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NATURAL GAS PRICE VOLATILITY

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Abstract

This staff report discusses natural gas price volatility and its effect on market participants, including the residential, commercial, industrial and power generation sectors, and natural gas producers. Historical natural gas prices are presented, followed by a discussion of the various factors that influence natural gas commodity prices and their volatility. These factors include weather, domestic production, storage, imports, infrastructure constraints, domestic and global demand, oil and natural gas price correlation, value of the U.S. dollar, and commodity speculation.

This staff report presents descriptions of and probable causes for four periods of significant natural gas price spikes during this decade:

- Winter 2000-2001
- February 2003
- Fall 2005
- Summer 2008

Investigating the causes for each of these price spikes provides further insight into how the natural gas market operates and how a number of largely independent and unpredictable factors affect prices. Because predicting the movement of these factors is difficult, accurately forecasting prices is uncertain. The "accuracy" of natural gas price forecasting is examined in this report through a comparison of past price forecasts to actual prices. Additionally, four recent price forecasts are presented, including a brief discussion of their basic methods and major input assumptions, while pointing out the differences in both near-term and long-term forecasted prices.

This staff report concludes that the natural gas commodity market will continue to experience periods of price spikes and volatility as the factors driving prices themselves remain volatile. Therefore, making accurate date-specific forecasts of future market prices will be difficult or infeasible.

Keywords: Natural gas, price spike, price volatility, mean reversion, stationarity, spot prices, market speculation, price forecasting, uncertainty

Executive Summary

Natural gas price volatility creates profit opportunities for some and increased costs for others impacting gas consumers, producers, and investors. Additionally, the uncertainty associated with factors affecting price volatility makes it challenging to accurately forecast natural gas prices. Because of its effects on market participants and on price forecasting, gaining a better understanding of price volatility is useful to California's policy makers.

This staff report describes the impact that price volatility has on natural gas consumers and producers, followed by a look at historical gas prices and some of the key factors that influence natural gas price volatility. Some of the major causes of price volatility include:

- Weather
- Supply and demand imbalances
- Infrastructure issues
- Unreliable data
- Regional and global economic conditions
- Speculative trading
- Market manipulation

The report also examines four major periods of significant price spikes:

- Winter 2000-2001
- February 2003
- Fall 2005
- Summer 2008

Examining the causes for each of these price spikes provides further insight into how the natural gas market operates and how the market is affected by various uncertain factors, including both physical and financial market factors. The report concludes that financial market factors do influence the market, affecting natural gas prices and contributing to price volatility, while acknowledging that disagreement does exist about the degree of that influence.

Finally, four natural gas price forecasts, the range of prices produced by these forecasts, and the uncertainty associated with each of the forecasts are examined. A comparison of price forecasts to actual natural gas prices does not provide encouraging results for the accuracy of long-range forecasts. The report concludes that the uncertainty of key physical and financial market factors that affect natural gas prices and volatility will persist, making forecasting accurate date-specific market prices difficult or infeasible.

CHAPTER 1: Natural Gas Prices and Volatility

Introduction

For much of the 20th century, the natural gas industry was a closely regulated market. The federal government regulated the price natural gas producers could charge for natural gas sold across state lines.[1] This regulated market resulted in stable prices for many years. However, because there was little incentive for producers to increase production or consumers to reduce consumption under a system of regulated prices, supply shortages occurred. The Natural Gas Policy Act of 1978 was passed to address chronic supply shortages, taking the initial steps to deregulate the natural gas market.[2] One outcome of moving to a less regulated market is that natural gas prices became more volatile as prices fluctuated, and market participants acted in response to market factors.

During 2008, natural gas spot prices[3] traded as high as $13.32 per thousand cubic feet (Mcf) and as low as $5.63 / Mcf. The large price fluctuations in 2008 increased the focus on price volatility and its effects on natural gas market participants. Price volatility increases uncertainty and reduces the potential value of date-specific natural gas price forecasts. Because of these impacts, an examination of price volatility is a key motivation for preparing this report.

Natural gas price volatility is of interest because volatility:

- Can have a negative effect on residential consumers by consuming more of a household's discretionary income.
- Makes budgeting and cost management more difficult for commercial and industrial consumers that use significant amounts of natural gas in their operations.
- Adds uncertainty in the power generation industry and ultimately affects the price of electricity, affecting electricity consumers.
- Contributes to the boom-bust cycle of drilling activity, ultimately affecting the availability of natural gas supply.
- Can have a negative effect on the national economy during periods of unstable energy costs.
- Adds to the uncertainty in predicting market movements, thus rendering natural gas price forecasts potentially less useful.

Understanding Price Volatility

Price volatility is defined as the magnitude of change in commodity prices over a given period. Volatility is typically presented as an annualized percentage of the day-to-day change in prices independent of the actual price level. Because volatility is measured as the

[1] The Natural Gas Act of 1938 began the federal government's role in regulating interstate sales of natural gas.

[2] The Natural Gas Policy Act of 1978 granted the Federal Energy Regulatory Commission authority over intrastate as well as interstate natural gas production.

[3] The spot price represents the price of natural gas for next-day delivery at a specific location.

magnitude of a price change, merely increasing or decreasing prices is not a good indication whether volatility is increasing. When natural gas prices are high, a large price fluctuation may represent a level of volatility similar to a much smaller price change when prices are low.

Although volatility is a measure of the magnitude of price changes, the impact to natural gas prices also depends on two additional concepts:

- *Mean reversion*, which is the tendency for prices to migrate back to an equilibrium or average level. In other words, when natural gas prices are high or low, the concept of mean reversion says prices will eventually move back to this average price level.
- *Stationarity*, which occurs when the average price level remains stable over time. Natural gas prices demonstrated non-stationarity as average prices moved from $2-$2.50/Mcf last decade, to $4/Mcf early this decade, and to about $6/Mcf today.

Figure 1 shows the distinction between prices and volatility; changing prices do not necessarily produce high levels of volatility. For example, the chart identifies major price spikes (green line) that occurred in late 2005 and mid-2008; however, the corresponding levels of volatility (orange line) are less than those during periods of smaller price changes, such as January 2002 or October 2004.

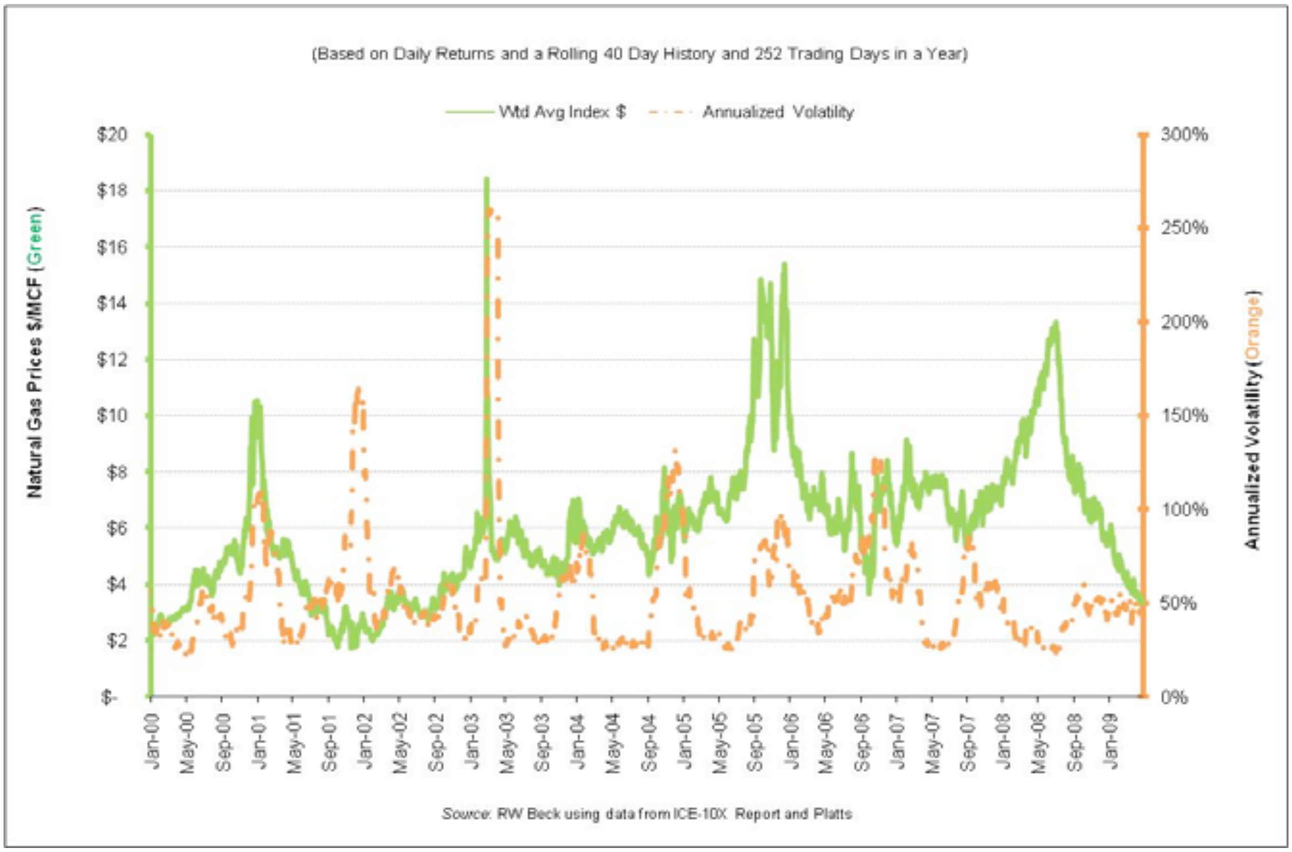
The divergence between high prices and moderate volatility in late 2005 is explained by:

- The level of volatility was less than might have been expected as the rate at which prices changed, measured day to day, was moderate compared to the day-to-day change experienced in February 2003.
- Mean reversion was low as prices remained at elevated levels much of the winter.

The divergence between high prices and moderate volatility in 2008 is explained by:

- The level of volatility was even lower than 2005, as the rate at which prices changed, measured day to day, again was at a moderate pace.
- Mean reversion again was low as prices continued to move higher (away from the mean price) through winter and the spring months.

Figure 1: Natural Gas Spot Prices and Volatility



Source: R.W. Beck, 2009

Appendix A, *Understanding Natural Gas Price Movements: A More Technical Discussion*, prepared by R.W. Beck, provides a more technical discussion of volatility, mean reversion, and stationarity.

Price Volatility Impacts

There is a growing interest in natural gas price volatility as the demand for natural gas increases in the residential, commercial, industrial, and power generation sectors. Natural gas demand increases amplify the potential impact of significant price changes. However, the effects of natural gas price volatility vary for the different consumer sectors. For example, residential and small commercial core customer demand is relatively inelastic (or insensitive to price changes) in the short term and tends to be somewhat less affected by price swings. Demand by these customers is largely driven by heating needs during cold weather periods and is typically insensitive to price changes as they have little opportunity to lower demand during the colder winter season.[4] The rates that utilities charge core customers are still subject to oversight by government agencies and are not subject to daily price changes. However, longer-term wholesale price changes do affect the retail rates these customers pay, as utilities receive approval to adjust their natural gas tariff rates to reflect a

[4] These core customers often are unaware of natural gas price changes until a monthly bill arrives in arrears. At that point, the opportunity to adjust consumption for that period has passed.

change in costs. Volatile prices can negatively affect core customers, especially low-income households, who have less disposable income to deal with unexpected price increases, expanding the number of consumers that require assistance, through programs such as the Low-Income Home Energy Assistance Program.

A workshop was held at the California Energy Commission to investigate the impacts of price volatility on utilities and their core customers.[5] An Energy Commission staff report presented at the workshop explained that utilities use several options to procure natural gas including:[6]

- Multi-month contracts
- One-month supply purchases during bidweek
- Daily spot market purchases
- Storage withdrawals
- Financial instruments

Utilities use different options to reduce risk and lessen the effects of price volatility. In an effort to hedge or protect against the negative effects of price spikes, various financial instruments are used, including:

- Physical fixed-price contracts
- Option contracts to purchase or sell gas at a fixed, predetermined price
- Futures contracts for future delivery at a fixed price
- Financial swaps between fixed and variable payments

Industrial consumers of natural gas tend to be much more sensitive to price volatility. Industrial, or non-core, consumers typically purchase large quantities directly from the market and are immediately affected by changing prices, making budgeting and cost management more difficult. For example, nitrogen fertilizer manufacturers use significant amounts of natural gas, and periods of high price volatility can have dramatic impacts on their manufacturing operations.[7] Because industrial consumers often are large users of natural gas, significant changes in natural gas prices can influence many operational decisions. If prices increase too high or are extremely volatile, industrial users might consider fuel switching where possible or even shutting down operations. While price volatility can have material consequences for the industrial sector, some large industrial consumers have the ability to take advantage of hedging opportunities to reduce risk. Large users potentially could purchase and store natural gas when prices are low. Large users could purchase supply under long-term fixed price contracts or could use financial instruments, such as options, to lower the risk and uncertainty of changing prices.

[5] On March 10, 2009, a public workshop on Natural Gas Core and Non-Core Procurement was held at the Energy Commission to discuss natural gas procurement by the utilities and the impact of volatile natural gas prices on the utilities and their customers.

[6] Lana Wong 2009. *Natural Gas Procurement by Utilities*, California Energy Commission CEC-200-2009-003-SD.

[7] Natural gas costs can account for 90 percent of the total cost of manufacturing nitrogen fertilizer.

The electric power generation sector is the largest consumer of natural gas, both nationally and in California according to the Energy Information Administration (EIA).[8] In 2007, electric power generation nationwide consumed 32 percent of delivered natural gas, and California's electric generation sector consumed 36 percent of delivered supply. Nearly a quarter of the nation's electricity, and over half of California's electricity, was generated by natural gas.[9] Because of the dominance of electric generation, natural gas price volatility can significantly impact this sector, ultimately affecting the price of electricity. Natural gas price volatility breeds increased uncertainty for both regulated utilities and merchant power firms related to the ongoing operational costs of natural gas-fired generation. Increased uncertainty heightens concern regarding the planned operation of existing facilities, as well as investment in new natural gas-fueled capacity. With greater natural gas price volatility, investment decisions in support of new natural gas-fueled power plants become more difficult and potentially more risky when compared to other generation technologies that use coal or renewable fuels.

Natural gas producers too are affected by price volatility, making project evaluation and investment decisions less certain. Price volatility may trigger concerns by lenders and investors, potentially increasing the cost of capital as lenders and investors demand greater returns for greater uncertainty. Price volatility also contributes to recurring boom-bust production cycles and associated operational problems, such as employee turnover and expensive start-up and shutdown costs. The current period of falling natural gas prices provides a good example. Natural gas production is largely a capital intensive venture during well development but has lower marginal production costs once the well is producing gas. Even during periods of low prices, active wells can remain profitable to operate. However, in the longer term, declining prices can lead to a bust period in production as the number of drilling rigs is reduced in response to sustained lower prices and uncertainty about when prices will begin moving higher. Since prices peaked in July 2008, U.S. drilling rig numbers dropped each week as prices continued to decline.[10]

Historical Natural Gas Prices

Gaining a better understanding of price volatility and its impacts requires an examination of prices at a specific pricing point over a specific period. This report includes an assessment of natural gas spot prices at Henry Hub, North America's main natural gas trading hub and most widely quoted natural gas pricing point.

Owned and operated by Sabine Pipe Line, LLC, Henry Hub is located in Vermillion Parish, Louisiana, and interconnects four intrastate and nine interstate pipelines that can transport nearly 2.0 billion cubic feet per day (Bcf), or enough natural gas to satisfy about 3 percent of total U.S. demand.[11] Because of its major interconnection infrastructure, Henry Hub operates as the official delivery mechanism for natural gas futures trading by the New York Mercantile Exchange (NYMEX) and North America's primary pricing point for the natural

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[8] EIA. Natural Gas Consumption by End Use data.

[9] EIA power generation data from 2007 shows 22 percent nationally and 55 percent in California of electric power was generated from natural gas-fueled power plants.

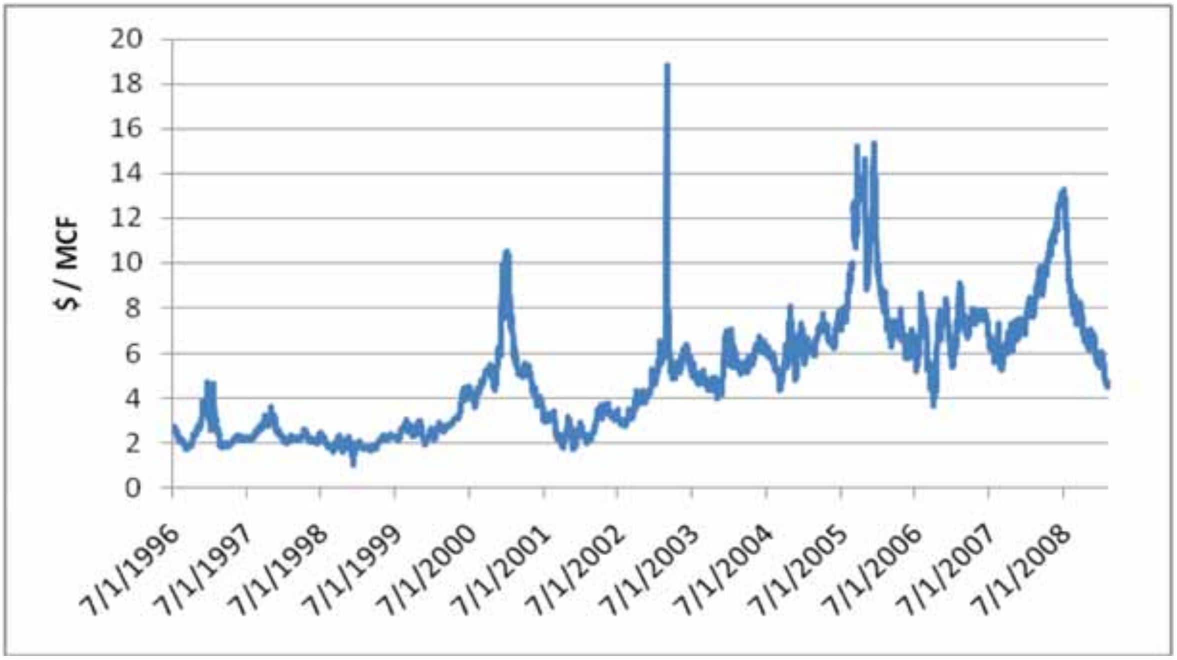
[10] EIA's April 23, 2009, *Natural Gas Weekly* update reports that the domestic drilling rig count is down over 50 percent from its high in August 2008, reached in response to July 2008 peak prices.

[11] Sabine Pipe Line, LLC
http://www.sabinepipeline.com/Home/Report/tabid/241/default.aspx?ID=52.

gas spot market. Pricing points throughout North America are often quoted at a "differential" to the Henry Hub price.

Figure 2 shows a period of relatively stable natural gas prices in the late 1990s, followed by several periods of large price spikes after 2000. Henry Hub spot prices traded within a $2/Mcf to $3/Mcf band throughout the late 1990s and early 2000s, rose to $4/Mcf, and surpassed $6/Mcf by the middle of the decade.

Figure 2: Henry Hub Spot Prices 1996–2008



Source: Natural Gas Intelligence data

Higher prices resulted from changes in the natural gas market. One key factor supporting higher prices was the growth in domestic demand that exceeded U.S. domestic production capabilities. North American basins were maturing and producing less gas. The combination of increasing domestic demand and declining domestic production resulted in natural gas prices moving higher.

CHAPTER 2: Factors That Influence Natural Gas Prices and Volatility

Material changes in either the supply or demand of natural gas cause price changes. During periods of a tight supply and demand balance, even a small change in either supply availability or consumer demand can cause a material movement in natural gas prices. There is a distinction between physical short-term changes in supply or demand caused by extreme weather events temporarily driving up demand for natural gas or reducing available supply, and long-term supply and demand changes caused by broad shifts in market conditions, such as declining domestic production or increased demand as more natural gas-fired power plants come on-line. And in addition to physical market factors, there are also financial market factors that drive natural gas prices and volatility. Factors that influence natural gas prices include:

- Supply factors including domestic production, storage, and imports can lead to supply and demand imbalances.
- Infrastructure issues—lack of pipeline capacity or bottlenecks during periods of high demand can impact delivery of gas supply.
- Weather—unexpected and severe weather can have major, short-term demand impacts.
- Regional and global economic conditions—sudden or prolonged changes to economic conditions can lead to boom-bust cycles that create recurring market imbalances.
- Link between oil and natural gas and the relative strength of the U.S. dollar.
- Speculative trading—energy traders and investors pursuing profit opportunities.
- Market manipulation—unfair or dishonest actions by market participants.
- Unreliable data— inaccurate or unavailable data can result in price impacts as market participants act based on "perception" of existing market conditions.

Many of these factors are discussed in more detail in the following sections.

Supply Factors That Influence Prices

Several factors related to natural gas supply can affect prices, including:

- Natural gas domestic production.
- Natural gas storage levels.
- Natural gas import quantities by pipeline or liquefied natural gas (LNG) shipments.
- Natural gas infrastructure constraints.

Recently, these factors have become increasingly important and visible as market components. Many market analysts agree that increasing domestic reserves and production of unconventional shale, tight sands, and coal-bed methane natural gas represent important market factors. With expectations for increasing domestic production, some analysts have argued "exploitation of shale gas could dramatically affect domestic supply of natural gas in

North America and hence demand for LNG imports."[12] The following provides brief discussions of key supply factors that can affect the price and volatility of natural gas.

Domestic Production

After nearly a decade of relatively flat or declining U.S. natural gas production, domestic production in the lower 48 states began rising in 2006 and by 2008 returned to levels last seen in 1974[13] (**Figure 3**).

Figure 3: U.S. Domestic Natural Gas Production

Source: EIA AEO 2009 Early Release.

Flat and declining domestic production in the late 1990s and early 2000s occurred as conventional production basins that provided the majority of domestic supply began to decline. The recent increased domestic production is a result of higher natural gas prices that supported expanded exploration and production. Technological advancement also accelerated the proliferation of horizontal drilling, a more efficient and cost-effective method for recovery of the domestic unconventional natural gas reserves, providing the potential for greater gas production per well. According to a recent Energy Commission staff report,[14] finding and development costs of a typical vertical well averages $1.71 / Mcf while costs for a horizontal well average between $1.06 / Mcf and $1.34 / Mcf.

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[12] EIA. *Annual Energy Outlook 2009,* March 2009; LNGpedia.com April 1, 2009, article "Shale Gas and the Future of US LNG Imports," by Kenneth B Medlock III and Peter Hartley, James A Baker III Institute for Public Policy, Economics Department, Rice University.

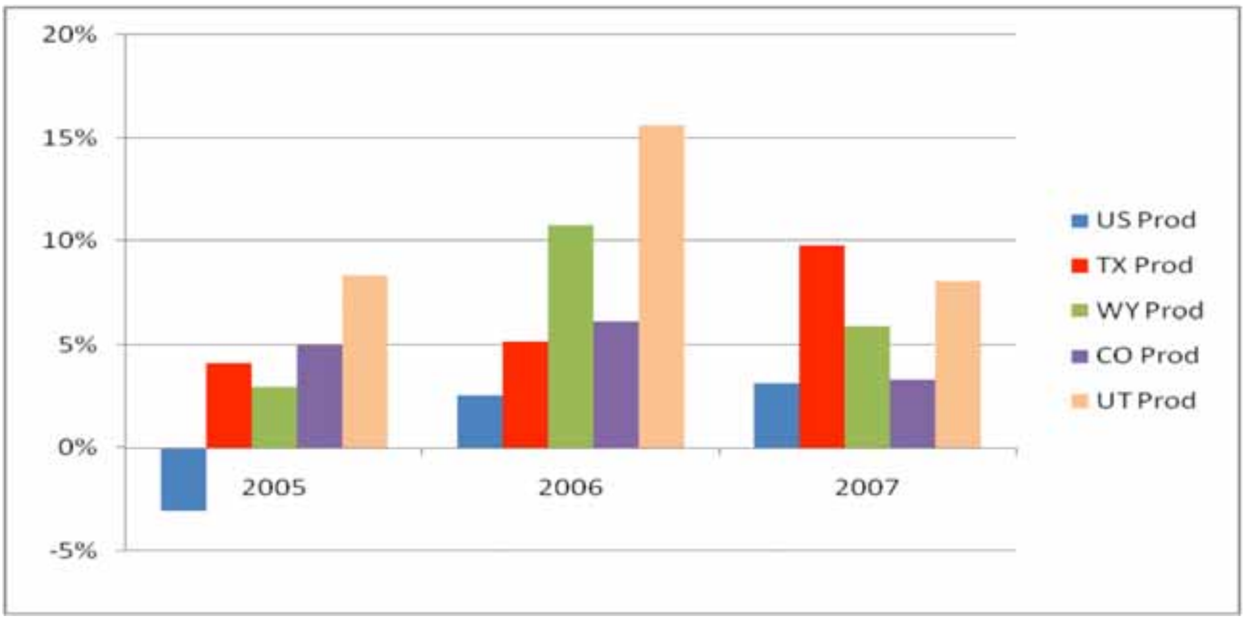
[13] Domestic natural gas production was 21.60 trillion cubic feet (Tcf) in 1974 and 21.40 Tcf in 2008.

[14] Leon Brathwaite 2009. *Shale Deposited in Natural Gas: A Review of Potential,* California Energy Commission CEC-200-2009-005-SD.

EIA data and **Figure 3** show that total U.S. natural gas marketed production grew to 19.4 Tcf in 2006, representing a 2.5 percent increase over 2005 (production in 2005 was the lowest level of production in over a decade). Of this 2006 growth in marketed production, three key Rocky Mountain states, Utah, Wyoming, and Colorado, had a year-over-year production growth of 15.6, 10.8, and 6.1 percent, respectively.[15] The Green River Basin and Powder River Basin in Wyoming and the Uinta-Piceance Basin in Utah have seen some of the most significant production gains. Similarly, Texas produced a year-over-year production gain of 5.2 percent for 2006. For 2007, Texas production grew 9.8 percent.

Figure 4 shows that marketed production growth for Texas and the Rocky Mountain states of Wyoming, Colorado, and Utah have outpaced total U.S. natural gas production.

Figure 4: United States and Regional Marketed Production Growth



Source: EIA *Annual Energy Outlook (AEO) 2009 Early Release*

Notwithstanding the recent increase in domestic production, the decrease in prices since July 2008 has lowered drilling activity. The EIA reports that as of April 2009, U.S. drilling rigs totaled 760, a 50 percent decline from the August 2008 total. This decline in drilling activity has begun to slow the robust production growth that began in 2006. EIA is projecting that domestic production will fall 1 percent in 2009 and 2.8 percent in 2010.[16] Following the national trend, California also is experiencing a decline in drilling.[17]

Natural Gas Storage

Storage provides a physical hedge, providing readily available natural gas supply during peak demand periods or unexpected production interruptions. Historically, natural gas has

[15] EIA. *Natural Gas Monthly*, February 2009.
[16] EIA. *Short-Term Energy Outlook*, May 2009.

[17] Jim Campion, California Department of Conservation, reported that no new drilling rig permits were issued in March 2009 for District 6, which includes the Sacramento Valley from Stanislaus County to the Oregon border. Campion added this was the first such occurrence this decade.

been a seasonal fuel with peak demand during winter heating season. Because peak demand can jump significantly during periods of extremely cold weather, storage inventory levels heading into winter are important to ensure adequate supplies are available to meet that demand. If natural gas storage was not available, higher levels of production capacity and pipeline infrastructure would be needed to deliver enough natural gas to meet this peak demand. Storage also provides a financial hedge, providing the ability for natural gas inventory owners to more efficiently manage the buying and selling of natural gas to maximize profit and/or minimize costs during periods of price volatility.

According to the EIA,[18] working gas storage capacity in the lower 48 states exceeds 4 Tcf, or nearly 20 percent of annual U.S. natural gas demand. While storage facilities are located throughout the United States, more than 50 percent of storage capacity is located in the Northeast, where significant winter demand occurs. Storage capacity and its concentration in the Northeast ensure adequate supply during peak winter demand and offer some opportunity to reduce price volatility through financial hedging actions.

Natural Gas Imports

Imports of natural gas into the U.S. market are an important component of overall supply. According to EIA data, the percentage of U.S. consumption provided by imported gas has slowly, but steadily, increased since 1997 when net imports of 2.8 Tcf represented 12 percent of total consumption. By 2007, 3.8 Tcf in net imports represented 16 percent of total consumption.[19] However, the trend reversed in 2008 as net imports fell to 3.0 Tcf, less than 13 percent of total consumption.[20] The 2008 decline resulted from lower LNG imports as higher overseas prices attracted more LNG product and lower net pipeline imports as U.S. domestic natural gas production continued to increase (**Figure 5**).

While these import levels might appear relatively small, the United States is the world's largest volume natural gas importer. Imported natural gas arrives by pipeline from Canada and Mexico and by ship delivering LNG from overseas producers. The North American pipeline grid connects Canada, Mexico, and the United States.[21] The number of domestic LNG regasification facilities also has grown, and LNG imports reached a record 771 Bcf in 2007 before falling in 2008.[22]

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[18] EIA. *Estimates of Peak Underground Working Gas Storage Capacity in the United States*, September 2008.

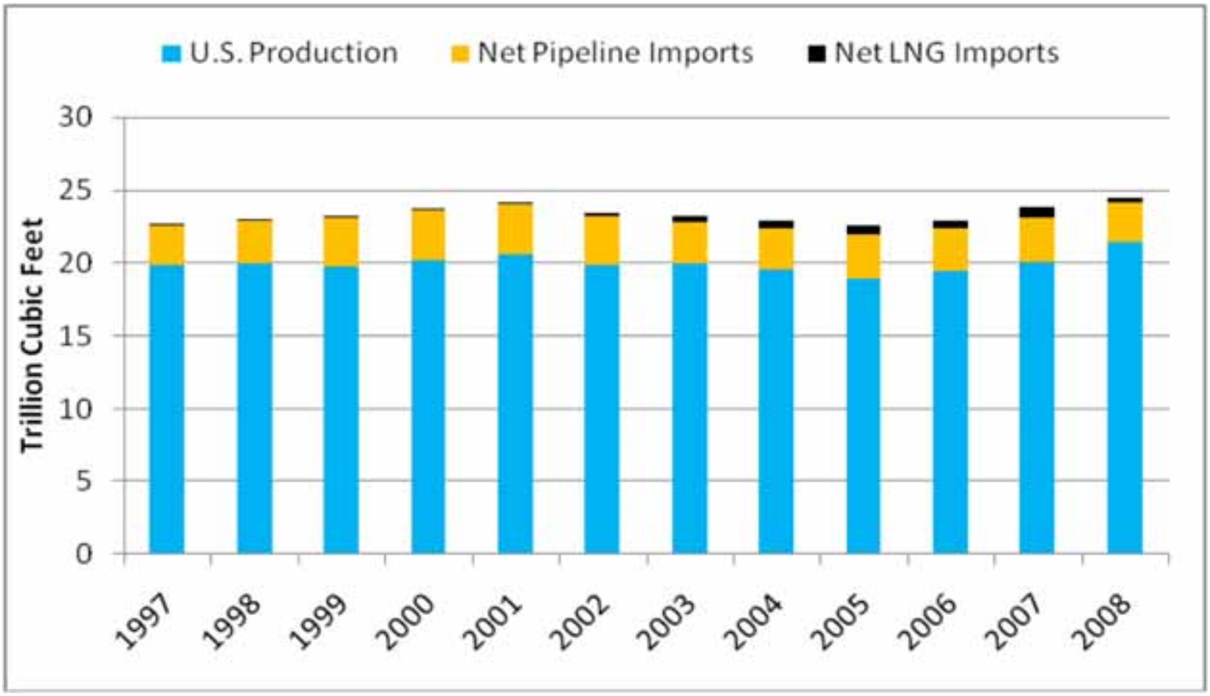
[19] EIA. *US Natural Gas Imports and Exports: 2007*, January 2009.

[20] EIA. *Natural Gas Monthly*, May 2009.

[21] The majority of U.S. pipeline imports originate in Canada; pipeline imports also originate in Mexico but are immaterial vis-à-vis U.S. demand.

[22] Robert Kennedy 2009. *Liquefied Natural Gas Uncertainty Issues*, California Energy Commission CEC-200-2009-006-SD.

Figure 5: U.S. Production—Net Pipeline Imports—Net LNG Imports



Source: EIA data

Infrastructure Constraints

Infrastructure constraints can affect the price of natural gas by restricting the amount of supply that reaches the marketplace. An excellent example of the impacts of limited pipeline capacity is found in the Rocky Mountains. As natural gas production increased, limited pipeline capacity produced excess regional supply and resulted in prices consistently below other key pricing points, including Henry Hub. Several times during the fall of 2008, Rocky Mountain spot prices fell below $2/Mcf when Henry Hub spot prices ranged between $6-$7/Mcf. In fact, in September 2008, Rocky Mountain spot prices fell below $1/Mcf in response to short-term pipeline constraints when a section of the Rockies Express Pipeline[23] was shut for safety testing.

Hurricane damage in the Gulf of Mexico is another example of infrastructure constraints. In 2007, the Gulf of Mexico region supplied nearly 14 percent of total U.S. production.[24] Therefore, hurricane infrastructure damage to this producing region can have a significant short-term impact on natural gas prices, such as the $15.40/Mcf[25] price that occurred on December 13, 2005, in the aftermath of hurricanes Katrina and Rita.

[23] The Rockies Express Pipeline, a 1,679-mile pipeline originating in Rio Blanco County, Colorado, and terminating in Monroe County, Ohio, underwent pressure testing September 5-26, 2008, stranding over 500 MMCf/d, representing approximately 7 percent of the tri-state area production.

[24] EIA. *Natural Gas Annual 2007.*

[25] Natural Gas Intelligence data.

Demand Factors That Influence Prices

Thirty years ago when California began increasing the use of cleaner-burning natural gas for electricity generation, there was less competition for natural gas supply coming out of the Rocky Mountains, the Southwest, and Canada. However, in recent years demand for these North American supplies increased, not only because of greenhouse gas concerns, but because natural gas-fired power plants have lower capital costs, take less time to construct, and are more easily permitted than coal-fired plants. The following provides brief discussions of key demand factors influencing the price of natural gas including:

- Weather patterns
- Regional and global economic conditions

Weather Patterns

Weather is a key factor driving natural gas demand and prices. Natural gas demand increases during the winter months as both residential and small commercial consumers use more natural gas for space heating. This increase in demand is partially met by drawdowns on storage inventories built during off-peak demand periods. Peak winter demand can drive prices higher, especially in tight supply-and-demand markets such as the Northeast. While California's climate is milder compared with much of the country, localized cold weather and even severe weather in other regions can impact California border prices.

Upward pressure on prices also occurs during summer periods of hot weather. As cooling demand increases during high temperatures, natural gas demand increases to fuel electric generation. A summer peak gas demand spike may immediately affect natural gas prices and, if increased summer demand consumes supply that would have been injected into natural gas storage for winter use, could accelerate winter price pressure. Hydroelectric production declines or nuclear power plant outages could further affect the demand for natural gas-fired electricity during weather-related spikes.

Regional and Global Economic Conditions

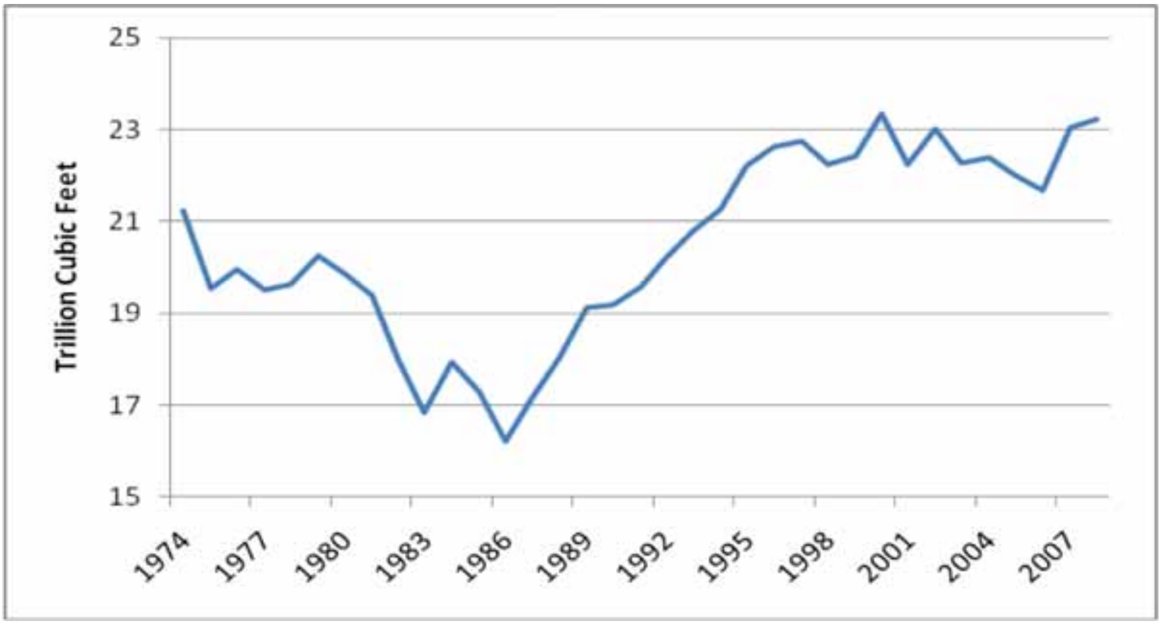
During periods of strong economic growth, demand increases as more homes are built, the commercial business sector expands, industrial factories multiply and expand, and the power generation sector requires more natural gas to provide the electricity necessary to support a growing economy. Over the past two decades, an increasing number of homes were built in California's warmer interior regions, such as the Central Valley, as home buyers avoided the cooler, but higher cost coastal regions. This population migration to California's warmer areas further increased natural gas demand for electricity generation to meet higher air conditioning loads.

Conversely, during periods of a weak or contracting economy, demand declines, such as during the current recession. EIA is forecasting that the continuing economic downturn will reduce natural gas demand in 2009 by 1.9 percent overall. Industrial, residential, and commercial demand is projected to fall, while power generation demand is projected to increase 2.1 percent, taking advantage of lower natural gas fuel prices.[26] This lower demand forecasted for 2009 will continue to exert downward pressure on prices. In its *Short-Term Energy Outlook*, the EIA recognizes that the timing and degree of economic recovery is a key factor that will affect domestic natural gas demand in 2010. EIA projects small (less than 1 percent) growth in domestic natural gas demand in 2010 but acknowledges uncertainty in

[26] EIA. *Short-Term Energy Outlook*, May 2009.

the 2010 economic outlook and its potential impact on demand. **Figure 6** shows U.S. natural gas demand over the past 35 years, including the drop in demand that occurred during the global recession that began in the early 1980s.

Figure 6: U.S. Natural Gas Demand 1974–2008



Source: EIA AEO 2009 Early Release

Current global economic conditions continue to shrink worldwide demand, driving global prices lower. In its *2009 Annual Energy Outlook (AEO),* EIA forecasts that LNG imports will slowly begin to recover, increasing 17 percent in 2009 and 100 percent by 2012, to total 700 Bcf. Falling global demand, lower global prices, and U.S. storage capacity could result in the United States becoming the dumping ground for excess worldwide LNG supply in 2009.[27]

Other Factors That Influence Prices

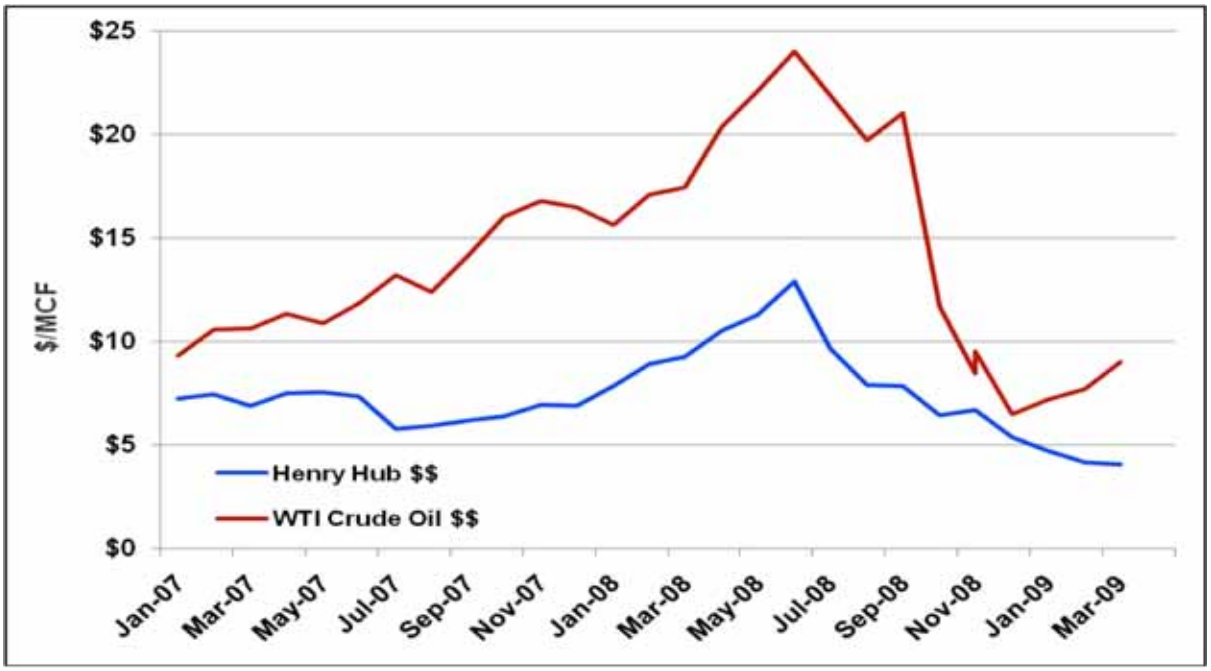
Supply and demand factors play major roles in the natural gas market. Changes in supply or demand push natural gas prices higher or lower. In addition to these fundamental physical market factors, other variables can affect the price and volatility of natural gas, including the relationship between oil and natural gas prices, the strength of the U.S. dollar, and market speculation.

Oil and Natural Gas Price Link

Historically, certain refined petroleum products and natural gas have been fuel substitutes in electric power generation, industrial applications, and commercial and home heating. Because of these relationships, some analysts claim oil and natural gas prices are related.

[27] Robert Kennedy. *Liquefied Natural Gas Uncertainty Issues*, California Energy Commission CEC-200-2009-006-SD.

Figure 7: Oil and Natural Gas Spot Prices



Source: Energy Commission staff

Figure 7 compares spot prices of West Texas Intermediate (WTI) crude oil to Henry Hub prices during the past two years. Natural gas prices do appear to track movements of oil; however, that relationship appears stronger at lower prices. Looking at early 2007, **Figure 7** shows a closer correlation when oil prices were around a $10 / Mcf equivalent.[28] As oil prices increased significantly in July 2008, the spread between oil and natural gas prices widened. Once prices began to decline in late July 2008, the spread in prices began tightening.

The explanation for this relationship is at least partially tied to market fundamentals. Increases in crude oil prices tend to drive consumers, where possible, to substitute natural gas, thus increasing natural gas demand and exerting upward pressure on prices. While in recent years the opportunities to fuel switch in the United States have declined, even small increases in demand for natural gas can have an impact on prices, particularly when supply and demand conditions are tight. Additionally, increases in crude oil prices promote additional drilling and the associated demand for equipment and labor. This additional demand for drilling resources could also impact the natural gas sector, as both oil and natural gas use similar technology to explore and produce, competing for similar equipment and labor resources. Associated natural gas is sometimes produced along with crude oil; thus, increased oil drilling in response to higher prices could result in additional natural gas supply.

Investigating the relationship between oil and natural gas price movements, a February 2007 research paper by the Federal Reserve Bank of Dallas concludes "the relationship has complex short-term dynamics, but is quite stable in the long run."[29] The authors

[28] One barrel of WTI oil contains approximately 5.825 / MMBtu, equivalent to 5.825 / Mcf of natural gas; therefore a direct link of prices would produce a WTI price 5.825 times the price of natural gas.

[29] Stephen P.A. Brown and Mine K. Yucel, Federal Reserve Bank of Dallas, Research Department. *What Drives Natural Gas Prices*, Working Paper 0703, February 2007.

acknowledge that fuel-switching between oil and natural gas has significantly diminished in recent years and natural gas prices have in fact shown “considerable independent movement.” They argue that seasonal factors such as weather, storage, and shut-in[30] production can independently affect natural gas prices in the short term. However, they add, “when these additional factors are taken into account, movements in natural gas prices are well explained by crude oil prices.”

In 2007, an Energy Commission sponsored analysis of this subject concludes:

> In summary, based on the reviewed literature and market data observations, the relationship between oil and natural gas prices is complex: there is a relationship, but it is difficult to characterize and it is not constant.[31]

Reduction in the ability to switch fuels may have weakened the link between oil and natural gas prices in recent years, but on the other hand, energy commodities have become the target of increased speculative investment (discussed later in this report). Such investment may provide the basis for a continuing correlation between oil and natural gas prices, as speculators invest in both oil and natural gas futures. Another fact supporting an oil and natural gas link is that LNG prices in Europe and Asia are largely indexed to oil prices.[32] A 2006 EIA analysis on the link between oil and gas prices states: “A “world market” for natural gas would reinforce the linkages between natural gas and crude oil prices.”[33]

Still, some industry analysts argue the relationship between the price of oil and natural gas is no longer applicable, largely the result of diminishing fuel-switching ability. Such disagreement by industry analysts demonstrates the complexity and uncertainty of an oil and natural gas price correlation. The oil and natural gas price relationship debate will continue, contributing to the challenges of producing accurate price forecasts.

Strength of the U.S. Dollar

The relative strength of the U.S. dollar (USD) also plays a role in commodity prices, including natural gas. During the run-up in oil and natural gas prices during the first half of 2008, the value of the USD fell compared to the value of other currencies. However, when peak commodity prices began to decline in late July 2008, the USD changed direction and began increasing. **Figure 8** illustrates this inverse relationship.

As the USD continued to weaken through the first half of 2008, the price of oil and natural gas continued to increase. The USD moved lower as the U.S. Federal Reserve repeatedly cut interest rates, further weakening its value. The prospects of additional interest rate cuts and an even lower USD drove investors out of U.S. currency and into commodities, serving as a hedge against the weakening USD and possible future inflation. Additionally, because energy futures are traded in USDs, a weakening USD makes these commodities more attractive to foreign investors as their currency increases in relative value. However, in late July 2008, as the prospects for a deepening global economic crisis increased, the USD began

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[30] *Shut-in* refers to temporarily termination of production due to damage, maintenance, and repair.

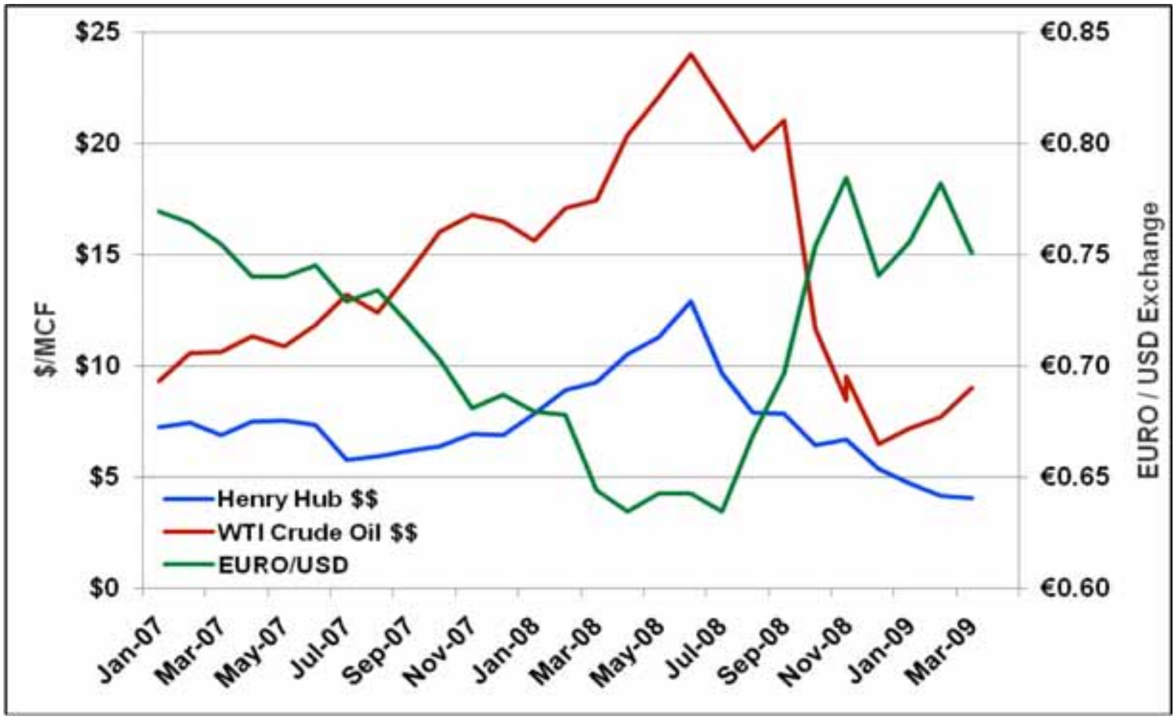
[31] Analysis by RW Beck in the California Energy Commission, Final Staff Report: *2007 Final Natural Gas Market Assessment*, CEC-200-2007-009-SF, December 2007, p. 104.

[32] Robert Kennedy 2009. *Liquefied Natural Gas Uncertainty Issues*, California Energy Commission CEC-200-2009-006-SD.

[33] EIA. Office of Oil and Gas: Jose A. Villar, EIA and Frederick L. Joutz, Department of Economics, George Washington University. *The Relationship Between Crude Oil and Natural Gas Prices*, October 2006.

strengthening, becoming a haven for safety as domestic and foreign investors switched course and began selling commodities to buy USDs.[34]

Figure 8: Relationship of Oil and Natural Gas Spot Prices to USD



Source: Energy Commission staff

Speculation

Futures trading can be either a physical trade (trading the actual commodity) or a financial trade. Today the value of financial trading is estimated at 10 to 12 times the value of physical trading.[35] Natural gas futures trading began in April 1990 on the NYMEX. The first day, 918 future contracts were traded, but today more than 100,000 contracts are traded daily.[36] The growth in the number of contracts traded and the total value of those contracts demonstrate the potential impact of speculative trading on the natural gas market.

Financial trading is performed as either a hedge against future price volatility and risk, or as speculation for profit. The Commodity Futures Trading Commission (CFTC) defines a commodity futures speculator as:

[34] Yue-Jun Zhang, Ying Fan, Hsien-Tang Tsai, Yi-Ming Wei. *Spillover Effect of U.S. Dollar Exchange Rate on Oil Prices,* October 2007.

[35] Natural Gas Supply Association education website NaturalGas.org http://www.naturalgas.org/naturalgas/marketing.asp.

[36] EIA. *Major Legislative and Regulatory Actions.*

> …a trader who does not hedge, but who trades with the objective of achieving profits through the successful anticipation of outright price movements or through relative price movements.[37]

The National Regulatory Research Institute (NRRI) states:

> Some analysts have contended that the large amount of capital poured into commodity markets, including oil and natural gas, have lowered prices and their volatility. Other analysts disagree, saying that increased speculation has had the opposite effect by causing extreme highs in commodity prices in addition to more volatile prices.[38]

The poor performance of the stock market in 2000–2002 resulted in institutional investors moving funds into the commodity markets in search of better returns. During a May 20, 2008, hearing of the U.S. Senate's Committee on Homeland Security and Governmental Affairs, Michael Masters testified:

> Today, Index Speculators are pouring billions of dollars into the commodities futures markets, speculating that commodity prices will increase. …Assets allocated to commodity index trading strategies have risen from $13 billion at the end of 2003 to $260 billion as of March 2008, and the prices of the 25 commodities that compose these indices have risen by an average of 183% in those five years.[39]

Masters testified that the CFTC and spot market buyers affirm that futures market prices drive spot market prices. On its Education Center website, the CFTC states:

> In many physical commodities, cash market participants base spot and forward prices on future prices that are "discovered" in the competitive, open auction market of a futures exchange.[40]

Masters argues that a 1,900 percent increase in the level of investment in commodity indices in just 5 years served to drive up spot prices in all commodities, including natural gas. Clearly, the jump in speculative investment peaked as energy commodity prices increased sharply in 2008. Still, like the oil and natural gas link, ongoing debate remains on the influence speculative investment has on higher prices and price volatility of natural gas.

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[37] *Report on Commodity Swap Dealers & Index Traders with Commission Recommendations*, September 2008 www.cftc.gov/stellent/groups/public/@newsroom/documents/file/cftcstaffreportonswapdealers09.pdf

[38] NRRI. *Speculation in the Natural Gas Market: What It Is and What It Isn't: When It's Good and When It's* Bad, November 2008, http://nrri.org/pubs/gas/speculation_gas_nov08-11.pdf.

[39] Testimony of Michael W. Masters, Managing Member/Portfolio Manager, Masters Capital Management, LLC.

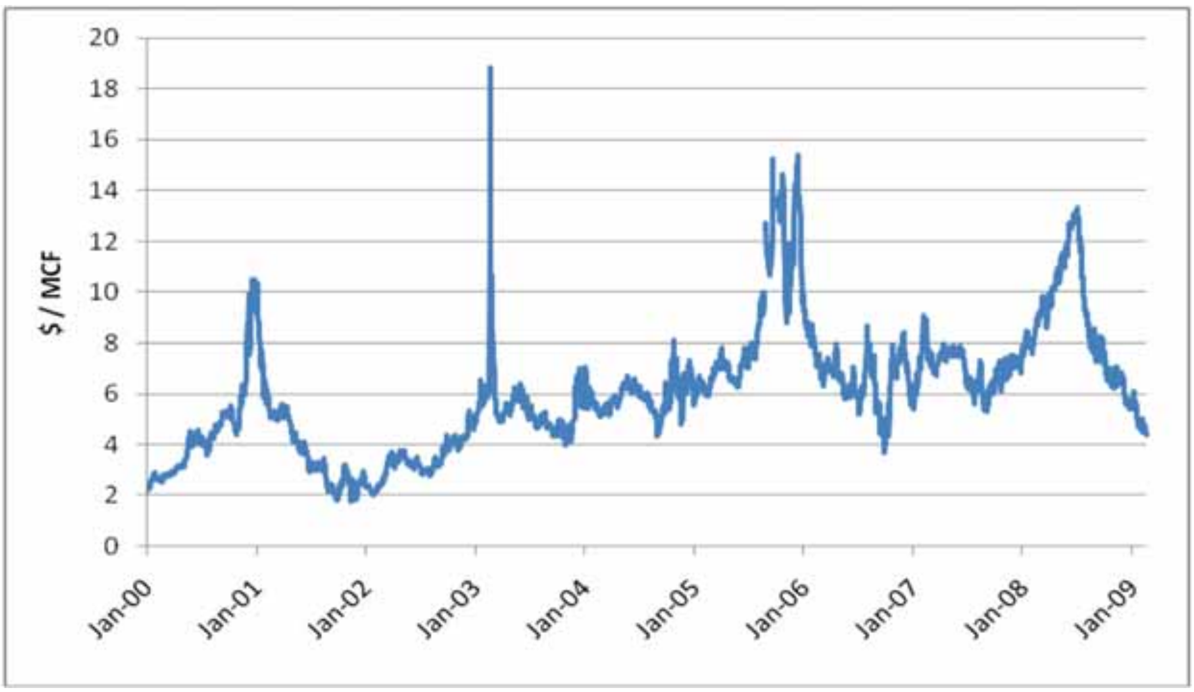
[40] CFTC education website: http://www.cftc.gov/educationcenter/index.htm.

CHAPTER 3: Occurrences of Major Price Spikes Since 2000

Natural gas prices moved higher through most of this decade. Four price spikes punctuate this trend. Although these four spikes do not represent the highest levels of annualized volatility, investigating the causality for each price spike provides further insight into how the natural gas market operates, how the market is affected by a number of different market forces, and how producing accurate date-specific forecasts of future market prices is infeasible. **Figure 9** identifies four periods of significant price spikes:

- Winter 2000–-2001
- February 2003
- Fall 2005
- Summer 2008

Figure 9: Henry Hub Spot Prices 2000–2009



Source: Natural Gas Intelligence data

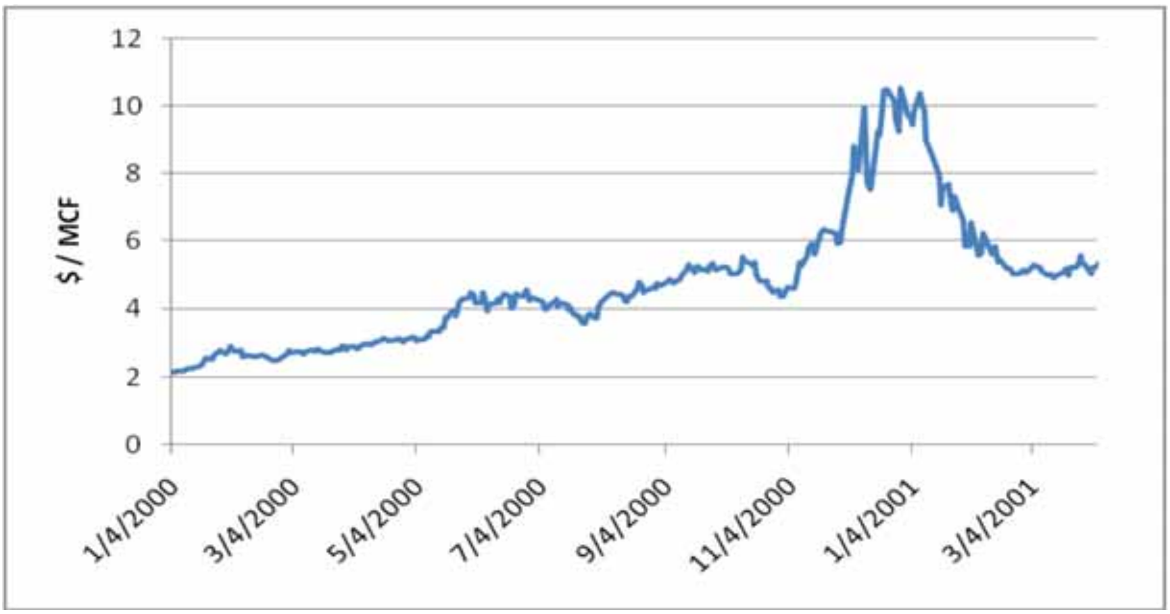
These four periods include the most significant price spikes during this decade and were caused by many of the physical and financial market factors discussed in the previous sections. However, each price spike was influenced to different degrees by the various factors. For example, a severe cold winter storm played the significant role in the February 2003 price spike, and back-to-back hurricanes played the significant role in the fall 2005 price spike. The price spikes of winter 2000-2001 and summer 2008 were the result of a number of different factors, including market manipulation and market speculation. The following pages specifically discuss these price spikes and their probable causes.

Winter 2000-2001 Period of Price Volatility

Henry Hub spot prices began the decade slightly above $2 / Mcf and entered a sustained period of increasing prices, spiking above $10 / Mcf one year later. During the winter of 2000-2001, the Henry Hub spot price for natural gas closed above $10 / Mcf five non-consecutive days peaking at $10.52 / Mcf on December 29, 2000 (**Figure 10**).

A unique aspect of this period was the relatively long length of time that the market experienced elevated prices. While there were previous periods of significant price spikes, most notably a natural gas price of $14.50 / Mcf on February 2, 1996, that period of higher prices was short-lived, with prices falling below $4 / Mcf the next trading day.[41] The price volatility during winter 2000-2001 was longer lasting, therefore causing greater concern for government officials and market analysts and exerting a much greater impact on natural gas consumers. Nationally, for example, residential consumers experienced 64 percent higher winter heating costs, as the average monthly bill increased from $380 to $624.[42]

Figure 10: Winter 2000–2001 Henry Hub Spot Prices



Source: NGI data

Fundamental market factors of supply and demand in part caused the price spike of winter 2000-2001. The factors that contributed to these volatile prices include: High demand because of extreme weather and continued economic growth, low storage levels heading into the winter heating season, and the market's inability to quickly increase production. However, California natural gas prices far exceeded the levels at Henry Hub, partly a result of market manipulation (discussed later) and a major pipeline explosion. In August 2000, an El Paso Natural Gas Company pipeline near Carlsbad, New Mexico, ruptured and burned. As a result of this damage, California natural gas deliveries dropped by 400 million cubic

[41] Spot price traded at $14.50 / Mcf on February 2, 1996, and $3.74 / Mcf the next business day.

[42] U.S. General Accounting Office (GAO). *Analysis of Changes in Market Price,* December 2002.

feet per day,[43] or nearly 6 percent of California's demand.[44] This loss of supply required the withdrawal of even more gas from storage to meet demand, exerting more upward pressure on prices.

Nationally, winter 2000–2001 began early and extremely cold. According to the National Climatic Data Center, November 2000 was the coldest November in decades throughout much of the nation, and in December 2000, 40 of the lower 48 states experienced below normal temperatures. As a result, natural gas demand for heating in the residential and commercial sectors spiked. In fact, EIA storage data showed near-record withdrawals from storage during these two months.[45]

Heading into winter 2000–2001, natural gas storage levels were low for several reasons. Warmer than normal summer temperatures in the Southern and Western United States increased demand for natural gas-fired electric generation to meet regional cooling demand. Much of this natural gas came from existing storage inventory, reducing available storage for the coming winter season. Additionally, many storage holders delayed purchasing and injecting new, higher-priced natural gas into storage, betting prices would decline before the start of the winter season. However, prices did not decline and the winter season began with lower-than-normal storage levels. According to the EIA, the winter 2000-2001 heating season began with the lowest storage levels since 1976. Withdrawals from storage during that winter were significant, and at the end of the winter heating season on March 31, 2001, nationwide storage fell to 742 Bcf, the lowest storage levels ever reported by the EIA (**Figure 11**).

In addition to demand increases during a cold winter, several years of strong economic growth had increased natural gas demand in all sectors: residential, commercial, industrial, and power generation. This robust economic growth during the 1990s resulted in a construction boom of new and larger houses and expanded commercial and industrial market sectors, all major consumers of natural gas. Growing environmental concerns nationwide led to increasing natural gas demand for electric power generation, as natural gas became the fuel of choice for electric generation.

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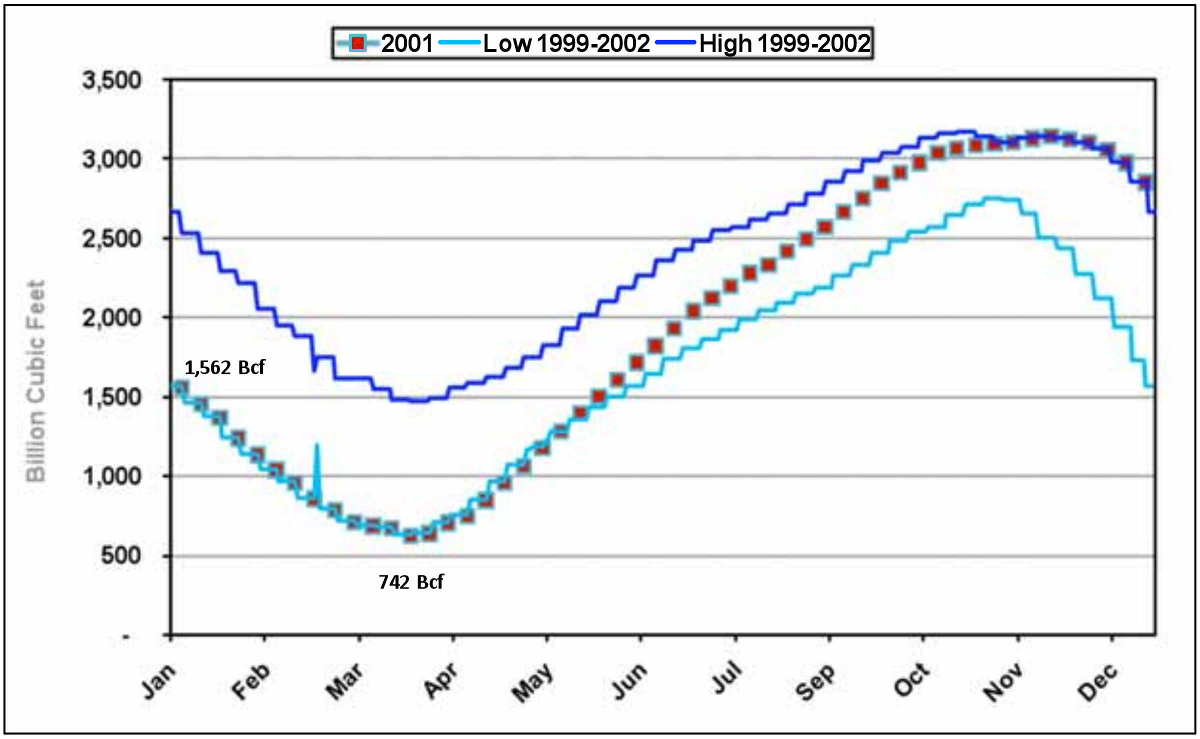
[43] California Energy Commission Staff Report. *California Natural Gas Analysis and Issues,* P200-00-006 November 2000.

[44] EIA historical data: California's natural gas demand in 2000 was 2.509 Tcf or 6,873MMcf/d.

[45] U.S. GAO Report to Congress. *Analysis of Changes in Market Price,* December 2002.

Figure 11: Winter 2000–2001 Natural Gas Storage Levels



Source: EIA Historic Storage Data

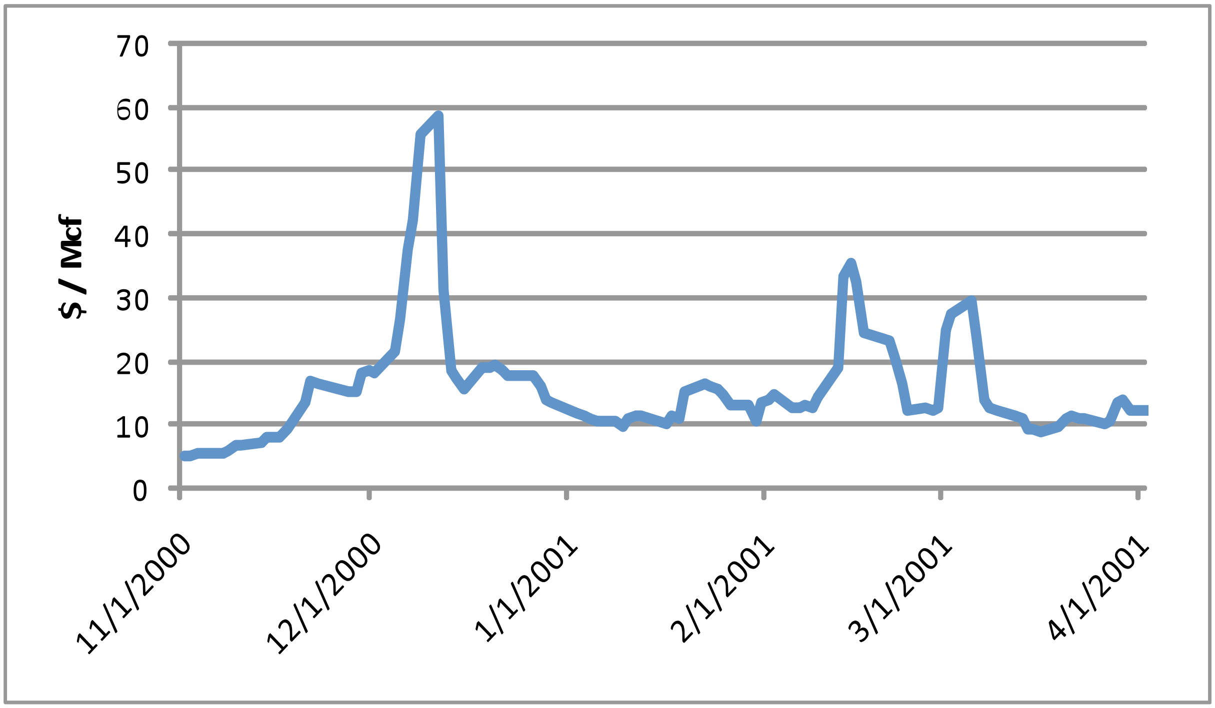
In California, natural gas demand for power generation increased significantly in 2000,[46] putting upward pressure on regional prices, while a continuing multi-year drought added additional demands for natural gas-fired generation. However, California experienced natural gas prices that far exceeded the $10.50 / Mcf price levels at Henry Hub, reaching nearly $60 / Mcf at the Southern California border in December 2000 (**Figure 12**). As a result of calls from California officials and others, the Federal Energy Regulatory Commission (FERC) on February 13, 2002, directed its staff:

> to investigate whether any entity, including but not limited to Enron or any of its affiliates, manipulated short-term prices for electric energy or natural gas in the West or otherwise exercised undue influence over these prices and whether this resulted in unjust and unreasonable rates in long-term power sales contracts.[47]

[46] EIA. *Electric Power Monthly* January 2001.

[47] FERC. *Final Report on Price Manipulation in Western Markets,* Docket No. PA02-2-000 March 2003.

Figure 12: Winter 2000–2001 Southern California Border Average Prices



Source: NGI data

In its March 2003 *Final Report on Price Manipulation in Western Markets*, FERC published several findings, including:

- Reliant Energy Services used Enron Corporation's on-line trading platform to exercise a churning strategy of repeated buying and selling excessive and unneeded quantities of natural gas, resulting in significantly higher prices and "significant price volatility."[48]
- Traders manipulated pricing indices across the nation to artificially inflate prices.[49]
- "The preponderance of evidence reviewed by [FERC] staff during this investigation indicates that Enron and its affiliates intentionally engaged in a variety of market manipulation schemes that had profound adverse impacts on market outcomes."[50]
- Numerous firms admitted to practicing "wash trading," or the simultaneous buying and selling of natural gas. The result inflates the volume of natural gas traded and could artificially increase prices.[51]

FERC's report did acknowledge that market fundamentals played a major role in the high prices and volatility that occurred during the winter of 2000-2001. FERC also concluded that the specific practices of various market participants contributed to the extremely high and extremely volatile natural gas prices experienced in California. Additionally, the improper actions of market participants likely contributed to greater long-term uncertainty and

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[48] Ibid, Chapter II Analysis of Gas Trading Activity in Southern California.

[49] Ibid, Chapter III Manipulations of Published Natural Gas Indices.

[50] Ibid, Chapter VI Trading Strategies, Economic Withholding, Inflated Bidding, and Other Anomalous Activities.

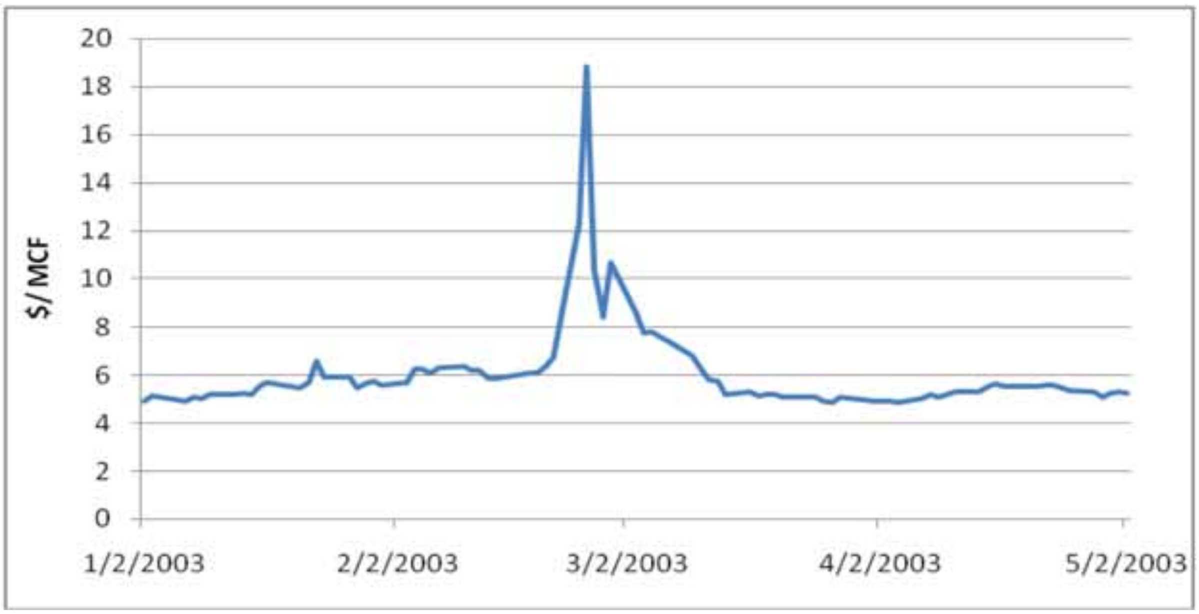
[51] Ibid, Chapter VII Wash Trading in EnronOnline.

ultimately less confidence in the natural gas market. The long-term damage to the natural gas market resulting from participants' improper actions arguably exceeded the short-term cost of higher prices during 2000–2001.

February 2003 Period of Price Volatility

The week of February 24, 2003, domestic natural gas spot prices increased significantly, reaching a high of $18.85 / Mcf at Henry Hub on February 25, 2003, representing more than a 200 percent price increase in just seven days[52] (**Figure 13**). While Henry Hub prices increased sharply, prices around the nation increased to even higher levels.[53]

Figure 13: February 2003 Henry Hub Spot Prices



Source: NGI data

Similar to the winter 2000–2001 period of price volatility, fundamental supply and demand factors contributed to the sudden and severe increase in natural gas prices. FERC again assembled a team of investigators to determine if market manipulation played any role in the February 2003 price spike. As part of its analysis, FERC collected data on tens of thousands of trades and more than one hundred thousand bids and offers for both physical and financial trades at more than one hundred locations nationwide. FERC examined the data and interviewed numerous market participants, concluding there was no evidence of market manipulation. FERC concluded that both the physical and financial natural gas markets operated rather efficiently during the period, and "natural gas price movements across the United States and regionally appeared to behave as expected given the prevailing supply, demand and regional capacity limitations."[54] FERC's conclusions raise the question:

[52] Henry Hub spot price February 18, 2003, was $6.10 / Mcf, rising to $18.85 / Mcf February 25, 2003.

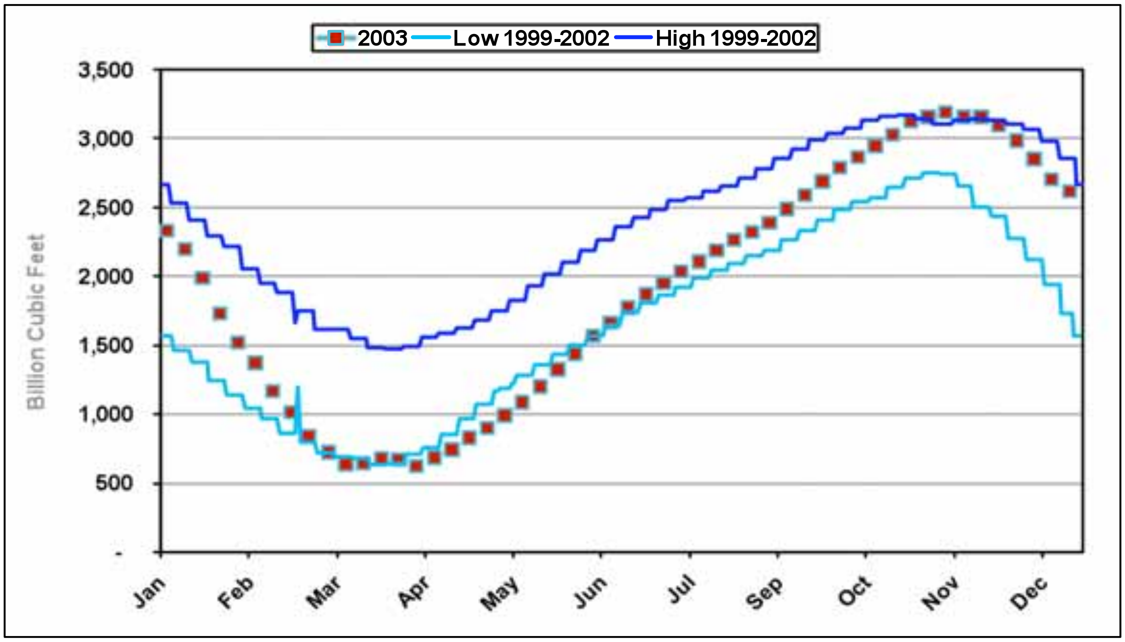
[53] West Texas spot prices approached $25.Mcf, and New York City spot prices traded at $40 / Mcf mid-day February 25, 2003, closing just under $30 / Mcf.

[54] FERC. *Report on the Natural Gas Price Spike of February 2003*, July 2003.

How could an apparently balanced market produce such significant price volatility? An analysis of weather data indicates that fundamental market forces likely were the primary cause of the February 2003 price spike: Low supply, high demand, and physical constraints.

Winter 2002-2003 was colder than normal in much of the nation. In fact, 27 Eastern states were colder than normal, most ranking 2002-2003 in the coldest 25 percent of winters since 1895. The colder winter resulted in higher withdrawals from underground storage, reducing storage inventories below levels of the prior year and below the five-year average. Storage levels dropped precipitously such that by the second week of March 2003, inventories stood at 654 Bcf, 20 percent lower than the 2001 level of 817 Bcf[55] (**Figure 14**).

Figure 14: February 2003 Natural Gas Storage Levels

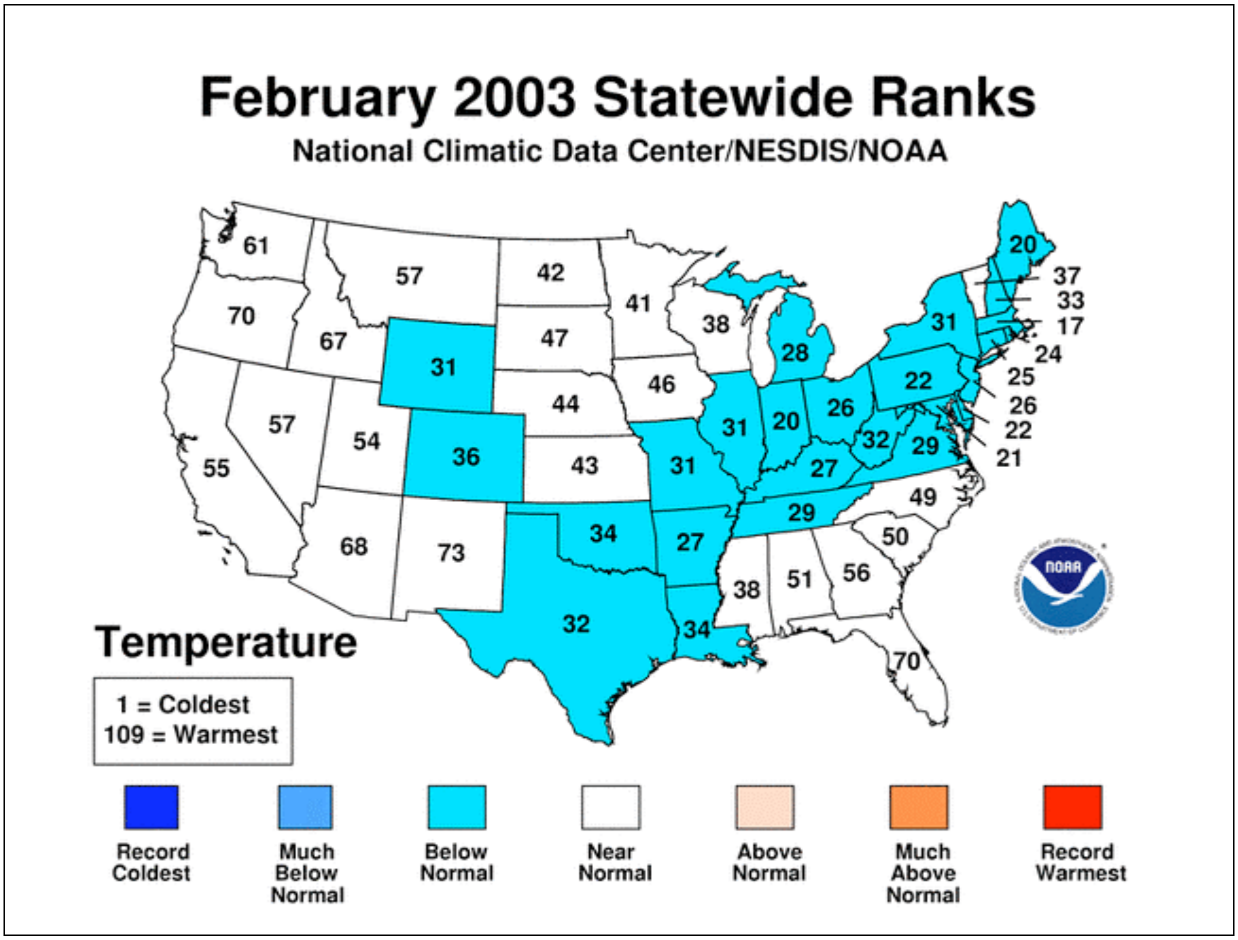


Source: EIA Historic Storage Data

In the midst of this abnormally cold winter, a large and extremely cold storm hit the United States in late February 2003. The storm was powerful and ensured that many states experienced a colder February than normal (**Figure 15**). These states included the high-consuming Northeast and the natural gas-producing mid-continent region. The cold temperatures in producing regions were so severe that wells froze off, reducing production and available supply to meet the increasing demand.

[55] EIA. Weekly Lower 48 States Natural Gas Working Underground Storage.

Figure 15: February 2003 National Temperatures

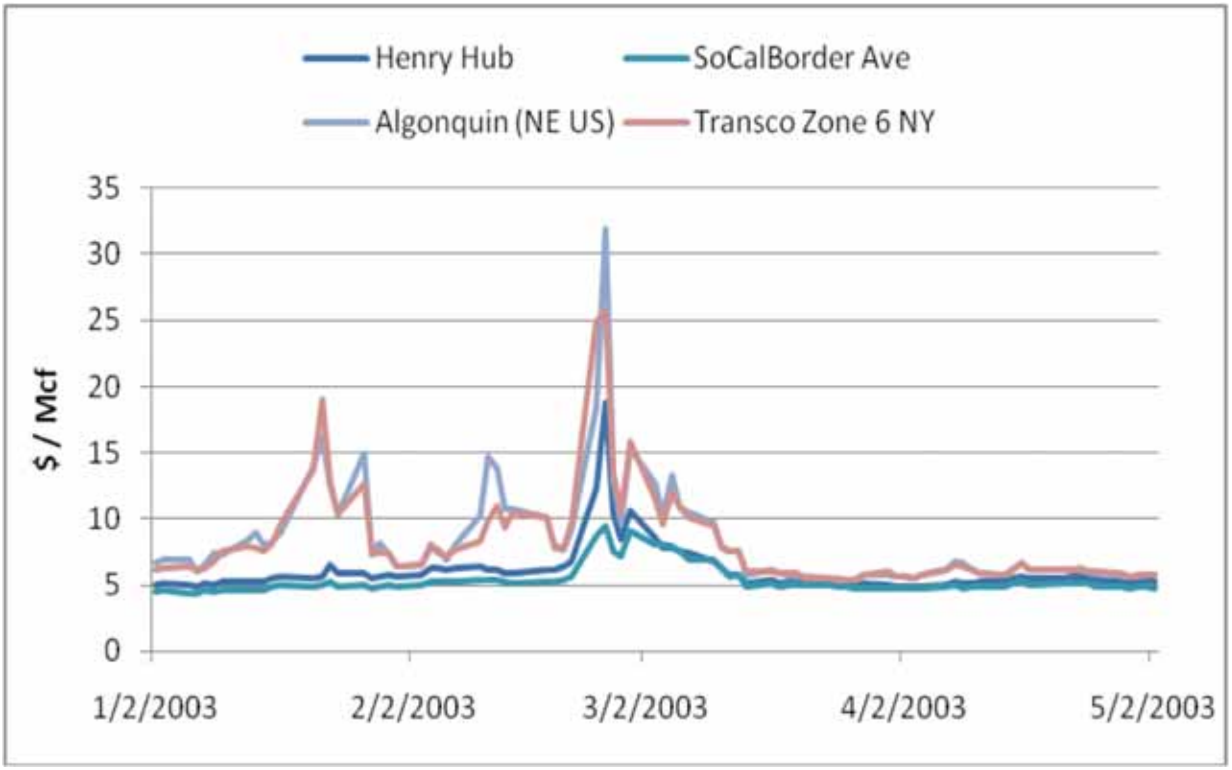


Source: National Oceanographic and Atmospheric Administration

By late winter, enough gas had been withdrawn from most storage reservoirs that field pressures began to drop. Low field pressure reduces the amount of natural gas that can be withdrawn in a given period. Thus, storage operators have more trouble meeting a late season peak in demand than earlier peaks. Supply deliveries to the Northeast were hampered further by operational troubles on regional pipeline systems.

The market's response to rising demand and falling supply was to push prices significantly higher, especially in the Northeast. **Figure 16** displays the spot price movements of four pricing points, two in the Northeast, Henry Hub, and the Southern California border average. Southern California border prices remained under $10/Mcf, and Henry Hub prices increased to nearly $19/Mcf, while Algonquin prices exceeded $30/Mcf. Pipeline constraints in the Northeast contributed to the supply-and-demand imbalance, producing large differentials in prices for natural gas delivered to this region. California's prices remained much lower due to added pipeline capacity over Kern River and Gas Transmission Northwest as well as the fact that, unlike the Northeast, California's storage capacity is located near load centers.

Figure 16: February 2003 U.S. Pricing Points Spot Prices



Source: NGI data

Fall 2005 Period of Price Volatility

Gas producers and industry analysts have long recognized the potential for damage to their production facilities by hurricanes. Others learned this lesson when two Category 5 hurricanes struck the Gulf of Mexico within a month of each other.[56] On August 29, 2005, Hurricane Katrina made landfall on the United States' Gulf Coast and on September 24, 2009, Hurricane Rita made landfall. The damage caused by these back-to-back hurricanes was staggering to much of coastal Alabama, Louisiana, and Mississippi. Hurricane Katrina destroyed or severely damaged over 300,000 homes and caused extensive damage to the natural gas and petroleum infrastructure offshore and onshore. Less than one month later, when Hurricane Rita arrived, the region's destruction intensified.

The damage to the natural gas infrastructure was extensive. Offshore, damage occurred to production platforms and pipelines, while onshore, damage occurred to production wells, pipelines, processing plants, and related delivery and production infrastructure. The Minerals Management Service (MMS) reported that in the Gulf of Mexico, Katrina destroyed 46 drilling platforms and damaged 20 additional platforms and 100 pipelines.[57] Delivering a second punch, Rita destroyed 69 platforms and damaged 32 additional

[56] Using the Saffir-Simpson Hurricane Scale, hurricane intensity is rated on a 1-5 scale, 5 representing the highest intensity. Category 5 hurricanes have sustained winds greater than 155 mph.

[57] Minerals Management Service. News Release 3418, January 19, 2006.

platforms and 83 pipelines. MMS reported that the back-to-back hurricanes resulted in the shut-in of about three-quarters of the region's natural gas processing capacity. The significant damage and destruction to both offshore and onshore natural gas infrastructure had an immediate and lasting impact on the region's production output.

During the first half of this decade, Gulf of Mexico federal offshore production[58] totaled about 10 Bcf per day (3.65 Tcf per year), or approximately 20 percent of total U.S. natural gas marketed production. As a result of the damage to the natural gas and petroleum infrastructure from Katrina and Rita, natural gas production fell markedly in 2005 and 2006. According to EIA, 2005 federal offshore production fell 21 percent from 2004 levels to 3.2 Tcf.[59] The impacts of hurricanes Katrina and Rita continued through 2006 as federal offshore production fell another 8 percent from 2005 levels to 2.95 Tcf, further reducing the region's output to about 15 percent of total domestic marketed production.

As Katrina approached the Gulf Region, production platforms were shut down, resulting in the lowest level of production immediately following its arrival—below 2 Bcf per day or an approximate 80 percent reduction of output. Repair work began immediately, and production was restored to nearly 6.5 Bcf per day by mid September. However, Rita moved through the region a few days later causing additional damage to previously impacted facilities and inflicting new damage to previously untouched facilities. Rita's damage resulted in production output falling once again to about 2 Bcf per day. Because of the compound effects, restoration of production output following Rita progressed more slowly. Production was restored to 6.5 Bcf per day less than one month after Katrina. After Rita, it was about two months before production was restored to 6.5 Bcf per day. A full six months after Katrina entered the Gulf of Mexico, natural gas production remained only 80 percent of pre-hurricane levels. **Figure 17** charts the monthly marketed production volumes in the federal offshore Gulf of Mexico for the months leading up to and following the destruction caused by hurricanes Katrina and Rita. The sudden loss of production followed a warmer-than-normal August that increased natural gas consumption for electricity generation. The increased demand for generation and the added demand to inject gas into storage had already exerted upward pressure on prices.

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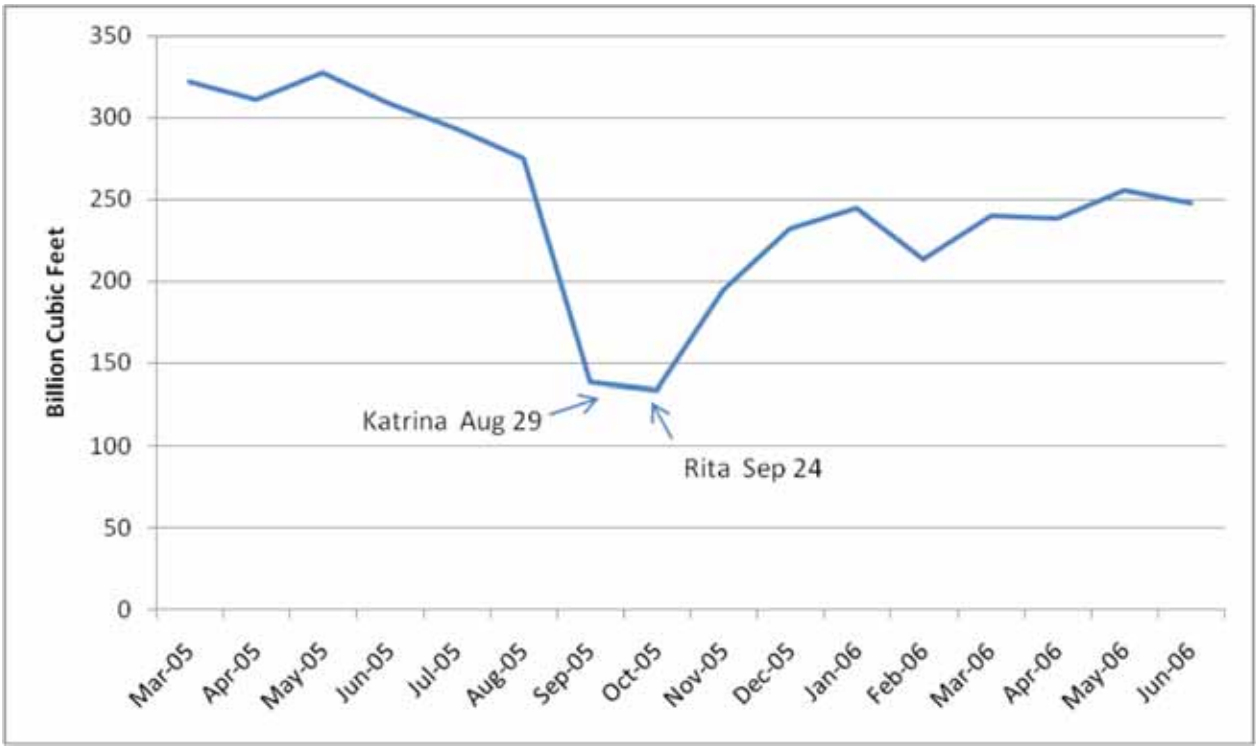
[58] Gulf of Mexico federal offshore refers to the offshore area in the Gulf of Mexico under federal jurisdiction. The U.S. Congress passed the Submerged Land Act in 1953, which recognized state ownership of the seabed within three miles of the shore. In 1953, Congress also passed the Outer Continental Shelf Act, granting the federal government jurisdiction over minerals on and under the seabed beyond state waters.

[59] EIA. *Natural Gas Year-In-Review 2006,* March 2007.

Figure 17: Fall 2005
Federal Offshore Gulf of Mexico
Monthly Marketed Production

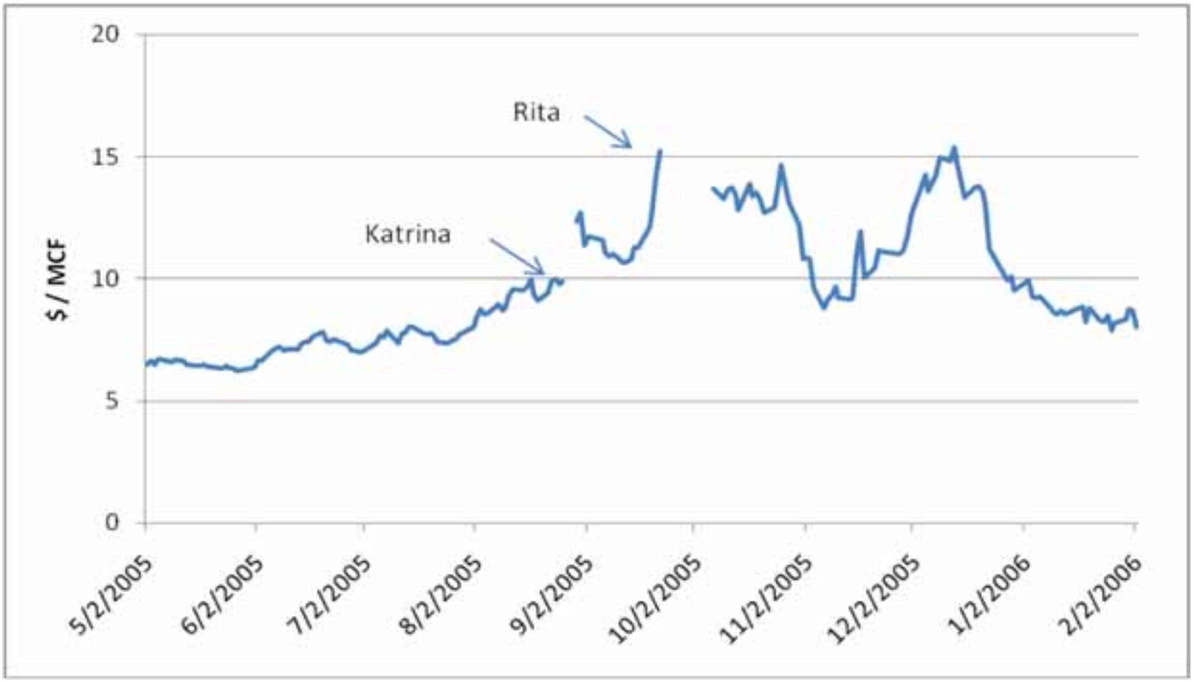


Source: EIA Historic Production Data

The damage to the production, processing, and transportation infrastructure in the region and the resulting decline in production produced a further jump in natural gas prices. **Figure 18** shows the volatile natural gas prices that occurred as a result of the damage produced by these two hurricanes. The two breaks in the line account for a suspension of natural gas trading on August 29 following Katrina and on September 23 following Rita.

Hurricanes Katrina and Rita had significant impacts on virtually every aspect of the natural gas industry. Combining this impact with an already tight supply and demand balance coming out of summer, price spiking was not unexpected following back-to-back hurricanes. The magnitude and duration of higher prices is the key aspect of this period.

Figure 18: Fall 2005
Henry Hub Spot Prices



Source: NGI data

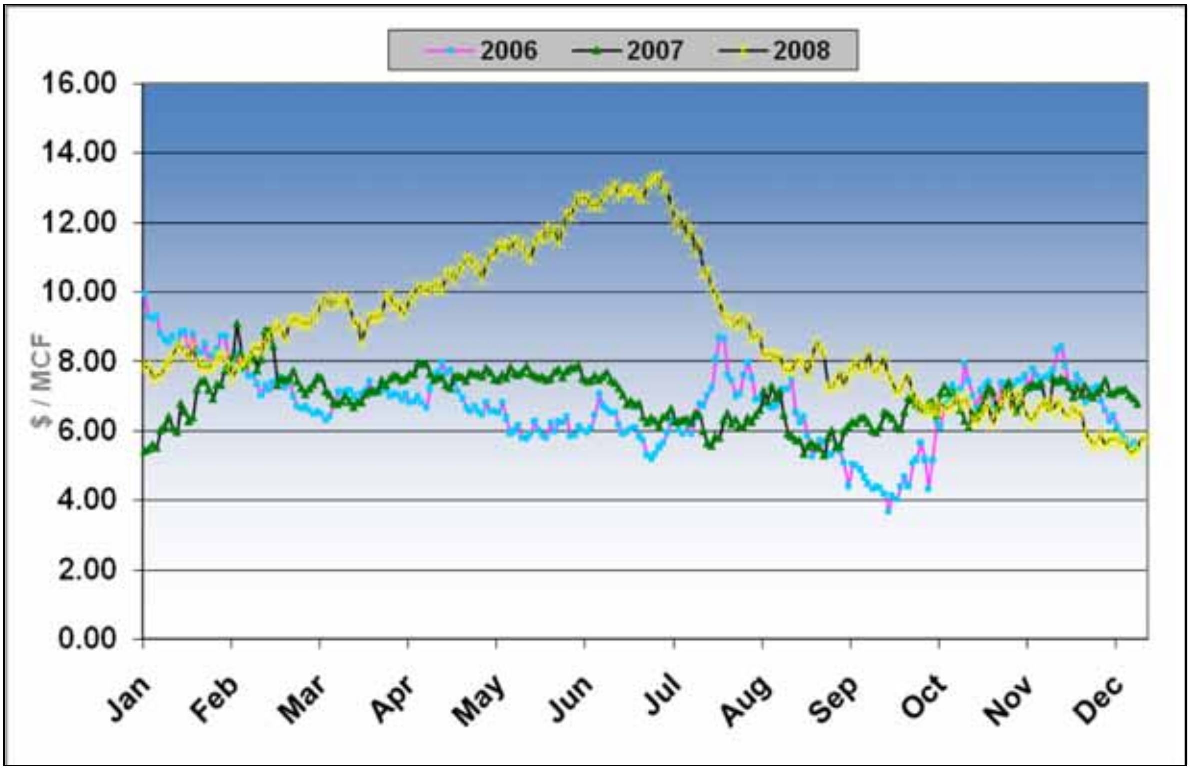
Summer 2008 Period of Price Volatility

The previous three periods of natural gas price volatility were the result of price reactions to specific physical market fundamentals (Winter 2000–2001 volatility was exacerbated by market manipulation). Volatility in 2008 is not as readily explained by reactions to physical market conditions. Rather, 2008 price movements resulted from both physical and financial market functions.

Figure 19 presents Henry Hub spot prices for 2006 through 2008. Prices during 2006 and 2007 moved in a relatively tight band between $6 / Mcf and $8 / Mcf. In fact, coming out of the winter peak demand season during those two years, prices actually drifted lower. However, from the outset of 2008, natural gas spot prices moved steadily higher. Even the shoulder months between winter heating and summer cooling demand, prices continued their move higher. Escalating natural gas prices continued increasing until reaching their peak level of $13.32 / Mcf on July 2, 2008, a 70 percent increase since the first of the year.[60] In late July, prices reversed course and began to decline. Once on their downward move, prices only took 6 weeks to fall back under $8 / Mcf, selling for $7.82 / Mcf on August 15, 2008, a 41 percent drop from the peak level.

[60] At the same time natural gas prices were rising, oil prices increased to record levels, West Texas Intermediate oil trading as high as $147.27 / barrel on July 11, 2008.

Figure 19: Summer 2008
Henry Hub Spot Prices 2006–2008



Source: NGI data

Unlike the previously examined periods, no significant weather events spiked demand or shut-in supply. What were the likely causes that produced the January-July price increases and the July-December price decreases? A number of factors contributed to these price changes.

In early April 2008, the Gulf of Mexico's Independence Hub was shut down after discovery of a gas leak nearly 100 feet below the ocean surface.[61] A loss of 900 MMcf per day in natural gas supply resulted, about 10 percent of total federal offshore Gulf of Mexico production, exerting upward pressure on prices. Still, this supply loss represented only about 1.5 percent of total U.S. demand, demonstrating that perception can play an important role in the market. If market supply is perceived to be tight, then even a relatively minor loss of supply appears to put additional upward pressure on prices.

In addition to concerns about low storage and lost production, several key weather forecasters predicted an active hurricane season, raising concern about further natural gas supply disruptions in the Gulf of Mexico. Coming only a few years after Katrina and Rita, these "active hurricane" forecasts added more upward pressure on prices as buyers worried about possible supply disruptions and even higher prices the coming fall.

Concern about shrinking supply did contribute to the increasing prices in 2008. However, increasing prices and recent technological advancements, such as horizontal drilling, created

[61] Independence Hub began production in July 2007, 120 miles southeast of Biloxi, Mississippi, and is the world's largest offshore natural gas processing facility with a capacity of 1 Bcf per day.

an environment that encouraged higher domestic natural gas production.[62] The outlook for increasing domestic production appeared to lessen the near-term prospects for developing LNG regasification facilities on the West Coast. In fact, several natural gas producers began discussing the possibility of exporting domestic LNG to take advantage of higher world LNG market prices.

During winter 2007, the nation experienced temperatures considerably colder than the two previous winters. Heating demand drew more natural gas from storage, resulting in below-normal storage levels heading into the spring and summer storage injection seasons. EIA reported storage levels of 1,791 Bcf as of May 2, 2008, 16 percent below 2007 levels and the lowest levels for that date during the previous four years.[63] Because of these low levels, demand increased as utilities injected more gas into storage to rebuild depleted inventories, creating further upward pressure on prices.

Electric power generation demand also played a role in increasing natural gas prices in 2008. With growing concern about climate change, natural gas remained the fuel of choice because of its lower carbon emission intensity. The uncertainty surrounding evolving climate change policies has created a disincentive for investment in coal-fired power plants.[64] According to FERC, in the 17 months preceding its report, 50 planned coal-fired power plants were cancelled or postponed, an indication that carbon emission reduction efforts to date are influencing the nation's electric power generation market. As further evidence of such influence, commercial lenders JP Morgan Chase, Citibank, and Morgan Stanley announced that this uncertainty would weigh heavily on their willingness to offer financing for coal projects.[65]

July 2008 oil prices traded at over $145 USD / barrel, concurrent with increasing natural gas prices. These record high oil prices, along with other emerging problems, such as subprime lending consequences, contributed to a global economic slowdown. As this economic slowdown grew, the natural gas market was affected as domestic demand for natural gas declined. Globally, natural gas demand also fell, leading to projections that excess LNG could land in the United States because of its sizeable storage capacity. This decline in both domestic and global demand played a significant role in falling natural gas prices during the second half of 2008 and into 2009. Predictably, these continuing low natural gas prices have contributed to another boom-bust cycle in production as domestic drilling rigs have fallen to 760 rigs as of April 2009, a reduction of more than 50 percent since August 2008 and 40 percent lower than the first of the year.[66]

Additionally, the relative value of the USD and growing commodity speculation, as previously discussed, likely played roles in the natural gas price movements of this period. The relative value of the USD during 2008 appeared related to price movements, moving inversely to the changing price of natural gas. And while conflicting opinions remain about the influence of commodity speculation on natural gas prices, the facts revealed during the 2008 U.S. Senate hearing (discussed on page 19) provide support for the position that growing speculative investments did impact natural gas prices during 2008.

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[62] EIA historical data shows domestic marketed production increased more than 7 percent from 2007 to 2008, a result of strong production from unconventional supply in the Rocky Mountains and mid-continent region.

[63] EIA. Weekly Lower 48 States Natural Gas Working Underground Storage.

[64] FERC. *Increasing Costs in Electric Markets*, Item: A-3, June 19, 2008.

[65] Natural Gas Intelligence.

[66] EIA. *Short-Term Energy Outlook*, April 2009.

CHAPTER 4: Natural Gas Price Forecasting and Uncertainty

A better understanding of price volatility and how it affects prices, and ultimately consumers and their budgets, is vital in natural gas price forecasting. Natural gas price forecasts (or predictions) should expressly consider the uncertainties in key factors that contribute to price volatility. Without recognizing this uncertainty, the reliance on date-specific, single-point price predictions of a historically price-volatile commodity can expose users of such predictions to potential vulnerabilities.

Given more periods of volatility, the perceived benefits of accurate natural gas price predictions to consumers are obvious. Accurate price predictions could allow residential and small commercial customers to prepare for possible changes in their costs for heating and cooking, lessening the impact on household and small business budgets. Large commercial and industrial customers and electric power generators could factor impending price changes into their operating budgets, cost of goods produced, and cost of electricity generated. Accurate price predictions would aid investment decisions of natural gas exploration and production companies and financers. The forecasted price level of natural gas is one of the significant components of the financial analysis necessary to make major investment decisions, such as whether to develop a new gas production area. Commodity traders could profit substantially with accurate price predictions.

Do accurate price predictions really exist? Can they actually be produced? A comparison of natural gas price forecasts vis-à-vis actual prices does not yield encouraging results for the accuracy of long-range forecasts. **Figure 20** charts the EIA's AEO wellhead price forecasts from 1982 to 2008, along with the actual average yearly wellhead cost.[67]

Throughout the 1980s, AEO forecasts were significantly higher than actual prices. However, in recent years AEO price forecasts have fallen below actual prices so consistently that, in a 2007 news article published on *Energy Bulletin*, the American Association of Petroleum Geologists called AEO forecasts "optimistic forecasts."[68] Together with their July 2007 article, "Betting on Bad Numbers,"[69] the authors document the AEO's "optimistic" forecasting record for 2000 through 2006, detailing:

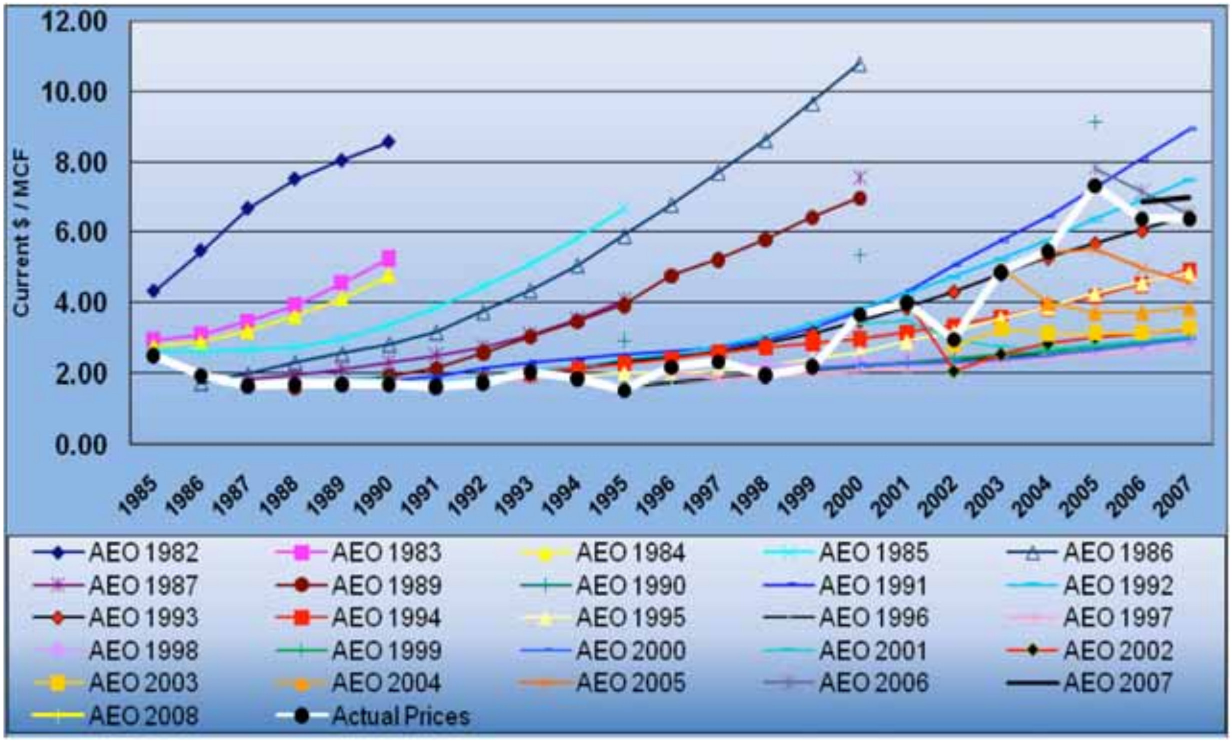
- Wellhead natural gas prices were underestimated in 21 of 22 forecasts.
- Electric generators' demand was underestimated in all 22 forecasts.
- Domestic natural gas production was overestimated in 19 of 22 forecasts.

[67] EIA-Annual Energy Outlook forecasts are produced annually, publically available, documented with extensive detail, and extensively used in many different arenas including policy decisions, regulatory proceedings, energy and investment activities, litigation, and research.

[68] Timothy J. Considine, Ph.D., and Frank A. Clemente, Ph.D. August 20, 2007, news article published on *Energy Bulletin*, www.energybulletin.net, described optimistic forecasts as underestimating price and overestimating supply.

[69] Timothy J. Considine, Ph.D., and Frank A. Clemente, Ph.D. "Betting on Bad Numbers," July 2007, published on *Public Utilities Fortnightly*, www.fortnightly.com.

Figure 20: EIA Wellhead Price Forecast Comparison—AEO 1982–2008



Source: EIA: *Annual Energy Outlook 2008 Retrospective Review*

The authors concluded that the AEO made "optimistic" forecasts in 62 of 66 forecasts or 94 percent of the time, representing a systematic bias with potentially far-reaching impacts, given AEO forecasts are used by policy makers, regulators, utilities, scientists, and investors. The authors also added that the EIA failed to acknowledge any systematic bias or pattern in their forecasts, referencing EIA Deputy Administrator Howard Gruenspecht's comment at a January 2007 U.S. Senate hearing that "EIA stands behind the results" of their modeling.

Regardless of whether systematic bias exists, there is still much uncertainty with the many factors that contribute to price fluctuations and volatility, ultimately rendering long-range, date-specific, single-point natural gas price forecasts unreliable or perhaps useless. Some of these uncertain factors are:

- Growth of United States domestic natural gas production.
- Level of natural gas imports.
- Construction of additional domestic LNG regasification facilities.
- Construction of new pipeline infrastructure, accessing areas of increasing production.
- Availability of adequate storage capacity.
- Economic conditions that can significantly impact natural gas demand and production.
- Efficiency improvements and growth of renewable generation that reduces demand.
- Carbon regulation policies.
- Price of other energy fuels and impact on natural gas.
- Level of energy commodity speculation and its impact on prices.

- The value of the U.S. dollar and its impact on prices.

While these factors can drive price volatility, they also represent many of the input variables used in forecasting the natural gas market. "There is tremendous uncertainty about the appropriate values to assign most of the key fundamental and structural variables,"[70] which results in greater forecasting uncertainty and, therefore, less reliable natural gas price forecasts. As the market responds to the relatively recent and evolving variable of carbon regulation, the effects carbon regulation will have on natural gas prices are uncertain. In an October 2008 article titled "The Future of Fuels in a Carbon-Constrained World," natural gas analyst Catherine Elder stated:

> How we change the electricity resource mix to incorporate other fuels in order to meet adopted carbon goals will have a massive impact on how much natural gas we burn to generate electricity. That gross uncertainty will drive the volatility of fuel prices, accelerate the race for advanced technologies in coal, nuclear and renewable, drive efforts to reduce electricity growth rates, and become the dominate factor in determining the fuel mix for electricity generation in the decades to come. In short, carbon regulation changes everything.[71]

Many analysts are not questioning whether carbon regulation policies will impact the natural gas market and prices, but to what degree they will be impacted.[72]

Natural Gas Price Forecasts

Natural gas price forecasts are produced by public and private organizations to provide information to policy makers, regulators, market participants, investors, and consumers. Price forecasts can differ significantly. Differences occur because:

- Forecasts are produced for different purposes and audiences.
- Different methods and / or models are used to produce individual forecasts.
- Different assumptions or judgments are made about key input variables.

A forecast may be produced for use by exploration and production companies trying to attract investors; thus there may be a bias toward forecast results that project higher prices and lower production costs. Forecasters use different methods and / or models. These different methods may recognize and use significantly different inputs or may treat similar inputs quite differently, which can affect forecast outcomes tremendously. The myriad of complex input variables that must be characterized is arguably the most influential reason for the differences between forecasts. Clearly, natural gas prices are impacted by a number of highly uncertain, but related, variables. The degree or range of uncertainty associated with these variables is often open to debate among market analysts. Even more perplexing is that market analysts sometimes do not even agree on the relevance of a key variable. A good example is the question whether there is a correlation between oil and natural gas

[70] California Energy Commission, *2007 Final Natural Gas Market Assessment*, CEC-200-2007-009-SF, December 2007, p. 78.

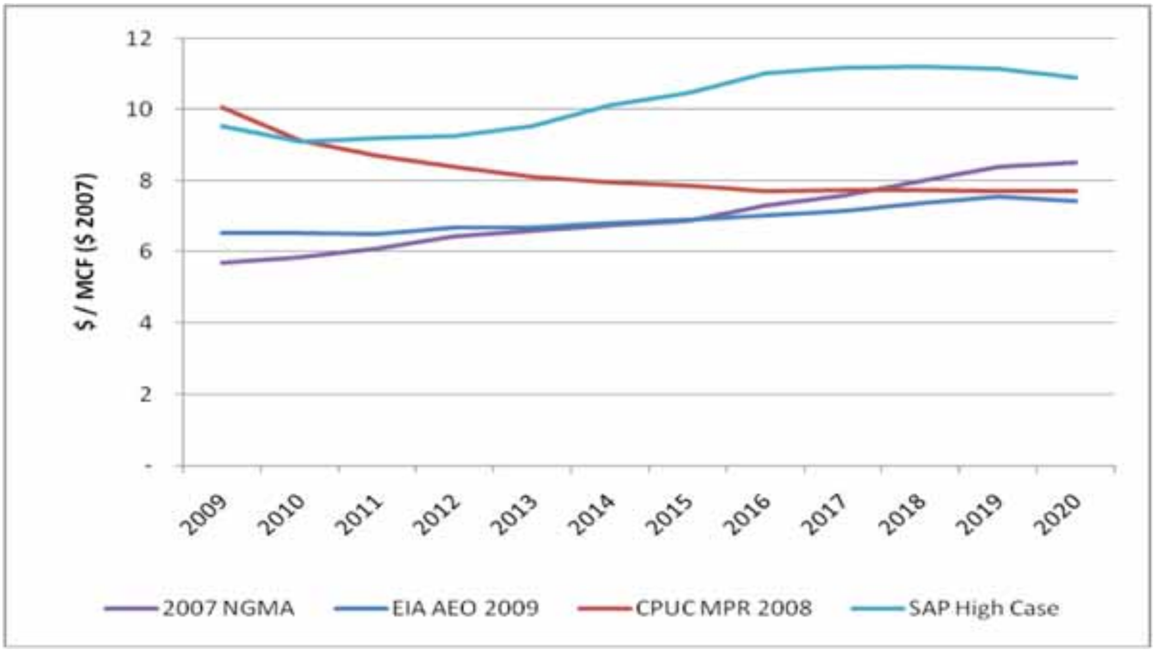
[71] Catherine Elder is a senior director with R.W. Beck. Her article was published in the American Public Power Association's (APPA) *Public Power*, October 2008, Volume 66, Number 7.

[72] An Energy Commission staff report is being prepared on the topic of carbon regulation impacts on the natural gas system and markets.

prices, as substantive arguments can be made on both sides of this issue. The treatment of this and the many other input variables required in forecasting prices is a key factor that can produce differences between forecasts.

Figure 21 compares four Henry Hub natural gas spot price forecasts: California Energy Commission's *2007 Final Natural Gas Market Assessment* (2007 NGMA) prepared in support of the *2007 Integrated Energy Policy Report*, *Energy Information Administration's Annual Energy Outlook 2009* (*EIA AEO 2009*), Energy Commission *Scenario Analysis Project Case 2* (SAP High Case), and California Public Utilities Commission (CPUC) *Market Price Referent* (CPUC *MPR 2008*).

Figure 21: Natural Gas Price Forecast Comparison 2009–2020



Source: Energy Commission staff

Table 1 provides the projected average annual spot natural gas prices for each of the four forecasts. The forecasts begin at significantly different price levels, moving higher each year, with the exception of the CPUC MPR 2008 forecast, which projects declining prices over the forecast period.

These forecasts project natural gas prices in 2009 as low as $5.70 / Mcf and as high as $10.07 / Mcf, representing a 77 percent difference between the low and high forecasts. Such a significant difference provides a good indication of the uncertainty in forecasting prices, even in the very near term. In 2020, the forecast differences are less, ranging between $10.92 / Mcf and $7.43 / Mcf (SAP High Case and EIA AEO 2009, respectively), a difference of 47 percent. A brief discussion of the purpose, basic methods, structure, and assumptions used in these forecasts will provide a better understanding for the differing results between them and the degree of uncertainty associated with these specific forecasts and forecasting results in general.

Table 1: Average Annual Natural Gas Spot Price Forecast Comparison 2009–2020 ($2007)

Year	2007 NGMA	EIA AEO 2009	SAP High Case	CPUC MPR 2008
2009	5.70	6.54	9.55	10.07
2010	5.86	6.52	9.10	9.16
2011	6.10	6.50	9.21	8.71
2012	6.44	6.68	9.26	8.39
2013	6.59	6.69	9.53	8.13
2014	6.77	6.82	10.12	7.96
2015	6.89	6.89	10.48	7.87
2016	7.30	7.02	11.03	7.73
2017	7.60	7.16	11.20	7.75
2018	8.00	7.38	11.22	7.73
2019	8.40	7.55	11.16	7.73
2020	8.52	7.43	10.92	7.72

Source: Energy Commission staff

Energy Commission: 2007 Natural Gas Market Assessment, Final Staff Report

The 2007 NGMA natural gas price forecast was produced using the Market Point, Inc., World Gas Trade Model (WGTM)/ North American Regional Gas (NARG) component, produced as part of a natural gas market assessment, and in support of the Energy Commission *2007 IEPR*.[73] The WGTM is a generalized, equilibrium model that produces market-clearing natural gas wholesale prices, quantities, natural gas production, and pipeline flows at a market equilibrium of supply and demand. The model simulates the physical structure of the market, accounting for expected market changes. Major assumptions and data sources in the 2007 NGMA forecast included:

- All WGTM/NARG model outputs determined based on equilibrium between supply and demand.
- Residential, commercial, and industrial natural gas demand for California was developed by the Energy Commission, and United States demand was developed by the Rice University's James A. Baker III Institute for Public Policy Energy Forum.
- Natural gas demand for electric power generation includes EIA estimates.
- Natural gas pipeline from the North Slope of Alaska to the Lower 48 will be constructed, and supply will begin flowing after 2020.

[73] California Energy Commission. *2007 Final Natural Gas Market Assessment*, CEC-200-2007-009-SF, December 2007. Appendix F provides a more detailed description of the model and its features.

- High LNG import levels were based on the assumption that LNG would be imported at a lower cost than the production of marginal domestic supply.

Energy Information Administration Annual Energy Outlook 2009 Forecast

The EIA AEO 2009 forecast was produced using the National Energy Modeling System (NEMS). This annual forecast is widely used by analysts, planners, and decision makers inside and outside government for study, analysis, planning, and investment decisions.[74] NEMS contains separate modules for major fuel markets and consumer sectors, as well as macroeconomic and international modules,[75] and the model balances supply and demand for each of the fuel markets, while accounting for competition between different fuels. Major assumptions and data sources in the EIA AEO 2009 reference case forecast included:

- North American flow of natural gas is determined based on equilibrium between supply and demand.
- Pipeline and storage capacity expansions that have been issued permits, and/or proposed and likely to be constructed are included in the in the early years, while later expansions are included when forecasted demand and adequate price levels support expansion.
- Recoverable natural gas reserve estimates are from the U.S. Geological Survey and the U.S. Department of Interior's Minerals Management Service.
- Natural gas demand increases are primarily in response to an increased use of natural gas for electric generation.
- Domestic production is sharply higher, accounting for an expected expansion of unconventional supply.
- Offshore production in the Gulf of Mexico is estimated to decline between 20 to 30 percent annually.
- A natural gas pipeline from the North Slope of Alaska to the Lower 48 will be constructed, and supply will begin flowing in 2020.
- LNG import levels are significantly lower.
- Adopted regulations and legislation are included; however, pending or proposed regulations and legislation are not recognized-for example, pending carbon regulation.

Energy Commission 2007 Scenario Analysis Project—Case 2—High Sustained Natural Gas and Coal Prices

The Scenario Analysis Project, prepared in support of the Energy Commission *2007 IEPR*, was designed to provide a greater understanding of the implications of various levels of

[74] The users of the EIA forecast come from different industries and perspectives. Such diversity of client and purpose makes EIA's forecasting task even more problematic.

[75] NEMS integrated modules include: Oil and Gas Supply, Natural Gas Transmission and Distribution, Coal Market, Renewable Fuel, Electricity Market, Petroleum Market, Industrial Demand, Transportation Demand, Commercial Demand, Residential Demand, International Energy, and Macroeconomic Activity.

market penetration of "preferred resources," such as energy efficiency measures and renewable electricity generation, in both California and the Western United States. In support of developing one scenario, SAP Case 2, the High Sustained Natural Gas and Coal Prices, Global Energy Decisions' Gas Pipeline Competition Model (GPCM), which allows users flexibility in analytical structure, was used to forecast gas prices that potentially could result from a prolonged scarcity of domestic natural gas supply.[76] Major GPCM assumptions for this scenario included:

- Domestic natural gas production declines between 12 to 32 percent over the forecast period.
- Neither the Alaska North Slope nor MacKenzie Gas Project pipelines are constructed during the forecast period.
- LNG imports increase, supplanting the declining domestic supply.
- High oil prices and a closer correlation between oil and natural gas prices would result if climate change regulatory policies accelerate the use of natural gas for electric generation.

California Public Utilities Commission, Market Price Referent 2008

In accordance with the state's Renewables Portfolio Standards Program, the CPUC develops a natural gas price forecast (CPUC MPR 2008) to establish an avoided electricity cost benchmark, the Market Price Referent (MPR) for non-renewable energy. The MPR then serves as a benchmark to evaluate the reasonableness of the prices paid by investor-owned utilities for renewable energy. To prepare the CPUC's 2008 MPR, the CPUC authorized its staff[77] to use between 9–12 years of NYMEX natural gas forward contract prices.[78] For years 13 and beyond, CPUC staff was directed to produce a fundamental long-range forecast by using the average of 3 out of 4 private sector forecasts from Cambridge Energy Research Associates, Petroleum Industry Research Associates Energy Group, Global Insight, and Wood MacKenzie. The CPUC did not reveal which three forecasts were used, stating contractual obligations required confidentiality.

The unique aspect of this forecast method is the use of the NYMEX forward contract prices for the front years of the forecast. Critics of this approach argue that using NYMEX forward contract prices is flawed because there is a lack of actual trades or market liquidity, especially in later years of the NYMEX strip. In fact, before 2008, when only six years of NYMEX forward contract prices were available, critics voiced concern there was too little market liquidity. They argue that doubling the range to 12 years of trades further devalues this data. Conversely, proponents argue that extending the NYMEX strip to 12 years is an indication that actual buyers and sellers are willing to trade longer term, thus actually establishing a real price for natural gas. Proponents claim any level of trading in an actual market with settlement and disclosure rules provides a better prediction of future prices than a fundamental, modeling forecast.

[76] The importance of this alternate scenario is because of the impact high natural gas prices would have on the cost of gas-fired electric generation.

[77] CPUC decision, D.08-10-026, October 16, 2008.

[78] The NYMEX forward contract trading period was extended from 6 to 12 years in 2008.

Forecast Uncertainty Summary

As shown in **Figure 21** and **Table 1**, there are material differences between the various forecasts presented. The appropriate response is to consider why forecasts, whose methods share much in common, produce such different results. While there may be similarity in the fundamental market variables that feed into each forecast, there can be real differences in the values assigned to each variable. The uncertainty level inherent in each of the input variables serves to decrease the usefulness of the forecast results. The graphic representation of the EIA forecast history shown in **Figure 20** visually documents the uncertainty and inaccuracies of past natural gas price forecasts.

Historic forecast results have been poor vis-à-vis actual prices, and, unfortunately, the future may include more market volatility and even greater forecasting uncertainty. As discussed previously, the natural gas price volatility experienced in 2008 was somewhat unique, as traditional, physical market fundamentals alone did not explain the market's actions. Various financial market fundamentals, such as commodity speculation, contributed to the significant price volatility in 2008. In a recent report on the 2008 natural gas market, FERC concluded:

> As we discussed at the Winter Assessment last fall, the rise in natural gas prices coincided with a global increase in many commodity prices. This increase in commodity prices occurred as large pools of capital flowed into various financial instruments that essentially turn commodities like natural gas into investment vehicles. Ultimately, we believe that financial fundamentals along with the modest tightening in the supply and demand balance for gas during the first part of 2008 explains natural gas prices during the year.[79]

Natural gas markets have complex and dynamic interactions with electricity and other fuel markets affecting many sectors of the state, national and world economies. Existing and future greenhouse gas and energy policies increase the complexity of these interactions, the number of alternative choices that can affect these interactions, and the uncertainty inherent to making predictions about key drivers of these interactions. Past efforts to predict natural gas prices have been highly inaccurate. With complexity and uncertainty increasing, it may not be feasible to make useful date-specific, single-point forecasts.

Based on the volatile prices that occurred in 2008 and the plausible explanations that extend beyond traditional, physical market fundamentals, a reasonable expectation would be that future natural gas price forecasts will be even less accurate as natural gas prices continue to experience price volatility for reasons that are perhaps less understood and less predictable. As the United States continues to move to a carbon-constrained existence, the impacts of new policies and regulations on the natural gas market remain unclear. And as LNG provides a greater percentage of the world natural gas supply, the globalization of the natural gas market may contribute to even a greater level of uncertainty in predicting market prices. Thus, future natural gas price forecasts likely will be more uncertain and less useful.

[79] FERC. *State of the Markets 2008,* April 16, 2009 presented at FERC's April 2009 monthly meeting.

CHAPTER 5: Conclusion

This report presented information on natural gas price volatility, historical natural gas prices, and the uncertainty in forecasting natural gas prices. The intent was to present significant factors that drive natural gas commodity prices and price volatility, to recognize the uncertainty inherent in natural gas price forecasts, and to serve as the foundation for a public discussion of these topics in support of the Energy Commission's *2009 IEPR*.

Generally, there is widespread agreement that the physical market factors of supply and demand are primary contributors to natural gas prices and volatility. Domestic production increases of unconventional natural gas have changed the long-term prospects of the nation's natural gas supply. However, the degree of impact expanding unconventional domestic natural gas reserves and increasing domestic production will have on long-term gas prices and volatility is less than certain. Additionally, the global economic slowdown that began in 2008 has reduced demand, especially in the industrial sector, putting downward pressure on prices.

There also is growing interest and concerns about the influence financial market factors, particularly commodity speculation, have on natural gas prices and volatility. The growth in speculative commodity trading from non-traditional participants, such as pension funds, university endowments, hedge funds, and index portfolios, has certainly changed the futures market. Unlike traditional participants such as utilities and refiners who used the market to hedge against volatile energy costs, these new participants use the market as an opportunity for profit. Significant disagreement exists about the influence speculative trading has on the natural gas market, prices and volatility, and regulatory debate is underway to determine how to effectively address this influence.[80]

Finally, past efforts to forecast natural gas prices have been highly inaccurate compared to actual prices, even when price volatility was largely dominated by traditional, physical market factors. Recent natural gas price volatility is at least partially explained by evolving, less traditional, financial market factors, complicating efforts to accurately forecast future natural gas prices. Additionally, as the United States continues moving to a carbon-constrained existence, future greenhouse gas policies will further complicate these efforts, likely rendering future natural gas price forecasts even less accurate and more uncertain. The uncertainty associated with predicting major input variables and the resulting natural gas price forecasts brings into question the value in producing date specific, single point natural gas price forecasts.

The ongoing debate on these issues, particularly commodity speculation, will ensure continuing interest in the operation of the natural gas market. Further, recent periods of volatility in natural gas physical and financial market factors and natural gas prices have created additional uncertainty in predicting future prices. The future of the market appears likely to include continuing periods of volatility and uncertainty.

[80] The CFTC held three public hearings, July 28 and 29 and August 5, 2009, to discuss commodity speculation and consider imposing trading and position limits in an effort to eliminate, diminish, or prevent potential negative consequences of excessive commodity speculation. A number of industry participants and academics testified. CFTC action is expected later in 2009. Congress is again considering changes in the federal tax code, eliminating favorable tax treatment currently afforded non-commercial commodity speculators.

Glossary

Annual Energy Outlook (AEO) - Energy Information Administration's annual projection and analysis of U.S. energy supply, demand, and prices through 2030.

Basis - or basis differential, is the difference in the price of a commodity at different physical locations and/or different points in time (spot vs. futures price).

Bidweek - the last five business days of the month, when buyers and sellers contract for physical delivery of natural gas during the following month at a fixed price.

Boom-bust cycle - a period of significant increase in economic activity or price, followed by a significant decrease in economic activity or price as a result of changing economic conditions or the collapse of unrealistic expectations.

Btu - British thermal unit, represents the standard measure of heat energy.

Churning - repeated buying and selling of excessive and unneeded quantities of natural gas for the purpose of increasing prices.

Commodities Futures Trading Commissions (CFTC) - authorized under the Commodity Futures Trading Commission Act of 1974 to regulate futures trading in all commodities.

Energy Information Administration (EIA) - created by Congress in 1977 as the statistical agency of the U.S. Department of Energy, provides policy-neutral data, forecasts, and analyses to promote sound policy making, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment.

Federal Energy Regulatory Commission (FERC) - an independent federal agency that regulates the interstate transmission of natural gas, oil, and electricity.

Financial market factors - non-physical market factors that affect price and volatility including market speculation, market manipulation, and strength of the U.S. dollar.

Financial swap - a derivative or financial contract to manage risk where parties exchange financial rates or prices for a fixed quantity of an underlying commodity. In a standard commodity swap, parties exchange payments based on price changes of a commodity or a market index, while fixing the price they effectively pay for the physical commodity.

Futures contract - a contract obligating the buyer to take delivery and the seller provide delivery at a specified location of a fixed amount of commodity at a predetermined price.

Hedging - the buying and selling of futures contracts or options to protect the trader from the negative effects of unexpected price changes.

Henry Hub - North America's main natural gas trading hub and pricing point.

Marketed production - gross withdrawals less gas used for repressuring, quantities vented and flared, and non-hydrocarbon gases removed in treating or processing operations. Includes all quantities of gas used in field and processing plant operations.

Mean reversion - tendency for prices to migrate back to an equilibrium or average price level.

Minerals Management Service (MMS) - part of the U.S. Department of the Interior that manages natural gas, oil and other mineral resources on the outer continental shelf.

National Regulatory Research Institute (NRRI) - founded in 1976 by the National Association of Regulatory Utility Commissioners, NRRI provides research services to state utility commissions.

Natural gas futures price - predetermined price of natural gas on a specified future date.

Natural gas spot price - price of natural gas for next-day delivery at a specific location.

New York Mercantile Exchange (NYMEX) - largest physical commodity futures exchange. Trading is conducted in commodity futures and options. NYMEX initiated the development of energy futures and options contracts in 1978.

Option contract - a contract providing the holder the right, but not the obligation, to purchase or to sell a futures contract at a specified price within a specified period of time in exchange for a one-time premium payment.

Physical market factors - natural gas market factors that affect price and volatility including supply, demand, storage, and delivery infrastructure issues.

Price volatility - change in commodity price over a given period, commonly presented as an annualized percentage of the day-to-day change in prices.

Shut-in - temporary termination of natural gas production at the wellhead. Most shut-ins are weather-related, such as when hurricanes impact the Gulf of Mexico region.

Stationarity - prices do not change over time, a flat series of prices.

Wash trading - simultaneous buying and selling of natural gas between the same parties creating the illusion of high demand for the purpose of increasing prices.

APPENDIX A: Understanding Natural Gas Price Movements: A More Technical Discussion

This brief appendix provides a more rigorous but intuitive understanding of commodity price movement. It helps explain why volatility and the related concepts of mean reversion and stationarity are such critical elements affecting commodity price forecasting and budgeting.

Definitions

Volatility is the statistical *degree* at which prices fluctuate, or, the rate of price change. High levels of volatility indicate a price series that changes drastically (such as natural gas), whereas low levels of volatility are reflective of commodity prices that don't tend to change much (such as prices of coal). Volatility is normally expressed as an annualized percentage in the day-to-day change in prices and is typically measured using historical data.

Mean reversion is the tendency for the price of the commodity to return to some equilibrium or core price that acts like a magnet around a cycle of exuberant and depressed prices. The market typically doesn't know when it has reached this core price, but it seems to correct itself when it deviates significantly from this level.

Stationarity is the statistical property that indicates if the core price is stable or not. In the case of natural gas, the measure of the core price has evolved over time from $2.50 / MMBtu in the mid-1990s, to roughly $6 / MMBtu today. This non-stationarity of natural gas prices makes it more difficult to gauge when the core price has been reached, especially when forecasting.

Although the most common way to measure volatility is by analyzing historical data, volatility can be measured in different ways. The best approach depends on available market information and the intended use.

Table A-1 summarizes the definition of these three concepts.

Table A-2 summarizes the meaning and usage of the most common approaches of calculating volatility.

Table A-1: Definitions

	Volatility	Mean Reversion	Stationarity
Meaning	Reflects how fast/slow prices might change from one observation to another and may be generalized to indicate where they might be as a compounded effect.	Price level market seems to revert to after periods of exuberant or depressed levels is analogous to a core or equilibrium price.	Indicates whether the value that the market considers as equilibrium is stable, or it is changing over time.
Example	When compared to coal prices, natural gas has a higher volatility and therefore reflects larger price changes on a day-to-day basis.	Crude price has fluctuated between $25/MMBtu and $4/MMBtu, but it is generally accepted that $6/MMBtu is the core long term value of gas.	Equilibrium price of gas has changed and now stands at $6/MMBtu whereas $2.50/MMBtu was the price during the mid 1990s.

Source: R.W. Beck

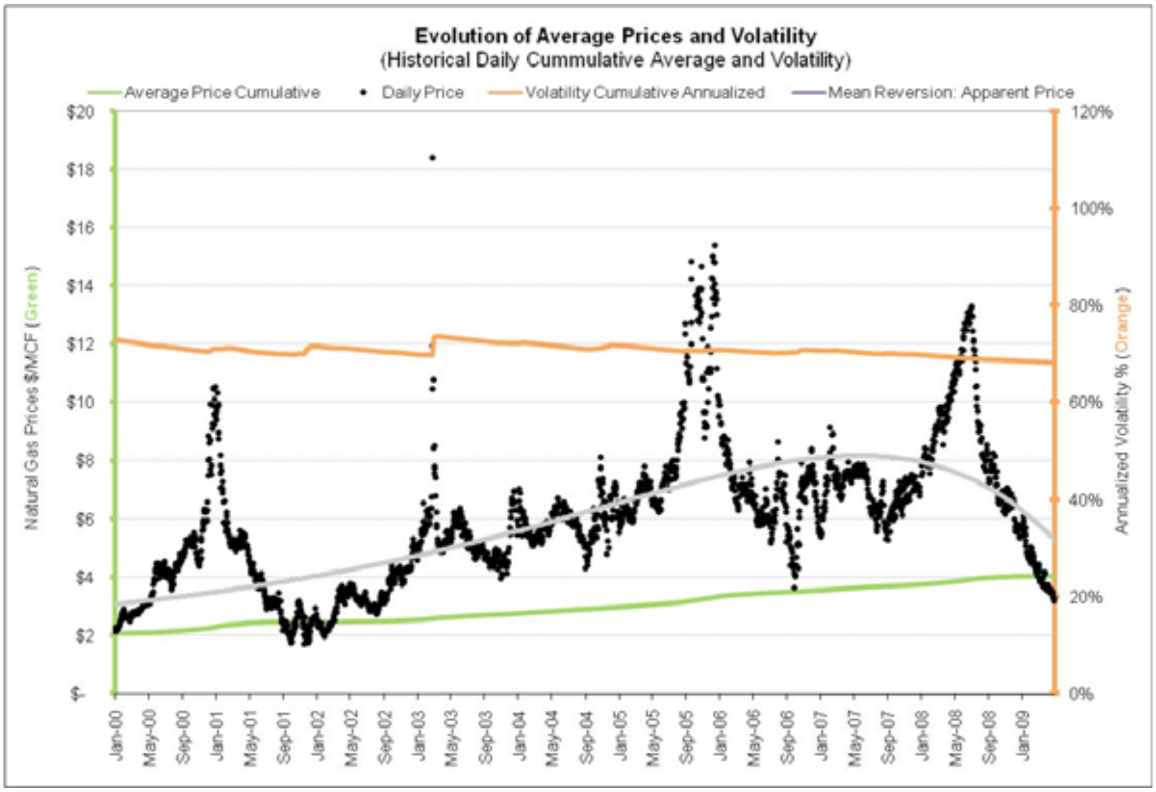
Table A-2: Most Common Approaches and Usage of Volatility

Volatility Calculation	Meaning	Usage
Historical	Volatility derived from historical data and based on the distribution of daily logarithmic price returns.	Historical data is representative, and focus of analysis is short-term.
Implied	Volatility that is derived by observing the prices of derivative instruments such as options, and therefore reflects a perspective of how the future might evolve as evidenced by how an option trader prices an option.	Historical prices are deemed to be unreliable due to issues like illiquidity, large bid-ask spreads and/or few market participants.
Monte Carlo	Similar to implied volatilities, it calculates volatility based on simulated prices that have a significant random component in their simulation.	Historical prices or trading activity is unreliable or unavailable.
Estimated (such as General Auto Regressive Conditional Heteroscedastic models)	Instead of relying on historical patterns or derived from derivative instruments, it is estimated using econometric relationships and may include some fundamental drivers.	Useful for long-term analysis or when historical data or extrapolations are not valid as it is very likely that the pattern will change in the future.

Source: R.W. Beck

Figure A-1 shows the historical daily prices (black), the all-time cumulative average of prices (green), the all-time cumulative historical volatility (orange), and a price level to which the market has apparently been reverting (gray), determined from a visual perspective.

Figure A-1: Evolution of Average Natural Gas Spot Prices and Cumulative Volatility



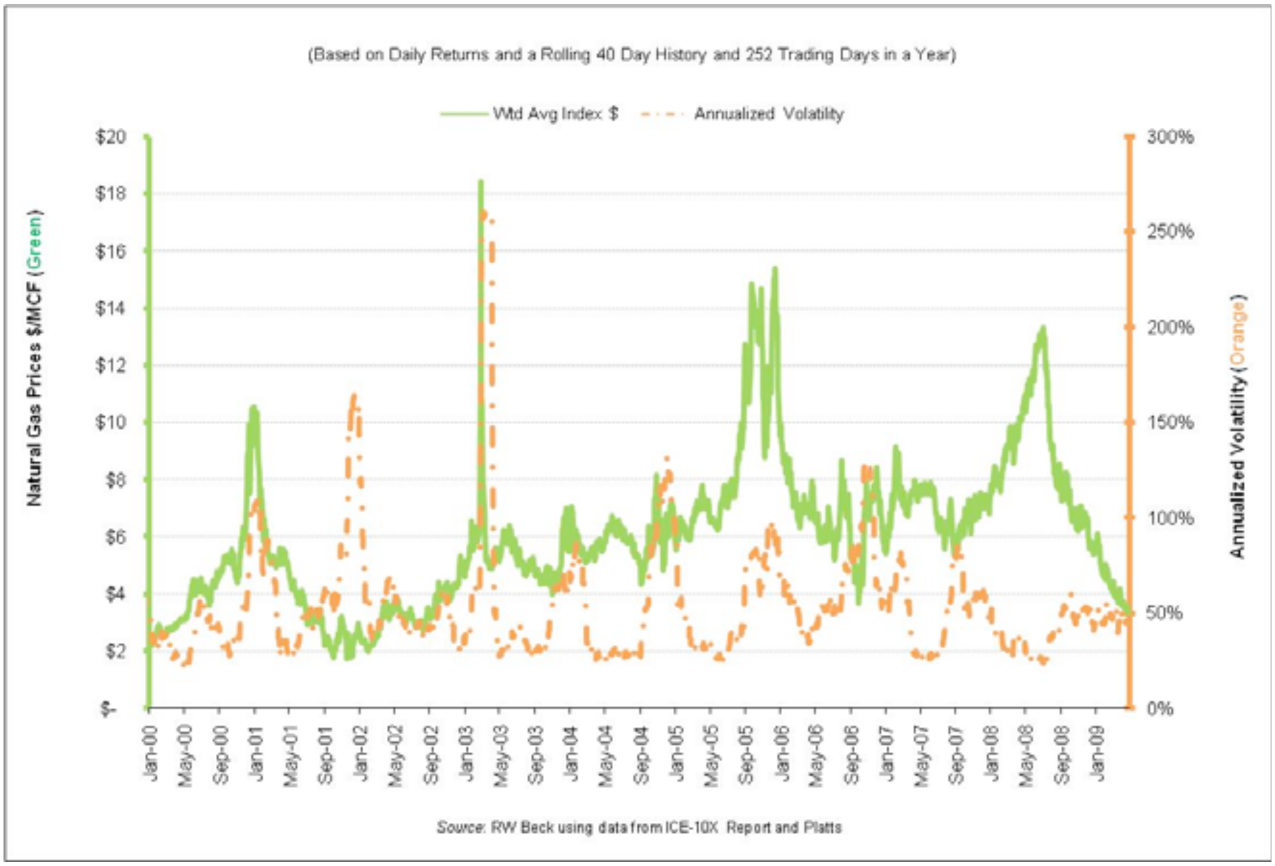
Source: R.W. Beck

- The average price of natural gas keeps changing. As more price data is incorporated into the average, the price keeps changing. This statistical property is called *non-stationarity*, and it adds a measure of uncertainty as to what prices should be in the future because an equilibrium price seems to be changing over time. If calculated using less historical data (such as a rolling 100 days of history), the average price will show a large seasonality, but the same pattern of non-stationarity is apparent.
- The average volatility of natural gas prices has not stabilized. Similar to the average price, the annualized cumulative volatility continues to change as more data is incorporated. The assumption of constant volatility moving forward is clearly not supported by the historical record. If calculated using less historical data (such as a rolling 100 days of history), the annualized volatility will also show a large seasonality, but the same pattern of non-stationarity is evident.
- Natural gas prices are cyclical and tend to oscillate around a (moving) mean reverting price. This mean-reverting price is here determined from a visual perspective but may be approximated through more formal methods.
- Exuberant price run-ups are typically followed by dramatic price downturns. This is largely what the mean-reversion estimate is trying to depict. For instance, the run-ups in 2005 and 2008 are clearly showing that the force to pull back is largely determined with the observed run-up in prices.

- Volatility by itself does not explain price movement.

Figure A-2 shows natural gas prices (green) and annualized volatility (orange), calculating volatility using daily returns and a rolling 40-day historical perspective.

Figure A-2: Rolling 40-Day Spot Natural Gas Price Volatility



Source: R.W. Beck

- Volatility around October 2004 was exceptionally high (above 100 percent), but the ultimate effect on prices was very small because mean reversion at the time was also very strong. Since the price run-up was quickly corrected, the underlying notion of an equilibrium price of natural gas didn’t change, and the final outcome was no severe (short-term) impact to prices or budgets.
- Volatility around October 2007 was very low and getting smaller (below 50 percent), but the mean-reverting properties of the market were almost non-existent, so the price run-up and effect on prices was very dramatic because the market lost the notion of equilibrium or core prices, largely influenced by the exuberant oil prices.
- Unless the market notion of equilibrium or core changes, the current run-down in prices may be followed by a sustained (but measured) price run-up, largely aided by increasing volatilities and a soft mean reversion.

Volatility, mean reversion, and non-stationarity, as defined above, can be incorporated into forecasting models, especially in helping to develop a probabilistic or stochastic analysis of how a “base case scenario” might deviate from a deterministic view. The interplay of these three statistical properties nevertheless does not detract from the need for forecasting; it actually enhances the need to not only challenge the fundamental assumptions of how forecasters believe the market may evolve, but also as to how volatility should behave. As a reminder, traditional portfolio theory indicates that volatility is assumed “constant,” but data argue this does not apply to energy commodities.

For budgetary purposes, the confluence of these three properties should also be incorporated in the context of a probabilistic behavior of how prices may evolve and affect budgets. This will give an opportunity for policy makers to try to identify (and protect) against undesirable price movements. It is unrealistic for budgets to be set under a static expectation and that the financial instruments are mature to be able to protect or diminish the impact of undesirable price movements.

In summary, the three statistical properties discussed should give an intuitive understanding to policy makers and forecasters that the natural gas market (and most energy commodities for that matter) are largely unstable, but that there are ways to try to address or understand the undesirable effects of this uncertainty. Assuming that a budget or a forecast involving natural gas prices is stable is itself a risky proposition.