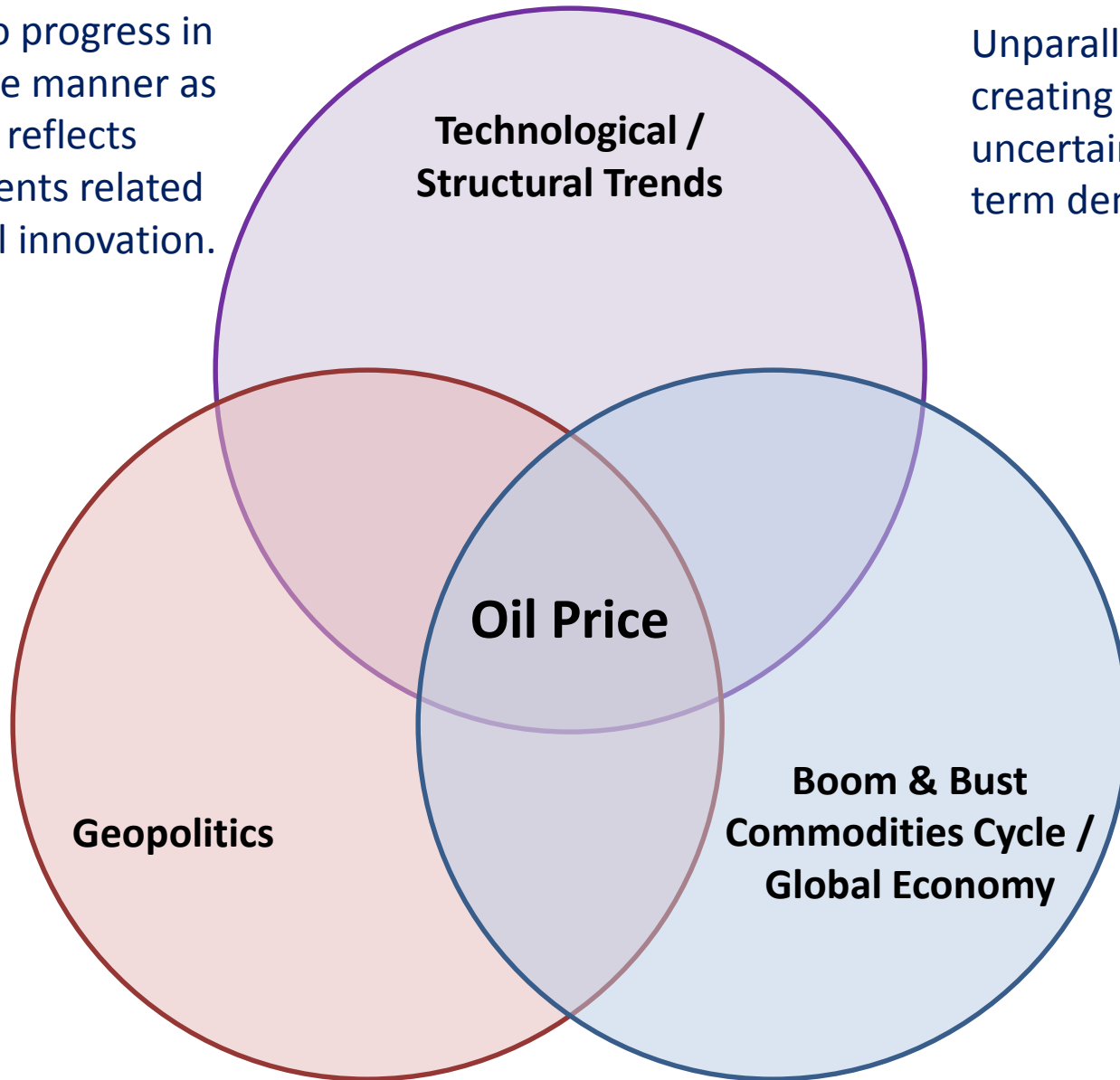




Amy Myers Jaffe  
Executive Director  
Energy and Sustainability  
University of California - DAVIS

## Outlook for Global Oil Markets

Cycle unlikely to progress in exactly the same manner as past cycles as it reflects structural elements related to technological innovation.



Unparalleled changes creating confusion and uncertainty about long term demand trends.

## Old Vs New Forces Impacting Demand

Technology  
Legislative and tax policy  
Energy efficiency (energy per GDP declining)  
Millennials reject vehicle ownership  
Growth of alternative energy



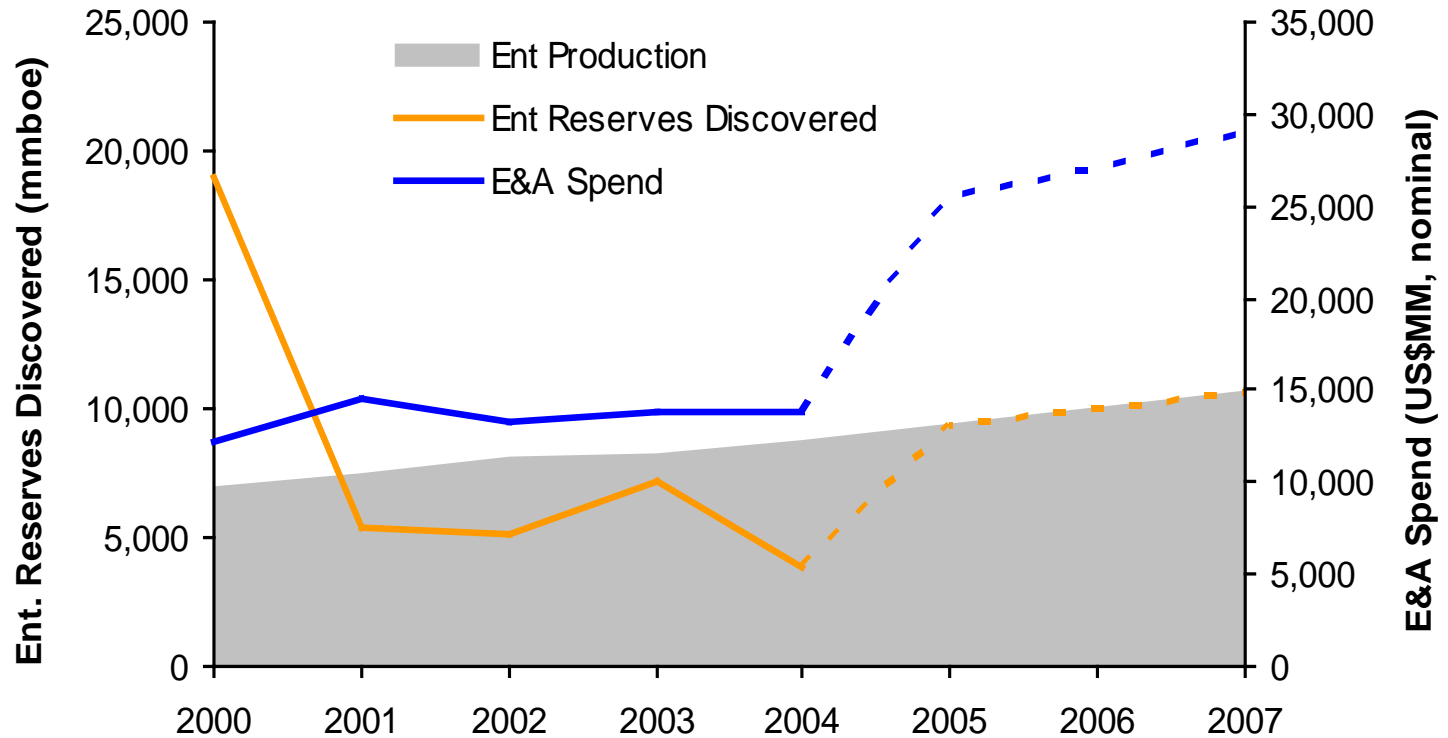
Population growth  
Emerging economy expansion  
Expanding global middle class

# The 2018-2020 Supply Hole Theory: Real or Chimera?

**Real: There has been a significant drop in upstream capex spending since 2014. But...**

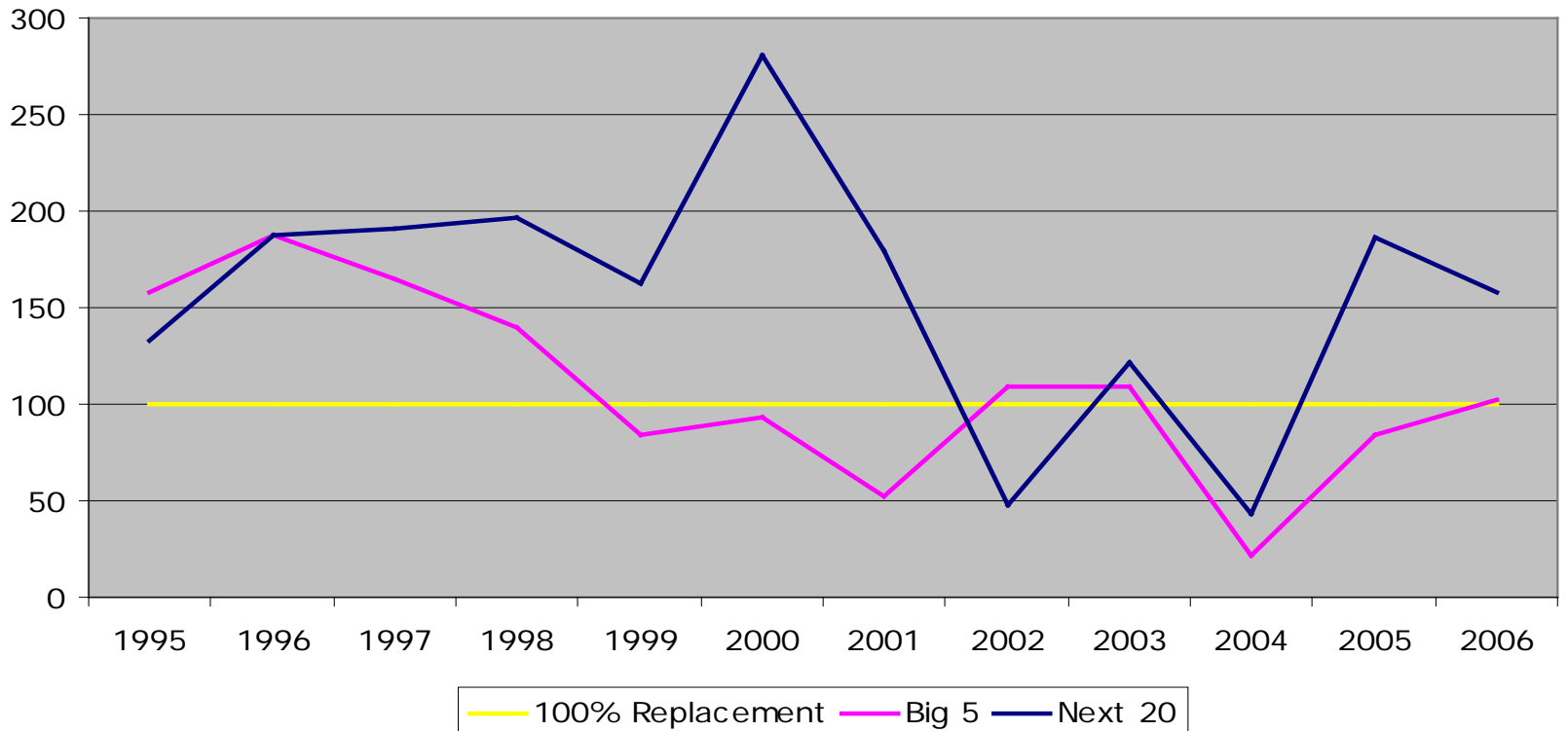
- Drop in capex spending partly offset by falling costs
- Capex spending by majors in 2000s was plagued by cost overruns, write-downs and delays to first oil
- Billions of dollars deployed by majors wound up non-performing – Alaska, Libya, oil sands, Venezuela, Caspian, Iran, Saudi gas initiative, Yamal
- New spending by majors could potentially be better performing, with a shortened time horizon

# The 2000s: The Myth of High Capex-Discovery Link



\* Dashed lines are hypothetical illustration of minimum future exploration spend that would have been required to achieve 100% reserve replacement. SOURCE: WOODMACKENSIE CONSULTANTS

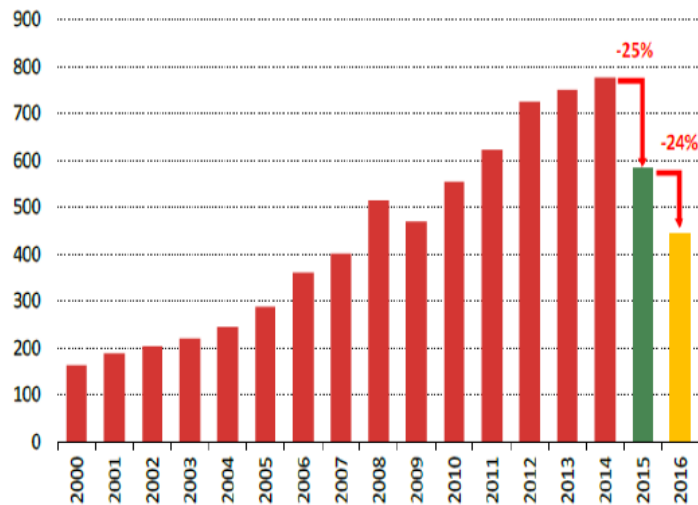
## Reserve Replacement Ratio



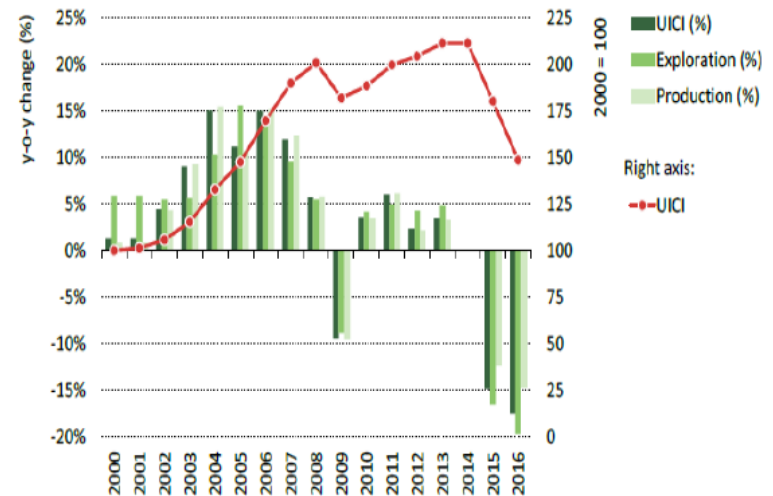
# Stretching E & P Dollars: Decline in Upstream Capex Spending Is Offset by 25% Lower Costs, Shift Away From High Cost “Frontier”

## Energy Investment Has Been Cut But Mostly Due to Falling Costs

World Upstream Oil and Gas Investment (bln 2015 \$)



Upstream Investment Cost Index (UICI)



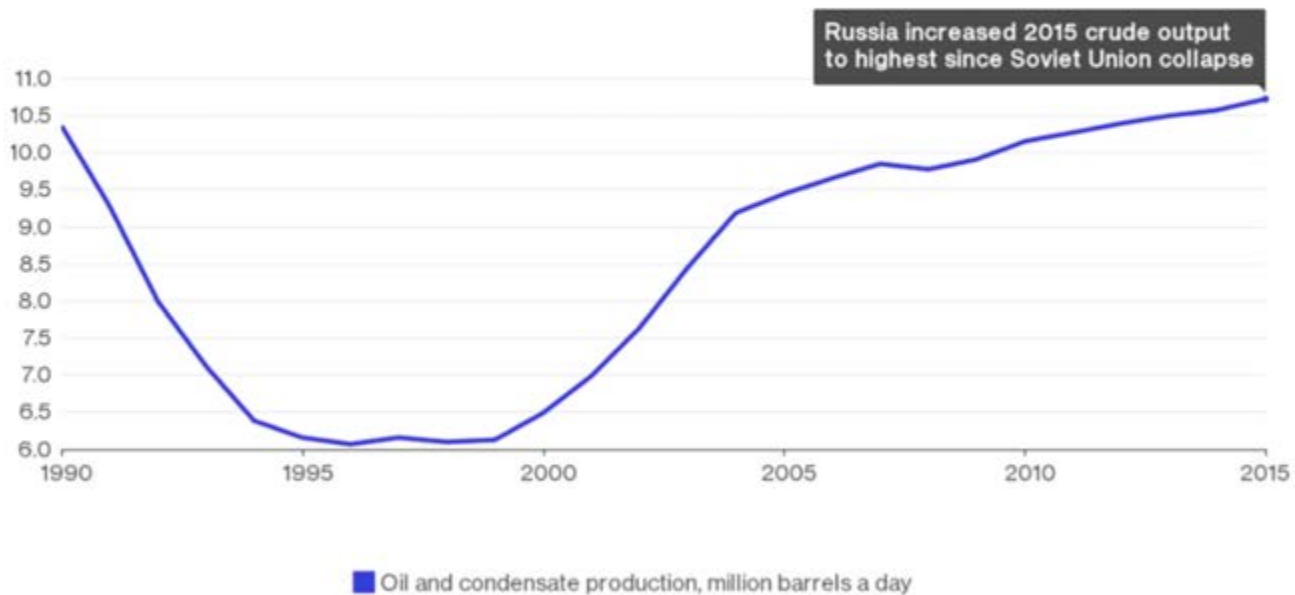
- Upstream investment expected to be higher in 2017, with potentially +40% y/y growth in NAM E&P capex and +10% in global ex-NAM E&P capex.

Source: IEA, Citi Research

# Ruble Collapse Effect: Russian Oil Production Hit 11.2 mbd in October, up from 10.7 mbd

Russian fields would be typical location for “natural declines”

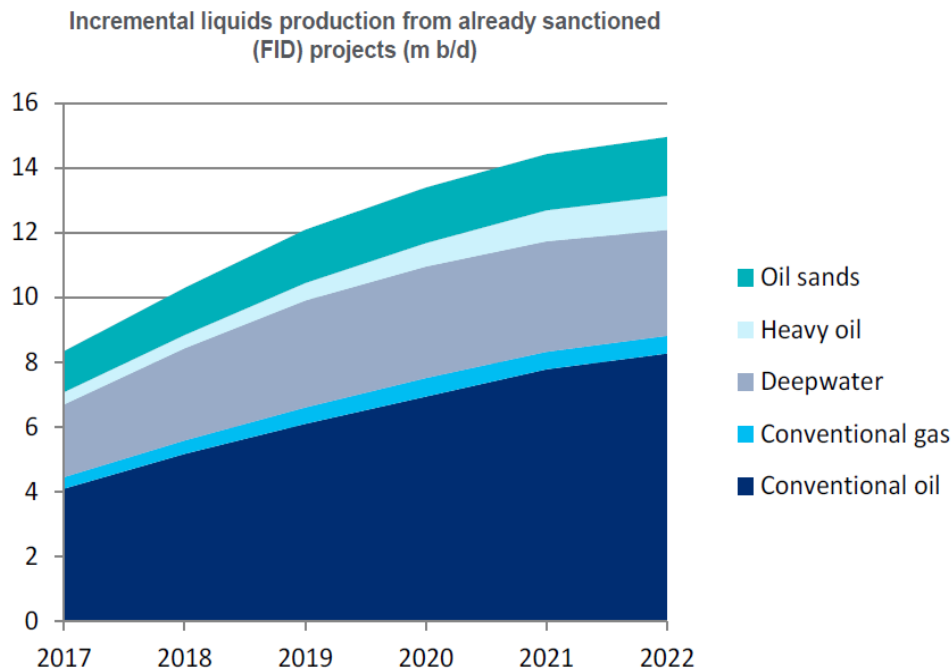
## Russia Boosting Crude Output Amid Plunging Prices





# The Traditional Upstream Supply Hole Could Be More Like a 15 Million b/d Gain Between Now and 2022

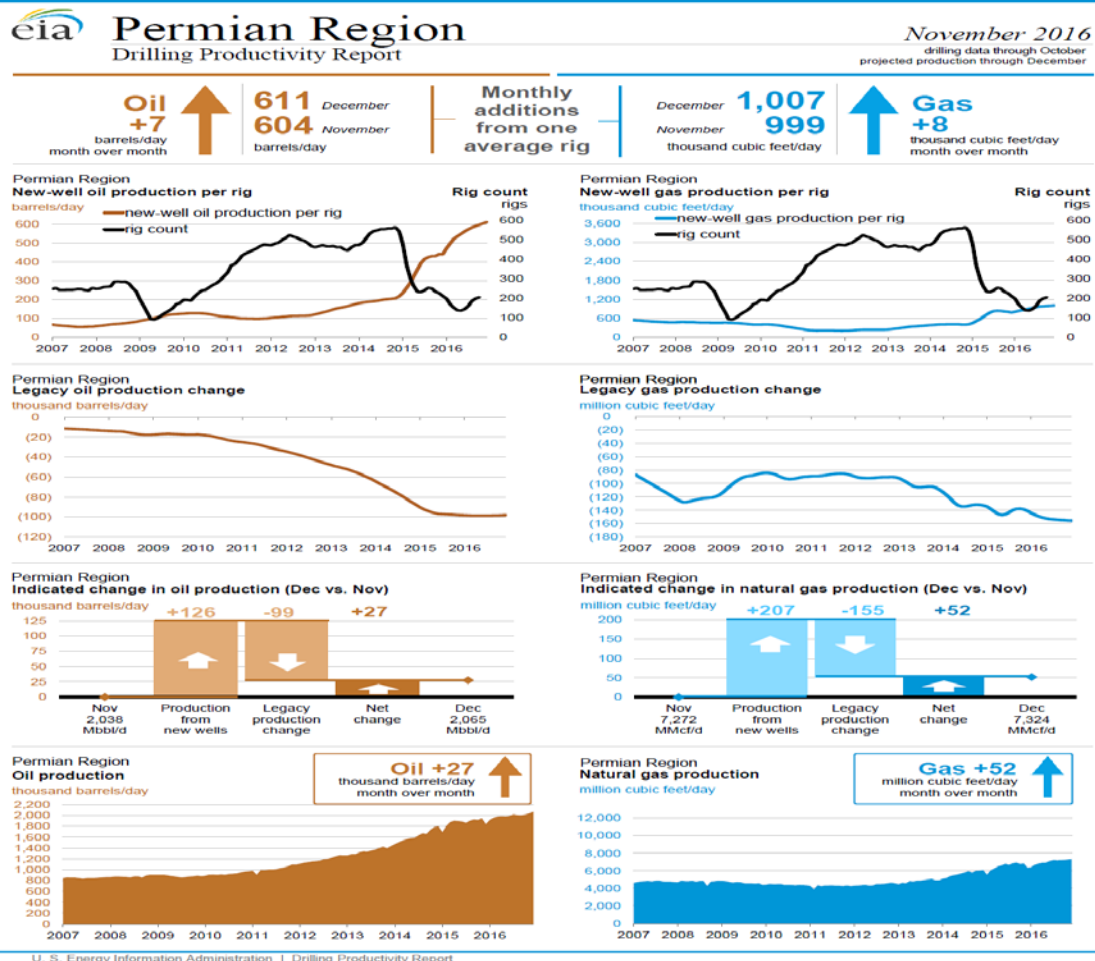
## Already-sanctioned non-OPEC conventional/deepwater/oil sands projects



- There is already significant momentum in supply growth from sanctioned (FID) greenfield or expansion projects that continue to add oil production even with the recent weaker price environment; however, this all contributes to offsetting underlying declines of pre-existing production

# Flexibly Filling the “Supply Hole”: All Eyes on the Permian

## Region could some day reach 10 million b/d



# Supply Hole Could Be Geopolitical

- Venezuela
- Mideast Conflict Escalations
- New Sanctions?
- OPEC Agreement

**But then there is shale!**

# The 2018-2020 Supply Hole Theory: What's at Stake?

**Volume of debt reaching maturity after 2019 is significantly larger than current, reflecting some workouts and extensions (eg basis repayment as oil prices recover).**

**The question is whether changes in oil prices or continued improvement in productivity will be sufficient to allow debt to either be extended or reduced as 2020 approaches.**

**US E&P companies' high yield debt based on maturities estimated by S&P:**

**2015: \$1.7 billion**

**2016: \$3.5 billion**

**2017: \$7.7 billion**

**2019: \$19.7 billion**

**2020: \$30.8 billion**

# Technology revolution is already impacting costs across the entire energy chain.

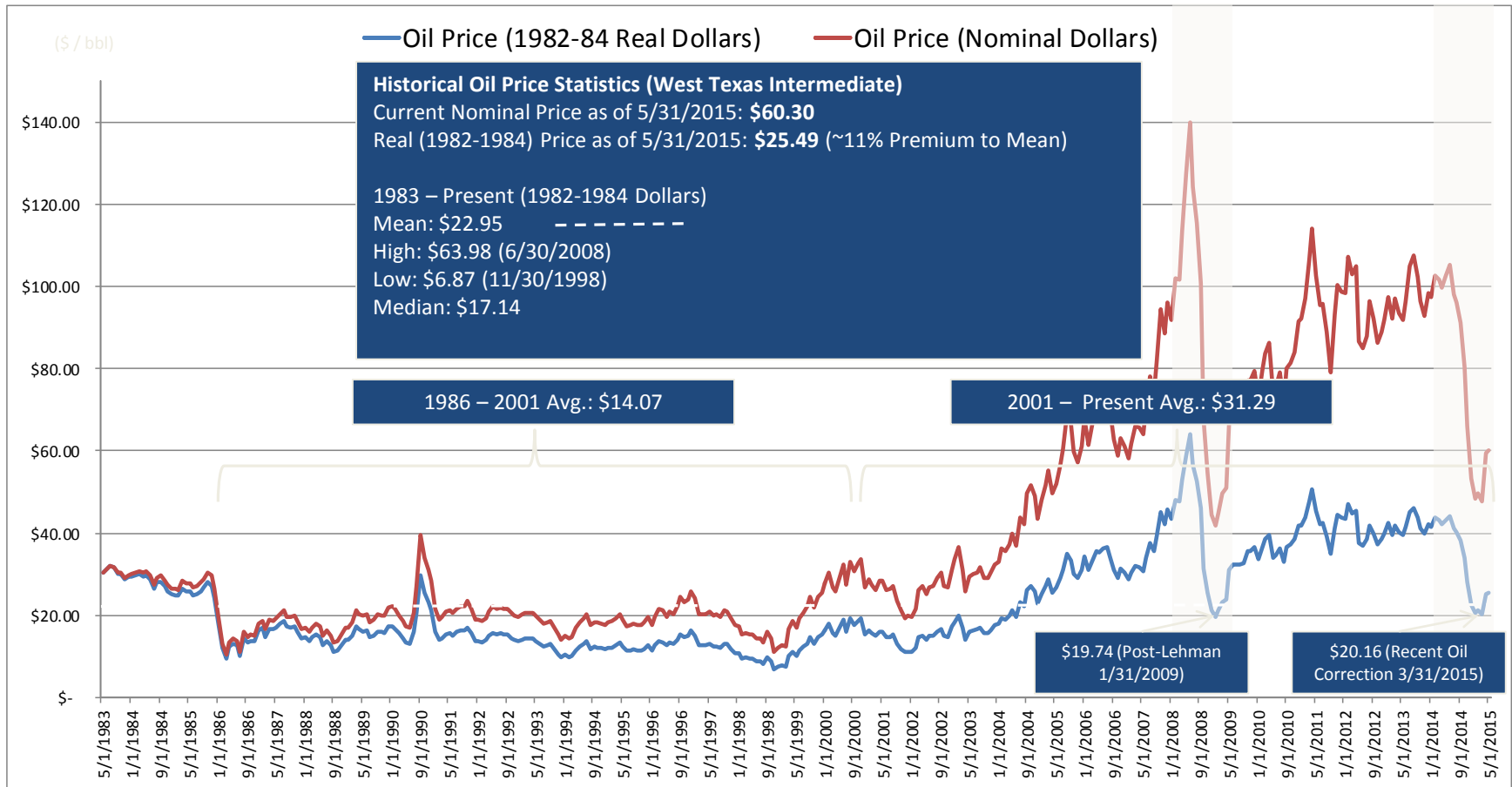
- Shale economics
- Utility scale renewables
- Logistics planning
- Mobility services
- Energy efficiency and the industrial internet
- To come, energy storage

Rapidly falling costs causing some to predict an explosive S curve deployment effect that will strand fossil fuels

# In historical terms, 2000s look anomalous

## Monthly Nominal and Real Oil Prices from May 1983 - Present

- Will Long term oil prices have reverted back to historical long-term mean?
- As US Shale production continues to come on line, coupled with technological advances in oil and gas recovery, oil price cycle could shorten
- 1986-2001 average price implies a potential low of ~\$33/bbl in nominal terms



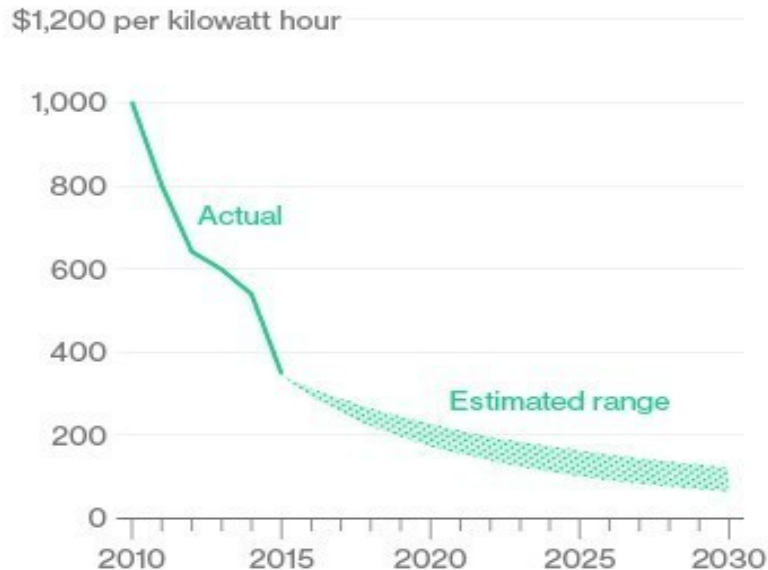
Source: Bloomberg, West Texas Intermediate (WTI) Cushing Crude Oil Spot Price: USCRWTIC Index, CPURNSA Index as of May 31, 2015

# Are Batteries The Next Great Disruptor?

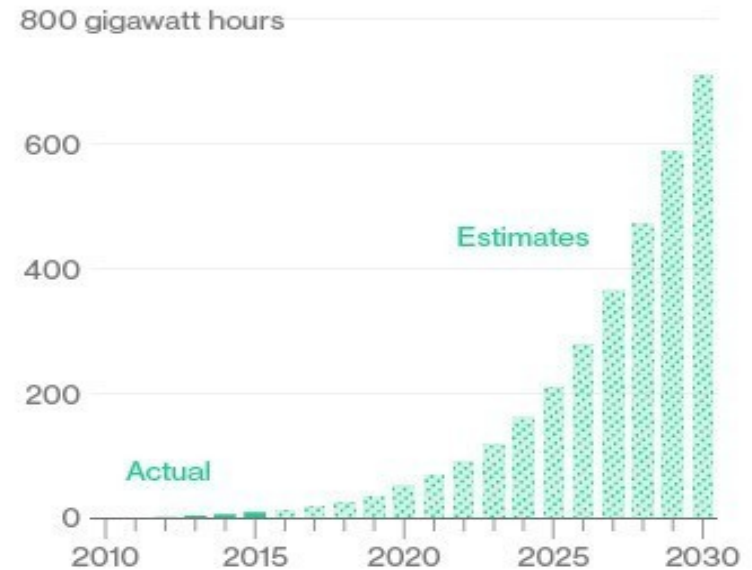
## It's All About the Batteries

Batteries make up a third of the cost of an electric vehicle. As battery costs continue to fall, demand for EVs will rise.

Cost for lithium-ion battery packs



Yearly demand for EV battery power



Source: Data compiled by Bloomberg New Energy Finance

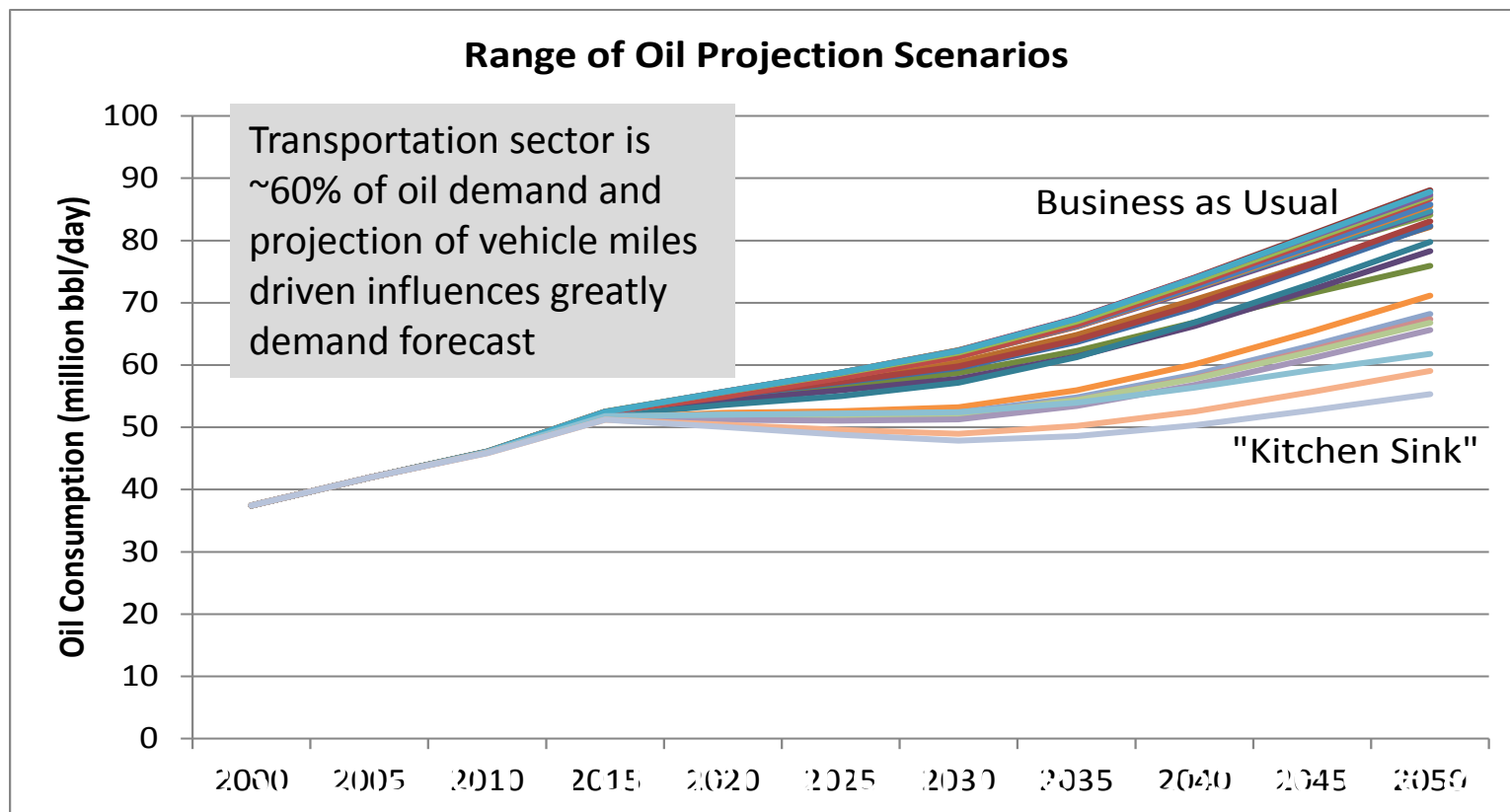


# Comparing Battery Breakthrough Scenario to Other Forecasts

	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



Technological factors could be sufficient to reduce demand in the next two decades, but given the overwhelming influence of population growth, permanent peak in oil demand likely requires policy intervention.

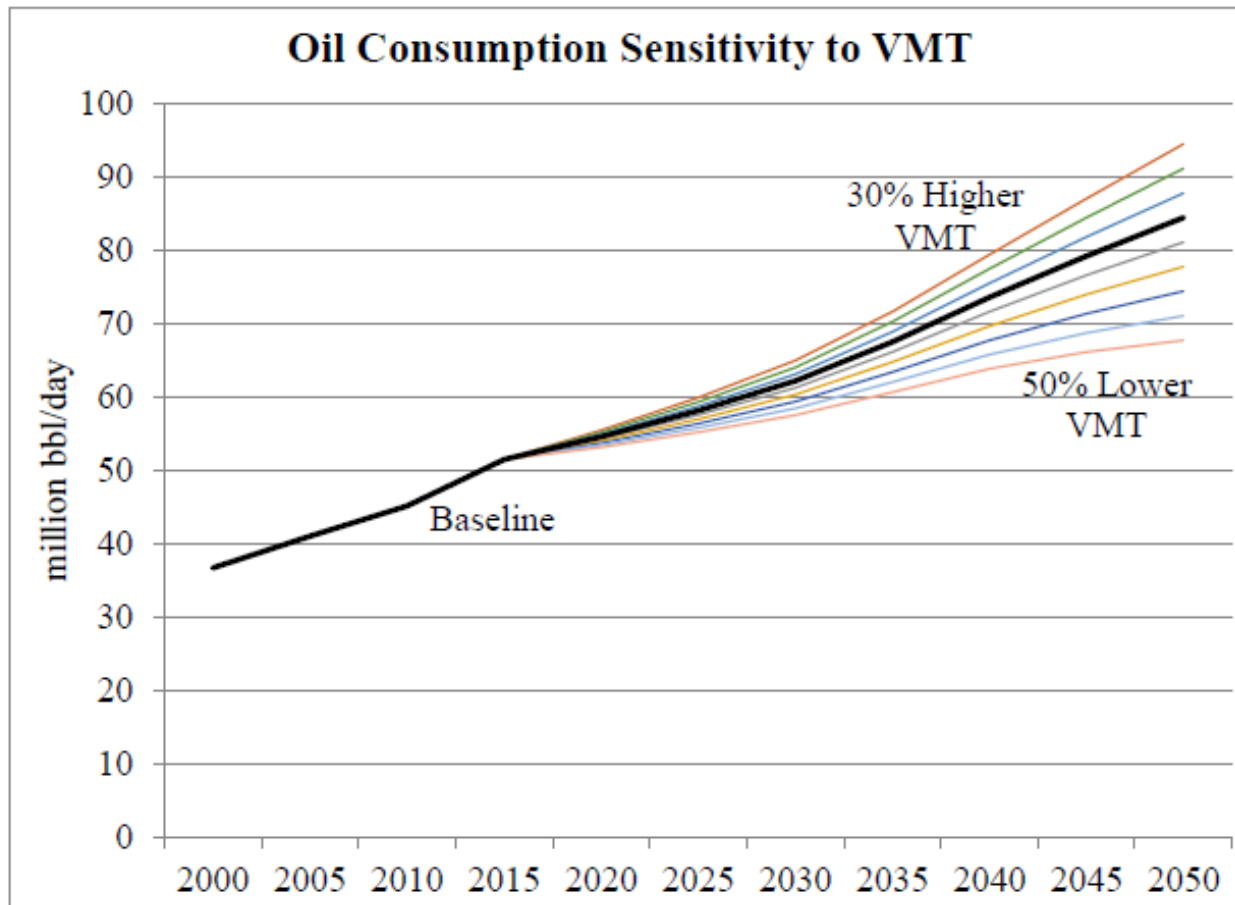


# UC Davis Oil Demand Scenario Study: Testing Sensitivities of Peak Demand Transport Scenarios

Oil consumption projections through 2050.

Projected Oil Consumption (million bbl/day)									
	2015	2020	2025	2030	2035	2040	2045	2050	% Reduction Relative to Baseline 2050
<b>Baseline</b>	52.5	55.7	58.8	62.3	67.5	74.1	81.0	88.1	
<b>No China-India Growth</b>	52.1	54.5	56.5	58.7	62.3	66.9	71.6	76.0	<b>13.8%</b>
<b>Global GDP Growth Reduction 10%</b>	51.8	53.6	55.0	57.1	61.2	66.8	73.1	79.8	<b>9.4%</b>
<b>No China Growth</b>	52.4	55.1	57.6	60.4	64.8	70.4	76.4	82.2	<b>6.7%</b>
<b>Shipping Logistics Improvement</b>	52.4	55.0	57.2	59.5	63.7	69.2	75.7	82.3	<b>6.5%</b>
<b>Road Freight Efficiency Improvement</b>	52.4	55.1	57.3	59.8	64.0	69.7	76.3	83.1	<b>5.7%</b>
<b>China-US-India GDP Parity</b>	52.5	55.7	58.8	62.4	67.1	72.9	78.6	84.1	<b>4.6%</b>
<b>Ridesharing</b>	52.5	55.4	58.2	61.4	66.1	72.1	78.3	84.5	<b>4.0%</b>
<b>China-US GDP Parity</b>	52.4	55.4	58.2	61.5	66.3	72.3	78.6	84.8	<b>3.8%</b>
<b>ASEAN Extra Congestion</b>	52.3	55.1	58.0	61.3	66.2	72.4	78.9	85.5	<b>2.9%</b>
<b>Congestion</b>	52.3	55.1	58.0	61.4	66.3	72.5	79.1	85.8	<b>2.6%</b>
<b>Air Traffic</b>	52.5	54.9	57.9	61.4	66.5	72.9	79.8	86.7	<b>1.6%</b>
<b>Natural Gas Trucks Share Increase</b>	52.5	55.6	58.6	62.0	67.0	73.4	80.2	87.0	<b>1.2%</b>
<b>Electric Vehicle Advancement</b>	52.5	55.7	58.8	62.3	67.5	73.9	80.6	87.4	<b>0.8%</b>
<b>ASEAN Only Congestion</b>	52.5	55.7	58.8	62.3	67.4	73.9	80.8	87.8	<b>0.3%</b>

# How sensitive is oil demand to vehicle miles traveled?



# 30 years of conventional wisdom is over now, forever

- Since 1980s, conventional wisdom held that “**easy oil**” in non-OPEC would be depleted by 2010s and the world would be **increasingly reliant on OPEC oil**.
- OPEC responded to this view by taking a revenues oriented strategy in the 2000s. Gulf countries viewed reserves as increasing in value over time for “future generations.”
- Paris climate accords and US shale boom throws this future reserves scarcity model into question
- Uncertainty about long term demand outlook shifting strategic calculus of largest reserve holders

# Implications for OPEC

- 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 –timing to monetize reserves moves forward

# New Market Realities

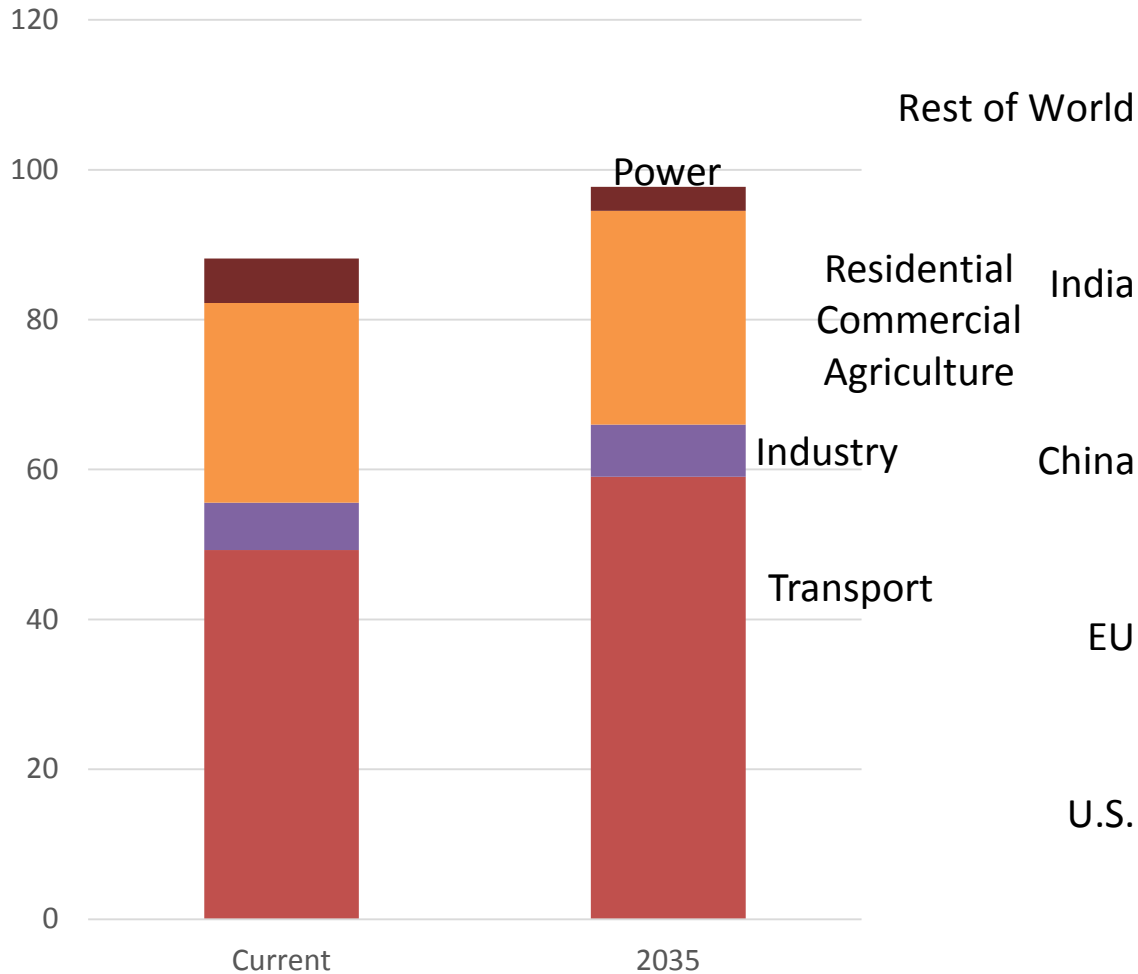
**“Freeze” dynamic led all players to seek higher output from which to begin agreement**

- 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

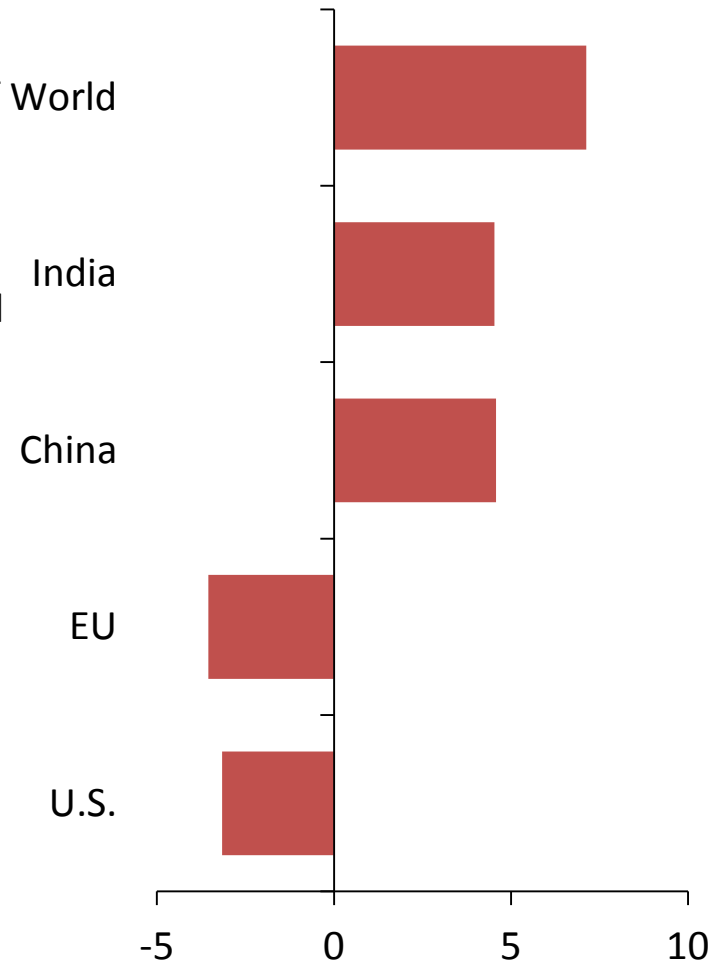


# Mobility in Emerging Markets Driver of Future Oil Demand

## Global Oil Demand by Sector (Million Barrels of Oil per Day)

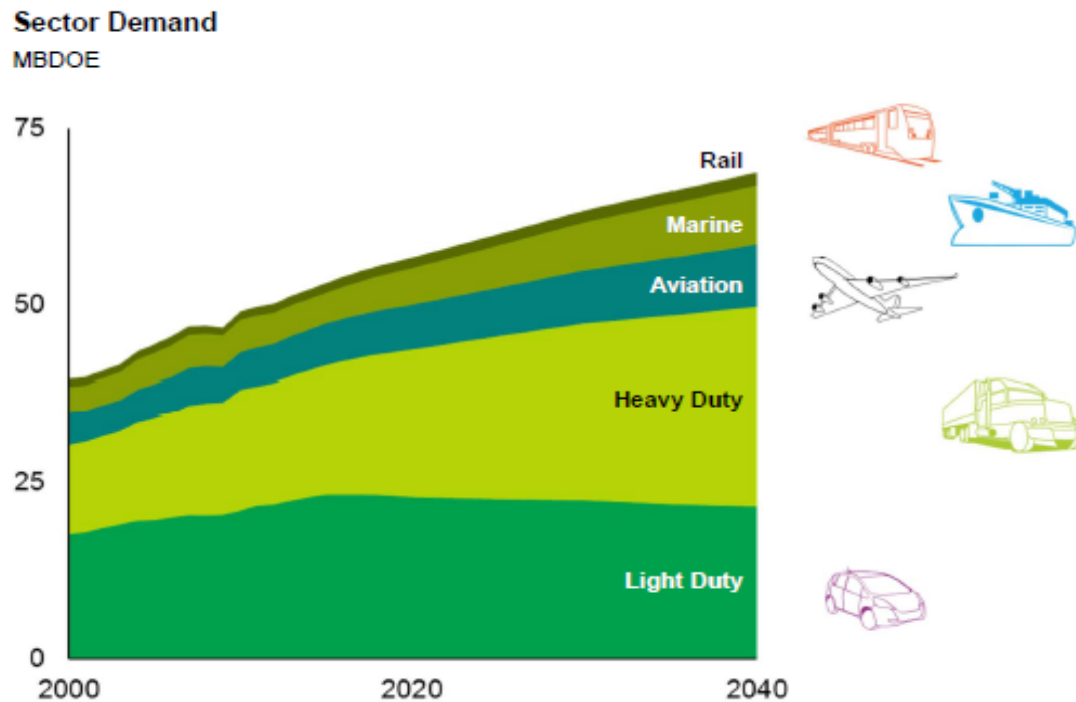


## Global Oil Demand Growth by Region (Million Barrels of Oil Equivalent/Day)



# ExxonMobil forecasts freight/diesel to dominate demand growth

## Transportation Demand





# Economies are Expanding, but Getting more Efficient

## GDP vs. Energy Demand by Country/Region

