About EPRINC

• Founded 1944
• Not-for-profit organization
• Studies intersection of petroleum economics and public policy
• Provides independent and technical analyses for distribution to the public
• Supports USG projects, e.g. Quadrennial Energy Review, DoD strategic outlook
• EPRINC Embassy Series
• IEEJ-EPRINC Project on “Future of ASIAN LNG
• www.eprinc.org
The Future of Asian LNG

Challenges and Opportunities for Policy Makers

A Joint Project of the Institute of Energy Economics Japan (IEEJ) and the Energy Policy Research Foundation, Inc. (EPRINC)

October 20

- Joint Effort IEEJ and EPRINC
- Supported by Governments of Japan and U.S.
- Policy Proposals Presented in Tokyo (Oct 2017) -- Accepted by both Governments
- Discussions on Follow Up Study for 7th Annual LNG Producer Consumer Meeting in Nagoya (October 2018)
VENEZUELA
(NO LIGHT AT THE END OF THE TUNNEL)
Venezuelan and OPEC Crude Oil Production
(millions of barrels/day)

Opening of the Orinoco with IOC JVs

Note: Historically PDVSA produced 10% of OPEC production

Source: EIA, OPEC, PDVSA

Venezuela (bpd)  OPEC (bpd)
The Good Old Days!!!!

- In the 1970s, Venezuela had the highest growth rate and lowest inequality in Latin America.
- From 1974 to 1979, Venezuela had the highest per capita GDP in the region and spent more than it had in its entire history.
- Scotch whiskey consumption was the highest in the world, the middle class drove Cadillacs and Buicks.
- Politically, the country was one of only three democracies in Latin America in 1977, along with Costa Rica and Colombia.
THE MOST MISERABLE ECONOMIES

Misery Index Forecasts for 2018

<table>
<thead>
<tr>
<th>Country</th>
<th>Unemployment, annual var in %</th>
<th>Inflation, annual var in %</th>
<th>Misery Index: (Unemployment + Inflation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venezuela</td>
<td>1</td>
<td>1993</td>
<td></td>
</tr>
<tr>
<td>Yemen</td>
<td>2</td>
<td>47.0</td>
<td></td>
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<tr>
<td>DRC</td>
<td>3</td>
<td>45.3</td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>4</td>
<td>34.2</td>
<td></td>
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<td>South Africa</td>
<td>5</td>
<td>33.4</td>
<td></td>
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<td>Kosovo</td>
<td>6</td>
<td>28.4</td>
<td></td>
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<tr>
<td>Argentina</td>
<td>7</td>
<td>28.0</td>
<td></td>
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<td>Nigeria</td>
<td>8</td>
<td>26.5</td>
<td></td>
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<tr>
<td>Egypt</td>
<td>9</td>
<td>26.5</td>
<td></td>
</tr>
<tr>
<td>Angola</td>
<td>10</td>
<td>26.4</td>
<td></td>
</tr>
</tbody>
</table>

Source: EconFocus
Venezuela Far Exceeding OPEC Compliance Cuts As Agreed in Oct 2016

Source: OPEC
Cash Flow Crunch – Where Does the Money Go
(Most produced oil does not generate cash flow to PDVSA)

Of 1.8 MMB/D of 2017 Output......................

• 400,000 b/d sold domestically at heavily subsidized prices
• 500,000 b/d, mostly for loan repayments to China & Russia
• 50,000 b/d at large discount to Caribbean countries, mainly Cuba
• 100,000 b/d purchased as diluent, select products
• Net Cash Flow Equivalent to 800,000 b/d!!

*Cuba provides extensive security services and internal surveillance for Maduro
Venezuela’s Growing Debt Obligations

Debt Servicing Pressures Rising Rapidly, 2018 and 2019

Source: Capital markets reports
Venezuela Likely to Decline by at least 200,000 bbls/d in 2018 But Catastrophic Collapse Remains Possible

Source: EIA, IEA, Bloomberg, OPEC
Economic, Financial and Travel Sanctions on Venezuela

- No long-term credit in the U.S.
- Sanctions do not target oil imports or exports, but both are falling
- Buyers are trying to find alternative sources to Venezuela’s supplies and banks are unwilling to give letters of credit to PDVSA.
- Venezuelan exports to the US have been declining at a faster pace

======
- 28 EU ministers agreed that travel bans to the EU and the freezing of any Venezuelan assets in the bloc “will be used in a gradual and flexible manner and can be expanded.”
- Canada, Latin America Countries also joining in a various degrees
Venezuelan Default Risk Accelerating

- 2018 Venezuela Faces $8 billion in payments, late payments in 2017
- China or Russia can provide a lifeline, but unlikely to do so
- Russia faces headwinds in taking on additional financial exposure (but Rosneft increasing its footprint in marketing exports)
- Russian and Chinese oil companies are going to have a larger role in the Venezuelan oil sector, even more so in case of severe sanctions or a full blown default
Lose of Venezuelan crude only small problem for US refiners.
US Oil PRODUCTION (& DEMAND) REMAINS RESILIENT
U.S. Shale Plays

- Cretaceous
- Devonian
- Devonian-Mississippian
- Middle Devonian
- Miocene
- Miocene-Oligocene
- Mississippian
- Mississippian-Penn.
- Pennsylvanian
- Others
Recent History of US Oil Production (million of barrels/day)

- **1920s**: US car sales boom, and production cannot keep up with surging demand.
- **1950**: US oil production peaks at over 10m barrels a day.
- **1970**: Oil starts flowing through the Trans-Alaska Pipeline system.
- **2008**: First experiments with producing ‘tight’ oil from shale formations.
- **2010**: US oil production surpasses 10m b/d for the first time since the 1970s.
- **2015**: Production peaks after prices more than halve to less than $50 per barrel.
- **2017**: US oil production would average 10.85m b/d in 2019.

Source: Financial Times
Dueling Chemistries: Batteries & Barrels

Range Per Pound Of Fuel

Source: Courtesy of Mark Mills, Manhattan Institute
Dueling Hardware & Technology Asymptotes

Energy Output Per $1 Million CapEx

Solar & Wind: Cost per kW

Source: Courtesy of Mark Mills, Manhattan Institute
US ENERGY CONSUMPTION FORECAST BY SECTOR & FUEL

Energy consumption by sector
(Reference case)
quadrillion British thermal units

- Residential
- Commercial
- Transportation
- Industrial
- Electric power

Energy consumption by fuel
(Reference case)
quadrillion British thermal units

- Natural gas
- Coal
- Nuclear
- Hydro
- Other renewable energy
- Petroleum and other liquids
- Liquid biofuels

Source: EIA
EIA Reference Case 2018 Outlook
(annual output in quadrillion BTUs)

Source: EIA 2018 Annual Outlook
US Shale Liquid Production by Play

Source: EPRINC, PetroNerds
Drilling and Production Per Rig (Permian Basin – Texas)

Drilled wells minus completed wells (left axis)

Increase in inventory of drilled but uncompleted wells

Decrease in inventory of drilled but uncompleted wells

Monthly change in production per rig barrels per day (right axis)

Source: EIA
Permian Basin Horizontal Decline Curves (Texas and New Mexico) (b/d)

Source: PetroNerds, DrillingInfo.
Source: Completion Design Changes on Well Productivity, Curtis & Montalbano, EPRINC paper, (November 2017). Note: Well productivity indexed to a base curve, which equals 1.
Total Dry Gas Production Y/Y Growth

Associated gas production (e.g. Bakken, Eagle Ford, Niobrara, and Permian) and major dry gas plays (Marcellus, Haynesville) is driving a significant portion of the Y/Y growth in total dry gas.

Source: Raymond James, EIA
## North American E&P Spending by Company Type ($ in billions)

<table>
<thead>
<tr>
<th>Company</th>
<th>2016</th>
<th>2017</th>
<th>2018  (estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US IOCs</td>
<td>20.58</td>
<td>27.65</td>
<td>30.50</td>
</tr>
<tr>
<td>North American Large Caps</td>
<td>22.62</td>
<td>35.11</td>
<td>45.65</td>
</tr>
<tr>
<td>North American Small, Medium Caps</td>
<td>15.59</td>
<td>27.27</td>
<td>31.59</td>
</tr>
<tr>
<td>North American Small &amp; Private E&amp;Ps</td>
<td>1.11</td>
<td>1.92</td>
<td>2.49</td>
</tr>
<tr>
<td>International IOCs, NOCs</td>
<td>5.03</td>
<td>5.47</td>
<td>5.35</td>
</tr>
</tbody>
</table>

Source: Oil and Gas Investor, Barclays Capital Reports