
Energy Part 2

Sources, Uses & Impact

Osher Lifelong Learning Institute
At Tufts University
Fall 2018

Peter Baldwin

617-306-7419

pete_baldwin@base-e.net



“Practical Strategies for Emerging Energy Technologies”

Basic Comparisons

	China	USA	India	Japan	Germany	Russia
Population - July 2014 est	1,379,302,771	326,525,791	1,281,935,911	126,451,398	80,594,017	142,257,519
Population Growth Rate	0.41%	0.81%	1.17%	-0.21%	-0.16%	-0.08%
Area - km ²	9,596,960	9,826,675	3,287,263	377,915	357,022	17,098,242
GDP - Purchasing Power Parity (\$trillion)	23.1	19.4	9.4	5.4	4.2	4.0
Installed Generating Capacity GW	1,646	1,074	309	322	204	264
% of World at 6301GW	26%	17%	5%	5%	3%	4%
Electric Production TWh	6,142	4,088	1,289	976	559	1,008
Electric Consumption TWh	5,920	3,911	1,048	934	515	890
Aggregate Load Factor	42.6%	43.5%	47.6%	34.6%	31.3%	43.6%
Natural Gas Production - BCM	138.4	766.2	31.2	4.5	8.7	598.6
Natural Gas Consumption - BCM	210.3	773.2	102.3	123.6	79.2	418.9
Refined Petroleum Products Production - mmbbl/d	10.9	20.1	4.8	3.5	2.2	6.2
Refined Petroleum Products Consumption - mmbbl/d	11.8	19.7	4.1	4.0	2.4	3.6
Coal Production - Million Tonnes Oil Equivalent	1827.0	455.2	283.9	0.7	42.9	184.5
Coal Consumption - Million Tonnes Oil Equivalent	1920.4	396.3	407.2	119.4	78.3	88.7

Source: CIA World Factbook

World Total Installed Electrical Generating Capacity **6301GW**

CIA World Factbook

base_e

“Practical Strategies for Emerging Energy Technologies”

PS... Total Value of Outstanding Student Loans - \$1.5 trillion
 U.S. health care cost 2017 - \$3.5 trillion
 U.S. Household Debt Q:1:18 - \$13.2 trillion

Primary Energy Consumption by Fuel 2017 - Mtoe

U.S. = 91.86 Quads

Primary Energy: Consumption by fuel*

Million tonnes oil equivalent	2016							2017							Percent of 2017 Total
	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew - ables	Total	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew - ables	Total	
US	907.6	645.1	340.6	191.9	59.7	83.1	2228.0	913.3	635.8	332.1	191.7	67.1	94.8	2234.9	16.5%
Canada	107.0	94.1	18.9	21.8	87.6	9.6	339.0	108.6	99.5	18.6	21.9	89.8	10.3	348.7	2.6%
Mexico	90.1	79.0	12.4	2.4	6.9	4.1	194.9	86.8	75.3	13.1	2.5	7.2	4.4	189.3	1.4%
Total North America	1104.6	818.2	371.9	216.1	154.2	96.8	2761.9	1108.6	810.7	363.8	216.1	164.1	109.5	2772.8	20.5%
Brazil	135.7	32.4	15.9	3.6	86.2	19.1	293.0	135.6	33.0	16.5	3.6	83.6	22.2	294.4	2.2%
Total S. & Cent. America	320.8	150.6	34.9	5.5	156.4	28.6	696.8	318.8	149.1	32.7	5.0	162.3	32.6	700.6	5.2%
France	79.2	38.3	8.2	91.2	13.6	8.4	238.9	79.7	38.5	9.1	90.1	11.1	9.4	237.9	1.8%
Germany	117.3	73.0	75.8	19.2	4.6	38.3	328.2	119.8	77.5	71.3	17.2	4.5	44.8	335.1	2.5%
Italy	59.8	58.5	11.0	-	9.6	14.8	153.8	60.6	62.0	9.8	-	8.2	15.5	156.0	1.2%
Spain	64.2	25.0	10.5	13.3	8.2	15.4	136.7	64.8	27.5	13.4	13.1	4.2	15.7	138.8	1.0%
Turkey	47.1	38.2	38.5	-	15.2	5.4	144.4	48.8	44.4	44.6	-	13.2	6.6	157.7	1.2%
United Kingdom	76.3	69.6	11.2	16.2	1.2	17.6	192.2	76.3	67.7	9.0	15.9	1.3	21.0	191.3	1.4%
Total Europe	719.3	434.7	295.1	195.2	146.1	144.2	1934.6	731.2	457.2	296.4	192.5	130.4	161.8	1969.5	14.6%
Russian Federation	152.5	361.3	89.2	44.5	41.8	0.3	689.6	153.0	365.2	92.3	46.0	41.5	0.3	698.3	5.2%
Total CIS	202.8	492.6	156.2	63.3	56.3	0.8	972.0	203.4	494.1	157.0	65.9	56.7	0.9	978.0	7.2%
Iran	80.7	173.1	0.9	1.5	3.5	0.1	259.8	84.6	184.4	0.9	1.6	3.7	0.1	275.4	2.0%
Saudi Arabia	173.8	90.6	0.1	-	-	^	264.5	172.4	95.8	0.1	-	-	^	268.3	2.0%
United Arab Emirates	45.7	62.3	1.5	-	-	0.1	109.6	45.0	62.1	1.6	-	-	0.1	108.7	0.8%
Total Middle East	416.0	437.6	9.1	1.5	4.6	1.0	869.7	420.0	461.3	8.5	1.6	4.5	1.4	897.2	6.6%
South Africa	28.7	4.0	84.7	3.6	0.2	1.8	123.0	28.8	3.9	82.2	3.6	0.2	2.0	120.6	0.9%
Total Africa	192.6	114.5	94.9	3.6	27.1	5.2	438.0	196.3	121.9	93.1	3.6	29.1	5.5	449.5	3.3%
Australia	50.5	35.9	43.6	-	4.0	5.4	139.5	52.4	36.0	42.3	-	3.1	5.7	139.4	1.0%
China	587.2	180.1	1889.1	48.3	261.0	81.7	3047.2	608.4	206.7	1892.6	56.2	261.5	106.7	3132.2	23.2%
India	217.1	43.7	405.6	8.6	29.0	18.3	722.3	222.1	46.6	424.0	8.5	30.7	21.8	753.7	5.6%
Indonesia	74.2	32.9	53.4	-	4.4	2.6	167.4	77.3	33.7	57.2	-	4.2	2.9	175.2	1.3%
Japan	191.4	100.1	118.8	4.0	18.1	18.8	451.2	188.3	100.7	120.5	6.6	17.9	22.4	456.4	3.4%
South Korea	128.9	41.0	81.9	36.7	0.6	3.1	292.2	129.3	42.4	86.3	33.6	0.7	3.6	295.9	2.2%
Taiwan	48.6	17.2	38.6	7.2	1.5	1.0	114.0	49.2	19.1	39.4	5.1	1.2	1.2	115.1	0.9%
Thailand	62.1	43.5	17.7	-	0.8	2.8	126.9	63.9	43.1	18.3	-	1.1	3.4	129.7	1.0%
Total Asia Pacific	1601.1	625.1	2744.0	106.0	368.5	140.8	5585.5	1643.4	661.8	2780.0	111.7	371.6	175.1	5743.6	42.5%
Total World	4557.3	3073.2	3706.0	591.2	913.3	417.4	13258.5	4621.9	3156.0	3731.5	596.4	918.6	486.8	13511.2	100.0%
	34.4%	23.2%	28.0%	4.5%	6.9%	3.1%	100.0%	34.2%	23.4%	27.6%	4.4%	6.8%	3.6%	100.0%	100.0%



“Practical Strategies for Emerging Energy Technologies”

13,511.2 Mtoe = 555.4 Quads

Source: BP Statistical Review of World Energy 2018

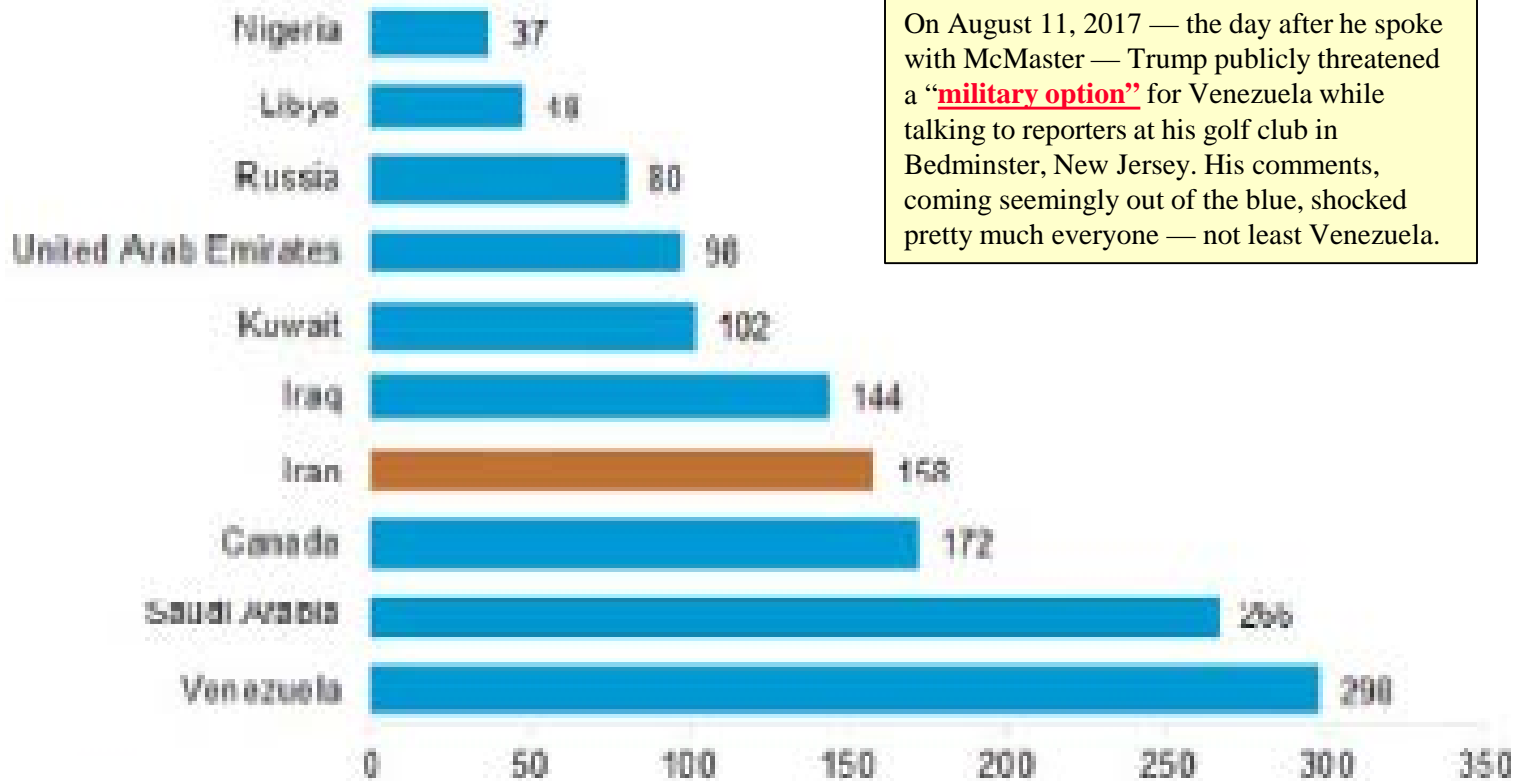
Oil

base_e

“Practical Strategies for Emerging Energy Technologies”

Largest Proven Crude Oil Reserves

Largest proved reserve holders of crude oil
billion barrels



On August 11, 2017 — the day after he spoke with McMaster — Trump publicly threatened a “**military option**” for Venezuela while talking to reporters at his golf club in Bedminster, New Jersey. His comments, coming seemingly out of the blue, shocked pretty much everyone — not least Venezuela.



SOURCE: OIL & GAS JOURNAL, JANUARY 2015.

Crude Oil Consumption 2017 – 98.2 MMbbl/d

Oil: Consumption*

Thousand barrels daily	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share
												2017	2006-16	2017
US	20680	19490	18771	19180	18882	18490	18961	19106	19531	19687	19880	1.0%	-0.5%	20.2%
Canada	2342	2297	2174	2306	2381	2342	2383	2399	2348	2401	2428	1.2%	0.5%	2.5%
Mexico	2089	2080	2021	2040	2065	2083	2034	1960	1939	1977	1910	-3.4%	-0.2%	1.9%
Total North America	25111	23868	22967	23526	23329	22915	23379	23465	23818	24065	24219	0.6%	-0.4%	24.7%
Brazil	2308	2481	2498	2716	2839	2915	3124	3242	3181	3013	3017	0.1%	3.4%	3.1%
Total S. & Cent. America	5742	6032	6006	6334	6570	6742	6987	7058	7021	6811	6794	-0.2%	2.2%	6.9%
France	1911	1889	1822	1763	1730	1676	1664	1616	1615	1600	1615	1.0%	-1.9%	1.6%
Germany	2380	2502	2409	2445	2369	2356	2408	2348	2340	2378	2447	2.9%	-0.9%	2.5%
Italy	1740	1661	1563	1532	1475	1346	1260	1184	1222	1228	1247	1.6%	-3.7%	1.3%
Spain	1613	1558	1473	1446	1378	1291	1195	1191	1237	1280	1293	1.1%	-2.2%	1.3%
United Kingdom	1752	1720	1646	1623	1590	1533	1518	1518	1561	1592	1598	0.3%	-1.3%	1.6%
Total Europe	16356	16227	15537	15418	14975	14443	14263	14049	14413	14696	14980	1.9%	-1.2%	15.3%
Russian Federation	2780	2861	2775	2878	3074	3119	3135	3301	3162	3193	3224	1.0%	1.5%	3.3%
Total CIS	3844	3900	3768	3834	4118	4206	4176	4323	4162	4243	4282	0.9%	1.1%	4.4%
Iran	1838	1925	1919	1791	1826	1849	2011	1953	1766	1722	1816	5.4%	-0.4%	1.8%
Saudi Arabia	2407	2622	2914	3206	3294	3461	3451	3753	3875	3939	3918	-0.5%	5.6%	4.0%
Total Middle East	6970	7385	7724	7973	8271	8595	8870	9032	9029	9161	9290	1.4%	3.1%	9.5%
Total Africa	3040	3201	3325	3482	3388	3569	3724	3785	3877	3950	4047	2.5%	3.1%	4.1%
Australia	935	944	950	957	1001	1025	1034	1046	1030	1041	1079	3.6%	1.1%	1.1%
China	7808	7941	8278	9436	9796	10230	10734	11209	11986	12302	12799	4.0%	5.2%	13.0%
India	2941	3077	3237	3319	3488	3685	3727	3849	4164	4560	4690	2.9%	5.2%	4.8%
Indonesia	1318	1287	1317	1411	1589	1640	1663	1681	1564	1580	1652	4.5%	2.4%	1.7%
Japan	5013	4847	4390	4442	4442	4702	4516	4303	4151	4031	3988	-1.1%	-2.5%	4.1%
Singapore	921	973	1049	1157	1208	1202	1225	1268	1338	1381	1430	3.5%	5.0%	1.5%
South Korea	2399	2308	2339	2370	2394	2458	2455	2454	2577	2771	2796	0.9%	1.8%	2.8%
Taiwan	1110	1005	1020	1045	983	983	1010	1040	1037	1043	1051	0.8%	-0.1%	1.1%
Thailand	1030	1018	1076	1122	1185	1250	1299	1310	1354	1377	1423	3.4%	3.3%	1.4%
Total Asia Pacific	26041	25901	26260	27967	28911	30038	30689	31274	32521	33562	34574	3.0%	2.9%	35.2%
Total World	87105	86515	85587	88535	89561	90509	92088	92986	94843	96488	98186	1.8%	1.2%	100.0%

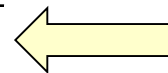
+1,698 MMbbl/d

Source: BP Statistical Review of World Energy 2018

Crude Oil Production 2017 – 92.6 MMbbl/d

Oil: Production*

Thousand barrels daily	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share 2017
												2017	2006-16	
US	6860	6784	7263	7549	7859	8904	10071	11768	12750	12366	13057	5.6%	6.1%	14.1%
Canada	3290	3207	3202	3332	3515	3740	4000	4271	4389	4470	4831	8.1%	3.4%	5.2%
Mexico	3479	3165	2978	2959	2940	2911	2875	2784	2587	2456	2224	-9.4%	-4.0%	2.4%
Total North America	13628	13156	13444	13841	14314	15555	16946	18823	19726	19292	20112	4.3%	3.5%	21.7%
Brazil	1831	1897	2029	2137	2179	2145	2110	2341	2525	2608	2734	4.8%	3.7%	3.0%
Colombia	531	588	671	786	915	944	1004	990	1006	886	851	-3.9%	5.3%	0.9%
Venezuela	3237	3228	3038	2842	2755	2704	2680	2692	2631	2387	2110	-11.6%	-3.3%	2.3%
Total S. & Cent. America	7344	7439	7385	7410	7449	7373	7403	7663	7759	7418	7182	-3.2%	-0.1%	7.8%
Norway	2551	2466	2349	2137	2039	1917	1838	1889	1946	1995	1969	-1.3%	-3.2%	2.1%
United Kingdom	1651	1549	1469	1356	1112	946	864	852	963	1013	999	-1.3%	-4.8%	1.1%
Total Europe	5032	4790	4539	4198	3835	3523	3356	3390	3538	3566	3519	-1.3%	-3.9%	3.8%
Azerbaijan	876	916	1027	1037	932	882	888	861	851	838	795	-5.1%	2.6%	0.9%
Kazakhstan	1415	1485	1609	1676	1684	1664	1737	1710	1695	1655	1835	10.8%	1.9%	2.0%
Russian Federation	10062	9969	10157	10383	10538	10660	10809	10860	11009	11269	11257	-0.1%	1.4%	12.2%
Total CIS	12795	12825	13232	13502	13557	13609	13834	13830	13966	14162	14288	0.9%	1.4%	15.4%
Iran	4359	4421	4292	4430	4472	3820	3617	3724	3862	4602	4982	8.2%	0.7%	5.4%
Iraq	2143	2428	2446	2469	2773	3079	3103	3239	3986	4423	4520	2.2%	8.3%	4.9%
Kuwait	2660	2784	2499	2560	2913	3169	3129	3101	3065	3145	3025	-3.8%	1.4%	3.3%
Oman	710	757	813	865	885	918	942	943	981	1004	971	-3.4%	3.1%	1.0%
Qatar	1267	1438	1421	1638	1834	1939	2002	1985	1958	1970	1916	-2.7%	4.7%	2.1%
Saudi Arabia	10268	10663	9663	10075	11144	11635	11393	11505	11994	12402	11951	-3.6%	1.5%	12.9%
United Arab Emirates	3094	3113	2783	2915	3285	3430	3543	3599	3873	4020	3935	-2.1%	2.5%	4.2%
Total Middle East	25440	26517	24818	25834	28082	28523	28194	28496	30023	31849	31597	-0.8%	2.1%	34.1%
Algeria	1992	1969	1775	1689	1642	1537	1485	1589	1558	1577	1540	-2.3%	-2.2%	1.7%
Angola	1656	1876	1754	1812	1670	1734	1748	1668	1772	1755	1674	-4.6%	2.3%	1.8%
Egypt	698	715	730	725	714	715	710	714	726	691	660	-4.5%	0.2%	0.7%
Libya	1820	1820	1652	1659	479	1509	989	498	432	426	865	102.9%	-13.5%	0.9%
Nigeria	2208	2174	2212	2534	2463	2413	2280	2278	2204	1903	1988	4.5%	-2.2%	2.1%
Total Africa	10139	10263	9838	10104	8494	9264	8580	8191	8130	7687	8072	5.0%	-2.5%	8.7%
China	3742	3814	3805	4077	4074	4155	4216	4246	4309	3999	3846	-3.8%	0.8%	4.2%
India	768	803	816	882	916	906	906	887	876	856	865	1.1%	1.2%	0.9%
Indonesia	972	1006	994	1003	952	918	882	852	841	882	949	7.6%	-1.4%	1.0%
Malaysia	730	731	691	726	660	662	626	650	698	704	697	-1.0%	0.1%	0.8%
Total Asia Pacific	7951	8076	8028	8436	8296	8382	8257	8327	8405	8050	7879	-2.1%	0.2%	8.5%
Total World	82330	83067	81284	83325	84027	86229	86570	88721	91547	92023	92649	0.7%	1.1%	100.0%
of which: OECD	19136	18426	18436	18534	18566	19487	20626	22571	23571	23139	23901	3.3%	1.8%	25.8%
OPEC	35835	37029	34596	35665	36478	38034	37004	36945	38362	39601	39436	-0.4%	0.9%	42.6%



WW Oil Supply/Demand

	2016					2017				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
DEMAND										
OECD										
Americas	24.5	24.4	25.0	24.6	24.6	24.5	24.5	24.9	24.6	24.6
Europe	13.6	13.9	14.4	13.7	13.9	13.7	14.0	14.3	13.7	13.9
Asia Pacific	8.5	7.6	7.8	8.2	8.1	8.6	7.6	7.7	8.2	8.0
Total OECD	46.7	46.0	47.2	46.5	46.6	46.8	46.1	46.1	46.4	46.6
Non-OECD										
FSU	4.6	4.6	4.9	5.0	4.8	4.7	4.8	5.1	5.0	4.9
Europe	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
China	11.7	12.0	11.7	12.0	11.9	11.9	12.1	12.2	12.4	12.2
Other Asia	13.1	13.1	12.8	13.4	13.1	13.6	13.7	13.4	13.9	13.7
Latin America	6.5	6.8	6.9	6.8	6.8	6.5	6.7	6.8	6.8	6.7
Middle East	7.9	8.5	8.8	8.4	8.4	8.2	8.6	8.9	8.5	8.6
Africa	4.2	4.2	4.1	4.3	4.2	4.3	4.4	4.2	4.4	4.3
Total Non-OECD	48.7	49.8	49.8	50.5	49.7	50.0	51.0	51.4	51.8	51.0
Total Demand	95.4	95.8	97.1	96.9	96.3	96.8	97.1	98.3	98.2	97.6
Supply										
OECD										
Americas	19.9	19.0	19.4	19.4	19.4	19.5	19.4	19.5	19.5	19.5
Europe	3.6	3.4	3.3	3.4	3.5	3.4	3.4	3.3	3.4	3.4
Asia Pacific	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.5
Total OECD	24.0	22.8	23.1	23.3	23.3	23.4	23.3	23.3	23.4	23.3
Non-OECD										
FSU	14.3	14.0	14.0	14.5	14.2	14.3	14.2	14.3	14.5	14.4
Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
China	4.2	4.1	3.9	3.8	4.0	3.8	3.8	3.7	3.7	3.8
Other Asia	2.8	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6
Latin America	4.4	4.4	4.6	4.6	4.5	4.6	4.7	4.7	4.7	4.7
Middle East	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.3	1.2
Africa	2.0	1.9	2.0	2.1	2.0	2.1	2.1	2.1	2.1	2.1
Total Non-OECD	29.0	28.6	28.6	29.1	26.8	28.8	28.7	28.9	29.1	28.9
Processing gains	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Global biofuels	1.9	2.4	2.8	2.4	2.4	2.0	2.5	2.9	2.5	2.5
Total Non-OPEC	57.1	56.1	56.8	57.0	56.8	56.5	56.8	57.4	57.3	57.0
OPEC										
Crude	32.8	33.1	33.6	34.1	33.4	32.7	32.7	32.7	32.7	32.7
NGL	6.7	6.8	6.9	6.9	6.8	7.0	7.0	7.0	7.0	7.0
Total OPEC	39.6	39.9	40.5	41.0	40.2	39.7	39.7	39.7	39.7	39.7
Total supply	96.7	96.0	97.3	98.0	97.0	96.2	96.5	97.1	97.0	96.7
Stock change	1.3	0.2	0.2	1.1	0.7	(0.6)	(0.6)	(1.2)	(1.2)	(0.9)

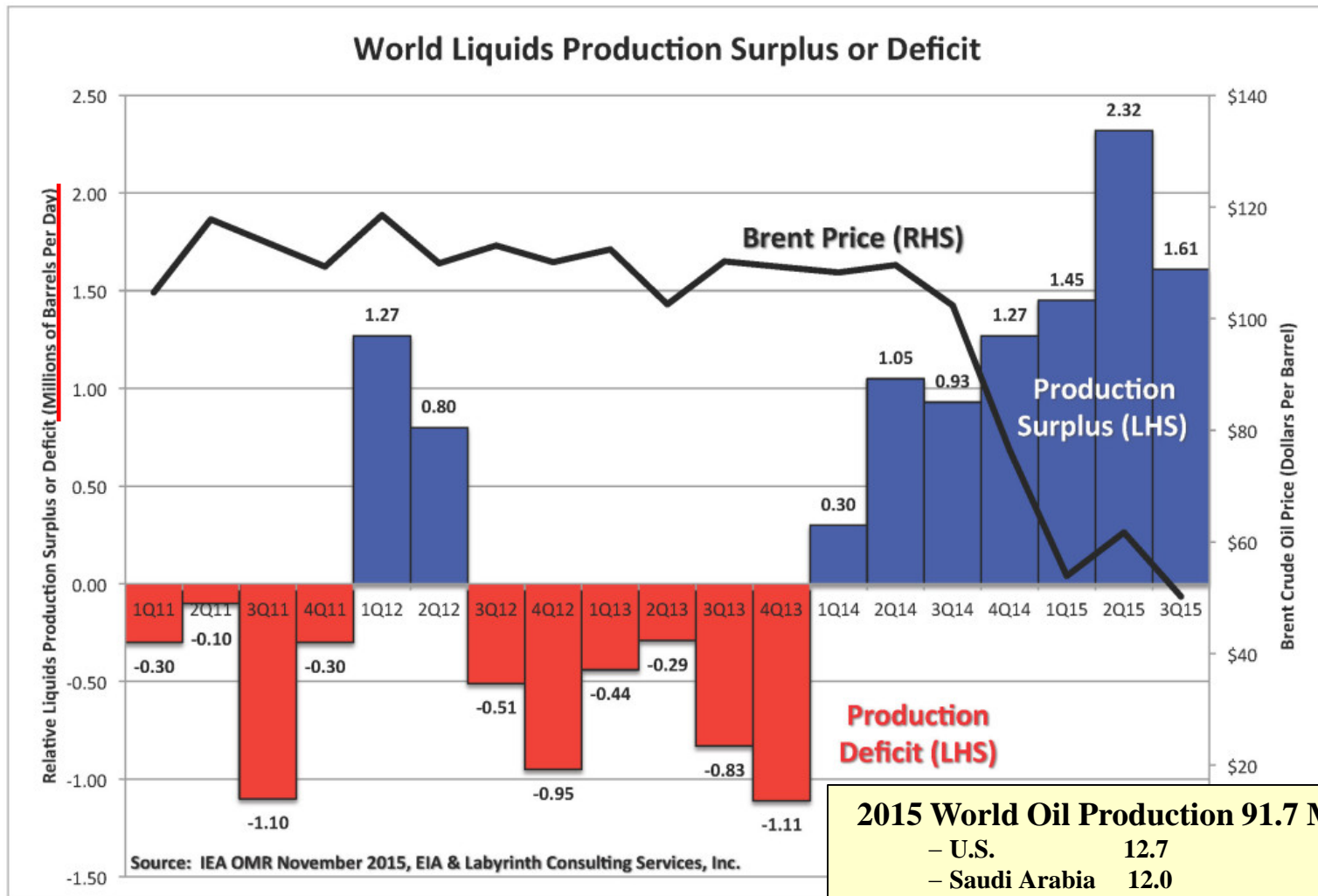
Totals may not add due to rounding.
Source: International Energy Agency; OGJ estimate of OPEC crude supply 4Q 2016 through 2017.

Source: O&G Journal January 2, 2017

base_e

“Practical Strategies for Emerging Energy Technologies”

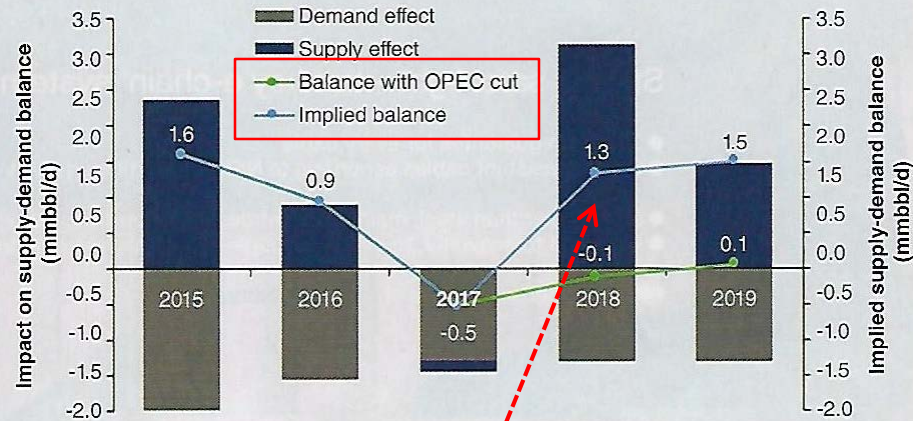
Oil Price – The Supply/Demand Balance



2015 World Oil Production 91.7 MMbbl/d	
– U.S.	12.7
– Saudi Arabia	12.0
– Russia	11.0
– Iran	3.9

2015-2019 Supply-Demand Balance

2015-2019 supply-demand balance: base case vs extended OPEC cut



Source: Sectors

OPEC Production cut ~1.8 mmbbl/d

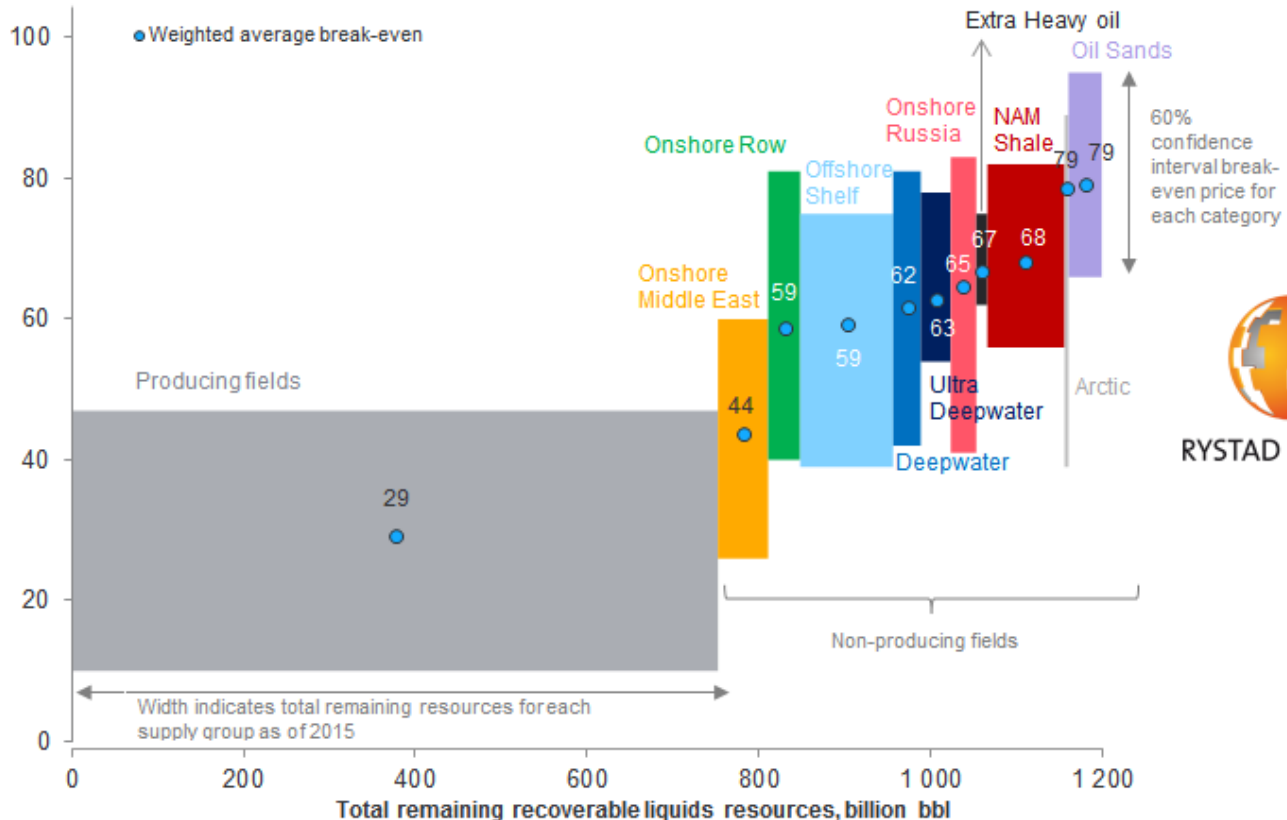
WORLDWIDE SUPPLY AND DEMAND

	2017				Year	2016				Year
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Million b/d										
DEMAND										
OECD										
Americas	24.5	25.0	25.0	25.1	24.9	24.6	24.9	25.3	25.1	25.0
Europe	13.9	14.3	14.7	14.1	14.3	13.8	14.2	14.7	14.3	14.3
Asia Pacific	8.6	7.8	7.9	8.4	8.1	8.5	7.6	7.7	8.2	8.0
Total OECD	47.0	47.0	47.6	47.5	47.3	46.9	46.8	47.7	47.6	47.3
Non-OECD										
FSU	4.6	4.7	5.0	4.9	4.8	4.7	4.8	5.1	5.0	4.9
Europe	0.7	0.7	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.8
China	12.5	12.6	12.2	12.4	12.4	12.8	12.9	12.6	13.0	12.8
Other Asia	13.2	13.5	13.2	13.6	13.4	13.8	14.0	13.6	14.3	13.9
Americas	6.4	6.6	6.7	6.6	6.6	6.5	6.7	6.8	6.7	6.7
Middle East	7.9	8.5	8.7	8.1	8.3	8.1	8.5	8.8	8.2	8.4
Africa	4.5	4.3	4.3	4.4	4.4	4.5	4.4	4.3	4.5	4.5
Total Non-OECD	49.8	51.0	50.7	50.7	50.6	51.1	52.0	52.0	52.4	51.9
Total Demand	96.7	98.0	98.3	98.3	97.8	98.0	98.8	99.7	100.0	99.1
Supply										
OECD										
Americas	19.9	19.8	20.2	20.5	20.1	21.1	21.1	21.5	21.9	21.4
Europe	3.7	3.5	3.4	3.4	3.5	3.6	3.6	3.5	3.6	3.6
Asia Pacific	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4
Total OECD	24.0	23.6	23.9	24.3	24.0	25.2	25.1	25.4	25.9	25.4
Non-OECD										
FSU	14.5	14.4	14.3	14.4	14.4	14.4	14.4	14.4	14.5	14.4
Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
China	3.9	3.9	3.8	3.8	3.9	3.8	3.7	3.7	3.7	3.7
Other Asia	3.5	3.5	3.4	3.4	3.5	3.4	3.4	3.4	3.3	3.4
Latin America	4.6	4.5	4.5	4.6	4.6	4.6	4.7	4.7	4.8	4.7
Middle East	1.2	1.2	1.2	1.3	1.2	1.3	1.3	1.3	1.3	1.3
Africa	1.7	1.7	1.8	1.8	1.7	1.8	1.8	1.8	1.8	1.8
Total Non-OECD	29.5	29.3	29.2	29.3	29.4	29.3	29.4	29.4	29.6	29.4
Processing gains	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Global biofuels	1.9	2.4	2.8	2.5	2.4	2.0	2.5	2.8	2.5	2.5
Total Non-OPEC	57.7	57.7	58.2	58.4	58.0	58.8	59.4	59.9	60.3	59.6
OPEC										
Crude	32.1	32.3	32.7	32.4	32.4	32.4	32.5	32.6	32.6	32.5
NGL	6.8	6.9	7.0	6.9	6.9	7.0	7.0	7.0	7.0	7.0
Total OPEC	38.9	39.2	39.6	39.3	39.3	39.4	39.5	39.6	39.6	39.5
Total supply	96.6	96.9	97.9	97.7	97.3	98.2	98.9	99.5	99.9	99.1
Stock change	(0.1)	(1.1)	(0.5)	(0.6)	(0.5)	0.2	0.1	(0.2)	(0.1)	0.0

Totals may not add due to rounding.
Source: International Energy Agency; OGJ estimate of OPEC crude supply 4Q 2017 through 2018.

Global Liquids Cost Curve - 2015

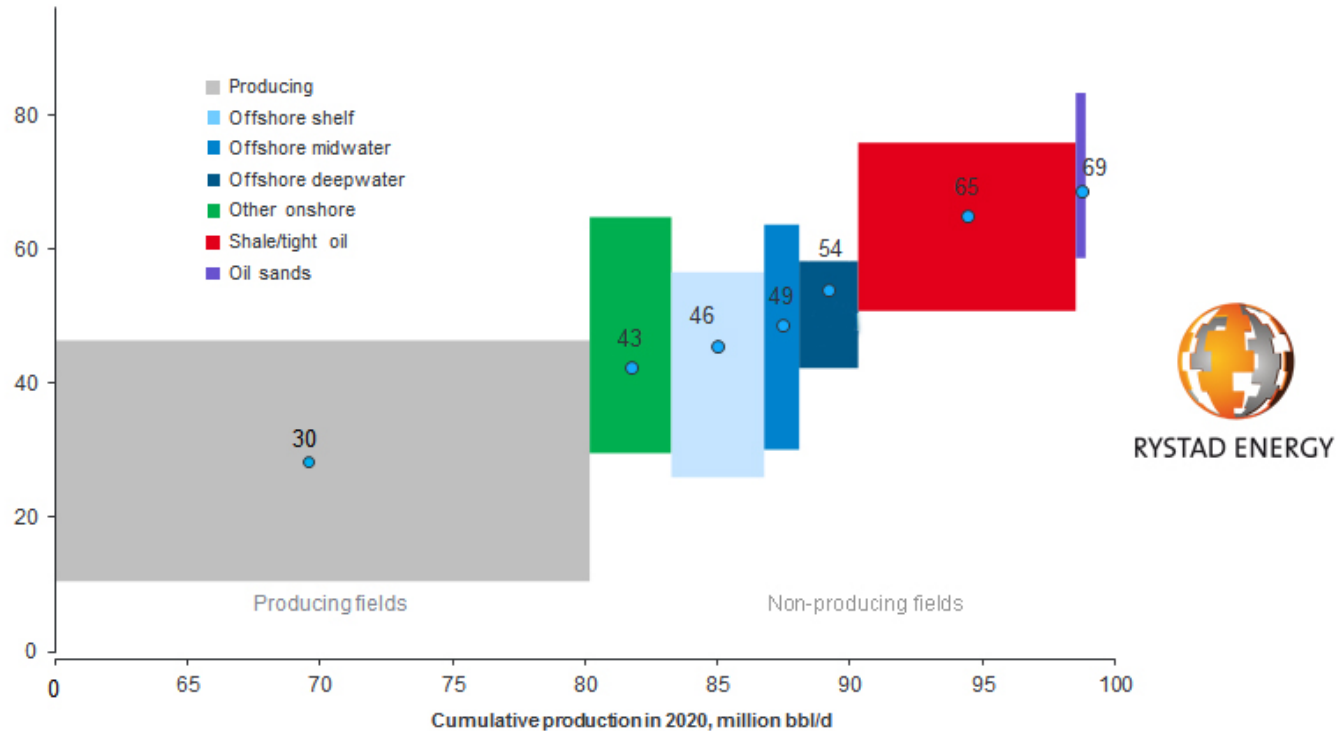
GLOBAL LIQUIDS COST CURVE*
Real Brent USD/bbl



*The break-even price is the Brent oil price at which NPV equals zero using a real discount rate of 7.5%. Resources are split into two life cycle categories: producing and non-producing (under development and discoveries). The latter is further split into several supply segment groups. The curve is made up of more than 20,000 unique assets based on each asset's break-even price and remaining liquids resources in 2015. Source: Rystad Energy UCube September 2015

Global Liquids Cost Curve - 2016

Global liquids cost curve
Brent-equivalent breakeven oil price, USD/bbl



Producing fields are the cheapest supply source, as opposed to the most expensive – non producing oil sands – with 69 USD/bbl. The producing fields' low breakeven price is due to past capex that we consider as sunk, cheap Middle East and shale production. Non-producing shale and oil sands are the marginal sources of supply in 2020, with high drilling/completion costs for the former and high capex/opex for the latter.

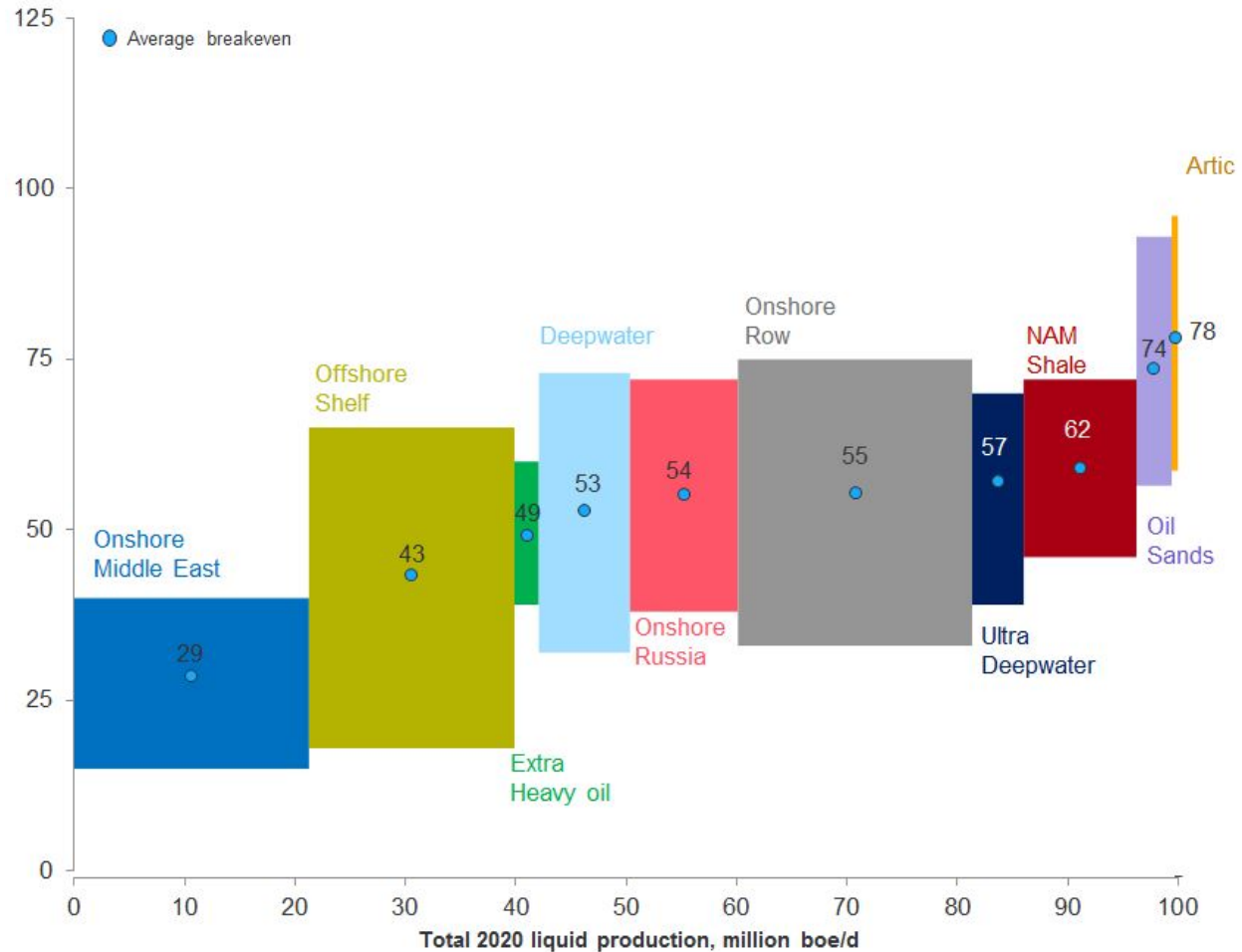
Rystad Energy's liquids cost curve is made up of nearly 20,000 unique assets by considering each asset's breakeven oil price and potential production in 2020. The breakeven price is the Brent oil price at which NPV equals zero, considering all future cash flows using a real discount rate of 7.5%.

Source: Rystad Energy research and analysis; UCube March 2016



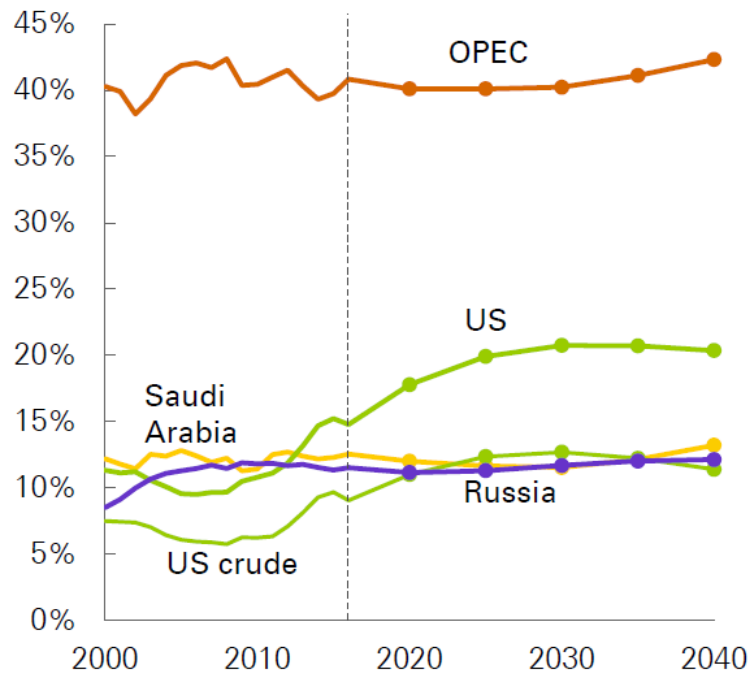
Global Liquids Cost Curve - 2020

Break-even prices for non-producing assets
Break-even price, USD/bbl

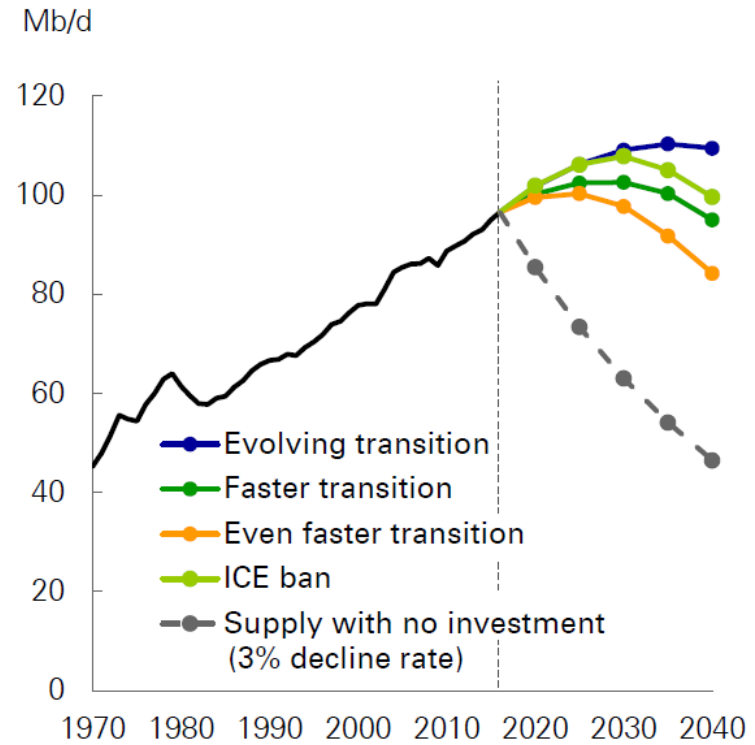


Share of World Liquid Supply

Share of world liquids supply

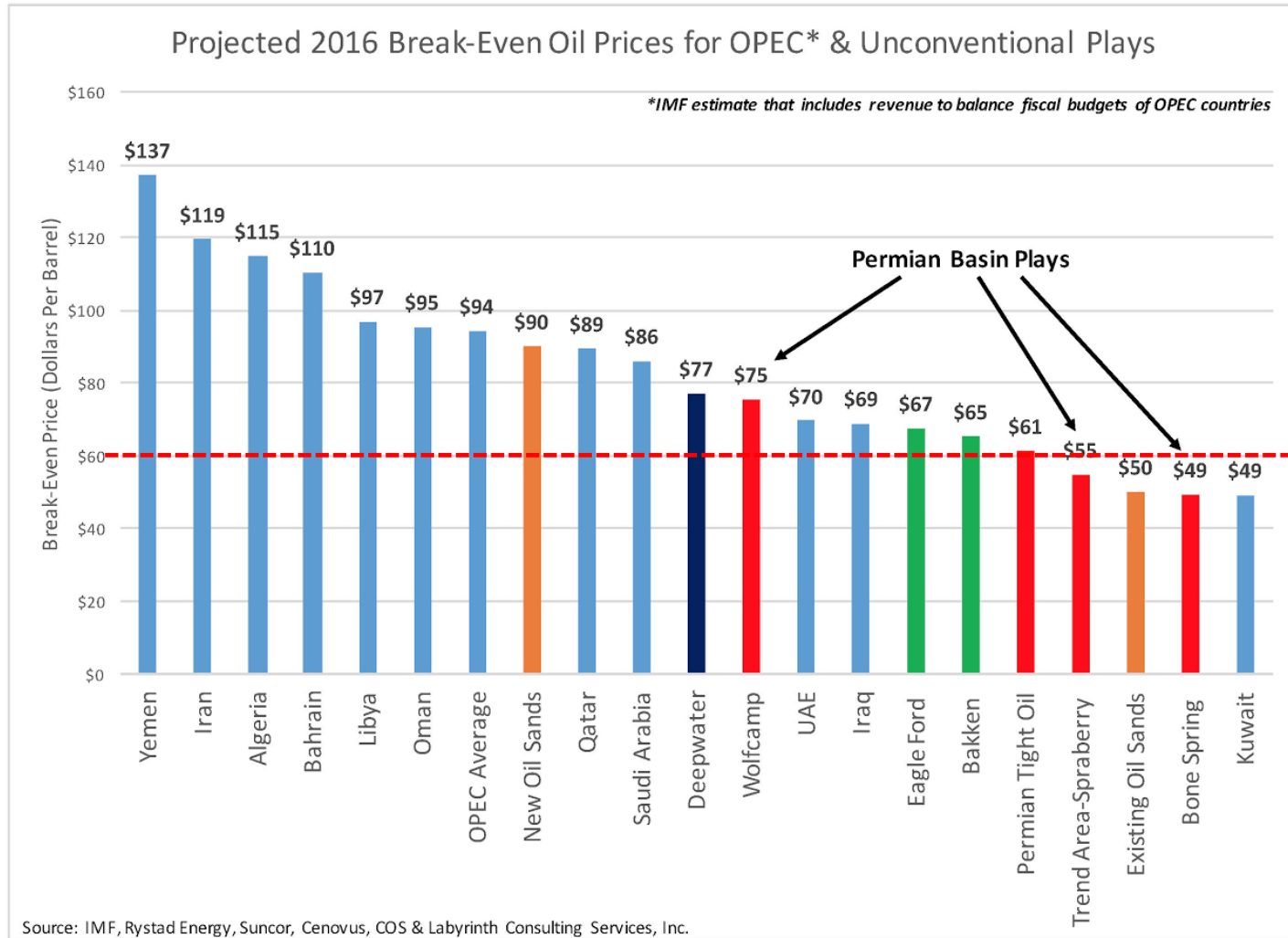


Demand and supply of liquid fuels



2018 BP Energy Outlook
© BP p.l.c. 2018

Break-Even Price of Oil Selected Locations



Coal

Coal Consumption 2017– 3732 Mtoe

- Coal consumption declined by 1.6% in 2017
- India grew by 4.8%
- China grew by 0.5%
- Asia represents 74.5% of 2017
- China represents 50.7% of consumption in 2017

Coal: Consumption*

Million tonnes oil equivalent	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share 2017
												2017	2006-16	
US	544.6	535.9	471.4	498.8	470.6	416.0	431.8	430.9	372.2	340.6	332.1	-2.2%	-4.5%	8.9%
Total North America	586.2	575.5	505.2	536.3	507.1	449.9	465.4	463.2	404.8	371.9	363.8	-1.9%	-4.3%	9.7%
Total S. & Cent. America	25.8	28.3	23.1	28.1	30.0	31.6	34.3	35.9	36.2	34.9	32.7	-5.9%	3.7%	0.9%
Germany	86.7	80.1	71.7	77.1	78.3	80.5	82.8	79.6	78.7	75.8	71.3	-5.8%	-1.1%	1.9%
Poland	55.9	55.2	51.8	55.1	55.0	51.2	53.4	49.4	48.7	49.5	48.7	-1.4%	-1.5%	1.3%
Turkey	29.5	29.6	30.9	31.4	33.9	36.5	31.6	36.1	34.7	38.5	44.6	16.3%	3.9%	1.2%
Total Europe	372.9	349.3	314.3	327.8	340.2	347.3	336.4	319.3	313.1	295.1	296.4	0.7%	-2.2%	7.9%
Kazakhstan	31.1	33.8	30.9	33.4	36.3	37.9	37.5	37.0	34.2	33.9	36.2	7.0%	1.8%	1.0%
Russian Federation	93.9	100.7	92.2	90.5	94.0	98.4	90.5	87.6	92.1	89.2	92.3	3.8%	-0.8%	2.5%
Ukraine	39.8	41.8	35.9	38.3	41.5	42.5	41.6	35.6	27.3	29.7	24.6	-17.1%	-2.9%	0.7%
Total CIS	167.3	179.0	161.5	164.7	174.7	182.1	173.0	163.8	157.3	156.2	157.0	0.8%	-0.7%	4.2%
Total Middle East	9.9	9.7	9.6	10.1	10.3	11.9	11.5	11.5	10.7	9.1	8.5	-5.9%	-0.8%	0.2%
South Africa	83.7	93.3	93.8	92.8	90.5	88.3	88.4	89.5	83.0	84.7	82.2	-2.7%	0.4%	2.2%
Total Africa	92.0	101.4	101.0	100.1	98.4	96.0	97.2	101.9	94.6	94.9	93.1	-1.7%	0.5%	2.5%
Australia	52.7	54.9	53.1	49.4	48.1	45.1	43.0	42.6	43.9	43.6	42.3	-2.8%	-1.9%	1.1%
China	1584.2	1609.3	1685.8	1748.9	1903.9	1927.8	1969.1	1954.5	1914.0	1889.1	1892.6	0.5%	2.6%	50.7%
India	240.0	259.3	280.8	290.4	304.6	330.0	352.8	387.5	395.3	405.6	424.0	4.8%	6.3%	11.4%
Indonesia	36.2	31.5	33.2	39.5	46.9	53.0	57.0	45.1	51.2	53.4	57.2	7.4%	6.3%	1.5%
Japan	117.7	120.3	101.6	115.7	109.6	115.8	121.2	119.1	119.0	118.8	120.5	1.7%	0.6%	3.2%
Malaysia	8.8	9.8	10.6	14.8	14.8	15.9	15.1	15.4	17.4	19.6	20.0	2.5%	10.4%	0.5%
South Korea	59.7	66.1	68.6	75.9	83.6	81.0	81.9	84.6	85.5	81.9	86.3	5.7%	4.1%	2.3%
Taiwan	38.8	37.0	35.2	37.6	38.9	38.0	38.6	39.0	37.8	38.6	39.4	2.5%	0.4%	1.1%
Vietnam	6.3	11.9	11.2	14.6	17.3	16.1	17.2	20.8	26.2	28.3	28.2	♦	17.3%	0.8%
Total Asia Pacific	2197.6	2257.5	2332.3	2438.6	2618.3	2675.5	2747.5	2766.5	2748.3	2744.0	2780.0	1.6%	3.1%	74.5%
Total World	3451.8	3500.6	3447.0	3605.6	3778.9	3794.5	3865.3	3862.2	3765.0	3706.0	3731.5	1.0%	1.3%	100.0%

Coal Production 2017 – 3769 Mtoe

Coal: Production*

Million tonnes oil equivalent	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share
												2017	2006-16	2017
US	558.3	566.9	513.7	523.7	528.3	491.9	475.8	482.3	426.9	348.3	371.3	6.9%	-4.7%	9.9%
Canada	35.7	35.6	33.1	35.4	35.5	35.5	36.1	35.9	32.3	31.8	31.1	-2.0%	-0.9%	0.8%
Total North America	601.3	609.4	552.9	566.4	573.1	534.9	519.1	525.5	466.1	386.2	407.9	5.9%	-4.4%	10.8%
Colombia	48.0	50.5	50.0	51.1	58.9	61.2	58.7	60.8	58.8	62.2	61.4	-0.9%	3.2%	1.6%
Total S. & Cent. America	55.9	57.5	55.1	55.7	63.6	65.9	65.0	67.8	64.4	67.8	66.8	-1.3%	2.4%	1.8%
Czech Republic	23.8	22.8	20.9	20.8	21.0	20.3	17.8	17.0	17.1	16.1	15.4	-3.8%	-3.9%	0.4%
Germany	54.4	50.1	46.4	45.9	46.7	47.8	45.1	44.1	42.8	39.8	39.6	-0.3%	-2.9%	1.0%
Poland	62.5	60.9	56.4	55.4	55.7	57.8	57.2	54.0	53.0	52.1	49.6	-4.4%	-2.6%	1.3%
Turkey	14.8	16.7	17.4	17.5	17.9	17.0	15.5	16.4	12.8	15.5	20.8	34.8%	1.6%	0.6%
Total Europe	216.6	211.0	200.1	197.4	201.4	199.2	187.5	179.0	171.2	161.3	164.6	2.3%	-3.1%	4.4%
Kazakhstan	42.2	47.9	43.4	47.5	49.8	51.6	51.4	48.9	46.2	44.3	47.9	8.5%	0.7%	1.3%
Russian Federation	143.5	149.0	141.7	151.0	157.6	168.3	173.1	176.6	186.4	194.0	206.3	6.7%	3.2%	5.5%
Ukraine	34.0	34.4	31.8	31.8	36.3	38.0	36.6	25.9	16.4	17.1	14.4	-15.6%	-7.1%	0.4%
Total CIS	221.5	233.0	218.8	232.0	245.7	260.3	263.5	254.0	251.5	258.1	271.8	5.6%	1.6%	7.2%
Total Middle East	1.1	1.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	-	-2.9%	♦
South Africa	138.4	141.0	139.7	144.1	143.2	146.6	145.3	148.2	142.9	142.4	143.0	0.7%	0.3%	3.8%
Total Africa	140.5	142.7	141.5	146.8	146.0	151.9	152.4	157.7	151.6	149.6	154.5	3.6%	0.6%	4.1%
Australia	227.0	234.2	242.5	250.6	245.1	265.9	285.8	305.9	306.4	307.7	297.4	-3.1%	3.4%	7.9%
China	1439.3	1491.8	1537.9	1665.3	1851.7	1873.5	1894.6	1864.2	1825.6	1691.4	1747.2	3.6%	2.4%	46.4%
India	210.3	227.5	246.0	252.4	250.8	255.0	255.7	269.5	281.0	284.9	294.2	3.5%	3.7%	7.8%
Indonesia	127.8	141.6	151.0	162.1	208.2	227.4	279.7	269.9	272.0	268.8	271.6	1.3%	8.9%	7.2%
Mongolia	4.8	5.2	8.2	15.2	19.9	17.9	18.0	15.2	14.3	21.5	30.3	41.4%	18.2%	0.8%
Vietnam	23.8	22.3	24.7	25.1	26.1	23.6	23.0	23.0	23.3	21.6	21.3	-0.9%	-0.1%	0.6%
Total Asia Pacific	2065.5	2156.2	2240.5	2402.6	2636.0	2697.0	2790.6	2781.7	2756.7	2639.6	2702.3	2.7%	3.2%	71.7%
Total World	3302.4	3410.8	3409.6	3601.6	3866.6	3909.8	3978.9	3966.4	3862.1	3663.5	3768.6	3.2%	1.5%	100.0%

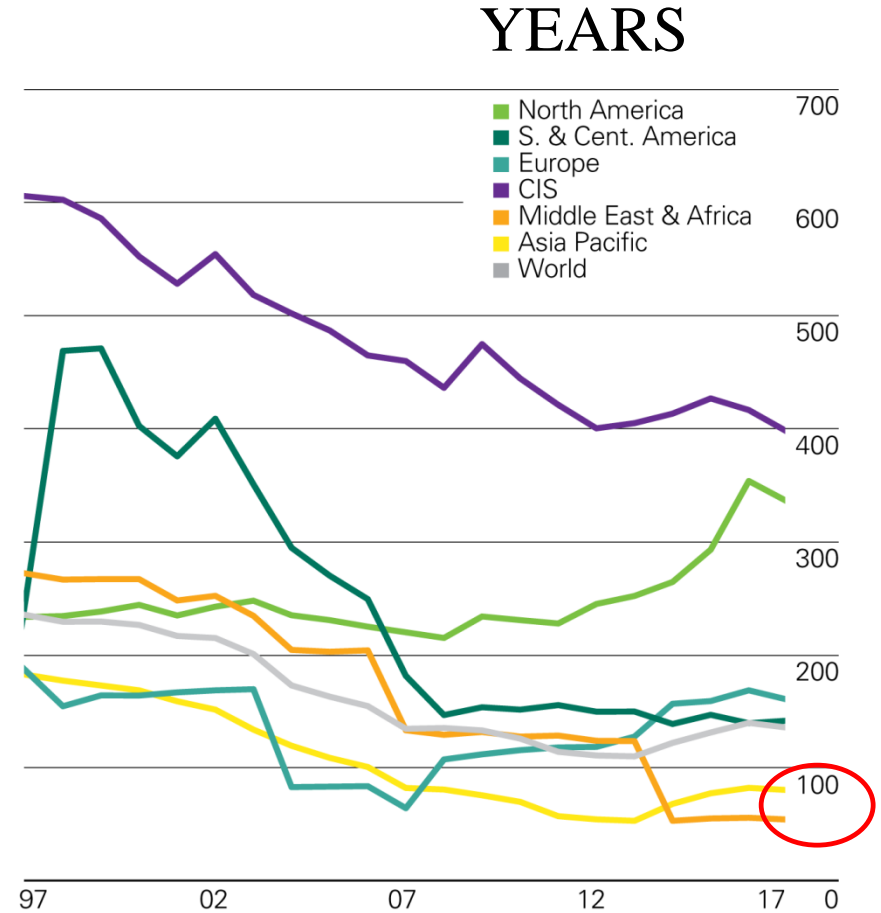
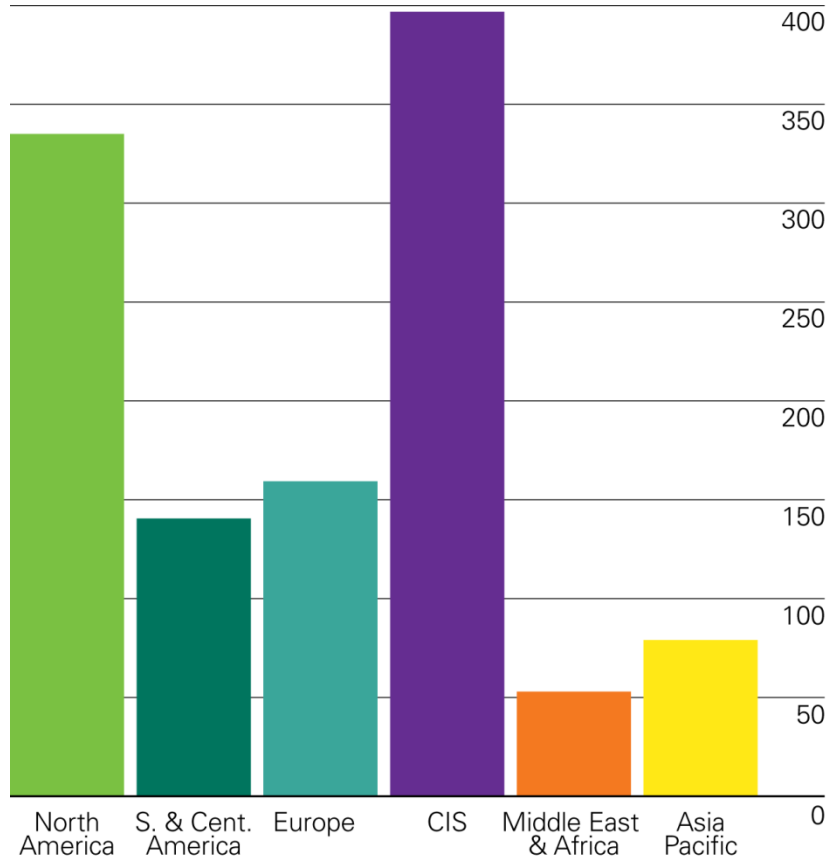
Calorific equivalents

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



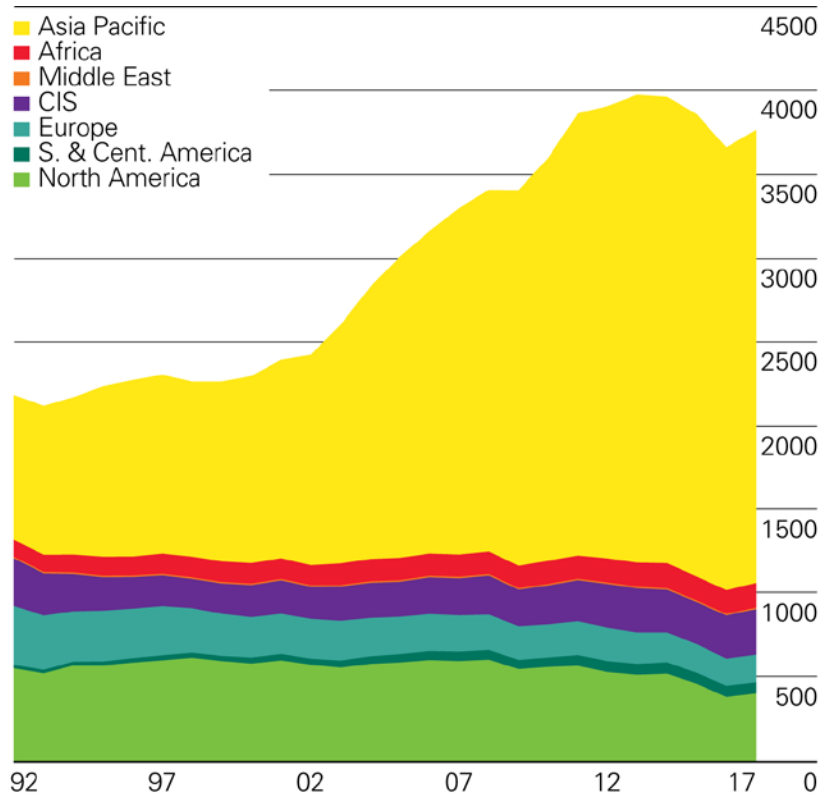
Coal Reserves to Production Ratio - 2017



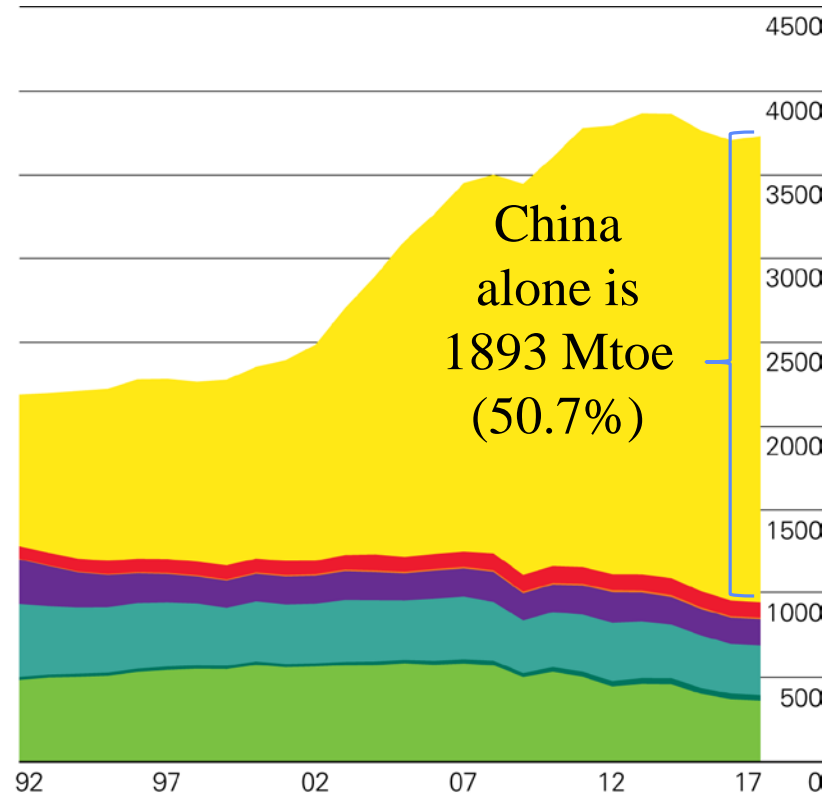
Coal - Regional Consumption 2017 - Mtoe

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.

Production by region



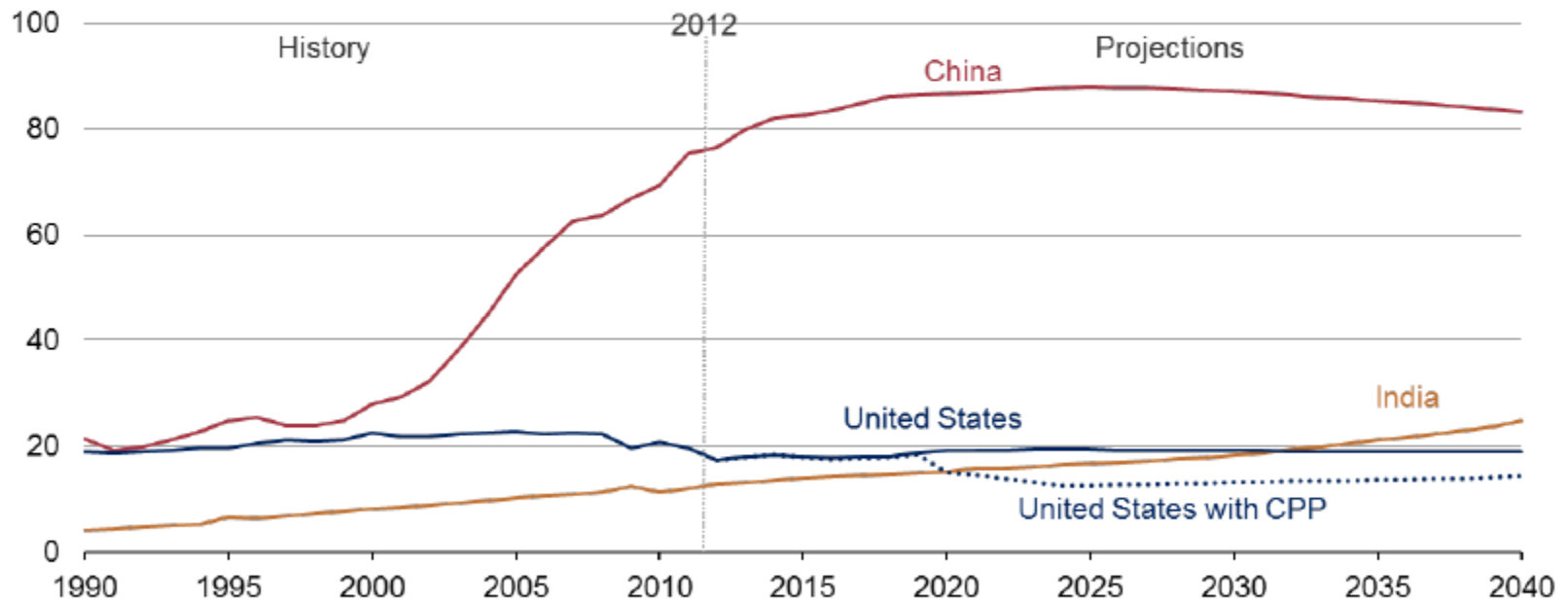
Consumption by region



India Coal

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

coal consumption in the US, China, and India
quadrillion Btu



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



Adam Sieminski, Center for Strategic and International Studies
May 11, 2016

Coal Exports 2016

- The United States remained a net exporter of coal in 2016
 - Exporting 60.3 million short tons = \$3.316 billion
 - Importing 9.8 million short tons = \$0.539 billion
 - Net = \$2.777 billion
- U.S. coal exports fell for the fourth consecutive year, down 13.7 MMst from 2015, with 2016 exports less than half of the record volume of coal exported in 2012 (125.7 MMst).
- Nearly 80% of the coal exported by the United States in 2016 went to 10 countries.
- Declining exports to 9 of those 10 countries accounted for two-thirds of the total drop in U.S. exports.



Coal Company Bankruptcies

Largest mines owned by companies recently in bankruptcy

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

As of March 1, 2016.

Includes coal production for bankrupt coal companies as operator, owner and ultimate owner of mines that have filed bankruptcy since 2012.

* Mines in bankruptcy are defined as mines owned by companies in bankruptcy since 2012 as tracked by S&P Global Market Intelligence compared to ownership and production data from the U.S. Mine Safety and Health Administration as of the end of the fourth quarter of 2015. Some mines may have since been transferred to solvent companies and some companies may have since emerged from bankruptcy.

¹ Peabody Energy Corp.; Northern Illinois Municipal; Kentucky Muni Power Agency; Southern Illinois Power Coop; Prairie Power Inc.; MJMEUC; Indiana Municipal Power Agency; Illinois Municipal Elec Agency; American Mun Power Inc.

Source: S&P Global Market Intelligence

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

Q4'15 coal production by major coal basins

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

As of March 1, 2016.

Includes coal production for bankrupt coal companies as operator, owner and ultimate owner of mines that have filed bankruptcy since 2012.

* Mines in bankruptcy are defined as mines owned by companies in bankruptcy since 2012 as tracked by S&P Global Market Intelligence compared to ownership and production data from the U.S. Mine Safety and Health Administration as of the end of the fourth quarter of 2015. Some mines may have since been transferred to solvent companies and some companies may have since emerged from bankruptcy.

Source: S&P Global Market Intelligence

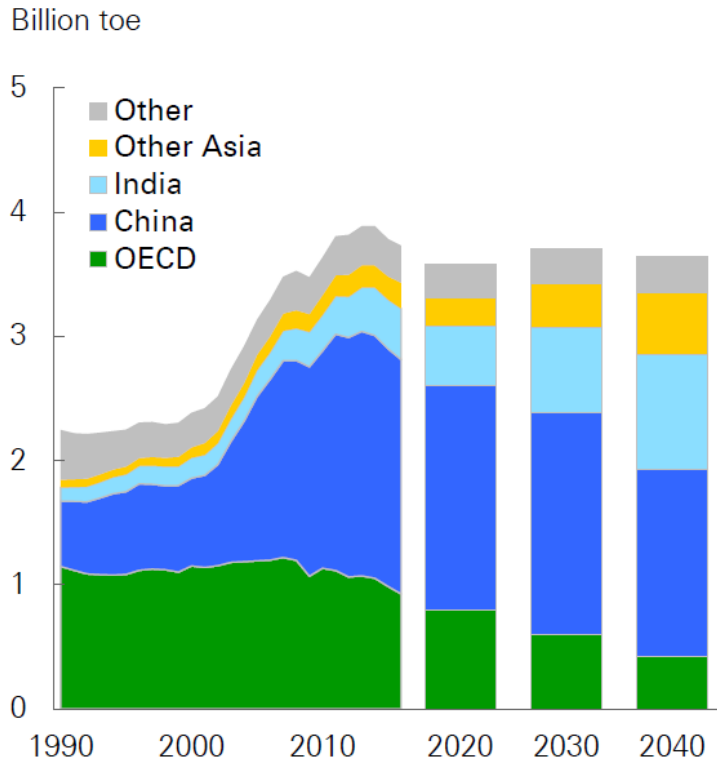
Source: SNL April 13, 2016



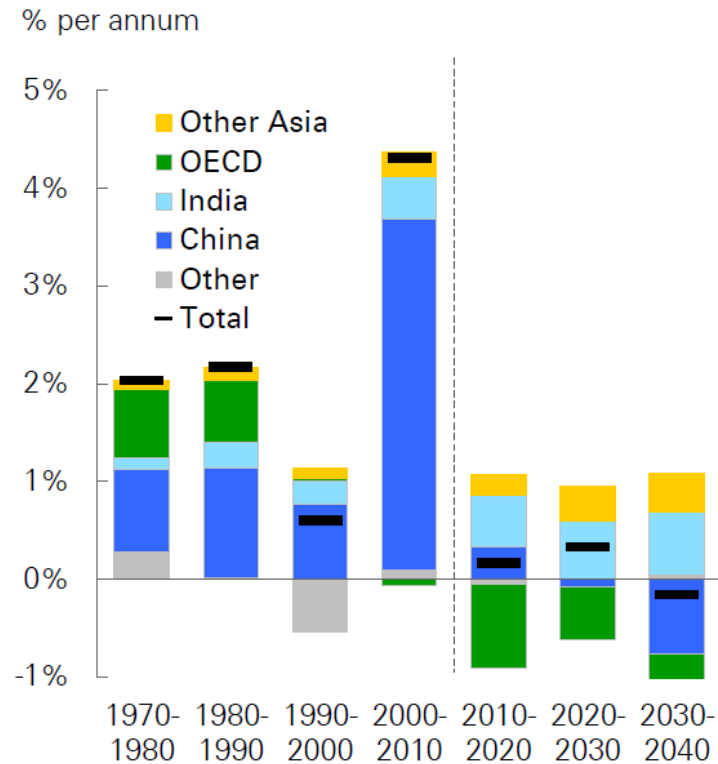
“Practical Strategies for Emerging Energy Technologies”

Coal “Flat Lines”

Coal consumption by region



Coal consumption growth and regional contributions

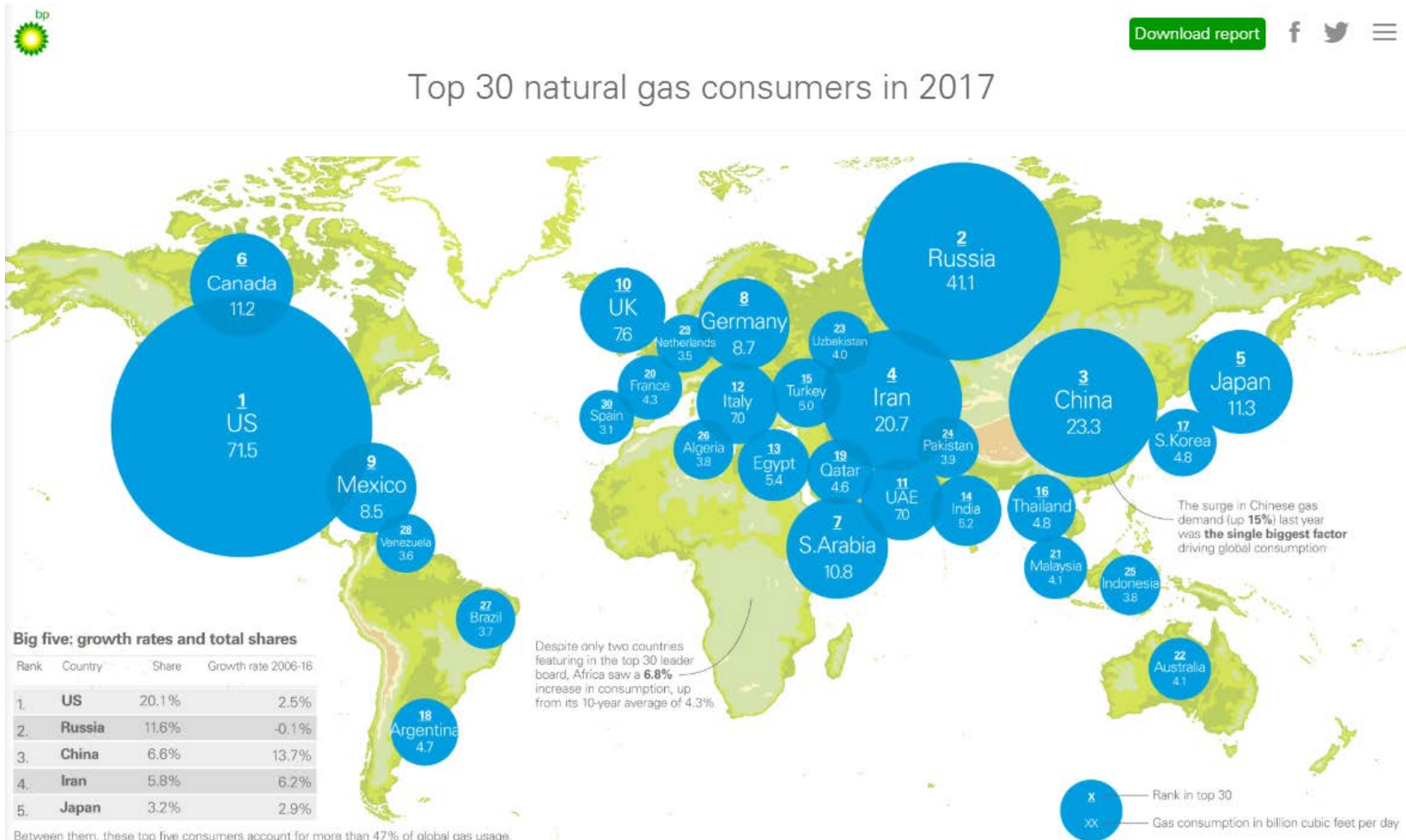


2018 BP Energy Outlook

© BP p.l.c. 2018

Natural Gas

Top 30 Natural Gas Consumers 2017



Natural Gas Demand 2017 – 3670.4 BCM

Natural Gas: Consumption*

Billion cubic metres	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share
												2017	2006-16	2017
US	624.1	628.9	617.6	648.2	658.2	688.1	707.0	722.3	743.6	750.3	739.5	-1.2%	2.5%	20.1%
Canada	90.9	89.3	86.6	88.7	95.6	92.8	98.0	103.2	102.9	109.5	115.7	6.0%	2.5%	3.2%
Mexico	57.0	60.0	65.2	66.0	70.8	73.7	78.5	80.1	78.0	91.8	87.6	-4.4%	4.7%	2.4%
Total North America	772.1	778.2	769.4	803.0	824.6	854.6	883.6	905.6	924.5	951.6	942.8	-0.7%	2.7%	25.7%
Argentina	42.7	43.2	41.0	42.2	44.0	45.7	45.8	46.2	46.7	48.3	48.5	0.5%	1.7%	1.3%
Brazil	22.2	26.1	21.0	28.0	28.0	33.1	39.0	41.3	43.7	37.7	38.3	1.9%	5.8%	1.0%
Venezuela	37.3	35.1	33.2	32.2	32.6	34.0	32.9	32.9	36.5	38.3	37.6	-1.5%	0.9%	1.0%
Total S. & Cent. America	143.1	143.5	136.6	150.1	153.1	162.2	168.7	172.2	178.6	175.1	173.4	-0.7%	2.3%	4.7%
France	44.7	46.4	44.7	49.6	43.0	44.5	45.2	37.9	40.8	44.6	44.7	0.7%	-0.3%	1.2%
Germany	88.6	89.5	84.4	88.1	80.9	81.1	85.0	73.9	77.0	84.9	90.2	6.5%	-0.8%	2.5%
Italy	81.5	81.4	74.9	79.7	74.8	71.9	67.2	59.4	64.8	68.0	72.1	6.3%	-1.7%	2.0%
Netherlands	38.6	40.3	40.7	45.6	39.8	37.7	38.2	33.3	32.9	34.5	36.1	4.7%	-1.4%	1.0%
Turkey	33.9	35.3	33.7	35.8	41.8	43.3	44.0	46.6	46.0	44.4	51.7	16.6%	4.3%	1.4%
United Kingdom	95.3	97.9	91.2	98.5	81.9	76.9	76.3	70.1	71.8	81.0	78.8	-2.4%	-1.5%	2.1%
Total Europe	550.7	563.1	527.9	567.7	523.3	512.3	506.2	458.9	475.8	505.6	531.7	5.5%	-0.9%	14.5%
Russian Federation	428.8	422.7	399.5	422.6	435.6	429.6	423.0	423.6	409.6	420.2	424.8	1.4%	♦	11.6%
Uzbekistan	48.0	50.9	41.7	42.7	44.1	43.7	43.3	45.3	48.6	41.6	41.6	0.3%	-0.5%	1.1%
Total CIS	609.9	605.4	551.8	588.7	606.2	600.5	583.1	582.7	568.4	572.9	574.6	0.6%	-0.4%	15.7%
Iran	123.6	131.2	140.6	150.6	159.8	159.1	160.4	180.9	191.9	201.4	214.4	6.8%	6.2%	5.8%
Qatar	24.0	19.3	19.6	24.7	27.3	33.7	35.0	38.8	44.1	43.1	47.4	10.3%	8.3%	1.3%
Saudi Arabia	70.7	76.4	74.5	83.3	87.6	94.4	95.0	97.3	99.2	105.3	111.4	6.1%	4.2%	3.0%
United Arab Emirates	47.9	58.0	57.6	59.3	61.6	63.9	64.4	63.4	71.0	72.5	72.2	-0.2%	5.5%	2.0%
Total Middle East	315.8	341.0	351.3	385.6	403.6	417.6	429.0	455.0	487.2	508.9	536.5	5.7%	5.9%	14.6%
Algeria	23.4	24.4	26.2	25.3	26.8	29.9	32.1	36.1	37.9	38.6	38.9	1.0%	5.4%	1.1%
Egypt	36.9	39.3	40.9	43.4	47.8	50.6	49.5	46.2	46.0	49.4	56.0	13.7%	3.5%	1.5%
Total Africa	94.6	98.6	97.2	102.5	108.3	116.2	116.6	122.1	129.6	133.2	141.8	6.8%	4.3%	3.9%
Australia	29.0	28.5	29.1	33.8	35.3	35.4	37.2	40.1	42.1	41.7	41.9	0.6%	4.9%	1.1%
China	71.1	81.9	90.2	108.9	135.2	150.9	171.9	188.4	194.7	209.4	240.4	15.1%	13.7%	6.6%
India	38.8	40.0	48.3	59.5	61.3	56.7	49.8	49.6	46.4	50.8	54.2	6.9%	3.5%	1.5%
Indonesia	34.6	39.7	42.1	44.0	42.7	42.9	41.4	41.5	41.0	38.3	39.2	2.6%	0.3%	1.1%
Japan	94.4	98.1	91.5	98.9	110.4	122.4	122.3	120.5	118.7	116.4	117.1	0.8%	2.9%	3.2%
Malaysia	40.4	43.5	40.0	39.8	38.3	42.0	44.6	44.7	43.9	41.9	42.8	2.4%	0.5%	1.2%
Pakistan	33.8	34.6	34.7	35.3	35.3	36.6	35.6	35.0	36.5	38.3	40.7	6.7%	1.4%	1.1%
South Korea	36.3	37.3	35.5	45.0	48.4	52.5	55.0	50.0	45.6	47.6	49.4	3.9%	3.6%	1.3%
Thailand	35.2	36.9	38.1	43.2	44.3	48.6	48.9	49.9	51.0	50.6	50.1	-0.7%	4.4%	1.4%
Total Asia Pacific	472.0	502.3	513.5	578.3	621.9	663.6	684.3	702.2	710.1	727.0	769.6	6.2%	5.2%	21.0%
Total World	2958.0	3032.1	2947.8	3175.9	3241.0	3327.1	3371.5	3398.7	3474.2	3574.2	3670.4	3.0%	2.3%	100.0%

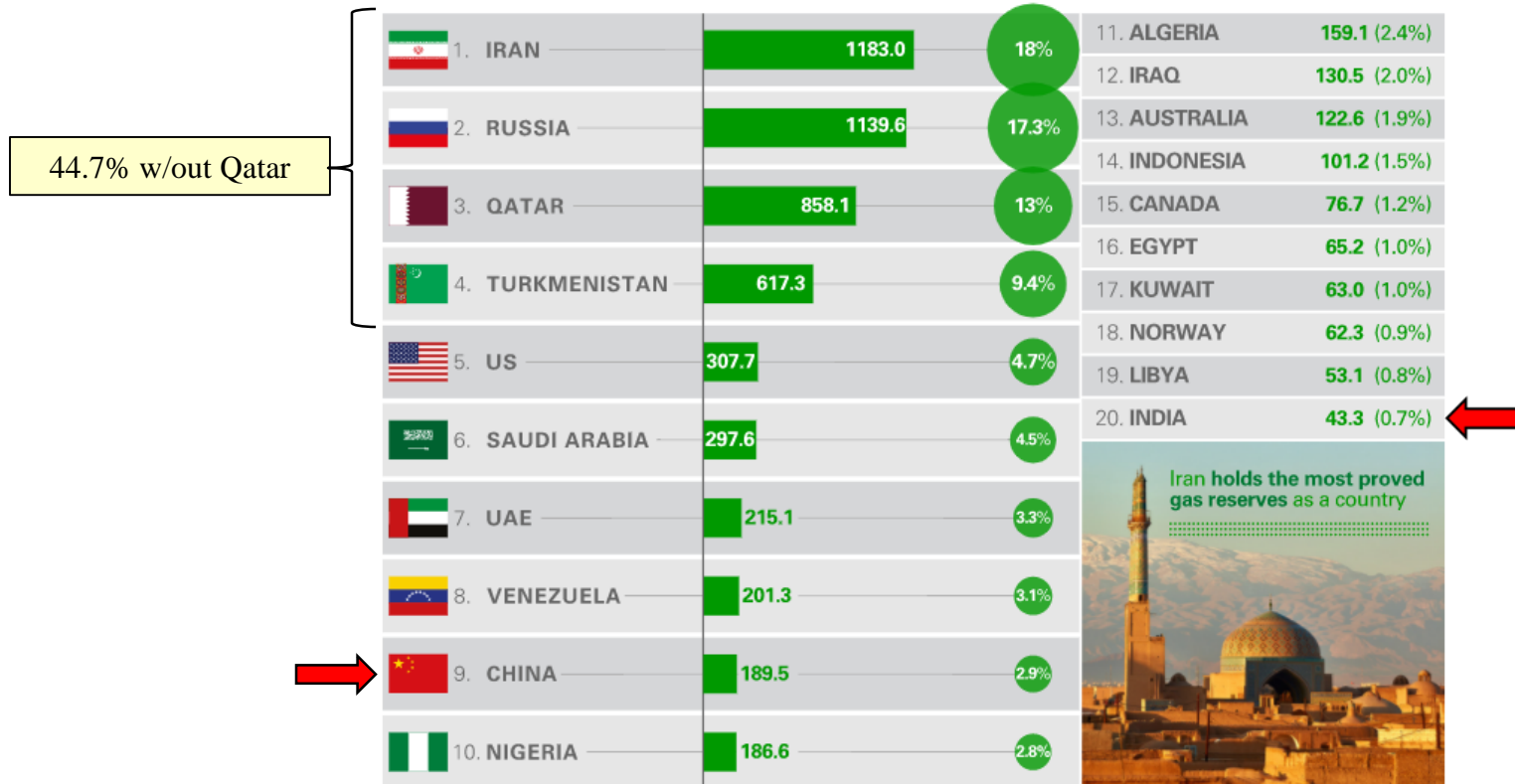
Natural Gas Production 2017 – 3680.4BCM

Natural Gas: Production*

Billion cubic metres	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share
												2017	2006-16	2017
US	521.9	546.1	557.6	575.2	617.4	649.1	655.7	704.7	740.3	729.3	734.5	1.0%	3.8%	20.0%
Canada	174.7	166.5	155.0	149.6	151.1	150.3	151.9	159.1	160.9	171.6	176.3	3.0%	-0.4%	4.8%
Total North America	743.4	759.8	765.2	775.9	820.5	850.3	860.1	915.1	949.2	944.6	951.5	1.0%	2.6%	25.9%
Argentina	43.6	42.8	40.3	39.0	37.7	36.7	34.6	34.5	35.5	37.3	37.1	-0.1%	-1.8%	1.0%
Trinidad & Tobago	41.0	40.8	42.4	43.5	41.9	41.5	41.7	40.9	38.5	33.5	33.8	1.2%	-1.5%	0.9%
Venezuela	37.2	33.4	31.8	30.5	30.2	31.9	30.6	31.8	36.1	38.0	37.4	-1.3%	0.9%	1.0%
Total S. & Cent. America	160.7	161.5	156.3	163.8	167.5	173.8	176.9	179.1	180.9	178.8	179.0	0.4%	1.4%	4.9%
Netherlands	63.3	69.6	65.6	73.8	67.1	66.8	71.8	60.6	45.4	42.0	36.6	-12.6%	-4.2%	1.0%
Norway	89.6	99.4	103.6	106.4	100.5	113.9	107.9	108.0	116.2	115.8	123.2	6.7%	2.8%	3.3%
United Kingdom	75.5	72.8	61.2	57.9	46.1	39.2	37.0	37.4	40.7	41.8	41.9	0.6%	-6.7%	1.1%
Total Europe	287.6	299.0	283.5	289.5	262.9	266.5	259.4	246.7	241.7	238.6	241.9	1.7%	-2.3%	6.6%
Russian Federation	601.6	611.5	536.2	598.4	616.8	601.9	614.5	591.2	584.4	589.3	635.6	8.2%	-0.3%	17.3%
Turkmenistan	68.4	69.1	38.0	44.3	62.3	65.1	65.2	70.2	72.8	66.9	62.0	-7.1%	0.6%	1.7%
Uzbekistan	60.9	60.4	58.1	56.9	53.9	53.9	53.9	54.2	54.6	53.1	53.4	0.8%	-1.1%	1.5%
Total CIS	777.4	795.7	687.8	755.9	788.9	777.1	792.8	776.1	771.6	769.8	815.5	6.2%	♦	22.2%
Iran	123.1	128.9	141.6	150.1	157.5	163.7	164.3	183.1	191.4	203.2	223.9	10.5%	6.3%	6.1%
Qatar	65.4	79.7	92.4	123.9	150.4	162.5	167.7	169.1	175.2	177.0	175.7	-0.5%	12.9%	4.8%
Saudi Arabia	70.7	76.4	74.5	83.3	87.6	94.4	95.0	97.3	99.2	105.3	111.4	6.1%	4.2%	3.0%
United Arab Emirates	49.0	49.0	47.6	50.0	51.0	52.9	53.2	52.9	58.7	59.6	60.4	1.8%	2.3%	1.6%
Total Middle East	367.7	397.6	419.6	481.6	526.4	552.2	569.1	589.9	608.4	630.8	659.9	4.9%	6.5%	17.9%
Algeria	81.6	82.6	76.6	77.4	79.6	78.4	79.3	80.2	81.4	91.4	91.2	0.1%	1.2%	2.5%
Egypt	53.6	56.8	60.3	59.0	59.1	58.6	54.0	47.0	42.6	40.3	49.0	22.1%	-2.6%	1.3%
Nigeria	35.0	34.4	24.7	35.5	38.6	41.1	34.4	42.8	47.6	42.6	47.2	11.0%	4.3%	1.3%
Total Africa	197.4	205.5	192.8	206.1	202.6	207.8	198.3	200.6	203.6	207.0	225.0	9.0%	1.1%	6.1%
Australia	42.8	41.7	46.7	54.0	55.7	59.5	61.8	66.6	76.0	96.4	113.5	18.0%	9.0%	3.1%
China	69.8	80.9	85.9	96.5	106.2	111.5	121.8	131.2	135.7	137.9	149.2	8.5%	8.9%	4.1%
Indonesia	72.6	74.8	78.0	87.0	82.7	78.3	77.6	76.4	76.2	70.7	68.0	-3.6%	-0.6%	1.8%
Malaysia	67.6	69.2	66.9	67.6	67.0	69.3	72.9	72.0	73.9	75.6	78.4	4.1%	1.0%	2.1%
Total Asia Pacific	407.1	426.4	447.5	496.5	500.1	509.4	519.6	539.4	564.0	580.3	607.5	5.0%	4.0%	16.5%
Total World	2941.3	3045.4	2952.8	3169.3	3269.0	3337.1	3376.2	3446.9	3519.4	3549.8	3680.4	4.0%	2.2%	100.0%

Natural Gas Reserves

3. Top 20 countries with largest proved reserves (in trillion cubic feet and as equivalent % of total world share)



At more than 6,588 trillion cubic feet recorded in 2016, global proved gas reserves are sufficient to meet more than 52 years of current production. As a region, the Middle East holds the largest reserves with 42.5% of the global total, while Iran holds the most proved gas resources as a country.

EIA/ARI Technically 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

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.

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.

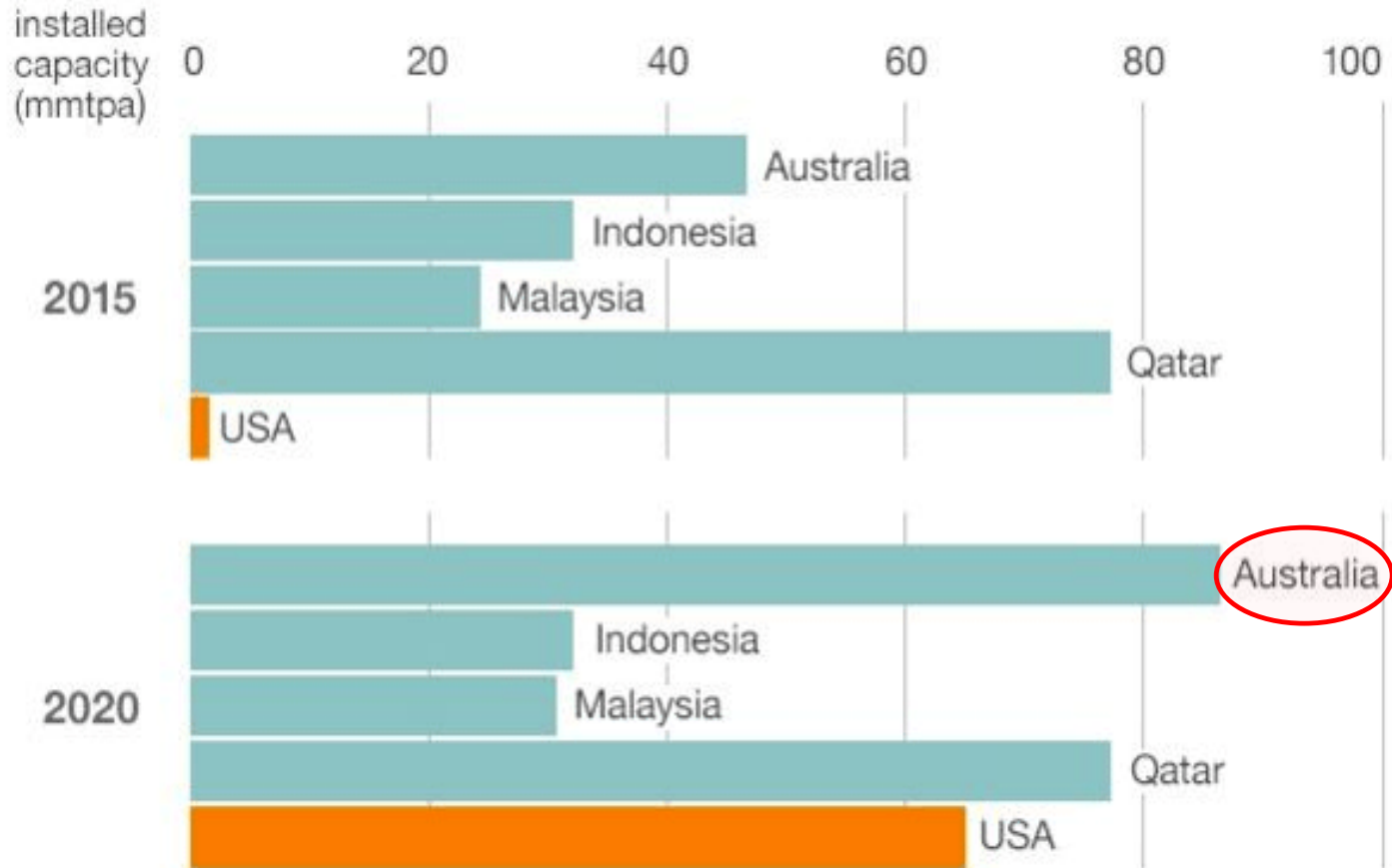
Table 6. Top 10 countries with technically recoverable shale gas resources

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.

Top LNG Producers 2015

World's top LNG producers



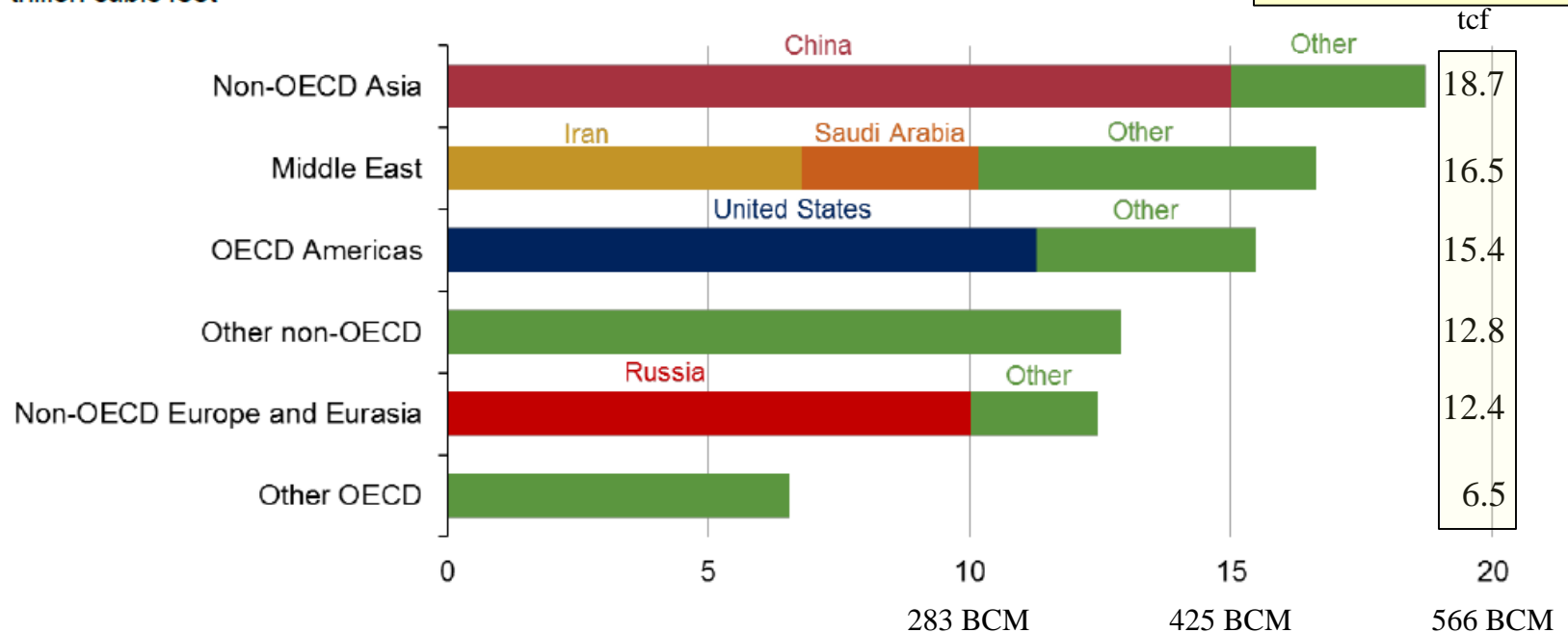
Source: Poyry Management Consulting

World Change in Gas Production – 2012-2040

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

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

+82.3 tcf = 2330 BCM



Source: EIA, International Energy Outlook 2016



Adam Sieminski, Center for Strategic and International Studies
May 11, 2016

Natural Gas Prices – March 2013

LNG LANDED PRICES: MARCH 2013*



FIG. 1

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

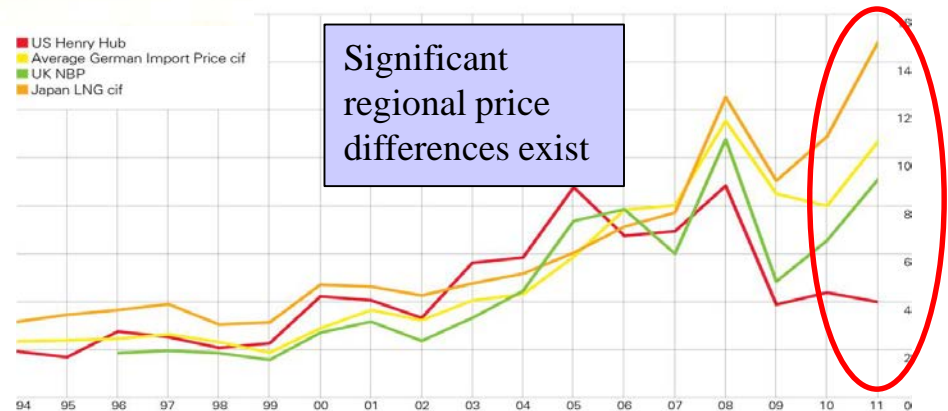
Supply:

North America

- Significant shale resource
- Significant associated gas production

Australia & East Africa

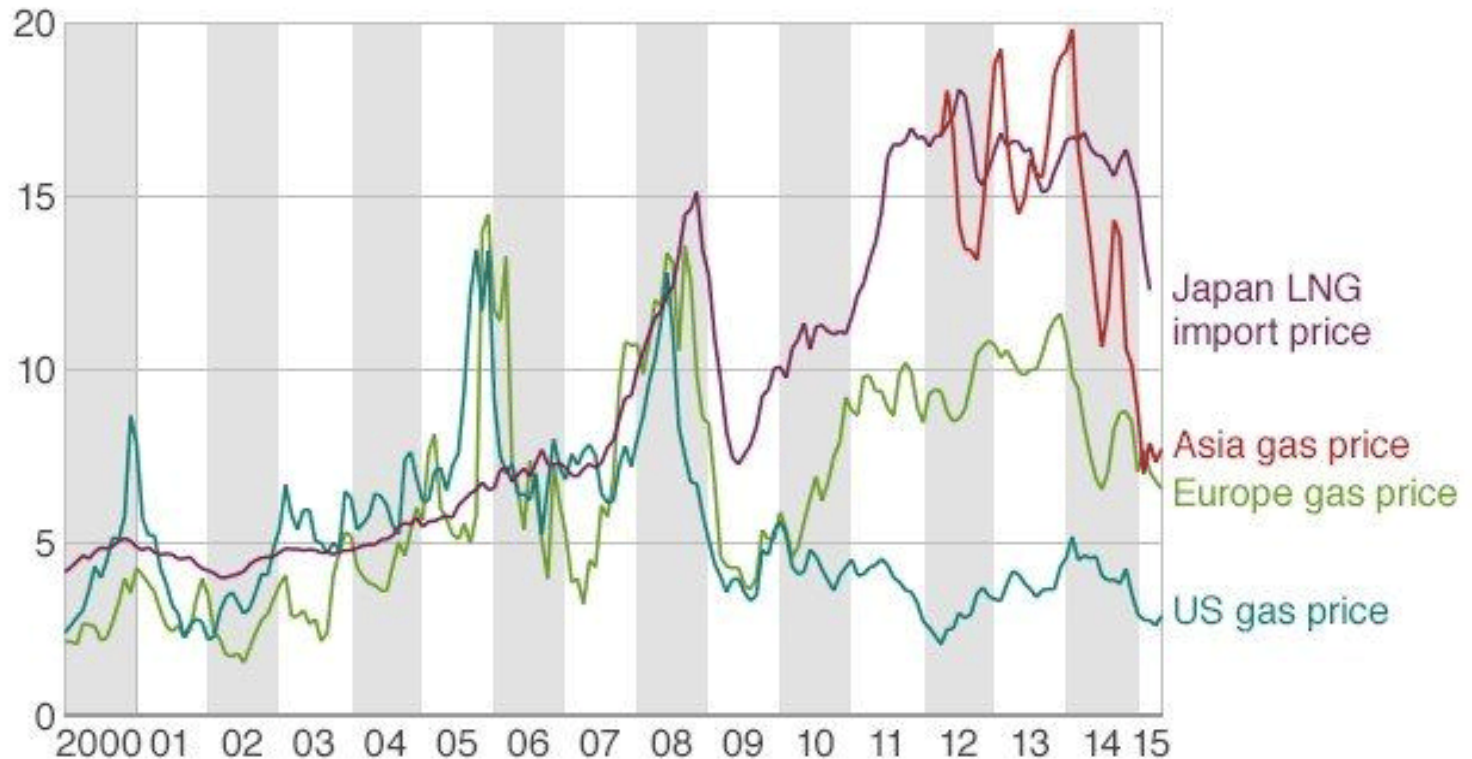
- Project cost/timing uncertainties



Natural Gas Prices 2015

Global gas prices, 2000-2015

\$ Million metric British units



World LNG Estimated Landed Prices January 2018



Source: *Waterborne Energy, Inc.* Data in \$US/MMBtu.

Note: Includes information and Data supplied by IHS Global Inc. and its affiliates ("IHS"); Copyright (publication year) all rights reserved. Prices are the monthly average of the weekly landed prices for the listed month. Landed prices are based on a netback calculation.

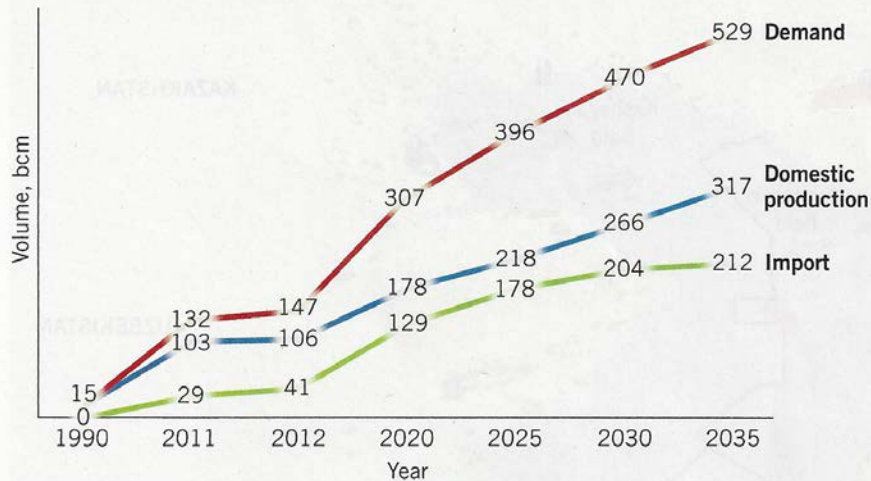
Updated: Feb-18

base_e

"Practical Strategies for Emerging Energy Technologies"

China Natural Gas

NATURAL GAS IN CHINA

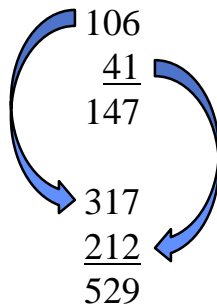


Sources: IEA (2013), BP (2013)

- 147 in 2012
 - Domestic production
 - Imported

3x @ 3.5% pa

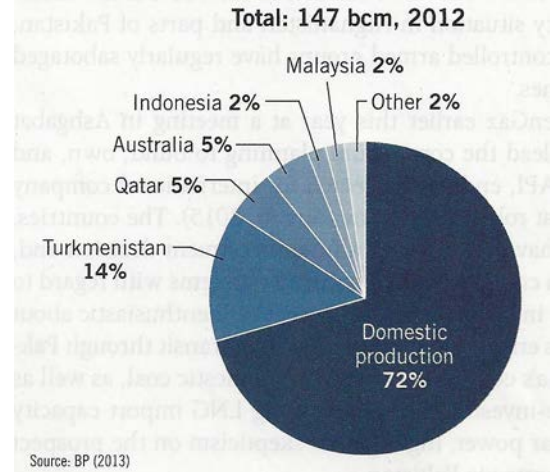
- 529 in 2035
 - Domestic production
 - Imported



5x @ 12.8% pa

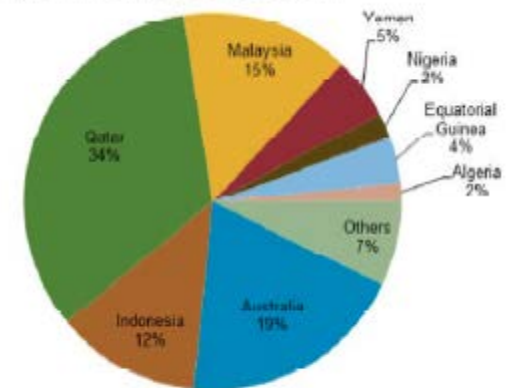
$$(529/147)^{1/33} = 4.0\% \text{ per year}$$

SOURCES, CONSUMED NATURAL GAS IN CHINA



Source: BP (2013)

China LNG import sources, 2014

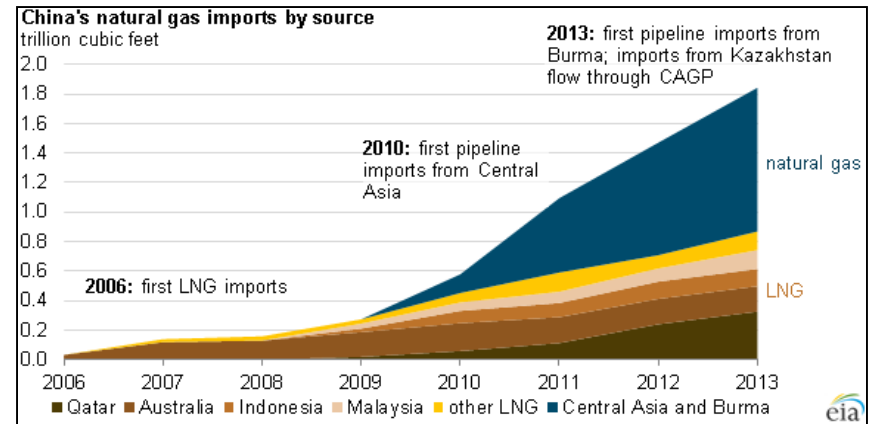
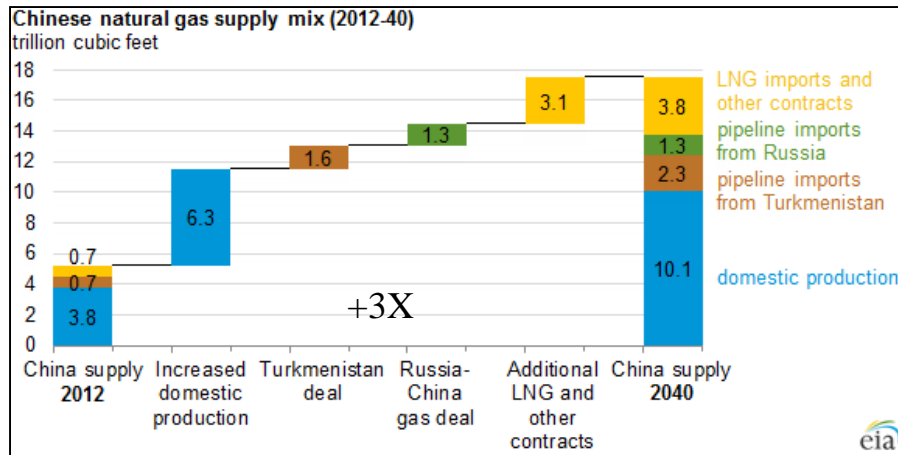


Source: IHS Energy.
Others: Angola, Brunei, Egypt, Norway, Oman, Papua New Guinea, Russia, Trinidad & Tobago, and re-exports from Spain and South Korea.

base_e

“Practical Strategies for Emerging Energy Technologies”

China Natural Gas



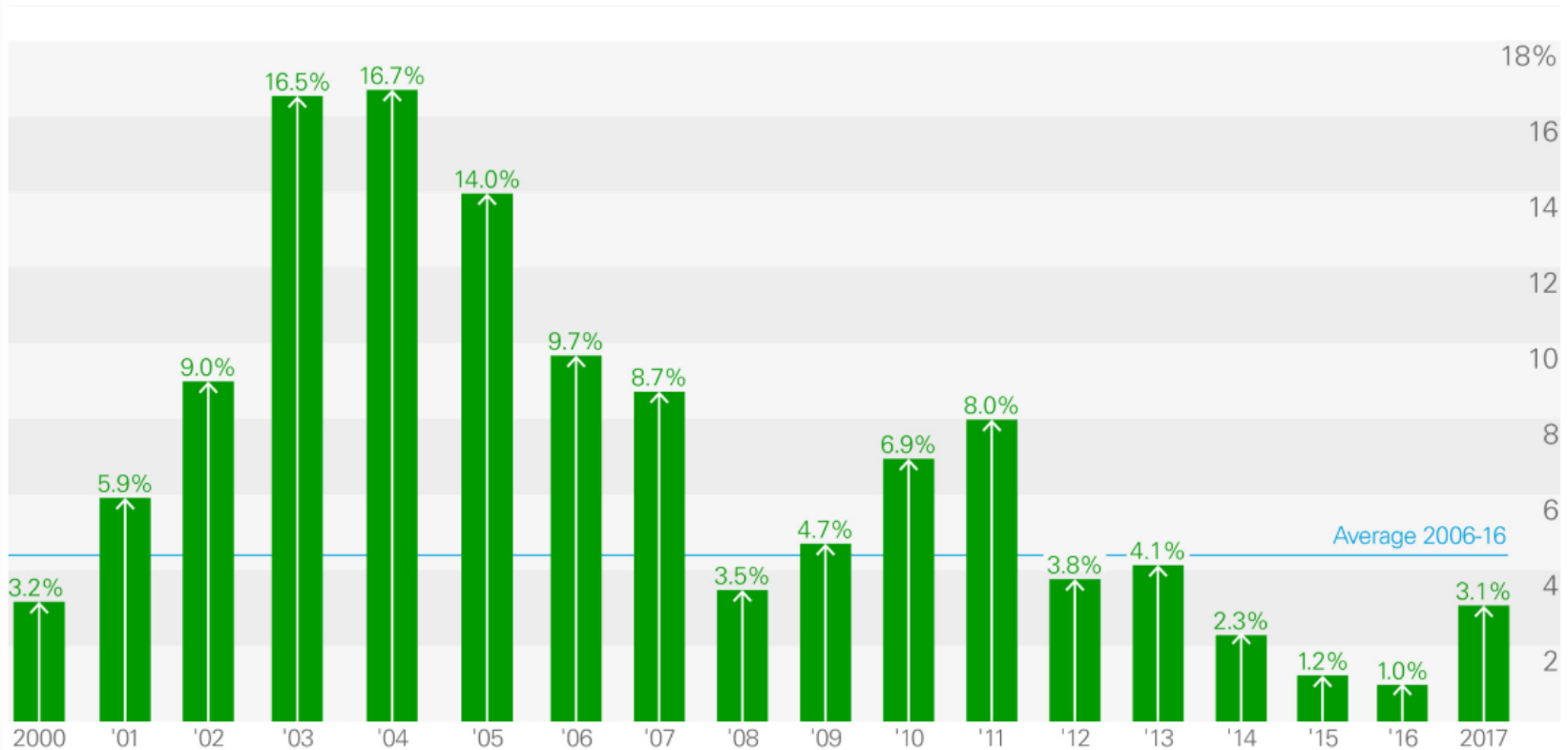
China Energy Demand Growth



Download report



Annual growth in China's primary energy use



“Practical Strategies for Emerging Energy Technologies”

Changing LNG Contract Terms – More Flex together

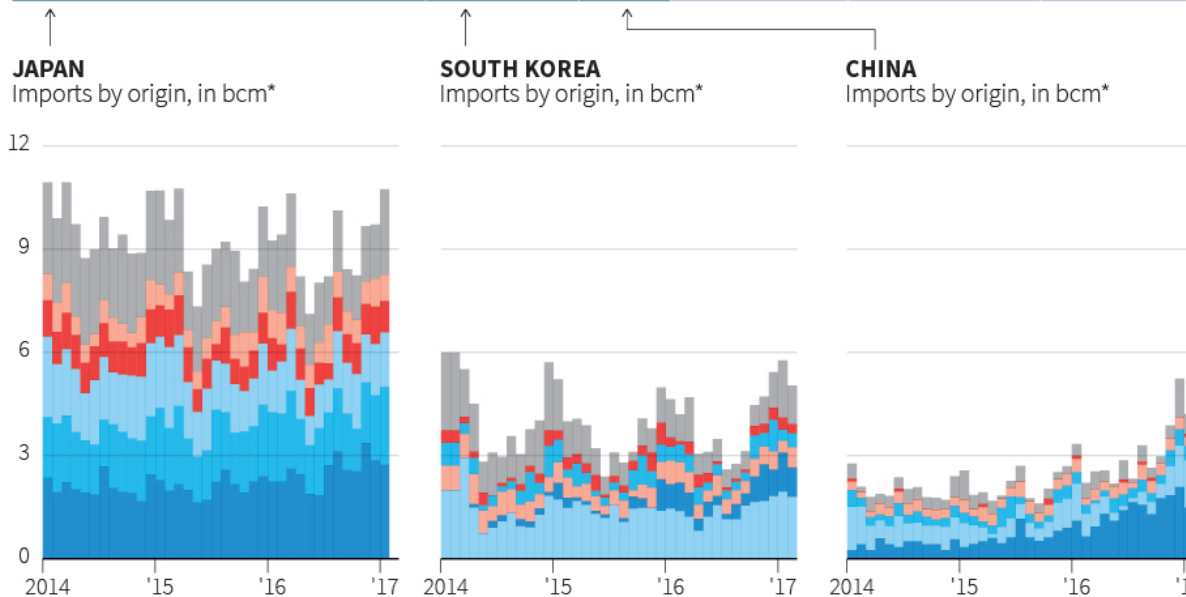
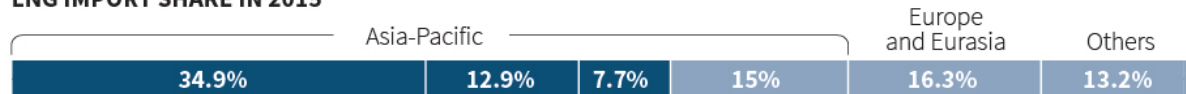
Top Asian LNG buyers form alliance

The top LNG buyers of Japan, South Korea and China, which are the world's biggest importers of fuel, have agreed to work together to secure more flexible contracts when buying the commodity. The three countries accounted for half of global LNG trade in 2015, according to BP Statistical Review of World Energy.

LNG origin:

- Others
- Russia
- Indonesia
- Qatar
- Malaysia
- Australia

LNG IMPORT SHARE IN 2015



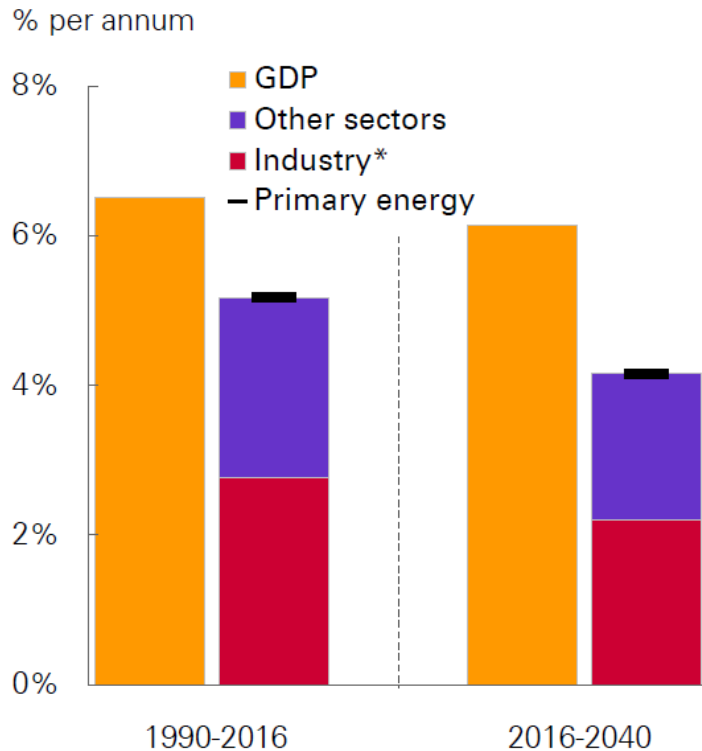
Note: February data for Japan is not available. *Billion cubic metres

Sources: Thomson Reuters; British Petroleum

C. Inton, 23/03/2017

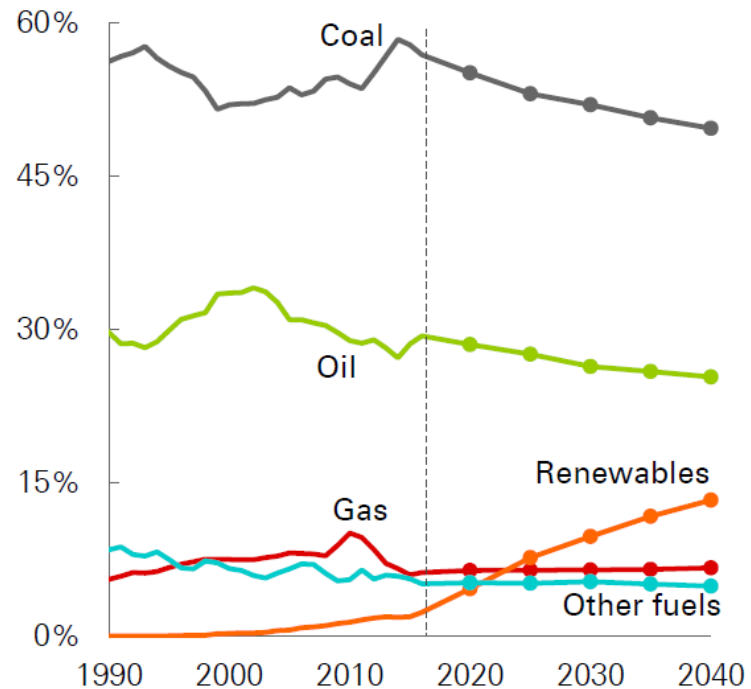
India Emerges as Largest Energy Growth Market

Growth of GDP and primary energy



*Excludes non-combusted fuels

Shares of primary energy



2018 BP Energy Outlook
© BP p.l.c. 2018

India Natural Gas

- India plans to dramatically increase its LNG import capacity
 - Indian gas production meets nearly half of domestic demand
 - The country's domestic natural gas production peaked in 2010 at 44.5 Bm³,
 - Production has declined over the past few years, settling at 29.2 Bm³ in 2015
 - India must rely on imports to satisfy demand
- India is expanding import capacity at its LNG terminals, as well as building grassroots facilities and utilizing floating storage and regasification unit (FSRU) vessels
 - The country has four operational LNG import terminals with a combined installed capacity of 25 MMtpy
 - India's Ministry of Petroleum and Natural Gas announced that LNG import capacity will increase from 25 MMtpy to 50 MMtpy
 - Nearly 80% of these new LNG supplies will come from Australia and the US.
- **India is also planning to utilize LNG as a bunker fuel and transportation fuel.**
 - The country has plans to build four LNG barges along the Ganges River.
 - These barges will provide waterway transport vessels with cleaner-burning LNG, as opposed to diesel fuel.
- **India promoting the use of LNG-fueled vehicles to curb emissions and mitigate its dependence on oil imports**
 - India's Petronet is heavily involved in promoting LNG as a transportation fuel
 - Plan includes LNG to be used in vehicles, water vessels and trains
 - Petronet is also in talks with major Indian fuel retailers to install LNG pumps at their fuel locations.
- **LNG-fueled vehicles, in combination with new Bharat Stage 6 fuel regulations, could have a dramatic impact on vehicle emissions in the country**
 - Air pollution has become such a crucial issue that New Delhi and other cities are requiring drivers to use their vehicles only every other day
 - The government is investing in the construction of compressed natural gas (CNG) fueling stations in the hope that citizens will switch to the cheaper, more fuel-efficient transportation option.



India – Gas Supply

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

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

Source: Petroleum & Natural Gas Regulatory Board of India

10 JANUARY 2016 | HydrocarbonProcessing.com

INDIA'S GAS SUPPLY

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

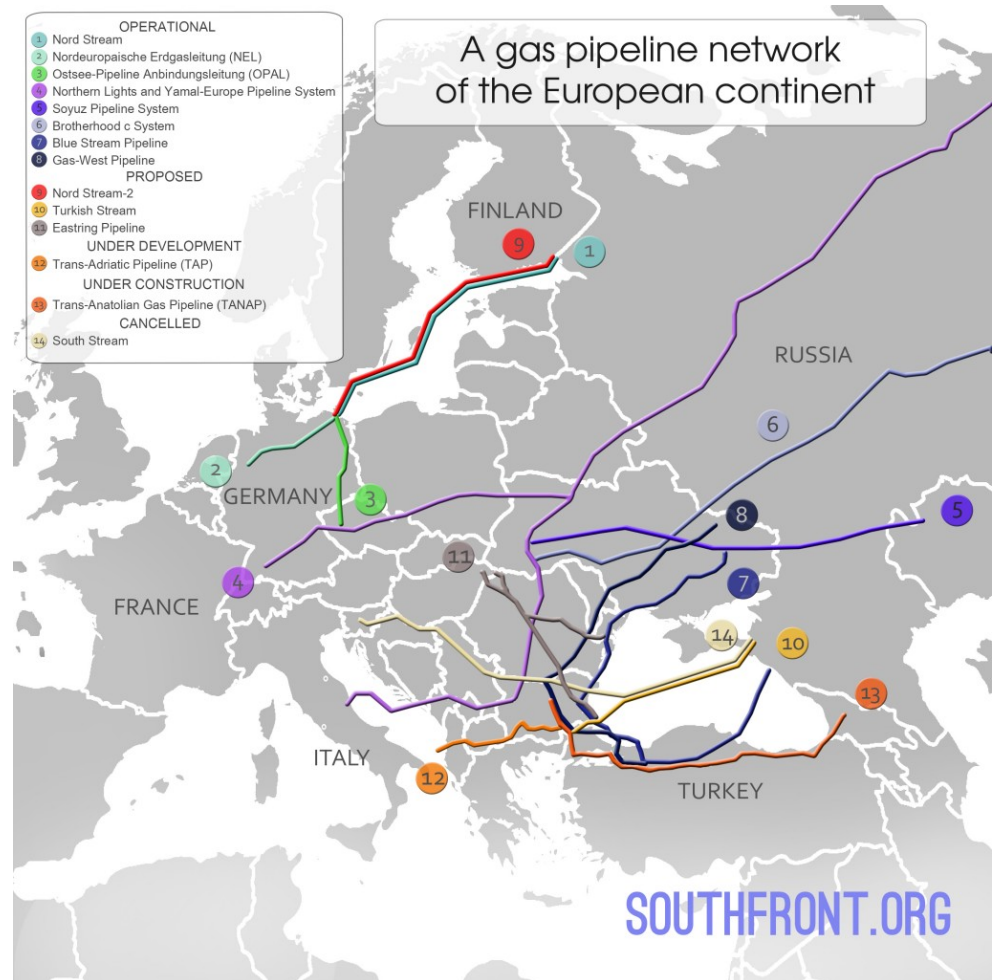
*TAPI pipeline projected commissioning 2017-18

Source: "Vision 2030 – Natural Gas Infrastructure in India," PNGRB

53	110	146	166	173 BCM
----	-----	-----	-----	---------

Gas to Europe - 489 BCM Demand

- Europe/Eurasia Pipeline Imports - 423 BCM
 - Russia 189
 - Norway 109
 - The Netherlands 43
 - Algeria 37
 - Other Europe/Mideast 50
- Europe/Eurasia LNG Imports - 66 BCM
 - Qatar 24
 - Algeria 14
 - Nigeria 12
 - Other 16



Australia Supply Strategy

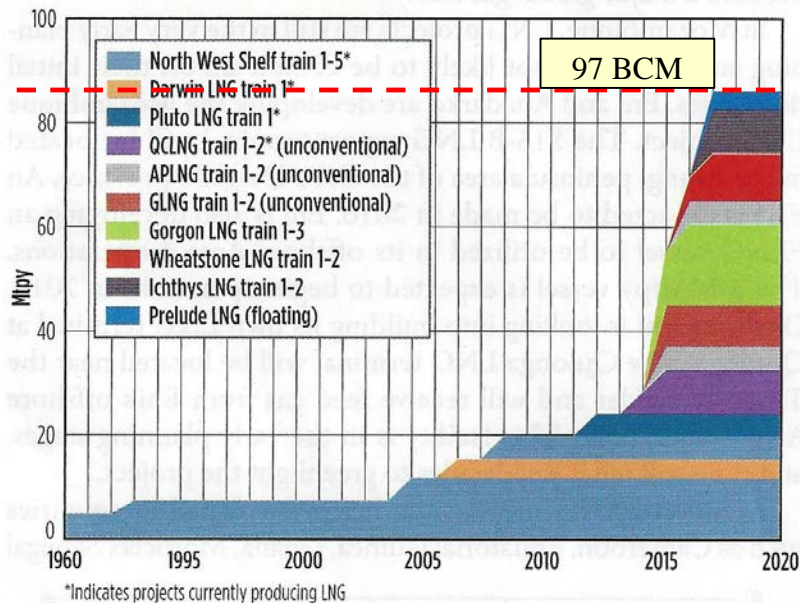
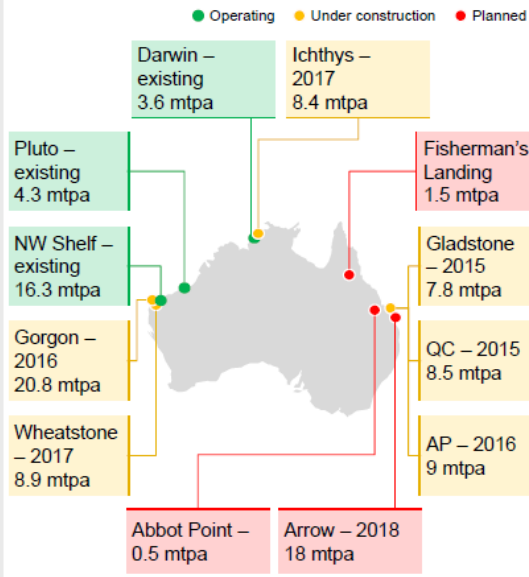


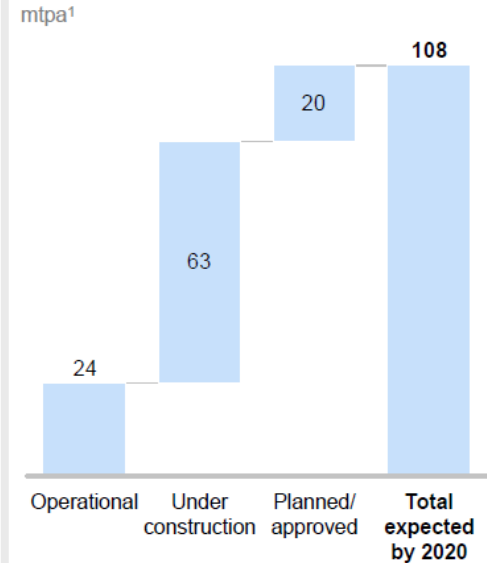
FIG. 2. Australian liquefaction capacity. Source: Australian Department of Industry and Reserve Bank of Australia.

S2 Australian supply projects are progressing

Map of onshore Australian LNG projects¹



Project status

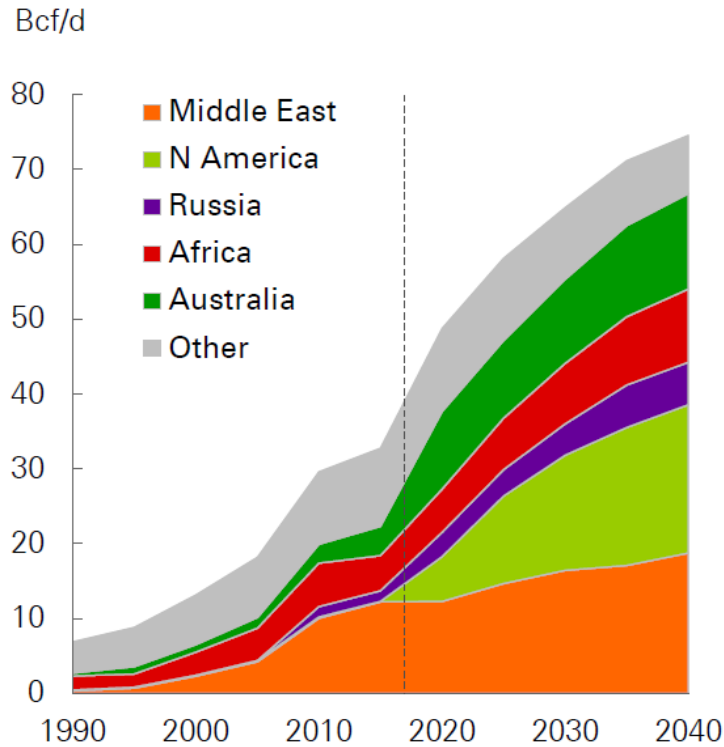


¹ Excludes 5 FLNG projects of total 18.1 mtpa (Prelude, Greater Sunrise, Bonaparte, Scarborough and Tassie)

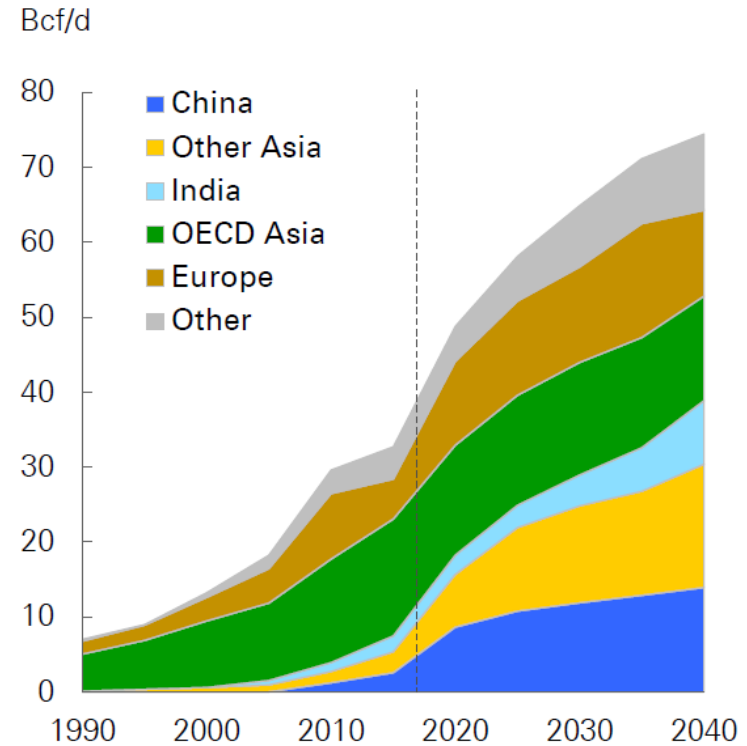
SOURCE: Enerdata; literature search; McKinsey analysis

LNG Increases Global Gas Availability

LNG exports



LNG imports



Global LNG Growth

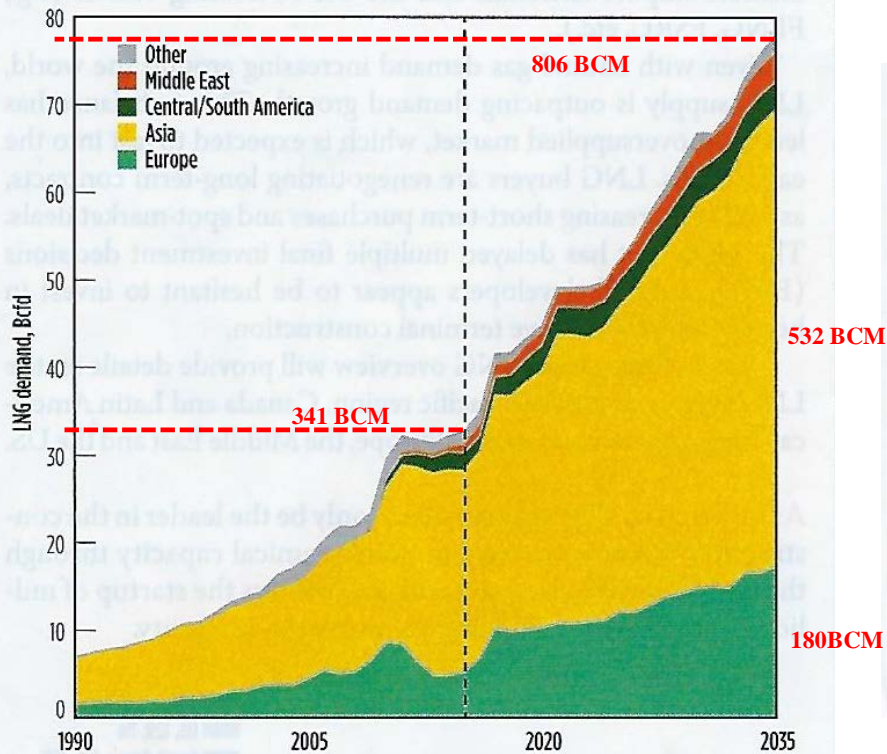


FIG. 3. Global growth in LNG demand to 2035. Source: BP.

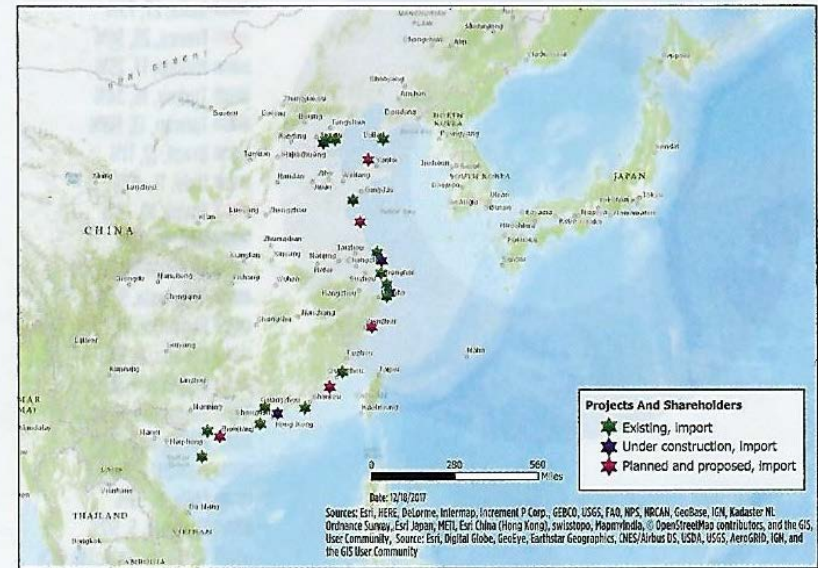
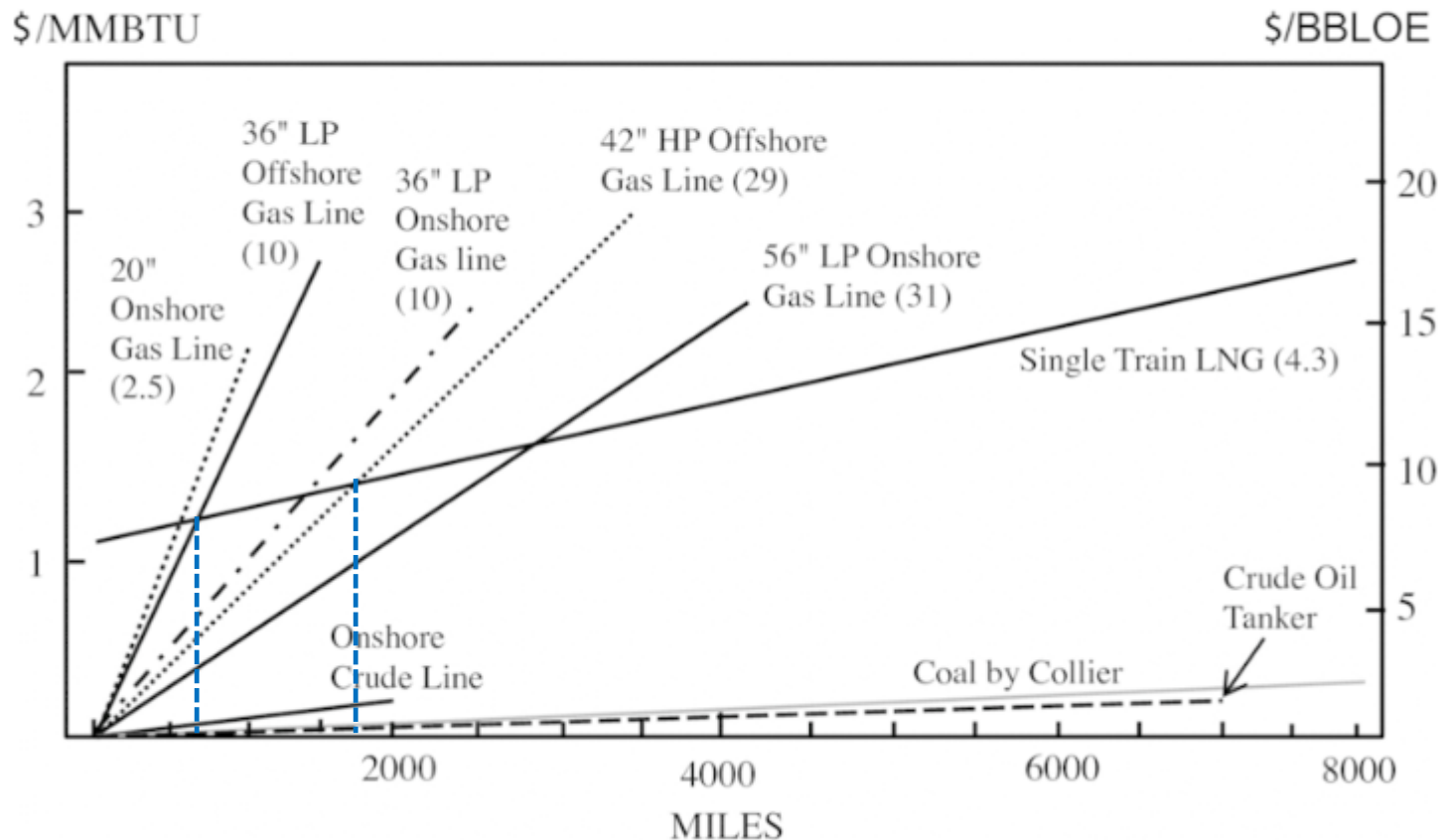


FIG. 4. LNG import terminals in China. Source: Energy Web Atlas.

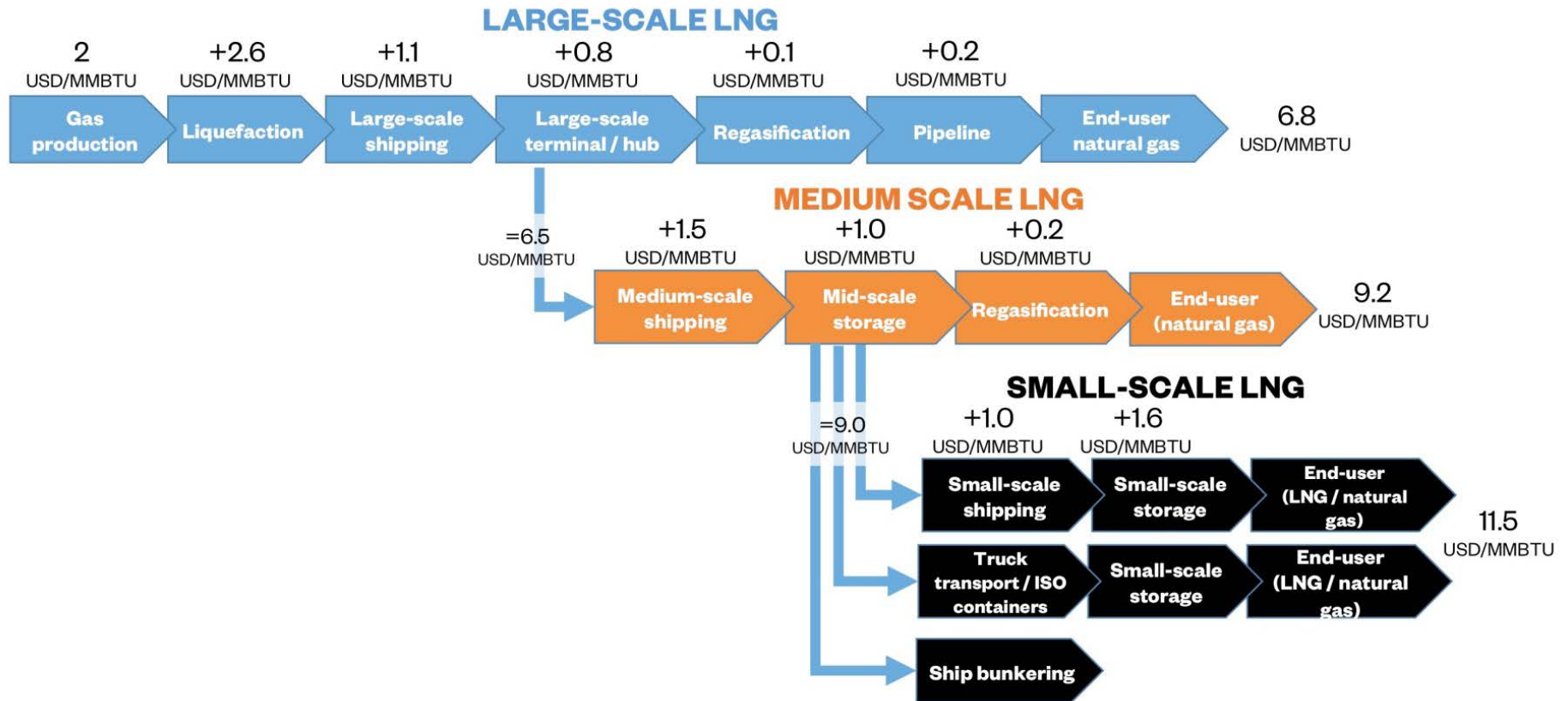
Jensen 2004 Break-even Points

Figure 1 Break-even points. Source of data: [6]6. Jensen, J. 2004. The Development of a Global LNG Market. Is it Likely? If So, When?, Oxford: Oxford Institute for Energy Studies. View all references.



Note: Figures in brackets show gas delivery capability in BCM

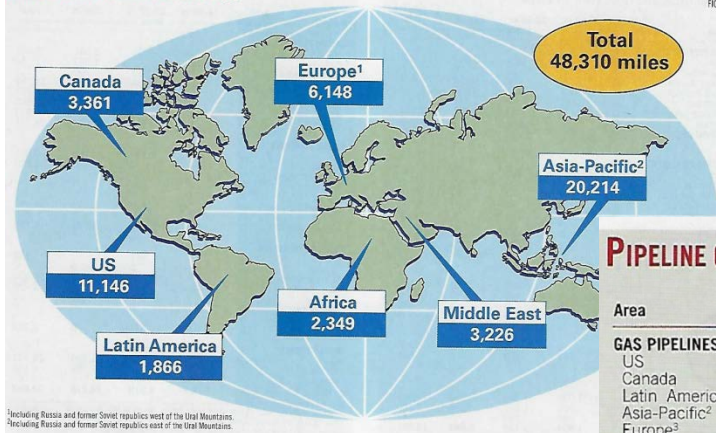
LNG Value Chain



Wärtsilä Technical Journal October 20, 2016

Lots of Gas Pipelines

FORECAST PIPELINE CONSTRUCTION



Oil & Gas Journal Feb 5, 2018

PIPELINE CONSTRUCTION IN 2018¹

Table 1

Area	4-10 in.	12-20 in.	22-30 in.	32+ in.	Total
	Miles				
GAS PIPELINES					
US	30	70	212	2,512	2,824
Canada	0	0	0	0	0
Latin America	0	0	0	879	879
Asia-Pacific ²	0	848	652	3,658	5,158
Europe ³	0	111	0	1,141	1,252
Middle East	0	0	16	1,321	1,337
Africa	0	0	465	21	486
Total gas	30	1,029	1,345	9,532	11,936
CRUDE PIPELINES					
US	34	151	220	0	405
Canada	0	0	0	0	0
Latin America	0	136	0	0	136
Asia-Pacific ²	0	0	0	0	0
Europe ³	0	0	0	0	0
Middle East	0	0	0	0	0
Africa	0	0	0	0	0
Total product	34	287	220	0	541
PRODUCT PIPELINES					
US	34	151	220	0	405
Canada	0	0	0	0	0
Latin America	0	136	0	0	136
Asia-Pacific ²	0	0	0	0	0
Europe ³	0	0	0	0	0
Middle East	0	0	0	0	0
Africa	0	0	0	0	0
Total product	34	287	220	0	541
WORLD TOTALS					
Gas	30	1,029	1,345	9,532	11,936
Crude	65	188	1,570	357	2,180
Product	34	287	220	0	541
Total	129	1,504	3,135	9,889	14,657

¹Projects planned to be completed in 2018. ²Regions east of the Ural Mountains and south of the Caucasus Mountains, excluding the Middle East. ³Regions west of the Ural Mountains and north of the Caucasus Mountains.

PIPELINE CONSTRUCTION BEYOND 2018¹

Table 2

Area	4-10 in.	12-20 in.	22-30 in.	30+ in.	Total
	Miles				
GAS PIPELINES					
US	0	0	91	3,541	3,632
Canada	0	85	0	1,989	2,074
Latin America	0	0	15	700	715
Asia-Pacific ²	0	0	1,884	10,107	11,991
Europe ³	0	93	832	3,796	4,721
Middle East	0	0	292	373	665
Africa	0	0	0	933	933
Total gas	0	178	3,114	21,439	24,731
CRUDE PIPELINES					
US	0	535	1,795	515	2,845
Canada	0	0	0	1,228	1,228
Latin America	0	0	0	0	0
Asia-Pacific ²	0	0	0	0	0
Europe ³	0	0	0	0	0
Middle East	0	0	109	1,043	1,152
Africa	0	0	930	0	930
Total crude	0	535	2,834	2,786	6,155
PRODUCT PIPELINES					
US	0	561	571	0	1,132
Canada	0	0	0	0	0
Latin America	0	136	0	0	136
Asia-Pacific ²	0	1,499	0	0	1,499
Europe ³	0	0	0	0	0
Middle East	0	0	0	0	0
Africa	0	0	0	0	0
Total product	0	2,196	571	0	2,767
WORLD TOTALS					
Gas	0	178	3,114	21,439	24,731
Crude	0	535	2,834	2,786	6,155
Product	0	2,196	571	0	2,767
Total	0	2,909	6,519	24,225	33,653

¹Projects under way at the start of or set to begin in 2018 and be completed after 2018. Includes some probable major projects whose installation will begin in 2018 or later. ²Regions east of the Ural Mountains and south of the Caucasus Mountains, excluding the Middle East. ³Regions west of the Ural Mountains and north of the Caucasus Mountains.

Natural Gas Trade 2017 – 1134.1 BCM

Pipeline trade grew 3.7%
LNG trade grew 10.3%
Consumption grew 5.9%

Gas Trade in 2016 and 2017

Billion cubic metres	2016				2017			
	Pipeline imports	LNG imports	Pipeline exports	LNG exports	Pipeline imports	LNG imports	Pipeline exports	LNG exports
US	79.5	2.4	58.6	4.3	80.7	2.2	66.1	17.4
Canada	21.1	0.3	79.5	†	24.0	0.4	80.7	†
Mexico	37.5	5.9	†	-	42.1	6.6	†	-
Trinidad and Tobago	-	-	-	14.3	-	-	-	13.4
Other S. & Cent. America	16.2	15.6	16.2	6.4	15.4	13.8	15.4	5.8
France	32.2	9.1	-	1.5	33.5	10.8	-	1.0
Germany	95.6	-	9.1	-	94.8	-	7.1	-
Italy	60.5	5.9	-	-	53.8	8.4	-	-
Netherlands	36.8	1.3	46.8	0.9	40.9	1.6	43.3	0.8
Norway	†	-	109.4	6.0	†	-	109.2	5.8
Spain	15.5	13.8	0.6	0.2	14.4	16.6	0.1	0.1
Turkey	36.9	7.8	0.6	-	42.8	10.9	0.6	-
United Kingdom	35.2	11.0	9.7	0.6	39.4	7.2	10.8	0.3
Other Europe	94.8	7.9	13.9	1.3	103.7	10.2	21.6	0.2
Russian Federation	18.1	-	200.1	14.6	18.9	-	215.4	15.5
Ukraine	10.5	-	-	-	13.3	-	-	-
Other CIS	29.3	-	68.5	-	30.1	-	67.5	-
Qatar	-	-	18.5	107.2	-	-	18.4	103.4
Other Middle East	25.8	13.7	8.0	18.8	22.2	13.0	12.5	19.1
Algeria	-	-	38.1	15.8	-	-	36.4	16.6
Other Africa	8.3	10.7	8.6	30.0	7.6	8.2	8.7	38.9
Australia	6.4	0.1	-	59.2	5.8	-	-	75.9
China	36.0	35.9	-	-	39.4	52.6	-	-
India	-	23.6	-	0.1	-	25.7	-	-
Japan	-	113.6	-	-	-	113.9	-	-
Indonesia	-	-	8.2	22.2	-	-	8.0	21.7
South Korea	-	45.7	-	0.1	-	51.3	-	0.1
Other Asia Pacific	18.1	32.5	20.0	53.4	17.7	40.0	18.8	57.2
Total World	714.4	356.7	714.4	356.7	740.7	393.4	740.7	393.4

2017 vs. 2016			
Pipeline imports	LNG imports	Pipeline exports	LNG exports
1.2	(0.3)	7.4	13.1
2.9	0.1	1.2	0.0
4.5	0.7	0.0	0.0
0.0	0.0	0.0	(0.9)
(0.8)	(1.8)	(0.8)	(0.6)
1.4	1.7	0.0	(0.5)
(0.8)	0.0	(2.0)	0.0
(6.7)	2.5	0.0	0.0
4.1	0.3	(3.6)	(0.0)
0.0	0.0	(0.2)	(0.3)
(1.1)	2.8	(0.5)	(0.0)
5.9	3.1	(0.0)	0.0
4.2	(3.9)	1.2	(0.3)
8.9	2.3	7.8	(1.1)
0.8	0.0	15.4	0.9
2.8	0.0	0.0	0.0
0.8	0.0	(0.9)	0.0
0.0	0.0	(0.1)	(3.8)
(3.6)	(0.6)	4.5	0.3
0.0	0.0	(1.7)	0.8
(0.7)	(2.5)	0.1	9.0
(0.6)	(0.1)	0.0	16.7
3.4	16.7	0.0	0.0
0.0	2.1	0.0	(0.1)
0.0	0.4	0.0	0.0
0.0	0.0	(0.2)	(0.5)
0.0	5.6	0.0	(0.0)
(0.4)	7.4	(1.2)	3.8
26.3	36.7	26.3	36.7

Source: Includes data from FGE MENA gas service, IHS.

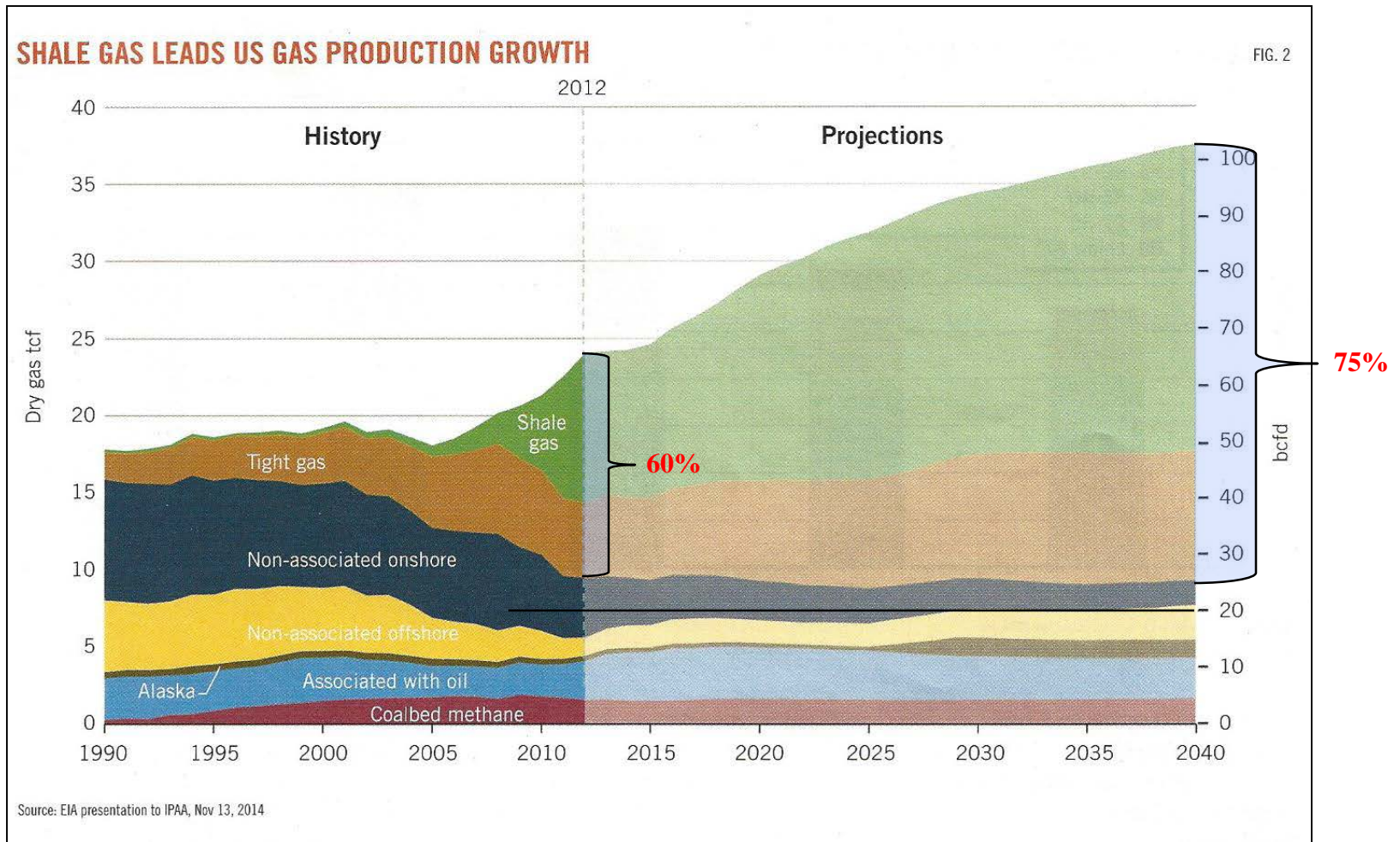
Trade represents approximately 30% of the consumption
Japan, China & Korea represent almost 55% of all LNG Imports



Source: BP Statistical Review of World Energy 2018

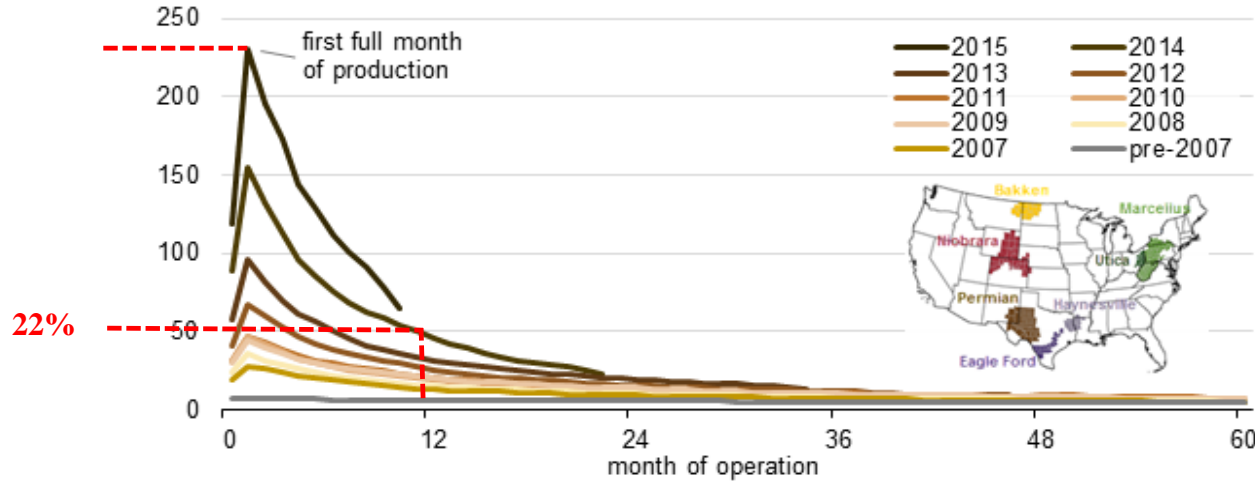
“Practical Strategies for Emerging Energy Technologies”

U.S. Shale Gas

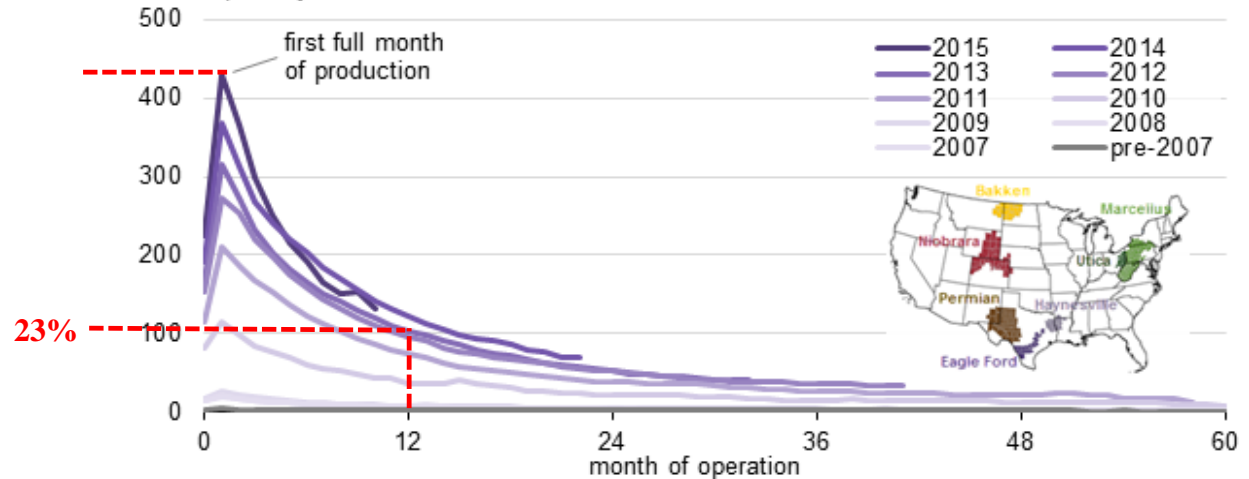


Production Well Decline Rate

Average oil production per well in the Permian region
barrels per day



Average oil production per well in the Eagle Ford region
barrels per day



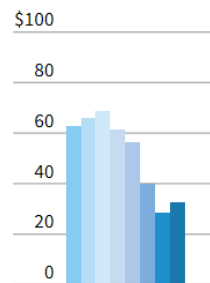
Reuters Break-even Shale Price

U.S. shale producers' break-even price per barrel is projected to rise in 2017 for first time in five years. The wellhead price required to generate a profit is about half of what it was in 2010.

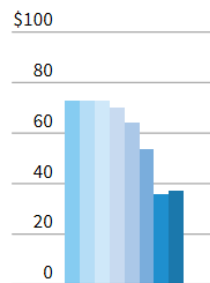
PRICE PER BARREL

■ 2010 ■ 2011 ■ 2012 ■ 2013
■ 2014 ■ 2015 ■ 2016 ■ 2017*

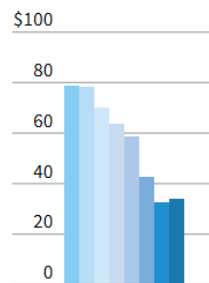
BAKKEN



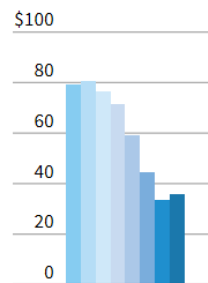
EAGLE FORD



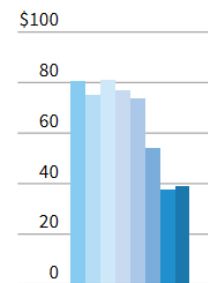
NIOBRARA



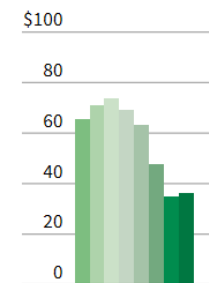
DELAWARE BASIN



MIDLAND BASIN



U.S. SHALE AVERAGE



•Estimated
 •Source Rystad Energy

- Drilling innovations over the past decade have generated a dizzying reduction in the cost of pumping oil from shale formations across the United States
- The first time since 2012, shale producers will see a rise in break-even production costs this year
- **The per-barrel costs will rise an average of \$1.60 across the shale patch to \$36.50**
- The wellhead price required to generate a profit is about half of what it was in 2010

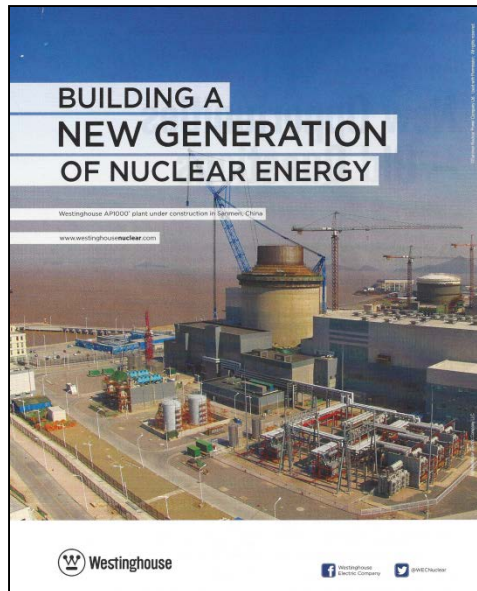
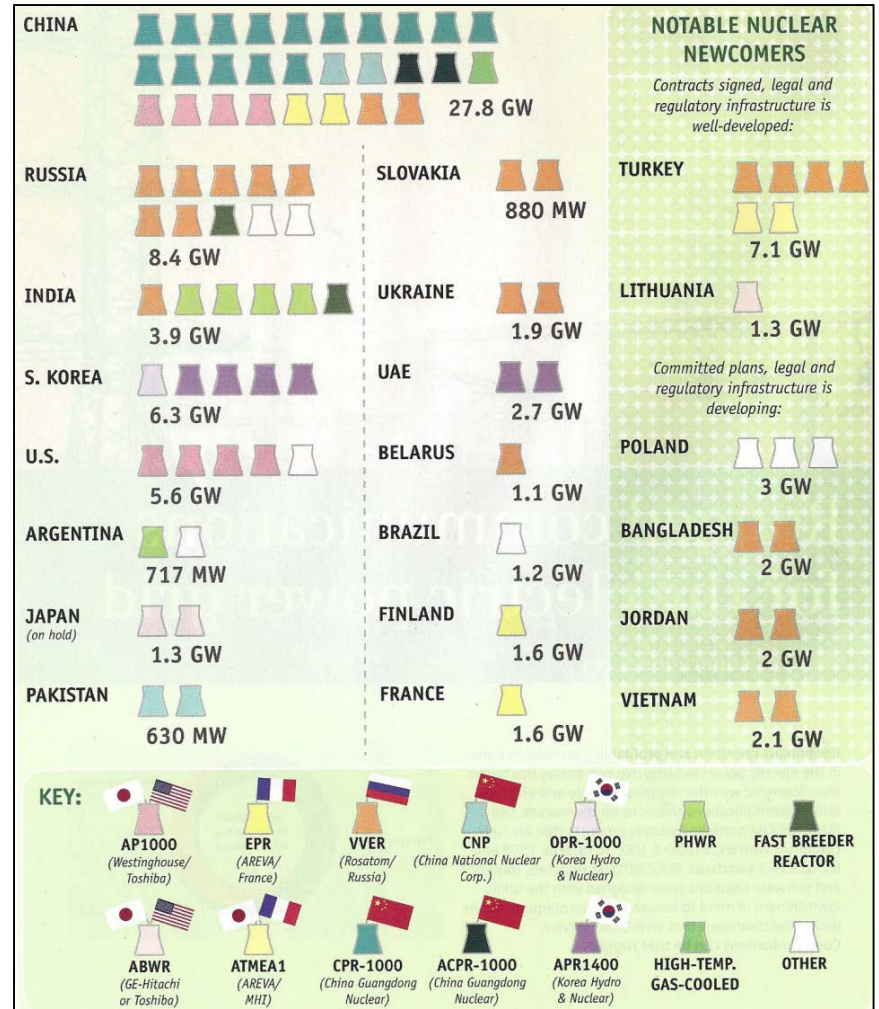
Nuclear, Hydro & Geothermal

base_e

“Practical Strategies for Emerging Energy Technologies”

“The Big Picture: Next-Gen Nuclear”

- Compliments of Power magazine April 2014
- 72 mostly advanced nuclear reactions under construction
- A total of 68GW (12% of installed base)
- 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

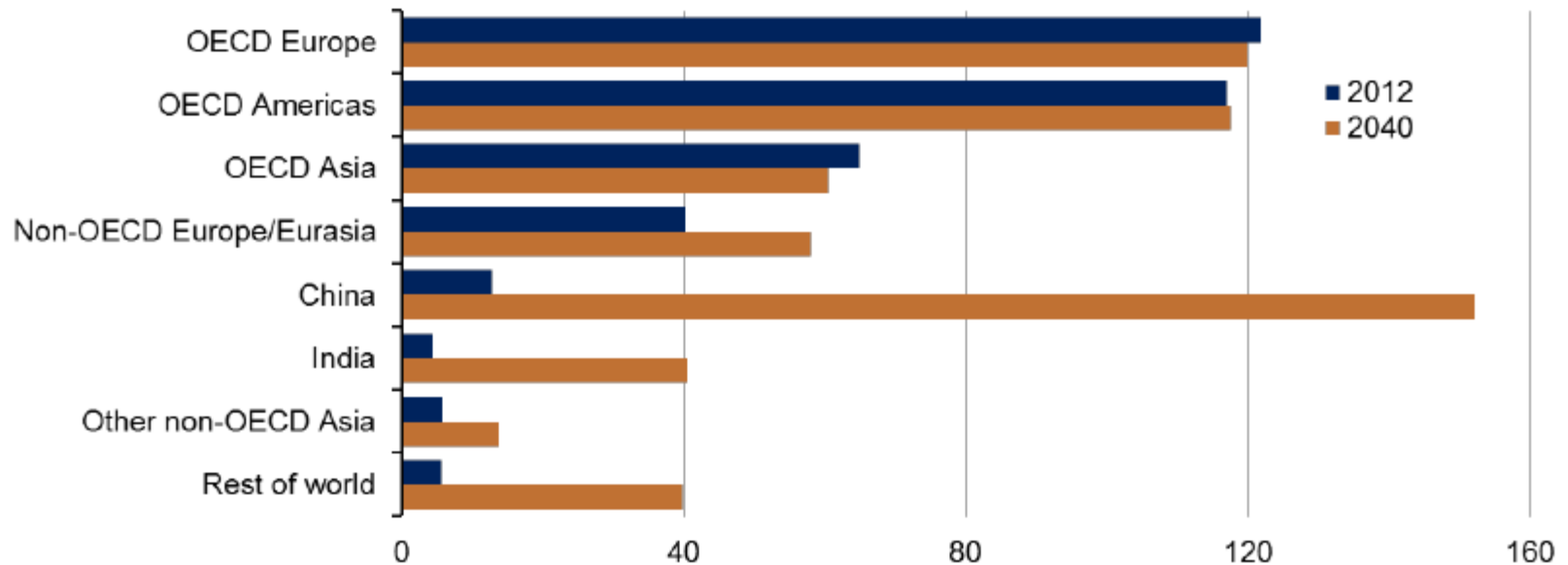
Installed Generating Capacity (2012) = 5,550 GW



Nuclear Power Growth

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

world installed nuclear capacity by region
gigawatts



Source: EIA, International Energy Outlook 2016

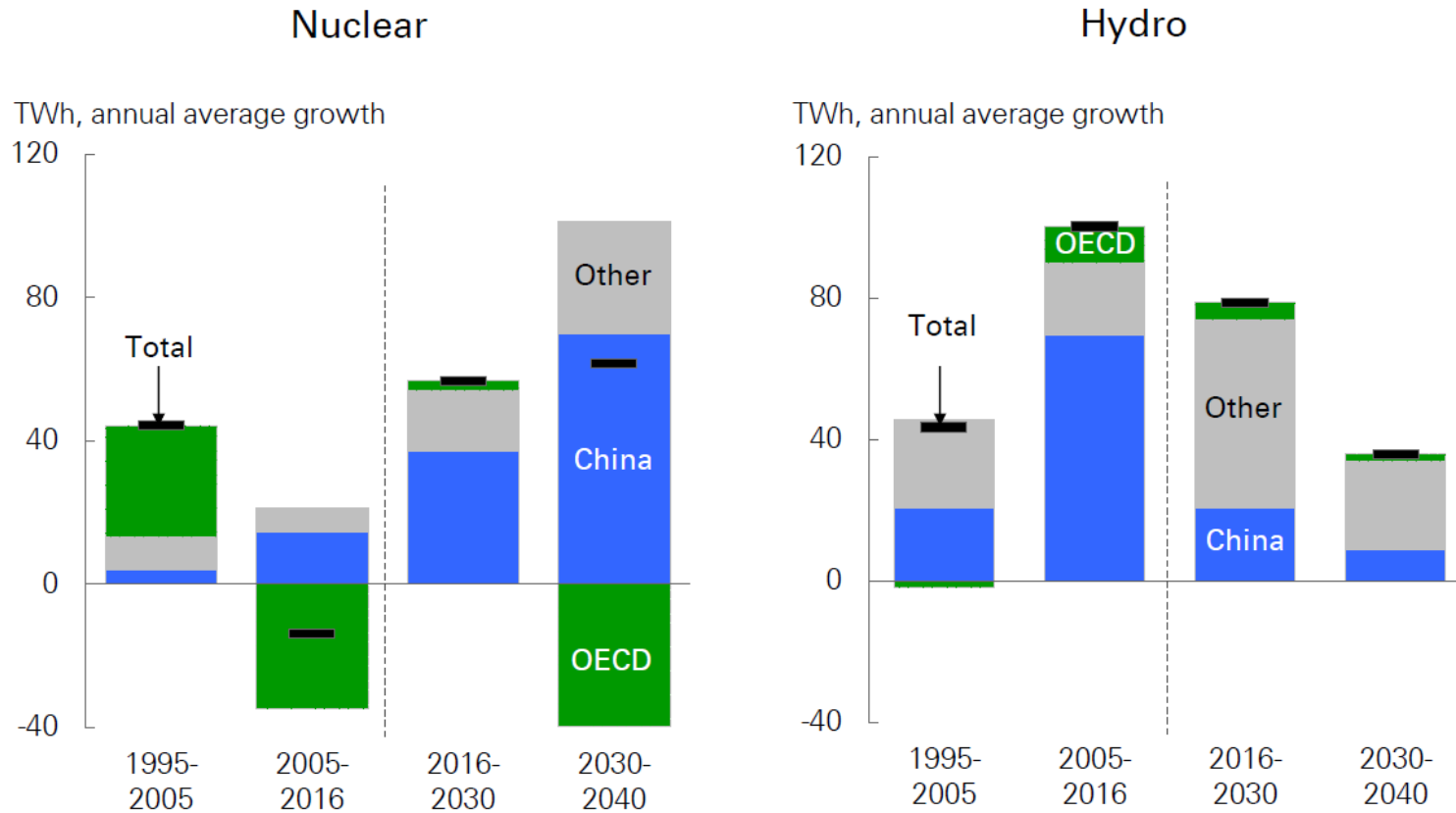


Adam Sieminski, Center for Strategic and International Studies
May 11, 2016

French - Nuclear

- France's outlook for nuclear sector in the next 10 years will be decisive for the country's capacity to meet its climate and energy goals, and – at the same time -- maintain electricity security
- **Cut the share of nuclear power from 78% of electricity produced today to 50% by 2025, while also reducing greenhouse gas emissions by 40% in 2030**
- The IEA report highlights five avenues to accelerate the energy transition and guide energy investment:
 - Track progress along robust scenarios
 - Continue with clear and long-term carbon pricing instruments
 - Take timely decisions on the safe and long-term operation of the nuclear reactors
 - Further reduce barriers to renewable deployment
 - Strengthen efforts towards market opening, competition and consumer choice.
- France's Transition Act is a first-class energy and climate framework, based on:
 - A low-carbon strategy, carbon budgets, and the related investment planning
 - France leads on carbon pricing with a long-term carbon price trajectory set by law up to 2030.”
- **France's nuclear fleet is the world's second-largest, and has reached a 30-year average lifetime**
 - For now, no decision has been taken in favor of long-term operation pending safety reviews.

Nuclear & Hydro



Worldwide Hydro Generation 2017 - TWh

Hydroelectricity: Generation*

Terawatt-hours												Growth rate per annum		Share 2017
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2017	2006-16	
US	243.0	251.1	271.5	257.3	316.1	274.0	266.5	255.8	246.5	263.8	296.5	12.7%	-0.8%	7.3%
Canada	367.6	377.5	368.7	351.4	375.7	380.3	391.8	382.5	382.2	387.1	396.9	2.8%	0.9%	9.8%
Total North America	638.0	667.8	666.9	645.8	728.1	686.2	686.4	677.1	659.6	681.6	725.1	6.7%	0.2%	17.9%
Argentina	37.7	37.2	40.8	40.5	39.6	36.9	40.7	40.9	41.8	38.3	41.6	8.9%	-1.3%	1.0%
Brazil	374.0	369.6	391.0	403.3	428.3	415.3	391.0	373.4	359.7	380.9	369.5	-2.7%	0.9%	9.1%
Colombia	44.2	46.2	40.8	40.6	48.4	47.6	44.4	44.7	44.7	46.8	57.3	22.9%	1.0%	1.4%
Venezuela	83.0	86.7	85.8	76.7	83.2	81.7	83.4	78.7	73.4	66.3	76.7	16.1%	-2.0%	1.9%
Total S. & Cent. America	676.2	680.6	697.9	701.2	744.5	730.8	710.3	686.6	671.6	691.3	717.4	4.1%	0.6%	17.7%
France	57.6	63.7	57.0	62.7	44.8	58.7	70.7	62.8	54.4	60.0	49.2	-17.8%	0.6%	1.2%
Norway	133.7	139.0	125.3	116.8	120.3	141.7	128.2	135.4	137.3	142.4	141.4	-0.4%	1.8%	3.5%
Sweden	66.2	69.0	65.4	66.4	67.1	78.9	61.4	63.8	75.3	62.0	64.7	4.7%	0.1%	1.6%
Turkey	35.9	33.3	36.0	51.8	52.3	57.9	59.4	40.6	67.1	67.2	58.4	-12.8%	4.3%	1.4%
Total Europe	553.8	581.5	577.7	636.6	557.9	614.5	647.1	634.8	631.2	645.7	576.2	-10.5%	1.6%	14.2%
Russian Federation	177.0	164.8	174.2	166.5	163.1	163.5	181.2	173.4	168.0	184.8	183.3	-0.5%	0.6%	4.5%
Total CIS	237.5	226.2	233.1	232.6	228.2	228.4	248.5	235.3	226.7	248.9	250.6	0.9%	0.4%	6.2%
Total Middle East	26.7	13.7	12.1	17.4	18.3	21.4	23.4	19.9	16.8	20.2	20.0	-0.6%	-3.3%	0.5%
Eastern Africa	46.4	45.8	48.0	54.0	55.5	58.1	61.7	66.0	65.2	63.8	66.5	4.4%	4.1%	1.6%
Total Africa	95.3	97.2	100.0	107.4	110.3	110.9	117.5	123.8	121.0	119.9	128.5	7.4%	2.7%	3.2%
China	485.3	637.0	615.6	711.4	688.0	862.8	909.6	1051.1	1114.5	1153.3	1155.8	0.5%	10.2%	28.5%
India	122.6	115.2	106.3	108.7	131.7	115.8	132.0	139.0	133.3	128.4	135.6	6.0%	1.3%	3.3%
Japan	74.7	74.4	68.8	86.9	80.8	76.1	78.0	80.0	83.8	80.0	79.2	-0.6%	-0.9%	2.0%
Vietnam	22.4	26.0	30.0	27.6	40.9	52.8	57.3	61.2	57.0	63.9	70.2	10.1%	12.5%	1.7%
Total Asia Pacific	852.3	996.7	965.8	1094.9	1115.9	1279.1	1364.8	1510.4	1564.6	1628.5	1642.2	1.1%	7.4%	40.4%
Total World	3079.8	3263.6	3253.6	3435.9	3503.2	3671.3	3798.0	3887.9	3891.4	4036.1	4059.9	0.9%	2.9%	100.0%



2017 WW Electric Generation 25551 TWh
WW Hydro 4060 (15.9%)

“Practical Strategies for Emerging Energy Technologies”

Worldwide Hydro Generation 2017 - Mtoe

Hydroelectricity: Consumption*

Million tonnes oil equivalent	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share
												2017	2006-16	2017
US	55.0	56.8	61.4	58.2	71.5	62.0	60.3	57.9	55.8	59.7	67.1	12.7%	-0.8%	7.3%
Canada	83.2	85.4	83.4	79.5	85.0	86.0	88.7	86.6	86.5	87.6	89.8	2.8%	0.9%	9.8%
Total North America	144.4	151.1	150.9	146.1	164.7	155.3	155.3	153.2	149.2	154.2	164.1	6.7%	0.2%	17.9%
Argentina	8.5	8.4	9.2	9.2	9.0	8.3	9.2	9.2	9.5	8.7	9.4	8.9%	-1.3%	1.0%
Brazil	84.6	83.6	88.5	91.3	96.9	94.0	88.5	84.5	81.4	86.2	83.6	-2.7%	0.9%	9.1%
Colombia	10.0	10.4	9.2	9.2	11.0	10.8	10.0	10.1	10.1	10.6	13.0	22.9%	1.0%	1.4%
Venezuela	18.8	19.6	19.4	17.3	18.8	18.5	18.9	17.8	16.6	15.0	17.4	16.1%	-2.0%	1.9%
Total S. & Cent. America	153.0	154.0	157.9	158.7	168.5	165.4	160.7	155.4	152.0	156.4	162.3	4.1%	0.6%	17.7%
France	13.0	14.4	12.9	14.2	10.1	13.3	16.0	14.2	12.3	13.6	11.1	-17.8%	0.6%	1.2%
Norway	30.2	31.5	28.3	26.4	27.2	32.1	29.0	30.6	31.1	32.2	32.0	-0.4%	1.8%	3.5%
Sweden	15.0	15.6	14.8	15.0	15.2	17.9	13.9	14.4	17.0	14.0	14.6	4.7%	0.1%	1.6%
Turkey	8.1	7.5	8.1	11.7	11.8	13.1	13.4	9.2	15.2	15.2	13.2	-12.8%	4.3%	1.4%
Total Europe	125.3	131.6	130.7	144.0	126.2	139.1	146.4	143.6	142.8	146.1	130.4	-10.5%	1.6%	14.2%
Russian Federation	40.1	37.3	39.4	37.7	36.9	37.0	41.0	39.2	38.0	41.8	41.5	-0.5%	0.6%	4.5%
Total CIS	53.7	51.2	52.7	52.6	51.6	51.7	56.2	53.2	51.3	56.3	56.7	0.9%	0.4%	6.2%
Total Middle East	6.0	3.1	2.7	3.9	4.1	4.8	5.3	4.5	3.8	4.6	4.5	-0.6%	-3.3%	0.5%
Eastern Africa	10.5	10.4	10.9	12.2	12.6	13.1	14.0	14.9	14.8	14.4	15.0	4.4%	4.1%	1.6%
Total Africa	21.6	22.0	22.6	24.3	25.0	25.1	26.6	28.0	27.4	27.1	29.1	7.4%	2.7%	3.2%
China	109.8	144.1	139.3	161.0	155.7	195.2	205.8	237.8	252.2	261.0	261.5	0.5%	10.2%	28.5%
India	27.7	26.1	24.1	24.6	29.8	26.2	29.9	31.5	30.2	29.0	30.7	6.0%	1.3%	3.3%
Japan	16.9	16.8	15.6	19.7	18.3	17.2	17.7	18.1	19.0	18.1	17.9	-0.6%	-0.9%	2.0%
Vietnam	5.1	5.9	6.8	6.2	9.3	11.9	13.0	13.8	12.9	14.5	15.9	10.1%	12.5%	1.7%
Total Asia Pacific	192.9	225.5	218.5	247.7	252.5	289.4	308.8	341.8	354.0	368.5	371.6	1.1%	7.4%	40.4%
Total World	696.9	738.5	736.2	777.5	792.7	830.7	859.4	879.7	880.5	913.3	918.6	0.9%	2.9%	100.0%



2017 WW Primary Energy Consumption 13511 Mtoe
WW Hydro 919 Mtoe (6.9%)

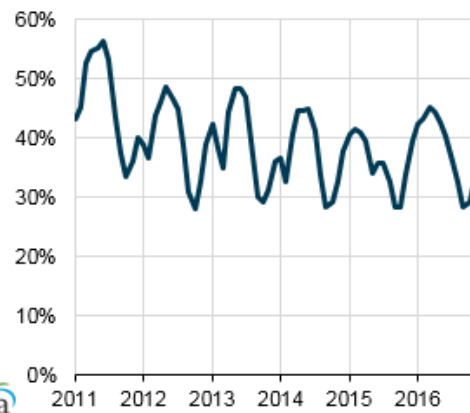
“Practical Strategies for Emerging Energy Technologies”

U.S. Hydro Capacity is Very Old

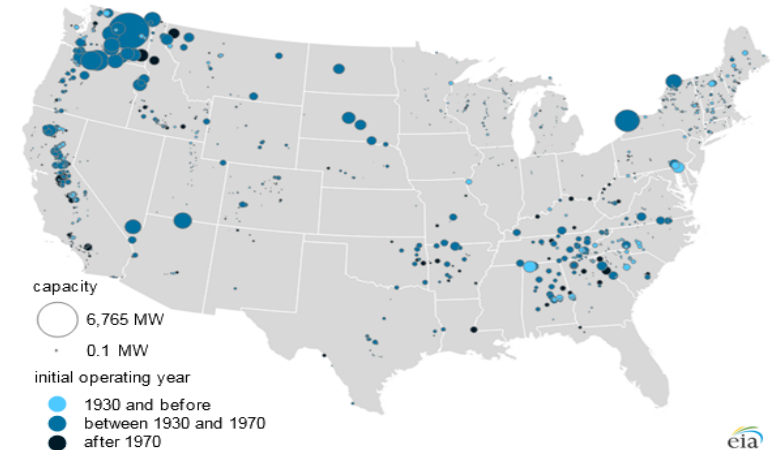
Conventional hydroelectric net generation
million megawatthours



Conventional hydroelectric capacity factors
percent



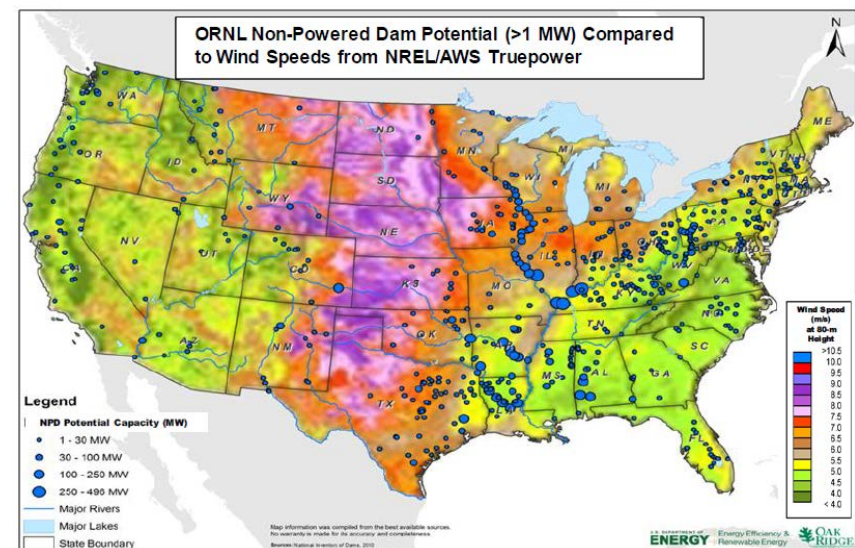
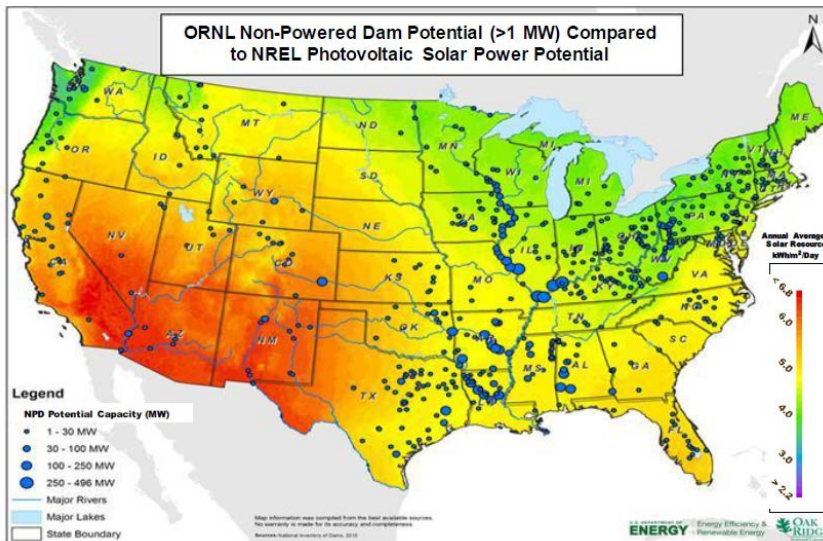
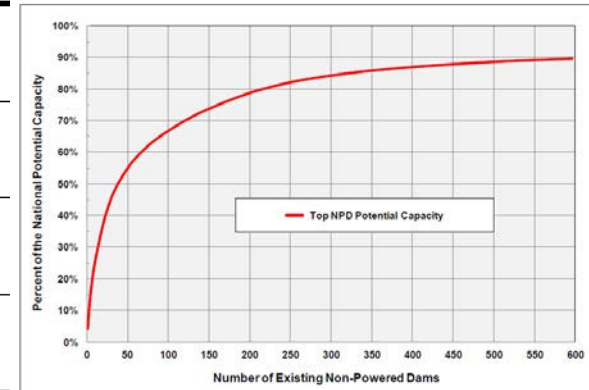
Distribution of conventional hydroelectric plants in the Lower 48 states



- Conventional hydroelectric generators account for 7% of the operating electricity generating capacity in the United States and about 6% to 7% of U.S. electricity generation each year.
- **Hydropower plants account for 99% of all currently operating capacity built before 1930**
- The 50 oldest electric generating plants in the United States are all hydroelectric generators; each has been in service since 1908.
- Many reservoirs must balance power output with competing water demand for irrigation, municipal, industrial, and other needs, as well as concerns with fish migration.
- As a result, hydroelectric facilities often do not run at full output. U.S. hydroelectric capacity factors, which measure actual output as a percent of total capacity, average between 30% and 40%.

12GW Complimentary Non-Power Dams (NPD)

Hydrologic Regions (HUC02)	Potential Capacity (MW)	Potential Generation (TWh/yr)	Hydrologic Regions (HUC02)	Potential Capacity (MW)	Potential Generation (MWh/yr)
1 New England	243	1.110	10 Missouri	258	0.865
2 Mid-Atlantic	479	1.997	11 Arkansas-White-Red	1898	5.960
3 South Atlantic-Gulf	1618	3.778	12 Texas-Gulf	608	1.308
4 Great Lakes	156	0.903	13 Rio Grande	98	0.241
5 Ohio	3236	13.603	14 Upper Colorado	53	0.145
6 Tennessee	53	0.197	15 Lower Colorado	124	0.370
7 Upper Mississippi	2027	9.943	16 Great Basin	29	0.080
8 Lower Mississippi	743	2.802	17 Pacific Northwest	225	0.871
9 Souris-Red-Rainy	58	0.239	18 California	156	0.586



base_e

“Practical Strategies for Emerging Energy Technologies”

Cumulative Geothermal Installed Capacity – 12.6GW

Cumulative installed geothermal power capacity*

Megawatts	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change	2014
												2014 over	share
												2013	of total
China	28	28	28	28	24	24	24	24	24	27	27	0.0%	0.2%
Costa Rica	163	163	163	163	163	166	166	208	208	208	208	0.0%	1.7%
El Salvador	151	151	195	195	204	204	204	204	204	204	204	0.0%	1.6%
Iceland	202	202	312	485	576	576	575	665	665	665	665	0.0%	5.3%
Indonesia	807	850	850	980	1052	1189	1193	1209	1339	1339	1401	4.6%	11.1%
Italy	791	791	811	811	811	843	883	883	875	876	916	4.6%	7.3%
Japan	535	534	534	532	532	500	502	502	502	503	539	7.2%	4.3%
Kenya	167	167	167	170	174	174	209	212	217	253	590	133.7%	4.7%
Mexico	960	960	960	960	965	965	965	887	812	834	834	0.0%	6.6%
New Zealand	370	425	425	443	585	625	723	723	723	971	971	0.0%	7.7%
Philippines	1932	1978	1978	1958	1958	1953	1966	1783	1848	1868	1917	2.6%	15.2%
Russia (Kamchatka)	79	79	79	82	82	82	82	82	82	82	82	0.0%	0.7%
Turkey	20	20	28	28	35	82	94	114	114	226	368	62.6%	2.9%
US	2866	2893	2940	3037	3163	3289	3308	3318	3450	3524	3525	0.0%	28.0%
Total World	9225	9396	9655	10121	10575	10928	11152	11071	11397	11917	12594	5.7%	100.0%

Sources: International Geothermal Association, ThinkGeoEnergy, and national sources

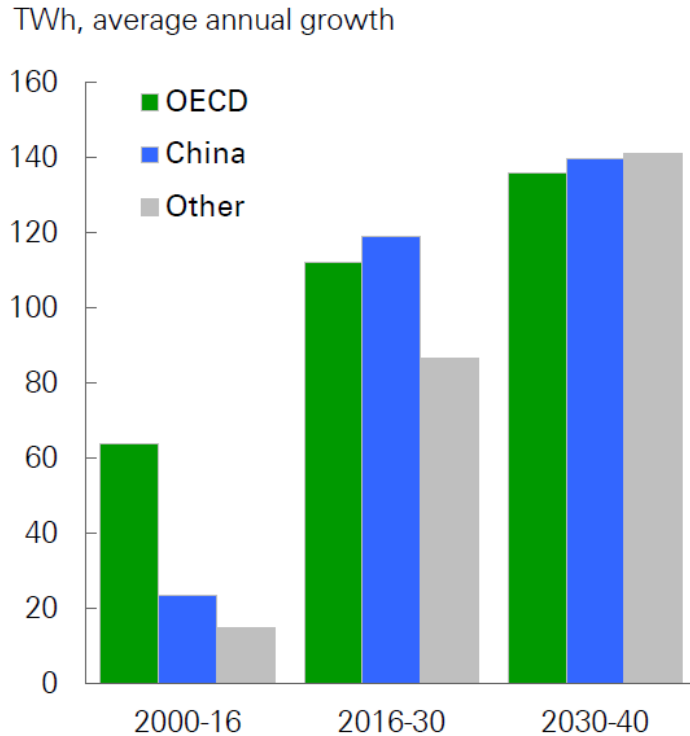


“Practical Strategies for Emerging Energy Technologies”

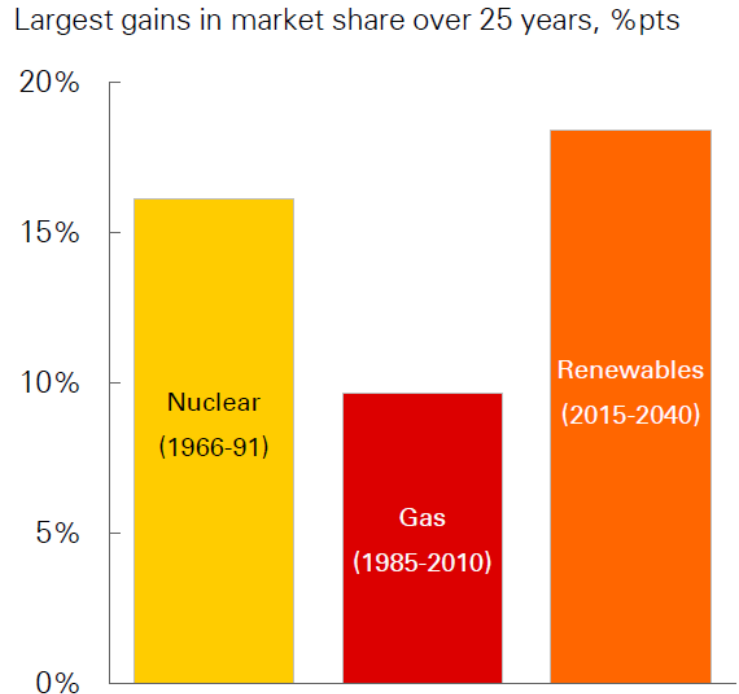
Renewables

Renewables Growth

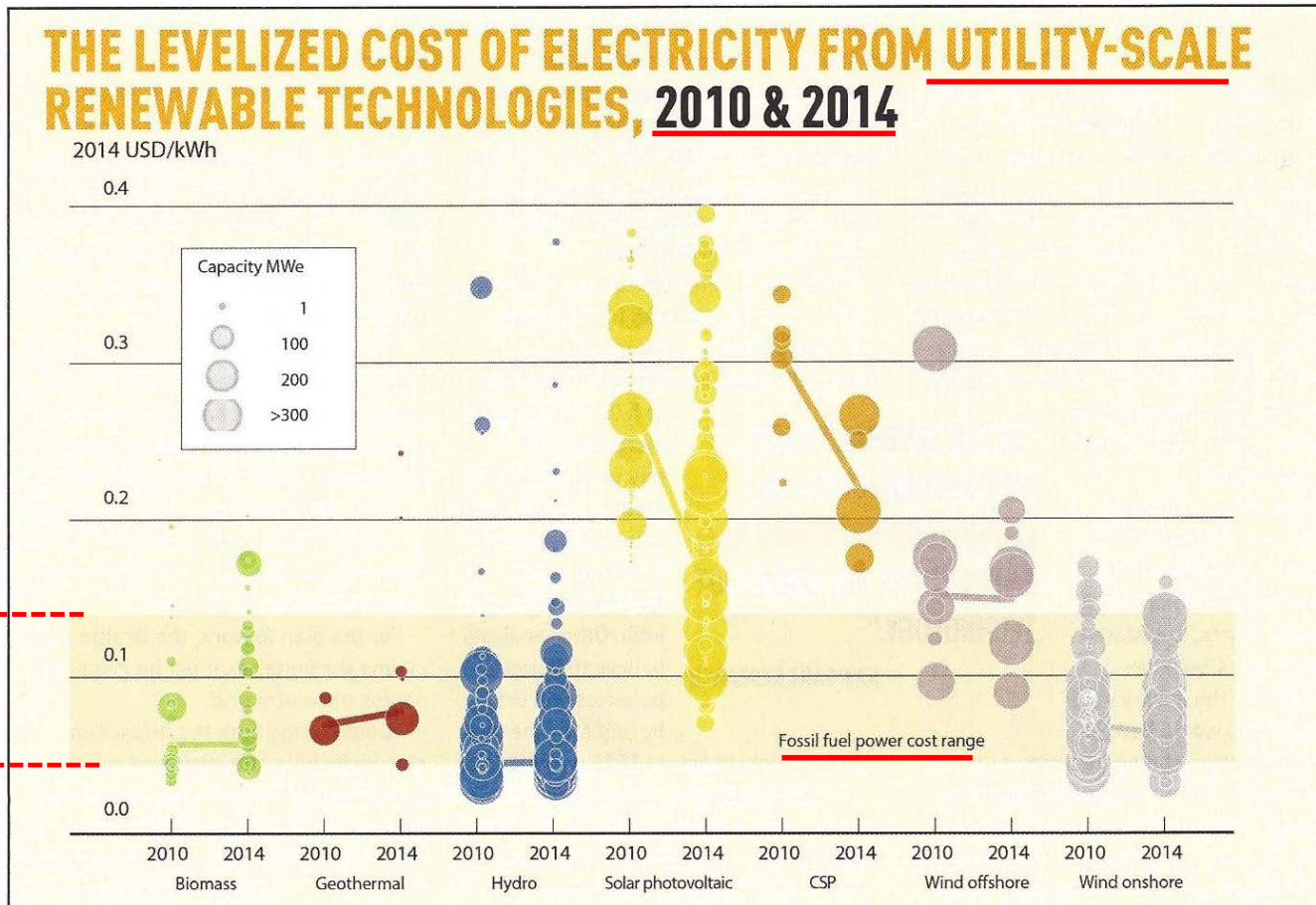
Growth of renewable power



Pace of power market penetration



Renewables Levelized Cost 2010 & 2014



Source: IRENA Renewable Cost Database.

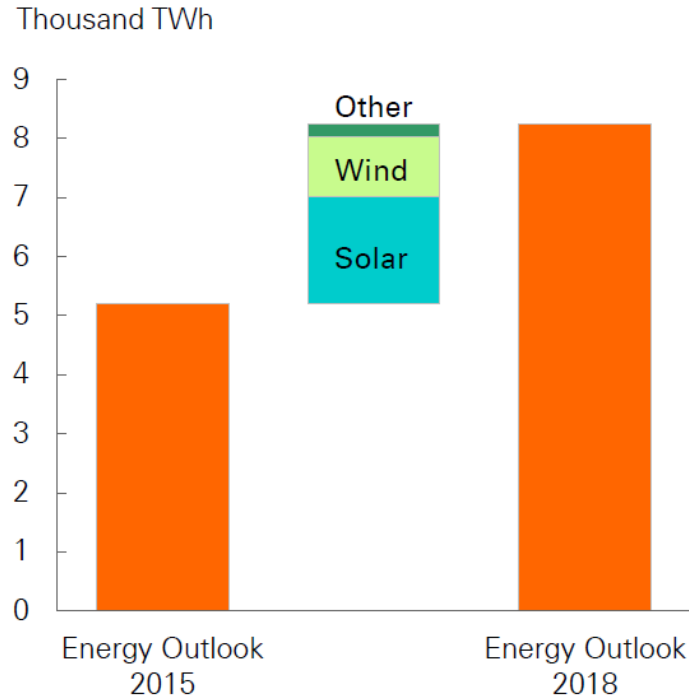
Note: Size of the diameter of the circle represents the size of the project. The centre of each circle is the value for the cost of each project on the Y axis. Real weighted average cost of capital is 7.5% in OECD countries and China; 10% in the rest of the world.

base_e

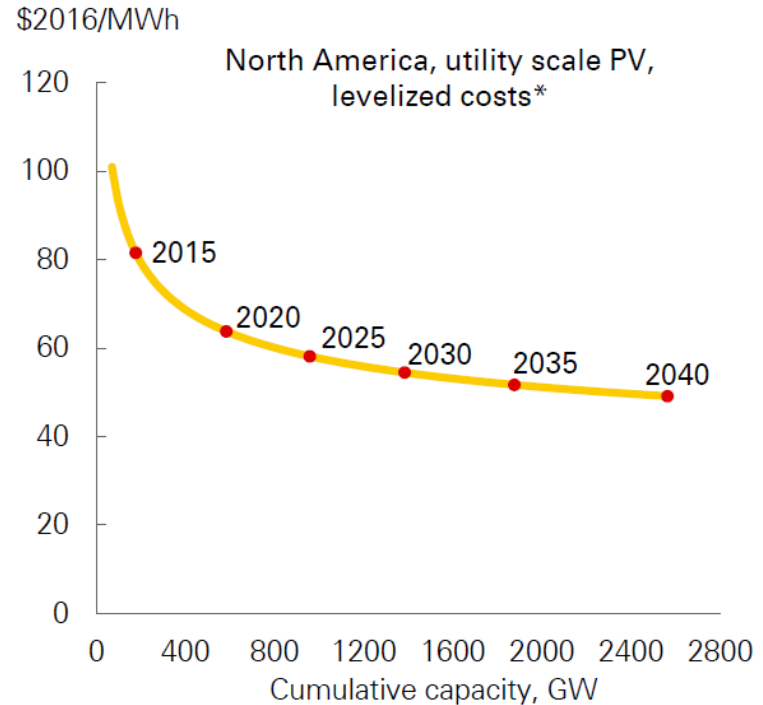
“Practical Strategies for Emerging Energy Technologies”

Renewables Outlook

Change to the projected level of renewable power in 2035



Solar PV learning curve



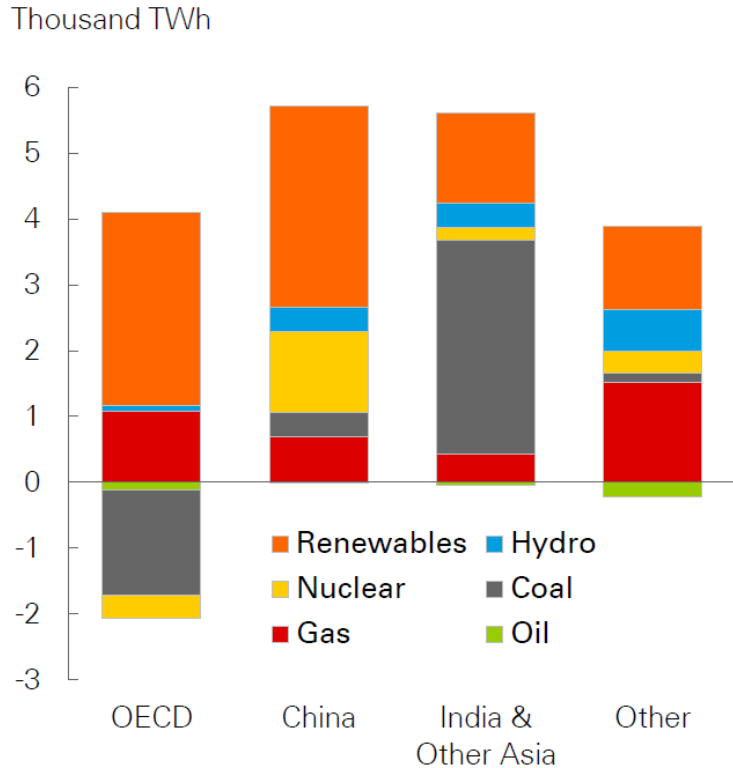
*Cost per MWh of building and operating a plant over its lifetime. Excludes subsidies, tariffs and the cost of grid integration.

2018 BP Energy Outlook

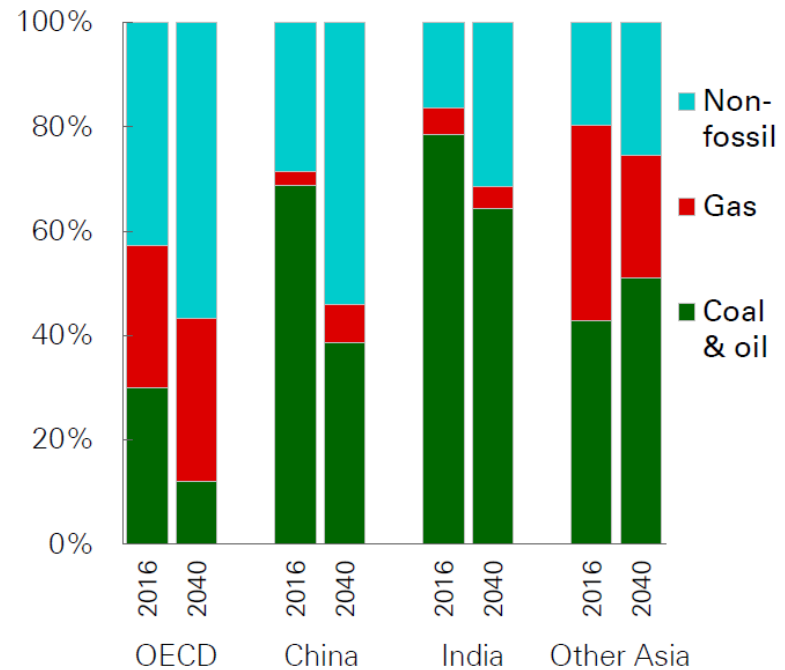
© BP p.l.c. 2018

Increase in Renewables led by China and OECD

Growth of power generation, 2016-2040



Shares of power generation, 2016 and 2040



2018 BP Energy Outlook
© BP p.l.c. 2018

China's Solar Curb

China's suspension of approval for new subsidized grid-scale photovoltaic (PV) solar projects has led to sharply reduced forecasts for global capacity expansion in 2018.

- [The government's decision](#), at the end of May, came into effect in June and effectively means only projects subject to competitive bidding will be sanctioned in 2018, while feed-in tariffs have also been cut.
- The rationale for the move is familiar, echoing similar moves in Spain and Germany, the countries that led the solar drive in Europe.
 - A combination of attractive subsidies and falling installation costs led to more projects being built than those governments had envisaged, or grids could cope with, forcing an overhaul of the market.
 - In China, there has been the added problem that some big solar projects are being built in remote regions of the country, which are a long way from the country's most energy-hungry population centers.
 - Money is being poured into improving the long-distance transmission network, but much work still needs to be done.
- As a result of the edict, global capacity forecasts for the year have been slashed.
 - [Wood Mackenzie's GTM Research](#) has reduced its estimate of fresh Chinese PV demand in 2018 to 28.2 gigawatts (GW) from a previously anticipated 48.2GW.
 - Accordingly, the firm's global PV demand forecast for 2018 has been cut to 85.2 GW from 103.5 GW.

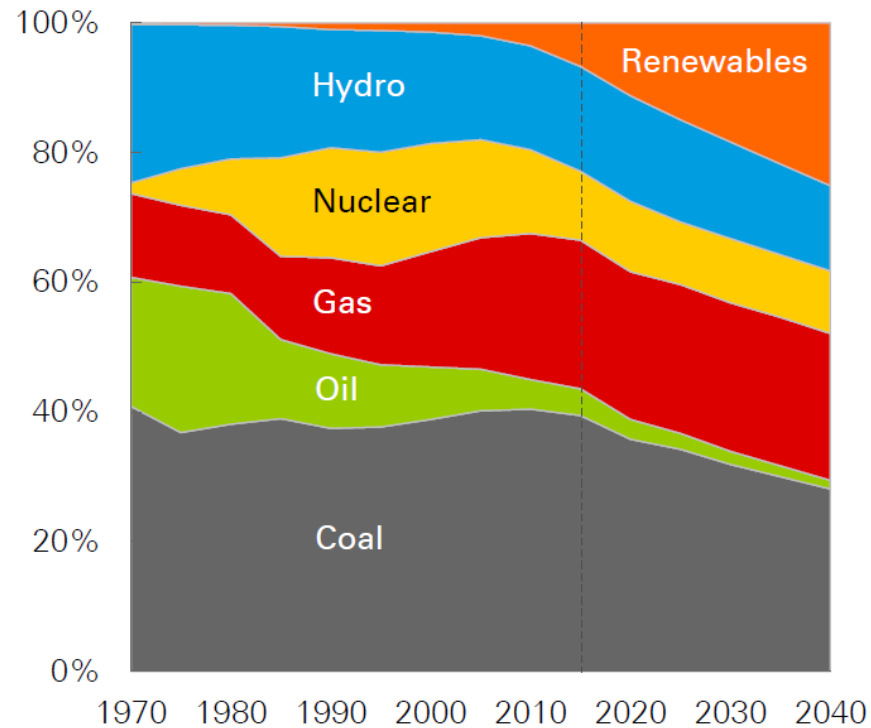
German States to Put Brakes On Green Energy

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

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

The World Continues to Electrify

Shares of total power generation

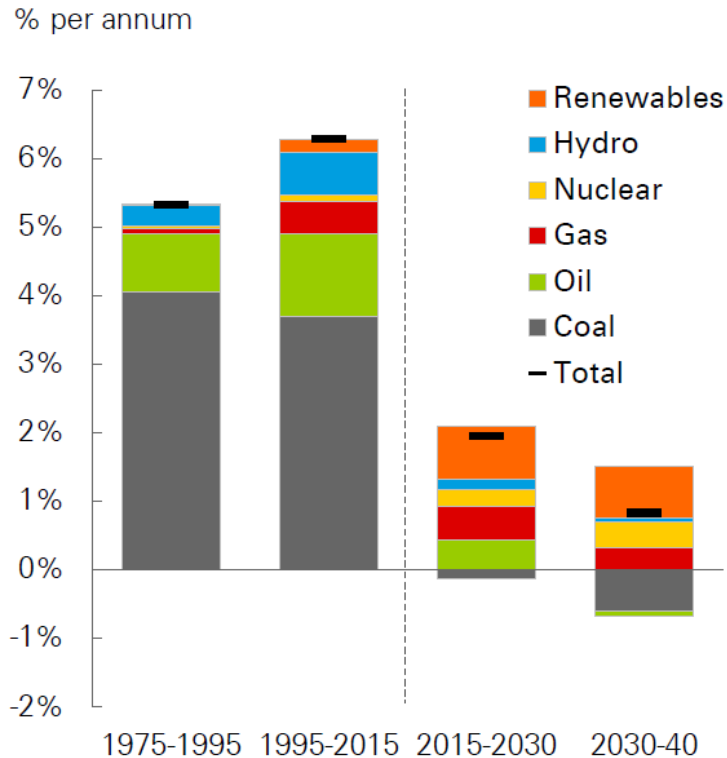


2018 BP Energy Outlook

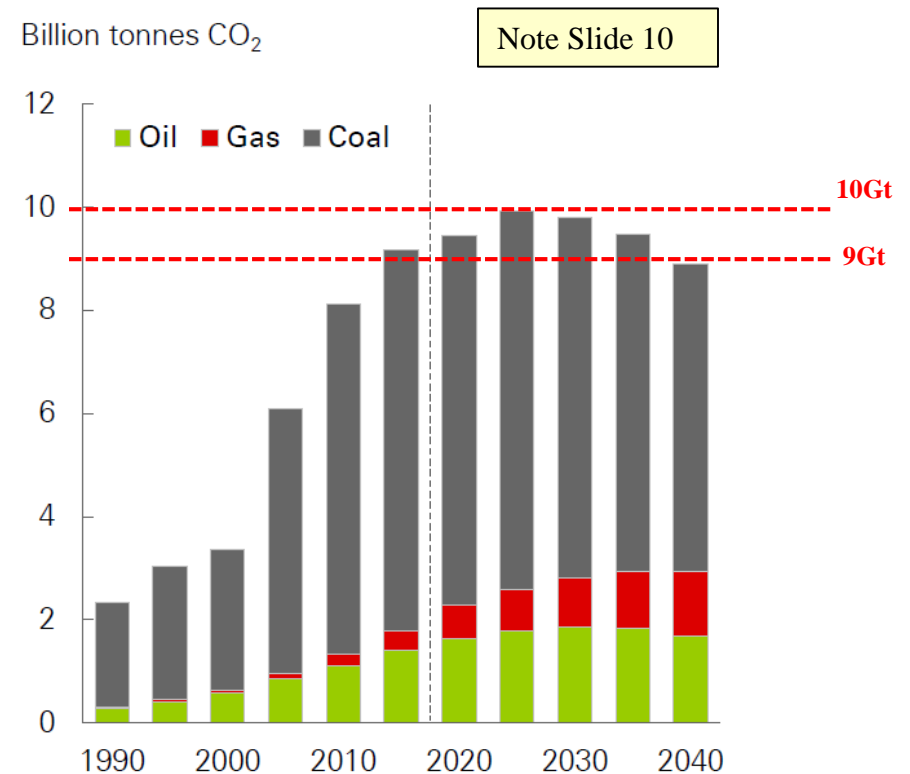
© BP p.l.c. 2018

China's Energy Needs Forecast

Primary energy demand growth and contributions by fuels

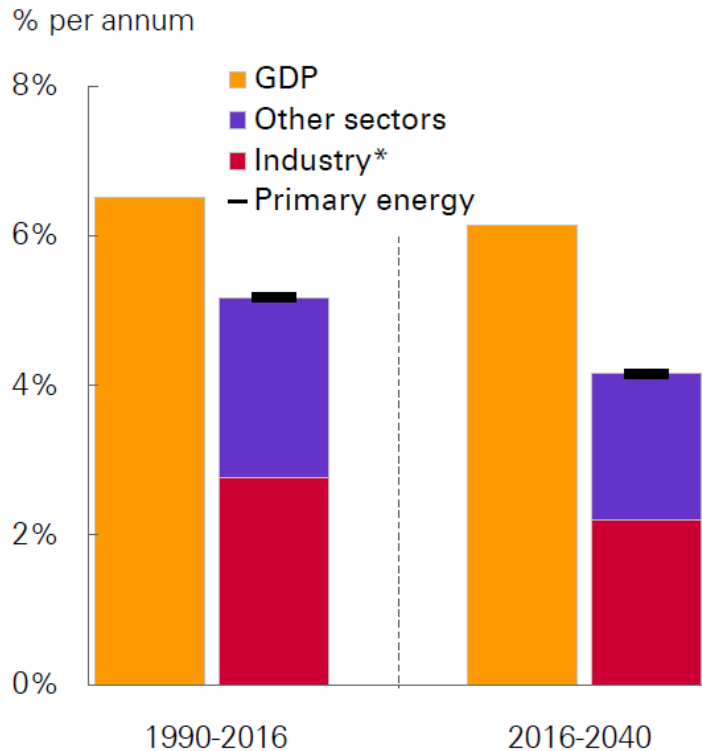


Carbon emissions by source



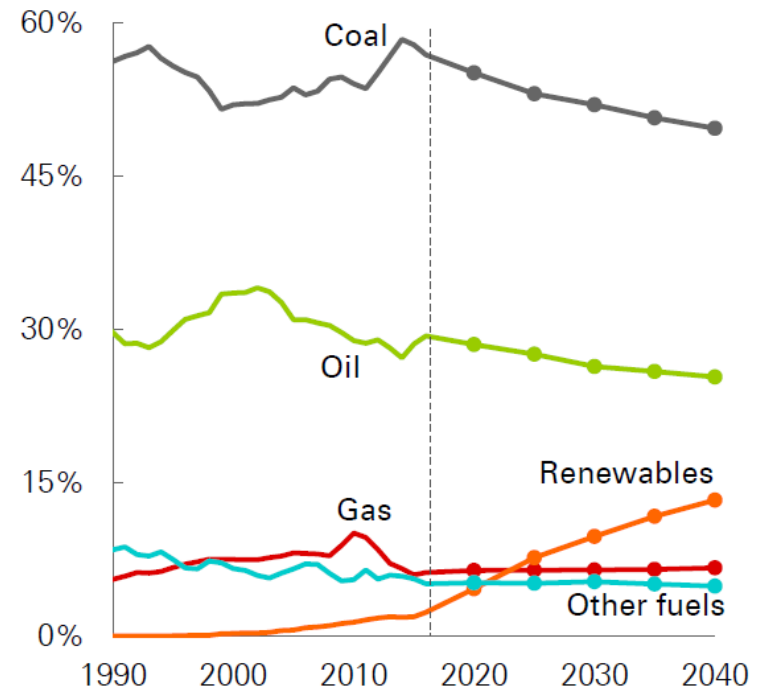
India Emerges as Largest Energy Growth Market

Growth of GDP and primary energy



*Excludes non-combusted fuels

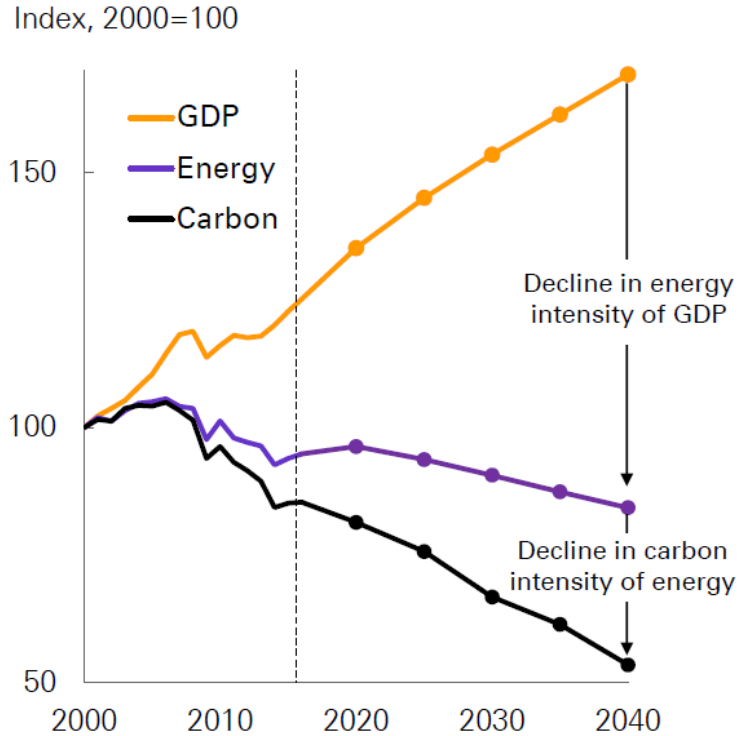
Shares of primary energy



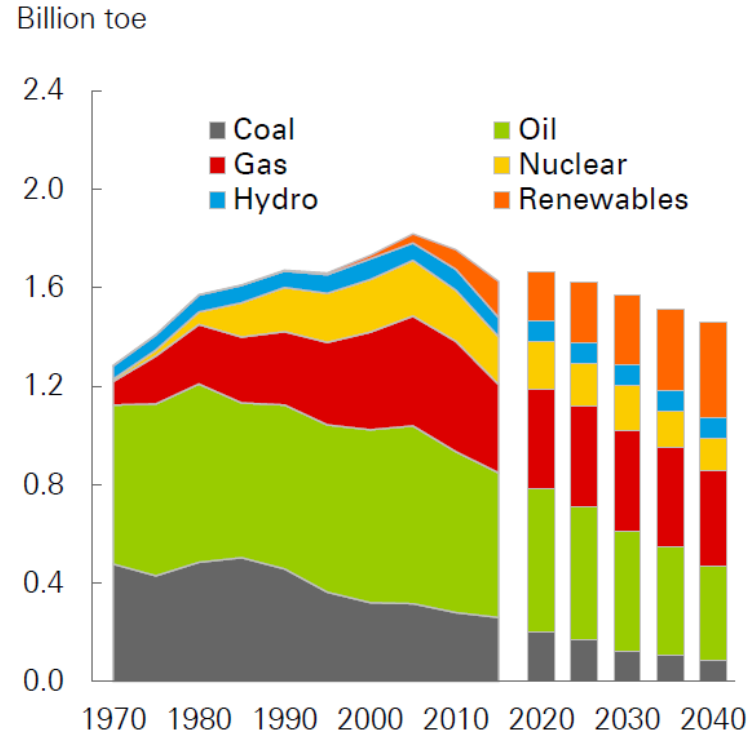
2018 BP Energy Outlook
© BP p.l.c. 2018

EU Leads Transition to Lower Carbon Economy

GDP, energy and carbon emissions



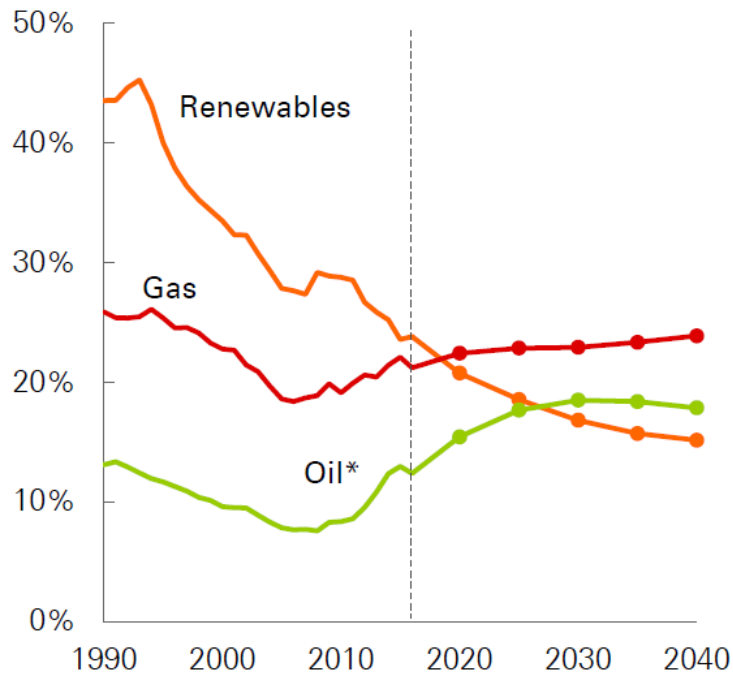
Primary energy consumption



2018 BP Energy Outlook
© BP p.l.c. 2018

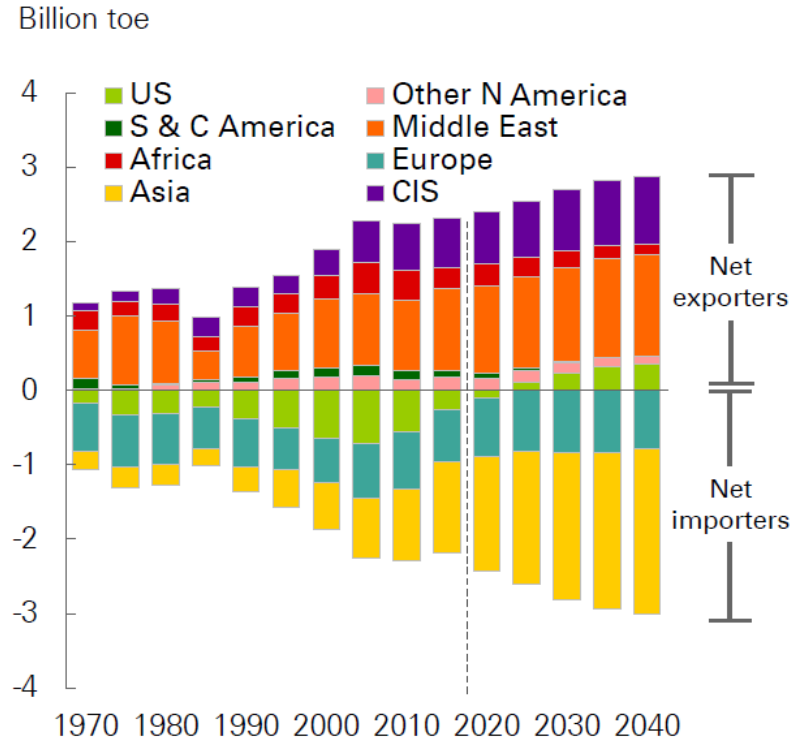
U.S. Extends Leads in O&G Production

US shares of global production



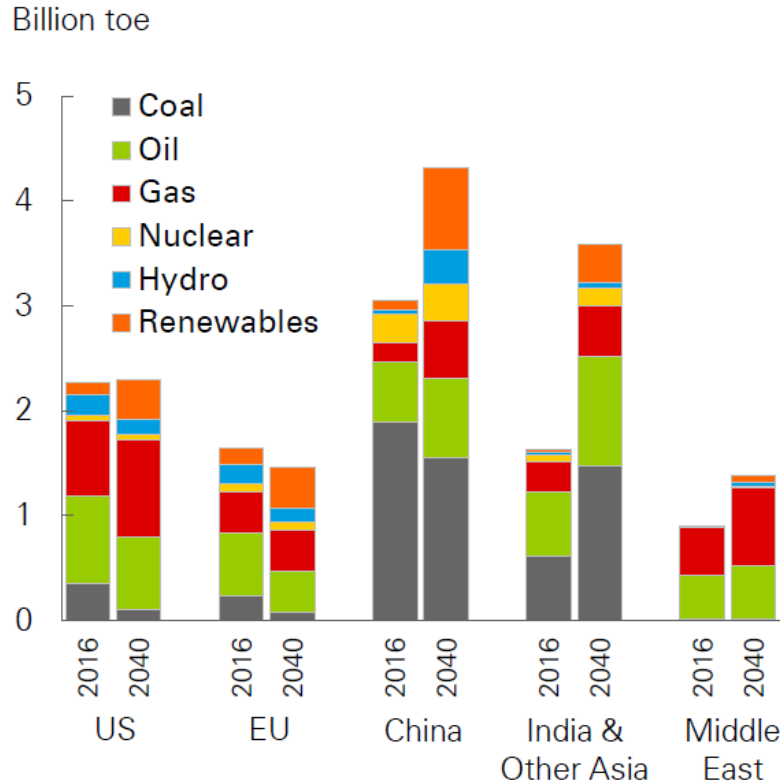
* Includes crude and NGLs

Regional oil/gas imbalances

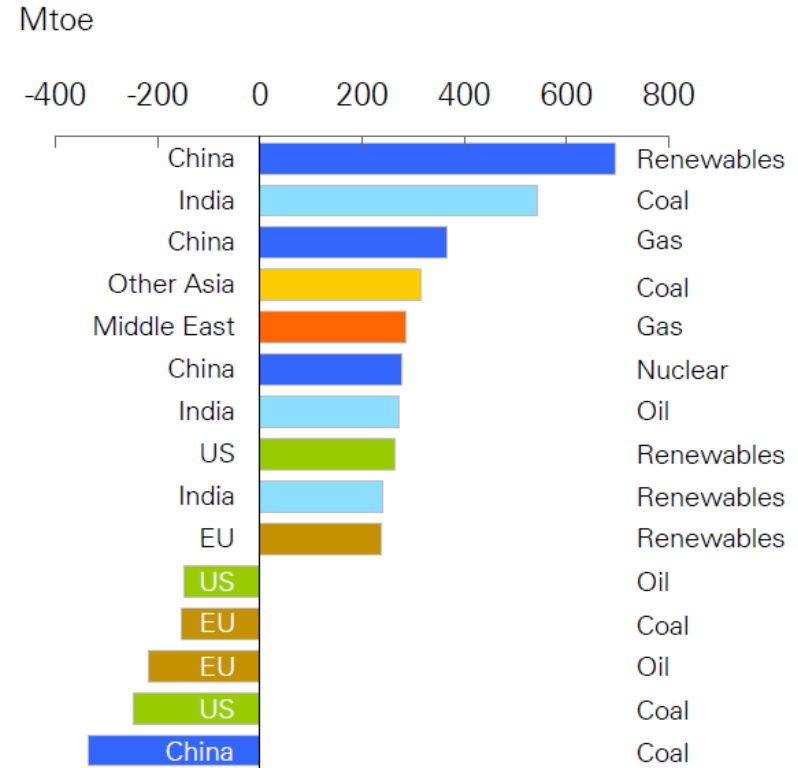


Regional Differences in Fuel Mix

Primary energy demand by fuel and region



Changes 2016-2040[†] by fuel and region



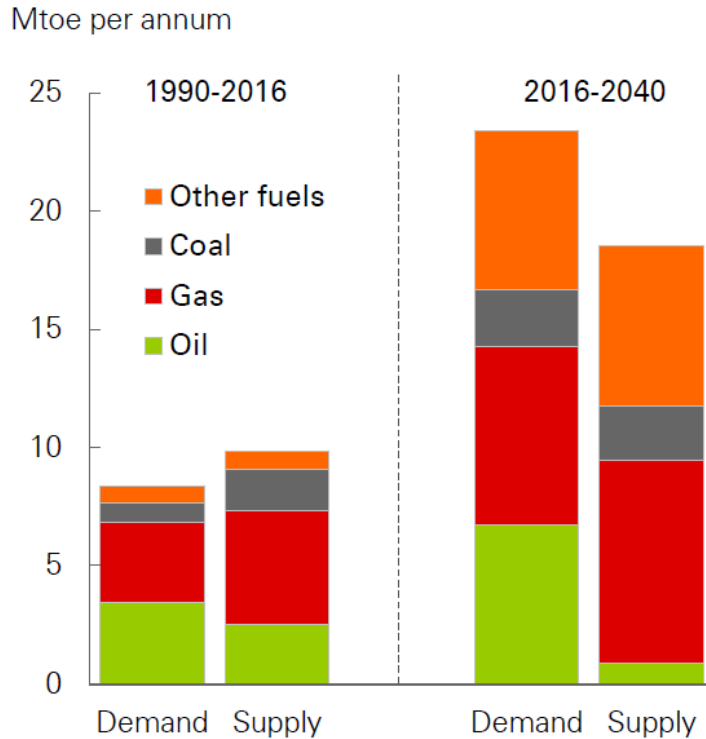
†Ten largest increases and five largest declines

2018 BP Energy Outlook

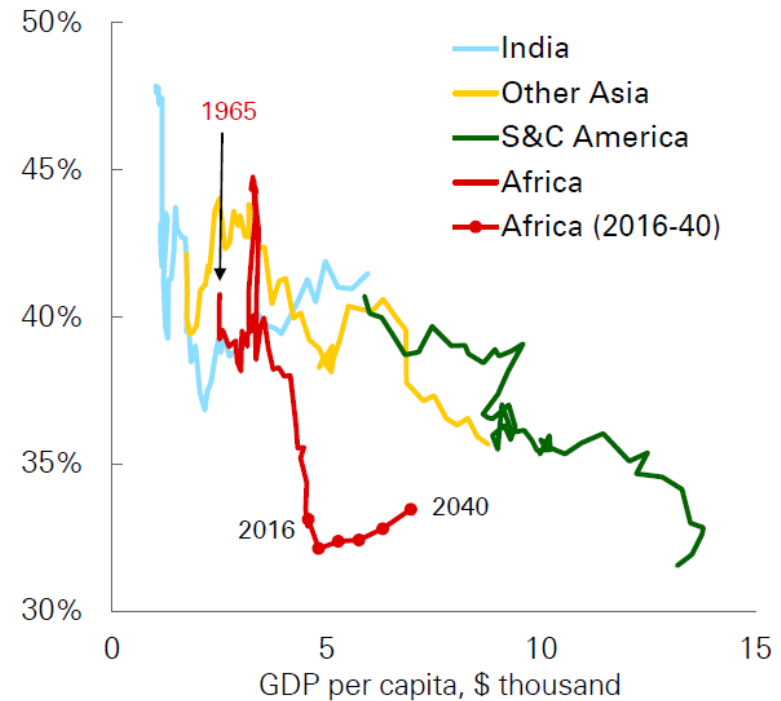
© BP p.l.c. 2018

Africa's Increasing Role

Energy supply and demand growth



Industrial energy share* (1965-2016 unless stated)



*Includes non-combusted fuels

2018 BP Energy Outlook

© BP p.l.c. 2018

Bloomberg Energy News – (1)

- **“We claim solar and wind have already won the race...”**
 - well situated and equipped wind farms and solar parks are already as cheap as, or cheaper than, fossil fuel alternatives, almost everywhere.
- **China to Dominate Energy Storage**
 - The key to renewables is being able to store the electricity generated so it can be utilized during the times when solar panels and wind turbines are not providing enough to meet demand. Falling prices for lithium ion batteries will help put that last piece of the renewable energy revolution in place.
 - *“Today we can identify 131 GWh of lithium ion battery manufacturing capacity worldwide. The bulk of that is in Asia, and almost 60% is in China. By 2021, we expect that GWh number to more than triple, with China controlling around 73%. It is clear that China is positioning itself to dominate the global battery market just as it cornered the market for PV technology.*
 - *“Following the experience curve, we expect batteries to fall another 54% to \$96/kWh in 2025, and 67% to \$70/kWh by 2030. However there will probably be some bumps along the way – for instance, lithium and cobalt prices have tripled in the past 18 months and are set to slow down cost declines in the near term.”*
- **More Gas-Fired Peaker Plants**
 - Henbest and his team see more open cycle gas-fired peaker plants becoming part of the energy mix with “730 GW of peakers added worldwide between 2025 and 2050.”
 - The losers will be the combined cycle gas turbine facilities that provide baseload power.
 - As renewables and battery storage increasingly serve the need for baseload power, those CCGT plants will become too expensive to operate.



Bloomberg Energy News – (2)

– More Electric Cars and More Air Conditioning

- BNEF sees the number of electric cars climbing to 60 million vehicles by 2040. It also expects the demand for air conditioning to grow significantly in emerging markets like southeast Asia, India, and South America.
- Electricity for charging electric cars will grow to 9% of worldwide demand but will be much higher in some countries

– BNEF sees a major shift ahead in how consumers use electricity. It expects both commercial users of air conditioning and most EV drivers to shift their usage to times of the day when power from solar panels is abundant, further lessening the need for baseload power during the daytime.

- *“We’re already seeing special time-of-use tariffs emerge for EV owners in the U.S. and Europe, and we expect this trend to continue. The relative predictability and super-low marginal cost of electricity from PV suggests that much of this dynamic EV demand might flow toward the middle of the day.”*
- *“More generally, we think that growing flexibility in demand will fundamentally change the gross load shape. No longer will supply have to dispatch and ramp to meet changes in demand, but demand itself will shift to meet cheap renewables generation, helping wind and solar to achieve higher shares of the electricity mix.”*
- *“By 2050, we’re painting a picture of an electricity system utterly reshaped around cheap wind, solar and batteries. These technologies provide bulk electricity and are supported by thermal plants that run at low overall capacity factors, but can be dispatched when needed.”*



Bloomberg Energy News – (3)

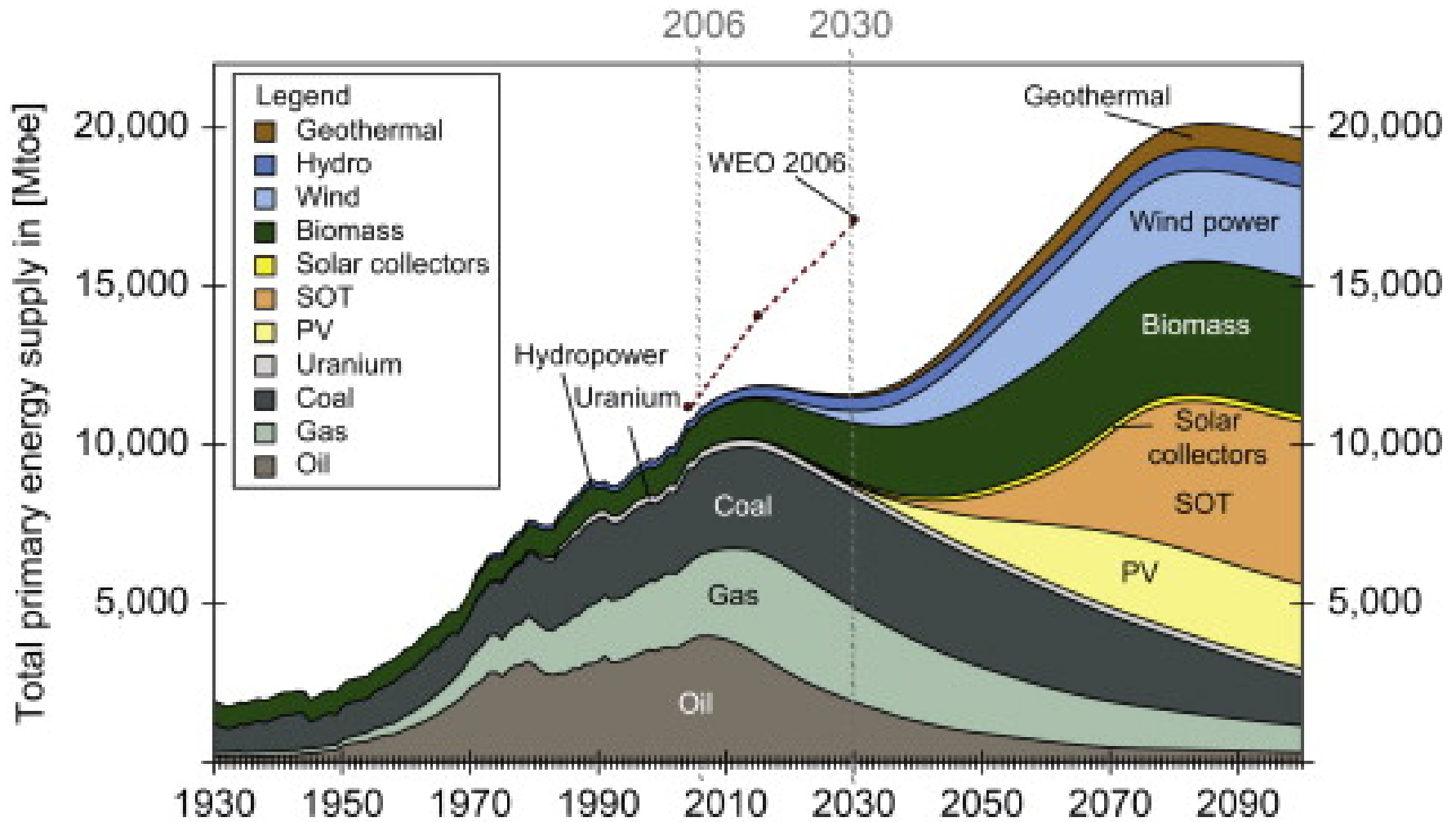
– Coal is the Biggest Loser

- Coal accounts for 37% of global energy production today. BNEF sees that falling to just 11% by 2050. It will peak in China by 2025 as the Chinese continue their quest to replace coal-fired plants in order to clean up the skies above. The peak in India is projected for 2033. In the US and Europe, renewables are already shouldering coal aside thanks to the cost advantage.
- *“In short, coal loses the market for bulk electricity to cheaper renewables, and the market for round-the-clock availability to more flexible gas, which better complements variable wind and solar.”*

– Renewables Are Not Enough

- All that good news and rosy projections notwithstanding, BNEF admits carbon emissions are not likely to fall far enough fast enough to meet the goal of limiting a rise in average global temperatures to less than 2° Celsius.
- *“The demise of coal and growth of renewables lowers the carbon intensity of electricity generation all over the world. Power sector emissions peak in 2027, the same year as coal-fired electricity generation, before falling at 2% per year to 2050.*
- *However, none of this happens fast enough, and the power sector remains on track to outstrip a two-degree emissions trajectory by some margin.*
- *Even in the unlikely event the world agreed to a coal moratorium and shuttered all plants by 2035, the additional gas needed to ensure system security would still produce too many emissions.”*
- What is needed, BNEF says is “the next phase of low carbon technology that can offer a zero emissions substitute for gas to balance the system and bridge the seasonality gap.”
- Unfortunately, BNEF’s crystal ball contains no clues as to what that low carbon technology might be. Keep following *CleanTechnica* as we continue following developments that may suggest an answer to that question.

The Long View



*base*_e

“Practical Strategies for Emerging Energy Technologies”

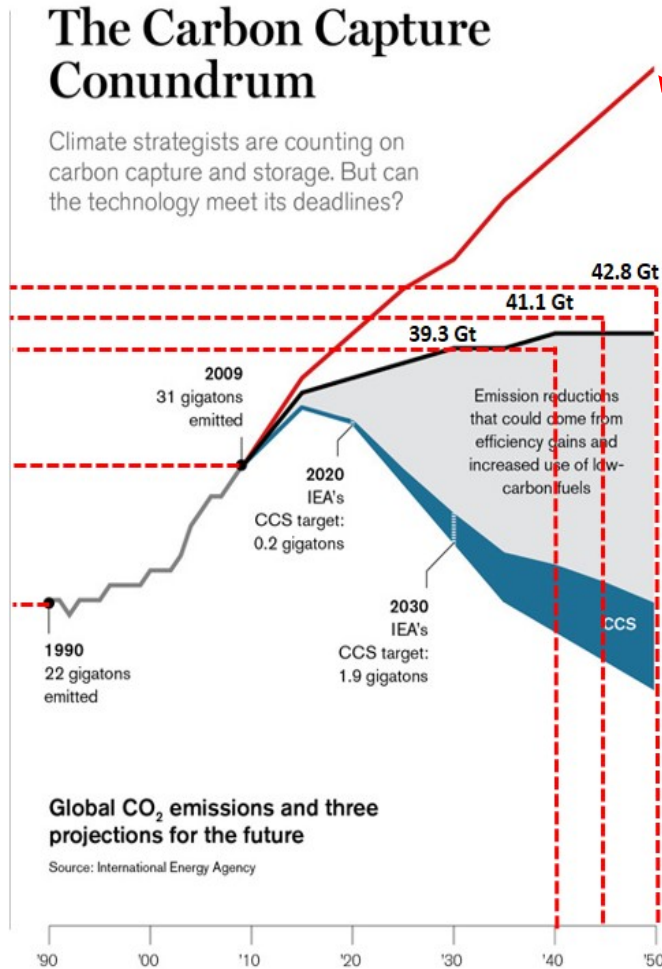
Source: ? The Internet

EIA Annual Energy Outlook 2018

The Carbon Capture Conundrum

Climate strategists are counting on carbon capture and storage. But can the technology meet its deadlines?

Values from EIA WW Annual Energy Outlook 2017 (slide 19)

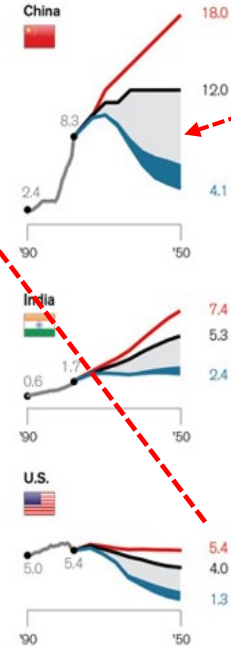


Current trajectory 58 gigatons
This projection assumes that essentially no action is taken to address climate change. Models predict a long-term global temperature rise of 6 °C in such a scenario.

Global pledges 40 gigatons
If countries make good on their pledges to reduce emissions, the projected trajectory is much less steep. Models suggest a long-term global temperature rise of 4 °C.

Target 16 gigatons
Models associate this trajectory with a long-term global temperature rise no higher than 2 °C. That has been a long-standing goal in climate change negotiations.

Scenarios and CCS targets for the three highest-emitting countries (in gigatons)



9.8GT (3°C)?

5.0GT (4°C)?

The U.S. is on the 6°C trajectory

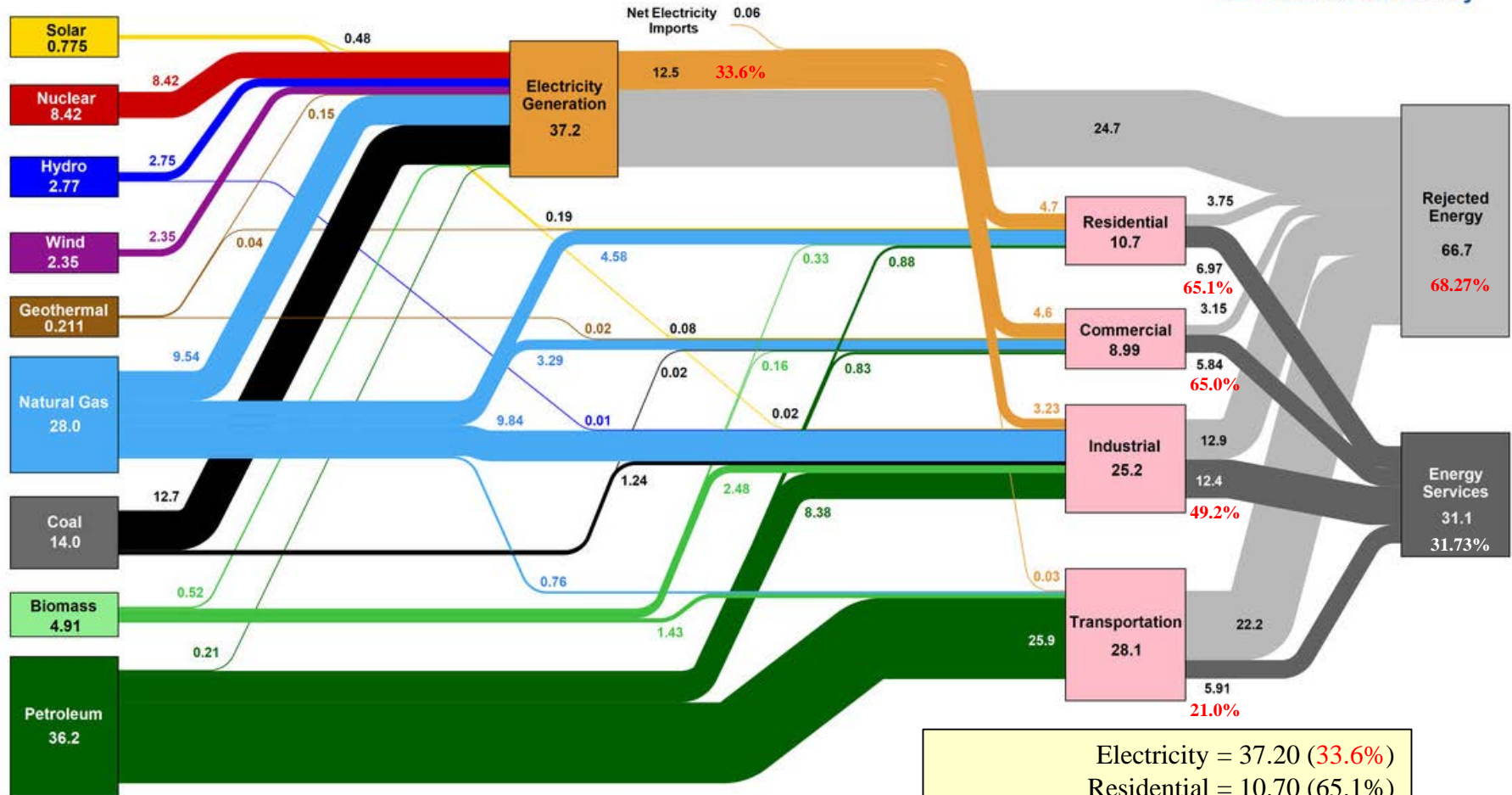
EIA 2017 International Energy Outlook
U.S. w/CPP 5.072 Gt
U.S. w/o CPP 5.554 Gt

EIA 2018 International Energy Outlook
U.S. w/ CPP 5.013 Gt
U.S. w/o CPP 5.279 Gt
High Growth 5.815 Gt

Appendix

U.S. 2017 Energy Flow – 97.7 Quads

Estimated U.S. Energy Consumption in 2017: 97.7 Quads



Electricity = 37.20 (33.6%)
 Residential = 10.70 (65.1%)
 Commercial/Industrial = 34.19 (53.3%)
 Transportation = 28.10 (21.0%)



EIA WW Annual Energy Outlook 2017

Reference Case includes CPP

Carbon dioxide emissions (Mmt): Reference Case											Growth	
	2010	2015	2016	2017	2020	2025	2030	2035	2040	2045	2050	(2015-2050)
OECD Americas	6622.5	6341.5	6237.4	6271.3	6341.1	6175.4	5966.9	5970.4	6074.2	6217.4	6384.6	0.00%
United States	5570.5	5247.6	5145.5	5171.3	5260.2	5057.0	4839.4	4815.6	4866.8	4956.8	5072.6	-0.10%
Canada	555.0	590.3	592.6	603.8	586.8	600.6	595.7	607.6	626.3	649.2	671.8	0.40%
Mexico/Chile	497.0	503.7	499.2	496.3	494.2	517.8	531.8	547.2	581.0	611.3	640.1	0.70%
OECD Europe	4159.8	3858.0	3930.0	3962.6	3922.6	3814.0	3798.1	3902.6	3988.2	4096.9	4260.6	0.30%
OECD Asia	2093.9	2233.6	2240.6	2228.4	2185.8	2209.0	2243.1	2284.3	2332.5	2389.0	2466.2	0.30%
Japan	1108.0	1154.1	1139.6	1132.8	1072.6	1058.4	1038.2	1014.2	987.1	961.3	944.5	-0.60%
South Korea	563.0	663.0	687.8	683.4	702.3	720.9	751.3	791.0	835.2	881.2	930.2	1.00%
Australia/New Zealand	422.9	416.5	413.3	412.3	410.9	429.7	453.7	479.1	510.1	546.5	591.5	1.00%
Total OECD	12876.2	12433.1	12408.0	12462.4	12449.5	12198.4	12008.1	12157.4	12394.9	12703.2	13111.4	0.20%
Non-OECD Europe and Eurasia	2646.7	2691.8	2661.9	2665.1	2630.4	2582.8	2570.0	2616.9	2624.6	2599.8	2574.1	-0.10%
Russia	1620.0	1675.8	1636.5	1632.9	1609.8	1583.3	1587.1	1615.8	1615.0	1582.3	1540.9	-0.20%
Other	1026.7	1016.0	1025.3	1032.3	1020.6	999.4	983.0	1001.1	1009.6	1017.5	1033.3	0.00%
Non-OECD Asia	11320.1	14293.8	14546.9	14819.4	15167.5	16050.0	16589.1	17384.2	18285.7	19226.4	20056.6	1.00%
China	7746.0	9923.6	10009.5	10157.3	10205.1	10464.0	10421.8	10298.1	10161.1	10017.6	9792.9	0.00%
India	1612.0	2001.8	2108.3	2160.7	2305.3	2552.1	2883.6	3388.8	3959.2	4544.9	5043.1	2.70%
Other	1962.1	2368.4	2429.1	2501.3	2657.1	3033.8	3283.6	3697.3	4165.4	4663.9	5220.6	2.30%
Middle East	1730.4	1959.1	1966.1	2020.3	2085.0	2192.3	2315.6	2495.1	2691.8	2923.3	3117.4	1.30%
Africa	1067.3	1251.4	1274.6	1319.7	1370.4	1444.2	1505.5	1591.5	1739.8	1905.7	2100.1	1.50%
Non-OECD Americas	1193.7	1272.4	1237.9	1232.3	1269.6	1354.9	1409.5	1472.8	1580.8	1693.7	1811.7	1.00%
Brazil	457.0	482.3	459.8	452.1	470.0	513.7	540.2	561.1	595.8	633.2	668.4	0.90%
Other	736.7	790.2	778.1	780.2	799.7	841.2	869.3	911.7	985.0	1060.5	1143.3	1.10%
Total Non-OECD	17958.2	21468.6	21687.3	22056.8	22522.9	23624.1	24389.7	25560.6	26922.7	28349.0	29660.0	0.90%
Total World	30834.4	33901.8	34095.3	34519.2	34972.4	35822.5	36397.8	37717.9	39317.6	41052.2	42771.4	0.70%

Source: U.S. Energy Information Administration

<https://www.eia.gov/outlooks/aeo/data/browser/#/?id=10-IEO2017®ion=0-0&cases=Reference&start=2010&end=2050&f=A&linechart=Reference-d082317.2-10-IEO2017&sourcekey=0>

Wed Sep 20 2017 12:46:07 GMT-0400 (Eastern Daylight Time)

34519.2 MMt = 34.5 Gt

base_e

“Practical Strategies for Emerging Energy Technologies”