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MEMORANDUM

From: **Mark Bolinger and Ryan Wiser, Berkeley Lab (LBNL)**
Subject: **Comparison of AEO 2010 Natural Gas Price Forecast to NYMEX Futures Prices**
Date: **January 4, 2010**

1. Introduction

Context

On December 14, 2009, the reference-case projections from *Annual Energy Outlook 2010* (*AEO 2010*) 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), 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

[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.

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 2010* 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 2010*. 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 nine years (*AEO 2001-AEO 2009*), 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 2010* reference-case gas price forecast falls slightly below where the NYMEX natural gas futures strip was trading at the time the EIA finalized its forecast, but that in general the two projections match up better than they ever have in the ten years that we've been drawing these comparisons. Specifically, the NYMEX-*AEO 2010* premium is just $0.11/MMBtu levelized over the full twelve-year period from 2010-2021. In other words, on average, one would have had to pay just $0.11/MMBtu *more* than the *AEO 2010* 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 similar in magnitude to that observed last year (relative to *AEO 2009*), but is considerably smaller than has existed in

previous years, and arguably falls within "the noise" that surrounds high-level comparisons of this nature.

Despite the better match (i.e., smaller premium) between NYMEX gas futures prices and the *AEO* gas price projections over the past two years, it is hard to know whether or for how long this relative degree of alignment might persist. As such, we continue to recommend that analysts and policymakers select among "blended" base-case gas price forecasts that utilize NYMEX futures price data when available and long-term fundamental price forecasts thereafter. We also recommend analyzing a wide range of plausible price projections around these blended base-case forecasts, using either stochastic or scenario analysis.

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 December 29, 2009) 156-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 $5.8/MMBtu and $9.0/MMBtu over the next thirteen years (through 2022), with the entire strip averaging around $7.24/MMBtu. Although they are far below past highs, these prices remain well above the range of $1-3/MMBtu that persisted throughout the 1990s.

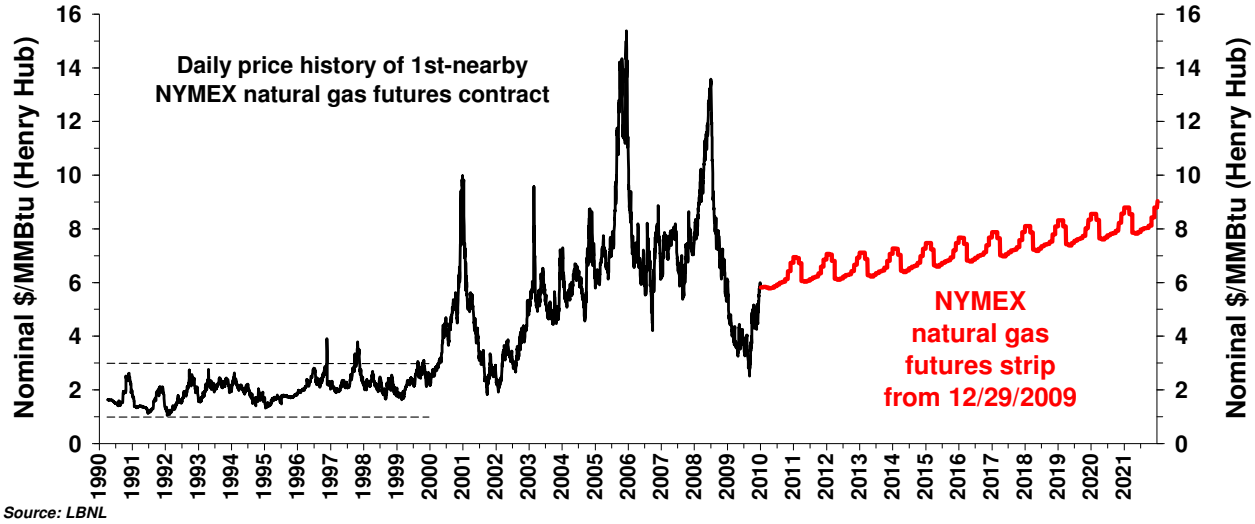

Figure 1: NYMEX Natural Gas Futures Prices

It should be noted that liquidity in the later years of the extended forward curve is quite thin. In fact, beyond 2016, 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 substantially 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 156-month futures strip (i.e., the prices that can currently be locked in for the next 156 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). After falling sharply in the second half of 2008, the average 5-year strip has traded in a range between $6 and $7/MMBtu for most of 2009.

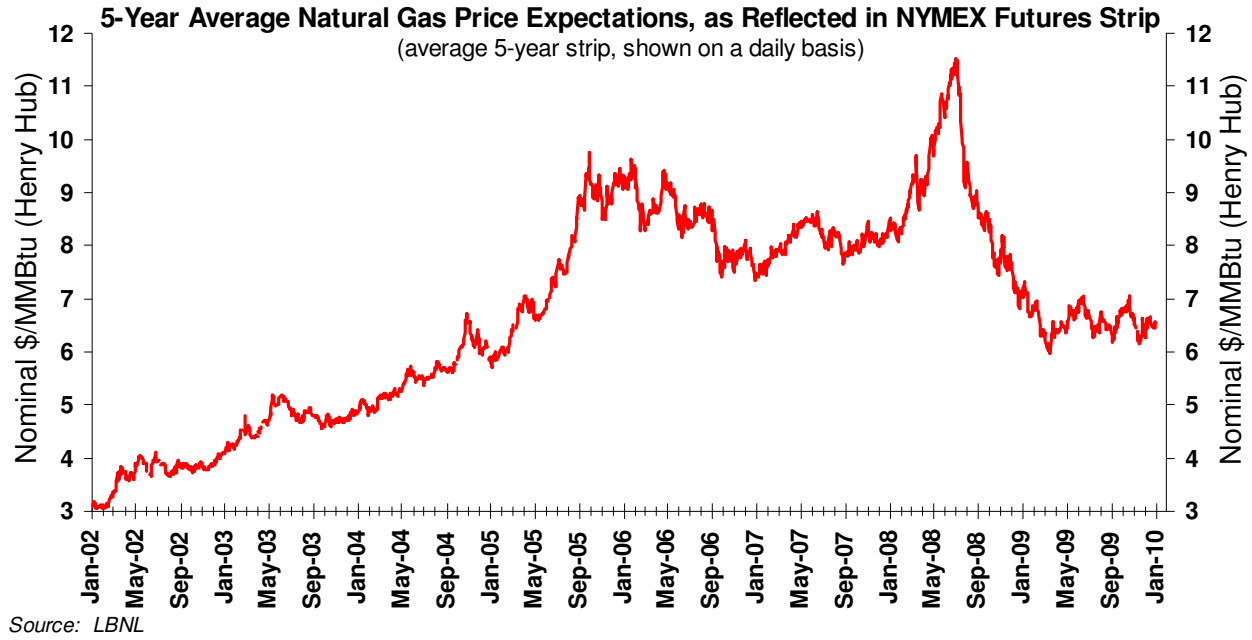

Figure 2: Change in 5-Year Natural Gas Price Expectations Over Time

3. The AEO 2010 Natural Gas Price Forecast

In *AEO 2010*, the EIA has revised its reference-case gas price forecast downwards from *AEO 2009* (even from the updated April 2009 *AEO 2009* release – as pictured – that reflected the passage of the *American Recovery and Reinvestment Act of 2009*). Figure 3 compares the *AEO 2010* projection of nominal natural gas prices at the Henry Hub to the same price projections from *AEO 2007-2009*.[2] Figure 4 depicts the same price series in real (2008) dollars.

[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*).

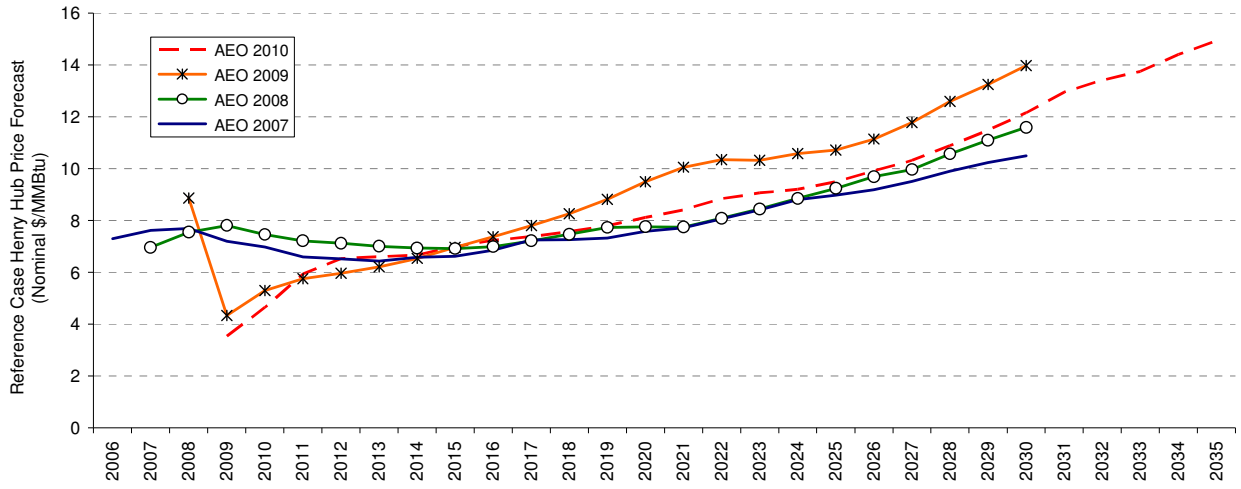

Figure 3: Reference Case Henry Hub Natural Gas Price Forecasts (Nominal $/MMBtu)

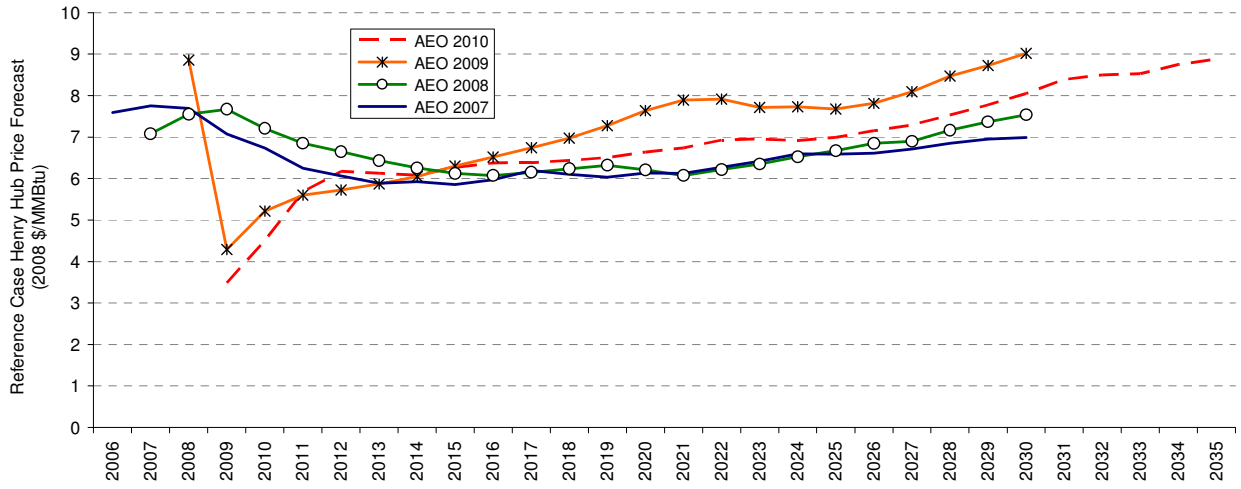

Figure 4: Reference Case Henry Hub Natural Gas Price Forecasts (2008 $/MMBtu)

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.

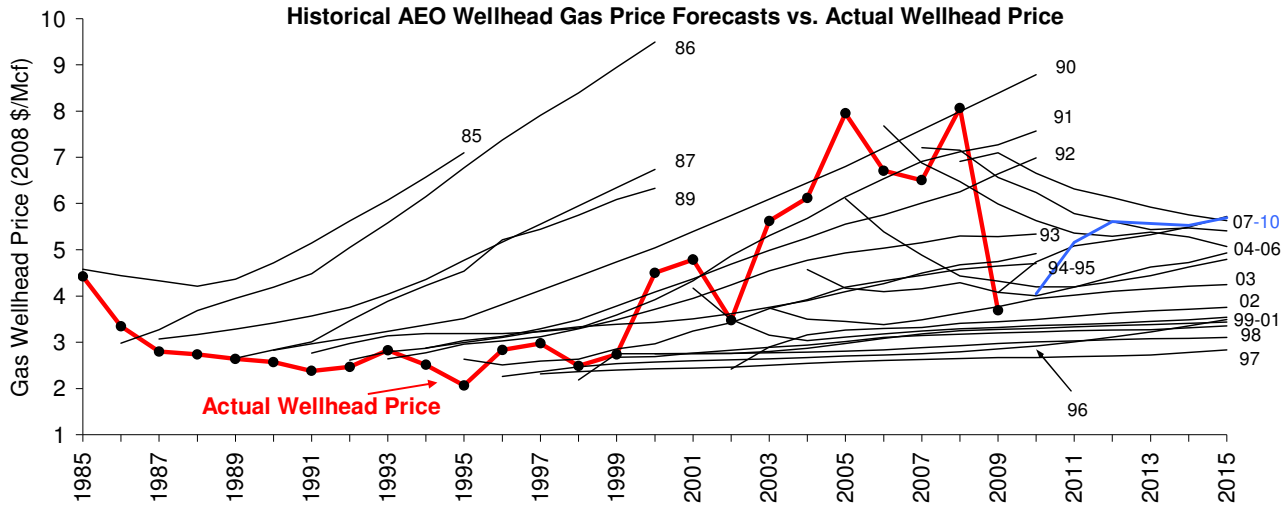

Figure 5: Historical AEO Wellhead Gas Price Forecasts vs. Actual Wellhead Price

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 analagous to fuel-free renewables – e.g., anyone contracting for wind or solar power today knows with great certainty what his or her future costs will be.

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

Figure 6 compares the *AEO 2010* reference-case projection of Henry Hub gas prices (which resulted from a November 18, 2009 modeling run) to the NYMEX natural gas futures strip (with monthly prices averaged each year[3]) from November 17, 2009. As shown, the two curves match up quite well – i.e., the closest match witnessed over the ten years that we have been drawing these comparisons. Nevertheless, the NYMEX futures are trading at a slight premium to the *AEO 2010* forecast, particularly during 2010 and 2011 (all other years out to 2021 are much closer). As such, the levelized premium declines as the term of the comparison is extended. For example, the three-year premium comes to $0.37/MMBtu, while the 12-year premium is just $0.11/MMBtu – i.e., small enough to be considered "in the noise."

[3] 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.

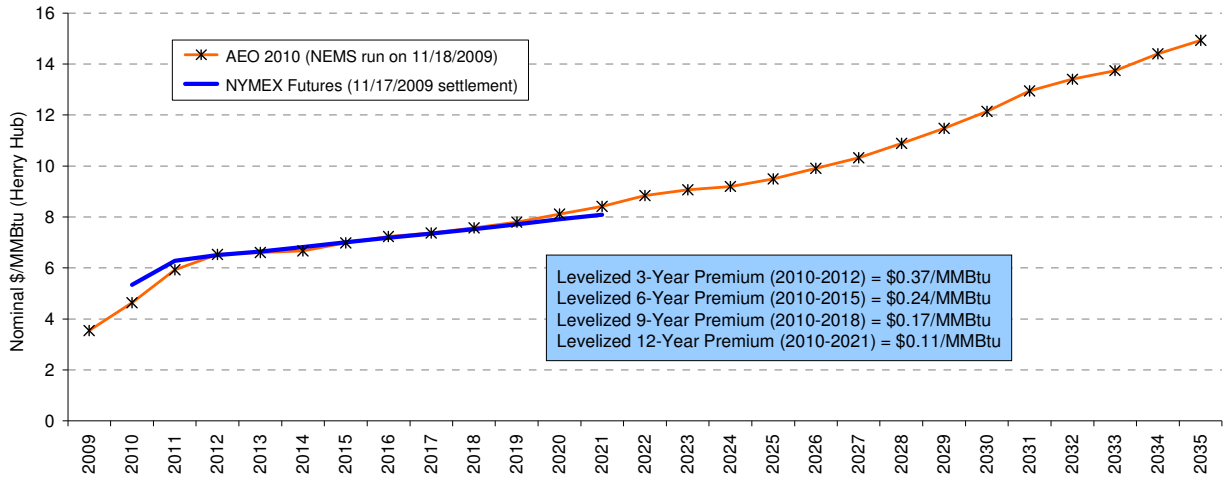

Figure 6: Comparison of NYMEX Futures Strip to AEO 2010 Gas Price Projection

5. Picking the Correct Date of Comparison

As mentioned above, the *AEO 2010* reference-case natural gas price projection resulted from a NEMS run completed on November 18, 2009. For the comparison made above in Figure 6, we chose to sample the NYMEX strip from November 17, 2009 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 2009 through December 29, 2009, in order to gauge whether the settlement prices on November 17, 2009 are, in fact, representative of where gas futures had been trading around the time the EIA was finalizing its *AEO 2010* forecast. The results, which are shown in Figure 7, suggest that November 17 is a conservative choice, given that it represents among the lowest gas prices over this period (with prices approaching similar lows in early September, before rebounding later that month and into October). In other words, had the comparison been made on just about any day other than November 17, it would have yielded a 12-year premium larger than the $0.11/MMBtu calculated for November 17. The average 12-year premium over this period comes to $0.39/MMBtu.

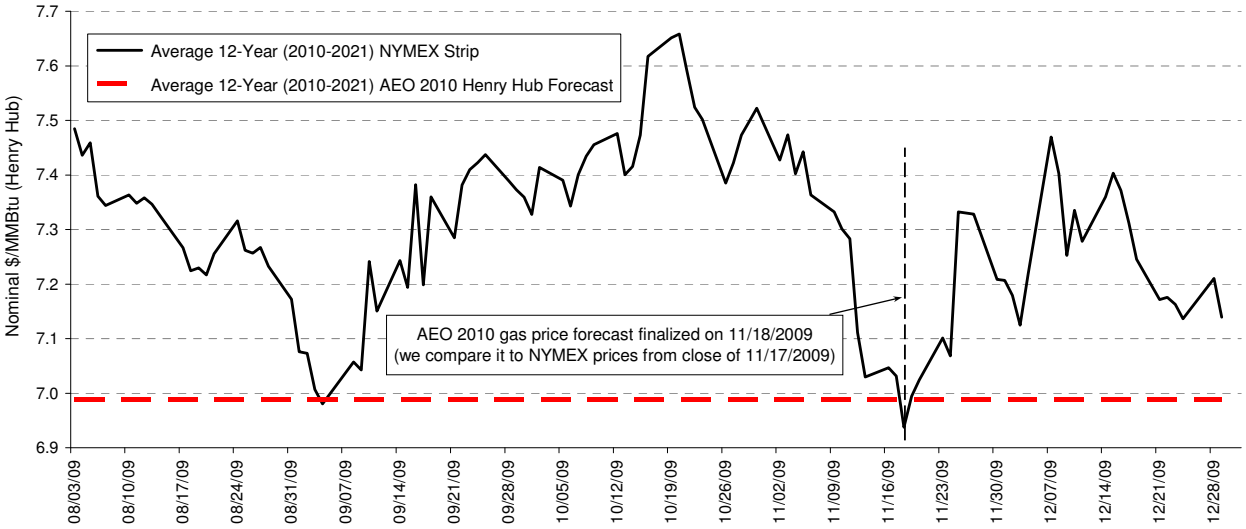

Figure 7: Average NYMEX Strip vs. Average AEO 2010 Forecast (2010-2021)

6. Increasing our Sample Size

The early release of *AEO 2010* 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 2010* forecast is similar to what we observed last year, but considerably less than what we have observed in previous years.

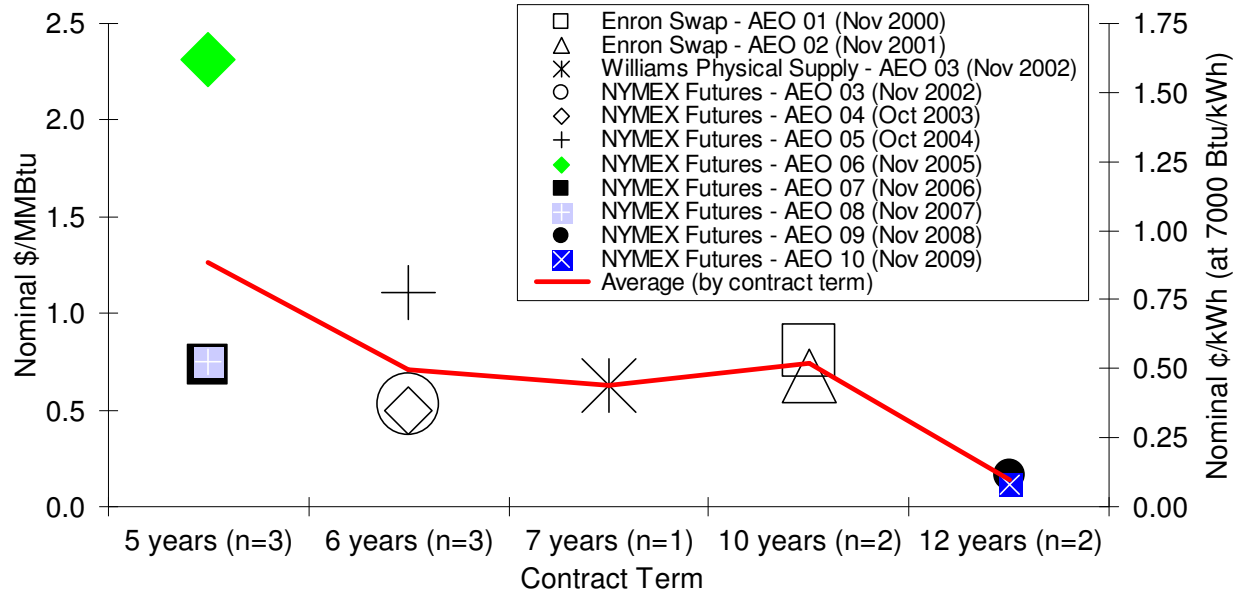

Figure 8: Levelized Premiums (Forwards – Forecasts)

Assuming a heat rate of 7,000 Btu/kWh (typical of an advanced combined cycle gas turbine), the $0.11/MMBtu NYMEX premium relative to the *AEO 2010* reference-case translates to just

0.08¢/kWh – smaller than premiums observed in the past, and arguably a difference that is "in the noise."

7. Findings

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 ten years, thereby creating the appearance of a premium.

Regardless of the *reason* for the premium, however, the fact that it persists (albeit to a much smaller degree over the past two years) suggests that futures prices should form the basis of any natural gas price projection, at least when comparing the levelized cost of gas-fired to renewable generation. For example, 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. 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 ten years, then any levelized cost comparison using only that *AEO* forecast (or using it as the "base case") will arguably be skewed in favor of gas-fired generation, unless clear documentation shows that the accuracy of the *AEO* reference-case forecast is superior to market expectations (as revealed through the NYMEX strip).

All that said, this year (like last year) we find that the $0.11/MMBtu NYMEX premium relative to the *AEO 2010* reference-case forecast (equal to 0.08¢/kWh assuming an aggressive heat rate) is once again smaller than premiums observed in the past, and is arguably a difference that is "in the noise." Because it is hard to know whether or for how long this relative degree of alignment might persist, however, we continue to recommend that 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 futures 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.