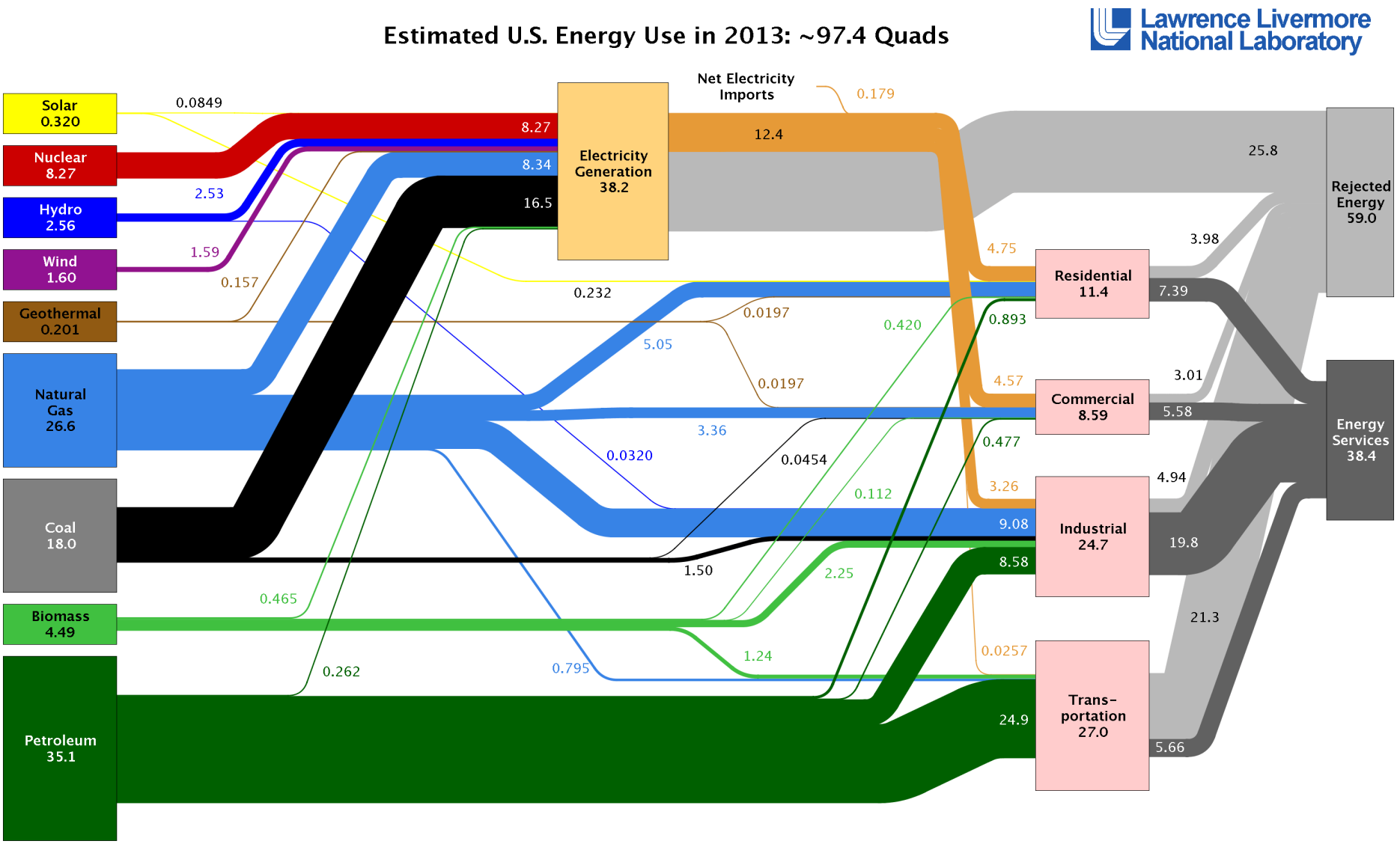
Energy and the Built Environment
CRP 470.004 /570.004

Christian E. Casillas

Lecture 8

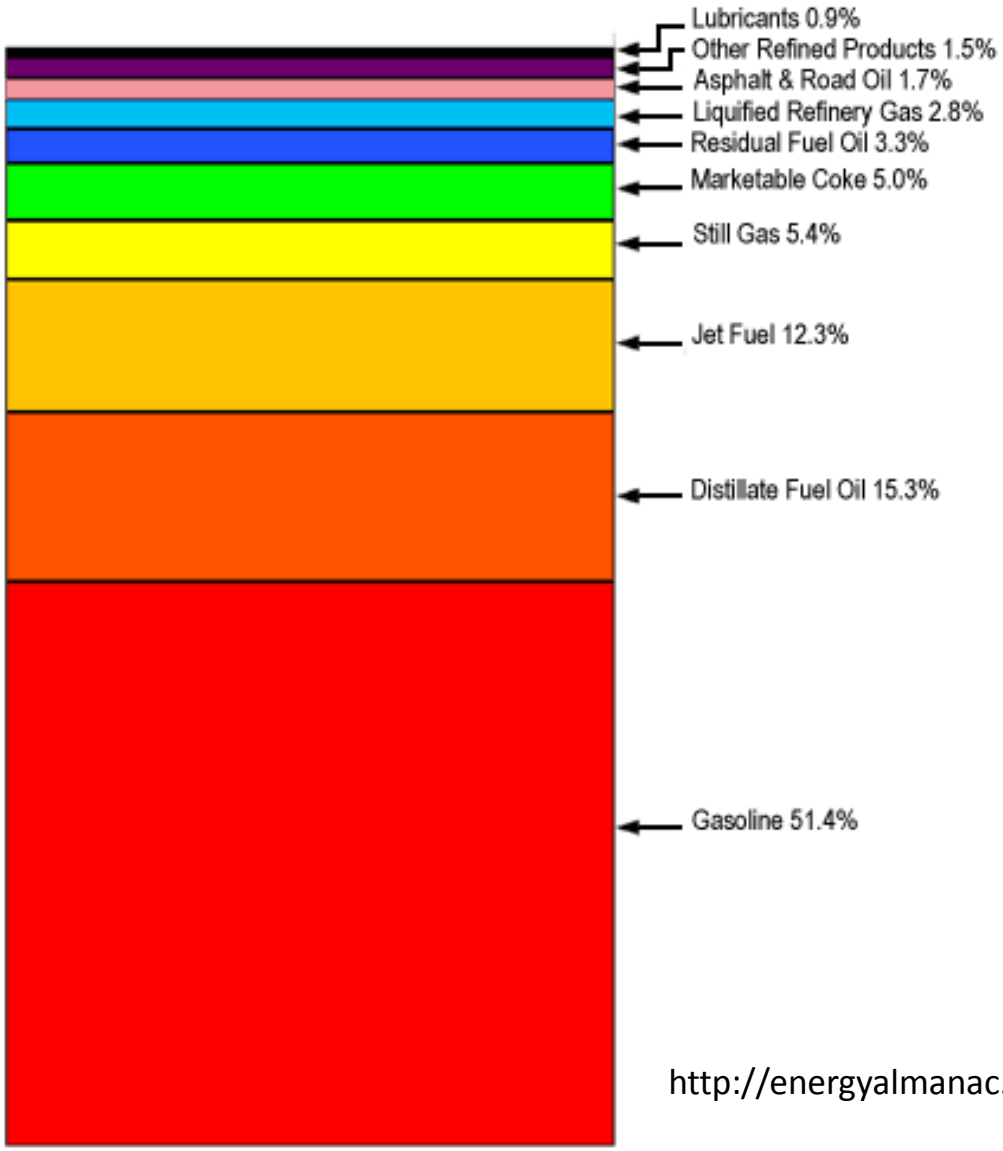
Oil

Sankey Diagram of US energy use



Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Products from a barrel of oil



Product	Percent of Total
Finished Motor Gasoline	51.4%
Distillate Fuel Oil	15.3%
Jet Fuel	12.3%
Still Gas	5.4%
Marketable Coke	5.0%
Residual Fuel Oil	3.3%
Liquefied Refinery Gas	2.8%
Asphalt and Road Oil	1.7%
Other Refined Products	1.5%
Lubricants	0.9%

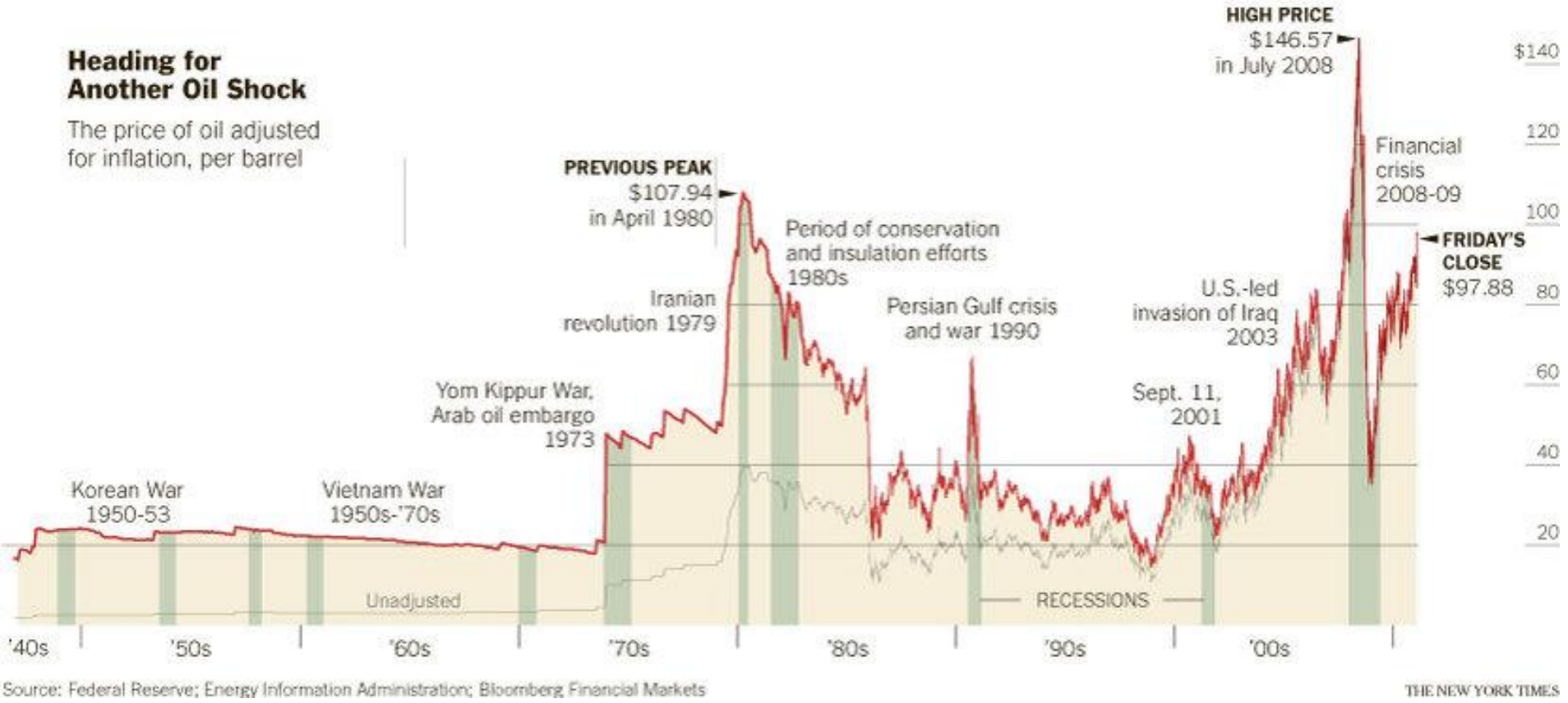
http://energyalmanac.ca.gov/gasoline/whats_in_barrel_oil.html

How we use oil…

- 36% of our primary energy comes from oil
- 70% of oil used in the energy sector is for transportation, 25% in industry
- 8.9 kg of CO2/ gasoline of gas

The price of oil….

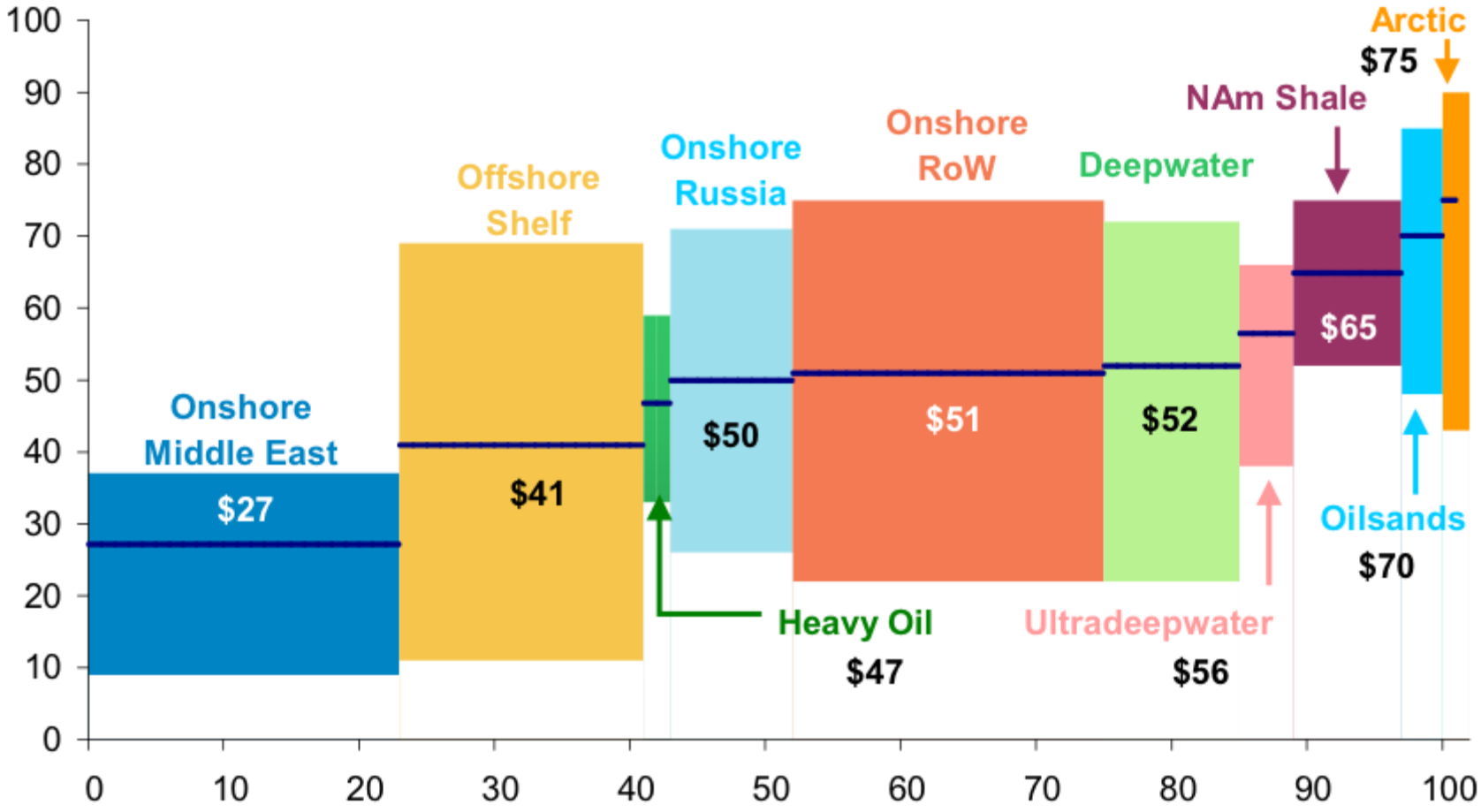
- Determined by economics of supply/demand
- Speculation by future's traders
- Market power by OPEC…
- Political upheaval that impacts production



Source: NYT, data from Federal Reserve, EIA, Bloomberg

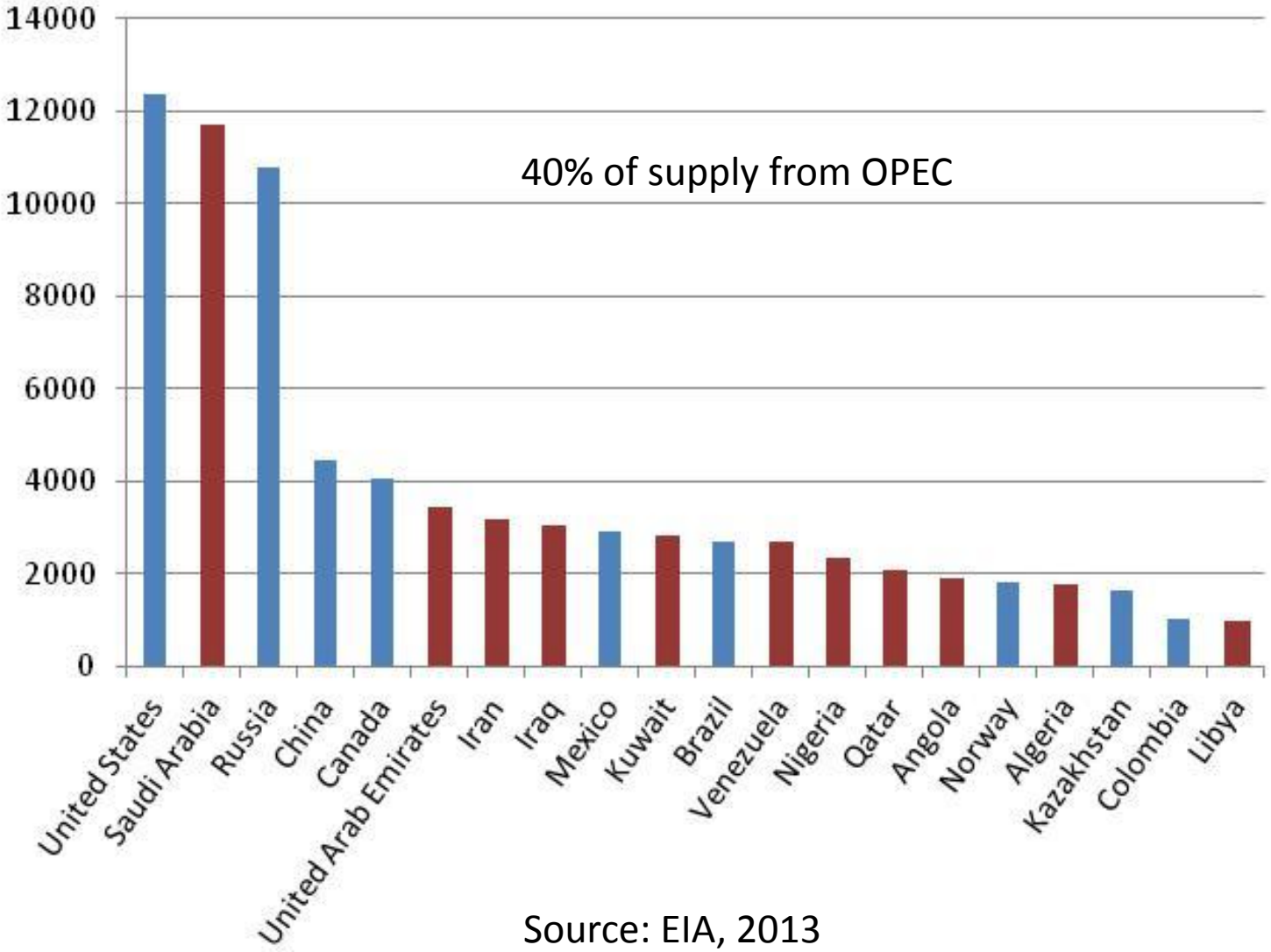
Cost of extraction

(x-axis: total liquids production; y-axis: avg Brent-equivalent breakeven price*, $/bbl)



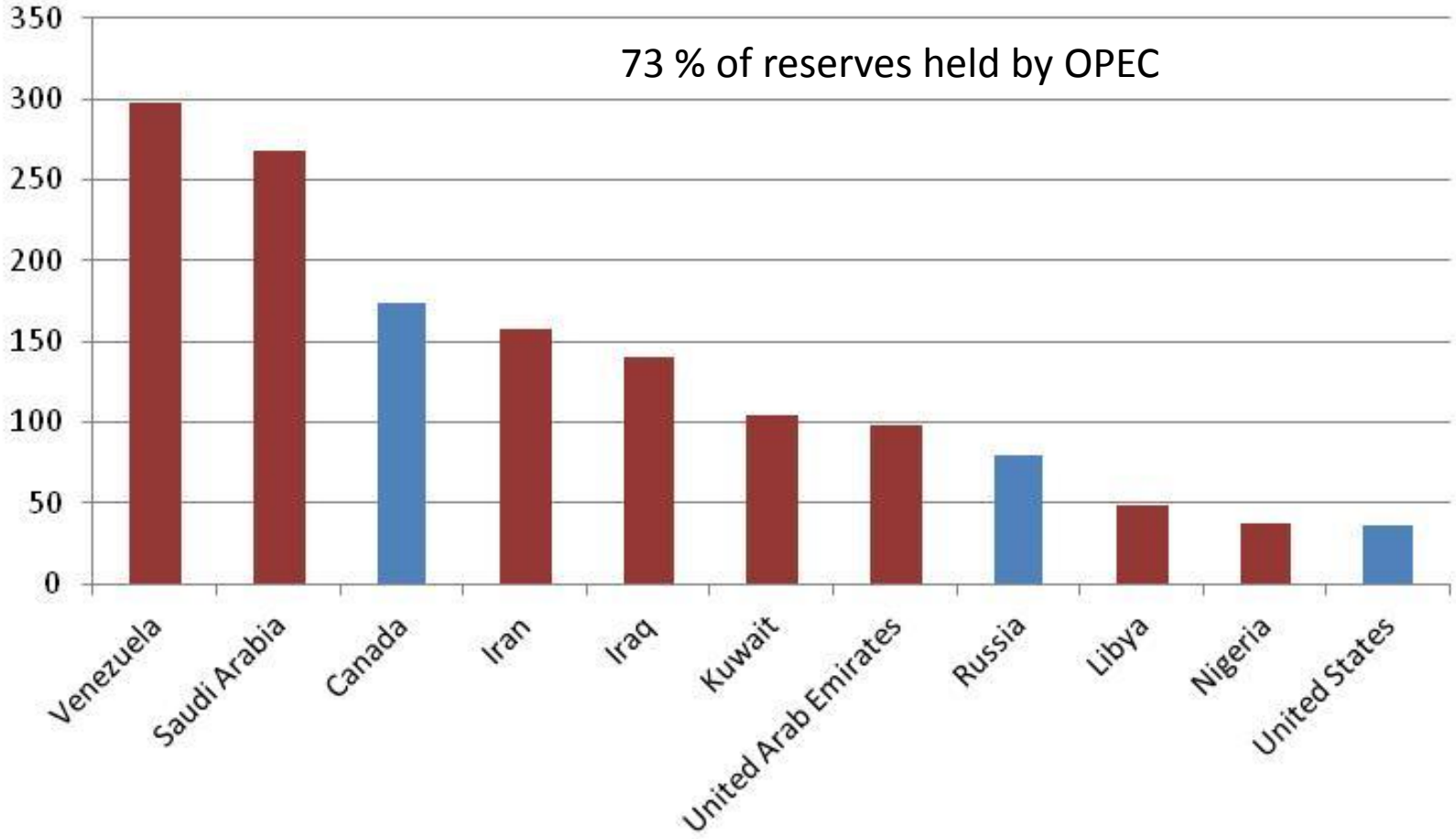
Source: Rystad Energy, Morgan Stanley Commodity Research estimates

Top 20 suppliers of oil 2013 (thousand bbl/day)

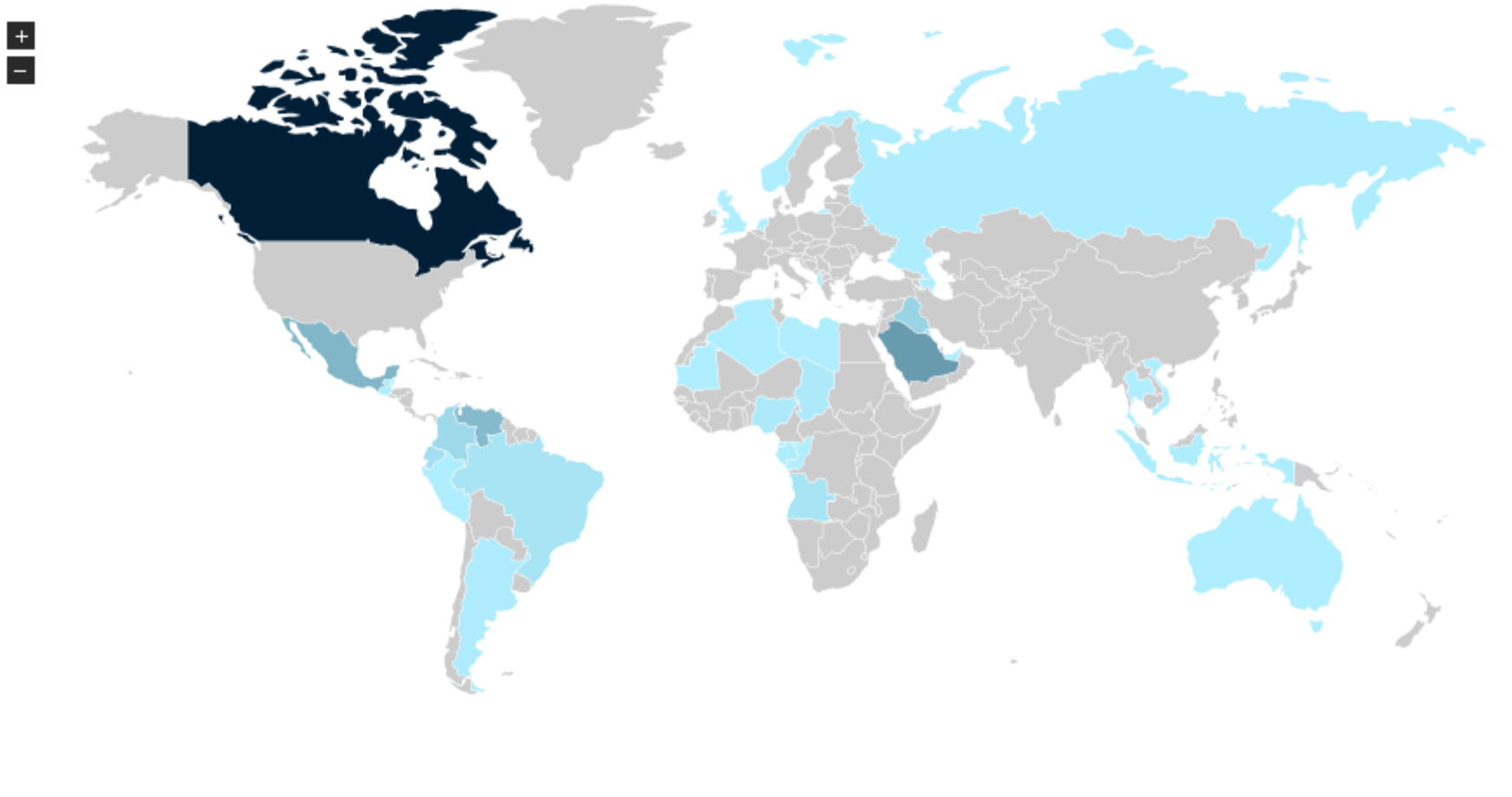


Source: EIA, 2013

Top 10 Proved Reserves of Crude Oil, 2014 (billion barrels)

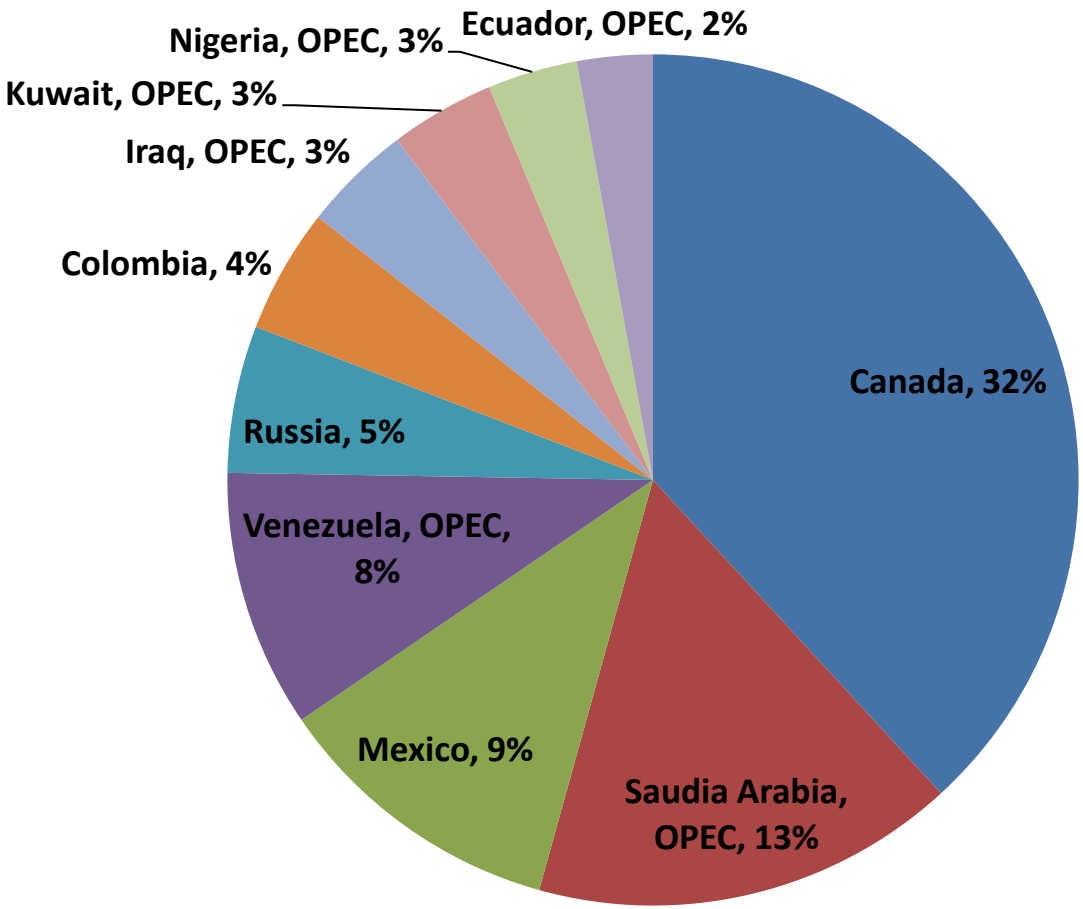


Imports of all grades to Total U.S. 2014



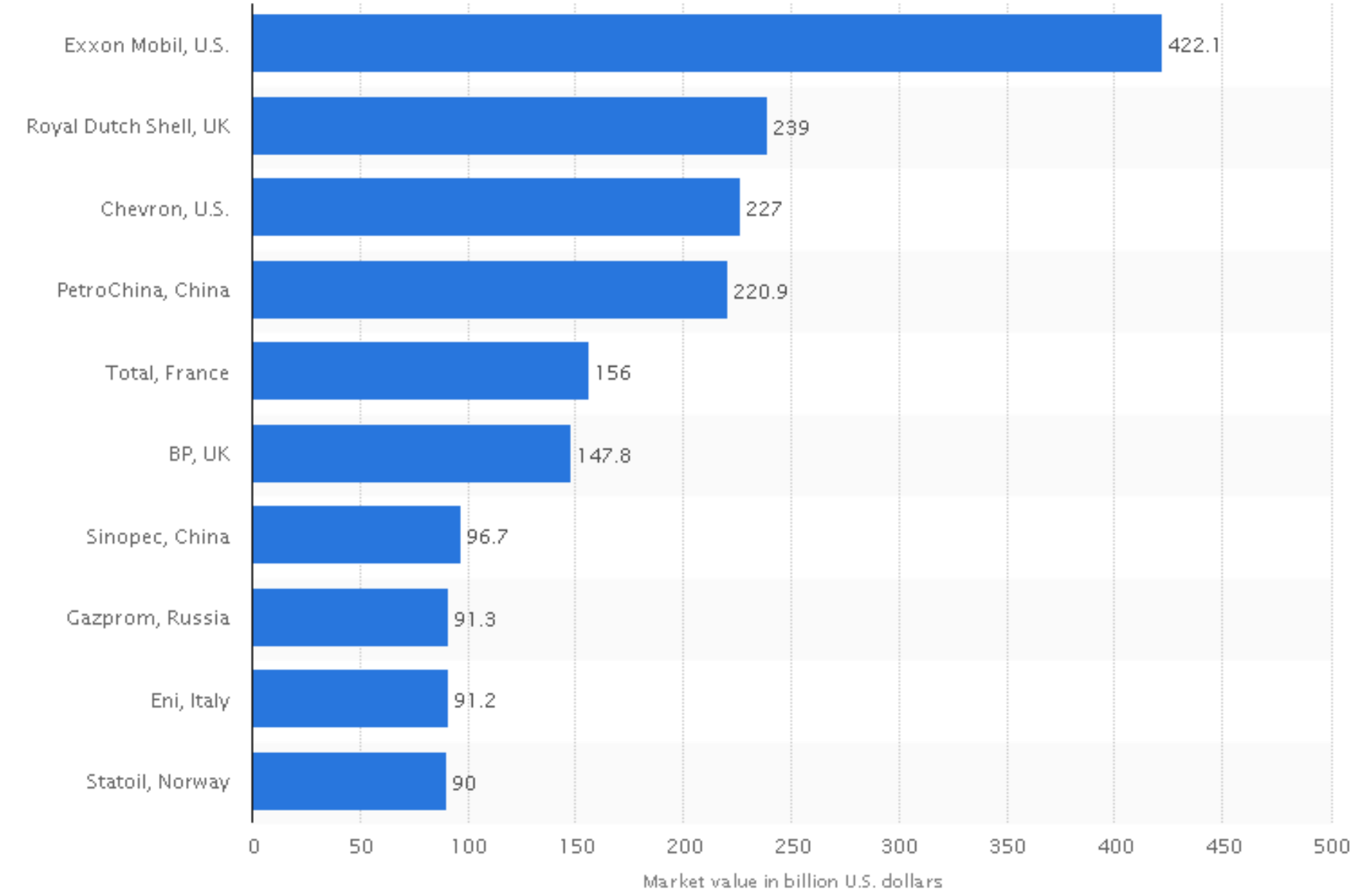
Source: EIA

Top 10 Sources of Oil Imports to the US, 2013



Accounting for 84% of imported oil. Data source: EIA, Dec, 2014

Market value (billions) 2014



Forbes, 2014 World's largest companies

1		**ICBC**	China	$148.7 B	$42.7 B	$3,124.9 B	$215.6 B
2		**China Construction Bank**	China	$121.3 B	$34.2 B	$2,449.5 B	$174.4 B
3		**Agricultural Bank of China**	China	$136.4 B	$27 B	$2,405.4 B	$141.1 B
4		**JPMorgan Chase**	United States	$105.7 B	$17.3 B	$2,435.3 B	$229.7 B
5		**Berkshire Hathaway**	United States	$178.8 B	$19.5 B	$493.4 B	$309.1 B
6		**Exxon Mobil**	United States	$394 B	$32.6 B	$346.8 B	$422.3 B
7		**General Electric**	United States	$143.3 B	$14.8 B	$656.6 B	$259.6 B

Peak Oil - Hubbert's prediction

In 1956, M. King Hubbert made a prediction

- Hubbert was at the top of the Research unit of Shell
- Presented findings at API conference in San Antonio paper called "Nuclear Energy and the Fossil Fuels"
- Used a the "bell curve" or *Normal Curve* to predict production
- If symmetrical bell curve, production would peak at 50% depletion

Hubbert's curve

(Hubbert, Shell Development Company document #95, June 1956)

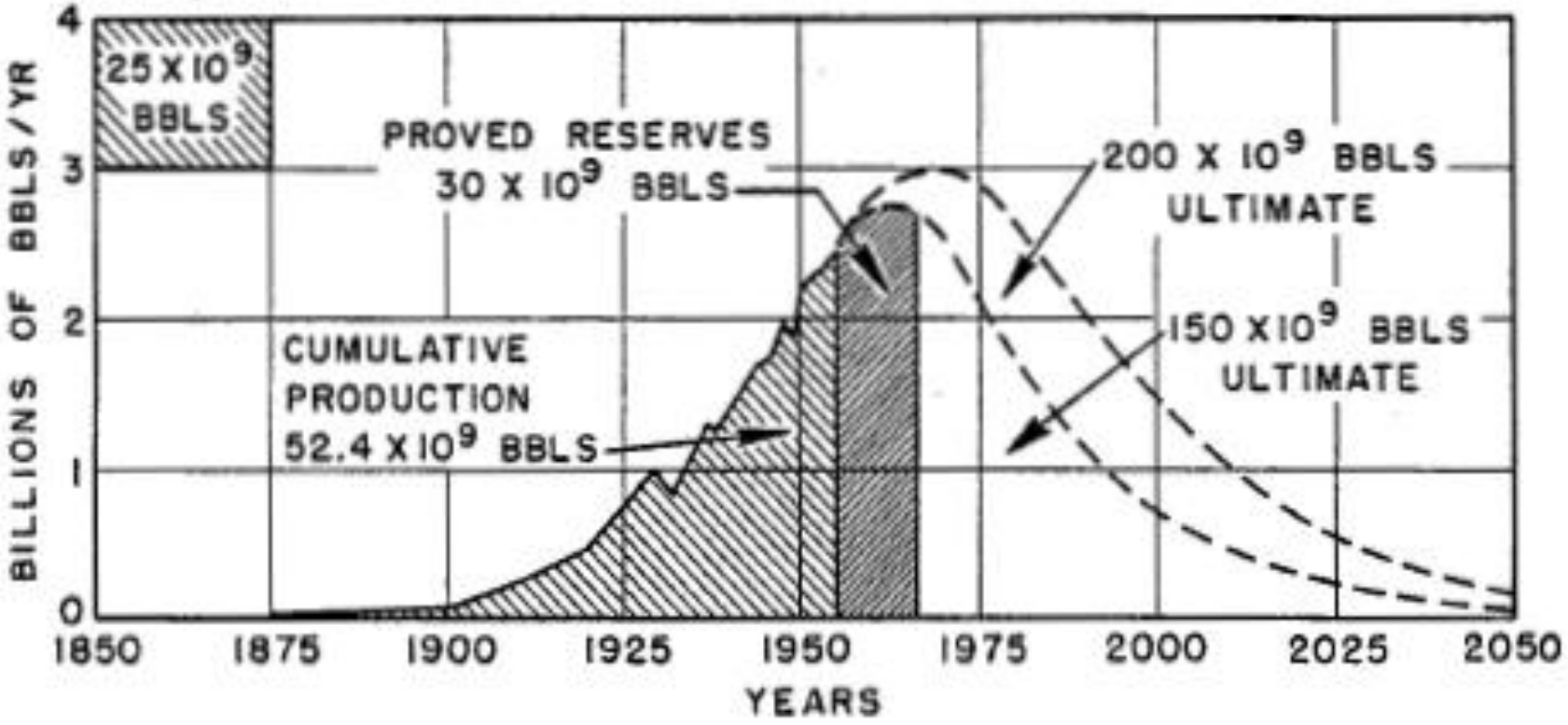
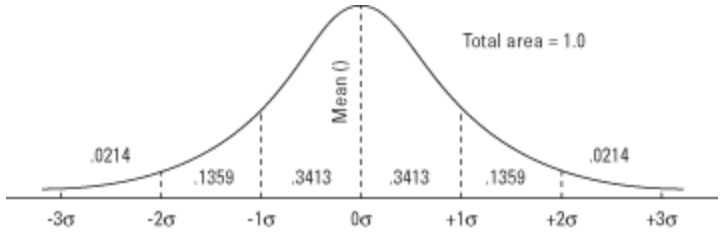


Figure 21 – Ultimate United States crude-oil production based on assumed initial reserves of 150 and 200 billion barrels.

Resource Depletion

Hubbert (1956) argued that production would begin with exponential growth, then plateau, then decline (symmetrically) as in bell curve:

$$P = P_m \exp\left[-\frac{1}{2}\left(\frac{t - t_m}{\sigma} \right)^2 \right]$$



Where P = production of the resource

P_m= maximum production rate

t_m = time of maximum production

σ = standard deviation

So the total amount over all time (reserves) produced would be:

$$Q = \int_{-\infty}^{\infty} P dt = \int_{-\infty}^{\infty} P_m \exp\left[-\frac{1}{2}\left(\frac{t - t_m}{\sigma} \right)^2 \right] dt$$

$$Q = \sigma P_m \sqrt{2\pi} \quad \text{or} \quad \sigma = \frac{Q}{P_m \sqrt{2\pi}}$$

Using the normal curve to find peak production…

- If you know your total reserves Q, and the maximum production rate P_m, then you can solve for the standard deviation of the curve:

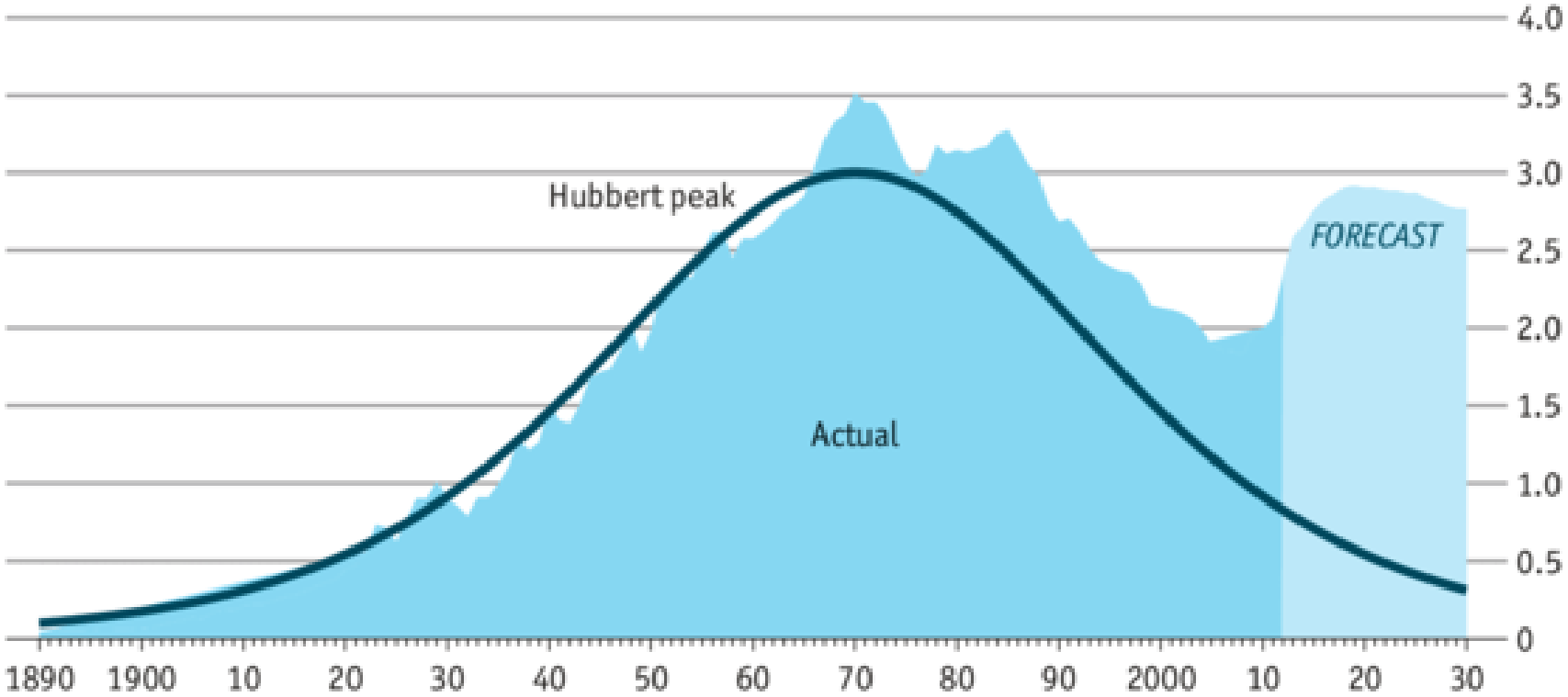
$$\sigma = \frac{Q}{P_m \sqrt{2\pi}}$$

- This then gives you your equation for production, and with known production at a past time, you can solve for t_m, time of the peak.

$$P_o = P_m \exp\left[-\frac{1}{2}\left(\frac{t_0 - t_m}{\sigma}\right)^2\right] \qquad t_m = t_0 + \sigma\sqrt{2\ln\frac{P_m}{P_0}}$$

American* crude oil production

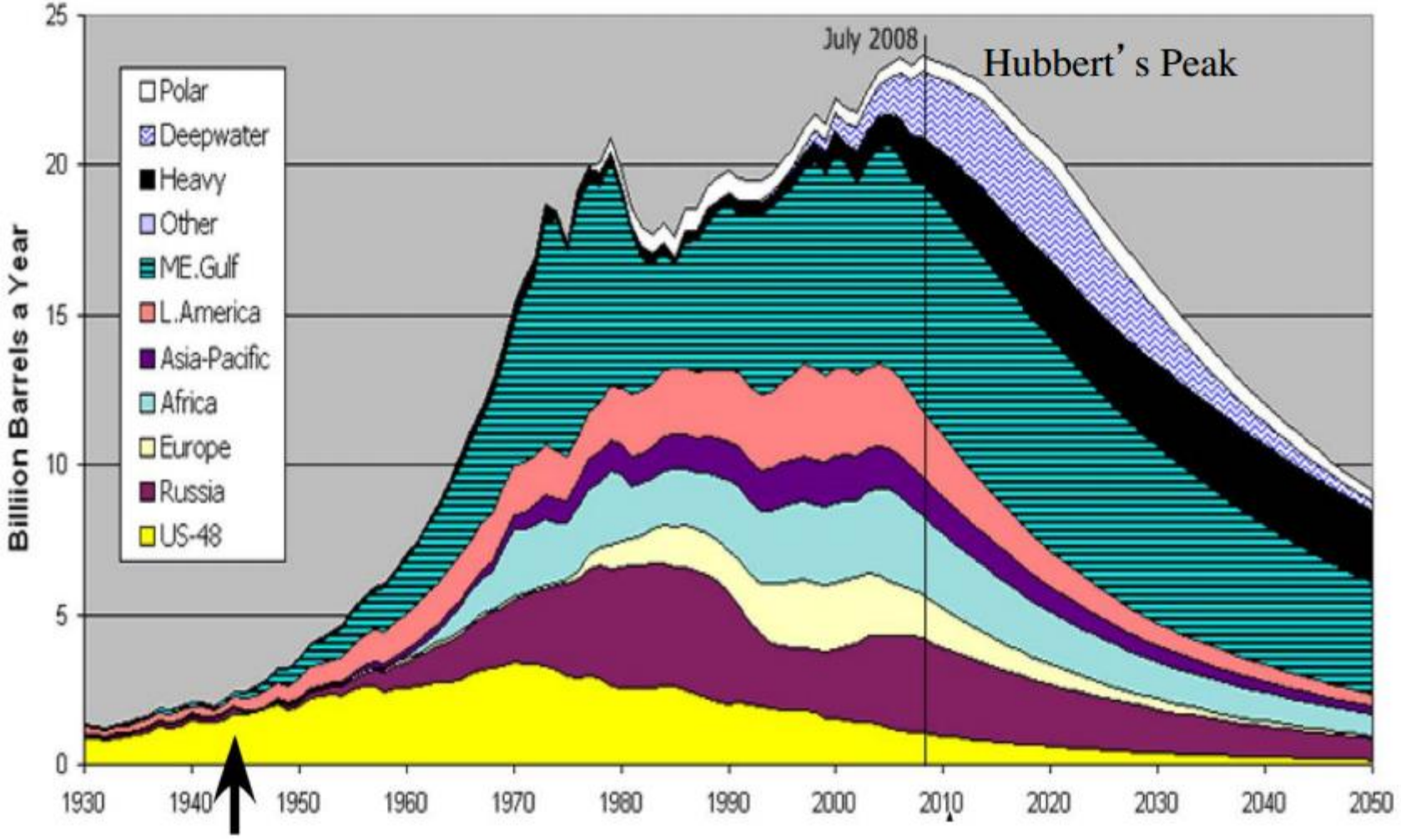
Billion barrels per year



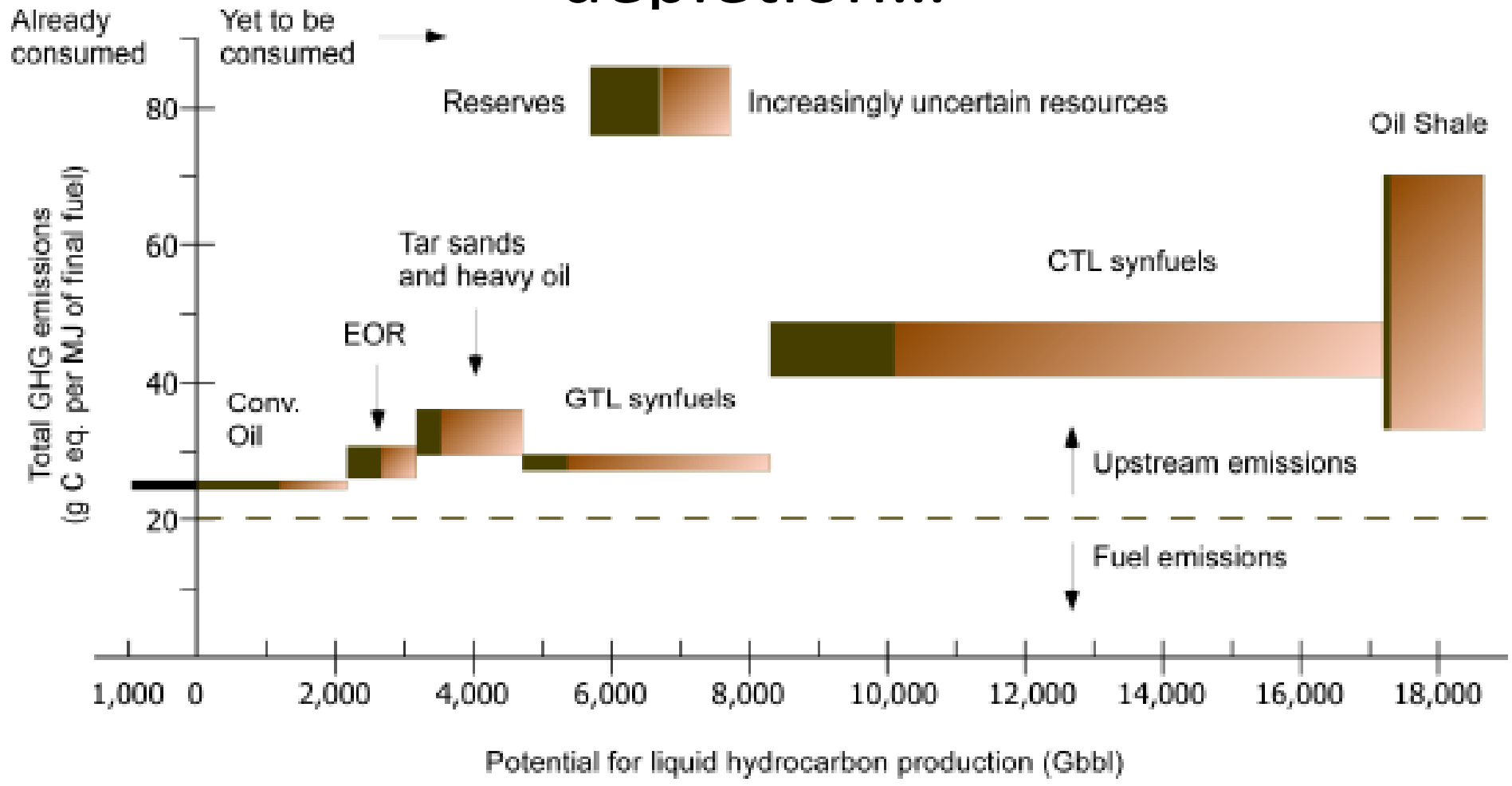
Source: BP

*48 states including Alaska

Global oil production…



The issue is climate change, not oil depletion…



Source: Brandt and Farrell (2006) ***Environmental Research Letters (erl.iop.org)***