IGTI Fuels Report

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Montreal, Canada

pete_baldwin@base-e.net

+1-781-721-6200 (o)

+1-617-306-7419 (m)

Fuel Value Chain Systemic Shocks

- **Oil**
  - Oil price
  - U.S. shale oil production
  - U.S. crude oil export restrictions
- **Natural Gas**
  - Oil-linked price indexing Asia & EU
  - Developing resource worldwide
  - LNG export
  - Russian gas to EU or China
- **Coal**
  - EPA New Source Performance Standard
  - EPA Clean Power Plan
- **Nuclear**
  - Continuing Fukushima effects
- **Renewables**
  - System integration
  - Energy storage
  - Renewable Portfolio Standards (RPS)
  - Production Tax Credits (PTC)
- **Technology**
  - Seismic & imaging tools
  - Horizontal drilling
  - Fracking
- **Environmental Issues**
  - Climate Change
  - Oil-Water nexus
  - Pipelines & tank cars
  - Fracking methods & produced water disposal
  - Canadian "Dirty Oil" resources
  - Nuclear waste disposal
- **Geo-Political Instabilities**
  - Russia/Ukraine
  - Iran Sanctions
  - Iraq/Syria/Yemen/Libya
  - Nigeria/Venezuela
- **Supply Shortfalls**
  - UK
  - Mexico
  - Brazil
- **Territorial Disputes/Issues**
  - South China Sea
  - The Arctic

Primary Energy Consumption by Fuel - Mtoe

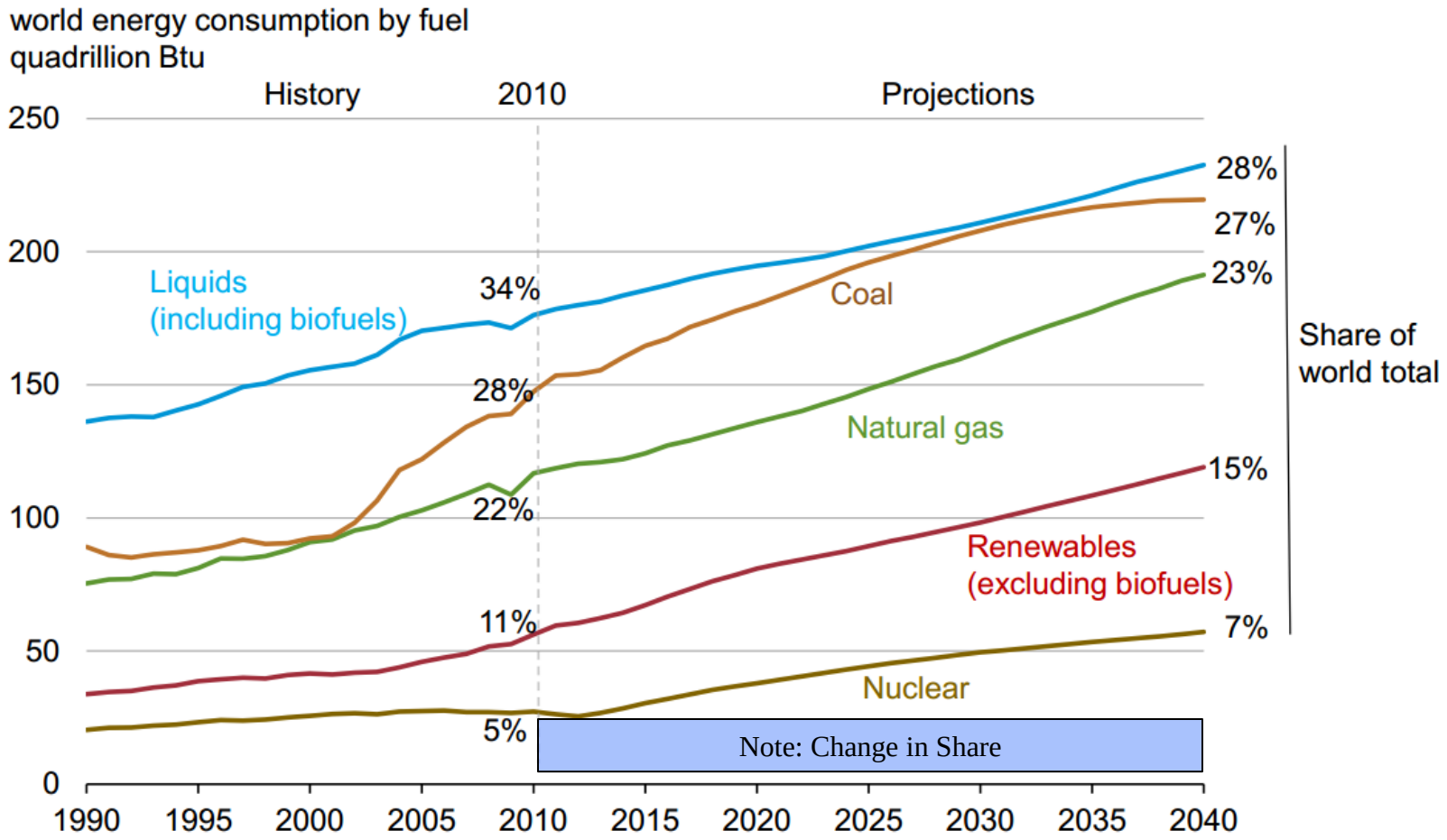
Consumption by fuel*

Million tonnes oil equivalent	Oil	Natural Gas	Coal	Nuclear Energy	Hydro electric	Renew-ables	2013 Total	Oil	Natural Gas	Coal	Nuclear Energy	Hydro electric	Renew-ables	2014 Total	Percent of 2014
US	832.1	675.8	454.6	187.9	61.4	58.7	2270.5	836.1	695.3	453.4	189.8	59.1	65.0	**2298.7**	17.8%
Canada	103.5	93.5	20.8	23.1	88.5	4.8	334.3	103.0	93.8	21.2	24.0	85.7	4.9	**332.7**	2.6%
Mexico	89.7	76.2	13.4	2.7	6.2	3.4	191.5	85.2	77.2	14.4	2.2	8.6	3.7	**191.4**	1.5%
Total North America	**1025.3**	**845.5**	**488.8**	**213.7**	**156.1**	**66.9**	**2796.3**	**1024.4**	**866.3**	**488.9**	**216.1**	**153.5**	**73.6**	**2822.8**	21.8%
Brazil	135.2	33.6	16.5	3.3	88.5	11.9	288.9	142.5	35.7	15.3	3.5	83.6	15.4	**296.0**	2.3%
Total S. & Cent. America	**317.8**	**151.6**	**33.6**	**4.7**	**160.4**	**16.9**	**684.9**	**326.5**	**153.1**	**31.6**	**4.7**	**155.4**	**21.5**	**692.8**	5.4%
France	79.3	38.6	11.8	95.9	15.8	5.9	247.2	76.9	32.3	9.0	98.6	14.2	6.5	**237.5**	1.8%
Germany	113.4	74.2	81.7	22.0	5.2	29.3	325.8	111.5	63.8	77.4	22.0	4.6	31.7	**311.0**	2.4%
Italy	60.8	57.8	14.0	-	11.9	13.4	157.9	56.6	51.1	13.5	-	12.9	14.8	**148.9**	1.2%
Russian Federation	146.8	372.1	90.5	39.0	41.3	0.1	689.9	148.1	368.3	85.2	40.9	39.3	0.1	**681.9**	5.3%
Spain	59.0	26.1	11.4	12.8	8.3	16.3	133.9	59.5	23.7	12.0	13.0	8.9	16.0	**133.0**	1.0%
Turkey	33.6	41.1	31.6	-	13.4	2.3	122.0	33.8	43.7	35.9	-	9.1	2.8	**125.3**	1.0%
Ukraine	11.9	41.0	41.4	18.8	3.1	0.3	116.6	10.2	34.6	33.0	20.0	1.9	0.4	**100.1**	0.8%
United Kingdom	69.3	66.1	37.1	16.0	1.1	11.1	200.6	69.3	60.0	29.5	14.4	1.3	13.2	**187.9**	1.5%
Total Europe & Eurasia	**869.3**	**954.7**	**508.2**	**262.9**	**201.9**	**114.7**	**2911.7**	**858.9**	**908.7**	**476.5**	**266.1**	**195.7**	**124.4**	**2830.3**	21.9%
Iran	95.1	143.4	1.1	0.9	3.4	0.1	244.0	93.2	153.2	1.1	1.0	3.4	0.1	**252.0**	1.9%
Saudi Arabia	132.4	90.0	0.1	-	-	^	222.5	142.0	97.4	0.1	-	-	^	**239.5**	1.9%
Other Middle East	76.8	40.5	0.1	-	2.0	^	119.5	76.0	40.4	0.1	-	1.8	^	**118.3**	0.9%
Total Middle East	**382.5**	**393.9**	**10.3**	**0.9**	**5.4**	**0.2**	**793.3**	**393.0**	**418.6**	**9.7**	**1.0**	**5.2**	**0.3**	**827.9**	6.4%
South Africa	27.8	3.5	88.7	3.4	0.3	0.1	123.6	29.1	3.7	89.4	3.6	0.3	0.6	**126.7**	1.0%
Other Africa	91.0	28.5	7.6	-	23.2	1.3	151.5	93.6	27.4	8.2	-	24.2	1.8	**155.3**	1.2%
Total Africa	**172.2**	**108.2**	**96.6**	**3.4**	**26.4**	**1.8**	**408.6**	**179.4**	**108.1**	**98.6**	**3.6**	**27.5**	**2.9**	**420.1**	3.2%
Australia	46.9	26.3	44.9	-	4.4	3.7	126.2	45.5	26.3	43.8	-	3.3	4.1	**122.9**	1.0%
China	503.5	153.7	1961.2	25.3	208.2	46.1	2898.1	520.3	166.9	1962.4	28.6	240.8	53.1	**2972.1**	23.0%
India	175.3	46.3	324.3	7.5	29.8	12.5	595.7	180.7	45.6	360.2	7.8	29.6	13.9	**637.8**	4.9%
Indonesia	73.1	32.8	57.6	-	3.8	2.2	169.6	73.9	34.5	60.8	-	3.4	2.2	**174.8**	1.4%
Japan	207.5	102.2	128.6	3.3	19.0	9.5	470.1	196.8	101.2	126.5	-	19.8	11.6	**456.1**	3.5%
South Korea	108.3	47.3	81.9	31.4	1.0	0.9	270.8	108.0	43.0	84.8	35.4	0.8	1.1	**273.2**	2.1%
Total Asia Pacific	**1412.1**	**598.8**	**2729.5**	**78.1**	**311.4**	**82.5**	**5212.3**	**1428.9**	**610.7**	**2776.6**	**82.5**	**341.6**	**94.2**	**5334.6**	41.3%
Total World	**4179.1**	**3052.8**	**3867.0**	**563.7**	**861.6**	**283.0**	**12807.1**	**4211.1**	**3065.5**	**3881.8**	**574.0**	**879.0**	**316.9**	**12928.4**	100.0%
	32.6%	23.8%	30.2%	4.4%	6.7%	2.2%	100.0%	32.6%	23.7%	30.0%	4.4%	6.8%	2.5%	100.0%	

513.3 Quads =12,928.4 Mtoe

Source: BP Statistical Review of World Energy 2015

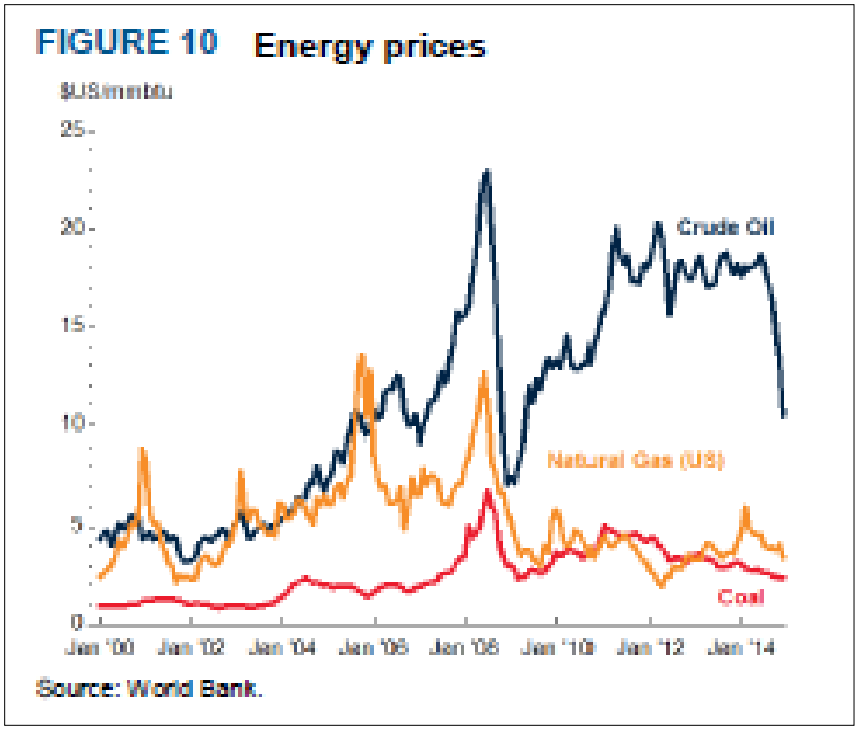
World Energy Consumption - Quads



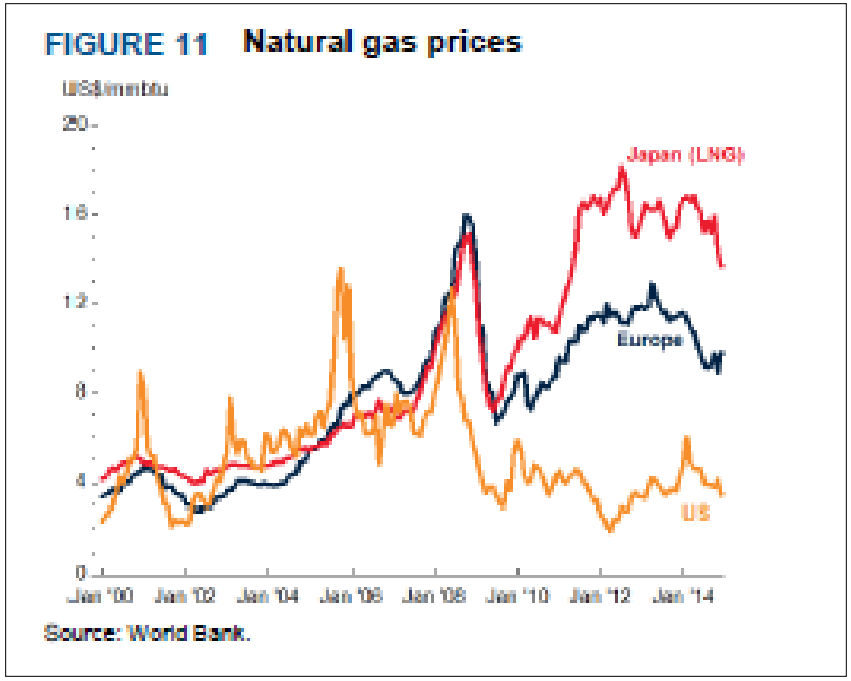
Source: EIA, International Energy Outlook 2013

Energy Pricing

Pricing Anomalies in a State of Flux



Natural Gas differentials driving LNG and/or pipeline investment decisions



Production/Demand Imbalance Driving Oil Price Lower

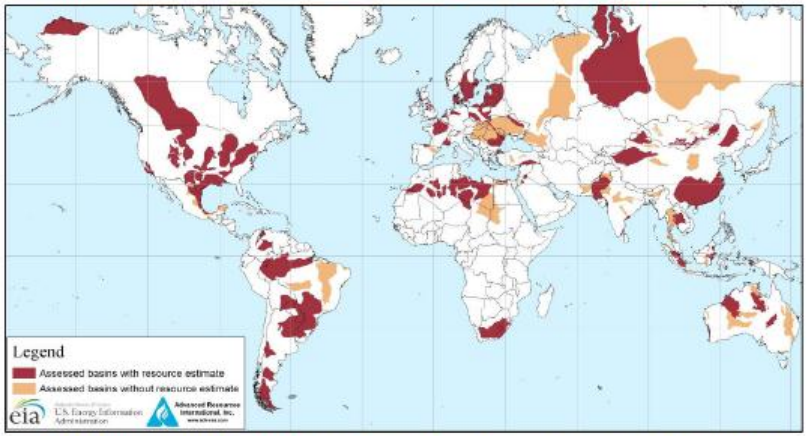
Recoverable Shale Resources - 2013

Table 1. Comparison of the 2011 and 2013 reports

ARI report coverage	2011 Report	2013 Report
Number of countries	32	41
Number of basins	48	95
Number of formations	69	137
Technically recoverable resources, including U.S.		
Shale gas (trillion cubic feet)	6,622	7,299
Shale / tight oil (billion barrels)	32	345

Note: The 2011 report did not include shale oil; however, the *Annual Energy Outlook 2011* did (for only the U.S.) and is included here for completeness

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

Table 5. Top 10 countries with technically recoverable shale oil resources

Rank	Country	Shale oil (billion barrels)	
1	Russia	75	
2	U.S.[1]	58	(48)
3	China	32	
4	Argentina	27	
5	Libya	26	
6	Venezuela	13	
7	Mexico	13	
8	Pakistan	9	
9	Canada	9	
10	Indonesia	8	
	World Total	345	(335)

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

Table 6. Top 10 countries with technically recoverable shale gas resources

Rank	Country	Shale gas (trillion cubic feet)	
1	China	1,115	
2	Argentina	802	
3	Algeria	707	
4	U.S.[1]	665	(1,161)
5	Canada	573	
6	Mexico	545	
7	Australia	437	
8	South Africa	390	
9	Russia	285	
10	Brazil	245	
	World Total	7,299	(7,795)

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

A Decade of Reserve Changes

A DECADE OF RESERVES CHANGES

Table 1

Jan. 1	World (1,000 bbl)		OPEC (1,000 bbl)		World gas, bcf	
2015	1,655,924,908		1,206,170,000		6,966,138	
2014	1,647,444,295		1,200,840,000		6,942,320	
2013	1,640,497,209		1,199,710,000		6,871,924	
2012	1,520,094,835		1,112,850,000		6,746,581	
2011	1,469,614,970	28%	1,064,790,000	33%	6,647,341	14%
2010	1,354,182,395		951,277,000		6,609,346	
2009	1,342,207,320		944,017,000		6,254,363	
2008	1,331,698,077		927,482,000		6,185,693	
2007	1,317,447,415		902,343,000		6,182,692	
2006	1,293,344,534		901,659,000		6,101,158	

Source: OGJ Worldwide Production Reports

RUSSIAN OIL PRODUCTION

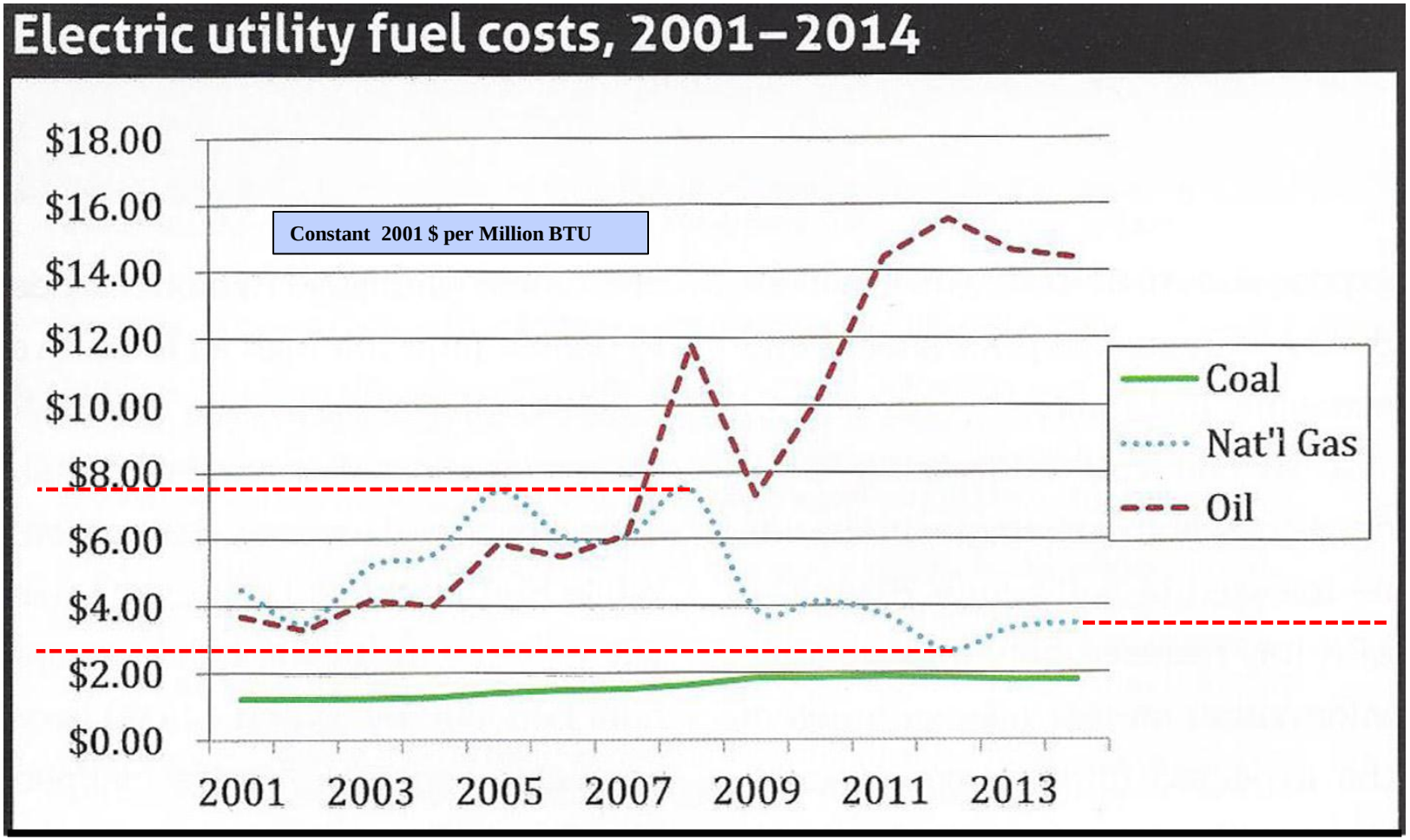
Table 2

	1,000 b/d	
2014*	10,490	
2013	10,423	
2012	10,318	
2011	10,330	
2010	10,200	
2009	9,917	14%
2008	9,750	
2007	9,830	
2006	9,498	
2005	9,190	

*Estimate.

O&G Journal Dec 2014

U.S. Electric Utility Fuel Cost – 2001 to 2014



Source: ACCCE, Trisko (2014)

Competitive Positioning Based on EPA NSPS-2014

Case 12 vs. Case 13
- 5X first cost
- ½ the efficiency
- Coal cost up 44% since 2010
- Coal cost up 80% since original 2007 baseline

		Supercritical PC			NGCC
Case		11	12	13	14
CO2 Capture		No	Yes	No	Yes
Gross Power Output - kWe		580,400	662,800	564,700	511,000
Auxilliary Power Requirements - kWe		30,410	112,830	9,620	37,430
Report Net Power Output - kWe		549,990	549,970	555,080	473,570
Net Plant HHV Efficiency - %		39.30%	28.40%	50.20%	42.80%
Net Plant HHV Heat Rate - Btu/kWh		8,687	12,002	6,798	7,968
Total Plant Cost - $/kW		1995	3583	725	1509
Total Overnight Cost - $/kW		2452	4391	891	1842
Total as Spent Cost - $/kW		2782	5006	957	1986
LCOE - mils/kWh		80.95	137.28	59.59	86.58
CO2 Emissions - lb/MWh		1768	244	804	94
$/MMBtu		2.94	2.94	6.13	6.13
Load Factor		85%	85%	85%	85%
kW Nominal Gross		580,411	662,836	559,532	593,471
550,000	kW Nominal Net	550,000	550,000	550,000	550,000
Total as Spent Capital		$1,529,834,783	$2,753,292,297	$526,223,607	$1,092,280,160
Cost Premium vs. NGCC Case 13		1,003,611,175	2,227,068,690	–	566,056,553
kWh/year		4,095,300,000	4,095,300,000	4,095,300,000	4,095,300,000
MMBtu/year		35,575,871	49,151,791	27,839,849	32,631,350
Annual Fuel		$104,593,061	$144,506,264	$170,658,277	$200,030,178
Fuel Cost vs. NGCC Case 13		($66,065,216)	($26,152,012)	–	$29,371,901
LCOE		$331,514,535	$562,202,784	$244,038,927	$354,571,074
Fuel%		31.6%	25.7%	69.9%	56.4%
$60.00	per tonne	$197,051	$27,194	$90,438	$9,021
CO2 Cost vs. NGCC Case 13		$106,612	($63,244)	–	($81,417)
tonnes-CO2/year		3,284	453	1,507	150

Source data:
DOE/NETL- Baseline
341/082312
August 2012

DOE/NETL- Baseline
2010/1397
November 2010

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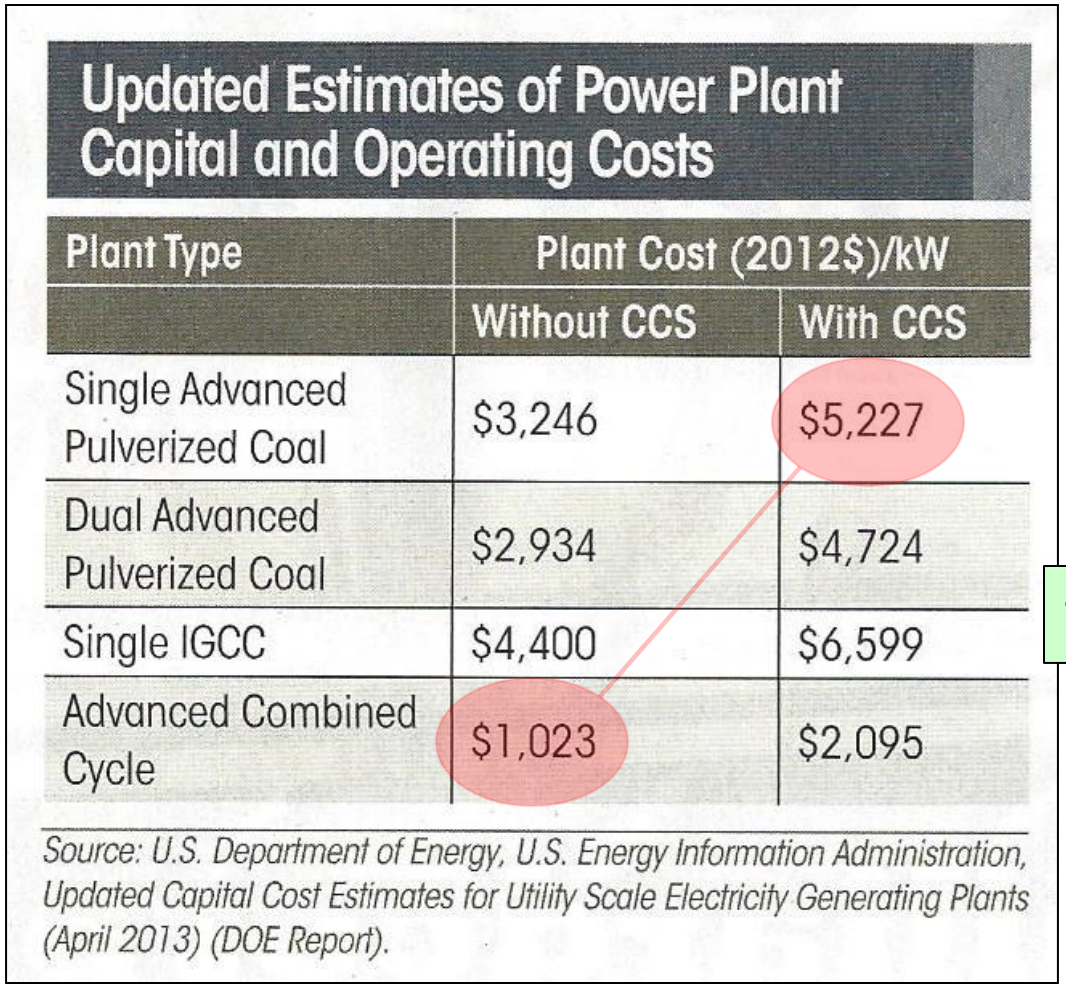
"Practical Strategies for Emerging Energy Technologies"

At $4.00/mmBtu gas
LCOE for NGCC is 1/3 of Coal w/CCS

Power Engineering



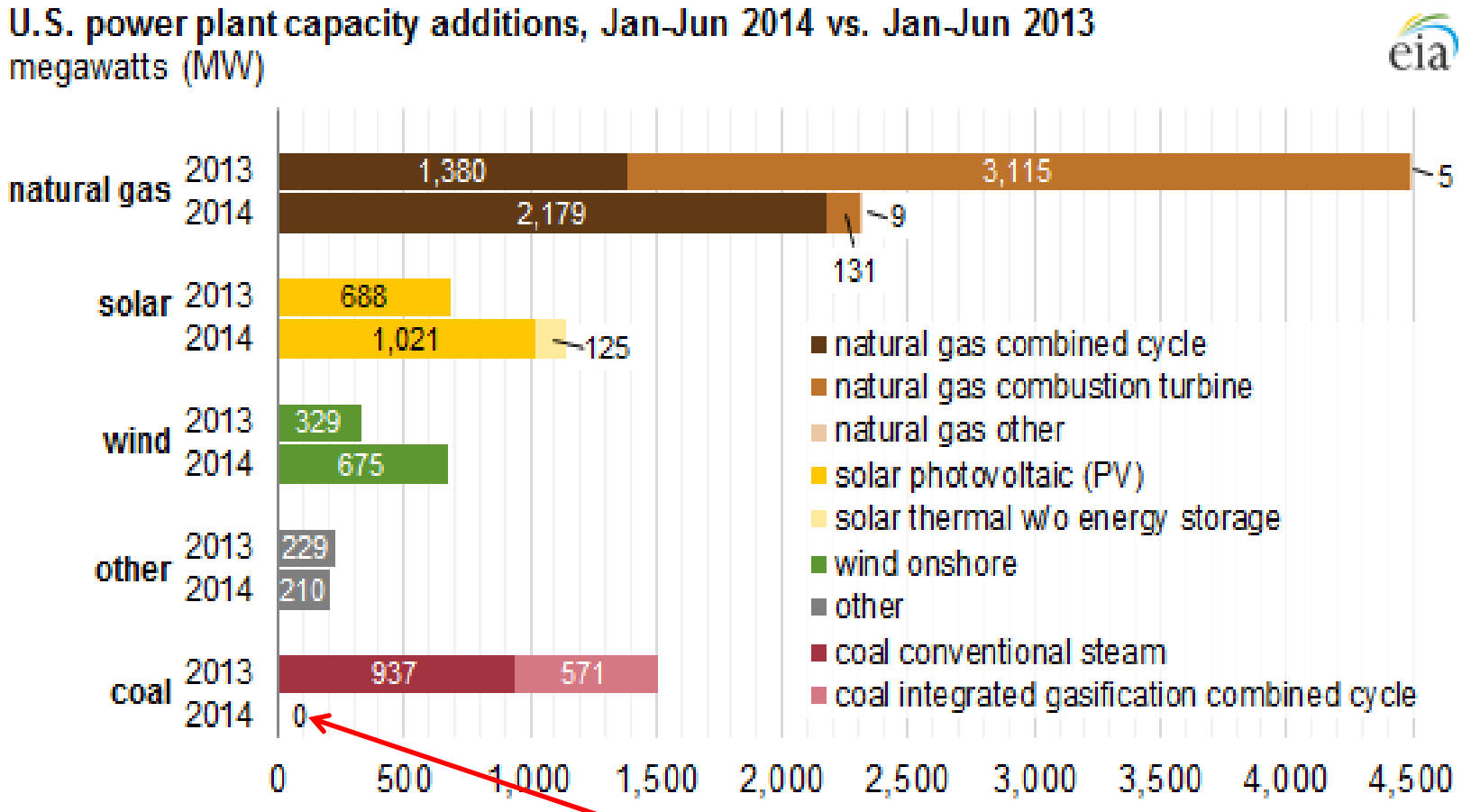
Updated Estimates of Power Plant Capital and Operating Costs

Plant Type	Plant Cost (2012$)/kW	
	Without CCS	With CCS
Single Advanced Pulverized Coal	$3,246	$5,227
Dual Advanced Pulverized Coal	$2,934	$4,724
Single IGCC	$4,400	$6,599
Advanced Combined Cycle	$1,023	$2,095

Source: U.S. Department of Energy, U.S. Energy Information Administration, Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants (April 2013) (DOE Report).

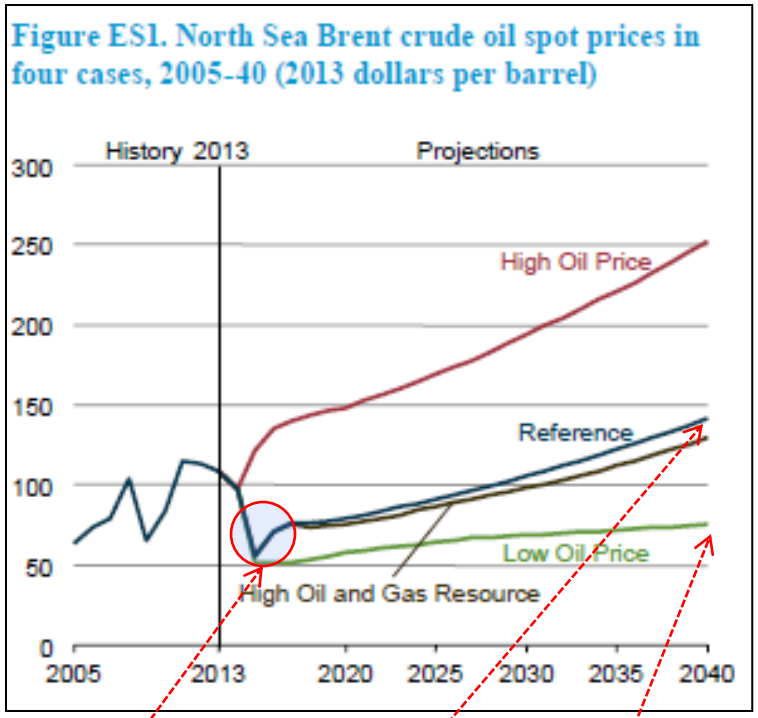
"It's still 5X"

U.S. Power Plant Addition 2013-2014 (6 mos.)



It's working exactly as planned! And, BTW, killing CCS and Nuclear in the process

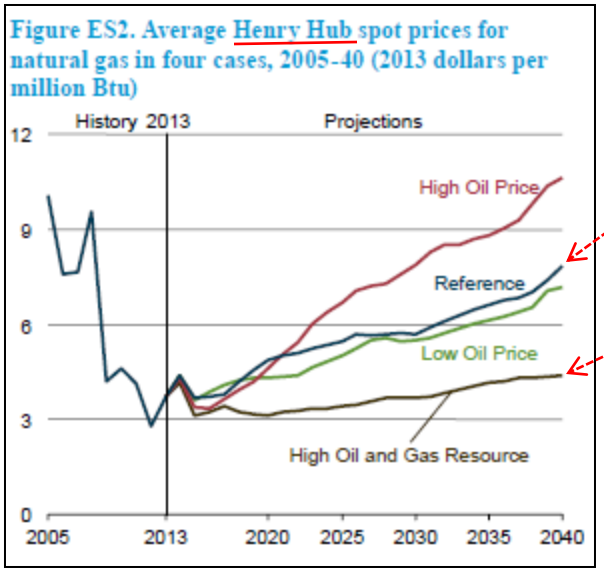
AEO 2015 Long Term Fuel Cost Scenarios



"UP"

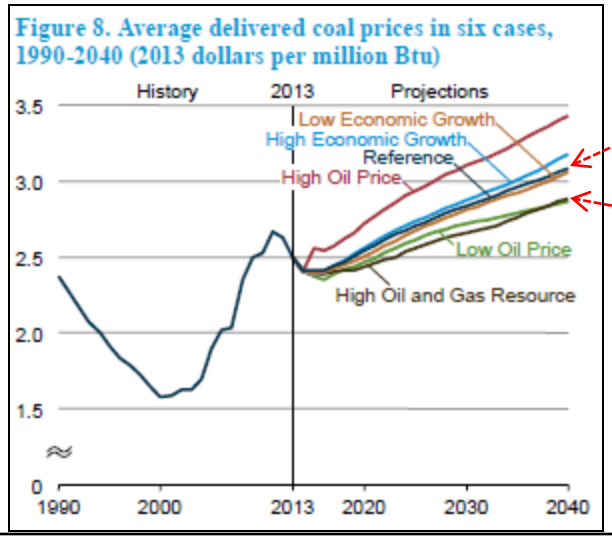
$140

$75



$7.80

$4.50



$3.10

$2.75

base e

"Practical Strategies for Emerging Energy Technologies"

Oil

Crude Oil Consumption – 92.1 MMbbl/d

Oil: Consumption *

Thousand barrels daily	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change 2014 over 2013	2014 share of total	
US	20732	20802	20687	20680	19490	18771	19180	18882	18490	18961	**19035**	0.5%	19.9%	
Canada	2309	2288	2295	2361	2315	2190	2316	2404	2372	2383	**2371**	-0.5%	2.4%	
Mexico	1983	2030	2019	2067	2054	1996	2014	2043	2063	2020	**1941**	-5.0%	2.0%	
Total North America	**25023**	**25119**	**25002**	**25109**	**23860**	**22957**	**23511**	**23330**	**22926**	**23364**	**23347**	**-0.1%**	**24.3%**	**1/3**
Brazil	2050	2108	2139	2297	2452	2486	2701	2813	2860	3048	**3229**	5.4%	3.4%	
Total S. & Cent. America	**5058**	**5214**	**5384**	**5672**	**5911**	**5930**	**6220**	**6454**	**6599**	**6913**	**7125**	**2.7%**	**7.8%**	
France	1963	1946	1942	1911	1889	1822	1763	1730	1676	1664	**1615**	-3.0%	1.8%	
Germany	2619	2592	2609	2380	2502	2409	2445	2369	2356	2408	**2371**	-1.7%	2.6%	
Italy	1850	1798	1791	1740	1661	1563	1532	1475	1346	1288	**1200**	-6.9%	1.3%	
Russian Federation	2660	2679	2761	2780	2866	2774	2895	3096	3137	3179	**3196**	0.9%	3.5%	
Spain	1575	1594	1592	1613	1557	1473	1394	1377	1285	1194	**1205**	0.8%	1.4%	
United Kingdom	1766	1806	1788	1716	1683	1610	1588	1532	1520	1494	**1501**	♦	1.6%	
Total Europe & Eurasia	**20076**	**20199**	**20366**	**20098**	**20017**	**19210**	**19125**	**19007**	**18551**	**18450**	**18252**	**-1.2%**	**20.4%**	**1/3**
Iran	1549	1700	1845	1875	1960	2012	1874	1910	1928	2038	**2024**	-2.0%	2.2%	
Saudi Arabia	1913	2013	2084	2203	2378	2593	2793	2838	2991	3000	**3185**	7.3%	3.4%	
Total Middle East	**5940**	**6346**	**6469**	**6764**	**7212**	**7530**	**7766**	**7985**	**8296**	**8450**	**8706**	**2.8%**	**9.3%**	
Other Africa	1470	1535	1536	1578	1699	1740	1828	1737	1861	1924	**1985**	2.9%	2.2%	
Total Africa	**2777**	**2919**	**2923**	**3062**	**3229**	**3301**	**3479**	**3390**	**3561**	**3650**	**3800**	**4.2%**	**4.3%**	
Australia	865	897	930	937	950	943	955	997	1029	1022	**998**	-2.9%	1.1%	
China	6740	6923	7437	7817	7937	8212	9266	9791	10231	10664	**11056**	3.3%	12.4%	
India	2556	2606	2737	2941	3077	3237	3319	3488	3685	3727	**3846**	3.0%	4.3%	
Indonesia	1299	1285	1247	1299	1294	1334	1458	1567	1599	1615	**1641**	1.0%	1.8%	
Japan	5270	5354	5174	5014	4848	4389	4442	4439	4688	4521	**4298**	-5.2%	4.7%	**1/3**
Singapore	732	796	848	922	974	1049	1157	1216	1204	1235	**1273**	2.3%	1.6%	
South Korea	2294	2312	2320	2399	2308	2339	2370	2394	2458	2455	**2456**	-0.3%	2.6%	
Taiwan	1057	1053	1052	1110	1005	982	1011	946	946	980	**992**	1.0%	1.0%	
Thailand	1025	1041	1023	1026	1007	1062	1118	1170	1244	1255	**1274**	1.6%	1.3%	
Total Asia Pacific	**24232**	**24614**	**25184**	**26035**	**25887**	**26138**	**27766**	**28808**	**29914**	**30415**	**30856**	**1.2%**	**33.9%**	
Total World	**83107**	**84411**	**85328**	**86741**	**86115**	**85066**	**87867**	**88974**	**89846**	**91243**	**92086**	**0.8%**	**100.0%**	

Source: BP Statistical Review of World Energy 2015

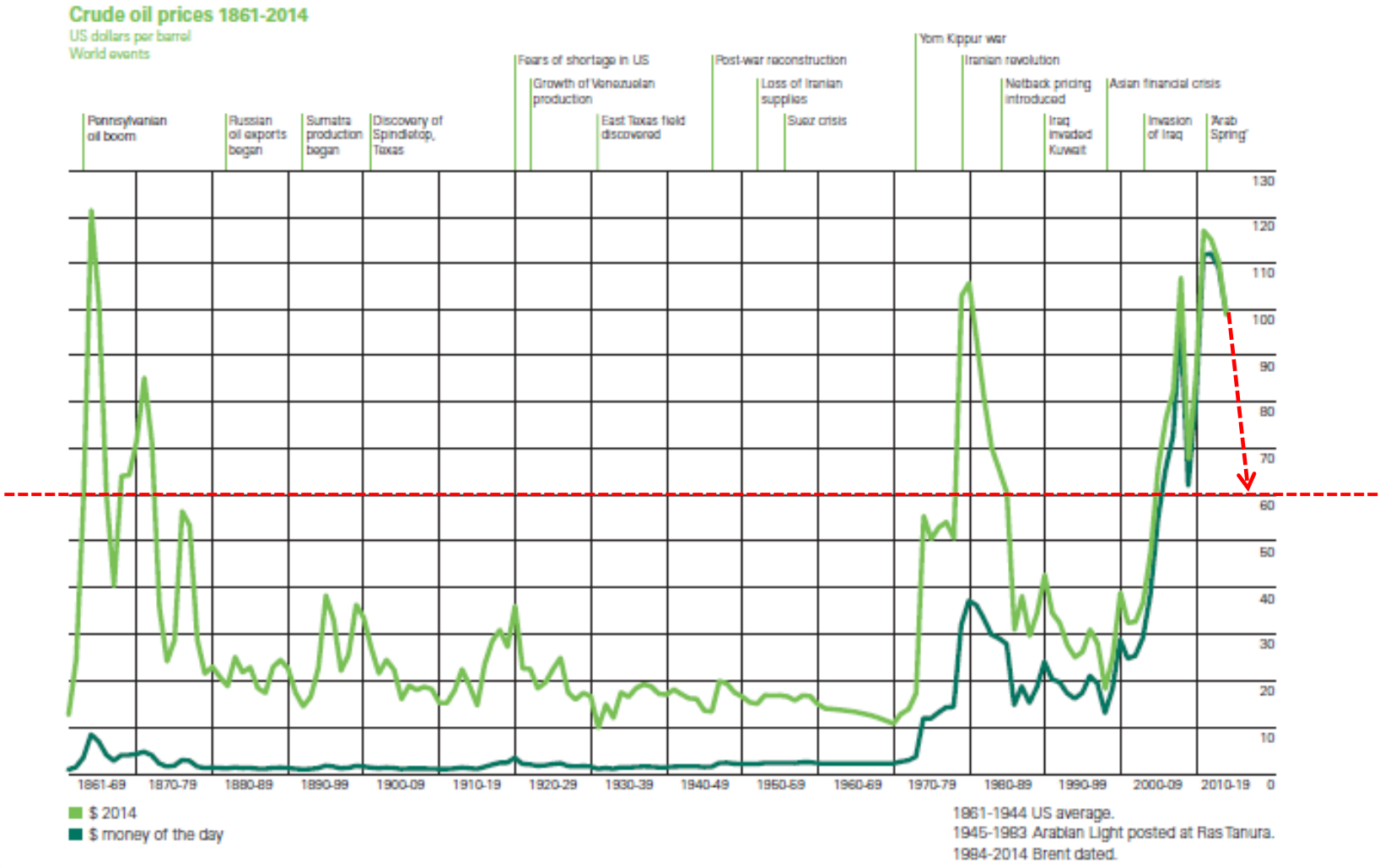
Crude Oil Production – 88.6 MMbbl/d

Oil: Production *

Thousand barrels daily	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	Change 2014 over 2013	2014 share of total
US	7250	6897	6827	6860	6784	7260	7556	7861	8904	10069	**11644**	15.9%	12.3%
Canada	3080	3041	3208	3290	3207	3202	3332	3515	3740	3977	**4292**	7.9%	5.0%
Mexico	3830	3766	3689	3479	3165	2978	2959	2940	2911	2875	**2784**	-3.3%	3.2%
Total North America	**14160**	**13704**	**13724**	**13629**	**13156**	**13441**	**13847**	**14316**	**15555**	**16921**	**18721**	**10.5%**	**20.5%**
Brazil	1543	1713	1809	1833	1899	2029	2137	2193	2149	2114	**2346**	11.2%	2.9%
Colombia	528	526	529	531	588	671	786	915	944	1004	**990**	-1.4%	1.2%
Venezuela	3305	3308	3336	3230	3222	3033	2838	2734	2704	2687	**2719**	1.1%	3.3%
Total S. & Cent. America	**7166**	**7339**	**7479**	**7322**	**7398**	**7326**	**7350**	**7379**	**7317**	**7335**	**7613**	**3.9%**	**9.3%**
Azerbaijan	309	445	646	856	895	1014	1023	919	872	877	**848**	-3.3%	1.0%
Kazakhstan	1248	1294	1368	1413	1485	1609	1672	1684	1662	1720	**1701**	-1.2%	1.9%
Norway	3180	2961	2772	2551	2466	2349	2136	2040	1917	1838	**1895**	2.9%	2.0%
Russian Federation	9335	9598	9818	10044	9950	10139	10366	10516	10640	10777	**10838**	0.6%	12.7%
United Kingdom	2064	1843	1666	1659	1555	1477	1361	1116	949	867	**850**	-2.3%	0.9%
Total Europe & Eurasia	**17572**	**17524**	**17587**	**17799**	**17576**	**17757**	**17692**	**17385**	**17119**	**17155**	**17198**	**0.2%**	**19.8%**
Iran	4201	4184	4260	4303	4396	4249	4352	4373	3742	3525	**3614**	2.0%	4.0%
Iraq	2030	1833	1999	2143	2428	2452	2490	2801	3116	3141	**3285**	4.6%	3.8%
Kuwait	2523	2668	2737	2663	2786	2511	2562	2915	3172	3135	**3123**	-0.5%	3.6%
Oman	783	777	738	710	757	813	865	885	918	942	**943**	0.3%	1.1%
Qatar	1082	1149	1241	1279	1449	1416	1655	1850	1968	1998	**1982**	-0.9%	2.0%
Saudi Arabia	10458	10931	10671	10268	10663	9663	10075	11144	11635	11393	**11505**	0.9%	12.9%
United Arab Emirates	2836	2922	3099	3001	3026	2723	2895	3325	3406	3648	**3712**	0.9%	4.0%
Total Middle East	**24873**	**25518**	**25734**	**25305**	**26417**	**24727**	**25777**	**28088**	**28502**	**28198**	**28555**	**1.1%**	**31.7%**
Algeria	1921	1990	1979	1992	1969	1775	1689	1642	1537	1485	**1525**	1.8%	1.6%
Angola	1103	1404	1421	1684	1901	1804	1863	1726	1784	1799	**1712**	-4.9%	2.0%
Egypt	701	672	679	698	715	730	725	714	715	714	**717**	0.5%	0.8%
Nigeria	2430	2502	2392	2265	2113	2211	2509	2450	2395	2302	**2361**	2.5%	2.7%
Total Africa	**9313**	**9891**	**9945**	**10194**	**10203**	**9849**	**10095**	**8524**	**9275**	**8684**	**8263**	**-5.0%**	**9.3%**
China	3486	3642	3711	3742	3814	3805	4077	4074	4155	4216	**4246**	0.7%	5.0%
India	773	737	760	768	803	816	882	916	906	906	**895**	-1.3%	1.0%
Indonesia	1130	1096	1018	972	1006	994	1003	952	918	882	**852**	-3.5%	1.0%
Total Asia Pacific	**7854**	**7988**	**7947**	**7970**	**8097**	**8049**	**8428**	**8288**	**8382**	**8286**	**8324**	**0.5%**	**9.4%**
Total World	**80938**	**81963**	**82417**	**82220**	**82847**	**81149**	**83190**	**83980**	**86150**	**86579**	**88673**	**2.3%**	**100.0%**

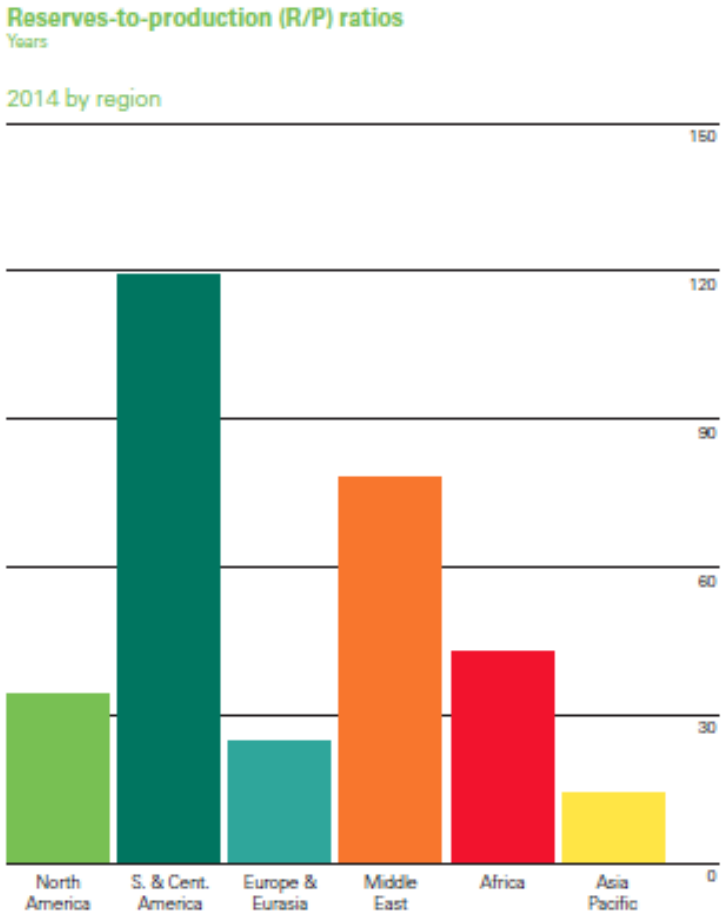
Source: BP Statistical Review of World Energy 2015

Crude Oil Prices - $/bbl

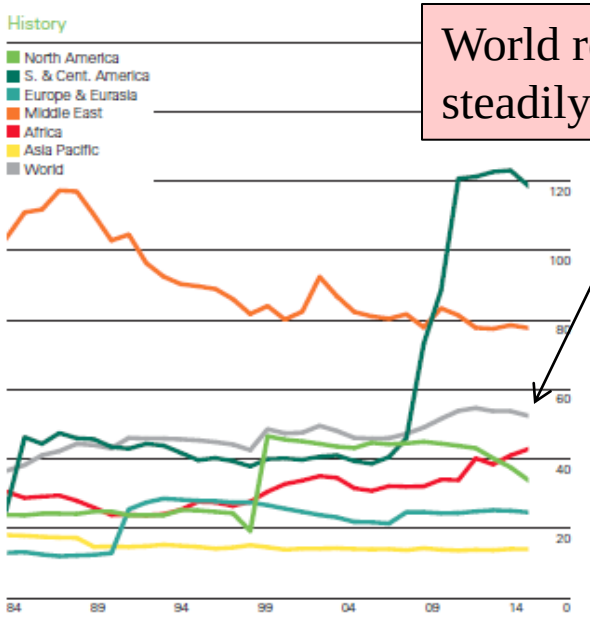


Source: BP Statistical Review of World Energy 2015

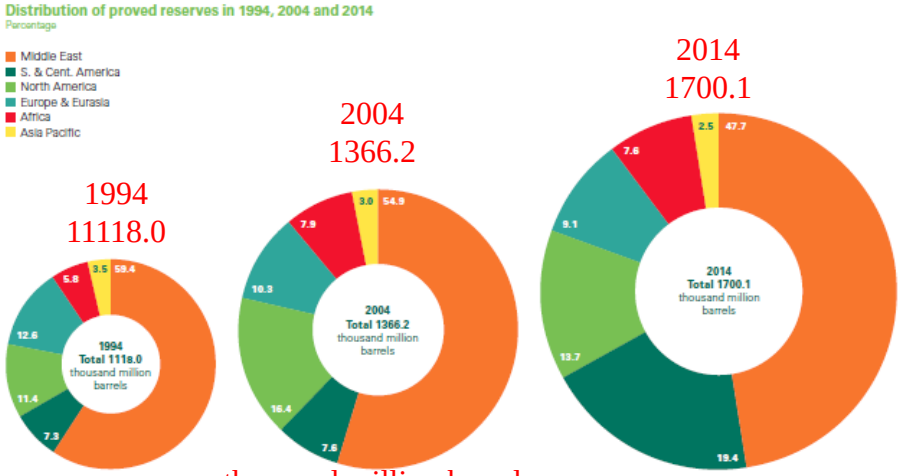
Crude Oil to Production Ratio - 2014



Source: BP Statistical Review of World Energy 2015



World reserves are steadily increasing



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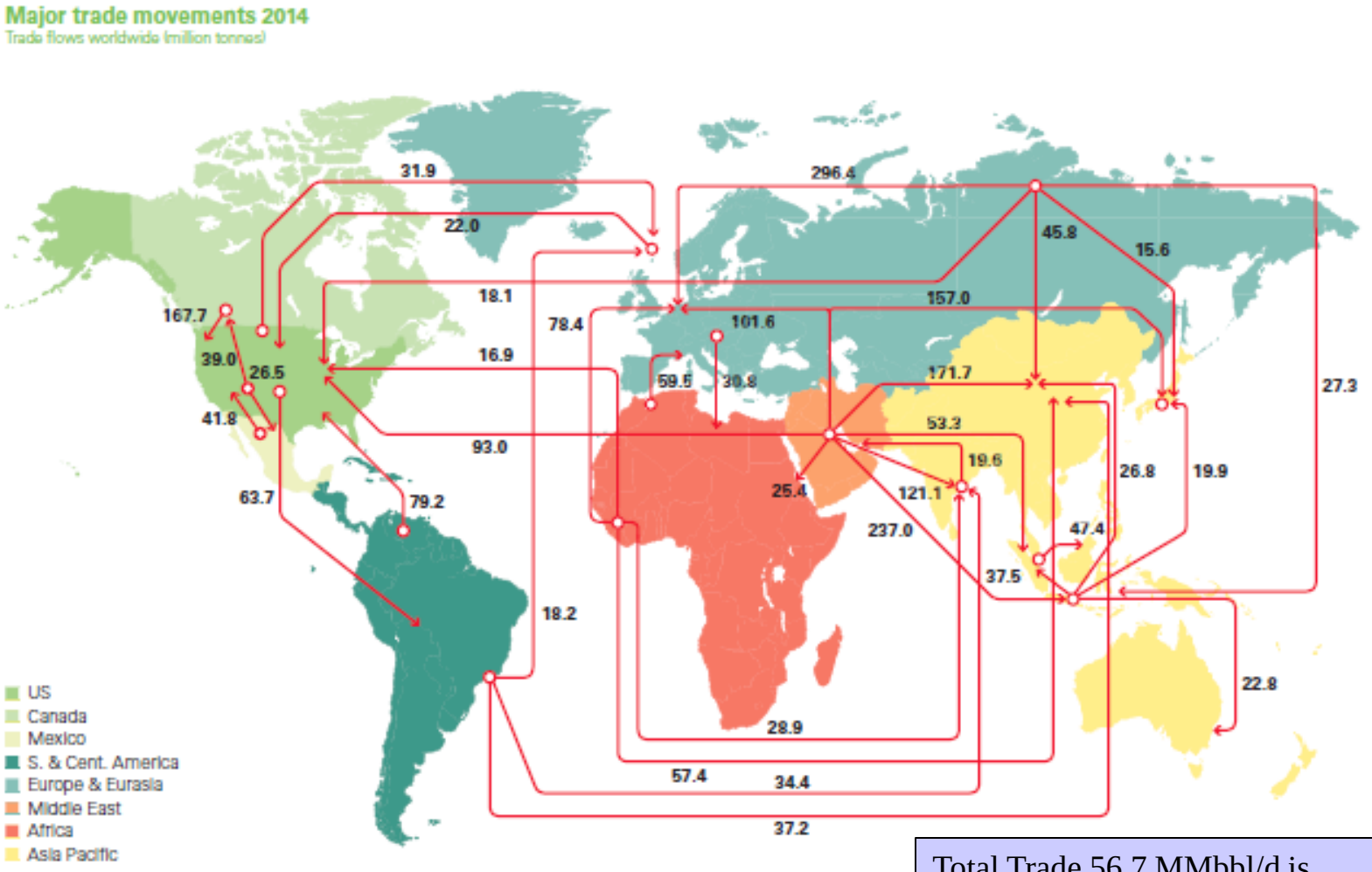
Crude Oil Trade Movements -2014



Total Trade 56.7 MMbbl/d is approximately 2/3rd of consumption

Source: BP Statistical Review of World Energy 2015

World Oil Choke Points

Table 1. Volume of crude oil and petroleum products transported through world chokepoints, 2009-13

Location	2009	2010	2011	2012	2013
Strait of Hormuz	15.7	15.9	17.0	16.9	17.0
Strait of Malacca	13.5	14.5	14.6	15.1	15.2
Suez Canal and SUMED Pipeline	3.0	3.1	3.8	4.5	4.6
Bab el-Mandab	2.9	2.7	3.4	3.7	3.8
Danish Straits	3.0	3.2	3.3	3.1	3.3
Turkish Straits	2.8	2.8	3.0	2.9	2.9
Panama Canal	0.8	0.7	0.8	0.8	0.8
World maritime oil trade	53.9	55.5	55.6	56.7	56.5
World total oil supply	84.9	87.5	87.8	89.7	90.1

- 36% of World Oil Supply
- 57% of World Maritime Oil Trade

Figure 2. Map of the Strait of Hormuz

Source: U.S. Government (See full map for alternate routes)

Figure 3. Map of the Strait of Malacca

Source: CIA Factbook (See closer view of Strait of Malacca)

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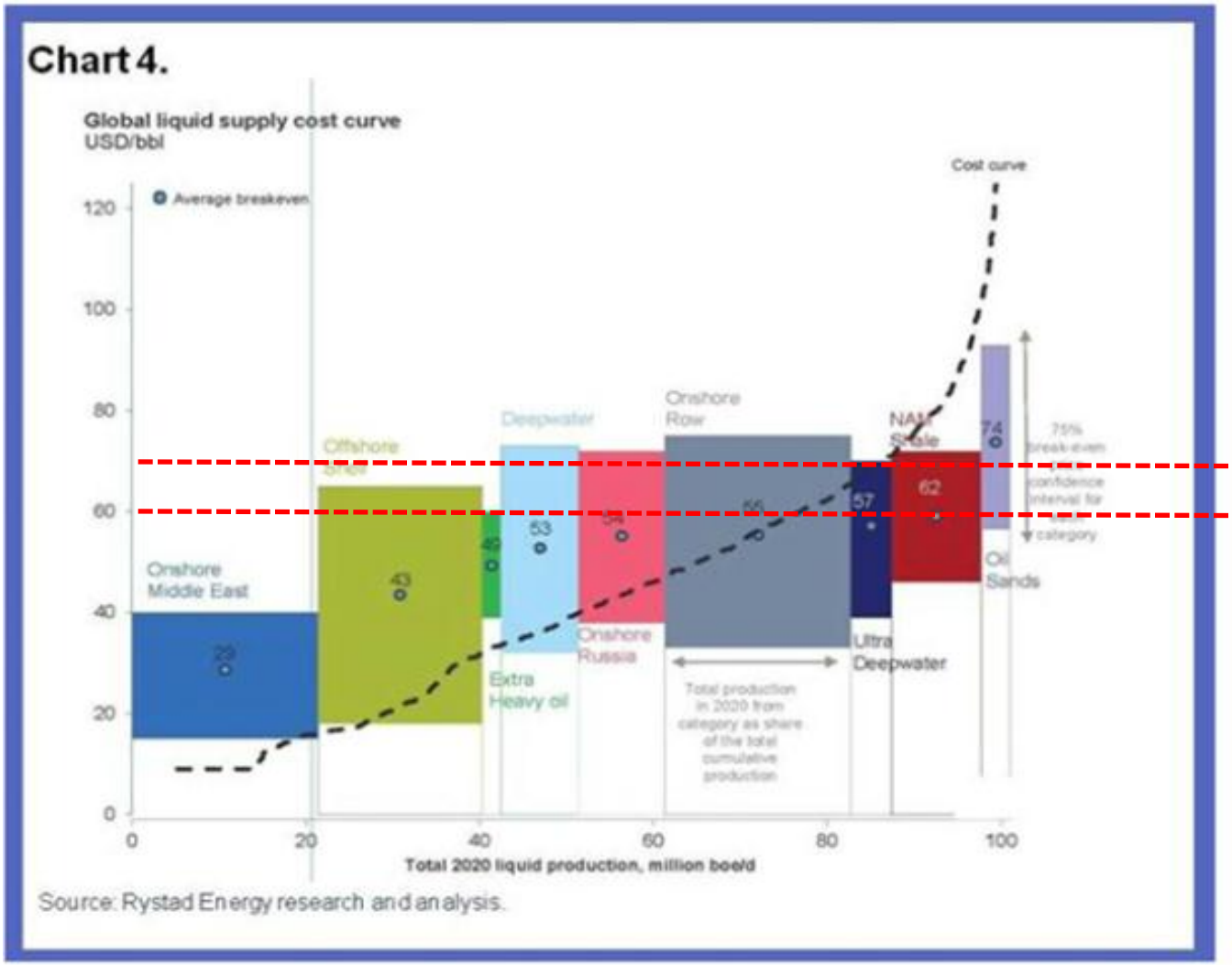
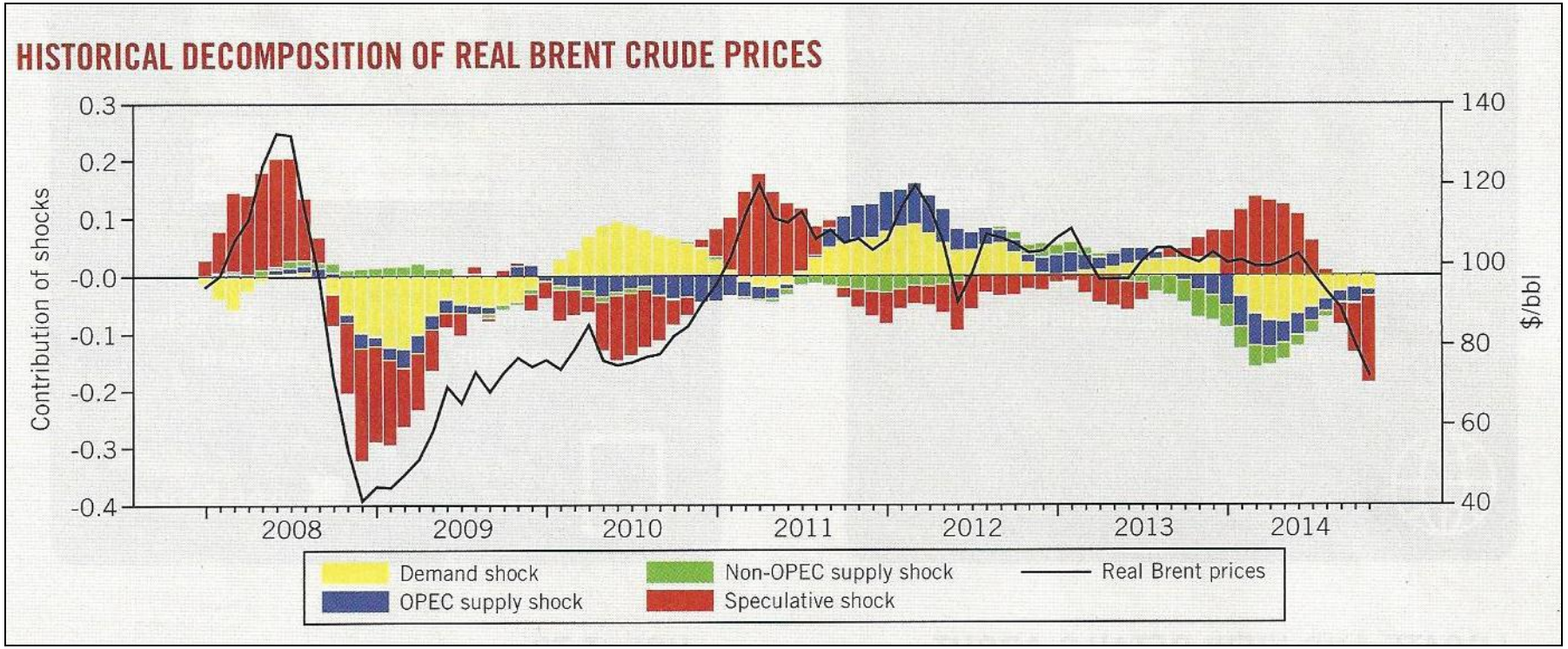
Global Liquid Supply Cost Curve



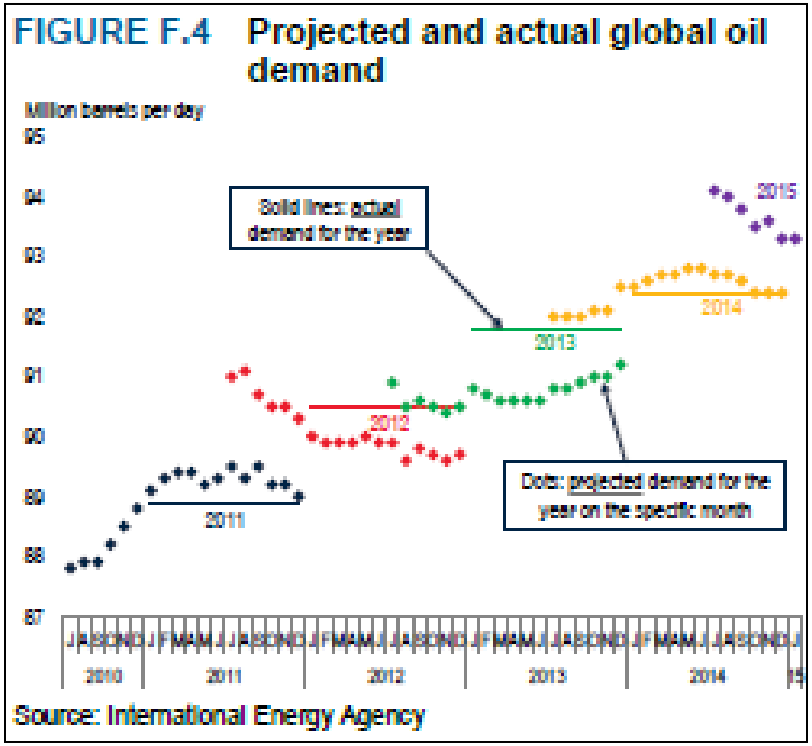
Source: Rabah Arezki, Oliver Blanchard, IMF blog Dec. 22, 2014

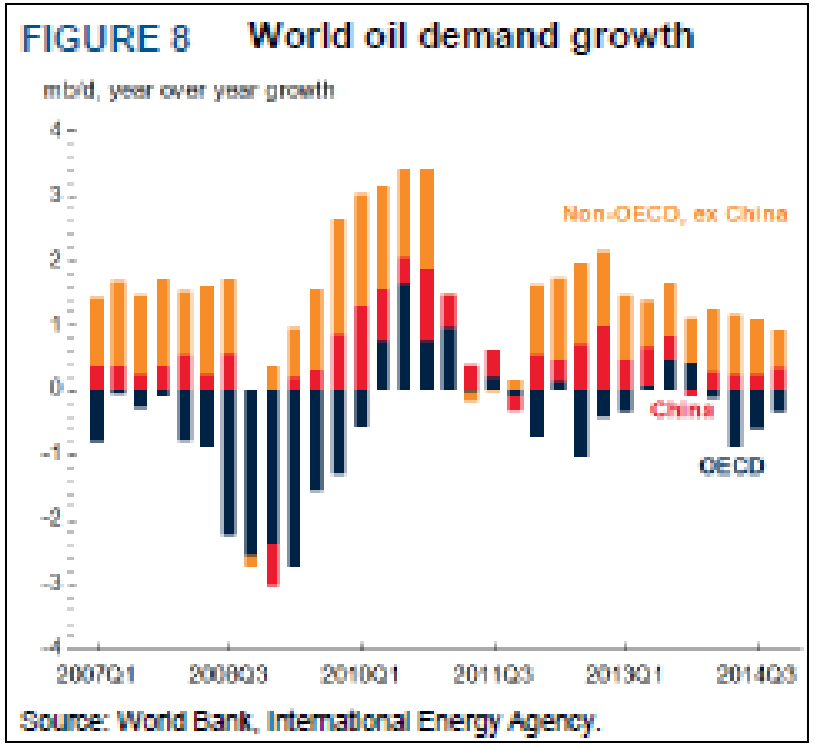
O&G Journal – Conglin Xu



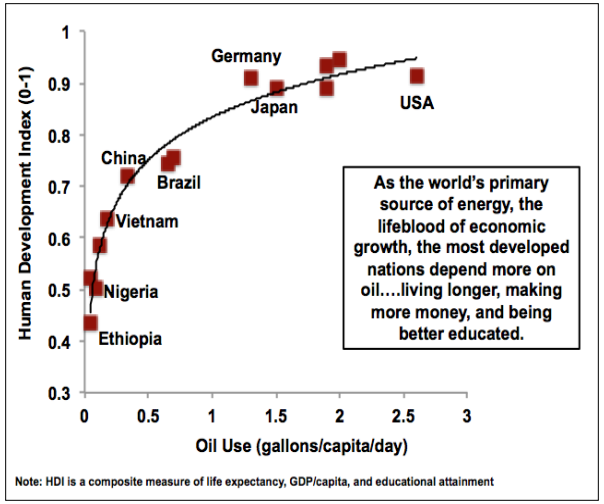
Source: O& G Journal Jan 2015

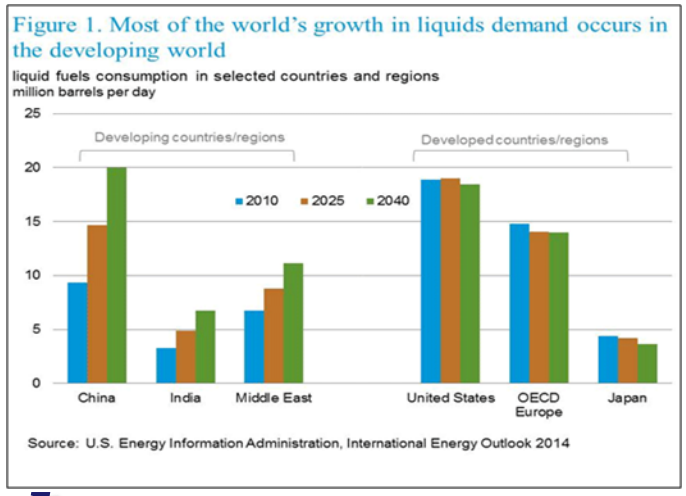
Oil Demand Side

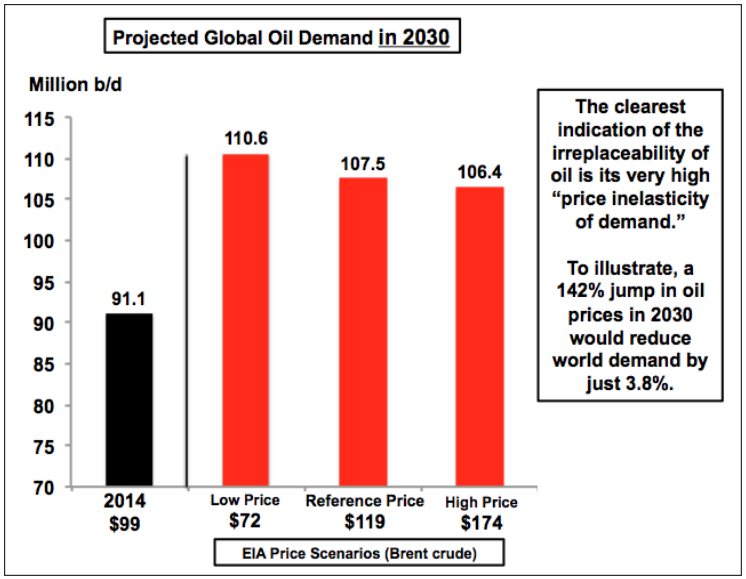




Oil Demand is Not Going Away







Source: EIA; CIA

- There is no real substitute for this primary transportation fuel
- Wind and solar will not displace oil used for transport
- Oil has exhibits a very high inelasticity of demand
- There are 9 trillion barrels of oil in place globally and only 12% (1.1 trillion barrels) has been extracted.

IEA 2040 Oil Consumption Forecast

- **World liquid fuels consumption increases 38% from 87 million barrels per day (MMbbl/d) in 2010 to 119 MMbbl/d in 2040.**
  - The largest potential for growth in demand for liquid fuels lies in the emerging economies of China, India, and countries in the Middle East
  - China, India, and other developing countries in Asia account for 72% of the net world increase in liquid fuels consumption, with Middle East consumers accounting for another 13%.
  - Most liquid fuel demand is for industrial uses and transportation.
  - United States, Europe, Japan, and other mature industrialized economies, liquid fuel demand has leveled off and is projected to slowly decline.

- **IEO2014 projects that 33 MMbbl/d of additional liquid fuel supply will be needed in 2040 compared to 2010.**
  - Organization of the Petroleum Exporting Countries (OPEC) producers invest in incremental production capacity that enables them to increase crude and lease condensate production by 14 MMbbl/d from 2010 to 2040
  - Non-OPEC crude and lease condensate production is projected to increase by 10 MMbbl/d between 2010 and 2040.
  - Much of this production is projected to come from areas previously considered uneconomical, as a combination of technological improvements and rising world oil prices attract additional investment.
-
- **Oil from tight and shale resources will help to meet growing demand**
  - Compared to previous reports, IEO2014 incorporates larger new supplies of tight oil from the United States and Canada
  - Other countries as well, including Mexico, Russia, Argentina, and China, begin producing substantial volumes of tight oil in the IEO2014 Reference case.

- **All of this is before recent oil price decline**

Reference case projection International Energy Outlook 2014(IEO2014).

Facts Global Energy (FGE) – Fereidun Fesharaki

"An oil price rise to $80-90/bbl in the next couple of years requires a production cut unlikely to be by Saudi Arabia"

- Without a Saudi production cut "prices can lag at $40-60/bbl for some time to come"
- "Lower U.S. production will not support prices on it own"
- "Before agreeing to cut output, the Saudi's need to see growth in U.S. oil production to no more than 200,000 bbl/d and Iraq accept real quotas"
- Production growth
- U.S. 2014 1.5 million b/d
- U.S. 2015e 1.0 million b/d
- Iraq 2015e 4.0 million b/d
- Iraq "absolutely reluctant" to accept a quota
- "Iraq unlikely to negotiate a quota before their production reaches 6-7 million b/d "

"Market needs to shed 3.0-3.5 million b/d of current and future production to allow price to exceed $80/bbl"

- Saudi Arabia lowers production to 8.0 million b/d
- U.S production growth fell by 500-800,000 b/d
- U.S. growth expected to fall to 0-200,000 b/d by 2016
- Iraq accepted quotas not to exceed 3.5-4.0 million b/d
- Other OPEC members would also have to cut production
- Russia likely to lose 300-500,000 b/d due to low prices and sanctions
- This combination can impact the market positively to the $50-60/bbl range, but is not enough o raise prices to $80/bbl
- Meanwhile, Iran might increase production by 500,000 b/d in 3-6 months if freed of sanctions, and by 700,000 b/d a year beyond that.

- **Two scenarios**
  - Prices fluctuate $50-80/bbl for next 10 years assuming U.S. producers don't cut cost dramatically
  - If costs do plummet, price range for the next ten years will drop to $40-60/bbl
  - If production does not fall price could be $30-40/bbl
  - "We feel confident that oil price in the 40-45/bbl will cut 80% of U.S. production growth

Source: O&G Journal April 2015

Natural Gas

Natural Gas Demand – 3393.0 BCM

China forecast:
2015 - 230 BCM (15.6%/year)
2020 - 375 BCM (12.6%/year)

Natural Gas: Consumption*

Billion cubic metres	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	Change 2014 over 2013	2014 share of total
US	634.4	623.4	614.4	654.2	659.1	648.7	682.1	693.1	723.2	739.9	**759.4**	2.9%	22.7%
Canada	95.1	97.8	96.9	96.2	96.1	94.9	95.0	100.9	100.3	103.9	**104.2**	0.3%	3.1%
Mexico	54.3	60.9	66.6	63.4	66.3	72.2	72.5	76.6	79.9	84.7	**85.8**	1.4%	2.5%
Total North America	**783.7**	**782.1**	**778.0**	**813.8**	**821.5**	**815.9**	**849.6**	**870.6**	**903.4**	**928.5**	**949.4**	**2.5%**	**28.3%**
Argentina	37.9	40.4	41.8	43.9	44.4	43.2	43.3	45.7	47.0	47.7	**47.2**	-1.1%	1.4%
Brazil	18.8	19.6	20.6	21.2	24.9	20.1	26.8	26.7	31.7	37.3	**39.6**	6.3%	1.2%
Total S. & Cent. America	**119.0**	**124.0**	**136.0**	**142.7**	**143.7**	**139.1**	**148.6**	**152.1**	**161.7**	**168.4**	**170.1**	**1.0%**	**5.0%**
France	45.1	44.8	43.7	42.4	43.8	41.8	46.9	40.5	42.2	42.8	**35.9**	-16.3%	1.1%
Germany	85.9	86.2	87.2	82.9	81.2	78.0	83.3	74.5	78.4	82.5	**70.9**	-14.0%	2.1%
Italy	73.9	79.1	77.4	77.8	77.8	71.5	76.2	71.4	68.7	64.2	**56.8**	-11.6%	1.7%
Russian Federation	389.3	394.0	415.0	422.0	416.0	389.6	414.1	424.6	416.2	413.5	**409.2**	-1.0%	12.0%
Turkey	22.1	26.9	30.5	36.1	37.5	35.7	39.0	44.7	45.3	45.6	**48.6**	6.5%	1.4%
Ukraine	68.5	69.0	67.0	63.2	60.0	46.8	52.2	53.7	49.6	45.6	**38.4**	-15.7%	1.1%
United Kingdom	97.4	94.9	90.0	91.0	93.8	87.1	94.2	78.2	73.9	73.4	**66.7**	-9.2%	2.0%
Uzbekistan	43.4	42.7	41.9	45.9	48.7	39.9	40.8	47.6	47.2	46.8	**48.8**	4.1%	1.4%
Total Europe & Eurasia	**1077.9**	**1098.4**	**1122.0**	**1127.2**	**1135.8**	**1041.5**	**1121.3**	**1097.8**	**1080.9**	**1060.8**	**1009.6**	**-4.8%**	**29.6%**
Iran	98.7	102.8	112.0	125.5	134.8	143.2	152.9	162.4	161.5	159.4	**170.2**	6.8%	5.0%
Qatar	15.0	18.7	19.6	19.3	19.3	24.9	30.0	38.2	41.0	41.0	**44.8**	9.3%	1.3%
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%	3.2%
United Arab Emirates	40.2	42.1	43.4	49.2	59.5	59.1	60.8	63.2	65.6	66.8	**69.3**	3.8%	2.0%
Total Middle East	**259.3**	**277.0**	**294.7**	**315.7**	**347.0**	**361.1**	**395.4**	**418.7**	**430.5**	**437.7**	**465.2**	**6.3%**	**13.7%**
Algeria	22.0	23.2	23.7	24.3	25.4	27.2	26.3	27.8	31.0	33.4	**37.5**	12.4%	1.1%
Egypt	31.7	31.6	36.5	38.4	40.8	42.5	45.1	49.6	52.6	51.4	**48.0**	-6.6%	1.4%
Total Africa	**81.1**	**85.5**	**89.1**	**96.0**	**100.9**	**99.6**	**107.2**	**113.9**	**121.8**	**120.3**	**120.1**	**-0.1%**	**3.5%**
China	41.0	48.3	58.0	72.9	84.0	92.5	110.5	134.9	151.2	170.8	**185.5**	8.6%	5.4%
India	31.9	35.7	37.3	40.3	41.5	52.4	62.7	63.5	59.2	51.4	**50.6**	-1.5%	1.5%
Indonesia	35.7	35.9	36.6	34.1	39.1	41.5	43.4	42.1	42.2	36.5	**38.4**	5.1%	1.1%
Japan	77.0	78.6	83.7	90.2	93.7	87.4	94.5	105.5	113.5	113.5	**112.5**	-0.9%	3.3%
Malaysia	30.5	34.9	35.3	35.5	39.2	35.4	34.5	34.8	35.5	40.3	**41.0**	1.8%	1.2%
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%
South Korea	28.4	30.4	32.0	34.7	35.7	33.9	43.0	46.3	50.2	52.5	**47.8**	-9.0%	1.4%
Thailand	29.9	32.5	33.3	35.4	37.4	39.2	45.1	46.6	51.3	52.3	**52.7**	0.9%	1.5%
Total Asia Pacific	**377.7**	**408.2**	**436.3**	**468.9**	**499.3**	**512.6**	**571.6**	**612.2**	**647.6**	**665.3**	**678.6**	**2.0%**	**19.9%**
Total World	**2698.8**	**2775.2**	**2856.1**	**2964.4**	**3048.2**	**2969.9**	**3193.7**	**3265.3**	**3345.8**	**3381.0**	**3393.0**	**0.4%**	**100.0%**

Source: BP Statistical Review of World Energy 2015

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

Natural Gas Reserves to Production Ratio – 2014

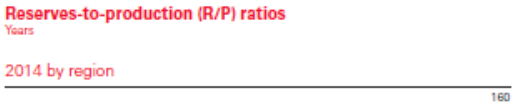
Natural Gas: Total proved reserves

	at end 1994 Trillion cubic metres	at end 2004 Trillion cubic metres	at end 2013 Trillion cubic metres	Trillion cubic feet	at end 2014 Trillion cubic metres	Share of total	R/P ratio
US	4.6	5.5	9.6	345.0	9.8	5.2%	13.4
Canada	1.9	1.6	2.0	71.7	2.0	1.1%	12.5
Total North America	**8.5**	**7.5**	**12.0**	**429.0**	**12.1**	**6.5%**	**12.8**
Venezuela	4.0	4.3	5.6	197.1	5.6	3.0%	*
Total S. & Cent. America	**5.7**	**7.0**	**7.7**	**270.6**	**7.7**	**4.1%**	**43.8**
Russian Federation	n/a	31.1	32.3	1152.8	32.6	17.4%	56.4
Turkmenistan	n/a	2.3	17.5	617.3	17.5	9.3%	*
Total Europe & Eurasia	**40.6**	**42.7**	**57.5**	**2049.5**	**58.0**	**31.0%**	**57.9**
Iran	20.8	27.5	34.0	1201.4	34.0	18.2%	*
Iraq	3.1	3.2	3.6	126.7	3.6	1.9%	*
Qatar	7.1	25.4	24.7	866.2	24.5	13.1%	*
Saudi Arabia	5.3	6.8	8.2	288.4	8.2	4.4%	75.4
United Arab Emirates	6.8	6.1	6.1	215.1	6.1	3.3%	*
Total Middle East	**45.5**	**72.2**	**80.0**	**2818.6**	**79.8**	**42.7%**	*****
Algeria	3.0	4.5	4.5	159.1	4.5	2.4%	54.1
Nigeria	3.5	5.2	5.1	180.1	5.1	2.7%	*
Total Africa	**9.1**	**14.2**	**14.2**	**499.8**	**14.2**	**7.6%**	**69.8**
Australia	1.3	2.3	3.7	132.0	3.7	2.0%	67.6
China	1.7	1.5	3.5	122.2	3.5	1.8%	25.7
India	0.7	0.9	1.4	50.4	1.4	0.8%	45.0
Indonesia	1.8	2.8	2.9	101.5	2.9	1.5%	39.2
Total Asia Pacific	**9.7**	**13.0**	**15.2**	**539.0**	**15.3**	**8.2%**	**28.7**
Total World	**119.1**	**156.5**	**186.5**	**6606.4**	**187.1**	**100.0%**	**54.1**

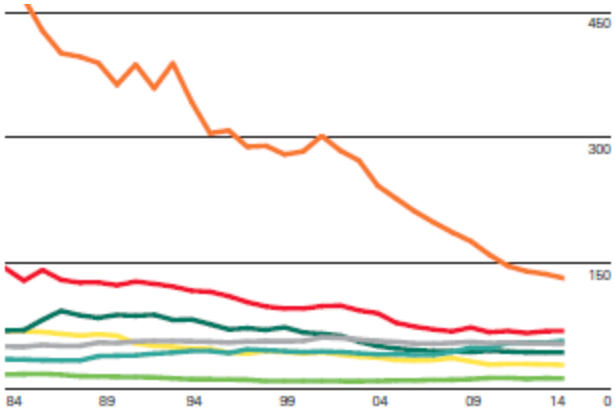
US Lower 48 technically recoverable shale gas 21.2 TCM INTEK AEO 2011

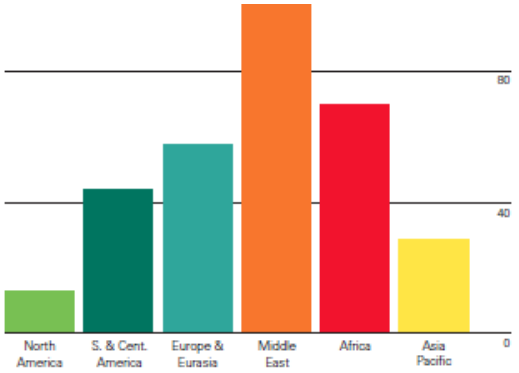
Source: BP Statistical Review of World Energy 2015

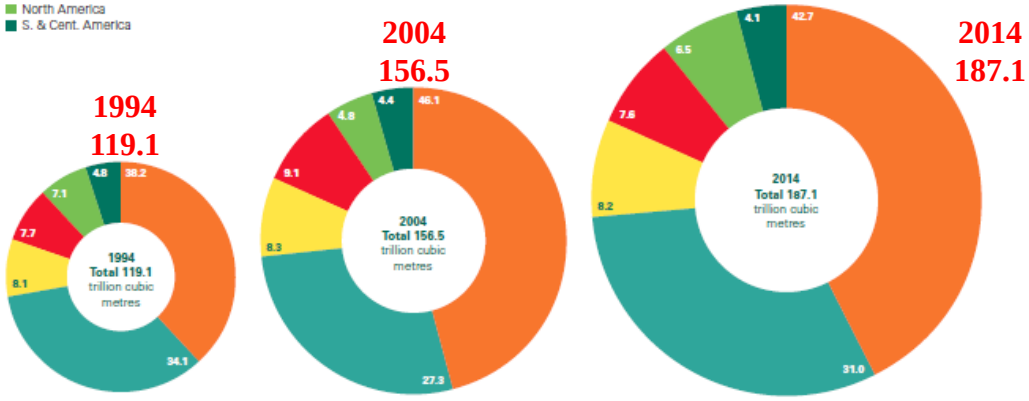
Natural Gas Reserves to Production Ratio



World proven natural gas reserves at end-2014 stood at 187.1 trillion cubic metres (tcm), sufficient to meet 54.1 years of global production. Proved reserves grew by 0.3% relative to end-2013. Growth in Russia (+0.4 tcm), Azerbaijan (+0.3 tcm) and the US (+0.2 tcm) accounted for all of the gross increase in global proved reserves in 2014. Iran (34.0 tcm) and Russia (32.6 tcm) hold the largest proved reserves.







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Source: BP Statistical Review of World Energy 2015

Natural Gas Trade – 997.17 BCM

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

Gas trade in 2013 and 2014

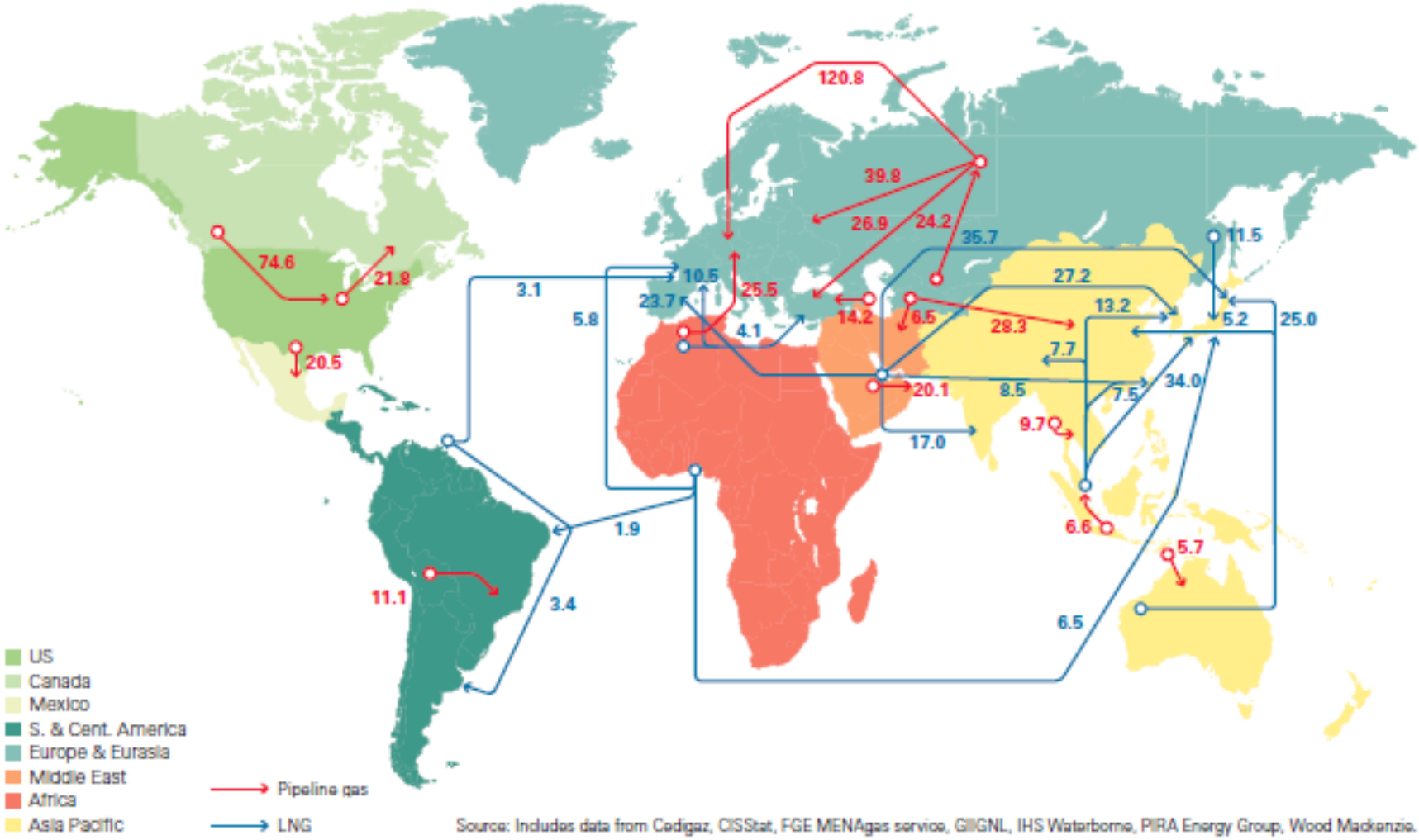
Billion cubic metres	2013				2014							
	Pipeline imports	LNG imports	Pipeline exports	LNG exports	Pipeline imports	LNG imports	Pipeline exports	LNG exports	Pipeline imports	LNG imports	Pipeline exports	LNG exports
US	78.9	2.7	44.4	0.1	74.6	1.7	42.3	0.4	94.6%	61.6%	95.1%	501.9%
Canada	25.8	1.1	78.9	-	21.8	0.6	74.6	-	84.4%	54.9%	94.6%	
Mexico	18.6	7.8	0.0	-	20.5	9.3	0.0	-	109.8%	119.5%	133.4%	
Trinidad and Tobago	-	-	-	19.8	-	-	-	19.3				97.5%
Other S. &Cent. America	18.6	19.6	18.6	5.7	17.8	21.4	17.8	5.8	95.8%	108.9%	95.8%	102.7%
France	30.5	8.7	1.1	0.6	27.4	7.1	1.1	0.6	89.9%	81.6%	98.8%	87.9%
Germany	98.4	-	15.1	-	85.0		10.1	-	86.4%		67.1%	
Italy	51.6	5.5	0.2	-	46.9	4.5	0.2	-	90.9%	82.3%	104.1%	
Netherlands	21.5	0.8	51.3	0.2	23.2	1.1	44.1	0.6	107.8%	138.9%	85.9%	288.6%
Norway	0.0		102.4	3.8	0.0		101.1	5.3	88.4%		98.7%	137.9%
Spain	15.3	14.9	0.9	2.6	15.4	15.5	0.6	5.1	100.5%	103.5%	63.9%	193.7%
Turkey	38.2	6.1	0.6	-	41.1	7.3	0.6	-	107.7%	120.1%	92.5%	
United Kingdom	40.0	9.4	9.0	-	32.9	11.3	10.6	-	82.1%	120.1%	117.8%	
Other Europe	99.5	6.0	11.8	1.6	90.0	5.3	10.8	2.0	90.5%	88.8%	91.9%	121.0%
Russian Federation	27.0	-	212.0	14.2	24.2	-	187.4	14.5	89.6%		88.4%	101.7%
Ukraine	25.0	-	-	-	17.5	-	-	-	70.1%			
Other Former Soviet Union	32.2	-	67.1	-	32.1	-	69.3	-	99.6%		103.2%	
Qatar	-	-	19.9	105.6	-	-	20.1	103.4			100.8%	97.9%
Other Middle East	25.5	4.5	9.4	28.5	27.2	5.4	9.6	27.5	106.8%	120.0%	101.9%	96.4%
Algeria	-	-	28.8	14.9	-	-	23.5	17.3			81.6%	115.7%
Other Africa	7.2	-	9.3	31.6	8.5	-	10.8	31.2	117.5%		115.6%	98.7%
China	27.3	24.5	-	-	31.3	27.1	-	-	114.9%	110.8%		
Japan	-	119.0	-	-	-	120.6	-	-		101.4%		
Indonesia	-	-	10.0	22.4	-	-	9.5	21.7			95.4%	96.8%
South Korea	-	54.2	-	-	-	51.1	-	0.2		94.3%		
Other Asia Pacific	26.4	40.4	16.7	73.5	26.5	43.9	20.0	78.6	100.3%	108.6%	120.0%	106.8%
Total World	**707.5**	**325.3**	**707.5**	**325.3**	**663.9**	**333.3**	**663.9**	**333.3**	93.8%	102.4%	93.8%	102.4%

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

1,032.78 | 997.17 | 96.6%

Source: BP Statistical Review of World Energy 2015

Major Natural Gas Trade Movements BCM - 2014

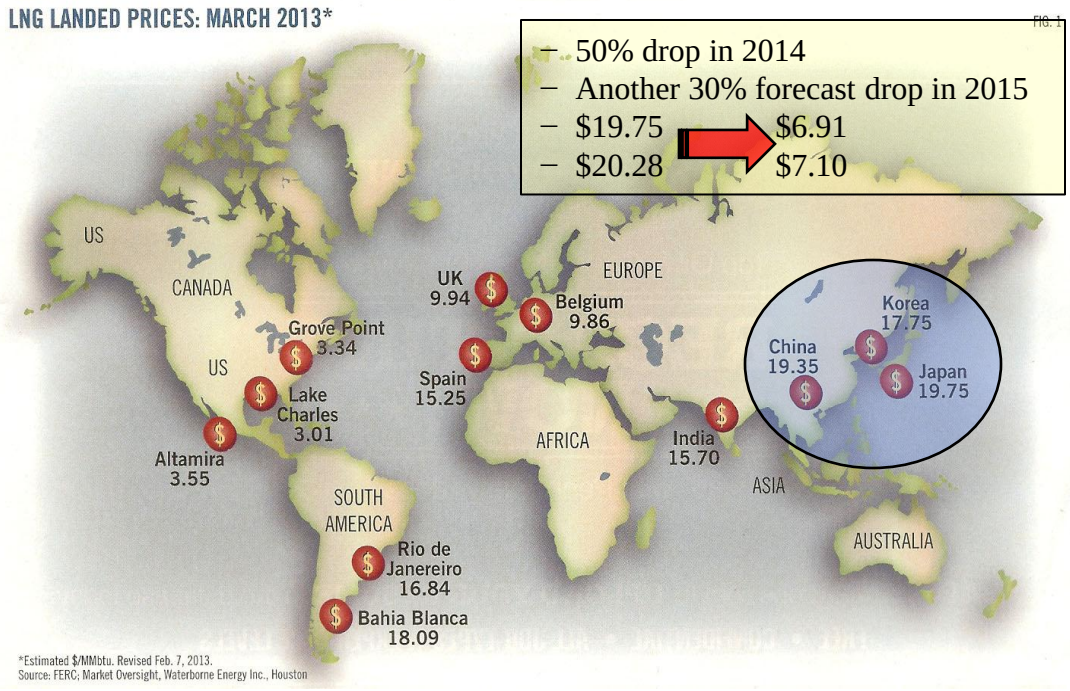


Source: BP Statistical Review of World Energy 2015

Natural Gas Prices are "Normalizing"?

Spot Asian LNG prices LNG-AS held steady at $7.10 per million British thermal units (mmBtu) last week, but are down almost 30 percent so far this year and are about one-third of record $20.50 per mmBtu reached in February last year.

Reuters 4/20/2015



- 50% drop in 2014
- Another 30% forecast drop in 2015
- $19.75 → $6.91
- $20.28 → $7.10

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

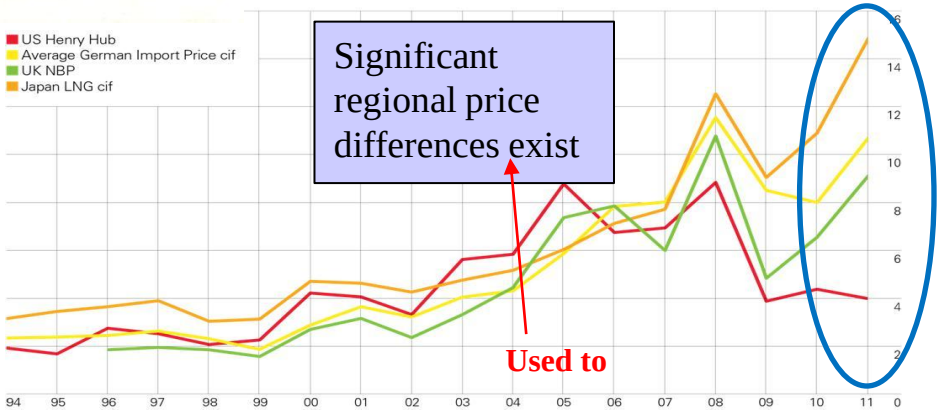
Supply:

North America

- Significant shale resource
- Significant associated gas production

Australia & East Africa

- Project cost/timing uncertainties



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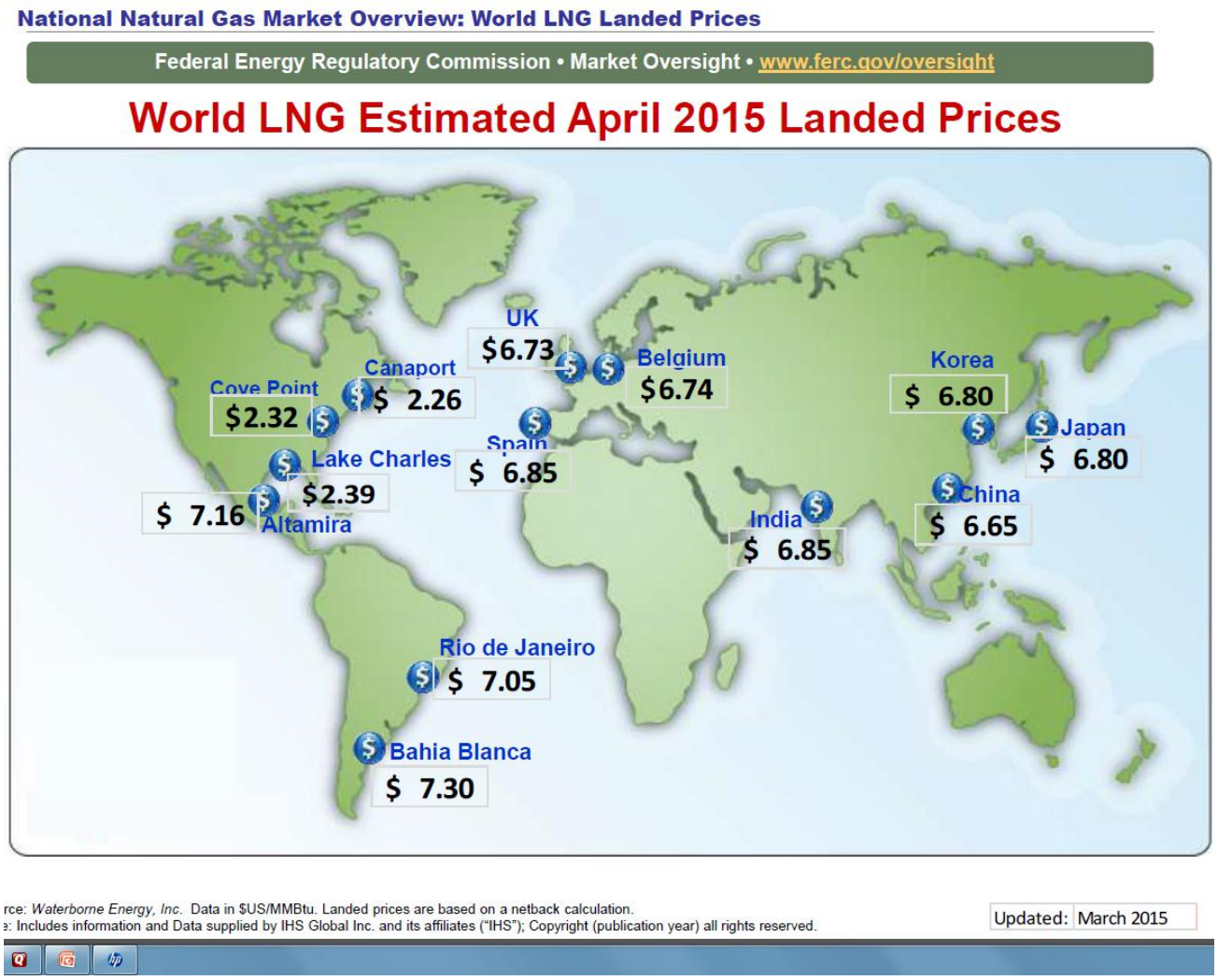
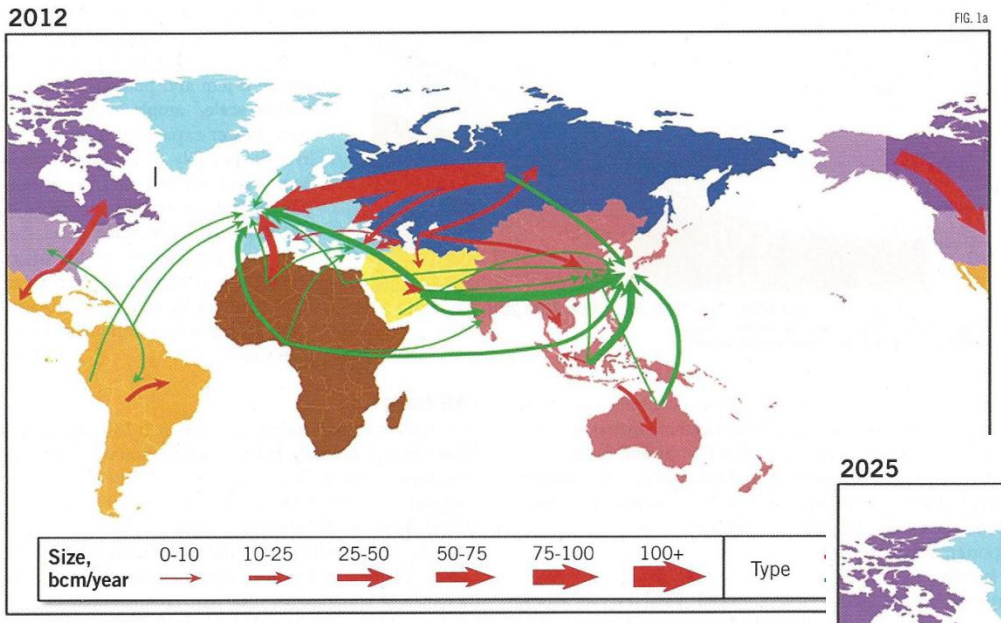
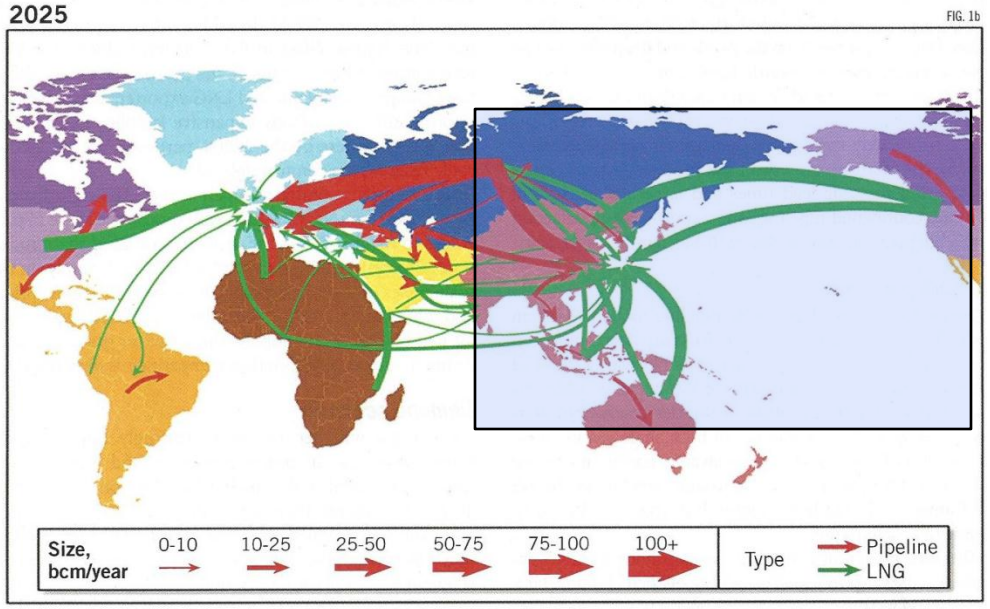
March 15, 2015 LNG Prices



Eurasian Pipelines Threaten LNG Growth



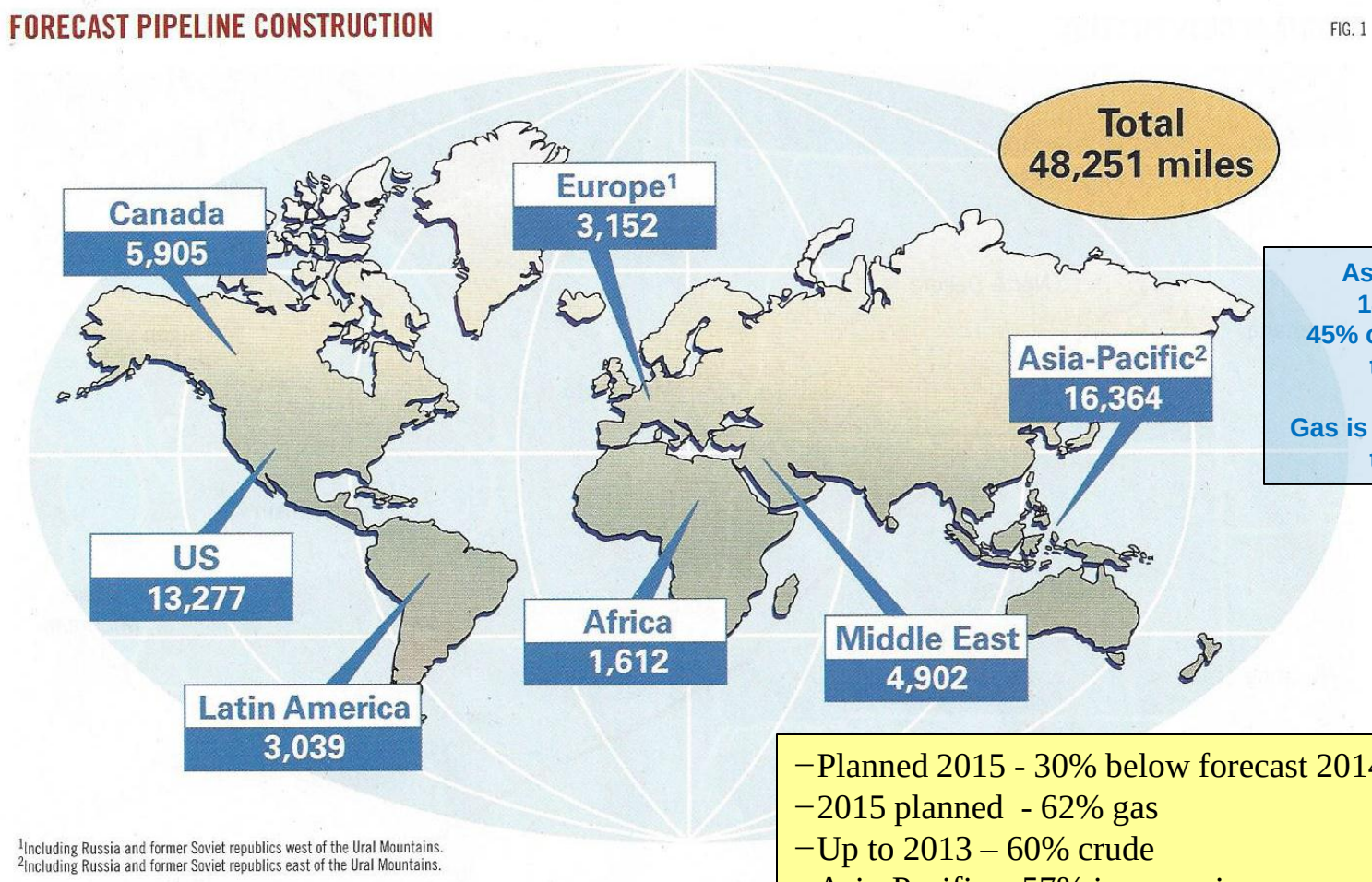
- China/India infrastructure emerges late 2020's
- China , plus Asia neighbors will become focal point of LNG trade in both pipeline gas and LNG
- Russian and Caspian States eastward pipelines will create new trade dynamics
- Russian diversification toward Asia with pipeline resources will compete favorable with LNG
- Iran can provide a stabilizing resource for Europe



O&G Journal Oct. 6, 2014

- U.S. proved gas reserves 9,900 BCM (2011)
- Undeveloped shale resources 21,000 BCM
- U.S. LNG export approvals to-date 200 BCM/year
- Non-LNG export thru 2025 add 300 BCM/year
- Iran accounts for 20% global reserves, with 5% production and no exports
- North American liquefaction and transport cost is $4.00-6.00/mmBtu.

O&G Journal - 2/2/2015



Asia Gas
14,290
45% of the gas total

Gas is 66% of the total

- Planned 2015 - 30% below forecast 2014
- 2015 planned - 62% gas
- Up to 2013 – 60% crude
- Asia-Pacific – 57% increase in gas
- U.S. – sharp increase in all three categories

Coal

Coal Consumption – 3867.0 Mtoe

- Coal consumption grew by 1.7% in 2014
- India grew by 11.1%
- China had no growth
- Asia represents 71.5% of 2014

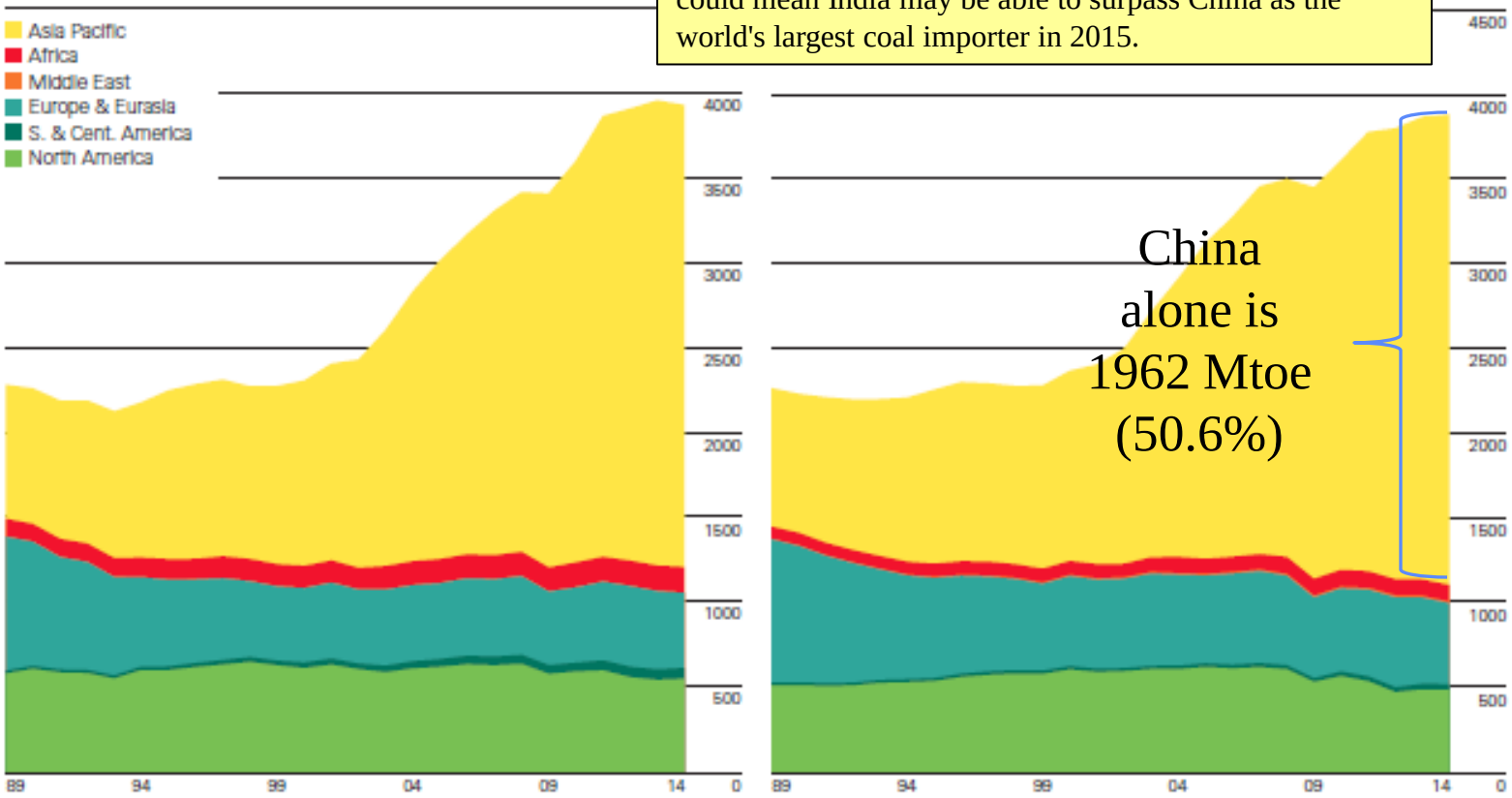
Coal: Consumption *

Million tonnes oil equivalent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	Change 2014 over 2013	2014 share of total
US	566.1	574.5	565.7	573.3	564.2	496.2	525.0	495.4	437.9	454.6	**453.4**	-0.3%	11.7%
Total North America	**607.9**	**621.5**	**612.6**	**620.4**	**607.2**	**532.9**	**567.5**	**536.5**	**472.4**	**488.8**	**488.9**	♦	**12.6%**
Total S. & Cent. America	**21.5**	**22.1**	**22.6**	**24.4**	**25.3**	**23.0**	**27.3**	**29.9**	**30.1**	**33.6**	**31.6**	**-6.0%**	**0.8%**
Czech Republic	21.0	20.2	21.0	21.4	19.7	17.6	18.4	18.1	17.2	16.4	**16.0**	-2.2%	0.4%
Germany	85.0	81.3	84.6	86.7	80.1	71.7	77.1	78.3	80.5	81.7	**77.4**	-5.3%	2.0%
Italy	16.6	16.5	16.7	16.8	16.3	12.8	14.2	15.9	16.3	14.0	**13.5**	-3.7%	0.3%
Kazakhstan	26.5	27.2	29.8	31.7	33.4	32.6	31.6	34.0	36.6	35.9	**34.5**	-3.8%	0.9%
Poland	57.3	55.7	58.0	57.9	56.0	51.9	56.4	56.1	54.3	55.8	**52.9**	-5.2%	1.4%
Russian Federation	99.9	94.6	97.0	93.9	100.7	92.2	90.5	94.0	98.4	90.5	**85.2**	-5.8%	2.2%
Ukraine	39.3	37.5	39.8	39.8	41.8	35.9	38.3	41.5	42.7	41.4	**33.0**	-20.2%	0.9%
United Kingdom	36.6	37.4	40.9	38.4	35.6	29.8	30.9	31.4	38.9	37.1	**29.5**	-20.3%	0.8%
Other Europe & Eurasia	23.7	22.1	19.0	20.5	21.0	19.9	21.2	23.1	21.4	22.5	**20.4**	-9.2%	0.5%
Total Europe & Eurasia	**536.6**	**517.4**	**536.9**	**542.0**	**527.6**	**475.9**	**490.2**	**511.5**	**529.9**	**508.2**	**476.5**	**-6.2%**	**12.3%**
Total Middle East	**9.6**	**9.8**	**9.8**	**9.9**	**9.6**	**9.8**	**9.9**	**10.8**	**11.9**	**10.3**	**9.7**	**-5.4%**	**0.3%**
South Africa	86.9	80.1	81.5	83.6	93.3	93.8	92.8	90.4	88.3	88.7	**89.4**	0.9%	2.3%
Total Africa	**96.0**	**89.0**	**90.4**	**91.5**	**101.2**	**100.4**	**100.0**	**97.8**	**95.3**	**96.6**	**98.6**	**2.0%**	**2.5%**
Australia	50.7	53.9	56.6	54.9	55.4	53.4	50.6	50.2	47.3	44.9	**43.8**	-2.5%	1.1%
China	1125.0	1318.2	1445.5	1573.1	1598.5	1679.0	1740.8	1896.0	1922.5	1961.2	**1962.4**	0.1%	50.6%
India	172.3	184.4	195.4	210.3	230.4	250.3	260.2	270.1	302.3	324.3	**360.2**	11.1%	9.3%
Indonesia	21.3	24.4	28.9	36.2	31.5	33.2	39.5	46.9	53.0	57.6	**60.8**	5.6%	1.6%
Japan	120.8	121.3	119.1	125.3	128.7	108.8	123.7	117.7	124.4	128.6	**126.5**	-1.6%	3.3%
Malaysia	6.6	6.9	7.3	8.8	9.8	10.6	14.8	14.8	15.9	17.0	**15.9**	-6.2%	0.4%
South Korea	53.1	54.8	54.8	59.7	66.1	68.6	75.9	83.6	81.0	81.9	**84.8**	3.5%	2.2%
Taiwan	36.5	38.0	39.5	41.2	39.5	38.0	39.9	41.5	41.1	41.0	**40.9**	-0.2%	1.1%
Thailand	10.4	11.2	12.4	14.2	15.3	15.4	15.8	16.0	16.8	16.2	**18.4**	13.3%	0.5%
Vietnam	8.8	9.0	5.3	5.8	11.4	10.7	14.0	16.5	15.0	15.8	**19.1**	20.6%	0.5%
Other Asia Pacific	19.8	21.0	21.6	18.5	20.3	20.4	20.0	15.4	15.9	16.3	**16.7**	2.7%	0.4%
Total Asia Pacific	**1642.8**	**1862.6**	**2005.7**	**2169.2**	**2229.3**	**2309.9**	**2416.3**	**2590.8**	**2659.3**	**2729.5**	**2776.6**	**1.7%**	**71.5%**
Total World	**2914.5**	**3122.4**	**3278.0**	**3457.5**	**3500.1**	**3451.9**	**3611.2**	**3777.4**	**3798.8**	**3867.0**	**3881.8**	**0.4%**	**100.0%**

Source: BP Statistical Review of World Energy 2015

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 coal production declined by 0.7% in 2014, while consumption grew by 0.4%. India (+6.4%) recorded the largest production increment, while China contributed the biggest decline (-2.6%). India accounted for the largest increment to consumption (+11.1%) and Ukraine for the largest decline (-20.2%).

Source: BP Statistical Review of World Energy 2015

Coal Production – 3933.5 Mtoe

Coal: Production *

Million tonnes oil equivalent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	Change 2014 over 2013	2014 share of total
US	572.4	580.2	595.1	587.7	596.7	540.8	551.2	556.1	517.8	500.9	**507.8**	1.4%	12.9%
Canada	33.9	35.3	34.8	35.7	35.6	33.1	35.4	35.5	35.9	36.6	**36.7**	0.2%	0.9%
Total North America	**612.2**	**621.6**	**636.7**	**630.7**	**639.2**	**580.0**	**594.0**	**600.9**	**561.1**	**545.0**	**551.4**	**1.2%**	**14.0%**
Colombia	34.9	38.4	42.6	45.4	47.8	47.3	48.3	55.8	57.9	55.6	**57.6**	3.6%	1.5%
Total S. & Cent. America	**43.1**	**46.3**	**51.2**	**52.5**	**54.3**	**52.2**	**52.7**	**59.8**	**61.8**	**62.4**	**65.0**	**4.2%**	**1.7%**
Czech Republic	23.5	23.5	23.8	23.6	22.8	21.0	20.8	21.6	20.7	18.0	**17.3**	-3.5%	0.4%
Germany	58.4	56.5	53.3	54.4	50.1	46.4	45.9	46.7	47.8	44.7	**43.8**	-2.1%	1.1%
Kazakhstan	44.4	44.2	49.1	50.0	56.8	51.5	54.0	56.2	58.6	58.2	**55.3**	-4.9%	1.4%
Poland	70.5	68.7	67.0	62.3	60.5	56.4	55.5	56.6	58.8	57.6	**55.0**	-4.5%	1.4%
Russian Federation	132.2	139.6	145.5	148.4	153.8	142.3	151.4	158.8	169.5	168.8	**170.9**	1.2%	4.3%
Turkey	10.5	11.2	13.2	14.8	16.7	17.4	17.5	17.8	16.9	15.3	**17.8**	15.9%	0.5%
Ukraine	42.4	41.2	41.9	40.0	41.4	38.5	40.0	44.1	45.3	44.4	**31.5**	-29.0%	0.8%
Other Europe & Eurasia	20.4	20.7	22.6	22.3	22.7	23.0	23.0	23.9	21.9	24.8	**21.9**	-11.5%	0.6%
Total Europe & Eurasia	**448.4**	**447.5**	**456.1**	**455.4**	**463.2**	**433.5**	**443.6**	**463.4**	**475.7**	**461.0**	**441.6**	**-4.2%**	**11.2%**
Total Middle East	**0.8**	**1.0**	**1.0**	**1.1**	**1.0**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**-**	**♦**
South Africa	137.1	138.4	138.3	138.4	141.0	139.7	144.1	143.2	146.6	145.3	**147.7**	1.6%	3.8%
Total Africa	**140.8**	**141.7**	**140.9**	**140.7**	**143.0**	**141.8**	**147.1**	**146.0**	**149.2**	**150.4**	**152.2**	**1.2%**	**3.9%**
Australia	197.1	206.5	211.6	217.9	224.9	232.6	240.5	233.4	250.4	268.2	**280.8**	4.7%	7.1%
China	1106.6	1240.9	1327.8	1438.7	1491.4	1538.0	1664.9	1852.6	1872.5	1893.7	**1844.6**	-2.6%	46.9%
India	155.7	162.1	170.2	181.0	195.6	210.8	217.5	215.7	229.1	228.8	**243.5**	6.4%	6.2%
Indonesia	81.4	93.9	119.2	133.4	147.8	157.6	169.2	217.3	237.3	276.2	**281.7**	2.0%	7.2%
Vietnam	15.3	19.1	21.7	23.8	22.3	24.7	25.1	26.1	23.6	23.0	**23.1**	0.5%	0.6%
Other Asia Pacific	22.1	25.0	25.5	24.2	26.2	29.7	37.5	41.2	40.4	41.4	**38.4**	-7.2%	1.0%
Total Asia Pacific	**1590.8**	**1760.1**	**1888.7**	**2030.9**	**2119.8**	**2204.6**	**2366.2**	**2598.5**	**2664.4**	**2741.9**	**2722.5**	**-0.7%**	**69.2%**
Total World	**2835.9**	**3018.2**	**3174.7**	**3311.2**	**3420.6**	**3412.7**	**3604.3**	**3869.4**	**3912.9**	**3961.4**	**3933.5**	**-0.7%**	**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 2015

Coal Reserves to Production Ratio - 2014

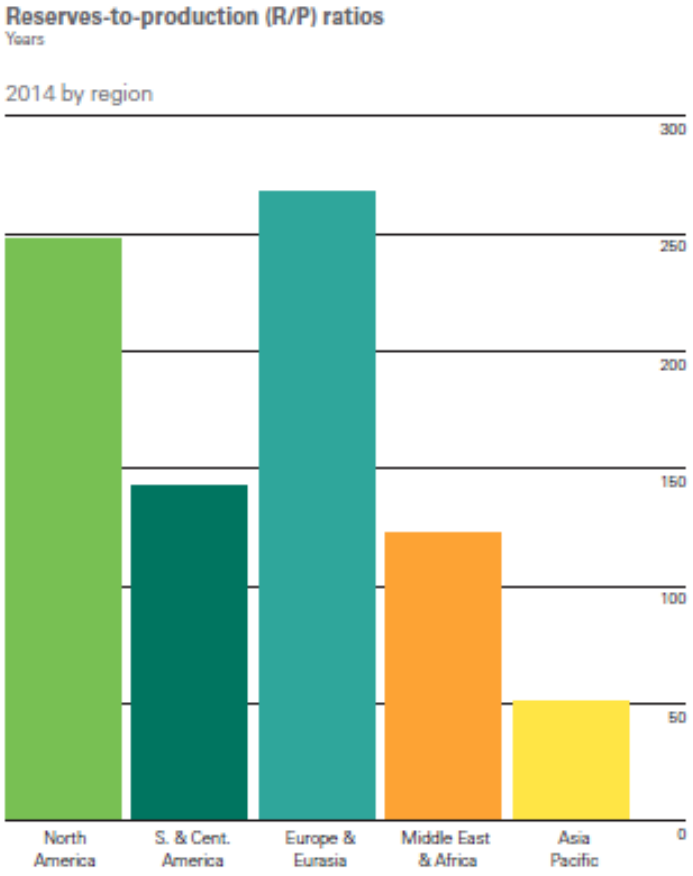
Coal: Total proved reserves at end 2014

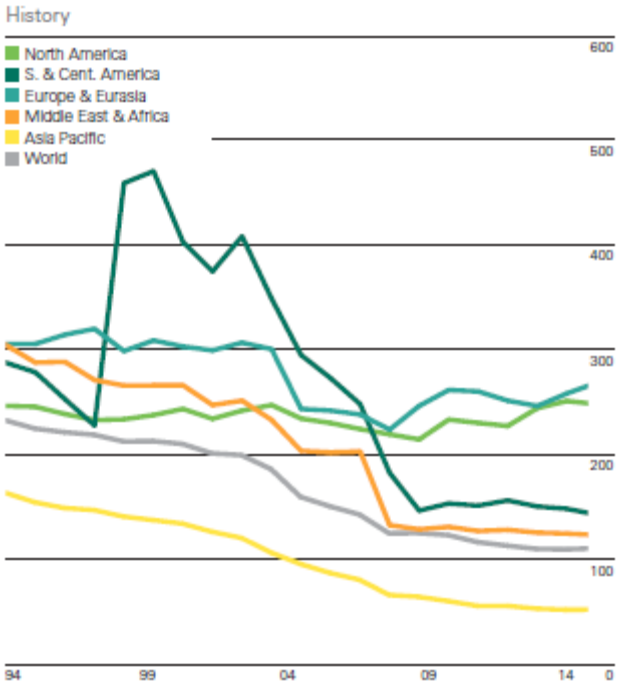
Million tonnes	Anthracite and bituminus	Sub-bituminous and lignite	Total	Share of Total	R/P ratio
US	108501	128794	**237295**	26.6%	262
Canada	3474	3108	**6582**	0.7%	96
Mexico	860	351	**1211**	0.1%	87
Total North America	**112835**	**132253**	**245088**	**27.5%**	**248**
Colombia	6746	-	**6746**	0.8%	76
Venezuela	479	-	**479**	0.1%	189
Total S. & Cent. America	**7282**	**7359**	**14641**	**1.6%**	**142**
Bulgaria	2	2364	**2366**	0.3%	76
Czech Republic	181	871	**1052**	0.1%	22
Germany	48	40500	**40548**	4.5%	218
Greece	-	3020	**3020**	0.3%	61
Hungary	13	1647	**1660**	0.2%	174
Kazakhstan	21500	12100	**33600**	3.8%	309
Poland	4178	1287	**5465**	0.6%	40
Romania	10	281	**291**	◆	12
Russian Federation	49088	107922	**157010**	17.6%	441
Spain	200	330	**530**	0.1%	136
Turkey	322	8380	**8702**	1.0%	125
Ukraine	15351	18522	**33873**	3.8%	*
United Kingdom	228	-	**228**	◆	20
Uzbekistan	47	1853	**1900**	0.2%	432
Other Europe & Eurasia	1389	18904	**20293**	2.3%	337
Total Europe & Eurasia	**92557**	**217981**	**310538**	**34.8%**	**268**
South Africa	30156	-	**30156**	3.4%	116
Zimbabw e	502	-	**502**	0.1%	120
Total Middle East & Africa	**32722**	**214**	**32936**	**3.7%**	**122**
Australia	37100	39300	**76400**	8.6%	155
China	62200	52300	**114500**	12.8%	30
India	56100	4500	**60600**	6.8%	94
Indonesia	-	28017	**28017**	3.1%	61
Japan	337	10	**347**	◆	265
New Zealand	33	538	**571**	0.1%	143
North Korea	300	300	**600**	0.1%	19
Pakistan	-	2070	**2070**	0.2%	*
South Korea	-	126	**126**	◆	72
Thailand	-	1239	**1239**	0.1%	69
Vietnam	150	-	**150**	◆	4
Other Asia Pacific	1583	2125	**3708**	0.4%	97
Total Asia Pacific	**157803**	**130525**	**288328**	**32.3%**	**51**
Total World	**403199**	**488332**	**891531**	**100.0%**	**110**

There's a lot of it except in China!

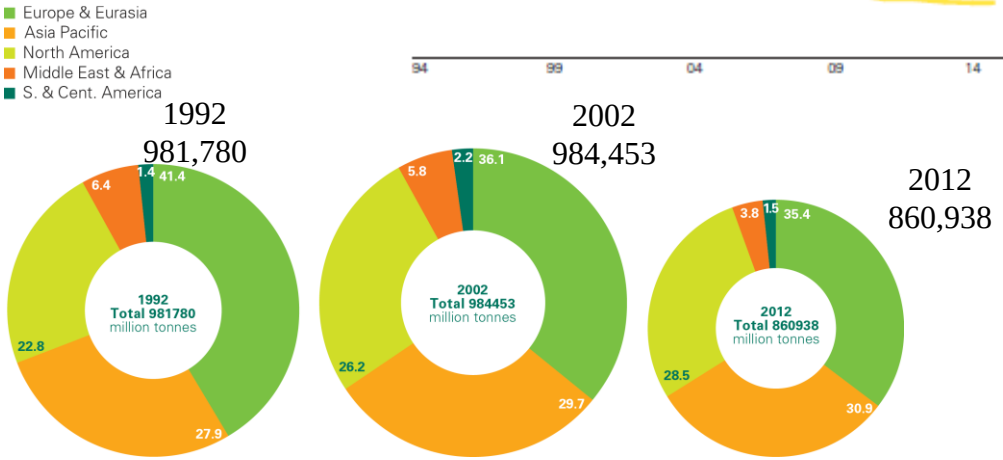
Source: BP Statistical Review of World Energy 2015

Coal Reserves to Production Ratio - 2014





Asia →



base e®

"Practical Strategies for Emerging Energy Technologies"

Source: BP Statistical Review of World Energy 2015

High Efficiency, Low Emissions Coal (HELE)

Figure 10: Reducing CO_2 emissions from pulverised coal-fired power generation

1000 gCO2/kWh = 2204 lb/MWh

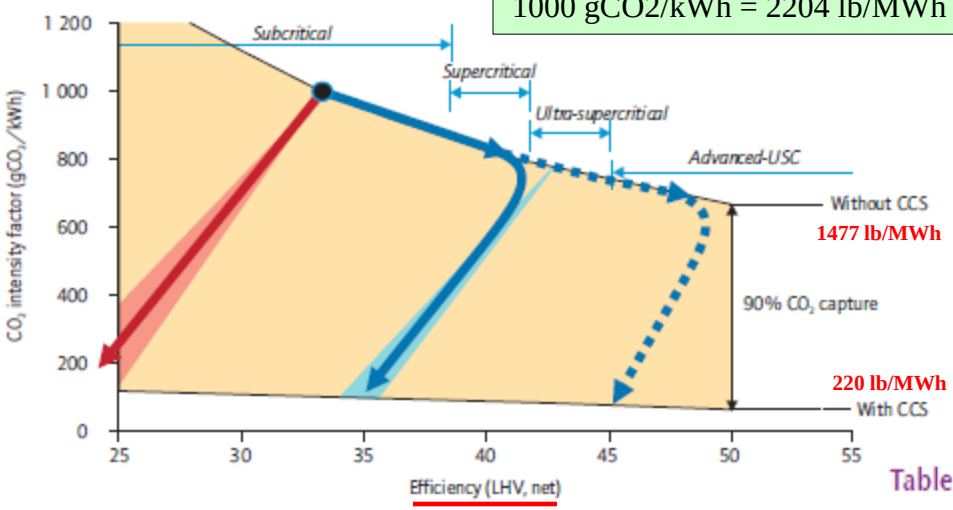
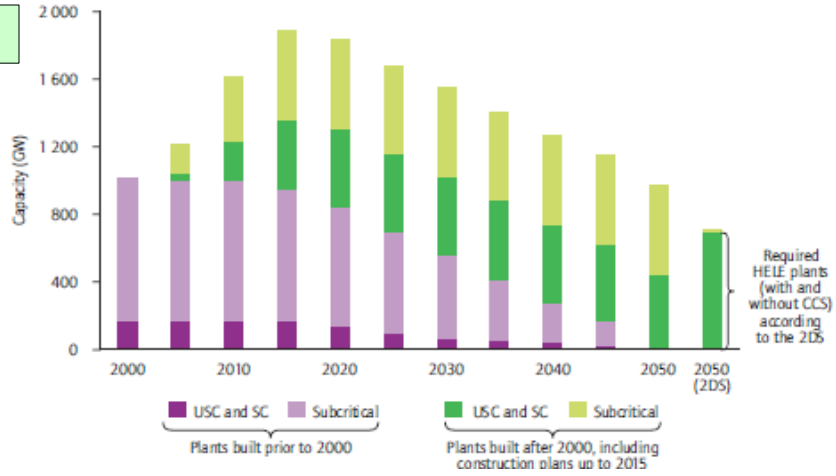


Figure 8: Projected capacity of coal-fired power generation to 2050



- U.S. consumption of coal totaled 18 quadrillion Btu in 2013, a 4-percent increase from 2012
- Electric power sector consumption accounted for 91 percent of total consumption in 2013
- The price of coal averaged $2.52 per million Btu in the United States in 2013, a 3-percent decrease from 2012
- Prices ranged from $1.44 per million Btu in Nebraska to $4.90 per million Btu in Alaska.

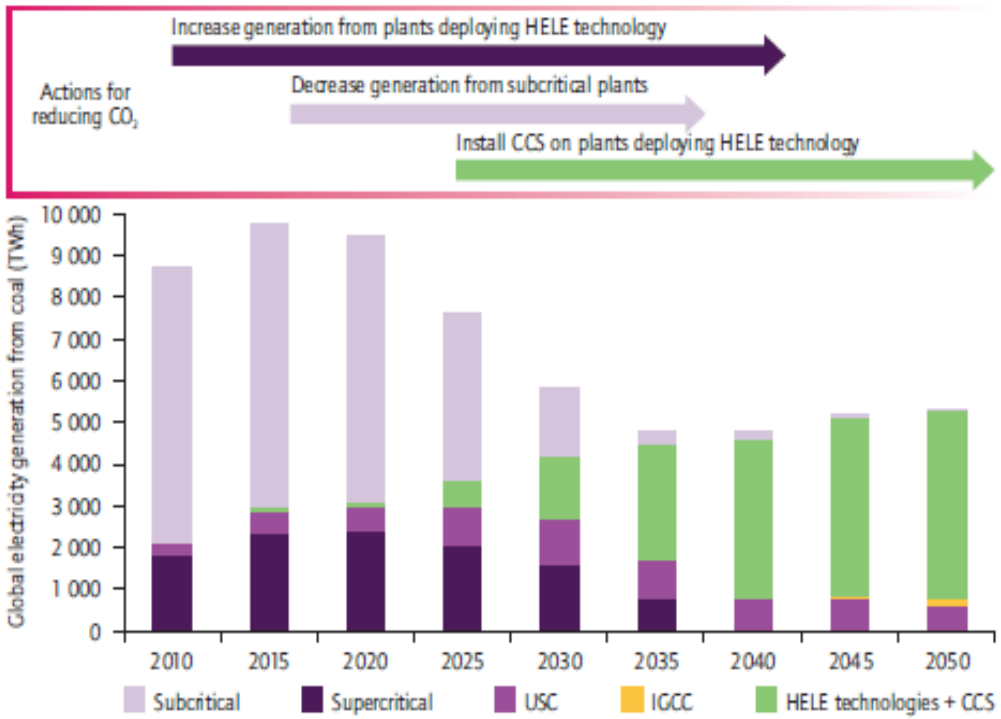
Table 3: Performance of HELE coal-fired power technologies

Fuel type	Plant type	Emissions CO_2 (g/kWh)	Emissions NO_x	Emissions SO_2 (mg/Nm^3)	Emissions PM	Max. unit capacity (MWe)	Capacity factor (%)	CCS energy penalty (%-points)
Coal	PC (USC)	740	<50 to 100 (by SCR)	<20 to 100 (by FGD)	<10	1 100[3]	80	7 to 10 (post-combustion and oxy-fuel)
	CFBC	880 to 900	<200	<50 to 100 (in situ)	<50	460	80	
	PC (A-USC)[1]	670 (700°C)	<50 to 100 (by SCR)	<20 to 100 (by FGD)	<10	<1 000 (possible)	-	
	IGCC[1,2]	670 to 740	<30	<20	<1	335	70	7
	IGFC[1]	500 to 550	<30	<20	<1	<500	-	

Source: IEA Technology Roadmap
High Efficiency Low Emissions Coal-fired Power Generation

Coal-fired PowerGen Options - 2DS

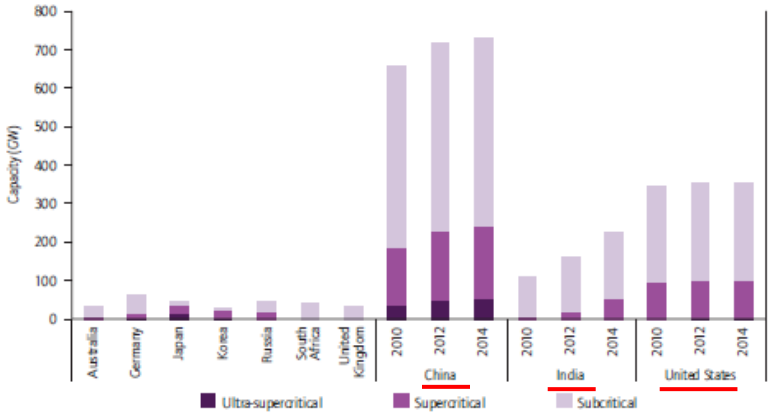
Figure 7: Electricity generation from different coal-fired power technologies in the 2DS



Note: Carbon capture is integrated with HELE coal-fired units to minimise coal consumption and CO_2 abatement cost.

Source: IEA Technology Roadmap
High Efficiency Low Emissions Coal-fired Power Generation

Figure 4: Capacity of supercritical and ultra-supercritical plant in major countries



Note: Refers to capacity in 2010 unless specified otherwise. Definitions of subcritical, supercritical (SC) and ultra-supercritical (USC) technology are described in Box 3.
Source: Platts, 2011.

Table 1: CO_2 intensity factors and fuel consumption values

	CO_2 intensity factor (Efficiency [LHV, net])	Coal consumption[1]
A-USC (700°C[2]) IGCC (1 500°C[3])	670-740 g CO_2/kWh (45-50%)	290-320 g/kWh
Ultra-supercritical	740-800 g CO CO_2/kWh (up to 45%)	320-340 g/kWh
Supercritical	800-880 g CO CO_2/kWh (up to 45%)	340-380 g/kWh
Subcritical	≥880 g CO CO_2/kWh (up to 45%)	≥380 g/kWh

[1] For coal with heating value 25 MJ/kg; [2] Steam temperature; [3] Turbine inlet temperature.
Note: The CO_2 intensity factor is the amount of carbon dioxide emitted per unit of electricity generated from a plant. For example, a CO_2 intensity factor of 800g CO_2/kWh means that the coal-fired unit emits 800g of CO_2 for each kWh of electricity generated.
Source: VBG, 2011.

1000 gCO2/kWh = 2204 lb/MWh

U.S. Coal Exports

Ref. Case 1125 → 12.5% → Ref. Case 140

Figure 29. U.S. coal production in six cases, 1990-2040 (million short tons)

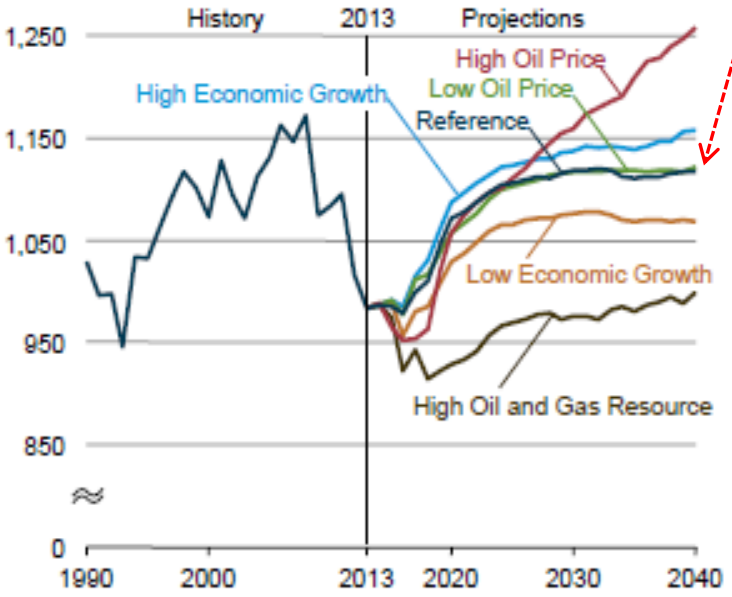
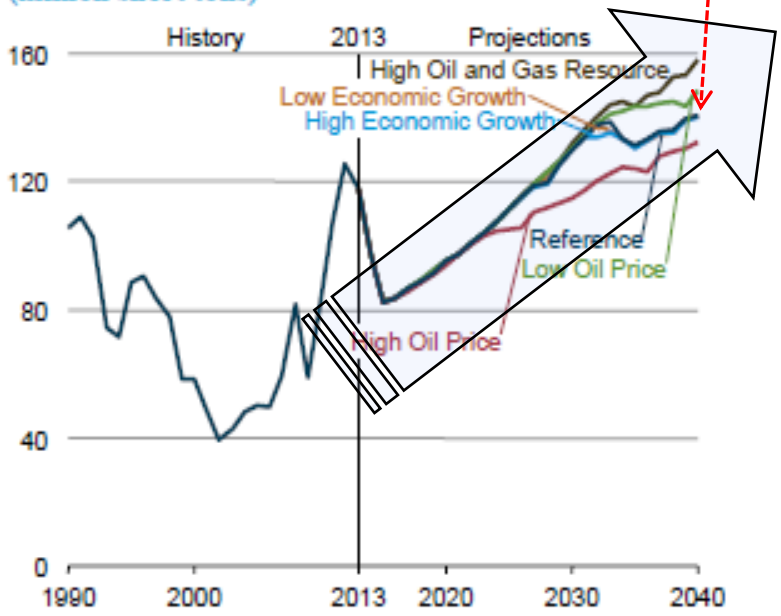


Figure 30. U.S. coal exports in six cases, 1990-2040 (million short tons)



Coal Prices - $/tonne

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 †	Northwest Europe vs. App'l	Japan steam coal Vs. App'l
1987	31.30	-	53.44	41.28	-		
1988	39.94	-	55.06	42.47	-		
1989	42.08	-	58.68	48.86	-		
1990	43.48	31.59	60.54	50.81	-	37.6%	60.8%
1991	42.80	29.01	60.45	50.30	-	47.5%	73.4%
1992	38.53	28.53	57.82	48.45	-	35.0%	69.8%
1993	33.68	29.85	55.26	45.71	-	12.8%	53.1%
1994	37.18	31.72	51.77	43.66	-	17.2%	37.7%
1995	44.50	27.01	54.47	47.58	-	64.8%	76.2%
1996	41.25	29.86	56.68	49.54	-	38.1%	65.9%
1997	38.92	29.76	55.51	45.53	-	30.8%	53.0%
1998	32.00	31.00	50.76	40.51	29.48	3.2%	30.7%
1999	28.79	31.29	42.83	35.74	27.82	-8.0%	14.2%
2000	35.99	29.90	39.69	34.58	31.76	20.3%	15.6%
2001	39.03	50.15	41.33	37.96	36.89	-22.2%	-24.3%
2002	31.65	33.20	42.01	36.90	30.41	-4.7%	11.1%
2003	43.60	38.52	41.57	34.74	36.53	13.2%	-9.8%
2004	72.08	64.90	60.96	51.34	72.42	11.1%	-20.9%
2005	60.54	70.12	89.33	62.91	61.84	-13.7%	-10.3%
2006	64.11	62.96	93.46	63.04	56.47	1.8%	0.1%
2007	88.79	51.16	88.24	69.86	84.57	73.5%	36.5%
2008	147.67	118.79	179.03	122.81	148.06	24.3%	3.4%
2009	70.66	68.08	167.82	110.11	78.81	3.8%	61.7%
2010	92.50	71.63	158.95	105.19	105.43	29.1%	46.9%
2011	121.52	87.38	229.12	136.21	125.74	39.1%	55.9%
2012	92.50	72.06	191.46	133.61	105.50	28.4%	85.4%
2013	81.69	71.39	140.45	111.16	90.90	14.4%	55.7%
2014	75.38	69.00	114.41	97.65	77.89	9.3%	41.5%

Significant relative price decreases 2010 - 2014 narrowing differences between U.S. and export prices have developed

† Source: McCloskey Coal Information Service. Prices for 1990-2000 are the average of the monthly marker, 2001-2014 the average of weekly prices.

‡ Source: Platts. Prices are for CAPP 12,500 Btu, 1.2 SO2 coal, fob.

Prices for 1990-2000 are by coal price publication date, 2001-2014 by coal price assessment date.

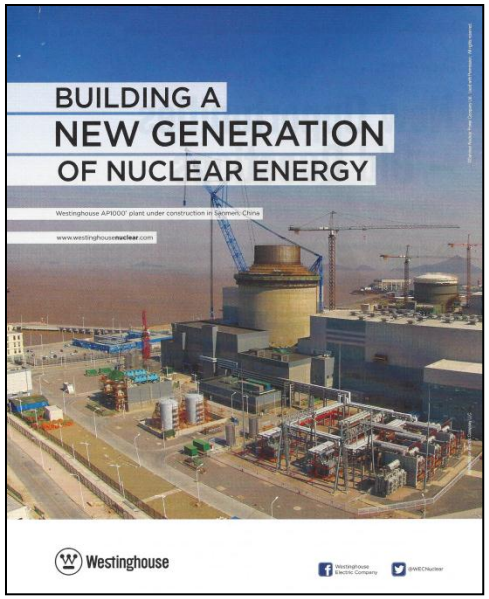
Note: CAPP = Central Appalachian; cif = cost+insurance+freight (average prices); fob = free on board.

Source: BP Statistical Review of World Energy 2015

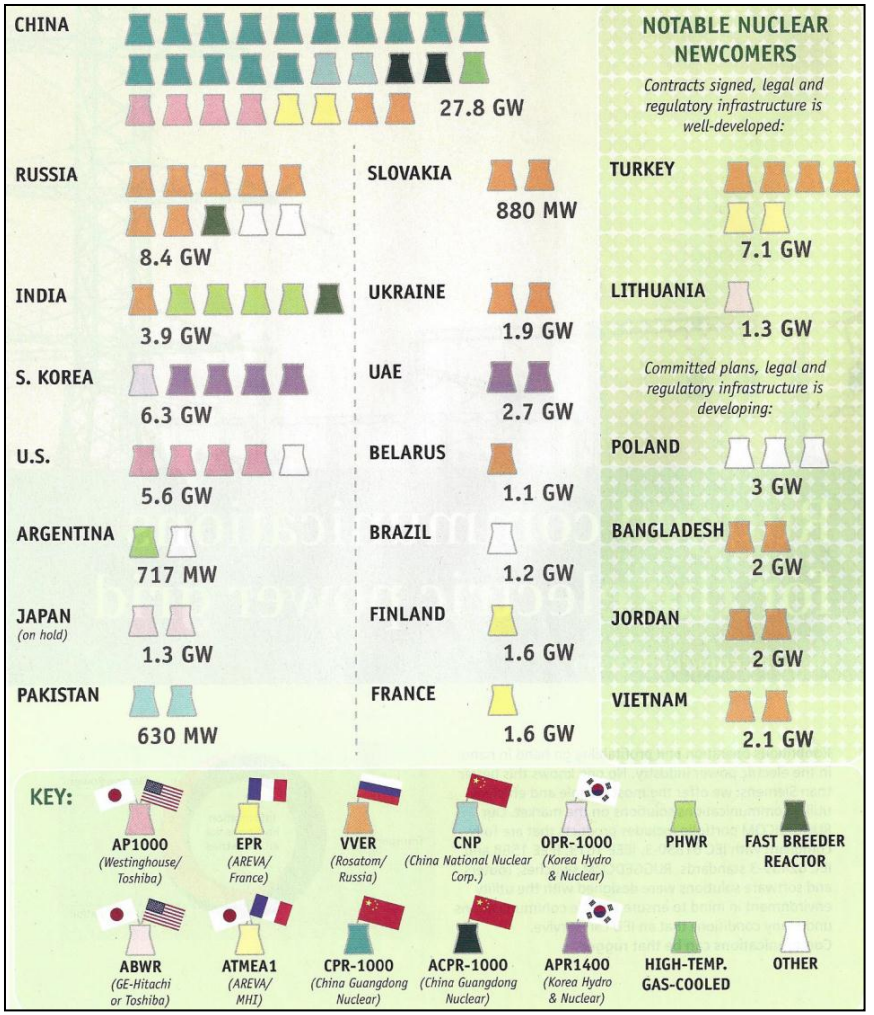
Nuclear

“The Big Picture: Next-Gen Nuclear”

- Compliments of Power magazine April 2014
- 72 mostly advanced nuclear reactions under construction
- A total of 68GW
- China represents 40% of the total
- France will cap nuclear capacity at the current 63.2GW, forcing closures w/capacity additions
  - Currently at 75% share of generation
  - Goal is 50% by 2025



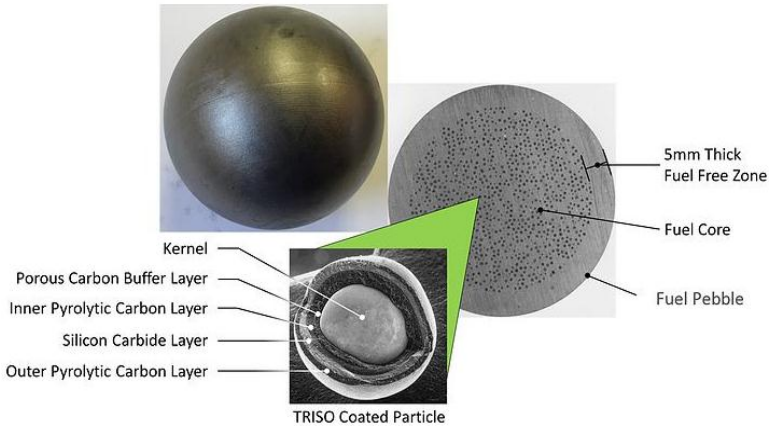
Westinghouse AP1000® plant under construction in Sanmen, China



Small Modular Reactors

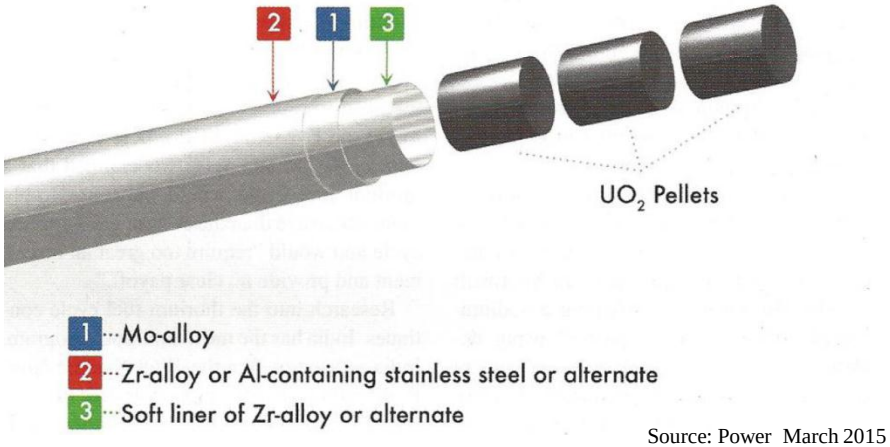
Nuclear Fuel Developments

- The Xe-100 is a small-sized pebble-bed High Temperature Gas-Cooled Reactor (HTGR)
- HTGR uses gas in the core instead of water
- Thousands of pebbles fill the reactor core, forming a bed
- Graphite pebbles encompass thousands of ceramic-coated TRISO fuel particles
- A single reactor can produce 50MWe
- The Xe-100 is designed to be ultra-safe, small-scale, and able to respond in real-time to fluctuating grid demands
- Pebble-bed reactor projects around the world
  - AVR and HTGR reactors in West Germany,
  - PBMR in South Africa,
  - HTR-10 currently in operation in China.



- EPRI Pursuing dual cladding technology
  - Maintain integrity up to 1500°C
  - Thin wall Mo tubes w/oxidation resistant layers
  - Zirconium alloy, or
  - Aluminum coated stainless steel
- DOE supporting
  - Multiple fuel cladding projects
  - Extending fuel burnup
  - Advanced structural design

3. Adding Mo protection. Fuel cladding incorporating molybdenum (Mo) offers one potential technological pathway toward accident-tolerant nuclear fuel concepts. *Courtesy: EPRI*



Source: Power March 2015

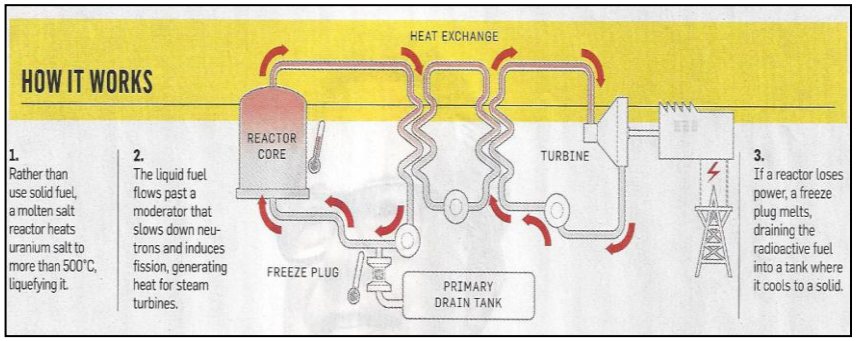
Molten Salt Reactors

Molten salt reactors use either the thorium/uranium fuel cycle or the uranium/plutonium fuel cycle to generate energy as heat.

Unlike light-water reactors which use solid uranium as their fuel, molten salt reactors use liquid fuel. This results in a safer, cleaner, more efficient reactor.

Key Advantages:

- Unlike solid fuel reactors, an MSR can operate safely at high temperatures with no risk of melt down which leads to higher efficiencies.
- Molten salts in the reactor core can remain liquid at very high temperatures and atmospheric pressure so in case of an accidental hazard there is no risk of explosion.
- An MSR produces around 2.5% of the waste produced by an uranium fueled light water reactor.
- An MSR can fully recycle actinide wastes and only emit fission product wastes. This results in nuclear waste remaining toxic for only about 200 to 300 years as opposed to thousands of years for other nuclear reactors.
- A molten salt reactor cannot spew a jet of radioactive smoke or steam even if containment was completely destroyed. When the molten salt cools, it crystallizes, and can be easily picked up, recovered, and reused.
- An MSR does not emit CO_2.
- The use of liquid fuels allows for the reactor to remain in operation longer than a solid fuel reactor.



Source: Transatomic Power (via Popular Science – June 2015)

Competitive Landscape

ELYSIUM INDUSTRIES

TRANSATOMIC

TERRESTRIAL ENERGY

World Uranium Mining Production

Company	tonnes U	%
KazAtomProm	13801	25
Cameco	8956	16
ARMZ - Uranium	6944	12
Areva	6496	12
BHP Billiton	3351	6
CNNC & CGN	2684	5
Paladin	2316	4
Navoi	2400	4
Rio Tinto	2296	4
Other	6940	12
Total	56184	100

65%

- During the 1990s the uranium production industry was consolidated by takeovers, mergers and closures
- This has diversified in recent years with Kazakhstan's diverse ownership structure
- In 2014, ten companies marketed 88% of the world's uranium mine production
- An increasing proportion of uranium, now 46%, is produced by in situ leaching.

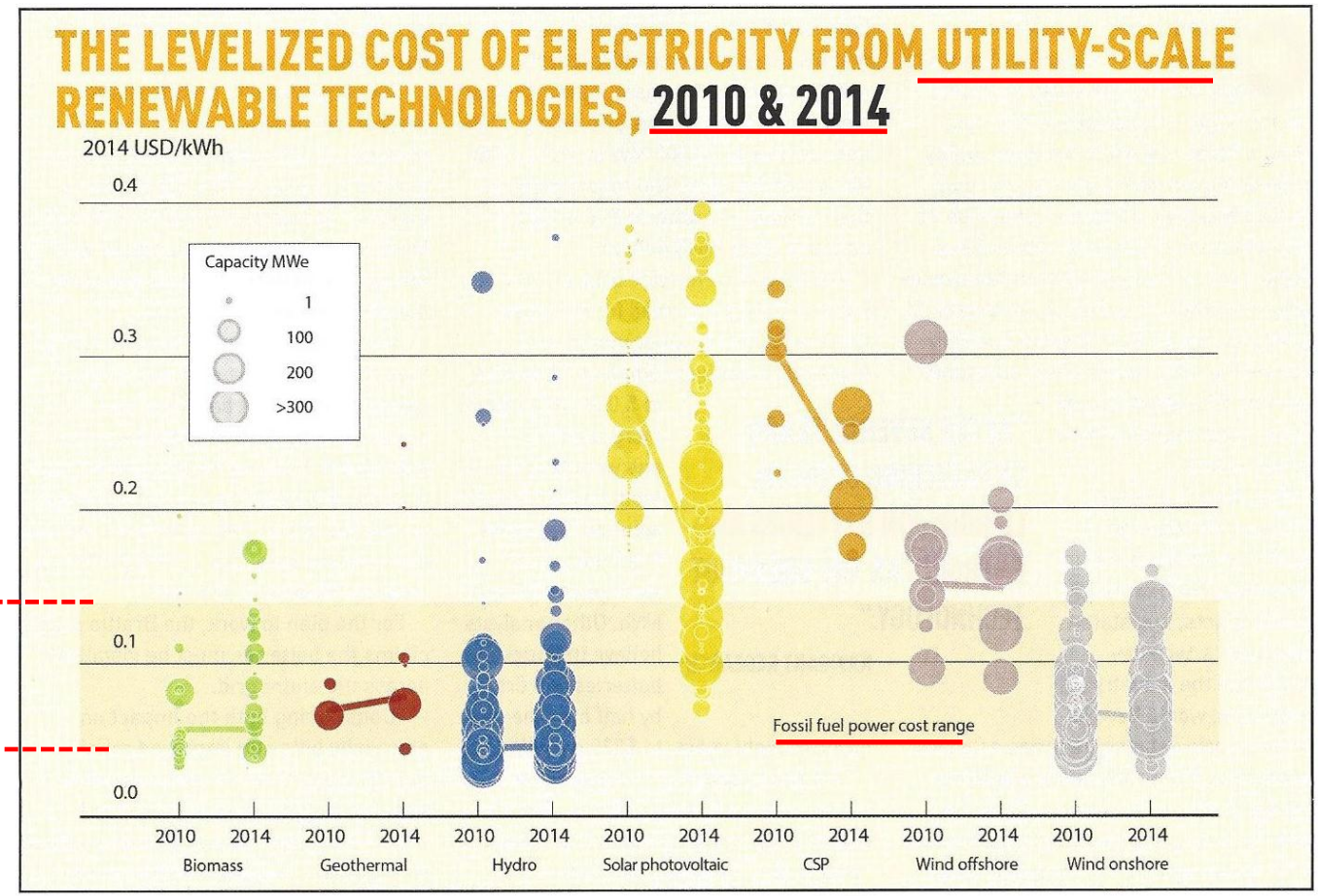
tonnes U	2007	2008	2009	2010	2011	2012	2013	2014
Kazakhstan	6637	8521	14020	17803	19451	21317	22451	23127
Canada	9476	9000	10173	9783	9145	8999	9331	9134
Australia	8611	8430	7982	5900	5983	6991	6350	5001
Niger	3153	3032	3243	4198	4351	4667	4518	4057
Namibia	2879	4366	4626	4496	3258	4495	4323	3255
Russia	3413	3521	3564	3562	2993	2872	3135	2990
Uzbekistan (est)	2320	2338	2429	2400	2500	2400	2400	2400
USA	1654	1430	1453	1660	1537	1596	1792	1919
China (est)	712	769	750	827	885	1500	1500	1500
Ukraine (est)	846	800	840	850	890	960	922	926
South Africa	539	655	563	583	582	465	531	573
India (est)	270	271	290	400	400	385	385	385
Malawi			104	670	846	1101	1132	369
Brazil (est)	299	330	345	148	265	231	231	231
Czech Republic	306	263	258	254	229	228	215	193
Romania (est)	77	77	75	77	77	90	77	77
Pakistan (est)	45	45	50	45	45	45	45	45
Germany	41	0	0	8	51	50	27	0
France	4	5	8	7	6	3	5	3
Total World	41 282	43 764	50 772	53 671	53 493	58 394	59,370	56,184
tonnes U3O8	48 683	51 611	59 875	63 295	63 084	68 864	70,015	66,258
Percentage of World Demand*	64%	68%	78%	78%	85%	86%	92%	85%

- 2/3 of the world's production of uranium from mines is from Kazakhstan, Canada and Australia.
- After a decade of falling mine production to 1993, output of uranium has generally risen since then and now meets over 90% of demand for power generation.
- Kazakhstan produces the largest share of uranium from mines (41% of world supply from mines in 2013), followed by Canada (16%) and Australia (9%).

Source: World Nuclear Association; www.world-nuclear.org

Renewables

Renewables Levelized Cost 2010 & 2014

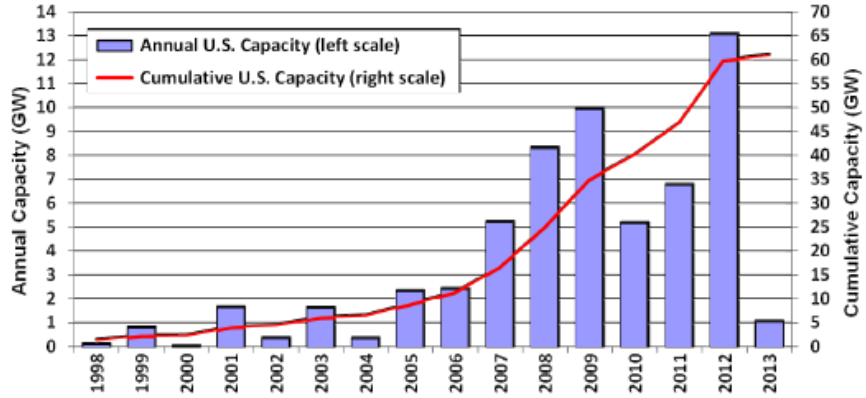


$0.14/kWh --------

$0.05/kWh ---------

Source: IRENA Renewable Cost Database.
Note: Size of the diameter of the circle represents the size of the project. The centre of each circle is the value for the cost of each project on the Y axis. Real weighted average cost of capital is 7.5% in OECD countries and China; 10% in the rest of the world.

Wind Data



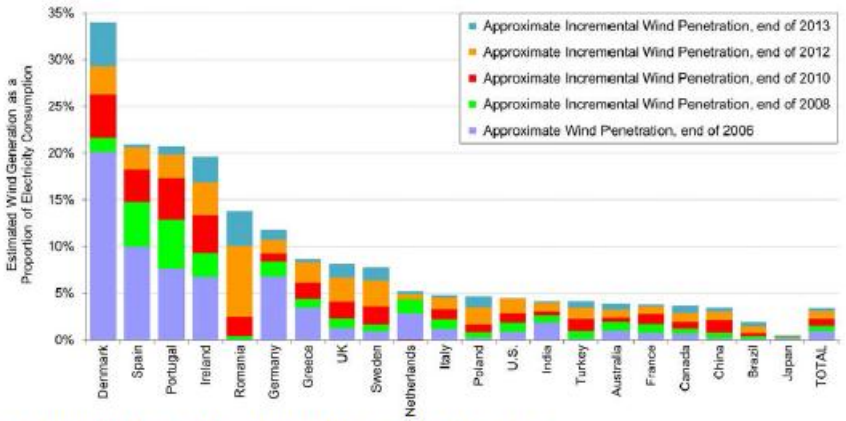
Source: AWEA project database

Figure 1. Annual and cumulative growth in U.S. wind power capacity

Table 1. International rankings of wind power capacity

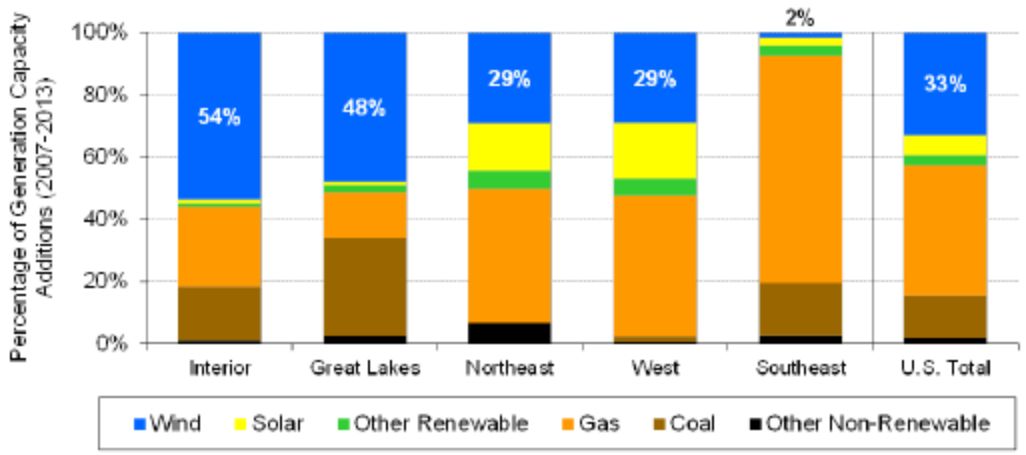
Annual Capacity (2013, MW)		Cumulative Capacity (end of 2013, MW)	
China	16,088	China	91,460
Germany	3,237	United States	61,110
India	1,987	Germany	34,468
United Kingdom	1,833	Spain	22,637
Canada	1,599	India	20,589
United States	1,087	United Kingdom	10,946
Brazil	948	Italy	8,448
Poland	894	France	8,128
Sweden	724	Canada	7,813
Romania	695	Denmark	4,747
Rest of World	7,045	*Rest of World*	51,031
TOTAL	36,137	TOTAL	321,377

Source: Navigant; AWEA project database for U.S. capacity



Source: Berkeley Lab estimates based on data from Navigant, EIA, and elsewhere

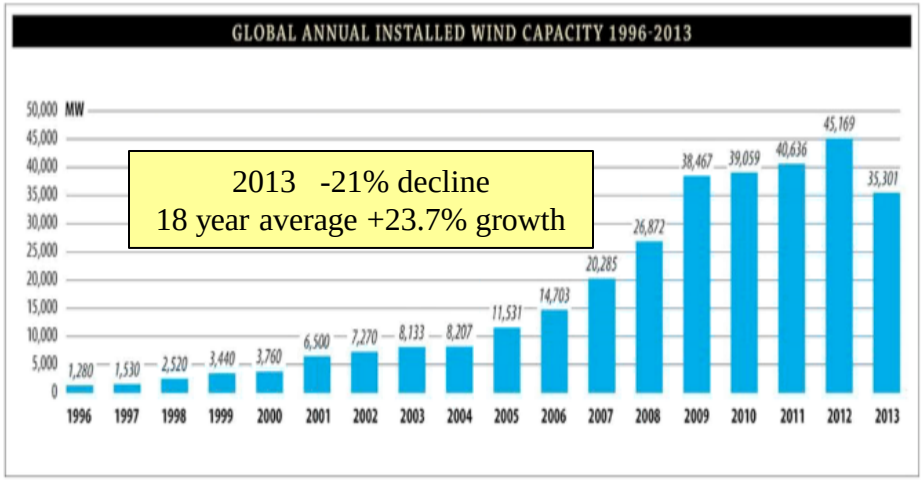
Figure 4. Approximate wind energy penetration in the countries with the greatest installed wind power capacity

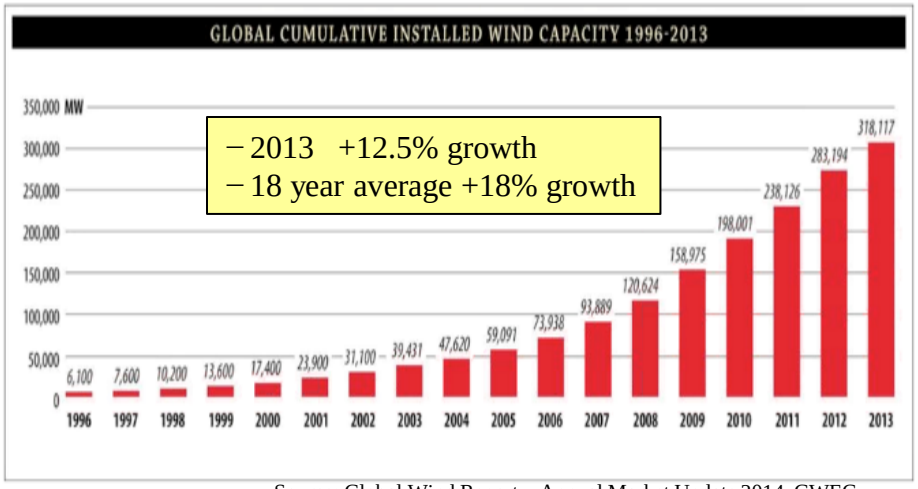


Source: EIA, Ventyx, AWEA, Interstate Renewable Energy Council, SEIA/GTM Research, Berkeley Lab

Figure 3. Generation capacity additions by region (2007–2013)

Wind Installed Capacity & Load Factors (2012)





Source: Global Wind Report – Annual Market Update 2014, GWEC

Average Load Factor is 21.5%
- High 28.3% - Denmark
  26.8% - USA
  17.9% - China
- Low 16.8% - Germany

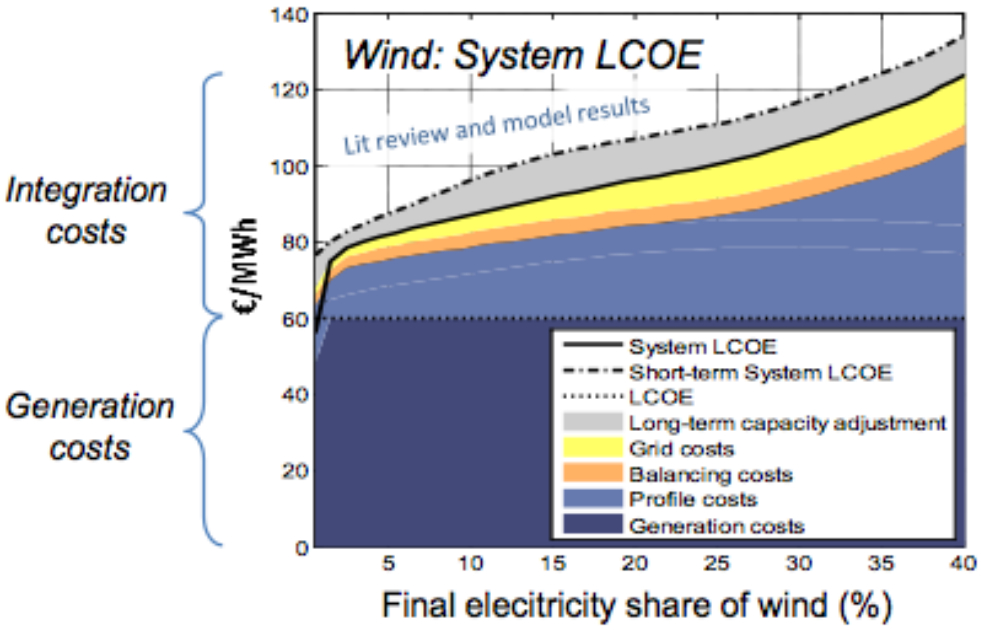
Top windpower electricity producing countries in 2012 (TWh)

Country	Windpower Production	% of World Total	Nameplate GW	Nameplate TWh	Load Factor
United States	140.9	26.40%	60.0	526	26.8%
China	118.1	22.10%	75.3	660	17.9%
Spain	49.1	9.20%	22.8	200	24.6%
Germany	46.0	8.60%	31.3	274	16.8%
India	30.0	5.60%	18.4	161	18.6%
United Kingdom	19.6	3.70%	8.4	74	26.6%
France	14.9	2.80%	7.6	67	22.4%
Italy	13.4	2.00%	8.1	71	18.9%
Canada	11.8	2.20%	6.2	54	21.7%
Denmark	10.3	1.90%	4.2	36	28.3%
Rest of World	80.2	15.00%	40.9	358	22.4%
World Total	534.3	100.00%	283.1	2480	21.5%

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.

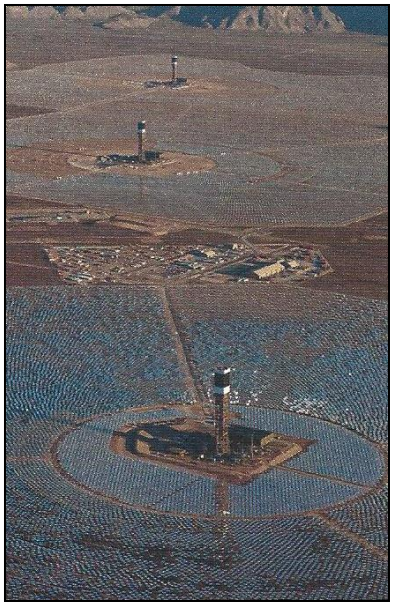


Source: System LCOE: What are the costs of variable renewables? Falko Ueckerdt, Lion Hirth, Gunnar Luderer, Ottmar Edenhofer Paris, June 20, 2013 32th International Energy Workshop

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

Concentrating "Big Solar"

Parameter	Ivanpah
Output	392 MW (gross), 377 MW (net)
Boiler inlet temp	368F
Steam temp	1,013F
Steam pressure	2,479 psi
Heliostats	173,500 (each holds two mirrors)
Heliostat solar-field aperture area	2,600,000 m^3
Tower height	459 ft
Net generation (first 100 days)	116,000 MWh
Gross efficiency	28.72%

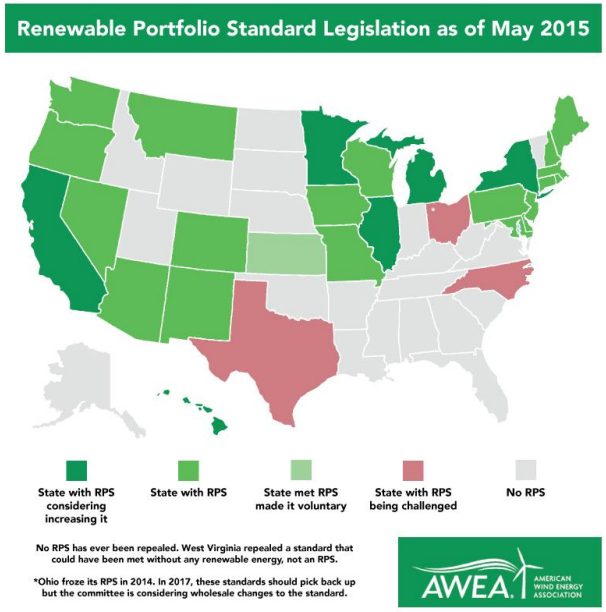


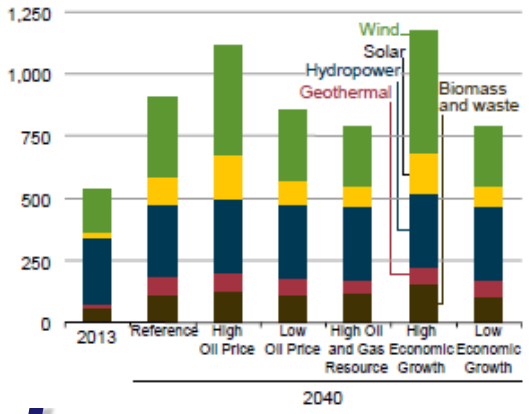
- Three self-contained units
- 3500 acres
- 5 miles end-to-end
- 4 types of heliostats depending on distance
- Air-cooled condensers

- Project Partners
- Bright Source Energy
- NRG Energy (NRG Renew)
- Google
- Bechtel

Source: Power Magazine August 2104

Renewable Portfolio Standards





- Seven states—Hawaii, California, Nevada, Colorado, Minnesota, Connecticut, and Oregon—have effective RPS requirements of 25 percent or greater.
- Six states – CA, MI, NY, MN, IL and VT – are seriously debating an increase in their RPS this year.
- Ohio: With the signing of Senate Bill 310 in 2014, Ohio became the only state to "freeze" its RPS, effectively halting the state's mandates for efficiency and renewables until 2017. In 2017, these standards should pick up where they left off when the freeze occurred, however an Energy Mandates Study Committee is reviewing wholesale changes to the standard. In this context of policy uncertainty, renewable energy employment and investment is moving away, to more welcoming states.
- Legislators in four states (CO, MT, CT, and NH) have voted down proposals to diminish or repeal RPS policies this year.

AEO 2015 Total U.S. renewable generation by fuel in 2013 & six 2040 cases (billion kWh)

Net total available to the grid

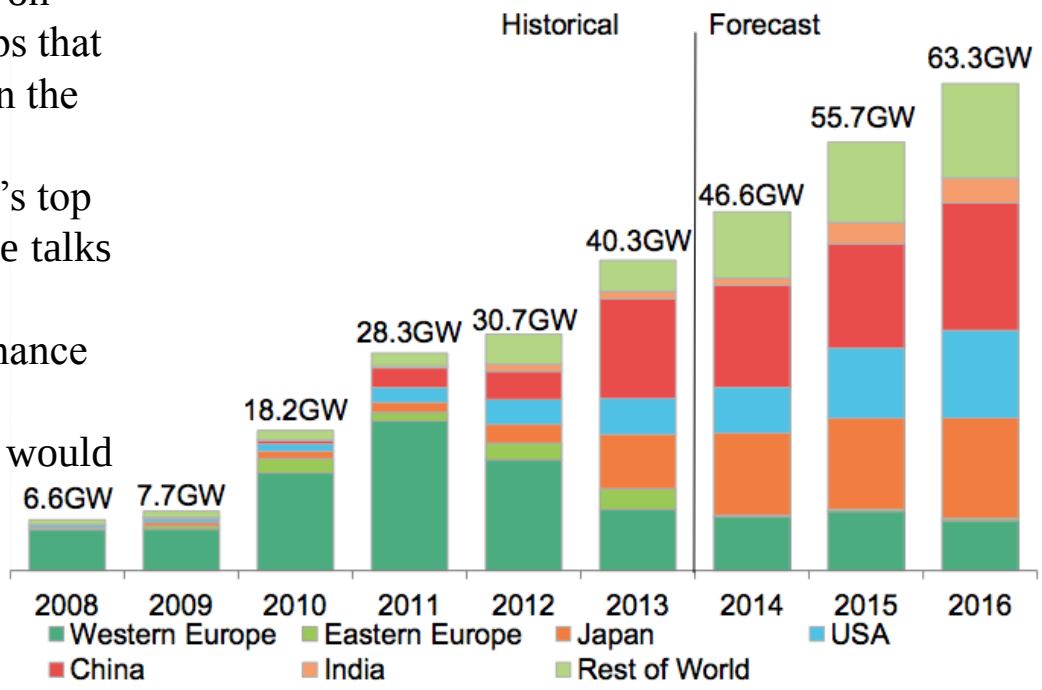
2013 = 3,888 billion kWh (~14%)
2040 Ref = 4,672 billion kWh (~19%)

Source: American Wind Energy Association (AWEA)

Global Investment in Clean Energy

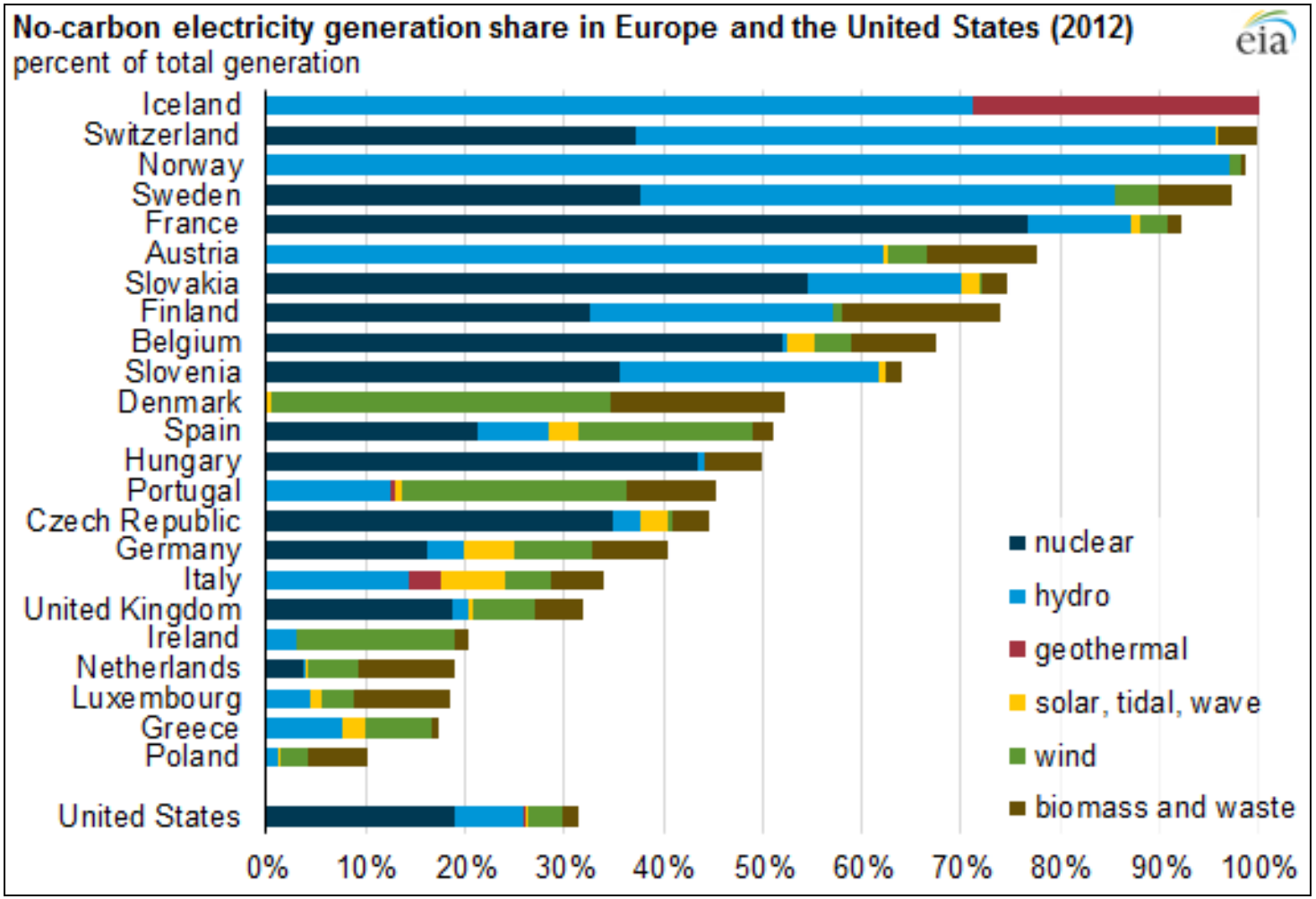
- Global investment in clean energy increased 16 percent last year, to $310 billion, according to data compiled by BNEF.
- The U.S. and China, the world's biggest emitters, reached a historic deal in November to rein in greenhouse gases.
- Pope Francis is preparing a papal encyclical on climate change, a letter to the world's bishops that will formalize the church's moral position on the issue for 1.2 billion Catholics
- He may also convene a summit of the world's top religious leaders in advance of global climate talks in Paris in December.
- Those talks represent the world's last best chance to mitigate the damage from climate change
- National policies to reduce carbon pollution would speed up the adoption of clean energy

BNEF's conservative scenario
More optimistic scenario is 8%-10% higher.



Source: Bloomberg New Energy Finance

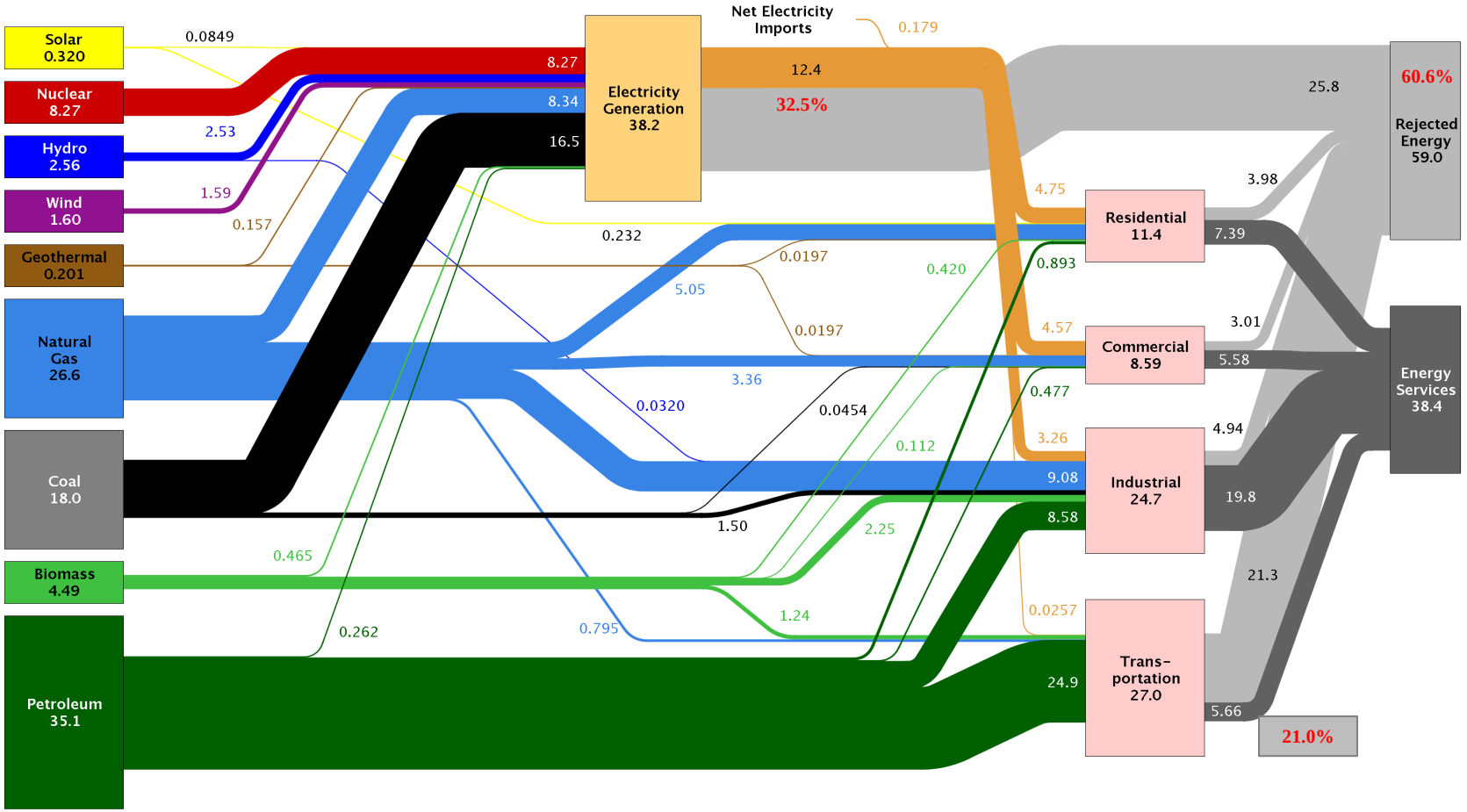
No Carbon Sources



Geo-Political Issues

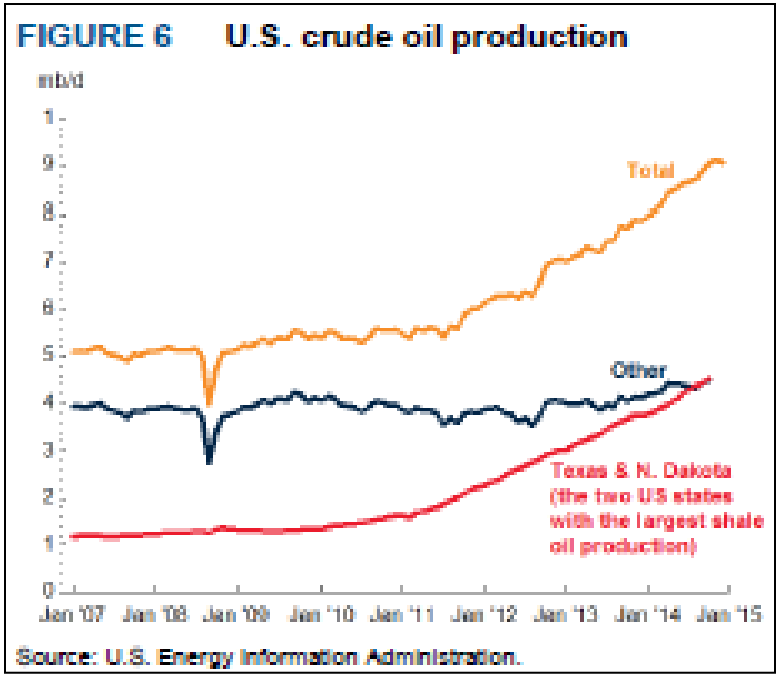
USA

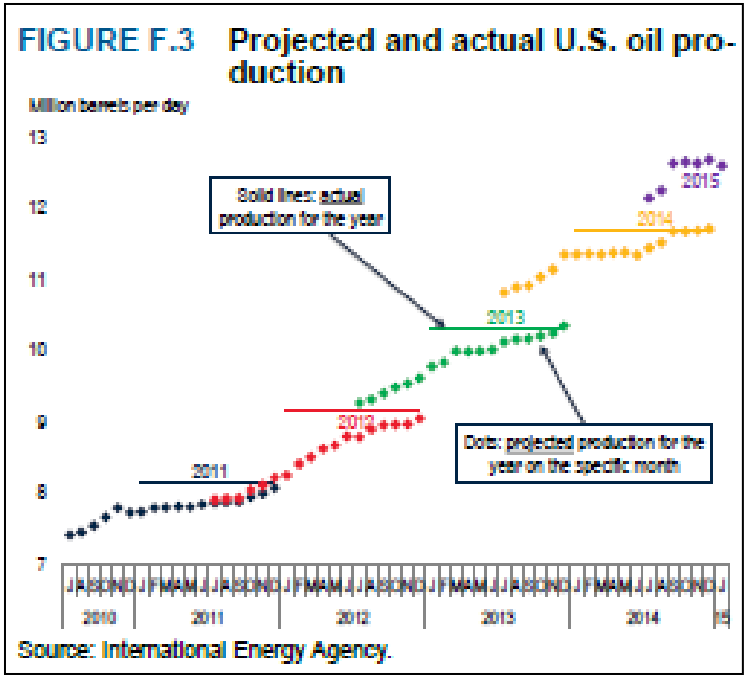
U.S. Energy Consumption 2013 – 97.4 Quads



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

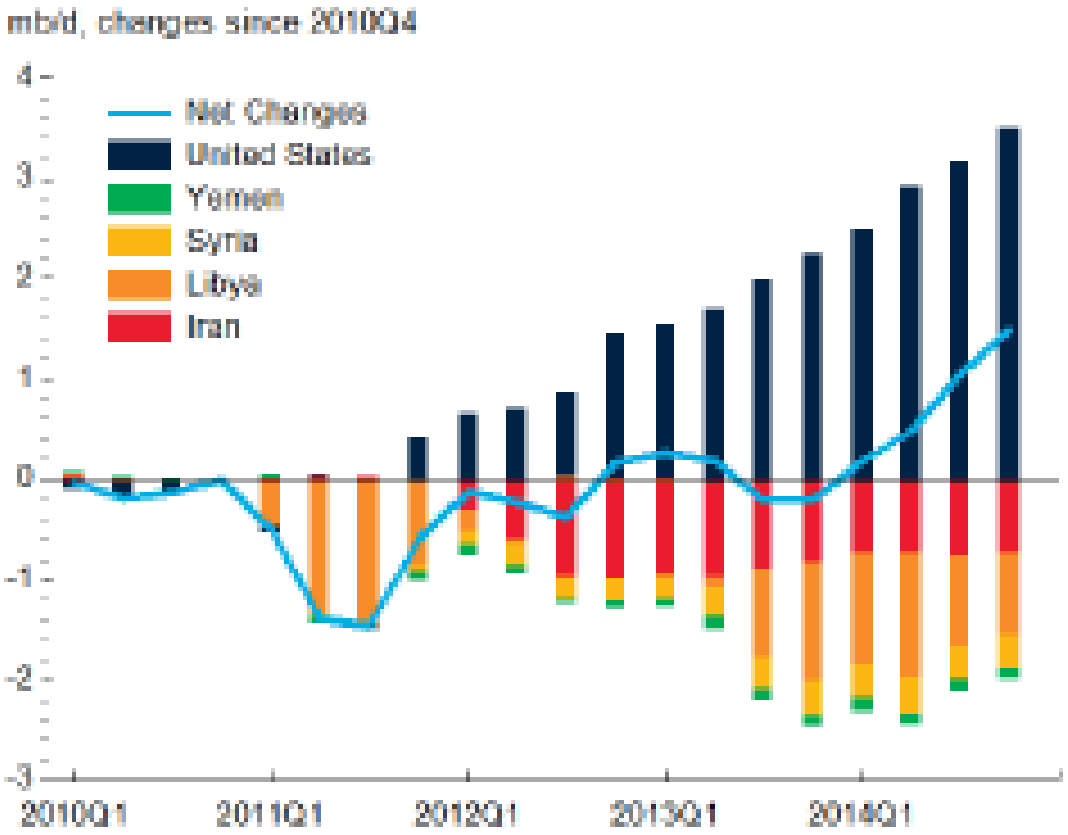
Supply Side – U.S. Production





The U.S. is the Swing Producer

FIGURE 4 U.S. crude oil supply growth and disruptions elsewhere



Source: : World Bank, International Energy Agency.

Annual Energy Outlook - 2015

Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040 (quadrillion Btu)

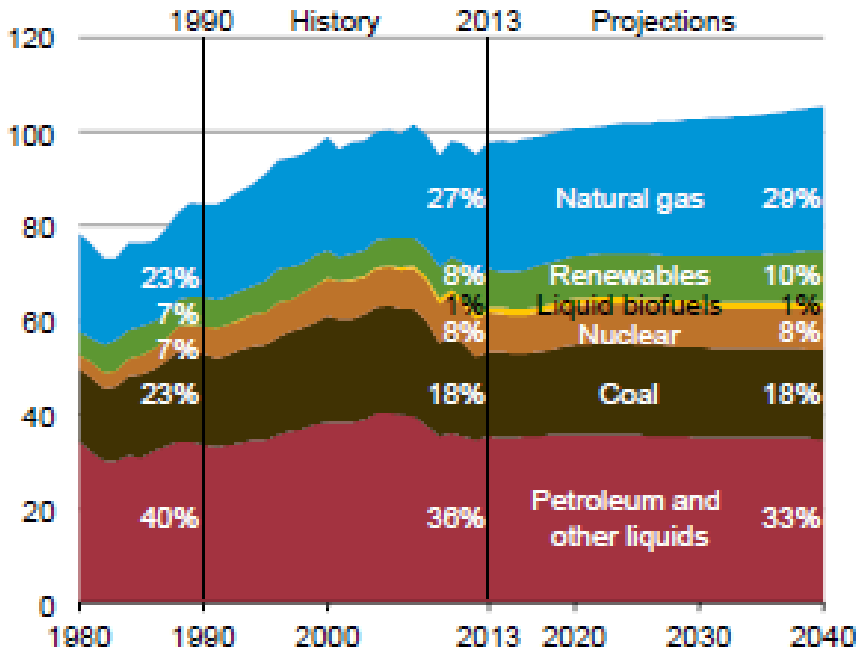
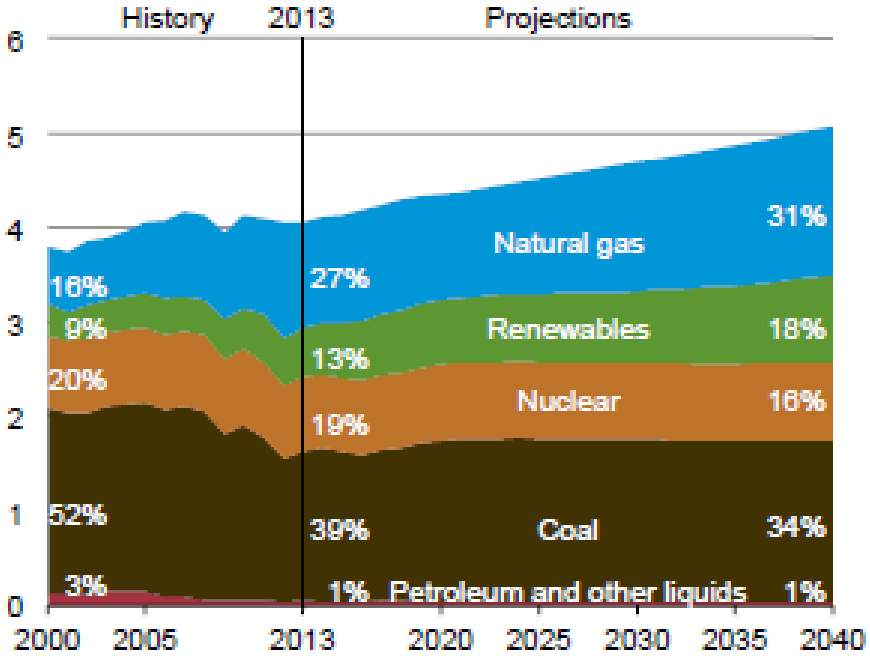
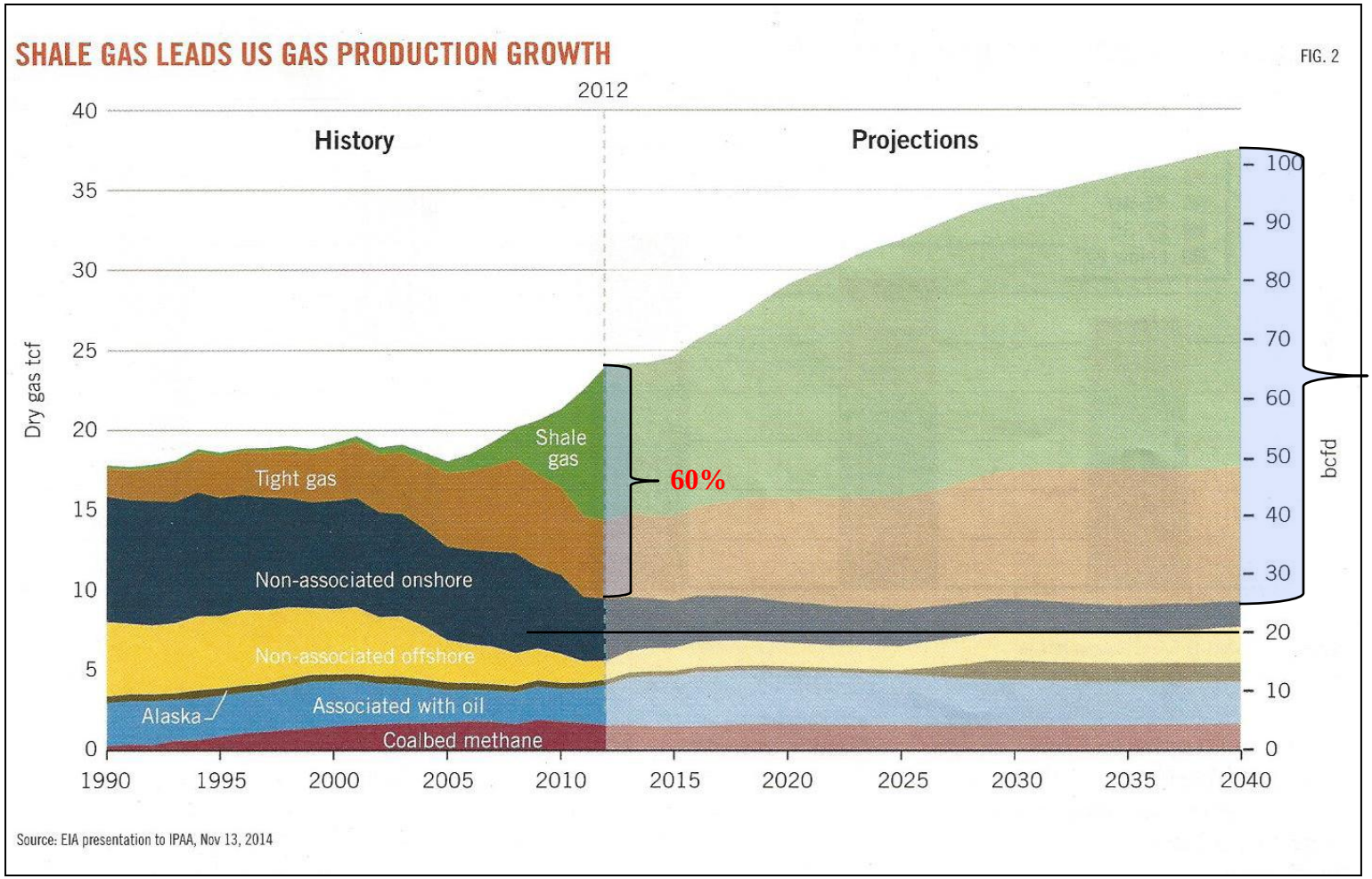


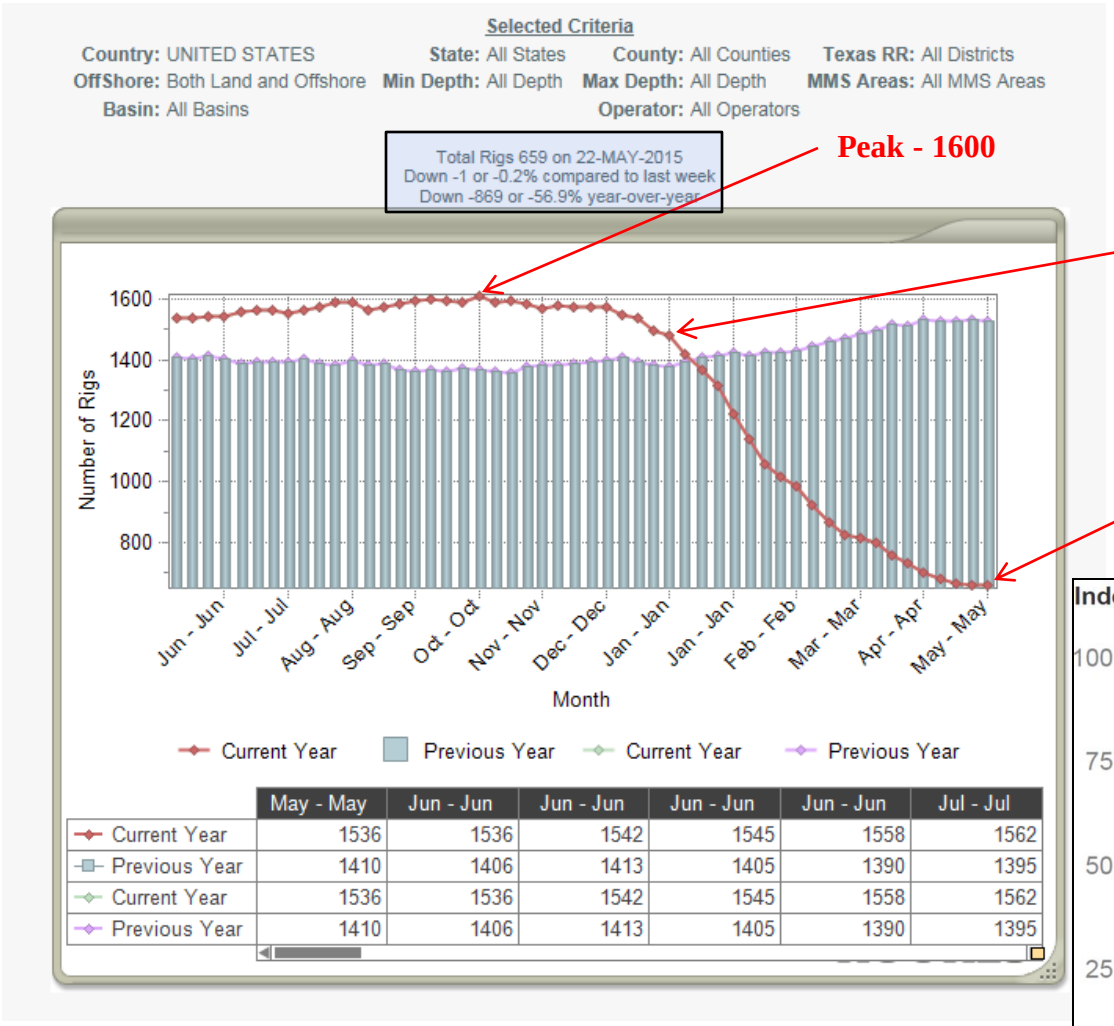
Figure 31. Electricity generation by fuel in the Reference case, 2000-2040 (trillion kilowatthours)



U.S. Shale Gas

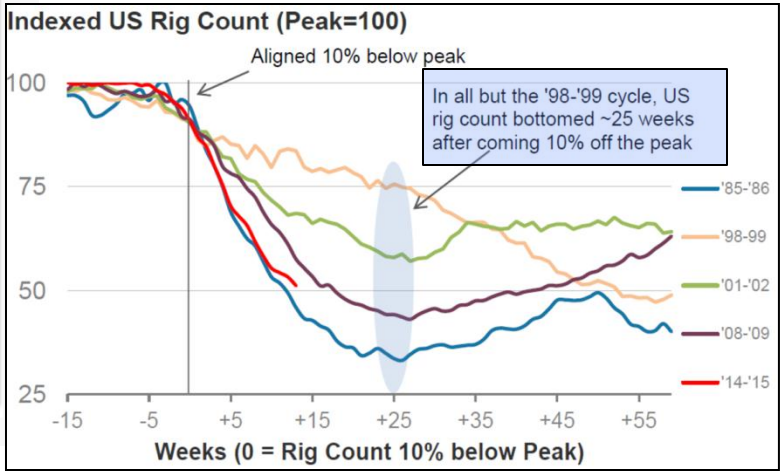

SHALE GAS LEADS US GAS PRODUCTION GROWTH
FIG. 2
2012
History
Projections
Dry gas tcf
bcfd
Shale gas
Tight gas
Non-associated onshore
Non-associated offshore
Alaska
Associated with oil
Coalbed methane
60%
75%
40
35
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020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

Baker Hughes Rig Count



	May - May	Jun - Jun	Jun - Jun	Jun - Jun	Jun - Jun	Jul - Jul
Current Year	1536	1536	1542	1545	1558	1562
Previous Year	1410	1406	1413	1405	1390	1395
Current Year	1536	1536	1542	1545	1558	1562
Previous Year	1410	1406	1413	1405	1390	1395

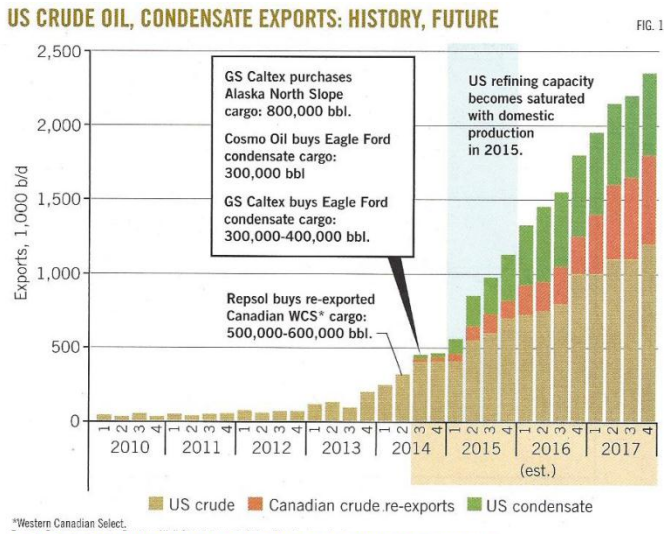
Rig Count 659
May 22, 2015

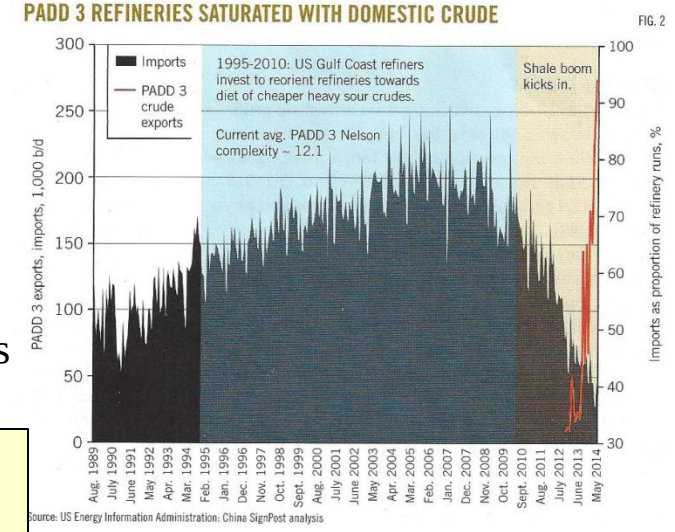


Source: Bloomberg Business

U.S. Crude Oil Exports

- Available for export
  - 1.5 MMbbl/d of domestic crude
  - 0.5 MMbbl/d re-exported Canadian crude
  - On par with Kuwait
- Refinery constraints began to appear late 2012
  - Max import substitution threshold 65%/35% domestic/imports
  - Domestic production gains will increase pressure to export
- Fig. 1 based on $75/bbl for U.S. shale
- Mid-east operational disruptions disturb Asian customers
- U.S political mechanisms appear to be in place to support lifting the existing bans
- U.S. competitive advantages
  - Asian refineries have room for substantial light sweet crude
  - U.S. lighter crude can be blended with heavier Canadian to match refinery preferences
  - U.S. Crude exports will be the global swing barrels, putting pressure on Mid-East supplies
- U.S. independent suppliers will be driven by market opportunities rather than oil ministry mandates imposed on NOC's



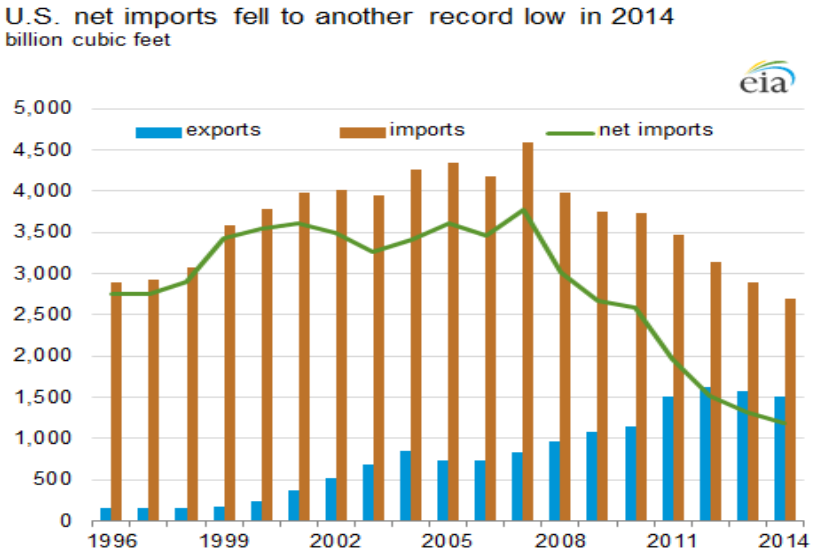


This is why producers want export restrictions removed

Source: O&G Journal Dec 2014

U.S. Balance of Trade Natural Gas

- Lower natural gas imports from Canada resulted in the decline of net imports in 2014, which were 41% below the five-year average.
- Natural gas imports to the United States, 98% of which arrive via pipeline from Canada:
  - Have decreased almost every year since 2007
  - In 2014 reached the lowest level (2,636 Bcf) since January 1995.
- Natural gas exports from the United States decreased 4% in 2014 to 1,509 Bcf, but they remained 9% above the five-year average
- Natural gas exports to Mexico increased 10% in 2014, setting a record, but exports to Mexico did not offset the 16% decline of natural gas exports to Canada.
- The United States also traded liquefied natural gas (LNG) and compressed natural gas (CNG) with its partners, but these volumes were minimal in 2014.

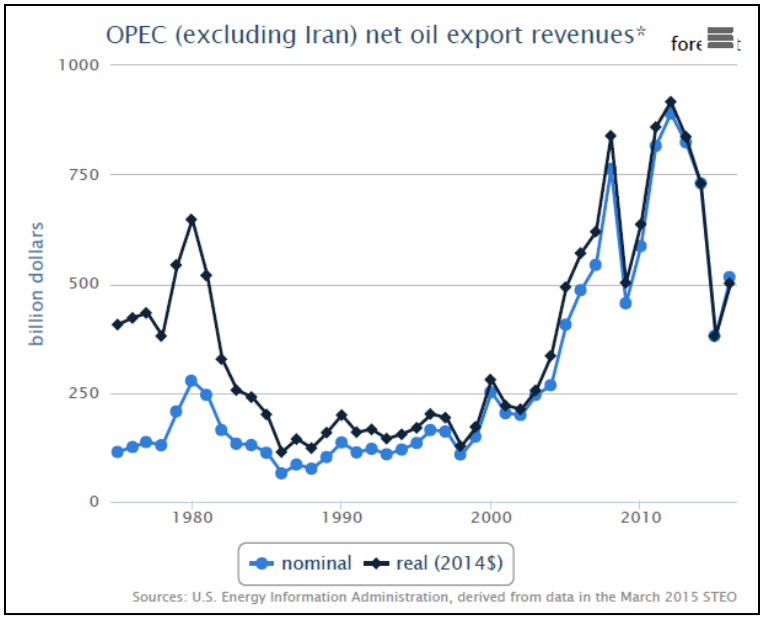


U.S. Natural Gas Imports & Exports 2014

	5-year avg.	2013	2014	2014 vs. 5-year avg.	2014 vs. 2013
Imports (Bcf)					
Pipeline	3,095.7	2,786.5	2,635.9	-15%	-5%
LNG	300.7	96.9	59.2	-80%	-39%
CNG			0.3		na
Total	3,396.4	2,883.4	2,695.4	-21%	-7%
Exports					
Pipleline	1,341.3	1,569.4	1,492.4	11%	-5%
LNG	17.5	0.2	13.6	-22%	6739%
LNG re-exports	22.4	2.7	2.7	-88%	-2%
CNG		0.1	0.2		89%
Total	1,381.2	1,572.4	1,508.9	9%	-4%
Net	2,015.2	1,310.9	1,186.5	-41%	-9%

OPEC

OPEC Net Oil Export Revenue



OPEC (excluding Iran) net oil export revenues

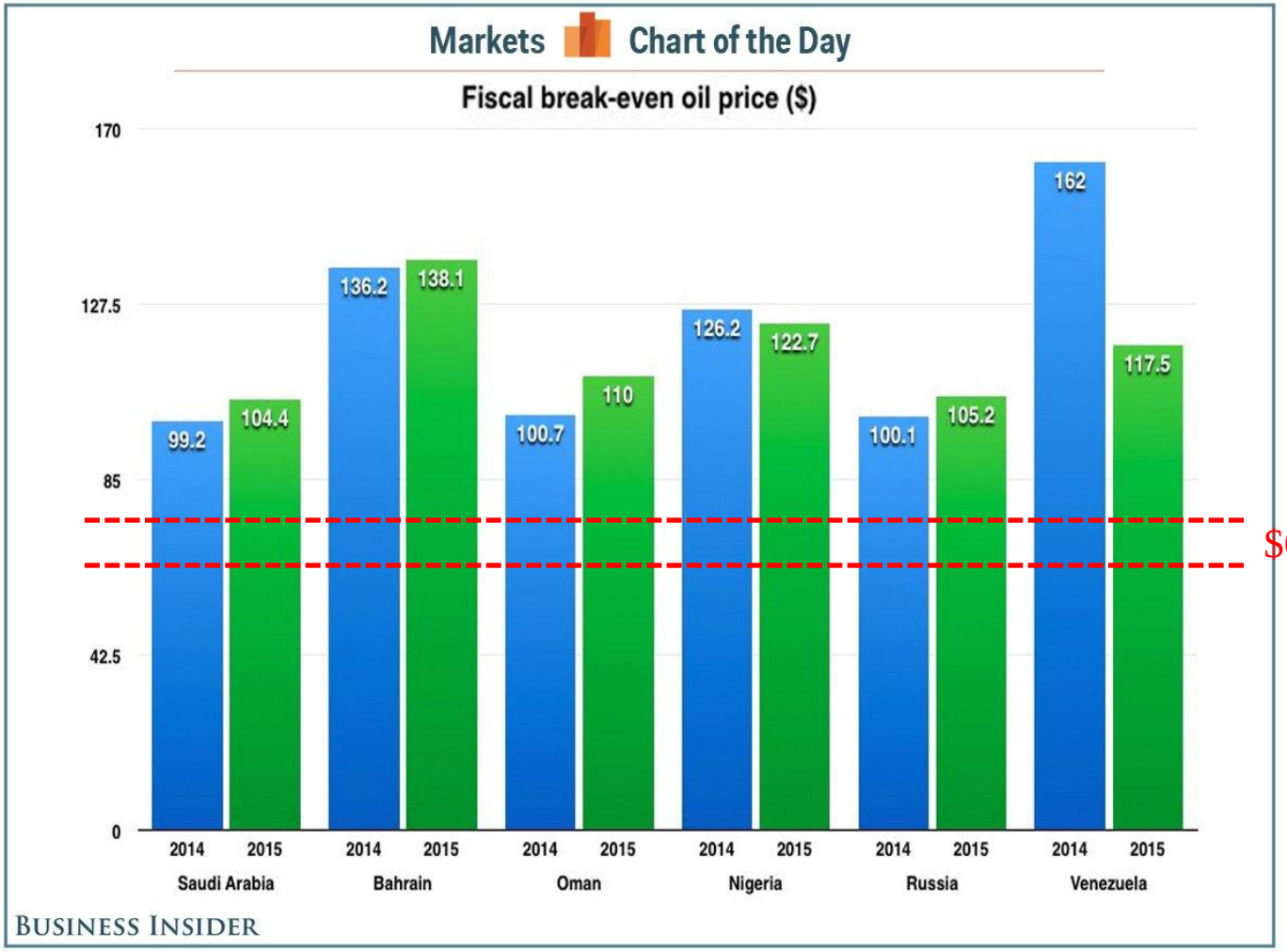
	Nominal (billion $)					Real (billion 2014$)				
Country	2013	2014	2015	2016	Jan-Feb 2015	2013	2014	2015	2016	Jan-Feb 2015
Algeria	$55	$48	--	--	$4	$56	$48	--		$4
Angola	$27	$24	--	--	$2	$27	$24	--		$2
Ecuador	$10	$10	--	--	$1	$10	$10	--		$1
Iran	--	--	--	--	--	--	--	--		--
Iraq	$87	$87	--	--	$7	$88	$87	--		$7
Kuwait	$90	$81	--	--	$7	$91	$81	--		$7
Libya	$29	$9	--	--	$0	$29	$	--		$0
Nigeria	$82	$77	--	--	$6	$84	$77	--		$6
Qatar	$42	$38	--	--	$3	$42	$38	--		$3
Saudi Arabia	$278	$246	--	--	$19	$282	$246	--		$19
UAE	$57	$53	--	--	$4	$58	$53	--		$4
Venezuela	$67	$58	--	--	$5	$68	$58	--		$5
OPEC	$824	$730	$380	$515	$58	$837	$730	$380	$501	$58

View nominal or real data (2005-16)

Source: U.S. Energy Information Administration, derived from EIA's March 2015 Short-Term Energy Outlook.

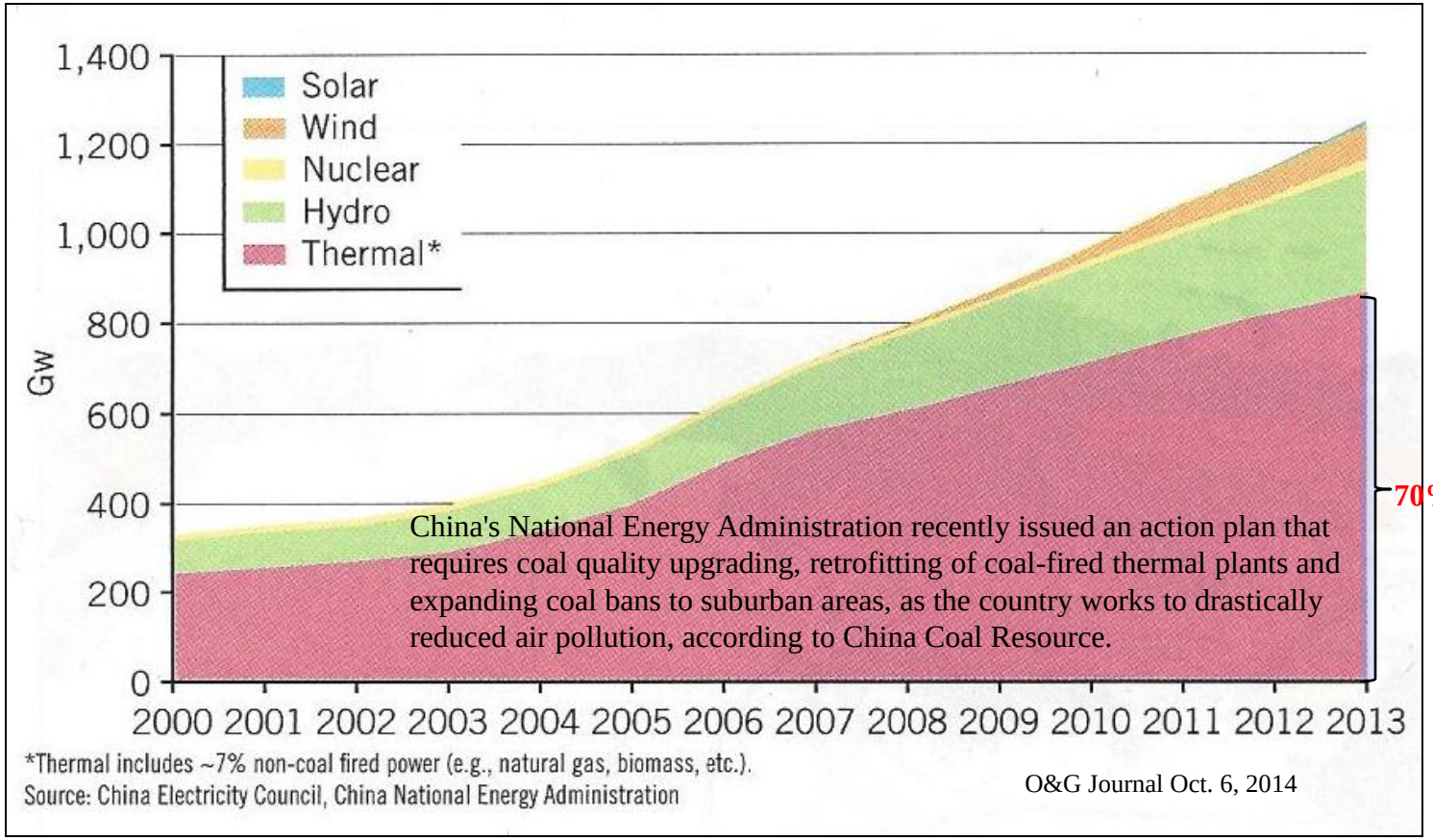
- 2014 at $730b declined 11% from $824b in 2013
- EIA projects further decline to $380b in 2015
- Saudi Arabia represents 1/3 of this revenue
- Saudi Arabia has indicated it intends to maintain export market share, rather than cut production
- 2016 forecast of $515b based on a forecast crude oil price recovery

Fiscal Break-Even by Producing Country

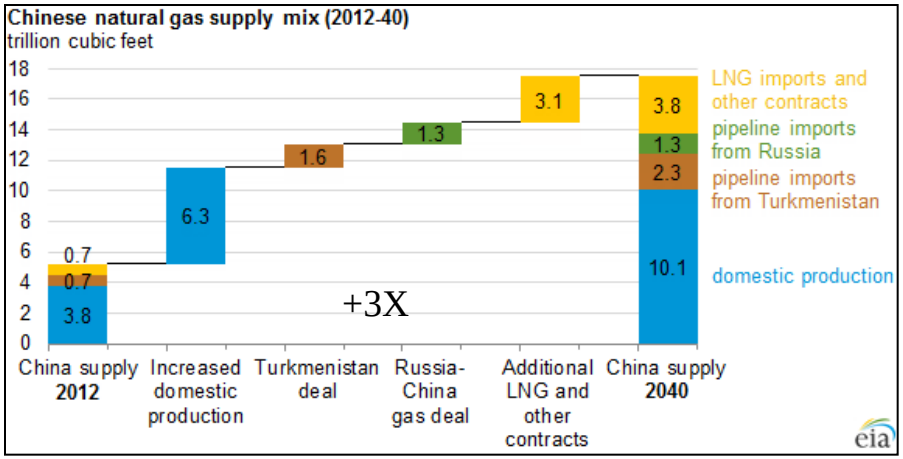


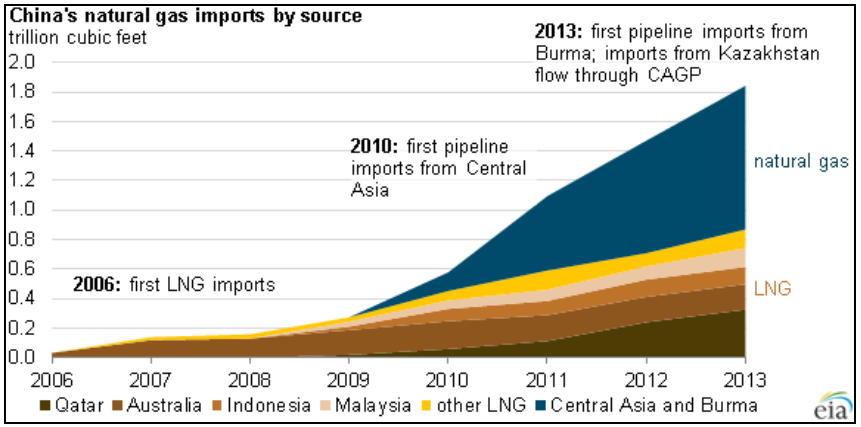
China

Installed Generating Capacity - China

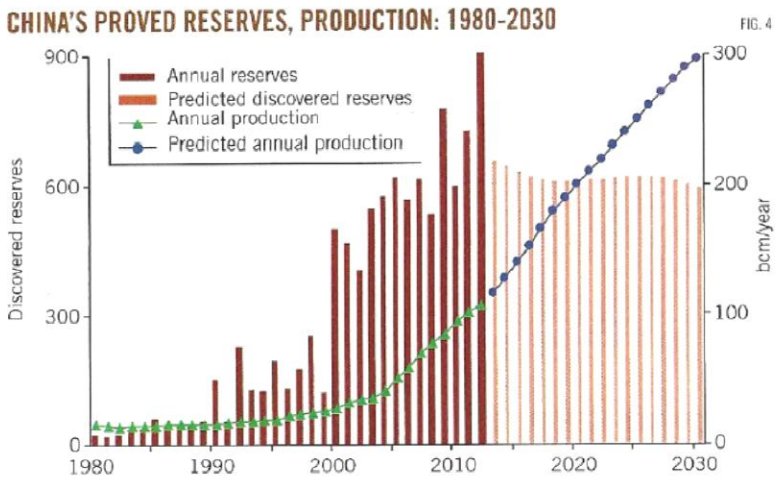


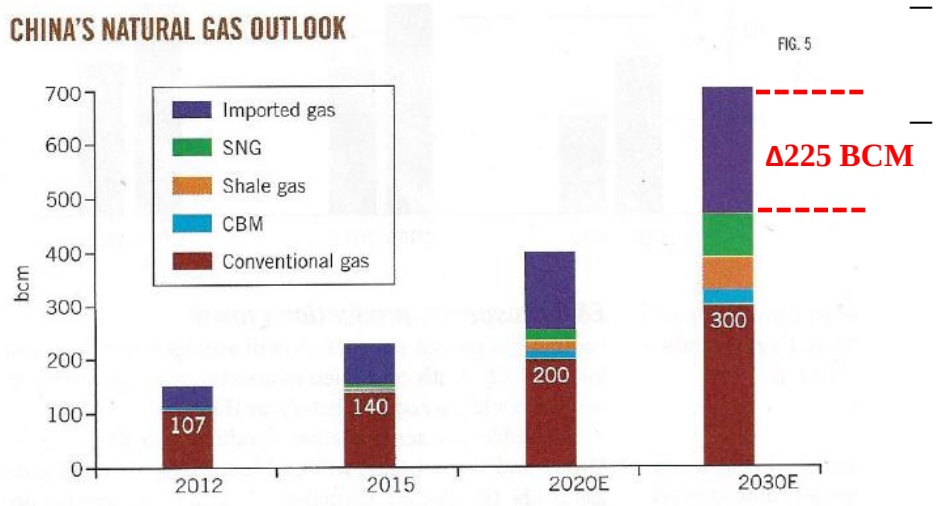
China Natural Gas





China Natural Gas





Oil & Gas Journal Sept. 2014

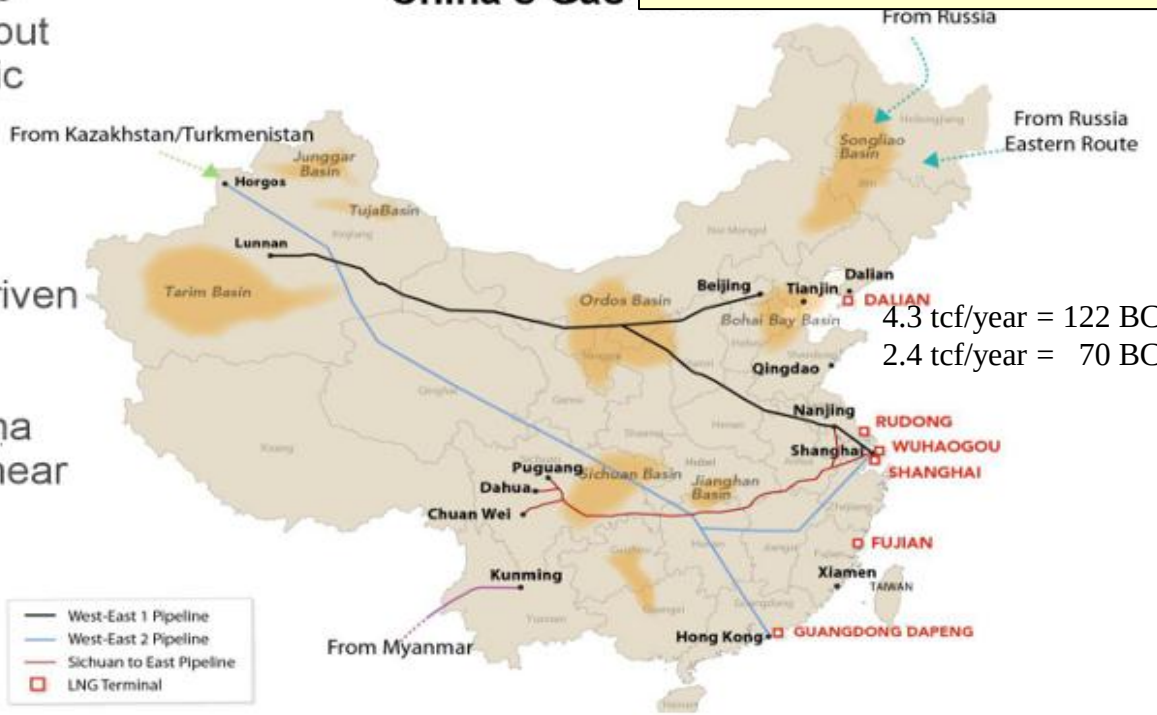
- China 2012
  - Consumption - 147.1 BCM
  - Production - 107.1 BCM
  - Imported - 42.5 BCM
- China 2015
  - Consumption - 230.0 BCM
- China 2020
  - Consumption - 375.0 BCM
- China 2030
  - Consumption - 700.0 BCM
- Demand growth driven by:
  - Continued Industrialization
  - Urban & Agricultural Modernization
  - Switch from coal to natural for power generation
  - Future use of CNG for cars and trucks
  - Alternative fuels

China: World's Second Largest Importer by 2025

Over 2.4 tcf per year of LNG demand, growing at a fast pace with high uncertainty

China forecast:
2015 - 230 BCM (15.6%/year)
2020 - 375 BCM (12.6%/year)

- LNG demand expected to grow near 15% per year but is dependent on economic growth, domestic gas production and pipeline imports
- Chinese LNG demand driven by GDP growth
- Pipeline imports into China are projected to grow to near 4.3 tcf a year
- Domestic production will remain the major gas source



4.3 tcf/year = 122 BCM/year
2.4 tcf/year = 70 BCM/year

China has built LNG import terminals along its eastern coast and pipelines to move natural gas from Central Asia suppliers to serve its population centers

Source: Poten & Partners

Natural Gas Pipelines to China - 227 BCM

新疆天然气输出管道和输送能力（十亿立方米/年，更新至2013年5月）
Xinjiang Gas Out-Pumping Pipelines and Capacities (in bnNm³/a, as of May 2013)

管道工程名称 Pipeline Name	投资者 Investor	输送能力 Capacity	状态 Status	投运时间 Startup Time
西气东输一线 West-to-East #1	中石油 PetroChina	17	运营 In Operation	2004
西气东输二线 West-to-East #2	中石油 PetroChina	30	运营 In Operation	2011
西气东输三线 West-to-East #3	中石油 PetroChina	30	即将完工 To be started up	H2 2013
西气东输四线 West-to-East #4	中石油 PetroChina	45	环评 Environmental Assessment	N/A
西气东输五线 West-to-East #5	中石油 PetroChina	45	规划 Proposed	N/A
新粤浙煤制天然气管道 Xinjiang-Guangdong-Zhejiang SNG	中石化 Sinopec	30	已获路条 Pre-approved	2016
新鲁煤制天然气管道 Xinjiang-Shandong SNG	中石化 Sinopec	30	规划 Proposed	N/A
总计 Total		227		

Source: ASIACHEM

Big coal-based SNG plant starts in China

HOUSTON, Oct. 28
10/28/2013
By OGJ editors

- Haldor Topsoe, AS, Denmark, reported the start-up in Xinjiang, China, of what it calls the world's largest substitute natural gas plant.
- The $4.1 billion, single-train plant has a planned output of 1.4 normal cu m/year of SNG Qinghua Group of China owns and operates the facility.
- The plant uses Hador Topsoe technology for methanation of synthesis gas derived from coal.
- Most of the SNG produced at the Qinghua will be moved by pipeline to populous areas of China, especially in the eastern part of the country.

China Shale Gas

China was ranked as the largest holder of shale gas resources among the 41 countries assessed for technically recoverable shale resources in the study released by EIA/ARI this past June.

FIG. 2. China shale gas and oil reserves assessment. Sources: US EIA and Advanced Resources International Inc.

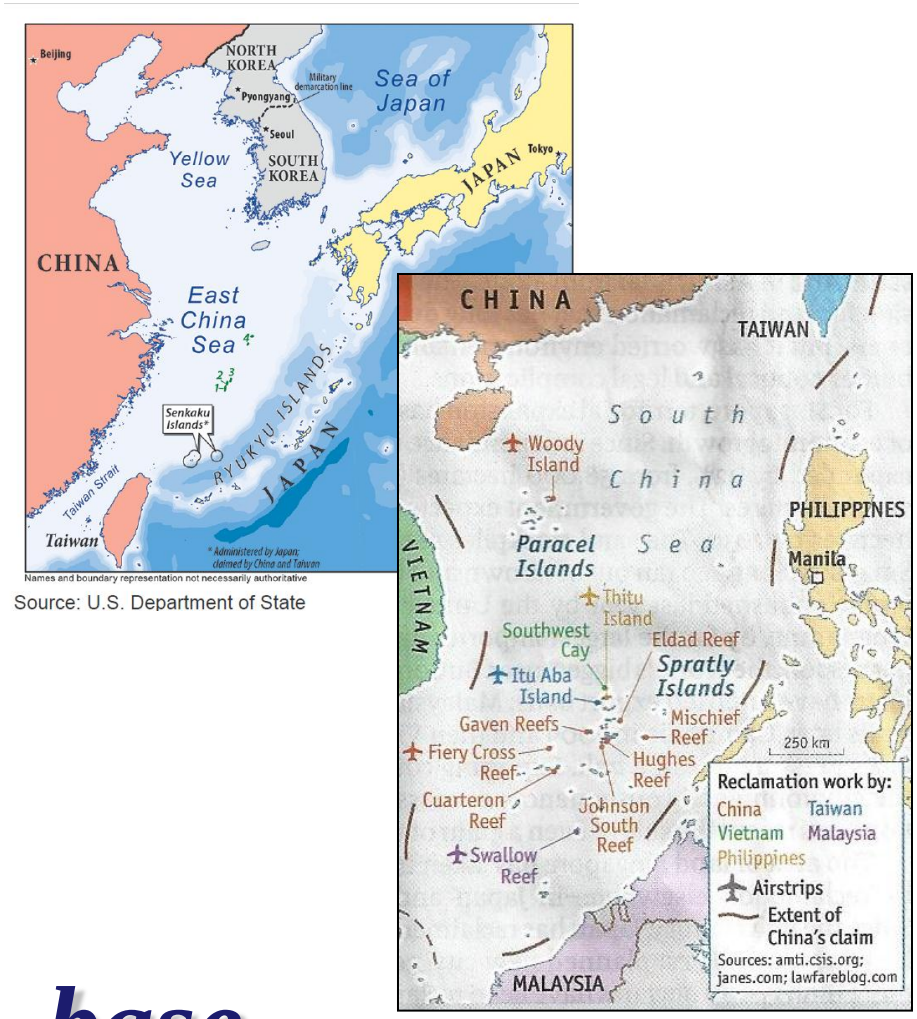
ESTIMATED CHINESE SHALE GAS RESOURCES

Table

Year	Institute, expert	Geological resources, trillion cu m	Technically recoverable resources, trillion cu m
2009	Research Inst. Of Petroleum Exploration & Development (RIPED), Dong Dazhong, Chen Kemming, et al.	86-166	15-32
2010	RIPED, Zou Caineng, et al.	30-100	10-15
2010	RIPED, Liu Honglin, et al.	30-100	21.4-45
2010	China University of Geosciences (Bejing), Zhang Jinchuan, et al.	30-100	15-30
2010	CNPC Consulting Center, Qiu Jianzhong	30-100	18-29
2011	RIPED, Dong Dazhong, Wang Shejiao, etal.	30-100	12-18
2011	CNPC, Zhao Wenzhi	30-100	7-10
2011	US Energy Information Administration	144.40	36.10
2012	Ministry of Land and Resources, People's Republic of China	134.42	25.08

O&G Journal Oct 2014

East China Sea & South China Sea



Source: U.S. Department of State

- China said its recent gas discovery in the South China Sea could yield 100 BCM natural gas
- Petroleum reserves and fisheries are among the resources at stake in disputes over the South China Sea
- The South China Sea is one of the world's busiest shipping routes
- There is a patchwork of overlapping claims by governments including China, the Philippines, Malaysia, Vietnam and Taiwan.
- China claims virtually all of the South China Sea.
- The gas field has a depth of about 1,500 meters
- China is building and militarizing islands to further its land mass claims

India

India

1. Total renewable capacity. Although India's Central Electricity Authority provides 29,462 MW as the total renewable capacity at the end of December 2013 (as cited in the text) and the Ministry of New and Renewable Energy (MNRE) finds a total of 29,989 MW, the variance is small. Numbers in the chart are rounded. *Source: MNRE*

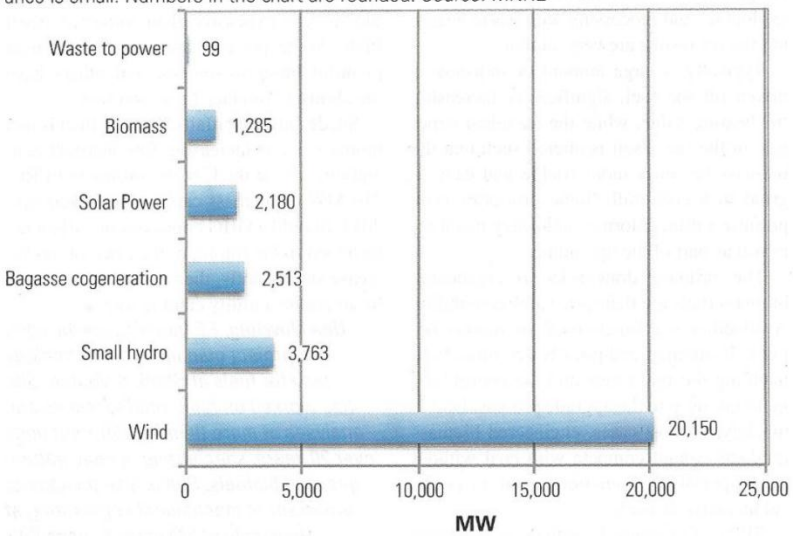


Table 1. India's installed capacity. *Source: Central Electricity Authority*

	Dec. 31, 2012 capacity (MW)	Dec. 31, 2013 capacity (MW)	Capacity added (MW)
Renewables	25,856	29,463	3,606
Coal	120,873	138,213	17,340
Gas	18,903	20,381	1,478
Diesel	1,200	1,200	0
Nuclear	4,780	4,780	0
Hydro	39,339	39,893	554
Total	**210,952**	**233,930**	**22,978**

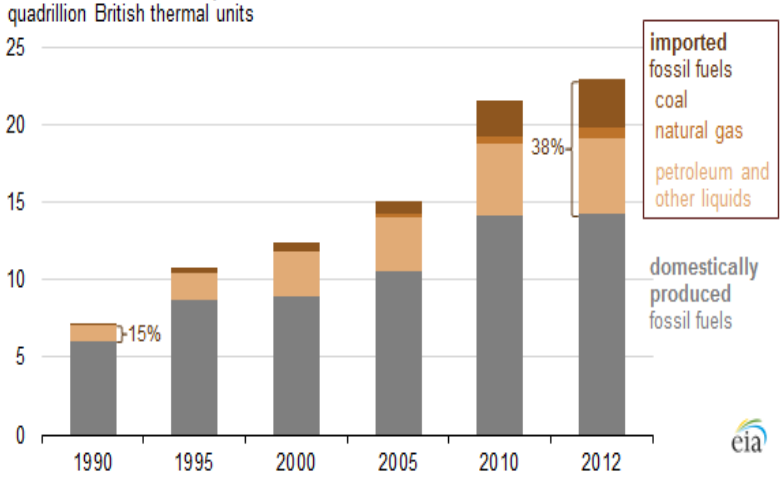
Source: Power Magazine May 2014

Table 3. Installed solar PV capacities (GW). Values are approximate. *Source: Sterling & Wilson*

Country	PV capacity
Germany	36
China	20
U.S.	11–12
Spain	6–7
India	2

Source: Power Magazine May 2014

India fossil fuel consumption
quadrillion British thermal units

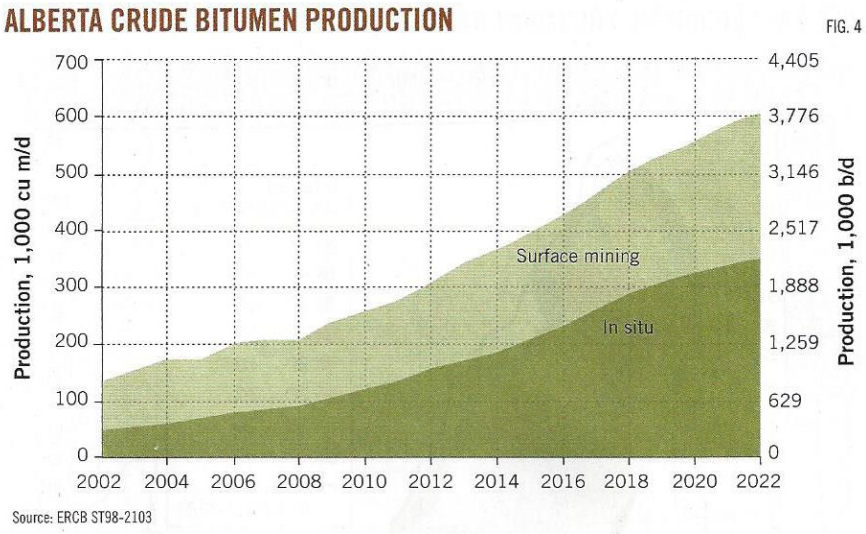


Canada

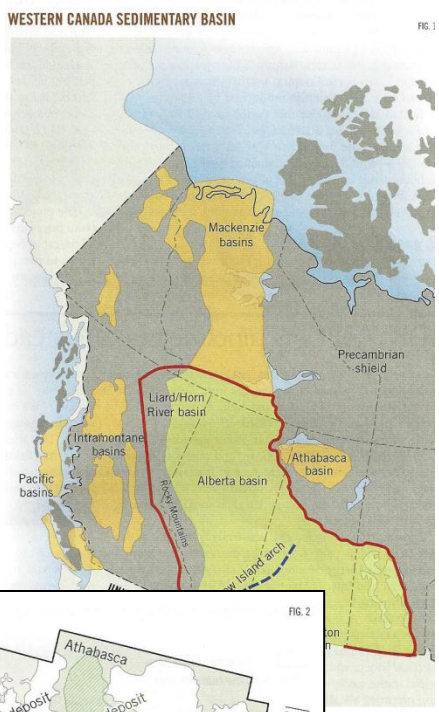
Canada's Bitumen

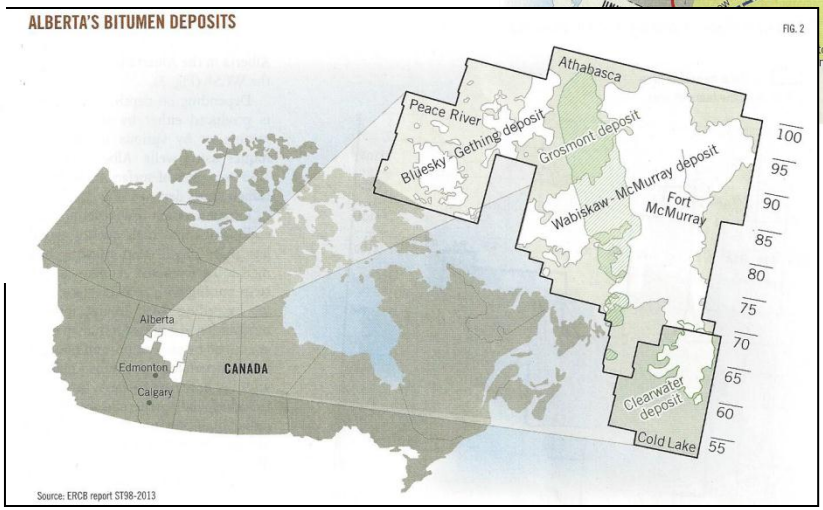
LARGEST CRUDE RESERVES Table 3

Jurisdiction	OOIP, billion bbl	Remaining reserves, billion bbl	Average recovery after shrinkage, %
Alberta	2,268	848	37
Venezuela	1,300	550	42
Saudi Arabia	716	260	54



Source: O&G Journal July 2014

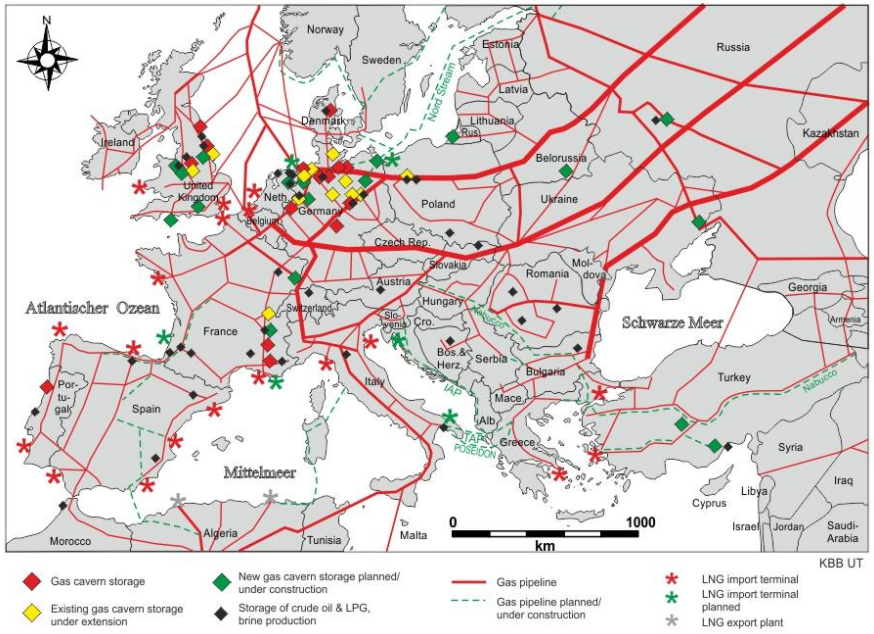




EU

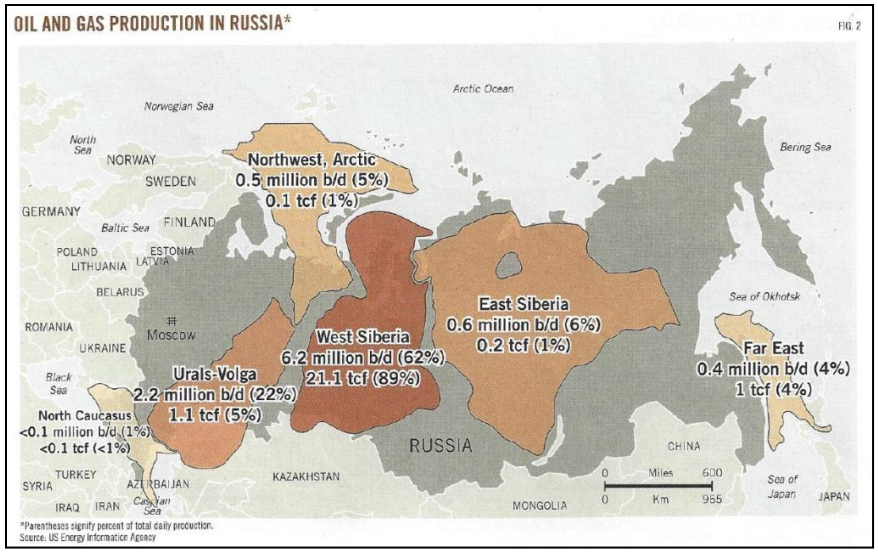
Gas to Europe - 1101 BCM Demand

- Europe/Eurasia Pipeline Imports - 470 BCM
  - Russia 208
  - Norway 93
  - The Netherlands 50
  - Algeria 33
- Europe/Eurasia LNG Imports - 91 BCM
  - Qatar 43
  - Algeria 16
  - Nigeria 16



Russia

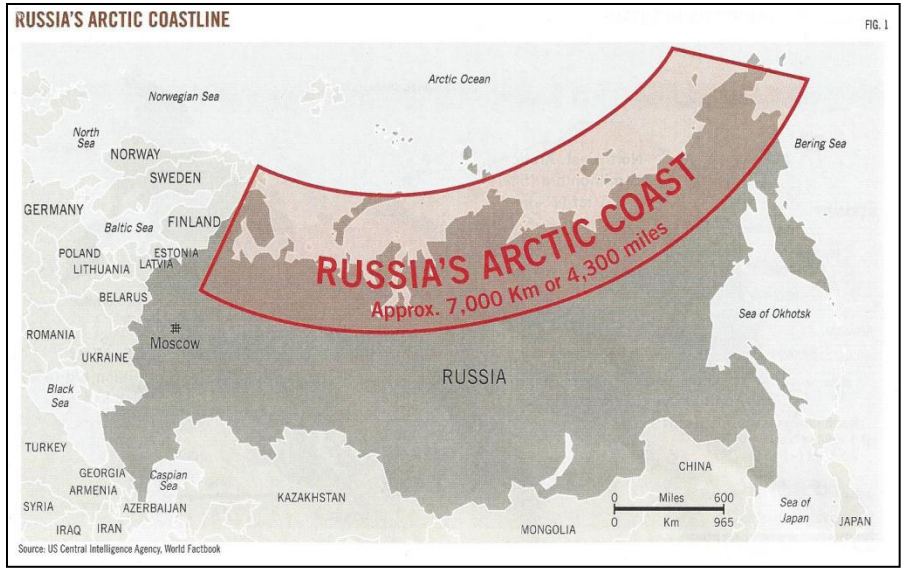
Russian O&G Production



Source: US EIA /O&G Journal Jan 2015

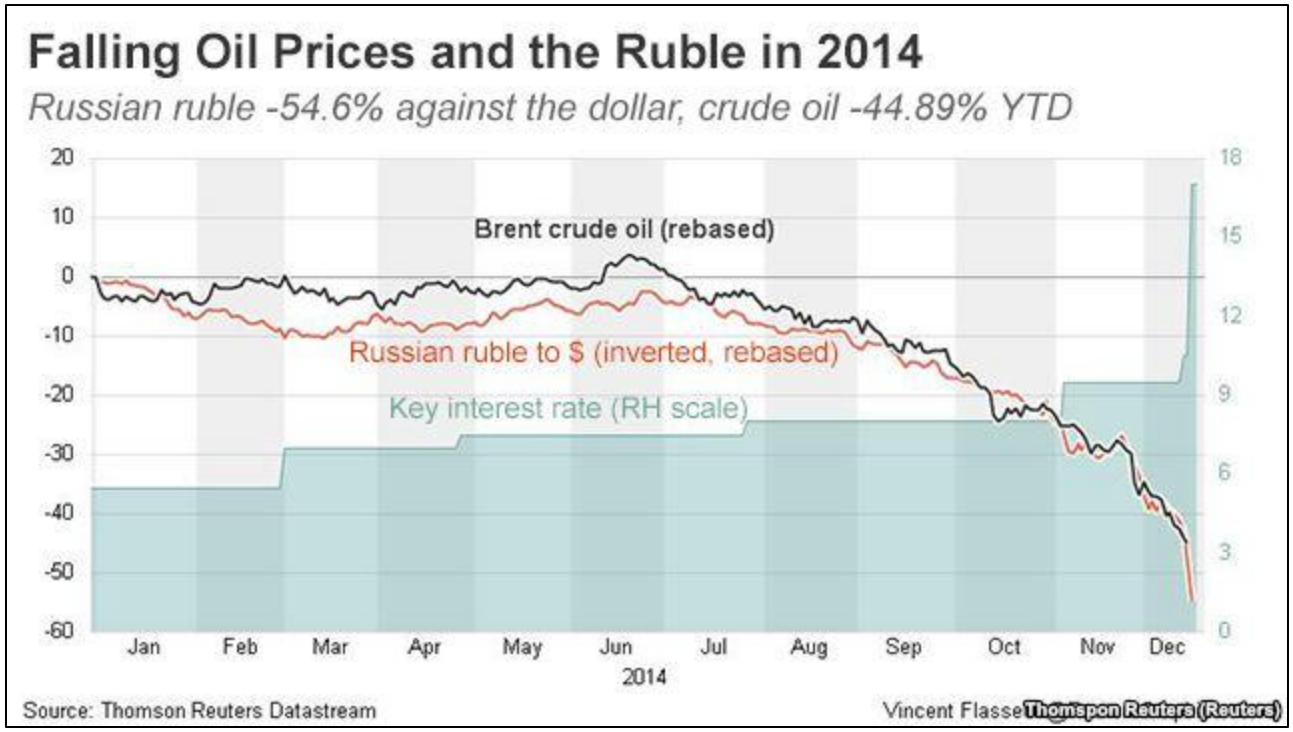
	bbl/d	%	tcf	BCM	%
Northern Caucasus	0.10	1%	0.01	0.3	0%
Urals-Volga	2.20	22%	1.10	31.1	5%
Northwest Arctic	0.50	5%	0.10	2.8	0%
West Siberia	6.20	62%	21.10	597.5	90%
East Siberia	0.60	6%	0.20	5.7	1%
Far East	0.40	4%	1.00	28.3	4%
Total	10.00	100%	23.51	665.7	100%

- Arctic is Russia's priority resource base for the 21st century
- Capability & knowledge unmatched by Arctic Council
- Governance of the AC inconsistent with NATO
- The UN Convention on the Law of the Seal (UNCLOS) may be replaced by a sovereignty rights
- U.S. failure to ratify UNCLOS will be an issue
- Russian sanction complicate things
- Potential for Russia/China alliance



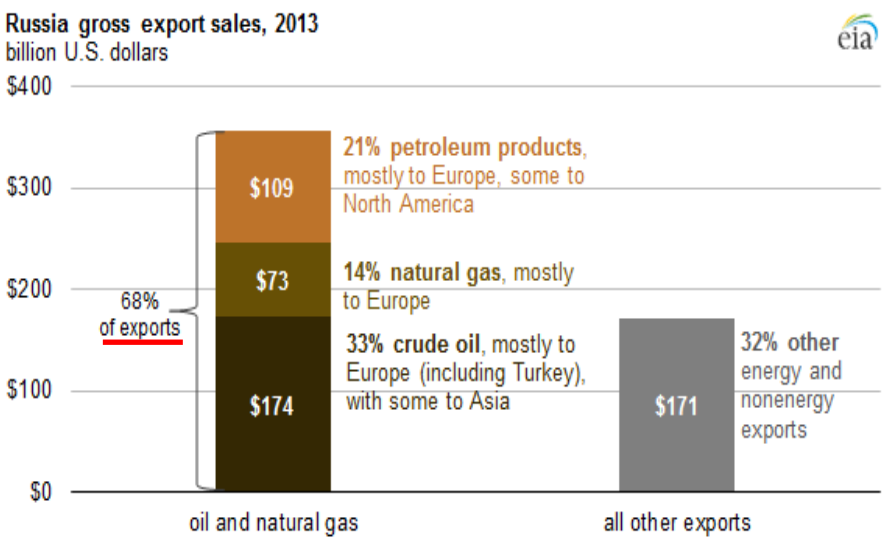
Source: US Central Intelligence Agency, World Factbook

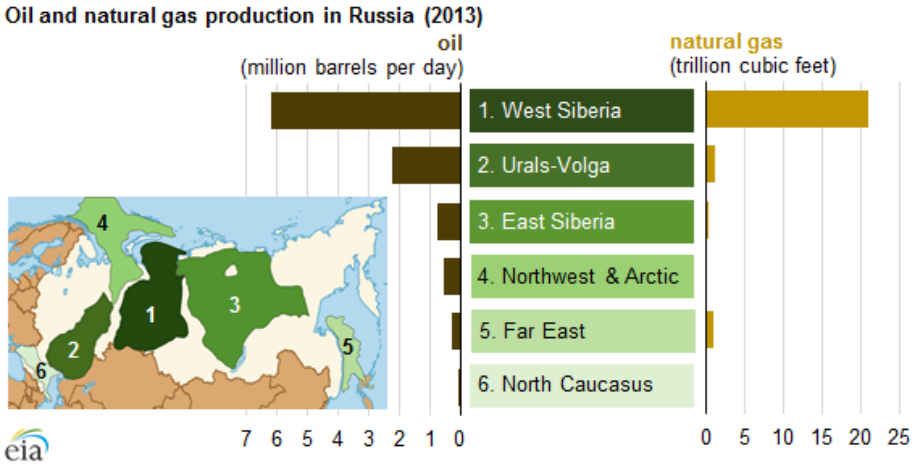
Russian Oil Price vs. Ruble Devaluation

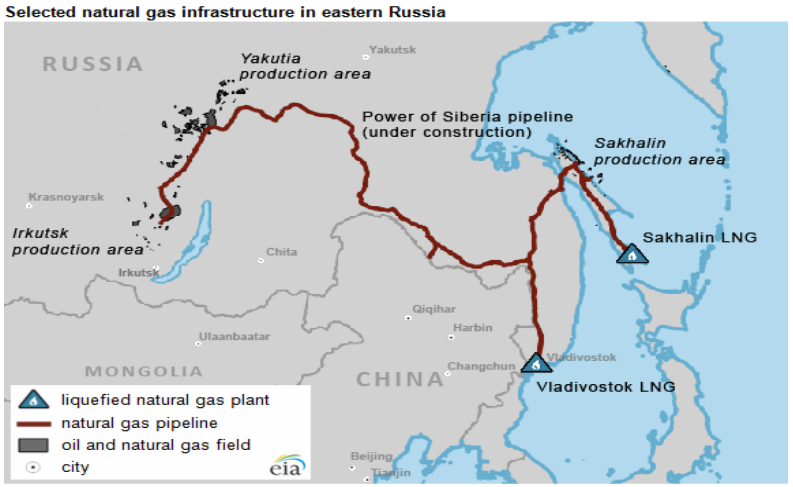


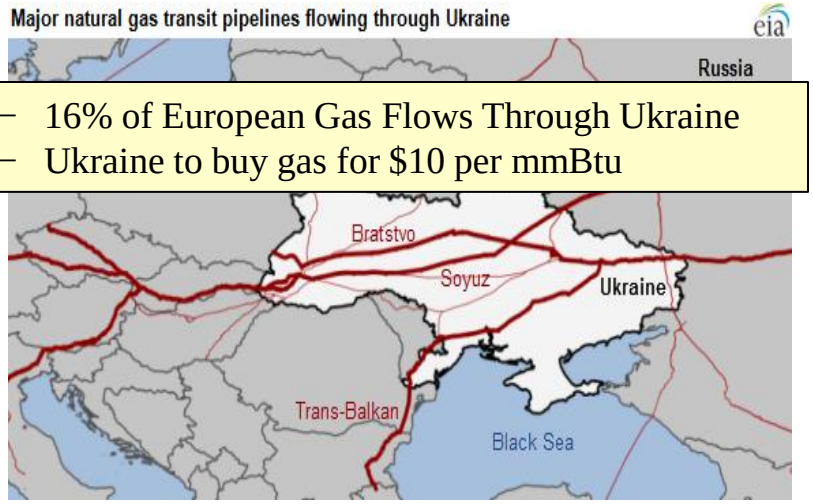
Within Russia,
the price of oil (in Ruble)
remains the same

Russia









- 16% of European Gas Flows Through Ukraine
- Ukraine to buy gas for $10 per mmBtu

Russian Gas - 607 BCM Production

44,600 BCM Reserves
Reserves/Production Ratio - 73.5

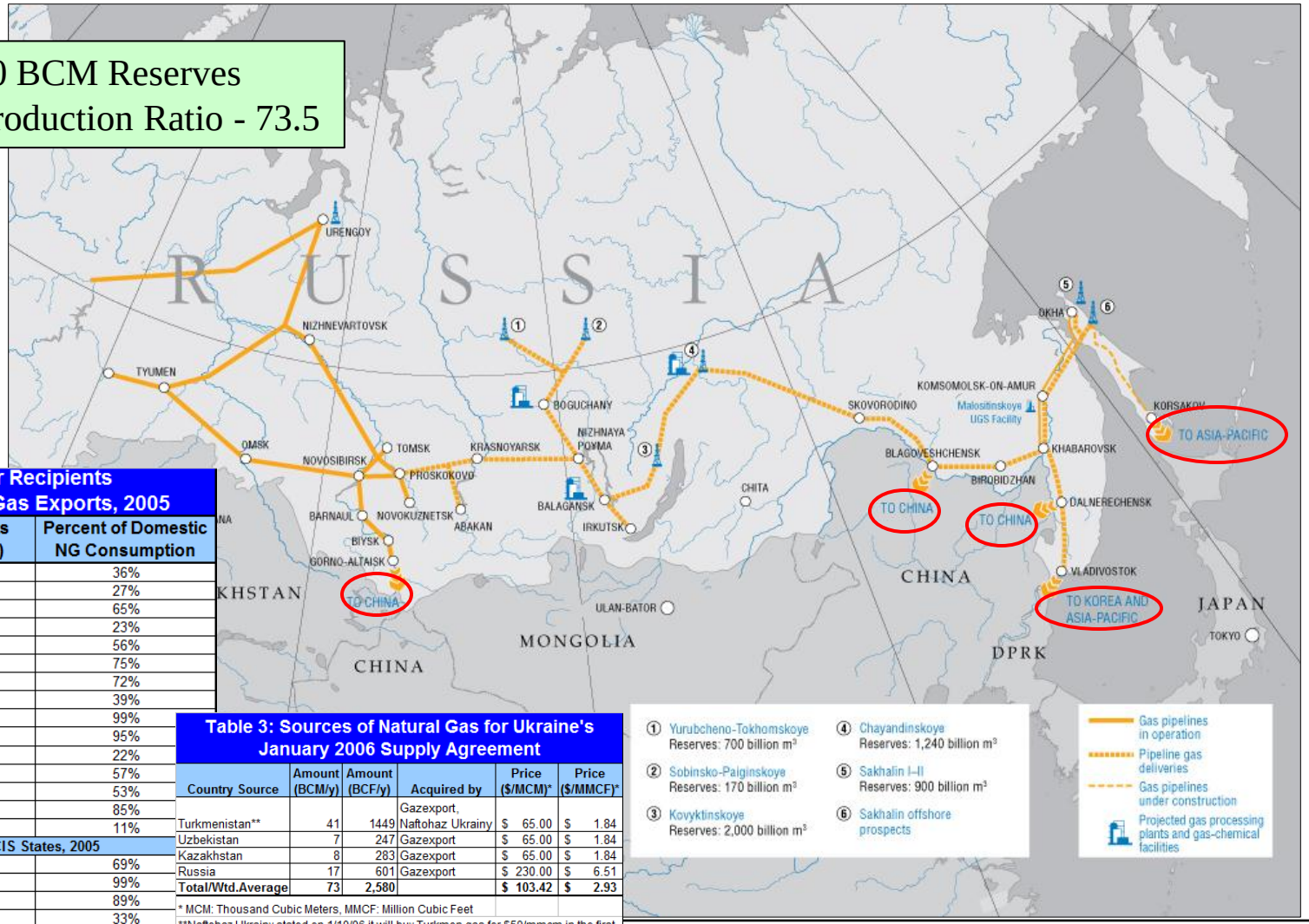


Table 2: Major Recipients of Russian Natural Gas Exports, 2005

Rank	Country	Imports (bcf/y)	Percent of Domestic NG Consumption
1	Germany	1,291	36%
2	Italy	824	27%
3	Turkey	630	65%
4	France	406	23%
5	Hungary	294	56%
6	Czech Republic	252	75%
7	Austria	246	72%
8	Poland	226	39%
9	Slovakia	226	99%
10	Finland	148	95%
11	Romania	140	22%
12	Fmr Yugoslavia	134	57%
13	Bulgaria	101	53%
14	Greece	85	85%
15	Switzerland	13	11%
	Sales to Baltic & CIS States, 2005		
	Ukraine	2,113	69%
	Belarus	710	99%
	Baltic States	205	89%
	Azerbaijan	120	33%
	Georgia	46	88%

Sources: Domestic Consumption: EIA International Energy Annual, 2005; Imports: Cedigaz 2006 and BP Statistical Review 2007.

Table 3: Sources of Natural Gas for Ukraine's January 2006 Supply Agreement

Country Source	Amount (BCM/y)	Amount (BCF/y)	Acquired by	Price ($/MCM)*	Price ($/MMCF)*
Turkmenistan**	41	1449	Gazexport, Naftohaz Ukrainy	$ 65.00	$ 1.84
Uzbekistan	7	247	Gazexport	$ 65.00	$ 1.84
Kazakhstan	8	283	Gazexport	$ 65.00	$ 1.84
Russia	17	601	Gazexport	$ 230.00	$ 6.51
Total/Wtd.Average	**73**	**2,580**		**$ 103.42**	**$ 2.93**

* MCM: Thousand Cubic Meters, MMCF: Million Cubic Feet

**Naftohaz Ukrainy stated on 1/10/06 it will buy Turkmen gas for $50/mmcm in the first half of 2006 and $60 during the second half, but the final agreement's price was higher. Using the lower price for Turkmen gas, the wtd. average price is $97.8/MCM.

Source: Russian Energy Monthly, January 2006

The (Confused) Caspian Sea Region Gas

- South Stream project cancelled
- New Turkish Stream 63 BCM/y committed
- Operational 2016

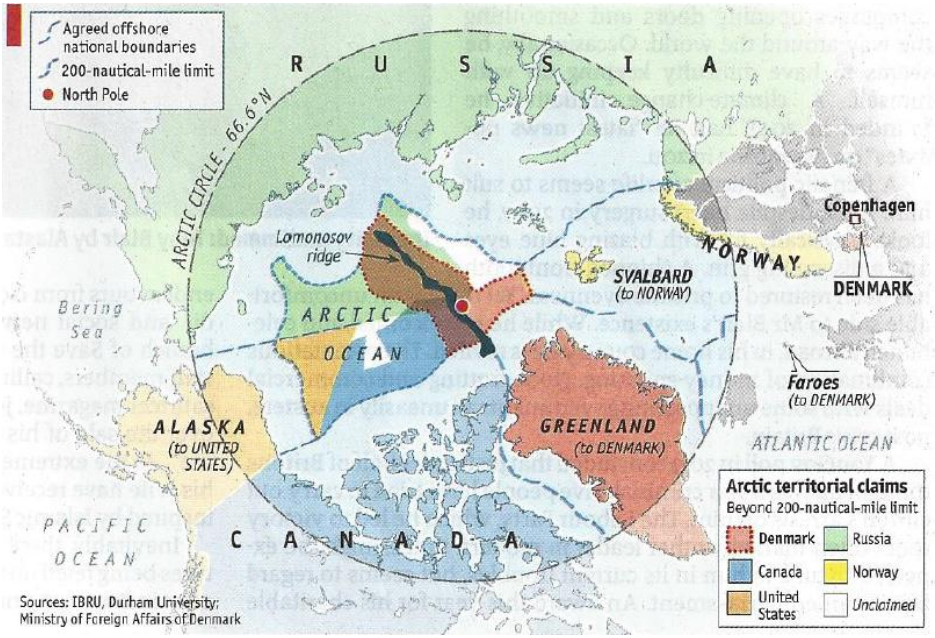
24,300 BCM Reserves
No established Reserve/Production Ratio

Argentina Shale Gas

- **EIA recent update of global shale resources ranked Argentina's potential second in the world**
  - 802 TCF/22,700 BCM
- **Argentina rates their shale prospects at:**
  - 1181 TCF/33,400 BCM
- **Argentina was not a factor in gas reserves last year**
- **Gas Plus program**
  - A 300% hike in as prices effectively ending price controls
  - Energy Co's expected to reinvest profits in gas production

Arctic Oil & Gas

- Estimated 13% (90 billion barrels) of the world's undiscovered conventional oil
- 30% of its undiscovered conventional natural gas
- Costs to develop reserves in the region can be 50-100% more than similar projects undertaken in Texas.
- Profitable development challenging due to the following factors:
  - Equipment needs to be specially designed to withstand the frigid temperatures.
  - On Arctic lands, poor soil conditions
  - Long supply lines
  - Natural gas hydrates can pose operational problems
  - Natural gas development could be impeded by the low market value of natural gas relative to that of oil. and higher transportation costs
  - Environmental issues include the preservation of animal and plant species unique to the Arctic
  - The adequacy of existing technology to manage offshore oil spills in an arctic environment



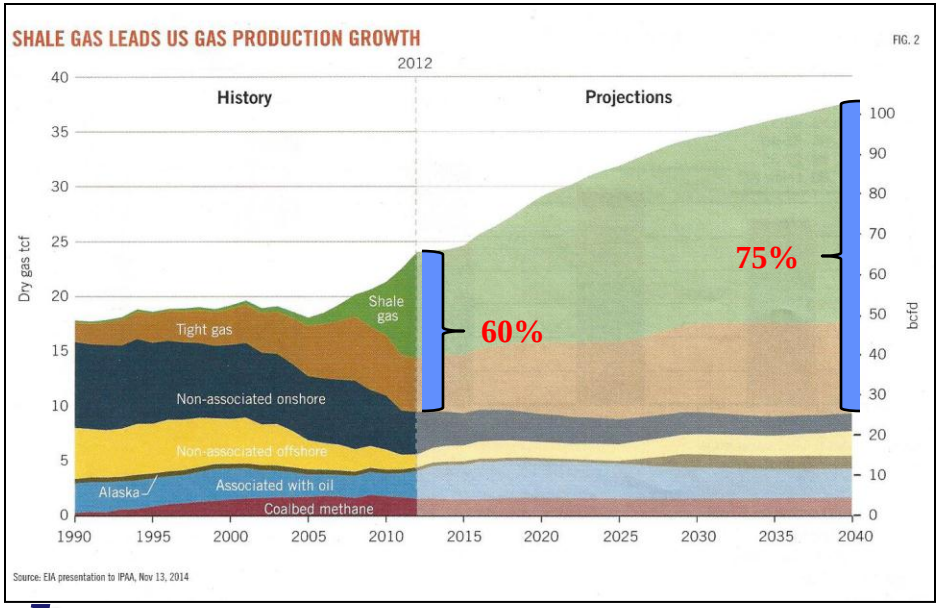
The Economist 2014

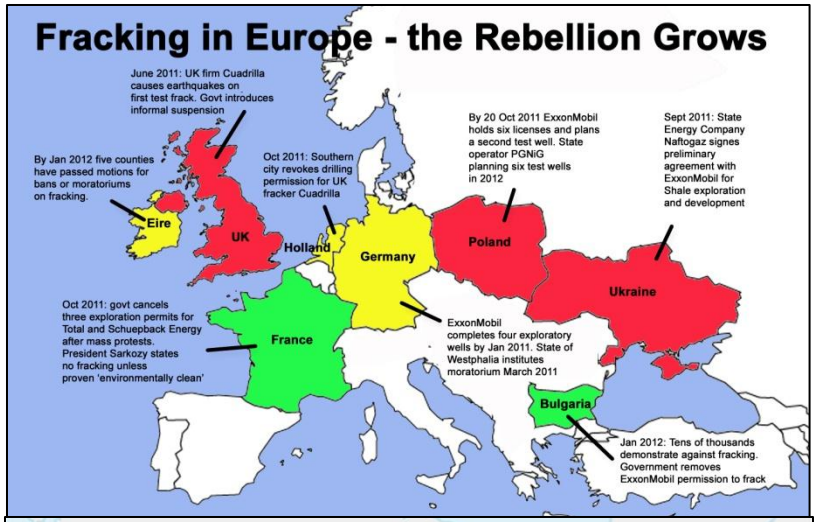
- Overlapping and disputed claims of economic sovereignty.
  - Exclusive Economic Zone (EEZ)- countries have exclusive rights to seabed resources up to 200 miles
  - Beyond the EEZ, assessments of "natural prolongation" of the continental shelf may influence countries' seabed boundaries.

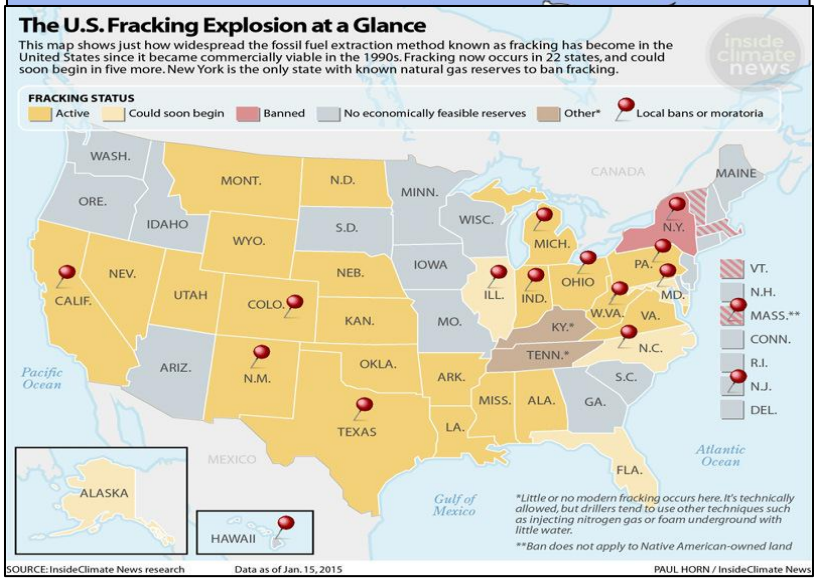
Environmental

Fracking

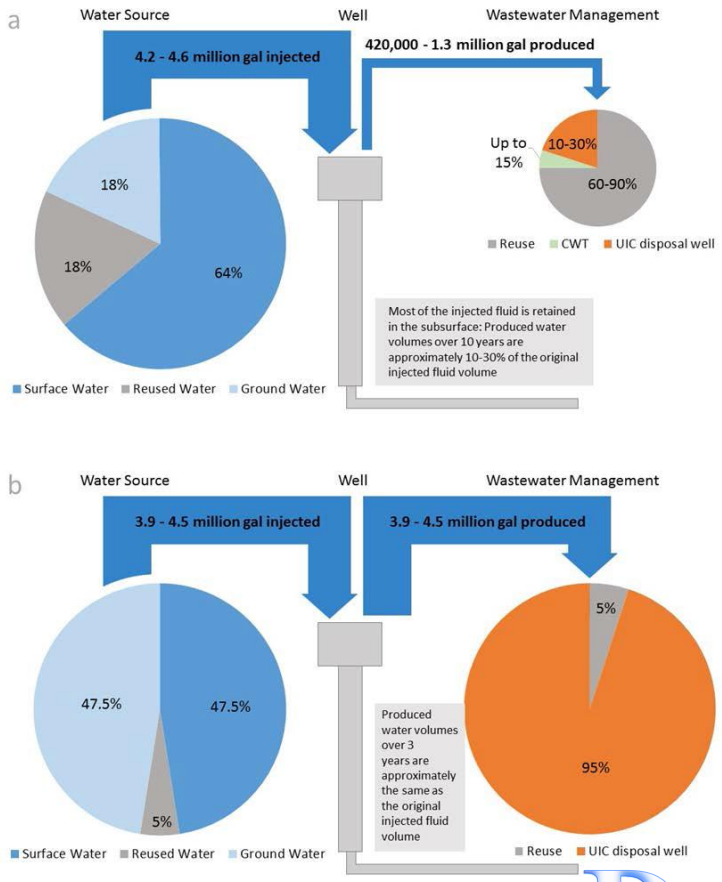
- Fracking components
  - Fracking fluids
  - Produced (waste) water disposal
  - Induced seismicity, aka “earthquakes”
- Requirements to succeed
  - Re-cycle waste water
  - Environmentally acceptable fracking fluids







EPA Fracking Report -EPA/600/R-15/047c June 2015



- Figure ES-3. Water budgets representative of practices in the Marcellus Shale in the Susquehanna River Basin in Pennsylvania (a) and the Barnett Shale in Texas (b).
- Pie size and arrow thickness represent the relative volume of water as it flows through the hydraulic fracturing water cycle
- Wastewater going to a centralized waste treatment (CWT) facility may be either discharged to surface water or reused
- Wastewater going to an underground injection control (UIC) well is disposed of below ground
- These examples represent typical water management practices as depicted for the most recent time period reviewed by this assessment
- They do not represent any specific well
  - Note: Values for Marcellus Shale are specific to the Susquenhanna River Basin, except for the produced water volumes
  - The longest-term measurement available was from the West Virginia portion of the Marcellus Shale.

Draft EPA Report

Flaring

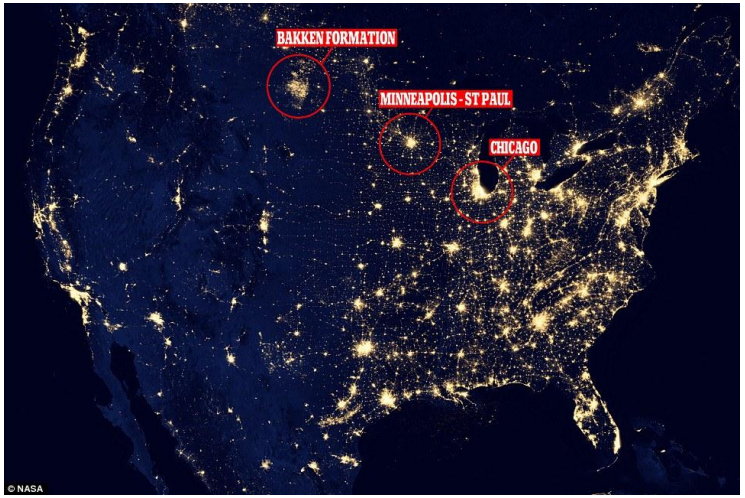
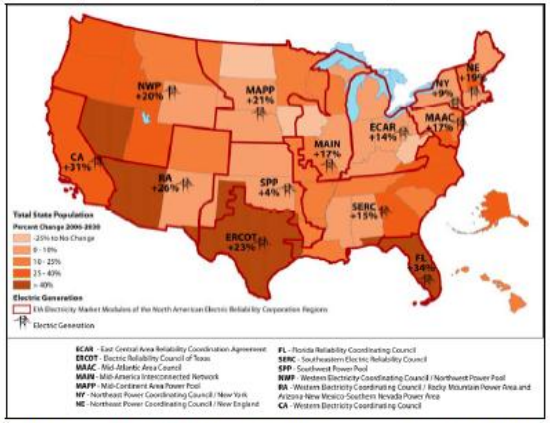


Figure 4: Development of associated gas production and gas flared in North Dakota in the last years. Source: NDIC and rbnenergy.com

This is a big number

Energy Water Nexus

Figure 3. Population and Electricity Generation Projections, 2010 to 2030



Source: EIA, *Supplemental Tables, Updated Annual Energy Outlook 2009 Reference Case with ARRA*, Wash., DC, April 2009, http://www.eia.doe.gov/oiaf/aeo/supplement/stimulus/suparra.htm); and U.S. Census Bureau, *U.S. Population Projections*, March 2004. EIA did not include Alaska and Hawaii.

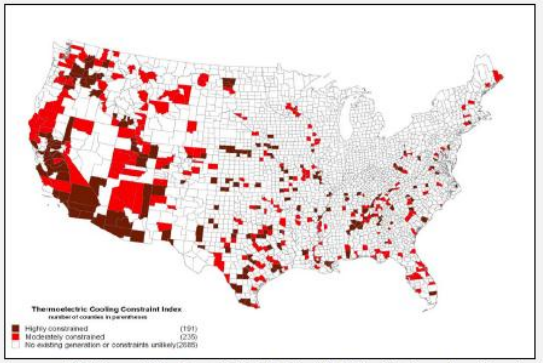


Figure source: EPRI, *A Survey of Water Use and Sustainability in the United States with a Focus on Power Generation*, Topical Report, Nov. 2003. EPRI's analysis did not include Alaska and Hawaii.

Table 1. Energy Trends Produce Water Use Trends

Energy Trend	Resulting Trend in Energy's Water Use
Shift from foreign oil to biofuels	Increases energy's water consumption if domestic agricultural irrigation water (and other inputs) is needed for fuel production.
Shift to shale gas	Natural gas development using hydraulic fracturing may raise water quantity concerns if well development is geographically concentrated in areas with water constraints. However, natural gas from fracturing consumes less U.S. freshwater than domestic ethanol or onshore oil.
Growth in domestic electricity demand	More water used for electricity generation; how much more depends on how the electricity is produced (e.g., smaller quantities needed if electricity demands are met with wind and photovoltaic solar, larger quantities if met with fossil fuels or certain renewable sources).
Shift to renewable electricity	Concentrating solar power technologies can use more water to produce electricity than coal or natural gas; these solar facilities are likely to be concentrated in water-constrained areas. Technologies are available to reduce this water use. Other renewable technologies, such as photovoltaic solar and wind, use little water.
Use of carbon mitigation measures	Carbon capture and sequestration may double water consumption for fossil fuel electric generation.

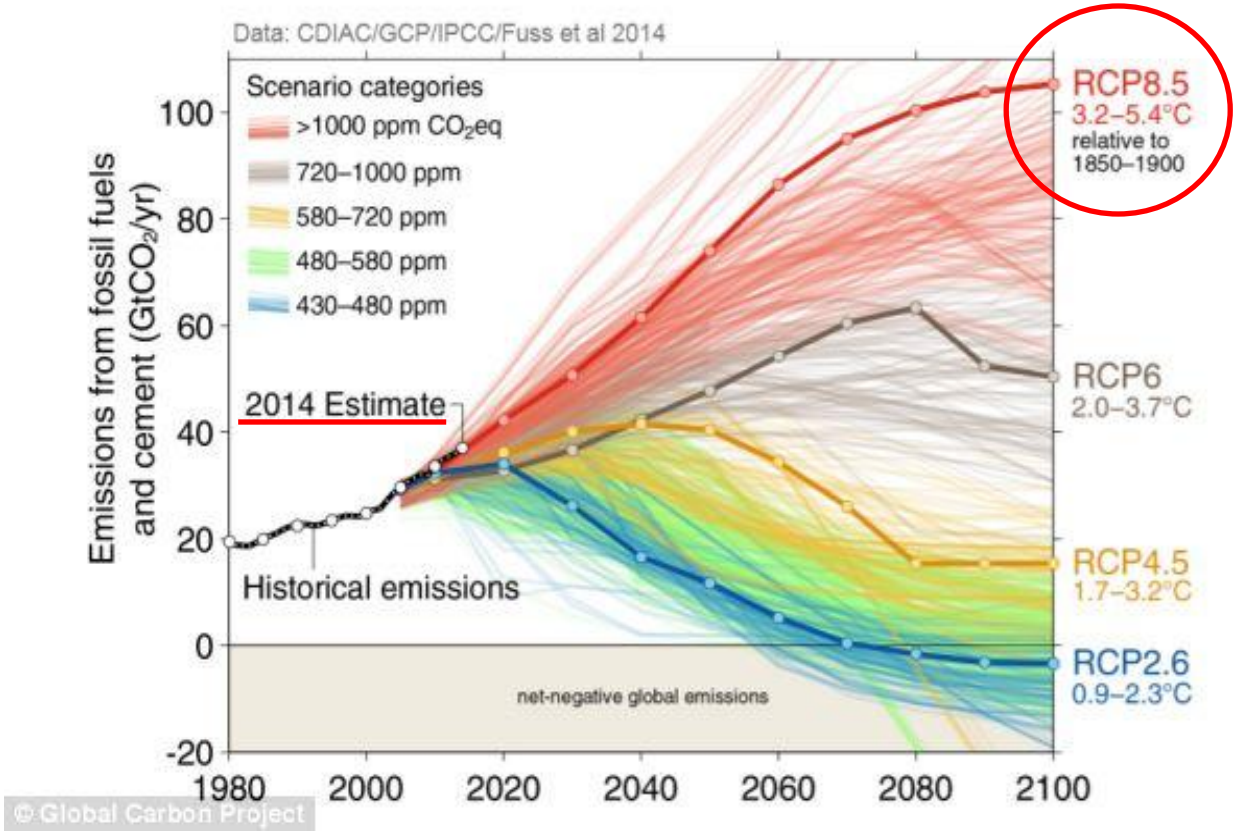
Source: CRS.

CO2

“Busted”

- The world pumped 36.1 Gt of carbon dioxide into the air last year by burning coal, oil and gas.
- That is 0.706 Gt or 2.3 per cent more than the previous year, despite increasingly urgent warnings over the need to curb greenhouse gases

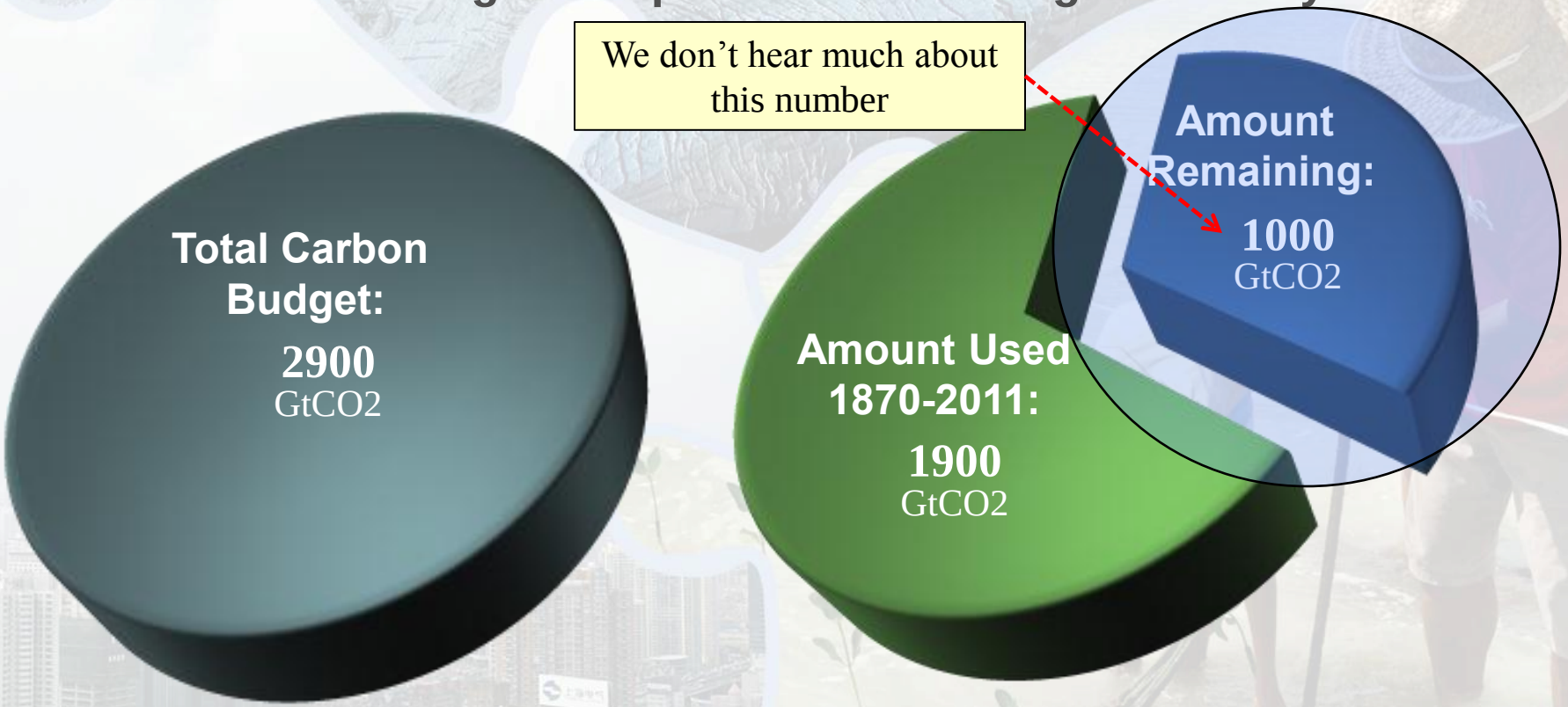
The world appears to be on the >1000 ppm path



The window for action is rapidly closing

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

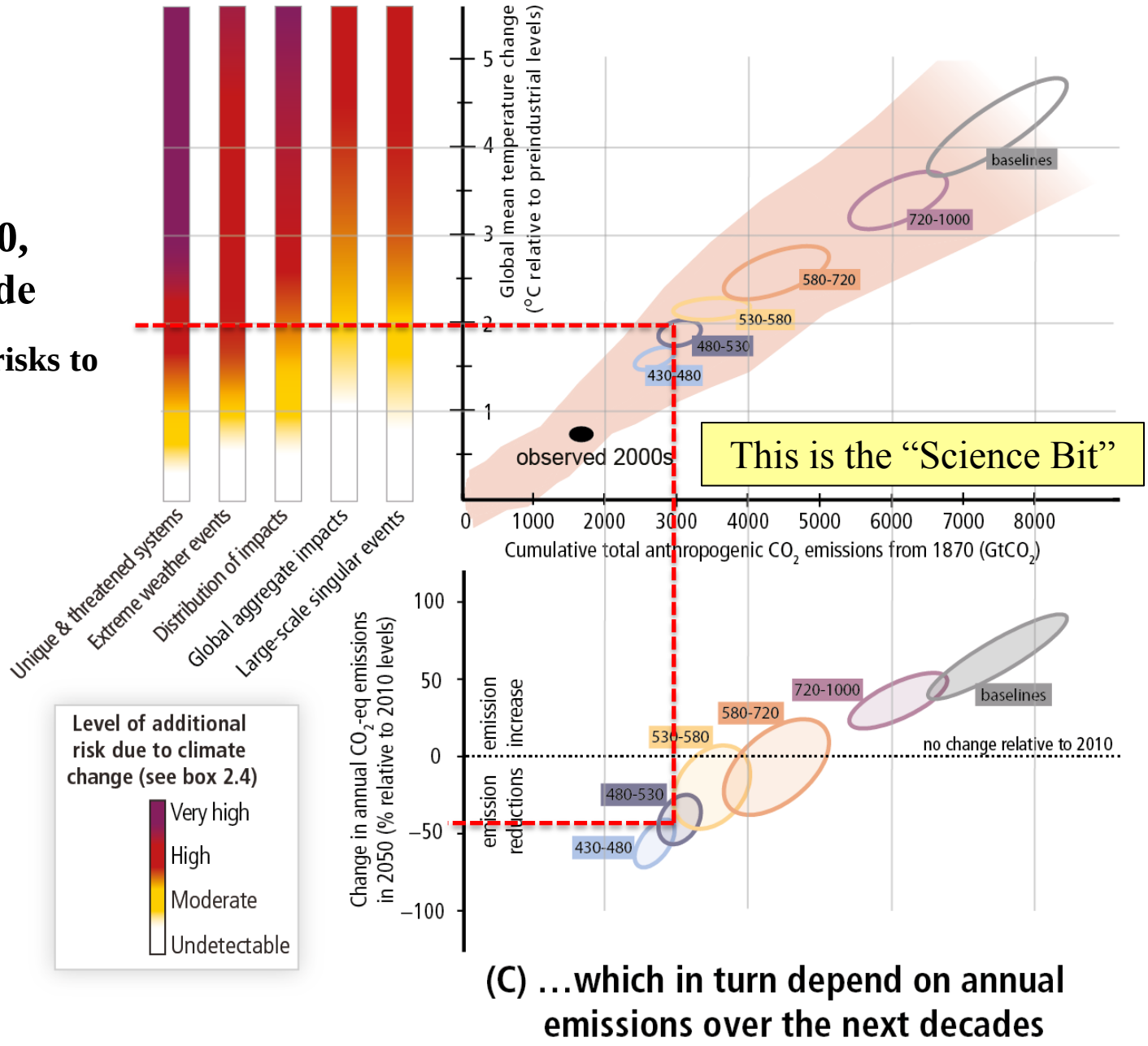
We don't hear much about this number



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%**

31.6 Gt

Actual through 2011

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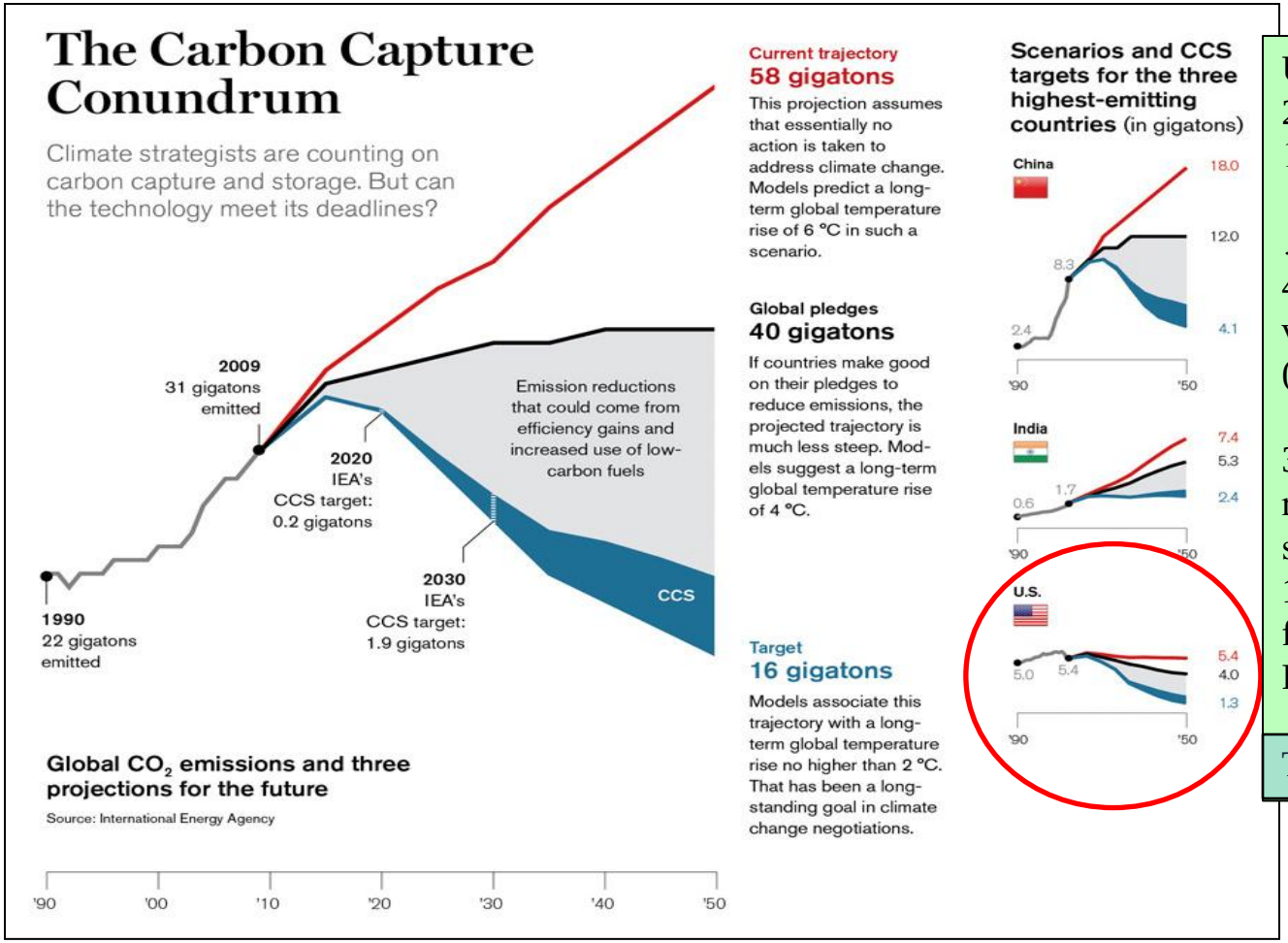
The Carbon Conundrum



MIT Technology Review – Mike Orcott

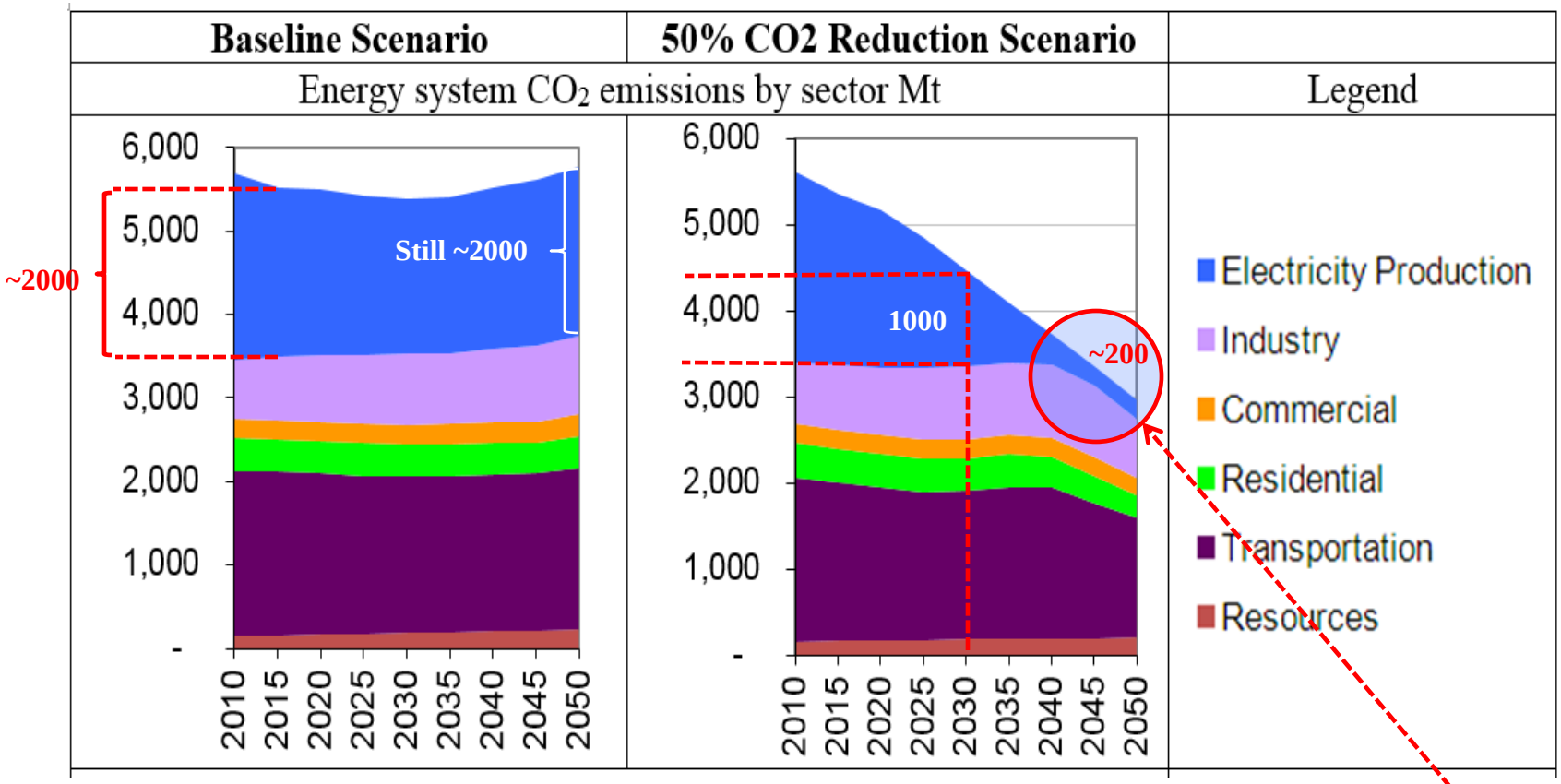
U.S. target to sustain 2°C/450ppmv is 1.3Gt …..

…..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

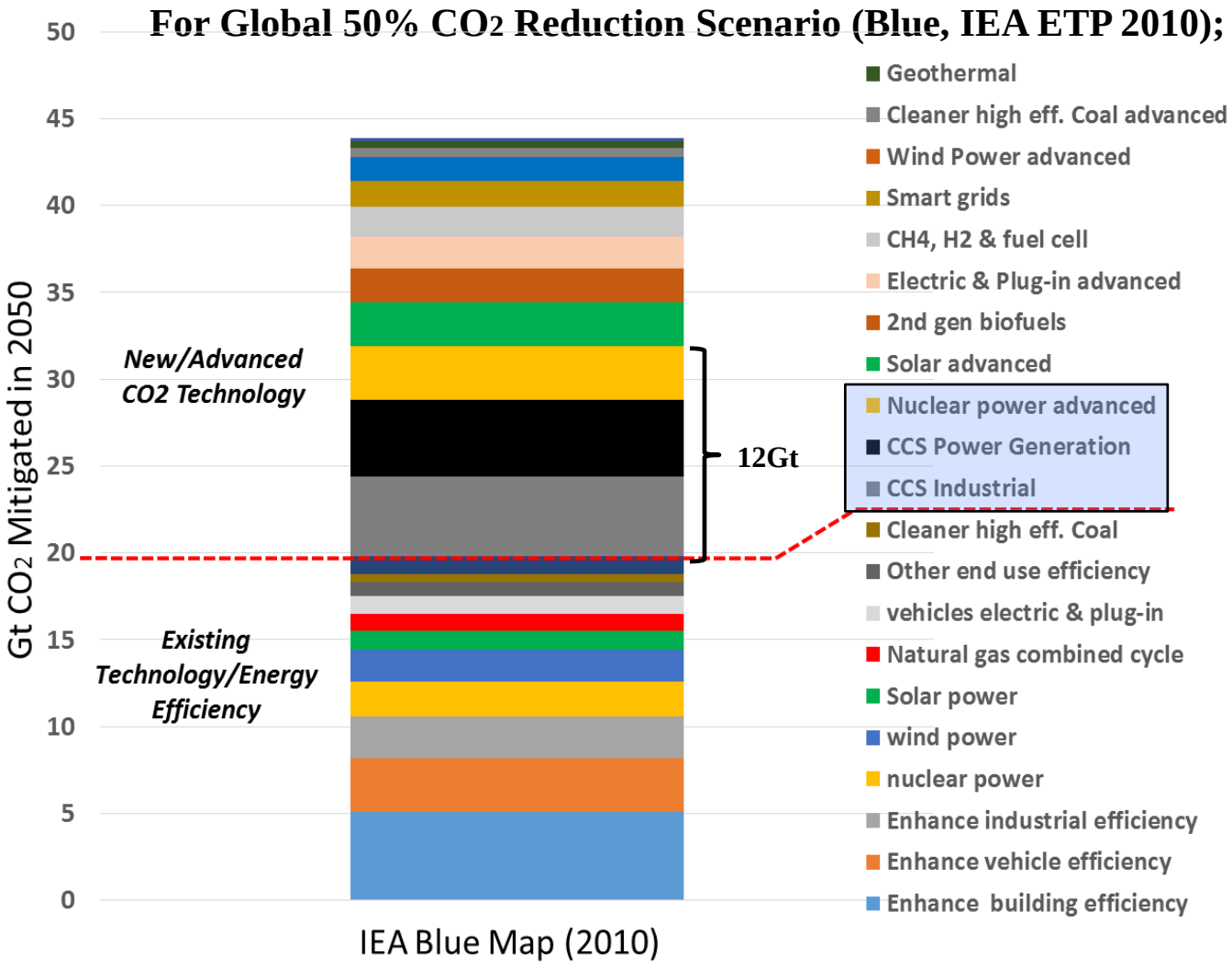
A Credible 50% CO2 Reduction Scenario by 2050



Source: DOE SCO2 Conference 2014, as presented by EPA

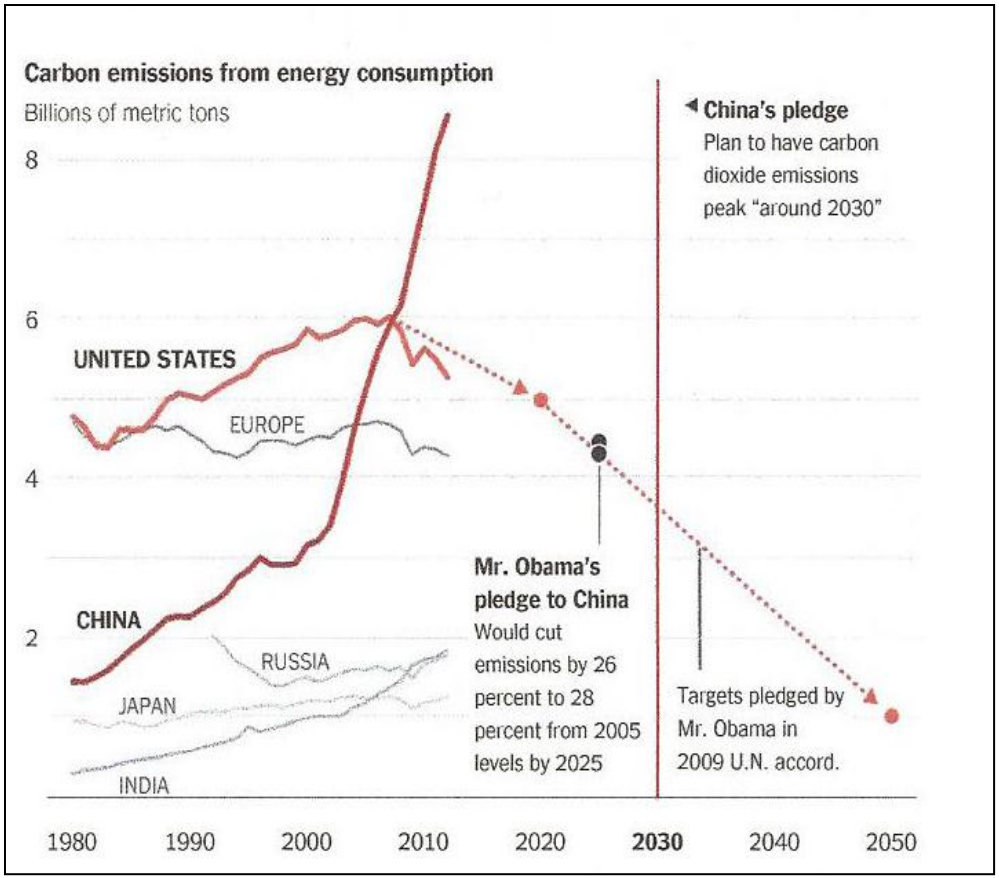
My number for Electricity Production is 500 (0.5 Gt)
if everyone pulls their fair share
2°/450 ppm number is 1300 (1.3 Gt), not 3000 (3.0 Gt)

New & Advanced Technologies Needed



Source: DOE SCO2 Conference 2014, as presented by EPA

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



New York Times

China agreed to peak CO2 emission by 2030

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

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CO2 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

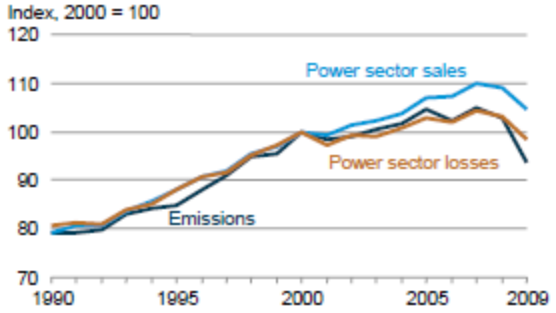

Table 12. U.S. carbon dioxide emissions from electric power sector energy consumption, 1990-2009 (million metric tons carbon dioxide)

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

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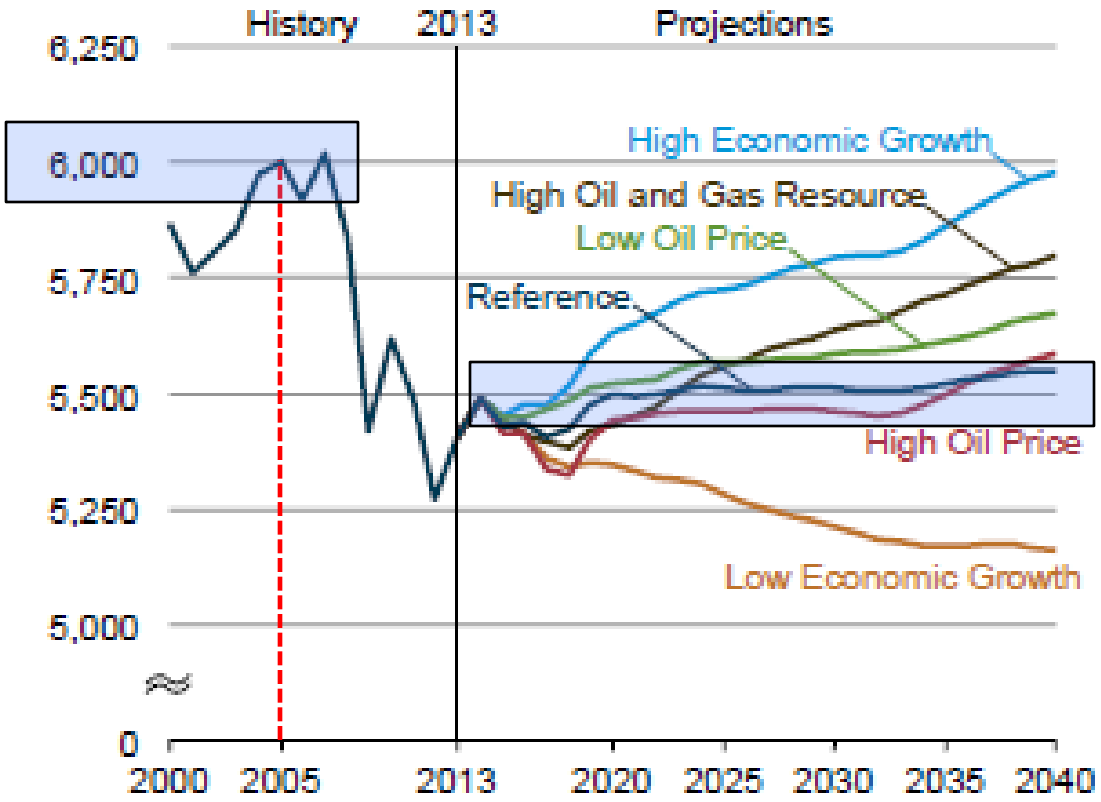
EIA Energy Related CO2 Foreast

"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"

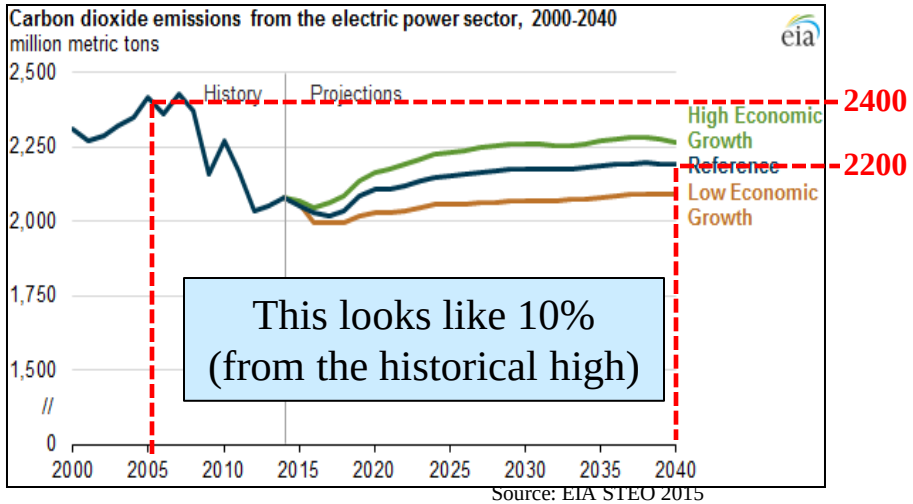
U.S. Emissions from Electric Power

- Carbon dioxide (CO2) emissions associated with electricity generation have fallen from the 2005 level
- They are projected to increase in the coming decades, based on analysis in EIA's *Annual Energy Outlook 2015*
- AEO2015 that reflects current laws and regulations, and therefore ***does not include proposed rules such as the U.S. Environmental Protection Agency's Clean Power Plan.***
- Power sector emissions in the United States are subject to federal regulation under the Clean Air Act
- In June 2014, the EPA proposed the Clean Power Plan (CPP) to regulate CO2 emissions from existing power plants.
- The CPP specifies intensity rate targets for existing fossil fuel-fired electric generating units operating or under construction as of early 2014, with the stated aim of reducing carbon emissions in the power sector by 2030.

30% from 2005 levels by 2030 = 1691.8)

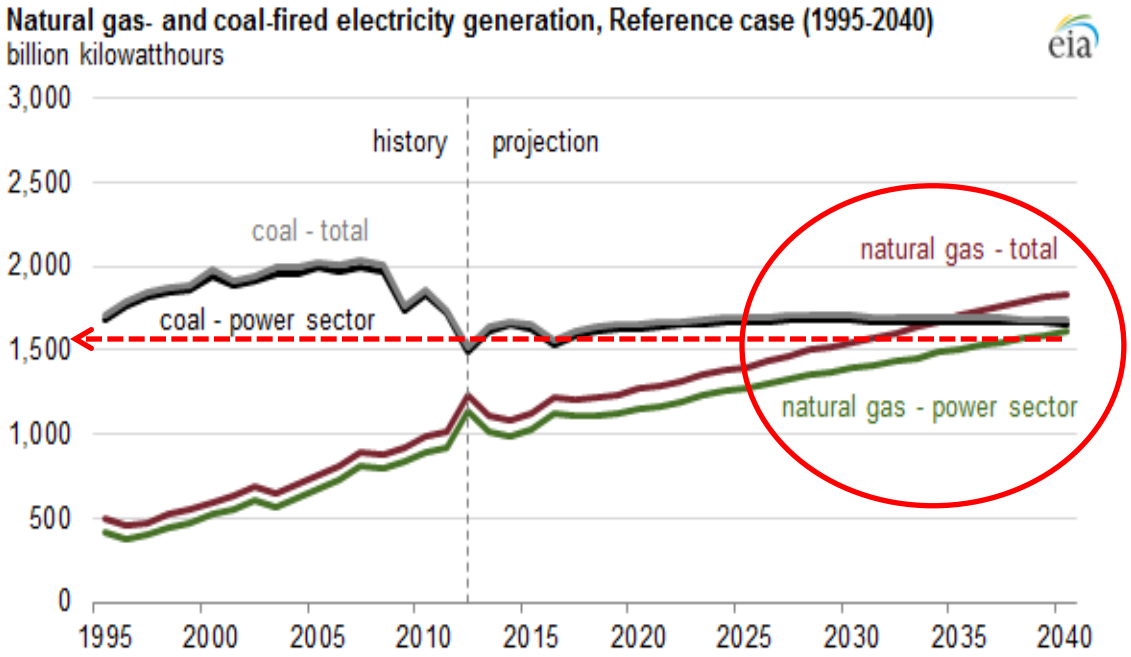
The two new EPA regulations
- NSPS 2014
- 2014 Clean Power Plan

Do not mention Climate Change, nor the notion of a target, let alone a target of 2C/450 ppm



Source: EIA STEO 2015

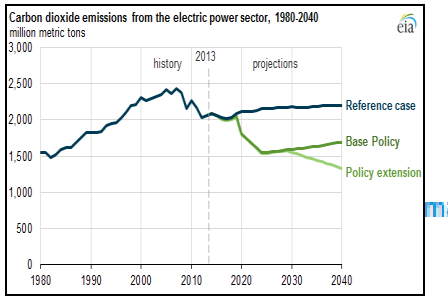
PowerGen Fuel Mix Reference Case – 2040



Unfortunately…
- 1,600 billion kWh of gas &
- 1,600 billion kWh of coal yields
- ~2.2Gt of CO2.
- At 38.5% PowerGen contribution, the U.S. would be at 5.7Gt in total
- **This is the virtually the same level as 2005.**

CCS with some combination of nuclear is the only way we can get to a level of 1.3Gt
- 38.5% of 1.3Gt for PowerGen is a budget of 0.5Gt
- A reduction of 1.7Gt from PowerGen
- **We would have to capture 80% of the CO2 from all gas- and coal-fired power plant to reach this level.**

Clean Power Plan Policy Extension



The 2030-2040 Policy Extension remains is still 2.65x the level required to reach 2°C/450ppm

mary results for AEO2015 Reference case and Clean Power Plan cases, selected years

	2005	2013	2020				2030				2040			
			AEO	CPP	CPPEXT	CPPNUC	AEO	CPP	CPPEXT	CPPNUC	AEO	CPP	CPPEXT	CPPNUC
ELECTRIC GENERATION (billion kWh)														
Coal	2,013	1,586	1,709	1,340	1,324	1,357	1,713	1,153	1,101	1,165	1,702	1,278	904	1,306
Natural Gas	761	1,118	1,117	1,382	1,359	1,371	1,371	1,429	1,464	1,401	1,569	1,456	1,560	1,400
Nuclear	782	789	804	804	804	804	808	808	808	900	833	813	811	962
Hydro	270	267	292	295	296	295	295	299	298	298	297	300	301	299
Wind	18	168	232	272	313	269	245	562	575	548	319	602	812	604
Solar	1	19	51	60	60	60	71	148	151	96	110	275	292	171
Other renewables	69	76	104	114	112	114	146	146	148	138	183	178	184	166
Oil/other	142	47	43	41	41	41	43	40	40	40	43	41	39	41
Total	4,055	4,070	4,351	4,308	4,308	4,311	4,691	4,584	4,586	4,586	5,056	4,942	4,903	4,948
ELECTRIC GENERATION CAPACITY (GW)														
Coal	313	304	263	217	210	222	260	209	200	214	260	209	197	214
Natural gas / Oil	442	470	482	490	491	490	519	518	528	521	595	579	582	578
Nuclear	100	99	101	101	101	101	102	101	101	113	105	102	102	121
Hydro	78	79	80	80	80	80	80	81	81	81	80	81	81	81
Wind	9	61	83	100	114	99	87	192	198	188	110	205	273	206
Solar	0	13	28	32	32	32	39	76	77	51	61	136	146	87
Other renewables	12	15	17	18	18	18	20	23	23	22	24	26	28	25
Other	24	25	26	26	26	26	26	26	26	26	26	26	26	26
Total	978	1,065	1,079	1,065	1,074	1,068	1,133	1,226	1,235	1,215	1,261	1,365	1,435	1,337
ELECTRICITY-RELATED CARBON DIOXIDE EMISSIONS (million metric tons)														
Power sector	2,416	2,053	2,107	1,814	1,794	1,825	2,177	1,596	1,553	1,598	2,195	1,691	1,329	1,696

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EIA Analysis of the Clean Power Plan – 5/22/2015

	2005	2013	2020				2030				2040			
			AEO HOGR	CPP HOGR	AEO HEG	CPP HEG	AEO HOGR	CPP HOGR	AEO HEG	CPP HEG	AEO HOGR	CPP HOGR	AEO HEG	CPP HEG
ELECTRIC GENERATION (billion kWh)														
Coal	2,013	1,586	1,443	1,212	1,733	1,415	1,441	898	1,733	1,293	1,440	910	1,744	1,421
Natural Gas	761	1,118	1,450	1,610	1,204	1,377	1,832	2,092	1,573	1,422	2,200	2,439	1,705	1,475
Nuclear	782	789	804	804	804	804	808	808	818	808	808	808	911	863
Hydro	270	267	289	294	294	305	290	295	297	305	290	295	298	308
Wind	18	168	229	263	243	315	232	407	301	634	234	412	489	725
Solar	1	19	51	59	52	70	65	85	80	247	85	106	160	420
Other renewables	69	76	107	110	106	117	146	128	158	161	175	145	222	207
Oil/other	142	47	44	41	43	42	42	39	43	41	42	40	43	42
Total	4,055	4,070	4,417	4,392	4,480	4,445	4,854	4,753	5,003	4,912	5,274	5,154	5,574	5,461
ELECTRIC GENERATION CAPACITY (GW)														
Coal	313	304	245	201	265	230	242	173	263	223	242	173	264	223
Natural gas / Oil	442	470	497	516	490	497	573	607	564	540	674	704	657	629
Nuclear	100	99	101	101	101	101	101	101	103	102	101	101	115	109
Hydro	78	79	79	80	80	82	79	80	80	82	79	80	81	83
Wind	9	61	82	97	87	115	83	142	105	216	84	144	165	245
Solar	0	13	27	32	28	38	36	45	44	121	48	58	82	200
Other renewables	12	15	17	18	18	19	20	21	23	26	22	23	32	31
Other	24	25	26	26	26	26	26	26	26	26	26	26	26	26
Total	978	1,065	1,075	1,070	1,094	1,108	1,159	1,196	1,207	1,335	1,275	1,309	1,422	1,546
ELECTRICITY-RELATED CARBON DIOXIDE EMISSIONS (million metric tons)														
Power sector	2,416	2,053	1,973	1,789	2,165	1,886	2,089	1,605	2,262	1,727	2,179	1,701	2,266	1,827

- Reference (AEO)
- Base Policy (CPP)
- Policy with High Oil & Gas Resource (CPPHOGR)

There is no mention of Climate Change in the report and…
There is no mention of CO2 concentration…
Let alone a target of 2C/450 ppm!

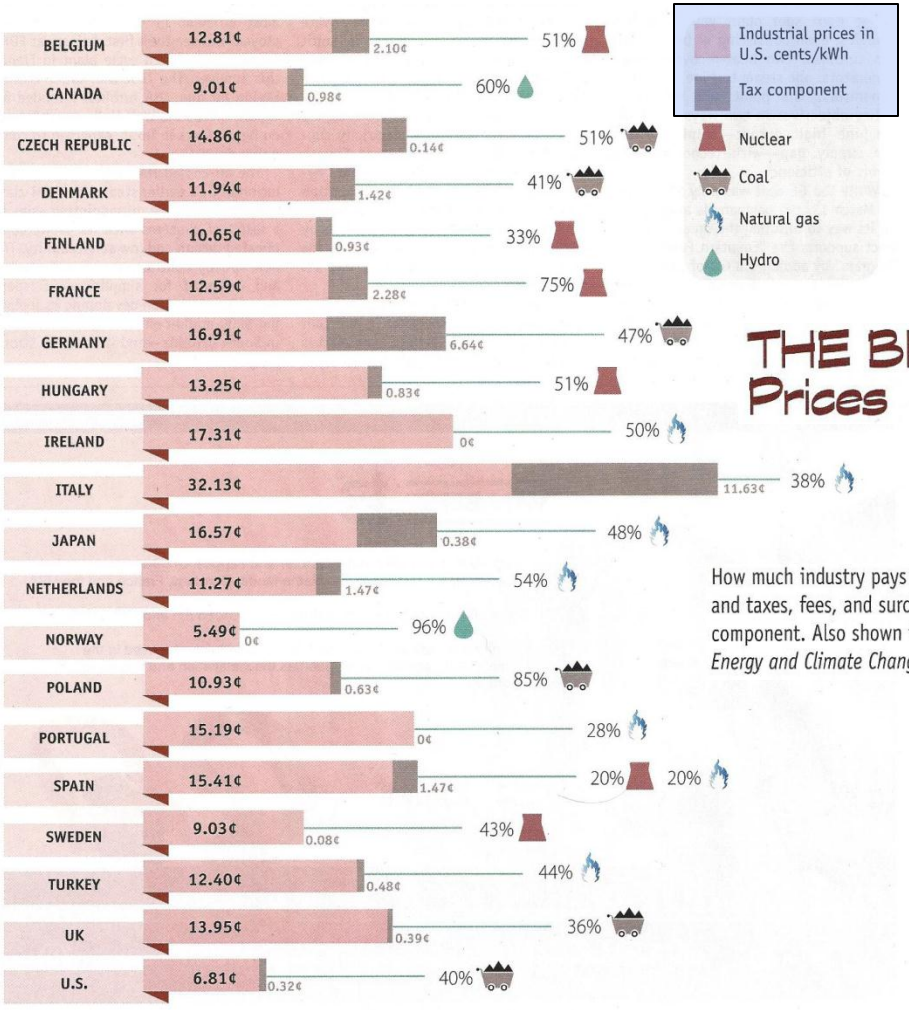
Page 18; Para (4) "…..and static CPP targets in the post-2030 period in the CPP case allow existing coal-fired plants to operate at a higher utilization rate which rises from a low of 60% in 2024 to 71% in 2040."

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[4] (2012 $/kW)	Variable O&M[5] (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

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***

Pete Baldwin

781-721-6200 (o)

617-306-7419 (c)

pete_baldwin@base-e.net