The State of Energy: Economic Impacts, Risk, and Resiliency

Leadership California: Session III
California Issues & Trends
Los Angeles, California
18 July 2016

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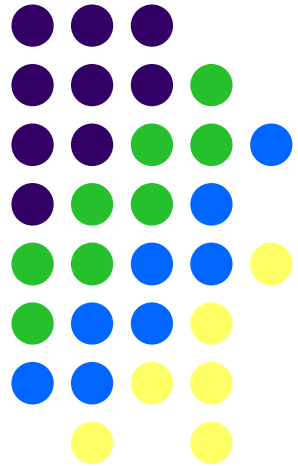

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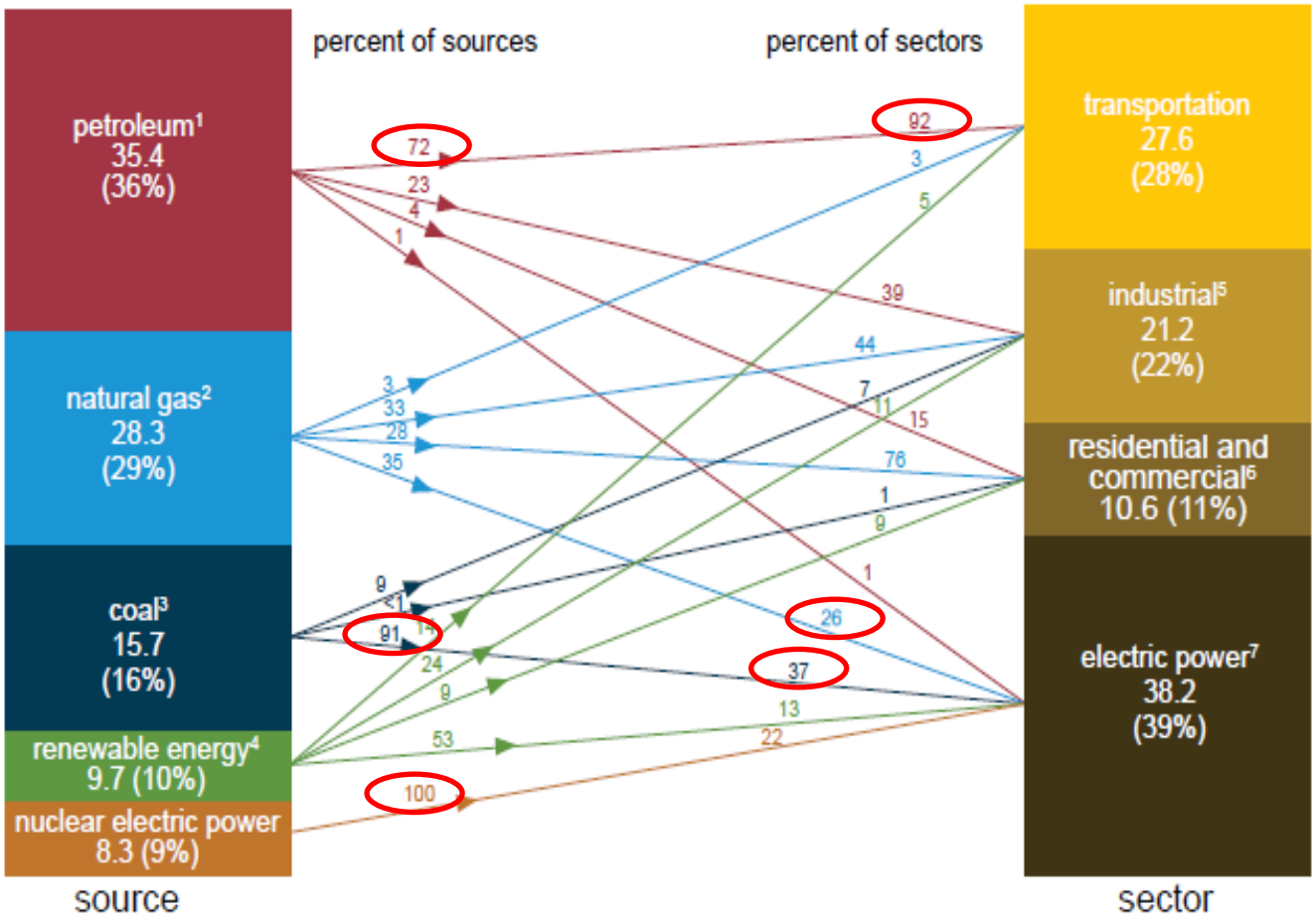
U.S. Energy Complex: Slow-Moving Ship with Much Inertia

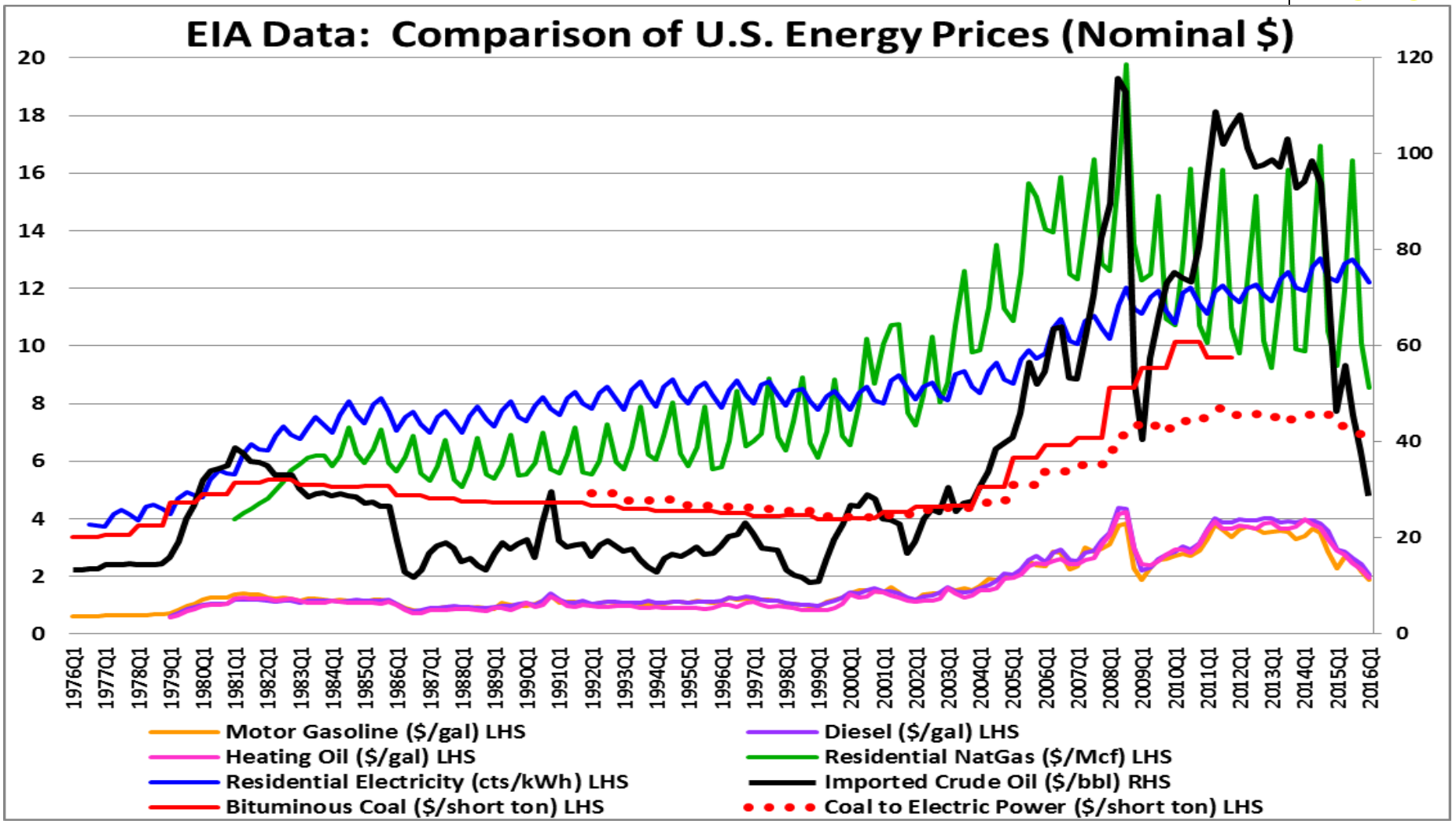
U.S. primary energy consumption by source and sector, 2015

Total = 97.7 quadrillion British thermal units (Btu)

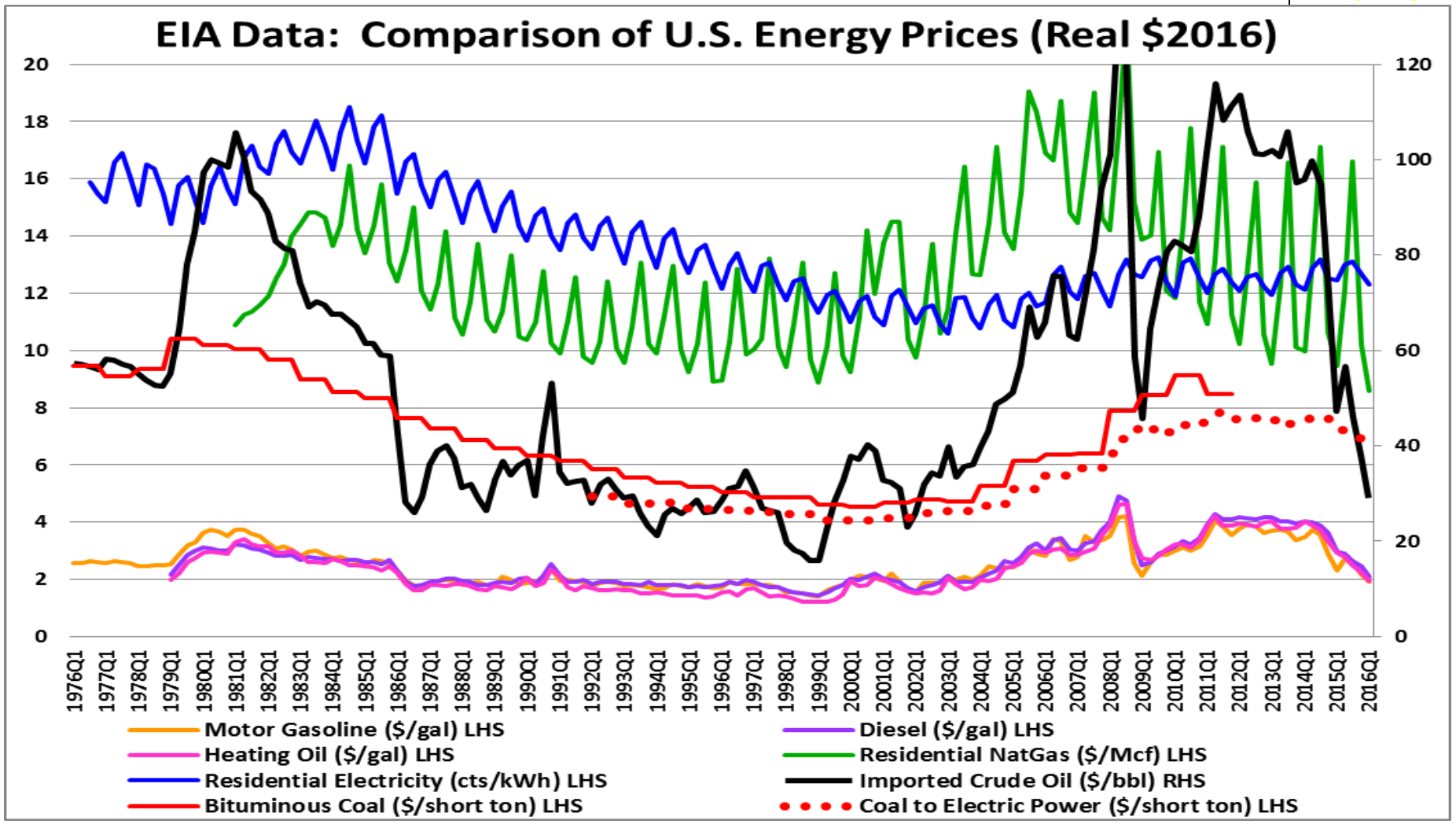


Source: U.S. Energy Information Administration, http://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2015_energy.pdf

Energy Prices Are Dynamic and Can Be Highly Volatile…



And *Never* Conform to Standard "Hockey Stick" Forecasts



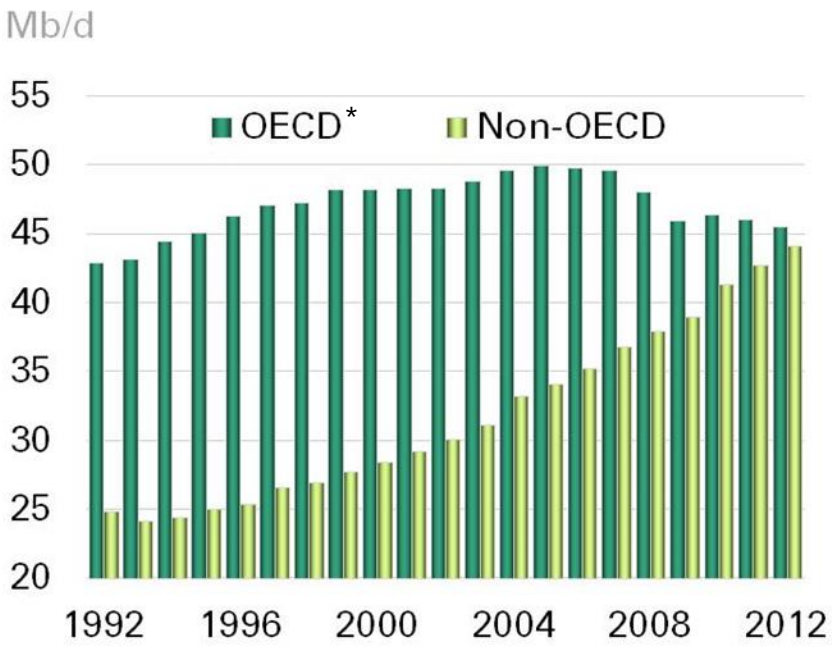
Oil Remains Transportation King Pin…But for How Long??

The competition *is* coming…..

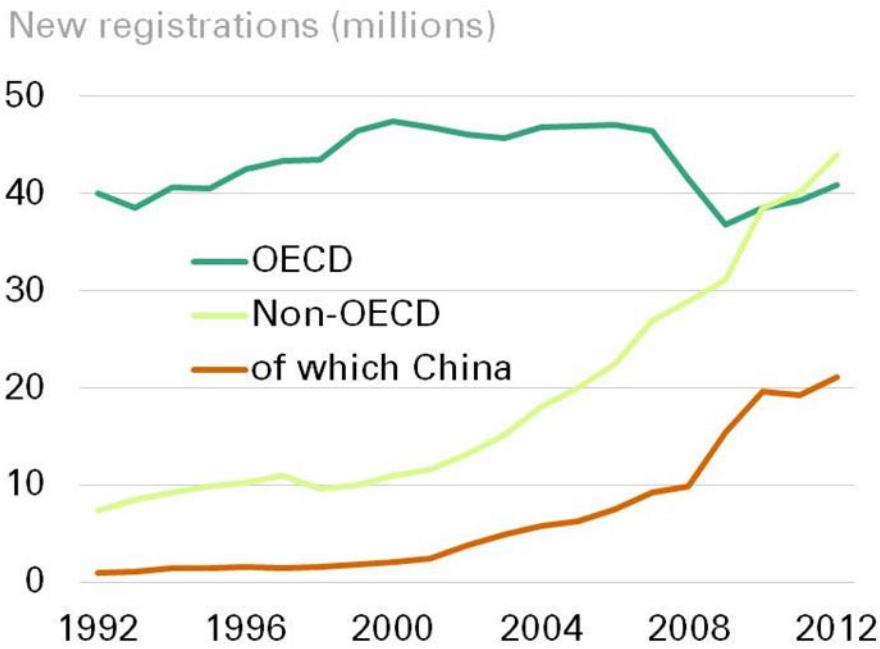
- **Plug-In Electric Vehicles**
- **Hybrid Vehicles**
- **CNG/LNG Vehicles**
- **H_2 Fuel Cell Vehicles**

Oil consumption and mobility

Oil consumption trends



Vehicle sales



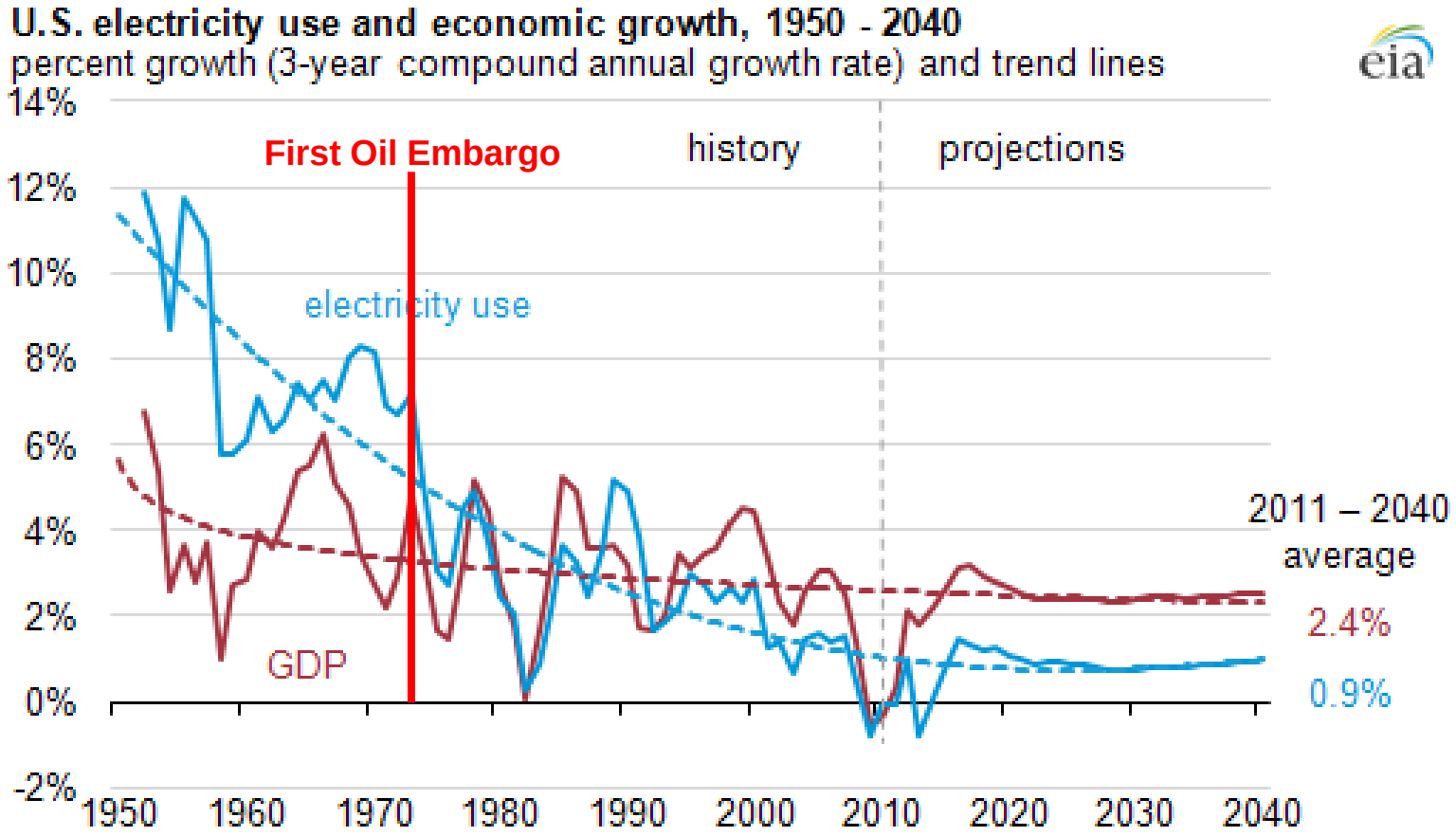
Source: includes data from R. L. Polk & Co.

BP Statistical Review of World Energy

* OECD = Organisation for Economic Co-operation and Development

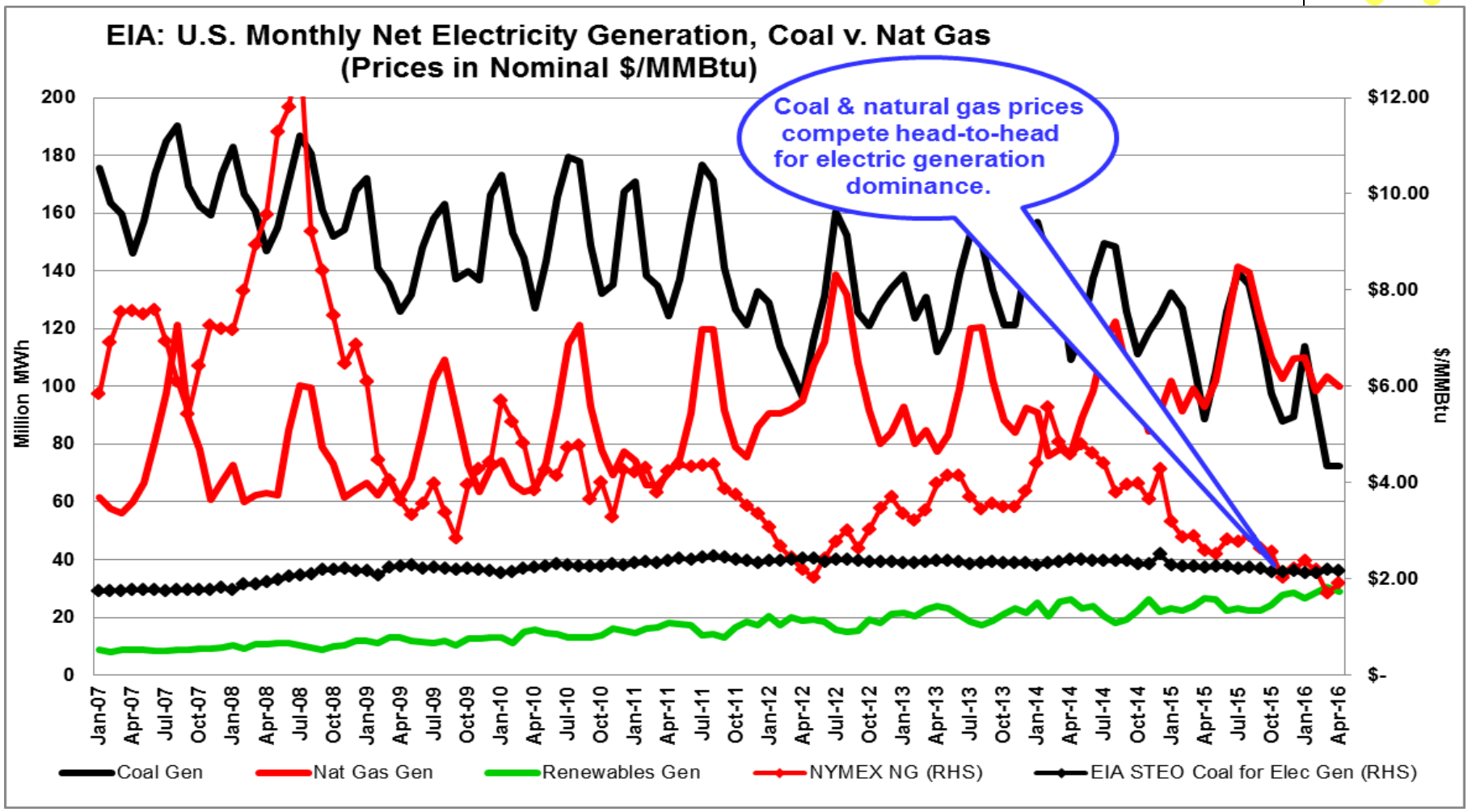
U.S. Electricity Use: Declining Per Capita; Slow Total Growth

- Slow demand growth = market share battles



Source: U.S. Energy Information Administration, Annual Energy Outlook 2013 Early Release

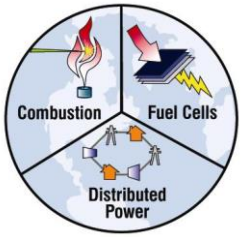
Coal & Nat Gas Still Dominate But Renewables on the Rise



Source of Data: U.S. Energy Information Administration and New York Mercantile Exchange (NYMEX).

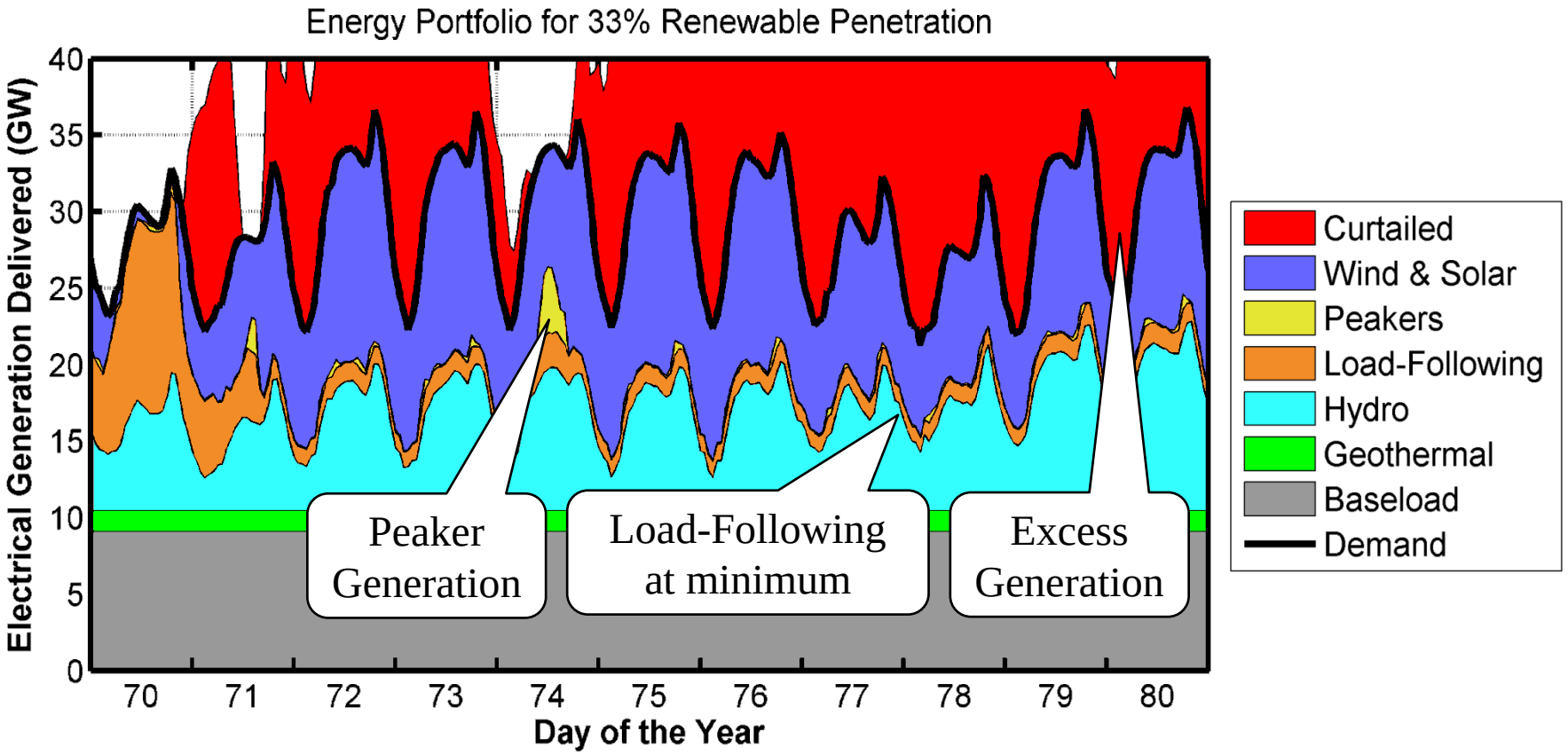
HiGRID Results: Renewables Integration

- **Task 4.1: Perform spanning analysis for different resources in California**
  - **Installation of renewables affects how other generators operate**

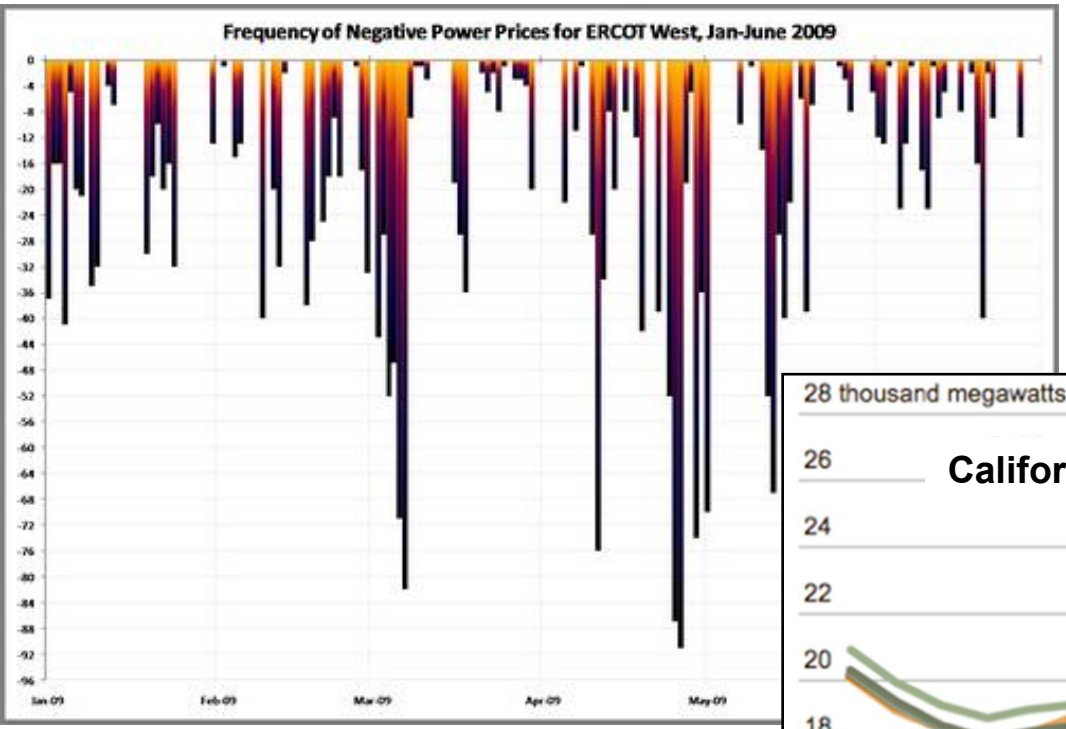


Advanced Power and Energy Program

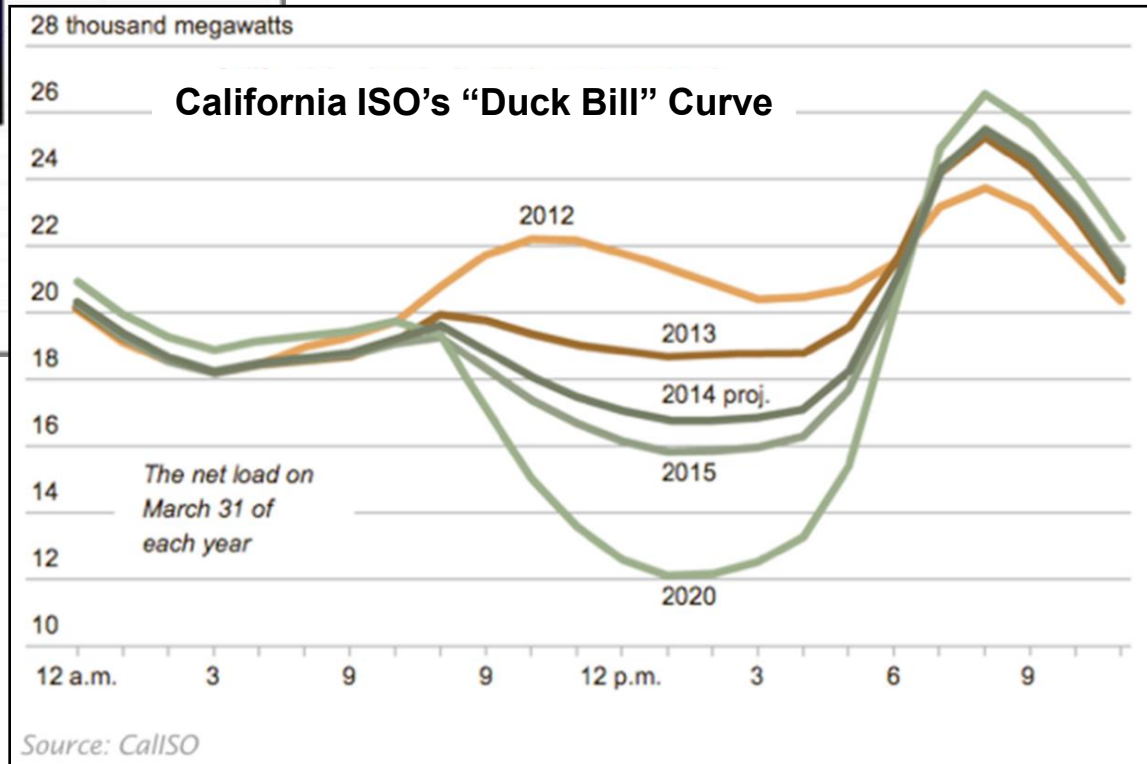
UCIrvine | University of California



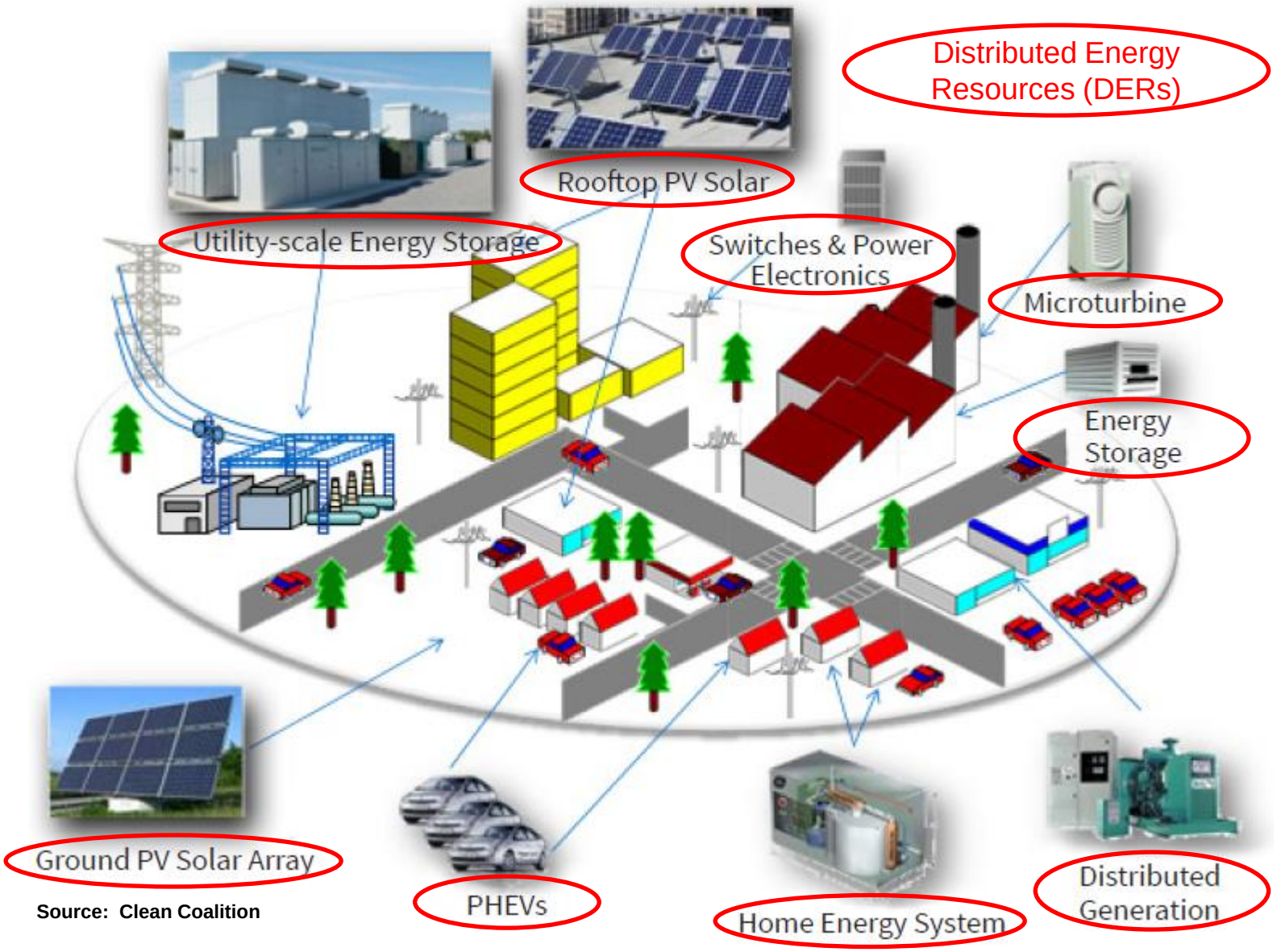
More Renewables Impact Both Electric Grid Flows & Pricing…



Source: http://knowledgeproblem.com/2009/07/22/negative-power-prices-in-ercot-west-charts-for-jan-june-2009/



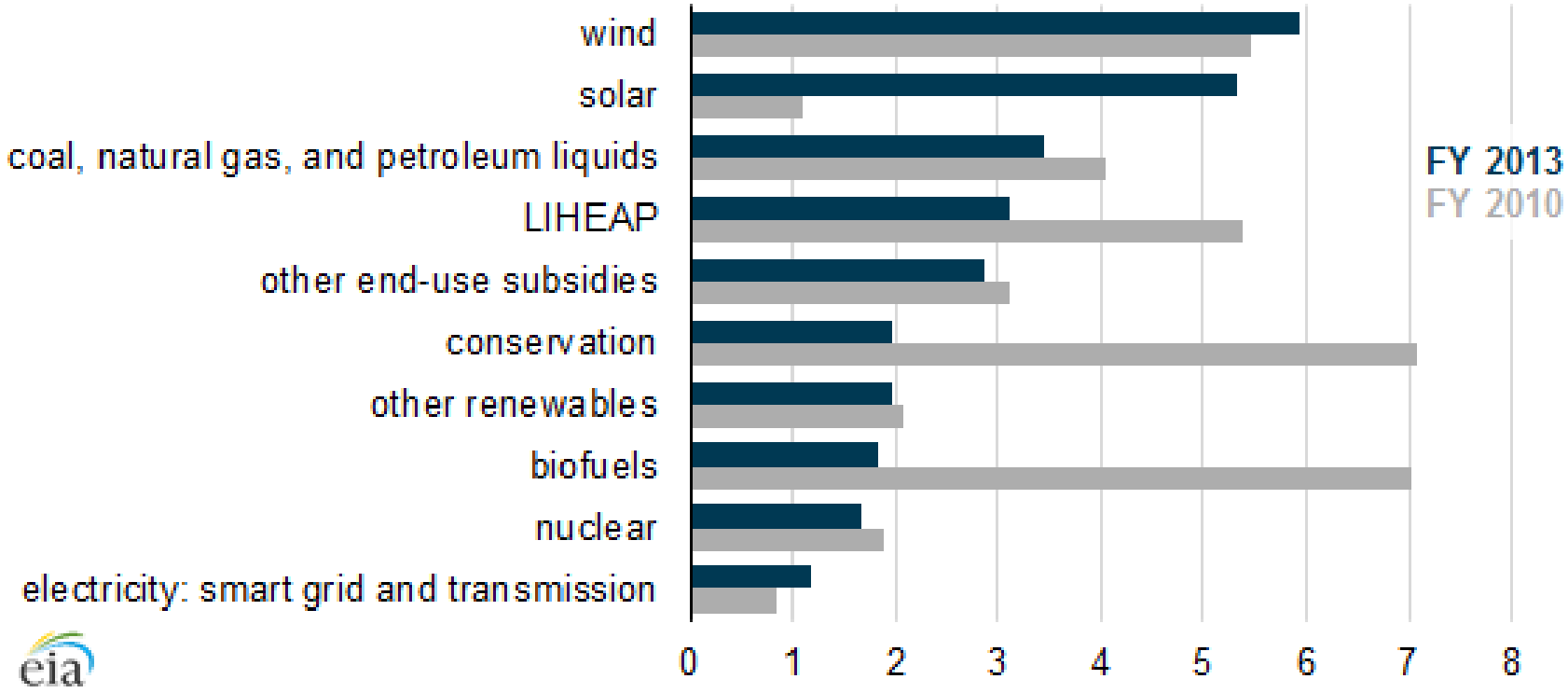
Dominated by Local Resources



Source: Clean Coalition

Transforming the Market - Aided By Generous Subsidies

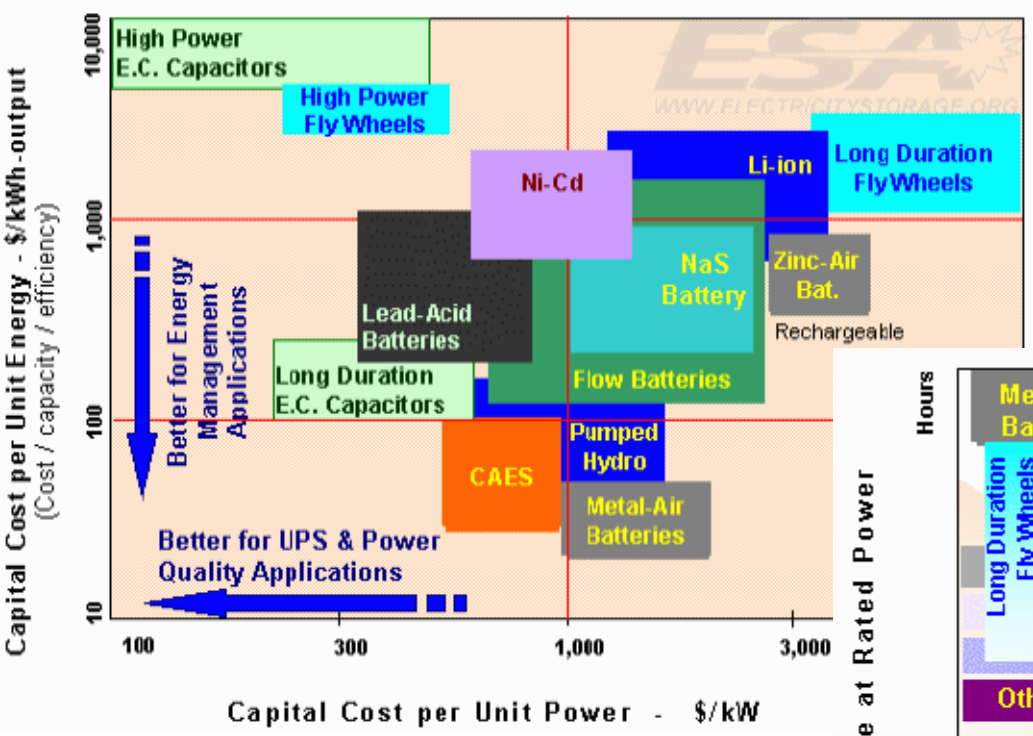
Quantified energy-specific subsidies and support by type, fiscal years 2010 and 2013
billion 2013 dollars



Source: EIA, Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013, http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf

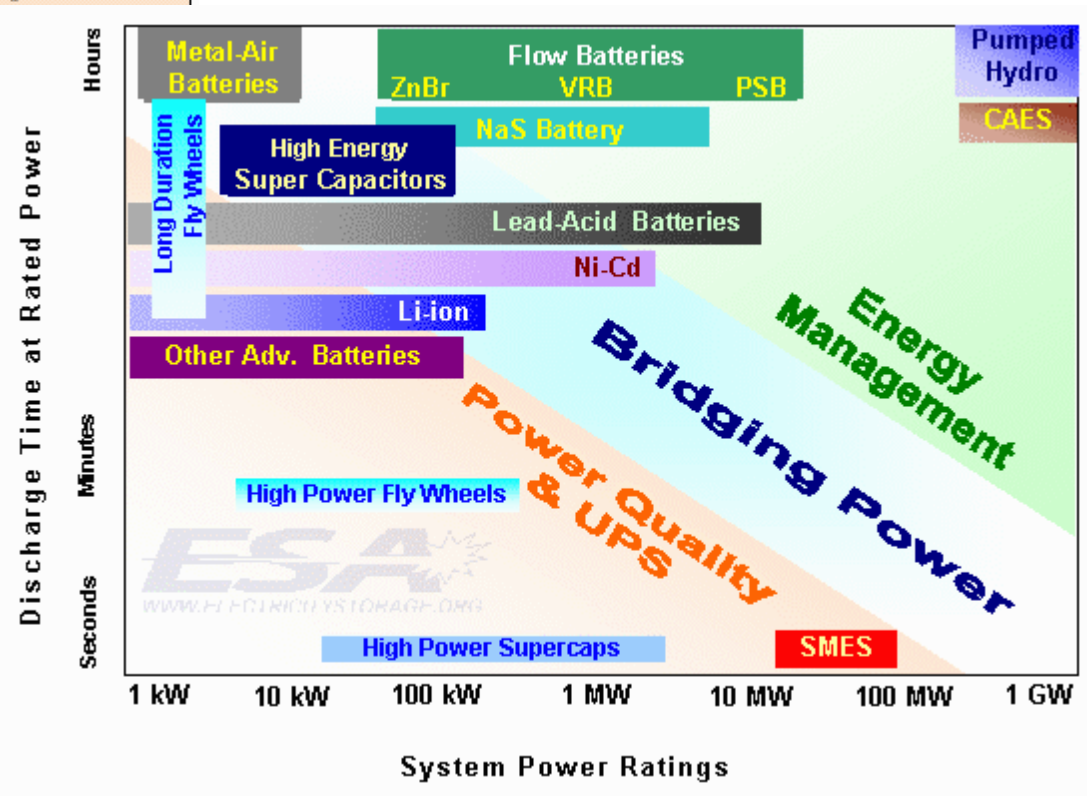
Note: LIHEAP is the Low Income Home Energy Assistance Program.

Energy Resiliency at All Levels Depends on Adequate Storage

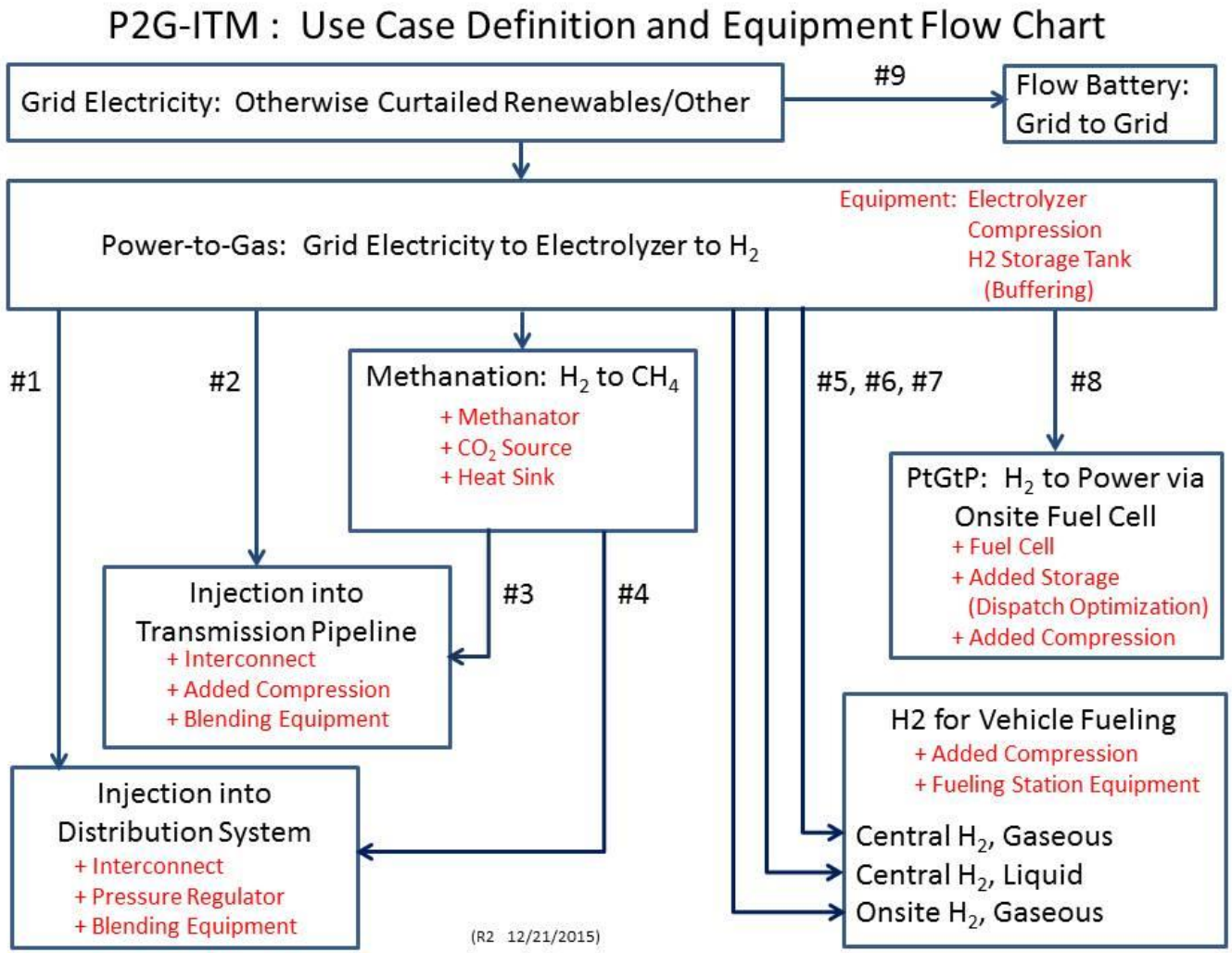


- Is electricity storage energy's holy grail?

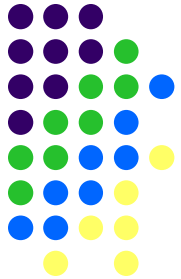
- Power vs. Energy
- Capacity vs. Flow



Power-to-Gas: Flexible Electricity Storage/Conversion



Climate Change – It's Not Just About the Carbon…



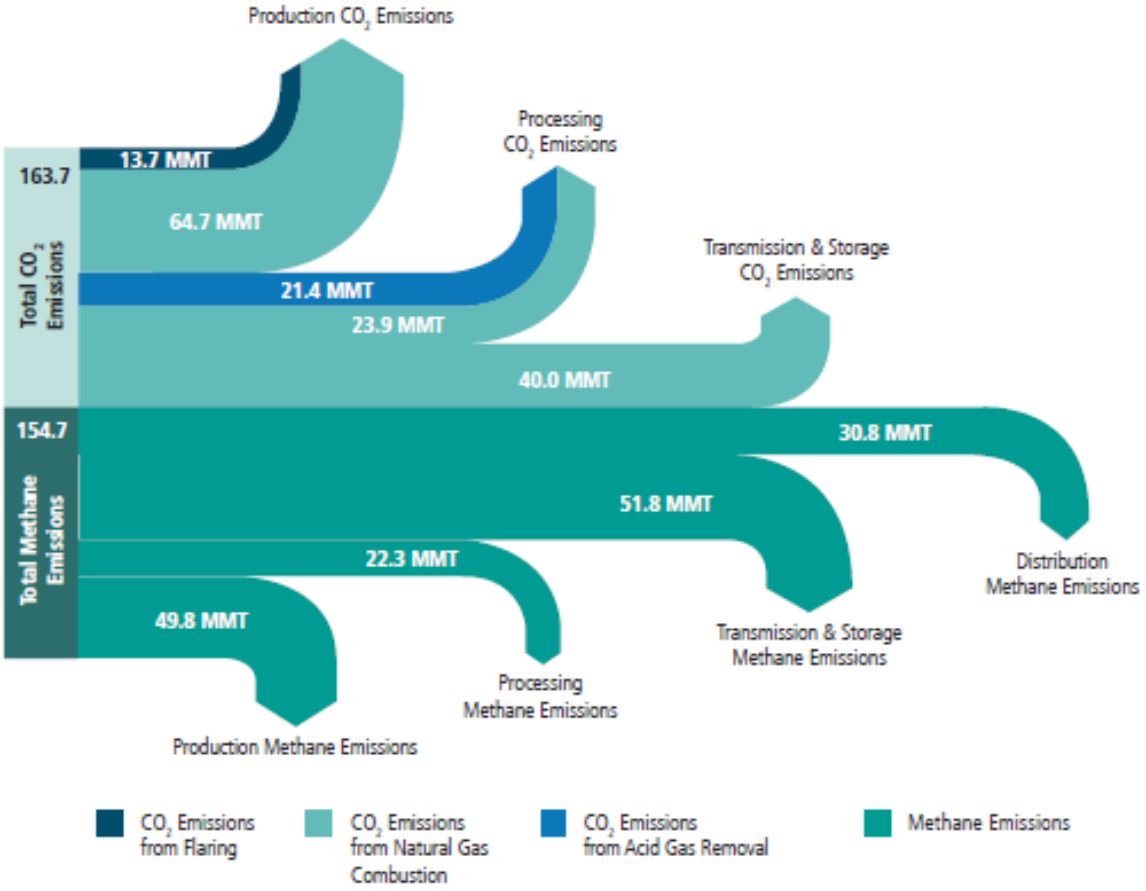
- GHG = Greenhouse Gas
- GWP = Global Warming Potential

GHG	GWP (100 Yr)	
Carbon Dioxide – CO_2	1	
Methane – CH_4	21	
Nitrous Oxide – N_2O	310	
SF_6 – Sulfur Hexafluoride	23,900	"F-gases"
Hydrofluorocarbons (13) – HFCs	140-11,700	
Perfluorocarbons (6) – PFCs	6,500-9,200	

- CO2e = Carbon dioxide-equivalents
- MT = metric tonne = 2,200 pounds
- MMTCO2e = Million metric tonnes of CO2-equivalents (x 1000 = Giga tonnes)

Natural Gas GHG Emissions Half Those of Coal, But Still…

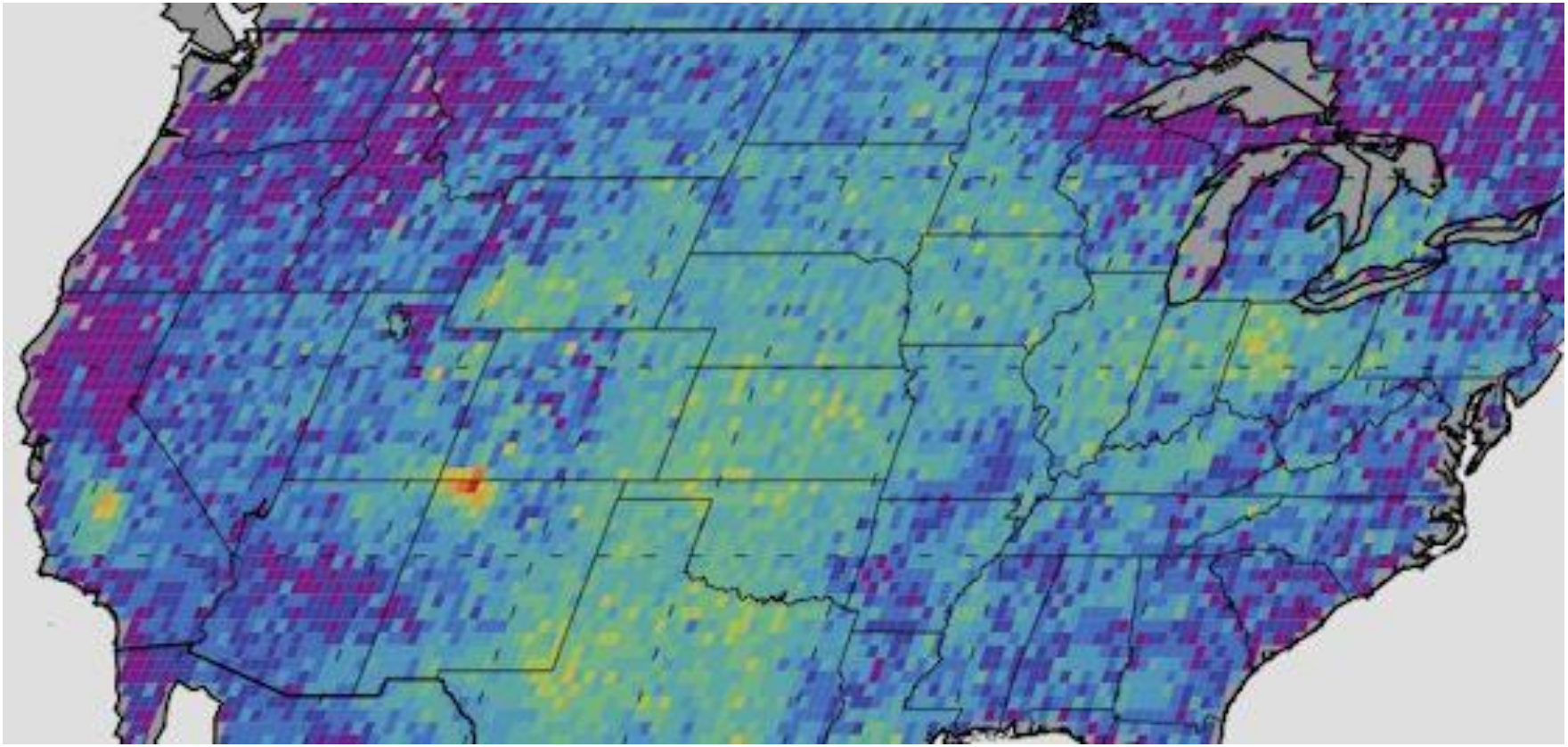
Figure 7-1. 2012 GHG Emissions from Natural Gas Production, Processing, Transmission, Storage, and Distribution[38]



Both CO_2 (top of diagram) and methane (bottom of diagram) are emitted in roughly equal amounts from various sources and processes upstream of end-use consumers. Eighty percent of the GHG emissions from the natural gas system result from consumer end use of natural gas. However, these emissions are omitted from this figure to enable a more detailed picture of emissions from natural gas infrastructure.

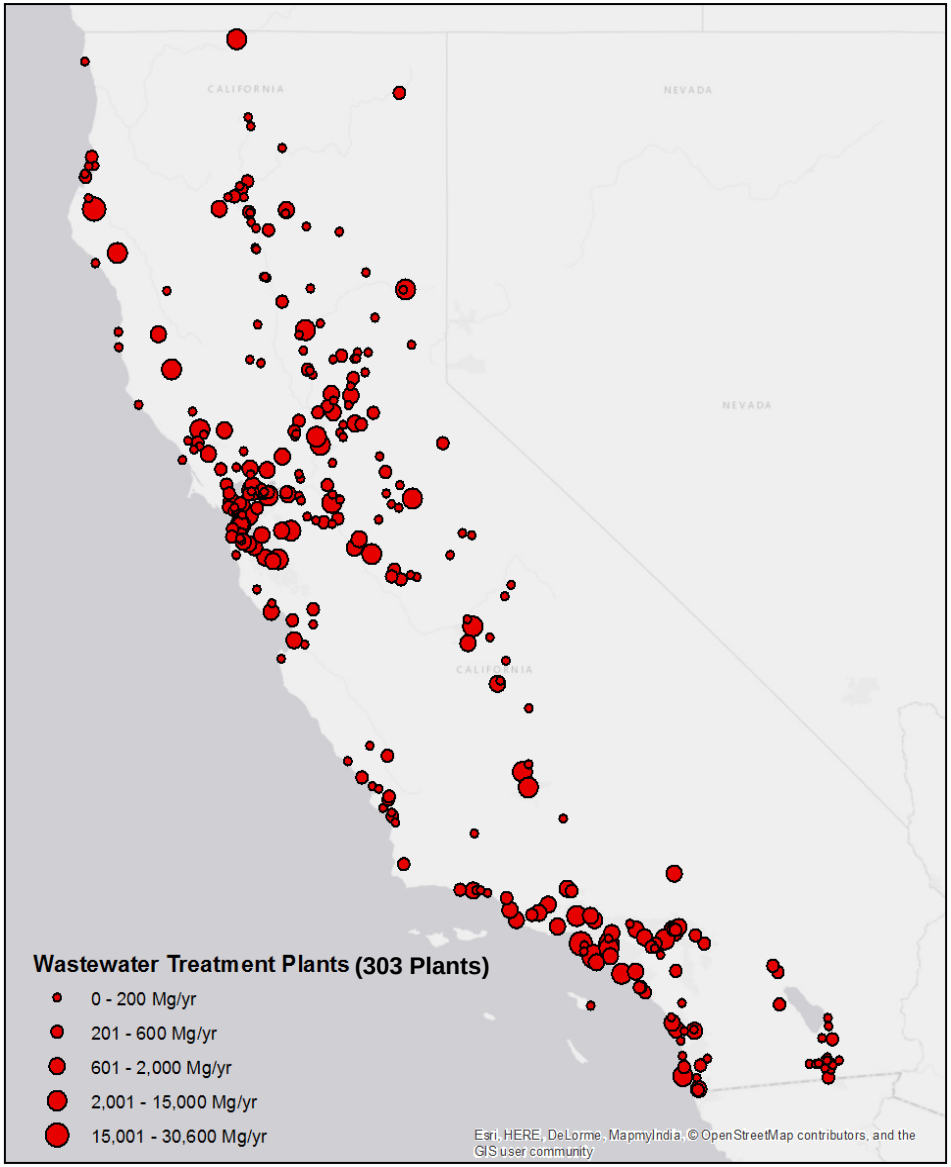
Source: U.S. Department of Energy. Quadrennial Energy Report, April 2015, p. 7-8. http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report

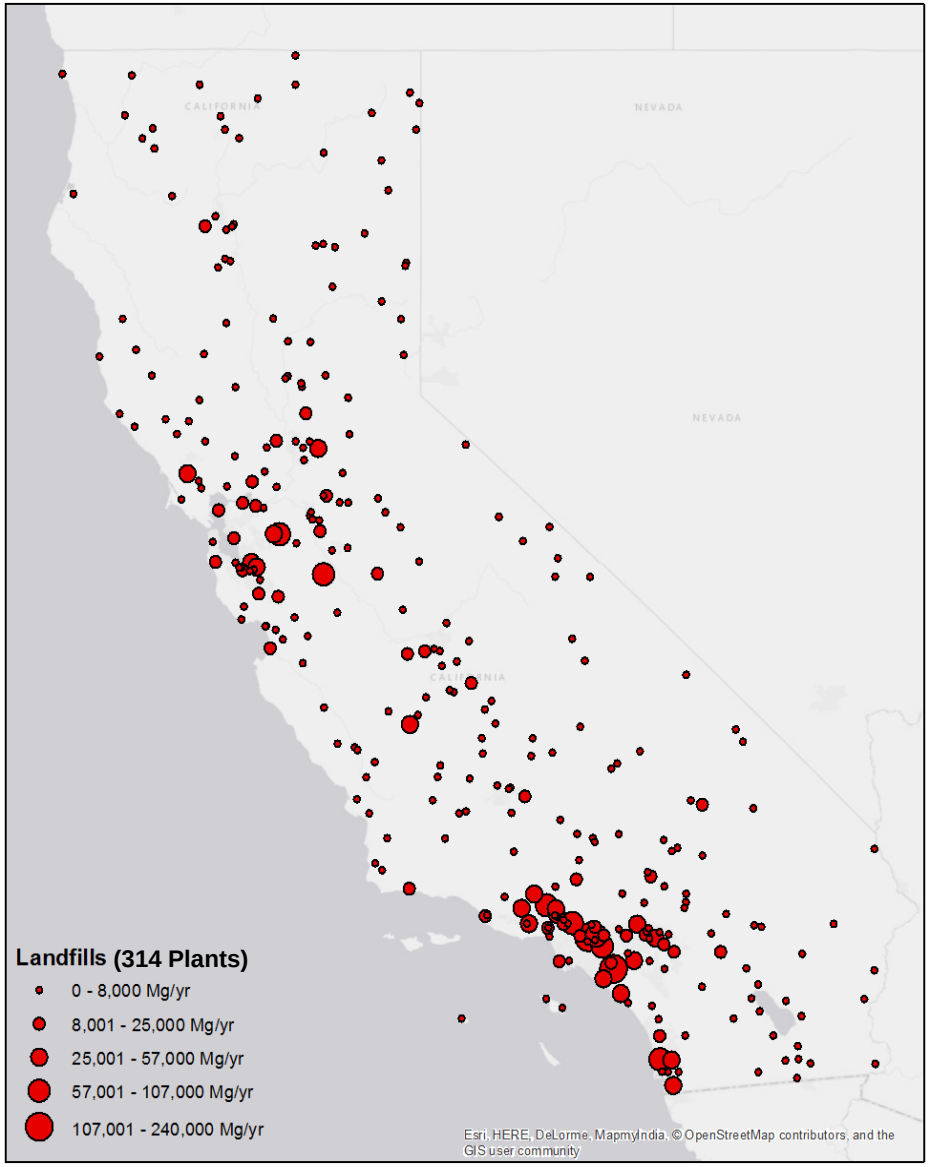
Existence of Regional Methane Clouds Are Troubling…



Source: NASA, October 9, 2014, U.S. Methane Hot Spot Bigger Than Expected, http://science.nasa.gov/science-news/science-at-nasa/2014/09oct_methanehotspot/

California: Capture Biogas to Reduce CO_2





Strong Regulatory Support for Biogas Use

AB 32:	Requires carbon reduction in all sectors; the proposed cap and trade system may elevate demand for biogas credits
RPS:	Renewable Portfolio Standard requires 33% renewable electricity generation by 2020
LCFS:	Low Carbon Fuel Standard requires carbon intensity of vehicle fuels to be reduced over time with specific goals in 2020
CAFE:	Corporate Average Fuel Economy requires automakers to improve the average fuel economy of their fleets
SB 1505:	Requires 33% of hydrogen vehicle fuel to be generated renewably
SB 1122:	Requires investor owned utilities to procure 250 MW of new small biopower
ZEV:	Zero Emission Vehicle Mandate requires automakers to market zero emission vehicles; one compelling option is the hydrogen fuel cell vehicle. Combined with SB 1505, this is potentially a large end-use of biogas
EPA NAAQS:	National Ambient Air Quality Standards require improvements in air quality in several regions of California

Source: California Energy Commission, March 2015, Air Quality and Greenhouse Gas Emissions Impact Assessment from Biomass and Biogas Derived Transportation Fuels and Electricity and Heat Generation, CEC-500-2016-022, Prepared by Advanced Power and Energy Program, p. 7.

CA Biogas: Examined Utilization Scenarios

Scenario 1	• Onsite combined cycle combustion
Scenario 2	• Onsite reciprocating engine
Scenario 3	• Onsite reciprocating engine combined heat and power system or onsite combined cycle system if available biogas would support 3 MW of combined cycle capacity
Scenario 4	• Onsite micro turbine combined heat and power system or onsite combined cycle system if available biogas would support 3 MW of combined cycle capacity
Scenario 5	• Onsite fuel cell combined heat and power system
Scenario 6	• Onsite fuel cell combined heat and power system or onsite combined cycle system if available biogas would support 3 MW of combined cycle capacity
Scenario 7	• Onsite fuel cell tri-generation system (power, heat, and hydrogen production)
Scenario 8	• Onsite Compressed Natural Gas (CNG) production
Scenario 9	• Onsite Liquefied Natural Gas (LNG) production
Scenario 10	• Pipeline injection of biomethane (Sized for 1 million scfd of available biomethane)
Scenario 11	• Pipeline injection for central CNG production
Scenario 12	• Pipeline injection for combined cycle electricity generation
Scenario 13	• Onsite direct-fired boiler
Scenario 14	• Onsite hydrogen production using steam methane reformation (SMR)
Scenario 15	• Onsite microturbine
Scenario 16	• Onsite gas turbine combustion

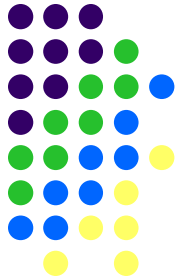
CA Biogas: Useful Product Potential

Utilization Scenario	Landfills				Wastewater Treatment Plants				
	Additional MW_e Capacity	CNG (Mg)	LNG (Mg)	H2 (Mg)	Additional MW_e capacity	Heat Capacity (MW_{th})	CNG (Mg)	LNG (Mg)	H2 (Mg)
1	815				69				
2	590				69	76			
3	883				101	27			
4	917				132	45			
5	621				85	46			
6	875				104	16			
7	687			105,024	78	34			16,348
8		932,300					189,685		
9			862,341					178,013	
10	923				184				
11		918,317					186,839		
12	923				171				
13	579				94				
14				606,428					85,253
15	575				90	44			
16	258				24	28			

= 1.17% of existing 78,890 MW installed generating capacity

Mg = megagram = 1,000,000 grams = 1,000 kilograms = 1 metric tonne = 2,200 pounds.

There's Never Been a Better Time to Be in Energy



- Markets are in a state of dynamic transformation
  - Ironically, importance of regulators has increased
    - Regulatory changes need to reflect 21st century market realities
      - "Utility of the Future" must remain financially viable
    - Strength of policy commitment determines rate of change
  - There is no silver bullet
  - Alignment of incentives is crucial
    - New technologies, DERs, renewables integration, climate issues
    - Energy storage reduces "edginess" both physically & mentally
    - Integration of electrified transportation; vehicle-to-grid potential
  - Smarter smart phones are key to customer engagement
    - The recipe for success is already in our hands.

Thank you!

Questions?

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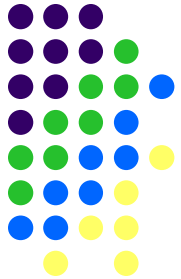
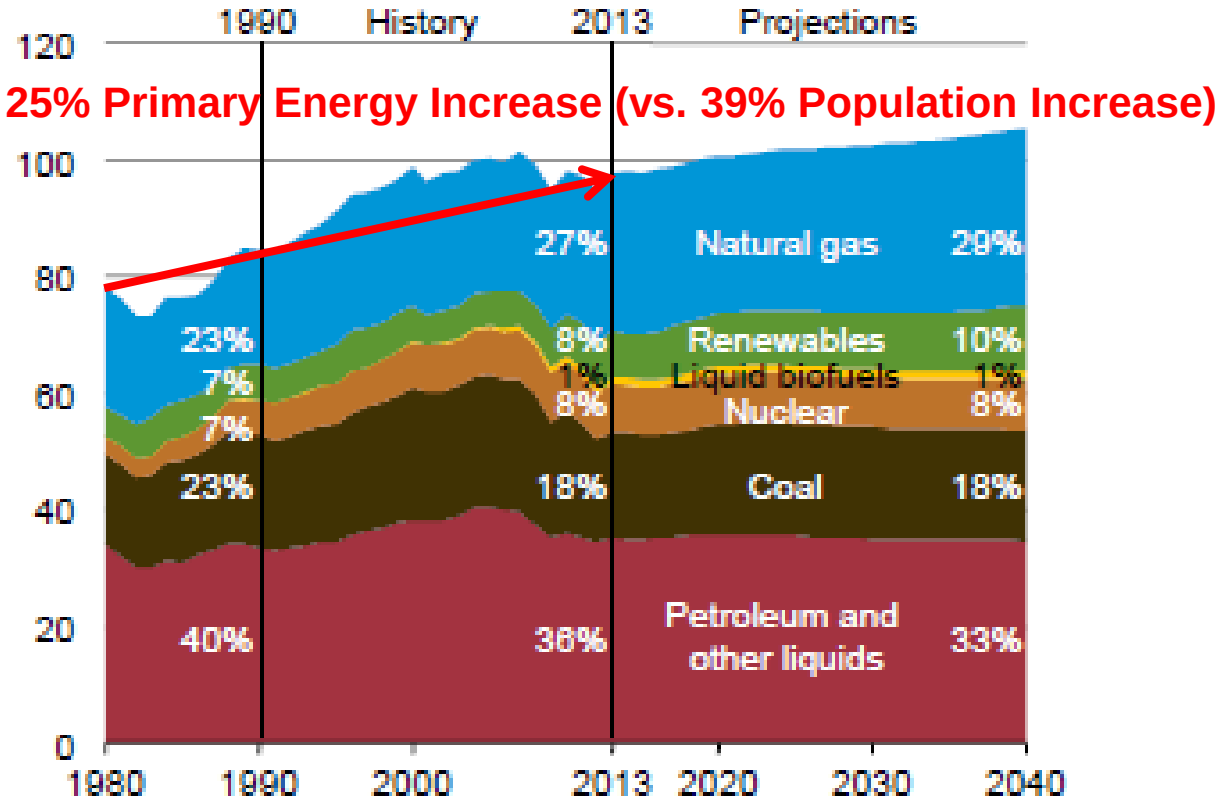
Backup Slides



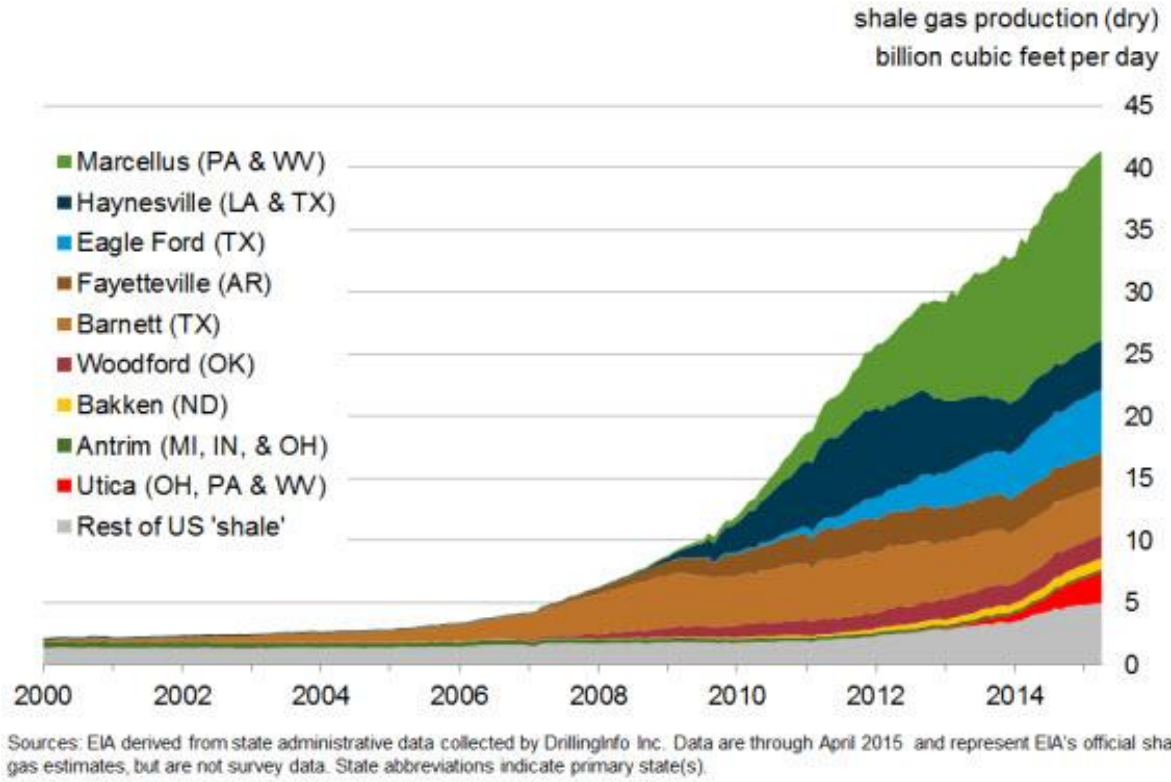
U.S. Primary Energy Use: Large, Slow-Moving Ship

Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040 (quadrillion Btu)

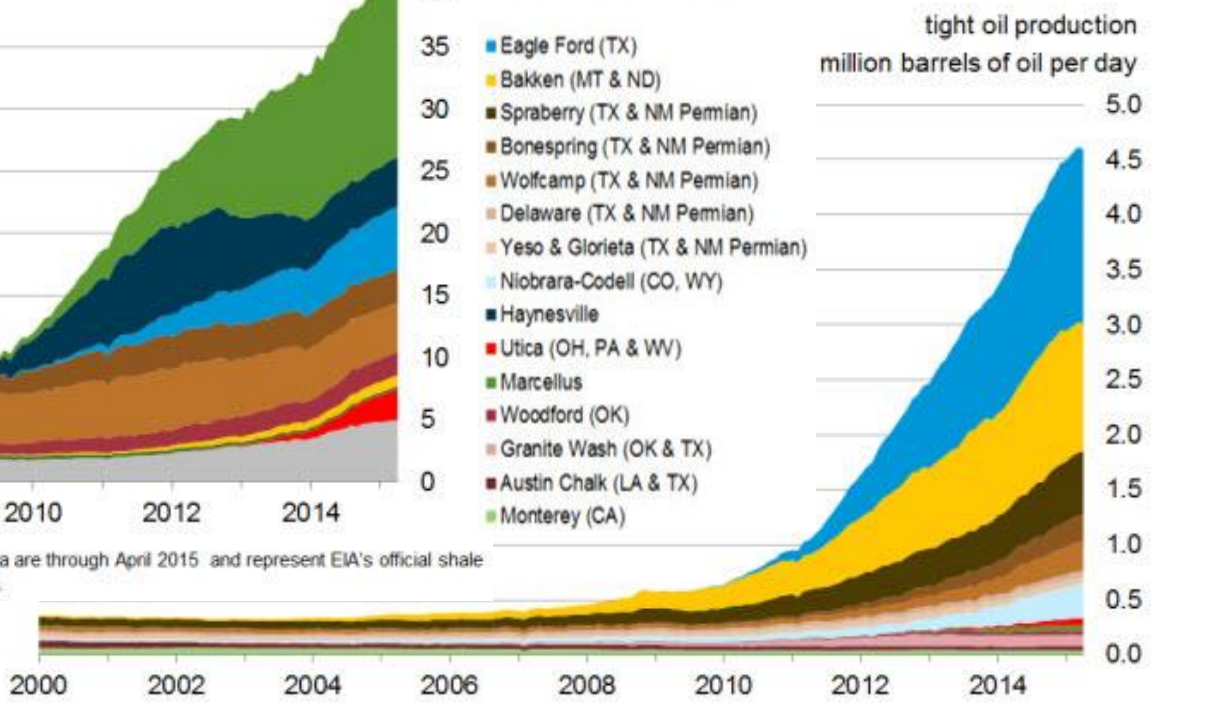


Source: EIA, 2015 Annual Energy Outlook, p. 15, http://www.eia.gov/forecasts/aeo/pdf/0383%282015%29.pdf.

U.S. Shale "Revolution" Is a Fairly Recent Phenomenon



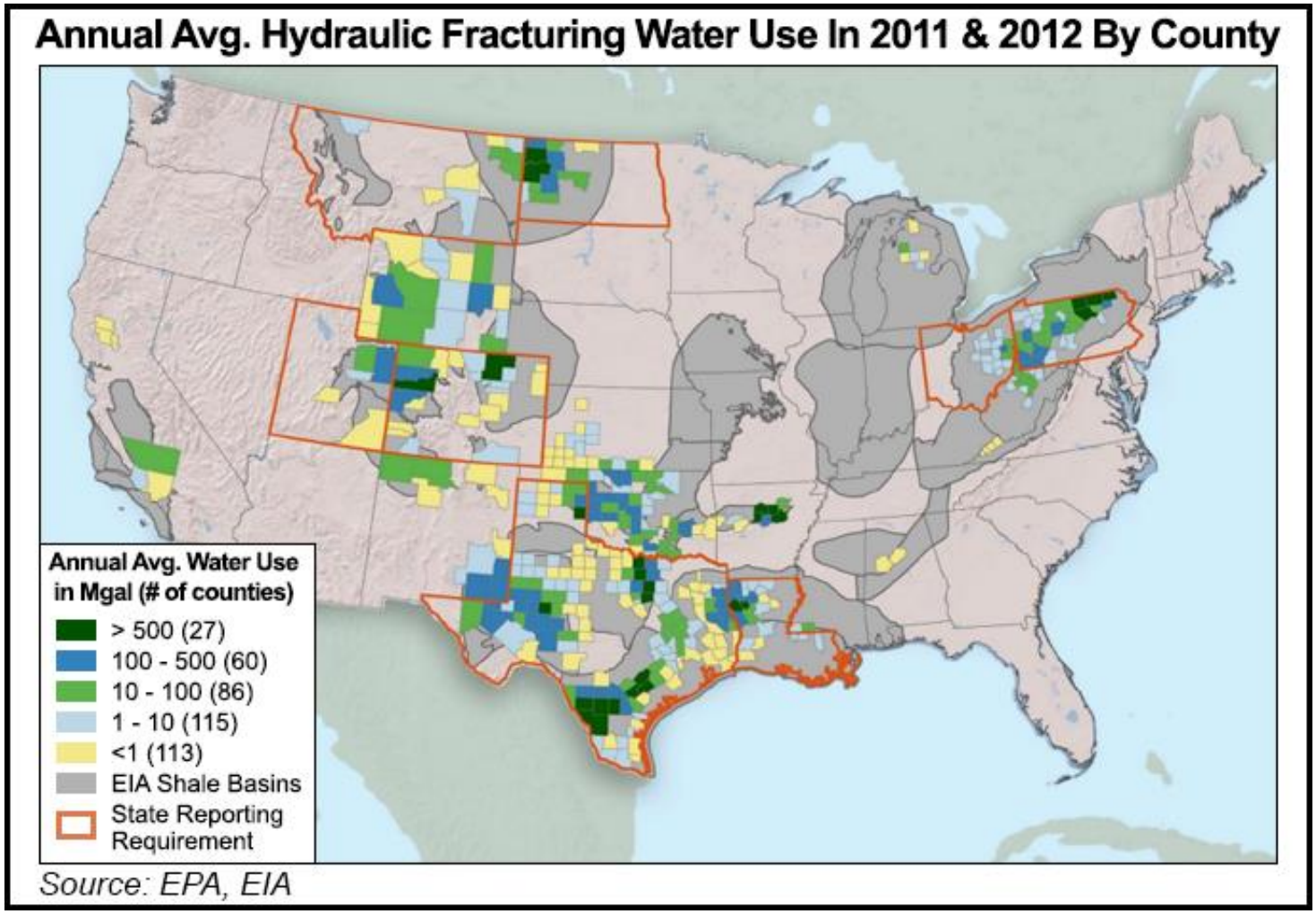
Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through April 2015 and represent EIA's official shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).



Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through April 2015 and represent EIA's official tight oil estimates, but are not survey data. State abbreviations indicate primary state(s).

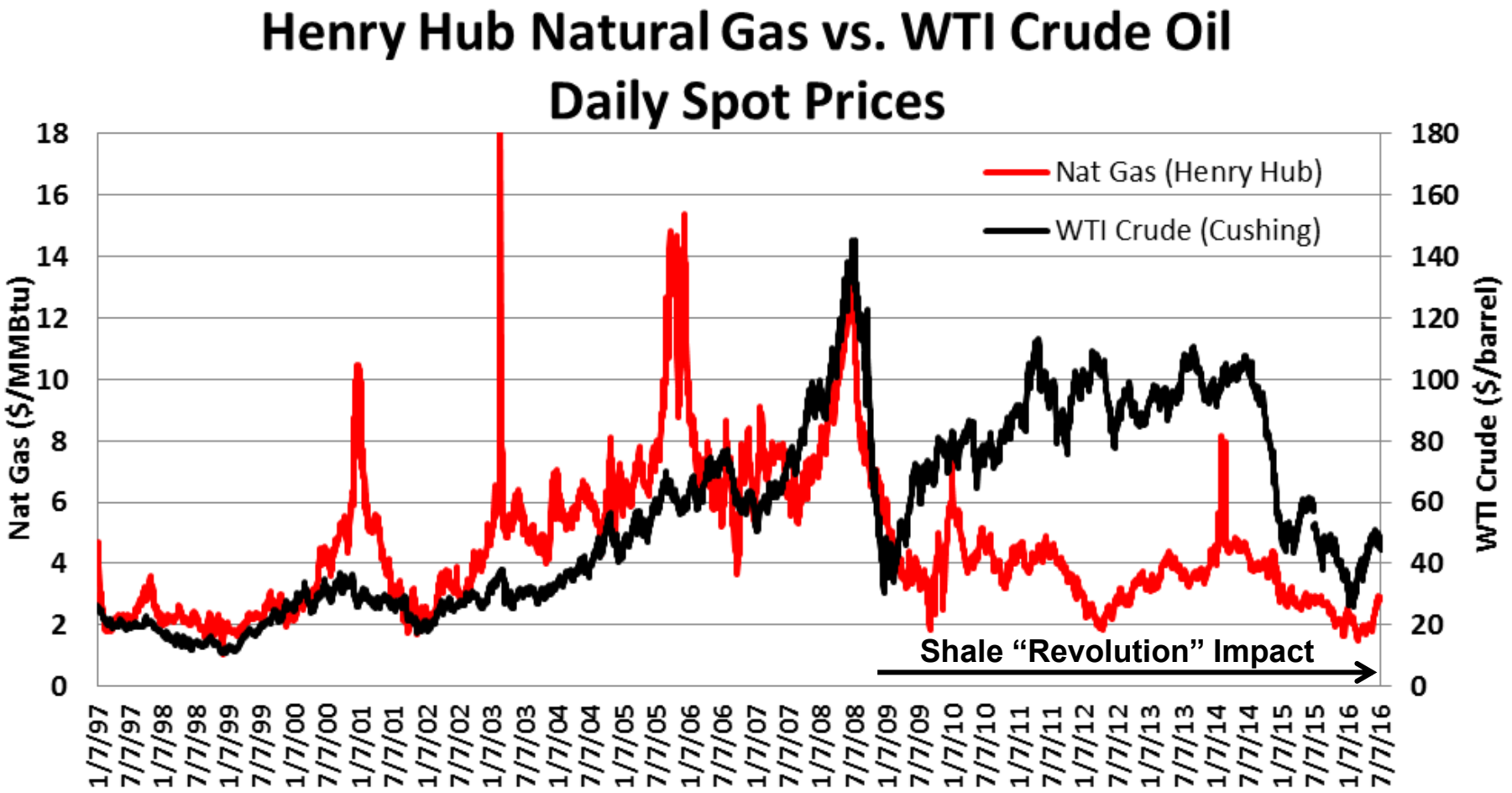
Source: EIA, May 14, 2015, *Shale in the United States*, http://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm

Water Use for Fracking Tracks Major Shale Field Development



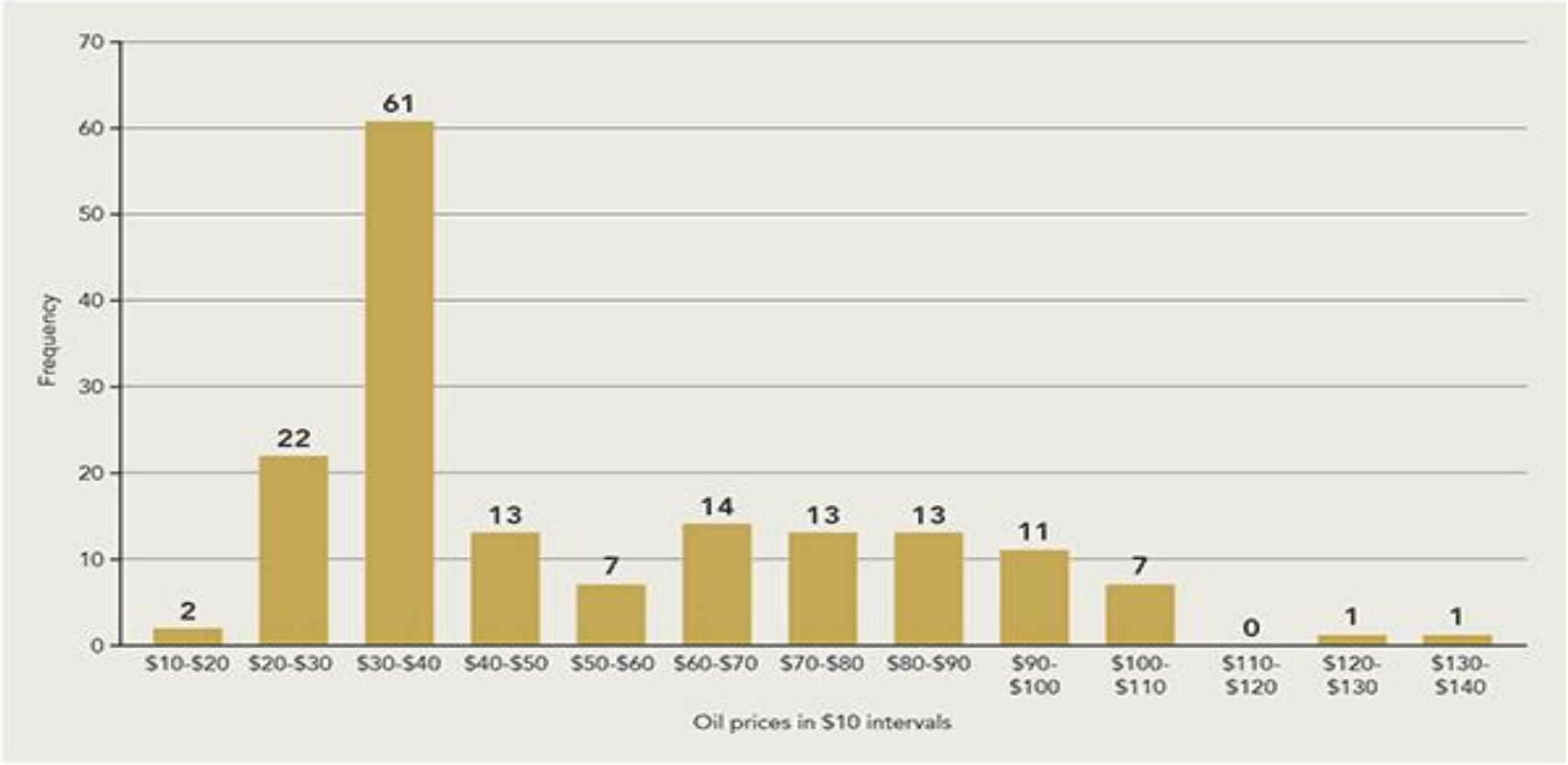
- Each well requires1.2-3.5 million gallons of water
- Fracking fluid chemicals
- Produced water disposal
- Ground-water issues?

Natural Gas & Oil Prices – Both Volatile, No Direct Linkage Now



"Bucketed" Oil Prices Suggest Current Prices Not Abnormal

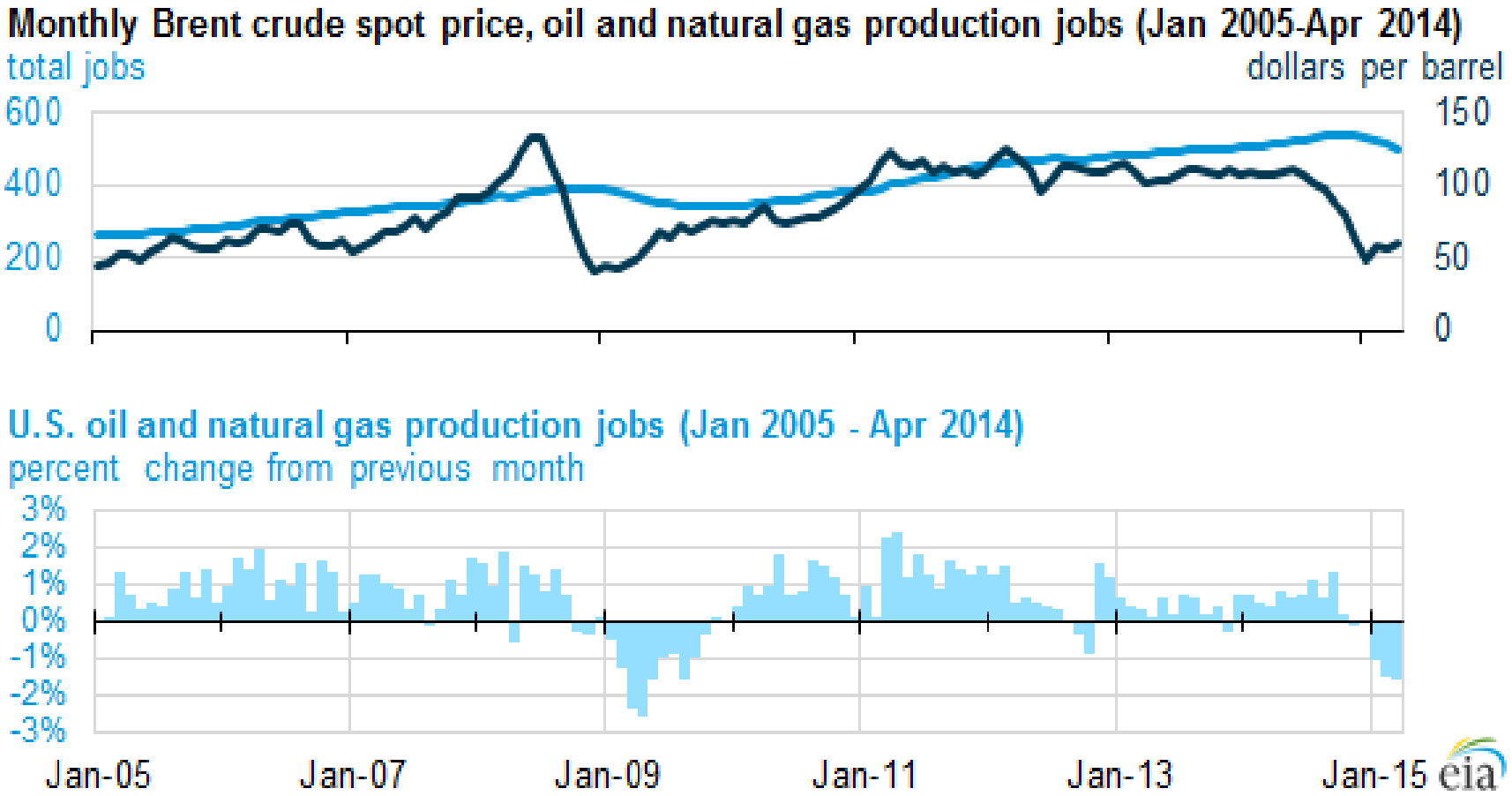
F3: QUARTERLY OCCURRENCES OF INFLATION ADJ. OIL PRICES 1Q74-1Q15



Source: EIA and EnerCom analysis

Source: OGFJ, *A Look at Key E&P Metrics*, July 2015, p. 28. http://www.ogfj.com/articles/print/volume-12/issue-7/features/a-look-at-key-e-p-metrics.html

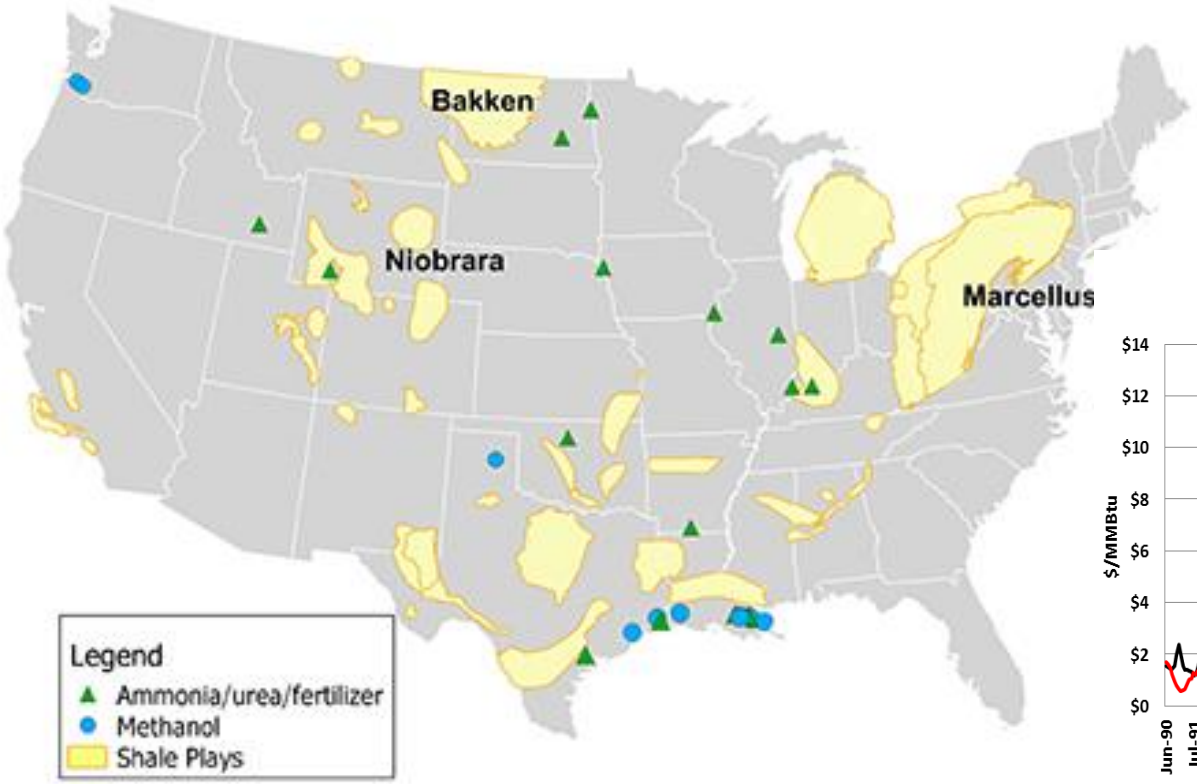
Oil & Gas Employment Has Declined with Low Prices…

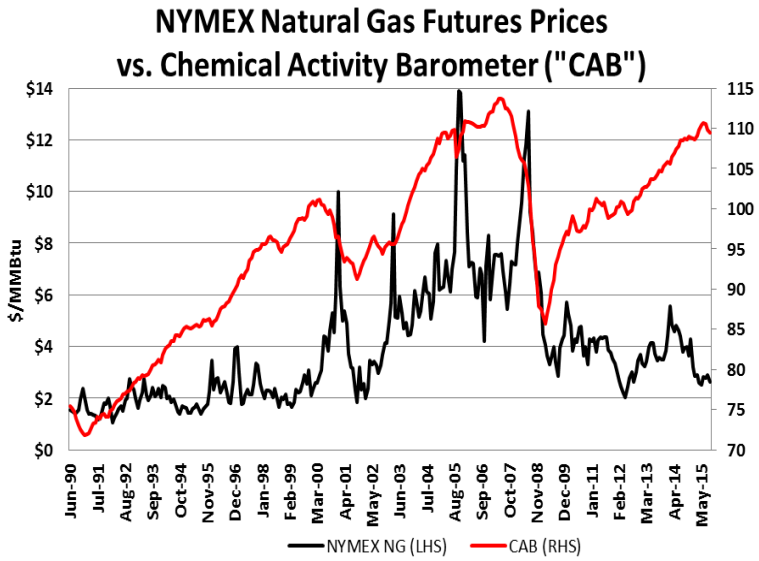


Source: EIA, *Today in Energy*, June 23, 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=21772

But Chemicals Manufacturing Competitiveness Has Increased

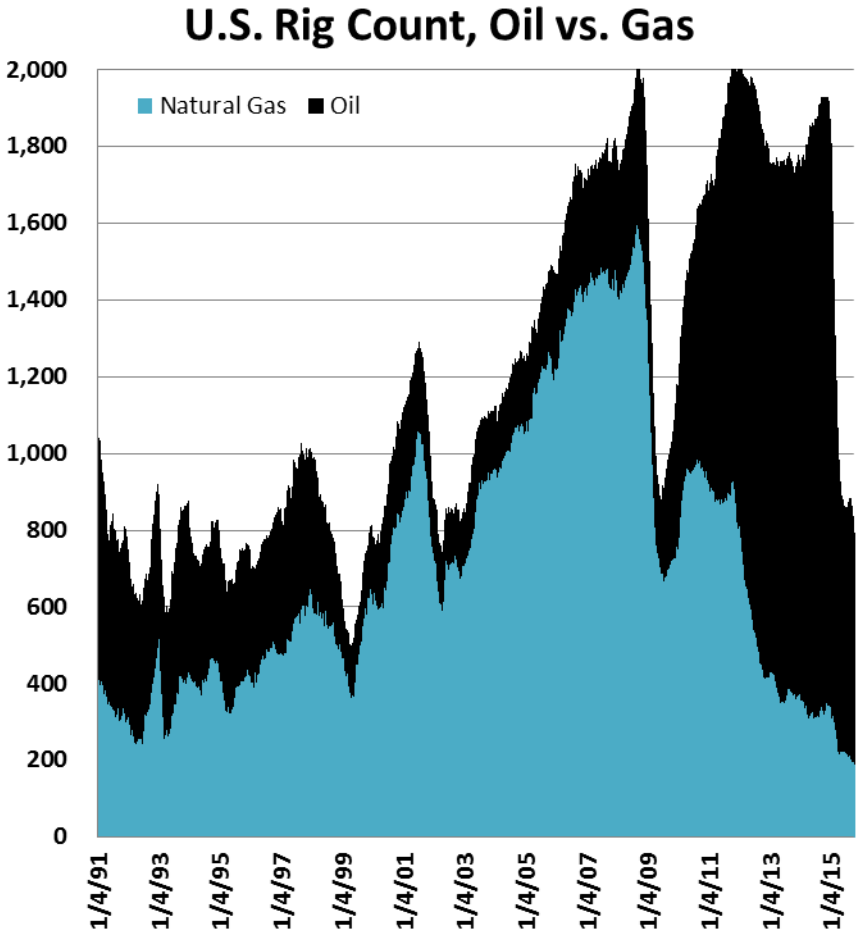
Major proposed methanol and ammonia-based fertilizer plants, 2015-18

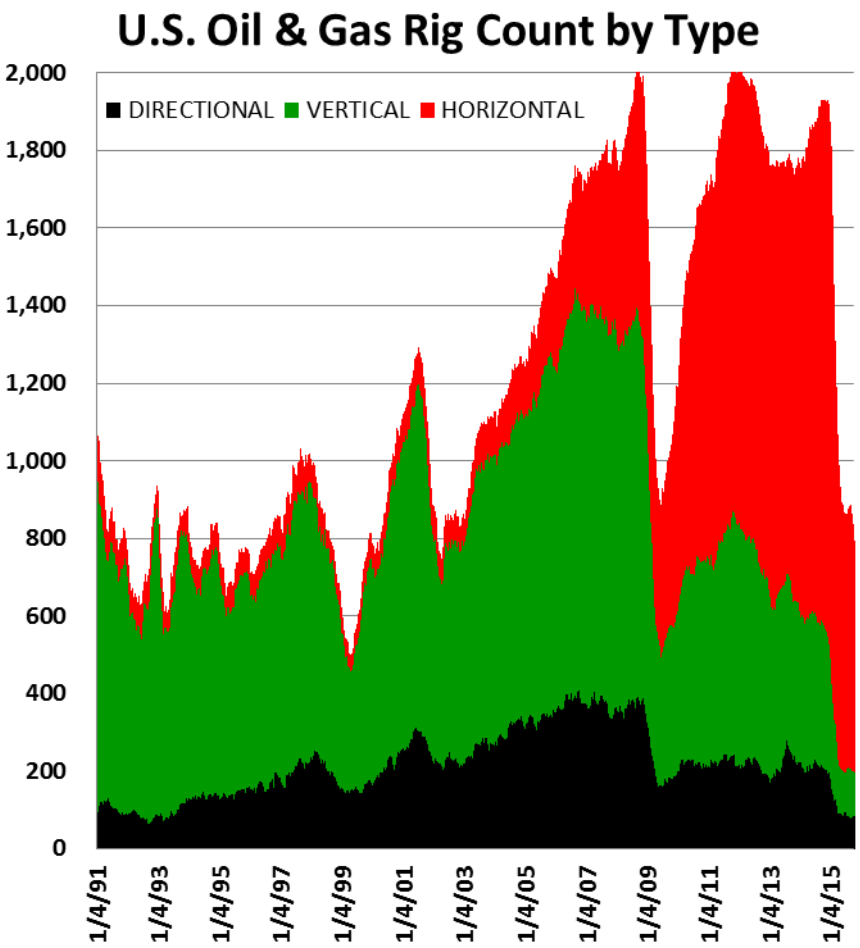




Source: U.S. Energy Information Administration based on Bentek Energy and industry reports. **http://www.eia.gov/naturalgas/weekly/archive/2015/05_21/index.cfm**

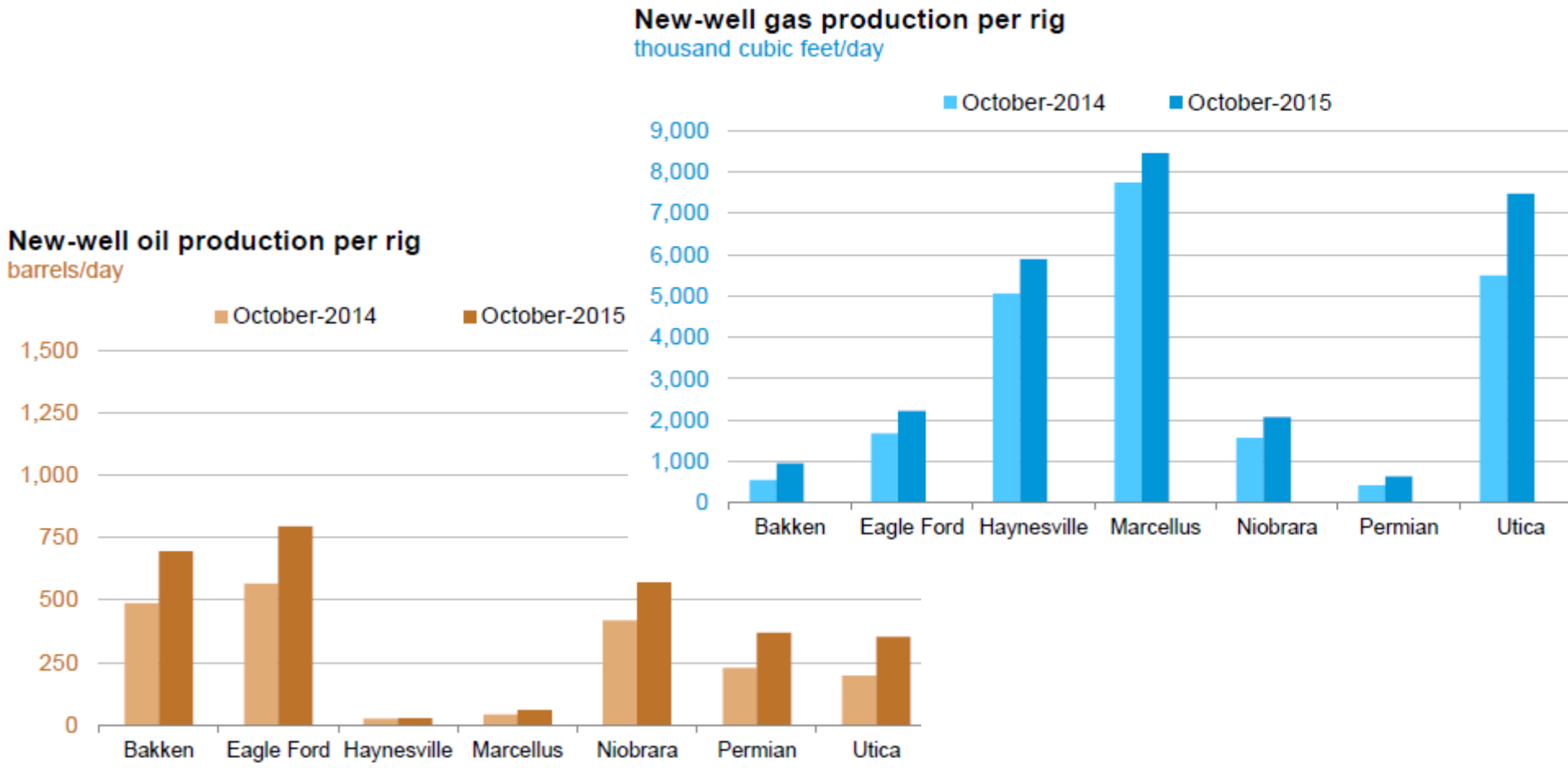
Low Rig Count?? We've Been Here Before…





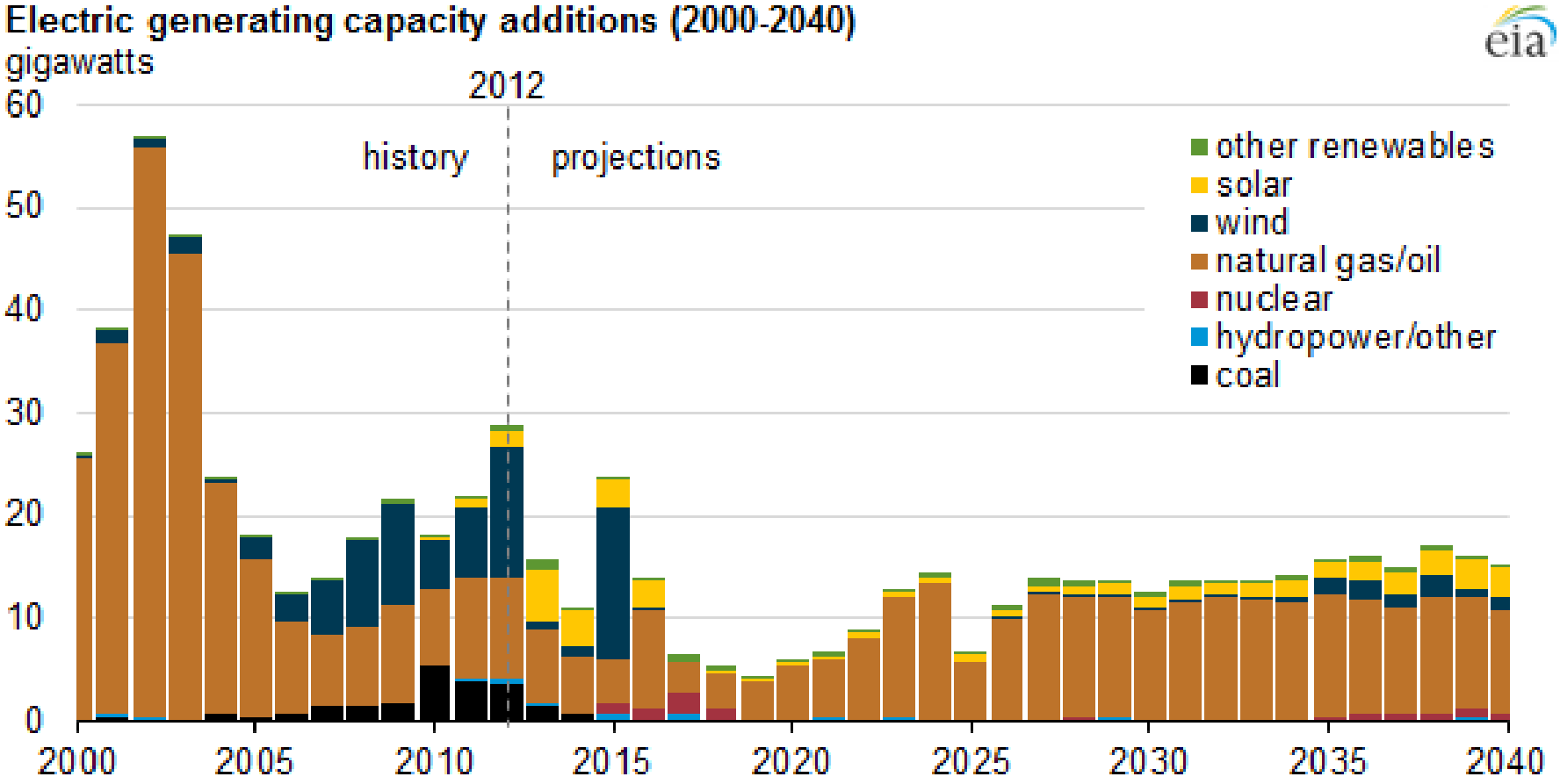
Source of Data: Baker Hughes, http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother

Rig Count Is Down But Production Per Rig Is Up



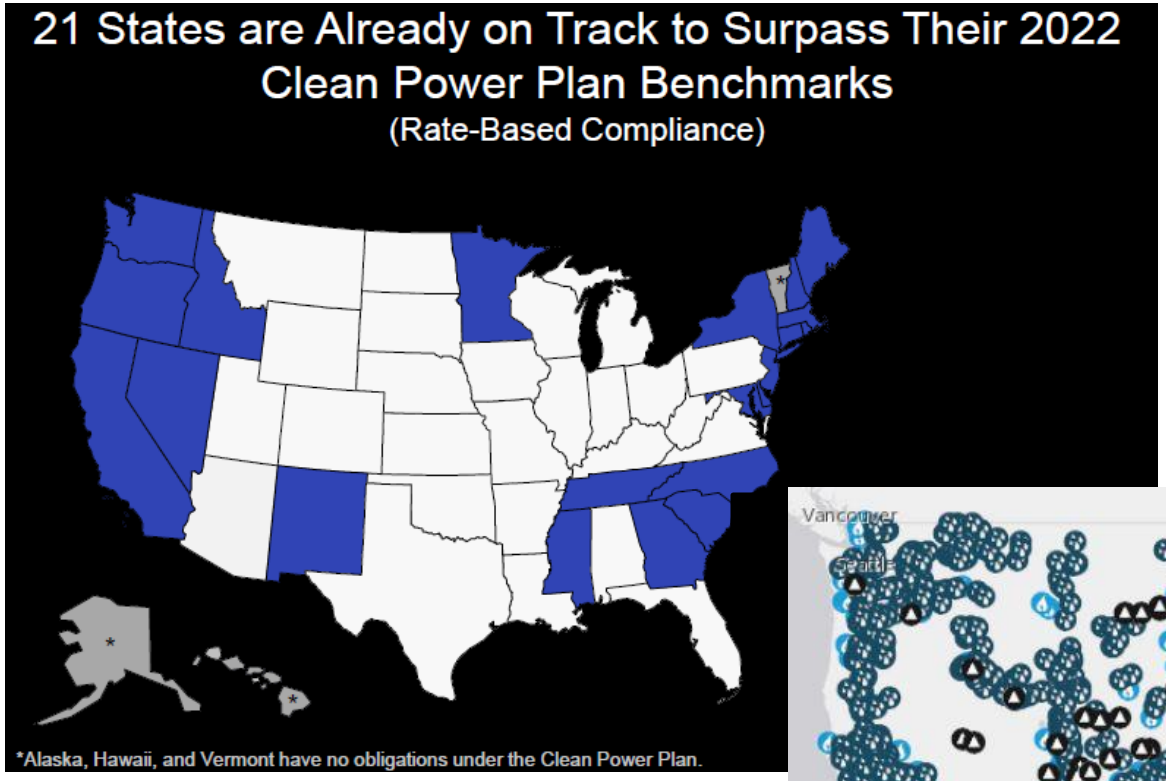
Source: EIA, September 2015, *Drilling Productivity Report*, p. 2, http://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf

With Increased Electrification Seen as the Best Solution

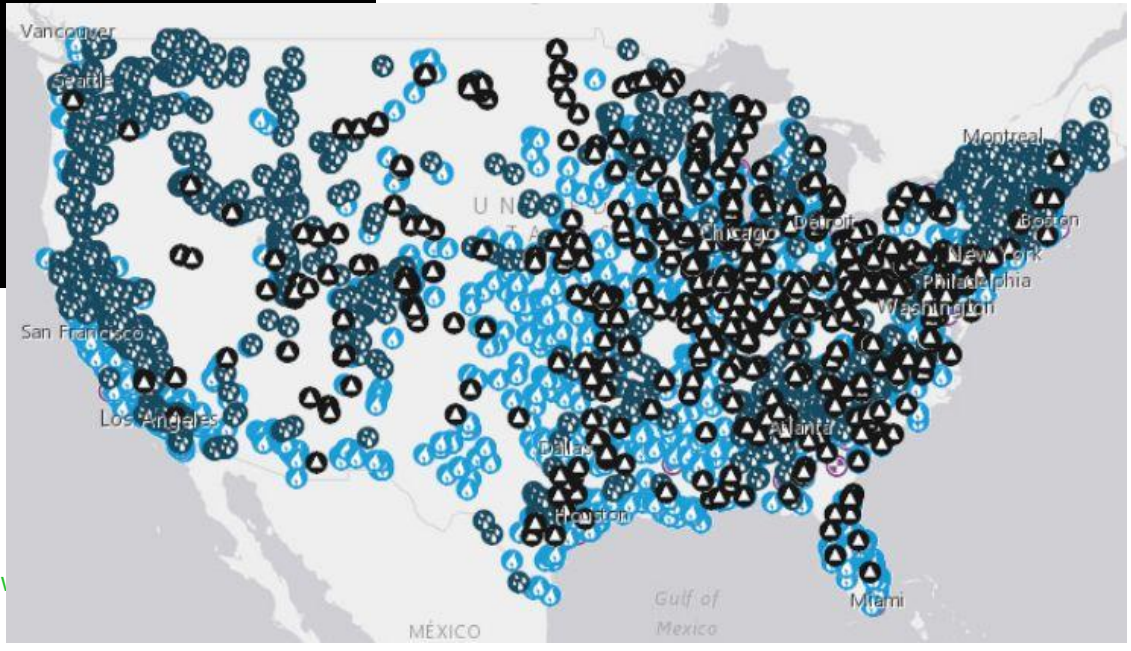


Source: Form Eia-860 and Annual Energy Outlook 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=17131

EPA's Clean Power Plan: Stalled in U.S. Supreme Court



- Power sector CO_2 reductions
- Rate- vs. mass-based; state-specific targets



Source: Union of Concerned Scientists, August 13, 2015, *States of Progress Update: Existing Clean Energy Commitments Put Most States in Strong Position to Meet the EPA's Final Clean Power Plan*, pp. 12-13, http://www.ucsusa.org/sites/default/files/attach/2015/08/States-of-Progress-Update-Slidedeck.pdf