Emerging Issues in Forecasting Energy Consumption

PRESENTED TO

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THE Brattle GROUP

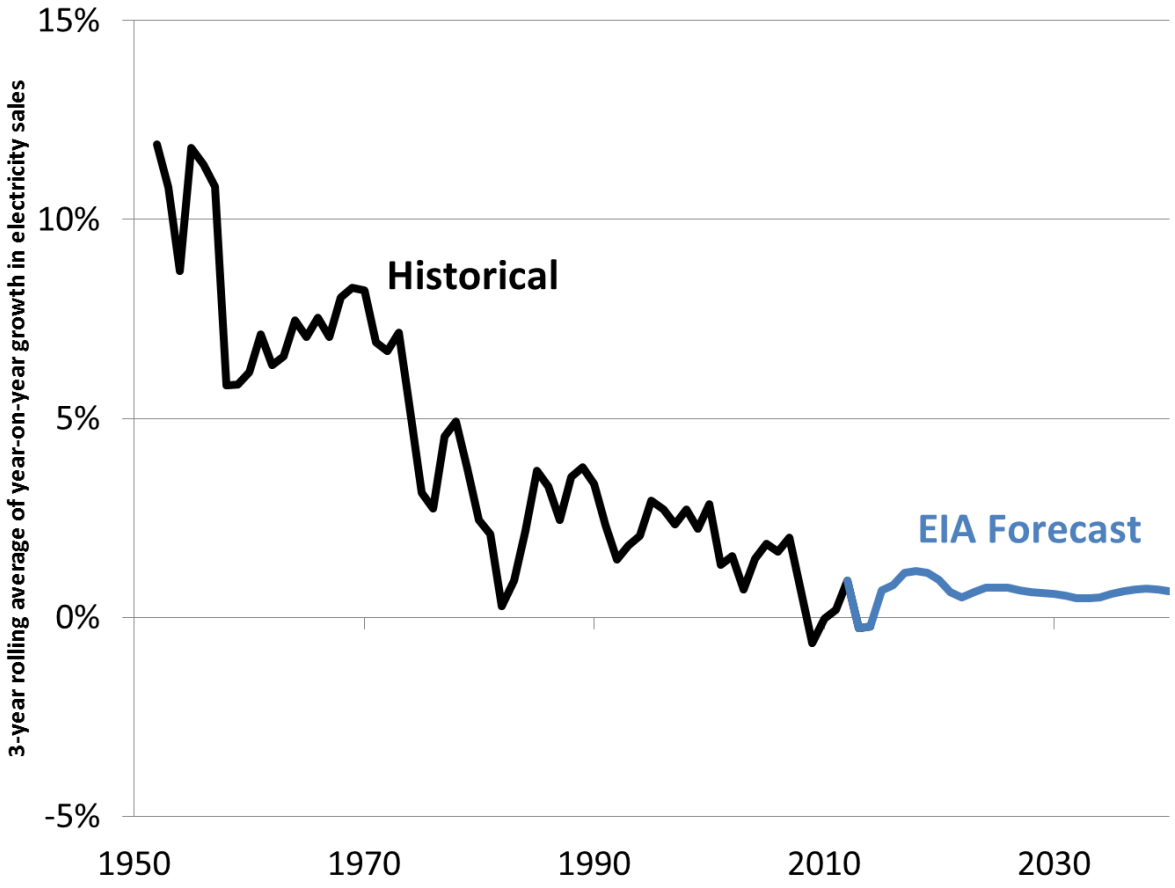
Agenda

Growth in energy sales has slowed down and its driving forces

Emerging issues in forecasting energy sales

Key lessons learned from case studies

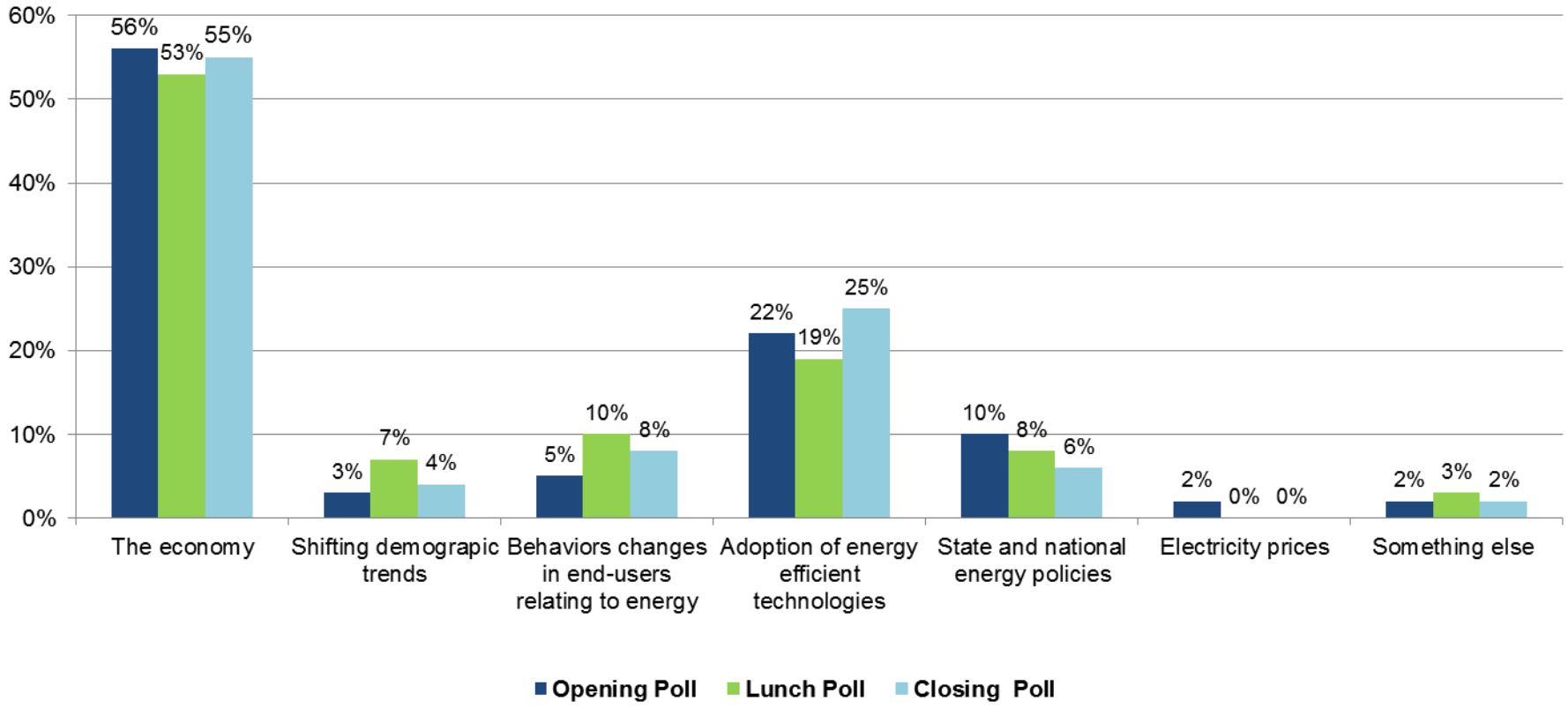
In the United States, growth in energy sales has slowed down since the mid-1950s



- Source: 2015 Annual Energy Outlook, U.S. Energy Information Administration

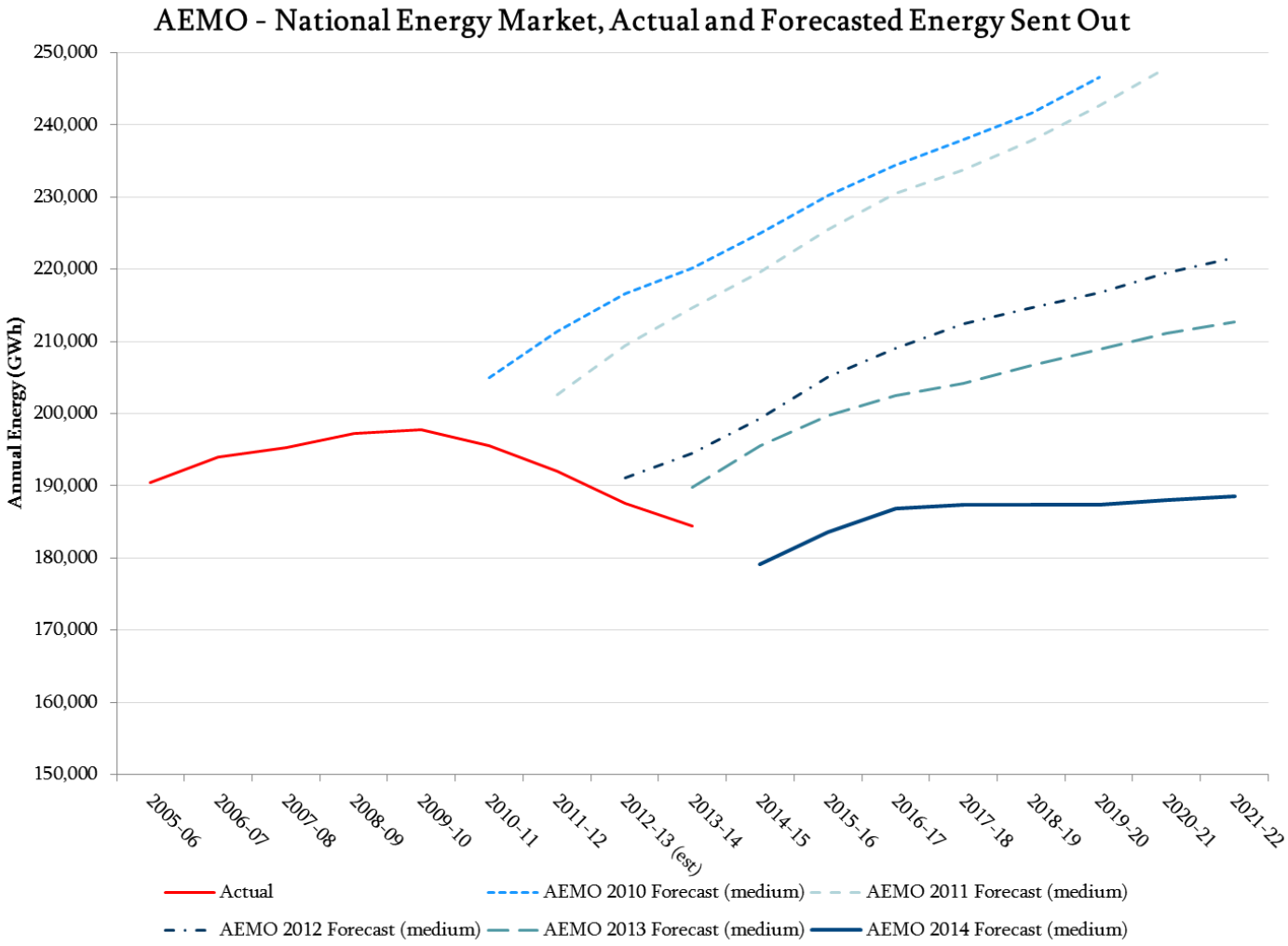
Reasons for the slowdown in US electricity sales

Based on an audience poll from a major energy conference that was held last year by the PJM Interconnection

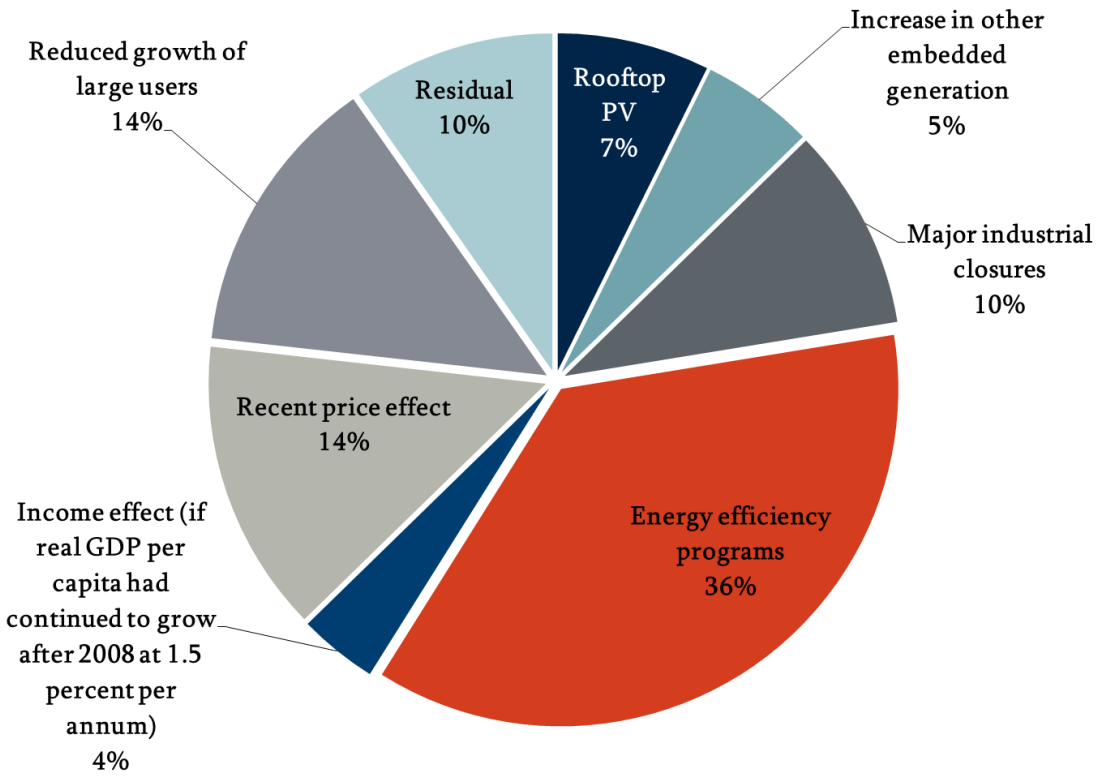


Source: http://www.pjm.com/committees-and-groups/stakeholder-meetings/symposiums-forums/grid-2020-focus-on-energy-demand.aspx

Similar trends in Australia have been observed over the past decade



There are several reasons for the decline in energy sales in National Energy Market



Saddler (13/2015) shows that the largest contributors to the 37 TWh "reduction" in electricity consumption were:

1. Energy efficiency programs (36%)
2. Structural change in the economy away from energy-intensive industries (24%)
3. Consumer response to rising prices (14%)

In light of recent trends, difficult issues arise for forecasters

1. **Impending changes will not be reflected in historical data**

2. **Unobserved structural shifts in electricity consumption may be obscured**

3. **Forecasts, particularly in recent years, can contain a high degree of uncertainty**

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Difficult issues warrant creative approaches

	Collaborate across teams and coordinate resources	Leverage on econometric techniques
Impending changes will not be reflected in historical data	Work with other teams to develop forecasts for pieces with high uncertainty	• Use time-series models for short-term forecasts • Use microdata to estimate program impacts
Unobserved structural shifts in electricity consumption may be obscured	Incorporate insights from discussions with stakeholders or customers survey	• Perform "descriptive" analysis to understand drivers • Analyze residuals for systematic patterns

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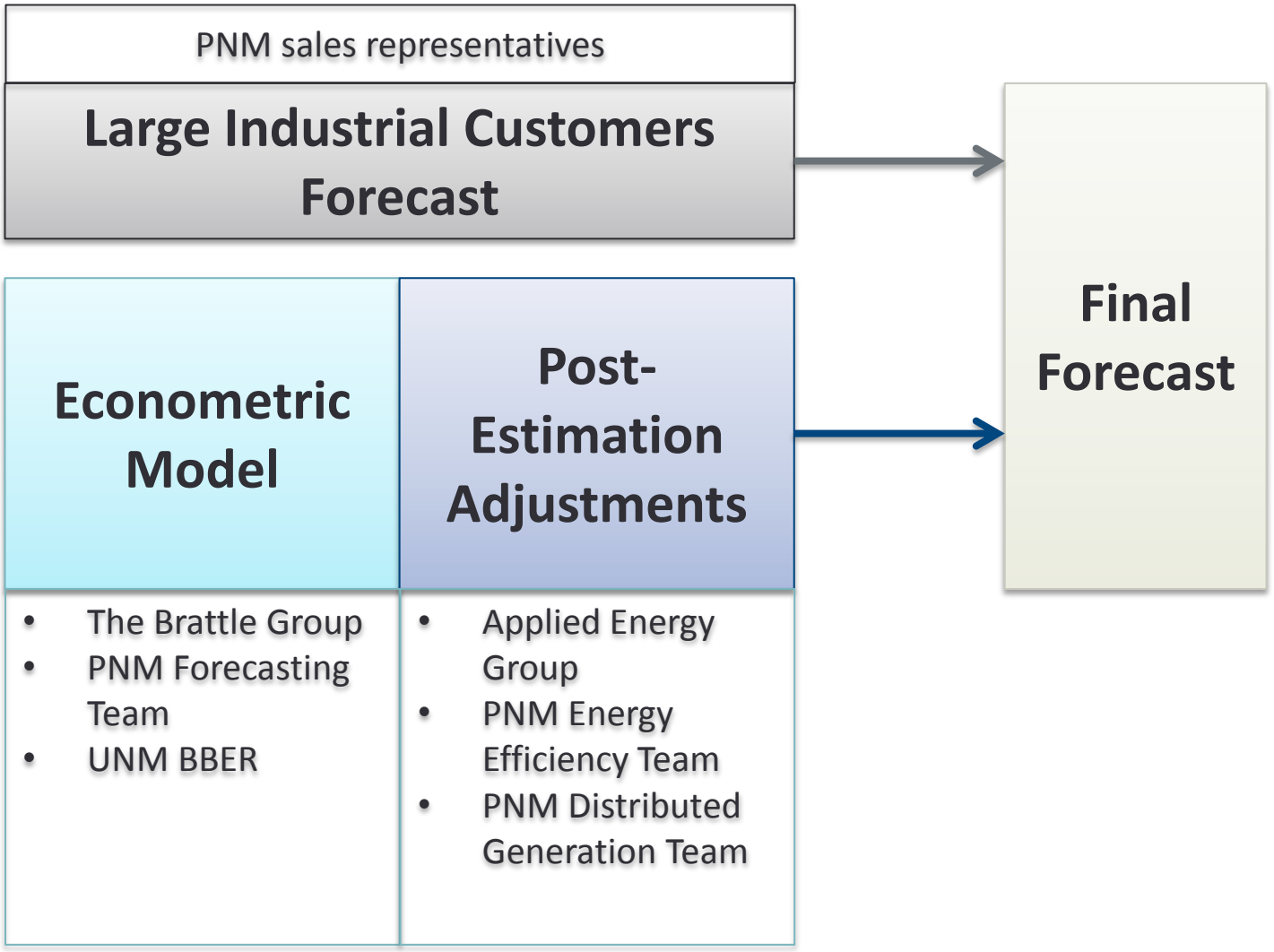
"It takes a village to raise a child"



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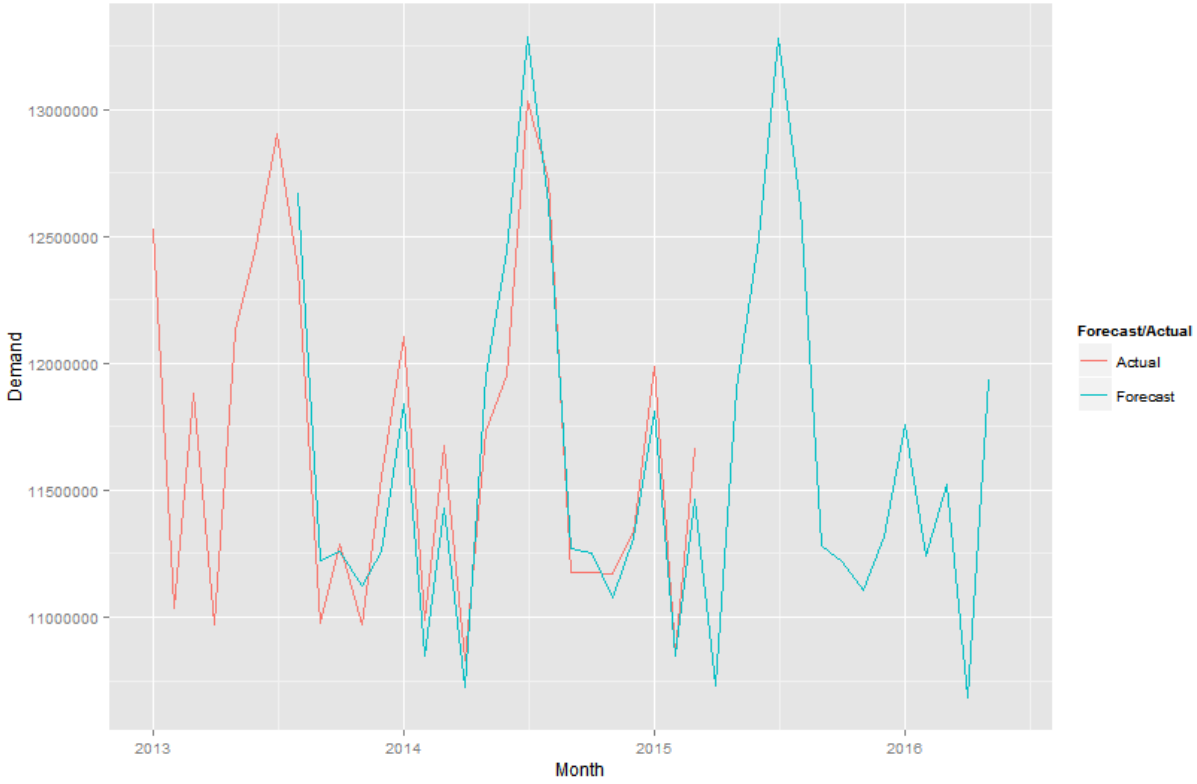
Example of ARIMA forecasting model

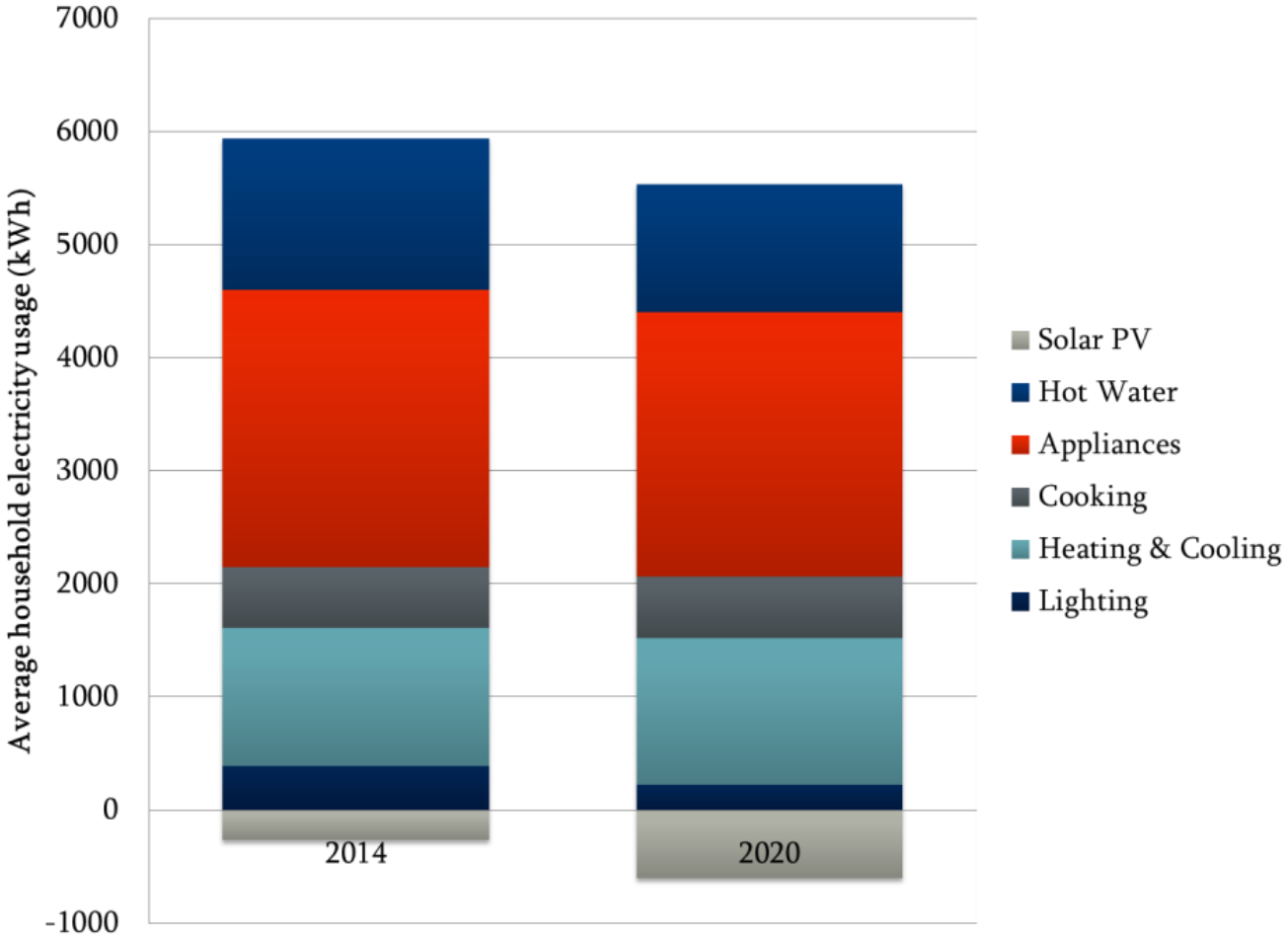
The out-of-sample predictions from a simple ARIMA model and actual monthly energy consumption for New South Wales are shown below

- ARIMA model was estimated using half-hourly data from January 2002-June 2013
- Out-of-sample MAPE = 6.0 percent



Example of applying the end-use model to forecast change in electricity consumption

End-Use Model predicts that fuel-switching and take-up of EE appliances and light bulbs drive decrease in energy consumption



Comparison of strategies to estimate impact of an impending program

	Advantage	Disadvantage
1. Econometric program-evaluation approaches	If done properly, estimate is scientifically sound	Data may not be available
2. End-use modeling	Flexibility to calculate impact of very specific changes	Can be highly data intensive or requires “heroic” assumptions

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A "decomposition analysis" can be a useful tool to identify key driver(s)

Decomposition Analysis of Decline in UPC for Rate Class 2.0 between 2013 and 2017

RATE CLASS 2.0	Annual UPC (kwh per customer)	% Decline relative to Predicted UPC in 2013	Share of overall forecasted decline from 2013 to 2017
Predicted UPC in 2013	18,894		
Forecasted UPC in 2017	17,867	-5.43%	
UPC in 2013 with **2017 Price levels**	18,828	-0.35%	6.4%
UPC in 2013 with **2017 Income* levels**	18,938	0.24%	-4.3%
UPC in 2013 with **2017 CDD levels**	18,896	0.01%	-0.2%
UPC in 2013 with **2017 HDD levels**	18,825	-0.36%	6.7%
UPC in 2013 with **2017 "Time" value**	17,928	-5.11%	94.1%

UPC: usage per customer

Check for systematic patterns in the prediction errors

year	month	% Error with ARIMA	% Error with GLS
2014	1	0.7%	0.8%
2014	2	-0.6%	1.6%
2014	3	5.4%	6.7%
2014	4	3.2%	-0.2%
2014	5	3.0%	1.2%
2014	6	2.3%	4.9%
2014	7	-1.1%	0.4%
2014	8	-0.5%	5.0%
2014	9	-1.1%	5.1%
2014	10	0.6%	2.0%
2014	11	1.7%	3.1%
2014	12	1.1%	1.5%
2015	1	-2.2%	-0.3%
2015	2	2.7%	3.1%
2015	3	-1.0%	1.1%
2015	4	5.4%	6.9%
2015	5	3.7%	1.6%

Example from PNM's Residential Class

- Prediction errors from GLS model were higher in most of the cases
- PNM ended up using an ARIMA model

In light of recent trends, difficult issues arise for forecasters

1. Impending changes will not be reflected in historical data

2. Unobserved structural shifts in electricity consumption may be obscured

3. **Forecasts, particularly in recent years, can contain a high degree of uncertainty.**

To deal with uncertainty in the forecast, we need to quantify the sources

In general, three types can be distinguished (EPRI, 1992):

1. **Parameters**
   - Standard errors for parameters can be used to construct bands of uncertainty around the forecast; these are conditional on explanatory variables being fixed

2. **Projections of explanatory variables**
   - Monte Carlo simulation can be used to arrive at probability distributions that allow for uncertainty in parameter estimates and explanatory variable projections
   - Or scenario analysis can be used to construct low, medium and high cases in a deterministic fashion

Sources of forecast uncertainty (concluded)

3. Model structure

- Multiple models can be estimated to bracket the possibilities and bound the forecast
- The following options should be considered
  - Structural econometric model
  - Time series model, *e.g.*, ARIMA
  - End-use model
  - Statistically-adjusted end use (SAE) model (Train, 1985; Train, 1992)
  - Qualitative consumer panel surveys

Conclusions

Growth in energy sales has slowed down in the U.S. and other regions

Three difficult issues arise for forecasters

- New programs and policies are not reflected in historical data
- Unobserved structural shifts are taking place at the micro level
- Forecasts are increasingly uncertain

Key lessons Learned

- Collaborate across teams and coordinate resources
- Leverage econometric techniques with end-use models and other techniques
- Identify sources of uncertainty and apply feasible strategies

Presenter Information

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Dr. Zhen Wang is an Associate at The Brattle Group where she focuses on litigation, demand forecasting, and marketing modeling. She has worked closely with utility companies to critically review and develop demand forecasting models. Dr. Wang also works with law firms, government agencies and corporate firms on a variety of legal, regulatory and policy issues. She has performed damages analyses in several high-stake environmental lawsuits and conducted econometric analyses in antitrust/competition related matters. She has also worked on liability determination and damage calculations for commercial arbitrations.

Dr. Wang holds a Ph.D. in Economics from North Carolina State University and a B.S. in Finance from Shanghai Jiao Tong University (Shanghai, China).

Additional Resources

Testimony of Ahmad Faruqui in the matter of the application of PNM for revision of its retail electric rates.
http://www.pnmresources.com/~/media/Files/P/PNM-Resources/rates-and-filings/11-dec-2014/33-direct-testimony-and-exhibits-of-ahmad-faruqui.pdf

Faruqui, Ahmad and Eric Shultz. 2012. “Demand Growth and the New Normal,” Public Utilities Fortnightly, December 2012: 22-28.

Faruqui, Ahmad. 2013. "Surviving Sub-One-Percent Growth," Electricity Policy, June 2013: 2-11.

Faruqui, Ahmad.and K. Seiden. 1992 "Practical Applications of Forecasting under Uncertainty," Final report. EPRI, 1992.

Saddler, Hugh. 2014 "Why is Electricity Consumption Decreasing in Australia?." Australian Options 75 (2014): 13.

Saddler, Hugh. 2015 "Power Down II, the Continuing Decline in Australia's Electricity Demand?."

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