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U.S. DEPARTMENT OF ENERGY

Load Forecasting in Electric Utility Integrated Resource Planning

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Electricity Markets and Policy Group

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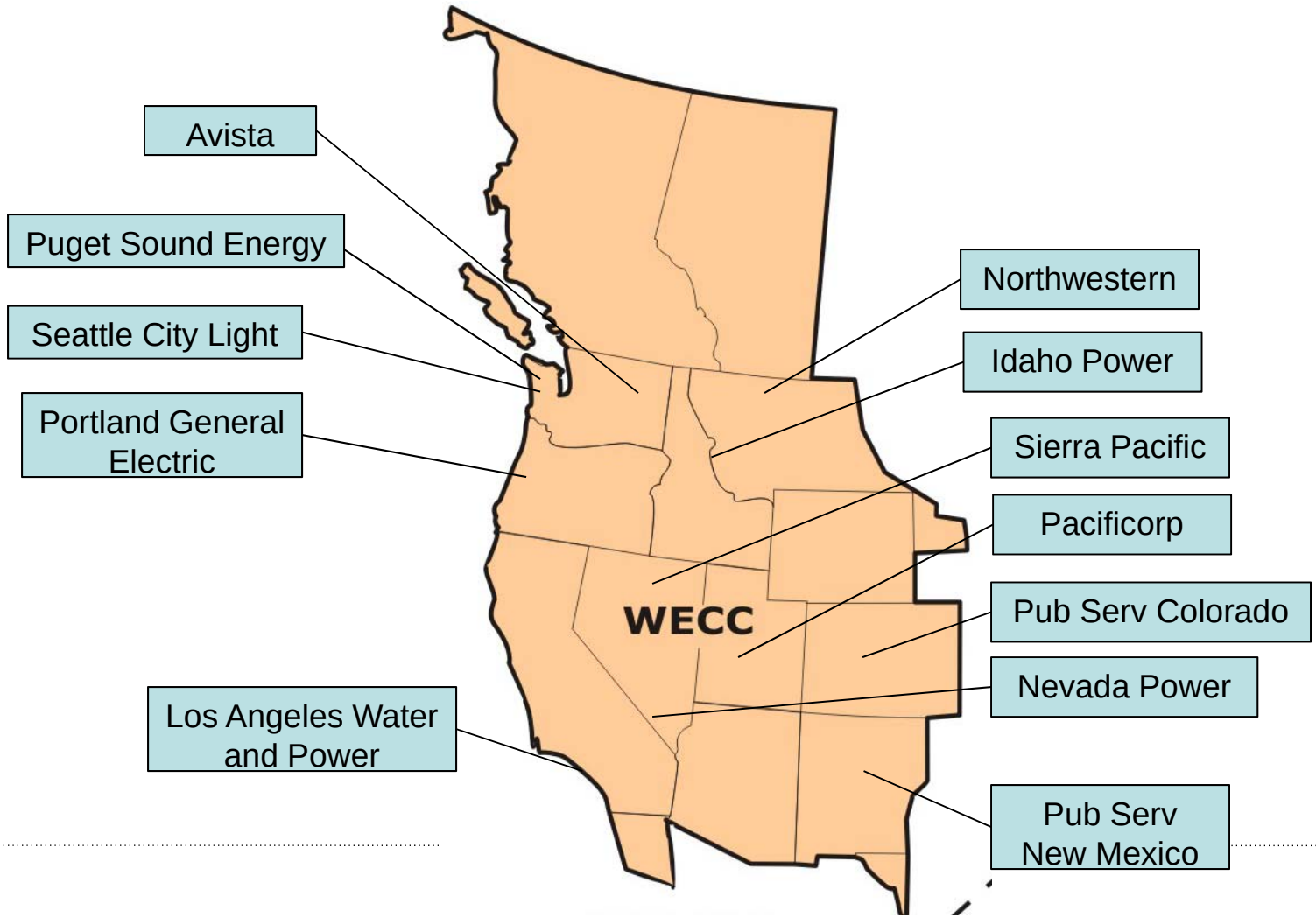
Background

- **Integrated resource planning** (IRP) used by ~30 U.S. states.
  - Regulatory tool to determine **least-cost/risk** supply and demand-side resources that meet **future obligations** to customers.
  - IRPs are developed periodically and include a **host of information** about assumptions, methods, and strategies to deal with uncertainty.
- There is little to no empirical research on the **outcome of the planning process**.

Research design

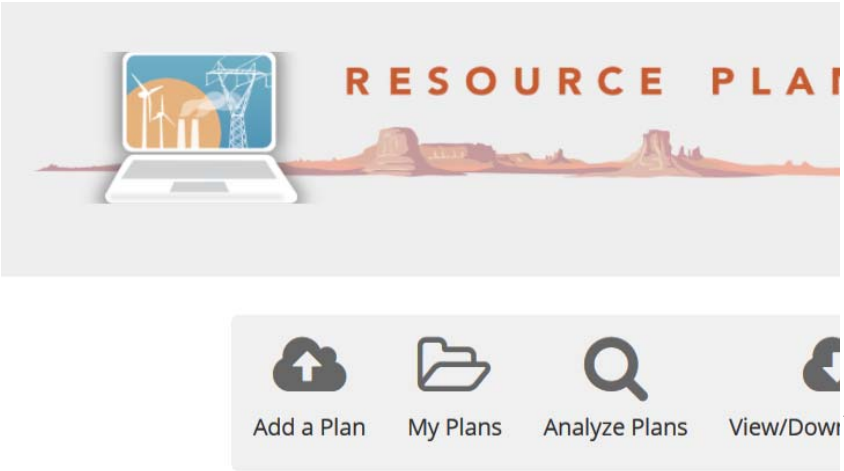
- We split our research on ***inputs* and *outcomes.***
- Long term **load forecasts** are a cornerstone of IRP.
- This presentation:
  - How did load forecasts **perform** for plans developed in the early 2000s?
  - How did forecasts and their techniques **evolved**?
  - What **load forecast sensitivities** were used and how?
  - How does load **correlate** to resource expansion?
- Our follow-up paper:
  - How does **planning compare to procurement** and what explains the differences?

Sample of LSEs and IRPs



Methods and data

- We study older (2003-2007) and recent (2012-2015) plans for a given utility.
- Data:
  - Load forecast assumptions; resource expansion collected from IRP in the Resource Planning Portal (http:\\resourceplanning.lbl.gov)



- Actual energy and peak demand load; actual incremental procurement from Ventyx.

Load forecast methodologies

Variable	Avista	COPSC	Idaho	LADWP	NVPower	NW	PacifiCorp	PGE	PNM	PugetSound	Seattle	SierraPacific
Historical sales												
Cooling degree days												
Heating degree days												
Population growth												
Electricity price/tariffs												
Employment												
Household size												
Number of customers												
Energy intensity trends												
Appliance saturation												
Time dummies (day,month,season,year)												
Housing stock												
Household income												
Gross product (national/regional)												
Air conditioning usage												
Model complexity												

Coding

- Low complexity
- Medium complexity
- High complexity
- Residential
- Commercial/Industrial
- All

Changes in load forecast methodologies

LSE	Older IRP Year	Recent IRP Year	Analysis Framework	Variables/Analytical Techniques	Key Data Sources	*Overall Change*
NV Power	2006	2012				
Sierra Pacific	2004	2013				
Avista	2005	2013				
LADWP	2006	2012				
PNM	2007	2011				
Seattle	2006	2012				
Puget Sound	2005	2013				
PGE	2007	2013				
NW	2004	2013				
Idaho	2006	2013				
Pacificorp	2004	2015				
COPSC	2004	2011				

Legend:

Little or no change

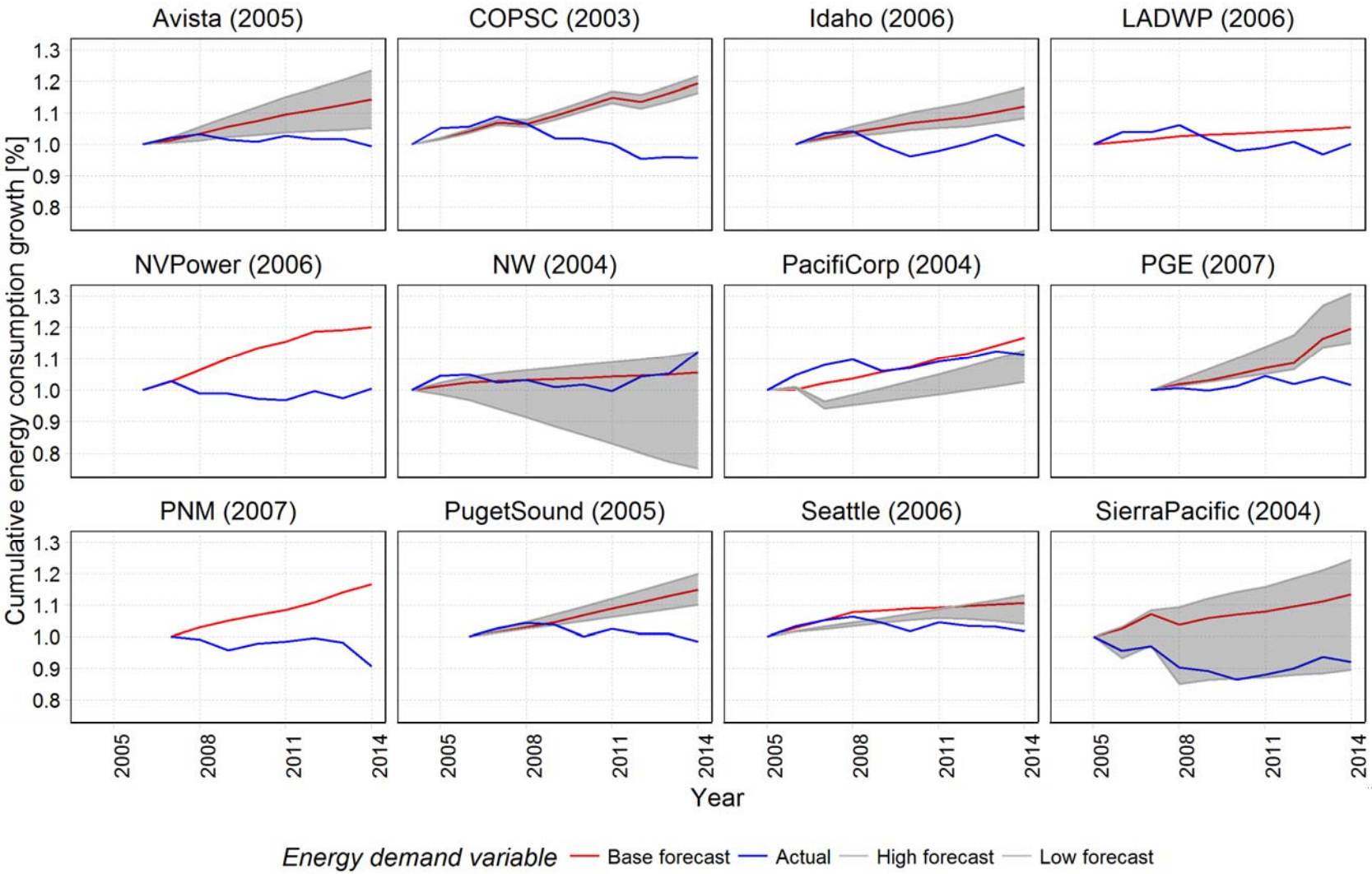
Some change

Significant change

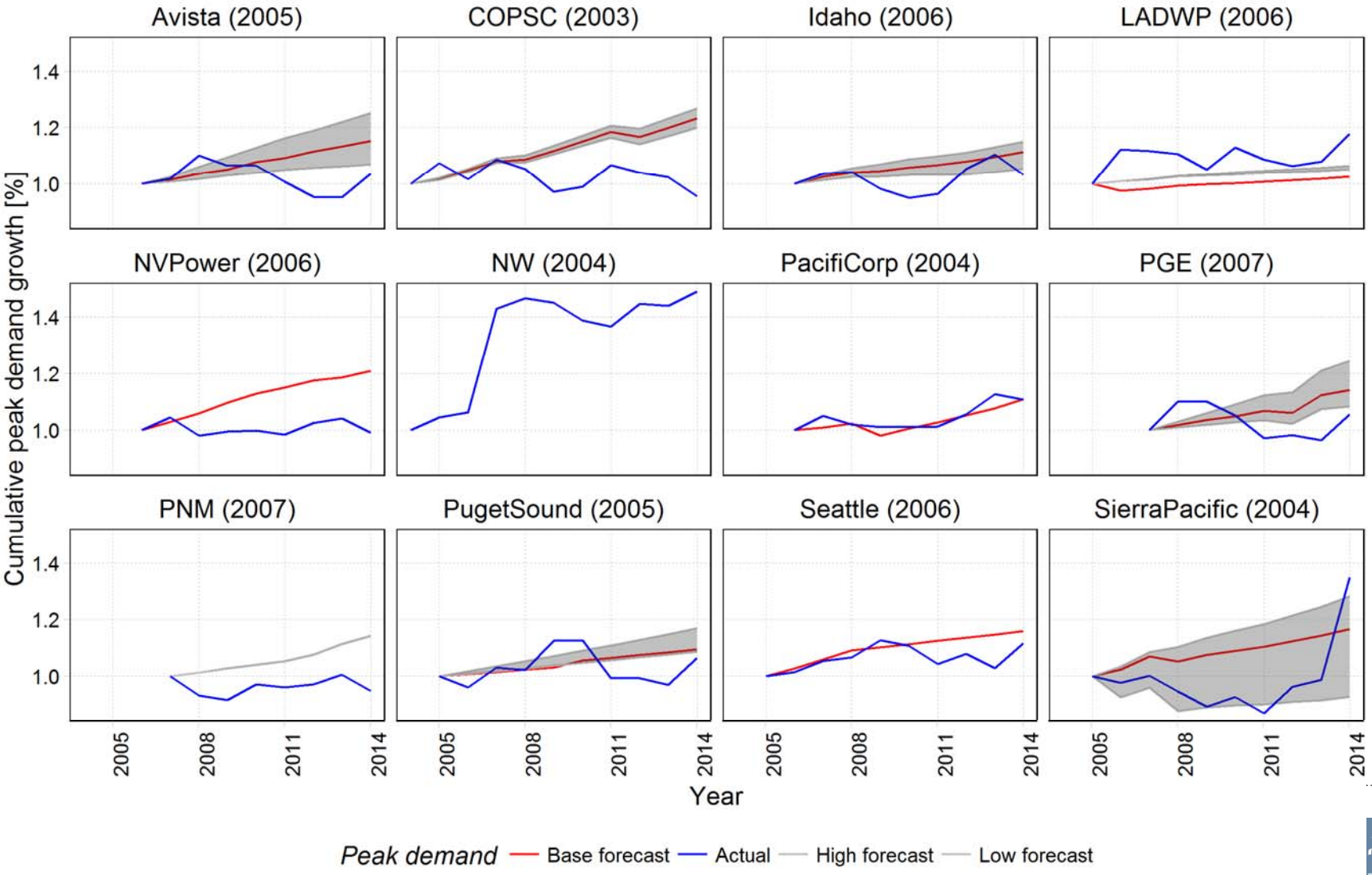
Cumulative energy consumption error

LSE	Sum of errors (1) [TWh]	Sum of actual load (2) [TWh]	Proportional Error (1)/(2)
PGE	29.12	151.31	19%
Avista	14.73	85.36	17%
NVPower	26	199.01	13%
SierraPacific	10.57	89.37	12%
Idaho	13.47	138.43	10%
PNM	5.64	85.17	7%
COPSC	21.41	365.05	6%
LADWP	13.04	236.45	6%
PacifiCorp	33.43	580.63	6%
Seattle	5.15	100.48	5%
PugetSound	2.09	206.15	1%
NW	-1.29	68.5	-2%

Energy consumption forecast error and sensitivities



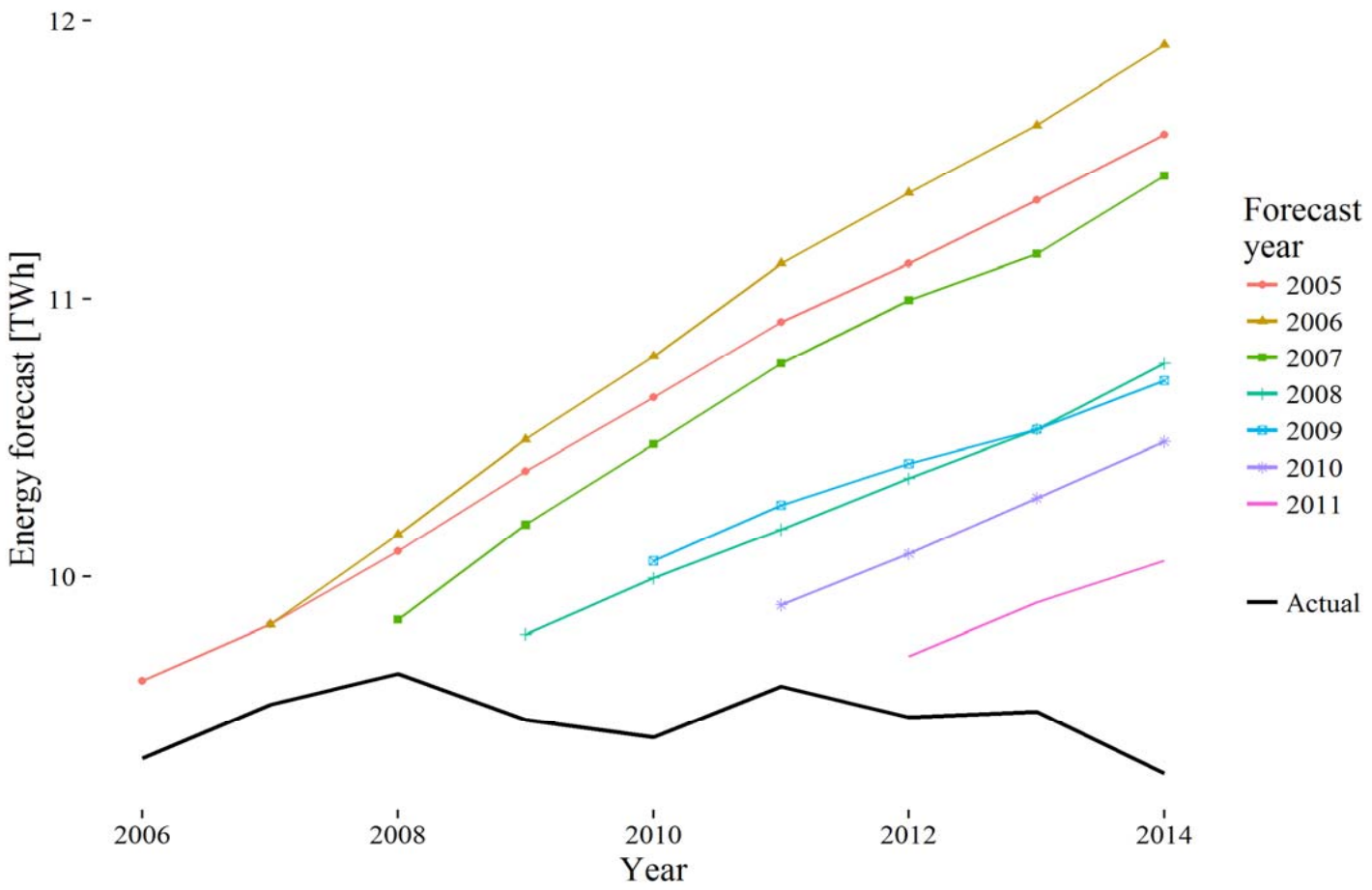
Peak demand error and sensitivities



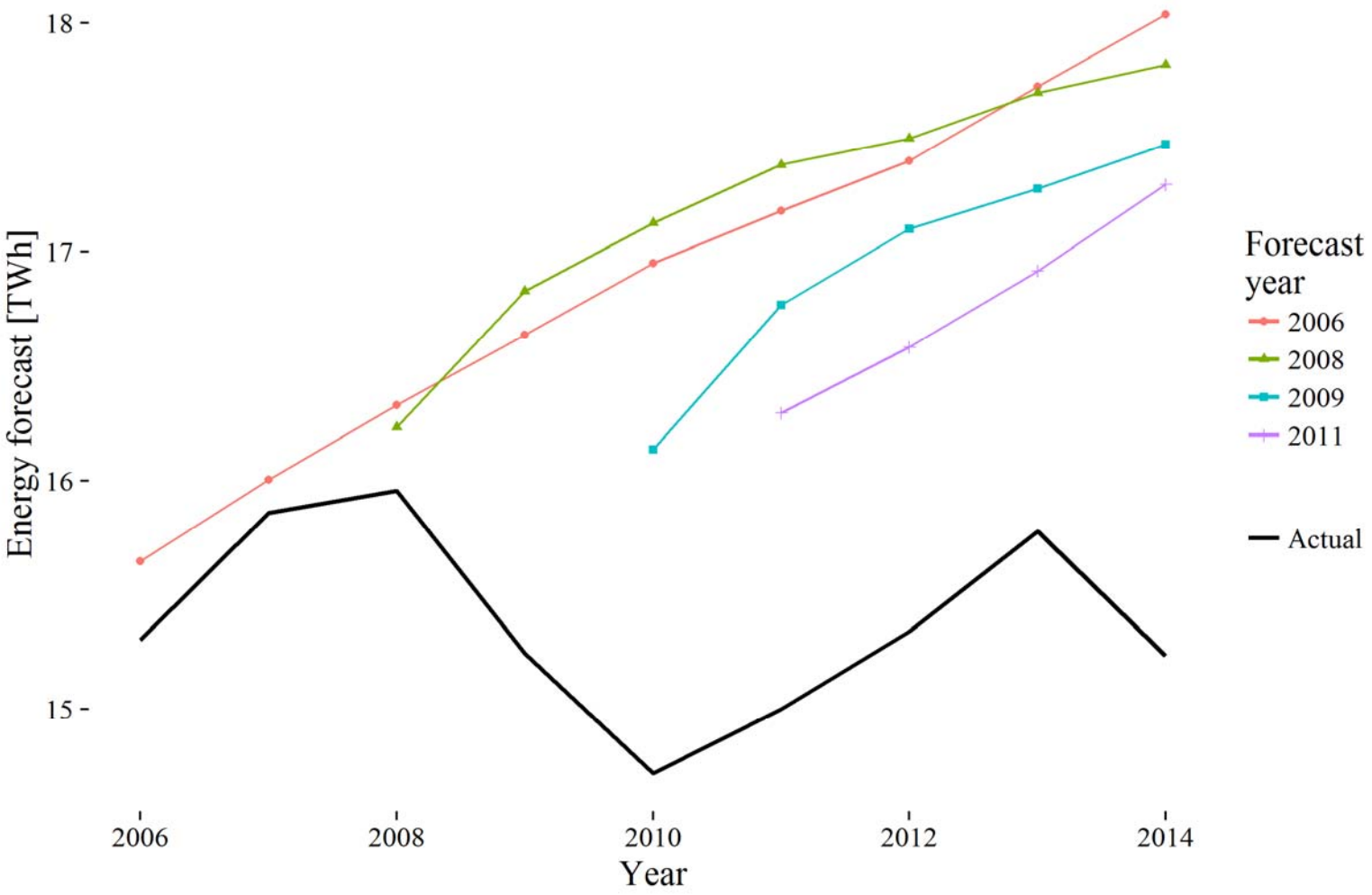
Load forecast sensitivities

- Designed to (i) **test a preferred portfolio** or (ii) offer **alternative** plans.
- Most LSEs migrated from earlier **scenario-based** to more recent **stochastic** analysis.
- The effect of **load changes** in revenue requirement is much larger than the differences between portfolios.
- General absence of **methods/strategies to respond** to alternative load growth.
  - Two strategies for adaptation: resource flexibility and market transactions.

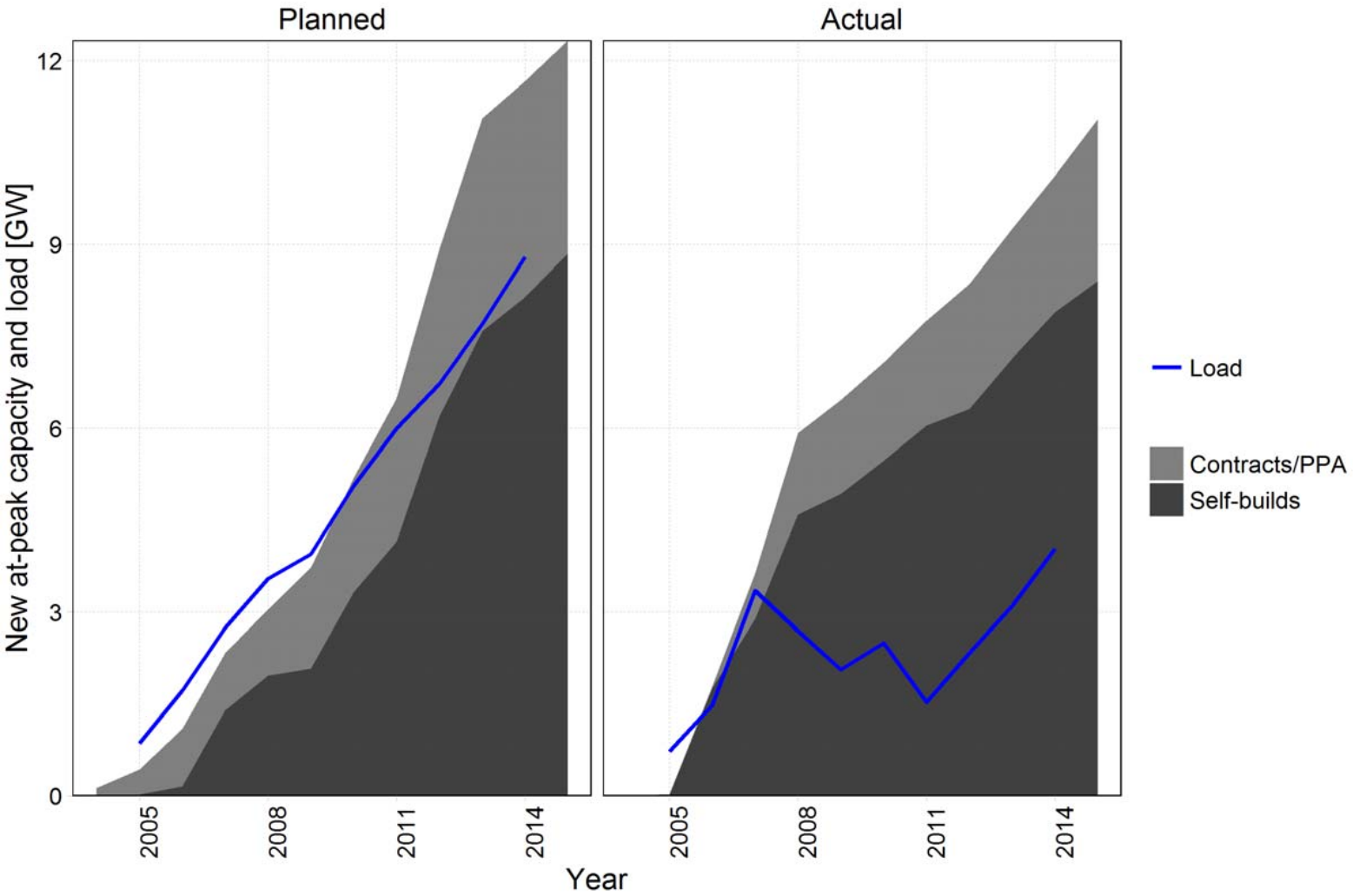
Subsequent IRP forecast evolution - Avista



Subsequent IRP forecast evolution - Idaho



Load-Resource relationship



Conclusions

- **Sustained over-estimation** of load in older and subsequent IRPs.
- There may **be small marginal benefits to model complexity** in terms of improved performance.
- Lack of **actionable strategy component** to respond to alternative load growth scenarios.
- Aggregate **procurement followed planning**, but actual **load was significantly smaller than forecast**.
- Load forecast **techniques present little to no change** in time, making our analysis applicable to current planning efforts.

Contacts/Acknowledgments

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