U.S. Natural Gas Markets: Relationship Between Henry Hub Spot Prices and U.S. Wellhead Prices

by
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The relationship between Henry Hub spot prices for natural gas and the U.S. wellhead price is examined for the period spanning August 1996 through December 2000. This analysis determines the extent to which the two price series are linearly correlated and also evaluates the statistical properties of two simple price relationships—the actual difference and the percent difference. The results of the analysis indicate that there is a strong linear relationship between the two price series. The analysis also indicates that, on average, Henry Hub spot prices were 32 cents per thousand cubic feet (10.8 percent) higher than wellhead prices. The median value of the actual difference is 24 cents per thousand cubic feet, and the median value of the percent difference is 10.4 percent.

Introduction

The Energy Information Administration (EIA) reports an average wellhead price for natural gas in its monthly and annual data publications and forecasts this price in both the *Short-Term Energy Outlook* and the *Annual Energy Outlook.* Monthly and annual wellhead prices are reported after the final production and price data are received from the States and the U.S. Minerals Management Service (MMS).[1] In the absence of "real-time" wellhead natural gas prices, market participants have adopted Henry Hub spot and futures prices as a surrogate measure for the current wellhead price, because they are reported on a daily basis by several natural gas industry news publications.

The Henry Hub is the largest centralized point for natural gas spot and futures trading in the United States. The New York Mercantile Exchange (NYMEX) uses the Henry Hub as the point of delivery for its natural gas futures contract. The NYMEX gas futures contract began trading on April 3, 1990 and is currently traded 72 months into the future. NYMEX deliveries at the Henry Hub are treated in the same way as cash-market transactions. Many natural gas marketers also use the Henry Hub as their physical contract delivery point or their price benchmark for spot trades of natural gas.

Because Henry Hub spot and futures prices have become the surrogate for "real-time" wellhead natural gas prices, EIA frequently has been asked about the relationship between these two prices series. This analysis examines the relationship by comparing U.S. wellhead gas prices with Henry Hub spot prices.

Description of the Henry Hub

The Henry Hub is owned and operated by Sabine Pipe Line, LLC, which is a wholly owned subsidiary of ChevronTexaco. The Sabine Pipe Line starts in eastern Texas near Port Arthur, runs through south Louisiana, not far from the Gulf of Mexico, and ends in Vermillion Parish, Louisiana, at the Henry Hub near the town of Erath. The Henry Hub is physically situated at Sabine's Henry Gas Processing Plant.

The Henry Hub interconnects nine interstate and four intrastate pipelines, including: Acadian, Columbia Gulf, Dow, Equitable (Jefferson Island), Koch Gateway, LRC, Natural Gas Pipe Line, Sea Robin, Southern Natural, Texas Gas, Transco, Trunkline, and Sabine's mainline. Collectively, these pipelines provide access to markets in the Midwest, Northeast, Southeast, and Gulf Coast

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[1]EIA does not directly collect wellhead production and price data from natural gas producers. The data are obtained from State and Federal (MMS) royalty and severance tax collection efforts. Because of the time delay in reporting measured data, EIA provides estimates of monthly wellhead prices.

regions of the United States.[2] Sabine currently has the ability to transport 1.8 billion cubic feet per day across the Henry Hub.[3] Relative to the total U.S. lower 48 average daily gas consumption of 60.6 billion cubic feet per day in 2000,[4] the Henry Hub can handle up to 3.0 percent of average daily gas consumption.[5]

Approximately 49 percent of U.S. wellhead production either occurs near the Henry Hub or passes close to the Henry Hub as it moves to downstream consumption markets. This is based on 2000 production levels reported for the Gulf of Mexico and the onshore Louisiana and Texas regions encircling the Gulf of Mexico.[6]

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

The U.S. wellhead price, as reported in EIA's *Natural Gas Monthly*, is the price received by natural gas producers for marketed gas,[7] as reported on Form EIA-895 by the States and the MMS. The wellhead price is reported in EIA publications in dollars per thousand cubic feet.

Henry Hub "spot gas," as defined by the data series used in this analysis, represents natural gas sales contracted for *next day* delivery and title transfer at the Henry Hub. This analysis uses the monthly Henry Hub spot price collected and reported by *Natural Gas Week* (NGW). The NGW Henry Hub price data begin in January 1995. The NGW monthly price represents a volume-weighted average price of spot transactions, collected by NGW staff on a daily basis from natural gas marketers.[8]

Henry Hub spot prices are reported in dollars per million Btu.[9]

The Henry Hub spot price and the wellhead price reflect the supply and demand conditions for two distinct facets of the natural gas market. The Henry Hub spot price pertains to transactions for next-day delivery occurring at the Henry Gas Processing Plant and is measured downstream of the wellhead, after the natural gas liquids have been removed and after a transportation cost has been incurred. In contrast, the wellhead price includes the value of natural gas liquids and pertains to all transactions occurring in the United States, thereby encompassing purchase commitments of all durations.

For the period spanning all of 2001 through early 2002, the average monthly wellhead gas price currently reported by EIA is an estimated number. Because these wellhead prices are estimated rather than measured quantities, the prices for 2001 and 2002 were excluded from consideration.

Analysis Results

A graph of the history of Henry Hub spot prices and wellhead prices for natural gas from January 1995 through December 2000 (Figure 1) suggests that their relationship changed during 1996. For example, during the winter of 1995-1996, the Henry Hub spot gas price rose to more than $4.50 per thousand cubic feet, while wellhead prices rose only slightly. For the period from January 1995 through July 1996, the correlation coefficient between the two price series is 0.702. From August 1996 through December 2000, however, the two price

[2]The Sabine Pipe Line is connected to an additional 13 pipelines outside the Henry Hub site: ANR, Bridgeline, Centana, Channel, Cypress, Florida, HPL, Meches, Midcon, Olympic, Tejas, Tennessee, and Transco.

[3]Represents maximum Henry Hub throughput under optimal conditions. See Sabine Pipe Line, LLC, web site www.sabnet.com/henry.htm.

[4]Energy Information Administration, *Natural Gas Annual 2000*, DOE/EIA-0131(00) (Washington, DC, November 2001), Table 2, p. 8, web site www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_002.pdf. Average U.S. daily consumption calculated as 22,547 billion cubic feet per year (total U.S. consumption) minus 427 billion cubic feet per year (Alaska's total consumption) divided by 365 days per year.

[5]This figure is even smaller when compared with peak consumption periods. For example, the 1.8 billion cubic feet per day of Henry Hub capacity is only 2.1 percent of the peak month consumption of 84.9 billion cubic feet per day during the winter of 2000-2001, which occurred in January 2001. See Energy Information Administration, *Natural Gas Monthly December 2001*, DOE/EIA-0130(2001/12) (Washington, DC, December 2001), Table 2, p. 6, web site http://tonto.eia.doe.gov/FTPROOT/natgas/ngm/01300112.pdf. Approximately 1 billion cubic feet of Alaskan gas consumption is included in the January 2002 total natural gas consumption of 2,632 billion cubic feet.

[6]Energy Information Administration, *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves: 2000 Annual Report*, Table 8, p. 28, web site www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/current/pdf/ch4.pdf. Based on offshore Gulf of Mexico production, plus South Louisiana onshore production, plus gas production from onshore Texas Railroad Districts 1 through 6. In 2000, total production of dry natural gas in these regions was 9,389 billion cubic feet, as compared with total U.S. production of 19,219 billion cubic feet.

[7]"Marketed" natural gas production includes nonmethane natural gas liquids (e.g., ethane, butane, propane), which are removed by separation plants near the point of production. The resulting "dry" natural gas, which is predominantly methane, is ready for transport to end users. In 2000, 1,016 billion cubic feet of natural gas liquids was removed from 20,002 billion cubic feet of "marketed" gas production. Energy Information Administration, *Natural Gas Annual 2000*, Table 2, p. 8.

[8]Based on telephone conversations with NGW staff.

[9]For this analysis, the Henry Hub prices were converted into dollars per thousand cubic feet for comparison with the wellhead gas price. A separate gas production conversion factor was used for each year, based on the number of Btu per cubic foot reported in EIA's *Natural Gas Annual* (Table B2) for each particular year. For the period covered by the NGW data, the conversion factors ranged from 1,025 to 1,031 Btu per cubic foot.

series moved more in tandem, with a correlation coefficient of 0.975 for the period.

An econometric analysis of the two time periods demonstrated that a change in the relationship between the two prices occurred during the summer of 1996.[10] In view of these econometric results, the price data before August 1996 were excluded from consideration, so that the data series used in this analysis consisted of 53 monthly observations, from August 1996 through December 2000.[11]

The actual difference equals the Henry Hub spot price minus the wellhead price (expressed in 2000 dollars) and is shown in Figure 2 for the period August 1996 through December 2000. The table below lists descriptive statistics for the actual difference. The mean (arithmetic average) price difference is 31.6 cents per thousand cubic feet, and the median value is 23.6 cents per thousand cubic feet.[12] Both values are consistent with the notion that the Henry Hub, being a downstream location, incurs a transportation cost for moving the natural gas from the wellhead.

Descriptive Statistics for the Actual Price Difference: Henry Hub Spot Price Minus U.S. Wellhead Price, August 1996–December 2000 (2000 Cents per Thousand Cubic Feet)

Mean Value of the Difference	31.6
Median Value of the Difference	23.6
Standard Deviation of the Mean Value of the Difference	38.5

The spread of 8 cents per thousand cubic feet between the mean and median values in the table above indicates that the distribution of observations is not symmetric around the mean, as shown in Figure 3. Moreover, the standard deviation of 38.5 cents per thousand cubic feet indicates a relatively wide distribution of observations around the mean value of 31.6 cents per thousand cubic feet. Given the large difference between the mean and median values and the relatively large standard deviation, the price difference is not a particularly precise expression of the relationship between the two prices. Because of the nonsymmetric nature of the observations,

Figure 1. Monthly Natural Gas Prices, 1995-2000
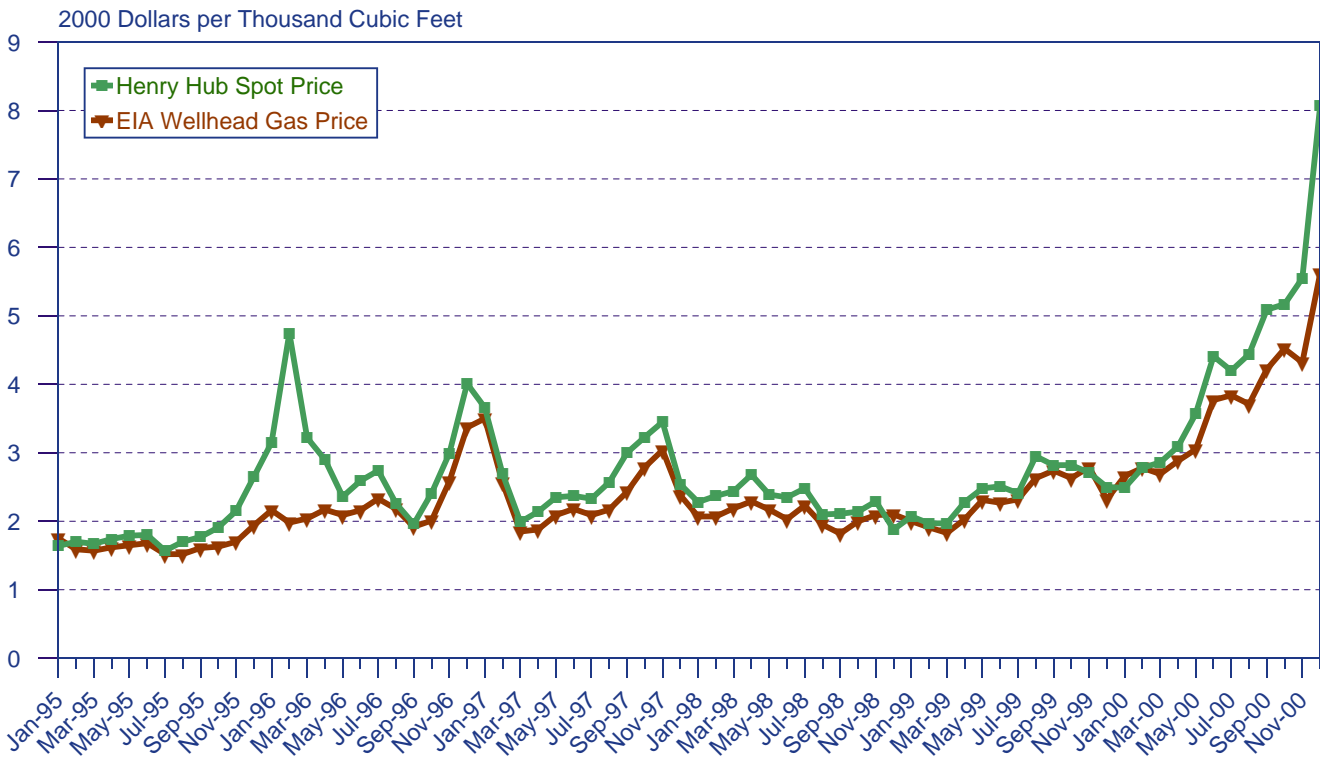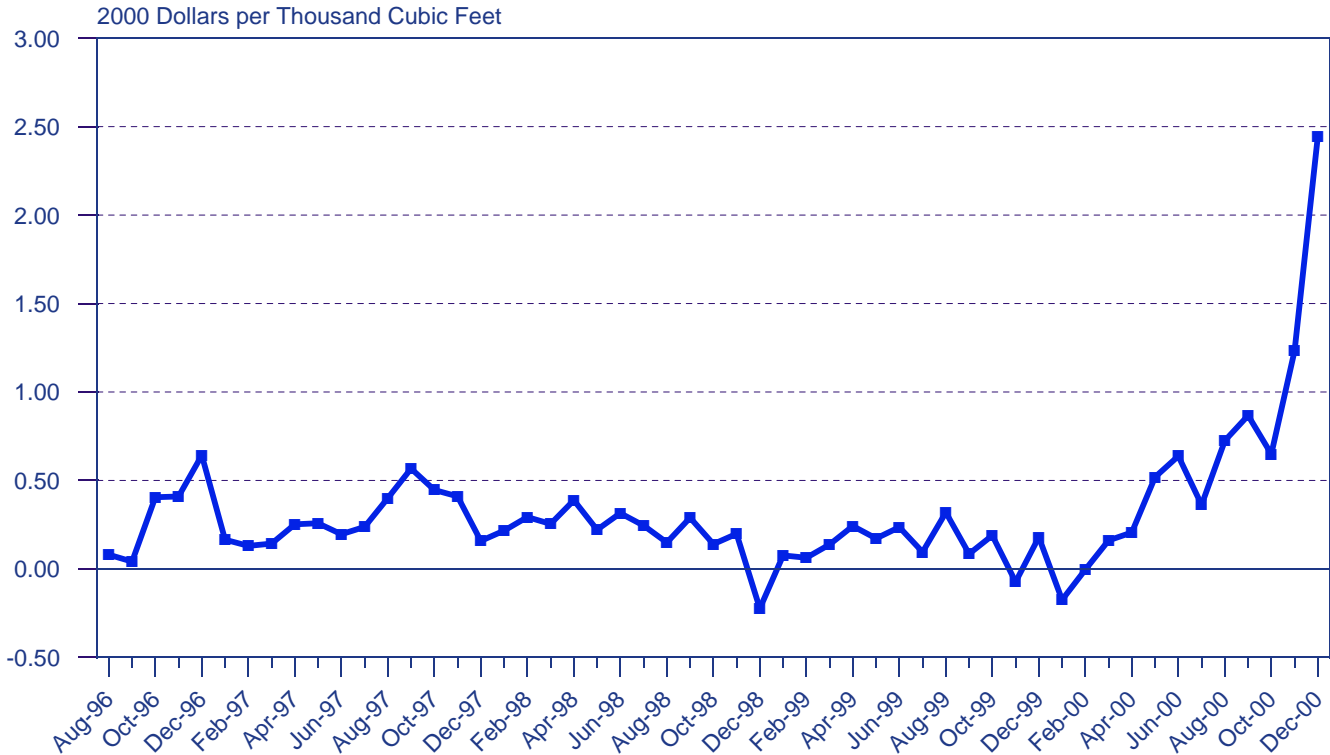
2000 Dollars per Thousand Cubic Feet

Sources: *Natural Gas Week*, monthly prices series; and Energy Information Administration, "Avg NG Prices" (downloadable Microsoft Excel® spreadsheet), web site http://tonto.eia.doe.gov/oog/ftparea/wogirs/xls/ngm04vmwhprc.xls.

[10]Information regarding the econometric test performed and the results of the test are available upon request.

[11]For this portion of the analysis, the price series were converted to constant 2000 dollars using the monthly Bureau of Labor Statistics, Producer Price Index—All Commodities (BLS series ID: WPU00000000; not seasonally adjusted). The price conversion to annual 2000 dollars was accomplished using the monthly producer price index in conjunction with the annual index for 2000 of 132.7.

[12]The median value represents the midpoint in the distribution of observed values, with half the observations above the median and half below the median.

Figure 2. Actual Difference: Henry Hub Spot Price Minus U.S. Wellhead Price, August 1996–December 2000
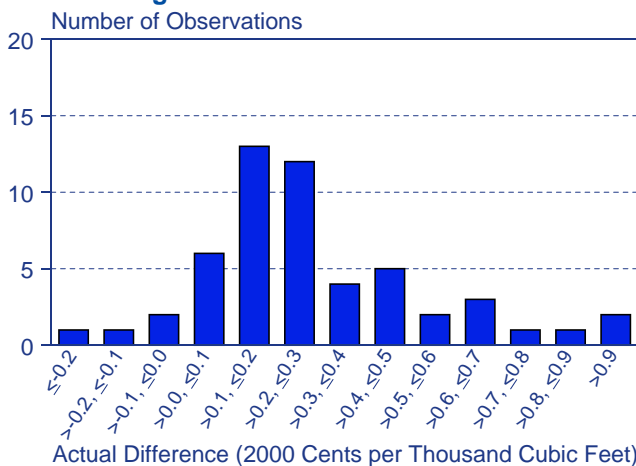

Sources: *Natural Gas Week*, monthly prices series; and Energy Information Administration, "Avg NG Prices" (downloadable Microsoft Excel® spreadsheet), web site http://tonto.eia.doe.gov/oog/ftparea/wogirs/xls/ngm04vmwhprc.xls.

the median value might be more representative of the central tendency of the data than is the mean value.[13]

Figure 4 shows the percent differences between the monthly data for the two price series from August 1996

Figure 3. Distribution of Observations: Henry Hub Spot Price Minus U.S. Wellhead Price, August 1996–December 2000

Sources: *Natural Gas Week*, monthly prices series; and Energy Information Administration, "Avg NG Prices" (down-loadable Microsoft Excel® spreadsheet), web site http://tonto.eia.doe.gov/oog/ftparea/wogirs/xls/ngm04vmwhprc.xls.

through December 2000, calculated as the Henry Hub price minus the wellhead price, divided by the wellhead price.[14] The table below lists descriptive statistics for the percent difference. The table shows that the percent difference approach has several advantages relative to the actual difference. First, the mean and median values are close to each other, at 10.8 percent and 10.4 percent, respectively, indicating a more symmetrical distribution, as shown in Figure 5. Moreover, the standard deviation (8.5 percent) is less than both the mean (10.8) and median (10.4) values, indicating a narrower distribution of observations. Indeed, 27 of the 53 observations are larger than 5 percent and less than 15 percent. Consequently, the percent difference measure appears to be a better measure of the relationship between the Henry Hub spot price and the wellhead price of natural gas.
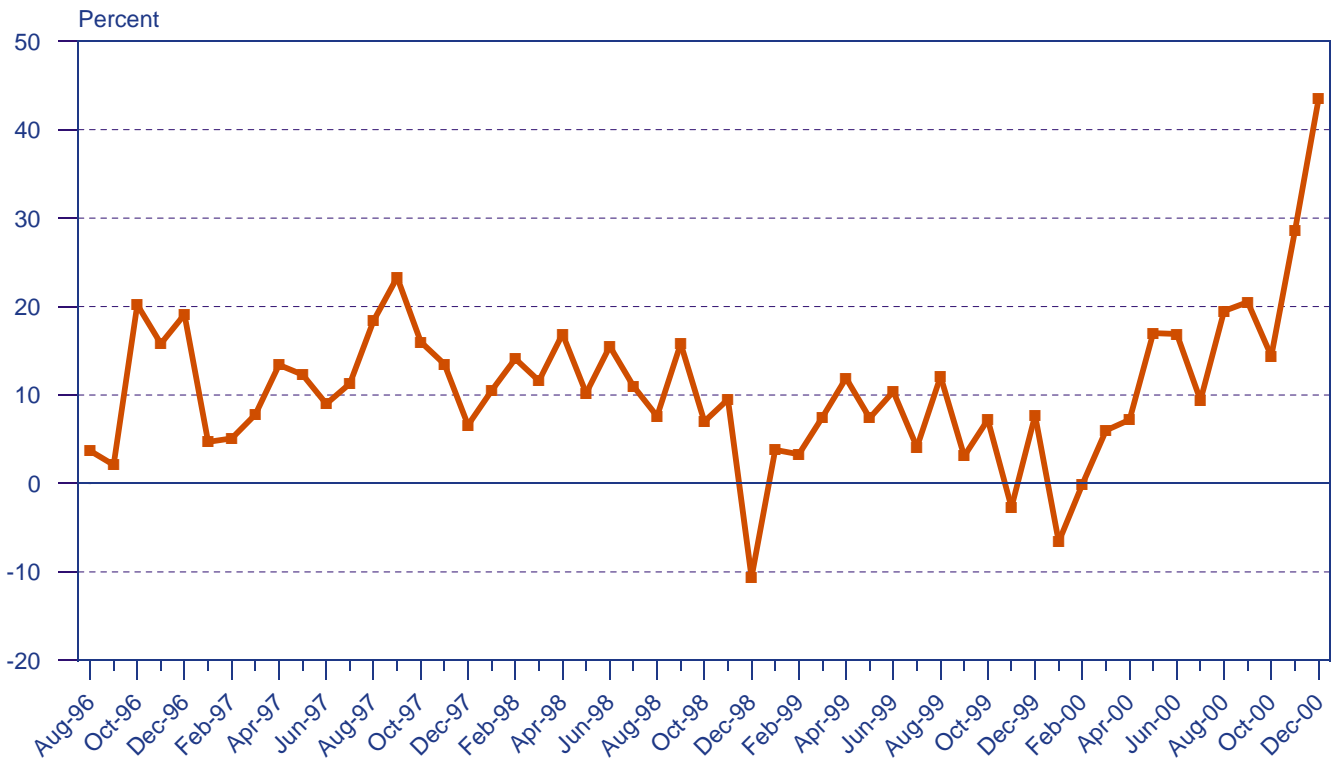
Descriptive Statistics for the Percent Difference: Henry Hub Spot Price Minus U.S. Wellhead Price, Divided by U.S. Wellhead Price, August 1996–December 2000

Mean Value of the Percent Difference	10.8%
Median Value of the Percent Difference	10.4%
Standard Deviation of the Mean Value of the Percent Difference	8.5%

[13]The median value of 23.6 cents per thousand cubic feet is the same both for the January 1995 through December 2000 period and for the August 1996 through December 2000 period, which further recommends the use of this number in preference to the mean value.

[14]One benefit of this approach is that the calculated result does not require converting nominal dollar prices into real dollar prices.

Figure 4. Percent Difference: Henry Hub Spot Price Minus U.S. Wellhead Price, Divided by U.S. Wellhead Price, August 1996–December 2000

Sources: *Natural Gas Week*, monthly prices series; and Energy Information Administration, "Avg NG Prices" (downloadable Microsoft Excel® spreadsheet), web site http://tonto.eia.doe.gov/oog/ftparea/wogirs/xls/ngm04vmwhprc.xls.
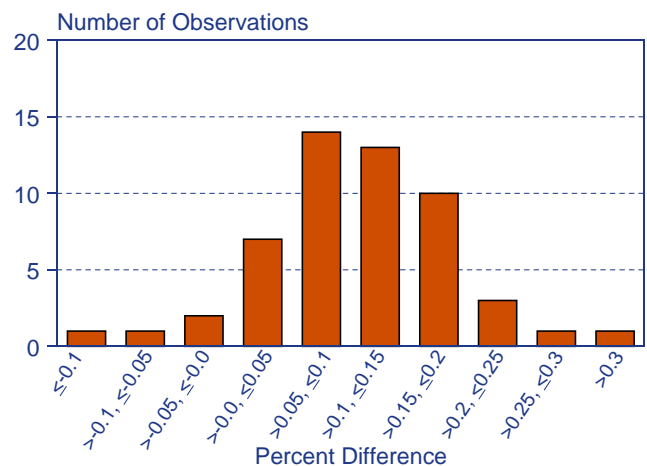
Conclusions

For the period from August 1996 through December 2000, the correlation coefficient for the two natural gas price series examined—Henry Hub spot prices and U.S. wellhead prices—is 0.97, indicating a strong linear relationship.

The relationship between Henry Hub spot prices and wellhead natural gas prices for the period from August 1996 through December 2000 can be measured in terms of both actual difference and percent difference. The actual difference has a mean value of 32 cents per thousand cubic feet, a median value of 24 cents per thousand cubic feet, and a standard deviation around the mean of 39 cents per thousand cubic feet. The percent difference has a mean value of 10.8 percent, a median value of 10.4 percent, and a standard deviation of 8.5 percent.

The percent difference appears to be a better measure of the relationship between the two prices than does the actual difference, because (1) the mean and median values of the percent difference are in close agreement, indicating a more symmetric distribution of observations; (2) the magnitude of the standard deviation is lower, indicating a narrower distribution of observations around the mean; and (3) the percent difference relationship can be evaluated without translating nominal prices into real (constant dollar) prices.

Figure 5. Distribution of Observations: Henry Hub Spot Price Minus U.S. Wellhead Price, Divided by U.S. Wellhead Price, August 1996–December 2000

Sources: *Natural Gas Week*, monthly prices series; and Energy Information Administration, "Avg NG Prices" (downloadable Microsoft Excel® spreadsheet), web site http://tonto.eia.doe.gov/oog/ftparea/wogirs/xls/ngm04vmwhprc.xls.