PACIFIC ENERGY FORUM

AN INTERVIEW WITH
ARMOND COHEN

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Learning from China: A Blueprint for the Future of Coal in Asia

The surge in coal consumption in emerging Asia and how to mitigate the environmental impact

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This April, NBR and the Slade Gorton International Policy Center, in collaboration with the Asia Pacific Foundation of Canada, will co-host the 2014 Pacific Energy Forum, focusing on "New Frontiers in Trans-Pacific Energy Trade," in Seattle, Washington. The forum gathers high-level policymakers, industry leaders, and government representatives from across the Asia-Pacific region to explore shifting dynamics in the trans-Pacific energy trade and the challenge to help Asia meet its energy demand while safeguarding the environment.

Coal will dominate China's power landscape for decades to come and is increasing in Southeast Asia's energy mix as well. The International Energy Agency (IEA) has reported that coal will replace natural gas as the dominant power-generating fuel in the ten member states of the Association of Southeast Asian Nations (ASEAN). At the same time, energy consumption in this region is expected to double in the next twenty years, and the Asian Development Bank (ADB) estimates that coal will account for approximately 83% of electricity production in the Asia-Pacific by 2035. In advance of the 2014 Pacific Energy Forum, NBR spoke with Armond Cohen, Co-Founder and Executive Director of the Clean Air Task Force, to explore the implications of coal's growing role in the fuel mix of China and ASEAN countries—as well as India—and assess the tools and policy options available to reduce the environmental impacts.

Why is coal growing rapidly in South and Southeast Asian countries?

First and foremost, coal consumption is accelerating because of sheer power demand growth, combined with coal's rapid scalability. China offers a key example. It is already the world's largest coal consumer and has a coal power fleet that is two and half times the size of the United States' fleet. China also expects to move another 100 million people from the countryside to the city in the next 12 years and grow its middle class by 200 million by 2035. Given these projections, China estimates electric demand to roughly double by 2030. Let's also consider India, a nation of 1.2 billion people—four times the U.S. population—where the

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rapid growth of the middle class is also underway. It has only 211 gigawatts of installed electrical generating capacity, equivalent to approximately one-fifth of the capacity of the United States, and India is expected to triple its electric demand by 2030.

When power demand is growing that rapidly, you build what you can, and this very well may include taking all measures to improve efficiency, scale up renewable resources, and diversify the energy mix to include natural gas and nuclear. However, coal is readily available and transportable (no pipelines required), and coal plants can be built quickly—typically in 18 months. While figures have fallen from a much higher peak a few years ago, China still built approximately one large plant every week in 2013.

There is still considerable discussion about the wind, solar, and even nuclear boom in Asia (China is building 28 nuclear plants), yet these other power sources are slow to develop to scale, so coal is still the winner. This has played a big role in the projections for the coming years: 75% of the annual new generating capacity being added in Southeast Asia is expected to be coal-fired. It's also important to remember that only about half of China's coal is used for producing power, while slightly over 40% of its coal is used directly for industry—for example, cement and steel.

The second greatest contributor to the rapid rise in coal use is cost. Mining coal in China currently costs as little as $2–$4 per million British thermal units (mmbtu). Imported liquefied natural gas (LNG) costs $15–$20 per mmbtu in Asia, and limited domestic gas production—while in the $10 or more per mmbtu range—is husbanded for industry, not electricity. Ironically, global coal prices have dropped somewhat in recent years due to decreased electric demand from member countries of the Organization for Economic Co-operation and Development (OECD). This trend has been bolstered by the shale gas revolution in the United States, which has freed up U.S. coal for export, helping further depress global coal prices. Even nuclear plants in China are two to three times more expensive to build than coal plants. Coal plants are cheap in China not only because of lower labor costs, but due to lower intellectual property and licensing costs as well as the high level of China's construction management capability. According to the International Energy Agency (IEA), despite recent price drops, wind and solar power in Asia remains three to five times more expensive per kilowatt hour to develop than new coal power plants, ignoring the costs of the generating capacity needed to back up these renewable resources when the sun doesn't shine and wind doesn't blow.

The third factor pushing greater coal use in Asia is availability. China has the world's third largest coal reserves, after the United States and Russia. Australia and India are fourth and fifth. Globally, world proven reserves of coal are sufficient for over 100 years of consumption at current rates. True, India and China have substantial natural gas reserves as well, including shale gas, but they have been slow to scale up conventional production infrastructure, and lifting costs for gas are still much higher than for coal.

As reported by the IEA, coal will replace natural gas as the dominant power-generating fuel in the ten member states of ASEAN. What does this transition represent in terms of the use of cleaner and more efficient coal-burning technology? What are obstacles to more widespread use of this technology, and how could they be overcome?

To date, China's primary strategy has been to introduce more efficient power plants such as supercritical (high temperature), ultra-supercritical, and circulating fluidized bed plants, all of which have higher efficiency factors than the sub-critical plants dominant in OECD countries. Indeed, because of the relative youth of China's coal plants (most have been built since 2000), these plants operate at higher average efficiency than those in the United States! Needless to say, they will not be scrapped any time soon. China is the world's largest market for scrubbers—pollution control devices—and most new plants are equipped with them, although how often and how well they operate is a matter of dispute.

A second trend is towards gasification and polygeneration—the production of electricity as well as gas, chemicals, and transportation fuels through coal gasification. While this method can provide more economic output per unit of coal, the resultant combustion of the synthetic liquid fuels and synthetic natural gas results in a net addition of carbon dioxide (CO_2) to the atmosphere compared with use of oil for transportation or the use of natural gas.

Ultimately, to reconcile China's large and growing coal fleet with any reasonable climate goals will require the application of carbon capture and storage (CCS), paired with either gasification or post-combustion capture. In addition, CCS or conversion to natural gas will be required for non-process industrial coal use.

Where will the ASEAN countries be sourcing their coal? What are their options?

China, India, and Australia are the world's first-, third-, and fourth-largest coal producers, respectively. China and India supply most of their own coal, but imports from Australia and Indonesia are growing as domestic demand outstrips current mining capabilities. Japan has dramatically increased its coal use and imports since the Fukushima nuclear accident in 2011—25% alone in the last year—with a resultant increase in CO_2 emissions, and is diversifying its supply source away from Australia and toward the United States and Canada in order to increase its market leverage.

Over the long run, there are many options for coal sourcing to the region. Indonesia, Australia, Russia, and the United States are the largest exporters in the world, while China, Japan, India, South Korea, and Taiwan are the top five importers. Partly due to slack demand in the United States and Europe—as well as gas's displacement of coal there—and excess capacity in Australia, world coal prices have been on a steady downward trend for several years. Anyone counting on "peak coal" to reduce Asian coal demand will be sorely disappointed in the coming decades.

What are the projected consequences of this surge of coal consumption? What are the other tools or policies available to mitigate it?

The chief consequences of the region's coal surge are environmental and primarily related to climate. Relatively inexpensive scrubbing technologies can reduce emissions of particulates, smog precursors, emissions, and mercury to very low levels. Nevertheless, CO_2 is much tougher to address. Due to their enormous coal dependence, China and India are the world's first- and fourth-largest emitters of CO_2, respectively, with Indonesia ranked fifteenth; Malaysia and Thailand are also in the top 30. By 2035, the IEA estimates that non-OECD Asia plus Japan will account for 56% of global energy-related CO_2 emissions.

In principle, there are only three ways to reduce CO_2 from coal-based electricity production. First, you can replace coal use with other fuels or increased energy efficiency. Second, you can increase the efficiency of coal combustion itself. The third strategy is CCS. China and India are beginning to deploy the first two strategies, but not fast enough to change the story dramatically in the next few decades. Japan, as noted, with its nuclear plant closures, is going backwards on reducing CO_2 emissions by deploying more coal and gas. That elevates the importance of CCS. And, as noted before, CCS is really the only strategy available for coal use for certain processes in heavy industry.

Energy efficiency is important—but, given the surge in first-time demand resulting from urbanization and increased wealth, improvements in efficiency are not expected to significantly dent absolute demand growth. Indeed, substantial efficiency improvements are already "baked in" to the high-growth scenarios for

Asia; growth would be even higher if efficiency lagged. Improving the efficiency of coal plants is useful, but will only reduce CO_2 emissions at the margin.

Then there are renewables. Each year brings news and discussions regarding the dramatic percent increase in additions of wind and solar power in China, but this is from a very small base. Today, China derives 74% of its power from coal and about 3% from wind and solar. In 2013, China added in excess of three times more new coal electricity in kilowatt hours (kWh) than wind and solar combined. While China is building 28 new nuclear plants and aims to have up to 150 on line within two decades, this would still only produce a fraction of the power produced from coal. A recent Bloomberg study predicted that China coal use might peak as percentage of total power supply in the coming decades, but until then (and even after, according to the U. S. Department of Energy) would continue to grow in absolute amounts and still provide well over half of China's electricity in 2030, even in the best-case scenario. Moreover, this scenario will not be significantly affected by the recent coal plant construction ban in parts of coastal China; substantial development is proposed in the western and northern provinces. Due to the long life of coal plants—lasting 50 years or more—and given that China's plants are mostly less than a decade old, the current and soon-to-be-built plants will continue to retard climate progress for another half-century if nothing is done to address their CO_2 emissions.

However, there are potential game-changers. They include modular, less expensive nuclear plants that could step in to replace coal boilers on an economical retrofit basis, or the "reforming" of natural gas, which removes the carbon and produces hydrogen to make price-competitive carbon-free liquid fuels like ammonia. My organization is working hard with developers to commercialize this technology. But CCS on coal-fired power plants seems like the most likely and necessary option in the near term.

If CCS is a viable option, why has it not gained greater traction?

CCS is a real option for China coal plants both new and existing. But there are two primary barriers for deploying CCS in China, and for that matter, anywhere in the world. The first is the high cost of capturing and compressing the CO_2 emitted by a coal plant. Current CCS technology in the United States and China adds roughly 50% to the cost of operating a new coal plant, and as much as 70% to the cost of operating an existing plant. The second barrier comes in the task of disposing of the CO_2 once it has been captured. CO_2 disposal requires a dedicated network of pipelines and underground storage sites that can inject it miles underground. With the exception of certain regions in North America, this disposal network does not yet exist.

These two problems—high capture cost and the lack of pipeline and storage site availability—are interconnected. With the right strategy, they can be solved in China and the rest of the world.

A strategic approach to establish widespread CCS in China begins with using recovered CO_2 for enhanced oil recovery (EOR) on a transitional basis. In this process, carbon is injected into a new or depleted oil field, where its properties free up the oil that would otherwise not be extractable. The revenue from EOR can pay for the cost of injection, pipelines, and a substantial portion of the cost of capturing CO_2. After the oil from the fields is extracted, the second step is to inject the captured CO_2 for permanent storage in the field itself, or in saline aquifers underneath. Shenhua Coal is already undertaking the second step and is currently injecting 100,000 tons of CO_2 per year underground on a pilot basis. Japan also is starting up a pilot project to inject carbon into the seabed floor. My organization is bringing U.S. expertise to China to accelerate EOR using CO_2.

To build this pipeline and EOR network, China needs to start with cheaper sources of CO_2 than what comes from coal-fired power plants. Approximately

7% of the industrial CO_2 that is vented worldwide comes from high-purity sources such as ammonia and methanol production. This industrial subset is economical for EOR without the need for subsidies. Conservative estimates show that more than 130 million tons of CO_2 are vented from these sources each year in China alone. In Shaanxi Province, just nine methanol and ammonia plants together vent nearly 24 million tons of pure CO_2.

Once this pipeline and storage site network is built with industrial sources, it will be cheaper and easier to add CCS to China's vast coal power plant fleet. That's because the network can act as a nucleus or hub for capture-cost innovation. This is another area where my organization is pairing companies in China and the United States to work together to develop and demonstrate novel CCS technologies that are more efficient and lower-cost. For example, China's largest power producer, Huaneng, has partnered with U.S. technology start-up Powerspan to develop a lower-cost amine-capture system. With China's manufacturing costs advantages, these partnerships have the potential to drive CCS deployment far faster than a "West only" approach.

A key point to keep in mind is that innovation isn't limited to the back end of capture. In India and China, the use of underground coal gasification—where coal is gasified in the coal seam itself—could reduce CCS costs substantially; this process is being demonstrated at commercial scale and is highly suitable for China and India's coal supply. Chinese universities and industries have substantial scientific and engineering innovation capacity, and we need to increase and pick up the pace of collaboration between East and West to accelerate our CCS options.

You have suggested that we look beyond China when evaluating the implications of increased regional coal consumption. Are there lessons China has to offer in the effort to address the environmental impacts for ASEAN countries or India? What would you highlight as the most promising examples of China's efforts?

The principal lesson from China is that there are no easy or quick answers to the problem of rapidly accelerating energy consumption and the need to curb CO_2. To tame this massive problem, we will need an unprecedented technological push on multiple fronts. Here, China has pointed the way and offers both lessons and concrete value.

China has shown the unprecedented ability to manage down the costs of all forms of energy, including clean energy. China builds highly efficient coal plants at roughly half the cost of those in the United States and Europe, and has also driven down the price of wind and solar installations to below OECD levels. This is not solely due to labor cost differences; it also has to do with technical innovation and proficiency in the management of large engineering projects. If this capability can be harnessed to CCS and nuclear power, the world will benefit.

On the nuclear front, we are seeing the beginnings of this innovation path. China has begun a substantial nuclear-power development program, with 28 power plants under construction, and is building reactors at much lower costs than in the West, in part due to using several standard designs and typically building several units at each nuclear site. China is constructing advanced Western reactor designs—such as the Westinghouse AP1000 (four units) and Areva EPR (one unit)—and doing so at approximately half the cost of current Western projects building these reactors. China's AP1000 partnership with Westinghouse provides for China's evolution of this technology and associated IP ownership—which has led to design of the larger CAP1400—the first unit of which recently began construction. In addition, China is ahead of the United States and Europe in developing and demonstrating a new generation of reactors that are potentially safer, lower-cost, and, in some cases, produce less high-level nuclear waste, including those using high-temperature gas coolant technology, as well as molten salt reactors that could use thorium (or uranium) fuel. India also has undertaken a thorium demonstration program—primarily focused on using thorium to fuel conventional light-water reactors. Combined with a strengthening of nuclear safety governance and practices through China-Western cooperation, nuclear could be a competitive and highly scalable replacement for new coal plant construction in Asia by 2025 and beyond.

China and India also offer the potential to scale up CCS rapidly, utilizing EOR as a near-term accelerant, and thereby drive costs down through learning. China and India also may have the ability to innovate new CCS technologies with their growing scientific and engineering innovation capabilities. Similar innovations could occur to decarbonize the region's substantial natural gas reserves. For example, natural gas can be processed—sequestering carbon—to produce hydrogen that combines with nitrogen to create ammonia liquid fuel. Produced this way, ammonia is a "zero-carbon" fuel that can be burned in a power plant or car or truck engine. Another way to create zero-carbon ammonia is to use carbon-free electricity (such as nuclear power or renewables) to split water to produce hydrogen, which is then combined with nitrogen to produce liquid ammonia.

The ultimate hope that China, and perhaps all of Asia, offers to solve the global warming and energy problem is this: energy innovation historically tends to occur more rapidly where there is economic growth and the underlying need for more power. Asia's energy demand will grow rapidly in the coming decades, generating the markets in which experimentation can take place. By contrast, shrinking OECD energy markets are largely saturated with existing supply, so producing clean energy involves the costly replacement of functioning equipment. The incremental cost of building something that is new and clean is generally lower than the total cost of replacing something old and dirty. If Asian nations put their strategic minds to finding solutions and collaborate with global companies and nations, the steep Asia energy growth curve could move from being a major global warming liability into a powerful asset.

THE PACIFIC ENERGY FORUM *convenes experts and leaders from Asia and North America to enhance energy and environmental cooperation across the Pacific. The Forum will begin with a high-level assessment of energy and environmental projections for the Asia-Pacific. Over the course of the subsequent discussions, participants will assess key considerations for increasing trans-Pacific energy trade and investment.*

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