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Natural Gas Prices Forecast Comparison - AEO vs. Natural Gas Markets

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Acknowledgments

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Abstract

This paper evaluates the accuracy of two methods to forecast natural gas prices: using the Energy Information Administration's *Annual Energy Outlook* forecasted price (AEO) and the *Henry Hub* compared to U.S. Wellhead futures price. A statistical analysis is performed to determine the relative accuracy of the two measures in the recent past. A statistical analysis suggests that the Henry Hub futures price provides a more accurate average forecast of natural gas prices than the AEO. For example, the Henry Hub futures price underestimated the natural gas price by 35 cents per thousand cubic feet (11.5 percent) between 1996 and 2003 and the AEO underestimated by 71 cents per thousand cubic feet (23.4 percent). Upon closer inspection, a liner regression analysis reveals that two distinct time periods exist, the period between 1996 to 1999 and the period between 2000 to 2003. For the time period between 1996 to 1999, AEO showed a weak negative correlation (R-square = 0.19) between forecast price by actual U.S. Wellhead natural gas price versus the Henry Hub with a weak positive correlation (R-square = 0.20) between forecasted price and U.S. Wellhead natural gas price. During the time period between 2000 to 2003, AEO shows a moderate positive correlation (R-square = 0.37) between forecasted natural gas price and U.S. Wellhead natural gas price versus the Henry Hub that show a moderate positive correlation (R-square = 0.36) between forecast price and U.S. Wellhead natural gas price. These results suggest that agencies forecasting natural gas prices should consider incorporating the Henry Hub natural gas futures price into their forecasting models along with the AEO forecast. Our analysis is very preliminary and is based on a very small data set. Naturally the results of the analysis may change, as more data is made available.

1. Introduction

In the United States natural gas consumption is on the rise, natural gas demand is expected to grow 2.4% per year until 2020, while oil demand is expected to grow 1.7% per year and coal demand 1.5% per year.[1] The 2003 National Petroleum Council Study reported "there exists a fundamental shift in the supply/demand balance which has resulted in higher natural gas demand and volatility and they project that this trend is expected to continue."[2] The electricity crisis of the winter of 2000/2001 in California is a clear example of our precarious reliance on natural gas. This price volatility affects all sector end-users from electric generation to residential.

In the residential sector, current natural gas consumption is approximately 7.23 trillion cubic feet per year and that demand is expected to grow to approximately 10.3 trillion cubic feet by 2025.[3] Natural gas as a fuel for residential appliances, such as furnaces and boilers, continues to grow as alternative forms of energy become less and less attractive. Therefore when a Rulemaking, in this case the Federal Residential Furnace and Boiler Rulemaking commissioned by the Department of Energy, assesses the impact of natural gas prices on life-cycle cost analysis; the accuracy of the models that are set to predict natural gas prices is now of immediate importance in being able to provide the best information possible to inform manufacturers and policy makers.

Historically, the Annual Energy Outlook (AEO) has been used as the national benchmark for reporting futures natural gas prices. Recently, the accuracy of AEO's natural gas prices for the Furnace and Boiler Rulemaking has come into question with stakeholders suggesting that other models might more accurately reflect the commodity market.

This paper first presents a picture of the history and development of the natural gas market in the United States, with a close examination of AEO and the Henry Hub. An evaluation of the accuracy of two methods to forecast natural gas prices is performed: using the Energy Information Administrations' *Annual Energy Outlook* forecasted price (AEO) and using the *Henry Hub* compared to U.S. Wellhead futures price. By performing this work, insight will be gained on the accuracy of forecasting methods and on the behavior of future forecasts.

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[1]Scott A. Nauman, Forces of Change in the Natural Gas Industry, Conference: GasMart 2004 (May 11, 2004), ExxonMobil <http://www.gasmart.com/presentations/Nauman.pdf>

[2]National Petroleum Council (2003). Balancing Natural Gas Policy - Fueling the Demands of a Growing Economy, Volume I Summary of Findings and Recommendations, Report of the National Petroleum Council, September 25, 2003.

[3]U.S. Department of Energy, Annual Energy Outlook 2004 with Projections to 2025, Posted January 2004, 2004. Report No. DOE/EIA-0383(2003). <http://www.eia.doe.gov/oial\f/analysispaper/pdf/table13.pdf>

1.1 History of Natural Gas Regulation

The natural gas market has had over 100 years of evolution in the United States. Understanding the history of the natural gas market helps to explain how the role of regulation, and subsequent deregulation, shape today's market. In the early days of regulation (mid-1800s), local municipalities decided one company with a single distribution network could deliver natural gas more efficiently and cheaply than if two companies had separate distribution networks and markets. In order to prevent these natural monopolies from abusing their position, local government decided that regulation was needed to ensure the quality of service and low price to customers. In the early 1900s, as local distribution networks grew in size, gas companies began to spread outside of an enclosed municipality border and into others. At this point, intrastate regulations at the state level began to pop up, the first states to do so were New York and Wisconsin.[4]

With improved technologies, companies began to develop the capability of developing pipeline distribution networks that crossed state borders. Out of growing concern, between 1911 and 1928, several states attempted to exercise control over the growing power of gas companies that owned production, pipelines and distributions. However, these attempts proved futile because the U.S. Supreme Court upheld the "interstate commerce clause" of the U.S. Constitution. Still, something needed to be done to curb the growing power of gas companies. In 1935 Congress passed the Public Utility Holding Company Act to curb the power of these utility companies to exercise unfair control of the natural gas market, however, this still did not regulate interstate gas sales. The Natural Gas Act (NGA) the federal government first involvement with the regulation of interstate natural gas sales. NGA gave power to the Federal Power Commission (FPC) to oversee the regulation of natural gas sales by regulating the rates charged for interstate natural gas delivery. Under the FPC, gas companies could not build a new pipeline to a region that was already being served by an existing pipeline and by 1942, a gas company interested in building a new pipeline had to get approval. Although natural gas rates of transit were being regulated, the price of natural gas was not being regulated at it's source, the wellhead.

The FPC originally decided to leave the wellhead price unregulated because natural gas producers and pipelines were distinct entities and the FPC operated on the belief that the market would keep prices low. However, the Supreme Court's 1954 Phillips Petroleum Co. v. Wisconsin (347 U.S. 672 (1954)) ruling said that natural gas producers that sold to the interstate pipelines could be classified as natural gas companies and therefore were subject to regulation by the FPC. While interstate pipelines were relatively simple to regulate, it was much more burdensome to regulate natural gas producers because there were so many of them. In 1960, the FPC decided to set rates based by region and divided the country into 5 distinct geographic areas. This again proved to be burdensome on the FPC, it was much more difficult to determine

[4]NaturalGas.Org, Natural Gas Overview, (Last Accessed on July 13, 2004). <http://www.naturalgas.org/overview/background.asp>

the correct geographic area than previously believed. Therefore, the FPC decided to set price ceilings on natural gas rates sold at the wellhead. This price ceiling had a few wide-ranging effects. The first is that the rates were far below market value so there was little incentive for natural gas producers to invest money in exploration and drilling for new wellheads. Second, although there was regulation of natural gas sold to interstate pipelines, there were no regulation on natural gas produced and sold to intra-state pipelines. Therefore, natural gas sold to the intra-state pipelines were relatively high, but natural gas was abundant in gas producing states while non-gas producing states experienced shortages.

This lead to the Natural Gas Policy Act (NGPA) in 1978 which essentially created a single nation-wide natural gas market, equalizing supply with demand, and allowing market forces to determine the price of natural gas at the wellhead. In 1982, the first AEO was published based on the Intermediate Future Forecasting System (IFFS), replacing the Annual Report to Congress (published from 1977-1981) which satisfied a 1977 Department of Energy Organization Congress Act mandate which required energy forecasts to be provided and updated annually. At the request of Congress and with the assistance of the National Academy in the early 1990s, the Energy Information Administration (EIA) began developing the National Energy Modeling System (NEMS), which improved upon the IFFS model "representation o f electricity and natural gas markets, demand-side management programs, development of renewable sources, and environmental policies."[5] This sets the stage for our current natural gas situation and price volatility.

[5]Kate Calvin, The Energy Information Administrations' Changing Energy Forecasts: A study of the Annual Energy Outlooks from 1983 to 2004, March 3, 2004, Stanford University, Palo Alto.

2. Annual Energy Outlook (AEO)

This section contains a description of AEO and of NEMS, the modeling system that provides data for the AEO.

2.1 Description of AEO

The Annual Energy Outlook is an annual report produced by EIA of midterm forecasts of energy supply, demand, and prices. AEO's projections are based on the NEMS. Projections are based on Federal, State, and local laws on effect September 1st the year prior to publication, projections are not based on pending regulations, policies, and standards of the prior year. In order to deal with potential shifts in regulations and the economy, the AEO focuses on primarily on a reference case, which uses mid-range assumptions for economic growth and world oil prices, and four other cases that assume higher and lower economic growth and higher and lower world oil prices. Assumptions for economic growth are based on growth in labor force and productivity while varying oil price levels are based on oil production in the Organization of Petroleum Exporting Countries (OPEC). The AEO examines other cases that explore the impacts of a variety of other assumptions in NEMS, such as the impact of new and improved technologies and are run as fully integrated cases or by running only a portion of the entire modeling system. Historical data, used for reference purposes are based on EIA's Annual Energy Review. For AEO 2004, projections for 2003 and 2004 were taken from EIA's September 2003 Short-Term Energy Outlook (STEO).[6]

2.2 Description of National Energy Modeling System (NEMS)

Basically, NEMS represents the interaction between energy markets and the U.S. Economy. According to the EIA, "the model achieves a supply/demand balance in the end-use demand regions, defined as the nine Census divisions, by solving for the prices of each energy product that will balance the quantities consumers wish to consume."[4] NEMS contains details for the following: residential demand, commercial demand, industrial demand, transportation demand, electricity, renewables, oil supply, natural gas supply, natural gas transmission and distribution, refining, and coal supply. The natural gas supply covers six categories: conventional lower-48 onshore, lower-48 deep and shallow offshore, coalbed methane, gas shales, tight sands, Canadian, Mexican and liquefied natural gas, and Alaskan Gas which includes the following regions: six lower 48 onshore regions, three lower 48 offshore regions, three Alaska regions and eight liquefied natural gas import regions. The natural gas transmission and distribution covers three categories: core vs. noncore, peak vs. offpeak, and pipeline capacity expansion.[7]

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[6]U.S. Department of Energy, Annual Energy Outlook 2004 with Projections to 2025, Posted January 2004, 2004. Report No. DOE/EIA-0383(2003). <http://www.eia.doe.gov/oial\f/analysispaper/pdf/table13.pdf>

[7]Energy Information Administration, The National Energy Modeling System: An Overview 2003, 2003. (Last Accessed July 12, 2003)

2.2.1 Structure of NEMS

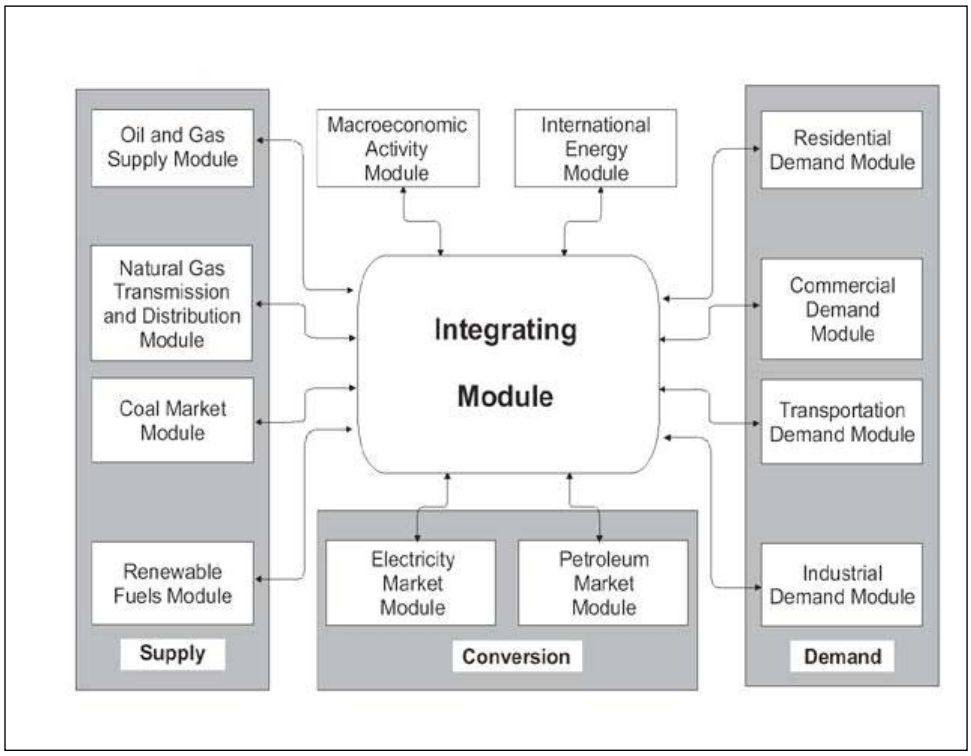

Figure 1. National Energy Modeling System

NEMS contains four demand modules which consist of Residential, Commercial, Transportation, and Industrial; four supply modules which consist of Oil and Gas, Natural Gas Transmission and Distribution, Coal Market, and Renewable Fuels; two conversion modules which consist of Electricity Market and Petroleum Market; Macroeconomic Activity Module, International Energy Module, and Integrating Module. The flexible modular structure of NEMS allows for a variety of different focuses and for the model to run using only a few specific modules at a time. Interactions between modules are controlled by the Integrating Module. The Integrating Module has five main functions, it manages the global data structure, executes all or any of the user self-selected options in an iterative convergence algorithm, checks for convergence and checks for anomalies, implements convergence relaxation between iterations to speed up convergence, and updates values of important NEMS variables. NEMS uses data from the nine census regions: New England, Middle Atlantic, South Atlantic, East South Central, East North Central, West South Central, West North Central, Mountain, and Pacific.[5, 8]

<http://www.eia.doe.gov/oiaf/overview.html>

[8]Energy Information Administration, Price Responsiveness in the AEO2003 NEMS Residential and Commercial Buildings Sector Model, Table 13. Natural Gas Wellhead Prices, Actual vs. Forecasts, 2003. (Posted October 2003).

3. Henry Hub

This section contains a description of the Henry Hub and briefly details market structure.

3.1 The Marketplace: Henry Hub

Two distinct markets exist for natural gas, the spot market and the futures market. The spot market is the daily market, natural gas is bought and sold within a one day time period; the price of natural gas for a particular day can be determined by the spot market.[3] The futures market is when natural gas is under contract for one month up to thirty-six months in advance. Natural gas futures are traded in 10,000 million British thermal units (mmBtu) on the New York Mercantile Exchange (NYMEX) and are widely used as the national benchmark price. Natural gas is priced and traded at different locations throughout the country called 'market hubs', one of the principle hubs is the Henry Hub. Henry Hub is owned and operated by Sabine Pipe Line LCC which is the most active and publicized hub in the United States. The Henry Hub interconnects with 9 interstate and 4 intrastate pipelines that provide access to markets in the Midwest, Northeast, Southeast and Gulf Coast. Since November 1989, futures contracts traded on NYMEX are Henry Hub contracts, which means the that the price at NYMEX for natural gas reflects natural gas for physical delivery at this hub.[9] The difference between Henry Hub natural gas price and another hub is called the location differential. Another location where natural gas can incur additional price factor are at the Citygate, locations where the pipeline meets the distributors, before the gas reaches the consumer.[3]

3.1.1 Types of Trading

There are two main types of trading, physical trading and financial trading. Physical trading involves the buying and selling of the physical commodity, in this case natural gas. Financial trading consists of derivatives where the buyer and seller never actually take physical delivery of the commodity. There are three principle types of physical trading: swing contracts, baseload contracts, and firm contracts. Swing contracts are short-term contract that can last as little as one day or up to one month. These contracts are usually in effect when supply from the seller or demand from the buyer is unreliable. Baseload contracts are much like swing contracts expect that the buyers and sellers reach an understanding that they will not back out of the contracts even if there are price fluctuations. Firm contracts are when the buyer and seller can choose to pursue legal recourse if one of the parties should pull out of the contract. These contracts are usually used when the supply and demand for natural gas are unlikely to change.[3]

Financial trading involves natural gas derivatives which derive their value from the underlying price of natural gas. Prices of natural gas are determined by supply and demand conditions. If

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<http://www.eia.doe.gov/oiaf/analysispaper/>

[9]New York Mercantile Exchange, Henry Hub Natural Gas Futures (Last Accessed on August 8, 2004) <http://www.nymex.com/jsp/markets/NG_spec.jsp>

there are more buyers than sellers, the price will go up, and if there are more sellers than buyers, the price will go down. It has been estimated that the value of natural gas derivatives are ten to twelve times greater than value of physical natural gas trading. In fact, less than two percent of all natural gas contracts that come into effect are ever settled through deliveries. There are two main reasons to trade in financial gas markets: hedging and speculation, "the main difference between speculation and hedging is that the objective of hedging is to reduce risk, whereas the objective of speculation is to take on the risk in hope of earning a financial return," both hedgers and speculators use forecasts to determine the price of natural gas, the only difference between the forecasts is the way that the are used.[3]

4. Analysis of AEO and Henry Hub Compared to U.S. Wellhead

This section contains the results of a brief analysis comparing AEO's natural gas price forecast to the U.S. Wellhead and the Henry Hub natural gas price forecast to the U.S. Wellhead. This analysis will be useful information for future Rulemakings.

4.1 U.S. Wellhead and AEO Natural Gas Prices

AEO bases it's forecast on U.S. Wellhead Prices, the price received by natural gas producers for marketed gas, as reported on Form EIA-895 by the States and Minerals Management Services (MMS).[10] Form EIA-895 requests that State agencies report the quantity and value of marketed production, this replaces preliminary data which are estimated from the New York Mercantile Exchange (NYMEX) futures closing for natural gas delivery at the Henry Hub.[11] U.S. Wellhead prices are reported in dollars per thousand cubic feet. The wellhead price includes the value of natural gas liquids and pertains to all transaction occurring in the United States (lower 48 States), thereby encompassing purchase commitments of all durations.[9] For AEO 1996-2002, the data on which the natural gas price forecast was based reflects data available as of July of the previous year. AEO 2003 reflects data available as of August 2002 while AEO 2004 reflects data available as of September 2003.

Table 1. AEO Predicted Price from 1996-2003 for the years between 1994-2003

Forecast Year	Predictor Year								Average	Actual
	1996	1997	1998	1999	2000	2001	2002	2003		
1996	2.20								2.20	2.16
1997	2.35	1.98							2.16	2.32
1998	2.52	2.07	2.45						2.35	1.95
1999	2.66	2.18	2.54	2.45					2.46	2.19
2000	2.76	2.21	2.55	2.46	2.52				2.50	3.69
2001	2.88	2.32	2.64	2.60	2.56	3.64			2.77	4.01
2002	3.00	2.41	2.72	2.72	2.61	3.10	2.21		2.68	2.95
2003	3.12	2.53	2.81	2.85	2.38	2.86	2.72	3.57	2.85	4.98

Table 1 summarizes AEO 1996 to AEO 2003 forecasted natural gas prices from 1996 to 2003. As shown in this table, AEO reports forecasted data from the predictor year onward. For example, in 1996 AEO predicts for the current year and seven years ahead. We only show the

[10]Philip Budzick, U.S. Natural Gas Markets: Relationship Between Henry Hub Spot Prices and U.S. Wellhead Prices, 2004.
<http://www.eia.doe.gov/oaif/analysispaper/henryhub/index.html>

[11]Energy Information Administration, Natural Gas Monthly June 2001: Appendix A, June, 2001, Energy Information Administration.
<http://www.eia.doe.gov/pub/oil_gas/data_publications/natural_gas_monthly/historical/2001/2001_06/pdf/appendix_a.pdf>

forecast years for which Henry Hub has also predicted. The average forecast for each forecasted year is shown, for the forecast year 1998 the average natural gas price is $2.35. The far right column shows the actual natural gas price from 1996 to 2003, which is defined as an national annual average.

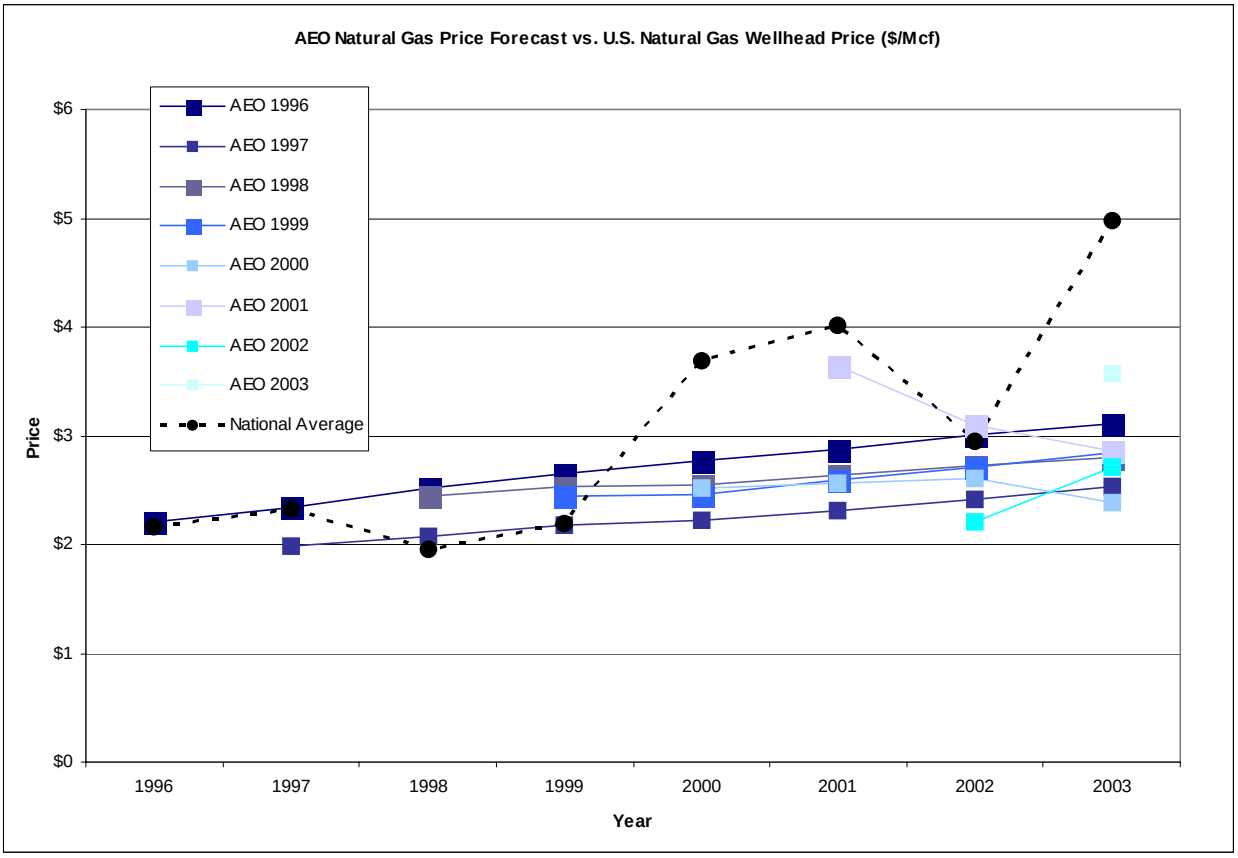

Figure 2. AEO Natural Gas Price Forecast vs. U.S. Natural Gas Wellhead Price ($/Mcf).

This information is charted in Figure 2 (the dashed black line represents the actual price for natural gas). For the period of 1996-1999, on average AEO's forecast was relatively accurate. In 2000, the market experienced a period of significant fluctuations of natural gas prices; overall, AEO's forecast was significantly lower, and continues to be, than the actual price. In the beginning of 2003, AEO forecasted a natural gas price of $3.57 whereas the actual price for 2003 is $4.98 (39% underestimation).

4.2 U.S. Wellhead and Henry Hub Natural Gas Prices

Henry Hub spot gas prices represents natural gas sales contracted for next day delivery and title transfer. Natural Gas Weekly (NGW) is the standard for the report of Henry Hub spot gas prices, this price represents a volume-weighted average price of spot transactions. Henry Hub spot prices are reported in dollars per million Btu. The Henry Hub spot price pertains to

transactions for next day deliver occurring at the Henry Hub Processing Plant and it is measured downstream of the wellhead, after the natural gas liquids have been removed and after a transportation cost has been incurred.[12]

Table 2. Futures Predicted Price from 1996-2003 for the years between 1996-2003

Forecast Year	Predictor Year								Average	Actual
	1996	1997	1998	1999	2000	2001	2002	2003		
1996	2.59								2.59	2.16
1997	2.41	2.58							2.50	2.32
1998	2.33	2.54	2.11						2.33	1.95
1999	2.27	2.49	2.19	2.26					2.30	2.19
2000	2.20	2.40	2.26	2.34	3.89				2.62	3.69
2001	2.16	2.33	2.31	2.39	3.92	4.28			2.90	4.01
2002	2.13	2.28	2.34	2.39	3.92	4.31	3.21		2.94	2.95
2003	2.11	2.26	2.36	2.40	3.87	4.29	3.23	5.37	3.24	4.98

Table 2 summarizes the futures market forecasted natural gas prices from 1996-2003.[2] The Future's Market data is projected daily for one month ahead (e.g., every day for the month of April 1997, there is a price projected for the month of May 1997), on the last day of the month there is a final projection (forecast) for the next month (which is often the next day). In order to compare the Future's Market forecast data to AEO's forecast data, the final projection for each month (12 values total, one value for each month) was averaged in order to get one annual average value. The average forecast for each forecasted year is shown, for the forecast year 1996 the average henry hub natural gas spot price is $2.59. The far right column shows the actual natural gas price from 1996 to 2003, which is defined as an annual average.

[12]Philip Budzick, U.S. Natural Gas Markets: Relationship Between Henry Hub Spot Prices and U.S. Wellhead Prices, 2004. <http://www.eia.doe.gov/oiaf/analysispaper/henryhub/index.html>

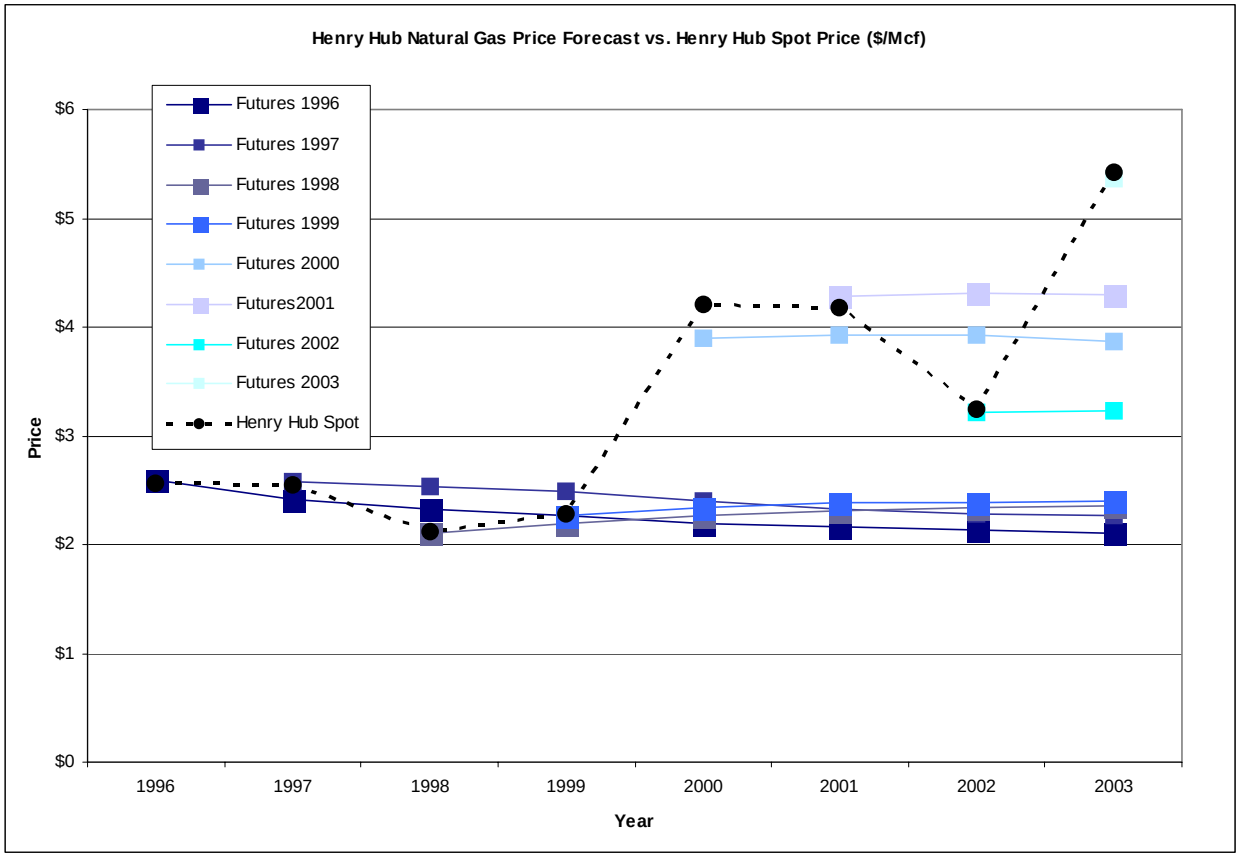

Figure 3. Henry Hub Natural Gas Price Forecast vs. Henry Hub Spot Price ($/Mcf)

This information is charted in Figure 3 (the dashed black line represents the actual price for natural gas). As shown in Figure 3, the Future's Market forecast in the mid to late-1990s, the Future's Market forecast tended to slightly overestimate natural gas prices as compared to the actual price. From 2000 on, although the Future's Market continued (with an exception of the 2001 forecast) to underestimate natural gas prices, overall, the projections are much closer to the actual market value than AEO's estimate during the same period.

4.3 U.S. Wellhead versus AEO and Henry Hub Natural Gas Prices

Table 3. AEO vs Futures Market Predicted Price from 1996-1998 for the years between 1996-1998

Forecast Year	Predictor Year								Actual
	AEO				Futures Market				
	1996	1997	1998	1999	1996	1997	1998	1999	
1996	2.20				2.59				2.16
1997	2.35	1.98			2.41	2.58			2.32
1998	2.52	2.07	2.45		2.33	2.54	2.11		1.95
1999	2.66	2.18	2.54	2.45	2.27	2.49	2.19	2.26	2.19

Table 4. AEO vs Futures Market Predicted Price from 1998-2003 for the years between 1998-2003

Forecast Year	Predictor Year								Actual
	AEO				Futures Market				
	2000	2001	2002	2003	2000	2001	2002	2003	
2000	2.52				3.89				3.69
2001	2.56	3.64			3.92	4.28			4.01
2002	2.61	3.10	2.21		3.92	4.31	3.21		2.95
2003	2.38	2.86	2.72	3.57	3.87	4.29	3.23	5.37	4.98

Table 3 summarizes the natural gas price forecasts for the period between 1996-1999 as reported by AEO and Henry Hub as well as the U.S. Natural Gas Wellhead Price observed during the same period. Table 4 summarizes the natural gas price forecasts for the period between 2000-2003 reported by AEO and Henry Hub as well as the U.S. Natural Gas Wellhead Price observed during the same period.

Figure 4 charts the information presented in Table 3. As shown in Figure 4, this is a graphical comparison of AEO and Henry Hub reported projections from 1996-1999. During this period, AEO tended to accurately estimate the actual U.S. Wellhead natural gas price while the Futures Market consistently overestimated.

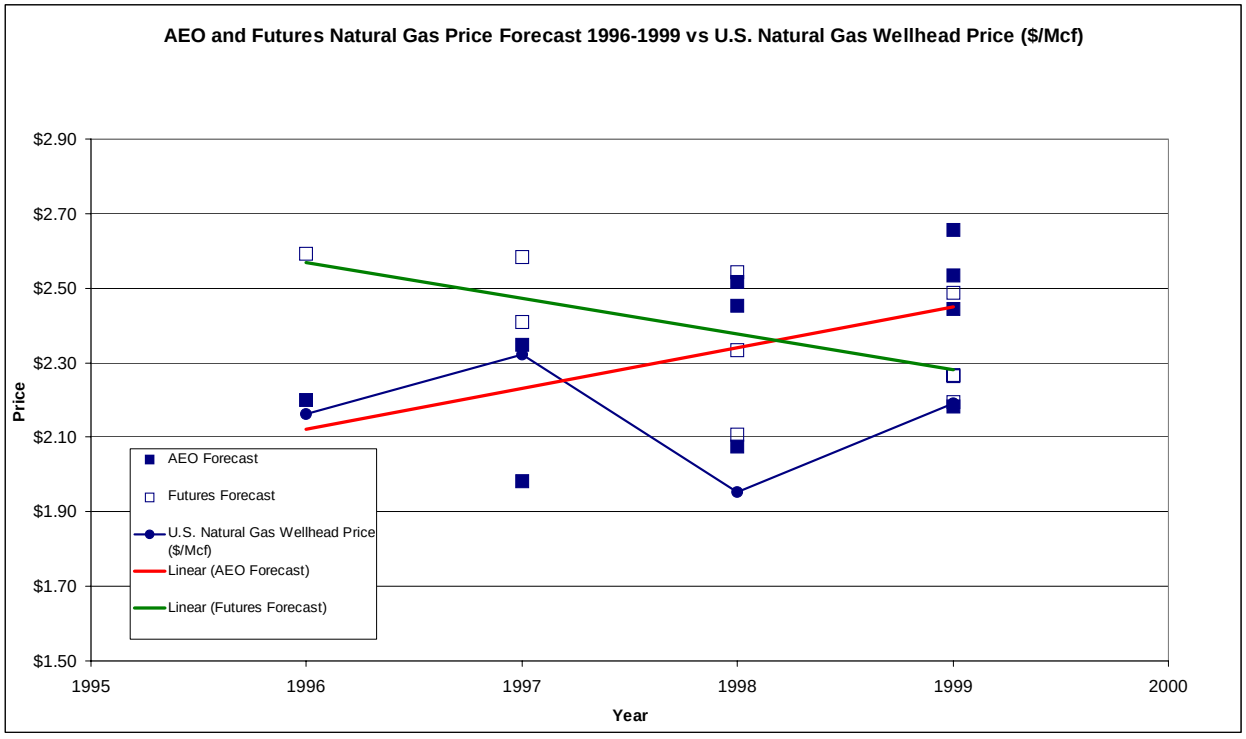

Figure 4. Futures Market vs AEO Forecast from 1996-1999 as Compared to the U.S. Natural Gas Wellhead Price ($/Mcf)

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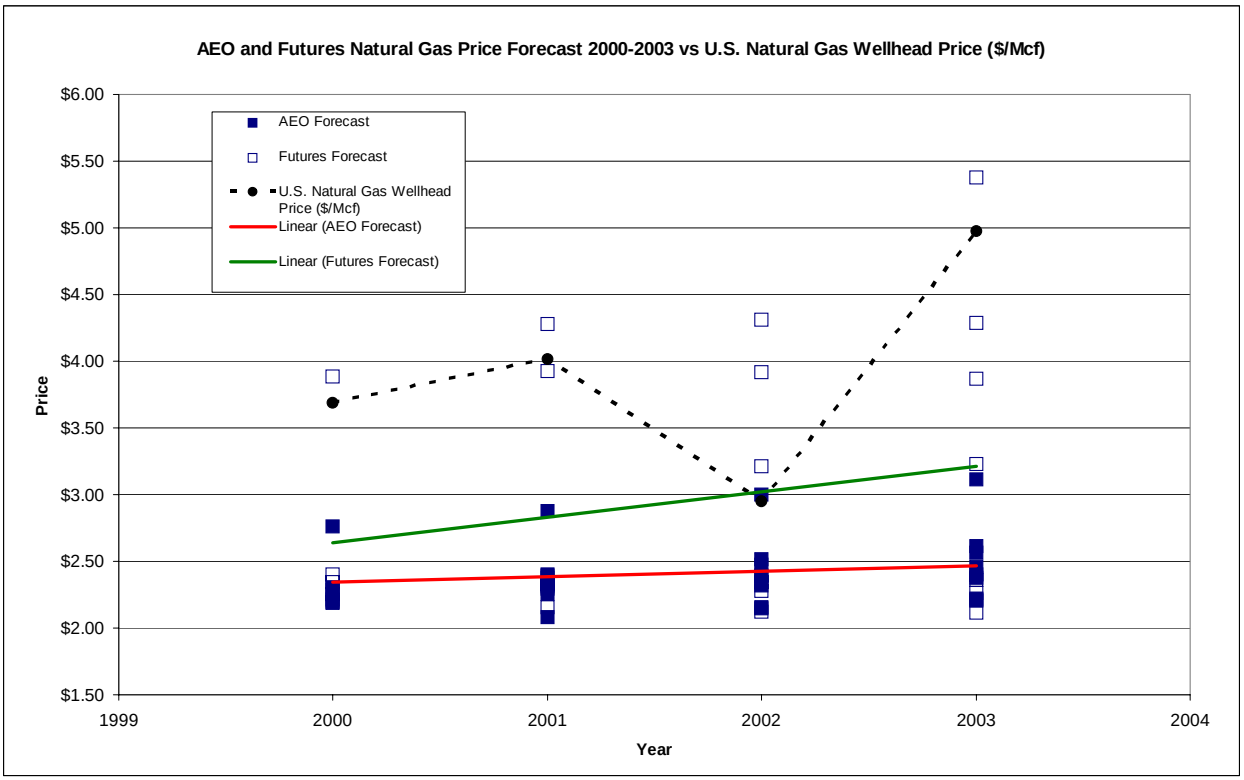

Figure 5. Futures Market vs AEO Forecast from 2000-2003 as Compared to the U.S. Natural Gas Wellhead Price ($/Mcf)

Figure 5 charts the information presented in Table 4. As shown in Figure 5, this is a graphical comparison of AEO and Henry Hub reported projections from 2000-2003. During this period, AEO consistently underestimated the actual U.S. Wellhead natural gas price while the Futures Market more accurately estimated the actual price.

Table 5. Descriptive Statistics of Futures Market, AEO and U.S. Natural Gas Wellhead Prices

Natural Gas Forecast Variable	Mean	Standard Deviation	Sum	Minimum	Maximum
U.S. Wellhead Price	3.03	1.09	24.25	1.95	4.98
Futures Market	2.68	0.11	21.41	2.30	3.24
AEO	2.32	0.04	18.59	2.16	2.47

* Descriptive Statistics using MS Excel Data Analysis

Table 5 shows descriptive statistics of the Futures Market, AEO and U.S. Natural Gas Wellhead Prices. U.S. Natural Gas Wellhead (mean = $3.03, standard deviation = $1.09) prices show much higher prices and price variability than both the Futures Market (mean = $2.56, standard deviation = $0.11) and AEO (mean = $2.32, standard deviation = $0.04). The Henry Hub

futures price underestimated the natural gas price by 35 cents per thousand cubic feet (11.5 percent) between 1996 and 2003 and AEO underestimated by 71 cents per thousand cubic feet (23.4 percent).

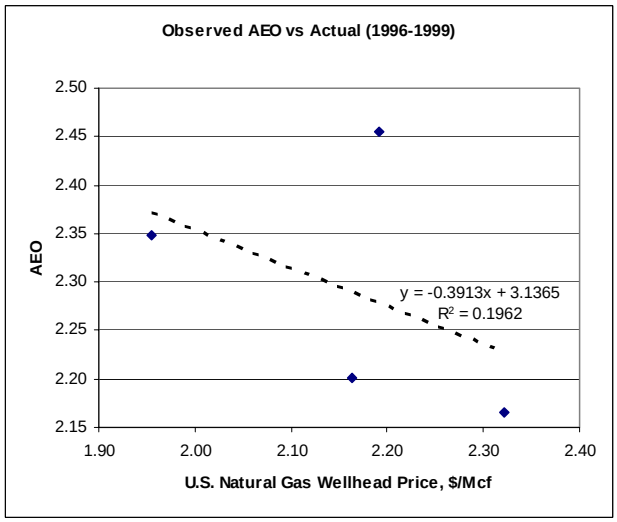

Figure 6. Regression Analysis Plots Observed AEO by Actual (1996-1999)

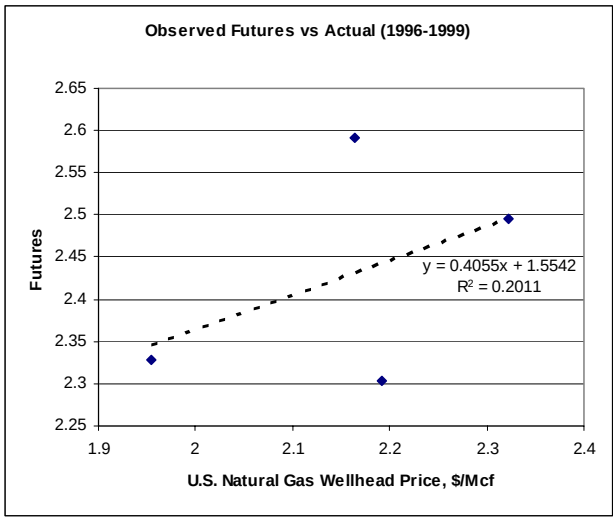

Figure 7. Regression Analysis Plots Observed Futures by Actual (1996-1999)

Figure 6 shows a weak negative correlation between forecasted AEO natural gas price by actual U.S. wellhead natural gas prices (R-square = -0.19) for the period between 1996 to 1999. Figure 7 shows a weak positive correlation between forecasted Futures Market natural gas price by actual U.S. wellhead natural gas prices (R-square = 0.20) for the period between 1996 to 1999.

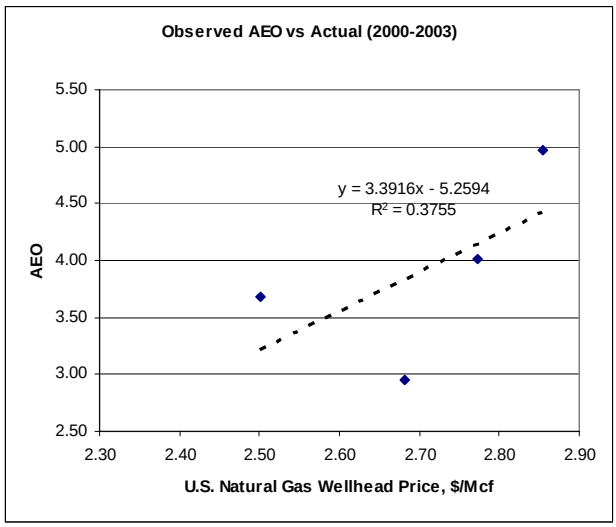

Figure 8. Regression Analysis Plots Observed AEO by Actual (2000-2003)

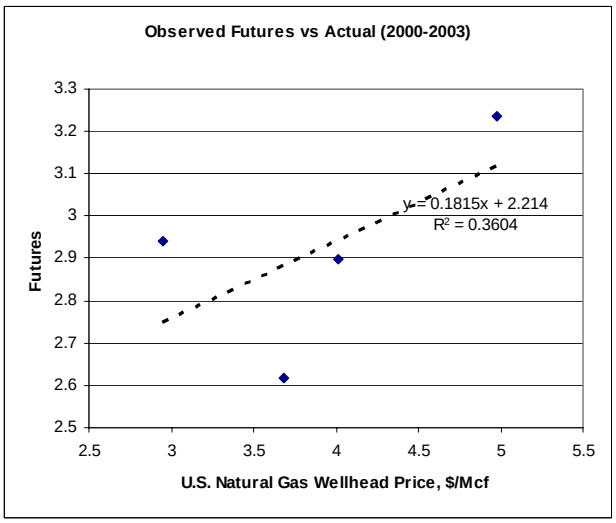

Figure 9. Regression Analysis Plots Observed Futures by Actual (2000-2003)

Figure 8 shows a moderate positive correlation between forecasted AEO natural gas price by actual U.S. wellhead natural gas prices (R-square = 0.37) for the period between 2000 to 2003. Figure 9 shows a moderate positive correlation between forecasted Futures Market natural gas price by actual U.S. wellhead natural gas prices (R-square = 0.36) for the period between 2000 to 2003.

4.4 Conclusions

Overall, the above information shows that two distinct periods between 1996 to 2003 existed. During the period between 1996 to 1999, U.S. wellhead natural gas prices were relatively stable, but by the end of 2000 the natural gas market started to show signs of price volatility.

Between the period of 1996 to 1999, the Futures market tended to accurately estimate the actual natural prices whereas AEO tended to slightly underestimate natural gas prices. The trends changed after 2000, for the period between 2000 to 2003, both AEO and the Futures market tended to accurately estimate natural gas prices.

These trends suggest that during periods of relative stability in the natural gas market, the Futures Market is a better predictor of actual natural gas prices than AEO. But, during periods of price volatility, there is no difference between the Futures Market and AEO in predicting natural gas prices Overall, the Futures Market is better barometer of natural gas prices than AEO during periods of stability and instability. These results suggest that agencies should consider incorporating the Henry Hub natural gas futures into their forecasting models along with the AEO forecast.

Appendix A

Table 1. AEO Predicted Price from 1996-2003 for the years between 1996-2003 (Not Normalized)

Forecast Year	Predictor Year								Average	Actual
	1996	1997	1998	1999	2000	2001	2002	2003		
1996	1.67								1.67	2.16
1997	1.74	1.74							1.74	2.32
1997	1.82	1.77	2.10						1.90	1.95
1998	1.87	1.81	2.11	2.09					1.97	2.19
1999	1.89	1.82	2.11	2.10	2.17				2.02	3.69
2000	1.91	1.84	2.12	2.16	2.17	3.34			2.26	4.01
2001	1.93	1.85	2.12	2.20	2.17	2.79	1.98		2.15	2.95
2002	1.94	1.88	2.12	2.25	2.20	2.52	2.37	3.13	2.30	4.98

Table 2. Futures Predicted Price from 1996-2003 for the years between 1996-2003

Forecast Year	Predictor Year								Average	Actual
	1996	1997	1998	1999	2000	2001	2002	2003		
1996	2.59								2.59	2.16
1997	2.41	2.58							2.50	2.32
1998	2.33	2.54	2.11						2.33	1.95
1999	2.27	2.49	2.19	2.26					2.30	2.19
2000	2.20	2.40	2.26	2.34	3.89				2.62	3.69
2001	2.16	2.33	2.31	2.39	3.92	4.28			2.90	4.01
2002	2.13	2.28	2.34	2.39	3.92	4.31	3.21		2.94	2.95
2003	2.11	2.26	2.36	2.40	3.87	4.29	3.23	5.37	3.24	4.98