

EMD Coal Committee Annual Report

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April 1, 2017

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Coal Commodity Report

Executive Summary

Coal is the second-largest energy commodity worldwide in terms of energy use, exceeded only by oil. Production from the top twelve coal-producing countries in early 2014 was ~8.2 bst (billion short tons [~7.4 billion metric tons]). The top 12 coal producing countries account for about 90% of the world's total coal production, with China being the top coal-producing and consuming country. The world's top twelve coal-producing countries in the last four years, in terms of decreasing production according to the Energy Information Administration, were: (1) China, (2) United States, (3) India, (4) Indonesia, (5) Australia, (6) Russia, (7) South Africa, (8) Germany, (9) Poland, (10) Kazakhstan, (11) Colombia, and (12) Canada. This report presents recent developments for the top-five coal-producing countries, with an emphasis on the United States. It also summarizes recent and current issues in CTL (coal-to-liquids) and in-situ coal gasification (ISCG) technology.

A current global oversupply of coal since 2012 has led to a downturn in coal prices. However, many of the leading coal-producing countries are planning to ramp up production in expectation of the oversupply being consumed by the end of 2016. Reduced global demand for coal imports in 2014 and 2015 resulted in declining coal-export sales from Indonesia and the United States. Coal exports from the United States have been reduced, mainly because of higher production costs relative to other coal exporting countries. China's Energy Development Strategy Action Plan (2014-2020) has set caps on annual primary energy and coal consumption until 2020, calling for reducing primary energy consumption from coal while at the same time increasing nonfossil energy use.

Although natural gas continues to compete with coal as a source for electricity generation, coal still has a powerful influence on electricity prices worldwide, and coal plants are likely to remain price-setting power units for many countries. Consequently, future security of coal supply will be necessary to maintain stability in wholesale electricity prices. Metallurgical coal prices are also reduced in the global markets. Recent declines in U.S. coal exports are related to a decrease in world coal demand, depressed international coal prices, and greater coal production in other coal-exporting countries. Decreased U.S. coal production has resulted from competition from lower natural gas prices, increasingly strict federal regulations, and coal-plant retirements because of implementation of new air-quality and emission standards. U.S. coal production in 2015 was 895,936 Mst (0.896 bst [0.813 billion metric tons]), representing an 11.5% reduction from 2014. Coal production in the first half of 2016 was 333,543 Mst (0.334 bst [0.303 billion metric tons]), a decline relative to the first half of 2015. U.S. coal production has been steadily declining since 2008.

CTL production continues to be important in China, Botswana, South Africa, although, recent changes in environmental policy in China may adversely affect the CTL industry, reducing its profitability. Work continues in pursuing the potential for ISCG in Alaska, although policy decisions by the Government of Queensland have halted potential ISCG development for the present.

China

China continues to be the number one producer and consumer of coal in the world (World Coal Association, 2014), using more coal than the United States, Europe, and Japan combined (Moore, 2011; Vince, 2012; Energy Information Administration, 2016a). China accounts for almost half of the world's coal consumption and is the world's largest power generator (Energy Information Administration, 2016b). China contained an estimated 126 bst (114.3 billion metric tons) of proved recoverable coal reserves in 2011, the third-largest in the world behind the United States and Russia, and equivalent to about 13% of the world's total coal reserves. Of the 28 provinces in China that produce coal, Shanxi, Inner Mongolia, Shaanxi, and Xinjiang contain most of China's coal resources (Meng et al., 2009).

Beginning in 2014, China experienced the first decline in its coal industry in 14 years, mainly because of an economic downturn that affected coal-consuming industries such as cement and steel (Reuters, 2015). Other factors include slower electricity demand growth and increased use of hydroelectricity. China currently has ~12,000 coal mines producing primarily bituminous coal and lesser amounts of anthracite and lignite. More than 90% of coal produced by China is from underground mines (Meng et al., 2009).

Coal accounts for 66% of China's total energy consumption, with coal representing >60% of electricity generation (Energy Information Administration, 2016b). China's coal consumption in 2014 declined because of downturns in industrial production and imposition of stricter air-quality regulations in cities (Energy Information Administration, 2016c). China plans to place a ceiling on coal consumption at 4.6 bst (4.17 billion metric tons) by 2020. Moreover, China has closed 2,000 small coal mines since 2013 to enhance overall efficiency and safety. Although China has experienced an oversupply of coal and rising inventories, some major coal producers in north-central and northwestern China have continued to increase production. These coal producers, especially those owned by

the Chinese government, have been able to reduce their unit costs through higher output and economies of scale.

Electricity generation in China is operated by state-owned holding companies, although limited private and foreign investments have recently been made in the electricity sector. Improvements to power grids are also being made to deal with power shortages. China has expanded the construction of natural gas-fired and renewable power plants to introduce power to remote population centers.

Shenhua Group and China National Coal Group, China's largest state-owned coal companies, produce ~50% of the coal in China. Local state-owned companies account for ~20%, with small mines producing 30%. Because of new government regulations and decreasing prices, many of the ~10,000 inefficient and small mines in the country are closing, with the result of large state-owned companies having a greater share in China's overall coal production. China is also welcoming foreign investment to modernize existing large-scale coal mines and to apply new technologies. In addition to coal, China is also becoming more open to foreign investment in CTL, coalbed methane (CBM), coal-to-gas (CTG), and slurry pipeline transportation projects.

Recent increased demand for steel has reduced surplus stock in China's inventory of coking coal. Prices for steelmaking coal are projected by Wood Mackenzie to be maintained in the near future as a result of strong demand for steel in Asia. Australian thermal-coal benchmark prices, commonly dominated by China-centric markets, should remain steady at approximately US \$60 a ton in the first quarter of 2017 (Strumpf and Hoyle, 2016).

China's Energy Development Strategy Action Plan (2014-2020) has set caps on annual primary energy and coal consumption until 2020 (Energy Information Administration, 2016d). It calls for reducing primary energy consumption from coal to 62% of total energy use and for increasing nonfossil energy use to 15% by 2020 and to 20% by 2030. China is also planning to set caps on coal prices in 2017 (Strumpf and Hoyle, 2016). Coal

prices have recently risen to record high prices (more than 30% since April, 2016) as a result of government-enforced mine closures, reducing coal supplies to electric-power companies. The National Development and Reform Commission (NDRC) has requested that miners agree to establish 2017 prices at 12 cents or less per kilocalorie (kcal) for 5,000-kilocalorie thermal coal (Meng and Mason, 2016). These prices are approximately equivalent to 600 yuan (\$88.63 US) per metric ton.

United States

Production and Exports

According to the April-June 2016 Quarterly Coal Report (Energy Information Administration, 2016d), released in September, 2016, U.S. coal production in 2015 was 895,936 Mst (0.896 bst [0.813 billion metric tons]), representing an 11.5% reduction from 2014 (Table 1). Coal production in the first half of 2016 was 333,543 Mst (0.334 bst [0.303 billion metric tons]), considerably down from the first half of 2015. U.S. coal production has been steadily declining since 2008, although net imports of coal have slightly risen over the same interval of time (Fig. 1).

Wyoming continues to be the greatest coal-producing state in the U.S., having accounted for 125,070 Mst (0.125 bst [0.113 billion metric tons]) in the first half of 2016 (Table 2). However, coal production in Wyoming in the first half of 2016 experienced a 32.3% decline relative to the first half of 2015. Other states with significant coal production in the first half of 2016 include West Virginia with 38,081 Mst (0.038 bst [0.034 billion metric tons]), Illinois with 22,437 Mst (0.022 bst [0.020 billion metric tons]), Pennsylvania with 21,558 Mst (0.022 bst [0.020 billion metric tons]), and Kentucky with 21,253 Mst (0.021 bst [0.019 billion metric tons]) (Table 2). All states experienced decreased coal production in 2016 relative to 2015. Of the five states listed above, Kentucky experienced the greatest percent decrease (35.0). The Western region leads the U.S. in coal production, with production from the Appalachian and Interior regions being

similar (Fig. 2). Average coal commodity spot prices in early-November 2016 were highest in central Appalachia, being \$45.05 USD per short ton (Table 3).

U.S. coal exports have steadily declined since 2012, falling from 125,746 Mst (0.126 bst) in 2012 to 73,958 Mst (0.074 bst) in 2015 (Table 4). Coal exports in the first half of 2016, compared to those in the first half of 2015, declined by ~33% (Fig. 3). Prices for coal exports have also continued to decline (Fig. 4). Europe accounted for ~46% of U.S. coal exports in the first half of 2016, with exports of 13,162,321 short tons (0.132 bst [0.120 billion metric tons]) (Table 5). Other important U.S. coal-export destinations in the same time period include Asia with 7,449,508 short tons (0.074 bst [0.067 billion metric tons]) and South America with 3,696,035 short tons (0.037 bst [0.034 billion metric tons]).

Electricity Generation

Recent changes in laws and regulations from the EPA (Environmental Protection Agency) through the Clean Power Plan (CPP) require reductions in carbon dioxide emissions and increased tax credits for wind and solar energy. These actions, combined with recent lower prices for natural gas, have impacted coal's share of electricity generation in the U.S. Although electricity generation from coal in the U.S. continues to fall relative to natural gas, it still accounts for a greater share than natural gas in some regions such as the Eastern U.S. (Fig. 5). In contrast, electric generation from natural gas in Texas (ERCOT [Electric Reliability Council of Texas]) far exceeds that from coal. However, recent reports from the Energy Information Administration indicate that coal will generate 31% of U.S. electricity in 2017, compared with 30% in 2016 (Utilitydive, 2016). This is contingent on increased prices for natural gas concomitant with increased demand. Moreover, with recent federal election results in November, 2016, existing EPA regulations may be substantially modified, favoring renewed electricity generation from coal. Nevertheless, the combination of competition from cheaper natural-gas electricity generation and at least eight years of increasingly strict emissions regulations from the federal government may result in

permanent losses of U.S. coal-mining jobs, particularly in Appalachia (Cama, 2016; Kemp, 2016; Worstall, 2016), unless the U.S. coal-export market can be revitalized.

For example, EPA recently approved a plan for retiring the 750 MW coal-fired power plant (Navajo Generating Station) in northeastern Arizona by 2019 (Utilitydive, 2014). This proposed power-plant closure would bring the total coal-fired retirement figure in the southwestern U.S. to 2,760 MW. The plant's operator would have to spend more than \$1 billion USD in order to be compliant with EPA's emissions standards.

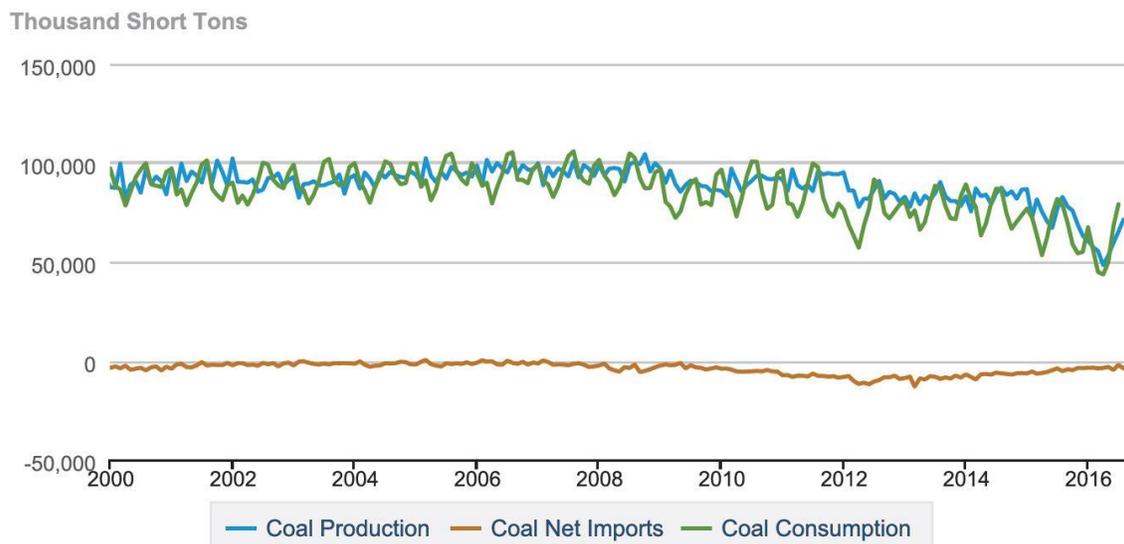
Coal Data Sources

The Energy Information Administration has an interactive, online Coal Data Browser that provides detailed information on U.S. coal. Accessible at <http://www.eia.gov/beta/coal/data/browser/>, this data site integrates comprehensive information, statistics, and visualizations for U.S. coal, including electricity generation. The browser also allows users to access data from the Mine Safety and Health Administration and coal trade information from the U.S. Census Bureau.

The Coal Data Browser allows the user to:

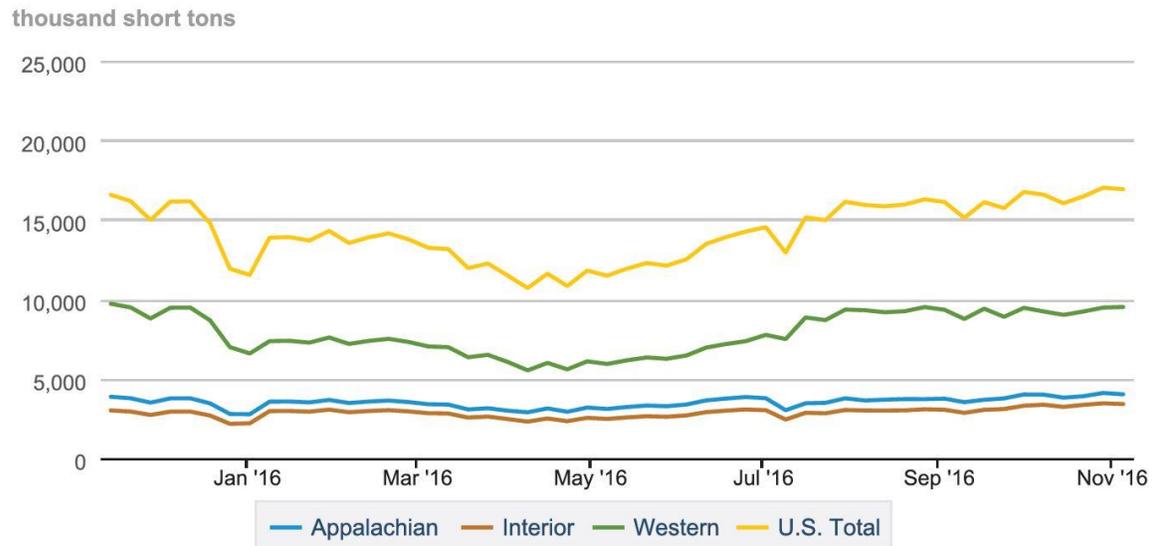
- Map coal imports and exports by country and by U.S. ports handling coal.
- Map where mines send coal and where power plants obtain coal.
- Analyze coal receipts by sulfur, ash, and heat content, as well as per mine.
- Observe changes in coal prices.
- Cross-link mine-level data pages with EIA's [U.S. Energy Mapping System](#) to discover data on all active coal mines.
- Observe changes in coal-worker employment in specific states.

The Energy Information Administration also provides an energy mapping system for a variety of energy sources that include coal, including coal mines and location and identity of coal-fired electricity installations in the United States. Information on coal can be accessed at: <https://www.eia.gov/state/maps.cfm?v=Coal>. The general site can be reached via: <https://www.eia.gov/state/maps.cfm?v=Fossil%20Fuel%20Resources>.



 Source: U.S. Energy Information Administration

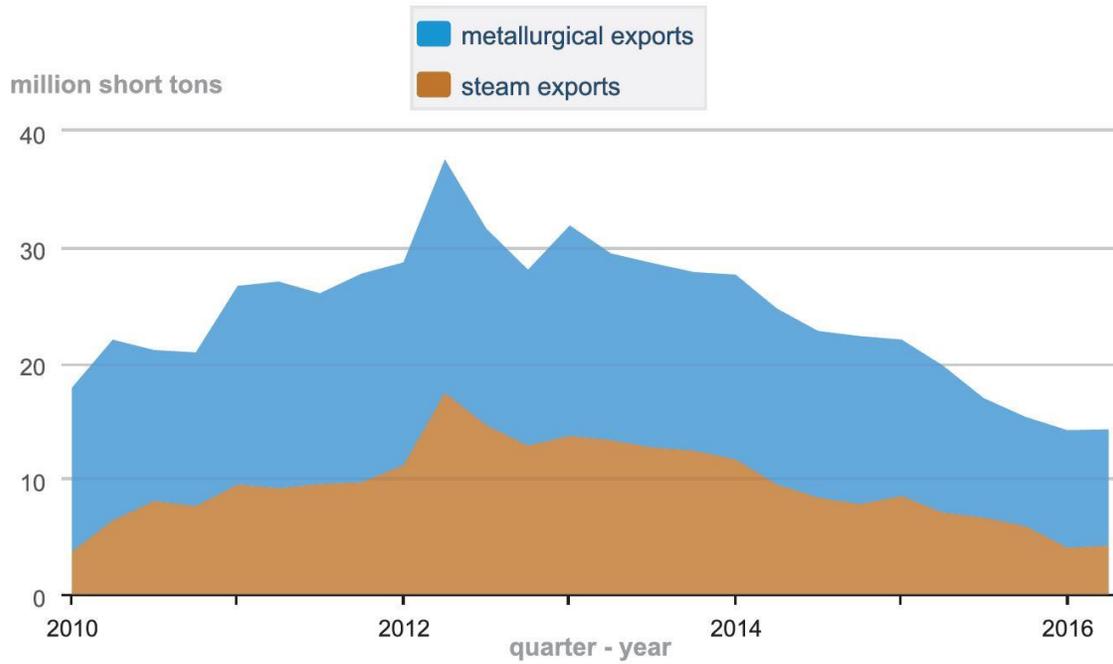
Fig 1. Coal production, import, and consumption overview in the United States, 2000 to 2016. Units are in thousand short tons (Mst). Modified from Energy Information Administration (2016e).



 Source: U.S. Energy Information Administration

Fig 2. Coal production by region in the United States, December 2015 to November 2016. Units are in thousand short tons (Mst). Modified from Energy Information Administration (2016g).

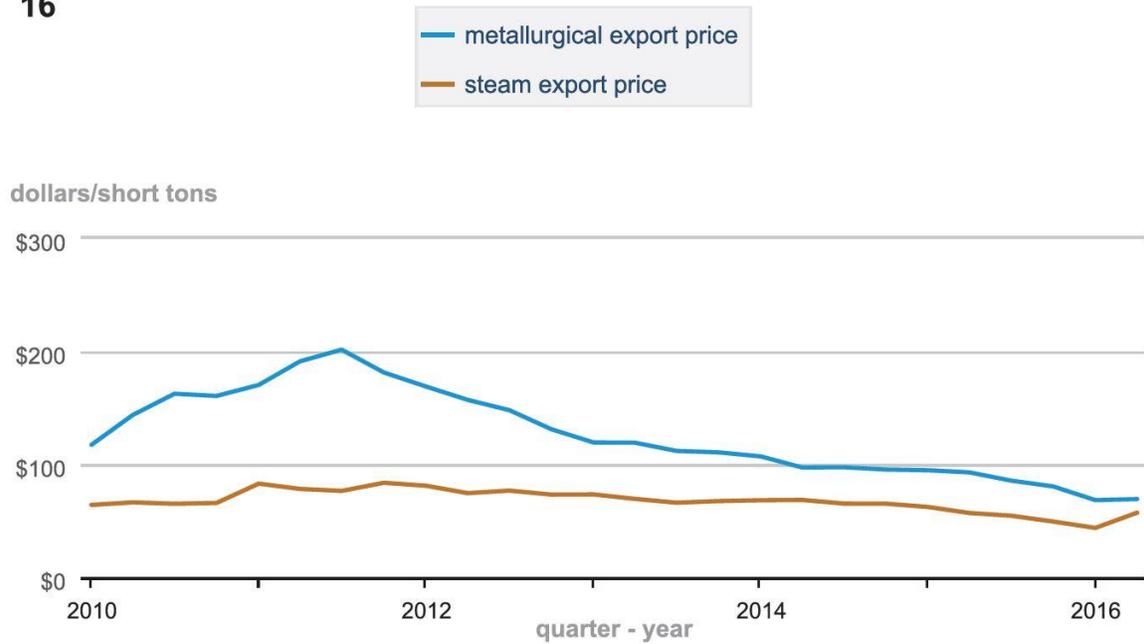
U.S. steam and metallurgical coal exports



Source: U.S. Energy Information Administration: "Quarterly Coal Report."

Fig 3. U.S. steam and metallurgical coal exports, 2010 to mid-2016. Units are in million short tons (MMst). Modified from Energy Information Administration (2016d).

Average price of U.S. steam and metallurgical coal exports, 2010 - 16



 Source: U.S. Energy Information Administration: "Quarterly Coal Report."

Fig 4. Average prices of U.S. steam and metallurgical coal exports, 2010 to early 2016. Units are USD per short tons. Modified from Energy Information Administration (2016d).

2015 capacity and generation mix by Interconnection

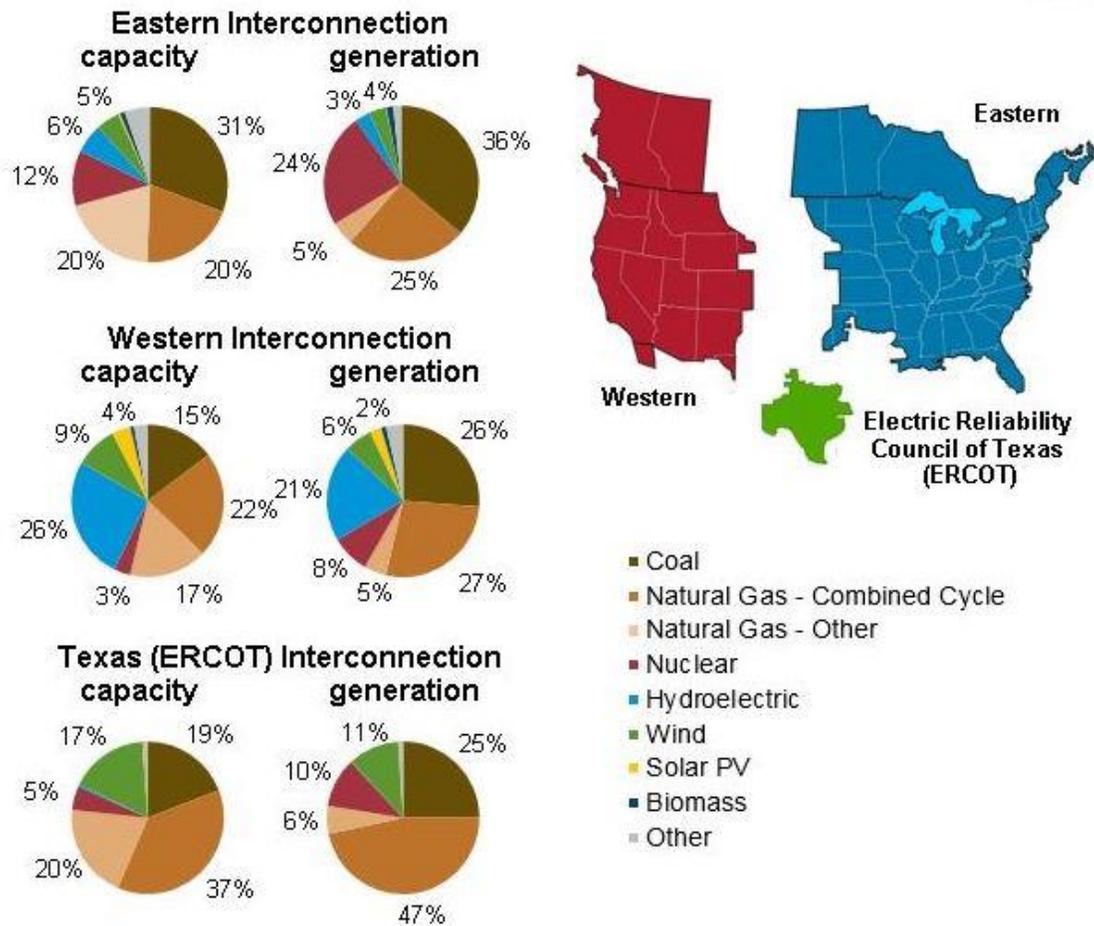


Fig 5. U.S. electric power capacity and generation mix by interconnection in 2015. From Energy Information Administration (2016h).

Table 1. U.S. Coal Production, 2010 - 2016

(thousand short tons)

Year	January - March	April - June	July - September	October - December	Total
2010	265,702	264,982	277,505	276,180	1,084,368
2011	273,478	264,291	275,006	282,853	1,095,628
2012	266,865	241,047	258,956	249,591	1,016,458
2013	244,867	243,211	257,595	239,169	984,842
2014	245,271	245,844	255,377	253,557	1,000,049
2015	240,299	212,452	236,990	207,237	896,977
2016	173,028	160,515	-	-	333,543

- = No data reported.

Note: Total may not equal sum of components because of independent rounding.

Source: U.S. Department of Labor, Mine Safety and Health Administration, Form 7000-2, 'Quarterly Mine Employment and Coal Production Report.'

Table 1. U.S. coal production from 2010 to 2016. Units are in thousand short tons (Mst).
From Energy Information Administration (2016d).

Table 2. Coal Production by State
(thousand short tons)

Coal-Producing Region and State	April - June 2016	January - March 2016	April - June 2015	Year to Date		Percent Change
				2016	2015	
Alabama	2,223	2,446	3,504	4,669	7,561	-38.2
Alaska	228	310	345	538	610	-11.9
Arizona	1,235	1,335	1,912	2,569	3,667	-29.9
Arkansas	15	11	27	27	48	-44.9
Colorado	3,081	2,482	5,078	5,564	10,341	-46.2
Illinois	11,125	11,312	13,391	22,437	30,221	-25.8
Indiana	6,963	7,224	8,577	14,187	18,040	-21.4
Kansas	-	27	49	27	102	-73.9
Kentucky Total	9,907	11,346	15,828	21,253	32,695	-35.0
Eastern (Kentucky)	3,973	4,583	7,431	8,556	15,249	-43.9
Western (Kentucky)	5,933	6,763	8,396	12,697	17,446	-27.2
Louisiana	696	656	686	1,352	1,445	-6.5
Maryland	293	360	489	653	1,048	-37.7
Mississippi	582	770	818	1,352	1,598	-15.4
Missouri	68	41	40	110	80	36.5
Montana	6,210	7,429	9,784	13,639	20,710	-34.1
New Mexico	2,460	4,295	5,286	6,755	9,162	-26.3
North Dakota	6,462	7,209	6,839	13,672	14,250	-4.1
Ohio	3,252	3,895	3,987	7,147	8,963	-20.3
Oklahoma	166	167	210	333	413	-19.3
Pennsylvania Total	11,233	10,325	11,797	21,558	25,241	-14.6
Anthracite (Pennsylvania)	405	424	490	829	949	-12.6
Bituminous (Pennsylvania)	10,828	9,901	11,307	20,729	24,292	-14.7
Tennessee	147	231	231	378	437	-13.5
Texas	8,818	9,917	7,586	18,735	15,551	20.5
Utah	3,486	3,363	3,592	6,849	7,195	-4.8
Virginia	3,149	3,097	3,491	6,246	7,207	-13.3
West Virginia Total	18,821	19,260	23,512	38,081	50,853	-25.1
Northern (West Virginia)	9,959	10,286	11,019	20,245	24,387	-17.0
Southern (West Virginia)	8,862	8,975	12,493	17,836	26,465	-32.6
Wyoming	59,663	65,407	85,117	125,070	184,710	-32.3
Appalachia Total	43,090	44,197	54,442	87,288	116,554	-25.1
Appalachia Central	16,131	16,886	23,646	33,017	49,354	-33.1
Appalachia Northern	24,737	24,865	27,292	49,602	59,639	-16.8
Appalachia Southern	2,223	2,446	3,504	4,669	7,561	-38.2
Interior Region Total	34,366	36,889	39,780	71,255	84,945	-16.1
Illinois Basin	24,021	25,299	30,365	49,321	65,707	-24.9
Interior	10,345	11,590	9,415	21,935	19,238	14.0
Western Region Total	82,825	91,829	117,953	174,655	250,645	-30.3
Powder River Basin	62,360	69,072	90,307	131,432	196,072	-33.0
Uinta Region	6,166	5,561	8,222	11,726	16,648	-29.6
Western	14,300	17,196	19,423	31,496	37,925	-17.0
East of Mississippi River	67,694	70,267	85,625	137,960	183,863	-25.0
West of Mississippi River	92,588	102,649	126,550	195,237	268,284	-27.2
U.S. Subtotal	160,282	172,915	212,175	333,198	452,148	-26.3
Refuse Recovery	233	112	277	345	603	-42.8
U.S. Total	160,515	173,028	212,452	333,543	452,751	-26.3

Note: Total may not equal sum of components because of independent rounding.

Source: U.S. Department of Labor, Mine Safety and Health Administration, Form 7000-2, 'Quarterly Mine Employment and Coal Production Report.'

Table 2. U.S. coal production by state in the first half of 2016, as well as April to June, 2015 and all of 2015. Units are in thousand short tons (Mst). From Energy Information Administration (2016d).

Recent Data

Average weekly coal commodity spot prices (dollars per short ton)

Coal commodity regions	Week ending			
	10/14/16	10/21/16	10/28/16	11/04/16
Central Appalachia <i>12,500 Btu, 1.2 SO₂</i>	\$45.05	\$45.05	\$45.05	\$45.05
Northern Appalachia <i>13,000 Btu, < 3.0 SO₂</i>	\$42.25	\$42.25	\$42.25	\$42.25
Illinois Basin <i>11,800 Btu, 5.0 SO₂</i>	\$33.25	\$33.25	\$33.25	\$33.25
Powder River Basin <i>8,800 Btu, 0.8 SO₂</i>	\$9.00	\$9.00	\$9.00	\$9.00
Uinta Basin <i>11,700 Btu, 0.8 SO₂</i>	\$39.40	\$39.40	\$39.40	\$39.40

Source: With permission, [Coal Markets](#)

Table 3. Average weekly coal commodity spot prices in the United States from October 14 to November 4, 2016. Units are in USD per short ton. From Energy Information Administration (2016f).

Year	January - March		April - June		July - September		October - December		Total	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
2010	17,807	4,803	21,965	5,058	21,074	4,680	20,870	4,811	81,716	19,353
2011	26,617	3,381	26,987	3,419	25,976	3,588	27,679	2,700	107,259	13,088
2012	28,642	2,022	37,534	2,329	31,563	2,415	28,006	2,394	125,746	9,159
2013	31,835	1,429	29,427	2,756	28,589	2,398	27,809	2,323	117,659	8,906
2014	27,584	2,450	24,674	3,574	22,723	3,151	22,276	2,174	97,257	11,350
2015	21,979	3,009	19,766	2,640	16,914	2,965	15,299	2,705	73,958	11,318
2016	14,153	2,698	14,223	2,292	-	-	-	-	28,376	4,989

-- No data reported.

Note: Total may not equal sum of components because of independent rounding.

Source: Exports: U.S. Department of Commerce, Bureau of the Census, 'Monthly Report EM 545;' and imports: U.S. Department of Commerce, Bureau of the Census, 'Monthly Report IM 145.'

Table 4. U.S. coal exports and imports from 2010 to the first half of 2016. Units are in thousand short tons (Mst). From Energy Information Administration (2016d).

Continent and Country of Destination	April - June 2016	January - March 2016	April - June 2015	Year to Date		Percent Change
				2016	2015	
North America Total	1,991,066	1,373,100	3,131,636	3,364,166	4,996,883	-32.7
Canada*	1,213,126	608,869	1,792,272	1,821,995	2,507,975	-27.4
Dominican Republic	14	19	54,923	33	56,668	-99.9
Guatemala	270	-	6,341	270	6,400	-95.8
Honduras	35,889	35,825	35,837	71,714	70,488	1.7
Jamaica	67	36,375	37,479	36,442	73,580	-50.5
Mexico	741,518	691,800	1,141,462	1,433,318	2,217,901	-35.4
Trinidad and Tobago	119	12	63,179	131	63,534	-99.8
Other**	63	200	143	263	337	-22.0
South America Total	1,722,150	1,973,885	1,704,310	3,696,035	3,664,365	0.9
Argentina	58,607	-	24	58,607	193,204	-69.7
Brazil	1,662,703	1,858,826	1,478,683	3,521,529	3,189,209	10.4
Chile	343	419	224,491	762	280,427	-99.7
Other**	497	114,640	1,112	115,137	1,525	NM
Europe Total	6,945,500	6,216,821	9,034,317	13,162,321	21,297,376	-38.2
Austria	1,124	206,234	109,491	207,358	302,517	-31.5
Belgium	261,248	264,275	227,845	525,523	722,771	-27.3
Croatia	477,500	202,475	474,029	679,975	1,034,570	-34.3
Finland	59,525	75,352	148,428	134,877	207,403	-35.0
France	230,593	227,174	366,119	457,767	824,947	-44.5
Germany, Federal Republic of	974,031	629,248	906,975	1,603,279	2,166,145	-26.0
Italy	479,590	485,023	874,292	964,613	1,687,272	-42.8
Netherlands	2,404,707	2,544,009	3,036,451	4,948,716	6,374,163	-22.4
Norway	20,507	20,783	16,373	41,290	40,484	2.0
Poland	60,663	27,557	141,558	88,220	404,742	-78.2
Romania	90,912	22,931	49,670	113,843	169,499	-32.8
Slovakia	-	23	77,162	23	158,199	-100.0
Slovenia	544	-	107,761	-	129,813	-
Spain	266,544	485,502	390,437	752,046	691,600	8.7
Sweden	69,604	-	143,175	69,604	243,760	-71.4
Turkey	686,176	297,015	247,118	983,191	1,510,433	-34.9
Ukraine	661,790	355,136	626,650	1,016,926	1,635,845	-37.8
United Kingdom	192,730	304,456	1,072,771	497,186	2,922,414	-83.0
Other**	8,256	69,628	18,012	77,884	70,799	10.0
Asia Total	3,369,682	4,079,826	5,581,968	7,449,508	11,394,295	-34.6
China	1,107	123,845	228,577	124,952	228,948	-45.4
India	1,771,137	1,869,932	2,270,539	3,641,069	4,845,323	-24.9
Japan	858,888	979,630	1,047,477	1,838,518	2,236,335	-17.8
Singapore	12	-	-	12	127,400	-100.0
South Korea (Republic of Korea)	736,496	1,104,643	2,032,636	1,841,139	3,952,364	-53.4
Other**	2,042	1,776	2,739	3,818	3,925	-2.7
Australia and Oceania Total	109	21	22	130	117	11.1
Other**	109	21	22	130	117	11.1
Africa Total	194,898	509,368	313,548	704,266	391,816	79.7
Egypt	233	116	163,379	349	163,414	-99.8
Morocco	116,625	433,914	69,953	550,539	69,953	NM
South Africa	78,040	75,310	80,216	153,350	158,391	-3.2
Other**	-	28	-	28	58	-51.7
Total	14,223,405	14,153,021	19,765,801	28,376,426	41,744,852	-32.0

* Based on the U.S. - Canada Free Trade Agreement; as of January 1990, the U.S. Department of Commerce began reporting statistics on U.S. exports to Canada based on information on imports provided monthly by the Canadian government.

** includes countries with coal exports less than or equal to 50,000 short tons in 2015.

- = No data reported.

NM = Not meaningful due to changes of 500 percent or more.

Note: Total may not equal sum of components because of independent rounding.

Source: U.S. Department of commerce, Bureau of the Census, 'Monthly Report EM 545.'

Table 5. Destinations of U.S. coal exports in the first half of 2016, as well as April to June, 2015 and all of 2015. Units are in short tons. From Energy Information Administration (2016d).

India

Coal is India's primary source of energy. India has the world's fifth-largest coal reserves, and ranks third both in coal production and consumption. India's government has a near-monopoly on coal production and distribution (Energy Information Administration, 2016i). Most of India's coal reserves occur in the eastern part of the country. Jharkhand, Chhattisgarh, and Odisha states together comprise 64% of the country's coal reserves. Other significant coal-producing states include West Bengal, Andhra Pradesh, Madhya Pradesh, and Maharashtra (Energy Information Administration, 2016i). Coal India Limited (CIL) is India's largest and the world's largest coal producer, having produced >80% of the country's coal in the last four years, although it may be divided into several smaller companies in 2017 (Reuters, 2016). The government of India is seeking to produce 1.65 bst (1.5 billion metric tons) of coal by 2020 (Economicstimes.com, 2015).

India plans to add 24.5 gigawatts (GW) of coal-fired electric power by the end of March, 2017, according to India's Central Electricity Authority (CEA) (Powerengineeringint.com, 2016). Over 47.8 GW of coal-fired capacity has been installed during India's 12th Five-Year Plan, with the goal of installed electric power capacity of 288 GW, of which coal will account for 201 GW.

The government of India, owing to current surpluses of coal, plans to bring a halt to thermal coal imports by state-run electric-power utilities in 2017, according to Union Minister Piyush Goyal (Economicstimes.com, 2015). Although current contracts will be honored in 2016, no new contracts will be signed in 2017. NTPC Ltd, India's largest power utility company, has already reduced imports of thermal coal for power generation. Coal India Ltd., another state-run coal company, has been in contact with private power utilities, requesting that they consume more domestic coal. However, some power companies who operate plants in coastal areas in southern India favor imported coal, which for them is more economical where land-haulage is not involved.

Even though coal is the greatest provider of electricity generation in India, accounting for approximately 60% of installed power capacity, coal shortages continue to cause shortfalls in electricity generation, resulting in frequent blackouts. Approximately 90% of the country's coal mines are opencast mines, which although being cost-effective, cause environmental damage. India lacks advanced technology for large-scale, underground mining operations with the result that overall productivity levels in the country are low. Low levels of competition in the coal sector inhibit private and foreign investment and state regulations continue to cause delays for mining companies in receiving mining permits. Additional delays are caused by limited railway capacity, delays in new railroad projects, and high transport costs. However, India has recently completed three major rail transportation projects for increased shipments of coal from major producing regions in northeastern India to other parts of the country. Although India's coal producers have already increased domestic production since 2014, a fourth major rail project called the Jharsuguda-Barpali railway link is not scheduled for completion until 2017 (Energy Information Administration, 2016a). The Indian coal ministry plans to scale down its production target of 876 MMst (0.88 bst [0.80 billion metric tons]) in the period from 2016 to 2017, owing to perceived problems in rail transport and compliance with environmental regulations (Thakkar, 2014).

Indonesia

Indonesia exports almost 80% of its produced coal and is the world's largest exporter of coal by weight (Energy Information Administration, 2016j). Indonesia has recently become important as a source for Chinese coal imports. Indonesia's coal exports are primarily destined for Asian markets, with 85% of total coal exports going to China, Japan, South Korea, India, and Taiwan. India has recently been the largest importer of Indonesian coal, even exceeding China.

However, coal production in Indonesia is expected to decline in 2017 (Indonesia Investments, 2016), although it had been rising in 2013 (Indonesia Investments, 2013). Continued declines in production from many smaller companies, strapped with low cash reserves, have resulted from lower coal prices. Another factor in the decline of domestic Indonesian coal production is competition from Australia, South Africa and Colombia, which have higher-quality coal. In addition, the government of Indonesia in February, 2016 increased the clean-energy tax on coal by a factor of two in its effort to reduce air and water pollution. This tax has a bigger impact on low-grade coal than on high-grade coal, which is less common in Indonesia.

Indonesia is fostering the use of coal in the power sector because of its abundant domestic supply and the use of coal lessens the need to use expensive diesel and fuel oil. Because of an increasing demand for domestic coal, Indonesia has imposed a domestic market obligation on large coal producers. The 2013 domestic market obligation was set at 82 MMst (74.4 million metric tons), ~18% of total coal production. The main beneficiary of this program is the electric power sector, of which slightly more than 50% is based on coal (Energy Information Administration, 2016j). Power plants accounted for ~70% of recent total coal sales, with the remainder for industrial use. Electricity sector demand for coal is expected to increase because of additions to coal-fired generation capacity.

PT Bumi Resources Tbk is Indonesia's largest mining company and coal producer, with 88 MMst (79.8 million metric tons) produced in 2013. PT Bumi plans to increase production of power-station coal in 2017, in expectation of stable coal prices that reflect recent rises in Chinese thermal coal futures (Jensen, 2016). PT Bumi is projecting coal sales in excess of 93.68 MMst (85 million metric tons) for the year 2016. As of the period January 1 to the end of September, 2016, it was 71.3 MMst (64.6 million metric tons), an increase of more than 10% during the same period in 2015.

PT Adaro is the second-largest coal producer in Indonesia, accounting for almost 60 MMst (54.4 million metric tons) of coal in 2013. Other major producers include PT Kideco Jaya, PT Indotambang Raya Megah, and PT Berau. The top five producers in

Indonesia accounted for more than 45% of coal production in 2013, with coal being produced in three principal areas in the country (South Sumatra, East Kalimantan, and South Kalimantan) (Indonesia Investments, 2013).

Australia

Australia is the world's second-largest exporter of coal by weight (Energy Information Administration (2016k). Coal accounts for 64% of Australia's electricity generation capacity, with natural gas providing 20%. Recently, Australia has been substituting coal-fired generation with natural gas and renewable power, with the result that overall coal use declined from a peak of 158 MMst (143.3 million metric tons) in 2009. However, coal still serves as a baseload source for power in Australia because of abundant resources and well-developed infrastructure.

Australia has >80 bst (>72.6 billion metric tons) of recoverable coal reserves, the fourth-largest in the world behind the United States, Russia, and China. The combined proved and probable commercial reserves were estimated to be 116 bst (105.2 billion metric tons), with 58% represented by black coal and 42% from brown coal (Energy Information Administration, 2016k). Queensland and New South Wales represent 98% of Australia's black coal production, and Victoria accounts for almost all of brown coal reserves and production.

Australia has ~120 privately-owned coal mines (Energy Information Administration (2016k). Most of Australia's coal production is from open pit operations. BHP Billiton, Anglo American (UK), Xstrata (Switzerland), and Rio Tinto (Australia-UK), are major players in Australia's coal industry. Australia has invested \$11.2 billion in advanced infrastructure projects to add nearly 80 MMst to production capacity by 2017.

Most exports are from the Queensland and New South Wales states, although Western Australia has been exporting coal since 2007. Queensland saw a record amount of coal exports in 2014, with exports of ~238 MMst (~215.9 million metric tons) (Latimer, 2015). Coal exports are supported by nine major coal ports and export terminals in Queensland and New South Wales. These terminals have a combined capacity of >510 MMst (>462.7 million metric tons) per year. New port projects are being developed and are projected to add >50 MMst (>45.4 million metric tons) to annual coal loading capacity by the end of 2016.

New coal-mining ventures in Australia in 2017 include the Olive Downs project in the Bowen Basin to produce coking coal for steel manufacture (Paul, 2016). Pembroke Resources, which purchased the project from Peabody Energy and CITIC Resources (China), is planning to mine at least 15.4 MMst (14 million metric tons) per year, followed by two additional new mines in 2019. Pembroke Resources cites the recent increases in hard coking coal spot prices, which have nearly doubled in 2016 to \$128.59 per short ton (\$141.75 per metric ton), at a time when the expensive U.S. supply has fallen out of the market and production from China has decreased.

Another new venture planned in Australia in 2017 involves the Indian Adani Group, which plans to work on the Carmichael thermal coal project in the Galilee Basin in Queensland (Times of India, 2016). The goal of this project is to produce up to 66 MMst (~60 million metric tons) per year. The project has experienced almost seven years of review during an extended environmental approval process, as well as legal challenges, as for example that of the Australian Conservation Foundation, which in September, 2016 lodged an appeal in Federal Court. Pending ultimate approval, the Carmichael thermal project is anticipated to produce 44 MMst (~40 million metric tons) per year over a seven-year period, with an ultimate goal of 66 MMst (~60 million metric tons) per year.

CTL (Coal-to-Liquids)

Informative overviews of CTL processes and recent developments are presented in Tennant (2014) and Jain and Gupta (2015). CTL, which involves the conversion of coal and carbonaceous material (petcoke and biomass products) into liquid fuels, is a technology that has been in existence for 100 years, having been originally developed in Germany in 1917. Either direct or indirect conversion processes are available in CTL technology. Indirect conversion (ICL), or Fischer-Tropsch synthesis (FTS), involves gasification of coal into syngas, followed by liquids production from syngas. Direct conversion of coal into liquids (DCL), is exemplified by the Catlettsburg, Kentucky plant that generates 1,800 barrels per day of liquid fuel, and the Shenhua direct conversion coal liquefaction plant in Mongolia, which produces approximately 24,000 barrels per day. China is actively developing CTL technology, as part of its energy-security policy and its long-term plans in fully realizing the energy potential of its coal resources with a coal-liquefaction industry (Wu, 2011). Historical governmental support for a coal-liquefaction industry, dating back to the 1980s, includes basic research on reaction kinetics, catalysts, reactor design, and chemical-process simulations, followed by an eleven-billion yuan fund designated as China's "Coal Replace Oil" fund, with the Shenhua Group being targeted for primary support. However, recent changes in environmental policy in China may adversely affect the CTL industry, reducing its profitability (Bloomberg, 2016). China's current five-year plan calls for a 23% reduction in water consumption per unit of GDP, as well as cutting carbon dioxide emissions per unit of GDP by 18%, actions which would reduce the economic viability of the CTL industry there.

Indirect coal conversion to liquids, which can generate zero-sulfur and near-zero aromatic hydrocarbon fuel, is exemplified by SASOL's facilities (SASOL II and III) in South Africa, that collectively produce approximately 160,000 barrels per day, down from a peak of 234,000 barrels per day in 2004 (EnergyGlobal, 2016). Most liquid hydrocarbon production in South Africa is from either CTL or GTL (gas-to-liquids) facilities. Other byproducts from Sasol II, which uses low-rank bituminous coal for feedstock, include

chemicals and miscellaneous fuels. Sasol had planned for a fourth complex (Project Mafutha), but plans have been curtailed because of carbon-emission issues.

Work was initiated on a \$4.2 billion coal-to-liquids plant in Botswana (Motsoeneng, 2015). The project, funded by Kumvest, is designed for production of 20,000 barrels of coal to liquids per day, and will be operated in three phases from 2016 to 2020. The plant will utilize 4.74 Mst (4.3 million metric tons) per year of coal from Morupule Mine in Botswana.

In Situ Coal Gasification

In-situ coal gasification (ISCG) involves the injection of oxygen, or an oxygen-rich air mixture into deep, unmineable coal seams. The injectants react with coal seams in a process known as pyrolysis with controlled, partial combustion to produce a syngas composed mainly of methane, carbon monoxide, hydrogen, and carbon dioxide. The syngas is then extracted at the surface with a production well. The syngas is the feedstock for a variety of refined products such as liquid fuels, or the syngas can be used in power generation (Canadian Clean Power Coalition, 2014).

Coal seams in Alaska have been under consideration for ISCG for many years, and extensive tests have been conducted on coal-seam samples to evaluate their potential for both syngas and oil (Bradner, 2017). Exploration and evolution of underground coal seams for ISCG potential continues at Beluga field (Alaska Earth Sciences, 2017). CIRI (Cook Inlet Regional Corporation) has been working with Laurua Energy to develop ISCG projects in Alaska since 2009. The goal of the project at Beluga field is to identify and complete a ISCG project to provide fuel feedstock for a 100 MW combined-cycle power plant.

The future of ISCG in Queensland, Australia is uncertain in light of a recent policy decision announced by the government of Queensland Government in April, 2016

(Queensland Department of Natural Resources and Mines, 2016). Following a review of ISCG environmental and technology issues introduced by the Queensland Parliament, the government has prohibited underground coal-seam injection, after having concluded that the potential environmental risks are unacceptably too high. This prohibition is also applied to in-situ gas injection in shales.

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