INTEGRATING ENERGY EFFICIENCY PROGRAM IMPACTS INTO THE FORECAST

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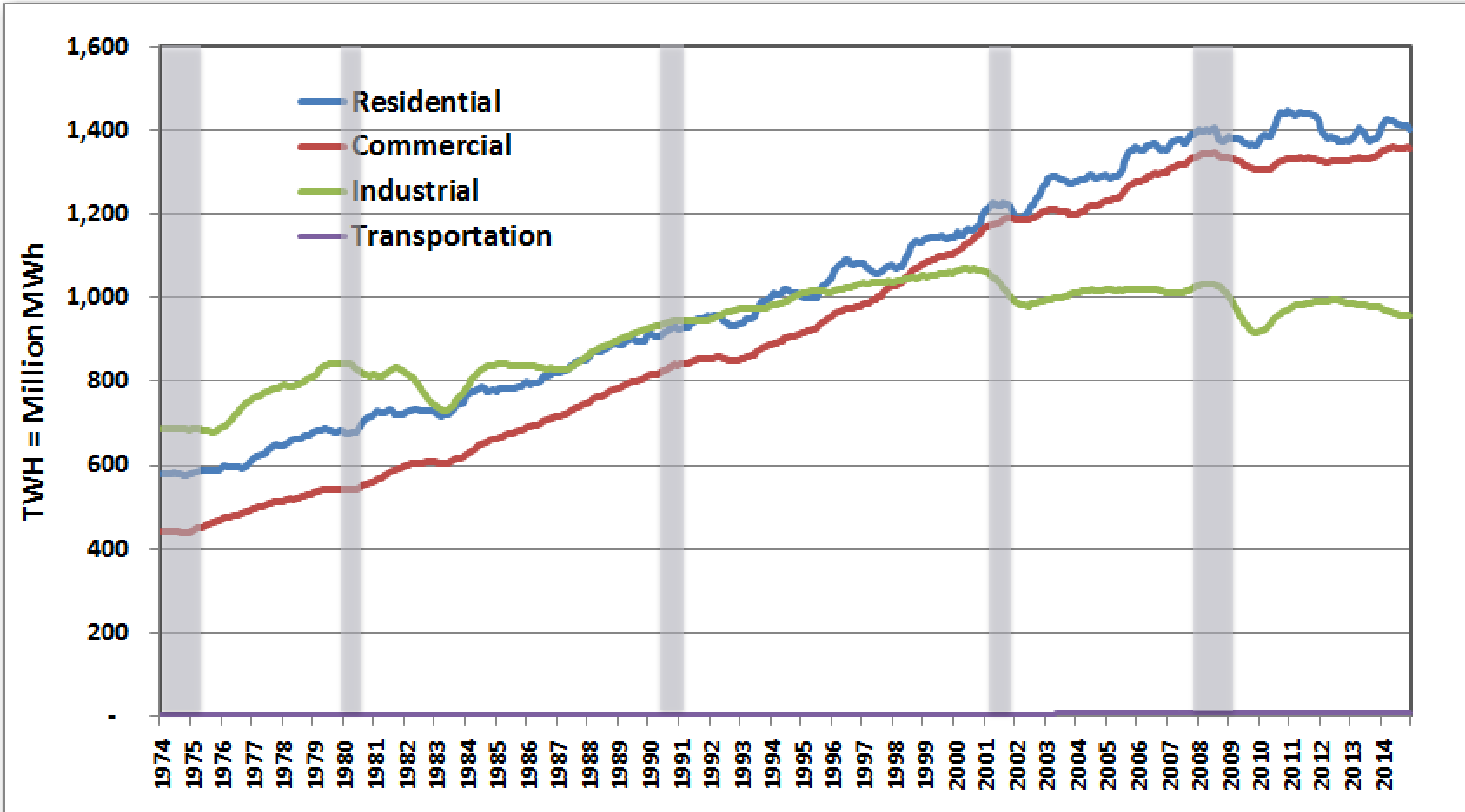
OVERVIEW

1. Energy Trends
2. Statistically Adjusted End-Use (SAE) Modeling Framework
3. Incorporating EE Program Savings into the Forecast

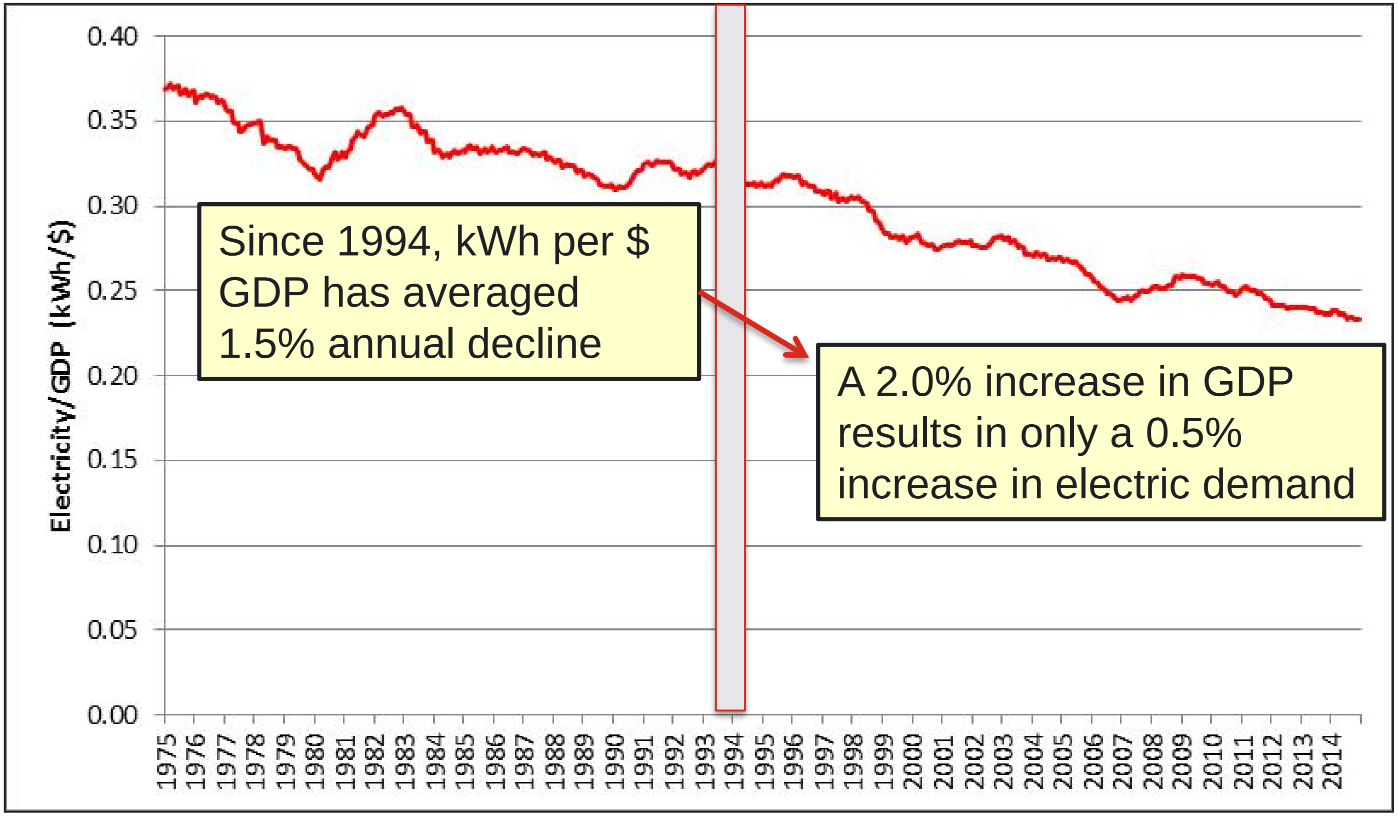
ENERGY TRENDS

U.S. ELECTRICITY SALES (TWH)

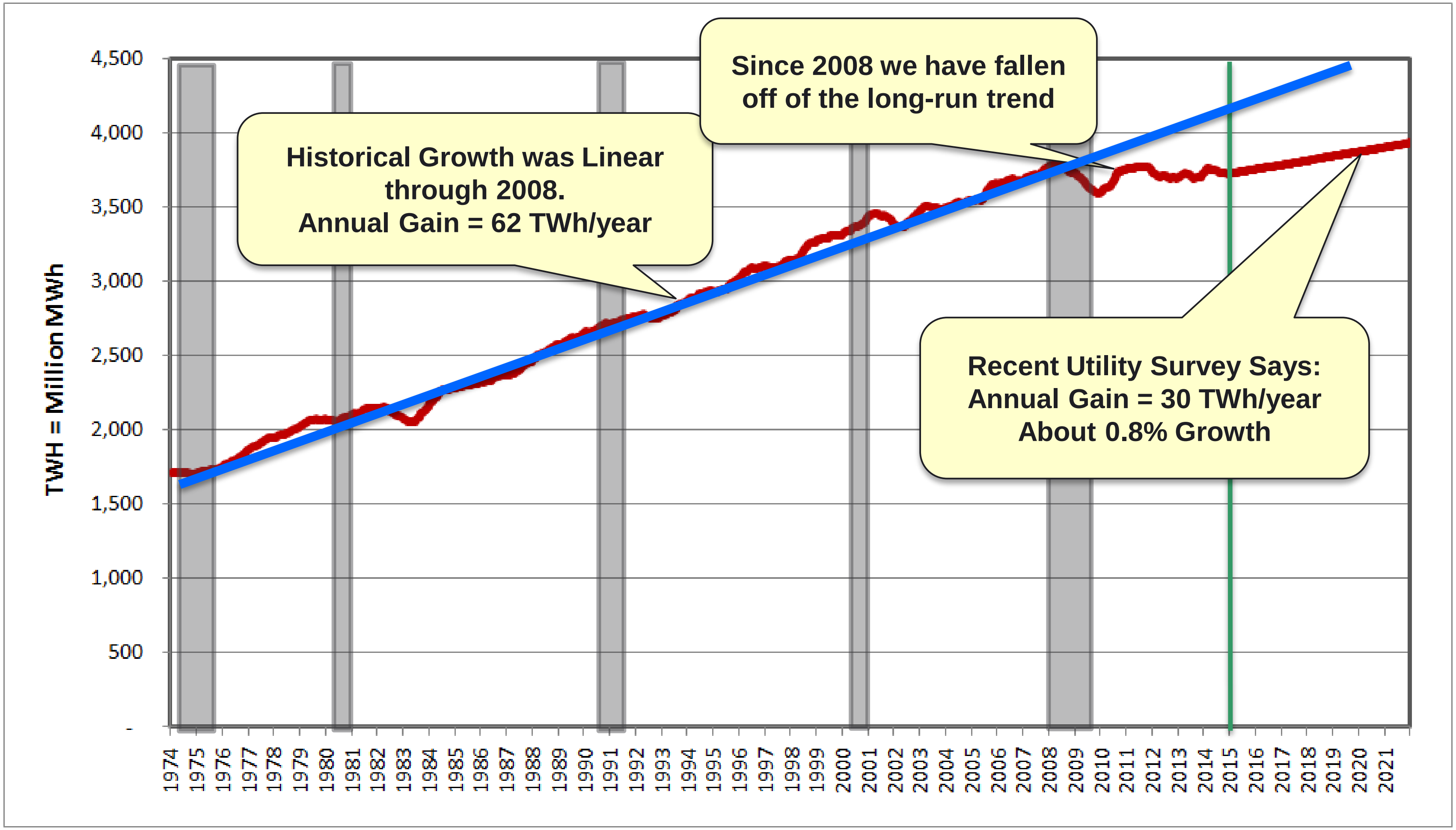


Computed as 12-month moving sum of monthly class sales
Data updated through March 2015

TOTAL ELECTRIC INTENSITY (KWH PER $ GDP)



LIVING IN A 1% WORLD. The New Normal?



If the economy recovers to its trend line, will electric sales recover too?

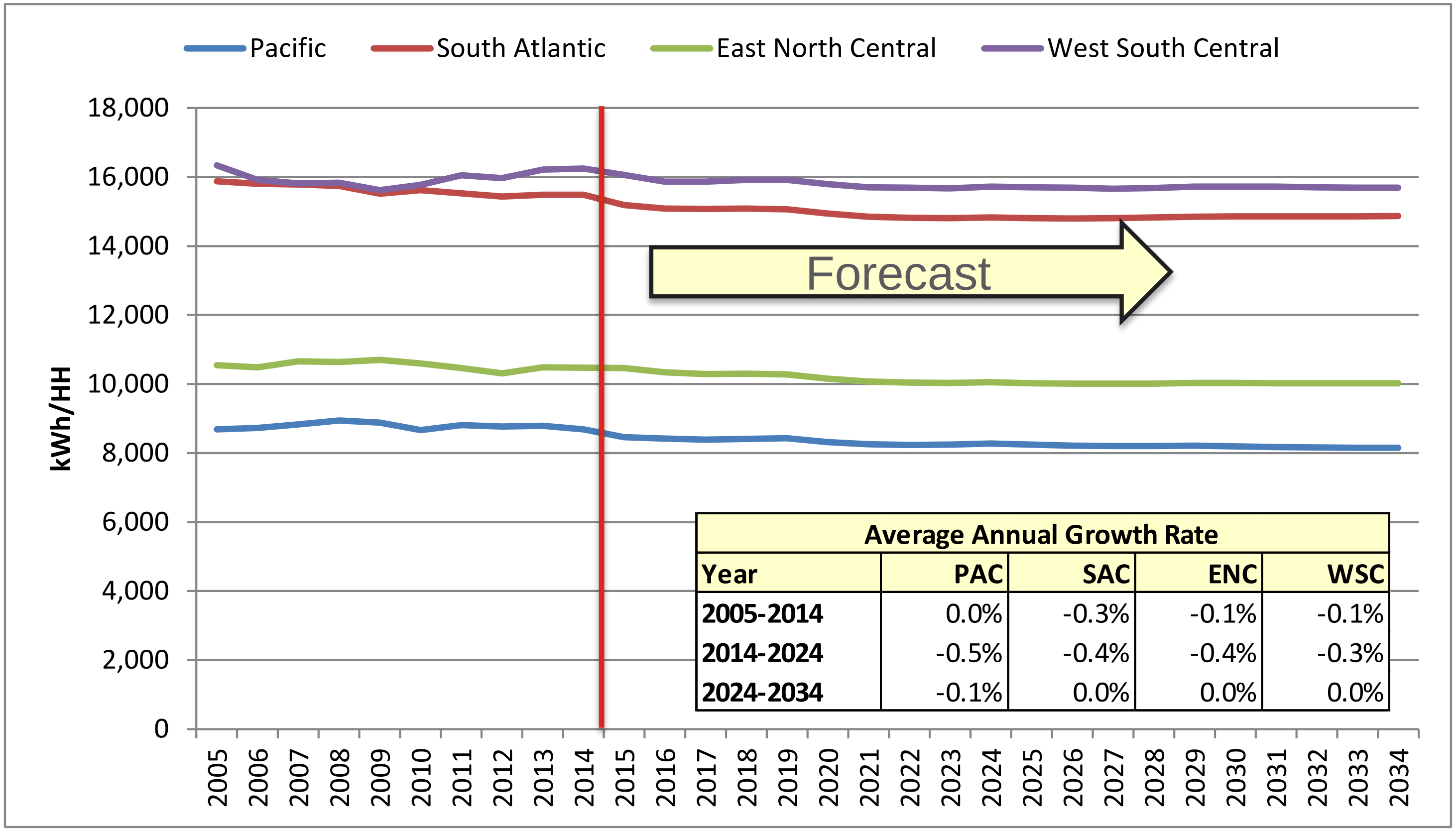
THE ECONOMY HAS SLOWLY BEEN IMPROVING, BUT ELECTRIC SALES ARE STILL FLAT. WHAT DO YOU THINK IS THE PRIMARY REASON ELECTRIC SALES HAVE NOT RECOVERED?

ANSWERS

1. It's mostly the economy
   - The economy has not yet shown any significant recovery
   - Structural changes – Less energy intensive industries, Increase in multi-family housing market share (apartments), slower household formation

2. It's mostly efficiency
   - New end-use standards that have significantly reduced end-use energy requirements
   - Utility and state efficiency programs and tax incentives have had a major impact on customer usage

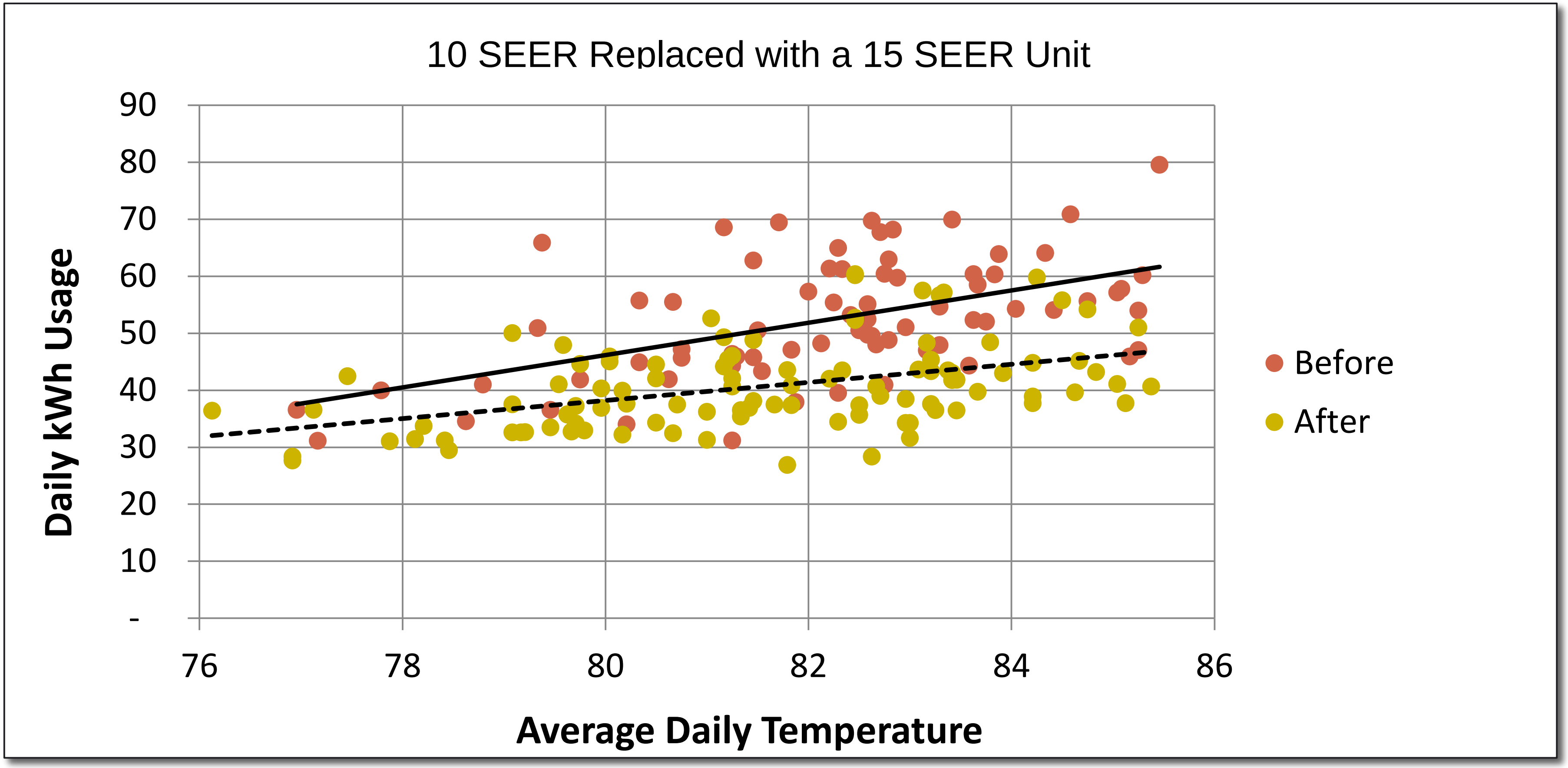
CASE FOR EFFICIENCY: RESIDENTIAL USE PER HH (KWH)



Average Annual Growth Rate				
Year	**PAC**	**SAC**	**ENC**	**WSC**
2005-2014	0.0%	-0.3%	-0.1%	-0.1%
2014-2024	-0.5%	-0.4%	-0.4%	-0.3%
2024-2034	-0.1%	0.0%	0.0%	0.0%

Residential average use has been flat to slightly declining for the last ten years. This trend will likely accelerate over the next ten years as end-use efficiency continues to improve.

IMPACT OF REPLACING A HEAT PUMP



A 20% reduction in summer energy use with new heat pump.
Actual data from a Florida load research survey customer.

ENERGY LEGISLATION HAS HAD A SIGNIFICANT IMPACT ON EFFICIENCY

» DOE Rule Making Authority for a large range of appliances and commercial equipment efficiency have been established by USC 6295 effective in 1990

- USC 6295 can be accessed at http://www.law.cornell.edu/uscode/text/42/6295

» DOE's authority has been reaffirmed in the following legislations:

- Energy Policy and Conservation Act (1975)
- National Appliance Energy Conservation Act (1987 and 1988)
- Energy Policy Act of 1992 (1992)
- Energy Policy Act of 1995 (1995)
- Energy Independence and Security Act (2007)

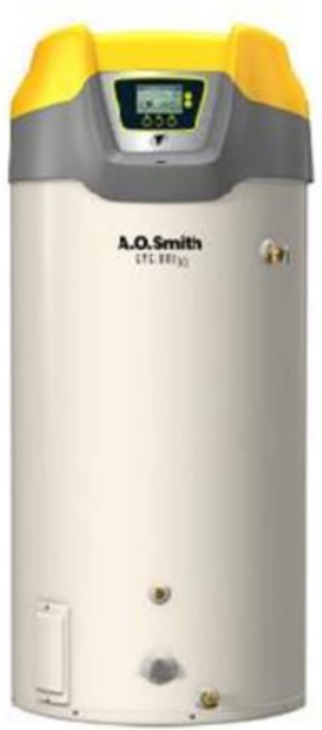
Current end-use standards can be found at the ASAP website

ASAP WEB SITE

http://www.appliance-standards.org/national

THE PRODUCT:

Residential water heaters are used primarily to provide hot water to residences for consumer use, appliances, and other functions. Water can be heated by electricity, gas, or oil. There are two main types of water heaters: typical heater/storage units and instantaneous water heaters.



Source: A.O Smith

THE STANDARD:

DOE published a final rule for amended standards for residential water heaters on April 16, 2010, which will become effective April 16, 2015. The required energy factor (EF) varies depending on the type of water heater and the rated storage volume. For gas-fired and electric storage water heaters with a volume greater than 55 gallons, the standards effectively require heat pumps for electric storage products and condensing technology for gas storage products. According to the DOE, the standard will save 2.6 quads of energy over 30 years or about enough energy to meet the total energy needs of about 13 million typical U.S. households for one year. Over the same 30-year period, consumers will save about $8.7 billion and carbon dioxide emissions will be cut by 154 million metric tons.

The 2012 ASAP/ACEEE report, *The Efficiency Boom*, analyzes standard levels for electric water heaters that would effectively require heat pump technology for water heaters with storage volumes at or above 40 gallons. This standard would result in approximately 43% energy savings. Lower electricity bills would cover typical incremental costs for more efficient water heaters (about $800) in seven years. Standards for gas water heaters were not analyzed in the report because, based on current information, condensing gas water heaters are not cost-effective for consumers. Tankless water heaters were not analyzed due to a lack of data available to verify savings.

KEY FACTS:

Water heating represents 20% percent of total annual household energy consumption in the U.S. About 53% of U.S. households use natural gas water heaters, while 38% use electric and less than 4% use oil. According to DOE, a baseline .90 EF electric water heater consumes around 2,700 kWh annually. Though electric water heaters are rated with higher energy factors than gas or oil, these ratings do not account for the fact that about 3 Btus of fuel need to be burned to generate 1 Btu of electricity. All water heaters generally waste a portion of fuel they use to keep storage water heated: for example, in a conventional gas water heater, only 43% of the fuel energy actually reaches the point of use. The remaining 57% dissipates through standby losses, distribution losses, or combustion losses. Thicker tank insulation can increase the efficiency of all types of water heaters, but this has decreasing gains at higher efficiency levels, which already have relatively thick insulation. There is not much potential for additional efficiency gains for conventional gas and electric storage water heaters. However, heat pumps can decrease energy use by about 50% compared to electric storage water heaters while condensing gas water heaters can reduce energy consumption by about 25% compared to conventional gas storage products.

STATISTICALLY ADJUSTED END-USE MODELING FRAMEWORK

HOW DO WE USE ELECTRICITY ?

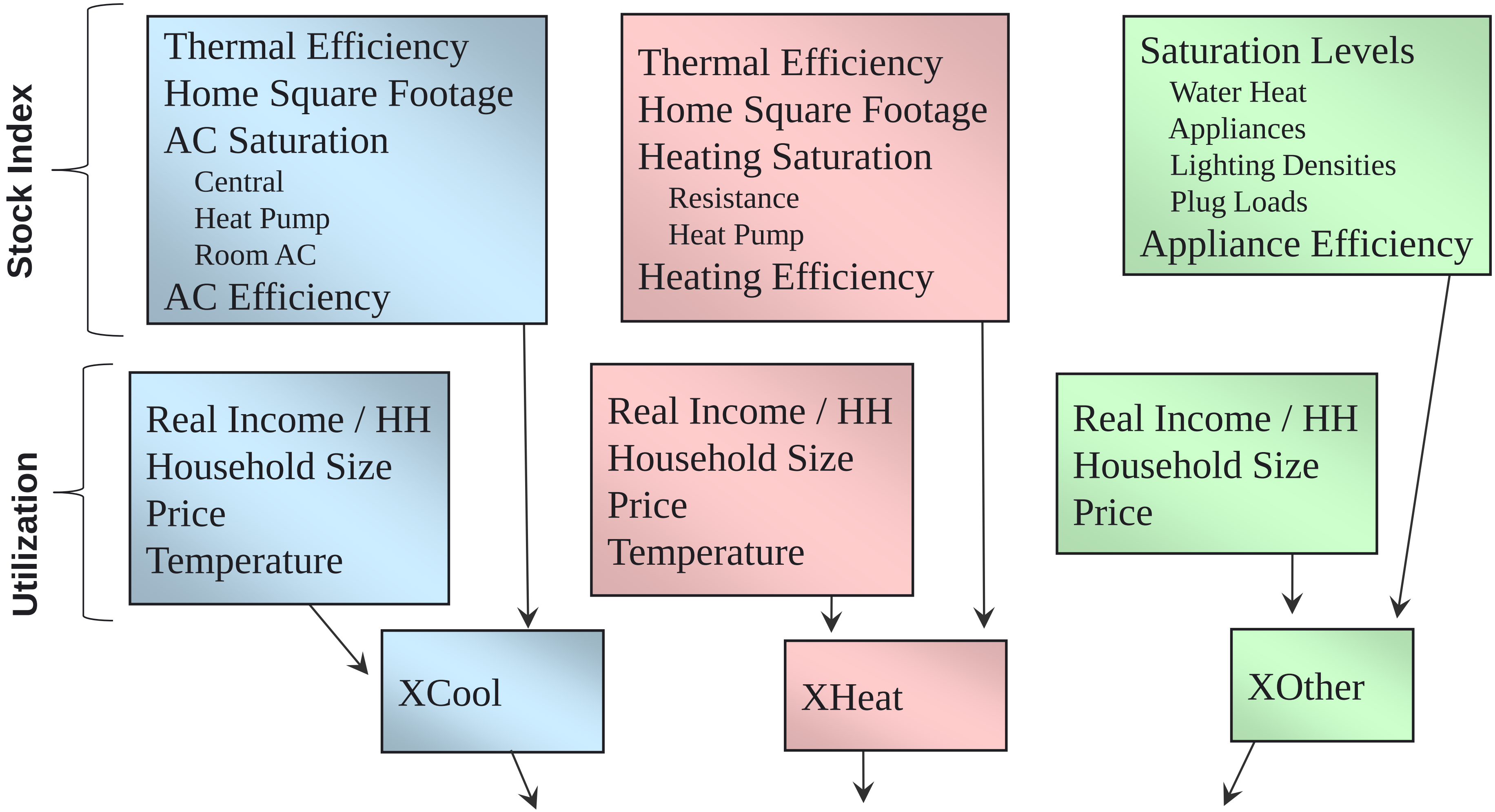
» We don't … We use the stuff that uses electricity

- We light our homes
- We refrigerate and cook our food
- We shower under hot water
- We vacuum up after the kids and dog
- We dry our clothes
- We watch TV

» To forecast electricity we reverse engineer the model

- If cooling output depends on electricity input then electricity use depends on cooling demand

CAPTURING EFFICIENCY THROUGH THE SAE MODELING FRAMEWORK



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

END-USE VARIABLE - COOLING

$$XCool_{y,m} = CoolIndex_y \times CoolUse_{y,m}$$

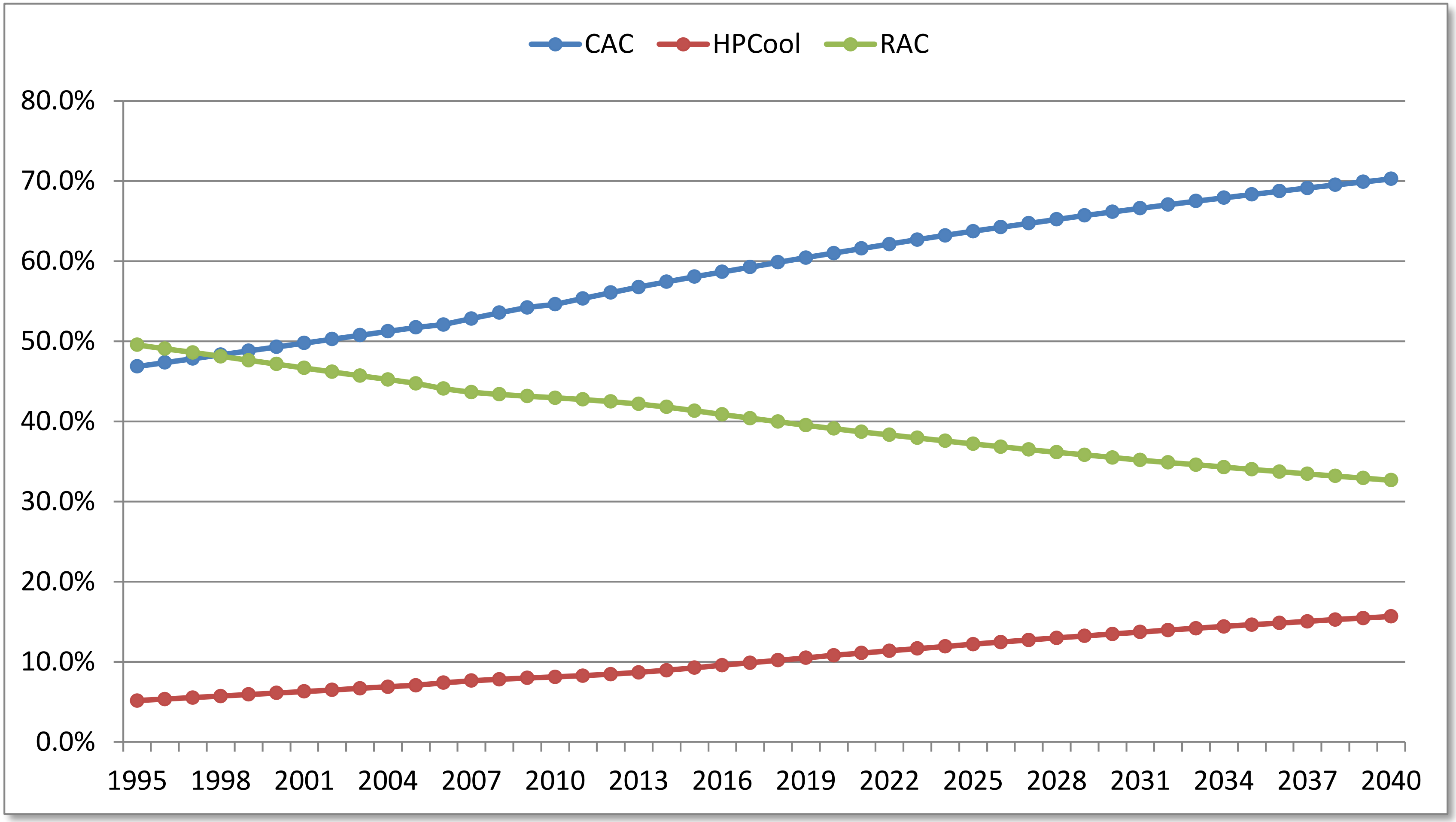
Structural Component:

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

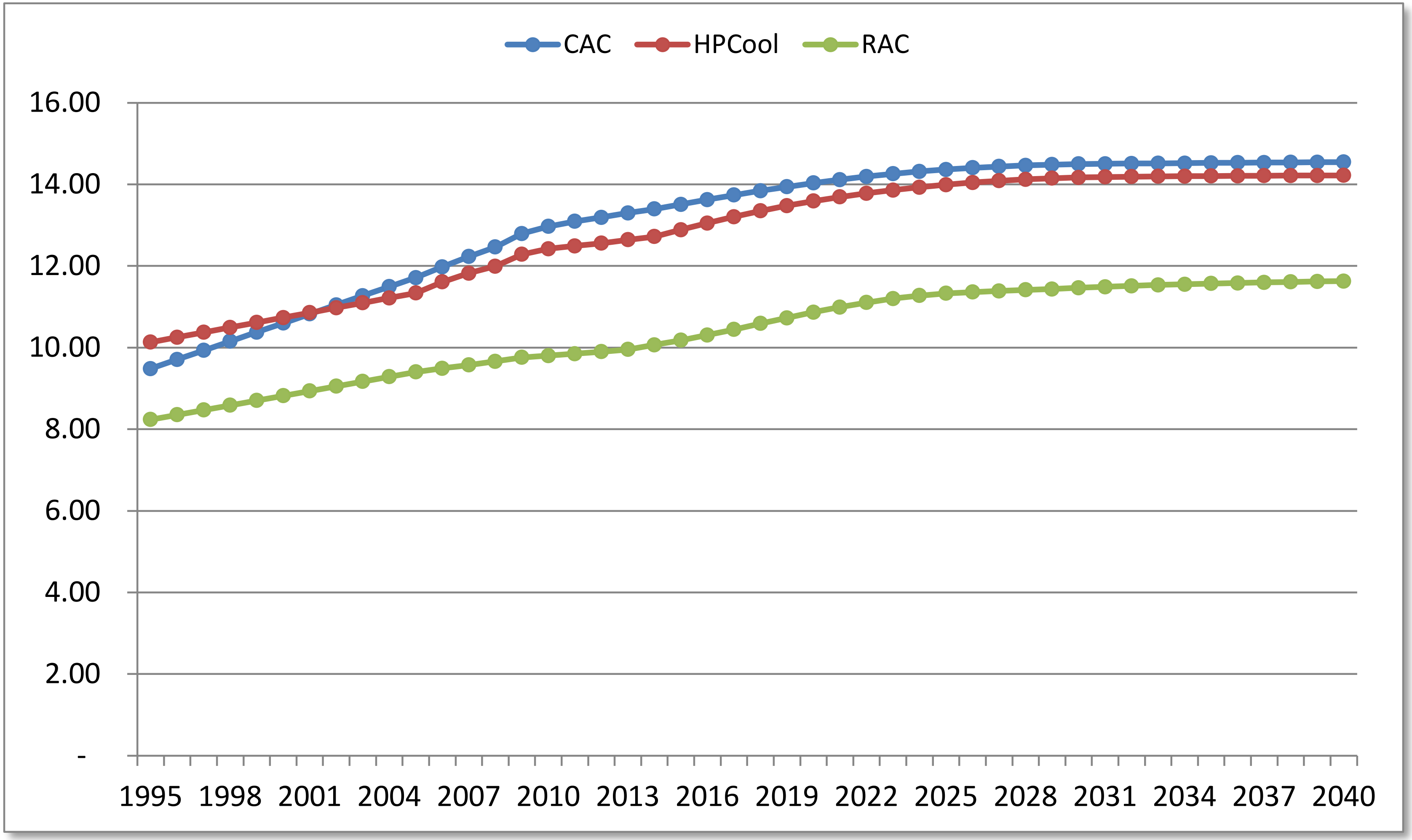
Utilization Component:

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

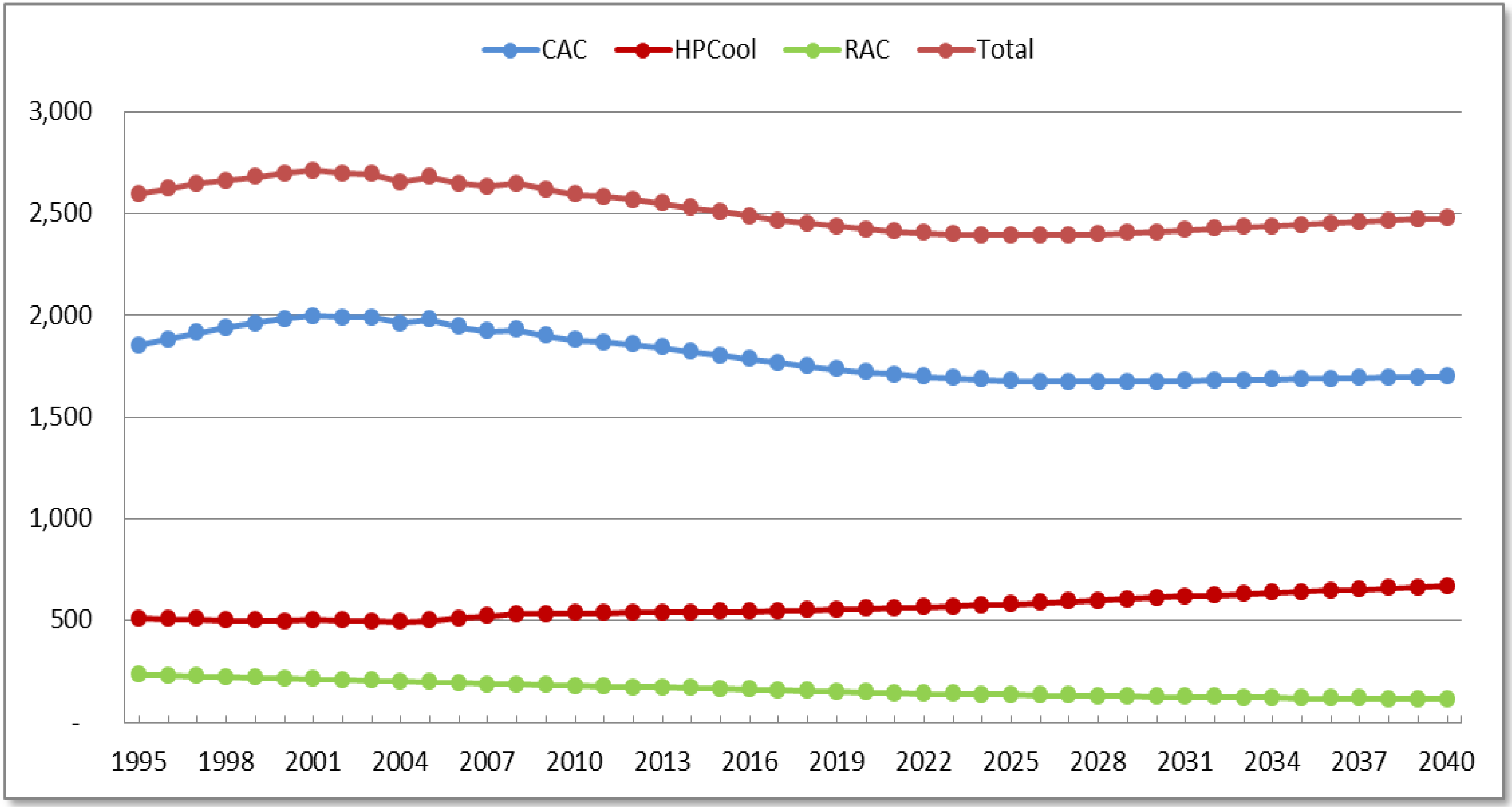
COOLING SATURATION TRENDS



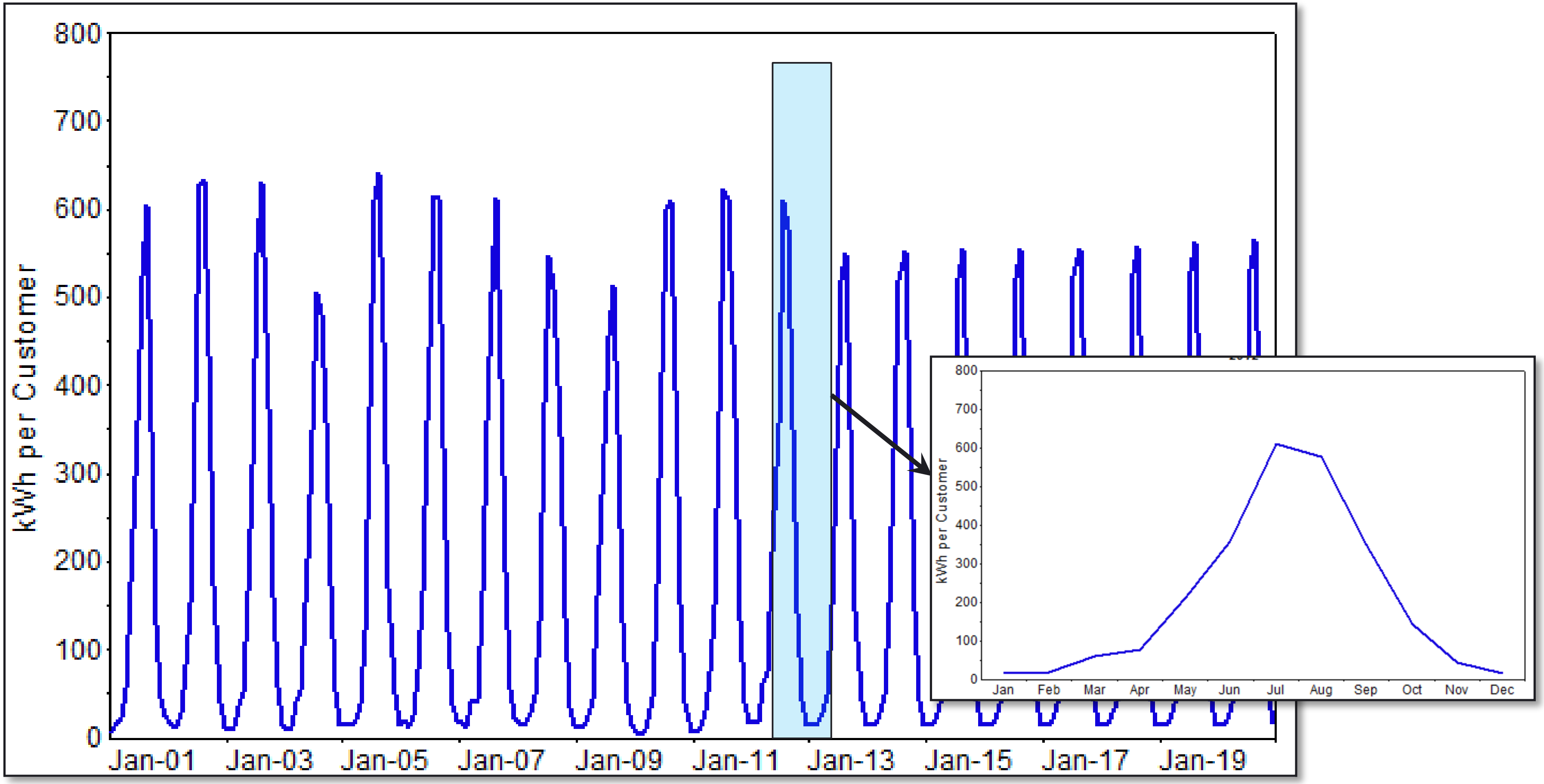
COOLING EFFICIENCY TRENDS



COOLING INTENSITY (KWH PER HH)



RESIDENTIAL XCOOL VARIABLE



Combine Cooling intensity with weather, price, and household income

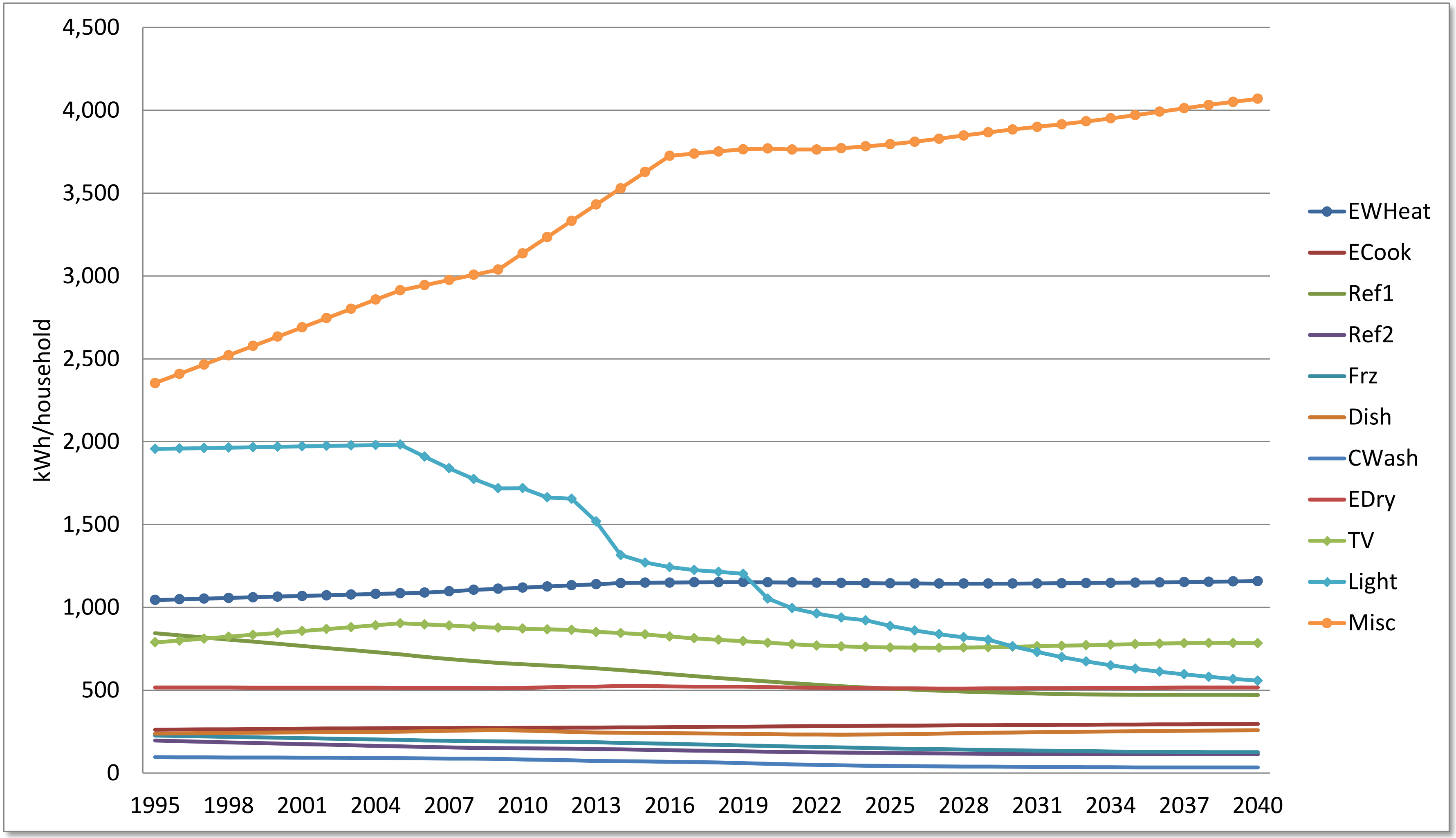
XOTHER VARIABLE

$$XOther_{y,m} = OtherEqpIndex_{y,m} \times OtherUse_{y,m}$$

$$OtherEqpIndex_{y,m} = EI_{09}^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} \big/ Eff_{09}^{Type} \right)} \times MoMult_m^{Type}$$

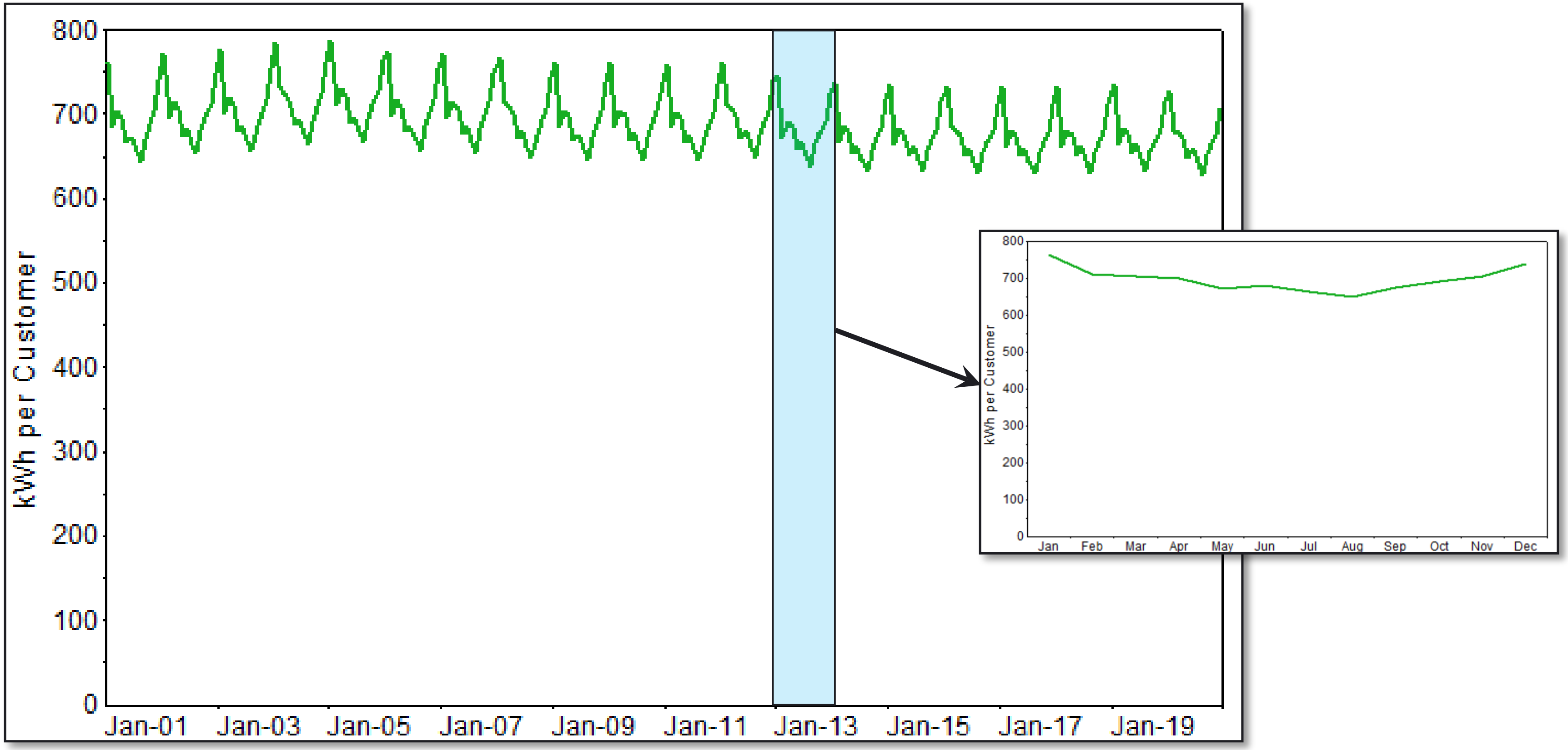
$$OtherUse_{y,m} = \left(\frac{Price_{y,m}}{Price_{09}} \right)^{-0.15} \times \left(\frac{Income_{y,m}}{Income_{09}} \right)^{0.10} \times \left(\frac{HHSize_{y,m}}{HHSize_{09}} \right)^{0.25} \times \left(\frac{BDays_{y,m}}{31} \right)$$

END-USE INTENSITIES (KWH / HOUSEHOLD)



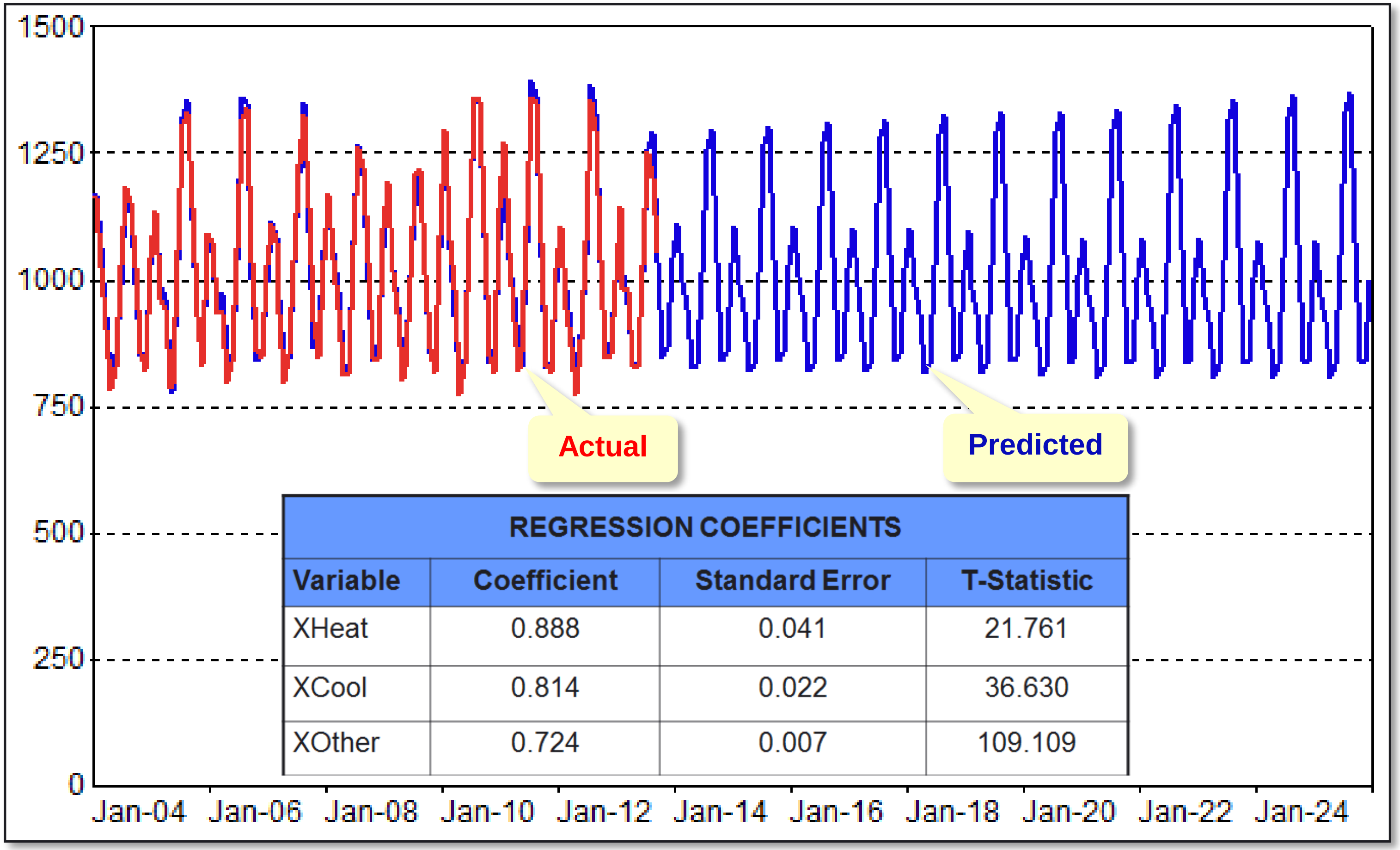
End- use intensities reflect change in saturation (ownership) and improvements in average stock efficiency.

RESIDENTIAL XOTHER VARIABLE



Combine Other Use intensities with number of days, price, and household income

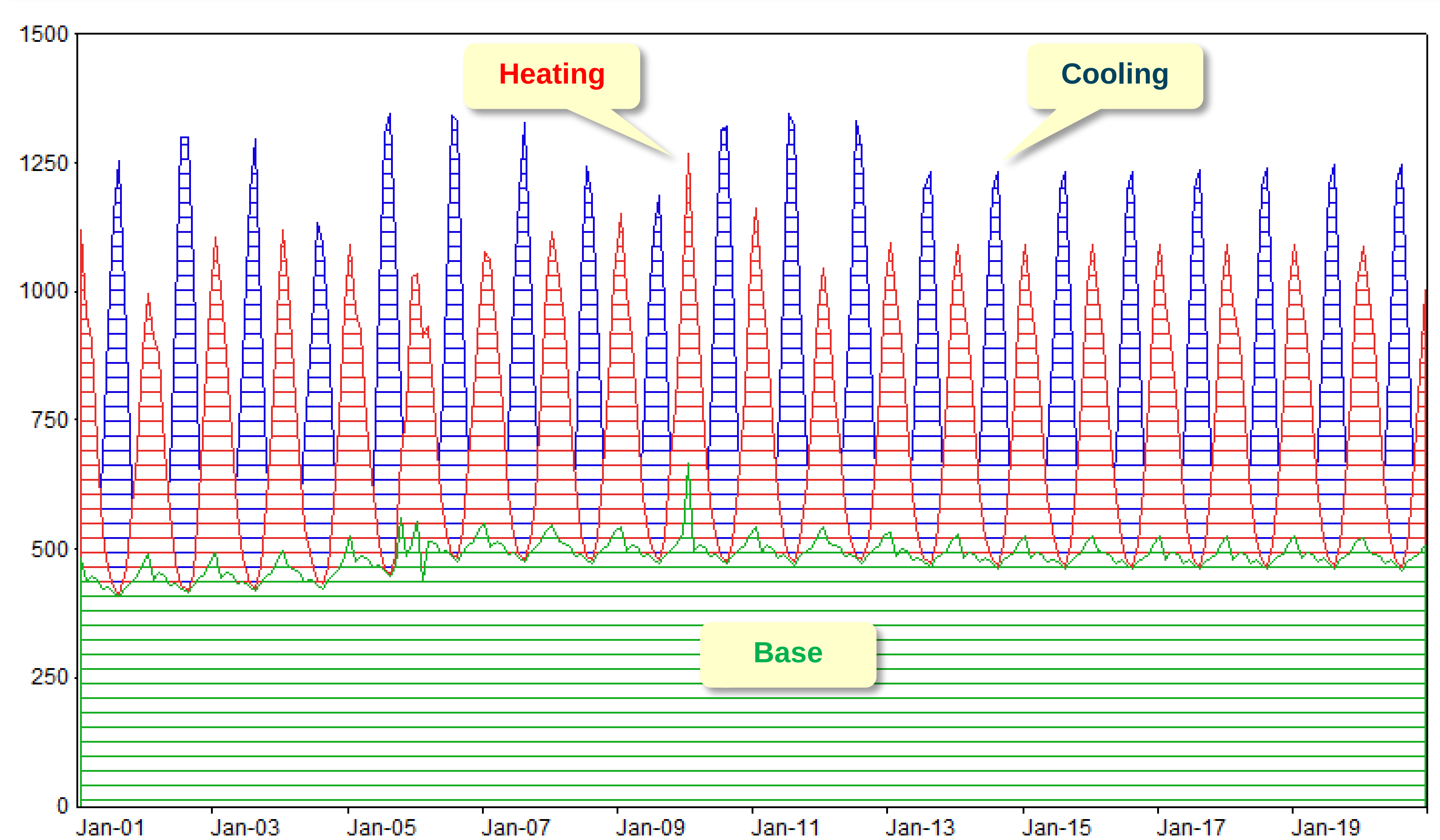
AVERAGE USE MODEL RESULTS



REGRESSION COEFFICIENTS			
Variable	**Coefficient**	**Standard Error**	**T-Statistic**
XHeat	0.888	0.041	21.761
XCool	0.814	0.022	36.630
XOther	0.724	0.007	109.109

SAE regression model coefficient calibrates end-use energy estimates to actual customer usage.

END-USE BREAKDOWN
MONTHLY KWH PER HOUSEHOLD



We can use model coefficients to break out sales into heating, cooling, and other use

INCORPORATING EE PROGRAM SAVINGS INTO THE FORECAST

CAPTURING EE PROGRAM SAVINGS

- Customer usage has been trending down (use per customer) for the last ten years
  - New appliance and construction efficiency standards
  - Increasing real electricity rates
  - Increasing multi-family home market share (smaller square footage)
  - Economic downturn (higher vacancy rates)
  - State and utility sponsored EE programs

- Models estimated with historical sales data already have significant efficiency embedded in the model

- May even be worse with an SAE model as end-use intensity inputs are calibrated to saturation survey information and shipments data that reflect the appliance stock. The appliance stock in part is impacted by EE program activity

BASELINE SAE FORECAST IS NOT A "NO DSM FORECAST"

» Strong efficiency gains are already embedded in the baseline forecast
  - EIA base-year end-use intensities (and thus projections) are re-calibrated each year to reflect changing end-use technology mix.
  - The models are estimated using actual sales data over a period where there has been strong, increasing efficiency program activity
    - Some level of increasing efficiency program savings is embedded in the estimated model parameters

» Issue: How do we avoid "double – counting" future EE program savings

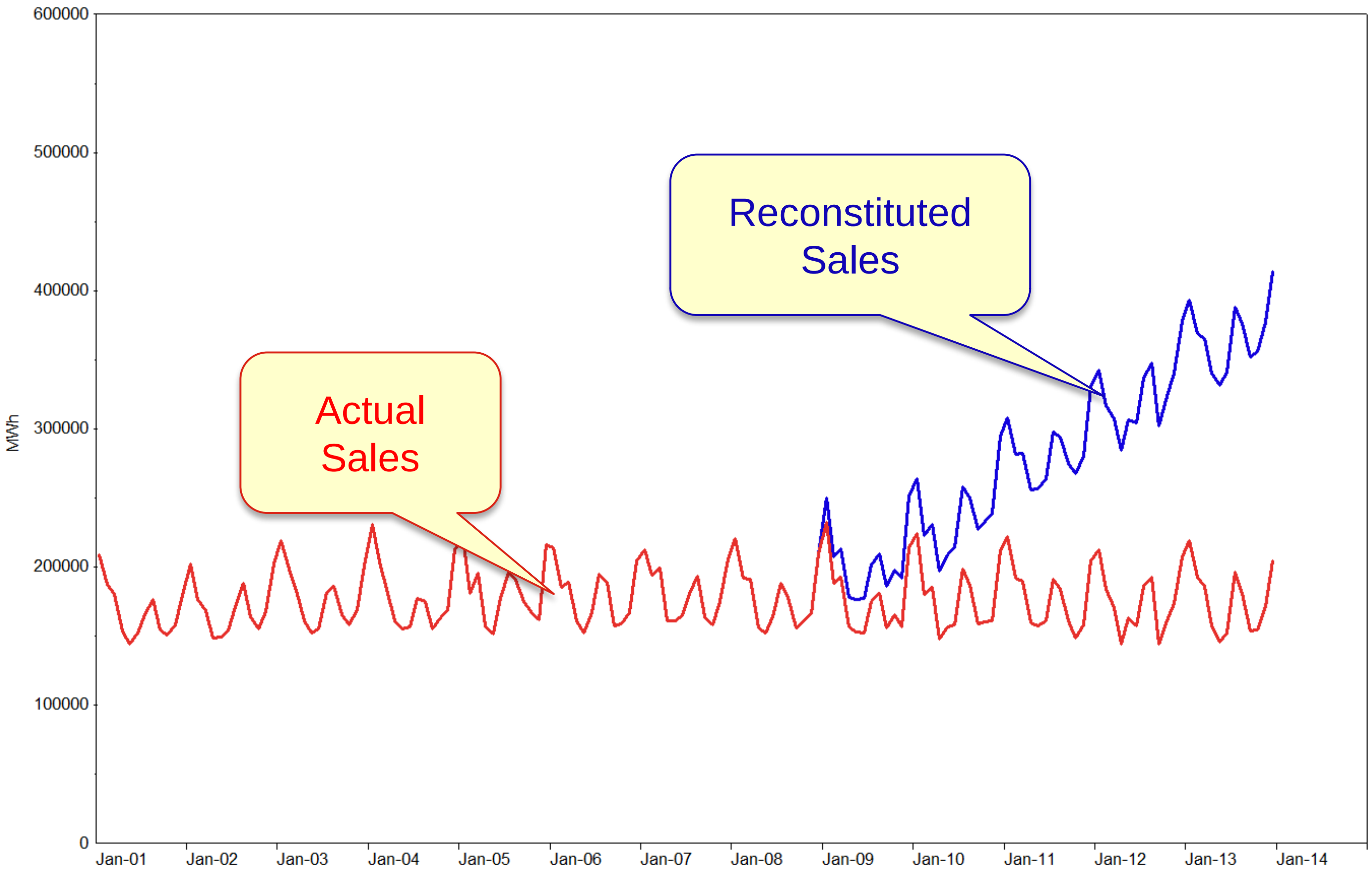
ADJUSTING FOR FUTURE EE SAVINGS - METHODS

- “Add-Back” Approach
  - Add historical EE savings back to actual sales data
  - Forecast the new “reconstituted” sale data – *No DSM Forecast*
  - Subtract out all cumulative EE savings (past and forecast)
  - Used by New England ISO

- “ Incremental” Approach
  - Assume all past EE program savings are embedded in the baseline forecast
  - Subtract only future cumulative EE program savings
  - Used by majority of electric and gas utilities

- Integrate through SAE model end-use intensity projections

VERMONT RECONSTITUTED SALES
ADD-BACK PAST EFFICIENCY SAVINGS

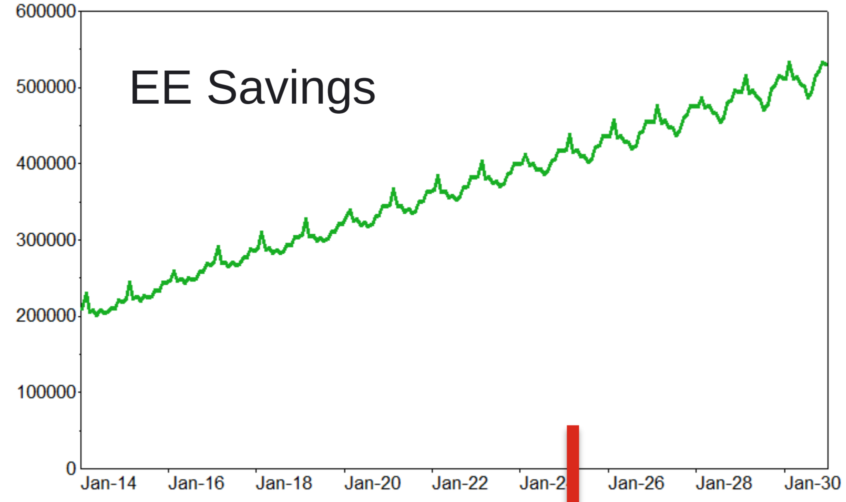


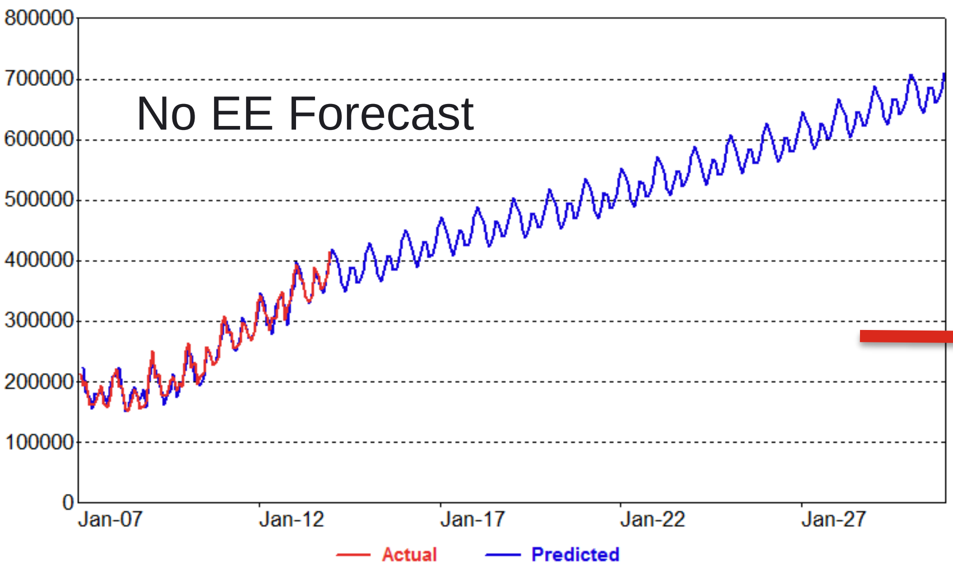
Itron

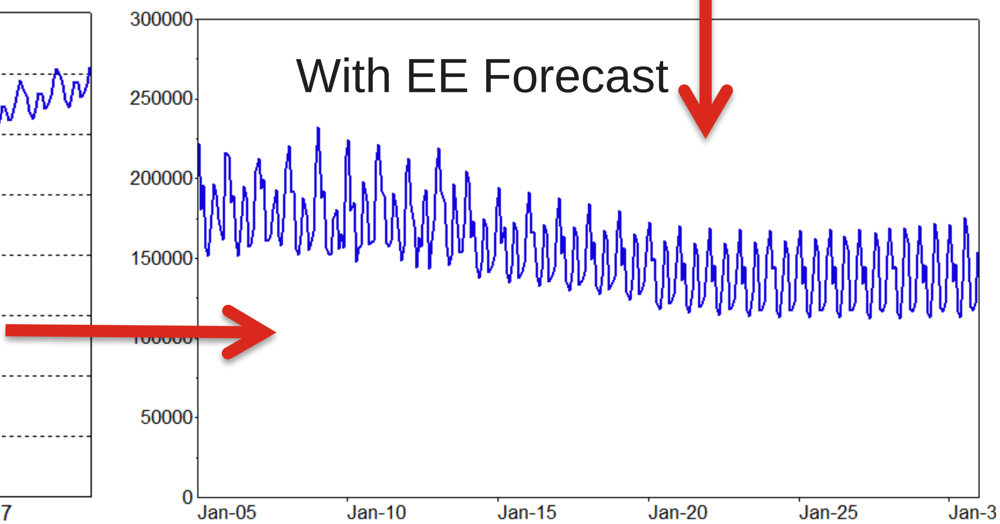
FIT A GENERALIZED ECONOMETRIC MODEL TO RECONSTITUTED SALES

No EE Model

Variable	Coefficient	StdErr	T-Stat
CONST	(1,815,390)	355,147	-5.11
HDD	74.430	7.710	9.65
LagHDD	(3.902)	7.662	-0.51
CDD	202.853	26.049	7.79
LagCDD	54.616	26.208	2.08
Real Personal Income	79.910	13.851	5.77
AR(1)	0.869	0.059	14.62







ISSUES WITH "ADD-BACK" APPROACH

» Can be difficult to construct a reasonable reconstituted data series.
  - Need a high level of confidence in historical EE savings data series
  - May not have EE historical savings that goes back far enough
  - How do you adjust for EE degradation (measure persistency)?
  - How do you translate annualized historical EE savings estimates to monthly rate class sales adjustments?

» Can be difficult to develop a reasonable forecast model
  - How would income or GDP impact energy use if we never had any EE programs?
    - Difficult to find a right-hand drivers to explain strong adjusted sales growth
  - Tend to be strong auto-regressive models
  - You can't validate model performance against actual sales data

INCREMENTAL APPROACH

- Develop baseline forecast with actual sales data and adjust for only future EE program savings.
  - Need a cumulative incremental monthly EE program savings projection (starting with the first forecast month)

- Generally starting with annualized program savings forecast
  - Annualized estimates assume that all measures are installed in the first month of the year
  - Meaningful for developing EE programs, not so meaningful for forecasting load impacts.

- The challenge is to turn annualized savings estimates into meaningful monthly sales impact series. "DSM accounting" is really hard.
  - Need to address the "double-counting" issue
  - Need to capture seasonal impacts (e.g., lighting programs have a larger impact in the winter months. cooling programs only impact summer months)

HOW MUCH IS FUTURE EE IS CAPTURED IN THE BASELINE MODEL?

» Add the cumulative historical savings as a model variable
  - If nothing is captured: DSM coefficient = -1.0
  - If half is captured: DSM coefficient = -.5
  - If everything is captured: DSM coefficient = 0.0

Vermont residential average use model: 2008 to 2013

Variable	Coefficient	StdErr	T-Stat	P-Value
XHeat	1.552	0.100	15.485	0.00%
XCool	0.989	0.114	8.659	0.00%
XOther	0.986	0.021	46.437	0.00%
DSM_perCust	**-0.224**	**0.118**	**-1.908**	**6.17%**

Indicates 80% of EE program savings is captured by the baseline model

SAE MODELING APPROACH

CAPTURE EE PROGRAMS IMPACTS THROUGH END-USE INTENSITY FORECASTS

$$XVar_{y,m} = EnergyIntensity(EI)_{y,m} \times Utilization_{y,m}$$

$$EI_{y,m} = \sum EI_{09}^{Type} \times \frac{\left(Sat_y^{Type} \Big/ Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} \Big/ Eff_{09}^{Type} \right)} \times MoMult_m^{Type}$$

- Incentives to remove second refrigerators reduces saturation
- Lighting program improves efficiency
- Promotional heat pump program increases saturation and efficiency

$$Utilization_{y,m} = \left(\frac{Price_{y,m}}{Price_{09}} \right)^{-0.15} \times \left(\frac{Income_{y,m}}{Income_{09}} \right)^{0.10} \times \left(\frac{HHSize_{y,m}}{HHSize_{09}} \right)^{0.25} \times \left(\frac{BDays_{y,m}}{31} \right)$$

SAE MODEL APPROACH

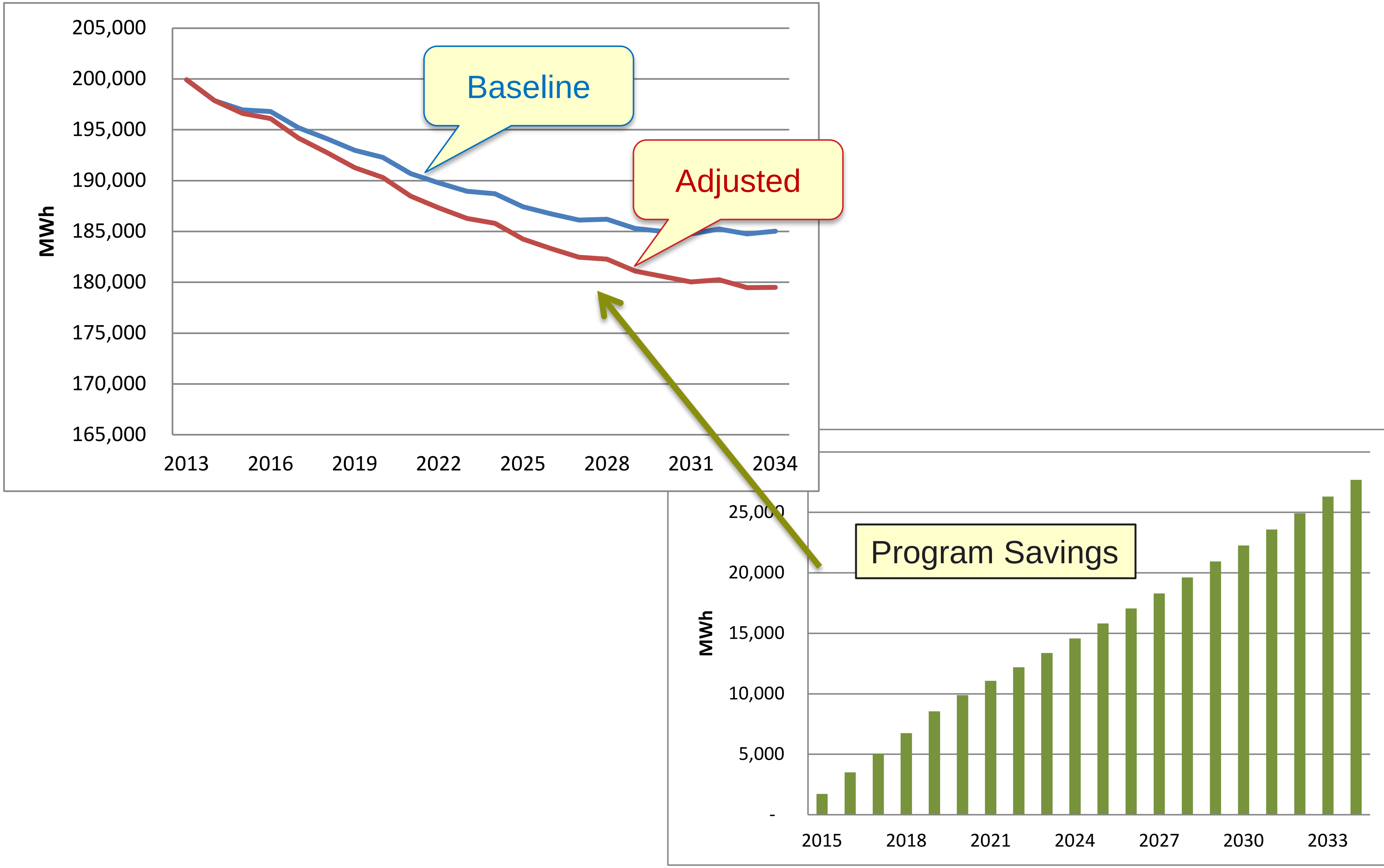
1. Develop baseline end-use sales forecasts from SAE model

2. Subtract out end-use EE program savings from baseline end-use sales forecasts
   - adjust future impacts to reflect savings captured by baseline forecast (apply 0.20 to future EE savings forecast)

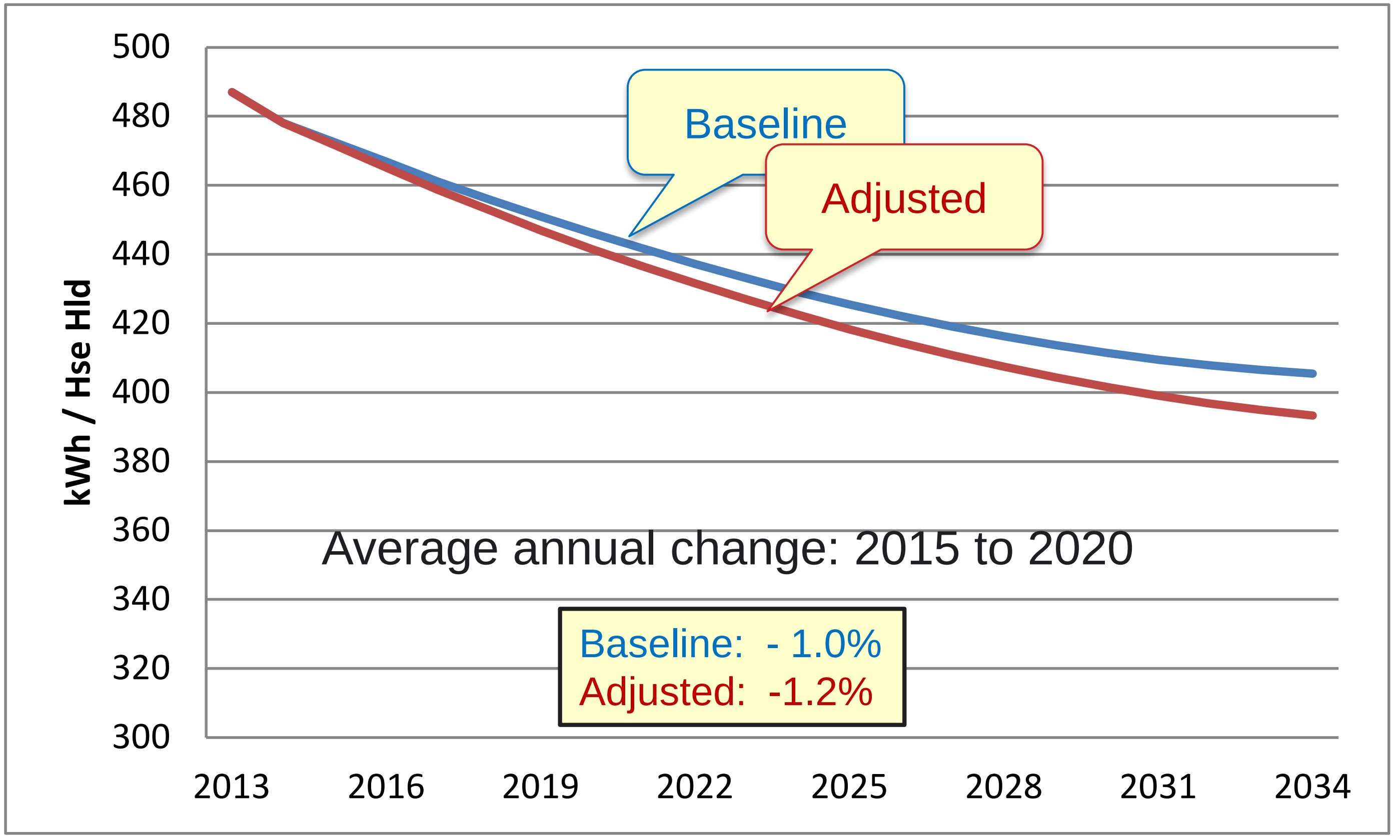
3. Calculate new end-use energy intensity forecasts that incorporate the EE program impacts

4. Execute estimated SAE model with EE program adjusted end-use intensity forecasts

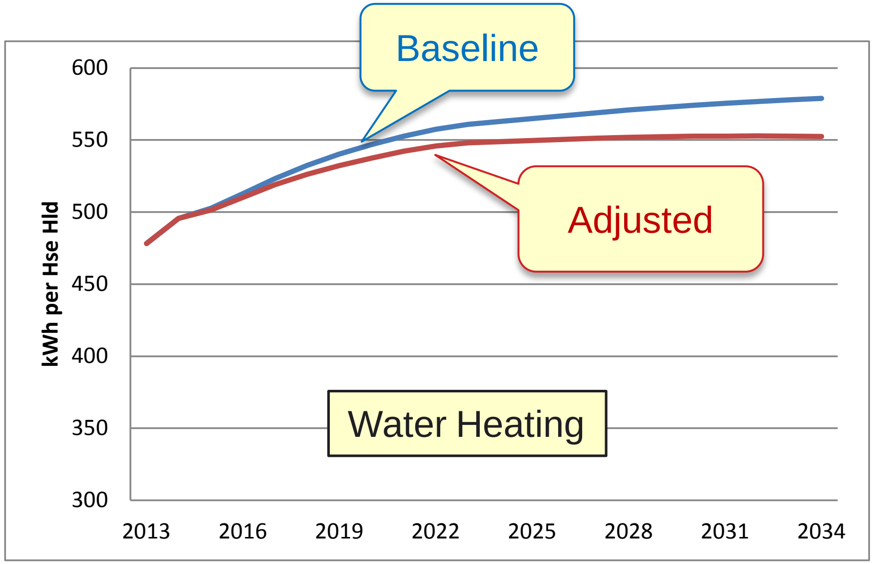
RESIDENTIAL REFRIGERATION FORECAST

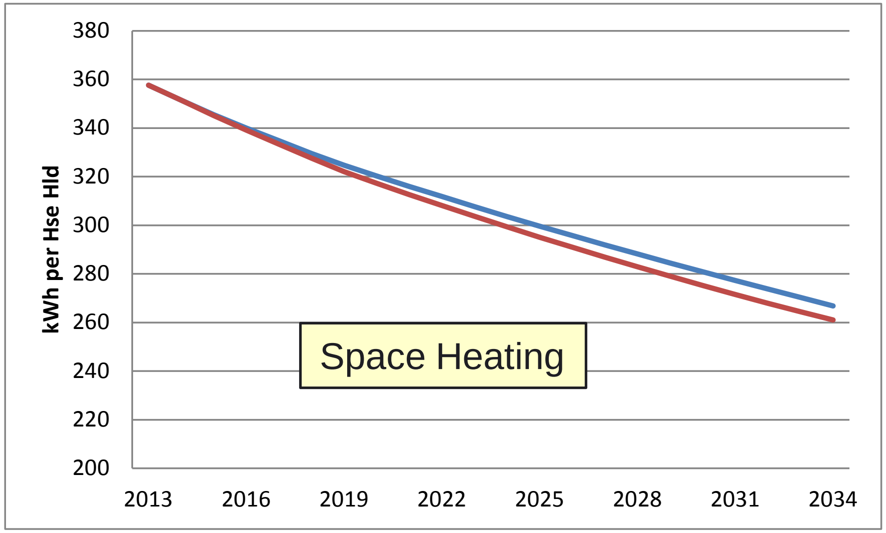


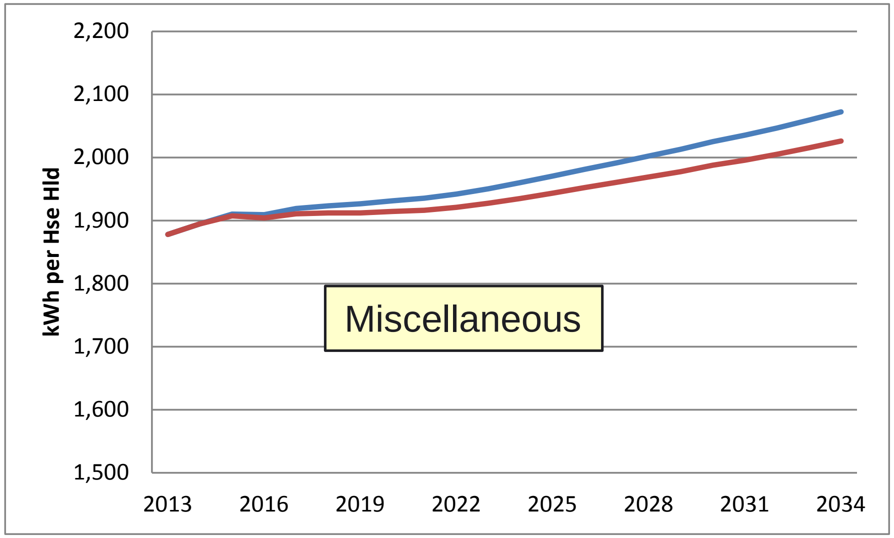
REFRIGERATION END-USE INTENSITY

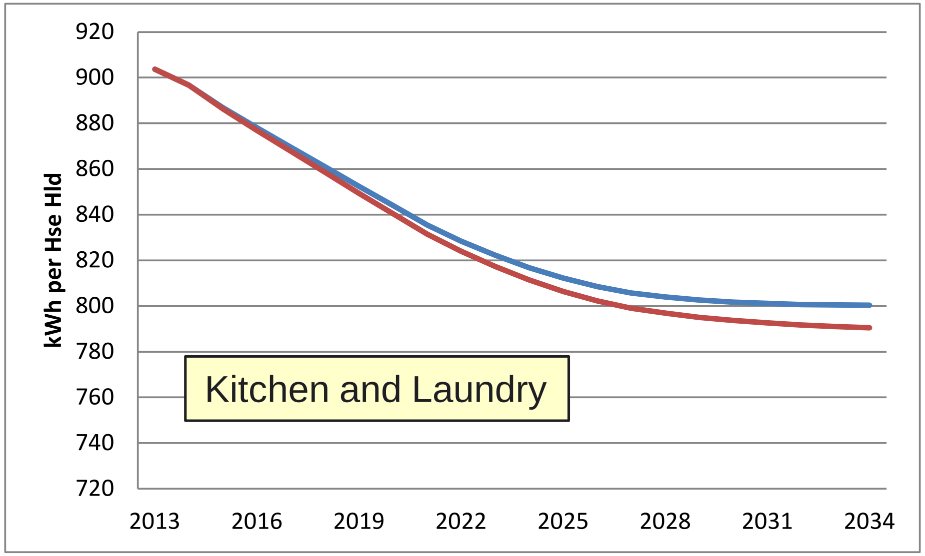


EE ADJUSTED END-USE INTENSITIES

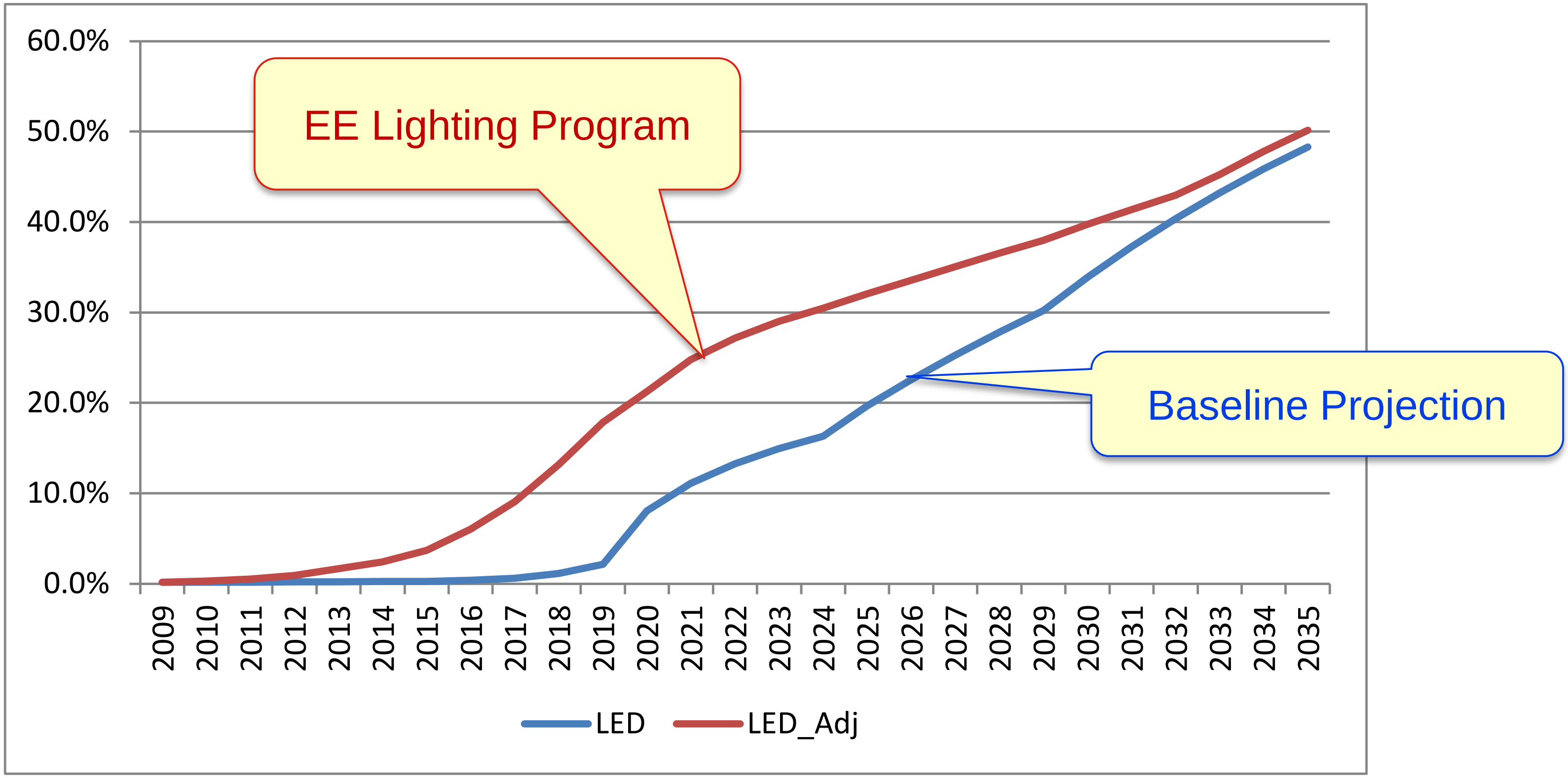






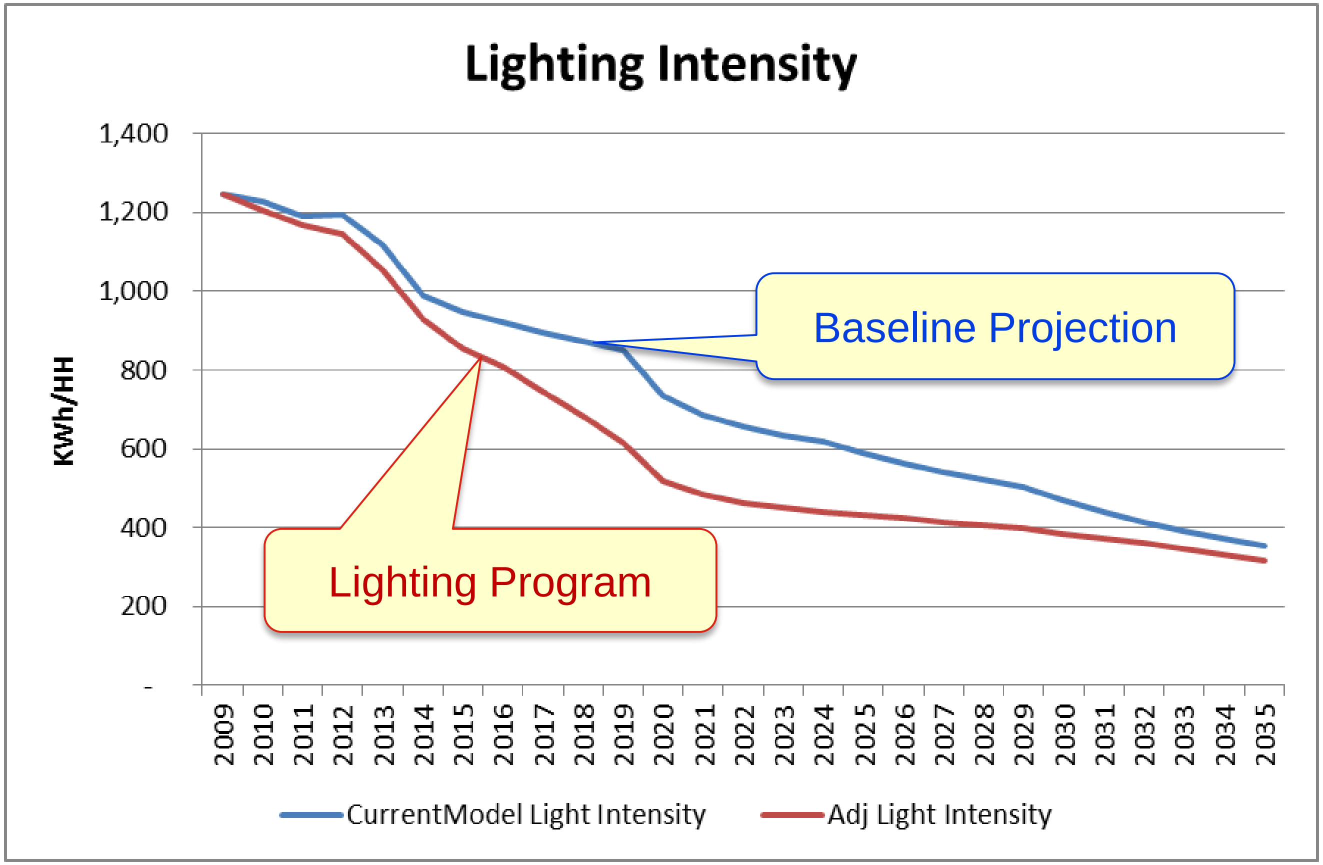


VERMONT EE LIGHTING PROGRAM
IMPACT ON LED TECHNOLOGY SHARE



Faster market penetration of LED as a result of VEIC lighting program

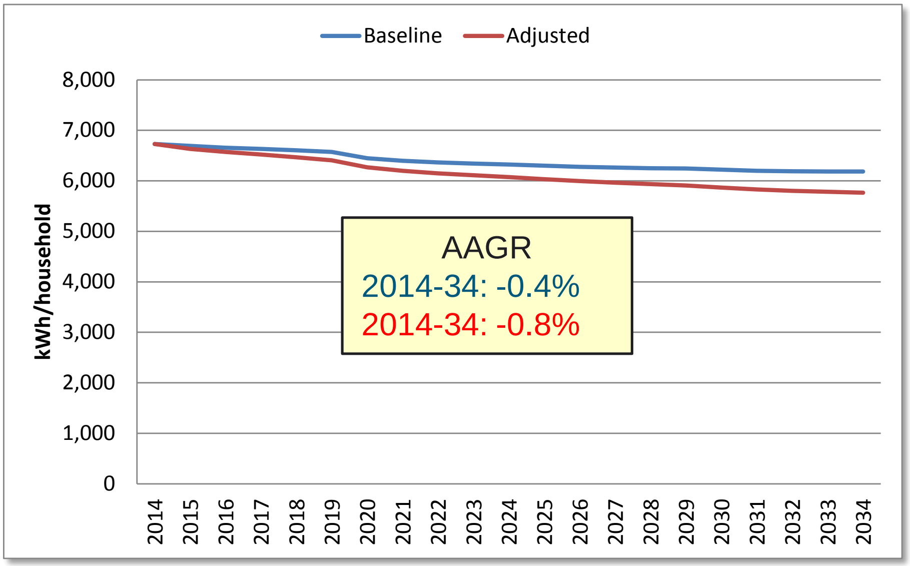
LIGHTING INTENSITY COMPARISON



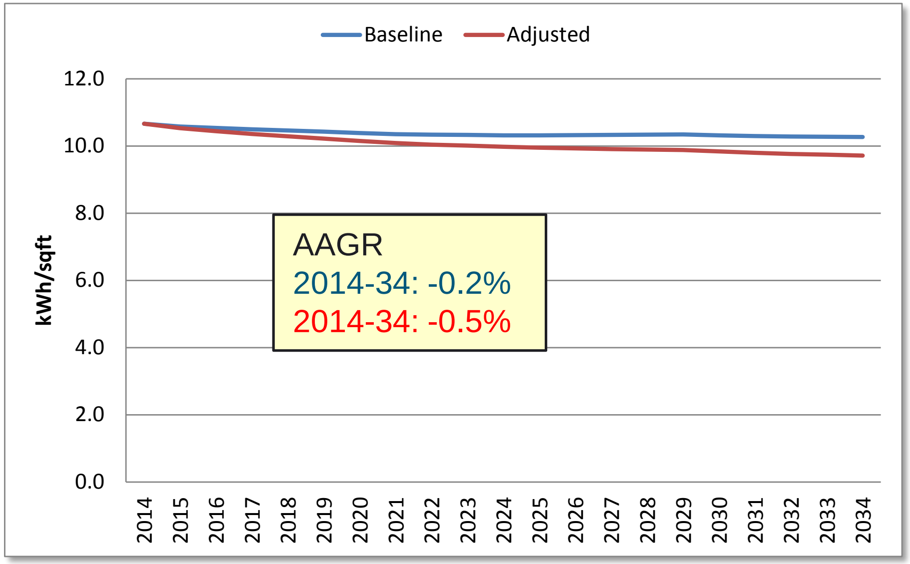
The impact of the lighting program is to push lighting savings forward

EFFICIENCY PROGRAM IMPACTS

Residential



Commercial



Estimate that Vermont EE programs will reduce average use growth by half

SUMMARY

- SAE/End-Use Models provides a rich modeling framework for evaluating the impact of structural changes as well as economic and demographic growth. This allows for developing long-term scenarios that may include:
  - EIA high end-use efficiency case
  - Stronger population and economic growth
  - Adoption of new technology (e.g., cold-climate heat pumps)
  - Global warming trend

- It's an ideal framework for incorporating the impact of EE programs into the forecast
  - No need for DSM Accounting
  - Can assess EE impact on specific technologies (provides a sanity check)
  - Requires thinking in terms of how we use electricity

THANK YOU

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