The Western Oil and Natural Gas Industry
2016 Economic Impact Study

Methodology and Documentation

Prepared for

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Executive Summary:

The *Western Oil and Natural Gas Industry 2016 Economic Impact Study* estimates the economic contributions made by the oil and gas exploration and production industry to the U.S. economy in 2016. John Dunham and Associates conducted this research, which was funded by Western Energy Alliance. This work used standard econometric models first developed by the U.S. Forest Service, and now maintained by MIG, Inc. Data came from industry sources, government publications, Dun and Bradstreet, Inc. and Infogroup.

The study defines the Western Energy Industry as those firms involved in the exploration, leasing, drilling, completion, production, field services and processing, segments of the oil and gas industry in 13 western states.[1] The study measures the number of jobs in this sector; the wages paid to employees, the value added and total output.

Industries are linked to each other when one industry buys from another to produce its own products. Each industry in turn makes purchases from a different mix of other industries, and so on. Employees in all industries extend the economic impact when they spend their earnings. Thus, economic activity started by the energy production industry generates output (and jobs) in hundreds of other industries, often in states far removed from the original economic activity. The impact of supplier firms, and the "Induced Impact" of the re-spending by employees of industry and supplier firms, is calculated using an input/output model of the United States. The study calculates the impact on a national basis, by state, by county and by Congressional district.

The study also estimates taxes paid by the industry and its employees. Federal taxes include industry-specific excise and sales taxes, business and personal income taxes, FICA, and unemployment insurance. State and local tax systems vary widely. Direct taxes include federal as well as state lease payments, royalties and severance taxes. Industry firms pay real estate and personal property taxes, business income taxes, and other business levies that vary in each state and municipality. All entities engaged in business activity generated by the industry pay similar taxes. In addition to these "business and personal taxes," firms involved in the production of oil and gas resources pay millions of dollars in state severance taxes, as well as lease payments and royalties to both the federal government and state governments. These payments are also documented in this study but are not a direct part of the model.

The Western Oil and Natural Gas Industry is a dynamic part of the U.S. economy, accounting for about $49.17 billion in output or roughly 0.27 percent of GDP. Western oil and gas producers directly or indirectly employed approximately 117,060 Americans in 2016. These workers earned almost $14.47 billion in wages and benefits. Members of the industry and their employees paid $6.43 billion in direct federal, state and local taxes, and nearly $6.90 billion in production related levies.

Summary Results:

The *Western Oil and Natural Gas Industry 2016 Economic Impact Study* measures the impact of the oil and gas exploration and production sector, as defined by the exploration, leasing, field services, drilling, completion, production, and initial processing of oil and natural gas products in 13 western states, on the entire economy of the United States. The industry contributes about $49.17 billion in economic output or

[1] Throughout this analysis, the "western states" are defined as: Arizona, Colorado, Idaho, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming.

0.27 percent of GDP and, through its production and distribution linkages impacts firms in 514 of the 536 sectors of the US economy.[2]

The oil and gas industry includes not only companies that directly drill for and produce oil and natural gas in the western United States, but the operations of hundreds of companies that manage leaseholds, explore for and quantify oil and gas resources, provide field services, and perform initial on-site natural gas refining operations. This includes major integrated energy firms like Exxon/Mobile and Conoco/Phillips, but also thousands of smaller companies located throughout the region that provide a range of services from well completion, to drilling, to field reclamation. All told, these firms employ 38,150 people in either on-site operations or at their office locations.

The vast majority of these employees are involved in drilling and production activities. These include a wide range of workers, from roughnecks on the wells, to pipefitters, to skilled chemists that complete wells. In addition, thousands of scientists, geologists, engineers and chemists design the wells and determine how and where they will be drilled. We estimate that there are nearly 1,429 firms involved in drilling and production activities in the 13 western states[3] that employ nearly 24,060 people.

In addition to these workers, there are hundreds of workers employed by other companies that are directly involved in the production of oil and gas. These include nearly 2,290 people working in on-field refining operations that separate usable liquid products from natural gas. Another 7,780 people are involved in field operations including carpenters that set up temporary on-site housing and office facilities, electricians that set up temporary electrical services, and geologists, landscapers and environmental engineers that reclaim drilling sites to their original conditions as well as in people work in companies that are involved in the financial side of oil and gas production – providing financing and leasing services. As many as 4,017 truck drivers, pipefitters and welders (among others) are directly involved in moving water, sand, and produced petroleum products around the oil fields.[4]

Other firms are related to the oil and gas production industry as suppliers. These firms produce and sell a broad range of items including pipe, pump jacks, generators, sand, drill-bits and electronics used in the production process. In addition, supplier firms provide a broad range of services, including personnel services, financial services, engineering services, consulting services environmental services, or even transportation services. Finally, a number of people are employed in government enterprises responsible for the regulation of the oil and gas industry. All told, we estimate that the Western Oil and Natural Gas industry is responsible for 51,240 supplier jobs with these firms generating about $11.73 billion in economic activity.

This economic analysis of the oil and gas production industry also takes additional linkages into account. While it is inappropriate to claim that suppliers to the supplier firms are part of the industry being analyzed[5] the spending by employees of the industry and those of supplier firms whose jobs are directly dependent on oil and natural gas sales and production should surely be included. This spending on everything from housing, to food, to educational services and medical care makes up what is traditionally called the "induced impact" or multiplier effect of the industry. In other words, this spending, and the jobs it creates is induced by the exploration and production of oil and gas in the western states. We estimate

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2 Based on GDP of $18.436 trillion. See: *Gross Domestic Product: Second Quarter 2016 (Second Estimate) Corporate Profits: Second Quarter 2016 (Preliminary Estimate*, News Release, US Department of Commerce, Bureau of Economic Analysis, August 26, 2016. Economic sectors based on IMPLAN sectors.

3 Physical locations.

4 This does not include those truck drivers, railroad workers or pipeline operators involved in the distribution of oil and gas from the fields to off-site refineries or tank farms.

5 These firms would more appropriately be considered as part of the supplier firms' industries.

that the induced impact of the industry is just over $14.58 billion, and generates 87,670 jobs, for a multiplier of about 2.30.[6]

An important part of an impact analysis is the calculation of the contribution of the industry to the public finances of the community. In the case of the oil and gas industry, the traditional direct taxes paid by the firms and their employees provide over $6.43 billion in revenues to the federal, state and local governments. In addition to this, producers and leaseholders pay state severance taxes, royalties and lease payments equal to nearly $6.90 billion.[7]

Table 1 below presents a summary of the total economic impact of the industry in the United States. Summary tables for each state are included in the Output Model, which is discussed in the following section.

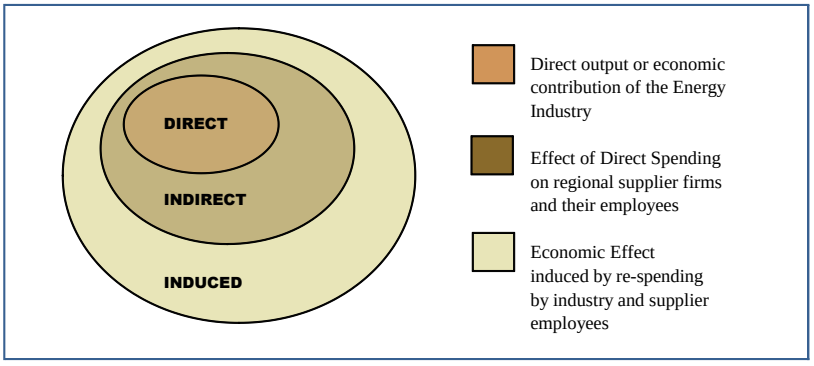
Economic Contribution of the Western Oil and Gas Production Industry: 2016

($ In Billions)	Direct	Supplier	Induced	Total
Jobs	38,152	51,239	87,667	177,058
Output	$22.86	$11.73	$14.58	$49.17
Wages	$5.96	$3.98	$4.53	$14.47
Taxes				$13.30

Output Model:

John Dunham and Associates, Inc. produced the Economic Impact study for Western Energy Alliance. The analysis consists of a number of parts, each of which will be described in the following sections of this document. These include data, models, calculations and outputs. These components were linked together into an interactive system that allows Western Energy Alliance to examine the links between the various parts of the industry and to produce detailed output documents on an as-needed basis. As such, there is no book – no thick report – outlining the impact of the industry, but rather a system of models and equations that can be continuously queried and updated.

Economic Impact Modeling – Summary:



The Economic Impact Study begins with an accounting of the direct employment in firms involved in oil and gas exploration and production in the 13 states included in the study. The data come from a variety of government and private sources.

It is sometimes mistakenly thought that initial spending

6 Often economic impact studies present results with very large multipliers – as high as 4 or 5. These studies invariably include the firms supplying the supplier industries as part of the induced impact. John Dunham and Associates believes that this is not an appropriate definition of the induced impact and as such limits this calculation to only the effect of spending by direct and supplier employees.

7 This figure is not generated by the economic impact mode. It comes from state departments of revenue, and natural resources, as well as from the US Department of Interior, Bureau of Land Management, and represents data for fiscal year 2012 and 2013 depending on the last year which is currently available.

accounts for all of the impact of an economic activity or a product. For example, at first glance it may appear that consumer expenditures for a product are the sum total of the impact on the local economy. However, one economic activity always leads to a ripple effect whereby other sectors and industries benefit from this initial spending. This inter-industry effect of an economic activity can be assessed using multipliers from regional input-output modeling.

The economic activities of events are linked to other industries in the state and national economies. The activities required to produce a barrel of crude oil for example, from planning the well design, to drilling and completion, to moving the product to a pipeline for distribution generate the direct effects on the economy. Regional (or indirect) impacts occur when these activities require purchases of goods and services such as pipe, cement or electricity from local or regional suppliers. Additional, induced impacts occur when workers involved in direct and indirect activities spend their wages. The ratio between induced economic and direct impact is termed the multiplier. The framework in the chart on the prior page illustrates these linkages.

This method of analysis allows the impact of local production activities to be quantified in terms of final demand, earnings, and employment in the states and the nation as a whole.

Once the direct impact of the industry has been calculated, the input-output methodology discussed below is used to calculate the contribution of the supplier sector and of the re-spending in the economy by employees in the industry and its suppliers. This induced impact is the most controversial part of economic impact studies and is often quite inflated. In the case of the Western Energy Alliance model, only the most conservative estimate of the Induced Impact has been used.

Model Description and Data:

This analysis is based on data provided by D & B, Inc., Western Energy Alliance and state and federal governments. The analysis utilizes the IMPLAN Model in order to quantify the economic impact of the Western Oil and Natural Gas industry on the economy of the United States.[8] The model adopts an accounting framework through which the relationships between different inputs and outputs across industries and sectors are computed. This model can show the impact of a given economic decision – such as a factory opening or operating a sports facility – on a pre-defined, geographic region. It is based on the national income accounts generated by the US Department of Commerce, Bureau of Economic Analysis (BEA).[9]

Every economic impact analysis begins with a description of the industry being examined. In the case of the Western Energy Alliance model, the industry is defined as the exploration, leasing, drilling and completion of wells, production, initial natural gas refining, and remediation of oil and gas fields in the western United States.

The IMPLAN Group model is designed to run based on the input of specific direct economic factors. It uses a detailed methodology (see IMPLAN Methodology section) to generate estimates of the other direct impacts, tax impacts and supplier and induced impacts based on these entries. In the case of the Western Energy Alliance Economic Impact Model, direct employment in the industry is a base starting point for the analysis. Direct employment is based directly on data provided to John Dunham and Associates by Dun & Bradstreet, Inc. as of March 18, 2016, data from Infogroup as of June 1, 2016, and data from

8 The model uses 2014 input/output accounts.

9 RIMS II is a product developed by the U.S. Department of Commerce, Bureau of Economic Analysis as a policy and economic decision analysis tool. IMPLAN was originally developed by the US Forest Service, the Federal Emergency Management Agency and the Bureau of Land Management. It was converted to a user-friendly model by the Minnesota IMPLAN Group in 1993.

Western Energy Alliance. Dun & Bradstreet data is recognized nationally as a premier source of micro industry data. The D&B database contains information on over 15 million businesses in the United States.[10] It is used extensively for credit reporting, and according to the vendor, encompasses about 98 percent of all business enterprises in the country. This data is gathered at the facility level; therefore, a company with a manufacturing plant, warehouse and sales office would have three facilities, each with separate employment counts. Since the D&B data are adjusted on a continual basis, staff from John Dunham and Associates scanned the data for discrepancies.

Infogroup data are recognized nationally as a premier source of micro industry data. Infogroup is the leading provider of business and consumer data for the top search engines and leading in-car navigation systems in North America. Infogroup gathers data from a variety of sources, by sourcing, refining, matching, appending, filtering, and delivering the best quality data. Infogroup verifies its data at the rate of almost 100,000 phone calls per day to ensure absolute accuracy. In addition, for cases where employment data for Western Energy Alliance member firms were available, Infogroup and D&B employment figures were replaced with those from the Alliance.

Direct jobs are then mapped to their physical locations using a geographic analysis package (Maptitude). In addition, the location of all active and licensed oil and gas wells in each of the states was gathered from the various state licensing agencies and departments of natural resources. These well locations were also mapped to their geographic location (longitude and latitude) using the Maptitude software. Since most of these direct jobs ended up being geographically located in the Denver, Colorado region, it was determined that many of the companies were reporting their employment at their headquarters or other physical location, even though most manpower worked at individual field locations. In order to account for this discrepancy, jobs were reallocated based on two factors. First, monthly rig count data by state is available from Baker Hughes.[11] The number of production and drilling jobs were allocated across states based on the percentage of rigs located in each. In addition, production data by state was gathered from the US Department of Energy.[12] These data were used to reallocate some of the pipeline and refining jobs away from Denver to the other states. In total, these adjustments led to a reallocation of jobs away from Colorado and Utah primarily to North Dakota and New Mexico. In addition, data were cross-referenced with the number of active wells in each state to ensure that they were within reasonable bounds.[13]

Once the initial direct employment figures have been established, they are entered into a model linked to the IMPLAN database. The IMPLAN data are used to generate estimates of direct wages and output. Wages are derived from data from the U.S. Department of Labor's ES-202 reports that are used by IMPLAN to provide annual average wage and salary establishment counts, employment counts and payrolls at the county level. Since this data only covers payroll employees, it is modified to add information on independent workers, agricultural employees, construction workers, and certain government employees. Data are then adjusted to account for counties where non-disclosure rules apply. Wage data include not only cash wages, but health and life insurance payments, retirement payments and other non-cash compensation. It includes all income paid to workers by employers.

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10 The D&B information database updates over 1 million times a day, over 350 million payment experiences are processed annually, and over 110 million phone calls are made to businesses. In addition, D&B uses a patented matching technology and over 2,000 information computer validations to ensure a high standard of data quality.

11 *Rotary Rigs Running - By State*, Baker Hughes Incorporated, at: http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountsoverview. Data for June 2015 through August 2016.

12 Crude Oil Production, US Department of Energy, Energy Information Administration, June 29, 2016, at: www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm.

13 Data on active wells were obtained from state permit and well registries. Information on active wells were not available in all states in which case nearby proxy states (for example Utah for Nevada) were used.

Total output is the value of production by industry in a given state. It is estimated by IMPLAN from sources similar to those used by the BEA in its RIMS II series. Where no Census or government surveys are available, IMPLAN uses models such as the Bureau of Labor Statistics Growth model to estimate the missing output.

The model also includes information on income received by the Federal, state and local governments, and produces estimates for the following taxes at the Federal level: corporate income payroll, personal income, estate, gift, and excise taxes; customs duties; and fines, fees, etc. State and local tax revenues include estimates of: corporate profits, property, sales, severance, estate and gift and personal income taxes; licenses and fees; and certain payroll taxes.

Data on severance taxes, lease payments and royalties to the federal government and governments of the 13 states is calculated separately from the impact model. In this case, data were gathered directly from the states and the Bureau of Land Management and aggregated for inclusion into the model.[14]

While IMPLAN is used to calculate the state level impacts, Infogroup data provide the basis for Congressional and state legislative district level estimates as well as county level impacts. Publicly available data at the county and Congressional district level is limited by disclosure restrictions, especially for smaller sectors of the economy like can manufacturing. Our model therefore uses actual physical location data provided by Infogroup in order to allocate jobs – and the resulting economic activity – by physical address or when that is not available, zip code. For zips entirely contained in a single geographic boundary, jobs are allocated based on the percentage of total sector jobs in each zip. For zips that are broken by geographic boundary, allocations are based on the percentage of total jobs physically located in each segment of the zip. Physical locations are based on either actual address of the facility, or the zip code of the facility, with facilities placed randomly throughout the zip code area. In the case of direct production, field services and distribution employment, the geographic allocations are based on an average of the physical location of jobs as reported to Infogroup, and the physical location of active wells.[15]

All supplier and indirect jobs are allocated based on the percentage of a state's employment in that sector in each of the districts. Again, these percentages are based on Infogroup data.

IMPLAN Methodology:[16]

Francoise Quesnay one of the fathers of modern economics, first developed the analytical concept of inter-industry relationships in 1758. The concept was actualized into input-output analysis by Wassily Leontief during the Second World War, an accomplishment for which he received the 1973 Nobel Prize in Economics.

Input-Output analysis is an econometric technique used to examine the relationships within an economy. It captures all monetary market transactions for consumption in a given period and for a specific geography. The IMPLAN model uses data from many different sources – as published government data series, unpublished data, sets of relationships, ratios, or as estimates. The Minnesota IMPLAN group gathers this data, converts it into a consistent format, and estimates the missing components.

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14 These tax data were gathered in June and July of 2016 by John Dunham and Associates staff using both agency websites, and through telephone calls to officials and the various agencies. More detailed information on sources by state can be obtained directly from JDA.

15 While this does not matter in Montana, North Dakota and Wyoming since these states have a single Congressional District, it did lead to significant reallocations in Colorado, Utah, New Mexico and Arizona.

16 This section is paraphrased from IMPLAN Professional: Users Guide, Analysis Guide, Data Guide, Version 2.0, MIG, Inc., June 2000.

There are three different levels of data generally available in the United States: Federal, state and county. Most of the detailed data is available at the county level, and as such there are many issues with disclosure, especially in the case of smaller industries. IMPLAN overcomes these disclosure problems by combining a large number of datasets and by estimating those variables that are not found from any of them. The data is then converted into national input-output matrices (Use, Make, By-products, Absorption and Market Shares) as well as national tables for deflators, regional purchase coefficients and margins.

The IMPLAN Make matrix represents the production of commodities by industry. The Bureau of Economic Analysis (BEA) Benchmark I/O Study of the US Make Table forms the bases of the IMPLAN model. The Benchmark Make Table is updated to current year prices, and rearranged into the IMPLAN sector format. The IMPLAN Use matrix is based on estimates of final demand, value-added by sector and total industry and commodity output data as provided by government statistics or estimated by IMPLAN. The BEA Benchmark Use Table is then bridged to the IMPLAN sectors. Once the re-sectoring is complete, the Use Tables can be updated based on the other data and model calculations of interstate and international trade.

In the IMPLAN model, as with any input-output framework, all expenditures are in terms of producer prices. This allocates all expenditures to the industries that produce goods and services. As a result, all data not received in producer prices is converted using margins which are derived from the BEA Input-Output model. Margins represent the difference between producer and consumer prices. As such, the margins for any good add to one. If, for example, 10 percent of the consumer (in this case the well-head) price of oil is from the purchase of steel, then the steel margin would be 0.1.

Deflators, which account for relative price changes during different time periods, are derived from the Bureau of Labor Statistics (BLS) Growth Model. The 224 sector BLS model is mapped to the 440 sectors of the IMPLAN model. Where data are missing, deflators from BEA's Survey of Current Businesses are used.

Finally, one of the most important parts of the IMPLAN model, the Regional Purchase Coefficients (RPCs) must be derived. IMPLAN is derived from a national model, which represents the "average" condition for a particular industry. Since national production functions do not necessarily represent particular regional differences, adjustments need to be made. Regional trade flows are estimated based on the Multi-Regional Input-Output Accounts, a cross-sectional database with consistent cross interstate trade flows developed in 1977. These data are updated and bridged to the 440 sector IMPLAN model.

Once the databases and matrices are created, they go through an extensive validation process. IMPLAN builds separate state and county models and evaluates them, checking to ensure that no ratios are outside of recognized bounds. The final datasets and matrices are not released before extensive testing takes place.