Center for American Progress

Research Note on U.S. and Chinese Coal-Fired Power Data

Assessing Combustion Technology, Efficiency, and Emissions

By Melanie Hart, Luke Bassett, and Blaine Johnson May 15, 2017

The Center for American Progress recently analyzed coal-fired power generation data from the United States and China to better understand where coal-fired power is trending in both nations. Key findings from that assessment are featured in the May 2017 CAP issue brief, "Everything You Think You Know About Coal in China Is Wrong."[1]

Too often, American observers make assumptions about China's energy and climate policy trajectory based on talking points rather than data points. These assumptions lead observers to misinterpret what is happening in China and where China is heading. Factual assessments based on rigorous data analysis better serve U.S. national interests because they provide a more accurate assessment of what is really happening, where China's energy sectors are likely to trend in the future, and how those trends may affect the United States. That is what CAP seeks to do in its U.S.-China coal work.

It is difficult for the average informed observer to make fact-based comparisons between U.S. and Chinese coal-fired power plants. The two nations use different methodologies in their power sector data, so apples-to-apples comparisons often require complex conversions. CAP is indebted to the many coal experts who provided feedback on the May 2017 brief, including experts at the U.S. Department of Energy, the U.S. Environmental Protection Agency, the U.S. Energy Information Administration, the Lawrence Berkeley National Laboratory, the Massachusetts Institute of Technology, and CoalSwarm.

To facilitate further comparative work of this nature, this research note will share key lessons learned during the data gathering and analysis for the May 2017 CAP brief. These lessons include the following:

1. U.S. and Chinese coal-fired power fleets are best analyzed at the unit level.

2. No Chinese data set is perfect, but there are multiple comprehensive, publicly available data sets that provide a relatively clear understanding of what is happening in China.

3. U.S. federal government energy and environment databases provide a vital resource to the public.

4. U.S. and Chinese efficiency is reported in different units, such that conversions are necessary to compare performance.

5. Capacity factors play an important role in emissions comparisons.

6. Data transparency benefits both nations.

Unit-level vs. plant-level data

A single coal-fired power plant generally contains multiple generation units that may differ in size—measured by a unit's capacity, or the amount of power it can produce—and combustion technology. In both the United States and China, there is a tremendous amount of change underway at the unit level. In China, older units—which are generally less efficient and produce more emissions—are being retired to make way for newer, more efficient, and lower-emission technologies. In the United States, cheap and abundant shale gas is pricing coal-fired power out of the market in some regions, and power plants are often responding by converting some coal-fired units to natural gas units. In other cases, U.S. coal-fired power plants and units have adopted additional technologies, such as so-called scrubbers, to reduce conventional air pollution.[2]

In both nations, if power generation is assessed at the plant level, that assessment will miss the tremendous amount of change that may be happening at the unit level within a single plant. Unit-level data are available for both nations and provide a more accurate assessment of the industry and technology shifts that are currently underway.

Data on coal-fired power units in China

As is the case with all Chinese statistical data, complete data on China's coal-fired power infrastructure is difficult to come by due to gaps in official reporting, particularly at the unit level. CAP addressed this challenge by working across multiple data sets.

There are three comprehensive, publicly available data sets providing unit-level information on coal-fired power in China, each with its own advantages and disadvantages:

1. **China Electricity Industry Development Annual Report 2016:** Issued by China's largest power industry association—the China Electricity Council, or CEC—this report covers coal-fired power units with nameplate capacity reported at or above 600 megawatts.[3*] The report provides each unit's nameplate capacity, turbine number, boiler manufacturer, commissioning date, net coal consumption rate, auxiliary power ratio, water consumption rate, and fuel oil consumption. The 2016 report covers 437 units.[4] The CEC is the only reliable, publicly available source that provides unit-level coal consumption rates. The major shortcomings are: It does not include carbon dioxide emissions; it only covers a selection of units that meet its technology and capacity thresholds; and the 2016 report includes data gathered in mid-2015, so it does not include the most recent installations and plant retirements. In general, the CEC provides superior data on China's large-scale units—which are generally newer and higher-tech—but does not cover sub-600-megawatt* units, many of which are older and less efficient.

2. **S&P Global Platts World Electric Power Plants Database, March 2017:** Platts is a business intelligence firm that provides fee-based services that include global power sector data.[5] The Platts database includes around 5,000 coal-fired power units located in China. For each unit, Platts provides the name, capacity, technology type, emission controls, and type of fuel used.[6] Platts is comprehensive and widely used across the energy industry. The biggest shortcomings are that it does not report steam temperatures for all units and does not provide unit-level carbon dioxide emissions. The fact that Platts is a third-party entity offers both pros and cons: Its business model depends on its reliability, but Platts must obtain data indirectly from a wide array of sources, and sourcing is not entirely transparent. Compared with the CEC, Platts provides broader coverage but limited specificity.

3. **CoalSwarm Global Coal Plant Tracker:** CoalSwarm[7] maintains a third-party global database of coal-fired power plants hosted by EndCoal, an environmental coalition website. CoalSwarm provides the Global Coal Plant Tracker as a free service to support research on coal and alternatives.** The site provides detailed information on coal-fired power units with a capacity of 30 megawatts and above. The database has close to 5,000 entries for coal-fired units in China. The data can be viewed on an interactive map or in table form. It provides plant and unit names, capacity, operational status, and annual carbon dioxide emissions in megatons per year. The emissions numbers are CoalSwarm calculations based on plant capacity, plant capacity factor, emission factor, and combustion technology.[8] No other public database provides such comprehensive emissions information.

The May 2017 CAP brief leveraged all three data sets. Since the CEC is the only reliable source for unit-level efficiency data, CAP utilized the CEC report to rank Chinese coal plants based on their efficiency performance and list the 100 most efficient units in China. Although the CEC data set does not provide information on units below 600 megawatts,* those smaller units are less efficient than the top 100 units captured in the CEC ranking, so leaving them out does not adversely affect the sample. Since the CEC database does not provide unit-level carbon dioxide emissions data, CAP imported that information from the CoalSwarm database.

CAP's brief supplemented unit-level CEC and CoalSwarm data with Platts data on China's entire coal-fired power fleet. Although Platts does not provide emissions data or detailed unit-level efficiency data, for other parameters—such as the total amount of capacity added in a given year—it is more comprehensive than the CEC data set and has gone through more industry review than the CoalSwarm data.

Data on coal-fired power units in the United States

Compared with the Chinese data, U.S. coal-fired power data are more reliable, more comprehensive, and easier to obtain. Energy databases compiled and managed by the U.S. government offer a regularly updated and fairly comprehensive overview of technical, economic, and emissions information at a detailed level across the country. The U.S. government collects, organizes, and publishes energy data on coal-fired electricity generation and associated emissions via three major data sources, all of which were incorporated in the May 2017 CAP brief:

1. **U.S. Environmental Protection Agency Air Markets Program Data:** This federal government database enables users to search for unit-level emissions and generation data across all U.S. power plants and provides 2015 unit-level data for carbon dioxide emissions and heat input as well as basic information on each electricity generating unit.[9]

2. **U.S. Energy Information Administration Form 860:** This federal government database provides an annually updated, comprehensive view of electricity data for existing, planned, and retiring units, including outputs such as capacity, fuel type, and location.[10]

3. **U.S. Energy Information Administration Form 923:** This federal government database provides monthly and annual unit-level data for fuel consumption, fuel availability, and fuel costs for fossil fuel burning generation units.[11]

Overall, U.S. federal government coal and electricity databases reveal the intricate economics, chemistry, physics, and environmental impacts of coal-fired power generation. The Energy Information Administration, or EIA, Form 923 data outline coal produc-

tion, including imports, exports, and stocks at power plants, and they illustrate the efficiency and generation of each unit, as well as resulting emissions and pollutants such as sulfur or ash.[12] Similarly, EIA Form 860 depicts the details of electricity generating units, from nameplate capacity to initial operating year to add-on technologies such as scrubbers.[13] The Environmental Protection Agency's, or EPA's, Air Monitoring Program Data enables users to search all U.S. continuous emissions monitoring devices to gain information on heat input and emissions information across all pollutants.[14]

The EPA also maintains an Emissions & Generation Resource Integrated Database, or eGRID, that combines key data from all three EIA and EPA sources in a comprehensive format, but its most recent publication used 2014 data rather than 2015 or later and therefore was not utilized for the May 2017 CAP brief.[15]

U.S.-China efficiency comparisons

The U.S. and Chinese data sets use different methodologies to report combustion efficiency. Whereas the United States reports efficiency data based on the total grams of raw coal consumed by a particular coal-fired power unit, China reports in grams of coal equivalent consumed, or gce, which is a standardized unit for measuring energy.[16]

To present the most accurate comparison possible given that the Chinese unit-level data do not specify the amount and type of raw coal consumed, CAP converted the U.S. data into gce.

To make the conversion, the authors triangulated the three U.S. data sources detailed above to pull together information on unit-level emissions, efficiency, fuel types, unit age, and capacity. Using those parameters, we calculated each unit's gce consumption rate by dividing its heat rate by net load. The EPA and the EIA report U.S. coal generation data using the higher heating value of coal, which accounts for the heat required to burn off water found in coal, but the Chinese data use its lower heating value.[17] To compare the data equally, we converted the U.S. data from higher heating value to lower heating value using the EIA Form 923 data to determine the type of coal burned by each unit; we used the International Energy Agency's methodology and standard ratios for various fuels.[18] The results allowed an apples-to-apples comparison of U.S. and Chinese coal-fired electricity generating units using best available data and standardized methodologies.

U.S.-China carbon dioxide emissions comparisons

In the United States, the U.S. Environmental Protection Agency monitors unit-level carbon dioxide emissions and reports emissions totals in its Air Markets Program Data. In China, unit-level carbon dioxide emissions are not yet publicly reported. The best unit-level information is via CoalSwarm, which calculates emissions levels based on unit capacity, capacity factor, emission factor, and combustion technology.

It is important to be aware of the role that capacity factors and utilization rates play in unit performance and emissions. The capacity factor is the ratio between the actual amount of energy produced in a given time period—usually one year—and the amount of energy a generation unit could theoretically produce operating continuously at maximum capacity over that same time period. The 2016 U.S. average capacity factor was 52.7 percent.[19] In comparison, China reports utilization hours—that is, operating hours, which if divided by total hours per year equal the utilization rate—and in 2016, those utilization rates hit record lows at 47.5 percent. A direct comparison of U.S. capacity factors and Chinese utilization rates remains difficult because the Chinese data do not include capacity factors explicitly. When coal-fired power units are run at lower capacity factors, they generally consume less coal; however, just as automobiles get worse gas mileage in city traffic than on the highway, said units also perform at slightly lower efficiency levels.

CoalSwarm bases its emissions calculations on the global average capacity factor for 2013—59.3 percent—which is higher than current utilization rates in China. The EPA Air Markets Program Data are directly measured, so capacity factors are endogenous. For comparative purposes, we know that in 2015—the year in which the latest data were gathered—the average annual U.S. capacity factor for coal generators was 54.6 percent.

CoalSwarm calculations do not perfectly capture China's actual utilization rate, so they cannot perfectly capture Chinese emissions, but CoalSwarm's assumed rate is close enough to provide a useful comparative assessment of U.S. and Chinese emissions performance.

Coal data transparency and reliability

Although the United States has the indisputable lead on data transparency and reliability, both nations are trending in a positive direction.

Transparency is good for all because it allows for the types of specific comparisons—between two different coal fleets and between one fleet's current and past performance—that are meaningful to policymakers and the general public. If China wants to demonstrate the progress it has made in upgrading its coal power fleet, it should aim to

do a better job at reporting performance data. If China wants to have credibility in international climate negotiations, if China wants to take credit for its transition toward less carbon-intensive sources of electricity, and if China wants to be a leader on the global stage, transparency is critical.

Similarly, transparency and accuracy remain the benchmark of U.S. electricity and emissions data, a testament to the benefits of clean air improvements, a rich tool for understanding the economics of the energy sector, and a critical method of holding polluters accountable.

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Endnotes

1 Melanie Hart, Luke Bassett and Blaine Johnson, "Everything You Think You Know About Coal in China is Wrong" (Washington: Center for American Progress, 2017), available at https://www.americanprogress.org/?p=432141.

2 U.S. Environmental Protection Agency, "Monitoring by Control Technique – Wet Scrubber for Particulate Matter," available at https://www.epa.gov/air-emissions-monitoring-knowledge-base/monitoring-control-technique-wet-scrubber-particulate-matter (last accessed May 2017).

3 China Electricity Council, *Zhong guo dian li hang ye nian du fa zhan bao gao (China Electricity Industry Development Annual Report 2016)* (Beijing: China Market Press, 2016). For information in English on the China Electricity Council and its members, see China Electricity Council, "Home," available at http://english.cec.org.cn/ (last accessed May 2017).

4 These units are reported in the following groups: 2015 Annual National Thermal Power 1000 Megawatt Ultra-supercritical Units Energy Efficiency Index; 2015 Annual National Thermal Power 600 Megawatt Ultra-supercritical Units Energy Efficiency Index; 2015 Annual National Thermal Power 600 Megawatt Supercritical Water-cooled Units Energy Efficiency Index; 2015 Annual National Thermal Power 600 Megawatt Supercritical Air-cooled Units Energy Efficiency Index; 2015 Annual National Thermal Power 600 Megawatt Subcritical Water-cooled Units Energy Efficiency Index; 2015 Annual National Thermal Power 600 Megawatt Subcritical Air-cooled Units Energy Efficiency Index; and 2015 Annual National Thermal Power 600 Megawatt Russian (Eastern European) Units Energy Efficiency Index. See China Electricity Council, *Zhong guo dian li hang ye nian du fa zhan bao gao (China Electricity Industry Development Annual Report 2016)*. *

5 S&P Global Platts, "World Electric Power Plants Database, March 2017" (2017), available at https://www.platts.com/products/world-electric-power-plants-database.

6 Ibid.

7 CoalSwarm, "about coalswarm," available at http://coalswarm.org/about-coalswarm/ (last accessed May 2017).

8 SourceWatch, "Estimating carbon dioxide emissions from coal plants," available at http://www.sourcewatch.org/index.php/Estimating_carbon_dioxide_emissions_from_coal_plants (last accessed February 2017).

9 U.S. Environmental Protection Agency, "Air Markets Program Data, 2015," available at https://ampd.epa.gov/ampd/ (last accessed April 2017).

10 U.S. Energy Information Administration, "Form EIA-860 detailed data," October 6, 2016, available at https://www.eia.gov/electricity/data/eia860/.

11 U.S. Energy Information Administration, "Form EIA-923 detailed data," April 26, 2017, available at https://www.eia.gov/electricity/data/eia923/.

12 Ibid.

13 U.S. Energy Information Administration, "Form EIA-860 detailed data."

14 U.S. Environmental Protection Agency, "Air Markets Program Data, 2015"; U.S. Environmental Protection Agency, "Air Emission Measurement Center (EMC): Continuous Emission Monitoring Systems Information and Guidelines," available at https://www.epa.gov/emc/emc-continuous-emission-monitoring-systems (last accessed April 2017).

15 U.S. Environmental Protection Agency, "Emissions & Generation Resource Integrated Database (eGRID): eGRID2014 Data File v2 (XLS)," February 2017, available at https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

16 For more detail on "grams of coal equivalent" and other specific energy units, see Zoran K. Morvay and Dušan D. Gvozdenac, "Toolbox 4: Energy Units, Conversions, Thermo-Physical Properties and Other Engineering Data." In Zoran Morvay and Dušan Gvozdenac, *Applied Industrial Energy and Environmental Management* (Hoboken, NJ: John Wiley & Sons, Ltd., 2008), available at http://www.wiley.com/legacy/wileychi/morvayindustrial/supp/toolbox4.pdf.

17 Personal communication from U.S. Department of Energy Office of Fossil Energy, April 2017.

18 International Energy Agency Coal Industry Advisory Board, "Power Generation from Coal: Measuring and Reporting Efficiency Performance" (2010), available at https://www.iea.org/ciab/papers/power_generation_from_coal.pdf.

19 U.S. Energy Information Administration, "Electric Power Monthly: Table 6.7.A. Capacity Factors for Utility Scale Generators Primarily Using Fossil Fuels, January 2013-February 2017," April 25, 2017, available at https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_6_07_a.

** **Correction, May 16, 2017:** This issue brief has been corrected to clarify that the indicated capacity sizes are measured in megawatts.*

*** **Correction, May 16, 2017:** This brief has been corrected to clarify the roles of CoalSwarm and EndCoal.*