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MEMORANDUM

From: **Mark Bolinger and Ryan Wiser, Berkeley Lab (LBNL)**
Subject: **Comparison of AEO 2008 Natural Gas Price Forecast to NYMEX Futures Prices**
Date: **January 7, 2008**

1. Introduction

Context

On December 12, 2007, the reference-case projections from *Annual Energy Outlook 2008* (*AEO 2008*) were posted on the Energy Information Administration's (EIA) web site. We at LBNL 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.[1]

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) 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 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 (though its appeal has diminished somewhat as prices have increased); 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 how renewables mitigate fuel price risk would also need to consider coal and other fuel prices.

[1] This work was funded by the Office of Energy Efficiency and Renewable Energy, Wind & Hydropower Technologies Program and the Office of Electricity Delivery and Energy Reliability, Permitting, Siting and Analysis of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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 2008* 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 2008*. 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

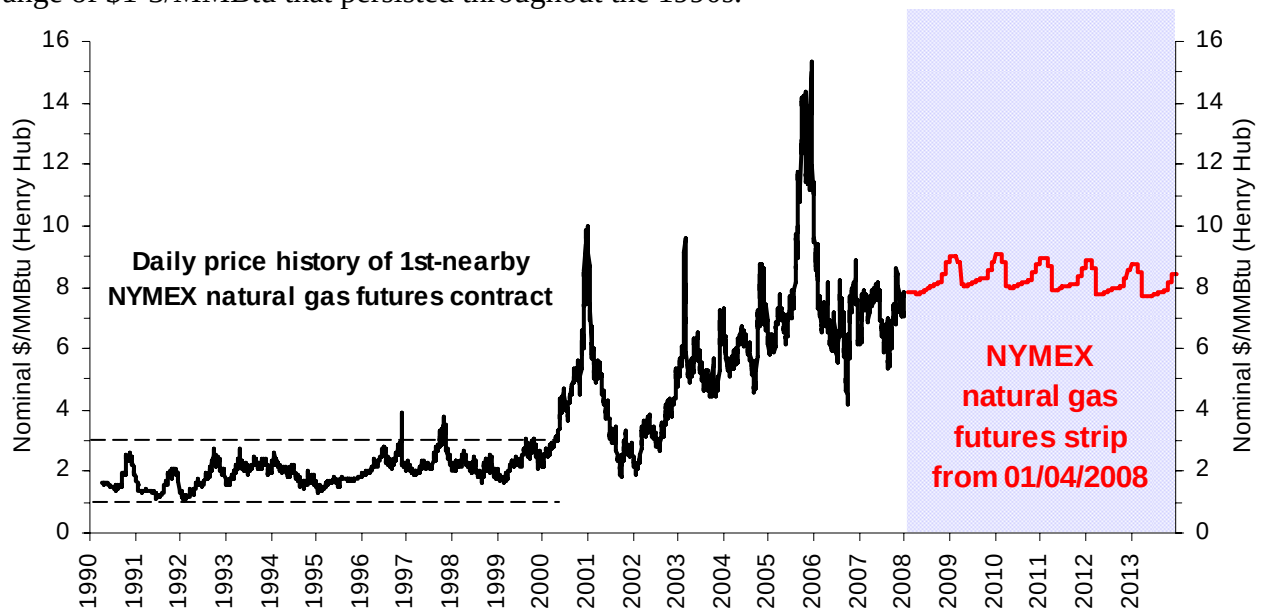
As a refresher, our past work in this area has found that over the past seven years (*AEO 2001*-*AEO 2007*), forward natural gas contracts (with prices that can be locked in – e.g., gas futures, swaps, and fixed-price physical supply) have traded at a premium relative to contemporaneous long-term reference-case gas price forecasts from the EIA. In this memo, we find that the *AEO 2008* reference-case gas price forecast also falls below where the NYMEX natural gas futures strip was trading at the time the EIA finalized its forecast. Specifically, the NYMEX-*AEO 2008* premium is $0.59/MMBtu levelized over five years. In other words, on average, one would have had to pay $0.59/MMBtu *more* than the *AEO 2008* reference-case natural gas price forecast in order to lock in natural gas prices over the coming five 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).

Regardless of the reason for this 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 well in excess of five years). Thus, any levelized cost comparison of fixed-price renewable generation with variable-price gas-fired generation that is based solely on the *AEO 2008* 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.

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 January 4, 2008) 72-month NYMEX futures "strip" tacked on to the end. The strip shows that one can currently lock in Henry Hub prices of between $7.5/MMBtu and $9/MMBtu over the next six years, with the entire strip averaging around $8.25/MMBtu.[2] These prices are well above the range of $1-3/MMBtu that persisted throughout the 1990s.



Source: LBNL

Figure 1: NYMEX Natural Gas Futures Prices

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 72-month futures strip (i.e., the prices that can currently be locked in for the next 72 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. Although "first nearby" prices (from Figure 1) have fallen roughly *in half* from their historic highs set in late 2005, the average 5-year strip has experienced a much more modest decline, and has been vacillating around $8/MMBtu over the past year – still about $5/MMBtu higher than in early 2002.

[2] It should be noted that liquidity in the later years of the forward curve is rather thin. That said, there is currently "open interest" in each contract – even the 2013 contracts, which have only been listed since November 29, 2007. Furthermore, while 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.

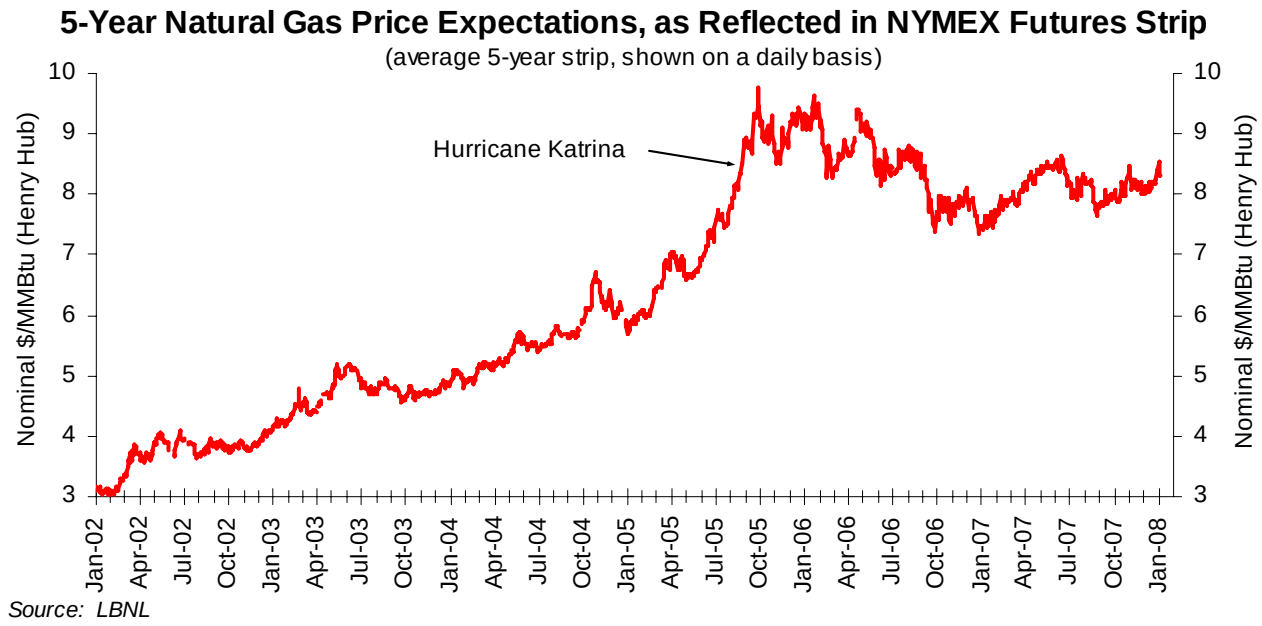


Figure 2: Increase in Average NYMEX Natural Gas Futures Strip Over Time

3. The AEO 2008 Natural Gas Price Forecast

In *AEO 2008*, the EIA has revised its reference-case gas price forecast slightly upwards from *AEO 2007*. Figure 3 compares the *AEO 2008* projection of nominal natural gas prices delivered to electricity generators to the same price projections from *AEO 2001-2007*.[3]

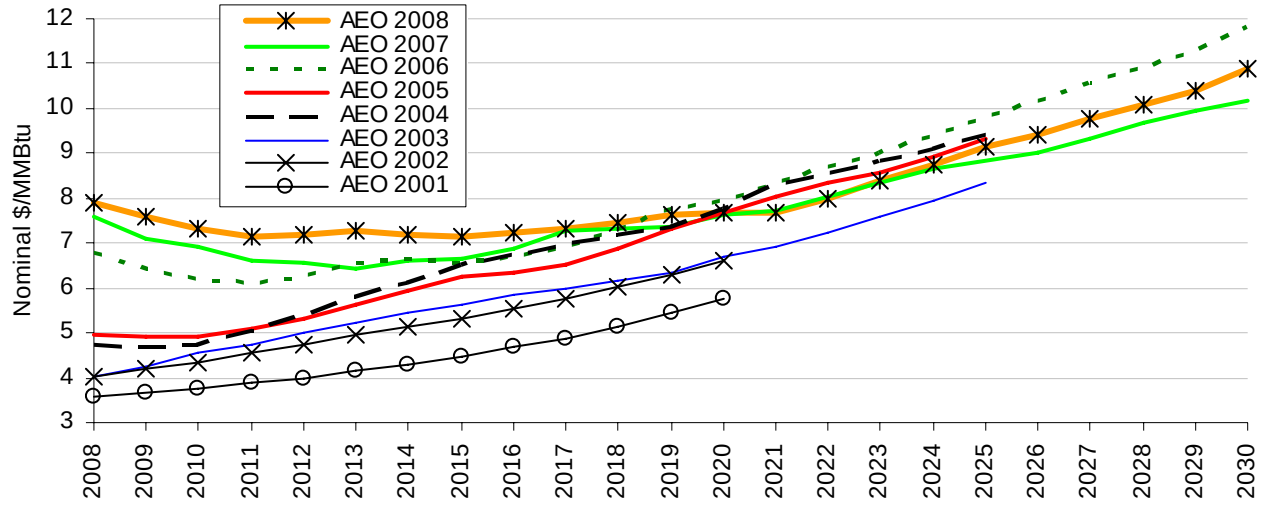


Figure 3: Natural Gas Prices Delivered to Electricity Generators, Nominal $/MMBtu

[3] 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 4 depicts the same price series in real (2006) dollars, and shows that *AEO 2008* contains somewhat higher natural gas price forecasts than projected in *AEO 2006* and *AEO 2007*, and prices considerably higher than those projected within *AEO 2001* through *AEO 2005*.

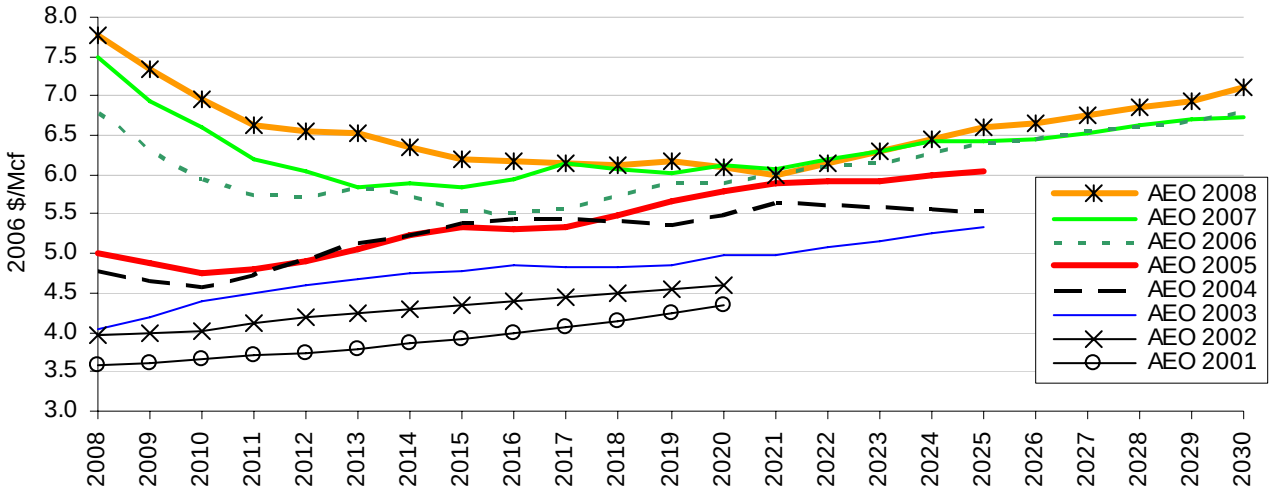


Figure 4: Natural Gas Prices Delivered to Electricity Generators, 2006 $/Mcf

The wide range of price forecasts exhibited in Figures 3 and 4 suggests that recent EIA reference-case gas price forecasts have significantly 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 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 used.

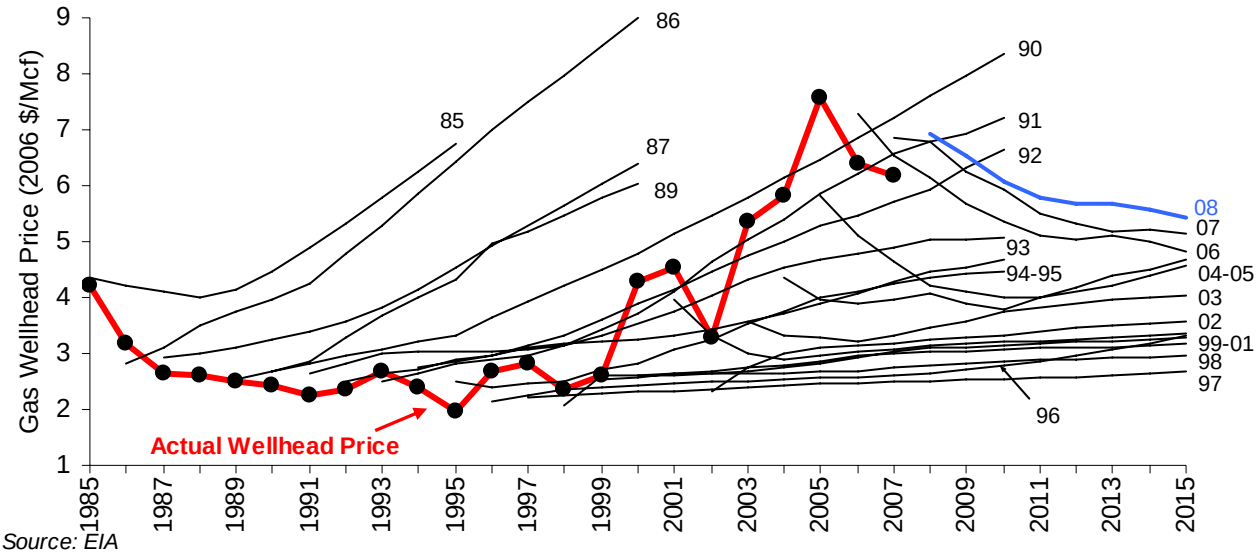


Figure 5: Historical AEO Wellhead Gas Price Forecasts vs. Actual Wellhead Price

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 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 limited 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 analagous 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 Still Trading at a Premium to AEO Reference-Case Price Forecasts

Despite the upward revision to the EIA's reference-case gas price forecast in *AEO 2008* (Figures 3 and 4), the first five years of the *AEO 2008* forecast are, on average, below where natural gas futures contracts have recently been trading (though 2008 is very close). Figure 6 compares the *AEO 2008* reference-case projection of Henry Hub gas prices (which resulted from a November 26, 2007 modeling run) to the NYMEX natural gas futures strip (with monthly prices averaged each year[4]) from November 23, 2007. Levelized over the entire 5-year period, the spread between the two data series comes to $0.59/MMBtu.

[4] 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.

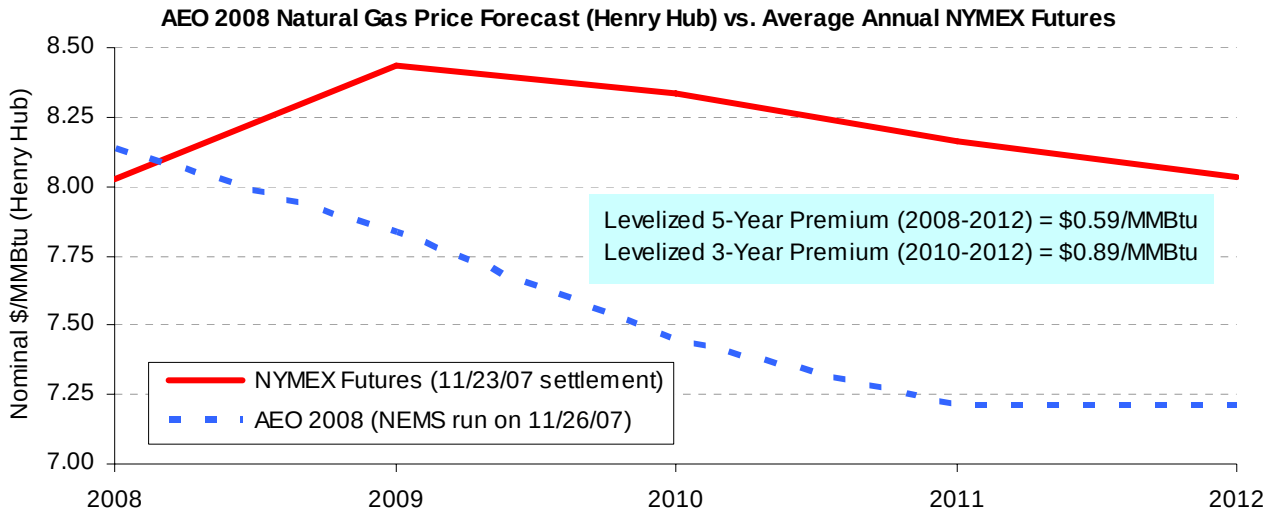


Figure 6: Comparison of NYMEX Futures Strip to AEO 2008 Gas Price Projection

One might reasonably argue that including the first two years (i.e., 2008-2009) of the *AEO 2008* projection and futures strip in the comparison is somewhat irrelevant, given that it would take at least a year or two to fully implement the results of any resource decision made today (i.e., it would take that long to bring a new gas-fired plant online). In response to this argument, Figure 6 also calculates the premium resulting from just the last three years of the comparison (i.e., 2010-2012) to be $0.89/MMBtu – i.e., $0.30/MMBtu higher than the full five-year premium.

5. Picking the Correct Date of Comparison

As mentioned above, the *AEO 2008* reference-case natural gas price projection resulted from a NEMS run completed on November 26, 2007. For the comparison made above in Figure 6, we chose to sample the NYMEX strip from November 23, 2007 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 5-year NYMEX strip from the beginning of August 2007 through January 4, 2008, in order to ensure that November 23, 2007 is, in fact, representative of where gas futures had been trading around the time the EIA was finalizing its *AEO 2008* forecast. The results, which are shown in Figure 7, suggest that November 23 was a fairly representative choice over this period (i.e., had we picked any other day on which to conduct this comparison, we still would have found a premium in excess of *AEO 2008*'s 2008-2012 reference-case forecast average of $7.57/MMBtu). At the lowest point on the NYMEX average curve – August 27, 2007 – the average 2008-2012 NYMEX strip is still higher than the *AEO 2008* price forecast, but the difference falls to just $0.16/MMBtu. If Figure 7 were to focus instead on only the 2010-2012 time period (in recognition that 2008-2009 may

be irrelevant given typical project development lead times), the minimum premium going back through August would fall on the same day (August 27) but would be larger, at $0.33/MMBtu.

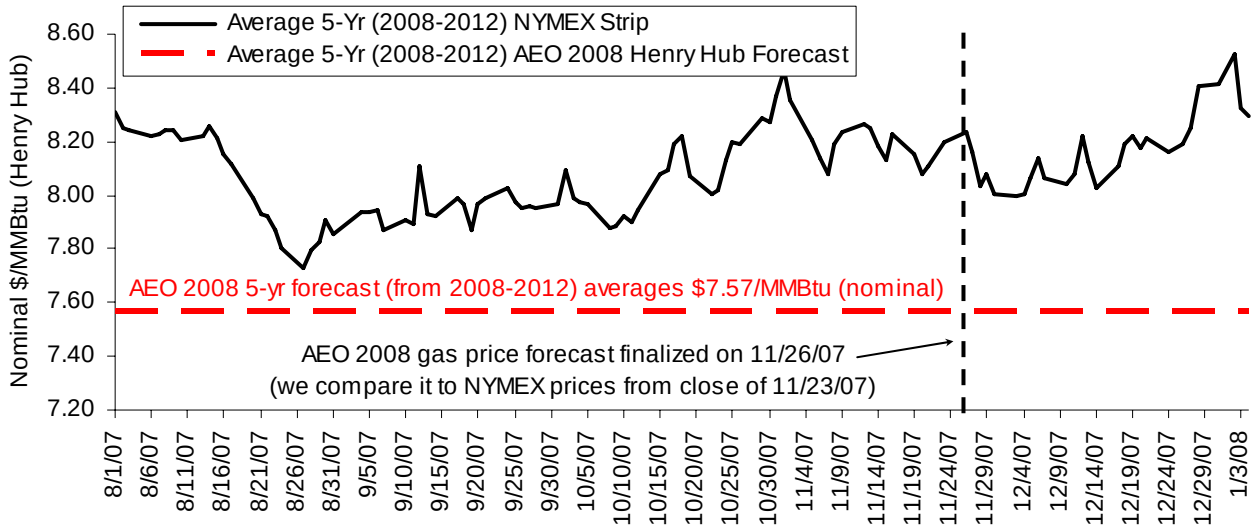


Figure 7: Average NYMEX Strip vs. Average AEO 2008 Forecast (2008-2012)

6. Increasing our Sample Size

The early release of *AEO 2008* 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 2008* forecast is on par with what we have observed in previous years, with the exception of the AEO 2006 comparison. Assuming a heat rate of 7,000 Btu/kWh (typical of an advanced combined cycle gas turbine), the $0.59/MMBtu NYMEX premium relative to the *AEO 2008* reference-case translates to 0.4¢/kWh – very similar to premiums observed in the past (with the exception of *AEO 2006*, which was notably higher). Focusing on just the last three years of the comparison (i.e., 2010-2012), the $0.89/MMBtu premium translates to roughly 0.6¢/kWh.

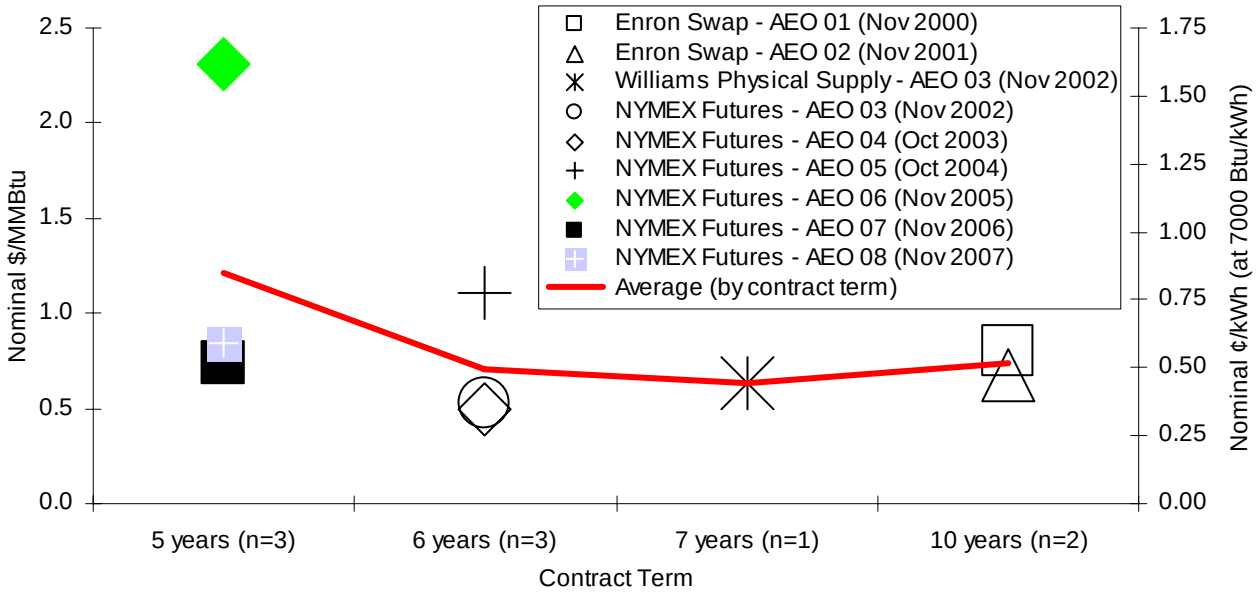


Figure 8: Levelized Premiums (Forwards – Forecasts)

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 eight years, thereby creating the appearance of a premium.[5]

Even with the addition of this *AEO 2008* 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.

[5] Along these lines, it is worth noting that the *AEO* reference-case projections are conducted assuming current policy, and as such do not take the possibility of future greenhouse gas regulation into account. As a result, it could be that the *AEO 2008* reference case projects much more coal-fired generation (and consequently less gas-fired generation) than is currently expected by "the market." Such differing views on the likely demand for natural gas among generators could account for some or all of the difference in the *AEO 2008* and NYMEX price projections.

8. Conclusion

As has been the case over at least the past seven years (*AEO 2001-AEO 2007*), levelized cost comparisons of fixed-price renewable generation with variable-price gas-fired generation that are based solely on the *AEO 2008* 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 eight 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.

In part as a result of these factors, electric utilities and electricity regulators have increasingly relied on NYMEX forward prices over fundamentals forecasts for assessing the likely cost of natural gas in the near term. To illustrate the potential impact of this choice between fundamentals forecasts and NYMEX futures prices as the source for "base case" gas price forecasts, Figure 9 presents two potential scenarios.

The first assumes that the trajectory of current NYMEX prices (from January 4, 2008) continues after 2013 until meeting and matching the AEO 2008 reference-case price forecast in 2019 and thereafter. Using this approach, a gas price projection consisting of NYMEX prices through 2013, and the *AEO 2008* reference-case forecast from 2019-2030 (with interpolations in 2014-2018 as described above and shown in Figure 9), would yield a 23-year levelized natural gas price that is $0.47/MMBtu higher than that provided by the *AEO 2008* reference-case forecast alone. Using this "blended" NYMEX/AEO gas price projection (i.e., the price path denoted by the open circles in Figure 9) instead of the unadulterated *AEO 2008* reference-case would therefore increase the levelized cost of gas-fired generation by 0.33¢/kWh (assuming a heat rate of 7,000 Btu/kWh).

The second scenario depicted in Figure 9 simply assumes that the NYMEX-AEO premium that exists in 2013 will persist through 2030. Using this alternative price forecast (i.e., the price path denoted by the X's in Figure 9) would yield a 23-year levelized natural gas price that is

$0.70/MMBtu higher than that provided by the AEO 2008 forecast alone, resulting in a 0.49¢/kWh increase in the levelized cost of gas-fired generation (assuming 7,000 Btu/kWh).

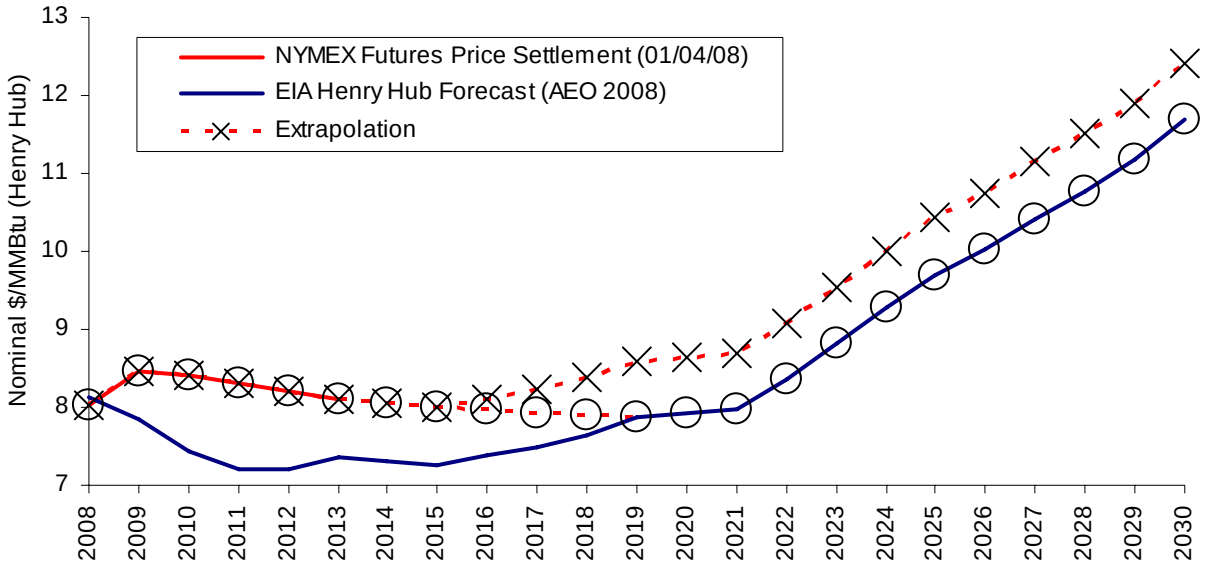


Figure 9: Two Alternative Price Forecasts (denoted by open circles and X's)

Absent an estimate of the underlying "value" of price stability, and not knowing which explanation for the premium is correct, we recommend that analysts and policymakers select among "blended" base-case gas price forecasts that utilize NYMEX futures data, where available. As shown above, ignoring such blends and instead relying solely on the *AEO 2008* reference-case forecast to conduct a 23-year levelized cost of energy comparison between a combined cycle gas turbine and a fixed-price renewable generator would yield results that are, arguably, skewed (with respect to fuel price risk) in favor of the gas-fired generator to the tune of 0.3¢-0.5¢/kWh (depending on which blended forecast is used).

Even so, we do not advocate that analysts and policymakers rely solely upon either of 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 the case given the fact that generation investments are long-lived assets that extend well beyond the current NYMEX futures strip, and renewables can provide price certainty over longer terms. In this light, the recent announcement from NYMEX that it will, in late January 2008, extend its natural gas futures strip an additional seven years (through 2020) is of interest.[6] This additional level of price discovery in longer-dated forwards should facilitate the construction of longer-term market-based forecasts that can be used to more-clearly replicate the long-term price stability that renewables can provide. In turn, this development should make next year's edition of this memo considerably more interesting.

[6] See http://nymex.mediaroom.com/index.php?s=43&item=1703 and http://www.nymex.com/notice_to_member.aspx?id=ntm545&archive=2007