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a view from Leonardo Maugeri

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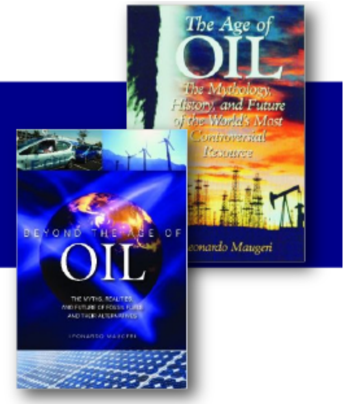


Briefing 2, November 19, 2014

Why US Shale Keeps Booming

Introduction

Since its inception more than ten years ago, the US shale revolution has repeatedly been labeled a temporary bubble. At different times, forecasters who had previously been wrong tried to reassert their point by saying, "*The moment is now…*" perhaps hoping that no one would remember their past errors.

The dire warnings have returned in recent weeks, with many predicting that the fall of oil prices would slash shale and tight oil production in the US. By the way, consider that, with natural gas prices plummeting since 2008, shale gas production in the US increased four-fold. No one seems to have explained this "impossible" circumstance.

Yet the US shale oil and gas revolution will likely continue to defy gloomy forecasts.

Several factors have caused most pessimistic analyses about US shale to grossly underestimate its potential:

- outdated data
- extensive use of models that do not take into account the rapid evolution of knowledge and technology in the shale arena
- persistent under-evaluation of per-well productivity increases
- declining drilling costs
- lack of specific data concerning different productivity and costs across the different areas of the same shale/tight oil and gas formation

These pitfalls also led to misleading numbers about shale break-even points and the marginal costs of US shale/tight oil and gas production.

I will try to clarify these points briefly, and counter these repeated wrong messages about the US shale potential.

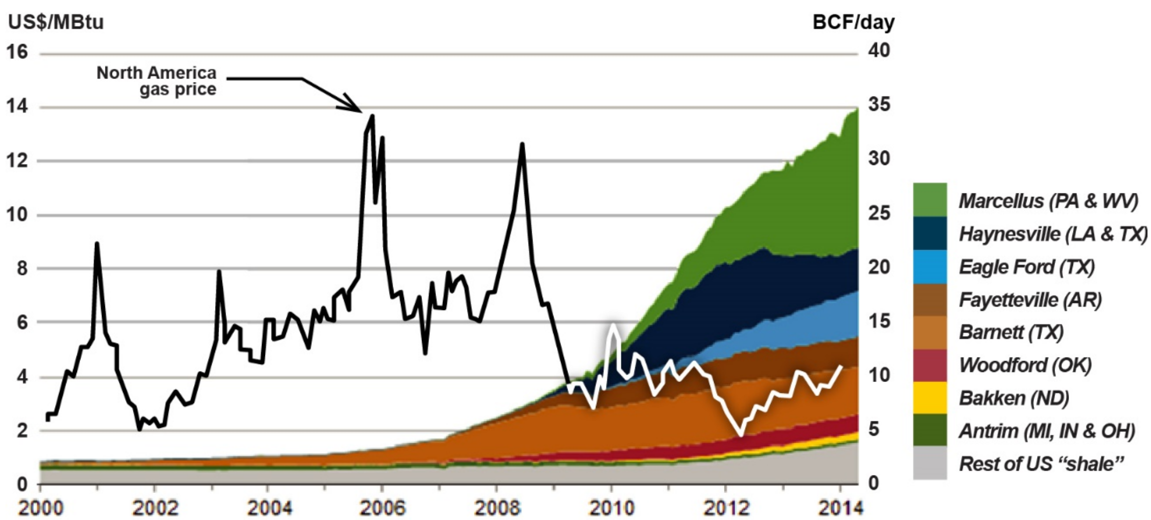
(NOTE: In current literature, the expression "shale gas," like the phrase "shale oil," has come to define resources and production that actually include also tight gas (and tight oil), whose formations have different geological features with respect to shale. However, that distinction is not significant for the purpose of this briefing, so I will use the term "shale" to include both shale and tight gas).

1 - Continuous Advancement of Technology and Knowledge: Why US Shale Is Still Booming

From almost zero in 2000, shale gas production has dramatically ramped up, reaching about 35 billion cubic feet per day (Bcf/d, equal to 365 Bcm per year) in July 2014,[1] as shown in Fig.1. It has continued to grow, and today, at 42 Bcf/d, shale gas represents more than half of total US natural gas production.

What is more startling about the continuous growth of shale gas production is that it has increased almost six-fold since 2008, in spite of both plummeting US natural gas prices (see Fig.1), and a falling drilling intensity for shale gas. Both factors were considered essential for sustaining shale gas production.

Fig. 1 – Against All Odds: US prices of natural gas and shale gas production, 2000-2014



On the price side, most observers were convinced that the majority of US shale gas resources were too expensive to develop, requiring prices of more than $ 6 per MBtu. Yet, shale production registered a real boom just after the dramatic fall of US natural gas prices started in 2008, and continued to thrive even after prices plunged at their lowest levels, lingering at around $ 1.90 per MBtu in April 2012.

As to drilling intensity (the number of wells drilled in a given area), it is worth noting that the output of each shale well declines quickly, losing more than 50 percent of its initial production (IP, generally average production for the first 30 days) after only twelve months of activity. Thus, to sustain and increase shale production, it is necessary to drill as many wells as possible on the same field.

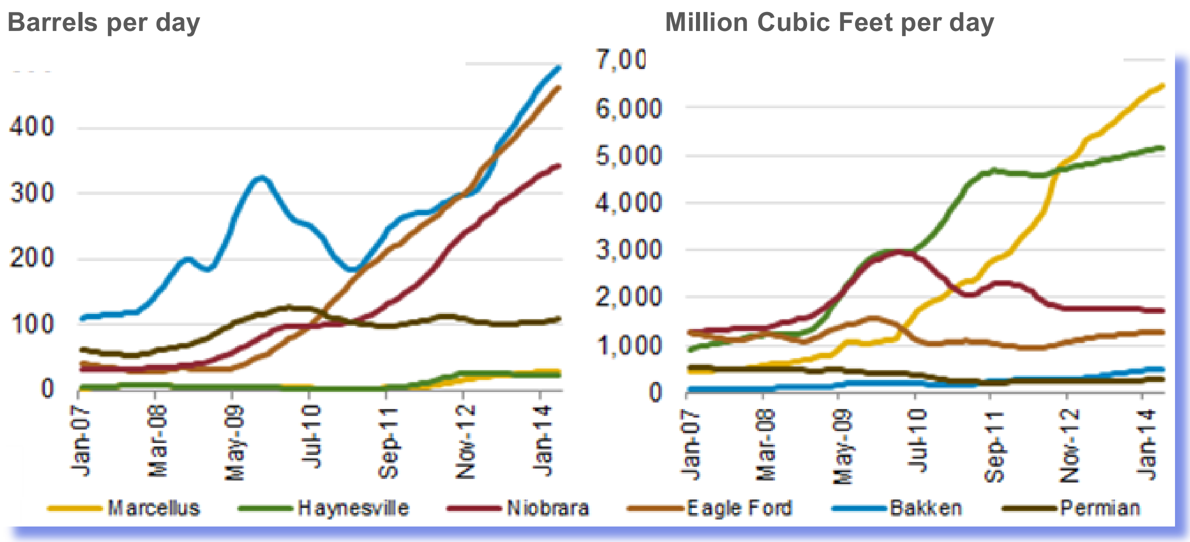
Despite this sort of "shale iron law", the number of natural gas weekly active drilling rigs fell dramatically from an average of 1,500 in 2008 to slightly more than 300 in 2014.[2] This was in line with the progressive fall of US natural gas prices. Nonetheless, shale gas production continued to rise.

What happened?

At least two main factors prevented the grim fate of shale gas predicted by many. First was growth from the prolific and relatively cheap Marcellus Shale, probably the largest gas field in the world. Through July 2014, Marcellus reached a production rate of 15 Bcf/d, accounting for almost 40 percent of US shale gas production: a staggering increase for a field that produced less than 2 Bcf/d in 2010.[3]

Second was the dramatic productivity increase of each new well across most US shale oil and gas plays, a consequence of better knowledge of shale, and improved technology to develop it (See Fig. 2).

Fig. 2 – US monthly new-well shale oil and gas production per rig, 2007-2014
(Predominantly shale oil fields: Bakken, Eagle Ford, Permian, Niobrara.
Predominantly shale gas: Marcellus, Haneysville)



Source: EIA (See Note for methodology) [4]

For example, new well production per rig in the Marcellus increased six-fold from 2010 to 2014. In the Haneysville shale, another big shale gas play, new wells are now producing four times as much as they did in 2007.[5] Similarly, in just four years, per-well productivity increased almost five-fold in the Eagle Ford (predominantly a shale oil play),.and more than doubled in the oil rich Bakken.

At the same time, according to my analysis, drilling and development costs per well decreased by about 40 percent from 2010 onwards.

This powerful combination of increased productivity and Draconian cost reduction explains why the shale gas revolution thrived in spite of plummeting US gas prices. It also explains why shale oil production will likely continue to grow in the near future. The combination results from a dramatic advancement of knowledge of shale formations and the technology used to develop them. Analyses that underestimate the actual evolution of US shale oil and gas production seem to have ignored the impact of those two factors.

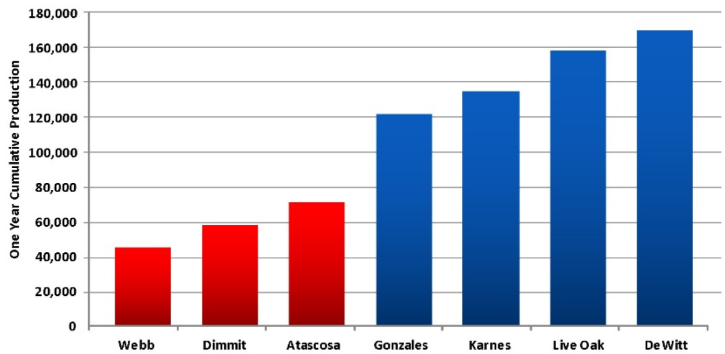
Those analyses, and the models used to simulate the ultimate recovery rate (URR, or also EUR, estimated ultimate recovery) of shale resources, are based on databases of wells drilled a few years ago, when both knowledge of shale and the technology were still in their infancy. The same models do not factor in technology advancements; the static picture of shale they offer does not reflect reality.

2 - Beware of "break-even" and "marginal cost" analyses

An additional mistake lies in the way break-even points and marginal costs analyses are usually calculated. A short digression is necessary to deal with this point.

As I have pointed out in the past,[6] shale oil and gas productivity and costs vary dramatically among the different areas of a shale formation, and the difference between owning the best acreage or the worst is what makes winners and losers. Fig.3 shows an example of productivity differences for Eagle Ford oil.

Fig. 3 – Eagle Ford: 2013 average per well crude oil production (first year) in different counties[7]



Clearly, the difference in productivity of each area of a shale formation reveals striking "break-even" differences across the same formation (on a micro-level, it also implies that wells drilled in a certain area have a bigger productivity than others). Thus, to have a sound assessment of how unprofitable a shale formation could become below a given price level, it is essential to have a clear understanding of the break-even point of each area and to weigh it against the production of that specific area.

This kind of evaluation is also necessary to obtain a correct view of the marginal costs of a given formation.

For example, McKenzie County, North Dakota, is the most prolific production area of the Bakken-Three Forks formation, with an average output of almost 350,000 barrels per day, or, more than one third of total Bakken production of 1.132,000 bd as of August 2014. The McKenzie break-even point (including a 10 percent internal rate of return) is $28 per barrel. Conversely, in August, Divide County, ND (also in the Bakken), produced slightly more than 35,000 bd, but with a break-even point of $85 per barrel. Overall, 80 percent of Bakken oil now has a break-even point below $42 per barrel.[8]

Finding these numbers is hard, so most analysts resort to oversimplified models and use input data that do not weigh specific break-even points against specific production levels. This creates misleading indications about both.

I do not understand, for example, how those claiming that the average break-even point of Bakken oil is higher than $70 per barrel have calculated that number. In any case, the notion of "average" may be highly misleading when referred to shale.

What's more, falling oil prices are prompting oil companies to ask service companies (those making fracking jobs and other related services) to review downward their tariffs, adding the threat of slashing their demand for services. From early insights, these kinds of requests seem to be destined to succeed, implying a general decrease of cost for shale activity in the near future.

As to marginal costs, while it is perhaps formally correct to say that the marginal cost of production in the Bakken has a break-even point of $85 per barrel, it is very misleading not to point out that this number refers to less than 3 percent of overall Bakken oil production.

3 - Conclusions

Having no crystal ball, I cannot forecast what the shale oil and gas production will be ten years from now.

As of today, however, the facts seem to indicate that improved knowledge of the inner secrets of shale and continuous technological advances have allowed the best performers to overcome the price/cost hurdle and to thrive in spite of plummeting prices. In purely economic terms, my expectation is that both US shale oil and gas production will continue to grow over the next few years unless a real collapse of prices take place.

At the same time, "drilling-intensity" and new drilling techniques, particularly "pad-drilling" (which allows for drilling several horizontal wells from a single surface rig), have offset the dramatic per well production decline, simply by drilling more wells on the same formation.

I tend to believe that this peculiar feature of shale exploitation – drilling intensity – will become the real limit to shale expansion across the United States and the world.

In particular, this could occur in more densely populated areas, where drilling intensity will bring out the problems of land aggression and environmental harm, which represent the dark side of the shale revolution.

But that is another story, worthy of its own specific analysis.

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For more info see: *http://belfercenter.ksg.harvard.edu/experts/2510/leonardo_maugeri.html*

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Previous Briefings:

1 – The Oil Surprise : Why I Was Right. *October 26, 2014.*[9]

NOTES

[1] US Energy Information Administration (EIA). Natural Gas Weekly Update for week ending June 25, 2014. At: http://www.eia.gov/naturalgas/weekly/

[2] Baker Hughes, North America Rotary Rig Count: January 2000 Current. At: http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother

[3] EIA, Drilling Productivity Report, August 2014. At: http://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf

[4] EIA's methodology to estimate new-well production per rig uses several months of recent historical data on total production from new wells for each field, divided by the region's monthly rig count, lagged by two months. A new well is defined as one that began producing for the first time in the previous month. Each well belongs to the new-well category for only one month. Reworked and recompleted wells are excluded from the calculation.

[5] EIA. Growth in U.S. hydrocarbon production from shale resources driven by drilling efficiency. March 11, 2014. At: http://www.eia.gov/todayinenergy/detail.cfm?id=15351

[6] Maugeri, Leonardo. The Shale Oil Boom: A U.S. Phenomenon. Discussion Paper #2013-05. Belfer Center for Science and International Affairs, John. F. Kennedy School of Government, Harvard University, 2013. At: http://belfercenter.ksg.harvard.edu/files/The%20US%20Shale%20Oil%20Boom%20Web.pdf

[7] Ibidem

[8] Author's processing, based on data from the North Dakota Department of Mineral Resources.

[9] http://belfercenter.ksg.harvard.edu/publication/24653/oil_crash.html?breadcrumb=%2Fexperts%2F2510%2Fleonardo_maugeri%3Fgroupby%3D3%26page%3D1%26hide%3D1%26id%3D2510%26back_url%3D%252Fexperts%252F%26%3Bback_text%3DBack%2Bto%2Blist%2Bof%2Bexperts