The Shale Revolution and Its Implications for the World Energy Market

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Since the mid-1990s, global energy markets have been in a period of dramatic transition. Indeed, the developments of the past two decades have challenged the long accepted global supply-demand paradigm. On the demand-side, stagnating energy demand growth in the OECD has been more than offset by rapidly growing demand in the developing economies of Asia, led recently by China but soon to be followed by India and the ASEAN countries. Given that the combined population of the OECD amounts to about 1.3 billion, or roughly 17% of the planet's population, while developing Asia accounts for almost 3 billion people, it is reasonable to expect the recent and emerging economic growth in non-OECD Asia will have an ongoing transformational impact on global energy markets.

Of course, future growth in the total non-OECD, which accounts for around 6.1 billion people when including Asian and non-Asian economies, will require new energy resources to meet the associated energy requirements. This is where US shale plays an important role. The so-called "shale revolution" caught many industry observers by surprise, largely because it was the progeny of the combined use of hydraulic fracturing and horizontal drilling – neither of which was a "new" technology but together represented a significant innovation – targeted at unlocking hydrocarbon resources in ultra-low permeability, ultra-low porosity shale formations. As a result of this unexpected upstream, onshore innovation, US crude oil production increased to the point that the US is now an exporter of light crude oils produced from shales. Moreover, US natural gas production increased so dramatically that the US departed from the consensus expectation of becoming a large importer of liquefied natural gas (LNG) to now becoming an exporter of LNG.

Oil Market Impact

The aforementioned developments have been revealed in price. With regard to the global oil market, since the late-1990s oil price increased from around $10 per barrel to over $140 by mid-2008, then declined back to the low $30s in late-2008 only to rise and stabilize near $100 through mid-2014. During this time, high prices prompted producers in the US to go after domestic oil resources in shale formations. The subsequent growth in domestic light tight oil (LTO) production since 2008 has put overall US oil production on an extended upward trend, something that had not happened in over 40 years. In fact, two of the largest year-on-year increases in oil

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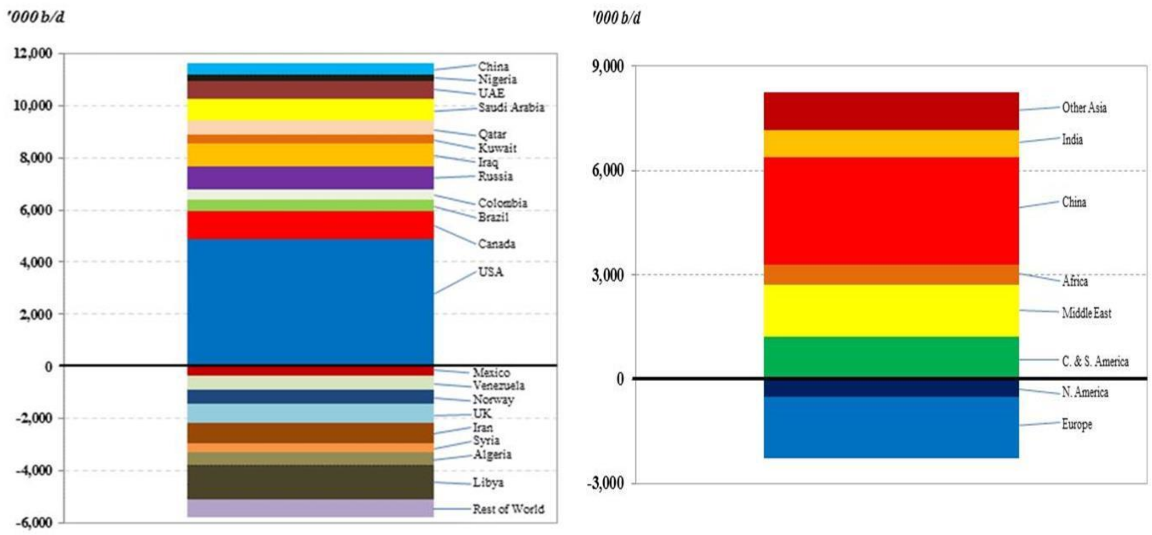
production ever recorded in the US occurred in 2012 and 2013. The growth in domestic LTO production led to significant declines in US crude oil imports and, coupled with the size of the domestic refining complex, drove the US into a position of being a significant net exporter of petroleum products. So, the US shale oil renaissance has been transformational.

Since mid-2014, the oil market has experienced incredible stress, as price has more than halved. This has been brought about by a perfect storm of demand and supply-side factors. On the demand-side, the economies of developing Asia (China in particular) have slowed and the economies of Europe remain weak. On the supply-side, OPEC appears to be striving for market share and the initial market instability of the “Arab Spring” has been subsiding. Exacerbating the implications of robust supply against a backdrop of weakening demand is the fact that US crude oil production has remained fairly resilient, at least through 2015.

As can be gleaned from Fig. 1, US production growth from 2008 through 2014 served a significant market balancing function. During this period, production in areas affected by sector mismanagement (Mexico, Venezuela), civil strife (Algeria, Syria, Libya), and sanctions (Iran) declined by a total of 3.81 million barrels per day (mbpd). At the same time, production in maturing areas (UK, Norway) and the rest of the World declined by 1.28 mbpd and 0.82 mbpd, respectively. Over the same period, US production grew by 4.86 mbpd, offsetting over 80% of the collective decline in global production. Growth in US production coupled with declining US demand reduced US imports and enabled supply from other regions to be directed to meet demand growth outside the US and Europe, which was driven largely by China, India and other Asian economies (see Fig. 1).

Fig. 1　Changes in Global Supply and Demand by Country, 2008-2014

Change in Global Supply　　*Change in Global Demand*



Source: Data from BP Statistical Review

US light tight oil (LTO) production growth from 2008 through 2014 was so dramatic that the prospect of exporting crude oil entered into mainstream policy discourse and motivated the lifting of a 40 year old federal ban on oil exports. Export of LTO from the US lower 48 states has since become a reality (although the US is still an importer of heavier crude oils). The extent to which this has been transformative cannot be overstated, especially considering that just a decade ago US dependence on oil imports was of such paramount concern that it triggered policy measures to raise domestic biofuels production in the name of energy security.

The successes realized in US shales also have longer term, albeit uncertain, implications for global energy market balances. In particular, one of the most important long term impacts is the tremendous interest that has been generated in unlocking shale resource potentials around the world. While an array of above-ground factors will ultimately limit the pace of development in many regions relative to what has been witnessed in the US, governments and industry players are seeking to make the opportunities real.[1]

While the impact of US shale production on global oil markets has been profound, the global oil market is already deep and very liquid. Therefore, while the growth of US shale production has substantial bearing on current and projected patterns of trade in the global crude oil market, which has implications for global geopolitical relationships, the structural aspects of crude oil pricing will not be significantly altered largely because price discovery is already robust and crude oil prices are linked regionally through trade and quality differences.[2] Thus, the market implications for crude oil are quite different than for natural gas, to which we now turn.

Natural Gas Market Impact

The transformative impacts of US shale development extend into natural gas as well. Just a decade ago, the US was largely believed to be an emerging *sink* for global LNG. North America was generally viewed as a mature gas province with limited upstream opportunity, and natural gas intensive industry was leaving the US in favor of lower cost supplies in other parts of the world. This manifested from the fact that natural gas prices between 2003 and 2006 were higher in North America than anywhere else in the world. However, this period of high prices prompted small, independent oil and gas producers to seek new profit opportunities in production areas that had previously been deemed commercially unviable. The result of these efforts are well known, as the shale revolution was born and US natural gas production accelerated, only to be followed by US light tight oil production (see Fig. 2).

As a result of such dramatic growth in domestic production, the price of natural gas has fallen dramatically in the US. The average price of natural gas at Henry Hub from 2003-2008 was $7.14

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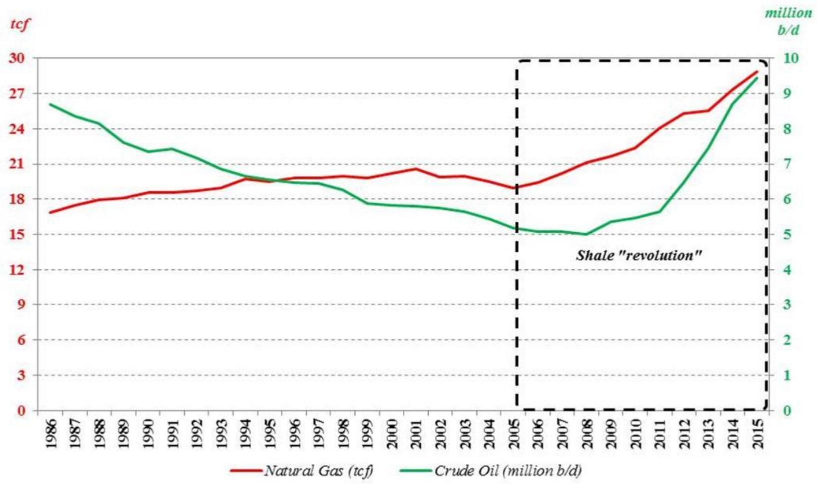
1 For more on the above ground factors that have driven successful shale development in the US, see Kenneth B Medlock III, “Land of Opportunity? Policy, Constraints, and Energy Security in North America” (June 2014) available at http://bakerinstitute.org/research/north-american-energy/.

2 For more on the implications of crude oil quality differences, see Kenneth B Medlock III, “To Lift or Not to Lift? The US Crude Oil Export Ban: Implications for Price and Energy Security” (March 2015) available at http://bakerinstitute.org/research/lift-or-not-lift-us-crude-oil-export-ban-implications-price-and-energy-security/.

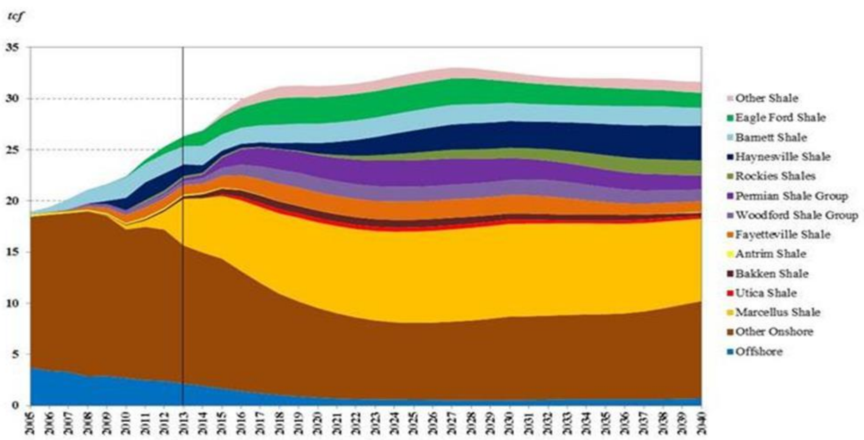
per thousand cubic feet (mcf), reaching highs over $13/mcf in the winter of 2005 and summer of 2008. Since January 2009, price has averaged only $3.69/mcf, with a high of $6/mcf in the bitterly cold winter of 2014. Despite a halving of price, production has remained robust due to continued cost-reducing innovations in the upstream. So, as is typically the case with new frontiers in upstream oil and gas, the first steps into shale were prompted by high prices, but the learning-by-doing that ensued has allowed profitable development to continue despite lower prices. Projections such as those in Fig. 3 highlight the role that shale will continue to have in shaping the future of US natural gas production. In turn, this view of the future natural gas supply future is the foundation for the revitalization of the US industrial sector and has signaled significant arbitrage opportunities through LNG exports.

Fig. 2 US Oil and Natural Gas Production, 1986-2015



Source: Data from the US Energy Information Administration

Fig. 3 US Natural Gas Supply, 2005-2040[3]



Source: Rice World Gas Trade Model, Baker Institute Center for Energy Studies

3 The results indicated are from the Rice World Gas Trade Model (RWGTM). The RWGTM was developed by Kenneth B Medlock III and Peter Hartley at Rice University using the Market Builder software platform provided through a research license with Deloitte MarketPoint, Inc. The architecture of the RWGTM, the data inputs, and modeled political dimensions are distinct to Rice and its researchers. The data in the Fig. 3 depicted are from the recent CES/Oxford study for the US DOE, "The Macroeconomic Impacts of Increased US LNG Exports."

At the time of this writing, one new LNG export terminal has already begun operations (Cheniere's Sabine Pass terminal), and construction is underway to develop additional LNG export capacity at multiple terminal locations. Moreover, the aggregate filings for licenses to export LNG are so large that if every proposed terminal were constructed, it would more than double the size of the *global* liquefaction fleet. Of course, it is highly unlikely that every proposed terminal will be constructed, but the signal of interest is undeniably large, and reflects the abundance of natural gas in North America.[4]

The wake of the disaster at Fukushima triggered an unexpected rise in demand for LNG supplies. Constraints on the ability to meet this unexpected demand shock resulted in Asian LNG prices rising to unprecedented levels relative to other global spot price markers. The phenomenon is not unprecedented; extreme cold in the Northeastern US has driven daily price increases of more than $70/mcf over the Henry Hub price when pipeline capacity is not sufficient to meet the sudden surge in space heating demand. Such dramatic price movement is often referred to as a "basis blowout" by North American natural gas traders. However, unlike the deliverability constraint that developed following the disaster at Fukushima, weather-driven shocks are short-lived, subsiding when the extreme cold passes. Nevertheless, and more important to this thesis, the depth of the US market provides significant liquidity thus enabling large price differences to be quickly arbitraged. As the global LNG market deepens, similar liquidity benefits will matriculate into price determination in Asia.

Indeed, we are already seeing a shift in global natural gas market paradigm. The global natural gas market was previously characterized as three distinct markets – Asia-Pacific, Europe and North America – but the last decade has seen significant growth in liquidity, an expansion of trading and the emergence of market hubs. The arrival of the US as an LNG exporter will only further catalyze this. Already, the continental European natural gas market has seen movement away from trade being almost solely characterized by oil-indexed contract-dominated sales to one where commodity transportation services are increasingly being offered on the basis of price. Notably, this is similar to what transpired in the US three decades ago. The Asian market, which is dominated by LNG trade, is undergoing its own transformation as new supplies compete for existing and anticipated demands that have been slow to materialize. The LNG market is, as a result, currently flush with supply, and participants are left seeking arbitrage opportunities to maximize value in a buyer's market. This growth in physical liquidity is, in turn, triggering interest in the development of market hubs where price discovery and transparency can evolve. As US LNG exports increase, the historical global gas market paradigm of regionally distinct consumers and producers with different pricing structures will be increasingly challenged. In particular, the physical and financial liquidity inherent to the North American gas market will matriculate into the Asian and European markets through regional market hubs, and as this occurs, Asia, Europe and North America will become increasingly linked through trade.

4 Baker Institute Center for Energy Studies research indicates there is an estimated 2,500 tcf of natural gas resource can be profitably developed at wellhead prices below $6/mcf in North America, over 1,400 tcf of which is shale.

Since 2014, spot LNG prices in Asia (often cited as the Platts JKM marker) have fallen significantly. An overall falling commodity price basket has certainly been a barometer for this, but the constraint on LNG deliverability has also been alleviated through lower demand and the introduction of new supplies from Papua New Guinea and Australia. As the market continues to develop, Asian LNG spot price should center on a level that is consistent with a globally arbitraged price. The evolution of a new market paradigm in Asia could happen quickly; after all, the rise to unprecedented price levels in Asia relative to other international spot prices over the 2012-2015 period happened in a six month window in 2011, a fact too often forgotten in the discussion about future pricing in Asia. US LNG liquefaction capacity represents the establishment of a link from US supplies to foreign markets that will accelerate international market liquidity, thereby lowering liquidity risk. This could, all else equal, alter the financing risk of LNG projects and lower the importance of oil-linked bilateral relationships. This is not to imply that contracts are not important for underpinning financing; indeed they are. But, liquidity should incentivize an evolution of terms and contract structures that beget greater flexibility in execution. Regardless, the international gas market will evolve into something dramatically different from what it is today, which is a result heavily impacted by US shale.

Impact on Energy Security

Perhaps one of the most esoteric and underappreciated facets of the US shale revolution is the impact it is having on the notion of energy security. The concept of energy security gained prominence in public policy discourse following the oil price shocks of the 1970s as a documented negative correlation between oil price movement and macroeconomic performance in oil importing countries prompted interest in designing policies aimed at mitigating any deleterious impact of rising oil prices. In this context, “energy security” generally refers to the concept of ensuring an *adequate* supply of energy at a *stable* and *reasonable* price. Hence, the three basic tenets of energy security are adequacy, stability and reasonableness.

Unimpeded access to a diversity of energy supply sources is a crucial component in many energy security arguments, precisely because a highly fungible physical market allows ample arbitrage opportunity to mitigate short term dislocations. Diversification of supply is generally viewed to be beneficial for energy security, a point that Europe has embraced as tensions around natural gas payments from Ukraine to Russia have resulted in temporary pressure reductions on pipelines providing supply to Europe from Russia traversing Ukraine. Shale oil and gas resources provide an important diversification element to the overall global energy supply portfolio. In fact, many political figures have advocated US LNG exports as a means of diversification for Ukraine, and Eastern Europe more generally. Despite the fact that such options are not attainable without some significant capital investment and infrastructure development, this option would not even be on the table if not for US shale. Thus, in a very short period of time the US shale revolution has tilted conversations around energy security in significant ways.

The more profound energy security impact of shale ties back to the impacts on oil and gas markets discussed above. In particular, as markets deepen and become more liquid, the ability to trade through short term market disruptions will result in any single disruption being spread more broadly, thus mitigating its impact on the directly affected region. In this way, the evolution of markets through expanded trade will drive a more energy secure future, with the US, as a stable investment environment, providing a foundation for this paradigm. To be clear, it is almost certain that there will still be disruptive events affecting global energy markets, but the counterfactual world that is absent shale would look very different from a trade and energy security perspective.

Writer's Profile

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He directs the Masters of Energy Economics Program at Rice University, where he also holds adjunct professor appointments in the Department of Economics and the Department of Civil and Environmental Engineering. He teaches advanced courses in energy economics and supervises Ph.D. students in the energy economics field. Dr. Medlock is a principal in the development of the Rice World Natural Gas Trade Model, which is aimed at assessing the future of international natural gas trade. He has published numerous scholarly articles. He is an active member of American Association for the Advancement of Science (AAAS), American Economic Association (AEA), and International Association for Energy Economics (IAEE). He received his Ph.D. in economics from Rice University in May 2000.