



Saskatchewan Oil and Gas Supply Chain Requirement Guide

May 11, 2015

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Government of
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the Economy

Prepared by:
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Authorship & Disclaimer

Authorship

Stantec Consulting Ltd. (Stantec) is pleased to offer the following document as an introductory guide to the oil and gas industry in Saskatchewan. The objective of this report is to provide readers with an introductory level understanding of the lifecycle of a typical oil and/or gas well in Saskatchewan and the multitude of supplies and services required to support the industry throughout the lifecycle.

Restrictions and Limitations

This report is intended for general circulation to the public at large at the discretion of the Government of Saskatchewan Ministry of the Economy. The report is intentionally written to be understandable to persons who may not have knowledge of the oil and gas industry. The report is intended to educate readers on the processes and terminologies commonly used in the industry and to provide direction for obtaining additional information. Readers are strongly cautioned that the report is not an exhaustive review of the industry and is not to be used as a basis for any investment decisions related to any product or service offerings discussed in the report. All pricing/costing information in the report is provided for information purposes only and is not to be relied upon in making investment or business decisions.

In preparing this report, Stantec has relied upon the completeness, accuracy and fair presentation of information in the public domain as well as internal knowledge and experience with oil and gas clients, and representations obtained from other parties involved and the Client. The representations in this report are conditional upon the completeness, accuracy and fair presentation of the information collected.

This report contains both current and forward-looking information with respect to, among other things, anticipated product and service costs and industry supply and demand. This forward-looking information involves significant uncertainties related to both local and international market factors that may cause the actual results or events to differ materially from those provided in this report. Readers are strongly cautioned that there can be no assurance that forward-looking actual results will be consistent with the same forward-looking statements made in the report.

All information is given as of the date hereof and Stantec is under no obligation to advise any person of any change or matter brought to its attention after such date which may affect the findings and conclusions contained in this report.

Executive Summary

The intent of this report is to provide the insight necessary for a prospective entrant into the oil and gas sector within Saskatchewan. The goal of this report is not to provide a step-by-step methodology for a potential entrant, rather, to serve as a preliminary introduction to the knowledge necessary to consider entering the market.

Background

The economy of the province of Saskatchewan is a growing and vibrant one. While historically known for the production of agriculture commodities and livestock, Saskatchewan's economy has advanced to becoming a leader in potash and uranium mining, biofuels as well as oil and gas production. As of 2015, Saskatchewan is only surpassed by Alberta in terms of total oil and gas production. However, this dramatic increase in terms of local oil production has led to increased demands for goods and services related to oil and gas production across the lifecycle of a typical well. As such, the Ministry of the Economy for the Government of Saskatchewan commissioned this report to determine the current state of the local supply chain as it pertains to the oil and gas sector in order to ascertain how suppliers based within the province can increase their presence.

Project Overview

The report covers general information as it pertains to the oil and gas industry in Saskatchewan including:

- General information and statistics to provide an existing snapshot of oil and gas in Saskatchewan including historical drilling statistics, reservoir maps, as well production volumes and disposition.
- Definition of typical well in Saskatchewan is provided based upon the most commonly featured techniques of extraction. The report provides basic information for enhanced oil recovery techniques, however, it does not cover delve into equivalent levels of detail.
- The key points throughout the lifecycle of a typical well, from exploration to reclamation, are discussed at a high-level.
- Some perceived opportunities for perspective suppliers to enter into the market are provided and categorized based upon capital, experience, and technical requirements.
- The current state of the oil and gas industry is discussed, as well as a general overview of the present state of the market. Large scale oil service companies are referenced.
- Prospective market conditions are contained within the report. These potential conditions are based upon anticipated market trends and are not to be considered to be forecasts of the future of the industry.
- Certain issues that are currently impacting the oil and gas supply chain within Saskatchewan, such as policies & regulations, availability of skilled labour and others.

Conclusions

Similarly to the other oil producing regions, the Saskatchewan oil and gas industry is currently being impacted by the decline in prices by the global over supply of oil. While these effects will cause increased competition and smaller margins within the oil and gas sector of Saskatchewan's economy, there are still opportunities for entry to be found provided that adequate due diligence is undertaken.

Glossary

Abandonment: Converting a drilled well to a condition that can be left indefinitely without further attention and will not damage freshwater supplies, potential petroleum reservoirs or the environment.

Annulus: The void between any piping, tubing or casing and the piping, tubing, or casing immediately surrounding it.

API Gravity: is a measure of how heavy or light a petroleum liquid is when compared to water.

Bitumen: Petroleum in semi-solid or forms.

Conventional Crude Oil: Petroleum found in liquid form, following naturally or capable of being pumped without processing

Desiccant: A hygroscopic substance used as a drying agent.

Downstream: The refining and marketing sector of the petroleum industry

Enhanced Oil Recovery (EOR): Methods that increase oil production by using techniques or materials that are not typical of normal production operations

Flaring: The controlled burning of natural gas from an oil & gas production site that cannot be processed for sale due to technical or economic reasons

Heavy Crude Oil: Oil with a specific API gravity below 22

Horizontal Drilling: The drilling of an oil well that deviates from the vertical axis and travels through the producing layer.

Injection Well: A well that is utilized to inject fluids (air, steam, gases, surfactant, polymers etc.) into an underground formation in order to increase the amount or ease of oil recovery

Light Crude Oil: Liquid petroleum that has an API Gravity greater than 31 and that will flow freely at room temperature

Medium Crude Oil: Petroleum with an API Gravity of between 22 and 31

Midstream: The sector concerned with the storage, processing, and transportation of oil and gas products

Oil Sands: A reservoir of sand saturated with bitumen

Petroleum: A naturally occurring mixture composed predominantly of hydrocarbons that may be in the gaseous, liquid or solid state of matter.

Proppant: Is a solid material, typically treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment

Secondary Recovery: The extraction of additional crude oil, natural gas or other related substances from reservoirs through techniques such as water flooding or gas injection

Seismic Exploration: The search for commercially economic subsurface deposits of crude oil, natural gas, and minerals by the recording, processing, and interpretation of artificially induced shock waves in the earth

Steam Assisted Gravity Drainage (SAGD): A technique for the recovery of bitumen or heavy oil that relies upon the drilling of two separate horizontal wells, one above the other. Steam is injected into the top well, instigating a decrease in viscosity within the oil reservoir causing it to drain into the lower well for collection

Tight Oil & Gas: Petroleum reservoirs that are contained within low permeability rock formations, typically shale or sandstone

Upstream: Pertaining to those companies that explore, develop and produce petroleum resources

Venting: The controlled release into the environment of natural gas from an oil & gas production site that cannot be processed for sale due to technical or economic reasons

Acronyms

ANSI: American National Standards Institute

AOR: Acknowledgement of Reclamation

API: American Petroleum Institute

CAODC: Canadian Association of Oilwell Drilling Contractors

CAPP: Canadian Association of Petroleum Producers

DSA: Detailed Site Assessment

EOR: Enhanced Oil Recovery

EPC: Energy Production Company

ESA: Environmental Site Assessment

FKOD: Flare Knock Out Drum

FWKO: Free Water Knock Out

HSE: Health Safety and Environment

ISO: International Organization for Standardization

LACT: Lease Automatic Custody Transfer

LPG: Liquefied Petroleum Gas

MWD: Measurement While Drilling

PD: Positive Displacement

PDC: Polycrystalline Diamond Compact

PNG: Petroleum Natural Gas

PPB: Price per Barrel

PSAC: Petroleum Services Association of Canada

SCADA: Supervisory Control and Data Acquisition

SAGD: Steam Assisted Gravity Drainage

UPS: Utility Power Supply

WTI: West Texas Intermediate

1.0 BACKGROUND OF THE OIL AND GAS INDUSTRY IN SASKATCHEWAN

HISTORICAL INFORMATION

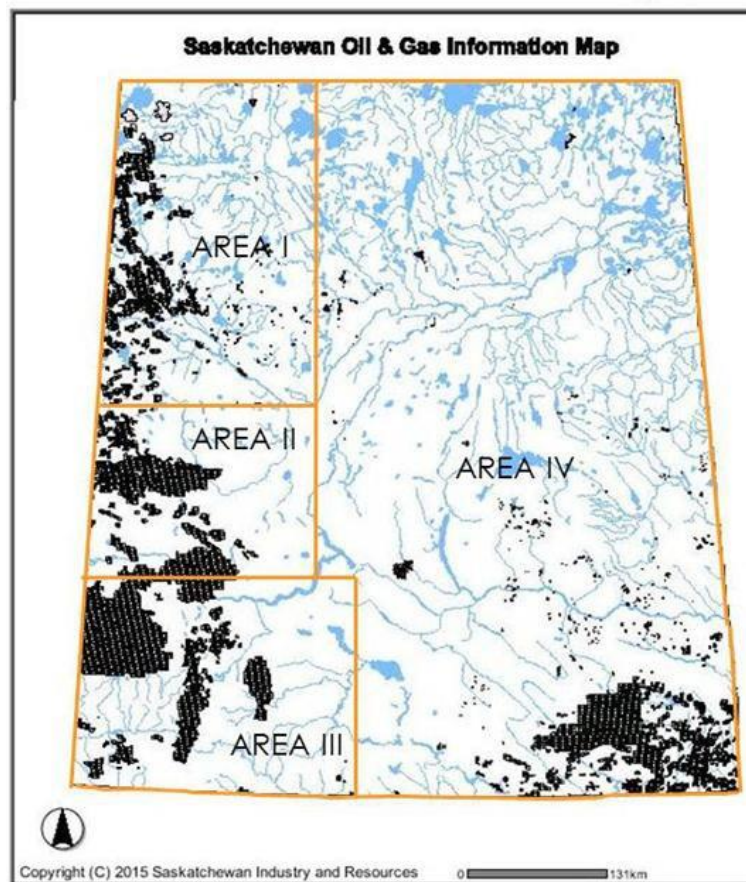
Although Natural Gas was originally discovered in Saskatchewan as early as 150 years ago, the oil and gas industry was not truly developed in earnest within the province until the 1950s. Since then, Saskatchewan has matured into the second largest producer of oil in Canada, trailing only Alberta in terms of yearly production. Saskatchewan also ranks third in Canadian provinces in terms of gas production. At present, the Canadian Association of Petroleum Producers (CAPP) estimates that Saskatchewan possesses approximately 8 billion barrels of recoverable crude oil trapped within both conventional and unconventional oil plays within the province, given currently available technologies and techniques. This significant quantity of crude oil, along with the approximate 10 trillion cubic feet of natural gas that is projected to be situated within the province, presents a compelling market opportunity.

In 2013, Saskatchewan produced over 178 million barrels of oil or approximately 486,000 barrels of oil per day. For gas production, the province produced in excess of 195 billion cubic feet in 2013 alone. The primary productive areas within the province are divided into four key areas as approximately depicted within the image below:

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Figure 1.1 Saskatchewan Oil & Gas Information Map



Within each of these regions the primary areas of oil production are noted below:

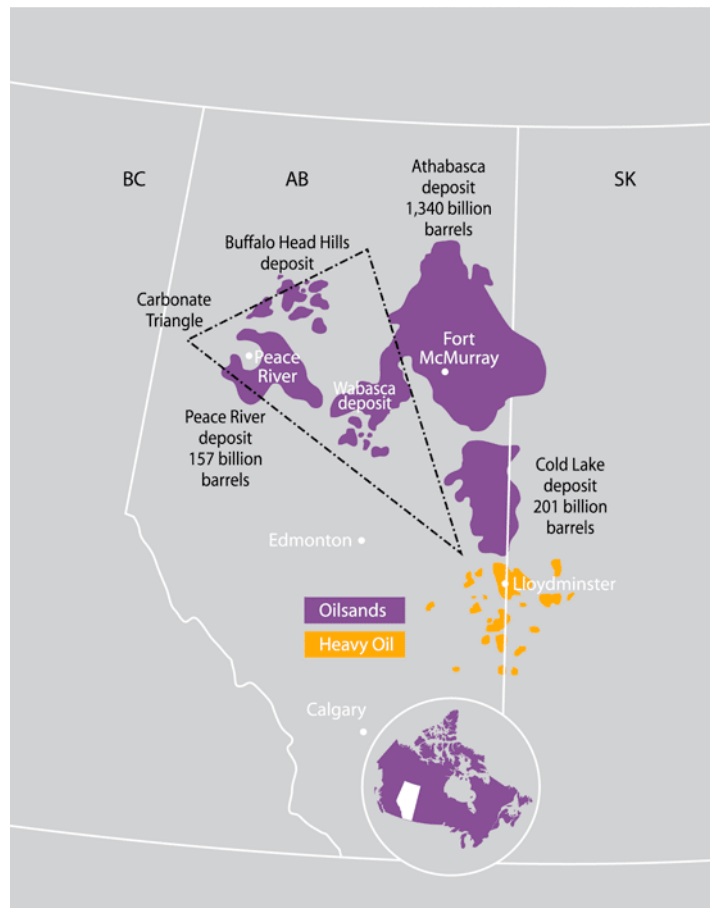
- AREA I: The region located near Lloydminster and the Alberta border, producing primarily Heavy Crude Oil
- AREA II: Located near the Kindersley Region a mix of Heavy and Light Crude Oil from the Viking deposits
- AREA III: Swift Current is located within this southwestern region, which primarily produces Medium Crude Oil from the Shaunavon reservoirs
- AREA IV: This area comprises a large region of the southeastern portion of the province. However, the oil producing regions are mostly located near Estevan. The oil within this area is typically Light and Medium Crude from the Bakken Deposits.

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Although primarily located within the province of Alberta, the Athabasca and Cold Lake Oil sands deposits do extend into the Northwestern portion of Saskatchewan as well.

Figure 1.2 Athabasca and Cold Lake Oil Sands Deposits Information Map



Source: Canadian Centre for Energy Information

Crude oil is typically categorized based upon the American Petroleum Institute (API) Gravity measure of the oil. The API Gravity measure is through a specific formula calculated based upon the density of the liquid petroleum relative to the density of water at a temperature constant of 60 degrees Fahrenheit.

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The API Gravity is then utilized to classify the petroleum liquid into four weight classifications:

- Light – API > 31.1
- Medium – API between 22.3 and 31.1
- Heavy – API < 22.3
- Extra Heavy – API < 10.0

The API gravity weight of the oil is typically utilized not only to calculate the market value of the oil, but also to determine how many barrels of oil can be produce from a ton of the given oil. Generally speaking, Light crude oil is perceived to be the most valuable API weight, as it is able to generate a higher percentage of gasoline and other fuels from the refinery process.

The volume of crude oil produced in Saskatchewan for the year 2014 is depicted in Figure 1.3. The production volumes have been broken into the production areas, as well as API weight on a monthly basis.

Figure 1.3 2014 Crude Oil Volume by Area (Excluding Recovered Crude Oil) in Cubic Meters

| Crude Oil Volume by Area (Excluding Recovered Crude Oil) (Cubic Metres M3) | | | | | | | |
|--|-----------------|------------------|------------------|--------------------|------------------|-------------------|--------------|
| Production Month Range: 2014-01 To 2014-12 | | | | | | | |
| 2014 | Area I Heavy | Area II Light | Area II Heavy | Area III Medium | Area IV Light | Area IV Medium | TOTAL |
| January | 764,034.3 | 251,009.1 | 183,714.3 | 272,296.0 | 738,112.8 | 276,493.9 | 2,485,660.4 |
| February | 719,671.5 | 243,894.5 | 167,358.2 | 252,881.1 | 681,331.7 | 249,667.6 | 2,314,804.6 |
| March | 828,381.5 | 288,739.2 | 191,319.6 | 282,224.4 | 737,233.8 | 275,457.8 | 2,603,356.3 |
| April | 793,329.0 | 267,529.1 | 175,058.5 | 272,600.1 | 720,526.3 | 267,099.5 | 2,496,142.5 |
| May | 817,508.0 | 264,191.3 | 187,480.4 | 261,888.5 | 695,127.7 | 267,289.6 | 2,493,485.5 |
| June | 763,665.3 | 243,444.9 | 173,065.7 | 250,602.6 | 659,221.9 | 264,324.2 | 2,354,324.6 |
| July | 801,833.1 | 256,430.7 | 174,833.0 | 269,126.2 | 659,243.2 | 271,305.9 | 2,432,772.1 |
| August | 806,153.0 | 264,740.1 | 179,710.6 | 271,042.8 | 680,190.7 | 270,799.8 | 2,472,637.0 |
| September | 787,166.7 | 274,337.6 | 184,027.0 | 266,150.9 | 670,231.5 | 257,230.1 | 2,439,143.8 |
| October | 815,693.5 | 312,679.6 | 192,932.4 | 281,854.0 | 710,177.5 | 272,109.2 | 2,585,446.2 |
| November | 758,190.6 | 304,419.1 | 184,671.1 | 292,374.2 | 703,932.5 | 261,504.2 | 2,505,091.7 |
| December | 802,994.8 | 335,415.2 | 191,113.0 | 300,267.5 | 735,234.6 | 269,486.3 | 2,634,511.4 |
| TOTAL | 9,458,621.3 | 3,306,830.4 | 2,185,283.8 | 3,273,308.3 | 8,390,564.2 | 3,202,768.1 | 29,817,376.1 |

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Similar to the chart above, Figure 1.4 demonstrates the amount of Crude oil produced via Enhanced Oil Recovery (EOR) techniques. Such techniques will be discussed later on in this report.

Figure 1.4 2014 Crude Oil Volume by Area (Recovered Crude Oil) in Cubic Meters

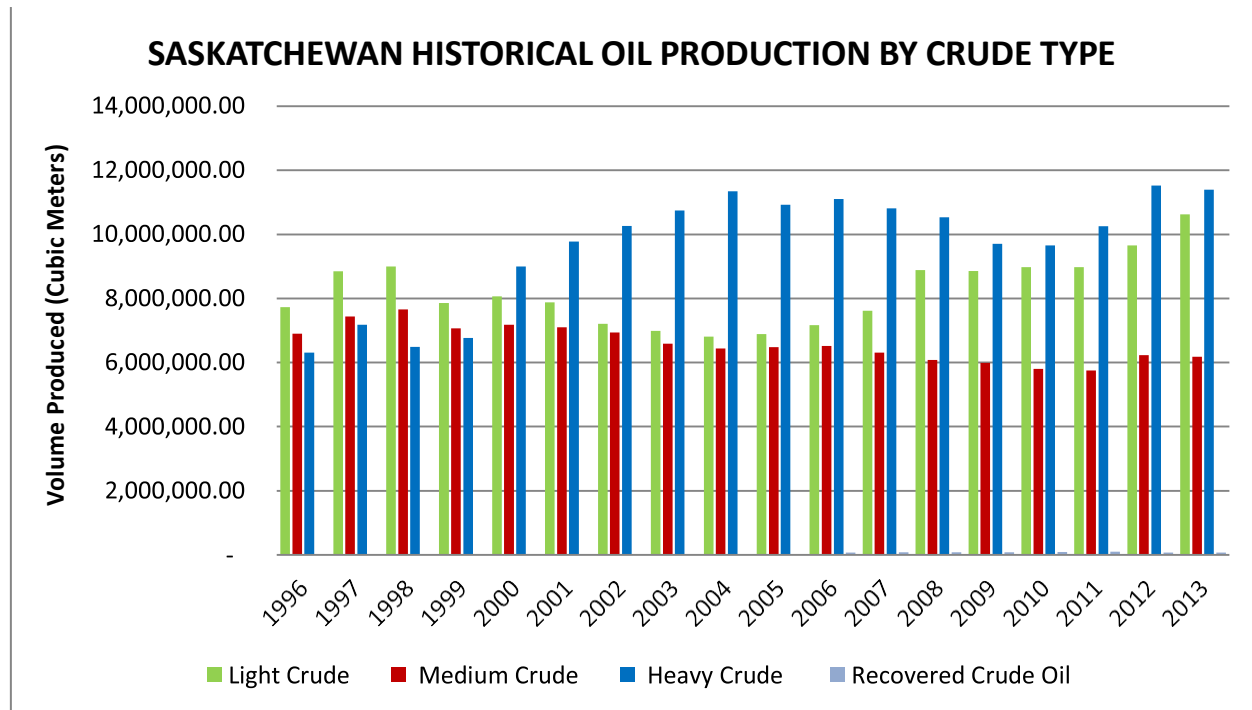
| Crude Oil Volume by Area Crude Type (Recovered Crude Oil) (Cubic Metres M3) | | | | | | | |
|---|-----------------|------------------|------------------|--------------------|------------------|-------------------|----------|
| Production Month Range: 2014-01 To 2014-12 | | | | | | | |
| 2014 | Area I Heavy | Area II Light | Area II Heavy | Area III Medium | Area IV Light | Area IV Medium | TOTAL |
| January | 4,926.0 | - | 1,466.2 | 146.6 | - | 955.7 | 7,494.5 |
| February | 3,755.7 | - | 1,393.1 | 10.0 | - | 898.6 | 6,057.4 |
| March | 3,775.9 | - | 1,513.9 | 61.0 | - | 1,176.3 | 6,527.1 |
| April | 3,610.2 | - | 968.4 | 102.9 | - | 726.3 | 5,407.8 |
| May | 3,566.6 | - | 978.7 | 163.7 | - | 742.4 | 5,451.4 |
| June | 3,545.2 | - | 634.5 | 83.2 | - | 526.4 | 4,789.3 |
| July | 3,578.3 | - | 680.9 | 73.3 | - | 925.6 | 5,258.1 |
| August | 3,826.0 | - | 1,133.5 | 114.2 | - | 828.2 | 5,901.9 |
| September | 3,827.0 | - | 1,502.9 | 271.3 | - | 674.6 | 6,275.8 |
| October | 4,388.5 | - | 754.9 | 167.2 | - | 767.4 | 6,078.0 |
| November | 3,805.9 | - | 1,159.1 | 41.0 | - | 852.9 | 5,858.9 |
| December | 4,540.1 | - | 2,868.5 | 100.1 | - | 1,155.2 | 8,663.9 |
| TOTAL | 47,145.4 | - | 15,054.6 | 1,334.5 | - | 10,229.6 | 73,764.1 |

For a historical perspective, Crude production for Saskatchewan for the period from 1996 to 2013 has been provided in Figure 1.5. As this data has been broken out by the API gravity of the oil, the growth trends for both Heavy and Light crude are readily apparent. However, it is important to remember that Light and Medium crude are typically more valuable than Heavy crude on a per volume basis.

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Figure 1.5 Saskatchewan Historical Oil Production by Crude Type



VERTICAL VERSUS HORIZONTAL DRILLING & PRODUCTION LEVELS

The transformation of the Saskatchewan oil patch is reflected in the fact that, although the majority of existing wells in the province are vertical wells, the majority of new wells being drilled are horizontal wells. Figure 1.6 provided by the Government of Saskatchewan Ministry of the Economy, depicts the trend towards horizontal drilling. In 2012, horizontal drilling accounted for 61% of all new wells, for the year 2014, newly drilled horizontal wells outnumber the vertical type by a ratio of approximately 3:1.

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Figure 1.6 Saskatchewan Oil Well Drilling Statistics for 2012 to 2014

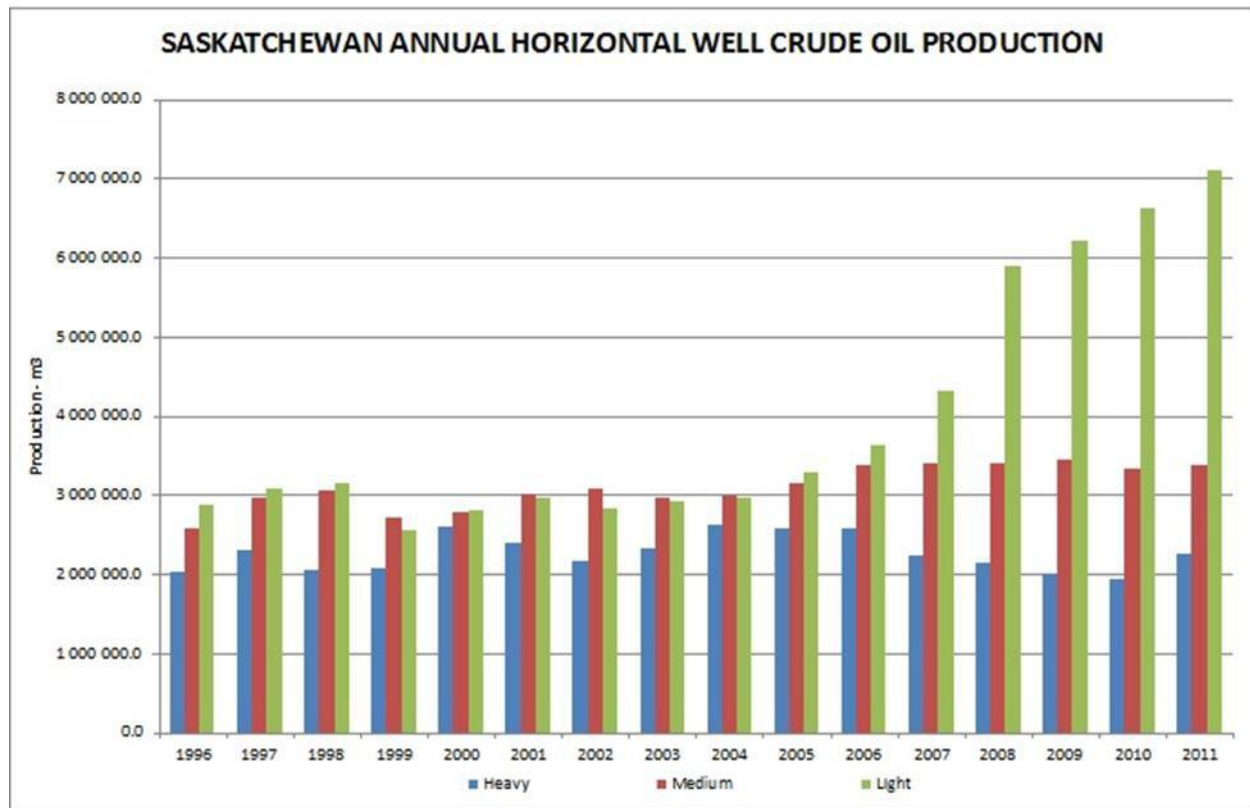
| Year-to-Date | Vertical | Horizontal | Total |
|----------------------------------|------------|--------------|--------------|
| 2014 - January | 99 | 300 | 399 |
| 2014 - February | 107 | 346 | 453 |
| 2014 - March | 64 | 175 | 239 |
| 2014 - April | 4 | 18 | 22 |
| 2014 - May | 21 | 51 | 72 |
| 2014 - June | 73 | 204 | 277 |
| 2014 - July | 96 | 271 | 367 |
| 2014 - August | 86 | 311 | 397 |
| 2014 - September | 81 | 341 | 422 |
| 2014 - October | 79 | 350 | 429 |
| 2014 - November | 63 | 301 | 364 |
| 2014 - December | 47 | 169 | 216 |
| YEARLY TOTAL | 820 | 2,837 | 3,657 |
| Previous Years Comparison | | | |
| 2013 - To June 30 | 626 | 1,406 | 2,032 |
| 2012 - To June 30 | 768 | 1,214 | 1,982 |

As a result of the increase in the quantity of horizontal wells being drilled within Saskatchewan, horizontal well site production especially in terms of Light crude production has dramatically risen. Figure 1.7 depicts the previous 18 years of Crude oil production from Horizontal well sites within Saskatchewan. For the period between 1996 and 2005, the level of horizontal production remains relatively constant. However, beginning in 2006 the horizontal well production of Light crude develops rapidly, increasing its production by two fold.

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Figure 1.7 Saskatchewan Annual Horizontal Well Crude Oil Production



Historically, designated gas producers within Saskatchewan had primarily relied upon vertical drilling for the creation of gas wells. Due to the lower initial capital cost of vertical drilling when compared to horizontal drilling, the number of gas wells drilled is very low by historic standards due to the lower gas commodity prices, so future trends are difficult to project at this time. Liquids rich gas plays may still be economic in some areas.

THE DRILLING RIG

Regardless of the drilling method, the surface components and layout of an oil and gas rig tend to feature the same key aspects. The onsite structures & components of the oil rig facilities on the site are more dependent on the API gravity of the crude oil, the size & depth of the reservoir, the presence of gas within a reservoir and the intent of the organization harvesting the reservoir.

SURFACE PRODUCTION FACILITIES

The production, storage, and processing equipment on surface facilities will vary depending upon the characteristics of the produced fluids, the size of the reservoir, the presence of gas within a reservoir, the amount of daily production, as well as the presence of supporting infrastructure and resources. For instance, a field with a small production capacity may only feature equipment to produce oil into local storage tanks and collected until it is transported by truck to other locations for handling. At these smaller facilities, the small amounts of gas produced may simply be vented or flared off.

Fields with large scale production capacity will feature a host of additional facilities and equipment such as: separators, flow meters, compressors (for natural gas), production tanks (water and oil), chemical storage, and more. In addition, pipelines network, or gathering system, will be needed transport various fluids such as, wet (liquids rich) natural gas, water, and chemicals involved in production between facility and storage locations to processing facilities and batteries. Before the processed oil and gas can be sold to a midstream pipeline or rail car for transportation, it will flow through a Lease Automatic Custody Transfer (LACT) unit, which samples the products for volume and quality. Figure 1.8 on the following page depicts this process in detail.

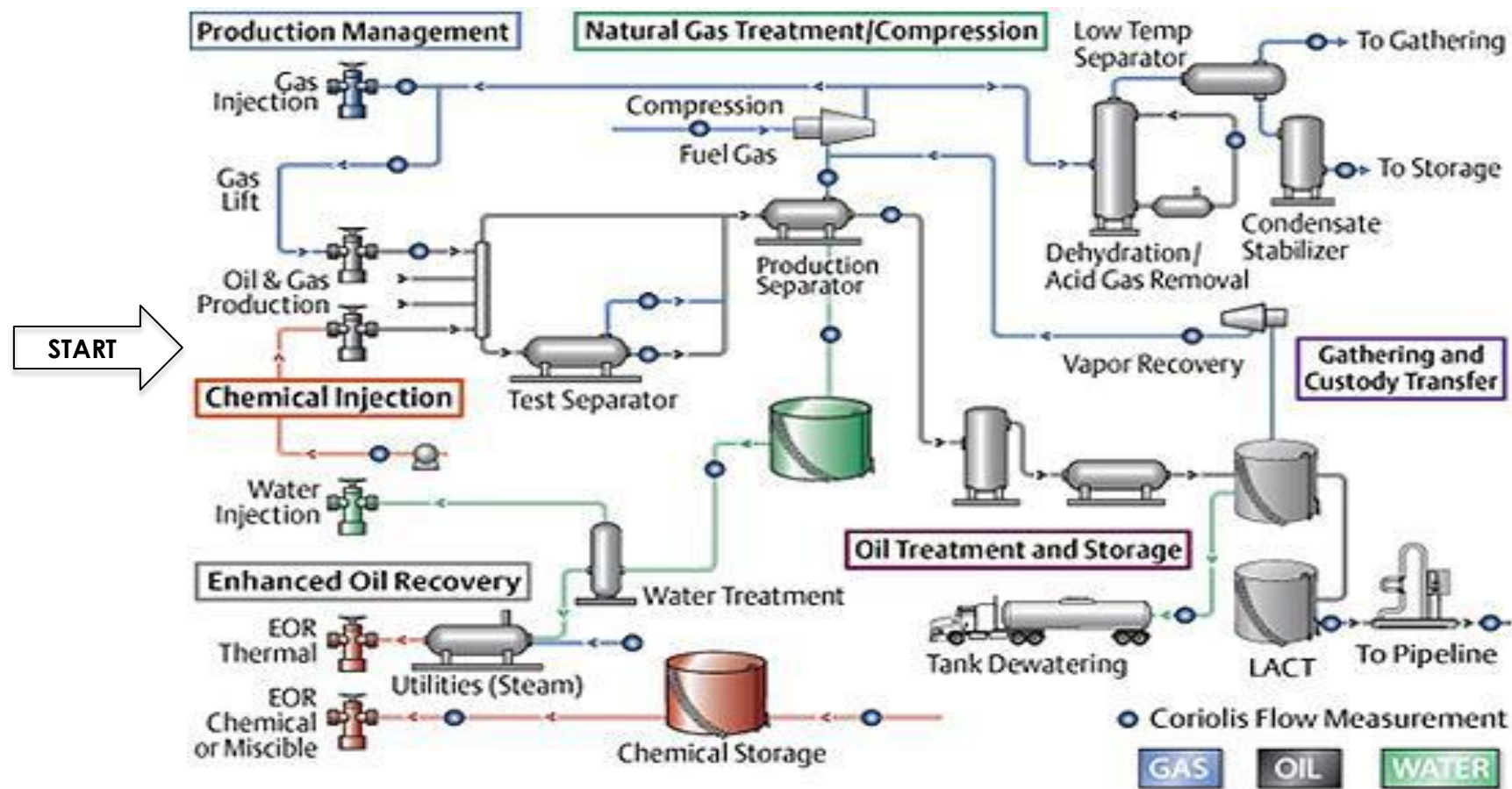
The upstream oil and gas production process can be quite complex. There are many separate processes that must be put in place before the product can begin to be produced from the well and the production cycle begins long before oil or gas begins flowing.

The methods utilized for production and processing will differ, depending on a variety of factors, including the individual producers' preferred techniques, the scope of the production facility and the characteristics of the hydrocarbon. For instance, producers will not incorporate entire process lines, such as chemical injection or gas injection if conditions do not necessitate the use of such techniques.

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Figure 1.8 Typical Upstream Production Management



2.1 LIFE CYCLE STAGES OF A TYPICAL WELL

At a high level, the life cycle of a typical oil or gas well follows the following main stages:

1. Exploration – Where new reserves are found (rare) or existing reserves are further developed. The regulatory processes and decision to drill are the predominant activities in the exploration phase.
2. Drilling and Completions – Where the well is drilled, cased, perforated, fractured, and set to produce.
3. Production – Where the natural resource is extracted from the reservoir and brought to market.
4. Recompletion – Where the well characteristics are changed to produce the more difficult volumes within the reservoir. This stage is a sub set of the main production phase, and would include production methods such as artificial lift, injection stimulation, recompletion, and enhanced recovery methods.
5. Reclamation – Where the decision is made to return the production well site, or surface lease, to its original, natural, condition.

Numerous construction, maintenance, and support activities are required to support the overall life cycle of a well. These will be discussed in further detail in section 3.

EXPLORATION

Permission to Explore

The first stage in a well's life cycle begins with the exploratory processes. In order to explore (conduct a seismic program), the stakeholder must first acquire permission to conduct work within the area by the landowner, typically, this in the form of a lease or agreement. Following this, a License to Conduct Seismic Exploration as well as carry out the appropriate Environmental Assessment work, must be obtained prior to performing any activities on the land. The Government of Saskatchewan requires a prospective driller to first meet the requirements set in place by the Ministry of the Economy and the Ministry of Environment pertaining to *The Seismic Exploration Regulations 1999*, *The Crown Minerals Act*, *The Mineral Resources Act*, and *The Environmental Assessment Act* or the guidelines thereunder and *The Oil and Gas Conservation Act*.

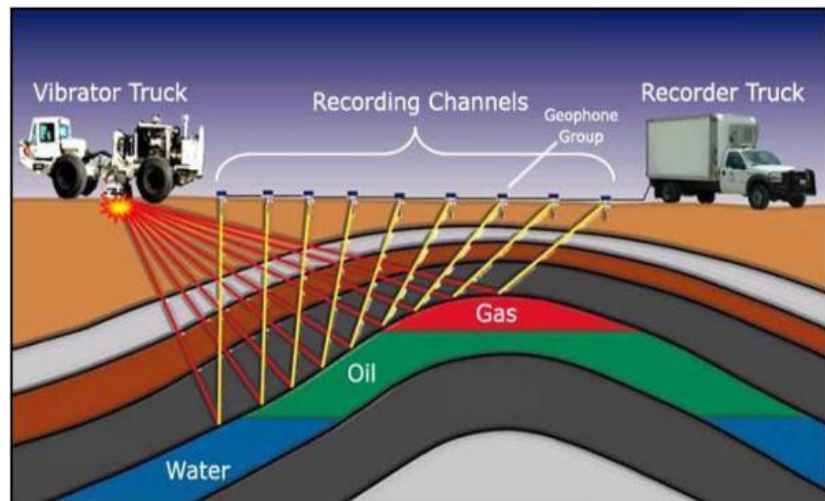
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Exploratory Process

The drilling process is a costly and time consuming commitment that must be properly planned before a company decides to proceed. Seismic exploration helps prospective drillers determine the general properties of a remote new play's subsurface. Seismic exploration is a mapping process that is meant to reduce the high degree of risk associated with oil and gas exploration by providing information that may indicate the location of oil and gas reserves below the surface.

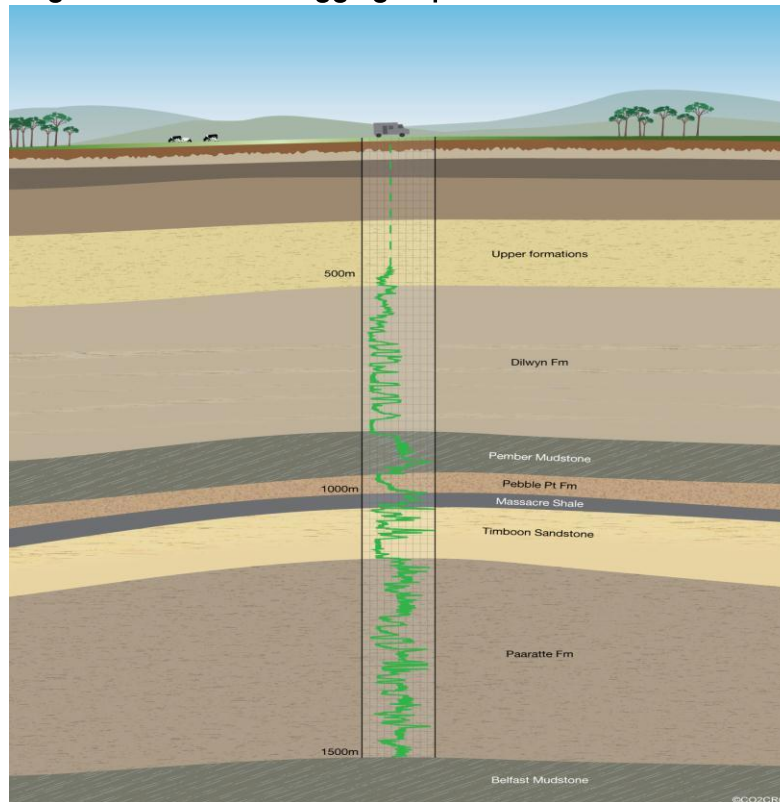
Seismic exploration is conducted using a network of receivers (geophones) and a sounding source. The first step is to generate a significant seismic source, typically from a vibrator truck. The objective of the process is to measure the strength of the returning signal that is bounced off various layers of subsurface rock and registered with the



strategically placed receivers (geophones). This method allows the surveyor to move the seismic source to multiple points, resulting in a validated set of data. The next step is seismic acquisition which pertains to the consolidation of each individual sounding to create a single cross section showing the various layers of the bedrock structure to help identify the potentially promising locations where oil or gas may be located.

Seismic exploration is not always conducted prior to drilling a well, especially in established oil and gas fields. In an area where significant data is available, companies will be able to make better drilling decisions using actual production, geological, and drilling data from adjacent wells and properties. Core well samples provide valuable information about the rock and its likelihood to contain, and transmit oil and gas to a well. Wireline logs involve sending a group of sensors down an existing well bore to test the rock formations for their resistance, permeability, and other characteristics, to further determine the likelihood of the presence of oil and gas. Geologists can use core sample data, wireline logs, and other tests from nearby wells to better determine the proven and probable reserves in a formation.

Figure 2.1 – Wireline Logging Depiction



Ultimately, companies are looking at reducing the risk of drilling a dry well. In newer development areas, where adequate data to make decisions is not available, seismic is one of the better options for companies to reduce their risk. Should the seismic test results return positive results, companies will typically proceed by drilling exploratory, vertical wells to take core samples and complete wireline logs to gauge the site's potential to contain economic deposits of oil or gas. As testing continues in the area, more data is collected to interpret the reservoir, reducing the risk involved in drilling future wells in the same vicinity.

Once the reservoir data has been evaluated and the drilling license has been awarded, a producer may choose to drill exploration wells. The purpose is to complete core samples and wireline log analysis where information is not readily available. From there, appraisal wells can be used to determine characteristics required for the remaining regulatory processes and to provide data for the future engineering of the surface facilities. Here, the oil and gas reserves are tested for their varying characteristics (i.e. API Gravity or kg/m³ Density for oil) to determine the quality of the reserve and production requirements.

Development Analysis

Once a decision to drill and develop an area has been made, the operating company and investors need to establish a development plan. Due to the nature of oil and gas markets, this

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can be a tricky process. A production schedule is developed that incorporates the company's best predictions in the market fluctuations of the commodity, so that the company can estimate its payback periods. Upper management will make the decision to proceed based on their knowledge in the life cycle costs and the return on investment they expect.

Management is looking to estimate the potential revenue of an operation, which is highly dependent many factors. Some of these factors include:

- Pressures and flow rates of the oil or gas produced each day
- Gas and fluid analysis, indicating the properties of the oil and gas to be produced
- Helps determine the cost of the associated surface facilities and potential recoverable reserves. For instance, wet gas will have a good amount of propane or butane, which is a higher priced commodity than methane (natural gas)
- Price per barrel (oil) or gigajoule (gas) of the given product, estimated based on the production schedule
- An analysis of market differentials (comparing the current prices of crude oil in North America (West Texas Intermediate) to that of other regions (i.e. Brent Crude) and refined products (i.e. Methane, Propane, Ethane, etc.
- Location of production treatment and upgrading facilities, and transportation facilities, as it affects the cost of development

Regulation and Land Acquisition

Once a sufficiently promising potential source of oil and or gas is identified, the necessary land titles, access rights and lease agreements will need to be secured before any further field work can be undertaken.

As such processes are periodically updated, organizations should consult the Government of Saskatchewan's "PNG & Seismic Approvals" webpage under the "Our Oil & Gas Resources" banner on the government's webpage.

Once these measures have been secured, the site can then be prepared for drilling operations.

DRILLING DEVELOPMENT

Site Preparation

Once all regulatory permits and land agreements have been reached, the site can be prepared for drilling activities. An access crew will begin by preparing the well site by clearing vegetation, removing and storing topsoil, leveling uneven terrain, deploying rig matting and creating necessary access roads to allow heavy equipment, personnel, and materials to be transported to the site. Reserve for settling/mud pits will also be dug at this stage in order to hold the discharged drilling mud, where mud boxes are not used.



(Geology.com, 2015)

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A reliable source of water will be required for drilling operations to commence. This supply of water can either be a local above ground source such as a river, stream, slough, or dugout, provided such a source is nearby and proper usage rights and regulatory approvals have been secured. In nearly all cases the water will need to be transported to site by trucks and stored in large drilling tanks.

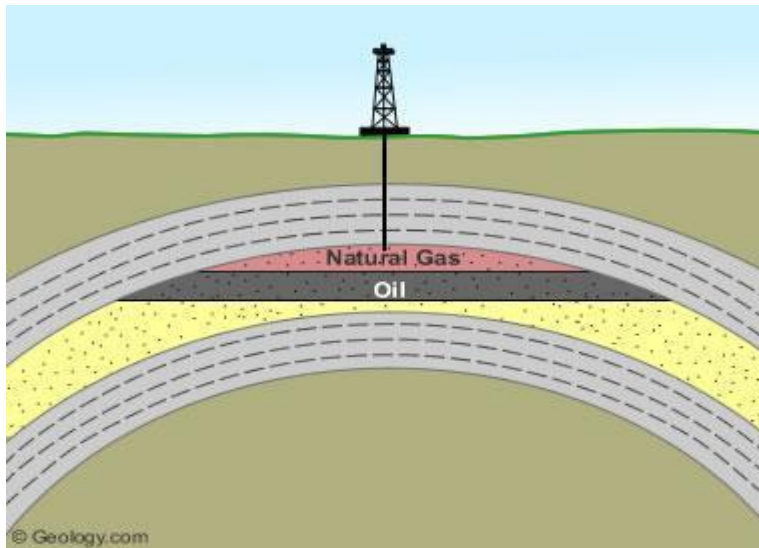
On a typical oil and gas well site, a pit denoted as the Cellar is also dug. This pit will host the rig itself and is dug to depth to allow it to accommodate blowout preventers and other supporting equipment, as well as to collect any fluids or discharge that escapes from the well during operations so that these fluids can be disposed of properly. Typically at this stage, a preliminary bore hole is drilled using a portable drilling truck. This initial bore hole is of a larger diameter than subsequent drilling efforts, and is called the Starter hole or Conductor hole.

Depending on the project delivery processes of the owner company, engineering design activities for the well site facilities may begin, or be fully completed, prior to site prep commencing. This ensures that the site is prepared and the well is located in a fashion that supports the end design of the well site.

Conventional Drilling

Vertical drilling is the historical standard for oil and gas drilling both in the Province of Saskatchewan, as well as globally, and used to be considered the conventional drilling method. Vertical drilling is quite straight forward compared to horizontal drilling. As such, it is typically much less expensive to drill a vertical well than a horizontal well. This reduction in costs is tempered, however, by a reduction in the total prospective oil and gas recovered due to the limited reach of the vertical well compared to a horizontal well. It must also be noted that vertical wells tend to have shorter productive service lifecycles. A vertical well will typically produce very well over a short period, with a fast decline in production rates that can lead to a long production life with small flow rates. Vertical wells are can also be easily converted for EOR production, which will be discussed later.

Figure 2.2 Conventional Oil Well



Another advantage to a vertical well is the ability to produce from more than one formation at a time. An additional tube string is required for the well, and plugs are inserted between the zones to ensure they can't transmit production to each other. Special regulatory permits are required to produce co-mingled zones through a single well bore, and areas where this is possible can be difficult to reach, or are rare. Production in this method can also lead to other challenges which may need additional support from service companies over the lifecycle of these wells. As stated in

Section 2.2.1, one of the final steps in the site preparation stage is the drilling of an initial “starter” bore hole through the use of a portable drill truck. Once the drilling rig arrives at site, it will be situated over the starter hole, and a drill truck may be then utilized to drill two additional holes known as the Rat hole and Mouse hole respectively. The Rat hole typically reaches a maximum depth of 10 meters (35 feet), and is lined with metal casing in order to host the drive system. The Mouse hole is a relatively shallow hole, and is lined with metal casing similar to the Rat Hole. The Mouse Hole will be used to temporarily hold sections of drill pipe until they are required during the drilling process. The metal casing that lines both the Rat Hole and the Mouse Hole is not cemented in place and can be removed once the drilling operation has finished.

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The next stage in the process is to complete the Rigging Up process. Rigging Up consists of the installation and integration of the temporary buildings and systems required for drilling operations, along with the hoisting of the Rig Mast. This report will not go into detail on this process, due to the numerous methods and techniques that can be utilized to successfully complete this process. Depending on the scope and complexity of the drilling rig being assembled, the Rigging Up process may consist primarily of manual labour and light equipment such as bob cats, or may require the use of heavy machinery and specialized equipment such as cranes.

At this stage, the oil rig is now ready to begin drilling operations. The Drill Bit utilized in oil and gas wells typically contains carbide or embedded diamonds and is installed into a thickly walled section of pipe known as a Collar and placed into the Starter hole. Other bits are used for coring purposes, and are more specialized as they need to keep the rock intact as it's removed from the well bore.

The weight of these drill Collars assists in the drilling process by applying steady pressure to the drill bit. Drill Stabilizers may be installed between the Collar segments to assist in keeping the drill string centered within the hole. This arrangement, commonly known as the Drill String is then connected to the Kelly Drive and Turntable or Top drive, depending on which is present, which provide the torque for the boring process. As the depth of the well increases, additional sections of pipe will be taken from the Mouse Hole and installed into the Drill String.

As the Drill String bores deeper, a specialized fluid must be pumped into the cavity. This fluid is known as Drilling Fluid or Mud, and is usually a combination of water, bentonite clay, and chemical compounds. Drilling Fluid serves a multitude of purposes within the well hole including:

- Cooling and lubricating the drill bit
- Removing the rock fragments and drill cuttings from the well
- Applying stabilizing pressure within the well and to the drill bit, helping keep formation pressure from blowing out.
- Supporting the walls of the hole, preventing their collapse

Rock and soil samples will be taken from the drill cuttings which are brought to the surface by the drill fluid. These samples will be analyzed in order to determine mineral composition, the presence of hydrocarbons, and geological considerations to identify the formation the bit is currently drilling through, and to help verify the depth of the bit to ensure the drillers hit their mark.

Throughout the drilling process, the installation of casing is conducted. This process is comprehensively depicted in Section 2.3.

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Unconventional Drilling

The term unconventional well is something of a catchall designation, which covers a multitude of techniques and technologies.

Effectively, the term unconventional drilling is used to denote any form of drilling that is not conducted at a vertical angle. As such, unconventional drilling may refer to slant drilling, directional drilling, or horizontal drilling. As horizontal drilling has now become more of a standard, it is considered to be a part of the conventional drilling options. For the purpose of this report, horizontal drilling is included in the conventional section.

Slant and Directional Drilling

Slant or directional drilling refers to a well drilled in a straight line, but at some angle, therefore not vertical. Slant/directional wells are effectively drilled in the same methods as a vertical well, with the exception that the derrick is installed at some angle to the surface (i.e. not perpendicular to the earth). This type of drilling is generally utilized to avoid some form of obstacle or hazard in the well bore path, either of a natural or manmade variety, or to avoid land area conflicts. For instance, in the event of a land owner dispute, the owner company can move their well site to a neighboring property to complete the well and use a directional drill to reach their target.

Vertical versus Horizontal Wells

As previously discussed, vertical wells are less costly to drill and complete, but aren't able to reach a large area of the production zone, therefore cannot recover as much of the reserves from a single well.

Horizontal drilling is utilized in order to increase the productive capacity of a well site by dramatically increasing the amount of contact between the reservoir rock and the well bore. Figure 2.3 depicts the difference between vertical and horizontal drilling.

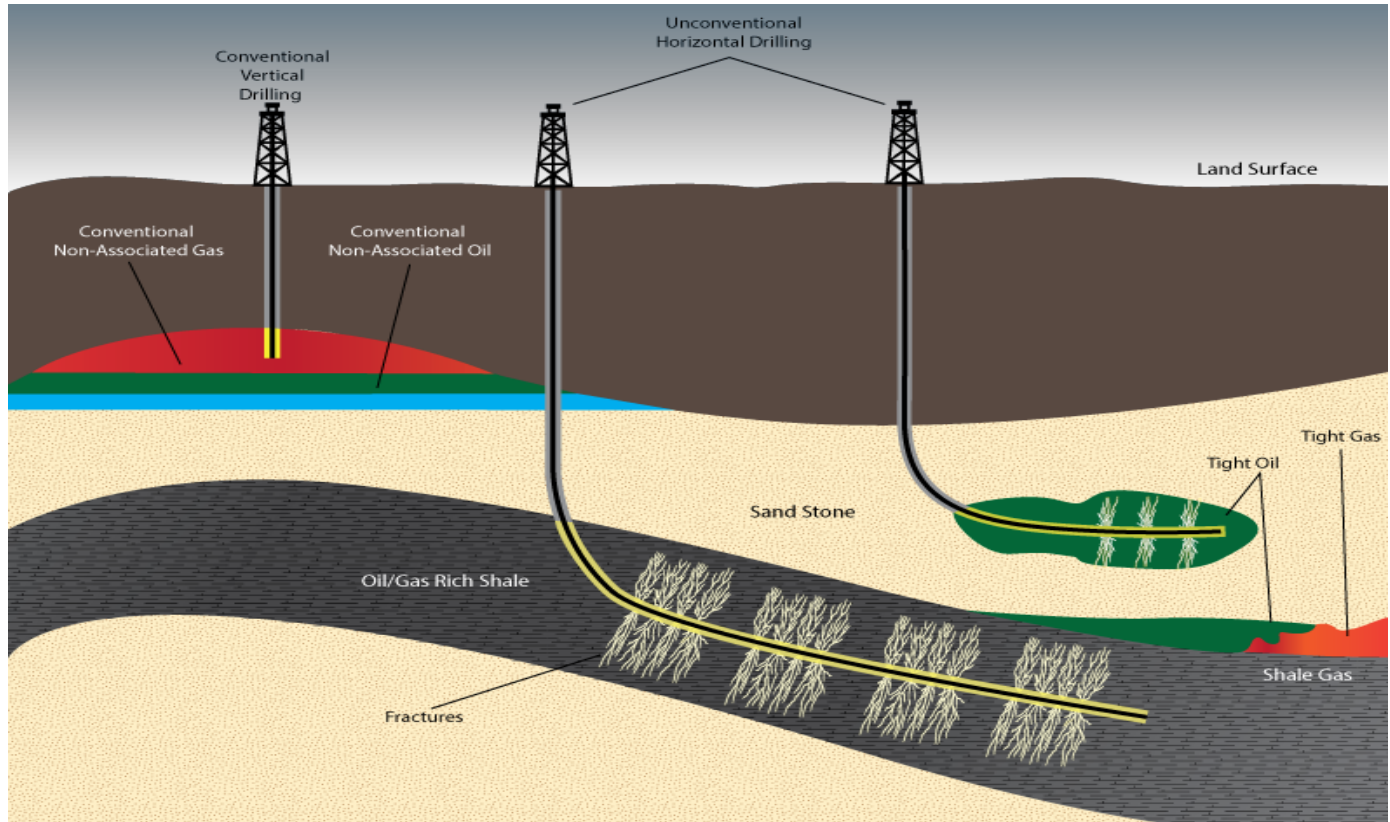
As depicted in the image below, the key difference between the two well types is the "Lshape" of the horizontal well. On all three of the wells depicted, the area of the piping highlighted in yellow represents the amount of pipe surface that is exposed to the reservoir of oil and gas. The larger the area exposed to a reservoir, the greater the potential productive capacity of the well. On a typical vertical well, the length of the production zone, or the thickness of the reservoir formation, is typically between 3 to 40 meters (10 to 120 feet). In comparison, a horizontal well typically runs for a length of 1,000 to 2,500 meters, but could run to a length of up to 3,500 meters (10,000 feet). The majority of a horizontal section of a well is in direct contact reservoir, and is very effective in a reservoir that is wide but only a few meters thick.

The cost of a horizontal well is much higher than that of a vertical well. As such, depending on the reservoir characteristics, multiple vertical wells may be more cost effective than a single horizontal well, which will be part of an owner company's evaluation when they chose to develop the property.



(Geology.com, 2015)

Figure 2.3 A Comparison of Vertical & Horizontal Drilling Techniques



Horizontal Drilling

The process of drilling a horizontal well is initially identical to that of a vertical well. The selected site is prepared in the same fashion as a vertical well, although the regulatory requirements are slightly different than for vertical wells.

In order to drill a horizontal well, a rig initially drills a vertical well until the entry point for the oil reservoir is reached. This entry point is commonly referred to as the Kickoff Point as it represents the point in the well where the curvature of the pipe run will begin. The curvature of the drill pipe will be slowly increased until it reaches the required horizontal angle plane. In certain cases this may even be in excess of 90 degrees, as it follows the formation of the reservoir. In all cases, the route that the drill will be taking during both the vertical and horizontal phases of the drill will need to be carefully planned and executed by trained professionals before the hole boring process can begin.

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Once the kickoff point has been reached, the drilling of a horizontal well requires greater technical expertise than a vertical well. Additionally, certain specialized equipment is required for the drilling of a horizontal well. To avoid unnecessary risk to the specialized equipment, different rig equipment will be used for the vertical and horizontal portions of the well. At the kick off point, the vertical drill assembly is removed from the bore hole and is replaced with the necessary equipment required to begin horizontal drill operations. This equipment consists of a steerable drill motor as well as a dedicated sensor and reporting suite known as a Measurement-While-Drilling (MWD) package. The MWD package provides real-time location and sensory data to the directional drill operator, who employs this information in tandem with the steerable drill motor to adjust the angle of the bore hole until the correct drill plane is reached. If necessary, these technologies can also be used to avoid obstacles and hazards during the drilling operation. Once the required horizontal plane has been established, the drill operation continues with the operator making any corrections to course as necessary until the prescribed length of pipe run has been reached. At this point, the drill assembly is removed and the production casing can be installed.

COMPLETIONS

Casing and Casing Techniques

In a typical oil and gas well within Saskatchewan, a variety of casing types are utilized in conjunction with cementing techniques. Casing helps protect onsite personnel, the drilling rig itself, as well as the local surface and sub-surface environment. Additionally, casings assist in providing stability within the bore hole and regulate pressure during drilling operations. Different diameters of casing are installed for the different stages in the drilling process, with each subsequent drilling and casing stage becoming narrower. The image below demonstrates a simplified casing arrangement.

Once the target depth for each phase of drilling has been reached, the drilling assembly is retracted and the casing for that portion of the bore hole can begin. With each type of casing, the prerequisite length of casing segments has to be installed within the bore hole, run back to the surface, and then securely mounted upon a casing hanger before the cementing process can begin for that stage. Once the aforementioned activities have been completed, cement slurry is pumped into the well cavity through the inside of the casing followed by a flushing agent that forces the slurry from the casing and into the annulus. The pressure of cement slurry is carefully calculated and monitored to ensure that the external area of the casing is securely anchored to the walls of the bore hole. Similarly to the makeup of the drilling mud, the chemical composition of the cement slurry will need to be adjusted to the environmental and geologic circumstances of the individual well site. The different sections of casing that are typically at different depths are outlined in the following figure and described in detail in the image to the right.

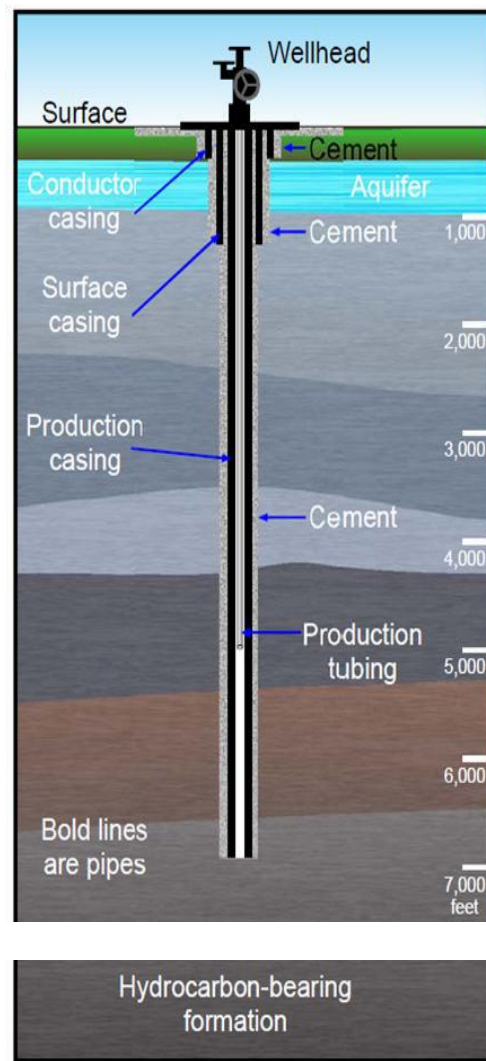


FIGURE 8. WELL CONSTRUCTION

Perforation & Stimulation

Perforation of the production casing is required for the oil and gas to enter into the well bore. This is typically conducted via the use of a single explosive charge, known as a bullet gun, which fires several “bullets” into the casing to create perforations, or numerous shaped explosive charges placed along the casing to create the same effect. Regardless of which method is selected, the amount and interval of the perforations must be carefully planned and designed to allow for optimum oil and gas flow, and must be limited to the permitted production zone.

Once the well casing is perforated, the reservoir formation may be fractured to stimulate the flow of fluid into the well bore, depending on reservoir conditions. Hydraulic fracturing has become common place in many areas in North America due to its ability to help the flow of oil and gas within the reservoir.

Perforating (and fracturing, if it is required) is completed multiple times down the length of the portion of the casing that is in contact with the reservoir, especially in a horizontal well. To stop immediate production from reaching the surface, until such time as the surface facilities are in place, downhole plugs are utilized to maintain pressure until the well site is prepared to receive product and production can begin.

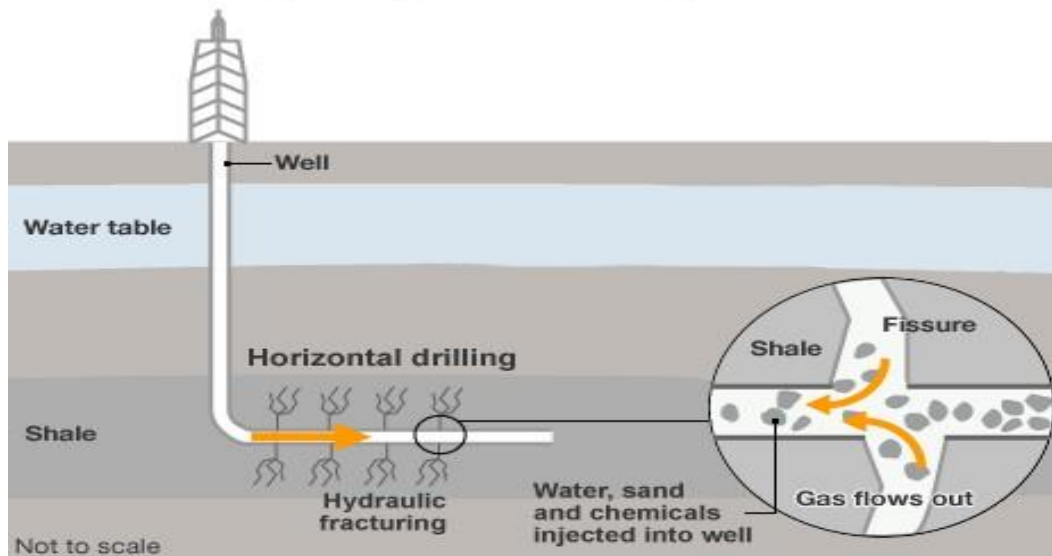
Hydraulic Fracturing

Previously, certain areas of strata had deposits within their formations that were not accessible. Fracturing creates pressure in the formation through a hydraulically pressurized mixture of water, chemicals, and proppant, usually special sand, which is injected into the wellbore. Once the pressure reaches a certain point the rock begins to form cracks and fractures within the formation. These fractures create the ability for the gas and oil trapped in the formation (i.e. shale gas, tight gas, tight oil, and coal seam gas) to flow back up the well. Hydraulic fracturing can be used for both vertical and horizontal wells, but is often used in conjunction with horizontal drilling techniques due to the amount of increased production that can be experienced. The illustration below, shows how fracturing is achieved.

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Horizontal drilling and hydraulic fracturing



Despite its recent prevalence associated with the production of shale gas and tight oil, improving extraction through the use of hydraulic fracturing is not a new process for recovering hydrocarbons. In fact, hydraulic fracturing has been used in Saskatchewan since the 1950s.

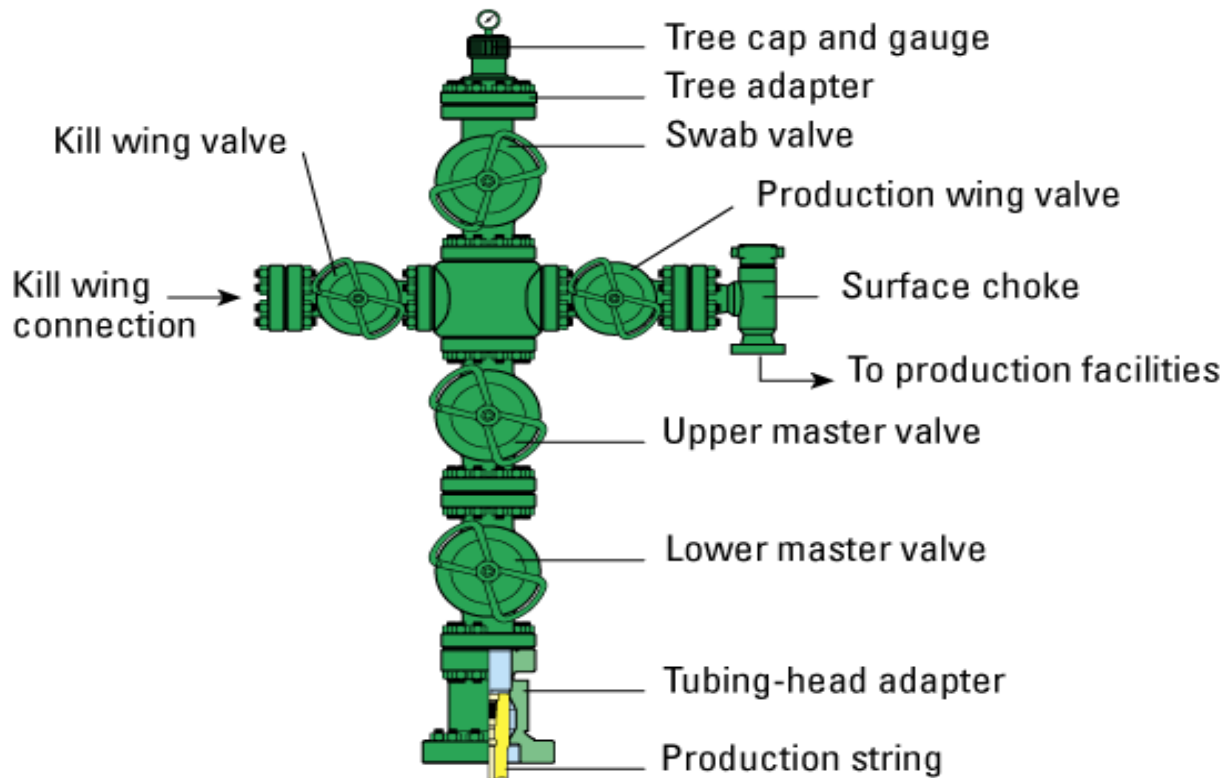
The Production Tree

The production tree, commonly known within the industry as the Christmas tree, is an assembly of valves used primarily to control flow from the well. This piece of equipment is often and incorrectly referred to as the well head. However, the production tree is in fact installed on top of the well head. Certain valves are opened once the well has been deemed ready to produce. Oil and gas flows through the Production Tree and towards the processing facilities.

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The production tree also serves as a location for various other chemical injection points, monitoring equipment, well intervention access, and connection points for other down-hole well devices.



The illustration above provides a good example of a typical production tree; however the number of valves and overall configuration will differ from site to site.

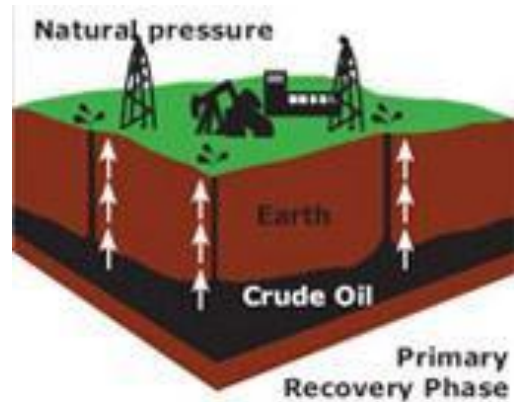
PRODUCTION

Extraction

There are several stages to the production of a well, allowing the owner company to recover the maximum potential amount of the reservoir, starting from the easiest methods, then proceeding to extract the remainder using more complicated and more expensive (unconventional) methods.

The first stage, known as primary recovery, is the most economical form of extraction. During this stage the high pressure pocket of fluid and gas in the strata is capable of flowing directly into the well and to the surface with no additional influence. This is the most profitable time during a well's lifespan because it is the only phase that doesn't require further inputs, and therefore operating expenses, to recover the product from the reservoir.

Most assets in North America have depleted their primary reserves, but every well under conventional processes experiences a certain time frame where primary style of production can be achieved. This amount of time is called the decline – the longer the decline, the longer the primary stage of production. Very few wells in Saskatchewan experience this type of primary production for any significant length of time. Almost all Saskatchewan wells immediately start at the next stage of production as soon as they are completed and begin production.



Once the high initial reservoir pressure is depleted, the extraction process progresses to the secondary recovery stage. The first common secondary recovery method is known as artificial lift, which involves moving the production to the surface through either a pump system, or by using artificial gas lift. Gas lift is not as common in Western Canada unless the production is heavy oil or SAGD (Steam Assisted Gravity Drainage). The most common practice of artificial lift



for oil extraction is beam pumping, or a Pump Jack. Similar to an old fashion hand water pump, this utilizes a sucker rod string and pump to pull oil and other liquids from the reservoir. At the surface, gas (natural gas or propane) or electrically driven motor, known as the prime mover, powers the units. Top drive and submersible electric pumps are also used. Instead of a sucker rod, these pumps use a helical screw or progressive cavity design to lift liquids to the surface. These types of pumps are more

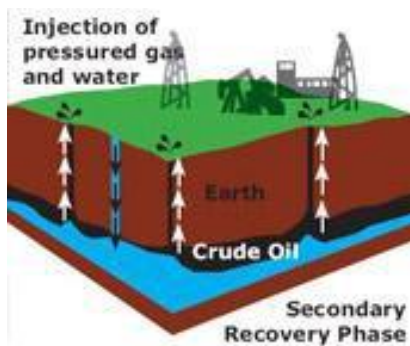
expensive but are very reliable and can move higher volumes of produced fluid.

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For gas wells, another type of artificial lift is a Plunger Lift. This system works similarly to a pump jack, in that the pumping system is inserted into the well, but in this case there is no sucker rod or prime mover to pull the fluid to the surface. Instead, the plunger lift relies on a gas pressure build up in the well to lift water and oil, and help the gas to free flow for an amount of time. These systems are controlled using surface instruments, typically connected to a FloBoss or SCADA system, that monitors production and tells the plunger lift when to drop to the bottom of the well again.

The Gas lift process involves injecting compressed gas into the wells to generate the additional pressure required for extraction. The intention of the injected gas is to create a high enough pressure that the liquid can flow to the surface, and lowers the viscosity of the fluids in the well. A producer will inject gas into the tubing annulus at multiple points to facilitate the process.



Water injection or water flooding is another form of secondary production, and is one of the oldest and most widely used. To reduce costs, some of the existing wells in the production field will be converted to injectors, ensuring that additional wells aren't required. Water is then injected into the injector wells to increase the pressure within the reservoir. As the density of water is greater than that of oil, oil "floats" on the water, and is forced up the well once again.

In all, secondary production methods may allow for the recovery of up to 10% to 30% of total producible reserves. Combined with the primary production, approximately 50% of the reserve may be recoverable.

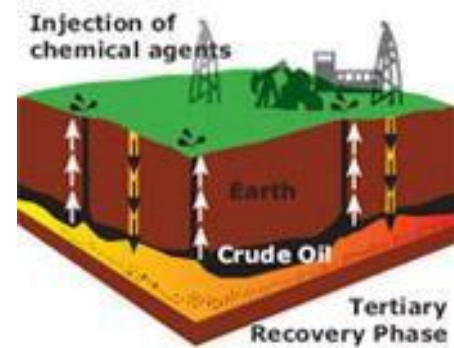
For many years, the methods mentioned above were all that an operator had available. Today, Enhanced Oil Recovery techniques have improved to recover more products from older wells and depleted formations. However, the cost of EOR can be high, so this will only be effective in some areas depending on resultant margins of EOR products.

Maintenance, Work Overs and Reliability

Any activity that takes place on an oil well during or near the end of the wells active life is known as a well intervention, and includes maintenance, work over and re-completion activities. Before any intervention operations take place, the drilling company must ensure that an adequate emergency response plan has been drafted and approved.

RECOMPLETION AND ENHANCED OIL RECOVERY

While primary and secondary extraction tend to be the easiest and most economical options for the retrieval of petroleum deposits, the development of Enhanced Oil Recovery (EOR) techniques and technologies now allow operators to tap reserves that were previously unfeasible or unreachable. The development of these EOR techniques has progressed to the point that it now allows older reserves or even “dry” deposits to once again be profitable. After the primary and secondary techniques have exhausted their potential to extract, Enhanced Oil Recovery begins, and may take various forms.



Alternate Production Methods

As technology progresses, new techniques are being developed that result in a higher extraction percentage from previously under producing wells, and the ability to extract from reserves previously deemed unattainable.

Recompletions

Recompletion refers to the process of re-entering a previously exhausted well for repair or redoing the original completion and restoring production ability to the well. Recompletion activities employ the same techniques that are common in initial drilling explorations and hydraulic fracturing and absolute re-drilling techniques are common.

Thermal Recovery

Thermal recovery is an alternative method of enhanced recovery and involves heating the reservoir to decrease the viscosity and increase the mobility of the oil. The two common variations of this technique are Steam Injection and Fire Flooding.

Steam Injection

Injection wells have the ability to introduce heat and steam into the formation. After the injection of steam, previously viscous oil is thinned to a point where it can now flow through the reservoir and into the well. Water molecules then replace the oil and bond to the sand, allowing the oil to flow freely. Steam injection, depending on the reservoir, can be very water friendly, with the average site able to recycle over 95% of its injected steam.

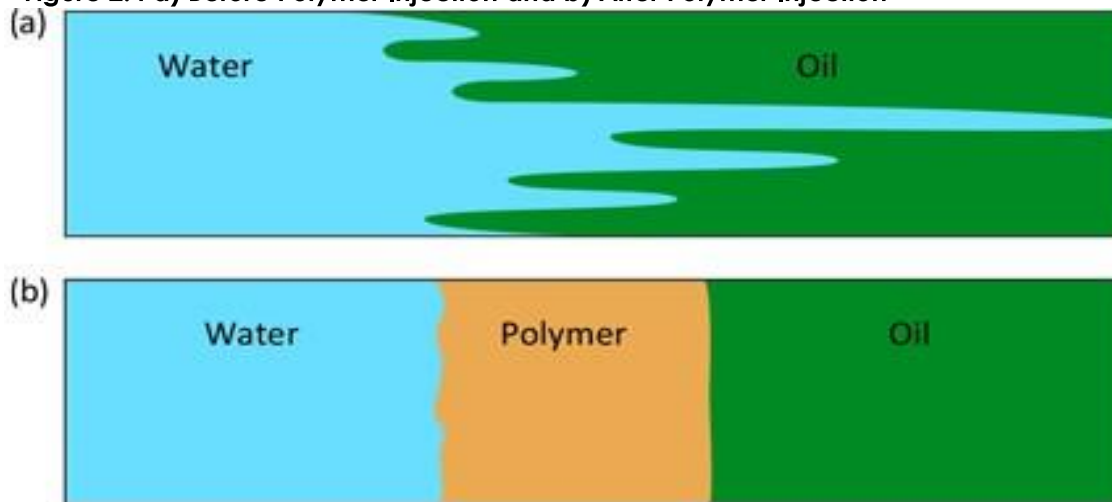
Fire Flood

Fire flooding involves heating the reservoir by means of, essentially, lighting a flame at the sand face of an injection well. Once the flame is lit, it is maintained with a constant supply of air or oxygen that permits the fire to distribute throughout the reservoir. This process is meant to heat the oil so it becomes less viscous and raise the temperature of the reservoir water until it becomes steam. The heating process works to heat the entire reservoir, and drive the oil towards the production wells.

Polymer Flooding

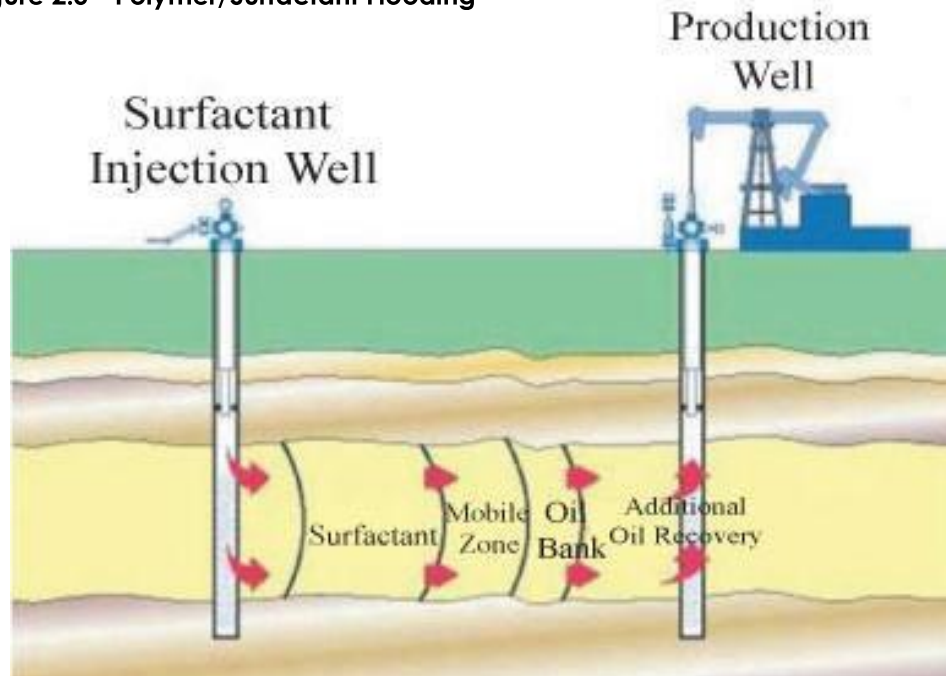
Polymer flooding is a process that builds upon the simple injection of water. Gel based polymers are added to the injection water. Instead of pumping just water into a reserve, the polymer solution increases viscosity of the oil in the formation. As a result, the producer is able to increase the amount of recoverable oil from a well. Figure 2.4 demonstrates the separating effects of this process.

Figure 2.4 a) Before Polymer Injection and b) After Polymer Injection



Surfactants, or “soaps”, may also be combined into the polymer mix in order to decrease the surface tension between the oil and the water. The introduction of surfactants reduces oil saturation and increases the microscopic efficiency of the process. Figure 2.5 illustrates the polymer/surfactant flooding process:

Figure 2.5 - Polymer/Surfactant Flooding



Polymer and surfactant mixes are pumped into the strata from an external well, forcing the oil towards the production well and effectively sweeping the cavity of all the remaining and hard to reach oil.

Solvent Injection

An alternative to thermal recovery, which requires the use of large amounts of energy and water, is solvent injection. Depending upon the solvent selected, solvent injection may produce less of an overall footprint on the environment. The chosen solvent must be fairly gaseous, have a high solubility in water or affinity to oil, and be economical. After injection, there is a soaking phase where the oil begins to swell, increasing the pressure and decreasing the viscosity. The purpose of solvent injection is to manipulate the properties of the previously inaccessible strata to recover a higher percentage of the reserve. The solvent injection process is similar to the surfactant/polymer injection process, except the chemical compounds used are different.

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Depending upon the solvent utilized and its associated cost, the largest hurdle for solvent injection may be to recover the solvent that was injected. If only a small percentage of the solvent can be recovered, the process no longer becomes profitable. In circumstances, where nitrogen gas or air is utilized, the cost of the solvent is effectively zero, so recovery is a nonissue. In situations where carbon dioxide is the chosen solvent, then it can be sequestered underground rather than recycled. In most cases, solvents are propane and butane, and as they come up with the produced oil, they are recoverable. The oil in the well is “upgraded” within the formation, leaving the heaviest products behind. The drawback is that you leave the asphaltines in the well, which, if collected and produced, can be used to make asphalts and other plastics as well.

Liquid CO₂ is a common solvent used in this technique due to its viscosity reducing properties and inexpensive price. In Saskatchewan a large scale CO₂ EOR project has been implemented in the Weyburn Oil Field. By injecting CO₂ into the wells it is expected that the active lifespan of the oil field will be increased by 25 years.

ABANDONMENT AND DECOMMISSIONING

Abandonment

Wells abandoned without meeting the province's standards pose a major problem as environmental and health concerns can arise as a result of leaving a well. In most cases, the well is cut off below the surface level and the equipment is recovered. The rules for abandonment and decommissioning place the onus on the licensee or operator to take care of every aspect of abandonment, decommissioning, and reclamation. Owners typically build such fees and costs into the initial cost calculation before a well is constructed.



Although the wells pose a minimal risk to land owners once they have been successfully abandoned, as the above figure shows, a properly reclaimed well may be difficult to locate but landowners must be fully aware of the wells location in order to avoid disturbing the sealed wells.

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Life Cycle Stages Of A typical Well
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Saskatchewan Reclamation Standards

Before a well can be decommissioned or abandoned in Saskatchewan, there are specific regulatory requirements set by the Oil and Gas Conservation Regulations that must be complied with before a well can receive an acknowledgement of reclamation. The Act is administered by the Saskatchewan Ministry of the Economy and includes the submission of landowner's acknowledgement, Phase 1 Environmental Site Assessment (ESA), a Phase 2 ESA (where applicable), remediation report (where applicable) and a Detailed Site Assessment (DSA). Within six months of approval of the detailed site assessment, the Acknowledgment of Reclamation application can be submitted. The reclamation liability associated with the site will be removed once the Acknowledgement of Reclamation is issued and accepted by the Ministry of the Economy. The Government of Saskatchewan has specific requirements for a licensee to fulfill before the company can walk away from the site.

Complete details of this process can be located within the Government of Saskatchewan's Ministry of the Economy website within the Licensing, Environmental Protection, Orphan Fund, LLR and Acknowledgement of Reclamation (AOR) Programs and Field Office Operations page. These resources should be reviewed on frequent basis, as these standards are periodically updated.

3.1 REQUIRED WELL GOODS AND SERVICES

INTRODUCTION

Throughout its lifecycle, the typical Oil and Gas well requires numerous components, parts and consumables. This section of the report will provide a broad overview of the major components. Focus will be on the production phase due the wide variety of components that are required, as well as the prospective opportunities to provide goods and services to this sector.

This section is divided into two portions. The initial portion provides a brief overview of the typical components of a well site, while the second portion will provide a costing breakdown of a typical well and sample components.

Detailed estimates were prepared based on actual projects in various locations within Western Canada. Various factors will directly impact drilling and completion costs. Costing should be taken as speculative and should not be considered actuals. Drilling rigs often set prices for a four-to-five month period. This pricing has been incorporated into the Study costs.

Many factors directly impact drilling and completion costs even within a field or typical area, for example, leases impacted by weather conditions. Costing is therefore at best speculative and should not be taken to represent "actual" well costs. However, major services such as drilling rigs often set prices for a four-to-five month period. This pricing has been incorporated into the Study costs.

DEFINING A TYPICAL OIL AND GAS FACILITY

An oil and gas facility can see many changes during its lifecycle, and the equipment required to maintain production may change as well. **For the purposes of this report, a “typical” well site is defined as one in early secondary production.** A typical well (oil or gas) may include the following pieces of equipment:

- Separation equipment
- Production Storage Tanks
- Flow Control and Safety Control Valves
- Flare or Venting equipment
- Flow Lines (pipelines)
- On Site Power Generation (Utility Power Supply, UPS)
- Line Heater

This equipment can be used, in various sizing requirements, for vertical and horizontal well applications, sweet or sour production, in either primary or artificial lift operating modes. EOR processes like flooding (water, polymer or solvent) or thermal applications require more specialized equipment in addition to that mentioned above. However, almost every well site installation, including EOR, will have some combination of the equipment listed above.

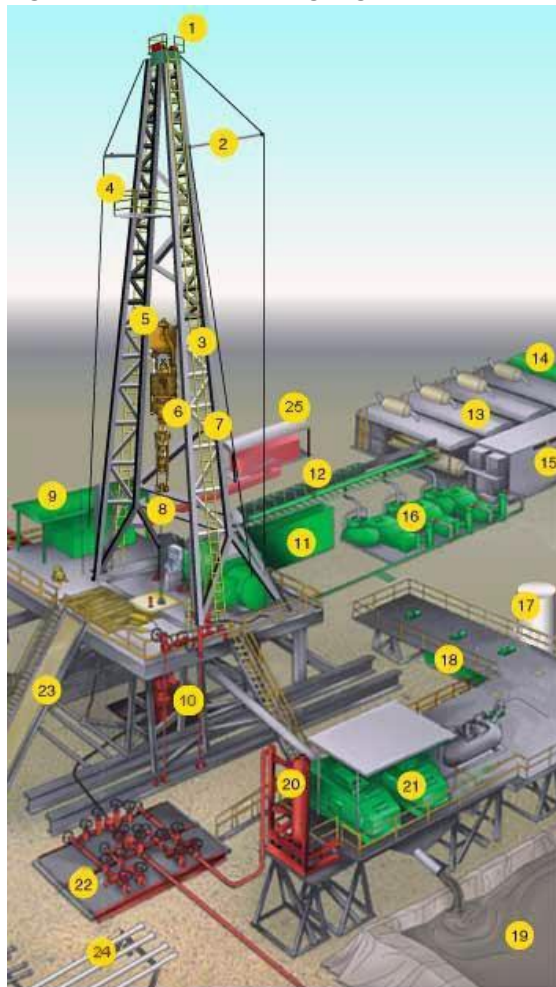
These typical well sites feed production to larger processing facilities. These larger facilities can vary significantly from one site to another. This report will define some major components of these typical facilities only (i.e. treaters, dehydrators, etc.). Other production methods, such as polymer flooding, SAGD, and solvent injection, are not typical in Saskatchewan and will therefore not be covered in detail. The report will, however, touch on some of the support services that may be required for general knowledge and understanding.

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This report does not attempt to account for every possible combination of equipment or rig variety. However, a standard long-term stationary well drilling site will largely consist of the following structures and equipment:

Figure 3.1 Typical Drilling Rig Components



1. Crown Block and Water Table
2. Catline Boom and Hoist Line
3. Drilling Line
4. Monkeyboard
5. Traveling Block
6. Top Drive
7. Mast
8. Drill Pipe
9. Doghouse
10. Blowout Preventer
11. Water Tank
12. Electric Cable Tray
13. Power Generation
14. Fuel Tanks
15. Electric Control House
16. Mud Pump
17. Bulk Mud Components Storage
18. Mud Pits/Boxes
19. Reserve Pits
20. Mud Gas Separator
21. Shale Shaker
22. Choke Manifold
23. Pipe Ramp
24. Pipe Racks
25. Accumulator

EXPLORATION

Major Components

The major components of a drilling rig typically consist of the following items, the majority of which have been referenced in the previous section:

Drilling Operations Equipment:

Drilling Rig or Oil Derrick

The Drilling Rig or Oil Derrick is the primary structure within the drilling process and houses much of the equipment required to bore into the Earth. While smaller, mobile rigs may be employed within the well site, for the purposes of boring Rat holes, Mouse holes or access to water, this section is devoted to the large scale derricks capable of drilling deep within the Earth's surface in order to reach a hydrocarbon reservoir. The use of an oil derrick in conjunction with hydraulic rotary drilling techniques remains the preferred method of drilling for hydrocarbons.

The derrick performs a multitude of roles within the drilling process, ranging from housing the top drive, mud pumps and other ancillary equipment. During the drilling process, the oil derrick is used to hoist and position the drilling string, as well as, to adjust the pressure of the drill string as it bores into the rock strata to ensure optimum drill efficiency is maintained.

As the drilling rig is only truly required during the boring process, once the well has been drilled the drilling rig will be disassembled and relocated. In its place, a service rig that has been customized for the installation of completion equipment will be assembled.

The oil derrick and much of its supporting equipment is typically leased from external organizations, due to the high capital expenditures and specialized knowledge required for the building and ownership of these devices.

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Top Drive

Replacing the role of the Kelly Drive or Rotary Table, the Top Drive is a large electric or hydraulic motor that is suspended from the oil derrick for the purpose of rotating the drill string during the boring process. Typically, a derrick mounted top drive will possess several thousand foot pounds of torque, in order to turn the drill string shaft in order to bore into the Earth. Top drives are viewed as being both more efficient during drilling operations when compared to the Kelly drive system, as well as safer for rig workers as less manual labour is required as the top drive is largely automated. This automation is especially valuable during directional boring as it allows for greater control by the operator, therefore, top drives are typically used in the drilling of horizontal wells.



Power Generation

Modern oil derricks and their supporting equipment require a reliable source of energy in order to power their operations. Typically, the required energy is supplied by onsite gasoline or diesel generators. Due to the demands of the drilling process, these generators must be reliable in the harsh conditions often encountered in the field. Furthermore, these generators must be able to respond to the rapid cycling of power loads, ranging from periods of high power demands to long periods of light loads.

In certain circumstances, there has been an increase in demand for the use of onsite natural gas for power generation. This demand is driven by the need to meet ever more stringent emission requirements, the lower cost of natural gas relative to diesel fuel, and the desire to utilize the natural gas that may be present within a reservoir as opposed to wastefully flaring it off. However, at time of writing natural gas fueled power generation while an exciting development, is still the exception rather than the norm.

The Drill String

Drill Bit

The Drill Bit is the mechanical device which conducts the actual earth boring operation at the end of the drill string. The modern oil and gas well drill bit is a tri-cone configuration armed with hardened teeth composed of tungsten carbide. More recently, the Polycrystalline Diamond

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Compact (PDC) Bit has become increasingly popular, particularly in the drilling of tight oil formations such as those in the Bakken Formations. The polycrystalline diamond compact bit possesses no moving parts but, instead relies upon the extreme strength of the diamonds embedded within its tip to scrape away at the rock. Both of these bits are hollow to allow for the drilling fluid to be forced from the drill bit in a high pressure jet to assist in the breaking down of the rock formations. An example of each of these drill bits is included below; the Polycrystalline Diamond Compact Bit is featured on the left, while the Conical Tungsten Bit is on the right:



Polycrystalline Diamond Compact Drill Bit



Conical Tungsten Drill Bit

Measurement-While-Drilling Package

The Measurement-While-Drilling (MWD) Package is utilized primarily in horizontal drilling to allow for the drill operator to monitor and adjust the direction of the drill string as appropriate. This is possible via the use of a complex system of gyroscopes, magnetometers, and accelerometers that are contained within the MWD Package. These sensor relay drill string progress and orientation to the operator in real time via electronic telemetry or through pulse telemetry systems, which communicate information in a binary fashion by adjusting the pressure of the drilling fluid depending on conditions encountered.

Drill Pipe

Drill Pipe is hollow but thickly walled steel tubing typically 10 meters (30 feet) in length and may come in an assortment of diameters ranging from 2.375 inches to 6.625 inches. Drill pipe is equipped with both a "Male" and "Female" end allowing it to be coupled together to comprise the majority of the length of the drill string.



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Due to the extreme depths that the drill string may reach, it is very important that the drill pipe be of sufficient strength to support not only its own weight but to withstand the pressure of drilling fluids as well as the conditions within the borehole. Selection of the proper Grade of drill pipe is essential with the four most common grades of drill pipe including E, X, G, and S grades. Of the four, Grade E pipe possesses the lowest amount of tensile and yield strength, while Grade S possesses the greatest amount of both values. Figure 3.2 below summarizes the tensile and yield strength of each of these grades.

Figure 3.2 Yield & Tensile Strength of Common Drill Pipe Varieties

| | Yield strength MPa | | Tensile strength MPa |
|------------------------|-----------------------|-------|-------------------------|
| | min. | max. | min. |
| | | | |
| Drill-pipe-body | | | |
| Grade E | 517 | 724 | 689 |
| Grade X | 655 | 862 | 724 |
| Grade G | 724 | 931 | 793 |
| Grade S | 931 | 1 138 | 1 000 |
| Tool joint | 827 | 1 138 | 965 |

Due the amount of drill pipe that is typically required in drilling operations, as well as the relative cost for each length of pipe, well operators often attempt to reuse drill pipe following its retrieval in order to minimize costs.

Drilling Fluid Support Equipment

Mud Pump

The Mud Pump is a large scale reciprocating pump whose purpose is to force drilling fluid, or mud, along the length of drill run through the annulus and then back up the well hole in order to drive the drill cuttings to the surface. Given the prospective distance between the surface and the depth of the well, these mud pumps must be able to provide sufficient pressure to bring the debris all the way back to the surface and into the mud pit for disposal. Given the important nature of this pump, it is critical to ensure that it is being properly maintained to prevent breakdowns that will slow or halt drilling operations.

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Mud Tanks

The Mud Tank is a steel container utilized to hold the drilling fluid; both prior to injection into the well and again after it has been circulated into the well cavity. As the drilling fluid is returned the surface, run through screening devices to remove the drill cuttings and sentiments and returned to the mud tank. Originally, mud tanks did not have a top in order to allow rig workers to monitor the drill fluid levels and for solid separating equipment to be installed. However, modern Mud Tanks are now covered for worker's safety.

Consumables & Feedstock

Drilling Fluid

Drilling Fluid is a chemical compound that is injected into the bore hole during the drilling process. These chemical compounds typically consist of a combination of barite, calcium carbonate, and glycol. In specific circumstances, oil based fluids such as diesel fuel is utilized in lieu of water, however, a water and clay mixture is used in 80% of cases. Regardless of whether oil or water is employed as a base, the Drilling Mud must be customized to the individual drill site to ensure that the well can be bored in the safest possible manner. As such, the exact composition of this fluid is dependent on the makeup of the geological formations and the depth of the well being drilled; typically of a heavy, viscous composition. Drilling Fluid serves a multitude purposes within the well hole including:

- Cooling and lubricating the drill bit
- Removing the rock fragments and drill cuttings from the well
- Applying stabilizing pressure within the well and to the drill bit
- Supporting the walls of the hole, preventing their collapse

Once Drilling fluid returns to the surface it is typically collected before being run through several different pieces of equipment to remove drill cuttings after which it can be reused.

Rig Mats

Rig mats are starting to become a more consumable item where in the past they used to be reusable. For example, in muskeg areas, rig mats are sunk into the marsh to support rigs, and aren't recovered. Rig mat supply is therefore becoming a large and important service industry as delays in shipments of rig matting can cause project delays.

Supporting Services & Resources

- Landman services
- Regulatory services
- Environmental survey
- Geotechnical Survey
- Safety
- Medical
- Food, & Lodgings



(American Institute of Steel Construction, 1986)

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Figure 3.3 DETAILED DRILLING ESTIMATE

The following is a detailed breakdown of the expected costs associated for the drilling and operation of a new horizontal well at a remote reservoir site.

| Operations, Services or Equipment | # | Units | Unit Type | Cost Per Unit | Comments and Detail | Abandoned | Cased |
|---|---|-------|-----------|------------------|---------------------------------|------------------|------------------|
| Predrill and Planning | | | | | | | |
| Lease Acquisition | | 1.6 | Hectares | \$2,600 | Surface Lease Entry | \$2,600 | \$2,600 |
| Surveying | | 3 | Days | \$5,000 | Site and Plan | \$15,000 | \$15,000 |
| Planning and Programs | | 200 | Hours | \$175 | Engineering and Programming | \$35,000 | \$35,000 |
| Total | | | | | | \$52,600 | \$52,600 |
| Construction | | | | | | | |
| Road | | 5 | Kms | \$5,500 | Engineering and Construction | \$27,500 | \$27,500 |
| Location | | 18 | Days | \$11,000 | Engineering and Construction | \$198,000 | \$198,000 |
| Lease Maintenance | | 180 | Days | \$500 | Labour and Equipment | \$90,000 | \$90,000 |
| Lease Cleanup | | 0 | Days | \$11,000 | Labour, Materials and Equipment | \$0 | \$0 |
| Bridges / Culverts / Cattle Guards | | 6 | Each | \$5,000 | Labour and Equipment | \$30,000 | \$30,000 |
| Standby Equipment | | 0 | Days | \$550 | Grader, Hoe, Cat | \$0 | \$0 |
| Supervision | | 18 | Days | \$1,200 | Daily Rate incl. Sub and Exp | \$21,600 | \$21,600 |
| Lease Reclamation | | 18 | Days | \$8,800 | Labour and Equipment | \$158,400 | \$158,400 |
| Lease Reclamation Supervision | | 18 | Days | \$1,200 | Daily Rate incl. Sub and Exp | \$21,600 | \$21,600 |
| Total | | | | | | \$547,100 | \$547,100 |
| Rig Contract | | | | | | | |
| Rig Move | | 50 | Loads | \$3,600 | \$300/hr. and 8 hr./100km/load | \$180,000 | \$180,000 |
| Rig Permit | | 4 | Days | \$500 | As required by area | \$2,000 | \$2,000 |
| Demob / Inter-well Move | | 40 | Loads | \$3,600 | \$300/hr. and 8 hr./100km/load | \$144,000 | \$144,000 |
| Rig-in Set Up | | 8 | Each | \$20,000 | Move in, set up | \$160,000 | \$160,000 |



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| | | | | | | | |
|----------------------------------|----|-----|-----------|----------|---|--------------------|--------------------|
| Labour | | | | | | | |
| Day work | | 180 | Days | \$25,000 | Rig rate from Spud to RR w/ drill pipe | \$4,500,000 | \$4,500,000 |
| Loader | | 180 | Days | \$600 | Rig loader | \$108,000 | \$108,000 |
| Additional Labour Costs | | 180 | Days | \$250 | Additional crew as required | \$45,000 | \$45,000 |
| Camp | | 188 | Crew Days | \$7,000 | Camp / hotel including meals etc. | \$1,316,000 | \$1,316,000 |
| Crew Subsistence Allowance (CSA) | | 188 | Days | \$650 | Crew Subsistence Allowance | \$122,200 | \$122,200 |
| Crew Transportation | | 188 | Each | \$350 | Crew Truck, Mileage, Bus or Aircraft | \$65,800 | \$65,800 |
| Boiler | | 188 | Days | \$1,920 | Basic rate fuel out | \$360,960 | \$360,960 |
| Fuel | | 188 | Days | \$4,320 | Fuel | \$812,160 | \$812,160 |
| Fuel Storage | | 0 | Days | \$0 | Additional fuel storage | \$0 | \$0 |
| Standby | | 0 | Days | \$20,000 | Testing, logging, waiting on orders | \$0 | \$0 |
| Water and Trucking | | 188 | Days | \$1,000 | Water access and supply | \$188,000 | \$188,000 |
| Total | | | | | | \$8,004,120 | \$8,004,120 |
| Rentals | | | | | | | |
| Well site Trailer(s) | 4 | 188 | Days | \$225 | Well site Unit rental | \$169,200 | \$169,200 |
| Sump Pump(s) | 1 | 188 | Days | \$135 | Centrifugal pump rental | \$25,380 | \$25,380 |
| Surface Equipment | 1 | 188 | Days | \$1,850 | Garbage bin, Pumps, Pason, Invert acc, | \$347,800 | \$347,800 |
| Solids Control Equipment | 2 | 188 | Days | \$1,615 | Centrifuge(s), BOS tank etc. | \$607,240 | \$607,240 |
| High Speed Mixer(s) | 1 | 188 | Days | \$800 | High speed mixer, pill tank, lines | \$150,400 | \$150,400 |
| Tank Rental | 1 | 188 | Days | \$300 | Floc, Flare, 400 bbl. tank etc. | \$56,400 | \$56,400 |
| Downhole Tool Rentals | 1 | 188 | Days | \$3,685 | Perf Motors, subs, jars, stabilizers etc. | \$692,780 | \$692,780 |
| Drill string | 80 | 188 | Days | \$13 | HWDP, Small inch drill pipe, etc. | \$195,520 | \$195,520 |
| Total | | | | | | \$2,244,720 | \$2,244,720 |
| Service and Supplies | | | | | | | |



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| | | | | | | | |
|---------------------------------------|---|------|-------------|----------|--|--------------------|--------------------|
| Bits - Surface Hole | | 2 | Each | \$5,000 | Bit(s) required to drill surface hole | \$10,000 | \$10,000 |
| Bits - Intermediate Hole | | 7 | Each | \$10,000 | Bit(s) required to drill intermediate hole | \$70,000 | \$70,000 |
| Bits - Main Hole | | 5 | Each | \$10,000 | Bit(s) required to drill main hole | \$50,000 | \$50,000 |
| Bits - Open hole | | 0 | Each | \$10,000 | N/A | \$0 | \$0 |
| Surface Mud and Chemicals | | 250 | Cubic metre | \$45 | Cost per cubic metre water out | \$11,250 | \$11,250 |
| Main Mud and Chemicals | | 500 | Cubic metre | \$475 | Cost per cubic metre Invert out | \$237,500 | \$237,500 |
| Mud Logging | | 125 | Days | \$775 | Daily rate - crew plus costs | \$96,875 | \$96,875 |
| Drill Stem Tests | | 2 | Each | \$10,000 | Unit, crew, analysis, samples | \$20,000 | \$20,000 |
| Cores Cut | | 1 | Each | \$15,000 | Equipment, crew, analysis | \$15,000 | \$15,000 |
| Electric Logging | | 3900 | m MD | \$10 | Cost per m logged all in | \$39,000 | \$39,000 |
| Environmental Services | 0 | 5 | Each | \$750 | Spray field sampling, reporting, etc. | \$0 | \$0 |
| Drilling Waste Management | 1 | 10 | Each | \$1,500 | Cost per fluid samples and analysis | \$15,000 | \$15,000 |
| Safety | | 188 | Days | \$1,050 | Daily Rate Crew and Equipment | \$197,400 | \$197,400 |
| Directional Drilling Services | | 100 | Days | \$12,000 | Daily rate all in crews and tools | \$1,200,000 | \$1,200,000 |
| Trucking | | 188 | Days | \$1,500 | Equipment and tool trucking | \$282,000 | \$282,000 |
| Fluid and/or Cuttings Hauling | 1 | 165 | Days | \$1,600 | Fluid hauling other than water | \$264,000 | \$264,000 |
| Fluid and/or Cuttings Disposal | 1 | 500 | Cubic metre | \$50 | Drilling fluid hauled for disposal | \$25,000 | \$25,000 |
| Vacuum Truck (LSWD) | 0 | 165 | Days | \$1,650 | Cost per day for Vac Truck | \$0 | \$0 |
| Welding | | 3 | Each | \$2,500 | Cost per well | \$7,500 | \$7,500 |
| Inspection and Repair | | 3 | Each | \$4,200 | Cost per well | \$12,600 | \$12,600 |
| Total | | | | | | \$2,553,125 | \$2,553,125 |
| Supervision and Administration | | | | | | | |
| Drilling Supervisor | 1 | 188 | Days | \$1,650 | Drilling consultant rate all in | \$310,200 | \$310,200 |
| Well Site Geologist | 1 | 125 | Days | \$1,500 | Geological consultant rate all in | \$187,500 | \$187,500 |



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| | | | | | | | |
|--------------------|--|-----|------|-------|--------------------|------------------------------|---------------------|
| Geological Rentals | | 125 | Days | \$210 | Gas detector etc. | \$26,250 | \$26,250 |
| Insurance | | 188 | Each | \$100 | Drilling insurance | \$18,800 | \$18,800 |
| Communications | | 188 | Days | \$100 | | \$18,800 | \$18,800 |
| Total | | | | | | \$561,550 | \$561,550 |
| | | | | | | Subtotal | \$13,963,215 |
| | | | | | | Contingency @ 5 % | \$698,186 |
| | | | | | | Miscellaneous @ 2 % | \$279,274 |
| | | | | | | Overhead on Subtotal @ 3,2,1 | \$153,500 |
| | | | | | | Total Cost Estimate | \$15,094,175 |

COMPLETIONS

Major Components

Casing

The first casing installed in the well is the conductor casing, identified as such, because it is installed into the conductor/ starter bore hole. It is the widest casing that will be installed, with a typical diameter of between 40 to 80 centimeters. The top most levels of soil are often unstable and the conductor casing helps prevent the bore hole from collapsing in on itself. In addition, conductor casing, once cemented into place, prevents drilling mud from returning to the surface in an uncontrolled manner, thus regulating pressure within the well and preventing environmental contamination. Conductor casing is not common in all wells and, as such, the next type of casing, the surface casing, often will be the first casing stage.

The surface casing, in spite of its name, typically extends between 75 and 350 meters underground in Saskatchewan. Surface casing protects freshwater formations from possible contamination from drilling operations and hydrocarbons, which is arguably the most important role within the casing chain. Given the severity of possible ramifications from a failure of surface casing, this stage of casing is mostly heavily regulated by government entities.

Intermediate casing is required in areas of the bore hole that feature terrain instability or unusual pressure zones. Both of these conditions are typically found within deposits of hydrocarbons and can therefore be perforated and utilized for production at a later date.

Production casing is the final casing that is run through a well hole, and is the narrowest width of all the casings. To allow the oil and gas to flow into the production casing, it is perforated at calculated intervals. This ensures that an optimal flow of oil and gas can enter the production casing and be brought to the surface.



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The strength of steel that each tier of casing requires is based upon the appraisal of the worst conditions that the casing is expected to experience during its lifecycle. The figure below depicts the relative strengths of common steel grades utilized in the manufacture of casing.

Figure 3.4 Tensile Strength of Common Steel Grades

| TABLE 7.1—API STEEL GRADES | | | | |
|----------------------------|-------------------|---------|---------------------------|-----------------------|
| API Grade | Yield Stress, psi | | Minimum Ult. Tensile, psi | Minimum Elongation, % |
| | Minimum | Maximum | | |
| H-40 | 40,000 | 80,000 | 60,000 | 29.5 |
| J-55 | 55,000 | 80,000 | 75,000 | 24.0 |
| K-55 | 55,000 | 80,000 | 95,000 | 19.5 |
| N-80 | 80,000 | 110,000 | 100,000 | 18.5 |
| L-80 | 80,000 | 95,000 | 95,000 | 19.5 |
| C-90 | 90,000 | 105,000 | 100,000 | 18.5 |
| C-95 | 95,000 | 110,000 | 105,000 | 18.5 |
| T-95 | 95,000 | 110,000 | 105,000 | 18.0 |
| P-110 | 110,000 | 140,000 | 125,000 | 15.0 |
| Q-125 | 125,000 | 150,000 | 135,000 | 18.0 |

Tubing

The majority of the petroleum products are conveyed to the surface by Tubing not the production casing. The tubing is a separate string run through the well line to serve as a conduit for the pump to pull oil to the surface. The smaller diameter of the tube string allows for higher pressures and thus a higher flow rate of product to the surface. Due to the corrosive nature of the hydrocarbons, this tubing must be routinely replaced in order to ensure consistent production.

Consumables & Feedstock

- Cement
- Explosives and charges

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Figure 3.5 Detailed Completion Estimate

The following is a detailed breakdown of the expected costs for the casing of a new horizontal well at the same site as the detailed drilling estimate.

| Operations, Services or Equipment | # | Units | Unit Type | Per Unit | Comments and Detail | Abandoned | Completed |
|-----------------------------------|---|-------|-----------|----------|---------------------------------------|--------------------|--------------------|
| Casing and Cementing | | | | | | | |
| Surface Casing | | 600 | Meters | \$220 | 339.7 mm 90.78 kg/m J-55 | \$132,000 | \$132,000 |
| Attachments and Accessories | | 60 | Each | \$25 | Scratchers, centralizers, float equip | \$1,500 | \$1,500 |
| Tongs | | 600 | Meters | \$8 | Crew and Equipment | \$4,800 | \$4,800 |
| Cement and Service | | 600 | Meters | \$40 | Pumping, tonnage, additives | \$24,000 | \$24,000 |
| Intermediate Casing | | 3340 | Meters | \$263 | 244.5 mm 79.6 kg/m L-80 | \$878,086 | \$878,086 |
| Attachments and Accessories | | 334 | Each | \$25 | Scratchers, centralizers, float equip | \$8,350 | \$8,350 |
| Tongs | | 3340 | Meters | \$5 | Crew and Equipment | \$16,700 | \$16,700 |
| Cement and Service | | 3340 | Meters | \$30 | Pumping, tonnage, additives | \$100,200 | \$100,200 |
| Production Casing | | 4500 | Meters | \$100 | 177.8 mm 43.20 kg/m L-80 | \$0 | \$450,000 |
| Attachments and Accessories | | 450 | Each | \$25 | Scratchers, centralizers, float equip | \$0 | \$11,250 |
| Tongs | | 4500 | Meters | \$6 | Crew and Equipment | \$0 | \$27,000 |
| Cement and Service | | 4500 | Meters | \$30 | Pumping, tonnage, additives | \$0 | \$135,000 |
| Abandonment Cement | | 2 | Plugs | \$6,300 | Pumping, tonnage, additives | \$12,600 | \$0 |
| Cement Plug Logging | | 2 | Plugs | \$5,250 | Run plug logs, all in | \$10,500 | \$0 |
| Total | | | | | | \$1,188,736 | \$1,788,886 |
| Completion and Testing | | | | | | | |
| Wellhead | | 1 | Each | \$30,000 | Type and accessories | | \$30,000 |
| Tubing | | 4300 | Each | \$36 | 88.9 mm 13.85 kg/m, J-55 SML | | \$154,714 |
| Packers, Plugs, | | 1 | Each | \$45,000 | Anchors, packers, profiles, nipples | | \$45,000 |

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| | | | | | |
|-----------------|-----|-------|----------|--|---------------------|
| Service Rig | 10 | Day | \$7,836 | Daily rig rate all in | \$78,360 |
| CSA | 10 | Day | \$1,140 | Subsistence and accommodation | \$11,400 |
| Crew | 10 | Day | \$300 | Mileage, bus or air | \$3,000 |
| Hauling and | 10 | Day | \$3,000 | Tubing and other equipment | \$30,000 |
| Vacuum Truck | 10 | Day | \$1,200 | Rig days plus prod test days | \$12,000 |
| Water and | 10 | Day | \$1,000 | Water access and supply | \$10,000 |
| Completion | 160 | Cubic | \$200 | Reformate, KCl, MeOH | \$32,000 |
| Surface | 1 | Each | \$12,000 | Rotating heads, frac heads etc. | \$12,000 |
| Downhole | 1 | Each | \$10,000 | mud motors, packers, frac strings | \$10,000 |
| Cased Hole | 1 | Each | \$12,000 | CBL etc. | \$12,000 |
| Perforating and | 1 | Each | \$30,000 | TCP/Csg guns | \$30,000 |
| Wireline | 4 | Runs | \$6,000 | Gauge ring, run and pull recorders | \$24,000 |
| Stimulation | 1 | Each | \$80,000 | Acid | \$80,000 |
| Completions | 12 | Day | \$1,700 | Daily rate all in | \$20,400 |
| Inspection / | 10 | Each | \$1,500 | Environmental, operational, | \$15,000 |
| Environmental | 2 | Each | \$1,000 | Technician | \$2,000 |
| Lease and Road | 10 | Day | \$500 | Crew and Equipment | \$5,000 |
| Production Test | 8 | Day | \$5,500 | Includes equipment, crews and | \$44,000 |
| Fluids Analysis | 4 | Each | \$500 | Oil, gas and water | \$2,000 |
| | | | | Subtotal Completion | \$662,874 |
| | | | | Contingency @ 5 % | \$33,100 |
| | | | | Miscellaneous @ 2 % | \$13,300 |
| | | | | Overhead on Subtotal @ 3,2,1 | \$8,600 |
| | | | | Total Completion Estimate | \$717,874 |
| | | | | Total Drill, Case and Complete Estimate | \$17,732,675 |

Hydraulic Fracturing & Associated Costs

As stated previously, hydraulic fracturing may be utilized by a production company to extend the productive lifecycle of a well site. In fact a well may be hydraulically fractured multiple times throughout its lifecycle to maximize total production. However, hydraulic fracturing requires additional materials, technologies, expertise, and regulatory approvals. As such, there are considerable costs with hydraulic fracturing a well site. In certain circumstances, these costs may match or exceed the costs of drilling the original well.

PRODUCTION

Major Components

Storage Tanks

Tanks for containing produced well fluids (water and oil) are fabricated in a variety of sizes and configurations depending upon what purpose the tank is being utilized. The type of construction as well as the materials used to build the storage tank will largely depend upon the substance being contained as well as the local environmental conditions. Plastic, fiberglass and steel are all common materials for smaller capacity tanks, and larger capacity storage tanks, are field assembled of steel and custom engineered for each site application. A sample listing of storage capacities for large scale vessels is included below.

Figure 3.6 Nominal Capacity of Welded Storage Tanks

| Diameter, ft | Height, 20 ft [6.1 m] Capacity | | Height, 30 ft [9.1 m] Capacity | | Height, 40 ft [12.2 m] Capacity | | Height 50 ft [15.2 m] Capacity | | Height 60 ft [18.3 m] Capacity | | Diameter, m |
|-----------------|--------------------------------------|------------------|--------------------------------------|------------------|---------------------------------------|------------------|--------------------------------------|-----------------|--------------------------------------|-----------------|----------------|
| | Mbbl* | m ^{3**} | Mbbl* | m ^{3**} | Mbbl* | m ^{3**} | Mbbl* | m ^{3*} | Mbbl* | m ^{3*} | |
| 20 | 1.1 | 178 | 1.7 | 267 | 2.2 | 356 | 2.8 | 445 | 3.4 | 534 | 6.1 |
| 25 | 1.7 | 278 | 2.6 | 417 | 3.5 | 556 | 4.4 | 695 | 5.2 | 834 | 7.6 |
| 30 | 2.5 | 400 | 3.8 | 600 | 5.0 | 801 | 6.3 | 1,001 | 7.6 | 1,201 | 9.1 |
| 35 | 3.4 | 545 | 5.1 | 817 | 6.9 | 1,090 | 8.6 | 1,362 | 10.3 | 1,635 | 10.7 |
| 40 | 4.5 | 712 | 6.7 | 1,067 | 9.0 | 1,423 | 11.2 | 1,779 | 13.4 | 2,135 | 12.2 |
| 45 | 5.7 | 901 | 8.5 | 1,351 | 11.3 | 1,801 | 14.2 | 2,252 | 17.0 | 2,702 | 13.7 |
| 50 | 7.0 | 1,112 | 10.5 | 1,668 | 14.0 | 2,224 | 17.5 | 2,780 | 21.0 | 3,336 | 15.2 |
| 55 | 8.5 | 1,345 | 12.7 | 2,018 | 16.9 | 2,691 | 21.2 | 3,364 | 25.4 | 4,036 | 16.8 |
| 60 | 10.1 | 1,601 | 15.1 | 2,402 | 20.1 | 3,202 | 25.2 | 4,003 | 30.2 | 4,804 | 18.3 |
| 65 | 11.8 | 1,879 | 17.7 | 2,819 | 23.6 | 3,758 | 29.6 | 4,698 | 35.5 | 5,638 | 19.8 |
| 70 | 13.7 | 2,179 | 20.6 | 3,269 | 27.4 | 4,359 | 34.3 | 5,449 | 41.1 | 6,538 | 21.3 |
| 80 | 19.7 | 2,847 | 26.9 | 4,270 | 35.8 | 5,693 | 44.8 | 7,117 | 53.7 | 8,540 | 24.4 |
| 90 | 22.7 | 3,603 | 34.0 | 5,404 | 45.3 | 7,206 | 56.7 | 9,007 | 68.0 | 10,808 | 27.4 |
| 100 | 28.0 | 4,448 | 42.0 | 6,672 | 56.0 | 8,896 | 69.9 | 11,120 | 83.9 | 13,344 | 30.5 |
| 110 | 33.9 | 5,382 | 50.8 | 8,073 | 67.7 | 10,764 | 84.6 | 13,455 | 101.6 | 16,146 | 33.5 |
| 120 | 40.3 | 6,405 | 60.4 | 9,607 | 80.6 | 12,810 | 100.7 | 16,012 | 120.9 | 19,215 | 36.6 |
| 130 | 47.3 | 7,517 | 70.9 | 11,275 | 94.6 | 15,034 | 118.2 | 18,792 | 141.8 | 22,551 | 39.6 |
| 140 | 54.8 | 8,718 | 82.3 | 13,077 | 109.7 | 17,436 | 137.1 | 21,795 | 164.5 | 26,153 | 42.7 |
| 150 | 62.9 | 10,008 | 94.4 | 15,012 | 125.9 | 20,015 | 157.4 | 25,019 | 188.8 | 30,023 | 45.7 |
| 160 | 71.6 | 11,387 | 107.4 | 17,080 | 143.2 | 22,773 | 179.1 | 28,466 | 214.9 | 34,160 | 48.8 |
| 180 | 90.6 | 14,411 | 136.0 | 21,617 | 181.3 | 28,822 | 226.6 | 36,028 | 271.9 | 43,233 | 54.9 |
| 200 | 111.9 | 17,791 | 167.9 | 26,687 | 223.8 | 35,583 | 279.8 | 44,479 | 335.7 | 53,374 | 61.0 |
| 220 | 135.4 | 21,528 | 203.1 | 32,291 | 270.8 | 43,055 | 338.5 | 53,819 | 406.2 | 64,583 | 67.1 |
| 240 | 161.1 | 25,620 | 241.7 | 38,430 | 322.3 | 51,239 | 402.9 | 64,049 | 483.4 | 76,859 | 73.2 |
| 260 | 189.1 | 30,068 | 283.7 | 45,101 | 378.2 | 60,135 | 472.8 | 75,169 | 567.4 | 90,203 | 79.3 |
| 280 | 219.3 | 34,871 | 329.0 | 52,307 | 438.7 | 69,742 | 548.4 | 87,178 | 658.0 | 104,614 | 85.4 |
| 300 | 251.8 | 40,031 | 377.7 | 60,046 | 503.6 | 80,062 | 629.5 | 100,077 | 755.4 | 120,092 | 91.5 |

*Mbbl = 1,000 API bbl, **m³ = cubic meters, API bbl = 42 gal, 1 m³ = 6.29 bbl

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A typical oil field tank will be between 100 bbl. and 1,000 bbl., with be shop fabricated and skid mounted (i.e. transportable on a self-erecting frame). The majority of storage tanks used in Saskatchewan oil fields are 400 bbl. on self-supporting skids.

Storage Bullets

Horizontal mounted storage bullets are located on-site and contain Liquefied Petroleum Gas (LPG). LPG bullets are intended to store pressurized gases, typically, butane and propane, under pressure they become a liquid which is the safest state for transportation. Ideally, tanks are filled approximately to 85% of their volumetric capacity. The extra capacity is meant to account for the changing volumes of the gas due to ambient temperature fluctuations. There is an opportunity to reduce the temperature using a refrigeration storage process, resulting in decreased pressure, but at an increased operating cost.

Figure 3.7 Typical Horizontal Storage Bullets



Line Heaters

For higher pressure production, line heaters may be required to ensure the product flows through the production equipment without problems. After the wellhead, a pressure let down valve (choke valve or regulating valve) may be used to drop the pressure to so that a lesser expensive equipment configuration can be used. The pressure drop causes a cooling effect in the product, known as the Jules Thompson (JT) effect, which can cause freezing in the piping and equipment. A line heater re-heats this cooled product to keep the product flowing safely and decrease the likelihood of a freeze up.



(American Petroleum Institute, 2002)

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Separation

The fluid that is discharged from the wellhead is not typically a single state oil or natural gas. Instead, it is produced as an emulsified fluid containing oil, water and gas that will need to be separated into their base streams. There are various mechanisms to create such a separation, ranging from the use of gravity, the application of heat, applying centrifugal force, or the addition of chemicals. Gravity separation is the most commonly used style in typical oil field installations,

Separators

A separator is a pressure vessel that is utilized for the dissolution of the emulsion fluid produced by the oil well into gas and liquid components using a gravity separation method. Generally, the separator is the first vessel that the emulsified well fluid enters after it is drawn from the ground via the production well.

Separators typically fall into four main categories: the two primary categories vertical separators or horizontal separators. As the name implies vertical separators are orientated skywards while horizontal separators are designed to be installed parallel to the ground. Images of both types are shown in figure 3.8 and 3.9. Both vertical and horizontal separators are then identified as either two phase separators, which separate gas from liquids, or three phase separators, which are capable of separating gas, oil and water.

Another type of separator is a Free Water Knock Out or FWKO, which is used to drop out fluids from a gas stream that is going to be flared or vented. Depending on the process requirements, separators may be utilized in stages, with the first stage providing initial separation and the subsequent stages providing additional treatments to the oil, gas and water, typically at central processing facilities.

Figure 3.8 Typical Three Phase Vertical Separator Vessel

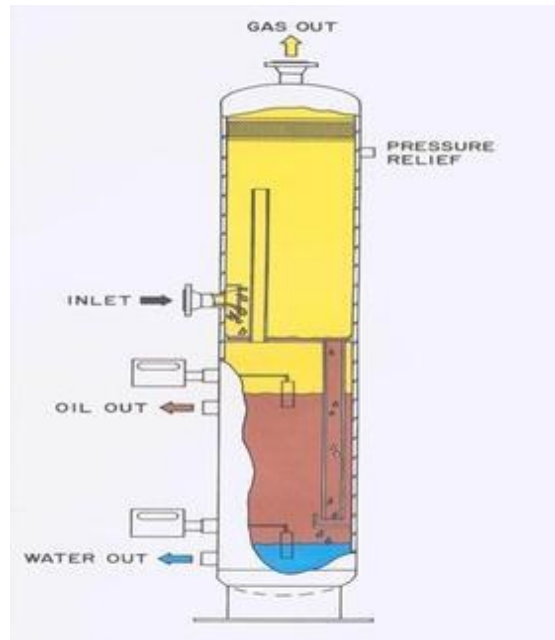
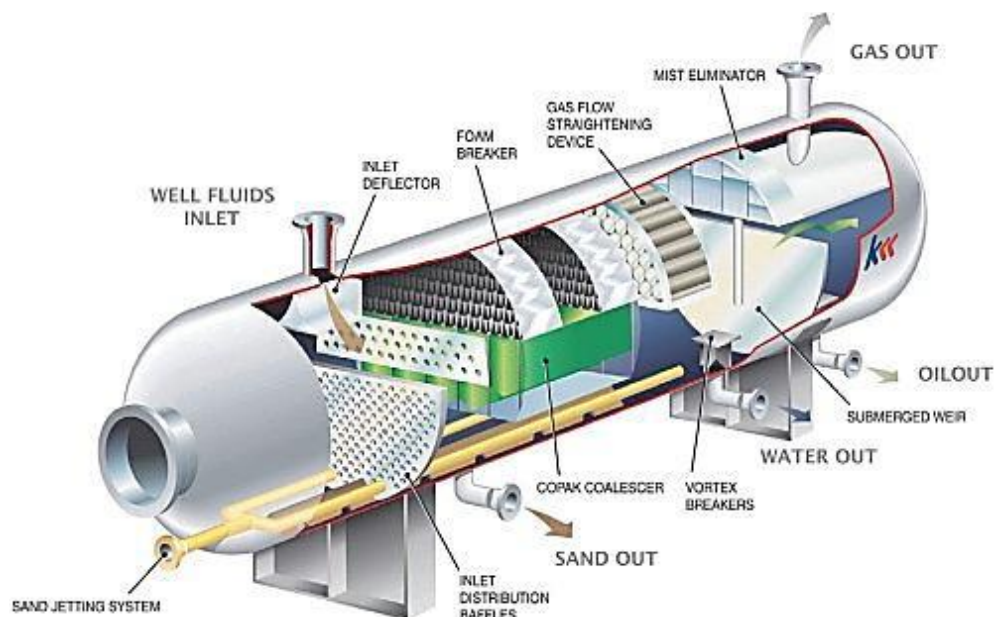


Figure 3.9 Typical Three Phase Horizontal Separator Vessel



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Generally, horizontal separators are used in larger, centralized facilities (or batteries), where vertical separators are the primary choice for well sites. Vertical separators at well sites can come in a wide range of sizes, but most commonly built separators (stock units) are roughly 8-12" in diameter, and 6-10 feet tall. These well site separators are usually packaged in a prefabricated skidded building that includes all of the required associated piping, metering, and chemical injection pumps.

The majority of packages built for typical well sites will be designed for both sour and sweet products, and capable of maintaining a pressure of at least 300# ANSI rating. This way, a fabricator can design a single unit for many installations.

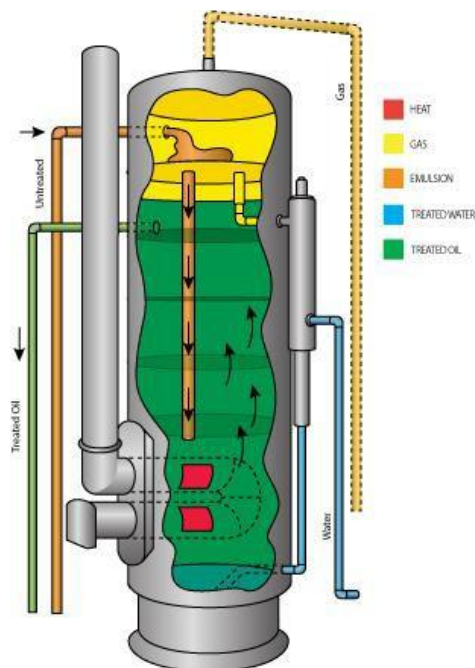
Heaters Treaters

Heater Treaters, as the name implies, are utilized to heat the emulsified product. Heating crude oil reduces the overall viscosity of the emulsion, creating the following benefits:

- The reduced viscosity assists in the coalescence process, as it also the dispersed water droplet to collide more quickly and thus be collected more efficiently
- The addition of heat assists in the dissolving of the paraffin wax crystals that may be emulsifying the well fluid. The removal of the wax from the fluid will assist in preventing the buildup of the paraffin in the production equipment or pipelines
- Increasing the amount of heat increases the difference in density between the oil and water improving the amount of separation between the fluids. However, this is dependent upon the API Gravity of the crude oil as very low API gravity crude oils may become less dense than water in certain circumstances when heated.

The most common design configuration for a treater is the Vertical Heater Treater. As indicated by its name, this design features an integrated heating element and the application heat serves to break up the emulsified fluid into its basic components. With the Vertical Heater Treater, the emulsified fluid enters into the top of the vessel and is filtered through a series of baffles until the fluid reaches the heated chamber where the applied heat causes the oil and gas to diffuse from the water molecules. The relatively dense water molecules will collect at the bottom of the vessel, while the comparatively less dense oil particles will rise and collect above the water layer, low density gas will also collect at the top of the vessel. The figure below depicts a basic treater:

Figure 3.10 A Typical Heater- Treater



It is important to realize however, that there are some drawbacks to heating the crude oil, as the addition of heat may cause the light ends of the oil to be boiled off, leaving only the lower API Gravity oil. The producer must also consider the added cost of heating the emulsified fluids in their operating expenses.

Gas Treatment

Gas Scrubbers

A gas scrubber is essentially a 2 phase separator, used to further separate the suspended liquid particulates that may still be present in the gas stream. Scrubbers are used to further “dry” fuel gas, prior to its use in well site burners or instruments, or prior to gas entering a compressor. Water condensing in a compressor has the potential to damage the compressor itself, causing downtime and loss of production. As with a separator, scrubbers normally work on gravity and retention based separation method.

Other types of scrubbers will use a desiccant bead or water solution to strip the water from the gas stream. These also go by names such as “dryers” or “desiccant dryer/filter”.

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Sweetening Systems

Where sour gas is present, sweetening “pots” can be used to scrub the H₂S (sour) gas from the produced stream, where flaring is not desirable. These units range in size depending on the required flow rates, but are more typically installed after the PSV (pressure Safety Valve) to ensure there are no off lease odours. This equipment uses a desiccant to scrub the H₂S from the gas stream.

Flare Systems

A flare system is used to dispose of unwanted gas components to the atmosphere in a safe and controlled combustion process. Flaring can be used as a part of production testing, routine operations, or in the case of emergency to reduce pressure within the system. A flare system typically consists of the following components:

- An Ignition Source
- Pressure-Vacuum Valve
- Flashback Protection, or flame arrestor
- Knockout Drum, discussed previously as FWKO, or Flare Knock Out Drum (FKOD)
- Gas Outlet
- Collection Piping

Flare stacks will vary in size, depending on the BTU/hr. of the gas and potential flow rate, to ensure the heat at the ground is below certain levels.

It should be noted, that Saskatchewan currently has two directives pertaining to flaring operations in the oil and gas sector in a draft form:

- Directive S-10 Saskatchewan Upstream Petroleum Industry Associated Gas Conservation
- Directive S-20 Saskatchewan Upstream Flaring and Incineration Requirements

While these directives are only partially in effect, they will be fully implemented into the Saskatchewan marketplace by July 2015. The intent of these policies is to decrease the amount of gas that is flared off during the oil production process and as a result reduce the amount of greenhouse gas generated during operations. By implementing these policies Saskatchewan will bring their flaring and venting standards into a close approximation of those that exist in Alberta, albeit in a simplified form.

With the full implementation of these two policies, it is expected that Saskatchewan will see an increase in demand in terms of requirements for services and technologies that promote the conservation, gathering and processing of gas during production operations. As well as, an

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increase environmental and engineering services as new and existing production facilities are brought into line with the new requirements.

Compressors

A variety of compressors may be used in the oil and gas production process depending upon the stage of operation as well as the requirements of the production organization. Types of compressors include:

- Flash Gas Compressors
- ReInjection Compressors
- Booster Compressors

For the purposes of this report, only the Booster compressor type will be discussed, as Vapor Recovery/Flash Gas and ReInjection compressors are installed in large scale facilities.

Booster Compressors

Booster compressors are integrated into the upstream gas gathering systems and pipelines, to prevent the pressure from declining during transmission. As such, booster compressors are typically used to assist in the transfer of gas at high rates but at comparatively low compression rates. There are many kinds of booster compressors used in gas field applications, each with a different strength/horsepower to be used in different instances. In low pressure gas applications, screw compressors are widely used. Reciprocating compressors are the “work horse” used to boost the gathering system to the plant and to sell the gas. Larger centrifugal compressors are quite expensive, and are utilized more in gas transmission applications.

Ancillary Equipment

Pumps

Pumps of many sizes and functions are present within the various production facilities. The majority of the pumps within the production facility will be either of the centrifugal variety, due to the advantages flow consistency and mechanical reliability that this design features, or of the Positive Displacement (PD) variety, due to their large pressure gains with minimal flow. Progressive cavity pumps have also become more prevalent in the industry due to their capability of pumping two phase flow (gas and oil combined). Pumps can be used in various applications, with the most common being for fluid transmission and chemical injection.

Of particular note is the integral role that pumps play within the Artificial Lift process. When the pressure within the oil reservoir is not sufficient to raise the oil to the surface, artificial lift techniques will be employed, as described in Section 2.

Supporting Equipment & Materials

In addition to the major equipment listed within this report, numerous other equipment and materials are required within a production facility. The exact components will be determined by

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the type of oil and gas being produced, the scope of the facility, the nature of supporting infrastructure, the conveyance method for the product as well as the preference of the organization operating the facility. Such components consist of:

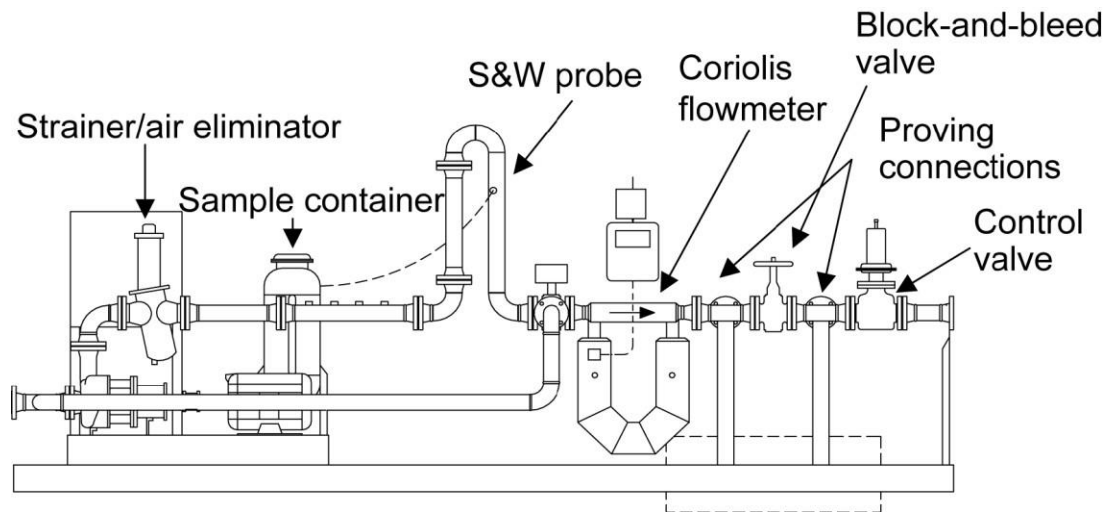
- **Strainers**
As the name implies, a strainer acts as barrier to solid particulates, preventing such debris from negatively impacting other pieces of equipment. Strainers are commonly used at start-up activities to ensure construction debris doesn't enter sensitive equipment, but they can also be located throughout the process, typically in front of equipment such as meters, compressors, pumps and LACT units.
- **Metering Devices**
The following other devices may be located within a production facility to quantify the amounts of fluid being transferred within the facility.
 - Meter Runs
 - Orifice Gas Meters
 - Turbine Flowmeters
 - Coriolis Meters
 - Positive Displacement Flowmeters
 - Differential Pressure Flowmeters
- **Valves**
Due to the variety available, it is difficult to account for all the possible valve types and combinations that could be installed within a production facility. Each valve has its own specific uses, strengths and ideal applications. Below is a sample of the more common valve types in the oil and gas industry.
 - Choke Valves
 - Ball Valves
 - Gate Valves
 - Check valves
 - Globe Valves
 - Rotary Valves
 - Piston Valves
 - Needle valves
 - Butterfly valves

Valves and piping can be one of the larger material costs on a project. In addition to these items, other piping components are required, including the pipe itself, various fittings, flanges, bolts and gaskets. The common bulk materials can be easy to source, and a number of suppliers will stock the more common items.

Lease Automatic Custody Transfer (LACT) Units

The primary function of the Lease Automatic Custody Transfer (LACT) unit is measure, sample and transfer the produced oil from the production facility into the pipeline. In circumstances where a local pipeline is unavailable, the LACT unit can be utilized to fill trucks or rail tanker cars directly, however, this is uncommon.

Figure 3.11 Simplified Lease Automatic Custody Transfer (LACT) Unit



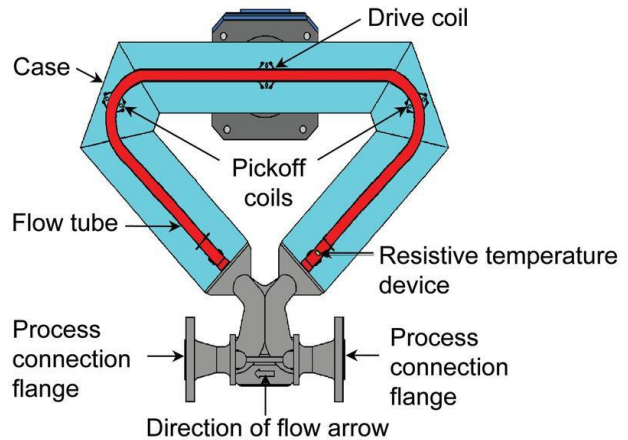
The LACT Unit is assembled as a chain of components, the standards of which consist of the following:

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- Meters

The meter is considered to be the most important component of the entire LACT unit. The meter measures the production stream in order to monitor both quantity and quality of oil. These are typically of the Positive Displacement or Turbine variety. However, most new units will feature a Coriolis meter, which has the benefits of containing no moving parts and being comparatively inexpensive. An example of a Coriolis meter is included to the right:



- Charge Pump & Motor

The charge pump provides the mechanism that conveys the liquid through the LACT Unit. Similar to the rest of the pumps that are required within the production facility, centrifugal pumps are typically used within the LACT unit. Gear based pumps can also be used, provided that the supporting infrastructure is also in place.

- Sediment & Water Monitors

The Sediment & Water Monitor (SW Monitor) is utilized to monitor for the presence of any remaining water with the oil stream. The parameters for acceptable water content within the oil stream will vary across organizations and is largely based upon the pipeline contracts, and density of the oil. In the event that the water content of the stream exceeds the established parameters then SW monitor will trigger an alarm and divert the flow from the pipeline.

- Sampling System

The sampling system is used to draw small quantities of the oil flow for testing to determine the specific API gravity and other details.

- Valves

Valves are mechanical devices to reduce or completely stop the flow of a liquid or gas. In the LACT Units, the following valves types are utilized:

- Block & Bleed Valves

Block and Bleed valves are intended to completely prevent the flow of liquid through the LACT unit in its entirety. A block & bleed valve is a compound of two different valves types, typical of the ball and needle valve varieties. The compound valves are utilized within the LACT unit chain before the presence of devices such as monitors or switches. Block & Bleed valves are also used to isolate

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these downstream components from the upstream fluid either to allow for sampling or maintenance.

- Control Valves

The Control Valve is a valve that is used to for the control the flow and pressure of the oil within the LACT unit prior to the fluid being allowed to enter into the pipeline. The amount that the control valve's aperture is allowed to open is dictated by the control panel, which is operated either automatically based upon sensor data or by a trained operator.

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ESTIMATE OF PRODUCTION COMPONENTS

The following is a detailed breakdown of the expected costs for the casing of a new horizontal well at the same site as the detailed drilling estimate.

| Component | Specifications | Cost |
|---|--|--|
| Storage Tank | <ul style="list-style-type: none">• 400 BBL.• (4) 12'-0" O.D. x 20'-0" high tank• 1/4" thick bottom• 3/16" thick cylindrical shell• 3/16" thick self-supporting roof standard• (3) saddle "L" type skid assembly• (2) lifting lugs | ~\$ 43,202.00 (each) |
| Propane Storage Bullet (bullet only) | <ul style="list-style-type: none">• 30,000 Gal capacity | ~\$200,000 (each) Or \$2,000 per month (rental fee) + \$4,200 (delivery fee) |
| Separator Package | <ul style="list-style-type: none">• (1) Sweet service• Ski Mounted 300 #2Phase horizontal group separator• c/w self-framed building• Electrical wiring• Instrumentation• Valves• Piping• Exhaust Fan• Vents / Drains | ~\$260,080 (each) |
| Gas scrubbers | <ul style="list-style-type: none">• (1): Sweet service• c/w self-framed building• electrical wiring• instrumentation• valves• piping• exhaust fan• vents /drains | ~\$260,000 (each) |
| | | |

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| | | |
|--|---|------------------|
| Flare Stack | <ul style="list-style-type: none"> • "6" x40' tall self-supporting flare stack with integral KO section • Wind Shroud • 316 SS Sch.40 material using slipstream concept • Stack Tip, 3' of 6" 316 SS welded onto stack flare • Stack Flue • A106B smls pipe (20' of 8", 12' of 6") | ~\$13,244 (each) |
| Pumps | | |
| Vertical Multi-Stage Pumps | <p>Possible Configurations</p> <ul style="list-style-type: none"> • Strokes from 75 mm (3 in) to 250 mm (10 in) • Flows to 1140 m³/h (5000 gpm) • Power to 3450 kW (4625 hp) • Standard pressures to 619 bar (8975 psi) • Temperatures from -40°C (-40°F) to 350°C (660°F) • Speeds to 530 rpm | ~\$5,867 (each) |
| 101T Pump Skid | <p>Possible Configurations</p> <ul style="list-style-type: none"> • Rear mount • V-Belt drive • Pump unitization (including skid and guard c/w motor/pump alignment structural skid to be sand blasted • Painted warm grey | ~\$5,330 (each) |
| Horizontal Slurry injection pumps | <p>Possible Configurations</p> <ul style="list-style-type: none"> • Flows to 10 000 m³/h (44 000 gpm) • Heads to 90 m (300 ft) • Pressures to 50 bar (725 psi) Temperatures to 120°C (250°F) • Solids from 2% to 70% by weight | ~\$14,500 (each) |

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METHODS OF TRANSPORTATION

Within Saskatchewan, there are three primary methods used to transport oil and gas to market. These are Pipelines, Truck, and Rail.

Pipelines

Within Canada, approximately 97% of all oil and gas products are shipped via pipeline. The four major types of pipelines are as follows:

- **Flow Lines**
Flow lines are short distance pipelines utilized to convey petroleum products from the wellheads to the production facilities or into appropriate storage facilities. As these lines will be handling the crude product, the lines must be able to handle the product in its raw emulsified state.
- **Feeder Lines**
Feeder Lines function as an intermediary pipeline, conveying the petroleum products from the processing facilities or storage tanks to the Transmission lines.
- **Transmission Lines**
The largest in diameter of the pipelines, Transmission lines are the long distance transportation lines that carry the petroleum product thousands of kilometers, often across countries or even continents in order for distribution or refinement. Transmission lines must be divided by product type. For example, natural gas is only transported in natural gas transmission lines. However, both crude oil and refined oil can be transported in the same line, provided that this is accomplished in batches with separation between the products. Due to the distances that the product must travel within the pipeline, the pressure generated at the beginning of the line would be completely diminished long before the product reached its destination. As such, pressure boosting equipment is stationed at pipeline pumping or compressor stations placed at key distances along the line in order to maintain the necessary pressure.
- **Distribution Lines**
Distribution lines are used to convey natural gas from distribution points to locations where the natural gas is to be utilized or the "end user", typically businesses, industries, or even personal residences.

Pipelines require significant investment, both in terms of capital expense and lead time from design to implement and construction. Furthermore, pipelines are heavily regulated by both provincial & federal governments across the lifecycle of the line and often require substantial reviews and approvals which may lead to delays in the construction process. At present, CAPP estimates that Canada faces a period of three to five years of constrained pipeline capacity due to extended regulatory process delaying several major pipelines. Regulatory timing can be

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the longest process for larger transmission lines, but the shorter pipelines aren't reviewed to the same detail.

Notable Parameters:

- Land, regulatory, environmental
- Leak Detection
- Emergency Response Plans
- Excavators and heavy equipment rental
- Clearing of right of ways, and other construction requirements.
- Hydraulic testing
- Pipe bends and risers – bends can be the longest lead item if special radius bends are required. Induction bending shops are a premium.

Pigging Equipment

Pigging is the activity of running a mechanical device known as a “Pig” through a pipeline for the purposes of cleaning, chemical treating, inspection and maintenance without interrupting the flow of product within the pipeline.

Pigs

Pigs refer to a multitude of devices that are inserted into oil and gas pipelines, in order to provide a variety of maintenance roles within the line. Typically, pipeline pigs are used to perform cleaning, coating, inspection, and debris removal within the pipeline. The design of the pig is largely based upon the role that the pig will be performing; a selection of various pigs is featured to the right:



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Pigs that are used in cleaning and drying are comparatively simple, ranging from simple spherical shapes to the slightly more complex tubular brushing systems. However, modern technology has resulted in the creation of “Intelligent” or “smart” pigs. Primarily used for pipeline inspection and integrity monitoring, these smart pigs can be equipped with a complex suite of electronics, including cameras, magnetic and ultrasonic sonic sensors, as well as the onboard data storage. As such, these intelligent pigs are able to recover detailed data on the current state of pitting, corrosion, defects, cracks and debris buildup within the pipeline. An intelligent pig being loaded to large natural gas pipeline is depicted below:



Pigging Facilities

In order to successfully deploy a pig into the pipeline without impacting the flow of oil or natural gas, the appropriate pigging facilities must be installed at periodic intervals along the pipeline. Typically, such facilities will consist of a launching platform (as depicted above) as well as a receiver to remove the pig from the pipe once it has completed its run. In the majority of circumstances, a typical run for a pig is approximately 80 to 160 kilometers as longer runs may result in the friction deteriorating the pig to such an extent that the pig may become stuck, or deteriorate to the point of being ineffective. The pig launcher is a length of attached pipe that is of a wider diameter to that of the pipeline, and has a closure apparatus installed on the exposed end of the launcher, designed to reduce blowout potential. It is through this opening that the pig is inserted. The closure is then sealed and the pressure between the pig launcher and the pipeline is equalized before the barrier between the lines is opened. The pig launcher must also have a pressure indicator, as well as, venting and draining valves.

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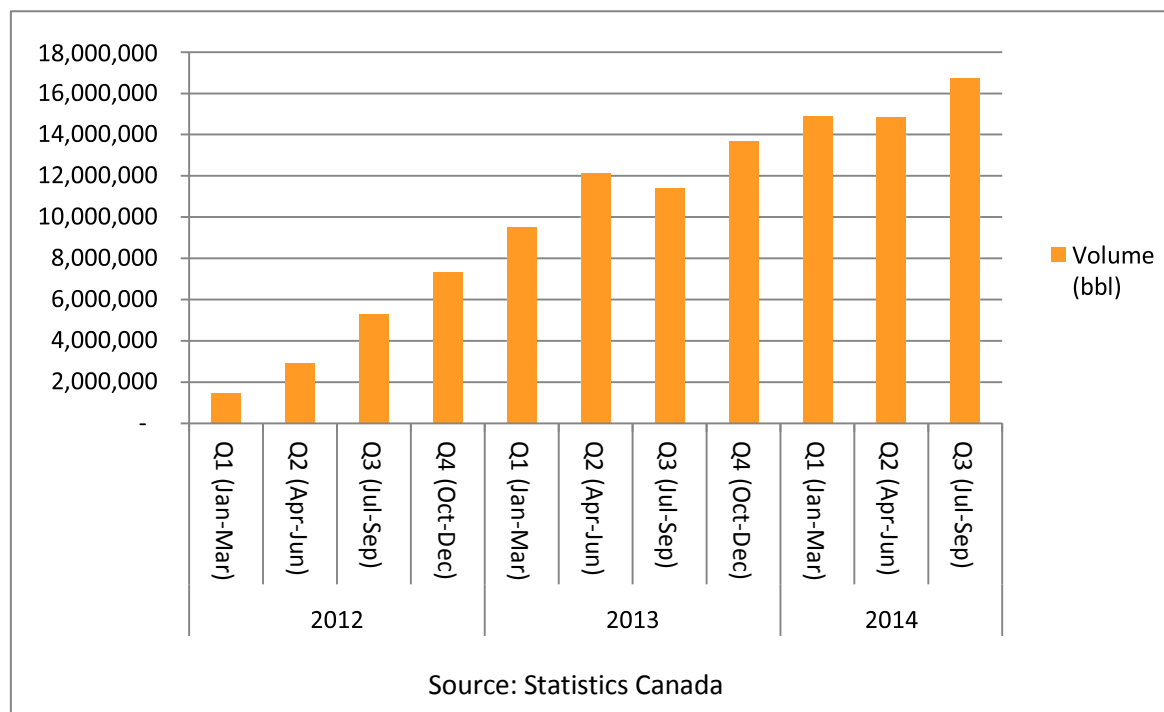
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The pig receiver, functions in largely the same capacity as the pig launcher, and features the same components. Typically, pig launchers and receivers are incorporated into the infrastructure at pipeline stations and production facilities.

Rail Car

Due to the growing constraints on the capacity of the pipelines within Canada, hydrocarbon producers are turning to rail transport to convey their products to their destinations. The graphic below demonstrates the rapid growth within the oil industry by rail transportation in Canada.

Figure 3.12 Canadian Crude Oil Exports by Rail by Quarter



One of the primary causes for this increase in rail transportation is the shift away from using the manifest shipping system for the distribution of oil products. In the Manifest system, petroleum carrying cars are attached to larger trains conveying a multitude of other products, such as agricultural or manufactured goods. These trains make numerous stops in order to offload these other products or to pick up additional products. However, the industry has now adopted the more efficient Unit train system, in which the petroleum products are shipped directly from the point of origin to the final destination exclusively with other petroleum products.

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Trucking

The third option for the transportation of crude oil is via the use of transport trucks. Due to their comparatively high cost per unit volume, trucks were not typically utilized to haul large volumes of crude over long distances. For instance, in 2012, the average distance of a shipment of crude petroleum product by truck was only 118 kilometers in Saskatchewan. This distance represents approximately a third the average distance of a shipment of other dangerous goods, which was approximately 313 kilometers. It should also be noted that the average single tank trailer is only capable of holding 200 barrels of oil, less than a third of the capacity of a rail tanker car.

Rather, in situations where other transportation options are nonexistent or practical, trucks are utilized for the purposes of transporting raw oil to storage facilities for distribution. Once at a storage facility, the raw product will then be loaded to either pipelines or rail cars for long distance transportation.

Another possibility for the use of truck transport in handling of crude oil is in the process of transloading. Transloading is the process of moving a product from one form of transportation directly into another. For crude oil, this typically indicates the loading of a rail car or feeder pipeline directly from the tanker truck.

However, due to the increasing constraint of the available capacity of both pipelines and rail cars, more producers are being forced to increasingly utilize transport trucks to move their crude oil.



4.0 POTENTIAL AREAS OF ENTRY INTO THE SASKATCHEWAN OIL & GAS SECTOR

After evaluating the life cycle of a well, the required goods and services, and the services currently provided within the province, one can identify areas where existing companies, new ventures, or individuals can enter the oil and gas supply chain. Some items listed in these categories could be used throughout multiple stages of a well's lifecycle.

In addition, to the information provided within the paragraphs below, four summary tables have been produced that depict possible entry strategies into the oil & gas sector. While not all encompassing, these sample strategies provided some level of insight to interested parties. The table have been sorted and colored coded as follows:

- **GREEN** – Moderate investment and training required for new venture or repurposing of existing venture
- **YELLOW** – Areas where existing merchants could break in to the oil and gas marketplace by shifting focus.
- **ORANGE** – Larger capital investment requirement and larger risk. More competition with established providers. However, in a better market, demand may allow inroads for these types of suppliers
- **GREY** – These are services that require a degree of specialty training or an aptitude towards a given field. Once trained, a person would be able to join an existing company that provides those services or alternatively pursue a start-up venture in order to offer those services to the oil & gas sector.

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For companies or individuals interested in investing into a new venture, or re-tooling an existing operation, the following areas could be considered. These offer inroads into the industry requiring relatively minimal capital, risk, and training.

Summary Table:

| Service Type | Examples | Good / Service Provided |
|---|---|---|
| Coiled Tubing Units, Small Filters, Other Small Assemblies | 2-3/8 to 3-1/2 In. Coiled tubing, CMS 80K Coiled Tubing Injector, V95K HP Coiled Tubing Injector, Air filtration units, | Used in drilling and areas of operations/production, these small units can be fabricated with minimal tool requirements in comparison to some larger equipment. |
| Hydrovac Trucks | Guzzler Guzzavator, Presvac Hydroexcavator, Custom Vac Hydrovac | While the capital cost may be higher for these units, purchasing one truck for a new venture may prove lucrative in an area where a larger provider is not present. A new entry could also be added to an existing fleet as a contract service. |
| Pumping Equipment: Installation and Startup | Decanter Centrifuges, Submersible Pumps, | Pumps of various capacities and sizes are utilized through the production facility. While competition to provide such services is relatively high, firms that provide pumps for other industries will find relatively few barriers to entry. |
| Rig Matting | Eco-Mats, Ground Access Mats, Swamp Mats | Rig mats are a high demand product across a multitude of industries, including the oil & gas sector, which are comparatively straight forward in terms of fabrication. Opportunities to repair and reuse damaged rig mats also exist. |

It is important to realize how that given the downturn in the oil & gas market within Saskatchewan, that even these comparatively accessible areas of entry are going to undergo increasing competition as fewer projects will be available.

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Some entries may require larger capital investments and would take on a higher hurdle to enter the market. For this category, an established company may be better suited to create new offerings to the Oil and Gas Industry and create inroads. Retooling industrial manufacturing for the oil and gas industry, or repurposing existing equipment for a new function could prove to be a good investment in order to enter the oil and gas supply chain.

Summary Table:

| Service Type | Examples | Good / Service Provided |
|---|---|--|
| Maintenance, Tooling, Repair, Retrofit | Maintenance Shops, Machining Shops, | Existing and established machine shops or millwrights may be able to break into the marketplace by retooling their existing offerings to a new clientele. Local shops may be able to provide more custom services to local producing facilities, and may be preferable to a producer versus needing to ship items to a centralized, more established provider. |
| Equipment Rentals, Loaders, Dozers, Trucking, and Hauling | Frontend Loaders, Bulldozers & Bobcats, Backhoes, Tractor Trailer Units | Construction equipment and heavy haulers can be easily transferred to the Oil and Gas industry. Some investment may be required for new parts or safety devices, but otherwise the equipment and training are relatively transferable. |
| Remanufactured Wellhead Equipment | Repairs for Gate Valves, Mud Valves, Casing Heads, Tubing Hangers, Isolation Tools | As production firms seek to reduce expenses, reliance upon extending the life of existing equipment, as well as refurbished equipment, is expected to increase. Existing maintenance shops may find increasing opportunities to restore used equipment for the oil & gas sector, even though the current downturn. |
| Valve Installations, Service and Instrumentations Solutions | Gate Valves, Mud Valves, Ball Valves, Check Valves, Globe Valves | Valves and instrumentation solutions are similar to pumps, inasmuch that both components are used extensively throughout the most of a typical well's lifecycle. However, installing and servicing valves and instrumentation typically require a different expertise when compared to pumping components. |
| Prefabricated Building Components | Mobile offices, Workforce Housing, Fold-A-Way Metal Buildings, Pre-engineered Metal Buildings | The labour force required to produce prefabricated buildings is extensive. Those firms within the province that are already offering this service other industries should be able to offer their services to the oil and gas sector with a moderate amount of effort. |

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Other areas with the oil and gas sector are substantially less accessible to external parties. Often these sectors require both specialized knowledge and equipment, or feature the requirement for large capital investment. These service sectors are typically served by established providers, limiting the opportunities to enter into such segments. As such, the risk associated with attempting to enter into these market segments are much greater those mentioned previously. The recent downturn is likely to make entry into this category challenging. However, during boom periods, the market demand may allow for the development of new inroads by firms dedicated to expanding into the Oil and Gas supply chain.

Summary Table:

| Service Type | Examples | Good / Service Provided |
|----------------------------------|---|--|
| Service Rigs | CWC WTD 550PB Rig, SR242 Double-Triple Service Rig, Mobile Class II Freestanding Double Tubing Rig | The large capital and operational expenses associated with purchasing and operating a service rig make the possibility of expanding or entering into this segment difficult, due to competition and the high hurdle. The reduction of number of wells that are projected to be drilled in 2015, the competition amongst existing service providers is likely to increase. However, due to regulatory changes, the number of wells requiring servicing, abandonment, or decommissioning will keep this part of the industry busy, even in a downturn. |
| Oil and Storage Tank Fabrication | Horizontal Double Wall Tanks, Free Fracture Sand Storage, Rig Mud Storage Tanks | The fabrication of oil storage vessels requires a trained staff experienced in fabricating tanks to industry standards. Production companies typically utilize companies for this service with whom they have an established relationship and who have demonstrated expertise in meeting quality standards. Companies that have an existing knowledge in material welding would find this area easier to enter, but training in welding techniques and code requirements will be required. |
| Surface Equipment Rentals | Rental and Transport of Surface Equipment to Client Sites (Line Heaters, Pressure Vessels, Mobile Flare Stacks) | There is a myriad of possible equipment that can be rented to oil production companies. While certain equipment offerings present a more realistic entry point for potential service providers. Major component offerings typically require large amounts of capital to purchase as well as specific knowledge to maintain the rental equipment to industry standards. Such specialized equipment would include line heaters, pressure vessels, flare and vent stacks, as well as related equipment. |

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| | | |
|------------------------------|---|---|
| Equipment Fabrication | Manufacturing or assembly of Separator Units, Compressors Packages, Pump Assemblies | Large equipment, (such as separators, large production tanks, compressors packages, pump packages, line heaters, etc.) requires specialized knowledge in equipment design and fabrication, applicable codes and standards, and pressure vessel registration. Competing against a large and established provider will be difficult. However, an existing industrial fabrication shop could retool their operation to begin to offer some small types of equipment and equipment packages without needing to expand their operation or investing large capital dollars. |
|------------------------------|---|---|

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Removing the capital requirements to create a new offering in supply, the industry is always looking for skilled and qualified people that can be employed in the oil and gas industry. Welders, fabricators, and journeymen are needed on most job sites and will be required for companies looking to break into the new market. Power engineers and operators are needed to work on the well site facilities, and other skills are always needed to support the life cycle.

| Summary Table: | | |
|---|---|--|
| Service Type | Examples | Good / Service Provided |
| Safety Personnel | Site Safety Supervisors, Field Safety Personnel | Safety personnel monitor activities on the well site to ensure that workers are performing their duties within both government regulations and company safety policies. Often these individuals are also responsible for safety inspections, safety training and providing orientations to new employees or visitors to a site. Given the rigors of this job within the oil & gas, it is not uncommon for a candidate to possess numerous years of field experience before transitioning into a safety role. |
| Land Clearing Crews | General Labourers, Bobcat Operators, Mulcher Operator | Land clearing crews may provide a wide array of services depending upon sophistication of the team in question. At the more basic level, this could range from mulching of vegetation and general site prep. On a more high-end level responsibilities could include drill site preparation and construction. Certain land clearing operations may also provide site cleanup and land reclamation services at the end of the site's lifecycle. |
| Environmental Services | Environmental Scientists, Laboratory Technicians, Archeologists, Permitting Specialists | Environmental services providers are typically teams of engineers and supporting personnel who specialize in the preparation of permit applications, habitat assessments, monitoring environmental impacts of site activities, generating decommissioning plans or even archeological services. Such activities are typically rather demanding in terms of technical expertise when compared to other service offerings. |
| Air & Noise Modelling and Monitoring | Environmental Scientists, Laboratory Technicians, Air sampling technicians | These services are offered by a combination of engineers, scientists, and technical specialists in order to monitor the effects of a well site in terms of air quality. Similar to environmental services this work is very technical and requires specialized training and equipment. As such, an individual attempting to enter into this field would be expected to possess a relevant technical background. However, given the Government of Saskatchewan's soon to be implemented regulations pertaining to air quality standards and monitoring (S-10 & S-20), demand within the sector is expected to increase. |

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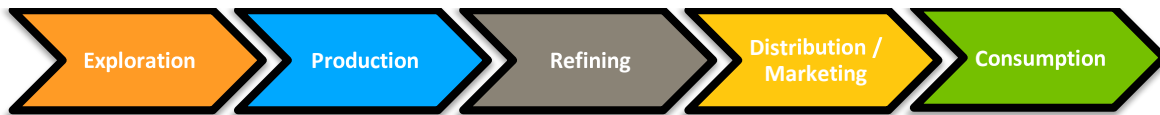
| | | |
|---|--|--|
| Landman Services | Mineral Rights Negotiators, Document Researchers, Registered Landman | Landman is a blanket designation referring to those individuals that offer business and technical skills in the acquisition, disposition and management of surface and mineral rights necessary for the exploration and development of petroleum resources. Given the nature of the work of a Landman they will typically possess many years of experience within the oil and gas sector, however, several universities are now offering programs to develop applicable skills in students. |
| Geotechnical Surveying | Geotechnical Engineer, Geotechnical Surveyor, Laboratory Technician | Geotechnical Surveying services are conducted by geotechnical engineers and geologists in order to ascertain the soil and rock compositions of a potential well site. This could consist of a variety of tests ranging from soil samples, to geologic mapping to borehole sampling. These field tests will often be complimented by laboratory work and additional tests. Given the highly technical nature of this type of work, specific education and training is required before an individual is able to enter into the field. |
| Medical Officers and Responders | Site Paramedics, Fire/Recue Personnel, Training Staff | Medical Officers and responders act as the back bone to a well site's ability to address any injuries that occur on the site. While the development of safety plans and presence of safety personnel are intended to reduce the frequency and severity of accidents, unfortunately some incidents will still occur. Medical responders will typically consist of an oilfield medical team but may also include fire/rescue teams or HSE/ First Aid training support teams. Individuals wishing to enter into this field will typically be required to possess relevant qualification in the paramedical field (EMR, EMT etc.) as well as other areas such as H2S, confined space and others. |
| Food & Lodging Providers and Professionals | Chefs & Cooks, Janitorial Staff, Security Personnel, Administrative Staff, House Keepers | The food & lodging field offers a large range of potential employment opportunities to an individual wishing to enter into oil and gas sector in this capacity. Opportunities range from janitorial services to administrative positions to security personnel to cook staff. As many of these roles are considered low skill positions, they offer a comparatively easy entry point to the oil and gas sector when compared to other fields. |

It may be best for new people in the industry to start their careers in these areas under an existing company. Companies already providing these services for other sectors (i.e. construction, fabrication, events, etc.) could begin offering more services to the oil and gas sector.

5.0 MARKET OVERVIEW & THE CURRENT STATE OF THE INDUSTRY

Few industries can benefit from maximizing supply-chain efficiencies more than the oil and gas sector. In addition, few industries require the same immense array of supplies to be moved as frequently in large quantities than the oil and gas industry does. In exploration and production, most of the work and activities are repetitive, requiring large quantities of the same components over the course of their lifecycles.

Figure 5.1 Overview of the Links within the Supply-Chain for the Oil and Gas Sector



For purposes of this report, only the aspects of the Upstream (Exploration and Production) supply chain will be addressed. However, the general information within this section may be applicable across the entire process.

One point of concern for oil production companies operating typical well sites is that they all produce essentially the same product, crude oil (specific API notwithstanding) and gas. All require similar components and services in order to generate production. They are unable to rely upon such techniques as marketing to differentiate their product in order to increase market share. Therefore, other than attempting to locate the most profitable reserves in which to drill, or improving internal efficiencies, production companies must rely upon effective supply chain management to minimize production costs and ensure routine operations proceed uninterrupted.

To give some insight into the complex nature of the supply chain process within the oil and gas industry, consider the number of major components discussed in sections 3.0 and 4.0. The Petroleum Services Association of Canada (PSAC) estimates that a minimum of 44 different suppliers would be required for the typical horizontal drilling of a tight oil well in Southeastern Saskatchewan. To illustrate this, PSAC has generated a sample list of contractors and suppliers that are likely to be required in a supporting capacity within the upstream well site sector across its lifecycle. It is within these products and service offerings where the greatest opportunities to enter in the oil and gas sector lay.

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Figure 5.2 Sample List of Unique Contractors Employed by Product or Service

- Surveyor
- Construction Company
- Trucking (Heavy Equipment) Class 1
- Trucking (Rig Moving) Class 1
- Trucking (Pipe) Class 1
- Trucking (Light) Class 3
- Camp and Catering
- Camp Waste Water Disposal
- Communications Equipment Supplier
- Equipment Rentals
- Conductor Hole Contractor
- Water Hauling
- Safety Services (H2S Medical) Contractors
- Drilling Instrumentation
- Drilling Contractor
- Casing & Tubing Supplier
- Power Tong Services
- Cement Supplier
- Cement Accessories
- Cementing Services
- Packer and Service Tool Services
- Casing Accessory Suppliers
- Drilling Supervisor
- Geologist
- Directional Drilling Services
- Drilling Tool Suppliers
- Rock Bit Suppliers
- Drilling Mud Services
- Solids Control Equipment Rentals
- Drilling Waste Management Services
- Service Rig Contractor
- Wellhead Protection Services
- Pressure Pumping Services
- Fire/Shower Services
- Production Testing & Flow back Services
- Coiled Tubing Services
- Completions Supervisor
- Wellhead & Valve Supplier
- Production Tank Supplier
- Artificial Lift Equipment Supplier
- Production Separator Supplier
- Instrumentation Supplier
- Mobile Welding Services
- Site Fencing Contractor

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The oilfield service and supply sector feeds directly off the capital expenditures of the producer companies. As such, demand for service and component supplies are negatively affected by declines in capital expenditures that the market is currently seeing in early 2015. Saskatchewan has not been impacted by this decline to same extent as Alberta or Newfoundland, however multiple forecasts point toward a similar downturn in capital expenditures in the oil and sector across North America. The topic of industry trends and forecasts will be discussed in further detail in Section 6.0.

To understand the current state of the market the biggest suppliers first need to be identified. Please note that the following companies are not an all-encompassing list of the most prominent providers. To provide a snapshot of the existing providers, 3 sample organizations are listed below:

Tri-can Well Service

Tri-can Well Service Ltd. was established in 1979 and is head quartered in Calgary, Alberta. Tri-can's service offerings include:

- Specialization in pumping services (acidizing, cementing, coiled tubing, fracturing)
- Reservoir Solutions (geological solutions, micro seismic, reservoir Services)
- Completion Systems and Downhole tool Services (completion systems, coiled tubing components)
- Industrial Services (Industrial cleaning, pipeline services)

In addition to servicing customer's immediate needs, a heavy emphasis is also placed on developing more efficient technology through extensive Research and Development. Operations are globally located in Canada, the United States, Russia, Kazakhstan, Algeria, and Saudi Arabia, and Australia.

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Baker Hughes

Baker Hughes is the product of multiple strategic acquisitions throughout the last 100 years that has yielded a top-tier oil field service competitor. Their service offerings are centered on creating additional reservoir value. A brief list of their offerings includes:

- Integrated operations (integrated services, contact integrated operations)
- Reservoir Services (Consulting, remote operations services, reservoir software, geoscience services)
- Drilling & Evaluation (Drill bits, drilling services, drilling and completion fluids, wireline services, geoscience services)
- Completions and Production (Well completions, artificial lift, pressure pumps, tubing services)
- Industrial Services (Process services, downstream chemicals)

Baker Hughes currently operates in over 80 countries and continues to be an oilfield service leader with the capability of increasing recovery from a well in order to boost productivity and reducing economic risk. Similar to Halliburton, Baker-Hughes has a small but growing portion of the well field goods and services market within Saskatchewan.

Distribution Now

Distribution Now is a large scale distributor of typical oil and gas components including pipe, valves and valve automation, fittings, industrial supplies, tools, safety products, and artificial lift systems to the upstream, midstream, and downstream markets. They also offer services relating to distribution such as supply chain management, project management, and e-commerce solutions.

Distribution Now currently has operations in 300 locations across 20 countries, including a large presence in Alberta and Saskatchewan.

A recent trend in Canada's oil & gas upstream oil & gas sector has seen a shift towards consolidation of services. Several companies are moving away from specialization for single components, and moving towards being able to provide for all aspects of the lifecycle. This service builds on a partnership model with the owner companies, where the two parties can work together to build their processes and relationship. The service provider becomes relied upon for their expertise, and is able to anticipate the needs of the producer by providing for the full life cycle.

The supply chain for the oil and gas sector within Saskatchewan is generally serviced well both by local and foreign organizations. However, there is opportunity for improvements and increased efficiencies in terms of the ability of the market to provide goods and services to this sector.

Given the current state of the oil and gas market, the prospect of entering into the supply chain can feel like a daunting process.

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Saskatchewan's suppliers and contractors can compete with external suppliers by leveraging their strengths and mitigating weaknesses. To compete within the province, Saskatchewan's suppliers must focus upon improving their relationships with buyers. This can be accomplished in a multitude of ways:

- The first is to capitalize upon the fact that being based in Saskatchewan they possess local knowledge. This improved understanding of the needs of the local producers should allow Saskatchewan based suppliers to better anticipate changes in demand and react accordingly.
- Similarly, local suppliers can improve competitiveness by building strategic buyer-supplier relationships by improving their understanding of the unique procurement processes of the organizations that are utilizing their goods or services. The ability to respond to your client's individual needs is paramount to being able to separate your company from the large external organizations that are likely to treat all production companies in the same manner.
- Finally, local suppliers must reduce their costs to become more competitive with offshore suppliers. This prospect is challenging considering the higher wages that employees are able to demand within Saskatchewan. However, becoming more competitive in terms of pricing will greatly enhance local supplier's abilities to contend within global suppliers.

One of the more difficult aspects of the supply chain from the producer's perspective is to fully understand the capabilities of their suppliers. If the producer understands what a supplier is able to provide on a regular and reliable basis, they will continue to seek out that supplier regardless of the changes in demand. A skilled supply chain manager will review the producer's needs in terms of lead times, schedule, standard capacity and quick turn-around needs, with the production company's suppliers to ensure the supplier's capabilities will meet the producer's requirements. For potential suppliers, this means being as transparent as possible when entering into discussions with a production company. Misrepresenting your abilities to meet the timeline or quality requirements of a producer is likely to negatively affect your current and future contract retention capabilities. Multiple failures to deliver as promised, may lead to the supplier being "black listed". This is especially true of quality issues which can result in a supplier being barred from all future work with a particular company.

Another possibility to improve competitiveness within the supply chain is for producers to implement Category Management. Category Management is a procurement approach where production companies identify which products or services possess similar characteristics and are bought from similar supply markets. In turn these products are grouped together and treated as a discrete group or category. These categories are then more manageable from a procurement perspective as the items in a category require the same supplier market intelligence, the same sourcing strategies and similar supplier relationship management programs. In the last 10 years,

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the majority of oil and gas project owners and EPC firms have adopted category management in varying degrees. Some are sophisticated users and have largely adopted this technique, while others are only beginning to implement it or are only incorporating select portions of the process. Suppliers are also able to benefit from this technique as their relationships with production companies become much more collaborative. Furthermore, producers utilizing category management have a better understanding of the market forces impacting their suppliers with improved synergies as a result.

Any new suppliers or contractors looking to start operations in the Saskatchewan oil and gas industry should get pre-qualified by the producers as a first step. This would help ensure that their organizations are included in the bidders list and sole source recommendations. Pre-qualification is an essential step in the procurement process, and its importance cannot be overstated. The pre-qualification process is utilized by most producers in order to minimize supply chain risks and narrow the field of prospective vendors. Health, safety and environmental (HSE) performance, corporate financial performance, quality plans, as well as ability to meet schedule, are critical criteria that must be present to be on a preferred vendor list. These criteria are reviewed at least annually to ensure compliance by vendors. A growing number of owners are using third-party prequalification firms to assist in this process such as ISNetwork and CanQual.

Obtaining ISO certifications such as ISO 9001, ISO 13628, and ISO 28000 can help demonstrate competence when it comes to quality. It should be stated however, that these certifications have become quite typical within the industry and possession of such qualifications should no longer be considered a differentiating factor rather than a minimum criteria.

More strategies to consider in meeting the supply chain demands within Saskatchewan include looking outside the province for strategic partnerships or acquisitions. Collaboration can greatly improve a firm's competitiveness, allowing for the transfer of knowledge and improved market share. This was (and still is) extensively utilized in Alberta, where global markets are approached via reverse-marketing. Some challenges to anticipate in this approach include additional freight and logistics complexities as well as increased risk. Furthermore, experienced personnel are required to ensure the material or service orders are managed at a professional level. Fortunately for Saskatchewan, Alberta has most of this infrastructure already in place to support the oil and gas supply chain demands. Partnering with companies in the neighboring province of Alberta will help in creating credibility and outside investment within the province of Saskatchewan.

Another consideration in order to help manage risk that suppliers face is to ensure that resources such as the Supply Chain Management Association of Saskatchewan, the Expediting Management Association of Canada, and the Canadian Supply Chain Sector Council are being utilized. These professional organizations can provide analytical data and experienced resources for the oil and gas industry, as well as offering learning and networking opportunities for supply chain professionals.

Prospective market conditions
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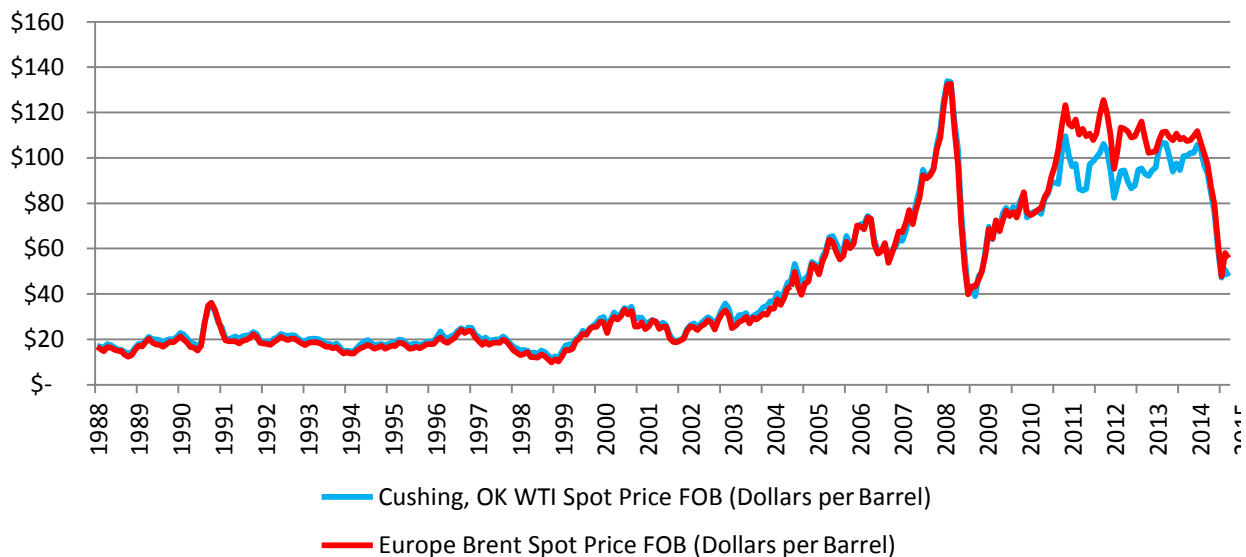
6.1 PROSPECTIVE MARKET CONDITIONS

Direction of the Economic Conditions for Oil and Gas

The Decline in the Global Price of Oil

Over the final six months of 2014 and first quarter of 2015 an increase in global oil production has resulted in a significant decline in the price of crude oil. It is still very premature to assume when, or even if, crude oil prices will return to the \$100 dollars a barrel mark witnessed in early to mid-2014. This level of uncertainty will impact the oil & gas sector as well as related industries over the near to mid-term.

Figure 6.1 WTI & Brent Spot Price Trends 1988 to 2015



With some exceptions, most industry forecasts indicate that based upon current production levels and amount of existing supplies, the price of WTI and Brent crude oil will remain in the \$50 to \$60 dollar range for the next 12 to 18 months. This decline in global oil prices will have a multitude of negative impacts on the components and services providers that operate within the oil and gas sector in Saskatchewan.

This decline in the price of crude oil has production companies reducing their capital expenditure budgets, which includes their drilling budgets. Suncor Energy Inc., Cenovus Energy Inc., and Husky Energy Limited, as well as a host of other production companies of various sizes, have all announced considerable reductions in their capital budgets, discretionary spending, and labour forces. Such reductions in staff are typically directed towards contract employees as well as those external service providers that were previously used to supplement internal capabilities.



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In January 2015, the Canadian Association of Oilwell Drilling Contractors (CAODC) estimates that the down turn in the price of oil, could result in a decline of 43% in terms of wells completed as well as the loss of 3,400 full time direct jobs and 19,234 indirect positions.

Of particular concern to the supply chain, is this reduction in terms of wells drilled and completed. Drilling activities for new wells will be mostly limited to highly profitable areas, and those land where mineral rights and leases are expiring (companies will drill to keep their rights).

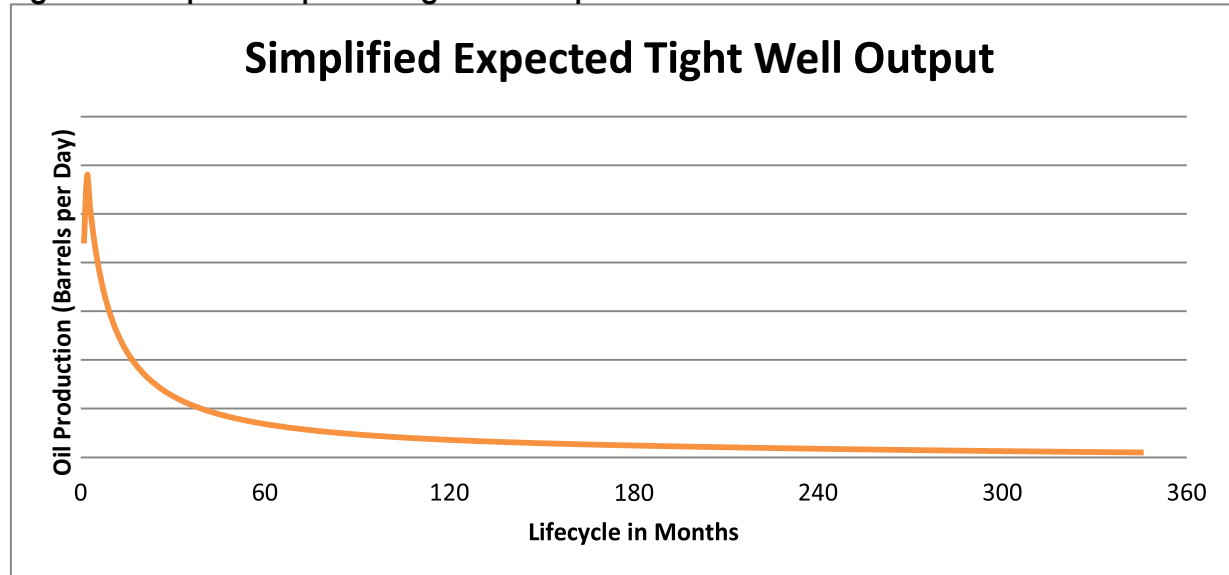
There may be potential for the low price of oil to have a disproportionate impact on oil producers that have concentrated on drilling wells in tight oil formations. Compared to typical global oilfields, which experience a production decline rate of 3% to 4% per year, tight oil deposits, such as those found in the Bakken formation in southeastern Saskatchewan, experience a yearly decline from as low as 30% to 40% to as high as 60% to 70%. This means that such a reserve may produce less than 20% of its initial production volume by the third year. While the production life of a Bakken region well-site could be as high as 30 years, the amount of barrels of oil produced during the mid to latter portion of the well's life may be just enough to offset the expense of operating and maintaining the well. Generally, many tight oil wells could be capped and shutdown after only six to ten years of production. Therefore, the majority of the profit seen from tight deposits is seen in the early portion of the well's lifecycle, before tapering off sharply.

An operator may utilize EOR technologies to increase production quantities following this decline, causing upticks in the amount of oil produced throughout a well's lifecycle. However, due the expensive nature of EOR technologies, they are only utilized on the most promising sites and are non-typical within Saskatchewan.

Figure 6.2 depicts a simplified tight well's production quantities over a 30 year lifecycle. Please note that this chart does not take into account the point at which the operations of this well are no longer feasible, nor does it include the use of hydraulic fracturing, EOR or similar techniques to raise production levels.

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Figure 6.2 Simplified Expected Tight Well Output



To offset this rapid yearly decline and to continue to increase overall production amounts, tight oil producers within the Saskatchewan oil and gas market have been drilling a large number of new wells each year. With the drop in the global price of oil, producers are now finding themselves with less capital to reinvest in order to fund exploration and drilling activities as the return on investment is no longer justifiable. Further compounding the issue, in order to accommodate the high capital costs associated with drilling a new horizontal well site, many smaller and medium sized producers may have relied heavily upon debt to finance their operations. Given that such producers rely upon drilling of new wells to maintain their current oil production levels, these heavily leveraged firms are likely to struggle repaying their outstanding debts. It remains uncertain as to how many will be able to survive an extended decline in global prices. Therefore, as fewer wells are able to be drilled to maintain production levels, we can expect to see a decline in the amount of oil production over the next few years until prices return to economical levels.

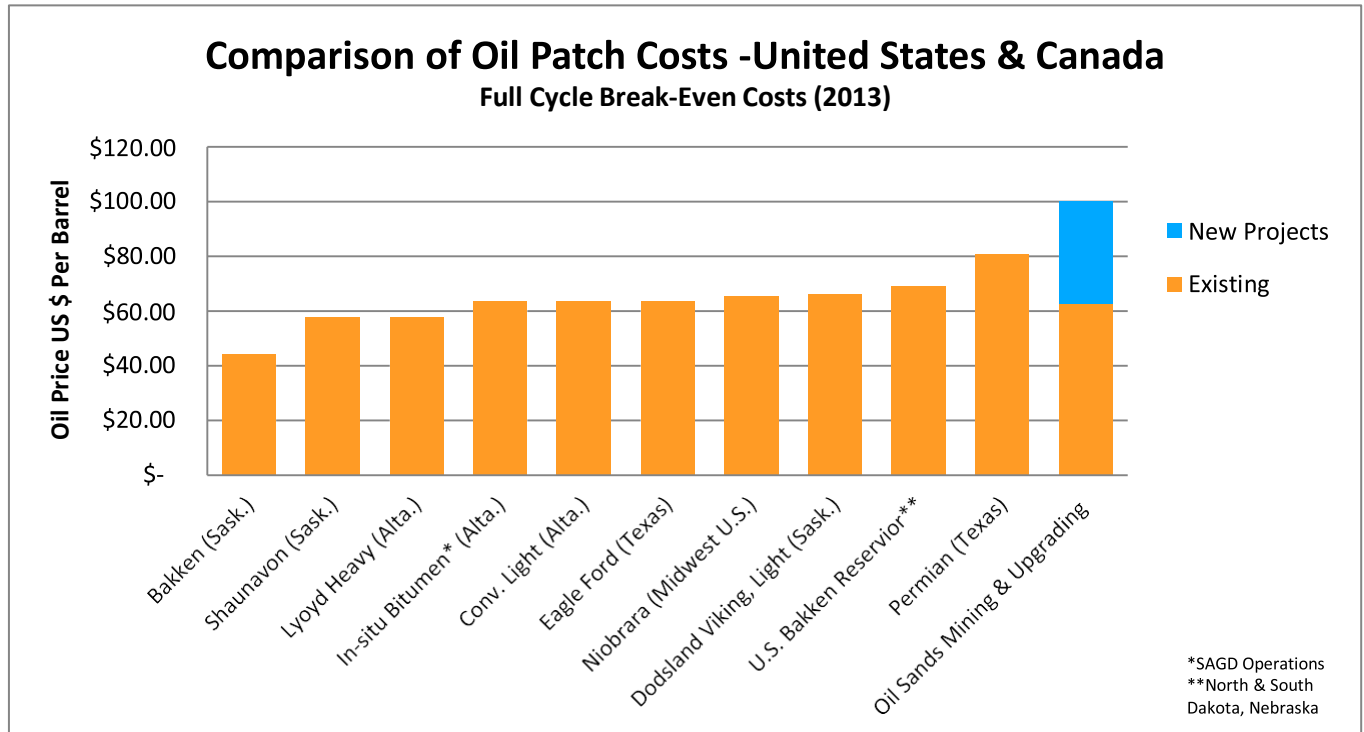
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Comparison of Oil Patch Cost

The oil and gas sector in Saskatchewan is fortunate in some regards however. When compared to their southern neighbors in North Dakota, Texas and the American Midwest, the full cycle break even costs for both the Bakken and Shaunavon regions are substantially lower. This competitive advantage can be partly attributed to the lower royalty rates within Saskatchewan.

Figure 6.3 Comparison of Oil Patch Costs -United States & Canada Full Cycle Break-Even Costs

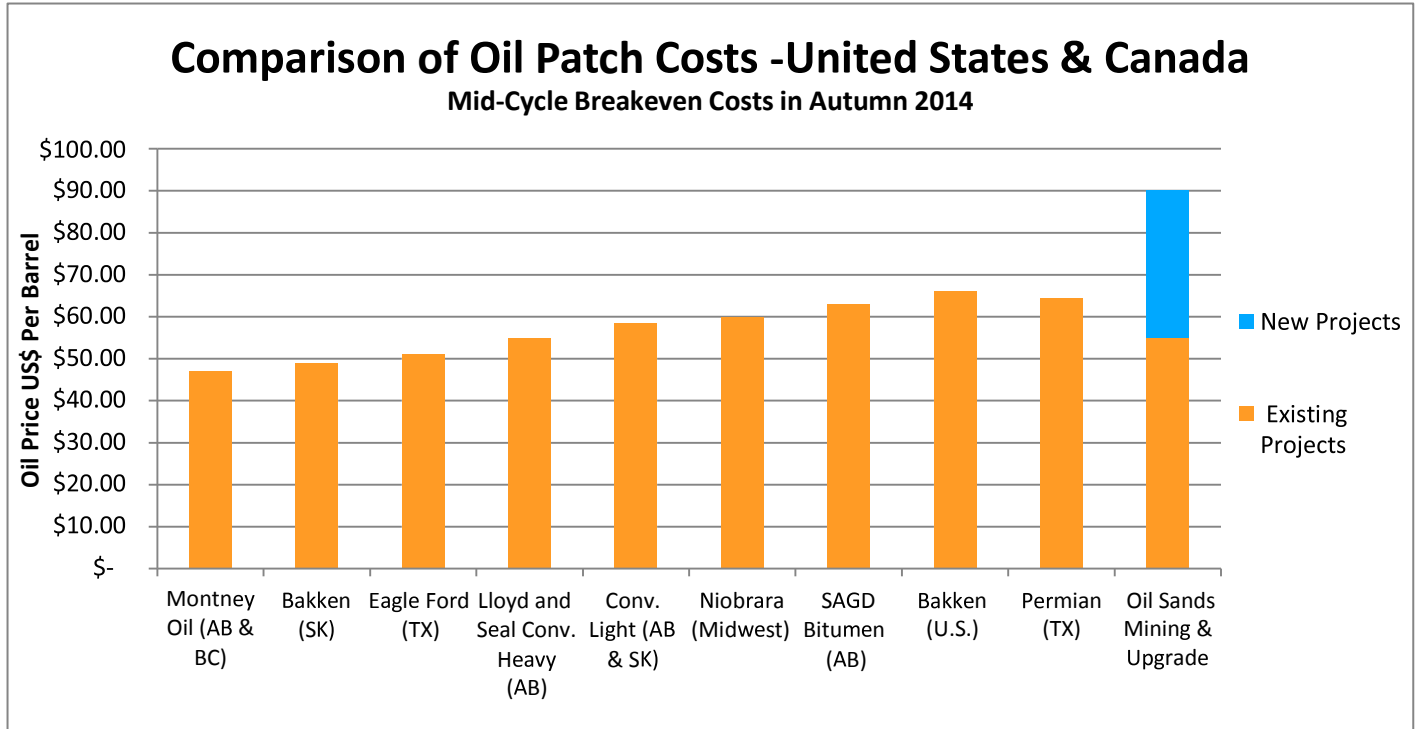


Similar competitive advantages are present within the mid-cycle costs for the Bakken reserve. Mid-cycle costs exclude initial costs, such as land acquisition, seismic exploration, and supporting infrastructure creation as these costs are deemed to be “sunk”.

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Figure 6.4 Comparison of Oil Patch Costs -United States & Canada Mid-Cycle Break-Even Costs



While these figures both paint an impressive scenario for Saskatchewan, it is important to recognize that these numbers are based upon aggregate average production costs for these regions. Therefore, they contain a variety of data sources including low cost producers operating from highly productive well sites to those operators that are producing in a higher cost, lower production environments. Ultimately, while the Saskatchewan oil and gas sector will still be impacted by the global downturn in oil prices, as seen by the reduction in land sales and new wells drilled this year. There is cause for optimism that Saskatchewan will be better positioned to weather this downturn than its regional competitions.

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Impacts on the Oil and Gas Supply Chain

Given the lower global price of oil and the subsequent reduction in capital expenditures by production companies, the oil and gas industry will need to adapt and account for this reduction in exploration and drilling. As a result, the oil producers will be forced to shift towards extending the productive lifespan of existing wells as well as attempting to improve the total production from existing wells. Those organizations within the supply chain servicing the industry will be similarly affected by this downturn and will need to adapt accordingly.

The areas of the supply chain that are expected to be the hardest hit by this downturn are those relating to the areas of drilling and site preparation. In particular, the demand for the large scale drilling rigs and the related equipment (top drives, drill bits, drill mud etc.) will diminish over the short term. As this equipment is typically leased from external contractors, those organizations that provide these services will face increased downtime between drills and decreased overall demand for their services. As this equipment is very capital intensive in terms of initial costs and maintenance fees, firms that specialize in offering this equipment will face decreased profits and narrowing margins.

Although firms that specialize in providing equipment and personnel for drilling operations will be the most impacted initially, the reduction in new drilling will affect all organizations within the oil and gas sector to varying degrees. As the drilling rates diminish, the amount of competition between suppliers is expected to increase dramatically as suppliers will be vying for market share in a contracting environment.

This increase in competition will lead to a reduction in associated costs as well as an increased focus on quality of components and efficiency of services provided by suppliers. Effectively, the market will shift to favour the production companies rather the components and service providers. From a producer perspective, this correction is very beneficial, as one of the major complaints during the boom period was the ever increasing price for components and services. Production companies will be looking for areas to reduce their costs, and will ask for cost reductions from their suppliers. Although, it may take several months for this correction to be fully realized, even existing supply contracts will be renegotiated quickly to ensure the producers get an early and competitive edge in reducing their expenses.

While a cost versus benefit evaluation will always be completed, suppliers can expect production companies to demand an increased quality in terms of component reliability. During the boom period, producers would occasionally be forced accept components and services that may not have fully met quality standards. Such deficient components would either need to be repaired on site or rejected outright, resulting in delays and a loss of production. During this drilling slowdown, producers have greater ability to demand a higher standard of component from their suppliers. Suppliers whose components do not meet sufficient quality standards are now far more likely to have their contracts rescinded and eventually lost to competitors who are able to adhere to requirements. As an added benefit to this higher basal level of component quality, producers can expect fewer breakdowns of material components, reducing downtime and improving safety.

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Over the longer term, those component and labour service providers that are not able to reduce costs or improve efficiencies will be forced to withdraw from the marketplace.

In spite of the contraction that the oil and gas sector will experience over the short term, some areas of projected growth exist. Given that production companies are no longer able to drill in previously seen quantities, producers will be forced to extend the lives of their existing facilities. Even during the periods of high oil prices, producers would frequently rely upon the reusing of components, drill pipes in particular, in order to reduce costs. Given that lower oil prices will dictate that producers reduce costs accordingly, material production components will need to be kept in service for longer periods before it can be replaced. As a result, we can expect to see an increase in demand for suppliers that provide maintenance and rehabilitation services for material components.

Components that will now need to be in service for longer periods include:

- Drill Pipes, while drill pipes are frequently reused when possible. The large quantities of pipe demanded during the drilling process is a major capital cost for a producer. Being able to restore and reutilize current stocks of pipe will become even more imperative in an environment where less capital is available
- Separator Units, the demanding tasks that the separator must perform, their individual capital expense and the numbers in which they are required on larger production facilities, make separators ideal candidates to be maintained or reused rather than replaced.
- Heater-treaters, similar to separators, have high capital costs and perform a demanding function within the production cycle. By extending the useful service life of these devices producers can better manage their capital expenditures.

Another possibility of growth, although to a lesser degree, is expected to occur in those areas that increase the overall production capacity of a well. Where it is economically viable to do so, producers may choose to increase the amount well servicing, recompletions (i.e. hydraulic fracturing), or utilize lift technologies such as down hole or top drive pumps (i.e. pump jack) on their existing wells to maintain production over a longer period. This does not indicate a move towards full recompletions or EOR becoming the standard, as the use of such techniques is cost prohibitive in most cases.

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Future Economic Conditions

As stated previously, it is difficult to predict the exact future of the oil & gas industry within Saskatchewan given the uncertainty in the market place. However, based upon existing trends and forecasts within the sector, some conclusions can be projected.

In spite of the rapid expansion of the horizontally drilled wells within Saskatchewan, numerous experts feel that this growth and development is not tenable over the long term, particularly within shale formations. For instance, a recent Western Canada Oil Production Outlook report developed by Ziff Energy, a division of HSB Solomon Associates LLC, provided analytics that suggested that the amount of light oil produced in Western Canada in 2020 would be about the same as in 2000. This prediction is largely based upon the high decline rate of production that tight oil wells feature.

This may seem counter intuitive given the higher full cycle break-even cost that both SAGD and mining based oil sands operations require when compared to the Shaunavon or Bakken reservoirs. While the initial capital costs of building an oil sand based operation (thermal and non-thermal) is greater than drilling a tight oil well, the actual operational costs can be comparatively lower over the long term. For instance Husky energy stated that the operating costs for their existing SAGD operations were under \$10 dollars per barrel in 2013.

For Saskatchewan, this may indicate potential shift away from production from the Bakken and Shaunavon reservoirs over the coming decade in a favour of developments around the heavy oil and SAGD operations within the province. As an example Husky Energy announced their plans to build two new SAGD operations within Saskatchewan in the Lloydminster region. Once these facilities are operational, in 2016, they will increase Husky's thermal based oil production by 20,000 barrels per day.

It is also important to bear in mind that the oil and gas sector is a cyclical market that experiences periodic booms and busts. While the current forecasts over the short to midterm are somewhat pessimistic, this does not indicate that the present downturn will become the new operating environment. Ultimately, as global demand for hydrocarbons continues to increase, the world will need to rely upon a multitude of oil and gas sources, be they from tight oil deposits or oil sand reservoirs. While the long term forecast appears to favour the development of opportunities within the oil sands, it is impossible to be certain that the development of new technologies or the reduction in costs of currently available technologies will not completely revise these forecasts.

7.1 POTENTIAL INDUSTRY HURDLES

When examining the supply chain that supports the oil and gas sector, we must remain cognizant of the fact that those conditions that negatively impact the production companies will have similar negative impacts the supplier organizations. With this fact in mind, the following criterion was identified as presenting hurdles to both production companies and suppliers within the Saskatchewan market place.

Some general hurdles that a potential entrant can expect to face are as follows:

- The oil and gas sector is a highly specialized and technical market sector, it may take years of experience to develop the necessary expertise to successfully operate within the environment
- As discussed in section 4.0, depending on what area of the supply chain a potential entrant is pursuing, they may need significant capital for investment in equipment and materials
- The market is presently served by a variety of companies ranging from small local organizations to billion dollar multinational companies. A new entrant will be competing with these entities

As with most industries, a successful entrant will need to develop a strong network of contacts throughout the oil and gas industry in Saskatchewan. As such, attending industry conferences and other events in order to network with organizations within the oil and gas sector is imperative. It is also important to realize that such networking opportunities are not just localized within Saskatchewan, and that opportunities to develop industry contacts and synergies can emerge from a variety of locations such as Calgary, Fort McMurray, North Dakota or even further afield.

Given the worsening economics of the current oil and gas marketplace across Western Canada, the most obvious hurdle to entry is the current state of the market environment itself. During boom periods, the market is better able to bare the effects of less competitive firms attempting to offer their services, as the heightened demand for product and the desire to increase revenues allow producers to tolerate inefficiencies and higher costs from their suppliers. However, periods of slowdown allow for production companies to mandate higher standards and lower costs from their suppliers as demand for their services and products declines.

Unfortunately, this decline in oil price is largely based upon global oversupply of crude oil. We can expect to see depressed oil prices for the immediate future until the global market corrects

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Potential Industry Hurdles

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the amount of available supply. Suppliers will find themselves being forced to tighten their margins and implement techniques to improve their competitiveness. This could range from reducing overhead and staff counts, to reducing profit margins on a per item basis, to reducing inefficiencies within their organizations. It should be noted that certain oil producers within the Western Canadian market are partially welcoming this contraction, as it will "Cut the fat from the sector and remove the inefficient organizations from the market". For instance, within Alberta, one steel manufacturer stated that their customers were requesting discounts in the double digits on the prices of components, while other customers were withdrawing orders entirely.

This ongoing market contraction will make it difficult for additional firms to enter into the oil and gas sector. Unless the supplier firm entering the market is able to be immediately competitive with existing firms in terms of price, quality of services and timelines for delivery, they will be unlikely to succeed in the current environment. If a prospective firm is considering entry into the Saskatchewan market place and is uncertain that it will be able to compete in the areas listed above, or possess some other factor that will differentiate itself from the existing competition, then it may be prudent to hold off entry until more favorable conditions arise.

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8.0 ISSUES IMPACTING THE EXISTING SUPPLY CHAIN

As mentioned previously, the Supply Chain industry within Saskatchewan is presently facing a number of deficiencies in terms of how it is serviced by local companies. While, it is not possible to account for every possible insufficiency in the larger market place within Saskatchewan the following items were identified as being major concerns.

Skilled Labor Force

The unemployment rate for January 2015, within Saskatchewan stands at 4.5 percent, tied with Alberta for the lowest in Canada. Providing services and components to the oil and gas industry requires a strong supply of skilled labor to maintain production levels and high-quality products. As discussed in section 7.0, a shortage of skilled labour is typically seen predominantly during the periods of high oil and gas demand. As discussed previously, this high demand for oil and gas allows for workers to command a higher standard wage to perform their role within an organization, due to the increased demand for their services. In turn, this environment leads to the wage escalation in this fashion within Saskatchewan may become a challenge when competing with firms from Alberta and global markets.

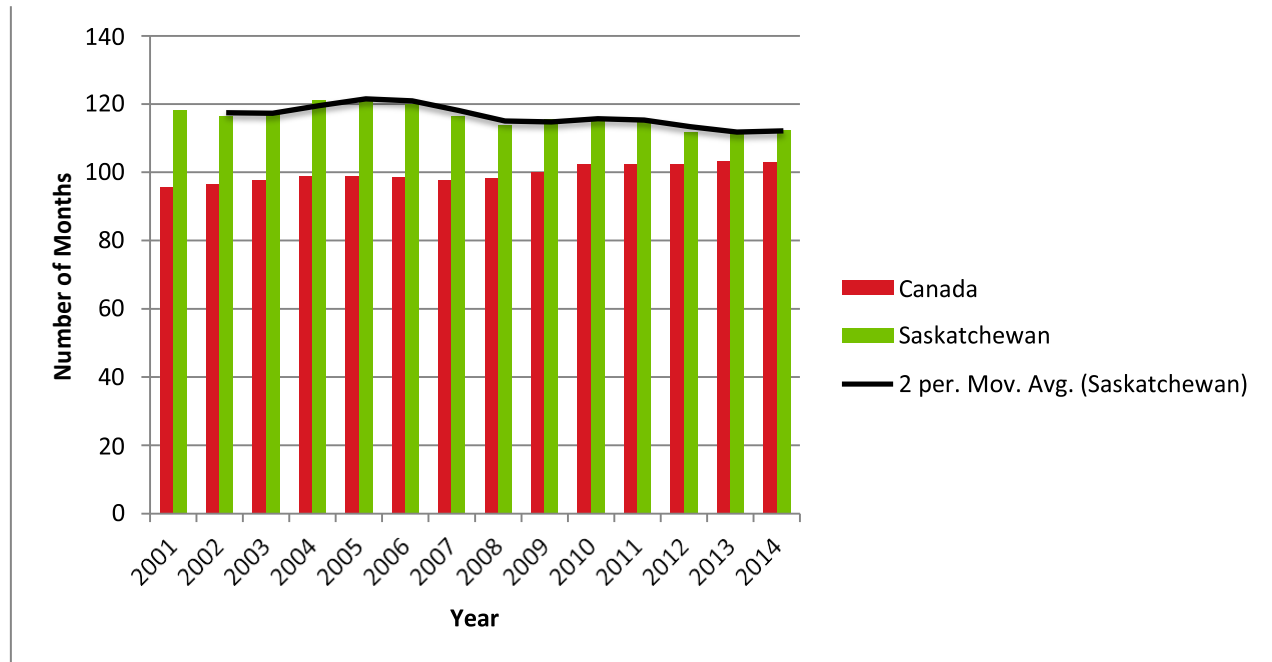
This has a two-fold effect on the supplier company. Initially, it may reduce an organization's ability to retain their skilled workers as such individuals may be recruited by rival firms which offer higher wages or other benefits. As result, firms see higher rates of employee turnover, impacting the organizations ability to meet schedules and often reducing quality of service. A secondary negative factor to this increased rate of employee turnover is that firms become less willing to invest in their employees in terms of training and development. As organizations' fear that after their employees have gained new knowledge or skills, they will take their enhanced abilities to a rival firm and receive a higher wage. This ultimately reduces an organization's ability to compete within the market, as its staff may no longer be trained in the best practices in the industry. During periods of extreme booms, we have seen examples of organizations having to rely upon contract or temporary foreign workers in order to account for service requirements due to a lack of available local labour.

Historically, Saskatchewan has featured higher than average job tenure amongst its residents. However, this does not indicate that it is entirely immune from the conditions described above, as recent trends indicate that Saskatchewan is falling more in line with the national average over time.

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Figure 8.1 Labour Force Tenure by Month Canadian vs Saskatchewan Averages



Addressing worker retention and increasing the number of total available workers within the province has been marked as priority by the government of Saskatchewan. However, it remains to be seen, just how deeply impacted the Saskatchewan labour market will be impacted by the ongoing crunch within the oil and gas sector.

Regulations and Environmental Concerns

With the implementation of S-10 and S-20, the current regulatory environment in Saskatchewan as it pertains to the venting and flaring of gas as a result of production operations will tighten. While these regulations will provide opportunities to certain suppliers, such as those that provide environmental services, they will also present additional challenges to other firms. Providers of flaring and venting equipment will now be required to adhere to increased regulatory scrutiny.

The presence of Hydrogen Sulfide gas (H_2S) is a major concern within the oil and gas industry, particularly with producers of natural gas. Hydrogen Sulfide, while naturally occurring in petroleum formations, is highly toxic to people, corrosive as well as being flammable. As oil produced from the Bakken formation appears to have elevated levels of hydrogen sulfide when compared to other deposits, concerns have been raised by such entities as Enbridge.

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As such, production companies within the Bakken formation that are encountering raised levels of Hydrogen Sulfide may be required to include additional safety procedures and technologies to ensure the health and wellness of their employees as well as the environment. Moreover, additional separation equipment may be required within the production facility in order to remove the H₂S from the petroleum.

It should be noted however, that not all reservoirs within the Bakken formation feature elevated levels of Hydrogen Sulfide.

Supply Chain Competition

External competition within the supply chain is increasingly becoming a major concern within Saskatchewan as the market place matures and becomes more compelling for firms. While the size of the reserves within Saskatchewan are relatively small compared with those of Alberta, the competitive regulatory and tax environment and tremendous growth potential has attracted the attention of external competition. Sample external firms include Tri-can Well Service Ltd., which is Calgary based, as well as international firms such as Baker-Hughes Inc., Halliburton Co., and Schlumberger Ltd. Typically, these entities attempt to operate as "one stop shops" for well drilling, completions and services, providing a majority of the required services that a production company would require allowing these firms to service large scale production firms more efficiently than numerous smaller firms would be able to.

A local Saskatchewan producer could face cost overruns when outsourcing portions of their supply chain to companies outside of Saskatchewan. For example, when a local company requests services from an Alberta-based company they may incur time lags which would inevitably increase the total project cost. The additional time it may take for the external service provider to reach Saskatchewan could also result in the inflated costs of maintaining operations while waiting for the product (ex. hoteling costs for current staff waiting for out-of-province product or service).

International investment is currently more lucrative than in Western Canada. Thus local industry is being driven to become more cost effective to compete with these international firms, and local suppliers are being driven to run leaner operations. Saskatchewan is beginning to see strong Category Management involvement within the owner clients.

State of Existing Infrastructure

Another overarching issue facing all aspects of the Saskatchewan oil and gas sector is the current state of infrastructure within the province, particularly as it pertains to transportation and pipeline capacity. Once again, any deficiencies that limit a producer's ability to get their product to market will negatively impact profitability. This reduction in ability to generate revenue by production companies in turn unnecessarily limits their demand for supplier's goods and services limiting their profits in course. For instance, Canada lost \$25 billion dollars in

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prospective revenues from oil and gas sales due to a lack of pipeline capacity in 2012 alone. Had producers been able to capitalize on this revenue, then expansion of their operations would have resulted. Such expansions would require increased quantities of goods and services, further fueling investment within oil producing provinces including Saskatchewan.

The inability of existing pipelines to convey product to desired markets and the long-term delays associated with the regulatory process during the planning and development of new pipeline are frequently cited as a major concern amongst oil producers. For instance, the Keystone XL, the Northern Gateway and the Energy East pipeline have all faced significant postponements, governmental/special interest interference, and increased regulatory scrutiny delaying the approval process.

Given that pipeline capacity is unable to currently meet the demands of producers, oil transportation by rail is rapidly growing and is already outstripping the capability of the rail infrastructure within the province. As seen in Figure 3.12 Canadian Crude Oil Exports by Rail by Quarter, the total volume of crude oil being shipped by rail in Canada has grown almost eight fold in less than two years. The industry shift to utilizing the unit train system, in which trains of cars solely devoted to the point to point delivery of crude oil, has greatly improved efficiency. However, existing systemic limiting factors within the rail system such as, supply connections, system bottlenecks, operational inefficiencies, limited hours of operation, ramp up times and even weather, all of which reduce producer's ability to get their product to market.

9.0 GUIDE TO OIL AND GAS IN SASKATCHEWAN

TYPICAL BEST PRACTICES WITHIN THE SUPPLY CHAIN

Obviously, no two organizations servicing the oil and gas industry within Saskatchewan operate in exactly the same fashion. All companies possess their own unique cultures, organizational values and methods of conducting business. However, those companies that have been the most successful typically feature some of the same key differentiating strategy in the manner they approach their business operations.

A key differentiating factor for the oil and gas sector, in terms of the supply chain, is that just-in-time delivery is not typically an acceptable practice. This is especially true during the exploration and production phases of operation as any delays in delivery of goods and services will have considerable impacts on the revenues of the production company. Suppliers entering into the oil and gas sector from other industries must be very cautious to ensure that they correctly adapt their forecasting and delivery estimation techniques to account for this difference, if they hope to be successful.

One of the single largest contributing factors to success in the supply chain is that of effective communication between suppliers and their customers. This is especially true of the oil and gas sector due to the overall sensitivity of profits as a result of production delays and the long lead-times associated with major components. The need for open and transparent communication between both parties is not just limited to when issues arise. Communication between supplier and customer should be developed at the onset of the relation and establish the direct needs and capabilities of both parties. This improved communication also allows for increased integration between supplier and client. In turn, this will ensure a more harmonious and effective relationship between organizations over the long-term.

Following the establishment of active communication between suppliers and the production companies that they serve, suppliers should identify commonalities, in terms of actual needs, between their various customers. In turn, suppliers should then group these customers based upon these common needs in segments and, adapt their supply chain accordingly to better serve said segments. This does not mean clustering customers simply based upon the products they require or their role within the oil and gas industry. This approach is about developing service offerings that are better suited to addressing the needs of the entire segment. The knowledge required in order to successfully divide customers into subdivisions, is best developed by interviewing and researching the suppliers customer base. Once again, the need for this primary research highlights the need for open communication between suppliers and their customers.

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For suppliers, customization of their logistics network is also critical to improving their overall competitiveness. In terms of oil and gas, this customization primarily pertains to offering additional complementary goods and services to support the principal offerings of the company. Customization is more than simply providing the suite of goods or services a customer desires, it is also critical to deliver these product-service packages in the quantities and timing requirements set by the customer.

As discussed previously in section 6.0, the ability to accurately predict and respond to market shifts within the oil and gas sector is imperative for long term success as a supplier. This process is more than simply forecasting demand based upon current sales and adjusting volume capacity accordingly. Instead, successful firms within the oil and gas supply chain, look for forthcoming trends within the sector in order to develop future capabilities to service these opportunities as they arise. By moving ahead of their competitors in this manner firms can obtain a first mover advantage and increase market share in the industry.

Adapting to shifting market trends is not the only reason for a company to modify its processes. By maintaining a proactive approach to the methods in which a firm conducts its operations, it can ensure that it sustains a competitive presence within the market. This is the process of operational innovation. By examining their own internal operations as well as those of their customers, suppliers can identify opportunities for improvement. This may include increased integration with a supplier's consumer base, increasing flexibility within the supply chain, or revising current techniques for providing products and services. Any such changes in this regard should fit within the supply company's existing corporate culture to ensure that changes can be quickly adopted. Furthermore, ideally, such innovations should be difficult for competitors to duplicate if at all possible.

The Government of Saskatchewan Ministry of the Economy has prepared a detailed document on standard practices relating to the supply chain for the mining industry within Saskatchewan. While it does not directly reference the oil and gas sector, the fundamental principles contained within its pages are highly valuable to any organization seeking to enter into the supply chain within Saskatchewan.

ADDITIONAL INFORMATION

Related Professional associations

Association of Consulting Engineers of Canada (ACEC)

Canadian Association of Drilling Engineers

Canadian Association of Geophysical Contractors (CAGC)

Canadian Association of Petroleum Producers (CAPP)

Canadian Association of Oilwell Drilling Contractors

Canadian Energy Pipeline Association (CEPA)

Canadian Gas Association (CGA)

Canadian Petroleum Safety Council (CPSC)

ENFORM

Estevan Oilfield Technical Society

Explorers and Producers Association of Canada

International Association of Drilling Contractors (IADC)

Petroleum Human Resources Council of Canada

Petroleum Services Association of Canada (PSAC)

Petroleum Technology Research Centre

Pipeline Contractors Association of Canada

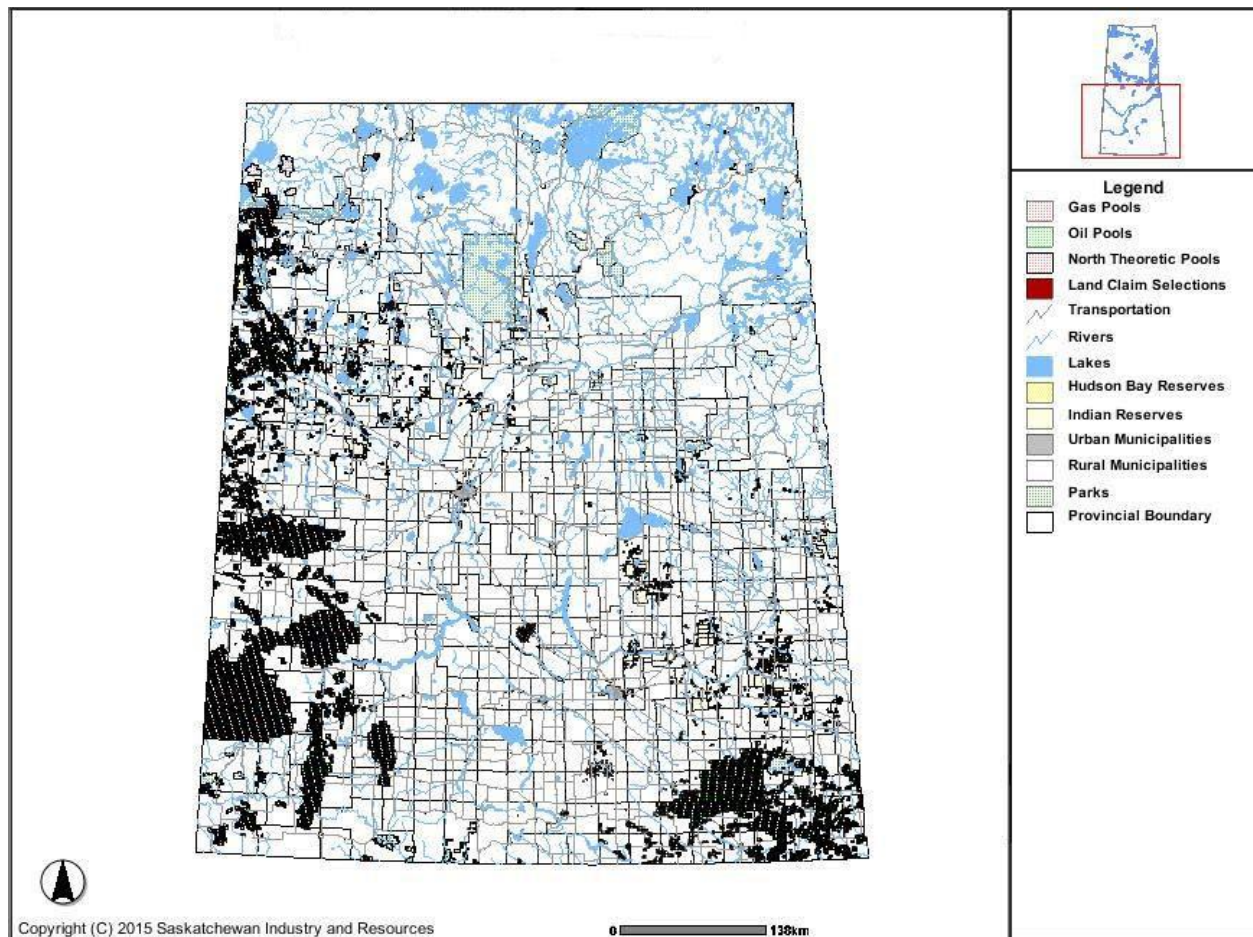
Saskatchewan Industrial & Mining Suppliers Association

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Location of Proved & Probable Reserves

The figure below provides a high level overview of the proved and probable reserves within the province of Saskatchewan.



Due to the immense amount of information presented within the picture above, we recommend that interested parties use the customizable GIS based map available on the Government of Saskatchewan Website at the following address:

http://www.infomaps.gov.sk.ca/website/SIR_Oil_And_Gas_Wells/viewer.htm

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WORKS CITED

- American Institute of Steel Construction. (1986). *Load and Resistance Factor Design Specification for Structural Steel Buildings*. Chicago.
- American Petroleum Institute. (2002). *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*. American Petroleum Institute.
- Angevine, G., Green, K., Fathers, F., & Jackson, T. (2014). *Global Petroleum Survey 2014*. Fraser Institute.
- Antonio, F. D. (2015). *Stantec Internal Costing Information Oil & Gas Sector*.
- Canadian Centre for Energy Information. (2013, April 2). *Exxon's Arkansas Tar Sands Spill: The Tar Sands Name Game*. Retrieved March 23, 2015, from http://switchboard.nrdc.org/blogs/aswift/exxons_arkansas_tar_sands_spil.html
- Chima, C. M. (2007). *Supply-Chain Management Issues In The Oil And Gas Industry*. Journal of Business & Economics Research
- CO2 CRC. (2010). *Wireline logging at the CO2CRC Otway Project*. Retrieved 2014, from http://www.co2crc.com.au/images/imagelibrary/otway_drilling/wireline_log_media.jpg
- Diverse Energy Systems. (2013). *Heater Treaters*. Retrieved 11 13, 2014, from <http://www.des-co.com/portfolioentry/heater-treaters/>
- Drilling Formulas . (2014, 1 5). *Basic of Drillpipe Tensile Capacity and Its Calculation*. Retrieved 11 2014, from <http://www.drillingformulas.com/basic-of-drillpipe-tensile-capacity-and-its-calculation/>
- Emerson Process Management. (2014). *LACT Units*. Retrieved 11 19, 2014, from http://www2.emersonprocess.com/siteadmincenter/PM%20Central%20Web%20Documents/FSG%20BRO-0011_LACT-ENG-14-web.pdf
- Emerson Process Management. (2015). *Industries > Oil and Gas > Production*. Retrieved 11 2014, from <http://www2.emersonprocess.com/en-us/brands/micromotion/industries/oil-and-gas/upstream-production/pages/index.aspx>
- Energy & Capital . (2013, 3 19). *Enhanced Oil Recovery Market Booming*. Retrieved 11 12, 2014, from <http://www.energyandcapital.com/articles/enhanced-oil-recovery-market-booming/3190>
- Geology.com. (2015). *Home » Rocks » Sedimentary Rocks » Shale*. Retrieved 09 28, 2014, from <http://geology.com/rocks/shale.shtml>
- Government of Saskatchewan. (2014, December). *Saskatchewan Oil and Gas Well Drilling Statistics*. Retrieved 02 19, 2015, from <http://www.economy.gov.sk.ca/monthlydrilling>
- Government of Saskatchewan. (2015, April). Retrieved March 5, 2015, from Saskatchewan Oil & Gas Information: http://www.infomaps.gov.sk.ca/website/SIR_Oil_And_Gas_Wells/viewer.htm
- Government of Saskatchewan. (2015, 02 09). *Crude Oil Volume and Value Summary by Area Crude Type*. Retrieved 02 19, 2015, from <http://www.economy.gov.sk.ca/2014-CrudeOil-Summary>
- Lane, T. (2015). *Drilling Down—Understanding Oil Prices and Their Economic Impact*. Madison: Bank of Canada.
- MNP LLP. (2014). *Horizontal Drilling Workforce Study*. Petroleum Services Association of Canada.
- NASDAQ . (2015, February). *NASDAQ Crude Oil WTI & Brent*.

SASKATCHEWAN OIL AND GAS SUPPLY CHAIN REQUIREMENT GUIDE

Guide to Oil and Gas in Saskatchewan
May 11, 2015

- National Energy Board. (2015, 03 11). *Canadian Crude Oil Exports by Rail - Quarterly Data*. Retrieved 1 18, 2015, from <https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/2014/cndncrdlxprtsr-eng.html>
- Occupational Safety & Health Administration. (2011). *Oil and Gas Well Drilling and Servicing eTool*. Retrieved 9 31, 2014, from Oil and Gas Home Illustrated Glossary: https://www.osha.gov/SLTC/etools/oilandgas/illustrated_glossary.html
- Piping Engineering. (2015). Retrieved 11 12, 2014, from Crude Oil Processing on Offshore Facilities: <http://www.piping-engineering.com/crude-oil-processing-offshore-facilities.html>
- Sanchez Energy Corporation. (2013). *SHALE DEVELOPMENT*. Retrieved 10 1, 2014, from <http://www.sanchezenergycorp.com/media-center-2/industry-library/shale-development/>
- Saskatchewan Ministry of the Economy. (2014, 4 15). *Crude Oil Volume and Value Summary by Area Crude Type*. Retrieved 2 19, 2015, from <http://www.economy.gov.sk.ca/2013-CrudeOil-Summary>
- Statistics Canada. (2015, 3 13). *Labour Force Information*. Retrieved 2 26, 2015, from <http://www.statcan.gc.ca/pub/71-001-x/71-001-x2015002-eng.htm>

SASKATCHEWAN OIL AND GAS SUPPLY CHAIN REQUIREMENT GUIDE

Guide to Oil and Gas in Saskatchewan
May 11, 2015

ADDITIONAL DIGITAL GENERAL REFERENCES

[http://www.sanchezenerycorp.com/media-center-2/industry-library/shale-development/Oilfield Market Report 2004. Spears & Assoc. Inc., Tulsa, Oklahoma](http://www.sanchezenerycorp.com/media-center-2/industry-library/shale-development/Oilfield%20Market%20Report%202004.pdf)
<https://blogs.siemens.com/measuringsuccess/stories/688/>
<http://www.pumpwell.ca/our-service/vertical-wells/>
http://www.slb.com/~media/Files/resources/mearr/wer16/rel_pub_mewer16_1.pdf
<http://www.croftsystems.net/blog/the-difference-between-a-wellhead-christmas-tree>
[http://www.04.abb.com/global/seitp/seitp202.nsf/0/f8414ee6c6813f5548257c14001f11f2/\\$file/Oil+and+gas+production+handbook.pdf](http://www.04.abb.com/global/seitp/seitp202.nsf/0/f8414ee6c6813f5548257c14001f11f2/$file/Oil+and+gas+production+handbook.pdf)
<http://www2.emersonprocess.com/siteadmincenter/PM%20Remote%20Automation%20Solutions%20Documents/pdf/OnshoreBrochure-D351494X012-Web.pdf>
<http://www.transgas.com/newsroom/link/pdfs/08Q2.pdf>
[http://www.theicct.org/sites/default/files/publications/ICCT05 Refining Tutorial FINAL R1.pdf](http://www.theicct.org/sites/default/files/publications/ICCT05%20Refining%20Tutorial%20FINAL%20R1.pdf)
http://www.rigzone.com/training/insight.asp?insight_id=313&c_id=4
http://www.rigzone.com/training/insight.asp?insight_id=346&c_id=4
<http://www.api.org/oil-and-natural-gas-overview>
<http://www.capp.ca/getdoc.aspx?DocId=247759&DT=NTV>
<https://blogs.siemens.com/measuringsuccess/stories/688/>
<http://boereport.com/well-map/>
<https://www.osha.gov/SLTC/etools/oilandgas/index.html>
http://www.powerincooperation.com/EN/Pages/drilling-and-completion.html?utm_campaign=PiC&utm_medium=PaidSearch&utm_source=Google&utm_content=oil_drilling_process#sthash.lqVWiZVP.dpbs
[http://www.csur.com/sites/default/files/Understanding Well Construction final.pdf](http://www.csur.com/sites/default/files/Understanding%20Well%20Construction%20final.pdf)
http://www.slb.com/~media/Files/resources/mearr/wer16/rel_pub_mewer16_1.pdf
http://www.rigzone.com/training/insight.asp?insight_id=326&c_id=1
<http://www.beatingtheindex.com/the-viking-oil-play-in-saskatchewan/>
[http://www.cspg.org/cspg/documents/Conventions/Archives/Annual/2011/146-Oil and Gas in Saskatchewan.pdf](http://www.cspg.org/cspg/documents/Conventions/Archives/Annual/2011/146-Oil%20and%20Gas%20in%20Saskatchewan.pdf)
<http://geology.com/articles/horizontal-drilling/>
<http://economy.gov.sk.ca/monthlydrilling>
<http://wbpc.ca/+pub/document/archived-talks/2011/presentation/Yurkowski%20Updates%202011%20Saskatchewan%20oil%20and%20Gas.pdf>
http://www.ihrdc.com/els/po-demo/module14/mod_014_02.htm
<http://www.netl.doe.gov/research/coal/crosscutting/pwmis/tech-desc/injectdisp>
<http://www.aocs.org/Membership/informArticleDetail.cfm?ItemNumber=8644>
<http://otsg.com/about/about-otsg/>
http://www.epa.gov/gasstar/documents/II_final_vap.pdf
https://www.rigzone.com/training/insight.asp?insight_id=291&c_id=24
http://www.slb.com/~media/Files/testing/other/epf_overview.pdf
<http://www.drillingformulas.com/basic-of-drillpipe-tensile-capacity-and-its-calculation/>
http://www.idsuk.com/products_drillpipe.htm
<http://www.tenaris.com/en/products/octg/drillpipe.aspx>
<http://www.sciencemediacentre.ca/smc/docs/pipelines.pdf>
<http://www.centreforenergy.com/Shopping/uploads/75.pdf>
<http://www.cepa.com/about-pipelines/pipeline-design-construction/pipeline-construction>
[http://petrowiki.org/Piping and pipeline systems](http://petrowiki.org/Piping_and_pipeline_systems)
[http://petrowiki.org/Liquid meters](http://petrowiki.org/Liquid_meters)
[http://petrowiki.org/Flare and vent disposal systems](http://petrowiki.org/Flare_and_vent_disposal_systems)

SASKATCHEWAN OIL AND GAS SUPPLY CHAIN REQUIREMENT GUIDE

Guide to Oil and Gas in Saskatchewan

May 11, 2015

[http://www.e6.com/wps/wcm/connect/E6_Content_EN/Home/Materials+and+products/Synthetic+Polycrystalline+Diamond+\(PCD\)/PDC+polycrystalline+diamond+compact+cutters+for+oil+and+gas/](http://www.e6.com/wps/wcm/connect/E6_Content_EN/Home/Materials+and+products/Synthetic+Polycrystalline+Diamond+(PCD)/PDC+polycrystalline+diamond+compact+cutters+for+oil+and+gas/)
http://www.halliburton.com/public/cem/contents/papers_and_articles/web/h/h05105_wp.pdf
http://www.varelintl.com/content/includes/pdc_technology.pdf
http://www.glossary.oilfield.slb.com/en/Terms/p/polycrystalline_diamond_compact_bit.aspx
https://www.rigzone.com/training/insight.asp?insight_id=296&c_id=1
<http://www.halliburton.com/en-US/ps/sperry/drilling/measurement-while-drilling-mwd.page?node-id=hfyjrqum>
<http://www.flowtechenergy.com/oil-gas-questions/drill-pipe/>
<http://drillpipesupply.com/drill-pipe>
https://www.cagc.ca/index.html?DISPLAY=information_alerts&DL=000395
<http://fracfocus.org/hydraulic-fracturing-how-it-works/casing>
[http://apps.nov.com/gp/catalog/catalog.cshhtml?puuid=5EdFzBZ\\$3oL35C](http://apps.nov.com/gp/catalog/catalog.cshhtml?puuid=5EdFzBZ$3oL35C)
<http://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/2014/cndncrdlxprtssl-eng.html>
<https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/cndncrdlxprttrnsprttnsstm5yr/cndncrdlxprttrnsprttnsstm5yr-eng.html>
<http://www.cepa.com/wp-content/uploads/2014/10/liquids-cepa2014.pdf>
<http://www.cepa.com/library/factoids>
<http://www.forbes.com/sites/jamesconca/2014/04/26/pick-your-poison-for-crude-pipeline-rail-truck-or-boat/>
<http://www.iadclexicon.org/manifold/>
http://www.en-fabinc.com/en/production_and_test_manifolds.shtml
http://www.sunrypetro.com/division_manifold.html
<http://www.capp.ca/aboutUs/mediaCentre/NewsReleases/Pages/access-to-markets-remains-critical.aspx>
<http://www.capp.ca/getdoc.aspx?DocID=258247>
<http://www.capp.ca/getdoc.aspx?DocID=247759>
<http://www.desmogblog.com/2014/10/27/drilling-deeper-post-carbon-institute-fracking-production-numbers>
http://www.postcarbon.org/wp-content/uploads/2014/10/Drilling-Deeper_PART-2-Tight-Oil.pdf
<http://peakoilbarrel.com/oil-field-models-decline-rates-convolution/>
<http://www.outsiderclub.com/report/the-coming-bust-of-the-us-shale-oil-gas-ponzi/1041>
<http://peakoilbarrel.com/debt-oil-price-bakken-red-queen/>