Peak Oil Demand

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Oil Industry: Conventional Wisdom

• Since 1980s, conventional wisdom held that “easy oil” would be used up in future and the world would be increasingly reliant on OPEC oil

• In this scenario, OPEC reserves would be increasingly valuable and OPEC would benefit from strategically delaying production to increase the net present value of production

• Recent events and developments in the oil market have led to a clear departure from the expected scenario

• Shale Boom: Recoverable Production in non-OPEC regions not necessarily scarce
Oil Industry: Conventional Wisdom

- Growth in oil demand is now starting to be questioned
  - Climate Initiatives
    - Paris Climate Agreement
    - Keep it in the Ground
  - Weakening Economic Growth
    - “China’s Economic Growth in 2015 Is Slowest in 25 Years”
      - Wall Street Journal, Jan 2016
    - “Risks to the global outlook remain tilted to the downside.”
      - International Monetary Fund, Jan 2016
  - Advances in fuel efficiency on the horizon
    - improved fuel economy standards
    - improved logistics
Methodology

- Projections based on the International Energy Agency (IEA) Mobility Model

- Measure the impact of demand reducing scenarios by making adjustments to the IEA baseline or “Business as Usual” scenario

- Adjustments considered are alterations to GDP growth, improvements in vehicle efficiency, congestion, and logistical advances

- We are not currently evaluating policy-based scenarios.

- We report projected oil consumption in all sectors of transit: bus, passenger vehicles, freight, air, rail, and shipping
What Events Could Peak Demand?

Reducing global GDP growth rate by 20% is not sufficient demand reduction to lead to a peak in oil consumption by 2050.
It is also hard to eliminate oil demand but “peak” no longer viewed as impossible for 2020s or 2030s

<table>
<thead>
<tr>
<th></th>
<th>2040</th>
<th>% change</th>
<th>Notes</th>
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<tbody>
<tr>
<td>IEA New Policy</td>
<td>103</td>
<td>Up 14%</td>
<td>Fossil fuels remain 75%</td>
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<td>IEA 2 Degrees</td>
<td>74.1</td>
<td>Down 19%</td>
<td></td>
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<td>Statoil Renewal</td>
<td>79</td>
<td>Down 15%</td>
<td>EV growth = Oil less than 40% of transport</td>
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<td>50% Battery cost decline scenario</td>
<td>74.6</td>
<td>Down 19%</td>
<td>EVs at close to 20% of all new car sales by 2030</td>
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## Results by Scenario

### Oil consumption projections through 2050

<table>
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<td>Baseline</td>
<td>36.6</td>
<td>41.0</td>
<td>45.1</td>
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<td>25% Reduced Vehicle Saturation</td>
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<td>45.1</td>
<td>50.3</td>
<td>51.7</td>
<td>53.7</td>
<td>56.5</td>
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<td>Global Growth Reduction 20%</td>
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<td>41.0</td>
<td>45.1</td>
<td>50.9</td>
<td>52.0</td>
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<td>55.1</td>
<td>58.6</td>
<td>63.3</td>
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<td>No China-India Growth</td>
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<td>41.0</td>
<td>45.1</td>
<td>51.2</td>
<td>53.3</td>
<td>55.5</td>
<td>58.1</td>
<td>62.0</td>
<td>66.8</td>
<td>71.3</td>
<td>75.6</td>
<td>10.38%</td>
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<td>20% Freight Improvement</td>
<td>36.6</td>
<td>41.0</td>
<td>45.1</td>
<td>51.3</td>
<td>53.3</td>
<td>54.8</td>
<td>57.3</td>
<td>61.6</td>
<td>67.0</td>
<td>72.4</td>
<td>77.5</td>
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<td>20% Lower VMT</td>
<td>36.6</td>
<td>41.0</td>
<td>45.1</td>
<td>51.4</td>
<td>54.0</td>
<td>56.9</td>
<td>60.3</td>
<td>64.7</td>
<td>69.6</td>
<td>73.9</td>
<td>77.7</td>
<td>7.93%</td>
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<td>Global Growth Reduction 10%</td>
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<td>54.2</td>
<td>56.7</td>
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<td>66.6</td>
<td>72.6</td>
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<td>6.34%</td>
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<td>10% Freight Improvement</td>
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<td>54.3</td>
<td>57.5</td>
<td>61.3</td>
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<td>72.0</td>
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<td>20% Air Efficiency Improvement</td>
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<td>53.0</td>
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<td>60.4</td>
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<td>71.5</td>
<td>77.0</td>
<td>82.1</td>
<td>2.70%</td>
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<tr>
<td>10% Air Efficiency Improvement</td>
<td>36.6</td>
<td>41.0</td>
<td>45.1</td>
<td>50.7</td>
<td>53.8</td>
<td>57.3</td>
<td>61.3</td>
<td>66.5</td>
<td>72.5</td>
<td>78.1</td>
<td>83.3</td>
<td>1.35%</td>
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<td>Shipping Improvement</td>
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<td>45.1</td>
<td>51.4</td>
<td>54.5</td>
<td>57.9</td>
<td>61.9</td>
<td>67.1</td>
<td>73.0</td>
<td>78.6</td>
<td>83.7</td>
<td>0.85%</td>
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<td>All Above (Kitchen Sink)</td>
<td>36.6</td>
<td>41.0</td>
<td>44.8</td>
<td>48.0</td>
<td>47.0</td>
<td>46.4</td>
<td>46.6</td>
<td>48.3</td>
<td>50.5</td>
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<td>55.8</td>
<td>33.91%</td>
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</table>
Oil Projections, single scenario and combinations

- Possible stagnation of oil demand through 2035-2040 before growth resumes
Oil Projections, sensitivity to VMT projections

Oil Consumption Sensitivity to VMT

- Baseline
- 30% Higher VMT
- 50% Lower VMT
Significant growth in oil consumption is projected for African, ASEAN, and ODA (other developing Asia) countries.
Vehicle Adoption Uncertainty

• Vehicle adoption rates have high levels of variability
  • *e.g.* Mexico vs China vs Africa

• Variation in vehicle adoption rates highlights the uncertainty projected oil consumption in growing economies

• Base case shows rising vehicle ownership in OECD
  • Some scenarios assessing social demographic changes question rising car ownership in developed world
Assessment of vehicle ownership rates

Vehicle Ownership Projections
(projected values transparent)

- USA
- Canada
- Germany
- Mexico

Cars per 1,000 citizens

Assessment of vehicle ownership rates

Vehicle Ownership Projections
(projected values transparent)
Assessment of vehicle ownership rates

Vehicle Ownership Projections
(projected values transparent)

Cars per 1,000 citizens

- USA
- Mexico
- ODA
- Africa

Sensitivity to vehicle adoption

Reduce the vehicles-per-person saturation point and adoption rate for developing countries by 25%. Freeze vehicles-per-person of developed nations at current levels.
Implications for OPEC

• Decreased oil consumption can lead to the situation where not all oil producing countries will be able to exhaust their reserves

• In such a situation, optimal OPEC strategy will differ from the delay-production strategy

• Musical Chairs
OPEC dynamic optimal extraction strategy

• OPEC is often modeled as a cohesive cartel operating as a first mover in the presence of a fringe of perfectly competitive producers (Salant 1976, Lewis and Schmalensee 1980, Huppman 2013, etc.)

• We model OPEC’s optimal oil extraction path given their expectation of the competitive fringe’s response to OPEC production decision
OPEC dynamic optimal extraction strategy

- We find in the presence of a competitive fringe, OPEC’s optimal extraction path changes in the following way:
  - Decrease production levels up to the point of exhausting fringe reserves
  - Increase production thereafter
OPEC response to changing demand outlook

- We find OPEC strategy changes dramatically in the face of reduced oil demand
- Cartel w/ Fringe facing constant demand versus demand falling by 2% per year
OPEC response to changing fringe reserves

- We find OPEC strategy also changes in response to growing Fringe reserves.
- Low Fringe reserve level versus high Fringe reserve level
Assessment of vehicle ownership rates

Vehicle Ownership Projections
(projected values transparent)

Cars per 1,000 citizens

USA
Canada
Germany
Mexico
ODA
Africa
India
China

Megatrends and Implications of Peak Demand Scenarios
Analysts on Wall Street predicting prices will stay low and then creep higher through 2017

Projections above $60 are outlying
But war, civil unrest constraining supplies

Boom and Bust Oil Price and War Cycle is repetitious

Outages in OPEC countries total 2 mb/d and by our forecasts are likely to return from April to July 2016

OPEC Unplanned Outages

Source: EIA (history), Barclays Research (forecast)
Oil’s Short term vs Long Term: Are structural changes coming in the 20 year time horizon and how does that impact strategies now?
Technology Revolution is ushering in exponential gains in productivity, via transportational logistics, automation, big data, material science and biotech, artificial intelligence, 3-D printing.

This revolution is structural and will further decouple energy use and economic growth.
Technology revolution is already impacting costs across the entire energy chain.

- Shale economics
- Utility scale renewables
- Logistics planning
- Mobility services
- Energy efficiency and the industrial internet
- To come, energy storage
Implications of possibility of a peak in oil demand

• Flattening or peaking global oil consumption can lead to the situation where not all oil producing countries will be able to exhaust their reserves.

• In such a situation, question becomes whether it is optimal for either OPEC or private oil companies to delay development and production of reserves.

• Musical chairs syndrome – if there is a remaining “carbon budget” timing considerations to “monetize” reserves moves forward in time
Smaller, nimbler and entrepreneurial Independents assembling valuable portfolios of assets, such as the shale oil and gas plays, outperformed large peers. Question is can they continue to attract institutional capital?

Falling service costs, increased productivity and large hedging programs have blunted the top independent operators from the pain of oil and gas price declines.

In the future, location, location, location...
New Market Realities

“Freeze” dynamic led all players to seek higher output from which to begin agreement

• Not a repeat of 1998: Context for freeze is long term adjustments that might be required to address peak in oil demand

• Game of Survivor: winner takes all
  • Downstream
  • Exploration
“Efficient markets will determine where on the cost curve the marginal barrel resides. The producers of these high cost barrels must find a way to lower their costs, borrow cash or liquidate...cutting low cost production to subsidize higher cost supplies only delays an inevitable reckoning “

--Saudi Oil Minister Ali Naimi
February 2016
Market signal: The Millennial Generation

What does it mean when the world’s largest oil producer declares it is betting on the end of oil?

HR DCP Prince Muhamed announces intended transfer of shares of Saudi Aramco to Public Investment Fund
Appendix

Do investors need to worry about “stranded” oil, gas and coal reserves as part of their risk management, and if so, in what time frame?
The Science of Unburnable Carbon

- 2795 GT CO₂
- 565 GT CO₂

2 °C of warming
Man-made CO₂ in atmosphere now
Global CO₂ in 1750

© 2012 Google
© 2012 CNES/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2012 TerraMetrics
It is hard to move global primary energy mix away from fossil fuels quickly

Current Fuel Mix, 2012
- Coal 29%
- Oil 31%
- Gas 21%
- Nuclear 5%
- Hydro 2%
- Bioenergy 10%
- Other Renewables 1%

Climate Aggressive Fuel Mix, 2040
- Coal 17%
- Oil 21%
- Gas 22%
- Nuclear 11%
- Hydro 4%
- Bioenergy 16%
- Other Renewables 10%

Source: IEA World Energy Outlook 2014
Can shareholders trust management to adapt efficiently to changing circumstances?

- Businesses can adjust over time and real and shadow prices for carbon exist in today’s marketplace
- Companies can tap opportunities that are emerging to address the technical challenges related to renewables growth
  - Storage and transport solutions to variability
  - Collaborations with vehicle manufacturers and mobility firms
  - Investments in clean tech and lower carbon businesses
Peabody Energy stock collapse highlights risk of disorderly decapitalization as competitive market conditions change and carbon gets repriced more accurately.