

The Brattle Group

Myths and Realities of Shale Gas Deposits: Implications for the Electric Market

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Electric Power Financial Institutions Natural Gas Petroleum Pharmaceuticals, Medical Devices, and Biotechnology Telecommunications and Media Transportation

Agenda

◆ **Shale Gas Production: Prospects & Prices**

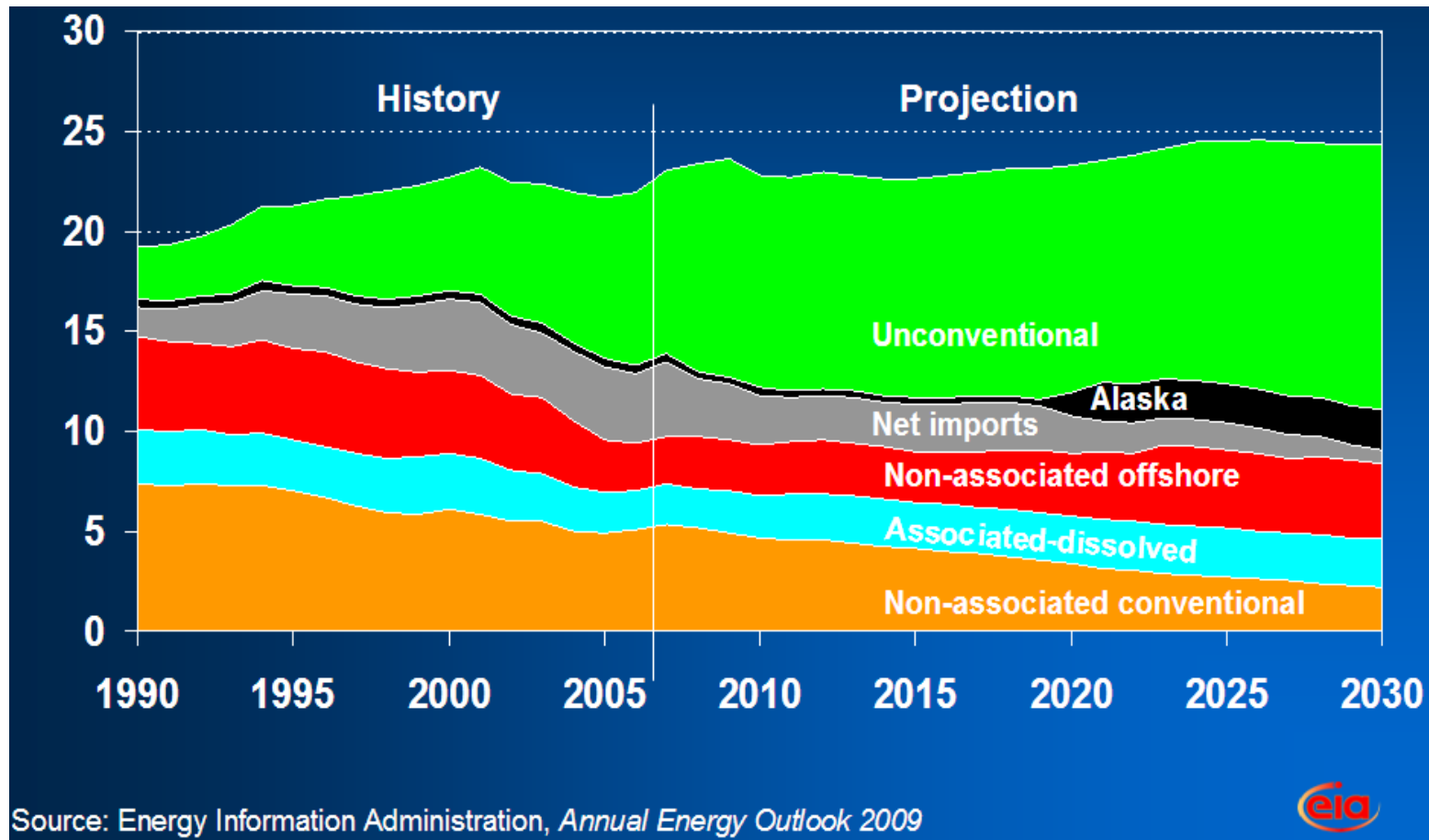
- U.S. Gas Supply
- Shale Gas & Production Economics
- Prices Past and Future

◆ **Shale Gas and Electricity Markets**

- Role of Gas in Electric Markets
- Impact of Shale Gas on Planning New Capacity
- Impact of Shale Gas on CO₂ Prices

◆ **Conclusions**

U.S. Natural Gas Supply



Rising Contribution of Unconventional Sources

Overview of U.S. Gas Supply

Declining conventional production

Declining imports

- Canadian
- LNG

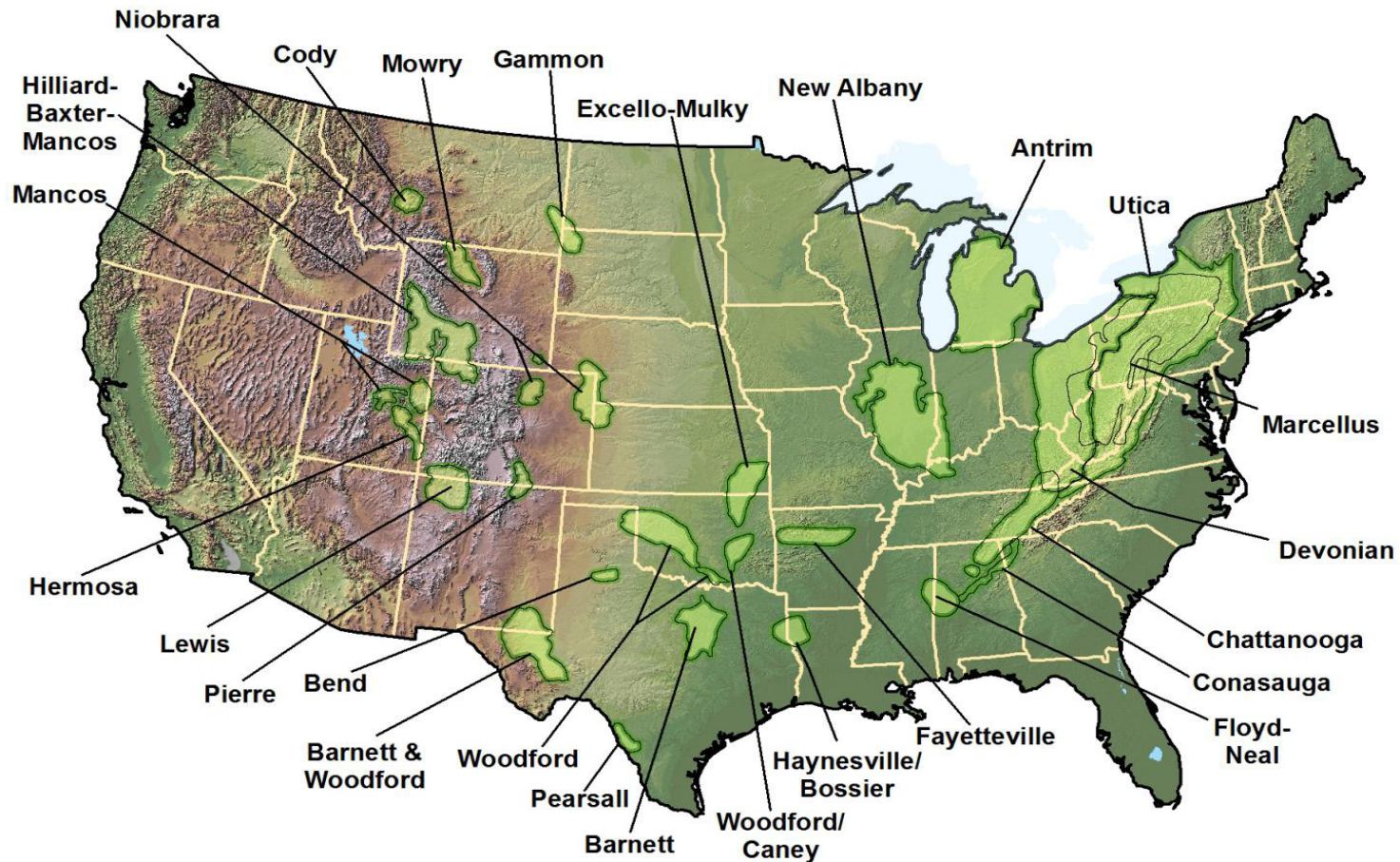
Expanding unconventional production

- Shale
- Coal bed methane
- Tight sands

Expanding reserves

- Primarily shale

U.S. Shale Plays



Different Geography than Conventional Gas

Production from Shale Plays

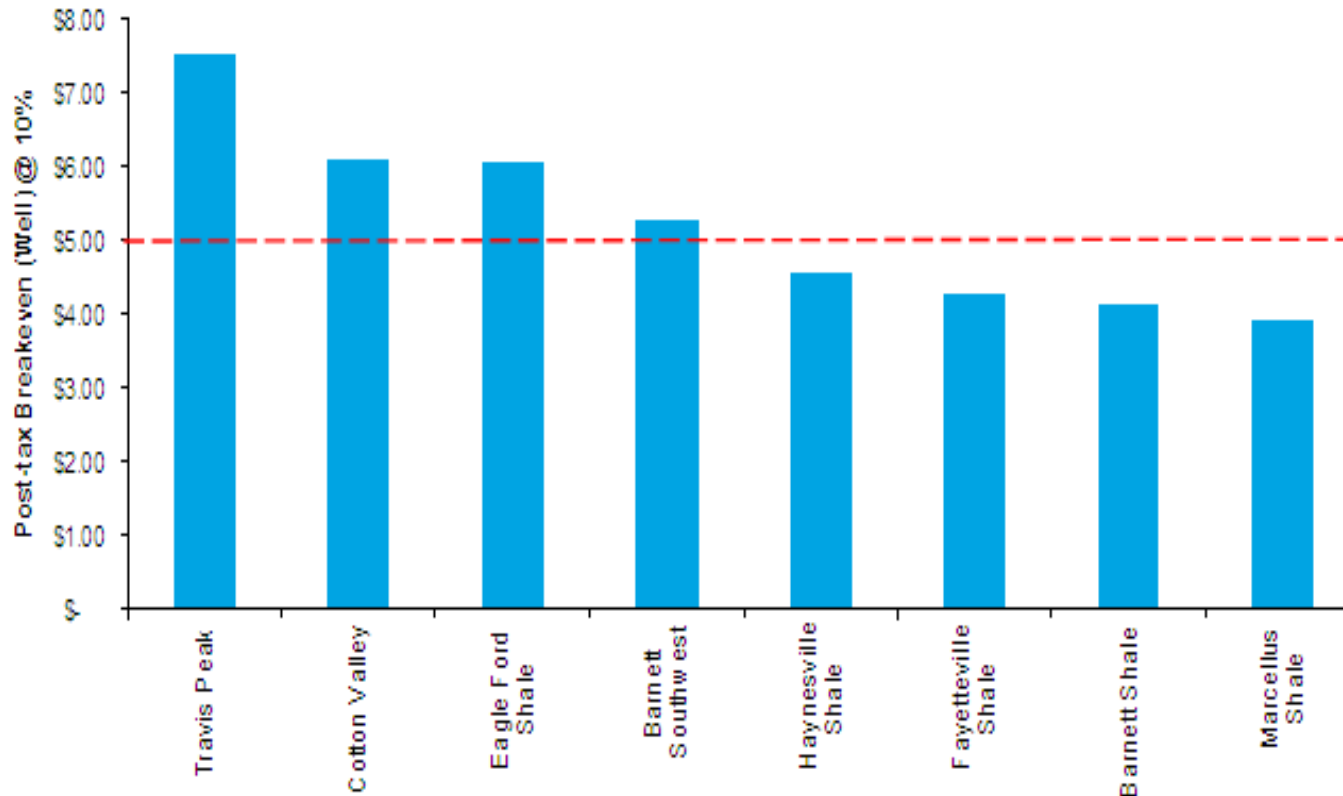
Shale Deposits

- ◆ Very broad (1,000's of square miles)
- ◆ Very deep (1,500 – 8,000 feet below surface)
- ◆ Below aquifers
- ◆ Gas is trapped in thick shale beds at the molecular level

Horizontal Drilling and Fracturing

- ◆ Inject hot water, sand (and a few other ingredients) into shale beds to liberate gas
- ◆ Requires a lot of water, and some environmental concerns
- ◆ New wells produce a lot – but steep declines
- ◆ Very replicable across shale plays

Production Economics – One View



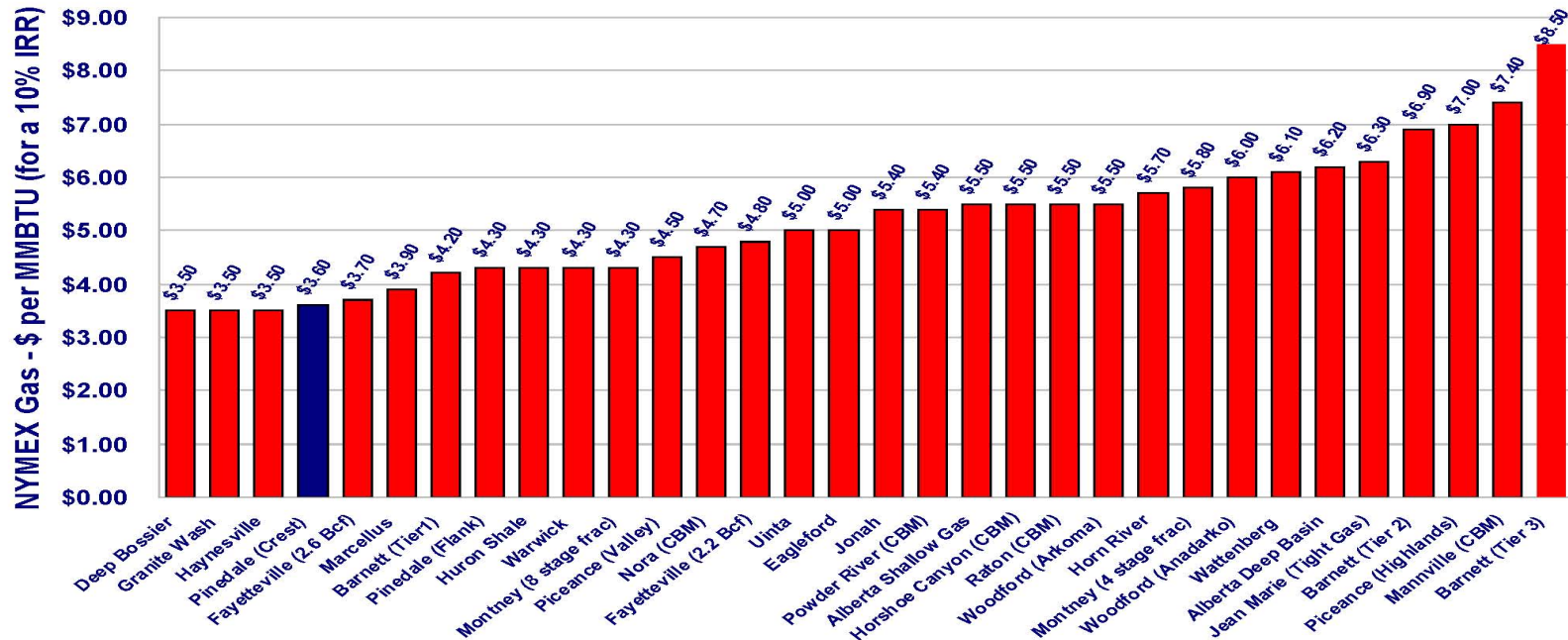
Source: Wood Mackenzie

Break-Even @ \$4.00 - \$7.50/MMBtu

Production Economics – Another View



Resource Play Break-Even Economics

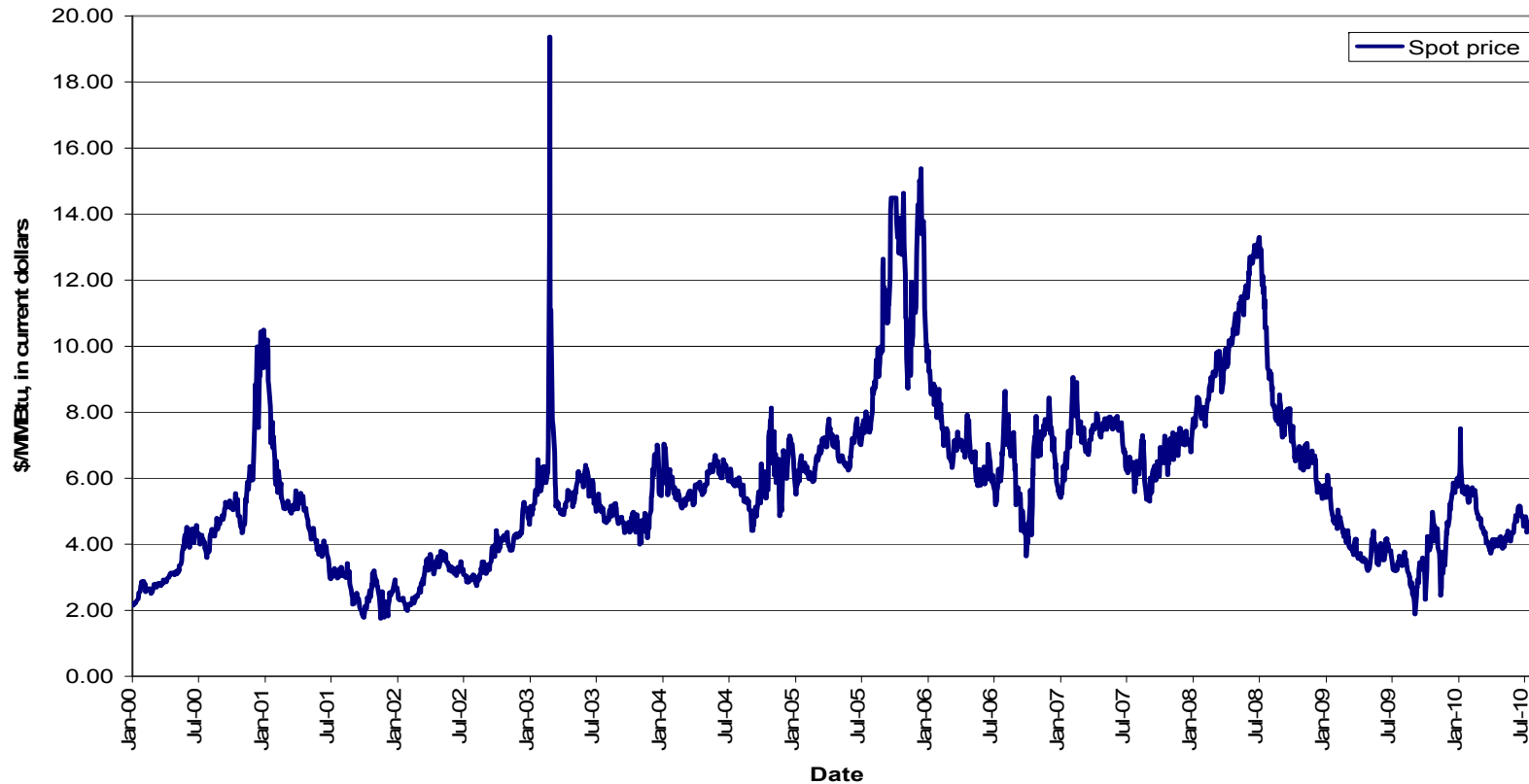


Source: Morgan Stanley Research

Break-Even @ \$3.50 - \$8.50/MMBtu

Gas Prices 2000 - 2010

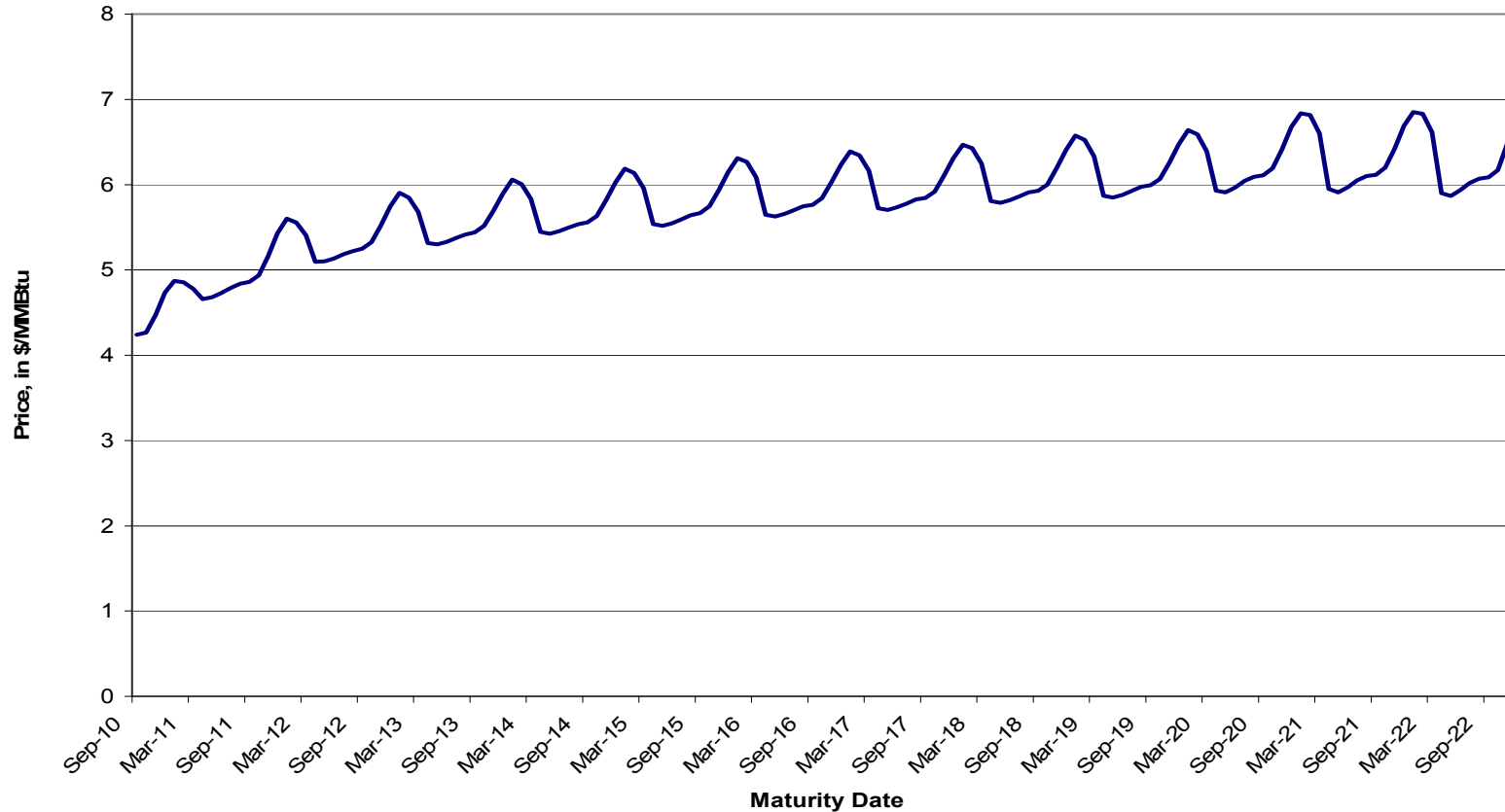
Henry Hub Spot Prices, Jan. 2000 - Aug. 2010



The “Wild Ride” after the Calm 1990s

Gas Prices – Next Decade?

Henry Hub Futures Curve
August 18, 2010



\$5 - \$7/MMBtu – But What Does That Mean?

Future Gas Prices and Shale Gas

Futures prices in line with shale break-even range

- ◆ But that does not imply that shale is necessarily the marginal gas, setting future prices
 - Could be inframarginal, and conventional gas remains price-setting in short run
 - Too close to call, with some shale plays vs. conventional costs
- ◆ Futures markets don't reflect volatility – just the betting line
 - Volatility or uncertainty in futures hasn't narrowed much, looking at options prices, implied volatility and 90/10 forecast outcomes
- ◆ Futures market not necessarily “right” forecast

Shale Gas Impact on Future Gas Prices

Three often-cited possible benefits from shale:

- ◆ Gas prices could be lower than otherwise
- ◆ Long-run gas prices could be more certain
- ◆ Gas prices could be less volatile

All of these claims are plausible, but none are assured:

- ◆ Shale could remain inframarginal, thus not contributing much to lower, less volatile prices
- ◆ Fluctuating demand conditions could still overwhelm the more flexible supply that shale implies

Nevertheless, for this presentation, we'll assume that all three claims hold (at least partially) true

Natural Gas and Electricity Markets

Why is gas important to the electricity markets?

- ◆ Gas-fired generation is on the margin most of the time in most major organized markets
- ◆ This means that the price of gas sets the price of electricity
- ◆ This means that gas sets asset values for all generators
- ◆ This means that the future price of gas is the most important determinant of technology/fuel choice of new capacity

High, uncertain and volatile gas prices have made capacity planning extremely difficult

- ◆ Especially hard for coal & nuclear, boom-bust experience
- ◆ Not as hard on gas generation, because its hedged
- ◆ Customers weary of fluctuating prices

Shale Gas and New Capacity

IF gas price levels, uncertainty or volatility falls due to shale gas, then planning new generation (or making technology/environmental policy) gets easier.

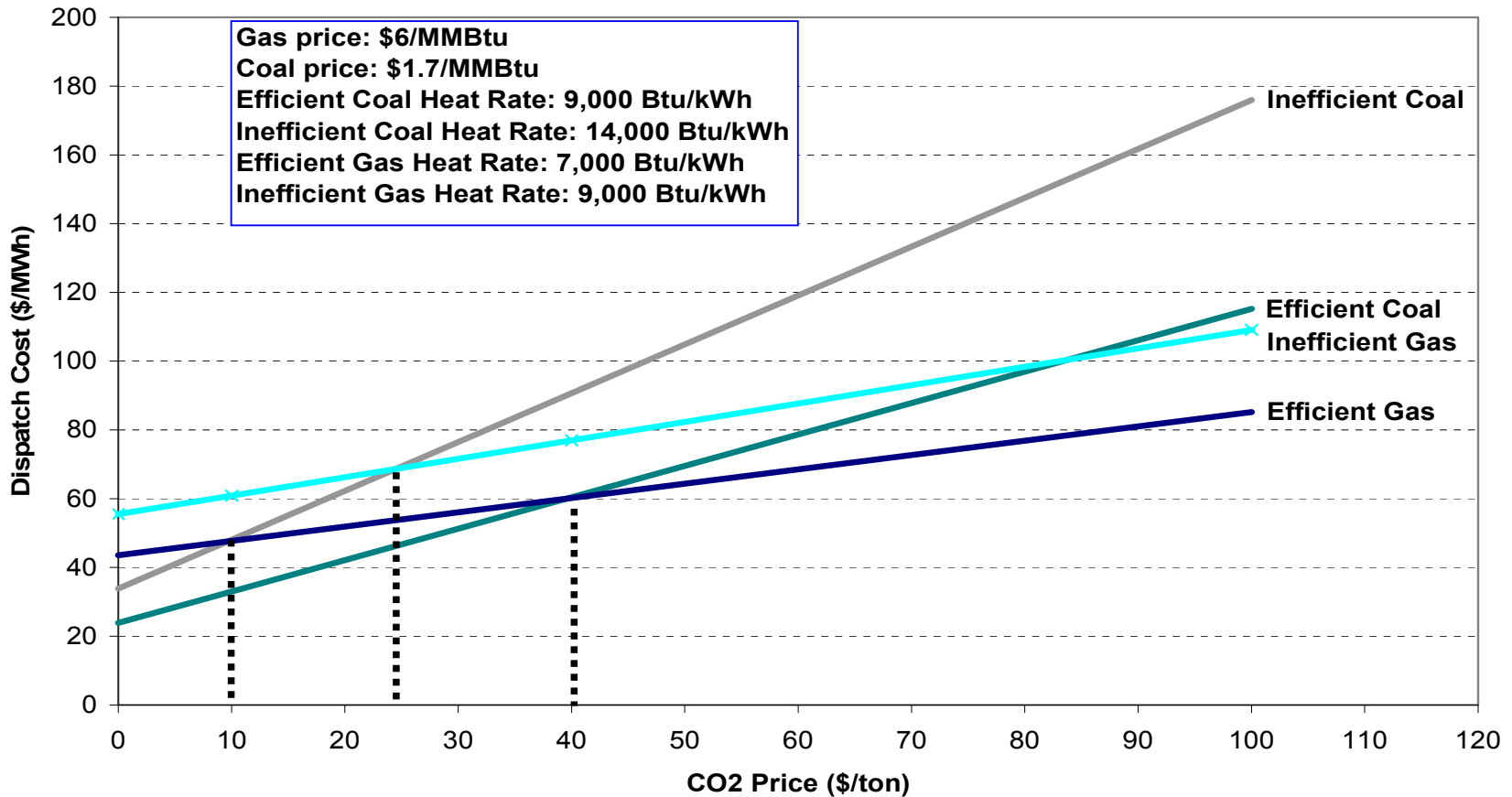
- ◆ Technology and fuel choices made with more confidence
- ◆ Returns on investment become more stable
- ◆ Technology subsidies (e.g., for renewables, nuclear, carbon capture) are easier to set
- ◆ Related environmental markets (renewable energy certificates (RECs) and emission allowances) will also stabilize
- ◆ This is especially important for potential CO₂ prices

Gas Price and CO₂ Price

Under a cap-and-trade allowance policy, the price of natural gas will determine the initial price of CO₂

- ◆ Gas-coal switching from re-dispatch of existing capacity the source of most early emission reductions
- ◆ More concern expressed about the price of CO₂ affecting gas, but this link is weaker
 - Gas demand increases for generation, but wholly or partially offset by falling demand in other sectors with economy-wide CO₂ price
 - This effect is stronger for “electricity-only” policy approach
 - Long-run CO₂ prices determined more by technology
- ◆ Following figure shows dispatch economics assuming a \$6/MMBtu gas price

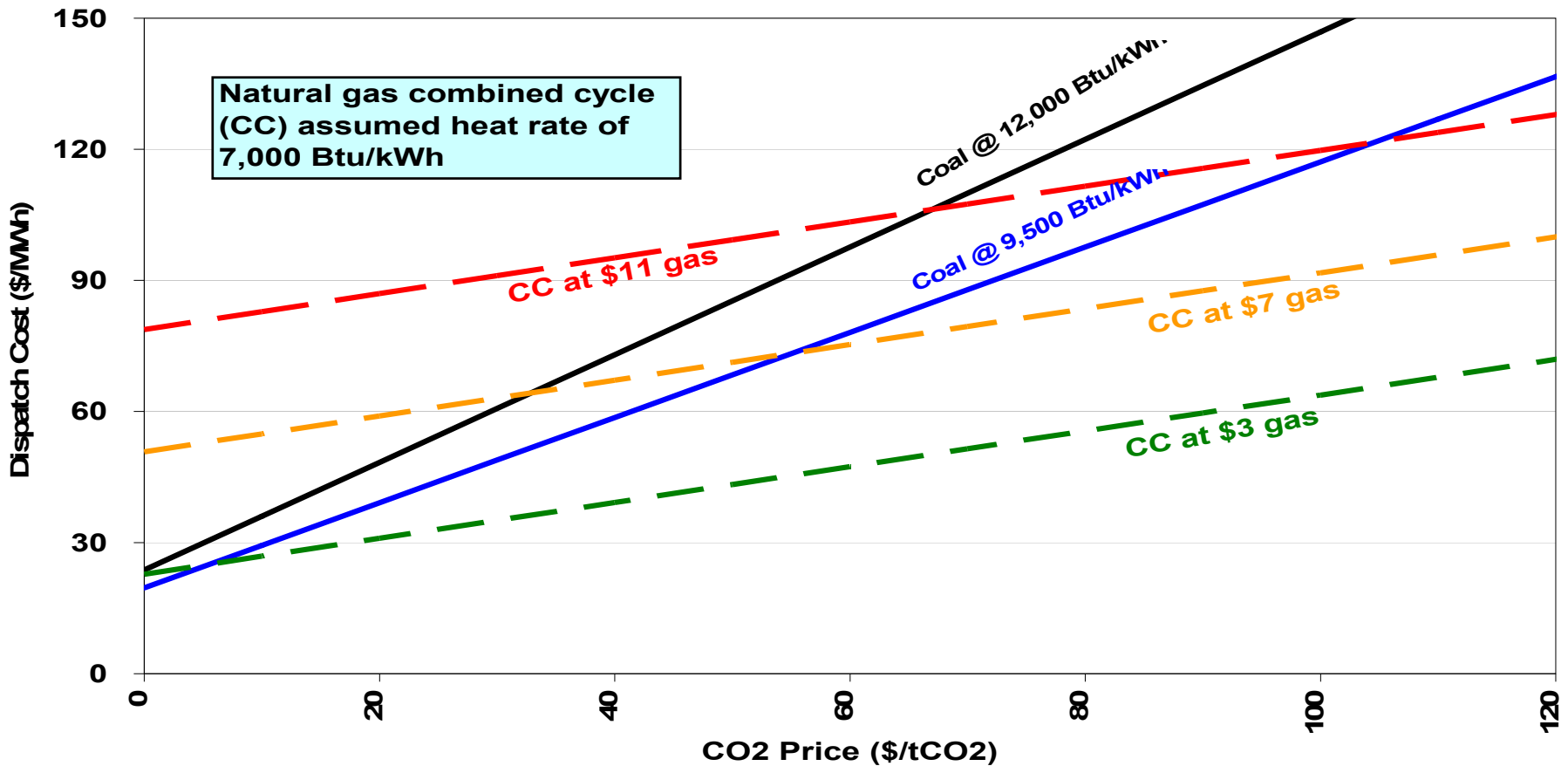
Coal-Gas Dispatch Switching



At \$6 gas, need \$10 - \$40/ton CO₂ to re-dispatch

Natural Gas Prices and Coal-Gas Re-dispatch

Gas & Coal Dispatch Costs vs. CO2 Price



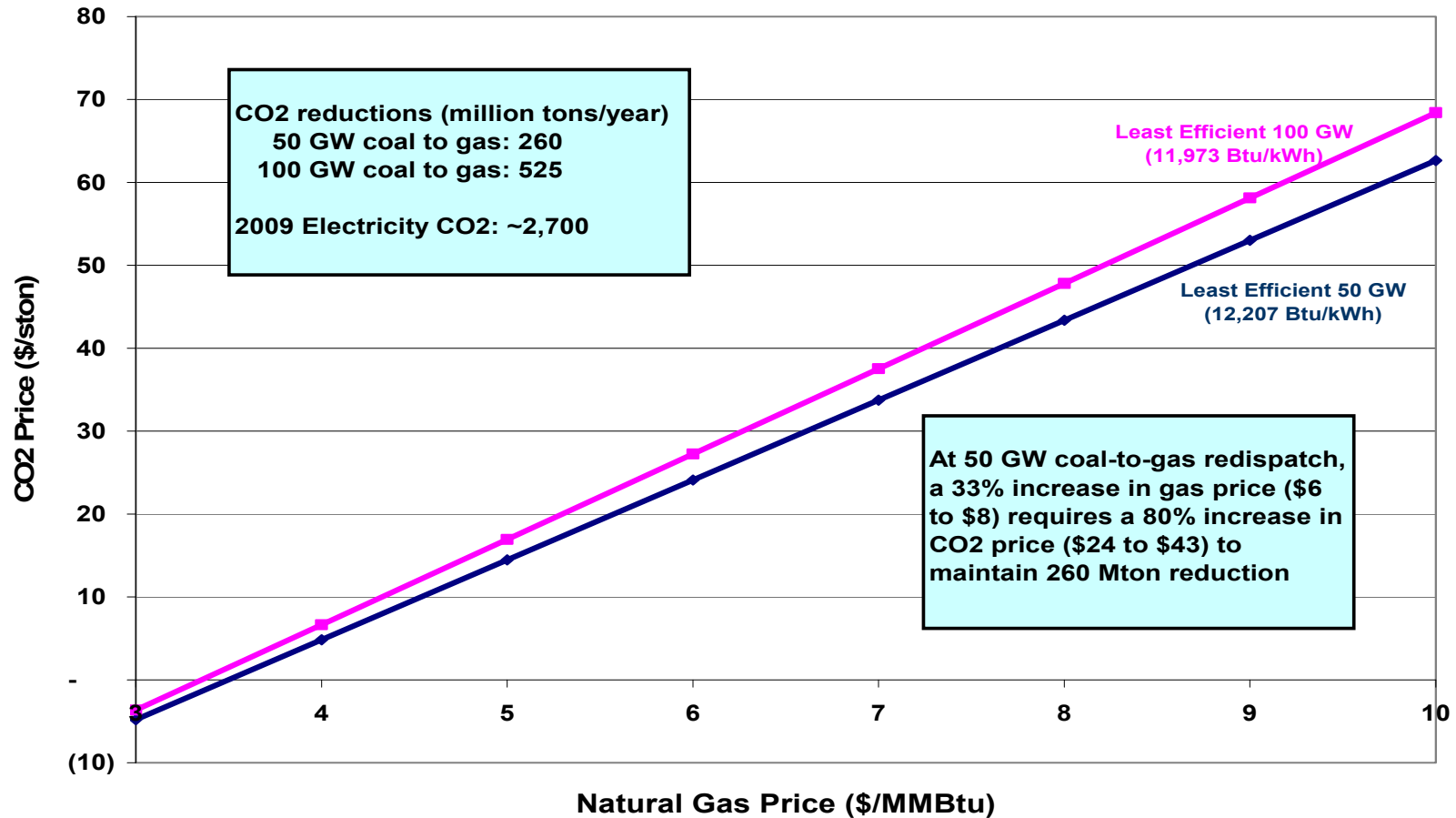
At \$3 gas, no CO₂ price needed, at \$11 need \$60-\$100

Gas Prices and CO₂ Prices

A cap-and-trade thought experiment:

- ◆ Assume that existing natural gas combined cycle (CC) displaces the least efficient 50 or 100 GW of coal fired capacity
 - 50 GW switch = 260 Mton net CO₂ reduction
 - 100 GW switch = 525 Mton net CO₂ reduction
 - 50 GW may be feasible, but regional constraints likely to limit re-dispatch well below 100 GW of coal capacity
- ◆ Calculate the natural gas price & CO₂ price combinations that make re-dispatch economic
- ◆ Slope of those lines indicate the CO₂ price necessary to maintain that level of emission reduction as a function of the price of natural gas

Break-even CO₂ & Gas Prices to Stay at Cap



Volatile gas prices make CO₂ prices even more volatile

CONCLUSIONS

- ◆ **Shale has significant potential as a domestic source of natural gas**
- ◆ **Too early to tell of its impact on overall gas price levels or volatility**
- ◆ **Natural gas price levels, uncertainty and volatility are biggest headaches for electricity and policy planning**
- ◆ **To the extent that shale can mitigate these, planning and policymaking will be much easier**
 - **More confident technology & fuel choices**
 - **Less volatility in related markets (RECs, CO₂)**