5. RECOMMENDATIONS

We group our recommendations into five broad categories:

A. Accelerate Market-Based Reforms

"Realizing the Chinese dream of the great national rejuvenation would mean China's becoming a prosperous country, a revitalized nation, and a happy people." — President Xi Jinping, March 13, 2013[1]

In this section we discuss four market-based reforms — some already underway — that can help China meet its shale gas objectives.

(i) Continue Natural Gas Price Reform

Natural gas price reform has the potential to stimulate technology and lead to a boom in shale gas production, as happened in the United States after natural gas price controls were lifted in the 1980s.

In recent years the central government has taken significant steps toward market-based pricing of natural gas. Wellhead prices of unconventional gas, including shale gas, are completely deregulated. However a number of factors have limited the practical utility of this reform, including the mixing of shale gas with conventional gas in pipelines and challenges shale gas producers face reaching a broad market for their product.[2]

Continuing the natural gas price reforms underway will help shale gas producers realize a return on their investment and stimulate shale gas production. This will likely be part of larger reform packages. Among the constraints on rapid movement toward full market-based pricing are higher fuel costs for households. NDRC's "ladder pricing" guideline, under which prices are cheapest for households with the lowest consumption, is an important response to this problem.[3] (The guidelines — which currently apply only to urban households — could be extended to rural households, especially those in the vicinity of shale gas production sites.) Another constraint is uneven market power between NOC producers and consumers. Movement toward full market-based pricing is naturally related to reforms opening upstream oil and gas production to companies in addition to the large NOCs.

(ii) Speed Pipeline Reform

China does not need to build a vast national pipeline network to meet its 2015 and 2020 shale gas goals. Most shale gas can be consumed in the same province or even locality where it is produced, at least in the short term. Provincial governments have begun building small LNG facilities to help move shale gas to markets. Although more expensive than pipelines, LNG trucks offer a reasonable short-term solution for shale gas transport.

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[1] "Xi Jinping's Speech on the 1st Session of the 12th National People's Congress," *people.com*, March 17, 2013, file://localhost/2013, http/::theory.people.com.cn:n:2013:0318:c40531-20819774.html.
[2] See fuller discussion in Section 3D above.
[3] Nan Zhong, "NDRC Issues Ladder Pricing Guideline for Gas," China Daily, March 21, 2013, http://www.chinadaily.com.cn/bizchina/greenchina/2014-03/21/content_17369412.htm.

In the medium and long term, however, pipelines will be important for the growth of the Chinese shale gas sector. Yet as the coal bed methane experience demonstrates, independent natural gas producers face challenges gaining access to pipeline infrastructure and ancillary services in China, because the major NOCs fully control the existing gas pipelines.[4] Open access to the pipeline system, with clear standards for tariffs and an independent regulator, will be key.

In the past year, NEA has taken important steps toward opening China's pipeline network, announcing policies to guarantee third-party access when pipelines have excess capacity. Next steps could include rules guaranteeing producers access to the pipeline network on non-discriminatory terms and establishment of an independent pipeline regulator. Further steps to open investment in the sector — including to foreign companies — would also be helpful. Over the longer- term, separating ownership of pipeline assets from upstream oil and gas production would enhance competition and help promote shale gas production.

(iii) Encourage Competition for Mineral Rights

Market-based reforms in the management of mineral rights can help China meet its shale gas goals. The second bid round was an important step in this direction, opening shale gas acreage to a wide range of companies. However, the lack of progress by the second round winners suggests that adjustments should be made in the third and subsequent bid rounds. Among the most important measures:

— Make better acreage available. There is a widespread perception that acreage offered as part of the second bid round was of poor quality. The better the acreage that is made available, the more the next bid round will advance China's shale gas goals.

— Make better data available. Data packages for the second round reportedly offered little useful information for evaluating the potential of blocks. The most capable bidders — who have many other opportunities in light of their capabilities — are unlikely to bid without adequate information. (See discussion of data availability below.)

— Provide clear instructions to help foreign companies engage in the auctions. Allowing foreign companies to get involved early would significantly increase the pace at which China develops its shale gas sector. Chinese companies are allowed to invest directly in U.S. shale acreage. Recognizing the different systems of land ownership in each country, both China and the U.S. would benefit if U.S. companies had more rights with respect to exploration and development in China.

— Allow provincial governments to play a larger role in the next bid round. Provincial governments have a substantial stake in the success of the auctions, including local economic growth and greater tax revenues. With a larger role in the auctions, the provincial governments can help move the

[4] See discussion at Section 3E above. See also Oil, Energy and Power, p. 308, 2013 White Paper, AmCham, China.

process forward and facilitate development. However, an expanded provincial role in the auctions creates risks of local favoritism and deal-making that could be counterproductive in meeting shale gas development goals. The results of local auctions could be evaluated after the next bid round to determine whether such auctions should be continued.

Another helpful step would be to establish a cure process for first- or second-round bid winners who have not met minimum work requirements. These bid winners could be allowed additional time to develop their acreage and an opportunity to engage in cooperative activities with other companies. A similar process could be established for NOCs that own parcels with overlapping mineral rights. These NOCs are currently required to transfer shale gas exploration rights if they do not explore for shale gas.[5] They could be given additional time to develop the shale gas, with a hard deadline after which the rights would be transferred.

(iv) Improve Data Availability

Data is crucial for the development of shale gas. Information on geological setting, 2D and 3D seismic data, well logs and core samples are important to assess a site and find the sweet spots. Indeed many experts cite publicly available data as a key factor in the U.S. shale gas revolution. State laws require public disclosure of well logs and shale gas production data. This data plays an important role in helping U.S. shale gas producers target the best opportunities and deploy their limited capital.

In China, the availability of data for shale gas operations is quite limited. CNPC and Sinopec have accumulated abundant data from their onshore conventional oil and gas operations but have no obligation to share that data. Other companies — domestic and foreign — struggle to obtain information needed to evaluate potential shale gas opportunities. Data packages for the first- and second-bid rounds, for example, were very basic and widely considered to be insufficient to assess shale gas prospects at the sites offered. Even when information can be obtained, its quality can vary and cost can be prohibitive.

State-secret laws are also a concern. The definition of a state secret is vague. In some cases oil and gas data have been considered a state secret.[6] The lack of clarity concerning state-secrets laws makes attempts to develop useful oil and gas data more challenging.

The Chinese government is working to help small- and medium-size companies overcome the data barrier for shale gas. MLR reportedly plans to conduct basic seismic surveys and drill exploratory wells, making the data obtained available in connection with the next bid round.[7] MLR collects geologic data from all companies conducting oil and gas operations[8]

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[5] MLR, "Notice with Regard to Reinforcing Exploration of Shale Gas Resources and Supervising Work Management," October 2012, http://www.mlr.gov.cn/zwgk/zytz/201211/t20121122_1158928.htm.
[6] Keith B. Richburg, "China Sentences American Geologist to 8 Years for Stealing State Secrets," Washington Post, July 5, 2010, http://www.washingtonpost.com/wp-dyn/content/article/2010/07/05/AR2010070500859.html.
[7] "3rd Bidding Round for Shale Gas Exploration Right May Start at Earliest at the Year-End," June 07, 2013, http://finance.sina.com.cn/stock/t/20130607/083215732283.shtml.
[8] State Council, Regulations on Administration of Geological Data, March 19, 2002, http://www.mlr.gov.cn/zwgk/flfg/kczyflfg/200406/t20040625_4601.htm.

and could make that data available if it chose to do so.

Requiring public disclosure of well logs and shale gas production data, as in the United States, would help in assessing the best opportunities for shale gas production. Reviewing and clarifying the state secrets law would remove concerns that inhibit work in this area. It is the right of any government to determine what information is considered a state secret. In the case of Chinese oil and gas data, a review of that policy could have benefits, including more rapid shale gas development.

RECOMMENDATIONS:

(i) Continue natural gas price reforms
(ii) Speed pipeline reforms
(iii) Encourage competition for mineral rights
(iv) Improve data availability

B. Provide a Clear Roadmap for Foreign Companies

Foreign companies can play an important role in helping China meet its shale gas objectives. Companies operating in the United States have considerable expertise in hydraulic fracturing, horizontal drilling and other technologies for shale gas production. Many of these companies are willing to work in China if satisfactory returns are available. Their expertise and technologies could help dramatically to quicken the pace at which the Chinese shale sector develops in the years ahead.

The Chinese government and state-owned enterprises have worked closely with foreign oil and gas companies for many years. In 1979, China entered into eight agreements for offshore oil exploration with foreign companies, including BP, Arco, Mobil, Texaco and Exxon. In 1998, China formally opened coal bed methane (CBM) to foreign investment.

These experiences provide a framework for foreign companies to participate in China's shale gas sector. Many well-established practices from previous projects with foreign oil and gas companies can be applied, including the use of production-sharing contracts (PSCs) and Overall Development Plans (ODPs). However, several provisions used in previous PSCs and ODPs will need to be revised to adapt to the special characteristics of shale gas projects, as explained below

(i) Develop a Model Production-Sharing Contract (PSC)

A production-sharing contract is an agreement in which a host country grants an international oil company (IOC) the right to explore for oil and gas and a percentage of the oil and gas produced at a site, in exchange for the IOC's commitment of funds, technology and expertise. China has used PSCs in the upstream oil and gas sector since the 1980s.

These traditional PSCs will need to be modified to work effectively in the shale gas sector. Conventional oil and gas production has distinct phases, with exploration, development and production easily separated and distinguishable. Traditional PSCs have been structured accordingly, with the rights and obligations of each party shifting in each phase. In shale gas development, however, the differences between phases are far less distinct — exploration, development and production can all go on simultaneously. A PSC for shale gas development must reflect this difference and others. PSC's used in coal bed methane development in China contain provisions that parties can draw on in developing PSCs in the shale gas sector.

One important tool for realizing the potential of the shale gas sector in China would be development of a model PSC. A model shale gas PSC could help China meet its shale gas goals for several reasons. First, a model PSC could encourage IOCs to explore opportunities in China's shale gas sector, by clarifying the likely structure of any commercial deal. Second, a model PSC would reduce the time and expense associated with contract negotiations.

Many provisions from previous PSCs in China can be used in a model shale gas PSC. However other provisions will need to be adapted to the unique circumstances of shale gas production. Following are some key features of a model shale gas PSC, reflecting the types of terms IOCs will be looking for to invest in Chinese shale gas development:

Production Period

Shale gas wells generally deplete more quickly than conventional wells. After an initial period of decline, shale gas wells typically approach a long-term production rate that remains stable for many years. As compared to conventional wells, shale gas wells generally take longer to reach payout and provide less economic benefit after payout is achieved. Furthermore, it could take many years for the cost of well drilling to drop sufficiently for all areas in a block to be economically attractive.

Taking exploration, drilling and completion costs into account, the production cycle for shale gas fields are likely to be longer than for conventional fields. As a result, to provide IOCs sufficient incentives to invest in Chinese shale blocks, neither the 15-year Production Period used in offshore oil projects nor the 20-year Production Period used in CBM projects are likely to be adequate. The Production Period under a model shale gas PSC will likely need to be longer, such as 30 years.

Relinquishment

PSCs for conventional oil and gas typically require the IOC to commit to explore a block and, after exploration work is completed, relinquish areas that have not shown commercial viability. The purpose of the relinquishment requirement is to provide the IOC with a mandate to invest in acreage efficiently and make some acreage available for newcomers.

Such forced relinquishments work poorly in shale gas projects. Shale gas development is typically dispersed over large areas. It involves locating "sweet

spots" in shale layers, applying the right mix of technologies and developing commercially attractive flow-rates at different locations within a block, sometimes over extended periods of time. The timeframe in which the commercial viability of a shale gas project can be determined is not necessarily predictable. Early relinquishments will not help generate the optimum results for the overall development.

The Onshore CBM PSC does not contain a relinquishment obligation for the IOC. This approach should also apply to a shale gas PSC.

Pilot Project Stage between Exploration and Development

The CBM PSC includes a Pilot Project Stage, including the drilling of exploratory wells, trial production and the completion of long-term gas sales. A similar concept is important for the shale gas model PSC. In the Pilot Project Stage, the IOC would have the opportunity to evaluate the potential returns from a shale gas block, before committing to the significant cost of full-scale development.

The CBM PSC does not address the ownership of gas during the Pilot Project Stage. It is reasonable to treat the gas produced in this stage the same as the equity gas during the Production Period, with each party having the right to market gas for the best commercial value.

Other Petroleum Discoveries

The objective of a shale gas PSC is to produce shale gas in the contract area. However, other hydrocarbons — such as conventional oil, conventional gas or liquids within the shale formation — may coexist in the same contract area and be discovered during exploration for shale gas. Shale gas PSCs should give the IOC a right to participate in development of any other hydrocarbons discovered. (The CBM PSC contains such a provision.) This will help avoid the building of redundant infrastructure in the same area by different operators with rights to different mineral types and improve the efficiency of resource development.

Rolling Overall Development Programs (ODPs)

At a conventional gas site, commerciality is determined once, at the end of the Exploration Period. The approval of an ODP then marks the beginning of the Development Period. At a shale gas project, commerciality is determined gradually in course of exploitation, as drilling progresses often over many years. ODPs should be prepared for sub-areas of the block, not the block as a whole. In a shale gas PSC, the entire nature of an ODP should be different than at a conventional site. (See discussion below.)

Attachment A sets forth terms for a model shale gas PSC.

In addition, the Chinese government should consider authorizing companies other than the national oil companies to enter into PSCs for shale gas.[9] Such a step could enhance competition and help promote innovation in the sector.

(ii) Use "Rolling Overall Development Programs (ODPs)"

The Overall Development Program (ODP) is the guidance document for development of an oil and gas field. Both Chinese law and Chinese PSCs require the operator (domestic or foreign) to compile an ODP before a field is developed. NDRC is in charge of ODP approvals. *[10]*

The ODP plays a critical role in an oil and gas project. The ODP provides detailed information on the project, with items including drilling techniques and health and safety practices.[11] However the guidance document for ODPs was developed with reference to conventional oil and gas fields. Several of its provisions work poorly for shale gas development, due to the differences between conventional and shale gas production. For example:

> Approval of technical plans. In an ODP for conventional gas production, development plans with drilling techniques are generally submitted for approval once at the beginning of a project. This is impractical at a shale gas project, where continual adjustment of drilling plans based on new information is required.
>
> Investment appraisal. At a shale gas project, the rate of return will likely be lower than with a conventional gas project. If a standard rate of return is applied as the threshold for granting approval of an ODP, the ODP will likely be rejected. Therefore, the government should allow a lower rate of return chosen by the operator.

Furthermore, even if an operator uses all available data collected during Exploration, Appraisal and Pilot Development to compile an accurate ODP, significant new information will be gained as drilling in the shale formation takes place during the Development Period. In order to realize the maximum potential of shale formations in the block, there must be flexibility to quickly adjust the way the shale formation is developed, taking into account the learning during development. This flexibility is essential to the success of a shale gas development.

Accordingly, "rolling ODPs" is needed. Such an instrument would allow for development of different areas within a shale gas block to be approved at different times. The objective would be greater flexibility in operations and quicker approvals than with a standard ODP.

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[9] Whether such PSCs are currently authorized under Chinese law is ambiguous. The Regulations of the People's Republic of China on Exploitation of On-shore Petroleum Resources under Foreign Cooperation, which limits PSCs to the three national oil companies, applies only to conventional oil and gas and coal bed methane projects, http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201110/t20111011_598575.htm.

[10] State Council of the People's Republic of China, "Decision to Amend Regulations on Exploitation of On-shore Petroleum Resources under Foreign Cooperation," November 2011, http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201110/t20111011_598575.htm.

[11] NDRC, Guide to Programing Overall Development Program for Oil Fields (SY/T 10011—2006).

In conventional oil and gas projects, ODPs are used by government authorities as fixed governing documents, requiring the operator's strict adherence. However, in shale gas projects, ODPs should instead be flexible guides to development.[12] This is a "rolling ODP."

(iii) Consider Other Legal Forms

As Chinese and foreign companies explore ways to work together in China's shale gas sector, the flexibility to use legal structures other than PSCs and ODPs could be helpful. One possibility is an equity joint venture (EJV). An EJV is a limited liability entity established under Chinese law with equity contributions from both parties. It is one of the most traditional vehicles to attract foreign direct investment in China. An EJV could be an attractive alternative to a PSC in a shale gas project, because EJVs are eligible to bid on shale gas mining licenses, forming an EJV is quicker than obtaining approval for a PSC and the legal structure is familiar.

According to NEA officials, there is no prohibition under Chinese law on the use of joint ventures between Chinese and foreign companies in the shale gas sector. Indeed, NDRC and MOFCOM guidance expressly authorizes such joint ventures.[13] Sinopec and Total are reportedly exploring the establishment of an equity joint venture for work in the Chinese shale gas sector.[14] There are also examples of EJVs between two Chinese companies to conduct shale gas exploration and production, including the EJV formed between Xinjiang Tianfu Energy Co., Ltd. (600509, Shanghai Stock Exchange) and Hubei Shale Gas Co., Ltd., a subsidiary of China Huadian Corporation, which was a winner in the second bidding round, and the EJV formed among Sinopec and Chongqing local state-owned enterprises.[15]

Based upon our interviews, the use of service contracts in the Chinese shale gas sector is under consideration by some parties. (A service contract is a long-term contractual framework in which an IOC explores and develops an oil or gas field in return for fees from a host government.) However, service contracts are new to Chinese NOCs and the relevant Chinese government agencies. Legal and regulatory reforms may be required before they are used. Furthermore, service contracts are unlikely to be attractive to IOCs, whose ability to book reserves with this type of legal instrument is limited. Other legal structures seem more promising for expanded work between NOCs and IOCs in the shale gas sector.

RECOMMENDATIONS:

- Develop a model Production Sharing Contract (PSC) for shale gas, with terms designed to reflect the unique nature of shale gas production.

[12] Oil, Energy and Power, p. 308, in note 143.
[13] China's NDRC and the Ministry of Commerce, Catalogue of Industries for Guiding Foreign Investment (Item 9 under Section 2), December 24, 2011, http://www.china.com.cn/policy/txt/2011-12/29/content_24283092.htm.
[14] Pei An, "Total and Sinopec are Exploring the Establishment of JV Company for Shale Gas," March 25, 2014, http://www.ineng.org/news/56742.html.
[15] "Tianfu Thermo Power Provides RMB165MM to Set Up Shale Gas JV," May 30, 2014, http://finance.china.com.cn/industry/energy/fcgny/20140530/2436758.shtml; Qi Yue, "Chongqing and Sinopec Establish JV Company Which May Set Model for Central and Local Government's Cooperation," NBD, May 6, 2014, http://www.mrjjxw.com/shtml/mrjjxw/20140505/48844.shtml.

- Use a "rolling Overall Development Program (ODP)" at shale gas projects.
- Give companies working in shale gas production flexibility to enter into agreements with other legal forms, including equity joint ventures.

C. Build Regulatory Capacity

Development of shale gas resources requires not only encouragement and promotion, but a robust and stable regulatory regime. Good regulation can encourage companies with advanced technology to participate in the sector, knowing that they can compete on a level playing field and that relevant environmental rules will be enforced fairly and completely.

Currently, the lack of an effective regulatory system represents a potential barrier to shale gas development and increases environmental risk. MLR, NEA and MEP have small staff sizes compared to equivalent agencies in other large countries. In light of small staff levels, inspections are infrequent, monitoring capabilities are low and agencies often rely extensively on citizen complaint hotlines and media coverage. This results in enforcement that bears little relationship to public health or environmental risks.[16] China's challenge in monitoring and enforcement of shale gas development will be immense.

Overlapping and unclear authorities are common in the shale sector. Groundwater protection, for example, is overseen by at least three agencies.[17] Overlapping responsibilities mean that when one agency issues regulations, the details or implementation may be left vague to account for lack of clear authority. Furthermore the central government issues a large number of directives, some of which matter more than others. Determining which are the most important often comes down to studying how frequently they are mentioned by officials at various levels. Companies, potential investors and the public are left guessing whether and when regulations will be enforced and whether some targets are optional or mandatory.

Local and provincial officials, and SOEs, wield considerable power in determining regulatory outcomes, especially on environmental issues. For years, observers have noted that most environmental enforcement is delegated to local environmental protection bureaus, which in turn answer to local officials concerned about meeting economic objectives. Local environmental protection bureaus also lack clout as compared to SOEs such as Sinopec and PetroChina. Fines are often tiny in comparison to the cost of compliance or profits at stake. (China's new environmental law, which increased fines and changes how frequently they can be applied, may help change this.) In some cases, local environmental protection bureaus have reportedly been reduced to sending anonymous complaints about polluters to the central government.[18]

[16] Li Wanxin, "Environmental Monitoring and Public Reporting," EU-China Environmental Governance Progam, December 2012.
[17] Feng Hu, "MEP Reform: From Mountaintop to Ocean?" (China Water Risk, March 12, 2014), http://chinawaterrisk.org/resources/analysis-reviews/mep-reform-from-mountaintop-to-ocean.
[18] Xin Qiu and Honglin Li, "China's Environmental Super Ministry Reform: Background, Challenges, and the Future," (Environmental Law Institute, 2009).

Though the central government has recently strengthened key performance indicators related to the environment, it is too early to say whether these measures will be effective.[19] Proposals to create an environmental super-ministry or make local environmental protection bureaus more accountable to the central government have so far not been adopted. Private players and investors remain uncertain whether regulations, if enforced, will be applied evenly.

RECOMMENDATIONS:

- Build a robust and stable regulatory capacity for shale gas, as a high priority.

D. Invest in Innovation

Growth in the Chinese shale gas sector will require innovation. Technologies used in shale gas development in the United States will need to be adapted to the Chinese context. China will need trucks and rigs with smaller footprints, modular water transport and novel stimulation technologies. Several experts we spoke with questioned whether horizontal drilling and multi-stage fracturing — the technologies at the core of the U.S. shale gas boom — can work in some shale-rich regions in China in light of the nature of Chinese source rock.

How can innovation in Chinese shale gas technologies be accelerated?

First, by ensuring that CNPC, Sinopec and other national oil companies have strong incentives to invest in innovation. By virtue of their experience, capital and exploration rights, these NOCs will likely dominate Chinese shale gas development for at least the next decade. They are enormously well-capitalized and have the financial resources to invest in shale gas innovation, should they choose to do so. The key will be ensuring they have adequate and appropriate incentives.[20]

At present, the incentives for NOCs to invest in shale gas innovation are relatively modest. They earn enormous revenues from conventional oil and gas production. Their managers and engineers have deep expertise in conventional oil and gas but little experience with shale gas. Any returns from investment in shale gas technologies are speculative.

The central government's strong messages concerning the priority of shale gas development provides the most important incentive. CNPC, Sinopec and the other NOCs are not just businesses but instruments of national policy, with senior party officials in top leadership positions. To the extent the NOCs believe they will continue to face aggressive production targets for shale gas, they will be motivated to invest in innovative technologies to help cut costs and increase revenues. Market pricing of natural gas and shale gas production subsidies (if available over the long term) also provide important incentives.

[19] In the past, greater spending on the environment have reportedly hurt local officials' promotion chances. See Malcolm Moore, "Green Politicians Less Likely to Be Promoted in China," The Telegraph (February 26, 2013).

[20] For a thoughtful analysis of this issue, see Lei Tan et al., Stimulating Shale Gas Development in China (Resources for the Future, July 2014) (arguing that NOCs are central to shale gas innovation in China).

Yet large companies — especially large state-owned companies — are often challenged when it comes to innovation. Small companies were central to the U.S. shale gas revolution. To promote innovation in shale gas technologies, the NOCs should pay attention to the principles of "open innovation."[21]

Chinese energy SOEs and other large Chinese companies with existing shale gas R&D capability could benefit from pursuing strategies reflecting attention to the principles of open innovation. These strategies recognize that innovation often happens best when companies reach beyond in-house expertise. Many of today's large multinationals have consciously adopted R&D activities characterized as open innovation, including a variety of collaborations with universities, suppliers and customers. In many cases, Western firms have opened R&D centers in China, connected with universities and local supplier networks—and the results of such collaborations have been positive for the firms involved.[22] Chinese firms as well have benefited from open innovation strategies, but large SOEs with in-house R&D capability have sometimes been reluctant to pursue open-ended, long-term collaborations.[23] These types of collaborations—both within and outside of China—could help enormously with development of China's shale gas sector. Joint ventures with major international service providers such as Schlumberger, Halliburton, BakerHughes and Weatherford are a first step. The shale gas R&D center established by Honghua Group and BakerHughes in Sichuan is an interesting model.[24] Indeed the partnership, announced in 2012, has already led to deployment of new hydraulic fracturing equipment in Texas.[25]

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[21] See Henry Chesbrough, Open Innovation: The New Imperative for Creating and Profiting from Technology, (Harvard Business Press, 2003).

[22] B. Jaruzelski and K. Dehoff, "Beyond borders: The Global Innovation 1000," Strategy+business (November 25, 2008), vol. 53, pp. 54–67, http://www.strategy-business.com/article/08405?pg=all; Lee Branstetter, Guangwei Li and Francisco Veloso, "The Rise of International Co-invention," National Bureau of Economic Research (October 2013), p. 3, http://www.nber.org/chapters/c13028.pdf; see also Gwynn Guilford, "China's engineers Are Innovating Like Crazy—To the Benefit of Foreign Companies," Quartz (November 13, 2013), http://qz.com/146945/chinas-engineers-are-innovating-like-crazy-to-the-benefit-of-foreign-companies/.

[23] Yuandi Wang et al., "How Chinese Firms Employ Open Innovation to Accelerate the Development of Their Technological Capability," Social Science Research Network, SSRN 1925149 (June 9, 2011), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1925149 (accessed July 30, 2014); Xiaolan Fu and Hongru Xiong, "Open Innovation in China: Policies and Practices," University of Oxford Department of International Development, TMD Working Paper Series No. 44, ISSN 2045-5119, - http://www.tmd-oxford.org/sites/www.tmd-oxford.org/files/SLPTMD-WP-044.pdf (accessed July 30, 2014).

[24] Honghua Group and Baker Hughes Collaborate to Explore and Develop China's Unconventional Hydrocarbons Market," PR Newswire (December 12, 2012), http://www.prnewswire.com/news-releases/honghua-group-and-baker-hughes-collaborate-to-explore-and-develop-chinas-unconventional-hydrocarbons-market-183144911.html.

[25] Honghua Developing New-Generation Shale-Drilling Rig, Plans Testing of Frac Pump," Drilling Contractor (May 23, 2013), http://www.drillingcontractor.org/honghua-developing-new-generation-shale-drilling-rig-plans-testing-of-frac-pump-23278.

Finally, the U.S.-China Clean Energy Research Center (CERC) should launch a shale gas program. Established in 2009 by the U.S. Department of Energy, the Ministry of Science and Technology and the National Energy Administration, the CERC's goal is

> to accelerate the development and deployment of clean energy technologies for the benefit of both countries. This is done by providing a supportive platform for collaborative research, protecting intellectual property, and encouraging top scientists and engineers in both countries to join forces, learn from each other, and capitalize on unique assets and complementary strengths.[26]

The CERC currently supports 1,100 researchers working in three areas: clean coal, electric vehicles and efficient buildings. A shale gas program would be an excellent complement to this work.

RECOMMENDATIONS:

- Ensure NOCs have strong incentives to invest in innovation.
- Pay attention to the principles of "open innovation."
- Add a shale gas consortium to the U.S.-China Clean Energy Research Center.

E. Coordinate among Ministries

At least a half-dozen ministries and agencies play an important role in Chinese shale gas policy. The National Development and Reform Commission (NDRC) shapes overall policy and regulates natural gas prices. The National Energy Administration (NEA) establishes shale gas production targets. The Ministry of Land and Resources (MLR) controls mineral rights and runs the bid rounds for shale gas. The Ministry of Finance (MOF) administers a shale gas production subsidy. The Ministry of Science and Technology (MOST) funds research and development in shale gas technologies. The Ministry of Environmental Protection (MEP) establishes rules to protect air and water quality.

During our interviews, we heard many comments about the lack of coordination among ministries. This is perceived to be a problem for at least two reasons. First, policy development on shale gas suffers. The development of clear policies with respect to groundwater protection, for example, is complicated by the overlapping jurisdictions of the Ministry of Environmental Protection, Ministry of Water and Ministry of Land and Resources.[27] Second, investment in the sector proceeds more slowly, because companies that receive an approval from one ministry remain unsure whether approvals from other

[26] U.S.-China Clean Energy Research Center: Recent Achievements (July 2014), http://www.us-china-cerc.org/pdfs/June_2014_Steering_Committee_Meeting/CERC_booklet_FINAL.pdf. See generally http://www.us-china-cerc.org/.

[27] See Hu, "MEP Reform: From Mountaintop to Ocean?," in note 156.

ministries will also be needed. This is particularly a challenge for foreign companies, some of which report a lack of clarity concerning the roles of MLR, NEA and NDRC.

Improved coordination among ministries would help address these concerns. Two years ago, the State Council's Development Research Center recommended a dedicated coordination mechanism for shale gas at the State Council level.[28] The existing inter-ministerial working group could also be strengthened. Of course inter-ministerial coordination can present challenges in any country, and each country will find its own ways to address these issues.[29]

One useful step would be for ministries to publish a joint guide listing all approvals required to work in the shale gas sector (or commission a respected outside authority to do so). Similar guides have been helpful in the United States.[30] A guide endorsed by ministries with responsibilities for shale gas development would help improve transparency and promote investment in the sector.

A related issue is coordination among ministries and other stakeholders at the local level. The Beijing Energy Club, with a membership of leaders from the Chinese energy community, has recommended focusing in particular on local-level coordination in shale gas development. In a November 2012 report, the Beijing Energy Club notes the challenges of regulatory coordination and recommends considering "an appropriate mechanism at the local level, to allow local government, NGOs and local communities to participate in environmental regulatory work."[31]

RECOMMENDATIONS:

- Improve inter-ministerial coordination on shale gas.
- Publish a guide to all approvals required to work in the shale gas sector.

[28] See Beijing Energy Club, Enabling Policy and Regulatory Conditions for Successful Shale Gas Development in China **(**November 16, 2012).
[29] For background on interministerial coordination mechanisms, see Naughton, "Deepening Reform, at note 41; China's National Leading Group to Address Climate Change, Zhu Xufeng, EAI Background Brief No. 572, http://www.eai.nus.edu.sg/BB572.pdf; "China sets up national energy leading group," China Daily (June 4, 2005), http://english.peopledaily.com.cn/200506/04/eng20050604_188432.html.
[30] See for example John Pertgen, Federal Regulatory Actions Impacting Offshore Drilling (International Association of Drilling Contractors, June 30, 2014), http://www.iadc.org/wp-content/uploads/2014/02/July14FederalSummary.pdf.
[31] Beijing Energy Club, Enabling Policy and Regulatory Conditions for Successful Shale Gas Development in China (November 16, 2012)

SUMMARY OF RECOMMENDATIONS

1. Accelerate Market-Based Reforms

- Accelerate natural gas price reforms.
- Accelerate pipeline reforms.
- Encourage competition for mineral rights.
- Improve data availability.

2. Provide a Clear Roadmap for Foreign Companies

- Develop a model Production Sharing Contract (PSC) for shale gas, with terms designed to reflect the unique nature of shale gas production.
- Use a "rolling Overall Development Program" (ODP) at shale gas projects.
- Give companies working in shale gas production flexibility to enter into agreements with other legal forms, including equity joint ventures.

3. Build Regulatory Capacity

- Build a robust and stable regulatory capacity for shale gas, as a high priority.

4. Invest in Innovation

- Ensure NOCs have strong incentives to invest in innovation.
- Pay attention to the principles of "open innovation."
- Add a shale gas consortium to the U.S.-China Clean Energy Research Center.

5. Coordinate among Ministries

- Improve inter-ministerial coordination on shale gas.
- Publish a guide to all approvals required to work in the shale gas sector.