ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

The Future of Electricity Generation in the U.S. – A Modest Set of Observations

Sue Tierney – Analysis Group

Opportunities for Technology & Policy Innovation in Energy & Environment
19th Annual MIT-NESCAUM Endicott House Symposium
August 16-18, 2011

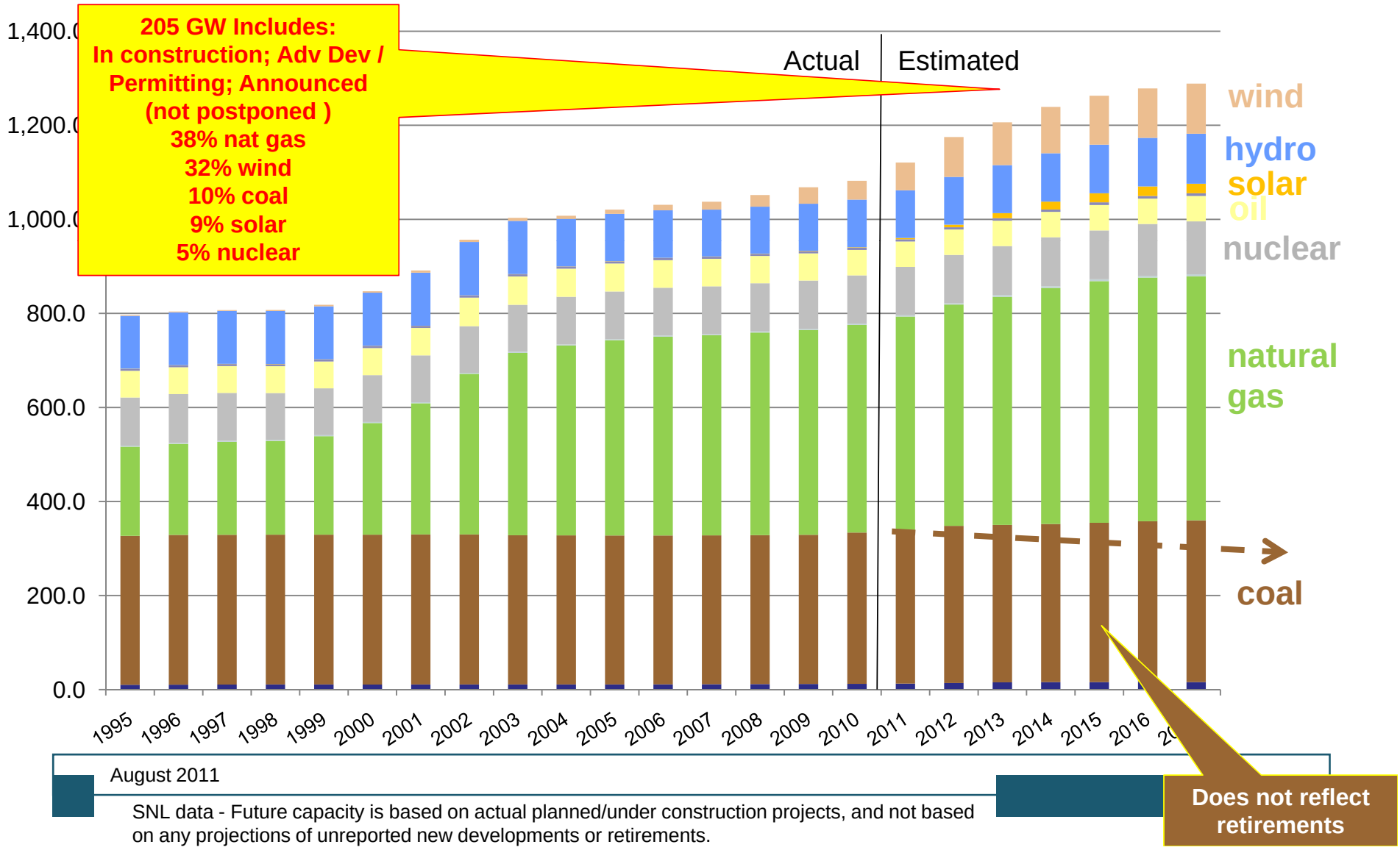
Some thoughts about ….

The outlook for U.S. electric generation –

- Some baseline conditions: the generating fleet
- Some "what if's" affecting the next investment cycle

SOME BASELINE CONDITIONS:

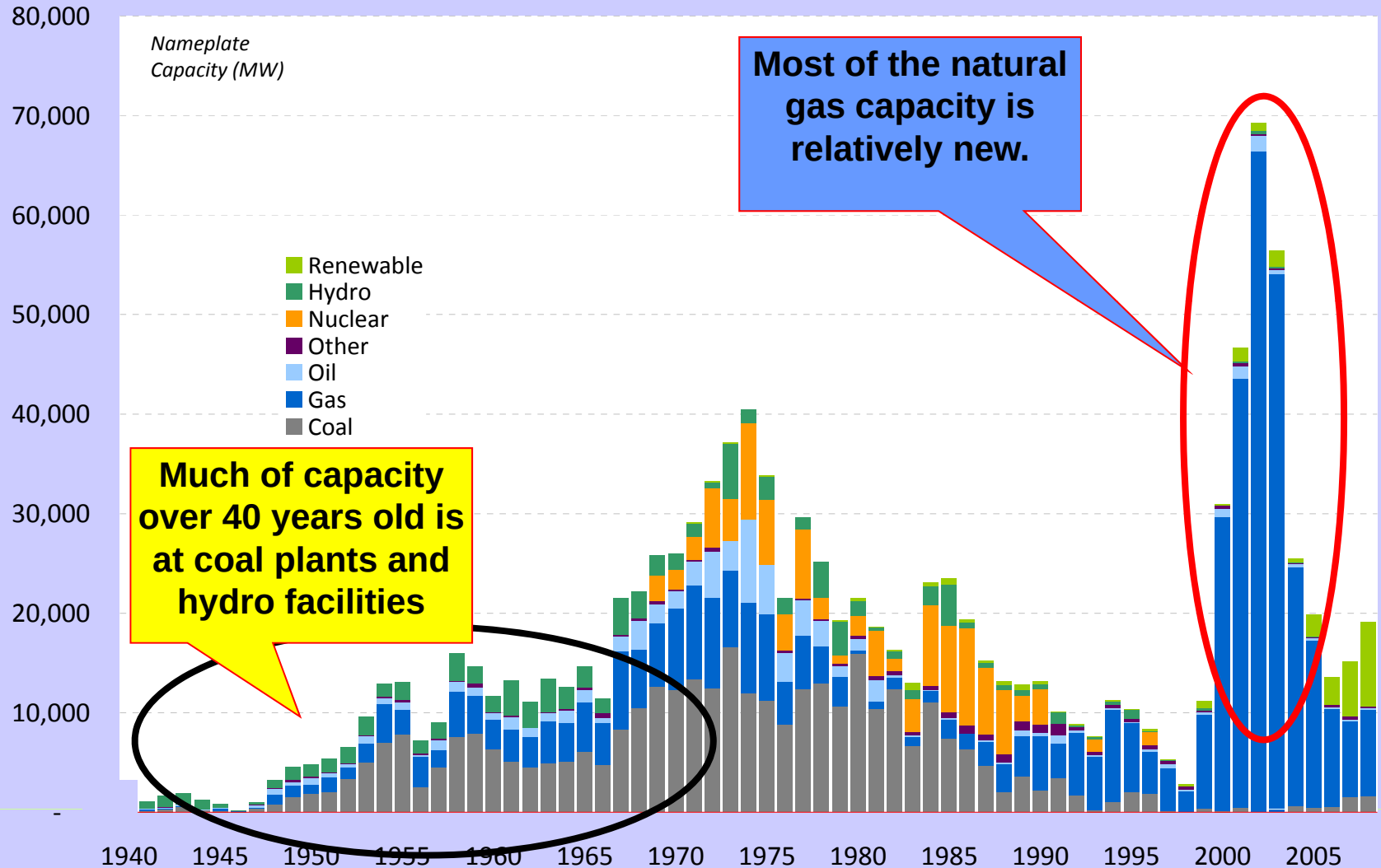
U.S. Generating Capacity – existing and proposed units (1995 – 2017)



August 2011

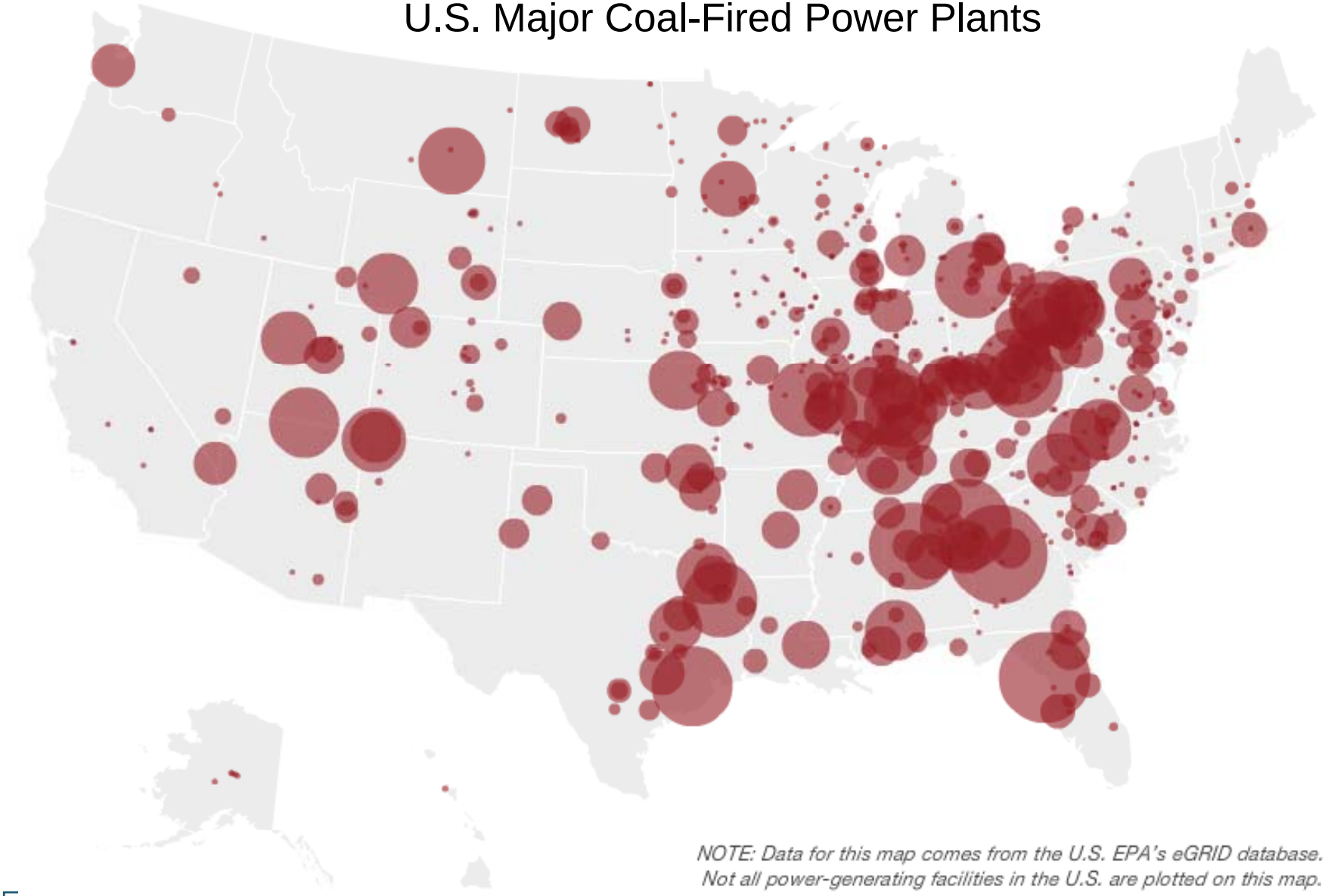
SNL data - Future capacity is based on actual planned/under construction projects, and not based on any projections of unreported new developments or retirements.

U.S. Power Plant Capacity Added By In-service Year



Source: Ceres, et al., Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States, June 2010.

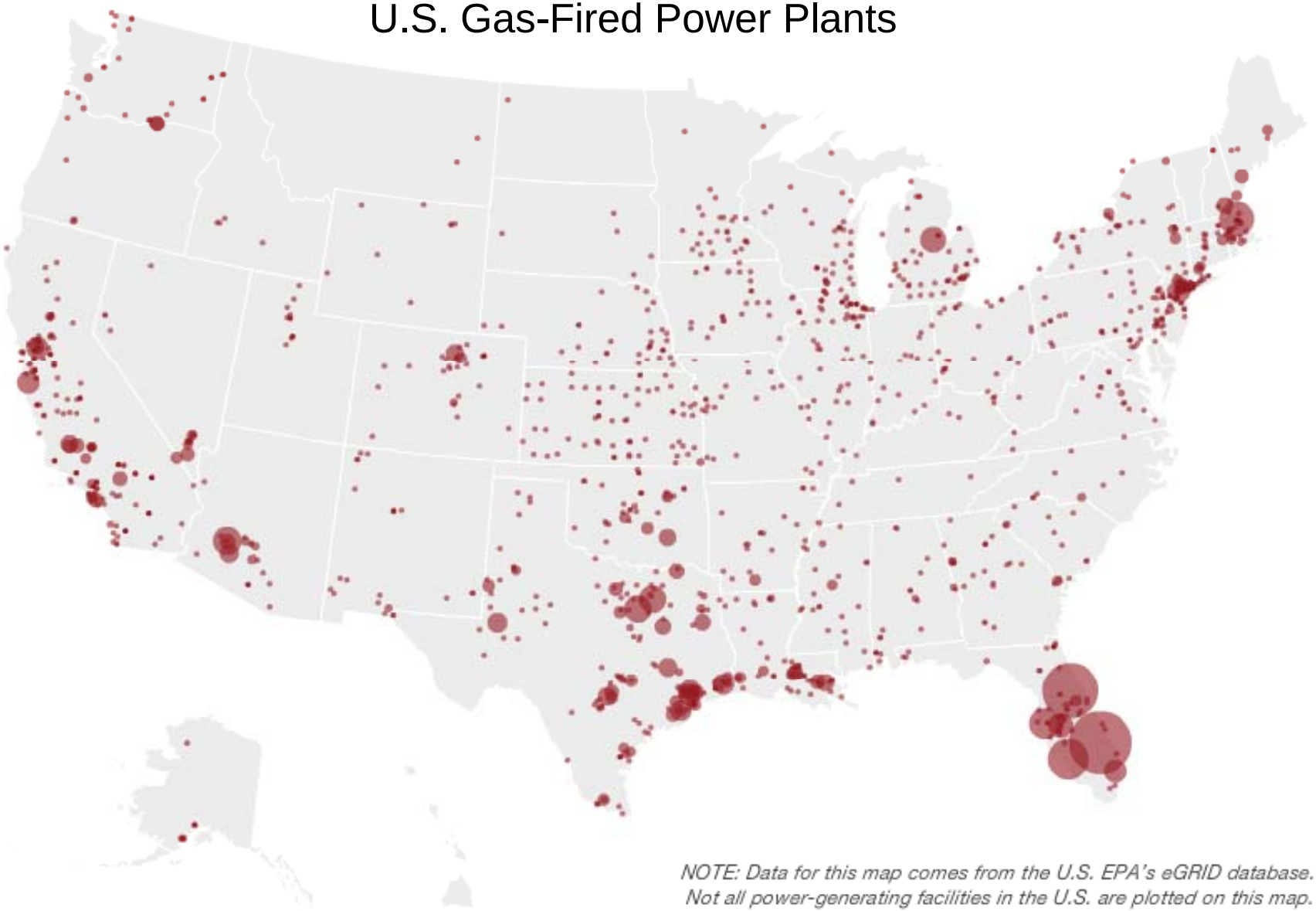
U.S. Major Coal-Fired Power Plants



NOTE: Data for this map comes from the U.S. EPA's eGRID database.
Not all power-generating facilities in the U.S. are plotted on this map.

Source: National Public Radio – http://www.npr.org/templates/story/story.php?storyId=110997398, based on information from: American Electric Power, American Wind Energy Association, Center for American Progress, Department of Energy, Edison Electric Institute, Energy Information Administration, Electric Power Research Institute, Federal Energy Regulatory Commission, National Renewable Energy Laboratory, Environmental Protection Agency, Western Resource Advocates

U.S. Gas-Fired Power Plants



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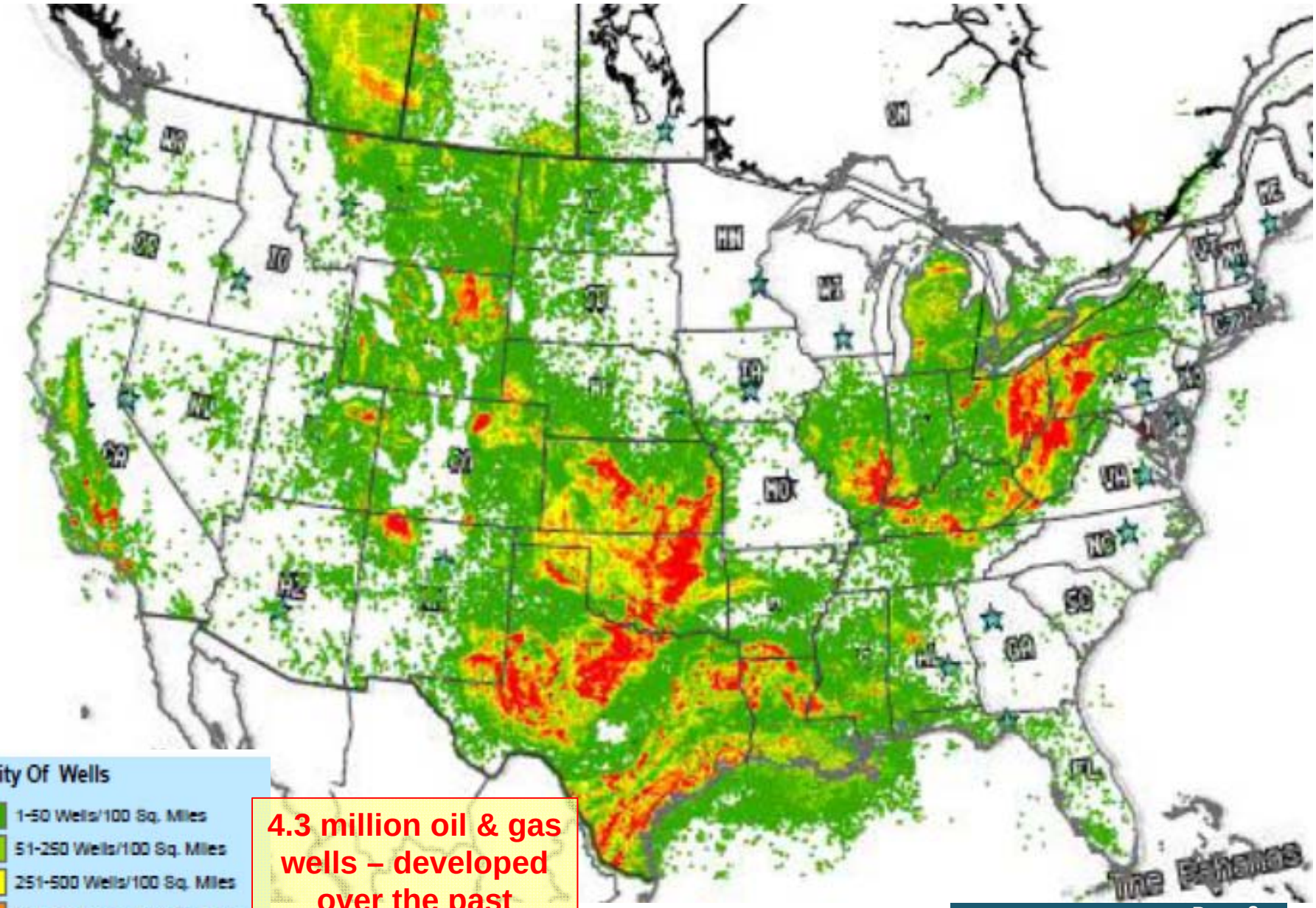
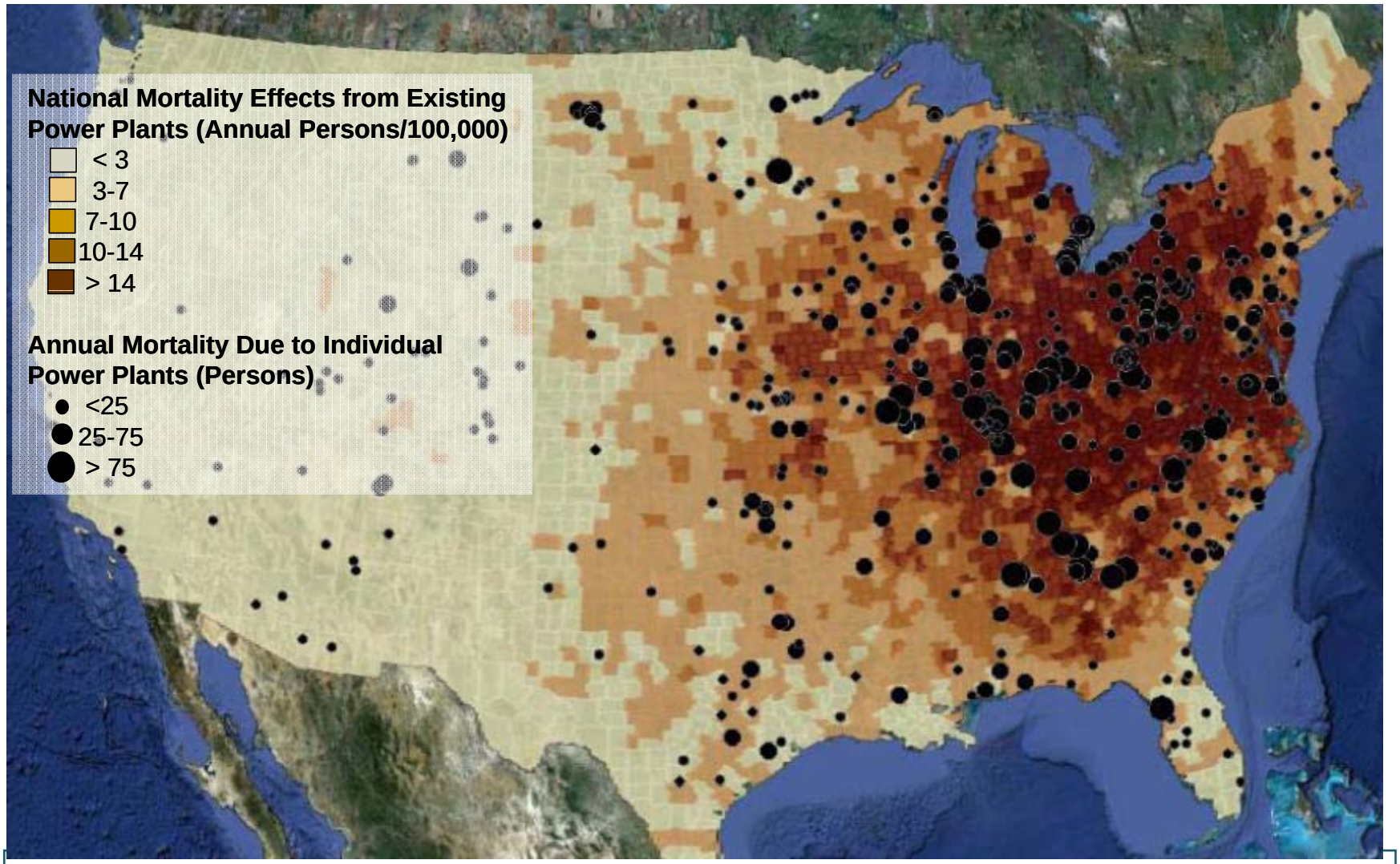


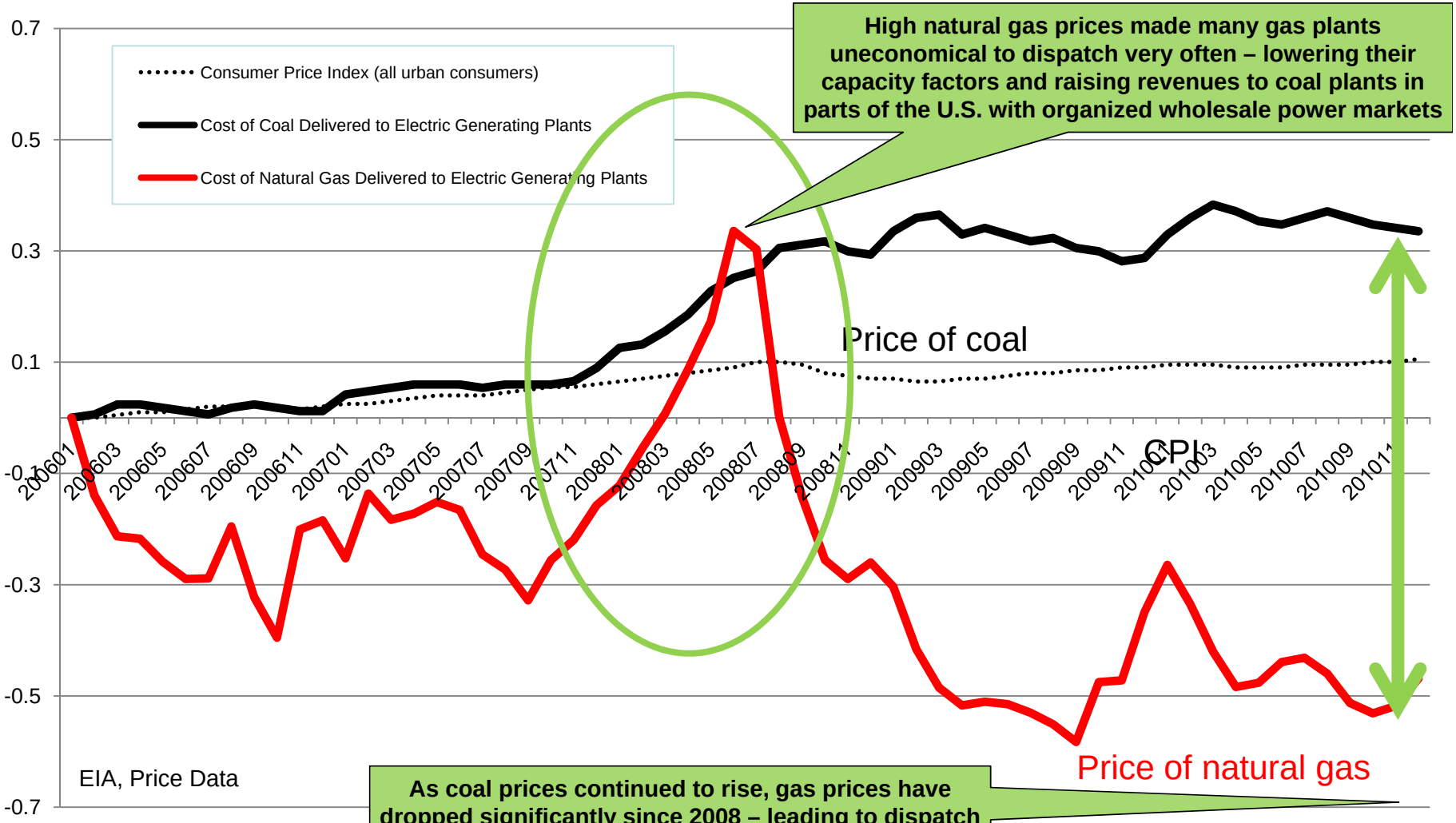
4.3 million oil & gas wells – developed over the past century

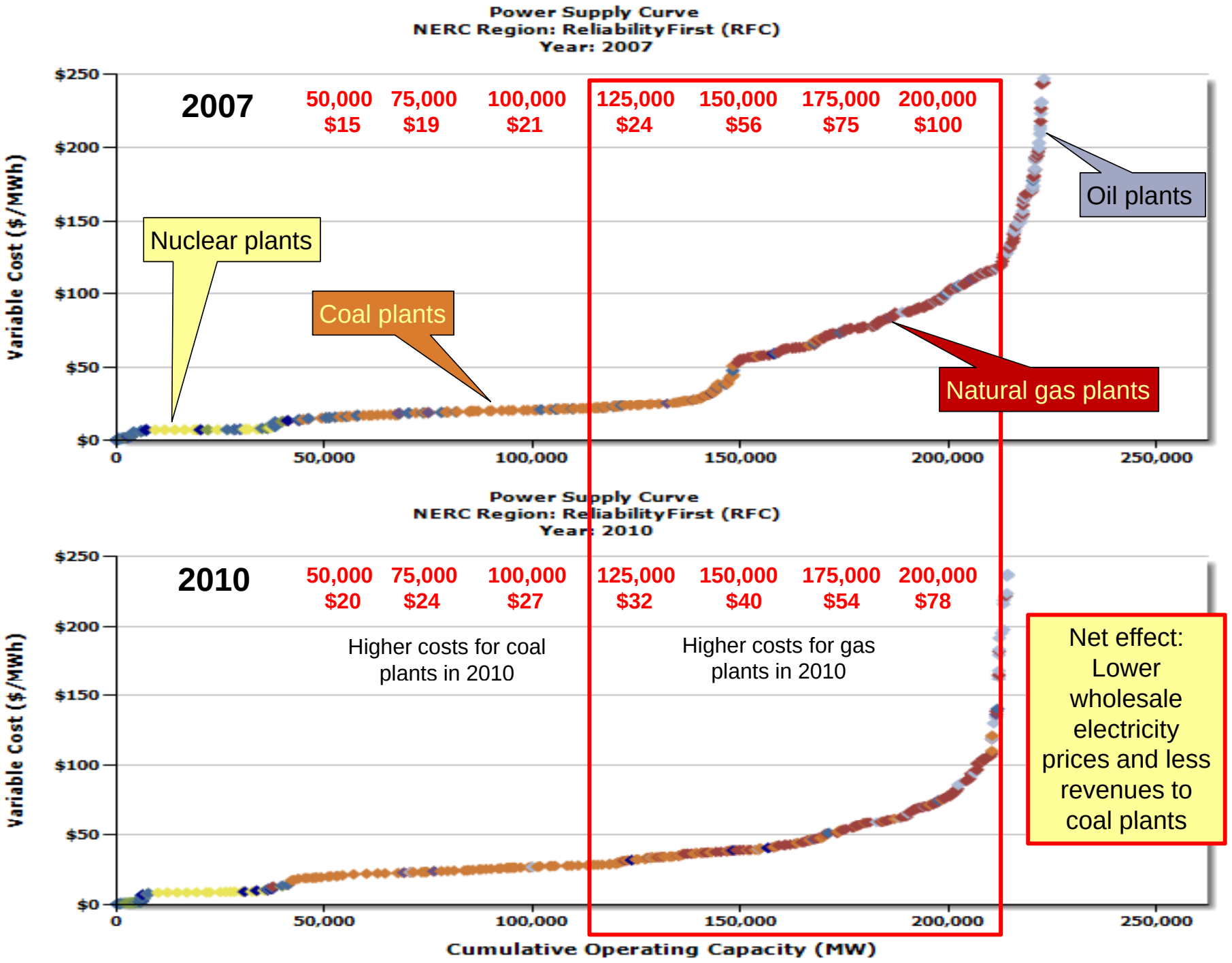
Impacts from electricity produced at coal power plants



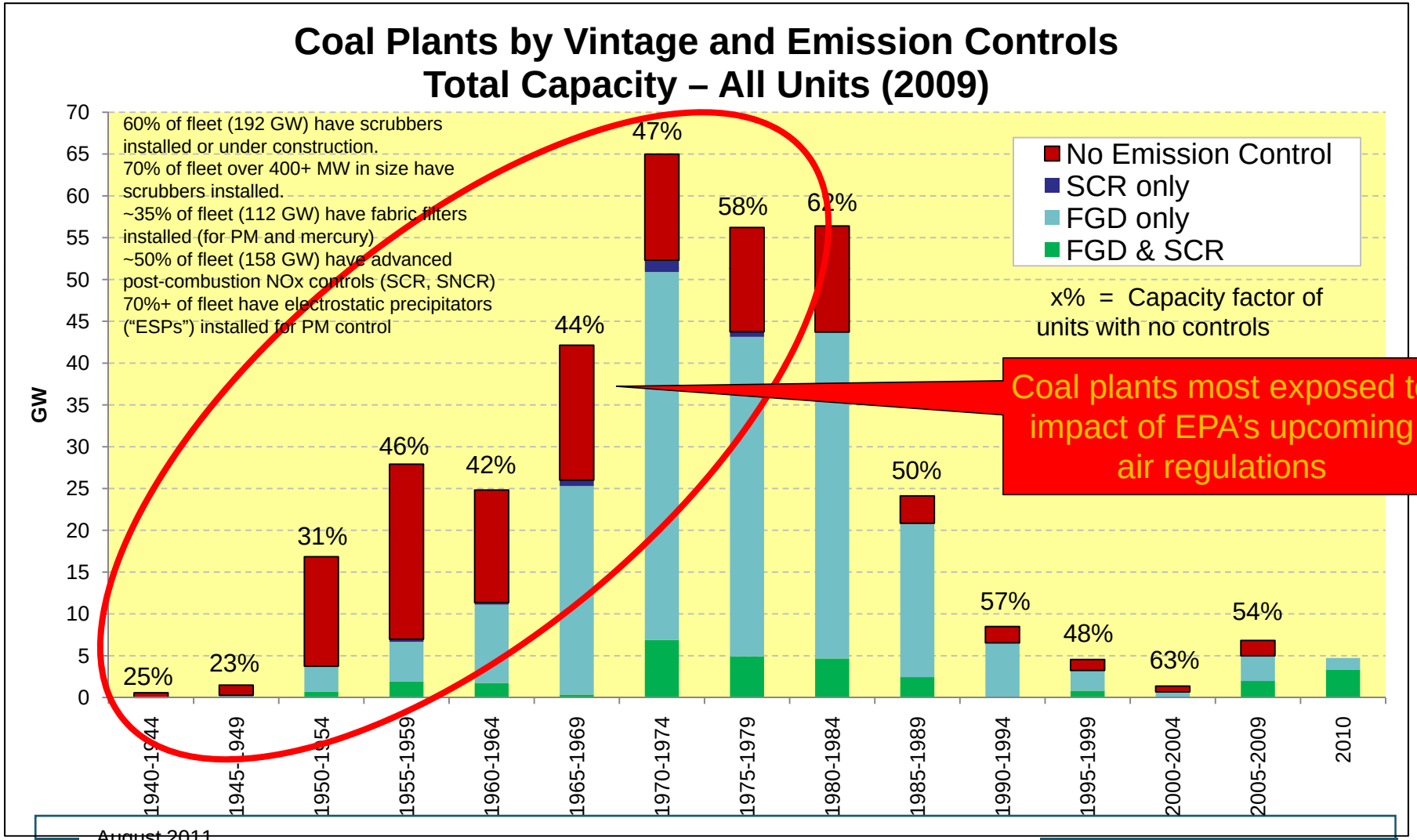
Clean Air Task Force, "Toll from Coal," 2010 (Google Maps programs)

Price of Coal v. Natural Gas v. CPI (2006 – 2011)




Power Supply Curve
NERC Region: ReliabilityFirst (RFC)
Year: 2007
2007
50,000 $15
75,000 $19
100,000 $21
125,000 $24
150,000 $56
175,000 $75
200,000 $100
Nuclear plants
Coal plants
Oil plants
Natural gas plants
Variable Cost ($/MWh)
$250
$200
$150
$100
$50
$0
0
50,000
100,000
150,000
200,000
250,000
Power Supply Curve
NERC Region: ReliabilityFirst (RFC)
Year: 2010
2010
50,000 $20
75,000 $24
100,000 $27
125,000 $32
150,000 $40
175,000 $54
200,000 $78
Higher costs for coal plants in 2010
Higher costs for gas plants in 2010
Net effect: Lower wholesale electricity prices and less revenues to coal plants
Cumulative Operating Capacity (MW)

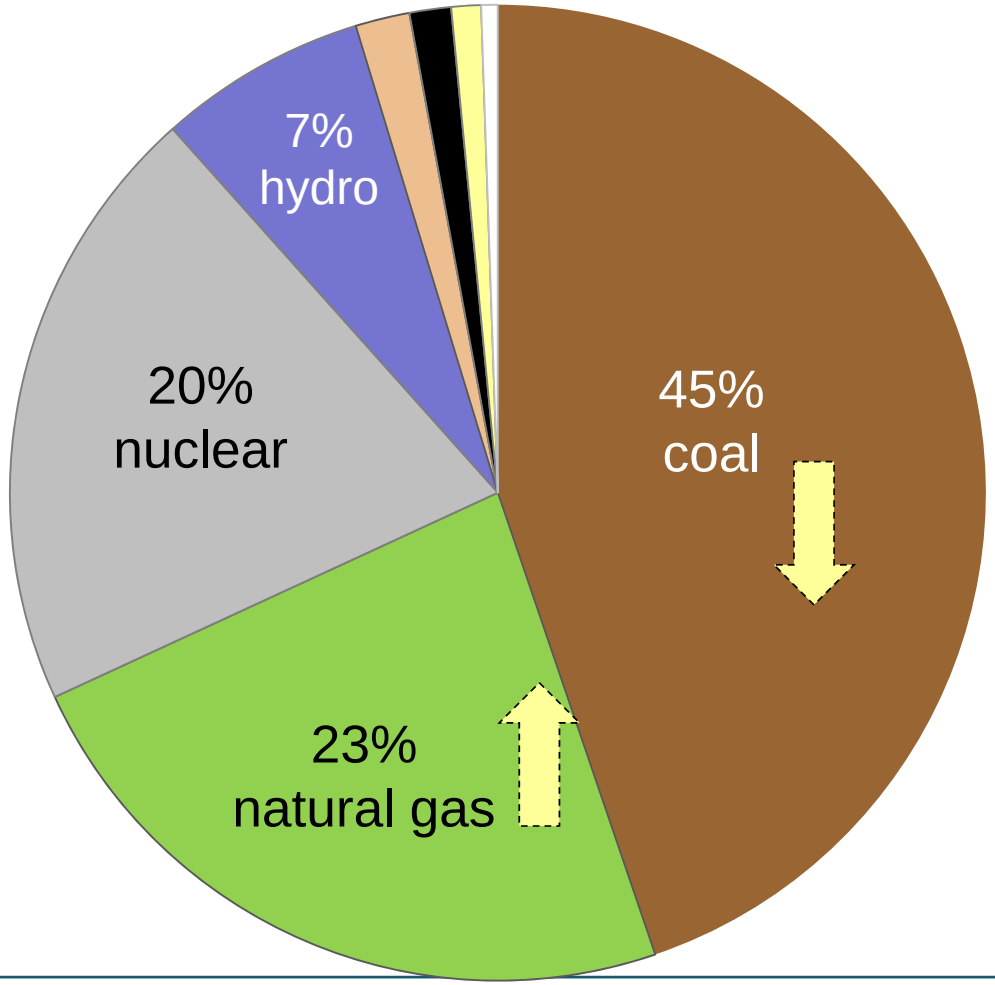
Older coal plants have fewer air-pollution controls and operate less



Notes:[1] Totals do not include Alaska or Hawaii. Source: SNL data.

U.S. generation – 2009

In the past few years, coal has dropped from 50% of electricity production.

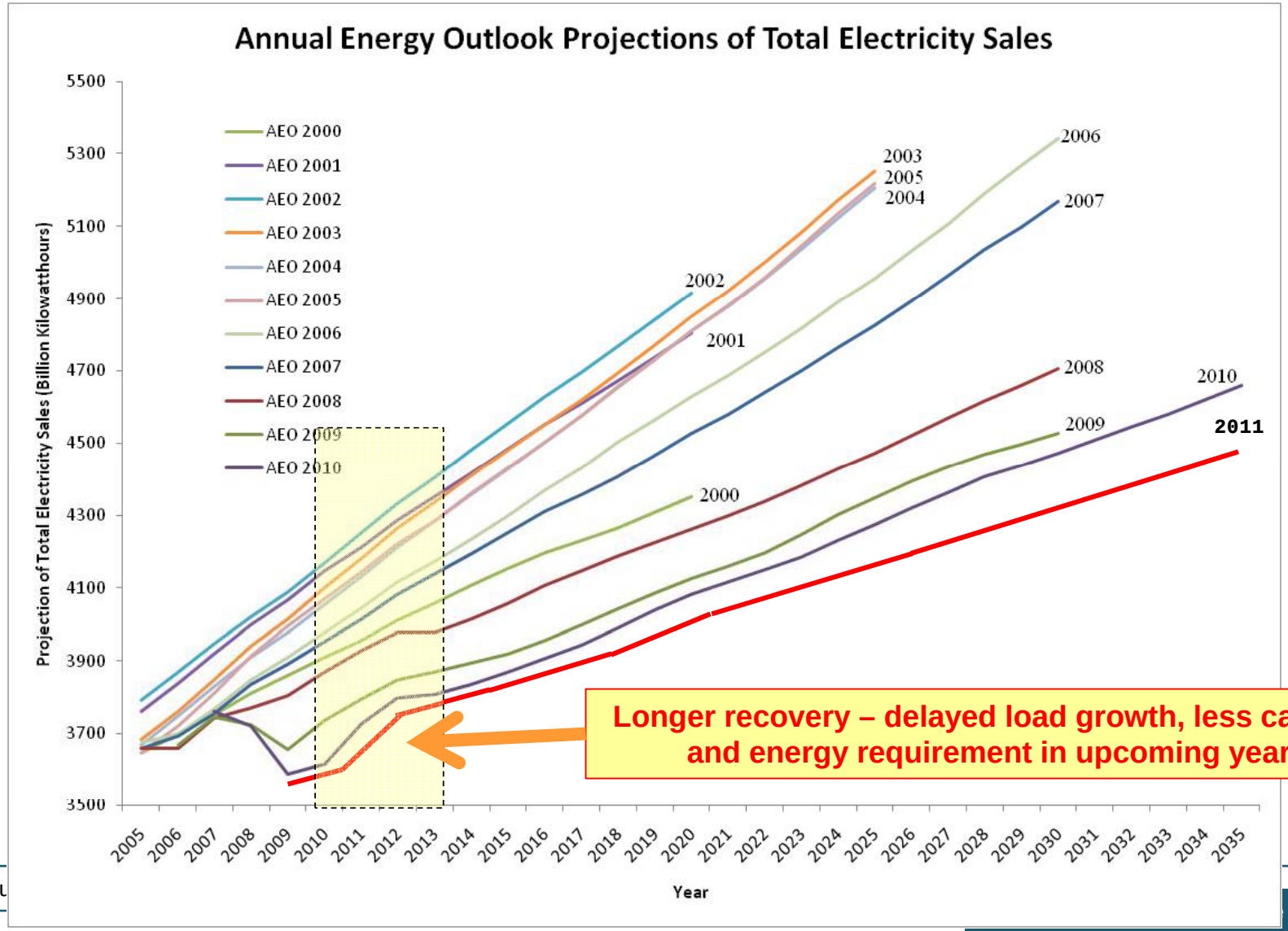


- coal
- natural gas
- nuclear
- conventional hydro
- wind
- biomass
- oil
- Other

source: EIA

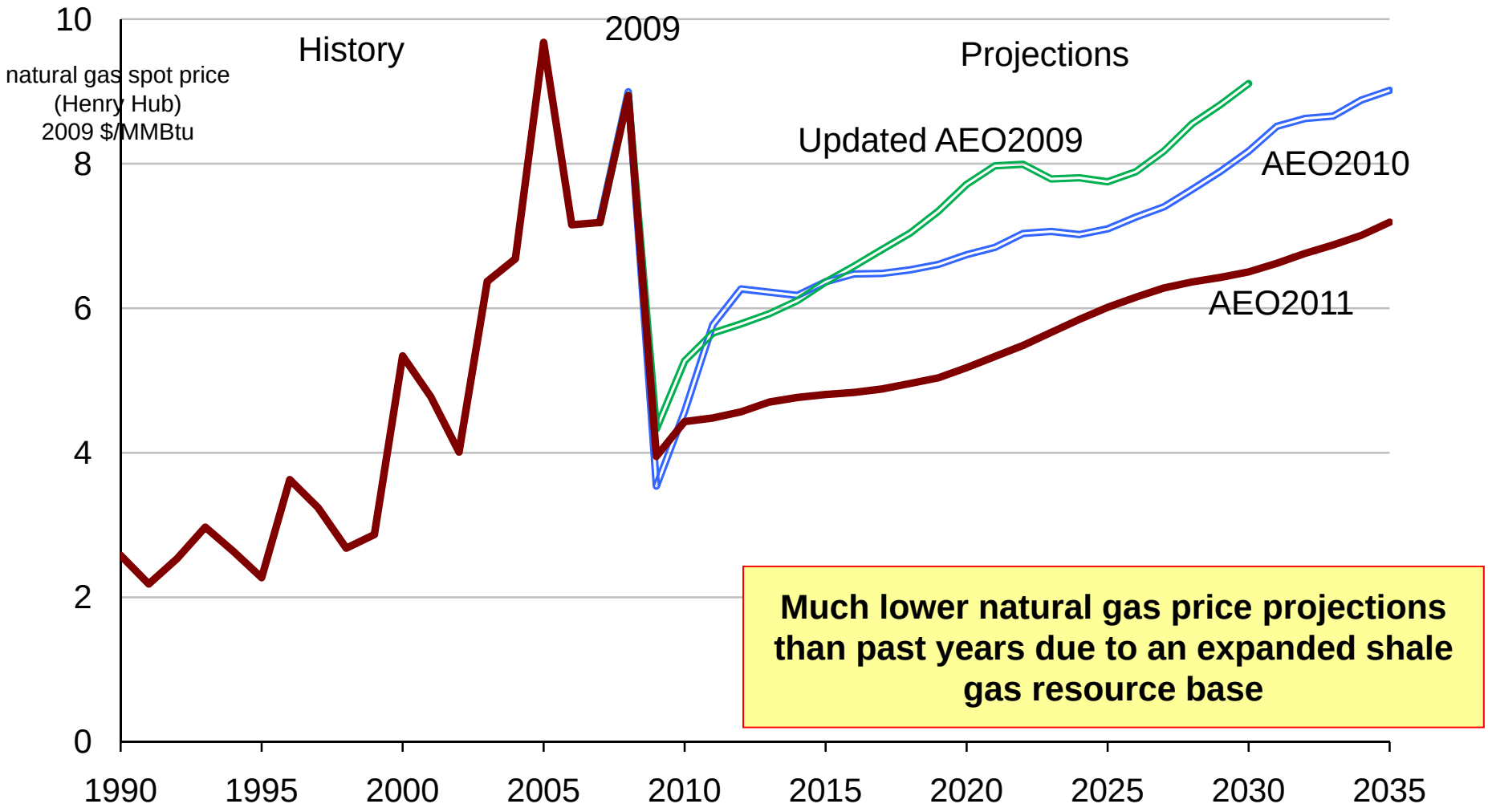
SOME "WHAT IFS" FOR THE UPCOMING GENERATION INVESTMENT CYCLE

Timing of the economic recovery? Uncertain Loads



EIA, Annual Energy Outlooks (2000-2011)

Outlook for natural gas prices? Lowered over time….

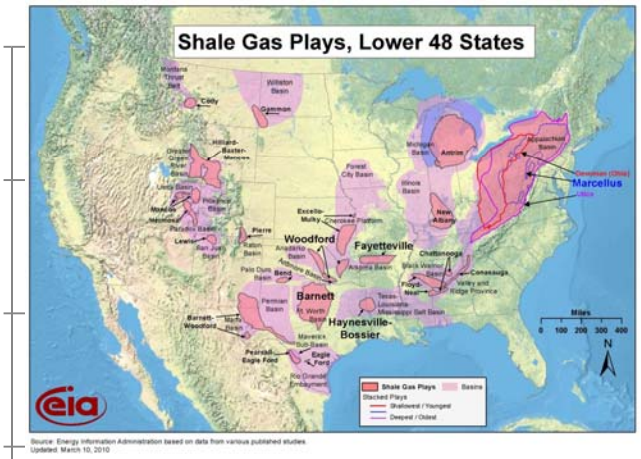


Much lower natural gas price projections than past years due to an expanded shale gas resource base

R. Newall, EIA, The Long-term Outlook for Natural Gas, presentation to the Saudi Arabia – United States Energy Consultation, February 2, 2011

How much natural gas is out there?

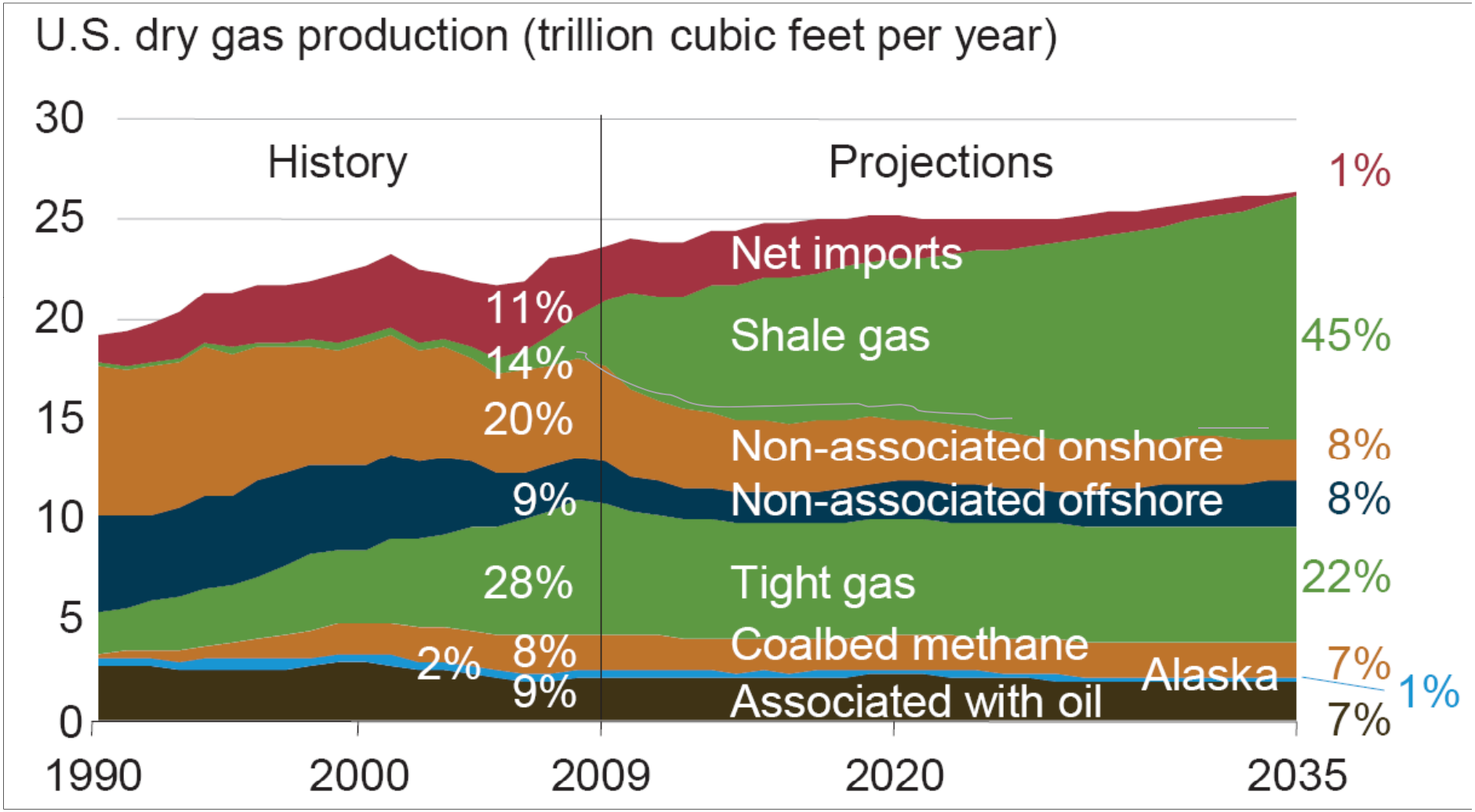
Changing estimates of the U.S. natural gas resources* 1999-2011



Shale gas – abundant resource

* Technically recoverable

Will natural gas continue on the upswing – but with lower prices?



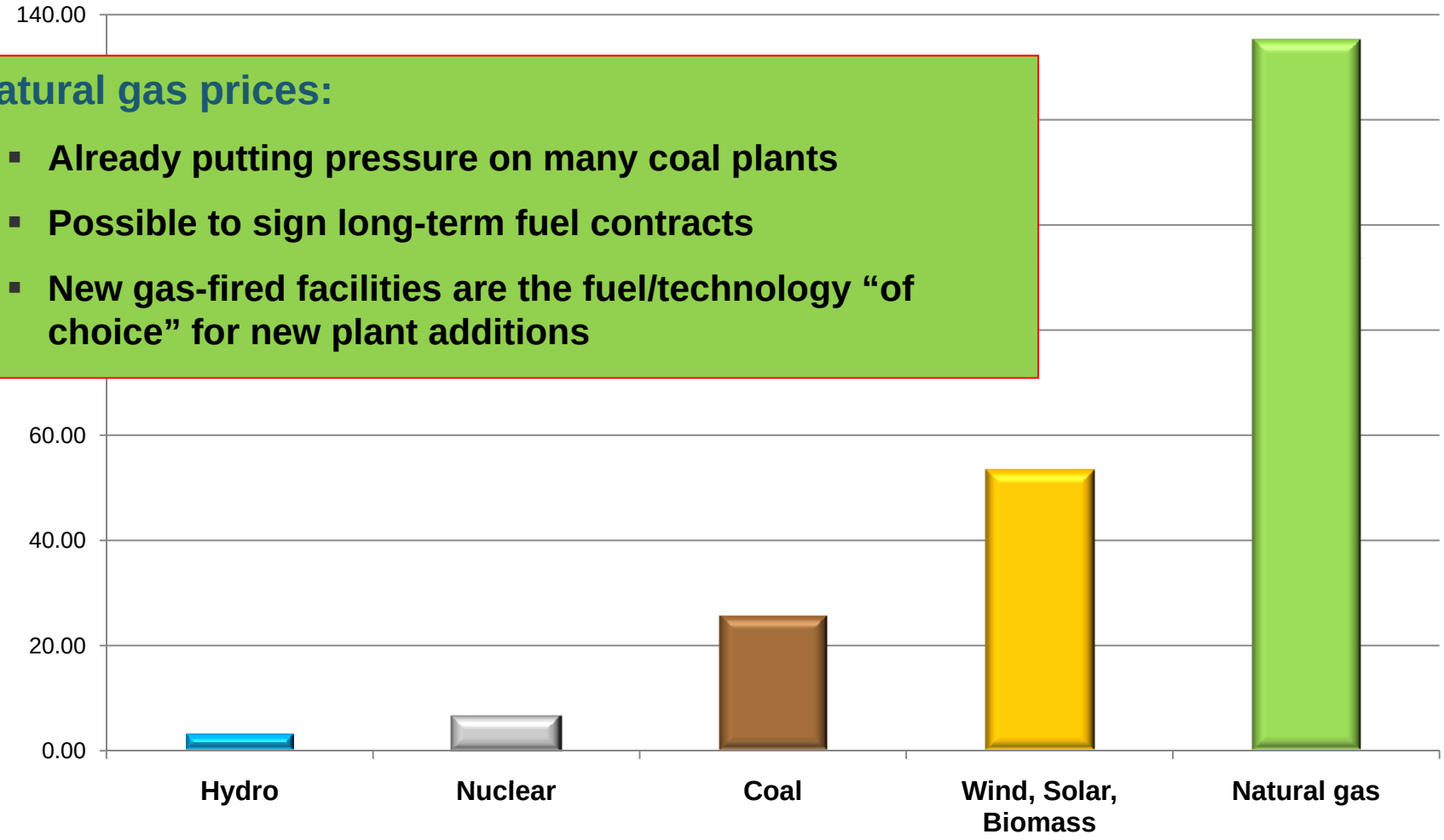
Source: EIA, Annual Energy Outlook, Early Release Overview,

How much new capacity will be based on gas?

EIA 2011: Estimates of Generating Capacity Additions (2011-2035)

Natural gas prices:

- **Already putting pressure on many coal plants**
- **Possible to sign long-term fuel contracts**
- **New gas-fired facilities are the fuel/technology "of choice" for new plant additions**

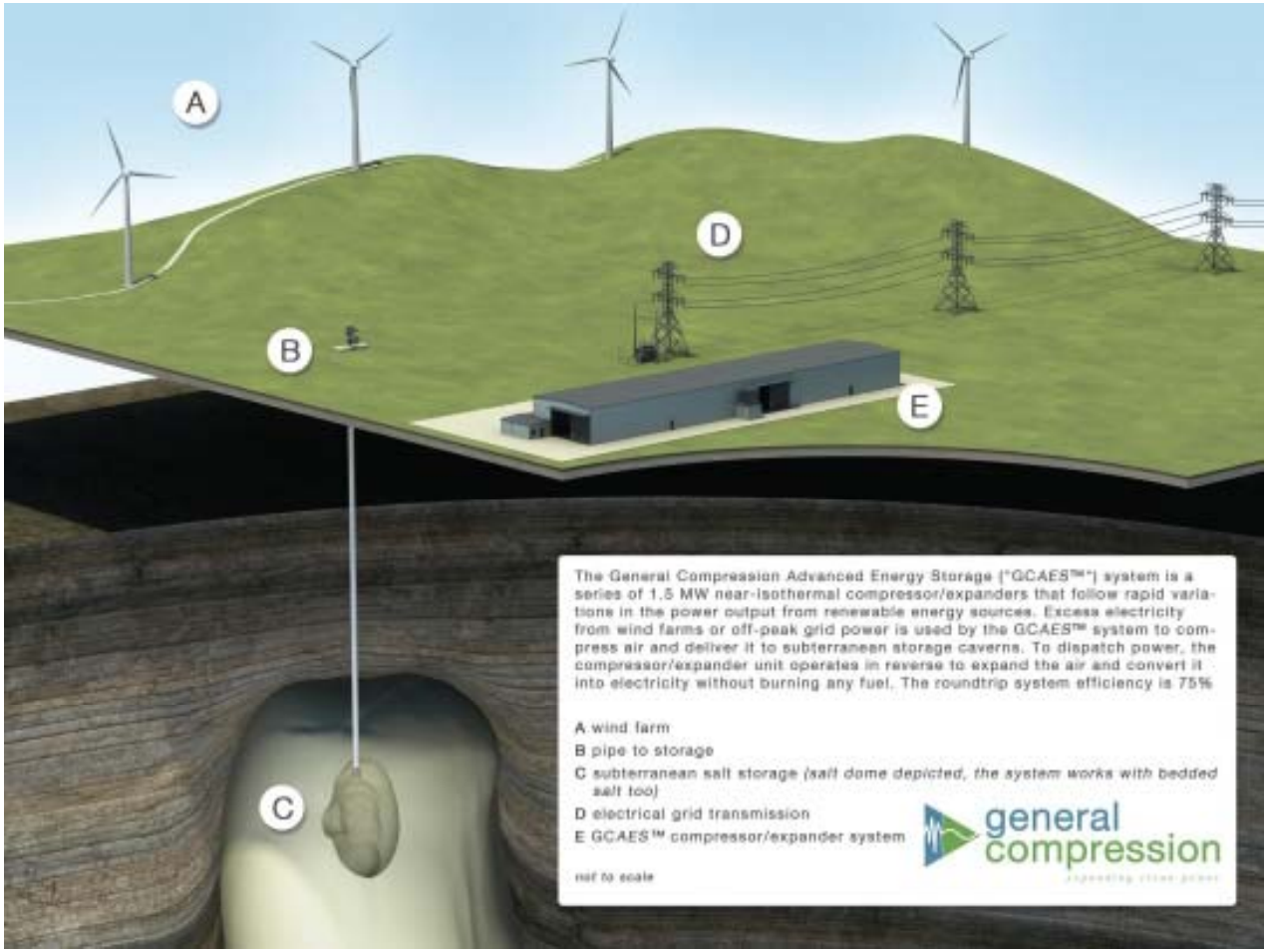


What if….. game changer technologies develop at scale?

For example:

General Compression's "compressed air energy storage" (CAES) system to store electric energy from wind….

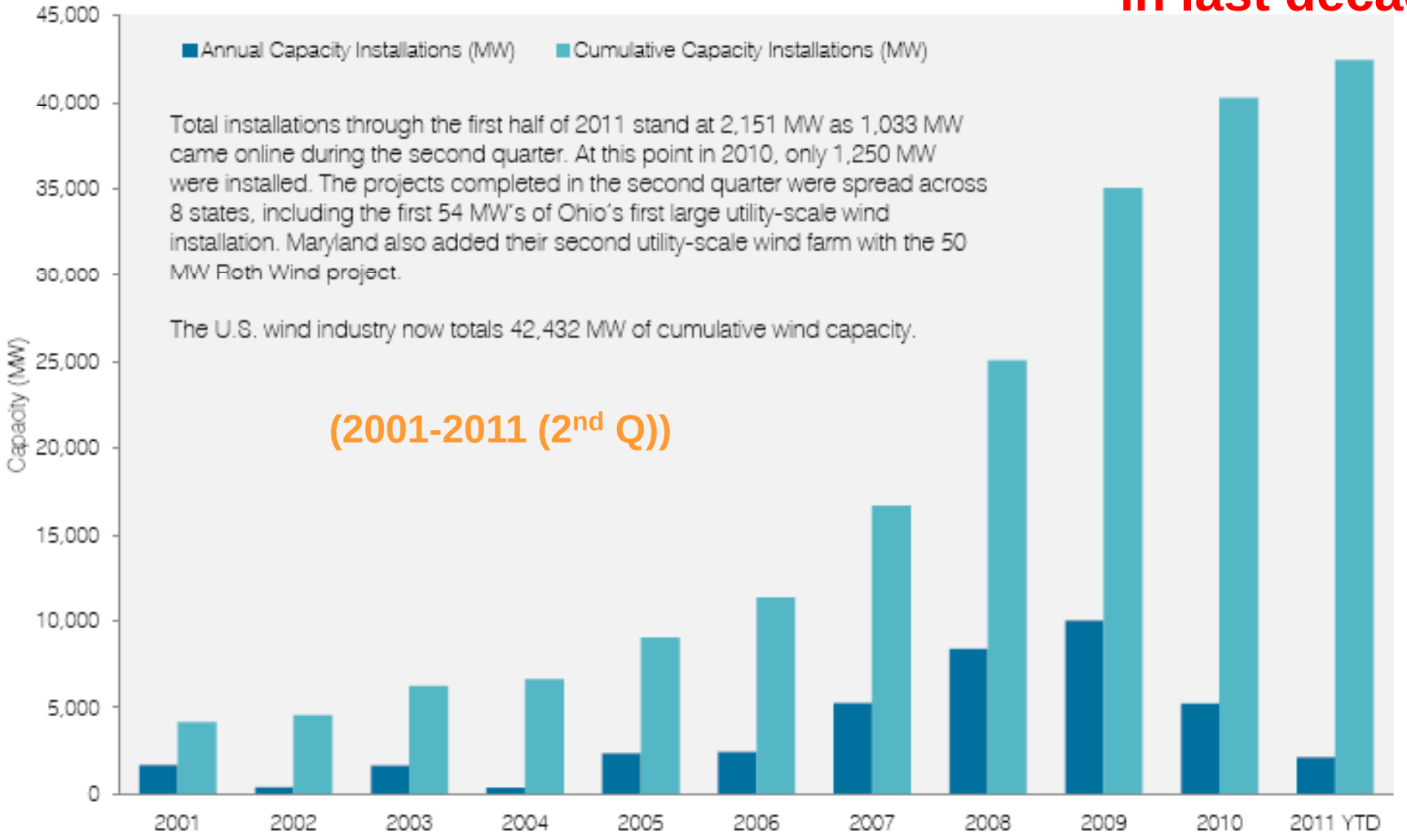
…. Do we need as much gas-fired generation?



http://news.cnet.com/8301-11128_3-20069772-54/start-up-pumped-for-compressed-air-wind-storage/

Continued growth in wind capacity?

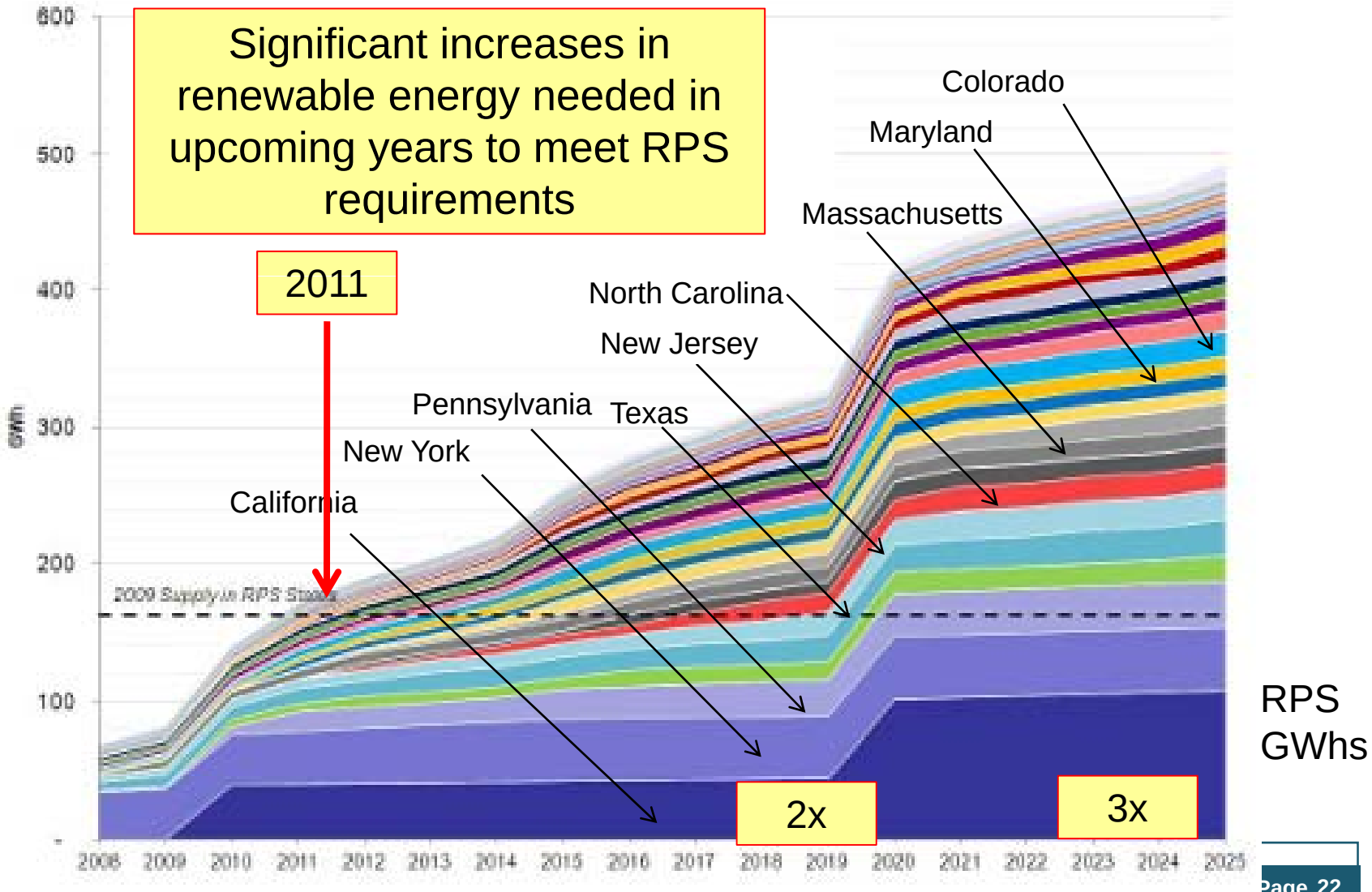
10x in last decade



August 2011

AWEA, 2nd Q 2011 Market Report

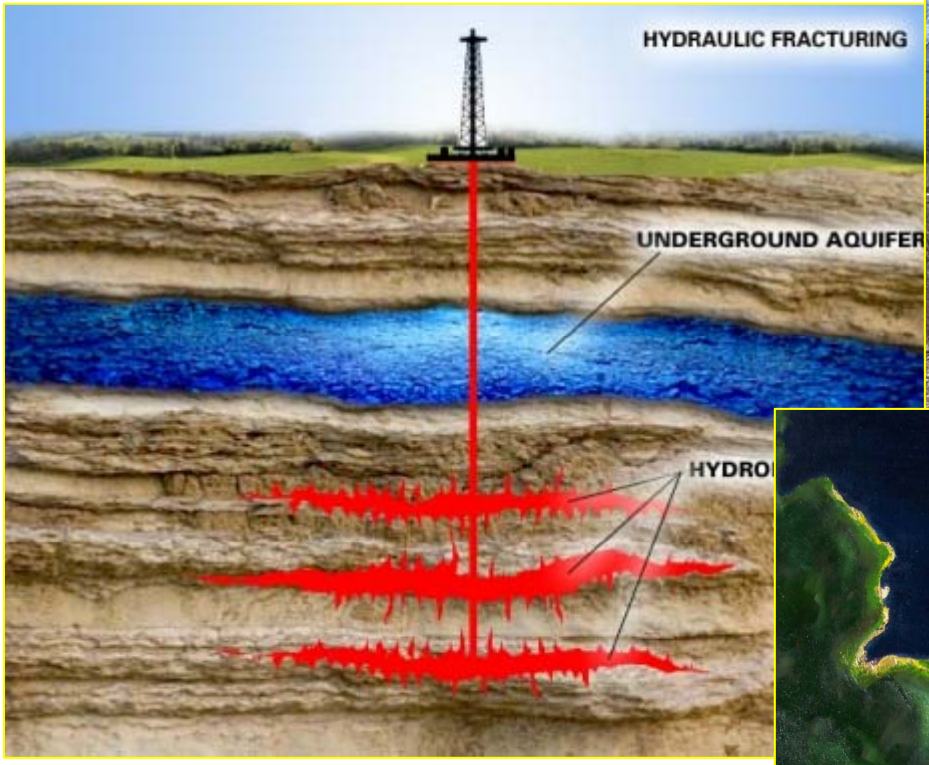
What if there's clean energy fatigue?

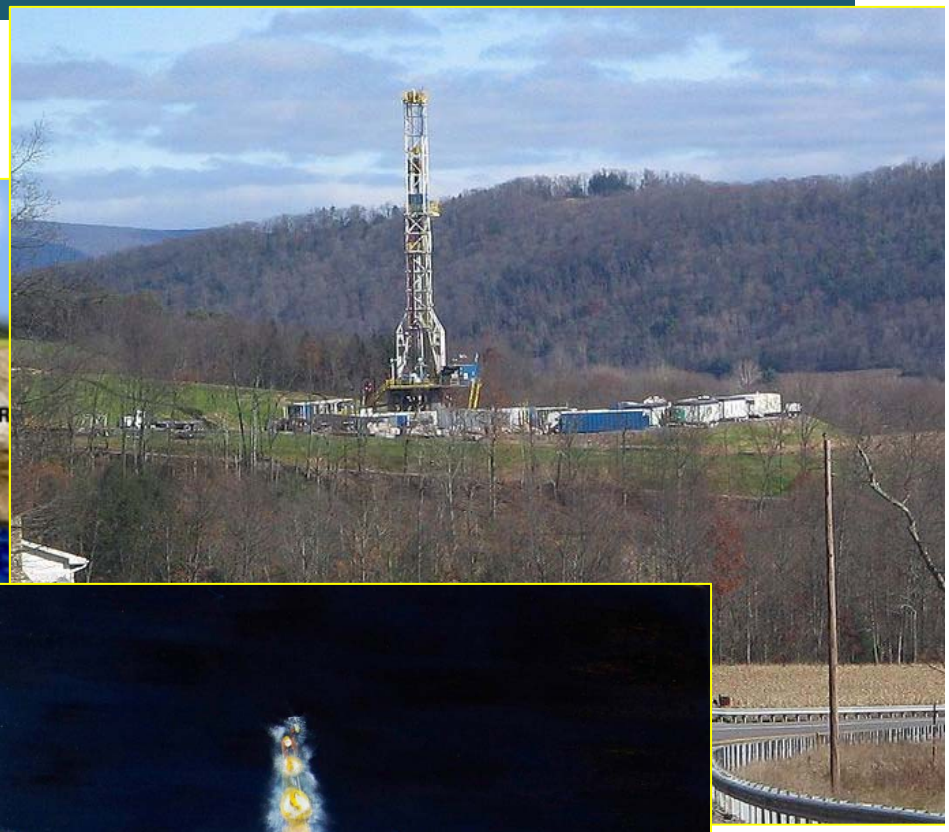


RPS GWhs

http://www.emerging-energy.com/content/press-details/State-RPS-Policies-Will-Drive-250-Increase-in-Renewable-Energy-Generation-by-2025/32.aspx

What if public concerns shut off shale gas extraction…?

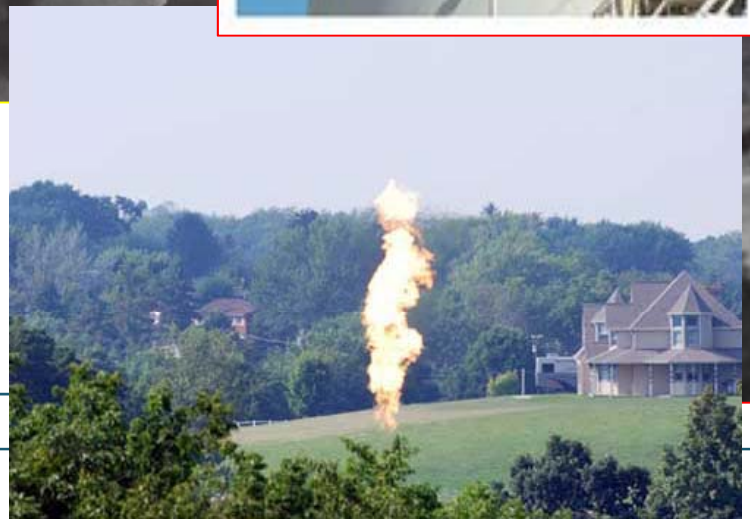




http://www.commodities-now.com/news/power-and-energy/2158-strengthens-us-shale-gas-position.html;
http://www.rockinggrannyfineart.com/the_gold_paintings.htm

What if we discover troublesome news about GHG emissions from natural gas* – in addition to coal?

* On a full fuel life cycle basis



A brief aside:
90-Day Report of the Shale Gas Subcommittee* - SEAB

Subcommittee charge

- **Focus on steps to improve the safety and environmental performance of shale gas extraction – but not about regulatory policy *per se***

Recommendations (August 11, 2011)

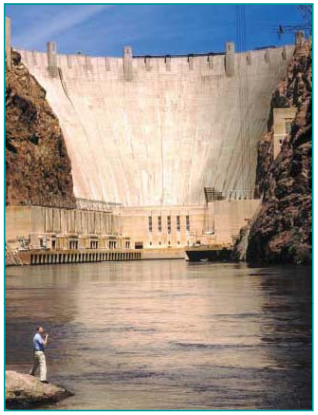
- **<u>Make information about shale gas production operations more accessible</u> – through disclosure, data access**
- **<u>Immediate actions to reduce env'l and safety risks</u> – through reducing air emissions, examination of GHG footprint, systematic water management and track, conducting field studies of methane leakage into water systems**
- **<u>Creation of a shale gas industry organization</u> committed to sharing and continuously improving best operating practice (e.g., on well integrity, limiting water use by controlling factures)**
- **<u>R&D to improve safety and env'l performance</u> – on fracturing, seismic, chemical interactions, green fluids, improved cementing and pressure testing**

*** Members: John Deutch (chair), Steven Holditch, Fred Krupp, Katie McGinty, Sue Tierney, Mark Zoback, Dan Yergin**

What if every energy production source has risks, concerns, challenges – but opposition to each makes each one toxic politically?

Nuclear

Wind



Hydro

Transmission

Oil

Solar PV

Natural Gas

Coal

Efficiency

CCS

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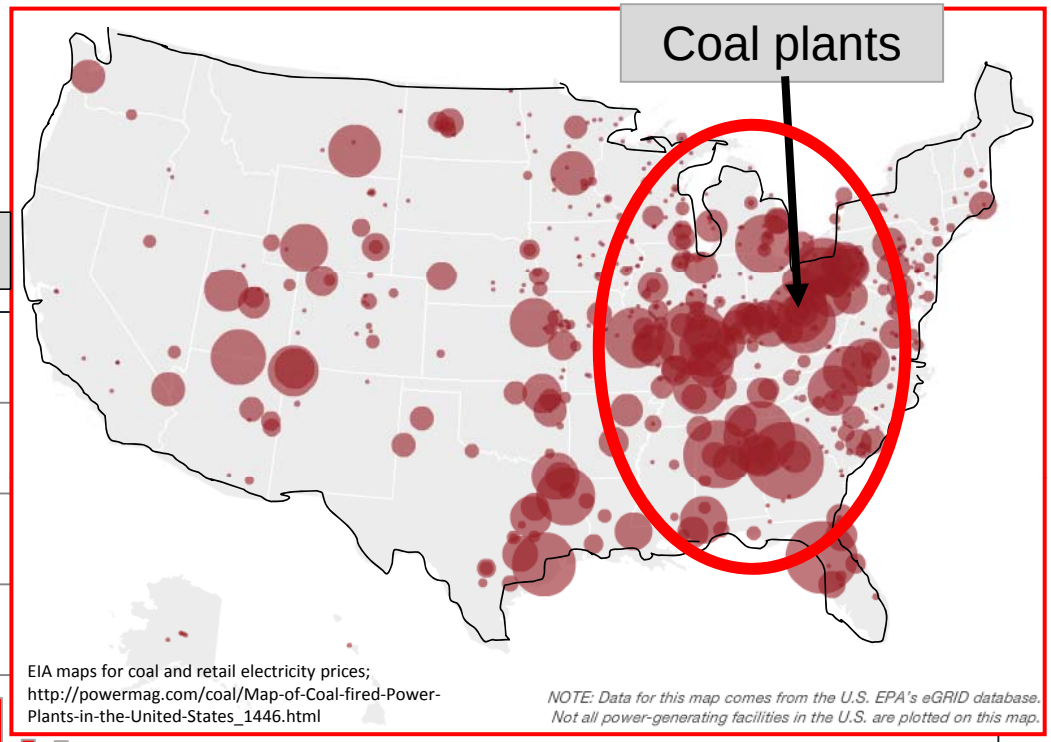
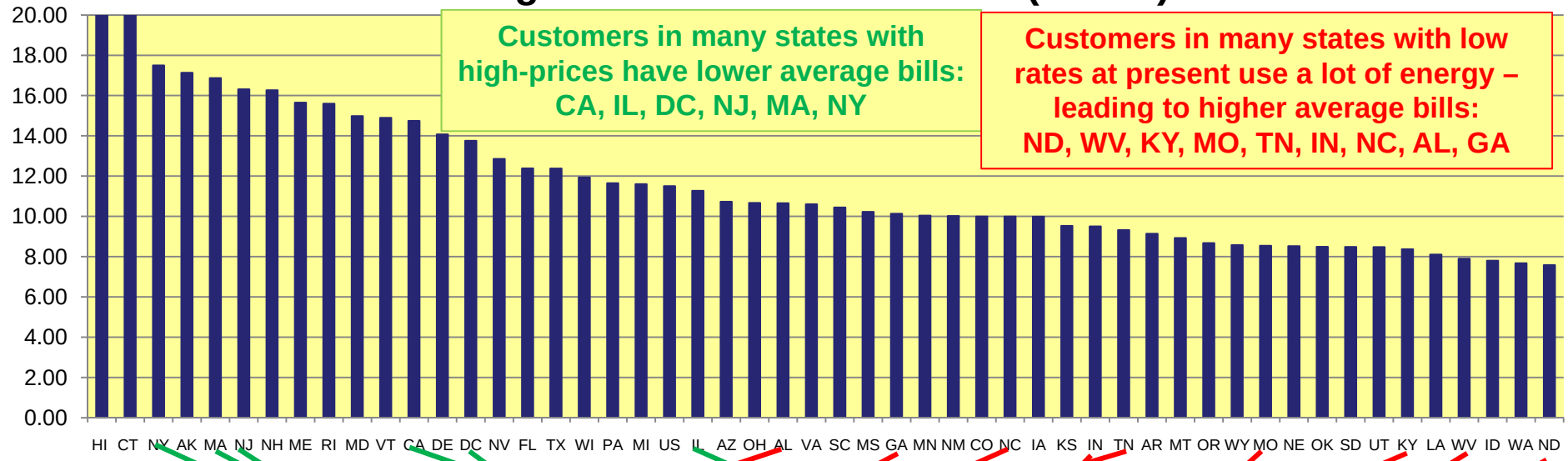
What if electricity prices rise in coal country?



In general, lower electricity prices

In general, higher electricity prices

Average Retail Price Residential (c/kWh)

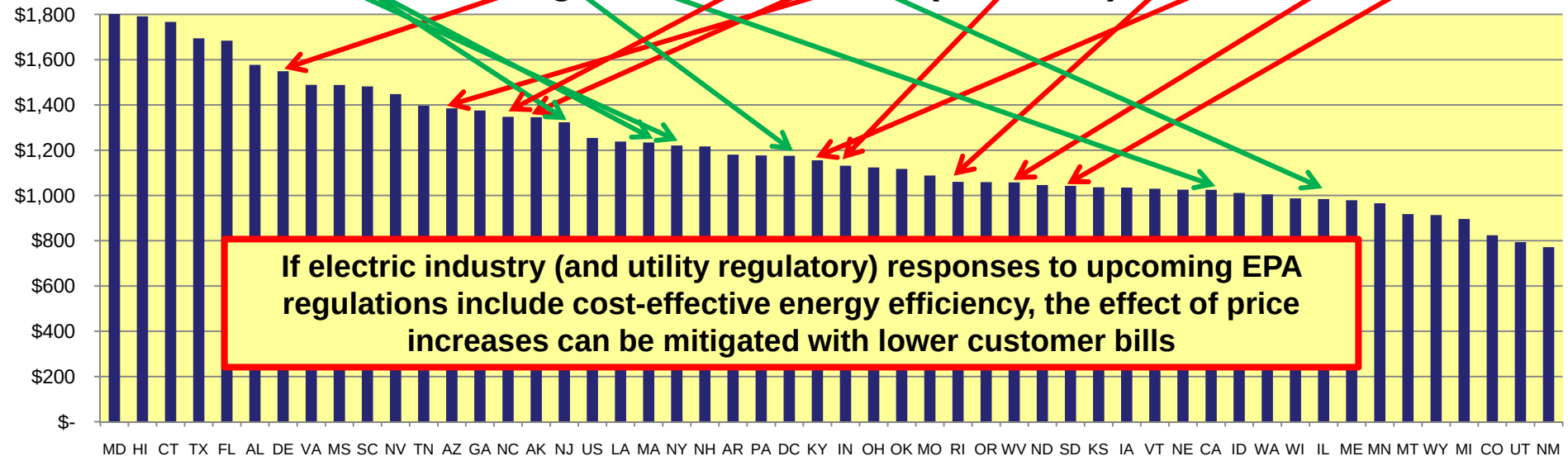


Customers in many states with high-prices have lower average bills: CA, IL, DC, NJ, MA, NY

Customers in many states with low rates at present use a lot of energy – leading to higher average bills: ND, WV, KY, MO, TN, IN, NC, AL, GA

EIA data (2010)

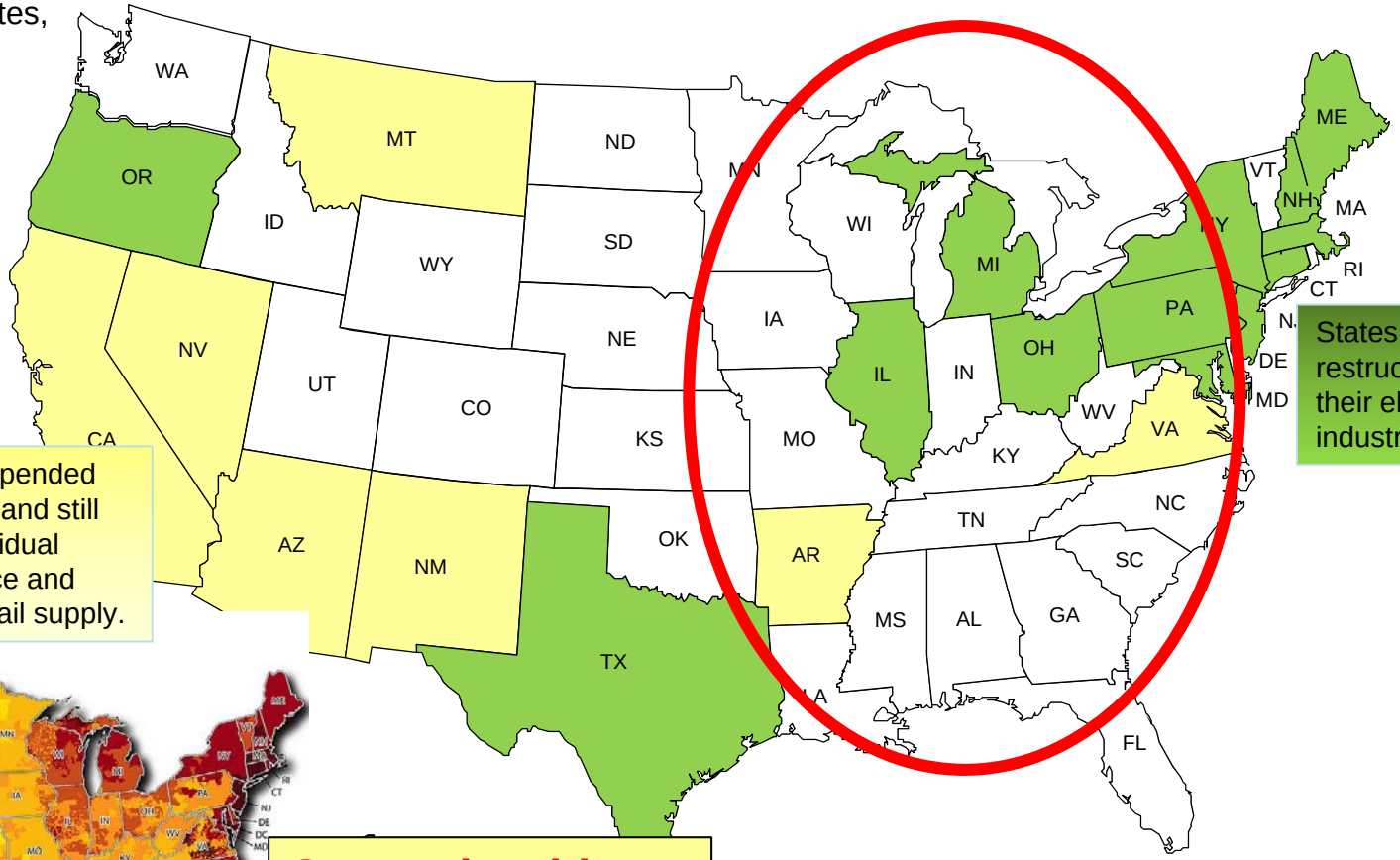
Average Bill - Residential (Annual $)



If electric industry (and utility regulatory) responses to upcoming EPA regulations include cost-effective energy efficiency, the effect of price increases can be mitigated with lower customer bills

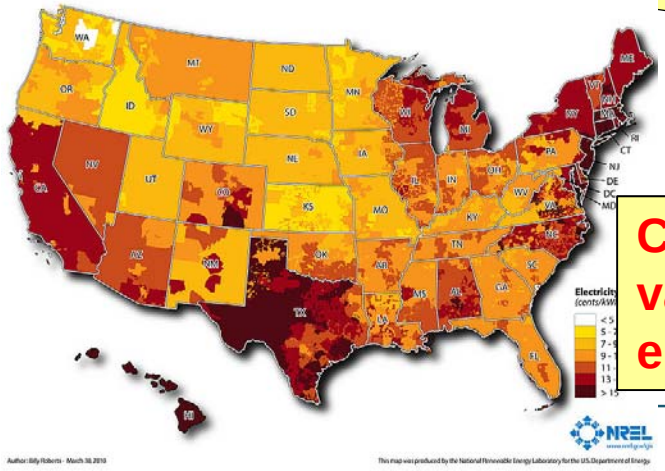
What if there's a new round of electric industry restructuring – based on rising generation prices?

Recall that in many states, pressure to restructure electric industry in the mid-1990s started with large industrial customers' concerns about electricity price increases (combined with their ability to self-generate to save money)



States that restructured their electric industry

States that suspended restructuring – and still have some residual customer choice and competitive retail supply.



Currently wide variation in retail electricity prices

Restructured states as share of U.S.:
= 34% of residential MWh sales
= 38% of commercial sales

Connecting some of the dots….

Upcoming capital investment cycle – adding/replacing generating capacity

Gas-fired generation: By far, the fuel/technology of choice –

- **Combined capital, fuel, operating costs, technology risk, financing, permitting advantages**
  - Except where federal and policy and resources support renewable investment – which face challenges going forward
- **Depends upon gas prices tied to shale gas production costs – and outlook for continuing access to the resource**
  - Which depends, in turn, on building greater trust on environmental, safety and health issues associated with shale gas extraction
- **Can help reduce GHG from current levels in power sector**
  - If lifecycle gas footprint is reduced for production and delivery of natural gas
  - But to go below 50% reduction in U.S. GHGs, need to address the emissions from gas-fired plants – which face risks from "silver bullet" shoot-outs (and potentially a new round of stranded costs in the future)….

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