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DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Anatomy of a Natural Gas Price Spike - Past and Future

Posted by Gail the Actuary on March 6, 2009 - 11:18am
Topic: Economics/Finance
Tags: natural gas, prices [list all tags]

This is a guest post by Jon Freise, a software engineer living in Minneapolis, Minnesota USA, and member of the Twin Cities Energy Transition Working Group dedicated to shifting away from fossil fuels.

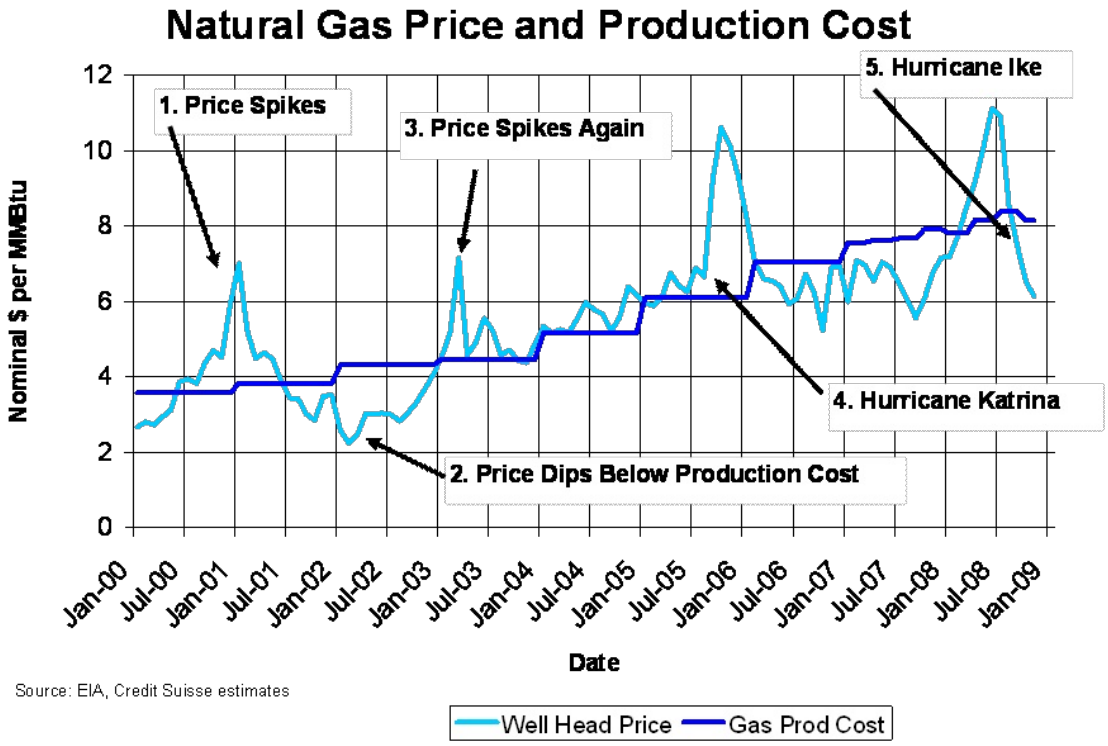

Figure 1. Natural gas average wellhead price and estimated production cost including a 10% rate of return. (On all graphs, click for larger image.)

I wanted to explore the recent history of natural gas prices and try to see what patterns existed and if those patterns could help us predict future prices. In this article I lay out an argument that the price spike of 2001 led to the price spike of 2003. And that our recent spike of 2008 will lead to another spike in 2010 (possibly made worse by the credit collapse).

Price Cycles and Volatility

Jeff Vail has been posting some very interesting theoretical pieces on price cycles and asking if we are going to see more volatile prices going forward. Here are three of his articles:

Mechanics of Future Oil Price Volatility (A Flubber Cobweb)
Predator-Prey Dynamics in Demand Destruction and Oil Prices
Oil Demand Destruction

After reading Jeff's pieces I was uncertain what I believed about volatility, so I started gathering data by creating a history of the last decade's natural gas prices. There have been 4 major price spikes. I believe that 2 of these were caused by a spike dip spike pattern. One I believe was caused by Hurricanes Katrina & Rita. (I don't have enough data to estimate how the first one was caused) Figure 1 shows the spike dip spike pattern. The way it works is that the first spike encourages drilling. The extra production causes a price collapse, and drilling stalls, causing an inventory shortage and the next price spike.

A Missing Piece Found: Minimum Production Cost

Nate Hagens wrote an article about the major natural gas producer Chesapeake cutting capital expenditures. The Marginal Btu - The Return of the Red Queen? Nate discusses how the cost of producing natural gas had been rising as fast as or faster than the price charged. He found Figure 2 (Exhibit 8), which I feel is key to understanding the decision making going on inside the natural gas producers.

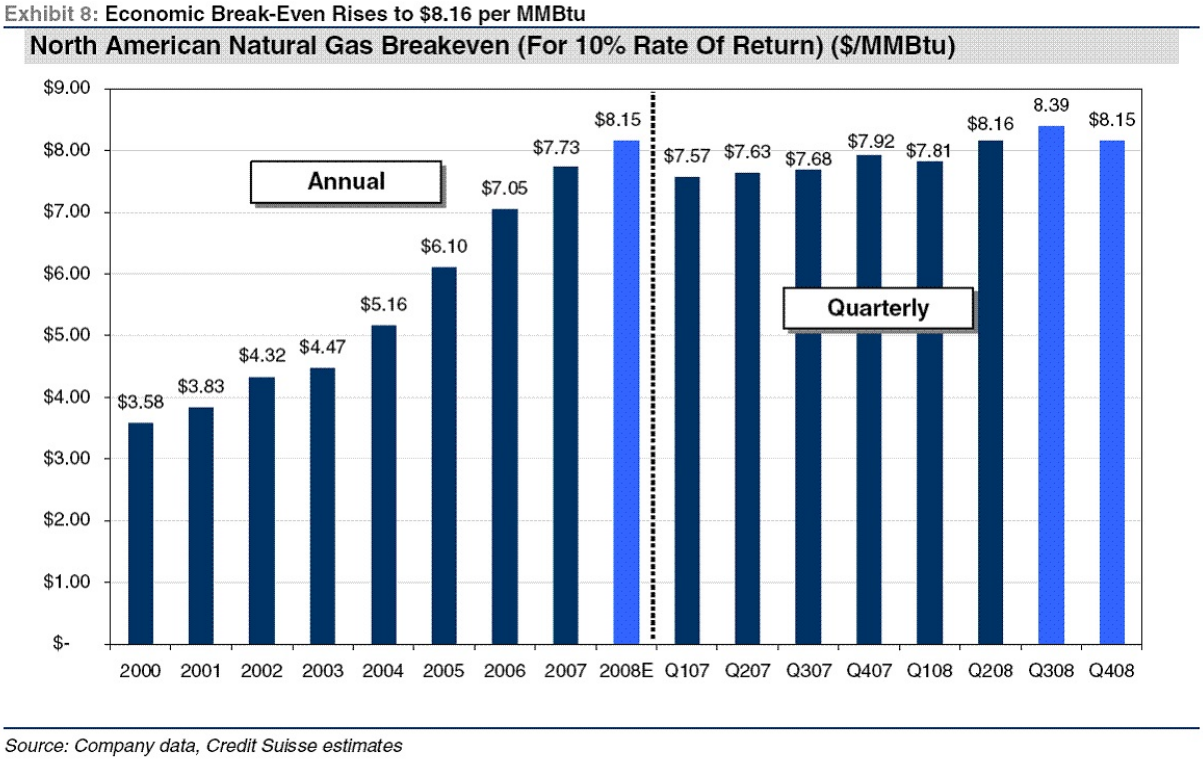

Figure 2. Credit Suisse Producer cost structure estimates.

Studying the System Components

Natural Gas production is a complex dynamic system with surprising behaviors. Even experienced operators have been placed in jeopardy by unexpected and volatile price swings. Being a novice to the field I fell back on the advice found in the book "Thinking in Systems". Author Donnella Meadows recommends "If possible, find or make a time graph of actual data

from the system…" and "Starting with the behavior of the system forces you to focus on facts, not theories. It keeps you from falling too quickly into your own beliefs or misconceptions, or those of others."

What I am going to present next is a series of graphs showing a time line of all the factors I could find about natural gas production over the last 8 years. I want to give you a chance to study the data yourself before I bias your views with my interpretations. Ask yourself: "why did this drilling trend suddenly reverse?" and "how does this price peak match up with the storage graph? " or "how did producers handle falling prices in this case?" ***Editor's note**: If you find this frustrating, fast forward to "Interpreting the Data", just before Figure 9.*

In Figure 3 I plotted well head price plus the drilling rate and Credit Suisse's estimate of North American Natural Gas Breakeven value together because it seemed logical that drilling will slow or stop if it is not profitable. Following the orange drilling line from left to right, in Figure 3, you can see it reverse trend as price falls below the breakeven cost in July 01.

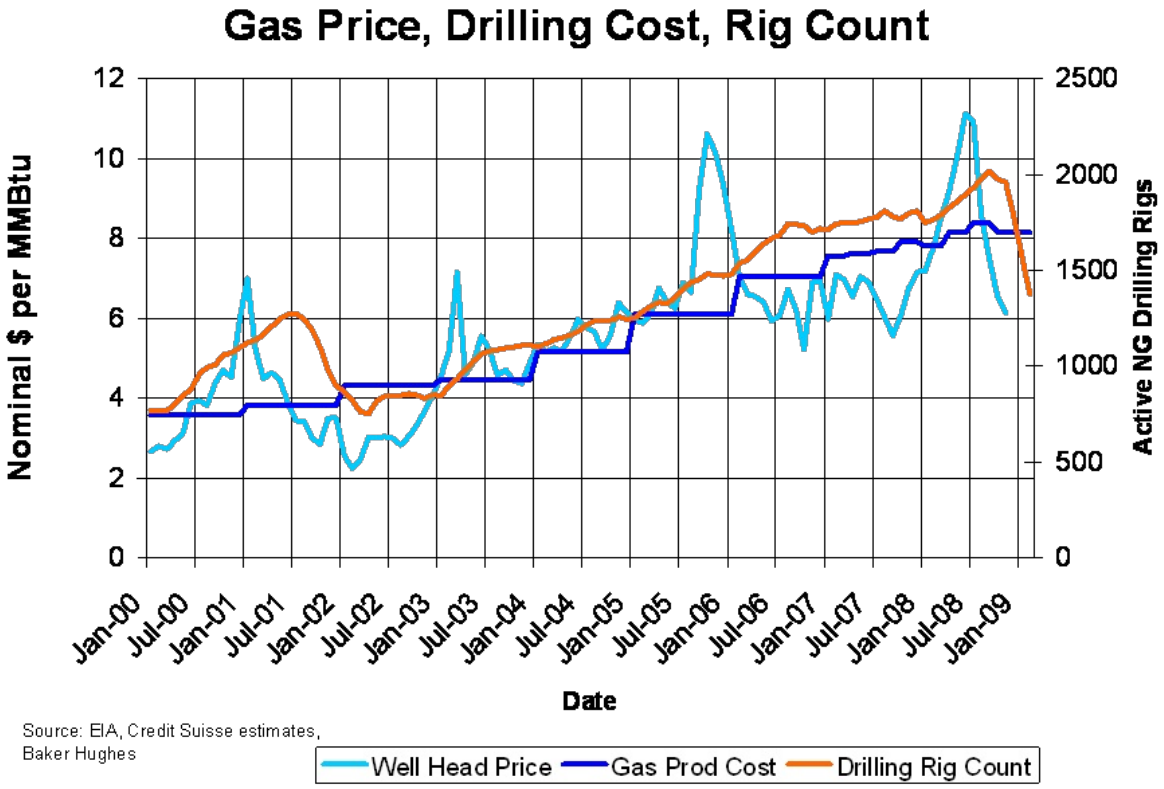

Figure 3. Well head price, breakeven production cost, and active drilling rig count plotted against each other.

(I want to mention that one factor we don't have is the maximum flow rate of currently operating wells. Drilling will be increasing this flow rate and depletion will be lowering it. I want to mention it here, because it is worth plotting in your head the increase in flow rate following just behind the Figure 3 drilling rate).

Inventory is a useful indicator of how well supply and demand are matching. Figure 4 shows the EIAs "Weekly Lower 48 States Natural Gas Working Underground Storage" plotted against Well head price and the Breakeven Cost. How low or high storage is relative to time of year gives a pretty good idea of why prices are high or low. Notice how low prices in July of 02 match with

high levels of storage.

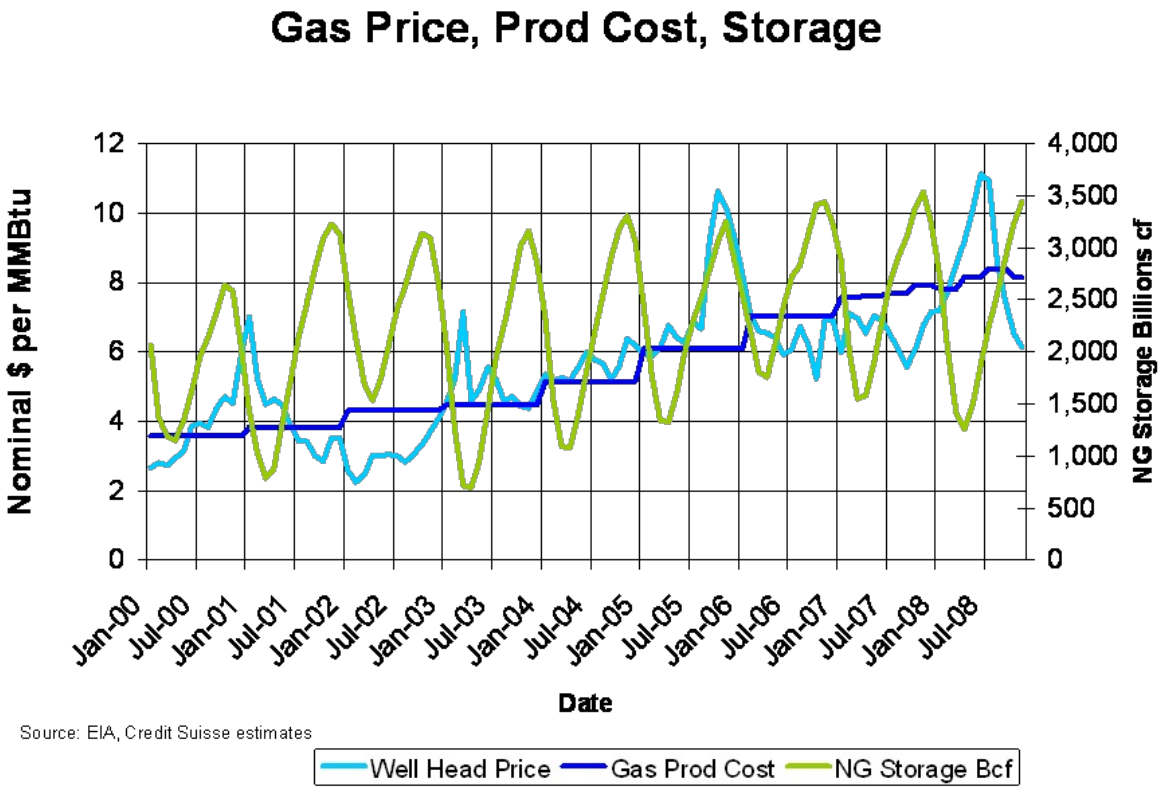

Figure 4. Well head price, drilling cost, and gas in storage compared.

Figure 5 shows the natural gas consumption by each sector. Drilling gives some idea of production, and Figure 5 Consumption gives a picture of demand. Storage and price should be showing the balance between supply and demand.

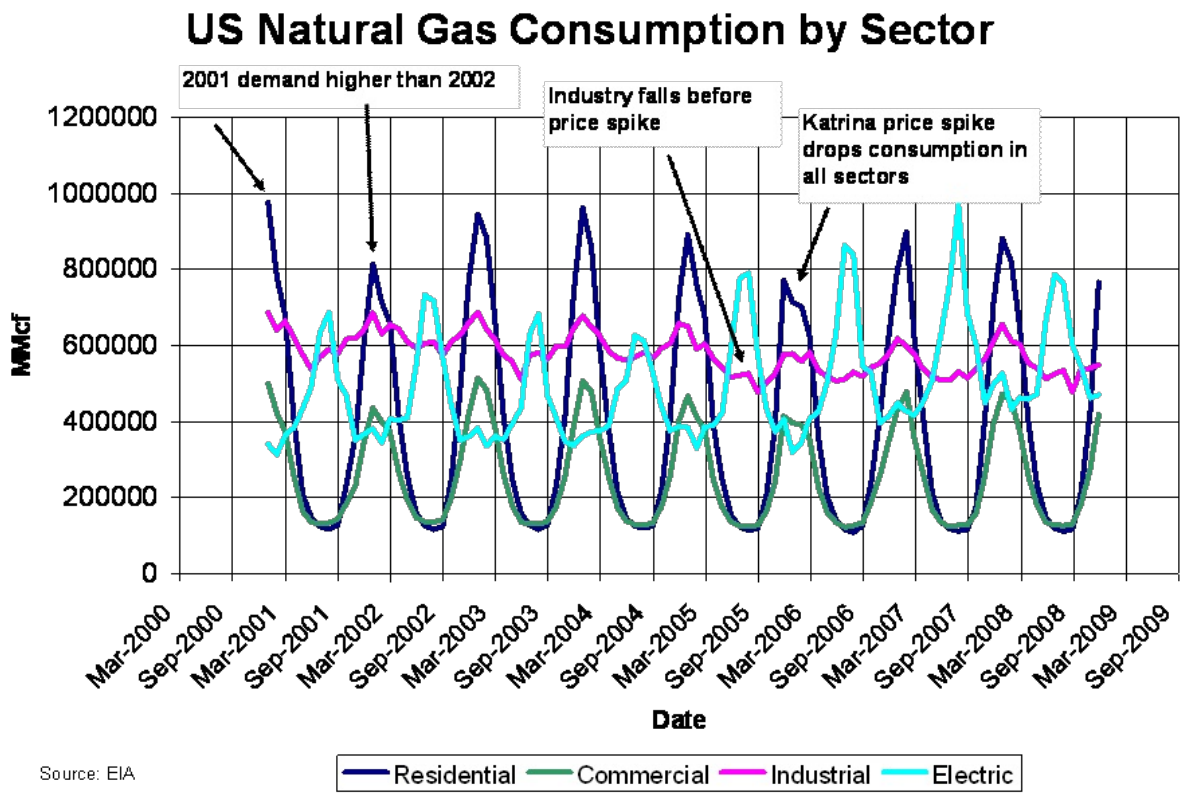

Figure 5. Natural Gas Consumption by Sector allows estimating temperature and price impacts on demand by sector.

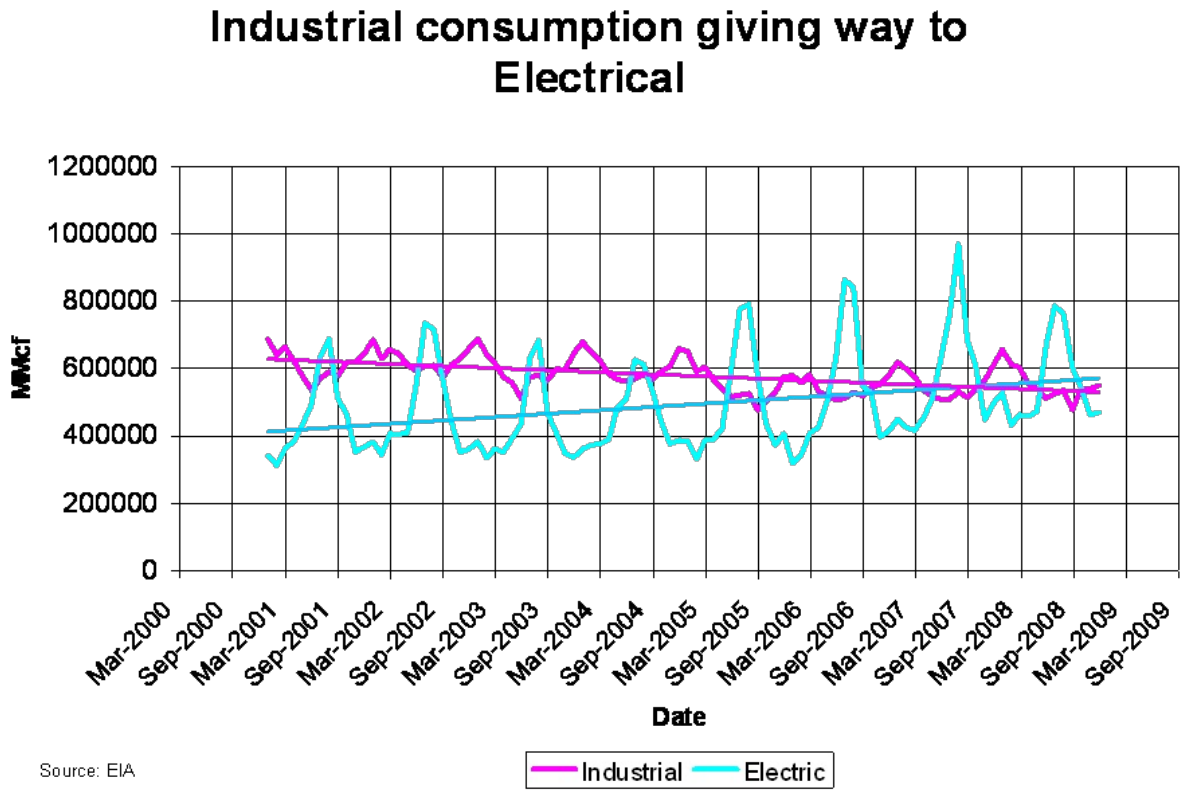

Figure 6. Trend lines showing Industrial gas usage falling while electrical

generation using natural gas grows.

Figure 6 is included to make clearer that Industrial consumption is on a long term decline trend as natural gas gets more expensive. Electrical generation from natural gas is growing even faster however. Electrical generation shows quite a bit of volatility itself.

Hurricane Damage

It would be a mistake to leave out some estimate of the damaging impact of Hurricanes. Figure 7 shows a 10 year history of gas shut ins from hurricanes up to 2005. And Figure 8 updates this by providing data for 2008 Hurricanes Gustav and Ike.

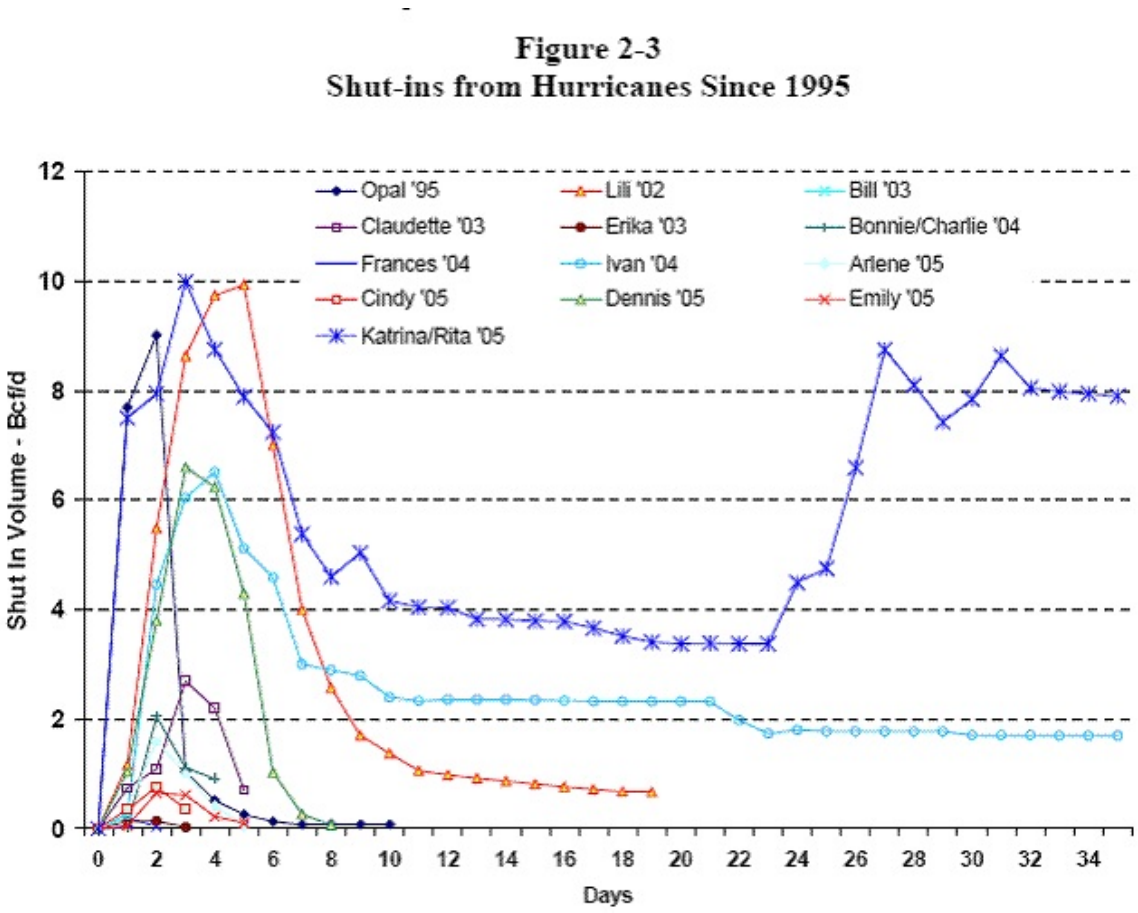

Figure 7 (labeled 2-3). From [EES 2005] showing the shut in volume of hurricanes.

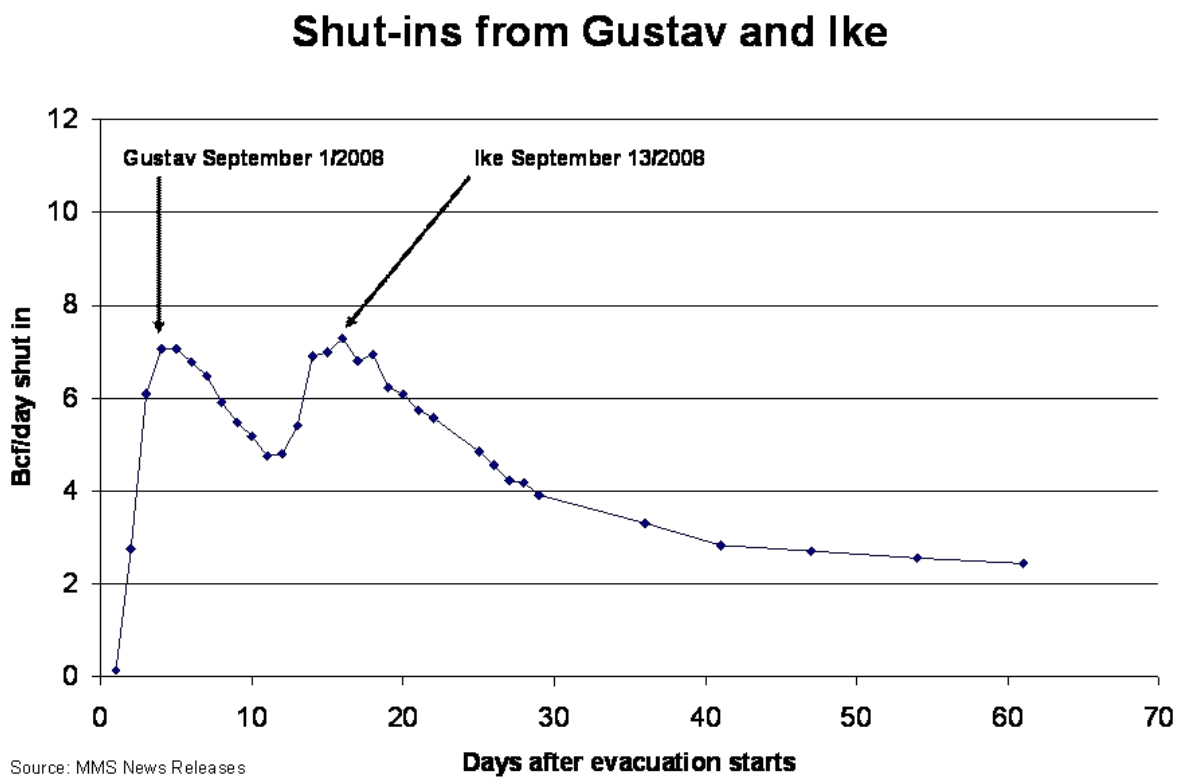

Figure 8. Shows shut in production from Gustav and Ike.

Figure 8 is graphed on the same scale as Figure 7 for easier comparison of impacts to Katrina.

You now have a large amount of raw data. I recommend taking some time to look it over and form your own opinions as to why the price spikes and dips form. Afterwards, continue on for my interpretation.

Interpreting the Data

Here are my views on how the price spike of 2001 turned directly into the price spike of 2003. The short story is that the price spike of 2001 encouraged producers to increase drilling. They went too far and caused prices to collapse. Unable to make a profit on new drilling operations, producers scaled back rapidly. Too rapidly. Flow rates were cut, inventories plunged and prices spiked again.

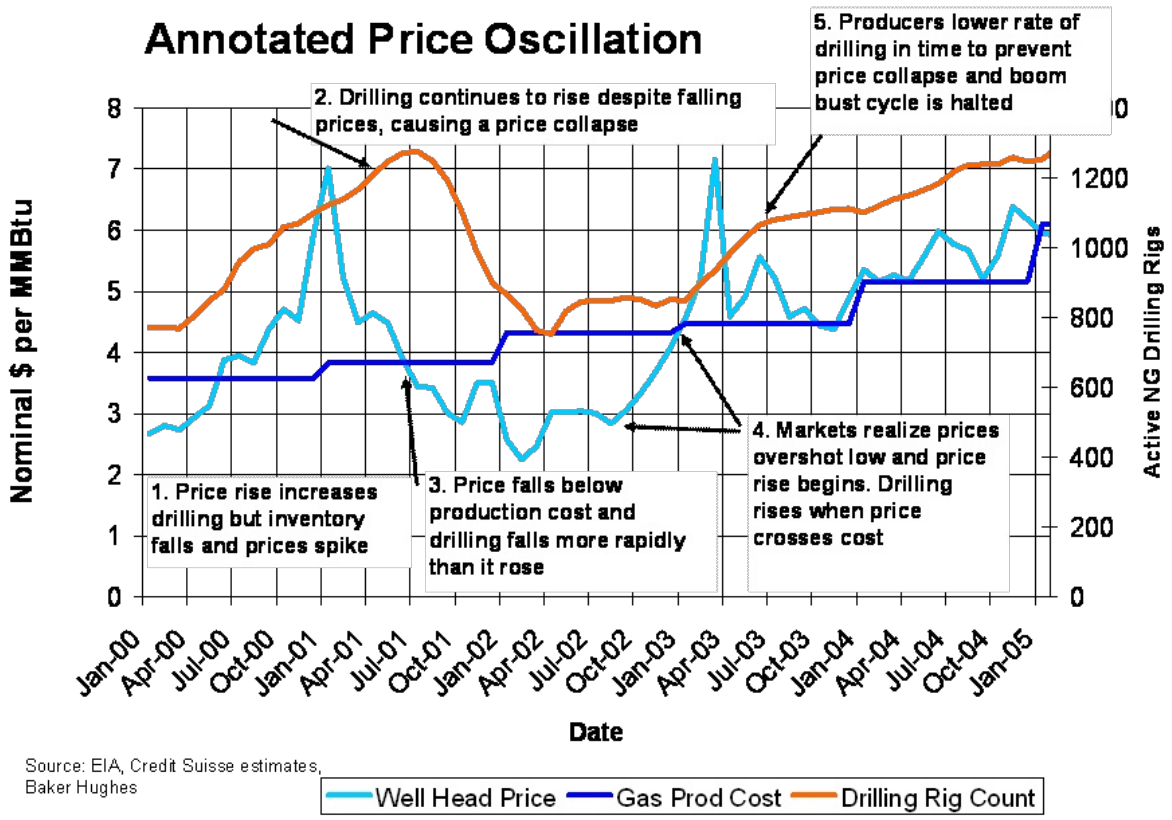

Figure 9. Shows my interpretation of how the 2001 and 2003 price spikes are related.

In Figure 9 at arrow 2, the drilling rate increased. I think this was a fatal mistake. Prices were still well above the breakeven point but they were heading sharply downwards. At the arrow 5 natural gas producers faced the same choice but instead prudently lowered the drilling rate. This prevented another deep overshoot in 2004 and stopped the spike dip spike cycle from repeating again.

It has been conjectured that producers being more conservative in risk taking will increase volatility. In Figure 9 we find evidence for and against this theory side by side. At arrow 2 producers were not conservative enough, and caused volatility by not cutting back. At arrow 4 producers were too conservative and did not start drilling soon enough and thus increase volatility.

Figure 10 has the needed view of storage levels to better understand the price movements.

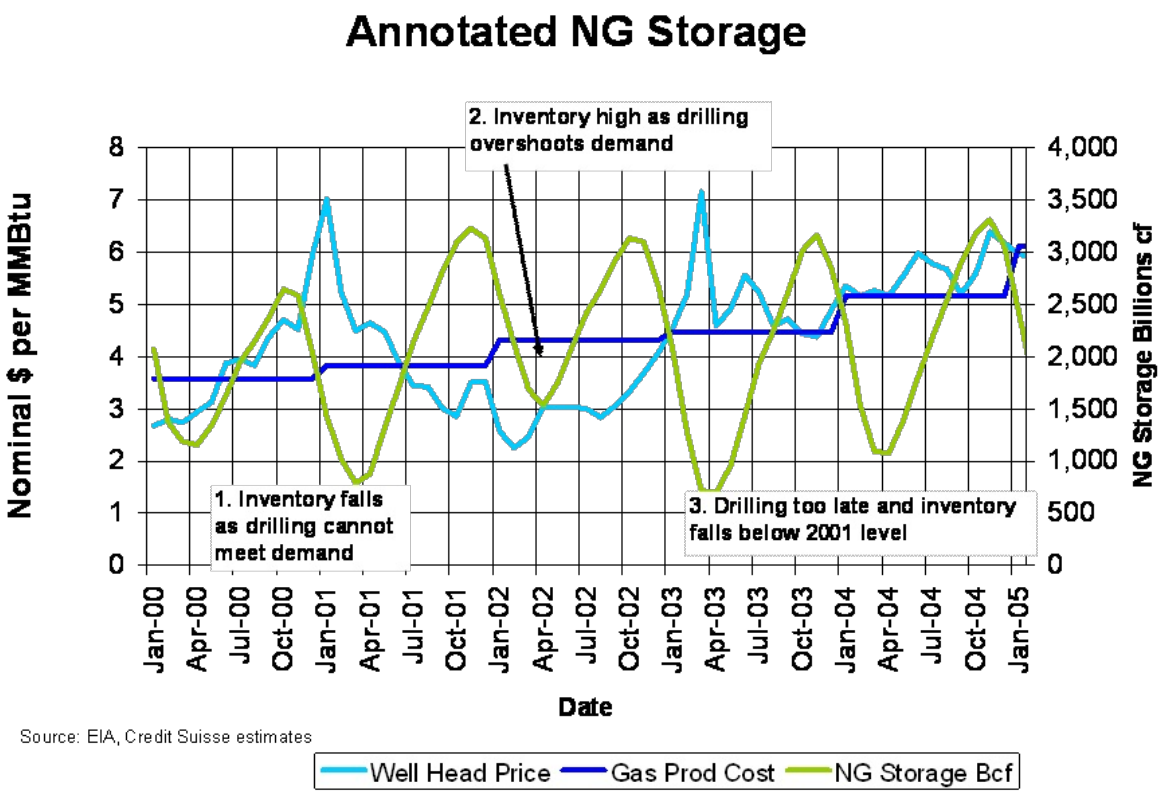

Figure 10. Shows how storage and price interacted during the 2001 and 2003 price spikes.

What is very interesting about Figure 10 is that storage in the winter of 01/02 and 02/03 both reached about the same high levels. Just by looking at storage as a measure of match between supply and demand would not be sufficient. What is not shown is that maximum flow rate was much lower in 02/03 because of the prior cut in drilling rate. By spring of 2003 the natural gas storage was badly depleted and prices were spiking. Since we don't have a graph of maximum flow rate, we are still missing a critical piece of information to model this system. (Suggestions on producing such a graph?)

Producers Regain Balance

After the 2001 price spike, producers mistakenly increased drilling too much and collapsed the price. They did not repeat that mistake in 2003. In Figure 9 arrow 5 you can see that they lowered the drilling rate and thus were able to prevent as deep an overshoot. Figure 10 shows that inventory did not fall as far in April 04 as they had in April 01 or April 03. So by not over producing and then over cutting, producers were able to stabilize inventories and prevented the spike dip spike cycle. It was a near thing. A few Bcf less storage and the cycle could have repeated.

The natural gas producers managed to balance the market for nearly a year and a half. Figure 9 shows prices were hovering just over the cost of production from 04 to 05 Inventories rose in 05 and that might have started another oscillation in 2006, but the arrival of Hurricane Katrina never gave it the chance.

Katrina Restarts the Oscillation

Hurricane Katrina struck at the end of August 2005, doing tremendous damage to the natural gas infrastructure. Katrina was followed quickly by Rita. Figure 11 shows that natural gas prices spiked far above the 2001 and 2003 levels. Producers were actually quite slow to increase drilling during this spike. It was clearly unexpected. Drilling did start to pick up, but by then prices were falling back towards a rapidly rising break even cost. Looking at Figure 12 shows that inventories never really fell despite the amount of gas shut in, so it is possible that a fair amount of the spike was fear related or because gasoline costs were spiking.

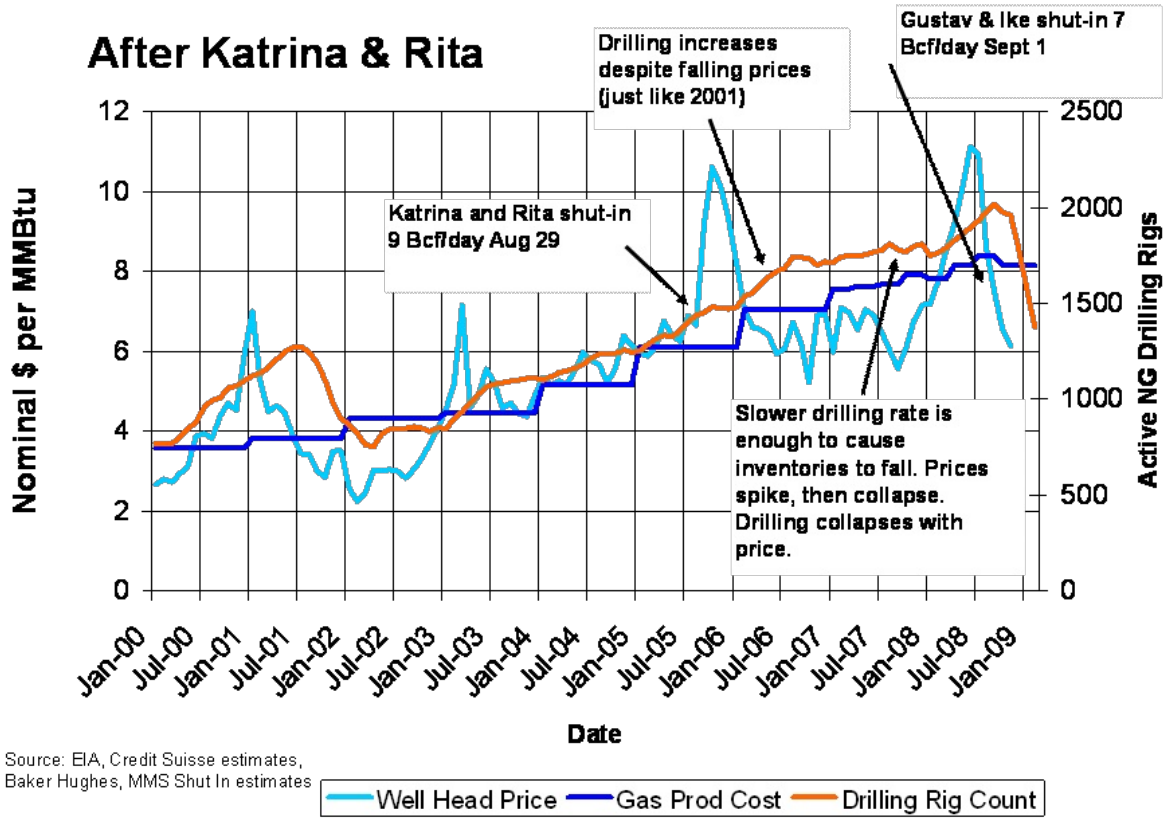

Figure 11. Showing the Hurricane impacts of 2005 and 2008.

Figure 11 shows that producers were also slow to respond to the drop in prices. They just kept increasing the drilling rate while inventories remained high and prices were falling. Prices could not be stabilized above break even. From July 06 to Jan 08 drilling rates and prices struggled to balance, both jumping from month to month. Prices began to move up in January of 08. Figure 12 shows that inventory would drop to a rather low level by April 08. Prices continued to rise back to Katrina level highs. Figure 12 also shows that part of this price movement may have been natural gas following oil prices to record highs, because the storage inventory levels never fell as far as in 2001 and 2003.

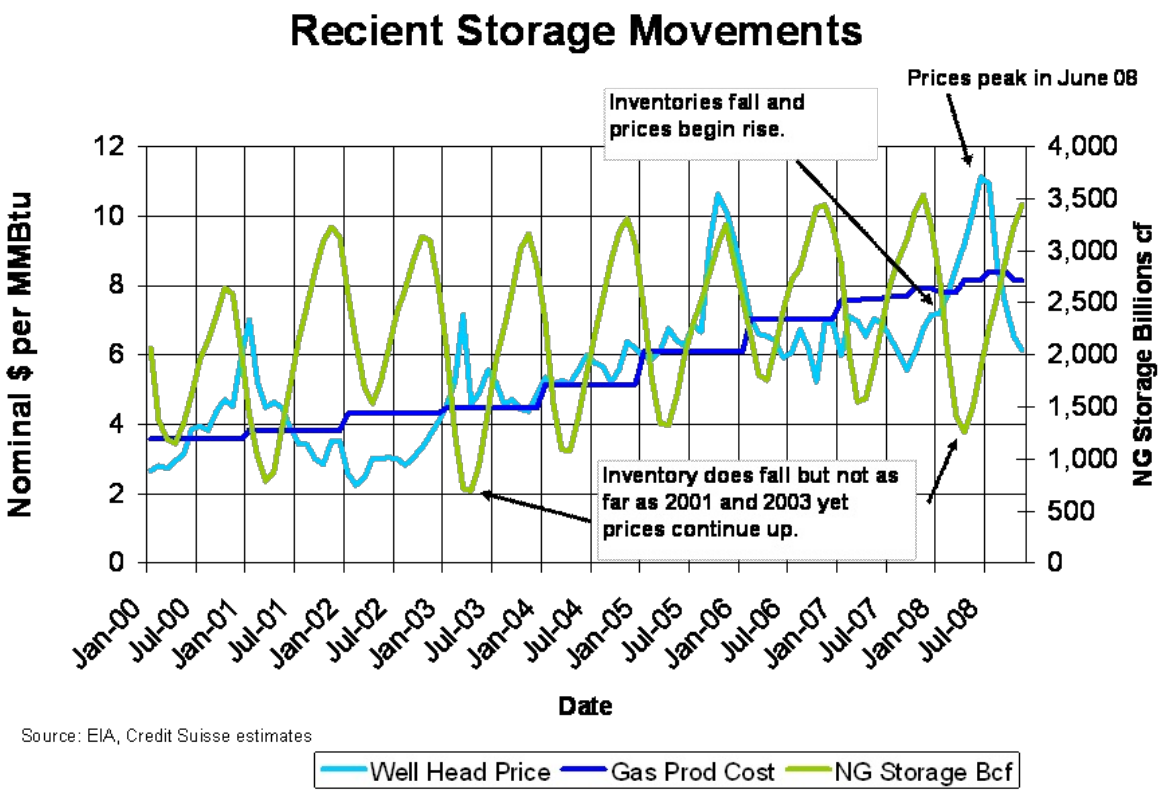

Figure 12. Showing annotated storage movements during the last 2 years and how inventory in 08 compared to 01 and 03.

Our Current Situation

In September - October the banking sector collapsed and the economy with it. Inventory levels rose above the 5 year average and prices fell rapidly. Producers scaled back drilling as soon as prices passed the break even point and drilling rates are now falling faster than any time this decade.

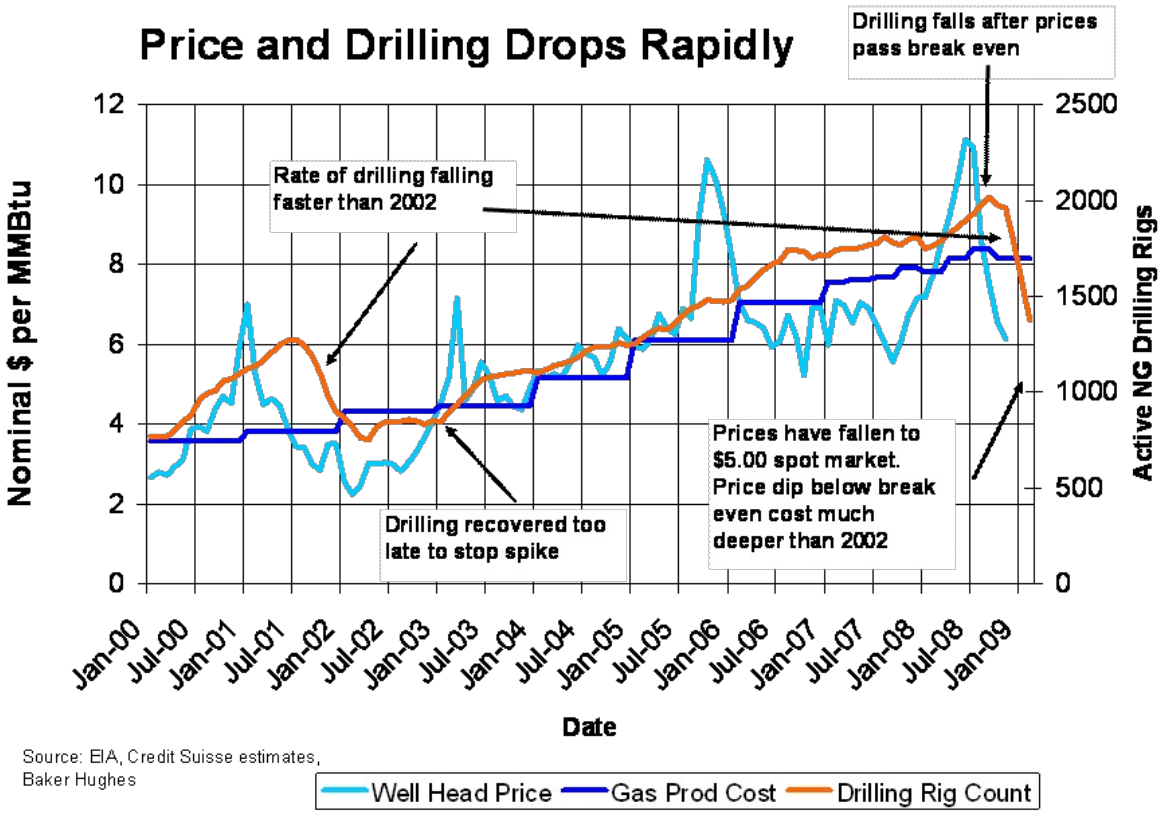

Figure 13. Our current drilling rate and price situation annotated and compared to the situation after the 2001 price spike.

Despite the rapid fall in drilling rate, inventories are above the 5 year average and the EIA reports that Northeast spot prices have dipped below $5.00 per MMBtu. This is far below the $8.15 breakeven costs estimated by Credit Suisse for 2008.

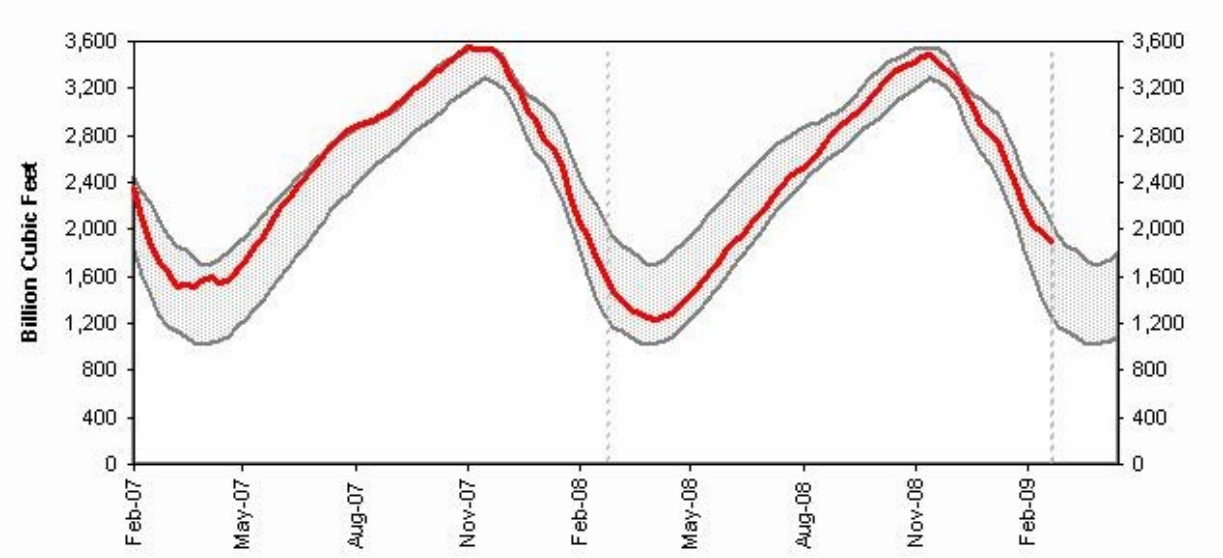

Figure 14. EIA Natural Gas Storage report showing inventories rising above the middle of the 5 year average.

Gustav and Ike both struck the Gulf of Mexico natural gas production. The total natural gas taken off line was less than Katrina & Rita and the outages did not last as long. Those impacts did

nothing to stop inventories from filling and prices from falling. Clearly domestic on shore production had over produced by quite a large margin.

The Perfect Spike Setup

We are now living through another perfect spike dip spike pattern. The 2008 price spike encouraged over production. High inventories will suppress prices. The drilling rate will continue to be cut back which will eventually cut maximum flow rate. By the time prices recover enough to restart drilling, it will be far too late to build up enough new wells to meet winter demand. Inventories will fall and prices will spike once more.

Look at Figure 13 and the way prices finally crossed breakeven in mid 2003 on the ramp up to the next high peak. It was not soon enough to stop the price spike. I expect this event again. The only question is how fast the decline in inventories will happen. It took two years from the spike in 2001 to setup the spike in 2003. The last price spike was late 2008, so if the frequency of the pattern holds we may see the next spike in Q1 2010.

Future Investigations

It would be worth examining depletion rates and seeing if there is some relation between the natural gas price oscillation period and rate of depletion. Part of what may be causing spikes is that rapid depletion rates are cutting flow rates faster than companies have experienced in the past. That mismatch may be the cause of undershooting on drilling levels. Clearly we have moved from a period of relative price stability into a period of great chaos. Could increasing depletion rates be the underlying reason?

Excel Spreadsheet: This is a link to Jon's spreadsheet.

References

[EES 2005] *Hurricane Damage to Natural Gas Infrastructure and Its Effect on the U.S. Natural Gas Market, Energy and Environmental Analysis, Inc.*, November 2005