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Enabling Clean-Coal Technologies in Emerging Asia

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EXECUTIVE SUMMARY

This working paper discusses the rapid increase of coal use in coal-fired power generation to meet growing electricity demand in emerging economies of the East Asia Summit region and calls for policies to support the dissemination of clean-coal technologies (CCT) to abate carbon dioxide (CO_2) and greenhouse gas (GHG) emissions.

Main Findings

Coal will continue to be the dominant energy source for emerging Asia. In order to address rising electricity demand, emerging Asia will likely continue to build low-cost coal-fired power generation—low-efficiency coal-fired power plants. At the same time, compared with past decades, world leaders are taking climate change more seriously. The U.S. and China reached bilateral agreements to cooperate on clean energy development and mitigate GHG emissions, and the Obama administration has attempted to ban coal use abroad in order to abate CO_2 and GHG emissions. Although the policy has its merits, it may force emerging Asia to seek non-OECD public financing, particularly from China, which is the largest coal public financier to emerging Asia. This scenario would result in the construction of less efficient coal-fired power plants, leading to increased CO_2 and GHG emissions.

Policy Implications

- The Obama administration's current policy approach of banning coal use abroad should be reviewed. The U.S. should work to help emerging Asia afford CCT, providing that there are few available alternative energy options for the region in the medium term to meet energy demand.
- To deliver public financing for CCT to emerging Asia, it is necessary to lower the upfront costs of ultra-supercritical technologies, which are currently higher than supercritical and subcritical technologies, through attractive financing and loan schemes or strong political institutions.
- A policy framework should clearly state the corporate social responsibilities of developed and developing nations, respectively, by highlighting the near- and long-term policy measures toward the coal industry and coal-fired power generation. R&D into commercial carbon capture and storage should be accelerated.

Amid fast-growing electricity demand in emerging Asia, coal, as the most abundant and reliable energy resource, will continue to be the dominant energy source for emerging Asia. This will lead to widespread construction of coal-fired power plants, which without the employment of the best available clean-coal technologies (CCT), will result in increased greenhouse gas (GHG) and CO_2 emissions. These emissions will yield profoundly negative effects on the global environment. Meanwhile, U.S. government efforts to reduce emissions from coal-fired power generation both at home and abroad, particularly through banning overseas financing for coal plants, may have the unintended effect of encouraging widespread construction of less efficient coal-fired power plants in power-hungry emerging Asian economies. Thus, policy approaches must be reviewed to assist emerging Asia to afford CCT and allow for more sustainable growth across the Asia-Pacific region.

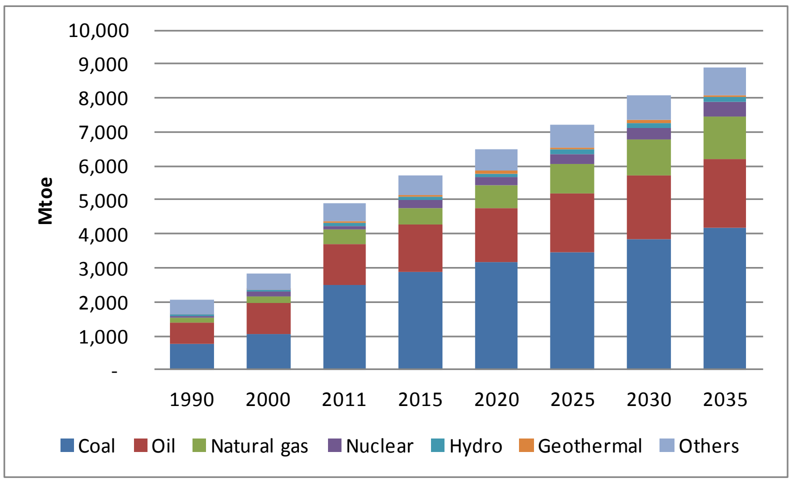
This paper describes growing energy demand in emerging Asia and the need for mechanisms to encourage the broader dissemination of CCT in developing countries. The paper begins with a discussion of the increase of coal use in emerging Asia in order to highlight how coal consumption will more than double by 2035. The second section highlights the affordability and secure supply of coal, its price competitiveness over natural gas, and the overall political factors behind coal use in terms of energy security. The paper then describes the negative effects of increasing coal use in emerging Asia on global and regional environmental security if not paired with the proliferation of more sustainable energy development. Next, the paper discusses how good policy intentions in the United States could actually worsen global emissions, as emerging Asia will seek financing from other actors for coal-fired power plants. It then examines the efficiency of CCT compared with other conventional technologies. The paper concludes by discussing the need for political, institutional, financial, and community support for CCT deployment and describing the mechanisms and support that should be in place to enable emerging Asia to afford CCT technologies.

The Increase of Energy Demand and Coal Use in Emerging Asia

The center of gravity of global economic growth has shifted to the Asia-Pacific. This dynamic region represents 55% of the world’s population and 53% of global GDP. Rapid economic growth has led to marked increases in energy demand in the region, and developing

Asia will continue to lead in energy demand growth. ERIA's study, "Preparation of Energy Outlook and Analysis on Energy Saving Potential in East Asia," which covers East Asia, Southeast Asia, and India, shows that primary energy demand in these countries is projected to grow at a faster pace of 2.5% per year on average from 4,910 million tonnes of oil equivalent (Mtoe) in 2011 to 8,912 Mtoe in 2035.[1] The share of coal in total primary energy demand will decline from 51.1% in 2011 to 46.6% in 2035. Although coal will still constitute the largest share of primary demand, its growth is expected to be slower, increasing at 2.1% per year. In absolute terms, coal consumption will almost double from 2,507 Mtoe in 2011 to 4,155 Mtoe in 2035 (see **Figure 1**).

Figure 1 Primary Energy Demand in the EAS Region (1990–2035)

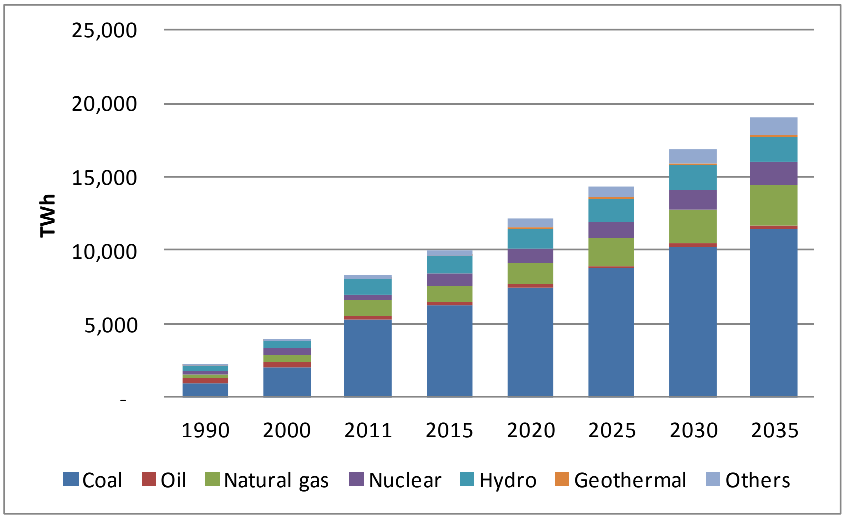


Source: Shigeru Kimura, "Preparation of Energy Outlook and Analysis on Energy Saving Potential in East Asia," Economic Research Institute for ASEAN and East Asia (ERIA), 2014.

Coal is projected to remain the dominant source of electricity generation in the East Asia Summit (EAS) region because of a strong increase of demand in power generation, which has grown at 3.5% per year on average from 2011 (see **Figure 2**). The share of coal consumption in the region's power generation mix is projected to continue to be the largest and will remain above 60% of the total until 2035.

[1] For the full study, see Shigeru Kimura, "Preparation of Energy Outlook and Analysis on Energy Saving Potential in East Asia," ERIA, 2014. The scope of data in this study refers to sixteen countries of ASEAN and East Asia. It excluded the United States and Russia. In regard to terminology, primary energy refers to energy in its raw form, before any transformations—most significantly, the generation of electricity.

Figure 2 Power Generation in the EAS Region (1990–2035)



Source: Kimura, "Preparation of Energy Outlook and Analysis."

Increased coal use in East Asia, Southeast Asia, and India mainly stems from a robust increase of electricity consumption to drive economic growth. Although these countries have also experienced fast-growing natural gas demand, coal will remain strategically important for the energy security of many in the region.

China's Coal Reliance

China is the world's largest coal producer and consumer and has the third-largest coal reserves, with recoverable reserves of 114.5 billion tonnes. In 2012, China produced 3.65 billion tonnes of raw coal. The current coal power fleet is two and half times the size of the U.S. fleet.[2] Coal-based power plants constitute 69% of China's installed capacity, making the country greatly dependent on coal as a source of power generation (see **Figure 3** and **Figure 4**).

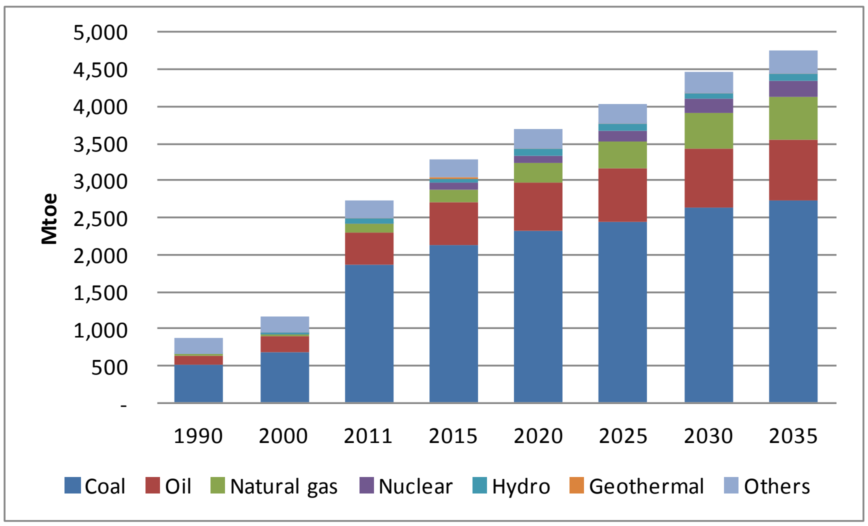
However, serious local pollution has led China to reinforce standards and measures aimed at reducing the share of coal-based electricity to less than 62%.[3] Though the country will largely

[2] Armond Cohen, "Learning from China: A Blueprint for the Future of Coal in Asia," interviewed by Jacqueline Koch," National Bureau of Asian Research (NBR), Policy Q&A, April 21, 2014.

[3] Mridul Chadha, "China Sets Coal Consumption Standards for Power Plants," September 30, 2014, http://cleantechnica.com/2014/09/30/china-sets-coal-consumption-standards-power-plants/.

continue to depend on coal use for power generation and other heavy industries for decades to come unless it finds its own technical breakthrough to tap shale gas in its territory, China's coal consumption will likely peak in 2020, with the share of coal-fired power under the business-as-usual (BAU) scenario projected to experience a decreasing trend from 79.0% in 2011 to 69.2% in 2035.[4] Shale gas has been considered an alternative to coal in the country's energy mix, but the current shale gas technology that has proved to be effective in the United States does not seem applicable to China because of geographical and water stress issues.

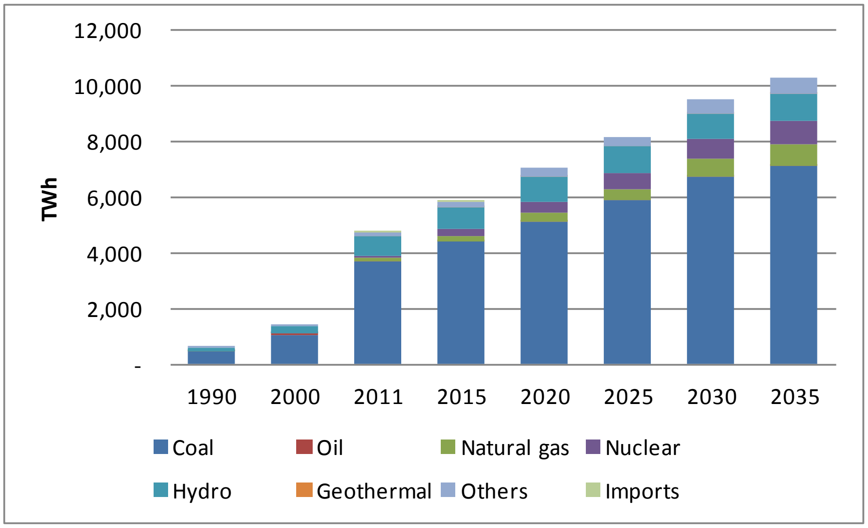
Figure 3 China's Primary Energy Demand



Source: Kimura, "Preparation of Energy Outlook and Analysis."

[4] Li Zhidong, "Peak Coal in China: Rethinking the Unimaginable," NBR, Special Report, no. 47, November 2014, http://www.nbr.org/publications/element.aspx?id=792.

Figure 4 Power Generation in China



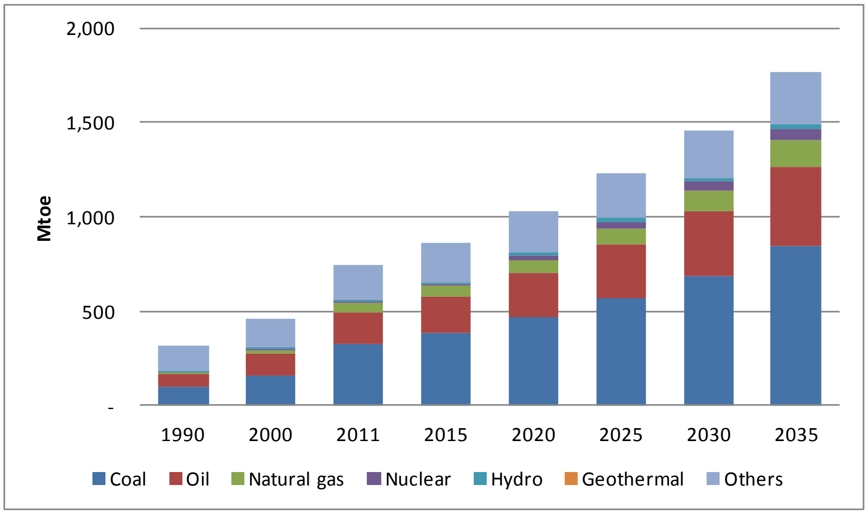
Source: Kimura, "Preparation of Energy Outlook and Analysis."

India: A Leader in Coal Consumption and Production

India is another large coal consumer in Asia and has huge coal reserves estimated at 301.56 billion tonnes, of which non-coking coal accounts for about 88%. India's coal demand will grow at 4.0% per year and reach 844 Mtoe in 2035, from 326 Mtoe in 2011, maintaining the largest share at 47.6% in 2035 (43.5% in 2011). India's overall coal imports have increased to about 168.4 million tonnes in fiscal year (FY) 2013–14, which is up approximately 140% from 70.4 million tonnes in FY2010–11. The current total coal production in India is estimated at 565.6 million tonnes, and coal demand in the power sector alone is estimated at 551.6 million tonnes.[5] Under the BAU scenario, India's power generation will be increasing at 5.5% per year to 3,827 terawatt-hours in 2035, and coal will continue to dominate India's power-generation mix, maintaining a share of over 65% (see **Figure 5**).

[5] Bidhu Bhushan Palo, "India's Coal Imports Due to Low Production, Regulatory Obstacles: Coal Minister," *Dollar Business*, December 18, 2014, https://www.thedollarbusiness.com/indias-coal-imports-due-to-low-production-regulatory-obstacles-coal-minister.

Figure 5 India's Primary Energy Demand



Source: Kimura, "Preparation of Energy Outlook and Analysis."

Rising Coal Demand in the Association of Southeast Asian Nations (ASEAN)

ASEAN coal demand is projected to triple from 2011 to 2035, growing on average at 4.7% per year.[6] The strong increase in demand for coal throughout ASEAN, particularly to generate electricity, is driven by its relative abundance and low prices compared with alternative fuels and technologies. Coal consumption in ASEAN is projected to overtake natural gas after 2020 to become the second-largest component of ASEAN's energy mix, with its share reaching 27% in 2035.[7] While this counters the shift away from coal in many other regions of the world, the trend is consistent with what has been experienced during periods of rapid economic and energy demand growth in major developing countries in Asia, notably China and India. However, rapidly rising coal demand means that ASEAN's energy-related CO_2 emissions could virtually double over the next 20 to 25 years, rising by more than 1 billion tonnes.[8]

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[6] Kimura, "Preparation of Energy Outlook and Analysis."

[7] Kimura, "Preparation of Energy Outlook and Analysis."

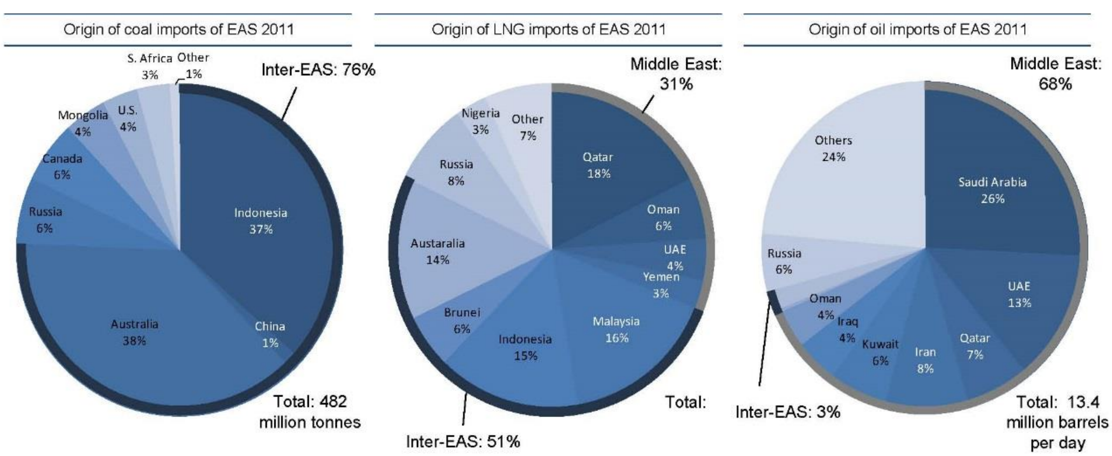
[8] Kimura, "Preparation of Energy Outlook and Analysis."

Why Is Emerging Asia Largely Reliant on Coal?

Developing countries in Asia will continue to rely on coal as a key source of energy due to the perception that it is reliable, abundant, and affordable. Coal production in East Asia, Southeast Asia, and India constitutes 76% of developing Asia's total coal consumption.[9] This means that since coal, unlike petroleum and natural gas, is mainly produced and consumed within the region, these countries do not need to be as dependent on the Middle East, where political uncertainty raises concerns over transport security at strategic pathways such as the Strait of Hormuz.

Coal has historically been self-sufficient in East Asia, Southeast Asia, and India, meaning its production has been sufficient to meet its consumption, and has also shown the highest self-sufficiency among all fossil fuels.[10] Therefore, it can be considered the most secure natural resource for these countries. In contrast, **Figure 6** shows that about 50% of the natural gas consumed is produced within the region, while 31% is being imported from the Middle East. About 3% of the petroleum consumed is regionally produced, with 68% being imported from the Middle East. Thus, coal has proved to be more viable and domestically available than natural gas and oil.

Figure 6 Origin of Coal, Natural Gas, and Oil Import in the EAS region



Source: Hironobu Oshima, ed., "Study on the Strategic Usage of Coal in the EAS Region," ERIA, Research Project Report, no. 27, June 2013.

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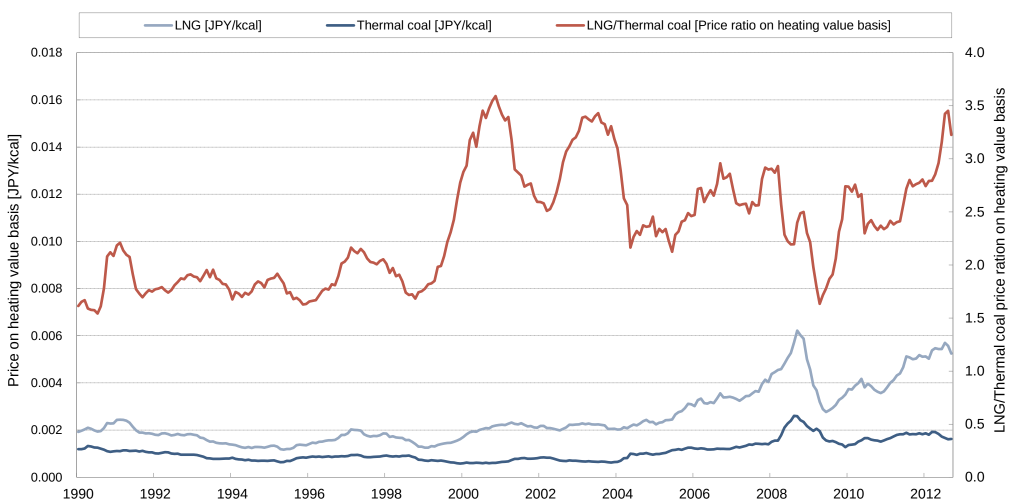
[9] Kimura, "Preparation of Energy Outlook and Analysis."

[10] Hironobu Oshima, ed., "Study on the Strategic Usage of Coal in the EAS Region," ERIA, Research Project Report, no. 27, June 2013.

Additionally, coal demand in East Asia is driven by the relative abundance and low price of coal in the region (see **Figure 7**), which leads to coal being favored over oil and natural gas, particularly in power generation where substantial new capacity is required. Many of the region's gas-producing basins are located far from demand centers; thus, gas demand will increasingly be met by imports of liquefied natural gas (LNG), which promise to be more expensive relative to coal. Furthermore, the price of coal on a heating value basis has always been more competitive than natural gas, providing high economic rationale to use coal in power generation and other heavy industries. Historically, the LNG/thermal coal price ratio has been between 1.5 and 3.5, except in 2009. In January 2013, LNG prices were 0.0056 Japanese yen per kilocalorie (kcal) ($15.85 per million British thermal units, or MMBtu) and thermal coal was priced at 0.0017 yen per kcal ($117.57 per tonne), putting the price ratio at 3.3.[11]

Figure 7 Comparison of Coal and Natural Gas Prices



Source: Ministry of Finance (Japan), Import Statistics, 2013.

The above facts and trends show that coal consumption in ASEAN, China, and India reflects affordability and energy security concerns. The heightened demand for coal is backed by the robust increase of electricity consumption. ASEAN, China, and India are considering

[11] For the heating value conversion, the IEA energy conversion rate was used at 1 MMBtu = 251,995.79631 kcal. The average exchange rate of the Federal Reserve for January 2013 was used at US$1 = JPY89.0581. The average heating value of imported thermal coal to Japan was 6,142 kcal/kg. The same exchange rate as for the LNG conversion was used at US$1 = JPY89.0581.

introducing CCT in order to utilize coal cleanly; however, emerging economies may face constrained access to this technology due to higher upfront costs.

The Balance of Energy and Environmental Security

If not paired with the proliferation of more sustainable energy development, increasing coal use in emerging Asia will have negative effects on the region's environmental security. With the projected increase in coal-fired generation capacity, local pollutants—CO_2 and GHG emissions—will become major issues in the future. Based on the Environmental Protection Agency's Global Greenhouse Gas Emissions Data, almost 60% of GHG emissions in 2008 were from the burning of fossil fuels.[12] China, the United States, and India are the largest emitters, contributing 23%, 19%, and 6% of global GHG emissions, respectively. Given the need for substantial new capacity to generate power, unabated coal-fired power-generation plants are increasingly being constructed in developing Asia. These trends highlight the importance of addressing the environmental sustainability of powering emerging Asia's economic development.

Concerns about the threat of global warming have resulted in a number of international treaties on climate change, including the Kyoto Protocol in 2005, Doha Amendment in 2012, and subsequent negotiations to agree on a post-Kyoto legal framework held in Paris in 2014. Yet these treaties have not produced any consensus that requires all major polluters to pay for CO_2 emissions. Recent months, however, have shown some progress, with world leaders introducing major changes in November 2014 at the Asia-Pacific Economic Cooperation (APEC) meeting held in Beijing and the recently announced bilateral agreement between the United States and China. This agreement calls for cooperation on clean energy development and the mitigation of GHG emissions. For the United States, the new target is to reduce emissions by 26%–28% from 2005 levels by 2025. Coal use in the United States peaked in 2008, due to the availability of cheap domestic natural gas, which has displaced huge amounts of coal demand. As a result, GHG emissions have been reduced by 7.7% since 2006.[13]

[12] "Global Greenhouse Gas Emissions Data," U.S. Environmental Protection Agency, http://www.epa.gov/climatechange/ghgemissions/global.html.

[13] Mark Thurber, "Coal in Asia and the Impact of the Shale Gas Revolution," interviewed by Lynann Butkiewicz, NBR, Policy Q&A, March 21, 2013, http://www.nbr.org/downloads/pdfs/ETA/PES_Thurber_interview_03212013.pdf.

Under the bilateral agreement with the United States, China committed to peak emissions by 2030. Efforts to reduce emissions are driven in part by local pollution and rising public concerns about the level of toxicity in the air. China's implementation of the Action Plan for Air Pollution Prevention and Control in 2013 capped the emissions of some provinces, and coal consumption is expected to be reduced by approximately 350 million tonnes by 2017 and 655 million tonnes by 2020 compared with a BAU scenario.[14] While Chinese leaders committed to peak emissions by 2030, coal will remain a major fuel used in power generation and other heavy industries. Yet the coal industry is expected to operate under stringent environmental standards by which new coal power plants will at least use ultra-supercritical technologies and add more generation capacity from nuclear power plants and renewable energy. China is also expected to reduce the coal-fired power generation capacity from about 800 gigawatts (GW) of installed capacity today to 650 GW by the end of 2020. This means that China will likely see a 20% decrease of its coal power capacity by the end of this decade.

The Role of the Asia-Pacific in Addressing Global Emissions

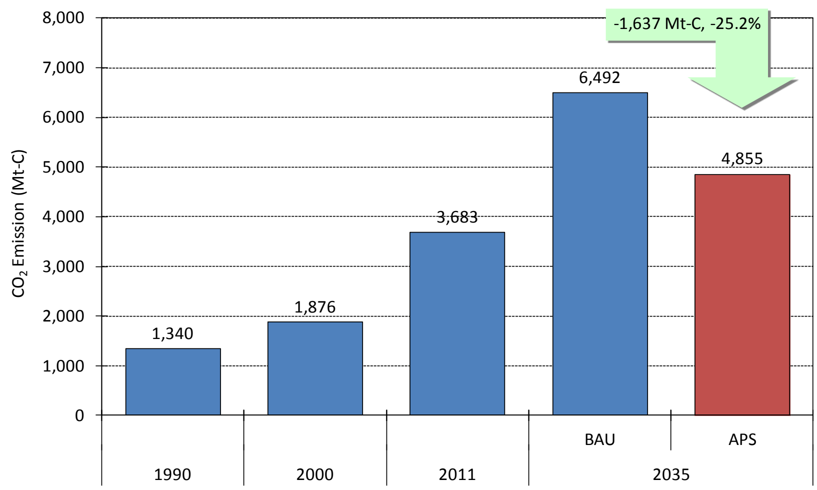
These steps to curb CO_2 and GHG emissions are positive, and the Asia-Pacific will need to play a key role in further combating the negative effects of climate change. The Intergovernmental Panel on Climate Change suggests that to keep the increase in global mean temperature to not more than two degrees centigrade compared with preindustrial levels, global CO_2 emissions would need to peak between 2000 and 2015 and be reduced to 15%–50% of year 2000 levels by 2050. Despite efforts to reduce emissions in major economies such as the United States and China, ERIA has shown that, for East Asia, Southeast Asia, and India, CO_2 emissions from energy consumption in the BAU scenario are projected to increase from 3,683 million tonnes of carbon (MtC) in 2011 to 6,492 MtC in 2035 (see **Figure 8**), implying an average annual growth rate of 2.4%.[15] As shown in

[14] "Debunking the Myths of OECD Export Credits for Coal," World Wildlife Fund, Briefing Paper, September 2014.

[15] Kimura, "Preparation of Energy Outlook and Analysis."

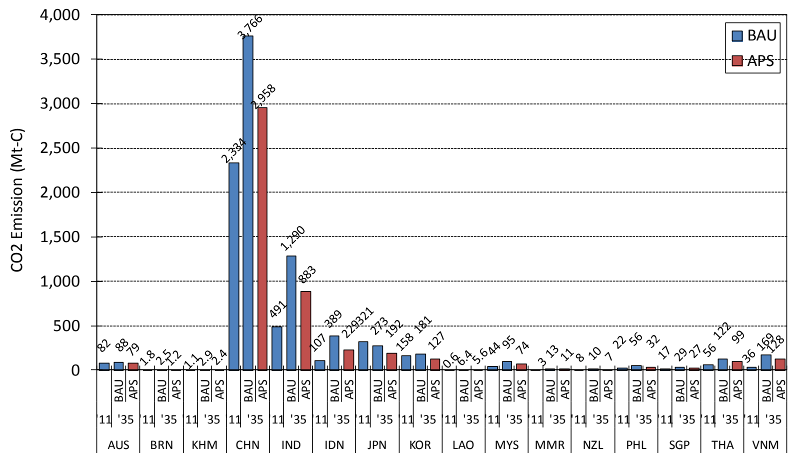
Figure 9, emissions and emission growth in this region are projected to be dominated by China and India.[16]

Figure 8 Total CO_2 Emissions under BAU and Alternative Policy Scenarios



Source: Kimura, "Preparation of Energy Outlook and Analysis."

Figure 9 CO_2 Emissions by Country under BAU and Alternative Policy Scenarios



Source: Kimura, "Preparation of Energy Outlook and Analysis."

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[16] In fact, China and India will account for 1,432 MtC and 799 MtC, respectively, of the projected 2,809 MtC increase in EAS region emissions from 2011 to 2035 under the BAU scenario, or 79.4% of the total growth in the EAS region. Adding Indonesia's growth of 281 MtC, these three countries account for 2,469 MtC or 89.4% of the total growth in the EAS region. Japan is the only country in the region whose emissions are projected to decline under the BAU scenario as a result of improved energy efficiency and increased utilization of renewable energy.

The Pros and Cons of Ending Public Financing for Coal

In part due to these projections of rising emissions, public financing for coal plants in the Asia-Pacific and elsewhere has been criticized by some policymakers and citizens. Coal has historically been a major fuel for steam coal-fired power generation in North America, especially the United States and Canada.[17] However, the Obama administration recently called for the end of public financing for new coal plants overseas in an attempt to implement the U.S. National Climate Action Plan, released in July 2013, a move that was supported by some countries in the Organisation for Economic Co-operation and Development (OECD) and multilateral development banks such as the World Bank Group, the European Investment Bank, and the European Bank for Reconstruction and Development.[18]

The implementation of this ban on overseas coal has affected institutions domestically and abroad and could have a profound effect on emerging Asia, where rapid increases in energy demand are needed to sustain economic growth. Emerging economies will build whatever they can to meet such demand, and from their perspective, coal is the most probable fuel to be utilized in power generation due both to its cost competitiveness compared with other fuels and to energy security reasons, with coal supply in the region being stable and reliable.

Thus, policies that ban public financing for coal plants have raised questions: Will the pace of building coal-fired power plants in emerging Asia slow down? Or will more coal-fired power plants with less efficiency be built in emerging Asia, thus increasing CO_2 and GHG emissions?

China Leads in Financing Coal Plant Development

To fulfill its energy demand, emerging Asia will look to other countries. From 2009 to 2013, China represented about 40% of the total amount of public financing for coal power plants in the developing world.[19] Thus, if public financing on coal power plants from the United States and other states halts, China will have a huge opportunity to fill the gap of providing public

[17] The United States was once called "king coal" as it possesses a huge coal reserve that could last for more than two hundred years with average production during high demand before 2008.

[18] "The United States and International Climate Policy: United States Coal Diplomacy," Climate Adviser, Monthly Report, September 2014.

[19] Takahiro Ueno, Miki Yanagi, and Jane Nakano, "Quantifying Chinese Public Financing for Foreign Coal Power Plant," Graduate School of Public Policy, University of Tokyo, Working Paper, November 2014, http://www.pp.u-tokyo.ac.jp/research/dp/documents/GraSPP-DP-E-14-003.pdf.

financing to foreign coal power plants and to expand the export of Chinese manufactured boilers and steam turbines to developing countries. As discussed above, emerging Asia will largely depend on coal to meet rapidly increasing demand and to sustain robust economic growth, and these countries can argue that developed countries were not constrained by any limits during their economic development.

Utilizing Clean-Coal Technologies: A Better Way to Build

Striking a balance between coal use and environmentally friendly technologies requires an approach to deal with coal use in emerging Asia as well as to combat the GHG emission potentials from burning coal. To date, the best available and mature technological developments on CCT to generate power from coal are combustion and gasification technologies.[20] CCT technologies for coal combustion generally deploy higher steam conditions, i.e., ultra-supercritical, supercritical, and subcritical technologies. The ultra-supercritical and supercritical technologies, however, are more suitable for larger units. For units of less than 400 megawatt-electrical output, the advantages of the higher steam conditions may not be realized. Integrated gasification combined cycle, though less mature than combustion technologies, can potentially offer high efficiencies from smaller capacity units.

The dissemination of CCT technologies for the clean and efficient use of coal in emerging Asia is of pressing importance. In 2013, ERIA concluded that the application of inefficient technologies and ineffective environmental standards and regulations would lead to a waste of valuable coal resources.[21] To facilitate informed decision-making, ERIA's study examined various technologies (ultra-supercritical, supercritical, and subcritical boiler types), comparing their thermal efficiencies, investment costs, maintenance costs, fuel consumption, and CO_2 emissions (see **Table 1**). ERIA found that the use of highly efficient technology such as ultra-supercritical will provide better economic returns in any coal price scenario, and the electricity produced from ultra-supercritical plants is cheaper than the electricity produced from supercritical or other conventional technologies.

[20] The CCT in this paper refer to ultra-supercritical technologies for combustion and also to integrated gasification combined cycle. Though there have been debates about whether CCT also include carbon capture and storage (CCS), because CCS is not commercialized, it is not considered for the CCT deployment to emerging Asia.

[21] Oshima, "Study on the Strategic Usage of Coal in the EAS Region."

Table 1 Comparing the Upfront Cost of Ultra-supercritical, Supercritical, and Subcritical Technologies

	Boiler Type		
	Ultra Super Critical (USC)	Super Critical (SC)	Sub-critical (C)
Thermal Efficiency	41.5% ~ 45.0%	40.1% ~ 42.7%	37.4% ~ 40.7%
Initial Cost	1,298 mln USD	991 ~ 1,240 mln USD	867 ~ 991 mln USD
Fuel Consumption	2,229,000 tons/year (100%)	2,275,000 tons/year (+2.1%)	2,413,000 tons/year (+8.3%)
CO2 Emission (ton/year)	5,126,000 tons/year (100%)	5,231,000 tons/year (+2.11%)	5,549.000 tons/year (8.3%)
O&M Cost	3.42 mln USD/year	4.1 mln USD/year	5.0 mln USD/year
Generation Cost at USD 100/ton (USD cent/kWh)	4.03 cent/kWh (100%)	4.19 cent/kWh (+3.9%)	4.44 cent/kWh (+10.2%)
Examples	✓ "Isogo" J-POWER ✓ "Tachibanawan" J-POWER ✓ "Nordjylland", Denmark ✓ Xinchang, China	✓ "Takehara" J-POWER ✓ "Matsushima" J-POWER	✓ Taichung Power Plant ✓ Thai Binh 2

Source: Oshima, "Study on the Strategic Usage of Coal in the EAS Region."

The Costs of Improved Efficiency

Although ultra-supercritical technology is one of the best options to raise plant efficiency and reduce CO_2 and GHG emissions, many developing countries cannot afford this technology because its upfront investment costs are higher than those of supercritical and conventional technologies. For example, the 3rd Energy Efficiency Conference held on January 16, 2015, in Phnom Penh showed that Cambodia is one of the Southeast Asian countries that has just recently started to use coal-fired power plants; but its plant efficiency is only about 32%. This is very low compared with ultra-supercritical technology, which could raise the plant efficiency to 50%.[22] Additional capacity of coal-fired generation in Cambodia will build on this type of low-efficiency or subcritical plant. This clearly showed that Cambodia will face local pollution in the future as a result of high emissions. Such a situation could be eased by the introduction of ultra-supercritical technology in emerging economies such as Cambodia. This situation will be common among emerging countries in Asia, such as Myanmar, Lao PDR, and others, and it raises the question of how we can help developing Asia afford CCT from in the future.

[22] Han Phoumin (remarks at the 3rd Energy Efficiency Conference held by ERIA and the Ministry of Mine and Energy, Cambodia, 2015).

It is also important to note that making CCT more affordable is in the interest of other powers in the Asia-Pacific as well. For example, Japan's public financing on coal-fired plants ranks third after China and South Korea,[23] and the country has an interest in deploying the best available technologies of coal-fired power plants to emerging Asia to drive down costs. Japan's CCT technologies include higher-efficiency thermal plants (with less CO_2 emissions) compared with the CCT of China and Korean, but the upfront costs are higher compared with those of China, South Korea, or conventional power plants. If barriers to access ultra-supercritical technologies are not addressed, and if support from developed countries is insufficient, these countries will be unable to afford these technologies, which have the ability to reduce CO_2 and GHG emissions. Thus, there is a need to lower upfront costs by exploring mechanisms to ensure that such available and matured technologies could be used in emerging Asia for the benefit of all.

The Need for Political, Institutional, Financial, and Community Support for CCT Deployment

The developed economies may understand the issue of coal consumption in Asia, as they once relied on coal as an engine of growth to meet power demand, until cheap natural gas and other forms of energy proved to be abundant and gradually replaced coal. As energy demand grows in Asia, the world cannot abate CO_2 and GHG emissions without active participation of the developing world. Coal will remain a vital part of emerging Asia's energy mix for decades, and coal is certainly regarded as the best available fuel option to meet growing electricity demand. Although developing Asia is trying to diversify through energy alternatives such as solar, wind, geothermal, and hydropower, the share of these alternatives in the energy mix is relatively small.

[23] Takahiro Ueno, Miki Yanagi, and Jane Nakano, "Quantifying Chinese Public Financing for Foreign Coal Power Plant," University of Tokyo, GraSPP Discussion Paper, November 2014, http://www.pp.u-tokyo.ac.jp/research/dp/documents/GraSPP-DP-E-14-003.pdf.

China remains greatly dependent on coal for heavy industries and electricity needs and has reached a crossroads in its development, facing the need of maintaining robust growth while keeping the environment in check. Domestic pollution in China threatens Beijing's air and water quality, and China has been forced to take serious action to limit CO_2 emissions through its Action Plan for Air Pollution Prevention and Control since 2013 and through its subsequent commitment to the U.S.-China Joint Announcement on Climate Change in November 2014 in Beijing. Thus, emerging Asia will take this position regarding the rising energy demand for growth and especially the demand for electricity, and thus their need for coal-fired power generation is understandable.

The efforts of developed economies to ban coal financing have their merits, but they need to understand the potential unintended impacts of these policies. Technological developments in CCT have been fast achieved in developed nations, while the transfer of CCT to the developing world has been slow. The actions taken to abate CO_2 and GHG emissions have gained momentum in the developed world, while developing nations lack the means to afford the available technologies to reduce emissions. Perhaps emerging economies do not need to be faulted for continuing to use conventional coal power plants and other cheap technologies; rather, it is the responsibility of developed nations to help and disseminate the best and available technologies of highly efficient coal-fired power plants to the developing world.

From an institutional viewpoint, legislation can drive industry to deploy effective, commercially available equipment to reduce emissions. The worldwide delay in demonstrating carbon capture and storage (CCS) as a technology option has led to the increased importance of raising plant efficiency at this point. It is crucial to encourage institutions to design policies that would deploy highly efficient, low-emission technologies, such as CCT. The use of CCT in coal-fired power plants will result in, for each unit of electricity generated, lower fuel consumption, reduced emissions of local pollutants, and decreased CO_2 emissions. In addition, a more efficient plant consumes less water and makes the future retrofit of CCS more attractive. In this regard, if the emerging economies could use CCT, the accumulated CO_2 and GHG emissions will be much lower in this scenario. However, policy barriers affect the deployment of CCT.

Through concerted efforts and political determination, developed nations need to continue to fund R&D to ensure that coal use is cleaner and better for society and to help diffuse technology transfer to the developing world as fast as possible. For example, commercializing

CCS cannot fall under the responsibility of developing nations because they lack the financial means for R&D on CCS as well as the necessary policy frameworks. In contrast, developed countries should invest in R&D to drive down the cost of CCS technologies and work toward future commercialization through policy frameworks, such as the Clean Development Mechanism, carbon trading, tradable permits, labeling, subsidies into R&D on coal, nuclear, and renewable technologies development.

Emerging Asia will rely on whatever CCT technologies are available in the market with affordable prices. Therefore, it is very crucial to assist these countries to acquire the best available technologies to help abate CO_2 and GHG emissions, a shared concern. Thus, the political will to speed up the technical breakthrough of using cleaner coal through combined CCS will definitely be a solution to the growing energy needs of emerging Asia. In the absence of CCS, the best available technology, such as ultra-supercritical, shall be a key priority. Policy instruments from both developed and developing nations to support CCT deployment should be in place to avoid the continuous building of low-efficiency coal-fired power plants in emerging Asia.

With the growing societal concern over global warming and pollution, a policy framework may need to a consider business approach that should clearly state the corporate social responsibilities of developed and developing nations, respectively, by highlighting the near- and long-term policy measures towards coal industries and coal-fired power generation, with the speedy acceleration of CCS R&D for commercialization.

The upfront costs of ultra-supercritical technologies are higher than lower-efficiency alternatives. Thus, lowering upfront costs is necessary through policy frameworks, such as attractive financing or loan schemes for ultra-supercritical; strong political institutions to deliver public financing on CCT to emerging Asia; and international cooperation frameworks to ensure the deployment of CCT. Without introducing these types of policy frameworks, slowing down public financial support for CCT to emerging Asia will result in the region’s use of non-OECD financing or other forms of financial support, which will result in the use of low-efficiency power plants.

Finally, community participation is essential to demand that local authorities choose technologies that are environmentally friendly and sustainable, and local participation will only be meaningful when local people are well informed of the potential impact of selected technologies. However, institutions in emerging Asia may not emphasize such local participation; thus, active organizations are needed to bridge the information gap on the potential harm of less efficient coal-fired power plants.

The deployment of CCT technologies in emerging Asia must be promoted through political, institutional, financial, and community support and participation. This will require both developed and developing nations to work together to promote economic development in emerging Asia while protecting the global environment.

Conclusions

Coal will continue to be the dominant energy source for emerging Asia, especially to generate electricity, for which demand is rising. The share of coal-fired generation is projected to be the largest and will remain above 60% of the total through 2035. The increase of coal demand for power generation is predominantly determined by its cost competitiveness compared with gas based on heating value. With such fast-growing electricity demand, emerging Asia will likely build coal-fired power generation with less capital cost—low-efficiency coal-fired power plants—whose resulting impact will harm the environment because of CO_2 and GHG emissions.

At the same time, compared with past decades, world leaders are taking climate change seriously. The U.S.-China bilateral agreement to cooperate on clean energy development and mitigate GHG emissions commits the United States to reduce emissions by 26%–28% from 2005 levels by 2025, while China committed to peak emissions by 2030. Additionally, the Obama administration announced the “end of public financing on coal-fired power generation” in an attempt to ban coal use abroad for abating CO_2 and GHG emissions. Although the policy has its merits, it may force emerging Asia to seek non-OECD public financing, particularly from China, the largest coal public financier to emerging Asia. This would result in the construction of less efficient coal-fired power plants, which would lead to increased CO_2 and GHG emissions.

This paper suggests that striking a balance between coal use and environment protections requires an approach to deal with coal use in emerging Asia while combating GHG emissions from burning coal. While CCS is yet to be commercialized, deploying the best available technologies to increase plant efficiency, such as ultra-supercritical technologies, is vitally important to reduce emissions. Thus, new architecture needs to be explored for the deployment of CCT to emerging Asia, which, as this study suggests, will require political, institutional, financial, and community participation, as well as the cooperation of developed and developing nations. With this prescription of multisector support, developed and developing economies can work together toward more sustainable growth.