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COAL IN THE 21ST CENTURY

Coal Markets in Motion

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Coal exemplifies the difficulty in balancing tradeoffs among the environmental, economic, and energy security objectives embedded in energy policymaking. Indeed, coal offers an array of advantages and disadvantages which can polarize views and leave nuance aside. Advantages include abundance, with large reserves widely dispersed globally. The United States alone is often cited as having 245 years of coal reserves remaining. Coal, by comparison to other sources of electricity generation, is a relatively cheap fuel source in many regions across the globe. Coal can enhance energy security, providing a domestic source of energy. In many emerging market countries it is a fuel critical to meet growing electricity demand, support economic growth and employment, and expand access to electricity. In this way, coal is a tool for poverty alleviation. Finally, more efficient coal combustion processes and carbon capture and storage (CCS) offer a technological path for cleaner use of coal, especially in regard to reducing greenhouse gas emissions (GHGs).

Nevertheless, coal has disadvantages. It is a major source of three chemicals: sulfur oxides (SO_x), nitrogen oxides (NOx), and particulates, together comprising major components of acid rain, smog, and soot, respectively. In addition, coal combustion emits other hazardous air pollutants such as lead, chromium, arsenic, and mercury, and produces solid waste such as fly ash, bottom ash, and scrubber sludge.[2] Coal-fired electricity generation is also a major source of the principal GHG, carbon dioxide (CO_2): for each unit of heat delivered, coal releases twice as much CO_2 as natural gas and about a third more than oil.[3] Finally, mining conditions in some countries are substandard, threatening worker safety and health as well as the local environment.

Moreover, global coal demand is growing, significantly complicating efforts to combat climate change (reducing GHGs). There is also a growing policy/regulatory risk involved in coal-fired electricity generation: the implementation of a carbon price and stricter emissions regulations on other pollutants make coal an increasingly risky investment, decreasing its competitiveness vis-a-vis other fuels. Lastly, the key technologies allowing a cleaner way to use coal remain expensive with most not yet

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[2] Although the amount and variety of emissions released vary by type and grade of coal.
[3] In this research we do not assess the ongoing debate about methane leakage from shale gas and its impact on the GHG footprint relative to coal.

operating on a commercial scale globally, requiring more time and policy support, such as financial incentives and research and development, to reach wide-scale deployment and reduce costs. In addition to these approaches, technology mandates could be employed. Critics have said that the U.S. Environmental Protection Agency (EPA)'s Clean Power Plan in essence does exactly that: coal-fired electricity generation will not be possible without addressing carbon emissions. This approach could work as long as the additional costs could be transferred to end users, but it would effectively mean that electricity costs would rise substantially.

These characteristics form the basis of an ongoing spirited debate over the role and future of coal, manifested in specific issues including the above-mentioned U.S. EPA's Clean Power Plan, the upcoming Conference of the Parties in Paris, support for coal-fired projects in developing countries, and policy incentives for CCS.

The Energy Security and Climate Initiative (ESCI) at Brookings has launched a major research project, *Coal in the 21st Century*, to assist policymakers in understanding the complexities described above and provide an unbiased assessment of how to deal with coal moving forward, both domestically and internationally. As part of our research methodology, we have formed a Coal Task Force (CTF) comprising government officials, the private sector, academia, international organizations, financial institutions, and others, to meet periodically to gain insight on important issues surrounding coal. The CTF will be a moderated, off-the-record discussion under Chatham House rule.[4]

In this issue brief, ESCI kicks off our research effort with a summary of key issues raised during the first Task Force meeting on February 4, 2015 dealing with global trends and the U.S. market.

THE GLOBAL COAL MARKET

Overview

Coal plays an important role in the global energy mix, representing 29 percent of total primary energy demand in 2012, according to the International Energy Agency's (IEA) World Energy Outlook 2014. While this percentage is expected to decline to 24 percent in 2040, the IEA projects global coal demand will increase 15 percent by 2040. The fortunes of coal, however, differ dramatically by region. Coal demand declines in all OECD regions, particularly in the United States where a sharp reduction in coal-fired electricity generation falls by nearly one third in the IEA's forecast, owing to increased regulation and competition from other fuels, especially unconventional gas and renewables. Coal demand in developing countries, on the other hand, is expected to increase by one third by 2040, with significant growth in Southeast Asia, India, Africa, and Brazil (China's coal demand is expected to peak in 2030).[5]

Regional Highlights

Coal is still the number one source of electricity generation in Europe and the United States, and is expected to continue to account for a major share over the next several decades. In North America, the main narrative has been that cheap and abundant natural gas has started the inevitable decline of coal. Indeed, in the U.S. initial data point in that direction, even though most reliable studies indicate that coal is going to be a prominent fuel source for a number of decades. Nevertheless, coal consumption will continue to decline. Currently in Europe, "coal is competitive but not profitable," reflecting not only existing underlying intra-fuel price dynamics with gas, but also flat power demand mainly owing to poor economic performance, increased energy efficiency, and more renewables pushing coal out of economic dispatch at the wholesale level. In addition, recoverable coal reserves in

[4] The conclusions and recommendations of this report are those of the authors and do not necessarily reflect the views of the members of the Task Force.

[5] International Energy Agency (IEA), *World Energy Outlook 2014*, November 12, 2014, www.worldenergyoutlook.org/publications/weo-2014/.

Europe are increasingly expensive and labor costs have risen steadily. Coal use will continue to decline in Europe barring a major event or decision, for example if France decided to phase out a large number of nuclear plants.

Germany is illustrative of these trends. While there have been recent additions of coal-fired capacity, these were the result of decisions made before the economic crisis of 2008 and prior to the accident at Fukushima. ESCI's recent assessment of the energy transition in Germany explained that low carbon prices in the European Trading Scheme, depressed coal prices in part owing to increased U.S. exports to the European market, and anticipated increases in electricity demand prior to the financial crisis in 2008 spurred the planning for more coal-fired generation in the mid- to late 2000s. Going forward, however, coal and lignite capacity in Germany will decline in the next 5 to10 years.[6]

Global coal production and pricing trends in the next 25 years will be led by Asia, where coal is going to be more competitive than gas for some time. The IEA highlights that China, India, Indonesia, and Australia will account for 70 percent of global coal production by 2040.[7] Illustrative of the competitiveness of coal is the example of Malaysia. This is a gas rich country with no coal resources and yet most incremental demand will be met by coal, reflecting that it is more profitable to export its gas and import coal.

Until 2030, the future of coal is tied to the future of China. The fight against local air pollution won't prompt a significant switch from gas to coal in the power sector. The scale of coal use for electricity generation is simply too great: no amount of gas could replace coal. Also, China has indicated that coal use will peak in 2030, leaving considerable time for the continued use of large amounts of coal. It is worth noting that it also leaves very significant amounts of coal consumption after 2030. As such, the climate agreement between China and the United Statessigned during the recent Asia-Pacific Economic Cooperation summit only suggests that growth of coal consumption in China will peak around 2030. The Chinese government's efforts to diversify the electricity generation mix is a serious effort that will result in large amounts of new nuclear and renewable capacity coming on-line. Nevertheless, China needs more power than these diverse sources can provide. There will, however, be coal to gas switching in the industrial sector and, as the country gradually moves toward a more service oriented economy, industrial demand will not grow at rates witnessed in the past 20 years.

The goals set in the recent U.S.-China climate agreement–principally that coal use will peak in 2030–is seen by some analysts as commensurate with recent projections and attainable. The key dynamic in China is that coal use is very sensitive to economic growth and energy intensity. For this reason, 2014 was not typical: China's coal consumption fell for the first time since 1997, but electricity generation increased about four percent and the economy continued to grow, albeit at a slower pace. Whether this is an anomaly or signifies a new trend remains to be seen. Some explanations offered include a significant addition of hydro capacity, an overcapacity of steel, aluminum, and cement production, and the implementation of stricter coal regulations impacting coal-fired generation.

In India, coal has been and will remain vital to the country's energy infrastructure and economic development. It is the world's third largest coal

[6] John P. Banks, Charles K. Ebinger and Alisa Schackmann, *Transforming the Electricity Portfolio: Lessons from Germany and Japan in Deploying Renewable Energy*, Energy Security Initiative, Brookings Institution, September 2014, www.brookings.edu/research/reports/2014/09/transforming-electricity-portfolio-renewable-energy.

[7] International Energy Agency (IEA), World Energy Outlook 2014, November 12, 2014, http://www.worldenergyoutlook.org/publications/weo-2014/.

producer and coal accounts for roughly 68 percent of electricity generation.[8] India's Planning Commission projects coal's use in power generation will have to expand to 2 billion tonnes by 2031-2032 in order to meet the country's growing electricity needs.[9]

Despite the importance of coal for India, serious challenges confront the sector. India's coal is mostly poor quality lignite which is highly polluting. Coal is also a major employer in India which makes reform of the sector very difficult, and the fact that coal subsidizes other rail freight and that most of the country's coal is located in politically important states such as Assam, West Bengal, Bihar, and Jharkhand only adds to the industry's political clout. The coal sector is also plagued by challenges such as the uncertainty of the actual size of India's reserves, a dilapidated railway network, and the mismatch of most of India's coal being located far from major electricity demand centers. Addressing these issues along with the implications for global climate change presents a daunting task if India moves ahead with its ambitious plans to increase both coal production and its use.

Coal in Emerging Markets

Virtually all the global demand growth in coal will occur in emerging markets, driven by a combination of factors illustrated most dramatically by the figures 90-90-70. It is estimated that 90 percent of global population growth, 90 percent of total energy demand increase, and 70 percent of economic output will occur in developing countries by 2030.[10] The persistence of energy subsidies, rapid urbanization, and a growing middle class are major contributors to the increased demand for modern energy. For example, in 2007, 87 percent of all households in the United States had access to air conditioning, while that share was 11 percent in Brazil and 2 percent in India.[11] With 1.2 billion people lacking access to electricity, there is still significant scope for more energy use.

Pricing Trends

Globally, coal prices have been decreasing consistently since 2011 owing to various factors. The shale gas revolution in the United States has pushed some U.S. coal into the global market, contributing to downward pressure on prices. However, U.S. coal exports are only around 1% of total global supply.. The Chinese market, however, is the major factor in the global price decline since Chinese coal use is a much larger share of the total world market (at over 1 billion metric tonnes). Thus, the slowdown in economic growth in China has impacted the overall market. In addition, the rising strength of the dollar has been a factor in the global price decline–producers operating in local currency have seen reduced costs, spurring more production. The recent global oil price decline is adding yet another facet to the declining price dynamic. Coal mining operations use large amounts of diesel to fuel operating equipment so declining petroleum costs reduce mine operating costs. Finally, the presence of Australian take-or-pay contracts has also influenced the price of coal, although these are being renegotiated. In short, the near-term market outlook for coal is for continued over-supply and low prices. At this point we can only speculate what the future will bring for coal producers.

[8] Sources: World Coal Association, "Coal Statistics," September 2014, www.worldcoal.org/resources/coal-statistics/; and The World Bank, "Electricity production from coal sources (% of total)," accessed March 5, 2014, http://data.worldbank.org/indicator/EG.ELC.COAL.ZS.

[9] Government of India, Planning Commission, "Integrated Energy Policy: Report of the Expert Committee," August 2006, http://planningcommission.nic.in/reports/genrep/rep_intengy.pdf.

[10] British Petroleum, "Energy Outlook 2030," January 2013, www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/BP_Energy_Outlook_Booklet_2013.pdf.

[11] Elisabeth Rosenthal, "The Cost of Cool," *New York Times*, August 18, 2012, www.nytimes.com/2012/08/19/sunday-review/air-conditioning-is-an-environmental-quandary.html?pagewanted=all&_r=0.

THE U.S. COAL MARKET

In the United States, a sluggish economy in the aftermath of the 2008 financial crisis, low natural gas prices, and stricter EPA regulations (the Clean Air Interstate Rule and the Mercury and Air Toxics Standards) continue to reduce coal's share of electricity generation and spur significant coal-fired generation retirements. Coal-fired generation dropped from 44 percent of total generation in March 2011, to 34 percent in April 2012–the lowest level since the early 1970s.[12] Although coal's share has rebounded to 37 percent of total electricity generation owing to the improving economy and higher natural gas prices, most forms of U.S. coal are uncompetitive with gas at $4-5 per million British thermal units (mmbtu). In the long-term, the U.S. EIA forecasts the electricity mix to shift toward greater shares of renewables and natural gas, with coal's share declining to 32 percent in 2040.[13] Moreover, the EIA expects 60 gigawatts (GW) of coal-fired generation to be retired by 2020, with most of that coming off-line in 2016.[14]

Exports

As a result of the shale gas boom in the United States backing out coal in electricity generation, there has been a steady increase in U.S. steam and metallurgical coal exports since 2005. Most of this coal (about 50 percent) is exported to Europe. Despite a decline in exports in 2013, volumes are expected to increase from record annual exports of nearly 126 million tons in 2012[15] to 161 million short tons in 2040,[16] though it is worth noting that in the future Europe will likely be a less attractive export destination due to increased competition from renewables and stricter air quality standards. In addition, with dramatically higher shipments of oil by rail, the costs of domestic coal shipments have increased.

Export terminals are primarily located in the Gulf of Mexico and along the East Coast but there are proposals for several terminals along the West Coast in Oregon and Washington. Despite the interest in these expansion projects, there is considerable environmental opposition especially in regard to coal dust from rail transport. There is also opposition from local tribal groups.

Climate Policy

Coal will be impacted directly by the future of U.S. energy and climate policy, especially in light of the change in political leadership in Congress as well as the presidential election next year. There is little doubt that the implementation of a carbon price would impact coal significantly. The EIA has modeled the implementation of two scenarios–a CO_2 price of $10 and $25 per metric ton both starting in 2015 and increasing gradually to 2040. The impact is a 35 percent and 80 percent reduction in CO_2 emissions compared to the EIA Reference Case, respectively. In both cases, nuclear energy would contribute more to the electricity generation mix as a carbon free alternative, while coal would be the biggest loser.

There is considerable skepticism that any type of carbon pricing scheme can realistically be implemented in the current political environment. The Obama administration's climate policy–principally the EPA's New and Existing Source Performance Standards (per sections 111(b) and 111(d), respectively, of the Clean Air Act)–is facing major opposition. There will be litigation challenging these proposed regulations and for a new Congress–and especially for Republican Presidential candidates–the EPA regulations could become a litmus test. Reversing EPA's regulatory proposals could happen, perhaps through defunding or by

[12] U.S. Energy Information Administration (EIA), "Today in Energy: U.S. coal's share of total net generation continues to decline," June 5, 2012, www.eia.gov/todayinenergy/detail.cfm?id=6550.
[13] EIA, "Annual Energy Outlook 2014 Early Release Overview," December 16, 2013, www.eia.gov/forecasts/aeo/er/early_elecgen.cfm.
[14] EIA, "Today in Energy: AEO2014 projects more coal-fired power plant retirements by 2016 than have been scheduled," February 14, 2014, www.eia.gov/todayinenergy/detail.cfm?id=15031.
[15] EIA, "Today in Energy: U.S. coal exports set monthly record," June 19, 2013, www.eia.gov/todayinenergy/detail.cfm?id=11751.
[16] EIA, "Annual Energy Outlook 2014, Coal supply, disposition, and prices table," May 2014, www.eia.gov/forecasts/aeo/er/pdf/tbla15.pdf.

the court's finding that the EPA has acted beyond its legal mandate. Nevertheless, any attempt to roll back proposed regulations under 111(b) and 111(d) will require at a minimum an alternative approach that fulfills the Supreme Court decision (Massachusetts v. EPA, 2007) requiring the EPA to regulate CO_2. Thus, if EPA's regulatory approach is rolled back or abandoned, there is hope that a Republican Presidential candidate could constructively offer solutions. Some believe that there is an opportunity to link the need for a carbon price with the need to find additional sources of revenue perhaps in a deal that would lower other taxes in exchange for a carbon tax.

TECHNOLOGY

Many believe that CCS is necessary to meet the two degrees Celsius climate goal, but the IEA has reduced its projections from 100 large-scale CCS projects by 2020 to 30.[17] There are several emerging key factors in making CCS work from an economic perspective: the use of cheap, stranded coal; a plant working at full load, and; a strong business case, e.g., for use in enhanced oil recovery (EOR).

These factors will not be present everywhere. For example, they are in the United States, but not in Europe. But the low price of gas in the United States is a disincentive to CCS–raising the question of whether CCS will largely be deployed elsewhere.

The recent decision by the Obama Administration to cease funding the FutureGen project has been criticized by some, arguing that the government is not serious about CCS. However, this is one project and one part of the overall policy support provided. Moreover, it is important to recognize that there are some positive developments and progress in CCS. In the FutureGen project the environmental permitting process proceeded in Illinois, and in general much progress has been made in ensuring the environmental safety of CCS. In addition, the commercial start-up of the Boundary Dam project in Saskatchewan is a major milestone.

The real issue is cost. The IEA states that 90 percent carbon capture increases capital costs between 45 to 75 percent and reduces plant efficiency 20 to 25 percent.[18] Without policy support, in particular a carbon price, and as long as natural gas is cheap, CCS will remain an uncompetitive option. There is also a disconcerting political component to this situation: CCS is becoming entangled in broader debates concerning the role of government and government spending. Starting in the Clinton administration and for many years there was bipartisan support for CCS but this is eroding: some Republicans view support of CCS as support for EPA's proposed carbon regulations and undisciplined spending, while some Democrats are wary of supporting fossil fuels and undermining renewables.

Globally there will be improvements in efficiency: many new plants coming on line are supercritical, and after 2020 more integrated gasification combined cycle (IGCC) and ultra-supercritical technology will be deployed. At least in the short-term, however, some of the associated efficiency gains are offset by a large number of subcritical plants being built, many in Southeast Asia.

[17] In 2009, the IEA's "Technology Roadmap: Carbon Capture and Storage," as part of modelling a pathway to meet the two degrees Celsius target, projected 100 large-scale CCS projects to be operation by 2020. In 2013 the "Roadmap" revised that number to 30. The projects include CCS for both power and industrial sectors, as well as for coal and other fuels. Thirty large scale projects is equivalent to approximately 50 Mt of CO2 captured and stored. Sources: IEA, "Technology Roadmap: Carbon Capture and Storage 2009," 2009, www.iea.org/publications/freepublications/publication/CCSRoadmap2009.pdf; and IEA, "Technology Roadmap: Carbon Capture and Storage 2013," 2013, www.iea.org/publications/freepublications/publication/TechnologyRoadmapCarbonCaptureandStorage.pdf.

[18] IEA, "Coal Medium Term Market Report 2014," December 2014, p. 99.

CONCLUDING REMARKS

Coal will be a major part of the global energy mix for many decades. The key question is whether coal can be used in a way commensurate with addressing climate change. This policy brief has summarized major global trends and issues discussed during ESCI's first Coal Task Force meeting surrounding this question. ESCI will continue the dialogue on coal and will publish more policy briefs on specific issues over the course of the year. We invite you to watch the developments in this space.

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About the Brookings Energy Security and Climate Initiative

The Energy Security and Climate Initiative (ESCI) at The Brookings Institution is designed to encourage the development, discussion, and dissemination of high-caliber energy security and climate research. ESCI, through its research and convening efforts, seeks to examine three key substantive aspects of energy security: the geopolitics of energy; the economics of energy; and the growing environmental imperative of balancing increasing global economic prosperity in a carbon-constrained context.

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