Joint Economic Committee
Republicans
Representative Kevin Brady
Chairman

North American Energy – Closing the Growth & Jobs Gap

Oil & Gas Development Boosts the Economy and Industrial Resurgence

July 24, 2013

Investment is streaming into domestic oil and gas attracted by stable long-run supply costs, inducing industrial expansion, economic growth, and creating millions of well-paying job opportunities.

INTRODUCTION

The revolution in oil and natural gas production technology has shifted the domestic energy supply curve dramatically to the right. Hydraulic fracturing and directional drilling (see Appendix #1) have made large domestic crude oil and natural gas reserves accessible at production costs that are competitive with international prices, enabling domestic producers to gain back a share of crude oil sales from imports, preserve North American self-sufficiency in natural gas, and even to seek a share of overseas natural gas markets.

The build-out of the domestic oil and gas supply is pumping billions of dollars into the still ailing economy and creates jobs in the industry, the largely domestic supply chain, and throughout the economy. Increased oil and gas production creates real value, lends a competitive advantage to U.S. manufacturing, and promises sustained economic growth.

Economic opportunities are opening up in the United States that are of a historic scale in terms of the:

- ***Reversal in international leverage over energy supply,***
- ***Investment and job creation in energy production, and***
- ***Favorable conditions for domestic manufacturing to which abundant energy resources contribute.***

The timing of the sea change in energy could not be better for the U.S. economy.

One can only hope the Administration will embrace this gift and make the most of it for American workers and consumers.

Exhibit 1: LOWER 48 STATES SHALE PLAYS

Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

VAST RECOVERABLE RESOURCES

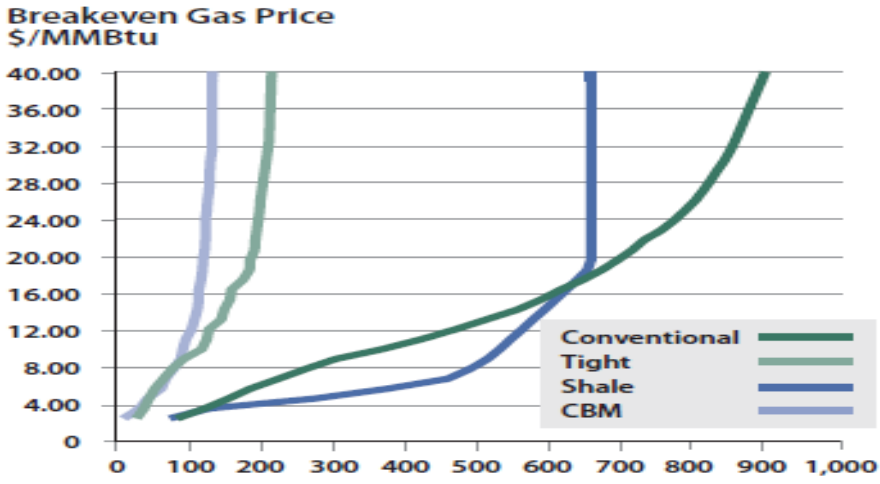
Large reserves have become accessible in the United States that promise to supply oil and natural gas at stable costs for a long time.

Abundant oil and gas reserves. The domestic reserves of crude oil and natural gas now accessible are so large they will last for many decades. The Energy Information Administration's (EIA) latest estimate of the country's technically recoverable natural gas resources is 2,327 trillion cubic feet, which would last roughly 100 years at the current rate of U.S. consumption; its estimate of crude oil resources is 222.6 billion barrels, which amounts to 90 years of U.S. field production at the current rate.[1]

According to a prominent University of Texas study of 15,000 wells in the Barnett Shale formation of northern Texas, 44 trillion cubic feet of natural gas, which is equal to two years of U.S. consumption at current rates, can yet be produced from Barnett alone. This is more than three times what has been produced so far from that formation. The Barnett study, and similar ones under way, suggests that natural gas production in the United States will not plateau until 2040.[2]

Stable production costs. The large resource base of tight oil and shale gas suggests that production can expand over a wide range of output without substantial cost increases. Unless it becomes more difficult to find and extract the resources, drilling and production costs per unit of output will not increase—and given the enormous size of shale plays in the United States that may not occur for a long time. Exhibit 2 shows estimates of long-run supply curves from different sources of natural gas in the United States based on present technology. A substantial portion of the estimated shale resource base is economic at prices between $4 and $8 per MMBtu.

Exhibit 2: LONG-RUN NATURAL GAS SUPPLY CURVES



"The Future of Natural Gas." An Interdisciplinary MIT Study, June 6, 2011, p. 26.

Source: MIT; ICF North American Hydrocarbon Supply Model

[1] EIA's *Annual Energy Outlook 2013*. The Potential Gas Committee recently increased its estimate of natural gas reserves to 2,384 trillion cubic feet.

[2] "Gas Boom Projected to Grow for Decades," Russell Gold, *The Wall Street Journal*, February 27, 2013. The Bureau of Economic Geology at the University of Texas at Austin conducted the study which is still under peer review.

The advancements that have made unconventional production economical occurred only a few years ago and costs may yet decline even further as the unconventional methods are honed—the supply curve may shift further down and to the right. Indeed, estimates of oil and gas resources typical increase over time.

ASSURED DEMAND

Domestic oil and natural gas producers face an assured market for their products because crude oil imports remain large and relatively costly, and the anticipated price of natural gas has undergone a favorable reversal.

Crude oil. In the United States, consumption of crude oil has been declining since 2007 and is not likely to grow. The U.S. economy is becoming ever less energy intensive, and the government is trying to limit fossil fuel consumption with mandates and supports for alternative fuels, such as for ethanol, and fuel use standards, such as CAFE.[3] Nevertheless, the United States is still importing about 10 million barrels of oil per day (b/d). [4] Unconventional domestic crude oil production is less than 2 million b/d and has to make up for declines in conventional domestic production. Global oil consumption continues to rise and numerous developing countries are importing more oil, which has pushed the price to historic heights in recent years. Hence, U.S. producers have plenty of opportunity to continue replacing high-priced imports with domestic supply.[5] Only in the EIA's most aggressive forecast scenario are crude oil imports to the United States replaced entirely by domestic production and only in 2035; in its reference case, imports stay at about 37% of the U.S. liquids fuel market throughout the forecast period ending in 2040.[6]

Natural gas. Consumers of natural gas in the United States have enjoyed a low price recently, but the combination of hydraulic fracturing and horizontal drilling more importantly brought about a huge reversal in the anticipated long-term cost of natural gas, especially to American firms that use it directly as an input or indirectly as an energy source and for whom energy is a large cost element. It is easiest to appreciate this from the perspective of several years ago when the decline in production from conventional natural gas wells gave rise to the anticipated need for LNG imports. Americans then would have had to pay higher overseas prices *plus* the cost of liquefaction, shipping, and regasification. That prospective burden has given way to an expected domestic price significantly *below* overseas prices. Indeed, the expectation is for foreign firms to seek natural gas imports from the United States and having to pay the added cost of processing and shipping LNG in the opposite direction, which means the U.S.

[3] Measures such as CAFÉ have "rebound" effects referring, for example, to motorists driving faster, more miles, and purchasing larger vehicles in response to reduced fuel costs per mile. Also, fuel conservation often is claimed not on a full cycle basis but on the basis of reductions in retail sales, which can be misleading. Still, governmental efforts likely are lessening the total domestic fossil fuel use.
[4] As of April 2013, 7.7 million b/d crude oil and 2.3 million b/d refined products.
[5] The cost per barrel of hydraulic fractured oil production appears to be well below the $100 Brent price on the world market, leaving adequate margin for domestic production to continue even if the oil price falls significantly.
[6] *Annual Energy Outlook 2013*.

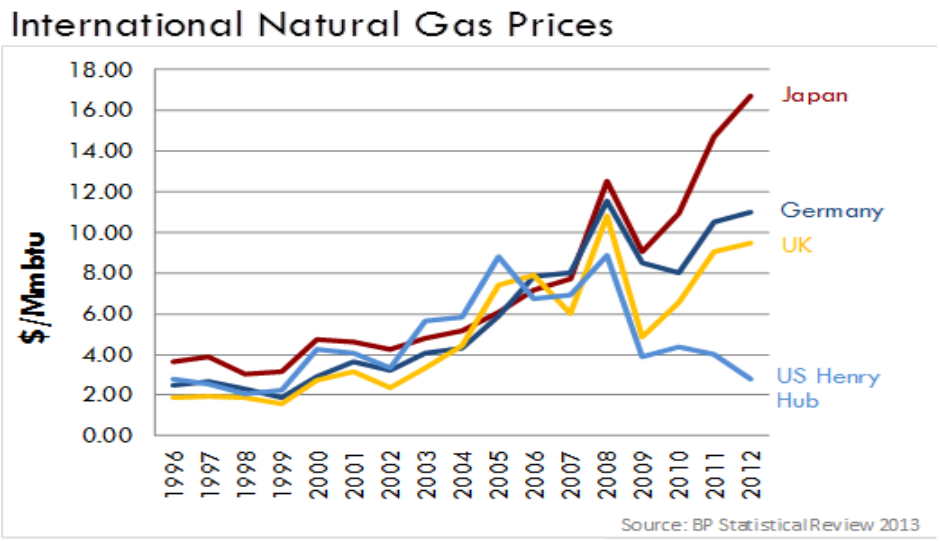
price would be lower than overseas prices by at least that cost. This represents a large swing in anticipated cost. By one estimate, processing and shipping LNG costs $4.10 per MMBtu, which implies an anticipated cost reversal in the order of 2 x 4.10/MMBtu=$8.20 per MMBtu.[7] For reference, the current U.S. price for natural gas is less than $4 per MMBtu. As businesses implement revised plans based on the newfound abundance of domestic natural gas and the cost reversal it prompted, their demand for shale gas likely will increase.

OIL AND GAS MARKETS

Geographic price differentials for natural gas. Prices for natural gas abroad rose just as unconventional production technology lowered the cost of producing natural gas in the United States. In foreign markets, governments often tie the price of natural gas to that of crude oil; hence, as the price of crude oil has risen in recent years, it has pulled the price of natural gas up with it.

U.S. natural gas customers also are paying a much lower price relative to foreign buyers in major markets. For industry, this implies a competitive advantage.

Exhibit 3



The divergence in price has positive implications for the United States, namely an improved competitive cost position for industry, an opportunity for LNG exports, and added assurance of growing demand for natural gas producers.

U.S. cost advantage. Natural gas is an important cost element in such industries as chemicals, cement, glass, primary metal, paper and pulp manufacturing. The recent price developments are helpful to these industries by virtue both of the reversal in anticipated absolute costs discussed above and the relative cost compared with competing firms located in other geographic natural gas markets. Large users of natural gas

[7] "The Future of Natural Gas." An Interdisciplinary MIT Study, June 6, 2011, p. 25. Also, see Appendix #2.

now have an incentive to consider expanding their operations in the United States and perhaps even relocating overseas operations to the United States. Foreign industry, indeed, is concerned with the cost advantage of American manufacturing facilities. The Association of German Industry, BDI, has warned that relatively inexpensive U.S. shale gas could damage European competitiveness.[8] In addition to the price difference, North American natural gas is accessible by indigenous pipelines and relatively safe from sabotage, whereas Europe receives much of its natural gas from former Soviet states via pipelines that transit third countries. Germany invested in two new parallel pipelines laid on the Baltic Seafloor to circumvent Ukraine where gas shipments from Russia have been subject to siphoning and disruption. The island of Japan is supplied exclusively via LNG tankers from across the oceans.

U.S. LNG exports. Large price differentials invite arbitrage. As of March 2013, the Department of Energy has approved 24 applications (three are pending) for LNG exports to countries that have Free Trade Agreements with the United States and two applications to countries that do not (20 more are pending). One export terminal is under construction with an anticipated completion date in 2016 and three more are proposed.[9] While the rush for export licenses may give the impression that a large share of the natural gas supply will be sold abroad, there are sizable conventional natural gas deposits in other countries, especially in the Middle East and in Russia, with lower costs of production (see Appendix #3). LNG processing and transportation costs insert a wedge between domestic cost and overseas delivery prices and will limit the amount of gas that leaves North America in the presence of large conventional reserves abroad. High natural gas prices in other geographic markets exist mostly because governments have set the price for their exports without reference to the cost of supply. However, when faced with competition from North American natural gas exports (Canada also is readying LNG export terminals), they may limit their prices to match the cost of producing the shale gas plus processing and shipping it as LNG to the markets they supply.

U.S. natural gas producers likely will export LNG to high-priced markets abroad, but should expect overseas suppliers of conventional gas with lower costs of supply to adjust their pricing in response.

By illustrative calculation, assuming long-term U.S. production costs in a range of $4 to $8 per MMBtu and adding $4.10 per MMBtu to export the shale gas as LNG, the price range for overseas deliveries is $8.10 to $12.10 per MMBtu, which is substantially below the price paid by Japanese buyers but encompassing European import price levels of the last two years. A plausible scenario is for existing suppliers to cede a share of the highest priced LNG market, Japan, to U.S. exports while moderating their price in Europe just enough to discourage imports from the United States.

[8] "Europe's fears over US energy gap," Gerrit Wiesmann, *Financial Times*, November 9, 2012.
[9] Construction requires Federal Energy Regulatory approval.

An average cost such as the $4.10 per MMBtu figure also does not reflect the market risk natural gas exporters face in the volatility of international price spreads. Gas liquefaction facilities cost billions of dollars and overseas importers may be asked by the investors to take on some of the risk of underutilization by making extended take-or-pay commitments and/or paying a premium over cost, which will reduce the appeal to them of importing LNG from North America. Some of the export license applicants may not follow through on their plans.

A large difference in the domestic prices of natural gas and crude oil will tend to narrow over time because the two commodities are substitutable to an extent in production and consumption.

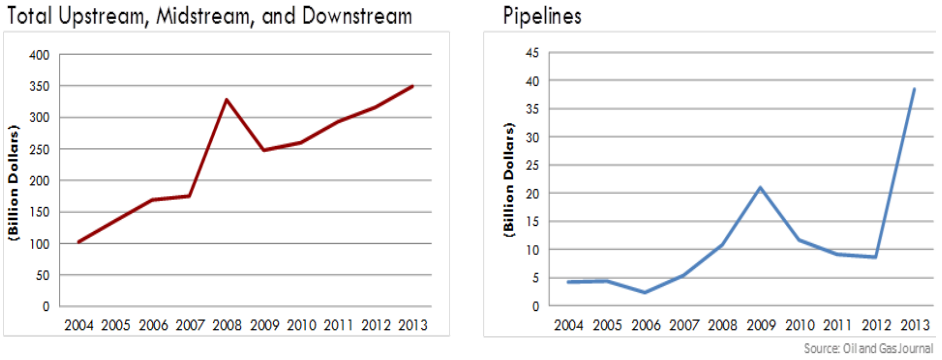
Natural gas as it relates to crude oil. The financial incentives of drilling for oil and gas will tend toward balance in the United States with or without LNG exports. The natural gas price will not settle at the lows it had fallen to last year, which occurred when hydraulic fracturing was first joined with horizontal drilling and generated a surplus.[10] The flexibility to apply hydraulic fracturing and horizontal drilling to either oil or gas limits the gas supply when the price is too low relative to oil. The unconventional production method already has been redirected to crude oil.

On the other hand, the high price of imported crude oil motivates the substitution of cheaper domestic natural gas wherever possible, although there is less flexibility to do so in the short run because crude oil is used primarily to produce fuel for cars and trucks that would require modifications and an alternate fueling infrastructure to run on natural gas (see Appendix #4). Nevertheless, ways will be found in time to increase the substitutability of natural gas for oil to save on fuel costs, and the demand for natural gas will increase for this reason as well. (See Appendix #5 for a summary of important market conditions.)

RENEWED ECONOMIC GROWTH

Capital Investment. The promise of sustained development opportunities in oil and gas is attracting large investments. Capital spending in the U.S. oil and gas industry has been rising for years; from about $100 billion in 2004 to $350 billion projected for 2013 (see Exhibit 4 and Appendix #6).

Exhibit 4: CAPITAL EXPENDITURES ON CRUDE OIL AND NATURAL GAS



[10] "U.S. Oil and Gas Reserve Study 2013," Ernst & Young, June 2013. Inventories swelled and price fell below $2 per MMBtu, which is non-compensatory long-term.

The spike in 2008 was caused by soaring worldwide demand for labor and capital inputs that drove up costs as the oil price reached $145 per barrel. Most spending occurs upstream on exploration, drilling, and production, although this year a nearly fivefold jump in expected investment spending on pipeline construction from $8.5 billion to $38.5 billion is noteworthy.

IHS Global Insight estimates that capital expenditures on upstream unconventional oil and gas activity for the lower 48 states totaled $87.3 billion in 2012. According to the EIA, investment in shale plays specifically amounted to $133.7 billion between 2008 and 2012, including $26 billion of foreign capital contributed to joint ventures with U.S. tight oil and shale gas operators and acreage holders. Acquisition activity of $169 billion from 2008 through April of this year gives further indication of the oil and gas sector's promise.[11] A study by Ernst and Young of U.S. oil and gas exploration and production by the 50 largest companies finds that their "plowback" percentage, the share of revenues less production costs reinvested, averaged 141 percent over the last three years and was 150 percent in 2012.[12] IHS Global Insight projects that upstream unconventional capital expenditures will increase to $172.5 billion per year by 2020 and that cumulative investment of $2.1 trillion in unconventional oil and $3 trillion in unconventional natural gas will take place by 2035.[13]

Domestic oil and gas investment is surging in response to enormous market opportunities.

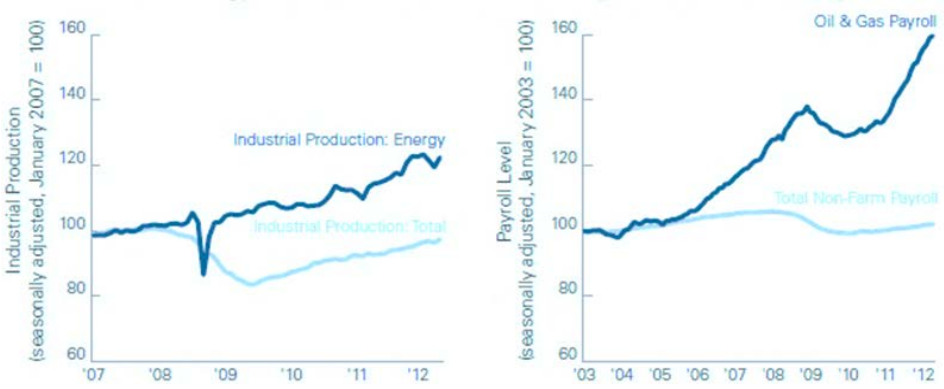
The capital expenditure chart for pipelines shows that investment is also surging in transportation, the industry's midstream segment. Reports are multiplying of railroads expanding capacity to carry more crude oil as well. Railroads are more flexible and quickly deployed although they lack the scale economies of pipeline transport for shipping crude oil.[14]

Industry expansion. Growth in the oil and gas sector has been a godsend for the nation's industrial production in the past decade as energy output has expanded about twice as fast as the national average. The oil and gas sector also had far faster payroll growth than the nation as a whole (see Exhibit 5).

These trends are likely to continue based on the volume of investment taking place. The expansion in oil and gas has come at a most opportune time for the economy because it is far from full employment. The transition costs and trade-offs that occur when an economy at full employment retools and reallocates resources in response to changing relative costs are mitigated when the economy has substantial unemployment and idle cash

[11] Unpublished PFC Energy data provided May 29, 2013.
[12] "U.S. Oil and Gas Reserves Study," Ernst & Young, June 2013, p. 5.
[13] "America's New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy, Volume 1: National Economic Contributions," IHS Report, October 2012, pp. 2, 12.
[14] For a discussion of the tradeoffs between railways and pipelines, see "Trains Leave Pipeline in Lurch," Ben Lefebvre, *The Wall Street Journal*, May 24, 2013.

Exhibit 5: The U.S. Energy Revolution has Boosted Industrial Production and Created Jobs



Source: Goldman Sachs, "U.S. Energy Revolution: How Shale Energy Could Ignite the U.S. Growth Engine," September 2012.

balances.[15] Investment and hiring by the expanding oil and gas industry itself, its suppliers and vendors of complementary oil and gas field services, and the factories providing tools and equipment are less likely to draw workers and investment funds away from other productive pursuits. The number of people officially unemployed stands at 11.8 million, and millions more have given up looking for work while corporate America is sitting on more than $1.5 trillion of cash and equivalents.

The expansion of oil and gas is occurring at an opportune time for the economy.

Wider economic impact. Increased capital investment, production and hiring in the oil and gas industry have wider positive effects on the economy. The higher level of economic activity drives business expansion beyond oil and gas through a well-established supply chain in the United States. Specialized services and machinery and virtually anything else the industry might require can be procured domestically. The indirect effects from growth in oil and gas are exemplified by the revival of a onetime icon of American industry, U.S. Steel, based on producing pipes, tubes, and joints for drillers extracting gas from shale deposits, and a builder of prefabricated homes in Idaho, where there is no oil and gas production, who has hired additional workers to meet orders from North Dakota's Bakken region.[16]

The rest of the economy is receiving a lift from the expansion in the oil and gas sector.

As income from activity in oil and gas and its supporting industries rises, wage earners, landowners, and governments spend more, inducing further economic expansion. Numerous studies have estimated the macroeconomic growth impact of the shale revolution on state economies and the national economy with input-output models. Such models use observed interactions among industries and with the general economy to simulate the effects on GDP, employment, and government tax revenues of a given change. The

[15] Keynesians invoke this point in their claim that government can borrow at no cost and spend with no crowding effects.
[16] "Steel Finds Sweet Spot in the Shale," John W. Miller, *The Wall Street Journal*, March 26, 2012; "Oil and Gas Boom lifts U.S. Economy," Russell Gold, *The Wall Street Journal*, February 8, 2012.

factor by which economic outcomes exceed an initial change is called the "multiplier."

In 2011, on request from Energy Secretary Steven Chu, the National Petroleum Council conducted a review of the North American oil and gas market in which it summarized the estimates of indirect and induced effects on GDP and employment generated by natural gas development and production. The Council cited ten studies, five of Marcellus Shale Gas in the states of West Virginia, Pennsylvania, and New York, one of Eagle Ford Shale oil and gas in Texas, one of oil and gas in Colorado, one of offshore oil and gas in the Gulf of Mexico, and two national studies, one of natural gas and one of oil and gas (see Appendix #7). The estimated value-added multipliers were between 1.48 and 1.98 among the states and 2.24 for the nation, meaning that for each additional dollar spent on investment or operating cost in oil and gas total GDP goes up by a multiple in that range. The estimates of employment multipliers—the total number of workers that eventually find jobs when one more is hired in oil and gas—ranged between 1.53 and 2.05 for individual states and reached 4.54 nationally. The national multipliers are higher because they include effects extending beyond a state's borders.

IHS Global Insight last year published the first two volumes of its three-volume study entitled "America's New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy."[17] The study estimated the direct, indirect, and induced economic effects of unconventional oil and gas activity and projected them to the year 2035 (see Appendix #8). IHS estimated that unconventional oil and natural gas activity supported more than 1.7 million jobs in 2012, and that the number of jobs will keep rising, to 2.5 million in 2015, 3 million in 2020, and 3.5 million in 2035. On average, direct employment will account for 20 percent of the jobs with the rest being created indirectly and induced. Counting direct, indirect and induced effects, unconventional oil and natural gas activity added $238 billion to GDP in 2012 according to the study and will contribute more each year, jumping by 75 percent to $416 billion in 2020 and then to $475 billion by 2035. In the same study, federal, state and local tax receipts derived from unconventional oil and natural gas activity and its effects totaled nearly $62 billion in 2012 and will grow to over $111 billion in 2020 and $124 billion by 2035. Cumulatively, estimated tax revenues collected from unconventional oil and natural gas activity will exceed $2.5 trillion by 2035.[18]

After years of hearing about the wonders of economic stimulus from fiscal multipliers, we now are observing the expansionary effect of real, private sector multipliers.

[17] Volume 1: National Economic Contributions, October 2012 and Volume 2: State Economic Contributions, December 2012. Congressional testimony by Dr. Daniel Yergin at the Energy and Power Subcommittee of the House Energy and Commerce Committee Hearing entitled "America's Energy Security and Innovation" held February 5, 2013 was based on this study.

[18] Tax revenue includes: (1) federal—corporate and personal income taxes; (2) state and local—corporate and personal income taxes, state severance taxes, and state *ad*

Other studies have arrived at similar findings. For example, Citigroup Global Markets Inc. in a major report entitled "Energy 2020—North America, the New Middle East?"[19] estimates that the new oil and gas production will add as much as $486 billion to GDP and add about 2.8 million jobs by 2020. Wood Mackenzie Energy Consulting studied a scenario defined in terms of policy changes it specified and found that more energy development friendly regulation would result in creation of an additional 1.1 million jobs by 2020. Its study uses an employment multiplier of 2.5.[20]

Oil and gas industry jobs are well-paying jobs.

High-quality jobs. IHS Global Insight also examined the relative wages in the upstream oil and gas sector, finding that its hourly wages exceed the national average and the somewhat higher average in manufacturing by more than 50 percent. Jobs associated with unconventional oil and gas activities in particular, given their innovative nature, pay the highest wages at a rate more than double the averages in manufacturing and the economy generally. Appendix #8 shows average hourly wages by occupation in the oil and gas and related industries.

The downstream effect of lower domestic energy costs is helping to create a more competitive basis for U.S. manufacturing internationally.

Lower costs induce expansion. The economic growth effects mentioned so far derive only from the increased development and production of oil and natural gas specifically. Additional economic benefits arise from the lower cost basis that shale gas provides, particularly to manufacturers for whom natural gas is an important feedstock or for whom electricity is a substantial cost element (since natural gas is used to generate electricity). The Boston Consulting Group (BCG) has been predicting a resurgence of U.S. manufacturing based on rising wages in China, an increasing U.S. labor cost advantage over Europe, and also because it expects natural gas to remain 50 to 75 percent cheaper in the United States than in Europe and Japan. BCG projects that by 2015 U.S. manufacturing costs on average will be five percent lower than in France and Germany, eight percent lower than in the UK, 23 percent lower than in Italy, and 21 percent lower than in Japan—in part due to a lower cost of natural gas. The combined effect of lower labor and energy costs could boost U.S. exports by $130 billion per year and create 2.5 to 5 million more jobs by the end of the decade, according to BCG.[21]

(Appendix #9 addresses skeptics' views of hydraulic fracturing.)

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valorem levies; and (3) federal royalties—payment for exploration on federal lands. In addition to government taxes and revenues, lease payments to private landowners are also reported.

[19] Citi GPS: Global Perspectives and Solutions, March 20, 2012. Congressional testimony by Daniel P. Ahn at the Energy and Power Subcommittee of the House Energy and Commerce Committee Hearing entitled "American Energy Initiative" held September 13, 2012 was based on this report.

[20] "U.S. Supply Forecast and Potential Jobs and Economic Impacts (2012-2030)," Wood Mackenzie Energy Consulting, September 7, 2011.

[21] See, "Rising U.S. Exports—Plus Reshoring—Could Help Create up to 5 Million Jobs by 2020," (http://www.bcg.com/media/pressreleasedetails.aspx?id=tcm:12-116389) and "Why America's Export Surge Is Just Beginning" (https://www.bcgperspectives.com/content/commentary/globalization_process_industries_why_americas_export_surge_is_just_beginning/), September 21, 2012.

CONCLUSION

In the short run, hydraulic fracturing is doing what federal programs have not, namely accelerate economic growth and job creation. The federal government has been claiming the same kind of economic and employment effects for all manner of its programs, calling them fiscal "stimulus." Together with trillions of dollars the Fed has poured into the bond market, they were supposed to bring back full employment.[22] But four years after the last recession officially ended a jobs shortfall of 4 million remains relative to an average recovery and the unemployment rate stands at 7.6 percent. The contrast between the real, value-creating investment, hiring, and production taking place in oil and gas and the meager results of government spending spurts, subsidies, and ongoing deficits could not be more striking.

Long-term, North America can supply an increasing share of its own oil demand and offer natural gas at prices that encourage expansion by domestic industry, as well as give some relief to overseas buyers dependent on unreliable sources and paying excessive prices. The Arab oil embargo ushered in an era of volatile, high-priced energy. Hydraulic fracturing may be ushering in an era of more stable, cost-oriented energy.

[22] True Keynesians believe that government programs financed with borrowed money and plenty of liquidity from the Fed need not have any value as such and will induce economic growth and hiring spontaneously.

APPENDIX

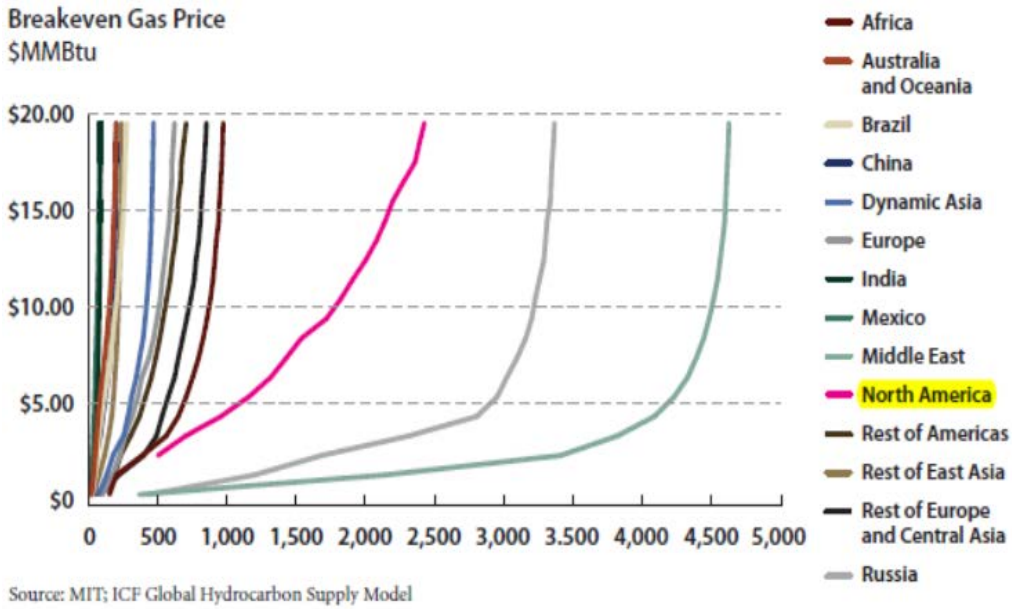
1. Hydraulic fracturing cracks shale formations to release oil or natural gas trapped deep underground, and horizontal drilling extends its reach to vast areas in multiple directions from a single drill pad. Advanced technologies map the underground geology, guide the drill, prop open cracks in the shale, and facilitate resource recovery.

2. The MIT study "The Future of Natural Gas," June 6, 2011, mentions a cost range of $3 to $5/MMBtu and presents an example of the cost components (p. 25):

	$/MMBtu
Liquefaction	2.15
Shipping	1.25
Regasification	0.70
	4.10

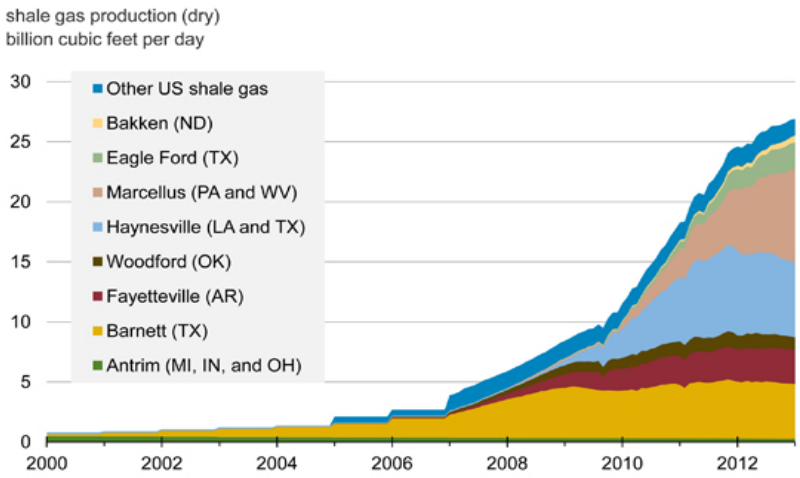
Other estimates found fall into this range; one is significantly higher at $6.50/MMBtu by Fact Global Energy (FGE), see "Asian Natural Gas: A Softer Market is coming," EIA International Natural Gas Workshop, August 23, 2012, by Robert Smith, principal consultant, FGE Dubai. The unit costs depend significantly on volume and also on distance, but because capital intensive facilities (especially for liquefaction) are needed that have no alternative use, the financial risk of underutilization is substantial. For this reason, much of the LNG trade is conducted under long-term take-or-pay contract as are shipments via pipeline.

3. **NATURAL GAS SUPPLY CURVES WORLDWIDE**



"The Future of Natural Gas." An Interdisciplinary MIT Study, June 6, 2011, p. 26.

4. **Oil and gas linkages**. First, a significant cross-elasticity of supply exists between oil and gas as exploration, development and production have much equipment and technology in common, such as for hydraulic fracturing and horizontal drilling. When the combination of these two technologies suddenly increased the natural gas supply in North America it severed the longstanding price relationship with oil and caused the natural gas price to fall below the opportunity cost of drilling for oil, which trades in a world market where its price remained elevated.



Sources: LCI Energy Insight gross withdrawal estimates as of January 2013 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.

Since hydraulic fracturing and horizontal drilling also work for crude oil, they soon were redirected to oil wells. This flexibility has helped lead natural gas inventories toward normal levels and the natural gas price to recover gradually from its low in 2012.

Second, a significant cross-elasticity of demand also exists between oil and gas because they are substitutable to varying degrees as fuel in different uses. The relatively high price of crude oil not only is shifting development and production activity from gas to oil; it also motivates expanding the uses of natural gas. Indications are that natural gas will make greater inroads as a vehicle fuel, for example, given the relatively high prices for diesel and gasoline. Fuel switching capability in transportation entails substantial investments for infrastructure especially, but targeted conversion of vehicle fleets that do not require a ubiquitous refueling infrastructure may become increasingly feasible. Local busses increasingly run on natural gas and there is interest in converting trucks from diesel to natural gas as well.

Third, oil and gas often can be found in the same reservoirs. It is not unusual for oil wells to produce some natural gas and natural gas liquids. (If the necessary gathering facilities and infrastructure are lacking, the gas is flared.) The processing of natural gas for delivery to consumers as the dry natural gas used for heating and electricity generation also produces natural gas plant liquids that contribute substantially to the liquid fuels supply. The United States would have to import much more crude oil if not for the addition of natural gas plant liquids to the domestic oil supply. The joint nature of oil and gas production means that when the production of one increases it raises the other's production to an extent, which lowers costs and enhances stability of supply for both.

5.

Ten important market conditions.

a. Large reserves exist in North America from which crude oil and natural gas can be produced for a long time at stable cost. (The shale gas supply curve in Exhibit 2 illustrates this condition. In addition, the curve does not reflect likely improvements in technology and the potential for upward revisions of the resource estimate, nor does it include the associated gas produced from oil wells.)

b. The cost of natural gas in the United States is far lower than buyers had anticipated and lower than the prices in other geographic markets where major industrial competitors to U.S. firms procure their gas.

c. However, there are large conventional natural gas reserves in other parts of the world with lower costs of production than shale gas, and the cost of shipping natural gas across the oceans is high relative to the value of the commodity. These conditions will limit the amount of shale gas that can be exported profitably.

d. A very high crude oil price on the world market provides a strong incentive to increase production in the United States, and it is greater than the incentive to produce more natural gas at its current price. Since the production process can change between gas and oil to an extent, oil production is drawing inputs away from natural gas production, curtailing its supply.

e. There also is a strong incentive to widen the uses of natural gas and substitute it for more expensive imported crude oil.

f. While market forces are at work to raise the domestic price for natural gas and moderate overseas prices eventually narrowing the international price spreads, it is unlikely that the cost advantage of domestic manufacturing will be erased.

g. Demand for domestic natural gas will increase from (a) industries that use natural gas directly and expected it to be much more costly, (b) increasing use as a substitute for more expensive crude oil, and (c) exports to markets with much higher natural gas prices.

h. Increased demand for natural gas, whatever its source, will gradually raise the cost of production along the supply curve in Exhibit 2. The long-term price trend should be consistent with that curve.

i. Hydraulic fracturing has given domestic manufacturers and other buyers access to a long-lasting supply of natural gas at stable cost. What matters most is that the long-run costs of production will be far lower than the import prices that had been anticipated. The precipitous drop in the domestic natural gas price drew attention to the new cost conditions but is temporary.

j. The domestic oil and gas industry, in any case, will experience an expansion as long as international crude oil and natural gas prices are higher than the domestic cost of production.

6.

Where Funds Will Go For U.S. Projects

(million $)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Exploration-Production										
Drilling-exploration	70,086	96,733	124,000	125,010	239,646	175,070	196,091	222,936	239,205	240,154
Production	13,316	18,379	23,560	23,760	45,533	33,263	37,257	42,358	45,449	45,629
OCS lease bonus	534	679	914	2,795	6,882	801	920	325	1,815	2,100
Subtotal	**83,936**	**115,791**	**148,474**	**151,565**	**292,061**	**209,134**	**234,268**	**265,619**	**286,469**	**287,883**
Other										
Refining and marketing	8,590	9,100	11,500	10,780	16,000	12,090	8,030	12,100	13,000	12,700
Petrochemicals	725	725	780	840	1,000	350	300	300	1,300	1,800
Crude and products pipelines	824	828	141	1,796	4,431	9,104	8,563	1,381	4,344	23,246
Natural gas pipelines	3,369	3,517	2,245	4,367	6,343	11,907	3,062	7,744	4,327	15,254
Other transportation	710	760	850	970	1,200	840	950	1,100	1,200	1,800
Mining, other energy	900	1,000	1,000	1,000	1,200	900	1,000	1,000	1,100	1,100
Miscellaneous	3,350	3,300	3,700	4,100	5,000	3,750	4,000	4,000	4,200	4,500
Subtotal	**18,468**	**19,230**	**20,216**	**23,853**	**35,174**	**38,941**	**25,905**	**27,625**	**29,471**	**60,401**
Total	**102,404**	**135,021**	**168,690**	**175,418**	**327,235**	**248,075**	**260,173**	**293,244**	**315,939**	**348,284**

Source: "Special Report: Capital Spending Outlook," *Oil & Gas Journal*, editions 2013-2006.

7.

Table 5-1. Summary of Multipliers Observed in Economic Impact Studies

Scope	State / Region	Year	Employment Multipliers (Jobs)	Value-Added Multipliers ($)
Marcellus Shale Gas*	West Virginia	2008	1.53	
Marcellus Shale Gas†	West Virginia	2009	1.57	1.48
Marcellus Shale Gas‡	Pennsylvania	2008	2.05	1.99
Marcellus Shale Gas§	Pennsylvania	2009	2.02	1.96
Marcellus Shale Gas¶	New York	2015	1.92	1.98
Oil and Gas#	Colorado	2008	2.67	
Offshore Oil and Gas**	Gulf of Mexico	2007	3.56	1.73
Eagle Ford Shale Oil and Gas††	Texas	2010	1.86	1.34
Oil and Gas‡‡	U.S. Total	2007	4.18	2.33
Natural Gas§§	U.S. Total	2007	4.54	2.24
			1.0X 3.5X 6.0X	1.0X 2.5X 4.0X

* National Energy Technology Laboratory, *Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia: A Preliminary Analysis Using Publicly Available Data*, U.S. Department of Energy, March 31, 2010, page IV.

† Considine, Timothy, *The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia*, National Resource Economics, Inc., July 2010, page 24.

‡ Considine, Timothy and Robert Watson, *An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play*, The Pennsylvania State University, College of Earth and Mineral Sciences, July 24, 2009, pages 25-26.

§ Considine, Timothy, *Economic Impacts*, pages 20-21.

¶ Considine, Timothy, *Economic Impacts*, page 29.

McDonald, Lisa, Booz Allen Hamilton, and David Taylor, *Oil and Gas Economic Impact Analysis*, Colorado Energy Research Institute, Colorado School of Mines, June 2007, page XI.

** IHS Global Insight, *The Economic Impact of the Gulf of Mexico Offshore Oil and Natural Gas Industry and the Role of the Independents*, July 2010, pages 8-9.

†† America's Natural Gas Alliance, *Economic Impact of the Eagle Ford Shale*, Center for Community and Business Research, The University of Texas at San Antonio, February 2011, page 4.

‡‡ PricewaterhouseCoopers, *Economic Impacts*, page 17.

§§ IHS Global Insight, *The Contributions of the Natural Gas Industry to the U.S. National and State Economies*, September 2009, page 1.

"Prudent Development—Realizing the Potential of North America's Abundant Natural Gas and Oil Resources," National Petroleum Council, 2011, Chapter 5 – Macroeconomics, p 363.

8.

US Lower 48 Employment Contribution

(Number of workers)

2012	Direct	Indirect	Induced	Total
Unconventional Oil Activity*	173,096	259,775	413,058	845,929
Unconventional Gas Activity**	187,360	277,888	437,427	902,675
Total Unconventional Activity	360,456	537,663	850,485	1,748,604
2015				
Unconventional Oil Activity*	242,607	371,062	595,816	1,209,485
Unconventional Gas Activity**	263,288	399,379	638,511	1,301,178
Total Unconventional Activity	505,895	770,441	1,234,327	2,510,663
2020				
Unconventional Oil Activity*	265,612	412,777	667,598	1,345,987
Unconventional Gas Activity**	334,808	503,011	801,362	1,639,181
Total Unconventional Activity	600,420	915,788	1,468,960	2,985,168
2035				
Unconventional Oil Activity*	287,606	428,459	674,132	1,390,197
Unconventional Gas Activity**	436,773	645,696	1,026,012	2,108,481
Total Unconventional Activity	724,379	1,074,155	1,700,144	3,498,678

NOTES: Numbers may not sum due to rounding.

*Unconventional oil activity represents the production of oil and condensate and associated gas recovered from tight oil plays.

**Unconventional gas activity represents the production of gas and liquids recovered from shale gas and tight gas plays.

Source: IHS Global Insight

US Lower 48 Value Added Contribution (2012 $M)				
2012	**Direct**	**Indirect**	**Induced**	**Total**
Unconventional Oil Activity*	47,605	32,563	35,846	116,014
Unconventional Gas Activity**	49,096	34,608	37,967	121,670
Total Unconventional Activity	**96,700**	**67,171**	**73,813**	**237,684**
2015				
Unconventional Oil Activity*	70,584	46,861	51,701	169,146
Unconventional Gas Activity**	74,697	50,282	55,409	180,387
Total Unconventional Activity	**145,281**	**97,142**	**107,110**	**349,533**
2020				
Unconventional Oil Activity*	80,726	52,432	57,924	191,081
Unconventional Gas Activity**	92,766	63,159	69,545	225,470
Total Unconventional Activity	**173,492**	**115,591**	**127,469**	**416,551**
2035				
Unconventional Oil Activity*	75,958	53,390	58,510	187,858
Unconventional Gas Activity**	117,272	80,806	89,049	287,127
Total Unconventional Activity	**193,230**	**134,195**	**147,559**	**474,985**

NOTES: Numbers may not sum due to rounding.

*Unconventional oil activity represents the production of oil and condensate and associated gas recovered from tight oil plays.

**Unconventional gas activity represents the production of gas and liquids recovered from shale gas and tight gas plays.

Source: IHS Global Insight

Average Hourly Wages by Occupation in the Oil and Gas, and Related Industries*		
Occupation	Occupation Code	Avg. Hourly Wages
Management, Business and Financial		
General and Operations Managers	111021	$63.03
Construction Managers	119021	$45.42
Engineering Managers	119041	$64.74
Cost Estimators	131051	$32.12
Accountants and Auditors	132011	$34.83
Professional and Related		
Architects, Except Landscape and Naval	171011	$37.79
Surveyors	171022	$27.44
Civil Engineers	172051	$40.18
Electrical Engineers	172071	$43.98
Mechanical Engineers	172141	$39.42
Petroleum Engineers	172171	$67.55
Engineers, all other	172199	$47.99
Architectural and Civil Drafters	173011	$24.00
Civil Engineering Technicians	173022	$23.22
Surveying and Mapping Technicians	173031	$19.98
Geoscientists, Except Hydrologists and Geographers	192042	$63.61
Geological and Petroleum Technicians	194041	$27.65
Sales and Related		
Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	414012	$31.85
Office and Administrative Support		
First-Line Supervisors/Managers of Office and Administrative Support Workers	431011	$27.62
Bookkeeping, Accounting, and Auditing Clerks	433031	$17.56
Secretaries and Administrative Assistants	436010	$18.60
Office Clerks, General	439061	$14.95
Skilled Blue Collar		
First-Line Supervisors/Managers of Construction Trades and Extraction Workers	471011	$32.63
Carpenters	472031	$23.29
Cement Masons and Concrete Finishers	472051	$19.33
Paving, Surfacing, and Tamping Equipment Operators	472071	$18.97
Operating Engineers and Other Construction Equipment Operators	472073	$21.70
Electricians	472111	$27.49
Plumbers, Pipefitters, and Steamfitters	472152	$26.99
Derrick Operators, Rotary Drill Operators and Service Unit Operators, Oil and Gas	475010	$23.28
Mobile Heavy Equipment Mechanics, Except Engines	493042	$22.22
Industrial Machinery Mechanics	499041	$24.36
Maintenance and Repair Workers, General	499071	$19.96
Petroleum Pump System Operators, Refinery Operators, and Gaugers	518093	$26.83

Average Hourly Wages by Occupation in the Oil and Gas, and Related Industries* (Continued)		
Occupation	Occupation Code	Avg. Hourly Wages
Crane and Tower Operators	537021	$24.55
Pump Operators and Wellhead Pumpers	537070	$21.59
Semi-skilled Blue Collar		
Roustabouts, Oil and Gas	475071	$16.72
Helpers--Extraction Workers and Other Extraction Workers	475080	$17.62
Welders, Cutters, Solderers, and Brazers	514121	$19.08
Inspectors, Testers, Sorters, Samplers, and Weighers	519061	$19.39
Truck Drivers, Heavy and Tractor-Trailer	533032	$18.37
Excavating and Loading Machine and Dragline Operators	537032	$19.25
Unskilled Blue Collar		
Construction Laborers	472061	$16.54
Fence Erectors	474031	$15.25
Laborers and Freight, Stock, and Material Movers, Hand	537062	$13.62

NOTE: *Average hourly wages by occupation in 2011 were calculated utilizing weights based on 2010 employment estimates for the following industries: Oil and Gas Extraction (NAICS 2111); Support Activities for Mining (NAICS 2131); Nonresidential Building Construction (NAICS 2362); Other Specialty Trade Contractors (NAICS 2389); Agriculture, Construction, and Mining Machinery Manufacturing (NAICS 3331); and Architectural, Engineering, and Related Services (NAICS 5413).

Source: Bureau of Labor Statistics, May 2011 Occupational Employment Statistics

"America's New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy, Volume 1: National Economic Contributions," IHS Report, October 2012, pp. 29-31.

9. **<u>Criticisms</u>**. Skeptics of hydraulic fracking's benefits point to crowding effects and dislocations that may occur where oil and gas field development takes place.[23] Such criticism assumes that fracking disturbs satisfactory economic conditions with normal employment, income, and debt levels. But when unemployed people struggling to make ends meet obtain gainful employment that generates real value, crowding effects will not diminish the net economic benefit very much. State and local governments, meanwhile, can use increased tax revenue from accelerated economic activity to assist low-income groups whose wages do not rise commensurately with the cost of living, as North Dakota is considering.[24] Crowding effects in any event are transitory and prices, if allowed to adjust, will provide the appropriate incentive to move resources where they are most needed.

   Skeptics also warn of a boom-and-bust cycle from new drilling activity that may leave communities worse off in the end. But even in the intensively drilled Barnett formation there still is room for as many as 13,000 more wells. With rising oil production, employment in the Bakken area of North Dakota and Montana increased rapidly, by over 60 percent since 2009, and continues to grow, by seven percent since June 2012, while employment has been relatively flat in the rest of North Dakota and Montana.[25] The North Dakota Department of Mineral Resources projects continued job creation that will transition from drilling and fracking to production, eventually stabilizing at a much elevated level from today (see graph below).[26]

[23] "A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale," Working Paper Series, Cornell University, City and Regional Planning Department, May 2011.
[24] "Oil-Boom By-Product: Unaffordable Housing," Kris Hudson, *The Wall Street Journal*, April 4, 2013.
[25] "Data on Demographic, Economic and Financial Activity in the Bakken." December 20, 2012, Federal Reserve Bank of Minneapolis.
[26] Ibid.

PROJECTION OF NORTH DAKOTA OIL INDUSTRY JOBS