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China’s Energy Future

Reaching for a Clean World

David C. Michael, Sam Zhou, Xinyi Wu, and Gang Chen

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Driven by the country’s ongoing rapid economic growth, China’s demand for electricity is soaring. Meeting this demand while mitigating the environmental effects of the country’s energy consumption will be an enormous challenge for China in the years ahead and require action on multiple fronts.

De-emphasizing Coal
Coal, a highly polluting fuel source, plays a major role in China’s electricity generation, and its use must be de-emphasized if China is to meet its environmental goals.

A Range of Possibilities for China’s Generation Landscape
The evolution of China’s power-generation landscape could vary considerably based on economic growth, government policy, and other variables.

Moving Toward a Cleaner World
The greener China’s ambitions, the more aggressively it will have to exploit key levers, including green power generation, pollution-mitigation technologies, distributed generation, and demand-side management.
China’s rapid economic growth has been matched by an enormous rise in the country’s energy usage. Finding cost-effective supplies to power the country’s next wave of economic growth—while mitigating the environmental impact of the country’s growing energy consumption—will be China’s greatest challenge in the years ahead.

The country is already the world’s largest energy user, having surpassed the U.S. in 2010. Its consumption is expected to continue to soar, growing at a rate nine times that of the U.S. and the European Union through 2020, according to the International Energy Agency. (See Exhibit 1.) By 2030, the IEA projects, China will account for nearly a quarter of the world’s energy demand, consuming 60 percent more energy than the U.S. and twice as much as the EU.

Satisfying this voracious appetite for energy will be a massive task for the Chinese government. The job is made proportionately more difficult by the many considerations—such as the environment, domestic retail energy prices, domestic industry, and China’s standing in the global community—that the government must weigh as it formulates policy. Every choice the government makes will have sizable effects on stakeholders—and entail major tradeoffs.

**EXHIBIT 1 | China’s Energy Consumption Is Expected to Continue to Soar**

<table>
<thead>
<tr>
<th>Country</th>
<th>2010–2020 CAGR (%)</th>
<th>2020–2030 CAGR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>European Union</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>India</td>
<td>3.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Japan</td>
<td>0.3</td>
<td>–0.2</td>
</tr>
</tbody>
</table>

What are the possible courses of evolution for China’s energy landscape? This report, the first in a series on China’s energy future by The Boston Consulting Group, explores the question by examining development prospects for the country’s power (that is, electricity generation) sector through the year 2030. We consider three development scenarios: base case, slow shift, and clean world. The scenarios represent three potential outcomes of the country’s efforts to meet its power needs while simultaneously pursuing an overarching and vastly challenging objective: reducing China’s heavy reliance on coal in favor of cleaner, more diversified, more sustainable generation.

**China’s Power Generation Today: Coal as the Cornerstone**

As is true in many rapidly developing economies (including India, which derives nearly 70 percent of its electricity from the resource), coal plays a dominant role in China’s power generation. In 2011, coal accounted for fully 80 percent of China’s generated electricity and represented 67 percent of its electricity-generation capacity. (The remaining 33 percent of China’s 2011 generation capacity consisted primarily of hydroelectric power, complemented by smaller shares of gas, wind, and other generation sources.)

Coal’s utility to China as a fuel source is straightforward. It is relatively cheap, abundant, and accessible: in 2011, China’s vast domestic supplies were sufficient to meet 97 percent of its consumption needs. The major drawbacks of coal are its inefficiency—the estimated average energy efficiency of China’s modern coal-fired plants is approximately 35 percent—and, most troubling, its harmful effects on the environment.

Concerned about the environmental impact of its coal use and seeking to reduce the country’s reliance on this commodity, China’s government has made cleaner generation a priority. (See Exhibit 2.) Recent comments suggest that the government remains strongly committed to that aim. Ex-president Hu Jintao, for example, in comments to China’s congress shortly before passing the leadership baton to his successor, Xi Jinping, in November 2012, called for more efforts to address pollution and boost energy efficiency and conservation. And President Xi, in his acceptance speech, said a target of his government would be to create a “more beautiful environment.”

This stated commitment has been backed by concrete action in recent years. China’s policymakers have established specific targets for the development of cleaner sources of energy and for scaling back coal’s role in the generation mix. In March 2012, for example, China’s National Energy Administration announced a plan for the domestic coal industry that would limit domestic production to 3.9 billion metric tons per year by 2015, an amount close to what the nation produced in 2011.

But reducing the country’s reliance on coal in the face of strongly rising demand for power will prove to be a massive, complex undertaking, the likes of which no country has ever had to face before. And there is no magic bullet, our analysis confirms. De-emphasizing coal will require a huge, commensurate buildup in...
China’s gas, nuclear, and renewable energy capabilities, for example. This, in turn, will demand action on multiple fronts, from accessing and transporting foreign and hard-to-tap domestic gas, to ramping up construction of nuclear plants, to increasing electricity prices while upgrading the electrical grid. The investment required to engineer this buildup is staggering. The China Electricity Council projects related capital expenditures of more than RMB 13 trillion ($2 trillion) from 2011 through 2020, for example.

In concert, China will have to tackle a number of other urgent issues as it seeks to reshape and decarbonize its energy profile. It will have to address the nation’s growing dependence on imported fuels—China currently imports more than half of its oil and 10 percent of its gas, for example, and the percentages are rising. It will have to accelerate investments in pollution-mitigation technologies and more actively manage energy demand. It will have to make major investments in transportation and transmission capacity to address the country’s geographical energy imbalance—demand is heaviest in the East and South, while resource density is greatest in the North and West. It will have to consolidate or shut down hundreds of energy-intensive industrial plants to help improve the country’s dismal energy-efficiency profile versus those of other major economies. (China’s unit-GDP energy consumption is three and a half times that of the United States, for example, and fully six times the unit-GDP energy consumption of Japan and Western Europe.) The list goes on.
Although China is moving to tackle this complex mix of challenges, the effectiveness of its efforts remains to be seen. One thing is certain: the government’s resolve will be tested. We can envision a range of courses and outcomes.

China’s Future Power Generation: Cleaner and Greener—but to What Extent?

Our scenarios are based on distinct sets of assumptions regarding China’s economic growth, government policy, and other variables.

**Base Case.** In this scenario we assume steady but gradually decreasing rates of growth, with the economy expanding at rates of 7.9 percent per year through 2015 (the remainder of the time period covered by the government’s twelfth Five-Year Plan), 6.9 percent from 2016 through 2020, 5.3 percent from 2021 through 2025, and 3.5 percent from 2026 through 2030. We also assume that the government adheres to, and makes reasonable progress on, most of its declared energy objectives.

We assume, for example, that the government makes moderate progress in consolidating or shutting down high-energy-consumption factories, thus boosting industry’s energy-utilization rate. We assume that the government maintains its current subsidies for wind, solar, and biomass, and meets the development objectives for these energy forms specified in the twelfth Five-Year Plan. We assume resumed development of nuclear energy following a self-imposed moratorium in the wake of Japan’s Fukushima Daiichi disaster. And we assume that the government’s emission-control efforts, including current control trials being conducted in Beijing, Tianjin, the Yangtze River Delta, and the Pearl River Delta to limit PM2.5 levels (particulate matter less than 2.5 micrometers in diameter is considered particularly harmful to humans), are successful and gradually extended to other regions.

In our base case scenario, China’s total electricity consumption more than doubles, from 4,693 terawatt hours in 2011 to 10,166 terawatt hours in 2030. Installed generation capacity also doubles, rising from 1,050 gigawatts to 2,211 gigawatts in the same time frame. (See Exhibit 3.) Coal’s share of the generation mix falls to 51 percent versus 67 percent in 2011; this is compensated for by large increases in the roles of gas (8 percent versus 3 percent), wind (14 percent versus 4 percent), nuclear (6 percent versus 1 percent), and solar energy (3 percent versus less than 1 percent). Accompanying this are modest increases in the roles of other sources, including oil, biomass, and geothermal energy, and a moderate decrease in the role of hydroelectric power.

**Slow Shift.** In the slow-shift scenario, we assume much stronger economic growth—rates of 8.3 percent per year from now through 2015 and 7.3 percent from 2016 through 2020, for example. We also assume that the there is less progress in areas such as energy efficiency and in the development of cleaner energy sources. In this scenario, China’s demand for electricity in 2030 reaches 11,506 terawatt hours, and total generation capacity rises to 2,503 gigawatts. The country’s reliance on coal as a generation source falls more moderately than in the base case scenario, to 60 percent of capacity. Its emphasis on other energy sources rises but to a lesser degree.
Clean World. This scenario, by far the greenest of the three, flips the assumptions underlying the slow-shift scenario. It assumes moderate (by China’s recent standards) annual economic growth rates and more rapid and/or stronger than expected progress from the government on the energy-efficiency, alternative-fuel-development, and emissions fronts. The government aggressively shuts down or consolidates high-energy-consumption companies and energy utilization efficiency increases rapidly, for example. The PM2.5 trials are successful and lead to both higher standards and broader adoption of emissions-reduction initiatives. Efforts to accelerate the development of shale gas and coal-bed methane exceed expectations. Targets for the development of wind, solar, biomass, and grid integration are exceeded, and the costs of renewable generation are greatly reduced. The government pursues large-scale development of nuclear energy.

In the clean-world scenario, China’s 2030 power demand rises to “only” 9,288 terawatt hours, and generation capacity increases to 2,021 gigawatts. Coal’s share of the generation mix falls sharply—to 40 percent—while the shares of other energy sources rise strongly: gas to 13 percent, wind to 15 percent, nuclear to 7 percent, and solar to 3 percent. Hydroelectric power—at 20 percent of generation capacity—is only modestly lower than it was in 2011.
Critical Steps Toward a Clean World

The three scenarios represent points on the continuum of China’s possibilities. In all cases, the government will have to make strides on multiple fronts simultaneously if it hopes to reduce or limit coal usage as it ramps up aggregate power generation. The following levers will be critical in that pursuit.

**Make coal usage cleaner and more efficient.** In our base case scenario, coal accounts for roughly half of China’s power-generation capacity in 2030, a material reduction from 67 percent in 2011. But this is a falling share of a sharply rising total. China’s absolute coal consumption will be markedly higher, climbing from 2,988 million metric tons in 2011 to 4,074 million metric tons in 2030. To limit the environmental effects of this dramatic increase, China will have to continue to make progress on the energy-efficiency front. China’s new Five-Year Plan calls for a 16 percent reduction in energy use per unit of GDP, and the government has ambitious programs for efficiency improvements. This area should be a major priority.

**Orchestrate a much stronger role for gas power.** Gas will be crucial in China’s push to move away from coal. The government will have to orchestrate significant increases in both supply and demand to ensure a successful transition.

On the supply side, the government will need to advance the development of all forms of domestically produced gas, especially from unconventional sources: shale gas will be particularly important. The government will also need to significantly boost gas imports, both via pipeline and through imports of liquefied natural gas. (See Exhibit 4.) Further, the government will have to offer financial incentives to ensure that the needed infrastructure investments—in gas power plants, pipelines, and storage facilities, for example—materialize.

On the demand side, the government must provide incentives (for example, direct taxes on coal consumption or carbon emissions) to drive the general transition away from coal toward more-costly alternative fuel sources. And it must prepare the public for the higher retail prices likely to result from that transition.

**Continue the development of nuclear energy.** China should continue its ambitious plan for developing nuclear capacity. The 20-plus plants currently under construction should be completed, and new projects should be pursued where economically viable. The government should also develop plans for sourcing uranium and, eventually, thorium; enhance plant safety and reliability; and optimize waste disposal.

**Manage the development of green energy.** The government must ensure sufficient, ongoing long-term development of green industries (through feed-in tariffs and tax incentives, for example) while smoothing out hiccups that occur along the way, such as the current overcapacity in the domestic wind and solar photovoltaic industries. The government must also encourage partnerships between domestic players and Western companies to help Chinese businesses acquire the skills and experience that they will need to develop green energy. It must help solve the stability and connectivity challenges posed to integrated energy systems by green
energy, including the challenges posed by intermittent generation from wind and solar sources. And it must continue to advance the development of hydroelectric power, provided that it can do so sustainably.

**Encourage the development of distributed energy.** Neither grid companies nor independent power producers have financial incentives to spur the development of distributed generation (that is, small-scale, decentralized generation, such as that from rooftop solar panels or small, localized wind farms), which can play a meaningful role in meeting the power needs of China’s rural population. The government must therefore lead the charge by increasing incentives to both equipment suppliers and power users.

**Ensure a “smarter,” more versatile network.** The transmission capacity, reliability, and safety of China’s power grid have increased significantly in recent years. A remaining challenge is to ensure that the grid is smart enough to accommodate increasing shares of green energy in the generation mix.

**Continue to push for better demand-side management of electric power.** Historically, China’s state-owned electrical grid and power-generation companies...
have had no incentive to reduce power consumption—indeed, quite the opposite. In recent years, regulators have begun to introduce conservation incentives, but much stronger policies will need to be introduced in order to have large impact.

**Implications for Business**

China’s energy transformation will create enormous commercial opportunities across the energy value chain for years to come. The opportunities will be particularly promising in the following areas:

- Supplying energy to China
- Cooperating with Chinese companies and investors to develop energy resources worldwide
- Providing China with energy-related technologies, products, and services
- Participating in China’s efforts to develop new and unconventional energy sources, such as domestic shale gas

Multinational and domestic companies alike must actively pursue these opportunities. Those that manage to get it right—that is, to position themselves as key participants in China’s quest—may well transform their businesses.

**NOTE**

1. In future reports in this series, BCG will more closely examine the respective roles that gas, renewable energy, and oil will play in China’s ongoing energy evolution.
About the Authors

David C. Michael is a senior partner and managing director in the Beijing office of The Boston Consulting Group and the leader of the Global Advantage practice. You may contact him by e-mail at michael.david@bcg.com.

Sam Zhou is a partner and managing director in the firm’s Beijing office and the leader of BCG’s power sector in China. You may contact him by e-mail at zhou.sam@bcg.com.

Xinyi Wu is a partner and managing director in BCG’s Beijing office and the leader of BCG’s oil and gas sector in China. You may contact him by e-mail at wu.xinyi@bcg.com.

Gang Chen is a consultant in the firm’s Shanghai office. You may contact him by e-mail at chen.gang@bcg.com.

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For Further Contact

If you would like to discuss this report, please contact one of the authors.