Firming and Shaping Wind Power: Comparison of CAES and Conventional Natural Gas Power Plants within the National Energy Independence Plan

Presented By

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National Energy Independence Plan (NEIP)

Two Threats:

–Serial Unaffordability of Fossil Fuels within a Decade (Path A—Eliminate 28 Q-Btu of oil imports in 10 years);

–Climate Change before mid-century (Path B—Eliminate 86% of fossil fuel use before 2050).

NEIP Design around CAES/HVDC

- Synergy
- Models reflect price to energy user
- Self-funding: Electricity sales payoff debt
- Infrastructure-centric: CAES/HVDC essential
- Savings are enormous: ~$1 Trillion per year (most of savings from energy domestication)

Sample Choices

Included:

- Existing technology
- Light vehicle conversion, 13.4 Q-Btu of 28 Q-Btu
- 80% to 100% renewable energy penetration
- Wind and solar with lowest retail electricity price

Not included:

- "30% Wind by 2030" NREL Studies
- Wind classes below 4.5
- Distributed energy
- Offshore wind
- PHEV Storage

Macro View: CAES/HVDC

CAES/HVDC infrastructure permits:

- **Eliminate need to import oil within ten years;**
- **True energy independence;**
- **Savings of about $1 trillion per year.**

Not possible without CAES.

Can CAES be "*too expensive*"?

www.NEIPlan.org

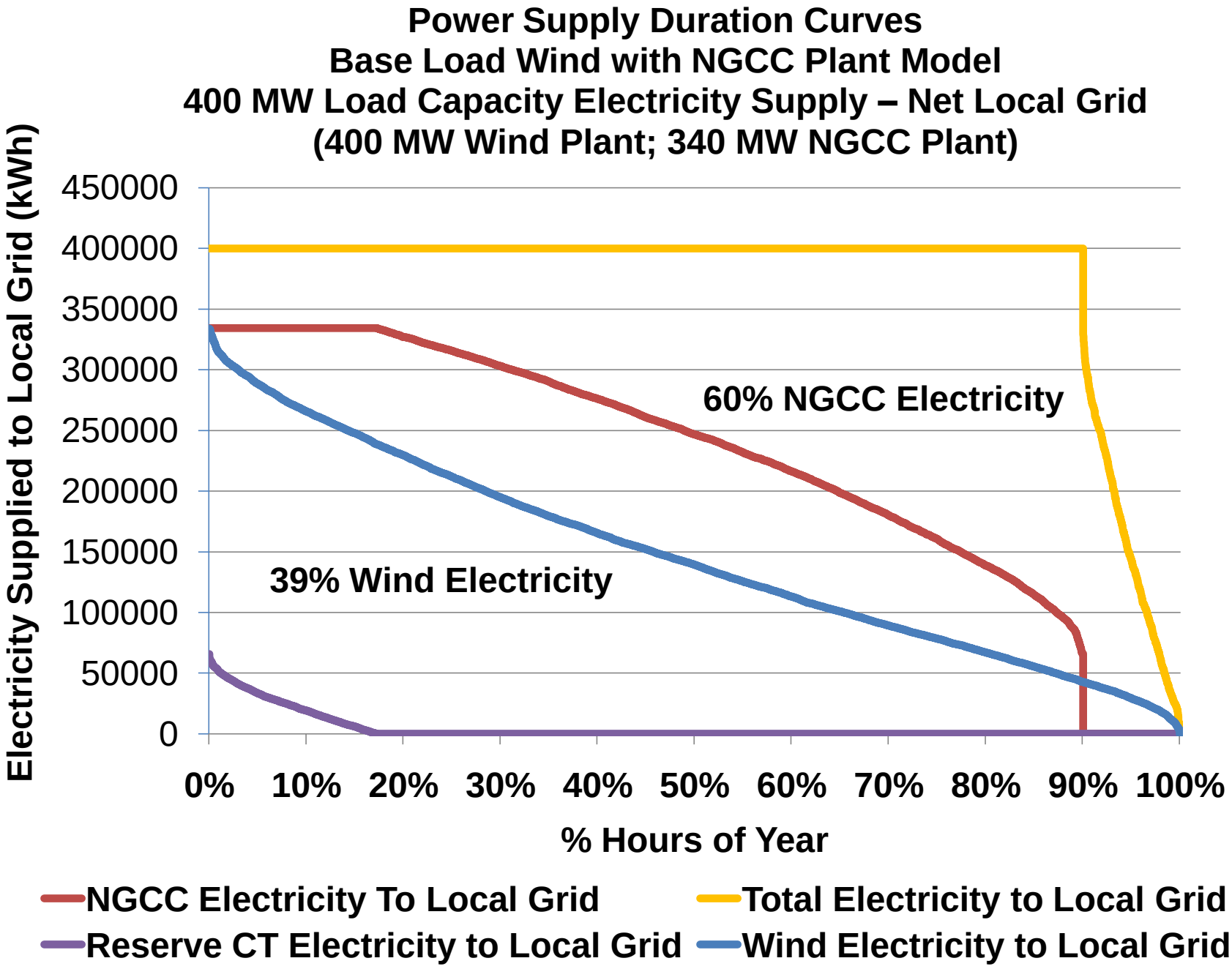
Research Question

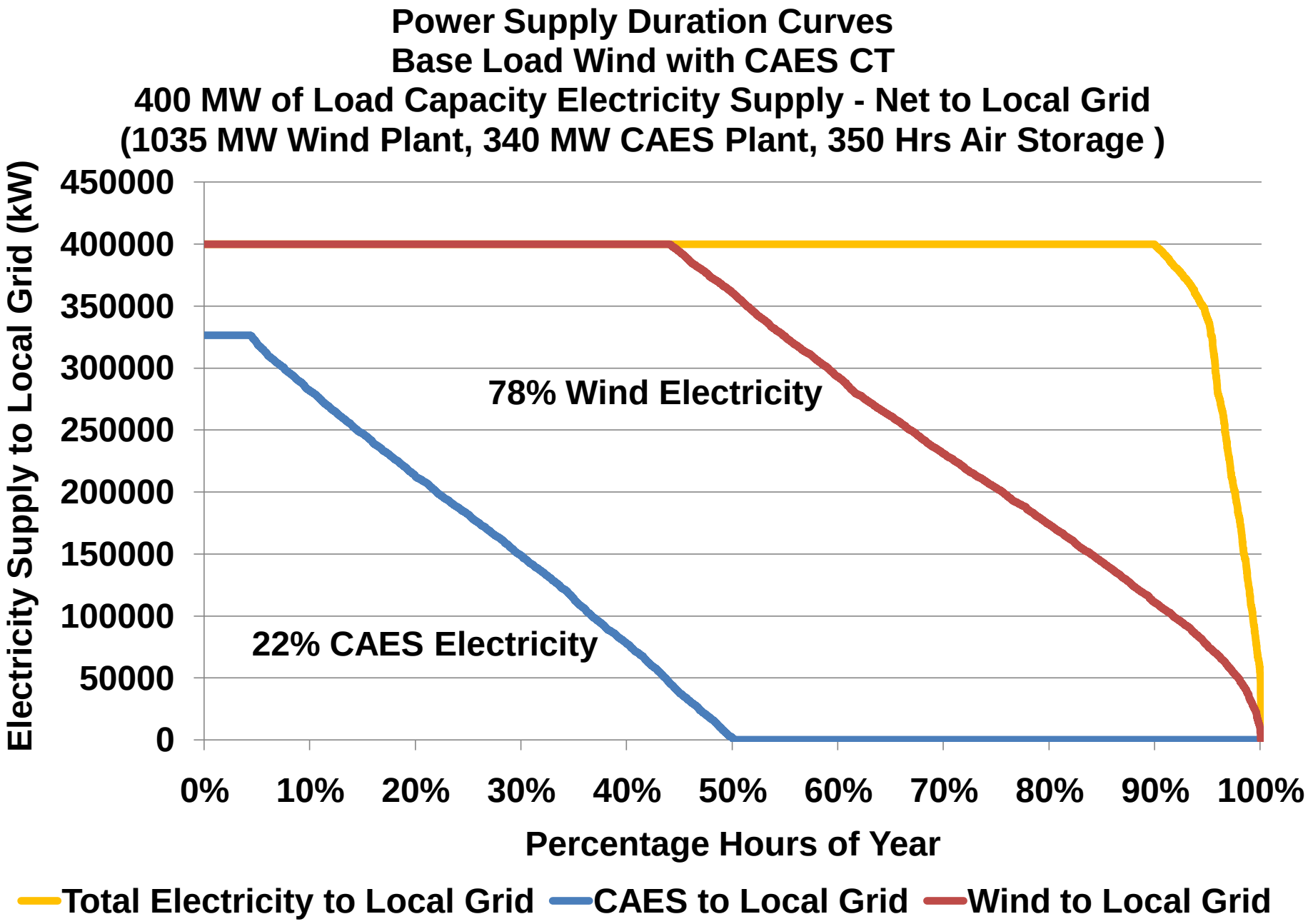
Can the added capital costs of CAES be justified for firming variable wind electricity?

Conclusion

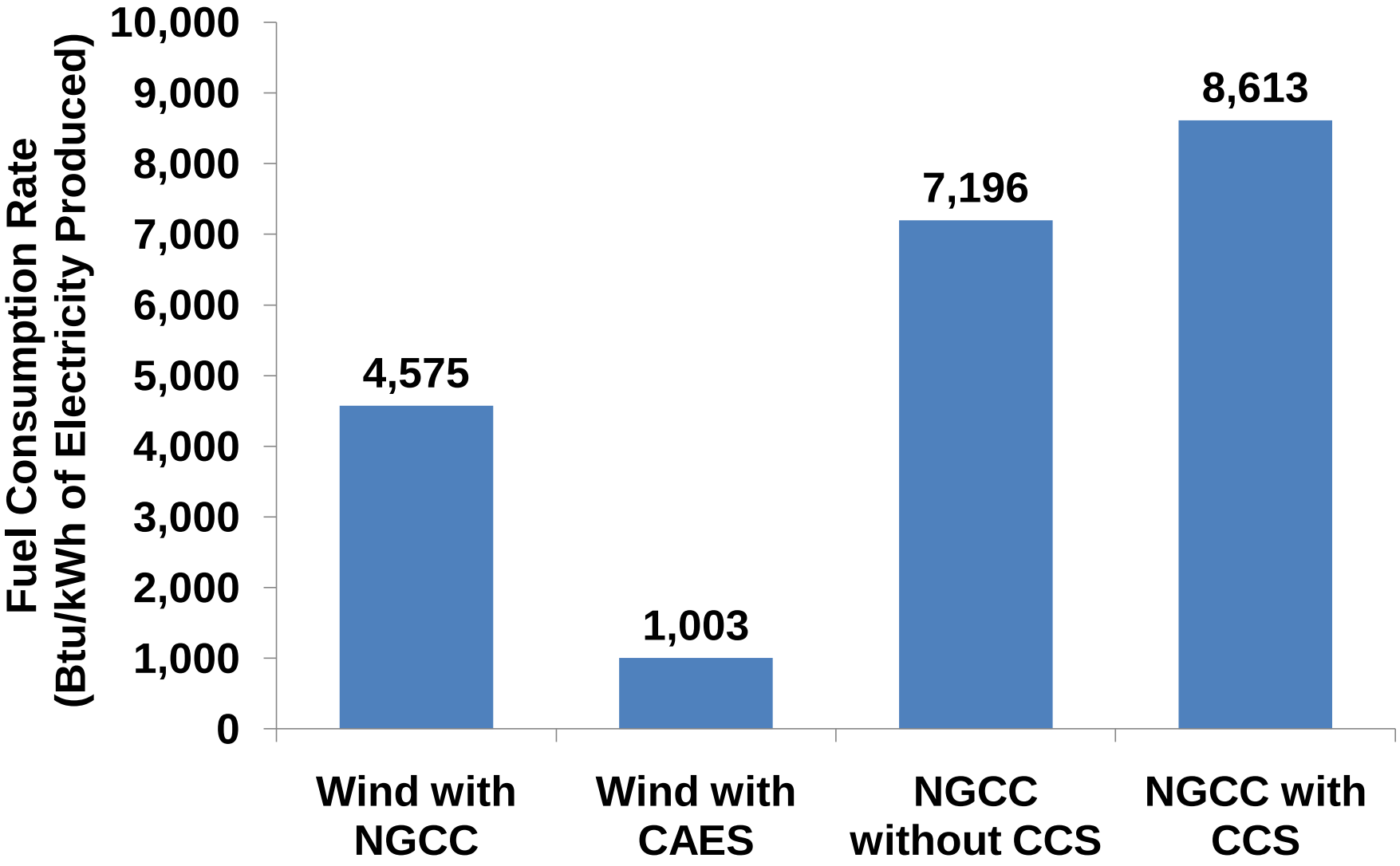
The added capital costs of CAES can be justified due to lower operating costs (fuel) when the price of natural gas is >$14/MMBtu.

Source: Mason and Archer, Wind CAES Study
www.solarplan.org


Power Supply Duration Curves
Base Load Wind with NGCC Plant Model
400 MW Load Capacity Electricity Supply – Net Local Grid
(400 MW Wind Plant; 340 MW NGCC Plant)
Electricity Supplied to Local Grid (kWh)
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
60% NGCC Electricity
39% Wind Electricity
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Hours of Year
NGCC Electricity To Local Grid
Total Electricity to Local Grid
Reserve CT Electricity to Local Grid
Wind Electricity to Local Grid

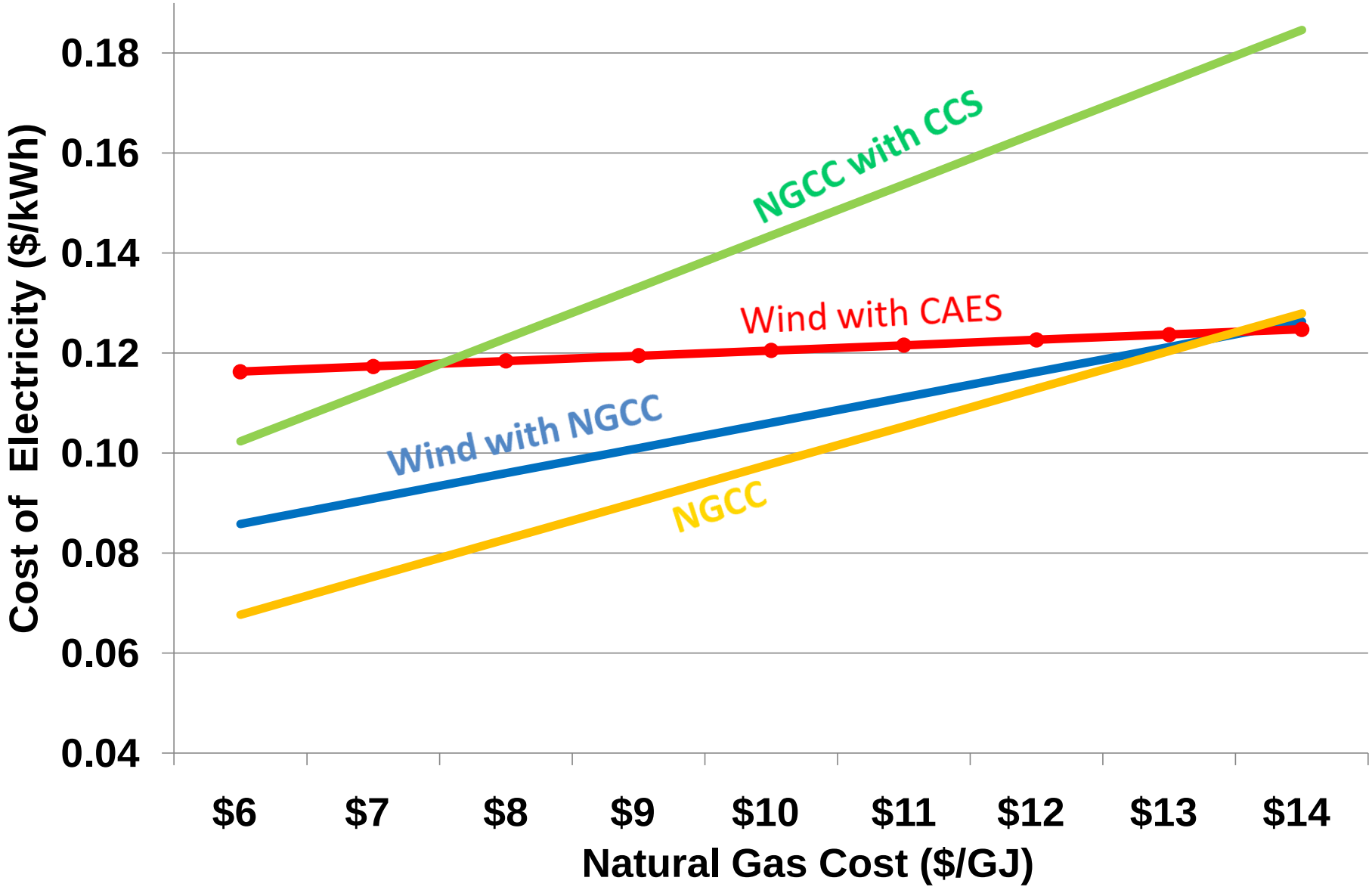

Power Supply Duration Curves
Base Load Wind with CAES CT
400 MW of Load Capacity Electricity Supply - Net to Local Grid
(1035 MW Wind Plant, 340 MW CAES Plant, 350 Hrs Air Storage)
Electricity Supply to Local Grid (kW)
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
78% Wind Electricity
22% CAES Electricity
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage Hours of Year
Total Electricity to Local Grid
CAES to Local Grid
Wind to Local Grid

Wind-CAES - low fuel consumption rate



Source: Mason and Archer, Wind CAES Study, Work in Progress

Electricity price is sensitive to fuel cost



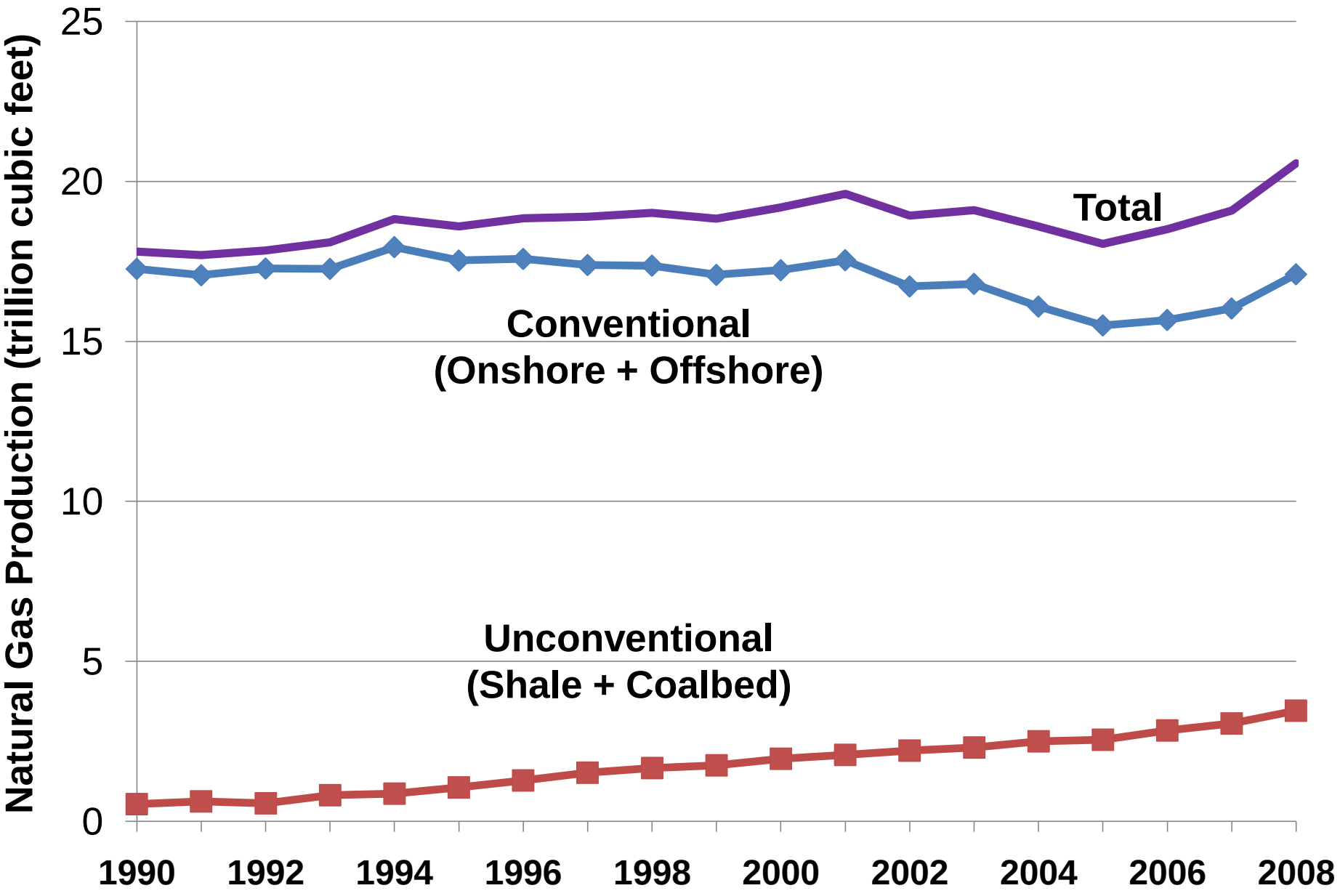
More wind = more natural gas

NREL Western and Eastern Wind Integration and Transmission Studies Project for 2030:

- **30% wind penetration (300 GW of capacity);**
- **Fewer new coal power plants (baseload);**
- **More new natural gas power plants (30 GW).**

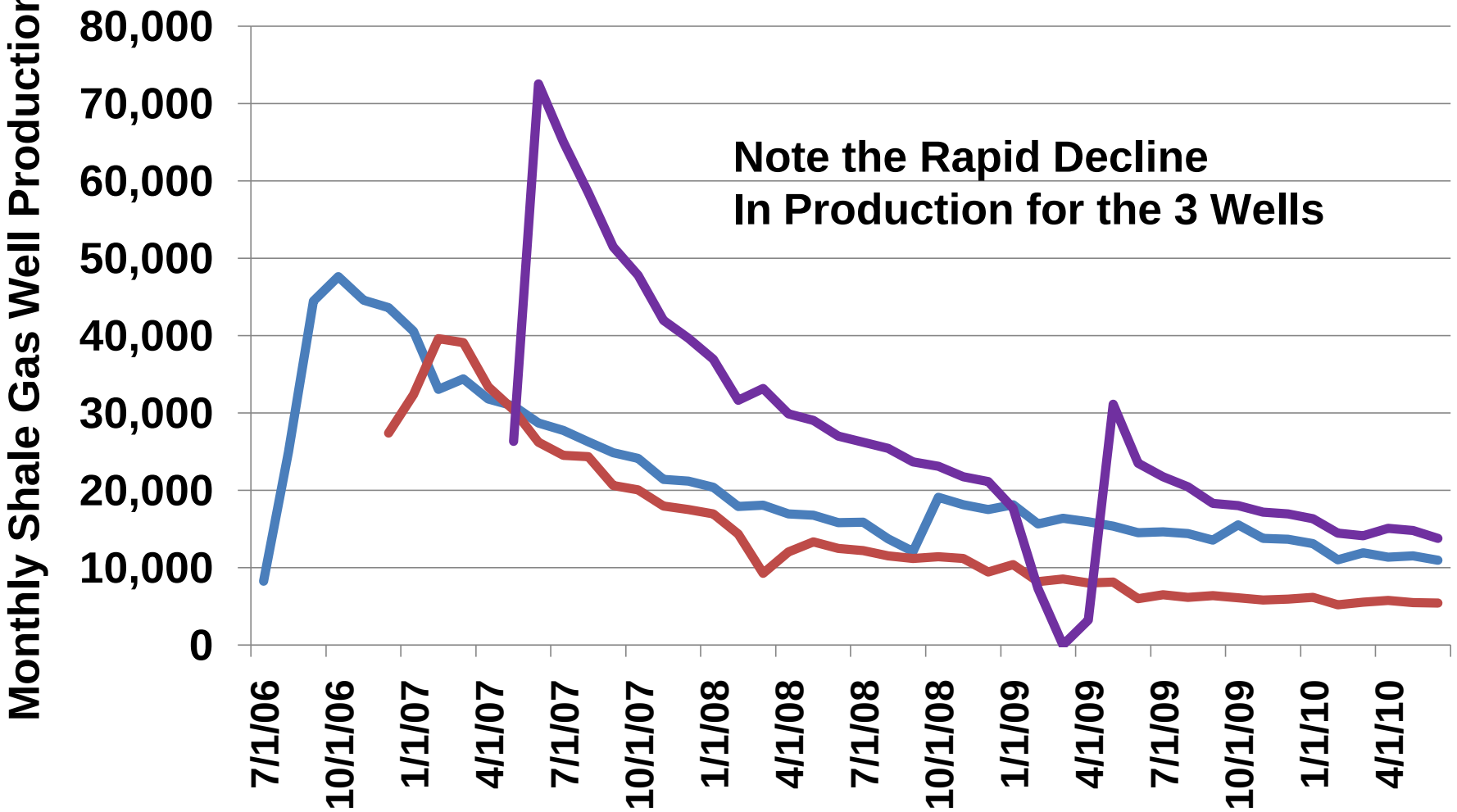
Is a 25% increase in US natural gas production in 20 years possible?

Growth of U.S. natural gas production is slow

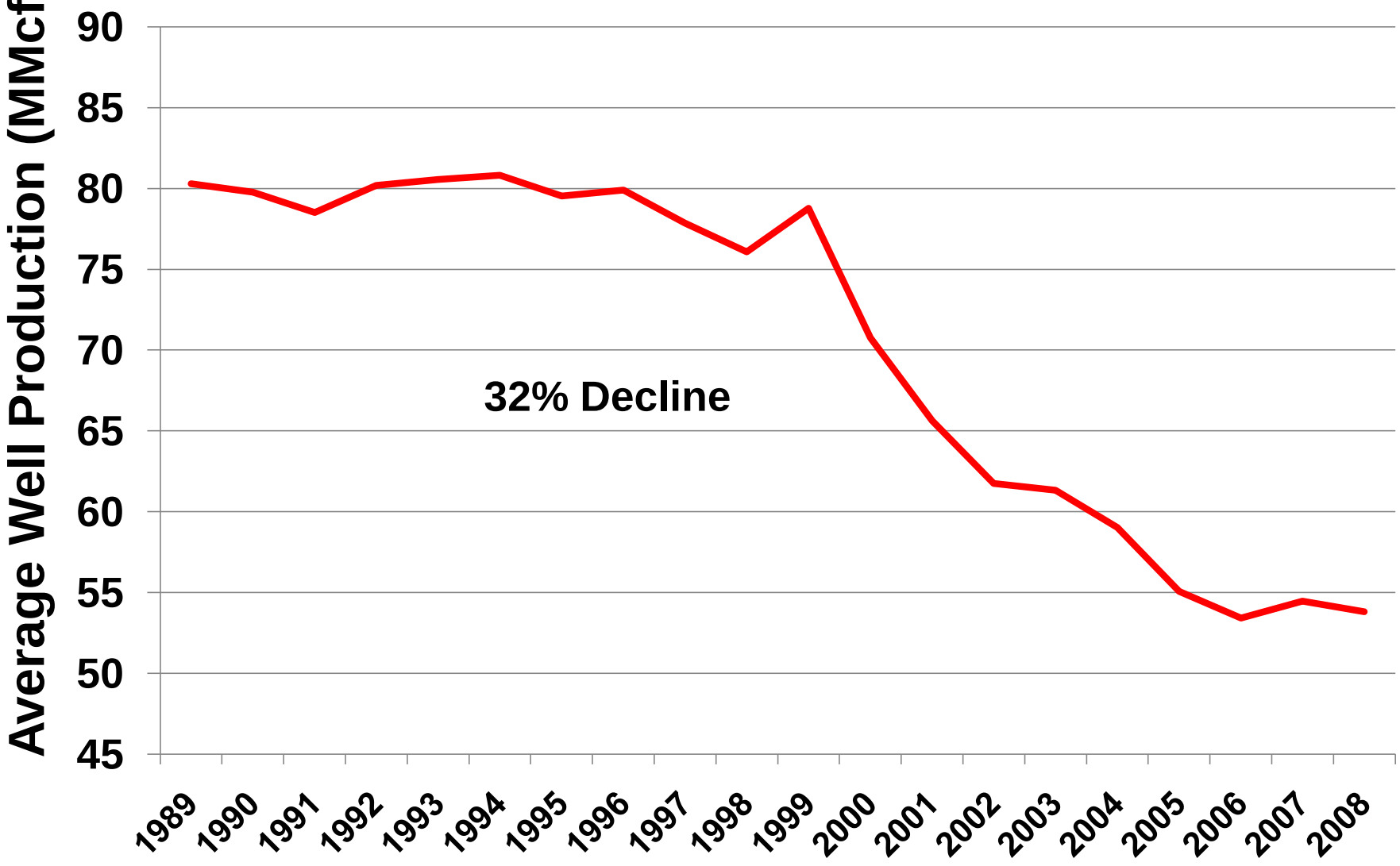


Is Shale Gas the Solution?
Shale Gas Well Production Profile

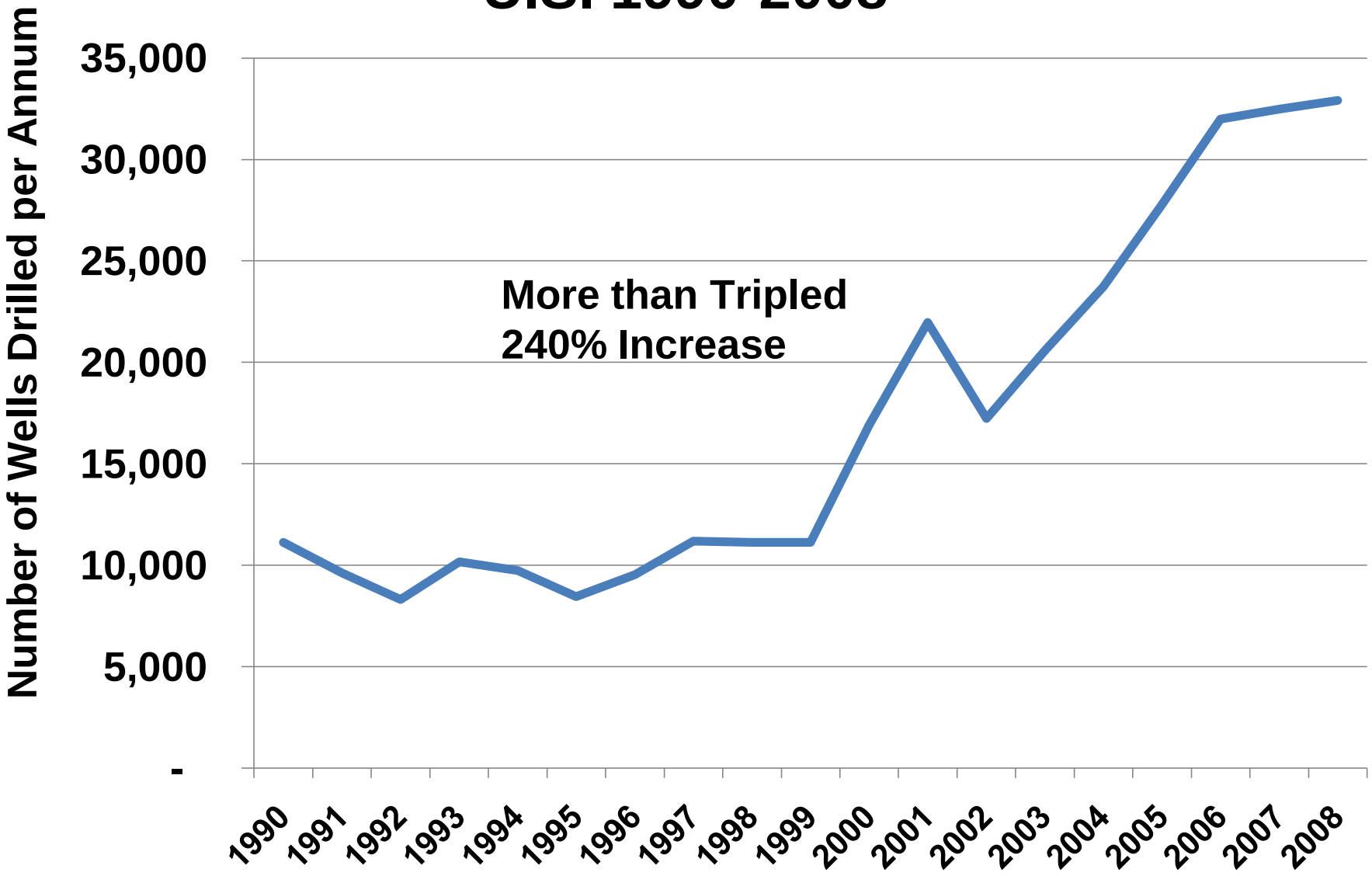
Source: Arkansas Oil and Gas Commission
Fayetteville Shale Gas Formation



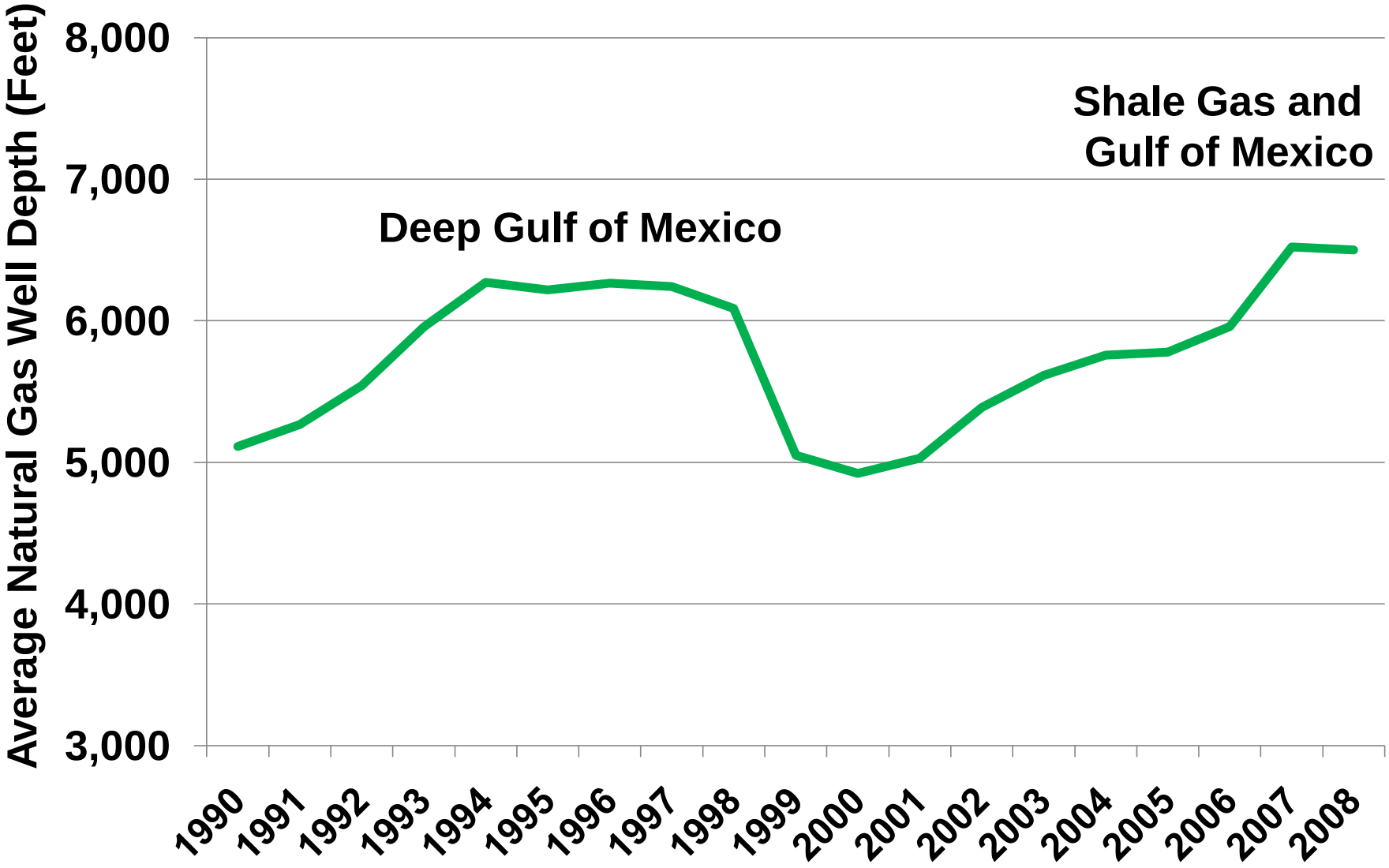
Declining natural gas well production U.S. 1989-2008



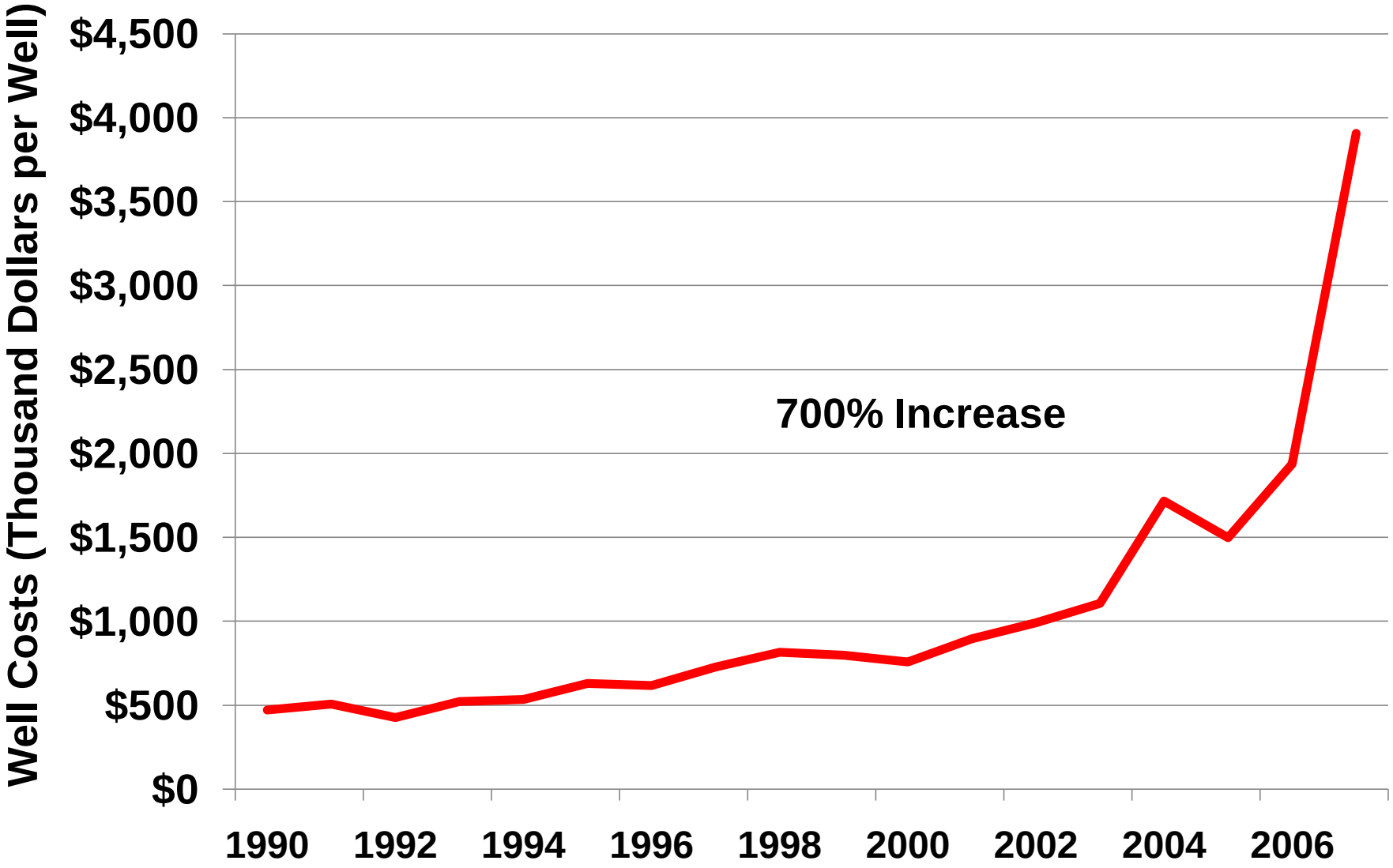
Increasing number of NG wells drilled U.S. 1990-2008



Drilling deeper natural gas wells U.S. 1990-2008

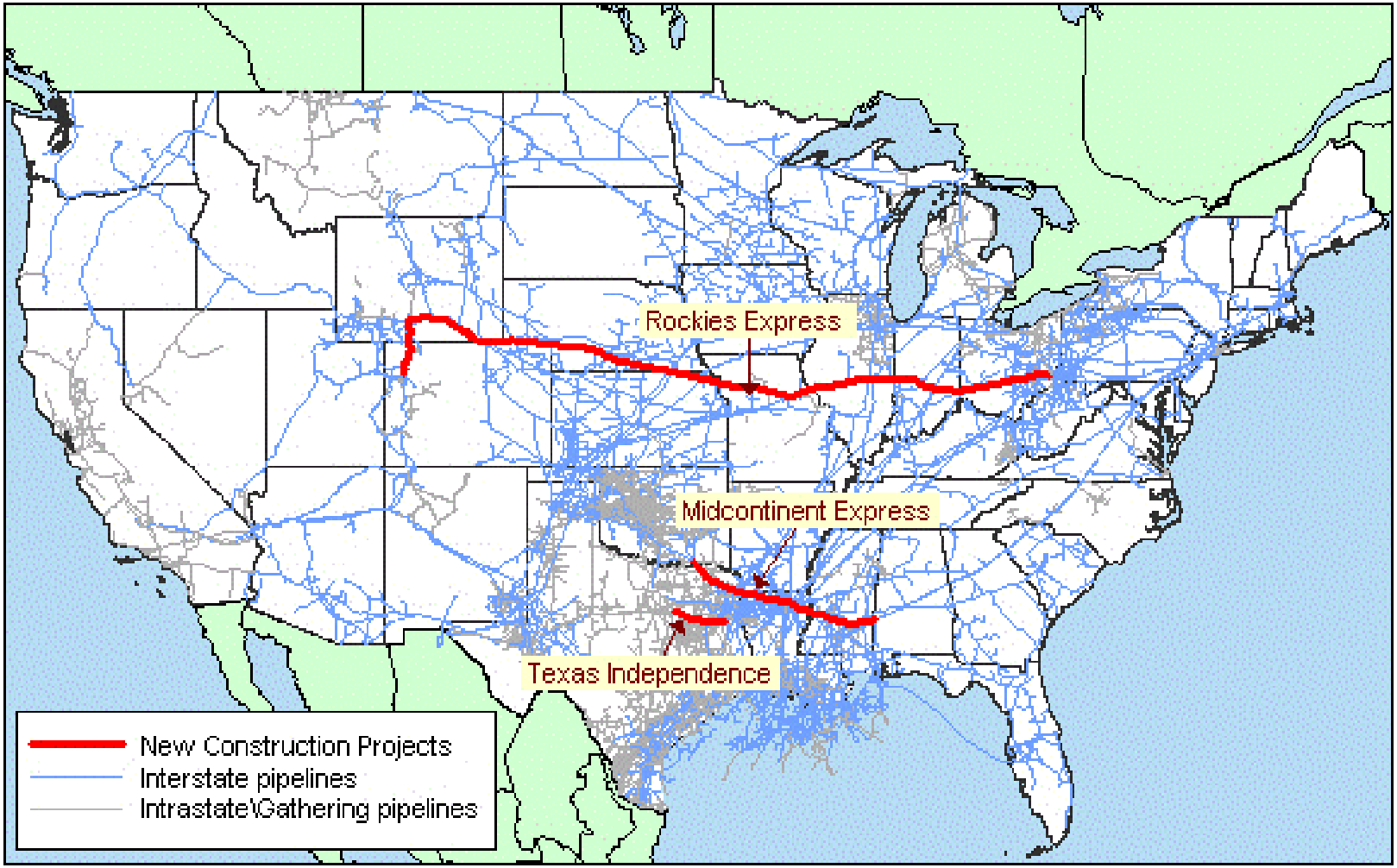


Increasing cost of drilling NG wells U.S. 1990-2008

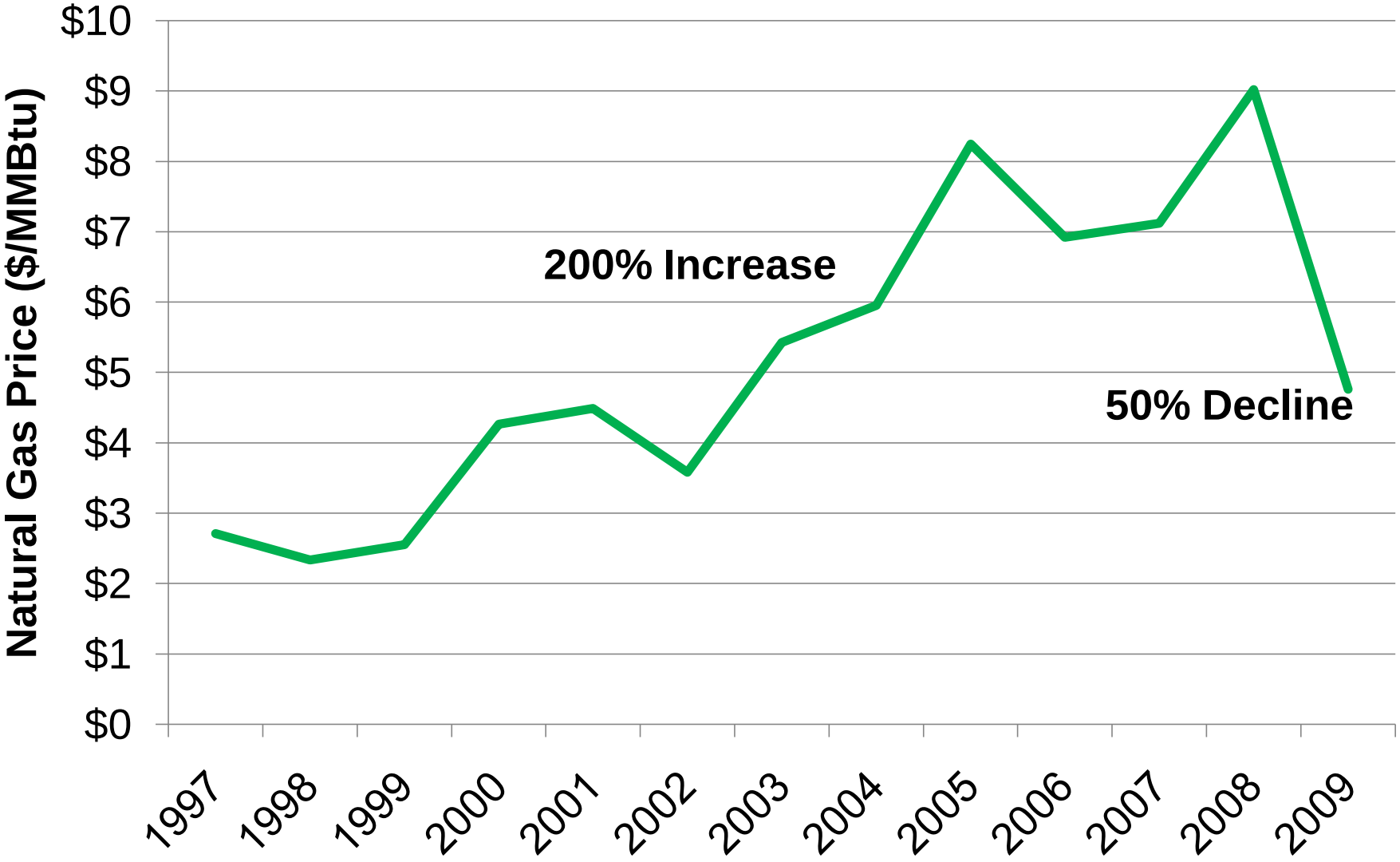


Need for pipelines slows shale gas

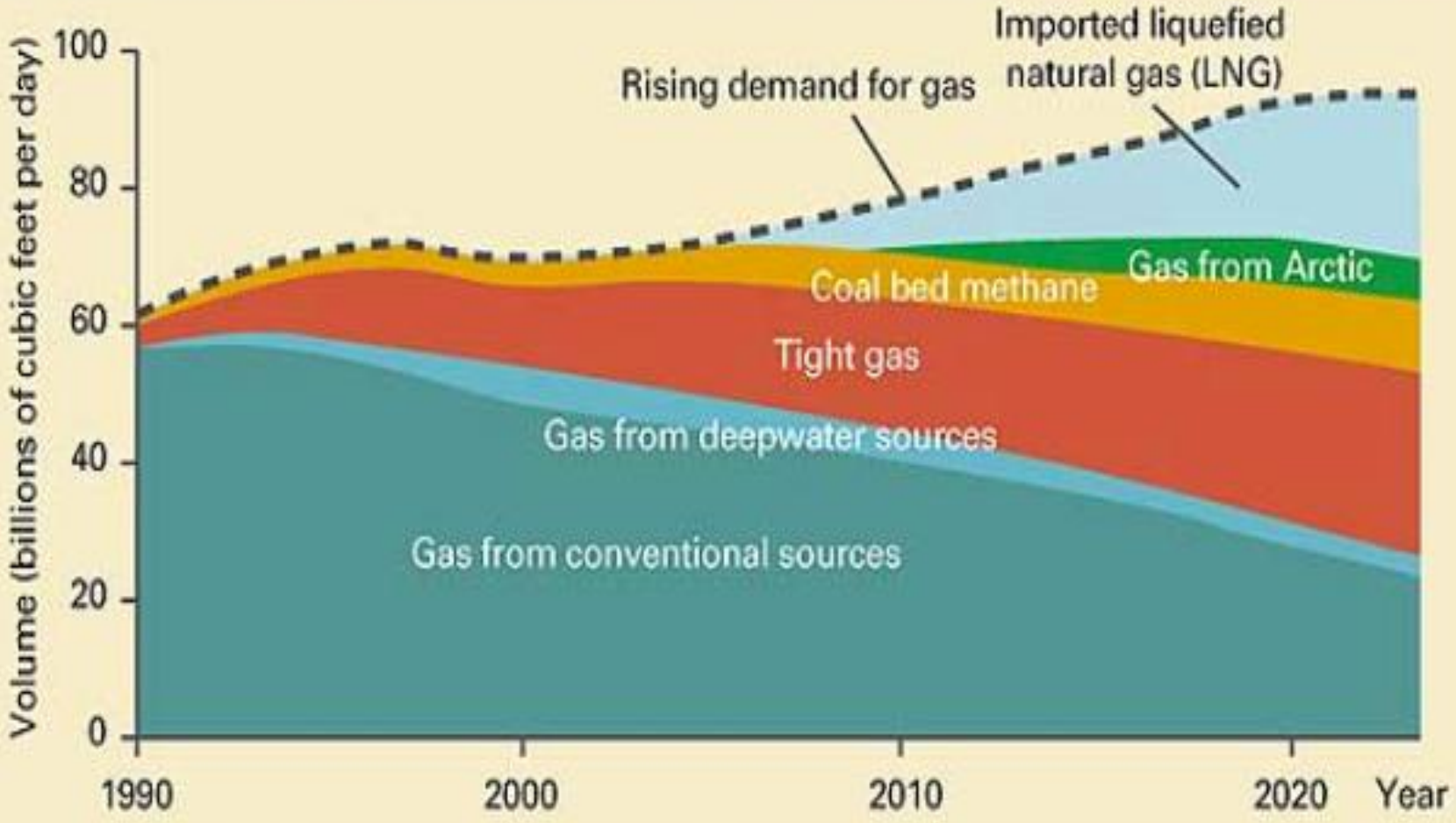
Figure 11. Major Pipeline Projects Came Online in 2009



High volatility of natural gas price for power plants

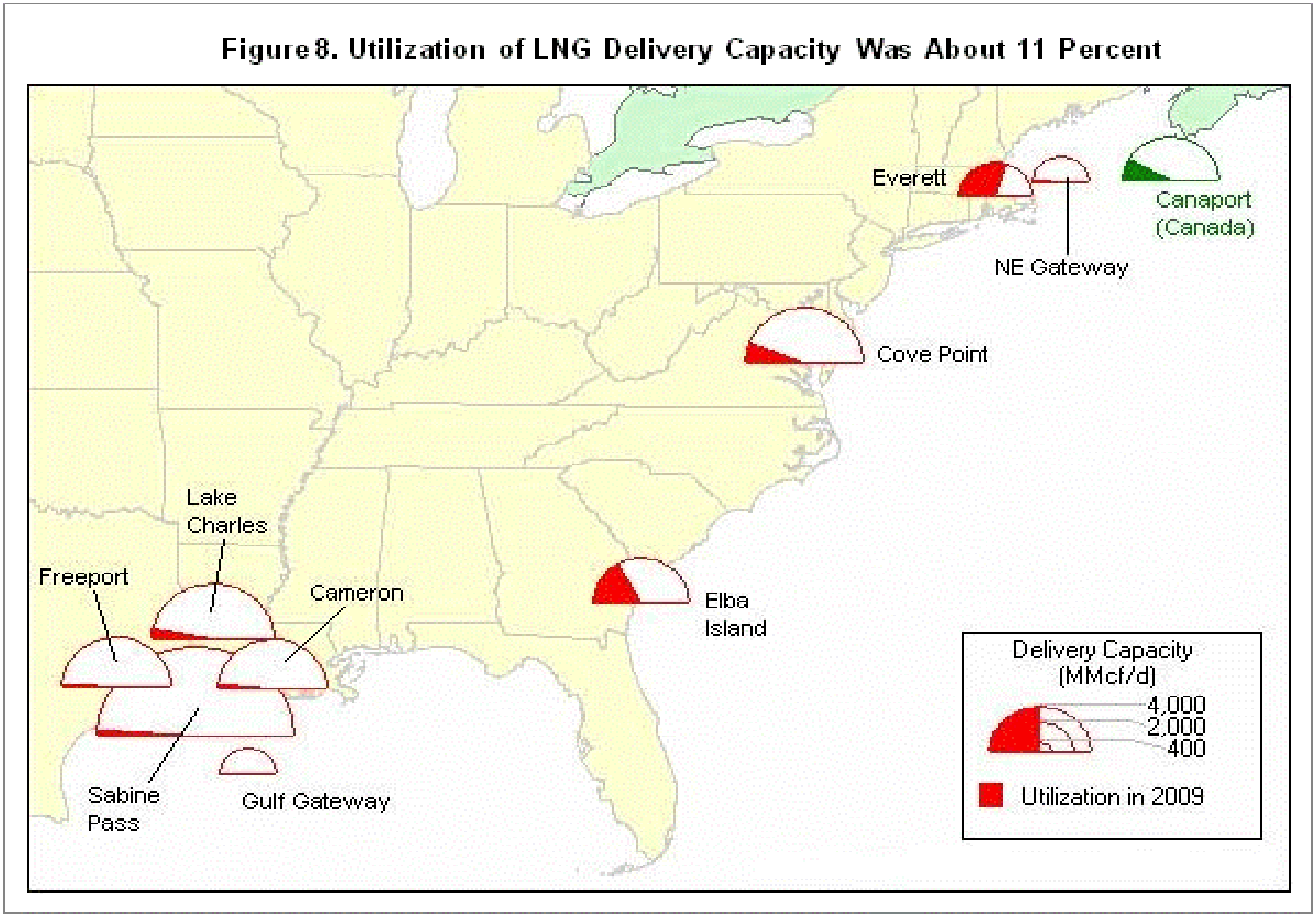


NATURAL GAS IN NORTH AMERICA – SUPPLY AND DEMAND



Demand for natural gas in North America and sources of gas supply. Source: CRA International

Liquid NG plants for importing NG



US natural gas supply in 2030 (NEIP)

- **Conventional natural gas production declines 2020-2030;**
- **Shale gas reserves are plentiful, but …**
- **…. cannot be ramped up to offset decline in conventional natural gas production;**
- **High natural gas price volatility in 2030 (like oil today).**

<u>Implications</u>:

- **Upward pressure on natural gas prices will nullify the economic benefits of amortized natural gas power plants;**
- **Use of natural gas for electricity will cause rise of home/business space and water heating costs;**
- **National standard of living will decrease.**

Conclusions

- **CAES can effectively be utilized to firm increases in wind and solar (PV) penetration;**

- **CAES can mitigate negative economic consequences of increasing natural gas consumption to support electricity generation from wind and solar (PV).**