Potential Load Forecast Enhancements

Load Analysis Subcommittee

March 14, 2018

Issue and Potential Proposed Solution

Background

Key Work Activities

The key work activities are the following:

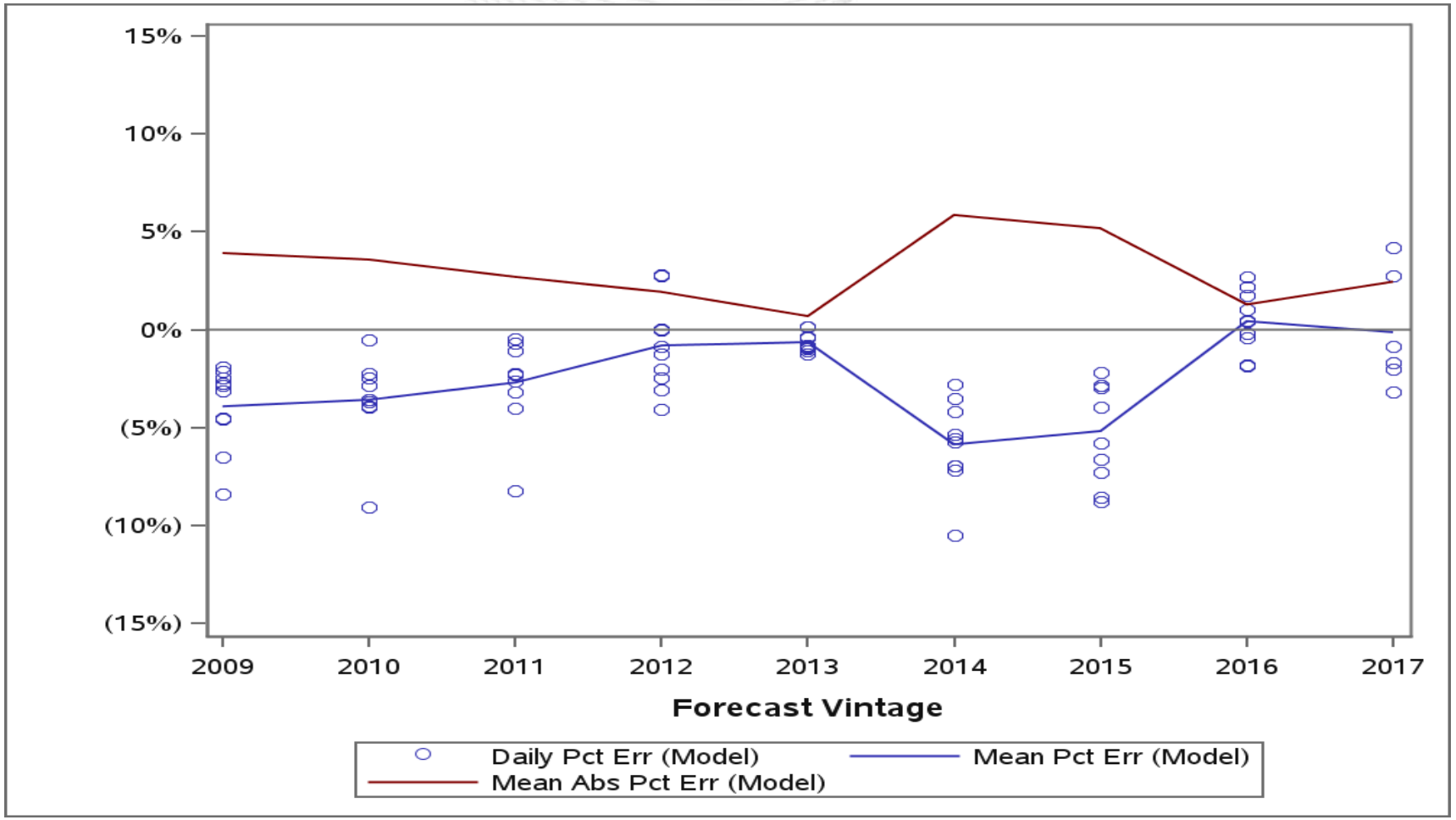
1. **Winter Peak Load Forecasting.**

    a. PJM staff to review PJM's load forecasting methodology to identify any potential issues with regard to the accuracy of PJM's RTO and zonal peak load forecasting for use in assessing resource adequacy during the winter season (defined as October through April). For example, the increasing penetration of certain end use technologies in recent years may have changed the relationship between extreme cold temperatures and electricity demand in some zones, and this may not be fully captured in the econometric modeling.

    b. If any issues are identified, PJM staff to craft potential solutions and to work with the LAS to evaluate and select recommended solutions.

Winter 10CP Model Error by Forecast Vintage

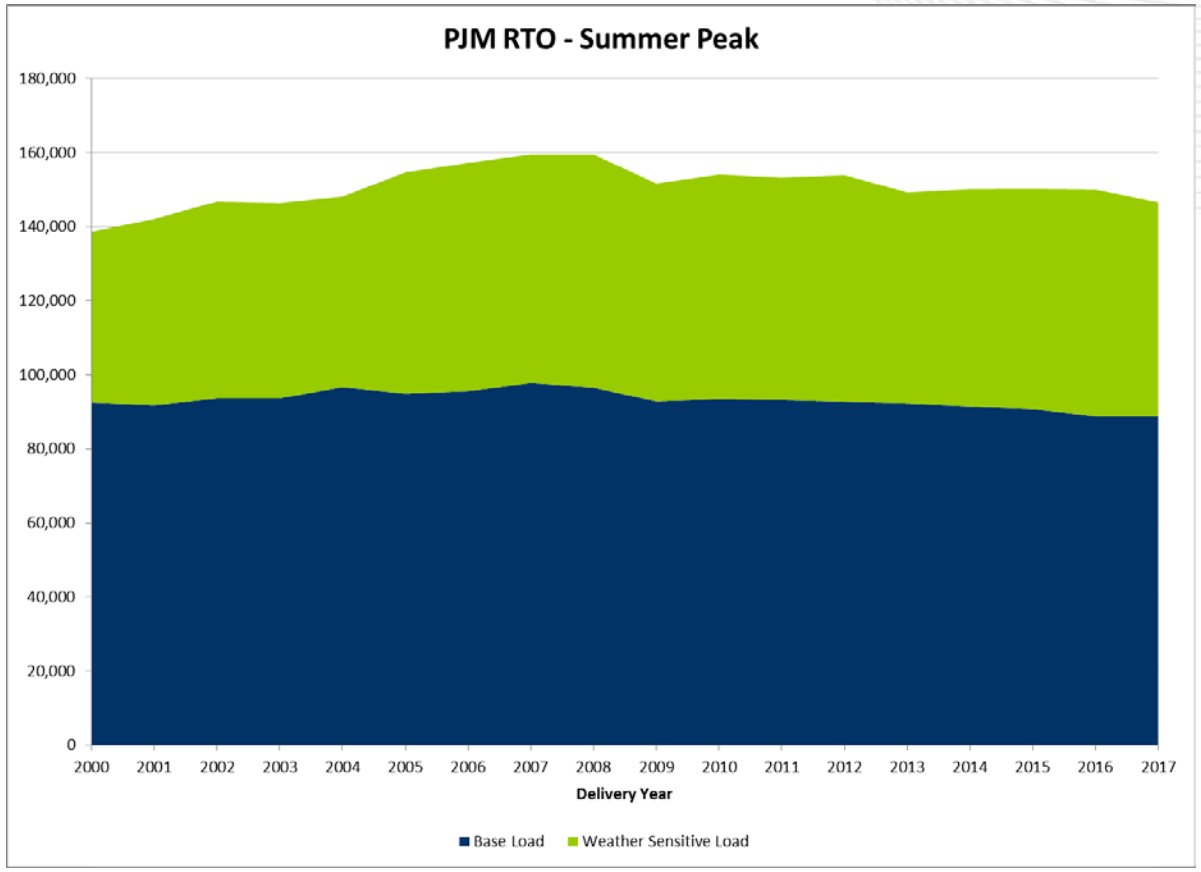
0 Year Out Forecast

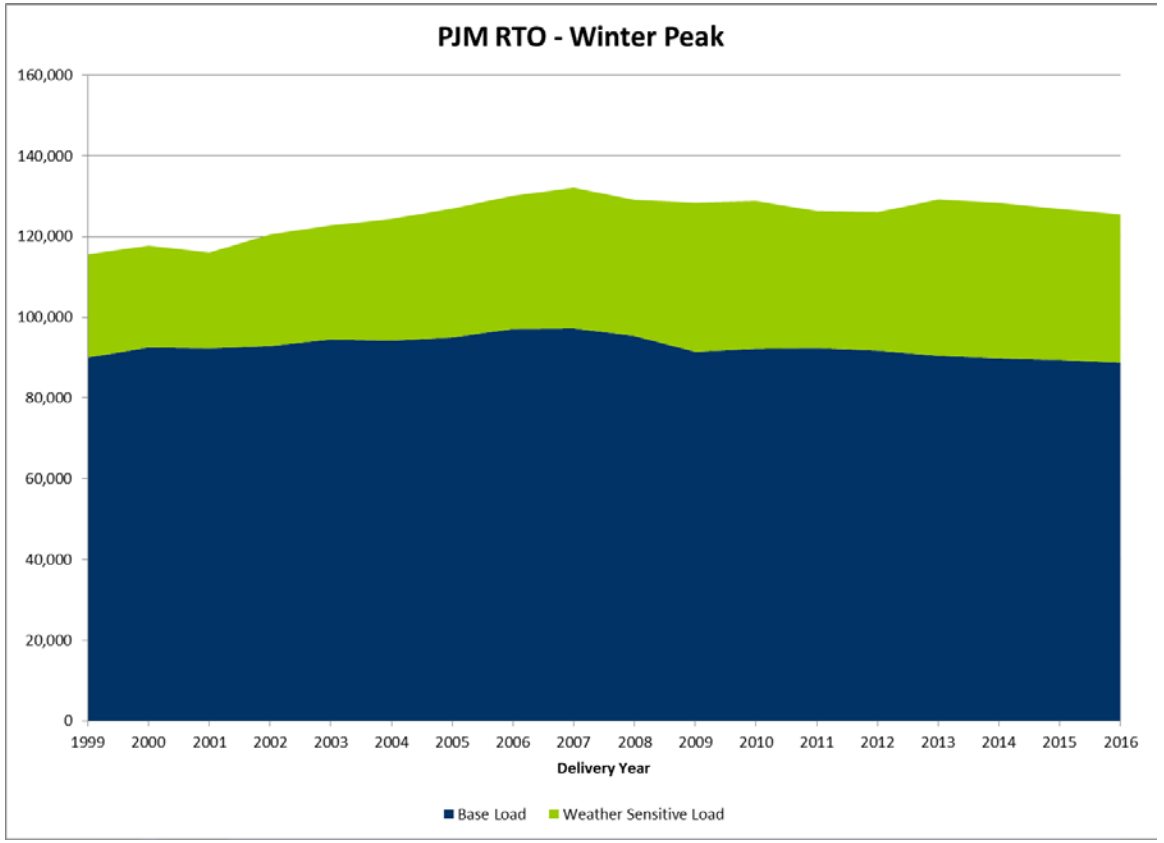


Development

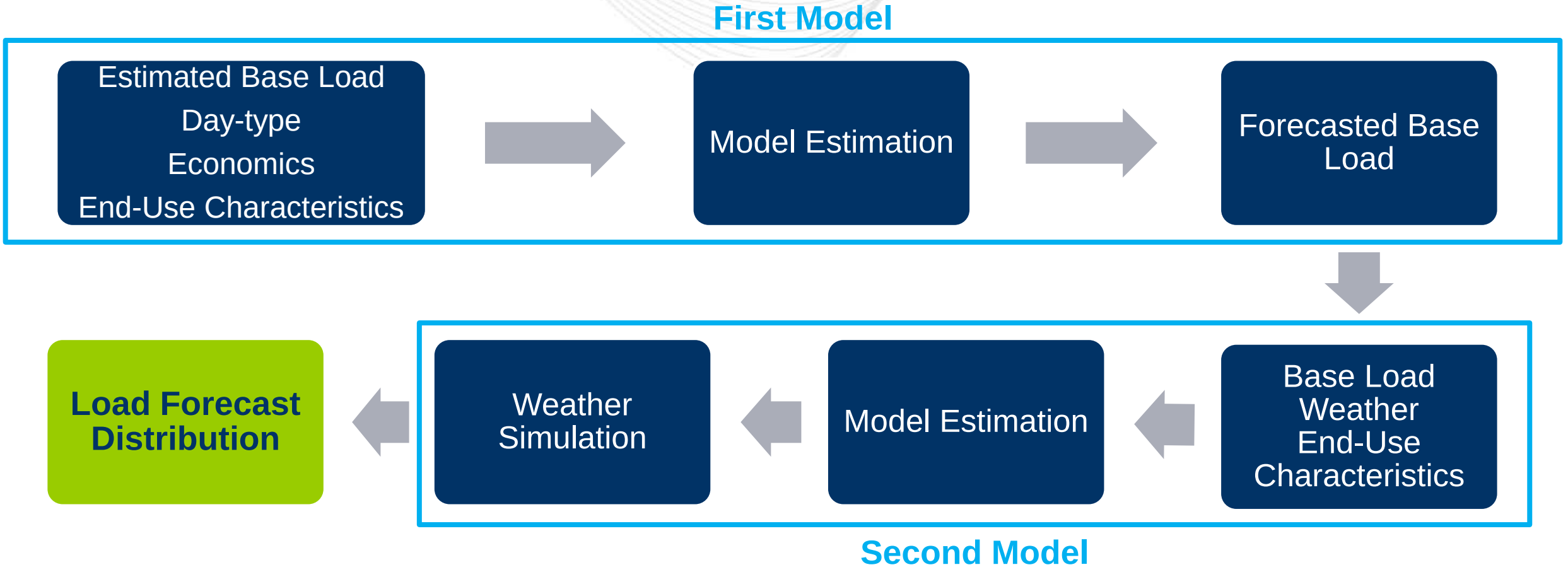
- PJM believes the most effective way to address the winter issue is not to just work on winter but to separate base and weather sensitive load to better address their level and growth by season.

Base and Weather Sensitive Load





Potential Process



Potential Timeline

- Introduce concepts
  - November 15, 2017
- **“First Model”**
  - **March 14, 2018**
- “Second Model”
  - April 11, 2018
- Refinements and Manual changes
  - June 20, 2018 and July 18, 2018

“First Model”
Establishing History and Forecast for Base Load

Process Overview

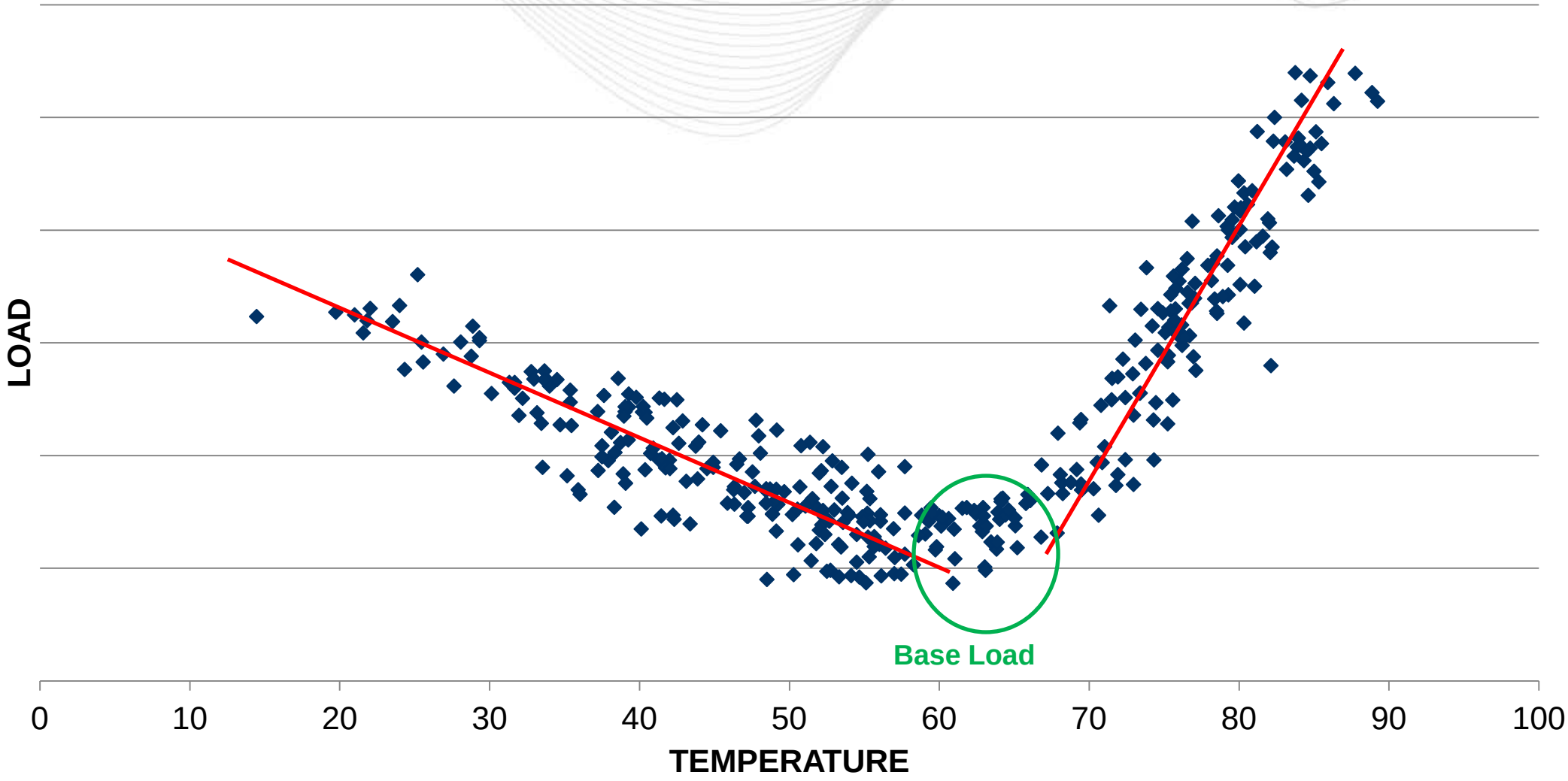
- Establish variables
  - Base load
  - Driver variables
- Forecast model

Establish History: Base Load

Establishing Base Load History

- We define base load as non-weather sensitive load.
  - It is not something we observe, but something we need to estimate.
    - Use modeling techniques to isolate year-to-year movements, day of the week, month, holidays, weather

Base Load Concept Illustration



Steps to Establish History

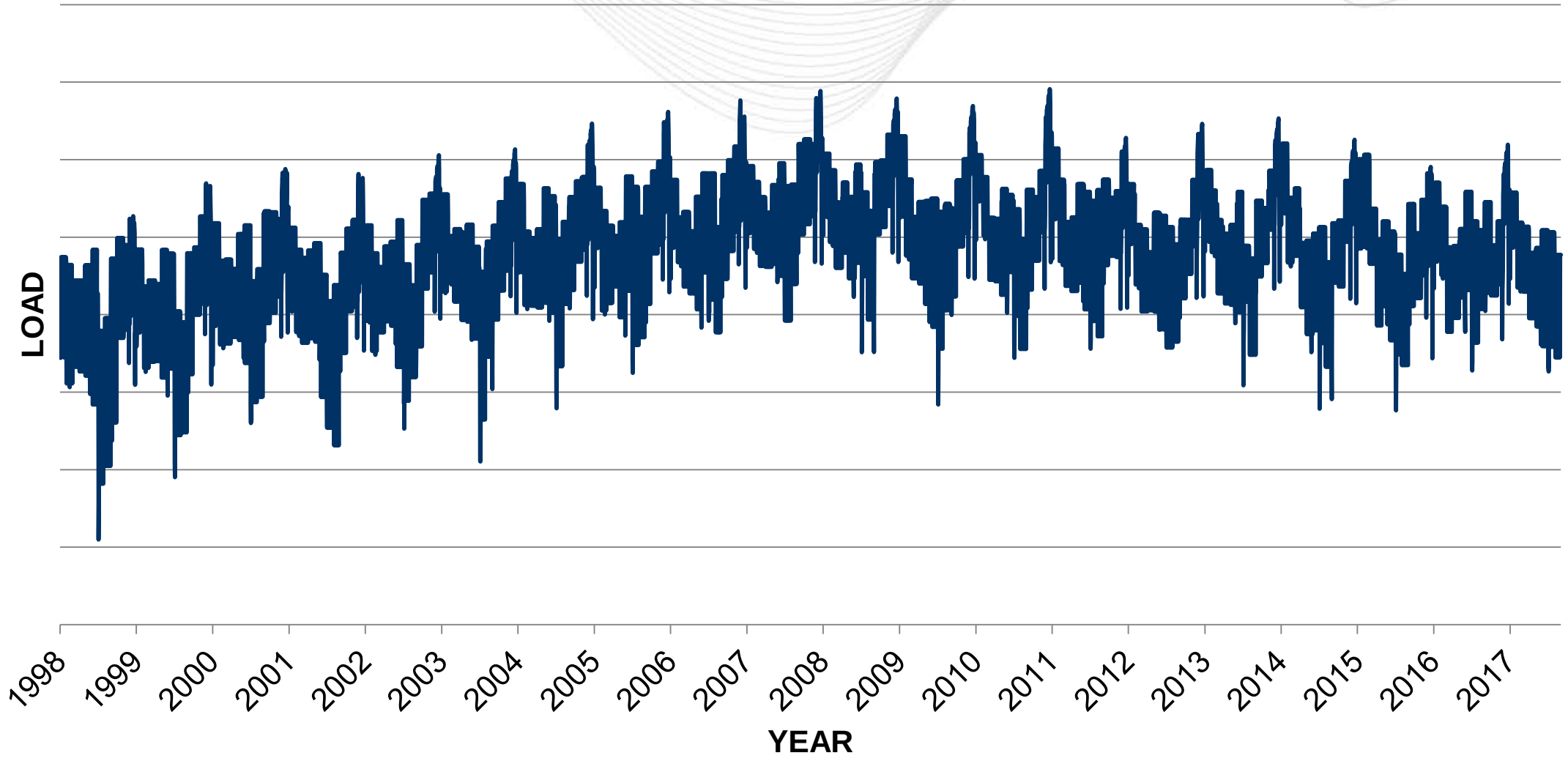
1. Establish daily history
   a) Use regression model (store coefficients for later use)
2. Convert to monthly values
   a) Use average daily weekday value within a month
3. Re-shape monthly values
   a) Determine typical shape and adjust months to mimic
   b) We do this to avoid odd shapes getting transposed onto the eventual forecast

Establish Daily History

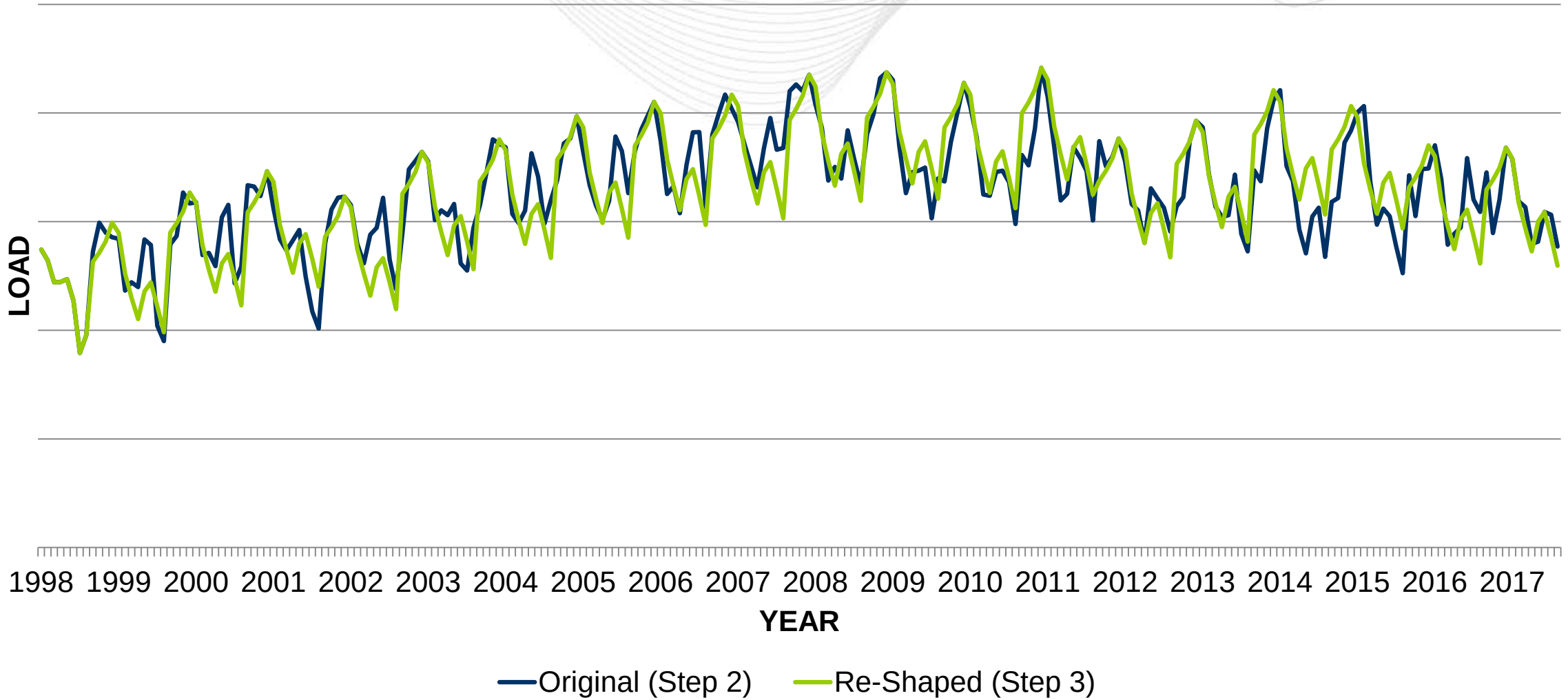
Total Load = f(Year, M-Th Weekday, Friday, Holidays, HDD, CDD)

Base Load = f(Year, M-Th Weekday, Friday, Holidays,
HDD=0, ***CDD=0***)

Steps to Establish History – Step 1 (Daily Values)



Steps to Establish History – Step 2 and 3 (Monthly Values)



Establish Drivers

Drivers Overview

- Develop driver variables
  - Break down sector energy use and customers, forecast each and combine
    - Residential
    - Commercial/Industrial
  - Combine sector driver variables together

Establish Drivers - Residential

Residential: Customers

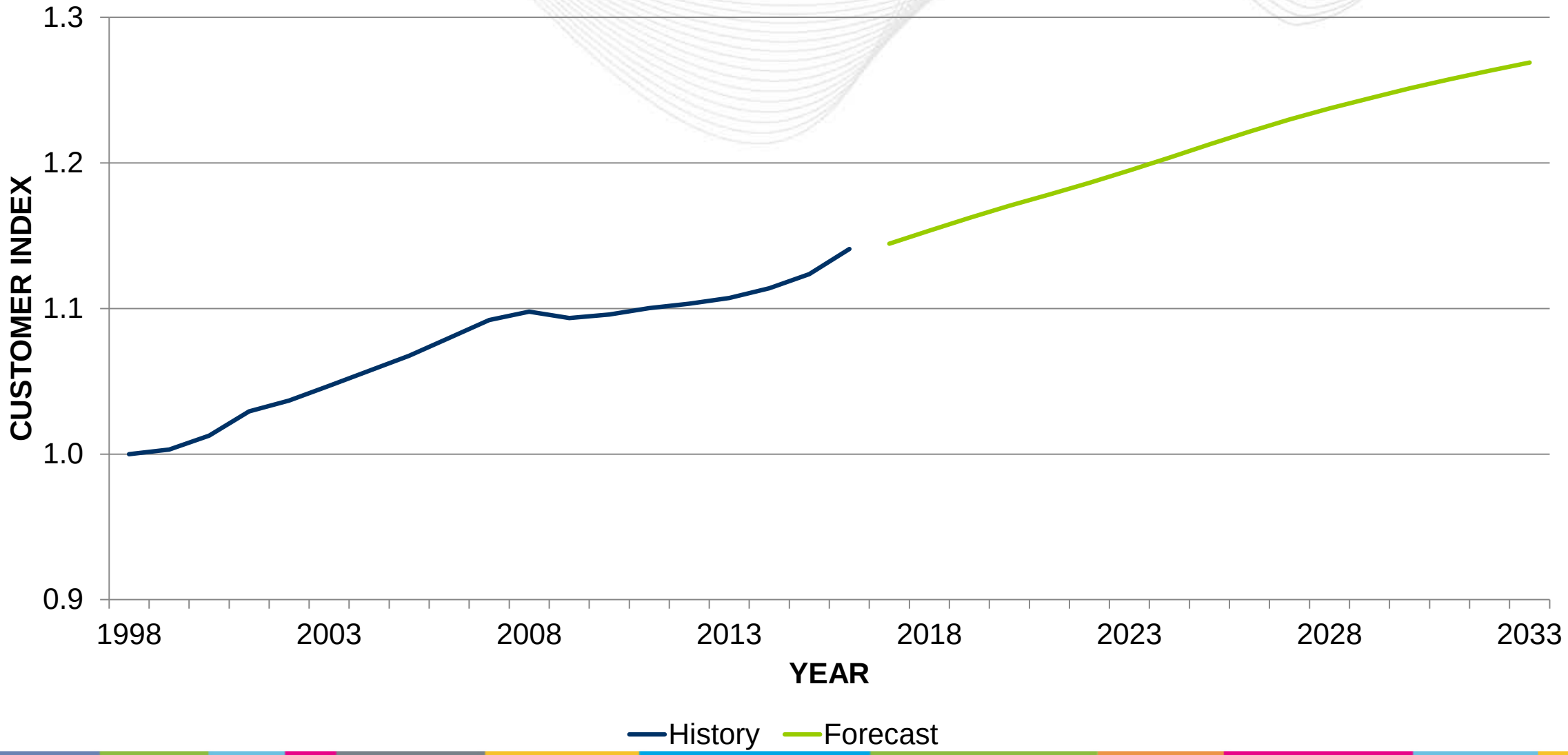
Customers = f(Households)

Where,

Customers (Source: FERC FORM 1)

Households (Source: Moody's Analytics)

Residential: Customers



Residential: Average Total Use

Energy Use = f(Heating Use, Cooling Use, Other Use)

Where,

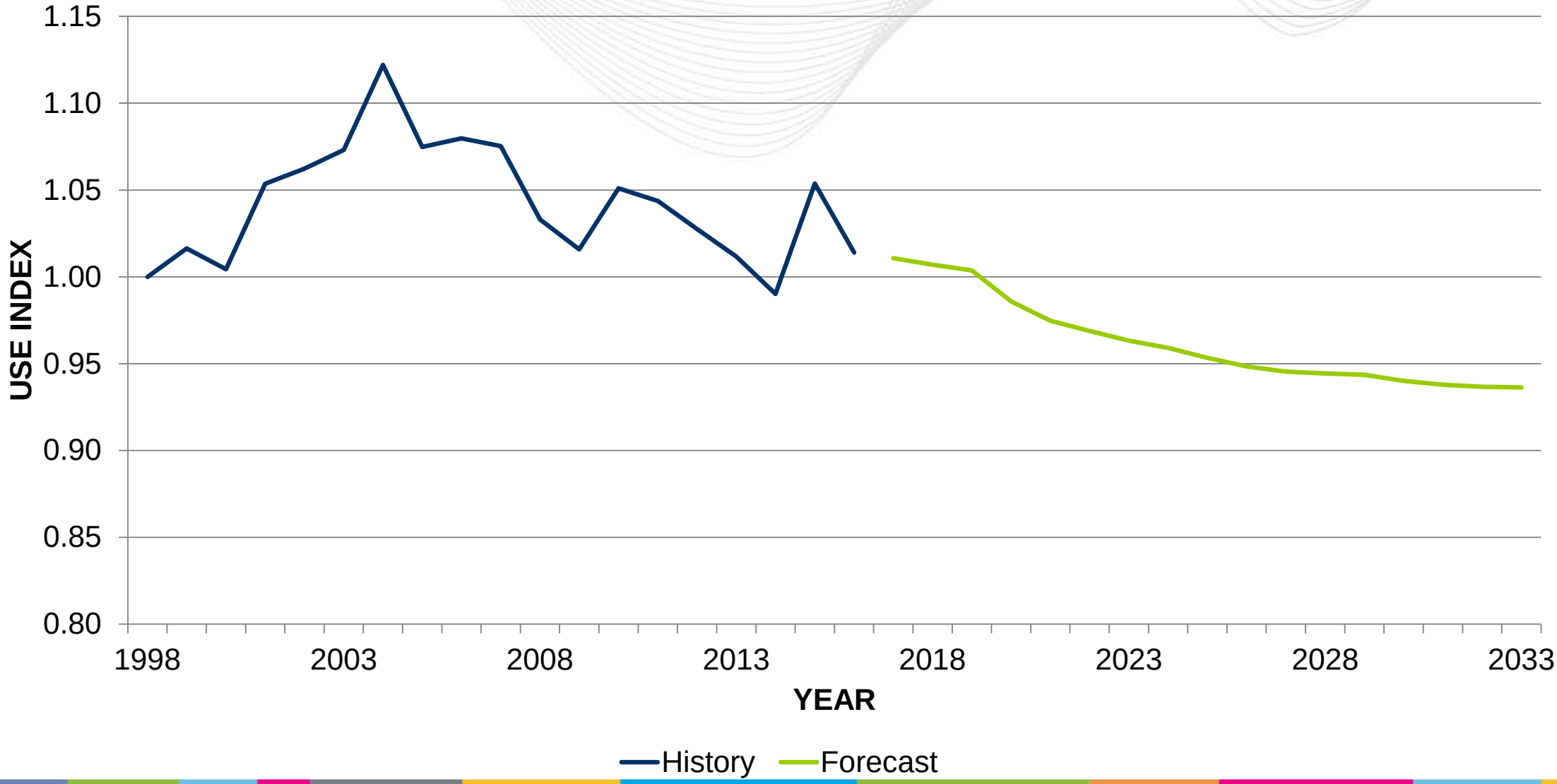
Energy Use (Source: FERC FORM 1)

Heating Use (Source: EIA/ITRON)= Heating Equip Intensity * HDD

Cooling Use (Source: EIA/ITRON) = Cooling Equip Intensity * CDD

Other Use (Source: EIA/ITRON) = Other Equipment Intensity

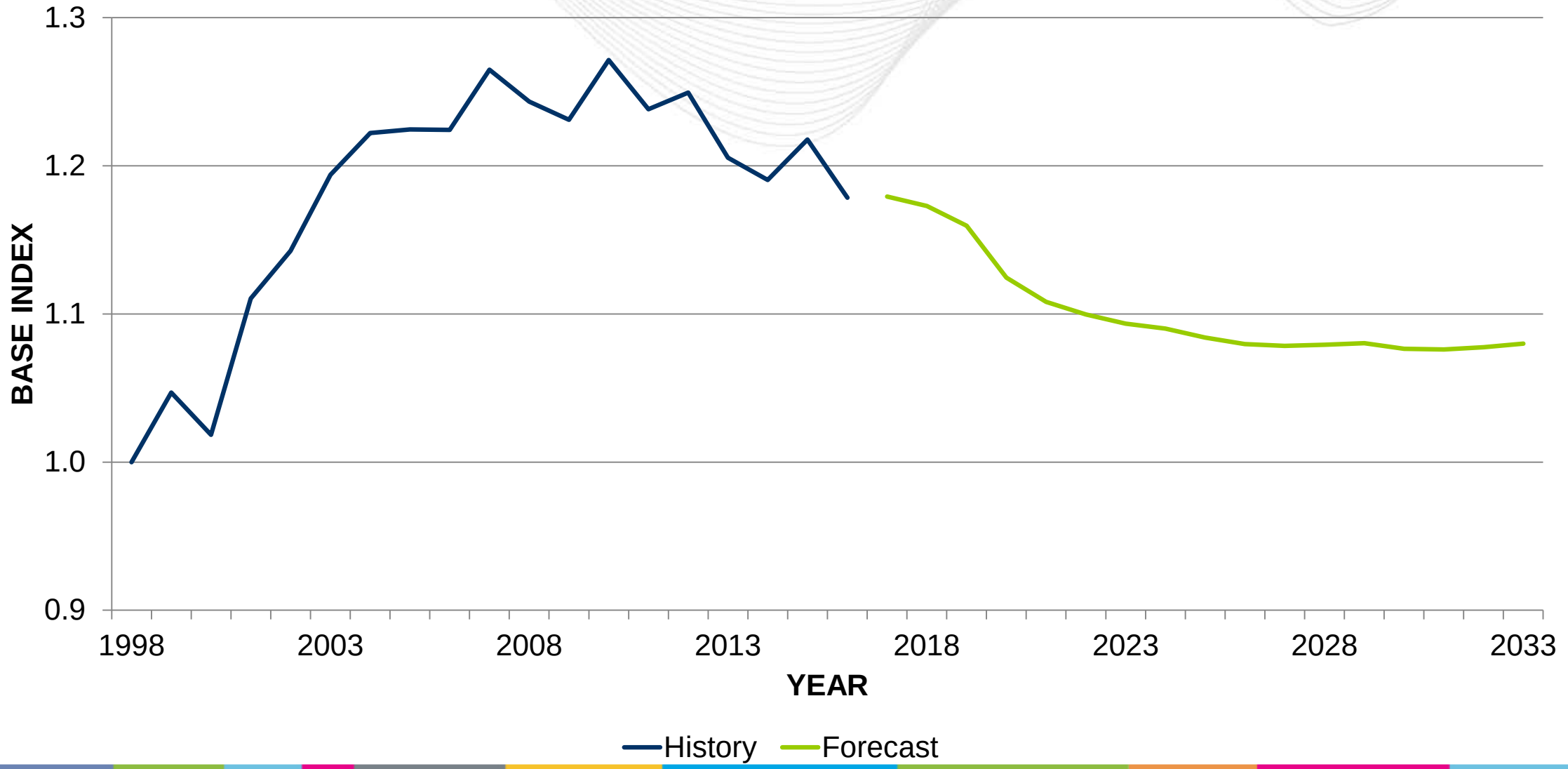
Residential: Average Other Use



Residential: Base Index

Base Index = Customers Index x Other Use Index

Residential: Base Index



Establish Drivers – Commercial/Industrial

Commercial/Industrial: Customers

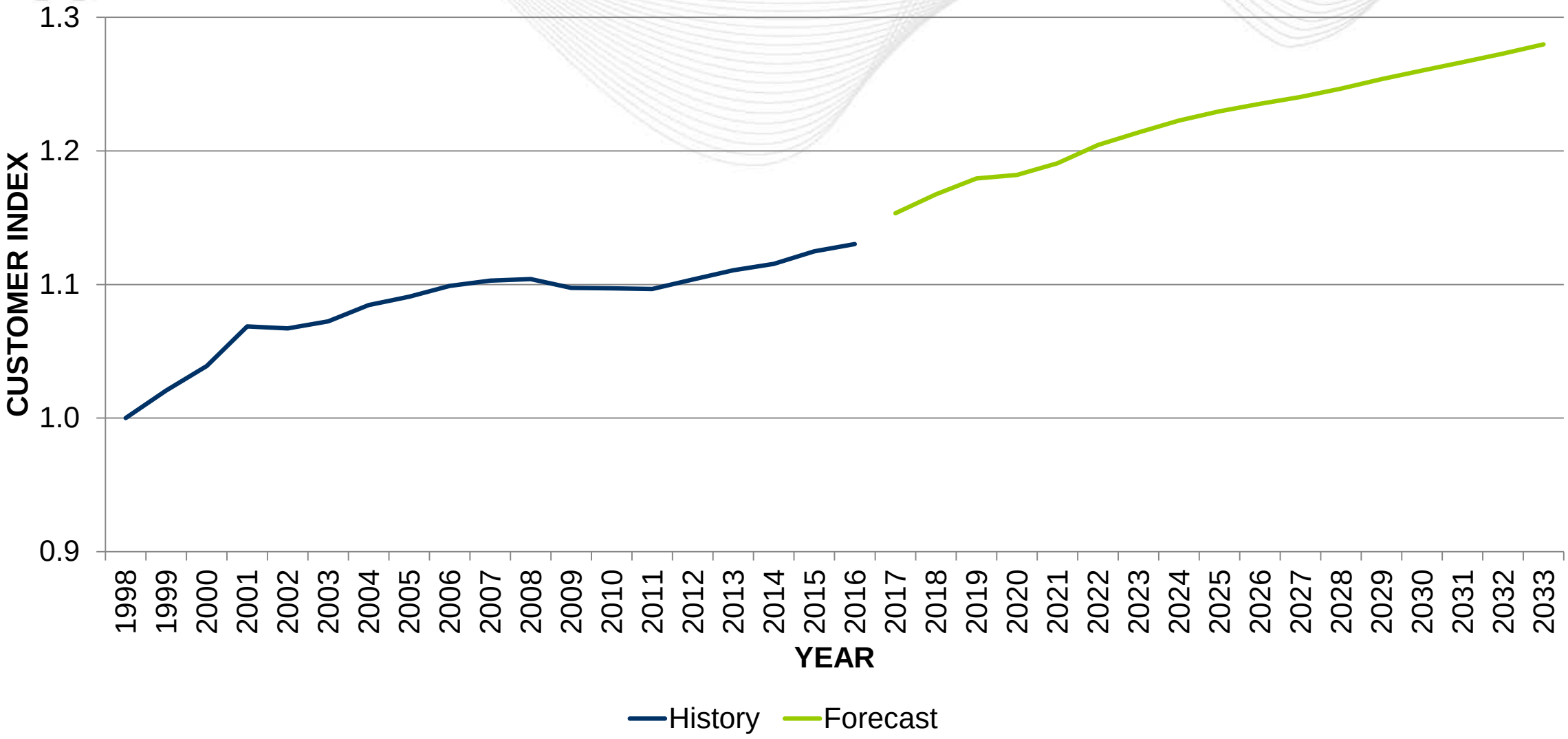
Customers = f(Employment)

Where,

Customers (Source: FERC FORM 1)

Employment (Source: Moody’s Analytics)

Commercial/Industrial: Customers



Commercial/Industrial: Average Total Use

Energy Use = f(Heating Use, Cooling Use, Other Use)

Where,

Energy Use (Source: FERC FORM 1)

Heating Use (Source: EIA/ITRON)= Heating Equip Intensity * HDD

Cooling Use (Source: EIA/ITRON) = Cooling Equip Intensity * CDD

Other Use (Source: EIA/ITRON) = Other Equipment Intensity

Commercial/Industrial: Average Total Use

- Whereas Energy Use and the Intensity drivers had unit alignment in the Residential case, they do not with Commercial/Industrial. Energy use is in energy per customer, whereas the Intensity driver is in use per square foot.
  - Do not have square footage by customer
  - Use employment per customer as a proxy

Commercial/Industrial: Average Total Use

Energy Use = f(Intensity, Employees per Customer)

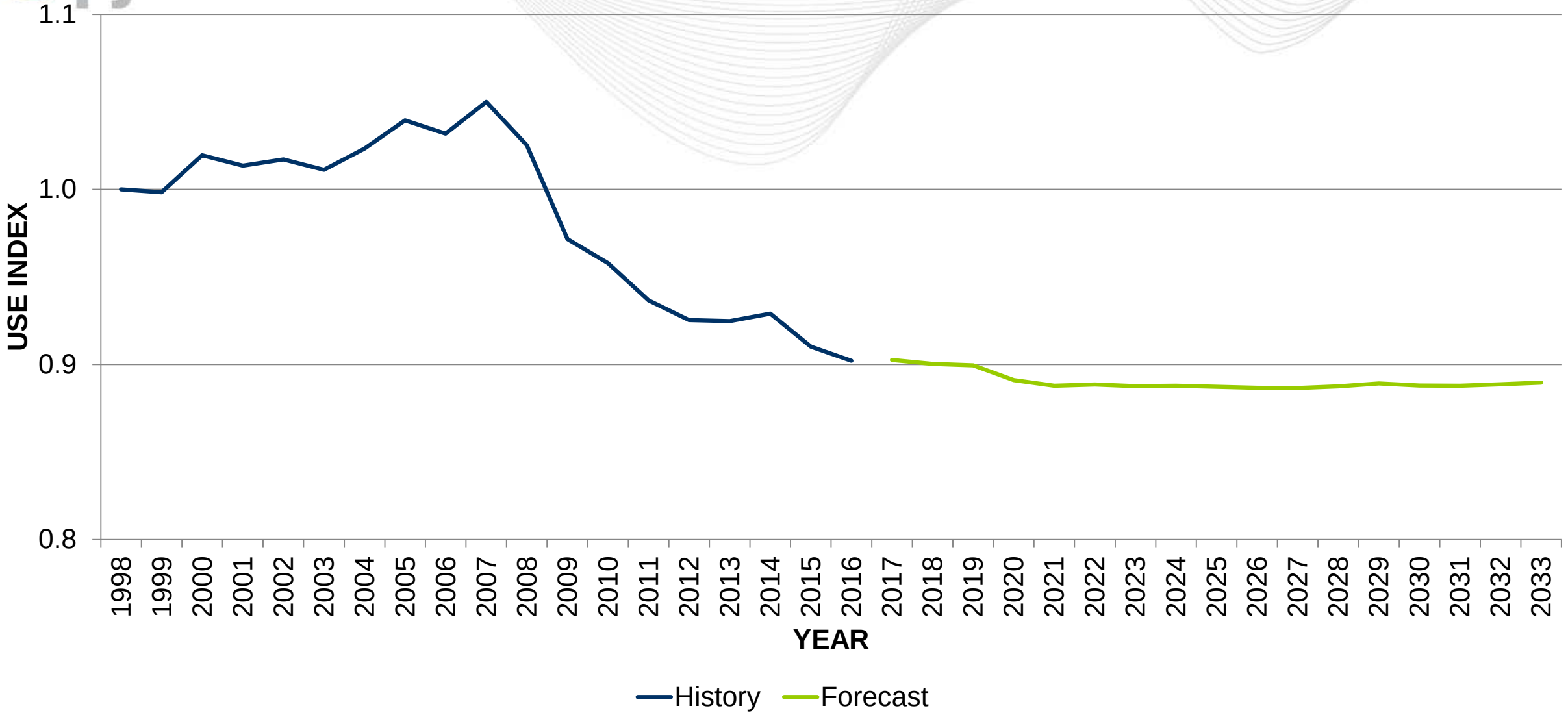
Where,

Intensity is the sum of Heating, Cooling, and Other Use described previously (Source: EIA/ITRON)

Customers (Source: FERC FORM 1)

Employment (Source: Moody’s Analytics)

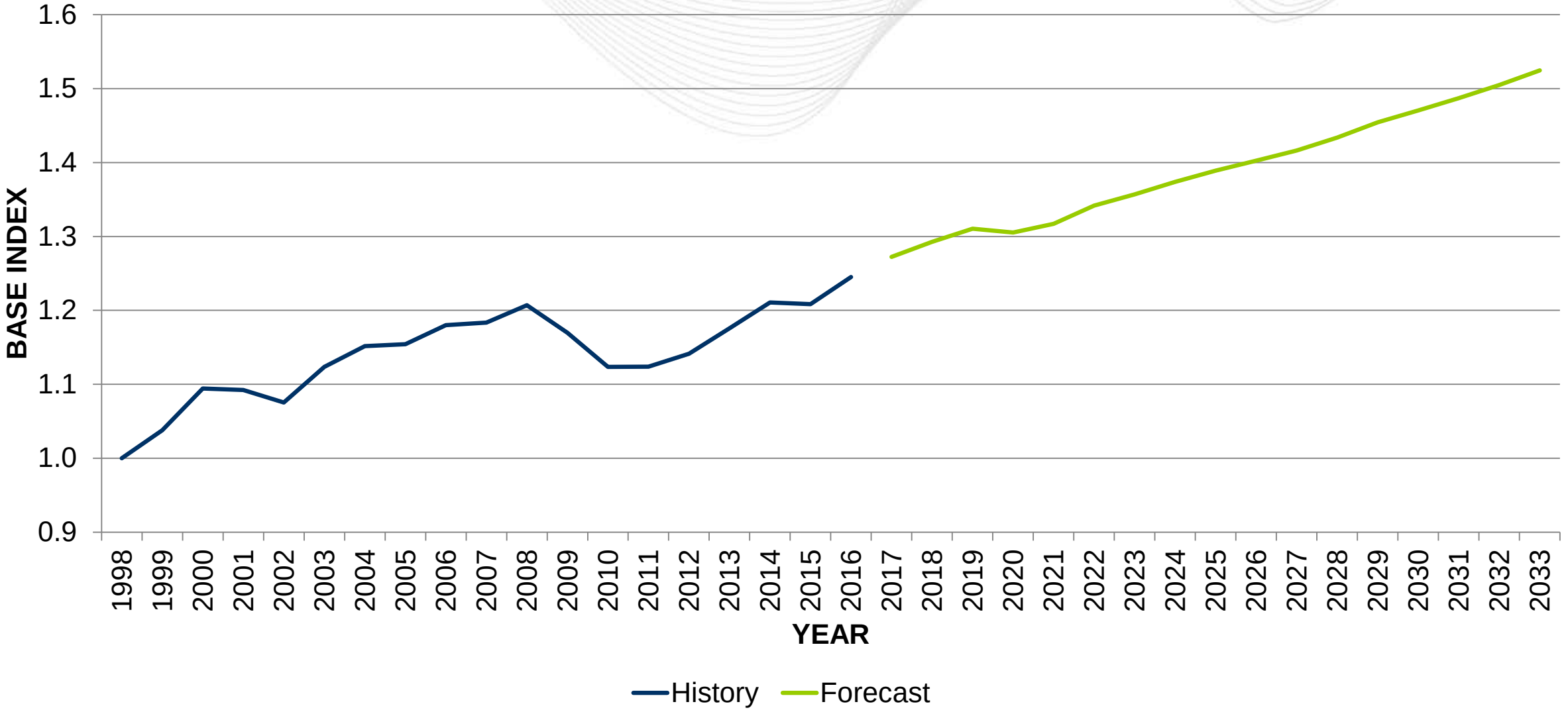
Commercial/Industrial: Average Other Use



Commercial/Industrial: Base Index

Base Index = Customers Index x Other Use Index

Commercial/Industrial: Base Index



Establish Drivers – Total Base

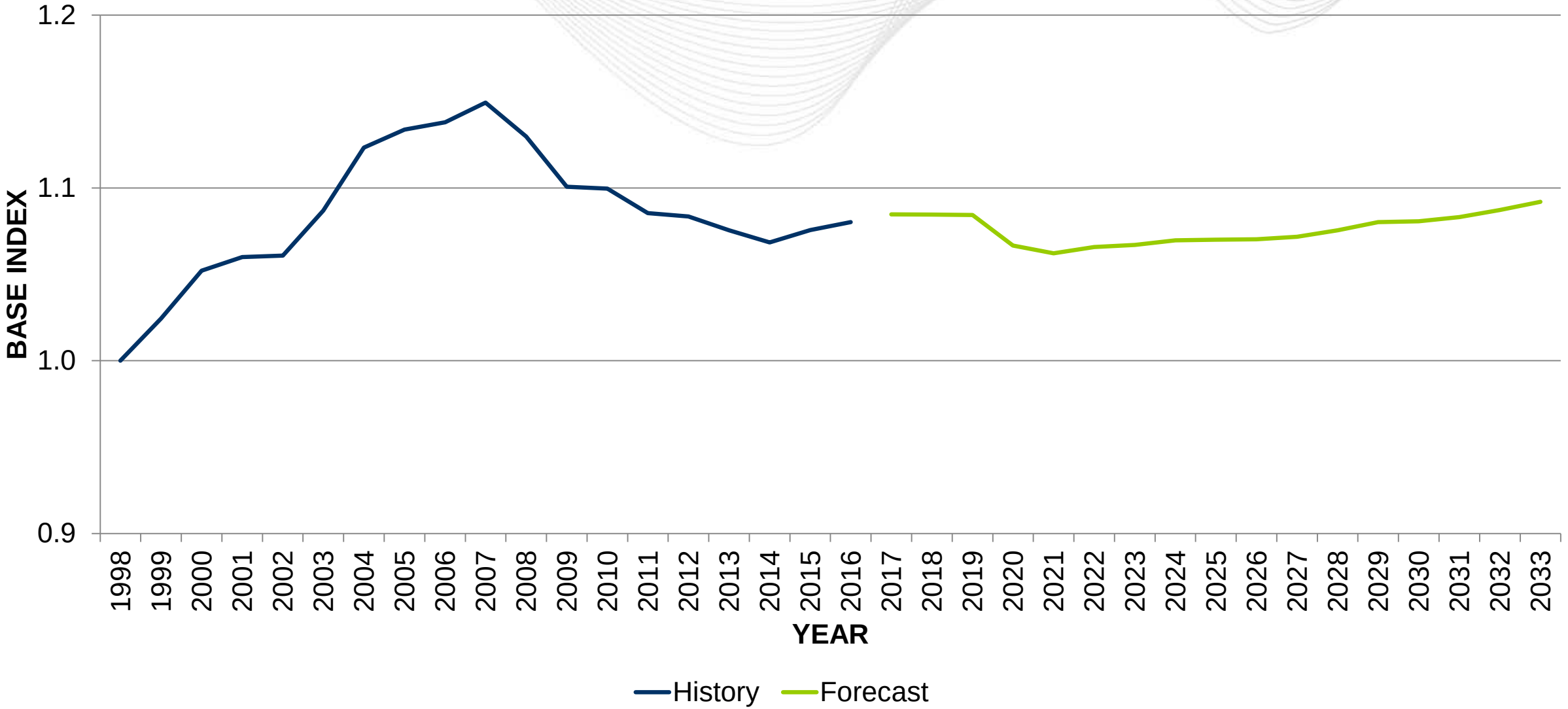
Total Base Index

Total Base Index = (Res Weight x Res Base Index)
+ (Com/Ind Weight x Com/Ind Base Index)

Where,

Res Weight is Residential Share of RCI sales over past 5 years
Com/Ind Weight is Com/Ind Share of RCI sales over past 5 years
(Source: FERC FORM 1)

Total Base Index



Forecast Base

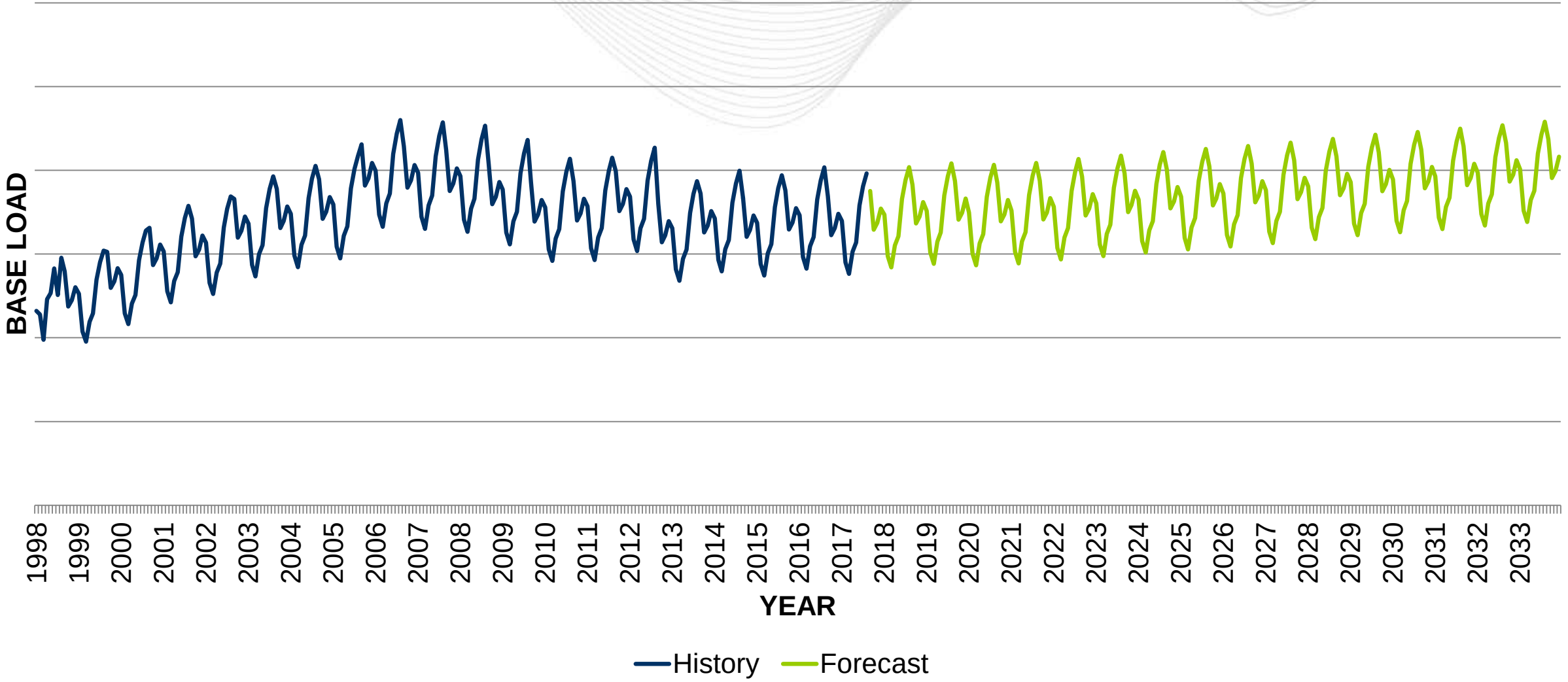
Base Forecast Model

- Hard work is done…
  - Base forecast will be a function of the base driver
  - Specification chosen is a year- to-year difference model:

$$\boldsymbol{BaseLoad_t - BaseLoad_{t-12} = BaseDriver_t - BaseDriver_{t-12}}$$

    - Leverages the last observation (mitigates jump-off)

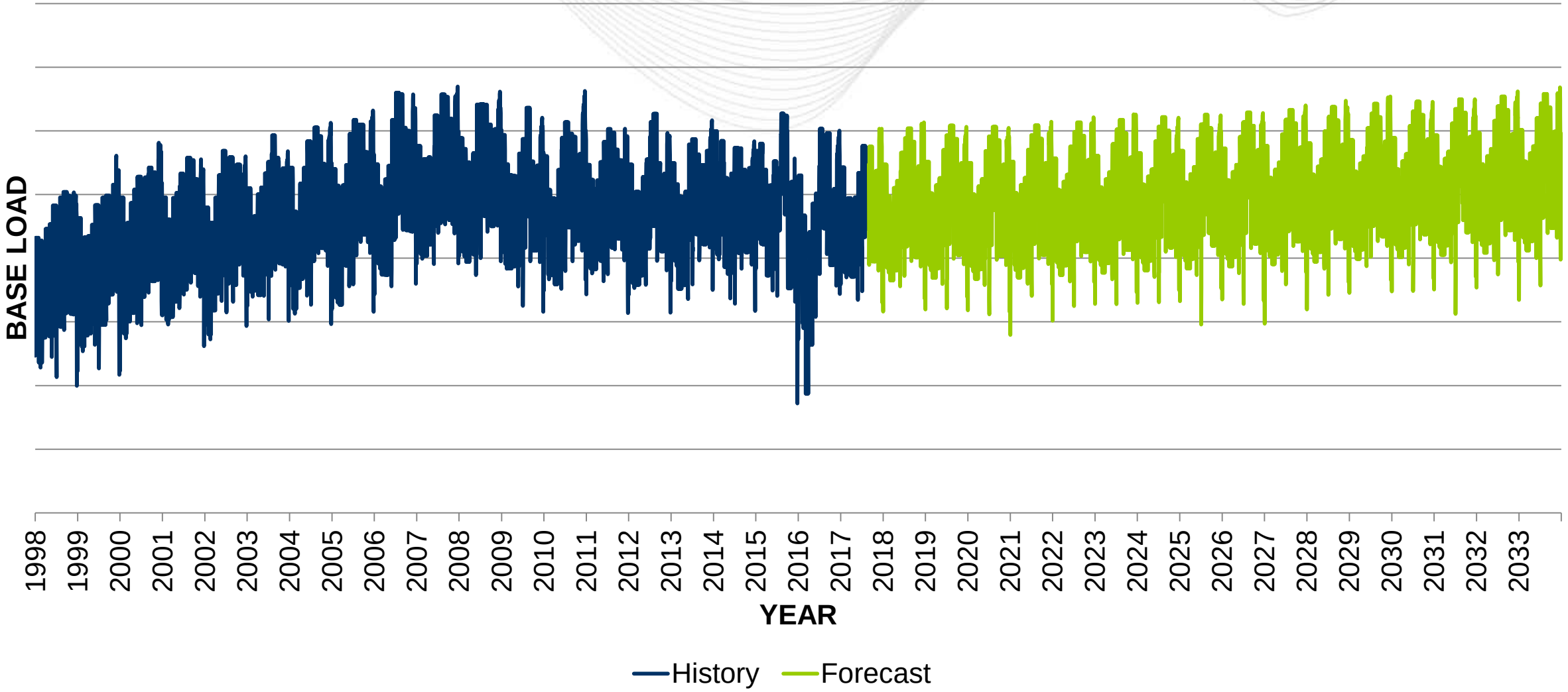
Base Load: History with Forecast



Convert Forecast to Daily

- At this point we have a monthly base forecast, though the total forecast will still process at a daily frequency.
  - Recall coefficients that we stored in earlier step. Use to adjust monthly values (which are the average M-Th weekday) for…
    - Fridays
    - Weekends
    - Holidays

Base Load: History with Forecast



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Appendix

Usage Variable Modifications

- With the model more resembling an end-use structure than prior, some modifications were made to the end-use variables.
  - Current: The basic structure incorporates an approach of having an economic variable (encompasses population, households, income, employment, output) interacted with an end-use variable (just considers saturation and efficiency).
  - Potential: Basic structure is an end-use variable (accounting for population, households, income, employment, output) interacted with a customer variable

Usage Variable Modifications

- Due to this change, the end-use variables previously used are not comparable to the end-use variables potentially used going forward.
    - Residential
        - Adjustments for population per household, income per household, and building shell
    - Commercial
        - Adjustments for employees per customers (discussed earlier)

Usage Variable Modifications

- To make the changes to the Residential series, the 2009 Residential Energy Consumption Survey is leveraged (may look at more recent survey at a later date for comparison)
  - Used micro data
  - Standardize observations
  - Run regressions of equipment use on household characteristics
    - Persons per household
    - Income per household
    - Building size

RECS Analysis

Equipment Type	Persons Per Household	Income Per Household	Residence Size
Cooling	*0.07*	*0.00*	*0.77*
Heating	*0.19*	*0.07*	*0.23*
Water Heater	*0.67*	*0.14*	
Refrigerator	*0.31*	*0.32*	
Remaining Other	*0.47*	*0.31*	

Intensity Formula

$$Intensity_j = OrigIntensity_j \times PopPerHH^{\alpha} \times IncPerHH^{\beta} \times Shell^{\varphi}$$

Where

- j is Equipment Type (i.e. Central A/C, Refrigerator, etc)
- OrigIntensity is intensity driven by Saturation/Efficiency trends alone (source: EIA/ITRON)
- PopPerHH is population per household (source: Moody's Analytics)
- IncPerHH is income per household (source: Moody's Analytics)
- Shell is building size adjusted for shell efficiency (source: EIA/ITRON)