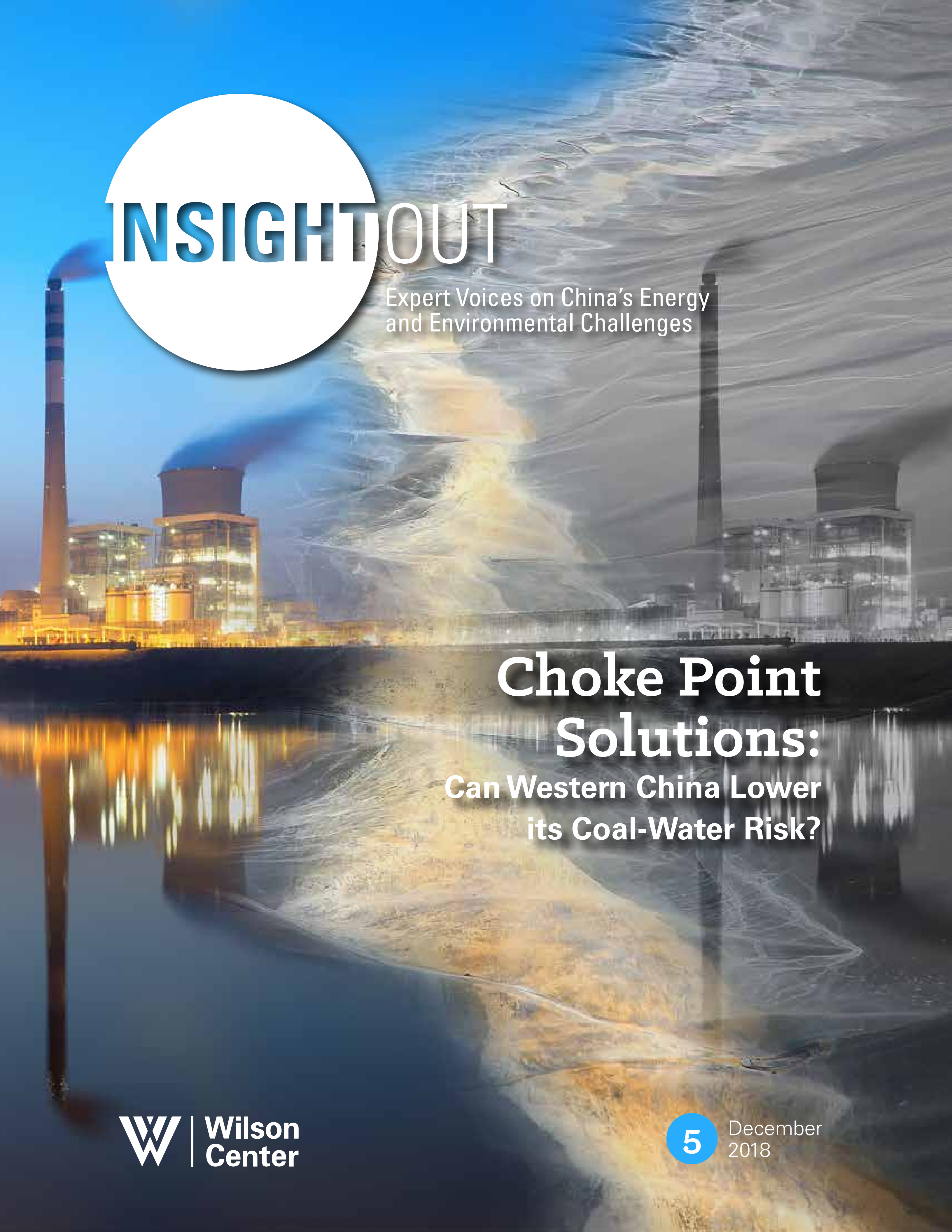


INSIGHT OUT

Expert Voices on China's Energy and Environmental Challenges

Choke Point Solutions:

Can Western China Lower its Coal-Water Risk?

Wilson Center

5 December 2018

Choke Point Solutions: Can Western China Lower its Coal-Water Risk?

By Molly Bradtke & Lyssa Freese

The last remaining coal-fired power plant has closed in Beijing, yet another casualty in Xi Jinping's war on pollution. Beijing now has bluer skies, but coal still powers the capital city—transmitted in from power plants far in China's coal-rich but water-scarce western provinces. Almost 60 percent of the water footprint from Beijing's energy consumption comes from coal mined and burned in two of China's most arid western provinces, Inner Mongolia and Shanxi. More stringent air emission targets and monitoring are improving air quality in Beijing and other east coast cities, but at a cost of increased water and pollution risks in western China.

In this fifth issue of the China Environment Forum's *InsightOut* series, we take a deep dive into the potential for science, technology, and policy innovation to mitigate the coal-water risks in Western China. As a country of 1.3 billion—20 percent of the world's population—China only has 7 percent of global freshwater. Yet nearly one-fifth of all the water used in the country goes to the thirsty coal sector. This water risk is particularly prominent in coal-rich provinces in the northwest that have only 20 percent of China's water reserves. According to Keith Schneider, chief correspondent for the Wilson Center and Circle of Blue *Global Choke Point* project, the quantity of water China uses for coal mining, washing, and power plants could exceed the available water in these regions within a decade, and has been "so significant that it challenges the country's capacity to succeed in this decade."

GAMBLING WITH WATER

Over the past few years, primarily due to public concerns over severe air pollution and international carbon reduction pledges, the Chinese leadership has shown a serious commitment to lessening the country's coal dependence. Through policies, clear targets, and financial investments, China is promoting clean energy and energy efficiency. In the first week of 2017, the Chinese government pledged 2.5 trillion yuan into renewable power generation by 2020. Regulation and emissions monitoring of the coal sector has intensified since the passage of the *Air Pollution Action Plan* in 2013 and the 13th Five-Year Plan air quality targets. These plans have catalyzed central and local governments to close coal plants, cancel planned projects, and impose stricter environmental regulations on the roughly 2,300 plants still operating. Despite these ambitious local efforts, coal consumption did rebound slightly in 2017 and 2018.

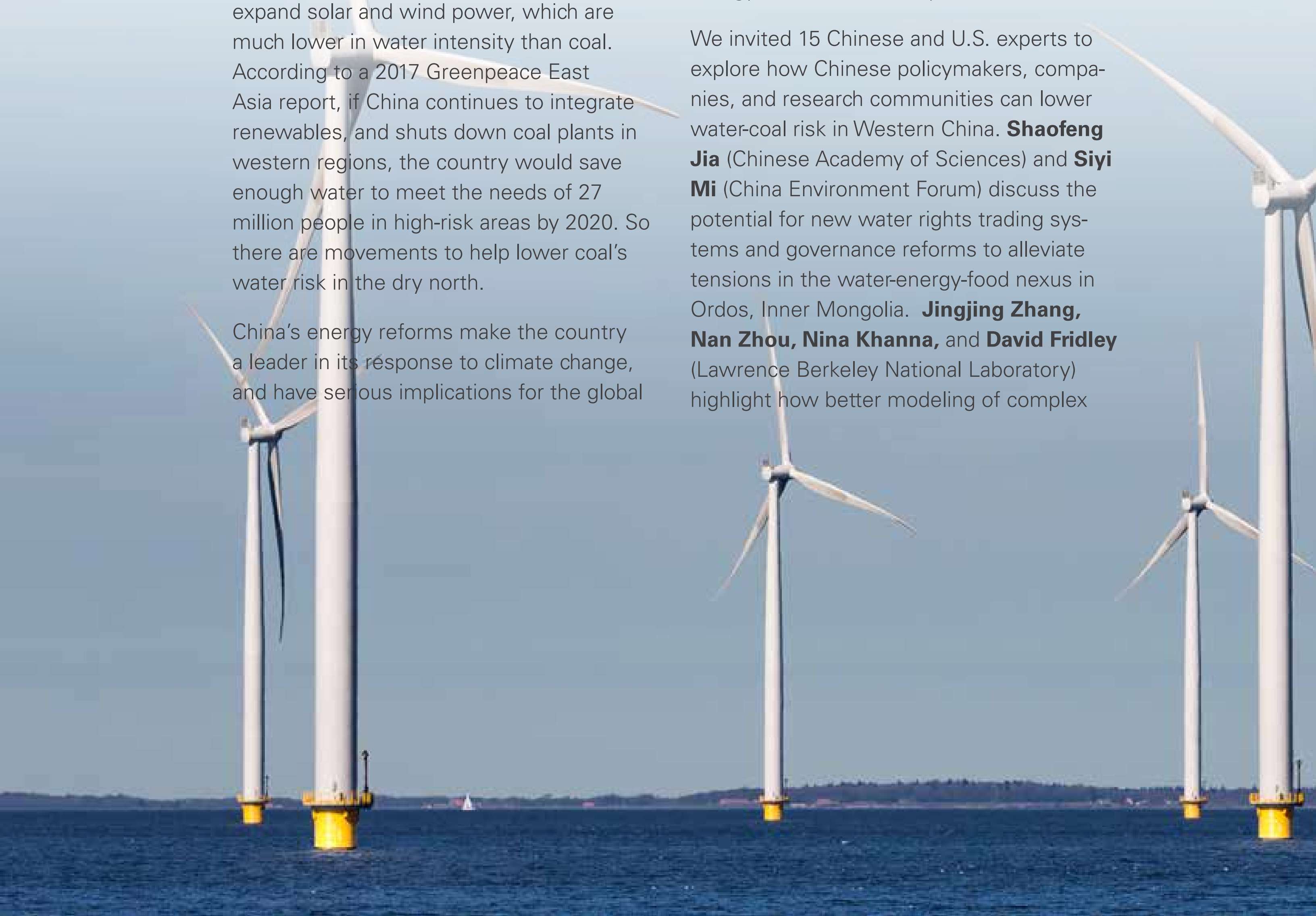
This historic shift in coal policy may help alleviate pollution in the east, but raises two particular concerns. First, the water footprint of coal, particularly in western arid provinces, is not yet high on the policy agenda. Second, Western China does not have strong coal reduction policies, leaving it vulnerable to new coal industries, including coal-to-liquids and coal-to-chemicals that threaten water security in the region. For example, in a 2015 report on Ningxia Hui Autonomous Region, the World Resources Institute estimated that over 70 percent of the province "faces very high levels of baseline water stress," and 91.5 percent of power generation facilities, primarily coal-fired, are based in areas suffering severe water shortages. The highly water-intensive coal-to-chemicals sector is also rapidly growing in Ningxia, further stressing the arid region. These water stresses are exacerbated by climate change—average temperatures in North China are rising and precipitation is declining. The South-North Water Transfer Project has been touted by central planners as a solution to water scarcity in the northwest; but does not solve the root of the problem—high levels of water demand. Rather than relying solely on supply-side management, water planners need to reduce water use throughout Northern China, particularly by the coal industry in the northwest.

LOWERING WATER RISKS

There are bright spots of technology and policy innovation emerging to reconcile economic and environmental goals and reduce coal-water conflicts in northwestern China. China's ultra-super critical coal-fired power plants use air cooling and require 40 percent less water than earlier generations of water-cooled plants. The Ministry of Water Resources has passed targets and regulations pushing for better water efficiency from Chinese industries and cities. The Chinese government's expanding investments into the power grid and continued push for renewables helped expand solar and wind power, which are much lower in water intensity than coal. According to a 2017 Greenpeace East Asia report, if China continues to integrate renewables, and shuts down coal plants in western regions, the country would save enough water to meet the needs of 27 million people in high-risk areas by 2020. So there are movements to help lower coal's water risk in the dry north.

China's energy reforms make the country a leader in its response to climate change, and have serious implications for the global energy and climate regimes. "The Asian Century is well underway in every way you can measure it: population growth, changing vectors in energy supply, investment, infrastructure development," Schneider explained, and its timing is significant as the United States takes a back seat in the global energy transition. China's war on pollution and goal to lower carbon emissions could significantly change the environmental health story in China and contribute to global efforts to lower greenhouse gas emissions. However, to continue to lead the way in this 'Asian Century', China must further incorporate water-saving reforms into its energy and environment plans.

We invited 15 Chinese and U.S. experts to explore how Chinese policymakers, companies, and research communities can lower water-coal risk in Western China. **Shaofeng Jia** (Chinese Academy of Sciences) and **Siyi Mi** (China Environment Forum) discuss the potential for new water rights trading systems and governance reforms to alleviate tensions in the water-energy-food nexus in Ordos, Inner Mongolia. **Jingjing Zhang, Nan Zhou, Nina Khanna,** and **David Fridley** (Lawrence Berkeley National Laboratory) highlight how better modeling of complex

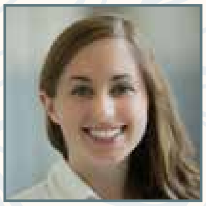


water-energy interactions in China can map out new policies and technology to help lessen the thirst of coal and decrease the electricity footprint of water. **Hengwei Liu** (Harvard and Tufts) explores technological advancements and policy changes that could help to unravel the climate-water-energy nexus in the country's most water-stressed regions. **Shan Jiang, Jianhua Wang, Yong Zhao,** and **Yongnan Zhu** (China Institute for Water and Hydropower Resources) report on a pilot project their institute conducted to help a prefecture in Gansu develop water-saving technologies and policies to keep water flowing for a massive coal base and surrounding cities. **Ma Jun, Kate Logan,** and **Mingxuan Wang** (Institute of Public & Environmental Affairs) explain the necessity for transparency on water consumption and pollution from coal companies, with examples from their Corporate Water Risk Assessment Tool. **Kaboo Leung**, drawing on her previous work at Trucost Limited, emphasizes the importance for businesses to consider environmental risks as financial risks in their investment and decision-making. **Huai Jiang, Frederich Kahrl**, and **Jasmin Ouyang** (E3) argue that the path forward for addressing Western China's water-energy challenges will not be driven by water shortages, but come from increasingly stringent air quality and climate-oriented policies.

This is the fifth issue of CEF's *InsightOut* series, a publication designed to tap on-the-ground expertise to understand the complex energy and environmental challenges faced by China. As with much of our work, we cast an eye on opportunities for the collaboration between American and Chinese researchers, businesses, NGOs, and governments.

As Managing Editors of this *InsightOut* issue, we want to give special thanks to CEF colleagues who assisted in research and editing: Jennifer Turner, David Bachrach, Siyi Mi, Qinqi Dai, Lan Geng, Jiameizi Jia, Kimberly Yang, Yujin Zhang, Jiaqiao Xiang and Gill Zwicker. We also are in awe of the lovely design and layout by Kathy Butterfield.

Our Authors



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Molly Bradtke worked as a research assistant for The Wilson Center's China Environment Forum in 2017. She graduated with a Master's in Global Environmental Policy from American University in August 2018. She is now working as a Senior Associate with the international conservation NGO Rare working on blended finance for natural capital.

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Mr. Fridley has 25 years of experience working in China. From 1993 to 1995, he worked as Business Development Manager in refining and marketing for Caltex China. Currently, Mr. Fridley is a staff scientist at the China Energy Group where his research involves extensive collaboration with the Chinese partners on end-use energy efficiency, industrial energy use, government energy management programs, data compilation and analysis, medium and long-term energy policy research.

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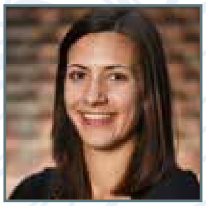
Kaboo Leung is a Senior Analyst at Trucost, part of S&P Dow Jones Indices. Her work focuses on assessing environmental risks through scenario analysis, natural capital valuation, and supply chain assessment. She has developed various climate risks initiatives such as the environmental stress testing on the aluminum sector with ICBC, carbon pricing tool and ESG assessment framework. Kaboo has years of experience in environmental research and consultancy in U.S., Europe, and Hong Kong.

Hengwei Liu

Dr. Liu is a seasoned energy professional with nearly 20 years of experience. He initially worked as a power plant engineer and an energy technologist. Later in his career, he advanced to policy and strategy positions performing global energy research and strategy formulation exercises to assist C-suite executives and politicians in making strategic decisions.



Kate Logan

Kate Logan is Green Choice Outreach Director at IPE, a nonprofit environmental organization based in Beijing that promotes information disclosure and public participation as means of strengthening environmental governance mechanisms, reducing emissions, and improving environmental quality. Her main work focuses on collaborating with stakeholders as part of IPE's green supply chain initiative to integrate transparency and stakeholder participation into existing supply chain management systems.

Ma Jun

As the founder the nonprofit organization IPE in Beijing, Mr. Ma led the development of China's first environmental public database, the Blue Map Database, and App that help the public use "micro-reports" against environmental violations and polluted rivers. In 2006, Ma Jun was recognized as China's "Green Person of the Year" and was one of the World's 100 Most Influential People in TIME Magazine. Ma also was honored with the Magsaysay Award in 2009, the Goldman Prize in 2012, and the 2015 Skoll Foundation Award for Social Entrepreneurship for his innovative approach to "lifting the veil" on China's pollution problems.

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Ms. Mi is an analyst at Collective Responsibility where she develops research on emerging sustainability issues in China and Asia that helps corporate clients build and execute strategic projects, particularly around urban development, waste management, energy and utility issues. In 2017, she was a researcher with the China Environment Forum at the Wilson Center. Siyi received her Master's degree in Public Affairs from the University of Texas at Austin.

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Yong Zhao

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Nan Zhou

At Lawrence Berkeley National Laboratory Dr. Zhou's research has focused on modeling and evaluating China's low-carbon development strategies, assessing building energy efficiency policies and technologies, and developing and evaluating China's appliance standards and labeling program. She also covers energy efficiency in industry, and assessments of energy efficiency policies.

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Competing for Water: Water-Energy-Food Nexus in Ordos

By Siyi Mi & Shaofeng Jia

COAL IN ORDOS

Total China Output

20%

Ordos, a city located in the heart of Inner Mongolia, became internationally famous in 2010 for its futuristic architecture and broad boulevards with hardly any residents. Today, the cutting-edge plazas, skyscrapers, and stadiums, in what was once called a "ghost city" are no longer empty. Home to nearly 2 million people, Ordos had a GDP of 358 billion RMB ($53 billion) and a 5.8 percent GDP growth rate in 2017. While the city continues to attract swells of investment and migrants to its streets, this remarkable urban growth would not be possible without its booming coal industry.

Sitting on approximately one-sixth of China's coal reserves, Ordos serves as the production base for the China Energy Investment Corp (Shenhua Group's new name after merging with Guodian), the world's largest coal company. Ordos hit peak industrial levels in 2012 when miners extracted so much ore—roughly one-fifth of the national coal output—that trucks hauling coal clogged highways in Inner Mongolia for days. Today, coal-fired power supplies 86.7 percent of the city's electricity and the municipal government is intent on expanding coal power generation for exports to the east coast. Modern coal-to-chemical industries thrive in Ordos as well, thanks to an industrial-scale experiment to turn coal into diesel and natural gas.

This boom in the coal economy comes at the cost of water resources. Ordos' coal industry guzzled 235.9 million tons of water in 2015—equivalent to the annual water use of 2.35 million Chinese people—with coal mining, coal power, and coal-to-chemicals swallowing 28, 45, and 27 percent of the water, respectively. A recent study by the Chinese Academy of Science projected a 110 percent increase in coal's water consumption by 2020 if the city follows through on its plans to scale up its coal-fired power plant fleet and coal-to-chemicals industry. Additionally, to counteract air pollution and greenhouse gas emissions from burning coal, Shenhua has built one of the nation's largest carbon capture and storage (CCS) projects in Ordos. However, this CCS technology could nearly double the amount of water a coal plant uses per kilowatt of electricity it generates.

Butting Heads: Agriculture and Coal

The rapid expansion of coal poses a challenge to another critical sector for Ordos – agriculture. In the face of desertification caused by degradation from crops and overgrazing, historic low precipitation and already limited water resources, the city is crying out for more water to produce agricultural goods. By 2020, the gap in water supply and demand in the agricultural sector will amount to 143.3 million tons.

Increasing competition between coal and agriculture has left the city scrambling for water. Ten years ago, an area 60 miles northwest of the Haole Baoji pastoral-agricultural region, what was once a fertile grassland that sat above the largest aquifer in Ordos, became the main water source for a Shenhua coal-to-diesel factory. Since then, the local water table has dropped 100 meters and the nearby lake has shrunk 62 percent. The thirsty coal industry has depleted water resources, destroyed the structure of the groundwater aquifer, deteriorated the vegetation and soil layers, and aggravated desertification and soil erosion on agricultural land. Ordos needs at least 2 billion tons of water—one-fifth more than its current water usage—to augment coal plants and to satisfy daily household, ecological, and agricultural needs.

Water Transfers: From Competition to Cooperation

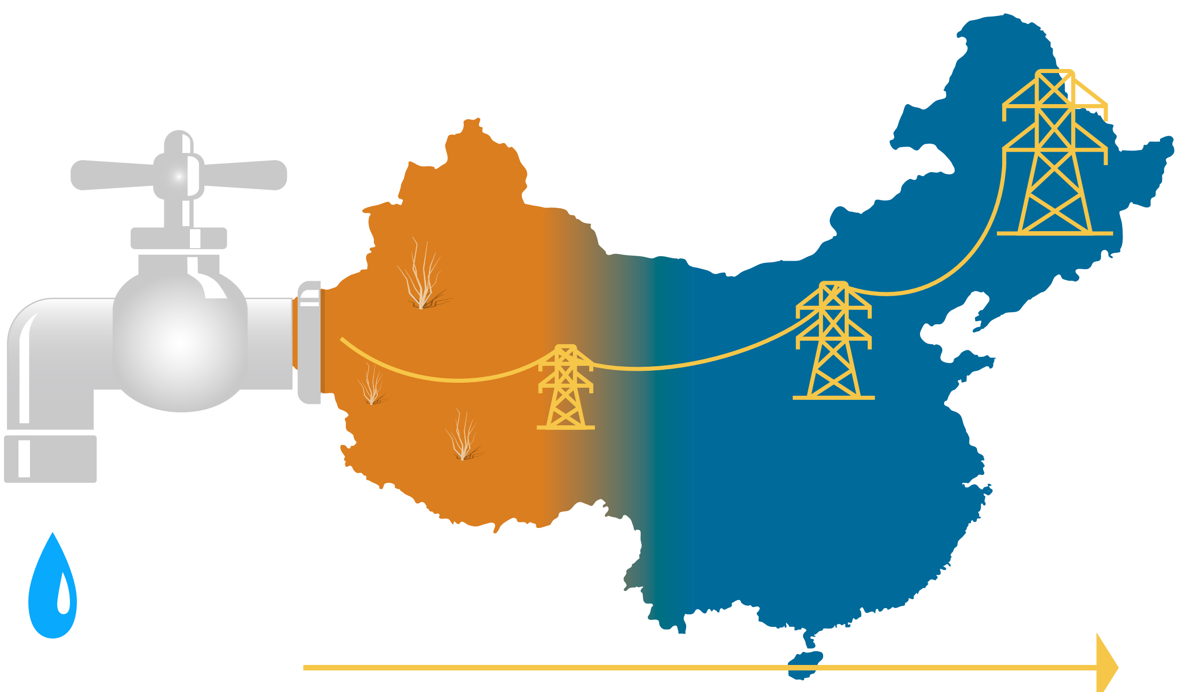
Rising up from vast deserts, Ordos has always been an arid place. Its major water supply comes from an annual withdrawal of 959 million tons of groundwater, augmented by the meager 772 million tons of water the city is allowed to tap from the Yellow River, which is essentially owned by the state. Because of the limited supply, China's Ministry of Water Resources launched a water permitting system to strictly allocate all Yellow River water following the principle of total quantity control.

Ten years ago, Inner Mongolia, as well as Ningxia, encouraged water rights trading to advance water conservation. Local governments used funds raised from the permits to invest in irrigation water-saving projects (mainly channel linings); this conserved water is then reallocated to industrial users, thereby solving their water shortages. Cities and industries no longer have to compete for scarce water resources. This approach has improved the water efficiency of local irrigation systems drastically.

However, the efficiency of agricultural areas surrounding Ordos has plateaued; any new efficiency gains would be incremental at best and insufficient to alleviate water shortages in the industrial sector. The Inner Mongolian government set up a cross-city water permit transfer program, enabling cities with high water saving potential to sell water to Ordos and other dry cities. In return, Ordos pays for irrigation water-saving projects in neighboring cities, and the saved water is sent back to Ordos. The city has already acquired 148 million tons of water through these innovative trades.

Moving Forward: Water Rights Trading

So far, the trading system has been merely an administrative arrangement of water use permit ownership, without actual trading occurring between different water users. The lack of a free market for water stems from China's Water Law that stipulates all water resources belong to the state and water trades must be managed under government control. The law does not provide an open market for trading permits. This clunky management plan has restricted efficient water use, particularly in energy and agriculture sectors. In Ordos, most industries are granted more water permits than they need as the local water bureau lacks the ability to gauge accurate water conservation potential. The idled water permits have not only wasted scarce water resources, but also hindered innovation to expand water-saving technologies. Moreover, under the current scheme, the amount of water Ordos can distribute has largely been assigned to longstanding users for agricultural irrigation, and the Chinese government has begun to prioritize finding ways to give new coal projects access to water.



Western coal exports exacerbate western China's droughts

Today, the Ministry of Water Resources is conducting pilot projects on large-scale water rights trading, further clarifying the water rights of micro-users (enterprises, irrigated areas, and even farmers) and experimenting with short and long-term water rights trades to improve the flexibility of the water allocation mechanism. However, there remains a gap between the existing mechanism and a true market-based approach. The government can take a few actions to bridge this gap, including:

- Considering water as an economic resource and allowing its free trade as a basic principle of resource allocation.
- Classifying water rights at each level of administration and specifying the quantity and quality of water usage as well as spatial requirements for water discharge.
- Applying regulations within the water market to every user and protecting them from being easily changed through administrative measures.

Another mechanism to help Ordos manage water more holistically is to establish a local government river chiefs system.

With crippling water shortages, water pollution, and ecological deterioration growing more prominent, emerging Chinese metropolises like Ordos have arrived at a water-energy-food tipping point. Water rights trading could help cities effectively allocate water and drive conservation efforts necessary to quench the thirst of coal. Ideally, officials in Ordos should recognize the interconnectedness of water, energy, and food in policymaking, and devise an inclusive resource utilization and management plan through open dialogues, information sharing, and scenario simulations with various stakeholders. This stands in great contrast to the current fragmented and uncoordinated water management "fiefdoms" in Ordos. Another mechanism to help Ordos manage water more holistically is to establish a local government river chiefs system. By the end of 2018, the central government has mandated that local governments establish river chiefs at provincial, city, county, and township levels. River chiefs will be held accountable for the development and protection of rivers and are therefore granted the authority and resources to coordinate water management between different government bureaus. River chiefs and open water markets are needed in China's coal regions to better coordinate water management and diminish the triple threat of water scarcity, food insecurity, and environmental pollution.

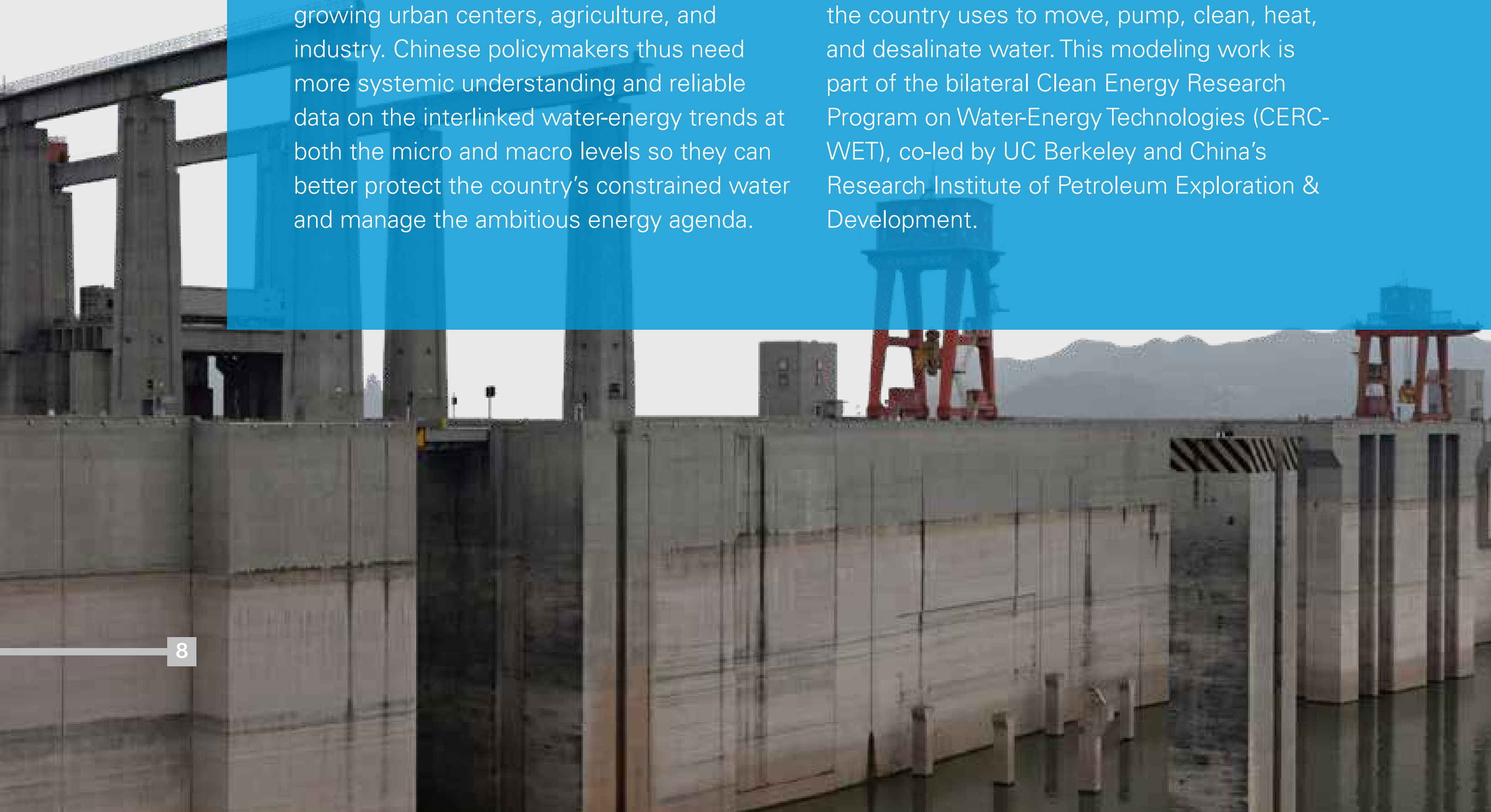
Mind the Nexus: Technical and Policy Gaps in Addressing China's Water-Energy Challenges

By Jingjing Zhang, Nan Zhou, Nina Khanna & David Fridley

MIND THE NEXUS

Almost all forms of energy development require water—to clean coal, cool thermal power plants, move hydropower turbines, frack gas, and grow biofuel crops. China's water availability is far below global average, yet the country continues to expand water-intensive energy development rapidly from new coal mines, power plants and shale gas fracking in the arid west to the world's most extensive hydropower boom in the southwest and growing inland nuclear power development. This intensifying energy development adds more pressure to China's water ecosystem that must also supply growing urban centers, agriculture, and industry. Chinese policymakers thus need more systemic understanding and reliable data on the interlinked water-energy trends at both the micro and macro levels so they can better protect the country's constrained water and manage the ambitious energy agenda.

In response to these challenges, a team of U.S. and Chinese energy and water researchers from Lawrence Berkeley National Lab (LBNL) and China Institute of Water Resources and Hydropower Research (IWHR) recently completed one of the most comprehensive national-level water-energy nexus models. This modeling work was not an academic exercise, rather an attempt to help Chinese policymakers understand more precisely how energy development at the national and regional levels consumes the country's limited water resources. The model also examines how much electricity the country uses to move, pump, clean, heat, and desalinate water. This modeling work is part of the bilateral Clean Energy Research Program on Water-Energy Technologies (CERC-WET), co-led by UC Berkeley and China's Research Institute of Petroleum Exploration & Development.



DATA AND GOVERNANCE GAPS

Managing water and energy together represents a major governance challenge in many countries. China's fragmented authoritarianism presents particular difficulties for water and energy policy coordination. Besides the inconsistent and often competing policy priorities among government agencies in these two sectors, at the most basic level both bureaucratic spheres lack the data and insights into the big impacts of water-energy confrontations. The current method for water-energy information gathering and regulation in China has focused on the facility-level. For example, how much water used to clean coal at one mine or cool one coal-fired power plant provides insights into how local water resources are impacted.

The CERC-WET project moves beyond the local, providing a system-level mapping of water and energy development and how they interact at the macro level. Our integrated model notably incorporates governance and policy frameworks, enabling us to produce deeper insights into regional water-energy trends that could help China's central and local governments more purposely invest in technologies and create plans to mitigate water-energy challenges.

CHINA'S THIRSTY ENERGY AND ENERGY-INTENSIVE WATER

So how thirsty is China's energy sector? Most thermal energy plants need to use significant quantities of water for cooling. Case in point, in 2014, water consumption from China's energy production and conversion sector amounted to 17.7 km3 - over half of industrial total water consumption for the year. Meanwhile, the coal sector withdrew over three times more water for cooling/processing (79km3) than it consumed. If the current trend continues, water consumption for energy could peak between 2033-2034, an increase of 30 percent from the current annual level, while the water withdrawal for energy will peak at 127.5 km3 in 2036. By comparison, the water withdrawal for agriculture was 387 km3 in 2014.

Although the Ministry of Water Resources regulates how much water energy projects can consume, there are not yet specific regulations to limit the potentially severe impacts of water withdrawals. Moreover, existing water limit standards focus on coal mining and washing, thermal coal power, and coking, but fail to address the macro-level impacts of energy development on water resources.

The CERC-WET modeling also dug into data around the energy footprint of water in China. Between 2005 and 2014, water supplied to agriculture, industry, residential and ecological use in China has increased 8 percent, but the corresponding energy demand to move, pump, clean, and heat water has grown 25 percent. This disparity is due mainly to increases in energy-intensive groundwater pumping and

inter-basin water transfer. The modeling results showed the energy use in the water sector will likely increase dramatically from its current level of 210.7 TWh (about 2 percent of China's final electricity consumption). As urbanization continues, by 2050 the nation's water demand will require 23 percent more energy annually, and China's wastewater treatment sector will need 29 percent more energy than today. Despite this trend, water's energy footprint does not garner much attention from government agencies, NGOs, or researchers except for indicating the economic concerns at the project or city level.

LOW CARBON DOESN'T ALWAYS SAVE WATER

Increasing the renewable and alternative energy supply can not only mitigate climate change, but also save water resources depending on the type of renewable energy that is developed. The CERC-WET team ran a clean/alternative energy scenario[1] that indicated a shift to 68 percent renewable energy sources by 2050 would lead the energy sector to consume 33 percent less water, and withdraw 61 percent less from rivers and aquifers. However, while shifting towards using inland nuclear power plants offers climate benefits, it could potentially increase freshwater consumption of this energy source by 44 percent (1.9 km3) by 2050. As an already controversial alternative energy to coal, the significant water footprint of nuclear power plants could hinder their development inland. Current Chinese government and energy company proposals seek to use more reclaimed water as an alternative source to freshwater for energy development, but more research is needed to evaluate the sustainability of these projects. Overall, the water-energy scenarios underscore further disincentives to increases in primary coal production and coal thermal power generation in China, pointing towards expanding renewable energy that also integrates a water perspective into its planning.

KEEPING A LOCAL PERSPECTIVE

CERC-WET showed the water-energy nexus picture at the aggregated national level, but it is important to note that water-energy conflicts can be exacerbated at the regional level. Arid western provinces are fossil fuel rich, but in order to utilize their fossil fuel resources, developers in these areas have to further overtap already diminishing water resources. Even eastern regions face challenges in supplying sufficient water and clean energy to their growing urban populations—the

Beijing-Tianjin-Hebei region provides such an example. In addition to these technical challenges, local communities often perceive these issues differently than policymakers, further complicating the research design to address nexus problems.

It is vital for researchers to take specific local water-energy issues into account and ask research/policy questions in an inclusive and adaptive process. Researchers, such as Endo et al.,[2] have laid out some groundwork to apply different research approaches and methodologies to examine water-energy nexus trends in varying local policy and technical contexts.

THE CHALLENGE OF POLICY COHERENCE

In addition to the modeling work mentioned above, CERC-WET also set the groundwork for understanding necessary characteristics of governance structure for this nexus, as there is currently very little social science research on water-energy nexus issues. We unveiled the governance differences that revolve around policy priorities, scale, regulatory and market structure, and actors involved. In order to address the policy coherence/coordination issues for the short term, it is imperative to develop a common dialogue and vision between two sectors that have very different policy goals. Future research needs to continue to work to develop knowledge on bridging the institutional, organizational and behavioral gaps between the water and energy sectors.

Finally, nexus issues require interdisciplinary efforts—before formulating research questions, it is necessary to engage with a diverse set of actors, including scientists from varying disciplines, policymakers, and community members. Through an inclusive and adaptive process, nexus research could avoid "a hammer looking for a nail" situation.

1 The clean/alternative energy scenario assumes the renewable energy share to be increased to 36% in 2030 and 68% in 2050, while share gas production is projected to grow from 1.2 Mtoe/year in 2014 to 180 Mtoe/year by 2050. The coal conversion processes are assumed to be the same as the reference scenario.

2 Endo, A., Burnett, K., Orencio, P. M., Kumazawa, T., Wada, C. A., Ishii, A., Taniguchi, M. (2015). Methods of the water-energy-food nexus. Water, 7, 5806–5830. https://doi.org/10.3390/w7105806

Creating a No-Regrets Climate-Energy-Water Strategy in China

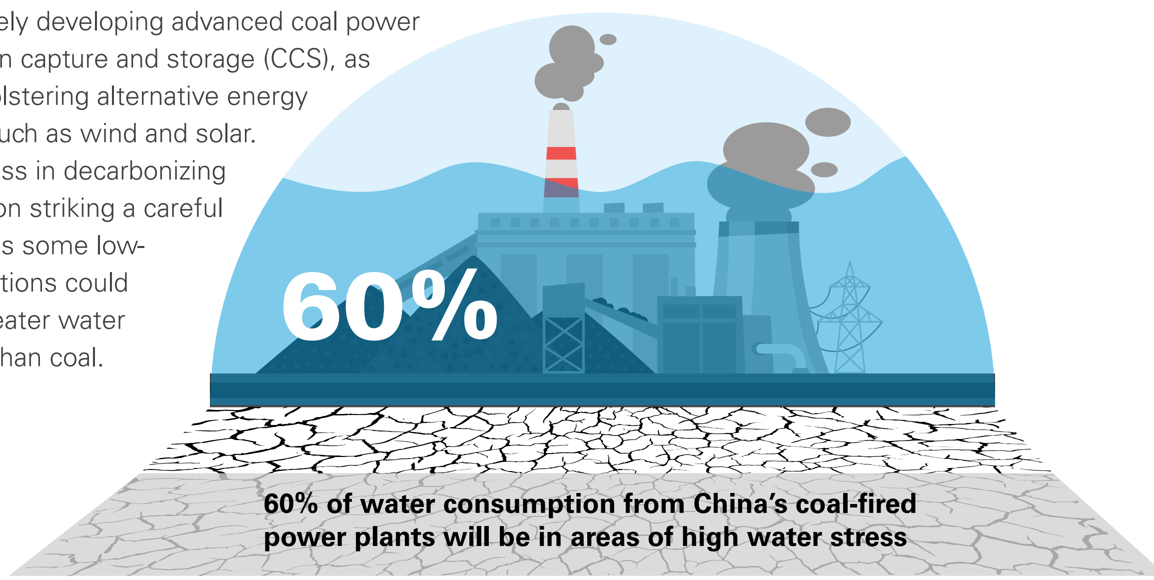
By Hengwei Liu

TRICKY TRADEOFFS

Water and energy are interlinked--energy production, particularly through coal burning, uses a large volume of water and moving, cleaning, and heating that water can be very energy intensive. In practice, policymakers and government bureaucracies rarely integrate energy policy and water management. In some instances, as in China, energy and water policies may even contradict one another and create high-carbon footprints.

As the Xi Jinping administration works to reduce the country's reliance on coal for power, China remains the world's biggest consumer and producer of coal, which is responsible for half the country's CO2 emissions. Coal power plants also account for more than 80 percent of the water used or consumed by China's coal industry. Most of this water is for cooling power plants. China's plan to build an additional 200 gigawatts worth of coal plants during the 13th Five-Year Plan (2016-2020) would significantly increase the country's carbon emissions and the amount of water guzzled by the coal sector. Most of these proposed plants are planned for the world's most water-stressed areas of western China.

In an ever more carbon-conscious world, addressing energy, water, and climate concerns in tandem should be a priority for the world's most populous nation. In order to decarbonize its power generation, China's leadership should prioritize aggressively developing advanced coal power and carbon capture and storage (CCS), as well as bolstering alternative energy sources such as wind and solar. But success in decarbonizing depends on striking a careful balance; as some low-carbon options could have a greater water footprint than coal.



The natural landscape of Ningxia, Shapotou, a large coal producing area.

EFFICIENT TECHNOLOGIES CAN BE LOWER CARBON….

There are two approaches to advanced coal power: one is through pulverized coal combustion (PCC) technologies, including high-efficiency supercritical and ultra-supercritical coal-fired power plant; another is integrated gasification combined cycle (IGCC) plants that gasify coal to produce electricity.

China leads the world in installed supercritical and ultra-supercritical coal power plants, which provide the golden opportunity to achieve necessary abatement in CO2 emissions. Not only do these higher efficiency plants emit less CO2 and use less water, but they are also better suited to capture carbon. As the most mature advanced coal power generation technologies, Chinese energy companies will build SC and USC in significant numbers for at least the next 10 years, and these new coal plants are likely to remain generating electricity until 2050.

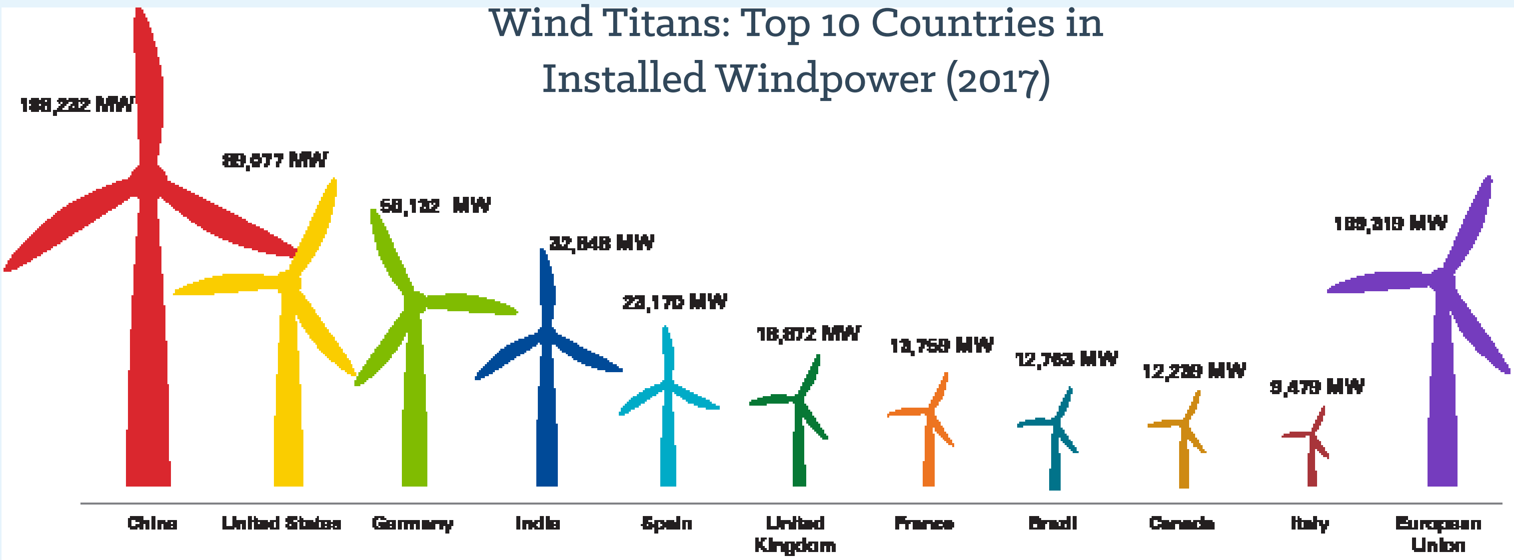
….BUT MAY BE MORE WATER INTENSIVE

Although IGCC looks promising in its ability to produce deep CO2 reductions with the least cost, it has been hindered by its higher capital investment, poorer reliability and availability, inflexibility of operation, and high water needs. Even advanced coal power plants with water-saving cooling technologies, such as air cooling or cooling with seawater, still use significant amounts of fresh water.

Carbon capture and storage (CCS) has the second largest potential to contribute to reductions in carbon emissions from coal power plants (PCC or IGCC). However, CCS requires more energy, reduces overall energy efficiency, and increases costs. According to the MIT study, The Future of Coal, PCC units with CCS lose an average of 9.2 percent of their efficiency, and IGCC efficiency is reduced by 7.2 percent.

Despite promising results for emissions reduction, CCS technologies do pose greater water risks. CCS requires additional water for chemical and physical processes, which limits the deployment of CO2 capture in arid areas. In PCC plants, water consumption per net unit of energy generation increases by 90 percent with the addition of CO2 capture, while IGCC plants recover CO2 prior to combustion, increasing water consumption by only 46 percent. Injection of CO2 may cause groundwater pollution, which is another major concern.

Wind Titans: Top 10 Countries in Installed Windpower (2017)



Source: Global Wind Energy Council's Global Wind Statistics 2017

It is widely recognized that coal will remain the dominant fuel for both the world and China in the coming decades. The rationale for using CCS comes down to simple logic then: the world has little chance of reducing CO2 emissions in line with Paris Agreement unless CCS technology becomes widely deployed in existing and future fossil-fuel power stations, especially coal-fired power plants.

WATER FOOTPRINT FROM ALTERNATIVE ENERGIES

China is installing nuclear, wind, and solar power faster than any other country in the world. As each offers low carbon alternatives to coal, they differ significantly on their water footprint.

Nuclear Power. In a nuclear power plant, energy from the decay of uranium heats pressurized water that is then used to produce steam in the steam generator. All power produced comes from the steam cycle in the same manner as in pulverized coal combustion (PCC) plants. Nuclear plants have a higher cooling tower load than PCC plants. Nuclear and coal-fired power plants consume nearly the same amount of water (~680 gallons/megawatt hour).

Solar Power. Most of China's solar power comes from solar photovoltaic (PV) technology, which converts sunlight directly into electricity. Only negligible amounts of water are needed to keep the solar panels clean. China is also expanding the water-intense concentrated solar power technology, which generates electricity by collecting and concentrating solar energy as a power plant fuel source, in a manner similar to other thermal power plants. Generally, concentrated solar power is much more water-intensive than nuclear power and coal power plants without CCS, while producing the same amount of electricity.

Wind Power. China leads the world in installed wind, but today 17 percent of it is not hooked onto the grid. The kinetic energy of blowing wind is converted into mechanical energy of turning blades, which is then converted into electrical energy using a generator. No water is required for wind power generation.

ALIGNING CLIMATE, ENERGY AND WATER STRATEGIES

China has formally launched its national carbon market. While the first phase of the market only covers power generation, this step will still have major climate benefits. China's power sector accounts for roughly 3.5 billion tons of annual CO_2 emissions. By comparison, the world's current largest CO_2 trading system in the European Union covers around 2 billion tons, and the biggest in the United States is California's, which covers approximately 395 million tons.

If designed correctly, a carbon market is a powerful policy to cost-effectively cut carbon pollution. However, it also implies potential water insecurity by promoting low-carbon, water-intensive technologies such as CCS, nuclear power, and concentrated solar power. On the other hand, policies to decrease water intensity can also promote potential energy and carbon-intensive projects, such as air-cooling systems.

To ensure that water is considered in carbon trading and other low-carbon initiatives in China, the leadership should include a water intensity target in its medium and long-term social and economic development plans and develop corresponding data and statistics to benchmark and monitor progress. Water has remained too low on the list of political priorities for too long, a situation that cannot be allowed to continue. Additionally, more site-specific and regional comparative data, such as those gathered by the U.S.-China CERC-WET is needed for a full understanding of the nature of the climate-energy-water nexus and for integration in planning for the future. [Editor's Note see the *Mind the Nexus* article in this volume]. More attention needs to be paid in the future to balancing the trade-offs between climate, energy, and water security strategies through coordinated policymaking.

Finally, the Chinese authorities must show a strong political will to significantly limit or stop new coal power plants from being built, especially in areas with high water stress. A no-regrets, long-term energy policy framework should be pursued to increase the share of renewables in the energy mix, such as wind and solar PV, which use little or no water and emit little or no carbon.

ACKNOWLEDGMENTS

This Op-Ed piece draws on *Unraveling the climate-energy-water conundrum in China*, a research project conducted when the author worked at Harvard University and Tufts University. The opinions expressed in this article are solely the author's own and not necessarily those of his employer.

Solar panels superimposed against Shanghai skyline.

Finding a Low Water Path: Technology Innovations for Coal Bases and Cities in China's Arid Northwest

By Shan Jiang, Lianhua Wang, Yong Zhao & Yongnan Zhu

China's arid northwest is short on water, but abundant in coal that is mined and processed in huge coal bases, which together have fueled China's economic engine. To expand the use of coal-fired power and coal converted into gas for heating, vehicle fuel, and chemicals, the Chinese central government set the goal to build additional large-scale coal bases during the 13th Five-Year Plan (2015–2020). In the future, this coal development in China's northwest will account for 53 percent of the increased water consumption across the nation. According to the 1999 China Coal Resources Forecasting and Evaluation report, ten major coal bases in Shandong, Ningdong, Shanbei, Jinzhong, Huanglong, Henan, Jizhong, Jinbei, Jindong, and Xinjiang account for more than 80% of the nation's forecasted coal resources. But these areas are distributed along the arid Yellow and Hai river basins. These areas only have 9% of the total water resources in China, so coal and water are increasingly in conflict.

In northwest China, energy efficient water processing technologies and stringent water demand side management regulations could help alleviate water shortages caused by extensive coal development. Since 2009, the Qingyang Prefecture in southern Gansu Province is working with the China Institute for Water Resources and Hydropower Research (IWHR) to investigate how to solve water-coal conflicts that threaten the economic growth of its urban district, 7 counties and 146 towns. This prefecture, with a population of 2+ million, used to have an economy based on grain production, but today is home to the Longdong Energy Base. Longdong will, according to its development plan, become a primary energy production

base that converts coal into petroleum and chemicals. It is targeted to become a model for the comprehensive utilization of traditional coal-fired power as well as new coal energy that utilizes upgraded and more energy-efficient coal gasification and liquefaction technologies. However, water shortages and weak water infrastructure in Qingyang threaten economic development and the expansion of coal industries in Longdong. As surrounding water supplies include considerably sandy and brackish waters, there is less than 100m3 of water per capita in Qingyang—one-eighth that of the average in China.

Qingyang prefecture's government commissioned our team at IWHR to conduct detailed planning and research on the water supply in the city. We calculated that the water demand of Longyang Energy Base in 2020 will reach at least 180 million m3 with an annual growth rate of 15 percent. Qingyang also faces a water quality crisis, as the largest source of water, the Malian River, cannot be used for drinking or irrigation because of high sediment content in the flood season.

IWHR proposed a two-pronged solution to the water problem in Qingyang that the prefecture is starting to implement. First, we recommended technologies to help the prefecture and the energy base fully exploit the potential of unconventional water resources in order to expand supply. Second, we strongly believe that the prefecture needs to establish stringent water resources demand management (DSM) in both the cities and the energy base. The prefecture should create DSM standards and pilot projects for water use that push water saving in all industries and require rapid adoption of new water-saving technologies across all sectors.

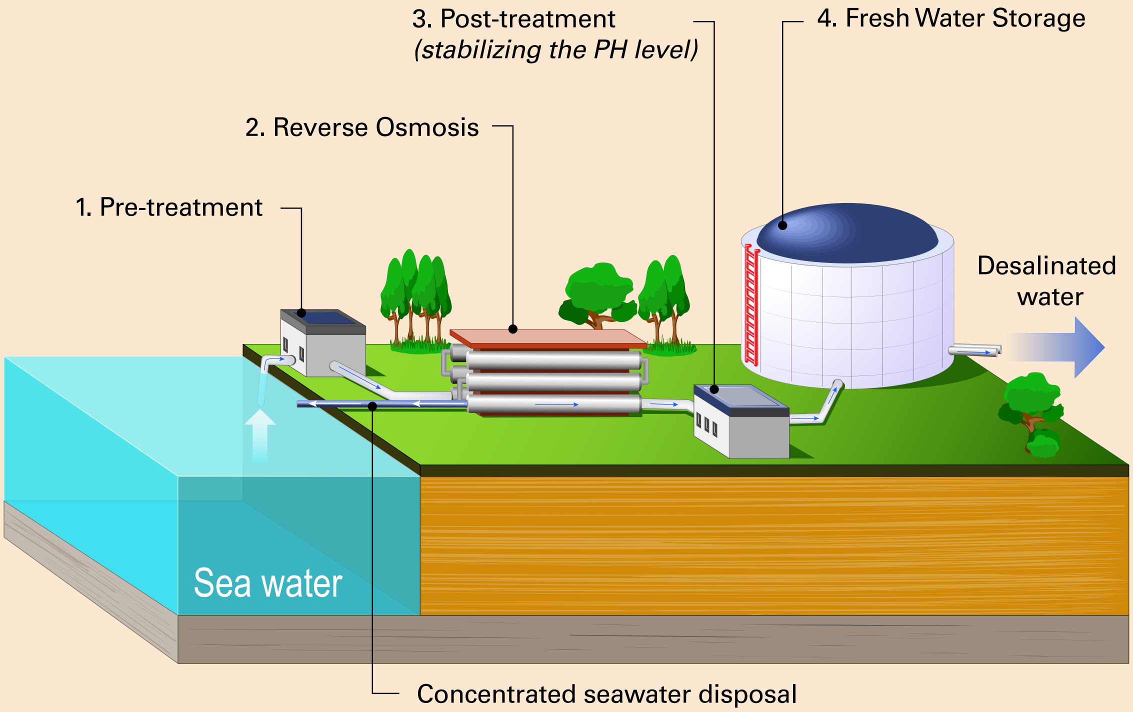
GAME-CHANGING SUPPLY MANAGEMENT TECHNOLOGIES

Based on a systematic analysis of the formation and distribution pattern of brackish water in the Malian River, IWHR researchers put forward the idea of creating storage ponds that can undergo desalination and enrichment treatment. We evaluated various technologies for the reduction and disposal of high-concentration brines and ultimately selected a double-membrane deep-desalination treatment process, which succeeded in producing usable water from the brackish Malian River. Additionally, we assessed an array of other promising water technologies (Hongde barrage gates, Sanshilipu ditch-injected reservoirs, large-scale water desalination treatment plants, and closed injection wells) that also could be used to improve the water quality. When the Malian River brackish water desalination project is fully in operation, it will provide about 23.7 million m3 of high-quality water for domestic and industrial production activities annually. Utilizing such water technologies could be a gamechanger for economic and social development in this arid region. To date, Qingyang Prefecture's Huan County has already completed well desalination projects for rural drinking water, brackish water desalination pilot projects for water companies, and a water desalination pilot.

WATER DEMAND MANAGEMENT

IWHR researchers also proposed a package of demand management solutions for Qingyang prefecture. The first is to plan economic development for coal and chemical industries at a scale that does not over-extract water or pollute water and land resources. One model

Desalination Process



for this is Xifeng Industrial Zone, the only provincial-level industrial campus approved by the National Development and Reform Commission in Qingyang Prefecture. To adapt to the local water resources conditions, Xifeng Industrial Concentration Zone has adjusted its economic plans for 2020 and 2030, and reduced the expected scale of development. The second demand management solution we recommended is for industries to utilize the most advanced water-saving technologies for coal washing, thermal power generation, and coal chemical and petrochemical production. Moreover, Qingyang prefecture needs to incentivize agricultural and urban areas to adopt more water-saving practices, from low-flow household appliances to low-water irrigation. Significantly stricter water-saving requirements could reduce water demand at the Longdong Base by 41.8 million m3 every year through 2030, greatly exceeding today's current water conservation efforts.

Qingyang strives to solve the problem of thirsty coal industry by revolutionizing its water management not only by conserving water, but also by tapping unconventional water sources and recycling water aggressively. If Qingyang succeeds it could be a model for other coal bases and cities in northwest China.

Interior of Desalination Plant

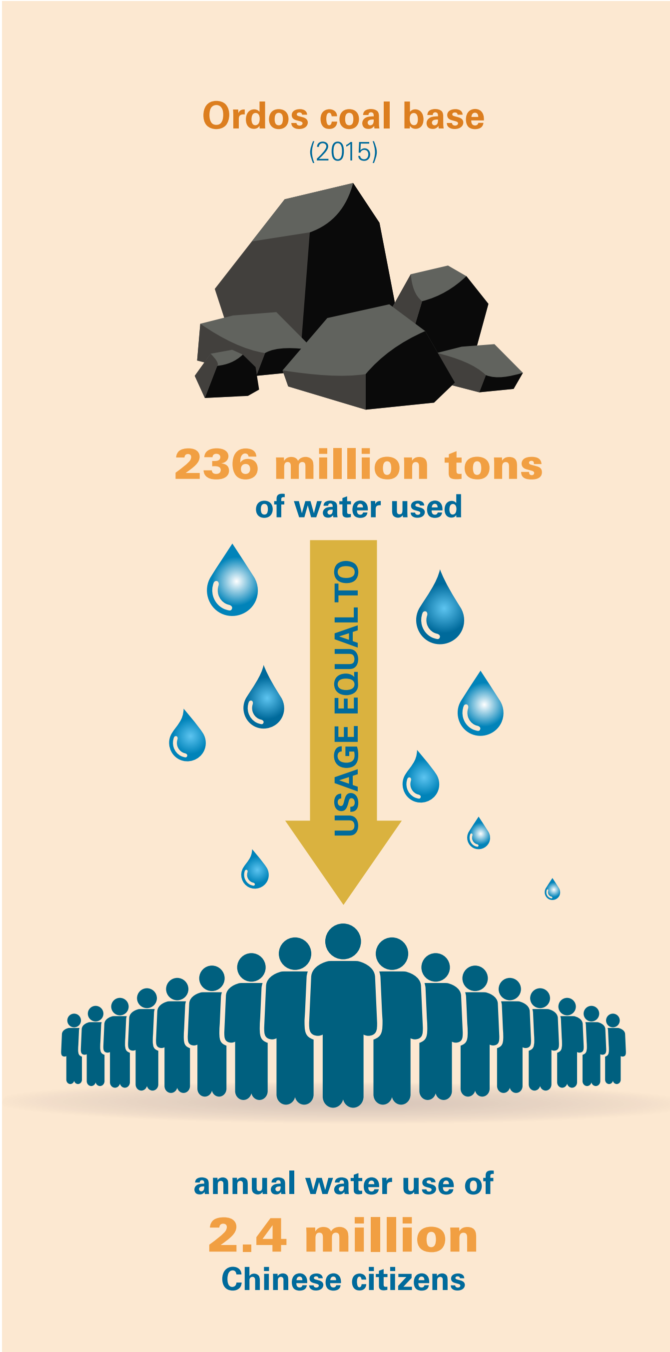
Can Transparency Help Reduce Water Risks From Coal?

By Ma Jun, Kate Logan & Mingxuan Wang

WATER-SAVING LEADERS

State-owned enterprises (SOEs) often get a bad rap for shortchanging sustainability, but a handful of major Chinese SOEs are reversing this stereotype. In 2015, China Shenhua Energy Co., Ltd. – China's largest coal company – saved 191.34 million tons of freshwater and reduced power consumption by 0.73 kg/kWh for its thermal power business unit. The company also desalinated 12.54 million tons of seawater to supply water to Shenhua plants located in severely water-stressed regions, thereby protecting local groundwater resources. Due in part to these sustainability efforts, Shenhua was deemed to have the lowest water risk rating among 30 coal-related companies assessed by the Corporate Water Risk Assessment Tool (CWRAT) that was created by the Institute of Public & Environmental Affairs (IPE).

Luckily, Shenhua is not alone in its attempts to tackle water risks inherent to coal. Another company facing similar challenges is China Coal Energy, whose emerging coal-to-chemicals projects consume an enormous amount of water. Nevertheless, one of the company's projects in Ordos, Inner Mongolia, has achieved "zero emissions," solving one part of the water resources problem inherent to the coal industry. The plant's zero wastewater discharge system has been running continuously so far, and the facility has achieved a wastewater reuse rate of 98 percent, while raw water consumption has decreased by 29.7 percent. Annual savings of freshwater totals around 7.3 million tons.



Both Shenhua and China Coal Energy have prioritized water conservation and taken encouraging steps toward reducing pollution and damage to the environment and ecosystems. Their actions are significant because the coal industry – spanning coal mining, washing, coal-to-chemicals, and coal power plants – relies heavily on water. Concerns over air pollution have drawn global attention to China's coal-fired power plants; however, little attention has been paid to the less visible but no less dangerous water consumption and wastewater discharge problems associated with the coal industry.

Compounding such problems is the complex issue of the mismatch between coal and water resources. Studies point out that coal resources are concentrated in areas facing severe water shortages. For example, the 2016 Greenpeace report "How the Coal Industry is Aggravating the Global Water Crisis," showed that 45 percent of the operations of coal-fired power plants in China – a whopping 358GW – are located in areas with excessive water withdrawal. The baseline water stress had already exceeded 100 percent.

National and local authorities are well aware that water risks faced by coal companies are becoming acuter. Management of water resources and aquatic environments has grown more stringent in recent years, following the release of the *Assessment Methods for Implementing the Strictest Water Resource Management Systems, the Water Pollution Prevention and Control Action Plan,* and other national policies. These policies provide a basis for water use limitations, water efficiency, and pollution limits in areas with functional water bodies.

UNCOVERING WATER RISKS

To address the increasing strain on China's water resources, IPE developed the methodology for CWRAT, which was initially applied to evaluate 30 top-earning coal companies listed on the Shanghai and Shenzhen stock exchanges. Using publicly available information, IPE examined the business operations and geographic location of the 30 coal companies' production-focused subsidiaries in order to assess water risks.

Water consumption, discharge, and compliance all pose direct or indirect impacts on a company's financial indicators, thereby resulting in clear or hidden financial risks. The CWRAT, therefore, does not simply examine water risks from the perspective of the company's internal production management, but also identifies how external factors relating to a company's local environment, such as water abundance and policy signals, can restrict or encourage future growth. This twofold analysis captures both business and regional risks.

Based on this assessment, it is possible to quickly identify the main problems of listed companies in terms of water use, discharge and compliance, and then raise the public's awareness to pay special attention to projects within areas suffering from a severe discrepancy between coal resources and water resources. Public oversight can help to strictly control water use and wastewater discharge and promote adherence to ecological red lines in vulnerable areas.

The results of the CWRAT assessment show high overall water risks for these 30 companies, with companies scoring an average of 58.27 points (out of 100;

the higher the score, the higher the risk). Of these 30 coal companies, Kailuan Energy Chemical, China Coal Xinji Energy, and Shanxi Meijin Energy rank highest in terms of risk, while China Shenhua Energy, Haohua Energy, and Sundiro Holding display relatively low water risks. Using IPE's Blue Map Green Securities Database, we discovered 19 of the 30 companies had over 100 environmental violation records, with total penalties exceeding four million RMB (~$580,000). Furthermore, these 19 companies failed to disclose these environmental violation records in their annual reports.

POLLUTION-REDUCING POWER OF INFORMATION TRANSPARENCY

The ability to carry out such an evaluation truly relies on the rapid expansion of government information disclosure and the continuous improvement of mechanisms for corporate environmental information disclosure.

Since 2006, IPE's Blue Map Database has continuously collected environmental violation records disclosed by local government departments. And beginning in 2007, IPE launched the Green Choice Alliance, cooperating with foreign and Chinese brands to green supply chains in China. Brands have successfully motivated over 800 suppliers to remove violation records from IPE's data platform and improve their environmental performance, and nearly 1000 suppliers have disclosed their annual environmental emissions data on IPE's data platform. Since 2014, IPE's Blue Map app has collated publicly-released online monitoring data of pollution sources from 30 provincial-level websites. The app has served as a tool to motivate over 650 enterprises to explain the reasons behind their environmental violation records or excessive emissions via the official micro-blogs of local environmental protection departments.

IPE Initiatives Timeline

2007 to present
21 environmental organizations launch the green choice initiative, forming the Green Choice Alliance.

2008 to present
Created the Pollution Information Transparency Index (PITI) and evaluated 120 key cities across China based on the PITI criteria, published 7 annual reports to date.

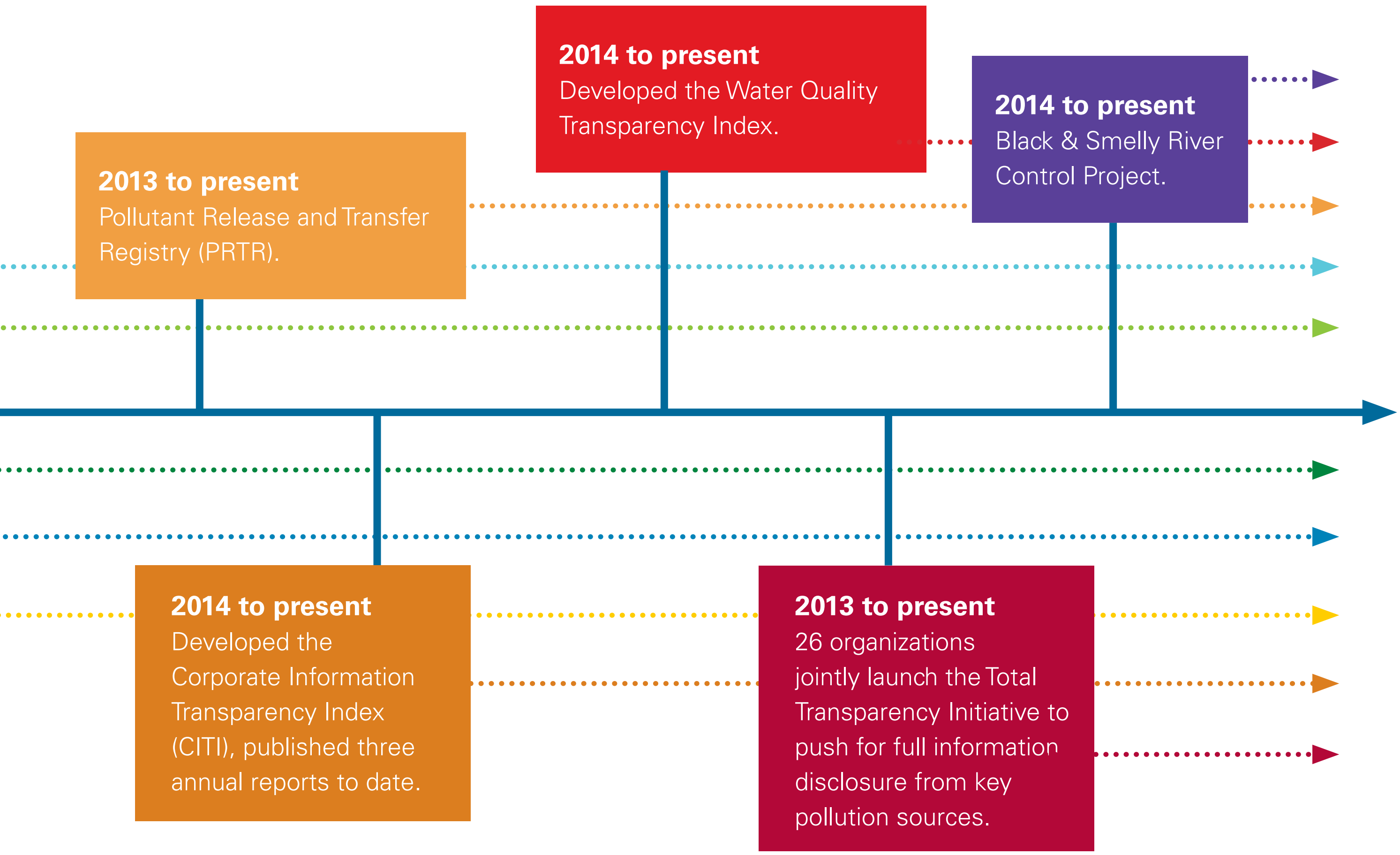
2010 to present
Launched investigations into the supply chains of key IT industry brands, published seven reports to date.

2011 to present
Developed Air Quality Transparency Index (AQTI), released four Blue Sky Roadmap reports to date

2012 to present
Launched investigations into the supply chains of key textile industry brands, released four reports to date.

China's government is also endeavoring to promote greater disclosure of information about water pollutants. China's newly revised *Law on Water Pollution Prevention and Control* (passed in 2017) includes specific provisions on the disclosure of a standardized list of toxic and harmful water pollutants. Enterprises that discharge wastewater pollutants on the list must also disclose related information about these pollutants. If such information is not disclosed, enterprises will be fined anywhere from 20,000 to 200,000 RMB ($3115 to $31,150), and may also be forced to cease production. Apart from promoting suppliers of Chinese and foreign brands to rectify their pollution issues and achieve environmental compliance, IPE's green supply chain project has also promoted the disclosure of Pollutant Release and Transfer Register information about factories' annual resource use and pollutant discharge data, creating an initial basis for disclosure of data about pollution in effluent.

The Coal-to-Chemicals Industry Coal Consumption Cap Plan and Policy Research Implementation Report, produced by Natural Resources Defense Council, points out that Shanxi, Shaanxi, Inner Mongolia, Ningxia, and Gansu are facing a particularly notable conflict between water supply and demand. The raw coal production in these five provinces is greater than 60 percent of China's total output, but their water resources account for only 4.8 percent of the entire country. Increasing



transparency in policymaking and regulations can also help put pressure on coal industries to conserve water, especially in Western China, which faces particularly severe water shortages.

Beyond environmental benefits, improving environmental risk management can help lower a company's capital costs. As the coal industry in China continues to shrink as a result of capacity cuts, environmental factors will impact a company's survival. For companies operating at a deficit, tackling pollution is even trickier. Moreover, as interest in responsible and green investment continues to grow, full disclosure can more accurately reflect the state of a company's environmental management. Listed companies that comprehensively disclose information about their operations can send more accurate risk signals to the market and thus prevent investors under or overestimating companies' risks.

Disclosure levels the playing field by forcing more companies to go transparent with their performance data in order to maintain their competitiveness. Greater data and information transparency from businesses and governments will promote healthy competition in the commercial community, and can thus play a role in heightening coal companies' attention to mitigating water risks.

Hidden Environmental Costs: Why Should Coal-to-Chemical Businesses Stress Test Their Risk Exposure?

By Kaboo Leung

Climate policy around the world has gained momentum since the Paris Agreement – many governments have set out plans to cut emissions, reduce damaging health effects of air and water pollution, and mitigate other environmental problems. This is particularly the case in China, where government action is forcing companies and investors to consider the financial implications of environmental impacts on their business.

The Chinese government is pursuing new policies to cut emissions, from carbon pricing to banning future sales of diesel and petrol cars. In addition, the need to reduce the damaging health effects of air and water pollution alongside other environmental impacts has sparked the Chinese policymakers to experiment with policies that would shift environmental costs away from society to polluters. Some of the new policies include reforming environmental taxes, piloting pollution and carbon emission trading systems, and testing a water resource tax.

Some companies are already looking into the risks that internalizing environmental costs may have on their financial performance. However, it is often unclear to businesses how these environmental impacts may translate into financial costs, and more importantly, how these risks could be incorporated into existing financial analysis to potentially improve risk management. The financial implications of environmental policies will be especially important for sectors with both great growth prospects and controversial environmental impacts, such as the coal-to-chemical sector.

The coal-to-chemical sector plays a crucial role in China's ability to diversify the use of coal and buffer economic disruptions to the industry during the low-carbon transition. Given China's commitment to peak carbon emissions by 2030 and the significant carbon footprint of coal-fired power, the coal-to-chemical sector offers a way to shift the use of coal away from power generation. The coal-to-chemical sector transforms coal into various chemical products such as oil, gas, and olefins via liquefaction or gasification processes. In the 13th Five-Year-Plan, the Chinese government set a goal of a fivefold increase in capacity for coal-to-oil and coal-to-gas by 2020 as a national strategic development target. Tremendous growth is expected for coal-to-chemical products, bringing the risk that their environmental impacts, especially greenhouse gas emissions and water use, will increase as well.

In the 13th Five-Year-Plan, the Chinese government set a goal of a fivefold increase in capacity for coal-to-oil and coal-to-gas by 2020 as a national strategic development target.

HOW DO ENVIRONMENTAL RISKS TRANSLATE INTO FINANCIAL RISKS?

In a recent study,[1] Trucost investigated the hidden costs of environmental risks in China's coal-to-chemical sector. Figure 1 illustrates the process how environmental risks could translate into financial costs, starting with environmental impacts that become financial costs to companies via various policy mechanisms such as taxes and regulations. These costs could be realized by companies on their profit and loss statements as increases in operating costs or decreases in revenue, or on their balance sheets as devalued assets. Trucost created three potential policy scenarios to assess future environmental risks of this booming coal sector in China.

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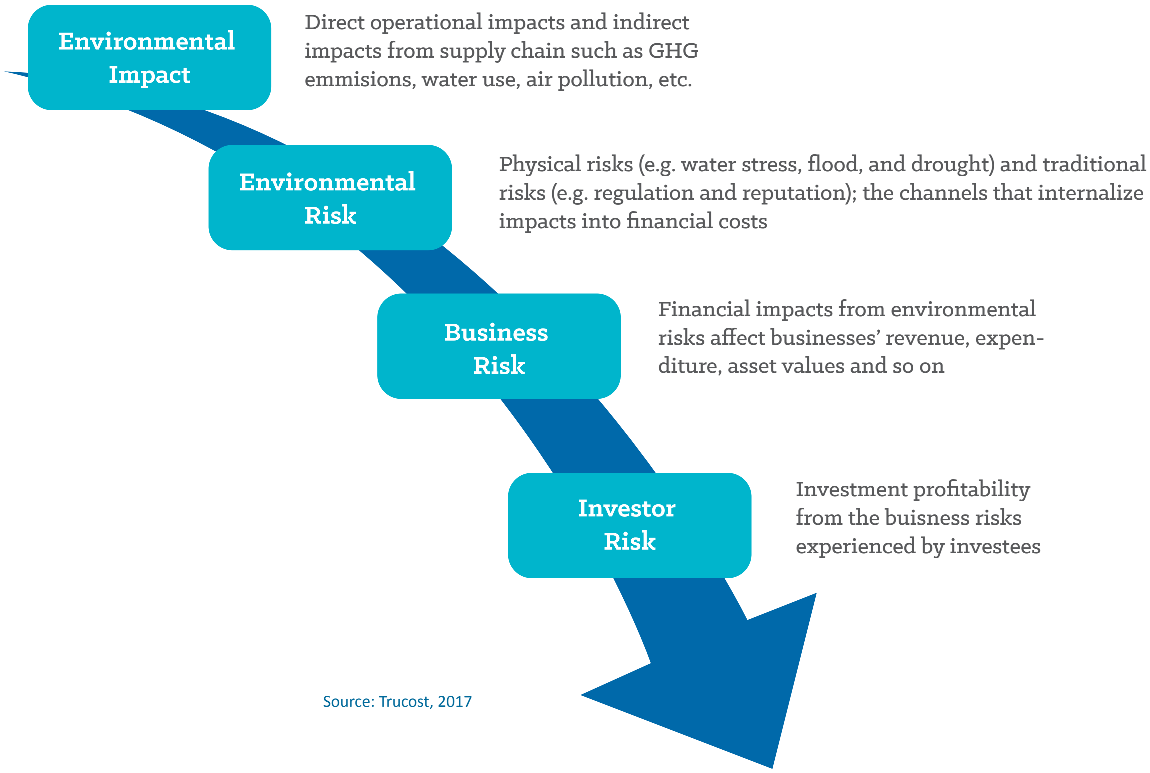
1 The Hidden Costs of China's Coal-to-Chemical Sector. 2017, Truecost. https://www.trucost.com/publication/the-hidden-costs-of-chinas-coal-to-chemical-sector/

Figure 1: The Key Types of Environmental Risks for Stress Testing

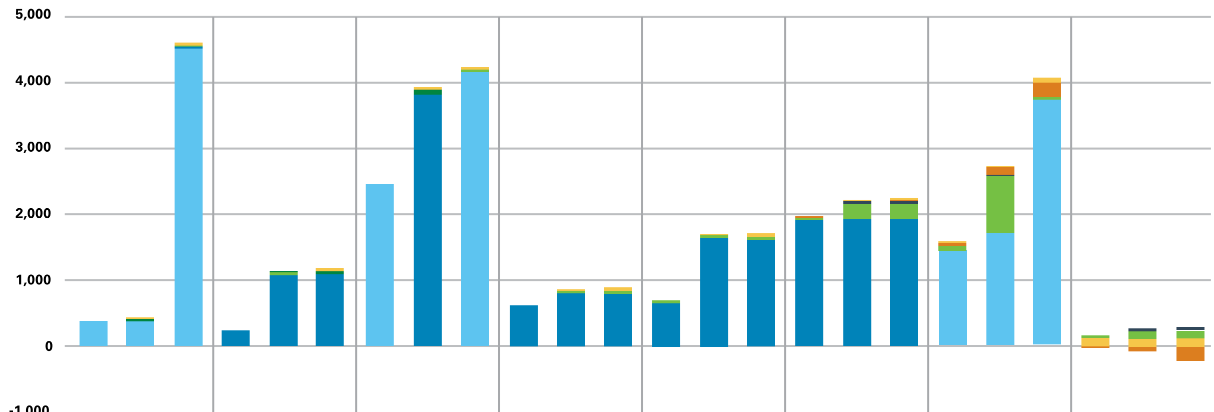


Source: Trucost, 2017

ENVIRONMENTAL COMPLIANCE AND WATER-RELATED RISKS ARE THE MOST PROMINENT

Trucost's research shows that environmental risks could lead to material financial impacts of 35 to 64 percent of the average unit price of coal-to-chemical products. These costs increase significantly as uncertainty about future policy grows. While the costs for some products may be low at present, they could be subject to disruptive rises in the future, bringing greater uncertainty for businesses.

Figure 2: Environmental Risk Intensity by Products and Scenarios, National Average



	极有可能	有可能	不大可能	极有可能	有可能	不大可能	极有可能	有可能	不大可能	极有可能	有可能	不大可能	极有可能	有可能	不大可能	极有可能	有可能	不大可能	极有可能	有可能	不大可能	极有可能	有可能	不大可能
排污权交易系统		0.1	0.1		0.1	0.1		0.2	0.2		0.1	0.1		0.6	0.6		1.5	1.5		4.9	4.9		1.1	1.1
国家碳排放交易系统																10	10	40	30	70	220	-30	-60	-180
水资源税		30	40		10	20		20	20		10	10					10	10		20	20		10	20
环境税		10	10		20	20		20	20		10	10	10	50	50	30	260	260	90	870	870	10	130	130
水压力																						110	110	110
用水量上限	370	370	4,500				2,470		4,180										1,480	1,760	2,900			
能源上限				250	1,120	1,120		3,860		620	810	810	700	1,620	1,620	1,930	1,930	1,930						

极有可能 有可能 不大可能

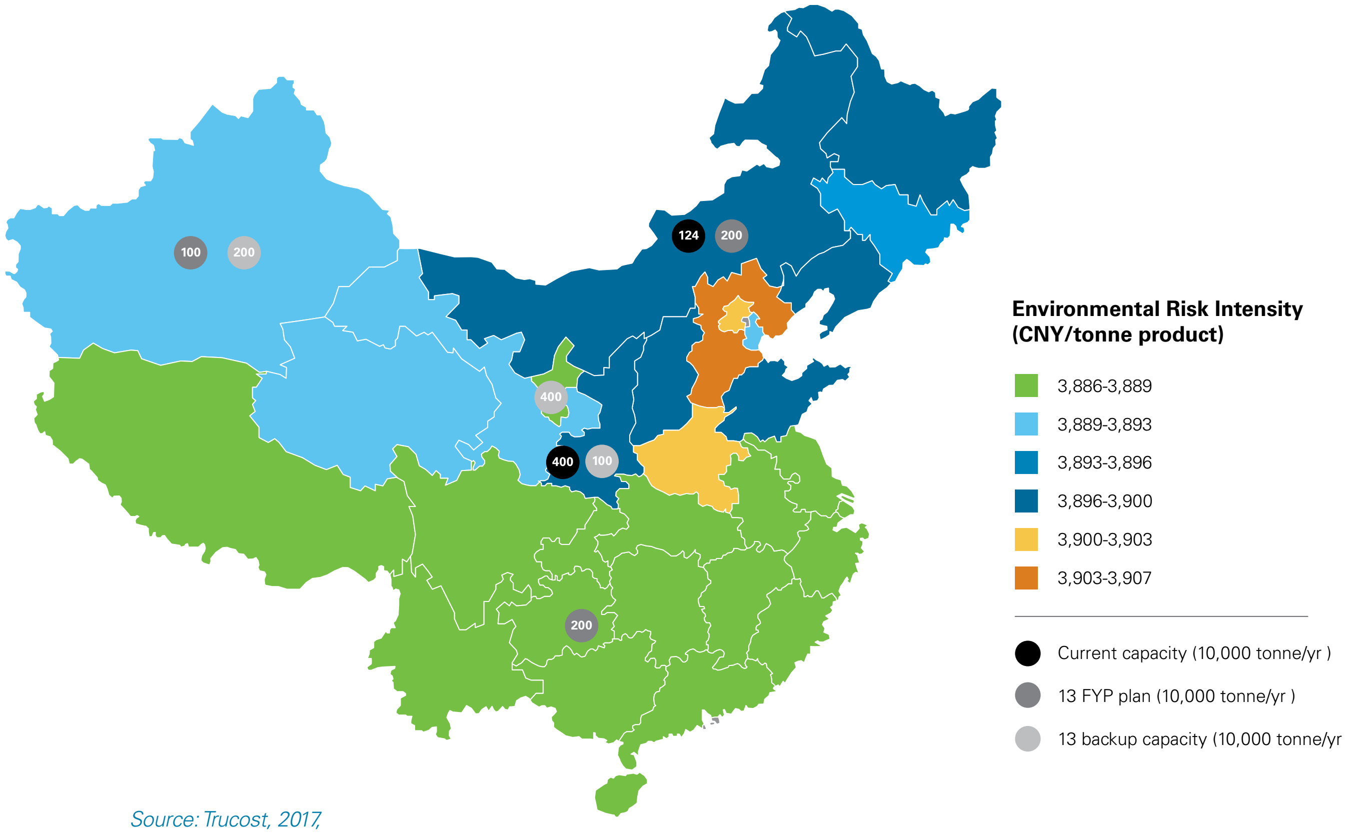
Source: Trucost, 2017

The potential loss of production from regulatory compliance accounts for the largest share of environmental risks for most coal-to-chemical products, equalling over 90 percent of total costs on average (see the blue portion of the bars shown in Figure 2). For instance, more stringent emissions control regulations could result in sites having to suspend operations while new pollution abatement equipment is installed.

Water is also a determining factor for risk exposure for the coal-to-chemical sector, accounting for about 45 percent of total environmental risks. Water also drives regional variations of risks. As shown in Figure 3, the highest risk is in the northeastern provinces, which overlaps with regions where the greatest coal-to-oil production capacity is located. A similar pattern of water risk and industrial development can be found in the coal-to-gas business.

The map in Figure 3 shows the overlap between environmental risk hotspots and target capacity growth of coal-to-oil under the 13th Five-Year Plan. With the current capacity, financial costs from environmental risks account for 2 to 6 percent of each project's investment, but with the target growth and expansion in regions with higher environmental risks, this ratio could increase to 8 percent.

Figure 3: Environmental Risk Heatmap with Potential Growth from 13th Five-Year Plan, Coal to Oil



Source: Trucost, 2017,

(National Energy Administration, 2017)

The link between environmental risks and profitability is best illustrated with an analysis of the internal rate of return (IRR) on an investment. Based on data published by two existing projects, Trucost calculated a risk-adjusted IRR of 3 percent to 5 percent, far below a typical threshold of 8 percent to 9 percent. While the current market conditions are challenging for most of the projects' economics, environmental risks may intensify the hardship from both the investment and corporate operational perspectives.

UNDERSTANDING RISK EXPOSURE AND MITIGATION OPTIONS

While environmental risks lead to material financial costs to corporations, understanding risk hotspots could identify mitigation actions to prioritize and enable strategic planning. Integrating these risks into financial assessments via scenario analysis could ensure the resilience of businesses and investments despite future uncertainty in climate policy development.

By understanding how policies link to financial implications for businesses, policymakers should address environmental risks through robust and consistent regulation and enforcement to encourage sustainable decision-making in business. This would provide clear and effective incentives for businesses to consider environmental impacts in the management of their operations.

Investors should consider integrating in-depth assessments of environmental risks into their current financial analysis. Investors may also recognize that conducting due diligence before and after investment is also vital to increase the resilience of portfolios to environmental risks.

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Western China's Water-Energy Challenges: Pathways Forward

By Huai Jiang, Fredrich Kahrl & Yueying (Jasmine) Ouyang

Addressing environmental challenges while sustaining economic growth in China's West will require a continued shift from intensity-based (per unit output) to absolute (overall limits) regulations on water consumption, air pollution, and CO_2 emissions. How this transition, or indeed transformation, should proceed remains a critical question. Although Western China's water and energy challenges are linked, they will require separate solutions. The future of the region's coal industry will likely be shaped by efforts to improve air quality and to limit CO_2 emissions, rather than by water scarcity.

Sustainable development in its Western region, particularly Xinjiang, Ningxia, Gansu, and Inner Mongolia, will be one of China's most pressing policy and regulatory challenges over the next decade. Many western provinces face severe environmental challenges — water scarcity, land degradation, and poor air quality — but have continued aspirations for rapid economic growth as per capita income levels remain significantly below those in Eastern provinces.

Ningxia Hui Autonomous Region ("Ningxia") is emblematic of Western China's sustainable development challenges, and in particular the challenge of water scarcity. Ningxia is one of China's most water-stressed regions, with per capita

water resources only around one-third of the national average. Faced with growing water scarcity, Ningxia has undertaken a number of measures since the early 2000s to conserve water and enable its economy to continue to grow. These include an innovative water rights transfer program, which enables industrial projects to obtain rights for water that is “freed up” as a result of conservation investments in the agricultural sector.

Despite these and other water conservation successes, stress on Ningxia’s water resources has intensified as a result of rapid economic growth. The growing coal industry, including coal mining, coal-fired electricity generation, and coal-to-chemicals production, is an important source of incremental water stress. Ningxia is one of several provinces that is in the midst of a decades-long process to develop large “coal bases” that integrate coal mining, power generation, and coal-to-chemicals (methanol, propylene, oil) production. Questions of water availability and water stress have regularly surrounded these projects.

Air quality and CO2 emissions in Ningxia and the West are also growing areas of policy concern for China’s central and provincial governments. The national Action Plan for Air Pollution Prevention and Control (2013) requires all major cities, including those in the West, to achieve reductions in ambient PM10 concentrations by 2017. Achieving national climate goals for 2030 will require Western provinces to begin to make absolute reductions in CO2 emissions sometime over the next two decades.

Provincial governments are responding to these directives. Ningxia's 2017 Pollution Prevention Work Plan, for instance, sets goals for reductions in PM10 and PM2.5 concentrations in the province's major cities. To meet these targets, however, provincial government agencies in Ningxia and throughout the West will need to reconcile the historical source- and standards-based approaches to regulating emissions with the need to achieve absolute reductions in pollution concentrations and CO_2 emissions. Even with tightened emissions standards, continued growth in emissions sources could thwart efforts to meet air quality and CO_2 goals.

In principle, water scarcity and restrictions on water consumption could impose limits on the largest source of emissions in the West: the coal industry. However, water is generally a very small share of the total costs for coal power plants and coal-to-chemical facilities. The coal industry can afford to pay higher prices for water rights as part of water rights transfer programs and for consumption if provincial governments raise industrial water prices. For example, if water prices were set at the high-cost of eight yuan/m3 of water, which is the price level of expensive desalinated water, costs of water to coal companies would still be no more than five percent of their total budgets. From a policy perspective, focusing on rising water consumption by the coal industry may not lead to effective solutions, as other industries (e.g., food processing) and sectors (e.g., agriculture and, residential) may be causing more water stress and have more cost-effective water conservation opportunities.

Thus, the future of Western China's coal industry and its concomitant air quality and climate impacts will likely be shaped by government efforts to improve air quality and limit CO_2 emissions, rather than by water scarcity per se. These efforts include environmental regulations, energy policies and planning that support the development of non-fossil fuel energy resources and transportation electrification (reducing demand for coal-to-chemicals plants), as well as measures to diversify the region's economy. More specifically, they also include improvements in resource and transmission planning in the electricity sector, which can help to guide the construction and retirement of coal plants in ways that reconcile goals for local employment, electricity costs, power reliability, air quality, and CO_2 emissions. In parallel, policymakers in Western China must also find ways to improve the economic efficiency of water use; for instance, through water pricing reforms and expansion of water rights transfer programs.

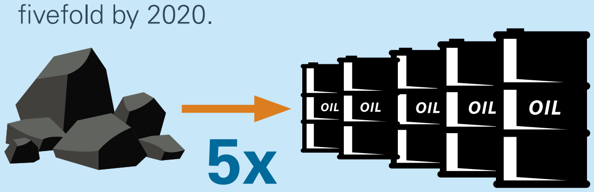
This shift to a more water-efficient economy that is less dependent on fossil fuels and heavy industry will be a multi-decadal transformation for Western China. The wheels of this transformation have already been set in motion through nascent air quality regulations, climate policies, energy policies, water management rules, and water rights transfer programs. The challenge will be in turning the corner from incremental improvements to stepwise change.

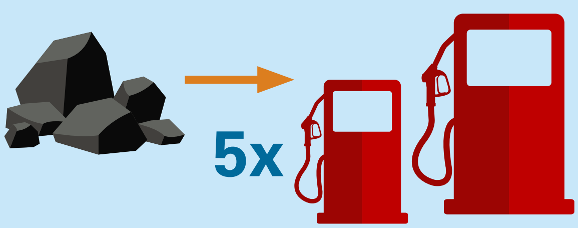
Turning this corner will require political will and innovative policies and regulations that strike the right balance between environmental limits and economic growth, increasingly relying on absolute (total) limits rather than intensity-based regulation. A more sustainable development pathway for Western China will depend on finding this balance.

Western China Coal-Water Factoids

Top 6 coal producing provinces: Inner Mongolia, Shanxi, Shaanxi, Guizhou, Xinjiang and Shandong

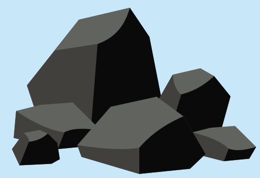
China's 13th FYP set a goal to **increase coal-to-oil and coal-to-gas** production fivefold by 2020.





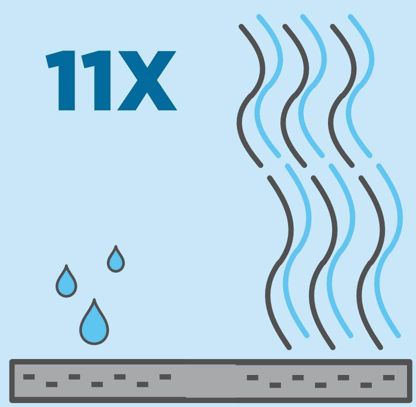
Electricity generation accounts for about **half of China's CO2 emissions**

45% of China's coal-fired power plants (358 GW) operate in areas of excessive water withdrawal.



Thirsty Coal: 15-20% of China's total national water withdrawals goes to coal mining, coal conversion, coal-fired power and coal ash control.

In China's arid northwest total evaporation can be up to 11 times the amount of precipitation.



Sources: BP Statistical Review of World Energy, June 2018, China Water-Energy Food Roadmap, Central People's Government Website's Review of Environmental Protection, and Sohu.com's "Top 10 highest coal production provinces in 2017"

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- Woodrow Wilson

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This fifth issue of *InsightOut* was supported by the Energy Foundation, China; Luce Foundation; and ClimateWorks Foundation, as part of our Choke Point: Solutions project. For three years as part of this project, we have created dialogues and publications for policy, business, research, and NGO professionals to understand water-energy trends in China and explore opportunities for U.S.-China cooperation.

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