

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

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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

- 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
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Reducing global GDP growth rate by 20% is not sufficient demand reduction to lead to a peak in oil consumption by 2050



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It is also hard to eliminate oil demand but "peak" no longer viewed as impossible for 2020s or 2030s

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



Results by Scenario

Oil consumption projections through 2050

Projected Oil Consumption (million bbl/day)												
								•				% Reduction
	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Relative to Baseline
												2050
Baseline	36.6	41.0	45.1	51.4	54.5	58.1	62.1	67.5	73.5	79.2	84.4	
25% Reduced Vehicle Saturation	36.6	41.0	45.1	50.3	51.7	53.7	56.5	60.6	65.0	69.1	73.0	13.48%
Global Growth Reduction 20%	36.6	41.0	45.1	50.9	52.0	53.1	55.1	58.6	63.3	68.4	74.0	12.38%
No China-India Growth	36.6	41.0	45.1	51.2	53.3	55.5	58.1	62.0	66.8	71.3	75.6	10.38%
20% Freight Improvement	36.6	41.0	45.1	51.3	53.3	54.8	57.3	61.6	67.0	72.4	77.5	8.23%
20% Lower VMT	36.6	41.0	45.1	51.4	54.0	56.9	60.3	64.7	69.6	73.9	77.7	7.93%
Global Growth Reduction 10%	36.6	41.0	45.1	51.0	52.5	54.2	56.7	61.1	66.6	72.6	79.1	6.34%
No China Growth	36.6	41.0	45.1	51.2	53.6	56.1	59.2	63.7	69.2	74.6	79.8	5.41%
10% Lower VMT	36.6	41.0	45.1	51.4	54.2	57.5	61.2	66.1	71.6	76.5	81.1	3.96%
10% Freight Improvement	36.6	41.0	45.1	51.4	54.3	57.5	61.3	66.4	72.0	77.2	82.0	2.91%
20% Air Efficiency Improvement	36.6	41.0	45.1	50.0	53.0	56.5	60.4	65.6	71.5	77.0	82.1	2.70%
10% Air Efficiency Improvement	36.6	41.0	45.1	50.7	53.8	57.3	61.3	66.5	72.5	78.1	83.3	1.35%
Shipping Improvement	36.6	41.0	45.1	51.4	54.5	57.9	61.9	67.1	73.0	78.6	83.7	0.85%
All Above (Kitchen Sink)	36.6	41.0	44.8	48.0	47.0	46.4	46.6	48.3	50.5	52.9	55.8	33.91%

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Oil Projections, single scenario and combinations



 Possible stagnation of oil demand through 2035-2040 before growth resumes

Oil Projections, sensitivity to VMT projections



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













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.



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- 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



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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









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

Looking Ahead at Oil Prices

Where investment banks currently see the price per barrel of U.S. crude-oil futures in the next few quarters



^{*}Through April 27 Sources: WSJ Market Data Group (Nymex crude prices); the companies

THE WALL STREET JOURNAL.

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

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



Onshore productivity, innovation creating new competitive landscape for capital and changing long term price outlook

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 brunted the top independent operators from the pain of oil and gas price declines.

In the future, location, location, location...



#4: Independents' Improvements in Initial Productivity by Shale Play Efficiency Gains in Both Oil and Gas Shale Plays



"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

UCDAVIS SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS "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



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





It is hard to move global primary energy mix away from fossil fuels quickly



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



Peabody Energy Co. (BTUUQ)

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