THE NEW GEOPOLITICS: ASIA



LOWER FOR LONGER: THE IMPLICATIONS OF LOW OIL AND GAS PRICES FOR CHINA AND INDIA

**SAMANTHA GROSS** 

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### **EXECUTIVE SUMMARY**

China and India represent the future of oil demand growth, as demand in OECD countries declines. The low oil and gas prices of the last two years have generally been beneficial for India, but have posed more challenges for China, which focused its energy policy in recent years around the assumption that oil and gas would be expensive and scarce. Low prices have been hard on China's domestic oil industry, which faces rising costs in its aging oil fields. China's national oil companies are shifting their strategy from a dash for resources, wherever they are found, to a focus on countries and projects tied to the One Belt, One Road (Belt and Road) initiative. On the other hand, India doesn't have much of an oil industry to lose, so low prices have brought economic benefits, even easing the burden on the population of removing government transportation fuel subsidies. China and India are in more similar situations with respect to natural gas imports, but even there India has been better positioned to take advantage of lowpriced spot liquefied natural gas (LNG). China's focus in recent years on securing oil and gas reserves, through investments and long-term contracts, did not anticipate the extreme price decreases that have occurred, leaving China less able to take advantage of the new market conditions.

## **INTRODUCTION**

China and India must have a prime place in any discussion of the energy future. Together these two countries have more than one-third of the world's population. As their economies continue to grow, the center of global energy demand is shifting from west to east. For example, oil demand in the OECD is expected to decline by about 200,000 barrels per day annually over the next few years, while demand in China and India is growing by more than twice that amount.<sup>1</sup> With such rapid growth, concerns about energy supply are important factors in the foreign policy and security decisions of both nations.



Sources: For historical data through 2016, see BP, "BP Statistical Review of World Energy 2011" and "BP Statistical Review of World Energy 2017"; for forecast data, see International Energy Agency, "Oil 2017."

At the same time, the oil and liquefied natural gas (LNG) markets today are experiencing a nearly unprecedented era of abundant supply and lower prices. Oil prices today are half their level of just three years ago, having dropped from an average of over \$100 per barrel from 2011 to 2014 to an average of less than \$50 per barrel from 2015 to the present. Price changes aren't so dramatic in the less-liquid LNG market, but large new projects already online or about to be online in Australia and the United States have coincided with slowing demand growth in Japan and South Korea, Asia's largest LNG customers. The June 2016 expansion of the Panama Canal also reduced shipping times and thus prices for U.S. LNG in Asia. The rise of floating LNG terminals has further increased liquidity in the LNG market, making it easier and faster for new countries to enter the market.

Since the price crash, there has been a flood of writing about how lower prices have affected oil and gas producers, but less about the geopolitical changes that low oil and gas prices bring. One might think that the low oil and gas price environment is bad for exporting countries, but good for importers. Yet the story is not always that simple. Concerns about energy security and protecting domestic energy producers can diminish the positive economic effect of low energy prices for importing countries.

China and India are the two giants of energy demand growth, but important differences in policy, economic conditions, and energy endowments mean that they are faring differently in the low price environment.

<sup>1</sup> International Energy Agency (IEA), "Oil 2017," (Paris: IEA, 2017).

#### CHINA HAS SOMETHING TO LOSE IN THE LOW OIL PRICE ENVIRONMENT

China's economy has been slowing since 2010, after several years of breakneck growth of more than 10 percent per year. The growth rate in China's oil demand has also slowed, but China is still likely to be the largest source of new oil demand over the next few years. The International Energy Agency (IEA) forecasts continued strong demand for crude oil in China, with average demand growth of 2.4 percent over the next five years, reaching 13.7 million barrels per day (bbl/day) in 2022.<sup>2</sup>

As the world's second largest oil importer, low global oil prices might seem to be an unmitigated good for China. But despite China's high levels of imports, the impact of the low oil price environment on China's energy security and foreign investment policy is mixed.

#### Low prices a mixed story for Chinese energy security

Since China is such a large oil importer, one often forgets that it is also a significant oil producing state. In 2016, China produced more than 4 million barrels of oil per day and was the world's fourth largest oil producer, behind Saudi Arabia, Russia, and the United States.<sup>3</sup>

But China's oil production has not kept up with rapidly growing demand. Crude oil demand in China is now more than 12 million barrels per day, leaving an 8 million barrel deficit to be filled by imports. China's dependence on oil imports has grown rapidly in recent years along with its demand, rising from 50 percent in 2009 to nearly 70 percent today.<sup>4</sup>

Low prices have certainly been a godsend for China's oil import costs; the cost of oil imports in 2016 was less than that in 2010, when oil imports were more than 30 percent lower. However, the low price environment is stifling the domestic oil industry, potentially creating a challenge for future Chinese energy security.



Source: U.S. Energy Information Administration.

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3 Ibid.
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4 Michael Lelyveld, "China's Oil Imports Soar as Output Declines," *Radio Free Asia*, May 15, 2017, <u>http://www.rfa.org/english/commentaries/energy\_watch/chinas-oil-imports-soar-as-output-declines-05152017110848.</u> html.

<sup>2</sup> Ibid.

Much of China's domestic oil production takes place in aging, expensive-to-operate fields where production is in decline. China's two largest oil fields, Daqing and Shengli, which have been in production for more than 50 years, saw the sharpest decline in output. Low oil prices have meant that China National Petroleum Company (CNPC) and Sinopec, the operators of these aging giants, are spending less to maintain production and are mothballing some facilities, further increasing the decline rate. Several other Chinese oil fields are also mature, and the expensive advanced recovery methods required to produce in these fields are a stretch in the low price environment. Overall oil production in China declined by a total of 300,000 barrels per day in 2016.<sup>5</sup> Production lost from these mature fields is not likely to come back if prices rise, because the advanced recovery techniques in use are technically difficult and sometimes impossible to restart after a well is shut in. The low oil price environment is helpful to China's economy overall, but clearly its oil and gas sector is an exception to the trend.

Furthermore, the Chinese national oil companies (NOCs) have little ability to profitably expand oil production within China. Undeveloped fields in China are often geologically challenging, including potential shale and tight oil resources, and are difficult to develop at today's oil prices. The Chinese NOCs have invested in American shale oil and gas companies in an attempt to gain technology expertise that can be applied in China, and are signing joint ventures with Western majors to develop resources in China. But American technology does not necessarily translate well to Chinese geology and China's oil industry lacks the nimble, risk-taking small companies and the stiff competition that drove the U.S. shale oil and gas boom.

Despite declining domestic production, low oil prices are contributing to Chinese energy security by encouraging emergency oil stockpiling. In response to growing oil demand and relatively flat domestic oil production, in 2007 China began building its strategic petroleum reserve to stockpile oil to cope with any unplanned disruption in oil supply. The current low-price period has allowed China to fill its growing reserves more quickly and at lower cost. The rate of additions has varied over time in recent years as the storage facilities are built, varying from a high of roughly 222,000 bbl/day over 2016<sup>6</sup> to as much as 1.7 million bbl/d in March 2017.<sup>7</sup> China's Commerce Ministry said that the government held 243 million barrels of oil in its reserves in mid-2016, the most recent update, enough to cover about 30 days of oil imports.<sup>8</sup> However, satellite data suggests that combined government and commercial stocks total as much as 600 million barrels, or roughly 75 days of oil imports.<sup>9</sup> China is not a member of the IEA, but for comparison, IEA member countries are required to hold 90 days of net imports in reserve.

<sup>5</sup> Ibid.

<sup>6 &</sup>quot;China's oil stockpiling in first-half 2016 slows on tank shortage," *Reuters*, April 28, 2017, <u>http://www.reuters.com/article/us-china-oil-reserves-idUSKBN17U1CK</u>.

<sup>7</sup> Michael Lelyveld, "China's Oil Imports Soar as Output Declines."

<sup>8 &</sup>quot;China's oil stockpiling."

<sup>9 &</sup>quot;Satellite Data Show China May Have Stored More Crude Than Estimated," *Bloomberg Markets*, September 29, 2016, <u>https://www.bloomberg.com/news/articles/2016-09-29/satellite-data-show-china-oil-reserves-may-top-official-estimate</u>.

### The Chinese oil industry's overseas efforts are refocusing in line with the Belt and Road initiative

Given the challenging geologic environment in China, in recent years the Chinese NOCs have largely focused their efforts abroad. An overwhelming feeling of scarcity and a dash for reserves drove many of these actions, as China sought to slake its rapidly increasing thirst for oil. Since the 2000s, the Chinese NOCs have invested widely around the world in order to increase their reserves, gain access to new technology (such as oil sands or tight oil production), and diversify China's supply base. China's dash for resources of all kinds, not just oil, became an important facet of its foreign policy.

By 2015, Chinese oil companies had invested in oil and gas projects in 54 countries.<sup>10</sup> In some cases, the Chinese NOCs pursued a market-for-resource strategy, trading access to China's vast and rapidly growing oil market for access to reserves abroad. In other cases, China offered loans to energy companies and oil producing countries—including Brazil, Ecuador, Russia, Turkmenistan, and Venezuela—that could be repaid with oil. The recipients of these loans pledged to deliver oil to China that is priced using an agreed-upon formula, sometimes at a discount to market prices.<sup>11</sup>



#### **COUNTRIES WITH CHINESE INVESTMENT IN UPSTEAM OIL AND GAS**

Source: Author research; International Energy Agency, "Update on Overseas Investments by China's National Oil Companies: Achievements and Challenges since 2011."

The sustained oil price decline is changing the Chinese NOCs' approach. The crash punished some Chinese investments made under the assumption of enduring high oil prices, and the new sense of abundance in the oil market has quelled fears of scarcity and shortage. Chinese NOCs' overseas investments plunged in 2015 and 2016, as anti-corruption investigations questioned the motives of many of their oil investments abroad. Chinese NOCs are now being more cautious and strategic in their overseas investments, less focused on bringing equity crude to China, and more willing to sell

<sup>10</sup> Ibid.

<sup>11</sup> Michal Meidan, "China's loans for oil: asset or liability?" (Oxford: Oxford Institute for Energy Studies, 2016), <u>https://www.oxfordenergy.org/publications/chinas-loans-oil-asset-liability/</u>.

crude oil on the open market when it makes financial sense.

China's One Belt, One Road (Belt and Road) initiative has further influenced Chinese NOCs' investments abroad. The Belt and Road is focused on creating networks of infrastructure connecting China to the Persian Gulf, the Indian Ocean, Europe via Central Asia, and the Mediterranean. China is beginning to focus more on finding export markets for its goods and services than on importing raw materials. These infrastructure investments will deepen China's economic and political ties around the region and also provide markets for excess industrial capacity in China. The Middle East and Central Asia are particularly important regions in the Belt and Road initiative.



**REVIVING THE SILK ROAD** 

China's relationship with Russia is changing as a result of the Belt and Road initiative and of lower oil prices. China's overall strategy for energy development is creating partnerships, using China's cash and excess capacity in industries like steel as negotiating points. Russia has been particularly hurt since the oil price crash and has strong incentives to cooperate in this way, since it is resource rich, but cash poor. For example, ChemChina took a 40 percent stake in Rosneft's VNHK petrochemical complex in the Russian Far East and Rosneft agreed to supply crude to ChemChina.<sup>12</sup> Rosneft

12 Denis Dyomkin, "Russia Secures Energy Deals, Talks Security with China as Putin Visits," *Reuters*, June 25, 2016, <u>http://www.reuters.com/article/us-rosneft-chemchina/russia-secures-energy-deals-talks-security-with-china-as-putin-visits-idUSKCN0ZB0AV</u>.

stated that the deal was intended to provide project financing and market access in the Asia-Pacific region.

China's relationship with Saudi Arabia has also changed as a result of sustained low oil prices. China has been the world's primary growth market for crude oil and Saudi Arabia is working to deepen its energy ties with China, culminating in Saudi King Salman's state visit to Beijing in March 2017. The Saudis are concerned about maintaining market share during this time of abundant supply and particularly fear losing market share to Russia. They also view China as a potential partner in their push to diversify their economy. China already has a significant footprint in the Saudi economy, particularly in telecommunications and construction.

Before King Salman's visit to Beijing, China's ambassador to Saudi Arabia said that the two countries have a comprehensive strategic partnership, including cooperation in the economic, political, and military fields.<sup>13</sup> During the visit, the two sides signed memoranda of understanding and letters of intent worth as much as \$65 billion in a number of industries. For example, Saudi Aramco is considering building refining and chemical projects in China in partnership with Norinco and SABIC and Sinopec have agreed to jointly develop petrochemical projects in China and Saudi Arabia.<sup>14</sup>

Some experts believe that China seeks to bolster its strategic presence in the Middle East as uncertainty about the U.S. role there grows. China is walking a fine line diplomatically, maintaining close relationships to both Saudi Arabia and Iran. However, China's willingness to take on security duties there that the United States has traditionally provided, such as securing the Persian Gulf and Strait of Hormuz, is doubtful, despite China's extensive investments in the area under the Belt and Road initiative.

# INDIA'S IMPORT DEPENDENCE MAKES LOW OIL PRICES AN ECONOMIC BOON

India's energy system is at a much earlier stage of development than China's. India's per-capita energy consumption today is less than the average for Africa. Although India is home to 18 percent of the world's population, it uses only 6 percent of the world's primary energy.<sup>15</sup> India still needs to make significant progress in providing access to modern energy services for its people. Approximately 23 percent of Indian households lack access to electricity and one-third of India's rural population lacks access to an all-weather road.<sup>16</sup>

Despite these ongoing development challenges, India is expected to become the world's most populous country in the next decade. According to the IEA, India will contribute more than any other country to rising global energy demand over the coming decades,

<sup>13</sup> Shi Jiangtao, "Saudi king's visit puts Beijing in Middle East spotlight," South China Morning Post, March 14, 2017, http://www.scmp.com/news/china/diplomacy-defence/article/2078696/saudi-kings-visit-puts-beijing-middle-east-spotlight.

<sup>14</sup> Ben Blanchard, "China, Saudi Arabia eye \$65 billion in deals as king visits," *Reuters*, March 16, 2017, https://www.reuters.com/article/us-saudi-asia-china/china-saudi-arabia-eye-65-billion-in-deals-as-king-visits-idUSKBN16N0G9.

<sup>15 &</sup>quot;GARV Dashboard," India Rural Electrification Commission, Accessed October 4, 2017, <u>http://garv.gov.</u> in/garv2/dashboard/garv.

<sup>16</sup> IEA, "India Energy Outlook," (Paris: IEA, 2015), <u>https://www.iea.org/publications/freepublications/</u> publication/IndiaEnergyOutlook\_WEO2015.pdf.

contributing about one-quarter to the total by 2040.<sup>17</sup> The path of energy development in India is crucially important to the world's response to the threat of climate change and to the geopolitics of the energy sector.

India's domestic oil production is small, with approximately 860,000 barrels per day of production, less than 20 percent of its 4.5 million barrels per day of demand.<sup>18</sup> Since India has little domestic oil production to be harmed, the low oil price environment has been generally beneficial there.



Source: U.S. Energy Information Administration.

Low oil prices have eased the consumer burden of India's removal of transportation fuel subsidies. Gasoline prices were deregulated in 2010 and the diesel subsidy was removed in 2014. Removal of these subsidies will help to improve fuel economy in India's vehicle fleet and save the government money. In August 2017, India announced the phase-out of subsidies for liquefied petroleum gas (LPG) and kerosene as well. These are fuels of the poor and are thus the last subsides to go. The kerosene subsidy was particularly damaging, as it is a polluting fuel that was also sometimes used as an adulterant in more expensive diesel fuel.

From a macroeconomic perspective, low oil prices have reduced India's total oil import bill and thus improved its balance of payments position and relieved downward pressure on the rupee.

India has a small domestic oil resource base, with proven reserves of 5.7 billion barrels. Nonetheless, India has made a number of changes in its oil and gas exploration and production rules in an attempt to attract more investment from international oil companies, both for new production and for joint ventures to enhance production in existing fields.

India has established several new terms to make oil and gas licensing more attractive. The new terms grant a single license to produce conventional or unconventional oil and gas. The previous terms allowed only production of the hydrocarbon for which

<sup>17</sup> Ibid.

<sup>18</sup> BP, "BP Statistical Review of World Energy," (London: BP, 2017), <u>https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf</u>.

the license was granted. The new "Hydrocarbon Exploration Licensing Policy" aims to increase India's oil production to about 3 million barrels per day by 2022.<sup>19</sup> Bidding under the new policy began in July 2017.

However, industry's response to the new terms has been tepid so far, with the exception of a partnership between India's Reliance Industries and BP to develop a deep-water natural gas field. This investment is part of a larger collaboration between the companies in transportation fuel, electrification, and mobility.<sup>20</sup> This kind of partnership could be an interesting model for oil and gas production in India, combining upstream resource development with access and insight into India's rapidly growing energy market.

# LOW PRICES AND ABUNDANT LNG ALSO BENEFIT INDIA MORE THAN CHINA

The LNG market in Asia is also experiencing a surplus and as a result becoming more of a buyers' market. New contracts are becoming more flexible and some existing contracts have been renegotiated. Concessions include a modified oil-linked price structure, loosened take-or-pay provisions (that required purchase of a certain volume of gas), and relaxed destination clauses (that restricted resale of cargoes). The LNG oversupply and looser contract conditions mean that more cargoes in Asia are being sold on a spot or short-term contract basis. LNG trading hubs are developing in Singapore and Tokyo to broker these spot market sales. As these markets become more active and liquid, they will allow price discovery and potentially break the oil-linked price paradigm that dominates in Asia.

Both China and India stand to benefit from the loosening LNG market, as both are LNG importers. Both countries can also use gas to displace coal in power generation and industrial boilers to cope with local air pollution problems and to help meet greenhouse gas emissions goals. But unlike for oil, domestic gas production in China and India meets more than half of supply–66 percent for China and 55 percent for India. The remainder of China's gas supply is about evenly split between LNG and pipeline gas from Central Asia. India does not have a supply of pipeline gas and relies on LNG to meet the other 45 percent of its gas demand.<sup>21</sup>

<sup>19 &</sup>quot;India gives out new hydrocarbon licensing policy to explore oil, gas means," Business Standard, March

<sup>7, 2017, &</sup>lt;u>http://www.business-standard.com/article/economy-policy/india-gives-out-new-hydrocarbon-licensing-policy-to-explore-oil-gas-means-117030700162\_1.html</u>.

<sup>20 &</sup>quot;BP and Reliance Industries to progress and expand partnership," *BP*, June 15, 2017, <u>http://www.bp.com/en/global/corporate/media/press-releases/bp-reliance-industries-to-progress-partnership.html</u>.

<sup>21</sup> BP, "BP Statistical Review of World Energy."

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Source: BP, "BP Statistical Review of World Energy," data tables 2009 - 2017.

Natural gas prices in China and India are set by the government and both countries face the same conundrum—finding a gas price high enough to encourage domestic production, but low enough to please gas-dependent industries and to allow gas to compete with coal in the power sector. Neither country has a "giant" domestic gas field; production comes from many smaller gas fields with relatively high costs.

Both countries have significant coal industries that provide an inexpensive fuel for power generation and significant jobs. In both China and India, state-owned coal companies are undergoing reform to become more competitive.

Despite the similarities, the LNG surplus is playing out differently in the two countries. China's entire LNG system is in a state of oversupply, a result of its recent economic slowdown and past over-build. China has 49 million tons per annum (MTPA) of LNG regasification capacity that runs at a utilization rate of about 50 percent. Another 21.4 MTPA of regasification capacity is under construction.<sup>22</sup> On the supply side, since 2015 China has had more firm contracted LNG than it needs to meet demand. Contracts that China signed prior to 2015, during a time of breakneck economic growth and concern about scarcity, are still in effect now that growth has slowed and the LNG market has moved into surplus. This situation of contractual oversupply is likely to continue through 2017, given that new Australian LNG capacity coming online has contracts with Chinese NOCs.<sup>23</sup>

For these reasons, the surplus of LNG in the Asian market is providing little benefit to China right now. China's government-controlled wholesale gas prices are nearly three times those in the United States, and gas cannot compete with coal on price. Nonetheless, policy from Beijing is encouraging greater gas use. For example, China's latest five-year plan calls for using gas instead of coal in industrial boilers in four major urban areas: greater Beijing, northeast China, the Yangtze River Delta near Shanghai, and the Pearl River Delta in Guangdong province.<sup>24</sup> This policy could bring about greater utilization of China's expanding LNG infrastructure.

<sup>22</sup> International Gas Union (IGU), "2017 World LNG Report," (Barcelona: IGU, 2017), <u>https://www.igu.org/sites/default/files/103419-World\_IGU\_Report\_no%20crops.pdf</u>.

<sup>23</sup> Ibid.

<sup>24 &</sup>quot;China, the King of Coal, Is Getting Gassy," *Bloomberg Markets*, May 24, 2017, <u>https://www.bloomberg.</u> com/news/articles/2017-05-25/coal-king-s-shift-to-more-gas-wins-believers-as-china-use-surges.

India has benefitted more than China from the current surplus in the LNG market. Four LNG regasification facilities with a total capacity of 27 MTPA are online in India today, with an additional 15 MTPA of capacity under construction and expected to be completed by 2019.<sup>25</sup> India has had sufficient demand and capacity to become a key destination for spot LNG cargoes, taking advantage of the current low prices.

LNG in India could eventually face competition from gas pipeline projects from Turkmenistan and Iran, but the prospects for and timing of these projects are very uncertain. Both of these projects go through politically difficult territory, face financing challenges, and require cooperation between India and neighboring Pakistan. Some surveying and design work has gone into the pipeline from Turkmenistan, but it is still far from certain. The U.S. government has long been opposed to the pipeline from Iran, although the recent lifting of sanctions has revived interest in India. Inexpensive LNG makes the rationale for these projects even more difficult.

Pricing is the primary factor influencing the future of gas in India, an issue that matters for the world's efforts to combat climate change as well as for LNG supply and demand. In April 2017, India reduced its customs duty on LNG imports from 5 percent to 2.5 percent, making LNG more competitive.<sup>26</sup> But low government-controlled prices for domestically produced gas are stifling local production, working at cross purposes with the oil and gas licensing reforms described earlier. The real competition will be with coal in the power sector, with low-cost local coal providing jobs, but exacerbating already-brutal air pollution.

# **CONCLUSION: THE BEST LAID PLANS SOMETIMES GO AWRY**

China has certainly put much more effort into providing energy to fuel its economic boom, through significant spending to maintain aging domestic oil fields, equity investments in oil reserves abroad, and long-term contracts to ensure sufficient supply of pipeline gas and LNG. But these decisions all relied on the underlying assumption that oil and gas would continue to be scarce and expensive. This assumption has been turned on its head in the past two years. Now China's domestic oil production is declining, its gas system is in a state of overcapacity, and it is ill-positioned to take full advantage of lower oil and gas prices.

On the other hand, India's energy system is generally at the whim of markets. India had little domestic oil production to lose during the price crash and the lack of growth in its domestic natural gas sector is due to low government-controlled prices, rather than the glut of LNG on the market. One generally would recommend planning ahead for the energy needs of a rapidly developing economy, but the current oversupply has happened at an opportune time in India's development. India's greater exposure to market conditions has been a benefit during this time of plenty. This advantage would reverse with a rise in oil and gas prices, and will not endure over time as both countries' energy systems adjust to market conditions. But for now, the lower-for-longer price environment is helping to bring modern energy services to millions of Indian citizens.

<sup>25</sup> IGU, "2017 World LNG Report."

<sup>26 &</sup>quot;India slashes LNG import tax," *LNG World News*, February 1, 2017, <u>http://www.lngworldnews.com/</u> india-slashes-Ing-import-tax/.

# **ABOUT THE AUTHOR**

Samantha Gross is a fellow in the Cross-Brookings Initiative on Energy and Climate. Her work is focused on the intersection of energy, environment, and policy, including climate policy and international cooperation, energy efficiency, unconventional oil and gas development, regional and global natural gas trade, and the energy-water nexus.

Gross has more than 20 years of experience in energy and environmental affairs. She has been a visiting fellow at the King Abdullah Petroleum Studies and Research Center, where she authored work on clean energy cooperation and on post-Paris climate policy. She was director of the Office of International Climate and Clean Energy at the U.S. Department of Energy. In that role, she directed U.S. activities under the Clean Energy Ministerial, including the secretariat and initiatives focusing on clean energy implementation and access and energy efficiency. Prior to her time at the Department of Energy, Gross was director of integrated research at IHS CERA. She managed the IHS CERA Climate Change and Clean Energy forum and the IHS relationship with the World Economic Forum. She also authored numerous papers on energy and environment topics and was a frequent speaker on these topics. She has also worked at the Government Accountability Office on the Natural Resources and Environment team and as an engineer directing environmental assessment and remediation projects.

Gross holds a Bachelor of Science in chemical engineering from the University of Illinois, a Master of Science in environmental engineering from Stanford, and a Master of Business Administration from the University of California at Berkeley.

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