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Shale We Dance?
Exploring a New Area of U.S.-China Energy Collaboration

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During the January 2011 state visit to Washington, DC by Chinese President Hu Jintao the United States and China announced new clean energy initiatives building on the nine bilateral agreements that were created at the Obama-Hu Presidential Summit in November 2009. While a number of the nine agreements were built on past, albeit stop-and-go, areas of energy cooperation—renewable energy, energy efficiency, cleaner coal—they also catalyzed some new kinds of collaboration. For example, the U.S.-China Clean Energy Research Center[1] will promote joint research on electric vehicles, green buildings, and carbon capture and sequestration, while the U.S.-China Energy Cooperation Program, established by more than 22 U.S. companies, aims to promote collaborative public-private partnerships on renewable energy, smart grid, clean transport, cleaner coal and energy efficiency.

The summit also pioneered the Shale Gas Initiative, an agreement that aims to increase bilateral collaboration on regulations and technology development of shale gas reserves while also protecting the environment and communities around such exploration in both countries. Bilateral cooperation in this area opens up an opportunity for both countries to jointly work to create and standardize environmental regulations and push technologies to lessen the environmental impact of shale gas exploration and extraction.

The United States and China are similarly rich in shale gas resources—with technically recoverable unproved reserves in the United States reaching 862 trillion cubic feet (TCF) and China an estimated 1,275 TCF.[1] Shale gas exploration in the United States dates back to 1821,[2] but significant commercial drilling has only occurred over the past decade. In 2009, natural gas was the second largest source of domestic energy production in the United States at 21 quadrillion British thermal units (Btu), second only to 22 quadrillion Btus from coal,[3] but the role of shale gas in total natural gas production is increasing rapidly. China, in contrast, has only recently started to explore its own shale gas reserves, but has been increasing targets and investments for natural gas development. Chinese companies are partnering with international companies to build up capacity in the shale gas field.

In 2010, the Strategic Research Centre for Oil and Gas of China's Ministry of Land and Resources set a goal of producing 8-12 percent of China's natural gas from shale gas by 2020. To begin meeting this goal Sinopec aims to reach shale gas production capacity to more than 2.5 billion cubic meters annually by the end of 2015.[4] In January 2011, PetroChina began exploratory drilling in a potentially sizable shale reserve on the Fushun-Yongchuan shale gas block in southwest Sichuan Province. In another part of the province at the Weiyuan formation after 11 months of drilling the National Petroleum Corporation completed China's first horizontal shale gas well in late March 2011.[5]

SHALE GAS PRIMER: FRACKING AND THE ASSOCIATED CARBON EMISSIONS AND WATER IMPACTS

How Does It Work?

Shale gas is natural gas produced from shale formations that typically function as both the reservoir and source for the natural gas. The gas is tightly locked in sedimentary shale rocks and is commonly extracted through a process called hydraulic fracturing, often referred to as "fracking." Small U.S. gas companies were the entrepreneurs who developed the technologies to do horizontal fracking, a process that enables an operator to pump fracturing fluid into the wellbore at a high rate, which then raises the pressure, causing the rocks to crack and release natural gas into the boreholes which are kept open with the help of proppants contained within the fracturing fluid.[6] Typically, around 98 percent of the fluid is made up with water and sand and the rest is chemicals. The fracturing process is highly water intensive and involves the injection and extraction of a large amount of potentially harmful contaminants, such as acid, iron control and gelling agents. (A video demonstrating the hydraulic fracturing process is available at the Southwestern Energy website and a graphic on Circle of Blue's website).[7]

Greenhouse Gas Emissions of Fracking

Shale, like natural gas, is promoted by government and industry advocates as a cleaner alternative to coal at similar cost levels.[8] Over the past year researchers and environmental NGOs have been publically questioning claimed low greenhouse gas (GHG) footprint of shale and other natural gas production, stressing a need for better regulation on the industry to keep it truly low carbon.

- According to a report issued by ProPublica in January 2011 assumptions on low GHG emissions from natural gas industry are calculated on emissions from the tailpipe or smokestack and do not "account for the methane and other pollution emitted when gas is extracted and piped to power plants and other customers."[9]

- Another little highlighted source of air pollution and GHG emissions is the use of trucks to transport clean and dirty water for shale well operations. Communities in drier areas also often balk at the noise and traffic associated with trucking in water for fracking.[10] For example in the Marcellus Shale play each well needs between 300 and 1,300 trucks to carry water in and out for the fracking operations.[11]

- A report by Resources for the Future suggested that without appropriate policies in place, the increase in use of shale gas does not lead to a low-carbon future, for the abundance of shale gas tends to drive up energy consumption, displace cleaner but more costly renewable energy resources, and potentially increase total carbon emissions by approximately 1 percent.[12]

The challenge of lessening the GHG footprint of shale gas exploration could be an important area of joint research and technology development in the growing U.S.-China shale gas collaboration. For example, U.S. and Chinese gas companies could work to develop technologies to capture leaking methane emissions at the well head. Developing ways to stop leaks could be cost effective in that the gas would be put back into the commodity stream—U.S. natural gas pipelines had similar fugitive gas emissions and the value of the gas motivated the industry to develop strategies to prevent the losses.[13]

U.S. and Chinese researchers could also investigate the full lifecycle of GHG emissions from hydraulic fracturing, which could discourage the practice in drier regions due to the need to truck water in and transport wastewater to out to treatment plants.

Shale Gas and Water

Water-intensive Process. The amount of water required for drilling and fracturing a horizontal shale gas well is very large—ranging from 2 million to over 4 million gallons per well.[14] Nevertheless, a recent Center for Strategic and International Studies publication on shale gas echoes previous industry and government analyses[15] that water consumption for shale gas drilling and fracturing is low when put in context of overall water consumption, such as municipal, agricultural and electricity generation from both fossil fuels and some renewable energy sources.[16] For example, for every one MMBTU of energy produced, shale gas only requires 0.84 - 4.70 gallons of water, while conventional oil requires 8 - 20 gallons, and coal requires 13 - 32 gallons (when accounting for slurry transport).[17] A recent Congressional Research Service report points out that fracking uses considerably less U.S. freshwater resources than the production of ethanol.[18]

While the level of water consumption for drilling and fracturing might be relatively insignificant in water-rich areas, multiple drilling and fracturing operations in a limited geographic area could intensify competition for water resources—such as in southwestern China where water resources are relatively abundant, but coming under growing pressure from hydropower expansion, urbanization, and increasing water transfers to the north.[19] Moreover, fracking could put stress on fragile and dry regions such as Western China which has long been plagued by water scarcity. Among the major shale plays in the United States, Marcellus Shale is most water intensive at 3.8 million gallons of injection water per well.[20]

Water Contamination Questions. Uncertainties surrounding water pollution is one of the more debated concerns surrounding fracking. The injection of multiple chemicals, including friction reducers, biocides, surfactants, and scale inhibitors during the hydraulic fracturing process, as well as leaks, spills, overflows, and other releases, can contaminate both surface and underground water sources. U.S. environmental organizations, which maintain that such accidents pose serious health risks (e.g., such as numbness, nosebleeds, burning pain, and brain tumor),[21] argue that the industry needs to be more strictly regulated and loopholes in the current regulatory structures fixed. For example, currently water emissions from fracking were deemed in the 2005 Energy Bill to be exempt from being regulated by the U.S. Safe Drinking Water Act. Most large companies involved in fracking do recycle much of the water, but the overall recycling rate industry wide is difficult to assess. For example, it is estimated that between 15-80 percent of the injected fluids are recovered to the surface, which indicates potentially great variability in recycling of proppants among companies and a potential lack of clear industry standards.[22]

The water pollution issue has made it difficult for operators to obtain permits or access to land for drilling. These obstacles combined with higher costs to treat water have begun to prompt some U.S. operators to start recycling more water, which is a crucial step in lowering the water footprint of hydraulic fracturing. It is difficult, however, to get information on the amount of water being currently recycled. It is possible that as shale gas development matures, the companies could follow trends in oil and gas production where a lot of brine water is produced and the costs of disposal and re-injecting are driving companies to explore ways to either reutilize this brine to maintain reservoir pressure or clean it up for use in agriculture.

SHALE GAS DEVELOPMENT IN THE UNITED STATES

Natural gas consumption (including shale) comprises approximately 25 percent of the U.S. energy mix. [23] According to the U.S. Energy Information Administration (EIA), over the past decade, U.S. shale gas production has increased eightfold (see Figure 2)—to 3.11 TCF—and now accounts for 10 percent of the U.S. gas production.[24] The 31.8 TCF of identified shale gas reserves[25] account for 20 percent of the total remaining recoverable gas resources in the country.[26] EIA is projecting that shale gas could rise to 12 TCF by 2035, making up 45 percent of natural gas production.[27]

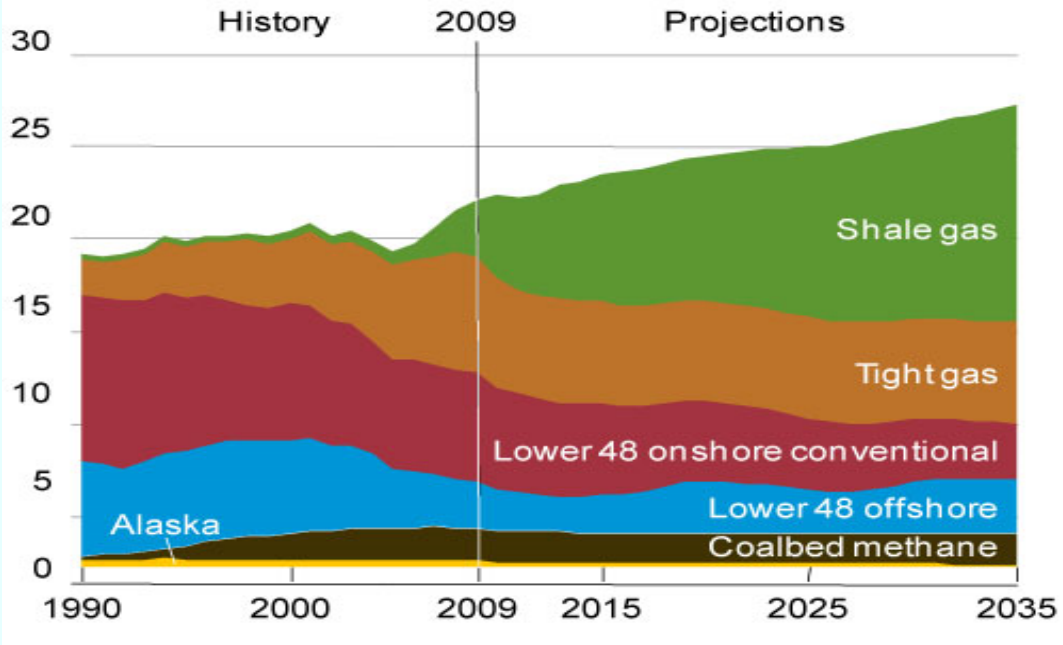
Most of the shale gas reserves in the United States come from three sources:

1) The Marcellus Shale in the Appalachian Basin in New York Pennsylvania and West Virginia with 262 TCF;
2) The Haynesville Shale in Louisiana and Texas with 251 TCF; and,
3) The Barnett Shale in Texas with 44 TCF.[28]

A map of shale gas plays in the lower 48 states is available at the EIA website.[29]

In April 2010, the U.S. Department of State launched the Global Shale Gas Initiative to help other countries identify and develop their unconventional gas resources safely and economically, with the ultimate goal of advancing U.S. economic and energy security interests.[30] Besides China, the United States has signed shale gas agreements with India, Jordan, and the Ukraine [31] and the State Department is discussing a shale agreement with Poland.[32]

Figure 2. U.S. natural gas production, 1990-2035
(trillion cubic feet per year)



Source: U.S. Energy Information Administration. (2011). *Annual Energy Outlook – 2011 Executive Sumamry.* [Online]. Available: http://www.eia.gov/forecasts/aeo/chapter_executive_summary.cfm#domestic

CHINA'S DOMESTIC NATURAL GAS AND SHALE GAS EXPLORATION

Since 2007, the share of natural gas consumption in China's energy mix has remained relatively low at 3.5 percent, while coal's share accounts for 69.5 percent. Natural gas consumption per capita was only 1,872 cubic feet in 2007, compared to the world's average of about 16,245 cubic feet. The Chinese central government has set targets to increase the share of natural gas in China's total primary energy consumption up to 10 percent by 2020.[33] China's natural gas production as a percentage of total energy production in 2008 was approximately 3 percent,[34] but the Chinese government is targeting this to reach 5 percent by 2020.[35]

One potential constraint to shale gas drilling in China is the scarcity of water; the energy sector is already the second largest user after agriculture and will consume 32 percent of the country's water by 2035—with coal mining in the dry north using the lion's share.[36] It is thus likely that China's oil companies will initially focus on shale gas reserves in the relatively water-rich south. Shale resources are relatively evenly divided in these regions:

1) Yangtze Basin in the south;
2) Bohai Bay and Songliao Plain in the northeast;
3) Dzungarian Basin in the northwest; and,
4) Hebei and Shanxi provinces in the north

Strategic Considerations for Shale Gas Production in China

Despite abundant coal reserves, choke points in production due to water shortages and transportation have meant supply can not always keep up with demand, which is one driver of the Chinese government's investments into diversifying the energy mix with renewables, nuclear power, and natural gas, including shale. Strategic considerations for pushing shale gas production include:

- China is entering a period of serious supply shortage of natural gas, estimated at 0.28 TCF by 2020.[37]

- Although there are still no proven shale gas reserves in China, estimated recoverable reserves are 1275 TCF and growing, on par with total reserves in the United States. In addition, the technological and geological prospect of shale gas exploration and production in China is encouraging.[38]

- While there is much debate over total savings in lifecycle carbon emissions from shale gas production and consumption, the emission of sulfur dioxide and other criteria air pollutants from coal-fired power plants that do not capture or treat flue gas can be significantly reduced by switching from traditional fossil fuel sources to shale or natural gas.

Policy Agreements and Investment in Shale Gas Development and Regulation in China

- The bilateral energy cooperation agreements signed by President Obama and President Hu in late 2009 outlines the U.S.-China Shale Gas Resource Initiative, which is designed to promote collaboration on shale gas resource assessment, technology and investment.[39] This marked the central government's first commitment to explore China's shale gas potential.

- In early 2010, the Strategic Research Center for Oil and Gas under the Ministry of Land and Resources set a target to identify 50-80 shale gas prospects, as well as 20-30 exploration and development blocks by 2020. Moreover, the research center proposed a goal of locating 35 TCF of recoverable shale gas reserves and building 0.53-1.06 TCF of production capacity in order to produce 8-12 percent of China's natural gas from shale gas wells by 2020.[40]

- In May 2010, officials announced that the Chinese central government will likely offer subsidies and tax incentives for shale gas production.[41]

Chinese State-Owned Enterprises On The Move

- **PetroChina**, which signed a joint agreement in November 2009 with **Royal Dutch Shell** to explore shale gas in the Fushun-Yongchuan block

in Sichuan Province, aims to produce 0.02 TCF of shale gas by 2015.[42] In early 2010 PetroChina was also in advanced talks with **ConocoPhilips** over the development of a 3,000-square kilometers shale gas block between Chengdu and Chongqing.[43]

- **Sinopec** plans to have a combined production capacity of 0.09 TCF of shale gas and coal bed methane gas by the end of 2015. In January 2010, Sinopec was reportedly in talks with **BP** over potential cooperation on the exploration and development of a 2,000-square kilometer shale gas block in Guizhou Province and a 1,000-square-kilometer block in Jiangsu Province.[44] Sinopec might also join forces with **Chevron** to explore and develop shale gas in Guizhou Province at the end of 2010.[45]

- In a recently confirmed deal, **CNOOC** will pay $1.08 billion for a one-third stake in **Chesapeake Energy Corporation's** Eagle Ford shale project in Texas, which represents the biggest acquisition of a U.S. oil and gas asset by a Chinese company.[46]

- The start of 2011 was marked by **PetroChina's** largest overseas acquisition in its history, as it agreed to pay $5.4 billion for a 50 percent stake in Canadian oil & gas giant **Encana's** shale gas project in British Columbia.[47]

- On April 29, 2011—less than a month after the **National Petroleum Corporation** completed China's first horizontal shale gas well in Sichuan—China's Ministry of Land and Resources announced that it has short listed six Chinese firms for the country's first auction of shale gas exploration blocks—**PetroChina**, **Sinopec**, **CNOOC Ltd**, **Shaanxi Yanchang Petroleum Group**, **China United Coal Bed Methane Company**, and **Henan Provincial Coal Seam Gas Development and Utilization Company**.[48]

MIND THE GAPS

As the leader in the development of shale gas, many countries are interested in learning the U.S. experience in shale exploration and hydraulic fracturing. Tapping domestic shale gas is particularly appealing because it promotes energy security by reducing dependence on imported oil or gas. However, over the past two years many environmental organizations and water management authorities in the United States have begun to argue that shale gas exploration has developed so rapidly that federal and state regulatory structures and industry practices have not kept pace and threats to water and air quality are growing. The boom in shale gas production has led a number of states to revise their regulations on permitting and monitoring hydraulic fracturing.[49] Underscoring the growing gridlock in the debate and low public trust, in August 2010 New York State passed a bill that mandated a 10-month ban on drilling in shale gas formations within the state due to concerns about drinking water.

Regulating the shale gas industry is challenging for it is made up of many small companies that have not yet developed a culture of information sharing and collaboration to undertake self regulation akin to the U.S. nuclear power operators. Thus, clear messaging on the environmental performance of the industry has not been strong, despite repeated claims by America's Natural Gas Alliance that new federal regulations are not necessary on top of existing local, state and federal rules. Central to their argument is the belief that "state regulatory agencies have the appropriate expertise and on-the-ground experience to conduct effective oversight of natural gas production activities specific to their local geology." Former Pennsylvania State Environment Chief echoed the appropriateness of state-level regulation of fracking, citing the BP oil spill as a powerful example of how federal regulation on the oil and gas industry is not always effective.[50]

The debate against shale gas operations became more contentious following the 2010 film *Gasland* and growing reports of communities complaining about water pollution and health problems around shale wells.[51] To date, such concerns have drowned out reports of how shale gas could promote considerable job creation in large plays such as the Marcellus Basin.[52] There have also been increasing news

media coverage on growing ozone and other air pollution problems in communities where shale and other natural gas drilling has occurred.[53] Some recent moves to push for better regulation of this industry include:

- In response to public complaints, the U.S. Environmental Protection Agency has initiated a major study into hydraulic fracturing to investigate the use of diesel in the process and other environmental impacts, particularly potential contamination of both surface and ground water resources.[54] This EPA study, which will be finished by 2014, will investigate the conditions associated with potential drinking water contamination, and its link to public health risks.[55] The study will likely determine the direction of the EPA's future regulation of hydraulic fracturing.

- On January 21, 2011 twenty-three U.S. environmental groups sent a joint letter to President Obama to express their concern about the need to strengthen regulation of water pollution surrounding shale gas exploration. The central concern is to close gaps in the two key federal laws aimed at protecting water[56] —the Clean Water Act—which does not require hydraulic fracturing companies to minimize uncontaminated sediment pollution from the construction or operation shale gas operations—and the Safe Drinking Water Act, which since 2005 does not regulate the injection of fluids used in hydraulic fracturing for oil and gas development.[57] Except in cases where diesel fuel is used for hydraulic fracturing.

- 36 percent of the Delaware River Basin is underlain by the Marcellus shale gas reserve and approximately 3,500 wells are currently in operation and a total of 15,000-18,000 horizontal wells are expected (8 horizontal wells per each vertical well).[58] In light of growing public complaints about water and traffic associated with the rapidly expanding hydraulic fracturing operations in the basin and concerns about the water and land needs for supporting this infrastructure, the Delaware River Basin Commission has been holding public hearings on new regulations for natural gas extraction in the basin. These proposed regulations aim to protect and manage water resources during the construction and operation of shale gas development projects within the basin. The proposed regulations are also expected to comply with the existing DRBC Compact and to supplement the Commission's Comprehensive Plan.[59]

- Shale gas development is slow to take off in Europe. For example, environmental and water concerns have led France to slow down or stop shale gas development. Besides environmental concerns, the major obstacle is that in most European countries the subsurface rights belong to the crown or government and not to landowners on the surface. Thus, unlike the United States, private citizens in Europe do not enjoy any financial benefits of shale gas development and may only feel the negative environmental consequences of the wells. U.S. private landowners have more power vis-à-vis developers, in that private citizens can band together to trade access to the shale gas for more careful management of the environment while both the owner and the developer can benefit from the financial returns.[60]

How the regulatory debate over shale gas drilling in the United States is resolved will likely have global environmental significance since countries such as China are following the U.S. lead in developing this sector.

Moves to Build Multi-Stakeholder Consensus and Cleaner Technologies

In a striking move to tone down the vitriolic debate, Southwestern Energy and Environmental Defense Fund have been working together to build a consensus among stakeholders to create a model regulatory framework for hydraulic fracturing. This framework document aims to build consensus among various stakeholders by suggesting components of state-level regulation that could improve the safety, regulation, and transparency of hydraulic fracturing. The project is in its nascent stages, but the negotiations the two have brokered have produced a 40-page draft of possible regulations that states officials can use as a model

for requiring disclosure of hydraulic fracturing fluids and better monitoring of the integrity of underground wells.

Besides improving well construction, some companies have been researching and developing technologies to save water through improved recycling and on-site water treatment for flow back water, as well as optimizing fracturing operations through modeling and use fewer additives in fracking fluids.[61] Halliburton has been developing a Chemical Scoring Index that assesses the relative health and environmental hazards of various fracturing fluids. The index will eventually rank various fluids and give operators a choice of which to use to lower the ecological footprint of drilling operations.

CONCLUDING THOUGHTS

The United States and China are motivated to shale gas exploration for similar reasons—energy security, job creation, and (potentially) low carbon energy. But as the U.S. situation underscores, it is vital for this industry to build the trust of the public and prioritize lowering the environmental footprint of drilling operations—particularly in terms of greenhouse gas emissions and water protection. China faces more extreme water quality and quantity problems than the United States and even with recycling hydraulic fracturing is a water-intense process that also can require considerable amounts of water to be transported in and out of the well site. Regulation, pricing, and environmental safeguards are likely to be larger challenges to shale gas production in China rather than technology acquisition and pipeline construction. For while pipelines are not yet in place for delivery of shale gas, the rapid construction of the west to east pipeline from Xinjiang to Shanghai demonstrated that when a decision is made the Chinese can build pipelines and other infrastructure rapidly.

China excels at bringing new energy technologies to scale—as demonstrated by the rapid expansion of wind, solar, coal liquefaction, and ultra-super critical power plants—but in the area of shale gas it will be important for Chinese policymakers to study the regulatory challenges in the United States and prioritize the joint ventures with international companies that deploy the most advanced water recycling technologies and lower CO_2 emissions of drilling. China does not yet possess comprehensive environmental regulations or monitoring infrastructure to ensure safe expansion of this promising natural gas drilling technology. Thus, as the U.S. government promotes shale gas initiatives with Chinese counterparts, it will be important for exchanges to include not only technology discussions, but also exploration the regulatory regime China needs in order to protect the country's already highly degraded water resources from further harm.

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