Economic Outlook

THE CARLYLE GROUP
GLOBAL ALTERNATIVE ASSET MANAGEMENT

April 30, 2012

Cheap Natural Gas and U.S. Reindustrialization

BY JASON M. THOMAS

At just over $2 per million British Thermal Units (BTUs), natural gas seems exceptionally cheap. The price of natural gas collapsed along with the price of oil in the depths of the Great Recession. Unlike oil, which has since recovered more than 60% of its peak-to-trough price decline, the price of natural gas has continued to fall. Natural gas is now so inexpensive that its price could increase five-fold from current levels and still be undervalued relative to oil on an energy content equivalent basis. Although the obvious implication is that an investor should buy natural gas and short oil futures, these productive commodities are not financial assets governed by arbitrage arguments. The mispricing has already deepened beyond levels most observers thought possible and continues to grow.

Although the obvious implication is that an investor should buy natural gas and short oil futures, these productive commodities are not financial assets governed by arbitrage arguments.

It has been said that the best "cure" for low commodity prices is low commodity prices. That is to say, natural gas prices are so low that burning natural gas should be extremely attractive to utilities and, more importantly, energy-intensive businesses. Cheap gas increases the expected return on investments in activities like manufacturing and mining, which generates demand for additional pipelines and other types of energy infrastructure. The best way to profit from low natural gas prices in the near term may be through investments in an American "reindustrialization" based on energy-intensive economic activity that can best exploit the economic windfall from cheap gas.

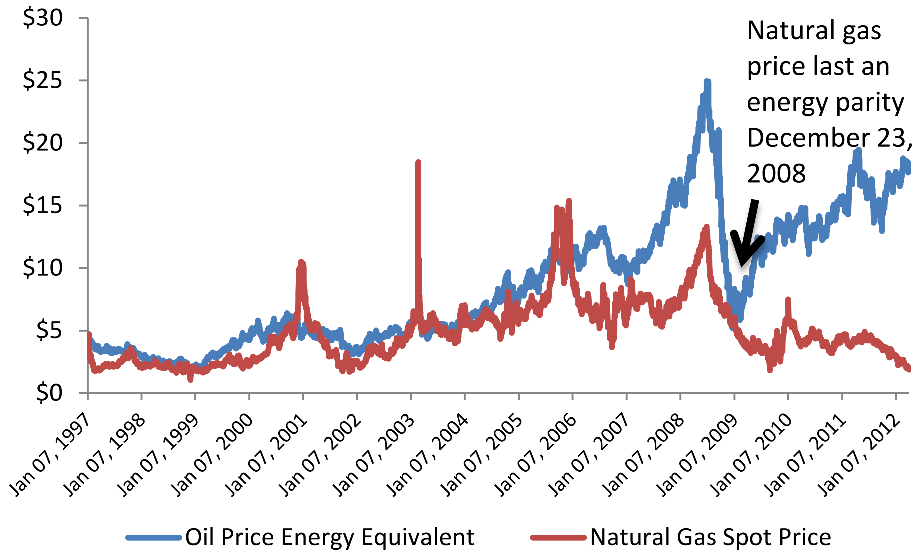
Natural Gas Spot Prices and Energy Content Equivalence

The principle of "energy content equivalence" suggests that the price of energy should be the same regardless of fuel source. Prices routinely depart from equivalence because of the barriers to perfectly elastic interfuel substitution. Aside from dual-fuel industrial boilers and burners for electricity generation, there are few technologies that use oil that can easily switch to natural gas. Differences in market structure, costs of production, transportation, and processing costs also impact relative prices. Crude oil can serve many purposes and is considered a more flexible commodity. Transportation costs are also significantly lower for oil. While liquid natural gas (LNG) technology has reduced transportation costs, LNG can only be delivered to locations with regasification facilities and requires significant irreversible investment.[1]

[1] Dahl, Oglend, Osmundsen and Sikvelend (2011), "Are oil and natural gas going separate ways in the UK? Cointegration Tests with Structural Shifts."

In spite of these factors, energy content equivalence actually has a fairly good track record forecasting natural gas prices. One barrel of oil (WTI crude) contains 5.825 million BTUs, which is the standard unit for measuring natural gas prices. Simply dividing the price of a barrel of WTI crude by 5.825 provides the "energy equivalent" price for natural gas.[2] As shown in Figure 1, between 1997 and late-2005, natural gas prices closely tracked energy parity. In late-2005, the price of natural gas briefly increased above its energy equivalent level before declining below it for the next two years. Parity was achieved again in December 2008 when the price of oil collapsed. Since then, the price of natural gas has drifted downward even as the price of oil has steadily increased.

Figure 1: Natural Gas Prices and Oil Parity



Source: EIA Weekly Spot Prices

The divergence has gone well beyond anything witnessed since standardized futures contracts on both commodities have been regularly traded. Natural gas prices continue to decline relative to oil prices more than 40 months since parity was last observed. Prior departures from parity have been dominated by seasonal factors or gas storage constraints.[3] As shown in Table 2, the price ratio of WTI crude to Henry Hub natural gas is currently 50:1, five times the historic average and 8.5-times energy parity.[4]

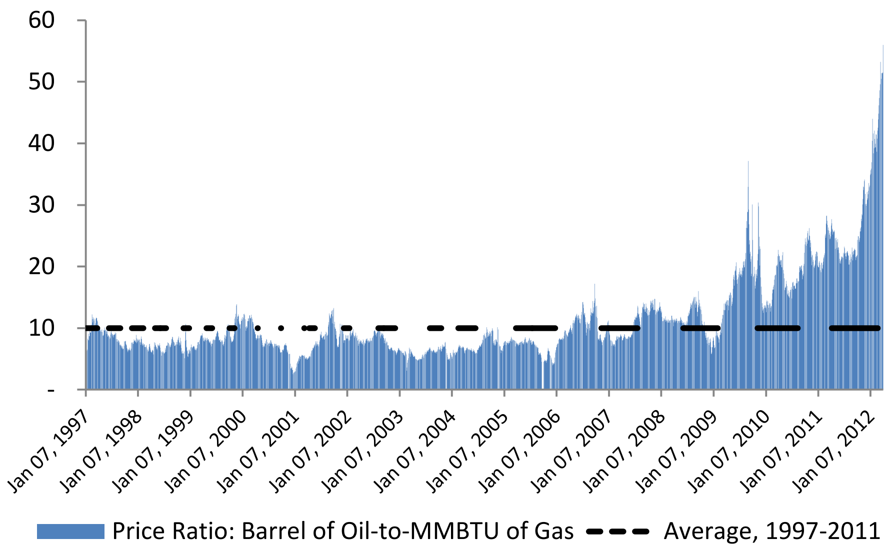
---

[2] One cubic foot of natural gas produces approximately 1,000 BTUs, so 1,000 cubic feet of gas is comparable to 1 million BTUs.

[3] Brown and Yucel (2007), "What Drives Natural Gas Prices," Federal Reserve Bank of Dallas.

[4] Natural gas prices are dominated in the short-run by seasonal factors, like the number of "heating days" during the winter or a sudden heat wave in the summer. The oil market is global and observes no seasonality so these temporary demand factors cause the natural gas price to divergence from equivalence temporarily. Similarly, natural gas storage capacity constraints have resulted in temporary deviations from long-run equilibrium, as supply overhangs (more gas than can be stored) and supply shortfalls (insufficient storage capacity to meet demand spikes) both have contributed to temporary disturbances to price parity. Ramberg and Parsons (2011), available at: http://dspace.mit.edu/handle/1721.1/61777.

Figure 2: Oil-to-Natural Gas Price Ratio



The Supply Shock from "Unconventional" Gas

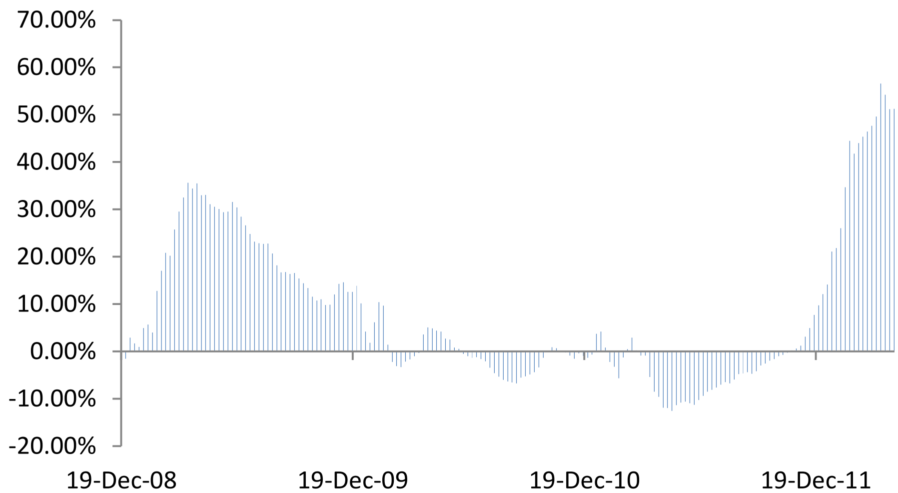
The most plausible explanation for the price divergence since late-2008 is the increase in amount of natural gas that could potentially be recovered from shale formations using horizontal drilling and hydraulic fracturing ("fracking") techniques. Between 2009 and 2011, the total volume of recoverable shale gas resources in the United States more than tripled from 269.3 trillion cubic feet (TCF) to 861.7 TCF, according to the Energy Information Administration (EIA).[5] The same EIA estimated that the total volume of recoverable shale gas fell by 44% to 481 TCF in 2012 due to updated data from the U.S. Geological survey.[6] The volatility of the EIA's estimates should not be surprising: the technology is barely a decade old and geologists and engineers have very limited experience with these reserves. The EIA's point estimate gives the appearance of precision to an inherently unknowable quantity that depends on future economic conditions, operating technology, and government regulations. As with all productive commodities, the amount recovered ultimately depends on the net present value of the marginal investment.

Whatever the "true" long-run recoverable volume of gas, unconventional natural gas has contributed to a boom in natural gas production that has outstripped short-run demand. The daily rate of natural gas production in the Marcellus shale, for example, doubled in 2011 alone.[7] At the same time, an unseasonably warm winter dramatically reduced the amount of natural gas consumed for heating relative to historic averages. The result has been huge increases in natural gas inventories (see Figure 3). If natural gas production continues to exceed natural gas consumption at the current rate, the entire 4.4 trillion cubic feet of natural gas storage capacity in the U.S. would be full by October.[8] This imbalance is the main driver of the recent price decline, which caused prices to dip nearly 30% below the $2.75 per million BTU level Moody's

[5] EIA, 2010 *Oil and Gas Supply Module*, available at: http://www.eia.gov/forecasts/aeo/assumptions/pdf/oil_gas.pdf.
[6] EIA, American Energy Outlook: 2012 Early Release Overview, available at: http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2012).pdf.
[7] EIA, 2012 AEO.
[8] Bentek Energy cited in Fahey (AP), "Natural gas glut means drilling boom must slow."

previously used as its "stressed scenario" for energy credits.[9] While a substantial price decline from current levels is improbable, many conventional natural gas wells continue to pump at $2 to $2.50 per million BTU prices because they also produce natural gas liquids, which can be sold to oil refineries. Similarly, the volume of "associated gas," which is a byproduct of oil drilling, also reduces the "breakeven" price for new natural gas production.[10]

Figure 3: Year/Year Change in Natural Gas Inventory



Source: EIA Weekly Natural Gas Storage Report

Energy Prices and Marginal Efficiency of Investment

EIA expects shale gas production to nearly triple over the next 25 years from 5.0 trillion cubic feet in 2010 (23% of total U.S. natural gas production) to 13.6 trillion cubic feet in 2035 (49% of total U.S. natural gas production). Under this scenario, natural gas would grow from 24% of the electricity generation market to just 27% over the next 25 years.[11] Even if prices double to $4 per million BTUs, this forecast will almost certainly prove too low. A recent paper finds that industrial natural gas consumption increases by 6.7% over the long run for each 10% decrease in natural gas prices.[12] This effect comes first from shifts among utilities. At low prices, natural gas will take a larger share of the market from coal (expected by EIA to fall from 45% to 39%), and slow the growth of renewables given the relatively high cost of these other low-carbon generation alternatives.

More significantly, low cost power is also likely to change the composition of economic activity in the U.S. and accelerate industrialization. Aggregate U.S. energy intensity has declined steadily since the oil price shock and natural gas shortages of the mid-1970s. More expensive energy reduces expected returns on energy-intensive activities like heavy manufacturing by reducing the stream of future operating income generated by a given investment. However, the energy price shock also increased the expected returns on

[9] Robert E. Willett (2012), "Natural Gas Prices: Shale gas makes Wall Street go Medieval on Prices," *Natural Gas & Electricity*.

[10] Oil or distillate is also often recovered, increasing revenues from incremental production. Willett (2012).

[11] EIA: http://www.eia.gov/forecasts/aeo/er/pdf/0383er%282012%29.pdf

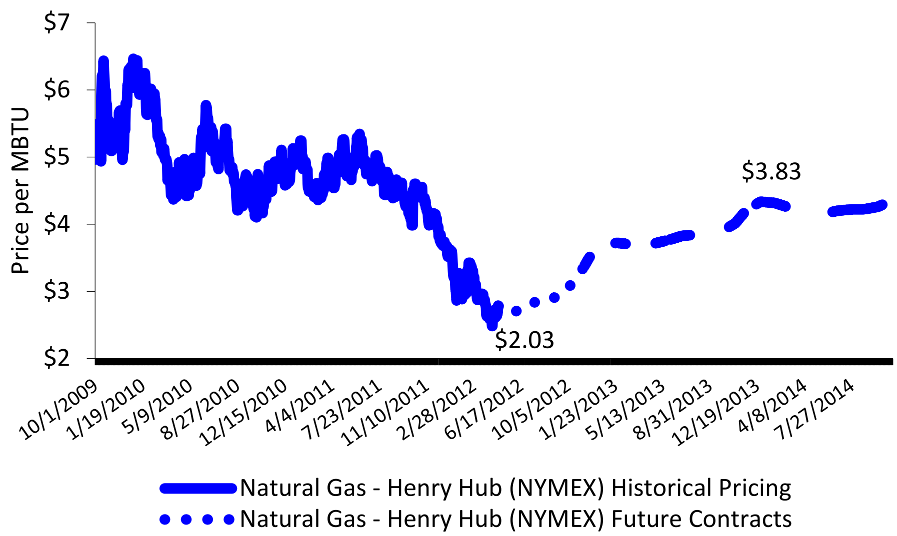
[12] Huntington (2007), "Industrial Natural Gas Consumption in the United States: An Empirical Model for Establishing Future Trends," *Energy Economics* 29, 743–759.

investments in fuel efficient technology.[13] As a result, about 39 percentage points of the 47% decline in energy intensity between 1973 and 2003 was attributable to increases in energy efficiency rather than declines in energy-intensive activities.[14]

Today's energy price shock comes in the opposite direction and increases the expected returns on the marginal investment in manufacturing, mining, agriculture, and other industrial uses of energy. If the primary metals, chemicals, and paper industries grow faster than the rest of the economy, the overall natural gas consumption per dollar of additional output will increase. The price shock would also likely increase prospective returns on the large, irreversible investments in energy infrastructure to supply natural gas directly to industrial users and construct the pipelines to the coast, liquefaction facilities, tanker transportation, and receipt/regasification terminals necessary for the development of an integrated global market in LNG.[15] If the price disparity persists, one would expect transformational technologies to emerge that would allow natural gas to gain a larger share of the transportation fuel market.

Futures prices for productive commodities are not unbiased predictors of future spot prices because they also must account for storage costs, interest rates, and the convenience yield to holding physical possession of the commodity.[16] Nonetheless, it is interesting to note that the December 2013 contract price is only \$3.83 per million BTUs. Based on the Huntington (2007) price elasticity estimate of -0.67, this price would increase long-run demand for natural gas by 49% from the 2008 level. The ability to buy forward natural gas delivery at 75% below the December 2013 energy equivalent price of \$16.65 (based on the corresponding oil future contract) allows prospective users of natural gas to hedge price risk and aides investment planning.

Figure 4: Natural Gas Spot and Futures Prices



Source: S&P Capital IQ

[13] Tobin and Brainard, (1977), "Asset Markets and the Cost of Capital," Cowles Foundation Paper 440.
[14] Metcalf (2008), "An Empirical Analysis of Energy Intensity and
Its Determinants at the State Level," *The Energy Journal*, Vol. 29, No. 3.
[15] Dahl, Oglend, Osmundsen and Sikvelend (2011),
[16] Casassus and Collin-Dufrense, (2005), "Convenience Yields Implied from Interest Rates and Commodity Futures," *Journal of Finance*.

Conclusion

The recent boom in natural gas production has the potential to change the composition of economic activity in America. The oil price shock and natural gas shortages of the 1970s reduced the expected returns on investment in heavy manufacturing and other energy-intensive activity and raised the returns on investments in fuel-efficient technologies. The current natural gas price shock has the potential to reverse this trend and increase the share of output generated by energy-intensive industries. This brightens the near-term prospects for investments in industrial facilities, as well as the pipelines and infrastructure necessary to bring this reindustrialization about.

Contact Information:
Jason Thomas
Director of Research
Jason.Thomas@carlyle.com
(202) 729-5420