



## MEMORANDUM

**From:** Mark Bolinger and Ryan Wiser, Berkeley Lab (BNL)  
**Subject:** Comparison of AEO 2009 Natural Gas Price Forecast to NYMEX Futures Prices  
**Date:** February 4, 2009

### 1. Introduction

#### *Context*

On December 17, 2008, the reference-case projections from *Annual Energy Outlook 2009 (AEO 2009)* were posted on the Energy Information Administration's (EIA) web site. We at BNL have, in the past, compared the EIA's reference-case long-term natural gas price forecasts from the *AEO* series to contemporaneous natural gas prices that can be locked in through the forward market, with the goal of better understanding fuel price risk and the role that renewables can play in mitigating such risk. As such, we were curious to see how the latest *AEO* reference-case gas price forecast compares to the NYMEX natural gas futures strip. This brief memo presents our findings.<sup>1</sup>

Note that this memo pertains *only* to natural gas fuel price risk (i.e., the risk that natural gas prices might differ over the life of a gas-fired generation asset from what was expected when the decision to build the gas-fired unit was made). We do not take into consideration any of the other distinct attributes of gas-fired and renewable generation, such as dispatchability (or lack thereof), differences in capital costs and O&M expenses, or environmental externalities. A comprehensive comparison of different resource types – which is well beyond the scope of this memo – would need to account for differences in *all* such attributes, including fuel price risk.

Furthermore, our analysis focuses solely on natural-gas-fired generation (as opposed to coal-fired or nuclear generation, for example), for several reasons: (1) price volatility has been more of a concern for natural gas than for other fuels used to generate power; (2) for environmental and other reasons, natural gas has, in recent years, been the fuel of choice among power plant developers; and (3) natural gas-fired generators often set the market clearing price in competitive wholesale power markets throughout the United States. That said, a more-complete analysis of

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how renewables mitigate fuel price risk would also need to consider coal, uranium, and other fuel prices.

Finally, we caution readers about drawing inferences or conclusions based solely on this memo in isolation: to place the information contained herein within its proper context, we strongly encourage readers interested in this issue to read through our previous, more-detailed studies, available at <http://eetd.lbl.gov/ea/EMS/reports/53587.pdf> or <http://eetd.lbl.gov/ea/ems/reports/54751.pdf>.

### *Methodology*

Any comparison of the levelized costs of fixed-price renewable generation with variable-price gas-fired generation requires making assumptions about the price of natural gas (i.e., the fuel) over the life of the generation asset. One approach sometimes used in resource planning exercises, but that may not adequately account for fuel price risk, is to simply adopt the latest reference-case fuel price projection from the EIA or some other long-term forecasting entity. Alternative approaches that may offer the basis for a better cost comparison (with respect to fuel price risk) include seeking to quantify the *value* of long-term price stability and incorporating that value into the cost comparison, or alternatively assessing the *cost* of achieving fixed-price gas-fired generation (through the use of natural gas futures or forwards) and comparing those costs with renewable electricity supply.

In this memo we focus on the last of these possible approaches, by comparing *AEO 2009* reference-case gas price forecasts with contemporaneous natural gas prices that can be locked in through the futures market. In other words, we simply update our past analysis to include the latest long-term gas price forecast from the EIA, as contained in *AEO 2009*. For the sake of brevity, we do not rehash information (on methodology, potential explanations for the premiums, appropriate caveats, etc.) contained in our earlier reports on this topic.

### *Summary of Findings*

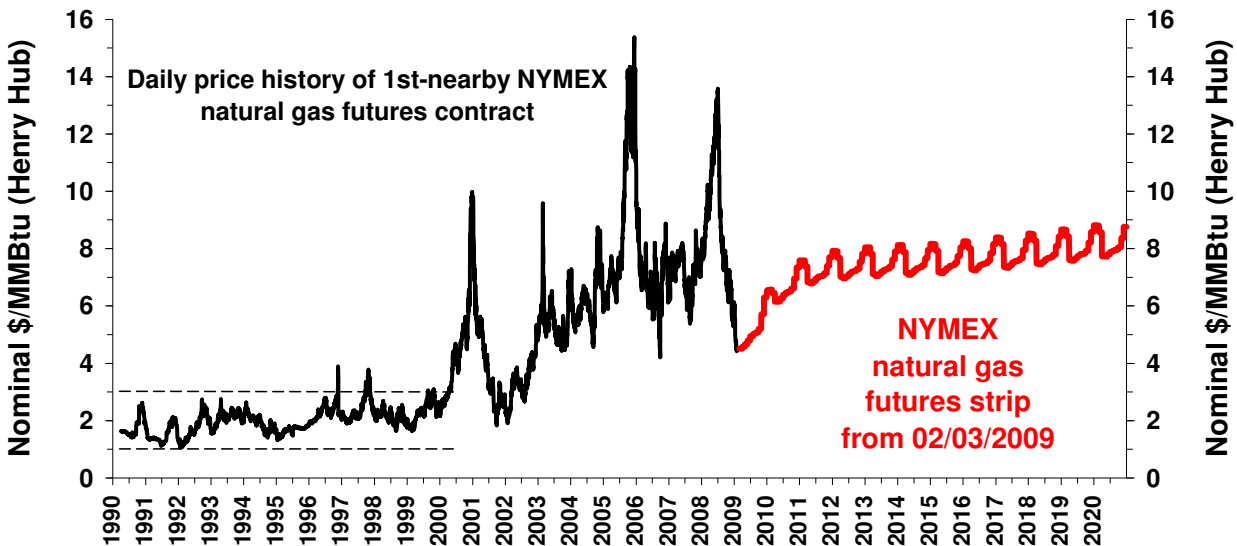
As a refresher, our past work in this area has found that over the past eight years (*AEO 2001-AEO 2008*), forward natural gas contracts (with prices that can be locked in – e.g., gas futures, swaps, and fixed-price physical supply) have traded at a premium relative to contemporaneous long-term reference-case gas price forecasts from the EIA. In this memo, we find that the *AEO 2009* reference-case gas price forecast also falls below where the NYMEX natural gas futures strip was trading – at least over the seven-year period from 2009-2015 – at the time the EIA finalized its forecast. Specifically, the NYMEX-*AEO 2009* premium is \$0.44/MMBtu levelized over the 7-year period from 2009-2015, but is just \$0.16/MMBtu levelized over the full twelve-year period from 2009-2020. In other words, on average, one would have had to pay \$0.16/MMBtu *more* than the *AEO 2009* reference-case natural gas price forecast in order to lock in natural gas prices over the coming twelve years and thereby replicate the price stability provided intrinsically by fixed-price renewable generation (or other forms of generation whose costs are not tied to the price of natural gas). This “premium” is considerably smaller than has existed in past years.

Regardless of the reason for this (modest) discrepancy (i.e., whether it represents a “risk premium” that must be paid to lock in prices, or whether it simply represents a difference in expectations), fuel-free renewable generation obviously need not bear this added cost in order to provide price stability (and, moreover, can provide price stability for terms in excess of twelve years). Thus, any levelized cost comparison of fixed-price renewable generation with variable-price gas-fired generation that is based solely on the *AEO 2009* reference-case natural gas price forecasts (rather than forward prices), and that has not otherwise considered fuel price risk, may yield results that are inappropriately skewed (at least with respect to fuel price risk) in favor of gas-fired generation.

Again, however, the discrepancy between NYMEX natural gas futures prices and the EIA’s reference case gas price forecast is much smaller, on average, this year than in the past.

## 2. Update on Natural Gas Prices

As context for our analysis, we provide this brief update on natural gas prices. Figure 1 shows the daily price history of “first-nearby” (i.e., closest to expiration, and therefore a proxy for spot prices) NYMEX natural gas futures contracts back to 1990, along with the current (from February 3, 2009) 154-month NYMEX futures “strip” tacked on to the end (in red). The strip shows that one can currently lock in Henry Hub prices of between \$4.50/MMBtu and \$9.00/MMBtu over the next thirteen years (through 2021), with the entire strip averaging around \$7.50/MMBtu. Although they have fallen sharply in recent months, these prices remain well above the range of \$1-3/MMBtu that persisted throughout the 1990s.



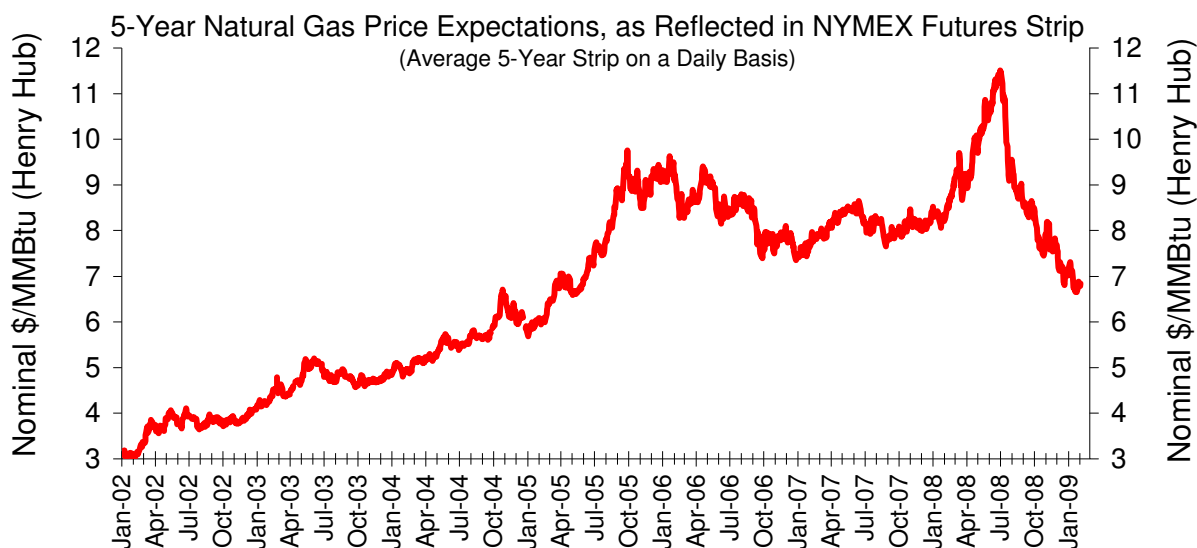
Source: LBNL

Figure 1: NYMEX Natural Gas Futures Prices

It should be noted that liquidity in the later years of the extended forward curve is quite thin. In fact, beyond 2015, many contract months have not even traded (i.e., there is no “open interest”). While such thin liquidity may prohibit large-volume trades, it does not necessarily discredit the quality of the price information contained in settlement prices. If the price were way out of line with general market expectations, traders and speculators would be expected to brave the wide

bid/offer spreads (resulting from illiquidity) to make a profit while driving the price back into line with expectations.

Figure 1 focuses on the history of “first-nearby” gas futures prices (a proxy for spot prices) and provides only a current snapshot of the 154-month futures strip (i.e., the prices that can currently be locked in for the next 154 months). Figure 2, in contrast, shows the daily history of the average 5-year natural gas futures strip going back to January 2002, a few weeks after the NYMEX first extended futures trading from 36 to 72 months (in February 2008, the NYMEX extended the curve out an additional 72-84 months, for 12-13 years total). Although “first nearby” prices (from Figure 1) have fallen by two-thirds from their highs set in mid-2008, the average 5-year strip has experienced a more-modest – but still quite sizable – decline, falling by about 40% to current 5-year expectations of about \$6.75/MMBtu.



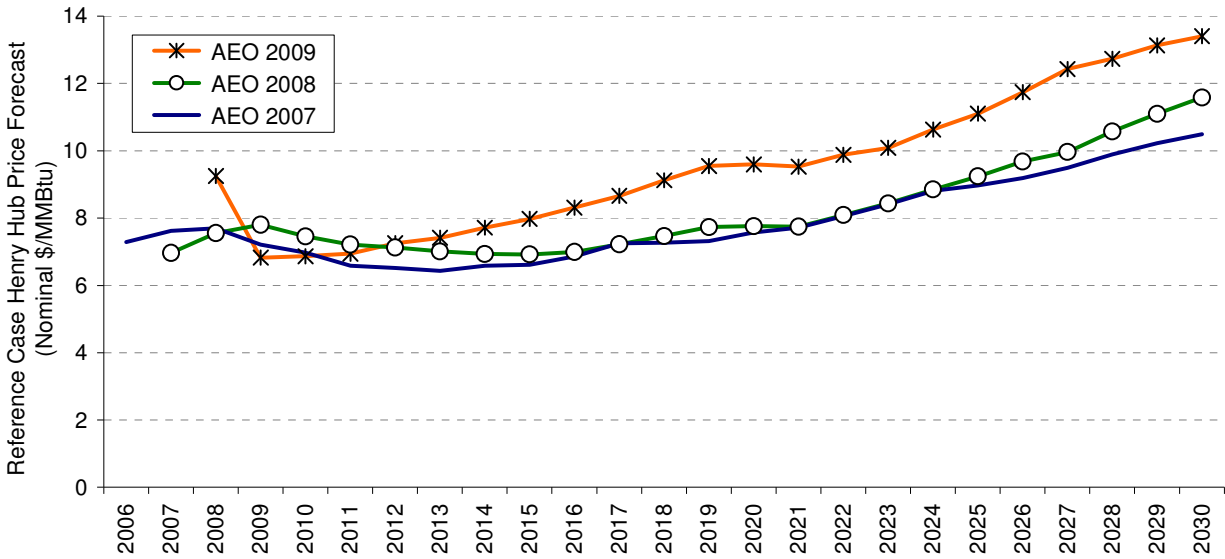
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**Figure 2: Change in 5-Year Natural Gas Price Expectations Over Time**

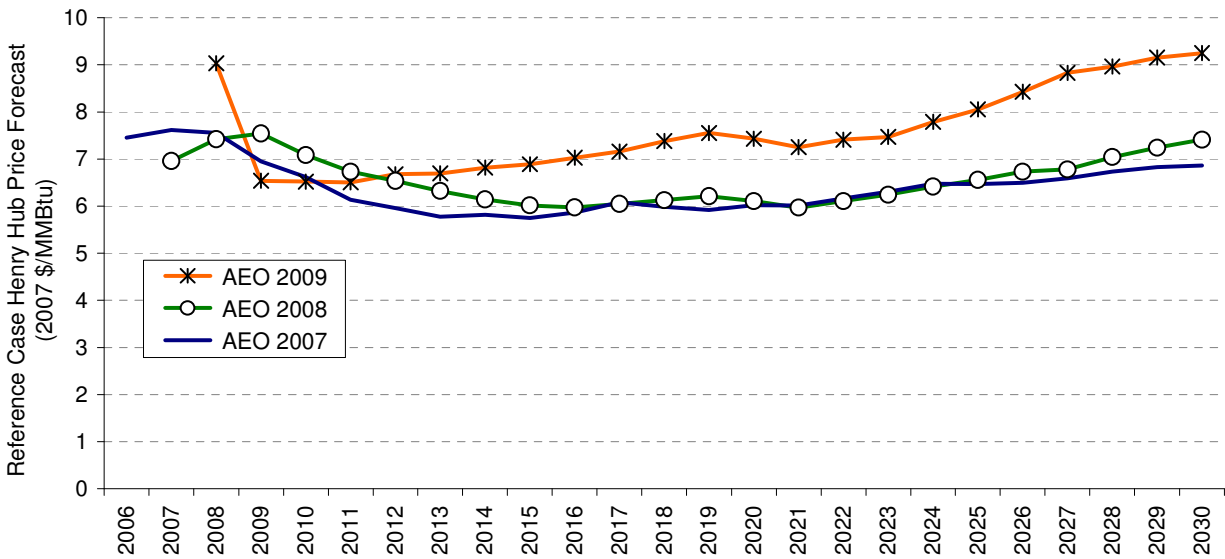
### 3. The AEO 2009 Natural Gas Price Forecast

In *AEO 2009*, the EIA has revised its reference-case gas price forecast significantly upwards from *AEO 2008*. Figure 3 compares the *AEO 2009* projection of nominal natural gas prices at the Henry Hub to the same price projections from *AEO 2007-2008*.<sup>2</sup> Figure 4 depicts the same price series in real (2007) dollars, demonstrating that the higher *AEO 2009* nominal price forecast shown in Figure 3 is not simply the result of higher inflation expectations.

<sup>2</sup> Each *AEO* projection in real dollars is converted to nominal dollars using the EIA’s projection of the GDP deflator (as contained in each *AEO*).



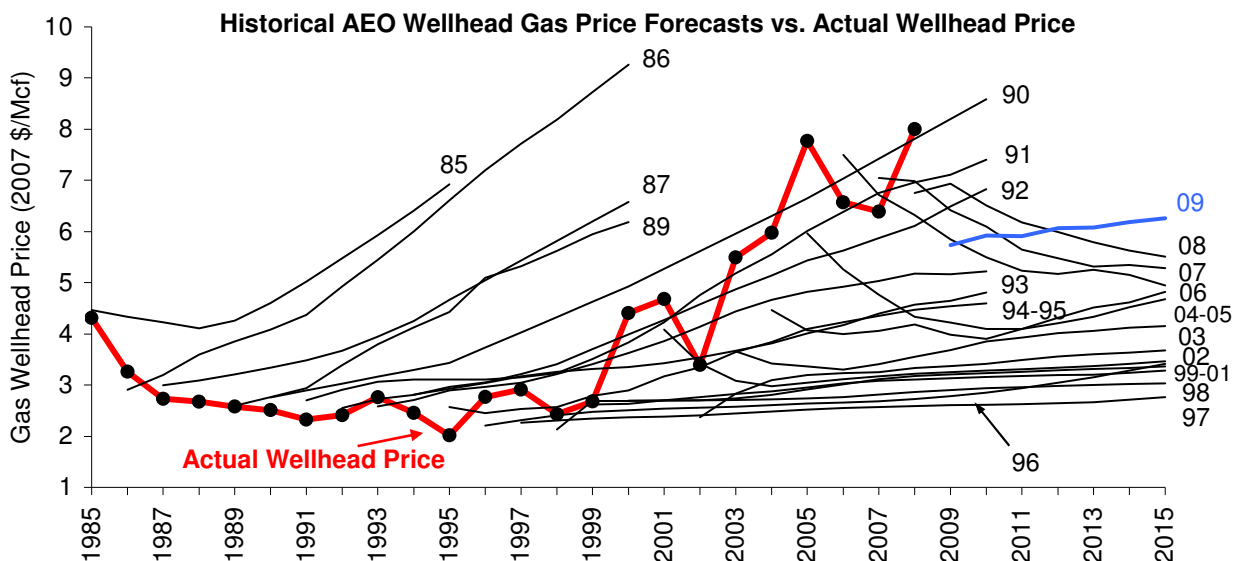
**Figure 3: Reference Case Henry Hub Natural Gas Price Forecasts (Nominal \$/MMBtu)**



**Figure 4: Reference Case Henry Hub Natural Gas Price Forecasts (2007 \$/MMBtu)**

The range of near-term price forecasts exhibited in Figures 3 and 4 suggests that recent EIA reference-case gas price forecasts may have missed their mark. Figure 5 confirms this notion, by showing the EIA’s wellhead gas price forecasts (going back to *AEO 1985*) plotted against subsequent actual wellhead prices (shown in red). Though the number of lines on the graph make it difficult to follow, it is nevertheless clear that past forecast accuracy has been wanting: although forecasts from the early 1990s have not strayed too far from the mark, the EIA grossly over-projected the price of gas in the mid-to-late 1980s, and conversely has grossly under-projected the near-term price of gas for much of the period since the mid-1990s. We suspect that other providers of fundamentals-based, long-term forecasts have experienced similar levels of inaccuracy. This poor track record, a reflection of the difficulty in accurately projecting natural

gas prices, suggests that, when valuing generation assets, little weight should be placed on any single long-term, reference-case fundamental price forecasts, and that sizable uncertainty bounds should be used regardless of which “base-case” forecast is chosen.



**Figure 5: Historical AEO Wellhead Gas Price Forecasts vs. Actual Wellhead Price**

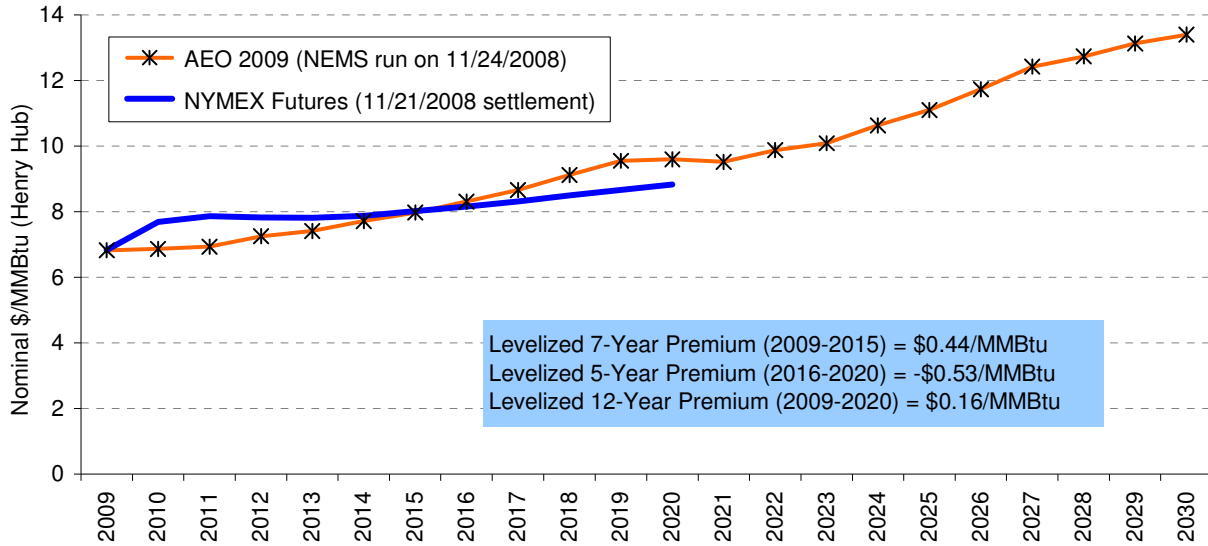
Some have mis-interpreted our work in this area as suggesting that forward prices are better predictors of future *spot* prices than are fundamental forecasts. This is certainly an area worthy of study, but we do not make this argument here, and our analysis does not depend upon it. In fact, all spot price forecasts – whether gleaned from futures prices or fundamental forecasts – have been, and will continue to be, “wrong” to some extent. An important distinction, however, is that – unlike a fundamental forecast – the NYMEX futures strip (or at least the liquid portions of it) can actually be bought and locked in to create price certainty. In other words, anyone who buys the strip will know with 100% certainty what his or her fuel costs will be over that term. In this sense, the NYMEX strip’s forecasting ability can be thought of as being 100% accurate – at least for those who buy the strip. This situation is analogous to fuel-free renewables: anyone contracting for wind power today knows with great certainty what his or her future costs will be.

#### **4. Natural Gas Futures Prices Trading at a Small Premium to AEO Reference-Case Price Forecasts**

Despite the upward revision to the EIA’s reference-case gas price forecast in *AEO 2009* (Figures 3 and 4), the first seven years of the *AEO 2009* forecast are, on average, below where natural gas futures contracts have recently been trading. The subsequent five years, however, show a reversal of this trend. Figure 6 compares the *AEO 2009* reference-case projection of Henry Hub gas prices (which resulted from a November 24, 2008 modeling run) to the NYMEX natural gas futures strip (with monthly prices averaged each year<sup>3</sup>) from November 21, 2008. Levelized

<sup>3</sup> Given that natural gas prices may exhibit seasonal patterns (e.g., see Figure 1), averaging monthly futures prices to derive an average annual price may introduce seasonal distortions that impact our analysis. Because the AEO price projections are only provided on an annual basis, however, averaging the monthly NYMEX prices seems to be the most straightforward way to place each data series on a comparable basis.

over the first 7-year period, the spread between the two data series comes to \$0.44/MMBtu. For the subsequent 5-year period (2016-2020), however, the levelized spread comes to *negative* \$0.53/MMBtu. Over the entire 12-year period (2009-2020), the levelized spread comes to just \$0.16/MMBtu.

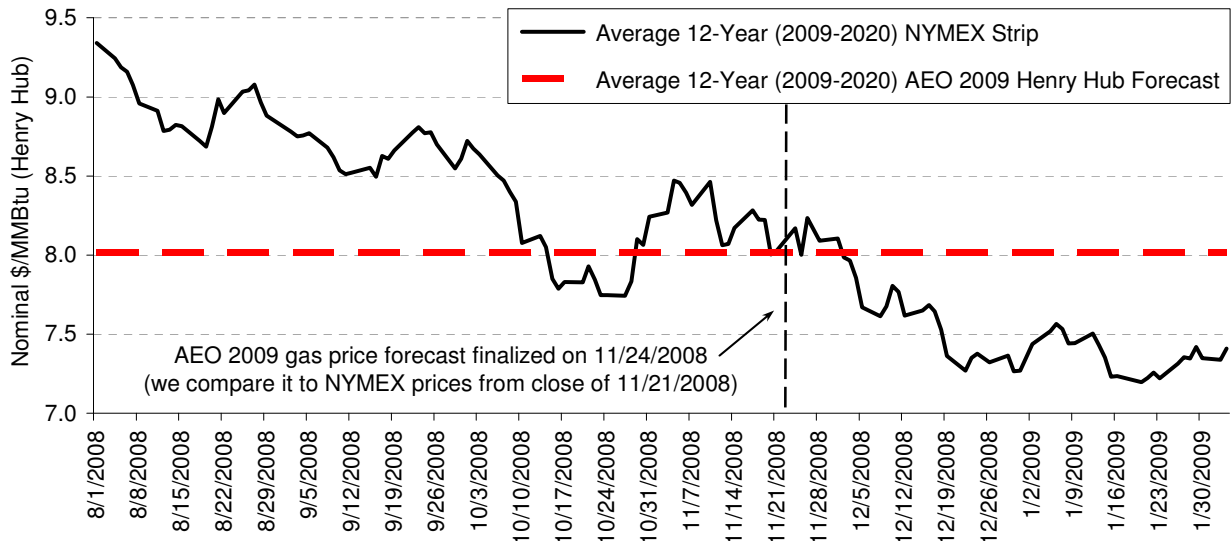


**Figure 6: Comparison of NYMEX Futures Strip to AEO 2009 Gas Price Projection**

## 5. Picking the Correct Date of Comparison

As mentioned above, the *AEO 2009* reference-case natural gas price projection resulted from a NEMS run completed on November 24, 2008. For the comparison made above in Figure 6, we chose to sample the NYMEX strip from November 21, 2008 in order to reflect the latest market information potentially available to the EIA at the time the gas price projections were being finalized. One should keep in mind, however, that the EIA’s reference-case price projections are developed over a period of months, with the core analysis behind the natural gas price projection being completed as early as August or September, while the oil price projections (which, in turn, impact the natural gas price projections) are completed even earlier in the year.

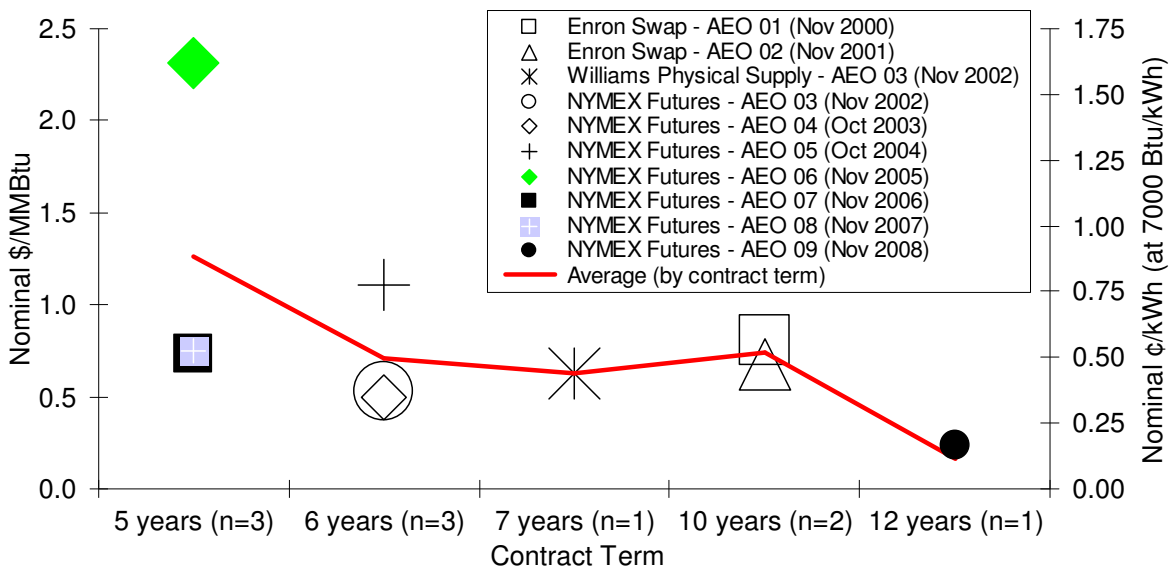
In light of these timing issues, we examined the average 12-year NYMEX strip from the beginning of August 2008 through February 3, 2009, in order to gauge whether the settlement prices on November 21, 2008 are, in fact, representative of where gas futures had been trading around the time the EIA was finalizing its *AEO 2009* forecast. The results, which are shown in Figure 7, suggest that November 21 was a fairly representative choice over this period. In fact, November 21 appears to be a somewhat conservative choice, presuming that the *AEO 2009* natural gas price forecast was largely formulated earlier in the fall, even if not finalized until November 24. Since November 24, natural gas futures prices have fallen considerably.



**Figure 7: Average NYMEX Strip vs. Average AEO 2009 Forecast (2009-2020)**

## 6. Increasing our Sample Size

The early release of *AEO 2009* allows us to add another data point to our growing sample of comparisons between contemporaneous forward prices and *AEO* reference-case gas price forecasts. As shown in Figure 8, the premium observed with respect to the *AEO 2009* forecast is less than what we have observed in previous years.



**Figure 8: Levelized Premiums (Forwards – Forecasts)**

Assuming a heat rate of 7,000 Btu/kWh (typical of an advanced combined cycle gas turbine), the \$0.16/MMBtu NYMEX premium relative to the *AEO 2009* reference-case translates to just

0.11¢/kWh – smaller than premiums observed in the past, and arguably a difference that is “in the noise.”

## 7. Cause of Premium Remains Elusive

As explained in our past reports on this topic (see <http://eetd.lbl.gov/ea/EMS/reports/53587.pdf> or <http://eetd.lbl.gov/ea/ems/reports/54751.pdf>), the cause of these observed empirical premiums relative to EIA’s fundamental reference-case forecasts of spot gas prices remains uncertain. One potential explanation is that the premiums represent the cost of locking in prices over time (e.g., an “insurance premium”) – a cost that owners or purchasers of renewable generation need not bear in order to achieve price stability. An alternative explanation is that the *AEO* reference-case gas price projections have simply fallen below the market’s expectations of future spot prices over the past nine years, thereby creating the appearance of a premium.

Even with the addition of this *AEO 2009* data point, our sample size remains prohibitively small for drawing any type of definitive conclusion on this matter, and previous academic literature on these issues is inconclusive. We nevertheless find it interesting that the empirical premium between forward prices and the EIA’s reference-case price forecast has persisted for as long as it has. This discrepancy between EIA reference-case forecasts of future spot gas prices and market-based forward price projections argues for further work in understanding the possible sources of the discrepancy, and an improved understanding of the conditions under which either fundamentals-based forecasts or NYMEX forward prices “ought” to be used. At the same time, it must be observed that the discrepancy is much smaller this year than in past years, and is arguably “in the noise” that unavoidably accompanies this type of analysis. The reasons for this narrowing of the premium are similarly unclear, though certainly the rapid and precipitous drop in commodity prices, including natural gas prices, since the middle of 2008 is one factor.

## 8. Conclusion

As has been the case over at least the past eight years (*AEO 2001-AEO 2008*), levelized cost comparisons of fixed-price renewable generation with variable-price gas-fired generation that are based solely on the *AEO 2009* reference-case natural gas price forecast, and that have not otherwise considered fuel price risk, may yield results that are inappropriately skewed in favor of gas-fired generation (with respect to fuel price risk, presuming that long-term price stability is valued, and that all other aspects of the comparison are unbiased). This conclusion holds true regardless of the *reason* for the premium (i.e., forward prices trading at levels that exceed the *AEO* price projection) described above:

- If the premium represents the incremental cost of locking in future gas prices (i.e., a risk premium), then moving towards a fair comparison (with respect to fuel price risk) would, arguably, require that the cost of *fixed-price* renewable generation be compared to the cost of similarly fixed-price gas-fired generation, which would entail using a natural gas price projection that incorporates any risk premium. Alternatively, one might compare fixed-price renewables with variable-price gas contracts, but only if the “value” of price stability is discerned and included in the comparison. Unfortunately, we are not aware of any recent estimates that have sought to quantify this value.

- If instead the premium simply reveals that the *AEO* reference-case gas price forecasts have fallen below the market's expectations of future spot prices over the past nine years, then any levelized cost comparison using only that forecast (or using that forecast as the "base case") will arguably be skewed in favor of gas-fired generation, unless clear documentation shows that the accuracy of the EIA reference-case forecast is superior to market expectations.

All that said, this year we find that the \$0.16/MMBtu NYMEX premium relative to the *AEO 2009* reference-case forecast (equal to 0.11¢/kWh assuming an aggressive heat rate) is smaller than premiums observed in the past, and is arguably a difference that is "in the noise."

Notwithstanding the small premium this year, we recommend that, absent an estimate of the underlying "value" of price stability, analysts and policymakers select among "blended" base-case gas price forecasts that utilize NYMEX futures data when available and long-term fundamental forecasts thereafter. Indeed, electric utilities and electricity regulators have increasingly relied on NYMEX forward prices (when available) over fundamentals forecasts for assessing the likely cost of natural gas in the near term.

Even so, we do not advocate that analysts and policymakers rely solely upon these blended forecasts (or any other forecast, for that matter) in making investment or planning decisions. Instead, a prudent approach to evaluating price risk would be to use such blends to estimate the base-case natural gas price forecast, but to also examine a wide range of different plausible price projections, using either stochastic or scenario analysis. This is especially necessary given the fact that generation investments are long-lived assets that extend well beyond the current NYMEX futures strip, and that renewables can provide price certainty over even longer terms.