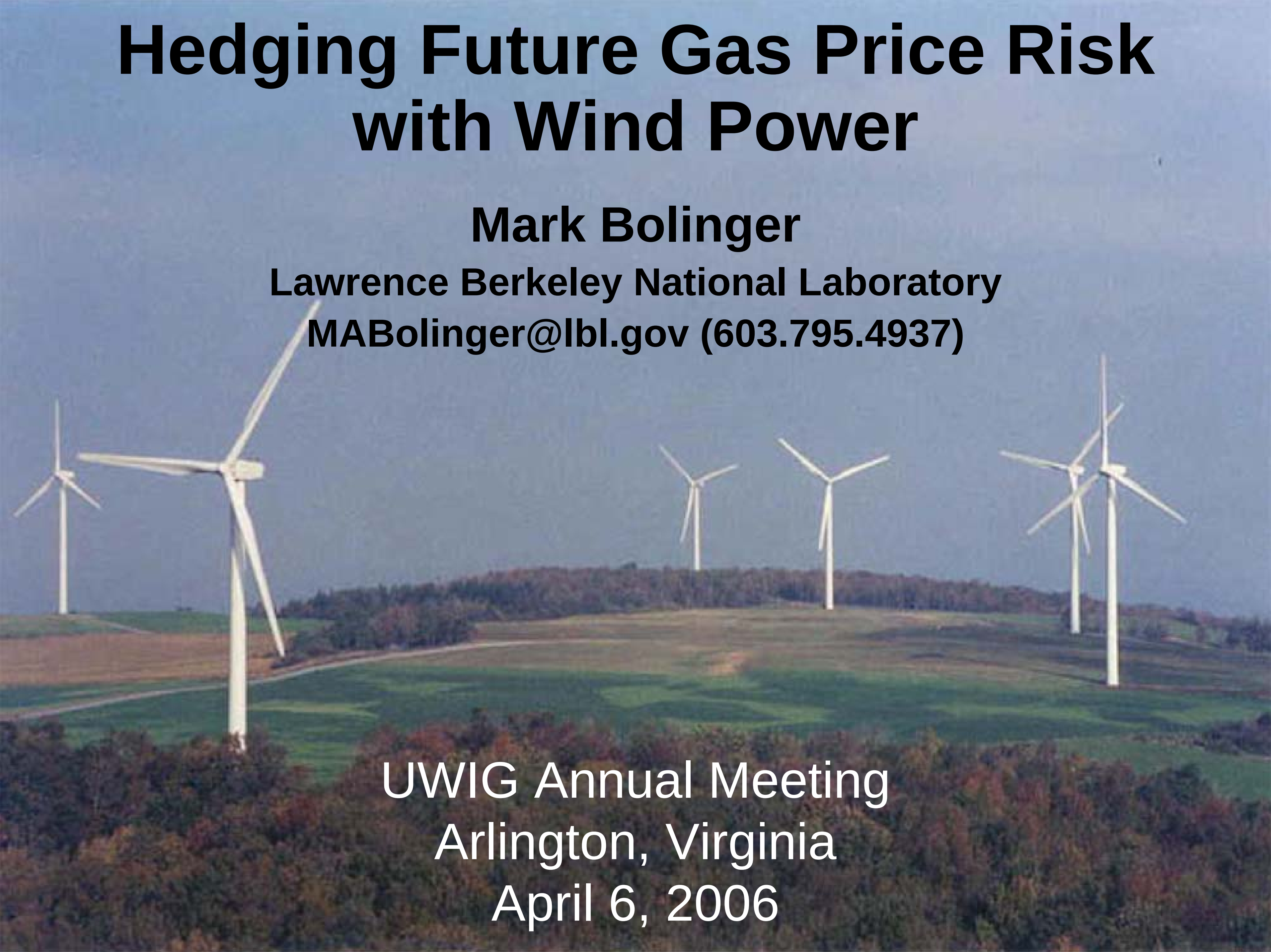

Hedging Future Gas Price Risk with Wind Power

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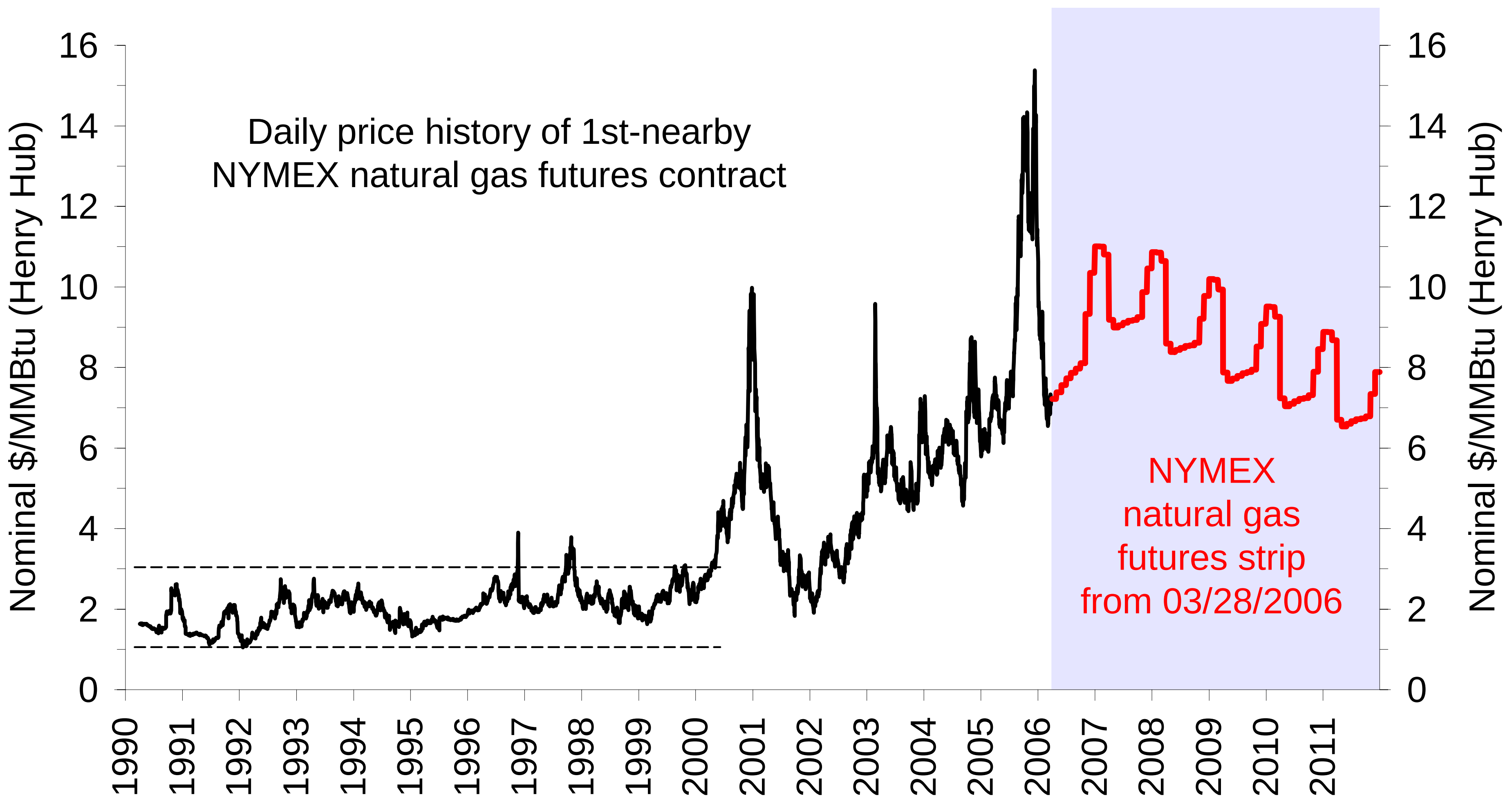
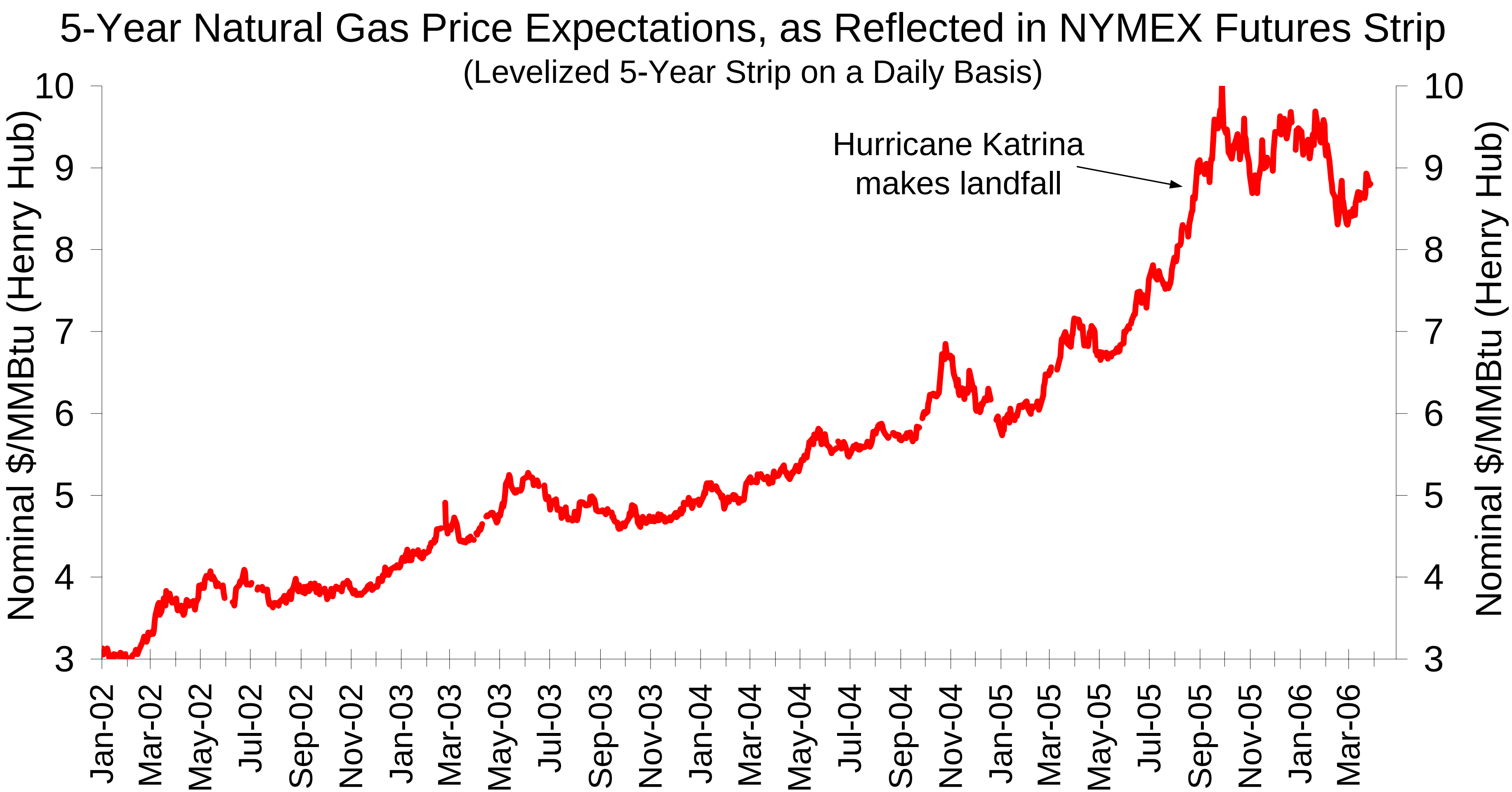
Natural Gas Prices Are High and Volatile



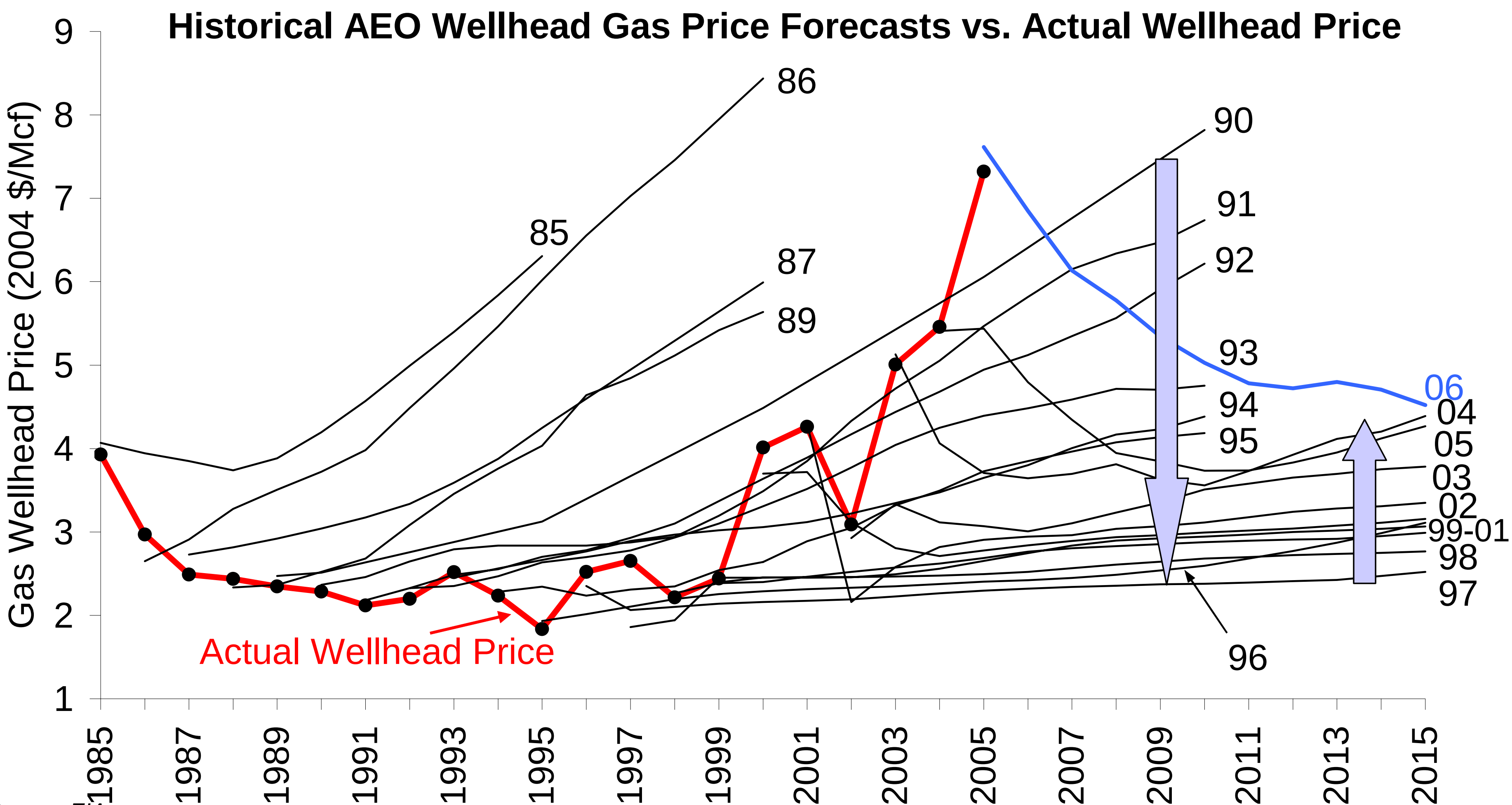
Source: LBNL

Natural Gas Price Expectations Have Risen Dramatically



Source: LBNL

Accuracy of Past Gas Price Forecasts Has Been Dismal



Source: EIA

Wind Power Can Help

Wind power provides a hedge against volatile and escalating gas prices in two ways:

#1: Wind Reduces Exposure to Gas Price Risk:

Incremental wind generation (often fixed-price) displaces gas-fired generation (often variable-price)

#2: Wind Reduces Natural Gas Prices:

By displacing gas-fired generation, incremental wind generation reduces demand for natural gas, and consequently puts downward pressure on gas prices

This presentation briefly covers both hedge benefits

#1: Wind Reduces Exposure to Gas Price Risk

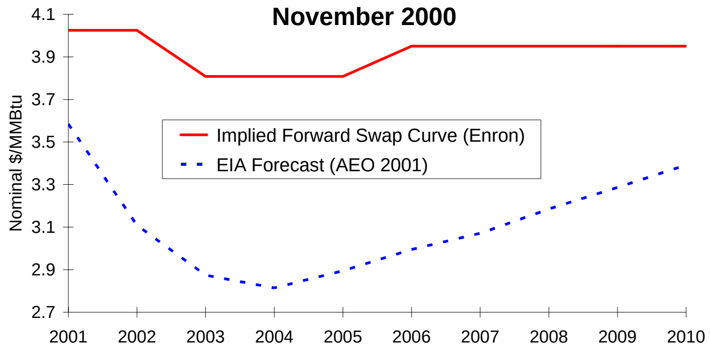
Of course, one could achieve a similar level of risk reduction by locking in natural gas prices through forward markets....

This means that an ***apples-to-apples*** comparison of the levelized cost of wind vs. gas-fired generation should be based on fuel prices that can be ***locked in*** through forward markets

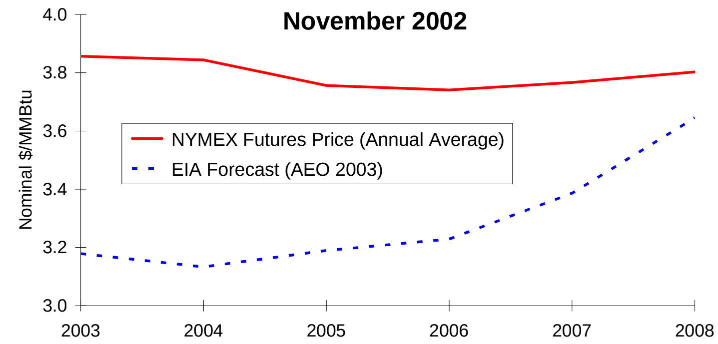
How do forward market prices compare to the long-term price forecasts that are typically used to calculate levelized costs?

- Approach: Compare long-term forward gas prices to contemporaneous long-term gas price forecasts from the EIA
- If forward prices systematically exceed price forecasts (for whatever reason), then policy or investment decisions based on those forecasts ***undervalue the risk reduction benefits of wind***

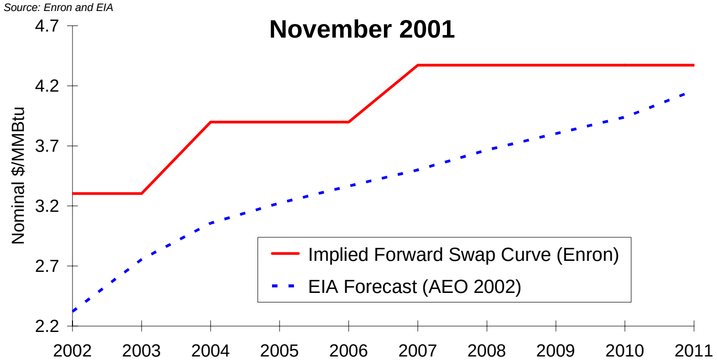
Forward Prices Exceed Price Forecasts: AEO 2001 – AEO 2005



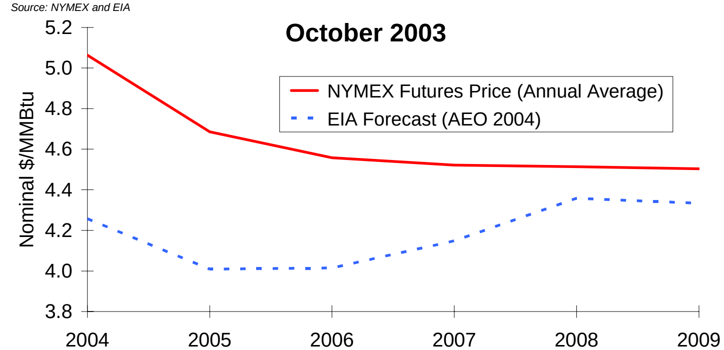
Source: Enron and EIA



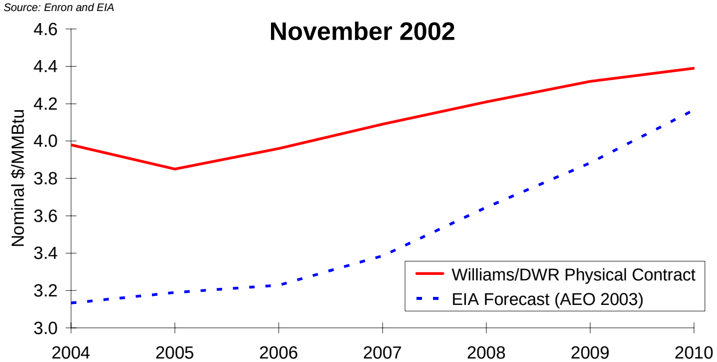
Source: NYMEX and EIA



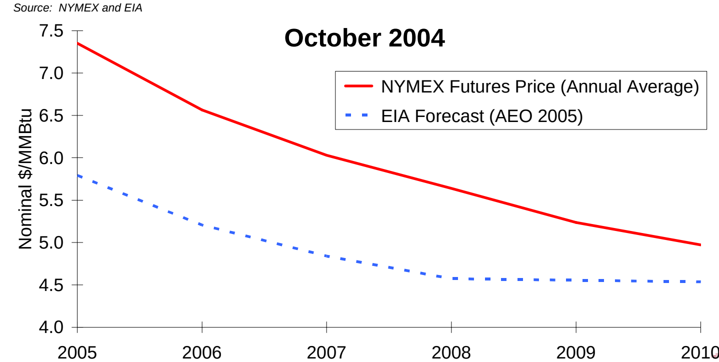
Source: Enron and EIA



Source: NYMEX and EIA

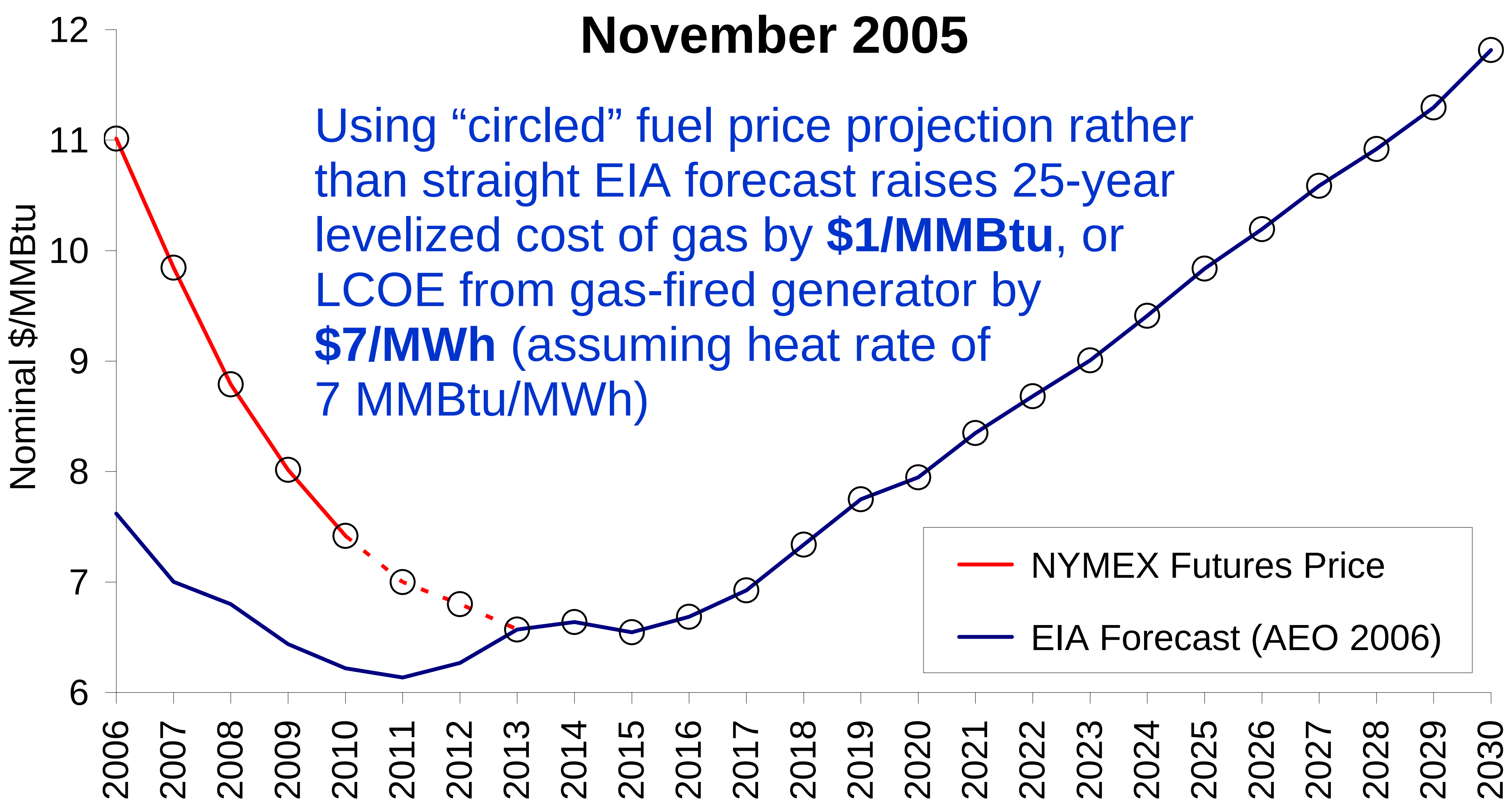


Source: Williams and EIA



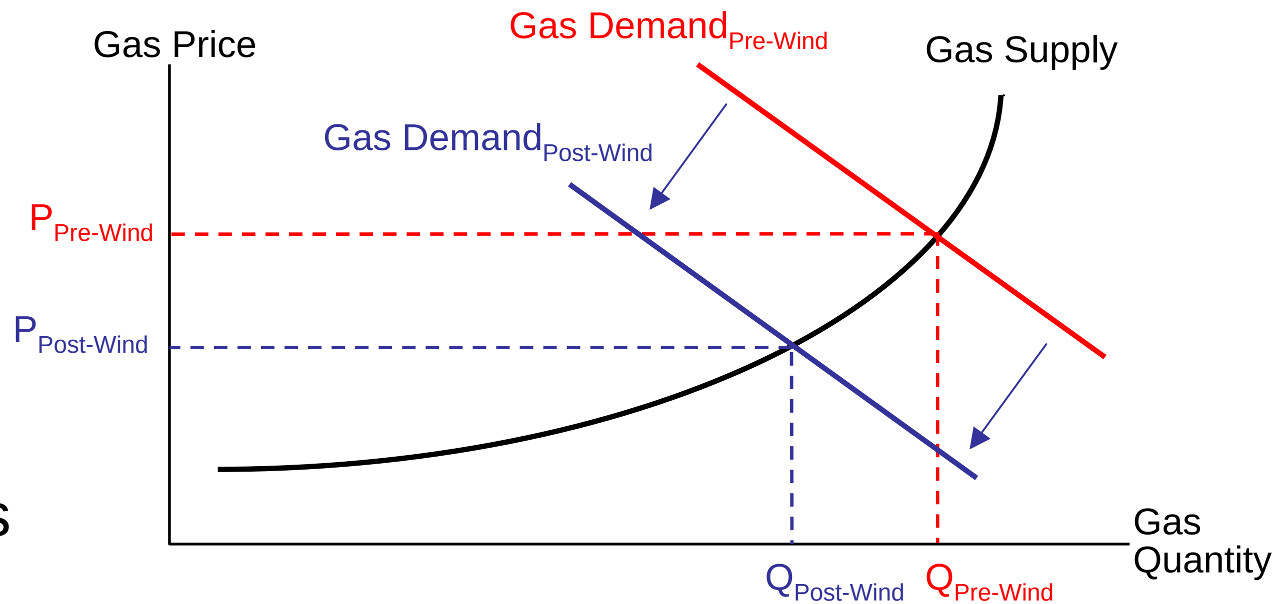
Source: NYMEX and EIA

Forward Prices Exceed Price Forecasts: AEO 2006



#2: Wind Reduces Gas Prices

Theory: Increased wind penetration displaces gas-fired generation, reducing demand for natural gas and placing downward pressure on natural gas prices



- Price reduction flows through to ***all*** consumers in the form of lower natural gas and electricity bills
- Magnitude of price reduction depends on shape of gas supply curve: impact expected to be larger in the short-term than in the long-term due to short-term supply constraints and longer-term price/supply adjustments
- Price reduction may be greater, in near-term, in regions with natural gas transportation constraints

Review of Recent Modeling Studies

Many modeling studies have evaluated the impact of increased renewable energy (RE) and energy efficiency (EE) deployment on natural gas prices.

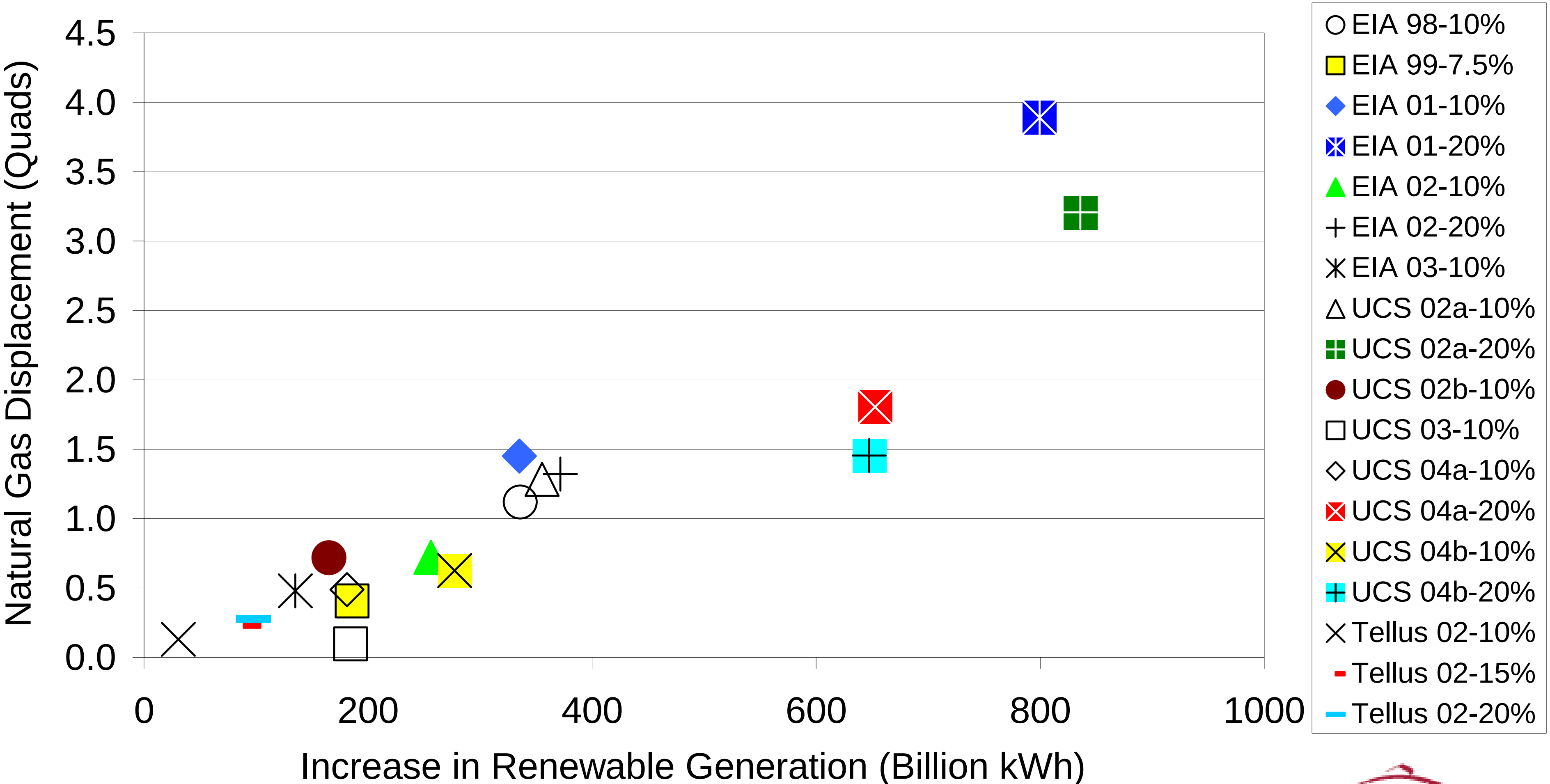
We analyzed results from 13 of these studies:

- 5 EIA studies of the impact of a national RPS, two of which model multiple RPS scenarios
- 6 UCS studies of the impact of a national RPS (3 model multiple RPS scenarios, 1 includes aggressive EE as well)
- 1 Tellus study of the impact of New England RPS (focus on RI)
- 1 ACEEE study of the impact of national RE/EE deployment

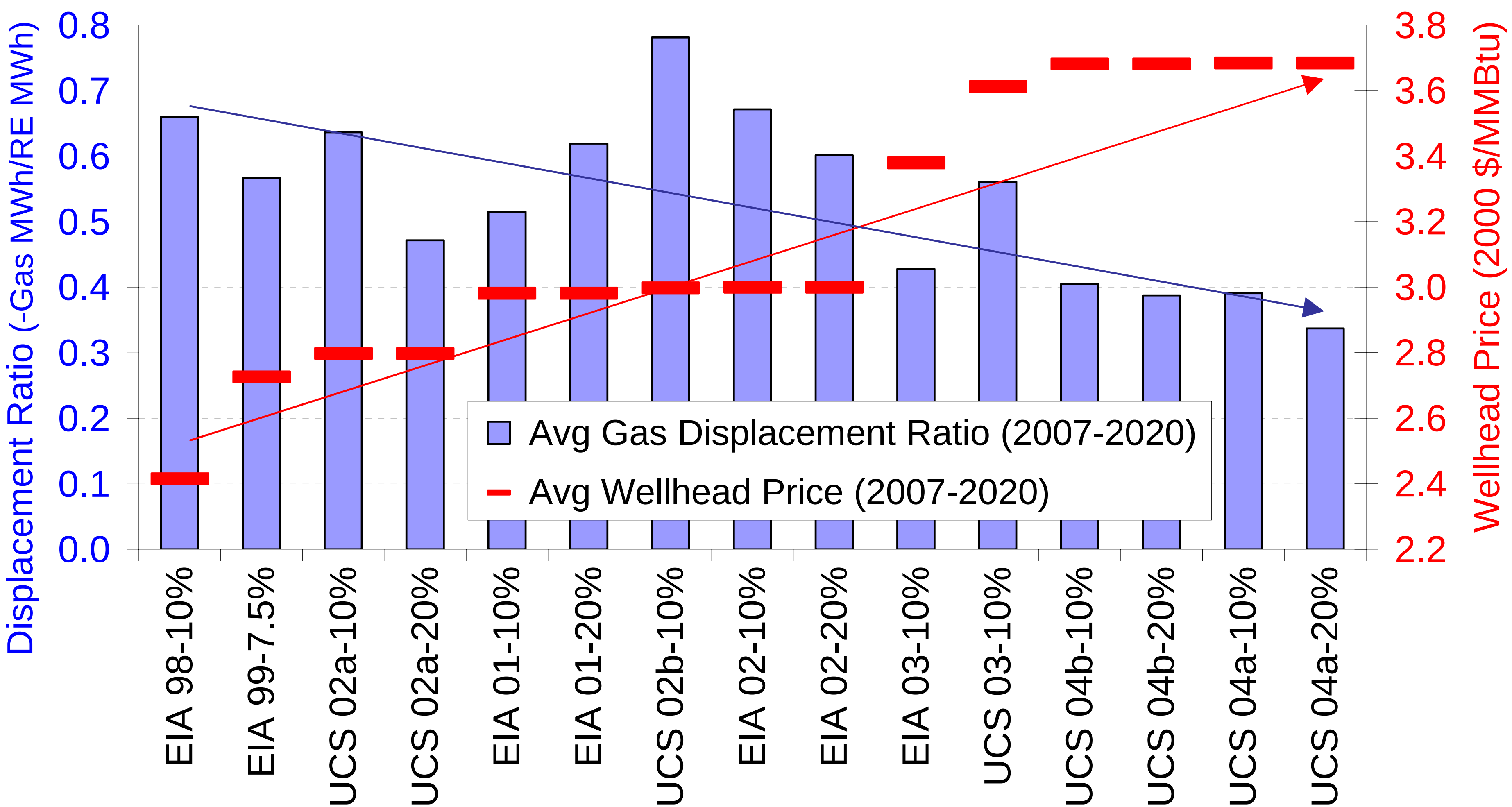
All use the EIA's NEMS, except ACEEE, which uses a model from EEA

Increased Renewables Penetration Displaces Natural Gas Demand

Projected Gas Displacement in 2020 Under RPS Studies

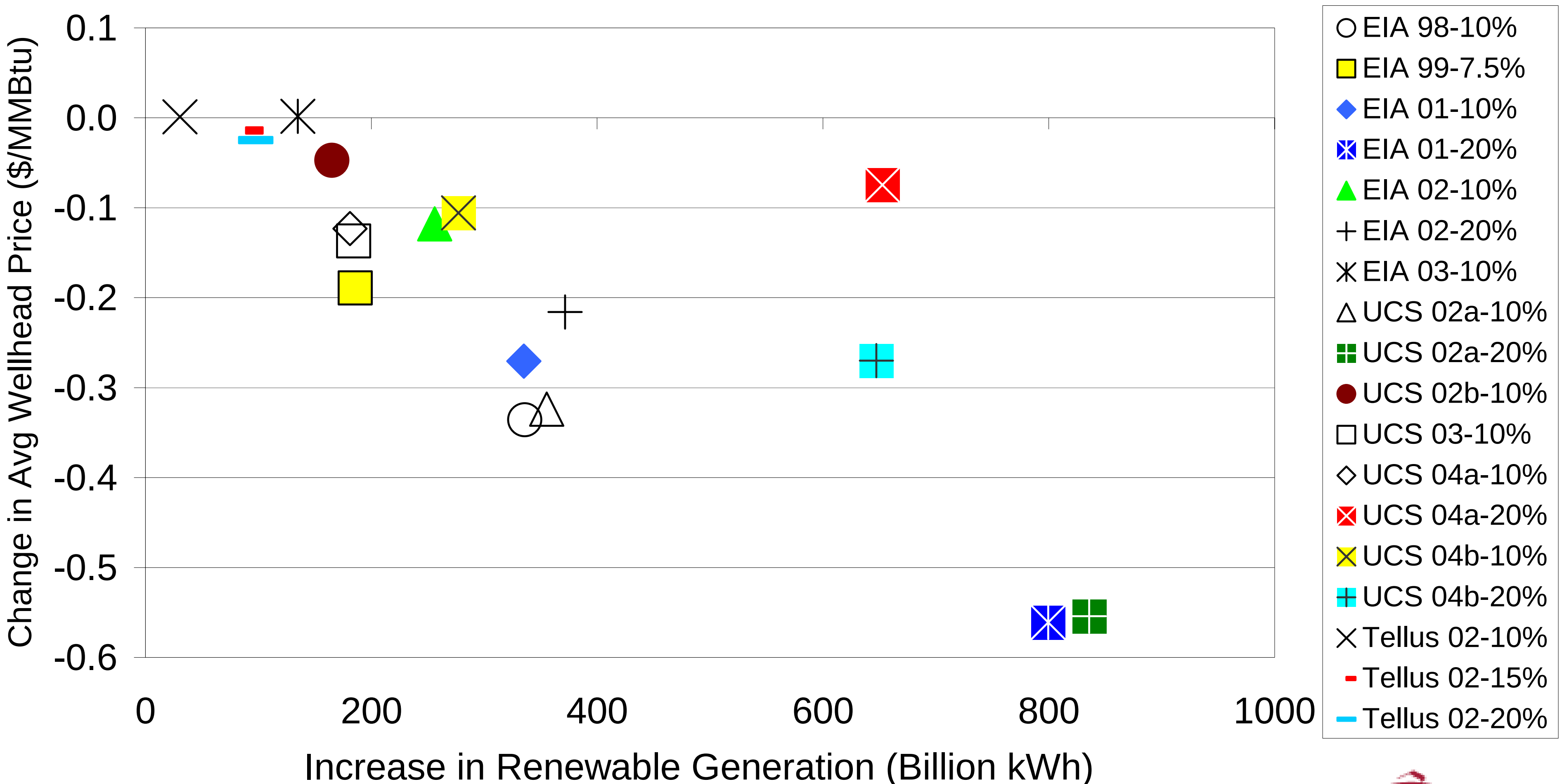


Gas Displacement Depends on Gas Prices: When Gas Prices High, Coal on the Margin



Increased Renewables Penetration Reduces Natural Gas Wellhead Prices

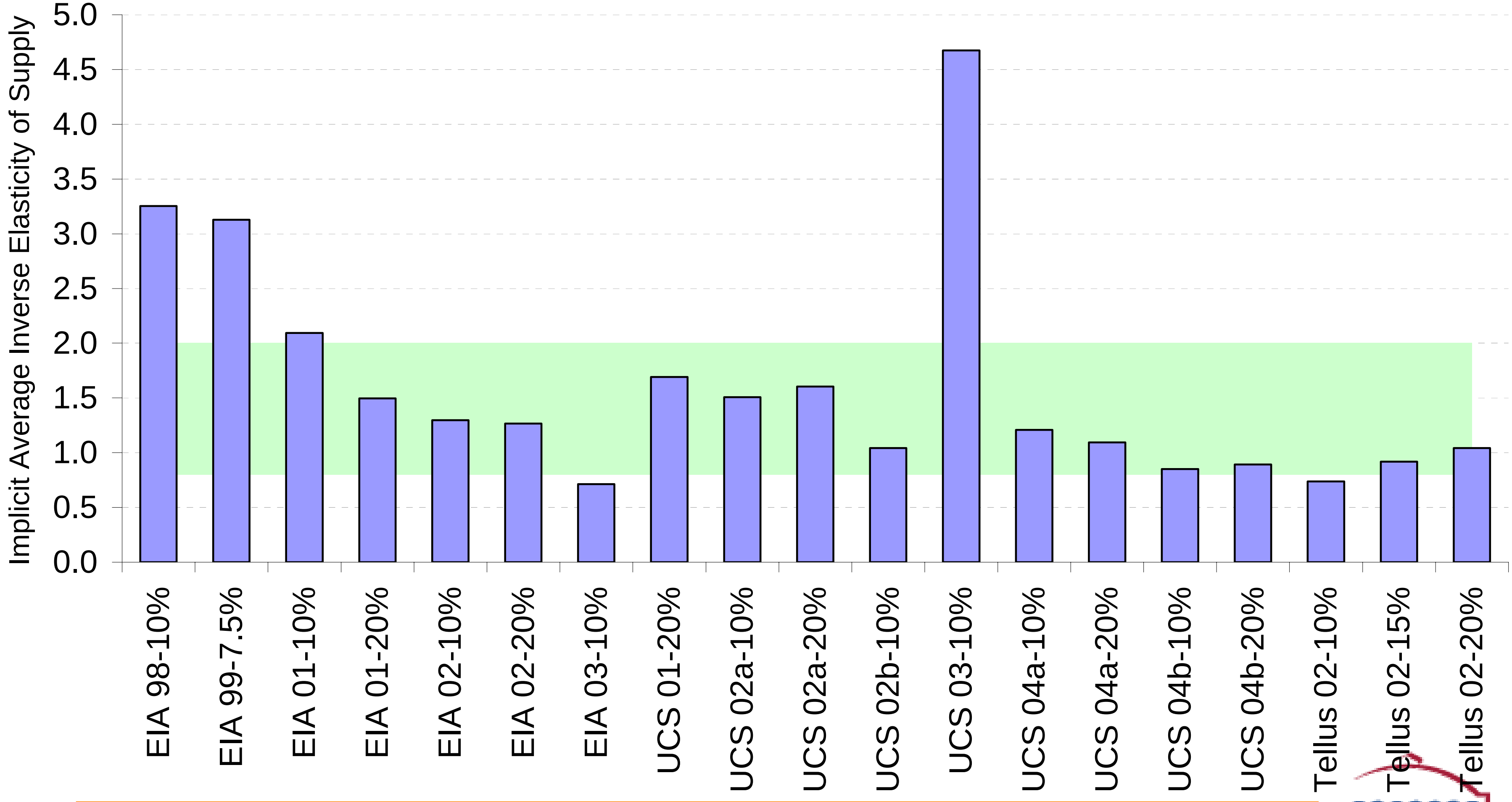
Projected Gas Price Change in 2020 Under RPS Studies



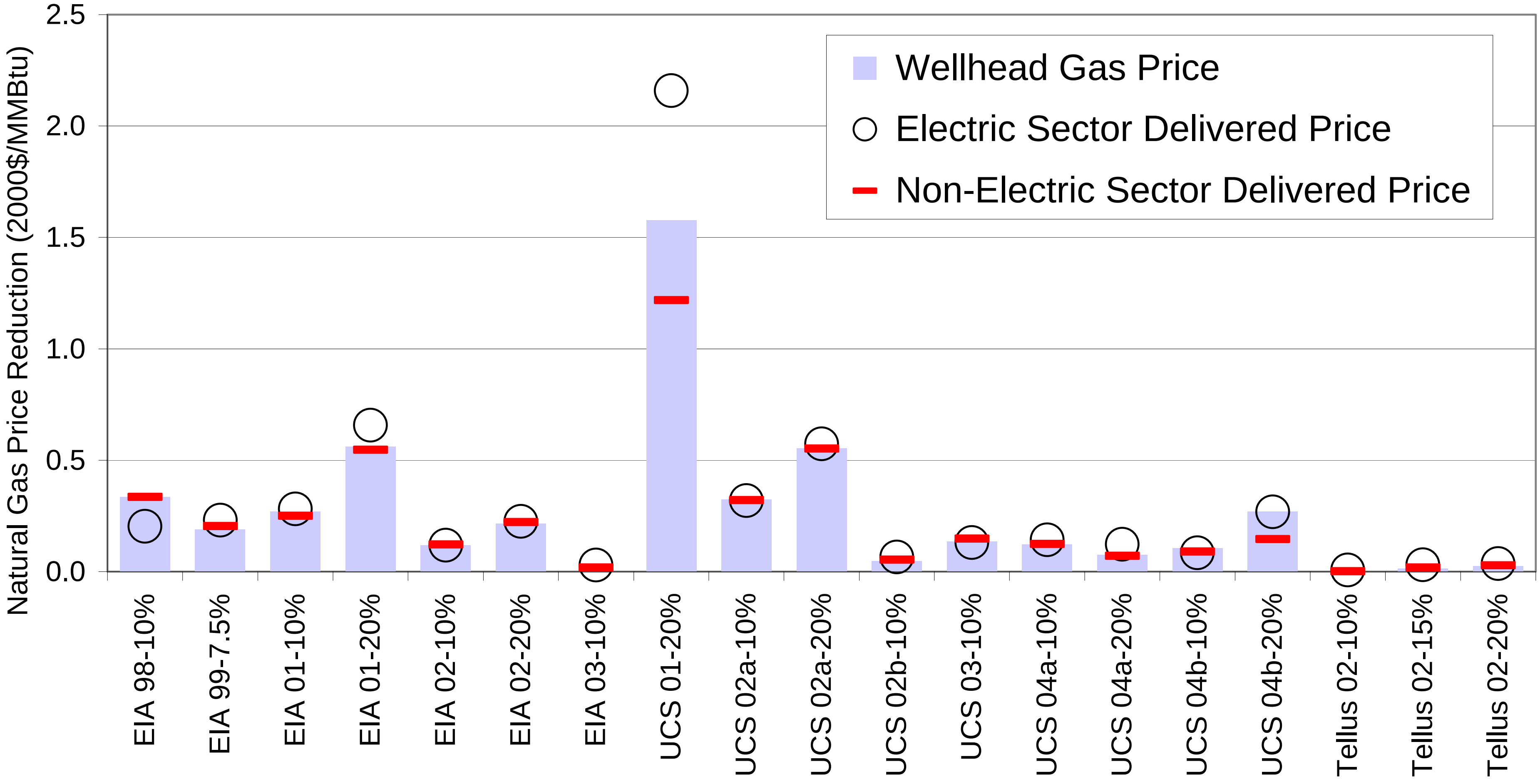
Implied "Inverse Elasticity of Supply"

(Defined as %ΔP/%ΔQ, measures shape of long-term supply curve)

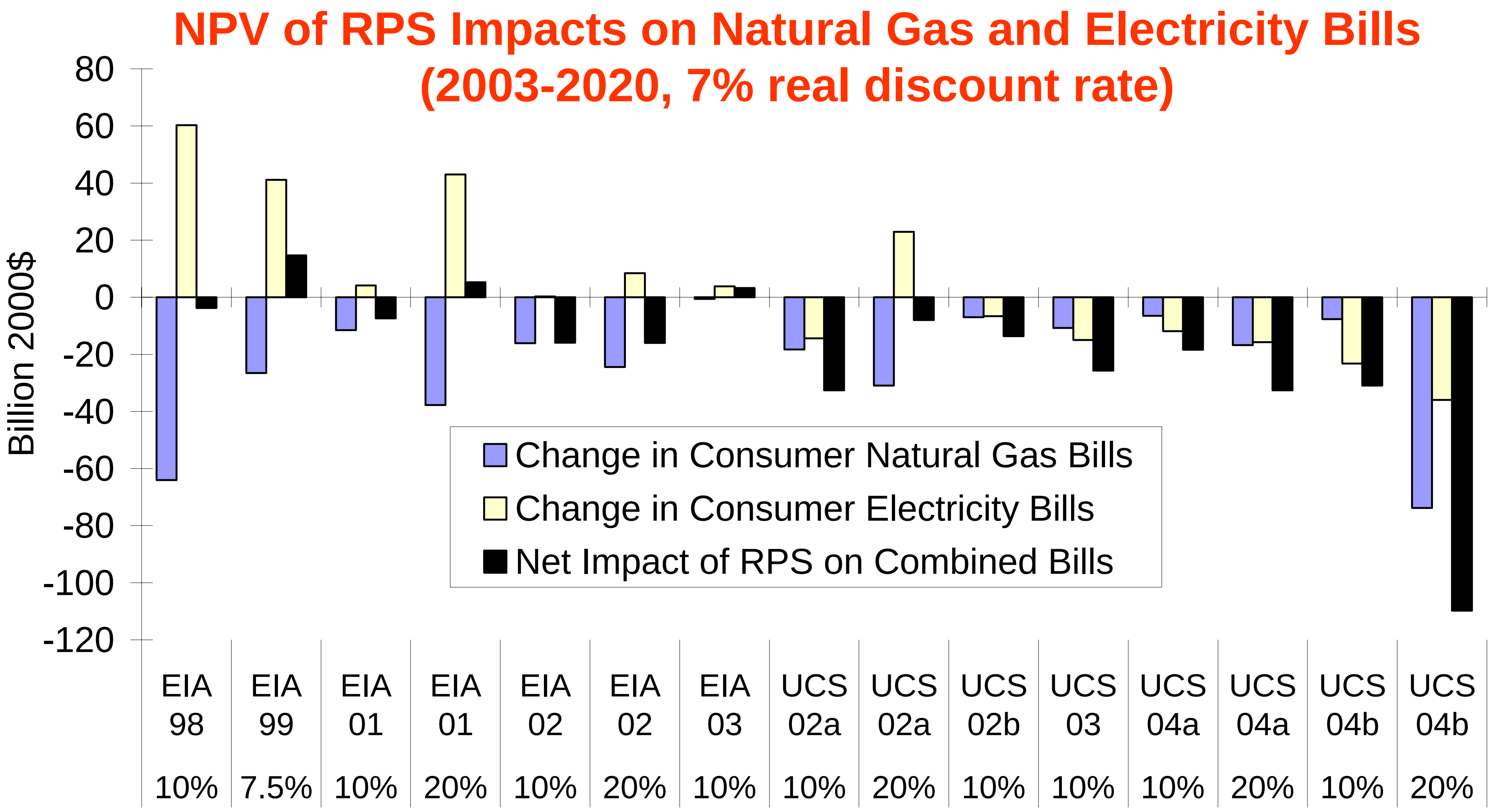
Central tendency of 0.8-2.0 suggests that *a 1% drop in gas demand causes a 0.8%-2.0% drop in wellhead prices over the long term*



Wellhead Price Reductions Flow Through to Delivered Prices Roughly 1:1

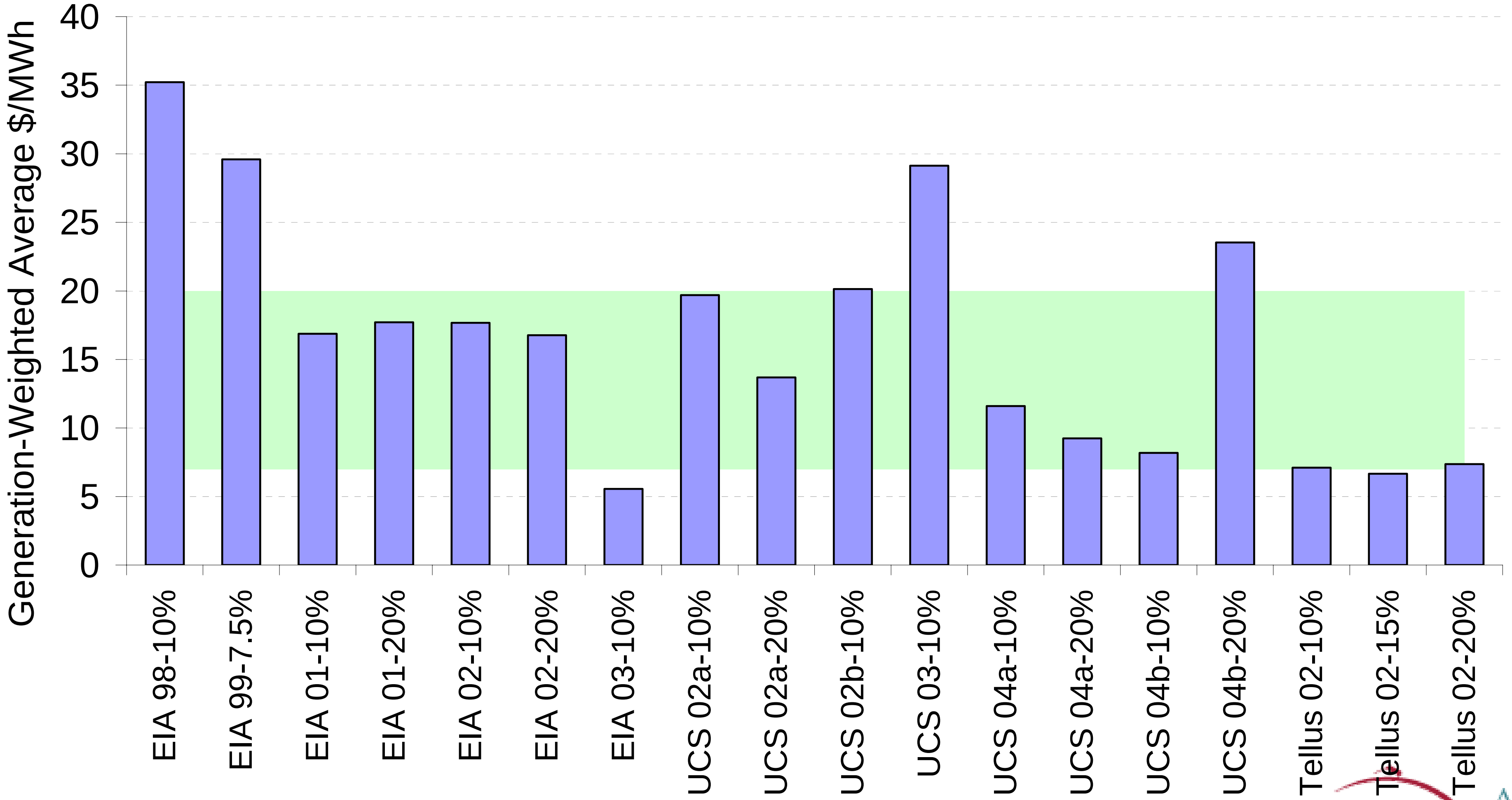


Gas Bill Reductions Substantially Offset Any Increase in Electricity Bills



Expressed as $/MWh of Incremental RE, National Gas Bill Savings are Substantial

Range of $7-$20/MWh captures most studies (some larger)



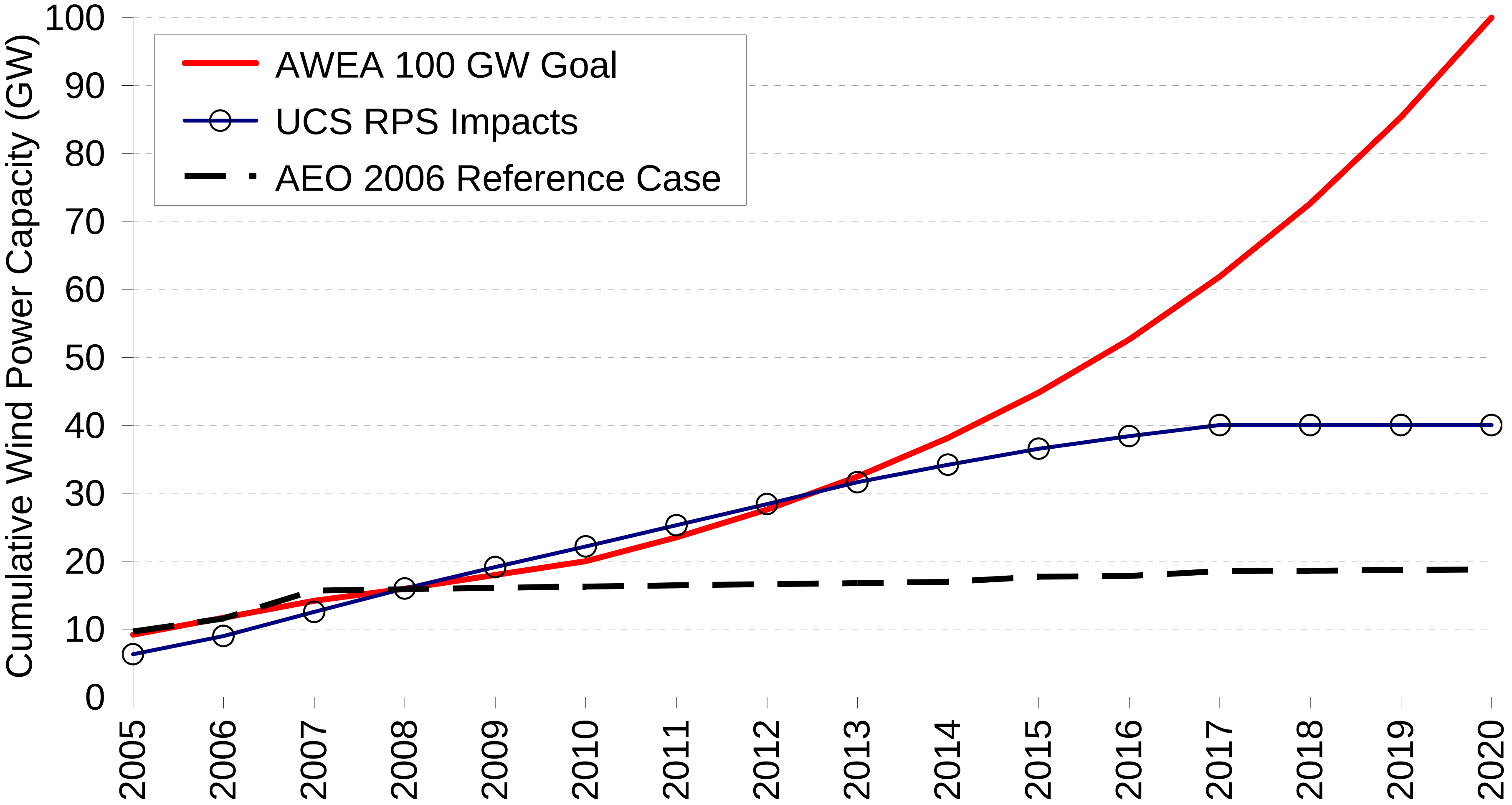
High Wind Penetration Scenario Analysis

We can use what we've learned from our review of these modeling studies to come up with a back-of-the-envelope approximation of the impact of high wind penetration on natural gas prices.

Two "high wind" penetration scenarios examined:

1) **AWEA 100 GW Goal:** 20 GW by 2010, 100 GW by 2020 (~6% of total electricity consumption in 2020)
2) **UCS State Policy Projections:** new RE generation required by state RPS policies through 2017 (equals ~40 GW if all wind)

High Wind Penetration Scenarios



Back-of-the-Envelope Methodology

Consumer Gas Price Impact in Year X = 1*2*3/4*5*6*7

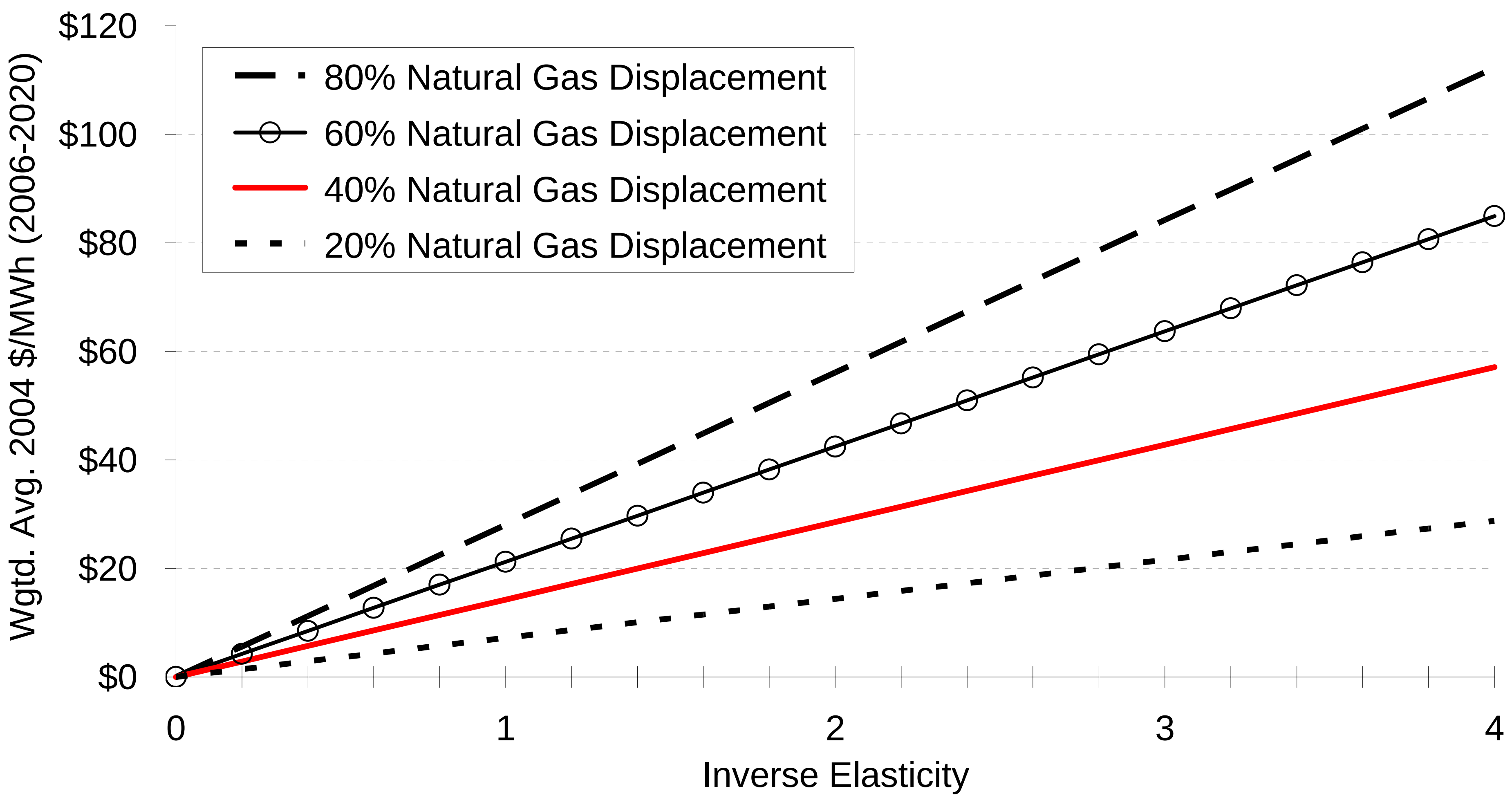
Step	Required Data	Description & Units	High Wind Penetration Assumptions
1	Incremental Renewable Generation in Year X	Δ renewable GWh	Scenario-dependent (see graph on previous slide)
2	Displacement Ratio of Gas-Fired Generation	Δ gas-fired GWh / Δ renewable GWh	**-0.40**
3	Heat Rate of Displaced Gas-Fired Generation	MMBtu gas / gas-fired GWh	**9,000 through 2007, falling to 7,500 by 2012**
4	Forecast of US Gas Consumption in Year X	MMBtu US gas demand	*AEO 2006* forecast from the EIA
5	Inverse Elasticity of Supply	% Δ $/MMBtu US wellhead / % Δ MMBtu US gas demand	**Range of +0.8 to +2.0**
6	Forecast of Average US Wellhead Price in Year X	$/MMBtu US wellhead	*AEO 2006* forecast from the EIA
7	Delivered Price Multiplier	Δ $/MMBtu US delivered / Δ $/MMBtu US wellhead	**+1.0**

Back-of-the-Envelope Results

Range in results due to range in assumed inverse elasticity	UCS	AWEA
Delivered Gas Price Reduction in 2020 (2004 $/MMBtu)	**$0.05-0.12/MMBtu**	**$0.11-0.27/MMBtu**
PV of Consumer Gas Bill Savings from 2006-2020 (Billion 2004 $)	**$8.0-19.9 billion**	**$9.6-23.9 billion**
Wgtd Avg $/MWh Gas Bill Savings from 2006-2020 (2004 $/MWh)	**$12-29/MWh**	**$11-29/MWh**

- Delivered gas price reductions are modest...
- But when applied to nationwide gas consumption, leads to ***substantial*** consumer gas bill savings...
- Both in absolute and $/MWh terms

Sensitivity Analysis on Elasticity and Gas Displacement: AWEA 100 GW Goal



Conclusions

- Natural gas prices are high, volatile, unpredictable
- Cost of wind is increasingly competitive, steady, predictable
- Wind reduces exposure to gas price risk (hedge benefit #1)
  - Where possible, use forward prices – *not uncertain price forecasts* – in economic and policy evaluations of wind vs. gas
- Wind reduces gas prices (hedge benefit #2)
  - A 1% drop in national gas demand may lead to a long-term 0.8%–2.0% drop in wellhead gas prices (some models show even larger impacts)
  - Implies gas bill savings of ~$7–20/MWh on a national basis
- When gas prices are high, coal is more often on the margin
  - Leads to *less* gas price savings....
  - But presumably *greater* carbon reduction savings
- Any policy evaluation of wind should extend beyond the power sector, to include gas sector impacts as well