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MEMORANDUM

From: Mark Bolinger and Ryan Wiser, Berkeley Lab (LBNL)
Subject: Comparison of AEO 2007 Natural Gas Price Forecast to NYMEX Futures Prices
Date: December 6, 2006

Introduction

On December 5, 2006, the reference case projections from *Annual Energy Outlook 2007 (AEO 2007)* 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 play in mitigating such risk (see, for example, <http://eetd.lbl.gov/ea/EMS/reports/53587.pdf> or <http://eetd.lbl.gov/ea/ems/reports/54751.pdf>). As such, we were curious to see how the latest *AEO* gas price forecast compares to the NYMEX natural gas futures strip. This brief memo presents our findings.¹

As a refresher, our past work in this area has found that over the past six years, forward natural gas contracts (with prices that can be locked in – e.g., gas futures, swaps, and physical supply) have traded at a premium relative to contemporaneous long-term reference case gas price forecasts from the EIA. As such, we have concluded that, over the past six years at least, levelized cost comparisons of fixed-price renewable generation with variable-price gas-fired generation that have been based on *AEO* natural gas price forecasts (rather than forward prices) have yielded results that are “biased” in favor of gas-fired generation, presuming that long-term price stability is valued. In this memo we simply update our past analysis to include the latest long-term gas price forecast from the EIA, as contained in *AEO 2007*. For the sake of brevity, we do not rehash information (on methodology, potential explanations for the premiums, etc.) contained in our earlier reports on this topic; readers interested in such information are encouraged to download that work from <http://eetd.lbl.gov/ea/EMS/reports/53587.pdf> or <http://eetd.lbl.gov/ea/ems/reports/54751.pdf>.

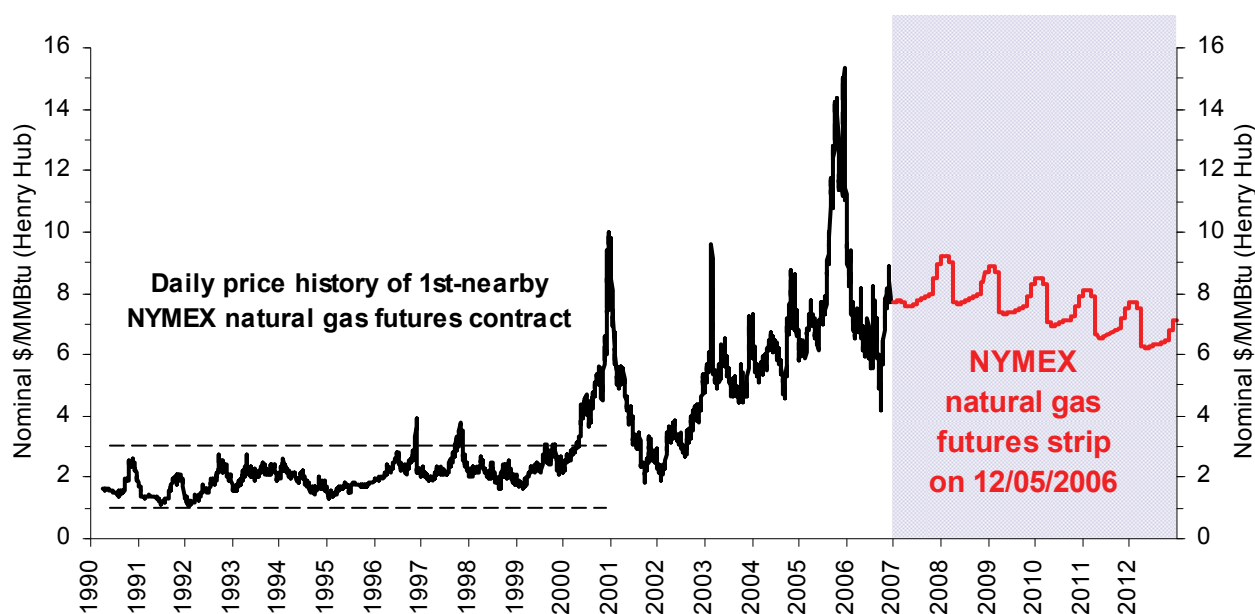
As was the case in the past six *AEO* releases (*AEO 2001-AEO 2006*), we once again find that the *AEO 2007* reference case gas price forecast falls well below where NYMEX natural gas futures contracts were trading at the time the EIA finalized its gas price forecast. Specifically, the NYMEX-*AEO 2007* premium is \$0.73/MMBtu levelized over five years. In other words, on

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average, one would have had to pay \$0.73/MMBtu *more* than the *AEO 2007* 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). Fixed-price generation (like certain forms of renewable generation) obviously need not bear this added cost, and moreover can provide price stability for terms well in excess of five years.

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 12/04/06) 72-month NYMEX futures “strip” tacked on to the end. The strip shows that one can currently lock in Henry Hub prices of between \$6.2/MMBtu and \$9.2/MMBtu over the next six years, with the entire 72-month strip averaging around \$7.6/MMBtu. 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 a year ago, the average 5-year strip has experienced a much more modest decline, and is currently only about 12%, or \$1/MMBtu, lower than it was last year at this time. As a result, the average price of natural gas that can be locked in over the coming 60 months is currently about \$8/MMBtu – still about \$5/MMBtu more than in early 2002.

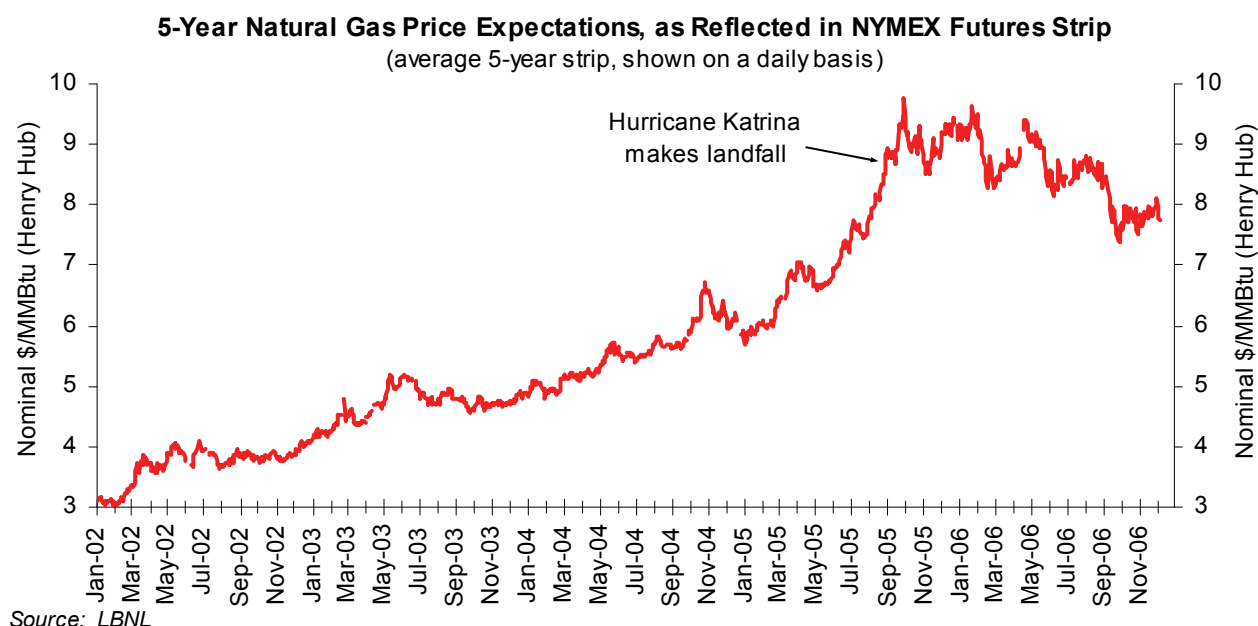


Figure 2: Increase in Average NYMEX Natural Gas Futures Strip Over Time

The AEO 2007 Natural Gas Price Forecast

Although natural gas prices are lower this fall than they were last (as seen in Figure 1 for current prices and Figure 2 for 5-year price projections), the EIA has, in *AEO 2007*, revised its reference case gas price forecast slightly upwards (at least in real terms). Figure 3 compares the *AEO 2007* projection of nominal natural gas prices delivered to electricity generators to the same price projections from *AEO 2001-2006*.²

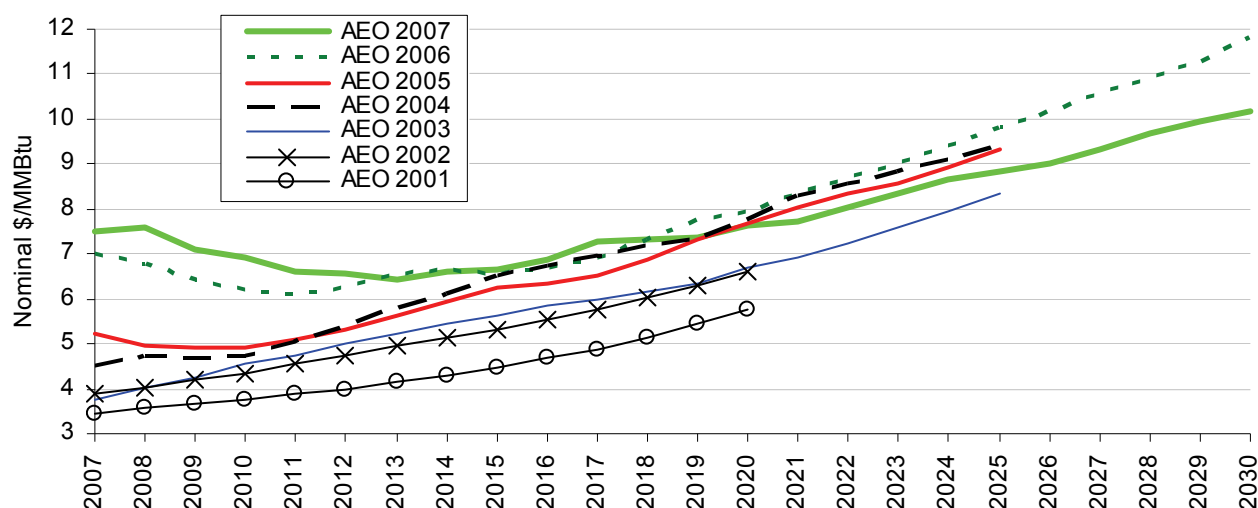


Figure 3: Natural Gas Prices Delivered to Electricity Generators, Nominal \$/MMBtu

² 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 shows the same price series in real (2005) dollars.

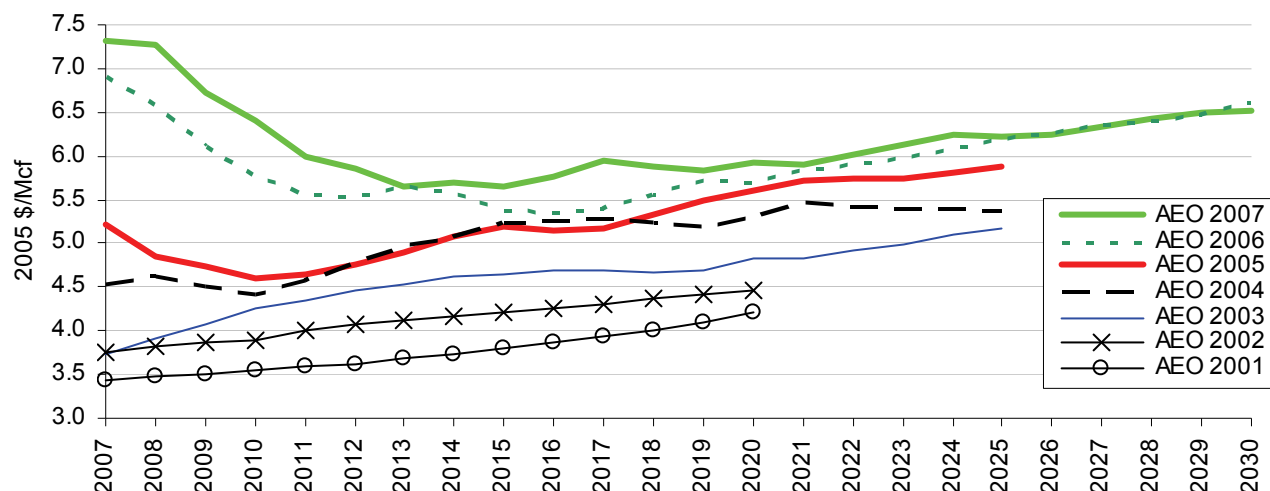


Figure 4: Natural Gas Prices Delivered to Electricity Generators, 2005 \$/Mcf

The wide range of price forecasts exhibited in the early years of Figures 3 and 4 suggests that recent EIA 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: the EIA grossly over-projected the price of gas in the late 1980s, and conversely has grossly under-projected the 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 suggests that, when valuing generation assets, little weight should be placed on long-term, fundamental forecasts such as those created by the EIA, and that sizable uncertainty bounds should be used regardless of which "base-case" forecast is used.

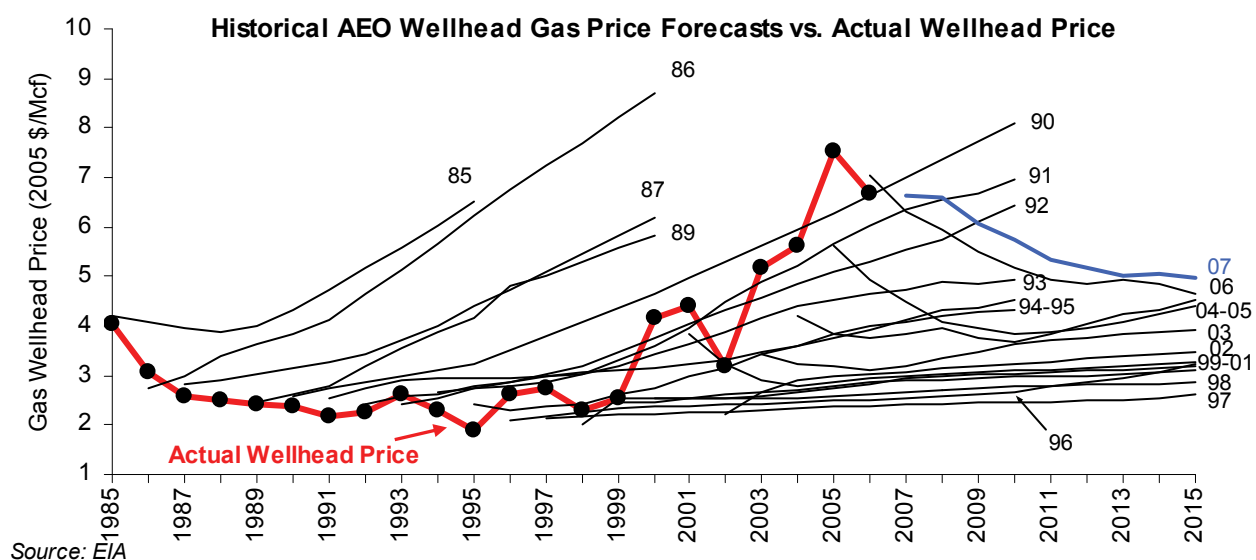


Figure 5: Historical AEO Wellhead Gas Price Forecasts vs. Actual Wellhead Price

Natural Gas Futures Prices Still Trading at a Premium to AEO Price Forecasts

Despite the drop in NYMEX futures prices since last year (Figures 1 and 2), as well as the upward revision to the EIA's constant dollar gas price forecast in *AEO 2007* (Figure 4), the first five years of the *AEO 2007* forecast are still not on par with where natural gas futures contracts have recently been trading. Figure 6 compares the *AEO 2007* reference case projection of Henry Hub gas prices (which resulted from a November 21, 2006 modeling run) to the NYMEX natural gas futures strip (with monthly prices averaged each year) from November 20, 2006. The spread between the two data series remains remarkably consistent from 2007-2011, with the premium equaling \$0.73/MMBtu on a 5-year levelized basis.³

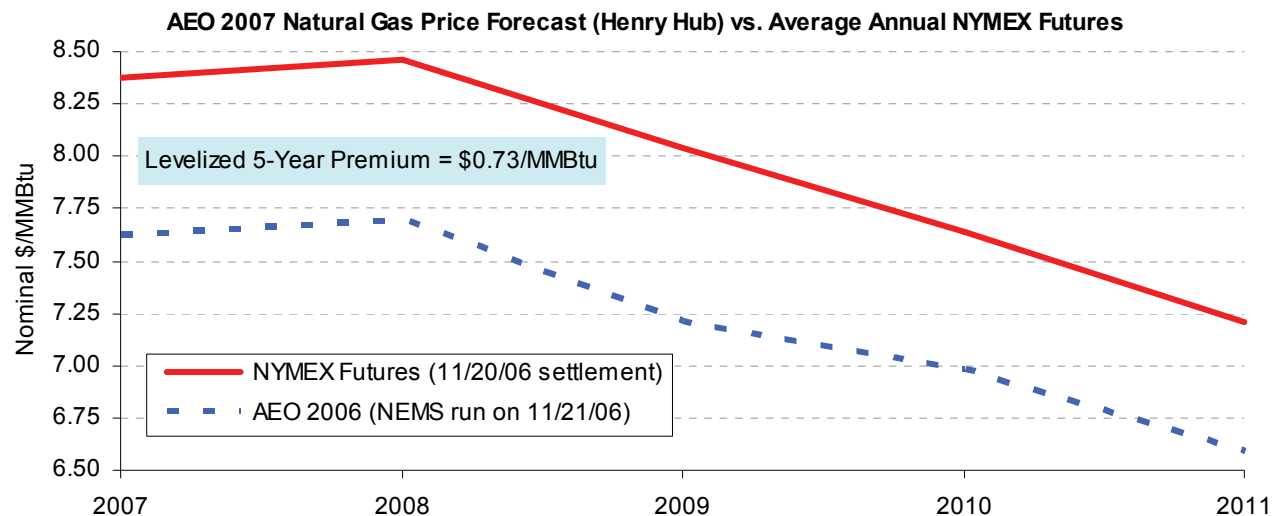


Figure 6: Comparison of NYMEX Futures Strip to AEO 2007 Gas Price Projection

Picking the Correct Date of Comparison

As mentioned above, the *AEO 2007* reference case natural gas price projection resulted from a NEMS run completed on November 21, 2006. For the comparison made above in Figure 6, we therefore chose to sample the NYMEX strip from November 20, 2006 in order to reflect the latest market information available to the EIA at the time the gas price projections were being finalized. In order to ensure that November 20, 2006 is, in fact, representative of where gas futures had been trading around the time the EIA was finalizing its *AEO 2007* forecast, we examined the average 5-year NYMEX strip from the beginning of September 2006 through the December 5 release date. The results, which are shown in Figure 7, suggest that November 20 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 2007*'s 2007-2011 forecast average of \$7.22/MMBtu). For example, at the lowest point on the NYMEX average curve – September 28, 2006 – the average 60-month NYMEX strip is still \$0.19/MMBtu higher than the average 2007-2011 *AEO 2007* price forecast.

³ As a new feature, *AEO 2007* projects prices at the Henry Hub, which is also the delivery location for NYMEX natural gas futures contracts. As such, the basis adjustments that we have had to make in the past are not necessary for the *AEO 2007* comparison.

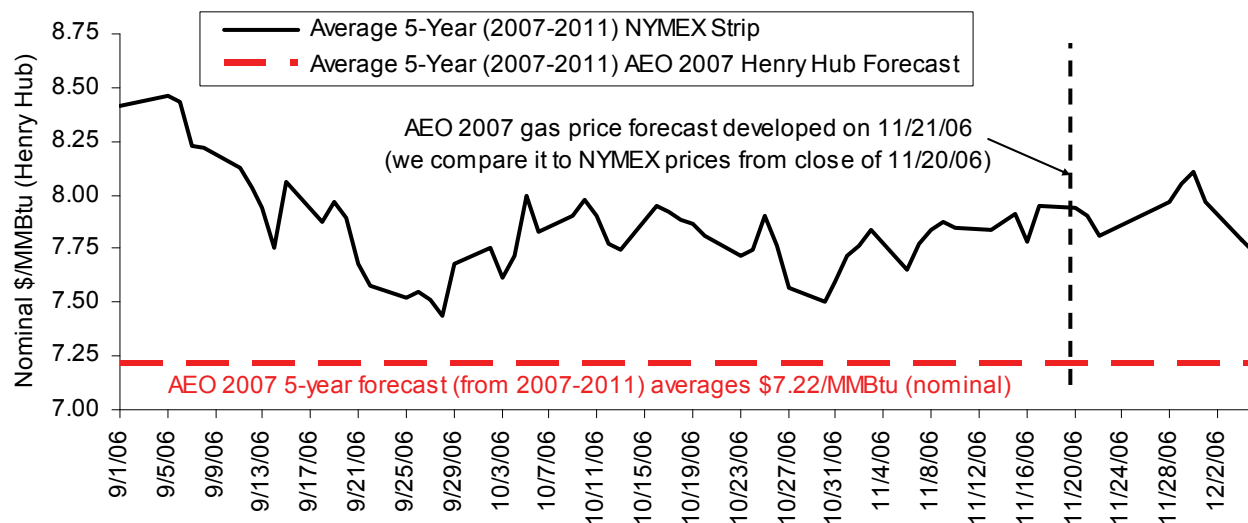


Figure 7: Average NYMEX Strip vs. Average AEO 2007 Forecast (2007-2011)

Increasing our Sample Size

The early release of *AEO 2007* allows us to add another data point to our small (but growing) sample of comparisons between contemporaneous forward prices and *AEO* gas price forecasts. As shown in Figure 8, the premium observed with respect to the *AEO 2007* forecast is on par with what we have observed in previous years relative to *AEO 2001-2005* (last year's premium relative to *AEO 2006* was significantly higher). Assuming a heat rate of 7,000 Btu/kWh (typical of an advanced combined cycle gas turbine), the \$0.73/MMBtu NYMEX premium relative to the *AEO 2007* reference case translates to 0.5¢/kWh – very similar to premiums observed in the past (at least with respect to *AEO 2001-AEO 2005*).

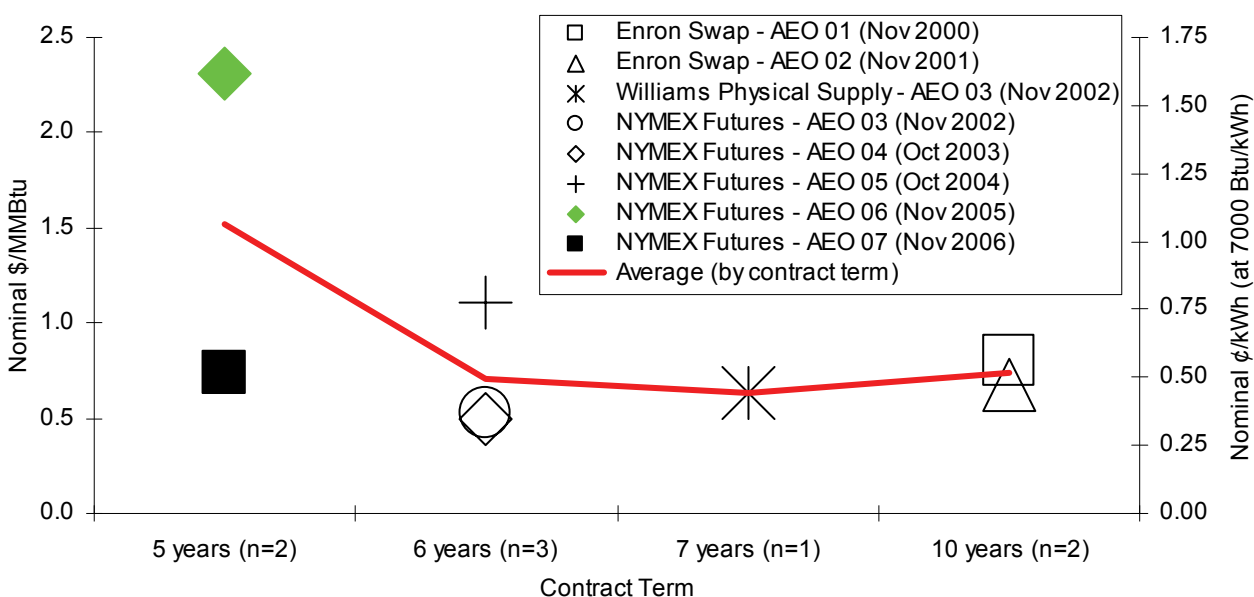


Figure 8: Levelized Premiums (Forwards – Forecasts)

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 fundamental 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* gas price forecasts have simply been biased downwards relative to market expectations over the past seven years, thereby creating the appearance of a premium.

Even with the addition of this *AEO 2007* 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 persists, despite rather sharp upward revisions to the EIA’s natural gas price forecasts in recent years, as well as the modest drop in forward prices over the past year. With such a substantial and long-standing discrepancy between EIA forecasts of future spot gas prices and market-based forward price projections, we call upon EIA and other analysts to better explain the logical reasoning for such differences, and to describe under what conditions fundamentals-based forecasts and NYMEX forward prices should be used.

Conclusion – Potential for Bias Still Exists

As has been the case over at least the past six years (*AEO 2001-AEO 2006*), levelized cost comparisons of fixed-price renewable generation with variable-price gas-fired generation that are based solely on the *AEO 2007* natural gas price forecasts will likely once again yield results that are “biased” in favor of gas-fired generation (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 described above. If the premium represents the cost of locking in future gas prices (i.e., a risk premium), then an apples-to-apples comparison requires 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. If instead the premium simply reveals a downward bias in the EIA’s long-term gas price forecasts, then by definition any levelized cost comparison using that forecast will be biased in favor of gas-fired generation.

To illustrate the potential importance of this “bias,” Figure 9 presents two potential scenarios. The first assumes that the spread shown above in Figure 6 narrows after 2011, such that the NYMEX and *AEO 2007* price projections match one another in 2014 and thereafter. A 24-year gas price projection consisting of NYMEX prices through 2011, and the *AEO 2007* reference case forecast from 2014-2030 (with interpolations in 2012 and 2013 as shown in Figure 9), would yield a 24-year levelized natural gas price that is \$0.35/MMBtu higher than that provided by the *AEO 2007* forecast alone. Using this “hybrid” NYMEX/*AEO* gas price projection (i.e., the price path denoted by the open circles in Figure 9) instead of the unadulterated *AEO 2007*

reference case would therefore increase the levelized cost of gas-fired generation by 0.25¢/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 2011 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 24-year levelized natural gas price that is \$0.67/MMBtu higher than that provided by the AEO 2007 forecast alone, resulting in a 0.5¢/kWh increase in the levelized cost of gas-fired generation (assuming 7,000 Btu/kWh).

Said another way, if price stability is valued, then using the unadulterated *AEO 2007* reference case forecast to conduct a 24-year levelized cost of energy comparison between a combined cycle gas turbine and a fixed-price renewable generator would yield results that are biased in favor of the gas-fired generator to the tune of 0.25¢-0.5¢/kWh. Of course, these alternative price projections do not provide a perfect “apples to apples” comparison with fixed-price renewable generation, because only a portion of the gas price forecast – through 2011 – can be locked in to create comparable fuel price certainty, whereas renewables can provide price certainty over longer terms.

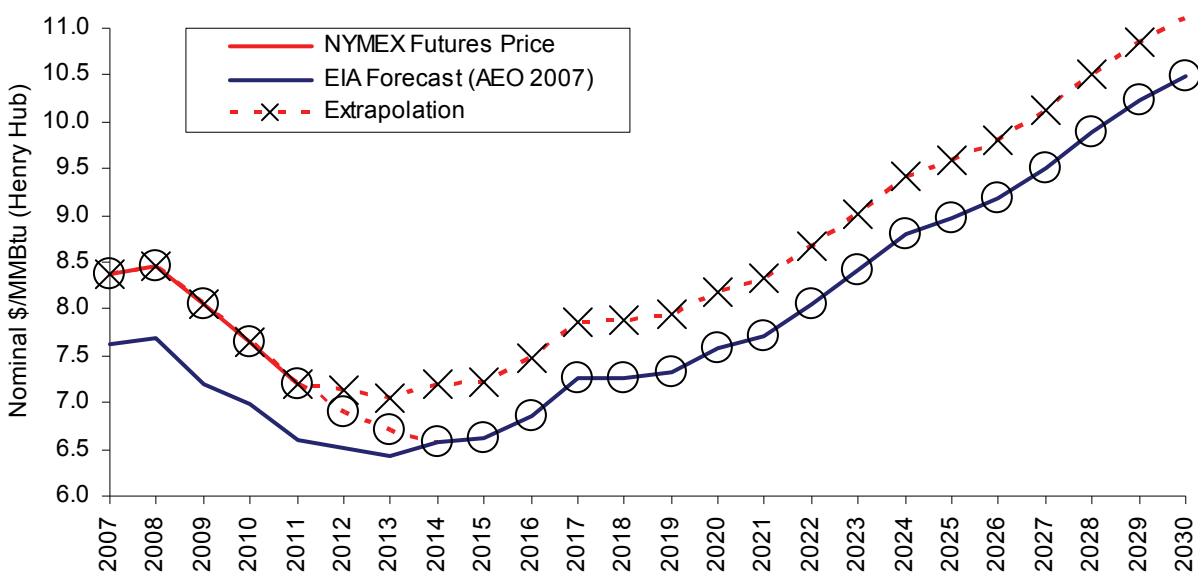


Figure 9: Two Alternative Price Forecasts (denoted by open circles and X's)