STATISTICALLY ADJUSTED END-USE MODELS

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WLRA Meeting

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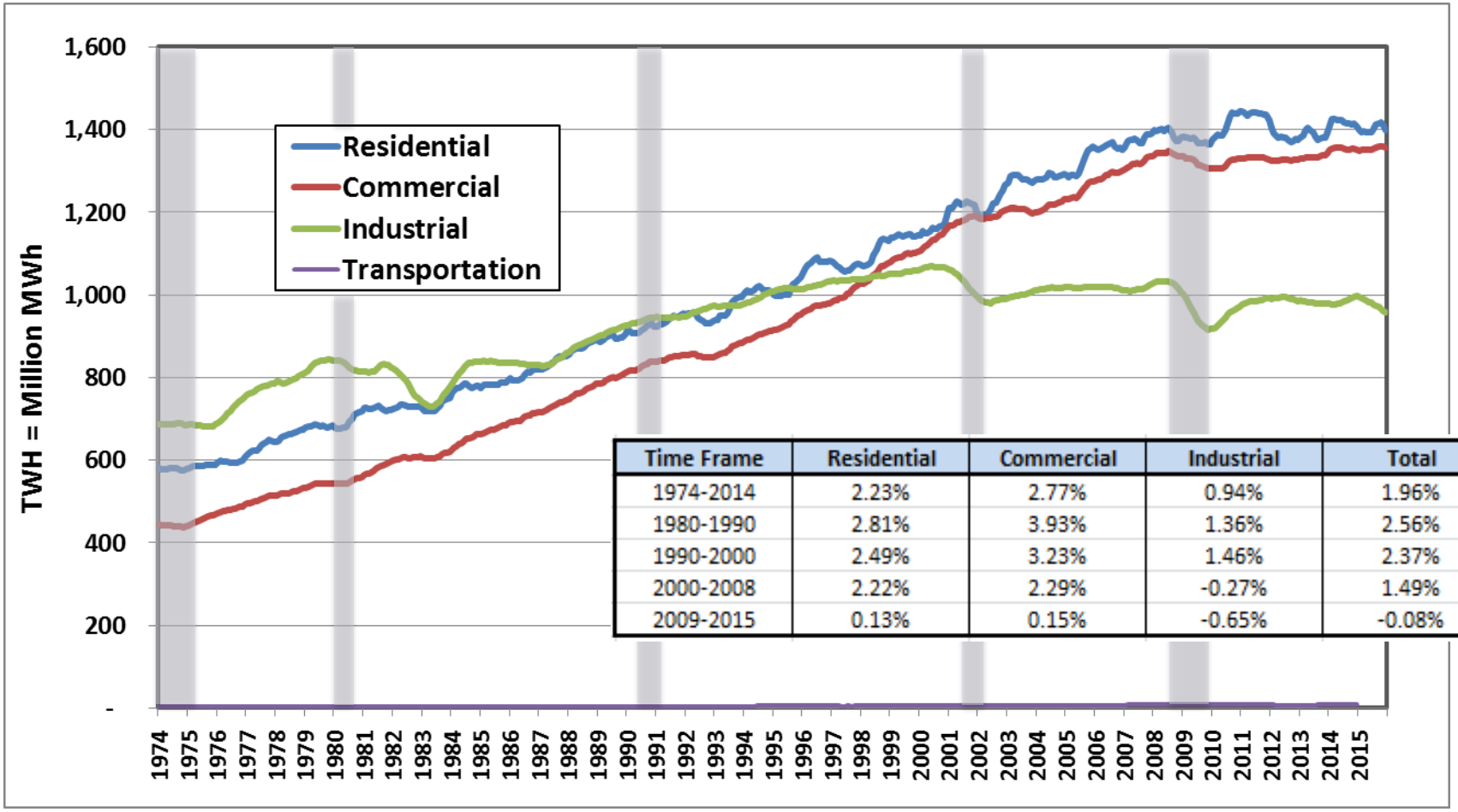
U.S. ELECTRICITY SALES (TWH)



Time Frame	Residential	Commercial	Industrial	Total
1974-2014	2.23%	2.77%	0.94%	1.96%
1980-1990	2.81%	3.93%	1.36%	2.56%
1990-2000	2.49%	3.23%	1.46%	2.37%
2000-2008	2.22%	2.29%	-0.27%	1.49%
2009-2015	0.13%	0.15%	-0.65%	-0.08%

Computed as 12 month moving sum of monthly class sales
Data updated through December 2015

FORECAST METHODS FOR ENERGY SALES

1. Econometric model
   - Estimate a regression model where sales or energy (usually monthly) is a function of weather, economics, price, and efficiency trend

2. End-Use model
   - Engineering based model (pre-determined model parameters) where annual energy is forecast at the end-use level (e.g. water heater, refrigerator, heating and cooling systems.)

3. Statistically Adjusted End-Use (SAE) model
   - Structured model variables based on end-use concepts are used to forecast sales (monthly) through an estimated regression model
   - A combination of 1 and 2

FORECAST METHODS FOR ENERGY SALES

1. Econometric model

$Sales_m = Customer_m \times Average\ Use_m$

$Customer_m = f(Population_m)$

$Average\ Use_m = f(HDD_m, CDD_m, HHIncome_m, Price_m, TrendVar_m)$

Doesn't account for changes in end use technology

2. End-Use model

$Sales_e = Households \times Saturation_e \times UEC_e$

$Sales_m = \sum_e Sales_e$

Difficult to obtain and maintain data

3. Statistically Adjusted End-Use (SAE) model

$Average\ Use_m = f(HDD_m, CDD_m, HHIncome_m, Price_m, Saturation_e, UEC_e)$

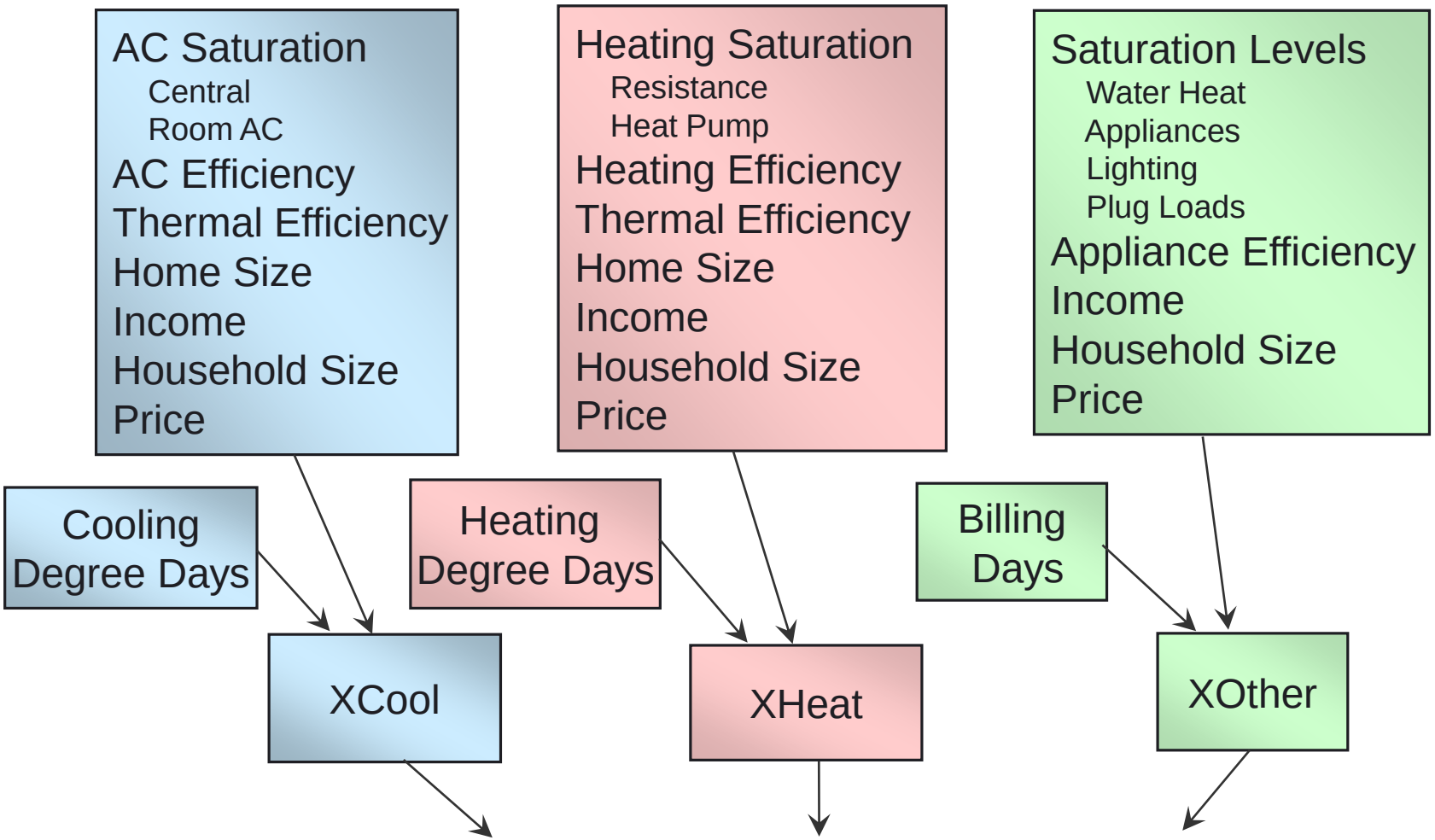
SAE MODEL
OBJECTIVE

» Develop an approach that incorporates the best characteristics of an econometric and end-use modeling framework

» We want to account for:
- Economic impacts: household income, size, growth
- Price impacts
- Structural changes: Saturation and efficiency trends, housing square footage, thermal shell integrity improvements
- Weather impacts
- Appropriate impact of these variables

» Ideally, one model for short and long-term forecasting

SAE MODEL: CONCEPTUAL EQUATION



$$AvgUse_m = b_c \times XCool_m + b_h \times XHeat_m + b_o \times XOther_m + e_m$$

Estimate monthly model with historical billed sales data

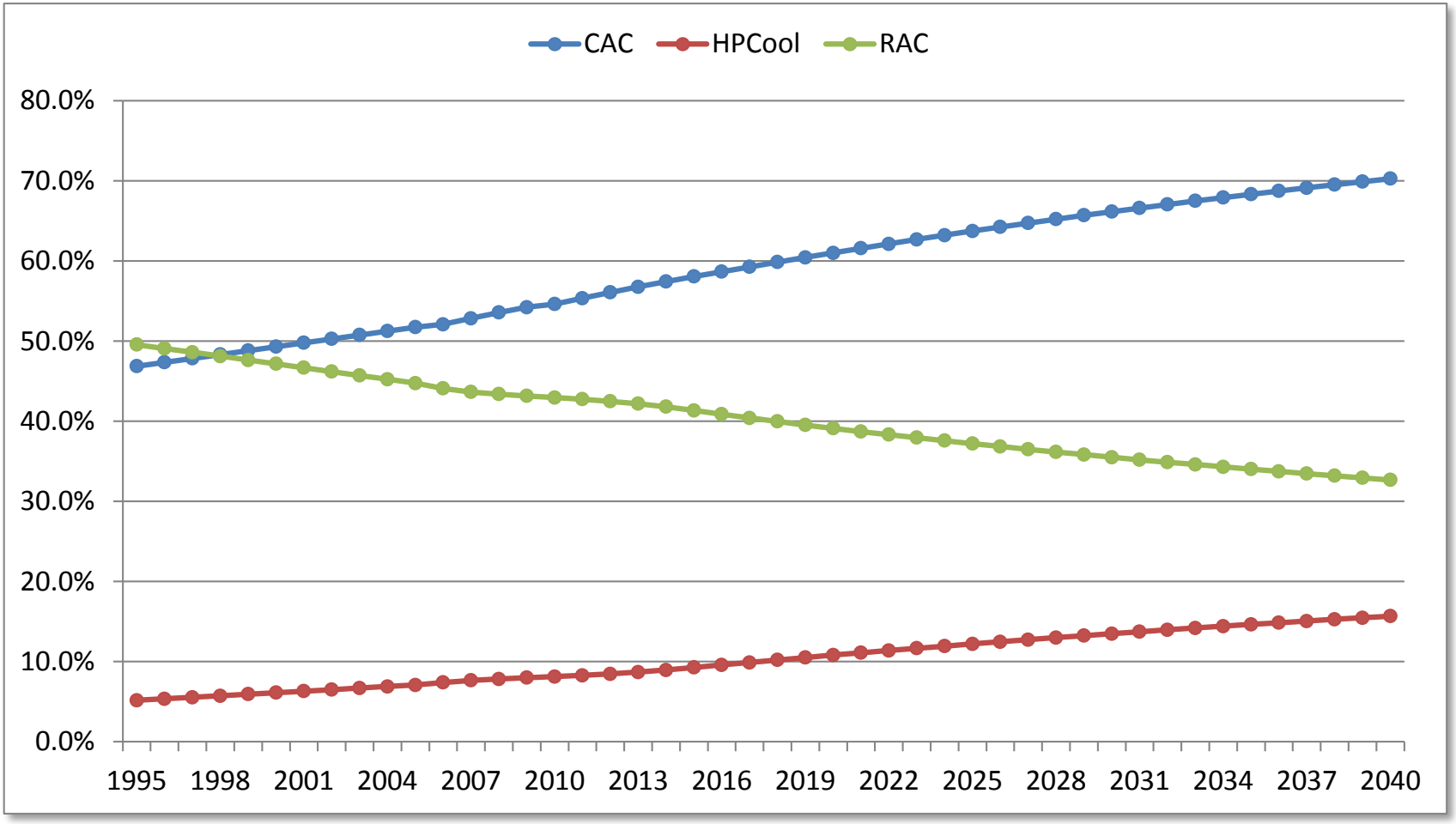
SAE MODEL: COOLING VARIABLE

$$\boxed{\mathrm{XCool}_{y,m} = \mathrm{CoolIndex}_{y} \times \mathrm{CoolUse}_{y,m}}$$

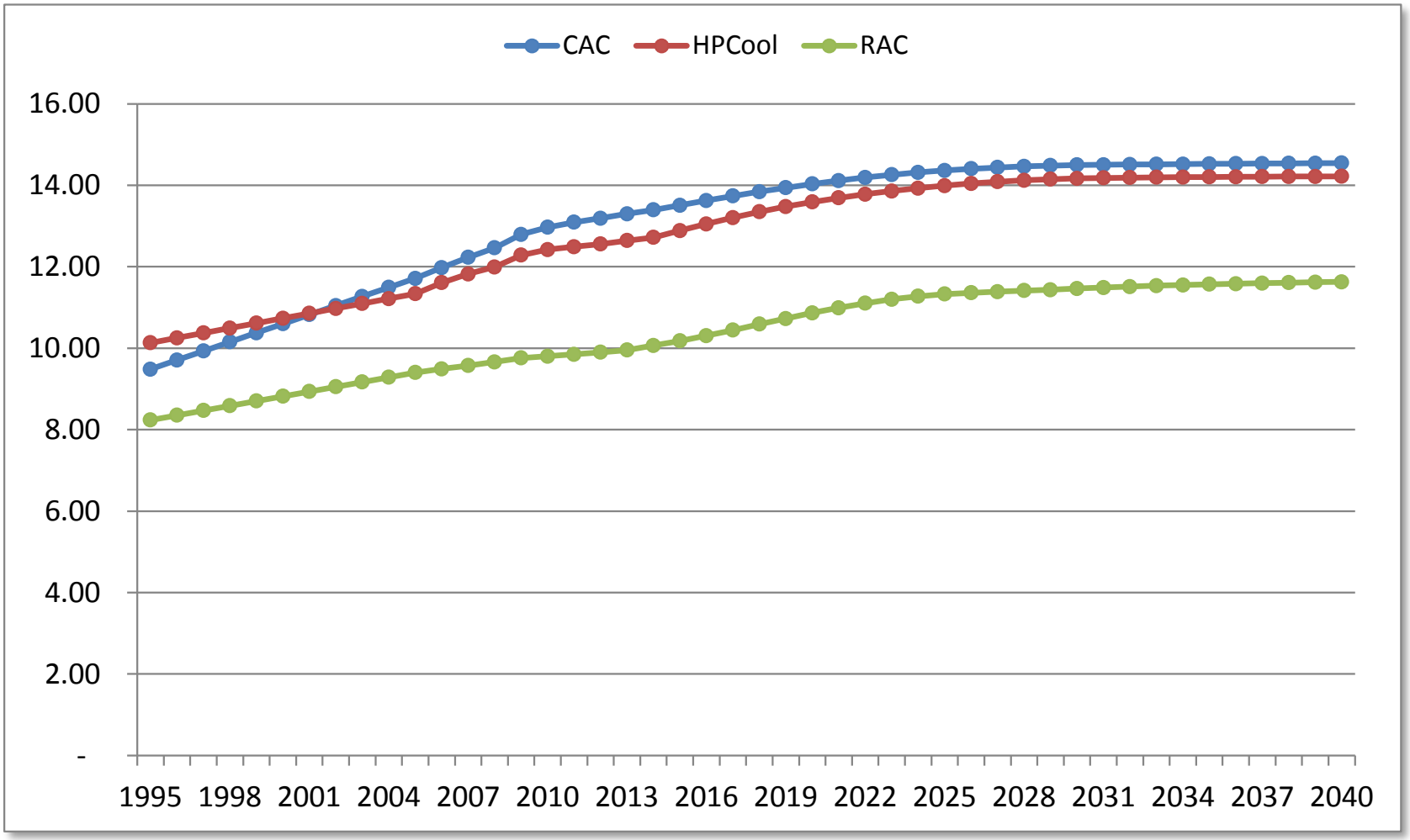
$$CoolIndex_y = StructuralIndex_y \times \sum_{Type} EI_{09}^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} \big/ Eff_{09}^{Type} \right)}$$

$$CoolUse_{y,m} = \left(\frac{CDD_{y,m}}{CDD_{09}} \right) \times \left(\frac{HHSize_{y,m}}{HHSize_{09}} \right)^{0.20} \times \left(\frac{Income_{y,m}}{Income_{09}} \right)^{0.20} \times \left(\frac{Price_{y,m}}{Price_{09}} \right)^{-0.15}$$

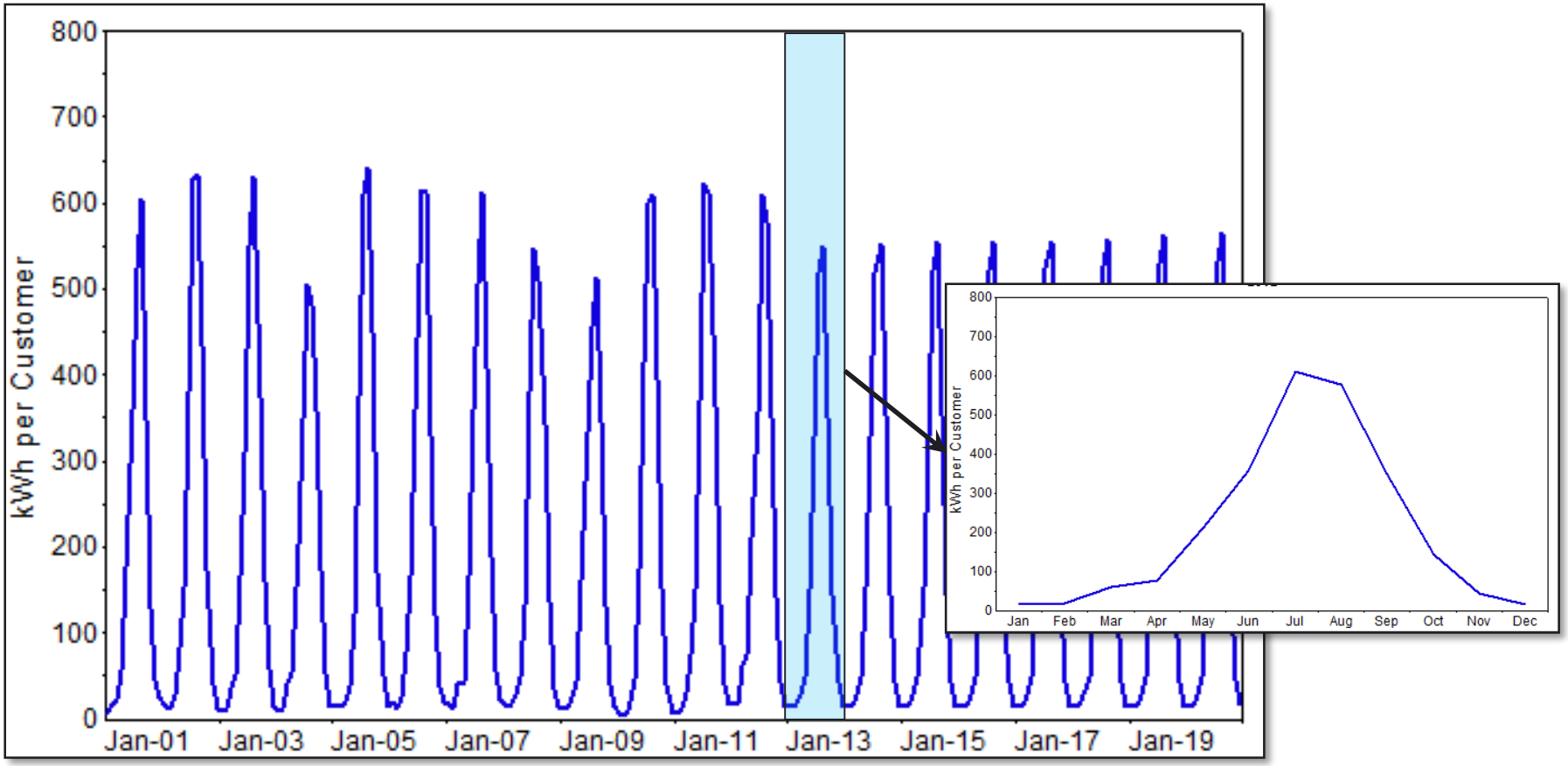
COOLING SATURATION TRENDS



COOLING EFFICIENCY TRENDS



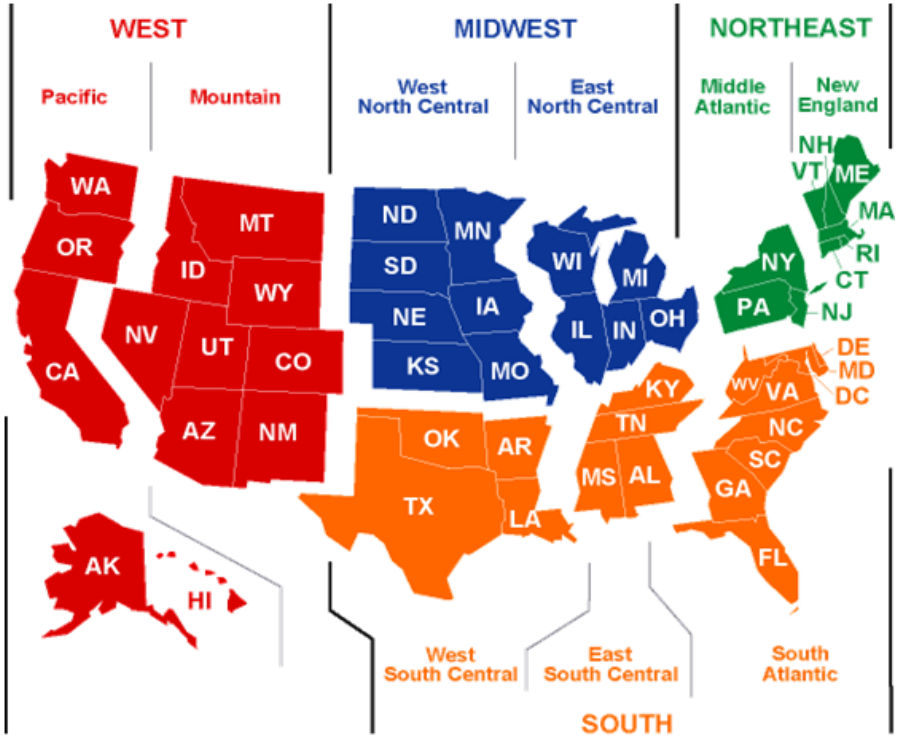
RESIDENTIAL XCOOL VARIABLE



WHERE DO THE INTENSITIES COME FROM?

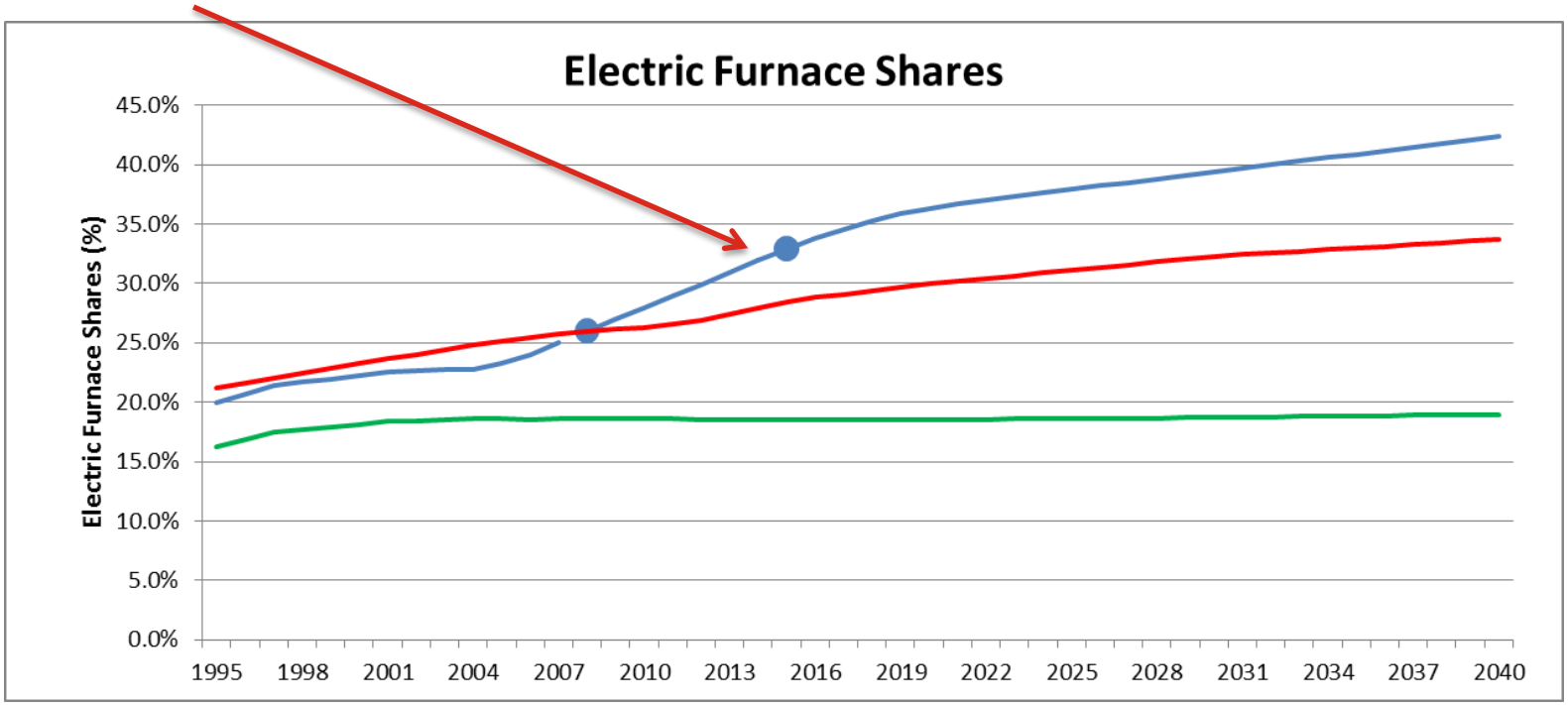
- The Energy Information Administration develops a detail end-use forecast for nine US census divisions
- Each year, we mine the forecast database for:
  - Number of households
  - Number of appliances
  - End-use consumption
  - End-use saturations
  - End-use average stock efficiency

Data is translated into model intensity Variables in SAE spreadsheets that are compatible with MetrixND



SERVICE AREAS ARE NOT CENSUS DIVISIONS

Updated Saturation shows growing electric heating shares



- 2008 Saturation is 26%
- 2015 Saturation is 33%
- Heating saturations are opposite to regional trend

SAE MODEL SPECIFICATION CONCLUSIONS

- The model specification works well in explaining historical sales trends. Generally we get strong statistical fits.

- Appliance saturation and efficiency trends are embedded in the model structure.
  - Integrates end-use structural indices that will withstand scrutiny in a regulatory environment
  - Allows us to decompose the monthly and annual forecasts into the primary end-use components

- SAE models are significantly easier to maintain and update than traditional end-use models

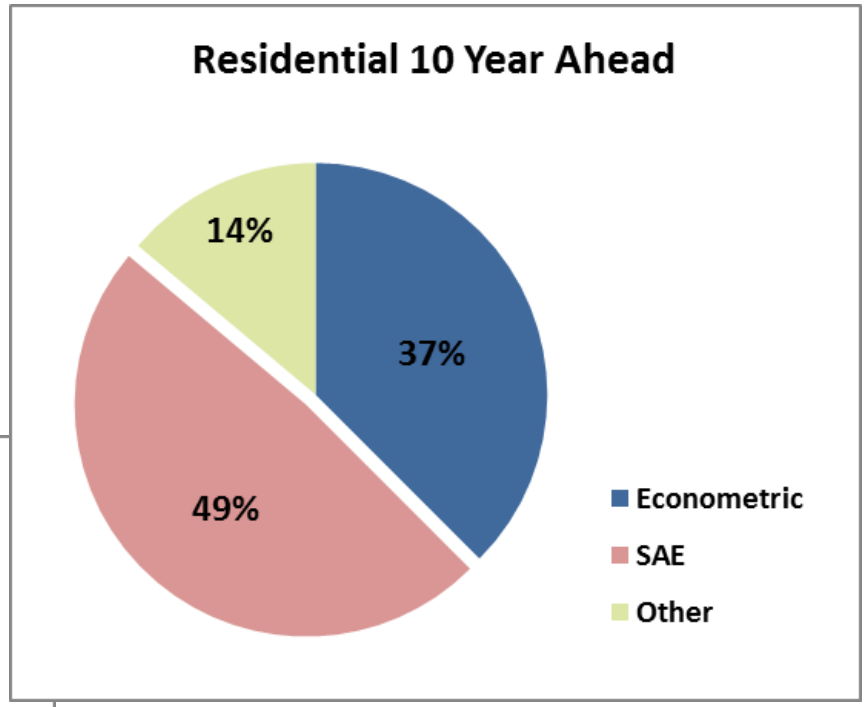
- By design, the SAE model “calibrates” into actual sales. We can use the same model for forecasting both short-term and long-term energy requirements.

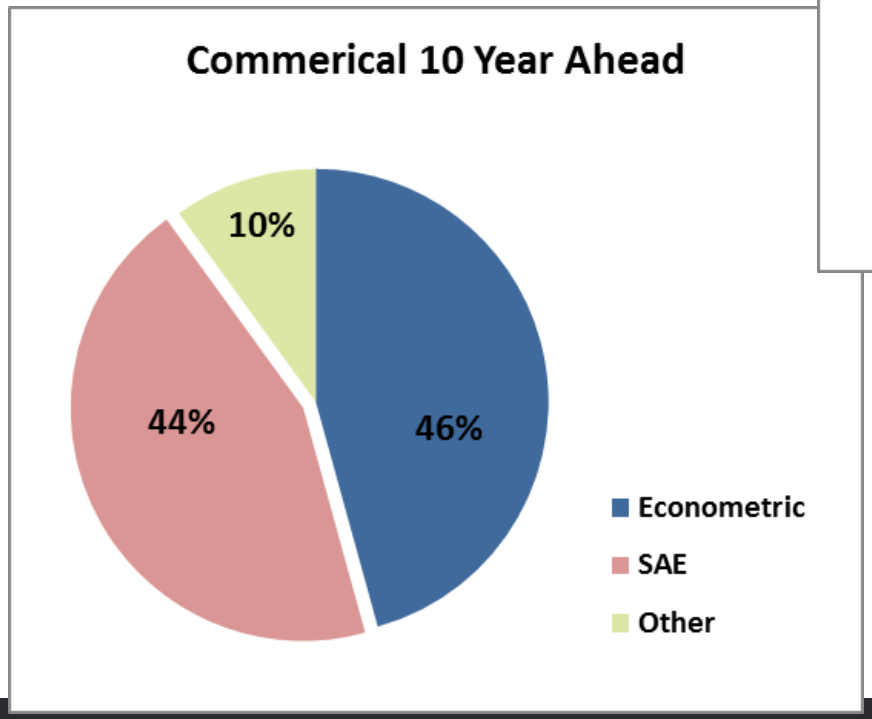
ENERGY FORECAST METHODS

Survey: 71 Utility Respondents

Residential

- Close to 50% use SAE
- Almost 85% use econometric or SAE models





Commercial

- Close to 45% use SAE
- Almost 90% use econometric or SAE models

2015 Itron Benchmarking Survey

THANK YOU

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