

EMD Coal Committee Mid-Year Report

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Coal Commodity Report

Executive Summary

Coal continues to be an important component of the world's energy supply and is second only to oil in terms of the world's energy mix. The United States and Russia lead the world in coal reserves, each containing >5 trillion BTU (British Thermal Units)-equivalent of coal reserves. China and Australia occupy the second tier of coal reserves, each with >3 trillion BTU-equivalent reserves, whereas third-tier nations with lesser coal reserves include India, Kazakhstan, The Union of South Africa, Turkey, Poland, Germany, Brazil, Canada, the Czech Republic, Pakistan, and Indonesia. Coal consumption is currently led by China (47%), the U.S (14%), and India (9%), together composing 70% of total world coal consumption in 2010. World coal consumption is currently rising at an average rate of 1.3% yr⁻¹, and is projected to increase from 147 quadrillion BTU (~7.77 billion short tons [bst]) in 2010 to 180 quadrillion BTU (~9.51 bst) in 2020 and 220 quadrillion BTU (~11.6 bst) in 2040. Also, coal-fired electricity will continue to be the largest source of world power generation through 2040.

U.S. coal production in 2013, based on quarter-by-quarter comparison with previous years, is down from 2011 and 2012 levels after peaking in 2008. Yearly cumulative coal production in the first three quarters of 2013 was slightly less than 750 mst (million short tons). Although U.S. coal production for exports continues to be strong, coal's share of the country's overall energy production is declining, primarily the result of expanded natural gas production. Lower demand for coal in U.S. markets is projected from a combination of factors that include increasingly strict federal regulations, lower natural gas prices, and coal-plant retirements. EPA has announced that proposed rules for existing and modified plants will be issued in 2014, with regulations to be finalized in 2015. These regulations are to be applied to existing power plants, even though annual U.S. SO₂ emissions from coal-fired electricity plants have declined from 16 to less than 6 mst since 1990 and annual NO_x emissions have declined from 7 to 1.8 mst in the same period.

Underground gas injection (UCG) still continues to be developed in western Cook Inlet, Alaska. UCG production is documented worldwide, including Uzbekistan, South Africa, and Australia. South Africa is currently the leader in coal-to-liquids (CTL) production, with Sasol Ltd. producing fuel from coal at its Secunda plant, the largest such facility in the world. China has several CTL projects in various stages of development and Sasol is involved in CTL projects in India as well.

World Coal Production and Consumption: Current Trends

World coal production and consumption continues at high levels and is a significant part of the world's energy mix. Total world coal production was ~8.4 billion short tons (bst), or ~7.7 billion metric tons in 2012 (Energy Information Administration, 2013). More than 1,400,000 megawatts (MW), or >1,400 gigawatts (GW) of electricity could be supplied from the ~1,200 new proposed coal-fired power plants worldwide (MIT Technology Review, 2011). China produced 45% of the world's coal in 2012, more than three times than the U.S., and more than the U.S, India, Australia, and Indonesia combined (Enerdata, 2013).

The United States and Russia lead the world in coal reserves, each containing >5 trillion BTU (British Thermal Units)-equivalent of coal reserves (British Petroleum, 2013). China and Australia occupy the second tier of coal reserves, each with >3 trillion BTU-equivalent reserves, whereas third-tier nations with lesser coal reserves include India, Kazakhstan, The Union of South Africa, Turkey, Poland, Germany, Brazil, Canada, the Czech Republic, Pakistan, and Indonesia.

China consumed 3.8 billion short tons (3.45 billion metric tons) of coal in 2011, nearly half the world's total consumption (Sweet, 2013). This increased consumption is in part the result of a more than threefold increase in electricity generation in China since 2000. Global demand for coal has grown by about 2.9 billion short tons (2.6 billion metric tons) since 2000, with 82% of the total current demand in China. However, risks in coal

markets in China have recently increased. In late 2011, coal prices began to fall as a result of slower growth and the central government's move to restrict formal credit creation by state-controlled banks (Stratfor, 2014). This has forced a number of small companies to seek alternate funding, with Chinese coal prices having fallen in the last three years. Coupled with increasingly strict government controls on air pollution, several of Shanxi's largest private coal mining companies have been in danger of bankruptcy, such as Zhenfu Energy which has been supported by loans, typical of many Chinese coal companies at the present time.

World Coal Production and Consumption: Future Trends

Coal is still the second-largest energy source worldwide, exceeded only by oil. Coal consumption is currently led by China (47%), the U.S (14%), and India (9%), together composing 70% of total world coal consumption in 2010. Their share of world coal use is projected to increase to 75% of the world total by 2040 (Fig. 1 and Table 1).

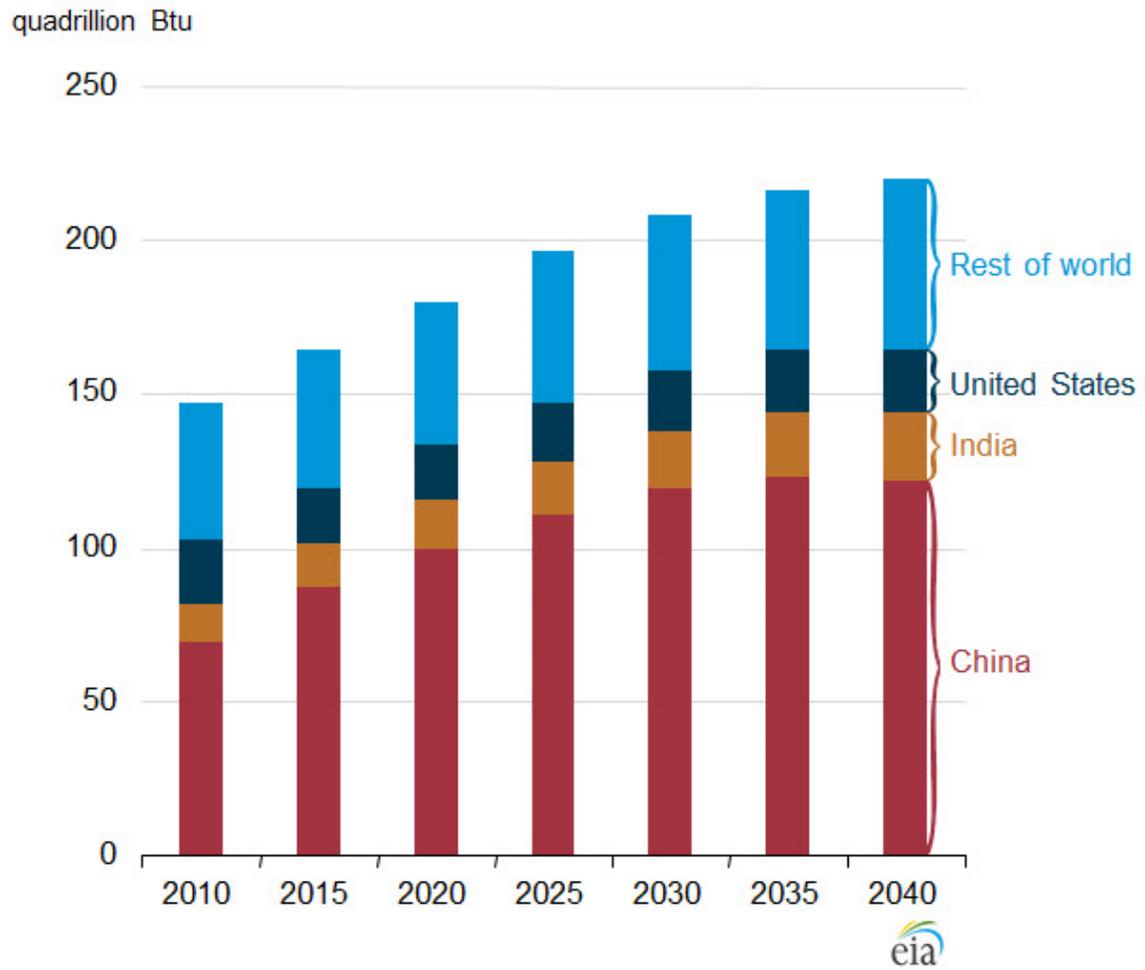


Figure 1. World coal consumption by country grouping, 2010-2040. Modified from Energy Information Administration (2014a).

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD Americas	1,171	1,138	1,174	1,217	1,256	1,272	1,283	0.3
United States	1,084	1,046	1,080	1,119	1,156	1,169	1,177	0.3
Canada	75	81	83	85	87	90	93	0.7
Mexico/Chile	12	12	12	12	12	13	13	0.3
OECD Europe	620	583	568	552	537	522	504	-0.7
OECD Asia	476	549	540	580	591	641	687	1.2
Japan	0	0	0	0	0	0	0	--
South Korea	2	2	3	2	2	2	2	-0.9
Australia/New Zealand	473	547	537	578	589	638	685	1.2
Total OECD	2,267	2,271	2,282	2,349	2,384	2,434	2,474	0.3
Non-OECD Europe and Eurasia	684	663	707	746	775	805	820	0.6
Russia	359	373	400	421	434	447	446	0.7
Other	325	290	307	325	341	358	374	0.5
Non-OECD Asia	4,625	5,310	6,903	6,631	7,116	7,438	7,478	1.6
China	3,506	4,130	4,725	5,257	5,633	5,829	5,722	1.6
India	612	624	696	776	850	926	993	1.6
Other	508	557	582	598	633	683	762	1.4
Middle East	1	2	3	3	3	3	3	3.6
Africa	286	315	358	400	432	462	501	1.9
Central and South America	91	131	145	168	195	209	224	3.0
Brazil	6	6	6	6	6	7	7	0.5
Other	85	125	139	162	189	203	217	3.2
Total non-OECD	5,688	6,422	7,216	7,948	8,521	8,919	9,026	1.6
Total world	7,954	8,693	9,499	10,297	10,905	11,353	11,500	1.2

Note: With the exception of North America, nonseaborne coal trade is not represented in EIA's projections. As a result, the projected levels of production assume that net nonseaborne coal trade will balance out across the *IEO2013* regions. Currently, a significant amount of nonseaborne coal trade takes place in Eurasia, represented by exports of steam coal from Kazakhstan to Russia and exports of coking coal from Russia to Ukraine.

Source: EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. Projections: EIA, World Energy Projection System Plus (2013) and *IEO2013* National Energy Modeling System, run IEO2013.D031113A.

Table 1. World coal production by region in million short tons (mst), 2010-2040.
Modified from Energy Information Administration (2014a).

World coal consumption is currently rising at an average rate of 1.3% yr⁻¹, and is projected to increase from 147 quadrillion BTU (~7.77 bst) in 2010 to 180 quadrillion BTU (~9.51 bst) in 2020 and 220 quadrillion BTU (~11.6 bst) in 2040 (Energy Information Administration, 2014a). Although near-term expansion of coal consumption is predicted in China, India, and other non-OECD countries, growth in coal-consumption is expected to decelerate as regulations emphasize cleaner energy sources. Natural gas will become more economically competitive because of increased shale-gas production. Therefore, coal's share of world energy consumption stops growing in the next decade and gradually declines after 2025. The coal-fired share of world electricity generation is expected to decline from 40% in 2010 to 36 percent in 2040, whereas renewables increase from 21 to 25%.

Worldwide Electricity from Coal: Future Trends

World electricity generation from all sources is projected to increase by 93%, from 20.2 trillion kilowatt hours (kwh) in 2010 to 39.0 trillion kwh in 2040 (Energy Information Administration, 2014a). Total net electricity generation in non-OECD countries will increase by an average of 3.1% yr⁻¹, led by non-OECD Asia (including China and India), where average annual increases are projected to be 3.6% from 2010 to 2040. In contrast, total net electricity generation from coal in the OECD nations is expected to grow by an average of only 1.1% yr⁻¹ from 2010 to 2040. Nevertheless, coal-fired electricity will continue to be the largest source of world power generation through 2040 (Fig. 2).

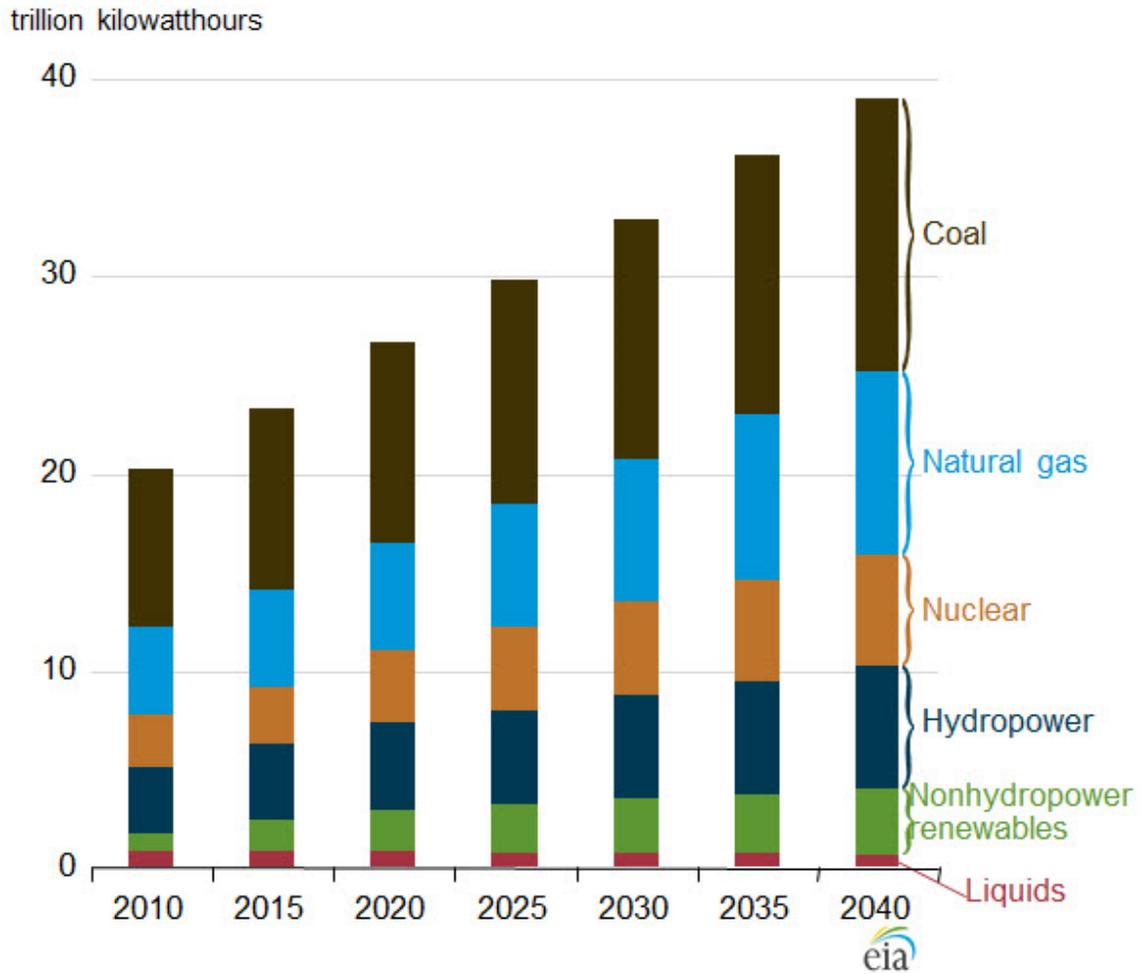
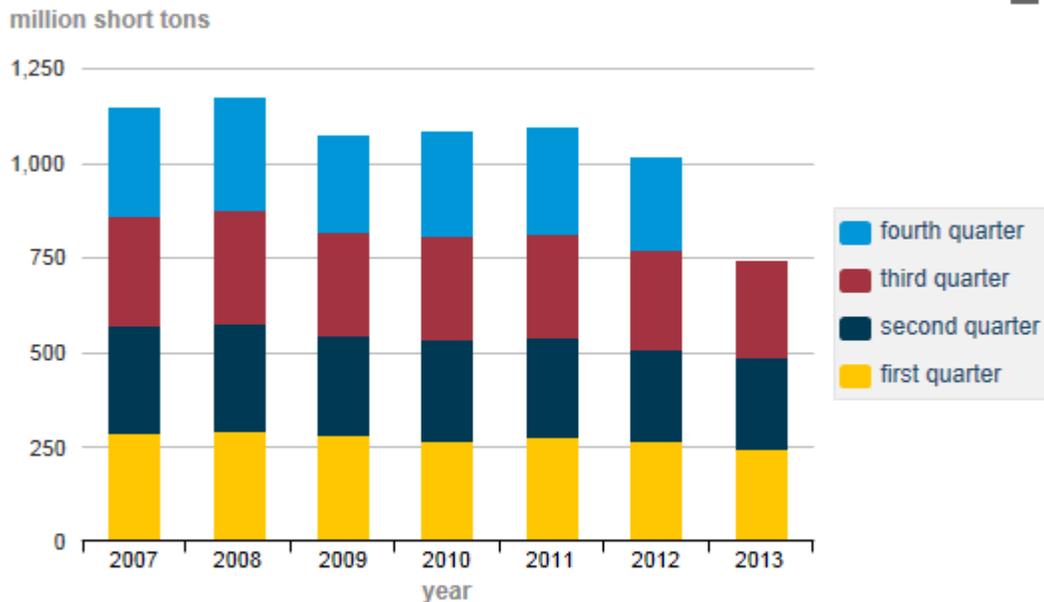


Figure 2. World net electricity generation by energy source, 2010-2040. Modified from Energy Information Administration (2014a).

U.S. Coal Production and Consumption

U.S. coal production in 2013, based on quarter-by-quarter comparison with previous years, is down from 2011 and 2012 levels (Energy Information Administration, 2014b) (Fig. 3).

U.S. coal production by quarter



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

Figure 3. U.S. coal production by quarter, 2007 to the third quarter of 2013. From Energy Information Administration, 2014b).

Peaking in 2008, U.S. coal has been declining. Yearly cumulative coal production in the first three quarters of 2013 was slightly less than 750 mst (million short tons). Although U.S. coal production for exports continues to be strong, coal's share of the country's overall energy production is declining, primarily the result of expanded natural gas production (Humphries and Sherlock, 2013). Lower demand for coal in U.S. markets is projected from a combination of factors that include increasingly strict federal regulations, lower natural gas prices, and coal-plant retirements. Elliott and others (2011)

and Reuters (2012), based on data from NERC (2011), estimated that market conditions and environmental regulations will contribute to 59 to 77 GW of coal plant retirements by 2016 (Fig. 4). Greatest loss of coal-fired electricity generation is projected to be in the southeastern U.S., with 27 to 30 GW of plant retirements, followed by the northeastern U.S. (18 to 26 GW).

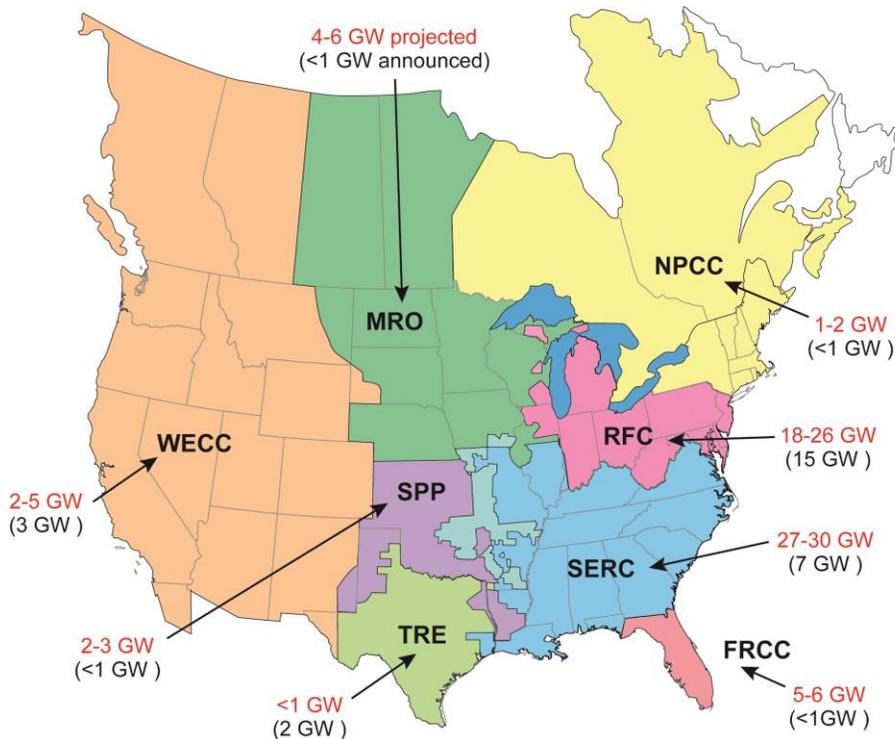
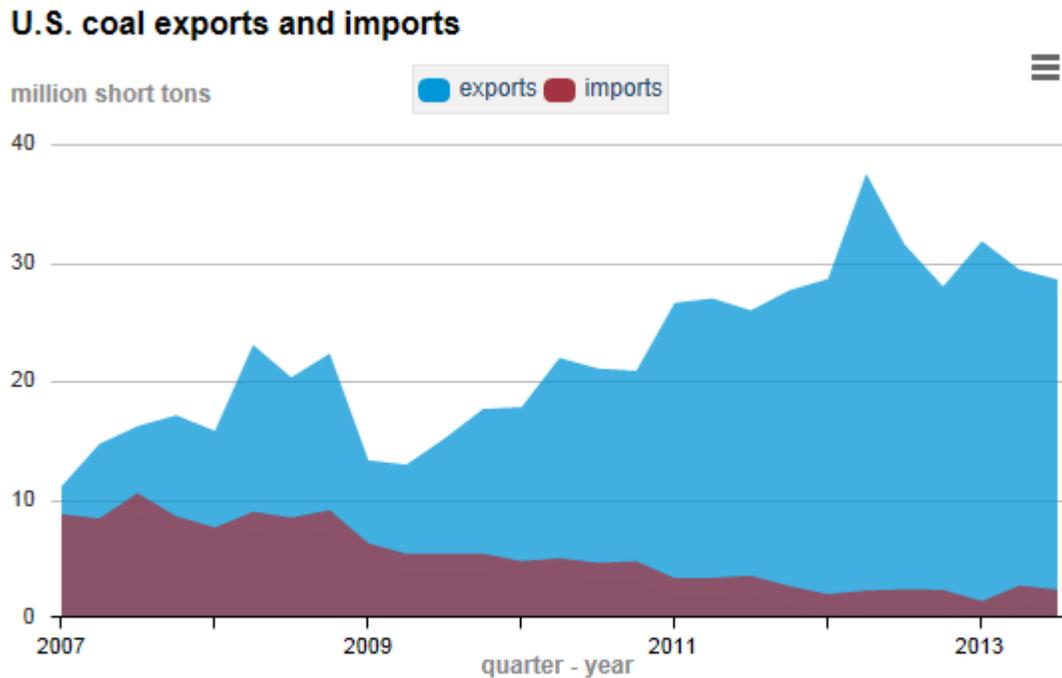


Figure 4. Distribution of anticipated U.S. coal plant retirements in terms of power-generation losses expressed in gigawatts (GW). Modified from Elliott and others (2011) and Reuters (2012), based on data from NERC (2011). Florida Reliability Coordinating Council (FRCC); Midwest Reliability Organization (MRO); Northeast Power Coordinating Council (NPCC); ReliabilityFirst Corporation (RFC); SERC Reliability Corporation (SERC); Southwest Power Pool, RE (SPP); Texas Reliability Entity (TRE); Western Electricity Coordinating Council (WECC).

Europe remains the primary export market for U.S. coal, accounting for 16.4 mst in 2012 (Energy Information Administration, 2014b). Exports to Asia in 2012 were 7.0 mst, representing a 23% increase from 2007 to 2012. Exports to South America and Africa were 1.8 and 1.2 mst, respectively. Exports reached a high point in the second quarter of 2012 (~37 mst) and fell to ~29 mst by the beginning of the second quarter of 2013 (Fig. 5).



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

Figure 5. U.S. coal imports and exports, 2007 to the beginning of the second quarter of 2013. From Energy Information Administration, 2014b).

U.S. Coal Data Sources

EIA has launched an interactive, online Coal Data Browser that provides detailed information on U.S. coal. Accessible at www.eia.gov/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.

Specifically, 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.

U.S. Coal Regulatory Issues

The Environmental Protection Agency (EPA) is in the process of developing new greenhouse-gas regulations that may impair the construction of new coal-fired power plants in the U.S. that do not employ clean-coal technology with carbon capture and storage (CCS). EPA has announced that proposed rules for existing and modified plants will be issued in 2014, with regulations to be finalized in 2015. These regulations are to be applied to existing power plants, even though annual U.S. SO₂ emissions from coal-

fired electricity plants have declined from 16 to less than 6 mst since 1990 and annual NO_x emissions have declined from 7 to 1.8 mst in the same period (Energy Information Administration, 2012). Despite recent stricter air-emission regulations, coal will still account for up to 37% of U.S. electricity generation for another 30 years (Energy Information Agency, 2014c). Currently, the U.S. maintains 316,000 MW of coal-fired generation, representing ~30% of the nation's total electricity generation fleet.

Underground Coal Gasification Developments

Underground coal gasification (UCG) is an underground process that involves the pumping of compressed air through a well into a coal seam, resulting in coal combustion. Heat evolved from this process converts the compressed air, coal, and coal-seam water into mostly carbon monoxide, hydrogen, and methane. These products are then produced from adjacent wells, thereby obviating the need for conventional mining methods. The produced methane, the chief component of natural gas, can be used for fuel power generation. Alternatively, a gas-to-liquids plant (see following section “Coal-to-Liquids Developments” in this report) can also convert the primary synthesis gas or “syngas” into diesel, jet fuel, or fertilizers. UCG production is documented worldwide, including Uzbekistan, South Africa, Australia, as well as the U.S. (Alaska, western Cook Inlet).

CIRI and Linc Energy (Alaska) Inc. are in the process of developing UCG at the western Cook Inlet site. CIRI has already spent >\$10 million on its part of UCG development in the area, partnering with Stone Horn Ridge LLC (Akbizmag, 2013). The joint venture has drilled 13 stratigraphic test wells and core samples have been extracted from depths of

500 to 2,500 ft. These well and core data have been augmented with high-resolution 2-D seismic data to precisely image coal-seam geometry. If successful, the site could be used to produce local electricity by burning syngas, which could also be chemically upgraded to methane, ethanol, fertilizer, or liquid fuel for export to the Pacific Rim. Costs associated with a gas-to-liquid facility could be as much as \$2 billion (Akbizmag, 2013).

Linc Energy is also making progress on several exploratory UCG wells in western Cook Inlet, where the company drilled the first of two UCG test wells in 2011. The target coal seam in the Tyonek Formation is subbituminous rank and is up to 60 ft thick.

Coal-to-Liquids Developments

Coal-to-liquids (CTL) technology involves developing liquid fuels from coal. CTL fuel can be processed from either direct or indirect liquefaction. CTL technology is well-established, having been used by Germany in World War II to produce diesel, gasoline, and jet fuel. South Africa is currently the leader in CTL production, with Sasol Ltd. producing fuel from coal at its Secunda plant, the largest such facility in the world. China has several CTL projects in various stages of development and Sasol is involved in CTL projects in India as well.

CTL fuels are currently used primarily in the transportation sector but can also be used as cooking fuel. Dimethyl ether (DME) from CTL, which is non-toxic and non-

carcinogenic, can be used as domestic fuel rather than liquefied petroleum gas (LPG). DME also generates less carbon monoxide than LPG.

Large quantities of coal reserves and well-established technology represent a large potential CTL market in the U.S. However, large up-front initial investments and great operational costs can limit economic development of CTL, although anticipated growth in the transportation sector in India and China may favor CTL markets (SbWire, 2013).

Current efforts to develop CTL in the U.S. are illustrated by the Adams Fork site in Mingo County, West Virginia near Wharncliffe (Greenwire, 2013). The \$3 billion plant to convert coal into gasoline, to be located within 100 miles of >100 coal mines, is not anticipated to be operational until at least 2016. However, the Adams Fork CTL project faces several hurdles, including large front-end costs, increased production of cheap domestic petroleum and natural gas, environmental regulations, and competition from renewable sources of energy.

Other planned developments of CTL in the U.S. include the Medicine Bow project in Carbon County Wyoming. The project is financed by Houston-based DKRW Advanced Fuels LLC, which has entered into a construction contract with the Chinese Sinopec Engineering Group. The facility will produce >11,000 barrels per day of low-sulfur gasoline and will create 400 full-time jobs. However, the project has experienced construction delays and non-compliance rulings from the Wyoming Department of Environmental Quality's industrial siting office. Similar problems have beset a long-

planned CTL plant in Pennsylvania being constructed by Waste Management & Processors Inc., in Schuylkill County.

Current federal spending levels for CTL is <\$5 million a year. The latest budget from the Obama administration has declared that this area of research is a low priority relative to other activities which are expected to yield greater public benefits. Despite federal, state and private efforts, the EIA has projected startup of the first significant U. S. CTL plants in the United States to be no earlier than 2023 (Greenwire, 2013). A peer-reviewed study by Höök and Aleklett (2009) questions the prospects of CTL around the world, and particularly in the United States. They concluded that CTL can be only a minor contributor to the overall liquid fuels market in light of increased production from less-expensive sources of oil.

References

Akbizmag, 2013, Going deep: Alaska's coal gasification pioneers:

<http://www.akbizmag.com/Alaska-Business-Monthly/August-2013/Going-deep->

[Alaskas-coal-gasification-pioneers/](http://www.akbizmag.com/Alaska-Business-Monthly/August-2013/Going-deep-Alaskas-coal-gasification-pioneers/), last accessed March 3, 2014.

British Petroleum, 2013, Statistical review of world energy 2013:

<http://www.bp.com/content/dam/bp/pdf/statistical->

[review/statistical_review_of_world_energy_2013.pdf](http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf), last accessed March 3, 2014.

Elliott, R. N., Gold, R., and Hayes, S., 2011, Avoiding a train wreck: replacing old coal plants with energy efficiency: ACEEE White Paper, http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/avoiding_train_wreck.pdf, last accessed March 3, 2014.

Enerdata, 2013, Coal and lignite production, 2012: <http://yearbook.enerdata.net/coal-and-lignite-production.html>, last accessed March 3, 2014.

Energy Information Administration, 2012, Power plant emission of sulfur dioxide and nitrogen oxides continue to decline in 2012, <http://www.eia.gov/todayinenergy/detail.cfm?id=10151>, last accessed March 3, 2014.

Energy Information Administration, 2013, International energy statistics: coal: <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=1>, last accessed March 3, 2014.

Energy Information Administration, 2014a, International energy outlook 2013: http://www.eia.gov/forecasts/ieo/more_highlights.cfm, last accessed February 28, 2014.

Energy Information Administration, 2014b, Quarterly coal report:

<http://www.eia.gov/coal/production/quarterly/pdf/qcr.pdf>, last accessed February 27, 2014.

Energy Information Administration, 2014c, AEO2014 Early release overview:

[http://www.eia.gov/forecasts/aeo/er/pdf/0383er\(2014\).pdf](http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2014).pdf), last accessed March 7, 2014.

Greenwire, 2013, Coal-to liquids' prospects dim, but boosters won't say die:

<http://www.eenews.net/stories/1059981383>, last accessed March 3, 2014.

Höök, M., and Aleklett, 2009, A review on coal-to-liquid fuels and its coal consumption:

International Journal of Energy Research, DOI: 10.1002/er.1596, 17 p.

Humphries, M., and Sherlock, M. F., 2013, U.S. and world coal production, federal taxes, and incentives: Congressional Research Service, Report for Congress:

<http://www.fas.org/sgp/crs/misc/R43011.pdf>, last accessed March 3, 2014.

MIT Technology Review, 2011, The enduring technology of coal:

<http://www.technologyreview.com/graphiti/513836/the-enduring-technology-of-coal/>, last accessed March 3, 2014.

NERC (North American Electric Reliability Corporation), 2011, Potential impacts of future environmental regulations: <http://www.nerc.com/files/EPA%20Section.pdf>, last accessed March 3, 2014.

Reuters, 2012, U.S. study sees 59,000 MW of coal output too costly to run: <http://www.reuters.com/article/2012/11/13/us-utilities-coal-idUSBRE8AC05D20121113>, last accessed March 3, 2014.

SBWire, 2013, Global Coal to Liquid Fuel (CTL) Market - Industry Analysis, Size, Share, Growth, Trends and Forecast (2013 - 2019): <http://www.sbwire.com/press-releases/global-coal-to-liquid-fuel-ctl-market-industry-analysis-size-share-growth-trends-and-forecast-2013-2019-383187.htm>, last accessed March 4, 2014.

Stratfor, 2014, Rising Financial Risks in China's Coal Sector (Free article): <http://www.stratfor.com/sample/analysis/rising-financial-risks-chinas-coal-sector>, last accessed February 27, 2014.

Sweet, C., 2013, China uses nearly as much coal as the rest of world combined, EIA says: The Wall Street Journal: <http://online.wsj.com/article/SB10001424127887323829504578272233059490240.html>, last accessed March 4, 2013.