



AN INTRODUCTION TO NATURAL GAS DEVELOPMENT AND WORKFORCES

INCLUDES GLOSSARY OF TERMS

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INTRODUCTION:

When preparing for the economic and social impacts from natural gas development it is important to understand the industrial process used by the natural gas industry. Impacts to local communities are primarily a function of industrial activity levels and workforce requirements, and the levels of activity and types of workforces that are required will vary significantly over the life of a natural gas field. While it is impossible to accurately predict all the fluctuations in activity that may occur during the development process, it is possible to describe the larger trends that are commonplace when developing a natural gas field.

This paper provides an introduction to the natural gas development process, the trends in industrial activity, and the types of workforces that are required.

The process can be best broken down into four distinct phases, and each of these phases will result in different levels of industrial activities and workforce requirements. The four phases are: **1) Pre-development or Exploratory Phase, 2) Development Phase, 3) Production Phase, and 4) Reclamation Phase.** It is important to note that the development process may slowly transition between these phases. It is during the Development Phase where the vast majority of industrial activity and labor is required.



THE PRE-DEVELOPMENT OR EXPLORATORY PHASE:

This phase largely consists of identifying the natural gas prospects, planning development locations and scenarios, performing research and analysis, securing mineral leases, and drilling test wells. This phase can occur over a period of several years.

The Primary Exploratory Phase Activities Include:

- Extensive seismic testing and other geological research
- Engineering and survey analysis
- Identification of pertinent land owners and regulating bodies
- Negotiation with land owners for rights to develop minerals
- The drilling of test wells (i.e. “wildcat wells”) as described in the “production phase” to “prove” the type and location of resource potential.
- Extensive commodity/price/economic market analysis
- Signing of contracts for equipment and services
- Obtaining requisite permits and other paperwork.
- Communication with pipeline companies for implementation of large scale transmission pipelines, etc.

Workforce Characteristics:

The workforces associated with this phase are for the most part highly educated and specialized, and will most likely come from outside the area unless these specialized services are available locally. The work produced in this phase will be a mix of work done in house by the energy companies (operators), and contracted out to specialized firms. Compared to the other phases of development, the workforce required for exploration will be relatively small (See graph above). Due to the relatively short time period of this phase, workers associated with the exploratory phase will likely maintain a transient or temporary residency status in the area.



THE DEVELOPMENT OR DRILLING PHASE:

After the type and size of the gas resource is identified and the economic considerations are deemed favorable, the wells can be developed. This phase is by far the most industrially active and labor intensive, and will require the largest amount of both transient and local workforces.

Because the workforce requirements of this stage are the

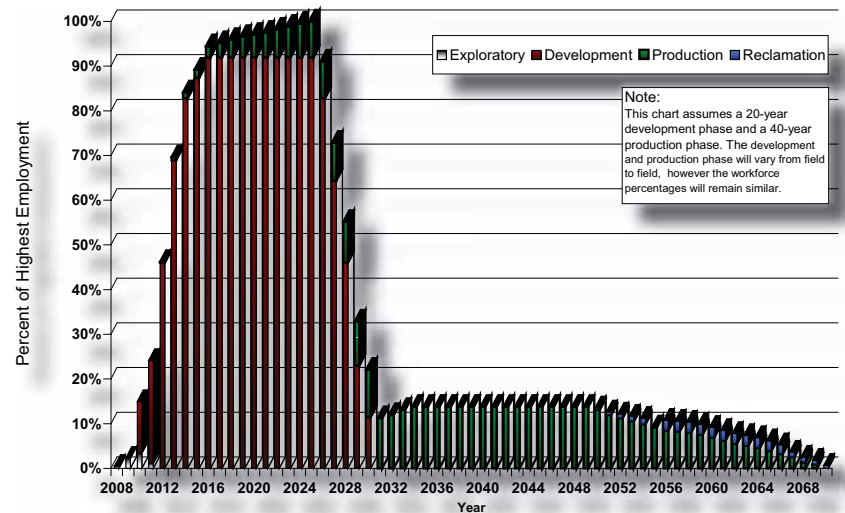


Figure courtesy of the author

largest and the ramp up of activity can often be very sudden, this phase of development can produce the most significant impacts to local communities as the local economy, infrastructure, and social ties adapt to the changes brought by the new residents and activity.

The Development Phase includes the drilling of the natural gas well and the associated activities required to make the well produce gas. While the majority of these work-

forces are unskilled or semi-skilled workers, there are many skilled positions additionally needed, such as engineers, welders, crane operators, heavy equipment operators, diesel mechanics, etc. All are prized on their ability to work very long and hard hours.

The primary Development Phase Activities Include:

- Clearing and construction of drilling locations (i.e. “wellpad”)
- Clearing and construction of access roads to these locations
- Construction of local pipeline infrastructure
- Digging and construction of water and other liquid collection pits

- Drilling of water wells (as needed)
- Mobilization and construction of drilling rigs, drilling mud, and related on-site equipment
- Mobilization and construction of man-camps or other living quarters, as well as water, waste, and other services both on site and at living quarters
- Drilling of the gas well
- Mobilization and construction of fracturing equipment
- Fracturing of the well
- Mobilization, construction, implementation of finishing rig and other well finishing equipment
- Construction and siting of production equipment (tanks, dehydrators, etc.)
- The removal and cleanup of equipment, evaporation or removal of water/waste, etc.
- Attaching wellhead to local production equipment and local pipeline
- Reclaiming disturbed areas no longer needed for production



It is important to note that these activities are usually very specialized and are produced by a sprawling array of different companies, independent contractors, and firms. Each of these activities can require untold numbers of secondary workers and services, including everything from land surveying to portable toilet rentals. The operators typically perform very little of this work directly.

These jobs are short-term, in the sense that the work ends when all the wells in a given field or area are drilled. The drilling phase can range from months to decades, depending on the number of wells that are ultimately drilled and the number of drilling rigs that are operating in the area. However, after the development phase ends, the vast majority of the workforce required cannot be sustained during the later stages.

Workforce Characteristics:

Transient Workers:

A majority of development phase workers will remain transitory or rotational in nature. They are often attached to crews that will move from field to field around the country as assignments arise. These workers are accustomed to the

often short and unpredictable nature of natural gas development and choose to keep their permanent residence in one location, commuting great distances to the worksite. Many drilling and fracturing companies will provide living quarters for their crews, and many crews will work one or two week shifts in the gas field, and then return to their homes outside of the area for one or two weeks off.

If the development phase is sustained for a number of years, these transient workforces can gradually be replaced with locally-based workforces as properly skilled and trained local workers are available or out of town workers find the area desirable enough to relocate.

Resident Workers:

Perhaps 20% of the Development Phase workforce will be comprised of the construction, excavation, roustabout, and secondary services companies, and these firms are generally local companies that require locally based workforces. Depending on the size of the local communities and the available economic sectors, a portion of these workforces may be available locally.

This is the phase that will often create large "secondary" workforce demands in the local economy.

The Pace and Length of the Development Phase:

Because all the industrial activity during this phase is oriented to the task of drilling natural gas wells, it is ultimately



ly the number of drilling rigs that are operating in an area that will determine the level of activity during the development phase. An increase or decrease in the number of drilling rigs will similarly cause an increase or decrease in the level of activity in all other tasks associated with the development phase. The size of the required workforces will similarly change with the number of drilling rigs working in the area. The number of drilling rigs can fluctuate for a number of reasons, including equipment availability, credit availability, or commodity price changes.

The length of the development phase will

depend largely on two factors: the total number of wells that are drilled, and the number of drilling rigs working in the field. It is often difficult to estimate the total number of wells that will be drilled in a given area until a large number of wells are drilled and the resource is mapped in detail.

If estimates of the total number of wells to be drilled are available, then the length of the development phase can be calculated using the total number of wells, the number of rigs operating, and the time it takes to drill a well.

$$\text{Years of Development Phase} = w \div ((t \div 52) * r)$$

w = Total Number of Wells; t = Time it takes a drilling rig to drill a well (in weeks); r = Number of drilling rigs operating

THE PRODUCTION PHASE:

This phase consists of monitoring and maintaining the wells and pipeline facilities for as long as the wells produce gas. These jobs are typically well-paying and are considered long-term as the expected life of these wells is often about 40 years. In addition, “workovers” are typically performed on these wells on occasion, perhaps once every 10 years. These workovers can include the replacement of equipment, cleaning up the well and well casing, and other activities. However, the workforce requirements for this phase are much, much smaller than the development phase, and depend on the type of wells, operators, and equipment.

It is currently unclear if the Marcellus Shale wells will require re-fracturing throughout the production phase similar to Barnett Shale wells, in addition to traditional workovers. Such re-fracturing would create additional workforce requirements during the production phase.

The Primary Production Phase Activities Include:

- Monitoring of gas production levels (every few days)
- The trucking away of excess produced water and condensate from the well site (every few days)
- Maintenance on production equipment (every several years)
- Workover of well, including partial re-drilling or re-fracturing (every several years)

Workforce Characteristics:

Unlike the development phase, the vast majority of workers associated with this phase will be long term perma-

nent residents of the area, as the jobs are long-term and stable throughout gas production. While it is currently unknown what the size of the production phase fracturing crew workforces will be, it is likely that these workforces will be similar or identical to the frac crew workforces in the development phase and will remain transient in nature.

THE RECLAMATION PHASE:

The reclamation phase consists of dismantling the well-pad infrastructure and reclaiming the disturbed areas used for the well pad and access roads. This phase is traditionally brief and not labor intensive compared to the other phases. The reclamation phase can roll throughout the fields as wells cease production at differing times. The



Courtesy: NY DEC

pumper crews in place during the production phase are no longer needed and the operators close their local offices. After the wellpad is reclaimed, no further development of any kind takes place.

The Primary Reclamation Phase Activities Include:

- Shutting in of the well
- Dismantling and removal of production equipment
- Reclamation of the disturbed well pad and access roads.

Workforce Characteristics

The workforces associated with this phase are similar to the development phase workforces. If these services are still available in the area, then the worker may be local in nature.

GLOSSARY OF OIL AND GAS TERMS:

*Adapted from the Colorado Oil and Gas
Conservation Commission*

Block An acreage sub-division measuring approximately 10 x 20 kms, forming part of a quadrant. e.g. Block 9/13 is the 13th block in Quadrant 9.

Blow-down Condensate and gas is produced simultaneously from the outset of production.

Blow-out When well pressure exceeds the ability of the wellhead valves to control it. Oil and gas "blow wild" at the surface.

Blow-out preventers (BOPs)

Are high pressure wellhead valves, designed to shut off the uncontrolled flow of hydrocarbons.

BOP See blow-out preventers.

Borehole The hole as drilled by the drill bit.

Bradenhead A casing head.

Casing Pipe cemented in the well to seal off formation fluids or keep the hole from caving in.

Casing string The steel tubing that lines a well after it has been drilled. It is formed from sections of steel tube screwed together.

Central estimate A range of exploration drilling scenarios from which the following activity levels, based on recent historical experience, are adopted as the central estimates.

Christmas tree The assembly of fittings and valves on the top of the casing which control the production rate of oil.

Commercial field An oil and/or gas field judged to be capable of producing enough net income to make it worth developing.

Completion The installation of permanent wellhead equipment for the production of oil and gas.

Condensate Hydrocarbons which are in the gaseous state under reservoir conditions and which become liquid when temperature or pressure is reduced. A mixture of pentanes and higher hydrocarbons.

Coring Taking rock samples from a well by means of a special tool -- a "core barrel".

Cubic foot A standard unit used to measure quantity of gas (at atmospheric pressure); 1 cubic foot = 0.0283 cubic meters.

Cuttings Rock chips cut from the formation by the drill bit, and brought to the surface with the mud. Used by geologists to obtain formation data.

Deepen To increase the distance below a specified reference datum.

Derrick The tower-like structure that houses most of the drilling controls.

Development phase The phase in which a proven oil or gas field is brought into production by drilling production (development) wells.

Drill (1)To bore a hole, Also see Drilling(2)An implement with cutting edges used to bore holes.

Drilling The using of a rig and crew for the drilling, suspension, completion, production testing, capping, plugging and abandoning, deepening, plugging back, sidetracking, re-drilling or reconditioning of a well (except routine cleanout and pump or rod pulling operations) or the converting of a well to a source, injection, observation, or producing well, and including stratigraphic tests. Also includes any related environmental studies. Associated costs include completion costs but do not include equipping costs.

Drilling rig A drilling unit that is not permanently fixed to the seabed, e.g. a drillship, a semi-submersible or a jack-up unit. Also means the derrick and its associated machinery.

Dry Gas Natural gas composed mainly of methane with only minor amounts of ethane, propane and butane and little or no heavier hydrocarbons in the gasoline range.

Dry hole A well which has proved to be non-productive.

E&A Abbreviation for exploration and appraisal.

E&P Abbreviation for exploration and production.

Enhanced oil recovery A process whereby oil is recovered other than by the natural pressure in a reservoir.

Exploration drilling Drilling carried out to determine whether hydrocarbons are present in a particular area or structure.

Exploration phase The phase of operations which covers the search for oil or gas by carrying out detailed geological and geophysical surveys followed up where appropriate by exploratory drilling.

Exploration well A well drilled in an unproven area. Also known as a "wildcat well".

Farm in When a company acquires an interest in a block by taking over all or part of the financial commitment for drilling an exploration well.

Field A geographical area under which an oil or gas reservoir lies.

Fishing Retrieving objects from the borehole, such as a broken drillstring, or tools.

Formation pressure The pressure at the bottom of a well when it is shut in at the wellhead.

Formation water Salt water underlying gas and oil in the formation.

Fracturing A method of breaking down a formation by pumping fluid at

very high pressures. The objective is to increase production rates from a reservoir.

G Gas.

G/C Gas Condensate.

Gas field A field containing natural gas but no oil.

Gas injection The process whereby separated associated gas is pumped back into a reservoir for conservation purposes or to maintain the reservoir pressure.

Gas/oil ratio The volume of gas at atmospheric pressure produced per unit of oil produced.

Geographic Information Systems (GIS) A computer system capable of assembling, storing, manipulating, and displaying geographically referenced information.

GIS See: Geographic Information Systems.

Hydrocarbon A compound containing only the elements hydrogen and carbon. May exist as a solid, a liquid or a gas. The term is mainly used in a catch-all sense for oil, gas and condensate.

Injection well A well used for pumping water or gas into the reservoir.

Jacket The lower section, or "legs", of an offshore platform.

Kick A well is said to "kick" if the formation pressure exceeds the pressure exerted by the mud column.

Lay barge A barge that is specially equipped to lay submarine pipelines.

Liquefied natural gas (LNG) Oilfield or naturally occurring gas, chiefly methane, liquefied for transportation.

Liquefied petroleum gas (LPG) Light hydrocarbon material, gaseous at atmospheric temperature and pressure, held in the liquid state by pressure to facilitate storage, transport and handling. Commercial liquefied gas consists essentially of either propane or butane, or mixtures thereof.

Location The worksite of a drilling rig or other crew. "He parked his truck on location"

mboe Million Barrels Oil Equivalent.

Mechanical Integrity Test The act of setting a packer or retrievable bridge plug above the perforations in a wellbore and applying pressure to the annulus in order to ensure soundness of the casing.

Metric ton Equivalent to 1000 kilos, 2204.61 lbs.; 7.5 barrels.

MIT Mechanical Integrity Test.

mmcf Millions of cubic feet per day (of gas).

Moonpool An aperture in the center of a drillship or semi-submersible drilling rig, through which drilling and diving operations can

be conducted.

MOU/MOA Memorandums of Understanding/Memorandums of Agreement.

Mud A mixture of base substance and additives used to lubricate the drill bit and to counteract the natural pressure of the formation.

Natural gas Gas, occurring naturally, and often found in association with crude petroleum.

NGLs Natural gas liquids. Liquid hydrocarbons found in association with natural gas.

Ngpa SEE: Natural Gas Policy Act of 1978.

O Oil.

O&G Oil and Gas.

Oil A mixture of liquid hydrocarbons of different molecular weights.

Oil field A geographic area under which an oil reservoir lies.

Oil in place An estimated measure of the total amount of oil contained in a reservoir, and, as such, a higher figure than the estimated recoverable reserves of oil.

Operator 1)The company that has legal authority to drill wells and undertake the production of hydrocarbons that are found. The Operator is often part of a consortium and acts on behalf of this consortium. 2) A Pumper.

Payzone Rock in which oil and gas are found in exploitable quantities.

Permeability The property of a formation which quantifies the flow of a fluid through the pore spaces and into the wellbore.

Petroleum A generic name for hydrocarbons, including crude oil, natural gas liquids, natural gas and their products.

Platform An offshore structure that is permanently fixed to the seabed.

Porosity The percentage of void in a porous rock compared to the solid formation.

Possible reserves Those reserves which at present cannot be regarded as 'probable' but are estimated to have a significant but less than 50% chance of being technically and economically producible.

Primary recovery Recovery of oil or gas from a reservoir purely by using the natural pressure in the reservoir to force the oil or gas out.

Probable reserves Those reserves which are not yet proven but which are estimated to have a better than 50% chance of being technically and economically producible.

Proven field An oil and/or gas field whose physical ex-

tent and estimated reserves have been determined.

Proven reserves Those reserves which on the available evidence are virtually certain to be technically and economically producible (i.e. having a better than 90% chance of being produced).

Pumper A long-term employee during the production phase that monitors gas production levels. (Also sometimes called an Operator)

Recomplete An operation involving any of the following: (1) Deepening from one zone to another zone. (2) Completing well in an additional zone.(3) Plugging back from one zone to another zone.(4) Sidetracking to purposely change the location of the bottom of the well, but not including sidetracking for the sole purpose of bypassing obstructions in the borehole.(5) Conversion of a service well to an oil or gas well in a different zone. (6) Conversion of an oil or gas well to a service well in a different zone.

Recoverable reserves That proportion of the oil and/gas in a reservoir that can be removed using currently available techniques.

Recovery factor That proportion of the oil and/gas in a reservoir that can be removed using currently available techniques.

Reenter To enter a previously abandoned well.

Reservoir The underground formation where oil and gas has accumulated. It consists of a porous rock to hold the oil or gas, and a cap rock that prevents its escape.

Roughneck Drill crew members who work on the derrick floor, screwing together the sections of drillpipe when running or pulling a drillstring.

Roustabout Drill crew members who handle the loading and unloading of equipment and assist in general operations around the rig.

Royalty payment The cash or kind paid to the owner of mineral rights.

Secondary recovery Recovery of oil or gas from a reservoir by artificially maintaining or enhancing the reservoir pressure by injecting gas, water or other substances into the reservoir rock.

Shut In Well A well which is capable of producing but is not presently producing. Reasons for a well being shut in may be lack of equipment, market or other.

Shutdown A production hiatus during which the platform ceases to produce while essential maintenance work is undertaken.

SI/TA Shut In /Temporarily Abandoned

Sidetrack A wellbore segment extending from a well-

bore intersection along a wellbore path to a different wellbore bottomhole from any previously existing wellbore bottomholes.

Sidetracking The well activity of drilling a new wellbore segment from a wellbore intersection to a new wellbore bottomhole or target.

Spud-in The operation of drilling the first part of a new well.

Surface Location The location of a well or facility/ measurement point.

Surface Reclamation A restoration of the surface as for productivity or usefulness.

Suspended well A well that has been capped off temporarily.

tcf Trillion Cubic Feet (of gas).

Temporarily Abandoned The act of isolating the completed interval or intervals within a wellbore from the surface by means of a cement retainer, cast iron bridge plug, cement plug, tubing and packer with tubing plug, or any combination thereof.

Toolpusher Second-in-command of a drilling crew under the drilling superintendent. Responsible for the day-to-day running of the rig and for ensuring that all the necessary equipment is available.

Topsides The superstructure of a platform.

UIC Underground Injection Control.

Underground Injection Control A program required in each state by a provision of the Safe Drinking Water Act (SDWA) for the regulation of Injection Wells, including a permit system. An applicant must demonstrate that the well has no reasonable chance of adversely affecting the quality of an underground source of drinking water before a permit is issued.

Well log A record of geological formation penetrated during drilling, including technical details of the operation.

Wildcat well A well drilled in an unproven area. Also known as an "exploration well". [The term comes from exploration wells in West Texas in the 1920s. Wildcats were abundant in the locality, and those unlucky enough to be shot were hung from oil derricks.]

Workover Remedial work to the equipment within a well, the well pipework, or relating to attempts to increase the rate of flow.

Worm: A new employee on a drilling rig.