IGTI Fuels Report

Presented at

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Basic Comparisons

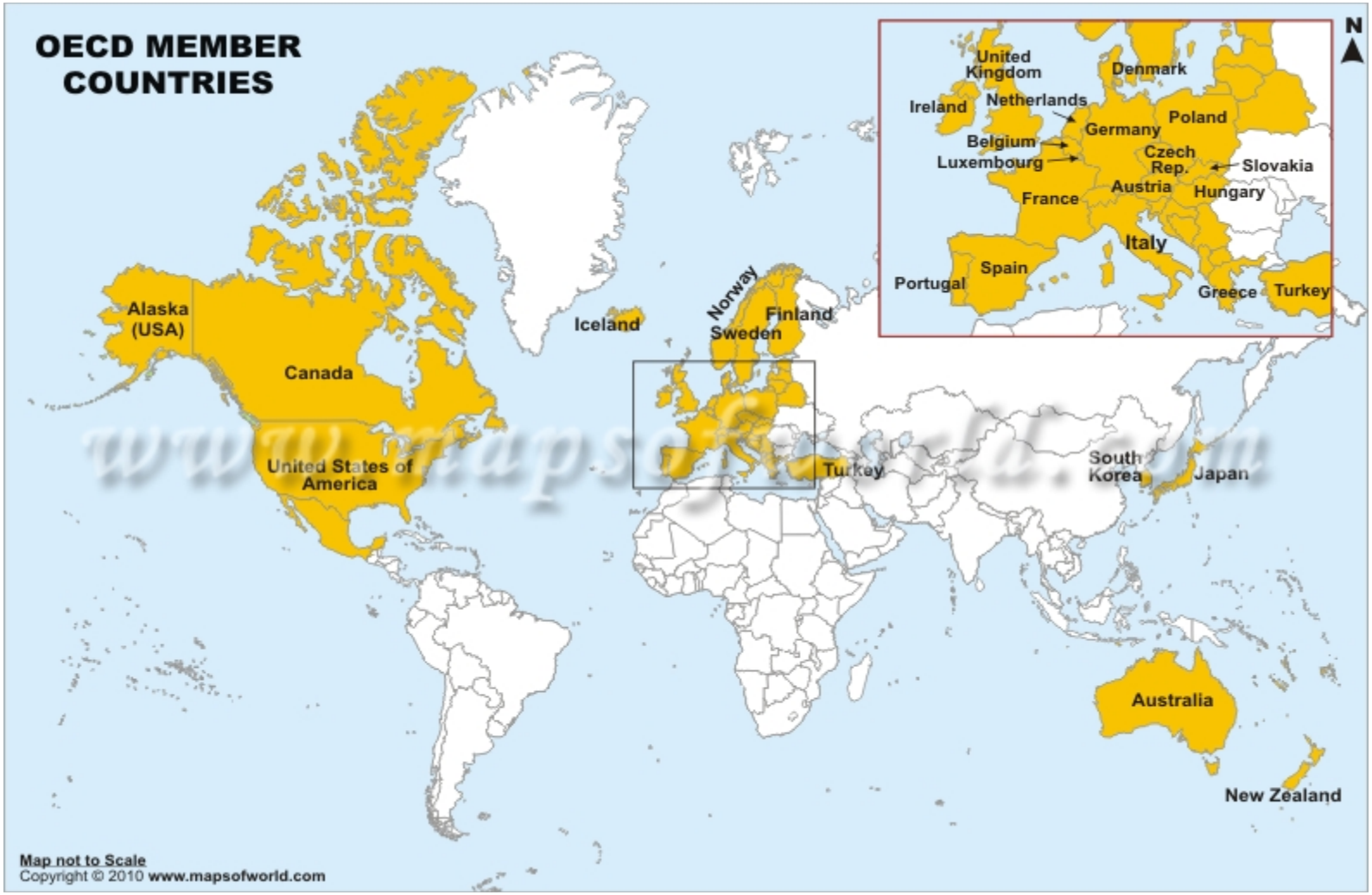
	China	USA	India	Japan	Germany	Russia
Population - July 2015 est	1,367,485,388	321,368,864	1,251,695,584	126,919,659	80,854,408	142,423,773
Population Growth Rate	0.45%	0.78%	1.22%	-0.16%	-0.17%	-0.04%
Area - km^2	9,596,960	9,826,675	3,287,263	377,915	357,022	17,098,242
GDP - Purchasing Power Parity ($trillion)	19.4	17.6	8.0	4.8	3.8	3.7
Installed Generating Capacity GW	1,505	1,063	255	293	177	242
% of World at 5,291 GW	28%	20%	5%	6%	3%	5%
Electric Production TWh	5,650	4,048	1,052	966	585	1,064
Electric Consumption TWh	5,523	3,832	865	921	540	1,065
Aggregate Load Factor	42.9%	43.5%	47.1%	37.6%	37.7%	50.2%
Natural Gas Production - BCM	121.5	782.2	31.7	4.7	10.1	578.7
Natural Gas Consumption - BCM	180.4	759.4	50.6	134.3	77.5	409.2
Refined Petroleum Products Production - mmbbl/d	9.9	19.1	4.4	3.3	2.2	6.1
Refined Petroleum Products Consumption - mmbbl/d	10.5	19.0	3.7	4.3	2.4	2.8
Coal Production - Million Tonnes Oil Equivalent	1827.0	455.2	283.9	0.7	42.9	184.5
Coal Consumption - Million Tonnes Oil Equivalent	1920.4	396.3	407.2	119.4	78.3	88.7

Source: CIA World Factbook

World Total Installed Electrical Generating Capacity 5,291 GW

Ps…….Total Value of Outstanding Student Loans - $1.3 trillion
U.S. health care cost 2014 - 3.0 trillion

OECD Member Countries -2010



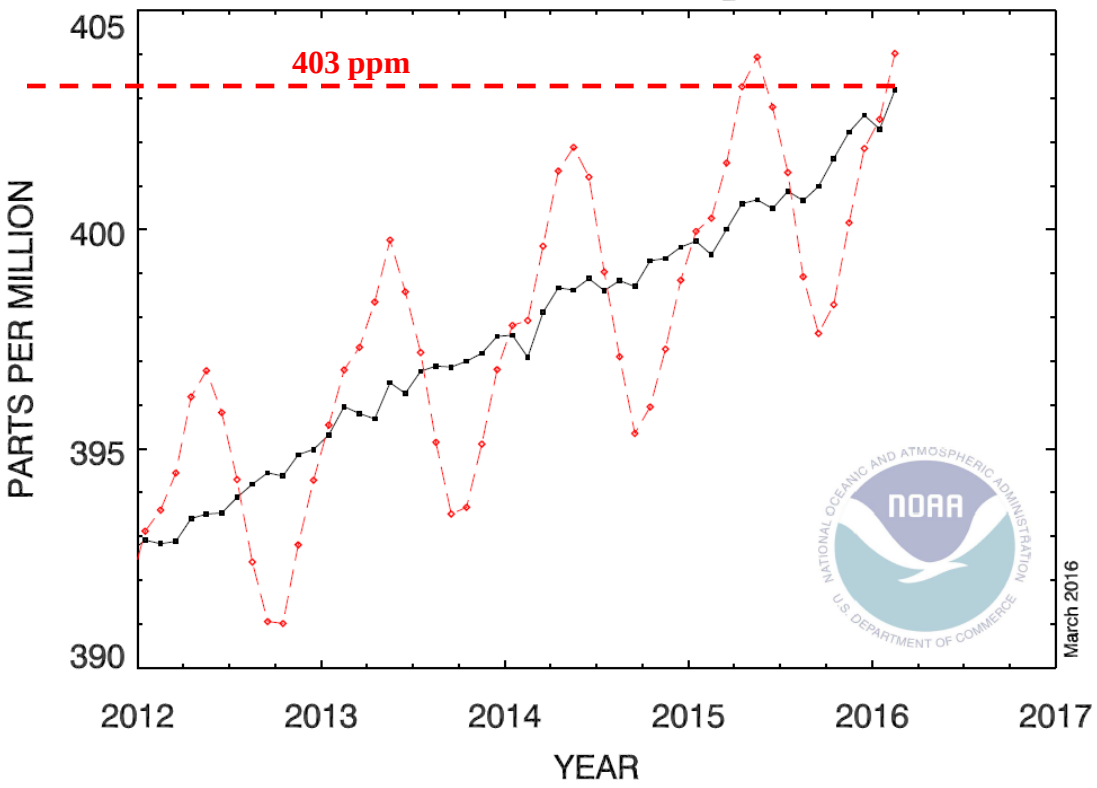
Many Global Issues Increase Uncertainty

Many global issues increase uncertainty…

- Economic growth in key economies (China, Brazil, Russia, among others)
- Implementation and strength of climate policies
- Technology improvement rates (both supply and demand)
- Unrest in oil producing countries
- OPEC production
- Future of nuclear generating capacity

China
Renewable Energy
Climate Change

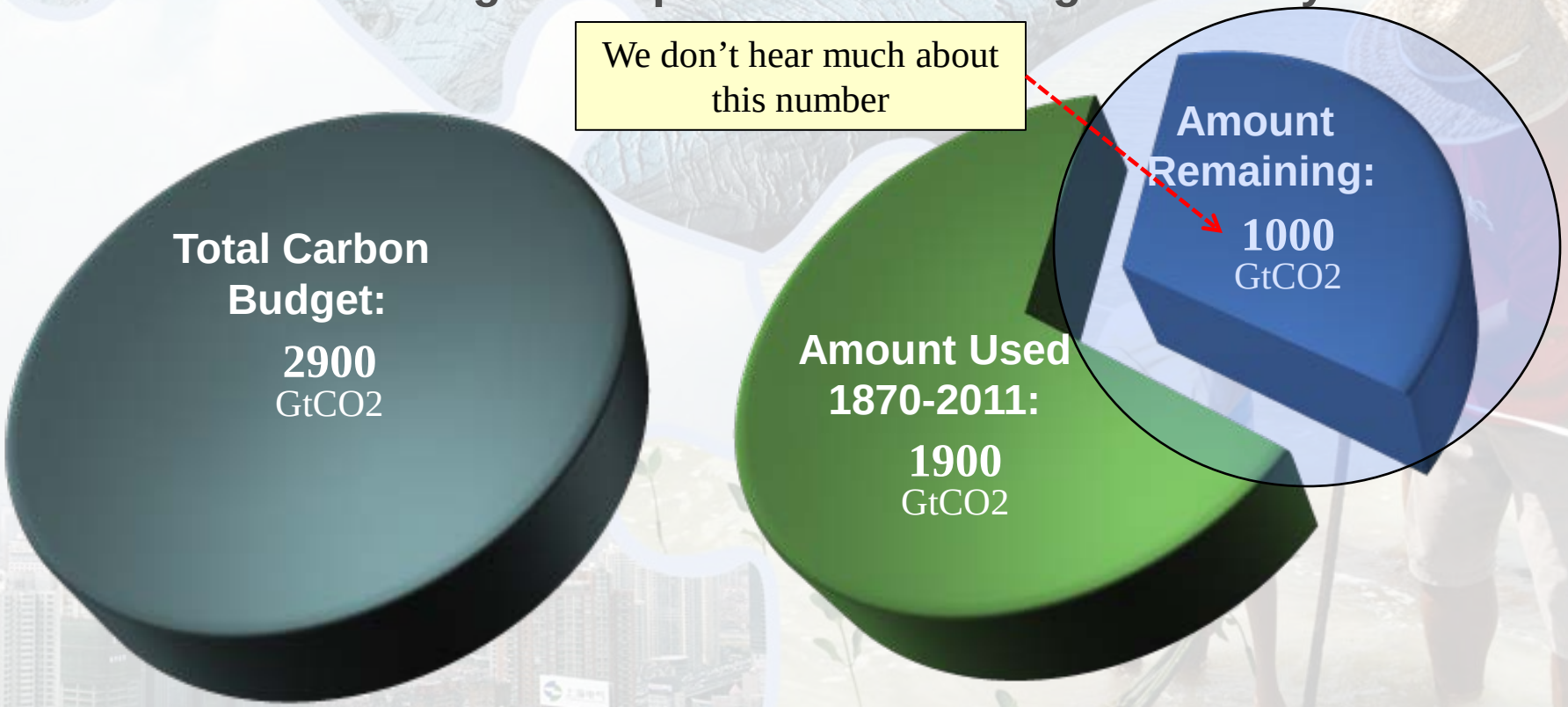
Recent Monthly Mean CO2 at Mauna Loa



The window for action is rapidly closing

65% of our carbon budget compatible with a 2°C goal already used

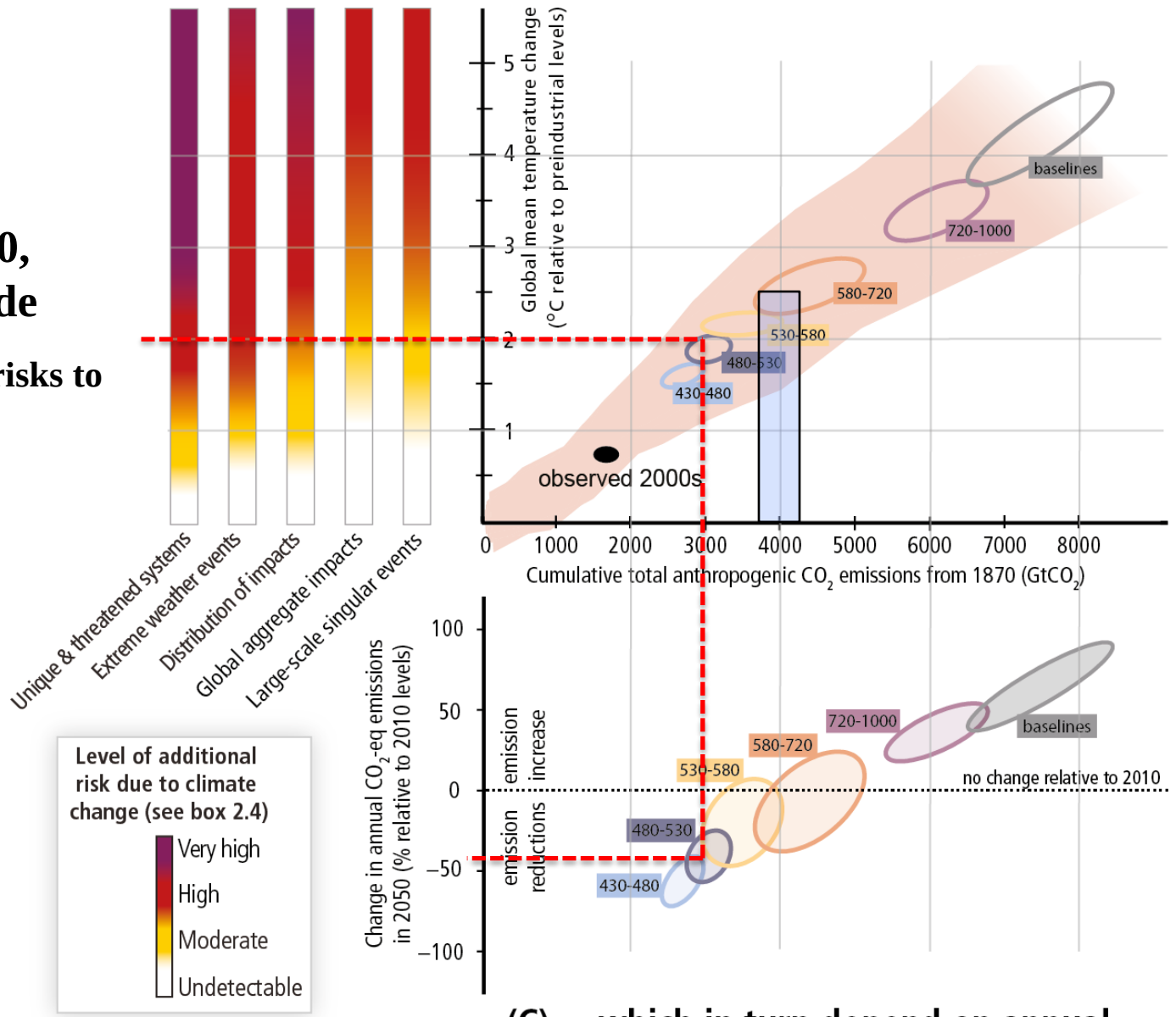
We don't hear much about this number



AR5 WGI SPM

Figure SPM.10, A reader's guide

From climate change risks to GHG emissions



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Worldwide CO_2 Emissions (million metric tonnes)

World carbon dioxide emissions by region, IEO2011 Reference case
(Million metric tons carbon dioxide)

Region/Country	2005	2008	2011	2015	2020	2025	2030	2035	Growth Rate (2008-2035)
OECD									
OECD Americas	**7079**	**6926**	**6665**	**6773**	**6924**	**7169**	**7431**	**7772**	**0.31%**
United States	5996	5838	5601	5680	5777	5938	6108	6311	0.17%
Canada	620	595	570	569	582	608	635	679	0.30%
Mexico/Chile	463	493	494	524	565	623	688	782	1.76%
OECD Europe	**4400**	**4345**	**4097**	**4115**	**4147**	**4156**	**4198**	**4257**	**-0.11%**
OECD Asia	**2172**	**2201**	**2112**	**2143**	**2181**	**2224**	**2253**	**2294**	**0.18%**
Japan	1241	1215	1114	1125	1142	1136	1110	1087	-0.44%
South Korea	494	522	539	553	562	597	634	678	1.06%
Australia/New Zealand	437	464	458	466	477	492	509	528	0.63%
Total OECD	**13651**	**13472**	**12873**	**13031**	**13252**	**13549**	**13882**	**14323**	**0.16%**
Non-OECD									
Non-OECD Europe and Eurasia	**2782**	**2832**	**2787**	**2803**	**2767**	**2782**	**2863**	**2964**	**0.21%**
Russia	1645	1663	1651	1648	1607	1603	1659	1747	0.20%
Other	1137	1169	1136	1154	1159	1179	1204	1217	0.23%
Non-OECD Asia	**8359**	**10100**	**11916**	**13238**	**14475**	**16475**	**18238**	**19688**	**2.90%**
China	5513	6801	8381	9386	10128	11492	12626	13441	3.02%
India	1182	1462	1633	1802	2056	2398	2728	3036	3.19%
Other	1665	1838	1901	2050	2291	2585	2884	3211	2.21%
Middle East	**1400**	**1581**	**1743**	**1889**	**2019**	**2199**	**2435**	**2659**	**2.16%**
Africa	**978**	**1078**	**1137**	**1209**	**1311**	**1430**	**1568**	**1735**	**1.93%**
Central and South America	**1011**	**1128**	**1184**	**1287**	**1386**	**1497**	**1654**	**1852**	**2.04%**
Brazil	365	423	468	528	579	644	739	874	2.95%
Other	646	705	716	759	807	853	916	978	1.39%
Total Non-OECD	**14530**	**16718**	**18766**	**20426**	**21958**	**24383**	**26758**	**28897**	**2.32%**
Total World	**28181**	**30190**	**31640**	**33457**	**35210**	**37932**	**40640**	**43220**	**1.44%**

Total U.S. 5996
PowerGen -2416
Non-PowerGen 3580

31.6 Gt

Actual through 2011

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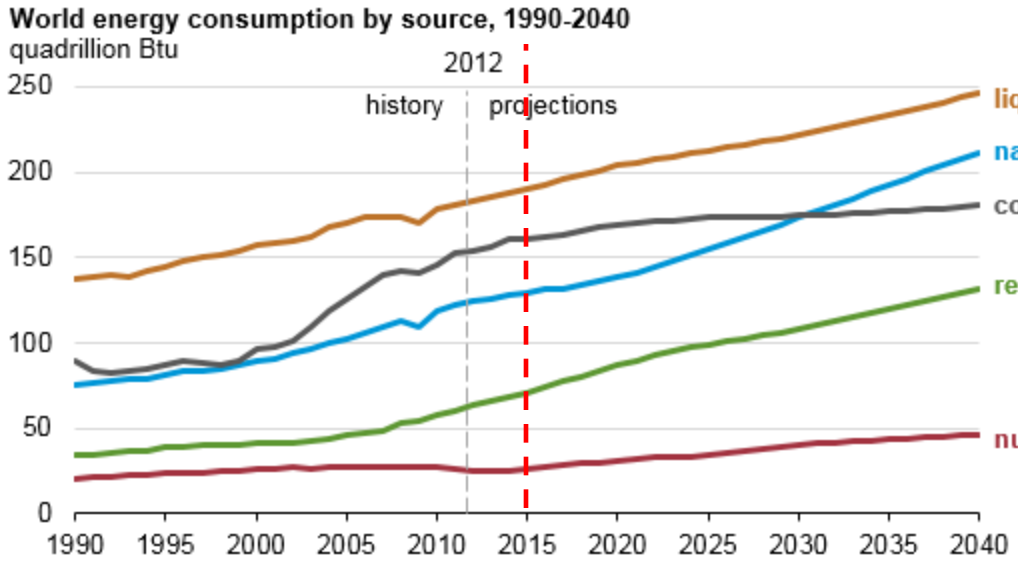
Primary Energy Consumption by Fuel - Mtoe

Million tonnes oil equivalent	2014 Oil	Natural Gas	Coal	Nuclear Energy	Hydro electric	Renew-ables	Total	2015 Oil	Natural Gas	Coal	Nuclear Energy	Hydro electric	Renew-ables	Total	Percent of 2015 Total
US	838.1	692.7	453.8	189.9	59.3	66.8	2300.5	851.6	713.6	396.3	189.9	57.4	71.7	**2280.6**	17.3%
Canada	103.3	93.8	21.4	24.2	86.6	6.3	335.5	100.3	92.2	19.8	23.6	86.7	7.3	**329.9**	2.5%
Mexico	85.2	78.1	12.8	2.2	8.6	3.0	190.0	84.3	74.9	12.8	2.6	6.8	3.5	**185.0**	1.4%
Total North America	**1026.6**	**864.6**	**487.9**	**216.3**	**154.5**	**76.1**	**2826.0**	**1036.3**	**880.7**	**429.0**	**216.1**	**150.9**	**82.6**	**2795.5**	21.3%
Brazil	143.4	35.5	17.6	3.5	84.5	13.2	297.6	137.3	36.8	17.4	3.3	81.7	16.3	**292.8**	2.2%
Total S. & Cent. America	**329.8**	**152.6**	**36.7**	**4.8**	**154.4**	**19.9**	**698.2**	**322.7**	**157.3**	**37.1**	**5.0**	**152.9**	**24.2**	**699.3**	5.3%
															0.0%
France	76.9	32.6	8.7	98.8	14.0	6.5	237.5	76.1	35.1	8.7	99.0	12.2	7.9	**239.0**	1.8%
Germany	110.4	64.0	78.8	22.0	4.4	32.3	311.9	110.2	67.2	78.3	20.7	4.4	40.0	**320.6**	2.4%
Italy	55.8	50.7	13.1	-	13.1	14.1	146.8	59.3	55.3	12.4	-	9.9	14.7	**151.7**	1.2%
Russian Federation	150.8	370.7	87.6	40.9	39.7	0.1	689.8	143.0	352.3	88.7	44.2	38.5	0.1	**666.8**	5.1%
Spain	59.0	23.7	11.6	13.0	8.8	16.0	132.1	60.5	24.8	14.4	12.9	6.3	15.4	**134.4**	1.0%
Turkey	34.4	40.2	36.1	-	9.2	2.8	122.8	38.8	39.2	34.4	-	15.1	3.8	**131.3**	1.0%
Ukraine	10.0	33.1	35.6	20.0	1.9	0.4	101.0	8.4	25.9	29.2	19.8	1.4	0.3	**85.1**	0.6%
United Kingdom	69.9	60.0	29.9	14.4	1.3	13.3	188.9	71.6	61.4	23.4	15.9	1.4	17.4	**191.2**	1.5%
Total Europe & Eurasia	**858.6**	**905.8**	**481.0**	**266.2**	**196.7**	**124.1**	**2832.3**	**862.2**	**903.1**	**467.9**	**264.0**	**194.4**	**142.8**	**2834.4**	21.6%
Iran	93.1	162.0	1.2	1.0	3.4	0.1	260.8	88.9	172.1	1.2	0.8	4.1	0.1	**267.2**	2.0%
Saudi Arabia	160.1	92.1	0.1	-	-	^	252.4	168.1	95.8	0.1	-	-	^	**264.0**	2.0%
Other Middle East	83.2	42.2	0.8	-	1.4	^	127.6	83.3	45.4	0.8	-	1.8	0.1	**131.4**	1.0%
Total Middle East	**417.1**	**415.3**	**10.7**	**1.0**	**4.8**	**0.4**	**849.2**	**425.7**	**441.2**	**10.5**	**0.8**	**5.9**	**0.5**	**884.7**	6.7%
South Africa	29.3	4.5	90.1	3.3	0.2	0.6	128.0	31.1	4.5	85.0	2.4	0.2	1.0	**124.2**	0.9%
Other Africa	91.4	34.1	11.4	-	23.8	1.8	162.6	93.5	39.2	11.0	-	23.8	2.4	**169.9**	1.3%
Total Africa	**177.2**	**115.6**	**102.4**	**3.3**	**27.0**	**2.7**	**428.2**	**183.0**	**121.9**	**96.9**	**2.4**	**27.0**	**3.8**	**435.0**	3.3%
Australia	45.4	32.4	44.7	-	3.3	4.1	129.9	46.2	30.9	46.6	-	3.1	4.5	**131.4**	1.0%
China	526.8	169.6	1949.3	30.0	242.8	51.9	2970.3	559.7	177.6	1920.4	38.6	254.9	62.7	**3014.0**	22.9%
India	180.8	45.6	388.7	7.8	29.6	13.6	666.2	195.5	45.5	407.2	8.6	28.1	15.5	**700.5**	5.3%
Indonesia	76.0	36.8	69.8	-	3.4	2.3	188.3	73.5	35.8	80.3	-	3.6	2.4	**195.6**	1.5%
Japan	197.3	106.2	118.7	-	20.0	11.6	453.9	189.6	102.1	119.4	1.0	21.9	14.5	**448.5**	3.4%
South Korea	107.9	43.0	84.6	35.4	0.9	1.2	273.1	113.7	39.2	84.5	37.3	0.7	1.6	**276.9**	2.1%
Other Asia Pacific	20.4	6.5	18.8	-	13.0	0.2	58.9	20.6	7.1	19.3	-	14.1	0.3	**61.3**	0.5%
Total Asia Pacific	**1442.2**	**627.7**	**2792.5**	**83.9**	**346.9**	**93.4**	**5386.6**	**1501.4**	**631.0**	**2798.5**	**94.9**	**361.9**	**110.9**	**5498.5**	41.8%
Total World	**4251.6**	**3081.5**	**3911.2**	**575.5**	**884.3**	**316.6**	**13020.6**	**4331.3**	**3135.2**	**3839.9**	**583.1**	**892.9**	**364.9**	**13147.3**	100.0%
	32.7%	23.7%	30.0%	4.4%	6.8%	2.4%	100.0%	32.9%	23.8%	29.2%	4.4%	6.8%	2.8%	100.0%	

13,147.3 Mtoe = 521.3 Quads

Source: BP Statistical Review of World Energy 2016

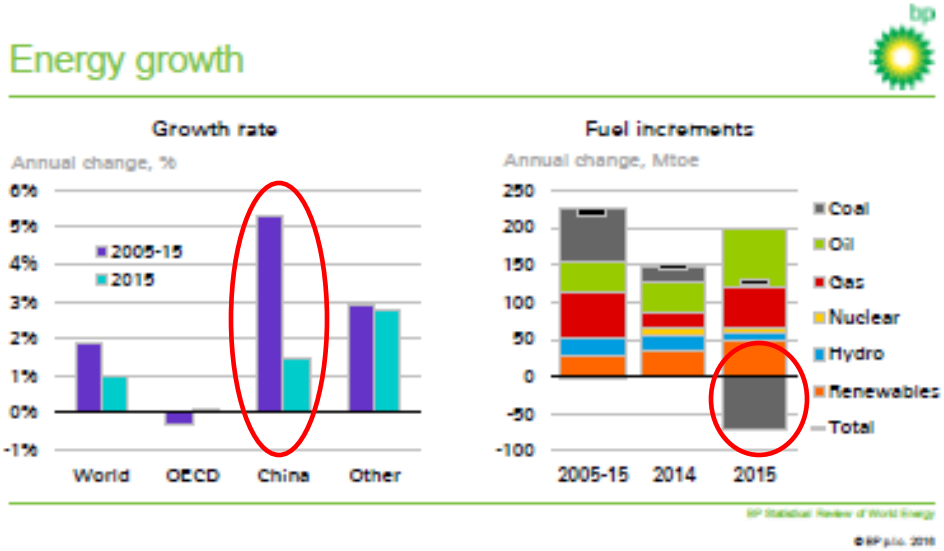
World Energy Consumption IEA IEO2016



	2015	2040
liquid fuels	171.7	248.0
natural gas	124.3	212.0
coal	152.3	180.0
renewables	49.9	135.0
nuclear	23.1	45.0
	521.3	820.0

Source: EIA International Energy Outlook 2016

Much of the analysis conducted for the IEO2016 was done before the release of the U.S. Environmental Protection Agency's final Clean Power Plan (CPP). For this reason, the IEO2016 Reference case does not include the potential effects of the CPP regulations in the United States, analysis that shows the potential for significant reductions in U.S. coal consumption and increases in U.S. renewable consumption compared with the Reference case projection.



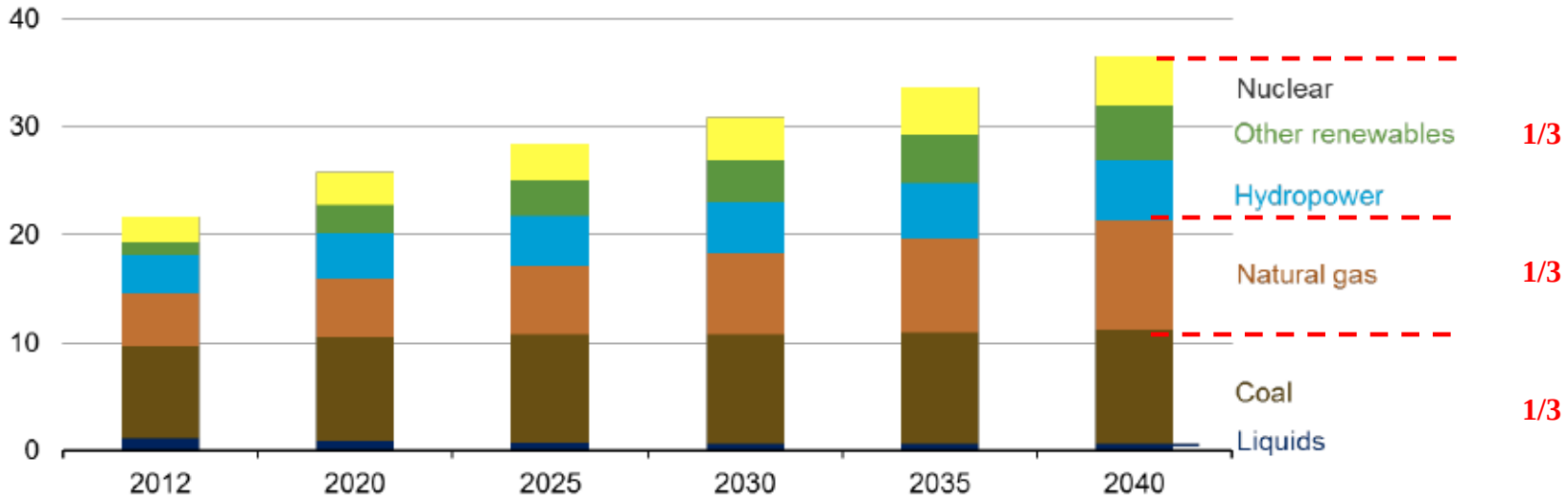
Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

Fuel Mix 2040

Renewables, natural gas, and coal all contribute roughly the same amount of global net electricity generation in 2040

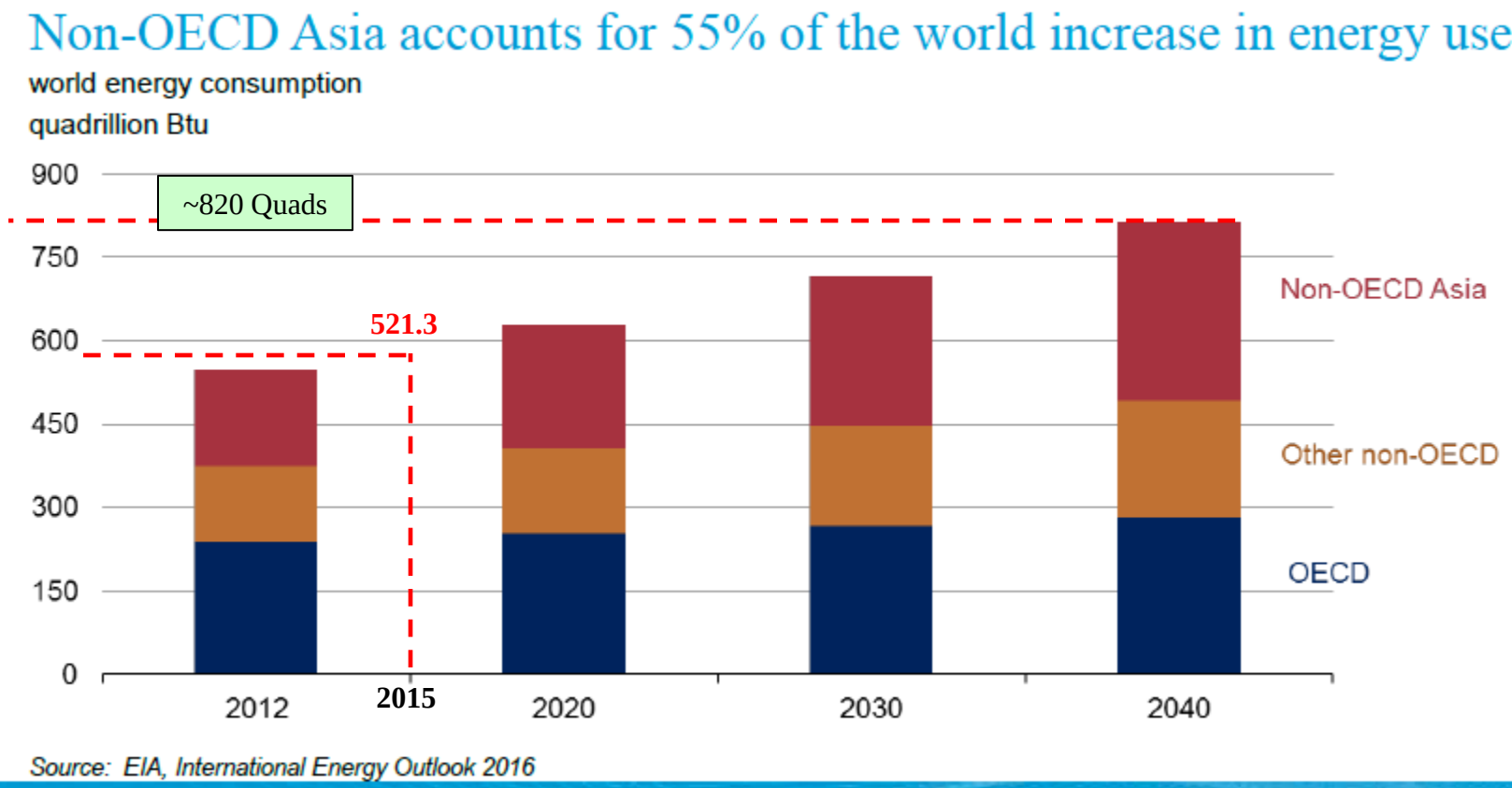
world net electricity generation by source

trillion kilowatthours



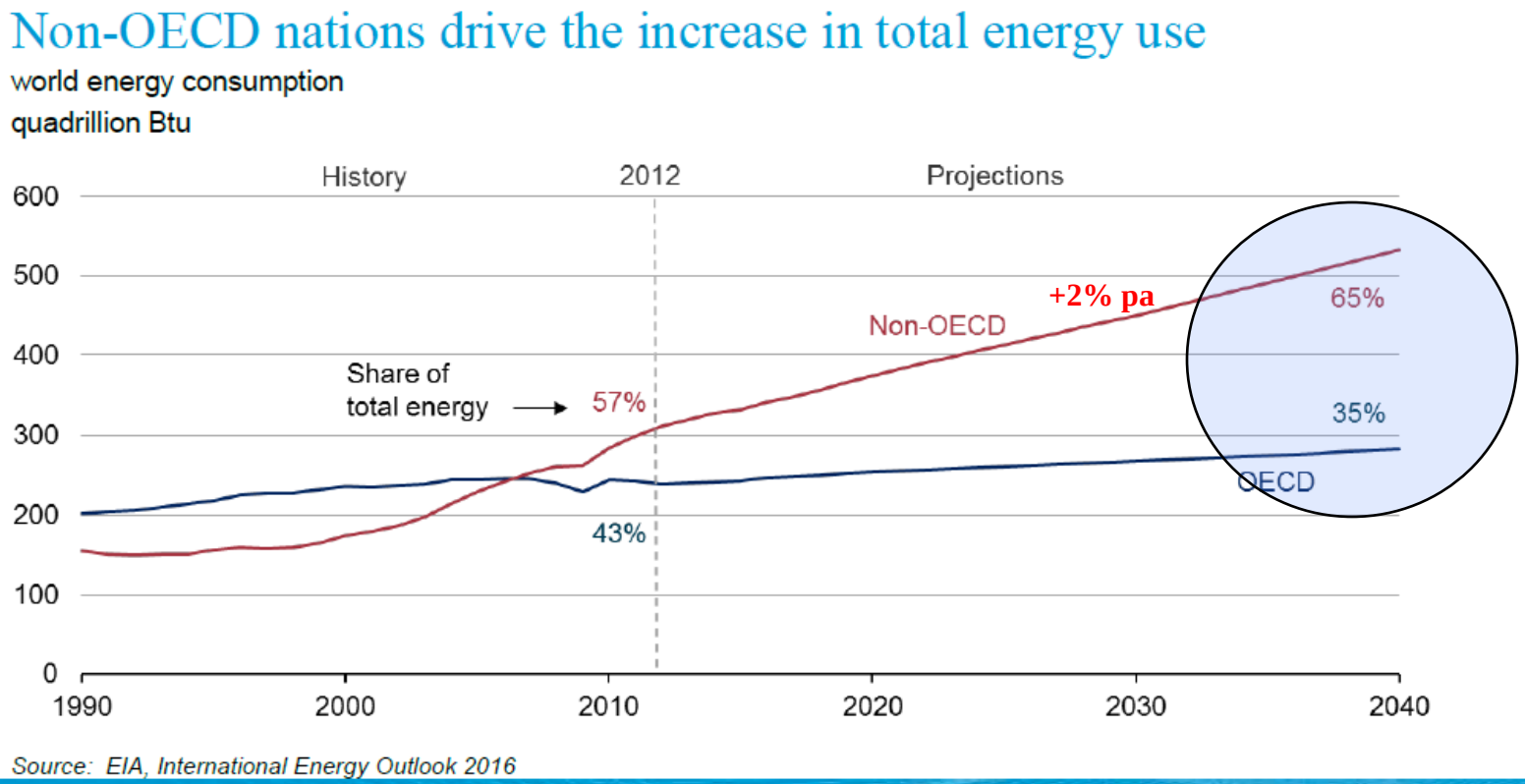
Source: EIA, International Energy Outlook 2016

Non-OECD Asia



Source: EIA, International Energy Outlook 2016

World Energy Consumption - Quads



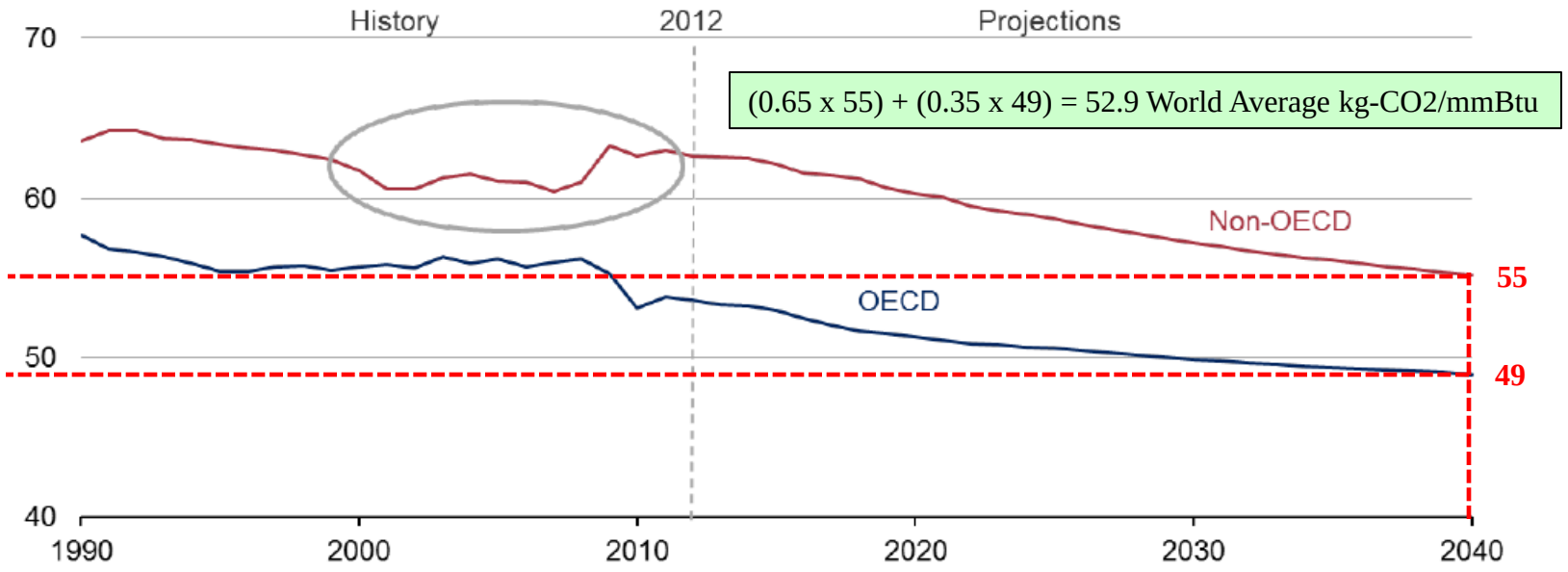
Source: EIA, International Energy Outlook 2016

Projected CO2e Decline to 52.9 kg/mmBtu in 2040

Projected carbon intensity of energy use (CO2/E) declines through 2040 in both OECD and non-OECD; non-OECD CO2/E rose over 2000–12

carbon intensity of energy consumption, 1990-2040

kilograms CO2 per million Btu



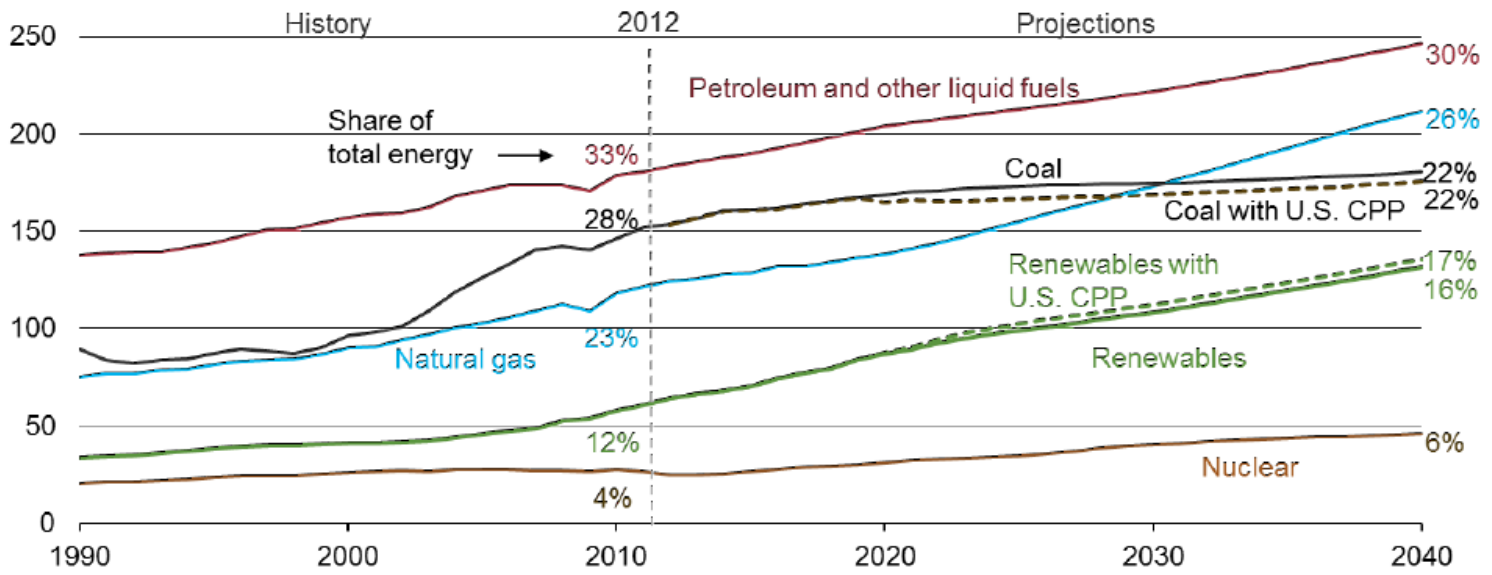
Source: EIA, International Energy Outlook 2016

820 Quads = 43.4Gt CO2e in 2040

Renewables grow fastest, coal use plateaus, natural gas surpasses coal by 2030, and oil maintains its leading share

world energy consumption
quadrillion Btu

820 x10^{15} Btu x 52.9kg/10^{9} Btu x 1t/kg x1Gt/10^{9} t = 43.4Gt in 2040



Source: EIA, International Energy Outlook 2016 and EIA, Analysis of the Impacts of the Clean Power Plan (May 2015)

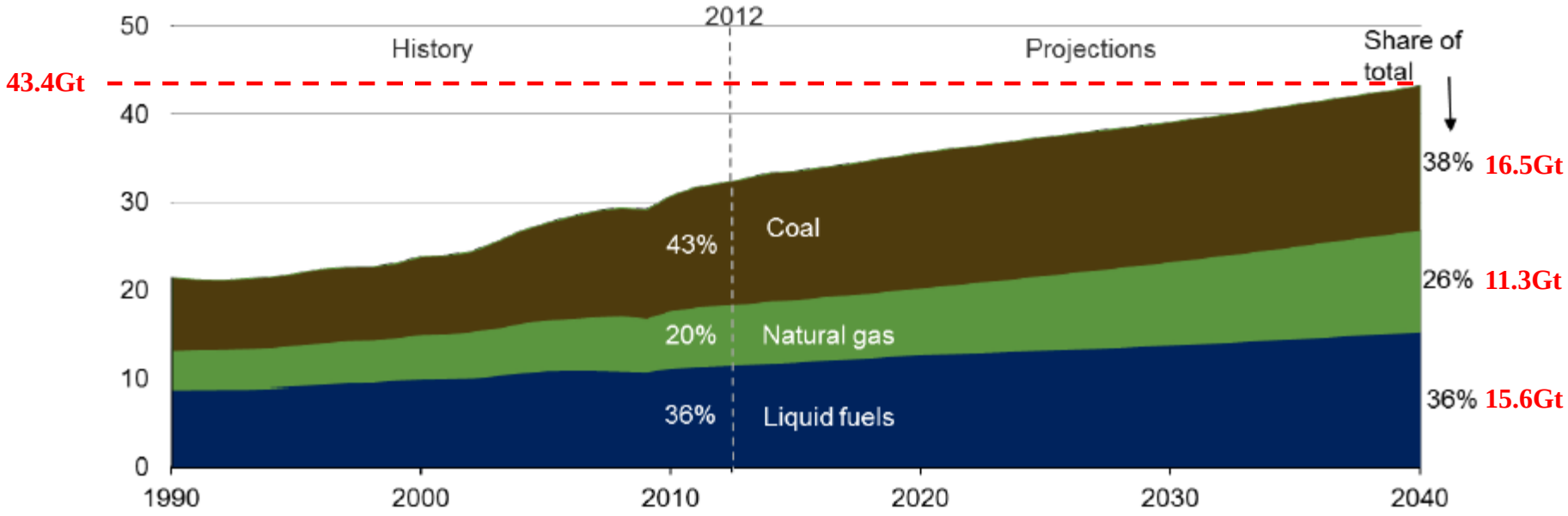
2015 = 521.3 Quads

Energy Related CO2 Emissions

Coal remains the world's largest source of energy-related CO2 emissions, but by 2040 its share declines to 38%

world energy-related carbon dioxide emissions

billion metric tons (Gt)



Source: EIA, International Energy Outlook 2016

CO_2 Emission from Electric Power

Electric power sector carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	1,831.0	2,416.9	2,373.7	2,160.3
Change from 1990 (million metric tons)		585.8	542.7	329.3
(percent)		*32.0%*	*29.6%*	*18.0%*
Average annual change from 1990 *(percent)*		*1.9%*	*1.5%*	*0.9%*
Change from 2005 (million metric tons)			-43.1	-256.5
(percent)			*-1.8%*	*-10.6%*
Change from 2008 (million metric tons)				-213.4
(percent)				*-9.0%*

Figure 15. U.S. electric power sector energy sales and losses and carbon dioxide emissions from primary fuel combustion, 1990-2009

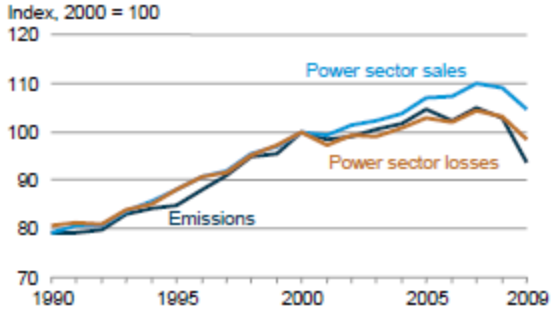


Table 12. U.S. carbon dioxide emissions from electric power sector energy consumption, 1990-2009 (million metric tons carbon dioxide)

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Petroleum										
Residual fuel oil	91.6	44.6	68.6	68.5	69.3	69.1	28.4	31.3	18.9	14.3
Distillate fuel oil	7.1	7.9	12.8	11.8	8.1	8.4	5.4	6.5	5.3	5.1
Petroleum coke	3.1	8.2	10.1	17.8	22.7	24.9	21.8	17.5	15.7	14.2
Petroleum subtotal	*101.8*	*60.7*	*91.5*	*98.1*	*100.1*	*102.3*	*55.6*	*55.3*	*40.0*	*33.6*
Coal	1,547.6	1,660.7	1,927.4	1,931.0	1,943.1	1,983.8	1,953.7	1,987.3	1,959.4	1,742.2
Natural gas	175.5	228.2	280.9	278.3	296.8	319.1	338.2	371.7	362.3	372.6
Municipal solid waste[a]	5.8	10.0	10.1	11.4	11.2	11.2	11.5	11.3	11.6	11.8
Geothermal	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	1,831.0	1,960.1	2,310.2	2,319.2	2,351.5	2,416.9	2,359.5	2,425.9	2,373.7	2,160.3

[a]Emissions from nonbiogenic sources, including fuels derived from recycled tires.
Notes: Emissions for total fuel consumption are allocated to end-use sectors in proportion to electricity sales. Totals may not equal sum of components due to independent rounding.

38.5% from Fossil Fuel PowerGen

2,302.9 total in 2005

base e

"Practical Strategies for Emerging Energy Technologies"

2005 @ 2416 Mt is benchmark for CPP (until EPA changes it again)

U.S. Energy Related CO2 Emissions – Million tonnes

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Residential								
Petroleum	61	64	50	45	41	37	33	-2.4%
Natural gas	225	267	246	241	240	235	229	-0.6%
Electricity[1]	757	773	761	761	770	776	779	0.0%
Total residential	**1,044**	**1,105**	**1,057**	**1,047**	**1,051**	**1,048**	**1,042**	**-0.2%**
Commercial								
Petroleum	40	41	44	43	42	41	41	-0.1%
Natural gas	157	178	175	175	182	189	197	0.4%
Coal	4	4	5	5	5	5	4	0.5%
Electricity[1]	731	744	755	772	788	801	814	0.3%
Total commercial	**933**	**968**	**979**	**994**	**1,016**	**1,037**	**1,057**	**0.3%**
Industrial[2]								
Petroleum	345	350	410	425	424	424	429	0.8%
Natural gas[3]	447	462	512	523	539	549	563	0.7%
Coal	142	143	150	148	144	139	139	-0.1%
Electricity[1]	543	531	586	615	613	601	592	0.4%
Total industrial	**1,476**	**1,486**	**1,658**	**1,711**	**1,719**	**1,714**	**1,723**	**0.5%**
Transportation								
Petroleum[4]	1,774	1,792	1,752	1,701	1,662	1,647	1,631	-0.3%
Natural gas[5]	41	49	49	53	59	67	89	2.2%
Electricity[1]	4	4	5	5	6	8	9	2.9%
Total transportation	**1,819**	**1,845**	**1,806**	**1,759**	**1,727**	**1,722**	**1,728**	**-0.2%**
Electric power[6]								
Petroleum	19	23	13	13	13	13	13	-2.1%
Natural gas	493	442	412	441	478	497	509	0.5%
Coal	1,511	1,575	1,670	1,687	1,674	1,664	1,661	0.2%
Other[7]	12	12	12	12	12	12	12	0.0%
Total electric power	**2,035**	**2,053**	**2,107**	**2,153**	**2,177**	**2,186**	**2,195**	**0.2%**
Total by fuel								
Petroleum[4]	2,240	2,272	2,269	2,227	2,182	2,163	2,147	-0.2%
Natural gas	1,363	1,399	1,394	1,432	1,497	1,538	1,586	0.5%
Coal	1,657	1,722	1,824	1,840	1,822	1,808	1,804	0.2%
Other[7]	12	12	12	12	12	12	12	0.0%
Total	**5,272**	**5,405**	**5,499**	**5,511**	**5,514**	**5,521**	**5,549**	**0.1%**
Carbon dioxide emissions (tons per person)	**16.8**	**17.1**	**16.5**	**15.9**	**15.4**	**14.9**	**14.6**	**-0.6%**

38.0%

39.1%

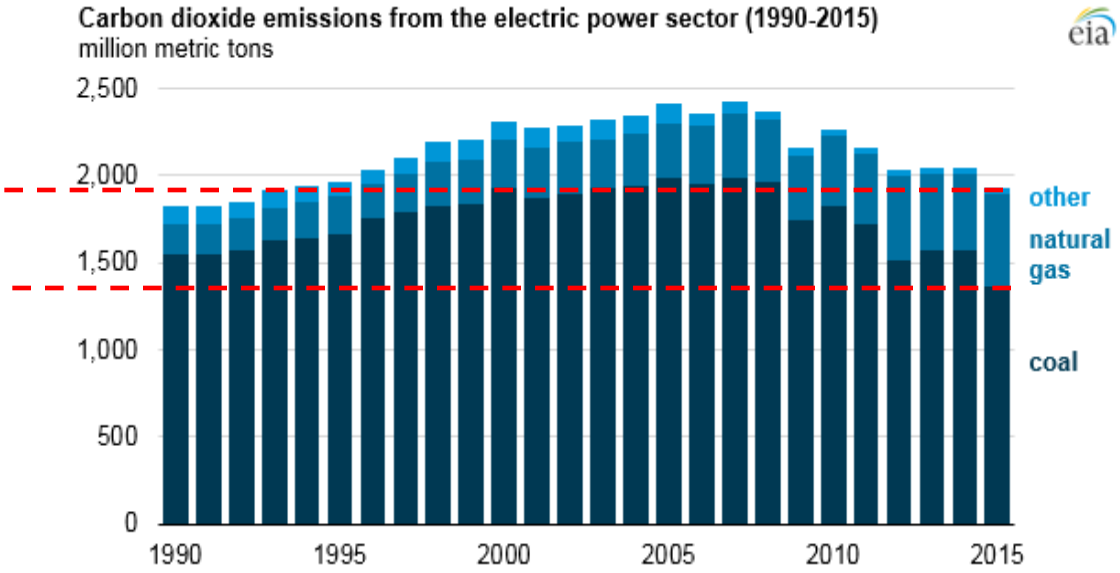
5,272 million tonnes
= 5.272 Gt
= 5.272 billion tonnes

base e

"Practical Strategies for Emerging Energy Technologies"

CO2 Emission from the Power Sector

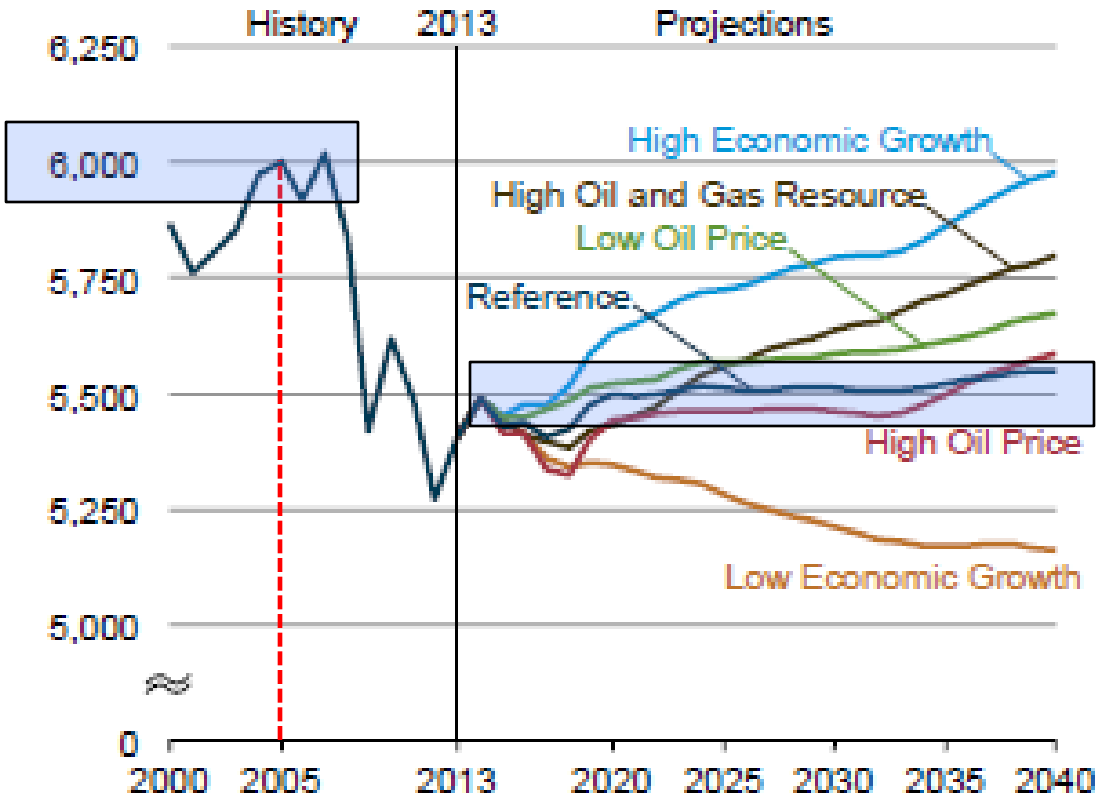
- Carbon dioxide (CO2) emissions from electricity generation totaled 1,925 million metric tons in 2015, the lowest since 1993 and 21% below their 2005 level.
- A shift on the electricity generation mix, with generation from natural gas and renewables displacing coal-fired power, drove the reductions in emissions.
- Total carbon dioxide emissions from the electric power sector declined even as demand for electricity remained relatively flat over the previous decade
- In both 2013 and 2014, total electricity sales and electricity-related CO2 emissions increased
- But in 2015, both sales and emissions fell
- In 2015, warm winter temperatures reduced the demand for electricity, lessened the need to bring marginal generators online, and lowered natural gas prices



EIA Energy Related CO2 Forecast

"High Water Mark" as basis for goal

Figure 36. Energy-related carbon dioxide emissions in six cases, 2000-2040 (million metric tons)



Ref. Case is "Business as Usual"

Key Findings IEO2016 Reference Case

- World energy consumption increases from 549 quadrillion Btu in 2012 to 629 quadrillion Btu in 2020 and then to 815 quadrillion Btu in 2040, a 48% increase (1.4%/year). Non-OECD Asia (including China and India) account for more than half of the increase.

- The industrial sector continues to account for the largest share of delivered energy consumption; the world industrial sector still consumes over half of global delivered energy in 2040.

- Renewable energy is the world's fastest-growing energy source, increasing by 2.6%/year; nuclear energy grows by 2.3%/year, from 4% of the global total in 2012 to 6% in 2040.

- Fossil fuels continue to supply more than three-fourths of world energy use in 2040.

- Among the fossil fuels, natural gas grows the fastest. Coal use plateaus in the mid-term as China shifts from energy-intensive industries to services and worldwide policies to limit coal use intensify. By 2030, natural gas surpasses coal as the world's second largest energy source.

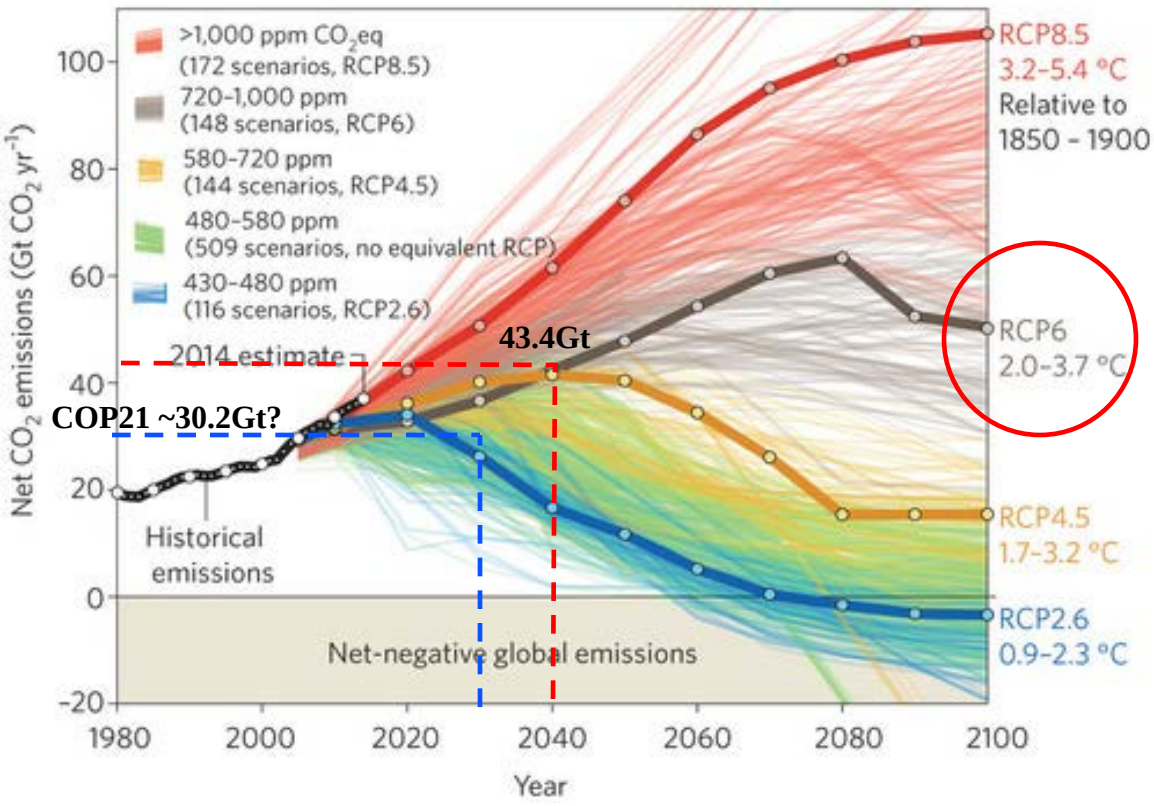
- In 2012, coal provided 40% of the world's total net electricity generation. By 2040, coal, natural gas, and renewable energy sources provide roughly equal shares (28-29%) of world generation.

- With current policies and regulations, worldwide energy-related carbon dioxide emissions rise from about 32 billion metric tons in 2012 to 36 billion metric tons in 2020 and then to 43 billion metric tons in 2040, a 34% increase.

“Busted”

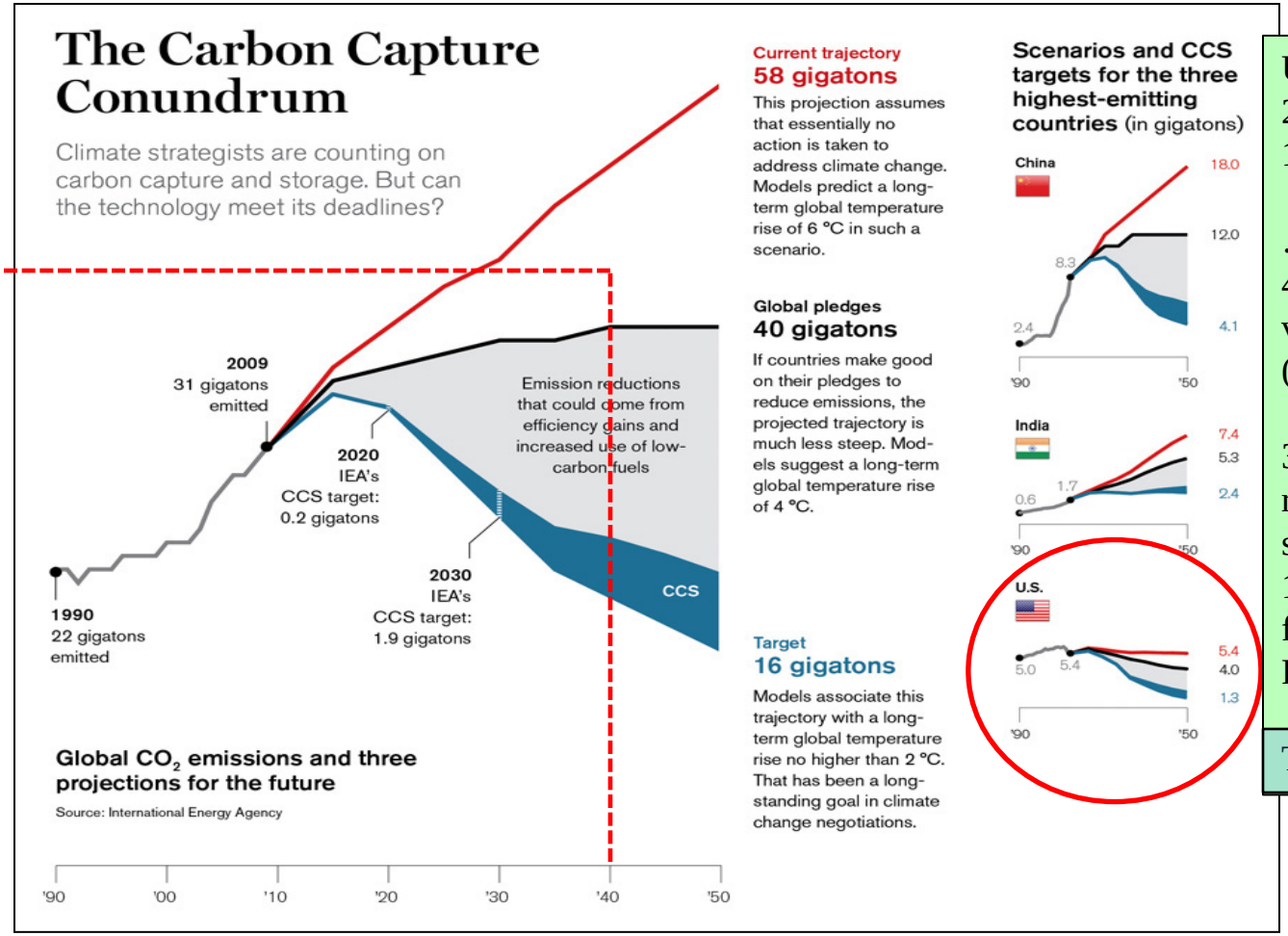
The world appears to be on the >RCP6 720-1000 ppm path

At least the CIA forecast appears to be a candid assessment☺



Source: IPCC AR5

The Carbon Conundrum



MIT Technology Review – Mike Orcott

U.S. target to sustain 2°C/450ppmv is 1.3Gt …..

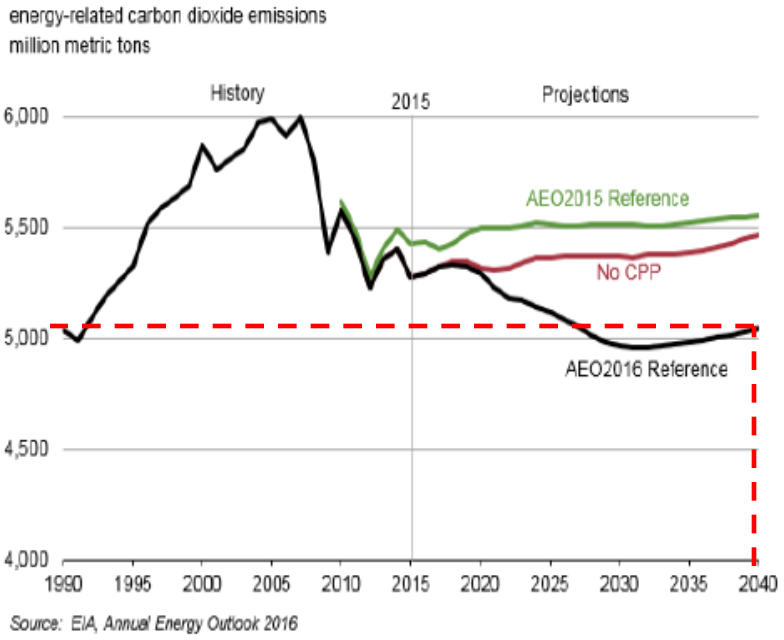
…..a reduction of 4.7 Gt from 2005 value of 6.0Gt (5.996)

38.5% of 4.7 Gt requires a "fair share" reduction of 1.8-2.0 Gt from fossil fuel PowerGen

To a level of 0.5Gt

AEO2016 Early Release – Two Cases May 17, 2016

CO2 emissions are lower in AEO2016 Reference case than AEO2015 Reference Case, even without the Clean Power Plan (CPP)



Source: EIA, Annual Energy Outlook 2016

- Key drivers for the lower energy-related CO2 emissions in AEO2016 include:
  - Lower natural gas prices that support higher electricity generation from natural gas with or without the CPP
  - Lower technology costs for wind and solar, combined with extended tax credits and the CPP, and
  - Reduced coal generation as a result of the CPP, which emit the most CO2 per kilowatthour.

The New Reference Case Includes Full Effect of CPP

Key takeaways from the two cases: Electricity

- Implementation of the Clean Power Plan (CPP) using a mass-based approach reduces annual electricity-related carbon dioxide (CO2) emissions to between 1,550 and 1,560 million metric tons (MMT) in the 2030-40 period, substantially below their 2005 and 2015 levels of 2,416 MMT and 1,891 MMT, respectively. Coal's share of total electricity generation, which was 50% in 2005 and 33% in 2015, falls to 21% in 2030 and to 18% in 2040.

- Even without the CPP, electricity-related CO2 emissions remain well below their 2005 level at 1,942 MMT in 2030 and 1,959 MMT in 2040; this outcome reflects both low load growth and generation mix changes driven by the extension of key renewable tax credits, reduced solar photovoltaic (PV) capital costs, and low natural gas prices.

Full CPP Δ to reference plan only 400 MMt

- With the mass-based approach, the strong growth in wind and solar generation spurred by tax credits leads to a short-term decline in natural gas-fired generation between 2015 and 2021. However, natural gas generation then grows significantly under a mass-based CPP implementation, increasing by more than 67% from 2021 through 2040, when it is by far the largest generation source.

New Reference Case IA May 17, 2005

	2015	2020	2025	2030	2035	2040
PowerGen	1925	1791	1666	1550	1555	1560
Non-PowerGen	3346	3737	4173	4660	5204	5812
U.S. Total	5271	5528	5839	6210	6759	7372
U.S. % of World	15.73%					15.73%
Worldwide	33508.4					46863.15

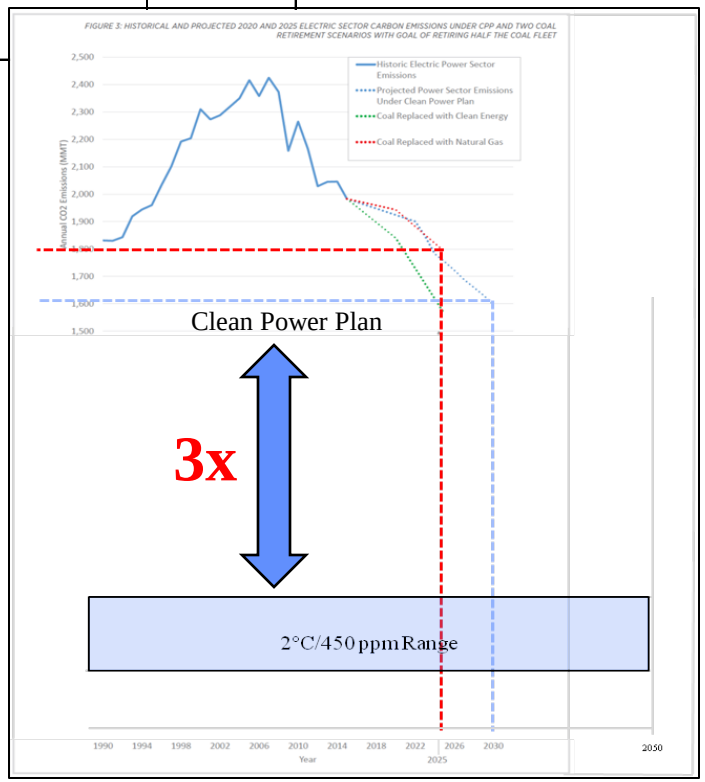
1) PowerGen at 1550 and 1560 per EIA May 17, 2016 Report
2) PowerGen forecast for 2020 & 2025 scaled between 1925 & 1550
4) 1925 & 5271 in 2015 EIA published values
3) U.S. PowerGen Calculated from Real GDP Growth Forecast @ +2.23%/year, combined with Energy Use per GDP improvements @ -2.12%/year
4) Energy Use improvemnts per GDP back-calculated at 2.12%/year to match 1560 in 2040
5) Non-PowerGen calculated from Real GDP Growth Forecast @ +2.23%/year, combined with Energy Use per Capita improvements @ -0.30%/year

GDP	2.23%	Given
Energy Use per GDP	-2.12%	Calculated
Energy Use per Capita	-0.30%	Given

Sierra Club "Fact Sheet" Nov. 3, 2015

	2005[1]	2015	2020	2022	2025[2]	2030	2035	2040	2045	2050	End Point	@38.5%
Total U.S.	5747	5357[3]			3607							
Total Elecric Production	2416											
32% below 2005 by 2030						1643						
Coal Replaced with Natural Gas		1983[3]	1940		1791						1790	4649
Projected Electric Power Sector Emissions under the Clean Power Plan		1983[3]	1930	1901	1754	1600					1600	4156
Coal replaced with Clean Energy		1983[3]	1840		1563						1563	4060
Electric Power % of Total	42.0%				49.7%							
					43.3%							

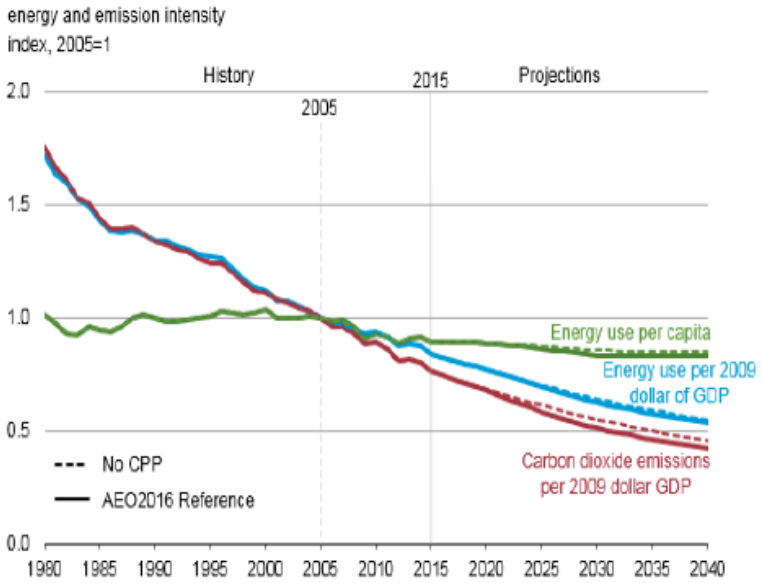
(1) U.S. GHG InventorySources & Sinks - EPA GHG Inventory 1990-2013 Table ES-2
(2) Assumes retiring half the coal fleet "in coming years" and reducing U.S. emissions by 1750MT
(3) Sierra Club "Accelerating U.S. Coal Phase-out"



"Practical Strategies for Emerging Energy Technologies"

Sorry But, CPP is Business as Usual!

CO2 emissions per dollar of gross domestic product (GDP) decline faster than energy use per dollar of GDP with a shift towards low- and no-carbon fuels



Source: EIA, Annual Energy Outlook 2016 Reference case

- The economy's energy intensity, carbon intensity, and per-capita energy use are projected to decline steadily. In the Reference case, energy use per dollar of GDP declines at an average annual rate of 1.8% over 2015-40, while energy use per capita declines at an average annual rate of 0.3%. With renewables and natural gas providing larger shares of total energy use, CO2 per dollar of GDP declines faster than energy intensity.
- The structure and efficiency of the U.S. economy changes in ways that lower total energy use and energy use per dollar of GDP. The nonindustrial and services sector share of the economy remains near 77% throughout the projection, but there is a shift towards non-energy-intensive industries within manufacturing that is slightly smaller in the absence of the CPP.
- Energy-use-per-capita declines, driven by gains in appliance efficiency, a shift in population from cooler to warmer regions, and an increase in vehicle efficiency standards, combined with modest growth in travel per licensed driver.

You know there is a problem when the discussion shifts to CO2 per GDP

EIA May 17, 2016 Early Release MMt/$Million GDP

Data table for: GDP long-term forecast, Total, Million US dollars, 2009 – 2060

	2005	2009	2010	2015
China		8,264,462	9,127,849	13,325,589
India		3,259,867	3,622,119	4,751,391
United States		13,263,170	13,595,648	15,423,341
World	47,104,046	54,942,708	57,674,148	68,077,321
Million tonnes CO2	28533	30,158.0	31,544.1	33,508.4
Cummulative				2,032,971
MMt/GDP	0.000606	0.000549	0.000547	0.000492
			0.9029	0.8999
US Percent of World GDP		24.1%	23.6%	22.7%

Source: OECD Economic Outlook: Statistics and Projections

- The key factor is the calculated MMt of CO2 per million dollars of GDP, 0.000492 in 2015.
- There was a 10% reduction in this value for both the 2005-2010 and the 2010-2015 periods, based on the data and can be interpreted as an improvement in overall efficiency of use.
- I included the 1900GtCO2 in the 2C/450 ppm already consumed between 1870-2011 as the 2012 staring value.

EIA May 17, 2016 Early Release MMt/$Million GDP

Data table for: GDP long-term forecast, Total, Million US dollars, 2009 – 2060

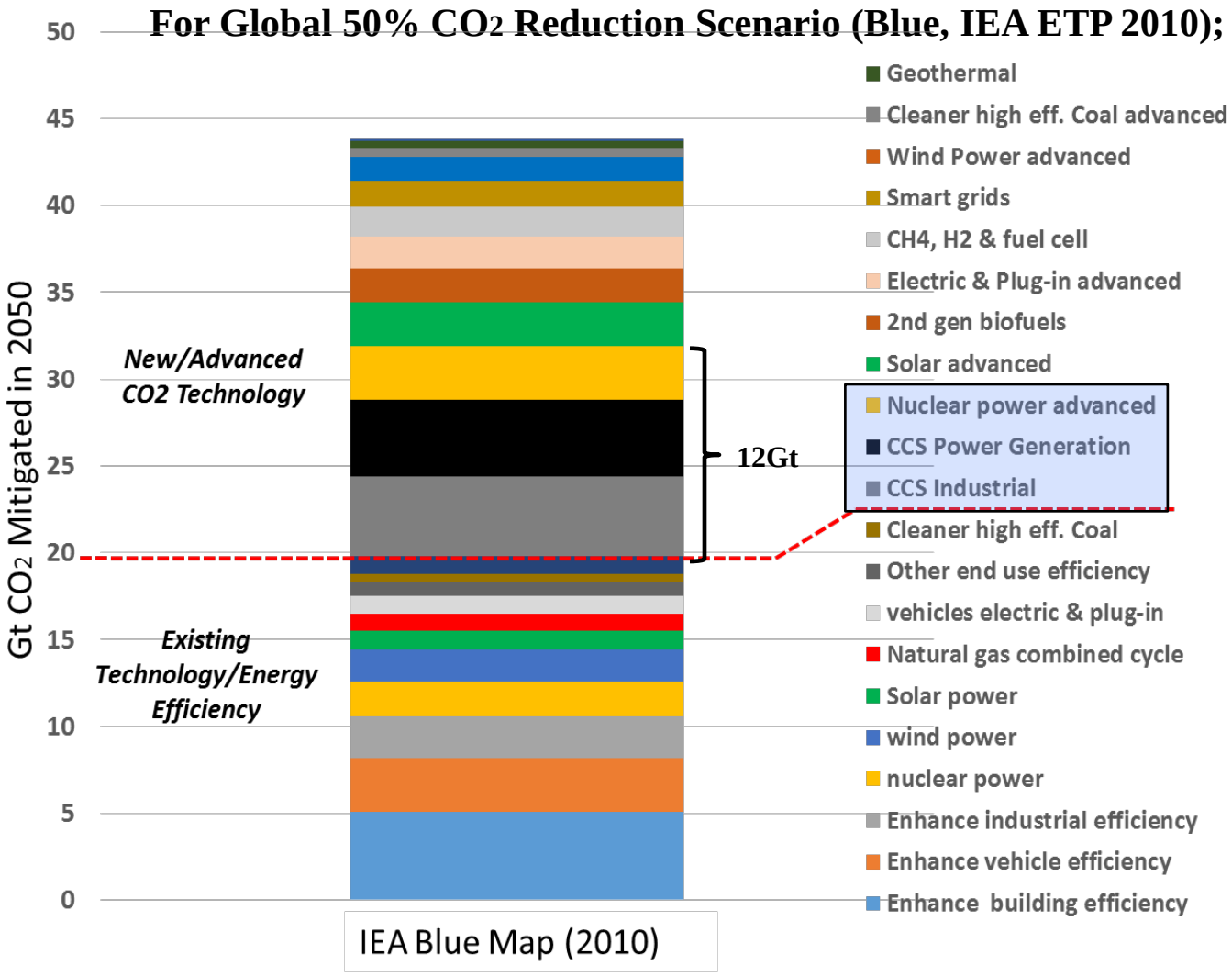
	2020	2025	2030	2035	2040	2041	2045	2050	2055	2060
China	17,709,685	21,987,556	26,307,248	31,117,405	36,477,854		41,497,785	45,730,397	49,722,574	53,827,698
India	6,337,715	8,437,521	11,162,212	14,504,379	18,401,049		22,832,998	27,817,822	33,324,548	39,211,023
United States	17,743,025	20,025,623	22,482,236	24,988,766	27,461,839		29,898,935	32,341,599	34,792,848	37,206,576
World	81,452,490	95,570,319	111,074,203	128,015,627	145,962,170	149,409,817	164,034,207	182,273,171	201,423,865	221,232,567
Million tonnes CO2	36,082.6	38,103.0	39,855.8	41,341.3	42,423.3	42,519.8	42,908.2	42,911.3	42,677.8	42,187.4
Cummulative	2,069,054	2,255,484	2,451,226	2,654,940	2,864,881	2,907,401	3,078,450	3,293,001	3,506,856	3,718,772
MMt/GDP	0.000443	0.0003987	0.0003588	0.0003229	0.0002906	0.0002846	0.0002616	0.0002354	0.0002119	0.0001907
	0.9000	0.9000	0.9000	0.9000	0.9000		0.9000	0.9000	0.9000	0.9000
US Percent of World GDP	21.8%	21.0%	20.2%	19.5%	18.8%		18.2%	17.7%	17.3%	16.8%

Source: OECD Economic Outlook: Statistics and Projections

- The OECD GDP Forecast is shown without modification.
- The same efficiency of use improvements are assumed throughout the forecast period to 2060
- The calculated yearly increment is based on this GDP Forecast data and underlying efficiency of use assumptions.
- This efficiency of use assumptions are not likely to apply uniformly around the world, but that assumption is embedded in the calculation.
- We bust the 2900Gt budget in 2041 and reach 3719Gt by 2060.
- This is equivalent to 550-600 ppm and perhaps 4°C temperature rise.

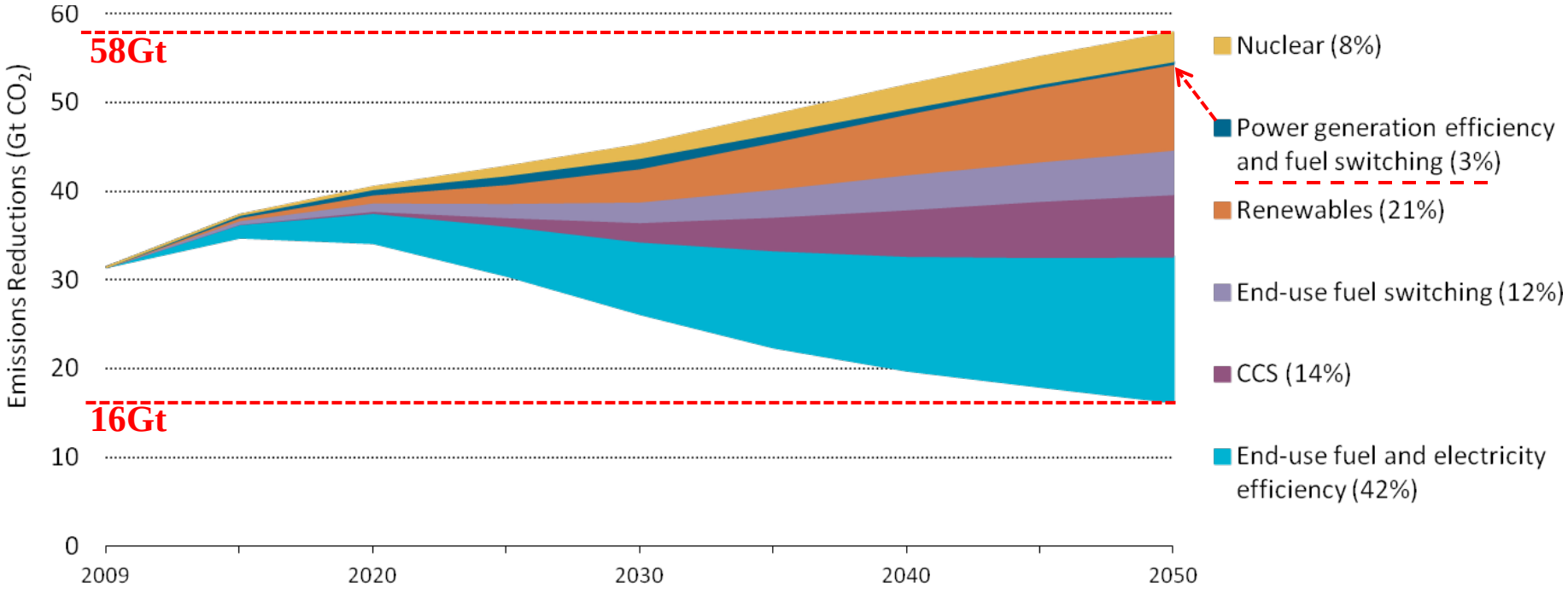
If 0.90 becomes 0.95:
- **We bust the 2900Gt budget in 2038**
- **Total ytd 2060 is 4272Gt**
- **Annual release 55Gt 2040; 69Gt 2060**

New & Advanced Technologies Needed



Source: DOE SCO2 Conference 2014, as presented by EPA

IEA Vision May 2013

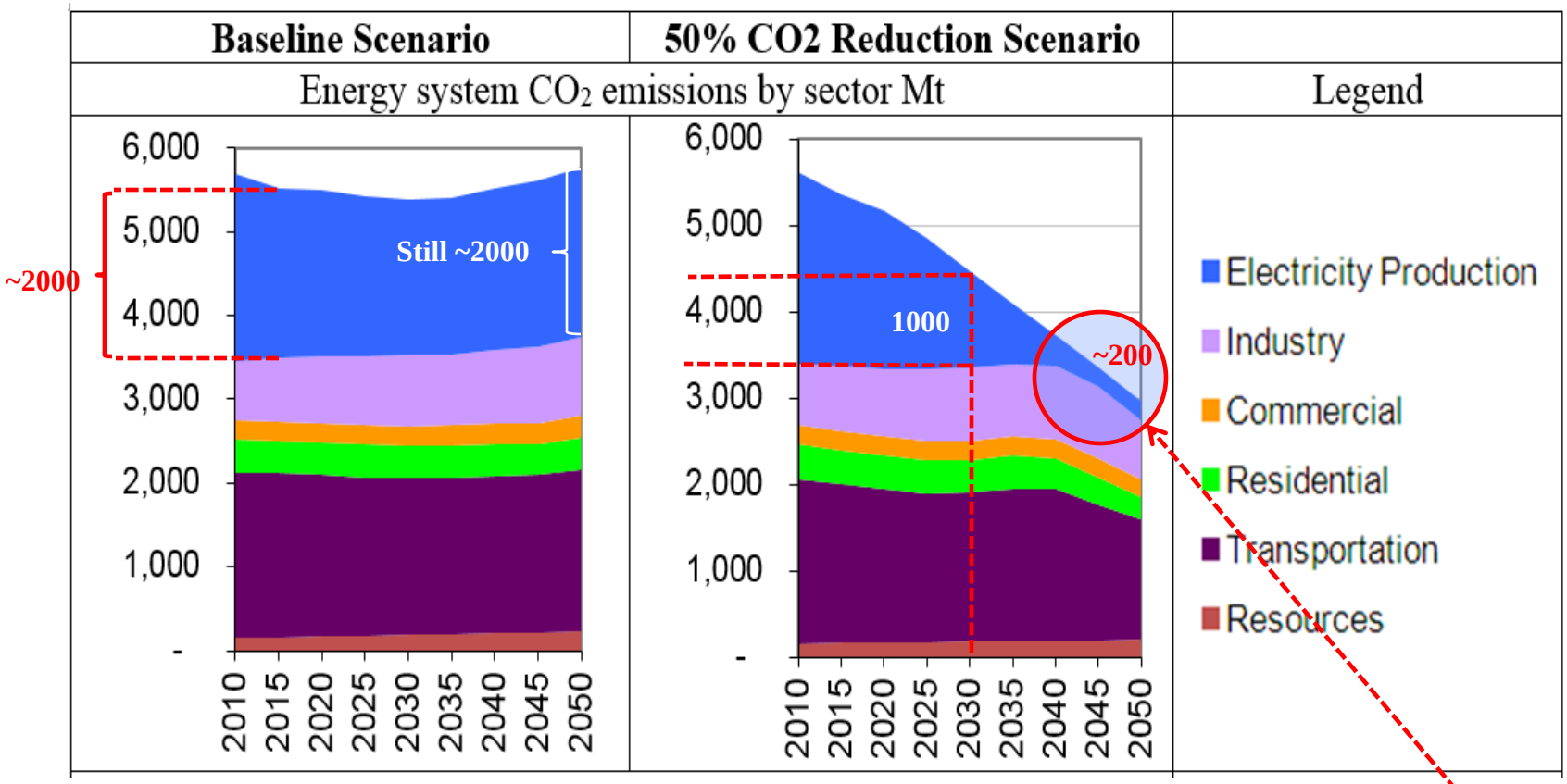


Nuclear and CCS technologies currently on "life support"

12th Annual CCUS Conference
Pittsburgh, 15 May 2013

Juho Lipponen
Head of Unit, Carbon Capture and Storage
International Energy Agency

A Credible 50% CO2 Reduction Scenario by 2050



Source: DOE SCO2 Conference 2014, as presented by EPA

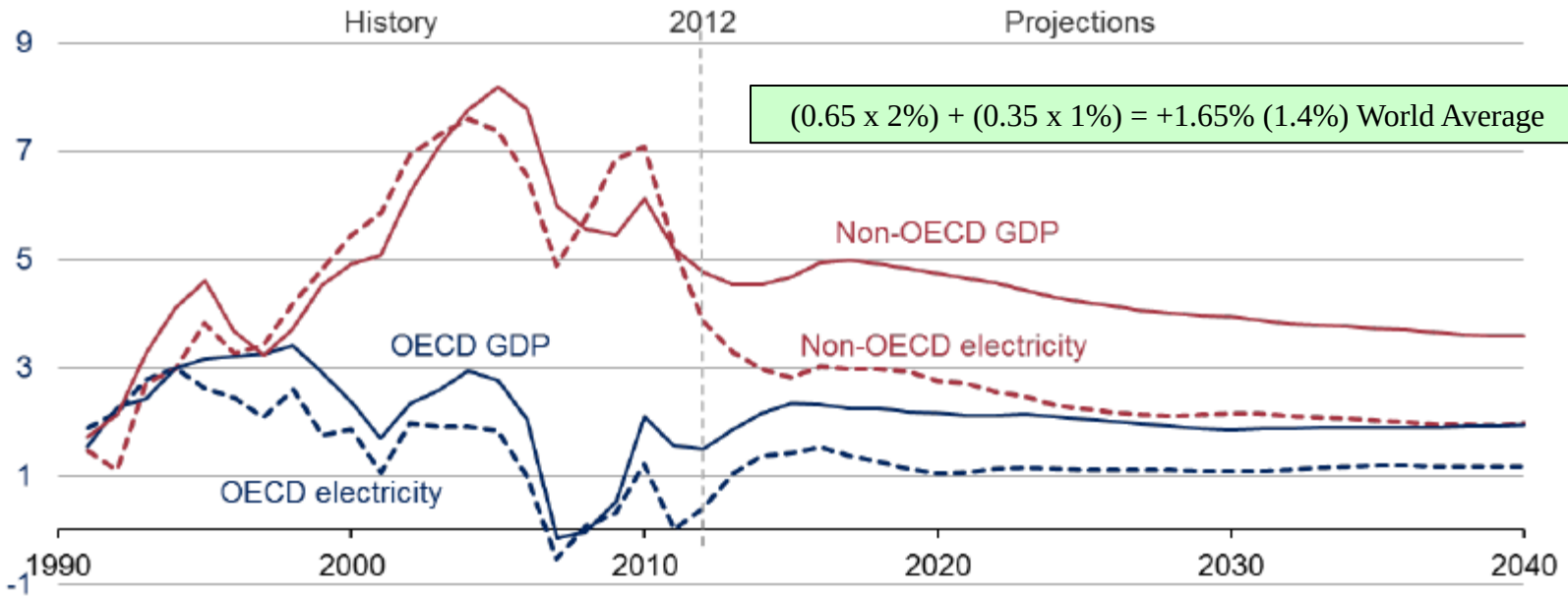
My number for Electricity Production is 500 (0.5 Gt)
if everyone pulls their fair share
2°/450 ppm number is 1300 (1.3 Gt), not 3000 (3.0 Gt)

Electric Power Generation Growth Rate

GDP drives electricity demand growth, but the electricity growth rate compared to the GDP growth rate becomes smaller over time

world GDP and net electricity generation

percent growth (rolling average of 3-year periods)



(0.65 x 2%) + (0.35 x 1%) = +1.65% (1.4%) World Average

Source: EIA, International Energy Outlook 2016

Projections – Carbon Emissions

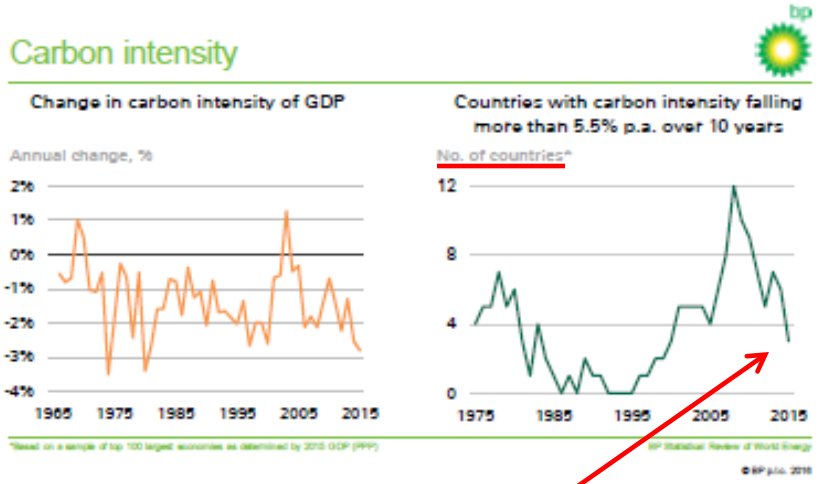
The third issue is to return to the stalling in the growth of carbon emissions in 2015. This equated to a fall in the carbon intensity of GDP – the average amount of carbon emissions per unit of GDP – of 2.8%. In the past 50 years, there have been only two other occasions in which carbon intensity of GDP has fallen by as much, and they both coincided with sharp upward movements in oil prices.

So real progress.

But before we take too much comfort: the IEA 450 scenario – which is used by many as a benchmark scenario for the progress we need to make to achieve the goals agreed at Paris – suggests that the carbon intensity of GDP has to fall at an average rate of close to 5.5% p.a. on a sustained basis for the next 20 years. So almost double the rate of decline achieved last year, each year for the next 20 years!

It's possible to find a few isolated countries which have achieved average rates of decline of this magnitude for 10 years or so, but these tend to be countries undergoing significant economic transitions and account for only a tiny fraction of global GDP.

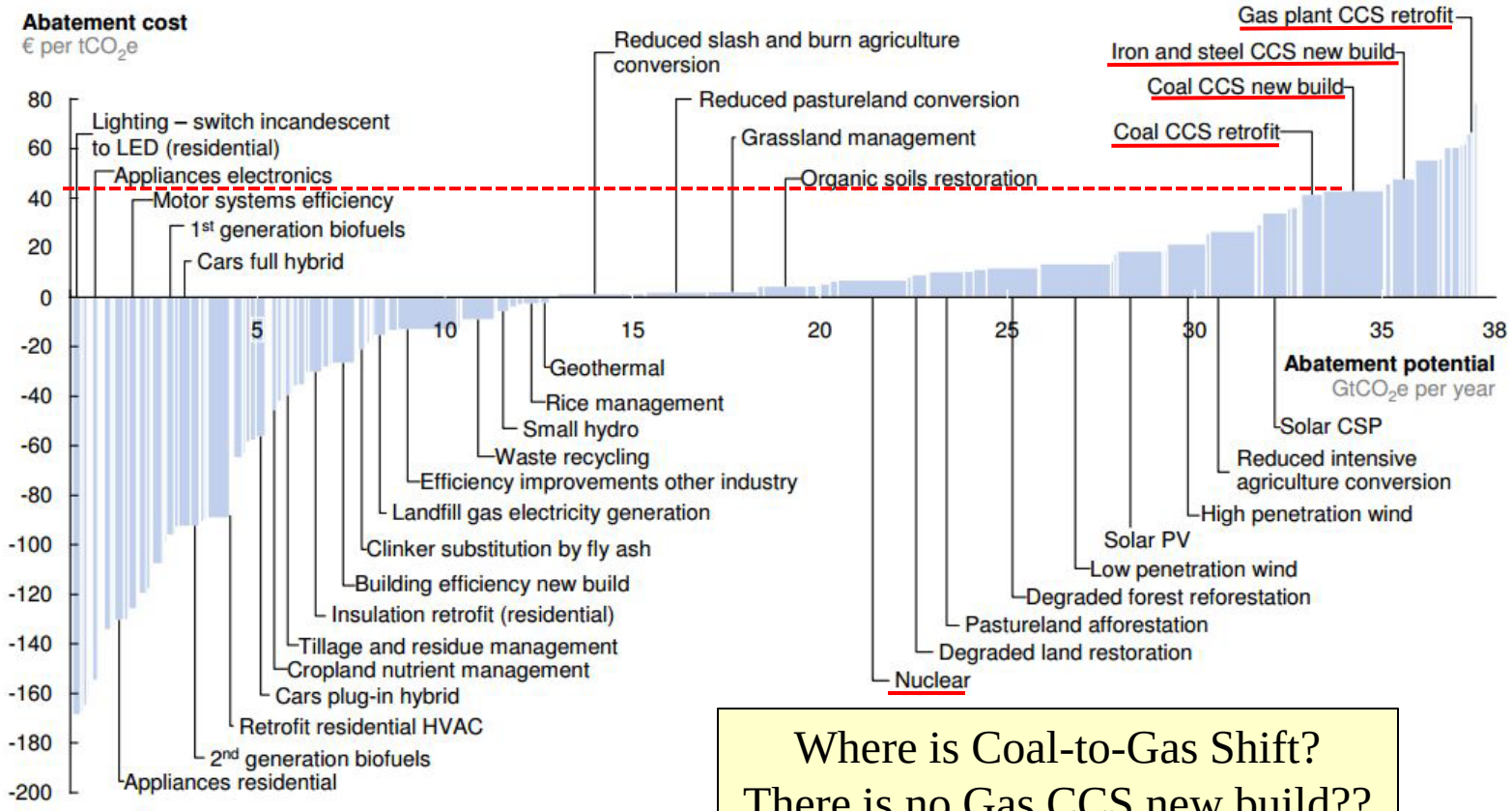
So certainly a step in the right direction towards meeting the goals agreed at Paris, but a relatively small step given the scale of the challenge.



Only three countries are declining at the carbon intensity rate required to meet the 2C/450 goal

Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

McKinsey Global GHG Cost Curve V2.1



Where is Coal-to-Gas Shift?
There is no Gas CCS new build??

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.1

Carbon Emissions

Perhaps the most striking number in the whole of this year's Statistical Review is that for carbon emissions.

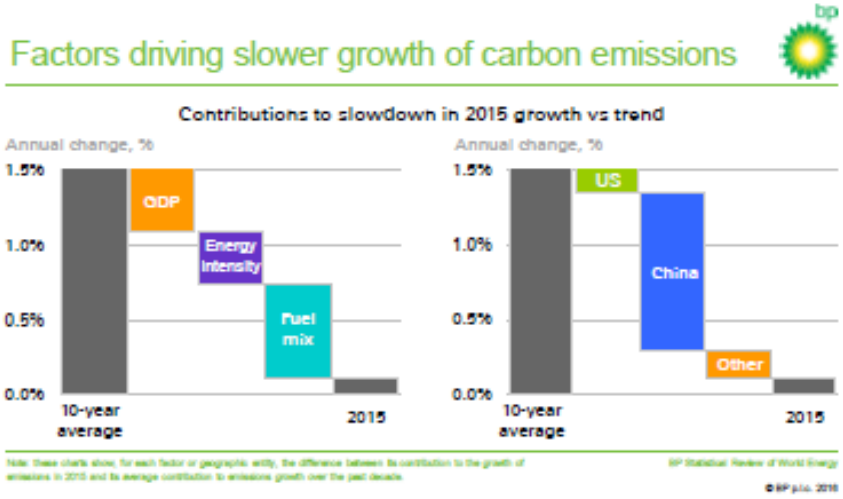
In particular, the slower growth of energy demand together with the shift in the fuel mix away from coal towards lower carbon fuels meant carbon emissions from energy use were essentially flat last year (0.1%) – the slowest growth in nearly a quarter of a century (other than in the immediate aftermath of the financial crisis).

This marks a sharp turnaround from the growth of carbon emissions over the past 10 years, which averaged a little over 1.5% a year. Some of the slowdown in 2015 is a natural consequence of weaker economic growth relative to the average of the past. But the majority reflects a faster rate of improvement in both energy efficiency and the fuel mix.

Viewed in terms of individual countries and regions, the vast majority of the turnaround in carbon emissions can be attributed to China: China's carbon emissions are estimated to have actually fallen slightly in 2015 (-0.1%) for the first time in almost 20 years.

So will this sharp decline in the growth of China's carbon emissions persist?

As with the decline in Chinese coal consumption, there are good reasons for thinking that some of this slowdown reflects structural forces that are likely to persist and grow in importance. But some probably reflect cyclical factors, particularly the contraction in some of China's most energy-intensive sectors, which are unlikely to keep being repeated and may well unwind in future years.



Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

Coal-to-Gas Shift – nature.com

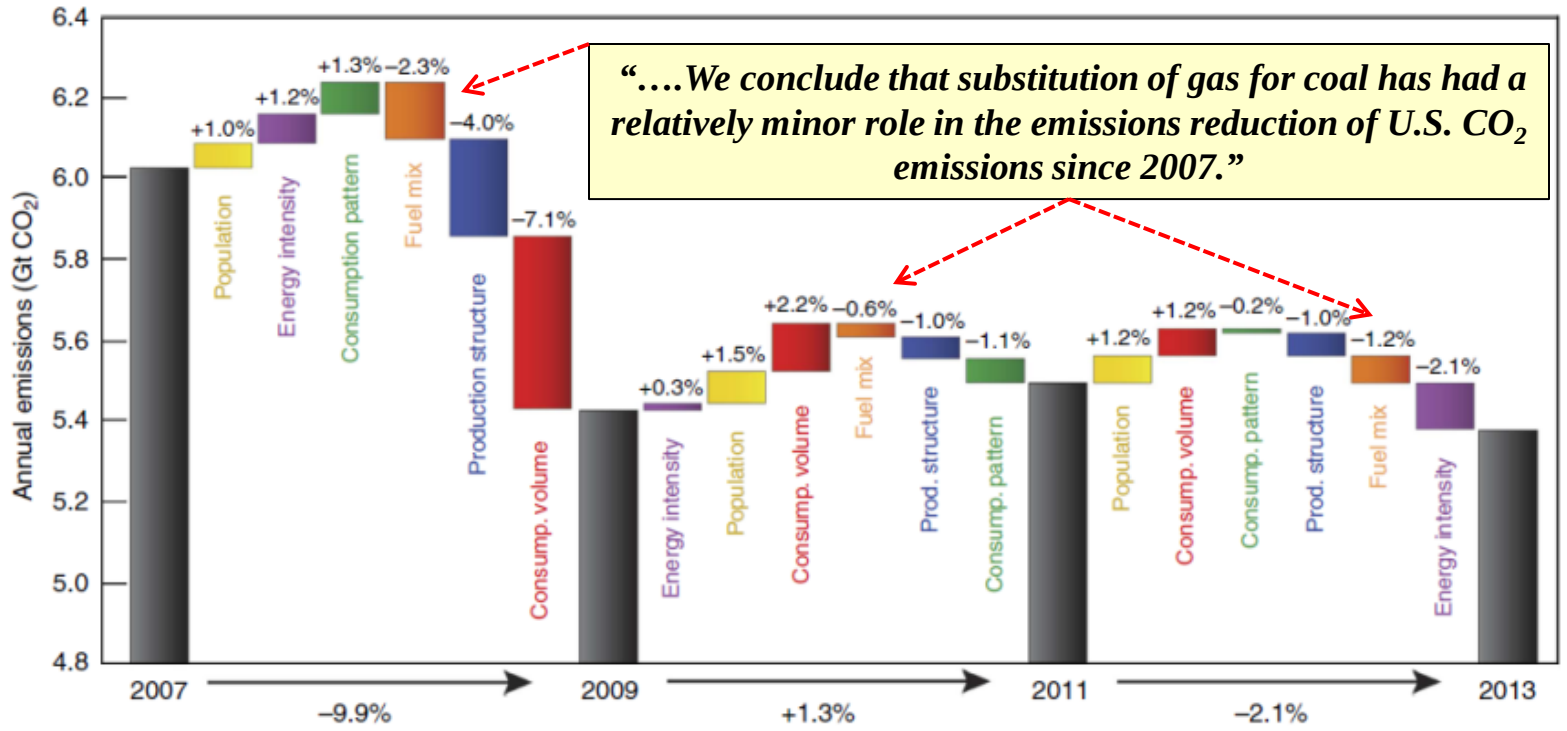


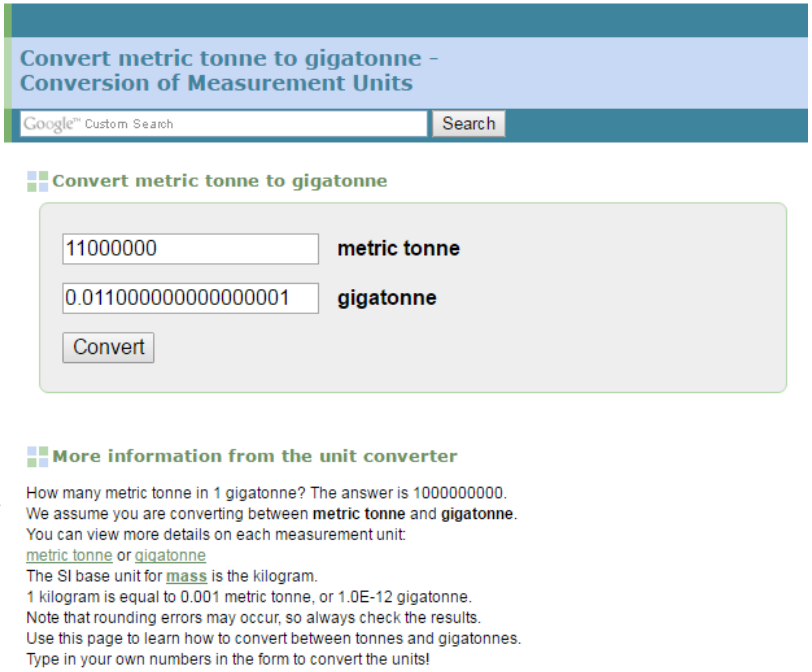
Figure 3 | Contributions of different factors to the decline in US CO_2 emissions 2007–2009 and 2009–2011 and 2011–2013. Between 2007 and 2009, decreases in the volume of goods and services consumed during the economic recession (red) was the primary contributor to the nearly 10% drop in emissions. But between 2009 and 2011, consumption (consump.) volume rebounded, population grew and the energy intensity of output increased, driving up emissions by 1.3% against modest decreases in the carbon intensity of the fuel mix and shifts in production structure and consumption patterns. Between 2011 and 2013, increases in population and consumption volume again pushed emissions upward, but overall emissions decreased by 2.1% due to further changes in production (prod.) structure, consumption patterns, decreasing use of coal and decreases in energy intensity of output. Not shown here, emissions increased by 1.7% between 2012 and 2013, driven primarily by increases in consumption volume.

"The new EPA Clean Power Plan is largely built on fuel switching and renewables deployment"

http://www.nature.com/ncomms/2015/150721/ncomms8714/full/ncomms8714.html

Methane Leaks & Regulation

- On May 12, 2016, the U.S. Environmental Protection Agency (EPA) announced a Strategy to:
  - Reduce Methane Emissions to cut methane emissions from the large and complex oil and natural gas industry
  - achieve its goal of cutting methane emissions from the oil and gas sector by 40 to 45 percent from 2012 levels by 2025.
- Methane has a global warming potential more than 25 times greater than that of carbon dioxide
- Methane is the second most prevalent greenhouse gas emitted by human activities in the United States,
- 1/3 come from oil production and the production, processing, transmission and storage of natural gas.
- **Reducing methane emissions is an essential part of an overall strategy to address climate change**.
- The final NSPS is expected to:
  - Reduce 510,000 short tons of methane in 2025, the equivalent of reducing 11 million metric tons of carbon dioxide.
  - 11,000,000 metric tonnes = 0.011 Gt = 0.28% of U.S. emissions of 4Gt



"Essential Part"….Really?

How about CO2 from Natural Gas Power Plants at 11.4Gt in 2040?

Gas Bridge to Renewables Already Built

- For the U.S. to reach its climate goals, the deadline for constructing the last gas-fired power plant is coming up shortly — if not already past
- Gas has a significant near-term role in reducing dependence on coal-fired power and helping the transition to intermittent renewable sources. But, to reduce greenhouse gas emissions to a target of 80% below 1990 levels by 2050, the nation must ultimately eliminate almost all use of fossil fuels, including natural gas
- "A power plant on the drawing boards today could still be operational in 2050 and well beyond. With each passing year, the likely life span of new natural gas power plants moves further beyond 2050 ".
- The U.S. EPA's Clean Power Plan might do more harm than good because substituting gas-fired power for coal capacity is one of the options for complying with the rules requirements. Rather, lawmakers should consider setting a final date beyond which no new natural gas power plants can be approved, Weissman advised.
- To make that possible while maintaining grid reliability, policymakers would have to require strategic adoption of renewable power, trying to match the types and locations for maximum impact.
- Lawmakers and regulators would also need to deploy a wide range of demand-response tools, focus on energy efficiency measures and better structure regional power markets to manage shifting demand.
- Almost 237 GW of gas-fired generation capacity was added between 2000 and 2010, making up 81% of all the generation capacity added in that decade. This momentum could increasingly complicate efforts to cut back on gas use.
- "As more people and institutions invest in natural gas, political pressure to sustain its use grows. It will become more and more difficult to achieve long-range greenhouse gas reduction goals". "Natural gas cannot play a long-term role in creating our desired carbon-constrained future, as its benefits are not enough to support our carbon reduction goals"

Steve Weissman – Senior Policy Advisor, Center for Sustainable Energy

Source: Sarah Smith SNL Thursday, March 31, 2016 12:56 PM ET

Oil

Crude Oil Consumption – 95.0 MMbbl/d

Oil: Consumption*

Thousand barrels daily	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	Change 2015 over 2014	2015 share of total	
US	20802	20687	20680	19490	18771	19180	18882	18490	18961	19106	**19396**	1.6%	19.7%	
Canada	2288	2295	2361	2315	2189	2324	2404	2372	2383	2371	**2322**	-2.9%	2.3%	
Mexico	2030	2019	2067	2054	1996	2014	2043	2063	2020	1941	**1926**	-1.1%	1.9%	
Total North America	25119	25002	25109	23860	22957	23518	23330	22926	23365	23418	**23644**	0.9%	23.9%	- 0.4%
Brazil	2123	2155	2313	2485	2502	2721	2842	2905	3106	3242	**3157**	-4.2%	3.2%	
Total S. & Cent. America	5332	5504	5780	6057	6054	6384	6624	6782	7035	7190	**7083**	-2.1%	7.5%	
France	1946	1942	1911	1889	1822	1763	1730	1676	1664	1617	**1606**	-1.0%	1.8%	
Germany	2592	2609	2380	2502	2409	2445	2369	2356	2408	2348	**2338**	-0.2%	2.5%	
Italy	1798	1791	1740	1661	1563	1532	1475	1346	1260	1185	**1262**	6.2%	1.4%	
Russian Federation	2647	2762	2780	2861	2775	2878	3074	3119	3145	3255	**3113**	-5.2%	3.3%	- 0.2%
Spain	1593	1592	1613	1558	1473	1446	1378	1291	1195	1191	**1226**	2.6%	1.4%	
United Kingdom	1828	1813	1752	1720	1646	1623	1591	1530	1525	1513	**1559**	2.4%	1.7%	
Total Europe & Eurasia	20213	20426	20166	20086	19276	19223	19075	18605	18372	18266	**18380**	0.4%	19.9%	- 0.5%
Iran	1699	1851	1879	1954	2008	1875	1904	1915	2048	2013	**1947**	-4.5%	2.1%	
Saudi Arabia	2203	2274	2407	2622	2914	3218	3295	3462	3469	3732	**3895**	5.0%	3.9%	
Other Middle East	1384	1288	1280	1425	1479	1545	1567	1601	1689	1734	**1733**	0.1%	1.9%	
Total Middle East	6576	6711	6935	7440	7855	8201	8455	8770	9011	9353	**9570**	2.1%	9.8%	+ 0.5%
Other Africa	1534	1542	1579	1706	1754	1834	1753	1873	1950	1947	**1993**	2.3%	2.2%	
Total Africa	2917	2928	3063	3236	3315	3486	3413	3579	3678	3763	**3888**	3.2%	4.2%	- 0.1%
Australia	881	939	921	934	940	948	990	1021	1014	993	**1006**	1.8%	1.1%	
China	6900	7432	7808	7941	8279	9436	9791	10229	10732	11201	**11968**	6.3%	12.9%	
India	2606	2737	2941	3077	3237	3319	3488	3685	3727	3849	**4159**	8.1%	4.5%	
Indonesia	1303	1244	1318	1287	1297	1402	1589	1631	1643	1676	**1628**	-3.2%	1.7%	
Japan	5354	5174	5014	4848	4389	4442	4441	4688	4531	4309	**4150**	-3.9%	4.4%	
Singapore	796	848	922	974	1049	1157	1209	1201	1222	1270	**1339**	5.4%	1.6%	
South Korea	2312	2320	2399	2308	2339	2370	2394	2458	2455	2454	**2575**	5.3%	2.6%	
Taiwan	1052	1051	1110	1005	1020	1045	983	983	1010	1019	**1031**	1.4%	1.1%	
Thailand	1015	996	1030	1018	1065	1122	1185	1252	1303	1313	**1344**	3.1%	1.3%	
Total Asia Pacific	24569	25157	26035	25900	26244	27954	28893	30001	30588	31119	**32444**	4.1%	34.7%	+ 0.8%
Total World	**84726**	**85728**	**87087**	**86578**	**85700**	**88765**	**89790**	**90663**	**92049**	**93109**	**95008**	**1.9%**	**100.0%**	

Source: BP Statistical Review of World Energy 2016

Crude Oil Production – 91.7 MMbbl/d

Oil: Production*

Thousand barrels daily	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	Change 2015 over 2014	2015 share of total
US	6900	6826	6860	6785	7264	7550	7853	8883	10059	11723	**12704**	8.5%	13.0%
Canada	3041	3208	3290	3207	3202	3332	3515	3740	4000	4278	**4385**	2.8%	4.9%
Mexico	3767	3692	3481	3167	2980	2961	2942	2912	2876	2785	**2588**	-7.0%	2.9%
Total North America	**13708**	**13726**	**13631**	**13159**	**13447**	**13843**	**14310**	**15535**	**16934**	**18786**	**19676**	**4.7%**	**20.9%**
Brazil	1713	1809	1833	1899	2029	2137	2193	2149	2114	2346	**2527**	7.9%	3.0%
Colombia	526	529	531	588	671	786	915	944	1004	990	**1008**	1.7%	1.2%
Venezuela	3308	3336	3230	3222	3033	2838	2758	2701	2678	2685	**2626**	-2.1%	3.1%
Total S. & Cent. America	**7328**	**7463**	**7295**	**7376**	**7322**	**7348**	**7401**	**7322**	**7344**	**7605**	**7712**	**1.5%**	**9.1%**
Azerbaijan	445	646	856	895	1014	1023	919	872	877	849	**841**	-1.0%	1.0%
Kazakhstan	1294	1368	1413	1483	1609	1676	1684	1662	1720	1701	**1669**	-1.9%	1.8%
Norway	2961	2772	2551	2466	2349	2136	2040	1917	1838	1889	**1948**	3.2%	2.0%
Russian Federation	9597	9818	10043	9950	10139	10366	10518	10639	10779	10838	**10980**	1.2%	12.4%
United Kingdom	1843	1666	1659	1555	1477	1361	1116	949	867	855	**965**	13.4%	1.0%
Total Europe & Eurasia	**17523**	**17587**	**17800**	**17577**	**17760**	**17699**	**17390**	**17124**	**17166**	**17206**	**17463**	**1.4%**	**19.4%**
Iran	4216	4290	4333	4361	4250	4420	4466	3814	3611	3736	**3920**	4.5%	4.2%
Iraq	1833	1999	2143	2428	2452	2490	2801	3116	3141	3285	**4031**	22.9%	4.5%
Kuwait	2668	2737	2661	2786	2500	2561	2915	3171	3134	3120	**3096**	-1.1%	3.4%
Oman	777	738	710	757	813	865	885	918	942	943	**952**	0.8%	1.1%
Qatar	1151	1241	1267	1438	1421	1638	1834	1931	1903	1893	**1898**	-0.4%	1.8%
Saudi Arabia	10931	10671	10268	10663	9663	10075	11144	11635	11393	11505	**12014**	4.6%	13.0%
United Arab Emirates	2919	3098	3002	3027	2725	2895	3320	3403	3640	3685	**3902**	5.3%	4.0%
Total Middle East	**25549**	**25764**	**25322**	**26372**	**24723**	**25827**	**28160**	**28532**	**28181**	**28557**	**30098**	**5.4%**	**32.4%**
Algeria	1990	1979	1992	1969	1775	1689	1642	1537	1485	1589	**1586**	-0.4%	1.6%
Angola	1282	1432	1699	1916	1804	1863	1726	1784	1799	1712	**1826**	6.8%	2.0%
Egypt	672	679	698	715	730	725	714	715	710	714	**723**	1.4%	0.8%
Nigeria	2527	2433	2314	2134	2234	2535	2476	2430	2321	2389	**2352**	-1.5%	2.6%
Total Africa	**9811**	**10011**	**10269**	**10246**	**9890**	**10142**	**8548**	**9327**	**8711**	**8371**	**8375**	**0.1%**	**9.1%**
China	3642	3711	3742	3814	3805	4077	4074	4155	4216	4246	**4309**	1.5%	4.9%
India	737	760	768	803	816	882	916	906	906	887	**876**	-1.1%	0.9%
Indonesia	1096	1018	972	1006	994	1003	952	918	882	852	**825**	-3.0%	0.9%
Total Asia Pacific	**7978**	**7937**	**7961**	**8088**	**8039**	**8424**	**8287**	**8378**	**8254**	**8310**	**8346**	**0.5%**	**9.1%**
Total World	**81896**	**82487**	**82277**	**82818**	**81182**	**83283**	**84097**	**86218**	**86591**	**88834**	**91670**	**3.2%**	**100.0%**

Source: BP Statistical Review of World Energy 2016

WW Oil Supply/Demand

	2015 1st Qtr.	2015 2nd Qtr.	2015 3rd Qtr.	2015 4th Qtr.	2015 Year	2016 1st Qtr.	2016 2nd Qtr.	2016 3rd Qtr.	2016 4th Qtr.	2016 Year
	Million b/d									
DEMAND										
OECD										
Americas	24.2	24.1	24.7	24.4	24.4	24.3	24.1	24.6	24.7	24.4
Europe	13.4	13.5	14.1	13.5	13.7	13.4	13.7	13.9	13.6	13.6
Asia Pacific	8.8	7.7	7.8	8.3	8.1	8.7	7.6	7.8	8.4	8.1
Total OECD	**46.5**	**45.3**	**46.7**	**46.2**	**46.2**	**46.4**	**45.4**	**46.4**	**46.7**	**46.2**
Non-OECD										
FSU	4.6	4.9	5.0	4.9	4.9	4.7	4.8	5.0	4.9	4.8
Europe	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
China	11.0	11.3	11.3	11.4	11.3	11.3	11.7	11.7	11.8	11.6
Other Asia	12.4	12.5	12.3	12.9	12.5	12.9	13.0	12.8	13.2	13.0
Latin America	6.7	6.8	6.9	6.9	6.8	6.6	6.8	6.9	7.0	6.8
Middle East	7.7	8.3	8.6	8.0	8.2	7.9	8.4	8.9	8.2	8.3
Africa	4.1	4.1	4.0	4.1	4.1	4.2	4.2	4.1	4.3	4.2
Total Non-OECD	**47.1**	**48.6**	**48.8**	**49.0**	**48.4**	**48.4**	**49.7**	**50.1**	**50.1**	**49.6**
Total Demand	**93.6**	**93.9**	**95.4**	**95.3**	**94.6**	**94.8**	**95.1**	**96.5**	**96.7**	**95.8**
Supply										
OECD										
Americas	19.9	19.5	19.9	19.9	19.8	19.5	19.2	19.3	19.6	19.4
Europe	3.4	3.5	3.3	3.4	3.4	3.4	3.2	3.0	3.3	3.2
Asia Pacific	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total OECD	**23.7**	**23.4**	**23.8**	**23.8**	**23.7**	**23.4**	**23.0**	**22.9**	**23.4**	**23.2**
Non-OECD										
FSU	14.0	14.0	13.9	13.9	14.0	13.9	13.9	13.8	13.8	13.9
Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
China	4.3	4.4	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Other Asia	3.6	3.6	3.5	3.5	3.6	3.5	3.5	3.4	3.4	3.5
Latin America	4.6	4.5	4.5	4.5	4.5	4.6	4.6	4.7	4.7	4.7
Middle East	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.2
Africa	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Total Non-OECD	**30.3**	**30.1**	**30.0**	**29.9**	**30.1**	**30.0**	**29.9**	**29.8**	**29.8**	**29.9**
Processing gains	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.4	2.3	2.3
Global biofuels	1.8	2.4	2.6	2.4	2.3	1.9	2.4	2.7	2.4	2.4
Total Non-OPEC	**58.1**	**58.2**	**58.6**	**58.4**	**58.3**	**57.6**	**57.5**	**57.7**	**57.9**	**57.7**
OPEC										
Crude	30.5	31.5	31.7	31.7	31.4	31.7	31.9	32.0	31.9	31.9
NGL	6.4	6.5	6.6	6.6	6.5	6.7	6.8	6.8	6.9	6.8
Total OPEC	**36.9**	**38.0**	**38.3**	**38.3**	**37.9**	**38.4**	**38.7**	**38.8**	**38.8**	**38.7**
Total supply	**95.0**	**96.2**	**96.9**	**96.7**	**96.2**	**96.0**	**96.2**	**96.5**	**96.7**	**96.4**
Stock change	1.4	2.3	1.5	1.4	1.6	1.2	1.1	—	—	0.6

*Note: Totals may not add due to rounding.
Source: International Energy Agency; OGJ estimate of OPEC crude supply 4Q 2015 through 2016

Source: O&G Journal January 4, 2016

OPEC Supply

But that wasn't all that happened: OPEC supply increased substantially, by 1.6 Mb/d to a new record of 38.2 Mb/d.

Rather than a general increase in OPEC supply, it is perhaps more accurate to describe this as an increase in production of two OPEC members: Iraq (0.7 Mb/d) and Saudi Arabia (0.5 Mb/d), which together accounted for the majority of the increase.

The net result was that, despite the adjustment in the price-sensitive components of oil demand and supply, the increase in aggregate oil production (2.8 Mb/d) again outstripped that of demand, further adding to the supply imbalance.

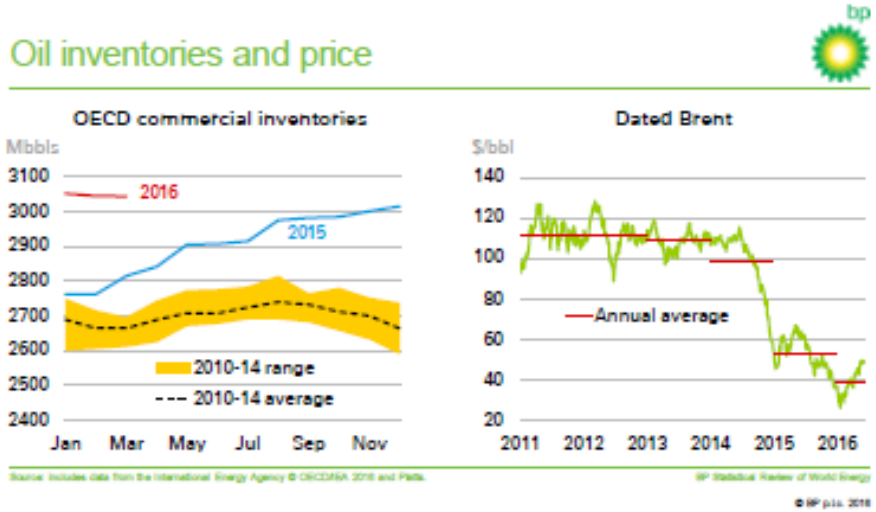
The adjustment to lower prices has continued this year, with indicators pointing to solid demand growth and a decline in non-OPEC supply. Based on current trends, it seems likely that the market will move broadly into balance in the second half of this year.

But to be clear: that doesn't mean the problem is solved, it simply means the problem in terms of accumulating oil stocks stops getting worse!

Crude and product stocks increased further from their already bloated levels: OECD commercial inventories rose by 280 Mbbls over 2015 as a whole, ending some 350 Mbbls above their 5-year average. Although comparable data for the non-OECD are not available, it is likely that non-OECD inventories also rose further.

The market will only truly return to normal when the sizeable stock overhang has been worked off.

As you would expect, the persistent supply imbalance and growing inventory levels weighed on oil prices, which fell sharply towards the end of 2014 and into 2015, before recovering somewhat in the early part of last year as demand strengthened and US tight oil peaked. But prices fell back in the wake of the increases in Iraqi and Saudi Arabian production, reaching a low point of $36 towards the end of December. Dated Brent averaged $52 in 2015, its lowest (nominal) annual average since 2004 and almost 50% below its 2014 level.



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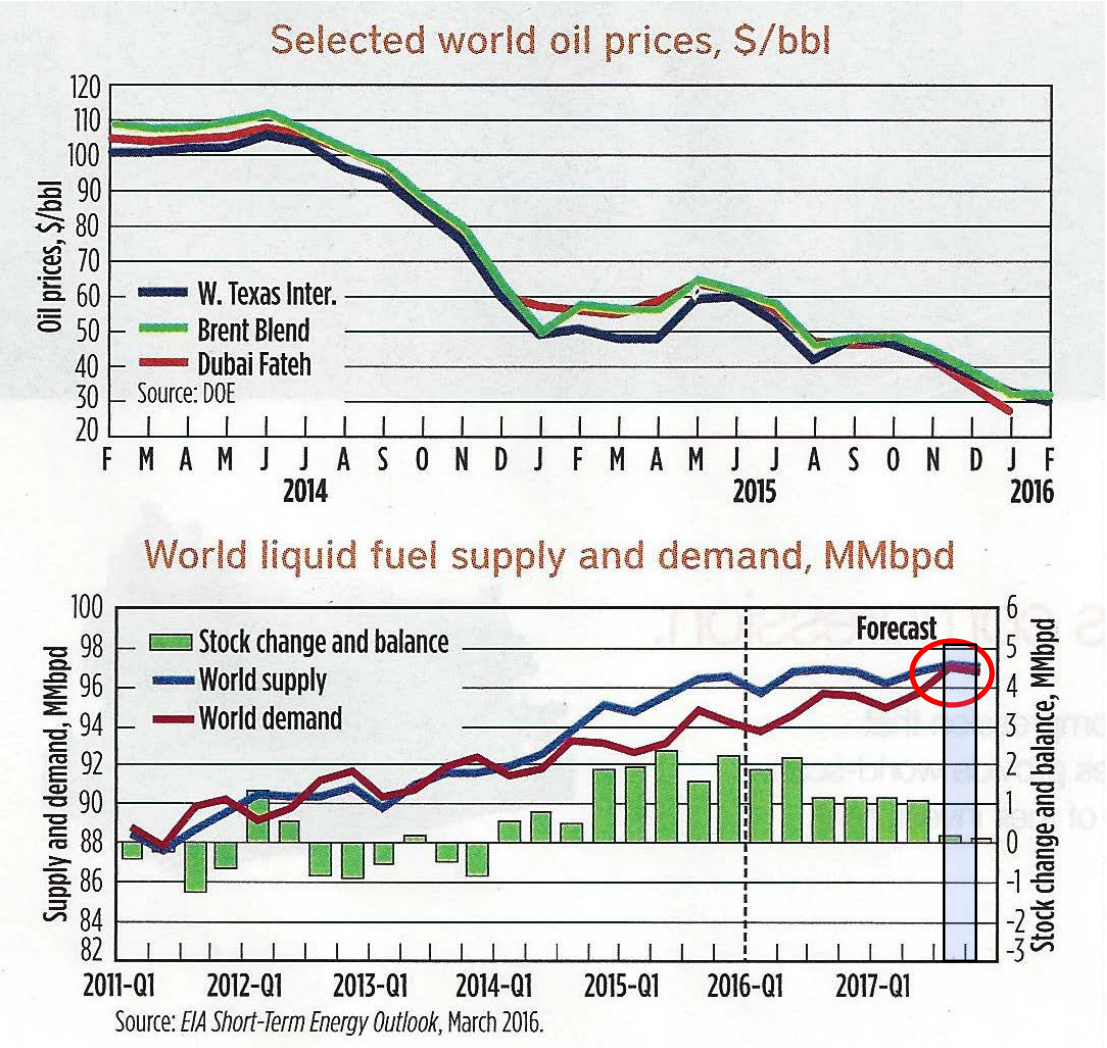
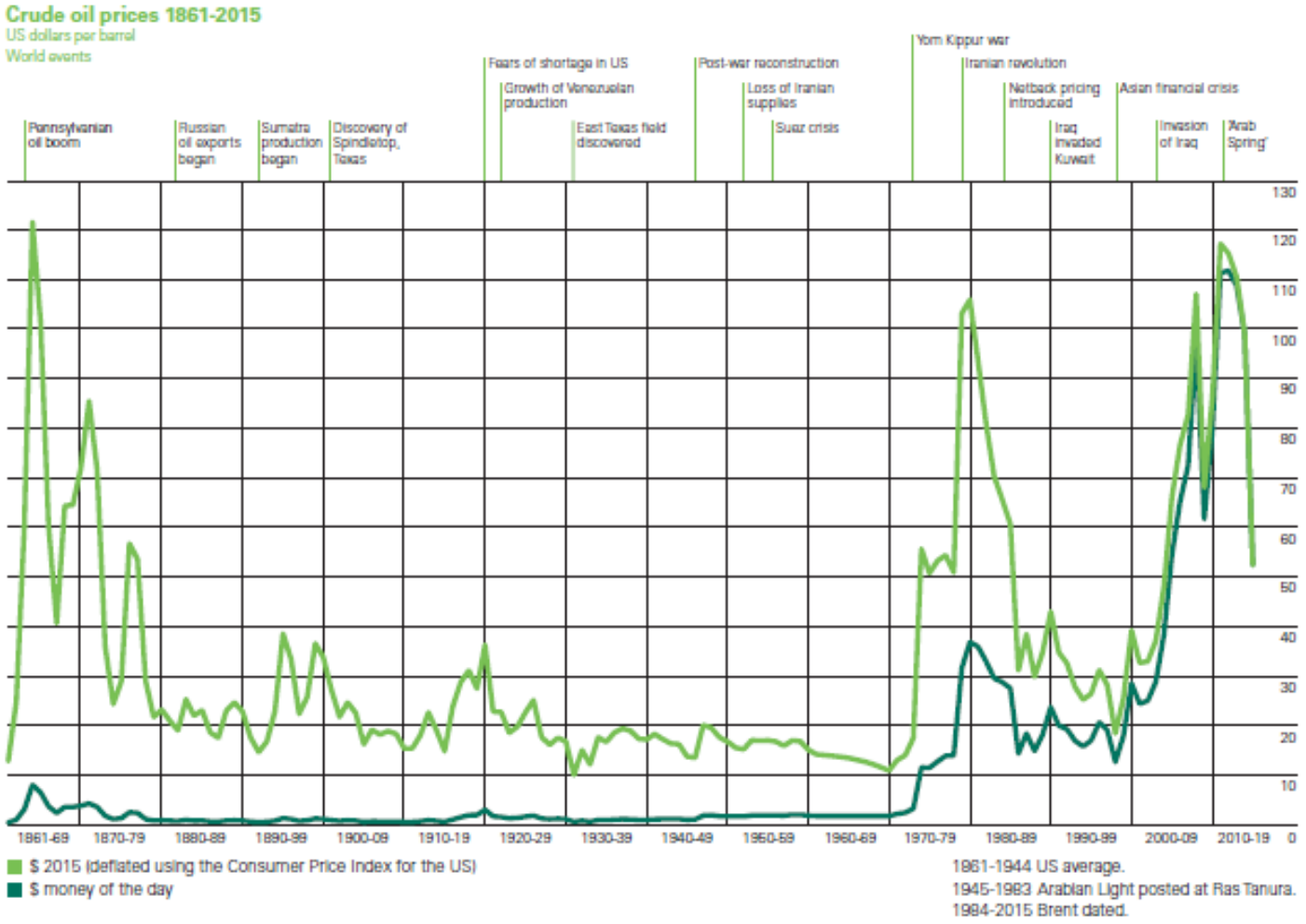
World Oil Price



Oil Supply/Demand in Balance Q:4:17

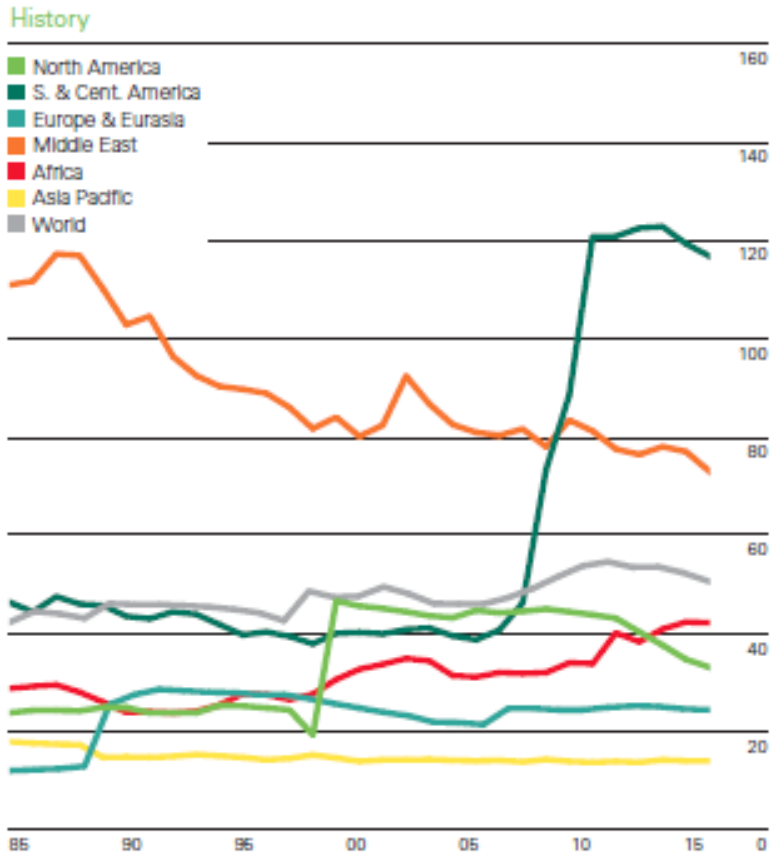
Source: Hydrocarbon Processing April 2016

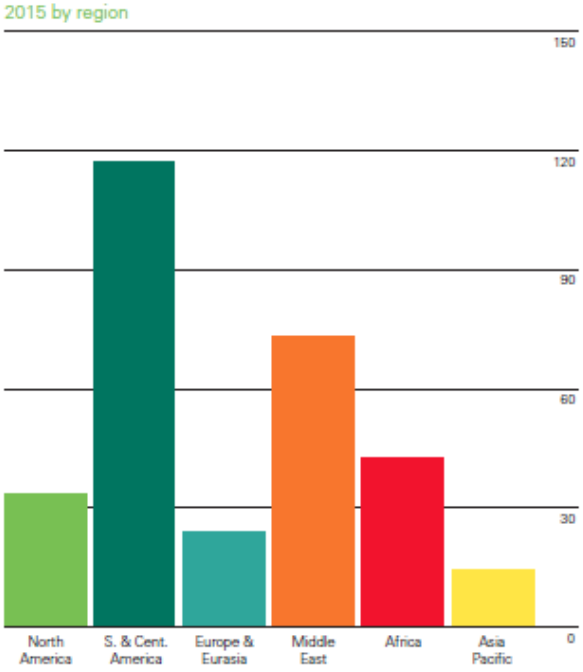
Crude Oil Prices - $/bbl

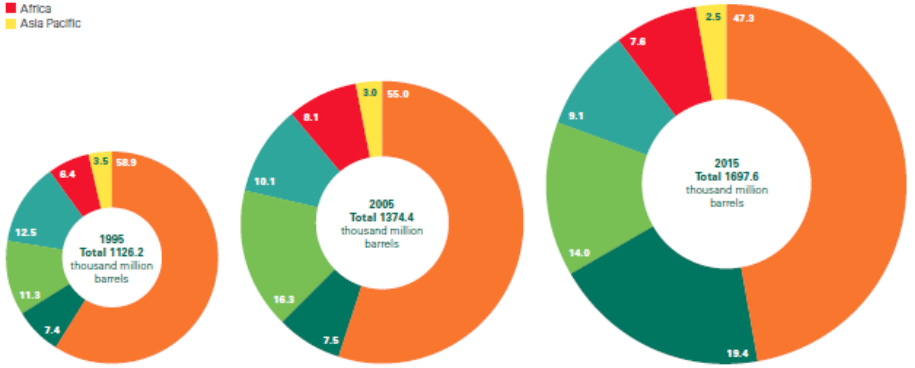


Source: BP Statistical Review of World Energy 2016

Crude Oil to Production Ratio - 2015







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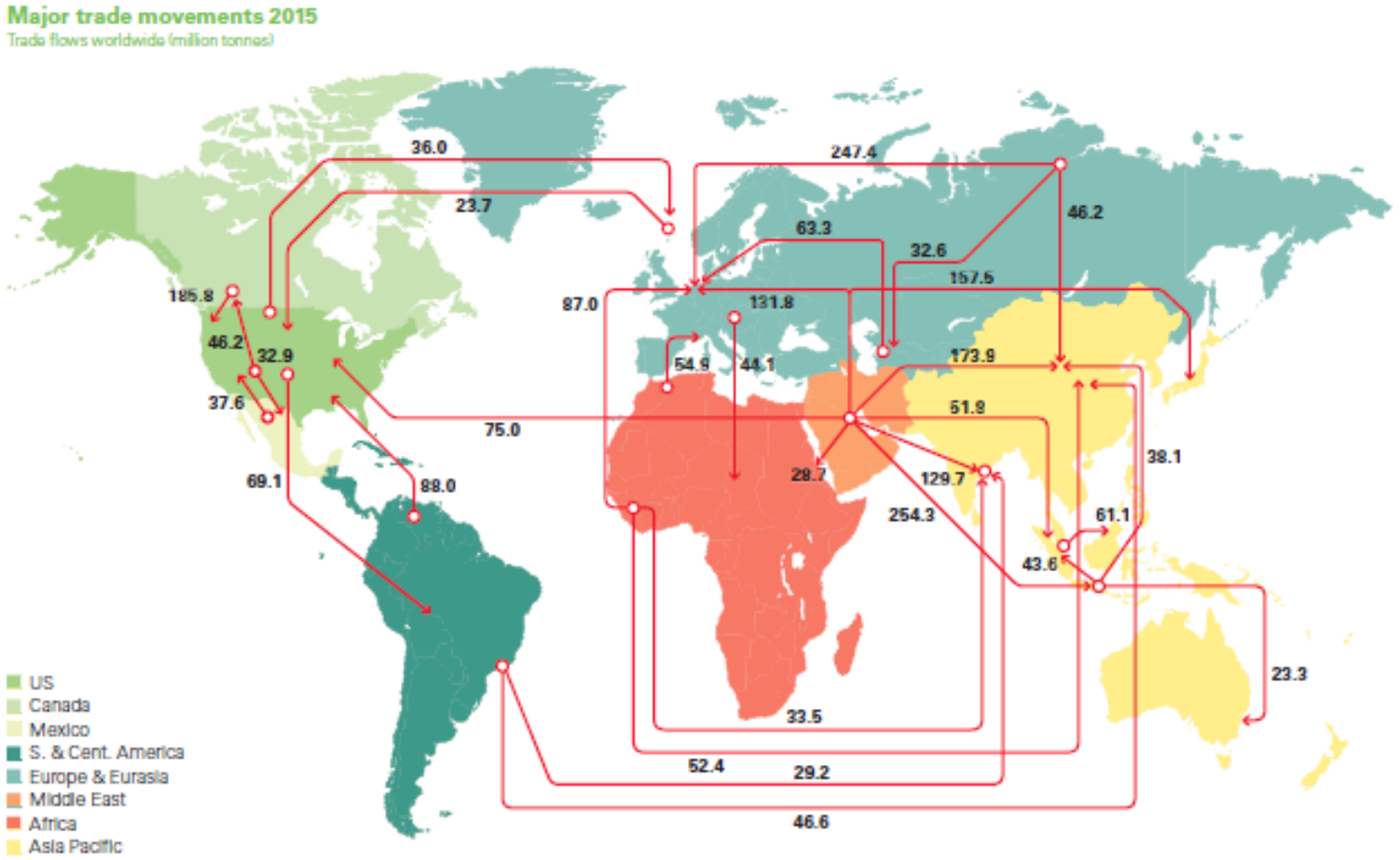
"Practical Strategies for Emerging Energy Technologies"

Source: BP Statistical Review of World Energy 2016

Crude Oil Trade Movements -2015



Total Trade 61.2 MMbbl/d is approximately 2/3rd of consumption

Source: BP Statistical Review of World Energy 2015

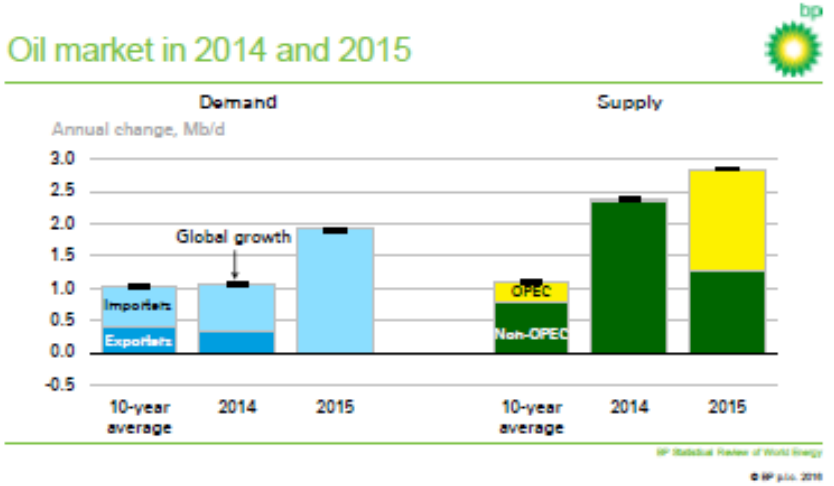
Oil Market 2014 and 2015

The key point I drew from the earlier version of this chart was that the sharp fall in oil prices in 2014 was a supply story. The increase in oil consumption was very close to its historical average: there was nothing particularly unusual about the growth of oil demand in 2014. In contrast, supply – or more accurately non-OPEC supply – had grown exceptionally strongly, led by US tight oil, triggering a sizeable supply imbalance and the consequent fall in oil prices.

The story for 2015 is that the oil market responded to this sharp fall in oil prices, but that this adjustment was offset by non-price led developments.

Global oil demand is estimated to have grown strongly last year: up 1.9 Mb/d, nearly twice its 10-year average (1.0 Mb/d). This strength was driven by net oil importers: the US (0.3 Mb/d), EU (0.2 Mb/d), China (0.8 Mb/d), and India (0.3 Mb/d) all recorded unusually strong increases. In contrast, demand growth within oil exporters was, unsurprisingly, weaker than usual.

The strength in oil demand was most pronounced in the consumer-focussed fuels, particularly gasoline and jet fuel, buoyed by the boost to consumers' purchasing power from low oil prices. Growth in diesel consumption, which is more exposed to industrial activity, was more subdued.



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Oil Supply Side

On the supply side, the impact of low oil prices was felt most immediately within US tight oil.

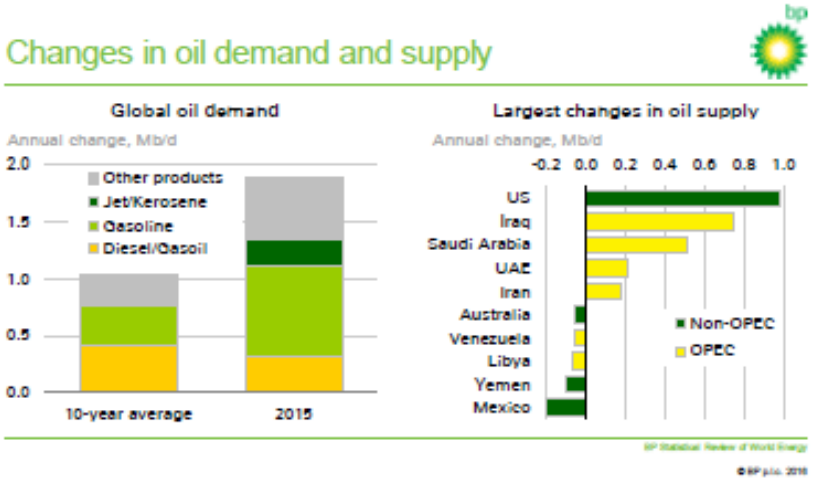
US oil rigs peaked in October 2014 at a little above 1600, falling by around two-thirds by the end of last year. The strong gains in rig productivity meant that the slowing in output growth was less pronounced, with total US production still increasing by 1.0 Mb/d in 2015. In doing so, the US reinforced its position as the world's largest oil producer.

Even so, the increase in US production was considerably smaller than in 2014 (1.7 Mb/d), pulled down by falls in US tight oil which peaked in March last year and is currently around 0.5 Mb/d off its highs.

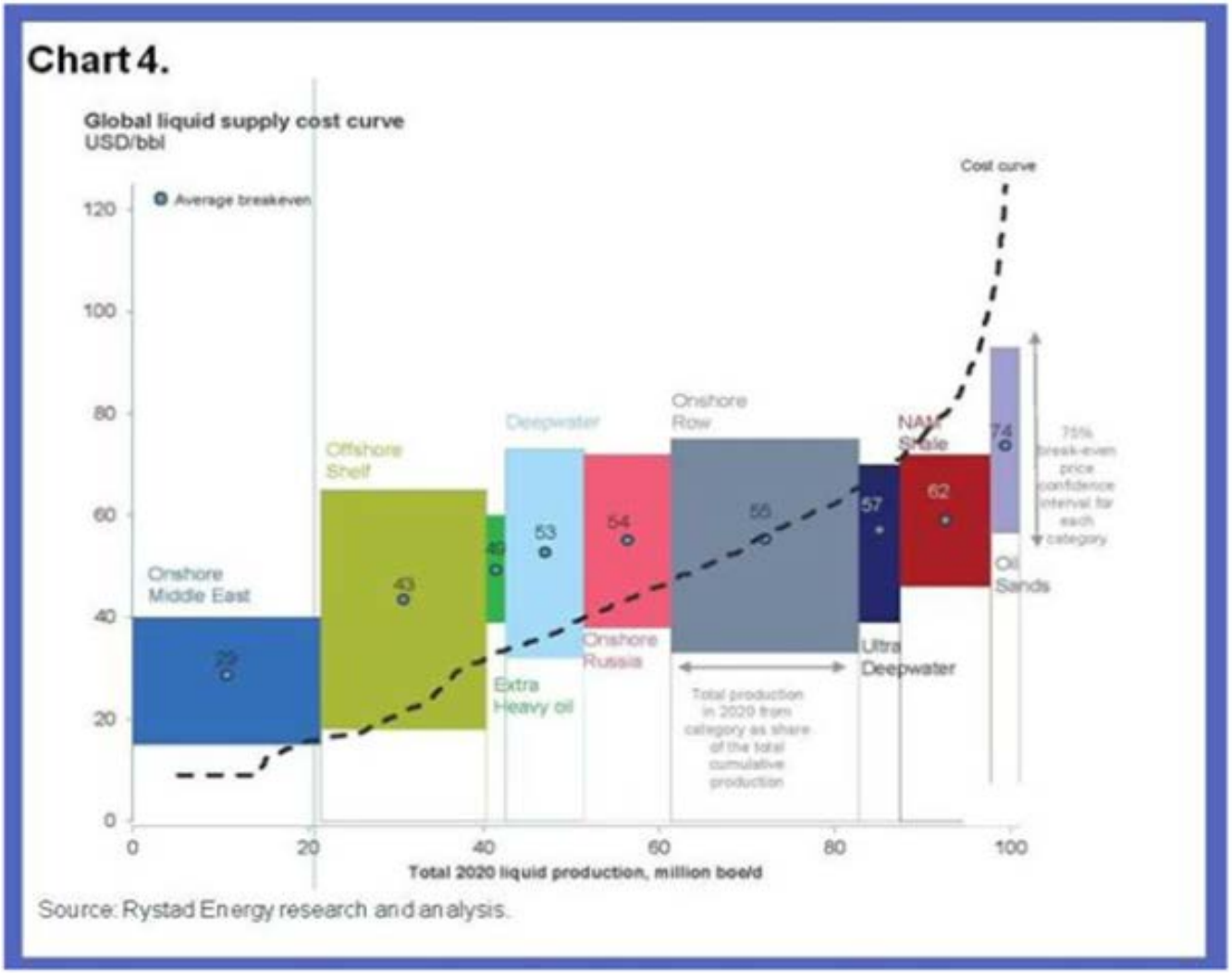
The longer lead times and higher levels of sunk capital meant other production was less affected than US tight oil. Total non-OPEC supply increased by 1.3 Mb/d, with Brazil, Russia, UK and Canada all registering production increases.

But don't be fooled: this comparative resilience of other types of production is partly a matter of timing. Investment in oil and gas-related projects is estimated to have fallen by around $160bn in 2015 – around a quarter off its 2014 level, which is the largest proportionate fall since the late 1970s.[1] And capital spending has continued to fall sharply this year. Although some of the reduction has been matched by cost deflation, the lower levels of investment will inevitably detract from future supply growth. Indeed, a key issue for the next few years is the impact this reduction in capex will have on future output growth and the risk that this will cause the oil market to tighten excessively.

If that was all that had happened last year, the combination of strong demand growth and smaller increases in non-OPEC supply would have gone a long way towards rebalancing the oil market.

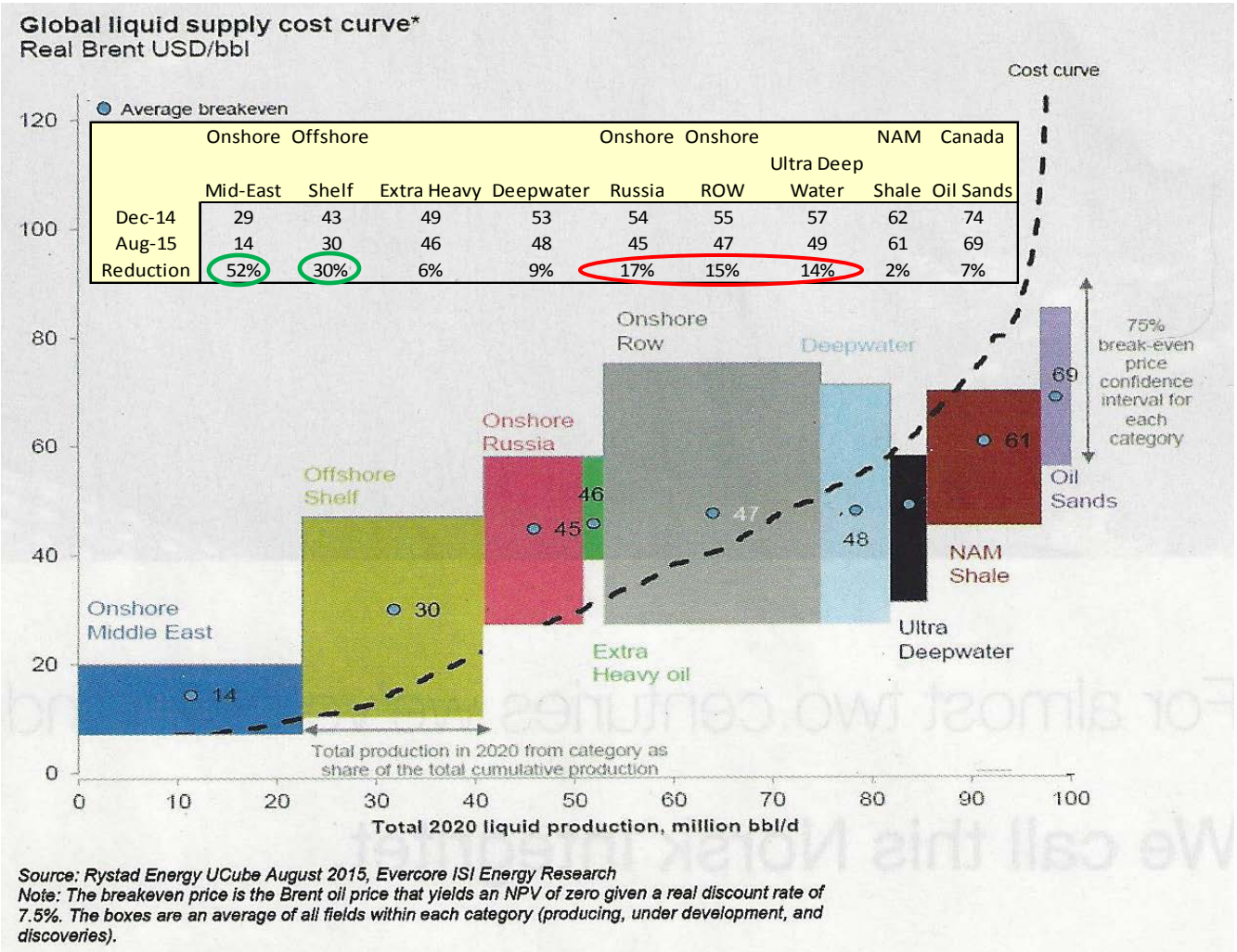


Global Liquid Supply Cost Curve December 2014



Source: Rabah Arezki, Oliver Blanchard, IMF blog Dec. 22, 2014

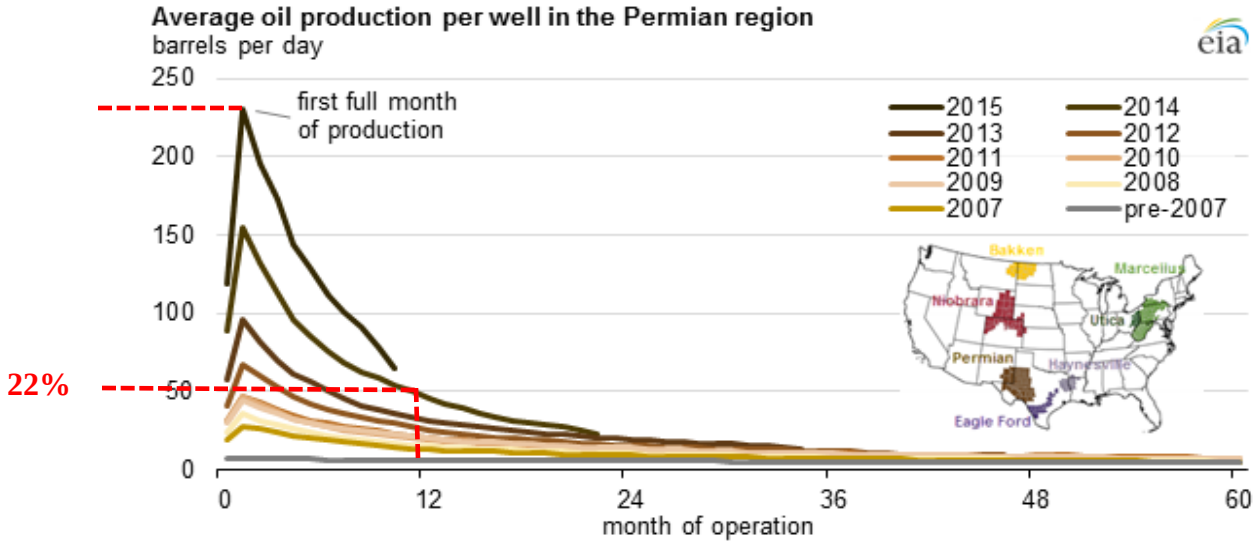
Global Liquid Supply Cost Curve August 2015

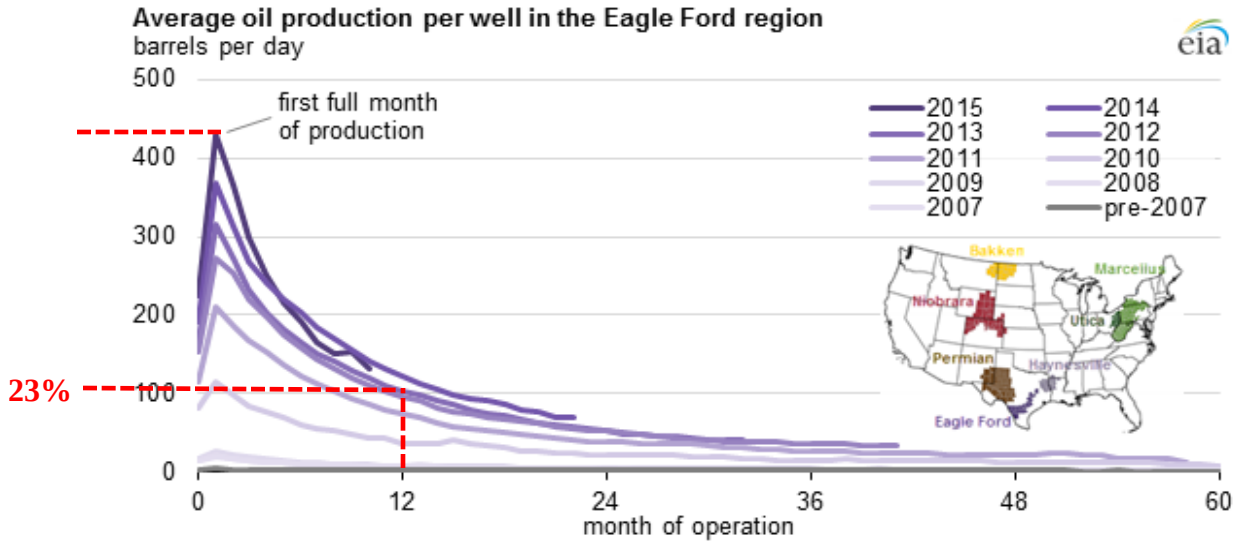


Source: Rystad Energy UCube August 2015, Evercore ISI Energy Research
Note: The breakeven price is the Brent oil price that yields an NPV of zero given a real discount rate of 7.5%. The boxes are an average of all fields within each category (producing, under development, and discoveries).

Source: Rystad Energy UCube through Offshore January 2016

Production Well Decline Rate





Fuel Mix and Prices

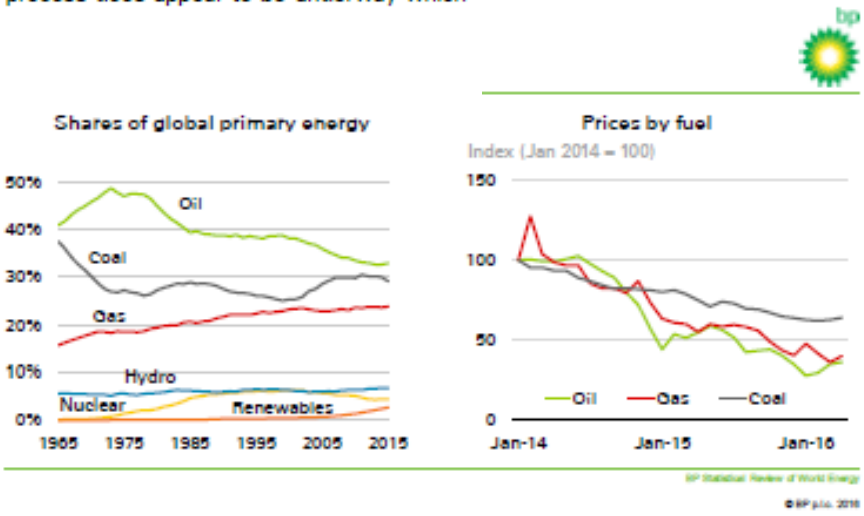
The extent of the price falls partly reflects that, unlike some times in the past, key suppliers did not make offsetting adjustments to help stabilise prices. That is true of OPEC's response to the rapid gains in US tight oil. It also appears to be the case for Russian gas exporter's response to increasing competition from liquefied natural gas (LNG).

The important point here is that ceding market share in order to support prices is less attractive when the underlying cause of the imbalance is expected to persist, rather than be relatively short-lived.

The other common feature is that in energy markets, as with other markets, prices work!

There are clear signs that energy markets responded to the signal provided by lower prices: demand in some cases was boosted; supplies in the form of current activity or future investment was severely curtailed; the fuel mix adjusted. There is still further to go. And in some markets, notably oil, the adjustment process was offset by non-price led developments. But even so, an adjustment process does appear to be underway which bodes well for future market stability.

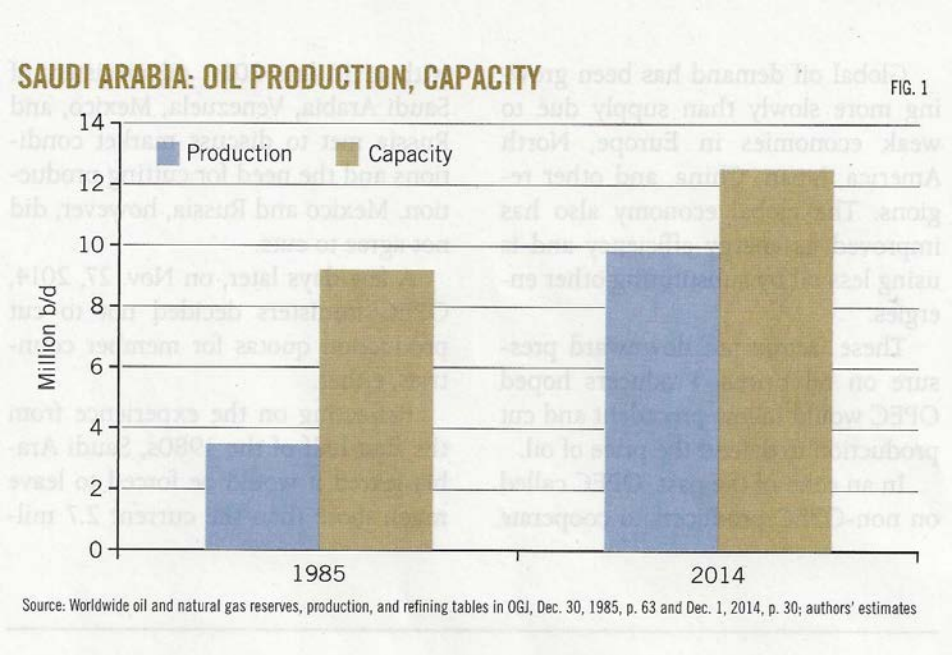
That's the big picture of 2015.



Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

Oil Price Collapse Similar to Previous Price Downturns

- An imbalance appeared in the oil market due to excess supply
- Underinvestment occurred between 1998-2004
- Investments returned in mid-2000s
- Supply could not catch up with strong growth in worldwide demand (e.g., Chinese economy)
- Fear of a "peak-oil" crisis and new developments in financial markets helping price to rise to nearly $150/bbl by July 2008
- Sustained ~$100/bbl encouraged major investment in high cost areas and application of new technologies
- New technology improved performance of older producing fields
- Social unrest, wars, security and sanctions kept notable producers off the market (Iraq, Libya, Nigeria, Iran



- Global economies and demand for oil have slowed down
- Global economy has improved overall energy Efficiency

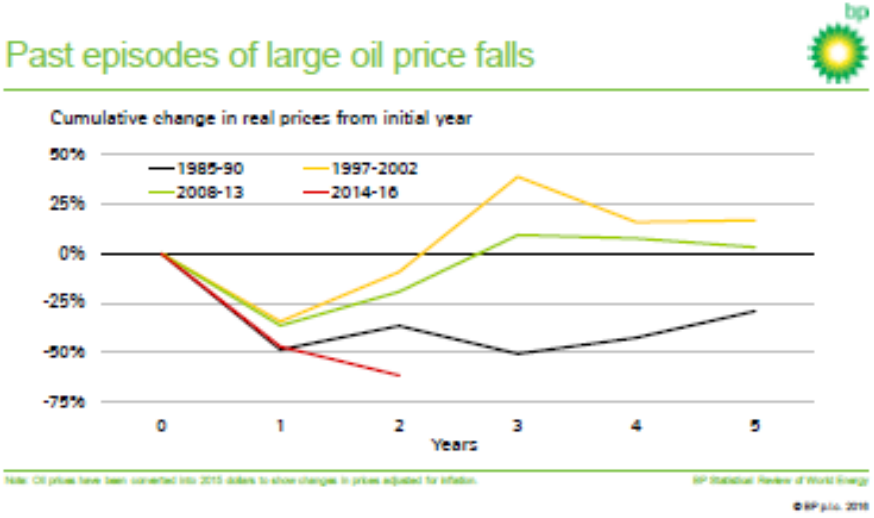
Source: O&G Journal July 6, 2015

Past “Oil Shock” Episodes

Comparing the recent fall in prices with previous episodes of sharp price declines, the experience so far has followed a pattern closer to that seen in the mid-1980s, than in either 2008-9 or 1997-8.

The latter two shocks were driven by sharp contractions in demand growth which reversed relatively quickly. In contrast, the mid-1980s price fall was driven in large part by new sources of supply, as new production from the North Sea and Alaska came on stream. This led to a more protracted period of weak prices as the market had to gradually absorb the additional supply.

Although different in many respects to the mid-1980s, the underlying cause of the current price weakness was also supply driven, in this case an increase in supply from US tight oil. As a consequence, as Bob suggested from the outset, prices have been lower for longer.



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OPEC Net Oil Export Revenue

OPEC net oil export revenues

	Nominal (billion $)					Real (billion 2015$)				
Country	2014	2015	2016	2017	Jan-May 2016	2014	2015	2016	2017	Jan-May 2016
Algeria	$48	$24	--	--	$7	$48	$24	--	--	$7
Angola	$23	$13	--	--	$4	$23	$13	--	--	$4
Ecuador	$10	$5	--	--	$2	$10	$5	--	--	$2
Indonesia	-$29	-$15	--	--	-$4	-$29	-$15	--	--	-$4
Iran	$47	$27	--	--	$11	$47	$27	--	--	$11
Iraq	$89	$57	--	--	$19	$89	$57	--	--	$18
Kuwait	$80	$40	--	--	$11	$80	$40	--	--	$11
Libya	$9	$4	--	--	$1	$9	$4	--	--	$1
Nigeria	$78	$39	--	--	$10	$78	$39	--	--	$10
Qatar	$38	$20	--	--	$6	$38	$20	--	--	$6
Saudi Arabia	$247	$130	--	--	$39	$247	$130	--	--	$39
UAE	$53	$29	--	--	$8	$53	$29	--	--	$8
Venezuela	$58	$32	--	--	$9	$58	$32	--	--	$9
OPEC	$753	$404	$341	$427	$121	$754	$404	$338	$415	$120

View nominal or real data (2005-17)
Note: Iranian net oil export revenues do not account for any discounts Iran may have offered its oil customers between end-2011 and January 2016.
Source: U.S. Energy Information Administration, derived from EIA's June 2016 Short-Term Energy Outlook.

OPEC per Capita Export Revenue

OPEC per capita net oil export revenues

	Nominal (billion $)					Real (billion 2015$)				
Country	2014	2015	2016	2017	Jan-May 2016	2014	2015	2016	2017	Jan-May 2016
Algeria	$1,331	$652	--	--	$184	$1,332	$652	--	--	$183
Angola	$1,646	$898	--	--	$263	$1,648	$898	--	--	$261
Ecuador	$693	$338	--	--	$103	$694	$338	--	--	$103
Indonesia	-$116	-$59	--	--	-$17	-$116	-$59	--	--	-$17
Iran	$679	$384	--	--	$153	$680	$384	--	--	$152
Iraq	$2,740	$1,718	--	--	$547	$2,743	$1,718	--	--	$542
Kuwait	$25,297	$12,133	--	--	$3,327	$25,327	$12,133	--	--	$3,299
Libya	$1,253	$517	--	--	$84	$1,254	$517	--	--	$83
Nigeria	$492	$240	--	--	$62	$492	$240	--	--	$62
Qatar	$36,812	$18,658	--	--	$5,430	$36,855	$18,658	--	--	$5,384
Saudi Arabia	$7,925	$4,125	--	--	$1,223	$7,934	$4,125	--	--	$1,212
UAE	$9,434	$4,940	--	--	$1,377	$9,445	$4,940	--	--	$1,366
Venezuela	$2,016	$1,088	--	--	$307	$2,019	$1,088	--	--	$304
OPEC	$1,146	$606	$503	$621	$180	$1,147	$606	$499	$603	$178

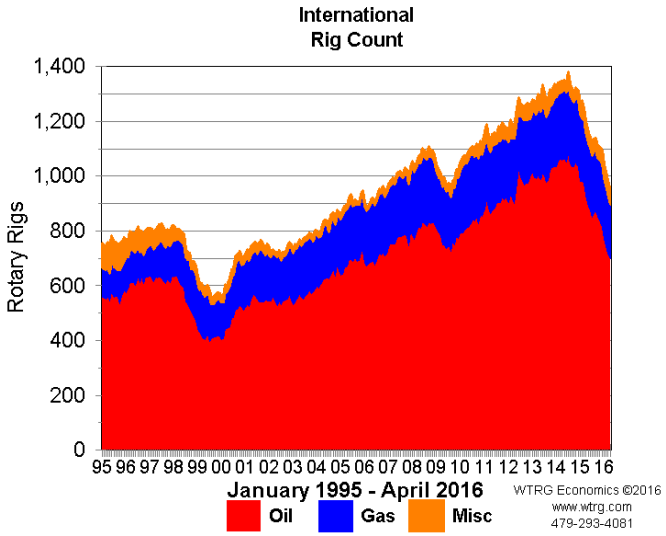
View nominal or real data (2005-2017)
Note: Iranian per capita net oil export revenues do not account for any discounts Iran may have offered its oil customers between end-2011 and January 2016.
Source: U.S. Energy Information Administration, derived from EIA's June 2016 Short-Term Energy Outlook.

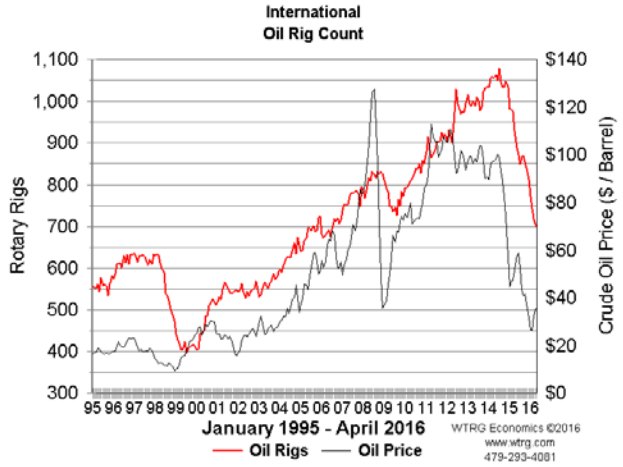
Impact of Lower Oil Prices

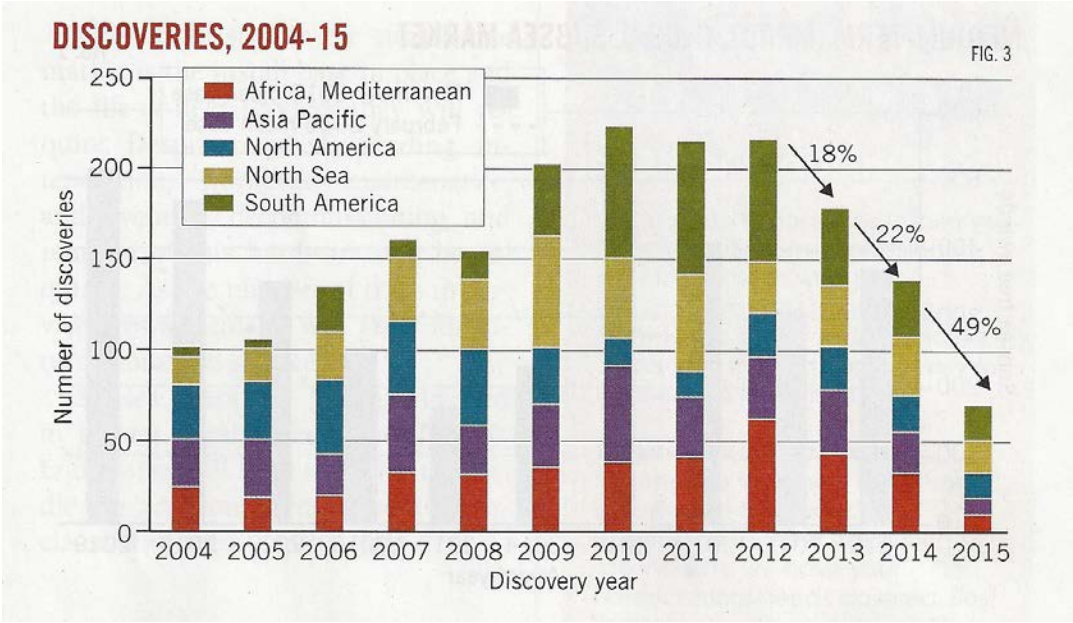
- Final Investment Decision (FID) on 68 Large Projects Delayed
- Deferred $380 billion of total project capex on the 68 projects
- Delayed spend $170 billion during 2016-2020
- Deepwater the worst affected accounting
  - 62% of total reserves
  - 56% of total capex
- 2.9 MMb/d of liquids production pushed back to early 2020s
- Average breakeven for delayed greenfield projects $62/boe
- $41/bbl forecast average annual price for Brent crude
- 3.4 MMb/d (3.5% of global supply) cash negative at $35/bbl
- No sign of significant oil production shut-ins at $35/bbl
- Globally - 100,000 b/d shut-in to date
  - Canadian onshore & oil sands
  - U.S. conventional
  - Older U.K. North Sea
- Oil most impacted
  - Deferred liquid volumes up 44%
  - Deferred gas volumes up 24%
- Largest inventory of delayed projects
- 90% of all deferred liquids
  - Canada
  - Angola
  - Kazakhstan
  - Nigeria
  - Norway
  - U.S.
- Largest gas reserves pending development
  - 85% of total volume, mostly offshore
    - Mozambique
    - Australia
    - Malaysia
    - Indonesia

Source: Wood McKenzie thru Offshore March 2106

Discoveries







Source: Hydrocarbon Processing February 2016

Natural Gas

Natural Gas Demand – 3468.6 BCM

Natural Gas: Consumption*

Billion cubic metres	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	Change 2015 over 2014	2015 share of total
US	623.4	614.4	654.2	659.1	648.7	682.1	693.1	723.2	740.6	756.0	**778.0**	3.0%	22.8%
Canada	97.8	96.9	96.2	96.1	94.9	95.0	100.9	100.2	103.9	104.2	**102.5**	-1.7%	2.9%
Mexico	60.9	66.6	63.4	66.3	72.2	72.5	76.6	79.9	83.3	86.8	**83.2**	-4.2%	2.4%
Total North America	**782.1**	**778.0**	**813.8**	**821.5**	**815.9**	**849.6**	**870.6**	**903.3**	**927.8**	**947.1**	**963.6**	**1.9%**	**28.1%**
Argentina	40.4	41.8	43.9	44.4	42.1	43.2	45.2	46.8	46.5	47.1	**47.5**	0.8%	1.4%
Brazil	19.6	20.6	21.2	24.9	20.1	26.8	26.7	31.7	37.3	39.4	**40.9**	3.8%	1.2%
Total S. & Cent. America	**123.5**	**135.4**	**142.5**	**143.4**	**136.8**	**150.8**	**151.5**	**160.6**	**165.8**	**169.5**	**174.8**	**3.1%**	**5.0%**
France	45.6	44.0	42.8	44.3	42.7	47.3	41.1	42.5	43.1	36.2	**39.1**	7.8%	1.1%
Germany	86.3	87.9	84.7	85.5	80.7	84.1	77.3	77.5	81.2	71.1	**74.6**	5.0%	2.1%
Italy	79.1	77.4	77.3	77.2	71.0	75.6	70.9	68.2	63.8	56.3	**61.4**	9.1%	1.8%
Russian Federation	394.0	415.0	422.0	416.0	389.6	414.1	424.6	416.2	413.5	411.9	**391.5**	-5.0%	11.2%
Turkey	26.9	30.5	36.1	37.5	35.7	39.0	40.9	41.4	41.8	44.7	**43.6**	-2.4%	1.3%
Turkmenistan	16.1	18.4	21.3	21.4	19.7	22.6	23.5	26.3	22.9	27.7	**34.3**	23.9%	1.0%
Ukraine	69.0	67.0	63.2	60.0	46.8	52.2	53.7	49.6	43.3	36.8	**28.8**	-21.8%	0.8%
United Kingdom	94.9	90.0	91.0	93.8	87.0	94.2	78.1	73.9	73.0	66.7	**68.3**	2.4%	2.0%
Total Europe & Eurasia	**1093.5**	**1117.2**	**1120.6**	**1132.7**	**1041.5**	**1116.0**	**1089.1**	**1071.6**	**1051.2**	**1006.4**	**1003.5**	**-0.3%**	**28.8%**
Iran	102.7	112.0	125.5	133.2	142.7	152.9	162.2	161.5	162.9	180.0	**191.2**	6.2%	5.5%
Qatar	18.7	19.6	23.6	19.0	19.9	32.1	20.7	25.9	42.7	39.7	**45.2**	13.8%	1.3%
Saudi Arabia	71.2	73.5	74.4	80.4	78.5	87.7	92.3	99.3	100.0	102.4	**106.4**	4.0%	3.1%
United Arab Emirates	42.1	43.4	49.2	59.5	59.1	60.8	63.2	65.6	67.3	66.3	**69.1**	4.3%	2.0%
Total Middle East	**279.3**	**296.8**	**321.8**	**347.0**	**358.2**	**399.5**	**404.6**	**417.9**	**446.9**	**461.4**	**490.2**	**6.2%**	**14.1%**
Algeria	23.2	23.7	24.3	25.4	27.2	26.3	27.8	31.0	33.4	37.5	**39.0**	4.1%	1.1%
Egypt	31.6	36.5	38.4	40.8	42.5	45.1	49.6	52.6	51.4	48.0	**47.8**	-0.4%	1.4%
Total Africa	**85.1**	**89.6**	**96.7**	**100.7**	**99.6**	**107.2**	**114.2**	**123.4**	**122.9**	**128.4**	**135.5**	**5.5%**	**3.9%**
Australia	24.9	27.7	31.5	31.9	32.2	33.2	32.5	33.2	34.3	36.0	**34.3**	-4.5%	1.0%
China	48.2	59.3	73.0	84.1	92.6	111.2	137.1	150.9	171.9	188.4	**197.3**	4.7%	5.7%
India	35.7	37.3	40.3	41.5	50.7	61.5	61.9	57.5	50.4	50.6	**50.6**	-0.1%	1.5%
Indonesia	35.9	36.6	34.1	39.1	41.5	43.4	42.1	42.2	40.8	40.9	**39.7**	-2.7%	1.1%
Japan	78.6	83.7	90.2	93.7	87.4	94.5	105.5	116.9	116.9	118.0	**113.4**	-3.9%	3.3%
Malaysia	34.9	35.3	35.5	39.2	35.4	34.5	34.8	35.5	40.3	40.8	**39.8**	-2.4%	1.1%
Pakistan	39.1	39.9	40.5	41.4	41.6	42.3	42.3	43.8	42.6	41.9	**43.4**	3.5%	1.2%
South Korea	30.4	32.0	34.7	35.7	33.9	43.0	46.3	50.2	52.5	47.8	**43.6**	-8.7%	1.3%
Thailand	32.5	33.3	35.4	37.4	39.2	45.1	46.6	51.3	52.3	52.7	**52.9**	0.3%	1.5%
Total Asia Pacific	**410.8**	**440.8**	**473.8**	**506.0**	**519.2**	**578.4**	**619.1**	**655.8**	**678.4**	**697.4**	**701.1**	**0.5%**	**20.1%**
Total World	**2774.3**	**2857.7**	**2969.2**	**3051.2**	**2971.1**	**3201.4**	**3249.2**	**3332.5**	**3392.9**	**3410.2**	**3468.6**	**1.7%**	**100.0%**

Source: BP Statistical Review of World Energy 2016

Natural Gas Production – 3460.6BCM

Natural Gas: Production *

Billion cubic metres	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	Change 2014 over 2013	2014 share of total
US	526.4	511.1	524.0	545.6	570.8	584.0	603.6	648.5	680.5	689.1	**728.3**	6.1%	21.4%
Canada	183.7	187.1	188.4	182.7	176.6	164.0	159.9	159.7	156.0	156.1	**162.0**	3.8%	4.7%
Total North America	**753.5**	**750.5**	**769.7**	**781.8**	**800.8**	**807.3**	**821.1**	**866.5**	**893.8**	**903.3**	**948.4**	**5.3%**	**27.7%**
Argentina	44.9	45.6	46.1	44.8	44.1	41.4	40.1	38.8	37.7	35.5	**35.4**	-0.3%	1.0%
Trinidad & Tobago	30.2	33.0	40.1	42.2	42.0	43.6	44.8	43.1	42.7	42.8	**42.1**	-1.8%	1.2%
Total S. & Cent. America	**134.7**	**140.7**	**154.3**	**162.3**	**163.2**	**158.5**	**163.2**	**167.2**	**173.7**	**173.3**	**175.0**	**1.0%**	**5.0%**
Netherlands	68.5	62.5	61.6	60.5	66.6	62.7	70.5	64.2	63.9	68.7	**55.8**	-18.7%	1.6%
Norway	79.2	85.8	88.7	90.3	100.1	104.4	107.3	101.3	114.7	108.7	**108.8**	0.1%	3.1%
Russian Federation	573.3	580.1	595.2	592.0	601.7	527.7	588.9	607.0	592.3	604.7	**578.7**	-4.3%	16.7%
Turkmenistan	52.8	57.0	60.4	65.4	66.1	36.4	42.4	59.5	62.3	62.3	**69.3**	11.1%	2.0%
United Kingdom	96.4	88.2	80.0	72.1	69.6	59.7	57.1	45.2	38.9	36.5	**36.6**	0.3%	1.1%
Uzbekistan	54.2	54.0	56.6	58.2	57.8	55.6	54.4	57.0	56.9	56.9	**57.3**	0.7%	1.6%
Total Europe & Eurasia	**1025.3**	**1028.8**	**1043.0**	**1041.2**	**1070.0**	**950.3**	**1021.7**	**1034.2**	**1028.2**	**1034.7**	**1002.4**	**-3.1%**	**28.8%**
Iran	96.4	102.3	111.5	125.0	132.4	144.2	152.4	159.9	165.6	164.0	**172.6**	5.2%	5.0%
Qatar	39.2	45.8	50.7	63.2	77.0	94.2	126.3	161.1	170.5	176.5	**177.2**	0.4%	5.1%
Saudi Arabia	65.7	71.2	73.5	74.4	80.4	78.5	87.7	92.3	99.3	100.0	**108.2**	8.2%	3.1%
United Arab Emirates	46.3	47.8	48.8	50.3	50.2	48.8	51.3	52.3	54.3	54.6	**57.8**	5.8%	1.7%
Total Middle East	**296.6**	**318.7**	**341.6**	**370.8**	**400.3**	**425.1**	**488.6**	**540.7**	**565.1**	**580.5**	**601.0**	**3.5%**	**17.3%**
Algeria	82.0	88.2	84.5	84.8	85.8	79.6	80.4	82.7	81.5	81.5	**83.3**	2.2%	2.4%
Egypt	33.0	42.5	54.7	55.7	59.0	62.7	61.3	61.4	60.9	56.1	**48.7**	-13.1%	1.4%
Nigeria	24.4	25.1	29.6	36.9	36.2	26.0	37.3	40.6	43.3	36.2	**38.6**	6.6%	1.1%
Total Africa	**156.4**	**177.3**	**192.2**	**204.7**	**212.3**	**200.0**	**213.3**	**210.2**	**215.4**	**204.7**	**202.6**	**-1.0%**	**5.8%**
Australia	35.3	37.1	38.9	40.0	38.3	42.3	45.9	46.5	51.6	53.4	**55.3**	3.6%	1.6%
China	42.8	51.0	60.5	71.5	83.0	88.1	99.0	108.8	114.3	124.9	**134.5**	7.7%	3.9%
India	29.2	29.6	29.3	30.1	30.5	39.2	50.8	46.1	40.3	33.7	**31.7**	-5.9%	0.9%
Indonesia	74.6	75.1	74.3	71.5	73.7	76.9	85.7	81.5	77.1	72.1	**73.4**	1.7%	2.1%
Malaysia	56.7	62.3	62.7	61.5	63.8	61.1	62.6	62.2	61.6	67.2	**66.4**	-1.2%	1.9%
Pakistan	34.5	39.1	39.8	40.5	41.4	41.6	42.3	42.3	43.7	42.7	**42.0**	-1.6%	1.2%
Thailand	22.4	23.7	24.3	26.0	28.8	30.9	36.2	37.0	41.4	41.8	**42.1**	0.8%	1.2%
Total Asia Pacific	**344.8**	**373.4**	**391.7**	**407.3**	**426.9**	**448.2**	**494.7**	**496.9**	**504.0**	**512.3**	**531.2**	**3.7%**	**15.3%**
Total World	**2711.3**	**2789.3**	**2892.5**	**2968.1**	**3073.4**	**2989.4**	**3202.6**	**3315.7**	**3380.2**	**3408.8**	**3460.6**	**1.6%**	**100.0%**

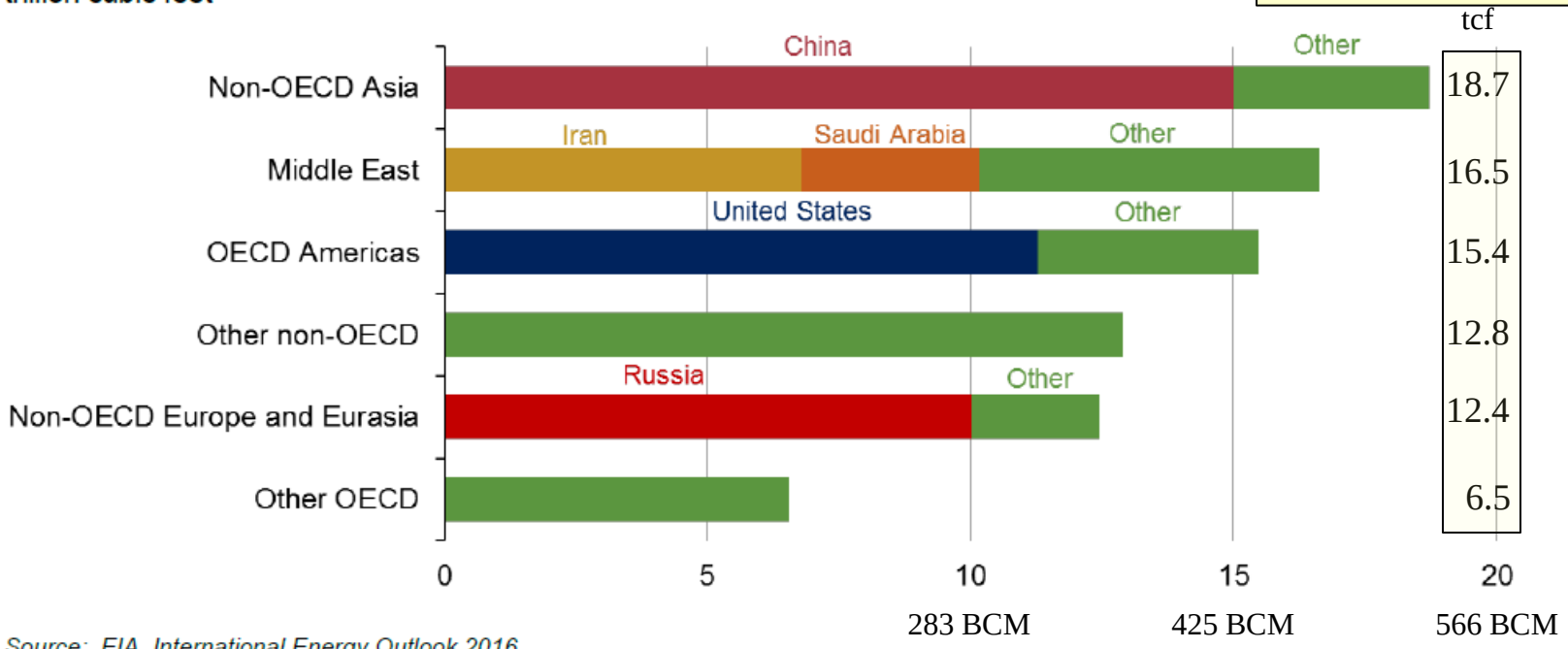
Source: BP Statistical Review of World Energy 2015

World Change in Gas Production – 2012-2040

Non-OECD Asia, Middle East, and OECD Americas account for the largest increases in natural gas production

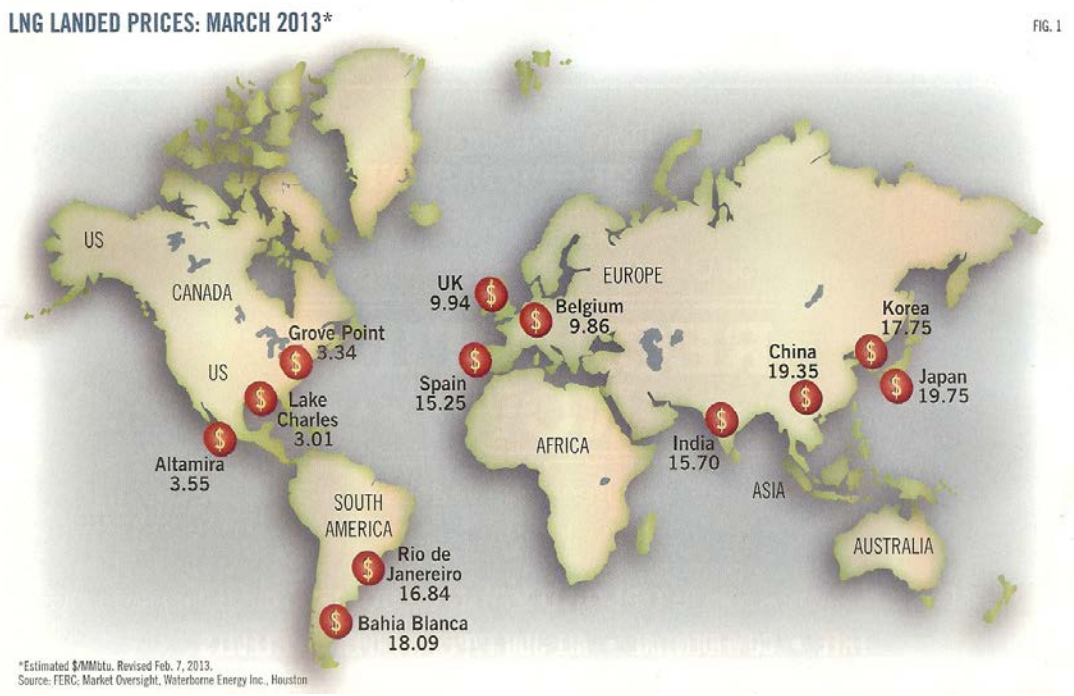
world change in natural gas production, 2012–40
trillion cubic feet

+82.3 tcf = 2330 BCM



Source: EIA, International Energy Outlook 2016

Natural Gas Prices – March 2013



Demand:

Japan

- Fukushima = Japan 36% WW LNG
- Oil-price-linked formula

China

- Demand Growth
- Oil-price-linked formula

Europe

- Concern over Russian dependency
- Oil-price-linked formula
- UK declining indigenous supply

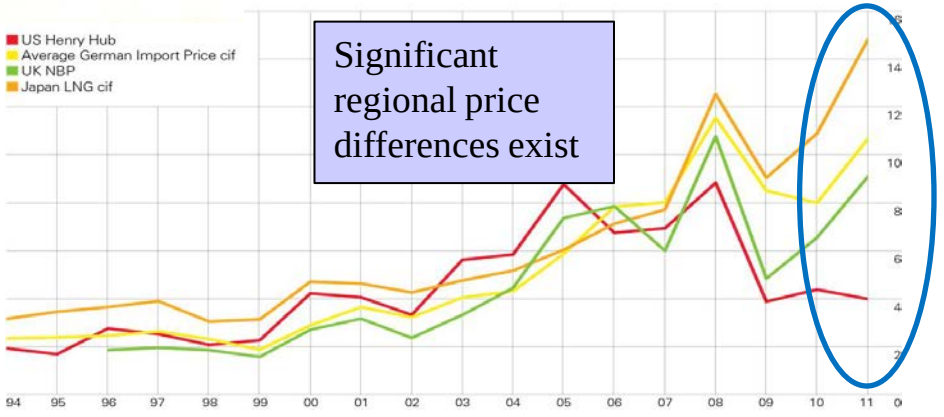
Supply:

North America

- Significant shale resource
- Significant associated gas production

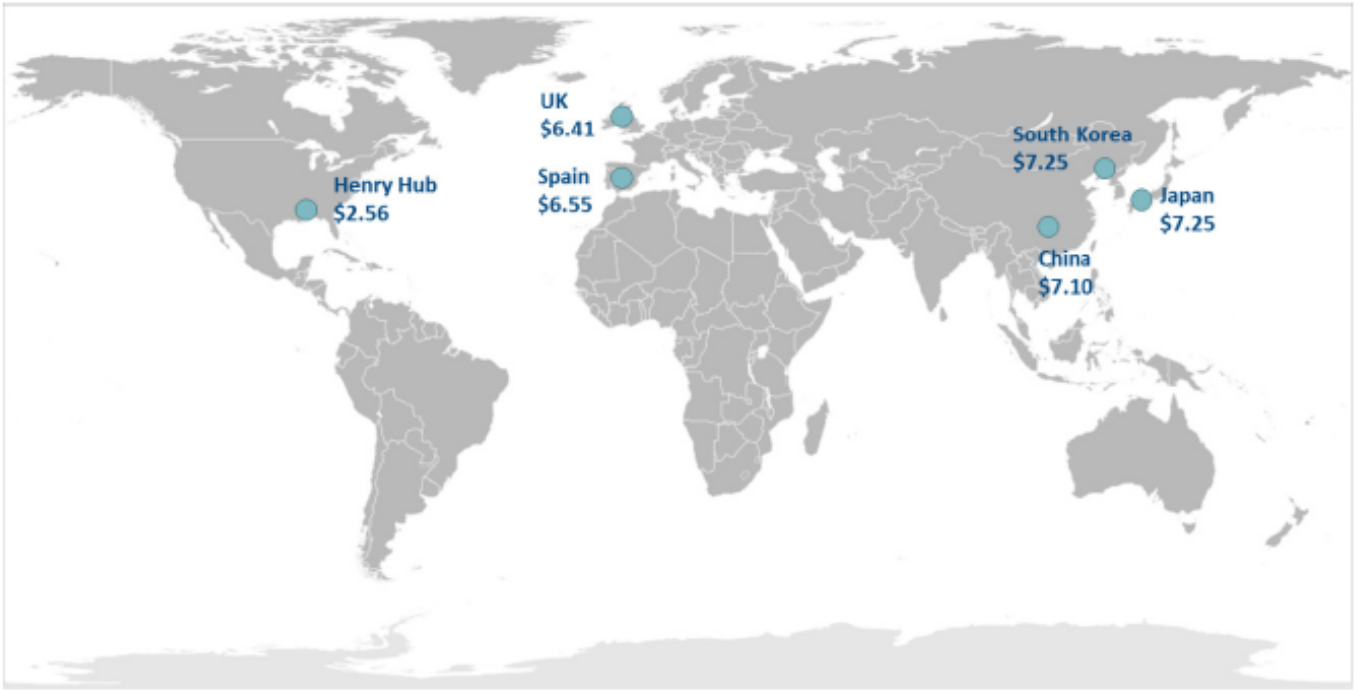
Australia & East Africa

- Project cost/timing uncertainties



LNG Landed Prices - October 2015

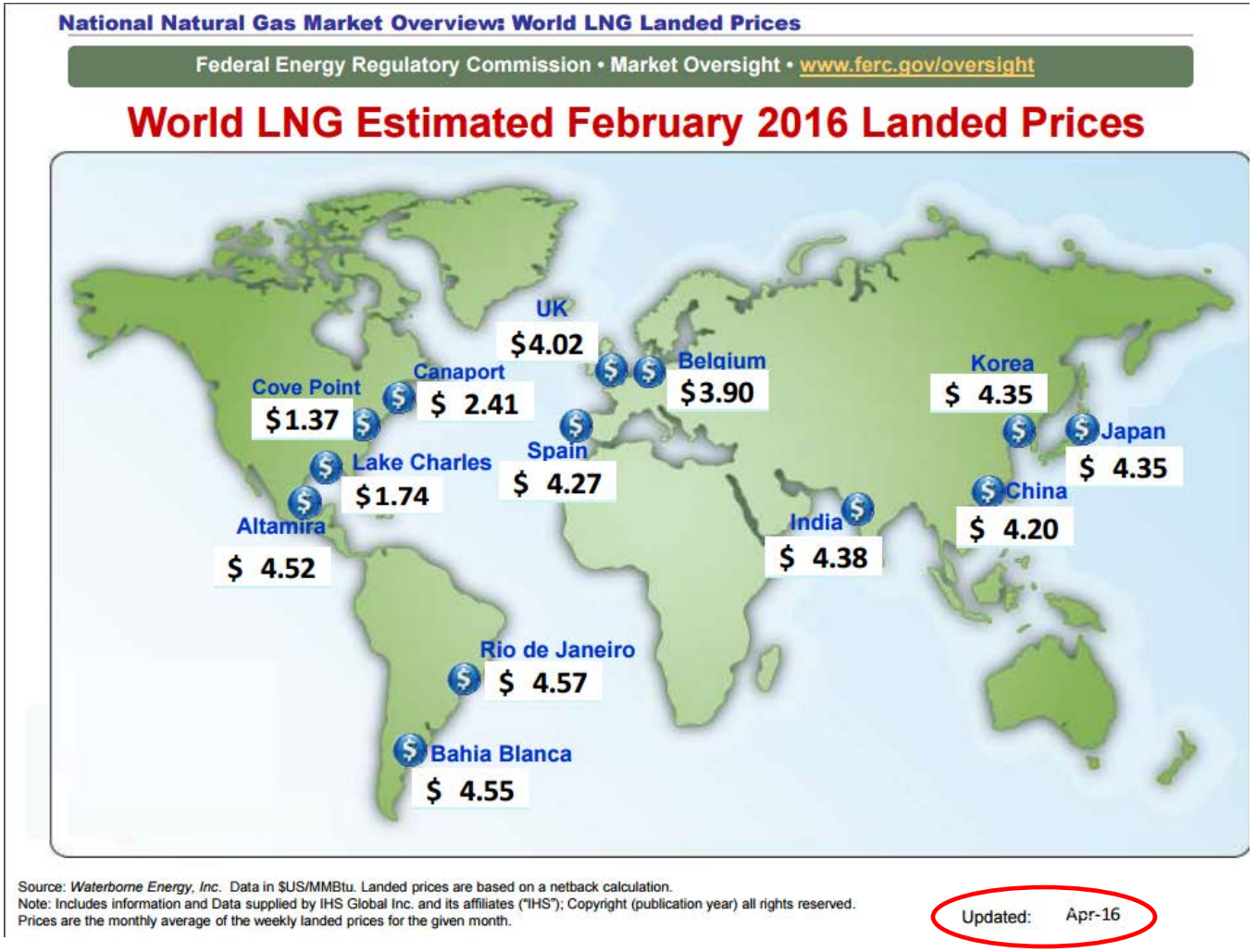
Figure 3
October 2015 Landed LNG Prices for Select Countries
$/MMBtu



Sources/Notes:

Henry Hub prices are from Platts. Estimated LNG landed prices are from the Federal Energy Regulatory Commission, National Natural Gas Market Overview (updated October 2015) available at http://www.ferc.gov/market-oversight/mkt-gas/overview/ngas-ovr-lng-wld-pr-est.pdf.

LNG Landed Prices - April 2016



Natural Gas Prices

Prices

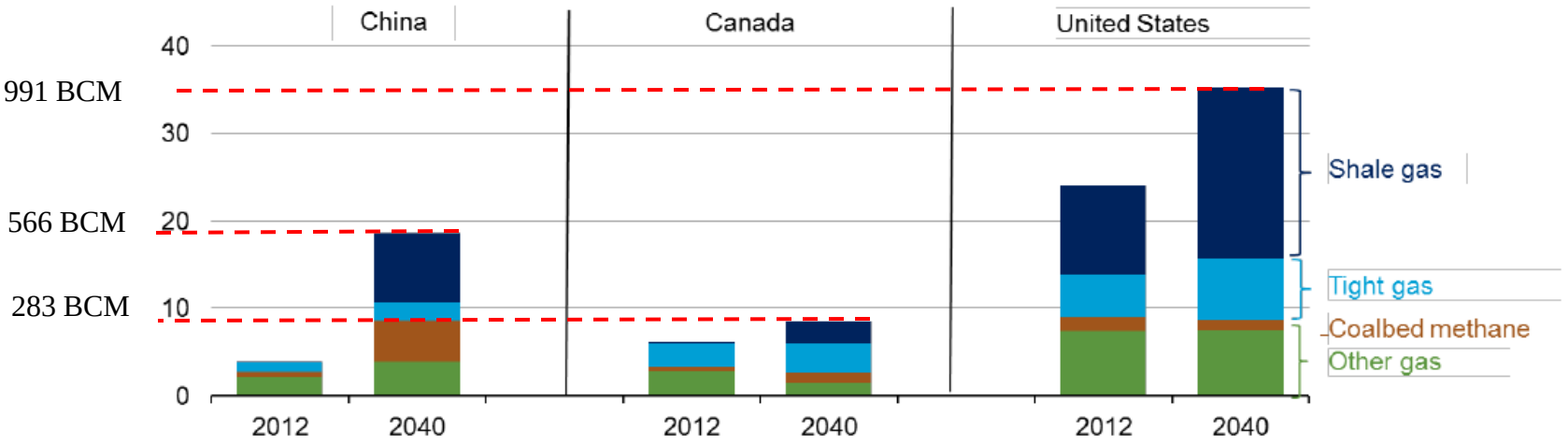
US dollars per million Btu	LNG Japan cif	Natural gas: Average German Import Price*	Natural gas: UK (Heren NBP Index)†	Natural gas: US Henry Hub‡	Natural gas: Canada (Alberta)‡	Crude oil OECD countries cif
1985	5.23	4.25	–	–	–	4.75
1986	4.10	3.93	–	–	–	2.57
1987	3.35	2.55	–	–	–	3.09
1988	3.34	2.22	–	–	–	2.56
1989	3.28	2.00	–	1.70	–	3.01
1990	3.64	2.78	–	1.64	1.05	3.82
1991	3.99	3.23	–	1.49	0.89	3.33
1992	3.62	2.70	–	1.77	0.98	3.19
1993	3.52	2.51	–	2.12	1.69	2.82
1994	3.18	2.35	–	1.92	1.45	2.70
1995	3.46	2.43	–	1.69	0.99	2.96
1996	3.66	2.50	1.87	2.76	1.12	3.54
1997	3.91	2.66	1.96	2.53	1.36	3.29
1998	3.05	2.33	1.96	2.08	1.42	2.16
1999	3.14	1.86	1.58	2.27	2.00	2.98
2000	4.72	2.91	2.71	4.23	3.75	4.83
2001	4.64	3.67	3.17	4.07	3.61	4.08
2002	4.27	3.21	2.37	3.33	2.57	4.17
2003	4.77	4.06	3.33	5.63	4.83	4.89
2004	5.18	4.30	4.46	5.85	5.03	6.27
2005	6.05	5.83	7.38	8.79	7.25	8.74
2006	7.14	7.87	7.87	6.76	5.83	10.66
2007	7.73	7.99	6.01	6.95	6.17	11.95
2008	12.55	11.60	10.79	8.85	7.99	16.76
2009	9.06	8.53	4.85	3.89	3.38	10.41
2010	10.91	8.03	6.56	4.39	3.69	13.47
2011	14.73	10.49	9.04	4.01	3.47	18.56
2012	16.75	10.93	9.46	2.76	2.27	18.82
2013	16.17	10.72	10.64	3.71	2.93	18.25
2014	16.33	9.11	8.25	4.35	3.97	16.80
2015	10.31	6.61	6.53	2.60	2.01	8.77

*Source: 1985-1990 German Federal Statistical Office, 1991-2015 German Federal Office of Economics and Export Control (BAFA).
†Source: ICIS Heren Energy Ltd.
‡Source: Energy Intelligence Group, *Natural Gas Week*.
Note: cif = cost+insurance+freight (average prices).

Shale Gas, Tight Gas and Coalbed Methane

Shale gas, tight gas, and coalbed methane will become increasingly important to gas supplies, not only for the U.S., but also China and Canada

natural gas production by type
trillion cubic feet



	China		Canada		United States	
Production	114 BCM	509 BCM	156 BCM	255 BCM	681 BCM	991 BCM

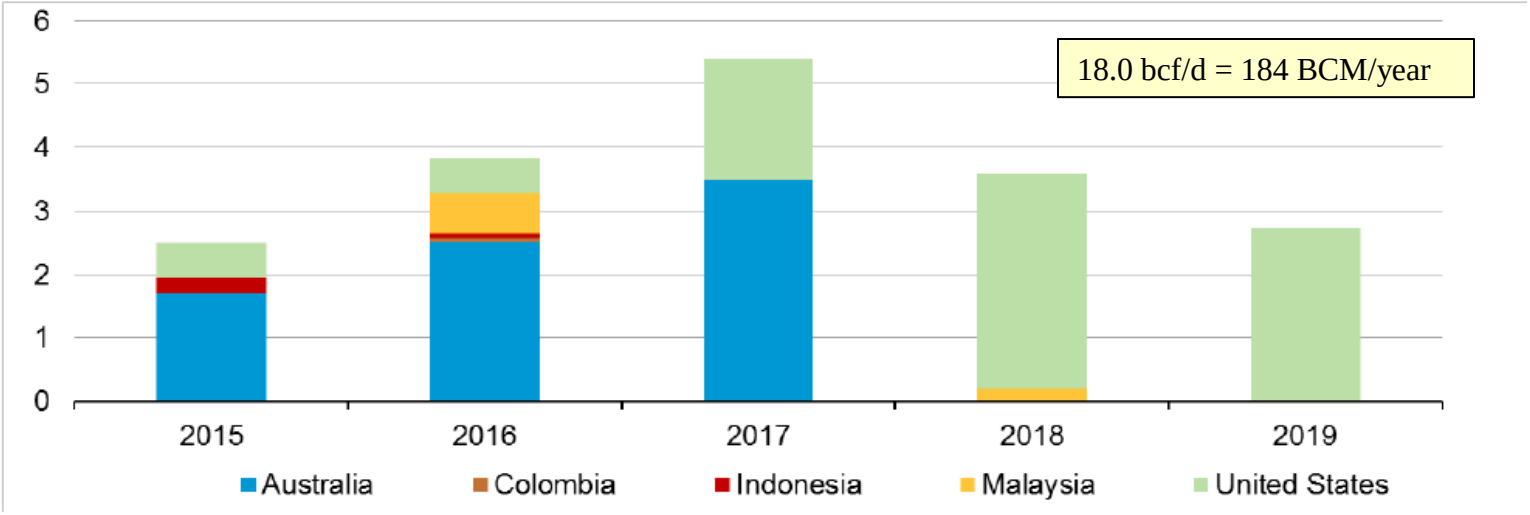
Note: Other natural gas includes natural gas produced from structural and stratigraphic traps (e.g. reservoirs), historically referred to as 'conventional' production.

Source: EIA, International Energy Outlook 2016

LNG Capacity Additions 2015-2019

Liquefaction capacity additions over the 2015-19 time period will increase global capacity by over 30%

LNG capacity additions
billion cubic feet per day



Note: Capacity additions in 2015-19 include projects currently under construction, and represent nameplate capacity, not adjusted for ramp-up
Source: U.S. Energy Information Administration estimates based on trade press

LNG Projected Capacity & Demand

907.87 BCM

430 MMtpy @
456 kg/m3 & 600:1 as a gas
565.78 BCM

250 MMtpy @
456 kg/m3 & 600:1 as a gas
328.94 BCM

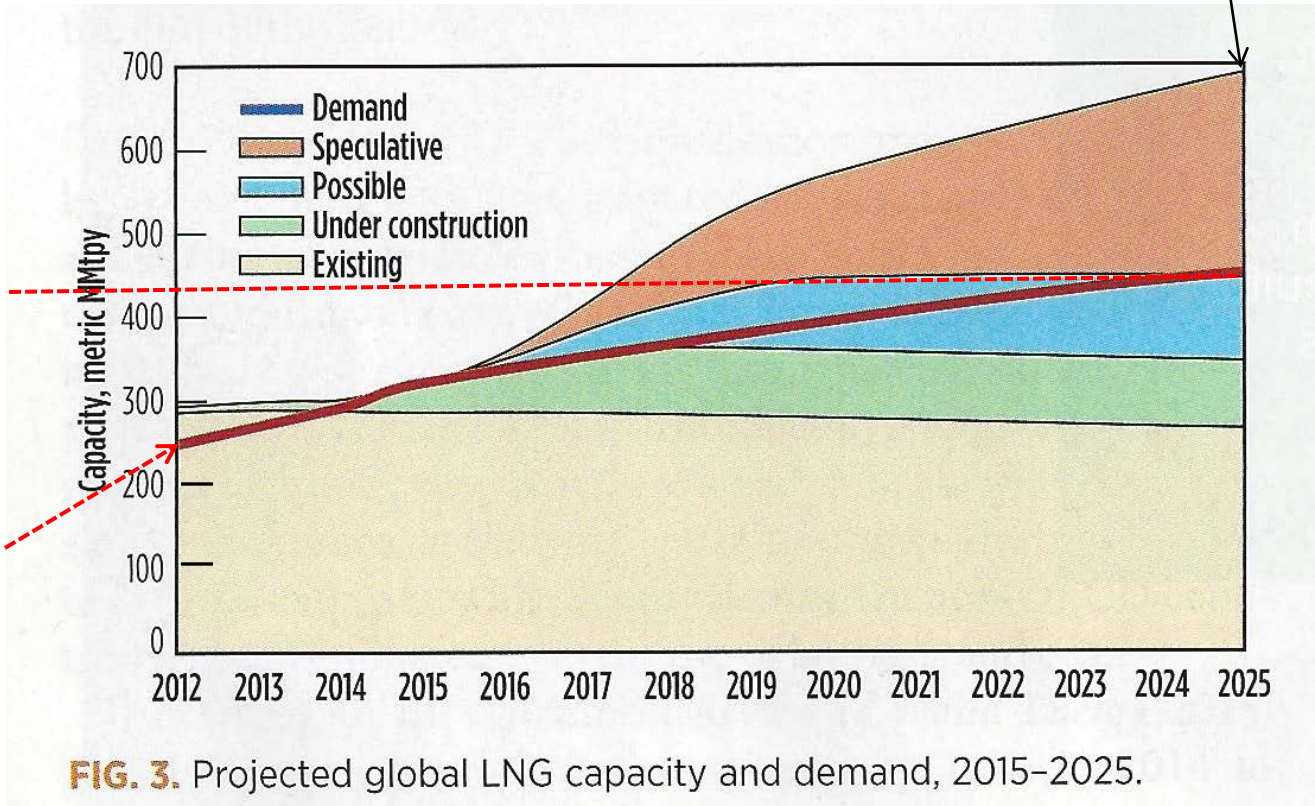


FIG. 3. Projected global LNG capacity and demand, 2015–2025.

Source: Hydrocarbon Processing December 2015

LNG Supply to 2035

807.5 BCM

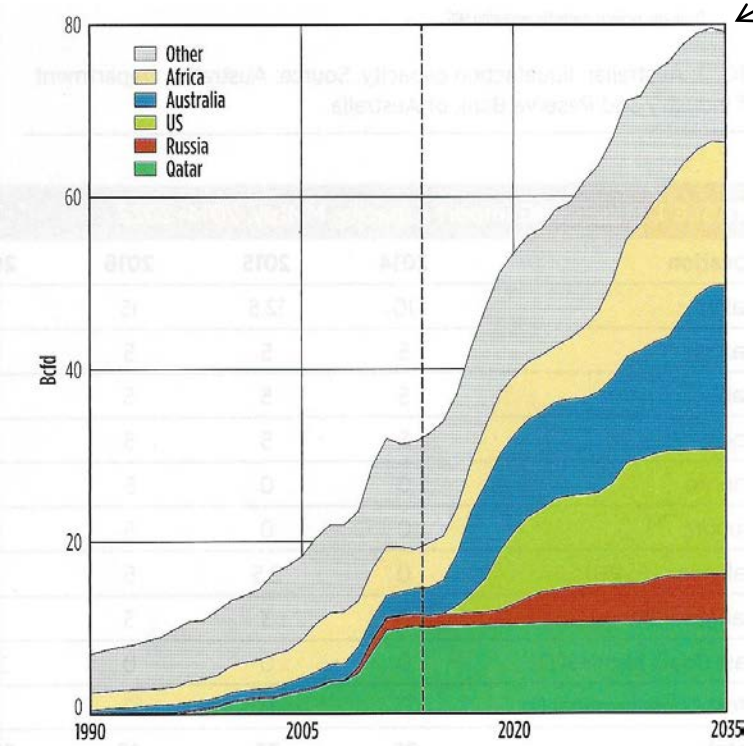


FIG. 1. Global LNG supply to 2035. Source: BP Energy Outlook 2035.

Hydrocarbon Processing | JANUARY 2016

Chile LNG Deal

- Chilean state producer ENAP and Argentine state producer ENARSA have been in negotiations in recent months to seal a deal, after Argentina's new business-friendly President Mauricio Macri indicated he was keen to get fuel flowing between the two.

- Engie declined to give more details on the contract, but a source close to Chilean state producer ENAP said around 1.5 million cubic meters/day of gas will be pumped at a price of $6.90/mmBtu.

- The gas will travel from the port of Mejillones in northern Chile, via Engie-controlled E-CL's pipeline, and across the Atacama desert to Argentina.

- A second contract, beginning on June 1, will see 3 million cubic meters daily pumped from the central port of Quintero, by Endesa, ENAP and distributor Metrogas, at a cost of $7.20/mmBtu.

Natural Gas Trade – 1042.44 BCM

Pipeline trade grew 4.0%
LNG trade grew 1.8%
Consumption grew 3.3%

Gas Trade in 2014 and 2015 in billion cubic metres

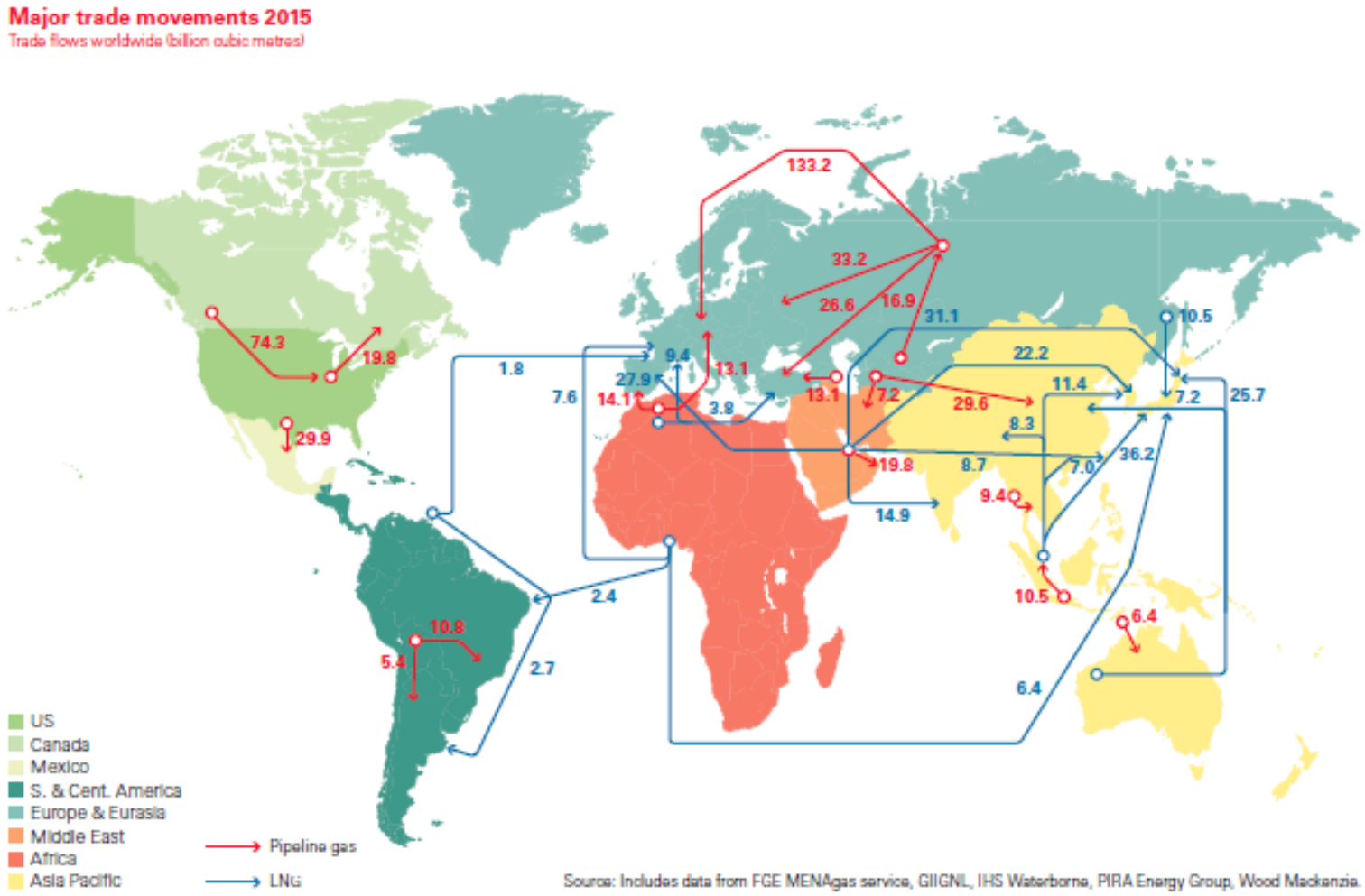
Billion cubic metres	2014				2015				2015 Net		
	Pipeline imports	LNG imports	Pipeline exports	LNG exports	Pipeline imports	LNG imports	Pipeline exports	LNG exports	Pipeline	LNG	Total
US	74.6	1.7	42.4	0.5	74.4	2.6	49.7	0.8	-24.68	-1.76	-26.44
Canada	21.8	0.5	74.6	-	19.8	0.6	74.3	-	54.51	-0.62	53.89
Mexico	20.6	9.4	†	-	29.9	7.1	†	-	-29.83	-7.11	-36.93
Trinidad and Tobago	-	-	-	18.4	-	-	-	17.0	0.00	17.03	17.03
Other S. & Cent. America	18.7	20.9	18.7	5.8	18.5	20.0	18.5	5.0	0.00	-15.01	-15.01
France	28.6	7.2	1.9	0.5	35.9	6.6	1.6	0.4	-34.37	-6.13	-40.50
Germany	88.4	-	20.0	-	104.0	-	29.0	-	-75.03	0.00	-75.03
Italy	46.6	4.6	0.2	-	50.2	6.0	0.2	-	-50.00	-5.96	-55.95
Netherlands	23.2	1.1	46.1	0.6	30.2	2.0	40.6	1.2	10.40	-0.84	9.57
Norway	†	-	102.4	5.3	†	-	109.5	6.0	109.55	5.96	115.51
Spain	17.0	15.5	†	5.1	15.2	13.1	0.5	1.6	-14.74	-11.50	-26.24
Turkey	41.1	7.3	0.6	-	39.7	7.5	0.6	-	-39.12	-7.49	-46.61
United Kingdom	29.4	10.7	10.0	-	29.0	12.8	13.4	0.3	-15.60	-12.56	-28.16
Other Europe	102.4	5.4	8.9	2.1	97.2	7.1	13.1	1.4	-84.03	-5.68	-89.71
Russian Federation	24.2	-	187.7	14.3	16.9	-	193.0	14.5	176.07	14.55	190.61
Ukraine	17.5	-	-	-	16.2	-	-	-	-16.21	0.00	-16.21
Other CIS	30.3	-	69.0	-	29.8	-	64.5	-	34.70	0.00	34.70
Qatar	-	-	20.5	102.9	-	-	19.8	106.4	19.79	106.36	126.15
Other Middle East	27.4	5.4	9.6	27.1	27.3	10.5	8.4	19.8	-18.89	9.26	-9.63
Algeria	-	-	25.4	17.5	-	-	25.0	16.2	24.95	16.19	41.14
Other Africa	8.8	-	10.9	31.9	8.9	3.8	11.1	32.5	2.19	28.71	30.90
China	31.3	26.5	-	-	33.6	26.2	-	-	-33.57	-26.20	-59.77
Japan	-	122.9	-	-	-	118.0	-	-	0.00	-118.04	-118.04
Indonesia	-	-	9.7	21.8	-	-	10.5	21.9	10.47	21.88	32.35
South Korea	-	48.6	-	0.2	-	43.7	-	0.3	0.00	-43.40	-43.40
Other Asia Pacific	25.4	44.6	18.7	78.4	27.6	50.7	21.0	93.0	-6.55	42.37	35.82
Total World	677.1	332.3	677.1	332.3	704.1	338.3	704.1	338.3	0.00	0.00	0.00

Source: Includes data from FGE MENAgas service, GIIGNL, IHS Waterborne, PIRA Energy Group, Wood Mackenzie.

Trade represents approximately 30% of the consumption
Japan represents 1/3rd of LNG Imports

Source: BP Statistical Review of World Energy 2016

Major Natural Gas Trade Movements BCM - 2015



Source: BP Statistical Review of World Energy 2016

Natural Gas - 1

The big picture on natural gas last year is one in which growth in global production remained relatively strong, but demand outside of the power sector was subdued, leading global prices to fall sharply: Henry Hub fell 40% relative to its 2014 average; Japan Korea Marker 46% and NBP 21%. These price falls, which were exacerbated in Asia and Europe by the decline in oil prices, helped to balance the market by allowing gas to gain share in the power sector, the most price-sensitive component of gas demand.

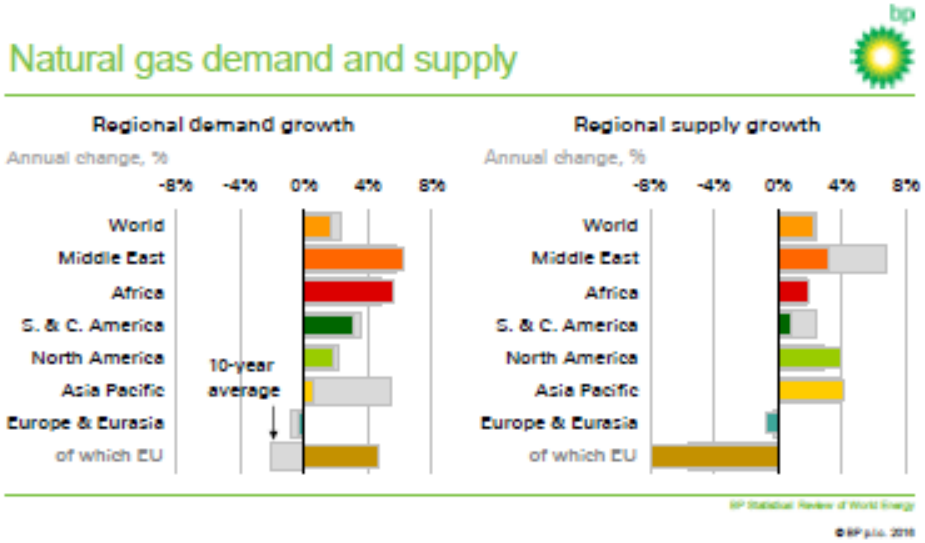
All told, aggregate gas consumption increased by 1.7% (58 Bcm) in 2015, significantly stronger than the weather-induced weakness seen last year (0.6%), although still below its historical average (2.3%).

But as always with natural gas, this broad narrative disguises considerable variation across different countries and regions.

On the demand side, the key source of weakness was Asia, where growth in gas consumption slowed to just 0.5% (3 Bcm). The big drag was China, where growth fell to below 5% in 2015, down from double-digit growth seen over much of the past 10 years, reflecting both the general slowdown in China's energy demand and increasing competition from alternative fuels. In the US, the mild winter and weak industrial production meant gas demand outside of the power sector fell last year. In contrast, gas consumption in the EU (16 Bcm, 4.6%) bounced back from the depressing effects of the exceptionally mild winter in 2014. And the Middle East also recorded strong growth (26 Bcm, 6.2%), as new sources of production came on stream.

On the supply side, the US remained the global powerhouse, with output growing by over 5% (39 Bcm) in 2015, accounting for more than half of the increase in world production. All of this increase was driven by US shale gas; conventional US gas production fell. In addition to the US and the Middle East, there were also notable supply increases in Norway (7.7%, 8 Bcm), China (4.8%, 6 Bcm) and Australia (9.4%, 6 Bcm).

Standing back from the detail of the country-specific movements, three general features of last year's gas market struck me as particularly interesting.



Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

Natural Gas - 2

First, natural gas gained significant share from coal within several major power markets around the world. These gains were most striking in the US, where the increasing price competitiveness of gas relative to coal allowed gas by the middle of last year to overtake coal as the dominant source of energy in the US power sector.

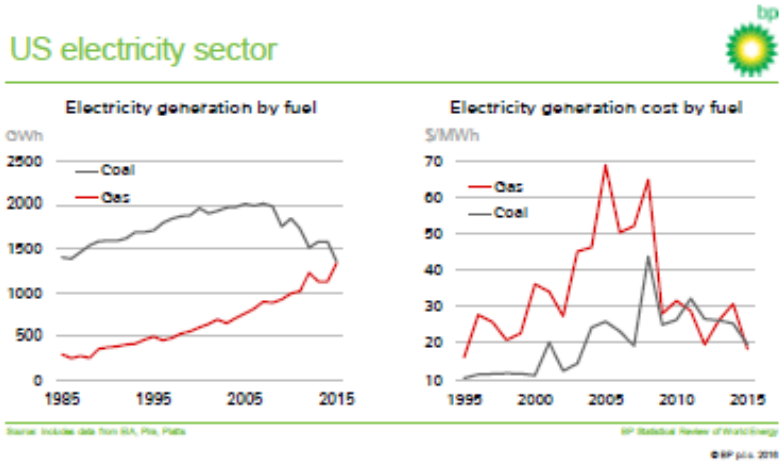
The second interesting feature was the changing trade pattern of global LNG.

LNG supplies rose by around 6 Bcm in 2015, with increases in Australia, Papua New Guinea and Qatar more than offsetting the disruptions to Yemeni supplies. The deceleration in China's gas consumption, combined with falls in South Korea (5 Bcm) and Japan (5 Bcm), meant that after being the primary growth market for LNG over the past 5 years or so, Asian LNG demand fell in 2015. As a result, LNG flows were diverted west, with increased LNG imports to both Middle East and North Africa (MENA); and Europe.

This shift in the pattern of trade flows went hand-in-hand with a sharp narrowing in price differentials, with the Asian premium over European gas prices virtually disappearing.

The key takeaway here is that, as global LNG supplies grow in importance and, as a consequence, global gas trade becomes increasingly price sensitive; the impact of shocks or disturbances in one part of the world, in this case weak Asian demand, will be increasingly transmitted to other parts of the globe.

We are moving towards a globally integrated gas market.



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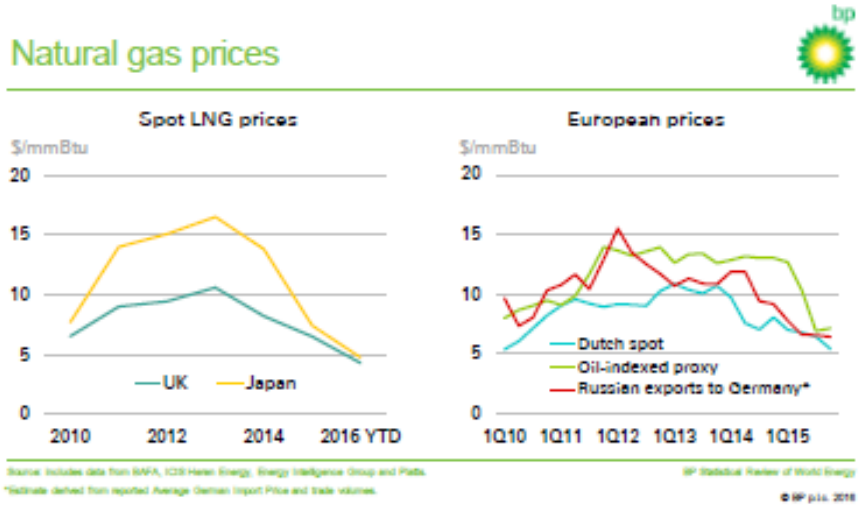
Natural Gas - 3

The final feature I want to highlight stems from this greater abundance of LNG flowing into Europe and the corresponding fall in European gas prices. In particular, to consider how Russian exporters responded to this increased competition.

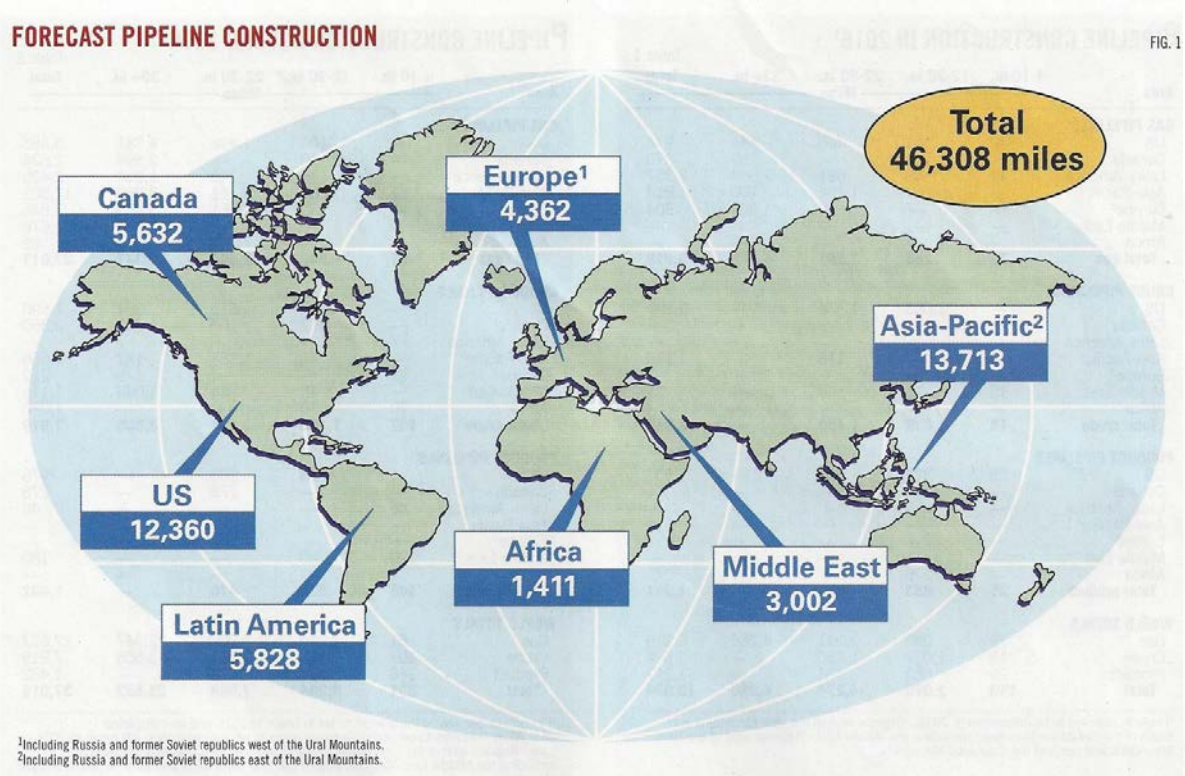
Given that much of Russia's gas exports to Europe are indexed to oil, one option would have been to maintain that link, although the flexibility built into those contracts means that might have resulted in some loss of demand. The alternative would have been for Russia to compete on price in order to maintain their market share.

Unfortunately, since rebates and discounts are granted on a contract specific basis it is not possible to observe Russian gas prices directly. But to get some idea, it is possible to back out a proxy for Russian export prices to Germany by using data on Average German Import Prices (AGIP) and the composition of those imports. Although this proxy is somewhat crude – and so I don't want to claim too much for it – it does suggest that Russian export prices to Europe fell more quickly last year than a simple link to oil prices would have implied, and have remained close to European spot prices.

As I mentioned earlier – and as we have seen with OPEC's response in the oil market – the option of giving up market share in order to support prices is less attractive if the source of the price weakness, in this case increased supplies of LNG, is expected to persist.



Pipeline Construction



Following is a breakdown of projected costs, using these assumptions and OGJ pipeline-cost data:

- Total onshore construction (10,033 miles) for 2016 only will cost roughly $52.5 billion:
  - —$561 million for 4-10 in.
  - —$9.5 billion for 12-20 in.
  - —$20.1 billion for 22-30 in.
  - —$22.3 billion for 32 in. and larger.
- Total offshore construction (641 miles) for 2016 only will cost nearly $4.9 billion:
  - —$91 million for 4-10 in.
  - —$1.5 billion for 12-20 in.
  - —$3.3 billion for 22-30 in.
- Total onshore construction (35,972 miles) for beyond 2016 will cost more than $188 billion:
  - —$1.6 billion for 4-10 in.
  - —$15.4 billion for 12-20 in.
  - —$36 billion for 22-30 in.
  - —$135 billion for 32 in. and larger.
- Total offshore construction (1,116 miles) for beyond 2016 will cost more than $8.5 billion:
  - —$252 million for 4-10 in.
  - —$2.5 billion for 12-20 in.
  - —$5.8 billion for 22-30 in.

Natural Gas Reserves to Production Ratio – 2015

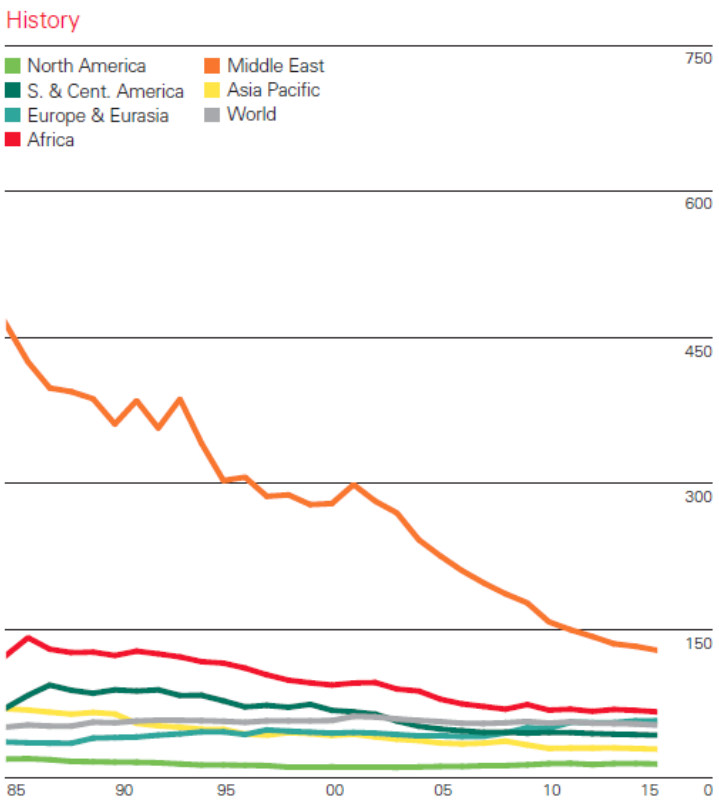
Natural gas
Total proved reserves

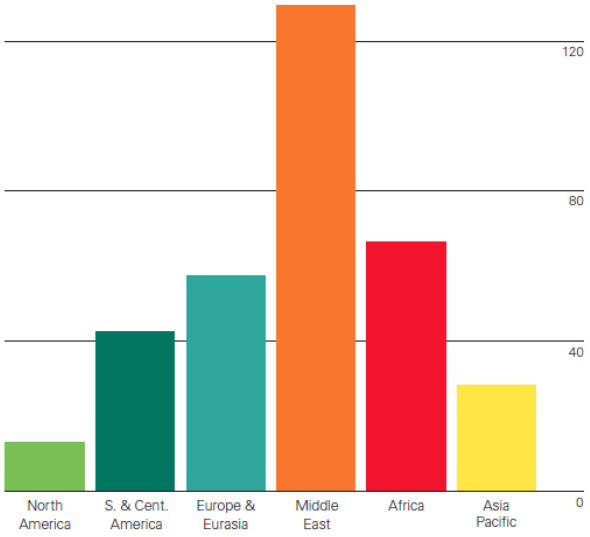
	at end 1995 Trillion cubic metres	at end 2005 Trillion cubic metres	at end 2014 Trillion cubic metres	at end 2015 Trillion cubic metres	Trillion cubic feet	Share of total	R/P ratio
US	4.7	5.8	10.4	**10.4**	**368.7**	5.6%	13.6
Canada	1.9	1.6	2.0	**2.0**	**70.2**	1.1%	12.2
Total North America	**8.5**	**7.8**	**12.8**	**12.8**	**450.3**	**6.8%**	**13.0**
Venezuela	4.1	4.3	5.6	**5.6**	**198.4**	3.0%	173.2
Total S. & Cent. America	**5.9**	**6.9**	**7.6**	**7.6**	**268.1**	**4.1%**	**42.5**
Russian Federation	31.1	31.2	32.4	**32.3**	**1139.6**	17.3%	56.3
Turkmenistan	n/a	2.3	17.5	**17.5**	**617.3**	9.4%	241.4
Total Europe & Eurasia	**40.2**	**43.0**	**57.0**	**56.8**	**2005.1**	**30.4%**	**57.4**
Iran	19.4	27.6	34.0	**34.0**	**1201.4**	18.2%	176.8
Iraq	3.4	3.2	3.7	**3.7**	**130.5**	2.0%	*
Qatar	8.5	25.6	24.5	**24.5**	**866.2**	13.1%	135.2
Saudi Arabia	5.5	6.8	8.3	**8.3**	**294.0**	4.5%	78.2
United Arab Emirates	5.9	6.1	6.1	**6.1**	**215.1**	3.3%	109.2
Total Middle East	**45.3**	**72.6**	**80.1**	**80.0**	**2826.6**	**42.8%**	**129.5**
Algeria	3.7	4.5	4.5	**4.5**	**159.1**	2.4%	54.3
Nigeria	3.5	5.2	5.1	**5.1**	**180.5**	2.7%	102.1
Total Africa	**9.9**	**14.1**	**14.1**	**14.1**	**496.7**	**7.5%**	**66.4**
Australia	1.2	2.2	3.5	**3.5**	**122.6**	1.9%	51.8
China	1.7	1.6	3.7	**3.8**	**135.7**	2.1%	27.8
India	0.7	1.1	1.4	**1.5**	**52.6**	0.8%	50.9
Indonesia	2.0	2.5	2.8	**2.8**	**100.3**	1.5%	37.8
Total Asia Pacific	**10.1**	**13.0**	**15.4**	**15.6**	**552.6**	**8.4%**	**28.1**
Total World	**119.9**	**157.3**	**187.0**	**186.9**	**6599.4**	**100.0%**	**52.8**

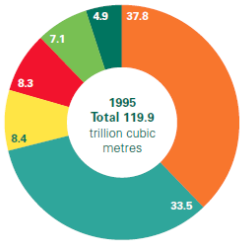
Source: BP Statistical Review of World Energy 2016

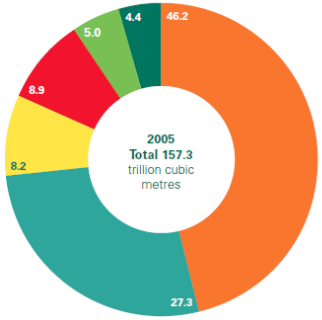
Natural Gas Reserves to Production Ratio

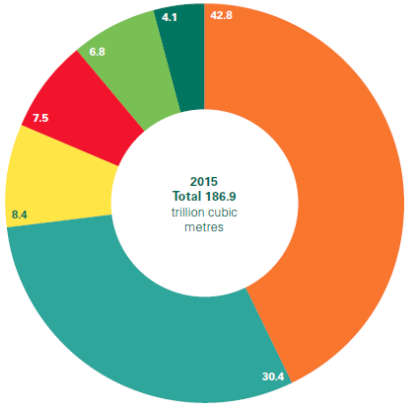
As was the case for oil, global proved natural gas reserves in 2015 fell slightly, (by 0.1 trillion cubic metres (tcm), or -0.1%) to 186.9 tcm, sufficient to meet 52.8 years of current production. Small declines in Russian and Norwegian reserves drove the decline. Reserves have increased by 29.6 tcm over the past decade. The Middle East region holds the largest proved reserves (80 tcm, 42.8% of the global total), and has the highest regional R/P ratio (129.5 years). Lags in reporting official data mean that 2015 figures for many countries are not yet available.











"Practical Strategies for Emerging Energy Technologies"

Source: BP Statistical Review of World Energy 2016

Coal

Coal Consumption – 3839.9 Mtoe

- Coal consumption declined by 1.8% in 2015
- India grew by 10.6%
- China declined by 1.5%
- Asia represents 72.9% of 2015

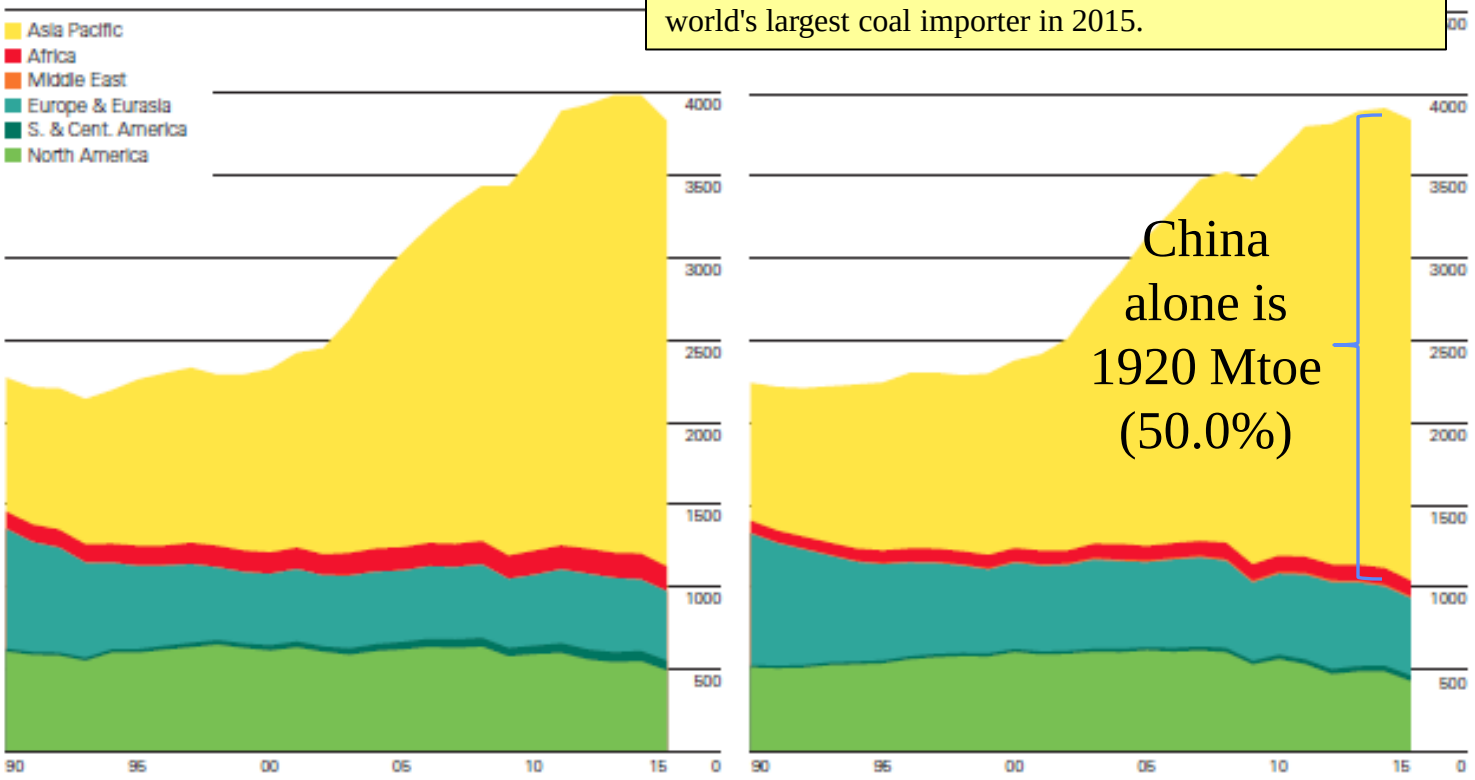
Coal: Consumption*

Million tonnes oil equivalent	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	Change 2015 over 2014	2015 share of total
US	574.5	565.7	573.3	564.2	496.2	525.0	495.4	437.9	454.6	453.8	**396.3**	-12.7%	10.3%
Total North America	**616.9**	**608.1**	**615.8**	**604.5**	**530.7**	**563.0**	**532.3**	**472.0**	**488.1**	**487.9**	**429.0**	**-12.1%**	**11.2%**
Total S. & Cent. America	**21.0**	**24.5**	**25.7**	**28.6**	**23.7**	**28.7**	**30.6**	**32.1**	**34.8**	**36.7**	**37.1**	**1.2%**	**1.0%**
Czech Republic	20.2	21.0	21.4	19.7	17.6	18.4	18.1	17.2	16.4	15.9	**15.6**	-2.0%	0.4%
Germany	81.3	84.5	86.7	80.1	71.7	77.1	78.3	80.5	82.8	78.8	**78.3**	-0.6%	2.0%
Kazakhstan	26.9	28.3	31.1	33.8	30.9	33.4	36.3	36.5	36.3	35.5	**32.6**	-8.3%	0.8%
Poland	55.1	57.4	55.9	55.2	51.8	55.1	55.0	51.2	53.4	49.4	**49.8**	0.7%	1.3%
Russian Federation	94.6	97.0	93.9	100.7	92.2	90.5	94.0	98.4	90.5	87.6	**88.7**	1.3%	2.3%
Spain	20.5	17.9	20.0	13.5	9.4	6.9	12.8	15.5	11.4	11.6	**14.4**	23.9%	0.4%
Turkey	22.5	26.6	29.5	29.6	30.9	31.4	33.9	36.5	31.6	36.1	**34.4**	-4.7%	0.9%
Ukraine	37.5	39.8	39.8	41.8	35.9	38.3	41.5	42.5	41.6	35.6	**29.2**	-18.0%	0.8%
United Kingdom	37.4	40.9	38.4	35.6	29.8	30.9	31.4	39.0	37.1	29.9	**23.4**	-21.6%	0.6%
Other Europe & Eurasia	20.7	21.2	21.8	22.4	21.4	22.5	24.6	22.9	23.8	22.0	**23.4**	6.3%	0.6%
Total Europe & Eurasia	**514.9**	**536.3**	**540.2**	**528.0**	**475.4**	**491.6**	**514.1**	**527.4**	**507.2**	**481.0**	**467.9**	**-2.7%**	**12.2%**
Total Middle East	**9.8**	**9.8**	**9.9**	**9.7**	**9.9**	**10.1**	**11.1**	**12.3**	**10.8**	**10.7**	**10.5**	**-1.7%**	**0.3%**
South Africa	80.1	81.5	83.6	93.3	93.8	92.8	90.4	88.3	88.9	90.1	**85.0**	-5.6%	2.2%
Total Africa	**89.4**	**90.6**	**92.0**	**101.4**	**100.8**	**100.4**	**98.5**	**95.8**	**97.8**	**102.4**	**96.9**	**-5.4%**	**2.5%**
Australia	53.9	56.6	54.9	55.4	53.4	50.6	50.2	47.3	45.0	44.7	**46.6**	4.3%	1.2%
China	1318.2	1448.4	1576.9	1603.1	1680.4	1743.4	1899.0	1923.0	1964.4	1949.3	**1920.4**	-1.5%	50.0%
India	211.3	219.4	240.1	259.4	282.8	292.9	300.4	330.0	355.6	388.7	**407.2**	4.8%	10.6%
Indonesia	24.4	28.9	36.2	31.5	33.2	39.5	46.9	53.0	57.6	69.8	**80.3**	15.0%	2.1%
Japan	114.0	112.3	117.7	120.3	101.6	115.7	109.6	115.8	120.7	118.7	**119.4**	0.6%	3.1%
Malaysia	6.9	7.3	8.8	9.8	10.6	14.8	14.8	15.9	15.1	15.4	**17.6**	14.8%	0.5%
South Korea	54.8	54.8	59.7	66.1	68.6	75.9	83.6	81.0	81.9	84.6	**84.5**	-0.2%	2.2%
Taiw an	35.3	37.0	38.8	37.0	35.2	37.6	38.9	38.0	38.6	39.0	**37.8**	-3.1%	1.0%
Thailand	11.6	12.4	13.9	15.1	15.1	15.5	15.8	16.4	15.8	17.9	**17.6**	-1.8%	0.5%
Vietnam	9.0	5.3	5.8	11.4	10.7	14.0	16.5	15.0	15.8	19.3	**22.2**	15.4%	0.6%
Total Asia Pacific	**1878.6**	**2022.9**	**2192.3**	**2251.7**	**2333.2**	**2440.4**	**2613.5**	**2674.8**	**2752.0**	**2792.5**	**2798.5**	**0.2%**	**72.9%**
Total World	**3130.6**	**3292.2**	**3476.0**	**3523.9**	**3473.6**	**3634.3**	**3800.0**	**3814.4**	**3890.7**	**3911.2**	**3839.9**	**-1.8%**	**100.0%**

Source: BP Statistical Review of World Energy 2016

Coal - Regional Consumption - Mtoe

China gets most of its coal from Indonesia and Australia. The tighter regulations on coal consumption and imports could mean India may be able to surpass China as the world's largest coal importer in 2015.



World production and consumption of coal declined in 2015, by 4% and 1.8%, respectively. Production fell for the first time since 1998, with large declines in Asia Pacific (-2.9%) and North America (-10.3%). China remained by far the world's largest producer even though output fell by 2%. Coal consumption declined in all regions except South & Central America and Asia Pacific. The US and China accounted for all of the net decline in global consumption.

Source: BP Statistical Review of World Energy 2015

Coal Production – 3830.1 Mtoe

Coal: Production*

Million tonnes oil equivalent	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	Change 2015 over 2014	2015 share of total
US	580.2	595.1	587.7	596.7	540.8	551.2	556.1	517.8	500.9	508.0	**455.2**	-10.4%	11.9%
Total North America	**621.6**	**636.7**	**630.7**	**639.2**	**580.0**	**594.0**	**600.9**	**561.1**	**544.6**	**551.1**	**494.3**	**-10.3%**	**12.9%**
Colombia	38.8	43.0	45.4	47.8	47.3	48.3	55.8	58.0	55.6	57.6	**55.6**	-3.4%	1.5%
Total S. & Cent. America	**47.2**	**51.2**	**53.4**	**54.8**	**52.4**	**52.9**	**60.5**	**62.7**	**61.9**	**64.0**	**61.3**	**-4.1%**	**1.6%**
Germany	56.6	53.3	54.4	50.1	46.4	45.9	46.7	47.8	45.1	44.1	**42.9**	-2.7%	1.1%
Kazakhstan	37.3	41.4	42.2	47.9	43.4	47.5	49.8	51.6	51.4	48.9	**45.8**	-6.3%	1.2%
Poland	69.4	68.0	62.5	60.9	56.4	55.4	55.7	57.8	57.2	54.0	**53.7**	-0.6%	1.4%
Russian Federation	135.6	141.0	143.5	149.0	141.7	151.0	157.6	168.3	173.1	176.6	**184.5**	4.5%	4.8%
Total Europe & Eurasia	**432.7**	**440.4**	**438.8**	**444.8**	**418.8**	**429.2**	**446.8**	**459.0**	**450.9**	**433.1**	**419.8**	**-3.1%**	**11.0%**
Total Middle East	**1.0**	**1.0**	**1.1**	**1.0**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**-**	**♦**
South Africa	138.4	138.3	138.4	141.0	139.7	144.1	143.2	146.6	145.4	148.2	**142.9**	-3.6%	3.7%
Total Africa	**141.5**	**140.7**	**140.5**	**142.8**	**141.6**	**146.8**	**146.1**	**152.1**	**152.8**	**157.8**	**151.4**	**-4.0%**	**4.0%**
Australia	206.5	211.6	217.9	224.9	232.6	240.5	233.4	250.4	268.2	287.3	**275.0**	-4.3%	7.2%
China	1241.7	1328.4	1439.3	1491.8	1537.9	1665.3	1851.7	1873.5	1894.6	1864.2	**1827.0**	-2.0%	47.7%
India	189.9	198.2	210.3	227.5	246.0	252.4	250.8	255.0	255.7	271.0	**283.9**	4.7%	7.4%
Indonesia	93.9	119.2	133.4	147.8	157.6	169.2	217.3	237.3	276.2	281.7	**241.1**	-14.4%	6.3%
Total Asia Pacific	**1789.5**	**1918.5**	**2062.2**	**2153.4**	**2241.8**	**2404.0**	**2636.4**	**2694.6**	**2775.5**	**2782.2**	**2702.6**	**-2.9%**	**70.6%**
Total World	**3033.6**	**3188.5**	**3326.7**	**3436.0**	**3435.3**	**3627.6**	**3891.4**	**3930.2**	**3986.5**	**3988.9**	**3830.1**	**-4.0%**	**100.0%**

Calorific equivalents
One tonne of oil equivalent equals approximately:
Solid fuels 1.5 tonnes of hard coal
3 tonnes of lignite

Production is ~70% bituminous/30% Lignite

Source: BP Statistical Review of World Energy 2016

Coal Market

The main manifestation of the technological wave driving energy supplies was the shift in the fuel mix in the US power sector that I just mentioned: the strong growth in US shale gas forced down US gas prices, causing gas to displace coal in the power sector. The switch, which was reinforced by tightening environmental policies, caused US coal consumption to fall sharply (-57 Mtoe, -12.7%).

In contrast to 2012 – the last time US coal consumption fell sharply – the general abundance of global coal supplies last year meant the surplus domestic US coal could not easily be exported to other parts of the world. Instead, US coal production also fell markedly (-53 Mtoe, -10.4%).

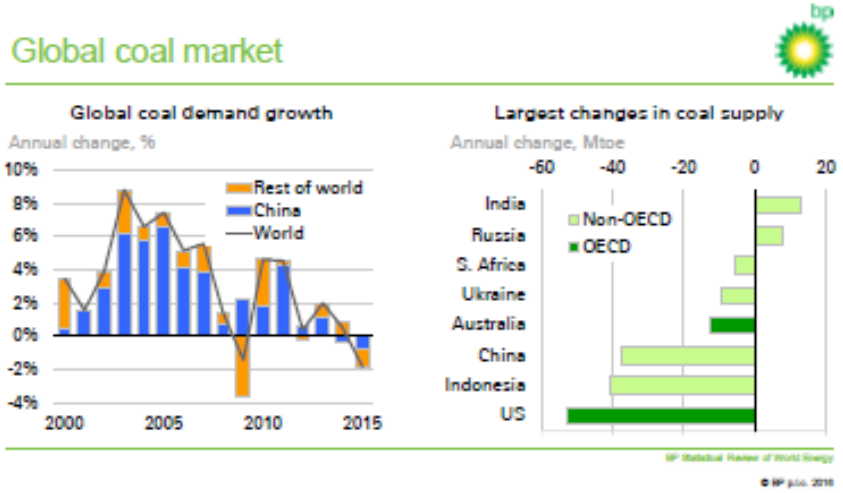
The process of transition underway in energy demand was seen most starkly in China. As China's period of rapid industrialization has come to an end, its demand for coal has slowed sharply.

Indeed, China's coal consumption fell for the second consecutive year in 2015 (-29 Mtoe, -1.5%), as Chinese industrial production braked more sharply than the rest of the economy and coal also lost out to increasing competition in the power sector.

Chinese coal production fell by a broadly similar amount (-37 Mtoe, -2.0%); Indonesian production also fell sharply (-41 Mtoe, -14.4%) as its key export market contracted.

The two trillion tonne question – or, more accurately, the two trillion tonnes of oil equivalent question – is whether we have now seen the peak in Chinese coal consumption?

There are clearly powerful structural factors pushing in this direction: most notably the shifting pattern of Chinese growth towards slower, more service-orientated growth; and the clear determination to switch to cleaner, lower-carbon fuels. But the falls in coal consumption last year were compounded by a sharp slowing in some of China's most energy-intensive – and coal-intensive sectors: output in Iron, steel and cement all fell in



absolute terms last year. It would be very surprising if there wasn't a strong cyclical element to these movements.

The net impact of these opposing forces is to my mind unclear.

The main source of strength for coal was developing Asia (ex China). India led the way, with both consumption (19 Mtoe, 4.8%) and production (13 Mtoe, 4.7%) growing solidly. As a result, India surpassed the US as the world's second largest coal consumer.

Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

Coal Company Bankruptcies

Largest mines owned by companies recently in bankruptcy

Mine name*	Ultimate owner	Coal produced (tons) 2015	Q4'14	Q4'15
North Antelope Rochelle	Peabody Energy Corp.	109,343,913	30,671,497	28,153,722
Black Thunder	Arch Coal Inc.	99,450,689	26,506,223	22,502,481
Eagle Butte	Alpha Natural Resources Inc.	19,649,723	5,210,041	4,873,247
Belle Ayr	Alpha Natural Resources Inc.	18,318,629	4,625,701	3,775,390
Rawhide	Peabody Energy Corp.	15,167,996	3,959,328	3,784,091
Caballo	Peabody Energy Corp.	11,402,062	2,239,334	2,794,723
Bear Run	Peabody Energy Corp.	7,878,025	2,145,839	1,739,479
Coal Creek	Arch Coal Inc.	7,840,491	2,412,109	2,200,692
Cumberland	Alpha Natural Resources Inc.	7,490,061	2,008,118	2,086,848
El Segundo	Peabody Energy Corp.	7,476,237	2,173,207	1,866,494
Kayenta	Peabody Energy Corp.	6,804,555	2,071,901	1,375,829
Lively Grove	Multi-owned1	5,953,533	1,187,294	1,281,696
West Elk	Arch Coal Inc.	5,074,821	1,668,373	854,076
Foidel Creek	Peabody Energy Corp.	4,122,448	1,200,546	1,186,340
Leer	Arch Coal Inc.	3,383,885	898,667	655,893
Prairie Eagle - Underground	Arch Coal Inc.; CBR Investments LLC	3,353,038	879,050	769,690
No. 7	Walter Energy	3,035,681	1,110,442	362,666
Francisco Underground Pit	Peabody Energy Corp.	2,935,577	810,675	704,954
No. 4	Walter Energy	2,416,556	720,849	316,649
Coal-Mac Inc. Holden No. 22 Surface	Arch Coal Inc.	2,259,286	628,888	504,244
Viper	Arch Coal Inc.	2,155,473	467,453	491,455
Somerville Central	Peabody Energy Corp.	2,143,884	470,800	490,245
Wild Boar	Peabody Energy Corp.	2,041,888	544,416	509,813
Wildcat Hills - Underground	Peabody Energy Corp.	2,026,081	538,322	447,865
Mountaineer II	Arch Coal Inc.	1,923,968	560,493	373,767

As of March 1, 2016.
Includes coal production for bankrupt coal companies as operator, owner and ultimate owner of mines that have filed bankruptcy since 2012.
* Mines in bankruptcy are defined as mines owned by companies in bankruptcy since 2012 as tracked by S&P Global Market Intelligence compared to ownership and production data from the U.S. Mine Safety and Health Administration as of the end of the fourth quarter of 2015. Some mines may have since been transferred to solvent companies and some companies may have since emerged from bankruptcy.
1 Peabody Energy Corp.; Northern Illinois Municipal; Kentucky Muni Power Agency; Southern Illinois Power Coop; Prairie Power Inc.; MJMEUC; Indiana Municipal Power Agency; Illinois Municipal Elec Agency; American Mun Power Inc.
Source: S&P Global Market Intelligence

Source: SNL April 13, 2016

- 44.3% of the coal produced in the U.S. came from a company that has filed for bankruptcy court protection since 2012.
- More than 69% of the coal produced in the Powder River Basin came from coal companies recently filing bankruptcy.
- Three of every four tons mined in Wyoming came from a coal company on the bankruptcy list.
- 28.9% of coal from the Illinois Basin comes from a coal company recently filing for bankruptcy court protections.

Q4'15 coal production by major coal basins

Coal basin	Coal produced (tons) Total	From mines of companies recently in bankruptcy*	% production from companies recently in bankruptcy*
Powder River Basin	98,013,293	68,084,346	69.46
Illinois Basin	26,410,510	7,628,394	28.88
Northern Appalachia	27,356,159	3,772,808	13.79
Central Appalachia	18,699,925	6,364,752	34.04
Entire U.S.	207,355,826	91,946,261	44.34

As of March 1, 2016.
Includes coal production for bankrupt coal companies as operator, owner and ultimate owner of mines that have filed bankruptcy since 2012.
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Source: S&P Global Market Intelligence

Coal Reserves to Production Ratio - 2015

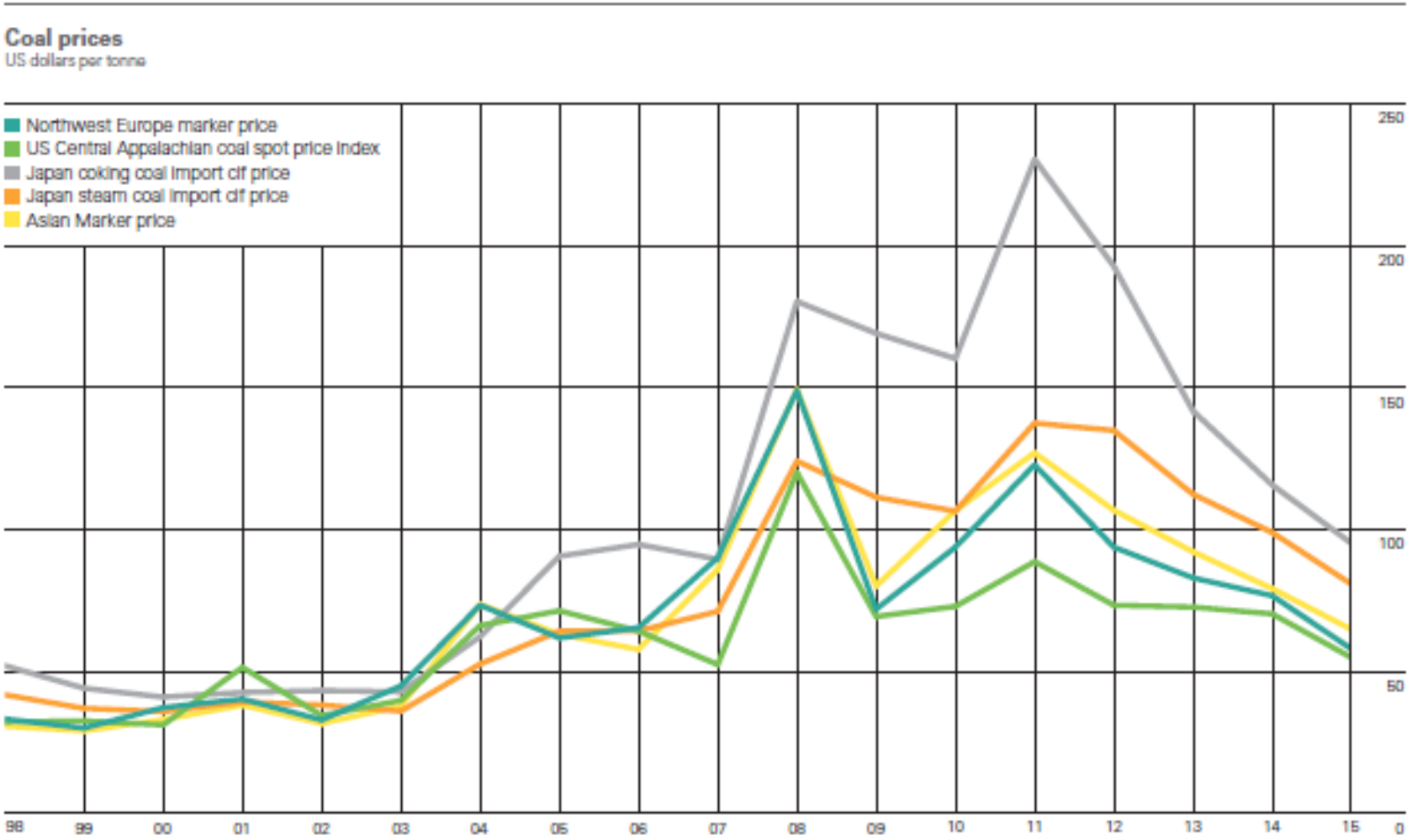
Coal:
Total proved reserves at end 2015

Million tonnes	Anthracite and bituminous	Sub-bituminous and lignite	Total	Share of Total	R/P ratio
US	108501	128794	**237295**	26.6%	292
Total North America	**112835**	**132253**	**245088**	**27.5%**	276
Colombia	6746	-	**6746**	0.8%	79
Total S. & Cent. America	**7282**	**7359**	**14641**	**1.6%**	150
Germany	48	40500	**40548**	4.5%	220
Kazakhstan	21500	12100	**33600**	3.8%	316
Poland	4178	1287	**5465**	0.6%	40
Russian Federation	49088	107922	**157010**	17.6%	422
Total Europe & Eurasia	**92557**	**217981**	**310538**	**34.8%**	273
South Africa	30156	-	**30156**	3.4%	120
Total Middle East & Africa	**32722**	**214**	**32936**	**3.7%**	123
Australia	37100	39300	**76400**	8.6%	158
China	62200	52300	**114500**	12.8%	31
India	56100	4500	**60600**	6.8%	89
Indonesia	-	28017	**28017**	3.1%	71
Total Asia Pacific	**157803**	**130525**	**288328**	**32.3%**	53
Total World	**403199**	**488332**	**891531**	**100.0%**	**114**

There's a lot of it except in China!

Source: BP Statistical Review of World Energy 2016

Coal Prices


Coal prices
US dollars per tonne
Northwest Europe marker price
US Central Appalachian coal spot price index
Japan coking coal import cif price
Japan steam coal import cif price
Asian Marker price
250
200
150
100
50
0
98
99
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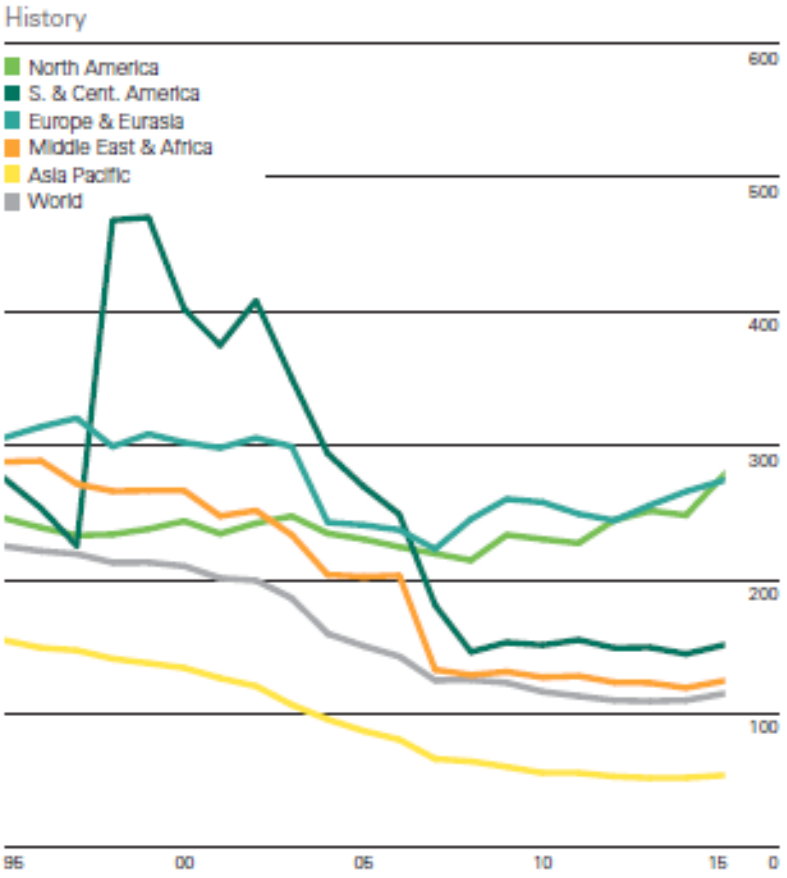
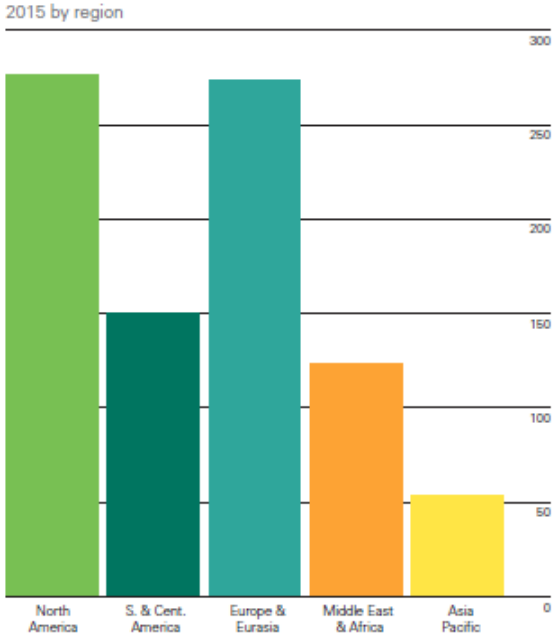
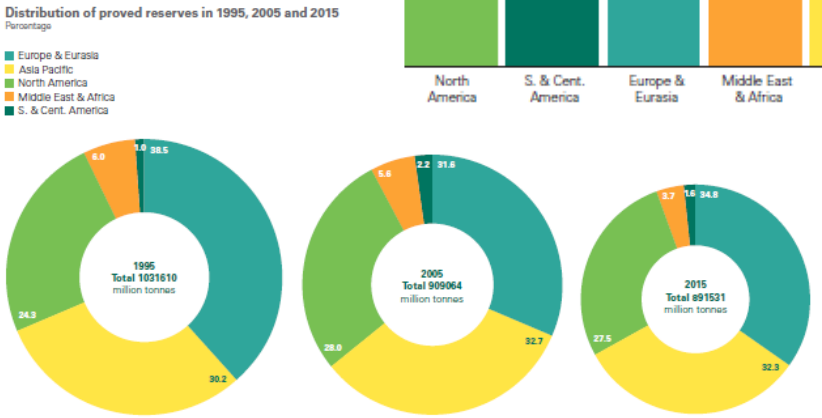
15

Coal Reserves to Production Ratio - 2015

World proved coal reserves in 2015 were sufficient to meet 114 years of global production, by far the largest R/P ratio for any fossil fuel. By region, Europe & Eurasia holds the largest proved reserves while North America has the highest R/P ratio – 276 years. The Asia Pacific region holds the second-largest reserves, but higher rates of production – accounting for 70.6% of global output – leave it with the lowest regional R/P ratio (53 years).







Source: World Energy Resources 2013 Survey, World Energy Council.

Source: BP Statistical Review of World Energy 2016

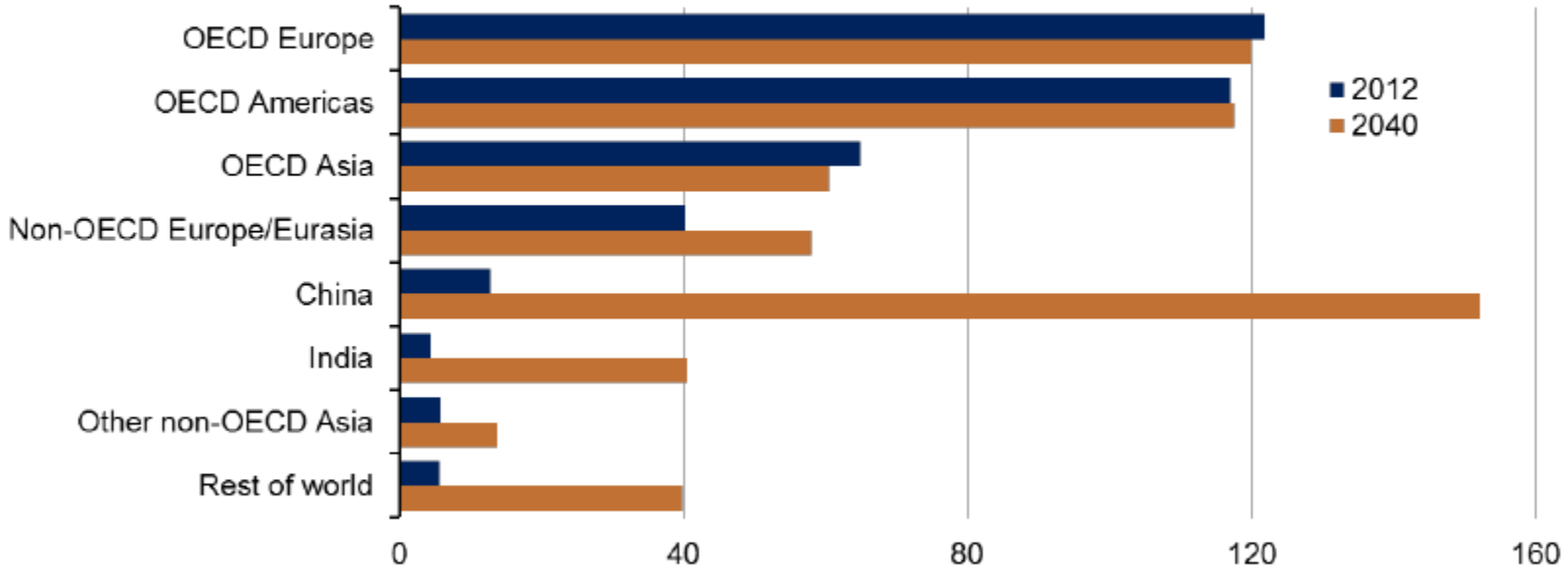
Nuclear

Nuclear Power Growth

Virtually all of the growth in nuclear power will occur in the non-OECD regions; China accounts for 61% of world nuclear capacity growth

world installed nuclear capacity by region

gigawatts



Source: EIA, International Energy Outlook 2016

Renewables

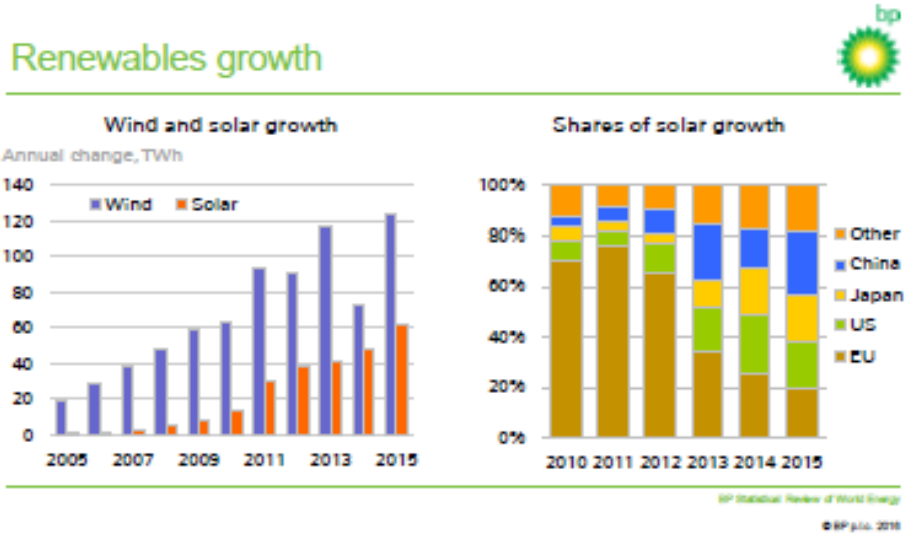
Renewables

Non-fossil fuels grew by 3.6% in 2015, up slightly on their average over the past 10 years.

As I stressed at the outset, renewable energy in the power sector further reinforced its reputation as the Next Big Thing: growing by over 15% (213 TWh) in 2015, supported by improving technology and falling costs. Although the share of renewable energy remains small (2.8%), its strong growth meant that it accounted for all of the increase in global power generation in 2015 and more than a third (38%) of the entire increase in global energy consumption.

The increasing importance of renewable energy continued to be led by wind power (17.4%, 125 TWh). But solar power is catching up fast, expanding by almost a third in 2015 (32.6%, 62 TWh), with China overtaking Germany and the US as the largest generator of solar power.

The older stalwarts of non-fossil fuels – hydro and nuclear energy – grew more modestly. Global hydro power increased by just 1.0% (38 TWh), held back by drought conditions in parts of the Americas and Central Europe. Nuclear energy increased by 1.3% (34 TWh), as rapid expansion in China offset secular declines within mainland Europe. This gradual shift of nuclear energy away from the traditional centres of North America and Europe towards Asia, particularly China, looks set to continue over the next 10-20 years.



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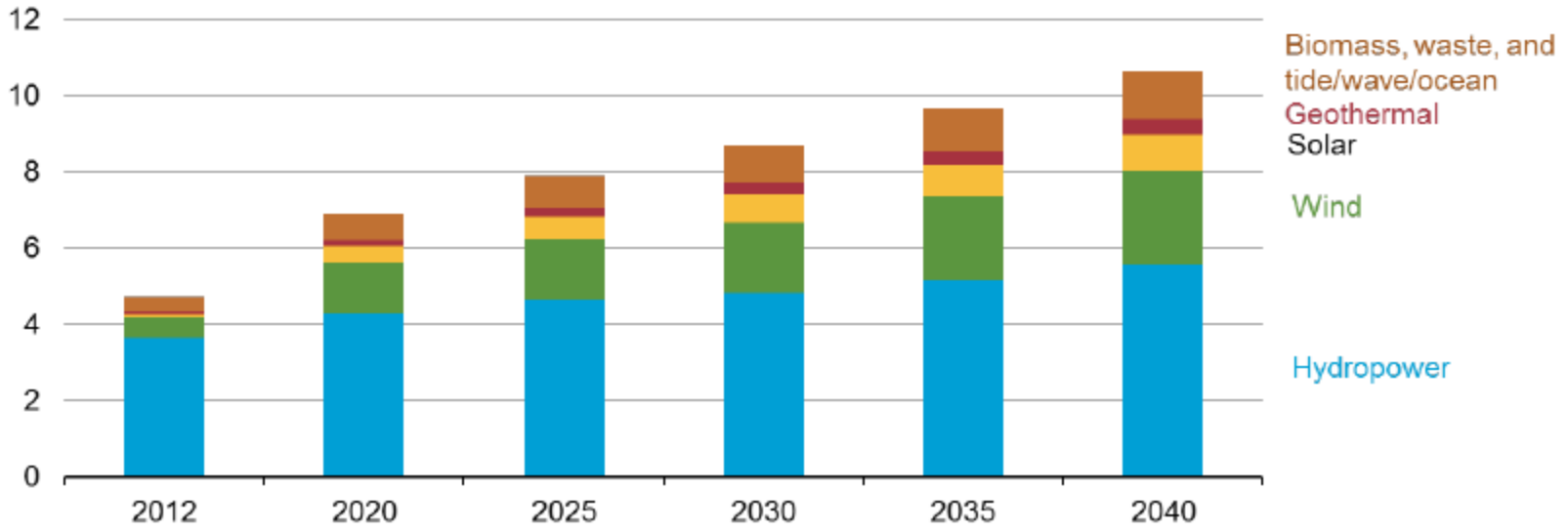
BP Statistical Review of World Energy 2015

Hydropower

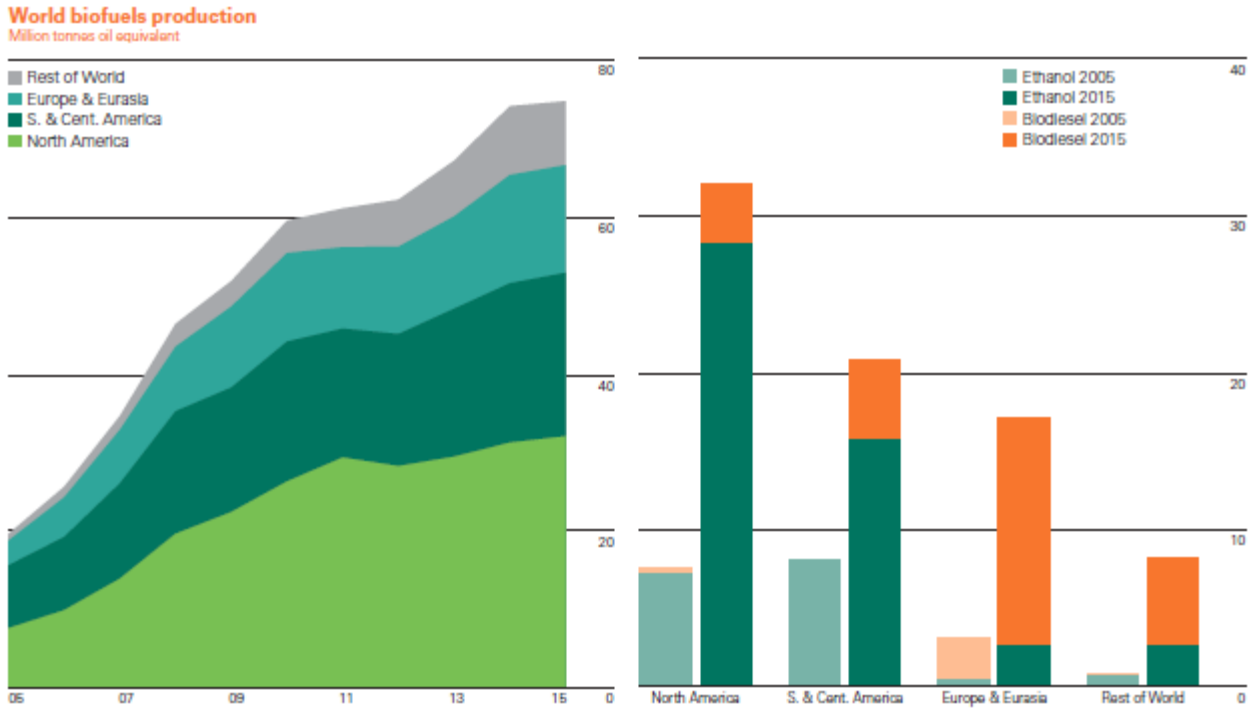
Wind and hydropower each account for one third of the increase in renewable generation; solar is fastest-growing (8.3%/year)

world net electricity generation from renewable energy by source
trillion kilowatthours



Source: EIA, International Energy Outlook 2016

World Biofuels

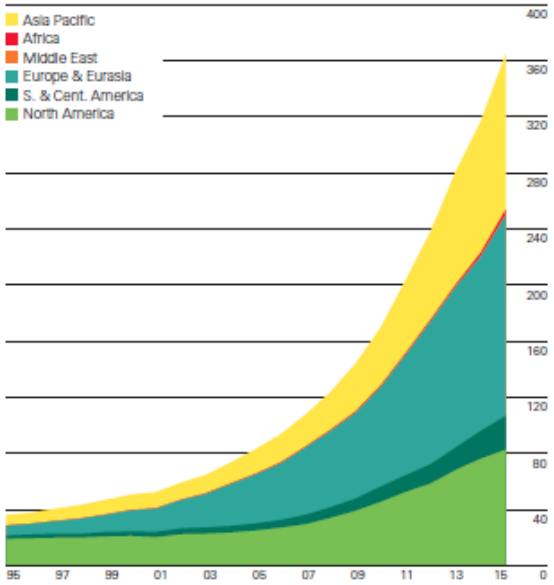


World biofuels production increased by 0.9% in 2015, the slowest rate of growth since output declined in 2000. Global ethanol production increased by 4.1%, the third consecutive year of growth, led by increases from Asia Pacific, South & Central America, and North America. Biodiesel production declined by 4.9% in 2015, with output declining in all of the major producing regions.

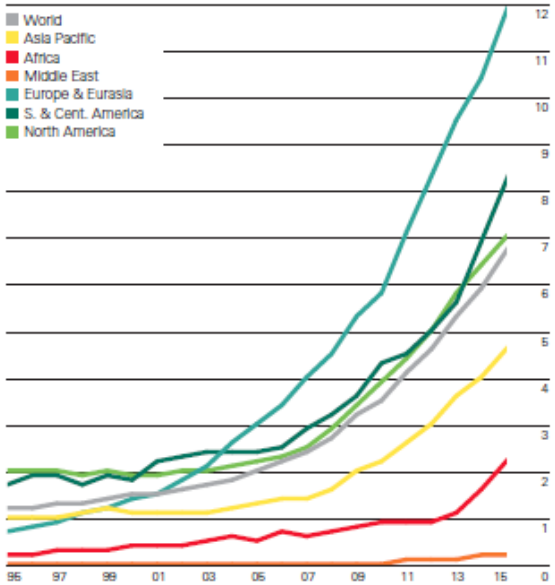
Source: BP Statistical Review of World Energy 2016

Renewables by Region

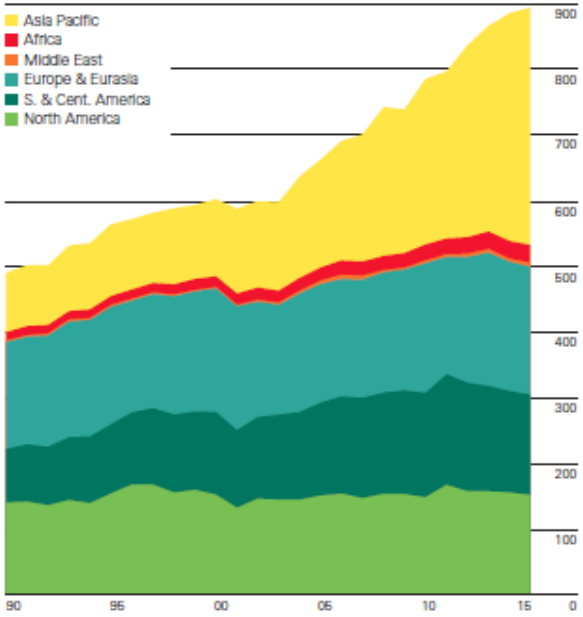
Other renewables consumption by region
Million tonnes oil equivalent



Other renewables share of power generation by region
Percentage



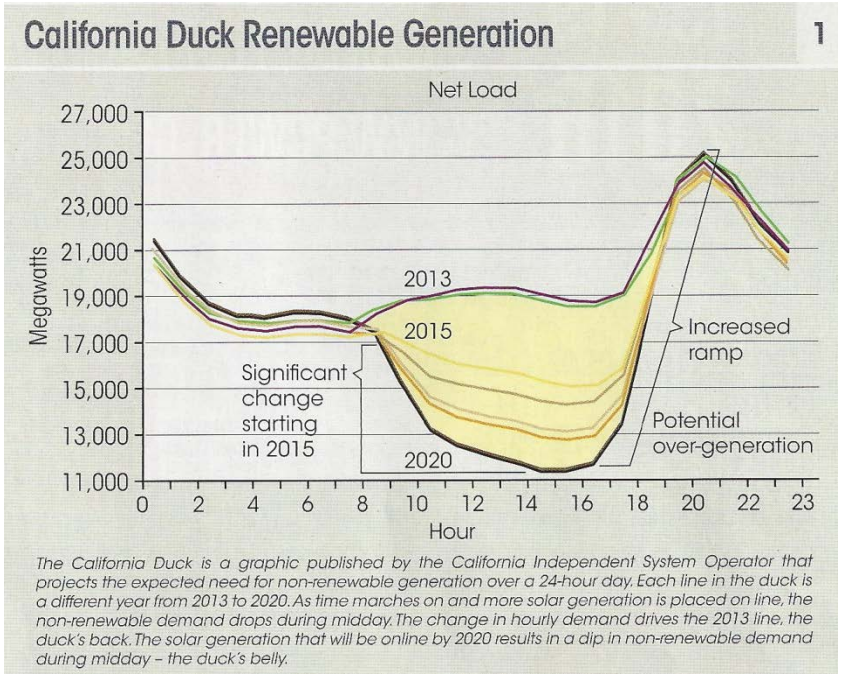
Hydroelectricity consumption by region
Million tonnes oil equivalent



Renewable energy in power generation grew by 15.2%, slightly below the 10-year average growth rate, but the largest increment on record (+48 mtoe). Globally, wind provided the largest growth increment (+29 mtoe), but solar had the highest growth rate (+32.6%). Regionally, Europe & Eurasia and Asia Pacific provided the largest growth increments (+18.8 mtoe and 17.5 mtoe, respectively). Non-hydro renewable energy accounted for 6.7% of global power generation in 2015, up from 2% a decade ago. The Europe & Eurasia region has the highest share of power from renewables, at 11.9% (reaching 18.6% in the EU).

Source: BP Statistical Review of World Energy 2016

Dealing with the Duck



The California Duck is a graphic published by the California Independent System Operator that projects the expected need for non-renewable generation over a 24-hour day. Each line in the duck is a different year from 2013 to 2020. As time marches on and more solar generation is placed on line, the non-renewable demand drops during midday. The change in hourly demand drives the 2013 line, the duck's back. The solar generation that will be online by 2020 results in a dip in non-renewable demand during midday – the duck's belly.

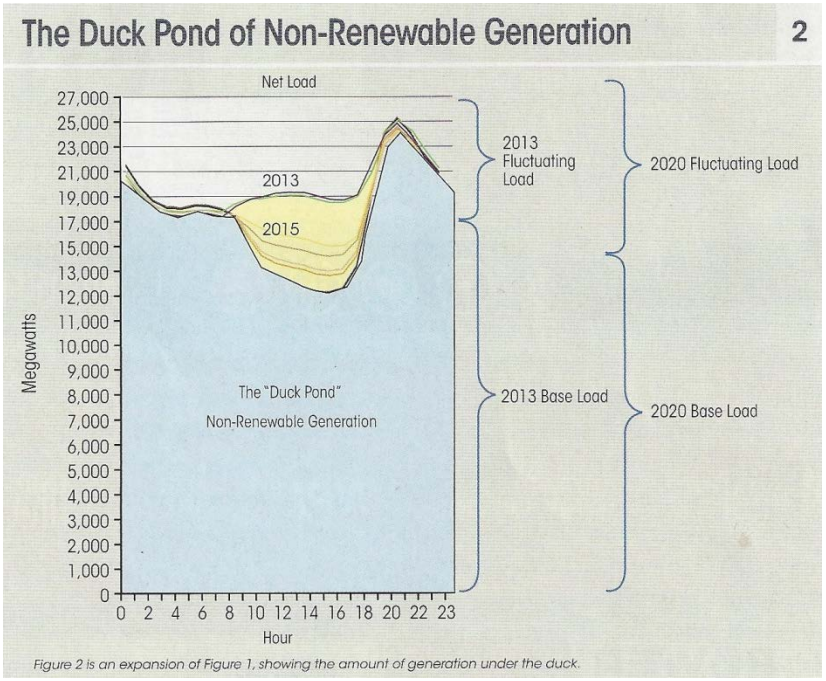


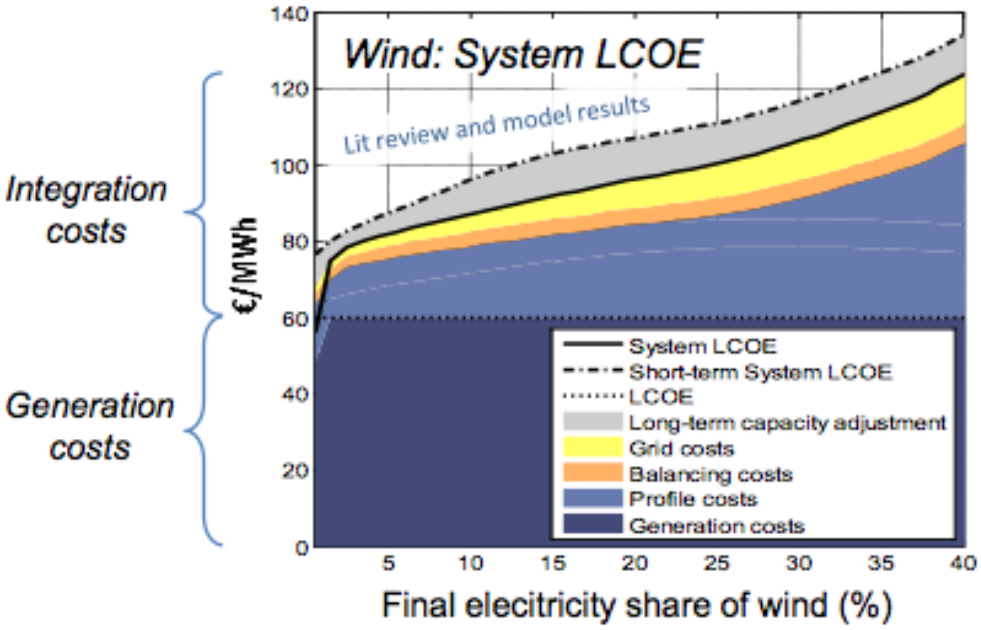
Figure 2 is an expansion of Figure 1, showing the amount of generation under the duck.

Source: Bonnie Marini – Siemens Energy
Through Power Engineering

Wind Integration Costs

- Integration includes:
  - Fluctuating output profile costs
  - Output uncertainties balancing costs
  - Grid costs

At higher penetration, integration costs for wind exceed generation costs.



Source: System LCOE: What are the costs of variable renewables? Falko Ueckerdt, Lion Hirth, Gunnar Luderer, Ottmar Edenhofer Paris, June 20, 2013 32th International Energy Workshop

As presented by John Thompson Clean Air Task Force CCS – Pittsburgh 2104

Projections - Renewables

Second, on the supply side, one of the key issues posed by the technological wave fostering new forms of energy is how quickly the share of renewable energy within global demand is likely to grow.

The key lesson from history is that it takes considerable time for new types of energy to penetrate the global market. Starting the clock at the point at which new fuels reached 1% share of primary energy, it took more than 40 years for oil to expand to 10% of primary energy; and even after 50 years, natural gas had reached a share of only 8%.

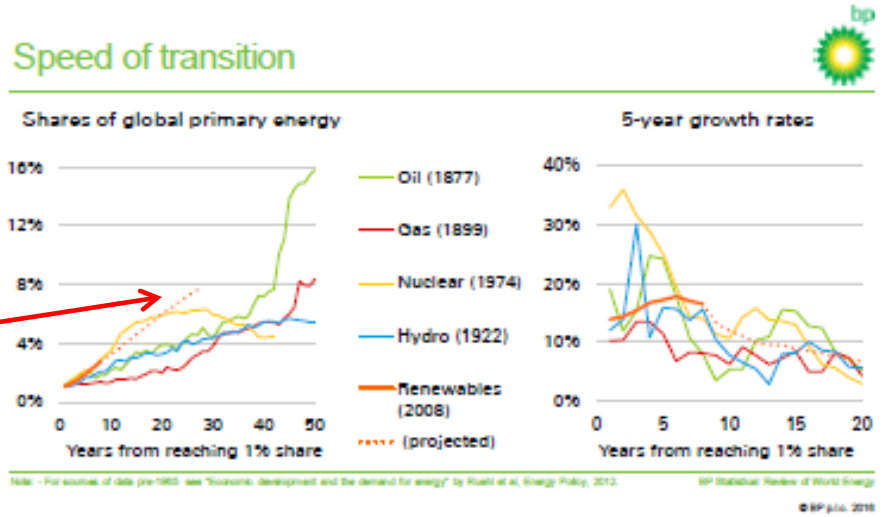
Some of that slow rate of penetration reflects the time it takes for resources and funding to be devoted in scale to new energy sources. But equally important, the highly capital-intensive nature of the energy eco-system, with many long-lived assets, provides a natural brake on the pace at which new energies can gain ground.

The growth rates achieved by renewable energy over the past 8 or 9 years have been broadly comparable to those recorded by other energies at the same early stage of development. Indeed, thus far, renewable energy has followed a similar path to nuclear energy.

The penetration of nuclear energy plateaued relatively quickly, however, as the pace of learning slowed and unit costs stopped falling. In contrast, in BP's Energy Outlook, we assume that the costs of both wind and solar power will continue to fall as they move down their learning curve, underpinning continued robust growth in renewable energy.

Indeed, the path of renewable energy in the base case of the Energy Outlook implies a quicker pace of penetration than any other fuel source in modern history. But even in that case, renewable power within primary energy barely reaches 8% in 20 years' time.

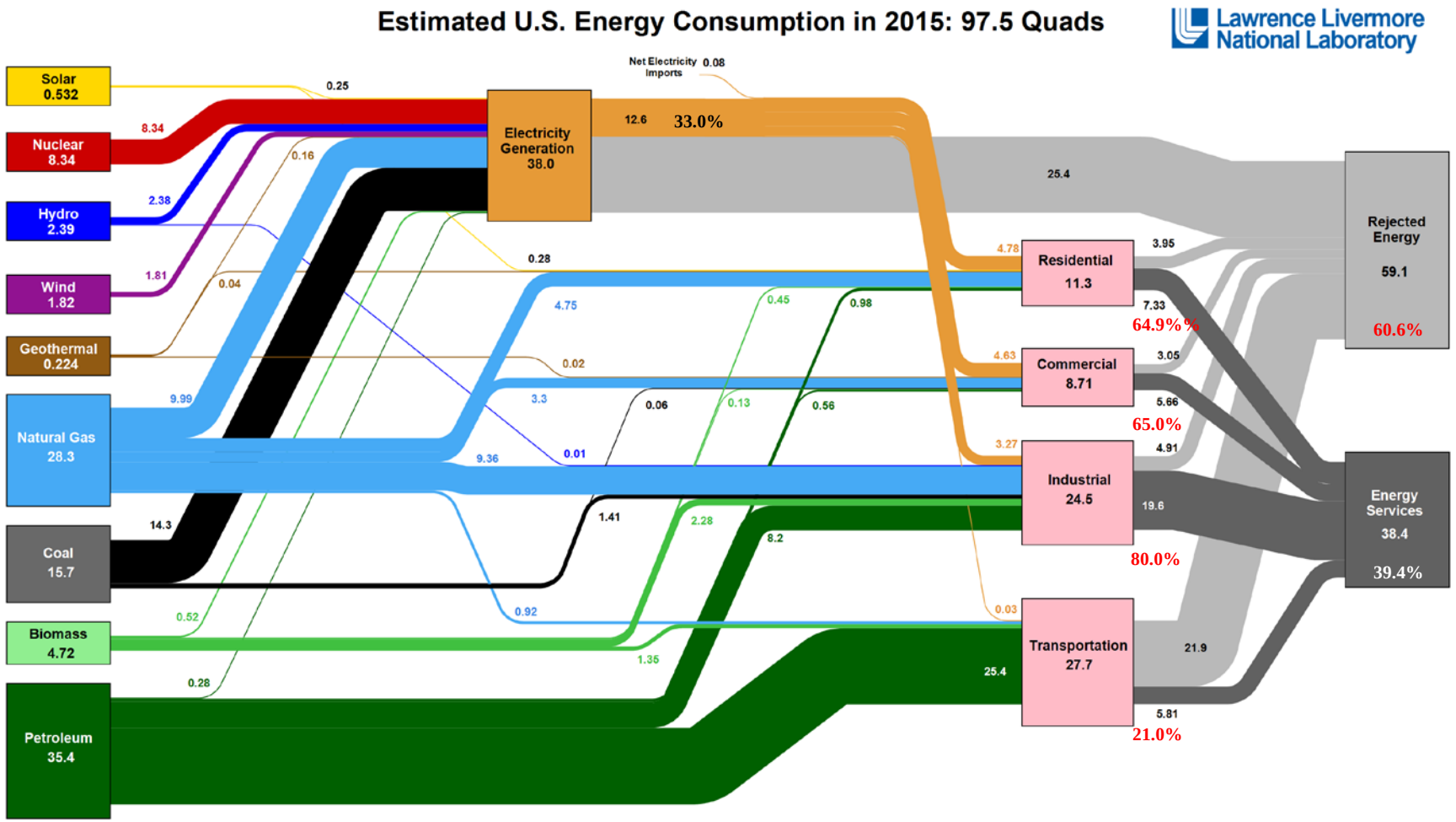
The simple message from history is that it takes a long time – numbering several decades – for new energies to gain a substantial foothold within global energy.



Energy in 2015: A Year of Plenty
Spencer Dale – BP June 8, 2016
BP Statistical Review of World Energy 2015

U.S. & Canada

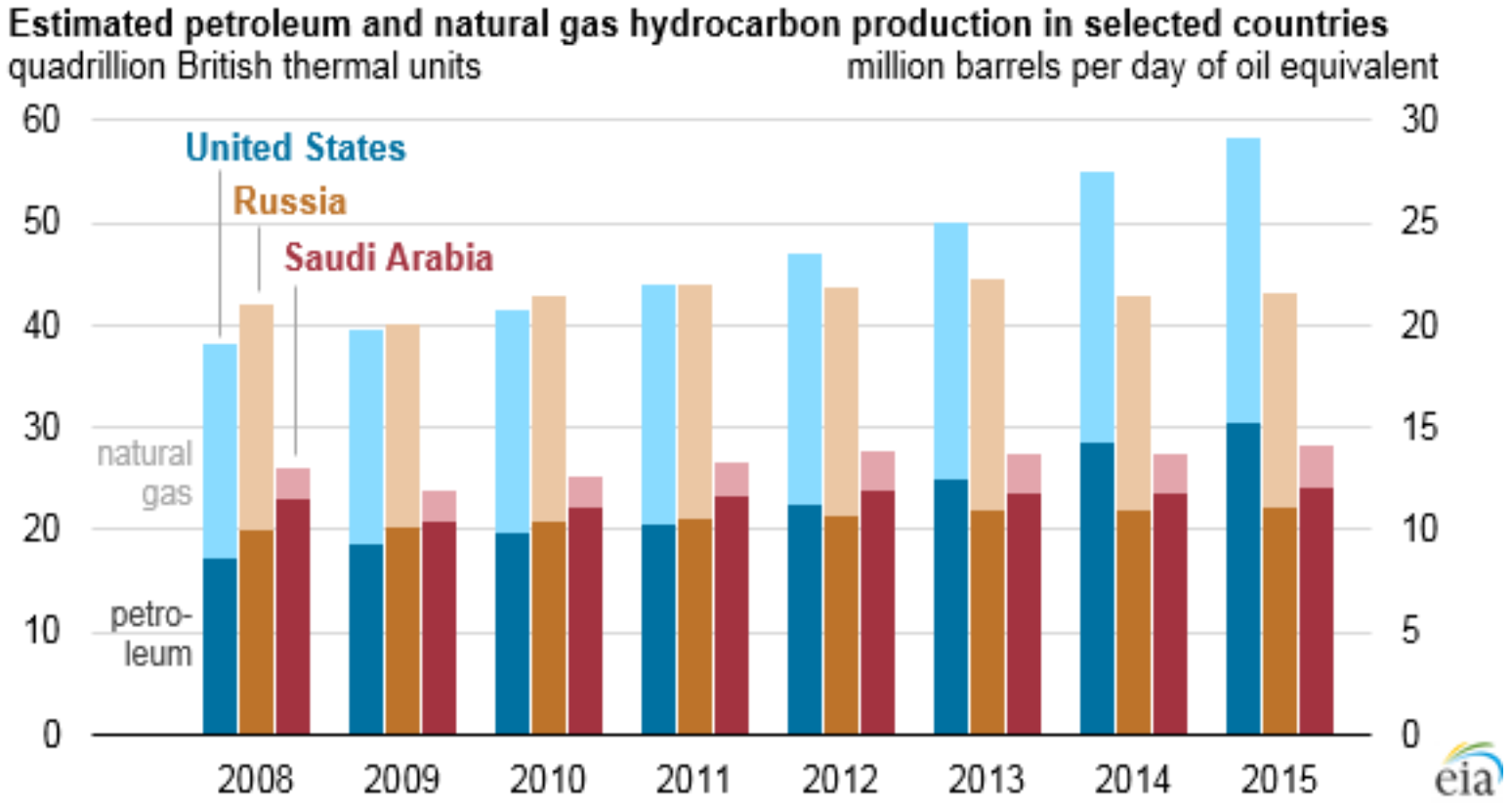
U.S. Energy Flow – 97.5 Quads



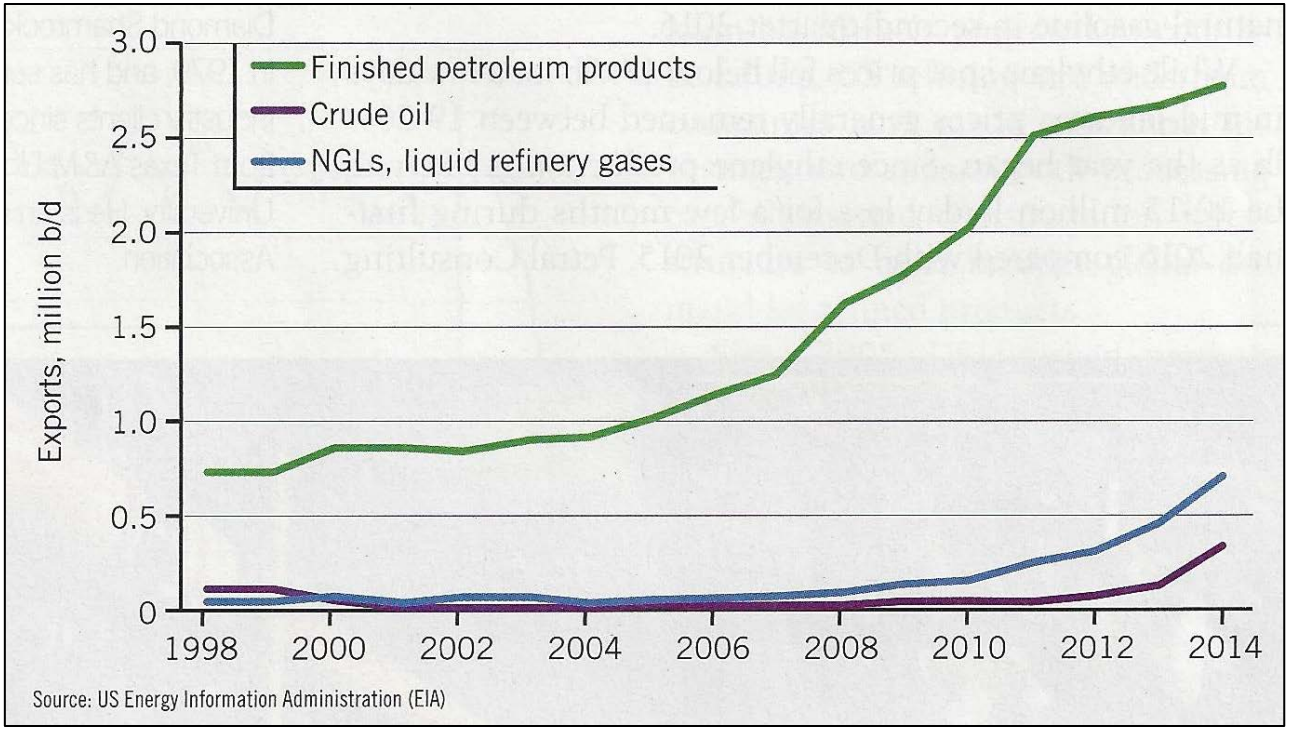
base e

"Practical Strategies for Emerging Energy Technologies"

U.S. Remains Largest Producer of O&G Hydrocarbons



U.S. Petroleum Exports

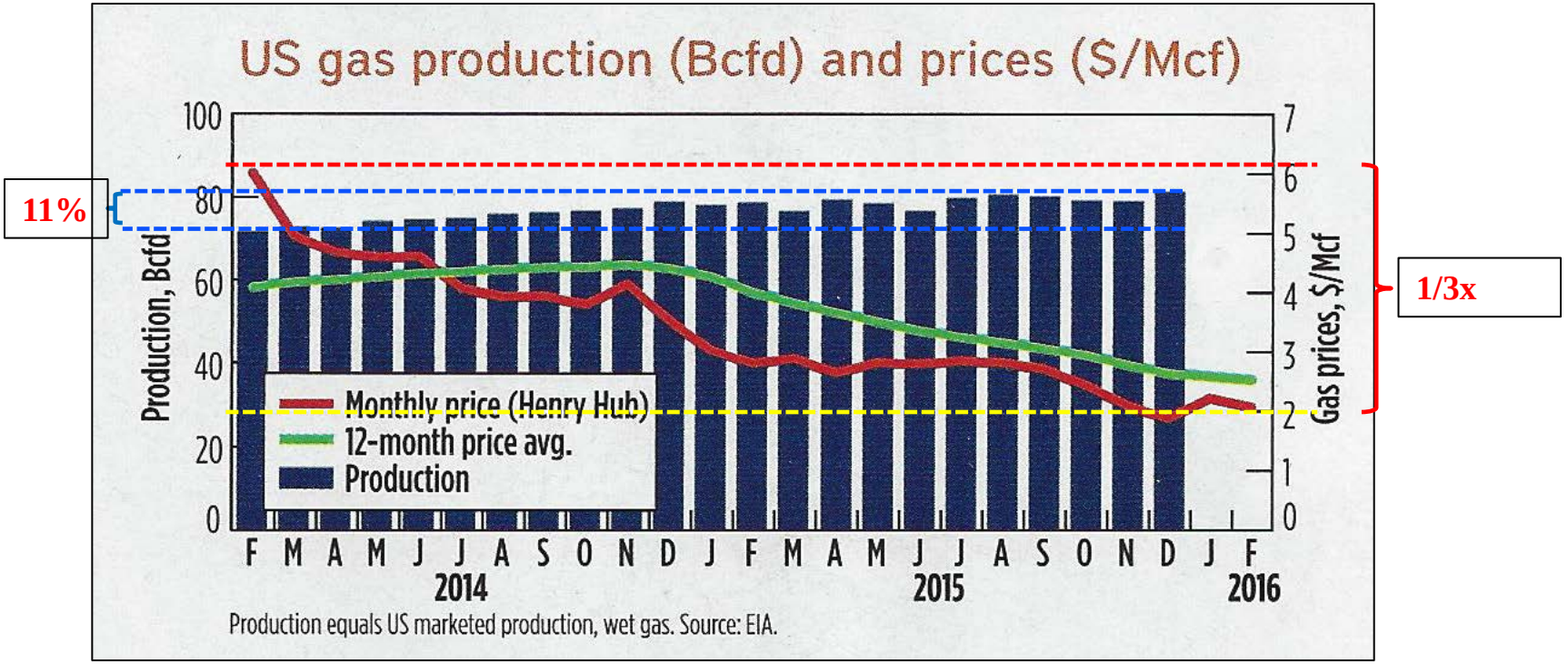


Canada LNG

FIG. 3. Canada has announced a multitude of LNG export projects on its west and east coasts.

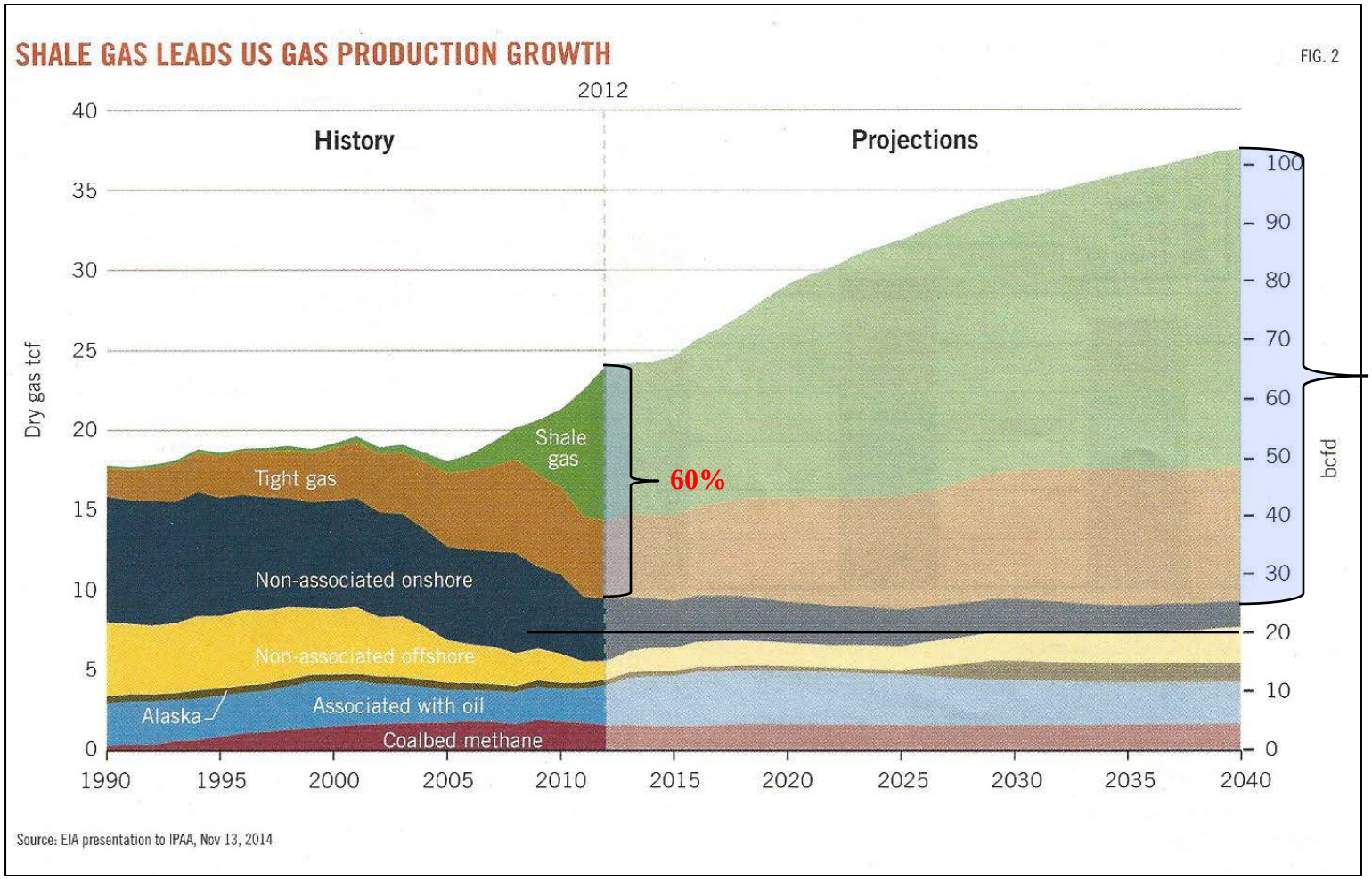
Source: O&G Journal December 7, 2015

U.S. Gas Production & Price

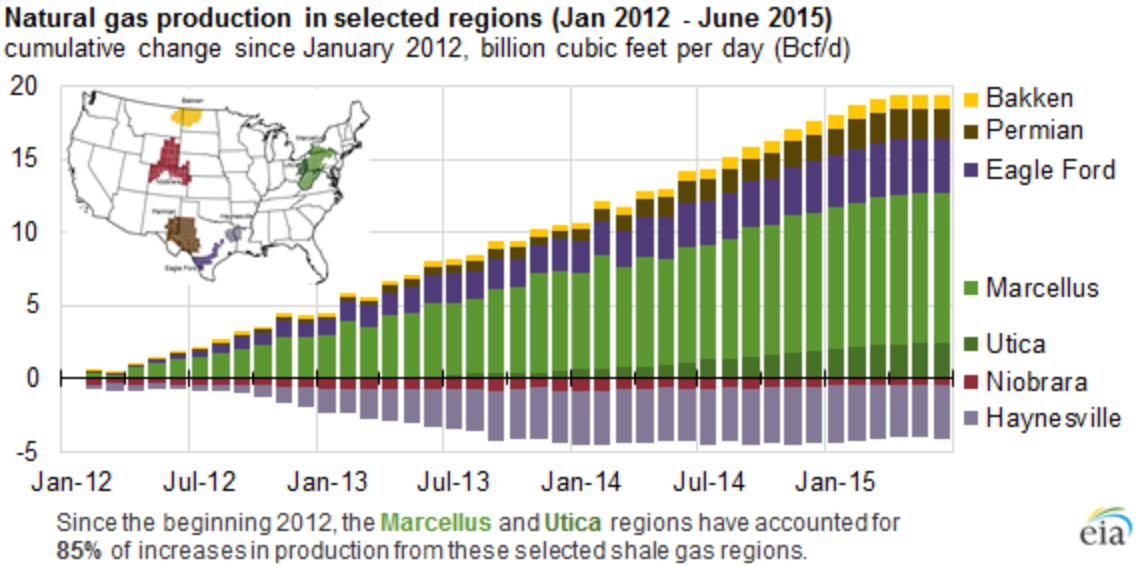


Source: Hydrocarbon Processing April 2016

U.S. Shale Gas

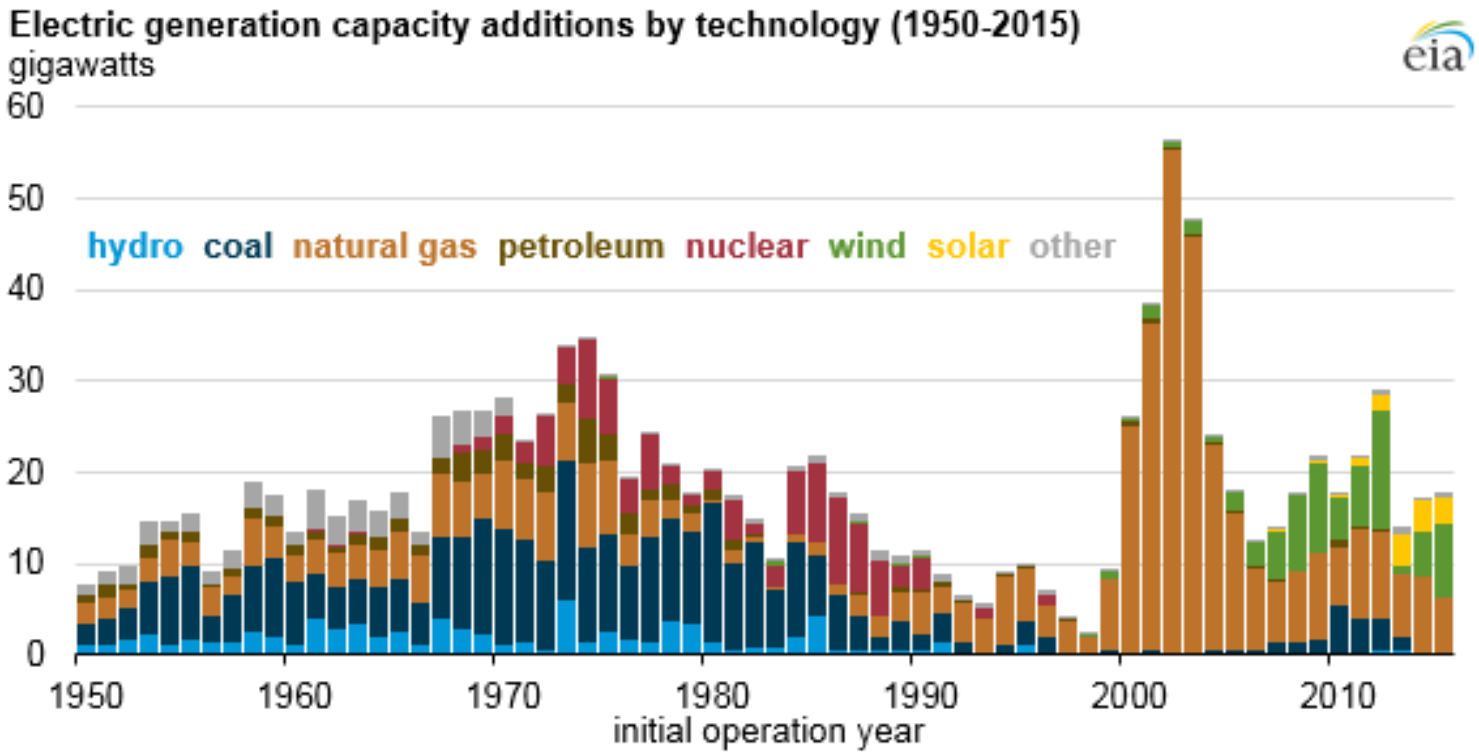

SHALE GAS LEADS US GAS PRODUCTION GROWTH
FIG. 2
2012
History
Projections
Dry gas tcf
bcfd
Shale gas
Tight gas
Non-associated onshore
Non-associated offshore
Alaska
Associated with oil
Coalbed methane
60%
75%
40
35
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
Source: EIA presentation to IPAA, Nov 13, 2014

Natural Gas Production by Region

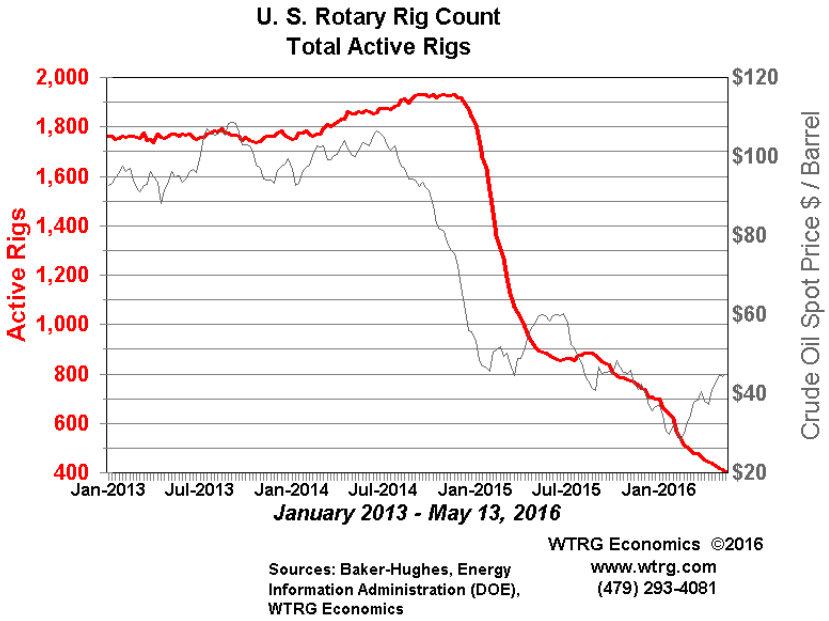


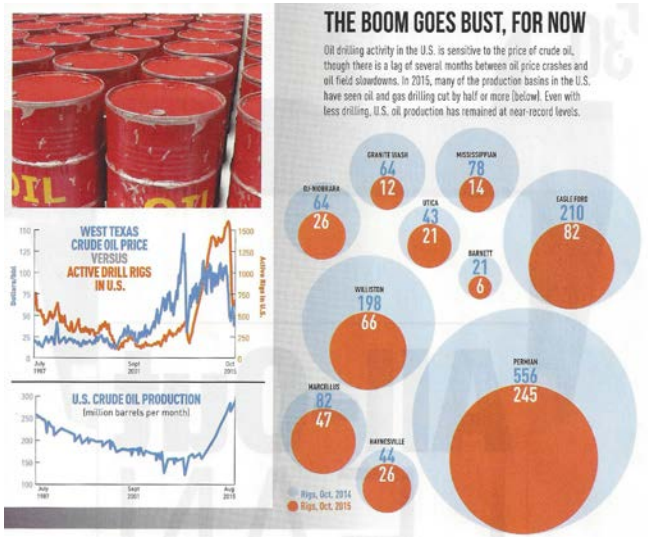
- Increases in natural gas production from these regions occurred because of many factors, including:
  - Greater use of advanced drilling techniques
  - Increased number of stages used in hydraulic fracturing operations
- Increased use of techniques such as zipper fracturing (simultaneous fracturing of individual stages of two parallel horizontal wells)
  - Use of specific components during well completion that aid in increasing fracture size and porosity of the geologic formation being targeted

Electric Generation Capacity Additions



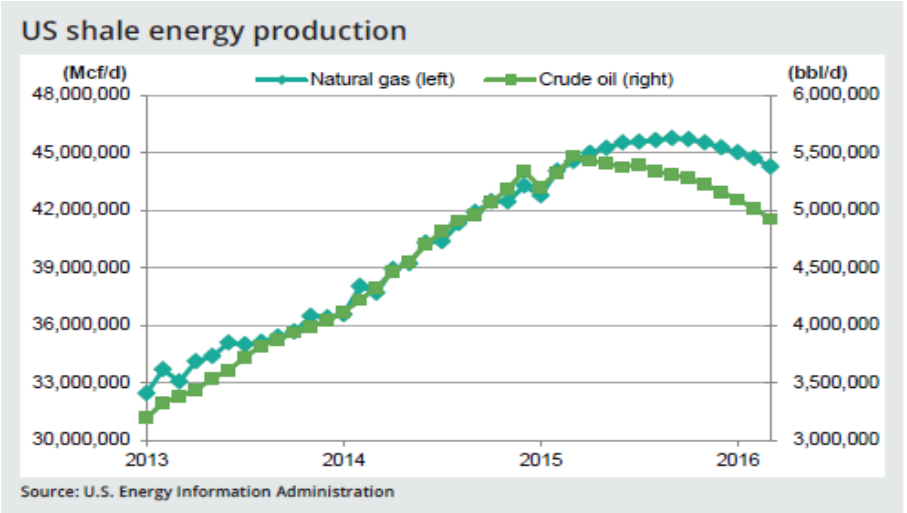
Rig Count



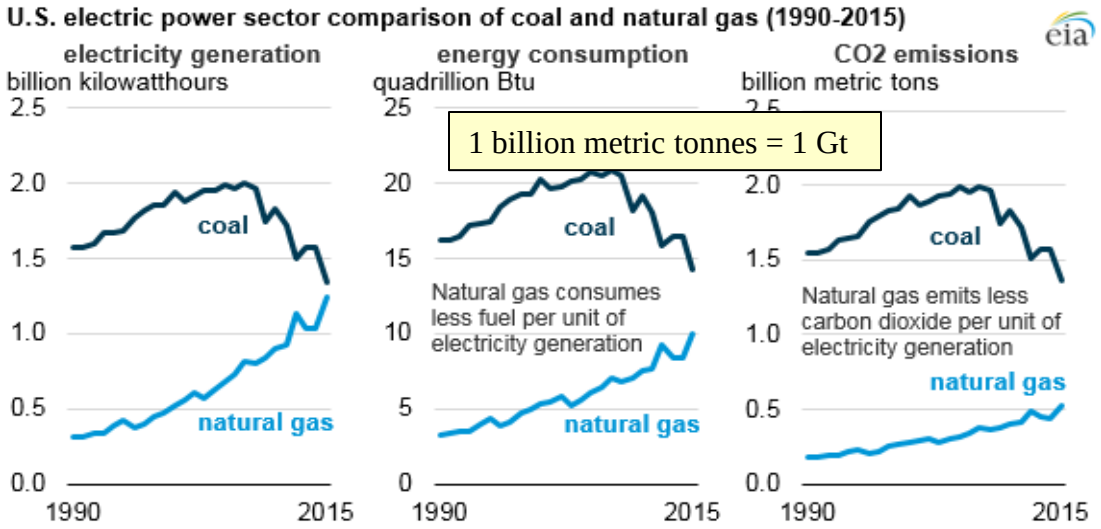


BHI rig count jumps (10) units, (9) targeting oil, to 424 in 3rd straight weekly rise….

O&G Journal 6/17/2016

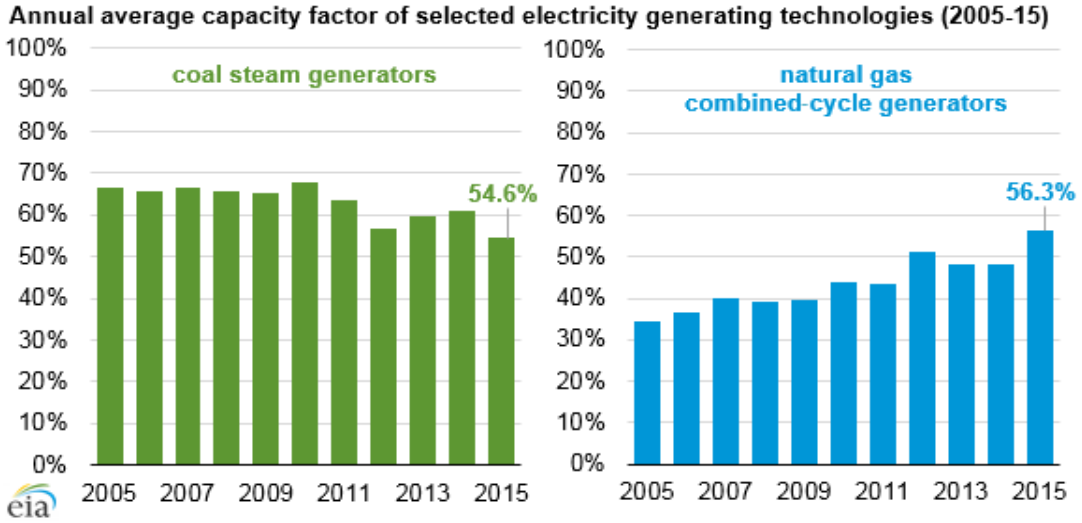


U.S. Power Generation



1.350

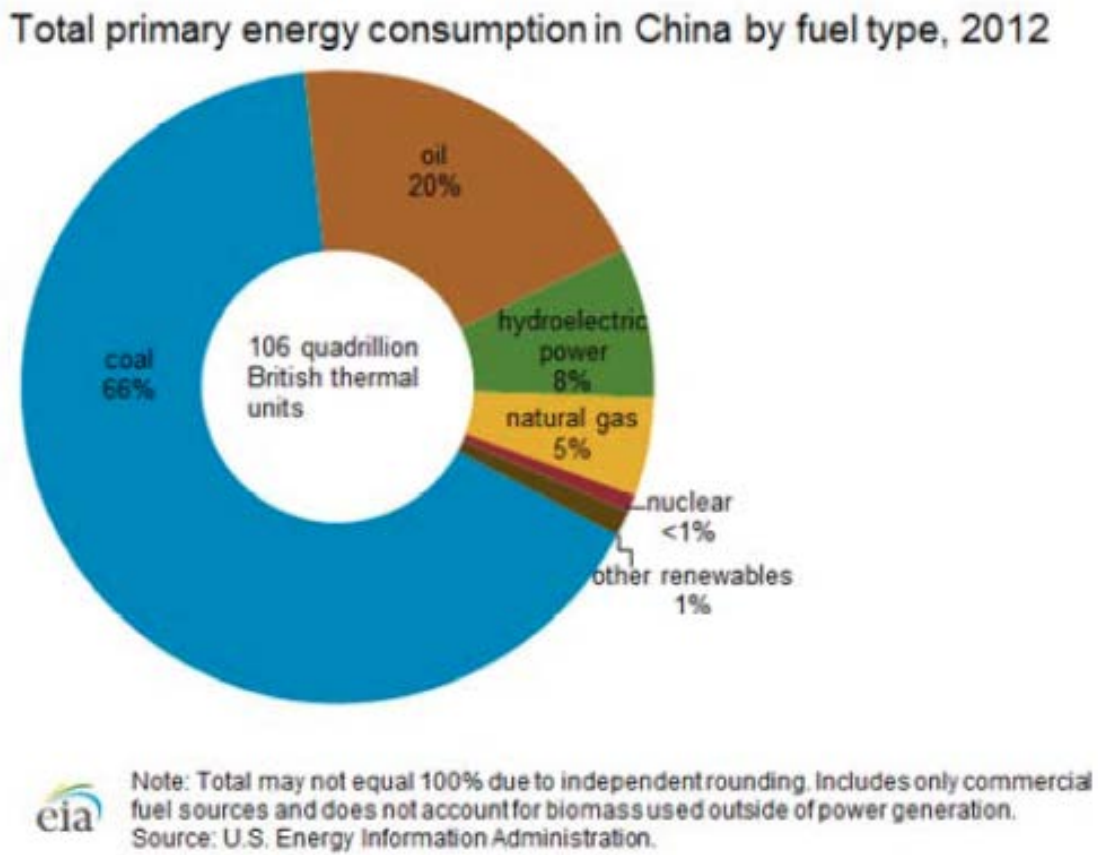
0.550



Source: EIA

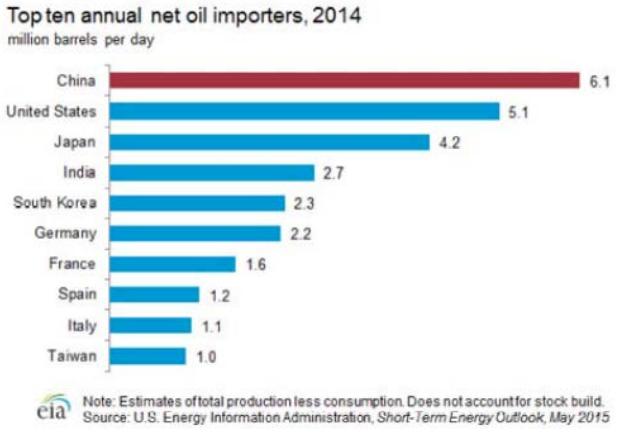
China

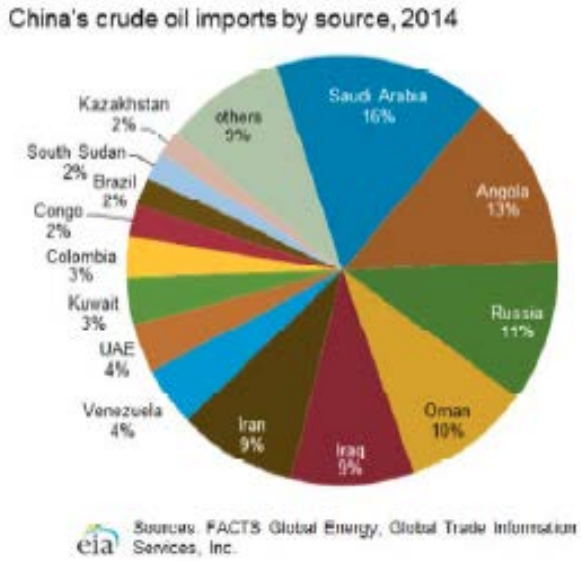
China Energy Consumption by Fuel

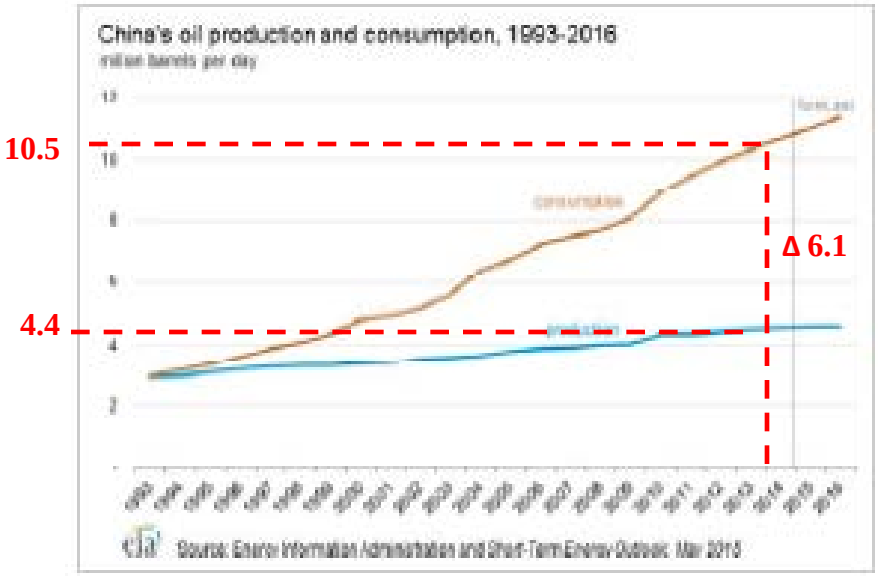


Source: O&G Journal December 7, 2015

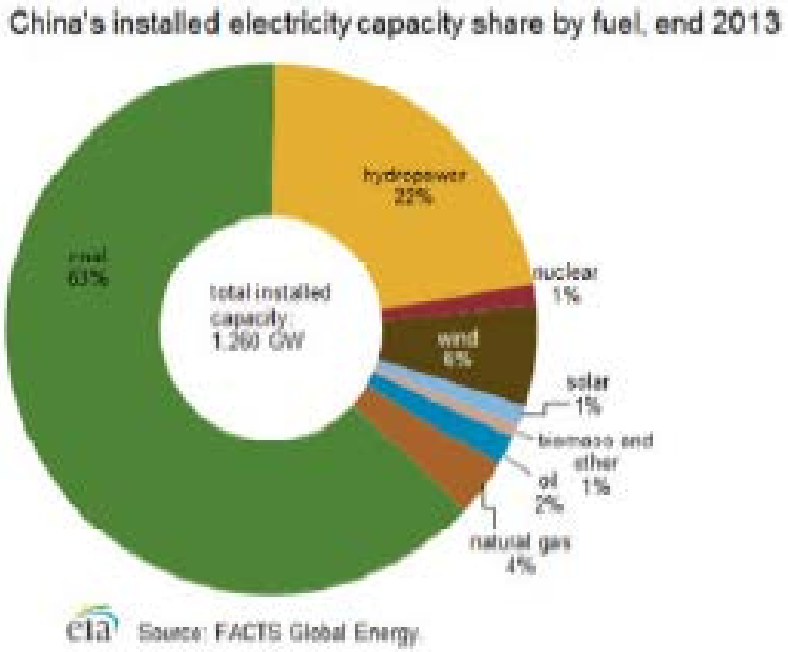
China Oil Imports

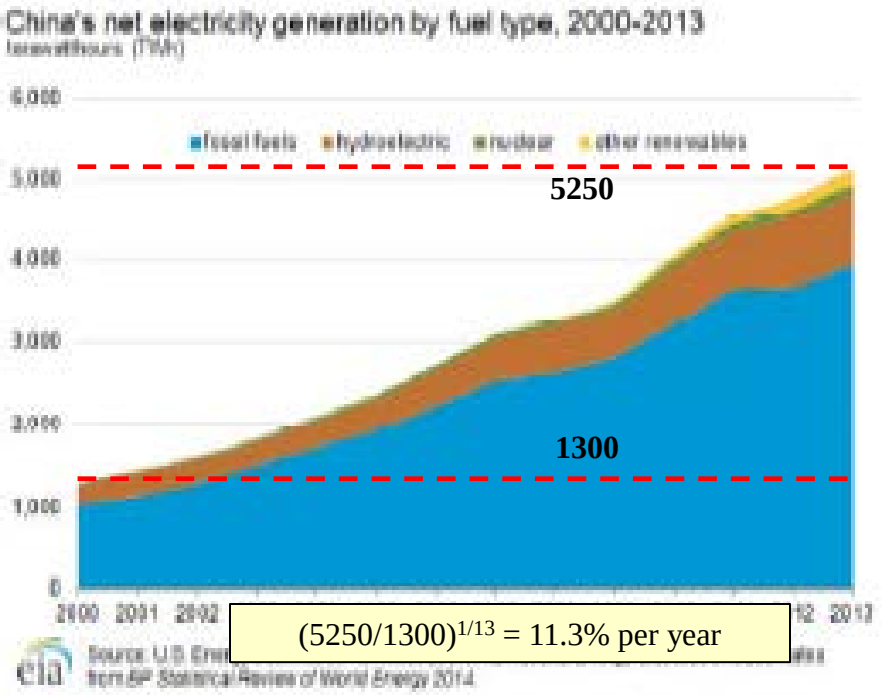






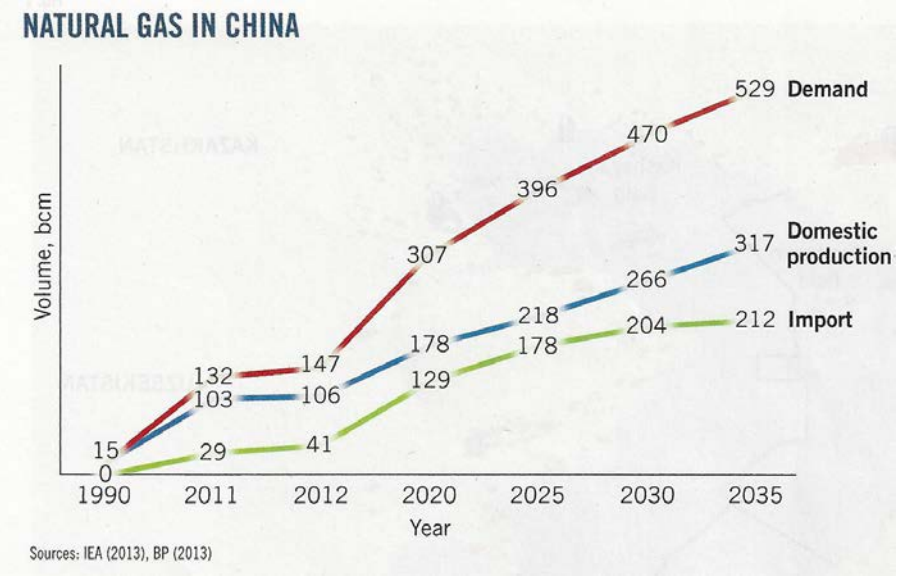
China Power Generation

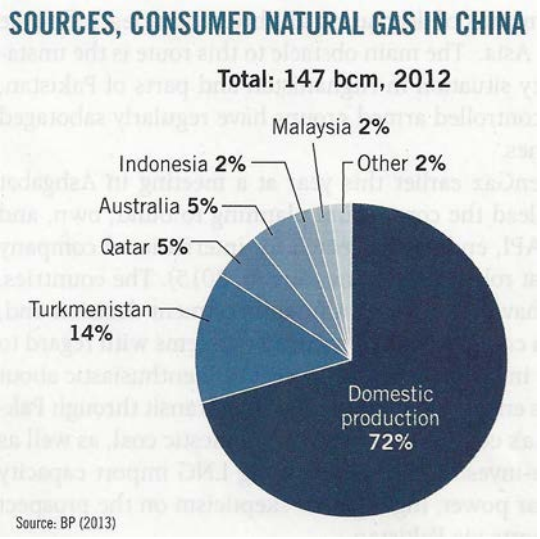




$(5250/1300)^{1/13}$ = 11.3% per year

China Natural Gas





- 147 in 2012
  - Domestic production
  - Imported

3x @3.5% pa

106
41
147

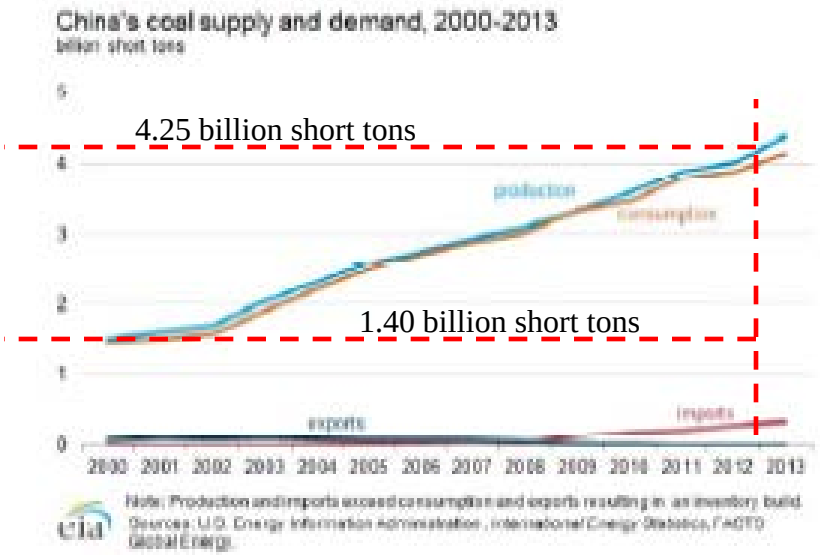
5x @ 12.8% pa

317
212
529

- 529 in 2035
  - Domestic production
  - Imported

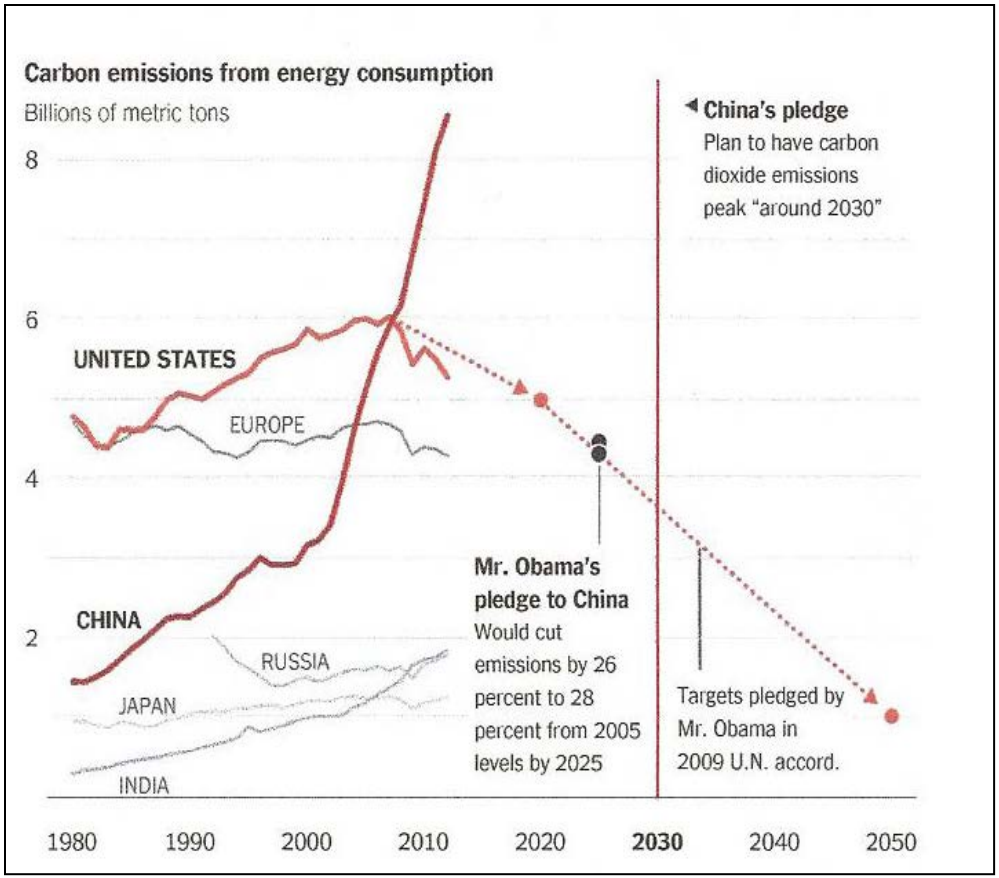
$(529/147)^{1/33}$ = 4.0% per year

China - Coal



$(4.25/1.40)^{1/12}$ = 9.7% per year

The China-U.S. – 2014 CO2 Emissions Agreement



New York Times

China agreed to peak CO2 emission by 2030

Projections - China

The developments detailed in this year's Statistical Review highlight some of the profound changes taking place in global energy markets as energy demand transitions and as advances in technology enable new and abundant sources of supply.

I want to conclude by speculating, just for a moment, where these forces may lead. In particular, by considering whether the past data, particular those compiled in the Statistical Review, may contain clues to future trends.

I want to consider three key issues for the future: China, renewable energy and carbon emissions.

First, on China: as I said, the recent slowing in global energy demand has been driven to a large extent by developments in China. Not so much by the slowdown in economic growth, but rather by the rapid declines in energy intensity as China's pattern of growth has adjusted.

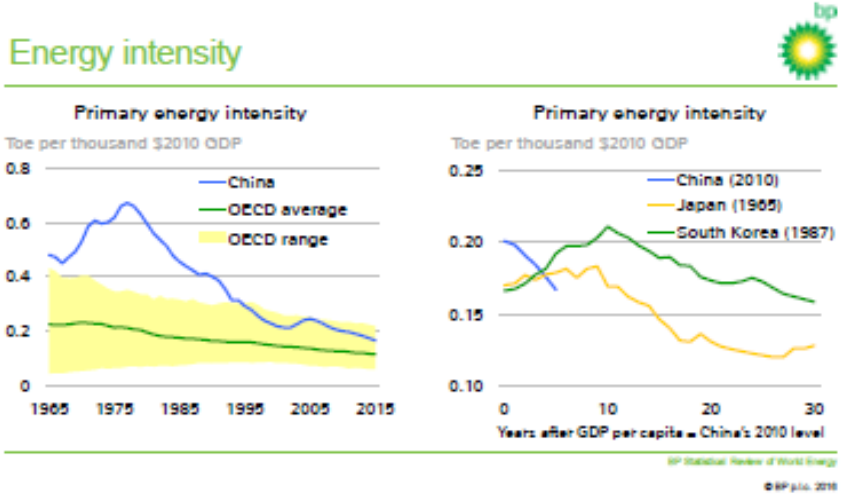
Indeed, if China's energy intensity hadn't declined over the past 5 years, global energy demand would have been almost 5% higher – roughly equivalent to the entire energy consumption of France, Germany and Belgium combined – even with the slowdown in Chinese GDP growth. Future trends in China's energy intensity matter as much, if not more so, for energy demand as its economic growth.

However, the level at which China's energy intensity will start to stabilize is uncertain.

There is considerable variation in energy intensity across developed economies, depending on their industrial structure and their levels of energy efficiency.

Perhaps more instructive is the experience of Japan and South Korea at a similar stage of development. Their falls in energy intensity happened somewhat later in their economic development than in China, but point to extended periods of quite sharp falls in energy intensity. But again here there is significant variation in the level of energy intensity at which they stabilized.

Ultimately, much will depend on the success of China in terms of its twin policy objectives of improving its level of energy efficiency and of shifting towards a more service-based (and hence less energy-intensive) pattern of growth.



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OPEC

Saudi Arabia

- Plans to spend $150B per year to become the global leader in refining and petrochemical production
- Including $70-80B of overseas downstream acquisitions
- Seeks to boost ties with China & Korea
- Satisfy domestic transport fuel and chemical demand, domestically
- Increase refined product export to Europe
- Worldwide target of 8-10 MMbpd
- Will add 1.2 MMbpd of new Middle Eastern refining capacity by 2018
- Double gas output by 2030
- Invest $190B in power generation

TABLE 1. HPI facilities in Saudi Arabia

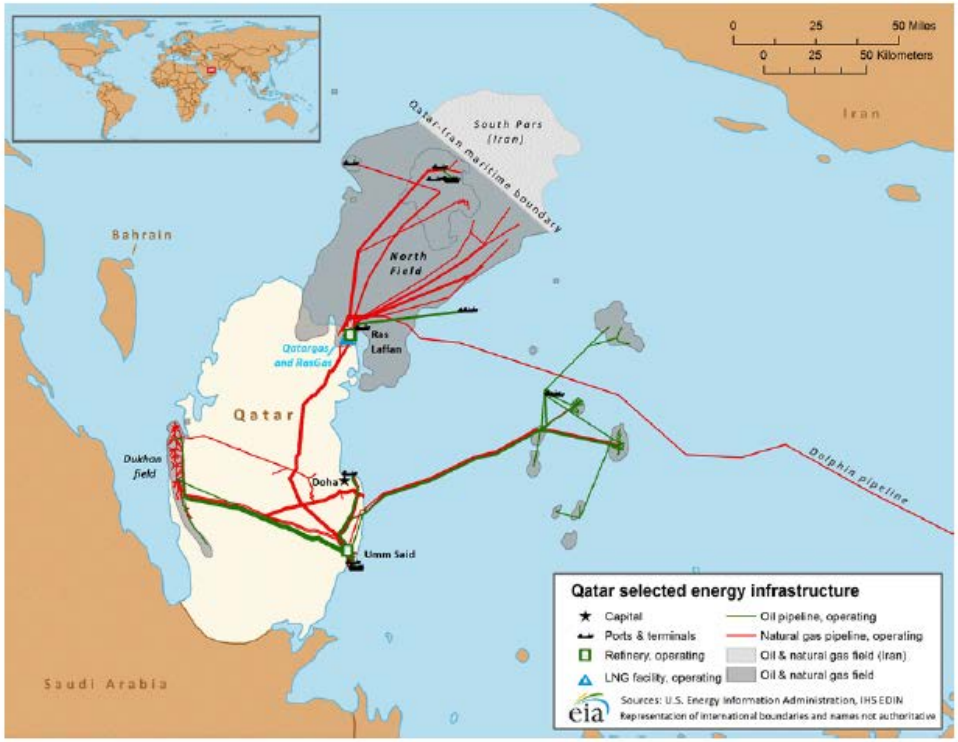
Refinery/plant	Capacity	Unit	Description	Location	Products
Jiddah refinery	100,000	bpd	May close by 2022 due to age and environmental concerns	Jiddah	LPG, unleaded gasoline, diesel, asphalt, naphtha, kerosine, jet fuel
Ras Tanura refinery	550,000	bpd	Will be upgraded to produce low-sulfur fuels	Ras Tanura	LPG, gasoline, diesel, jet fuel, fuel oil, asphalt
Riyadh refinery	120,000	bpd	Will be upgraded to produce low-sulfur fuels	Riyadh	Gasoline, diesel, asphalt, sulfur
Yanbu refinery	225,000	bpd	Mainly serves the domestic market	Yanbu	LPG, gasoline, jet fuel, diesel, fuel oil
SAMREF (Saudi Aramco Mobil Refinery Co.)	400,000	bpd	Completed clean fuels upgrade project in 4Q 2014	Yanbu	Gasoline, jet fuel, diesel, marine fuel oil, propane, sulfur
LUBEREF (Saudi Aramco Lubricating Oil Refining Co.)	4 million	bpy	The sole in-Kingdom producer of lubricating base oils	Jiddah and Yanbu	Base oils
SASREF (Saudi Aramco Shell Refinery Co.)	305,000	bpd	Produces petroleum products and chemical plant feedstocks, primarily for sale in markets outside Saudi Arabia	Jubail	LPG, sulfur, benzene, naphtha, kerosine, gasoil, fuel oil
Petro Rabigh complex (Saudi Aramco/Sumitomo Chemical Co. JV)	400,000	bpd	Will be upgraded to produce low-sulfur fuels	Rabigh	Polyethylene, polypropylene, monoethylene, glycol, LPG, naphtha, gasoline, gasoil, fuel oil, kerosine
Jazan refinery (under construction)	400,000	bpd	Estimated completion date is 2017	Jazan	Gasoline, ultra-low-sulfur diesel, fuel oil
SATORP refinery (Saudi Aramco Total Refining and Petrochemical Co.)	400,000	bpd	Completed in 2014	Jubail	Gasoline, diesel, jet fuel, petroleum coke, fuel oil, liquid sulfur, aromatics
Sadara Chemical Co. complex (Saudi Aramco/ Dow Chemical Co. JV)	3 million	tpy	Estimated completion date is 2016	Jubail	Amines, glycol ethers, isocyanates, polyether polyols, polyethylene, polyolefin elastomers, propylene glycol
YASREF (Yanbu Aramco Sinopec Refining Co.)	400,000	bpd	Completed in 2014	Yanbu	LPG, gasoline, jet fuel, diesel, fuel oil

Source: Hydrocarbon Processing November 2015

Qatar

- **RasGas**
  - JV ExxonMobil
  - Qatar Petroleum (state owned)
- **Long-term LNG Contracts w/Petronet (India)**
  - 5.0 MMtpa = 240 Bcf = 6.72 BCM
  - 2.5 MMtpa = 120 Bcf = 3.36 BCM
  - $12-13/MMBtu reduced to $6-7/Mmbtu
- **New Contract Terms**
  - Reduced 60 month moving average
  - Slope-to-crude (percent indexation to crude)
- **Qatari Asian contracts 2Tcf = 56.3 BCM**
- **Qatari LNG Exports**
  - India – 14.1%
  - Japan – 19.6%
  - South Korea – 15.0%
  - China – 6.6%

Qatar selected energy infrastructure

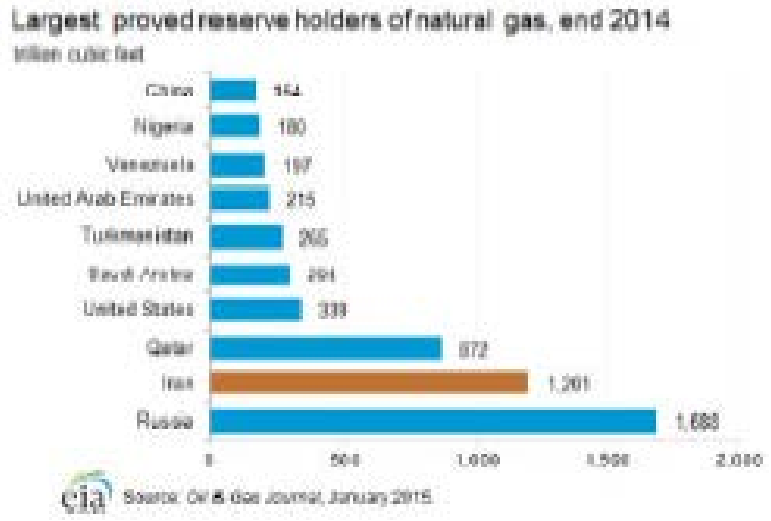


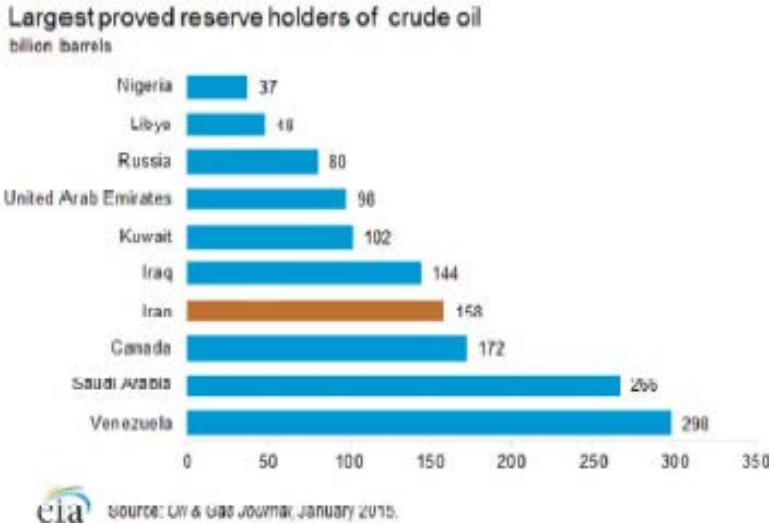
Iran

- Iran holds the world's fourth-largest proved crude oil reserves and the world's second-largest natural gas reserves
- Iran Petroleum Ministry reserves 1201tcf/33,988 BCM
- Iran may have more success with LNG rather than pipeline to Europe
- Target export of 11 MMtpy (15.2 BCM)
- LNG Foreign investment opportunities
  - LNG Plant near Tombak 25 MMtpy/35 BCM
  - Kish Island recoverable reserves 63.6 tcf/1,800 BCM

Source: U.S. Energy Information Administration, IHS EDIN

Source: U.S. Energy Information Administration, IHS EDIN

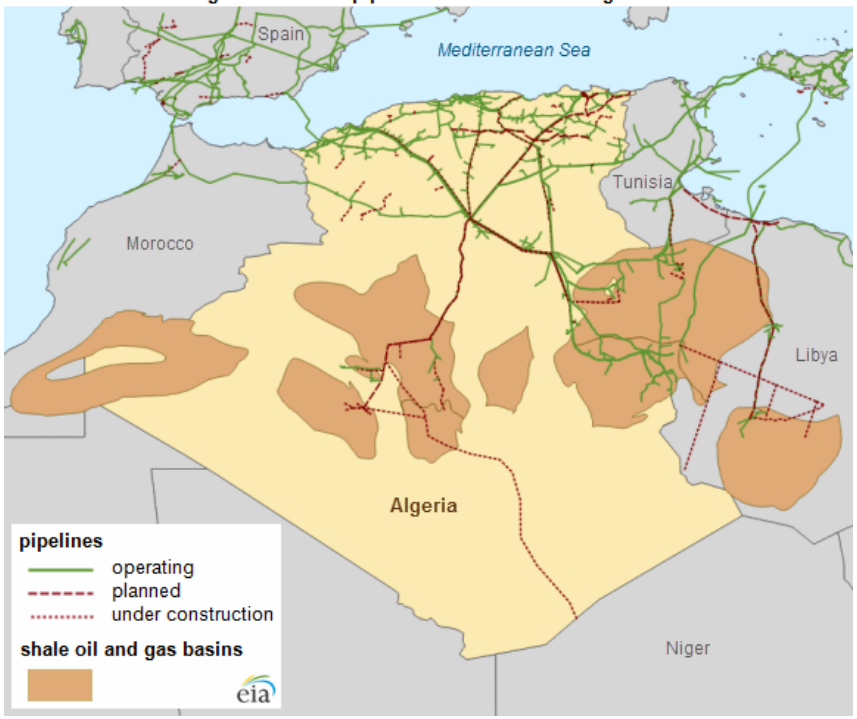




Algeria

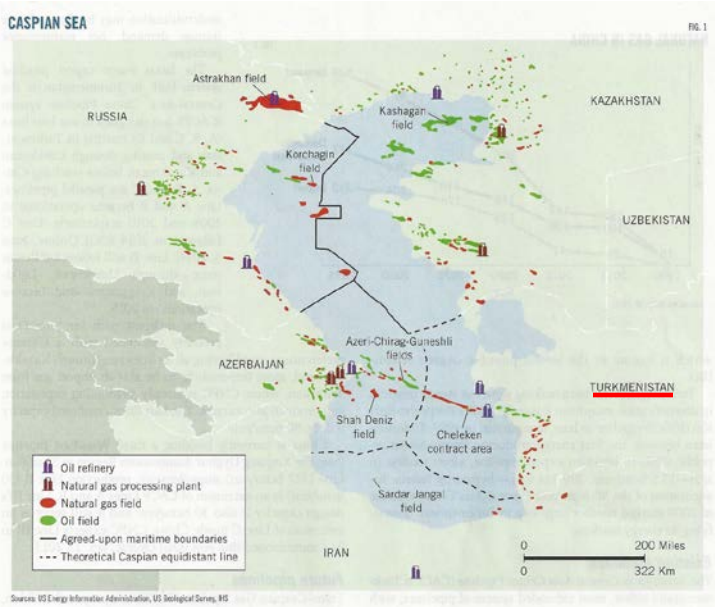
- Sonatrach announced plans to spend $64 billion, or 70% of its total investment program from 2015 to 2018, in upstream activities to reverse the decline in crude oil and natural gas production in Algeria
- Sonatrach set a target to increase gross hydrocarbon output:
  - 1,429 million barrels of oil equivalent (MMBOE) in 2014 to 1,649 MMBOE by 2019
  - 535 to 616 MMBOE of oil
  - 894 to 1,034 MMBOE of natural gas
- Declining production has led the Algerian government to amend its law regarding foreign investment in hydrocarbons in an attempt to attract the investment and technology improvements needed to help stop production declines

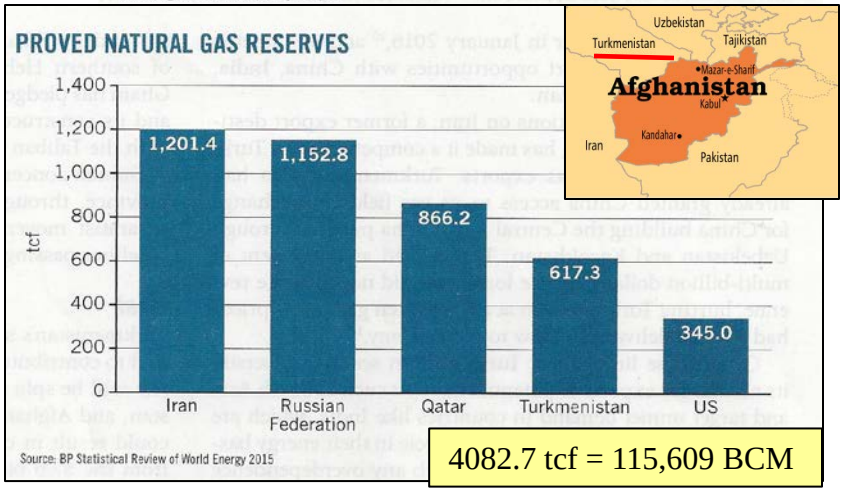
Shale oil and natural gas basins and pipeline infrastructure in Algeria



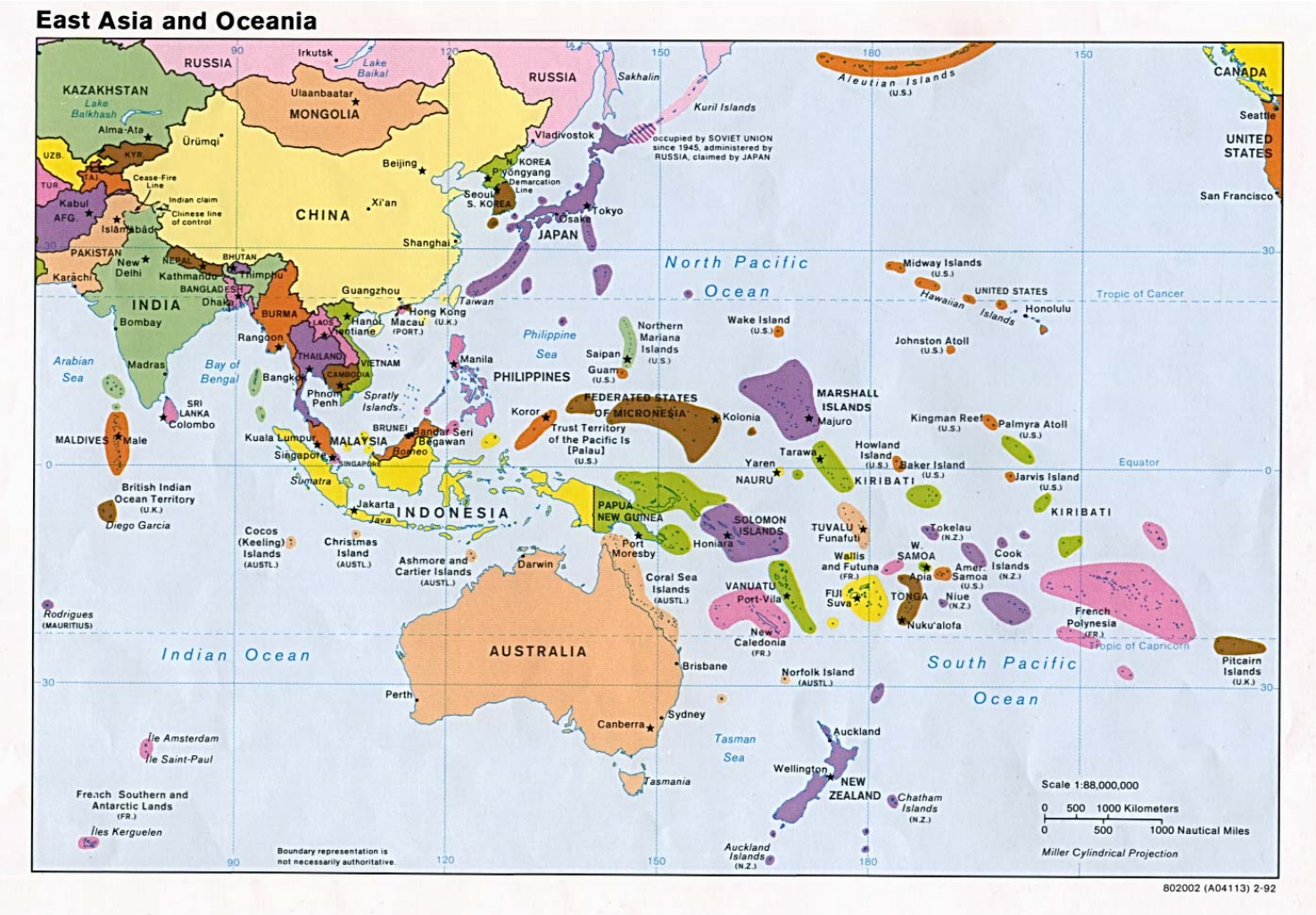
Turkmenistan – Serving Eurasia?

- Russian Gas Pipeline Access/Use
  - 1989 – 81 BCM
  - 1998 – 12 BCM
- 17,500 BCM proven natural gas reserves
- 9.3% of world total
- 74% in Galkynysh field near Afghan border
- China National Petroleum Corp. (CNPC)
  - CNPC controls 82% of Proven gas reserves
  - Produced 13 BCM (20%) in 2012
  - Export 30 BCM/year for 30 years
  - Expected to bring annual gas deliveries to 65 BCM/year
- Turkmengaz largest producer
  - Produced 51 BCM (80%) in 2012
- Does not directly border with Europe, China, or India and depends on transiting thru other countries.
- Trans-Caspian Gas Pipeline (300km) proposed but far from guaranteed





Source: O&G Journal December 7, 2015


East Asia and Oceania
RUSSIA
KAZAKHSTAN
Lake Balkhash
Alma-Ata
Ürümqi
MONGOLIA
Irkutsk
Lake Baikal
Ulaanbaatar
Vladivostok
Sakhalin
Kuril Islands
occupied by SOVIET UNION since 1945, administered by RUSSIA, claimed by JAPAN
Aleutian Islands (U.S.)
CANADA
Seattle
UNITED STATES
San Francisco
UZB
KYR
TAJ
TUR
AFG
Kabul
Islāmābād
Cease-Fire Line
Indian claim
Chinese line of control
CHINA
Xi'an
Beijing
N. KOREA
Pyongyang
Demarcation Line
Seoul
S. KOREA
Tokyo
Osaka
JAPAN
Shanghai
PAKISTAN
Karāchi
New Delhi
NEPAL
Kathmandu
BHUTAN
Thimphu
BANGLADESH
Dhaka
INDIA
Bombay
Madras
Guangzhou
Taiwan
Hong Kong (U.K.)
Macau (PORT.)
Hanoi
BURMA
Rangoon
LAOS
Vientiane
THAILAND
Bangkok
CAMBODIA
VIETNAM
Phnom Penh
Arabian Sea
Bay of Bengal
SRI LANKA
Colombo
MALDIVES
Male
Spratly Islands
Philippine Sea
Manila
PHILIPPINES
Northern Mariana Islands (U.S.)
Saipan
Guam (U.S.)
Wake Island (U.S.)
North Pacific Ocean
Midway Islands (U.S.)
UNITED STATES
Hawaiian Islands
Honolulu
Tropic of Cancer
Johnston Atoll (U.S.)
Koror
FEDERATED STATES OF MICRONESIA
Trust Territory of the Pacific Is [Palau] (U.S.)
Kolonia
MARSHALL ISLANDS
Majuro
Kingman Reef (U.S.)
Palmyra Atoll (U.S.)
Howland Island (U.S.)
Baker Island (U.S.)
Tarawa
Yaren
NAURU
KIRIBATI
Jarvis Island (U.S.)
Equator
KIRIBATI
BRUNEI
Bandar Seri Begawan
Kuala Lumpur
MALAYSIA
Singapore
SINGAPORE
Borneo
Sumatra
Jakarta
INDONESIA
Java
British Indian Ocean Territory (U.K.)
Diego Garcia
Cocos (Keeling) Islands (AUSTL.)
Christmas Island (AUSTL.)
Ashmore and Cartier Islands (AUSTL.)
PAPUA NEW GUINEA
Port Moresby
Darwin
Coral Sea Islands (AUSTL.)
SOLOMON ISLANDS
Honiara
TUVALU
Funafuti
Tokelau (N.Z.)
W. SAMOA
Apia
Amer. Samoa (U.S.)
Cook Islands (N.Z.)
Wallis and Futuna (FR.)
VANUATU
Port-Vila
FIJI
Suva
TONGA
Niue (N.Z.)
Nuku'alofa
French Polynesia (FR.)
Tropic of Capricorn
New Caledonia (FR.)
Norfolk Island (AUSTL.)
Pitcairn Islands (U.K.)
Rodrigues (MAURITIUS)
Indian Ocean
AUSTRALIA
Brisbane
Perth
Sydney
Canberra
South Pacific Ocean
Tasman Sea
Auckland
Wellington
NEW ZEALAND
Chatham Islands (N.Z.)
Tasmania
Île Amsterdam
Île Saint-Paul
French Southern and Antarctic Lands (FR.)
Îles Kerguelen
Auckland Islands (N.Z.)
Scale 1:88,000,000
0 500 1000 Kilometers
0 500 1000 Nautical Miles
Miller Cylindrical Projection
Boundary representation is not necessarily authoritative.
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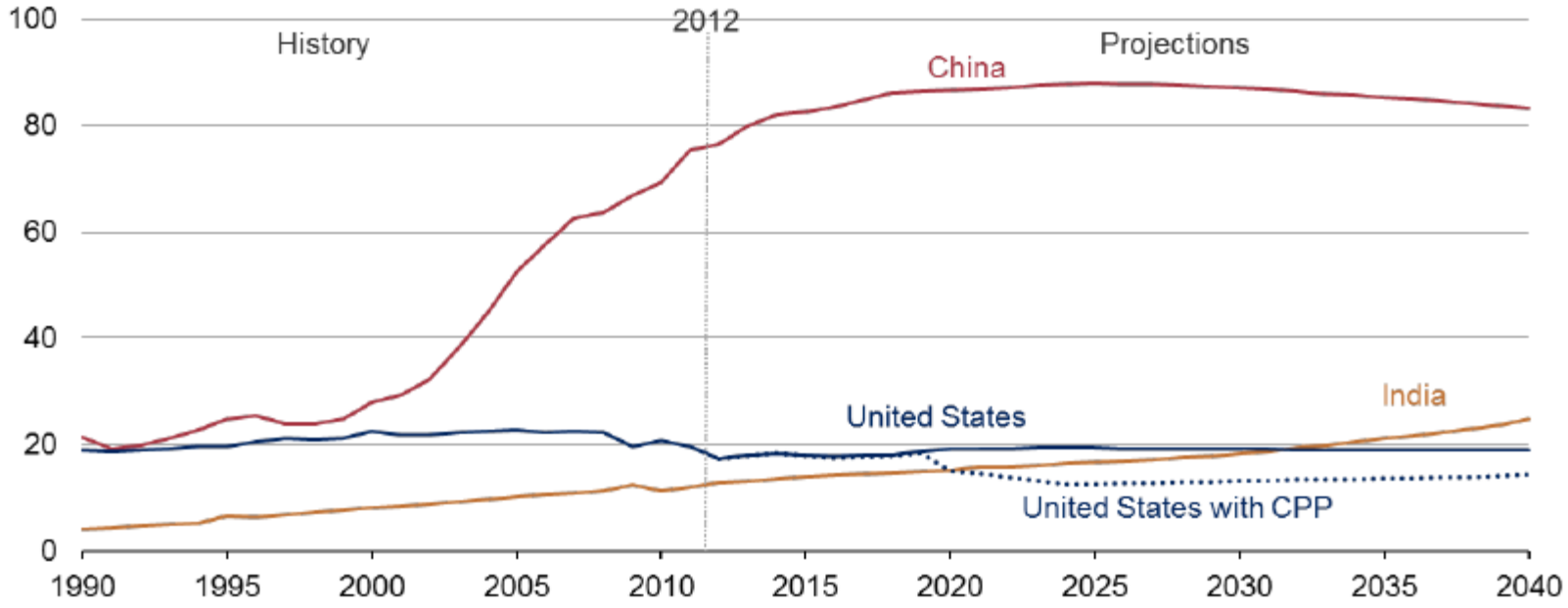
India Coal

Of the world's three largest coal consumers, only India is projected to continue to increase throughout the projection

coal consumption in the US, China, and India

quadrillion Btu



Source: EIA, International Energy Outlook 2016 and EIA, Analysis of the Impacts of the Clean Power Plan (May 2015)

India -LNG Imports

TABLE 1. India's LNG import capacity, MMtpy, 2014–2022

Location	2014	2015	2016	2017	2018	2019	2020	2021	2022
Dahej	10	12.5	15	15	15	15	15	15	15
Hazira	5	5	5	10	10	10	10	10	10
Dabhol	5	5	5	5	5	5	5	5	5
Kochi	5	5	5	5	10	10	10	10	10
Ennore	0	0	5	5	5	5	5	5	5
Mundra	0	0	5	5	10	10	10	10	10
Kakinada (FSRU)	0	2.5	5	5	5	5	5	5	5
Gangavaram	0	3	3	3	3	3	3	3	3
East Coast terminal (1)	0	0	0	2.5	2.5	5	5	5	5
West Coast terminal (1)	0	0	0	0	2.5	5	5	5	5
Total	**25**	**33**	**48**	**55.5**	**68**	**73**	**73**	**73**	**73**

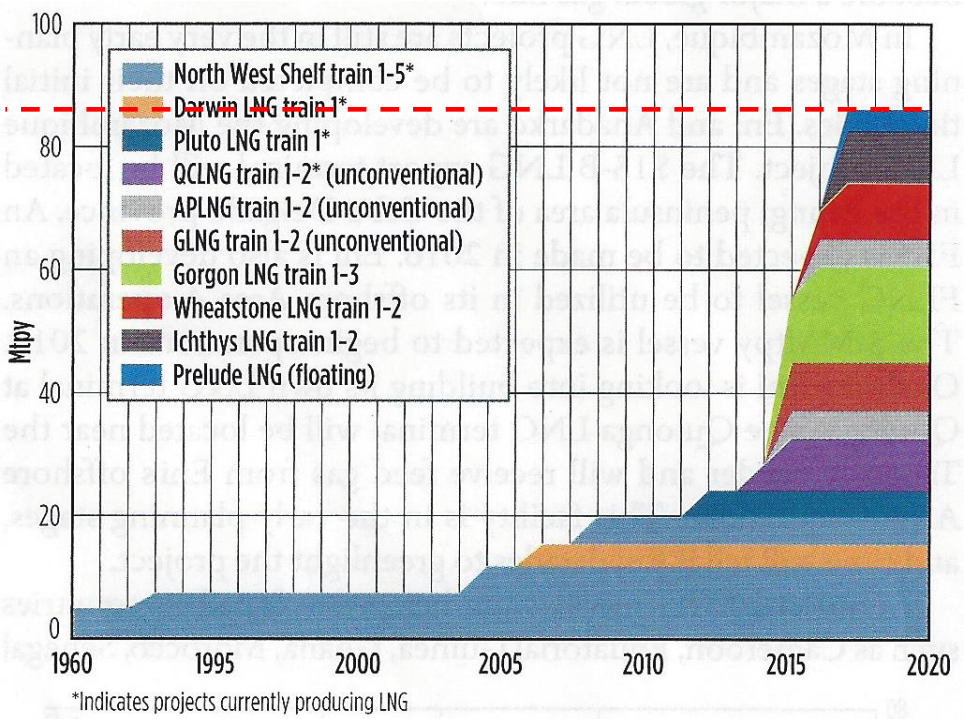
Source: Petroleum & Natural Gas Regulatory Board of India

INDIA'S GAS SUPPLY

	2012-13	2016-17	2021-22	2026-27	2029-30
			MMscmd		
Domestic sources	101.1	156.7	182.0	211.0	230.0
LNG imports	44.6	143.0	188.0	214.0	214.0
Cross border pipeline imports*	—	—	30.0	30.0	30.0
Total	**145.7**	**299.7**	**400.0**	**455.0**	**474.0**

*TAPI pipeline projected commissioning 2017-18
Source: "Vision 2030 – Natural Gas Infrastructure in India," PNGRB

Australia LNG



120 BCM

FIG. 2. Australian liquefaction capacity. Source: Australian Department of Industry and Reserve Bank of Australia.

EU

EU LNG Imports

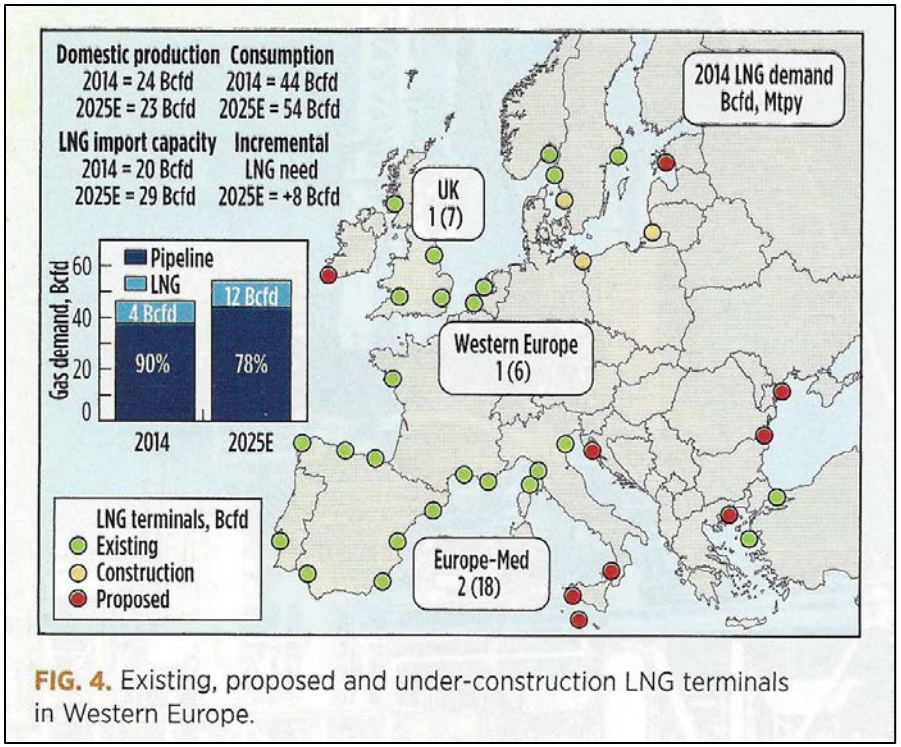
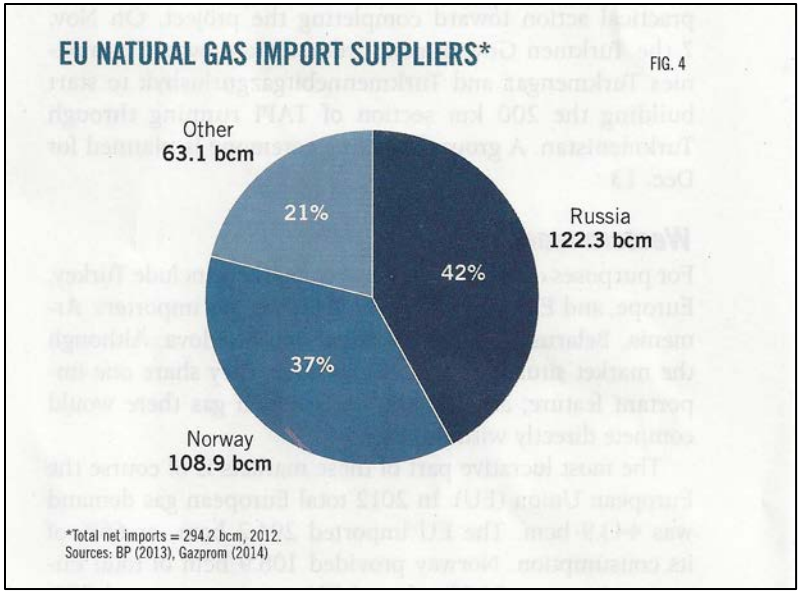


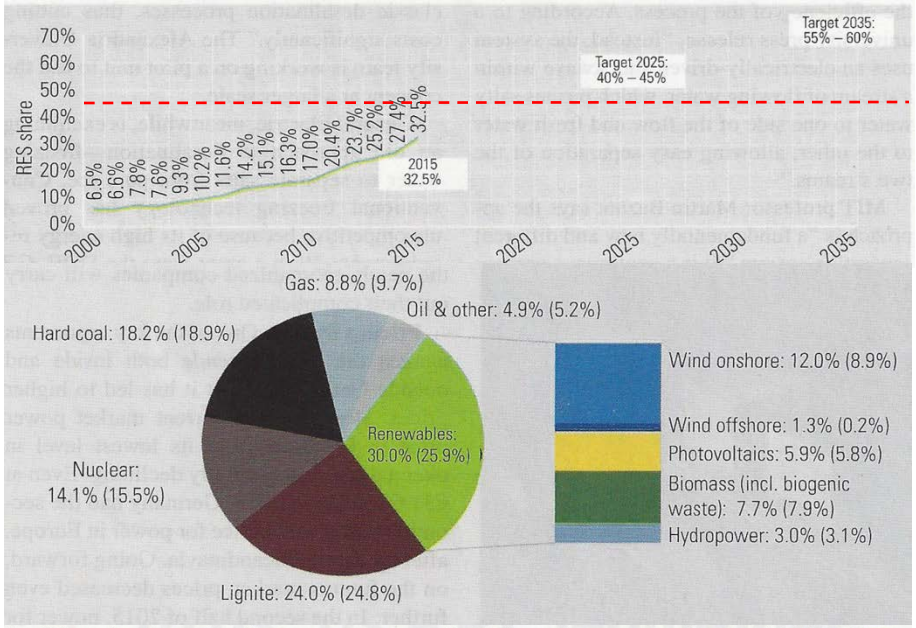
FIG. 4. Existing, proposed and under-construction LNG terminals in Western Europe.



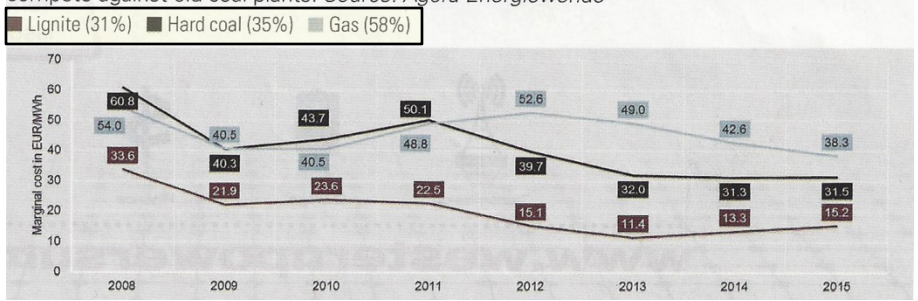
Germany

- Energiewende at a new turning point
- **No more than** 45% renewable energy by 2025
- Goal for completing underground transmission lines for wind in the north to industry in the south by 2022
- Rapidly decreasing load factors are killing financial returns of old-line power producers
- Conventional utilities restructuring into:
  - Legacy assets
  - Renewables
- RWE mothballed a brand new billion-euro Westfalen-D coal-fired plant
  - Damaged at start-up
  - Decision not to correct error, but to de-construct plant
- E.ON applied to shutter two new gas-fired unit in 2015 as unprofitable
- Merit Order Dispatch Consequences
  - First determined based on fuel input cost
  - However, all renewable energy must be absorbed first
  - Dispatch order is solar, wind, hydro, biomass, nuclear, lignite, hard coal, and then natural gas.
  - Germany burns imported hard coal, generating excess capacity, export that capacity elsewhere in Europe
  - New gas plants cannot compete

1. The path to more renewables in Germany. Renewable energy sources (RES) already supply about a third of the country's electricity. *Source: Agora Energiewende; data from AG Energiebilanzen 2015*



3. Marginal costs for new gas and old coal power plants 2008–2015. Despite lower prices for natural gas and slightly higher CO_2 prices, new gas plants cannot compete against old coal plants. *Source: Agora Energiewende*



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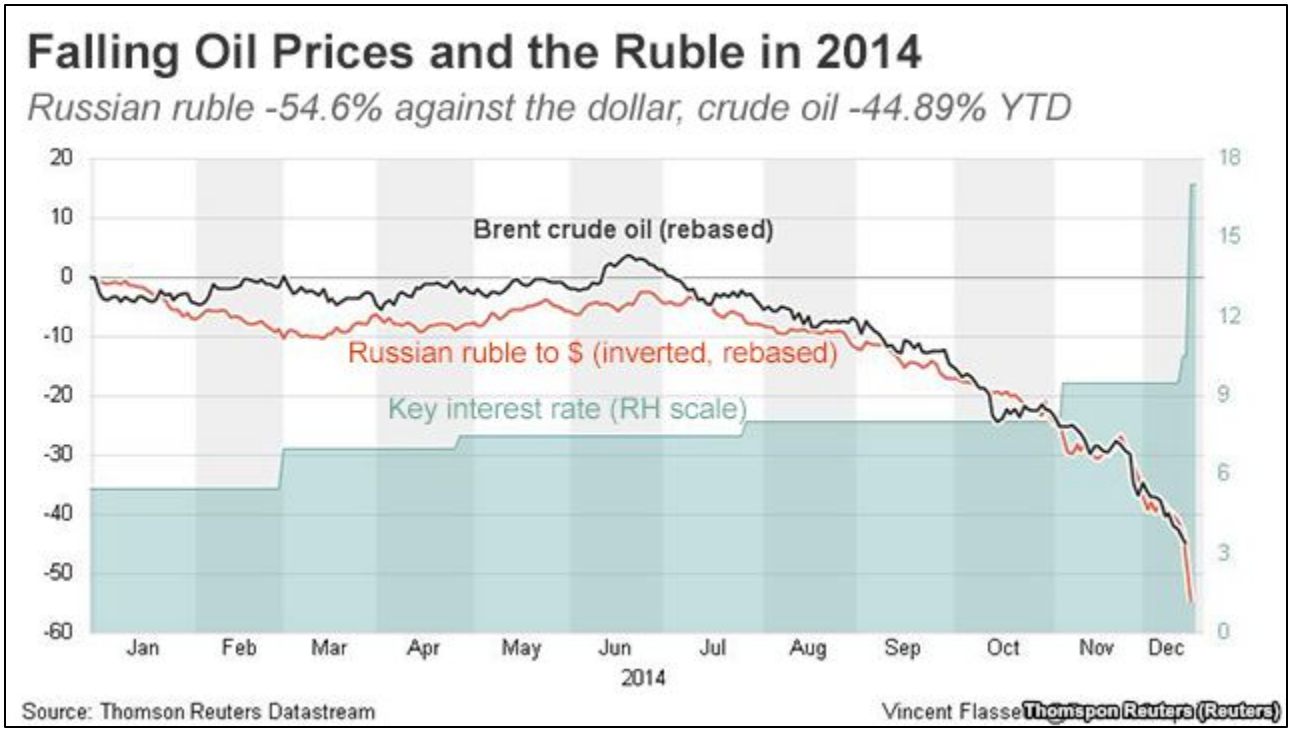
German States to Put Brakes On Green Energy

The German chancellor, Angela Merkel, has hammered out a deal with state premiers on the latest reform to Germany's renewable energy law aimed at curbing the costs and controlling the speed of the roll-out of green power sources.

- The government agreed to cap the expansion of onshore wind power at 2.8 GW in capacity per year
- Only a certain amount of new capacity will be permitted in north Germany to avoid overburdening the grid
- Generous green subsidies have led to a boom in renewable energy
- That rapid expansion has pushed up electricity costs and placed a strain on its grid.
- The latest reforms are aimed at slowing the growth in renewables, which accounted for around a third of Germany's electricity last year, up from 28% in 2014.
- The government will have to put the brakes on growth to avoid overshooting production target of 40-45% renewables of total electricity by 2025
- One of the biggest sticking points in the talks was a plan to limit the amount of onshore wind, with critics saying this would endanger Germany's long-term energy goals and put jobs in the sector at risk.
- The government and states failed to agree on upper limits for biomass, which is important in the southern state of Bavaria, but are expected to be able to clear up this point.
- The draft law is due to come into force at the start of 2017.

Russian Oil Price vs. Ruble Devaluation



Within Russia,
the price of oil (in Ruble)
remains the same

Pete Baldwin

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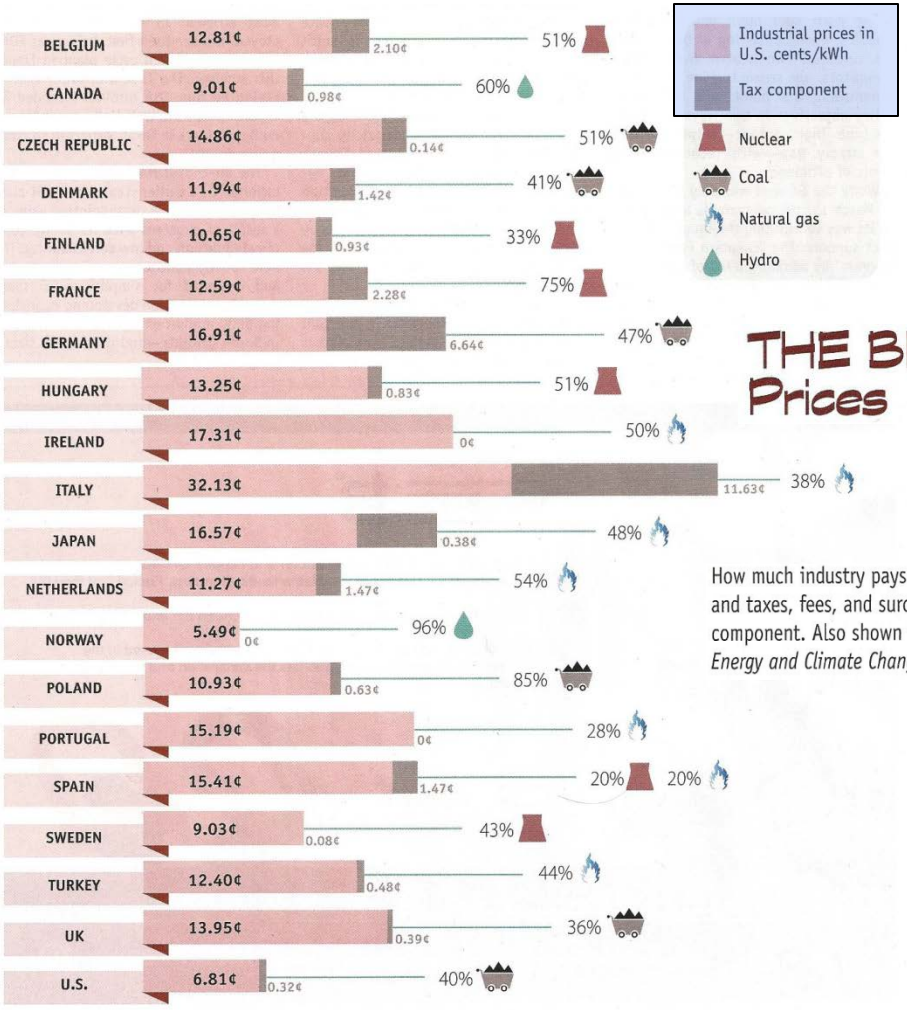
Stray Data

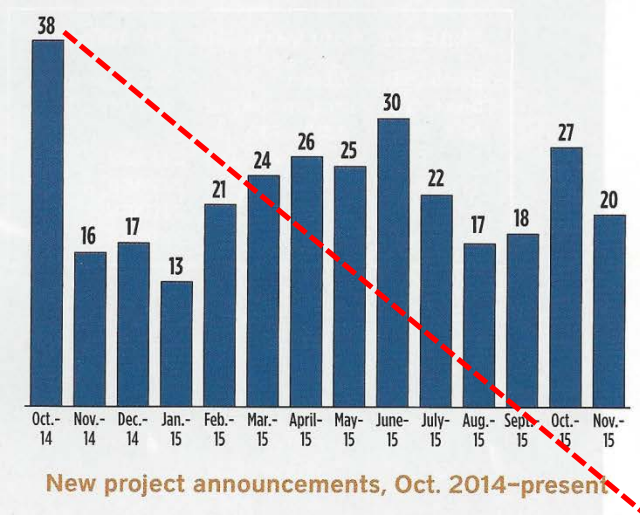
The Big Picture: World Industrial Power Prices



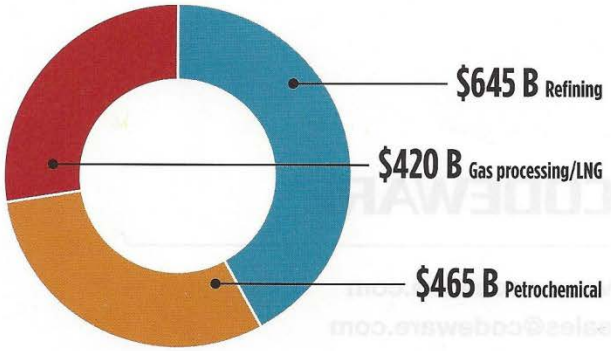
THE BIG PICTURE: World Industrial Power Prices

How much industry pays for power varies tremendously by country, owing to variations in generation costs, network costs, and taxes, fees, and surcharges. This comparison shows average industrial electricity prices in 2013, with each nation's tax component. Also shown is the fuel source that dominated each nation's power mix in 2013. *Source: UK Department of Energy and Climate Change, Eurostat, International Energy Agency* ***—Copy and artwork by Sonal Patel, associate editor***

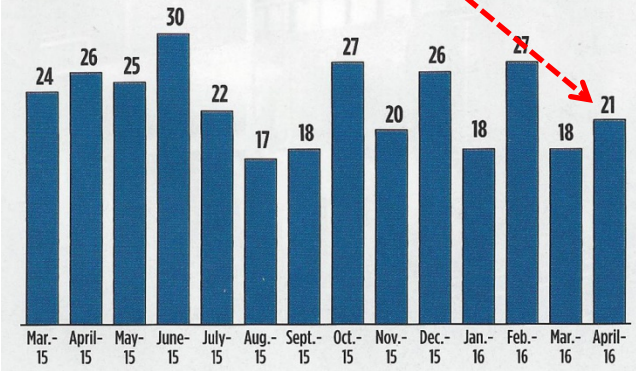
Global Project Data October 2014 vs. April 2016



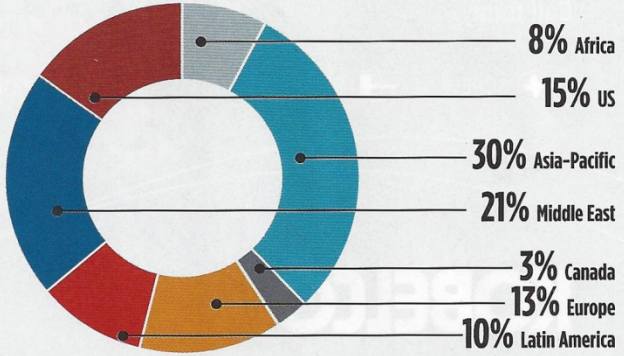
New project announcements, Oct. 2014–present



Total downstream project capital expenditures by sector



Boxscore new project announcements, February 2015–present



Market share breakdown of active downstream projects by region

Capital Spending Forecast

WHERE FUNDS WILL GO FOR US PROJECTS

Table 1

	2016 million $	2016-15 change, %	2015 million $	2015-14 change, %	2014 million $
Exploration-production					
Drilling-exploration	73,332	–40.0	122,220	–37.0	194,000
Production	13,933	–40.0	23,222	–37.0	36,860
OCS lease bonus	500	–10.8	561	–41.6	960
Subtotal	**87,765**	**–39.9**	**146,002**	**–37.0**	**231,820**
Other					
Refining and marketing	14,602	8.0	13,520	4.0	13,000
Petrochemicals	7,728	15.0	6,720	12.0	6,000
Crude and products pipelines	14,970	145.4	6,100	–73.3	22,834
Natural gas pipelines	5,000	61.3	3,100	–62.8	8,344
Other transportation	3,669	16.0	3,163	15.0	2,750
Miscellaneous	2,400	–37.5	3,840	–20.0	4,800
Subtotal	**48,368**	**32.7**	**36,443**	**–32.3**	**53,800**
Total	**136,133**	**–25.4**	**182,445**	**–36.1**	**285,620**

Source: O&G Journal March 7, 2016

Capital Spending Bubbles

Bubbles of capital spending

Conglin Xu
Senior Editor-Economics

The chart in this sidebar shows the real US exploration and production capital spending, measured by real private investments on the structures and equipment used in oil and gas extraction and supporting services, and real West Texas Intermediate prices, over the period 1960 to 2014.

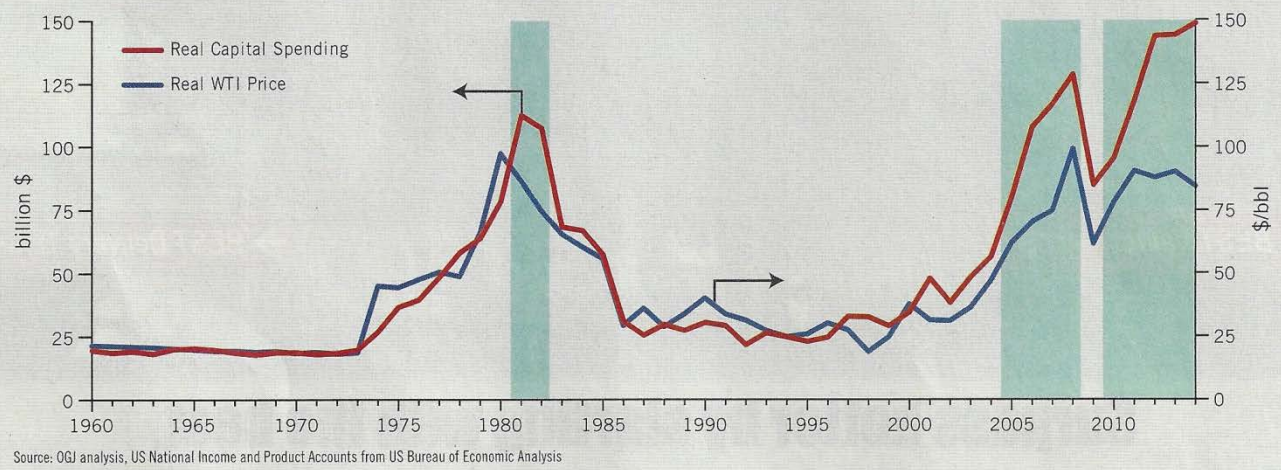
According to the Johansen test, the two series have a cointegrating relation. This means that capital spending and WTI prices share a long-run equilibrium relation and move together with each other over time in the long run.

However, as shown by the shaded areas, capital spending tended to deviate upwards from the "equilibrium" relation when oil prices had been persistently high, e.g. early 1980s, 2005-08, and the last couple of years. These deviations are called "investment bubbles."

The correction period following the fall of oil price brings lots of pains as capital spending has to decline fast to squeeze the large deviations.

REAL CAPITAL SPENDING AND REAL WTI PRICE, 2009 DOLLARS

FIG. 3



Source: OGJ analysis, US National Income and Product Accounts from US Bureau of Economic Analysis

Source: O&G Journal March 7, 2016

AEO2014 Cost & Performance New Generating Tech

Technology	Online Year[1]	Size (MW)	Lead time (years)	Base Overnight Cost in 2013 (2012 $/kW)	Project Contingency Factor[2]	Technological Optimism Factor[3]	Total Overnight Cost in 2013[~] (2012 $/kW)	Variable O&M[~] (2012 $/MWh)	Fixed O&M (2012$/kW-yr.)	Heatrate[6] in 2013 (Btu/kWh)	nth-of-a-kind Heatrate (Btu/kWh)
Scrubbed Coal New	2017	1300	4	2,734	1.07	1.00	2,925	4.47	31.18	8,800	8,740
Integrated Coal-Gasification Comb Cycle (IGCC)	2017	1200	4	3,525	1.07	1.00	3,771	7.22	51.39	8,700	7,450
IGCC with carbon sequestration	2017	520	4	5,958	1.07	1.03	6,567	8.45	72.84	10,700	8,307
Conv Gas/Oil Comb Cycle	2016	620	3	871	1.05	1.00	915	3.60	13.17	7,050	6,800
Adv Gas/Oil Comb Cycle (CC)	2016	400	3	945	1.08	1.00	1,021	3.27	15.37	6,430	6,333
Adv CC with carbon sequestration	2017	340	3	1,856	1.08	1.04	2,084	6.78	31.79	7,525	7,493
Conv Comb Turbine[8]	2015	85	2	924	1.05	1.00	971	15.45	7.34	10,817	10,450
Adv Comb Turbine	2015	210	2	641	1.05	1.00	673	10.37	7.04	9,750	8,550
Fuel Cells	2016	10	3	6,099	1.05	1.10	7,044	42.99	0.00	9,500	6,960
Adv Nuclear	2019	2234	6	4,763	1.10	1.05	5,501	2.14	93.28	10,464	10,464
Distributed Generation - Base	2016	2	3	1,414	1.05	1.00	1,485	7.76	17.45	9,027	8,900
Distributed Generation - Peak	2015	1	2	1,698	1.05	1.00	1,783	7.76	17.45	10,029	9,880
Biomass	2017	50	4	3,590	1.07	1.02	3,919	5.26	105.64	13,500	13,500
Geothermal[7,9]	2016	50	4	2,375	1.05	1.00	2,494	0.00	112.92	9,716	9,716
Municipal Solid Waste	2014	50	3	7,751	1.07	1.00	8,294	8.75	392.81	18,000	18,000
Conventional Hydropower[3]	2017	500	4	2,213	1.10	1.00	2,435	2.65	14.83	9,716	9,716
Wind	2014	100	3	2,061	1.07	1.00	2,205	0.00	39.55	9,716	9,716
Wind Offshore	2017	400	4	4,503	1.10	1.25	6,192	0.00	74.00	9,716	9,716
Solar Thermal[7]	2016	100	3	4,715	1.07	1.00	5,045	0.00	67.26	9,716	9,716
Photovoltaic[7,10]	2015	150	2	3,394	1.05	1.00	3,564	0.00	24.69	9,716	9,716

AEO 2014 Early Release

BP Conversion Factors

Approximate conversion factors

Crude oil*

From	To				
	tonnes (metric)	kilolitres	barrels	US gallons	tonnes per year
	Multiply by				
Tonnes (metric)	1	1.165	7.33	307.86	–
Kilolitres	0.8581	1	6.2898	264.17	–
Barrels	0.1364	0.159	1	42	–
US gallons	0.00325	0.0038	0.0238	1	–
Barrels per day	–	–	–	–	49.8

*Based on worldwide average gravity.

Products

	To convert			
	barrels to tonnes	tonnes to barrels	kilolitres to tonnes	tonnes to kilolitres
	Multiply by			
Liquefied petroleum gas (LPG)	0.086	11.60	0.542	1.844
Gasoline	0.120	8.35	0.753	1.328
Kerosene	0.127	7.88	0.798	1.253
Gas oil/diesel	0.134	7.46	0.843	1.186
Residual fuel oil	0.157	6.35	0.991	1.010
Product basket	0.125	7.98	0.788	1.269

Natural gas (NG) and liquefied natural gas (LNG)

From	To					
	billion cubic metres NG	billion cubic feet NG	million tonnes oil equivalent	million tonnes LNG	trillion British thermal units	million barrels oil equivalent
	Multiply by					
1 billion cubic metres NG	1	35.3	0.90	0.74	35.7	6.60
1 billion cubic feet NG	0.028	1	0.025	0.021	1.01	0.19
1 million tonnes oil equivalent	1.11	39.2	1	0.82	39.7	7.33
1 million tonnes LNG	1.36	48.0	1.22	1	48.6	8.97
1 trillion British thermal units	0.028	0.99	0.025	0.021	1	0.18
1 million barrels oil equivalent	0.15	5.35	0.14	0.11	5.41	1

Units

1 metric tonne	= 2204.62lb = 1.1023 short tons
1 kilolitre	= 6.2898 barrels = 1 cubic metre
1 kilocalorie (kcal)	= 4.187kJ = 3.968Btu
1 kilojoule (kJ)	= 0.239kcal = 0.948Btu
1 British thermal unit (Btu)	= 0.252kcal = 1.055kJ
1 kilowatt-hour (kWh)	= 860kcal = 3600kJ = 3412Btu

Calorific equivalents

One tonne of oil equivalent equals approximately:

Heat units	10 million kilocalories 42 gigajoules 40 million British thermal units
Solid fuels	1.5 tonnes of hard coal 3 tonnes of lignite
Gaseous fuels	See Natural gas and liquefied natural gas table
Electricity	12 megawatt-hours

One million tonnes of oil or oil equivalent produces about 4400 gigawatt-hours (= 4.4 terawatt-hours) of electricity in a modern power station.

1 barrel of ethanol = 0.57 barrel of oil
1 barrel of biodiesel = 0.88 barrel of oil

Low Sulfur Fuel

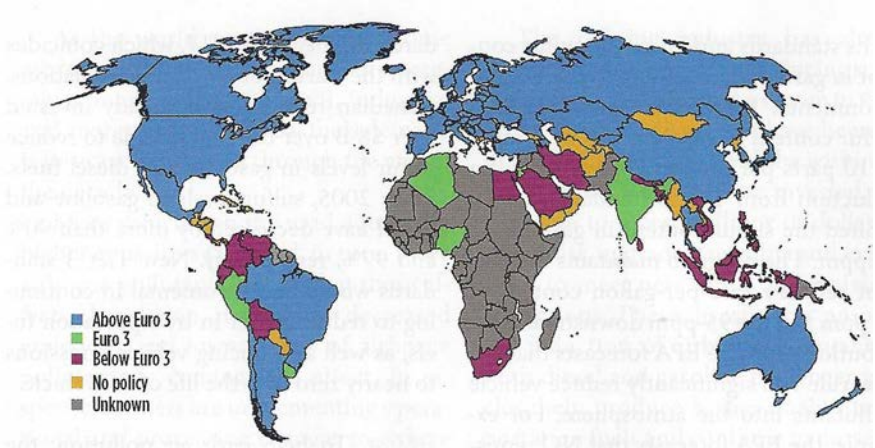


FIG. 1. Vehicle emissions standards: global status as of February 2015. Source: United Nations Environment Program, PCFV Secretariat.

TABLE 1. EU emissions standards for passenger vehicles (gasoline)

	CO, g/km	HC, g/km	NO_x, g/km	PM, g/km
Euro 4	1.0	0.10	0.08	–
Euro 5	1.0	0.10	0.06	–
Euro 6	1.0	0.10	0.06	0.005

TABLE 2. EU emissions standards for passenger vehicles (diesel)

	CO, g/km	HC + NO_x, g/km	NO_x, g/km	PM, g/km
Euro 4	0.50	0.30	0.25	0.025
Euro 5	0.50	0.23	0.18	0.005
Euro 6	0.50	0.17	0.08	0.005

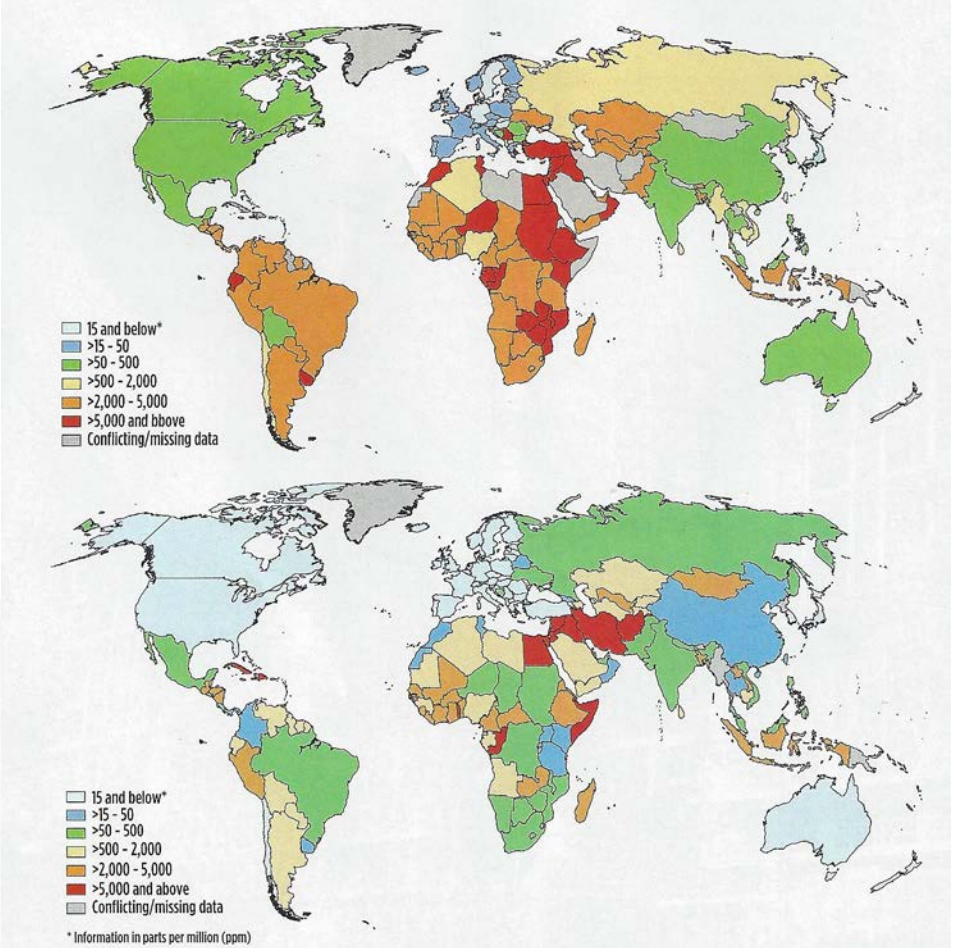
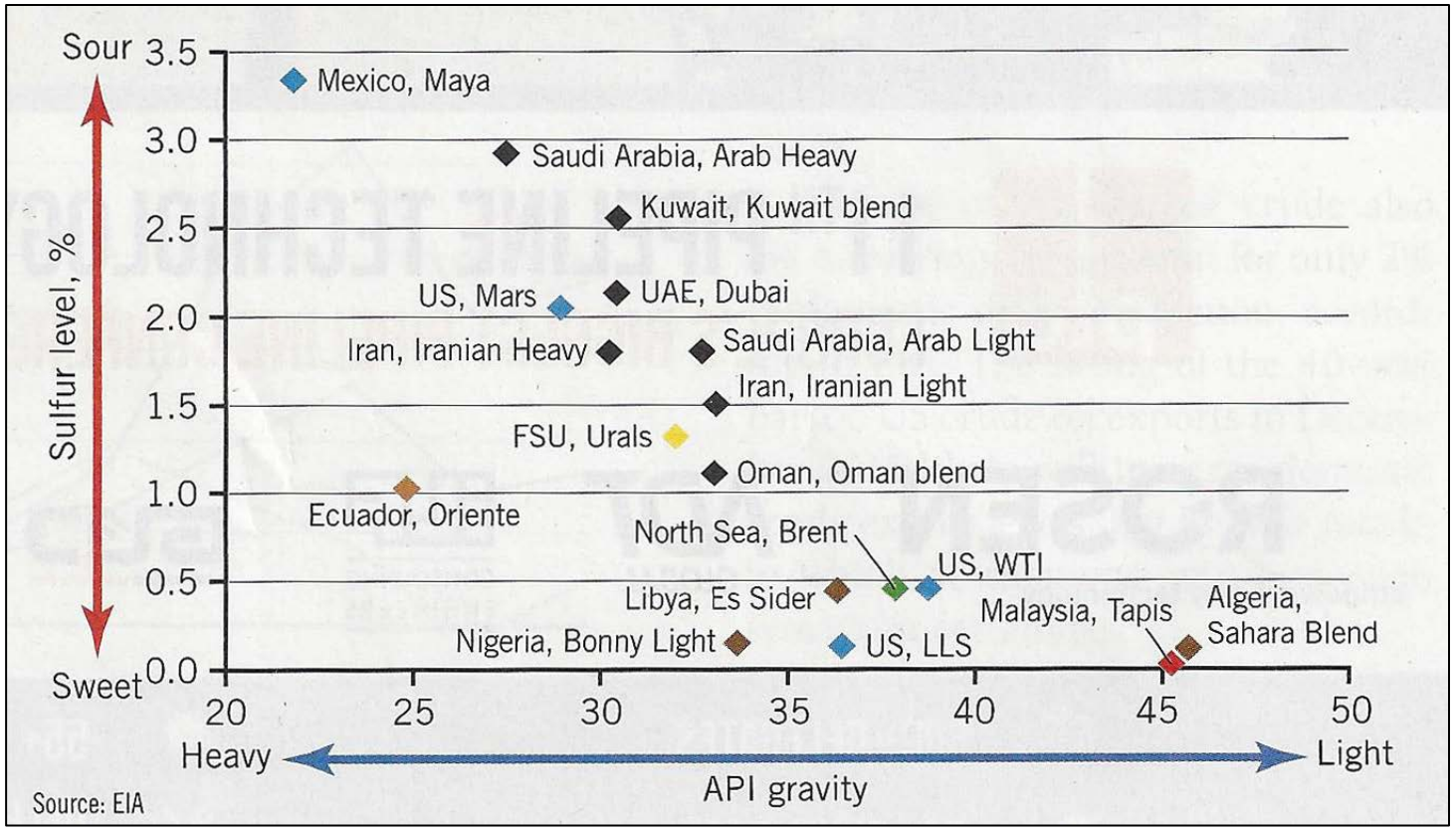


FIG. 1. Sulfur levels in diesel fuel: global status 2005 (top) vs. 2015 (bottom). Source: United Nations Environment Program, PCFV Secretariat.

Source: Hydrocarbon Processing February 2016

Crude Oil Characteristics



Source: EIA through O&G Journal March 7, 2016