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MEMORANDUM

From: **Mark Bolinger and Ryan Wiser, Berkeley Lab (LBNL)**
Subject: **Comparison of AEO 2006 Natural Gas Price Forecast to NYMEX Futures Prices**
Date: **December 19, 2005**

Introduction

On December 12, 2005, the reference case projections from *Annual Energy Outlook 2006* (*AEO 2006*) 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.

As a refresher, our past work in this area has found that over the past five 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 five 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 2006*. 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 five *AEO* releases (*AEO 2001-AEO 2005*), we once again find that the *AEO 2006* 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. In fact, the NYMEX-*AEO 2006* reference case comparison yields by far the largest premium – $2.3/MMBtu levelized over five years – that we have seen over the last six years. In other words, on average, one would have had to pay $2.3/MMBtu *more* than the *AEO 2006* 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 12/16/05) 72-month NYMEX futures "strip" tacked on to the end. The strip shows that one can currently lock in Henry Hub prices of between $6.3/MMBtu and $13.7/MMBtu over the next six years, with the entire 72-month strip averaging around $8.8/MMBtu. These prices are well above the range of $1-3/MMBtu that persisted throughout the 1990s.

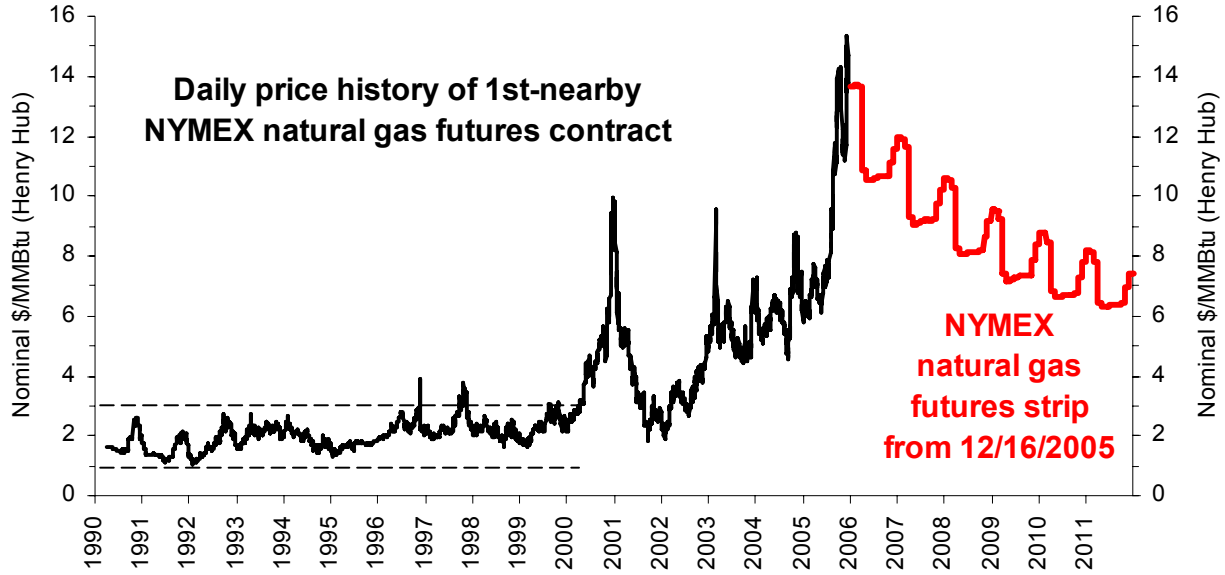

Figure 1: NYMEX Natural Gas Futures Prices

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 *levelized* (i.e., average) natural gas futures strip going back to January 2002, a few weeks after the NYMEX first extended futures trading from 36 to 72 months. Just as "first nearby" prices (from Figure 1) are currently at historic highs, the levelized NYMEX price strip is also currently at a historic high of around $9.4/MMBtu – roughly $3.5/MMBtu higher than it was last year at this time. While first-nearby (spot) prices jump around quite a bit (Figure 1), the average price of natural gas that can be locked in over the subsequent 60-72 months (Figure 2) has risen quite steadily over the past four years, *more than tripling* since early 2002. Though Hurricane Katrina has exacerbated the supply situation on the Gulf Coast, Figure 2 shows that average price expectations for 2006-2010 had risen to well above $8/MMBtu even before Katrina struck.

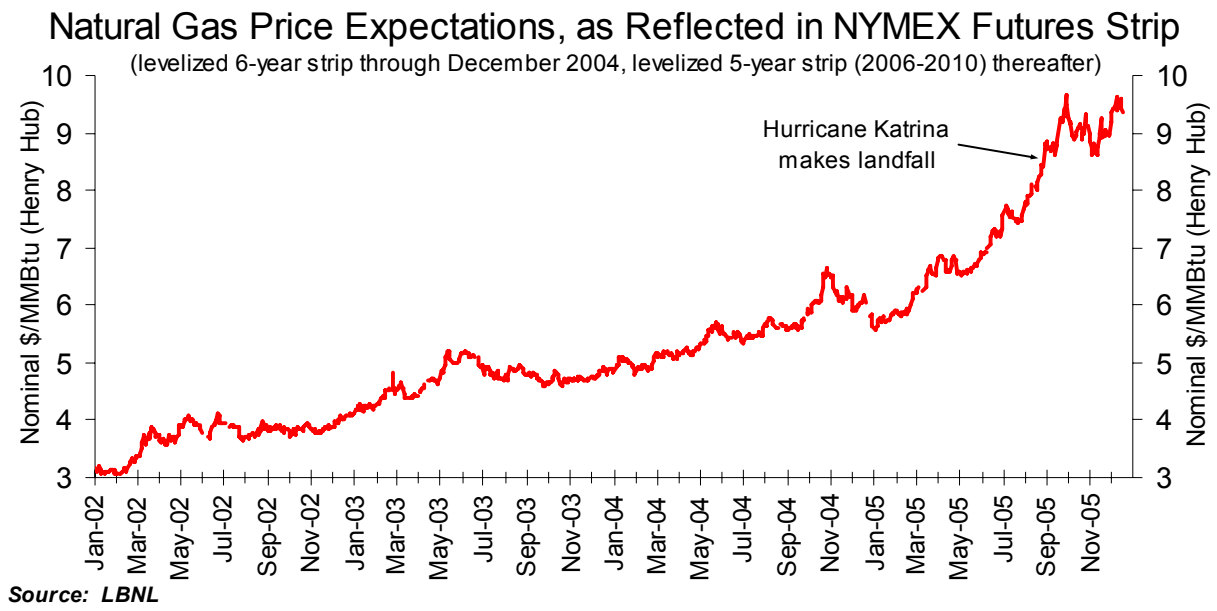

Figure 2: Increase in Levelized NYMEX Natural Gas Futures Strip Over Time

The AEO 2006 Natural Gas Price Forecast

With natural gas prices significantly higher this fall than last (as seen in Figure 1 for current prices and Figure 2 for 5-year price projections), it is not particularly surprising that the EIA has, in *AEO 2006*, revised its reference case gas price forecast significantly upwards. Figure 3 compares the *AEO 2006* projection of nominal natural gas prices delivered to electricity generators to the same price projections from *AEO 2001-2005*.[1] As shown, the *AEO 2006* forecast is significantly higher than the *AEO 2005* and *AEO 2004* forecasts until 2015, when the three forecasts more or less converge (the *AEO 2001-2003* forecasts, meanwhile, remain well below the others throughout the entire period of comparison).

[1] 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*).

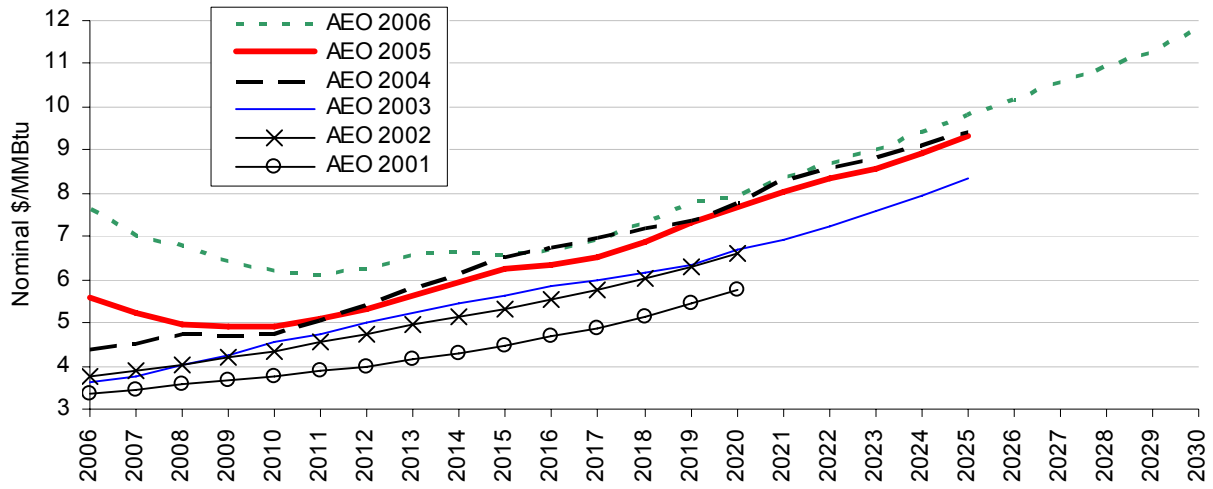

Figure 3: Natural Gas Prices Delivered to Electricity Generators, Nominal $/MMBtu

Figure 4 shows the same price series in real (2004) dollars.

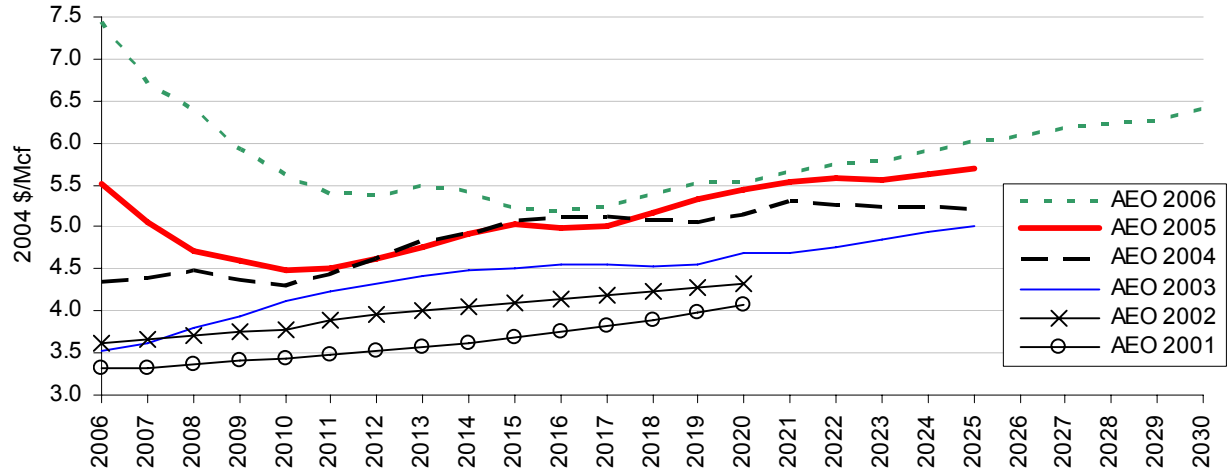

Figure 4: Natural Gas Prices Delivered to Electricity Generators, 2004 $/Mcf

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.

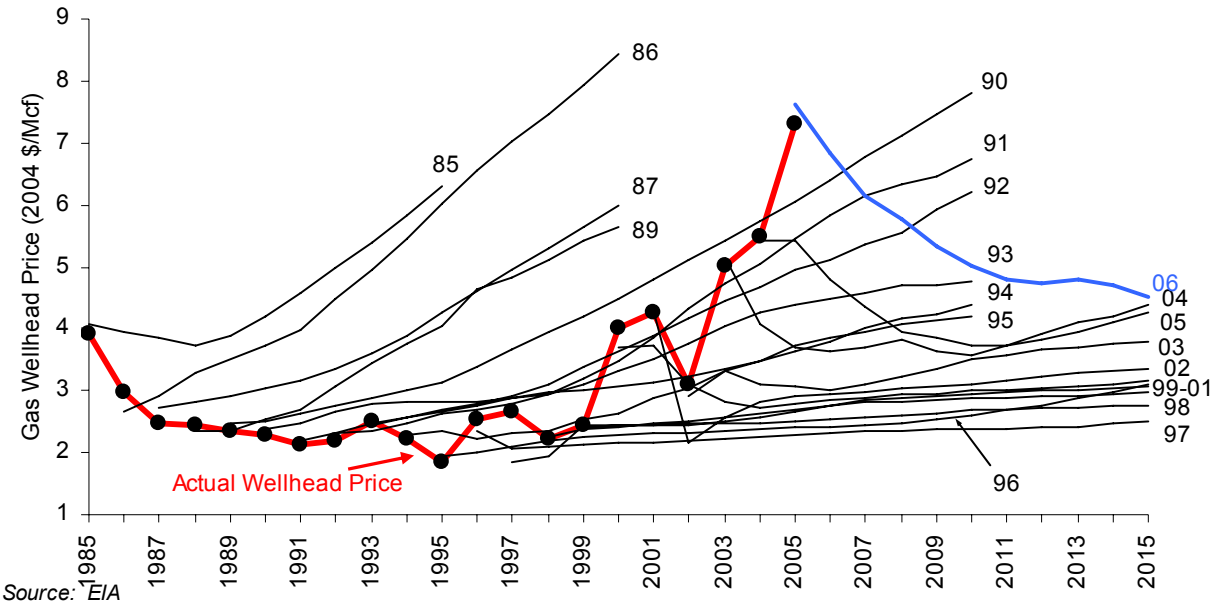

Figure 5: Historical AEO Wellhead Gas Price Forecasts vs. Actual Wellhead Price

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

Despite the sharp upward revision to the EIA's gas price forecast in *AEO 2006* (at least through 2015), the first five years of that forecast are still not on par with where natural gas futures contracts have been trading. Figure 6 compares the basis-adjusted *AEO 2006* reference case projection of gas prices delivered to electricity generators (which resulted from a November 19, 2005 modeling run) to the NYMEX natural gas futures strip (with monthly prices averaged each year) from November 18, 2005. Though the spread between the two data series varies somewhat from year to year, and narrows over time, on a 5-year levelized basis the premium equals $2.3/MMBtu.[2]

[2] To shift from the price of gas delivered to electricity generators to Henry Hub prices, we subtract $0.29/MMBtu from delivered prices. This average "transportation margin" is based on a historical comparison between average prices delivered to electricity generators in the US and first-nearby NYMEX futures prices from April 1990 to July 2005 (185 months, 95% confidence interval ranging from $0.24-$0.35/MMBtu). Alternatively, the EIA has, in http://www.eia.doe.gov/oiaf/analysispaper/henryhub/index.html, proposed two basis adjustments to shift from wellhead to Henry Hub prices. The first, increasing wellhead prices by 10.8%, yields a 5-year levelized premium of $2.0/MMBtu. The second, adding $0.316/Mcf to wellhead prices, results in a 6-year levelized premium of $2.3/MMBtu – the same as that derived above from delivered (to electricity generators) prices. Though the EIA basis analysis favored the 10.8% adjustment over the $0.316/Mcf adjustment, the substantial increase in natural gas prices since the EIA conducted its analysis calls into question whether the 10.8% basis adjustment is still appropriate (e.g., 10.8% of $14 gas is substantially more than 10.8% of $6 gas, and it is not entirely clear why basis adjustments should be proportionally impacted by underlying price levels). Though no basis adjustment is perfect, given the three different methods presented, a premium (in Henry Hub terms) in the range of $2.0-$2.3/MMBtu seems reasonable.

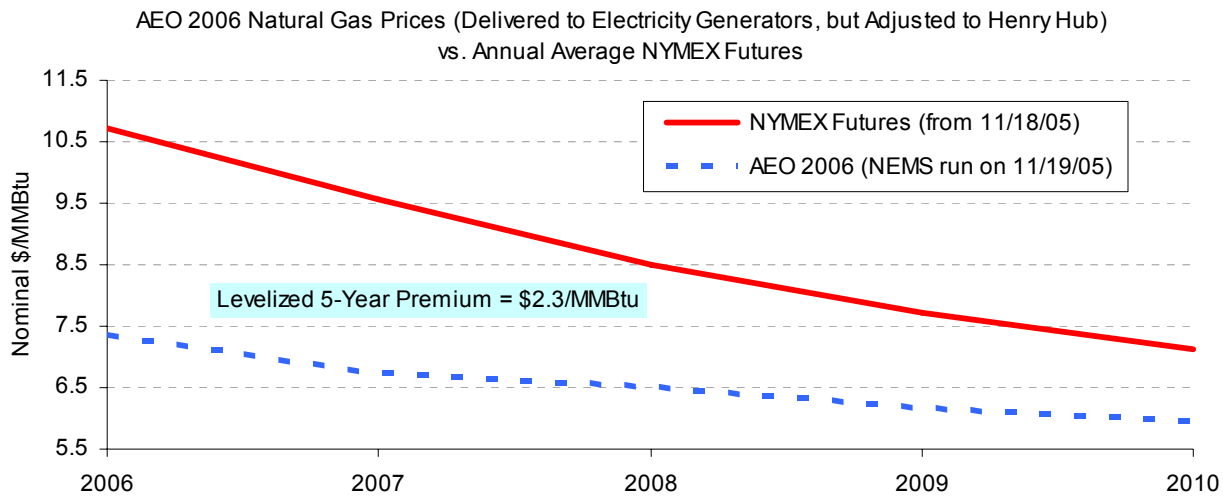

Figure 6: Comparison of NYMEX Futures Strip to AEO 2006 Gas Price Projection

Picking the Correct Date of Comparison

As mentioned above, the *AEO 2006* reference case natural gas price projection resulted from a NEMS run completed on November 19, 2005. For the comparison made above in Figure 6, we therefore chose to sample the NYMEX strip from November 18, 2005 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 18, 2005 is, in fact, representative of where gas futures had been trading around the time the EIA was finalizing its *AEO 2006* forecast, we examined the average 5-year NYMEX strip from the beginning of September 2005 through the December 12 release date. The results, which are shown in Figure 7, suggest that November 18 was a 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 similar-sized premium in excess of *AEO 2006*'s 2006-2010 forecast average of $6.5/MMBtu). For example, at the lowest point on the NYMEX curve – November 10, 2005 – the average 60-month NYMEX strip is still $2.0/MMBtu higher than the average 2006-2010 *AEO 2006* price forecast.

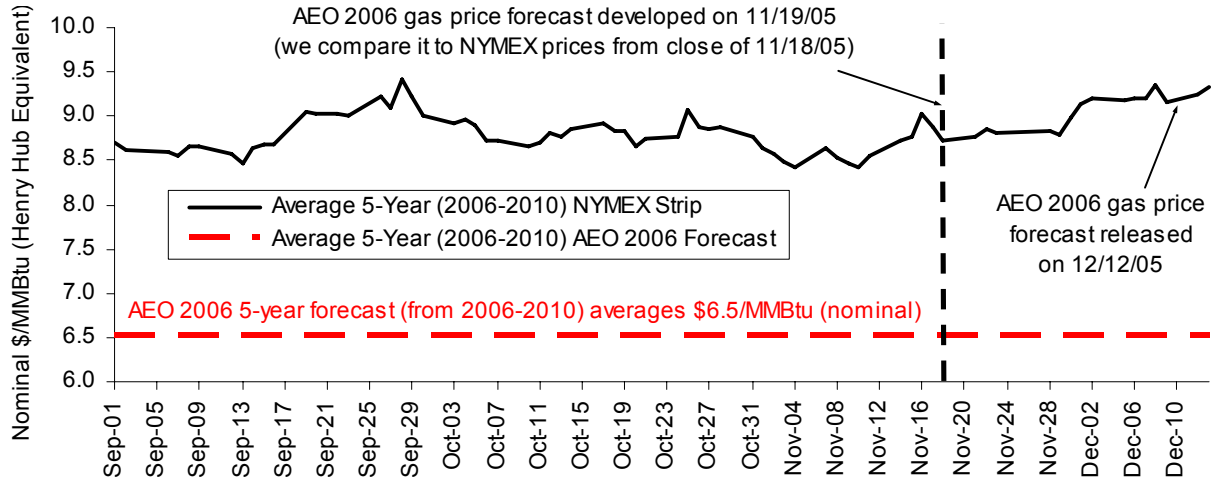

Figure 7: Average NYMEX Strip vs. Average AEO 2006 Forecast (2006-2010)

Increasing our Sample Size

The early release of *AEO 2006* 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 2006* forecast is notably larger than what we have observed in previous years relative to *AEO 2001-2005*. Assuming a heat rate of 7,000 Btu/kWh (typical of an advanced combined cycle gas turbine), the $2.3/MMBtu NYMEX premium relative to the *AEO 2006* reference case translates to 1.6¢/kWh – more than three times the 0.5¢/kWh premium observed in the past.

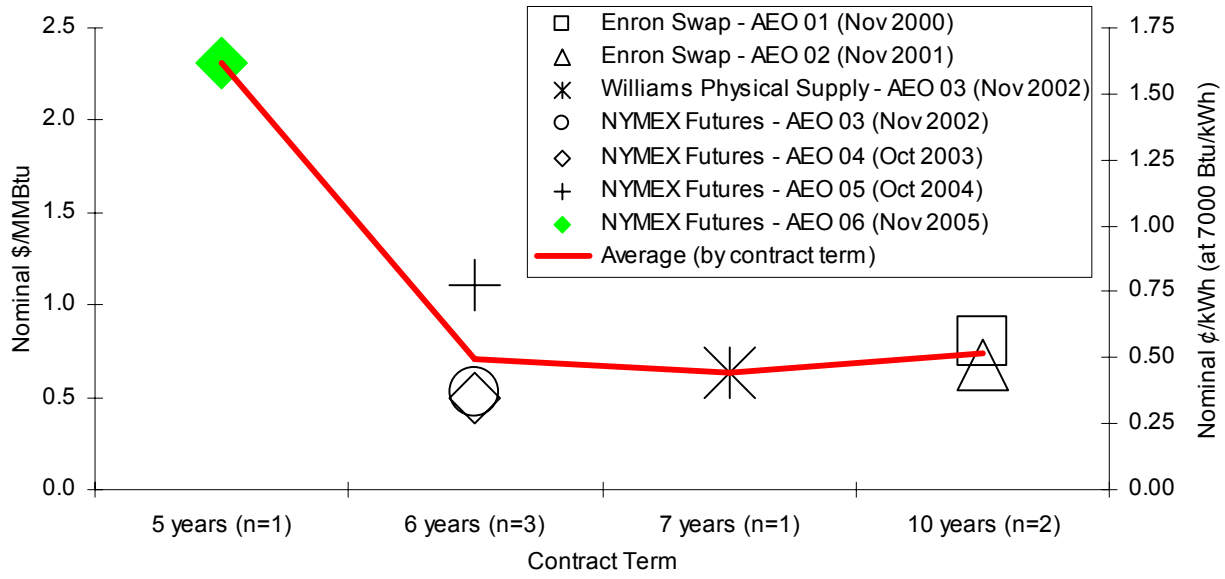

Figure 8: Levelized Premiums (Forwards – Forecasts)

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 six years, thereby creating the appearance of a premium.

Even with the addition of this *AEO 2006* 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. 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 five years (*AEO 2001-AEO 2005*), levelized cost comparisons of fixed-price renewable generation with variable-price gas-fired generation that are based solely on the *AEO 2006* 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," assume that the narrowing trend in the spread shown above in Figure 6 were to continue, such that the NYMEX and *AEO 2006* price projections matched one another in 2013 (and thereafter). A 25-year gas price projection consisting of basis-adjusted NYMEX prices through 2010, and the *AEO 2006* reference case forecast from 2013-2030 (with interpolations in 2011 and 2012, between the 2010 NYMEX price and the 2013 *AEO* price), would yield a 25-year levelized natural gas price that is $1/MMBtu *higher* than that provided by the *AEO 2006* forecast alone. Though this "hybrid" NYMEX-EIA gas price projection still does not provide a perfect "apples to apples" comparison with fixed-price renewable generation (because only a portion of the gas price forecast – through 2010 – can be locked in to create comparable fuel price certainty), using it instead of the pure *AEO 2006* reference case would nevertheless increase the levelized cost of gas-fired generation by 0.7¢/kWh (assuming a heat rate of 7,000 Btu/kWh). Said another way, if price stability is valued, then using the unadulterated *AEO 2006* reference case forecast to conduct a 25-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 by at least 0.7¢/kWh.