INTEGRATED RESOURCE PLAN

2016

Technical Workshop 1:

Load Forecast Methodology

Wednesday, July 15, 2015

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Load Forecasting

Portland General Electric


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Welcome

Welcome: Today’s Topics

- Welcome
  - Safety Moment
  - Timeline Review
- Overview of Modeling Initiatives
- Long Term Energy Model
- Peak Demand Model
- Treatment of Programmatic Energy Efficiency
- Q&A

Safety Moment – Vehicular Heat Safety

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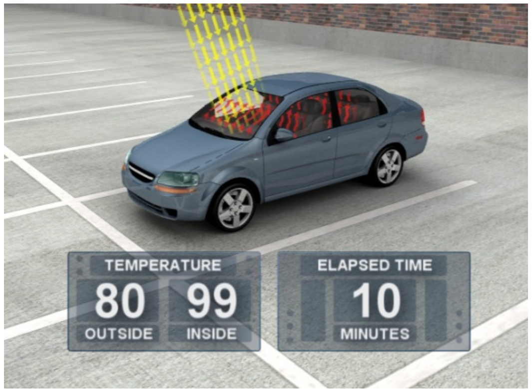

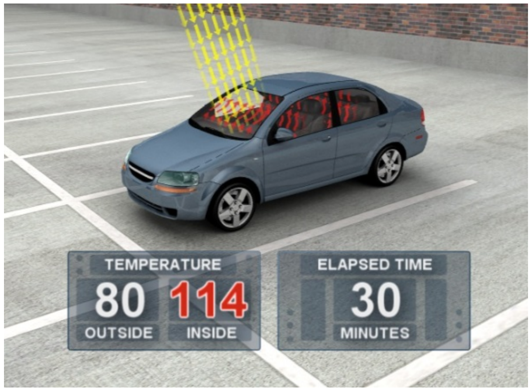

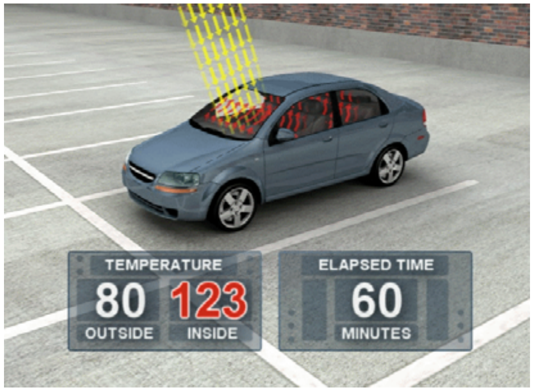

Touch a child's safety seat and safety belt before using it to ensure it's not too hot before securing a child

Never leave a child unattended in a vehicle, even with the windows down, even for just a minute

Teach children not to play in, on, or around cars.

Always lock car doors and trunks--even at home--and keep keys out of children's reach.

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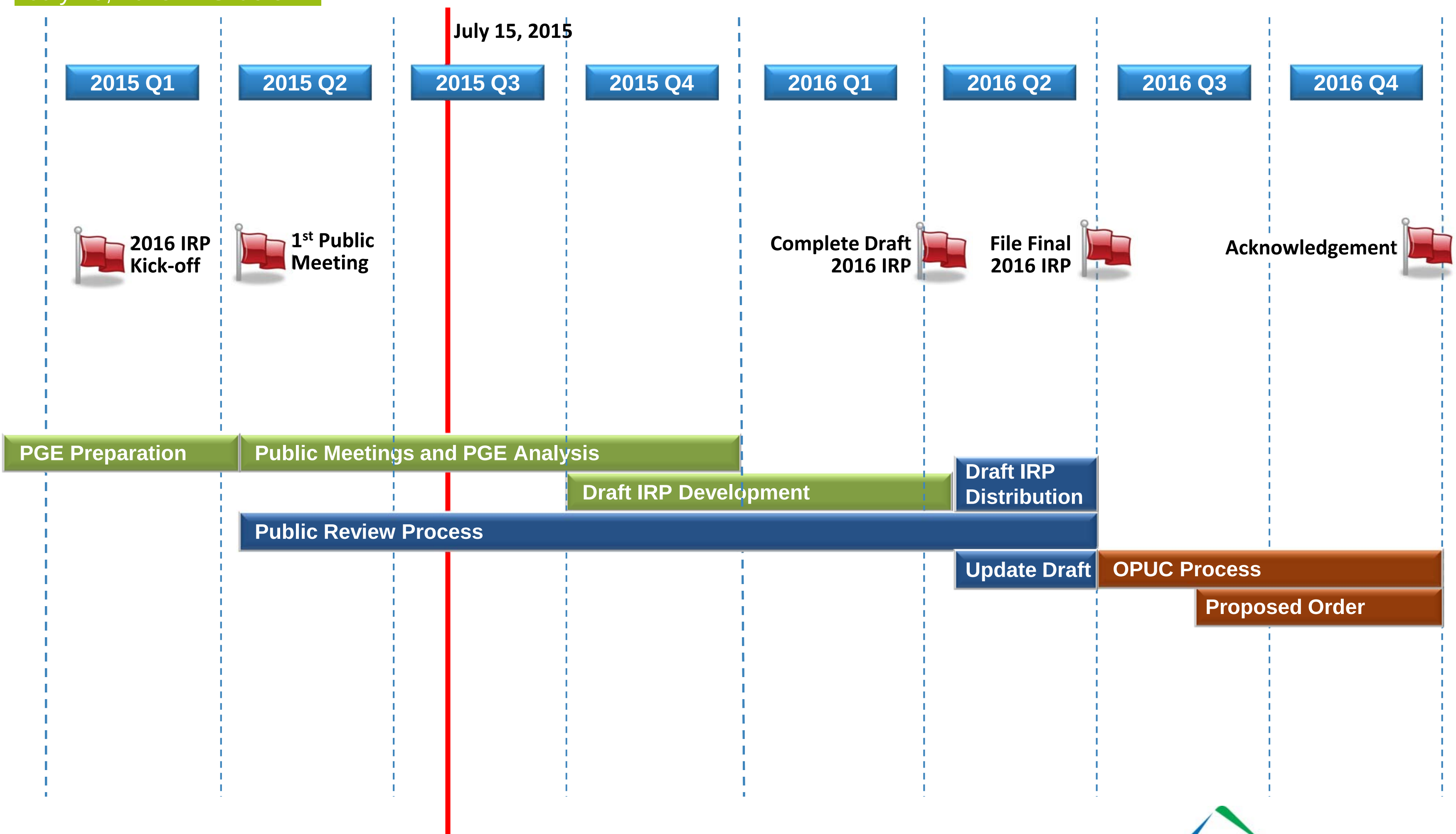
2016 IRP Timeline



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Itron Third-Party Review Purpose

- In late-2014, PGE hired Itron to review its load forecasting models and process.

- The objective of the review was to evaluate PGE's methodology and make recommendations based on industry benchmarking and best practices.

- Major aspects of the review included:
  - Short-Term Forecast Models
    weather variables, economic relationships, forecast process
  - Long-Term Forecast Approach
    long-term forecast methodology, assumptions and growth rates.
  - Peak Demand Model
    Review of load factor build-up approach and recommendations to incorporate changes in system load factor

Itron Third-Party Review Findings

Short-Term: Residential

Customer Method
Survival Equation - Minority

Energy Method
Econometric - Normal
Weather Variables – Minority
Economic Variables – Minority
Growth Rates - Normal

Short-Term: Commercial

Customer Method
Survival Equation - Minority

Energy Method
Econometric – Normal
Weather Variables – Normal/Refine
Economic Variables – Normal/Refine
Growth Rates - Normal

Short-Term: Industrial

Energy Method
Econometric - Normal
Economic Variables – Normal/Refine
Growth Rates – High

Price Adjustment

Method
Develop with Model –Normal
Elasticity - Normal

Long-Term Forecast

Energy Method
Average Growth - Minority
Growth Rates - High

DSM Adjustment

Method
Subtract Incremental - Normal

Peak Forecast

Peak Method
Load Factors – Minority
Use Load Research - Normal
Growth Rates - High

Key:
Standard Practice
Minority Practice
Consider Refinements

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Model Refinements based on Recommendations

December 2014 Forecast

- Short term energy models
  - Simplified specifications and structure
  - Implemented multipart spline weather variables (using lower breakpoint HDD and CDD)
  - Improved economic drivers and/or shortened estimation periods where appropriate

June 2015 Forecast

- Peak Demand Forecast
  - Develop & implement econometric forecast to replace load factor approach
- Long term Energy Forecast
  - Top-down econometric models by customer class for long-term growth rates

Future

- Long Term Energy Models
  - Further Refinements
- Peak Demand Forecast
  - Track weather-adjusted peaks and peak forecast performance
- Energy Efficiency
  - Work with ETO for hourly detail data or peak hour contribution

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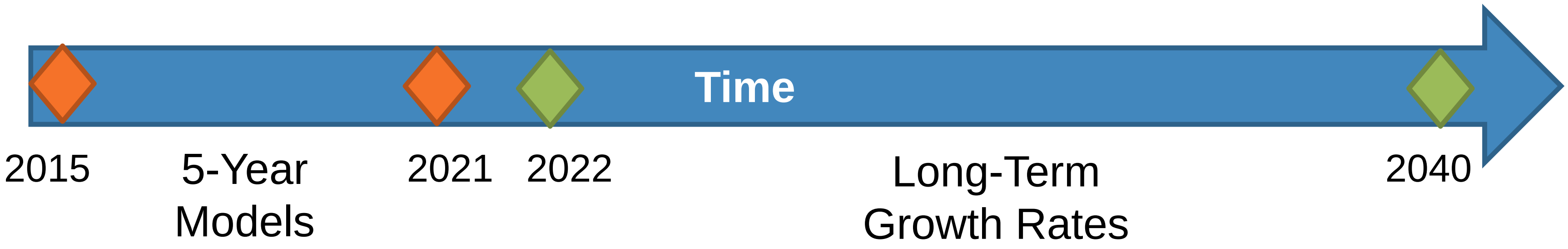
Energy Forecast

Energy Forecast Approach



5-Year Forecast Models

- Based on most current economic forecast capturing current business cycle
- Adjusts for any known rate changes, large customer changes, miscellaneous schedules.
- Explicitly removes incremental energy efficiency (Senate Bill 838) savings.
- Total of 25 medium-term models:
  - 7 residential use-per-customer models
  - 11 commercial energy models
  - 7 industrial energy models

Long Term Models

- Long term forecast converges to long-run growth rates and is agnostic of business cycle and customer specific expansions.
- Long term growth rates/models:
  - High-level customer class (5 in total)
  - Assumes future rate of energy efficiency and codes and standards similar to historic levels, thus embedded in growth rates.

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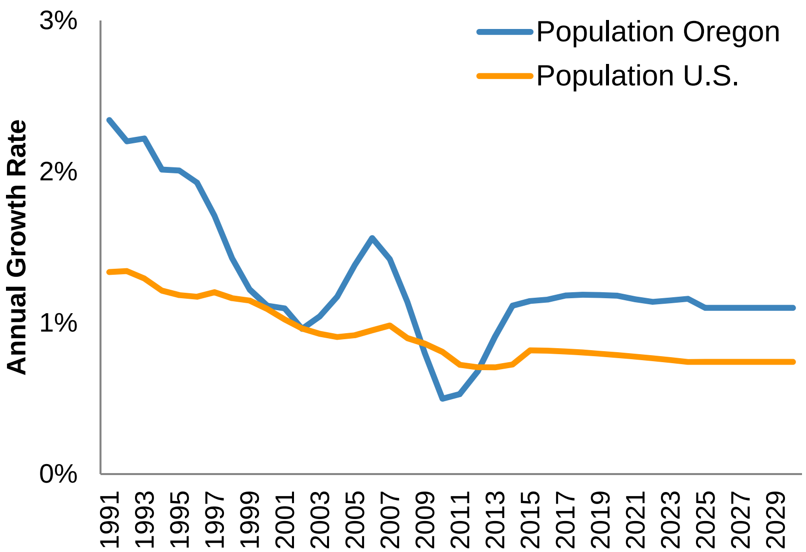
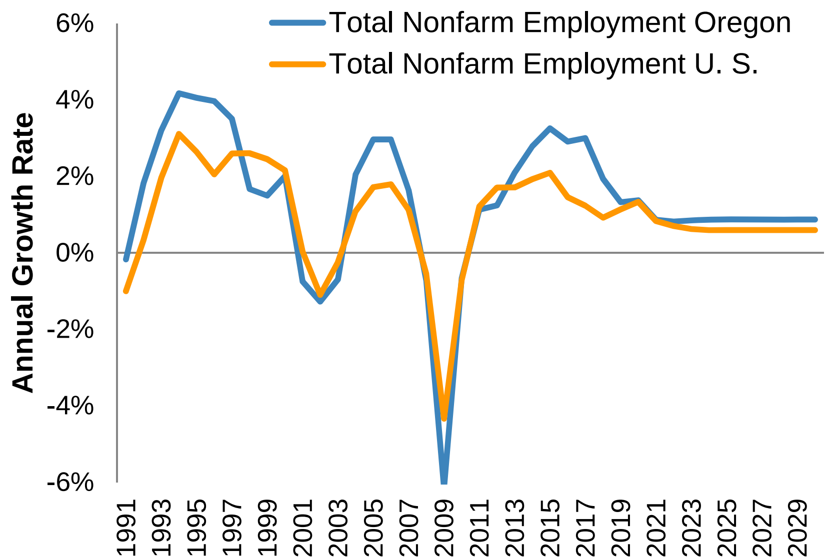
Oregon's (and PGE's) Growth Advantage





- Western U.S. is growing faster than the U.S., on average.
- Oregon continues to be a leading state for in-migration, with PGE service territory growing faster than the Oregon state average due to higher population growth in urban areas.
- Roughly 1.2% to 1.4% long-term population growth for PGE service territory.

- In Oregon, job growth is expected to be most rapid in the Portland metro area due to concentration of business activities.
- Oregon long-term employment forecast at 1.1% per year 2025 and beyond.
- Businesses associated with high-tech industry are typically energy intensive and cluster in Portland metro region.

Source: Oregon Office of Economic Analysis, Economic Forecast, May 2015. Oregon Employment forecasts only available to 2024, extended assuming convergence to long-run equilibrium rate at end of horizon based on Global Insight Long Term Economic Forecast for US GDP..

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Historic and Forecasted Annual Average Growth Rates

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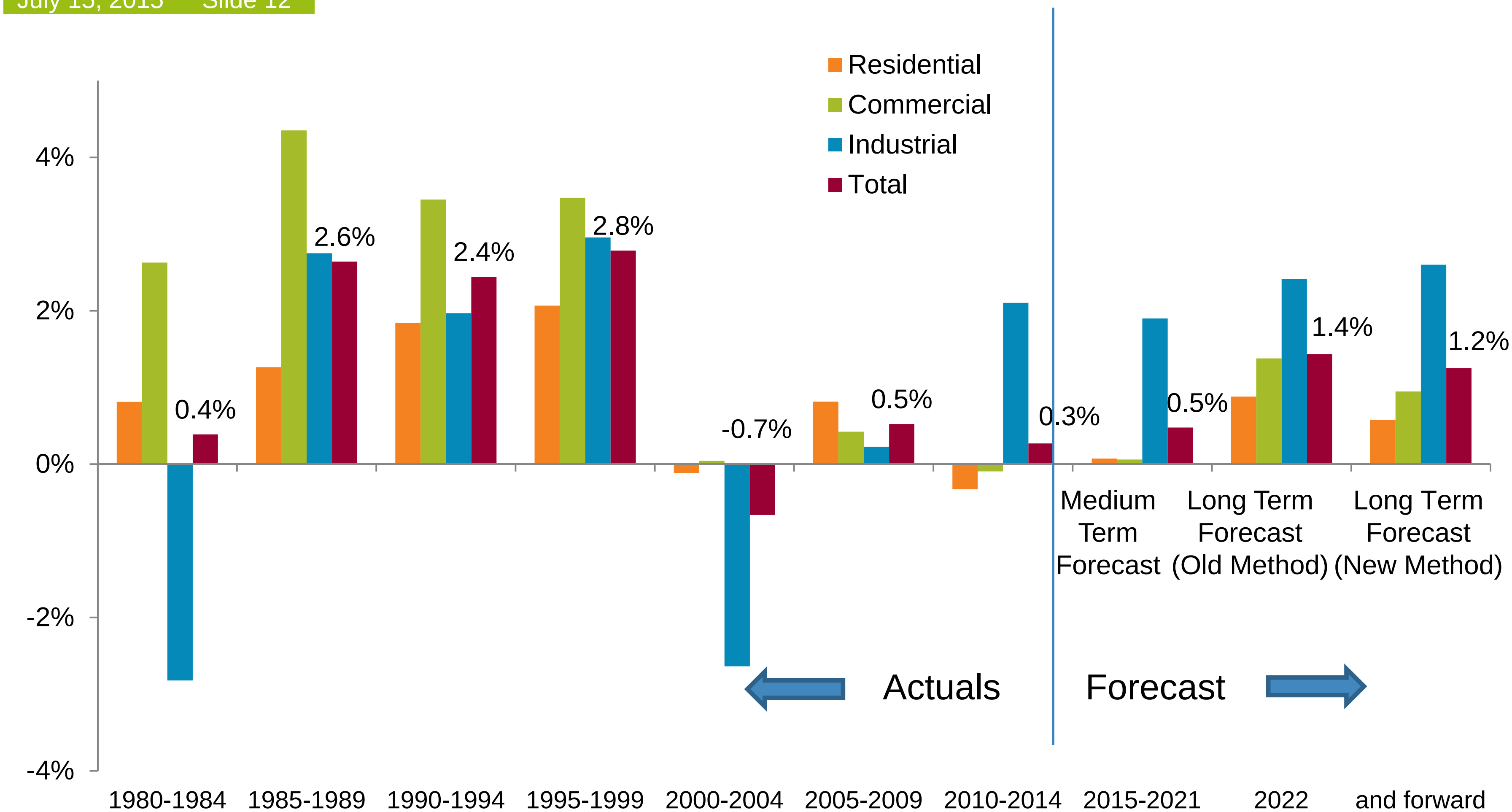

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Residential Model

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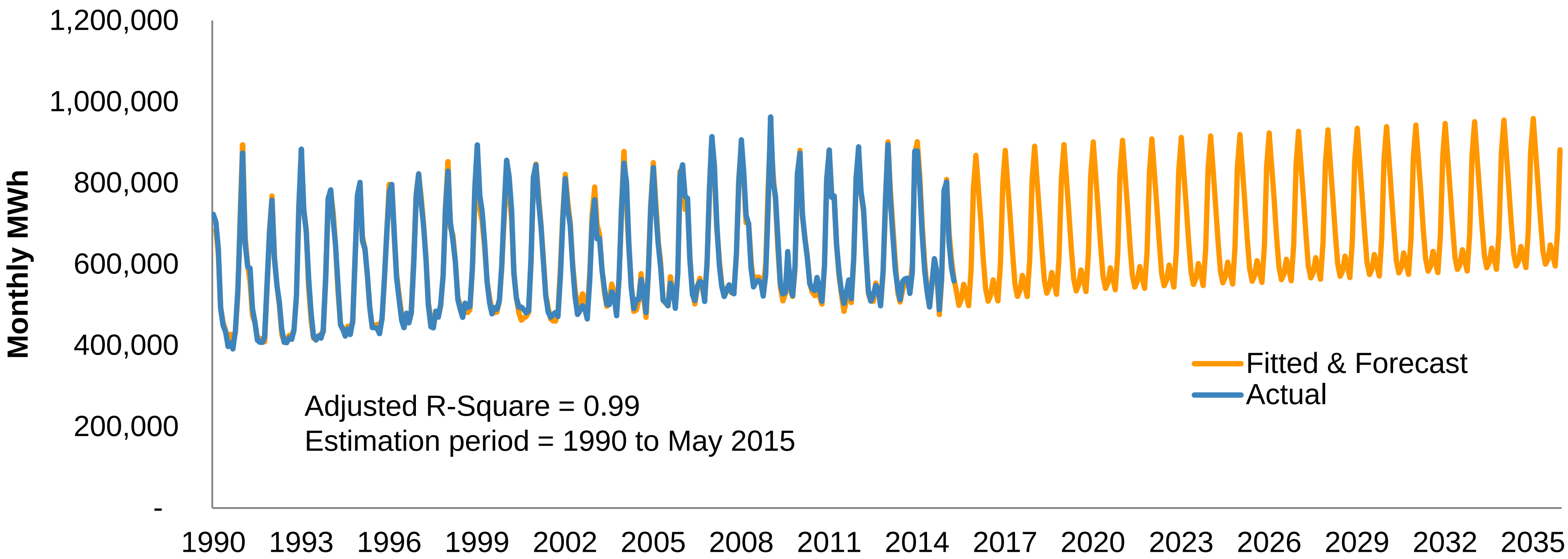

- Long-term residential energy forecast includes weather variables and Oregon total nonfarm employment as the economic driver.
- New residential energy growth rate of 0.6% and 1.1% customer growth rate
- Use-per-customer declining on average by 0.5% in the long-run—with no assumption that this decline levels-off.
- PGE residential energy growth rates are within industry projections: Itron survey found average 10-year residential growth rate of 0.65% across 77 utilities.

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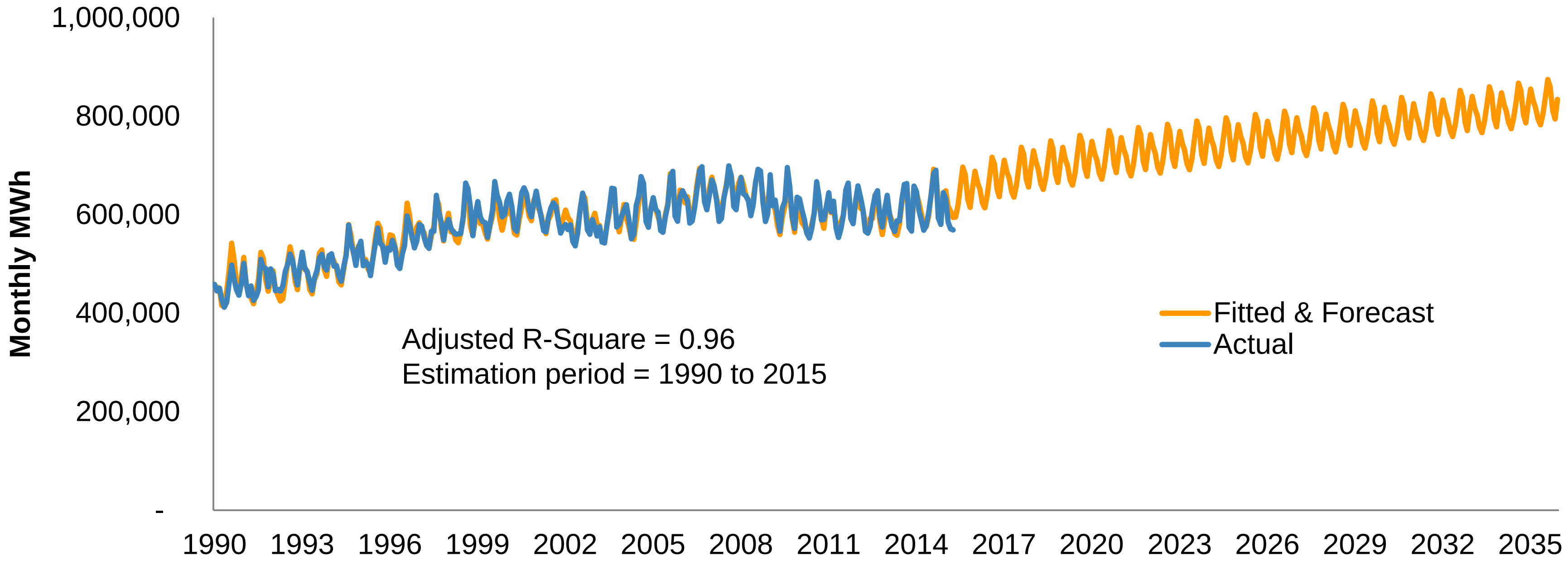
Energy Forecast: Commercial (Secondary Service)



- Long-run commercial forecast driven by Oregon total non-farm employment.
- Cooling and heating degree day variables are included in the model.
- Assume historic rate of energy efficiency and declining energy intensity due to codes and standards embedded within the growth rates produced by the model.
- Long-run commercial growth rate drops from 1.4% per year under old approach to 0.9% based on regression model and economic forecast.

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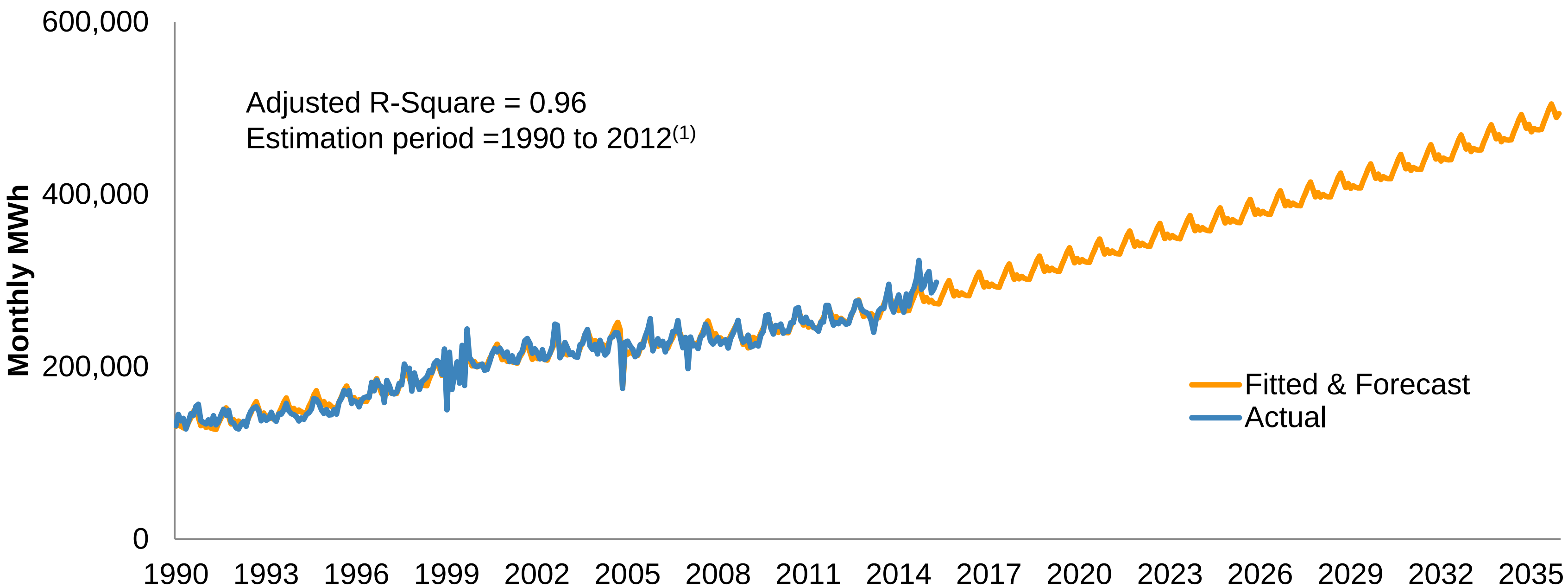
Energy Forecast: Industrial (Primary Service)



- Long-run industrial (primary delivery voltage) forecast driven by US GDP economic driver
- New model produces a slightly higher long-run growth rate of 2.6% compared to the previous method, which resulted in average effective growth rate of 2.4%.[2]
- Itron industry benchmark finds uneven distribution of industrial class growth rates driven by regional economic conditions.

(1) New model estimation excluded 2013 and 2014 due to abnormally high recent industrial growth rates.
(2) Historic growth rate from 1985 to 2014 is 3.2% for primary service, but averages to 2.4% when excluding months with greater than 10% annual growth.

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Energy Forecast: Comparison of Long-Term Growth Rates

Delivery Voltage Customer Class	Historic Growth Rate Approach(1)	Regression Model Results
Residential	0.9%	0.6%
Secondary (Commercial)	1.4%	0.9%
Primary (Industrial)	2.4%	2.6%
Transmission (Large Industrial)	0.0%	0.0%
Street Lighting	0.0%	0.0%
Net System	1.4%	1.2%

- The historic growth rate approach averaged the monthly historic growth rates from 1985 to 2014 with growth rates from 1992 to 2014 to develop average monthly growth rates by service delivery voltage class.
- New service delivery voltage class regression models incorporate long-run economic (equilibrium) growth rates, which reflect structural changes in employment levels due to demographic trends, but do not predict future business cycles.

(1) Months with growth exceeding 10% or -10% were excluded from the average historic growth rate approach.

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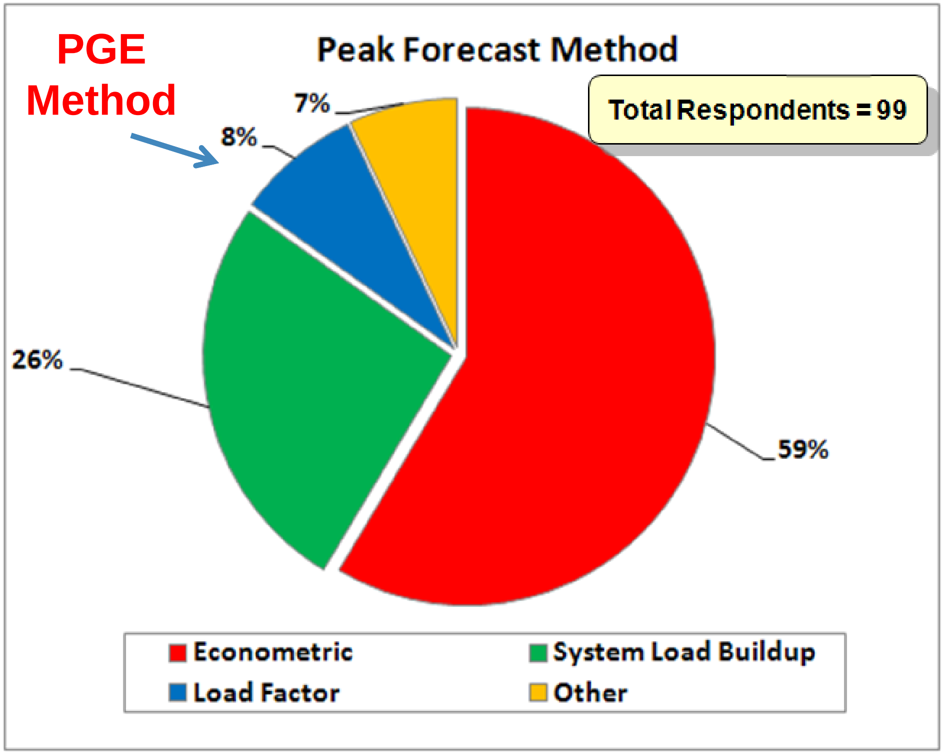
Peak Demand Model

Itron Review Peak Forecasting Methods



Source: Itron, Review of PJM Models, Phase 1 Load Forecast Model Evaluation, 2010

- PGE has used a load factor approach for peak forecasting in the past. While this is an acceptable practice, it is a minority practice in the industry
- Itron findings and recommendation
  - Annual peak forecast is within the bounds of a reasonable projection
  - Explore econometric models to forecast monthly peaks to improve explanatory power and flexibility in peak forecast.

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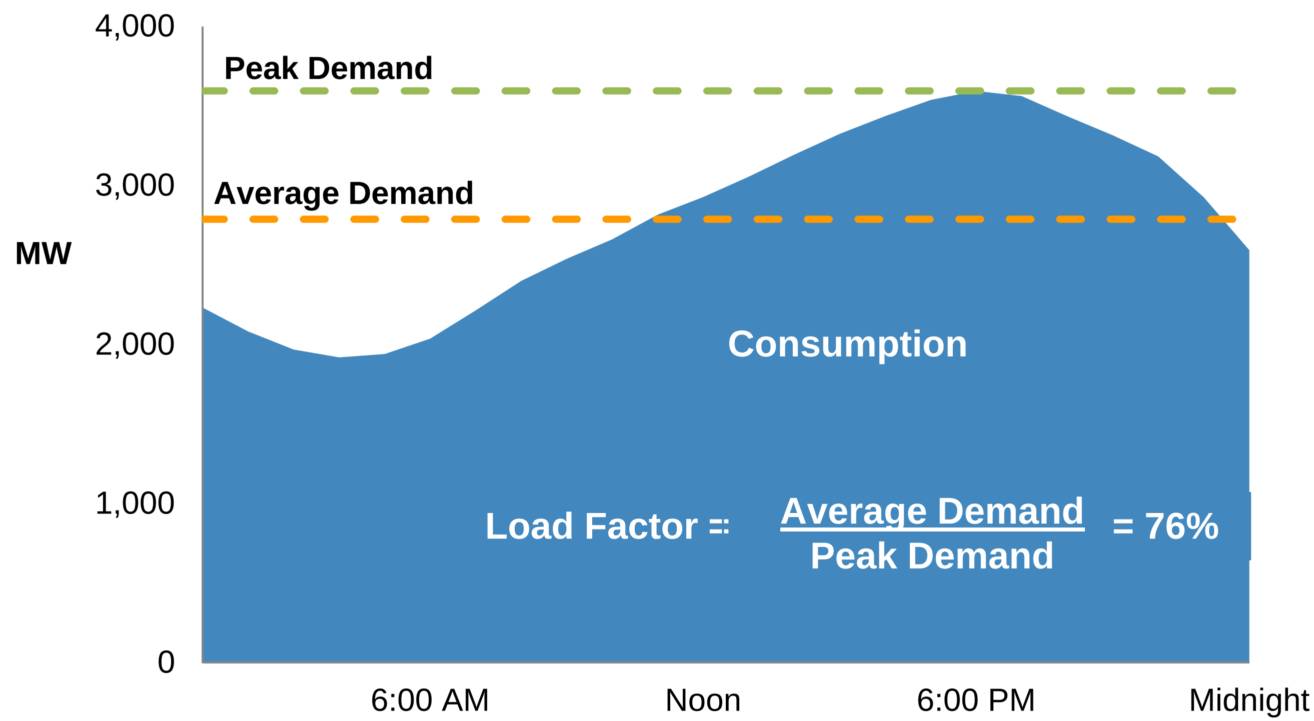
PGE’s Peak Demand Forecast



- PGE’s historic approach has been to analyze the relationship between monthly peak and monthly energy to create expected load factors and apply these load factors to the energy forecast.
  - Done monthly by class, residential, commercial, industrial
  - Build up to net system peak

- While this is a reasonable approach, it assumes load factor is constant.

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Trends in PGE’s Winter Peak

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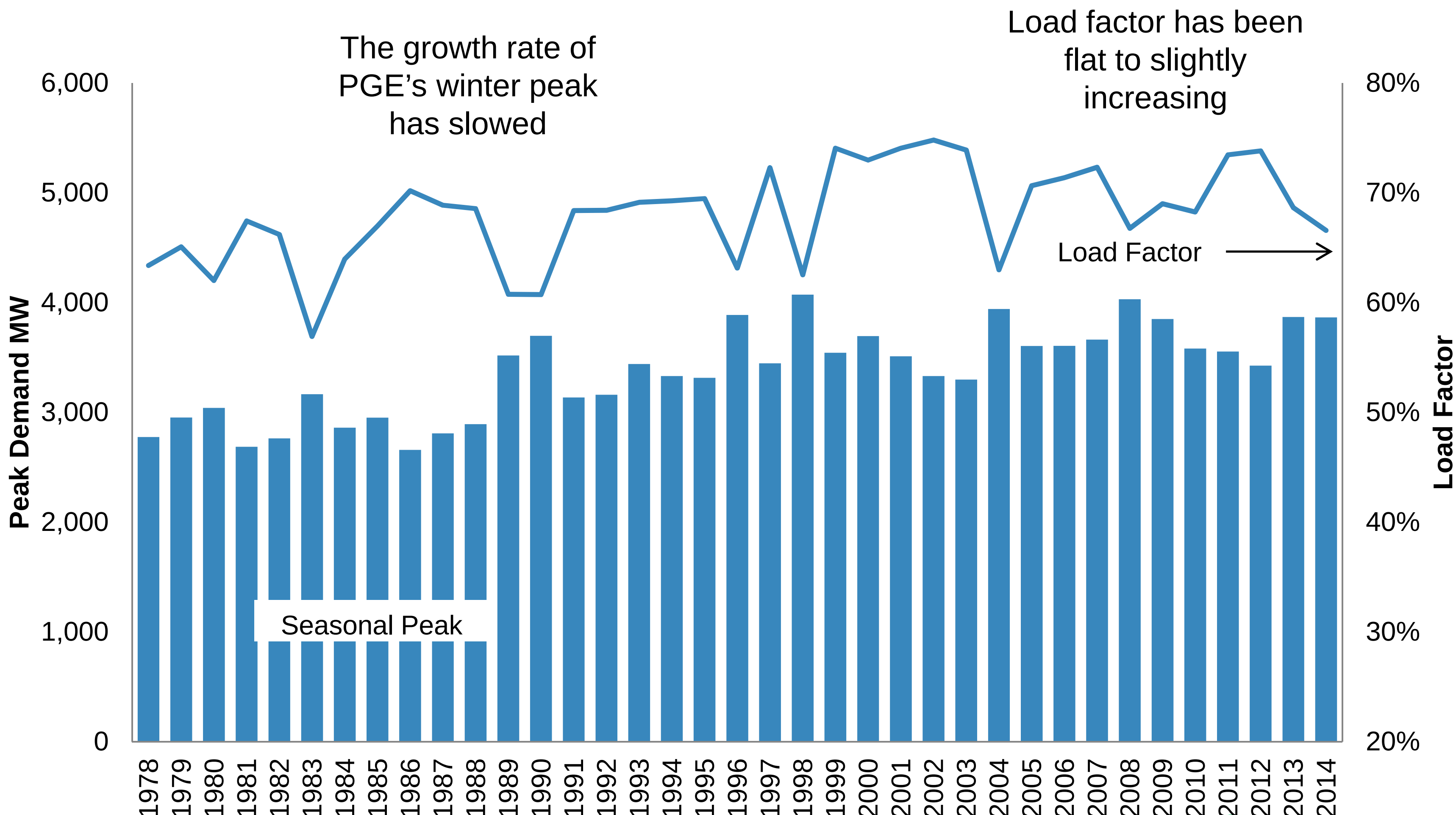

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Trends in PGE's Summer Peak

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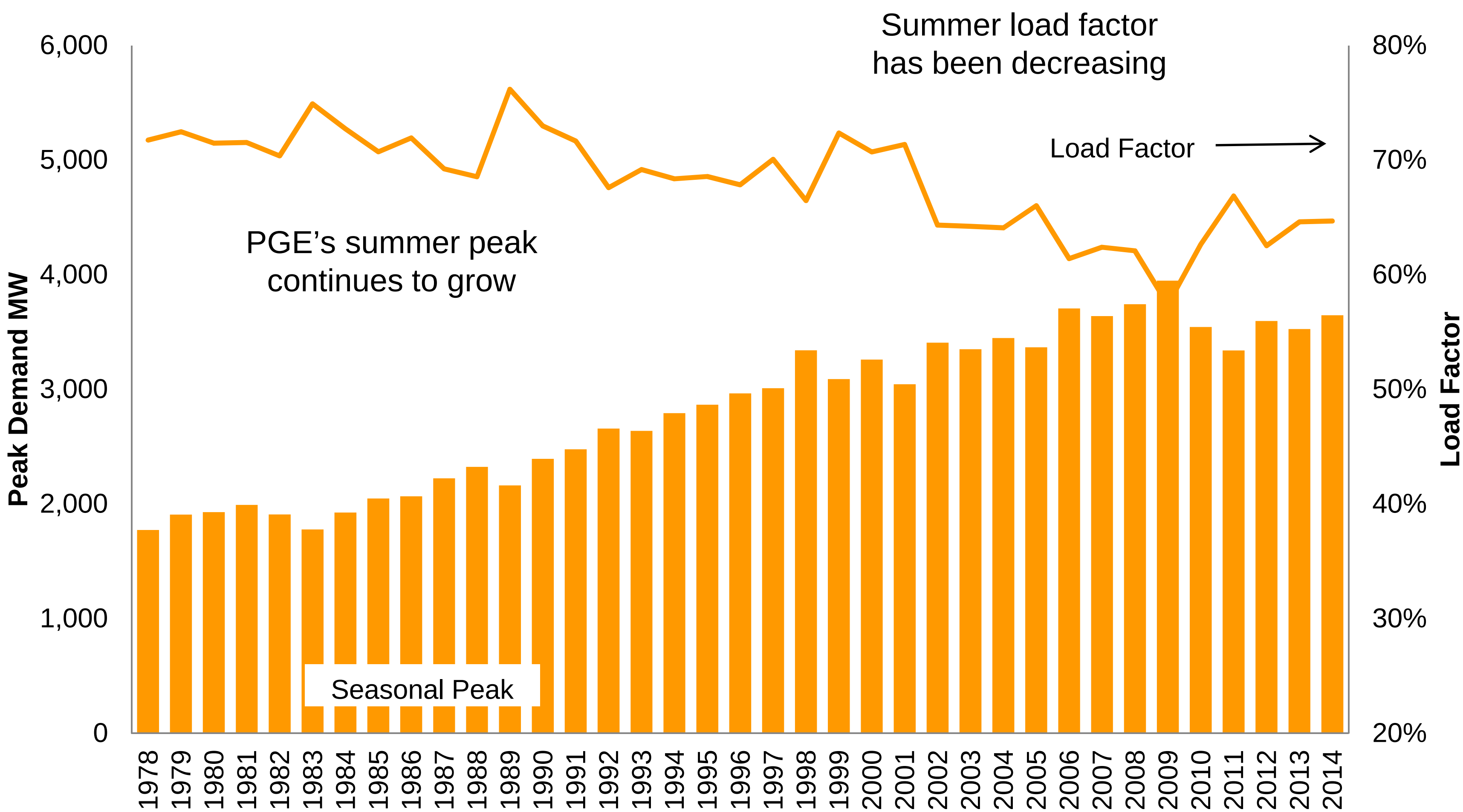

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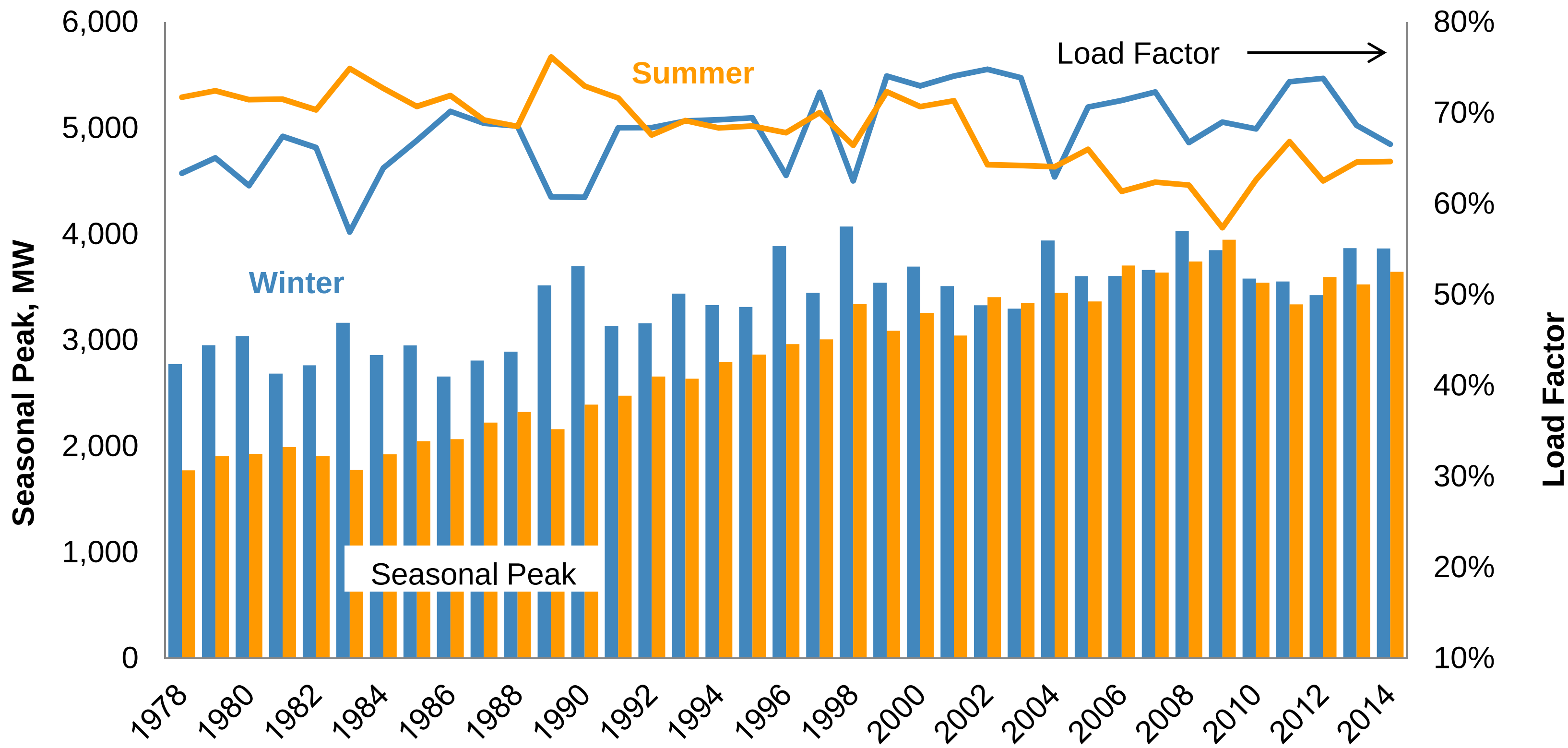
PGE Seasonal Peak Comparison



- Summer peak (MW) and average energy (MWa) has grown at a faster rate
- Traditionally, PGE has been a winter peaking utility. The system can now be described as dual peaking
- Residential end use trends, specifically in response to weather, are a major driver of changes in peak demand

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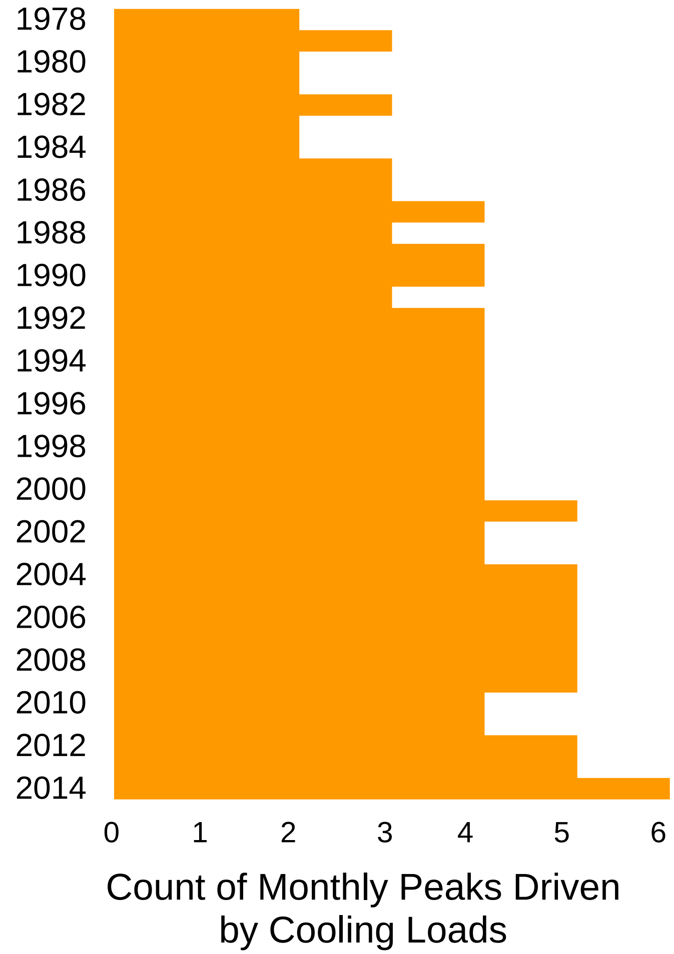
PGE Peak Trends

Monthly peaks are increasingly cooling driven

- In 5 of the last 15 years the annual system peak occurred in the summer
- The count of monthly peaks due to cooling within the year is also increasing
    - PGE saw its first cooling driven October peak in 2014, marking it the first year with half of the monthly peaks driven by cooling

We want to capture this as best we can in the development of our econometric model.



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Peak Forecasting Econometric Approach

Common Forecasting Structures

Increasing Complexity ↓

Peak = f(HDD, CDD, Economic Driver)

Peak = f(HDD, CDD, System Energy)

Peak = f(HDD, CDD, Summer Energy, Winter Energy)

Peak = f(HDD, CDD, End-Use Trends)

Advantages of an econometric model

- HDD and CDD allow for weather scenarios
- Energy drivers tie energy forecast to peaks
- Seasonal energy allow for changing load factors
- End-use trends allow for detailed changes to monthly peaks

Source: Itron PGE Forecast Review, 2014, peak forecast recommendation

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New Peak Demand Model

Peak = f(Heating, Cooling, Seasonal Energy)

Variables

- To capture heating loads: HDD, HDD30, WIND*HEATING
- To capture cooling loads: CDD*MWA, Prior Day CDD (heat gain)
- To capture energy growth: interactions which allow relationships between energy and peak to vary by season (seasonal dummies*MWA)

Model Characteristics

- Time period used 2000-2014

  Estimation period begins in 2000 as a proxy to capture most end use recent characteristics
- Weather Assumptions

  - Winter peak in December and summer peak in August

  - Use average of monthly peak producing weather for the past 15 years
- Strong model statistics, Adjusted R-squared is 0.93

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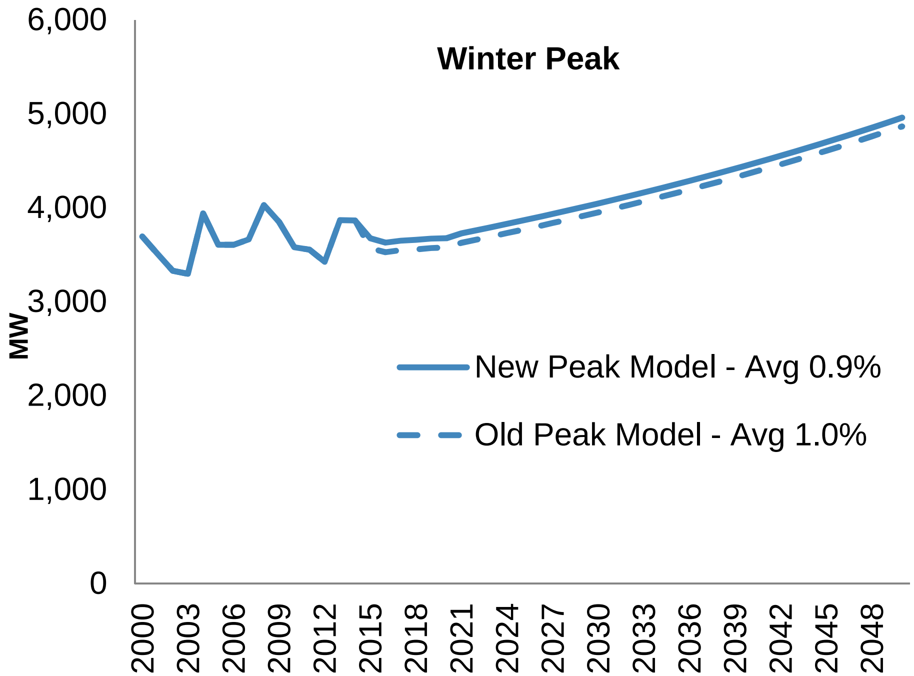
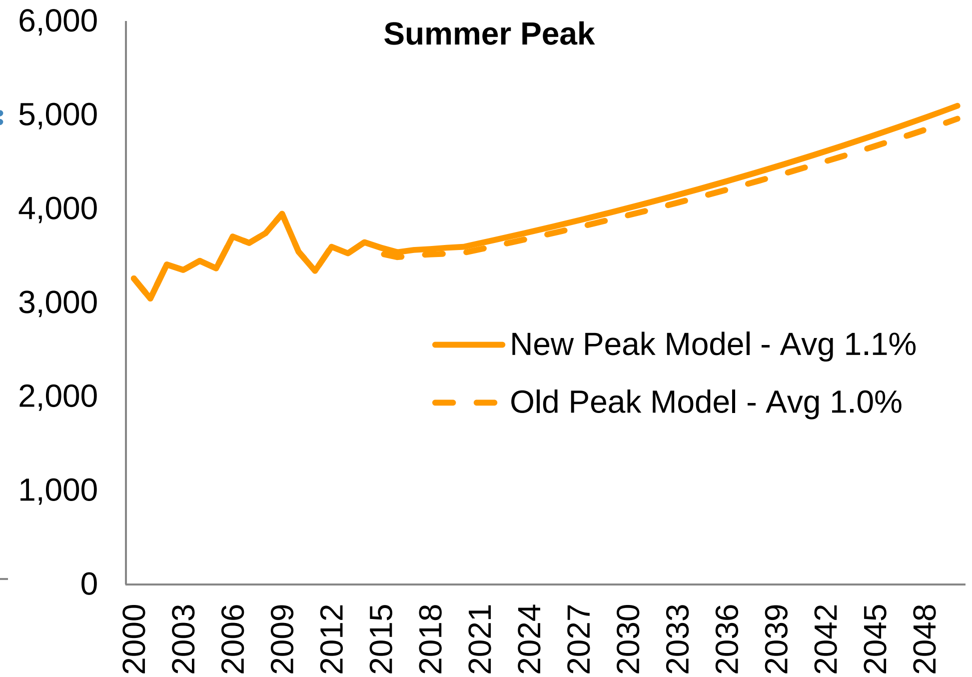
Peak Demand Results Seasonal Comparison





Model results show *very* similar growth rates to prior method.
A few differences

- Early years show upward magnitude shift
- Summer peak grows slightly faster than winter peak
- Higher shoulder peaks, better captures extended cooling season

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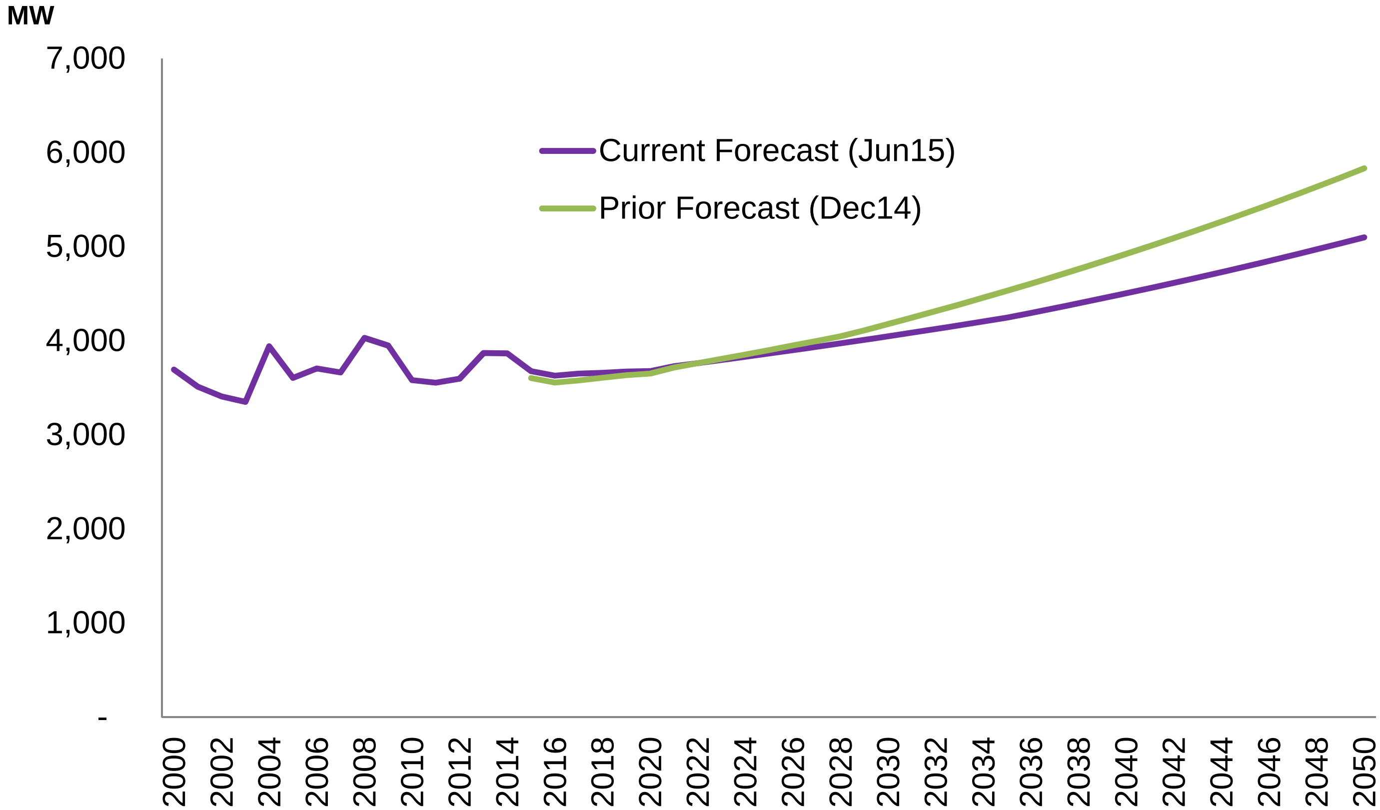
Annual Peak Demand Update



- The combination of updating the energy forecast and the peak forecast method results in a lower long term peak demand forecast than was presented in IRP Public Meeting #1

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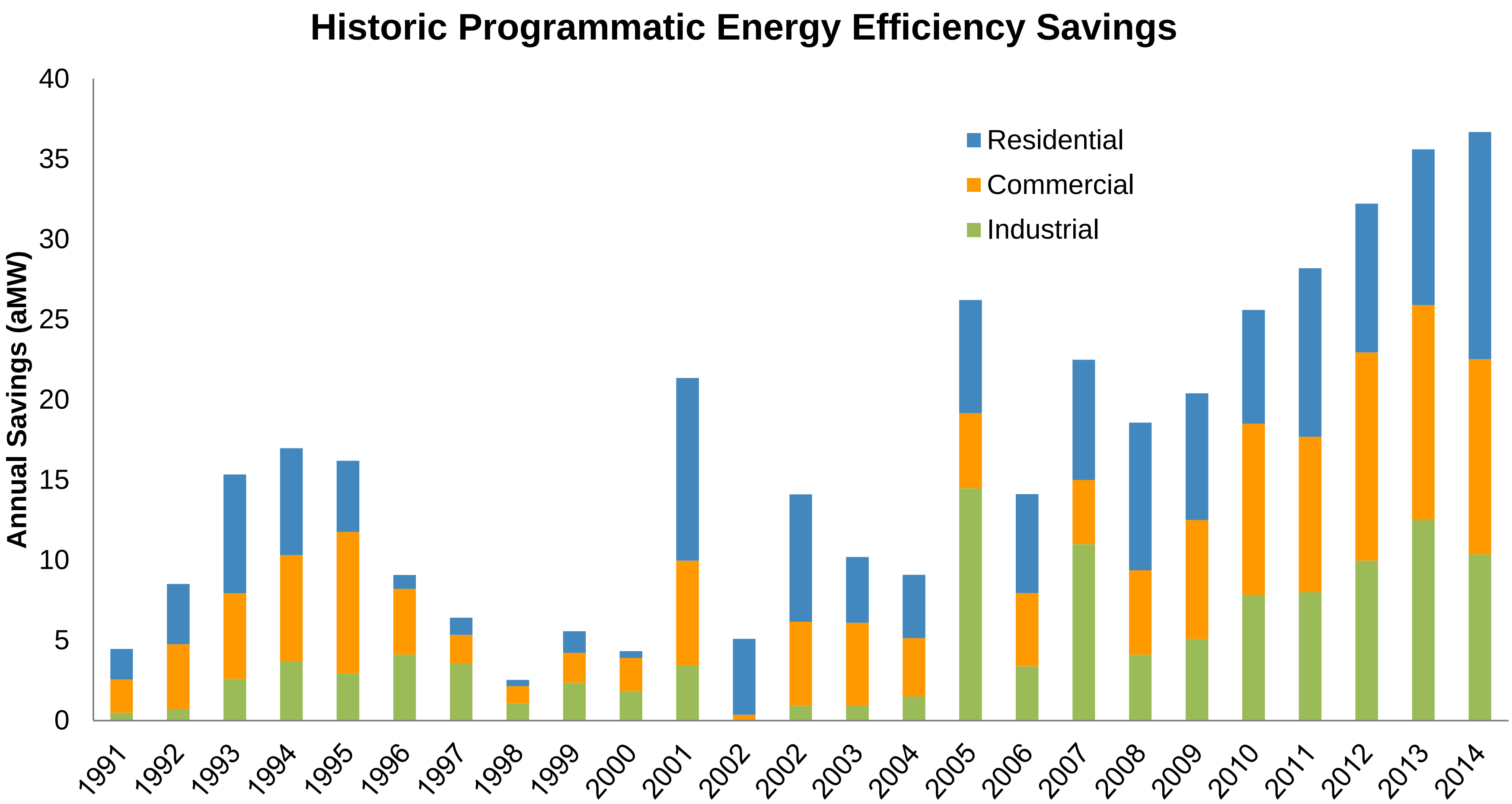
Energy Efficiency in the Load Forecast

Energy Efficiency: Historic Incremental Savings



Source: 1991 to 2001: PGE programmatic EE savings. 2001 to 2014: ETO annual claimed savings, ETO Annual Reports.

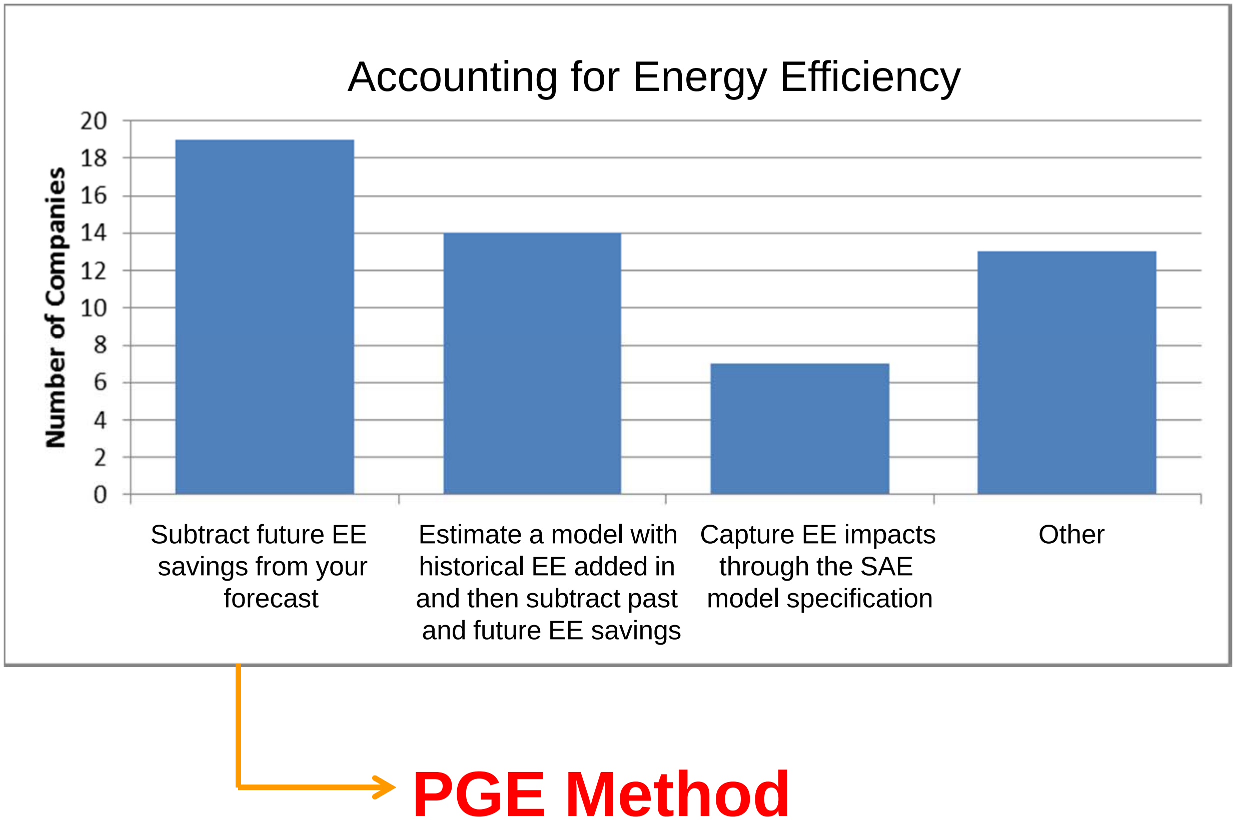
Embedded Energy Efficiency

- PGE's long history of energy efficiency programs implies that historic energy efficiency trends are "embedded" in the billing data used to estimate the load forecast models.
- For the mid-term models, PGE assumes Senate Bill 1149 incremental savings are embedded in base models, and only decrements load forecast by incremental Senate Bill 838 savings
- Considerations:
  - Persistency of savings: ETO, new technology replace existing measure before end of service life of original measure.
  - Service life of measures
  - Large industrial programs where customer or process no longer in operation
- Itron Recommendations:
  - PGE approach is commonly used (short-term forecast)
  - Consider shaping monthly energy efficiency based on seasonality of the measure (e.g. lighting produces more savings in the winter than summer)

Energy Efficiency: Current Approach

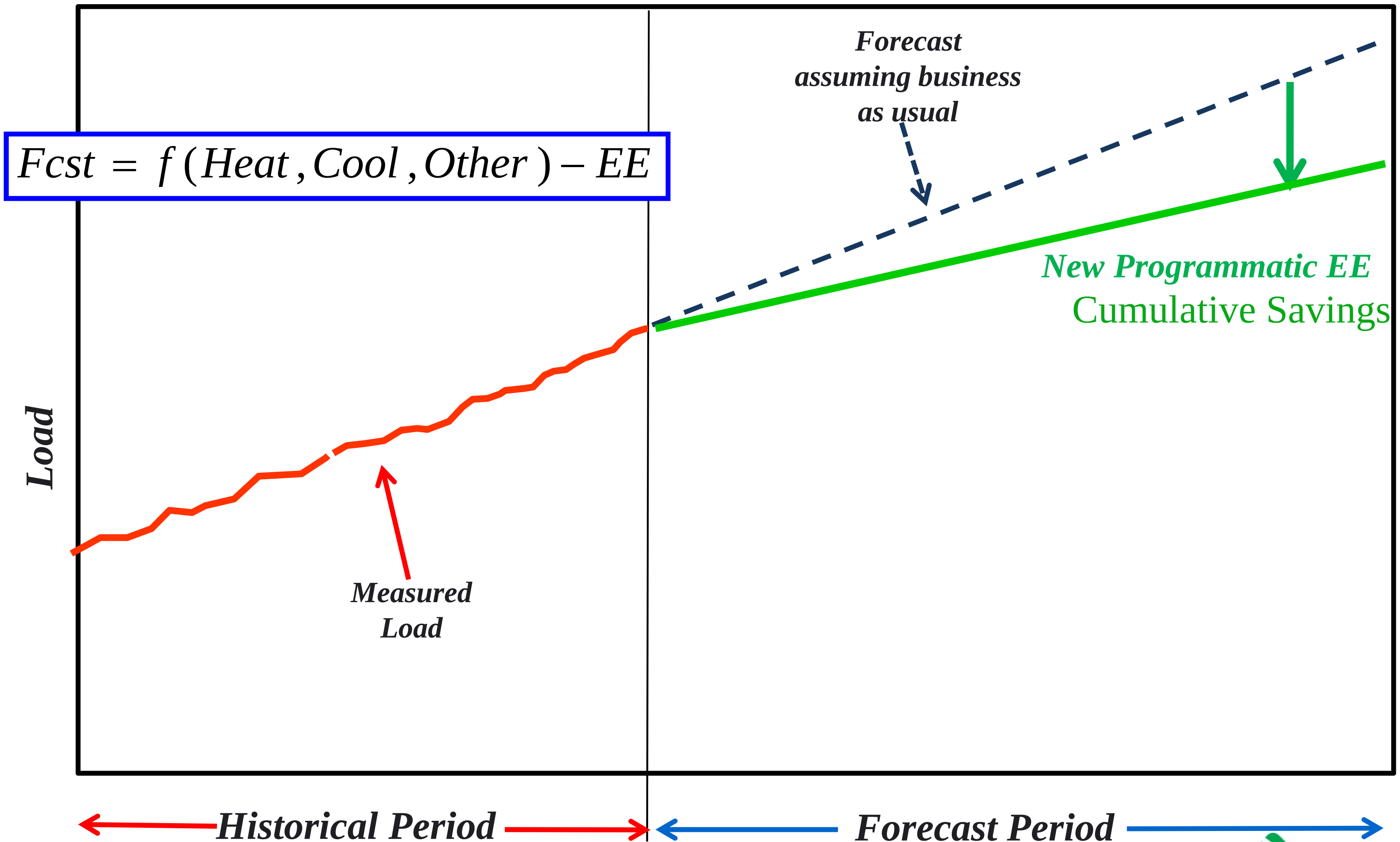
Current Method

- 5-year forecast is decremented for Senate Bill 838 incremental savings
- Long-term load forecast assumes all energy efficiency embedded in long-run.
- Forecast is grossed up for incremental energy efficiency and then energy efficiency is viewed as a resource in the IRP.



Source: Itron, 2013 Forecasting Benchmark Survey.

Typical Forecast Process



Source: Itron. Incorporating DSM into the Load Forecast. 2010.

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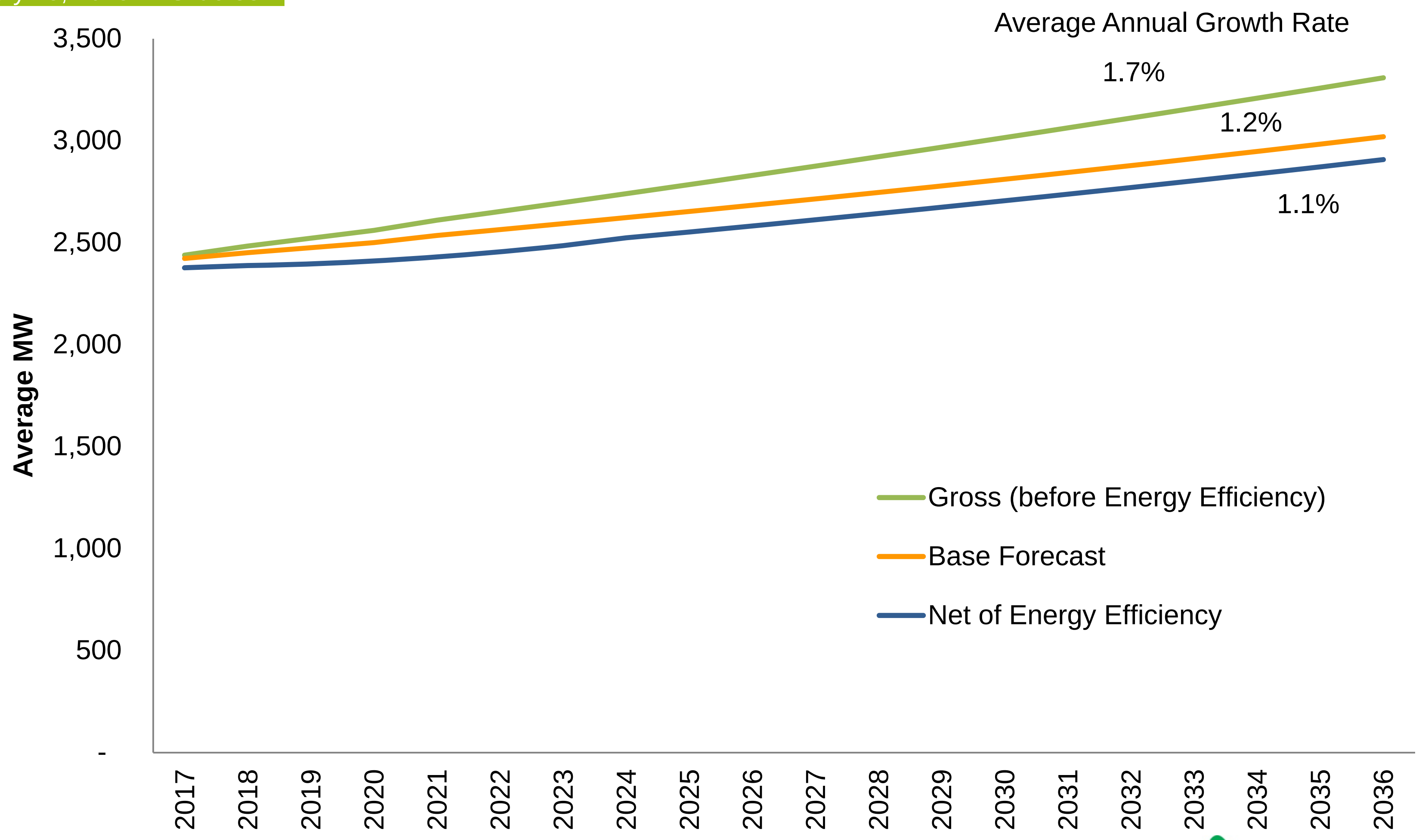
Forecast Before and After Energy Efficiency



Source: PGE June 2015 Load Forecast.

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Question and Answer