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NOT BEYOND COAL

How the Global Thirst for Low-Cost Electricity Continues Driving Coal Demand

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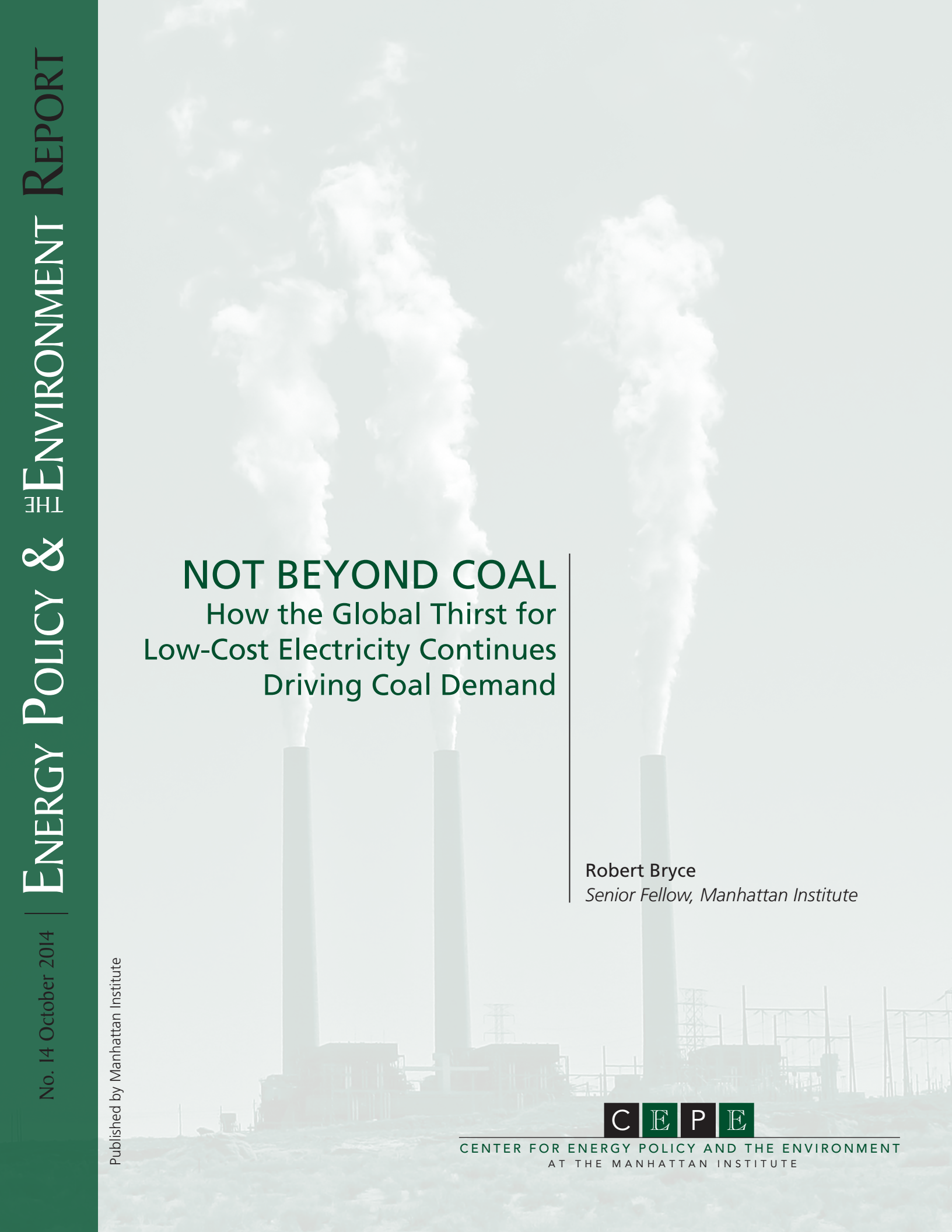

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Executive Summary

Since 1973, coal consumption has grown faster than any other form of energy. Growth in coal consumption has been critical in providing electricity access in developing countries.

Based on the results of three different estimates, this paper finds that between 1990 and 2010, about 830 million people—the vast majority in developing countries—gained access to electricity due to coal-fired generation. Indeed, roughly twice as many people gained access to electricity due to coal as due to natural gas; and for every person who obtained access to electricity over that period from non-hydro renewable sources, such as wind and solar, about 13 gained access due to coal.

Coal-fired-generation capacity continues to grow in wealthy countries, too. For electricity production, no other energy source can currently match the black fuel when it comes to cost, scale, and reliability. In all, more than 500 gigawatts of new coal-fired capacity will likely be built worldwide by 2040. Given coal's pivotal role in providing electricity to poor and wealthy countries alike, it is highly unlikely that global carbon-dioxide emissions will fall anytime soon.

About the Author

ROBERT BRYCE is a senior fellow at the Manhattan Institute's Center for Energy Policy and the Environment. He has been writing about the energy sector for more than two decades and his articles have appeared in dozens of publications, including the *Wall Street Journal*, *New York Times*, *Atlantic Monthly*, and *Sydney Morning Herald*.

Bryce is the author of five books. His first, *Pipe Dreams: Greed, Ego, and the Death of Enron*, was named one of the best nonfiction books of 2002 by *Publishers Weekly*. In 2004, he published *Cronies: Oil, The Bushes, and the Rise of Texas, America's Superstate*. In 2008, he published *Gusher of Lies: The Dangerous Delusions of Energy Independence*. A review of *Gusher of Lies* in the *New York Times* called Bryce "something of a visionary and perhaps even a revolutionary." His fourth book, *Power Hungry: The Myths of "Green" Energy and the Real Fuels of the Future*, was published in April 2010. The *Wall Street Journal* called it "precisely the kind of journalism we need to hold truth to power." In 2014, he published *Smaller Faster Lighter Denser Cheaper: How Innovation Keeps Proving the Catastrophists Wrong*. A *New York Times* review of *Smaller Faster* called it a "book well worth reading," while the *Wall Street Journal* called it an "engrossing survey."

Bryce has delivered over 200 invited and keynote lectures to groups of all kinds, ranging from the Marine Corps War College and University of Calgary, to the Sydney Institute and Melbourne's Institute of Public Affairs. Bryce appears regularly on major media outlets including CNN, Fox News, PBS, NPR, and the BBC. He received his B.F.A. from the University of Texas at Austin in 1986.

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Not Beyond Coal

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Robert Bryce

INTRODUCTION

Coal is the energy villain of the moment. In June, the Environmental Protection Agency (EPA) declared its intent to reduce carbon-dioxide emissions from the domestic electricity-generation sector by 30 percent by 2030. That regulatory effort will further cut U.S. coal demand. Although domestic use of the fuel is falling, global coal demand continues to grow at a rapid pace because, for rich and poor countries alike, coal provides the lowest-cost option for electricity generation.

Since 1973, global coal consumption has grown faster than any other form of energy.[1] Indeed, despite talk about surging investment in renewable-energy sources such as wind and solar, the growth in coal continues to dwarf the growth seen in renewables. For example, since 2003, global coal consumption has increased by about 24.4 million barrels of oil equivalent per day. In absolute terms, that was nine times faster than the growth seen in wind-energy consumption and 40 times that of solar energy.[2]

While the rate of growth in global coal use has slowed in recent months and coal prices have softened, coal demand remains strong because the fuel is cheap and abundant, deposits are geographically widespread, and the market for it is not affected by OPEC-like entities.

Coal, which now accounts for about 40 percent of all global electricity production, will likely maintain its dominant role for decades to come.[3] Electricity-poor countries, along with those that are electricity-rich, are currently building hundreds of gigawatts of new coal-fired electricity-generation capacity. The nine countries discussed in this paper—

China, Germany, India, Indonesia, Japan, Pakistan, Poland, Russia, and South Korea—are planning to build about 550 gigawatts of new coal-fired capacity over the next two and a half decades. The vast majority of that, some 400 gigawatts, is planned for China.[4] Given the coal industry's recent history and the ongoing surge in global coal use, there is little reason to believe that any of the much-discussed international efforts to impose a cap or tax on carbon-dioxide emissions will prevail. Furthermore, given the ongoing increase in global coal use—along with the fact that the U.S. has more coal resources than any other country—it makes no sense for U.S. policymakers to restrict the use of coal in America.

Key Findings

1. No viable substitutes can match the low cost and massive scale of electricity production that is now provided by coal-fired generators.

2. Coal remains an essential fuel to address "energy poverty," the lack of access to modern energy services such as electricity and clean cooking fuels. From 1990 to 2010, some 832 million people gained access to electricity due to coal-fired generation, the vast majority of whom live in developing countries.

3. Given the continuing growth of coal, policymakers should promote deployment of advanced combustion technologies in new electricity-generation plants. Doing so will wring more electricity out of the fuel used and reduce the amount of carbon dioxide produced per kilowatt-hour of output.

What qualifies as electricity access?

The International Energy Agency (IEA) defines electricity access at levels that are a minute fraction of the levels common in the developed world. For instance, the Paris-based agency describes electricity access as 250 kilowatt-hours per year in rural areas and 500 kilowatt-hours in urban locations.[5] For comparison, the average resident of France consumes over 7,100 kilowatt-hours per year.

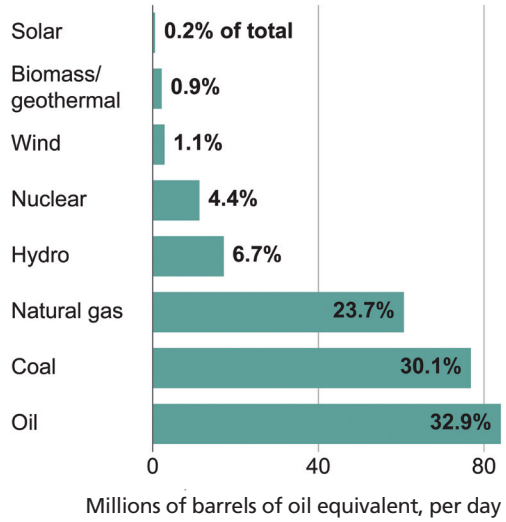
I. COAL ENDURES BECAUSE OF ITS MASSIVE SCALE

The world wants electricity. No other energy form is as versatile or as economically important. All over the world, in rich and poor countries alike, electricity producers are burning coal to reap the myriad benefits that come with the use of cheap, abundant flows of electrons.[6]

Ever since Thomas Edison used coal in the first central power station on Manhattan's Pearl Street in 1882, coal has been the fuel of choice for producing electricity. It remains so today. While its share of the electricity market is expected to decline gradually over the coming years because of the increasing use of natural gas and renewable energy, the Energy Information Administration (EIA) estimates that by 2040, coal will generate some 13,900 terawatt-hours of electricity—or about 36 percent of all electricity on the planet.[7]

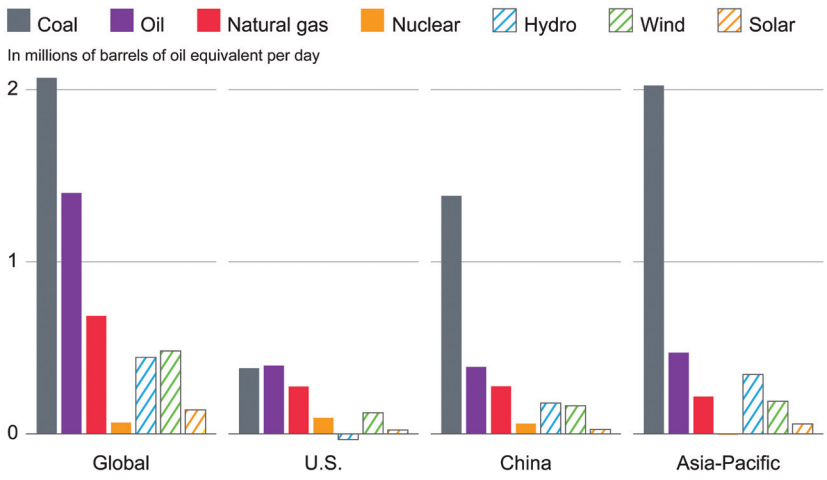
There is little doubt that renewable-energy sources such as wind and solar have been growing rapidly on a percentage basis in recent years. But their output in absolute terms is dwarfed by that of the global coal industry. For instance, in 2013, global wind-energy output was up 21 percent. Solar grew even faster, up by 33 percent last year.

Figure I: Scale of Global Energy Use, 2013



Source: BP Statistical Review of World Energy 2014

Figure 2: Change in Consumption of Coal Versus Other Fuels, 2013



Source: BP Statistical Review of World Energy 2014

Yet the key issue is scale. In 2013, coal use grew far less in percentage terms, up about 3 percent. But in absolute terms, that rather small percentage increase amounts to roughly 2 million barrels of oil equivalent per day of additional energy consumption. That dwarfs the increases seen in solar and wind, which together grew by about 620,000 barrels of oil equivalent per day. Thus, in one year, coal consumption jumped by three times the amount of growth that occurred in wind and solar combined.[8]

"Access to energy is absolutely fundamental in the struggle against poverty....Without energy, there is no economic growth, there is no dynamism, and there is no opportunity."[16]

—RACHEL KYTE, vice president and special envoy for climate change, World Bank

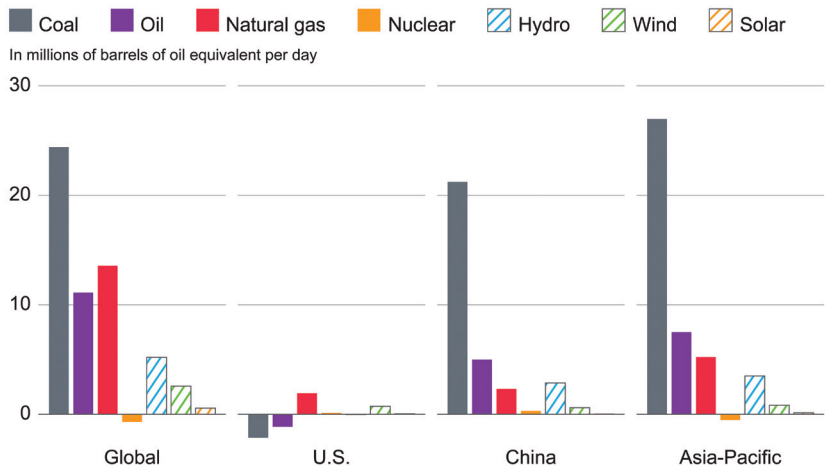
Global coal use also continues to grow at a faster rate than both oil and natural gas. In 2013, coal use rose by about 50 percent more than the growth in petroleum and nearly three times the growth seen in natural gas.[9]

Looking further back in history, one observes a similar story. Between 2003 and 2013, global coal consumption grew by nearly as much as the growth in oil and natural gas *combined.*[10] Over that period, coal use increased by about 24.4 million barrels of oil equivalent per day. (Oil was up by 11 million barrels per day and natural gas by about 13.5 million barrels of oil equivalent per day.) Meanwhile, over the past decade, wind-energy use grew by about 2.6 million barrels of oil equivalent per day, and solar use grew by about 600,000 barrels of oil equivalent per day. Thus, over the last decade, the growth in global coal use was seven times as great as the increase in wind and solar consumption *combined.*

Coal demand will continue growing sharply until the end of this decade. The IEA recently predicted that by 2018, global coal consumption could increase by another 12 million barrels of oil equivalent per day.[11] If that occurs, global coal use, on a BTU basis, would likely exceed global oil use. For perspective, consider that the last time coal consumption in the U.S. was greater than that of oil was in 1949.[12]

Historical data show coal's rapid growth, while projections from the EIA indicate that consumption of the fuel will continue to grow. Between 2013 and 2040, the EIA expects global coal-fired capacity to

Figure 3: Change in Consumption of Coal Versus Other Fuels, 2003–2013



Source: BP Statistical Review of World Energy 2014

expand by about 500 gigawatts, from about 1,800 gigawatts to about 2,300 gigawatts.[13]

That new capacity will mean rising coal demand, too. By 2040, the EIA expects global coal use to increase by about 37 percent—about 30 million barrels of oil equivalent per day—to about 103 million barrels of oil equivalent per day.[14] Thus, over the next three decades, global coal use is projected to increase by about three times Japan's current energy consumption.[15]

II. COAL-FIRED CAPACITY IS BEING BUILT IN THE DEVELOPING WORLD

The countries facing the most dire energy poverty also tend to be the ones that rely most heavily on coal to deal with that problem. Given coal's importance to electrification in the developing world, the following are a few examples of developing countries that are adding more coal-fired-generation capacity.

China: Global per-capita rank in electricity use, 75th (3,477 kilowatt-hours/capita/year)

China has brought hundreds of millions of its citizens out of dire energy poverty over the past few decades. In doing so, it has become a global superpower. And it has done so by burning coal. We can demonstrate that by looking back two decades and benchmarking China's energy use and economic output with the country's longtime rival, Japan.

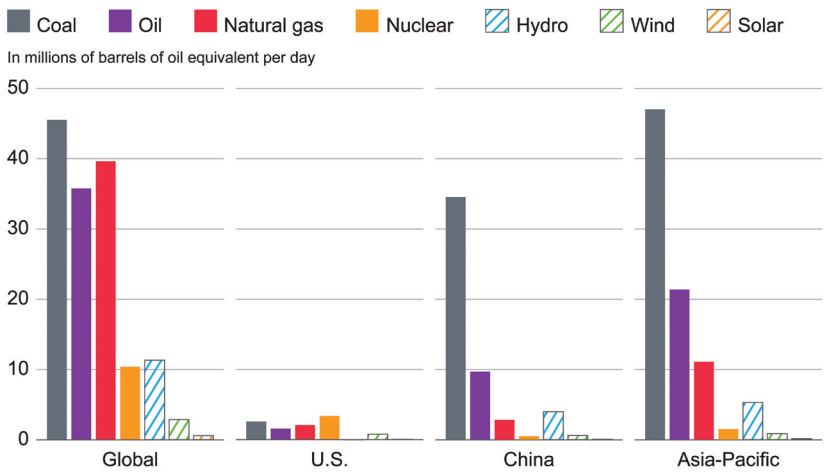
In 1994, the average resident of China was using 727 kilowatt-hours of electricity. For comparison, in 1994, the average resident of Japan was using ten times as much electricity—about 7,200 kilowatt-hours per year.[17]

China's energy poverty was reflected in its lackluster economic output. In 1994, China's GDP was about $560 billion.[18] That same year, China was producing about the same amount of electricity as Japan (about 930 terawatt-hours per year). Thus, in 1994, even though China and Japan were consuming roughly the same amount of electricity, Japan's GDP—at $4.8 trillion—was roughly eight times larger than China's GDP.[19]

Between 1994 and 2013, the volume of coal burned by China more than tripled, reaching 38.7 million barrels of oil equivalent per day. Coal allowed China to dramatically increase its electricity production *and* its GDP. Today, China produces five times as much electricity as Japan (nearly 5,400 terawatt-hours in 2013), while its GDP ($9.2 trillion in 2013) is nearly twice that of Japan's.[20]

Nevertheless, China's per-capita electricity consumption still lags that of its rival: about 3,480 kilowatt-

Figure 4: Change in Consumption of Coal Versus Other Fuels, 1973–2013



Source: BP Statistical Review of World Energy 2014

hours per year, about half the Japanese rate.[21]

China will continue adding coal-fired capacity to its fleet at a robust rate through the end of this decade—adding further capacity, albeit at a slower rate of growth, through the 2020s and 2030s. By 2040, the EIA expects China to add another 400 gigawatts of coal-fired capacity to its generation sector.[22] Put in perspective, the U.S. currently has about 300 megawatts of coal-fired-generation capacity. Thus, over the next 25 years, China is projected to add a new fleet of coal-fired generators that will be larger than America's entire *existing* coal-fired capacity.

India: Global per-capita rank in electricity use, 154th (572 kilowatt-hours/capita/year)

When it comes to energy poverty, few countries can match the scale of the challenge now faced by India, a country where as many as 400 million people still lack access to electricity.[23]

While the need for more electricity is acute, India has made significant progress. For instance, between 1990 and 2010, about 480 million Indians gained access to electricity.[24] But such access remains at very low levels. Indeed, the average resident of India consumes less than 600 kilowatt-hours of electricity per year. For comparison, the average resident of China uses about six times as much, while the average American uses about 21 times as much electricity.[25]

The inadequacy of India's electricity infrastructure was revealed in 2012, when blackouts swept across northern India, leaving more than 600 million people—about twice the population of the United States—without electricity. Those blackouts underscored India's need to alleviate electricity shortages: the country's politicians have made it clear that they are planning to reduce those shortages by burning more coal.

India's coal use is expected to more than double by 2035. And within the next six years or so, India will likely surpass China as the world's largest coal importer.[26] That imported coal will be used to feed the coal-fired power plants now under construction. India, moreover, is planning to add about 90 gigawatts of new generation capacity by 2018.[27] Such a plan may be ambitious, given India's long history of delayed infrastructure projects. But other forecasters are also predicting robust coal expansion: the EIA projects that India's coal-fired capacity will increase by about 100 gigawatts by 2040.[28]

Indonesia: Global per-capita rank in electricity, 151st (629 kilowatt-hours/capita/year)

Since 1985, on a percentage basis, no other country has increased its coal consumption faster than has

Indonesia. Over the past three decades, Indonesia has increased its coal use by more than 5,900 percent. Now consuming about 1 million barrels of oil equivalent per day in the form of coal, the archipelago nation continues to add new electricity-generation capability at a rapid rate. And that new generation capacity is driving up coal demand, which rose by 8.2 percent in 2013 alone.[29]

For decades, Indonesia has struggled with energy poverty, a struggle that continues to this day. The average Indonesian currently consumes about 630 kilowatt-hours of electricity per year, a level about one-fifth of the global average of 3,000 kilowatt-hours per annum.

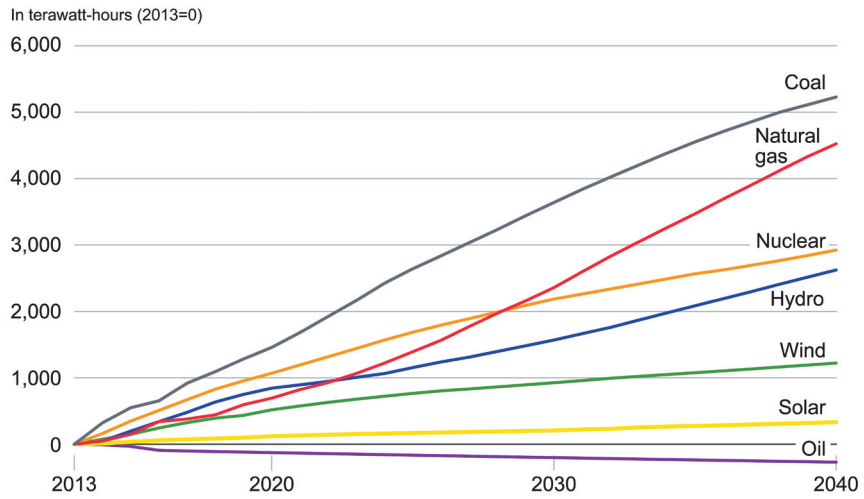
Indonesia's electricity use is expected to more than double by 2022; to meet that demand, the country is building more coal-fired power plants. One planned but still-delayed project is a $4 billion, 2-gigawatt plant slated for construction in Batang, in central Java. Yet the project, which is expected to use ultrasupercritical combustion technology, has been delayed because of disagreements about compensation for local landowners.[30] The delays on the Batang project—which is opposed by Greenpeace—have not stopped plans for additional coal-fired capacity.[31] In April, the Indonesian government announced plans to build a new 2- gigawatt, coal-fired power plant in Jakarta, the capital.[22]And in mid-July 2014, the state-owned electricity firm, PT PLN, announced that it was planning to build additional coal-fired power plants, with a total capacity of 2 gigawatts, to help meet the expected growth in electricity demand.[33]

Pakistan: Global per-capita rank in electricity use, 165th (363 kilowatt-hours/capita/year)

Pakistan often appears in U.S. news reports on issues related to terrorism and conflict. What is seldom mentioned is the country's dire energy poverty. The average Pakistani uses about 360 kilowatt-hours of electricity per year—about a third of the amount used by the average resident of Vietnam, who consumes about 1,125 kilowatt-hours per year.

Pakistan's energy poverty can also be understood by comparing its population and generation capacity with those of Texas. Pakistan has a population of 180 million people,[34] with under 23 gigawatts of generation capacity.[35] Texas, with a population of 26 million,[36] has about 110 gigawatts of electricity-generation capacity.[37] Put another way, Texas has about one-seventh of Pakistan's population, but more than four times more generation capacity.

Figure 5: Predicted Growth in Global Electricity Generation by Source



Source: Energy Information Administration, International Energy Outlook 2013

"The importance of coal in the global energy mix is now the highest since 1971. It remains the backbone of electricity generation and has been the fuel underpinning the rapid industrialization of emerging economies, helping to raise living standards and lift hundreds of millions of people out of poverty."[41]

—FATIH BIROL, chief economist, IEA

Pakistan aims to change its fortunes when it comes to electricity, by burning more coal. The country is planning to build 15 new coal-fired power plants, with a total capacity of about 15 gigawatts. In January, the country's prime minister, Nawaz Sharif, kicked off construction on a new 3.9-gigawatt complex of lignite-fired generators that are expected to come online in 2017.[38]

The new capacity is needed to alleviate dire electricity shortages and blackouts. Urban areas in Pakistan routinely have blackouts lasting ten hours per day; rural areas often face power outages lasting 15 hours per day.[39] Shortages of electricity are imposing heavy costs on the Pakistani economy—as much as $12.5 billion per year, or 6 percent of the country's GDP—according to a 2013 study done by Lahore's Beaconhouse National University.[40]

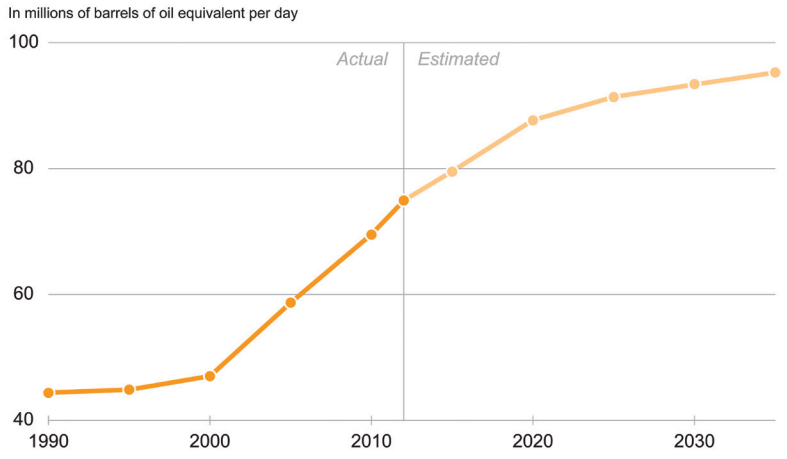
III. NEW COAL-FIRED CAPACITY IS ALSO BEING BUILT IN ELECTRICITY-RICH COUNTRIES

While much of the focus on coal consumption remains on developing countries, a number of electricity-rich countries are also adding new coal capacity. Here are a few of those countries.

Germany: Global per-capita rank in electricity use, 32nd (6,767 kilowatt-hours/capita/year)
The average German now uses about 6,800 kilowatt-hours of electricity per year, significantly above the European Union average of 6,100 kilowatt-hours per year.

Germany has embarked on an ambitious renewable-energy program. Although renewable-energy use

Figure 6: Global Coal Consumption, 1990-2012, and Projected to 2035



Source: BP Energy Outlook 2035, published January 2014

in Germany has grown rapidly in recent years, the country has also seen big increases in electricity prices. Renewable-energy subsidies are now costing consumers and industry some $32 billion per year. The costs have become so onerous that in January, Germany's economy and energy minister, Sigmar Gabriel, told attendees at an energy conference in Berlin that his country is risking "dramatic deindustrialization" if it does not reduce energy costs.

Germany's energy-price increases are occurring at the same time the country has moved to close its nuclear plants. In the wake of the Fukushima disaster in 2011, Germany shut down eight of its nuclear reactors.[42] It plans to retire the rest of its reactors by 2022.[43] Those moves have resulted in increased reliance on coal. In 2013, Germany's coal use rose by nearly 2 percent and amounted to about 1.6 million barrels of oil equivalent per day, the highest level since 2007.[44] It appears that Germany's reliance on coal will last for decades to come: by 2015, German utilities plan to bring some 7.3 gigawatts of new coal-fired power plants online.[45]

"[Coal use in Europe is rising because natural] gas prices are high ... [and] coal is cheap."[58]
—MARIA VAN DER HOEVEN, executive director, IEA

Japan: Global per-capita rank in electricity use, 33rd (6,756 kilowatt-hours/capita/year)
In Japan, home of the Kyoto Protocol, coal consumption is now at record levels.[46] In 2013, coal use in Japan, the world's fourth-largest coal consumer, totaled about 2.6 million barrels of oil equivalent per day, matching the highest level in the country's history. Consumption will likely continue to grow as the country moves away from nuclear energy in the wake of the Fukushima disaster.

Prior to Fukushima, nuclear energy provided 30 percent of Japan's electricity.[47] In April of this year, an official in the Japanese government, Akira Yasui of the Ministry of the Economy, Trade and Industry, told Bloomberg that it is "crucial to have diverse energy sources" for Japan, which imports nearly all its energy. "Our basic stance," he said, "is to use coal while caring for the environment as much as possible. Coal is economical and stable in supply."[48]

Last year, Japanese officials announced plans that call for construction of about 6 gigawatts of new coal-fired capacity over the next decade and a half.[49]

Poland: Global per-capita rank in electricity use, 68th (4,038 kilowatt-hours/capita/year)
Poland, which relies heavily on domestic coal deposits, is also building more coal-fired-generation capacity. The need for more domestically produced energy has become even more acute in Poland in the wake of Russia's invasion of Crimea. Indeed, in March, shortly after the invasion, Poland's prime minister, Donald Tusk, said that his country will need more domestic energy to avoid the possibility that Russia will "blackmail" Poland on natural gas supplies. Tusk went on to say that it was time to begin the "rehabilitation" of coal as an energy source.[50]

The average resident of Poland consumes about 4,000 kilowatt-hours of electricity per year, significantly less than the European Union average. To help boost electricity production, Poland, which produces about 86 percent of its electricity with coal,[51] will spend some $3.8 billion to add 1.8 gigawatts of new coal-fired capacity.[52] That new capacity is expected to come online in 2019.[53]

Russia: Global per-capita rank in electricity use, 27th (7,284 kilowatt-hours/capita/year)
Russia, the world's fifth-largest coal consumer, may also soon see a dramatic increase in coal use.[54] In May, Russian electricity giant Inter RAO said that it was considering construction of an 8-gigawatt coal-fired power plant, whose primary customer would be China. If built, the plant would be the world's largest of its kind, surpassing the 5.5-gigawatt Taichung plant in Taiwan.[55]

South Korea: Global per-capita rank in electricity use, 17th (9,296 kilowatt-hours/capita/year)
Per-capita electricity use in South Korea is about 9,300 kilowatt-hours per year. (For comparison,

consumption in North Korea is about 700 kilowatt-hours per year.) And the country is promoting private investment in new coal-fired power plants.[56] By 2018, the country will increase the size of its coal-fired fleet to some 39 gigawatts, an increase of 14 gigawatts over the size of its 2013 fleet.[57]

IV. HOW MANY PEOPLE HAVE GAINED ACCESS TO ELECTRICITY DUE TO COAL-FIRED GENERATION?

While environmental organizations in the U.S. and other developed countries actively campaign against its use, coal has allowed hundreds of millions of people in less developed countries to escape dire energy poverty.

World Bank data show that, between 1990 and 2010, some of the biggest gains in access to electricity occurred in regions that have long been energy-poor. For instance, between 1990 and 2010, the percentage of people living in sub-Saharan Africa who gained access to electricity increased from 23 to 32 percent. During the same period, electricity access in southern Asia rose from 52 to 75 percent; and in southeastern Asia, access rose from 71 to 88 percent.[59] Some of the developing countries that relied heavily on coal to boost electrification include South Africa, Vietnam, and Indonesia. For instance, South Africa increased electricity access from 65 to 83 percent over those two decades. Vietnam increased access from 88 to 96 percent. And Indonesia increased access from 67 to 94 percent. Indonesia is one of the developing world's success stories when it comes to electrification: between 1990 and 2010, roughly 104 million Indonesians gained access to electricity.[60]

This paper used three different methods to calculate the number of people who gained access to electricity between 1990 and 2010 due to coal-fired generators. Such calculations provided a range of estimates: from 671 million on the low end to 1.1 billion on the high end.

The low-end estimate was derived from a model created by Jacob Williams at Peabody Energy, the world's largest private-sector coal producer. The Peabody model calculated the amount of new electricity-generation capacity built each year between 1990 and 2010 in the developing world. (Capacity figures came from Platts databases.) Those figures were then multiplied by various capacity factors for each form of generation (i.e., 65 percent for coal, 30 percent for wind and solar) to calculate the amount of electricity produced over the two-decade period. The model then divided the latter figure by the amount of electricity that developing countries would need for new access to electricity—a threshold deemed to be 500 kilowatt-hours per capita, per year. Williams's team then benchmarked their model's results with published data on how many people had gained access in India over that period.

To obtain the most accurate estimate, the Peabody model segregated China's electrification data from that used for other developing countries. While China has accounted for a major portion of the increase in global coal use between 1990 and 2010, the country nonetheless accounts for a relatively small number of the people who gained access to electricity over that period. (By 1998, about 98 percent of the Chinese population already had access to electricity.)[61]

The Peabody model found that between 1990 and 2010, about 1.5 billion people in the developing world gained access to electricity. Of that number, some 671 million did so thanks to coal.

A second estimate was derived from a simple calculation based on World Bank and Organisation for Economic Co-operation and Development (OECD) data. According to the World Bank, between 1990 and 2010, the percentage of the world's population with access to electricity grew from 76 percent to 83 percent.[62] Over that same time period, the World Bank estimates that about 1.7 billion people gained access to electricity.[63]

OECD data show that over that two-decade period, electricity production increased by about 9,600 terawatt-hours (about 81 percent). The biggest portion of that new electrical energy—about 4,200 terawatt-hours, or 44 percent of all new electrical

energy added to global electricity supplies over the period—came from coal-fired generation.[64] Thus, if 44 percent of all new electricity production came from coal, and that figure is multiplied by the 1.7 billion people who gained access to electricity, one can assume that roughly 747 million people gained access due to coal-fired generation.[65]

For the final estimate, the Manhattan Institute engaged Jude Clemente, an energy analyst and principal at JTC Energy Research Associates LLC, to conduct his own analysis.[66] Clemente looked at electrification rates in the developing world and then applied those rates to 1990 population totals in the countries scrutinized, a process that gave him the number of people with access to electricity in 1990.

For 2010, Clemente used IEA data to find the number of people in the developing world who did not have electricity in 2010, and then subtracted that figure from the total 2010 population to get the number of people that did have electricity in 2010. He then subtracted the number of people with electricity in 1990 from the number of people with electricity in 2010 to get a new sum: the number of new people who had obtained electricity over the 1990–2010 period. Clemente then looked at the electricity-generation profile of each region to determine how many people got access to electricity from each source.

Averaging the three different estimates reveals that, between 1990 and 2010, some 832 million people gained access to electricity due to coal. Natural gas–fired generation provided new access to about 378 million people, hydropower to 289 million, nuclear to 78 million, non-hydro renewables to 65 million, and oil to 60 million.

Stated differently, between 1990 and 2010, for every person who gained access to electricity thanks to renewables sources such as wind and solar, about four gained access due to hydro, six gained access due to natural gas, and 13 gained access due to coal.

V. POLICY ISSUES TO BE CONSIDERED

Encourage advanced coal-combustion technologies
Given that coal will remain an integral element of the global electricity market for decades to come, policymakers should promote the best combustion technologies available. More effective combustion allows a given power plant to produce more electricity while producing fewer emissions of carbon dioxide and traditional air pollutants. Just as important, better combustion allows power plants to consume less fuel per kilowatt-hour produced, which saves money.

About 75 percent of the world's coal-fired plants use "subcritical" technology, a method of combustion that has a thermal efficiency of up to 38 percent. Such subcritical plants produce about 881 grams of carbon dioxide for each kilowatt-hour of electricity produced.

By contrast, "supercritical" combustion, which burns the coal at higher temperature and pressure, can achieve thermal efficiencies of up to 42 percent, while reducing the amount of carbon dioxide per kilowatt-hour

Figure 7: Estimates of Global Population That Gained Access to Electricity, by Generation Type, 1990–2010

	Peabody	World Bank/OECD	Clemente	Average
Coal	671,600,985	747,386,770	1,079,000,000	832,662,585
Natural gas	384,831,744	539,492,724	211,000,000	378,441,489
Hydro	314,460,241	229,250,458	325,000,000	289,570,233
Nuclear	64,006,748	131,379,729	39,000,000	78,128,826
Non-hydro renewables	20,118,643	117,502,595	58,000,000	65,207,079
Oil	44,109,012	0	77,000,000	60,554,506
Total, new access	1,499,127,373	1,700,000,000	1,789,000,000	1,662,709,124

Note: The average number for new access provided by oil includes estimates only from Peabody and Clemente.[67]

produced to about 798 grams. Furthermore, ultrasupercritical technology can achieve thermal efficiencies of up to 45 percent while cutting carbon-dioxide output even further, to about 743 grams per kilowatt-hour. Advanced ultrasupercritical combustion, which is now being tested, aims to increase thermal efficiency to about 50 percent while cutting carbon-dioxide emissions to 288 grams per kilowatt-hour.[68]

Promoting the deployment of supercritical, ultrasupercritical, and other advanced-combustion technologies makes sense. The U.S. can promote better combustion technology by making those technologies a prerequisite for coal-fired projects that seek funding through development entities like the Overseas Private Investment Corporation, Export-Import Bank, and World Bank.

Coal's Continued Growth Means Increasing Carbon-Dioxide Emissions

Coal combustion now accounts for about 44 percent of global carbon-dioxide emissions.[71] (Oil accounts for about 35 percent.)[72]

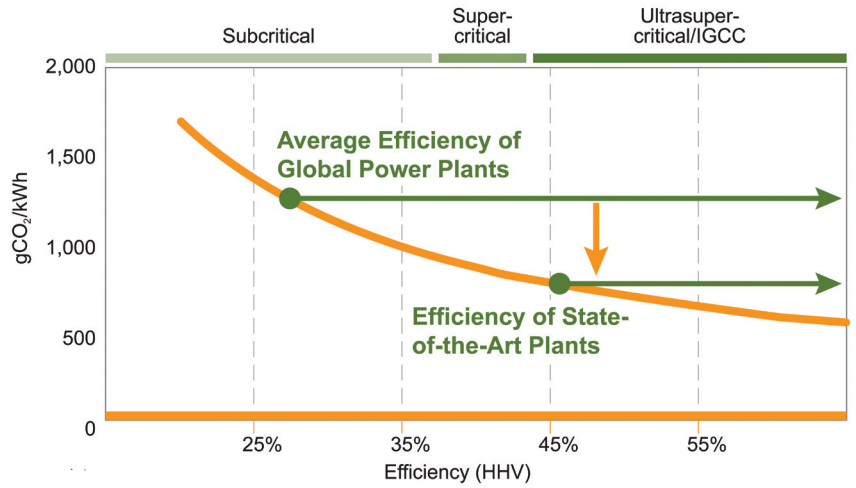
Given coal's irreplaceability in the global electricity-generation mix, there is little reason to expect significant reductions in global carbon-dioxide emissions over the next few decades. As shown in Figure 6, the latest BP Energy Outlook 2035 predicts that global coal use will likely reach about 95 million barrels of oil equivalent per day by 2035, an increase of about 18 million barrels of oil equivalent per day over 2013 levels.[73] (The EIA's projections are higher yet: 103 million barrels of oil equivalent per day by 2040.)[74]

Even if policymakers are able to encourage (or even mandate) the use of advanced-combustion technologies in coal-fired-generation stations, continued growth in coal consumption makes it virtually certain that global emissions will continue rising. Projections from the EIA show that by 2040, global coal-related carbon-dioxide emissions will total nearly 21 billion tons per year, an increase of about 41 percent (or 6 billion tons) over 2013 levels.[75]

Scrap the EPA's "Clean Power Plan"

In June, the EPA released a 645-page set of regulations called the "Clean Power Plan," which aims to reduce carbon-dioxide emissions from the U.S. electricity-generation sector. The measure, which will further reduce the use of coal in the domestic electricity sector, is unnecessary and should be blocked, or repealed, for the following four reasons:

Figure 8: Improving Coal Combustion Reduces Emissions and Increases Efficiency



Note: Integrated Gasification Combined Cycle (IGCC) is a process that turns hydrocarbons into a synthesis gas that can then be stripped of sulfur, mercury, and particulates before the gas is used as fuel in a combustion turbine.[69] Also, an improvement of 1 percent in thermal efficiency equals a 2–3 percent decrease in emissions.[70]
Source: BP Energy Outlook 2035, published January 2014

1. The U.S. already leads the world in "decarbonizing" its electric sector. Why? Many electricity generators have been voluntarily switching much of their generation from coal to natural gas. Between 2003 and 2013, U.S. coal consumption declined by about 2.1 million barrels of oil equivalent per day. Put another way, the U.S. is now burning about the same amount of coal as it did in 1987.[76] Such fuel switching—away from coal and toward natural gas for power production—has resulted in major reductions in carbon-dioxide emissions. Since 2003, the U.S. has cut its carbon-dioxide emissions by over 400 million tons. For comparison, Germany, which has spent more than $100 billion on renewable-energy mandates since 2000, has seen a reduction of about 67 million tons, roughly one-sixth as much as the U.S.'s reduction.

2. Given soaring global coal use, banning new coal-fired power plants in the U.S. will not make a significant dent in global carbon-dioxide emissions.

3. The U.S. should not repeat the policy mistakes of the past. In 1978, Congress was convinced that a crisis was at hand and that the U.S. was running out of natural gas. To address the issue, Congress passed the Powerplant and Industrial Fuel Use Act (FUA), which restricted use of natural gas for electricity generation.[77] The result: utilities rushed to build dozens of new coal-fired power plants that are now considered problematic. Today, the EPA insists that climate change is a crisis and, therefore, the U.S. should restrict the use of coal for electricity generation. The lesson from the passage and subsequent repeal (in 1987) of the FUA shows that regulators fare poorly when trying to predict the future—and, worse still, when picking the technologies of the future.

4. America should use its vast coal resources to maintain diversity in electricity generation. It is true that the U.S. has abundant supplies of natural gas. But by restricting the use of coal, the EPA's new policy creates a risk that the U.S. will become too reliant on natural gas. The U.S. is not the Saudi Arabia of coal; it is the OPEC of coal. America's coal deposits contain 900 billion barrels of oil equivalent, nearly as much as the 1 trillion barrels of proved oil reserves held by OPEC.[78] At current rates of consumption, the U.S. has about 240 years of coal supply.[79] Electricity generators should be able to use those vast resources to ensure cheap, abundant, and reliable electricity supplies.

CONCLUSION

For much of human history, coal has engendered an intense love-hate relationship. Coal heated people's homes and fueled the industrial revolution. It also came with a heavy cost, as it made some of the smog-ruined cities nearly uninhabitable.

Today, the love-hate relationship with coal continues. We love the electricity it produces but abhor the pollution, ash, mining deaths, and many other problems it creates. The Sierra Club calls coal "our dirtiest energy source" and has launched a campaign to convince the public that we can go "beyond coal."[80]

Despite these myriad problems, countries continue to produce electricity from coal because it is the cheapest fuel available. Until another energy source is able to compete directly with coal—in terms of cost, scale, and reliability—the black fuel will continue dominating the global electricity-generation business.

Appendix:
Countries Ranked by Electricity Consumption

	Country	(kWh/ capita/year)
1	Iceland	51,478
2	Norway	23,773
3	Kuwait	17,330
4	Finland	16,109
5	United Arab Emirates	15,559
6	Canada	14,461
7	Sweden	14,097
8	Luxembourg	12,518
9	United States	12,280
10	Taiwan	10,395
11	Cayman Islands	10,272
12	Guam	10,195
13	Bahrain	10,122
14	Qatar	10,042
15	Australia	9,590
16	New Zealand	9,338
17	South Korea	9,296
18	Bermuda	9,190
19	Saint Pierre and Miquelon	8,537
20	Aruba	8,350
21	Brunei	8,157
22	Belgium	8,108
23	Austria	7,760
24	Switzerland	7,556
25	Singapore	7,439
26	Virgin Islands	7,326
27	Russia	7,284
28	Macau	7,228
29	France	7,142
30	Saudi Arabia	7,086
31	New Caledonia	6,969
32	Germany	6,767
33	Japan	6,756
34	Andorra	6,594
35	Curaçao	6,592
36	Jersey	6,582
37	Netherlands	6,546

	Country	(kWh/ capita/year)
38	Hong Kong	6,364
39	Slovenia	6,323
40	Israel	6,323
41	Estonia	6,276
42	Trinidad and Tobago	6,192
43	Denmark	6,040
44	European Union	5,962
45	Czech Republic	5,767
46	Falkland Islands	5,627
47	Bahamas	5,626
48	Ireland	5,465
49	Puerto Rico	5,330
50	Gibraltar	5,314
51	Spain	5,271
52	Greece	5,235
53	United Kingdom	5,194
54	Serbia	5,159
55	Italy	5,104
56	Montenegro	5,018
57	Faroe Islands	5,009
58	Kazakhstan	4,968
59	Oman	4,857
60	Greenland	4,834
61	South Africa	4,819
62	Slovakia	4,787
63	Portugal	4,654
64	Bulgaria	4,363
65	Montserrat	4,301
66	Libya	4,205
67	Cyprus	4,149
68	Poland	4,038
69	Ukraine	3,933
70	Malta	3,895
71	Turks and Caicos Islands	3,895
72	Malaysia	3,780
73	Croatia	3,731
74	Hungary	3,635

	Country	(kWh/ capita/year)
75	China	3,477
76	Macedonia	3,474
77	Nauru	3,450
78	Lebanon	3,435
79	Barbados	3,415
80	Belarus	3,297
81	Chile	3,132
82	Kosovo	3,071
83	Latvia	3,011
84	Venezuela	2,989
85	Lithuania	2,930
86	Seychelles	2,897
87	Bosnia and Herzegovina	2,856
88	Cook Islands	2,771
89	American Samoa	2,703
90	Argentina	2,607
91	Suriname	2,510
92	Thailand	2,510
93	Romania	2,466
94	Saint Kitts and Nevis	2,456
95	Uruguay	2,394
96	Bhutan	2,316
97	Iran	2,288
98	Niue	2,270
99	Brazil	2,268
100	French Polynesia	2,254
101	Turkmenistan	2,175
102	Turkey	2,112
103	Jordan	2,089
104	Saint Lucia	2,045
105	Tajikistan	2,010
106	Georgia	1,898
107	Armenia	1,893
108	Belize	1,885
109	Costa Rica	1,817
110	Mexico	1,787
111	Mauritius	1,783
112	Panama	1,744
113	West Bank	1,708
114	Micronesia, Federated States of	1,683
115	Namibia	1,665
116	Grenada	1,628

	Country	(kWh/ capita/year)
117	Syria	1,586
118	Uzbekistan	1,553
119	Albania	1,550
120	Botswana	1,465
121	British Virgin Islands	1,457
122	Egypt	1,435
123	Azerbaijan	1,415
124	Mongolia	1,357
125	Kyrgyzstan	1,320
126	Dominican Republic	1,283
127	Dominica	1,275
128	Cuba	1,233
129	Tunisia	1,226
130	Saint Vincent and the Grenadines	1,226
131	Antigua and Barbuda	1,187
132	Peru	1,147
133	Vietnam	1,125
134	Iraq	1,102
135	Jamaica	1,054
136	Paraguay	1,023
137	Colombia	991
138	Moldova	986
139	Ecuador	966
140	Saint Helena, Ascension, and Tristan da Cunha	960
141	Zimbabwe	954
142	El Salvador	942
143	Fiji	901
144	Algeria	884
145	Gabon	879
146	Swaziland	754
147	Morocco	723
148	North Korea	713
149	Maldives	711
150	Guyana	692
151	Indonesia	629
152	Bolivia	602
153	Honduras	574
154	India	572
155	Samoa	572
156	Guatemala	568
157	Zambia	560
158	Philippines	538

	Country	(kWh/ capita/year)		Country	(kWh/ capita/year)
159	Nicaragua	508	**189**	Burma	110
160	Cape Verde	503	**190**	Malawi	109
161	Papua New Guinea	484	**191**	Togo	95
162	Sri Lanka	461	**192**	Nepal	90
163	Mozambique	423	**193**	Benin	88
164	Djibouti	382	**194**	Congo, Democratic Republic of the	82
165	Pakistan	363	**195**	Guinea	81
166	Tonga	359	**196**	Afghanistan	80
167	Laos	352	**197**	Liberia	78
168	Angola	247	**198**	Tanzania	71
169	Bangladesh	238	**199**	Uganda	63
170	Cameroon	230	**200**	South Sudan	63
171	Kiribati	225	**201**	Timor-Leste	58
172	Yemen	218	**202**	Madagascar	50
173	Ghana	211	**203**	Comoros	49
174	Vanuatu	196	**204**	Niger	49
175	Mauritania	190	**205**	Ethiopia	47
176	Côte d'Ivoire	173	**206**	Burkina Faso	43
177	Cambodia	169	**207**	Eritrea	41
178	Senegal	167	**208**	Guinea-Bissau	38
179	Sudan	163	**209**	Mali	30
180	Lesotho	159	**210**	Central African Republic	29
181	Western Sahara	155	**211**	Somalia	28
182	São Tomé and Principe	149	**212**	Rwanda	27
183	Kenya	140	**213**	Sierra Leone	24
184	Congo, Republic of the	129	**214**	Burundi	22
185	Equatorial Guinea	128	**215**	Haiti	21
186	Solomon Islands	128	**216**	Chad	8
187	Nigeria	117	**218**	Northern Mariana Islands	0.94
188	Gambia	114	**219**	Gaza Strip	0.11

Source: CIA World Factbook, http://www.photius.com/rankings/energy/electricity_consumption_per_capita_2014_0.html

Endnotes

[1] BP Statistical Review of World Energy 2014. Between 1973 and 2013, oil use grew by about 36 mmboe/d (million barrels of oil equivalent per day), natural gas use by about 40 mmboe/d, and coal use by about 46 mmboe/d.

[2] Ibid. Over that period, wind energy increased by about 2.5 mmboe/d, and solar increased by about 560,000 boe/d.

[3] IEA Key World Energy Statistics 2013, http://www.iea.org/publications/freepublications/publication/KeyWorld2013.pdf, 24.

[4] That list: China: 400 GW; Germany: 7.3; India: 90 GW; Indonesia: 6 GW; Japan: 6 GW; Pakistan: 15 GW; Poland: 1.8 GW; Russia: 8 GW; South Korea: 14 GW; Total: 548.1 GW.

[5] See http://theenergycollective.com/roger-pielke-jr/261771/electricity-all.

[6] This paper ignores policy issues related to the industrial use of coal, which accounts for about 40 percent of global coal use. Instead, it focuses on the use of the fuel for electricity generation, which accounts for about 60 percent of all coal consumption.

[7] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=4-IEO2013&table=30-IEO2013&region=0-0&cases=Reference-d041117.

[8] BP Statistical Review 2014. In 2013, wind energy use grew by about 480,000 boe/d, and solar use by about 140,000 boe/d.

[9] Ibid. Oil use grew by 1.4 mmbbl/d (million barrels per day). Gas use grew by about 700,000 boe/d.

[10] Ibid. Over that period, coal use grew by 24.4 mmboe/d, oil use by 11.1 mmbbl/d, and natural gas use by 13.6 mmboe/d. Wind use was up by 2.6 mmboe/d, and solar was up by 600,000 boe/d. Total increase for wind and solar: 3.2 mmboe/d. (Hydro use was up by 5.2 mmboe/d, while nuclear use was down by 700,000 boe/d.)

[11] IEA, "Tracking Clean Energy Progress 2013," http://www.iea.org/publications/TCEP_web.pdf, 49. The estimate for coal use goes from 155 Exajoules in 2011 to 180 EJ by 2017, an increase of 25 EJ. That is the equivalent of 4.3 billion barrels of oil equivalent—divided by 365 days gives 11.8 mmboe/d.

[12] EIA data. Annual Energy Review 2008, Figure 5, "Primary Energy Consumption by Source, 1635–2008."

[13] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=7-IEO2013&table=19-IEO2013&region=0-0&cases=Reference-d041117.

[14] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=7-IEO2013&table=7-IEO2013&region=0-0&cases=Reference-d041117.

[15] According to the BP Statistical Review of World Energy 2014, Japan consumed about 9.5 mmboe/d in 2013, from all sources.

[16] See Marianna Lavelle, "Five Surprising Facts About Energy Poverty," National Geographic, May 29, 2013, http://news.nationalgeographic.com/news/energy/2013/05/130529-surprising-facts-about-energy-poverty.

[17] World Bank data, http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC/countries/1W?page=3&display=default.

[18] See http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?page=3.

[19] Ibid.

[20] See http://data.worldbank.org/country/china.

[21] World Bank data, http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC/countries/1W?display=default.

[22] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=4-IEO2013&table=19-IEO2013&region=0-0&cases=Reference-d041117.

[23] World Bank data, http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY2/0,,contentMDK:22855502~pagePK:210058~piPK:210062~theSitePK:4114200,00.html.

[24] Lavelle, "Five Surprising Facts About Energy Poverty." This story says that since 1990, an average of about 24 million people in India gained access to electricity annually. Thus, over the 20-year period from 1990 to 2010, about 480 million Indians gained access to electricity.

[25] World Bank data; per-capita electricity use in the U.S. is about 12,280 kWh per year.

[26] Shoichi Itoh, "A New Era of Coal: The 'Black Diamond' Revisited," Pacific Energy Forum, May 2014, http://nbr.org/downloads/pdfs/ETA/PEF_2014_workingpaper_Itoh.pdf.

[27] Victor Mallet, "Indian Power Shortage Is Achilles Heel of Economy," *Financial Times*, May 30, 2013, http://www.ft.com/intl/cms/s/0/f5bc2d72-c8f1-11e2-9d2a-00144feab7de.html#axzz2VABnbzCn.

[28] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=4-IEO2013&table=19-IEO2013&region=0-0&cases=Reference-d041117.

[29] BP Statistical Review of World Energy 2014.

[30] See http://www.thejakartaglobe.com/business/batang-power-plant-delays-drag.

[31] See http://www.thejakartapost.com/news/2014/02/12/coal-fired-plant-project-faces-local-opposition.html.

[32] See http://www.powerengineeringint.com/articles/2014/04/indonesia-plans-1-8bn-coal-fired-power-plant.html.

[33] See http://www.thejakartapost.com/news/2014/07/15/pln-considering-new-power-plant-projects.html.

[34] See http://www.worldpopulationstatistics.com/pakistan-population-2013.

[35] See http://www.eia.gov/countries/country-data.cfm?fips=PK&trk=m.

[36] See http://quickfacts.census.gov/qfd/states/48000.html.

[37] See http://www.eia.gov/electricity/state/texas/pdf/Texas.pdf.

[38] See http://www.trust.org/item/20140611093028-fa051.

[39] Ibid.

[40] See http://online.wsj.com/news/articles/SB10001424052702304795804579097620793610020.

[41] See http://cornerstonemag.net/coals-role-in-the-global-energy-mix-treading-water-or-full-steam-ahead.

[42] See http://www.eia.gov/todayinenergy/detail.cfm?id=13151.

[43] See http://www.bbc.co.uk/news/world-europe-13592208.

[44] BP Statistical Review of World Energy 2014.

[45] "German Coal Extends Dominance in Power Mix as Gas Wanes," Platts, October 9, 2013, http://www.platts.com/latest-news/coal/london/analysis-german-coal-extends-dominance-in-power-26352497.

[46] See http://www.forbes.com/sites/kenrapoza/2014/04/14/japan-follows-chinas-coal-rush.

[47] See http://www.defence.gov.au/adc/docs/Publications2012/08_SAP%20Linda%20McCann%20-%20Japan.pdf.

[48] See http://www.bloomberg.com/news/2014-04-13/post-fukushima-japan-chooses-coal-over-renewable-energy.html.

[49] See http://www.reuters.com/article/2013/11/28/japan-power-coal-idUSL4N0JB1QU20131128.

[50] See http://www.thenews.pl/1/12/Artykul/166897,Poland-seeks-to-avoid-Russian-gas-blackmail.

[51] World Coal Association data, http://www.worldcoal.org/resources/coal-statistics.

[52] See http://www.upi.com/Business_News/Energy-Resources/2014/01/10/Polands-PGE-OKs-378-billion-expansion-of-Opole-coal-fired-plant/UPI-58621389330240.

[53] See http://www.alstom.com/press-centre/2014/1/alstom-to-provide-two-900-mw-units-for-the-largest-coal-fired-power-plant-in-poland.

[54] BP Statistical Review of World Energy 2014.

[55] See http://www.reuters.com/article/2014/05/26/russia-interrao-plant-idUSL6N0OC30R20140526.

[56] See http://www.bloomberg.com/news/2013-01-31/s-korea-approves-private-coal-power-plants-to-spread-investment.html.

[57] Christian Lelong et al., "The Thermal Coal paradox," Goldman Sachs, May 23, 2014, 9.

[58] See http://www.iea.org/newsroomandevents/speeches/140310_EWEA_Text.pdf.

[59] See http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/05/28/000112742_20130528084417/Rendered/PDF/778890GTF0full0report.pdf, 270.

[60] In 1990, Indonesia's population was 179 million. In 2010, it was 238 million. For population data, see http://www.bps.go.id/eng/tab_sub/view.php?tabel=1&id_subyek=12. If in 1990, 67 percent of Indonesia had access to electricity, then roughly 120 million Indonesians had power. By 2010, when 94 percent had power, the number with electricity had risen to about 224 million. Thus, over the 20-year period, roughly 104 million Indonesians gained access to electricity. Over that same period, Indonesia's coal use increased by about 750,000 barrels of oil equivalent per day, an increase of about 942 percent. Natural gas–fired generation likely played some role in increased electrification. Between 1990 and 2010, gas use increased by about 422,000 barrels of oil equivalent per day, an increase of about 138 percent.

[61] Author's correspondence with Jacob Williams of Peabody. This estimate is corroborated by World Bank data, which show that by 2000, 98 percent of the Chinese population had access to power. See http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/05/28/000112742_20130528084417/Rendered/PDF/778890GTF0full0report.pdf, 263.

[62] Ibid., 270.

[63] See http://www.worldbank.org/en/news/press-release/2013/05/28/first-set-of-global-data-on-energy-access-renewable-energy-and-energy-efficiency-released.

[64] OECD data, http://www.oecd-ilibrary.org/sites/factbook-2014-en/06/01/03/index.html?contentType=%2fns%2fBook%2c%2fns%2fStatisticalPublication%2c%2fns%2fOECDBook&itemId=%2fcontent%2fbook%2ffactbook-2014-en&mimeType=text%2fhtml&containerItemId=%2fcontent%2fserial%2f18147364&accessItemIds=&_csp_=4374d590db006092dd2523f252772f34.

[65] This is a very rough measure. To prove that point, the calculations show that more than 60 million people lost access to electricity from oil. Intuitively, this makes little sense: as it is for island economies and other remote locations, oil-fired generation is the most readily available option. For this reason, in Figure 7 the World Bank/OECD estimate of people who gained access because of oil is given as zero.

[66] For more on Clemente, see http://www.judeclemente.com/about_me.

[67] The simple calculations done using World Bank and OECD data show that between 1990 and 2010, about 65 million people *lost* access to electricity because of oil. Given that oil is a critical fuel for electricity production in rural areas and in island economies, that figure makes no sense—and is therefore not included in the average.

[68] Itoh, "A New Era of Coal."

[69] See http://www.duke-energy.com/about-us/how-igcc-works.asp.

[70] See http://www.worldcoal.org/coal-the-environment/coal-use-the-environment/improving-efficiencies.

[71] See http://www.c2es.org/energy/source/coal.

[72] See http://www.c2es.org/energy/source/oil.

[73] See http://www.bp.com/en/global/corporate/about-bp/energy-economics/energy-outlook/energy-outlook-downloads.html.

[74] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=7-IEO2013&table=7-IEO2013&region=0-0&cases=Reference-d041117.

[75] EIA data, http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=7-IEO2013&table=13-IEO2013&region=0-0&cases=Reference-d041117.

[76] BP Statistical Review of World Energy 2014.

[77] See http://www.eia.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/repeal.html.

[78] Congressional Research Service, "U.S. Fossil Fuel Resources: Terminology, Reporting, and Summary," March 25, 2011, http://assets.opencrs.com/rpts/R40872_20110325.pdf, 14.

[79] BP Statistical Review of World Energy 2011.

[80] See http://content.sierraclub.org/coal.

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