Challenges and Opportunities of the North American Petroleum Renaissance

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Imperial College
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EPRINC Overview

• Established in 1944
• Publishes original research on oil and gas developments
• Routinely testifies before Congress, consults with U.S. and other Gov’t officials
• Brief policymakers, Hill staff on relevant energy topics
• Presents finding through industry and public forums, universities and think tanks
• Engagement with Washington Diplomatic Community — EPRINC Embassy Series

EPRINC’s PRIMARY MISSION IS TO EVALUATE THE INTERACTION OF PETROLEUM ECONOMICS AND PUBLIC POLICY
EPRINC Embassy Series

Photo by Yulan Guo
Importance of the North American Lens

Source: Wood Mackenzie (includes NGLs)
U.S. Imports of Crude Oil and Petroleum Products as a Percent of GNP

Source: EIA, EPRINC Calculations
Major Global Challenge: Managing OPEC Spare Capacity

millions of barrels/day

Regional Rivalries and Downside Price Risk

Tight oil and Iraq are wild cards here
Outline

1. Breakdown of U.S. and Canadian Oil Production

2. Infrastructure Challenges in Moving Rising Volumes of North American Crude Oil

3. Regulatory Concerns and Conclusions

Source: EIA
North American Oil Production

August U.S. Oil Production: 7.5 mbd
June Canadian Oil Production: 3.7 mbd

Source: EIA
EPRINC’s Forecast for Major U.S. Shale Plays

EPRINC forecasts an additional 1.5 mbd by 2022

Source: HPDI data with EPRINC forecast estimates
CAPP 2013 Updated Production Forecast

Over 3 mbd increase by 2030

Source: CAPP
U.S. Total Imports, U.S. Production, U.S. Canadian Imports

Source: EIA
U.S. Activity
Drilling Then and Now

Source: From PIECE Course Workbook, Mark J Kaiser, Houston, July 2008, “Introduction to USA Petroleum Industry”

Figure I-1  Generation of oil and gas

Figure 11-2  Migration of oil and gas in a sedimentary basin

Source Rocks
North American Potential...Shale Oil Plays
So how much oil is there...?

<table>
<thead>
<tr>
<th>Bakken Reserve Estimates</th>
<th>Barrels</th>
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<tbody>
<tr>
<td>1995 USGS</td>
<td>151 million</td>
</tr>
<tr>
<td>2008 USGS</td>
<td>4.3 billion</td>
</tr>
<tr>
<td>2010 NDIC</td>
<td>Add 1.9 billion (Three-Forks Addition)</td>
</tr>
<tr>
<td>January 2011 ND State Officials</td>
<td>11 billion (North Dakota alone)</td>
</tr>
<tr>
<td>Continental Resources</td>
<td>20 billion</td>
</tr>
<tr>
<td>....Pending USGS Update</td>
<td>????? billion</td>
</tr>
</tbody>
</table>

Source: EPRINC
State Production Trends

Source: EIA
U.S. Rig Count

Source: Baker Hughes
U.S. Rig Activity by Drill Type

Source: HPDI Nov 2013 – Not 100% Complete
Shale Oil Play Break Even Costs

Source: ITG Investment Presentation Nov 2012
The Soaring Eagle Ford
Geology of the Eagle Ford

<table>
<thead>
<tr>
<th>Age (Ma)</th>
<th>System</th>
<th>Series</th>
<th>Stage</th>
<th>Formation Name</th>
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<tbody>
<tr>
<td>120</td>
<td>Lower</td>
<td>Aptian</td>
<td></td>
<td>Pearsall</td>
</tr>
<tr>
<td>115</td>
<td>Lower</td>
<td>Glen Rose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>Lower</td>
<td>Edwards</td>
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<td></td>
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<tr>
<td>105</td>
<td>Lower</td>
<td>Georgetown</td>
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<tr>
<td>100</td>
<td>Lower</td>
<td>Del Rio</td>
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<td>95</td>
<td>Lower</td>
<td>Buda</td>
<td></td>
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</tr>
<tr>
<td>90</td>
<td>Cretaceous</td>
<td>Coniacian</td>
<td></td>
<td>Anacacho</td>
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<tr>
<td>85</td>
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<td>Santonian</td>
<td>Austin Chalk</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Cretaceous</td>
<td>Campanian</td>
<td>San Miguel</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>Cretaceous</td>
<td>Maastrichtian</td>
<td>Olmos</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Cretaceous</td>
<td>Maastrichtian</td>
<td>Escondido</td>
<td></td>
</tr>
</tbody>
</table>

Geological Map:
- **Upper Eagle Ford**
- **Lower Eagle Ford**

Key Features:
- Increasing depth
- Increasing pore pressure
- Increasing thermal maturity
- Oil to dry gas
- Increasing API gravity

**Upper Eagle Ford** is carbonate rich.
**Lower Eagle Ford** has higher TOC.

Only Thickest Areas of Lithology Trends Shown

Source: Momentum Oil and Gas LLC, DUG Eagle Ford Conference Presentation Oct 2011
Eagle Ford Wells

Source: HPDI Nov 2013
Eagle Ford Production

Source: HPDI Nov 2013
The Prolific Permian Basin
Breakdown of the Permian Basin Province

Permian Basin Stratigraphy

Source: Concho Resources 2nd Quarter 2013 Investor Presentation
Permian Basin Production 1.3 mbd

Source: HPDI Oct 2013
Vertical and Horizontal Progression

Source: Pioneer Natural Resources Oct 2013 Investor Presentation
EPRINC November Revised Permian Forecast

Source: EPRINC
Bakken: The Case Study
Long History of the Williston Basin

Source: Time Magazine 1952
Bakken Basics

Source: EPRINC Diagram

Source: Julie LeFever Presentation
Bakken Geology

U.S. | CANADA
--- | ---
SW | SW
MATURE | MATURE
NE | NE

Nisku (Bottom Seal)
Three Forks
Lodgepole (Top Seal)

“Bakken Kitchen”
Continuous, over-pressured oil trap

M Bakken

275 Miles

Continental
Bakken Drilling

- Original dual-zone development plan
  - 8 wells per 1,280 acres – 4MB, 4TF
  - 603,000 Boe EUR per well (avg. 24.5 stages/completions)
  - ECO-Pad® design: 2 wells south, 2 wells north
- Additional Three Forks potential
Williston Basin Production

Source: NDIC
Possible Production Figures

Source: NDPA

Production forecast is for visual demonstration purposes only and should not be considered accurate for any near or long term planning.

JJ Kringstad - North Dakota Pipeline Authority
Decline Rates

Source: Lynn Helms, ND Dept. of Mineral Resources, NDPC
Meeting Sept. 2011 Medora ND
Unlocking the Rocks

Combining longer laterals with an increasing number of frac stages yields higher EURs is a short time period.

Source: Brigham Exploration via *World Oil*
Infrastructure Challenges
Pipeline Choke Points

Source: EPRINC Choke Point Map using Hart ArcGIS Mapping software
All Canadian Pipeline Export Options are Full

Source: Canadian Energy Pipeline Association
Market Saturation

Source: CAPP Crude Oil Forecast June 2013
Where light sweet Bakken and heavy (blended bitumen) needs to go...

Source: AFPM map, EIA data for graph
Regional Pricing Disparities

- Western Canadian Select -$41 to WTI

Source: Flint Hills, EIA, CME Group, and estimates
The Rise of Rail
North Dakota Crude Oil Transport

January 2012 Estimates

- Pipeline Export: 58%
- Truck to Canadian Pipelines: 25%
- Tesoro Refinery: 10%
- Estimated Rail: 7%

August 2013 Estimates

- Estimated Pipeline Export: 31%
- Tesoro Refinery: 61%
- Truck to Canadian Pipelines: 7%
- Estimated Rail: 1%

Source: North Dakota Pipeline Authority
Daily Crude by Rail Shipment in U.S. and Canada

Source: AAR; Crude and petroleum product includes liquefied gases, asphalt, fuel oil, lubricating oil, jet fuel, etc. U.S. operations exclude U.S. operations of CN and CP. Canadian operations include CN and CP and their U.S. operations. One carload holds 30,000 gallons (or 714.3 barrels).
Pipeline and Rail

- Severely limited due to lack of Keystone XL and lack of historical build out to the coasts – system designed to import into the Gulf and move up

- New markets
- Diversification
- Neat Barrels
- Nimble - Quickly adjustable
- Optionality for Canadian and U.S. crude, NGLS, and other petroleum products

Source: EPRINC Maps using Hart Energy data and ArcGIS Mapping software
Refineries Benefit
Refinery Acquisition Cost of Crude Oil

Source: EIA
Refinery Utilization by PADD

Source: EIA
Regulatory Concerns and Conclusions
Potential Issues, Hurdles, and Regulatory Concerns

- Oil prices
- Water Usage – Fracking and Recycling
- Oil spills (rail and pipeline)
- Environmental Concerns
- Regs on Federal Land-Fracking
- Infrastructure Delays-PERMITTING
- Lack of prudent policy making: failing to connect what is happening on the ground to what is understood in Washington
- Costs incurred
Conclusions

- Since 2008 the U.S. and Canada have added over 3 mbd of crude to global production, helping offset issues in Libya and the Middle East.
- Pipelines are being built, but right now their is tightness in the system and an increasing need for Gateway, XL, and other Coastal options for US and Canadian crude.
- Bakken crude has to get to the U.S. East and West Coasts (via rail) and heavy Canadian needs to get to the Gulf and West Coast (via pipeline and rail).
- Roughly 7.7 mbd of new capacity (as estimated by EPRINC) is comprised of pipeline reversals, expansions, twinning, repurposing, and retrofitting. There are serious regulatory and permitting hurdles which deserve consideration.
- Even with a narrowing spread, rail is a serious option for US producers distanced from refining centers, especially Bakken and Canadian crude—markets exist where pipelines do not (especially with XL delay and Gateway uncertainty).
- Market has changes for producers and refiners with optionality, market and regulatory uncertainty.
- Rail will be here in the long term, the question is simply how much and where.
- Refineries are going to play a vital role in this renaissance as they adapt to high volumes of light sweet and heavy crude oils.
APPENDIX
Natural Gas Flaring

In North Dakota, Flames of Wasted Natural Gas Light the Prairie

Source: NDPA
Why?

Source: NDPA
Value of an Oil Well in North Dakota

Typical 2012 North Dakota Bakken well will produce for 29 years (enhanced oil recovery efforts could extend the life of the well)

In those 29 years the average Bakken well:

• Produces approximately 580,000 barrels of oil
• Generates over $22 million net profit
• Cost $8,500,000 to drill and complete (up from 7.3 last year)

• Pays approximately $4,610,000 in taxes
  • $2,200,000 gross production taxes
  • $2,000,000 extraction tax
  • $410,000 sales tax
  • Pays royalties of $7,925,000 to mineral owners
  • Pays salaries and wages of $1,500,000
  • Pays operating expenses of $2,300,000

Source: ND Department of Mineral Resources 2012 Presentation
Cost of Oil Sands Production

<p>| Estimated Initial Capital Expenditure (CAPEX) and Threshold(^{(a)}) Prices for New Oil Sands Projects |</p>
<table>
<thead>
<tr>
<th>CAPEX ($Cdn \text{ / bbl of capacity, Cdn$2010}$)</th>
<th>Economic Threshold (WTI US$ equivalent / bbl, US$2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining, Extraction and Upgrading</td>
<td>$85,000-$105,000</td>
</tr>
<tr>
<td>Mining and Extraction Only (No upgrading)</td>
<td>$60,000-$75,000</td>
</tr>
<tr>
<td>Steam-assisted Gravity Drainage (SAGD)/Cyclic Steam Stimulation (CSS)</td>
<td>$25,000-$40,000</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Includes a realistic after-tax rate of return, commonly in the order of 10 to 15%.


Source: PacWest Consulting