



Energy Technologies Area

Lawrence Berkeley National Laboratory

***Power system reform under
the economic “New Normal”
and climate change:
lessons from the past***

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Peking University

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Lawrence Introduces Big Team Science LBNL: The First DOE National Laboratory



13 Nobel Prizes



Luis W. Alvarez



Melvin Calvin



Owen Chamberlain



Steven Chu



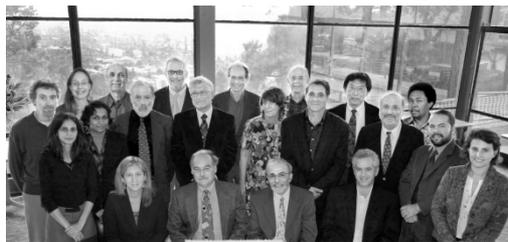
Donald A. Glaser



Ernest Orlando Lawrence



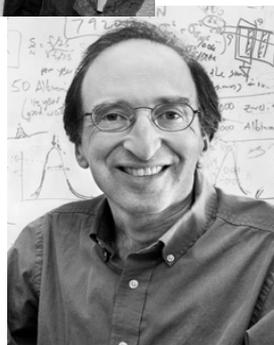
Yuan T. Lee



Intergovernmental Panel on Climate Change (IPCC)



Edwin M. McMillan



Saul Perlmutter



Glenn T. Seaborg

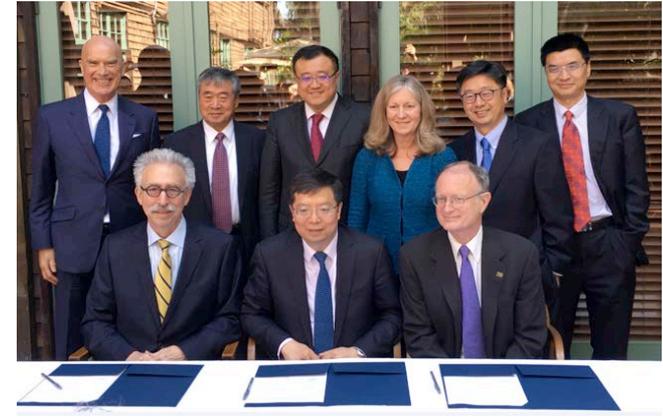


Emilio G. Segrè



George F. Smoot

Berkeley-Tsinghua Joint Research Center on Energy and Climate Change



Mission

*To drive ambitious clean energy and climate change mitigation policy through world-class scientific **research** combined with impactful **leadership training** and targeted **communications** and policy outreach*
(btjrc.lbl.gov)

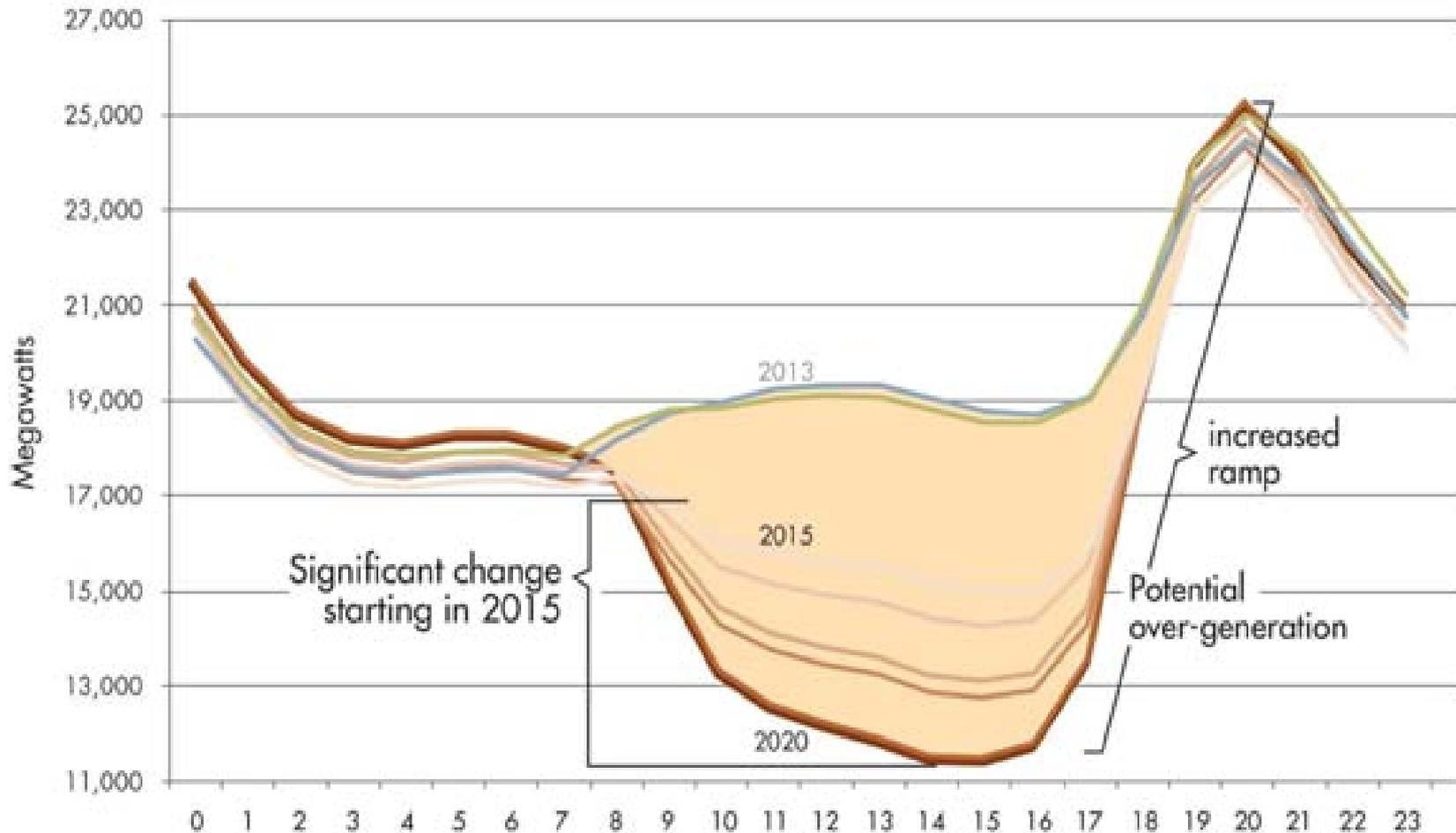
California: *the clean power frontier*

- Most ambitious goal for renewable power
 - 33% of renewables by 2020
 - 50% of renewables by 2030 (excluding hydro)
- Half of solar installation in US
- Leaders in energy efficiency in US
 - Appliance standards
 - Building codes (updated every three years)
 - “Decoupling” and strong utility efficiency programs
- Robust carbon market covering power sector

The Future: can the duck fly?

Duck Curve

Net load



History of deregulation since 1990

- Pre-1990
 - Vertically integrated utilities
 - Cost of services regulation
- 1990 Restructuring/deregulation
 - Unbundling of generations from T&D
 - Direct access/Retail competition
 - Wholesale power markets
- Current thinking
 - *Meeting environmental/climate targets*
 - Deregulation inactive
 - Emergence of ISO/RTO
 - Wholesale power market
 - Retail competition
 - *Future utility model (NY REV)*

History of power sector reform

- Goals
 - Reliable supply of power at least cost
- Pre-1990
 - Vertically integrated utilities
 - Cost of services regulation
- Problems
 - Overly optimistic forecast of future demand growth
 - High cost of generation
- Solutions
 - Lead to some separation of functions, ie, independent demand forecast
 - Lead to deregulation of utilities

Optimistic, or system-bias?

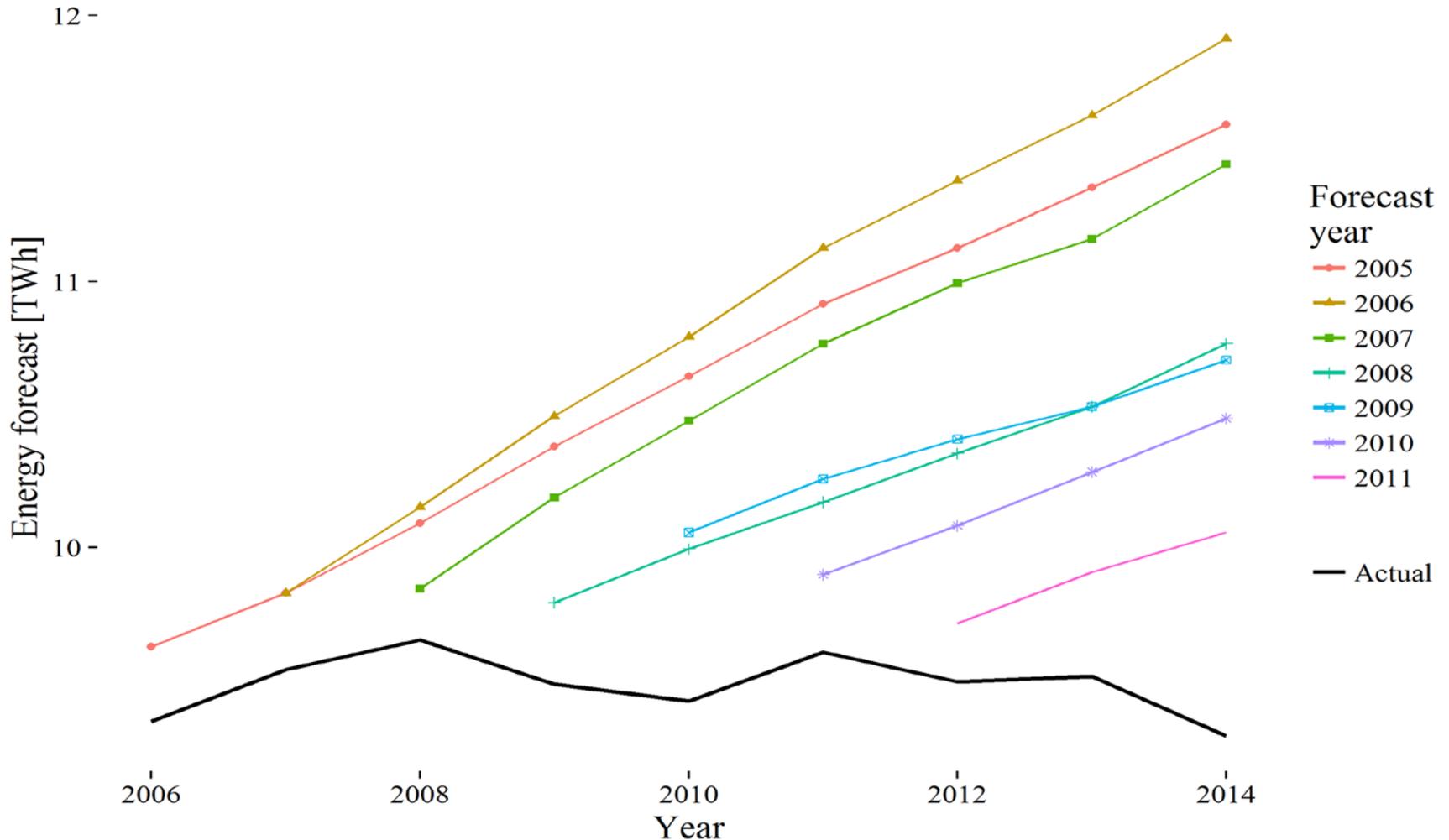
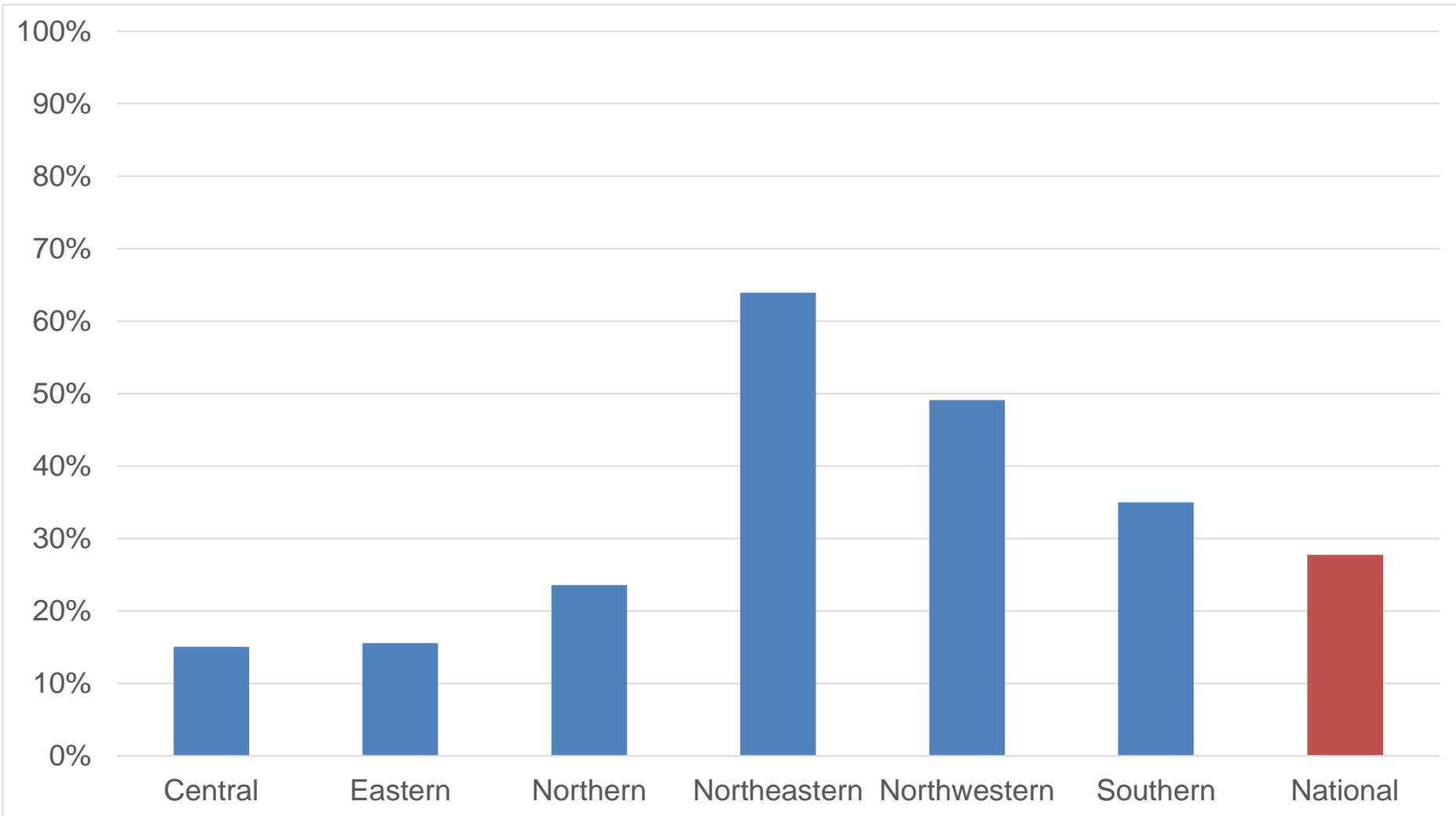


Figure ES-1 Load forecasts from seven subsequent IRPs and actual load for a Western U.S. utility.

Carvallo et al, 2016, LBNL Report

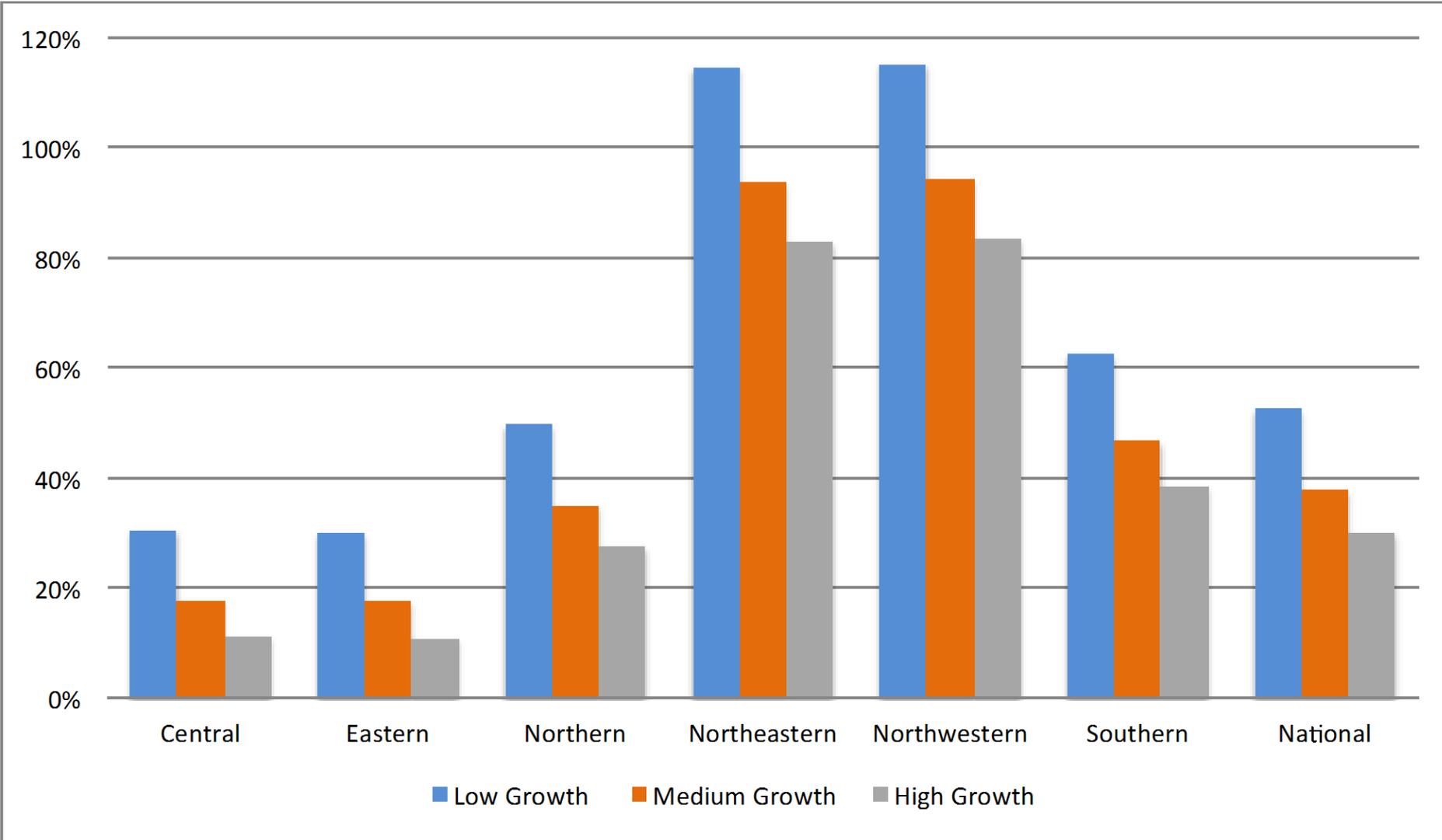
Planning reserve margins in China, 2014



LBNL report: [Excess Capacity in China's Power Systems: A Regional Analysis](#)



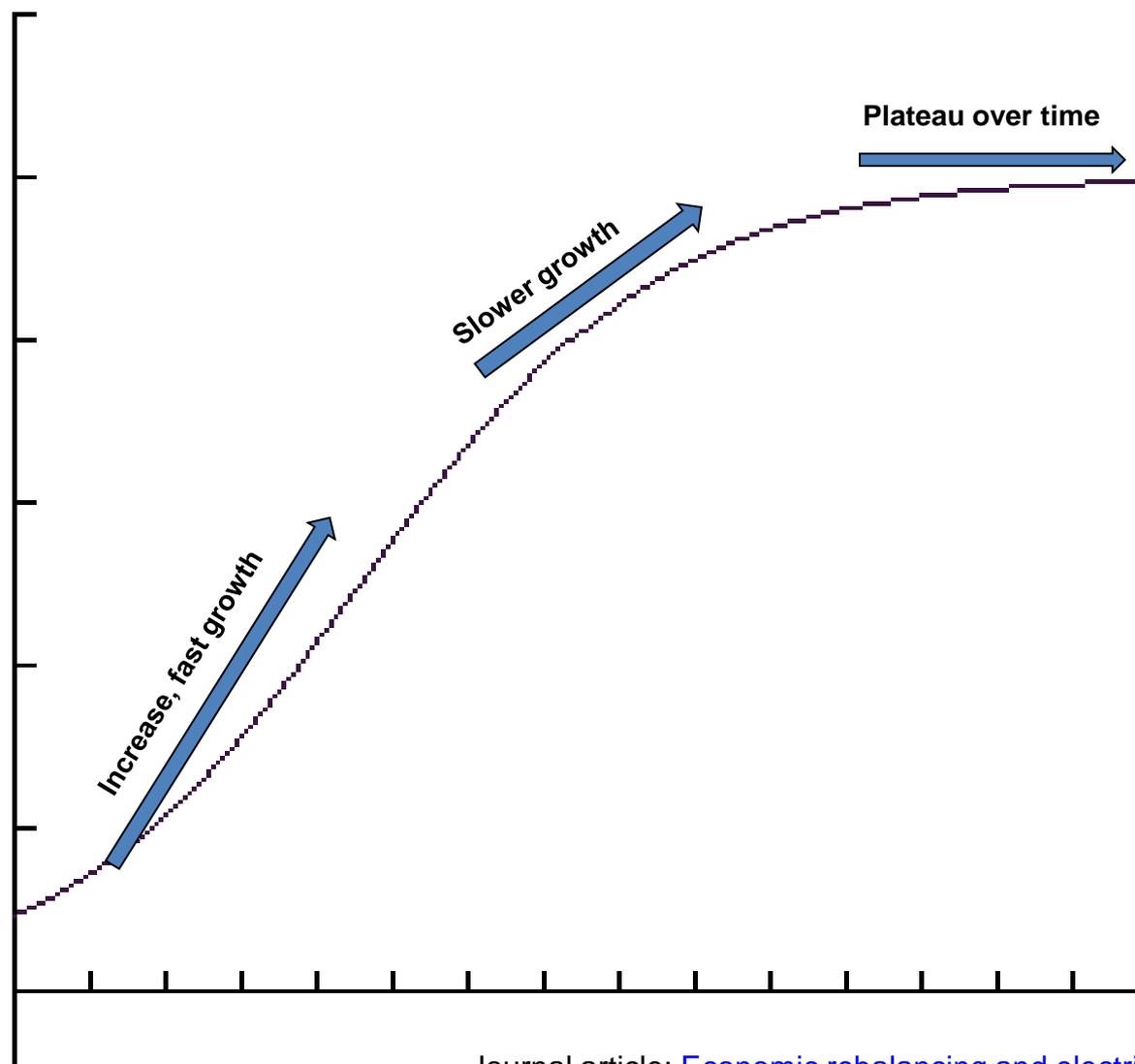
Planning reserve margins in 2020 under the low, mid, high growth scenarios



LBNL report: [Excess Capacity in China's Power Systems: A Regional Analysis](#)

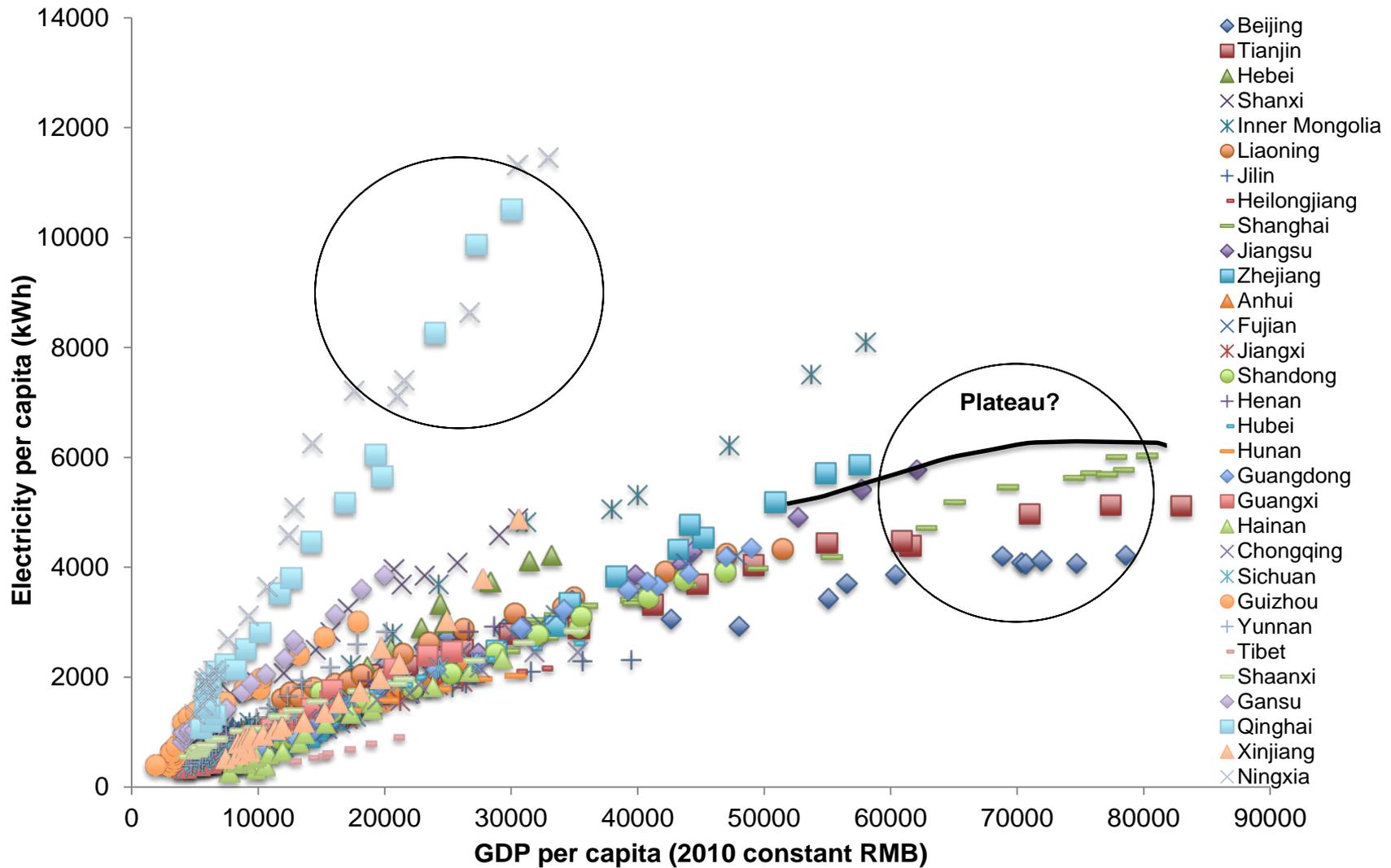
- Re-assessing China's electricity demand under the economic "New Normal"
- Is the slowdown in electricity consumption a temporary phenomenon or a long-term trend:
 - Slower economic growth
 - Significant shift in economic structure from industry to services
 - Reduction of overcapacity in major industries

What is the relationship between economic growth and electricity use?



Journal article: [Economic rebalancing and electricity demand in China](#)

Regional patterns?



Polynomial and logarithm model performs better: statistics

$$(1) \quad E_{cap} = 0.0836 GDP_{cap} - 29.37 Tertiary + 1546$$

$$(2) \quad E_{cap} = 0.133 GDP_{cap} - 7.67E(-7)(GDP_{cap})^2 - 20.77 Tertiary + 733.4$$

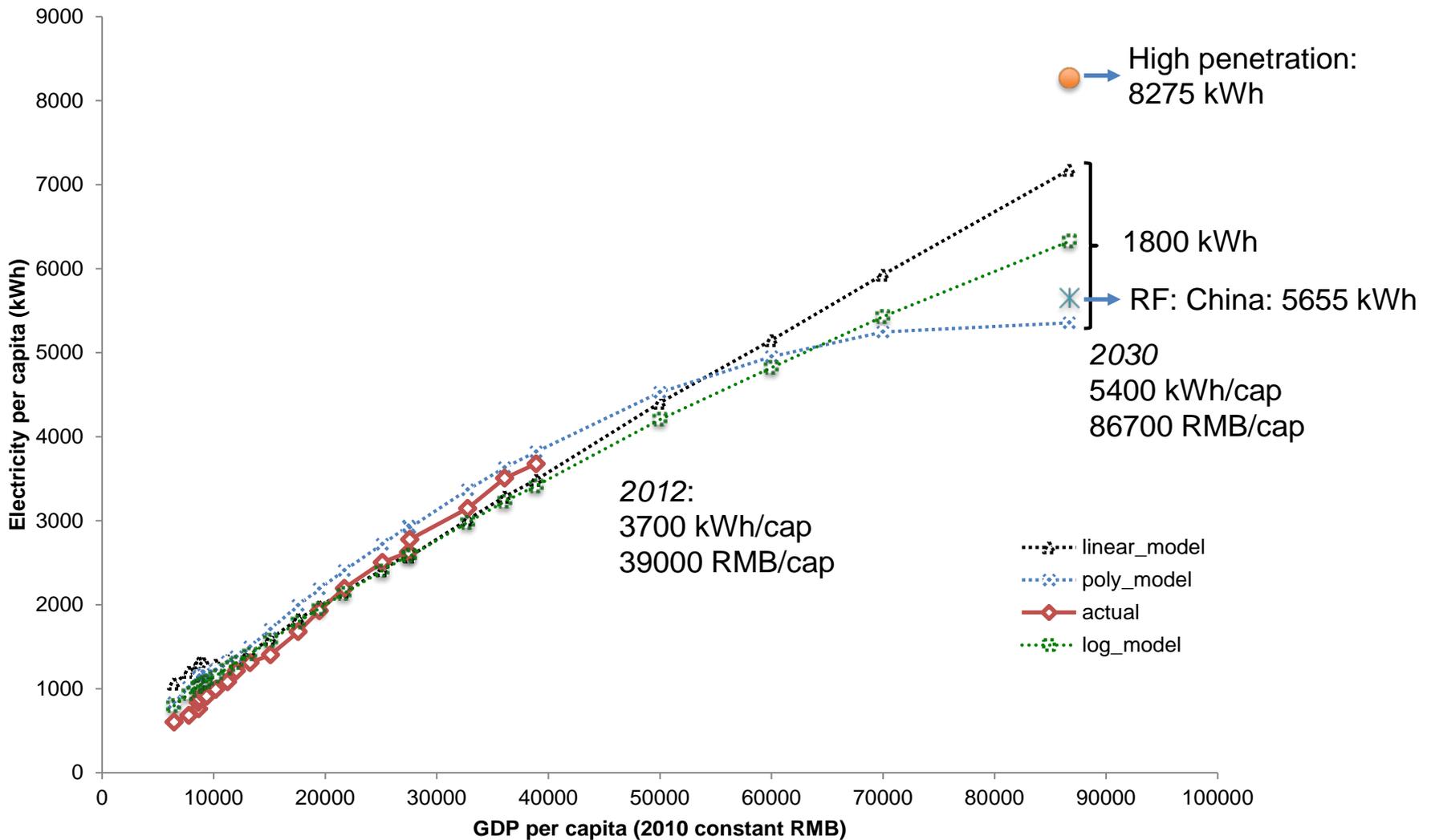
$$(3) \quad \ln E_{cap} = 0.836 \ln GDP_{cap} - 0.00520 Tertiary - 0.467$$

VARIABLES	(1) Linear	(2) Polynomial	(3) Logarithm
	Electricity Consumption per capita	Electricity Consumption per capita	Log electricity Consumption per capita
GDP per capita (Real RMB)	0.0836*** (0.00413)	0.133*** (0.0106)	
GDP per capita square (Real RMB)		-7.67e-07*** (1.32e-07)	
Tertiary GDP share	-29.37*** (8.344)	-20.77*** (7.369)	-0.00520* (0.00291)
Log GDP per capita (Real RMB)			0.836*** (0.0317)
Constant	1,546*** (276.2)	733.4*** (239.1)	-0.467* (0.238)
Observations	540	540	540
R-squared	0.528	0.554	0.662
Adjusted R-squared	0.526	0.551	0.661
RMSE	1133	1102	0.414

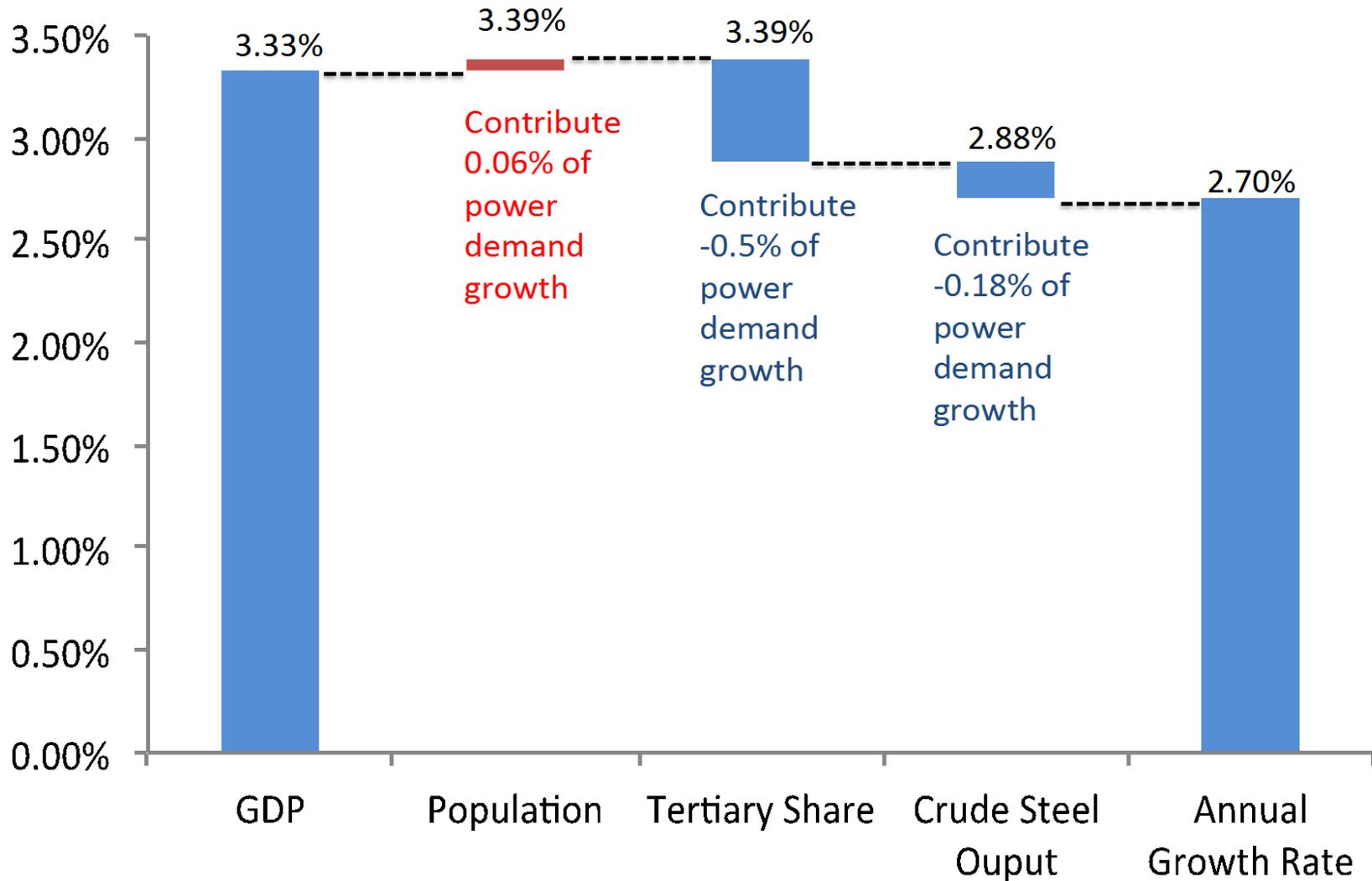
Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Linear model leads to 1/3 higher demand than a polynomial model

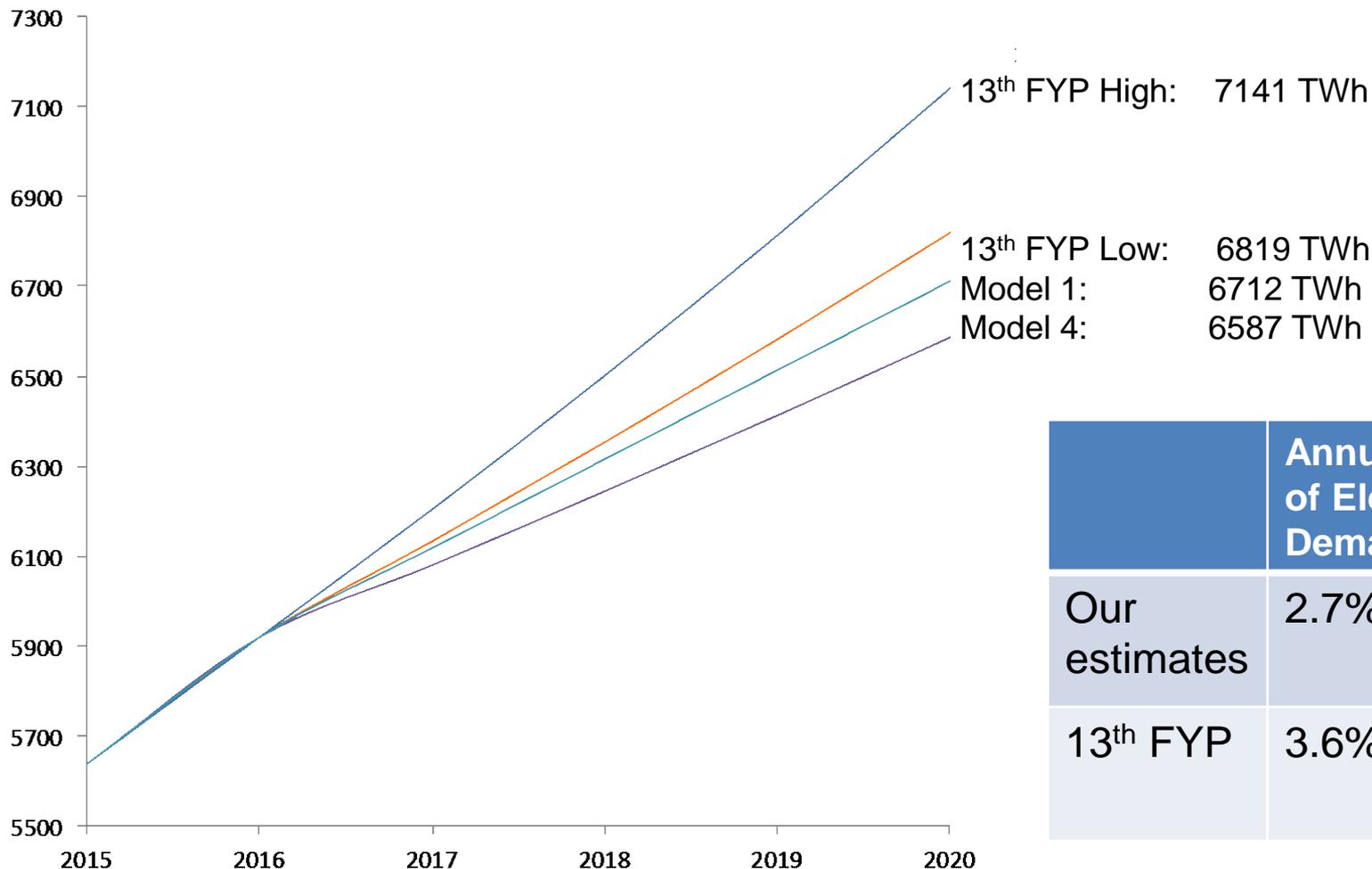


Contribution of GDP, population, structural change, overcapacity, and population to electricity demand



Model projections for electricity consumption are significantly smaller than those of the 13th FYP

Electricity Consumption (TWh)



	Annual Growth Rate of Electricity Demand
Our estimates	2.7%-3.3%
13 th FYP	3.6%-4.8%



History of power sector reform: mid-1990s to 2010

- **Goals**
 - Increasing economic efficiency and reduce costs
- **1990s Restructuring/deregulation**
 - Unbundling of generations/retails from T&D
 - wholesale market
 - Direct access/retail competition
- **Problems: CA crisis in late 1990s**
 - 2000-2001: poor market design and market manipulations led bankruptcy of two large IOUs
- **Solutions:**
 - Some states back to re-regulation
 - Many remain the unchanged

Rate Impact Limited

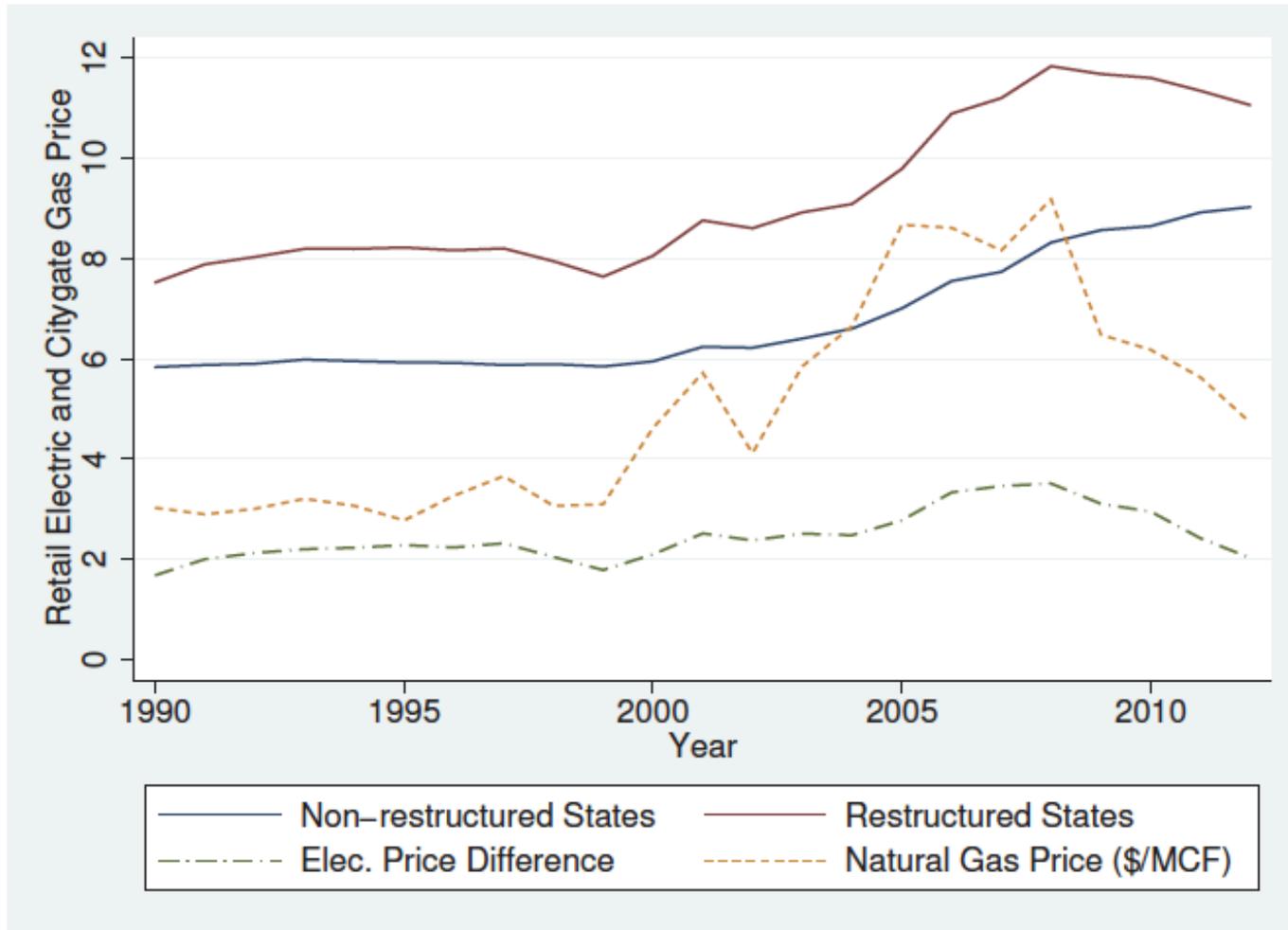


FIGURE 6. U.S. AVERAGE RETAIL RATES AND NATURAL GAS PRICES

Borenstein and Bushnell, 2015

Observation: Utility deregulation in US

- Still heavily regulated industry
- Unbundling of generation and competition improved efficiency at power plants
- Open access to transmission grid is essential
- *Improved coordination of power grids (ISO/RTO)*
- Limited impact on **average** consumer costs
 - Economic vs social costs?
- Other benefits unclear:
 - how to value customer choice?
- Implementation poses significant challenge

- Environmental/Climate Change
 - Meeting GHG targets
 - RPS
 - Clean Power Plan
- Technological
 - Rapid cost reductions and expansion of solar and wind
- Business model
 - Leasing
- Utility model
 - Customer defection
 - Declining revenue base

Lessons learned for China

- Utility industry is likely to remain carefully regulated
 - Wholesale market is complicated and takes time to form, needs to be carefully monitored and regulated
 - Need to balance economic, social, and climate goals
- Competitive generation has led most of the economic efficiency gains.
- Rate impact on average consumers has been limited.
- ISO/RTO have improved grid operation
- Independent demand forecast is foundational to good resource planning
- Meeting climate goals require new thinking

Research questions

- What types of models are best suited for load forecast?
 - At what geographic/demographic resolution?
- What KPIs to evaluate retail competition/choice? Wholesale competition?
- Green/economic dispatch vs Generation planning quota?
- What is the appropriate transition plan to existing Gencos if generation quota is phased out?
- What mechanism to ensure environmental and climate goals?
- What infrastructure is needed to make both production and demand more “responsive”
 - Dynamic pricing?
 - Tools to allow operators and consumers to make smart choices

Thank You!



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