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A New Era of Coal: The "Black Diamond" Revisited

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A negative view of coal as a “dirty” hydrocarbon has prevailed over the past two decades, given that climate change became a matter of global concern and burning hydrocarbons is a crucial factor in carbon dioxide (CO_2) emissions. In addition, environmentalists have severely criticized the process of utilizing coal because of its impact on air and water pollution.

Yet ignoring the inevitable role that coal will play in the global energy mix for the foreseeable future is a fundamental mistake. There exists no panacea to solve every single energy and environmental challenge all at once. Although it is true that we should work to minimize environmental burdens for future generations, the role that coal plays in economic sustainability and geopolitical stability should be acknowledged. Coal has been one of the most dependable energy sources over the centuries. With its relative abundance, geographic distribution on the world map, and competitive price vis-à-vis oil and natural gas, we are still nowhere near achieving a “Copernican revolution” to eliminate the central role that coal plays in energy security but will continue to depend on it for decades to come.

Because of so-called clean-coal technologies (CCT), however, an increasing number of options exist for the cleaner (if not perfectly clean in the strict sense) use of coal. The importance of diffusing best practices of CCT must be taken into account in order to tackle the global challenge of spiking energy demand, especially in Asian countries that are not part of the Organisation for Economic Co-operation and Development (OECD). These countries include China, India, and Indonesia, which have more than 2.8 billion people and account for over 40% of the world’s population. Despite the fact that the self-sufficiency rate for coal is by far higher than for oil and natural gas in Asia, the regional import volumes of coal are rapidly increasing. Strategic dissemination of CCT to stabilize energy markets is thus a pressing need.

Meanwhile, the potential for the United States to play a significant role as a coal supplier to the international market is increasing as the shale gas revolution boosts natural gas consumption as a replacement for coal domestically. With its abundant coal reserves and production potential, the United States could have a dramatic impact on international energy security in terms of both energy markets and geopolitics, regardless of tightening domestic environmental regulations.

Coal Market Trend

Despite increasing environmental opposition to the use of coal, coal still plays a crucial role in the global energy mix and will continue to do so for the foreseeable future. According to estimates by the International Energy Agency (IEA), coal will account for a quarter of the world's total primary energy demand in 2035.[1] The importance of coal use will be all the more persistent in Asia. Whereas coal consumption in OECD countries is projected to increase at the compound average growth rate of -1.1% in 2011–35, in Asia, excluding OECD members Japan and the Republic of Korea, consumption will grow by 1.3% during the same period. Coal is forecast to account for 45% of the energy mix and more than 60% of the power mix in non-OECD Asia in 2035 (see **Table 1**).

Table 1 *Energy demand in non-OECD Asia*

	million tons of equivalent (Mtoe)						Shares (%)	
	1990	2011	2020	2025	2030	2035	2011	2035
Total Primary Energy Demand	**1 578**	**4 324**	**5 548**	**6 107**	**6 584**	**7 045**	**100**	**100**
Coal	694	2 349	2 782	2 947	3 082	3 193	54	45
Oil	318	899	1 182	1 305	1 416	1 518	21	22
Gas	69	337	552	674	784	899	8	13
Nuclear	10	44	176	250	291	330	1	5
Hydro	24	84	141	160	177	192	2	3
Bioenergy	457	563	593	608	625	651	13	9
Other renewables	7	48	122	163	208	262	1	4
Power generation	**328**	**1 667**	**2 264**	**2 611**	**2 924**	**3 250**	**100**	**100**
Coal	226	1 299	1 556	1 709	1 857	1 994	78	61
Oil	45	43	29	24	20	17	3	1
Gas	16	131	190	235	277	331	8	10
Nuclear	10	44	176	250	291	330	3	10
Hydro	24	84	141	160	177	192	5	6
Bioenergy	0	34	79	107	136	171	2	5
Other renewables	7	33	92	126	166	214	2	7

Source: IEA, *World Energy Outlook 2013*, 616.

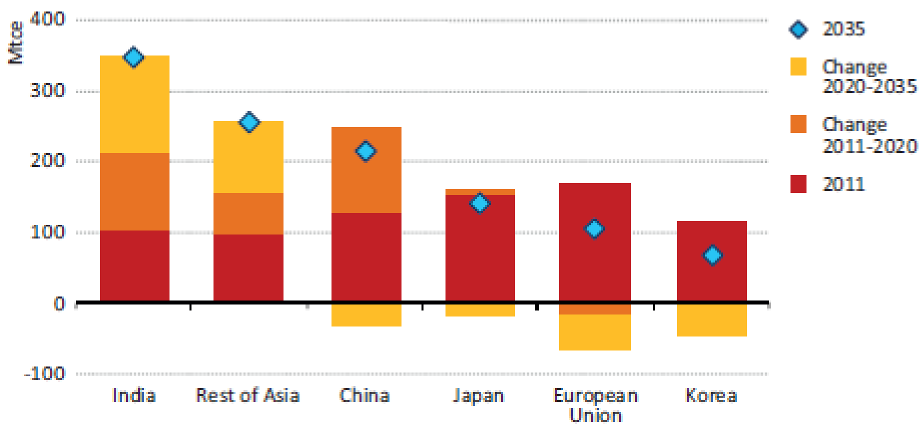
China, the biggest coal producer and consumer, accounted for roughly half the global coal demand in 2011 and is forecast to consume 3,050 million tonnes of coal equivalent (Mtce) out of 6,326 Mtce in 2035. Having become a net importer of coal as late as 2009, China imported about

[1] International Energy Agency (IEA), *World Energy Outlook 2013* (Paris: OECD/IEA, 2013), 58. The IEA's estimate is based on a "new policy scenario," "which takes into account broad policy commitments and plans that have already been implemented to address energy-related challenges as well as those that have been announced, even where the specific measures to implement these commitments have yet to be introduced. It assumes only cautious implementation of current commitments and plans." IEA, *World Energy Outlook 2013*, 645.

220 Mtce in 2012, in contrast with Japan's total coal consumption of 178 Mtce in that same year. Although it is forecast that China's net imports of coal will peak before 2020 due to improvements in coal use and the diversification of the country's power mix, among other factors,[2] the impact of China's high share of global coal consumption on the international coal market and the environment will remain tremendous.

Indian coal consumption is likewise surging and is forecast to more than double by 2035. India is projected to consume more coal than Europe and Japan combined and to overtake China as the world's largest coal importer by the early 2020s (see **Figure 1**).

Figure 1 *Major net importers of coal*



Source: IEA, *World Energy Outlook 2013*, 164.

In addition, coal consumption in member countries of the Association of Southeast Asian Nations (ASEAN) is beginning to climb dramatically in accordance with the spike in electricity demand, which is forecast to increase from 694 terawatt hours (TWh) in 2011 to 1,071 TWh in 2020 and 1,668 TWh in 2030.[3] The share of coal in the power mix of ASEAN countries is projected to rise from 31% in 2011 to 36% in 2030 as a result of coal demand increasing by 2.5 times from 129 Mtce in 2011 to 316 Mtce in 2030.[4] The power sector accounts for approximately

[2] IEA, *World Energy Outlook 2013*, 151.

[3] Institute of Energy Economics, Japan (IEEJ), "Asia/World Outlook 2013," 2014. The IEEJ's estimate is based on a "reference scenario," which assumes highly probable deployment of energy policies and technologies based on current economic and political situations and provides a normative future evolution of energy demand and supply.

[4] These calculations are based on IEEJ, "Asia/World Outlook 2013." The unit was originally given in the form of

60% of coal consumption today. In order to meet the rapid increase of electricity demand, ASEAN economies will need to replace oil and natural gas, which are more expensive fossil fuels in the international market, with more steam coal for thermal plants.

Indonesia, which accounts for approximately 40% of ASEAN's primary energy consumption, is projected to more than double its coal consumption from 44 Mtce in 2011 to 93 Mtce in 2020 and more than treble its consumption to 144 Mtce in 2030. Indonesia is the biggest coal supplier within ASEAN, but in order to meet sharply rising electricity demand the county will need to increase its use of coal by way reducing export volumes. As a replacement for oil, whose supply-demand gap keeps widening, the Indonesian government plans to burn more coal as a fuel source for thermal plants, in addition to using more natural gas. Given that exports of liquefied natural gas (LNG) remain Indonesia's prime industry, the efficient use of coal has become all the more important against the backdrop of sharply rising domestic demand for natural gas. The share of coal in the power mix is forecast to increase from 44% in 2011 to 60% in 2040.[5]

Similarly, coal demand is projected to more than double in Malaysia and Thailand from 2011 to 2040. This trend is caused by their greater reliance on coal, which is generally cheaper than natural gas, to satisfy the upsurge in electricity demand. Both countries plan to increase LNG imports against the tightening of the supply-demand balance of domestic natural gas markets. Coal is the expected replacement in the power mix. Domestic coal production in Malaysia and Thailand, however, is close to peaking, leading to projected increases in their coal imports. Vietnam's consumption of coal, on the other hand, is forecast to increase by more than four times from 2011 to 2040.[6] It is thus only a matter of time before Vietnam shifts from being a net exporter to being a net importer of coal.[7]

Compared with oil and natural gas, coal is the most cost-competitive per calorific value. This is especially true in Asia, where the prices of gas imports are basically indexed to crude oil in the absence of gas-on-gas competition, unlike in the U.S. gas market. For example, Japan's import price of LNG is currently about four times as high as the Henry Hub spot price. Aggressive use of

million tons of oil equivalent (Mtoe) but has been converted into Mtce with a coefficient of 0.7.

[5] IEEJ, "Asia/World Outlook 2013," Annex 31.

[6] IEEJ, "Asia/World Outlook 2013," Annex 36.

[7] IEA, *World Energy Outlook 2013*, 167.

coal, therefore, could minimize capital outflow, especially from economies with low hydrocarbon self-sufficiency. In other words, the growth rates of non-OECD economies would slow down without relying on coal as a primary source for power generation. Over two-thirds of the world's steam coal trade is consumed in Asia, including Japan and the Republic of Korea.

Clean-Coal Technologies

Enhancing the role of coal in the energy mix does not mean that the importance of adopting countermeasures to address environmental problems, including air pollution and greenhouse gas emissions, is ignored. The growth rate of coal consumption needs to be reduced by improving the combustion efficiency of coal-fired plants. It is also necessary to diffuse best practices of available technologies in order to minimize environmental pollutants and combat climate change. However, while making every effort to reduce the environmental impact of coal use, decision-makers must also take into account the immediate risks of failing to make the best use of coal for the economic sustainability of energy markets and geopolitical stability.

A wide variety of CCT exists, including technologies addressing coal combustion, gasification of coal, and carbon capture and storage (CCS).[8] Although CCS often attracts media attention as a prospective technology to curb CO_2 emissions, its commercialization is not expected to occur anytime soon.[9] Instead, countries should consider other options, such as disseminating coal-combustion technologies for thermal plants. Coal-fired power generation has made steady progress toward enhancing energy efficiency and reducing CO_2 emissions.

The energy sector accounts for more than two-thirds of global greenhouse-gas emissions today, and energy-related CO_2 emissions are projected to rise by 20% by 2035.[10] As late as 2011, coal accounted for 44% of the world's total CO_2 emissions and for 73% of CO_2 emissions from power generation.[11] CO_2 emissions are forecast to decline in OECD countries but will continue to

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[8] For more information on these technologies, see IEA, *Energy Technology Perspectives 2012: Pathways to a Clean Energy System* (Paris: IEA/OECD, 2012), chap. 8.

[9] The IEA projects that only around 1% of global fossil-fueled power plants will be equipped with CCS by 2035. IEA, *World Energy Outlook 2013*, 70.

[10] IEA, *World Energy Outlook 2013*, 79.

[11] IEA, *World Energy Outlook 2013*, 574.

climb dramatically in non-OECD Asia, overwhelmingly led by China and India. Coal is the least environmentally friendly energy source among fossil fuels, with the ratio of CO_2 per thermal unit emitted by coal, oil, and natural gas being 5:4:3.

That being said, the average efficiency of coal-fired power-generation units varies widely across countries because power-generation technologies affecting CO_2 intensity factors and fuel consumption are diverse.[12] Subcritical technology, the most commonly deployed in coal-fired power units, is typically designed to achieve up to 38% of thermal efficiencies with a CO_2 intensity factor of 881 grams (g) CO_2/kilowatt-hour (kWh) and with fuel consumption of 379 g coal/kWh.[13] Supercritical technology typically achieves up to 42% of thermal efficiencies with a CO_2 intensity factor of 798 g CO_2/kWh and with fuel consumption of 343 g coal/kWh. Ultra-supercritical technology achieves up to 45% of thermal efficiencies with a CO_2 intensity factor of 743 g coal/kWh and with fuel consumption of 320 g coal/kWh. Advanced ultra-supercritical technology aims to increase thermal efficiencies to up to 50% with a CO_2 intensity factor of 669 g CO_2/kWh and with fuel consumption of 288 g coal/kWh.[14]

Dissemination of other technologies to decrease needed volumes of coal per thermal unit, including integrated gasification combined-cycle and combined heat and power, is also anticipated. Approximately, three-quarters of coal-fired thermal plants in operation in the world today use subcritical technology.[15] In other words, there exists huge potential to replace outdated thermal units with upgraded technologies for cleaner use of coal. The IEA predicts that the average efficiency of coal-fired generation will improve from 36% to 40% by 2035 as old subcritical coal-fired thermal plants are retired and increasingly replaced with higher efficiency technologies, including supercritical, ultra-supercritical, integrated gasification combined-cycle, and combined heat and power technologies.[16]

The United States and Japan have been two of the countries leading the advancement of CCT.

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[12] IEA, *Energy Technology Perspectives 2012*, 284.

[13] In this paragraph, the CO_2 intensity factor is based on net lower heating values; and fuel consumption is estimated for coal with a heating value a 25 megajoule (MJ)/kg.

[14] IEA, *Energy Technology Perspectives 2012*, 284.

[15] IEA, *Energy Technology Perspectives 2012*, 279–80.

[16] IEA, *World Energy Outlook 2013*, 182.

They thus can play a critical role and even have the responsibility to accelerate R&D in the area of CCT to achieve further technological improvement as well as reduce the deployment cost of diffusing CCT globally. President Obama's Climate Action Plan, published in June 2013, defined the dissemination of CCT as one of its priorities. Likewise, CCT has been one of the main policy drivers for Japan to enhance international cooperation on energy, especially in Asia, including with China and India. Following a July 2013 meeting in Washington, D.C., the Japanese minister of economy, trade, and industry Toshimitsu Motegi and U.S. secretary of the department of energy Ernest Moniz issued a "Joint Statement Concerning Bilateral Cooperation in the Energy Field" that identified CCT as a priority area.

Geopolitical Implications

As a matter of fact, drastic increases in coal consumption are virtually inevitable and irreversible especially, in Asian markets, even if the growth rate of coal consumption could be slowed through the more efficient use of coal and increases in other energy sources. In fact, it can even be recommended that we should continue to make the best use of coal as a crucial energy source to meet the spiking global energy demand. The utilization of coal will have a positive impact on both economic sustainability, especially in developing countries, and geopolitical stability.

Coal production areas are geographically more dispersed and less concentrated than crude oil and natural gas. The self-sufficiency rate of coal is reasonably high in Asia. Even though China and India are net importers of coal, they are still projected to produce 92% and 65%, respectively, of the coal they consume as late as 2020.[17] Indonesia, notwithstanding increasingly aggressive use of coal for domestic consumption, will remain the biggest steam-coal exporter in the world through 2030.[18]

Against the backdrop of surging demand for natural gas, competition over natural gas, especially among the major importers, could be reduced by incrementally increasing the availability of coal supplies along with disseminating advanced technologies to minimize per-unit consumption of coal and negative impacts on the environment. As for non-fossil energy sources,

[17] IEA, *World Energy Outlook 2013*, 145, 149.

[18] IEA, *World Energy Outlook 2013*, 151.

such as renewables and nuclear power, however proactively they may be encouraged with policy incentives, they cannot realistically replace the overwhelming share of hydrocarbons in the energy mix in the foreseeable future. Renewables such as wind and solar energy, because they depend on weather conditions, cannot be used as a baseload source of power generation. The construction of new nuclear power plants, on the other hand, entails huge upfront costs, even if nuclear generation is cost-competitive after the plant is built.

Asia's demand for oil and natural gas is skyrocketing, with the region being projected to account for more than 60% of the incremental growth in global energy demand through 2030.[19] Non-OECD Asia is predicted to account for two-thirds of the gross increase in oil demand over 2012–35.[20] The IEA forecasts that China's external dependence on oil will increase from 56% to 78% over 2012–25, while its external dependence on natural gas will increase from 22% to 40% over 2011–35.[21] Likewise, India's external dependence on oil and natural gas will increase from 75% to 93% and 25% to 43%, respectively, over the same periods. The hike in external dependence on hydrocarbon resources has aggravated concerns about the vulnerability of these emerging powers to energy security threats. In fact, the anxiety about securing access to energy resources abroad has become one of the main pretexts for China's maritime policy to reinforce naval capability. Without maximizing coal use, uncertainties over energy security stemming from geopolitical rivalries focused on access to natural gas and oil could be further intensified.

The International Role of the U.S. Coal Potential

The drastic increase in shale gas production has decreased domestic gas prices in the United States and triggered greater use of gas-fired power generation to replace coal-fired thermal plants. The drop in coal prices has enhanced the international competitiveness of U.S. coal, boosting its exports to both Europe and Asia dramatically. U.S. total steam coal exports jumped from 23,023 thousand tons in 2010 to 50,629 thousand tons in 2012.[22] During the same period, U.S. coal

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19 IEEJ, "Asia/World Energy Outlook 2013."

20 IEA, *World Energy Outlook 2013*, 503–4.

21 IEA, *World Energy Outlook 2013*.

22 IEA, *Coal Information 2013* (Paris: IEA/OECD, 2013). With respect to coking coal, U.S. exports increased from

exports to the United Kingdom increased from 1,219 thousand tons to 8,700 thousand tons, and to Germany from 935 thousand tons to 7,402 thousand tons. China almost doubled imports of U.S. steam coal from 1,445 thousand tons to 2,876 thousand tons (see **Table 2**). International energy markets have greatly benefited from the massive supplies of coal from the United States in the aftermath of the shale gas revolution. Not only the drastic reduction of U.S. imports of natural gas but also lower coal prices have reduced the volatility of hydrocarbons markets amid mounting geopolitical uncertainties in the Middle East, North Africa, and the South and East China Seas, among other places.

Table 2 *U.S. exports of steam coal (thousand tons)*

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
United Kingdo	936	598	539	212	558	361	1,052	1,523	3,352	2,343	1,219	3,800	8,700
Germany	467	828	508	355	376	133	569	1,009	1,256	729	935	2,394	7,402
Italy	65	1,248	435	62	122	23	0	135	287	217	612	1,003	4,318
Republic of K	508	531	273	177	665	580	384	72	255	392	2,523	4,882	3,884
China	8	1	0	0	0	0	3	10	220	140	1,445	876	2,876
Morocco	825	194	127	184	358	63	190	2,204	1,583	630	1,015	2,289	2,811
Netherlands	643	613	208	459	591	829	593	2,278	3,279	2,682	1,700	3,893	2,532
Mexico	373	24	96	99	80	341	156	148	457	611	983	1,713	2,457
Canada	13,524	12,457	10,859	15,569	12,680	13,625	13,909	13,386	17,555	7,447	7,245	2,431	2,161
India	0	0	0	0	224	217	71	1	72	1	171	634	1,829
Chile	48	1	1	0	86	76	1	298	774	617	1,053	1,607	1,635
Turkey	55	0	7	0	0	67	0	1	34	1	220	422	1,515
France	564	78	0	0	0	28	195	578	1,263	1,111	1,080	2,078	1,146
Belgium	278	607	458	348	555	411	363	483	1,144	602	367	1,470	1,013
Others	4,932	3,833	2,755	1,392	2,707	2,340	2,428	2,035	3,558	2,053	2,455	4,565	6,350
Total	23,226	21,013	16,266	18,857	19,002	19,094	19,914	24,161	35,089	19,576	23,023	34,057	50,629

Source: IEA, *Coal Information*, various years.

Most recently, given the escalation of the crisis in Ukraine, triggered by Russia's unlawful annexation of Crimea, and growing skepticism in Europe about the future reliability of stable natural gas supplies from Russia, the potential of increasing U.S. coal exports could be a significant factor in Europe's new energy security, addressing a pressing need to reduce dependence on Russian gas supplies. U.S. LNG exports would also have a positive impact on Europe's effort to diversify future supply routes of natural gas. Yet, doing so would take time, given the lack of LNG receiving terminals and related supply infrastructure, even if the United States could expedite LNG export projects. Thus, the more effective use of coal, capitalizing on its price competitiveness, could be a more immediate solution for Europe.

50,906 thousand tons to 63,392 thousand tons over 2010–12.

In Asia, where increasing coal supplies is of growing importance, U.S. exports would certainly be one of the available options to cushion the impact of surging energy demand. Likewise, there are increased expectations for LNG imports from the United States and Canada toward the end of the current decade.

Conclusion

Despite the prevalent negative image of coal from the standpoint of environment protection, the importance of coal will undeniably increase over the foreseeable future. Given the growth of energy demand, the effective use of coal should be encouraged, especially in Asia, where the self-sufficiency rate of coal is remarkably high. Otherwise, surging demand is likely to increase the volatility of regional energy markets by raising consumption of alternative hydrocarbons—natural gas, in particular—which in turn may negatively affect the global energy market and economy.

To accept coal as a crucial component of the energy mix does not mean downplaying the importance of enhancing countermeasures against environmental burdens. A variety of clean-coal technologies are available and are expected to be disseminated globally. We need to choose a balanced approach that recognizes the merit of utilizing coal by taking into account both economic viability and environmental burdens. Making an either-or judgment would bring about a solution to neither challenge.

Beyond the question of the stability of energy markets, the proactive use of coal is also of rising importance for reducing geopolitical uncertainties. Minimizing the use of coal would intensify international competition over oil and natural gas. The United States can play a very positive role through increasing coal exports against the backdrop of the shale gas revolution. Accordingly, new market opportunities for CCT should be explored.

The United States and Japan have the world's most advanced CCT, and it is highly recommended that both countries make an effort to expand the economy of scale with regard to worldwide dissemination of this technology. This is critical to simultaneously stabilizing the global energy market, reducing geopolitical uncertainties over energy resources, and tackling environmental challenges.