Paper #5-3

U.S. OIL & GAS INDUSTRY BUSINESS MODELS

Prepared for the
Macroeconomic Subgroup

On September 15, 2011, The National Petroleum Council (NPC) in approving its report, *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Task Groups and/or Subgroups. These Topic and White Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic and White Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 57 such working documents used in the study analyses. Also included is a roster of the Subgroup for which this paper was developed or submitted. Appendix C of the final NPC report provides a complete list of the 57 Topic and White Papers and an abstract for each. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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MACROECONOMIC SUBGROUP

U.S. Oil & Gas Industry Business Models

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1. Defining a business model

A **business model** describes the structure under which an organization creates, delivers, and captures economic, social, or other forms of value. The process of business model design is part of business strategy.

In theory and practice the term business model is used for a broad range of informal and formal descriptions to represent core aspects of a business, including purpose, offerings, strategies, infrastructure, organizational structures, trading practices, and operational processes and policies.

Whenever a business is established, it either explicitly or implicitly employs a particular business model that describes the design or architecture of the value creation, delivery, and capture mechanisms employed by the business enterprise. The essence of a business model is that it defines the manner by which the business enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit: it thus reflects management's hypothesis about what customers want, how they want it, and how an enterprise can organize to best meet those needs, get paid for doing so, and make a profit. Business models are used to describe and classify businesses (especially in an entrepreneurial setting), but they are also used by managers inside companies to explore possibilities for future development, and finally well known business models operate as recipes for creative managers.

Note that, while this definition focuses on business models for industries, the same principles and goals are relevant to the discussion of the government's business model in promoting the production and use of natural gas.

Private sector, for-profit business models in the United States rely on many common, fundamental needs: free markets, established legal systems, and appropriate and reasonable government oversight, taxation and regulation. This differs materially from business models employed in many other oil & gas producing countries and defines why U.S. companies (and private-sector companies in other free-market countries) have succeeded at developing new technologies, finding new oil & gas resources and creating value for stakeholders.

2. How does this relate to promoting the production and use of natural gas in the US?

Understanding the petroleum industry's goals and how it achieves them (its business model) and the government's goals for natural gas and how it achieves them (its business model) are essential to any effort to efficiently and prudently promote greater gas supplies and use in the U.S.

Now, understanding what a business model is and how it governs the actions and policies of an industry, or a government, we can now assess

- For the supply of natural gas
  - How the domestic petroleum industry's business model functions in finding and producing natural gas and can it be enhanced to promote greater production
  - How the government's business model for domestic natural gas production functions and can it be enhanced to promote greater development
- For the demand for natural gas
  - How the business models for domestic industries currently using natural gas function and can these models (and the business models for industries not using natural gas at present) be enhanced to increase the use of natural gas
  - How the government's business model for domestic natural gas consumption functions and can it be enhanced to promote greater consumption

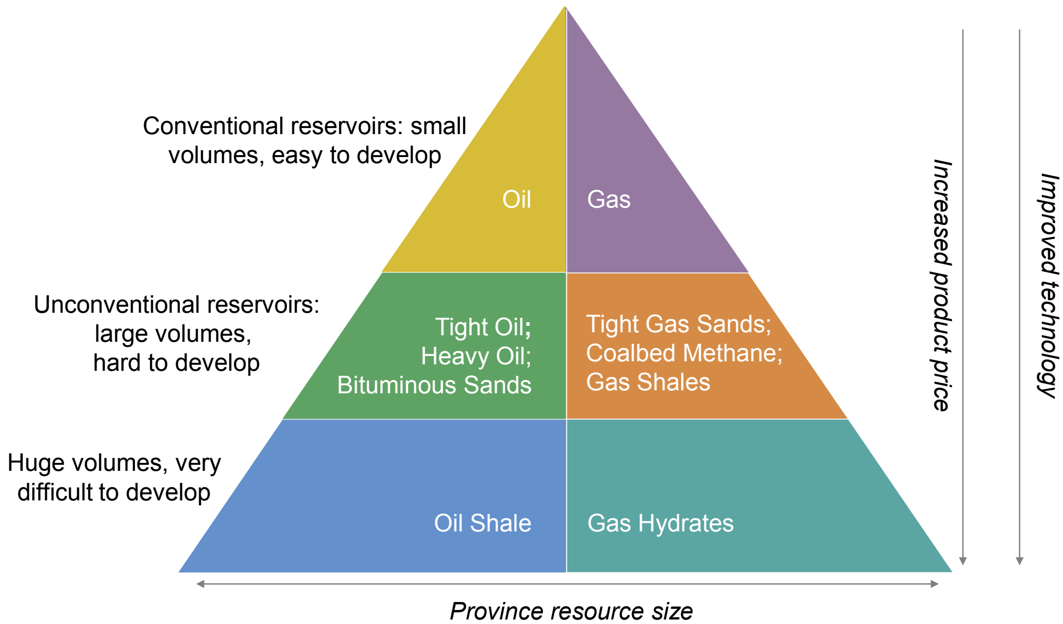
Supply of natural gas

In the last ten years the "conventional wisdom" that domestic natural gas resources were limited and that domestic natural gas production may have peaked has been completely overturned by the enormous new discoveries of natural gas–these new discoveries have been primarily in "unconventional" geologic formations.

As illustrated in this pyramid the domestic unconventional base dwarfs the conventional resource base, which has historically been the source of most of domestic supplies in the US. The keys to developing this enormous unconventional resource are to improve technologies to be technically and economically able to produce this gas as well as gas market prices, which are sufficient to justify the significant investment needed to find and produce these resources.

Exhibit 2.1

The Resource Pyramid



Source: Steve Sonnenberg. Colorado School of Mines

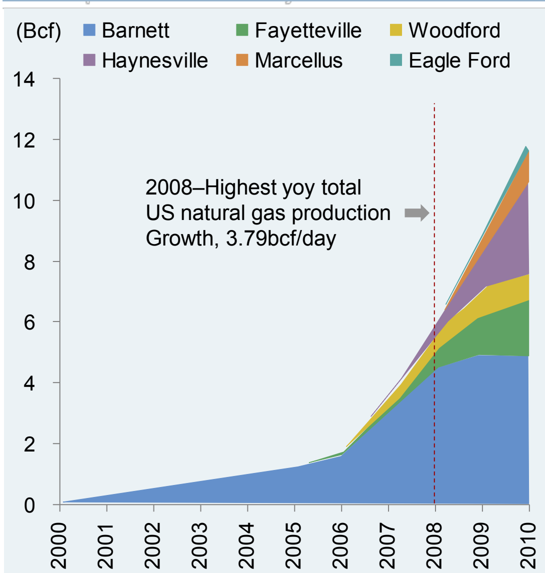
In recent years, the global natural gas business has gone from scarcity to surplus. The industry has gone from concerns about having adequate available resources to a situation where a near-term surplus-(the next 2–5years, or perhaps even longer)–is likely. The surplus is due to several factors, including the global economic down-turn, a surge in new natural gas liquefaction capacity, and, perhaps most important, the refinement of technologies that can unlock vast quantities of gas from shale deposits.

Shale gas has altered the supply-side equation in the U.S. It was not on the radar screen until a few years ago. Today, shale formations now account for more than 70% of total new production. Absent of any regulatory restrictions/limitations, the scale of potential production increases and speed with which this can be accomplished is groundbreaking.

Exhibit 2.2

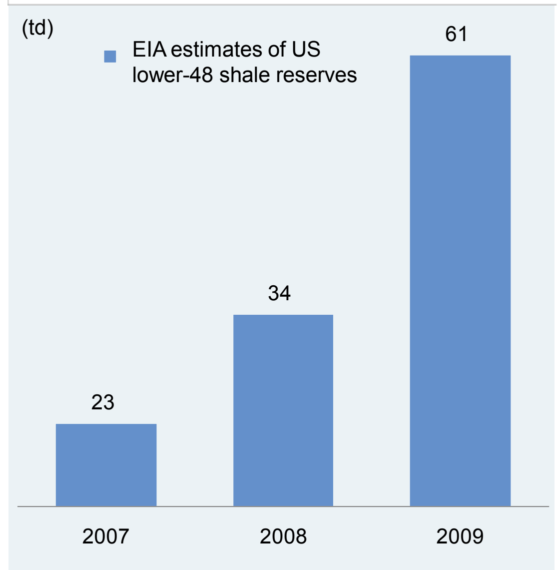
Major shale production (Bcf / day)

Annual production from major shale

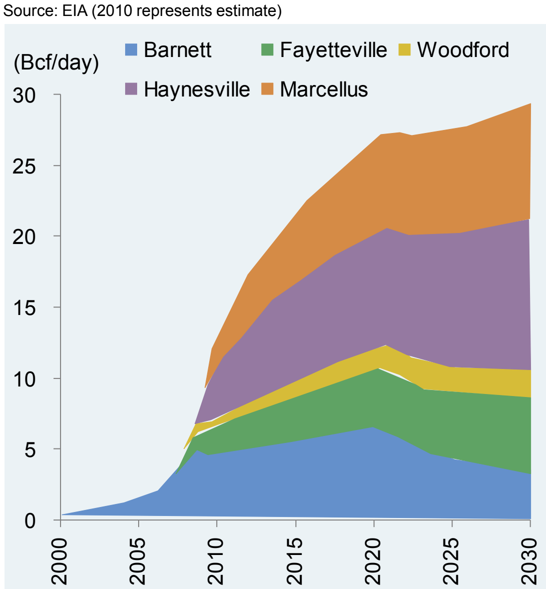


Source: EIA (2010 represents estimate)

Estimates of US lower-48 shale reserves



Source: EIA

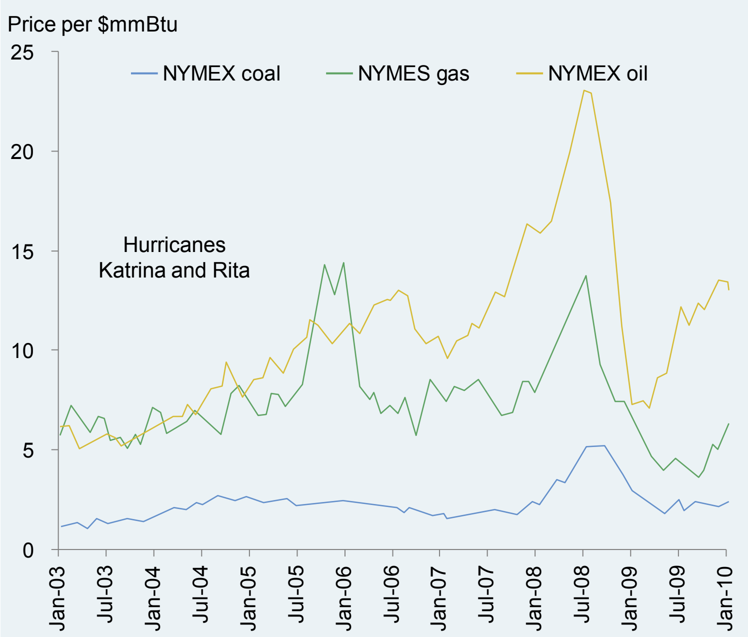


Source: MIT, www.energybusinesswatch.com

The vast natural gas supply increase has already had major price impacts. Abundant natural gas supply minimizes price fluctuations. There is the consensus view that sufficient supplies are available to satisfy needs of the US market for at least twenty years at cost of between $4–$6/MMBtu. Resource estimates are likely to continue increasing and cost estimates will decline, as techniques for shale gas development continue to improve.

Exhibit 2.3

NYMEX oil, coal and gas spot prices



- Abundant natural gas supply minimizes price fluctuations
- Cost of natural gas is at least 50% lower than oil

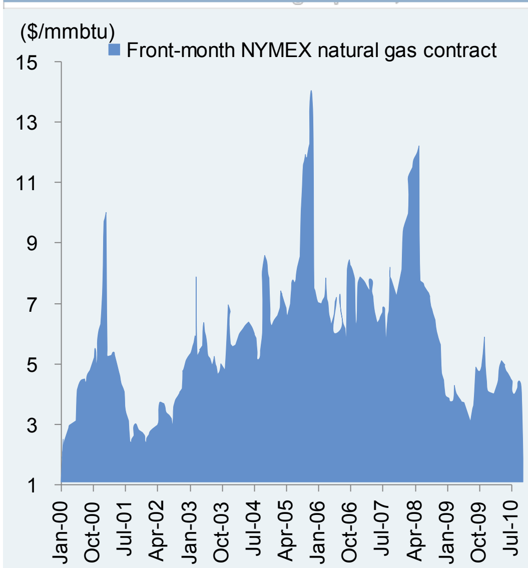
Source: Encana, www.energybusinesswatch.com

The bottom line is the natural gas industry has unlocked a vast, moderately priced, lower-emitting, intrinsically cleaner domestic fossil fuel resource in shale gas and it is transforming the market with lightning speed. We now are seeing natural gas and electricity markets in a midst of fundamental transformation. The frequency and magnitude of natural gas price spikes has declined and therefore the electricity market is less vulnerable. There are far-reaching implications for U.S. energy and environmental policy.

Exhibit 2.4

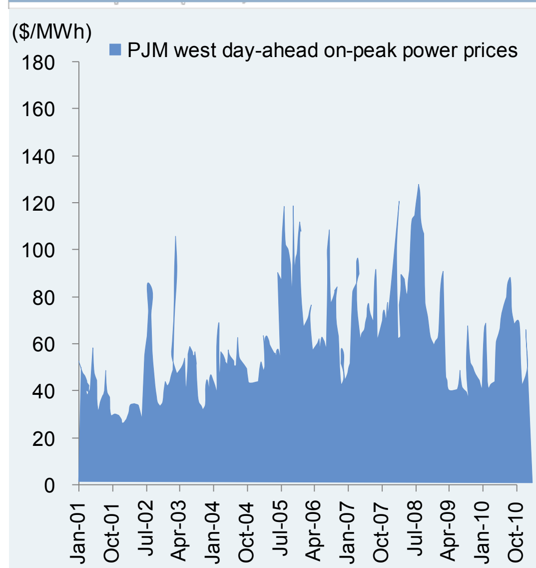
Natural gas and electricity prices

Front-month NYMEX natural gas prices, 2000–2010



Source: Bloomberg, www.energybusinesswatch.com

PJM west power prices, 2001–2010



Source: Bloomberg, www.energybusinesswatch.com

Unlocking the shale gas will require a market transformation resulting from structural changes. The key drivers include

- More complete integration of the physical delivery system in the North American market
- Major increases in storage capacity
- Massive reallocation of capital and human resources
- Huge influx of non-traditional players/rapid consolidation of industry as source of capital
- De-linkage with oil

These will change the market dynamics by having the ability to rapidly increase supply when market needs require, coupled with storage additions in line with growth in market demand. This presents a unique opportunity for the U.S. to make progress towards its economic, environmental and energy security goals through new industry and government initiatives.

Such transformational energy resource offers potential to

- Jump-start U.S. economy by expanding opportunities for the U.S. energy industry to compete effectively in the global market. Because the shale gas is touted to be the lowest cost source of natural gas (except for Middle East), it greatly enhances our ability to compete in global markets, and act as a catalyst for economic growth.
- Cost–effectively reduce carbon emissions far more quickly than a less natural gas-intensive mix of energy sources
- Rapidly and cost-effectively reduce power-plant emissions of other regulated pollutants
- Avoid the need to retrofit expensive pollution controls at high emitting coal-fired plants and to enable the retirement of aging, obsolete units

But this potential to expand production of natural gas could reverse if new coal-fired generation and renewables are dispatched before natural gas-fired generation. Such a trend would reduce use of natural gas. The potential is also curtailed or limited by large end users' (i.e. power producers and manufacturers) reluctance to expand use of natural gas. A 10 to 15 year commitment is required to justify a long-term capital investment to build or expand. Potential natural gas users need confidence that prices will remain stable long term.

Taking full advantage of this new vast resource should become a major national goal. Actions at national level should include

- Comprehensive, long-term program to replace older and less efficient coal-fired generating units
- Focused efforts to identify and pursue opportunities for U.S. industry to expand market share in gas-intensive export industries
- Aggressive goals for the use of natural gas vehicles
- Commitment to expand use of natural gas as the primary means to reduce emissions of air pollutants from power plants that endanger public health and to reduce coal ash

3. What is the domestic oil & gas industry's business model to produce natural gas and can it be enhanced to promote greater production of natural gas?

One of the most significant factors affecting the domestic natural gas industry's business model is the widely diverse geologic and operating conditions in which resources of natural gas reside. The physical and business realities that result include

- **Wide distribution in the output of natural gas wells:** The U.S. natural gas production system is characterized by a wide distribution of well output productivity: a relatively small number of high productivity wells carry the system, but there is also a very large number of low productivity wells. As an example, of the new wells drilled in 2009, the most productive 100 wells drilled each month (about 10% of the total) accounted for more than 50% of all new production.
- **Areal extent:** In contrast to conventional gas, which looks to tap underground structures, unconventional resources exist over very wide areas–sometimes hundreds or even thousands of square miles. The gas-bearing strata are generally well known and mapped. The wide areal extent of these resources creates land use issues as prospective acreage overlaps cities, parks, watersheds, etc.,
- **Statistical variation within plays:** Although the target reservoir may extend widely over large areas, there is tremendous heterogeneity in individual plays. Plays are then characterized by "cores" or "sweet spots" within the play. Controlled by geology, these areas are naturally more productive per dollar spent, while other areas may generate well results that are dramatically different. Thus, simply having a stake in a top shale play is not enough: companies that access only poor areas of the play often experience marginal or negative returns. For example, if we divide the total wells drilled into quintiles based on maximum production in the first 6 months of the well's life, it is important to note that a top quintile well is about 15 times as productive on average as a bottom quintile well.
- **Importance of commercial vs. exploration risk:** In contrast to conventional plays, the risk of a dry hole in an unconventional play is extremely low. Virtually all wells hit hydrocarbons. The key risk, then, is that the well does not produce in commercial quantities
- **Low permeability:** The overriding characteristic of shale and tight gas, of course, is that natural gas cannot travel effectively to the well bore because the connections between the pore spaces holding the gas are too small. For reference, some tight gas plays have less permeability that than cement. From a business and public interest standpoint, this has two practical implications
  - **Fracturing:** Unless and until another method is developed, hydraulic fracturing will remain absolutely necessary. Without the creation of artificial fissures, the gas will not flow in commercial quantities or at all
  - **Small drainage radius:** Compared to conventional developments, each unconventional well drains only a very small area, which means that play development requires drilling thousands of wellbores
- **Low recovery rates:** Even with fracturing, recovery rates (of the original gas in place) in unconventional gas plays are quite low–always less than 20% and usually less than 10% versus conventional gas recovery rates of as much as 75–95%. This means that there may be long-term upside if technology finds better ways to recover this precious resource
- **Low per well productivity:** While there are impressive shale gas wells and productivity has climbed dramatically, it is important to remember that most wells are small by global

standards. The attraction of unconventional plays is that they compensate for lack in reserves per well by the sheer number of wells to be drilled

- **Low individual well costs:** In terms of the oil and gas business, a single unconventional gas well represents a relatively modest outlay. This is critical to the technology model of the sector because modest costs allow companies to experiment with new drilling, completion, and operational techniques
- **Modularity:** In sharp contrast to large, discrete conventional projects (for example, in the deepwater), unconventional development is relatively flexible. Each well represents an independent project, and companies generally have discretion to either drill or not drill. While logistical factors (rig contracts, acreage expiration, etc) intervene, in the long-run, an unconventional system will tend to adjust to demand more nimbly than conventional assets, where investments must often continue during times of low prices and cannot be initiated in times of high prices

Company roles within the unconventional gas business

The unconventional onshore gas business was pioneered by the independent oil & gas exploration and production companies in North America. As a rule, the major (integrated) oil and gas companies slowly exited the US onshore over the past two decades in order to find assets of the scale necessary to allow them to sustain their business. Medium- and small-sized independents, often lacking the skills and financial resources necessary to compete internationally, focused on trying to more fully exploit or rejuvenate US basins and reduce costs to create profitable projects. Large Independents often sought out niche positions internationally, but in most cases derived the bulk of their production and reserves from North America (both Canada and the US, which are highly integrated both in terms of infrastructure and corporations).

As gas prices began to rise in the middle of the last decade, it was the Independents that began to perfect the technologies to unlock shale gas. As discussed below, the process of successfully birthing a new unconventional play requires companies to

- Be very nimble
- Make rapid decisions
- Strive for growth

In the US upstream industry, these are the characteristics most associated with independent companies. Thus, many analysts feel this set of competitors were uniquely able to develop this technology and deploy it so rapidly.

As the development of shale and other unconventional plays has progressed, the sector has seen the entry of the large integrated and international firms. While they may not have been pivotal in the inception of the key unconventional plays in North America, these firms have the ability to take unconventional gas even further. These giant companies bring strong technical skills, immense financial resources, the ability to manage world-scale projects, and disciplined processes.

It is also essential to understand the critical role played by the oilfield service companies. These firms provide the technology, logistics, knowledge, equipment and manpower that have driven the gas revolution. Simply put, unconventional gas cannot survive–much less flourish–without a vibrant service sector.

The continued presence of these three sets of players–Independents, large Integrated/International companies, and the Oilfield Service providers–along with governments and community groups should have the tools and resources to continue to meet the challenges of tapping unconventional gas to provide abundant, clean, safe affordable energy for consumers and to create jobs and economic impact for the country.

How the business model works: Process of development

Each unconventional play is different in its pace, scale, and exact path of development. However, it is possible to generalize somewhat about the various stages through which plays pass and the key activities and characteristics of each.

Stage 1: Prove it

The earliest stages of the life of a play involve companies' efforts to demonstrate geologic and reservoir potential and secure a landhold position. It should be noted that cash flows during this period are non-existent or meager. Funding must come from other assets.

- Major activities
  - Geoscience and other work to determine technical properties and suitability for exploration
  - Land acquisition
  - Drilling of pilot and test wells, not for production but for **information**
- Keys to overall success of play
  - Amount of relevant geotechnical and engineering information gathered per dollar spent
  - 1–3 technical "champions" with financial capabilities
  - Presence of service sector partners with science/experience

Stage 2: Optimize it by trial and error

If the industry establishes potential, the next stage involves an attempt by individual companies to raise the productivity and economics of the well to an optimal level. In this regard, each company will experiment with a number of techniques. At this stage, play development benefits from the participation of more firms since it leads to a greater variety of techniques and quantity of data and experience. It is also important to note that many wells drilled in this phase will be uneconomic and relatively high cost.

In general, companies seek to hold data and information proprietary. However, if most of the acreage in a particular play has been leased, then participants may be willing to share information, since each will benefit. Thus, we have seen consortia for technical collaboration. Moreover, even if companies sought to protect this information, the structure of operations prevents this. While there are exceptions, exploration and production companies do not drill and complete wells themselves. Rather, they outsource this to the service sector companies, who provide not only equipment and crews but also often have deep knowledge and technical capabilities. Thus, the experience accrues to these entities, which then seek to leverage their success for a given E&P company on others. In this way, the stream of lessons learned and improvements in technology migrate to all the players. This allows for optimization of the entire play.

Thus, it is vital to note that at this stage the whole is greater than the sum of the parts. In terms of an R&D model, the natural gas sector does not follow the traditional model. Rather, it is more akin to open source software, in which widespread experimentation and interaction lead to a solution that is then accessible to all participants.

- Major activities
  - Try everything
  - Interpretation of masses of data
  - Ramp drilling/create local operational and service sector hubs
- Keys to overall success of play
  - Constantly raise well productivity
  - Constantly decrease costs
  - Rapidly integrate diverse data streams

- Draw correct conclusions and apply learning to current and future drilling programs
- Share information or engage in heavy scouting
- Presence of multiple service sector partners with science/experience

Stage 3: Standardize it

In the third stage of a play's life, companies have "cracked the code" and the goal is to bring down unit costs by creating large programs focused on aboveground efficiencies. This involves reducing idle time for equipment and raising utilization. Unlike the previous phases, it is less technical. It also plays to the strengths of companies that can adequately fund activities across the price cycle and avoid the inefficiencies of stop-start programs. By this time, the core area(s) of the play are well known and the bulk of activity will take place in these high-productivity locations.

- Major activities
  - Large, steady programs
  - Focus on above ground efficiencies
- Keys to overall success of play
  - Standardization of everything grinds down unit costs
  - Effective coordination of chain of input
  - Efficiency gains
  - Adequate and timely ancillary infrastructure such as midstream and transport
  - No-frills approach
  - Economies of scale and volume discounts
  - Low cost of capital and adequate free cash flow at bottom of cycle
  - Sequential unit cost reduction (opex and capex)

This third stage is important because it is where the bulk of spending and activity takes place. At this stage, the development of unconventional plays has been compared to an industrial process and many observers call the development of these resources "gas manufacturing."

The comparison is apt in that the developer looks to repeat a particular set of tasks hundreds or even thousands of times in an identical way and in doing so to reduce costs and gain efficiencies. As such, companies have the ability to bring in numerous concepts and lessons and best practices from unrelated industries. These include supply chain analysis, inventory management, coordination of multiple parties, etc. Many of these concepts have historically had very limited application in upstream oil and gas since geologic risk is perhaps the overriding determinant of success in conventional oil and gas and because conventional fields require vastly fewer wells to fully develop. For unconventional plays, geologic risk is almost entirely eliminated and the emphasis is on gaining aboveground efficiencies.

While these manufacturing concepts have great potential, it is worth noting one difference between manufacturing of industrial goods and "gas manufacturing": a factory aims for precision and efficient inputs to achieve identical, high-quality products as the output. In the upstream business, companies also aim to optimize the chain of inputs; however, the quality of the outputs (i.e., the production of gas from a well) will still be controlled by the location of the well within the play. Unfortunately, no matter how well companies "manufacture" the gas, the difference in economics and price thresholds within and between plays will still be significant.

Stage 4: Rethink it

The final phase is typically characterized by falling unit productivity and rising unit costs as the core is saturated with wells and companies are forced to less desirable areas. At this point, a change in ownership is common since the asset often becomes non-core to the primary developer. The field almost always benefits from this renewal of focus.

The operator typically then pursues one or more of the following possibilities

- Drill the field more densely as economics and geology allow
- Find overlooked upside–usually in the form of new zones or reservoirs
- Spend capital and undertake operational measures to stem the decline of existing wells. In this regard, re-fracturing of wells may be a material source of new supply for certain fields
- Reduce costs enough to make previously uneconomic wells economic

All fields have a finite life, but that life can also occur in several cycles as technology progress and/or price increases create new ability and incentive to more fully exploit the resource.

- Major activities
  - Transfer of ownership
  - Downspace further
  - Rework and refrac
  - Expansion
- Keys to overall success of play
  - Strong cost control
  - Focus of the operators
  - Leveraging of existing well bores, infrastructure, and field personnel
  - Discovery of new zones
  - Application of new technologies

Necessary ingredients to the business model

- Geologic quality
  - Must have excellent basins
- Geologic quantity
  - Basins must be large enough to gain economies of scale and sustain many competitors
  - Must have multiple plays since many of the plays will fail
- Property rights clarity
  - Landowner and local cooperation is very important for effective development
  - Process is unavoidably busy
  - Risks are manageable, but they exist
  - Local communities must receive benefits since they bear real costs
- Cooperative and capable local and national governments
  - Governments are key stakeholders
  - Agencies must have the funds, staff, experience, and resources to effectively and efficiently regulate and facilitate
  - Much land in the U.S. still under control of governments
  - Many public goods/common resources need to be developed (e.g., roads)
- Abundant service sector capacity
  - System needs to have large fleets of equipment
    - Drilling rigs
    - Pressure pumping equipment
    - Water hauling
    - Waste disposal
    - Site preparation
  - Efficiencies and critical mass of experience and data are not possible if services are difficult to access or too costly

- Multiplicity of players
  - Helps to speed learning and creates competition
- Capital availability via private and public equity and debt markets
- Willingness to spend money
  - Reinvestment rates and the desire to grow are absolutely essential. The ability to keep the upside of price rises is also important as an incentive to the E&P companies to compensate for the substantial financial risks involved
- Favorable natural gas prices
  - Inducement to drill–futures prices
  - Ability to fund–spot prices
- Ease of processing and delivering gas
  - Midstream facilities and gas pipelines must be in place or growth will stall
- Voluntary (or not) technical collaboration
  - The speed of dissemination of technical information determines the overall pace of learning

International unconventional: Will it work?

Shale and Tight Gas and Coal Bed Methane resources are widespread around the globe. Many countries are waking up to what has happened in North America and are keen to achieve the same results in their own countries. To date, only Australia, with its large Coal Bed Methane reserves, has made significant progress and is on track to produce meaningful volumes in the next five years. In many countries, governments own the entire oil and gas resource and are seeking to prepare bid rounds.

While the long-term potential is real, many countries lack many of the characteristics listed above. In particular, there are four large obstacles

- **Government dominance of the sector:** The fact that governments own the resource creates several problems for development of unconventional resources
  - Governments lack the technical capabilities to unlock the plays
  - The dominance of one or two state entities prevents the kind of competition that speeds learning
  - Single-point ownership of land makes for cumbersome access. Countries with tax/royalty regimes (such as Canada or the U.K.) may have good experience, but in most places it can take years simply to access land. In a private ownership regime such as the US, it can take weeks or even days
  - Governments are exceedingly reluctant to take technical risk, but that is necessary
  - When the government owns the resource, surface rights owners and their communities can receive negligible benefits and compensation
- **Lack of infrastructure and service sector equipment:** North America drills the bulk of wells globally and therefore has the lion's share of trained personnel, technical expertise, and equipment. Accessing this infrastructure is relatively easy. This is not the case in most countries
- **Transparent and free pricing:** Across the globe, gas prices are often regulated at a very low level to subsidize industry or local demand. Without fair pricing or a viable forward market to reduce risk, most US companies have been hesitant to develop gas internationally except as LNG, which can access international markets and is usually linked by contract to oil prices
- **Lack of experience in unconventional gas production:** The business of unconventional gas is intellectually, physically, and organizationally challenging. The wave of international players signing joint venture agreements with US independents in order to gain exposure to

and experience in this sector to transfer abroad is proof both of its complexity and the inexperience of the players

It should be noted that the difficulties of transferring the unconventional gas revolution abroad offer an excellent chance for US companies to play a vital role in that process. While there are many issues that host governments must tackle on their own, partnerships between US companies and international players offer a good opportunity for creation of jobs and attainment of international clean energy goals.

Implications of the shift to unconventional gas business model

Unconventional gas development began with coalbed methane and tight gas, and has been an important contributor to U.S. supply for several decades. However, with the advent of shale gas development, unconventional drilling has come to dominate natural gas activity in every major onshore basin in the nation.

When compared to historical activities and business models, this new prominence has a number of implications for industry, mineral owners, regulators, shippers and consumers

- **New geographic distribution:** The "gas patch" has historically been comprised of the contiguous area formed by Texas, Louisiana, Oklahoma, New Mexico, and the shallow waters of the Gulf of Mexico. According to EIA data, this region accounted for 75% of Lower 48 production in 2000. Over the course of the 1990's and 2000's, significant growth was seen in the Rockies states–Colorado, Utah, and especially Wyoming. The very large Appalachian basin (the first basin to be produced in the country) remained a relatively minor, if steady, source of gas drilling and production. The advent of unconventional gas has led to a shift in the pattern of activity. While the "gas patch" has re-established itself as the heart of the movement, there are important implications for other regions
  - **Gulf of Mexico:** In light of the relative expense of drilling offshore, the geologic risk, and the maturity of the basin, new investment into the Gulf of Mexico shelf has been insufficient to maintain output, which has fallen by more than 50% since 2000. While certain companies continue to exhibit success in this area, many of the larger companies have preferred to focus on lower risk, less expensive onshore unconventional operations
  - **Rockies:** The low gas prices prevailing in the market since mid-2008 have forced companies to reduce their activity level and devote scarce resources to a smaller number of assets. While the Rockies contains a number of world class plays and resources, the industry has reduced the focus and spending level in the Rockies (though that activity remains quite substantial)
  - **North Dakota:** Though it is an oil-oriented play, the tools and techniques developed for shale gas have driven activity in the Bakken oil resource (primarily North Dakota and eastern Montana) to levels several orders of magnitude beyond that experienced in recent decades
  - **Northeast States (primarily Pennsylvania, New York, West Virginia):** The advent of the Marcellus play has led to an explosion of activity. This area has a very long history of oil and gas activity, of course, but in the modern era, these states have witnessed nothing like the tidal wave of investment and ensuing rush of activity they are now experiencing. The phenomenon may be long lasting, as the Marcellus formation is so immense that full development will require decades of drilling. Finally, besides the Marcellus, the Northeast contains other shale plays that may prove beneficial to develop. This rapid migration of oil and gas activity to the Northeast is leading to challenges as regulators, infrastructure, companies, workforces, and local populations seek to adapt to the scale of the opportunity and mitigate risks appropriately
- **Greater areal extent:** Since conventional fields represent a concentrated accumulation of oil or gas with a relatively high recovery factor, most conventional deposits cover a relatively small surface area. Unconventional plays are sometimes thought of as "blanket" resources.

Sweet spots with more productive wells are important to find, but all the major shale plays cover multiple counties–and sometimes multiple states. The natural result of this is to distribute the royalty lease and production benefits over a wider number of mineral rights holders

- **More wellbore-intensive:** Because unconventional wells tap into low-permeability reservoirs, they necessarily drain a small area around the wellbore (even after intensive fracturing) compared to conventional wells. As a result, effective and full development of a play necessitates many more wellbores than a conventional play covering the same surface area. If a shale play were developed using only vertical wells, then the land-use implications of this geologic fact would be commensurate. However, two developments are currently reducing the surface footprint materially: first, horizontal wells allow the subsurface drainage volume associated with one surface location to increase, with minimal impact on the size of that surface facility. Secondly, companies are increasingly drilling multiple horizontal wells in different directions from the same surface pad. Companies are adopting this “pad drilling” technique mostly to improve economics, but also to reduce the footprint of operations for environmental and/or regulatory reasons
- **More service sector-intensive:** Compared to onshore conventional wells, drilling and completing an unconventional well requires significantly more oilfield services (per unit of reserves or dollars expended). This is primarily due to the vast extent of equipment, expertise, and time associated with horizontal drilling and hydraulic fracturing, as well as relatively small reserves per well. During 2005–2007, gas production suffered from a shortage of rigs, qualified service sector employees, and fracturing equipment and drilling and completion costs rose as a consequence. The service sector responded by building and employing new equipment. While the overall shortage has eased, services are tight in a number of areas
- **More people-intensive:** The combination of the three factors above–more wellbores over a wider area and more effort to cause the gas to flow–leads to more job creation than either onshore conventional or offshore investment. The global oil and gas industry is perhaps the most capital-intensive in the world, with extremely high investment levels (to combat natural decline) and a relatively low ratio of employees-to-capital expenditures. While this is still true for unconventional resources compared to other industries, the migration of the industry toward a model dominated by unconventional resource development is likely to generate substantially more jobs than a model focused on conventional oil and gas

4. What is the government's business model to promote the production of natural gas and can IT be enhanced to stimulate more natural gas production?

Historically the Federal government has generally, as with most U.S. industries, treated the domestic natural gas industry with an overall "hands-off" approach[1] allowing the North American free market for natural gas supplies to determine prices as a result of the dynamic interaction of supply and demand. The emergence of significant quantities of technically recoverable unconventional natural gas resources presents the government with the opportunity to redefine its business model for interacting with the domestic natural gas industry, its goals for the industry, and how it can facilitate achieving those goals.

The government's goal of promoting natural gas development

The federal government's goal of promoting domestic supplies of natural gas is to achieve three things

- Enhance national energy security by becoming less reliant on foreign sources of oil and natural gas
- Enhance the economic welfare of the country by promoting economic activity in the natural gas and oil industry. This creates high-pay, high-skill jobs for U.S. workers. It also increases the government's tax revenues (and royalty revenues from federal lands) with the increase in industry activity. This also has particular value to the government because 29% of the estimated remaining technically recoverable U.S. natural gas resources and 45% of the estimated remaining technically recoverable U.S. oil resources are on federal lands (both on and offshore)–as these lands are developed, the federal treasury receives considerable bonuses, rents, and royalties,[2]
- To protect the environment by promoting the development of more efficient and environmentally sensitive E&P technologies and operating practices and substituting clean natural gas for other fossil fuels where possible.

Government tools to promote development

The tools the Federal government has to promote the development of domestic oil and gas resources are

- **Conducting R&D to develop new technologies and operating practices for the industry.** This work should not duplicate what the industry is doing on its own but should support a) sectors of the industry that do not have the financial resources to conduct their own research (e.g., small operators) or b) new frontier area development that may be too risky or expensive for private sector companies to pursue on their own

The government (through the Department of Energy) has traditionally conducted R&D that

- Examines areas of technology that are ignored since companies find them difficult or impossible to monetize (e.g., basic research or multi-industry application)
- Take advantages of government-owned assets (e.g., supercomputers or key personnel/skill sets) whose costs cannot be economically justified within the context of a single company
- Fills in the gaps in technology development needed by small operators who do not have the capital to conduct R&D on their own

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[1] An exception to this is the period following the Supreme Court Phillips decision in 1954, which caused wellhead price regulation for sales into the interstate system. The Natural Gas Policy Act of 1978 changed the pricing mechanisms but wellhead prices were still controlled. These price controls were not eliminated until the Natural Gas Wellhead Decontrol Act of 1989.

[2] EIA, *Annual Energy Outlook*, 2009.

- Provides government regulators with the technical expertise to effectively oversee the industry's operations

The 2010 Deepwater Horizon oil spill in the Gulf of Mexico also highlighted the need to understand and manage the risks associated with petroleum operations in complex and demanding geologic settings. In response to this the Department of Energy has initiated R&D to help the government understand the risks associated with petroleum operations and the capabilities needed to respond to any problems.

Historically, the Federal government has conducted effective R&D programs that do not duplicate or compete with private industry R&D. This R&D has made significant contributions to many aspects of technology development benefiting the industry and the nation. Basic research, new drilling technologies, seismic mapping, and fracture technology are just some of the areas in which government R&D has made contributions.

With a long history of government R&D, the implications of continuing this work, or taking it in new directions are clear

- Small producers that do not have the capital to conduct their own R&D will benefit from the government's work allowing them to be more efficient and competitive
- Basic and long-term, high-risk R&D that is not pursued by the industry could be done by the government. This will benefit current technology development as well as helping to bring long-term, high-risk resources (e.g., methane hydrates) to commercial viability
- Studying the risks associated with petroleum operations and the capabilities needed to respond to any problems helps manage the risks associated with petroleum operations in complex and demanding geologic settings

In this vein, the Department of Energy recently initiated new R&D and study to help the industry and government regulators to better understand and manage the risk associated with petroleum operations, and to ensure that the government has the capability to respond if a future accident occurs.

For deep water and ultra-Deepwater government R&D and study could collaborate with industry efforts and include

- Development of technology to recognize previously unknown changing downhole conditions that threaten overall safety of operations
- Researching the effective strategies for remote intervention, including quantifying risks associated with deepwater exploration and production and determining appropriate safeguards to include BOP standards

For gas shale resources government study and R&D could include

- Demand for water for use in fracturing
- Protection of drinking water aquifers during hydraulic fracturing; evaluation of the safety of chemicals used in hydraulic fracturing
- Air quality impacts resulting from increased drilling, natural gas production, and truck transportation activity
- Community safety issues surrounding high pressure fracturing operations in populated areas
- Water treatment and management technologies to address water requirements, fracture fluid flowback, and produced water
- Potential mitigation steps should groundwater contamination occur
- DOE could also conduct R&D to help bring the nation's long-term, high-risk gas resources, such as methane hydrates resources to commercial viability

- **Financial incentives**. Historically, the Federal government (and many states) has used financial incentives to promote the development of domestic natural gas resources that might not be developed (or would be developed more slowly and to a lesser degree). These financial incentives have taken the form of tax incentives in the Federal tax code or royalty incentives for development on Federal lands

These incentives have generally been used to promote the development of new frontier resource areas of the industry and the development of new technologies needed to develop these new resources. Examples of effective use of financial incentives to promote the development of new resources and technologies include

- **The Section 29 tax credit for the development of unconventional natural gas resources.** This tax credit, which was instituted in 1979, provided a significant push to the development of the new technologies and practices needed to produce these unconventional resources. This tax credit was eventually eliminated in the 1990's when it was determined the new technologies were now in widespread use and that the industry no longer needed this incentive. Today, unconventional gas resources are a significant source of the nation's supplies of natural gas and are expected to be the major source of growing supplies in the future
- **The deepwater royalty holiday to promote the development of new natural gas and oil resources in deep waters of the Gulf of Mexico (GOM).** With this incentive the industry has proceeded to create new technologies and operating practices to develop the vast petroleum resources found in the deep waters to the point where these regions are among the largest sources of petroleum supplies in the country. The "mandatory" deepwater royalty relief program expired in 2000 as provided for in the Deepwater Royalty Relief Act of 1995 which instituted this program
- **Accelerated depreciation of new transportation infrastructure (pipelines).** In 2005 as part of the Energy Policy Act the term over which a pipeline company could write-off new investment in natural gas pipelines was shortened from 20 to 15 years. This helped promote the development of new pipelines by allowing the pipeline companies to recapture their investment more quickly

While there is a history of financial incentives that have been very effective in promoting the development of new technologies and resource areas that now make significant contributions to the nation's supplies of natural gas and oil, it is essential in today's difficult budgetary environment (both at the Federal and state levels) that any new incentives do not add to the Federal deficit. Thus, any new incentive can be justified only if it is clear that the cost of the incentive (in terms of lower tax or royalty revenues) is at least balanced out by new economic activity, jobs, greater supplies of clean natural gas at competitive prices, etc. that will contribute more to the economy and ultimately bring in more revenues to the Federal Treasury than went out with the financial incentive.

- **Regulatory actions, which promote development.** This would include both regulations governing the industry's operations as well as regulations governing industry access to new resource areas formerly off-limits to develop. An example of this is the 2008 decision by then President Bush to remove the Presidential moratorium on developing certain areas of the Federal OCS. Regulatory action also includes the concept of removing or clarifying duplicative or confusing regulations that interfere with the market's ability to function properly

As the Federal government regulations and standards have developed and evolved over time, some of these regulations have not been coordinated or are clear. This has created situations where the industry is unsure about the regulations it needs to comply with and, as a result, responds with inefficient and more costly compliance strategies to insure compliance. This adds to the cost of supplying natural gas to the nation. Just as importantly, this uncertainty can inhibit investment and delay project schedules, which decrease supply, again raising costs to consumers and leaving resources undeveloped. This situation is further complicated by widely varying state regulatory standards, which frequently govern the same issues as the Federal standards.

The implications of inconsistent or unclear regulations are to make it more difficult for the industry to comply with these regulations. As a result, the industry will frequently respond with redundant, inefficient and more costly compliance strategies than should be necessary to meet the government's regulations. The inefficiencies and added costs of these compliance strategies can result in less natural gas being produced and, or higher prices of natural gas supplied to consumers.

Governing principles for the government

Some of the basic governing principles that the government considers in using any of the 3 tools described above are

- The government action should be focused on the development of new resources or technologies that would not be developed otherwise. The government should not create incentives for industry activity that is already occurring as a normal business practice without any government intervention. An example of this is the Section 29 tax credit for unconventional fuels passed in the late 1970's. This tax credit promoted the development of new technologies to discover and develop unconventional natural gas resources that were otherwise not feasible to develop at that time. When the development of unconventional resources became normal commercial activity the tax credit was eliminated as no longer needed
- In most instances, the government action should be focused on selected sectors of the industry rather than a general incentive for the industry as a whole. For example, incentivizing the development of new frontier resources, such as ultra-deep water resources, that are currently beyond today's technologies and practices can be an effective method to develop this new sector of the industry. Another example is the government R&D program to assist in the development of ultra-deep water technologies