Electric Power Committee Fuels Report

IGTI Conference
June 21, 2019
Phoenix, AZ

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Acknowledgement to Author

- **Material presented created by Pete Baldwin:**

–Founder of ***base-e***

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–Past President of Ramgen Power Systems

–Past President of Ingersoll-Rand (NREC)* – 33 years

–International industry experiences (UK and Italy)

–Contributing Editor to Turbomachinery International

–Past Associate with IHS-CERA

–BSME, Purdue University

PURDUE UNIVERSITY

- **Presentation available for download at : http://www.base-e.net/articles.php**

*Northern Research & Engineering Corporation

Primary Energy Consumption by Fuel 2018 - Mtoe

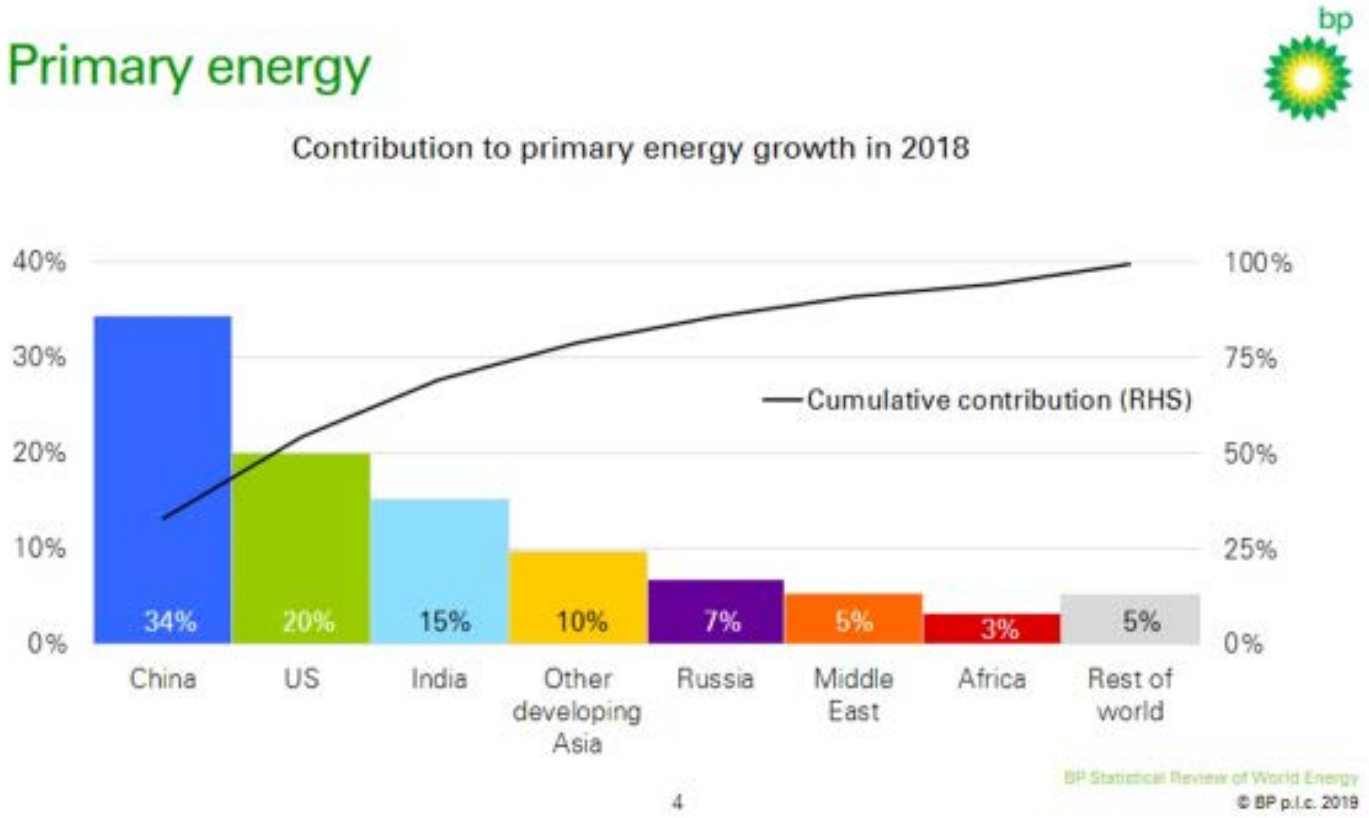
Million tonnes oil equivalent	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew-ables	2017 Total	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew-ables	2018 Total	Percent of 2018	Annual Change
Canada	108.8	94.3	18.6	22.7	89.7	9.5	343.7	110.0	99.5	14.4	22.6	87.6	10.3	**344.4**	2.5%	0.2%
Mexico	85.8	74.3	15.2	2.5	7.2	4.3	189.3	82.8	77.0	11.9	3.1	7.3	4.8	**186.9**	1.3%	-1.3%
US	902.0	635.8	331.3	191.7	67.2	94.5	2222.5	919.7	702.6	317.0	192.2	65.3	103.8	**2300.6**	16.6%	3.5%
Total North America	**1096.6**	**804.4**	**365.1**	**216.9**	**164.1**	**108.4**	**2755.5**	**1112.5**	**879.1**	**343.3**	**217.9**	**160.3**	**118.8**	**2832.0**	20.4%	2.8%
Brazil	136.1	32.4	16.6	3.6	83.9	21.4	293.9	135.9	30.9	15.9	3.5	87.7	23.6	**297.6**	2.1%	1.3%
Total S. & Cent. America	**317.2**	**148.4**	**34.8**	**4.9**	**163.0**	**31.5**	**699.8**	**315.3**	**144.8**	**36.0**	**5.1**	**165.5**	**35.4**	**702.0**	5.1%	0.3%
France	79.1	38.5	9.3	90.1	11.1	9.4	237.5	78.9	36.7	8.4	93.5	14.5	10.6	**242.6**	1.7%	2.2%
Germany	119.0	77.2	71.5	17.3	4.6	44.4	333.9	113.2	75.9	66.4	17.2	3.8	47.3	**323.9**	2.3%	-3.0%
Italy	62.0	61.5	9.6	-	7.8	15.3	156.3	60.8	59.5	8.9	-	10.4	14.9	**154.5**	1.1%	-1.1%
Poland	31.7	16.5	49.8	-	0.6	4.9	103.4	32.8	17.0	50.5	-	0.4	4.4	**105.2**	0.8%	1.7%
Spain	65.0	27.3	13.4	13.1	4.2	15.7	138.8	66.6	27.1	11.1	12.6	8.0	16.0	**141.4**	1.0%	1.8%
Turkey	49.2	44.3	39.5	-	13.2	6.6	152.7	48.6	40.7	42.3	-	13.5	8.5	**153.5**	1.1%	0.5%
United Kingdom	78.0	67.8	9.1	15.9	1.3	21.1	193.2	77.0	67.8	7.6	14.7	1.2	23.9	**192.3**	1.4%	-0.5%
Total Europe	**746.2**	**481.9**	**315.5**	**211.8**	**132.3**	**162.3**	**2050.0**	**742.0**	**472.0**	**307.1**	**212.1**	**145.3**	**172.2**	**2050.7**	14.8%	0.0%
Russian Federation	151.5	370.7	83.9	46.0	41.9	0.3	694.3	152.3	390.8	88.0	46.3	43.0	0.3	**720.7**	5.2%	3.8%
Total CIS	**191.1**	**472.3**	**126.4**	**46.6**	**54.3**	**0.5**	**891.2**	**193.5**	**499.4**	**134.9**	**46.7**	**55.4**	**0.6**	**930.5**	6.7%	4.4%
Iran	84.5	180.5	1.4	1.6	3.9	0.1	272.0	86.2	193.9	1.5	1.6	2.4	0.1	**285.7**	2.1%	5.0%
Saudi Arabia	168.8	93.9	0.1	-	-	^	262.8	162.6	96.4	0.1	-	-	^	**259.2**	1.9%	-1.4%
United Arab Emirates	43.8	64.0	1.0	-	-	0.1	109.0	45.1	65.8	1.1	-	-	0.2	**112.2**	0.8%	3.0%
Total Middle East	**412.5**	**453.2**	**8.2**	**1.6**	**4.7**	**1.3**	**881.4**	**412.1**	**475.6**	**7.9**	**1.6**	**3.4**	**1.7**	**902.3**	6.5%	2.4%
South Africa	27.5	3.8	84.3	3.6	0.2	2.4	121.8	26.3	3.7	86.0	2.5	0.2	2.8	**121.5**	0.9%	-0.2%
Total Africa	**192.1**	**121.0**	**97.6**	**3.6**	**28.2**	**6.1**	**448.6**	**191.3**	**129.0**	**101.4**	**2.5**	**30.1**	**7.2**	**461.5**	3.3%	2.9%
Australia	51.1	35.5	45.1	-	3.1	5.8	140.5	53.3	35.6	44.3	-	3.9	7.2	**144.3**	1.0%	2.7%
China	610.7	206.7	1890.4	56.1	263.6	111.4	3139.0	641.2	243.3	1906.7	66.6	272.1	143.5	**3273.5**	23.6%	4.3%
India	227.1	46.2	415.9	8.5	30.7	21.7	750.1	239.1	49.9	452.2	8.8	31.6	27.5	**809.2**	5.8%	7.9%
Indonesia	79.3	33.1	57.2	-	4.2	3.0	176.9	83.4	33.5	61.6	-	3.7	3.3	**185.5**	1.3%	4.9%
Japan	187.8	100.6	119.9	6.6	17.9	22.4	455.2	182.4	99.5	117.5	11.1	18.3	25.4	**454.1**	3.3%	-0.2%
South Korea	130.0	42.8	86.2	33.6	0.6	4.0	297.1	128.9	48.1	88.2	30.2	0.7	5.0	**301.0**	2.2%	1.3%
Taiwan	50.1	20.0	39.4	5.1	1.2	1.2	117.0	50.0	20.3	39.3	6.3	1.0	1.5	**118.4**	0.9%	1.2%
Thailand	64.4	43.1	18.3	-	1.1	3.4	130.2	65.8	42.9	18.5	-	1.7	4.0	**133.0**	1.0%	2.1%
Total Asia Pacific	**1651.3**	**660.6**	**2770.8**	**111.7**	**373.2**	**180.2**	**5748.0**	**1695.4**	**709.6**	**2841.3**	**125.3**	**388.9**	**225.4**	**5985.8**	43.2%	4.1%
Total World	**4607.0**	**3141.9**	**3718.4**	**597.1**	**919.9**	**490.2**	**13474.6**	**4662.1**	**3309.4**	**3772.1**	**611.3**	**948.8**	**561.3**	**13864.9**	100.0%	2.9%
% of Total	34.2%	23.3%	27.6%	4.4%	6.8%	3.6%	100.0%	33.6%	23.9%	27.2%	4.4%	6.8%	4.0%	100.0%		
Annual Change								1.2%	5.3%	1.4%	2.4%	3.1%	14.5%	2.9%		

U.S. = 91.2 Quads

13,864.9 Mtoe = 549.8 Quads

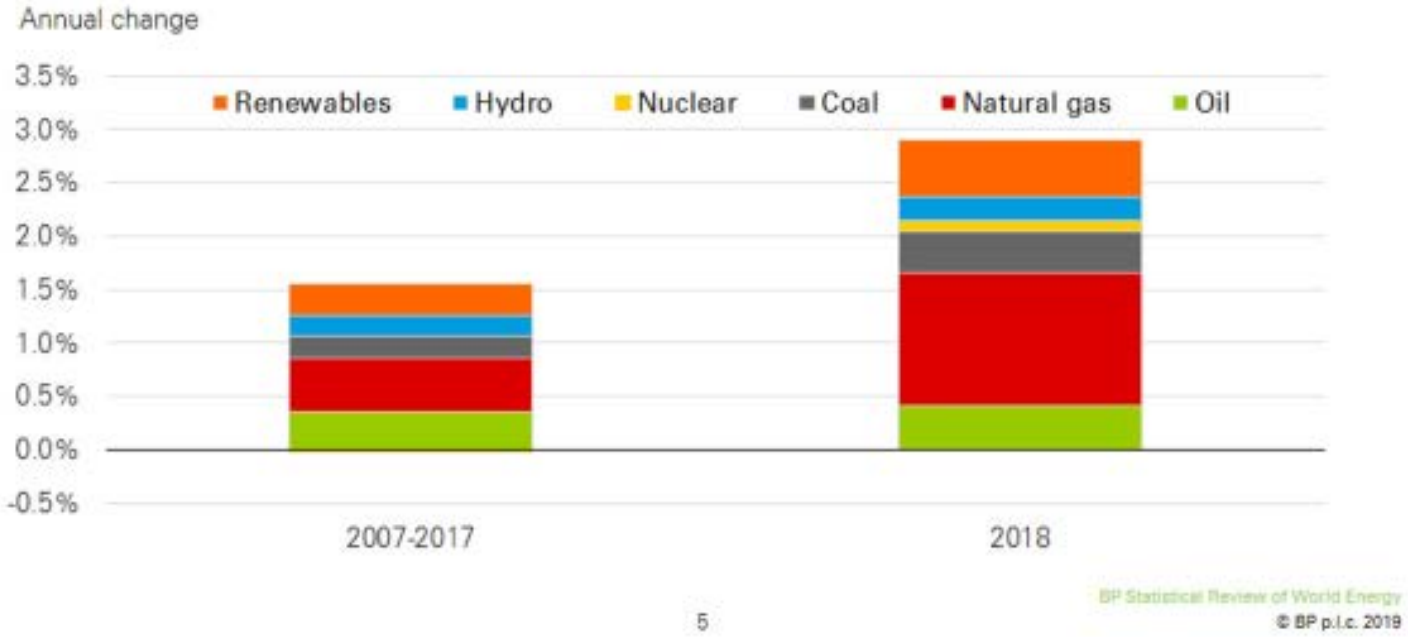
Source: BP Statistical Review of World Energy 2019

Primary Global Energy Growth 2018



Source: BP Statistical Review of World Energy 2019

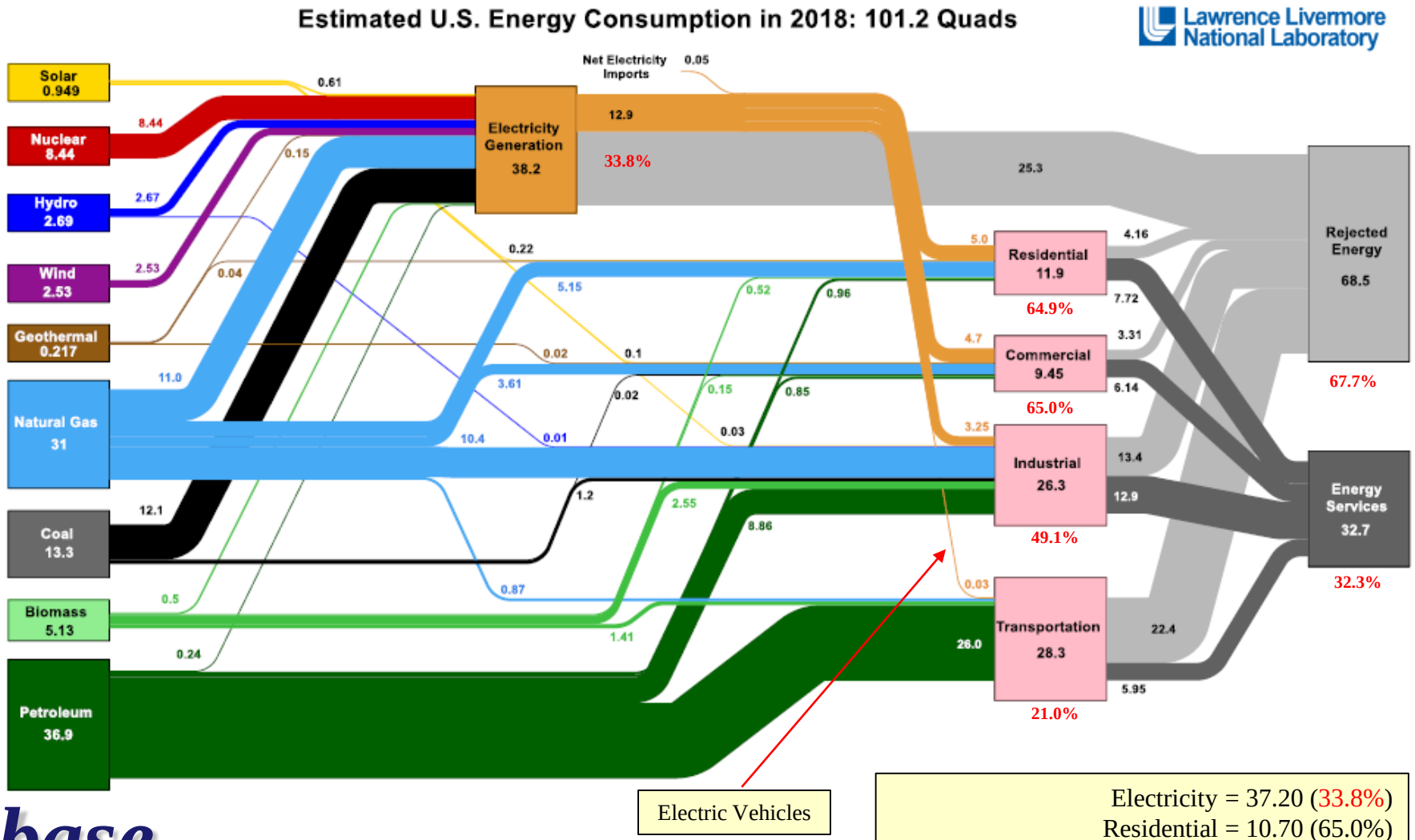
Primary Energy Growth by Fuel - Generation



Source: BP Statistical Review of World Energy 2019

U.S. 2018 Energy Flow – 101.2 Quads

BP Stats 2018 = 91.2
Renewables (no Hydro) = 8.8



Electric Vehicles

Electricity = 37.20 (33.8%)
Residential = 10.70 (65.0%)
Commercial/Industrial = 34.19 (49.1%)
Transportation = 28.10 (21.0%)

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EIA STEO Forecast – May 7, 2019

- Brent spot prices will average $70/b in 2019 and $67/b in 2020, compared with an average of $71/b in 2018
- Crude oil production in the Organization of the Petroleum Exporting Countries (OPEC) will average 30.3 MMb/d in 2019, down by 1.7 MMb/d from 2018, and in 2020, OPEC crude oil production to fall by 0.4 MMb/d to an average of 29.8 MMb/d
- Henry Hub natural gas spot prices will average $2.79/mmBtu in 2019, down 36 cents/mmBtu from 2018. The forecasted 2020 average Henry Hub spot price is $2.78/mmBtu
- Dry natural gas production will average 90.3 billion cubic feet per day (Bcf/d) in 2019, up 6.9 Bcf/d from 2018 and natural gas production will continue to grow in 2020 to an average of 92.2 Bcf/d
- U.S. total utility-scale electricity generation from natural gas-fired power plants to rise from 35% in 2018 to 37% in 2019 and to 38% in 2020
- The share of electricity generation from coal will average 24% in 2019 and 22% in 2020, down from 27% in 2018
- The nuclear share of generation was 19% in 2018, and will stay near that level in 2019 and in 2020
- The generation share of hydropower averages 7% of total generation for 2019 and 2020, similar to 2018
- Wind, solar, and other non-hydropower renewables together provided about 10% of electricity generation in 2018 and 11% in 2019 and 13% in 2020
- All renewable fuels, including wind, solar, and hydropower, will produce 18% of U.S. electricity in 2019 and almost 20% in 2020
- After rising by 2.7% in 2018, that U.S. energy-related carbon dioxide (CO2) emissions will decline by 2.1% in 2019 and by 0.8% in 2020

Oil

Crude Oil Consumption 2018 – 98.8 MMb/d

Thousand barrels daily	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	Growth rate per annum 2018	Growth rate per annum 2007-17	Share 2018
Canada	2323	2209	2358	2436	2376	2398	2442	2401	2448	2448	**2447**	♦	0.4%	2.5%
Mexico	2080	2021	2040	2065	2083	2034	1960	1939	1950	1883	**1812**	-3.8%	-1.0%	1.8%
US	19490	18771	19180	18882	18490	18961	19106	19531	19687	19958	**20456**	2.5%	-0.4%	20.5%
Total North America	**23894**	**23001**	**23578**	**23383**	**22949**	**23393**	**23507**	**23871**	**24086**	**24289**	**24714**	1.8%	-0.3%	24.8%
Brazil	2481	2498	2714	2832	2884	3100	3210	3140	2960	3052	**3081**	0.9%	2.8%	3.1%
Total S. & Cent. America	**6041**	**6016**	**6335**	**6579**	**6715**	**6964**	**7034**	**7001**	**6792**	**6798**	**6795**	♦	1.7%	6.8%
France	1889	1822	1763	1725	1673	1661	1613	1612	1597	1608	**1607**	-0.1%	-1.7%	1.6%
Germany	2502	2409	2441	2365	2352	2404	2344	2336	2374	2443	**2321**	-5.0%	0.3%	2.3%
Italy	1661	1563	1532	1475	1384	1274	1204	1257	1266	1279	**1253**	-2.0%	-3.0%	1.3%
Spain	1559	1474	1447	1383	1300	1203	1199	1243	1288	1301	**1335**	2.7%	-2.1%	1.3%
United Kingdom	1738	1669	1652	1600	1546	1532	1536	1578	1623	1637	**1618**	-1.2%	-0.7%	1.6%
Total Europe	**16558**	**15876**	**15752**	**15321**	**14826**	**14631**	**14389**	**14713**	**15032**	**15351**	**15276**	-0.5%	-0.8%	15.3%
Russian Federation	2861	2775	2878	3074	3119	3134	3298	3146	3217	3207	**3228**	0.7%	1.4%	3.2%
Total CIS	**3602**	**3486**	**3567**	**3838**	**3935**	**3914**	**4099**	**3955**	**4034**	**4033**	**4099**	1.6%	1.3%	4.1%
Iran	1925	1919	1788	1851	1882	2064	1959	1804	1749	1843	**1879**	2.0%	♦	1.9%
Saudi Arabia	2622	2914	3206	3295	3460	3451	3764	3886	3875	3838	**3724**	-3.0%	4.8%	3.7%
Total Middle East	**7386**	**7727**	**7974**	**8301**	**8631**	**8910**	**9053**	**9099**	**9172**	**9138**	**9136**	♦	2.7%	9.2%
Total Africa	**3198**	**3322**	**3481**	**3398**	**3574**	**3705**	**3770**	**3857**	**3878**	**3962**	**3959**	**-0.1%**	**2.7%**	**4.0%**
Australia	944	950	954	1001	1025	1034	1047	1005	1038	1055	**1094**	3.7%	1.2%	1.1%
China	7914	8295	9446	9808	10242	10750	11239	11986	12304	12840	**13525**	5.3%	5.1%	13.5%
India	3137	3300	3381	3550	3747	3789	3914	4245	4654	4870	**5156**	5.9%	5.0%	5.2%
Indonesia	1288	1321	1415	1590	1646	1677	1708	1571	1628	1696	**1785**	5.2%	2.5%	1.8%
Japan	4847	4390	4442	4442	4702	4516	4303	4151	4019	3975	**3854**	-3.1%	-2.3%	3.9%
Singapore	973	1049	1157	1208	1202	1225	1268	1338	1385	1419	**1449**	2.1%	4.4%	1.5%
South Korea	2312	2345	2378	2401	2466	2464	2463	2587	2781	2811	**2793**	-0.6%	1.6%	2.8%
Taiwan	1010	1022	1043	950	950	981	1013	1021	1046	1069	**1075**	0.5%	-0.4%	1.1%
Thailand	1016	1075	1121	1184	1250	1299	1309	1360	1396	1444	**1478**	2.3%	3.4%	1.5%
Total Asia Pacific	**25940**	**26351**	**28043**	**28942**	**30094**	**30759**	**31343**	**32551**	**33743**	**34835**	**35863**	3.0%	2.9%	35.9%
Total World	**86619**	**85780**	**88730**	**89763**	**90724**	**92276**	**93194**	**95048**	**96737**	**98406**	**99843**	**1.5%**	**1.2%**	**100.0%**

+1,437 MMb/d

Source: BP Statistical Review of World Energy 2019

Crude Oil Production 2018 – 94.7 MMbbl/d

Oil: Production*

Thousand barrels daily	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	Growth rate per annum 2018	Growth rate per annum 2007-17	Share 2018
Canada	3207	3202	3332	3515	3740	4000	4271	4388	4451	4798	**5208**	8.5%	3.8%	5.5%
Mexico	3165	2978	2959	2940	2911	2875	2784	2587	2456	2224	**2068**	-7.0%	-4.4%	2.2%
US	6783	7259	7552	7870	8910	10073	11773	12773	12340	13135	**15311**	16.6%	6.7%	16.2%
Total North America	**13156**	**13440**	**13843**	**14326**	**15561**	**16948**	**18828**	**19748**	**19247**	**20157**	**22587**	**12.1%**	**4.0%**	**23.8%**
Brazil	1887	2019	2125	2173	2132	2096	2341	2525	2591	2721	**2683**	-1.4%	4.1%	2.8%
Colombia	588	671	786	915	944	1010	990	1006	886	854	**866**	1.4%	4.9%	0.9%
Venezuela	3228	3038	2842	2755	2704	2680	2692	2631	2347	2096	**1514**	-27.8%	-4.3%	1.6%
Total S. & Cent. America	**7426**	**7387**	**7407**	**7450**	**7362**	**7397**	**7663**	**7759**	**7355**	**7160**	**6537**	**-8.7%**	**-0.2%**	**6.9%**
Norway	2458	2342	2132	2033	1911	1832	1881	1940	1991	1963	**1844**	-6.0%	-2.6%	1.9%
United Kingdom	1549	1469	1356	1112	946	864	852	963	1013	999	**1085**	8.6%	-4.9%	1.1%
Total Europe	**4876**	**4621**	**4274**	**3903**	**3592**	**3419**	**3443**	**3587**	**3616**	**3565**	**3523**	**-1.2%**	**-3.6%**	**3.7%**
Azerbaijan	916	1027	1037	932	882	888	861	851	838	792	**795**	0.4%	-1.0%	0.8%
Kazakhstan	1485	1609	1676	1684	1664	1737	1710	1695	1655	1838	**1927**	4.8%	2.7%	2.0%
Russian Federation	9965	10152	10379	10533	10656	10807	10860	11007	11269	11255	**11438**	1.6%	1.1%	12.1%
Total CIS	**12712**	**13125**	**13415**	**13485**	**13539**	**13784**	**13784**	**13909**	**14099**	**14215**	**14483**	**1.9%**	**1.1%**	**15.3%**
Iran	4415	4285	4421	4452	3810	3609	3714	3853	4586	5024	**4715**	-6.1%	1.4%	5.0%
Iraq	2428	2446	2469	2773	3079	3103	3239	3986	4423	4533	**4614**	1.8%	7.8%	4.9%
Kuwait	2781	2495	2556	2909	3164	3125	3097	3061	3141	3001	**3049**	1.6%	1.2%	3.2%
Oman	757	813	865	885	918	942	943	981	1004	971	**978**	0.8%	3.2%	1.0%
Qatar	1432	1415	1630	1824	1928	1991	1975	1933	1938	1874	**1879**	0.3%	4.0%	2.0%
Saudi Arabia	10665	9709	9865	11079	11622	11393	11519	11998	12406	11892	**12287**	3.3%	1.5%	13.0%
United Arab Emirates	3113	2795	2937	3303	3440	3577	3603	3898	4038	3910	**3942**	0.8%	2.4%	4.2%
Total Middle East	**26506**	**24859**	**25626**	**28001**	**28493**	**28205**	**28490**	**30012**	**31818**	**31497**	**31762**	**0.8%**	**2.2%**	**33.5%**
Algeria	1951	1775	1689	1642	1537	1485	1589	1558	1577	1540	**1510**	-2.0%	-2.5%	1.6%
Angola	1876	1754	1812	1670	1734	1738	1701	1796	1745	1676	**1534**	-8.5%	0.1%	1.6%
Egypt	715	730	725	714	715	710	714	726	691	660	**670**	1.4%	-0.6%	0.7%
Libya	1875	1739	1799	516	1539	1048	518	437	412	929	**1010**	8.7%	-6.9%	1.1%
Nigeria	2172	2211	2533	2461	2412	2279	2276	2201	1900	1991	**2051**	3.0%	-1.0%	2.2%
Total Africa	**10299**	**9923**	**10227**	**8520**	**9270**	**8607**	**8216**	**8133**	**7643**	**8133**	**8193**	**0.7%**	**-2.3%**	**8.6%**
China	3814	3805	4077	4074	4155	4216	4246	4309	3999	3846	**3798**	-1.3%	0.3%	4.0%
India	818	838	901	937	926	926	905	893	874	884	**869**	-1.7%	1.2%	0.9%
Indonesia	1006	994	1003	952	917	883	847	838	876	838	**808**	-3.5%	-1.5%	0.9%
Malaysia	727	688	733	659	663	627	649	696	704	683	**682**	-0.1%	-0.6%	0.7%
Total Asia Pacific	**8095**	**8055**	**8463**	**8324**	**8411**	**8287**	**8313**	**8399**	**8044**	**7774**	**7633**	**-1.8%**	**-0.2%**	**8.1%**
Total World	**83069**	**81410**	**83255**	**84009**	**86228**	**86647**	**88736**	**91547**	**91822**	**92502**	**94718**	**2.4%**	**1.2%**	**100.0%**
OPEC	37290	34999	35894	36724	38292	37293	37228	38601	39736	39673	**39338**	-0.8%	0.9%	41.5%
Non-OPEC	45779	46412	47361	47285	47936	49354	51508	52946	52086	52828	**55380**	4.8%	1.3%	58.5%

+2,176 MMb/d

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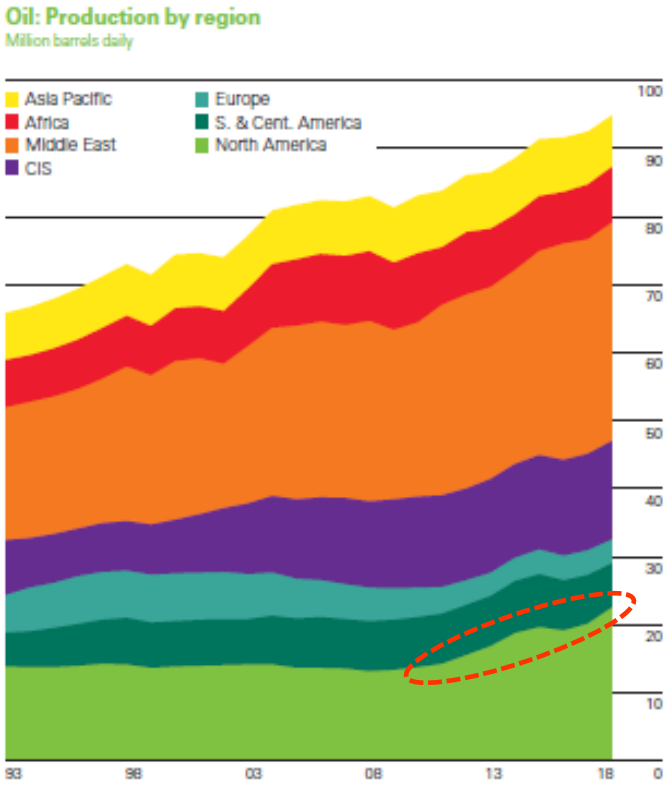
"Practical Strategies for Emerging Energy Technologies"

Source: BP Statistical Review of World Energy 2019

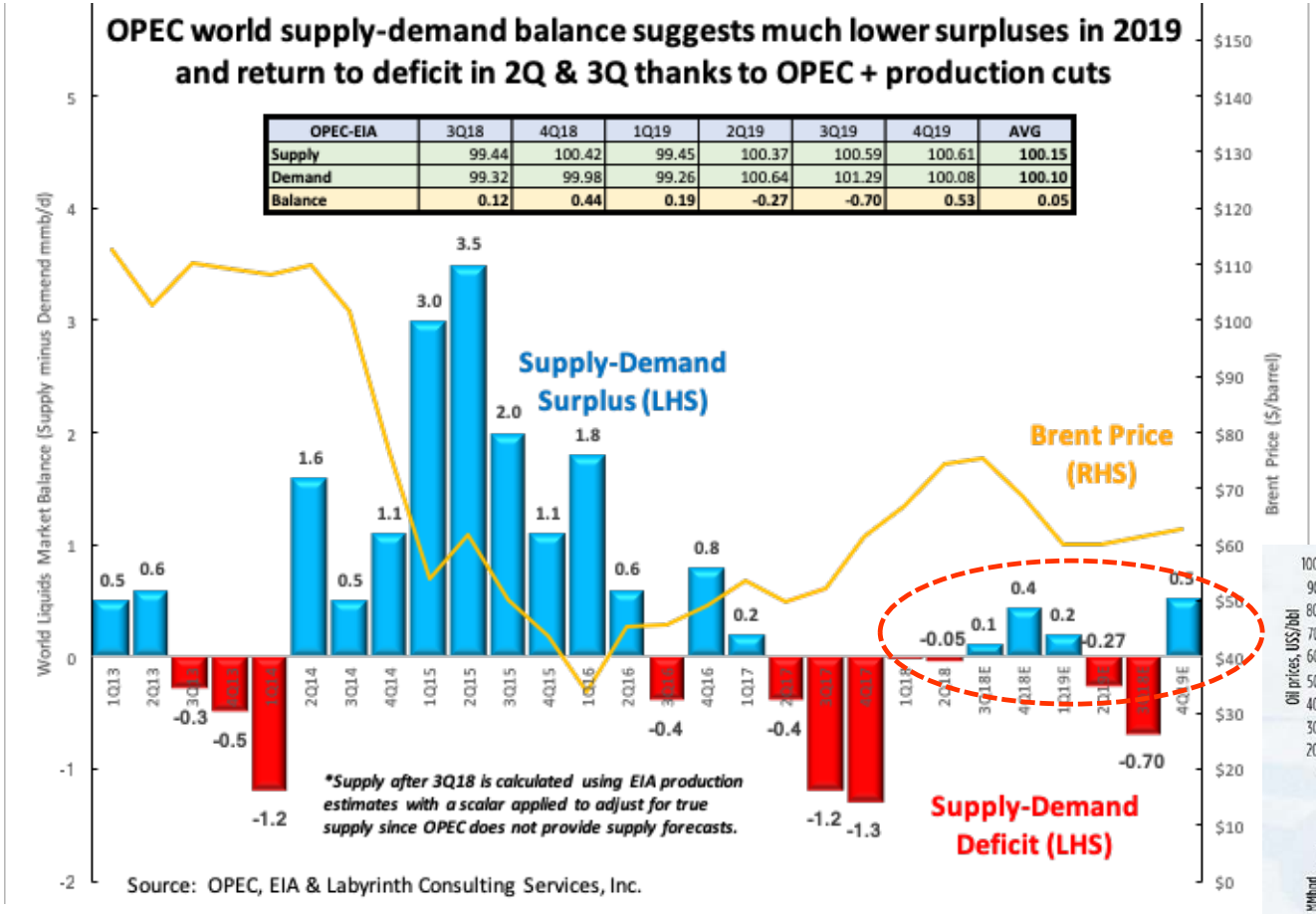
Oil Production

The U.S. is creating a problem for OPEC



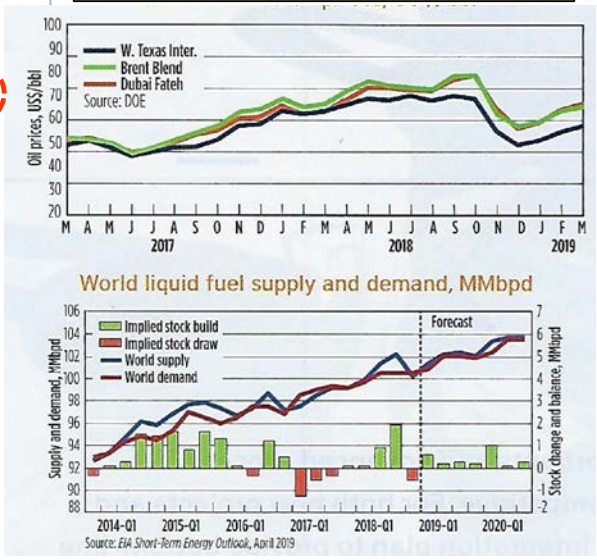
Source: BP Statistical Review of World Energy 2019

Oil Supply/Demand Forecast 3:Q:18



OPEC-EIA	3Q18	4Q18	1Q19	2Q19	3Q19	4Q19	AVG
Supply	99.44	100.42	99.45	100.37	100.59	100.61	100.15
Demand	99.32	99.98	99.26	100.64	101.29	100.08	100.10
Balance	0.12	0.44	0.19	-0.27	-0.70	0.53	0.05

Brent $65/bbl
WTI $60/bbl
Supply/Demand in balance



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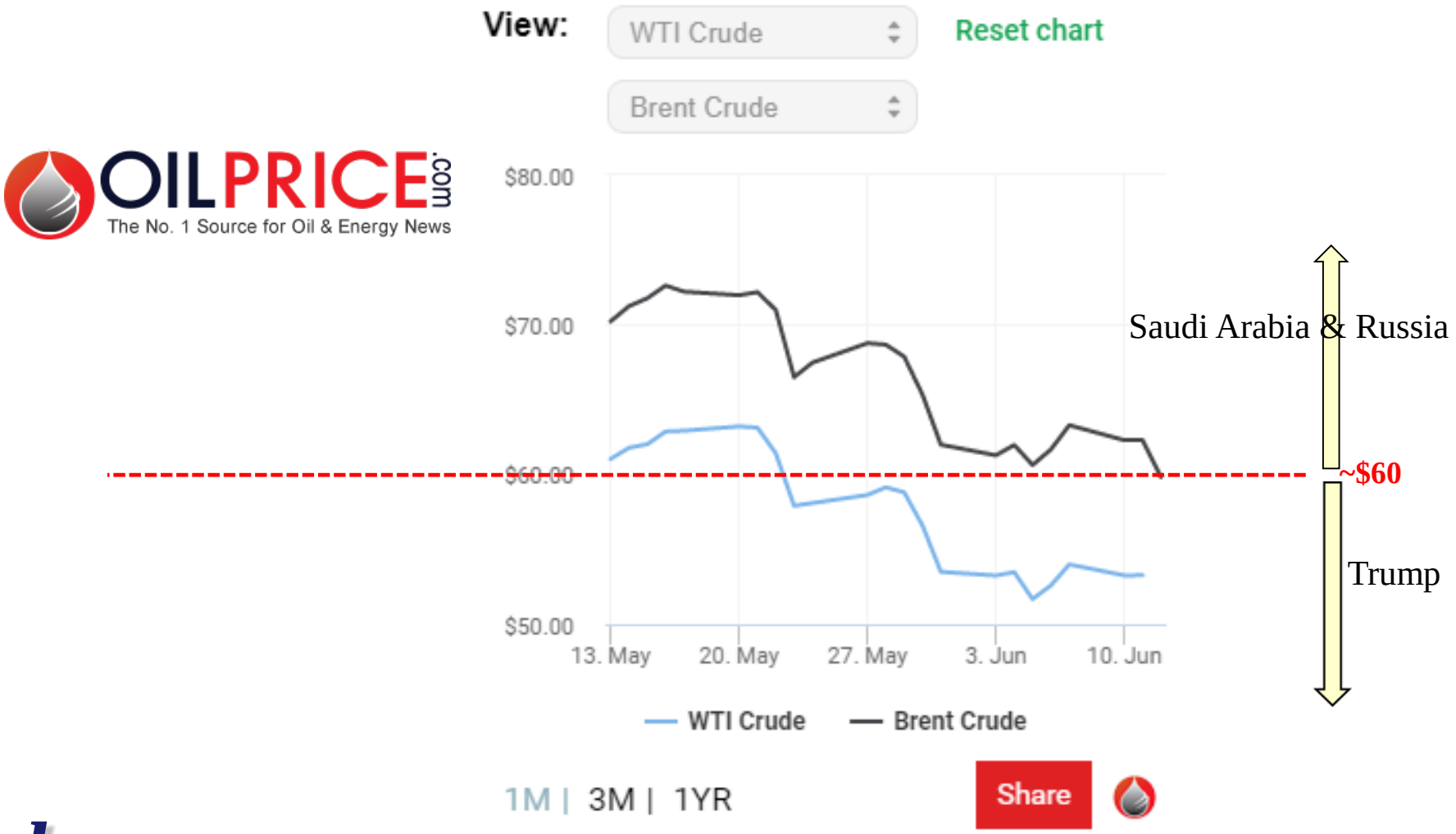
WTI $54/Brent $60/bbl – 6/12/19



Saudi Arabia Energy Minister Khalid al-Falih

- Saudi Arabia and other major producers will continue to act to cushion the market from oil price shocks
  - We could have another (round of) unanticipated disruptions that we have seen in Nigeria, Libya, Venezuela
  - Sanctions on Iran
  - India, the world's third-biggest oil importer, is grappling with a combination of rising oil prices and falling local currency

- Saudi Arabia has invested tens of billions of dollars to build spare capacity of 2-3 million barrels per day over years

- Saudi Arabia has the capacity to produce 12 million bpd and is currently producing 10.7 million bpd adding that production will rise further next month

- Saudi Arabia is committed to meeting India's rising oil demand and is the "shock absorber" for supply disruptions in the oil market

Energy Minister Khalid al-Falih at the IHS CERA conference - New Delhi (Reuters)

China Stopped Buying U.S. Oil in August 2018

- In 2017, China accounted for 20% of all U.S. oil exports.
- It played an out-sized role in the United States' fastest-growing significant export and trailed only Canada for market share.
- How fast-growing? Last year, the value of U.S. oil exports to the world grew 164% and "black gold" advanced 16 positions to rank as the nation's 11th most valuable export.
- This year, oil exports to the world are up a still-pretty-stunning 153% and oil is now the United States' third-leading export, by value.
- Year-to-date China is accounting for 18% of that total, and, still, only Canada is a larger purchaser.
- But for the month of August, the United States did not export oil to China. Not a drop.

CURRENT YEAR-TO-DATE (YTD) DATA IS THROUGH AUGUST 2018.

EXPORTS: OIL

Oil, the No. 5 export by value totaled $3.58 billion for the month of August, $28.33 billion through August of 2018, and $21.83 billion for all of 2017, the latest annual data available, according to U.S. Census Bureau data analyzed by WorldCity. Need more details? Read more

TOP MARKETS

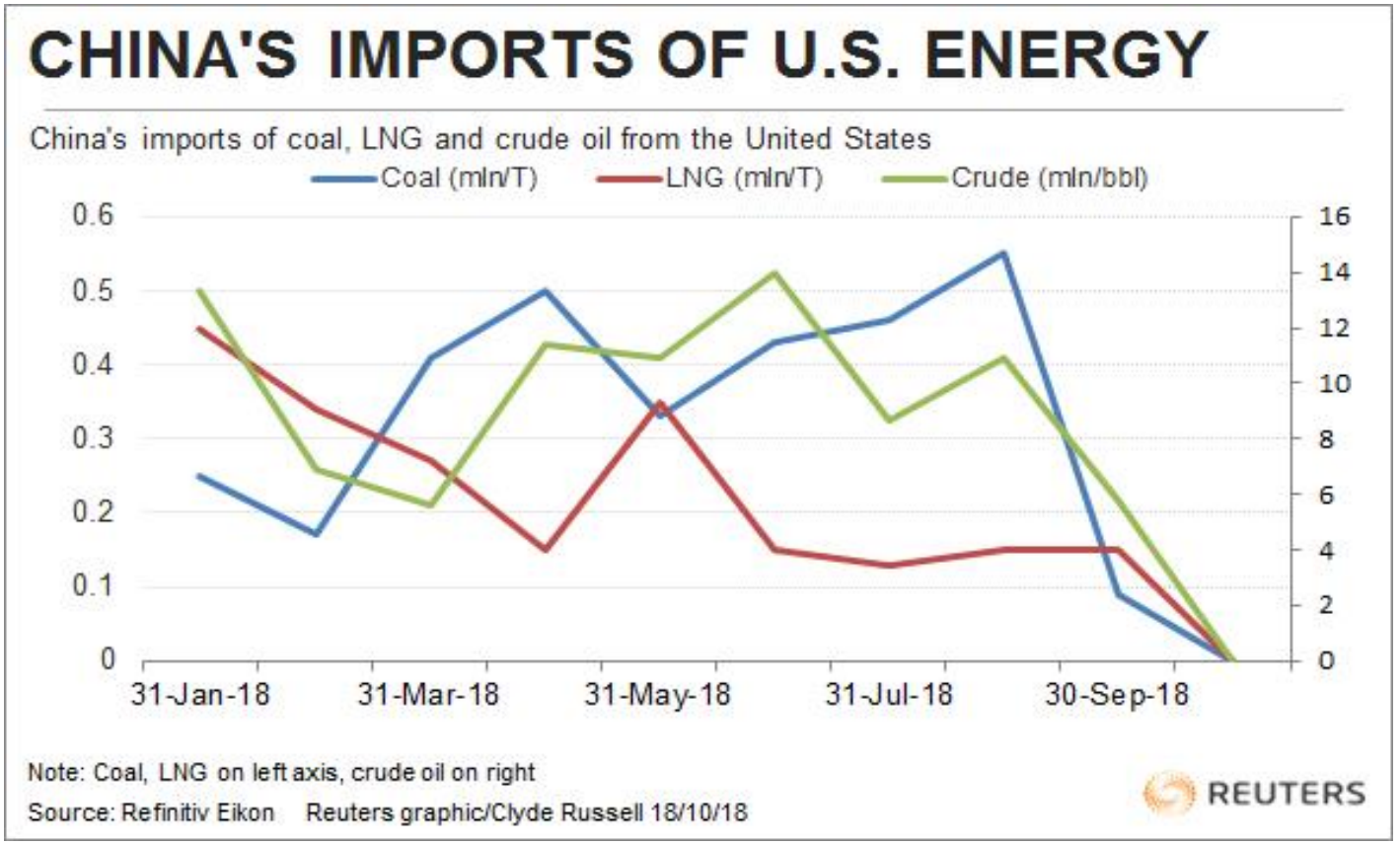
RANK	COUNTRY	YTD
1	Canada	$5.7 B
2	China	$5.22 B
3	Italy	$2.3 B
4	South Korea	$2.29 B
5	United Kingdom	$2.14 B
6	The Netherlands	$1.68 B
7	Taiwan	$1.62 B
8	India	$1.56 B
9	United Arab Emirates	$651.55 M
10	Norway	$610.13 M

TOP GATEWAYS

RANK	PORT	YTD
1	Port of Corpus Christi, Texas	$6.77 B
2	Port of Houston	$6.59 B
3	Port of Beaumont, Texas	$5.16 B
4	Port of Freeport, Texas	$1.49 B
5	Port of New Orleans	$1.4 B
6	Port of Texas City, Texas	$1.28 B
7	Port of Port Arthur, Texas	$1.01 B
8	Port of Southern Louisiana, Gramercy, St. James Parish	$937.17 M
9	Port Huron Blue Water Bridge, Mich.	$886.66 M
10	Rouses Point / Lacolle Border Crossing, N.Y.	$533.13 M

Oil Exports to China	August 2018	July 2018	June 2018
Total All U.S. Ports	$ -	$ 853,314,780	$ 1,025,764,923
Corpus Christi	$ -	$ -	$ 303,634,182
Beaumont, Texas	$ -	$ 323,938,346	$ 259,603,038
Port Houston	$ -	$ 152,542,034	$ 200,333,761
Texas City	$ -	$ -	$ 111,994,637
Freeport, Texas	$ -	$ 74,999,143	$ 73,986,480
Skagway, Alaska	$ -	$ -	$ 62,307,825
Portland, Oregon	$ -	$ -	$ 13,905,000

…..and, Other things



OPEC December 2018 - New “Oil Duopoly”

- Much has changed for OPEC since 2016:
  - Russia and Saudi Arabia ended their historic animosity and started to manage the market together.
  - The alliance has transformed the cartel into a duopoly in which the Kremlin is asserting its power.
  - Non-OPEC member Russia, which emerged as the key broker between arch rivals Saudi Arabia and Iran.
- Saudi Arabia, has been the head honcho of the oil world for nearly six decades; yet these days it seems unable to make a decision without Russia's blessing.
- Producers will use October production levels as a baseline for cuts and the agreement will be reviewed in April. Russia's contribution to the reduction is not yet known.
- Russia – “A de-facto member of OPEC?”

Iran Oil Exports

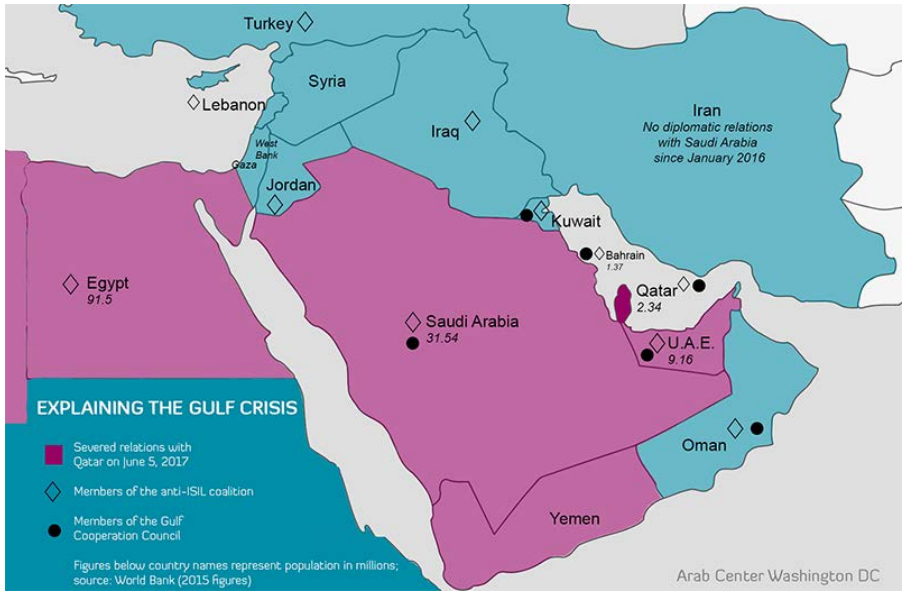
Japan, Korea, China, Turkey, India Waivers have been eliminated

Tariff ~~Threat~~ – US/China Crude & LNG trades at Risk

- Trump tweeted on May 5th that the 10% tariffs on $200 billion worth of Chinese goods will go up to 25% on Friday, and an additional $325 billion of Chinese goods imported into the US "remain untaxed, but will be shortly at a rate of 25%".
- If the tariffs were imposed, retaliatory action by China will mean that US crude and LNG flows into China attract a reciprocal 25% tariff. China does not currently impose tariffs on US crude imports, and implements a 10% tariff on US LNG.
- **Crude Flows at Risk**
  - Sinopec, bought two cargoes of US crude for delivery to China in late April and early May, its first such imports since September when purchases stopped due to trade tensions.
  - Sinopec has just completed its crude purchasing schedule for July arrivals, and the Sinopec Hainan refinery has secured 1 million barrels of US crude for July
  - "If the government adopts a tit-for-tat tariff approach and imposes additional tariffs on US crude, we may have to switch back to using West African crude," another source with a Sinopec refinery said separately.
  - Analysts said reciprocal tariffs by China will hurt the country's oil importers as they face higher feedstock costs than Asian refiners not affected by the trade war.
  - Additionally, the US has already narrowed China's options for crude oil sources with sanctions on Iran and Venezuela, while China's crude appetite is still increasing with new refining capacity coming on stream in the next two years.

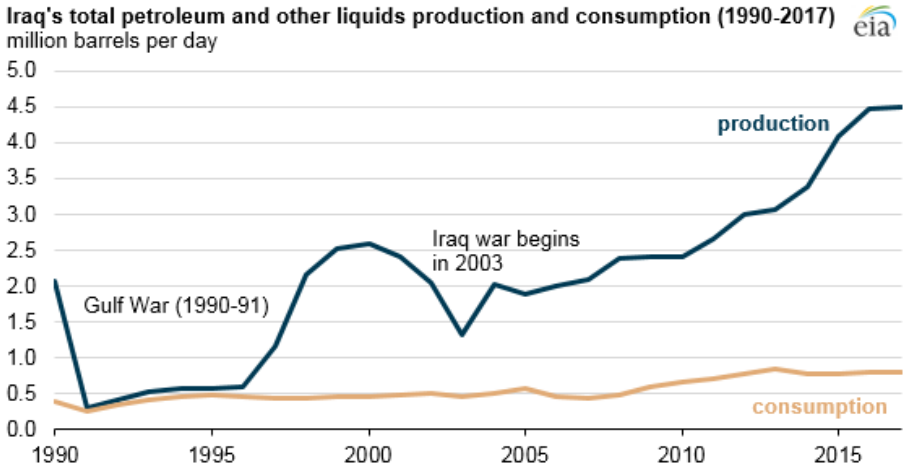
China and The Gulf Cooperation Council (GCC)

- The Gulf Cooperation Council—Kuwait, Saudi Arabia and the United Arab Emirates remain key suppliers; along with Iran & Iraq.
  - Kuwait's exports to China rose from 208,000 b/d in 2012 to 363,000 b/d in 2017
  - Export rates from Saudi Arabia and the UAE fluctuated slightly over the same period
  - Outside the GCC, Iran's sales to Chinese buyers rose from 438,000 b/d in 2012 to 621,000 b/d last year
  - Iraq's more than doubled from 313,000 b/d to 738,000 b/d.
- The Small Gulf producers
  - Oman's crude oil exports to China rose from 598,000 b/d in 2014 to 624,000 b/d in 2017
  - Qatar tripled its crude exports to China between 2014 and 2017, recording 21,000 b/d in the latter
  - Chinese companies are also active in Iraq, the Kurdish region of northern Iraq and the UAE, as well as Egypt, South Sudan and Algeria.



Iraq Production Nearly Doubled in Last Decade

- Crude oil production in Iraq averaged 4.5 million barrels per day (b/d) through August 2018, up from 4.4 million b/d in 2017.
- Iraq holds the world's fifth-largest proved crude oil reserves
- Iraq is the second-largest crude oil producer in the Organization of the Petroleum Exporting Countries (OPEC), after Saudi Arabia
  - 90% of Iraq's crude oil production comes from onshore oil fields in the southern part of the country under the control of the central government in Baghdad.
  - 10% of Iraqi crude oil production comes from oil fields in northern Iraq, mostly operated by the Kurdistan Regional Government (KRG).



Iraqi consumption of petroleum and other liquids has also been increasing over the past decade

Source: U.S. Energy Information Administration, International Energy Statistics

Nuclear

Nuclear Generation 1965-2018 – TWh

Terawatt-hours	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	Growth rate per annum 2018	Growth rate per annum 2007-17	Share 2018
Canada	0.1	1.0	11.8	35.7	60.5	72.5	97.2	72.3	91.4	90.0	92.9	94.2	102.7	106.5	101.1	100.4	100.4	**100.0**	-0.4%	0.8%	3.7%
US	3.8	23.0	181.6	264.3	403.9	607.2	708.8	793.6	823.1	849.4	831.8	809.8	830.5	839.1	839.1	848.1	847.3	**849.6**	0.3%	♦	31.4%
Total North America	**4.0**	**24.0**	**193.4**	**300.1**	**464.4**	**682.6**	**814.5**	**874.1**	**925.3**	**945.3**	**934.8**	**912.8**	**945.1**	**955.3**	**951.8**	**959.1**	**958.6**	**963.2**	**0.5%**	**0.1%**	**35.7%**
Total S. & Cent. America	**-**	**^**	**2.3**	**2.3**	**9.1**	**9.5**	**9.6**	**12.2**	**16.7**	**21.7**	**22.1**	**22.4**	**21.7**	**20.9**	**21.8**	**24.1**	**21.8**	**22.5**	**3.1%**	**1.1%**	**0.8%**
Belgium	-	0.1	6.8	12.5	34.6	42.7	41.4	48.2	47.6	47.9	48.2	40.3	42.6	33.7	26.1	43.5	42.2	**28.5**	-32.6%	-1.3%	1.1%
Czech Republic	-	-	-	-	2.4	12.6	12.2	13.6	24.7	28.0	28.3	30.3	30.7	30.3	26.8	24.1	28.3	**29.9**	5.6%	0.8%	1.1%
France	1.1	5.7	18.2	61.3	224.1	314.1	377.2	415.2	451.5	428.5	442.4	425.4	423.7	436.5	437.4	403.2	398.4	**413.2**	3.7%	-1.0%	15.3%
Germany	0.1	6.5	24.1	55.6	138.7	152.5	154.1	169.6	163.0	140.6	108.0	99.5	97.3	97.1	91.8	84.6	76.3	**76.1**	-0.3%	-5.9%	2.8%
Spain	-	0.9	7.5	5.2	28.0	54.3	55.5	62.2	57.5	61.6	57.7	61.5	56.7	57.3	57.3	58.6	58.1	**55.6**	-4.2%	0.5%	2.1%
Sweden	^	0.1	12.0	26.5	58.6	68.2	69.9	57.3	72.7	57.7	60.5	64.0	66.5	64.9	56.3	63.1	65.7	**68.6**	4.4%	-0.2%	2.5%
Switzerland	-	2.5	7.4	13.6	22.4	23.5	24.7	26.3	23.2	26.5	26.9	25.6	26.2	27.8	23.3	21.3	20.5	**25.7**	25.2%	-3.0%	1.0%
Ukraine	-	-	-	-	53.3	76.2	70.5	77.3	88.8	89.2	90.2	90.1	83.2	88.4	87.6	81.0	85.6	**84.4**	-1.4%	-0.8%	3.1%
United Kingdom	15.1	26.0	30.3	37.0	61.1	65.8	89.0	85.1	81.6	62.1	69.0	70.4	70.6	63.7	70.3	71.7	70.3	**65.1**	-7.5%	1.1%	2.4%
Total Europe	**19.9**	**45.4**	**115.6**	**238.2**	**695.6**	**894.4**	**977.0**	**1048.8**	**1110.2**	**1032.0**	**1024.2**	**998.4**	**986.5**	**992.7**	**968.3**	**942.2**	**936.1**	**937.5**	**0.1%**	**-1.2%**	**34.7%**
Russian Federation	n/a	n/a	n/a	n/a	99.3	118.3	99.5	130.7	149.4	170.4	172.9	177.5	172.5	180.8	195.5	196.6	203.1	**204.5**	0.7%	2.4%	7.6%
Total CIS	**1.9**	**4.4**	**28.6**	**73.9**	**104.6**	**118.3**	**99.9**	**132.7**	**152.2**	**172.9**	**175.5**	**179.8**	**174.9**	**183.2**	**198.3**	**199.0**	**205.8**	**206.6**	**0.4%**	**2.4%**	**7.6%**
Iran	-	-	-	-	-	-	-	-	-	-	0.1	1.5	4.3	4.1	3.5	6.6	7.1	**7.0**	-1.0%	♦	0.3%
Total Middle East	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.1**	**1.5**	**4.3**	**4.1**	**3.5**	**6.6**	**7.1**	**7.0**	**-1.0%**	**♦**	**0.3%**
Total Africa	**-**	**-**	**-**	**-**	**5.3**	**8.4**	**11.3**	**13.0**	**11.3**	**13.5**	**12.9**	**13.0**	**14.1**	**13.8**	**12.2**	**15.9**	**15.8**	**11.1**	**-29.6%**	**3.4%**	**0.4%**
China	-	-	-	-	-	-	12.8	16.7	53.1	73.9	86.4	97.4	111.6	132.5	170.8	213.3	248.1	**294.4**	18.6%	14.9%	10.9%
India	-	1.3	2.1	2.4	4.5	6.4	7.6	15.8	17.8	23.1	32.2	33.1	33.3	34.7	38.3	37.9	37.4	**39.1**	4.4%	7.7%	1.4%
Japan	^	3.3	21.7	82.6	159.6	194.6	286.9	319.1	293.0	292.4	162.9	18.0	14.6	-	4.5	17.7	29.1	**49.1**	68.9%	-20.2%	1.8%
South Korea	-	-	-	3.5	16.7	52.9	67.0	109.0	146.8	148.6	154.7	150.3	138.8	156.4	164.8	162.0	148.4	**133.5**	-10.1%	0.4%	4.9%
Taiwan	-	-	-	8.2	28.7	32.9	35.3	38.5	40.0	41.6	42.1	40.4	41.6	42.4	36.5	31.7	22.4	**27.7**	23.3%	-5.7%	1.0%
Total Asia Pacific	**^**	**4.6**	**24.5**	**96.8**	**209.9**	**287.1**	**410.2**	**500.0**	**553.3**	**581.9**	**482.2**	**344.6**	**345.2**	**370.7**	**419.7**	**468.3**	**493.8**	**553.6**	**12.1%**	**-1.0%**	**20.5%**
Total World	**25.8**	**78.4**	**364.4**	**711.4**	**1489.0**	**2000.5**	**2322.4**	**2580.9**	**2769.1**	**2767.5**	**2651.8**	**2472.4**	**2491.7**	**2540.8**	**2575.6**	**2615.2**	**2639.0**	**2701.4**	**2.4%**	**-0.4%**	**100.0%**

No Growth Between 2005-2018

- China 2007-17 CAGR 14.9%; 2018 +18.6%
- Iran shown for reference only
- U.S. more or less constant for 30 years

Source: BP Statistical Review of World Energy 2019

U.S. Announces China Export Policy – October 2018

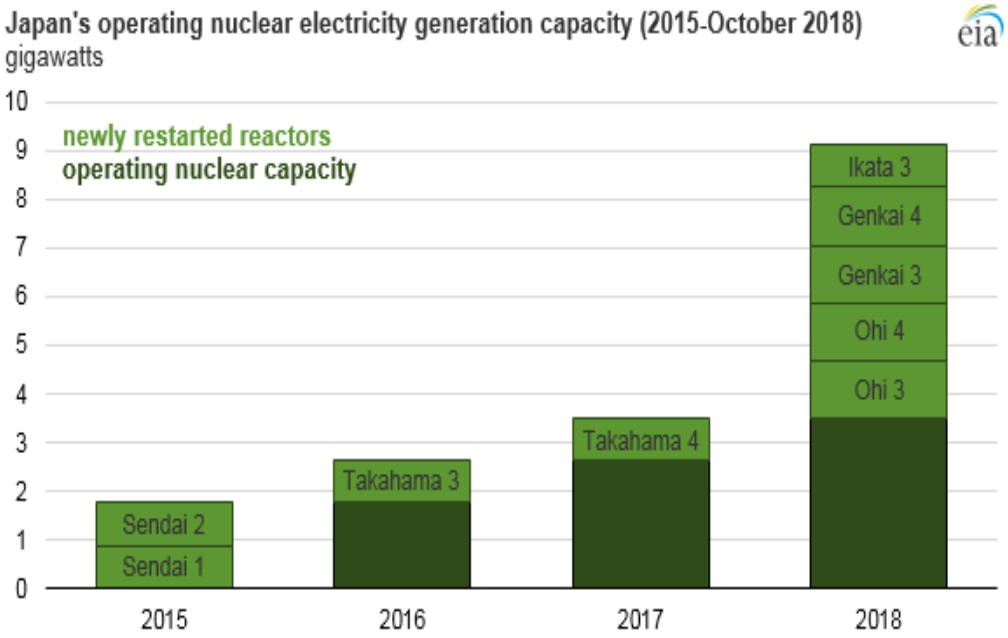
- For exports of technology, there will be a **presumption of approval**, contingent on end-user checks, for amendments or extensions for existing authorizations for technology transferred before 1 January 2018, with the exception of light water small modular reactors (SMR) and non-light water advanced reactors
- There is a **presumption of denial** for exports related to light water SMRs, non-light water advanced reactors, new technology transfers after 1 January 2018 and any transfer to China General Nuclear (CGN) and/or its subsidiaries or related entities.
- For equipment and components, there is **presumed approval** for requests for exports to support continued projects such as the construction of AP1000s and "major identical components" similar in type and technology level to those commonly available; and for SMRs and advanced reactors with no technology transfer other than installation and operation.
- There is a **presumption of denial** for requests related to "direct competition with the United States" such as the Hualong One reactor, and for any transfer to CGN and its subsidiaries and related companies.

There is a presumption of denial for exports related to light water SMRs, non-light water advanced reactors, and any transfer to China General Nuclear (CGN)

Westinghouse-designed AP1000s at Sanmen, China (Image: Westinghouse)

Japan Restarted Five Nuclear Power Reactors in 2018

- Shikoku Electric Power Co. restarted the 890 megawatt (MW) Ikata-3 reactor in Japan's Ehime Prefecture at the end of October, the **fifth nuclear reactor in Japan to be restarted in 2018**
- Following the Fukushima accident, Japan's entire reactor fleet was suspended from operation, leaving the country with no nuclear generation
- Sendai Units 1 and 2, in Japan's Kagoshima Prefecture, were the first reactors to be restarted in August and October 2015
- The **NRA issued more stringent safety regulations** to address issues dealing with tsunamis and seismic events, complete loss of station power, and emergency preparedness.



Scientists Urge Commitment To Nuclear

- Nuclear energy is recognized as one of the lowest carbon sources of electricity are 12g/kWh, similar to wind energy
- IPCC Summary include a **two-fold to six-fold increase in the use of nuclear power by 2050**
- The nuclear industry is currently undertaking a new wave of creative projects around innovative reactor technologies (e.g. Small Modular Reactors, Gen IV reactors), cross-cutting technologies and new applications all requiring significant R&D investment and new innovative approaches.
- Large proportion of the **R&D infrastructure are becoming obsolete** and needs to be renewed to support new wave of innovative reactors and radioisotopes needed for nuclear medicine.
- We ask that the Clean Energy Ministerial Conference takes nuclear innovation to broad multilateral discussions on clean energy so that nuclear energy can make its full expected contribution towards decarbonization goals.
- Commit to **doubling of public investment in nuclear-related R&D and innovation within the next five years**, with a focus on innovative applications of advanced nuclear systems to enable the clean energy mix of the future.
- ICAPP congresses are co-sponsored by the American Nuclear Society (ANS), the Atomic Energy Society of Japan (AESJ), the Korea Nuclear Society (KNS), the French Nuclear Society (SFEN) and a number of major international nuclear societies, including European Nuclear Society (ENS). At the latest congress of the 42 nuclear societies that signed the declaration represent 80,000 scientists.

Nuclear must be part of the Low Carbon Future

Coal

Coal Consumption 2018– 3772 Mtoe

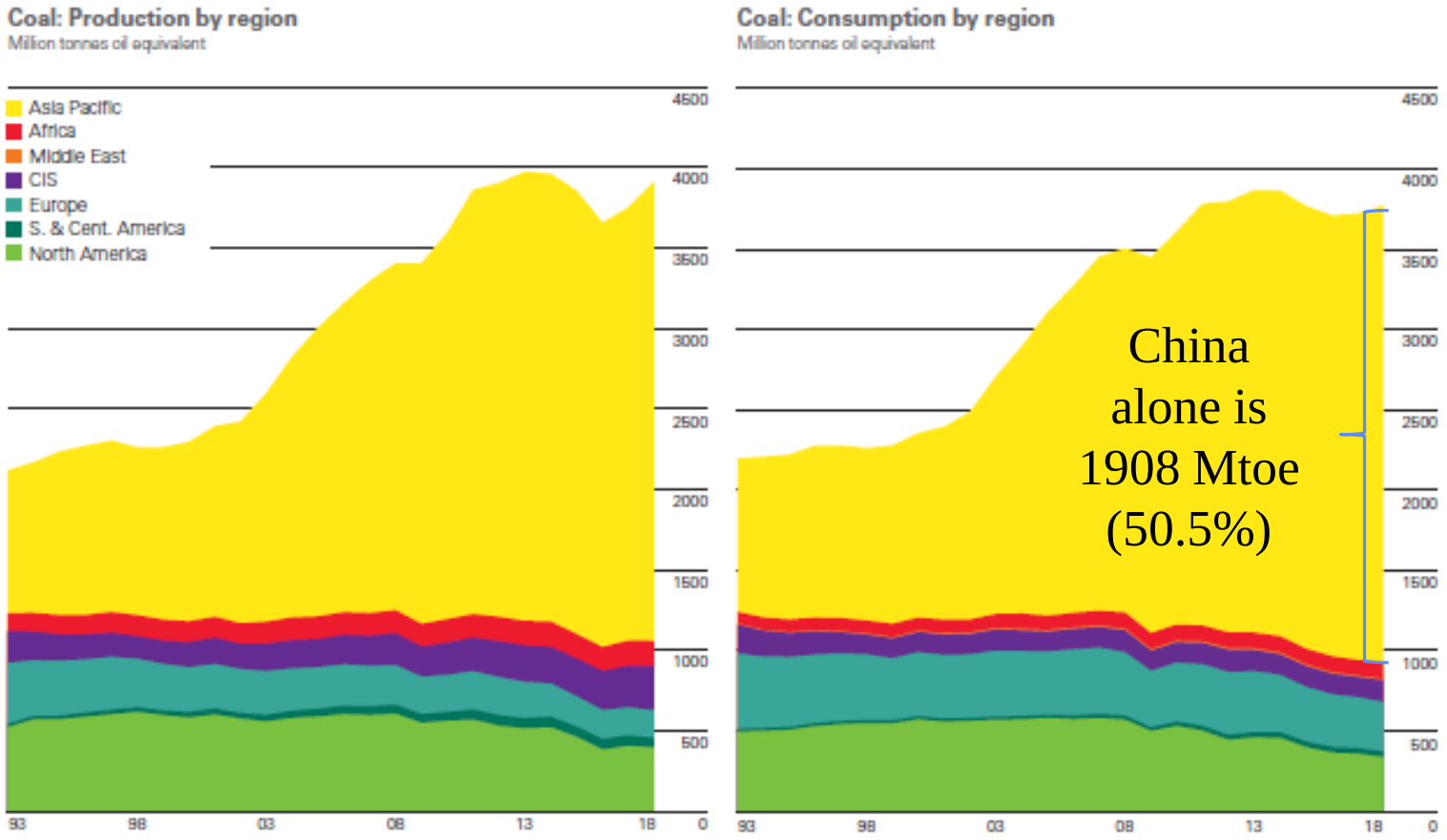
- Coal consumption increased by 14% in 2018
- India grew by 5.7%
- China grew by 0.9%
- Asia represents 75.3% of 2018
- China represents 50.5% of consumption in 2018

Million tonnes oil equivalent	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	Growth rate per annum 2018	Growth rate per annum 2007-17	Share 2018
US	535.9	471.4	498.8	470.6	416.0	431.8	430.9	372.2	340.6	331.3	**317.0**	-4.3%	-4.9%	8.4%
Total North America	**575.5**	**505.2**	**536.3**	**507.5**	**449.9**	**465.4**	**463.2**	**404.8**	**371.7**	**365.1**	**343.3**	**-6.0%**	**-4.6%**	**9.1%**
Total S. & Cent. America	**27.7**	**23.3**	**28.3**	**30.2**	**31.7**	**34.6**	**36.4**	**35.8**	**35.5**	**34.8**	**36.0**	**3.7%**	**2.9%**	**1.0%**
Germany	80.1	71.7	77.1	78.3	80.5	82.8	79.6	78.7	76.5	71.5	**66.4**	-7.2%	-1.9%	1.8%
Poland	55.2	51.8	55.1	55.0	51.2	53.4	49.4	48.7	49.5	49.8	**50.5**	1.5%	-1.2%	1.3%
Turkey	29.6	30.9	31.4	33.9	36.5	31.6	36.1	34.7	38.5	39.5	**42.3**	7.2%	3.0%	1.1%
Total Europe	**391.2**	**350.4**	**366.3**	**381.8**	**390.2**	**377.6**	**354.5**	**339.2**	**326.8**	**315.5**	**307.1**	**-2.7%**	**-2.6%**	**8.1%**
Kazakhstan	33.8	30.9	33.4	36.3	37.9	37.5	37.0	34.2	33.9	36.4	**40.8**	12.2%	1.6%	1.1%
Russian Federation	100.7	92.2	90.5	94.0	98.4	90.5	87.6	92.1	89.3	83.9	**88.0**	4.9%	-1.1%	2.3%
Total CIS	**137.2**	**125.6**	**126.4**	**133.2**	**139.6**	**131.4**	**128.3**	**130.0**	**128.3**	**126.4**	**134.9**	**6.7%**	**-0.1%**	**3.6%**
Total Middle East	**9.7**	**9.6**	**10.1**	**10.3**	**11.9**	**11.2**	**11.2**	**10.5**	**9.7**	**8.2**	**7.9**	**-2.7%**	**-1.9%**	**0.2%**
South Africa	93.3	93.8	92.8	90.5	88.3	88.4	89.5	85.2	86.9	84.3	**86.0**	2.0%	0.1%	2.3%
Total Africa	**101.4**	**101.0**	**100.1**	**98.4**	**96.0**	**97.2**	**101.9**	**97.7**	**99.1**	**97.6**	**101.4**	**3.9%**	**0.6%**	**2.7%**
Australia	58.2	56.3	52.2	50.9	47.8	45.4	45.0	46.5	46.5	45.1	**44.3**	-1.8%	-2.1%	1.2%
China	1609.3	1685.8	1748.9	1903.9	1927.8	1969.1	1954.5	1914.0	1889.1	1890.4	**1906.7**	0.9%	1.8%	50.5%
India	259.3	280.8	290.4	304.6	330.0	352.8	387.5	395.3	400.4	415.9	**452.2**	8.7%	5.7%	12.0%
Indonesia	31.5	33.2	39.5	46.9	53.0	57.0	45.1	51.2	53.4	57.2	**61.6**	7.7%	4.7%	1.6%
Japan	120.3	101.6	115.7	109.6	115.8	121.2	119.1	119.3	118.8	119.9	**117.5**	-2.1%	0.2%	3.1%
South Korea	66.1	68.6	77.1	83.7	80.6	81.5	84.4	85.4	81.5	86.2	**88.2**	2.4%	3.7%	2.3%
Taiwan	37.0	35.2	37.6	38.9	38.0	38.6	39.0	37.8	38.6	39.4	**39.3**	-0.3%	0.2%	1.0%
Total Asia Pacific	**2260.8**	**2335.5**	**2442.6**	**2621.1**	**2677.8**	**2749.7**	**2768.6**	**2751.0**	**2738.9**	**2770.8**	**2841.3**	**2.5%**	**2.3%**	**75.3%**
Total World	**3503.4**	**3450.6**	**3610.1**	**3782.5**	**3797.2**	**3867.0**	**3864.2**	**3769.0**	**3710.0**	**3718.4**	**3772.1**	**1.4%**	**0.7%**	**100.0%**

Source: BP Statistical Review of World Energy 2018

Coal - Regional Consumption - Mtoe

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

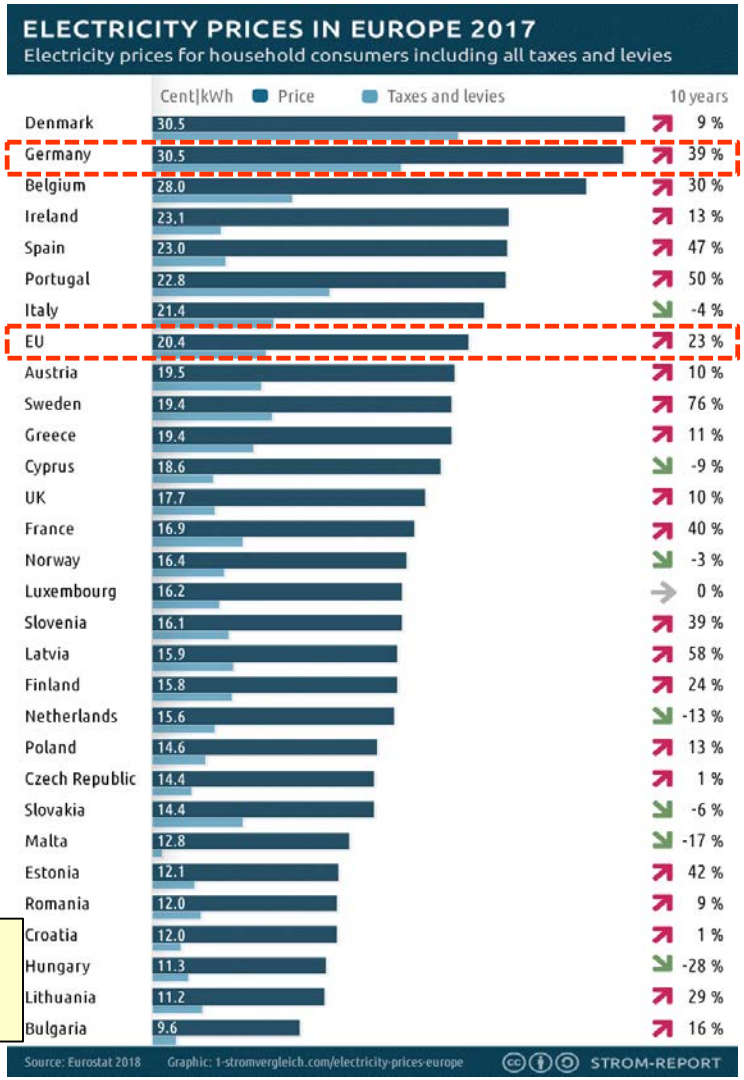


Source: BP Statistical Review of World Energy 2018

Germany to Close All 84 Coal-Fired Power Plants

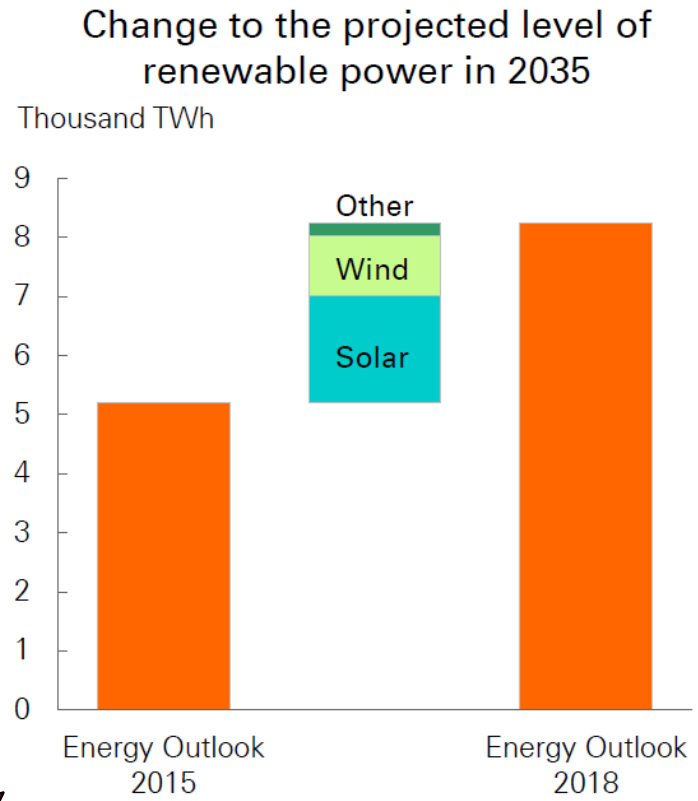
- Germany will shut down all 84 of its coal-fired power plants over the next 19 years to meet its international commitments in the fight against climate change
- The announcement marked a significant shift for Europe's largest country
  - Germany had long been a leader on cutting CO2 emissions
  - Before turning into a laggard in recent years and badly missing its reduction targets
  - Coal plants account for 40% of Germany's electricity
  - There won't be any more coal-burning plants in Germany by 2038
- The plan to eliminate coal-burning plants as well as nuclear means that Germany will be counting on renewable energy to provide 65% to 80% of the country's power by 2040
- Last year, renewables overtook coal as the leading source and now account for 41% of the country's electricity.

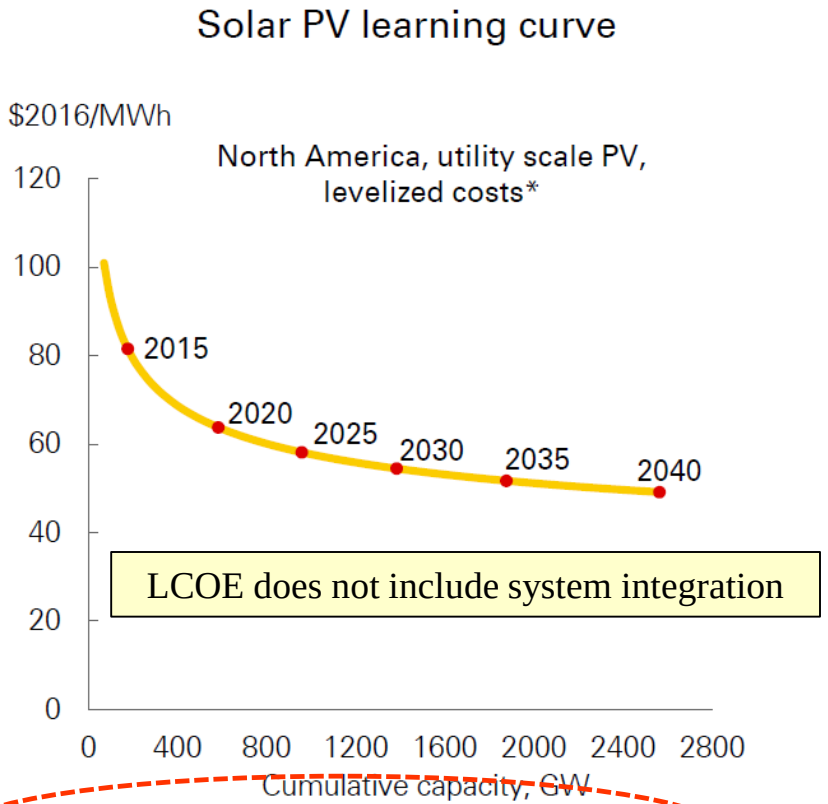
The Nuclear decision will be revisited
Note enormous price impact at 30 cents/kWh



Renewables

Renewables Outlook

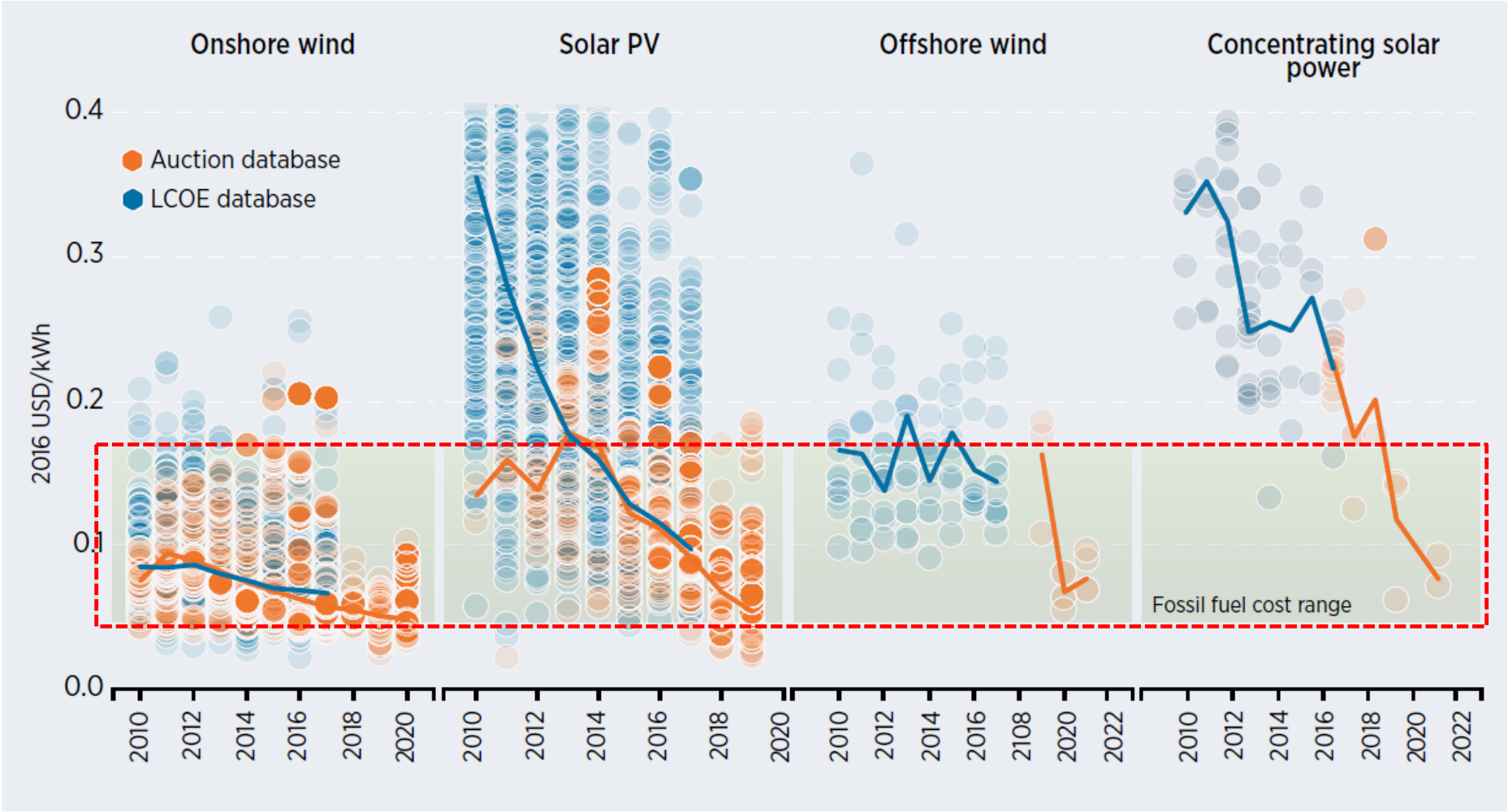




*Cost per MWh of building and operating a plant over its lifetime. Excludes subsidies, tariffs and the cost of grid integration.

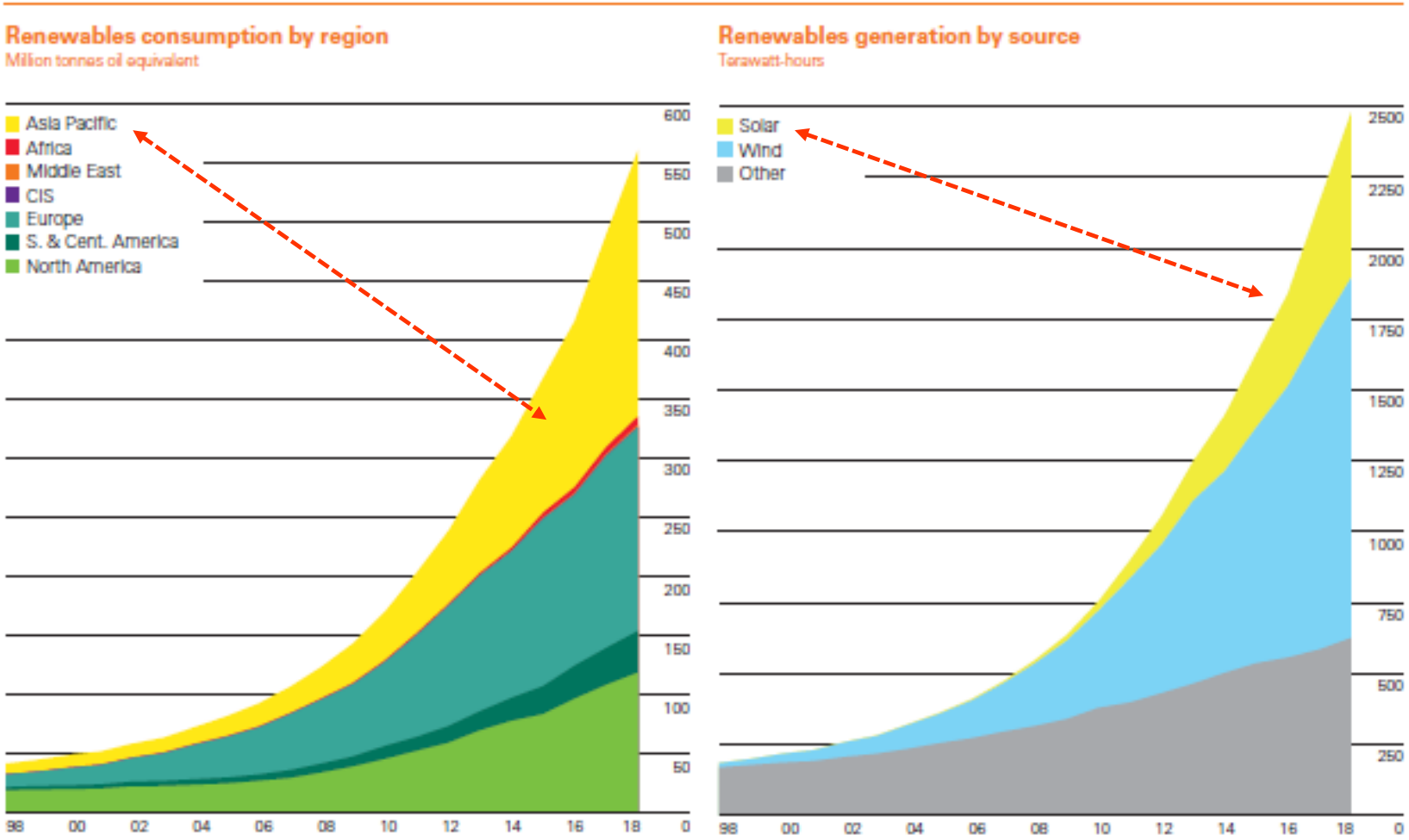
2018 BP Energy Outlook

Renewables Levelized Cost 2010 & 2014



Source: IRENA Renewable Cost Database and Auctions Database.

Renewables Adaptation



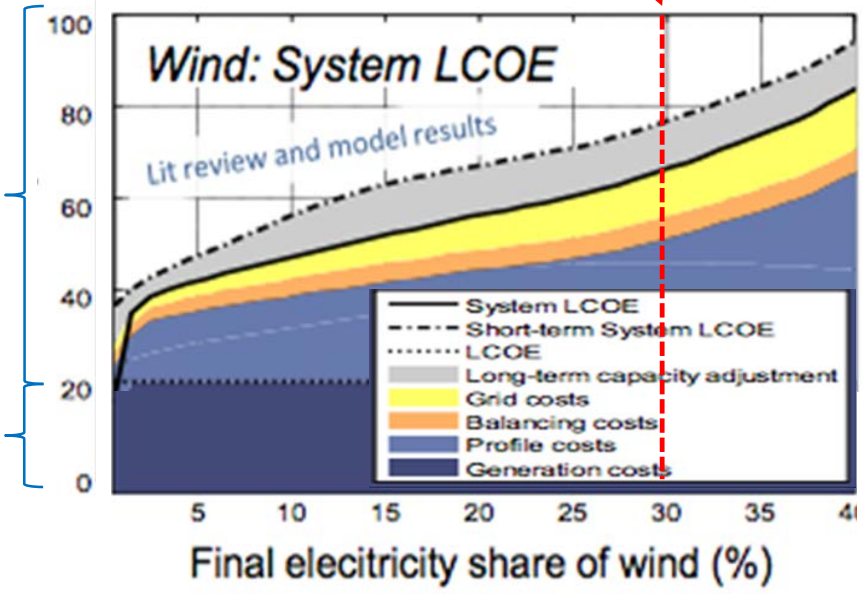
Wind System Integration Cost – "Eye-Balled"

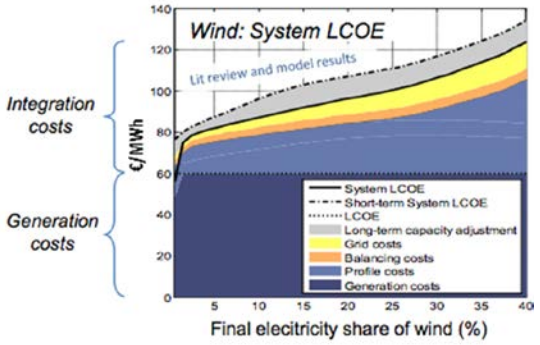
- Original slide (lower right) needed to be adjusted for lower wind generation costs
- I "eye-balled" this chart to adjust
- At a **30%** Renewable Portfolio Standard value
  - Generation is €20/MWh
  - Integration is €55/MWh
  - Total is €75/MWh (~$85/MWh)
- **The original study should be updated**

Who Pays for Renewables Integration????

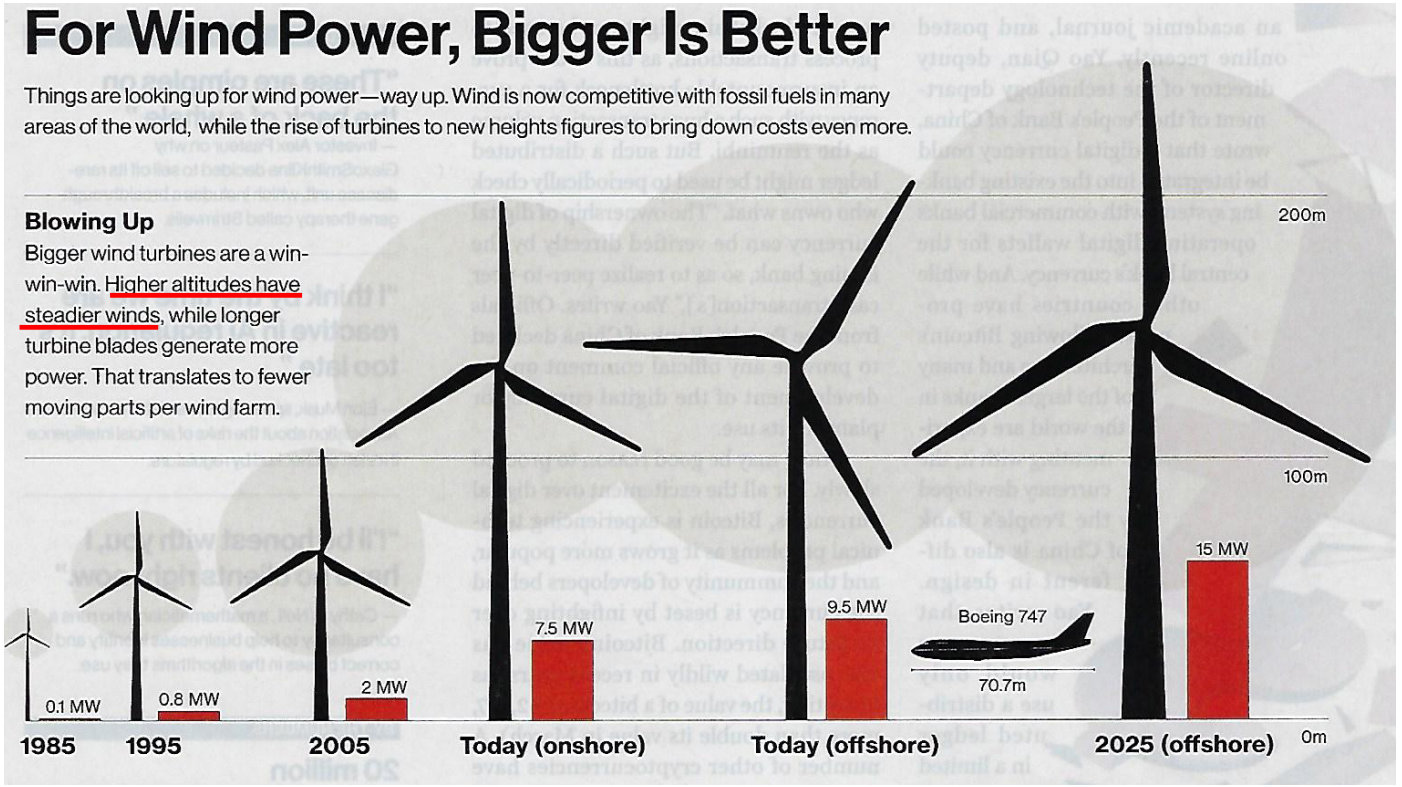
Integration Costs €/MWh

Generation Costs €/MWh

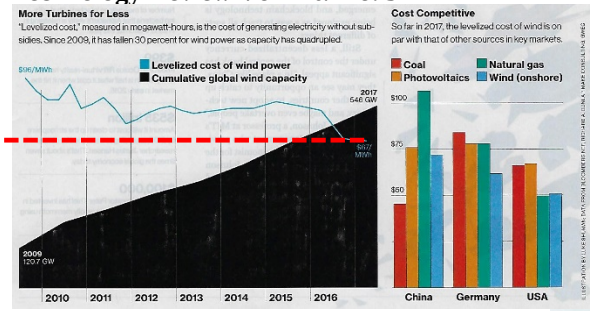




Wind



MIT Technology Review Vol 120/ No. 5

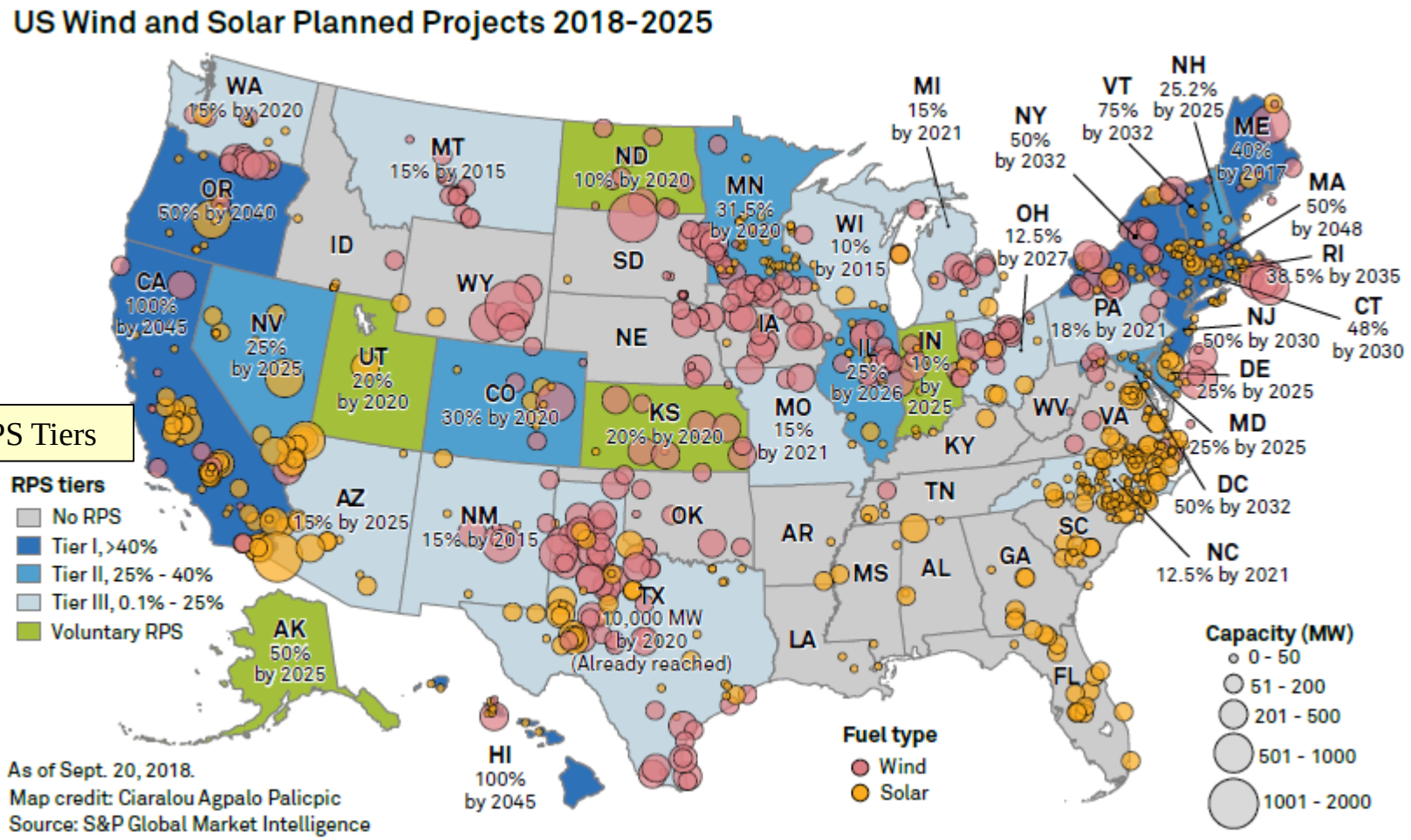


WIND CAPACITY FACTOR, ALL TURBINES, BY REGION

SPECIFIC POWER	WEST	NORTHEAST	GREAT LAKES	INTERIOR
Greater than 400 W/m²	22.8%	25.6%	15.4%	27.7%
350 to 400 W/m²	24.6%	25.0%	19.6%	29.3%
300 to 350 W/m²	24.9%	28.0%	30.0%	35.2%
250 to 300 W/m²	27.6%	29.8%	34.2%	40.4%
Less than 250 W/m²	32.6%	32.4%	37.4%	44.4%
REGIONAL AVERAGES	25.5%	27.9%	32.6%	37.9%

Source: 2017 Wind Technologies Market Report

Planned Wind & Solar Project 2018-2025



Note: RPS Tiers

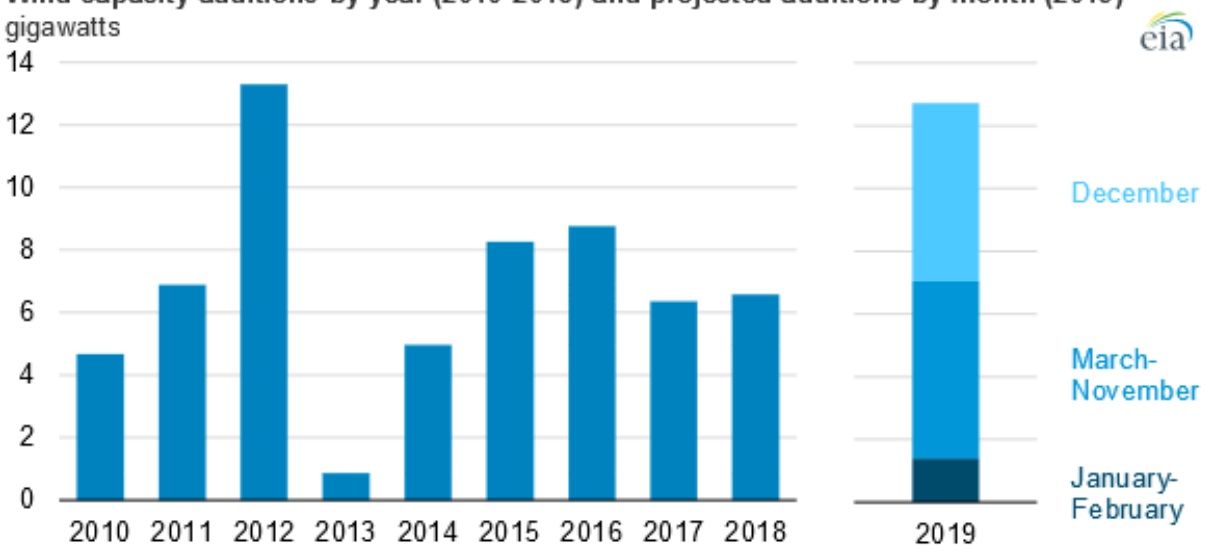
Phase Out of PTC in 2024

The Reality of Wind Subsidies (We pay for it!!!!)

MAY 15, 2019

Tax credit phaseout encourages more wind power plants to be added by end of year

Wind capacity additions by year (2010-2018) and projected additions by month (2019)

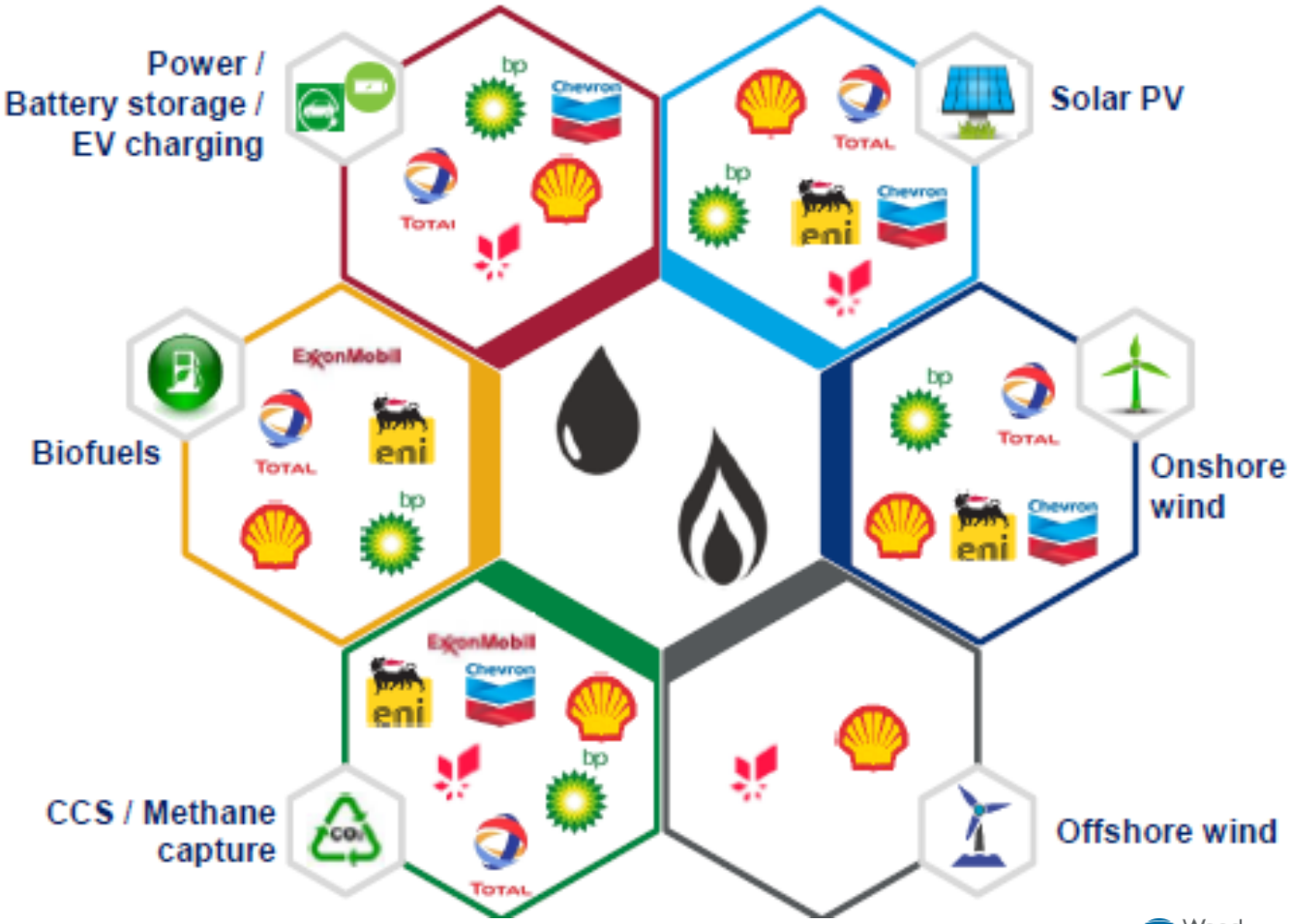


Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

Expiration Effect (election year)

- When renewed in 2013, the PTC provided a maximum tax credit for wind generation of 2.3 cents per kWh for the first 10 years of production
- Under the PTC phase-out, the amount of the tax credit decreases by 20 percentage points per year from 2017 through 2019
- Facilities that begin construction after December 31, 2019, will not be able to claim the PTC

Major Oil's Investments in Renewables



Wood Mackenzie
A Verisk Business

Natural Gas

Natural Gas Demand 2018 (+5.3%) – 3848.9 BCM

Billion cubic metres	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	Growth rate per annum 2018	Growth rate per annum 2007-17	Share 2018
Canada	89.3	86.6	88.3	97.5	97.2	104.3	109.6	109.8	105.9	109.7	**115.7**	5.5%	1.9%	3.0%
Mexico	60.0	65.2	66.0	70.8	73.7	77.8	78.8	80.8	83.0	86.4	**89.5**	3.6%	4.2%	2.3%
US	628.9	617.6	648.2	658.2	688.1	707.0	722.3	743.6	749.1	739.4	**817.1**	10.5%	1.7%	21.2%
Total North America	**778.2**	**769.4**	**802.5**	**826.6**	**859.0**	**889.1**	**910.7**	**934.1**	**938.0**	**935.5**	**1022.3**	**9.3%**	**1.9%**	**26.6%**
Argentina	43.2	41.8	42.1	43.8	45.7	46.0	46.2	46.7	48.2	48.3	**48.7**	0.8%	1.2%	1.3%
Total S. & Cent. America	**138.1**	**132.9**	**143.7**	**148.7**	**157.7**	**163.5**	**168.5**	**174.7**	**171.6**	**172.6**	**168.4**	**-2.5%**	**2.3%**	**4.4%**
France	46.4	44.7	49.6	43.0	44.4	45.1	37.9	40.8	44.5	44.8	**42.7**	-4.6%	♦	1.1%
Germany	89.5	84.4	88.1	80.9	81.1	85.0	73.9	77.0	84.9	89.7	**88.3**	-1.6%	0.1%	2.3%
Italy	80.9	74.3	79.1	74.2	71.4	66.7	59.0	64.3	67.5	71.6	**69.2**	-3.3%	-1.3%	1.8%
Turkey	35.3	33.7	35.8	41.8	43.3	44.0	46.6	46.0	44.5	51.6	**47.3**	-8.3%	4.3%	1.2%
United Kingdom	97.8	91.2	98.5	81.9	76.9	76.3	70.1	72.0	81.2	78.8	**78.9**	0.1%	-1.9%	2.0%
Total Europe	**625.6**	**577.1**	**622.6**	**580.1**	**565.4**	**554.4**	**500.0**	**508.8**	**537.6**	**560.4**	**549.0**	**-2.1%**	**-1.0%**	**14.3%**
Russian Federation	422.7	397.8	423.9	435.6	428.6	424.9	422.2	408.7	420.6	431.1	**454.5**	5.4%	0.1%	11.8%
Uzbekistan	44.1	44.1	44.0	47.4	46.2	46.2	48.5	46.3	43.3	43.1	**42.6**	-1.2%	-0.8%	1.1%
Total CIS	**521.3**	**499.9**	**531.3**	**549.5**	**545.2**	**537.3**	**539.9**	**530.0**	**537.7**	**549.3**	**580.8**	**5.7%**	**0.3%**	**15.1%**
Iran	125.8	134.8	144.4	153.2	152.5	153.8	173.4	184.0	196.3	209.9	**225.6**	7.4%	5.9%	5.9%
Qatar	20.7	21.3	25.4	28.7	33.6	35.6	38.6	42.5	40.4	43.1	**41.9**	-2.8%	8.4%	1.1%
Saudi Arabia	76.4	74.5	83.3	87.6	94.4	95.0	97.3	99.2	105.3	109.3	**112.1**	2.6%	4.4%	2.9%
United Arab Emirates	58.0	57.6	59.3	61.6	63.9	64.7	63.4	71.5	72.7	74.4	**76.6**	2.9%	4.5%	2.0%
Total Middle East	**337.1**	**347.3**	**380.1**	**398.1**	**410.8**	**423.3**	**447.5**	**478.3**	**500.9**	**527.0**	**553.1**	**4.9%**	**5.6%**	**14.4%**
Algeria	24.4	26.2	25.3	26.8	29.9	32.1	36.1	37.9	38.6	38.9	**42.7**	9.9%	5.2%	1.1%
Egypt	39.3	40.9	43.4	47.8	50.6	49.5	46.2	46.0	49.4	55.9	**59.6**	6.5%	4.2%	1.5%
Total Africa	**94.8**	**95.6**	**98.9**	**107.2**	**115.1**	**116.6**	**119.9**	**128.1**	**135.0**	**140.8**	**150.0**	**6.6%**	**4.5%**	**3.9%**
Australia	28.5	29.1	33.8	35.3	35.4	37.2	40.1	42.1	41.7	41.2	**41.4**	0.4%	3.6%	1.1%
China	81.9	90.2	108.9	135.2	150.9	171.9	188.4	194.7	209.4	240.4	**283.0**	17.7%	13.0%	7.4%
India	40.0	49.1	59.0	60.3	55.7	49.0	48.5	47.8	50.8	53.7	**58.1**	8.1%	3.3%	1.5%
Indonesia	39.7	42.1	44.0	42.7	42.9	41.4	41.5	41.0	39.1	38.5	**39.0**	1.1%	1.1%	1.0%
Japan	99.1	92.5	99.9	112.0	123.2	123.5	124.8	118.7	116.4	117.0	**115.7**	-1.1%	2.1%	3.0%
Malaysia	43.5	40.0	38.0	38.3	42.0	44.6	44.7	43.9	42.4	41.8	**41.3**	-1.2%	0.3%	1.1%
Pakistan	34.6	34.7	35.3	35.3	36.6	35.6	35.0	36.5	38.7	40.7	**43.6**	7.0%	1.9%	1.1%
South Korea	37.3	35.5	45.0	48.4	52.5	55.0	50.0	45.6	47.6	49.8	**55.9**	12.4%	3.2%	1.5%
Thailand	36.9	38.1	43.2	44.3	48.6	48.9	49.9	51.0	50.6	50.1	**49.9**	-0.3%	3.6%	1.3%
Total Asia Pacific	**503.7**	**515.6**	**577.6**	**623.1**	**664.3**	**685.5**	**706.2**	**712.5**	**729.3**	**768.3**	**825.3**	**7.4%**	**5.0%**	**21.4%**
Total World	**2998.8**	**2937.8**	**3156.7**	**3233.3**	**3317.5**	**3369.8**	**3392.6**	**3466.5**	**3550.2**	**3654.0**	**3848.9**	**5.3%**	**2.2%**	**100.0%**

Source: BP Statistical Review of World Energy 2019

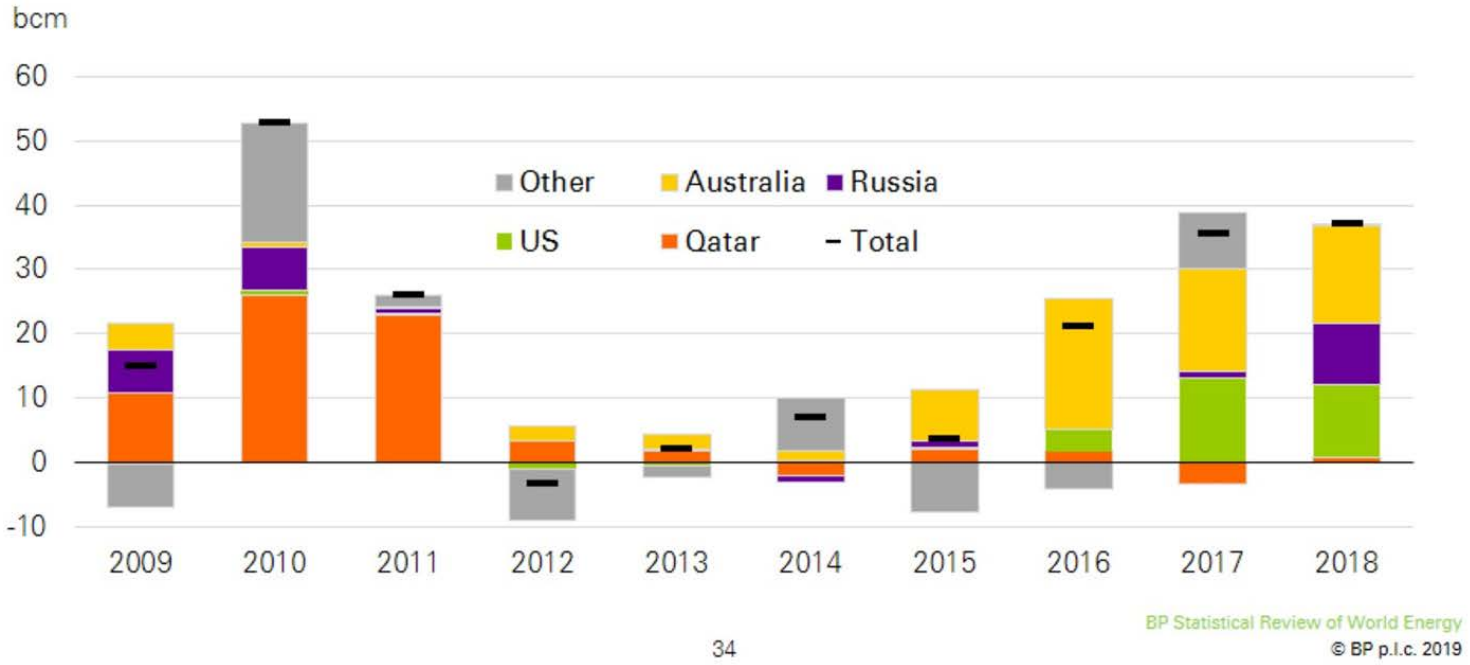
Natural Gas Production 2018 (+5.2%) – 3867.9BCM

Billion cubic metres	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	Growth rate per annum 2018	Growth rate per annum 2007-17	Share 2018
Canada	166.5	155.1	149.6	151.1	150.3	151.9	159.0	160.8	171.8	177.6	**184.7**	4.0%	0.2%	4.8%
Mexico	47.2	52.6	51.2	52.1	50.9	52.5	51.3	47.9	43.7	38.3	**37.4**	-2.4%	-2.0%	1.0%
US	546.1	557.6	575.2	617.4	649.1	655.7	704.7	740.3	727.4	745.8	**831.8**	11.5%	3.6%	21.5%
Total North America	**759.8**	**765.2**	**775.9**	**820.5**	**850.3**	**860.1**	**915.0**	**949.0**	**942.8**	**961.6**	**1053.9**	**9.6%**	**2.6%**	**27.2%**
Argentina	42.8	40.3	39.0	37.7	36.7	34.6	34.5	35.5	37.3	37.1	**39.4**	6.1%	-1.6%	1.0%
Trinidad & Tobago	37.4	38.6	40.3	38.7	38.5	38.7	38.1	36.0	31.3	31.9	**34.0**	6.6%	-1.7%	0.9%
Venezuela	33.4	31.8	30.5	30.2	31.9	30.6	31.8	36.1	37.2	38.6	**33.2**	-13.9%	0.4%	0.9%
Total S. & Cent. America	**157.9**	**152.3**	**160.4**	**164.1**	**170.6**	**173.8**	**176.0**	**178.0**	**176.7**	**180.3**	**176.7**	**-2.0%**	**1.4%**	**4.6%**
Norway	99.4	103.6	106.4	100.5	113.9	107.9	108.0	116.2	115.9	123.2	**120.6**	-2.1%	3.2%	3.1%
United Kingdom	72.8	61.2	57.9	46.1	39.2	37.0	37.4	40.7	41.7	41.9	**40.6**	-3.1%	-5.7%	1.0%
Total Europe	**321.0**	**304.1**	**310.7**	**285.5**	**288.1**	**280.6**	**267.5**	**261.7**	**260.5**	**263.2**	**250.7**	**-4.8%**	**-1.5%**	**6.5%**
Russian Federation	611.5	536.2	598.4	616.8	601.9	614.5	591.2	584.4	589.3	635.6	**669.5**	5.3%	0.6%	17.3%
Turkmenistan	61.6	33.3	40.1	56.3	59.0	59.0	63.5	65.9	63.2	58.7	**61.5**	4.8%	-0.5%	1.6%
Uzbekistan	61.0	58.4	57.1	56.6	56.5	55.9	56.3	53.6	53.1	53.4	**56.6**	6.1%	-1.0%	1.5%
Total CIS	**768.6**	**663.2**	**732.7**	**766.2**	**754.3**	**768.5**	**751.4**	**745.0**	**747.2**	**789.1**	**831.1**	**5.3%**	**0.5%**	**21.5%**
Iran	123.6	135.7	143.9	151.0	156.9	157.5	175.5	183.5	199.3	220.2	**239.5**	8.8%	6.4%	6.2%
Qatar	79.7	92.4	123.1	150.4	162.5	168.2	169.6	175.0	173.8	172.4	**175.5**	1.8%	10.2%	4.5%
Saudi Arabia	76.4	74.5	83.3	87.6	94.4	95.0	97.3	99.2	105.3	109.3	**112.1**	2.6%	4.4%	2.9%
United Arab Emirates	49.0	47.6	50.0	51.0	52.9	53.2	52.9	58.7	60.3	62.0	**64.7**	4.4%	2.4%	1.7%
Total Middle East	**392.3**	**413.8**	**474.7**	**520.0**	**545.5**	**562.9**	**582.7**	**600.3**	**624.1**	**650.4**	**687.3**	**5.7%**	**6.0%**	**17.8%**
Algeria	82.6	76.6	77.4	79.6	78.4	79.3	80.2	81.4	91.4	93.0	**92.3**	-0.7%	1.3%	2.4%
Egypt	56.8	60.3	59.0	59.1	58.6	54.0	47.0	42.6	40.3	48.8	**58.6**	20.0%	-0.9%	1.5%
Nigeria	32.8	23.2	30.9	36.4	39.2	33.1	40.0	48.0	46.2	48.1	**49.2**	2.4%	3.6%	1.3%
Total Africa	**203.8**	**192.1**	**202.3**	**201.7**	**206.8**	**198.3**	**198.6**	**203.6**	**208.8**	**225.7**	**236.6**	**4.8%**	**1.4%**	**6.1%**
Australia	41.7	46.7	54.0	55.7	59.5	61.8	66.6	76.0	96.4	112.8	**130.1**	15.3%	10.2%	3.4%
China	80.9	85.9	96.5	106.2	111.5	121.8	131.2	135.7	137.9	149.2	**161.5**	8.3%	7.9%	4.2%
Indonesia	74.8	78.0	87.0	82.7	78.3	77.6	76.4	76.2	75.1	72.9	**73.2**	0.4%	♦	1.9%
Malaysia	69.2	66.9	65.8	67.0	69.3	72.9	72.0	73.9	72.4	74.5	**72.5**	-2.6%	1.0%	1.9%
Thailand	29.8	32.0	37.5	38.3	42.9	43.3	43.6	41.2	40.4	38.7	**37.7**	-2.6%	3.7%	1.0%
Total Asia Pacific	**426.3**	**447.9**	**494.3**	**499.1**	**508.4**	**518.9**	**539.8**	**564.1**	**581.6**	**607.5**	**631.7**	**4.0%**	**4.1%**	**16.3%**
Total World	**3029.8**	**2938.6**	**3151.0**	**3257.0**	**3323.8**	**3363.1**	**3431.1**	**3501.7**	**3541.7**	**3677.7**	**3867.9**	**5.2%**	**2.3%**	**100.0%**

Source: BP Statistical Review of World Energy 2018

Annual Increase in LNG Exports

Qatar First, now Australia and US, with Russia Emerging



LNG Imports 2018 – 431BCM

Pipeline trade grew	3.7%
LNG trade grew	9.4%
Consumption grew	5.9%

												Growth rate per annum		Share
Billion cubic metres	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	2018	2007-17	2018
Mexico	3.8	3.7	6.1	3.8	4.9	7.8	9.3	6.8	5.6	6.6	**6.9**	4.2%	11.3%	1.6%
Total North America	13.5	17.3	20.2	16.8	11.4	11.4	11.5	10.0	8.3	9.2	**9.6**	5.0%	-9.1%	2.2%
Total S. & Cent. America	1.8	3.5	9.2	9.9	14.6	18.1	19.6	18.9	15.2	13.5	**14.5**	7.6%	27.9%	3.4%
France	12.8	13.3	14.7	14.4	9.8	8.3	6.9	6.4	9.1	10.9	**13.1**	20.8%	-1.9%	3.1%
Italy	1.6	3.0	9.3	9.1	7.1	5.8	4.5	5.9	5.9	8.2	**8.0**	-1.8%	12.4%	1.9%
Spain	29.8	27.5	28.2	23.9	21.4	15.7	16.2	13.7	13.8	16.6	**15.0**	-9.2%	-4.1%	3.5%
Turkey	5.6	6.0	7.8	5.9	7.6	5.9	7.1	7.5	7.6	10.9	**11.5**	6.1%	6.8%	2.7%
United Kingdom	0.8	10.1	18.8	24.7	13.9	9.2	11.2	13.7	10.8	7.2	**7.3**	1.5%	18.3%	1.7%
Other EU	3.7	3.7	3.9	4.9	4.4	3.7	3.3	5.2	6.9	10.2	**12.8**	25.3%	10.8%	3.0%
Total Europe	57.4	70.5	89.1	89.2	68.2	51.8	52.1	56.0	56.5	65.3	**71.5**	9.6%	1.8%	16.6%
Kuwait	-	0.9	2.8	3.0	2.8	2.3	3.6	4.3	4.7	4.8	**4.3**	-10.0%	n/a	1.0%
Total Middle East & Africa	-	0.9	3.0	4.4	4.2	4.3	5.3	13.7	24.5	21.4	**12.5**	-41.3%	n/a	2.9%
China	4.6	8.0	13.0	16.9	20.1	25.1	27.3	27.0	36.8	52.9	**73.5**	38.8%	29.3%	17.0%
India	11.3	13.0	11.5	17.4	18.4	18.0	19.1	20.0	24.3	26.1	**30.6**	17.0%	9.6%	7.1%
Japan	95.4	88.9	96.4	108.6	119.8	120.4	121.8	115.9	113.6	113.9	**113.0**	-0.9%	2.2%	26.2%
Pakistan	-	-	-	-	-	-	-	1.5	4.0	6.1	**9.4**	54.2%	n/a	2.2%
Singapore	-	-	-	-	-	1.3	2.6	3.0	3.2	4.1	**4.5**	8.6%	n/a	1.0%
South Korea	38.3	35.3	45.0	47.7	49.7	55.3	51.8	45.8	46.3	51.4	**60.2**	17.1%	3.6%	14.0%
Taiwan	12.6	12.4	15.0	16.3	17.1	17.2	18.6	19.6	20.4	22.7	**22.8**	0.5%	7.1%	5.3%
Thailand	-	-	-	1.1	1.4	2.0	1.9	3.6	3.9	5.2	**6.2**	19.1%	n/a	1.4%
Total Asia Pacific	162.2	157.5	180.9	207.9	226.6	241.2	245.2	238.5	253.9	284.6	**322.8**	13.4%	6.3%	74.9%
Total World	**234.9**	**249.7**	**302.4**	**328.3**	**324.9**	**326.8**	**333.6**	**337.1**	**358.3**	**393.9**	**431.0**	**9.4%**	**5.4%**	**100.0%**

LNG Trade represents approximately 11% of the consumption
Japan, China & Korea represent almost 55% of all LNG Imports

Source: BP Statistical Review of World Energy 2018

Global LNG Demand Growth

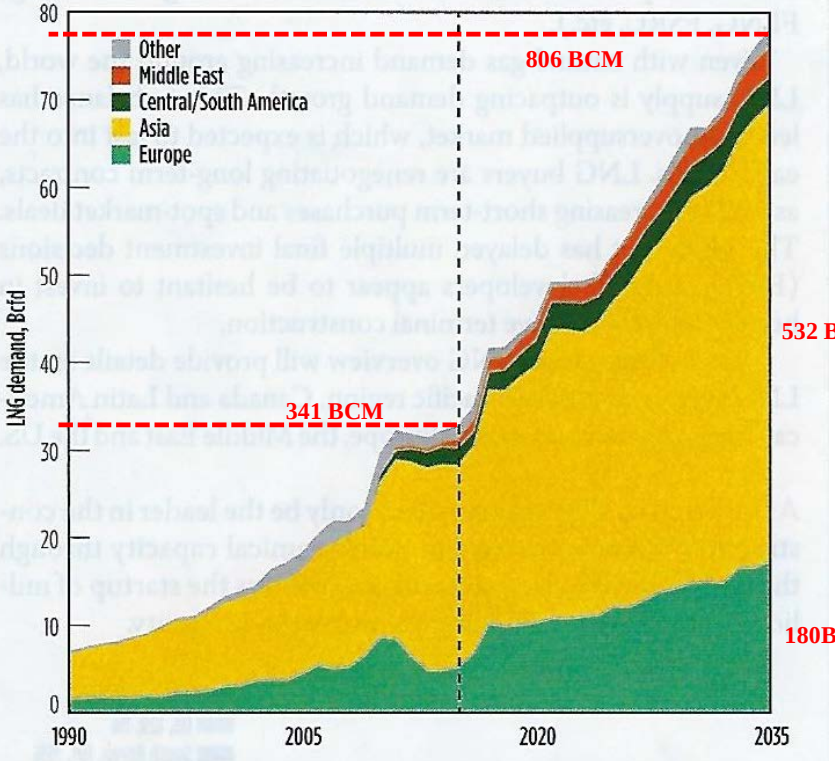


FIG. 3. Global growth in LNG demand to 2035. Source: BP.

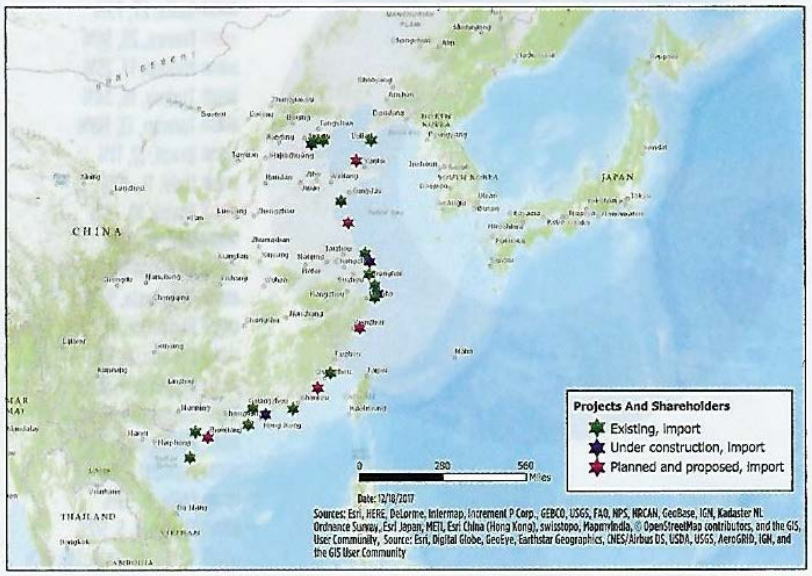
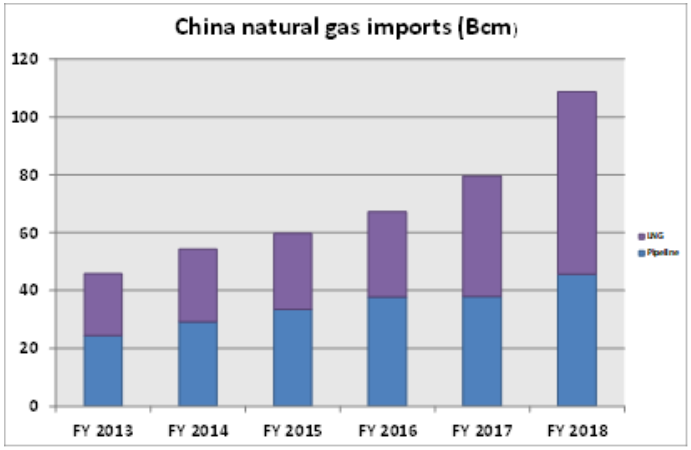


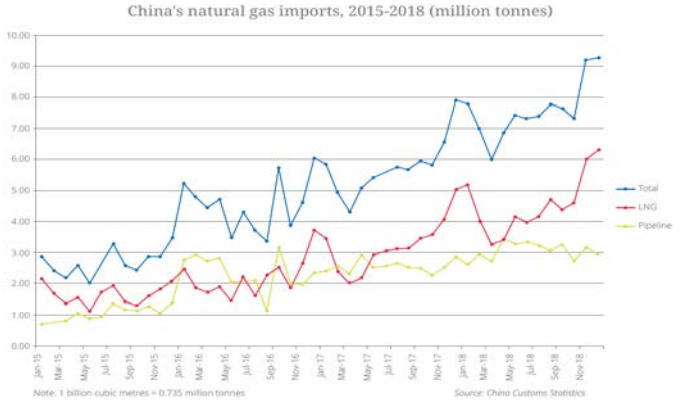
FIG. 4. LNG import terminals in China. Source: Energy Web Atlas.

China Natural Gas Imports – 2015-2018

- The growth in China's LNG imports is driven by government policy
- The outlook for LNG as changed dramatically in the last two years as China has more than doubled its LNG imports
- Average Chinese LNG import prices in September 2018 were US$9.89 per mmBtu, up by 37% on prices in 2016.
- It looks as though the trend will continue through 2019 as China chases its domestic clean-air goals, despite mistakes along the way
- Last year overly ambitious targets to replace coal led to gas shortages in the winter in northern China with serious consequences such as school students suffering from frostbite.

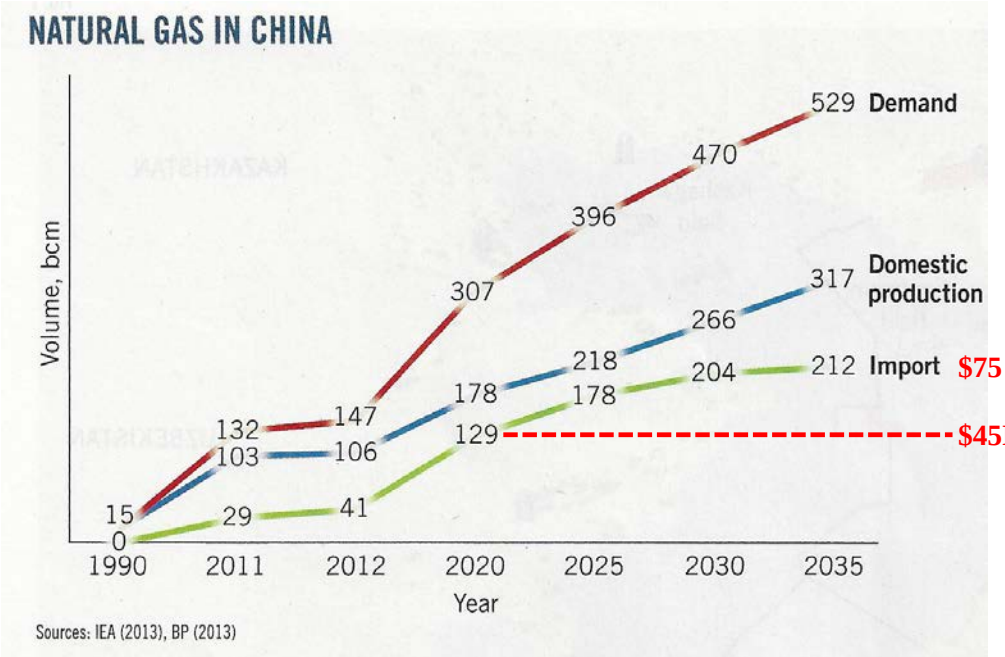
LNG Imports
2015 = 19.7 mmt = 26.8 BCM
2016 = 26.2 mmt = 35.6 +33%
2017 = 38.3 mmt = 52.0 +46%
2018 = 54.0 mmt = 73.4 +41%





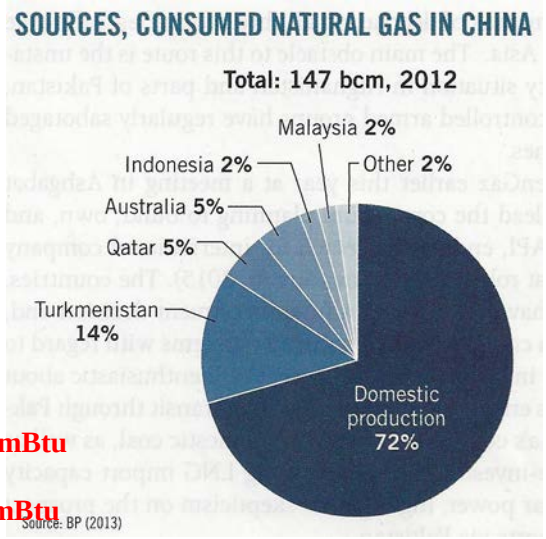
1 BCM = 0.735 mmt/yr
1 mmt/yr = 1.36 BCM

China Natural Gas



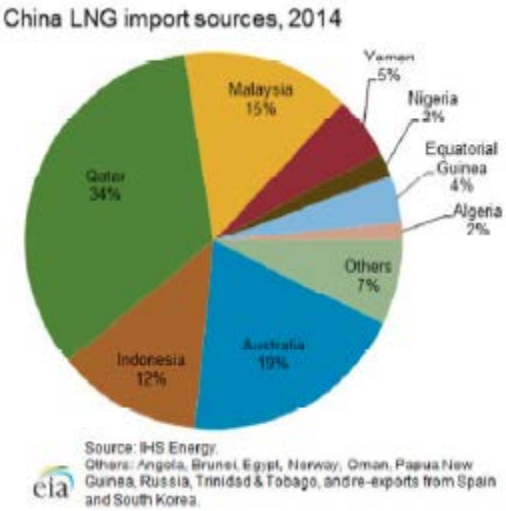
$75 Billion @$9.89/mmBtu

$45Billion @$9.89/mmBtu



China-U.S. Trade Deficit $375 Billion 2017

How to Cut the Trade Deficit???



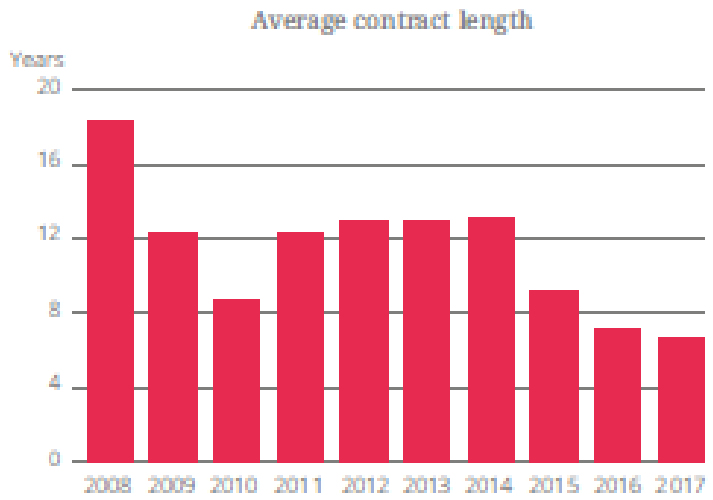
China Goes for Gas in Iran

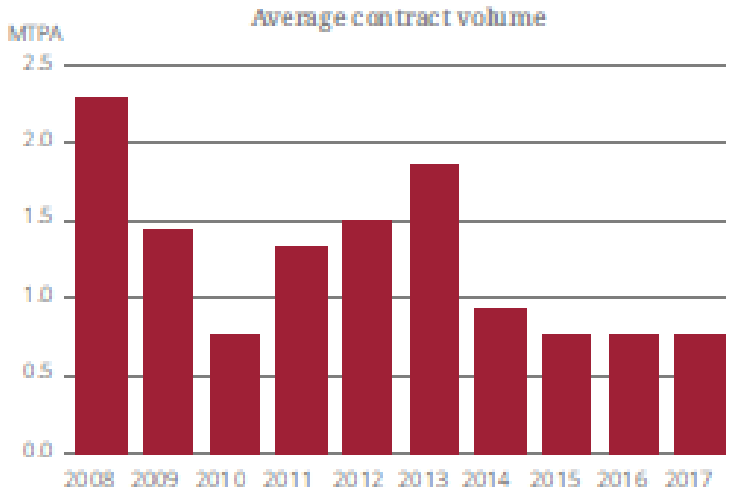
- If the US administration does not agree with Total staying in Iran, China will replace this company"
- China National Petroleum Corporation, expecting that Trump would target Iran over the nuclear issue, has been making preparations for several months to step into Total's shoes
- Beijing glimpses a Middle East energy consolidation, by replacing France's Total in South Pars gas expansion venture
- Total is involved in the Phase 11 development of the huge offshore South Pars gasfield, which is shared with Qatar
- If CNPC does indeed enter South Pars, then it will be a further and important step along the path of China deepening its energy ties with the Middle East

Whenever IOCs bow out of potentially rich hydrocarbon regions in the Middle East, or are forced to leave, expect China to be ready and willing to take over.

Newton's 3rd Law – for every action, there is an equal and opposite reaction

Shorter and Smaller LNG Contracts





Global LNG Report 2019 in association with Petroleum Economist

Market Dynamics
- Gas price not tied to Oil Price
- Globalization of excess capacity

LNG - 600 million tonnes in 2035?

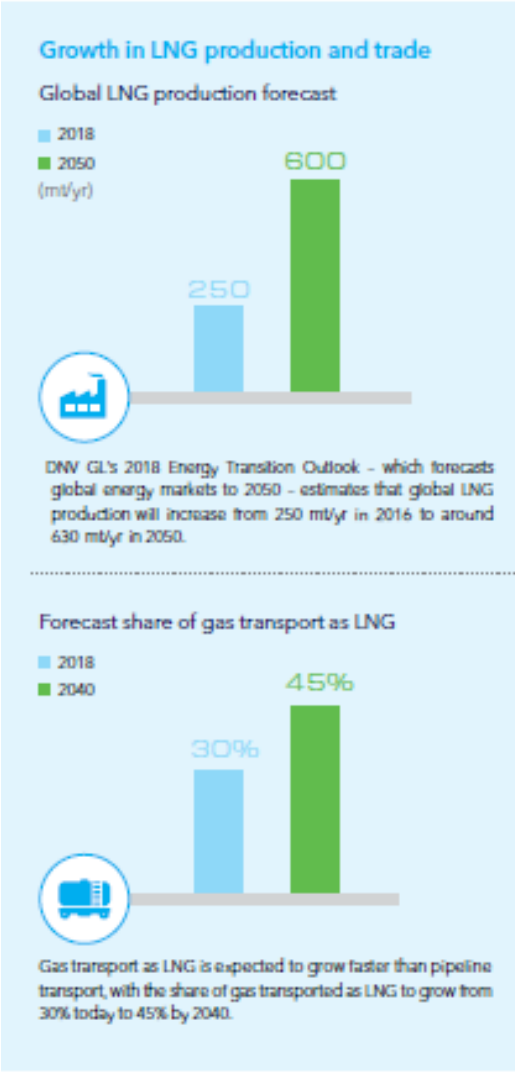
- LNG demand is expected to increase at an average four per cent annually to reach more than 600 million tonnes in 2035 (840 BCM) versus 290 million tonnes (406 BCM) in 2017
- The energy demand would continue to grow driven by emerging economies and the projected growth in global population, which will touch nine billion by 2040
- Natural gas is called to play a major role in the energy transition, supported by the industrialization and power demand particularly in emerging countries in Asia and Africa, and the continued 'coal to gas' switch, especially in India and China."
- The Indian government to a "top down" push for an enhancement of gas distribution infrastructure as well as reform of the applicable regulation and taxation
- "Natural gas remains the fastest growing fossil fuel globally, benefiting from its flexibility, competitive economics, and "low" emissions profile
- Natural gas is the ideal complement to renewables
- Qatar's contribution to this increase of LNG supply

Yes, gas is a cleaner fuel.....
.....but, it's not a clean fuel!

Qatargas CEO, Khalid bin Khalifa Al Thani

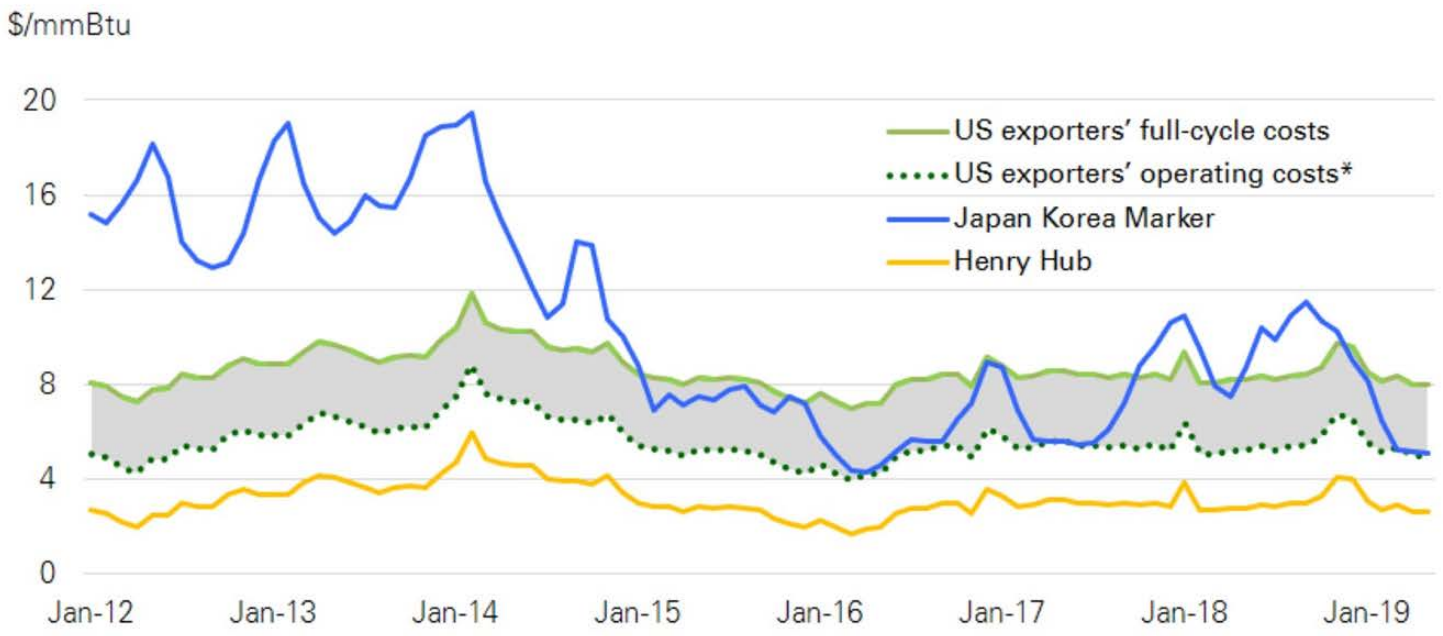
DNV-GL The Outlook for the LNG Market 2019

- Natural gas is on track to overtake oil as the world's primary energy source by the middle of the next decade
- Much of this expected increase in gas supply will be delivered to market as LNG
- DNV-GL estimates that global LNG production will increase from 250 mt/yr in 2016 to around **630 mt/yr by 2050**



U.S. LNG Exporters' Costs & Asian Spot Prices

U.S. continues to produce & sell at is operating cost, in Asia!!!



Australia - Largest LNG Exporter

- Australia has overtaken Qatar as the world's largest exporter of liquefied natural gas (LNG) in November 2018
  - Australia shipped out 6.7936 million tonnes of LNG in November
  - Qatar exported 6.2025 million tonnes.
- LNG exports jumped by over 15 percent from the previous month, while Qatar's exports slipped by 3 percent, falling for the first time at this time of the year since 2014.
- Earlier, the Resources and Energy Quarterly report for September, published by the Office of the Chief Economist in Australia revealed that Australia is on course to dethrone Qatar as the world's top LNG exporter in 2019 but the outcome is not a foregone conclusion.
- Australia's race to the top has been supported by a wave of new LNG projects that started operations in the past year.

Australia has pledged to cut CO2 emissions by 26% on 2005 levels by 2030.

If burnt, output from Carmichael would release 700m tonnes of carbon dioxide into the atmosphere every year for more than 50 years.

Australia Supply Strategy

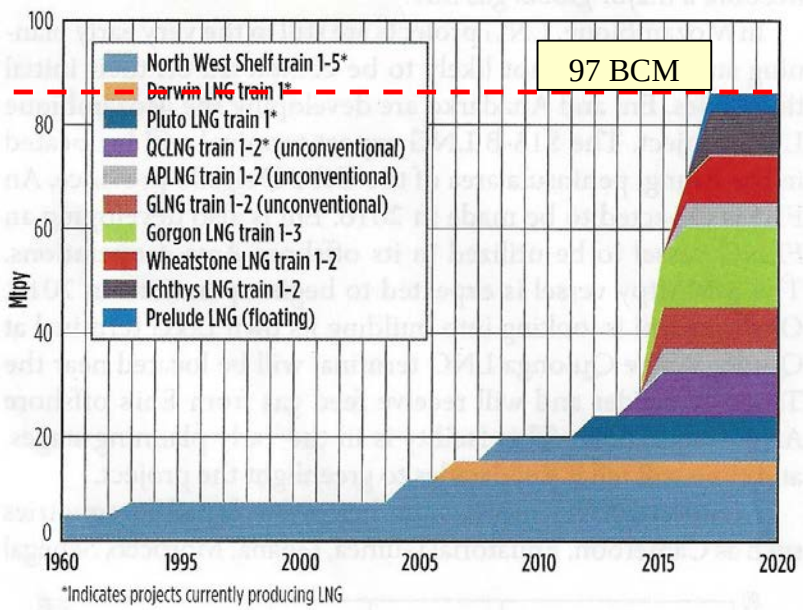
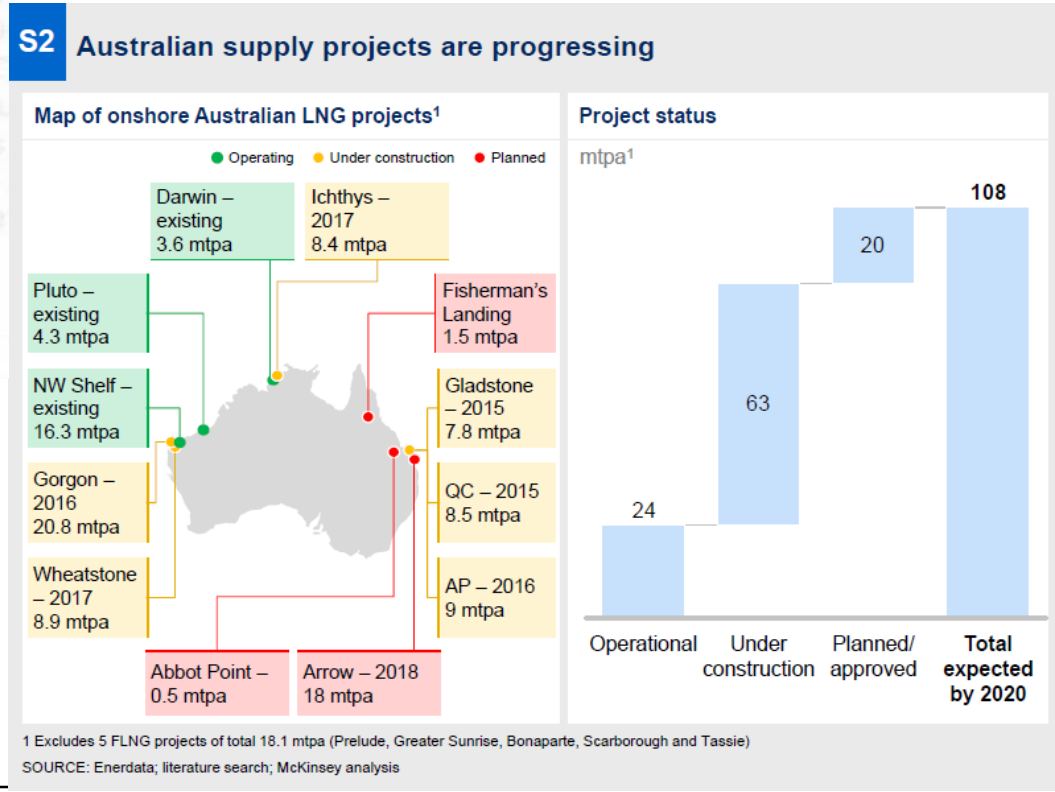


FIG. 2. Australian liquefaction capacity. Source: Australian Department of Industry and Reserve Bank of Australia.



Qatargas to Produce 110 mmt/yr by 2023

- Qatar plans to raise its liquefied natural gas (LNG) production to 110 million tonnes per year by 2023
- Qatargas, the largest LNG producer in the world, operates 14 production trains, with a total annual production capacity of 77 million tonnes
- Qatar's LNG production capacity will reach 110 million tonnes per annum (MTPA), an increase of around 43% percent from its current production capacity of 77MTPA
  - Existing capacity of 77 Mtpa
  - Addition of another 33 (Mtpa)
  - Overall production capacity to 110 Mtpa by next decade

- Qatargas has a fleet of 25 purpose-built conventional vessels as well as 31 Q-Flex and 14 Q-Max on long-term charter which can transport 210,000 cubic metres and 266,000 cubic metres of LNG
- In 2018, the merger of LNG producers Qatargas and RasGas was announced

Qatar Petroleum Tender for 100+ LNG Carriers

- Qatar Petroleum (QP) issued an invitation to tender for the reservation of ship construction capacity required for a fleet of over 100 LNG carriers
- The vessels will serve QP's
  - North Field Expansion (NFE) project which will increase Qatar's LNG production capacity from 77 million tons per annum (mta) to 110 mta starting in 2024.
  - Ocean LNG (a 70%/30% joint venture between QP & ExxonMobil from the Golden Pass LNG export project in the United States, currently under construction; planned to start by 2024.
  - Options for replacement requirements for Qatar's existing LNG fleet.
- The President & CEO of Qatar Petroleum Qatar Petroleum embarks on another major LNG ship-building campaign expected to initially deliver 60 LNG carriers in support of the planned production expansion, with a potential to exceed 100 new LNG carriers over the next decade. This initiative reinforces QP's commitment to its global reputation as a safe and reliable LNG producer at all times and under all circumstances."
- "This tender, along with the recently released EPC tender for four new mega LNG trains planned as part of the NFE Project, constitute two major strides in the further development of the world's largest non-associated gas field."

Seoul Orders 140 LNG Ships

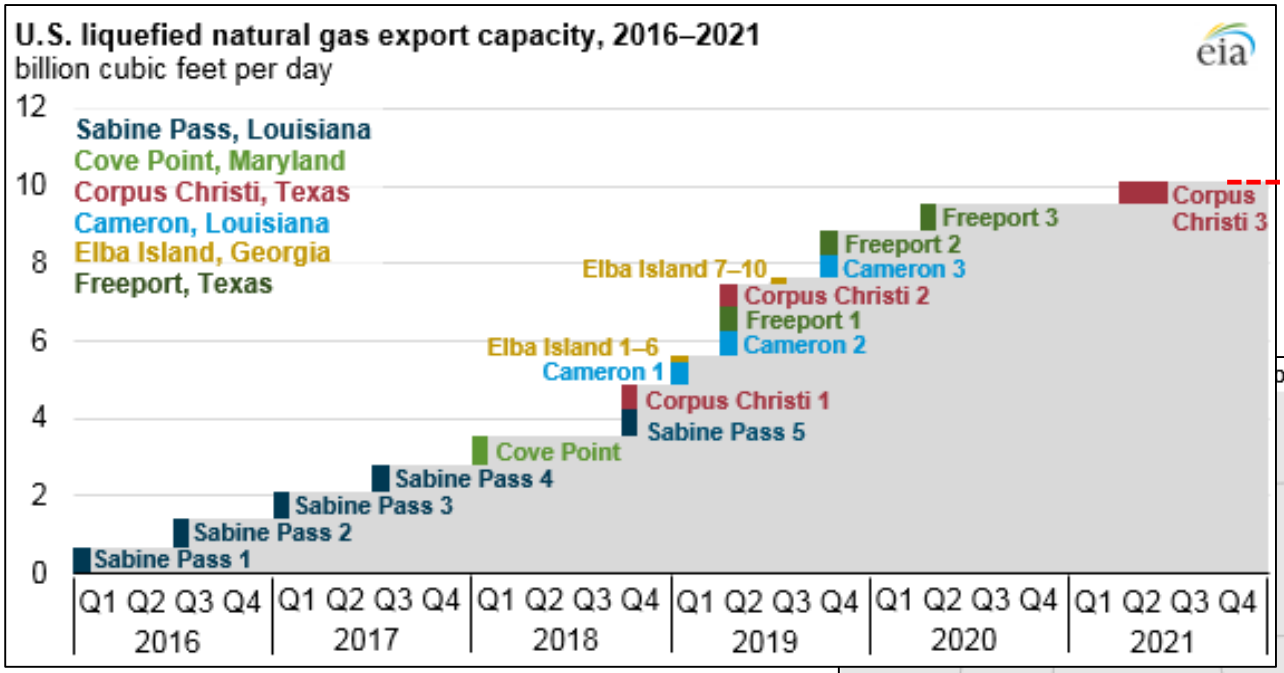
- The Korean government will order 140 liquefied natural gas ships, worth 1 trillion won ($880 million), from the nation's small and midsized shipbuilders by 2025.
- South Korea's Ministry of Trade, Industry and Energy said the government will provide shipbuilders and suppliers 1.7 trillion won ($1.5 billion) in financial aid to prop up the country's ailing shipbuilding industry.
- in order to set small and midsized shipbuilders apart from their rivals from China and Japan, it is necessary for them to be first movers in the eco-friendly shipbuilding market
- South Korea's push for LNG coincides with the global movement toward tighter emissions regulations.

The government plans to invest around $ 2.5 billion by 2025 in building up the LNG sector. The government will also invest in LNG infrastructure to develop bunkering.

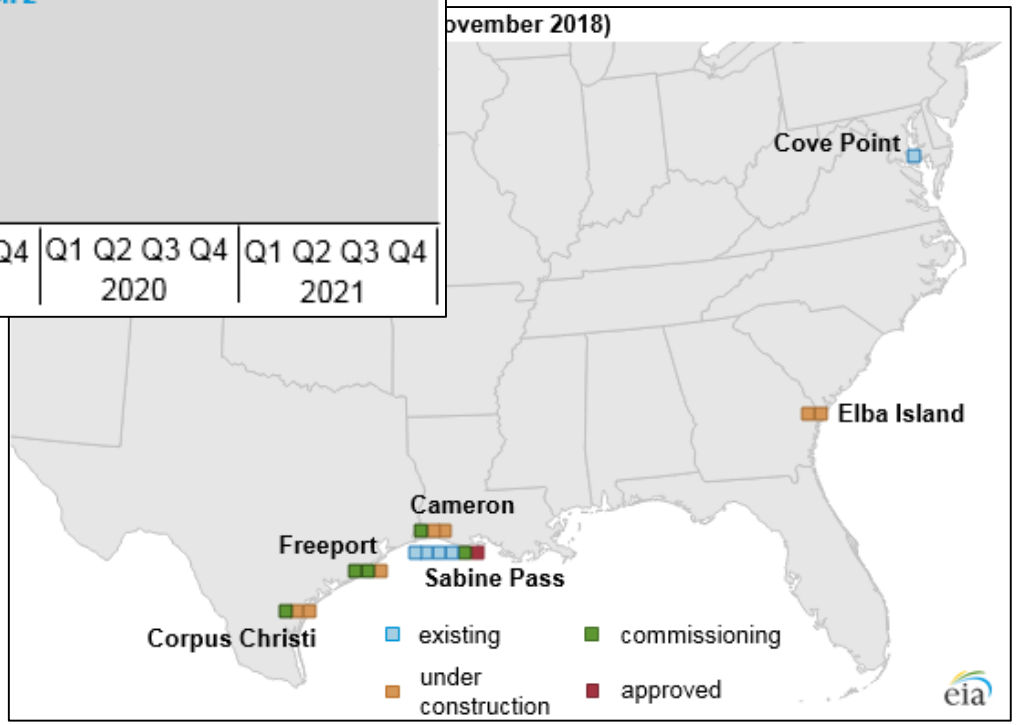
DNV GL

U.S. LNG Exports

1 BCM = 0.735 mmt/yr
1 mmt/yr = 1.36 BCM



104 BCM/yr
~15% of U.S. total gas production



EIA projects that U.S. liquefied natural gas (LNG) export capacity will reach 8.9 billion cubic feet per day (Bcf/d) by the end of 2019, making it the third largest in the world behind Australia and Qatar.

One million tons of LNG is equal to between 1.38 – 1.41 BCM of gas

Saudi Aramco to Buy LNG from US

MARINELINK

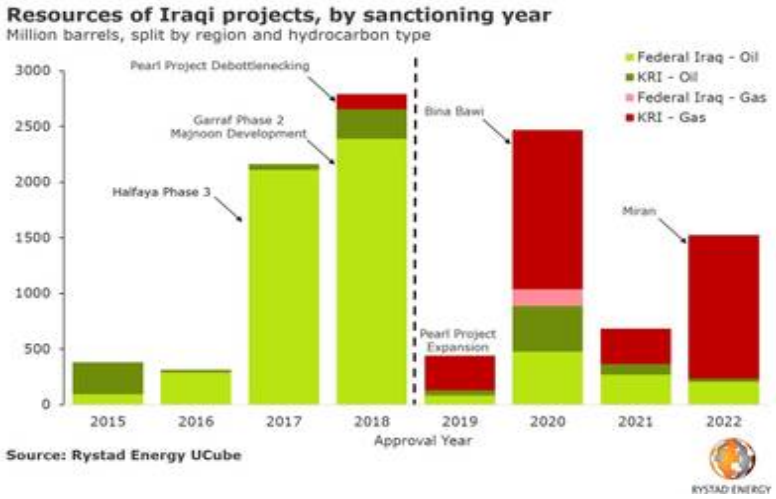
- Saudi Arabia's state owned oil company Saudi Aramco will buy 5 million tons of liquid natural gas (7 BCM) per year(LNG) from the U.S. company Sempra Energy, based in San Diego under a **20 year agreement**.
- The heads of agreement (HOA) 20-year liquefied natural gas (LNG) sale-and-purchase agreement (SPA) for five million tonnes per annum (Mtpa) of LNG offtake from Phase 1 of the Port Arthur LNG export-project under development. It also includes the negotiation and finalization of a **25% equity investment in Phase 1 of Port Arthur LNG.**
- global demand for LNG expected to grow by around 4% per year, and likely to exceed **500 million metric tons (700 BCM) a year by 2035**
- The proposed Port Arthur LNG **Phase 1** project is expected to include two liquefaction trains, up to three LNG storage tanks and associated facilities that should enable the export of approximately **11 Mtpa of LNG (15 BCM)** on a long-term basis.
- Port Arthur LNG could be one of the largest LNG export projects in North America, with potential expansion capabilities of **up to eight liquefaction trains or approximately 45 Mtpa (63 BCM)**of capacity.
- the U.S. Department of Energy issued Port Arthur LNG's authorization to export domestically produced natural gas to countries that do not have a free trade agreement with the U.S. Last month, Port Arthur LNG and its affiliates received authorization from the Federal Energy Regulatory Commission to site, construct and operate the liquefaction export facility and related natural gas pipelines.
- Port Arthur LNG is one of Sempra LNG's five strategically-located LNG development opportunities in North America and is a component of **Sempra LNG's goal of delivering 45 Mtpa (63 BCM) of clean natural gas to the global LNG market.**

The Saudi state oil giant plans to become a major global gas player, and this deal will provide it with access to some of the world's cheapest and most abundant natural gas via the U.S. shale boom.....IPO time!!!

Iraq Gas Production Set to Triple

- Gas developments in Iraq will overtake oil projects in 2019, measured in resources sanctioned for development.
- New developments are on track to **triple the country's gas production** from just over 1 Bcfd in 2017 to about 3 Bcfd in 2022.
- Gas developments in Iraq will overtake oil projects in 2019, measured in resources sanctioned for development, flying in the face of historical norms for the upstream industry in the country.
- The tripling gas production allow the country to satisfy its own growing domestic demand for gas and **possibly even launch Iraq into the global market as a gas exporter for the first time**

Source: Aditya Saraswat Rystad Energy



- The shift is driven by more favorable investment conditions in the Kurdistan Region of Iraq (KRI), combined with consistent export revenues and improved regional security
- **Previously, inadequate infrastructure and weak incentives meant that most produced gas in Iraq was simply flared**
- Upstream developments in the past were also generally oil fields under the jurisdiction of Federal Iraq, and **domestic gas demand was addressed primarily through imports from Iran**

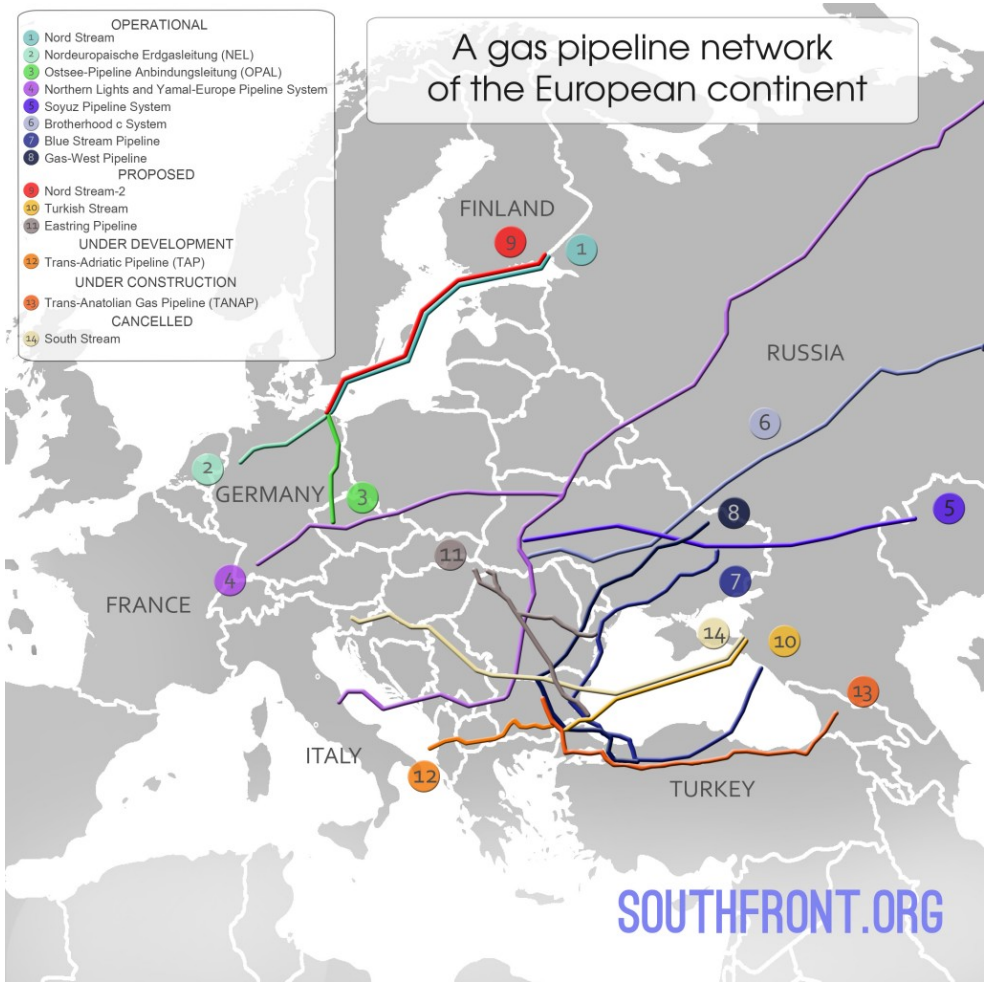
East Mediterranean Gas Gold Rush

- Consultancy Wood Mackenzie calls it "Egypt's astonishing gas renaissance!", estimating there is 61tn ft³ (1727 bcm) of gas reserves in existing fields with another 45tn ft³ (1274 bcm) waiting to be found
- There are two reasons for Egypt's gas boom
  1. Rapid advances in technology to find huge tracts of the western desert gas deposits undetectable 15 years ago
  2. Egypt's government has become serious about market reform
- And, some think Europe will welcome Egyptian gas even at a higher price than Russian gas, nervous about whether Vladimir Putin will use dominance as a political weapon

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



New Rules Doubles Panama Canal Capacity

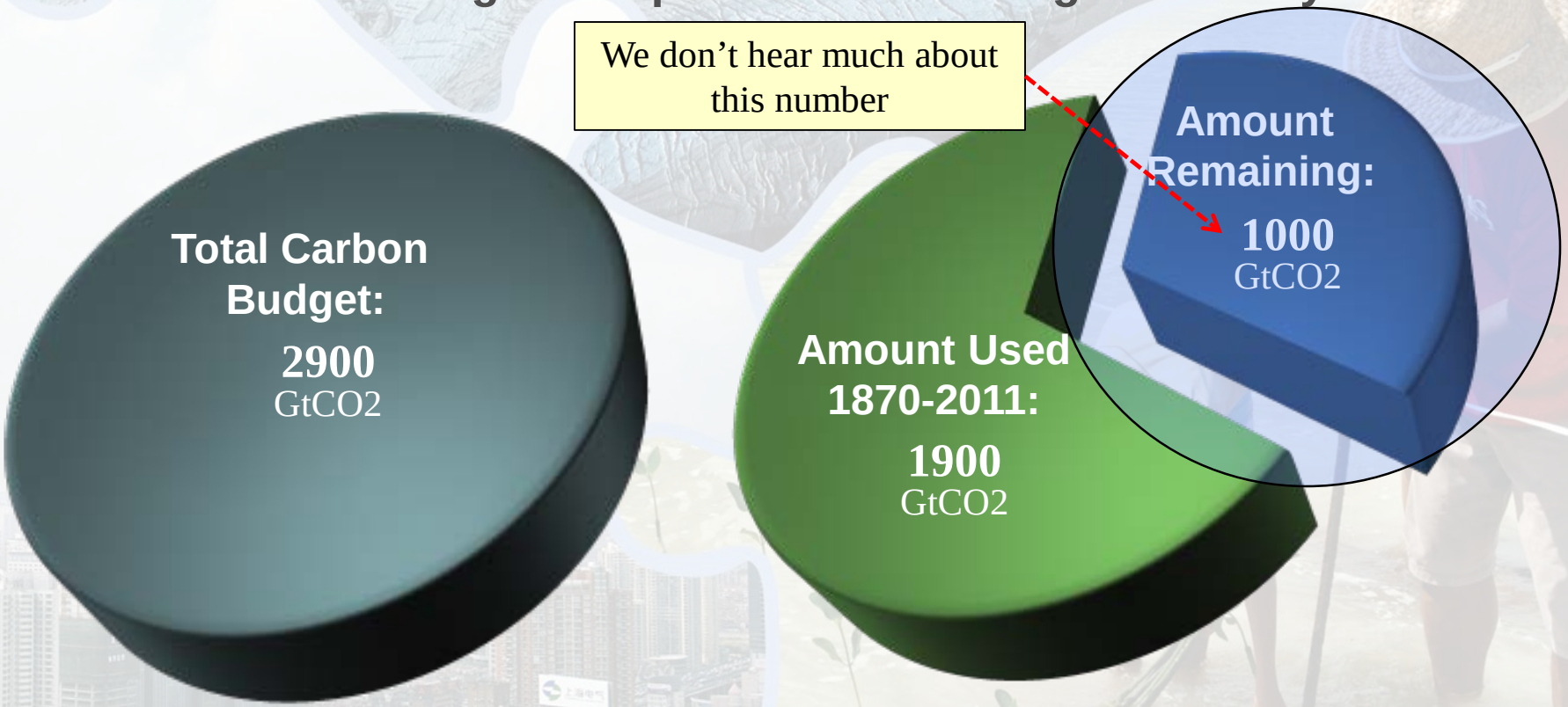
- **New rules** allowing a greater number of liquefied natural gas tankers to pass through the Panama Canal per day are expected to boost the development of the multibillion dollar industry along the U.S. Gulf Coast
- The rules went into effect in October 2018
- Canal officials now allow two LNG tankers traveling in opposite directions to be in the waterway's central lake at the same time
- The canal opened to LNG tankers in June 2016, but administrators had limited that traffic to one tanker per day during daylight hours

Climate Change

The window for action is rapidly closing

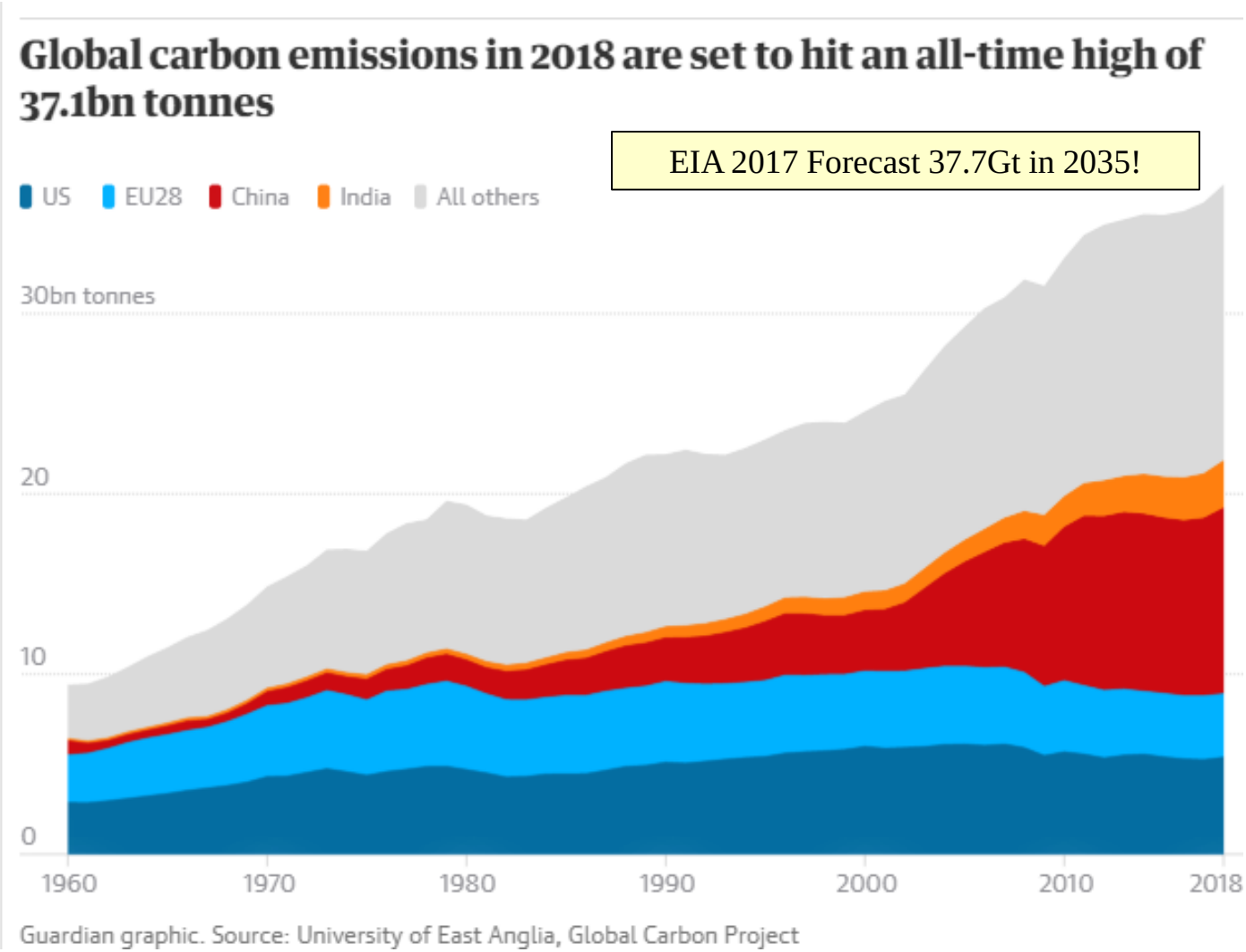
65% of our carbon budget compatible with a 2°C goal already used

We don't hear much about this number



AR5 WGI SPM

Global Carbon Emissions 37.1Gt - 2018



EIA WW Annual Energy Outlook 2017

Reference Case includes CPP

Carbon dioxide emissions (Mmt): Reference Case	2010	2015	2016	2017	2020	2025	2030	2035	2040	2045	2050	Growth (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&region=0-0&cases=Reference[illegible]2050&f=A&linechart=Reference-d082317.2-10-IEO2017&sourcekey=0
Wed Sep 20 2017 12:46:07 GMT-0400 (Eastern Daylight Time)

2018 = 37.1Gt

34519.2 MMt = 34.5 Gt

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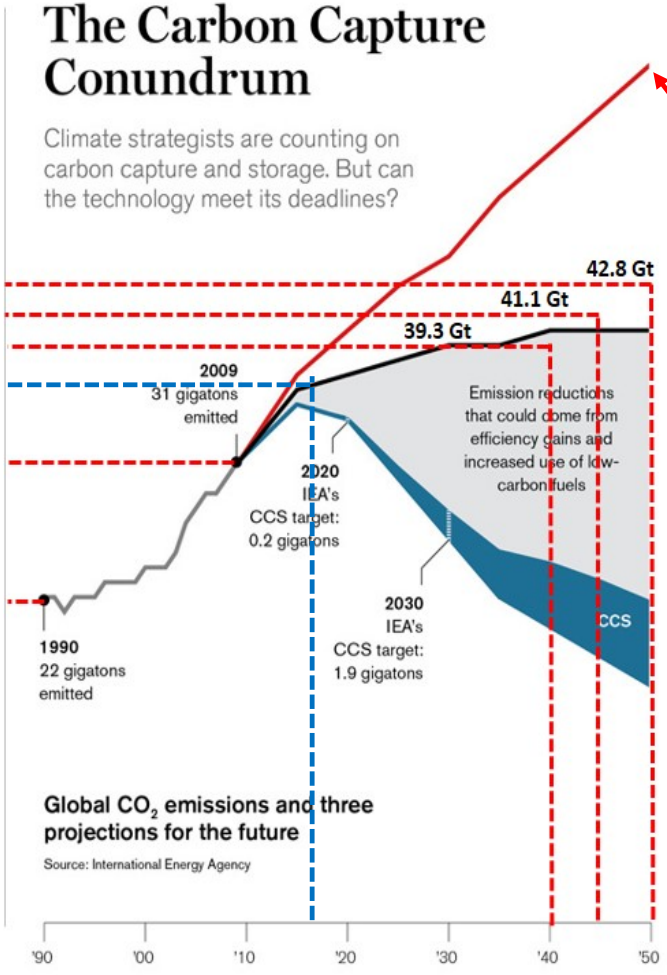
"Practical Strategies for Emerging Energy Technologies"

EIA Annual Energy Outlook 2018

The world is on the 4°C trajectory!!!

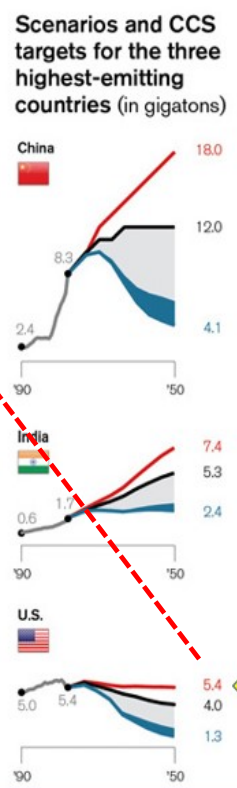
Values from EIA WW Annual Energy Outlook 2017 (previous slide)
37.1 Gt in 2018
4°C trajectory



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.



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

www.iea.org/etp2017 2°C Generation Mix Forecast

	Reference Case				2°C Scenario			
	2014	2030	2050	2060	2014	2030	2050	2060
Gross electricity generation (TWh)								
Oil	1%	0%	0%	0%	1%	0%	0%	0%
Coal	40%	19%	19%	17%	40%	13%	0%	0%
Coal with CCS	0%	0%	2%	3%	0%	2%	8%	5%
Natural gas	27%	33%	31%	30%	27%	28%	3%	0%
Natural gas with CCS	0%	0%	0%	0%	0%	0%	8%	3%
Nuclear	19%	19%	14%	14%	19%	21%	18%	18%
Biomass and waste	2%	3%	3%	3%	2%	4%	5%	4%
Biomass with CCS	0%	0%	0%	0%	0%	0%	1%	2%
Hydro (excl. pumped storage)	6%	7%	7%	7%	6%	7%	7%	7%
Geothermal	0%	1%	2%	3%	0%	1%	3%	4%
Wind onshore	4%	12%	12%	12%	4%	14%	20%	21%
Wind offshore	0%	0%	1%	1%	0%	1%	3%	5%
Solar PV	1%	5%	8%	10%	1%	7%	14%	18%
Solar CSP	0%	0%	1%	1%	0%	2%	7%	10%
Ocean	0%	0%	0%	0%	0%	0%	2%	3%
Other	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Fossil 50% ➡ 8%

Nuclear still in the mix

Wind 13% ➡ 26%

Solar 11% ➡ 28%

- The 2°C Scenario (2DS) energy system pathway & CO_2 emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100
- Annual energy-related CO_2 emissions are reduced by 70% from today's levels by 2060, with cumulative emissions of around 1170Gt of CO_2 ($GtCO_2$) between 2015 and 2100 (including industrial process emissions)
- CO_2 emissions from fuel combustion and industrial processes must continue their decline after 2060, and carbon neutrality in the energy system must be reached before 2100

Oil Companies Join Push for U.S. P2P (Carbon Tax)

- The leaders of 13 Fortune 500 companies have launched a new initiative calling for action on climate change, including lobbying lawmakers to develop an economy-wide price on carbon.
- The CEO Climate Dialogue says it aims to build bipartisan support for climate policies that address climate risk, increase regulatory and business certainty and spur investment "to meet science-based emissions reduction targets."
- The coalition includes major oil companies like Shell and BP, big utilities, including Pacific Gas & Electric (PG&E) and Dominion Energy, and environmental groups like the Environmental Defense Fund.
- Other companies involved in the CEO Dialogue project include: Exelon, DTE Energy, Unilever, BASF, DuPont, Dow, Ford, Citi and Lafarge Holcim.
- Advocacy groups include the Center for Climate and Energy Solutions, the Nature Conservancy and the World Resources Institute.

- But, on the same day the CEO Dialogue announced its plans, comments at a House Ways and Means Committee hearing on climate change illustrated the challenges ahead for those advocating for a carbon price.
- "We must instead incentivize affordable clean energy and make smart investments in cutting-edge technologies," said Texas Rep. Kevin Brady, the leading Republican on the committee. "But the way to do so is not through increased taxes and overly burdensome regulations."
- "We believe a carbon tax is not the solution to address our environmental challenges," Brady said, adding that countries that have implemented a price on carbon made only a "negligible" impact on global emissions and "many have simply exported their pollution."

Benoit's Summary

- Energy demand continues to grow unabated – Gas Turbine industry ripe for transition/opportunity
- Politics and Government stability play deeply in the momentum for change (Condos on beach)
- Electrons today more important than global warming tomorrow....paradigm shift
- Positive change is happening, in pockets, but more must and can be done
- Price to pollute (CO_2) is unavoidable.....today's "economical discussions" are rooted in a static environment
- Nuclear, Renewables and Gas Turbines can provide the answer, but will require CCS
- Subsidies = incentives = price to pollute = taxes (think plastic bags) = cover needed for politicians
- Hydrogen economy will happen, quicker than renewables, needs global cooperation
- CCS (yes, there are enough places to store it – next slide)….. And, we have H_2 storage (pipelines now) and distribution

NETL U.S. Carbon Storage Atlas V

Estimates of CO_2 Stationary Source Emissions and Estimates of CO_2 Storage Resources for Geologic Storage Sites

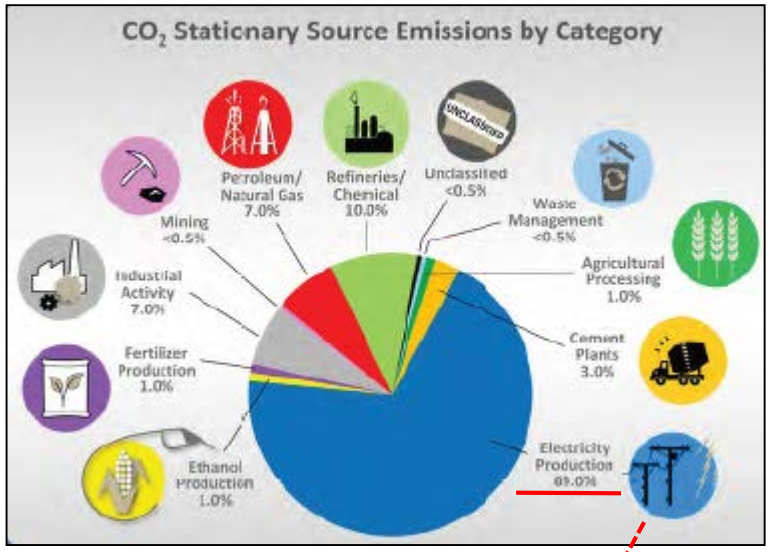
RCSP or Geographic Region	CO_2 Stationary Sources		CO_2 Storage Resource Estimates (billion metric tons of CO_2)								
			Saline Formations			Oil and Gas Reservoirs			Unmineable Coal Areas		
	CO_2 Emissions (million metric tons per year)	Number of Sources	Low	Med***	High	Low	Med***	High	Low	Med***	High
BSCSP	115	301	211	805	2,152	<1	<1	1	<1	<1	<1
MGSC	267	380	41	163	421	<1	<1	<1	2	3	3
MRCSP	604	1,308	108	122	143	9	14	26	<1	<1	<1
PCOR*	522	946	305	583	1,012	2	4	9	7	7	7
SECARB	1,022	1,857	1,376	5,257	14,089	27	34	41	33	51	75
SWP	326	779	256	1,000	2,693	144	147	148	<1	1	2
WESTCARB*	162	555	82	398	1,124	4	5	7	11	17	25
Non-RCSP**	53	232	--	--	--	--	--	--	--	--	--
Total	3,071	6,358	2,379	8,328	21,633	186	205	232	54	80	113

Source: U.S. Carbon Storage Atlas – Fifth Edition (Atlas V); data current as of November 2014

* Totals include Canadian sources identified by the RCSP

** As of November 2014, "U.S. Non-RCSP" includes Connecticut, Delaware, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, and Puerto Rico

*** Medium = p50



Sources >25,000 tonnes

Electricity Production 69%

2005 = 2416 Mt

2012 = 0.69 x 3,071 = 2,119 Mt

U.S. Totals

2011 = 5601 (37.6%)

2015 = 5680 (37.3%)

http://www.netl.doe.gov/research/coal/carbon-storage/natcarb-atlas

Appendix

Basic Comparisons 2017

	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**

Source: CIA World Factbook

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"Practical Strategies for Emerging Energy Technologies"

PS… .Total Value of Outstanding Student Loans - $1.5 trillion
U.S. health care cost 2014 - $3.3 trillion
U.S. Household Debt 2017 - $13.2 trillion

AEO2019 Cost & Performance New Generating Tech

Technology	First available year[1]	Size (MW)	Lead time (years)	Base overnight cost (2018 $/kW)	Project contin-gency factor[2]	Techno-logical optimism factor[3]	Total overnight cost[4,10] (2018 $/kW)	Variable O&M[5] (2018 $/MWh)	Fixed O&M (2018$/ kW/yr)	Heat rate[6] (Btu/kWh)	Final heat rate (Btu/kWh)	
Coal with 30% carbon sequestration (CCS)	2022	650	4	4,713	1.07	1.03	5,169	7.31	72.12	9,750	9,221	
Coal with 90% CCS	2022	650	4	5,212	1.07	1.03	5,716	9.89	83.75	11,650	9,257	36.9%
Conv gas/oil combined cycle (CC)	2021	702	3	952	1.05	1.00	999	3.61	11.33	6,600	6,350	53.7%
Adv gas/oil CC	2021	1,100	3	736	1.08	1.00	794	2.06	10.30	6,300	6,200	
Adv CC with CCS	2021	340	3	1,963	1.08	1.04	2,205	7.34	34.43	7,525	7,493	45.5%
Internal combustion engine	2020	85	2	1,306	1.05	1.00	1,371	6.03	7.11	8,500	8,160	
Conv combustion turbine[7]	2020	100	2	1,072	1.05	1.00	1,126	3.61	18.03	9,840	9,600	35.5%
Adv combustion turbine	2020	237	2	658	1.05	1.00	691	11.02	7.01	9,800	8,550	39.9%
Fuel cells	2021	10	3	6,250	1.05	1.10	7,197	46.56	0.00	9,500	6,960	
Adv nuclear	2022	2,234	6	5,224	1.10	1.05	6,034	2.37	103.31	10,461	10,461	32.6%
Distributed generation – base	2021	2	3	1,501	1.05	1.00	1,576	8.40	18.90	8,958	8,900	
Distributed generation – peak	2020	1	2	1,804	1.05	1.00	1,894	8.40	18.90	9,948	9,880	
Battery storage	2019	30	1	1,857	1.05	1.00	1,950	7.26	36.32	NA	NA	
Biomass	2022	50	4	3,642	1.07	1.00	3,900	5.70	114.39	13,500	13,500	
Geothermal[8,9]	2022	50	4	2,654	1.05	1.00	2,787	0.00	122.28	NA	NA	
MSW - landfill gas	2021	50	3	8,313	1.07	1.00	8,895	9.47	425.38	18,000	18,000	
Conventional hydropower[9]	2022	500	4	2,680	1.10	1.00	2,948	1.36	40.85	NA	NA	
Wind[10]	2021	100	3	1,518	1.07	1.00	1,624	0.00	48.42	NA	NA	
Wind offshore[8]	2022	400	4	4,758	1.10	1.25	6,542	0.00	80.14	NA	NA	
Solar thermal[8]	2021	100	3	4,011	1.07	1.00	4,291	0.00	72.84	NA	NA	
Solar PV - tracking[8, 10, 11]	2020	150	2	1,876	1.05	1.00	1,969	0.00	22.46	NA	NA	
Solar PV – fixed tilt[8,10,11]	2020	150	2	1,698	1.05	1.00	1,783	0.00	22.46	NA	NA	

AEO2019 Cost & Performance New Generating Tech

[1] Represents the first year that a new unit could become operational.

[2] AACE International (the Association for the Advancement of Cost Engineering) has defined contingency as, "An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs."

[3] The technological optimism factor is applied to the first four units of a new, unproven design; it reflects the demonstrated tendency to underestimate actual costs for a first-of-a-kind unit.

[4] Overnight capital cost includes contingency factors and excludes regional multipliers (except as noted for wind and solar PV) and learning effects. Interest charges are also excluded. The capital costs represent current costs for plants that would come online in 2019.

[5] O&M = Operations and maintenance.

[6] The nuclear average heat rate is the weighted average tested heat rate for nuclear units as reported on the Form EIA-860, *Annual Electric Generator Report*. No heat rate is reported for battery storage because it is not a primary conversion technology; conversion losses are accounted for when the electricity is first generated; electricity-to-storage losses are accounted for through the additional demand for electricity required to meet load. For hydropower, wind, solar, and geothermal technologies, no heat rate is reported because the power is generated without fuel combustion and no set Btu conversion factors exist. The model calculates the average heat rate for fossil generation in each year for purposes of reporting primary energy consumption displaced for these resources.

[7] Conventional combustion turbine units can be built by the model before 2020, if necessary, to meet a region's reserve margin.

[8] Capital costs are shown before investment tax credits are applied.

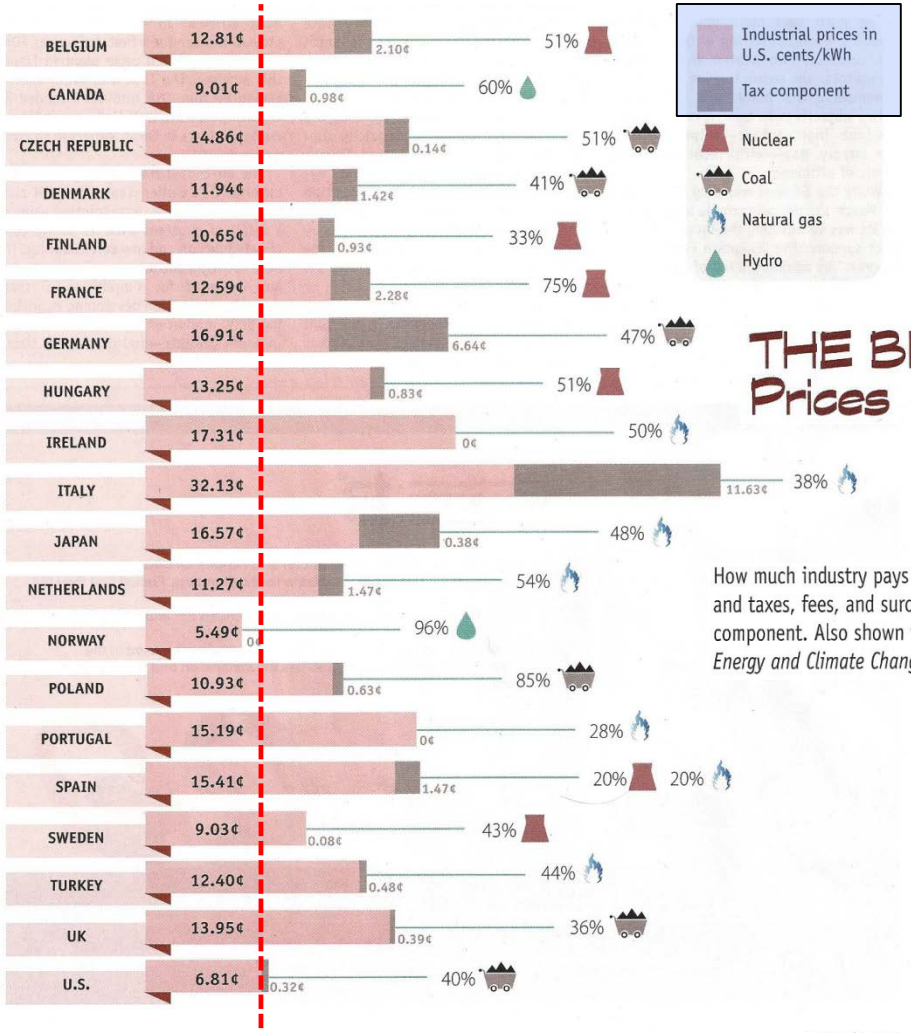
[9] Because geothermal and hydropower cost and performance characteristics are specific for each site, the table entries show the cost of the least expensive plant that could be built in the Northwest Power Pool region, where most of the proposed sites are located.

[10] Wind and both solar PV technologies' total overnight cost shown in the table shows the average input value across all 22 electricity market regions, as weighted by the respective capacity of that type installed during 2017 in each region to account for the substantial regional variation in wind and solar costs (as shown in Table 3). The input value used for wind in AEO2019 was $1,920 per kilowatt (kW), solar PV with tracking was $2,160/kW, and solar PV fixed tilt was $2,024, representing the cost of building a plant excluding regional factors. Region-specific factors contributing to the substantial regional variation in cost include differences in typical project size across regions, accessibility of resources, and variation in labor and other construction costs through the country.

[11] Costs and capacities are expressed in terms of net AC power available to the grid for the installed capacity.

Source: Input costs other than Advanced Combined Cycle are consistent with those used in AEO2018, and they are primarily based on a report provided by external consultants. The base costs shown above reflect calculated learning cost reductions based on recent builds that occurred since the cost report was provided. The cost differential between the two PV technologies was based on Lawrence Berkeley National Lab's *Utility-Scale Solar Report*. Hydropower site costs for non-powered dams were updated for AEO2018 using data from Oak Ridge National Lab. Costs for advanced CC were updated for AEO2019 based on a PJM Interconnection *Cost of New Entry* report and EIA analysis of reported costs.

The Big Picture: World Industrial Power Prices



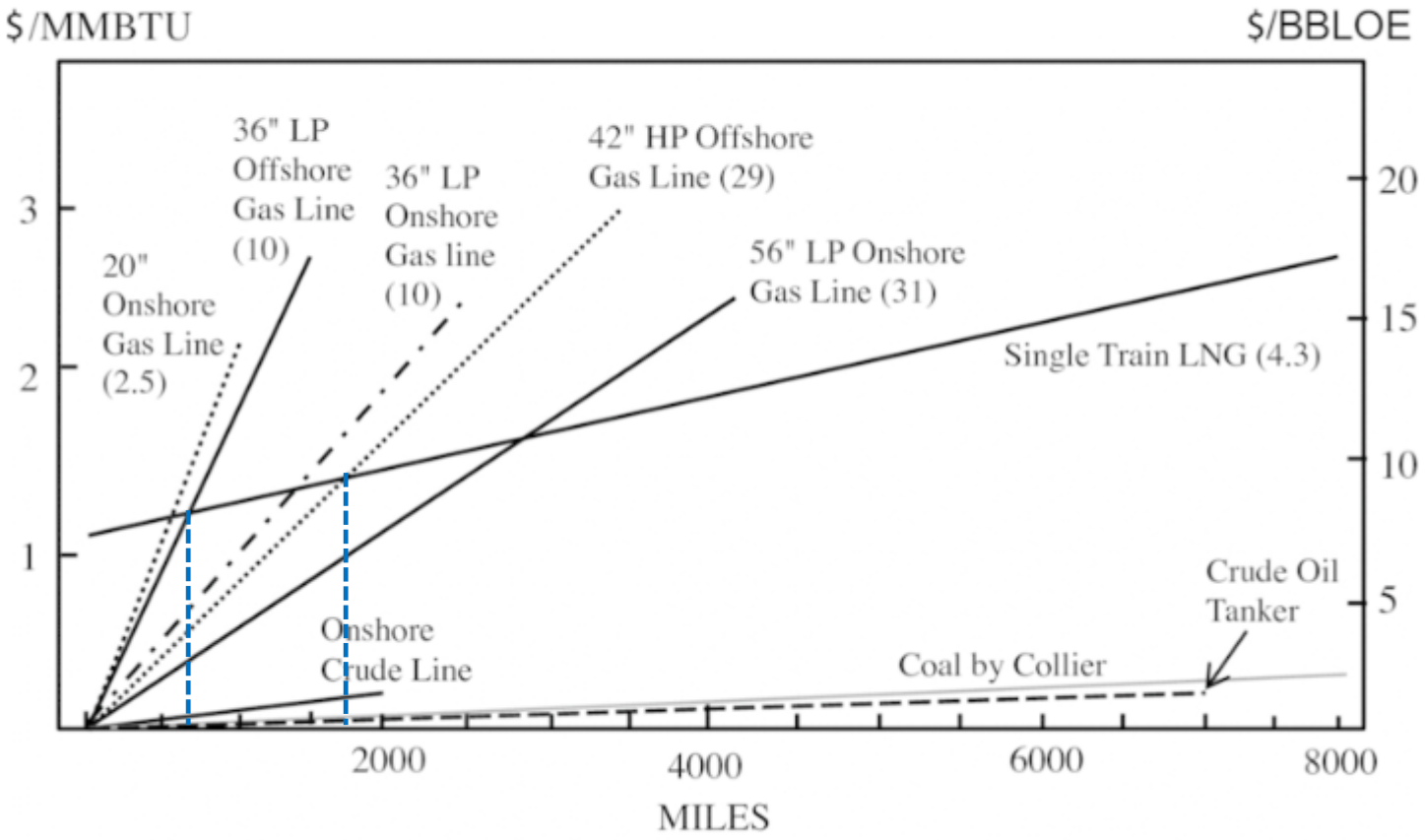
THE BIG PICTURE: World Industrial Power Prices

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

Only Norway has a lower Industrial Electricity price (without taxes) than the U.S.

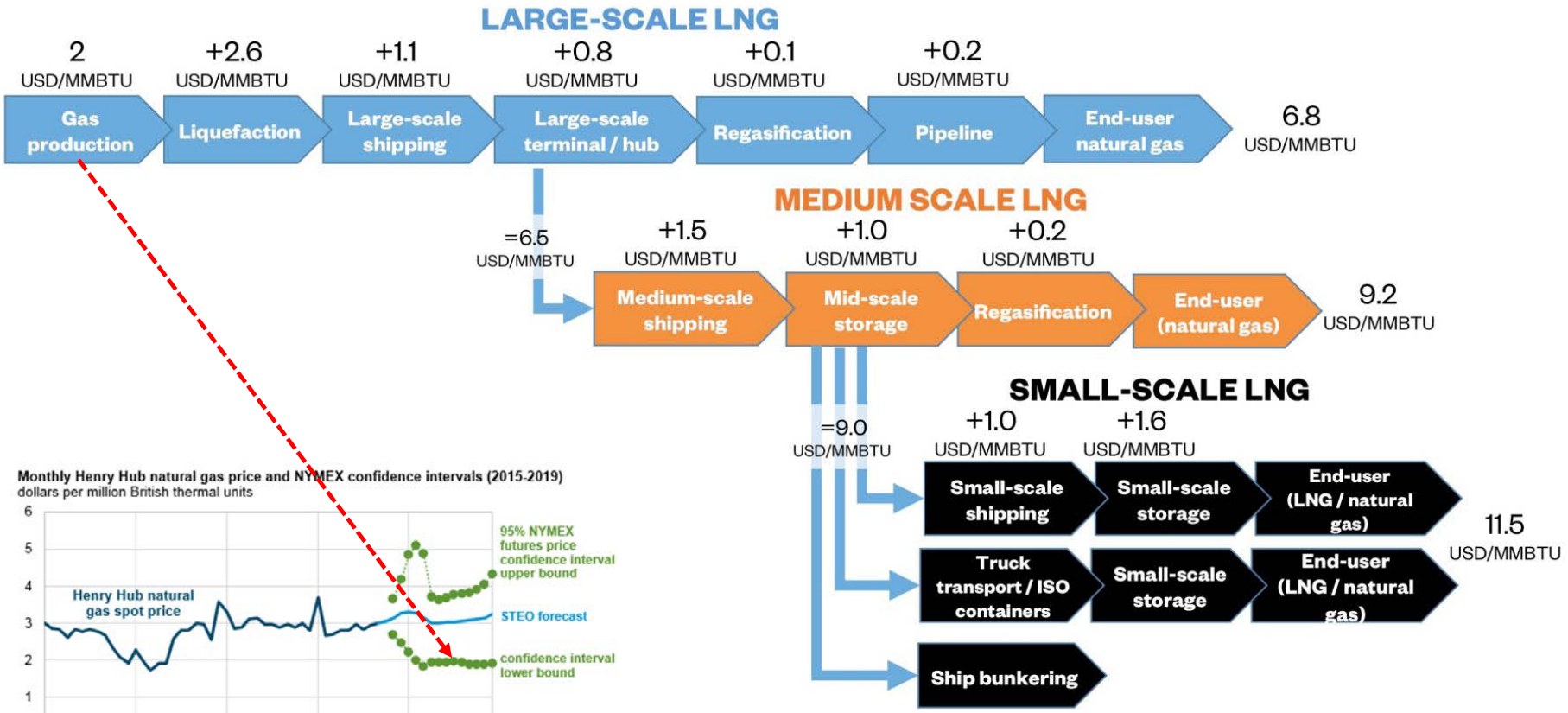
Jensen 2004 Break-even Points

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

BP Conversion Factors

Approximate conversion factors

Crude oil*

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

*Based on worldwide average gravity.

Products

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

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

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

Units

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

Calorific equivalents

One tonne of oil equivalent equals approximately:

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

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

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

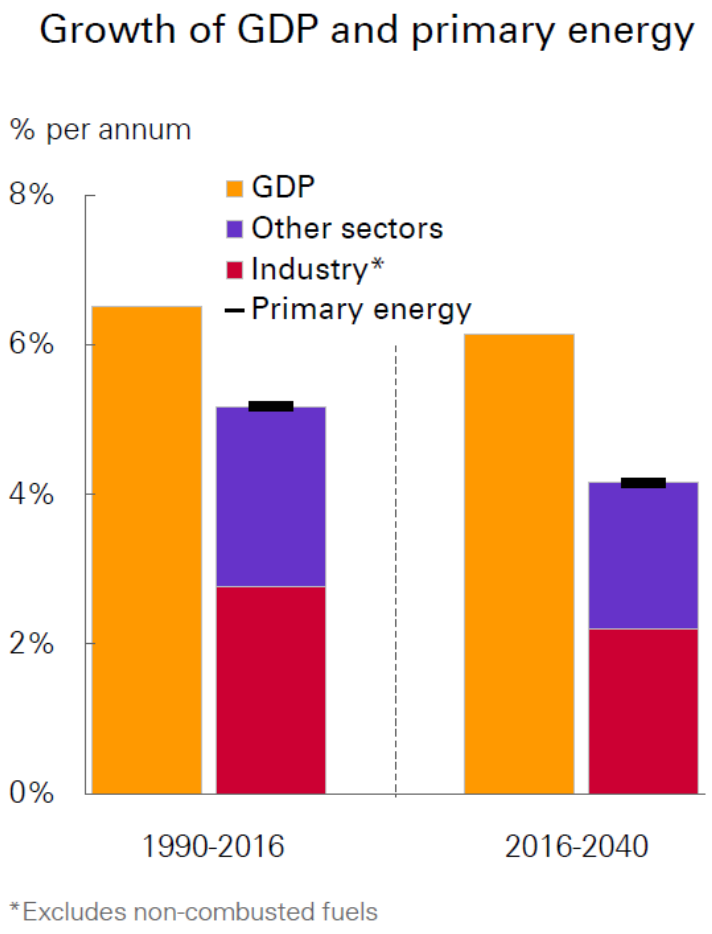
Inter-area Oil Movements in 2018

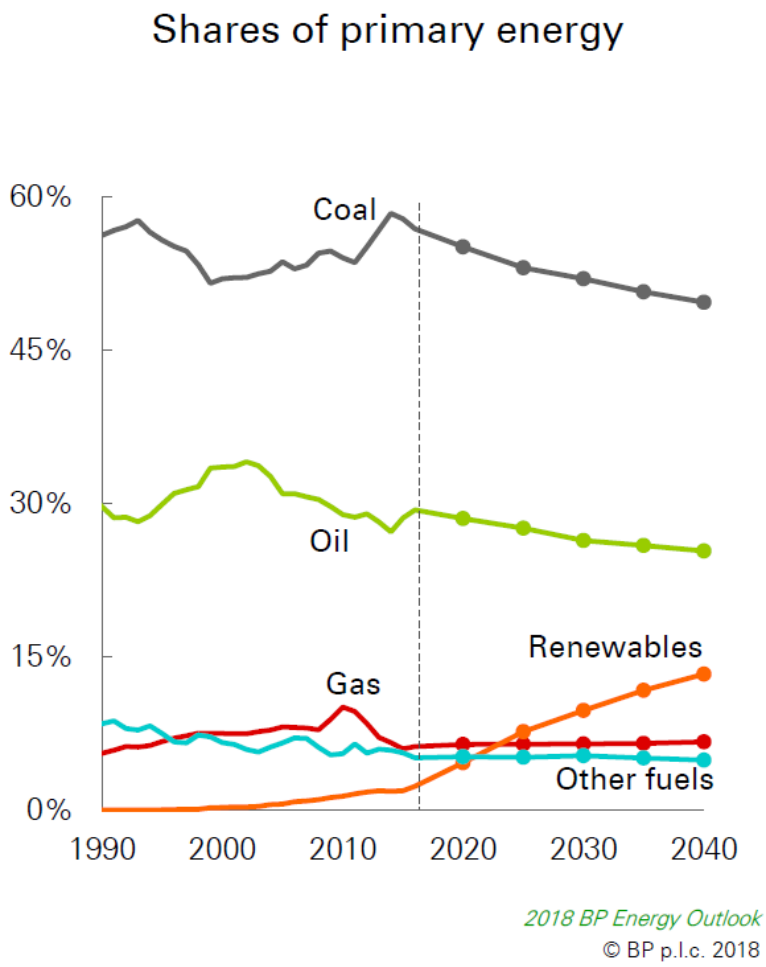
Crude (million tonnes)	To															
	Canada	Mexico	US	S. & Cent. America	Europe	Russia	Other CIS	Middle East	Africa	Australasia	China	India	Japan	Singapore	Other Asia Pacific	**Total**
From																
Canada	-	-	184.0	0.6	4.5	-	-	†	†	†	1.2	0.5	-	-	0.3	**190.9**
Mexico	†	-	33.1	0.5	12.0	†	-	0.1	-	-	0.7	8.9	1.8	-	4.6	**61.7**
US	18.8	0.1	-	5.4	29.2	-	†	1.5	†	0.3	12.3	4.9	2.5	1.1	17.1	**93.2**
S. & Cent. America	0.3	†	56.9	-	10.2	†	-	-	0.3	†	62.0	22.9	1.9	0.2	1.9	**156.7**
Europe	1.4	-	5.9	0.8	-	†	†	6.1	0.4	†	8.6	1.5	†	†	6.5	**31.2**
Russia	0.2	-	3.6	3.6	153.3	-	18.5	1.4	†	0.3	71.6	2.2	7.0	1.7	12.3	**275.9**
Other CIS	1.1	-	1.8	0.1	63.2	0.5	-	6.6	0.3	0.1	2.8	1.6	1.5	0.4	5.8	**85.9**
Iraq	-	-	25.8	0.8	48.7	†	-	3.2	2.3	-	45.0	47.7	2.7	1.3	23.4	**200.9**
Kuwait	†	-	3.9	-	5.8	-	-	†	4.0	-	23.2	11.4	11.7	7.0	36.0	**103.0**
Saudi Arabia	5.6	-	43.3	3.4	41.3	-	-	13.7	9.6	0.5	56.7	39.3	57.4	10.7	85.9	**367.4**
UAE	†	-	0.3	†	0.7	†	-	†	0.8	6.0	12.2	16.0	37.3	10.6	41.9	**125.9**
Other Middle East	†	-	-	0.1	27.6	-	†	5.7	0.2	0.1	66.0	32.4	21.9	10.5	27.5	**192.1**
North Africa	0.5	-	7.9	2.1	58.3	-	0.1	1.4	†	2.0	11.3	4.0	0.2	1.2	6.8	**95.6**
West Africa	1.1	-	16.8	9.5	63.1	†	-	0.5	10.9	2.5	71.9	27.6	0.5	1.3	14.3	**219.9**
East & S. Africa	-	-	†	-	1.2	†	-	†	†	-	4.4	1.2	0.1	†	0.8	**7.7**
Australasia	†	-	0.1	†	†	-	-	0.2	†	-	1.3	0.3	0.5	1.3	7.2	**10.9**
China	†	-	-	†	†	-	-	†	†	-	-	-	1.5	†	1.2	**2.7**
India	-	-	-	†	-	-	-	†	†	†	†	-	-	†	†	**0.1**
Japan	-	-	-	-	†	-	-	-	†	†	-	-	-	†	†	†
Singapore	-	-	-	†	0.1	-	-	†	†	0.1	0.1	-	-	-	0.4	**0.6**
Other Asia Pacific	†	-	3.0	†	†	-	-	0.4	0.1	11.9	13.1	5.2	2.3	4.8	-	**40.8**
Total imports	**29.1**	**0.1**	**386.3**	**27.0**	**519.2**	**0.5**	**18.6**	**40.8**	**29.2**	**23.6**	**464.5**	**227.5**	**150.8**	**52.2**	**293.8**	**2263.1**

- The bulk of shipments (54%) were sent to customers in Asia while Europe accounted for 23% of exports.
- The largest intake came from China, the world's top oil buyer and energy consumer, followed by India, South Korea and Japan.

Source: BP Statistical Review of World Energy 2019

India Emerges as Largest Energy Growth Market

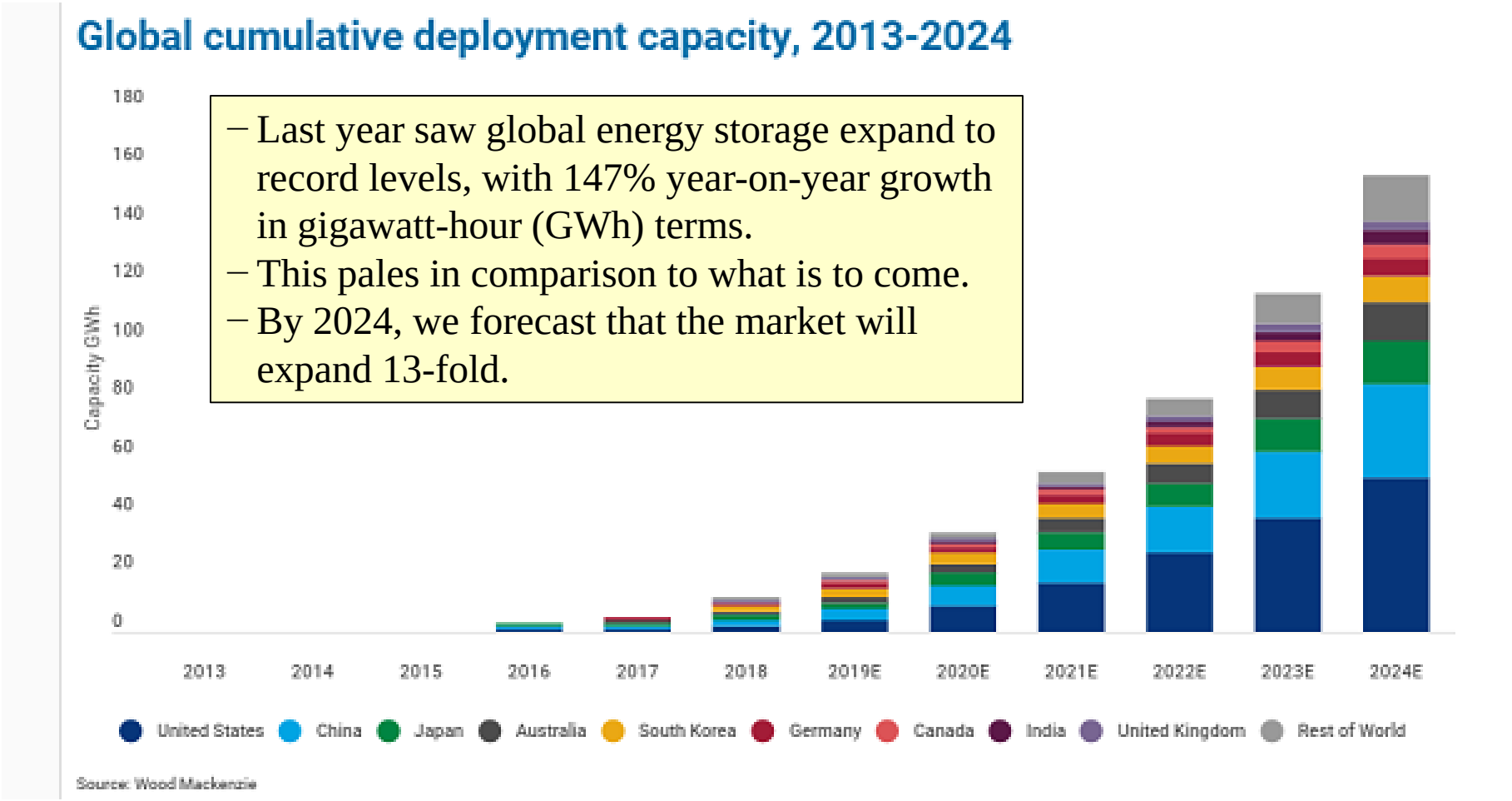




Novatek in Arctic LNG 2 Deal with TechnipFMC

- Russian largest independent gas producer and liquefied natural gas (LNG) player **Novatek** signed a deal with TechnipFMC for its Arctic LNG 2 project
- The contract was signed on engineering, procurement, supply, construction and commissioning (EPC) of an integrated liquefied natural gas facility with an annual liquefaction capacity of **19.8 Mtpa (28 BCM)** under the Arctic LNG 2 project
- The contract terms provide for the launch of the first train of the project in 2023
- The Arctic LNG 2 project envisages **constructing three LNG trains at 6.6 million tons per annum** each, using gravity-based structure (GBS) platforms.

Battery Cell Production Driven by EVs



New Brunswick Power – H2-Powered Baseload Grid

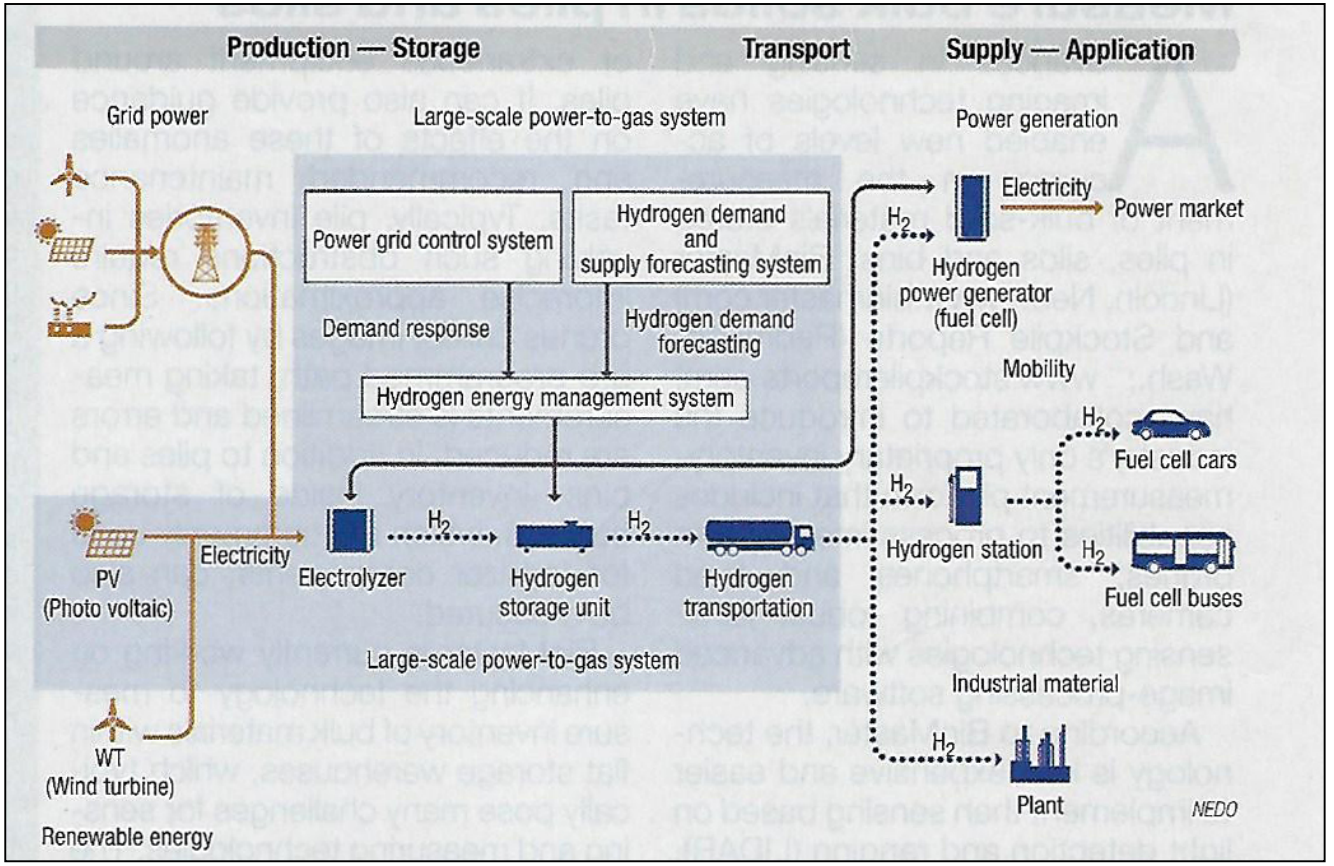
- Hydrogen energy company Joi Scientific is partnering with Canadian utility to create the **first hydrogen-powered baseload electric grid**
- The grid will utilize the **Hydrogen 2.0 extraction technology** to develop approximately 30 power stations fueled by hydrogen extracted from water
- A commercially operational prototype is about two to three years away
- The two companies hope to have 10-100 MW of capacity from the new technology.

Table 2 Current economics of renewable hydrogen production

From: Economics of converting renewable power to hydrogen

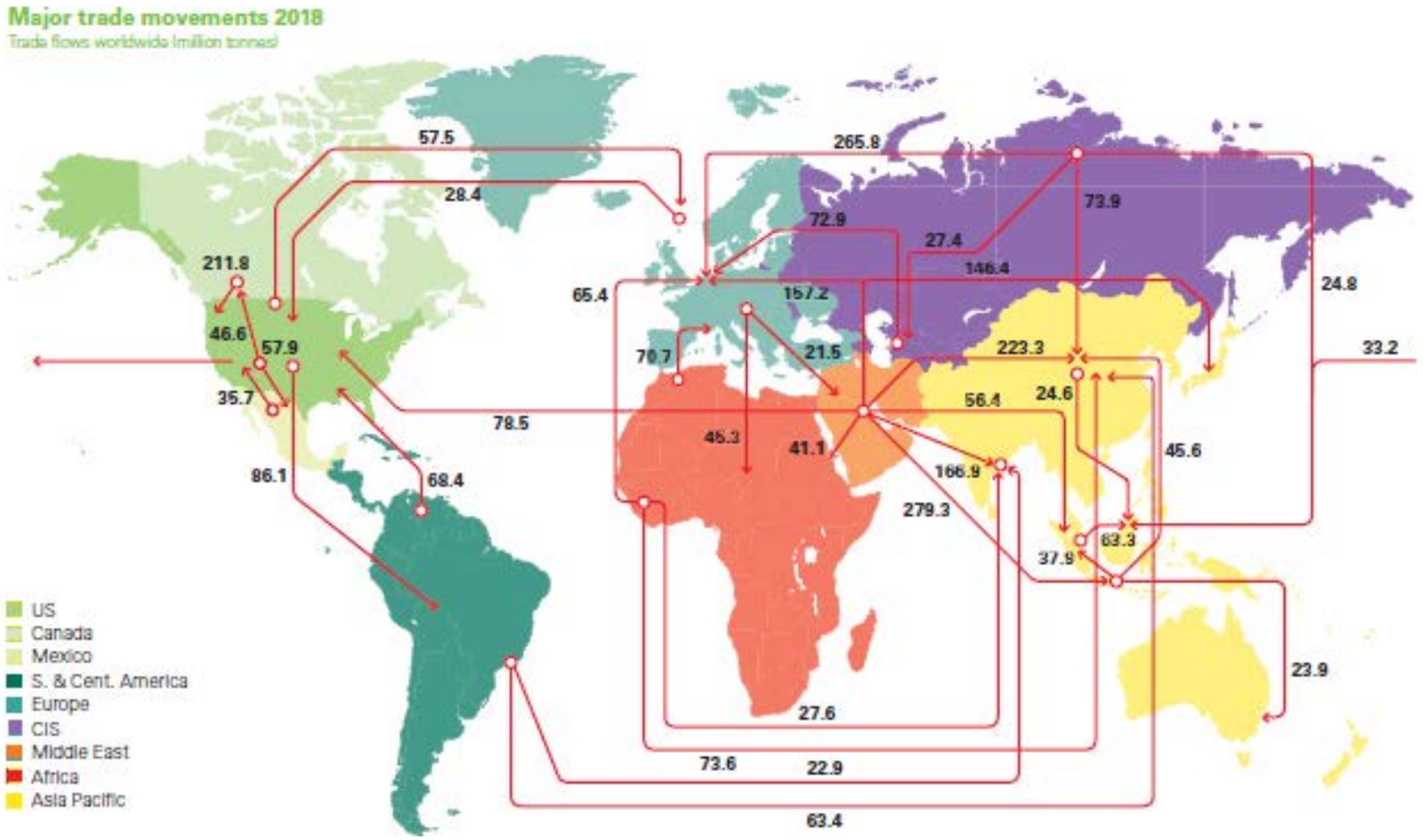
	Germany	Texas
Break-even price for hydrogen	€3.23 kg^{-1}	US$3.53 kg^{-1}
Co-variation coefficient	0.88	0.89
LCOE	€5.36 kWh^{-1}	US$5.02 kWh^{-1}
Levelized PP	€4.73 kWh^{-1}	US$0.00 kWh^{-1}
Levelized PTC	€0.00 kWh^{-1}	US$1.99 kWh^{-1}
Wind energy profit margin	€0.65 kWh^{-1}	US$−0.27 kWh^{-1}
Conversion premium	€2.85 kWh^{-1}	US$4.23 kWh^{-1}
LFCH	€2.54 kWh^{-1}	US$2.47 kWh^{-1}
Optimal PtG capacity	0.01 kW	0.29 kW

METI "Basic Hydrogen Strategy"

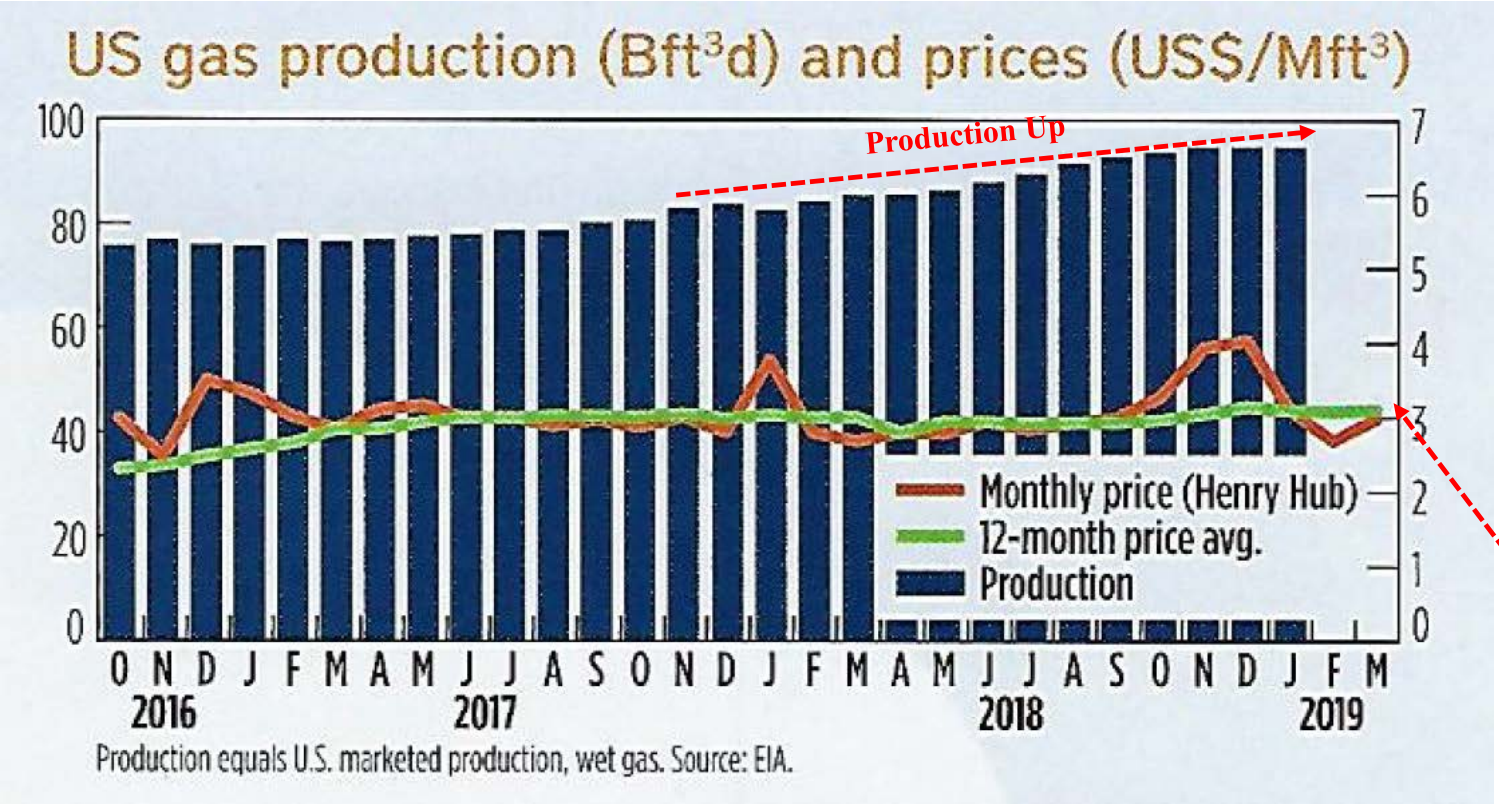


Fukushima Hydrogen Energy Research Field (FH2R)
900 ton/year H_2
Operational 2020

Major Oil Trade 2018



U.S. Gas Prices & Production

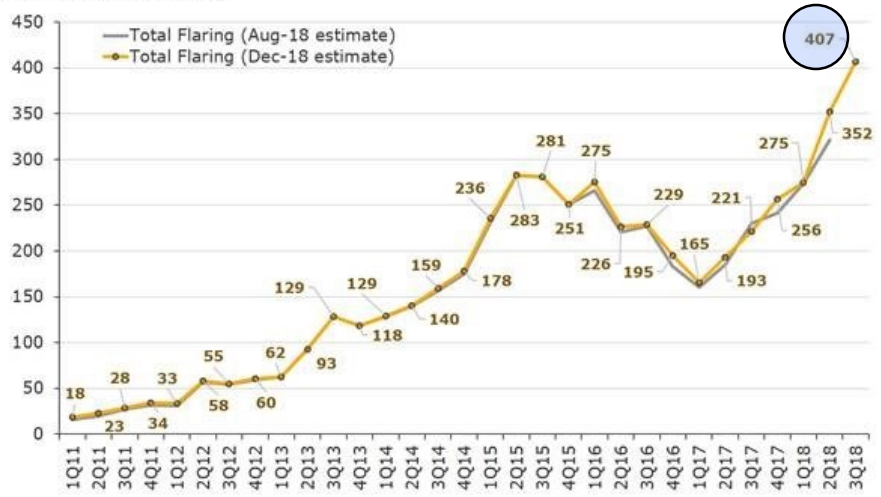


Hydrocarbon Processing May 2019

Gas Flaring in the Permian Basin

- **Gas flaring in the Permian basin reached an all-time high in this year's third quarter**
  - Persistent rise in production
  - Severe takeaway capacity challenges,
- Rystad estimates that gas flaring in the Permian averaged 407 MMcfd (4.2 BCM) in the third quarter
- Rystad also expects flaring to rise well into 2019, reaching a level of at least 600 MMcfd (6.2 BCM) by mid-2019 assuming West Texas Intermediate oil prices recover to $60/bbl to support existing activity levels.
- The energy research company also noted that, in Texas, there is an increased tendency whereby gas is flared on new wells for extended periods—often between 4-6 months—far beyond the 45-day period covered by the initial flaring permit.

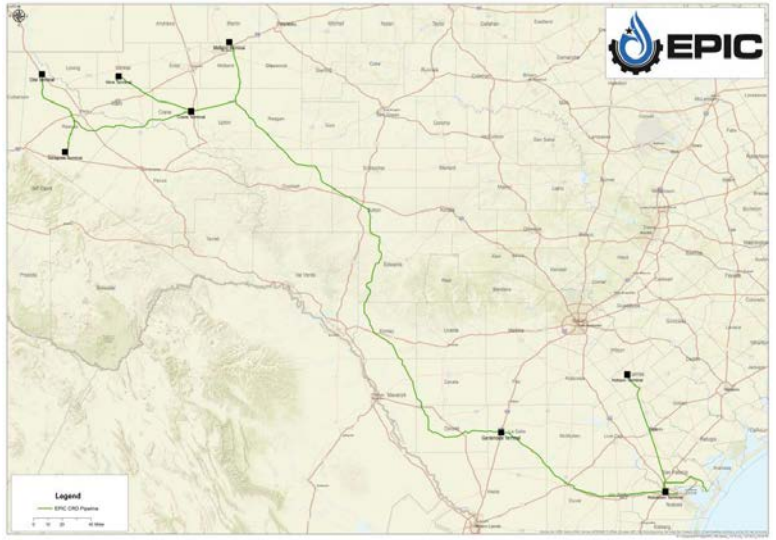
Figure 1: Natural gas flaring in the Permian Basin by quarter
Million cubic feet per day

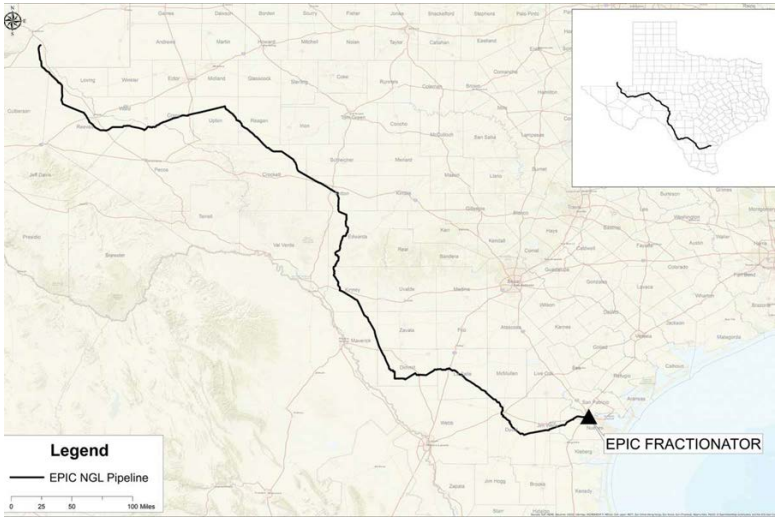


Source: Rystad Energy research and analysis, Rystad Energy ShaleWellCube

Permian Basin to Corpus Christi Pipelines

- **A pair of pipelines to move crude oil and natural gas liquids from the Permian Basin to Corpus Christi have received their final federal permits**
  - 2 of 3Crews working on the EPIC Crude Oil Pipeline, a project to move crude oil from the Permian Basin of West Texas to the Port of Corpus Christi.
  - 3 of 3EPIC Midstream Holdings is building a pipeline to move natural gas pipelines from the Permian Basin of West Texas to the Port of Corpus Christi
- Already largely complete, the EPIC Y-Grade Pipeline is a 700-mile project to move natural gas liquids, or NGLs, from the Permian Basin of New Mexico and West Texas to a facility in Robstown.
- Construction for the EPIC Crude Oil Pipeline is expected to be completed by January 2020. The 650-mile project will move crude oil and from seven terminals in the Permian Basin and Eagle Ford Shale of South Texas to a facility in Robstown.





Europe's Largest Tidal Project

- SIMEC Atlantis Energy announced the formation of a joint venture company with Development Agency for Normandy (AD Normandy) for the purpose of developing a **large-scale project in Raz Blanchard, Normandie**
- Normandie Hydrolienne has been established with the **intention of eventually harnessing up to 2GW of power from the Alderney Race**, the eight-mile strait that runs between Alderney and La Hague, France, **as well as more than 1GW of resource from adjacent concessions under the control of the States of Alderney**
- Combined, Normandie Hydrolienne has the **potential to provide more power than the Hinkley Point C Nuclear Power Station** in Somerset, England and at a lower cost