The US Tight Oil Revolution:
What Kind of a Revolution?

Dr Bassam Fattouh
Oxford Institute for Energy Studies
Presented at the Saudi Association for Energy Economics
28 May, 2013
Al Khobar, Saudi Arabia
The US Tight Oil Revolution: The Hype

- Robin West (PFC Energy): ‘the energy equivalent of the Berlin Wall coming down. Just as the trauma of the Cold War ended in Berlin, so the trauma of the 1973 oil embargo is ending now’.

- Ed Morse (Citigroup): ‘the growing continental surplus of hydrocarbons points to North America effectively becoming the new Middle East by the next decade’

- Ed Morse (Citigroup): ‘Some producer countries ….those suffering most acutely from the resource curse may see their leadership come under heightened pressure for economic and political reform, as revenues gradually diminish, raising the risk of creating new failed states in the process’.

- IEA: ‘The supply shock created by a surge in North American oil production will be as transformative to the market over the next five years as was the rise of Chinese demand over the last 15’ (note: between 1997 and 2012, Chinese oil consumption increased from less than 4 million b/d to more than 10 million b/d)

- Philip Verleger: ‘the low price of natural gas is going to drive oil from the market. Oil in the US is going to have a ‘Kodak Moment’.’
Structure of Presentation

- The Record so Far
- US Tight Oil in the Global Context
- Uncertainty Remains the Name of the Game
- Beyond the Supply Shock
- Conclusions
The Record So Far: The Things We Know
US Liquid Production Growth Been Impressive

From a negative annual growth in 2008, US added around 1 million b/d in liquid production in 2012 and similar growth expected for 2013.

US revolution not only about crude production, but also NGLs (annual average growth of 150,000 b/d between 2009 and 2012).

Source: Energy Aspects
Growth Thanks to Two Major Shale Plays

Share of tight oil out of total **crude** production increased from 2.5% in 2003 to over 40% in 2012

*Source: Energy Aspects*
Much of Crude is Super Light

Source: Energy Aspects
Dislocated Benchmarks

Due to infrastructure constraints US and Canadian crudes became disconnected from global benchmarks resulting in availability of highly discounted crudes.

Infrastructure constraints mostly overcome through investment in new pipelines, railways, barges, and reversal of key pipelines.

Source: Energy Aspects
- Net imports of gasoline has fallen to low levels while US has become a big net exporter of diesel
US Turned into Net Exporter of LPG in 2012

US LPG Exports, 1000 b/d

Source: EIA
Supply Improvements Accompanied with Decline in Liquid Consumption

Year-on-Year Change in Total Oil Demand, mb/d  Gasoline Demand, mb/d

- Year-on-Year change in total oil demand has turned negative (annual average decline of 230,000 b/d between 2009 and 2012)
- Decline is across all products including gasoline which peaked in 2007

Source: Energy Aspects
Impact of Revolution Not Felt at the Pump Yet

- Discounted crude prices have not been passed to US consumers
- Boost in the profitability of some refineries

Source: EIA
Reduction in Oil Imports

Crude Oil Imports, mb/d

Petroleum as a % of Trade Deficit

- US crude imports fell from 10.1 to less than 8.5 mb/d between 2005 and 2012
- Petroleum share of trade balance fell marginally but still high
The Enablers of this Robust Performance

- No shale revolution without high oil price
- Hydraulic fracturing key enabling technology
- But other US specific factors were also important
  - Private ownership of underground resources
  - Strong logistics and oil service providers
  - Well functioning capital markets and cheap cost of credit
  - Liquid futures markets allowing producers to hedge production
  - Heightened political risk in many parts of the world

- Enablers
  - Quality of reserve base
  - Turn activity into sustainable business model
  - Continuous improvement in technology
  - Access to new plays
  - US policy (enabler or disabler)?

---

2013E oil hedging profile for selected US Independents

<table>
<thead>
<tr>
<th>Total % Hedged</th>
<th>% Swaps</th>
<th>Price $/bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antero Resources</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Berry Petroleum</td>
<td>60%</td>
<td>--</td>
</tr>
<tr>
<td>Bill Barrett Corp</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>BreitBurn Energy</td>
<td>77%</td>
<td>66%</td>
</tr>
<tr>
<td>Carrizo Oil &amp; Gas</td>
<td>85%</td>
<td>21%</td>
</tr>
<tr>
<td>Chaparral Energy</td>
<td>70%</td>
<td>17%</td>
</tr>
<tr>
<td>Chesapeake Energy</td>
<td>85%</td>
<td>85%</td>
</tr>
<tr>
<td>Cimarex Energy</td>
<td>35%</td>
<td>35%</td>
</tr>
<tr>
<td>Comstock Resources</td>
<td>84%</td>
<td>84%</td>
</tr>
<tr>
<td>Concho Resources</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>Continental Resources</td>
<td>64%</td>
<td>64%</td>
</tr>
<tr>
<td>Denbury Resources</td>
<td>79%</td>
<td>--</td>
</tr>
<tr>
<td>Energy XXI</td>
<td>82%</td>
<td>--</td>
</tr>
<tr>
<td>EP Energy</td>
<td>89%</td>
<td>60%</td>
</tr>
<tr>
<td>Exco Resources</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>Forest Oil Corp</td>
<td>53%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Source: Energy Aspects
The US Tight Oil Revolution in Global Context
US Supply Shock Being Offset

Looking at world of oil supplies from prism of US gives impression of ‘oil abundance’

US helped offset decline in non-OPEC somewhere else

Source: Energy Aspects
Adjustment in OPEC Production

Year-on-Year Changes in OPEC Supply (mb/d)

Year-on-Year Changes in Saudi Arabia Supply
In a Context of Non-Inspiring Oil Demand Growth

Year-on-Year Changes in Global Oil Demand

*World GDP*  
% change on a year earlier

- Developed countries
- Developing countries
- BRICs
- World

Source: The Economist

Source: Energy Aspects
Impact of Revolution Not Felt on Global Oil Price

Quarterly OPEC basket prices, $/barrel

<table>
<thead>
<tr>
<th>Quarter</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>79</td>
<td>111</td>
<td>108</td>
<td>93</td>
</tr>
<tr>
<td>Q2</td>
<td>72</td>
<td>108</td>
<td>102</td>
<td>107</td>
</tr>
<tr>
<td>Q3</td>
<td>77</td>
<td>102</td>
<td>107</td>
<td>110</td>
</tr>
<tr>
<td>Q4</td>
<td>89</td>
<td>107</td>
<td>110</td>
<td>108</td>
</tr>
</tbody>
</table>

Brent Forward Curve, $/barrel

- Current
- 1 year ago
- 2 years ago
- 3 years ago
- 4 years ago
- 5 years ago

- Question could be posed differently: How high would oil prices have been without the US oil revolution?
US Developments Alone Can’t Have Long-term Transformative Effects on Global Oil Markets

- Other factors needed
  - Demand in US continues to go down due to efficiency and substitution of gas into transport sector
  - Global oil demand to slow down considerably
  - Non-OPEC supply ex-US reverses its downward trend (in part due to the diffusion of technology abroad)
  - OPEC members increase their output capacity
  - Cohesion within OPEC falls

Contradiction: But under these conditions, will US oil shale continue to grow at current rates?

Source: IEA MTOR, Energy Aspects
The Squeeze on OPEC

- Source of squeeze
  - Demand side
  - US production
  - Non-OPEC production outside US
  - Production within OPEC

- Source of squeeze matters: High cost versus low cost producer
  - US high cost producer but highly elastic supply curve: Supply responsive to upward or downward price movements

- Squeeze from a low cost producer different
  - Less responsive to price movements
  - Generate rents even in relatively low price environment

- Will entry of Iraq at a large scale affect cohesion within OPEC?
Competition through OSPs

Iraq and Saudi Arabia OSPs to Europe ($/barrel)  Iraq and Saudi Arabia OSPs to Asia

Source: Energy Aspects
Uncertainty is the Name of the Game
Range of Uncertainty High

- ‘The global understanding of tight oil is still evolving and the range of external forecasts reflects the uncertain landscape’

- ‘Different views on the North American resource base – in particular, whether to expect further growth – are the key factor behind the range of external forecasts’

- Projections sensitive to a large number of factors
  - Resource base of new shale plays
  - Well Productivity
  - Decline Rates
  - Number of wells to be drilled
  - Efficiency of drilling

- Modeling tight oil formations as conventional ones not useful

Source: BP Energy Outlook 2030
Variability in Performance of Shale Plays

Domestic production of tight oil has grown dramatically over the past few years. Tight oil production for select plays was 0.2 million barrels per day in 2012. Source: Drilling Info (formerly HPDI), Texas RRC, North Dakota department of mineral resources, and EIA, through October 2012.

Adam Sieminski, API, April 04, 2013

Within each shale play, production is concentrated within few counties (sweet spots). Source: Energy Aspects

Eagle Ford, Bakken and Spraberry (Permian) are responsible for the bulk of shale oil production. Source: EIA

Eagle Ford, Bakken and Spraberry (Permian) are responsible for the bulk of shale oil production. Within each shale play, production is concentrated within few counties (sweet spots).
High Decline Rates of Shale Oil Fields

Type decline curve for Bakken tight oil wells

Once output from a typical Bakken well begins to decline within 24 months production flow is down to 1/5 level achieved at its peak.

Suppose that no new wells were drilled after 2010, Bakken oil production would have fallen sharply.

Source: David Hughes, Drill Baby Drill, Feb 2013
Sharp Rise in Number of Wells Drilled

No of wells producing in North Dakota

Oil output per well, b/d

Source: Energy Aspects
Underlying Assumptions Not Clear

Citigroup 2012 Projection of U.S. Shale Oil, 2010-2022
(limitless well locations and no declines)

Source: Citi Investment Research and Analysis
Beyond the US Supply Shock
Change in Crude Oil Trade Flows

US Imports of Light Crude, mb/d

US Imports of Medium Crude, mb/d

US Imports of Heavy Crude, mb/d

Source: Energy Aspects
OPEC Exports to US Decline

US Crude Imports from OPEC (mb/d)  US Crude Imports from Algeria (mb/d)

Source: Energy Aspects
Middle East Producers Facing More Competition in Asia

Nigerian US Crude Imports from the US (mb/d)

WAF exports to Asia (mb/d)

Source: Energy Aspects

Back ing out of light sweet crude imports impacted WAF most, impacting Atlantic basin.

West African barrels are increasingly swinging into Asia, weighing on Dubai and supporting Brent-Dubai differentials.
Relative Prices Matter… in the Long Run?

Brent crude spot price vs. Henry Hub spot price (2000–13)

Source: Brown (2013)

Natural Gas Vehicles (millions)

Source: NGV Global, Credit Suisse estimates.
Low Penetration of Gas in Transport Sector & GTL

U.S. Alternative Fueling Station Count

Firm proposed large-scale GTL capacity outlook

<table>
<thead>
<tr>
<th>Plant name</th>
<th>Country</th>
<th>Operator</th>
<th>Proposed completion</th>
<th>Nameplate Capacity (bpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escravos</td>
<td>Nigeria</td>
<td>Chevron/NNPC</td>
<td>2013</td>
<td>34,000</td>
</tr>
<tr>
<td>Oltin Yo’l GTL</td>
<td>Uzbekistan</td>
<td>Sasol/UNG/Petron</td>
<td>2017</td>
<td>38,000</td>
</tr>
<tr>
<td>Sasol Louisiana</td>
<td>USA</td>
<td>Sasol</td>
<td>2018–19</td>
<td>96,000</td>
</tr>
</tbody>
</table>

| Firm Proposed GTL Capacity* | 168,000 |
| Existing capacity at end-2012 | 232,100 |
| Potential global capacity 2020 | 400,100 |

*Projects past the feasibility study and in FEED process

Note: Capacity outlook excludes modular GTL developments, pilot and demo units

Source: Alternative Fuels Data Center

Source: Brown (2013)
NGL Prices Going Down

Ethane Prices, cents/gal

Purity grade NGL prices, cents/gal

Source: Energy Aspects
## The Petrochemical Renaissance?

Thus, intent on capturing the 'ethane advantage', petrochemical companies have announced a string of expansions to existing ethane crackers and a number of brand new plants (see Fig 13, page 19). Although it is unlikely that all of these projects will eventually go ahead, the sheer scale of investment and pace at which the plans have been developed reflects the petrochemical renaissance currently is underway. Indeed, the investment does not stop with ethylene crackers as petrochemical manufacturers are also investing in polyethylene and related factory capacity. Overall, it is clear that US ethylene capacity, and hence ethane demand, is set to rise significantly in the next five years.

Ethane balances at Mont Belvieu are comfortable today… Increasing ethane demand prompts a question of whether US NGL production growth will expand sufficiently to keep pace. In fact, it poses an even more specific question of whether the supplies of ethane at Mont Belvieu, Texas will be sufficient. For ethane, as well as only having one source of demand (petrochemicals), also has very geographically concentrated demand. Mont Belvieu, just to the East of Houston, is the main pricing point for ethane, as almost all of the steam crackers are on the Gulf Coast, accounting for around 95% of ethane demand. Even the proposed capacity additions will not change this greatly; all but one of the projects are on the Gulf Coast with the exception being the Shell plant, which would be sited in Pennsylvania to take advantage of ethane produced from the Marcellus Shale. The inland pricing point for ethane at Conway, Kansas has long been a price taker as, aside from a couple

### Ethylene Capacity Additions

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Type</th>
<th>Cost ($ Mn)</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dow Chemical</td>
<td>Hahnville, LA</td>
<td>Restart</td>
<td>n/a</td>
<td>390</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LyondellBasell</td>
<td>Channelview, TX</td>
<td>Expansion</td>
<td>25</td>
<td>227</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Williams</td>
<td>Geismar, LA</td>
<td>Expansion</td>
<td>350</td>
<td>-</td>
<td>270</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ineos</td>
<td>Chocolate Bayou, TX</td>
<td>Expansion</td>
<td>n/a</td>
<td>-</td>
<td>115</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Westlake Chemical</td>
<td>Lake Charles, LA</td>
<td>Expansion</td>
<td>n/a</td>
<td>-</td>
<td>105</td>
<td>105</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LyondellBasell</td>
<td>La Porte, TX</td>
<td>Expansion</td>
<td>n/a</td>
<td>-</td>
<td>-</td>
<td>386</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Westlake Chemical</td>
<td>Calvert City, KY</td>
<td>Expansion</td>
<td>220</td>
<td>-</td>
<td>-</td>
<td>286</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BASF Fina Petrochem.</td>
<td>Port Arthur, TX</td>
<td>Expansion</td>
<td>n/a</td>
<td>-</td>
<td>-</td>
<td>115</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ExxonMobil Chemical</td>
<td>Baytown, TX</td>
<td>Expansion</td>
<td>n/a</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,500</td>
<td>-</td>
</tr>
<tr>
<td>Formosa</td>
<td>Point Comfort, TX</td>
<td>Construction</td>
<td>1,700</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>-</td>
</tr>
<tr>
<td>Mexichem / Oxychem</td>
<td>Ingleside, TX</td>
<td>Construction</td>
<td>1,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>544</td>
<td>-</td>
</tr>
<tr>
<td>Dow Chemical</td>
<td>Freeport, TX</td>
<td>Construction</td>
<td>1,700</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,500</td>
</tr>
<tr>
<td>ChevronPhillips Chem.</td>
<td>Baytown, TX</td>
<td>Construction</td>
<td>5,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,500</td>
</tr>
<tr>
<td>Shell</td>
<td>Monaca, PA</td>
<td>Construction</td>
<td>4,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,500</td>
</tr>
<tr>
<td>Sasol</td>
<td>Lake Charles, LA</td>
<td>Construction</td>
<td>4,500</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>18,495</td>
<td>617</td>
<td>490</td>
<td>787</td>
<td>105</td>
<td>2,844</td>
</tr>
</tbody>
</table>

*Source: Energy Aspects*
US Propane Exports Increased Sharply

U.S. Exports of Propane and Propylene (1000 b/d)

Source: EIA

Source: Platts
US Exporter of Natural Gasoline (Naphtha)?

- Canada takes US naphtha to dilute western oil sands
  - Sharp Increase in recent months
- But there are limits on Canadian demand especially as production growth slows down
- Some potential demand from Latin America
  - Mexico, Colombia and Venezuela
- But US cargoes will inevitably go to Asia

*Source: EIA*
Conclusions
What Type of Revolution?

• For the US certainly
  ▪ Reduce import dependency
  ▪ Improve balance of payments and trade balance
  ▪ Create employment in an environment of below full employment
  ▪ Promote industrial growth
  ▪ Change in relative prices of fuel

• For the rest of the world
  ▪ Positive supply shock
  ▪ Shift in perceptions from scarcity to abundance
  ▪ Potential diffusion of technology to rest of world
  ▪ Change in crude oil and petroleum product trade flows
  ▪ Shift in NGLs supply flows
  ▪ US energy policy now matters (export policy)
  ▪ Change in the US view of the world (and the world of US)

• Transformative supply shock highly uncertain
  ▪ Price and technology
Be Careful of Uni-Dimensional Analysis

- Some of story lines don’t make sense once they are inter-linked

- The natural gas story
  - Increase in demand from power sector
  - Increase in demand from transport sector
  - Increase in demand from industry
  - Export to other parts of the world
  - But the gas price remains low (The US can’t have it all!!!)

- The ethane story
  - Supply creates its own demand
  - But if all projects come through, ethane price will rise
  - Uncertainty in price; option to wait becomes valuable
  - Will all projects materialize?

- The US supply shock offset by a number of counter-shocks
  - Developments in oil market can’t be looked from prism of US alone
  - Non-OPEC supply, OPEC policy, oil demand, geopolitical shocks, investment decision, strategic behavior