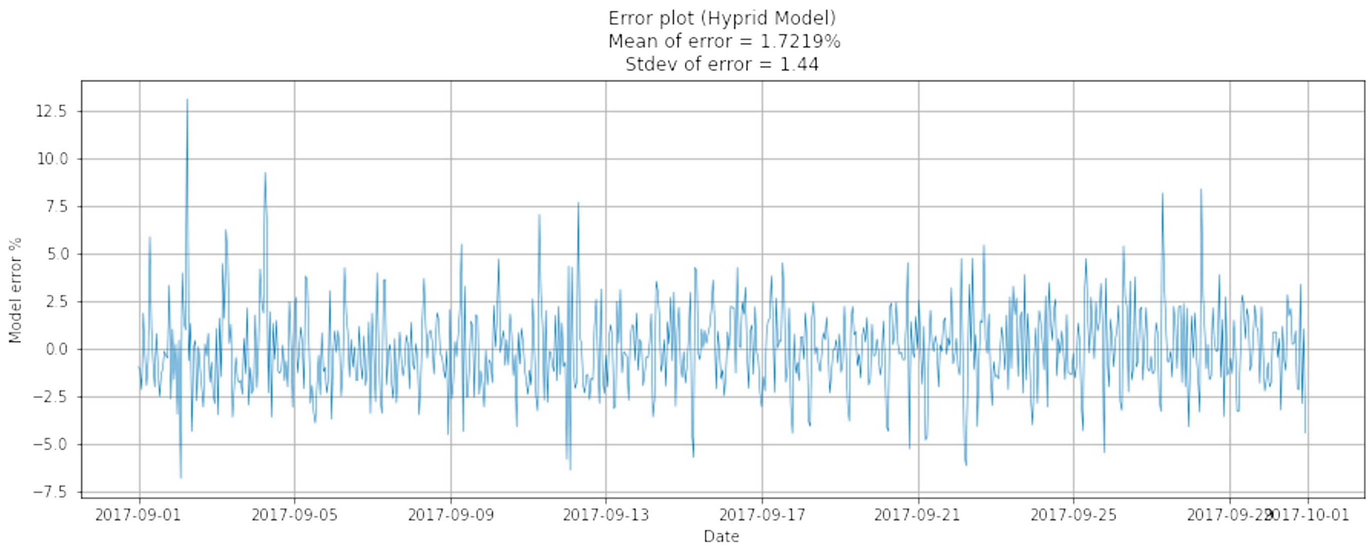
Hybrid Load Model

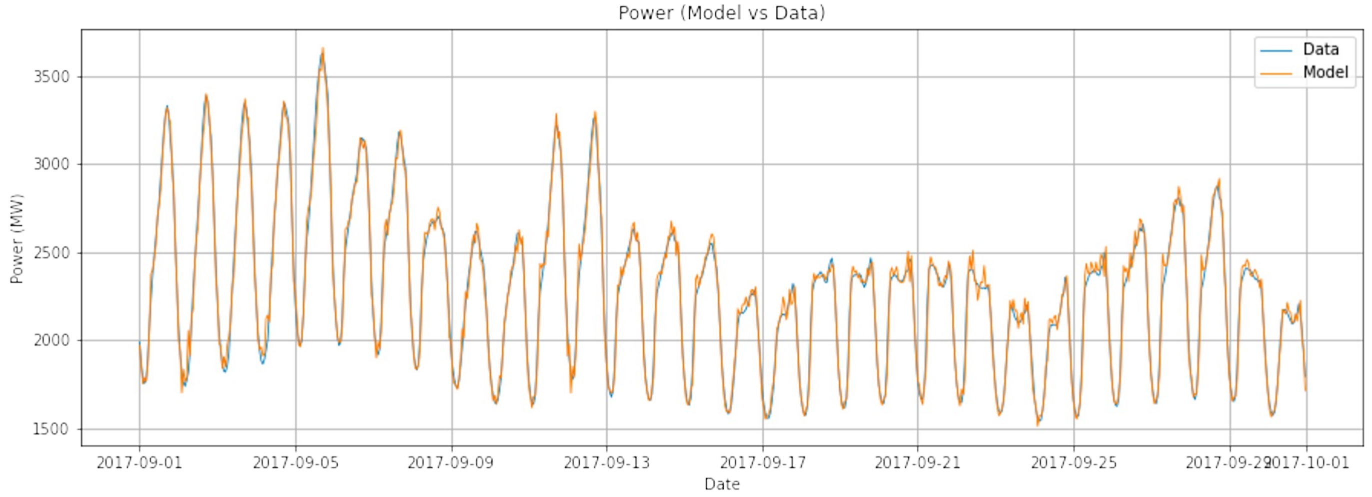
Mix static and dynamic models

- Fit static model first
- Remove static load
- Fit dynamic model to residual

Static model aligns to climate regions

Dynamic model aligns to building-mix





Low pass filter

Remove high-freq. responses

- Removes overshoot
- Reduces error by 50-75%
- Best result on hybrid model