
IGTI Fuels Report

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++1-617-306-7419



“Practical Strategies for Emerging Energy Technologies”

Primary Energy Consumption by Fuel 2017 - Mtoe

U.S. = 91.86 Quads

Primary Energy: Consumption by fuel*

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



13,511.2 Mtoe = 555.4 Quads

“Practical Strategies for Emerging Energy Technologies”

Source: BP Statistical Review of World Energy 2018

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

Source: CIA World Factbook

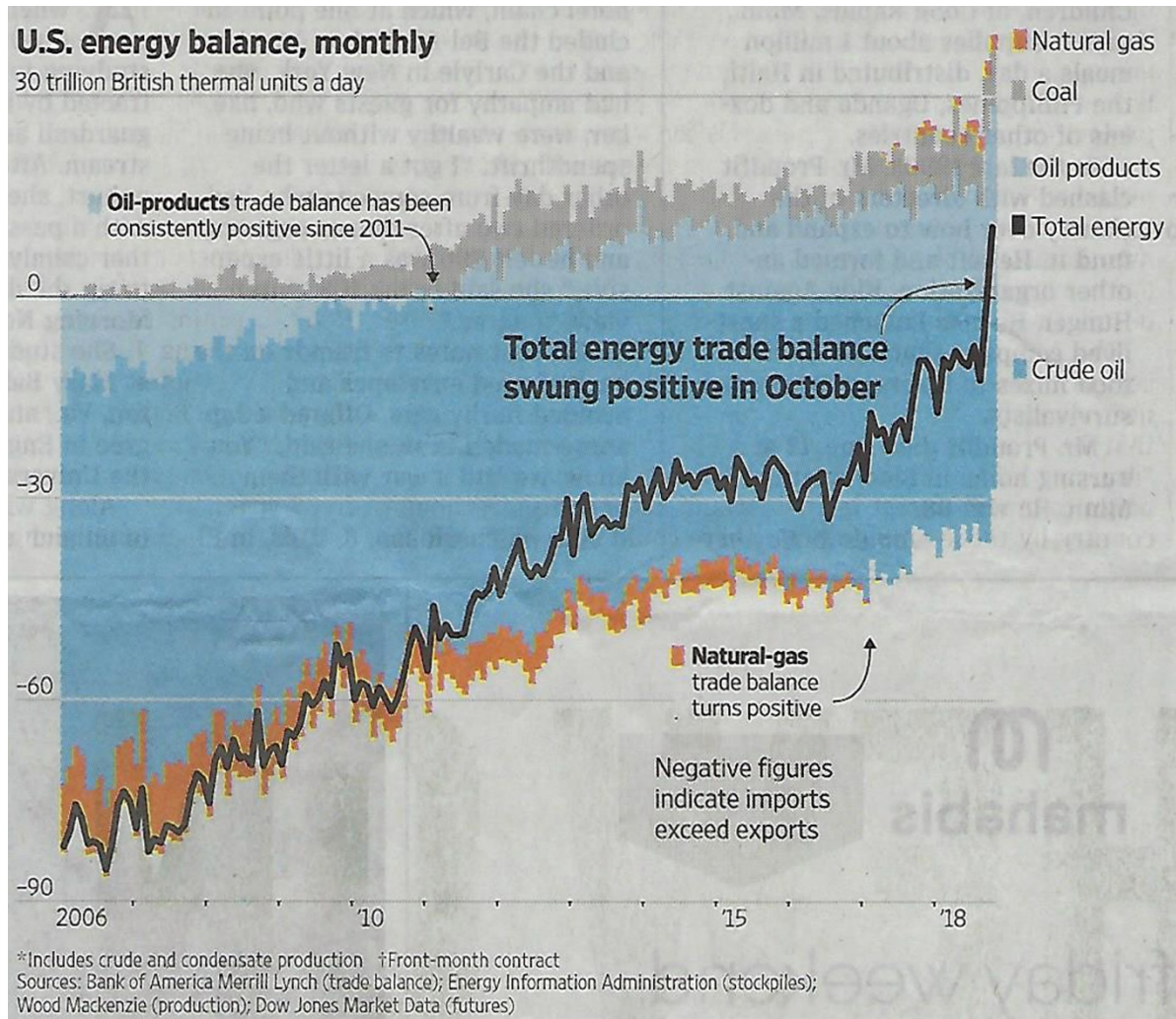
World Total Installed Electrical Generating Capacity **6301GW**

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“Practical Strategies for Emerging Energy Technologies”

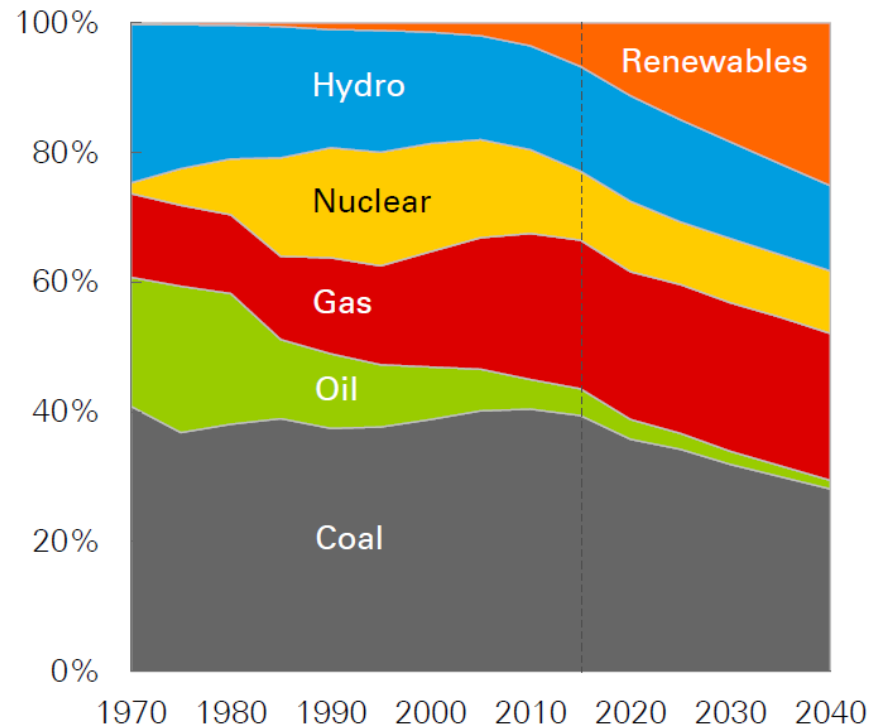
PS... Total Value of Outstanding Student Loans - \$1.5 trillion
 U.S. health care cost 2014 - \$3.3 trillion
 U.S. Household Debt 2017 - \$13.2 trillion

U.S. Energy Balance



The World Continues to Electrify

Shares of total power generation

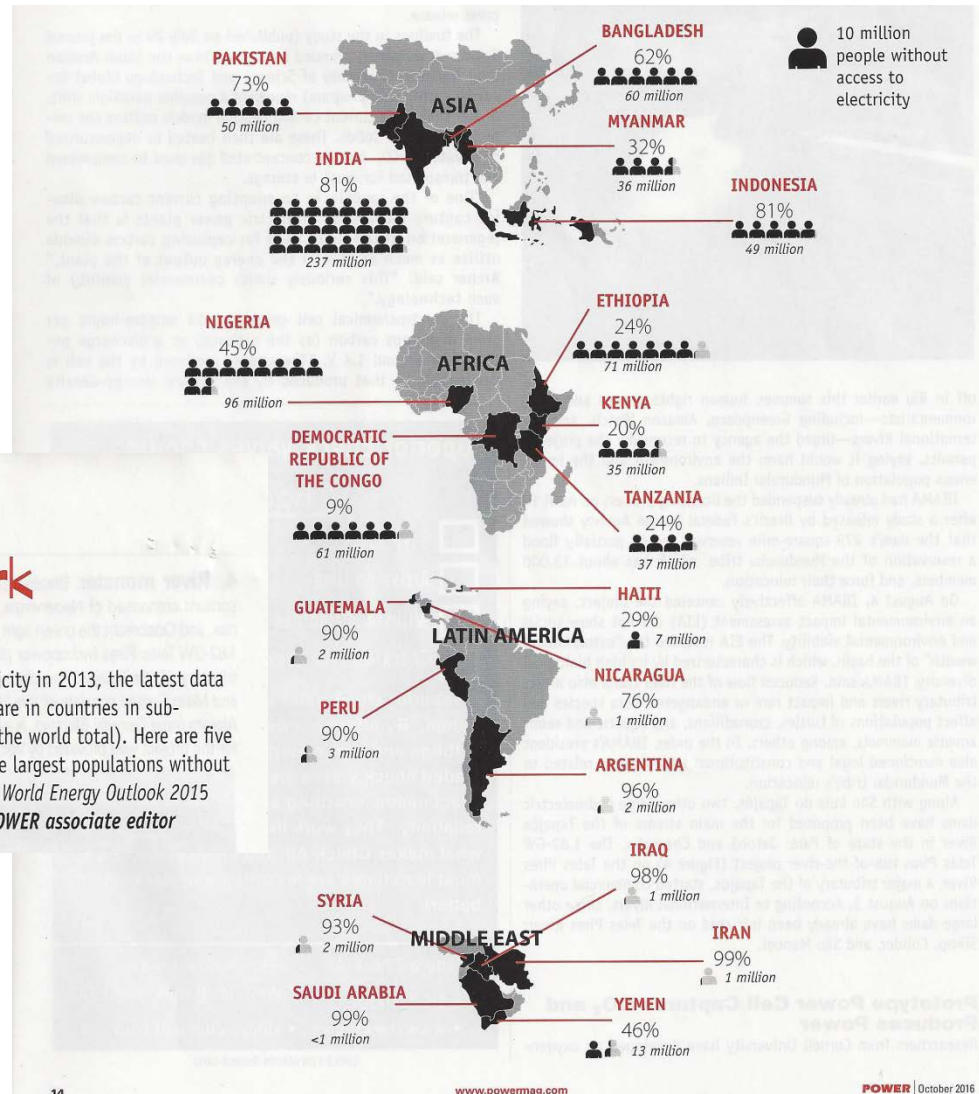


2018 BP Energy Outlook

© BP p.l.c. 2018

Power – “Still in the Dark”

1.2 billion people
17% of Global
Population do not
have access to
electricity



GLOBAL MONITOR

THE BIG PICTURE: Still in the Dark

An estimated 1.2 billion people—17% of the global population—did not have access to electricity in 2013, the latest data from the International Energy Agency show. More than 95% of those living without electricity are in countries in sub-Saharan Africa and developing Asia, and they are predominantly in rural areas (around 80% of the world total). Here are five countries per region (developing Asia, Africa, Latin America, and the Middle East) that have the largest populations without access to electricity. Also noted is that country's national electrification rate (%). Source: IEA, World Energy Outlook 2015

—Copy and artwork by Sonal Patel, a POWER associate editor

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Current Issues

– Climate Change

- IPCC AR6
- 4th National Climate Assessment

– Iran Sanctions

- Eight Un-named Country Temporary Waivers
- China, India, South Korea, Turkey, Italy, the United Arab Emirates and Japan have been top importers of Iran's oil,

– U.S.-China Trade War

– Other Current Issues

- Transportation
 - The New Silk Road
 - Straights of Malacca
 - South China Sea & Freedom of the Seas
 - Pak/China corridor
 - Panama canal
 - NAFTA/SCP-TANAP-TAP Pipeline
 - Arctic Passage
- Turkey – The Crossroads of Everything
- Saudi Arabia vs. Iran
- New NAFTA
- Oil (Tar) Sands
- Arctic Resource
- Rural Electrification
- Northeast gas pipeline

– Oil Supply/Demand

- OPEC + Russia - Qatar
- USA
- Iran & Saudi Arabia
- Canada
- Mexico
- Venezuela
- UK

– Natural Gas Supply/Demand

- Pipeline vs. LNG
- Gas to China & China-US Trade War
- EU Gas Demand
 - Nord2
 - Turk Stream
- USA Export
- India Demand Growth
- Australia
- Russia

U.S. EIA Annual Energy Outlook 2018

10 Cases
Sorted High-Low, 2050

Energy-Related Carbon Dioxide Emissions by Sector and Source (MMmt)									
	2016	2020	2025	2030	2035	2040	2045	2050	Growth (2017-2050)
High economic growth	5174	5207	5138	5170	5225	5372	5568	5814	0.40%
Low oil price	5174	5170	5163	5156	5165	5234	5365	5521	0.20%
High economic growth with Clean Power Plan	5174	5204	5041	4927	4943	5057	5234	5424	0.20%
High oil and gas resource and technology	5174	5132	4999	5014	5020	5069	5152	5307	0.10%
Reference case	5174	5187	5079	5053	5024	5080	5159	5279	0.10%
Low oil and gas resource and technology	5174	5300	5114	4984	4954	4968	5030	5103	0.00%
High oil price	5174	5141	4926	4937	4950	4950	4987	5061	-0.10%
Reference case with Clean Power Plan	5174	5179	4997	4840	4822	4852	4915	5013	-0.10%
Low economic growth	5174	5110	4919	4856	4780	4743	4728	4742	-0.20%
Low economic growth with Clean Power Plan	5174	5115	4861	4697	4611	4586	4561	4562	-0.40%

~6°C Trajectory

CPP Impact Ref Case	0	24	43	87	121	205	319	266	Clean Power Plan Effect is tiny
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Energy-Related Carbon Dioxide Emissions Intensity by Sector and Source (MMmtCO ₂ /capita)									
Reference case	16.0	15.5	14.7	14.1	13.6	13.4	13.3	13.3	-0.50%
Reference case with Clean Power Plan	16.0	15.5	14.4	13.5	13.0	12.8	12.6	12.6	-0.70%

Real Gross Domestic Product (\$billion)									
Reference case	16716	18335	20221	22421	24802	27356	30204	33205	2.00%
Reference case with Clean Power Plan	16716	18319	20195	22380	24775	27341	30177	33161	2.00%

Population (millions)									
Reference case	323.7	333.8	346.6	358.6	369.5	379.4	388.6	397.5	0.60%
Reference case with Clean Power Plan	323.7	333.8	346.6	358.6	369.5	379.4	388.6	397.5	0.60%



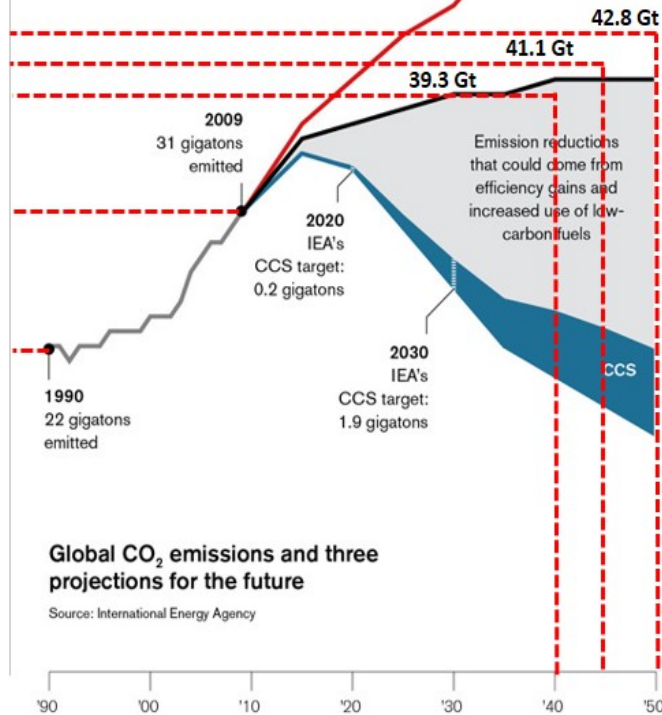
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EIA Annual Energy Outlook 2018

The Carbon Capture Conundrum

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

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

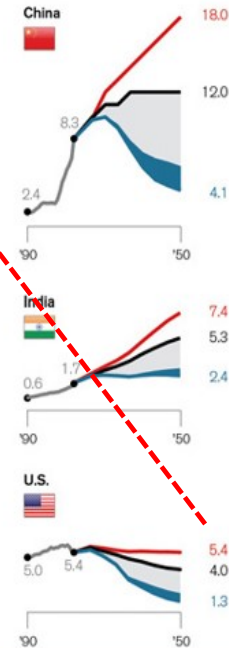


Current trajectory 58 gigatons
This projection assumes that essentially no action is taken to address climate change. Models predict a long-term global temperature rise of 6 °C in such a scenario.

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

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

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



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

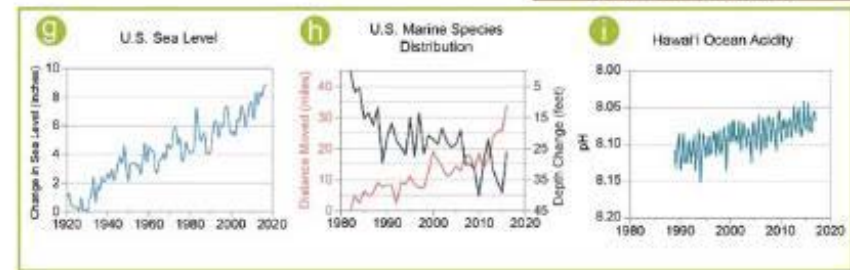
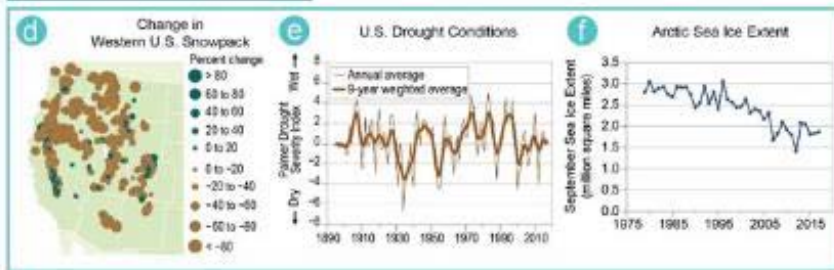
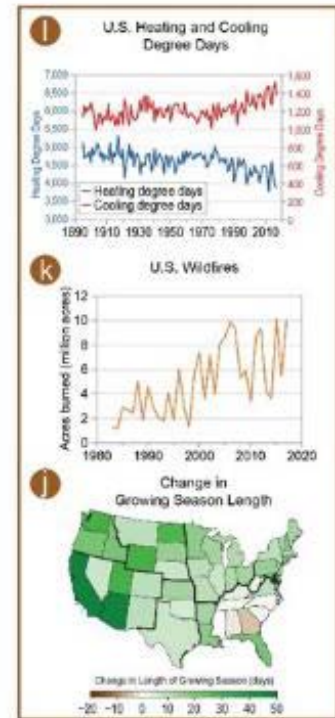
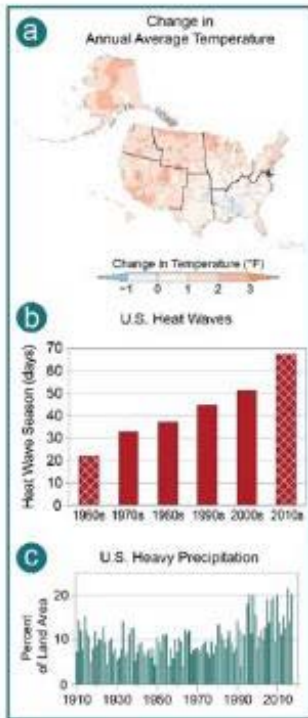
EIA 2018 International Energy Outlook
U.S. w/ CPP 5.013 Gt
U.S. w/o CPP 5.279 Gt
High Growth 5.815 Gt

1

Introduction: NCA4 Vol II

- Earth’s climate is now changing faster than at any point in modern civilization
- These changes are primarily the result of human activities, the evidence of which is overwhelming and continues to strengthen
- The impacts of climate change are already being felt across the country, and climate-related threats to Americans’ physical, social, and economic well-being are rising
- Americans are responding in ways that can reduce risks, build resilience, and improve livelihoods
- However, neither global efforts to mitigate the causes of climate change nor regional efforts to adapt to the impacts currently approach the scales needed to avoid substantial damages to the U.S. economy, environment, and human health and well-being over the coming decades

Climate Change Indicators- 4th Assessment



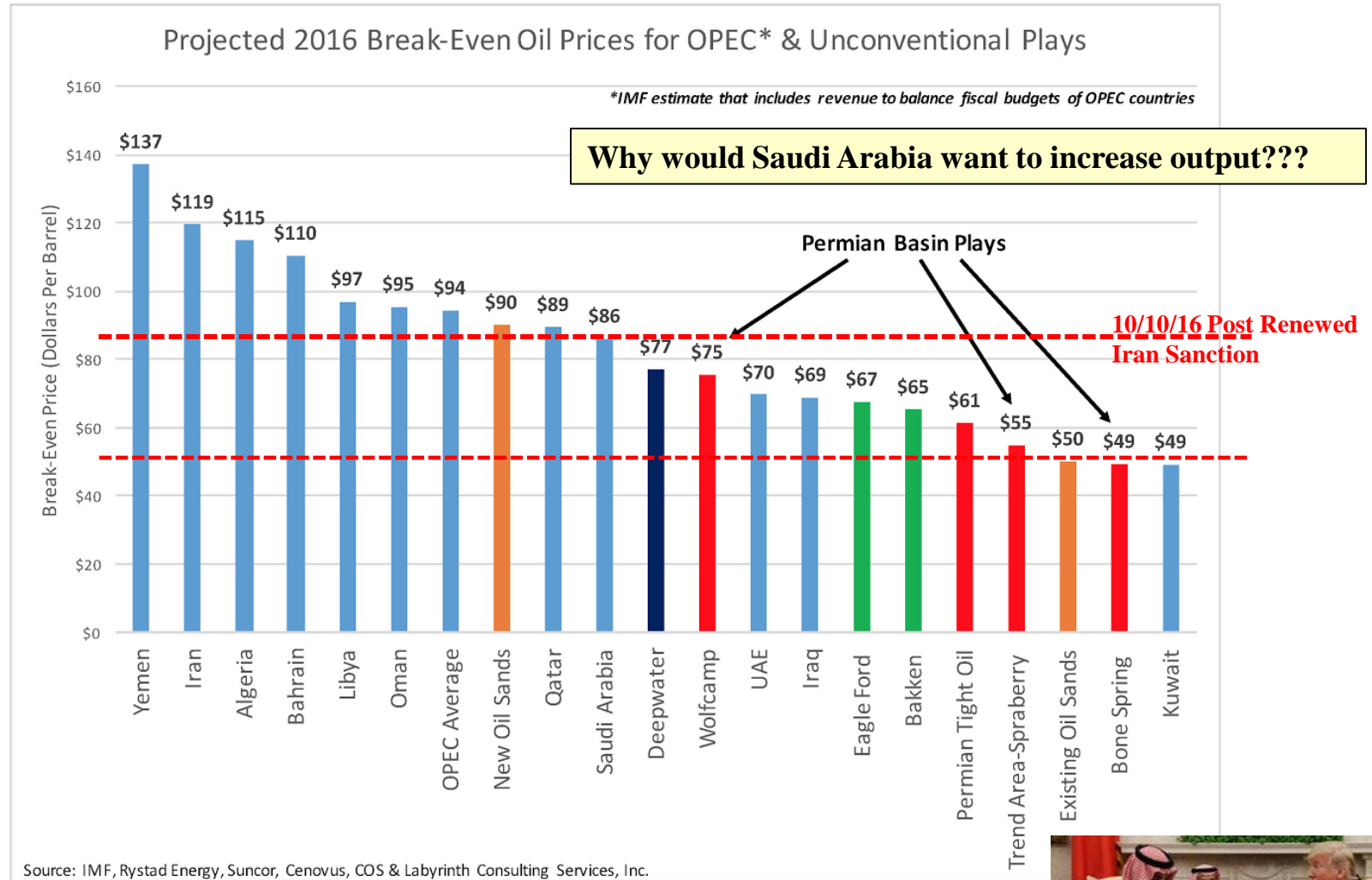
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“Practical Strategies for Emerging Energy Technologies”

Key events during the second quarter of 2018

- **Logistical bottlenecks became evident in the Permian Basin.**
 - Most operators and services companies mention production is very close to outstripping pipeline takeaway capacity.
 - Growth and investments are expected to be throttled back until new takeaway is available, with West Texas Intermediate (WTI) Midland having traded at a discount of over \$15 per barrel since mid-July as marginal barrels have begun to move by truck.
- **OPEC met in June**
 - Agreed to increase production by about 600,000 barrels per day.
 - In a coordinated move, Russia also agreed to increase production by about 150,000 to 200,000 barrels per day.
- **Mexico elected a new president, who will take office December 1**
 - Energy policy changes are expected, and auctions of oil and gas blocks could be delayed.
- **Venezuela continued to face political and economic challenges**
 - Which led to oil production dropping by more than 30 percent in the past year
 - From two million barrels per day in June 2017 to 1.34 million barrels per day in June 2018
- **The US government withdrew from the Iran nuclear deal and re-imposed economic sanctions on Iran**
 - The sanctions on Iran could eventually force traditional buyers, especially India, to seek alternate sources of crude oil, although deliberations between those nations continue.
 - Experts predict a sharp reduction, perhaps as much as one million barrels per day, of Iran’s current production level of about 2.5 million barrels per day when the sanctions become effective in November.
 - French national oil company Total has decided to withdraw from Iran, citing uncertain geopolitical environment.
- **Escalating US and China trade tensions continued**
 - The tariffs considered by China included a 25 percent duty on imports of liquefied natural gas (LNG) from the United States, which would reduce, though not eliminate, the advantage US LNG exporters enjoy due to low-cost domestic-gas production.

Break-Even Price of Oil Selected Locations

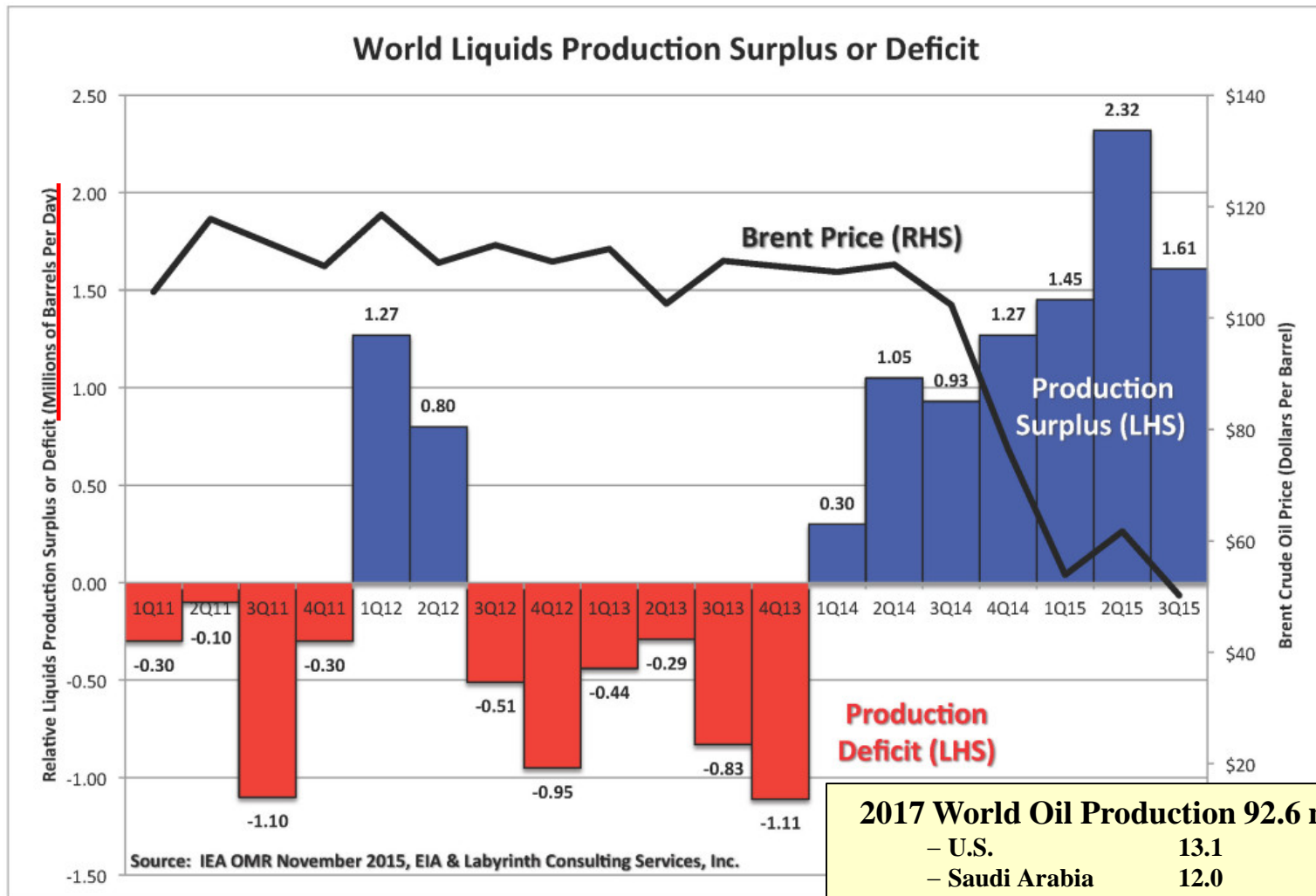


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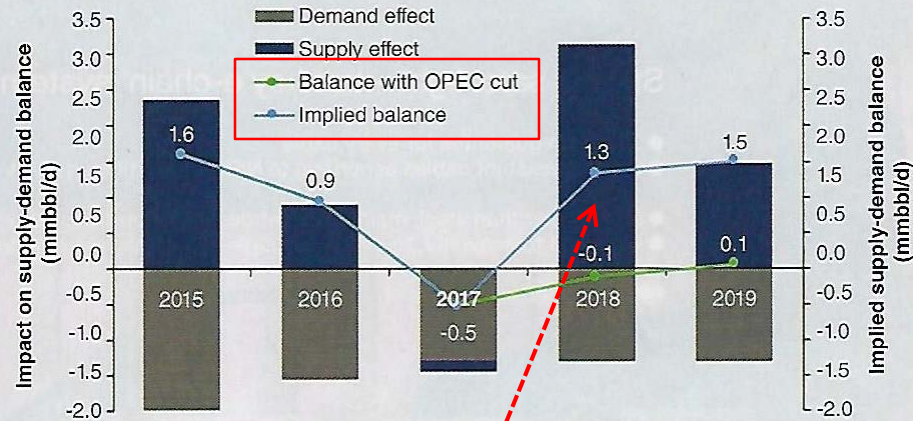
Oil Price – The Supply/Demand Balance



2017 World Oil Production 92.6 mmbbl/d	
– U.S.	13.1
– Saudi Arabia	12.0
– Russia	11.3
– Iran	5.0

2015-2019 Supply-Demand Balance

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



Source: Sectors

OPEC Production cut ~1.8 mmbbl/d

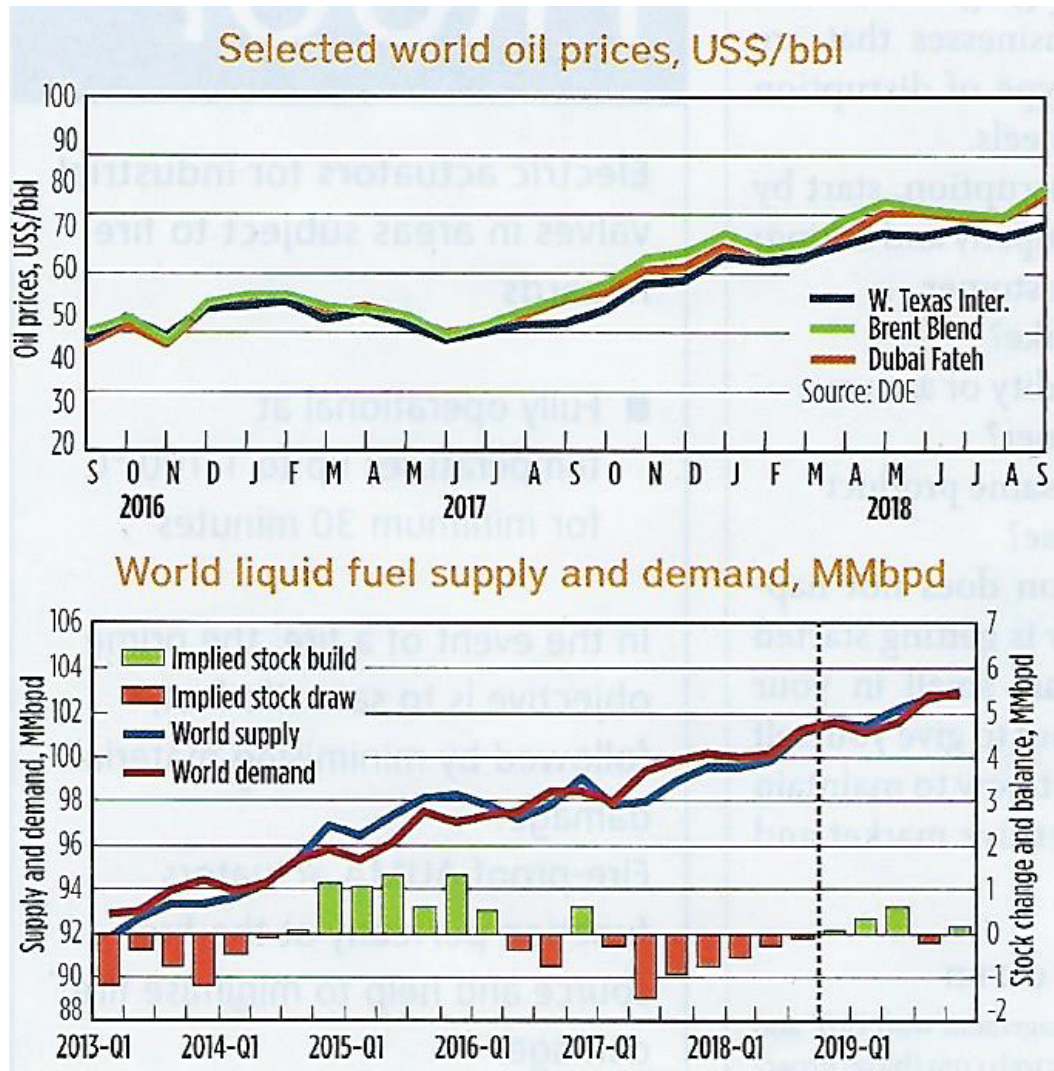
WORLDWIDE SUPPLY AND DEMAND

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

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

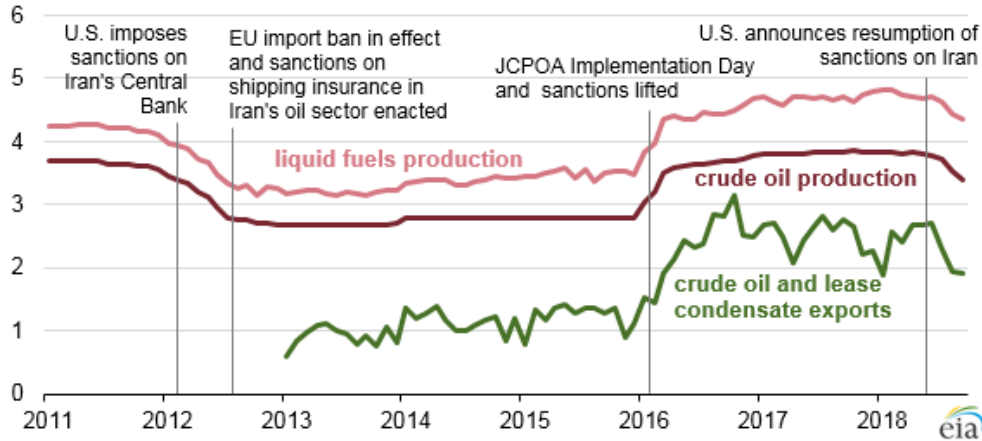
BP 92.6 mmbbl/d

Oil Supply/Demand in Balance Pre-Iran Embargo

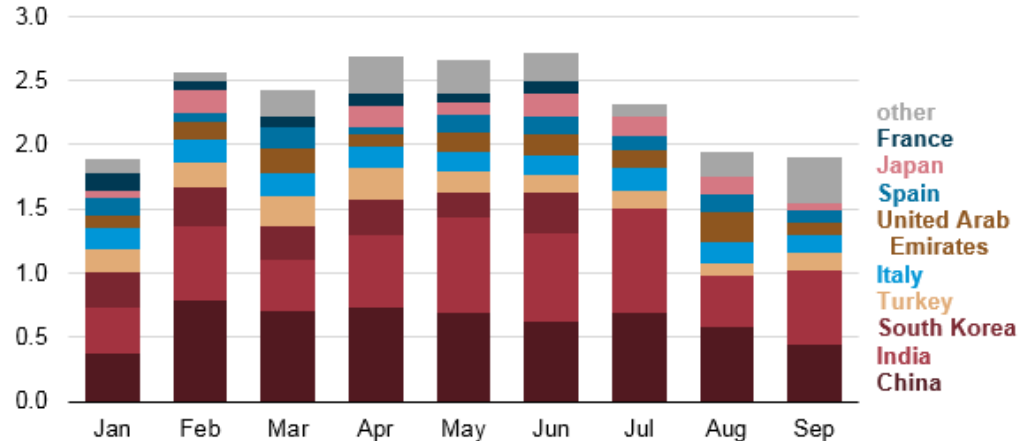


Iran Sanctions Resume – Exports Decline

Iran liquid fuels, crude oil, and condensate production and exports (Jan 2011- Sep 2018)
million barrels per day



Monthly Iran crude oil and lease condensate exports (2018)
million barrels per day



Eight Countries to Receive Waivers

Saudi Arabia

- Saudi Arabia is committed to meeting India’s rising oil demand and is the “shock absorber” for supply disruptions in the oil market
 - India, the world’s third-biggest oil importer, is grappling with a combination of rising oil prices and falling local currency.
 - Retail prices for gasoline and diesel fuel in India are at record highs
 - The Government has cut its excise tax on fuel to ease some of the pain for consumers.
- 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.
 - We have seen sanctions on Iran.
 - These supply disruptions need a shock absorber and the shock absorber to a large extent has been Saudi Arabia.”
- “We have invested tens of billions of dollars to build spare capacity of 2-3 million barrels per day over years,” he added.
- 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.

Russia (de facto) OPEC Member?

- Saudi Arabia and Russia's 'unparalleled' oil deal gets backing from OPEC
 - Riyadh and Moscow have been engaged in supply cuts over the past year in order to try to clear a global supply overhang and keep prices in check.
 - Yet, in an effort to further their influence over world crude supplies, the two countries are now reportedly working on a deal to actively manage markets for potentially the next 20 years.
 - At the start of the week, Saudi Arabia's Crown Prince, Mohammad Bin Salman, told Reuters: "We are working to shift from a year-to-year agreement to a 10-20 year agreement."

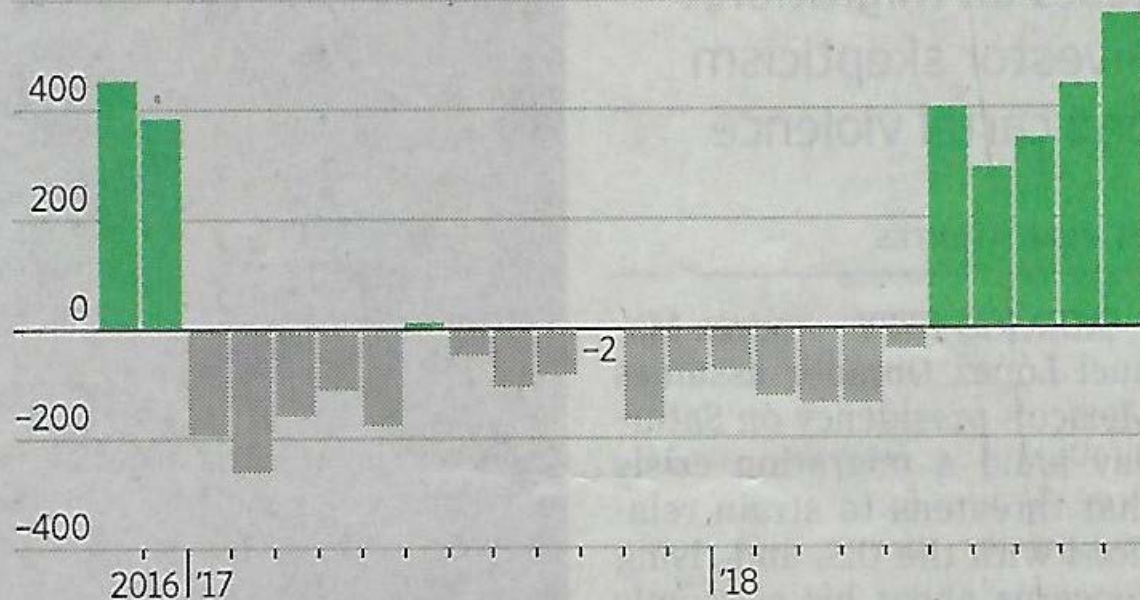
Saudi Arabia Production Above OPEC Quota

Pump Up the Volume

Saudi Arabia ramped up production well above its OPEC quota under U.S. pressure.

Crude-oil production above or below the quota

600 thousand barrels a day



Source: Organization of the Petroleum Exporting Countries THE WALL STREET JOURNAL.

WTI Crude Oil Prices - 10 Year Daily Chart



WTI Crude Prices – \$/bbl

Max - 2014

11:31 am CST 15/11/2018

Technicals

WTI Crude
56.75 +0.89%



1D | 1WK | 1M | 1YR | Max

Share

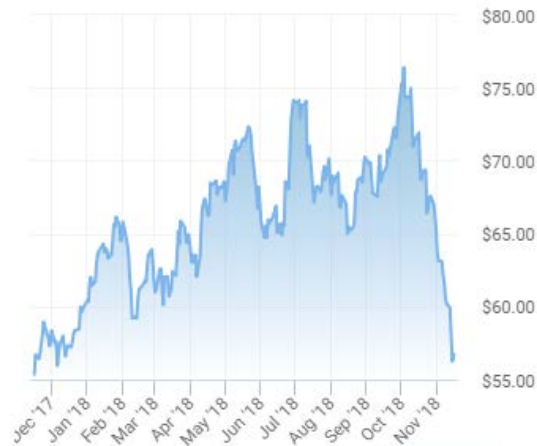


1 Year

11:33 am CST 15/11/2018

Technicals

WTI Crude
56.74 +0.87%



1D | 1WK | 1M | 1YR | Max

Share



1 Month

11:34 am CST 15/11/2018

Technicals

WTI Crude
56.70 +0.80%



1D | 1WK | 1M | 1YR | Max

Share



base_e

“Practical Strategies for Emerging Energy Technologies”

OPEC Meeting Tomorrow

December 6, 2018

base_e

“Practical Strategies for Emerging Energy Technologies”

5 Key Findings McKinsey Global Gas & LNG Outlook

1. China LNG imports grew by 52 percent year-over-year in the first half of 2018 (<https://www.mckinsey.com/solutions/energy-insights/global-gas-lng-outlook-to-2035>)
2. Asia is expected to fuel 50 percent of 2017-2022 global gas demand growth
3. South Asian gas demand is expected to grow by about 2 percent per annum by 2022, spurring LNG imports by 20 billion cubic meters
4. Europe is expected to require approximately 45 additional billion cubic meters of gas imports over the next 5 years
5. The LNG market is expected to rebalance by around 2022

LNG vs. U.S./China “Trade War”

Before the discussion of
tariffs on LNG

- (Reuters) - China's interest in reducing its trade surplus with the United States through increased energy imports could advance plans for U.S. liquefied natural gas (LNG) plants and ethanol sales
 - "China represents an enormous economic opportunity for U.S. LNG and ethanol exports as both products will likely see dramatic demand growth in the coming years"
 - Substantial LNG sales commitments could bring in \$20 billion to \$30 billion annually and ethanol sales could reach \$5 billion to \$7 billion annually.
 - LNG and ethanol markets were not big enough by themselves to meet President Donald Trump's goal of reducing the Chinese trade deficit by \$200 billion per year.
- There are more than two dozen proposed U.S. LNG plants waiting for customer commitments to reach a final investment decision, many of them looking to China for deals.
- China overtook South Korea in 2017 as the world's second biggest buyer of LNG behind Japan.
 - China imported 5.6 billion cubic feet per day last year, is looking to buy more low cost sources of energy, like gas, to reduce its use of coal and cut pollution.
- "If you look at some forecasts for 2035, there are really only two places that have significant increases in LNG imports.
 - Europe goes up about 100 mtpa
 - China goes up about 200 mtpa

China Stops Buying U.S. Oil in August

- 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

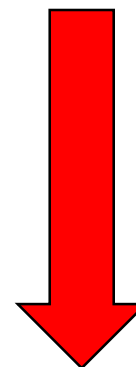
Oil, the No. 5 export by value totaled \$3.58 billion for the month of August, \$28.33 billion through August of 2018, and \$21.83 billion for all of 2017, the latest annual data available, according to U.S. Census Bureau data analyzed by WorldCity. Need more details? [Read more](#)

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



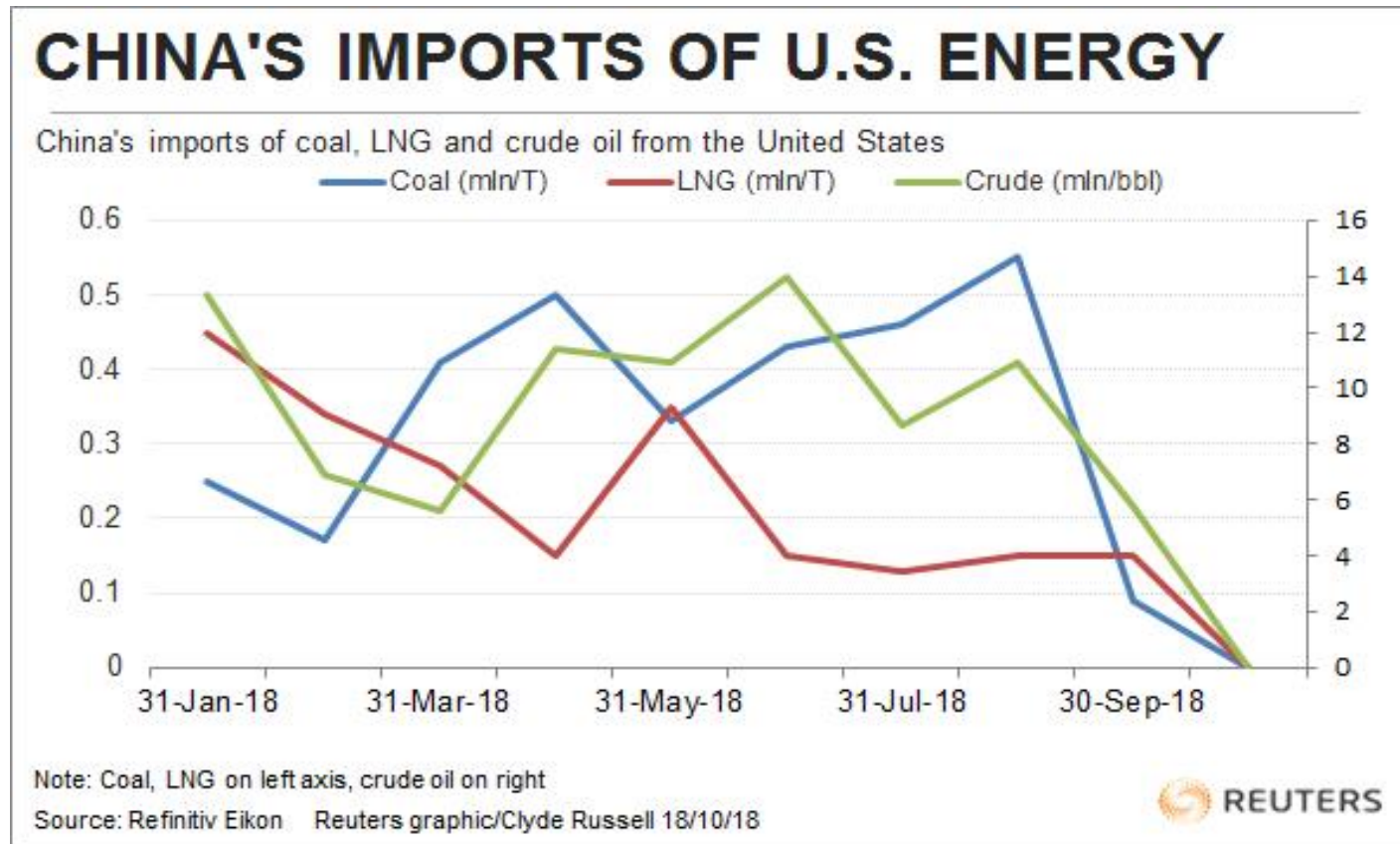
Oil Exports to China	August 2018	July 2018	June 2018
Total All U.S. Ports	\$ -	\$ 853,314,780	\$ 1,025,764,923
Corpus Christi	\$ -	\$ -	\$ 303,634,182
Beaumont, Texas	\$ -	\$ 323,938,346	\$ 259,603,038
Port Houston	\$ -	\$ 152,542,034	\$ 200,333,761
Texas City	\$ -	\$ -	\$ 111,994,637
Freeport, Texas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



“Practical Strategies for Emerging Energy Technologies”

Ken Roberts Forbes Contributor

.....and, Other things



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)

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.
- The report quoted Yoon Sung-hyuck, chief of the Ministry of Trade, Industry and Energy’s shipbuilding and offshore plant industry division as saying that, 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.
- There are 78 small and midsized builder companies in Korea, whose combined revenue stood at 601.2 billion won last year.
- 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

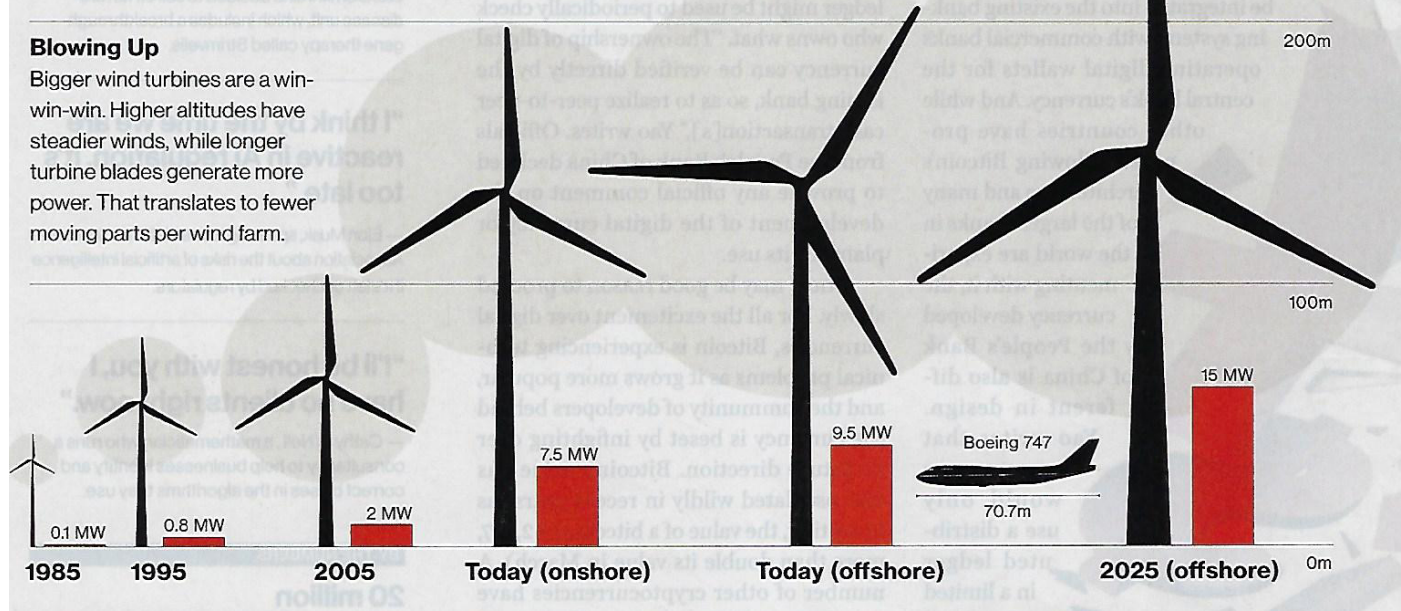
Wind

For Wind Power, Bigger Is Better

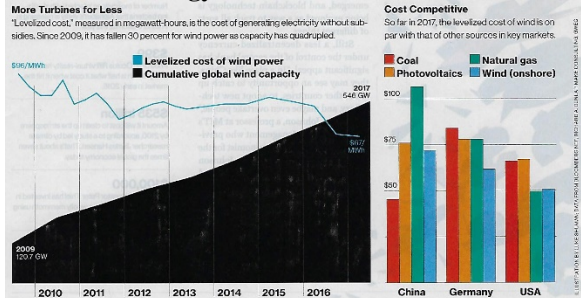
Things are looking up for wind power—way up. Wind is now competitive with fossil fuels in many areas of the world, while the rise of turbines to new heights figures to bring down costs even more.

Blowing Up

Bigger wind turbines are a win-win-win. Higher altitudes have steadier winds, while longer turbine blades generate more power. That translates to fewer moving parts per wind farm.



MIT Technology Review Vol 120/ No. 5



WIND CAPACITY FACTOR, ALL TURBINES, BY REGION

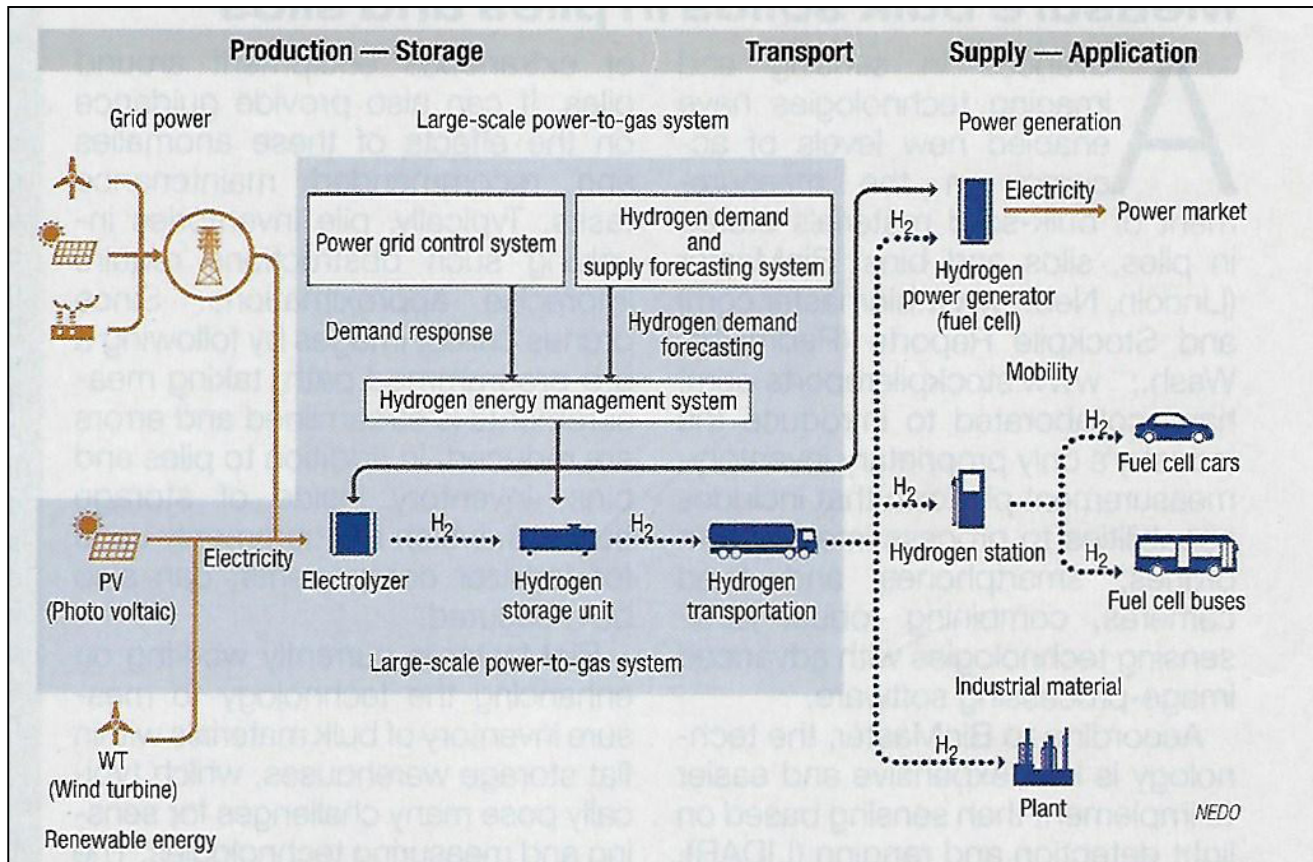
SPECIFIC POWER	WEST	NORTHEAST	GREAT LAKES	INTERIOR
Greater than 400 W/m ²	22.8%	25.6%	15.4%	27.7%
350 to 400 W/m ²	24.6%	25.0%	19.6%	29.3%
300 to 350 W/m ²	24.9%	28.0%	30.0%	35.2%
250 to 300 W/m ²	27.6%	29.8%	34.2%	40.4%
Less than 250 W/m ²	32.6%	32.4%	37.4%	44.4%
REGIONAL AVERAGES	25.5%	27.9%	32.6%	37.9%

Data source: 2017 Wind Technologies Market Report



“Practical Strategies for Emerging Energy Technologies”

METI “Basic Hydrogen Strategy”



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

Other Material

Oil

Crude Oil Consumption 2017 – 98.2 MMbbl/d

Oil: Consumption*

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

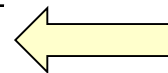
+1,698 MMbbl/d

Source: BP Statistical Review of World Energy 2018

Crude Oil Production 2017 – 92.6 MMbbl/d

Oil: Production*

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



Coal

Coal Consumption 2017– 3732 Mtoe

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

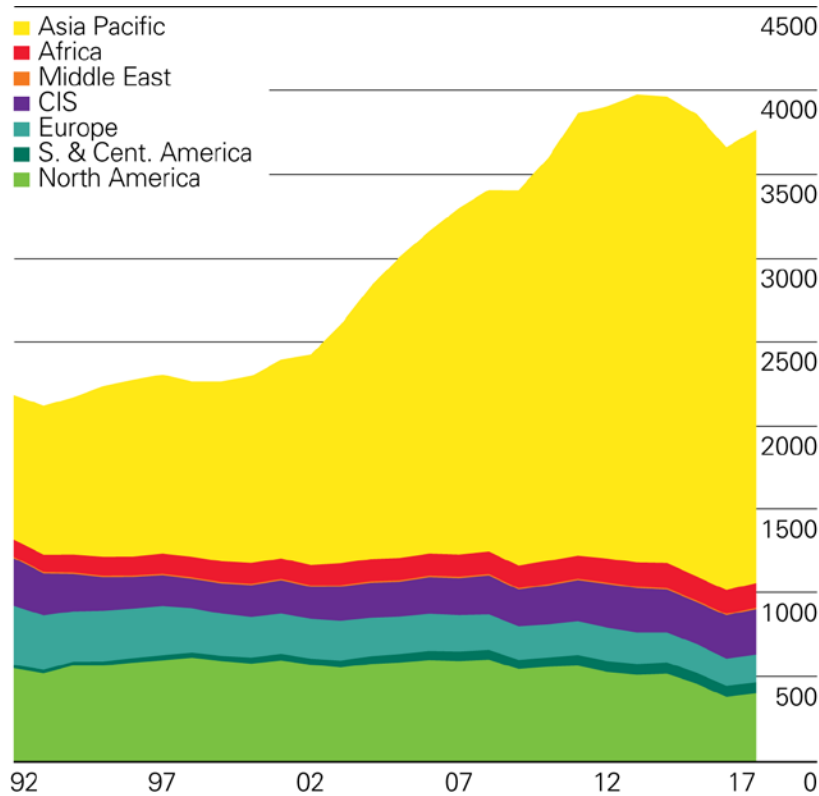
Coal: Consumption*

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

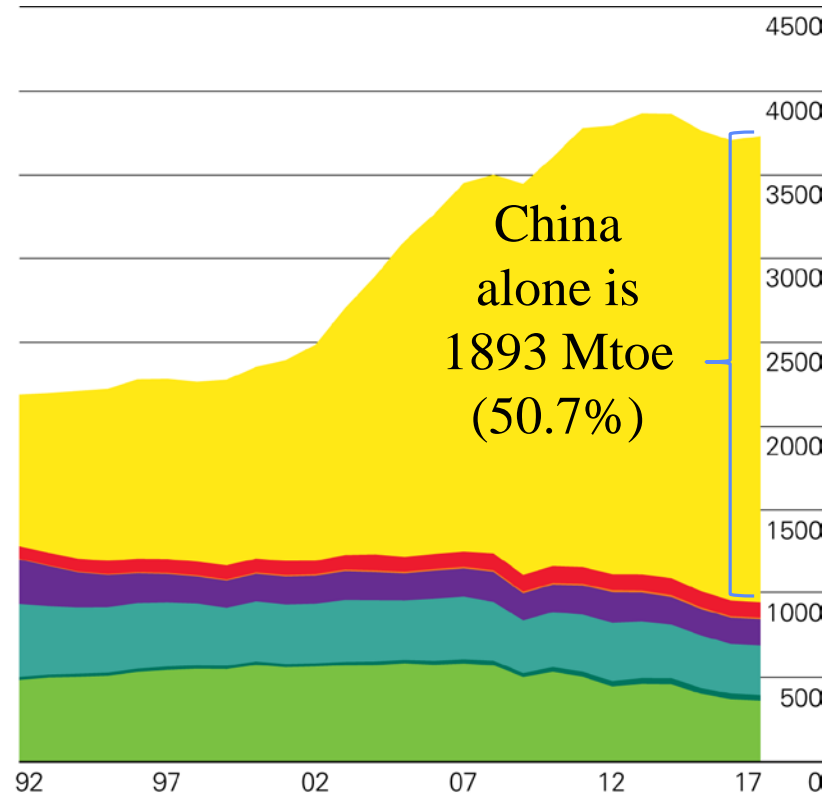
Coal - Regional Consumption 2017 - Mtoe

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

Production by region



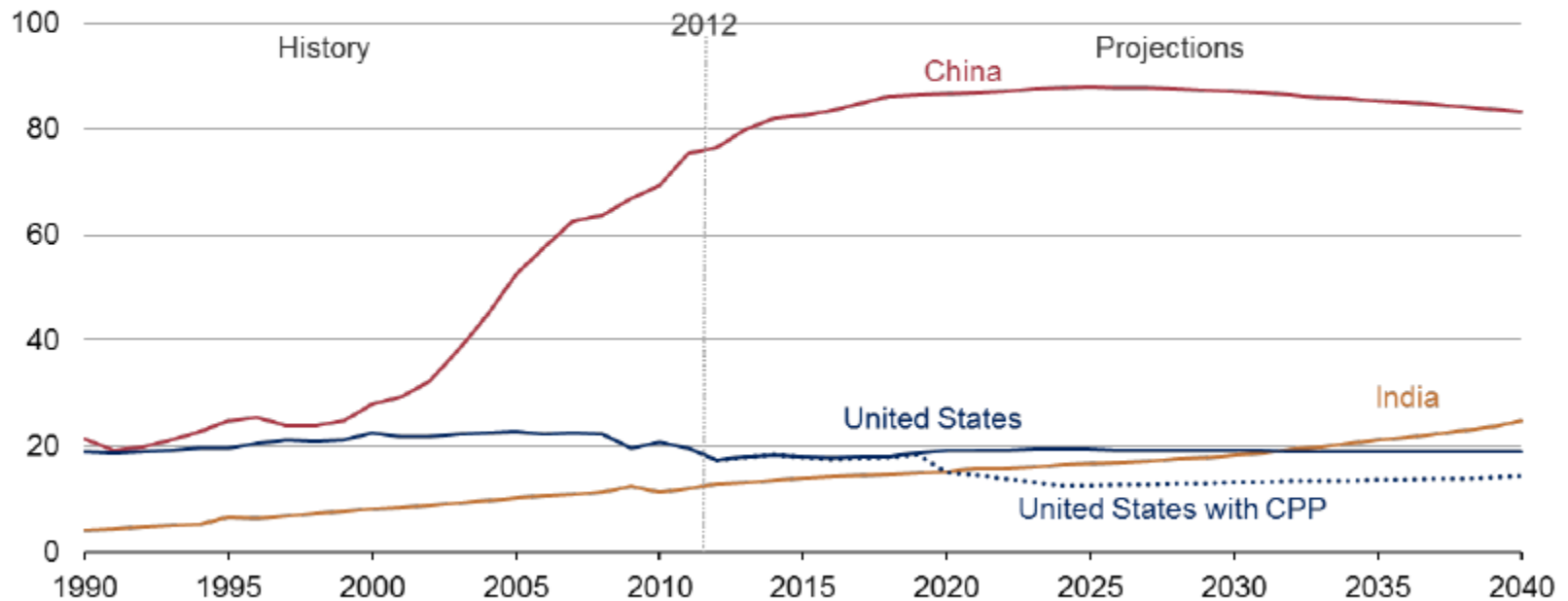
Consumption by region



India Coal

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

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



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

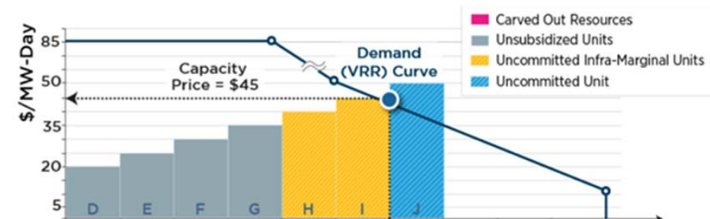
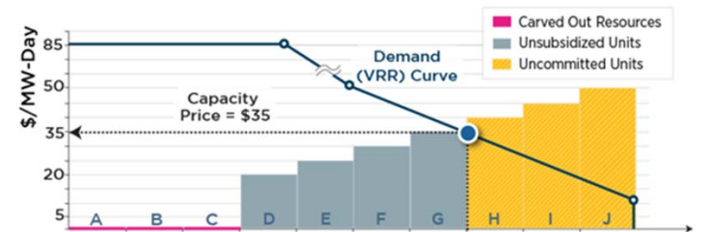


Adam Sieminski, Center for Strategic and International Studies
May 11, 2016

Nuclear

Zero Carbon Emissions Credits - ZECs

- Illinois and New York aimed at subsidizing under-performing and at-risk nuclear power plants.
- To significantly lower this country’s greenhouse gas emissions, they argue, we’ll need baseload power.
- Only three current large-scale power sources fit that bill: coal, natural gas, and nuclear.
- Of those three, only nuclear power can generate energy without carbon dioxide emissions.
- Nuclear energy does not qualify as a “renewable energy resource”
- State level Zero Emissions Credits (ZEC) subsidize nuclear plants
 - Illinois is \$16.50/MWh
 - NY is \$17.48/MWh



Natural Gas

Natural Gas Demand 2017 – 3670.4 BCM

Natural Gas: Consumption*

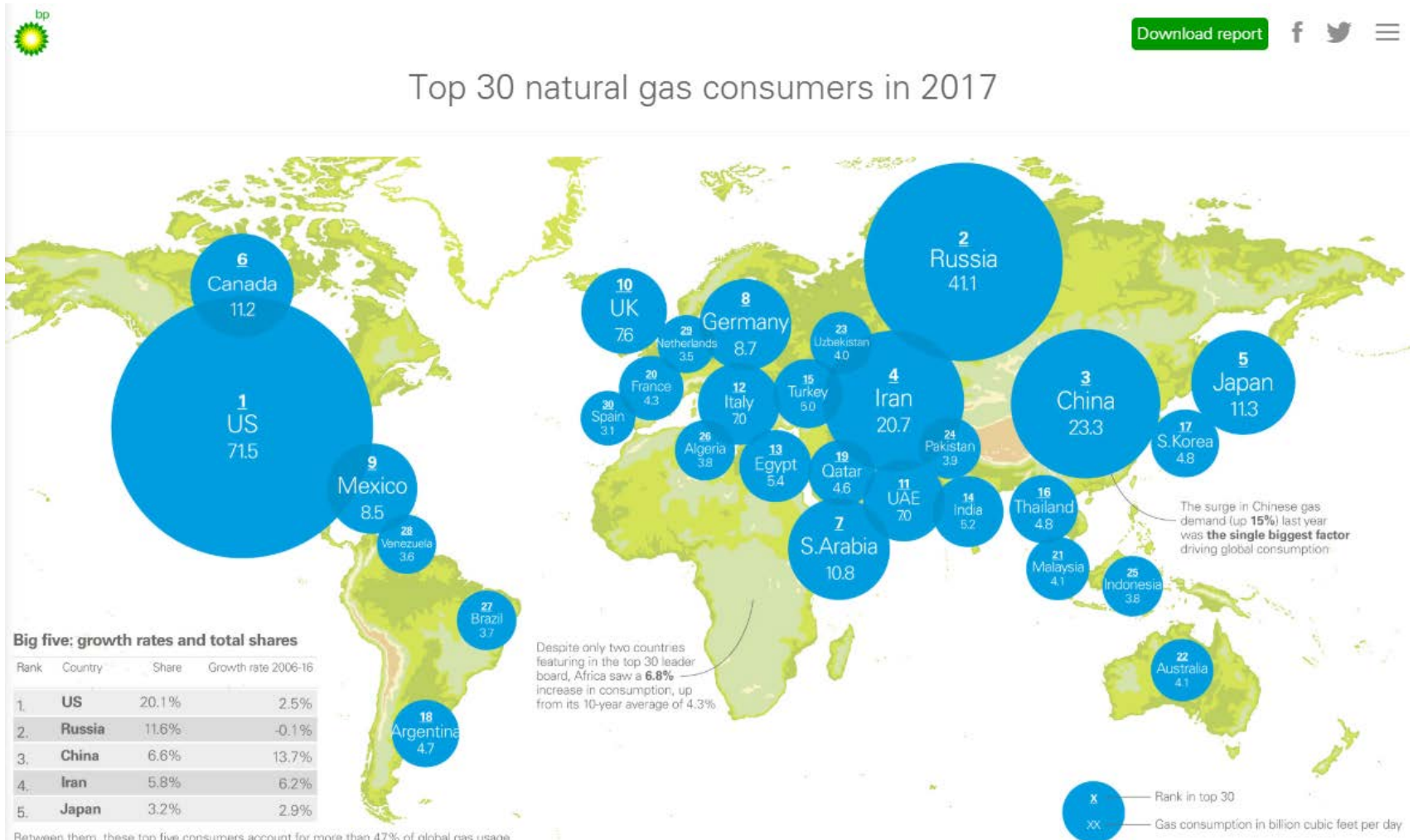
Billion cubic metres	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Growth rate per annum		Share
												2017	2006-16	2017
US	624.1	628.9	617.6	648.2	658.2	688.1	707.0	722.3	743.6	750.3	739.5	-1.2%	2.5%	20.1%
Canada	90.9	89.3	86.6	88.7	95.6	92.8	98.0	103.2	102.9	109.5	115.7	6.0%	2.5%	3.2%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

Natural Gas Production 2017 – 3680.4BCM

Natural Gas: Production*

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

Top 30 Natural Gas Consumers 2017



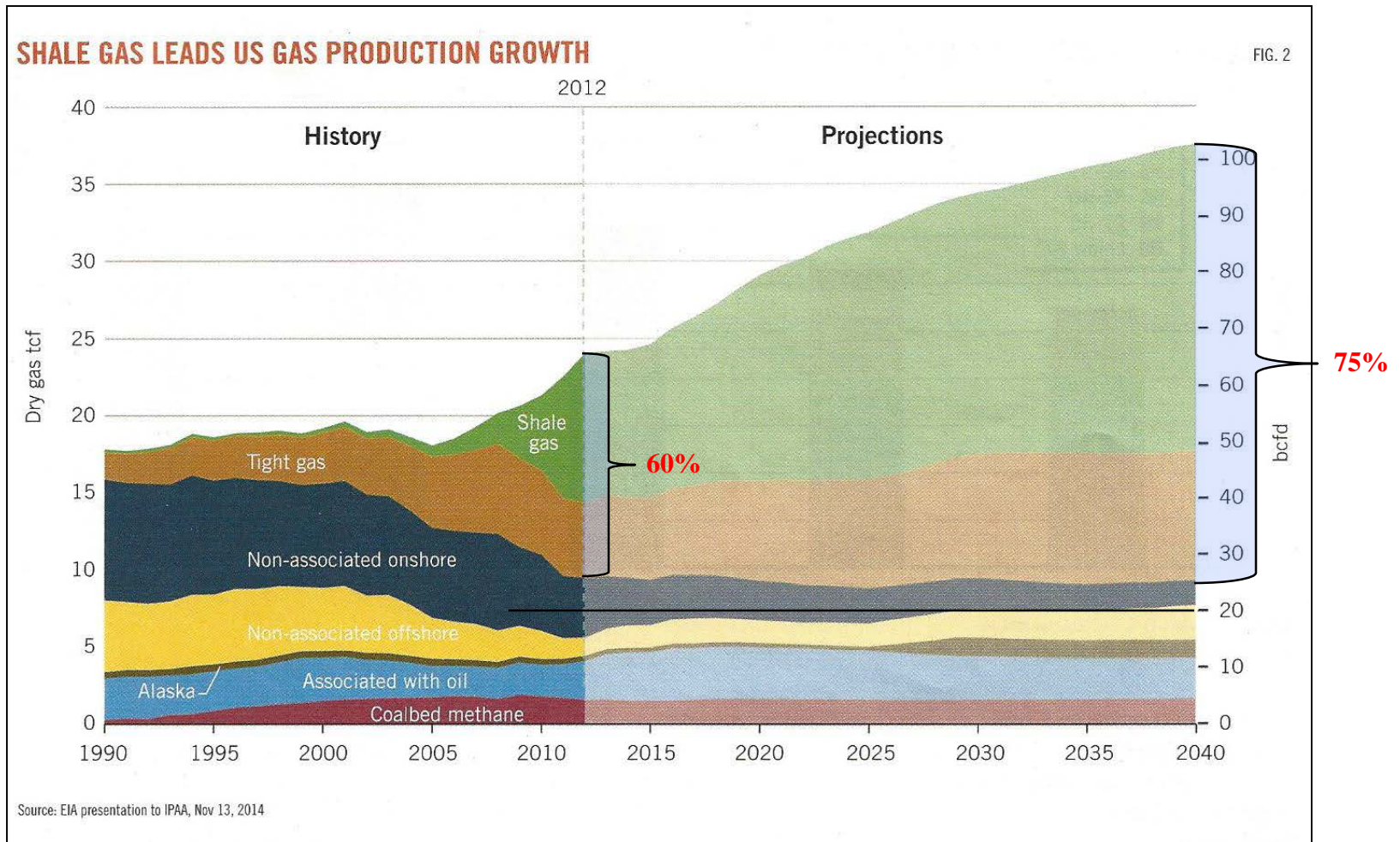
Natural Gas Reserves

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

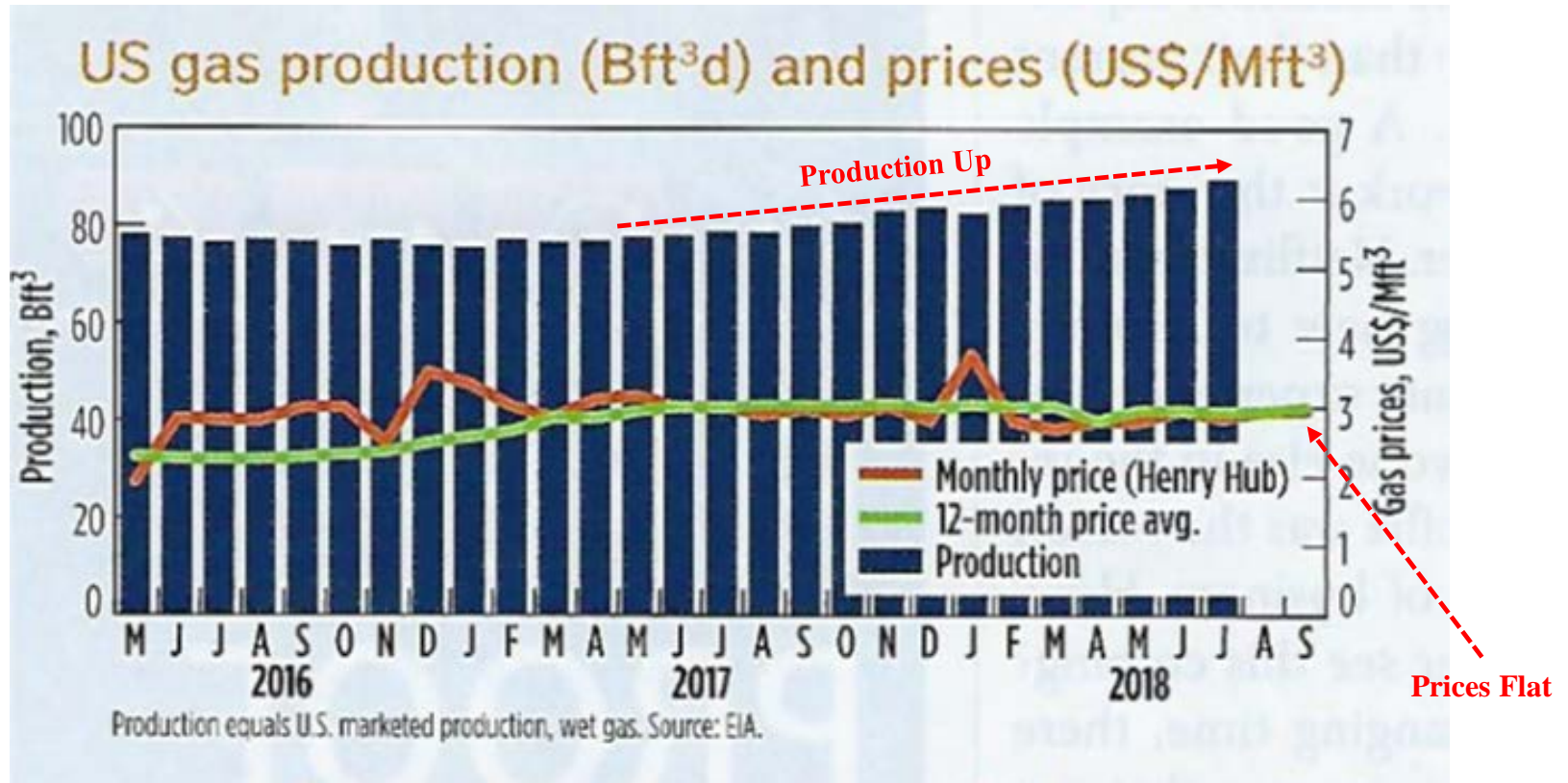


At more than 6,588 trillion cubic feet recorded in 2016, global proved gas reserves are sufficient to meet more than 52 years of current production. As a region, the Middle East holds the largest reserves with 42.5% of the global total, while Iran holds the most proved gas resources as a country.

U.S. Shale Gas

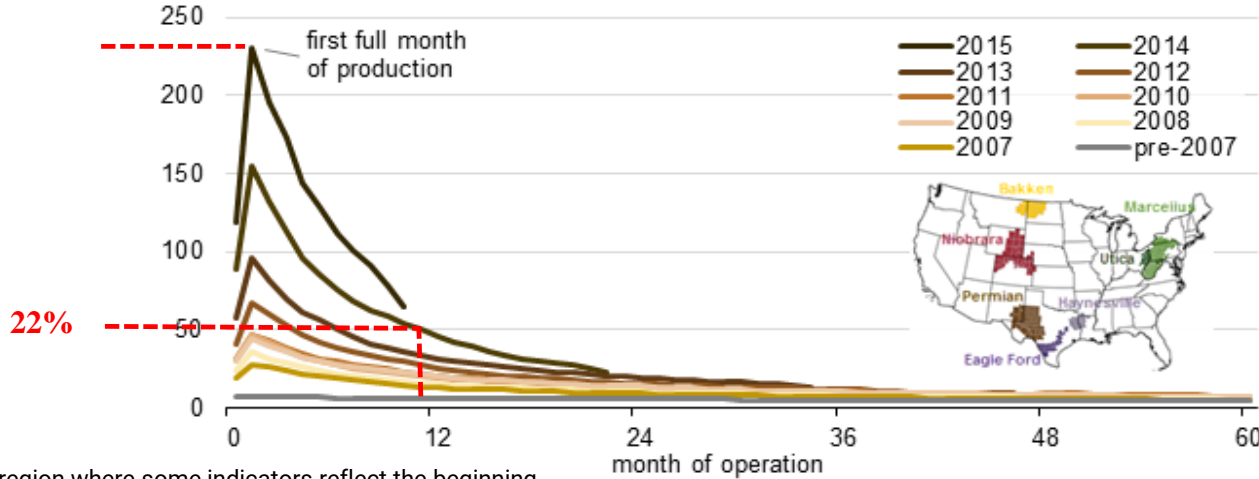


U.S. Gas Prices & Production



Production Well Decline Rate

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

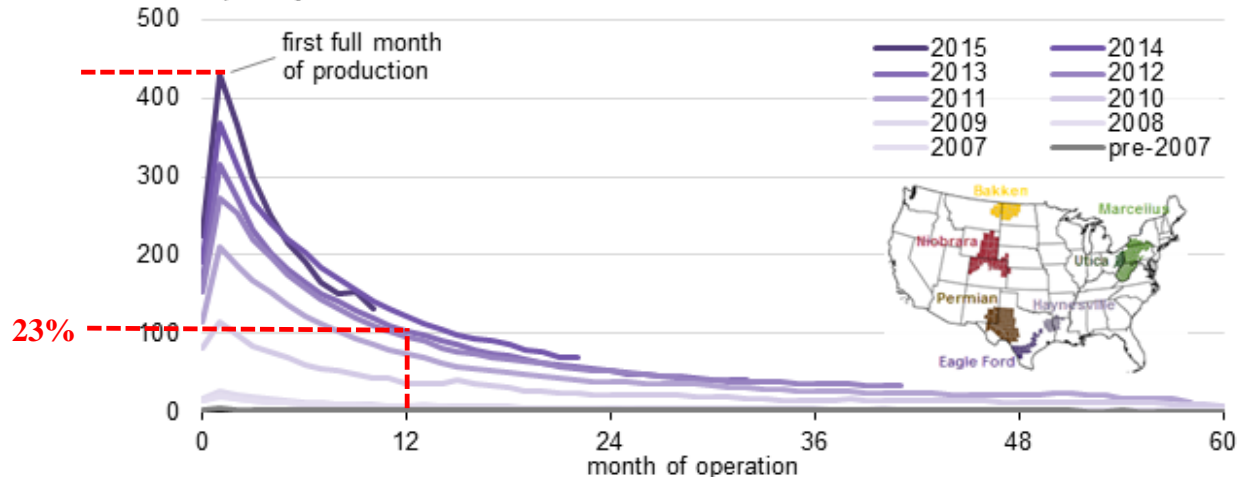


One region where some indicators reflect the beginning of a Shale Tail is the Eagle Ford Shale. Goldman Sachs said the amount of oil in the South Texas region is being revised down.

Of the major shale plays the Eagle Ford and the Bakken in North Dakota are closest to becoming legacy plays, where production would have peaked. Goldman Sachs says the Eagle Ford and Bakken have less than 30 years of resource life, compared to the more than 90 years for the Permian.

Goldman Sachs expects Eagle Ford and Bakken production growing slowly or plateauing through 2025. The analysis says peak production growth in the Eagle Ford and Bakken were seen in 2013 and 2012, respectively.

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



A new report says U.S. shale oil and gas will continue to drive supply growth through at least 2021, though some signs point to the limits of shale resources.

The report by Goldman Sachs says U.S. shale resources are expected to continue to grow by 1 million barrels a day through 2021, which would put the country at more than 13 million barrels a day of oil production.

Goldman Sachs said several factors would point to a Shale Tail, or when U.S. shale oil and gas production becomes less of an influence on global oil markets. They include fewer barrels of oil in the ground than initially estimated, decreases in the amount of oil coming out of each well, and a flattening of production growth.



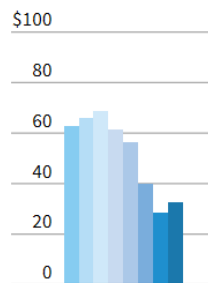
Reuters Break-even Shale Price

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

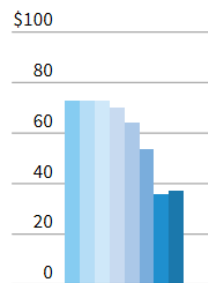
PRICE PER BARREL

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

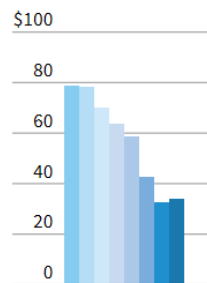
BAKKEN



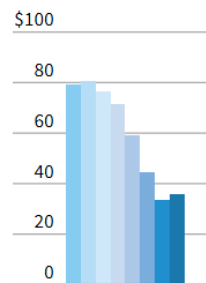
EAGLE FORD



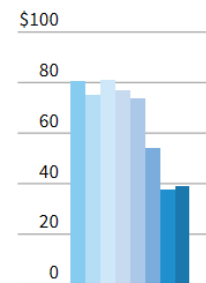
NIOBRARA



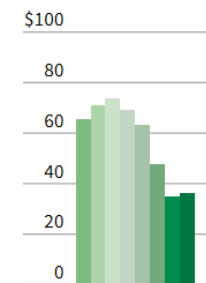
DELAWARE BASIN



MIDLAND BASIN



U.S. SHALE AVERAGE

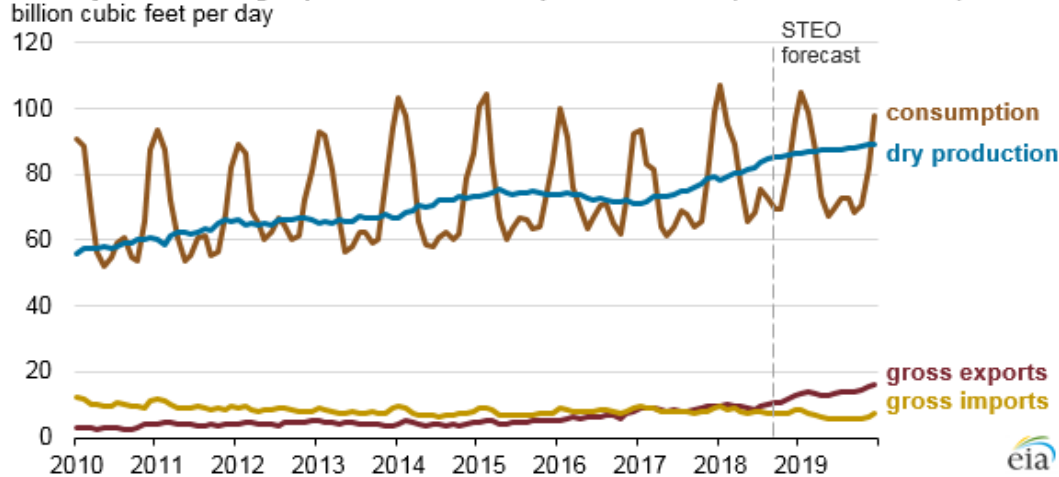


•Estimated
 •Source Rystad Energy

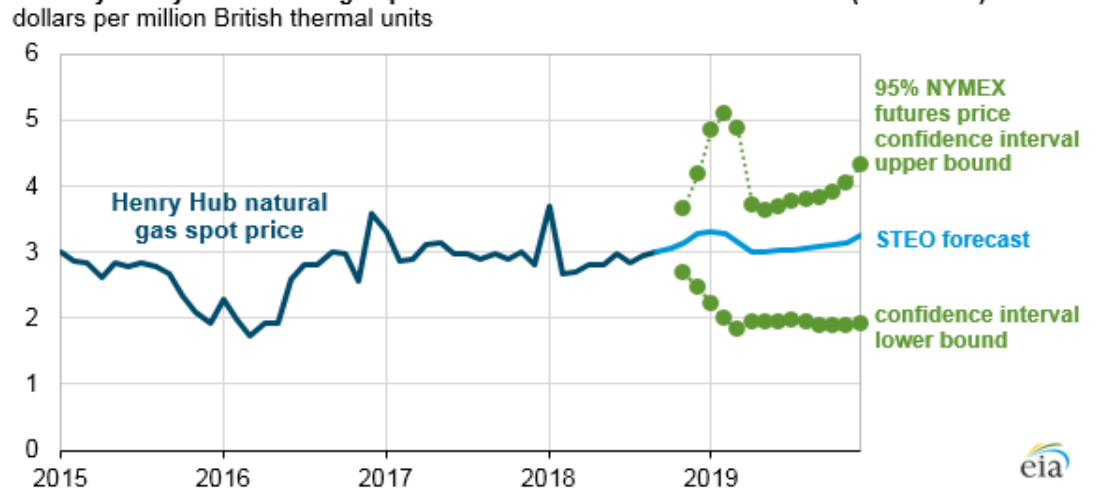
- Drilling innovations over the past decade have generated a dizzying reduction in the cost of pumping oil from shale formations across the United States
- The first time since 2012, shale producers will see a rise in break-even production costs this year
- The per-barrel costs will rise an average of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

EIA October 2018 STEO Forecast

Monthly U.S. natural gas production, consumption, and trade (Jan 2010-Dec 2019)



Monthly Henry Hub natural gas price and NYMEX confidence intervals (2015-2019)



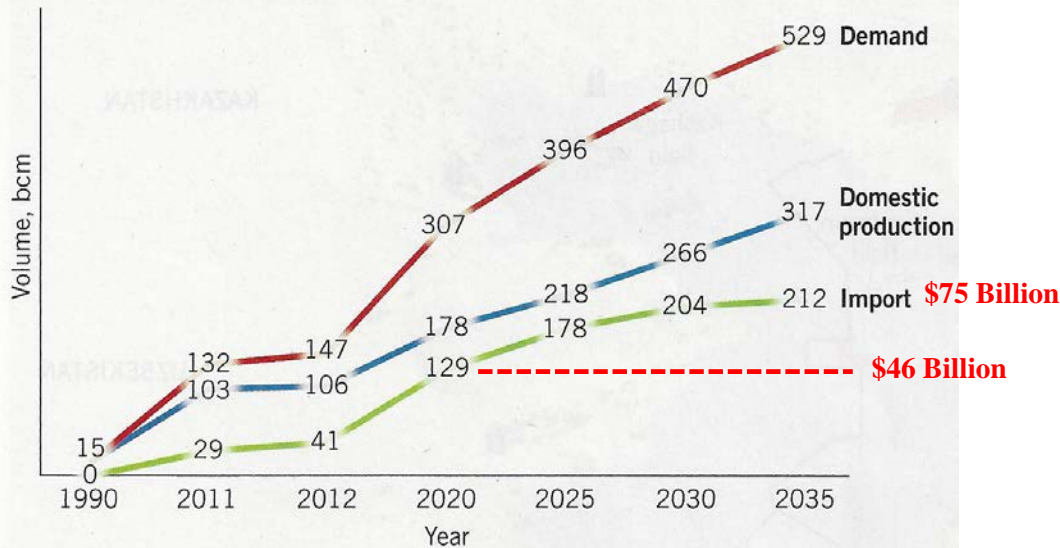
Getting Gas to Market

base_e

“Practical Strategies for Emerging Energy Technologies”

China Natural Gas

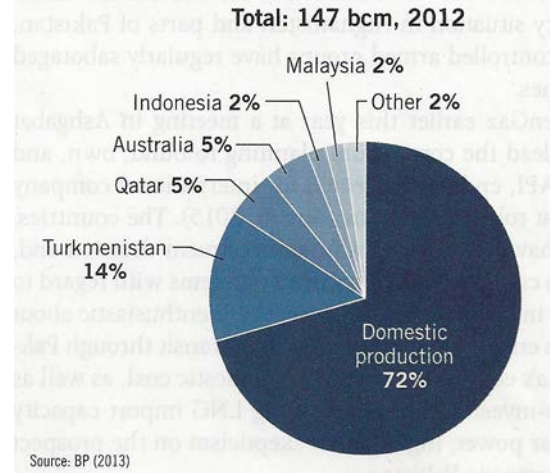
NATURAL GAS IN CHINA



Sources: IEA (2013), BP (2013)

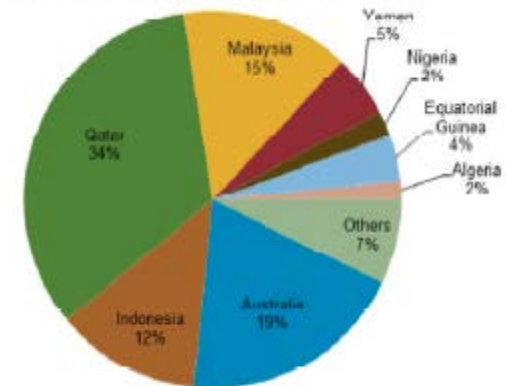
China-U.S. Trade Deficit \$375 Billion 2017

SOURCES, CONSUMED NATURAL GAS IN CHINA



Source: BP (2013)

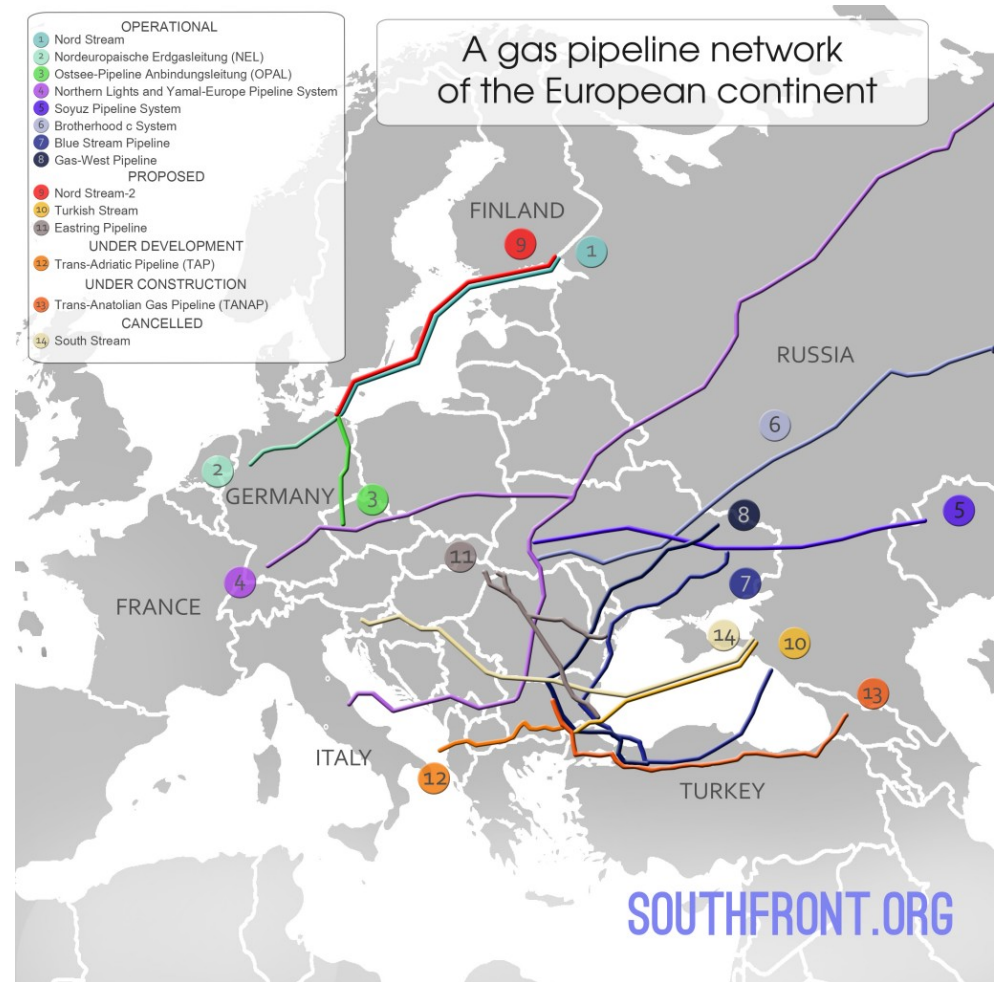
China LNG import sources, 2014



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

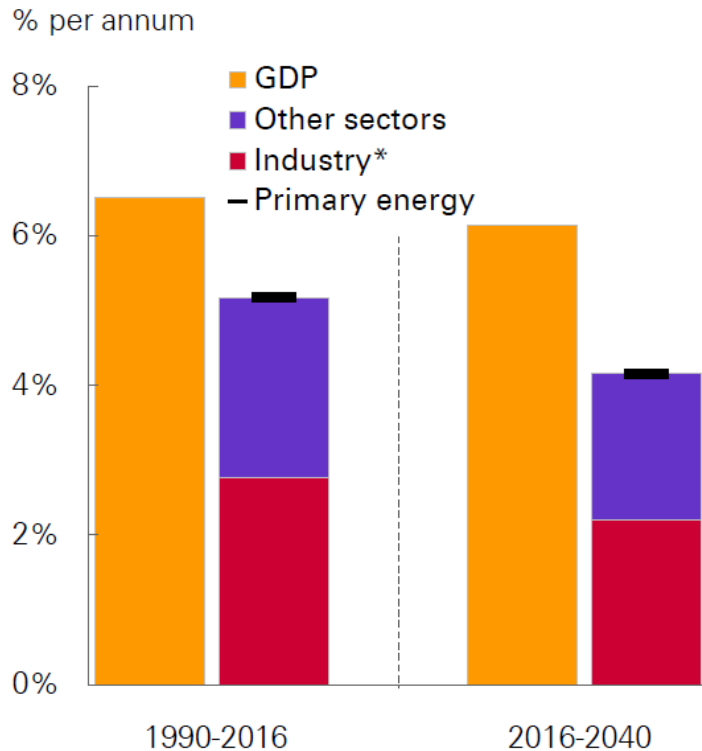
Gas to Europe - 489 BCM Demand

- 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



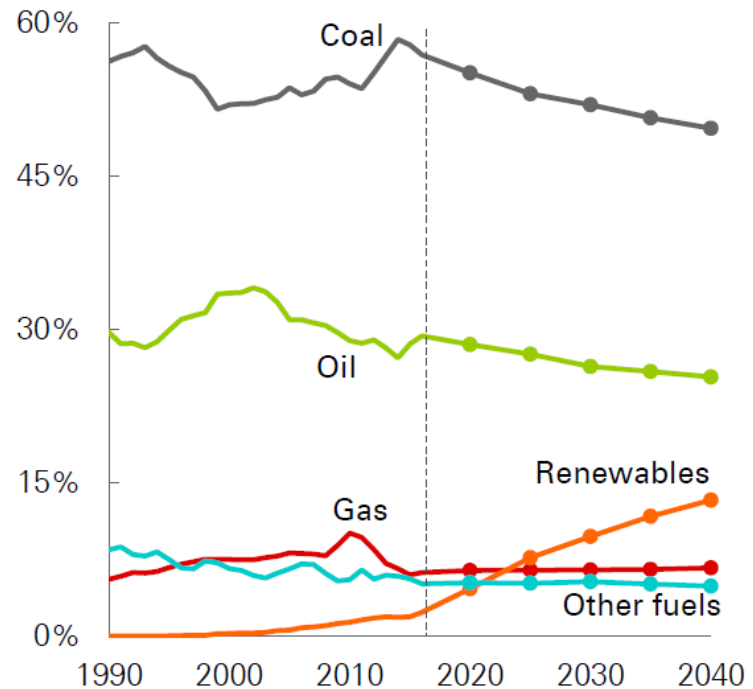
India Emerges as Largest Energy Growth Market

Growth of GDP and primary energy



*Excludes non-combusted fuels

Shares of primary energy



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

Natural Gas Trade 2017 – 1134.1 BCM

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

Gas Trade in 2016 and 2017

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

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

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

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

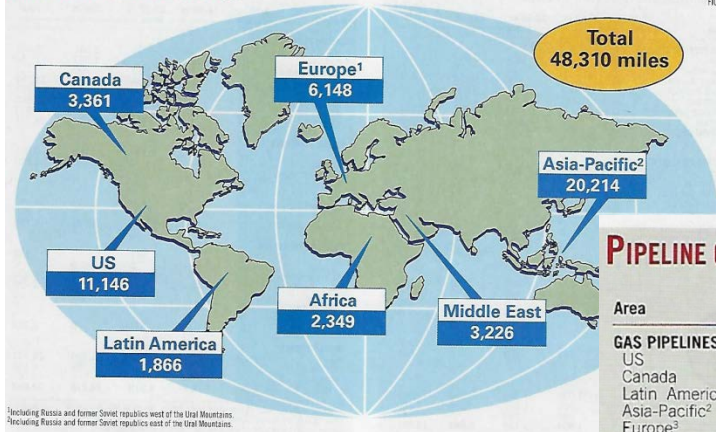


Source: BP Statistical Review of World Energy 2018

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Lots of Gas Pipelines

FORECAST PIPELINE CONSTRUCTION



Oil & Gas Journal Feb 5, 2018

PIPELINE CONSTRUCTION IN 2018¹

Table 1

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

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

PIPELINE CONSTRUCTION BEYOND 2018¹

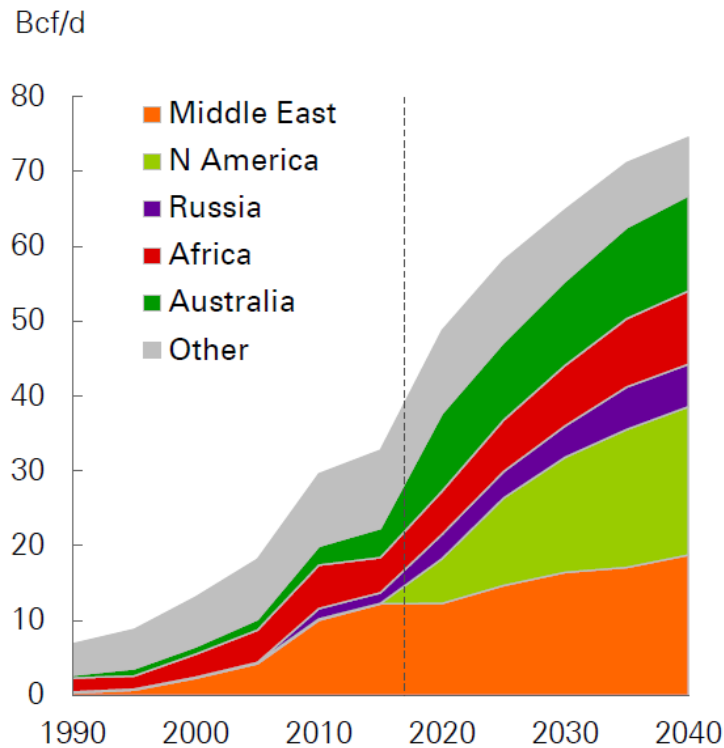
Table 2

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

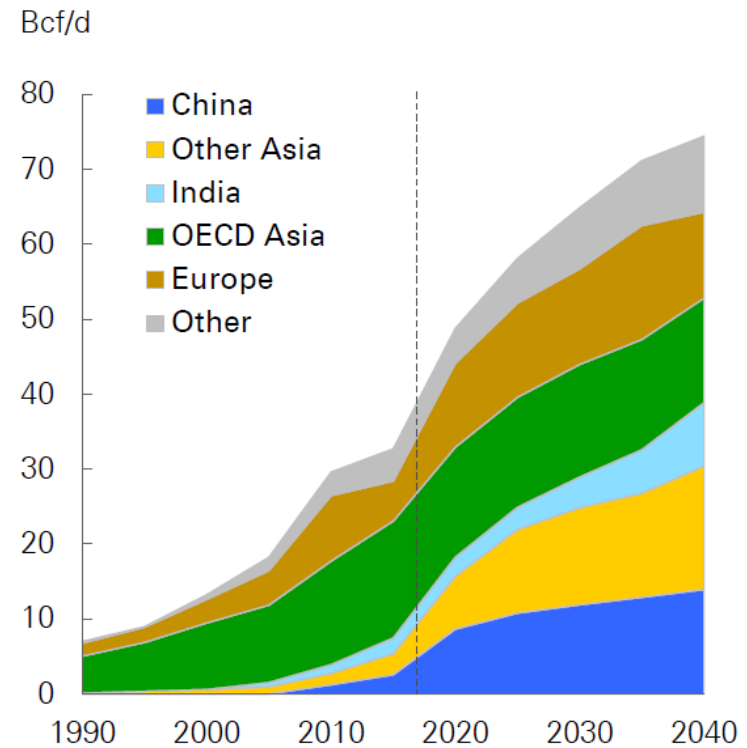
¹Projects under way at the start of or set to begin in 2018 and be completed after 2018. Includes some probable major projects whose installation will begin in 2018 or later. ²Regions east of the Ural Mountains and south of the Caucasus Mountains, excluding the Middle East. ³Regions west of the Ural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

LNG Increases Global Gas Availability

LNG exports



LNG imports



Global LNG Growth

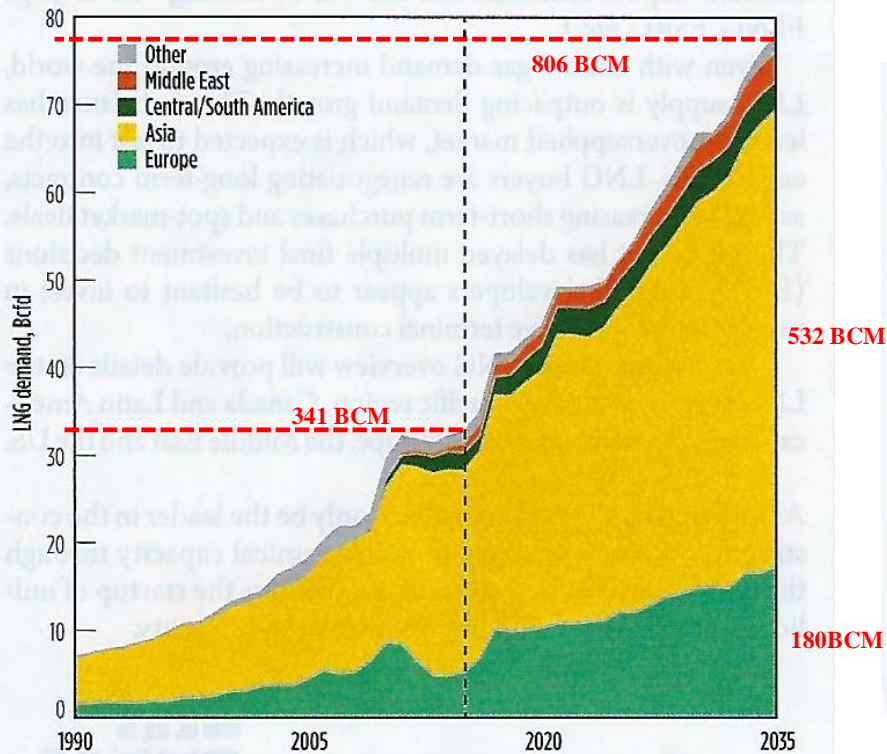


FIG. 3. Global growth in LNG demand to 2035. Source: BP.

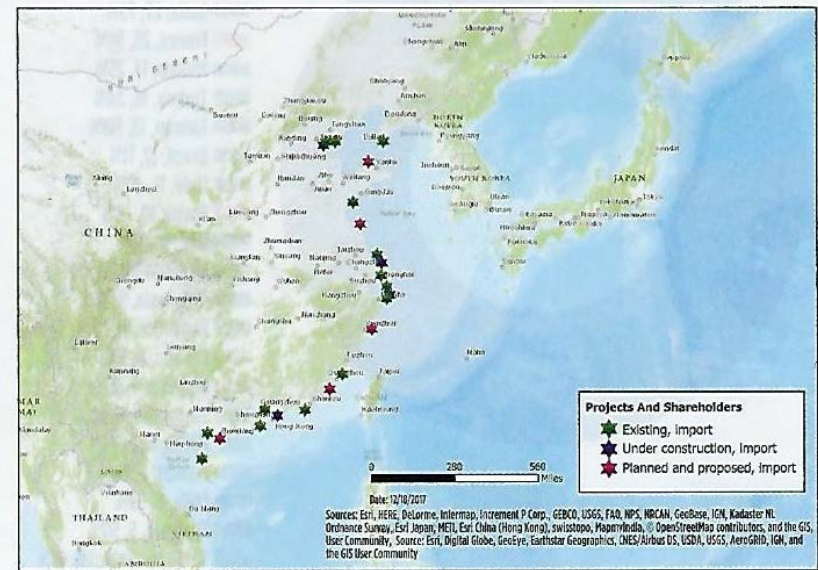
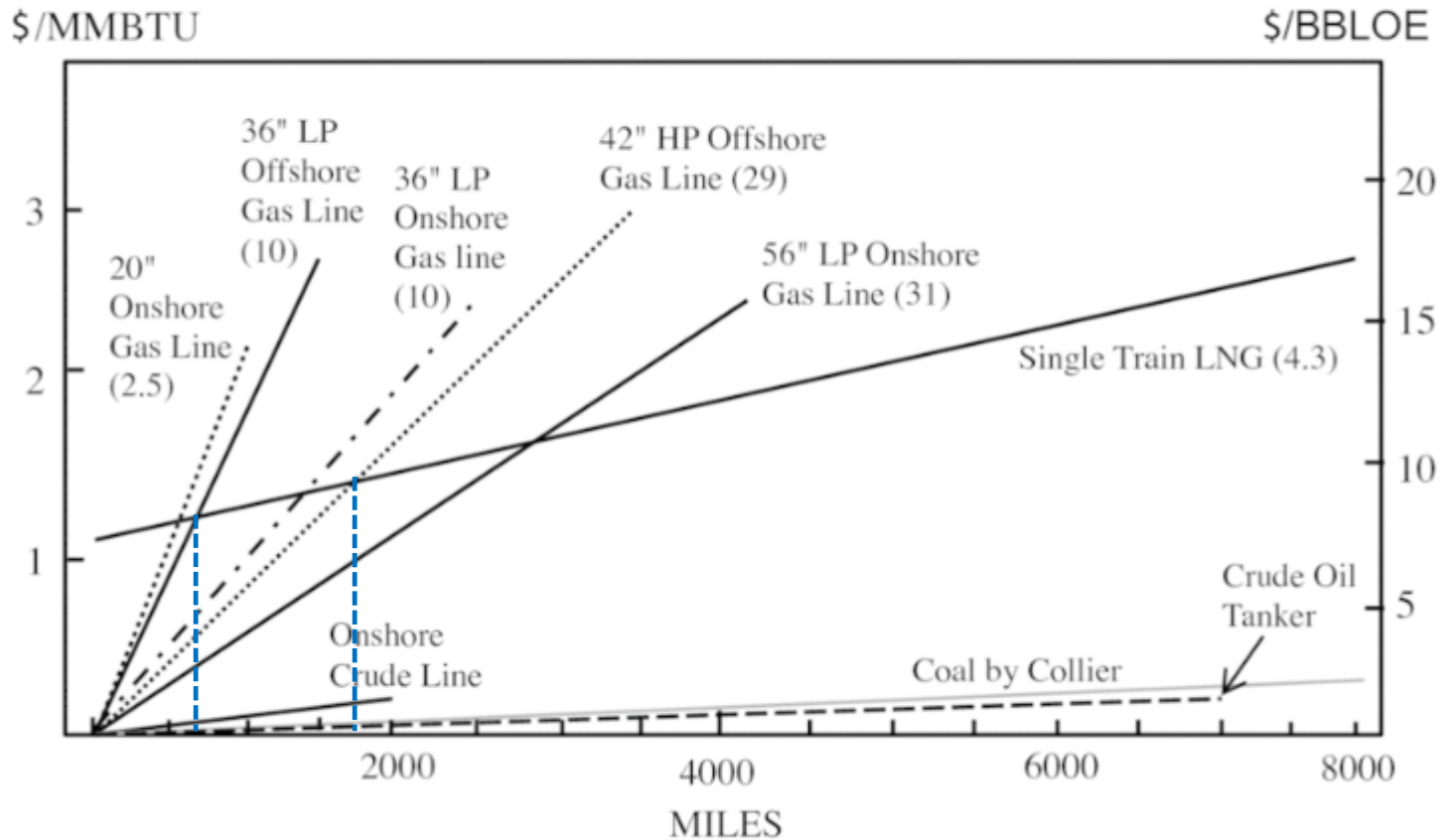


FIG. 4. LNG import terminals in China. Source: Energy Web Atlas.

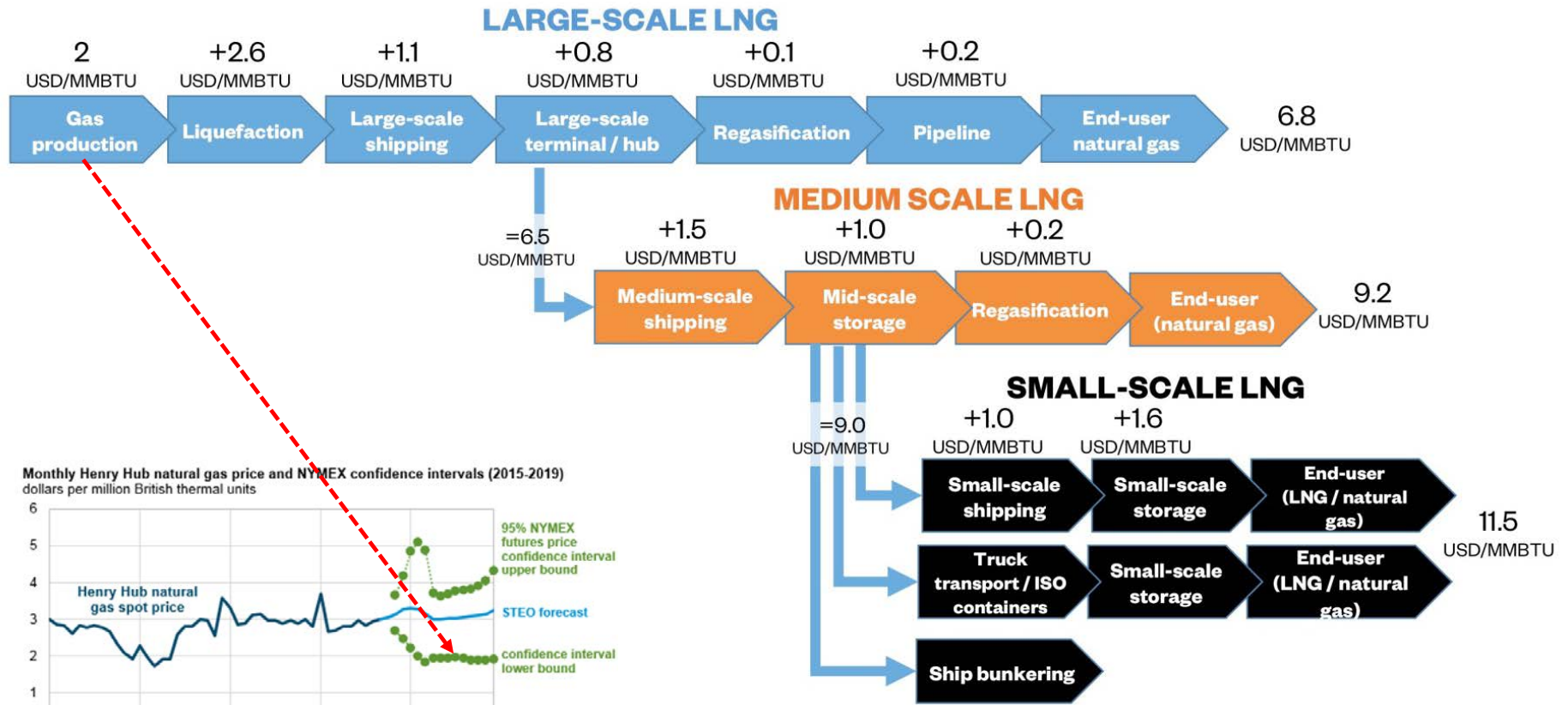
Jensen 2004 Break-even Points

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



Note: Figures in brackets show gas delivery capability in BCM

LNG Value Chain



Wärtsilä Technical Journal October 20, 2016



“Practical Strategies for Emerging Energy Technologies”

Australia Supply Strategy

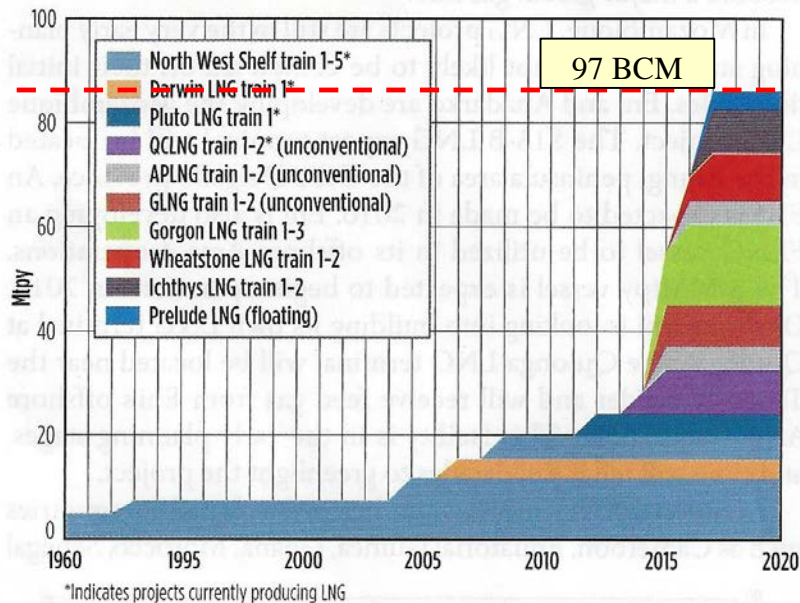
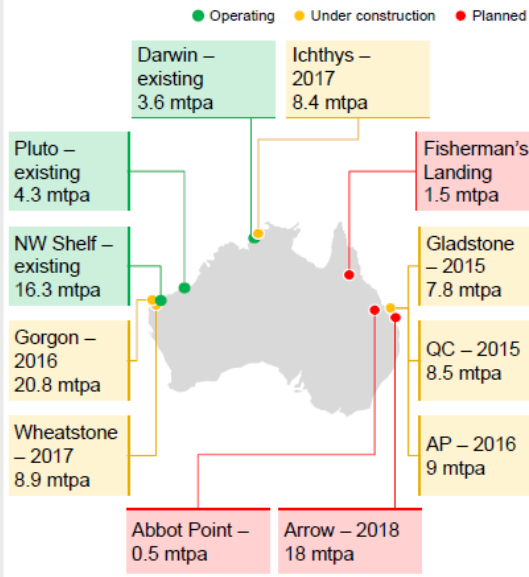


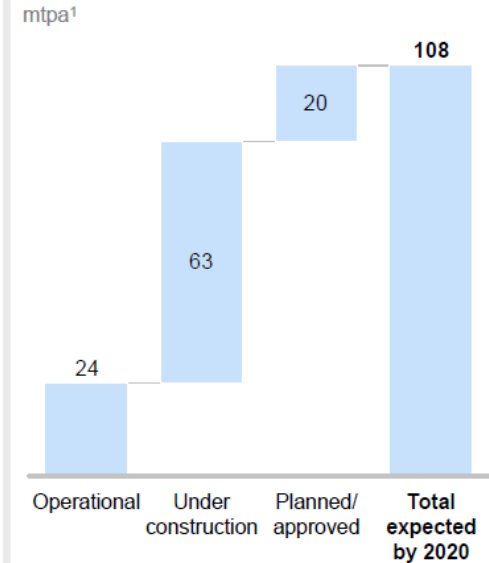
FIG. 2. Australian liquefaction capacity. Source: Australian Department of Industry and Reserve Bank of Australia.

S2 Australian supply projects are progressing

Map of onshore Australian LNG projects¹



Project status

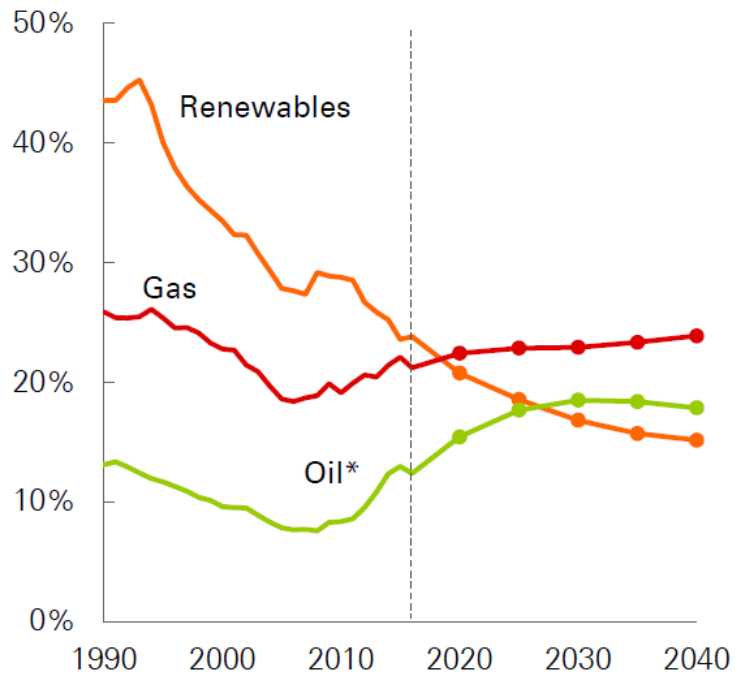


¹ Excludes 5 FLNG projects of total 18.1 mtpa (Prelude, Greater Sunrise, Bonaparte, Scarborough and Tassie)

SOURCE: Enerdata; literature search; McKinsey analysis

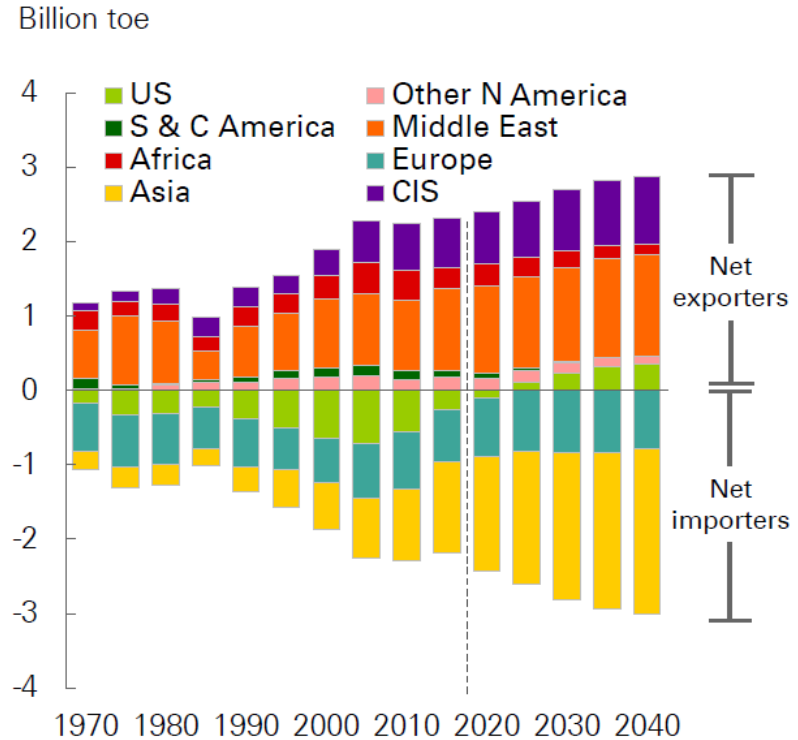
U.S. Extends Leads in O&G Production

US shares of global production

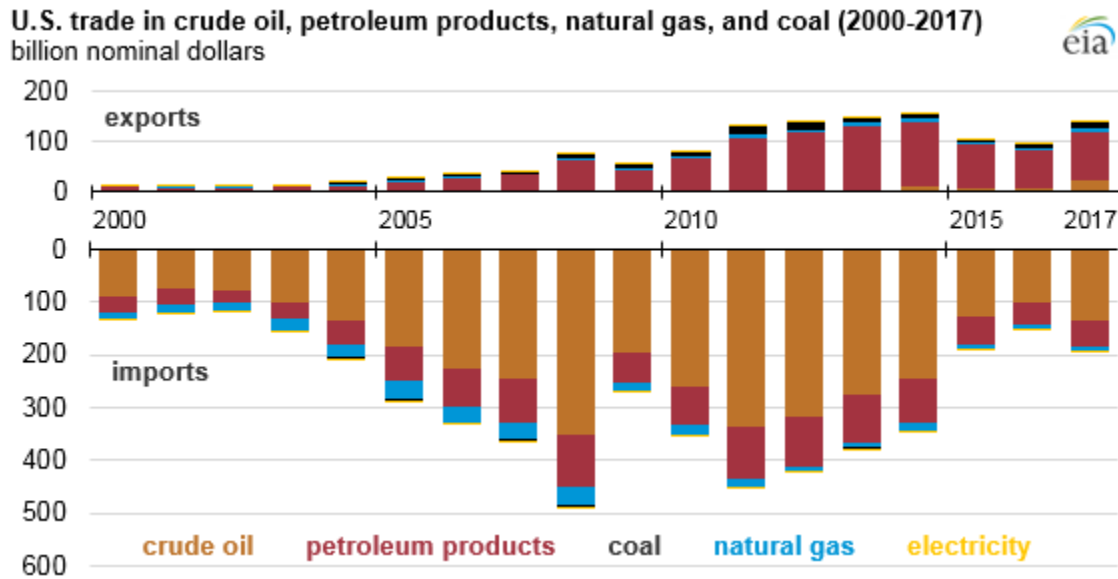


* Includes crude and NGLs

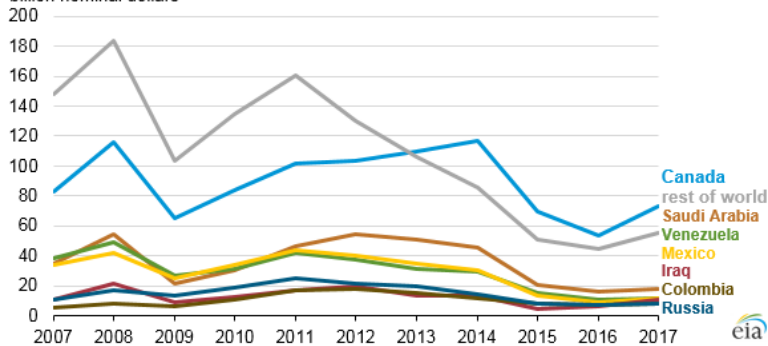
Regional oil/gas imbalances



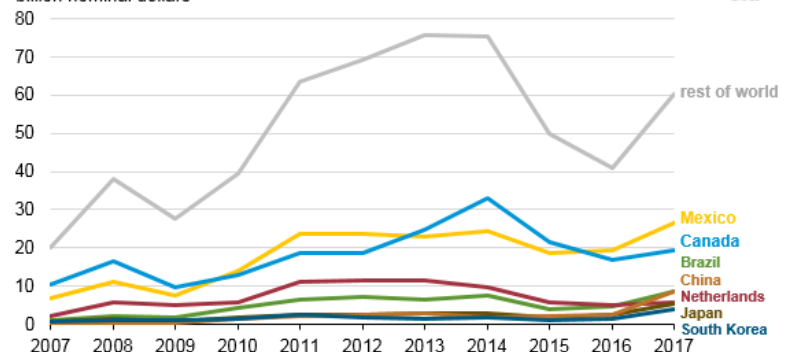
U.S. Trade in Hydrocarbons 2000-2017



Select U.S. energy imports by country of origin (2007-2017)
billion nominal dollars



Select U.S. energy exports by destination country (2007-2017)
billion nominal dollars



Climate Change & Renewables

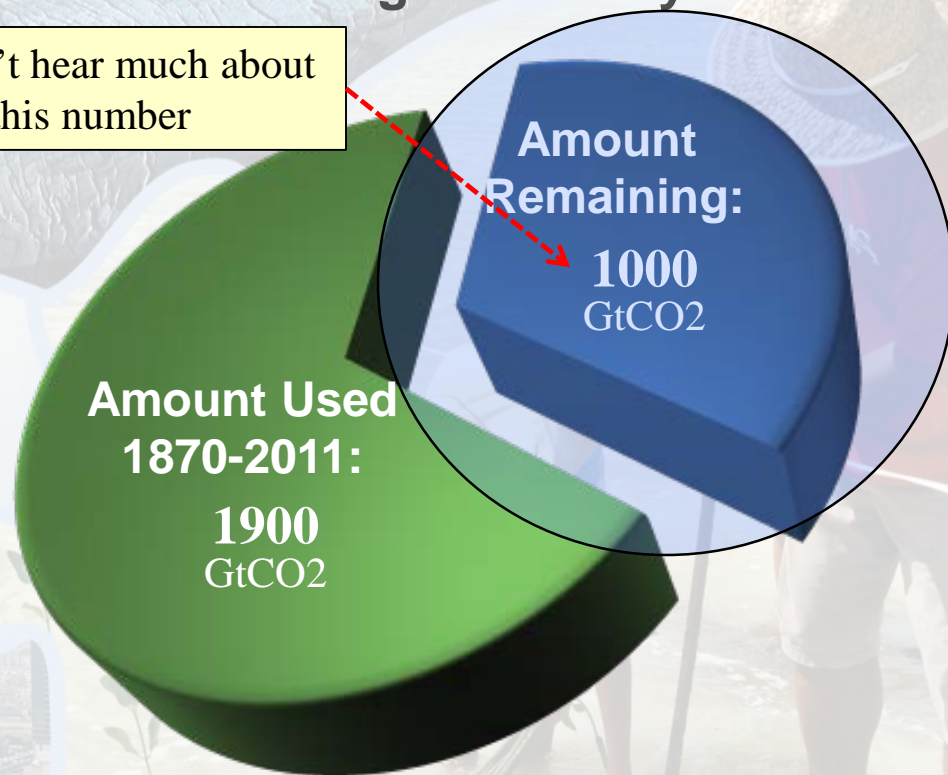
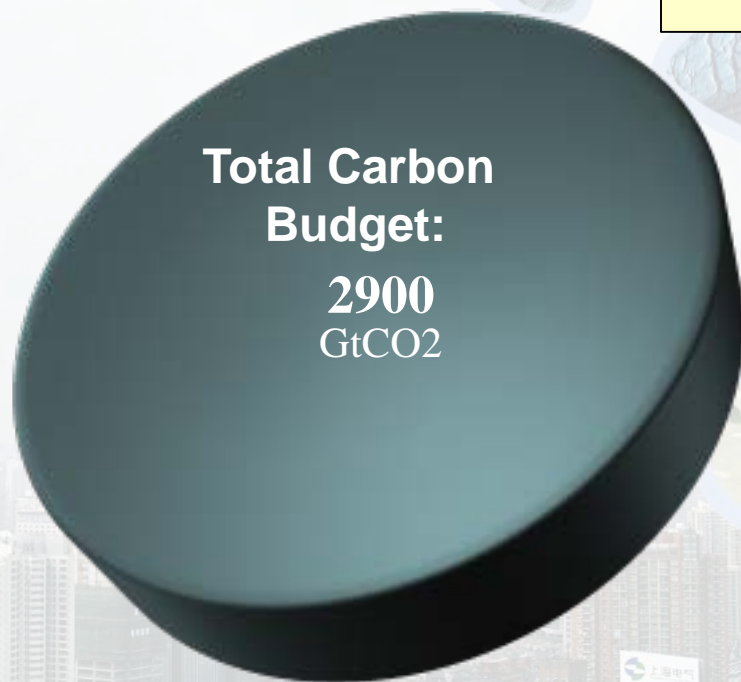
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“Practical Strategies for Emerging Energy Technologies”

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

base

IPCC AR5 Synthesis Report

“Practical Strategies for Emerging Energy Technologies”

ipcc

climate change



INTERGOVERNMENTAL PANEL ON

EIA WW Annual Energy Outlook 2017

Reference Case includes CPP

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

Source: U.S. Energy Information Administration

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

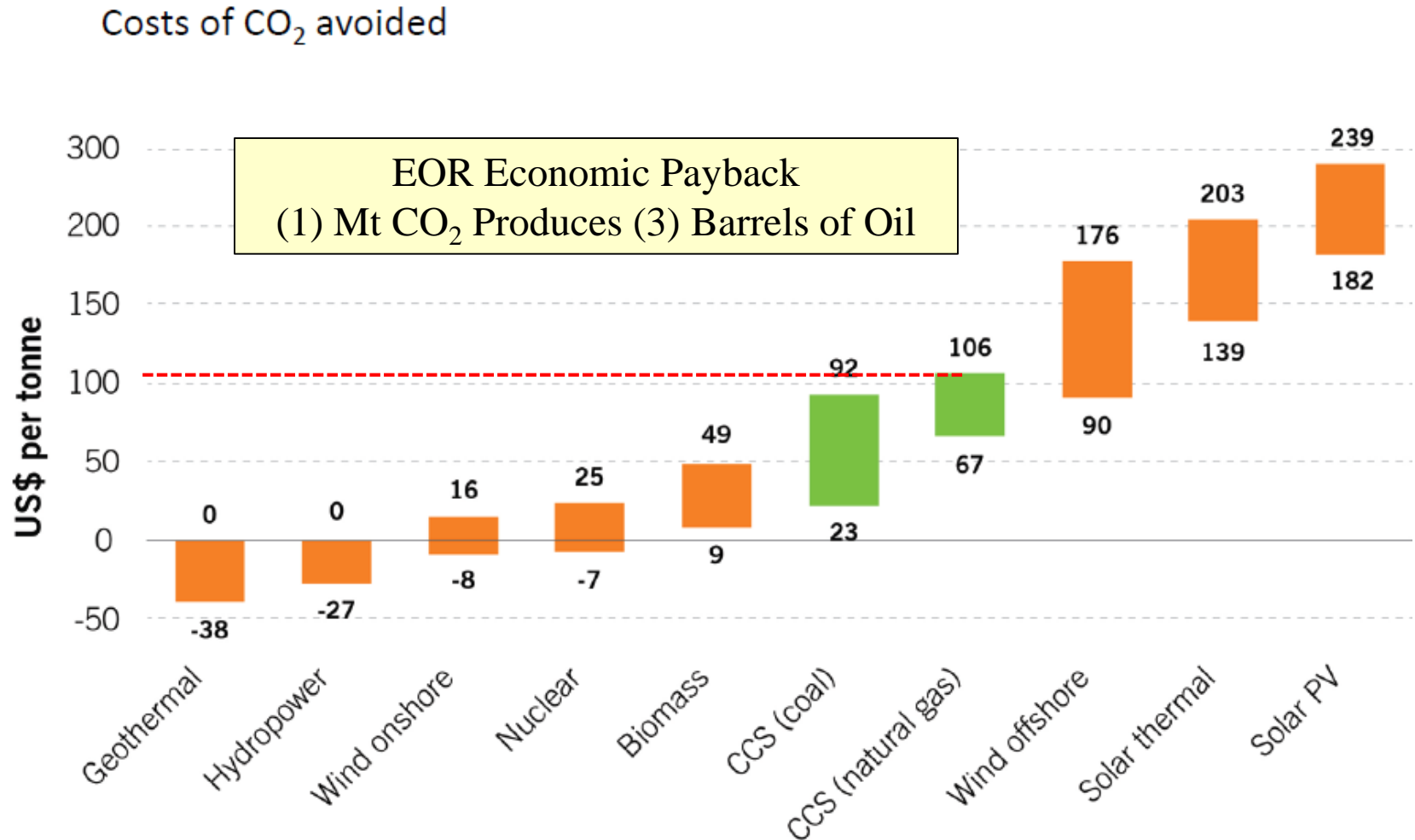
Wed Sep 20 2017 12:46:07 GMT-0400 (Eastern Daylight Time)

34519.2 MMt = 34.5 Gt

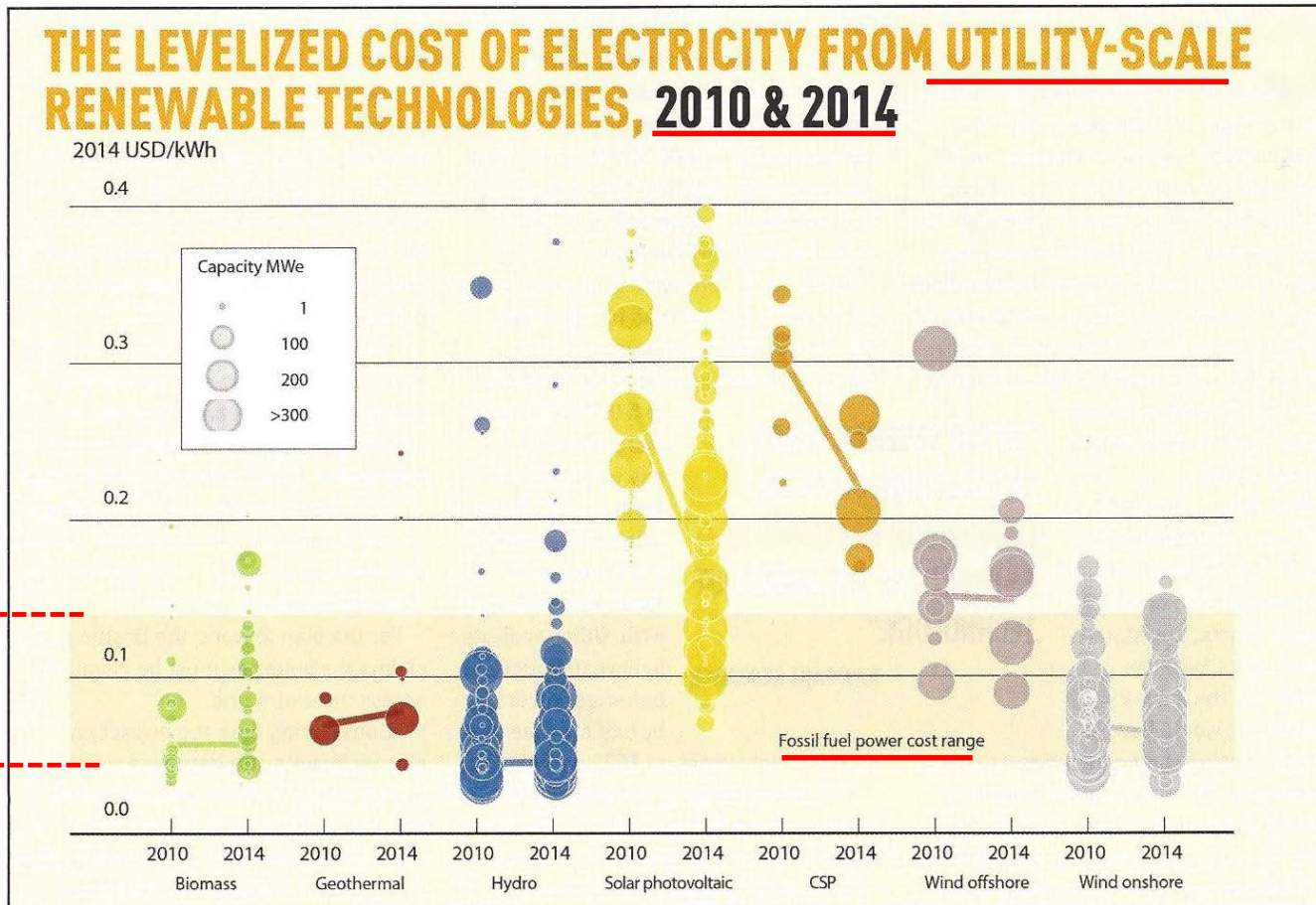
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“Practical Strategies for Emerging Energy Technologies”

Costs of CO₂ Avoided



Renewables Levelized Cost 2010 & 2014



Source: IRENA Renewable Cost Database.

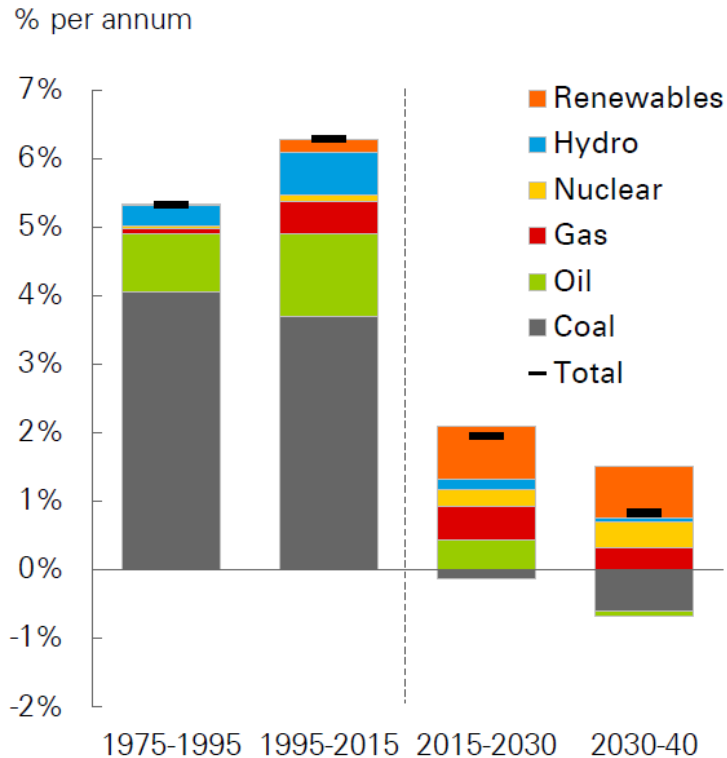
Note: Size of the diameter of the circle represents the size of the project. The centre of each circle is the value for the cost of each project on the Y axis. Real weighted average cost of capital is 7.5% in OECD countries and China; 10% in the rest of the world.

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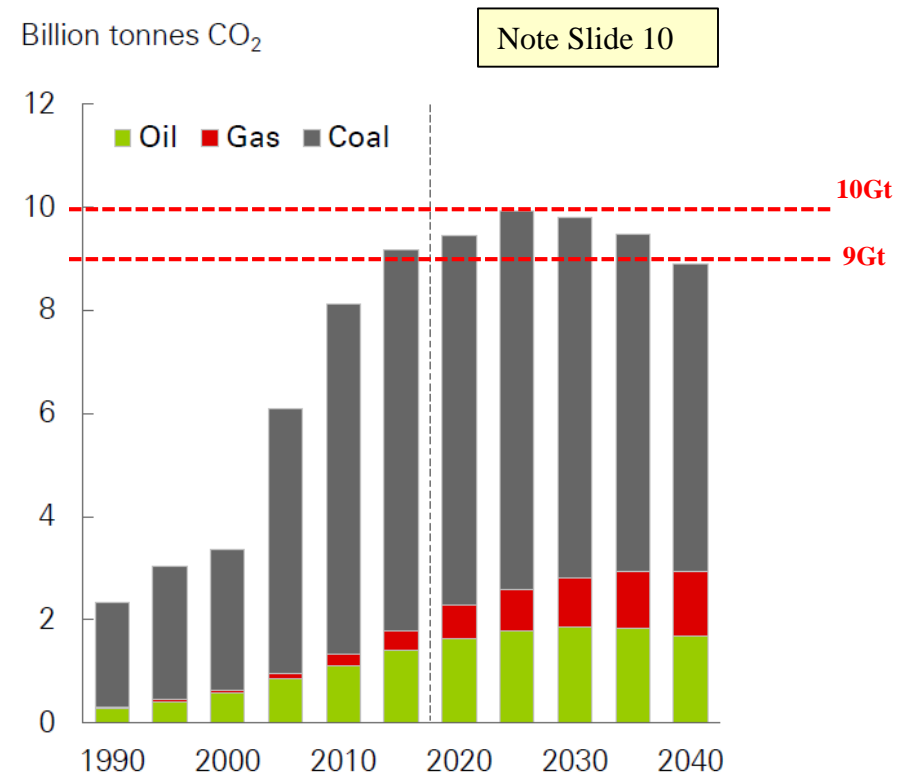
“Practical Strategies for Emerging Energy Technologies”

China's Energy Needs Forecast

Primary energy demand growth and contributions by fuels

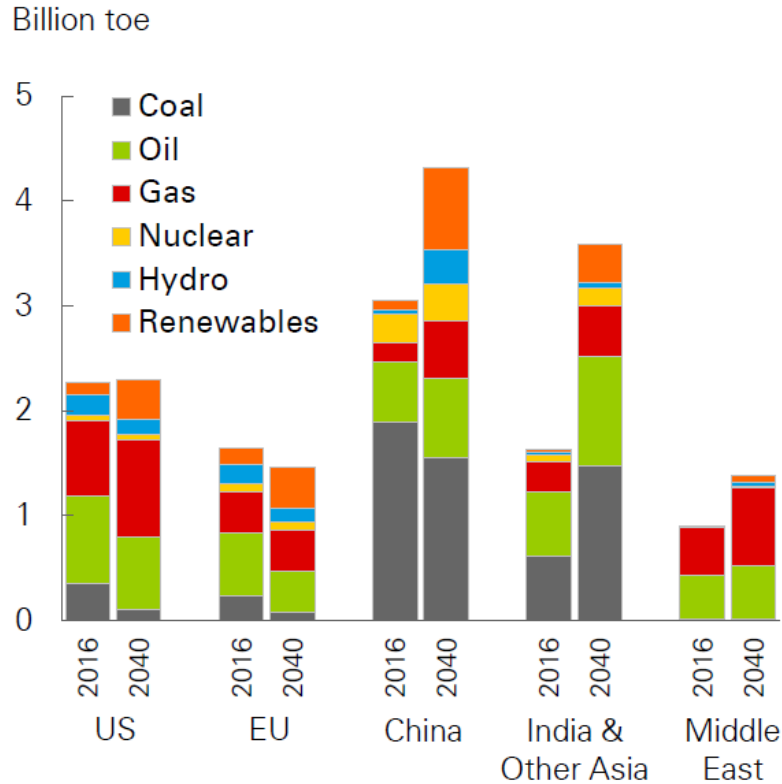


Carbon emissions by source

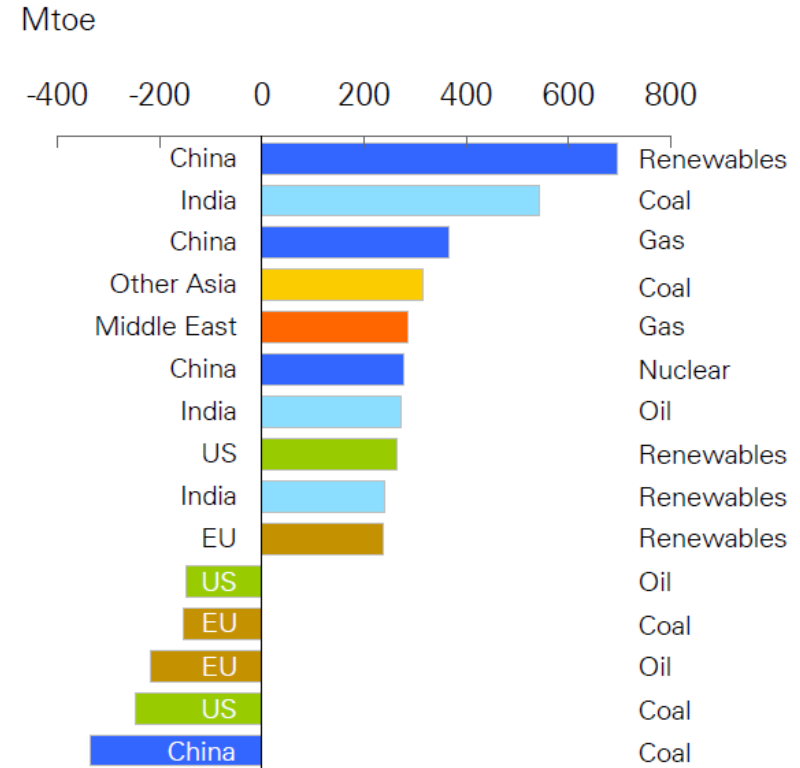


Regional Differences in Fuel Mix

Primary energy demand
by fuel and region



Changes 2016-2040[†]
by fuel and region



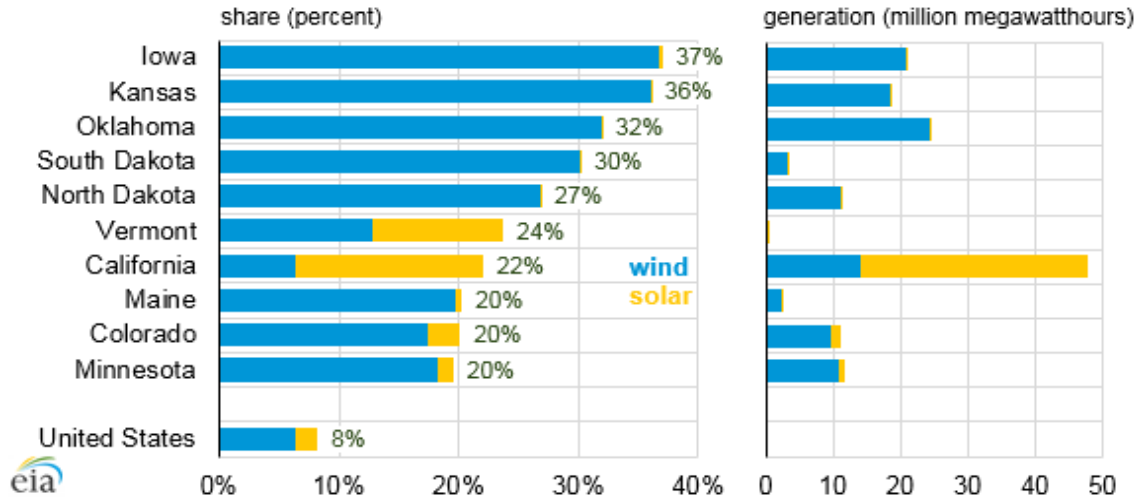
†Ten largest increases and five largest declines

2018 BP Energy Outlook

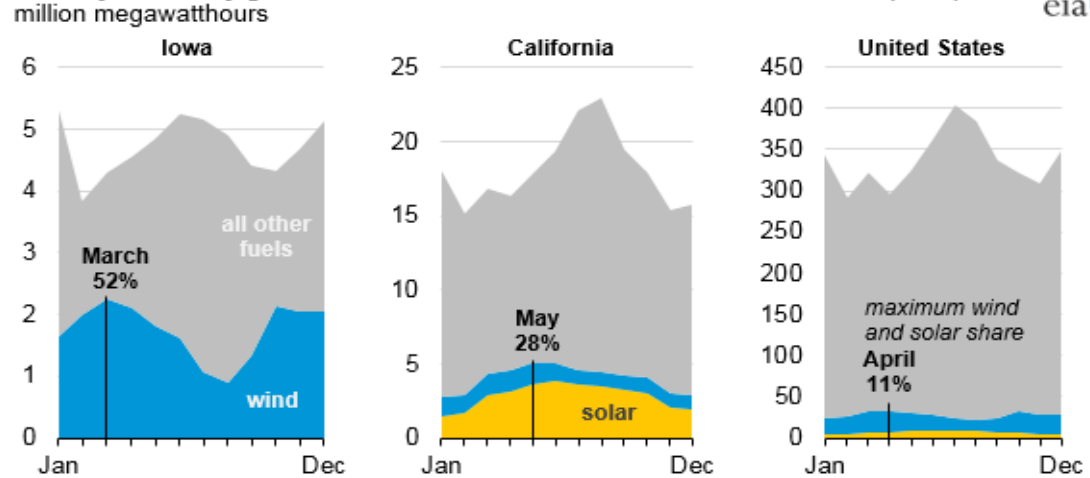
© BP p.l.c. 2018

Combined Wind & Solar 20% of Electric 10 States 2017

Electricity generated from wind and solar in selected states (2017)



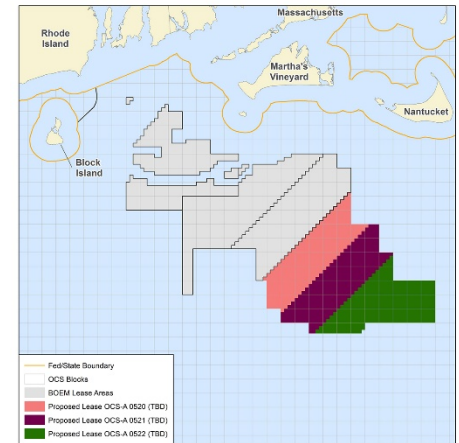
Monthly electricity generation in Iowa, California, and the United States (2017)



East Coast Offshore Wind

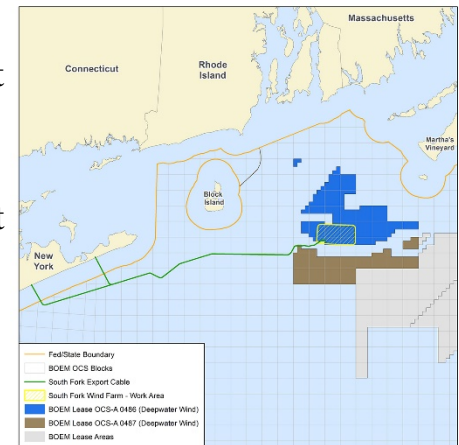
– Wind Auction Offshore Massachusetts

- The Bureau of Ocean Energy Management (BOEM) will hold the next offshore wind auction - to include nearly 390,000 acres offshore Massachusetts - on Dec. 13, 2018.
- Nineteen companies have qualified to participate in the auction for the Massachusetts Wind Energy Area
- "If fully developed, the wind auction could support approximately 4.1 gigawatts of power
- BOEM website <https://www.boem.gov/Commercial-Wind-Leasing/Massachusetts/Lease-Sale-4A/>.



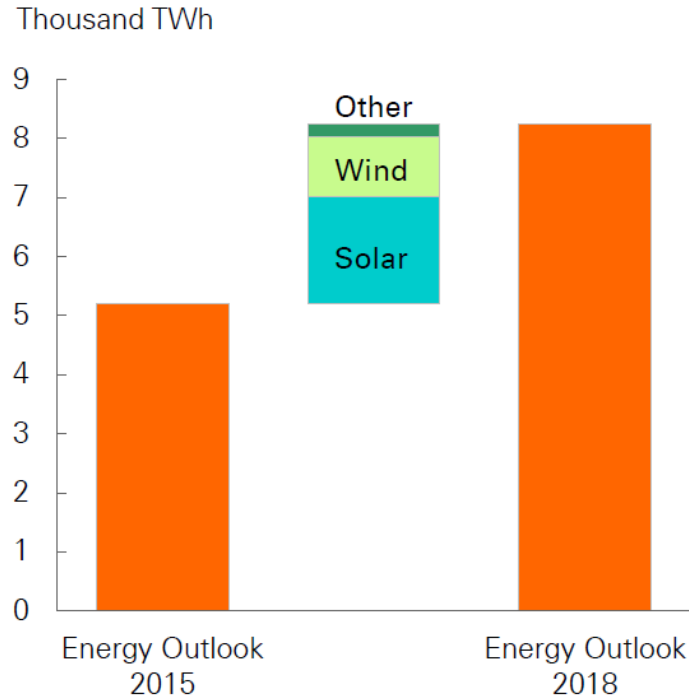
– Environmental Review of Wind Project Offshore Rhode Island

- BOEM will publish a Notice of Intent to prepare an Environmental Impact Statement for the Construction and Operations Plan for the South Fork Wind Project offshore Rhode Island.
- If approved, the plan would allow construction and operation of up to 15 turbines that connect via a transmission cable to a grid in East Hampton, New York - the east end of Long Island.
- The project is approximately 19 miles southeast of Block Island.
- BOEM website <https://www.boem.gov/South-Fork/>.

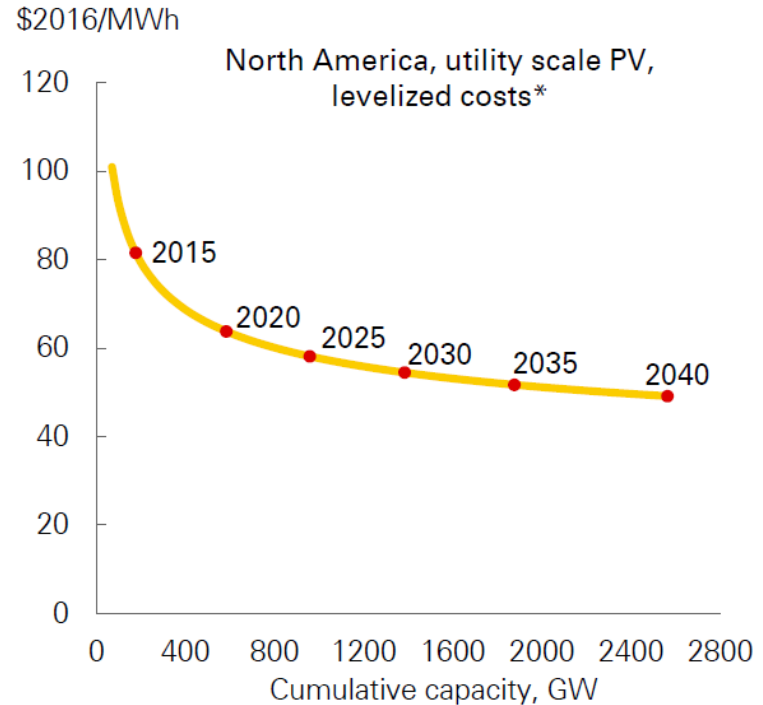


Renewables Outlook

Change to the projected level of renewable power in 2035



Solar PV learning curve



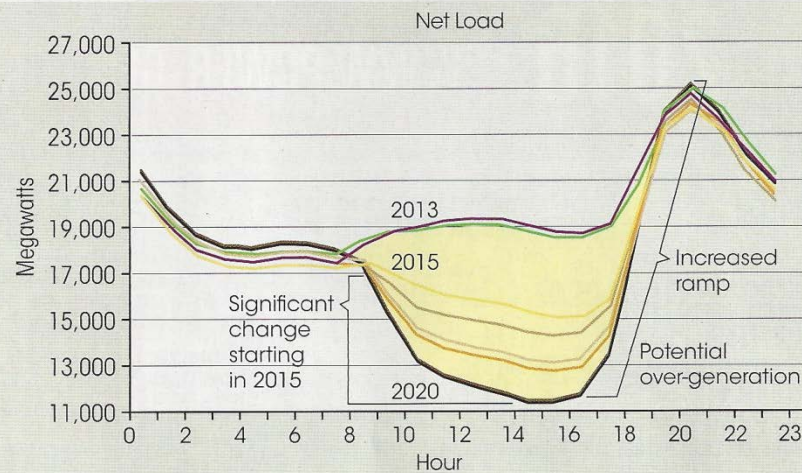
*Cost per MWh of building and operating a plant over its lifetime. Excludes subsidies, tariffs and the cost of grid integration.

2018 BP Energy Outlook

© BP p.l.c. 2018

Dealing with an even “Bigger” Duck

California Duck Renewable Generation 1



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

The Duck Pond of Non-Renewable Generation 2

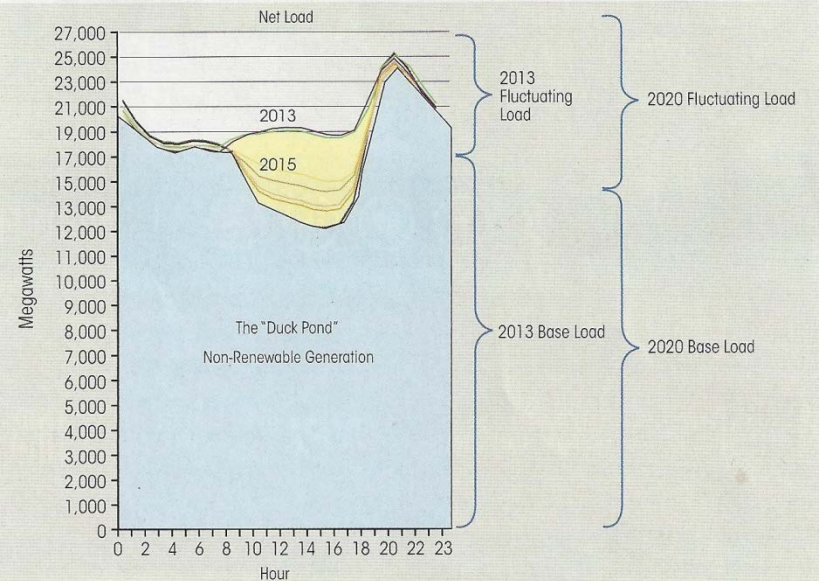
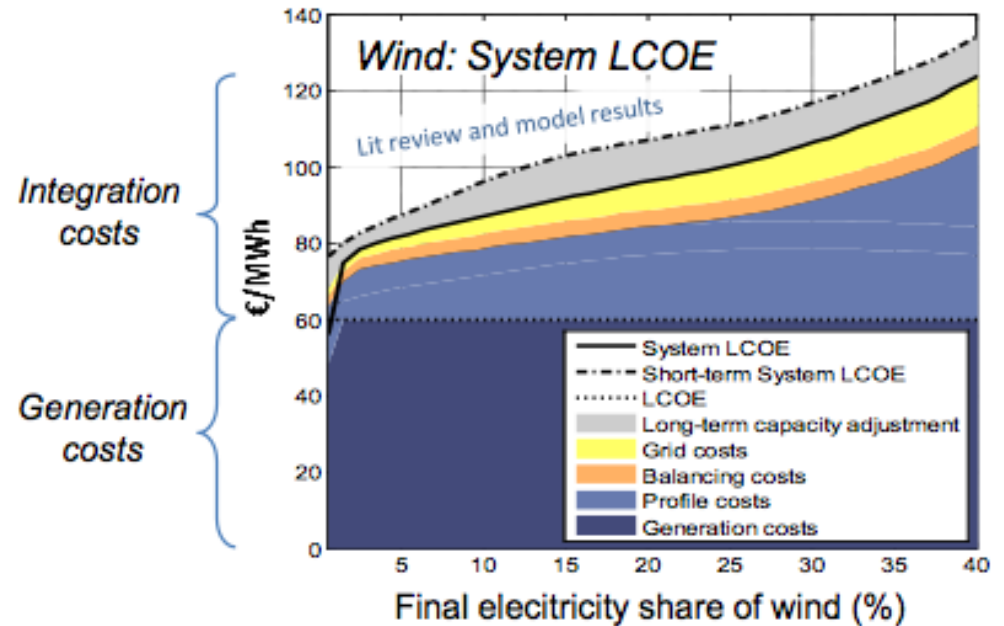


Figure 2 is an expansion of Figure 1, showing the amount of generation under the duck.

Wind Integration Costs

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

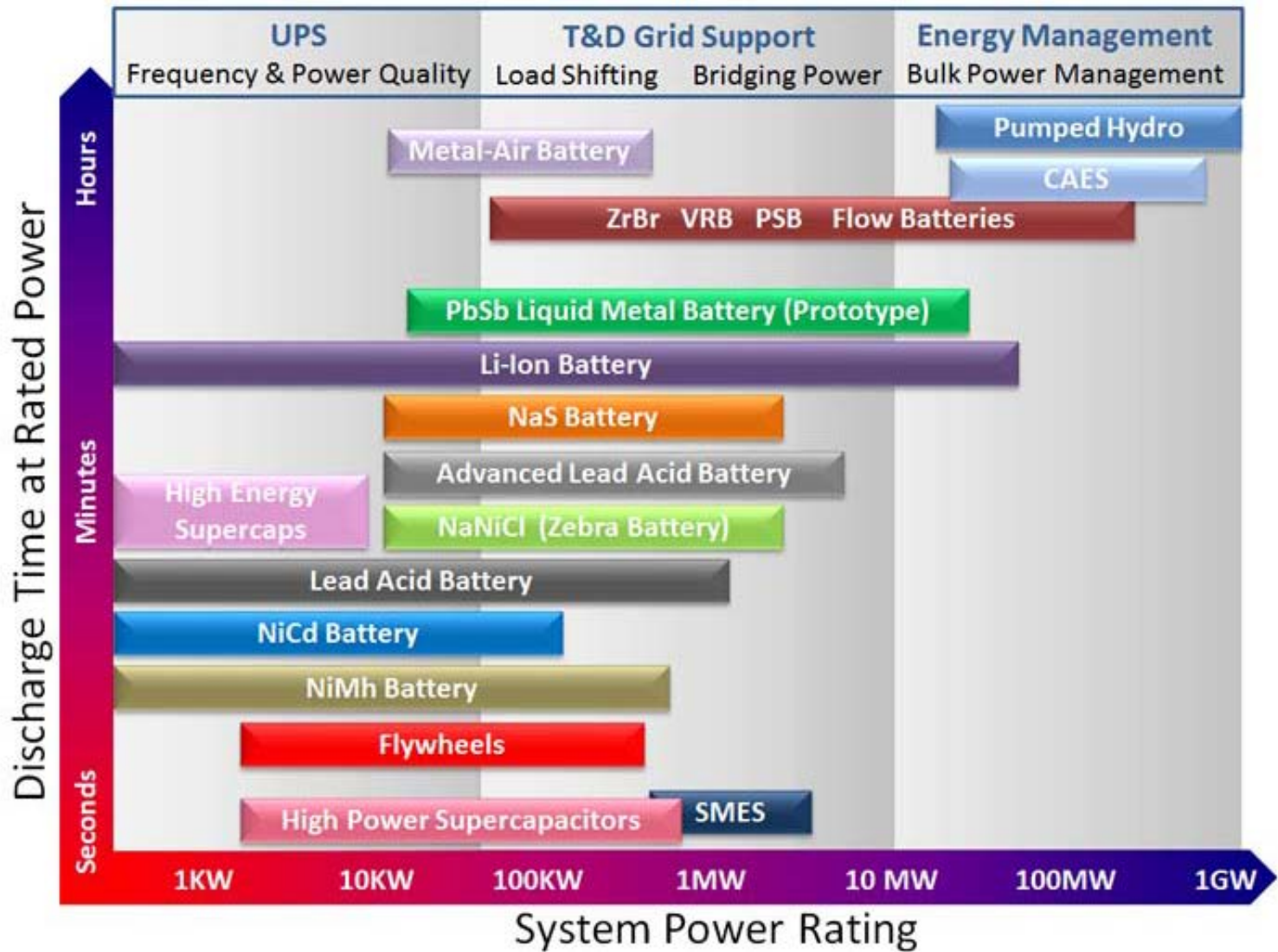
At higher penetration, integration costs for wind exceed generation costs.



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

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

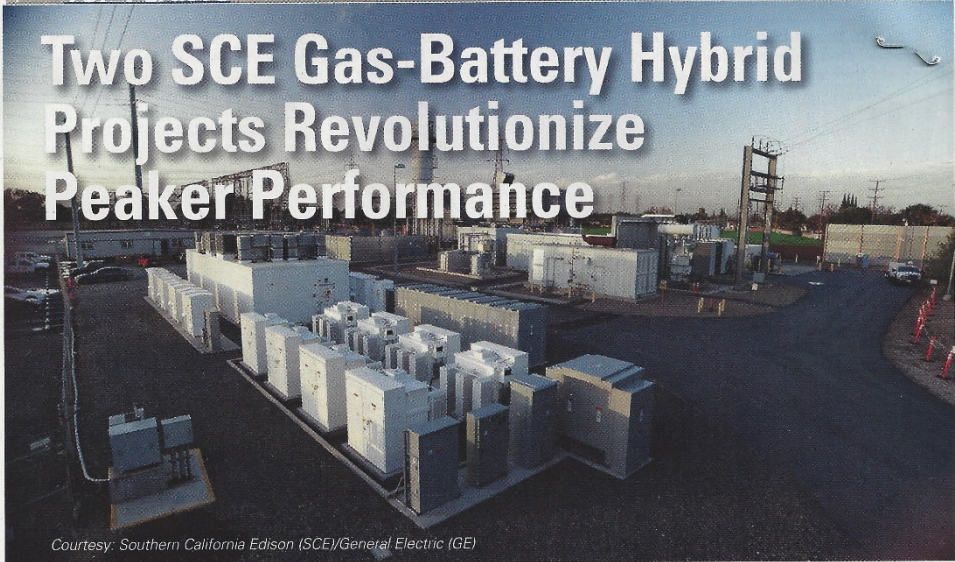
Energy Storage Technologies



Gas-Battery Spinning Reserve

TOP PLANTS

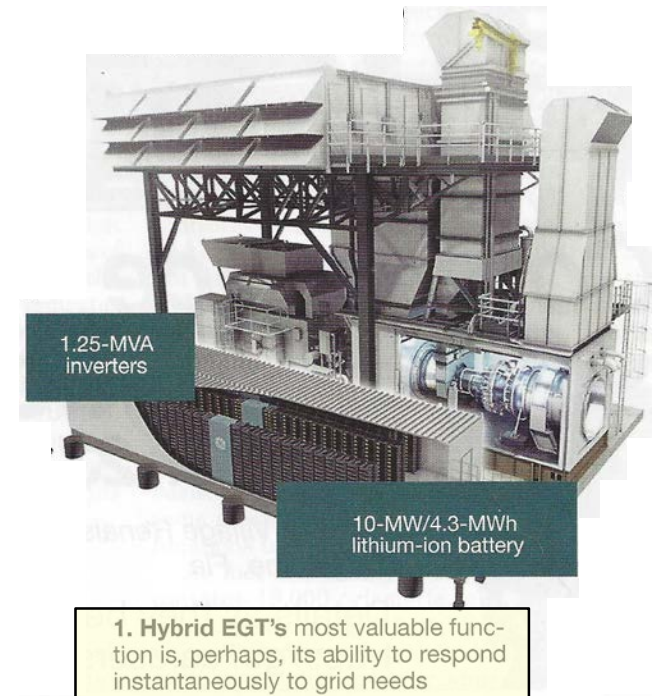
Two SCE Gas-Battery Hybrid Projects Revolutionize Peaker Performance



Courtesy: Southern California Edison (SCE)/General Electric (GE)

For deploying a novel, groundbreaking gas-battery hybrid technology along with environmentally significant upgrades within a tight installment window, and despite logistical hurdles, Southern California Edison's Center Peaker and Grapeland Peaker plants are especially deserving of *POWER's* Top Plant recognition.

Sonal Patel



“Practical Strategies for Emerging Energy Technologies”

Project Forward Achieve IMO Target by 2030

- The Project Forward initiative led by Athens-Based Arista Shipping, with Wärtsilä as one of the participants, demonstrates that with LNG as fuel, an advanced hull design, and highly efficient propulsion machinery, it will be possible to meet the IMO’s target for a 40 percent reduction in carbon intensity by 2030.
- Project Forward shows that this 70 percent reduction in CO2 emissions target can be met, even without lowering service speeds, through the use of carbon neutral fuels mixed with LNG. Such carbon neutral fuels can be transported, stored, and consumed in a similar way to that of fossil LNG.



Small Modular Reactor Technology Development

TECHNOLOGY DEVELOPMENT						
	BASIC DESIGN	CONCEPTUAL DESIGN	PRELIMINARY DESIGN	DETAILED DESIGN	UNDER DEVELOPMENT	UNDER CONSTRUCTION
<p>LAND-BASED WATER-COOLED SMRS: Designs that adopt integral light water reactor (LWR) technologies.</p>	<ul style="list-style-type: none"> 100-MW ACP100 300-MW DMS 	<ul style="list-style-type: none"> 200-MW CAP200 335-MW IRIS 350-MW IMR 68-kW ELENA 100-MW KARAT 70-MW RUTA 6.6-MW Unitherm 443-MW UK-SMR 225-MW W-SMR 	<ul style="list-style-type: none"> 160-MW SMR-100 	<ul style="list-style-type: none"> 250-MW VK 	<ul style="list-style-type: none"> 100-MW SMART 50-MW RITM 195-MW mPower 50-MW NuScale 	<ul style="list-style-type: none"> 30-MW CAREM <p>Construction began in February 2014. First criticality expected in 2022.</p>
<p>MARINE-BASED WATER-COOLED SMRS: Concepts that can be deployed in a marine environment.</p>			<ul style="list-style-type: none"> 60-MW ACPR50S 	<ul style="list-style-type: none"> 6.5-MW SHELF 	<ul style="list-style-type: none"> 6-MW ABV-6E 50-MW RITM-200M 325-MW VBER-300 	<ul style="list-style-type: none"> 70-MW KLT-40S (Akademik Lomonosov floating PWR) <p>Construction completed in 2017, commercial startup slated for 2019.</p>
<p>HIGH TEMPERATURE GAS-COOLED (HTGR) SMRS: Modular-type designs that provide heat of more than 750C.</p>	<ul style="list-style-type: none"> 300-MW GTHTR300 	<ul style="list-style-type: none"> 205-MW MHR-T 87-MW MHR 50-MW A-HTR-100 35-MW HTMR-100 272-MW SC-HTGR 35-MW Xe-100 	<ul style="list-style-type: none"> 285-MW GT-MHR 165-MW PBMR-400 			<ul style="list-style-type: none"> 210-MW HTR-PM <p>Construction began in 2012. First operation expected in 2019.</p>
<p>FAST NEUTRON SPECTRUM SMRS: Designs with fast neutron spectrum and an assortment of coolant options.</p>		<ul style="list-style-type: none"> 20-MW LFR-TL-X 3-MW SEALER 265-MW EM¹ 120-MW SUPERSTAR 450-MW WLFTR 	<ul style="list-style-type: none"> 200-MW LFR-AS 	<ul style="list-style-type: none"> 10-MW 4S 300-MW BREST-OD 100-MW SVBR 		
<p>MOLTEN SALT SMRS: Designs that are fueled and cooled with molten salt.</p>	<ul style="list-style-type: none"> 190-MW IMSR 250-MW ThorCon 	<ul style="list-style-type: none"> 100-MW CMSR 20-MW CA Waste Burner 37.5-MW Stable Salt Reactor 250-MW LFTR 50-MW MCSFR 			<ul style="list-style-type: none"> 200-MW FUJI 	
<p>OTHER SMRS: SMRs that cannot be classified in other categories.</p>					<ul style="list-style-type: none"> 2-kW to 15-MW eVinci (small heat pipe) 	

China Goes for Gas in Iran

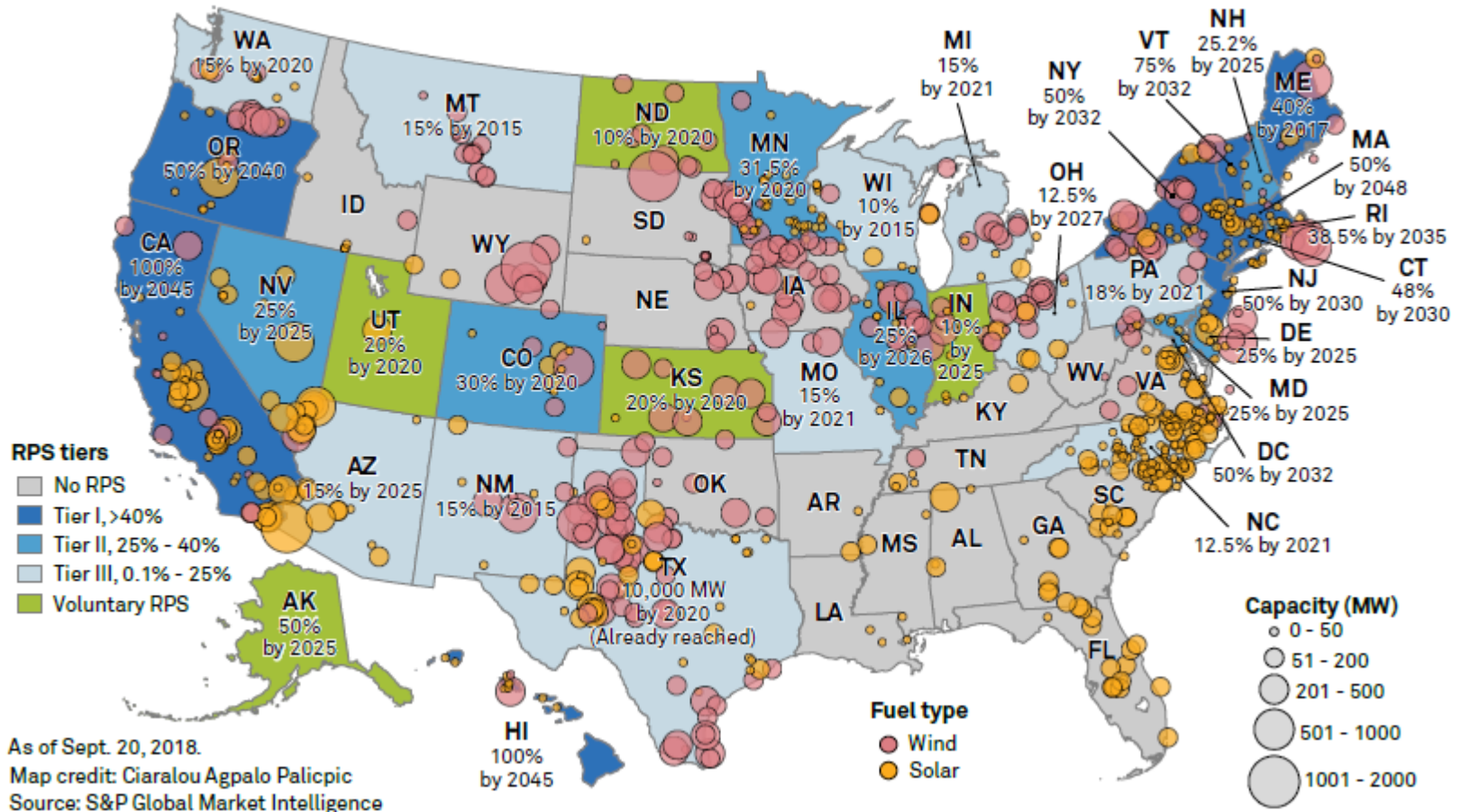


- Beijing glimpses a Middle East energy consolidation, by replacing France's Total in South Pars gas expansion venture
- Total is involved in the Phase 11 development of the huge offshore South Pars gasfield, which is shared with Qatar
- If the US administration does not agree with Total staying in Iran, 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.
- 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.
- China's domestic crude oil production is in decline, while demand is increasing
 - China produced 3.8m barrels a day in 2017, a fall of 150,000 b/d on 2016—and the third annual decline in succession.
 - Imports rose from 2m b/d in 2004 to 8.4m b/d in 2017
 - China has now overtaken the US as the world's biggest crude importer.
 - Russia is China's largest single supplier of crude oil, with exports soaring from 665,000 b/d in 2014 to 1.2 million b/d last year
 - Russia and China are also doubling the capacity of the East Siberia-Pacific Ocean oil pipeline to 600,000 b/d,
- Three countries of the Gulf Cooperation Council—Kuwait, Saudi Arabia and the United Arab Emirates—remain key suppliers; along with Iran and 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.
- Among 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.

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.

Planned Wind & Solar Project 2018-2025

US Wind and Solar Planned Projects 2018-2025



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.
- techno-economic feasibility study plans for the delivery of an initial 1GW of operational capacity by 2025, which could be quickly expanded to 2GW by 2027, at a Levelized Cost of Energy (LCOE) competitive with offshore wind farms currently in construction in France," he added.



AEO2017 Cost & Performance New Generating Tech

Technology	First available year ¹	Size (MW)	Lead time (years)	Base overnight cost in 2016 (2016 \$/kW)	Project Contingency Factor ²	Technological Optimism Factor ³	Total overnight cost in 2016 ^{4,10} (2016 \$/kW)	Variable O&M ⁵ (2016 \$/MWh)	Fixed O&M (2016\$/kW/yr)	Heat rate ⁶ in 2016 (Btu/kWh)	nth-of-a-kind heat rate (Btu/kWh)	
Coal with 30% carbon sequestration	2020	650	4	4,586	1.07	1.03	5,030	7.06	69.56	9,750	9,221	37.0%
Coal with 90% carbon sequestration	2020	650	4	5,072	1.07	1.03	5,562	9.54	80.78	11,650	9,257	36.8%
Conv Gas/Oil Comb Cycle	2019	702	3	923	1.05	1.00	969	3.48	10.93	6,600	6,350	53.7%
Adv Gas/Oil Comb Cycle (CC)	2019	429	3	1,013	1.08	1.00	1,094	1.99	9.94	6,300	6,200	55.0%
Adv CC with carbon sequestration	2019	340	3	1,917	1.08	1.04	2,153	7.08	33.21	7,525	7,493	45.5%
Conv Comb Turbine ⁷	2018	100	2	1,040	1.05	1.00	1,092	3.48	17.39	9,920	9,600	35.5%
Adv Comb Turbine	2018	237	2	640	1.05	1.00	672	10.63	6.76	9,800	8,550	39.9%
Fuel Cells	2019	10	3	6,252	1.05	1.10	7,221	44.91	0.00	9,500	6,960	49.0%
Adv Nuclear	2022	2,234	6	5,091	1.10	1.05	5,880	2.29	99.65	10,459	10,459	32.6%
Distributed Generation - Base	2019	2	3	1,463	1.05	1.00	1,536	8.10	18.23	8,981	8,900	38.3%
Distributed Generation - Peak	2018	1	2	1,757	1.05	1.00	1,845	8.10	18.23	9,975	9,880	34.5%
Biomass	2020	50	4	3,540	1.07	1.00	3,790	5.49	110.34	13,500	13,500	25.2%
Geothermal ^{8,9}	2020	50	4	2,586	1.05	1.00	2,715	0.00	117.95	9,510	9,510	35.8%
MSW - Landfill Gas	2019	50	3	8,059	1.07	1.00	8,623	9.14	410.32	18,000	18,000	19.0%
Conventional Hydropower ⁹	2020	500	4	2,220	1.10	1.00	2,442	2.66	14.93	9,510	9,510	35.8%
Wind ¹⁰	2019	100	3	1,576	1.07	1.00	1,686	0.00	46.71	9,510	9,510	
Wind Offshore	2020	400	4	4,648	1.10	1.25	6,391	0.00	77.30	9,510	9,510	
Solar Thermal ⁸	2019	100	3	3,908	1.07	1.00	4,182	0.00	70.26	9,510	9,510	
Photovoltaic ^{8,10,11}	2018	150	2	2,169	1.05	1.00	2,277	0.00	21.66	9,510	9,510	



“Practical Strategies for Emerging Energy Technologies”

Power Plant Conversion Efficiency (and Cost)

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

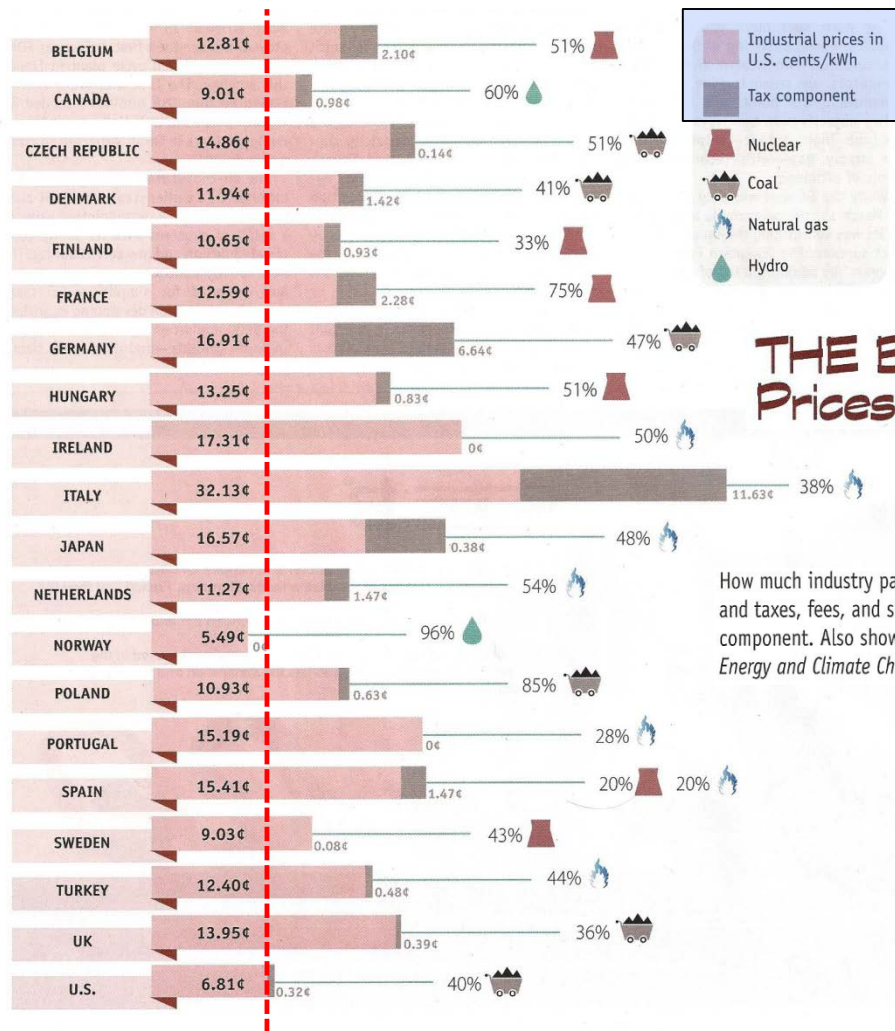
One tonne of oil equivalent equals approximately:

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

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.

