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SHALE GAS

TEN LEVERS TO ENSURE SAFE AND EFFECTIVE DEVELOPMENT

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THE SHALE GAS REVOLUTION, with its abundant yield of low-cost natural gas and natural-gas liquids, is reshaping the U.S. energy landscape and delivering significant peripheral benefits, including greater energy self-sufficiency, reduced carbon emissions, and a resurgence of the country's petrochemicals industry.[1] For a number of reasons, relatively few countries have yet attempted to engineer shale gas revolutions of their own. But that trend appears poised to change.

Indeed, we expect that over the next four to six years, growing numbers of countries will seek to emulate the U.S.'s success, given the potential economic and related advantages to those nations and the substantial shale reserves that many countries possess within their borders. (See the first article in this series on shale gas development, "The Great, Global Shale-Gas Development Race: Where to Focus Commercial Resources," BCG article, July 2013.)

These countries will face sizable challenges, however, ranging from addressing residents' environmental concerns to determining how to structure relationships with operators. To help policymakers chart a course forward, we have defined ten levers that we believe will ensure successful and sustainable shale-gas development.

Ten Key Levers for Development

Safe and successful development of shale gas demands a comprehensive plan. (See Exhibit 1.) We recommend the following actions (we will expand on these actions in a subsequent report):

1. Institute a licensing system that reflects the realities of shale gas development and is aligned with the country's development objectives. The development of shale gas is fundamentally different from the development of conventional oil and gas resources. Shale gas wells produce far less than conventional wells—an offshore well in Angola, for example, will produce about 4,000 barrels of oil equivalent per day (BOE/D), whereas a top-tier shale-gas well will produce roughly 800

EXHIBIT 1 | Safe and Successful Shale-Gas Development Demands a Comprehensive Plan

1. Institute a licensing system that reflects the realities of shale gas development and is aligned with the country's development objectives.
2. Authorize hydraulic fracturing for the exploration stage...
3. ...but develop a clearly defined monitoring framework.
4. Set up a transparent, well-resourced mechanism for granting permits.
5. Establish a simple and stable fiscal framework that encourages exploration.
6. Encourage and facilitate the use of top-tier oilfield-services companies by operators during the exploration phase.
7. Promote the acquisition and sharing of data.
8. Plan for the logistics implied by large-scale shale development.
9. Develop a specific strategy for the sourcing, treatment, and disposal of water.
10. Create a win-win partnership with communities, supported by intensive communication efforts.

Source: BCG analysis.

BOE/D. Shale wells' output also tails off rapidly: conventional wells observe a slow decline over their roughly decade-long lifetimes, but 50 percent of a typical shale well's production often occurs in the well's first year. The upshot: it takes many more wells to develop a shale gas field than a conventional one. Shale gas fields are also much less predictable than conventional fields for operators. With conventional fields, the long-term rate of development and positioning of wells can be gauged fairly early on, but with shale plays, the learning is constant and the model may need to be refined after every new well.

These realities should factor into the design of licensing policies. To encourage and facilitate exploration, governments should grant operators access to large amounts of land vis-à-vis the allotments typical for the development of conventional resources, reflecting the higher number of wells required (potentially 30 times as high over a ten-year period) to develop shale fields efficiently.[2] Operators should also be granted extended exploration periods, where the main criterion for approval is the commitment to execute large seismic surveys and to drill and fracture a large number of wells. The evaluation of field development plans for the granting of production licenses should allow for alteration of those plans down the line, given that the first batch of development wells will influence the rest of the development concept.

2. Authorize hydraulic fracturing for the exploration stage... A number of national governments have concerns about the safety and efficacy of hydraulic fracturing, which is a reservoir stimulation technique that involves pumping a mixture of water, chemicals, and sand into a well at high pressure to fracture shale rocks, thus increasing their permeability (that is, the degree to which liquids can pass through them). Today, hydraulic fracturing is the only reservoir-stimulation technique that will enable economical commercial development of shale plays. This technique has been used in the oil and gas industry since 1949, and it is widely estimated that more than 2 million hydraulic-fracturing operations have been performed worldwide.

We believe that governments seeking to develop shale gas reserves today essentially have no choice but to authorize hydraulic fracturing, at least for a few exploration wells. Absent hydraulic fracturing, there is no reliable way for governments and operators to determine the quantity of reserves held within a given basin, how the rock will respond to stimulation, and ultimately the potential for the basin's development.

3. ...but develop a clearly defined monitoring framework. Hydraulic fracturing is well tested but, as is the case with all methods of extracting hydrocarbons, not risk free. Governments thus need to put in place a solid monitoring framework to oversee operations that is built on two pillars: regulation and expertise.

Regulations should be transparent and explicit. Critical elements to be defined include the recommended operational processes, the level of disclosure required from operators regarding chemicals used in hydraulic-fracturing fluids, requirements for the submission of well-fracturing plans, details of the monitoring and data-collection process, and standards for the sourcing, disposal, and reuse of water.

Regulation must be backed by technical expertise. Governments must be staffed with enough skilled geologists, geophysicists, reservoir engineers, and field operators to act and be seen as credible stakeholders and have the capabilities necessary to analyze the data and provide advice on policy setting and evolution.

4. Set up a transparent, well-resourced mechanism for granting permits. Shale gas operations require a complex logistical setup, one that has to be repeated by operators a multitude of times for potentially thousands of wells. And permits are required at every step, from drilling to the use of explosives and chemicals. In some countries, more than 30 permits in total are required to drill the first exploration well. Given the sheer numbers, government agencies can become swamped by permitting requests, leading to delays and the rescheduling or even suspension of planned operations. This can translate into higher costs for operators and frustration all around.

To preempt this, governments must do three things. They must design permitting systems tailored specifically to the realities of shale gas development. They must model and test these systems to ensure that the systems are both efficient (that is, that they will allow the government to maintain the right level of control over operations) and practical (that is, that one step of the permitting chain will not create a bottleneck that has an impact on the rest of the chain). And they must staff up to ensure that they have adequate resources to handle the volume of requests.

5. Establish a simple and stable fiscal framework that encourages exploration. The fiscal framework that governments put in place for the exploration and production of shale gas will be a key factor in determining the attractiveness of a given play from the perspective of operators and investors. The two main elements needed are clarity and stability. There is nothing worse for investors and operators than having to navigate multiple unclear layers of tax regulations, with no certainty that those taxes will remain in effect. Simplicity is also critical. For an operator, it is much easier to pay a single 70 percent tax than to pay seven separate 10 percent taxes to seven different entities.

Governments should spell out a simple, clearly defined fiscal framework early on, one that allows both operators and regulators to easily forecast the impact on expenditures and revenues. Ideally, the framework should impose a relatively light tax burden during the exploration phase in order to maximize competition among operators bidding for licenses. But that burden should increase significantly for the production phase.

6. Encourage and facilitate the use of top-tier oilfield-services companies by operators during the exploration phase. Oilfield services companies perform a range of critical activities during the exploration phase, including the initial geological and geophysical studies, the actual drilling of wells, and the management of the wells' hydraulic fracturing. How effectively these are executed is a major determinant of a given development effort's overall results and the quality of the information collected. It is essential, therefore, that operators emphasize experienced, tier-one oilfield-services companies during this phase in favor of local players, most of which likely have little or no shale-gas experience. Top-tier players possess better tools, software, and equipment. They also have more-experienced personnel, more-robust processes, and, often, lower costs. Typically, too, they adhere to higher health, safety, and environmental (HSE) standards. Once the exploration phase has been completed successfully, governments can adjust policies to foster the deployment of local service and production companies during the production phase.

To encourage top-tier oilfield-services companies to participate in their country's shale-gas development, governments should exercise a range of levers. These include developing an enticing fiscal policy and a secure, stable legislative framework and facilitating the creation of permanent bases and the granting of work permits.

7. Promote the acquisition and sharing of data. Outside the U.S., one of the main hurdles that governments and operators face in formulating long-term strategies for shale gas development is simply the lack of available relevant geographical, geophysical, and environmental data. Operators in the U.S., for example, had roughly a thousand times the amount of data at their disposal that operators in Poland had at the launch of their respective shale-development campaigns.

To address this shortcoming, governments must do two things: encourage data acquisition and promote data sharing.

Governments can encourage data acquisition among operators by embedding it in the licensing process and fiscal policy. A simple way to do so is to increase the weight of "minimum work programs" in the bid evaluation process that governments use to determine whether to grant exploration licenses. Governments should not hesitate to be very thorough in the definition of these expectations: they should specify not only the minimum number of wells required but the wells' minimum cost and depth, the number of hydraulic-fracturing stages to be performed, and so forth. Governments should also define the set of HSE data and surveys that operators must provide. These efforts can be supplemented by fiscal policy—for instance, operators can be granted special tax treatment for exploration wells and seismic surveys.

To promote data sharing, governments should use regulation. In this traditionally secretive industry, only the regulator is in a position to foster collaboration. Governments could, for example, force operators to immediately share specific types of data, such as HSE data, and define a time period after which more-sensitive data would have to be shared.

8. Plan for the logistics implied by large-scale shale-gas development. Each shale-gas well is an equipment- and supply-intensive operation. (See Exhibit 2.) In planning for the logistical challenges, governments must attempt to address the needs of both operators and local communities. Operators must be able to transport the necessary people (for example, drilling and rig crews), equipment (including drilling and completion equipment, such as cement, casing, and tubing), and supplies (water, proppant [sand or ceramic materials used to "prop" the fractures open], and hydraulic-fracturing chemicals) to and from well sites at a reasonable cost. Communities must be spared the worst effects of the increase in road traffic, rail traffic, or both.

In designing plans, governments should focus on four major considerations: the impact on road and rail traffic, the impact on road and rail safety, potential damage to roadways and infrastructure, and the impact on shale economics. Early preparation is crucial. It is one thing to plan for and mitigate the effects on local communities of four or five exploration wells. It is quite another to do so for a thousand or more wells in the development phase.

9. Develop a specific strategy for the sourcing, treatment, and disposal of water. Hydraulic fracturing is highly water-intensive, with an average well requiring from 15,000 to 20,000 cubic meters of water over its lifetime.[3] For each exploration basin, plans must be made for how the needed water will be sourced and trans-

Exhibit 2 | The Logistical Challenges of Shale Gas Development Are Considerable

Operators must perform nine key logistical operations for each well.

- Prepare the well site.
- Mobilize the rig and crew.
- Bring drilling fluids and equipment.
- Bring casing and tubing (about 200 tons per well).
- Mobilize the frack fleet (about 25 to 35 trucks).
- Bring water to perform fracking (about 200,000 bbls per well[1]).
- Bring fracking sand (about 2,000[1] tons per well) and fluids.
- Bring water to disposal site (about 100,000[1] bbls per well).
- Transport produced hydrocarbons.

Operators and governments have three main choices for transport of materials...

Pipelines	Railroads	Trucks
• High up-front capital expenditure • Large throughput • Low cost per volume transported • Limited flexibility once installed • High disturbance for communities during construction, low after construction	• High to moderate up-front capital expenditure • In terms of volumes carried, one railcar is the equivalent of some four to eight trucks • Flexibility depends on the existing network and regulations • Low disturbance for communities	• No up-front capital expenditure • High cost per volume carried • The most flexible solution for operators • High disturbance for communities • Significant impact on local infrastructure system

...and will have to try to balance four considerations.

Impact on road and rail traffic
Impact on road and rail safety
Potential damage to roadways and infrastructure
Impact on shale economics
- Infrastructure costs
- Operating expenditures

Source: BCG analysis.
Note: Drilling multiple wells on a single pad ("pad drilling") will help reduce the overall logistical requirements but will increase traffic density near the well pad location. bbls = billion barrels.
[1]Based on a 20-stage hydraulic-fracturing job, with 50 percent of the injected water flowing back to the surface and the produced water then disposed of (as is the case in the majority of U.S. basins today).

ported to individual well sites. Given that the vast majority of the water will be transported by truck, particular attention should be paid to the potential impact on local roads.

Rules must also be written for the treatment and disposal of water—20 to 50 percent of the water injected into a well returns to the surface during the well's life, with 90 percent of that occurring during the first ten days. At the national level, standards must be set for spent water that is intended for discharge back into streams—must it be of drinking-water quality? At a local level, disposal options will have to be assessed and defined. Three main options are possible: disposing of untreated produced water in extradeep "waste" wells, treating the water and reusing it to fracture new wells to limit the need for fresh water, and treating the produced water to the point where it meets local HSE standards and discharging it into rivers.

10. Create a win-win partnership with communities, supported by intensive communication efforts. In the U.S., landowners also own their property's subsurface mineral rights. In contrast, in many countries, landowners lack those rights. As a result, the argument for local shale-gas development must be sufficiently compelling to win over entire communities, not simply individual homeowners. Governments and operators must determine what communities require to achieve this level of acceptability.

Ultimately, this involves answering two questions. First, how can development benefit the local community? This will vary among countries and regions but typically includes such things as tangible job creation, direct financial compensation, and direct and indirect investment in the community, including taxes paid, investment in schools and roads, and money pumped into the local economy. Second, which governance mechanisms are necessary to ensure that communities are engaged and feel that their concerns are being addressed? The answer may include the creation of independent monitoring bodies, the disclosure of operational and key HSE data, and the creation of local forums.

Government's key role here is to encourage and facilitate open dialogue among all parties—and to ensure that the dialogue commences early. Leaving that dialogue until later will only lead to subsequent anger, delays, and disruption.

Implementation Challenges

To fully seize the opportunities afforded by the development of their shale-gas resources, national governments will need to develop new skills and capabilities, create new bodies and processes, and move quickly. This is new territory for many governments and it will be a challenging journey, but the potential benefits are sizable. We strongly believe that the ten levers described herein will help governments establish the right framework for successful and safe development of their shale-gas resources.

NOTES

1. The Boston Consulting Group estimates that, by the end of 2013, the U.S. was producing 32 billion cubic feet of shale gas and 3.7 million barrels of liquids per day from shale plays. In concert with this surge in output, energy-related carbon dioxide emissions in the U.S. declined by 3.8 percent in 2012, even though the U.S. economy grew by 2.8 percent. For a discussion of the implications of the rise in NGL production, see "Natural-Gas Liquids: The Implications of the Next Energy Tsunami," BCG article, October 2012.
2. This calculation compares the number of conventional offshore wells in Angola required to maintain a 150,000 BOE/D plateau for ten years with the required number of onshore shale wells, assuming an average initial production of 500 BOE/D and a typical decline profile.
3. That amount of water would be equivalent to the amount it takes to fill six to eight Olympic-size swimming pools.

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This article is the second in a series of articles from the Energy practice on shale gas development. This article summarizes the findings of recent BCG research on this topic.