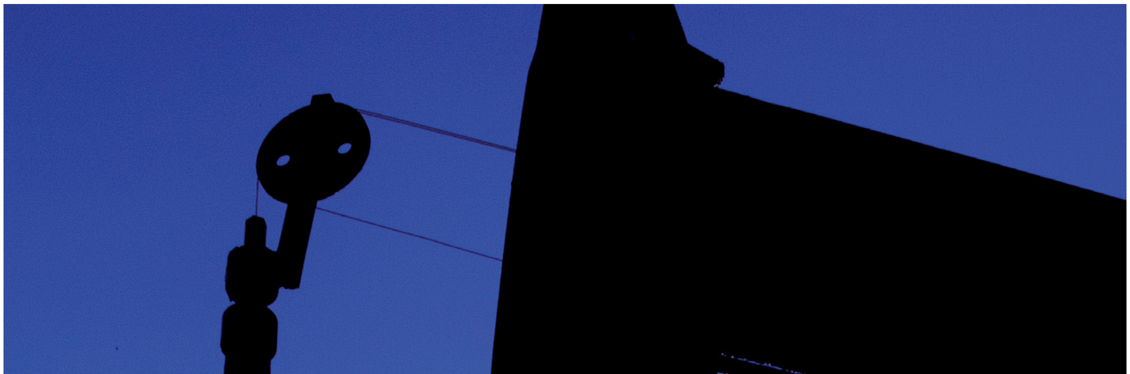


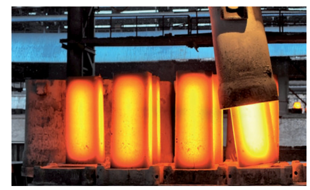
An IHS Report

September 2013

America's New Energy Future:

The Unconventional Oil and Gas Revolution and the US Economy

Volume 3: A Manufacturing Renaissance - Main Report



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This report offers an independent assessment of the importance of unconventional oil and gas to the US economy. This research was supported by the American Chemistry Council, America's Natural Gas Alliance, the American Petroleum Institute, the Fertilizer Institute, the US Chamber of Commerce–Institute for 21st Century Energy, the National Association of Manufacturers, the Natural Gas Supply Association, Rio Tinto, and the Society of the Plastics Industry. IHS is exclusively responsible for this report and all of the analysis and content contained herein. The analysis and metrics developed during the course of this research represent the independent views of IHS and are intended to contribute to the dialogue on the role of unconventional oil and gas production in promoting employment, economic growth, and energy security.

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Introduction

This is the third volume in a three-part series on the effects of unconventional oil and natural gas on the US economy. The first volume detailed the effects of upstream unconventional oil and gas development on the national economy, and the second volume presented the role of upstream unconventional oil and natural gas on each of the lower 48 states. In this volume, we extend the work undertaken in the first two volumes by examining three critical ways in which this unconventional revolution is impacting the US economy.

First, we look at the unconventional oil and natural gas value chain and assess the economic contributions associated with the capital and operational expenditures required to build out the midstream and downstream energy and the energy-related chemicals industrial base to support this unconventional oil and gas expansion. This growth in the unconventional oil and natural gas value chain will make significant contributions to the broader economy throughout the study period, increasing gross domestic product (GDP), employment, tax revenues.

- GDP: In 2012, total GDP contributions reached nearly $284 billion: the $238 billion upstream energy contribution to 2012 GDP was accompanied by an additional $39 billion from midstream and downstream energy while energy-related chemicals contributed nearly $7 billon. By 2025, total contributions to GDP are estimated to approach $533 billion: about $475 billion from upstream energy, almost $7 billion from midstream and downstream energy, and over $51 billion from energy-related chemicals.
- Employment: The unconventional oil and natural gas value chain and energy-related chemicals activity together supported more than 2.1 million jobs in 2012. Midstream and downstream energy and energy-related chemicals activity accounted for nearly 377,000 of these jobs. By 2025, the unconventional oil and natural gas value chain and energy-related chemicals activity will support almost 3.9 million jobs, of which nearly 376,000 will derive from midstream and downstream energy and energy-related chemicals activity.
- Tax Revenues: Government revenue will exceed $1.6 trillion from 2012 through 2025. Upstream energy activity will contribute more than $1.4 trillion, midstream and downstream energy activity will add more than $63 billion, and government revenue from energy-related chemicals is expected to reach more than $115 billion over the same period.

Second, we examine the macroeconomic implications of the newfound abundance of affordable unconventional oil and natural gas resources, with a particular emphasis on natural gas and natural gas liquids.

- Trade: The impact on US net trade of the unconventional revolution is expected to increase steadily before plateauing at a new, higher level of roughly $180 billion in 2022.
- Household Income: Savings from lower natural gas prices will add just over $2,700 to disposable household income in 2020. This would increase to more than $3,500 per household in 2025.

Third, we conclude with an examination of the resurgence that US manufacturing is enjoying as a result of affordable and abundant new resources that are being unlocked through unconventional extraction techniques.

Overall, the United States has added over 500,000 manufacturing jobs, and the industrial production index for the US manufacturing sector has increased 4.8% since the trough of the recession in 2009. As a result, manufacturing has become an important contributor to growth during these economically challenging times. Manufacturing added 6.2% to the value of all goods and services produced in this country in 2012, after adding 2.5% in 2011. This growth was led by durable-goods manufacturing, the largest contributor to overall growth in the economy for a third consecutive year. The value of durable goods manufacturing surged by 9.1% in 2012, after increasing 6.8% in 2011 and 13.3% in 2010.[1]

To provide a comprehensive analysis of the economic contribution of the unconventional oil and natural gas revolution, it is critical that this report examine its impact on major manufacturing industries. IHS has quantified and assessed this economic contribution using macroeconomic modeling and has found that this contribution is highly significant.

US manufacturers are benefitting from the availability of a secure supply of low-cost natural gas, especially for manufacturers in energy-intensive industries. Energy-intensive sectors like energy-related chemicals, petroleum refining, aluminum, glass, cement, and the food industry are expected to invest and expand their US operations in response to declining domestic prices for their energy inputs. This study quantifies these contributions to the US manufacturing sectors, including:

- By 2015, lower natural gas prices and higher activity will result in an impact of 2.8% higher industrial production. By 2025, industrial production will be 3.9% higher.
- Energy-intensive subsectors in manufacturing—iron and steel products, machinery, basic organic chemicals, resins and synthetic materials manufacturing, and agricultural chemicals manufacturing—will outperform the overall US industrial economy.

Other factors, beyond the contributions from the unconventional oil and natural gas revolution, are also contributing to the resurgence in manufacturing that places the United States in a strong position. These factors include:

- improvements in technology and in the efficiency of manufacturing processes that have shifted the balance away from the importance of low-cost labor and toward a higher-skilled workforce;
- relatively higher worker productivity in the United States;
- relatively higher growth in global manufacturing compensation than that of the United States;
- improved manufacturing efficiencies in the use of energy; and
- shortened supply and logistics chains due to research and development resources and end markets that are geographically closer to manufacturing locations.

While it is important to recognize these contributions to the US manufacturing renaissance, they were not within the purview of this study, which is focused on the impact of the revolution in unconventional oil and natural gas production. The results presented here highlight the critical role that affordable and abundant energy is playing in the manufacturing renaissance—independent of the potential effect of these other factors.

Report Structure

This report, Volume 3 in the America's New Energy Future series, contains the following six sections:

- **Midstream and Downstream Energy and Energy-Related Chemicals** discusses the unconventional revolution's implications for midstream and downstream energy activity and energy-related chemicals. The chapter will also discuss the details of an expected capacity expansion and the resulting production ramifications.
- **Establishing the Resource Base** identifies the specific oil and natural plays examined in this resource assessment.

1 http://www.bea.gov/newsreleases/industry/gdpindustry/gdpindnewsrelease.htm

- **Economic Contribution Assessment—Base Case** details the results of IHS' economic contribution analyses of midstream and downstream energy and energy-related chemicals and then aggregates the results with the findings of the upstream assessments presented in Volume 1 to present a comprehensive picture of the economic contribution of the unconventional oil and gas revolution. It will also explore findings on the employment contribution of the manufacturing sector.
- **The Macroeconomic Impact of Unconventional Oil and Gas** quantifies the impact of the Base Case for unconventional oil and gas activities, which includes lower prices and higher production and investment activities. The discussion will focus on broad economic barometers, as well as details of manufacturing industry growth.
- **Low Production Case** presents a comparative analysis of manufacturing sector activity, employment and value-added contributions to GDP in the event that federal regulations and policy restrict unconventional oil and natural gas production over the forecast time horizon relative to estimates used in the Base Case.
- **Conclusion** provides the key conclusions of the report.

Several appendices are also provided to explain the methodologies, research, and data relied upon for our analysis. The appendices also present more detailed results from our study. These appendices are available at http://www.ihs.com/info/ecc/a/americas-new-energy-future-report-vol-3.aspx.

Key Definitions

Midstream and Downstream Energy

The terms midstream and downstream can have varying definitions inside the oil and gas industry. For the purposes of this report, midstream and downstream energy activities involve converting raw crude oil and natural gas liquids into finished products and bringing these products to market. Midstream specifically refers to the transport and logistics functions of oil and natural gas, encompassing marine, truck, rail, and pipeline movements, as well as the dedicated storage of intermediate and finished products. Downstream refers to the processing or upgrading of natural gas liquids and crude oil into higher value intermediate and finished products. This report will also cover liquefied natural gas facilities, which are not typically considered part of midstream and downstream; they have been included here, since they constitute the additional processing of natural gas into liquid form.

For the remainder of this report, midstream and downstream energy encompass the following seven segments:

- Liquefied natural gas processing (LNG)
- Natural gas processing
- Natural gas logistics (pipelines)
- Natural gas liquids (NGL) processing
- NGL logistics (marine, pipelines, and storage)
- Crude oil processing (refining)
- Crude oil logistics (marine, pipelines, rail and storage).

Energy-Related Chemicals

Energy-related chemicals refers to processing and transforming natural gas and gas liquids into chemical raw material products. These products include the major commodity petrochemicals that use natural gas and gas liquids as feedstock, such as olefins, methanol, and ammonia. Over 70% of the cash cost of producing these chemicals is the cost of raw materials and energy from natural gas and NGLs.[2] Nine specific chemical product value chains, shown in the following chart, are included in this study.

Energy-Related Chemicals Coverage

Chemical	Type
Acrylics	Acrylic acid and acrylonitrile
Aromatics chain	Aniline and nitrobenzene
Nitrogen fertilizers	Ammonia, ammonium nitrate, and urea
Chlor-alkali	Chlorine and caustic
Olefins	Ethylene, propylene (PGCG), hexene, octene, butene-1, and butadiene
Polyolefins	High density PE, low density PE, linear low density PE, and polypropylene
Vinyls chain	Ethylene dichloride, vinyl chloride monomer, and PVC
Glycols chain	Ethylene oxide, proplylene oxide, monoethylene glycol, diethylene glycol, triethylene glycol, PEG, and ethoxylates
Methanol chain	Methanol, formaldehyde, methyl methacrylate, MTBE, and MDI

Base Case

The Base Case consists of a set of bottom-up resource build-outs and regulatory frameworks that represent IHS's current outlook for unconventional oil and natural gas production, capital expenditures, and operating expenses. It is consistent with the analysis presented in the first two volumes of this research series. Defined as the Base Case, this outlook includes 21 existing or emerging plays and covers private and federal lands for drilling and extractions within those plays, assuming that the status quo is maintained with regard to existing federal and state policies and regulatory frameworks such as the current moratoriums in states like New York. Average natural gas prices are assumed to be between $4 and $5 per thousand cubic feet (Mcf) and annual well completions in oil and natural gas plays are expected to average roughly 8,560 and 9,670, respectively, over the forecast period from 2012 through 2025. In the Base Case, unconventional oil production is assumed to average over 3.9 million barrels per day (mbd), and natural gas production will average 57.9 billion cubic feet (Bcf) per day. It also assumes that the United States will become a natural gas exporter, with LNG exports reaching 5.1 Bcf per day during the forecast period.[3] All of the above assumptions of the Base Case are reflected in IHS's baseline outlook in the US Macroeconomic Model.

Low Production Case

The Low Production Case estimates the broader economic impacts in the event that future unconventional oil and natural gas production is reduced by a significantly more restrictive policy and regulatory framework than the framework assumed in the Base Case. To forecast this, IHS derived a sequence of restrictions from a 2011 National Petroleum Council Study that, when applied, translates into our Low Production forecast. It reflects a continuous decline of production over the next decade, resulting in a 52% decrease in oil and natural gas production by 2025 relative to our Base Case. The ramifications of such policy and regulations will also change the outlook for the LNG market, shifting it to a more import-dependent market. Additionally, industrial- and power-sector demand for natural gas will experience a downward trajectory. As a result of both higher LNG imports and lower domestic production, natural gas prices are projected to peak in 2020 at over $16 per Mcf before dropping to over $14 per Mcf. The implications for capital expenditure requirements stemming from lower unconventional oil and natural gas production,

2 Cash cost is the total manufacturing cost excluding R&D, selling, and administrative expenses and depreciation.

3 LNG exports of 5.1 Bcf per day are based on 5.9 Bcf a day of LNG export capacity.

due to the restrictive policy and regulations, will mean a much lower capital expenditure path over the next decade than would play out in the Base Case, resulting in smaller economic contributions.

Counterfactual Case

To fully capture the vital role unconventional development plays in the US economy, IHS also considered a counterfactual case in which unconventional development was nonexistent. To do so, IHS ran its US Macroeconomic Model after removing any unconventional oil and natural gas activity and overlaying higher natural gas prices on the Base Case price path. This counterfactual scenario was then used as to make comparisons with both the Base Case and the Low Production Case.

To construct the counterfactual case, IHS introduced the following three exogenous shocks to the US Macroeconomic Model: 1) removed all domestic energy production attributable to unconventional oil and natural gas production; 2) removed from non-residential investment all capital expenditures attributable to unconventional oil and natural gas; and 3) substituted higher natural gas prices reflecting the requirement that the United States would enter the global LNG market to procure imports to meet domestic demand. The underlying price is equivalent to the European LNG price that ranges from $11 to nearly $14 per Mcf in the forecast period.

Midstream and Downstream Energy and Energy-Related Chemicals

Abundant new supplies of oil and natural gas in the United States are reviving US midstream and downstream energy and chemicals manufacturing beyond what we would expect simply from increasing domestic demand and an expanding global economy.

Midstream and Downstream Energy

Midstream and Downstream Economic Contribution

There are five primary ways in which the unconventional revolution in oil and natural gas will generate investments in midstream and downstream energy industries and contribute value added to US GDP.

- Oil and natural gas upgrading
- Feedstock cost reductions
- Trade arbitrage
- Net trade
- Direct capital investment

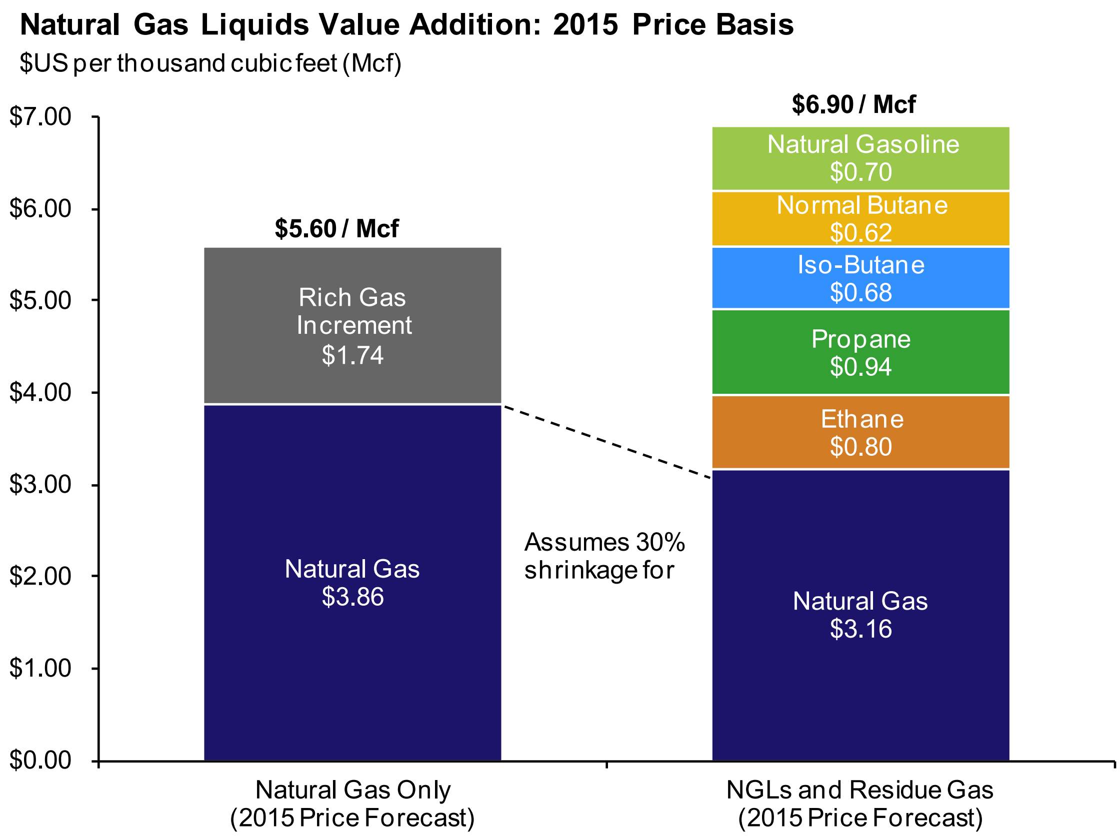
Oil and Natural Gas Upgrading

The most direct value added to US economic growth from midstream and downstream operations is the processing of crude oil and rich gas into higher-value refined and intermediate products.[4] The industry's upgrading ability to create value added is most evident in natural gas and natural gas liquids (NGL) processing. Gas processing, NGL processing, and the majority of NGL logistics projects are links in the value chain that convert unprocessed rich gas into lean natural gas and NGL.

A hypothetical example of the incremental value this creates is through a multi-step process that includes the transport of rich gas to gas processing plants, the extraction of residue or lean gas, the transport of unfractionated NGL to a fractionator, and the sale of the constituent components to end users, such as petrochemical operators, refiners, gasoline blenders, or consumers.

Integrating the various segments of the NGL value chain into this hypothetical example creates $1.30 per thousand cubic feet of additional value. Although this figure is relatively small on a per-unit basis, when it is translated across potential rich gas production of 22.5 Bcf per day, it adds $11 billion more annually in economic activity. The actual economic contribution will depend on the NGL composition of rich gas and on whether the lean gas being produced is further processed into Liquefied Natural Gas (LNG) for export.

4 Rich gas is produced natural gas which contains a significant amount of heavier components, natural gas liquids (NGLs), which increase the heating and monetary value of the natural gas.



Source: IHS Energy

Feedstock Cost Reductions

The second economic opportunity comes from reduced feedstock costs for oil and natural gas processors. The benefits are most evident in the crude oil refining and logistics segments, which are focused on reducing the delivered cost of crude oil. The cost to ship crude oil by marine tanker from overseas markets is typically in the $2-4 per barrel range. [5] This cost is typically borne by refiners and increases their manufacturing costs.[6] A net $1 per barrel reduction in the cost of delivered crude oil to US refineries has a total economic value added of $6 billion annually. This savings, if realized, has the potential to be reinvested domestically in the form of refinery-sustaining capital reinvestment and capital dividends.

Trade Arbitrage

Trade arbitrage opportunities constitute a third economic activity that adds value to GDP. [7] This will be reflected in investments in LNG liquefaction and export facilities and in NGL marine export terminals. Although the economics of each LNG project vary, their common objective is to utilize surplus domestic natural gas as a liquefaction feedstock for export into markets that command a price premium. Driving the potential for US investment is the ability to liquefy and transport $5-6 per million British thermal units (MMBtu) of natural gas and sell this product into the European market at a price of $10-12 per MMBtu

5 The estimate for total freight cost is typical for the 2008—2012 time period and calculated by IHS using the following inputs: Worldscale 100 Rates for Bonny Light crude oil travelling from the Bonny Light terminal in Nigeria to Houston; Platt's Market Rate Dirty VLCC West Africa to USGC Basis, inclusive of import duty, oil spill tax, OPLI (insurance), Texas-LA marine transfer fee, harbor maintenance fee, and lightering.

6 Based on Refiner Acquisition Cost of Crude Oil, EIA, http://www.eia.gov/tools/glossary/index.cfm?id=R

7 Trade arbitrage is the use of trade to realize a higher net value for a given good or product.

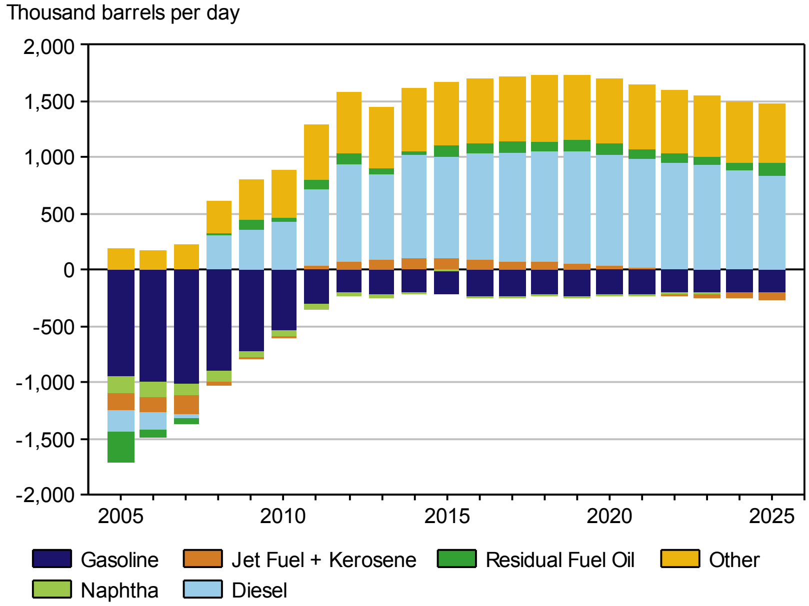
or into the Asian market at $15-17 per MMBtu. A large part of these regional price differences will be absorbed in liquefaction and freight costs. A $2 per MMBtu net difference in US natural gas prices and delivered costs to a foreign market can generate $5 billion annually.[8] This value added could be returned to the US economy in the form of capital dividends, reinvestment in facilities, and support for additional natural gas drilling and production.

Net Trade

The combination of low demand associated with the recession, government policy, increased efficiency standards, and increases in oil and natural gas production have reduced US imports of refined petroleum products by 1.2 mbd and increased exports by 1.4 mbd from 2007 to 2012.[9] Since 2007, domestic demand for refined products has declined due to the recession and is projected to increase only moderately over the next five years. Refined product demand, defined as total refined product consumption in the United States, is expected to grow incrementally—by less than 700,000 bd—by 2020, demand will be 1.6 mbd less than the levels seen during the 2005-2007 period. This has freed capacity, which is being used to provide additional products for export.

The competitive position of US refiners has been improved by the dual benefits of low-cost natural gas—a large component of a refinery's variable operating costs—and increased domestic crude oil production. US refineries are well-positioned to readily supply international markets on an ongoing basis since a large share of their refining capacity is located on the Gulf Coast with marine access and proximity to Latin America—our main refined products export partner. For US refiners, the alternative to supplying a small percentage of refined products to export markets is lower utilization rates, a contraction in capacity, job losses, reduced government revenue, and lower GDP.[10]

US Refined Product Net Exports



Source: EIA and IHS Energy

The larger economic effect of increasing US domestic production volumes will be in trade and import deficit reductions. Every incrementally produced barrel of crude oil will displace an equivalent imported barrel of crude oil. The incremental 2.5 mbd forecasted to be produced in 2025, over 2012 levels, will reduce crude oil imports by this volume at constant refinery capacity and utilization rates. At a $95 per barrel oil price, the net improvement on trade is approximately $87 billion annually.

Direct Capital Investment

Between 2012 and 2025, IHS projects over $216 billion in total will be invested in the midstream and downstream oil and gas industries. This has the potential to generate $25 billion in annual return on investments, with successful investment providing the seeds for future investment.

8 Assumes 5.1 billion cubic feet per day of liquefied natural gas exports.

9 History: EIA (2012 preliminary); forecast: IHS Energy.

10 For 2012, refined product net exports were 8.2% of total US refinery production.

Midstream and Downstream Energy Incremental Capital Expenditures: United States

(Current $M)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2012-25
LNG Processing	502	3,236	5,533	8,449	6,211	3,471	3,119	2,421	1,279	685	651	618	587	558	37,319
NG Processing	6,291	5,425	4,185	2,583	2,131	1,984	1,025	879	835	793	753	716	680	646	28,925
NG Logistics	8,871	9,148	7,222	5,084	3,069	4,295	5,065	3,545	2,244	3,608	3,560	4,045	3,994	2,315	66,065
NGL Processing	3,510	3,912	2,109	928	835	742	649	557	529	502	477	453	431	409	16,046
NGL Logistics	4,507	3,429	2,286	1,230	1,036	948	811	697	581	548	516	486	456	434	17,964
Crude Oil Processing	107	671	1,496	1,883	1,591	780	697	321	289	257	225	193	183	174	8,865
Crude Oil Logistics	5,199	7,590	8,272	5,960	2,742	2,635	1,812	1,519	1,206	1,046	885	834	785	746	41,233
Total	**28,987**	**33,412**	**31,102**	**26,117**	**17,615**	**14,855**	**13,179**	**9,938**	**6,963**	**7,439**	**7,068**	**7,345**	**7,117**	**5,282**	**16,418**

NOTE: Numbers may not sum due to rounding.

Source: IHS Energy

Midstream and Downstream Energy Cumulative Capital Expenditures: United States

(Current $M)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
LNG Processing	502	3,738	9,271	17,720	23,931	27,402	30,521	32,941	34,220	34,905	35,556	36,174	36,761	37,319
NG Processing	6,291	11,716	15,901	18,484	20,615	22,599	23,624	24,503	25,337	26,130	26,884	27,600	28,279	28,925
NG Logistics	8,871	18,019	25,241	30,325	33,394	37,689	42,754	46,299	48,543	52,151	55,711	59,756	63,750	66,065
NGL Processing	3,510	7,423	9,532	10,460	11,295	12,037	12,687	13,244	13,772	14,275	14,752	15,206	15,636	16,046
NGL Logistics	4,507	7,936	10,222	11,452	12,487	13,435	14,246	14,943	15,524	16,072	16,588	17,074	17,530	17,964
Crude Oil Processing	107	778	2,273	4,156	5,747	6,527	7,225	7,546	7,834	8,091	8,316	8,509	8,692	8,865
Crude Oil Logistics	5,199	12,789	21,062	27,022	29,764	32,399	34,211	35,730	36,936	37,982	38,867	39,702	40,487	41,233
Total	**28,987**	**62,399**	**93,501**	**119,618**	**137,233**	**152,088**	**165,267**	**175,204**	**182,167**	**189,606**	**196,674**	**204,019**	**211,136**	**216,418**

NOTE: Numbers may not sum due to rounding.

Source: IHS Energy

In this section, five potential benefits associated with growth in the domestic midstream and downstream industries will be discussed: oil and gas upgrading, feedstock cost reduction, trade arbitrage, net trade improvement, and direct capital investment. The section also highlights the importance of integrating the upstream, midstream, and downstream value chains to maximize the economic potential from hydrocarbon production.

Defining Midstream and Downstream

The terms midstream and downstream can have varying definitions inside the oil and gas industry. For the purposes of this report, midstream and downstream energy activities involve converting raw crude oil and natural gas liquids into finished products and bringing those products to market. **Midstream** refers to the transport and logistics functions of oil and natural gas, encompassing marine, truck, rail, and pipeline movements, as well as the dedicated storage of intermediate and finished products. **Downstream** refers to the processing or upgrading of Natural Gas Liquids (NGLs) and crude oil into higher value intermediate and finished products. This report will also cover liquefied natural gas (LNG) facilities, which are not typically considered part of midstream and downstream; they have been included here, since they constitute the additional processing of natural gas into liquid form.

For the remainder of this report, midstream and downstream energy encompasses the following segments:

- LNG processing
- Natural gas processing
- Natural gas logistics (pipelines)
- Natural gas liquids (NGL) processing
- NGL logistics (marine, pipelines, and storage)
- Crude oil processing (refining)
- Crude oil logistics (marine, pipelines, rail and storage)

To discern trends and gain critical insights into the unconventional oil and gas industry, these seven segments must be evaluated both individually and together. Development of the oil and natural gas value chain in each segment will allow the United States to realize the full benefit of the unconventional oil and gas revolution.

US Trends across Midstream and Downstream Segments

The period between 2000 and the beginning of the global financial crisis in 2008 was characterized by an extended bull run in global commodities prices and negative growth in domestic oil and natural gas production due to aging reservoirs and low crude oil prices during the first half of the decade.[11] With the exception of refining, investment stagnated and growth contracted as many integrated companies focused on international opportunities that offered higher returns.[12]

The global economic downturn that began in the final months of 2008 compounded this trend, and the future for the US midstream and downstream sectors seemed uncertain. Declining domestic natural gas and crude oil production forced these sectors to become increasingly dependent on higher priced imported feedstock. Dependence on imports steadily eroded the global competitiveness of the domestic gas processing, refining, and petrochemicals industries, and had additional impacts on the logistics operations that connected these industries. The US midstream and downstream sectors focused on operations and maintenance, as opposed to growth and investment.

The pessimistic outlook for the industry that existed at the end of 2008 proved to be premature. Four years after the recession, the midstream and downstream sectors are experiencing unprecedented growth and investment, as large and small companies add processing capacity and logistics capabilities that bring

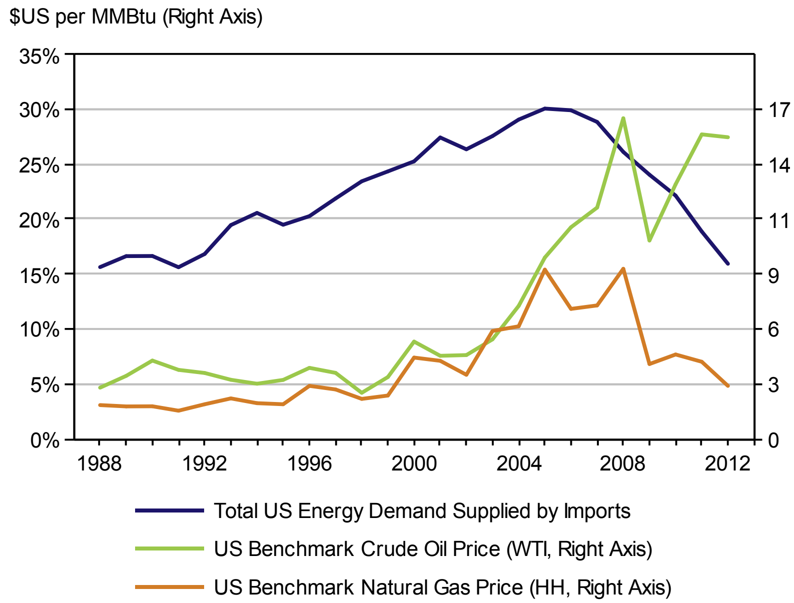
11 US domestic natural gas production began to increase in 2007 due to unconventional production breakthroughs.

12 IHS Downstream Energy estimates that the US refining industry expended over $60 billion from 2000 to 2008 on regulatory, feedstock flexibility, and capacity growth projects.

new products to market and maximize the economic benefits from the oil and gas value chain. These developments have been facilitated by technological advances in the upstream oil and natural gas sector, which have led and will continue to lead to significant increases in domestic oil and natural gas production.

A major trend that emerges from analyzing the industry's investment forecast is that the highest percentage of midstream and downstream investment is allocated to natural gas, NGL, and crude oil pipelines. Approximately half of the more than $216 billion investment in midstream and downstream infrastructure, forecasted over a 14-year period, is directed to over 47,000 miles of new and modified pipelines. The high infrastructure allocation required by the production of large volumes of oil and gas is taking place in non-traditional producing regions. One example is the Bakken shale formation in North Dakota and Montana, which has gone from producing less than 50,000 bd in 2005 to what is forecasted to be greater than 1 mbd by 2015. A major need for pipeline infrastructure is also anticipated for other non-traditional basins, such as the Niobrara and Utica shales predominantly located in Colorado and Ohio, respectively. By contrast, the Permian Basin, a traditional producing region for West Texas Intermediate (WTI) and West Texas Sour (WTS) crude oil, is experiencing a large increase in production and will have less need to add major new pipeline infrastructure.

US Energy Imports and Benchmark Oil and Gas Pricing



Source: IHS Energy

US Lower 48 Midstream and Downstream Energy Growth and Investment: 2012-25

Segment	Capacity Added	Total Investment ($B)
LNG Processing	5.9 Bcfd	37.3
Natural Gas Processing	22.5 Bcfd	28.9
Natural Gas Logistics	25.8 Bcfd	66.1
NGL Processing	2.7 mbd	16.1
NGL Logistics	3.4 mbd	18.0
Crude Oil Processing	0.5 mbd	8.9
Crude Oil Logistics	5.0 mbd	41.2

Source: IHS Energy

Midstream and Downstream Segment Specific Themes

LNG Processing

By the early 2000s, US natural gas production had stagnated and begun to decline, and liquefied natural gas imports became necessary to supplement US supplies of natural gas for electricity generation and large industrial operations. The industry widely assumed that North Africa, the Middle East, and West Africa would be the major suppliers of the US natural gas imports. The result was a construction wave of import facilities during the mid-2000s on the Atlantic and Gulf coasts to receive imports of LNG. By 2008, the United States had constructed 12 LNG import facilities with a total regasification capacity of 19 billion cubic feet (Bcf) per day, or enough to supply about one-third of US natural gas demand. But by the time the last domestic natural gas import terminal was completed, the revolution in unconventional oil and gas production had rendered the new LNG import facilities largely unnecessary.

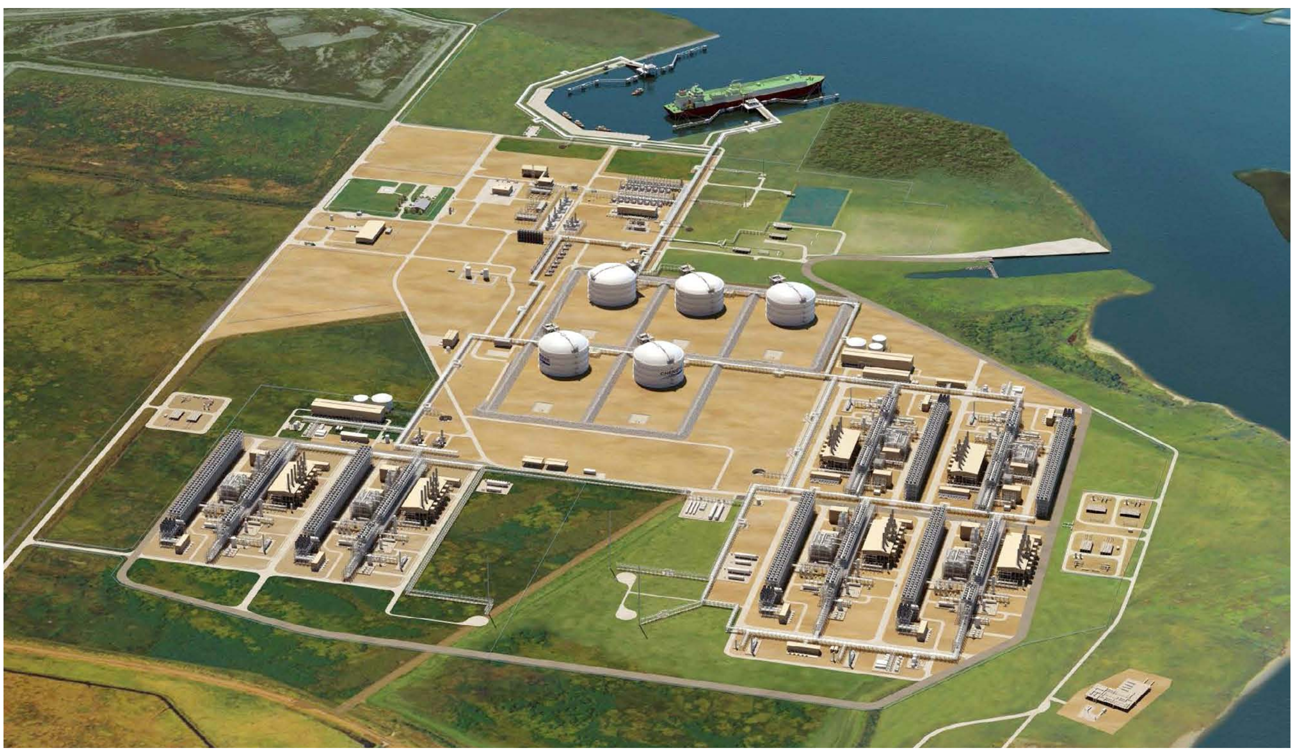
The unconventional oil and gas revolution has led many investors to actively pursue LNG export projects. IHS assumes that several of the LNG export projects now under development are likely to be completed. The expected total investment for these natural gas liquefaction projects over the 14-year forecast period (2012-2025) will be $37.3 billion dollars, based on the assumption of $550 per metric ton of annual capacity.

As of March 2012, there were 22 LNG projects—representing a total of 53 individual LNG production trains—under development in the United States, 20 of which are located in the US lower 48 and two in Alaska. If all of these proposed projects were to progress through permitting, funding, construction, and start-up, they would increase US natural gas liquefaction capacity to over 29 billion cubic feet per day, representing 35% of the projected US natural gas demand in 2025.

The IHS forecast for US LNG development takes a conservative approach, assuming that a total of five projects now under development will become operational. These projects represent 10 individual liquefaction trains with a total capacity of 5.9 Bcf per day. Based on natural gas producing regions and existing infrastructure, these LNG facilities are likely to be located in the US Gulf Coast and to involve the retrofitting of existing LNG import terminals into dual purpose import-export facilities. The approach of adding liquefaction trains to existing import terminals is a preferred strategy by developers as it reduces total project investment cost by reusing existing LNG storage tanks and marine facilities.

IHS is being conservative in its forecast because of on the significant development challenges still facing many LNG projects, including export license approvals, environmental impact reviews, local and state regulatory approvals, capital availability, cost escalation, competition from other global LNG developments (in areas such as Australia, East Africa, and British Columbia), costs, and standard construction and engineering challenges associated with projects of this scale. Successful execution of the LNG projects at the front of the export license approval queue could allow the industry to exceed the five projects that IHS forecasts to be completed. However, many key development checkpoints have yet to be crossed.

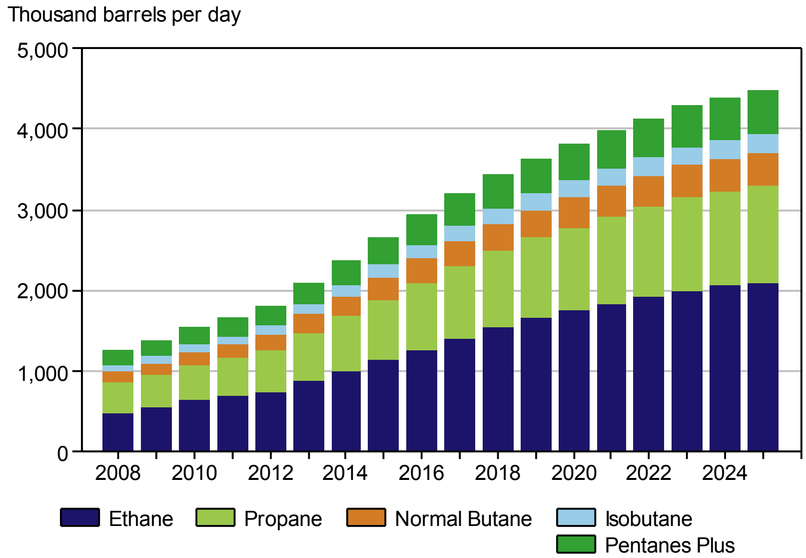
Proposed US Gulf Coast LNG Liquefaction Facility



Source: Cheniere Energy

Natural Gas and NGL Processing

US NGL Contained Production from Gas Processing



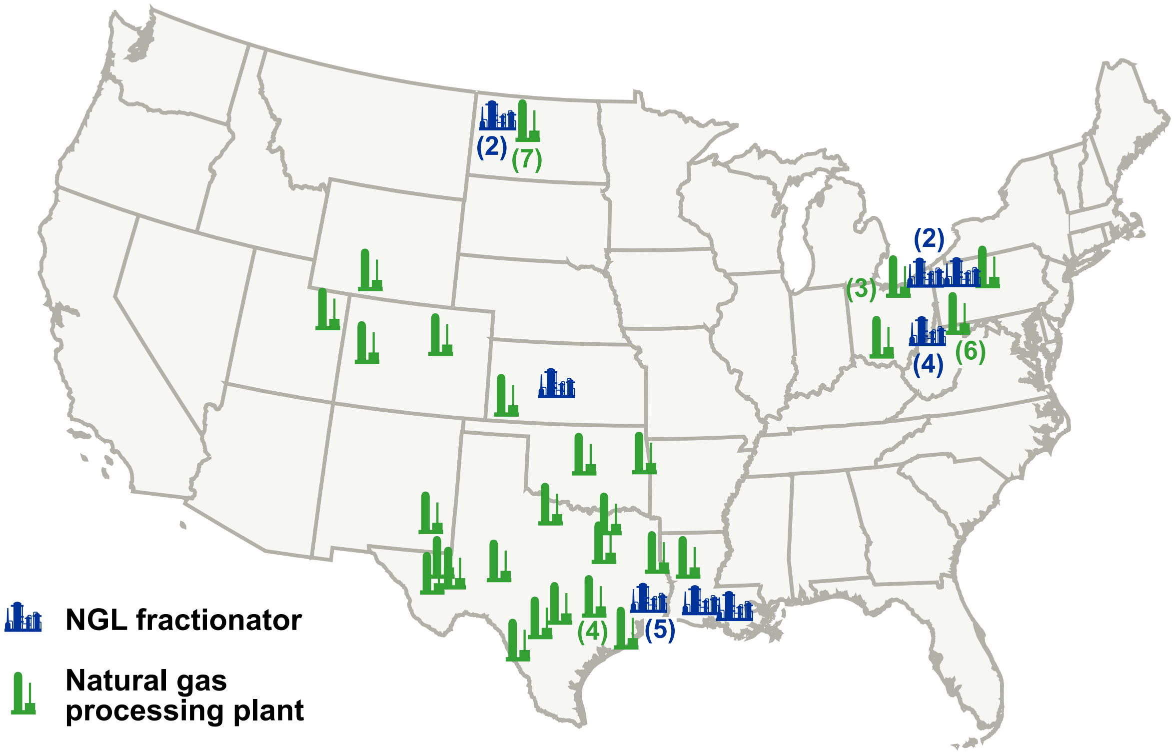
Source: IHS Chemical

The current pace of shale gas development is rapidly increasing domestic NGL production and keeping prices for US natural gas lower than prices in most overseas gas markets. Strong margins for NGL recovery, compared with the margins for natural gas, are further encouraging high NGL recovery levels. Since 2008, US NGL production from natural gas processing has already increased by over 500,000 bd, reaching about 1.8 mbd in 2012. Because of the ongoing development of shale gas and tight oil resources, NGL production is expected to continue expanding rapidly over the next decade. By 2020, total unconventional NGL production from natural gas processing is expected to reach about 3.8 mbd, which represents an increase of 100% over current levels.

Sixty of the 110 natural gas processing plants required to meet projected demand are already under development. These new plants are forecast to produce 17-19 Bcf per day of lean natural gas, of which 12-13 Bcf per day will be used to satisfy domestic demand growth and 5-6 Bcf per day will be used as feed gas for LNG facilities. IHS forecasts an investment of $28.9 billion in natural gas processing from 2012 through 2025, which represents 22.5 Bcf per day of gas processing capacity.[13]

13 Inlet or Rich Gas Processing Capacity

Announced New US Gas Processing Plants and NGL Fractionators



Source: IHS Energy
30704-3

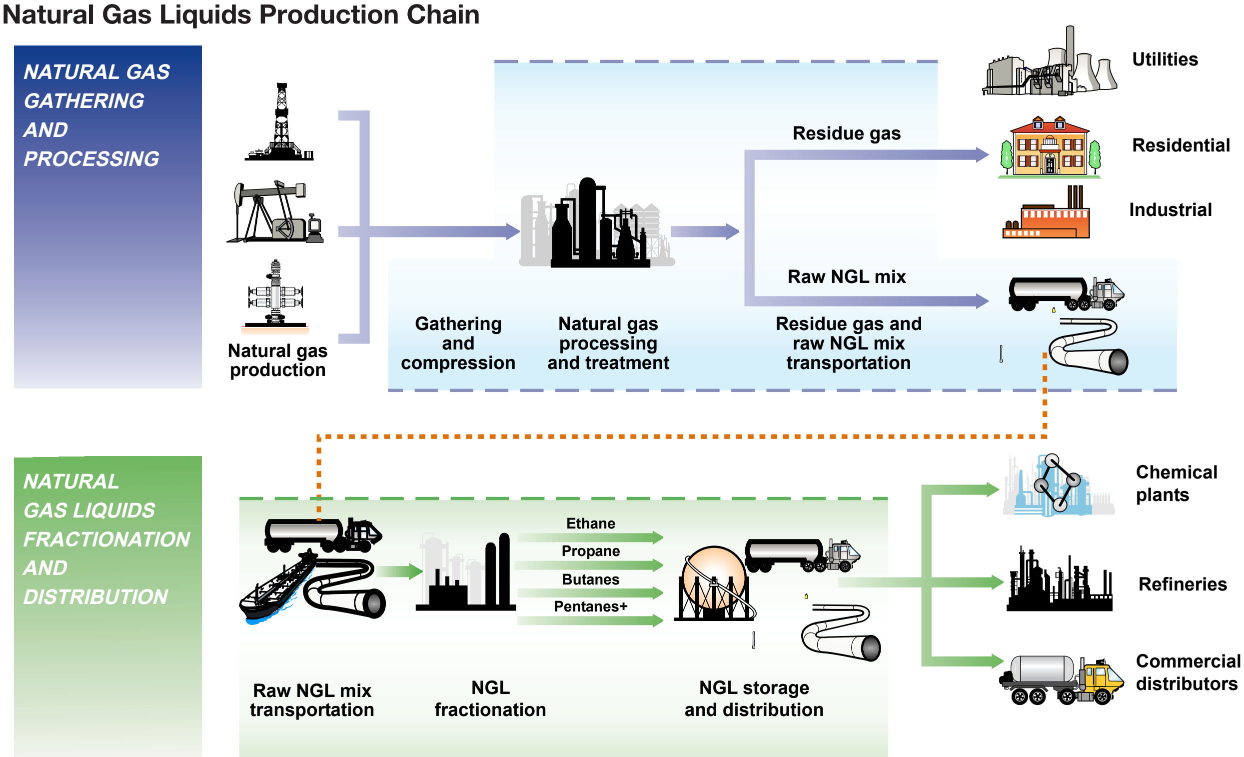
Natural Gas and NGL Processing

Natural Gas Liquids (NGLs) constitute a group of light hydrocarbons that are typically in liquid form when stored under pressure but become gaseous under ambient conditions. Examples include ethane, propane, butane, iso-butane, and pentanes, or simply NGLs when unseparated.[14]

The lighter molecules (ethane and propane) are typically used as feedstock for petrochemical steam cracking. The intermediate molecules (propane and butane) are used as either petrochemical feedstock or in heating applications. The heaviest molecules provide petrochemical feedstock or feedstock for gasoline blending.

14 The heavier component of natural gas liquids are sometimes referred to as natural gasoline.

Natural Gas Liquids Production Chain



Source: IHS Energy
30515-1

Since there is no end-use market for the raw mix of NGLs (typically referred to as Y-Grade), NGLs must be transported long distances to be fractionated into usable products. This most often takes place at large, centrally located merchant facilities typically located near large NGL markets. Mont Belvieu in East Texas and Conway, Kansas, are two large fractionation centers where local demand for NGLs is high, either from the residential and commercial sector or from large industrial users. A number of small fractionators at gas processing plants and refineries produce one or more purified NGLs for their local markets. These smaller plants are typically located further from the main fractionation and storage centers.

Over the forecast period 2012-2025, IHS projects an increase of 2.7 mbd of NGL fractionation capacity and capital investments of $16.1 billion. Two-thirds of this—or over 1.7 mbd — has been announced and is under development, with more than half of this capacity being added at Mont Belvieu.[15]

NG Logistics

To connect new natural gas supplies to the existing pipeline grid that delivers gas to growing consumer markets, over 10,000 miles of new pipelines will need to be constructed. Several factors are driving this pipeline expansion. Although North America already has an extensive network of natural gas pipelines, discoveries in new places are shifting supply from south to north and from west to east. Meanwhile, growing demand for natural gas used in power generation is highlighting pipeline constraints in all four corners of the United States. The retirement of coal capacity will also drive the need for additional pipeline capacity. In response to the Environmental Protection Agency's Mercury and Air Toxics Standards (MATS) rule, which takes effect April 2015, IHS Energy expects 55 gigawatts (GW) of coal capacity to be retired between 2010 and 2020, approximately 23 GW of that in 2015 alone. While this will ramp up the volume of natural gas demand for power generation during the summer, it will drive a larger increase for winter peak day pipeline capacity.

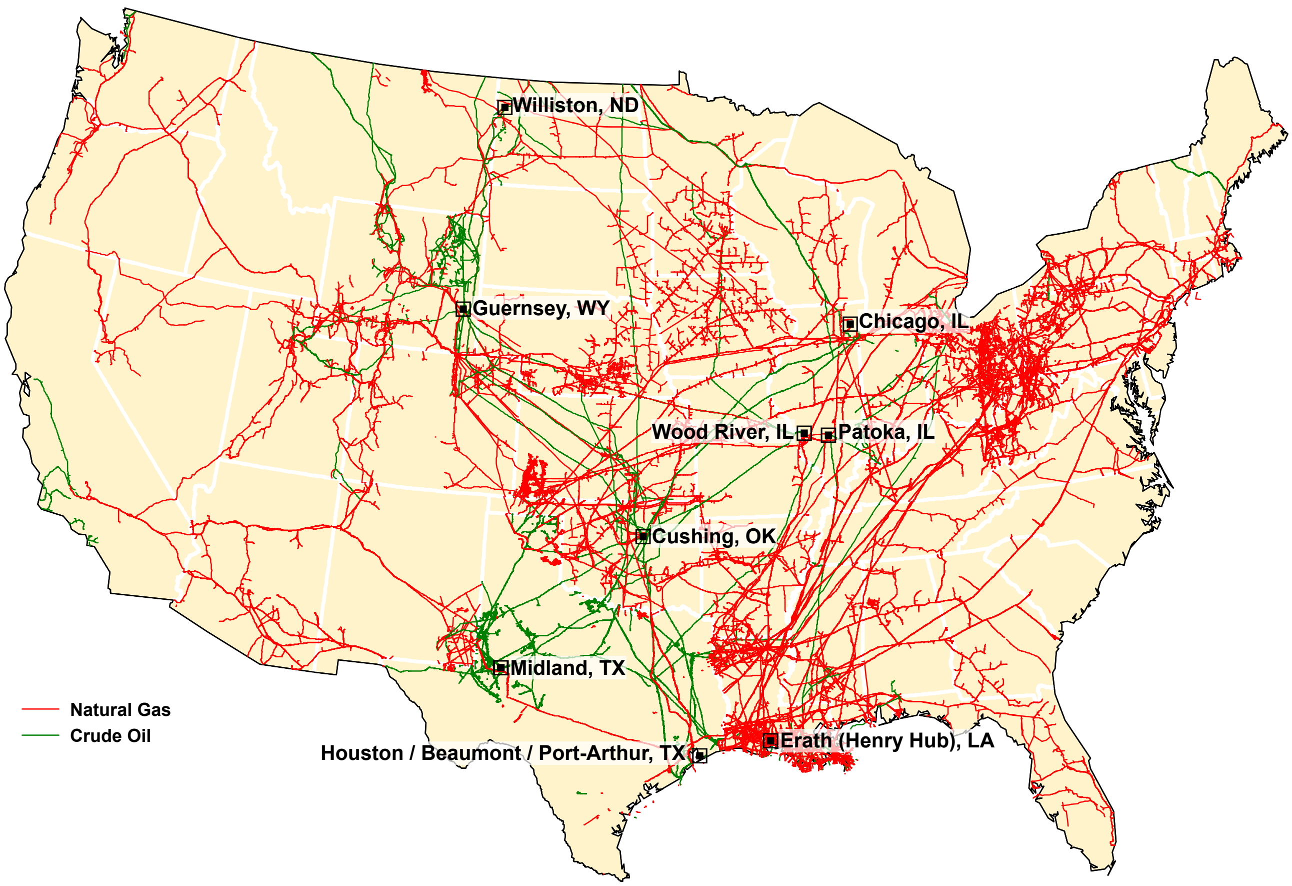
15 IHS's typical estimating metric assumes $4,000-5,000 per barrel per day of capacity, along with typical IHS estimating methodology factors.

Coal Retirements

The retirement by 2020 of 55 gigawatts of US coal-fired electrical generating capacity will ramp up gas demand for use in power generation, driving the need for additional pipeline capacity to connect supplies to power generators.[16]

16 Renewables are also forecasted to replace a share of this retired coal-generating capacity.

US Interstate Pipeline Network



Source: IHS Energy

Natural gas supply growth in the Marcellus basin, mainly situated in Pennsylvania, is driving the majority of interstate pipeline additions that connect resources to demand centers. Most of this capacity is and will continue to be focused on moving that natural gas east. As production increases in the Utica Shale play in Ohio over the remainder of this decade, most of the production initially will be consumed locally, displacing supplies from other sources. However, Utica production is expected to grow beyond local consumption and then will likely be used to meet incremental demand in adjacent demand centers along the Chicago to Ontario corridor. Southern Company, one of the largest consumers of Appalachian coal, with power generating facilities in Alabama, the Florida Panhandle, Georgia, and Mississippi, consumed over 20% of all of the natural gas used to displace coal for power generation in 2012. To comply with the MATS environmental rule, utility generators are choosing to invest in new natural gas-fired power generation as an alternative to capital-intensive retrofits of aging coal-fired generation. The mid-Atlantic and southeast regions will be major markets for this new gas-power generation.

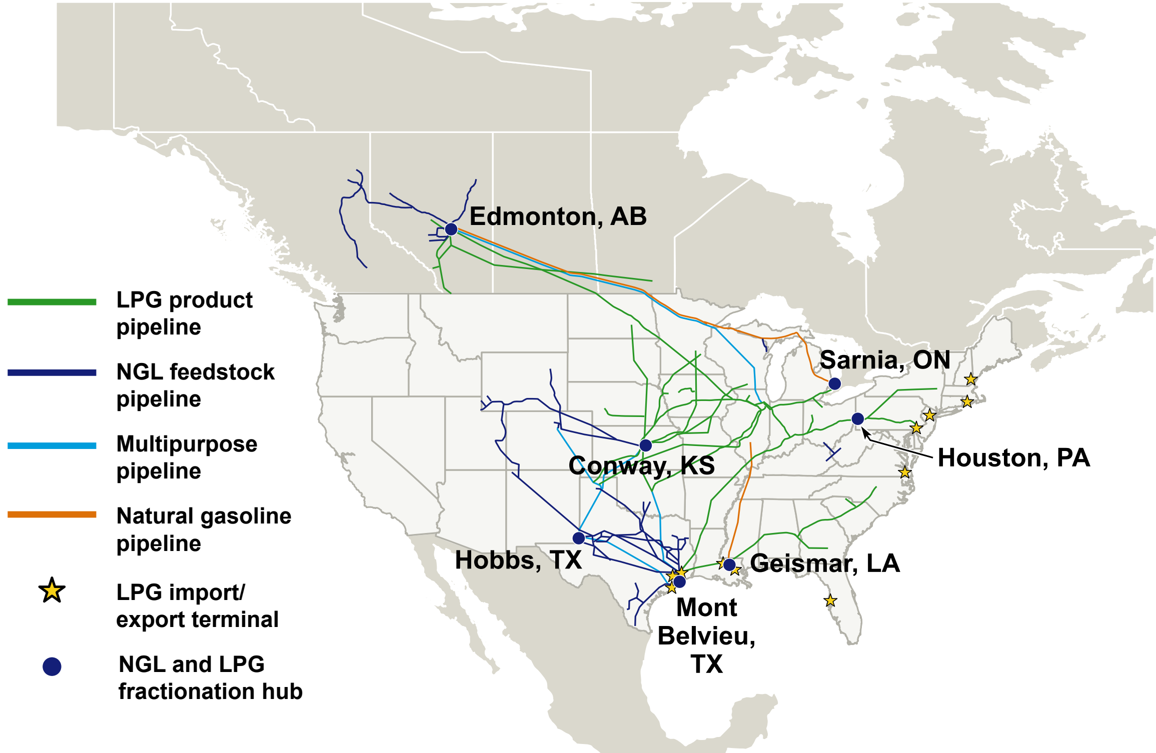
Pipelines to transport NGLs must also be constructed. The bulk of the liquids pipelines to be constructed will gather natural gas with entrained liquids for processing from new or emerging tight oil plays, including Eagle Ford, Cotton Valley, Niobrara, and Granite Wash. Several pipeline projects will focus on the transport of ethane, particularly in liquids-rich regions in which the ethane content makes the Btu content of the gas too high for transport in the primary interstate gas pipelines.

NGL Logistics

The NGL logistics segment comprises several types of infrastructure, including pipelines, storage facilities, and marine export terminals.

The infrastructure projects necessary for NGL logistics now in development will add approximately 2.8 mbd of NGL pipeline-transport capacity. This will include roughly 5,000 miles of new NGL trunk lines within the United States and several conversion, expansion, and reversal projects. The largest reversal project currently under way is Enterprise Products' ATEX project to construct 430 miles of new pipeline and convert 860 miles of former natural gas trunk lines, reversing the flow of surplus production to carry NGLs from the Midcontinent to growing demand centers in the southern United States. Once completed, this project will provide a key logistics link to transport ethane produced in the Marcellus play to ethylene steam crackers on the Gulf Coast. IHS forecasts total investment for this segment at $18 billion, with approximately 80% of it associated with large pipeline projects.

US NGL and LPG Pipeline Infrastructure



Source: IHS Energy
30704-5

Another large investment category for NGL logistics involves marine storage terminals for NGL (primarily liquefied petroleum gas, or LPG).[17] These custom-designed storage and loading facilities, by enabling the export of surplus LPG production, will transform the United States from a net LPG importer as recently as 2010 into a net LPG exporter. Our forecast includes the potential for 400,000-600,000 bd of coastal export facilities, providing export trade support for surplus production.

The impact of this reversal in the trade balance from negative to positive will enable the United States by 2020 to overtake Saudi Arabia as the world's third-largest exporter of LPG. The value of monetizing the trade arbitrage between the United States and northwestern Europe is estimated at $1.5 billion annually. However, we anticipate that as NGL domestic demand increases in the later years of the forecast period (2018-2025), in the form of additional petrochemical steam cracker capacity, the utilization of these marine export facilities will decrease to levels below their design capacity.

Crude Oil Processing

A large increase in US crude oil refining capacity is not anticipated. However, a revival in crude oil production has given a second life to several refineries that seemed destined for closure just two years ago. Nowhere has the tangible benefit of tight oil availability had more impact than on the East Coast. In 2008, 12 refineries with 1.7 mbd of crude oil processing capacity were located on the East Coast. The combination of low demand caused by the recession and an expensive crude oil feed slate, based on imports, jeopardized the long-term viability of these facilities. By 2011, half of these refineries had been shut down, and the largest refinery, Sunoco in Philadelphia, was on the verge of closure. The feedstock opportunities provided by the availability of tight oil resulted in restarting two of these refineries and the preservation of Sunoco's Philadelphia Refinery, which saved thousands of jobs and maintained local economic output.

17 Liquefied Petroleum Gas, an NGL sub-category referring to just the un-fractionated propane and butane molecules.

Repurposing and Renovating Delaware River Refineries

Sunoco announced in September 2011 that it would leave the oil refining business and close its Marcus Hook, Pennsylvania, refinery and attempt to sell its Philadelphia refinery—the largest on the East Coast, with a capacity of 330,000 barrels per day.

This announcement, coming after recent closings of other refineries also located along the Delaware River by Valero, ConocoPhillips and others, mobilized state and local elected officials and economic development agencies in Delaware, New Jersey, and Pennsylvania to try to save the refineries. Their efforts included finding alternative uses for the growing supply of natural gas and NGLs coming from the Marcellus shale play and oil coming from the Bakken and Utica shale formations.

Sunoco had said it would be forced to shut down its Philadelphia refinery in the summer of 2012 if it could not find a buyer. Its Marcus Hook refinery, also near Philadelphia, was closed in early 2012. In late April 2012, Energy Transfer Partners, a Houston natural gas pipeline company, announced plans to purchase Sunoco for $5.3 billion, including the two refineries. In June 2012, Sunoco agreed to sell two-thirds of its interest in the Philadelphia refinery to the Carlyle Group. The Philadelphia Refinery will be operated by a joint venture between Energy Transfer Partners and Carlyle. The venture, Philadelphia Energy Solutions, is currently investing hundreds of millions of dollars in upgrades to the refinery, which it will operate at up to its capacity of 330,000 barrels per day, depending on market conditions.

While the Marcus Hook refinery remains closed, it is being redesigned to store and process NGL. Sunoco's Logistics Mariner East pipeline project would bring NGL from the Marcellus and Utica shale formations to Marcus Hook, where they would be processed to produce propane and ethane.

Elsewhere along the Delaware River, Delta Airlines in May 2012 purchased the former Phillips 66 refinery in Trainer, Pennsylvania, and is using it to produce jet fuel and other refined products with the aim of reducing fuel costs. PBF, one of the largest independent refineries, operates refineries in Paulsboro, New Jersey, and Delaware City, Delaware, which it purchased from Valero in 2010.[18] PBF reopened the shuttered Delaware City refinery in the fall of 2011.

18 PBF: Petroplus Blackstone First Reserve

A major economic impact on the refining sector of greater domestic crude oil production will be to reduce imports and increase the diversity of its crude oil supply. Every incrementally produced barrel of crude oil will displace an equivalent imported barrel of crude oil. The incremental 2.5 mbd forecasted to be produced domestically by 2025 (over 2012 levels) will reduce crude oil imports by this volume, assuming constant refinery capacity and utilization rates. At a $95 per barrel oil price, the net improvement on trade is approximately $87 billion annually.

Crude Oil Logistics

IHS assumes that the majority of unconventional oil will ultimately be moved through pipelines, which have proved the most efficient and cost-effective means of transporting volumes exceeding 50,000 bd of crude oil. The number of pipeline systems installed, expanded, or reversed will have a direct relationship to the amount of incremental storage capacity added. Many of the planned pipeline projects are intended to connect newly emerging producing regions to large, established pipeline intersections that already have significant storage in place. In addition to Houston, they include such locations as Cushing, Oklahoma; Guernsey, Wyoming; Patoka and Wood River, Illinois; and Saint James, Louisiana.

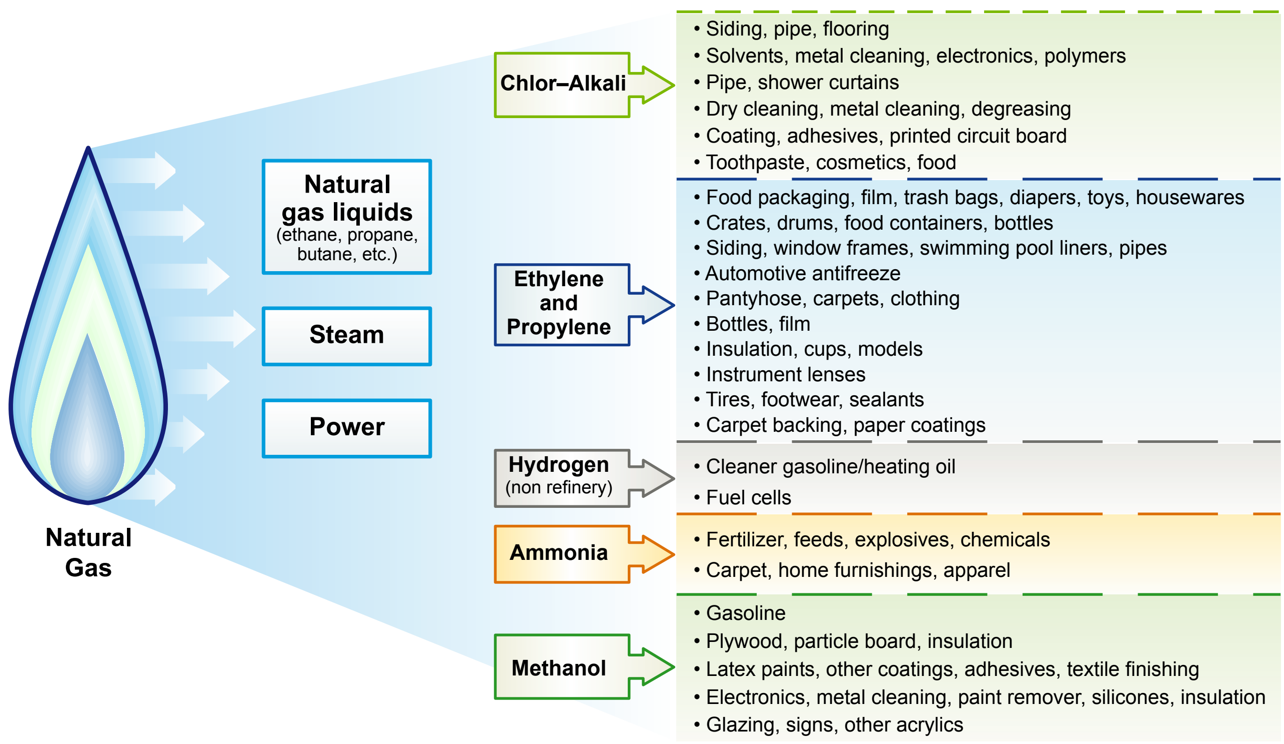
Between 2012 and 2025, IHS forecasts total capital investment of $41.2 billion in crude oil logistics facilities, with $28.3 billion of that—or approximately 70%—being invested in major pipeline projects.

IHS estimates that almost 5 mbd of incremental pipeline capacity will be added over the next six years, almost 30% of total US refining capacity.[19]

Energy-Related Chemicals

The primary beneficiary of lower prices for energy and feedstock in coming years will be the energy-related chemical industries, which will gain a significant competitive advantage in world markets. Natural gas plays a key role, both as a feedstock in the production of several major petrochemical products, and as a major source of energy required to run various manufacturing sites. As chemical manufacturers expand their plants and infrastructure, their investments will generate value added to US GDP, while having the added benefit of reducing the nation's trade deficit. Energy-related chemicals are the primary building blocks for a wide range of manufacturing and non-manufacturing industries, including automotive, agriculture, buildings and construction, pharmaceutical, transport, and textiles.

Everyday Connection to Natural Gas



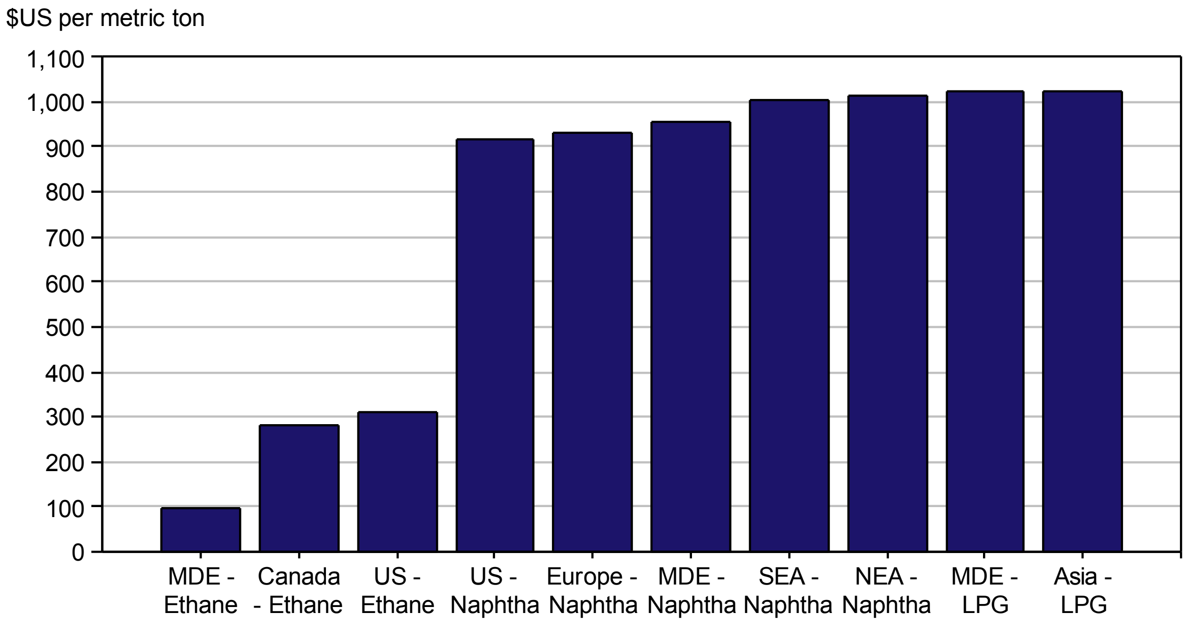
Source: IHS Chemical
30515-12

Natural gas liquids (NGL) produced from natural gas are also important feedstock for the chemical industry. America's abundance of unconventional natural gas is driving dynamic growth in the production of plastics, pharmaceuticals, fertilizers and other petrochemicals. The lower cost of natural gas relative to crude oil has also given ethane a large advantage over naphtha as a petrochemical feedstock.[20] We anticipate a production boom in ethylene, the primary building block for most plastics that is derived from cheap ethane (a natural gas liquid) instead of more costly naphtha (a crude oil derivative). Capacity expansion is also being planned by ammonia and methanol producers, which use natural gas directly as a feedstock.

19 This value does not include capacity associated with reversing the direction of existing pipeline systems.

20 Naptha is produced by petroleum refineries and is a hydrocarbon liquid that boils in the same range as gasoline, but does not meet finished gasoline specifications.

Cost to Produce One Metric Ton of Ethylene: 2013



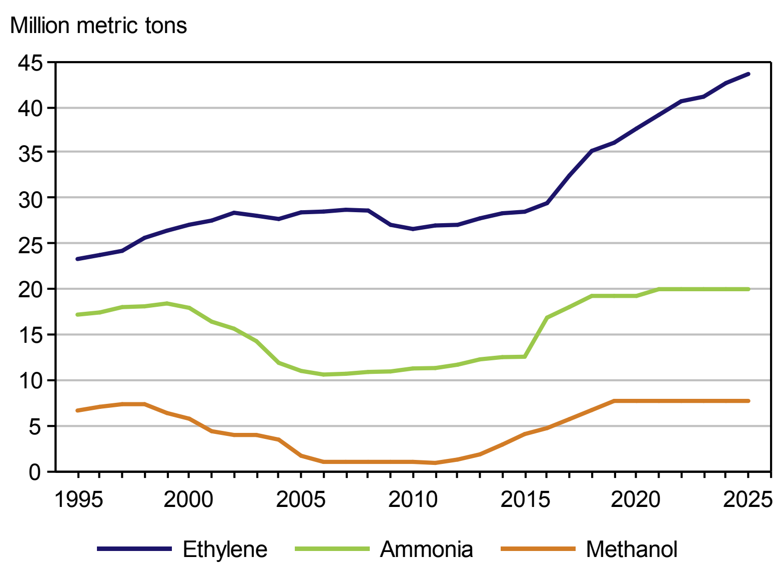
MDE = Middle East, NEA = Northeast Asia, SEA = Southeast Asia

Source: IHS Chemical

With natural gas now available at a fraction of its oil-equivalent price, the United States has become one of the world's lowest-cost petrochemical producers. About 75% of the cost of producing these petrochemicals, as well as plastics, is related to their cost of energy-derived raw materials, and the price of oil, versus natural gas, is playing a key role in determining where new petrochemical capacity is built and which feedstock is used. Right now, the United States has a clear competitive advantage, marking a dramatic turnaround from just a few years ago. The United States had been a major petrochemical producer up until the late 1990s, when it lost its competitiveness as a result of high oil and natural gas prices. This forced the closing of US chemical plants and the off-shoring of significant finished goods manufacturing, while at the same time attracting finished goods imports. Many US chemical plants closed down, even as new capacity arose in the ethane-rich Middle East and in demand-rich China. In the United States between 1999 and 2006, over 40% of its ammonia fertilizer capacity and 85% of its methanol capacity shut down, and the US became a large importer of both products. Several ethylene crackers were also shut down between 2003 and 2009.

Today, however, unconventional gas-derived feedstock is available at a fraction of the cost of oil-based feedstock, shifting the balance in favor of US producers who can take advantage of higher natural gas

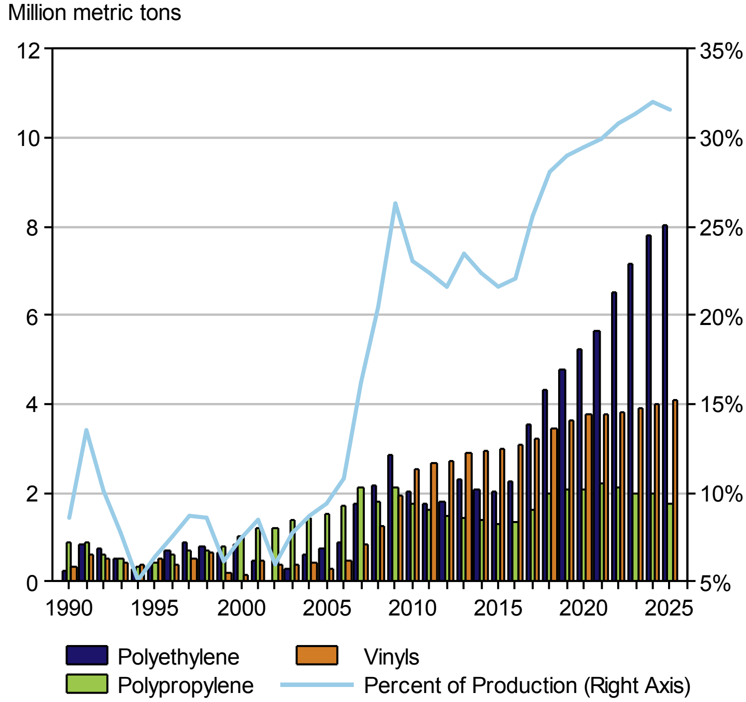
US Chemical Plant Capacities



Source: IHS Chemical

production and lower prices. New domestic capital investments, driven by these lower prices, are expected to reduce ammonia and methanol imports and expand exports of several ethylene derivatives, especially polyethylene and vinyls, as well as many other chemical products such as polypropylene. North America and the Middle East are major exporters due to advantaged feedstock positions, while northeastern Asia is expected to maintain its position as a major net importer of ethylene-based derivatives over the long term.

US Net Exports for Selected Products



Source: IHS Chemical

The rise in US net exports of energy-derived chemicals was first observed in the years immediately preceding the global recession of 2009.[21] This export expansion was driven in part by the widening price spread between natural gas-derived chemicals in the United States and oil derived chemicals in other parts of the world. Over the pre-recession period, while natural gas prices held relatively constant, oil experienced a rapid rise as the Brent Spot Price shot up from $54.57 in 2005 to $96.94 at its peak in 2008.[22] As a result, net exports as a percent of total production increased for energy-related chemicals in the United States, capitalizing on the industry's now relatively more affordable natural gas-based feedstock.

The unconventional oil and natural gas revolution is continuing to accelerate the net export position of US-based energy-related chemical producers. With oil projected to average $98 per barrel throughout the forecast horizon, high prices for oil-derived feedstock will continue to place significant cost pressures on many global chemical competitors. Simultaneously, affordable and abundant natural gas-derived feedstock unlocked by the unconventional revolution will continue to benefit US natural gas based energy-related chemical producers. The chemical manufacturing industry is currently one of America's largest exporting industries. Its $198 billion in annual exports accounted for 13% of all US merchandise exports in 2012.[23] The industry currently employs 783,600 workers and roughly one-third are supported by exports.[24] Exports of US-manufactured chemicals and plastics have increased by 11% since 2010.[25]

The chemical manufacturing industry is currently one of America's largest exporting industries. Its $198 billion in annual exports accounted for 13% of all US merchandise exports in 2012. The industry currently employs 783,600 workers and roughly one-third are supported by exports. Exports of US manufactured chemicals and plastics have increased by 11% since 2010.

21 Net exports defined as the industries total exports minus the value of its total imports

22 EIA Europe Brent Spot Price FOB (Dollar per Barrel).

23 United States Department of Commerce, Bureau of the Census, Foreign Trade Division.

24 United States Department of Labor, Bureau of Labor Statistics, Current Employment Statistics.

25 United States Department of Commerce, Bureau of the Census, Foreign Trade Division.

Expanding US chemical capacity will require a continued commitment to the export market, as growth in North American domestic consumption is expected to remain moderate. Fueled by exports, basic chemicals and plastics production is forecast to increase at an average rate of about 5% per year from 2013 to 2020. Over the longer term, given expectations that North America will remain a low-cost energy and feedstock source for the chemical industry, the region could return to more downstream manufacturing of durable and non-durable goods based on these low-cost chemicals and plastics. The result will be stronger growth in domestic consumption of basic chemicals and plastics as a result of the “on-shoring” of the manufacturing of certain products produced from polyethylene.

The impact of the unconventional oil and natural gas revolution on the chemical industry is very broad, and many product chains will benefit directly. This impact, which is already becoming evident in manufacturing further downstream, is transformational for the United States. New capacity will return North America to historic production levels—or beyond—for many chemical products.

Chemical investment will be largely focused on the following nine value chains, which accounted for about 45% of US capacity in 2012:

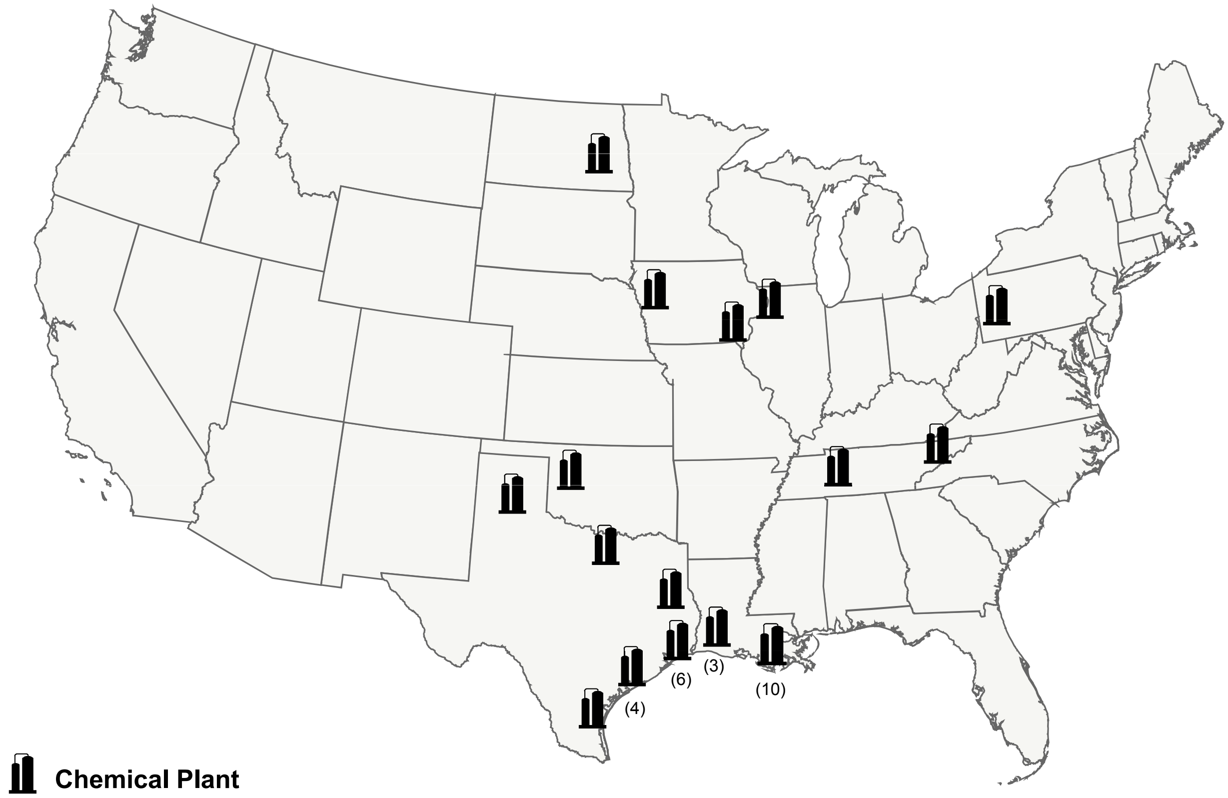
- Acrylics—acrylic acid and acrylonitrile
- Aromatics chain—aniline, nitrobenzene
- Nitrogen fertilizers—ammonia, ammonium nitrate, and urea
- Chlor-alkali—chlorine and caustic
- Olefins—ethylene, propylene, hexene, octene, butene-1, and butadiene
- Polyolefins—high density polyethylene (PE), low density PE, linear low density PE, and polypropylene
- Vinyls chain—ethylene dichloride, vinyl chloride monomer, and polyvinyl chloride (PVC)
- Glycols chain—ethylene oxide, proplylene oxide, monoethylene glycol, diethylene glycol, triethylene glycol, polyethylene glycol, and ethoxylates
- Methanol chain—methanol, formaldehyde, methyl methacrylate, MTBE, and MDI

In the near term, through 2015, IHS expects more than 16 million tons of chemical capacity to be added, growing to nearly 89 million tons of new capacity by 2025. By 2025, IHS estimates that as much as $100 billion will have been invested in new chemical, plastics, and related derivative manufacturing facilities in the United States. While the unconventional revolution will affect all parts of the petrochemical industry, the impact will be most profound in the following four segments:

- Ethylene (olefins)
- Propylene (olefins)
- Methanol
- Nitrogen fertilizers (ammonia)

In our view, ethylene and polyethylene will be the major beneficiaries of the industry’s newfound competitiveness, adding a total of nearly 30 million metric tons of capacity by 2025. Other chemical products that will see significant growth include methanol and nitrogen fertilizers (ammonia).

Announced or Anticipated US Chemical Plants



Source: IHS Chemical

Sasol Plans New Ethane Cracker and Integrated Gas-to-Liquids Plant in Westlake, LA

In December 2012, Louisiana Governor Bobby Jindal and Sasol, a South African company, announced that the company is planning to invest between $16 billion and $21 billion to construct an integrated gas-to-liquids (GTL) and ethane cracker complex near Westlake, Louisiana. Sasol's proposed complex is reported to be the largest single manufacturing investment in Louisiana history and one of the largest foreign direct investments in a manufacturing project in US history. According to the Louisiana Department of Economic Development, the total economic impact of the Sasol project over the next 20 years will be $46.2 billion, and it is expected to create roughly 7,000 construction jobs.

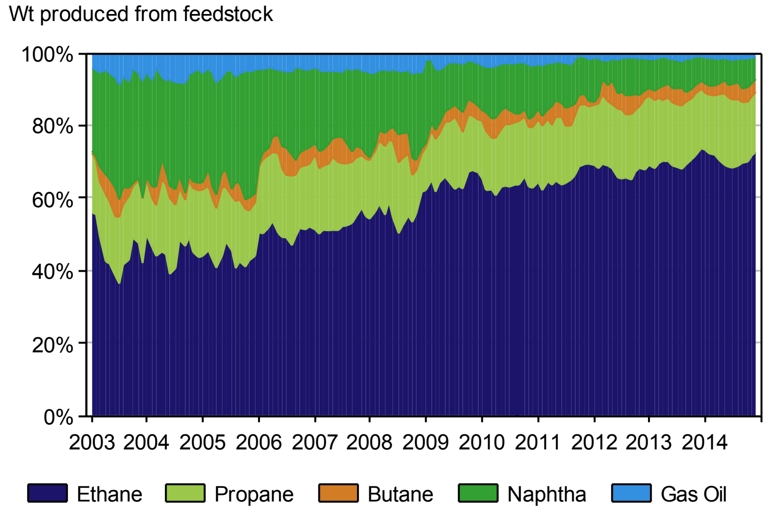
The GTL facility, the first of its kind in the United States, will produce transportation fuels, including GTL diesel and other high value-added chemical products. The project will consist of an integrated 96,000 bd GTL facility and an ethane cracker. The ethane cracker will produce 1.5 million tons annually of ethylene, which is used to make alcohol- and plastics-based products, such as solvents, surfactants and polymers.

Once the complex begins operating, it will create 1,253 direct jobs that pay an average salary, at full employment, of nearly $88,000, plus benefits. An additional 5,886 new indirect jobs would be generated, for a total employment increase of more than 7,000 jobs.

Chemical Feedstock

Several different feed stocks can be used to make petrochemicals. Natural gas is the most common feedstock used for ammonia and methanol production. Natural gas liquids (NGL) such as ethane, propane and butane, as well as naphtha refined from crude oil, are used to make olefins such as ethylene, propylene and butadiene, the basic building blocks for most plastics. The recent development of unconventional natural gas has increased the production of NGLs and has lowered their costs relative to naphtha and gas oil.[26] This has shifted feedstock usage for ethylene production, and the share of ethylene produced from ethane in the United States has risen from less than 50% in 2005 to about 70% today.

Monthly Ethylene Production By Feedstock

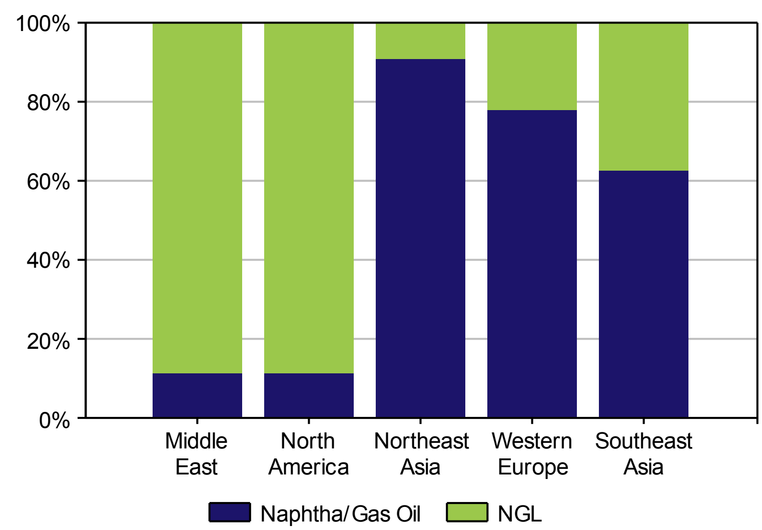


Source: IHS Chemical

Ethylene (Olefin)

Ethylene is the petrochemical with the largest production domestically and globally and is a key raw material for many polymers and other chemicals such as polyethylene (PE), polyvinyl chloride (PVC), and polyethylene terephthalate (PET). These products are used in a variety of industrial and consumer markets such as packaging, transportation, electronics, textiles, construction materials, consumer chemicals, coatings and adhesives. The production of ethylene in the United States is heavily dependent on NGLs, which account for 60% of production costs. Today, over 80% of the ethylene produced in North America is derived from these NGLs, while in the rest of the world (except for the Middle East) naphtha from crude oil is the key feedstock.

Regional Ethylene Capacity by Type of Feedstock



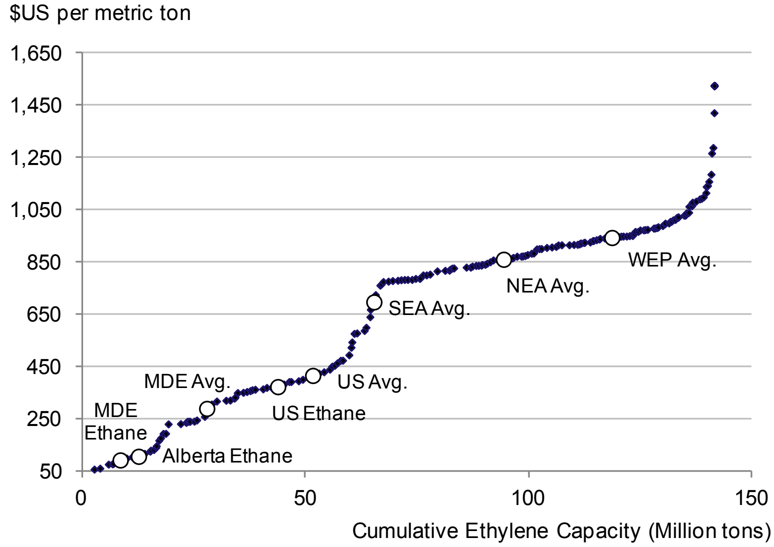
Source: IHS Chemical

The price differentials between North American natural gas and global crude oil now provide the North American petrochemical industry with a profound and sustainable competitive advantage. This is expected to persist for decades, thanks to the abundant and low-cost US natural gas supply, of which NGLs are a byproduct. US-based ethylene producers earlier in the millennium were among the highest-cost producers on the global supply curve due to high natural gas prices. But today, with natural

26 Gas oil is produced by petroleum refineries and is a hydrocarbon liquid that boils in the same range as diesel and home heating oil, but does not meet finished product specifications.

gas prices relatively low, US-based ethylene producers rank in the bottom third of all producers on the global supply curve in terms of cost. The estimated US weighted average cash cost of production is less than half the cost in Northeast Asia and Western Europe. The Middle East and Alberta ethane cash costs are the lowest in the world.[27]

Ethylene Cash Cost Curve: 2012



MDE = Middle East, NEA = Northeast Asia, SEA = Southeast Asia, WEP = Western Europe

Source: IHS Chemical

Note that North America is the only significant ethane-consuming region in the world where feedstock prices are set in an open market. Governments set prices in every other major ethane-consuming country. This adds an element of additional risk to investment in US ethane-based units. Despite this risk, IHS anticipates that significant investments will be made across the industry over the next 10 to 20 years to capitalize on the US feedstock advantage. With 75% of US NGL consumption located on the Gulf Coast, most NGL roads will lead to the Gulf Coast by 2014. Currently over 2.8 mbd of NGL pipeline capacity projects are in development and 1.6 mbd of fractionation capacity projects are under way, which will provide feedstock for the expected increases in olefin capacity. To date, announcements have already been made to expand or build new ethylene production facilities in the United States capable of producing well over 9 million metric tons per year of ethylene, based on ethane feed.

Ethylene producers, confident of an extended period of low natural gas prices, have already signaled their intentions to increase capacity, reversing the trend of closing plants in the United States during the first decade of this century. Chevron Phillips Chemical Co., ExxonMobil Chemical Co., Formosa, Shell Chemical, the Dow Chemical Co. and others are building new US ethylene plants, and several producers are expanding or restarting their facilities, including Ineos, The Williams Companies, LyondellBasell, and Westlake Chemical.

Expanding Ethylene Production

To date, announcements have been made to expand or build new ethylene production facilities in the United States capable of producing a more than 9 million metric tons per year of ethylene, based on ethane feed.

Most of these US ethylene manufacturers' expansion plans include provisions to export significant amounts of ethylene derivatives, based on expectations that their natural gas-based production will be extremely cost competitive with oil-based production in the rest of the world. Exports of US ethylene derivatives are projected to increase in the future, especially after the majority of the new capacity comes on stream after 2016, with most of the increase coming in the polyethylene and vinyl product lines.

27 Cash cost is the total manufacturing cost excluding R&D, selling, and administrative expenses and depreciation.

Dow Chemical to Construct a Hydrocarbon Cracker in Texas

Dow Chemical Co. will create 150 permanent jobs and spend $1.7 billion to build a hydrocarbon cracker in Brazoria County, Texas, south of Houston. The proposed ethylene cracker will process natural gas and NGLs extracted from US shale plays to produce ethylene, a key input in the manufacture of resins and other chemical intermediates. These, in turn, are used in a variety of other products in such sectors as transportation, construction, infrastructure, wire and cable, medical devices, personal care and food packaging. The proposed cracker will be Dow's largest worldwide, and the state of Texas will invest $1 million in the project through the Texas Enterprise Fund.

Along with driving greater exports, investments in new ethylene capacity will also increase domestic production and potential exports of sophisticated high-value finished plastic products used in consumer goods such as cars, computers and medical devices. Today, the United States imports many of these end products.

Propylene (Olefin)

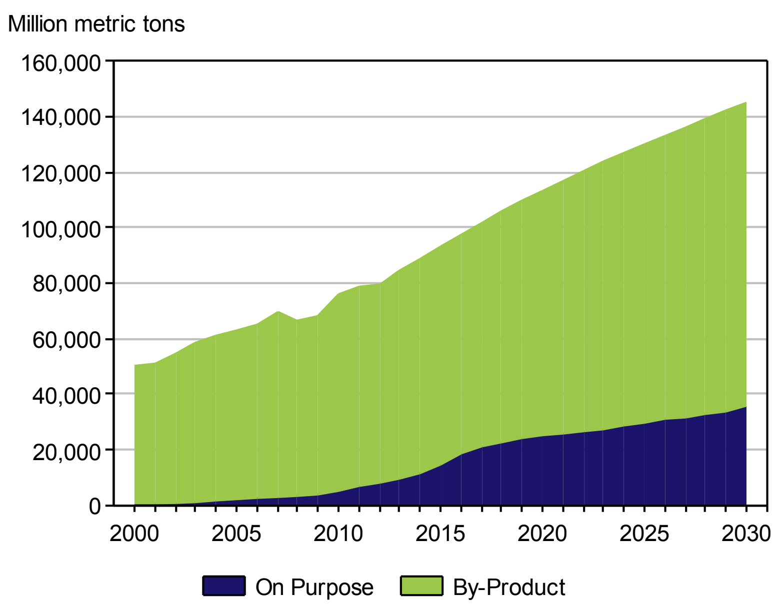
The US unconventional natural gas advantage does not benefit propylene as much as it does ethylene. Approximately half of the current production of propylene in the United States comes from petroleum refineries, and the other half is produced as a co-product in ethylene crackers. But ethane cracking results in very low production of propylene compared to the production from naphtha and gas oil cracking. Increases in ethane cracking in the United States have resulted in much lower production of propylene and other heavier co-products from steam crackers, which has changed propylene's volume growth trends. As ethane cracking has increased, US propylene production has declined by about 15% in recent years, and it is not expected to return to 2007 levels until at least 2018.

The production of propylene from steam crackers will continue to decrease as more ethane feedstock is used in ethylene production. Propylene production from steam crackers declined from 49% of total propylene production in 2005 to 38% in 2012 and is expected to drop further to 31% by 2020. During the same period, the refinery-based capacity share is expected to decline from 45% to 36%.

However, IHS expects on-purpose propylene production from propane via the dehydrogenation process to become a larger component of propylene supply, which will offset the lost cracker production.

Current and projected strong margins for producing on-purpose propylene from propane are triggering additional investment in North America to replace the lost supply from steam crackers. IHS expects a total of about 4 million metric tons of new propylene capacity to start-up between 2012 and 2020, including known and not-yet announced projects. By 2020, propane dehydrogenation (PDH) capacity, which is virtually non-existent today, is forecast to increase to 17% of total US capacity.

Propylene Supply Sources



Source: IHS Chemical

The startup of the Petro Logistics 540,000 metric ton PDH unit in Houston in the fourth quarter of 2010 was the first in a wave of on-purpose production units to be built in North America. The capacity of this unit has been rated at 658,000 metric tons. Dow has announced two PDH units for start-up in 2015 (750,000 metric tons) and possibly 2018; Enterprise has announced a 750,000 metric ton PDH unit for 2015; and Formosa has announced a 600,000 metric ton unit for 2016.

Propylene Production to Rise

IHS expects a total of about 4 million metric tons of new propylene capacity to start-up between 2012 and 2020, including known and not-yet announced projects. By 2020, PDH capacity, which is virtually non-existent today, is forecast to increase to 17% of total US capacity.

Methanol

The methanol industry stands to benefit from the US natural gas boom. Natural gas is used directly as a feedstock to make methanol in most regions of the world, although coal is used for a significant amount of production in China. Current global demand is around 65 million metric tons, but that will more than double over the next ten years, driven by investments in China for methanol-to-olefins production and for vehicle fuel (methanol is added into gasoline). Production for traditional end uses, such as formaldehyde and acetic acid, will also continue to grow.

Global methanol production for use in olefins (ethylene and propylene) manufacturing will rise by about 30 million tons between 2012 and 2016. There will also be incremental growth in the production of formaldehyde from methanol. Formaldehyde is used to make particle board for construction purposes and components used in traditional transportation fuel blending. China currently accounts for over half of global demand for methanol. About 80% of global capacity is spread across China, the Middle East and South America. Major capacity will be added over the next five years in China, the United States, and, after 2017, in the Middle East. A large amount of the Chinese methanol capacity is based on coal and, by 2016, about half of the world's methanol production will come from coal in China. In spite of a large increase in methanol-to-olefins capacity there, China's imports of olefins will double between 2012 and 2016 to over 11 million metric tons. Most of the world's exports will continue to come from the Middle East, Southeast Asia and Latin America.

Feedstock costs represent a significant share of the total cost of methanol production, and reduced prices for shale gas are now expected to allow significant margins for US methanol producers, even in slack periods. Prior to 2006, the United States was a marginal producer of methanol globally, owing to relatively high natural gas prices. (Between 1999 and 2006, the US methanol market had consolidated over 80% of its capacity.) With the expectation of improved margins, however, new investments are being made, and North American capacity is expected to grow rapidly. Methanol capacity, which peaked earlier at 6.7 million tons before falling to a low of 750,000 tons, is expected to rise to 7.6 million tons by 2017.

In one dramatic example of the change under way in the industry, the Canadian producer Methanex Corp., based in Vancouver, British Columbia, is moving two of its 1 million ton methanol units from Chile to Louisiana, and Celanese has recently announced a 1.3 million ton methanol unit in Texas. Some idled methanol units in the United States and Canada have or will be restarted. Additional methanol capacity—on top of that which is already announced—is also being contemplated. All but one of the new methanol plants will use natural gas as feedstock. Each metric ton of methanol uses nearly 35 MMBtu of natural gas, so the total natural gas usage from these new methanol investments is projected to exceed 200 Bcf per year or 0.5 Bcf per day by 2020.

Methanex is Relocating Plants from Chile to Louisiana

The Canadian methanol company Methanex Corp. is relocating two $550 million methanol plants from Chile to Geismar, Louisiana. The first one is expected to add 130 permanent jobs when it starts up in 2014. Methanex, described as the world's largest producer of methanol, expects to break ground on the second Louisiana plant in 2014, with construction lasting about two years. This second Louisiana plant will add 35 additional permanent jobs.

The US investment comes as limited gas supplies in Chile have kept Methanex factories there operating below capacity. Chile originally had four plants and Methanex has invested more than $1.3 billion there since 1998. The two plant relocations are expected to cost a total of $1.1 billion.

With the advent of unconventional natural gas-based methanol production in the United States starting in 2013, US net imports will decline from the current level of 5 million metric tons per year. The United States will continue to rely on imports for its near-term supply, but imports will decrease as domestic production increases. The potential exists for the region to become balanced, or possibly a net exporter, when the new capacity comes on line. Domestic demand in North America will grow modestly—at about 2% per year through the forecast period—on the back of a slowly recovering economy.

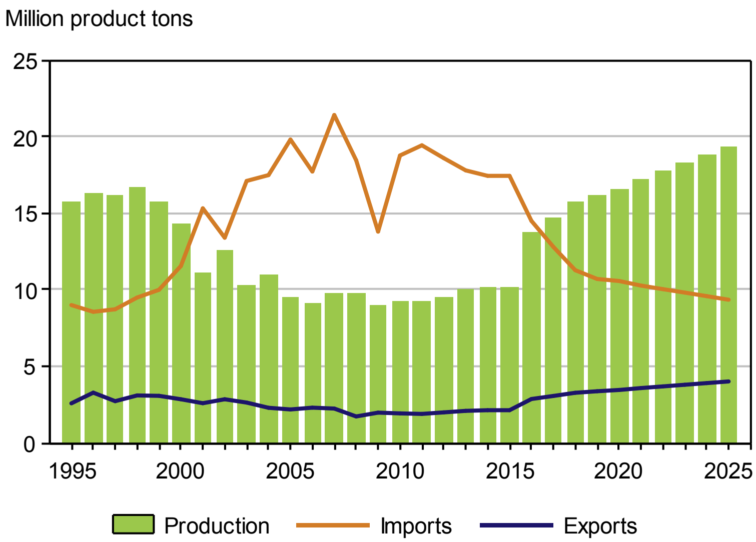
Nitrogen Fertilizers (Ammonia)

Ammonia is used both directly as a fertilizer and as a feedstock in the production of other types of fertilizers such as urea, ammonium sulfate, ammonium nitrate and ammonium phosphates. Natural gas is the feedstock for most of the world's ammonia, though coal is primarily used in China. The United States has gone from being a marginal producer of ammonia globally a decade ago to being one of today's lowest cost producers. Fuel oil-based natural gas pricing in other regions, such as Eastern Europe, makes them the high-cost producers now.

Cheap, abundant natural gas will drive significant investment in the US agricultural chemical industry and reduce fertilizer imports. About 80% of global ammonia production is used to make fertilizers, and lower natural gas feedstock prices will make US ammonia-based fertilizers more competitive internationally. The remaining 20% of ammonia produced worldwide goes into other consumable products, such as explosives, resins, pesticides and pharmaceuticals.

Between 1999 and 2006, over 40% of US fertilizer capacity was shut down. But today, low natural gas prices have increased the profitability of domestic production, resulting in the restarting of facilities such as the CF Industries Holdings Inc. (Terra) plant in Donaldsonville, Louisiana; the Orascom Construction Industries plant in Beaumont, Texas; the LSB Industries Inc. plant in Pryor, Oklahoma; and, the PCS Fertilizer plant in Geismar, Louisiana. Most of the other US plants that once produced fertilizers have been demolished. But the expected returns on investment are high enough to justify building new plants on the US Gulf Coast and in strategically located areas close to crop production and shale gas deposits that can take advantage of savings in logistics cost to improve returns.

US Fertilizer Industry: Nitrogen



Source: IHS Energy

Operating rates in 2013 for US ammonia producers are estimated to reach about 90% of capacity. However, production volumes this year will satisfy only 65% of domestic demand, with the remaining 35% provided by imports, primarily from low-cost South American producers, mainly located in Trinidad. Consequently, while low-cost unconventional natural gas has already had a positive impact on US fertilizer production, the impact has only begun to be felt. Many new projects have been announced and will be starting up between 2016 and 2018. New world-scale plants are being built on the US Gulf Coast by CF Industries, Dyno Nobel, and Mosaic. Other new plants are being built close to the Midwest market by Orascom Construction Industries in Iowa and CHS Inc. in North Dakota. In total, new or expanded production facilities in the United States are capable of producing over 6 million metric tons per year of natural gas-based ammonia and another 6 million metric tons per year of urea.

OCI Fertilizer Group Selects Iowa for New Plant

Orascom Construction Industries of Egypt is building a new green field nitrogen fertilizer plant in southeast Iowa to supply Corn Belt customers. The new plant — the first world-scale, natural gas-based fertilizer plant built in the United States in nearly 25 years—will produce up to 2 million metric tons per year of ammonia, urea, urea ammonium nitrate, and diesel exhaust fluid. The plant will help to reduce the country's dependence on fertilizer imports, which exceed 15 million metric tons of ammonia, urea, and urea ammonium nitrate annually. Plant construction is scheduled be completed by mid-2015 at an estimated cost of $1.4 billion.

Detailing the economic benefits of the new fertilizer plant, Iowa Governor Terry Branstad said, "I am pleased to welcome OCI to Iowa. Their project is the largest investment ever made in our state. The Iowa Fertilizer Company will bring high-paying permanent jobs to Lee County and will create approximately 2,500 construction jobs over the next three years."

Most of the new ammonia capacity will be used to provide fertilizer for the domestic market, reducing US agriculture's reliance on imports. Nearly 7 million metric tons of ammonia are imported into the United States each year, of which 5.3 million tons come from Trinidad and Canada. Most of the remainder comes from the former Soviet Union and elsewhere and could be displaced by local production. IHS also expects most current urea imports into the United States, valued at over $2.5 billion per year, to be displaced by local production. Ammonia is expensive to ship, but if enough domestic capacity is built to allow exports, the shipments will most likely be in the form of urea, which is easily shipped in bulk.

Direct Capital Investment

The dramatic drop in natural gas prices, brought on by the unconventional natural gas revolution, will dramatically increase US chemical industry production over the 2012 to 2025 forecast horizon. Chemical production will increase by an average of $39 billion per year between 2012 and 2025. Total direct cumulative fixed capital investment by the chemical industry is expected to exceed $129 billion by 2025. The expected increases in output and capital expenditures by chemical manufacturers can be directly tied to the domestic production of unconventional natural gas.

Energy-Related Chemicals Value of Production and Capital Expenditures: United States

(Current $M)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2012-25
Value of Production															
Acrylics	114	116	117	329	540	631	720	732	744	995	1,254	1,479	1,505	1,531	10,807
Nitrogen Fertilizers	333	526	686	697	2,128	3,641	4,838	4,919	5,003	5,981	6,087	6,194	6,302	6,411	53,747
Chlor-alkali	386	773	1,406	1,428	1,451	1,475	1,500	1,525	1,551	1,578	1,606	1,635	1,663	2,094	20,072
Olefins	28	203	302	436	802	1,256	1,738	2,661	3,720	4,019	5,194	5,285	5,455	5,890	36,990
Polyolefins	174	214	329	1,469	5,260	12,681	18,876	21,623	24,221	27,745	31,429	31,980	33,579	34,875	244,455
Vinyls Chain	112	114	146	705	1,176	2,043	2,540	3,792	4,706	5,610	6,554	6,669	7,759	7,969	49,893
Glycols Chain	378	384	688	731	743	2,525	2,600	2,693	3,648	4,068	4,140	4,212	4,286	4,360	35,457
Methanol Chain	170	435	1,179	1,914	2,782	4,104	4,174	4,824	5,041	5,264	5,358	5,452	6,122	6,524	53,342
Aromatics Chain	0	0	0	0	0	15	57	58	59	60	61	62	106	108	587
Total Value of Production	**1,695**	**2,765**	**4,854**	**7,709**	**14,883**	**28,371**	**37,042**	**42,827**	**48,694**	**55,320**	**61,683**	**62,968**	**66,777**	**69,761**	**505,350**
Total CapEx	**4,818**	**5,618**	**8,149**	**12,787**	**16,493**	**15,711**	**11,902**	**10,252**	**9,408**	**6,994**	**5,233**	**6,157**	**8,355**	**7,427**	**129,305**

Source: IHS Chemical

Establishing the Base Case

The economic contributions of midstream and downstream energy as well as energy-related chemicals are a function of the pace of upstream production activity. Estimates for upstream production were established as part of the Base Case associated with the October 2012 release of America's New Energy Future.[28] In that study, resource production is based on a set of bottom-up build-outs that represent IHS's current outlook for unconventional oil and natural gas production, capital expenditures, and operating expenses. It is consistent with the analysis presented in the first two volumes of this research series. Defined as the Base Case, this outlook includes 21 of the most significant existing or emerging plays, covers private and federal lands for drilling and extractions within those plays, and assumes the status quo is maintained with regard to existing policies and the regulatory framework. The 21 plays considered in this study are shown in this table:

Tight Oil Plays	Shale Gas Plays	Tight Sands Gas Plays
Bakken	Eagle Ford shale wet gas	Uinta-Piceance
Eagle Ford oil and volatile oil	Eagle Ford shale dry gas	Jonah-Pinedale
Delaware Basin—Bone Spring	Marcellus shale	Cotton Valley
Midland Basin—Spraberry-Wolfcamp	Utica shale (gas)	Granite Wash—Colony Wash
Mississippian	Woodford shale	
Cleveland-Tonkawa	Haynesville shale	
Utica (oil)	Fayetteville shale	
Emerging plays	Barnett shale	
	Niobrara	

The variables used to derive production profiles for each of these 21 plays were obtained from IHS databases and internal research. These variables include:

- Rig count (including assumptions about ramp up, maximum rigs, time at plateau, and ramp down);
- Number of days to drill and complete a well;
- Type curves showing production profiles over time for a typical well;
- Acreage to be developed;
- Well spacing;
- Probability of geologic and commercial success.

The number of possible locations to be developed was derived from the last three items (acreage, well spacing and probability of geologic success). Type curves were derived for each play using IHS databases and software tools (Enerdeq and PowerTools) and were based on actual well production data. The number of days to drill a well, from initial mobilization through demobilization of the rigs, was also obtained from well data in IHS databases. Rig forecasts were developed for each play based on historic rig counts and estimated active rig counts operating in 2012, along with the per-well economics of each individual play.

Land Coverage

While US oil production is at its highest level in nearly a quarter of a century, the increase in production is the result of unconventional activity located primarily on state and private onshore lands in the lower 48 states. A recent Congressional Research Service report, *US Crude Oil and Natural Gas Production in*

28 *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy*, *Volume 1:National Economic Contributions*

Federal and Non-Federal Areas, credited increased oil production since 2007 to activity on non-federal lands.[29] The data collected by the Office of Natural Resource Revenue—the agency responsible for the management of revenues associated with federal offshore and federal and American Indian onshore mineral leases—also suggests that the unconventional oil and natural gas revolution is due mostly to production on non-federal lands.

Crude Oil

The increase in production on non-federal lands cited by the Congressional Research Center accounted for 74% of total US production in 2012. Most of that growth has been onshore.

Production has also been growing on federal onshore lands, but at a slower pace. Production on private and state onshore lands has grown by 36% since 2007, or by nearly 1.2 million barrels per day (mbd). In contrast, production on federal onshore lands grew by only 44,000 bd in that same time period.

Offshore production predominantly occurs in federal waters and accounts for nearly 99% of the total US offshore production. (Production occurring in state-owned shallow waters has been flat since 2007, remaining between 60,000 and 70,000 bd.) Production in federal waters has bounced around primarily due to the timing and volumes that have come on-stream from large new projects in the deepwater Gulf of Mexico. We anticipate future projects in the deepwater Gulf to boost offshore production by over 300,000 bd by 2020. This is a significant increase, but the growth onshore in unconventional energy looms considerably larger. Just as the 2007-2013 growth is attributable to onshore activity on private and state land, so is the expected growth in the future. Production from onshore unconventional oil in 2020 is anticipated to grow by another 2 mbd—more than four times that of the offshore federal waters.

Natural Gas

Since 2007, US natural gas production has increased by 5,931 billion cubic feet (Bcf). The overwhelming majority of this increase—98.5—came from unconventional oil and natural gas resources beneath onshore non-federal land. This natural gas production accounted for approximately 82% of total US production in 2012 and grew by 40% between 2007 and 2012. Gas production from onshore federal lands also increased from 2007 to 2009, but has since returned to 2007 levels, representing a mere 3% gain over the entire 5-year period 2007-2012.

Onshore production growth has more than offset the decline in offshore production. Production from federally-owned waters has dropped over 50% since 2007, representing a loss of 1,379 Bcf of gas production annually. Production from state waters has declined less, by about 3% per year. However, state production represented only 25% of all offshore production in 2012 and does not have much impact on the overall decline in offshore gas production.

Federal Lands

The federal government owns approximately 640 million acres, or roughly 28% of the 2.27 billion acres of land in the United States. Four agencies—three under the Department of the Interior and one under the Department of Agriculture—administer 95% of this land:

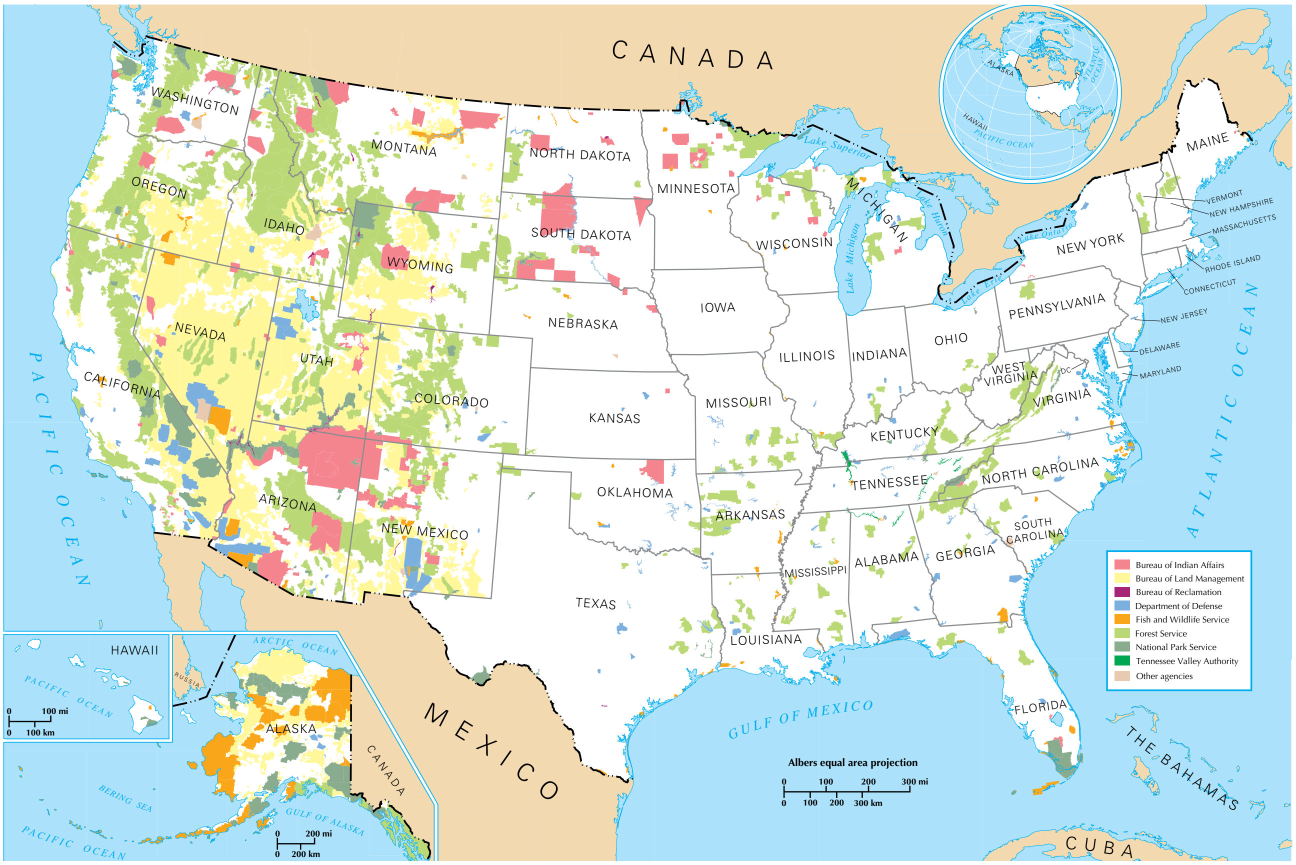
- Department of Agriculture:
- US Forest Service
- Department of the Interior:
- National Park Service

29 Congressional Research Center, Federal Land Ownership: Overview and Data, (February 2012).

- Bureau of Land Management (BLM)
- Fish and Wildlife Service[30]

However, the BLM has responsibility for managing the mineral estate, including areas where the surface is either publically or privately owned. Federal land ownership is disproportionately greater in the western half of the United States where the federal government owns 47% of the land in 11 western states. In four of these 11 states, which are contiguous, the federal government owns more than 50% of the land: Oregon, 52.5%; Idaho, 62.5%; Utah 64.5%, and Nevada 82.9%.

US Public and Indian Lands



Source: National Atlas

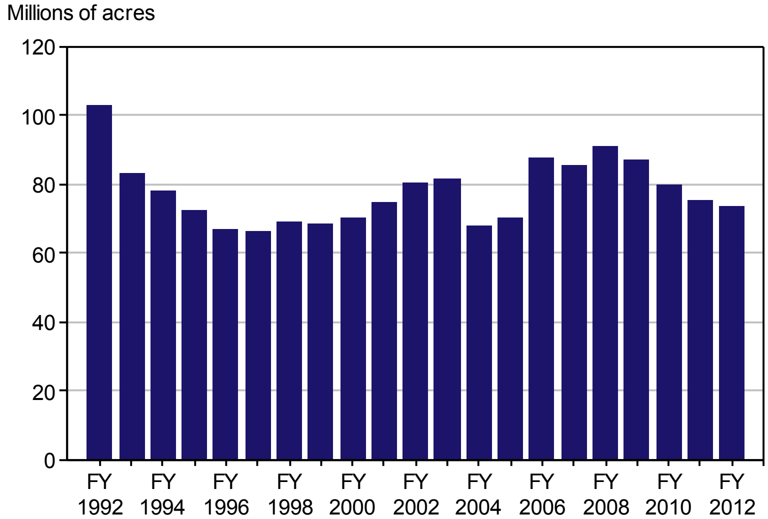
Despite the sizable ownership stake of the federal government, fewer commercial plays historically were identified and developed on federal lands, and production was traditionally lower than in other resource-producing states, such as Texas, Oklahoma and Louisiana. Moreover, the relatively limited regional and basin-wide geological data that is available within these federal lands in the western states suggests that commercial oil and gas potential within these areas—given current technology and scientific understanding—is limited. The relatively limited quantity of federal land that has actually been leased for oil and gas activity makes insight into the resource potential across this significant federal footprint incomplete at best. In fact, in 2012, the total leased acreage of nearly 38 million acres was just 5.9% of the 640 million acres administered by the BLM.[31] Without more active exploration activity, no one possesses the data necessary to accurately assess the total resource potential on federal lands.

30 Congressional Research Center, Federal Land Ownership: Overview and Data, (February 2012).

31 http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html

Additionally, given the significant resources that are already identified and accessible on state and private lands, there remains a great deal of uncertainty around the willingness of operators to navigate the complexities of the regulatory structures that govern oil and gas activities on federal lands in an effort to answer this critical question. As a consequence, our Base Case assessment of the unconventional energy resources available and the corresponding economic contributions presented in this study focus on opportunities on non-federal lands.

Federal Lands Under Lease As of the Last Day of the Fiscal Year (FY)



Source: Public Lands Statistics

In conclusion, the resource potential and economic contributions identified here are not inclusive of, nor do they offer insight into, the question of the resource base potential and corresponding economic opportunities associated with federal lands.

Economic Contribution Assessment– Base Case

Approach and Methodology

This section focuses on measuring the economic contributions that come from increased investments and activity in what we call the unconventional energy value chain and energy-related chemicals. The objective in this section is to fully capture the unconventional energy infrastructure's influence on the US economy through its supply-chain and its effects on workers' incomes in the targeted sectors. To capture these effects, the results of the production and capital expenditure analyses discussed in the previous section (and in the first volume in this series for upstream activity) were integrated into our modeling system.

Defining the Economic Contribution

The steps used to derive the economic contribution of any industry can be summarized as follows:

- Any dollar of industrial expenditure, in this case the capital expenditure and operating expenditure (represented by value of production) associated with the entire unconventional oil and gas value chain and energy-related chemicals, results in direct benefits to the economy.
- These expenditures also result in indirect effects on final demand. In theory, an increase in activity associated with the unconventional oil and gas value chain and energy-related chemicals, with all else constant, would lead to more revenue and output among supplier industries, such as machinery and engineering services. This increase would also result in higher US demand for manufactured products such as pumps and compressors, which in turn require more fabricated metal and steel. These are a few of the numerous reverberations in the supply chain resulting from the change in target activities and sectors.

Participants in the unconventional oil and gas value chain and in related chemicals industries use many different products and services. As a result, a change in the level of activity would result in both a direct contribution (through production and capital expenditures) and an indirect contribution (via supply-chain dynamics) across a broad spectrum of sectors. The contribution of these first-tier supply chain industries in turn has implications for each supplier industry's own supply chains, magnifying the indirect contribution.

The following explains the net effects on the US economy and its industrial sectors. These economic contributions are divided into three types: **direct**, **indirect**, and **induced**.

- The **direct contribution** is the effect of the core industry's output, employment, and income. For example, unconventional oil and natural gas direct contributions in midstream processes, downstream elements, and energy-related chemicals are generated by increased capital expenditures and production. These activities result in a direct contribution of the target activities.
- Any changes in the purchasing patterns of the target industry initiate **indirect contributions** to all of the supplier industries that support the industry's activities. Changes in demand from the direct industries lead to corresponding changes in output, employment, and labor income throughout their supply chains and via inter-industry linkages. The affected supplier activities span the majority of US industries.
- Finally, workers and their families in both the direct and indirect industries spend their incomes on food, housing, leisure, autos, household appliances, furniture, clothing, and other consumer items. The additional output, employment, and labor income effects that result from their consumer spending activities are categorized as the **induced economic contribution**.

For each stage in this analysis, the economic contribution is quantified in terms of employment, value added contributions to gross domestic product (GDP), and labor income. Separately, estimates of the entire unconventional energy value chain's contributions to federal, state, and local tax revenues are also calculated.

Underlying Assumptions

The data and assumptions required to assess the economic contribution are the expected capital expenditures of midstream and downstream energy and energy-related chemicals and the increased value of energy-related chemicals production.

IHS Energy researched the capital requirements necessary to support unconventional oil and natural gas activity. The midstream elements consist of natural gas, natural gas liquids (NGL), and oil pipelines and storage, while the downstream elements include natural gas processing plants, liquefied petroleum gas (LPG) and NGL processing, and refineries. Capacity requirements for these activities are largely a function of peak upstream production, which will occur in the front half of the forecast period (by 2019). From then on, additional capacity requirements will increase, though at a slower rate, through 2025. Cumulative midstream and downstream energy capital spending over the forecast period is expected to exceed $216 billion and is detailed in the following table.

Detailed Midstream and Downstream Energy Incremental Capital Expenditures: United States

(Current $M)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2012-25
LNG Processing	**502**	**3,236**	**5,533**	**8,449**	**6,211**	**3,471**	**3,119**	**2,421**	**1,279**	**685**	**651**	**618**	**587**	**558**	**37,319**
NG Processing	**6,291**	**5,425**	**4,185**	**2,583**	**2,131**	**1,984**	**1,025**	**879**	**835**	**793**	**753**	**716**	**680**	**646**	**28,925**
NG Logistics	**8,871**	**9,148**	**7,222**	**5,084**	**3,069**	**4,295**	**5,065**	**3,545**	**2,244**	**3,608**	**3,560**	**4,045**	**3,994**	**2,315**	**66,065**
NGL and LPG	**8,017**	**7,341**	**4,395**	**2,158**	**1,871**	**1,690**	**1,460**	**1,253**	**1,110**	**1,051**	**994**	**939**	**887**	**843**	**34,010**
Processing	3,510	3,912	2,109	928	835	742	649	557	529	502	477	453	431	409	16,046
Pipelines	4,120	2,919	1,947	916	792	704	616	528	502	476	453	430	409	388	15,200
Other	386	510	339	314	244	244	195	169	80	72	64	56	48	45	2,764
Crude Oil Processing	**107**	**671**	**1,496**	**1,883**	**1,591**	**780**	**697**	**321**	**289**	**257**	**225**	**193**	**183**	**174**	**8,865**
Crude Oil	**4,589**	**6,298**	**6,931**	**5,100**	**2,175**	**1,912**	**1,333**	**1,145**	**997**	**878**	**759**	**715**	**672**	**638**	**34,142**
Pipelines	4,057	5,285	6,138	4,272	1,322	1,264	1,054	948	843	738	632	601	571	542	28,267
Rail	402	623	241	211	170	95	84	63	42	40	38	36	34	33	2,112
Marine	130	390	553	618	683	553	195	134	111	100	89	78	67	64	3,763
Crude Oil & RP Storage	**610**	**1,293**	**1,341**	**860**	**567**	**723**	**479**	**374**	**210**	**168**	**126**	**120**	**114**	**108**	**7,091**
Total CapEx	**28,987**	**33,412**	**31,102**	**26,117**	**17,615**	**14,855**	**13,179**	**9,938**	**6,963**	**7,439**	**7,068**	**7,345**	**7,117**	**5,282**	**216,418**

NOTE: Numbers may not sum due to rounding.

Source: IHS Energy

For affected sectors of the chemical industry, IHS Chemical has estimated the capacity expansion and production increases being driven by the unconventional oil and gas revolution. All of the announced and expected plant expansions are compiled at the state level and divided into four census regions—Northeast, South, Southeast, and West—and then consolidated at the national level. Expected production increases are provided for nine categories of chemicals: acrylics, nitrogen fertilizers, chlor-alkali, olefins, polyolefins, vinyls chain, glycols chain, methanol chain, and aromatics chain.

Between 2012 and 2025, the total value of energy-related chemicals production is expected to exceed $505 billion. Capital spending is provided in detail, by types of equipment and structures. The cumulative capital expenditures over the forecast horizon are expected to reach more than $129 billion.

Energy-Related Chemicals Value of Production and Capital Expenditures: United States

(Current $M)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2012-25
Value of Production															
Acrylics	114	116	117	329	540	631	720	732	744	995	1,254	1,479	1,505	1,531	10,807
Nitrogen Fertilizers	333	526	686	697	2,128	3,641	4,838	4,919	5,003	5,981	6,087	6,194	6,302	6,411	53,747
Chlor-alkali	386	773	1,406	1,428	1,451	1,475	1,500	1,525	1,551	1,578	1,606	1,635	1,663	2,094	20,072
Olefins	28	203	302	436	802	1,256	1,738	2,661	3,720	4,019	5,194	5,285	5,455	5,890	36,990
Polyolefins	174	214	329	1,469	5,260	12,681	18,876	21,623	24,221	27,745	31,429	31,980	33,579	34,875	244,455
Vinyls Chain	112	114	146	705	1,176	2,043	2,540	3,792	4,706	5,610	6,554	6,669	7,759	7,969	49,893
Glycols Chain	378	384	688	731	743	2,525	2,600	2,693	3,648	4,068	4,140	4,212	4,286	4,360	35,457
Methanol Chain	170	435	1,179	1,914	2,782	4,104	4,174	4,824	5,041	5,264	5,358	5,452	6,122	6,524	53,342
Aromatics Chain	0	0	0	0	0	15	57	58	59	60	61	62	106	108	587
Total Value of Production	**1,695**	**2,765**	**4,854**	**7,709**	**14,883**	**28,371**	**37,042**	**42,827**	**48,694**	**55,320**	**61,683**	**62,968**	**66,777**	**69,761**	**505,350**
Total CapEx	**4,818**	**5,618**	**8,149**	**12,787**	**16,493**	**15,711**	**11,902**	**10,252**	**9,408**	**6,994**	**5,233**	**6,157**	**8,355**	**7,427**	**129,305**

Source: IHS Chemical

Methodology

As discussed previously in this report, unconventional oil and natural gas and energy-related chemicals production and their associated capital expenditures reflect market forces that take into account supply and demand conditions and market-clearing prices. Teams of analysts from IHS Energy, IHS Chemical, and IHS Economics collaborated to develop a number of "profiles."

For the unconventional upstream oil and gas value chain, one set of IHS profiles projected the total number of wells to be drilled and the expected production and capital expenditures during each year of the forecast horizon. A second set of profiles aggregated announced and expected projects in the midstream and downstream energy value chain, summarizing anticipated annual expenditures on processes including gas processing plants, natural gas liquids (NGL) and liquefied petroleum gas (LPG) processing and pipelines, LNG exports, natural gas pipelines, crude oil transportation (pipelines, rail, marine), refineries, and storage. A third set of profiles included the chemical industry's annual expenditures on infrastructure and any expected changes to production during each year of the forecast. Included is a summary of anticipated annual capital expenditures on raw and intermediate materials, final equipment, and supporting labor. By incorporating the timing of changes in production levels and in various classes of capital expenditures, we obtained a nuanced set of "bottom-up" production and capital spending assumptions associated with the unconventional oil and gas value chain and energy-related chemicals.

IHS Economics utilized the IMPLAN model to evaluate changes in these activities within the context of a comprehensive, linked industrial structure of the economy. To capture tailored capital expenditures, we decided not to enter data in the standard, aggregate categories of the IMPLAN model (e.g., drilling). Using our proprietary industry data and analyses, IHS instead focused on the unique mix of equipment, materials, and services to create a customized set of industry activities within the IMPLAN model. In this manner, IHS Economics worked in concert with our industry experts to develop modified production functions for the entire unconventional oil and gas value chain and energy-related chemicals, reflecting the unique purchasing and investment characteristics of each subsector. The capital expenditure profiles were used to compile customized technology requirements for each relevant activity. The process transformed the following subcategories of capital expenditures into a set of sector-level transactions for commodities and services that serves as inputs to the IMPLAN model.

This approach provides more accurate estimates of capital expenditures for upstream, midstream, and downstream energy and chemicals, which were then used as inputs to the IMPLAN model. For example, the requirements for upstream energy are comprised of steel, rigs, rig labor, cement, pipelines, machinery, and fabrication, while the chemicals category is comprised of instrumentation and electrical, engineering and project management, skilled and unskilled labor, insulation, paint, and piping. Similarly, each capital expenditure category was examined in detail to designate the best corresponding industry categories of the model (Appendix A contains more details).

Components of Unconventional Oil and Natural Gas and Energy-Related Chemical Expenditures

Upstream Energy	Midstream and Downstream Energy	Energy-Related Chemicals
Steel	Steel	Instrumentation and electrical
Rigs	Equipment (rotating, heat exchangers, etc)	Engineering and project management
Rig labor	Engineering and management	Skilled labor
Cement	Labor	Unskilled labor
Pipelines	Electrical	Concrete
Machinery	Construction and civil	Construction equipment
Fabrication		Insulation
		Paint
		Piping
		Structural steel

Source: IHS Energy

The IMPLAN model quantified the direct and indirect contributions of the unconventional oil and gas value chain and chemicals. The direct and indirect contributions, when combined, represent all of the production, marketing, and sales activities required to bring primary products to the marketplace in a consumable form. IMPLAN's input-output framework allows one to enter direct contributions, by industry, in order to analyze and quantify direct and indirect contributions. The sum of all contributions relative to the total size of the economy provides initial benchmark estimates to evaluate the importance of a given industry.

The induced economic contributions represent changes in consumer spending when incomes are altered. Induced contributions tend to be dynamic and react to shifts in consumer sentiment and employment outlooks. For this study, IHS Economics utilized its US Macroeconomic Model (Macro Model) to enhance IMPLAN's standard methodology of measuring the induced economic contributions. The Macro Model's dynamic equilibrium modeling methodology provides a more robust determination of the induced economic contributions than could be obtained from IMPLAN's static modeling approach.

IHS Economics established an algorithm that links IMPLAN's and the Macro Model's direct and indirect contributions. Both models were run using the initial set of input assumptions to produce direct and indirect contributions. The results were evaluated, and both the IMPLAN and Macro Model were refined, calibrated and run again in an iterative fashion, repeating the refinement and calibration process, until IMPLAN's and the Macro Model's direct and indirect contributions were consistent. Finally, the Macro Model was solved endogenously to produce the total economic contributions from the unconventional oil and natural gas revolution. The difference between the Macro Model and IMPLAN results (direct plus indirect) represents the expenditure-induced contributions of value added, labor income, and employment.

Measuring the Economic Contributions—Base Case

A baseline macroeconomic forecast of the US economy was used to evaluate and assess the contribution of the unconventional oil and gas value chain and energy-related chemicals over a 14-year forecast period, 2012-2025. The US economy is resilient and can adjust to a long-run state of full equilibrium. Hence, any contributions, policy changes, and external shocks will initially change the economic state, with a longer-term convergence to the Macroeconomic baseline. In other words, the economic ripples that result from a one-time shock this year, such as a federal stimulus program or natural disaster, will dissipate over the longer term as the US economy returns to its equilibrium state.

In our previous report, we analyzed and presented the economic, employment, and fiscal contributions of upstream unconventional oil and natural gas activity. Building on that, this report focuses on midstream and downstream energy and energy-related chemicals. While midstream and downstream energy activities were analyzed in a combined fashion, energy-related chemicals, whose structure is significantly different, was analyzed separately.

US Lower 48 Economic Contribution Summary due to the Unconventional Activity Value Chain: Base Case*

Employment (Number of workers)	2012	2015	2020	2025
Upstream Energy Activity	1,748,604	2,510,663	2,985,168	3,498,678
Midstream and Downstream Energy Activity	323,648	228,832	73,530	56,989
Energy-Related Chemicals Activity	53,252	148,722	277,356	318,748
Total Activity	**2,125,504**	**2,888,218**	**3,336,055**	**3,874,415**
Value Added (2012 $M)				
Upstream Energy Activity	237,684	349,533	416,551	474,985
Midstream and Downstream Energy Activity	39,327	27,991	8,927	6,857
Energy-Related Chemicals Activity	6,766	19,475	42,949	51,041
Total Activity	**283,777**	**396,999**	**468,427**	**532,884**
Labor Income (2012 $M)				
Upstream Energy Activity	124,541	180,770	215,132	248,957
Midstream and Downstream Energy Activity	21,107	15,040	4,795	3,682
Energy-Related Chemicals Activity	3,763	10,692	22,181	26,078
Total Activity	**149,411**	**206,502**	**242,108**	**278,717**

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

In contrast to upstream energy activity, the economic contribution of midstream and downstream energy is more heavily weighted in the early years of the forecast period when the investments in capacity and efficiency are made.

- **Employment:** In 2012, almost 324,000 jobs were associated with midstream and downstream energy activity. This decreases to almost 229,000 jobs in 2015, and falls to just below 57,000 jobs in 2025, the end of the forecast period.
- **Value Added to GDP:** Midstream and downstream energy value added and labor income will follow a similar path, with value added decreasing from over $39 billion in 2012 to just under $7 billion in 2025.
- **Labor income:** Labor income is expected to decrease from just over $21 billion in 2012 to under $4 billion in 2025.

As already discussed, expansions in midstream and downstream capacity peak in the early years as the industry builds pipeline and other facilities to meet its growing requirements. Expansions of midstream and downstream capacity peak in 2013 at $33 billion but continue at a high level of investment until 2015. Beginning in 2016, expansion is expected to start declining as the appropriate level of infrastructure is finally in place to address production. The curtailing of infrastructure investment will be accompanied by a slowdown in employment contributions. As the infrastructure build-out is completed, the raw materials, supply chain and services purchases required for construction—and the jobs supported by those purchases—will diminish.

In contrast, the economic contribution of energy-related chemicals is expected to grow over the entire forecast period, as early capital investments are leveraged to increase chemical production later in the forecast period. The path of capacity expansion for energy-related chemicals is also somewhat different. During the period 2012-2016, investment will trend upwards, as capacity is dramatically expanded to take advantage of low natural gas feedstock prices. Beginning in 2016, investment will moderate and capacity additions will be incremental. This approach will allow the industry to proactively sequence capacity to support continually rising levels of production throughout the forecast period, which will peak in 2025.

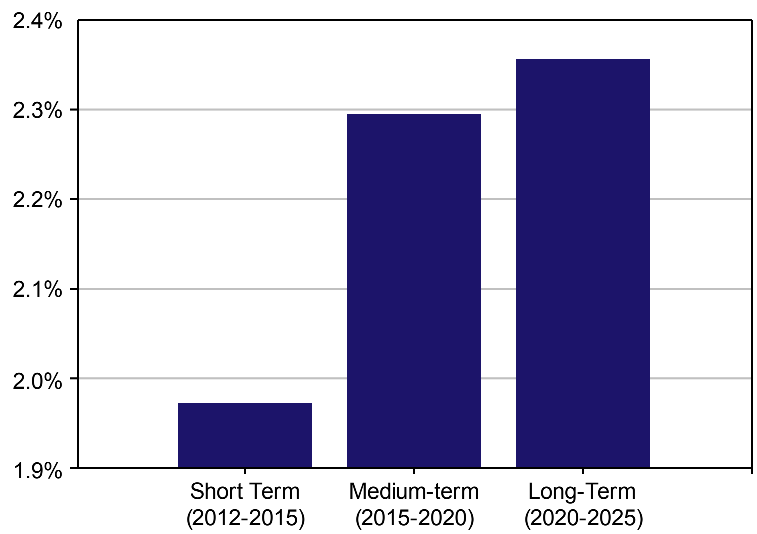
Investment in more capacity will enable the primary force driving economic activity—increases in chemicals production—to make larger contributions to GDP and employment. The transition from expanding capacity to ramping up production will result in a dramatic upward shift in economic contribution, which is detailed here:

- **Employment:** In 2012, employment in energy-related chemicals was more than 53,000 jobs; that will grow to almost 319,000 jobs by the end of the forecast period in 2025.
- **Value Added to GDP:** Energy-related chemicals value added will increase from nearly $6.8 billion in 2012 to just over $51 billion in 2025.
- **Labor Income**: Energy-related chemicals labor income will increase from nearly $3.8 billion in 2012 to just over $26 billion in 2025.

Employment Contribution—Base Case

IHS Economics estimates that the employment contribution from the entire unconventional oil and gas value chain and energy-related chemicals will exceed 2.1 million US jobs in 2012. By 2015, the resulting employment is expected to increase to almost 2.9 million jobs, and by 2025, to 3.9 million jobs.

Unconventional Oil and Natural Gas and Energy-Related Chemical Contribution to Employment



Source: IHS Economics

Midstream and downstream energy activity is already making massive contributions—together they created nearly 324,000 US jobs in 2012 alone—in order to connect the resource base with end-users. By 2015, as the necessary infrastructure is built-out and capital expenditures begin to decrease, employment will decrease to about 229,000, and, by 2025, to only 57,000 jobs. This downward trend over the course of the forecast period reflects infrastructure investment and completion in the near-term that will support production capacity in later years.

The employment contribution of energy-related chemicals in the short and intermediate term will mainly be due to capital expenditures for capacity expansion. During this period, the employment contribution of this sector will nearly triple from over 53,000 in 2012 to slightly less than 149,000 jobs in 2015. In the longer term as capacity expansion begins to decline beginning in 2017, production activities will become the dominate source of economic contribution from energy-related chemical activity. The continually increasing domestic production of the sector will lead to a contribution of almost 319,000 jobs throughout the US economy in 2025.

IHS Economics estimates that the employment contribution by the unconventional oil and gas value chain and energy-related chemicals, as a share of total US employment, will average 1.97% over the short-term (2012-2015), 2.27% over the intermediate term (2015-2020), and 2.36% over the long-term (2020-2025).

US Lower 48 Employment Contribution due to the Unconventional Activity Value Chain: Base Case*

(Number of workers)

2012	Direct	Indirect	Induced	Total
Upstream Energy Activity	360,456	537,663	850,485	1,748,604
Midstream and Downstream Energy Activity	116,342	86,108	121,198	323,648
Energy-Related Chemicals Activity	17,310	16,002	19,941	53,252
Total Activity	**494,108**	**639,772**	**991,624**	**2,125,504**
2015				
Upstream Energy Activity	505,895	770,441	1,234,327	2,510,663
Midstream and Downstream Energy Activity	81,581	61,298	85,954	228,832
Energy-Related Chemicals Activity	45,697	46,324	56,701	148,722
Total Activity	**633,173**	**878,063**	**1,376,982**	**2,888,218**
2020				
Upstream Energy Activity	600,420	915,788	1,468,960	2,985,168
Midstream and Downstream Energy Activity	26,386	19,636	27,509	73,530
Energy-Related Chemicals Activity	58,110	101,682	117,564	277,356
Total Activity	**684,915**	**1,037,106**	**1,614,033**	**3,336,055**
2025				
Upstream Energy Activity	724,379	1,074,155	1,700,144	3,498,678
Midstream and Downstream Energy Activity	20,611	15,161	21,216	56,989
Energy-Related Chemicals Activity	60,391	120,330	138,027	318,748
Total Activity	**805,381**	**1,209,647**	**1,859,388**	**3,874,415**

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

Manufacturing Employment Contribution

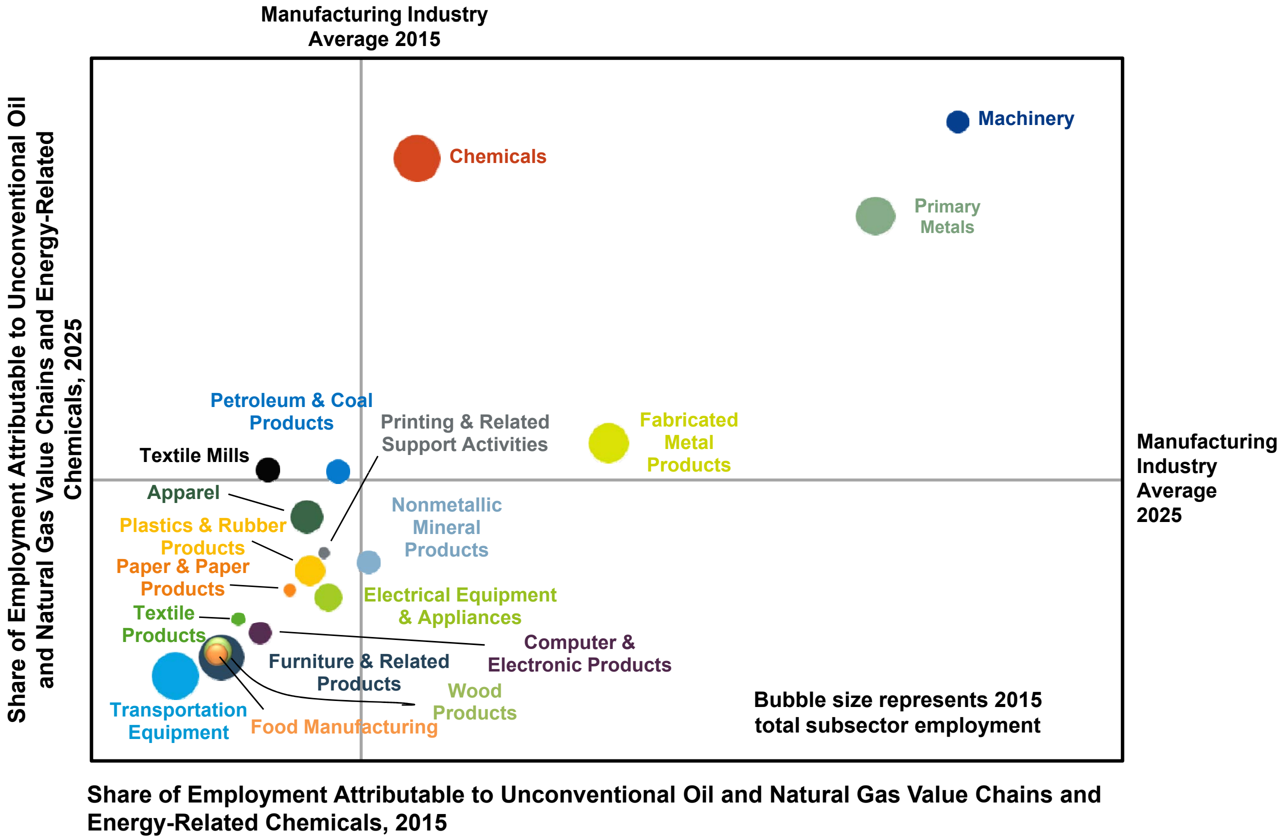
Over the entire forecast period, IHS estimates that one out of every eight US jobs supported by unconventional oil and natural gas development will be in manufacturing. However, its significance for manufacturing goes much deeper than that. Based on our analysis, IHS finds that manufacturing will become increasingly reliant on unconventional development as a primary way to create and sustain jobs. By 2015, 3.2% of all US manufacturing jobs will be linked to unconventional development. By 2025, this share will jump to 4.2%. This means that unconventional development will support close to 400,000 manufacturing jobs in 2015 and just over 500,000 in 2025.

The following graphic captures how much employment is attributable to the unconventional oil and natural gas value chains and energy-related chemicals for 19 manufacturing industries. By comparison, the average share of manufacturing employment due to the unconventional oil and natural gas value chains and energy-related chemicals in 2015 and 2025 is 3.2% and 4.2%, respectively.

The graphic can be interpreted as follows:

- A circle represents each industry affected by the unconventional oil and natural gas revolution.
- The size of each circle represents the size of each industry's total employment.
- The horizontal axis shows the full unconventional value chain's contribution to employment in 2015. Industries with above-average shares of their total employment attributable to unconventional oil and natural gas activity (greater than 3.2%) are in the right quadrants of the graph; those with below-average are in the left quadrants.
- The vertical axis shows this share of employment in 2025, with above-average employment (greater than 4.2%) in the upper quadrants, and below average in the lower quadrants.

Share of Employment Attributable to Unconventional Oil and Natural Gas Value Chains and Energy-Related Chemicals: Selected Manufacturing Industries



Source: IHS Economics

The graphic identifies four standout industries—located in the upper right quadrant—that will experience above-average shares of their total employment throughout the forecast period attributable to the unconventional oil and gas revolution: chemicals, fabricated metal products, primary metals, and machinery. This employment share within the chemicals industry will accelerate as capacity is added and some production returns to the United States to take advantage of lower prices for natural gas feedstock. Employment in the remaining three industries in the upper right quadrant will be stimulated by their roles as major suppliers to the unconventional sector. The subsequently higher capacity utilization will keep proportional employment above the overall manufacturing sector average during the forecast period. In addition, all four industries will enjoy improved cost structures from lower energy prices. The resulting improvement in capacity utilization will hold the share of employment above that of the overall manufacturing sector average during the forecast period.

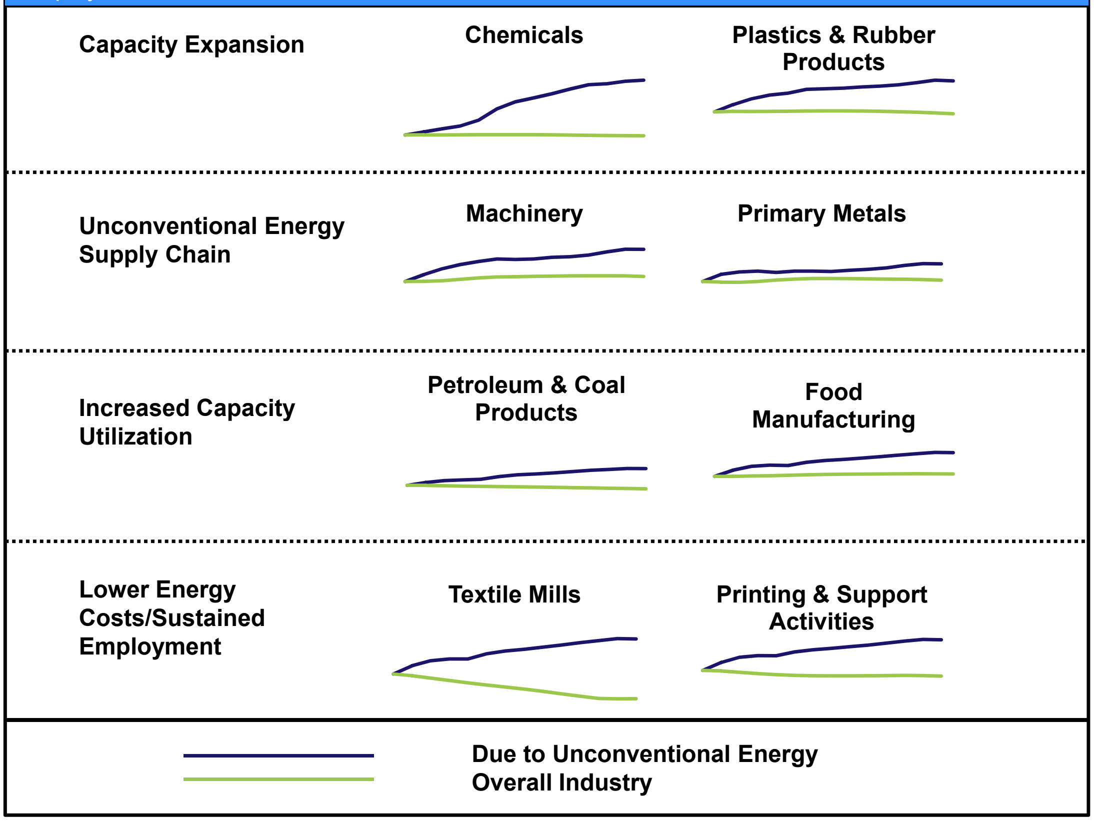
At first glance, unconventional energy appears to have little impact on employment in the industries located in the lower left quadrant of the graphic. However, these industries will benefit in one very important way: while the emergence of unconventional energy may not reverse the trend of contracting employment in these industries, it will slow that contraction and preserve jobs in these industries. At the same time, as explained in the previous chapter, production is expected to increase, which will translate to productivity gains for US manufacturers.

The table below distills unconventional energy's primary employment contribution through four broad mechanisms. The categories are:

- **Increased Production Capacity:** Employment levels will increase due to expansions in domestic production capacity. In addition to the chemicals industry, the US plastics industry is also expected to add capacity. Many of the industries that will expand production capacity use natural gas as a feedstock. Lower natural gas prices provide an incentive to add domestic production capacity.
- **Increased Capacity Utilization within Direct Industries:** Industries that are significant direct suppliers to the unconventional energy sector will also increase their capacity utilization. The rapid expansion of energy infrastructure will stimulate demand for steel, oil and gas field machinery, pumps, and other goods. This in turn will absorb some of the slack in capacity utilization, which currently hovers at 75% in primary metals and 80% in machinery. The increase in demand will also bring moderate employment gains to these industries.
- **Increased Capacity Utilization within Indirect Industries:** The increase in direct spending within the manufacturing sector will start a ripple effect that will stimulate indirect demand in the extended supply chain and create induced consumer demand. This will result in increased capacity utilization and potentially modest employment gains in industries such as gasoline and food.
- **Improved Cost Structures via Lower Energy Prices:** Lower energy costs will allow some contracting industries, such as textile mills, to remain more competitive. This will slow the industry contraction and preserve jobs through the forecast horizon.

Primary Employment Contribution Mechanisms of Unconventional Oil and Natural Gas and Energy-Related Chemicals on Manufacturing Industries

Employment, Indexed to 2012 Levels: 2012-2025



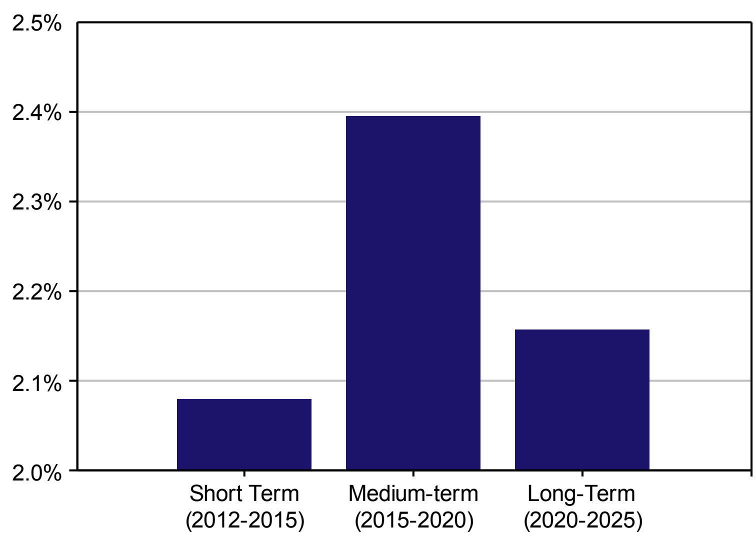
Source: IHS Economics

Value Added and Labor Income Contribution

Value added is the difference between the production costs of products or services and their sales prices. The constantly cited GDP measure is simply the sum of value added across all products and services produced in the United States. GDP is generally considered the broadest measure of the health of the US economy. The value-added contribution of unconventional energy and chemicals activity demonstrates the vital role they play in the US economy.

On a total direct, indirect, and induced basis, IHS expects the value added by the overall unconventional energy value chain and energy-related chemicals will amount to a 2.08% increase, on average, in the value of goods and

Unconventional Oil and Natural Gas and Energy-Related Chemicals Value Added Contribution to GDP



Source: IHS Economics

services produced over the short-term (2012-2015), 2.39% over the intermediate term (2015-2020), and 2.16% over the long-term (2020-2025).

We expect value added for the unconventional energy value chain and energy-related chemicals to grow faster than the rest of the economy through 2020. During the final six years of the forecast (2020-2025), IHS Economics' outlook for the US economy accelerates at the same time that much of the unconventional employment associated with the initial build-out dissipates. This slowing of growth is reflected in the chart, which shows that the value added contribution to overall GDP first increases in the 2015-2020 time frame and declines during 2020-2025.

Value added for the entire unconventional energy value chain and energy-related chemicals was more than $284 billion in 2012 and is expected to reach almost $397 billion by 2015. By 2025, value added, estimated at almost $533 billion, will be 31% higher than in 2015. However, the short-term gains from these activities are even more substantial: from 2012 to 2015, value added is expected to increase at a rate in excess of 5% per year.

US Lower 48 Value Added Contribution due to the Unconventional Activity Value Chain: Base Case*

(2012 $M)

2012	Direct	Indirect	Induced	Total
Upstream Energy Activity	96,700	67,171	73,813	237,684
Midstream and Downstream Energy Activity	11,768	12,405	15,153	39,327
Energy-Related Chemicals Activity	1,797	2,475	2,494	6,766
Total Activity	**110,265**	**82,051**	**91,461**	**283,777**
2015				
Upstream Energy Activity	145,281	97,142	107,110	349,533
Midstream and Downstream Energy Activity	8,406	8,838	10,747	27,991
Energy-Related Chemicals Activity	4,905	7,479	7,091	19,475
Total Activity	**158,592**	**113,459**	**124,948**	**396,999**
2020				
Upstream Energy Activity	173,492	115,591	127,469	416,551
Midstream and Downstream Energy Activity	2,659	2,828	3,439	8,927
Energy-Related Chemicals Activity	8,878	19,371	14,699	42,949
Total Activity	**185,029**	**137,790**	**145,607**	**468,427**
2025				
Upstream Energy Activity	193,230	134,195	147,559	474,985
Midstream and Downstream Energy Activity	2,025	2,180	2,653	6,857
Energy-Related Chemicals Activity	10,198	23,587	17,257	51,041
Total Activity	**205,452**	**159,962**	**167,469**	**532,884**

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

A common measure of the relative contribution of an industry to the larger economy is worker productivity, measured as the ratio of value added to employment. The higher worker productivity is, the more each worker contributes to GDP and the more efficient each worker is. In 2012, the average worker directly employed by the unconventional energy value chain and energy-related chemicals will contribute more than $223,000 to GDP. That is projected to increase steadily, to over $270,000 in 2020, reflecting a shift to more efficient and more valuable labor.

US Lower 48 Value Added Per Employee due to the Unconventional Activity Value Chain: Base Case*

(2012 $M)

2012	Direct	Indirect	Induced	Total
Upstream Energy Activity	268,273	124,931	86,789	135,928
Midstream and Downstream Energy Activity	101,148	144,067	125,031	121,510
Energy-Related Chemicals Activity	103,818	154,676	125,068	127,057
Total Activity	**223,160**	**128,250**	**92,233**	**133,510**
2015				
Upstream Energy Activity	287,176	126,087	86,776	139,219
Midstream and Downstream Energy Activity	103,038	144,176	125,032	122,319
Energy-Related Chemicals Activity	107,340	161,452	125,060	130,951
Total Activity	**250,472**	**129,215**	**90,740**	**137,455**
2020				
Upstream Energy Activity	288,951	126,220	86,775	139,540
Midstream and Downstream Energy Activity	100,790	144,020	125,032	121,404
Energy-Related Chemicals Activity	152,781	190,510	125,031	154,850
Total Activity	**270,149**	**132,860**	**90,213**	**140,413**
2025				
Upstream Energy Activity	266,753	124,931	86,792	135,761
Midstream and Downstream Energy Activity	98,235	143,785	125,031	120,329
Energy-Related Chemicals Activity	168,860	196,018	125,025	160,131
Total Activity	**255,100**	**132,239**	**90,067**	**137,539**

NOTES: Figures in the table are average ratios by category and are not intended to sum to the total.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

Workers' earnings from all unconventional energy and chemicals activity are estimated at almost $150 billion in 2012, $207 billion in 2015, and almost $269 billion in 2025.

US Lower 48 Labor Income Contribution due to the Unconventional Activity Value Chain: Base Case* (2012 $M)				
2012	**Direct**	**Indirect**	**Induced**	**Total**
Upstream Energy Activity	43,608	39,250	41,682	124,541
Midstream and Downstream Energy Activity	7,974	6,459	6,675	21,107
Energy-Related Chemicals Activity	1,371	1,294	1,099	3,763
Total Activity	**52,953**	**47,003**	**49,455**	**149,411**
2015				
Upstream Energy Activity	63,921	56,365	60,484	180,770
Midstream and Downstream Energy Activity	5,703	4,604	4,734	15,040
Energy-Related Chemicals Activity	3,731	3,837	3,124	10,692
Total Activity	**73,355**	**64,805**	**68,342**	**206,502**
2020				
Upstream Energy Activity	76,131	67,021	71,981	215,132
Midstream and Downstream Energy Activity	1,806	1,474	1,515	4,795
Energy-Related Chemicals Activity	6,361	9,345	6,475	22,181
Total Activity	**84,298**	**77,839**	**79,970**	**242,108**
2025				
Upstream Energy Activity	87,204	78,428	83,326	248,957
Midstream and Downstream Energy Activity	1,377	1,137	1,168	3,682
Energy-Related Chemicals Activity	7,207	11,270	7,601	26,078
Total Activity	**95,788**	**90,834**	**92,096**	**278,717**

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

On a direct basis, labor income for all unconventional energy and energy-related chemicals activity is estimated at more than $107,000 per employee in 2012. This increases to nearly $116,000 in 2015 and just over $123,000 in 2020, and then flattens out for the remainder of the forecast period.

US Lower 48 Labor Income Per Employee due to the Unconventional Activity Value Chain: Base Case*

(2012 $M)

2012	Direct	Indirect	Induced	Total
Upstream Energy Activity	120,981	73,002	49,010	71,223
Midstream and Downstream Energy Activity	68,538	75,010	55,073	65,217
Energy-Related Chemicals Activity	79,179	80,861	55,094	70,666
Total Activity	**107,168**	**73,469**	**49,873**	**70,294**
2015				
Upstream Energy Activity	126,352	73,159	49,002	72,001
Midstream and Downstream Energy Activity	69,904	75,101	55,074	65,726
Energy-Related Chemicals Activity	81,657	82,825	55,090	71,892
Total Activity	**115,853**	**73,804**	**49,631**	**71,498**
2020				
Upstream Energy Activity	126,796	73,184	49,001	72,067
Midstream and Downstream Energy Activity	68,449	75,046	55,074	65,207
Energy-Related Chemicals Activity	109,473	91,902	55,073	79,972
Total Activity	**123,079**	**75,054**	**49,547**	**72,573**
2025				
Upstream Energy Activity	120,384	73,014	49,011	71,157
Midstream and Downstream Energy Activity	66,816	74,972	55,073	64,614
Energy-Related Chemicals Activity	119,337	93,656	55,069	81,812
Total Activity	**118,935**	**75,092**	**49,530**	**71,938**

NOTES: Figures in the table are average ratios by category and are not intended to sum to the total.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

Government Revenues and Taxes

Increased activity in the entire unconventional energy value chain and energy-related chemicals will also increase the amount of federal, state, and local government taxes paid by energy producers and chemicals manufacturers, their employees, their extensive supply chains, and companies in ancillary industries. IHS estimates that annual government revenues from all unconventional energy and chemicals activity will increase from more than $74 billion in 2012 to more than $104 billion in 2015 and about $138 billion in 2025. Over the entire forecast period, government entities will collect more than $1.6 trillion as a result of the entire unconventional energy value chain and energy-related chemicals activity.

In addition, upstream oil and gas operators will pay $712 million in private lease payments in 2015 and over $1 billion in 2025. Over the entire forecast period, lease payments will total more than $11 billion. While private lease payments will have an income effect on the economy, royalties paid to the federal government will, in addition to the income effect, contribute to federal, state, and local budgets. State budgets will also benefit from direct federal payments based on each state's participation in production on federal lands. In fact, the more than $36 billion in state and local tax receipts in 2012 represent approximately 5% of the US lower 48 states' total expenditures of $647 billion and more than 45% of the estimated 2012 budget gaps of $75 billion.

Contribution to US Lower 48 Government Revenue due to the Unconventional Activity Value Chain: Base Case*

(2012 $M)

	2012	2015	2020	2025	2012-25**
Upstream Energy Activity* **					
Federal Taxes	28,903	42,132	50,167	55,620	644,286
Federal Royalty Payments	1,964	2,639	3,204	2,994	39,664
Federal Bonus Payments	148	167	150	138	2,139
State and Local Taxes	22,610	33,563	39,996	44,114	512,184
Severance Taxes	5,450	8,657	11,769	13,232	143,935
Ad Valorem Taxes	2,795	4,251	5,825	6,338	70,707
State Royalty Payments	715	1,050	1,359	1,443	16,767
State Bonus Payments	430	499	472	457	6,613
Total Government Revenue	**63,015**	**92,957**	**112,943**	**124,335**	**1,436,294**
Lease Payments to Private Landowners	504	712	915	1,103	11,696
Midstream and Downstream Energy Activity					
Federal Taxes	5,712	4,066	1,297	996	37,551
State and Local Taxes	4,038	2,771	871	669	25,582
Total Government Revenue	**9,750**	**6,837**	**2,168**	**1,665**	**63,133**
Energy-Related Chemicals Activity					
Federal Taxes	983	2,829	6,238	7,414	68,859
State and Local Taxes	695	1,928	4,191	4,981	46,350
Total Government Revenue	**1,677**	**4,757**	**10,429**	**12,395**	**115,209**
Total Activity					
Federal Taxes	35,598	49,026	57,702	64,030	750,696
Federal Royalty Payments	1,964	2,639	3,204	2,994	39,664
Federal Bonus Payments	148	167	150	138	2,139
State and Local Taxes	27,342	38,262	45,058	49,764	584,115
Severance Taxes	5,450	8,657	11,769	13,232	143,935
Ad Valorem Taxes	2,795	4,251	5,825	6,338	70,707
State Royalty Payments	715	1,050	1,359	1,443	16,767
State Bonus Payments	430	499	472	457	6,613
Total Government Revenue	**74,443**	**104,551**	**125,540**	**138,395**	**1,614,636**
Lease Payments to Private Landowners	504	712	915	1,103	11,696

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

**2012-2025 represents the total for all years including those years not reported.

***Federal royalty payments, federal bonus payments, and lease payments to private landowners only apply to the upstream energy activity where land is leased from private households for drilling.

Source: IHS Economics

The Macroeconomic Impact of Unconventional Oil and Gas

The previous section focused on quantifying the economic contribution—in terms of employment, value added to GDP, and labor income—of the entire unconventional energy value chain and energy-related chemical activities. The focus of this section is a broader assessment of the impact on the US economy that also incorporates energy pricing and trade effects in concert with the investment and production effects present in the Base Case.

This analysis is designed to also shed light on the benefits to the broader economy of higher unconventional oil and natural gas activity that result from the effects of lower prices and higher production and investment levels. But to put these impacts in a larger economic context, they are measured in terms of their *incremental* impacts on such indicators as GDP, industrial production, and trade—in other words, how much they add incrementally to these broad economic indicators.

Natural gas prices are and will continue to be substantially lower than they would have been if there had not been a revolution in unconventional oil and natural gas production. Lower prices boost disposable income, GDP and employment and are a positive force during this protracted period of economic uncertainty and very slow growth. These lower energy and feedstock costs will also lead to more investment, production, and employment by manufacturers, particularly in the chemicals and refining industries. Over the longer term, we expect a manufacturing renaissance that will lead to a compositional shift in the US economy, in concert with an improvement in its comparative global advantage.

Methodology

To isolate the incremental contributions, IHS constructed a counterfactual analysis in which we removed the unconventional activity and associated contributions from our baseline economic model. Measuring the difference in these contributions—with and without the unconventional activity—allowed us to quantify the contribution associated solely with the ongoing unconventional oil and natural gas revolution, which we refer to as the Base Case.

Three distinct first-order impacts—increased domestic energy production, lower natural gas prices, and increased energy investment—from the unconventional revolution were incorporated into the IHS models under a Base Case analysis of 21 major unconventional oil and natural gas plays. The following explains how IHS incorporated these impacts:

Additional domestic energy production was changed to reflect the increased investment and capacity expansion in the oil and natural gas industry.

The resulting lower natural gas prices estimated by IHS Energy were incorporated into the US Macroeconomic Model.

The increased upstream investments to expand capacity were incorporated into the US Macroeconomic Model as part of the overall investment outlook and then the model estimated investment changes in midstream and downstream energy, along with energy-related chemicals.

Again, these shocks allowed us to measure dynamically the *incremental* impacts of the unconventional oil and natural gas revolution on the US economy. The incremental changes analyzed include:

- Changes in industrial and consumer behavior following a reduction in prices and an increase in economic activity; and
- Changes in trade patterns for goods and services resulting from shifts in US comparative advantage.

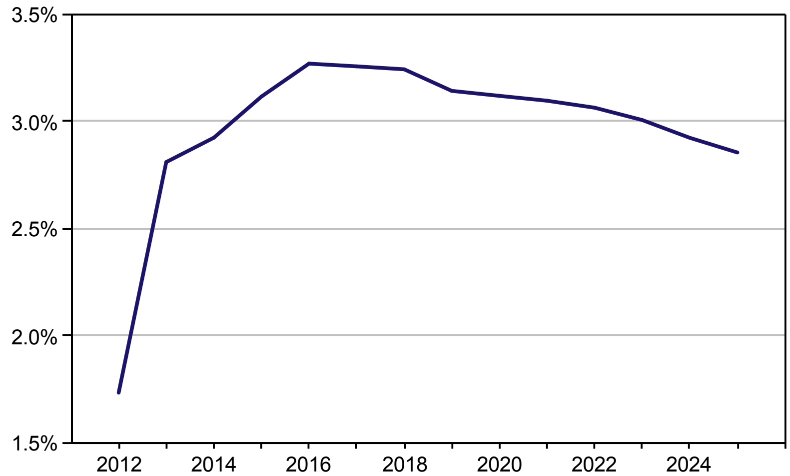
The IHS US Macroeconomic Model was then simulated a second time, removing the greater availability of energy at lower natural gas prices and removing the higher level of investment activity. This modeling framework allowed us to look at the impacts throughout the economy and how various actors change their behavior to take advantage of the new scenario.

Broad Impact on the Economy

At the macroeconomic level, we will present results of this analysis for four broad effects: the incremental impact on US gross domestic product (GDP), employment, trade, and household disposable income. This analysis is followed by an assessment of the impact on manufacturing industries, utilizing standard industrial production indexes as our metric.

The incremental boost from the full unconventional value chain—from upstream energy through energy-related chemicals—is expected to add 2% to 3.2% to the value of all goods and services produced in the United States. That impact is forecast to increase rapidly and will peak early in the forecast period, at 3.2% by 2016. In the context of a $13-15 trillion US economy, this translates to an increase in GDP of $500 to $600 billion in any given year over the forecast period. As the industry arrives at a new steady state of operations, the economy will absorb the shocks and will approach a new long-run equilibrium that is higher than it would have been without the benefits of unconventional energy.

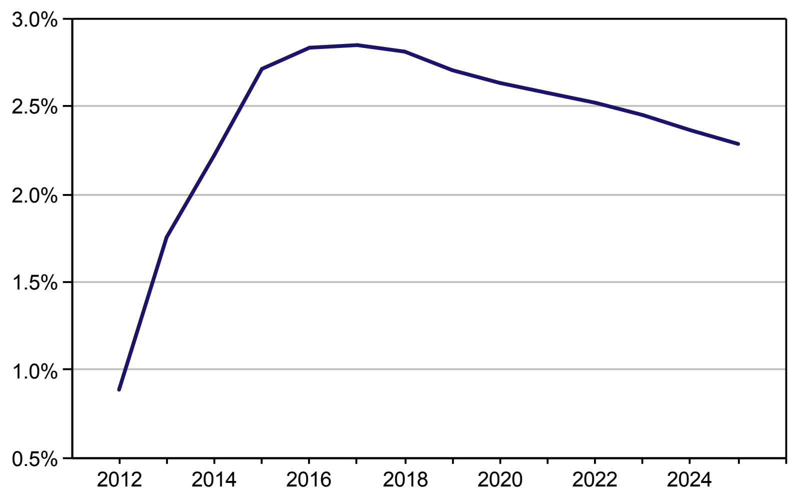
Change in Gross Domestic Product due to the Unconventional Activity Value Chain: Base Case*



Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

Change in Employment due to the Unconventional Activity Value Chain: Base Case*

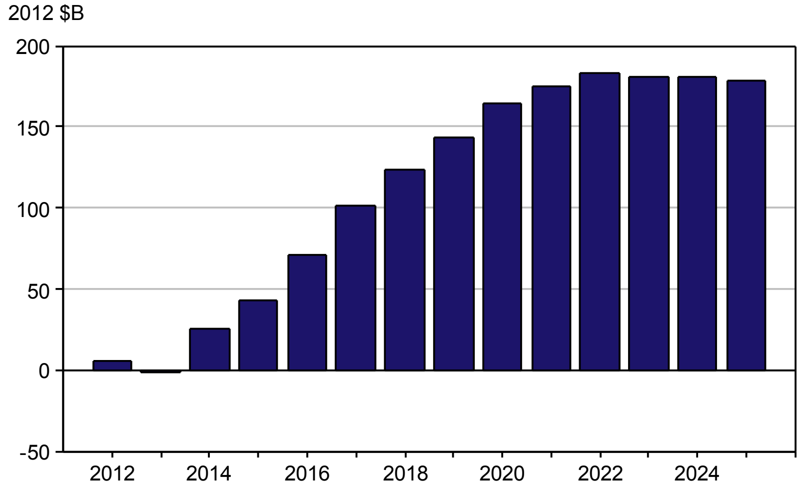


Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

The combination of lower energy prices and increased investment and domestic production benefit the labor market in a similar way: the gains are strongest in the early years of the analysis and moderate later in the forecast period to a new steady state that is consistently higher than what would exist without unconventional energy development in the United States. By 2025, nearly 4 million jobs will be supported by unconventional activity, which is consistent with the static analysis of total job gains previously presented in this report.

Change in Net Trade due to the Unconventional Activity Value Chain: Base Case*



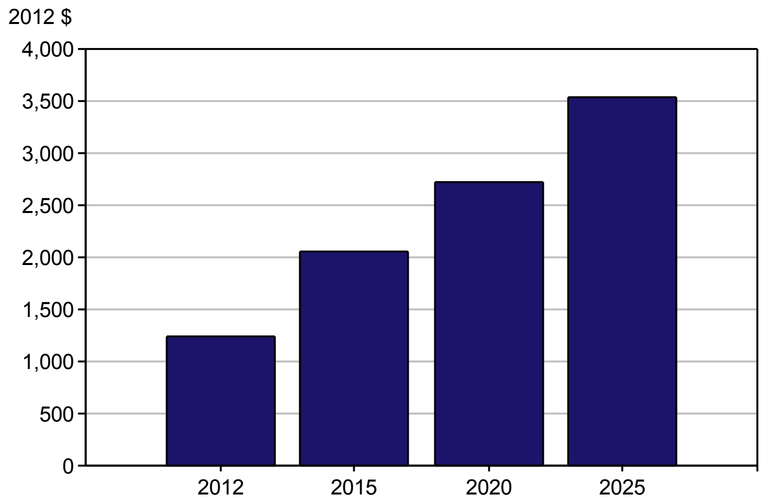
Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

The unconventional revolution will also substantially improve US net trade for several reasons. First, the increase in domestic energy production may allow the United States to export intermediate and refined energy products such as liquefied petroleum gases, liquefied natural gas, and refined petroleum products. Second, for energy products in which the United States is a large net importer, namely crude oil, increased domestic crude production reduces the volume of imported crude. Third, reduced energy costs, specifically for electricity and natural gas, improve the global competiveness of energy-intensive manufacturing industries.

This new competiveness in global markets may enable petroleum refiners to continue operating at high utilization rates, maintain employment and increase their contributions to GDP and government revenue. For example, the impact on US trade of the unconventional revolution will increase steadily through 2022 before plateauing at a new, higher level. In 2022 and beyond, the unconventional oil and natural gas revolution will mean $180 billion per year in additional real net trade relative to a US trade regime in which there is no unconventional activity.[32]

Change in Disposable Income per Household due to the Unconventional Activity Value Chain: Base Case*



Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

Finally—and most tangibly for American families—household disposable income will rise due to increased activity in the US unconventional oil and natural gas value chain and in energy-related chemicals. This is the cumulative impact of higher household wages and lower costs for energy and energy-intensive products. Specifically, these factors work through three primary avenues:

- Direct consumption costs are reduced as natural gas used to heat both homes and water becomes less expensive.
- Input costs for manufacturers of various consumer goods, including electricity prices, decline, reducing indirect costs for consumers.

32 Real net trade is defined as the real value (inflation-adjusted) of total exports less the real value of total imports.

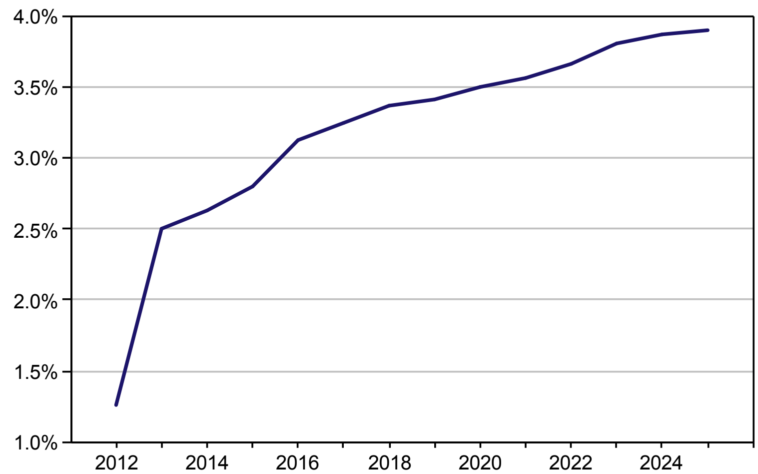
- Wages increase as the manufacturing renaissance increases industrial activity.

In 2012, the increase in real disposable income per household resulting from the unconventional oil and natural gas revolution was more than $1,200. With nearly 120 million households in the country, this equates to total annual gains to American households of $163 billion. These benefits are expected to grow continually throughout the entire forecast period: real disposable income per household will rise from just over $2,000 per household in 2015 to more than $3,500 in 2025.

Industrial Production Indices

The impact on the US industrial production index differs somewhat from the impact on other major macroeconomic indicators. Industrial production indices measure the growth of production volume in three basic aggregate industries: manufacturing, mining, and utilities. The index for manufacturing industries is disaggregated, and the detailed indices are included in the IHS US Macroeconomic Model.

Change in Industrial Production Index due to the Unconventional Activity Value Chain: Base Case*



Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

While growth in GDP and employment peak in the 2016-2017 time period, growth in US industrial production is unabated over the entire 2012-2025 forecast. Unconventional oil and natural gas development is projected to increase industrial production by 2.8% in 2015, by 3.5% in 2020, and by 3.9% in 2025.

The impact of the unconventional oil and gas revolution on the industrial production indices is captured in two ways. In the first-order impact, lower natural gas prices, increased energy investment and production, and implied lower electricity prices have direct positive ramifications for many manufacturing industries. Major industries that use energy feedstock or are intense energy users include non-durable goods manufacturers of organic chemicals, fertilizers, resins, and plastics, as well as durable goods manufacturers of primary and fabricated metals, machinery and some nonmetallic mineral products.

These impacts also have secondary effects (or second-order effects), which are captured across many manufacturing industries as the US economy continues to benefit from the unconventional energy revolution. This occurs when the first-order effects will feed through the economy to the supply chain, which in turn will have further ramifications (second-order effects) on the US economy through wages, income and prices. The dual effects of increased aggregate demand—for example, consumers spending some of their higher disposable incomes on US-made products—and reductions in imports are expected to bring new opportunities for domestic manufacturers. However, not all industries will experience large benefits from the unconventional revolution. For example, industries that are heavily import-dependent and not especially energy-intensive—textiles, apparel, consumer electronics, to name three—will not experience significant benefits from unconventional oil and natural gas development.

By contrasting the expected “lift” to certain US manufacturing sectors against historical growth rates of these select sectors, we can gain valuable insight into how they are expected to benefit from the unconventional energy revolution. Growth over the past two decades in most manufacturing sectors has been weak or even negative. With the exception of some sectors with an overarching global competitive advantage—pharmaceuticals, organic chemicals, computers and related products, transportation equipment, and miscellaneous durables—that have grown more than 1.2% over the past two decades, all other manufacturing sectors have shown sluggish growth. We do not foresee that the unconventional revolution will reverse the growth pattern for all US manufacturing sectors—in fact, many industries will continue on the same downward path through the remainder of the forecast horizon. However, the overall contribution from lower natural gas prices, increased energy activity, and the second-order economic impacts of the unconventional oil and gas revolution will improve the outlook of the manufacturing sectors.

Industrial Production Indices

Historical Performance and Forecasted Changes in the Unconventional Activity Value Chain on US Manufacturing Industries*

	% Contribution of the Base Case				Compound Annual Growth Rates		
	2012	2015	2020	2025	1995-2005	2005-2012	1995-2012
Total Industry	**1.3%**	**2.8%**	**3.5%**	**3.9%**	**3.4%**	**0.1%**	**2.0%**
Food Manufacturing (311)	0.6%	1.7%	1.6%	1.4%	1.4%	0.5%	1.0%
Beverage & Tobacco Product Manufacturing (312)	0.6%	1.2%	1.4%	1.2%	-0.5%	-1.6%	-1.0%
Textile Mills (313)	0.7%	2.0%	2.2%	2.3%	-2.9%	-6.1%	-4.2%
Textile Product Mills (314)	0.6%	2.2%	2.3%	2.4%	0.7%	-8.0%	-3.0%
Apparel Manufacturing (315)	0.1%	0.9%	0.1%	0.4%	-8.0%	-12.8%	-10.0%
Wood Product Manufacturing (321)	0.3%	1.4%	2.0%	1.7%	2.0%	-5.5%	-1.2%
Furniture and Related Product Manufacturing (337)	0.4%	2.2%	2.1%	2.2%	2.5%	-5.8%	-1.0%
Paper Manufacturing (322)	0.6%	2.8%	3.0%	3.4%	-0.9%	-2.4%	-1.5%
Printing Support Activities (323)	0.8%	1.5%	1.7%	2.0%	-0.4%	-3.5%	-1.7%
Petroleum and Coal Products Manufacturing (324)	1.0%	4.6%	5.8%	6.5%	1.8%	0.0%	1.1%
Chemical Manufacturing (325)	1.5%	3.6%	4.0%	4.3%	2.6%	-1.0%	1.1%
Basic Chemical Manufacturing (3251)	1.2%	3.7%	5.5%	7.2%	1.3%	-0.4%	0.6%
Basic Organic Chemical Manufacturing (32511A9)	1.5%	4.9%	7.1%	9.5%	1.6%	0.8%	1.3%
Basic Inorganic Chemical Manufacturing (32512T8)	0.8%	2.4%	3.9%	4.8%	0.8%	-2.9%	-0.8%
Resins & Synthetic Material Manufacturing (3252)	1.7%	4.4%	6.0%	8.1%	0.6%	-2.1%	-0.5%
Agricultural Chemical Manufacturing (3253)	1.2%	3.0%	6.9%	7.7%	-0.1%	-2.6%	-1.1%
Pharmaceutical and Medicine Manufacturing (3254)	0.8%	2.5%	2.4%	2.0%	5.1%	-1.8%	2.2%
Paints, Soaps, Toiletries & Misc. (3255T9)	1.8%	2.8%	3.4%	3.8%	1.9%	0.1%	1.1%
Plastics and Rubber Products Manufacturing (326)	1.5%	3.5%	4.1%	4.6%	1.9%	-2.3%	0.1%
Leather and Allied Product Manufacturing (316)	0.8%	1.2%	1.8%	2.1%	-5.7%	-2.8%	-4.5%
Nonmetallic Mineral Product Manufacturing (327)	1.2%	3.2%	3.5%	4.1%	2.0%	-4.7%	-0.8%
Glass and Glass Product Manufacturing (3272)	1.0%	3.0%	3.6%	4.1%	0.9%	-2.4%	-0.4%
Cement Manufacturing (32731)	0.9%	2.9%	3.4%	3.7%	2.7%	-8.1%	-1.9%
Concrete & Product Manufacturing (32732T9)	1.2%	4.2%	4.4%	4.7%	3.6%	-6.3%	-0.6%
Clay, Lime, Gypsum & Misc. (3271A4A9)	1.1%	3.4%	3.8%	4.3%	1.2%	-3.1%	-0.6%
Primary Metal Manufacturing (331)	1.8%	3.3%	5.1%	5.9%	0.0%	0.6%	0.2%
Iron & Steel Product Manufacturing (3311A2)	2.2%	3.7%	6.7%	7.4%	0.1%	1.0%	0.5%
Nonferrous Metal Manufacturing (3313A4)	1.1%	3.1%	3.6%	4.1%	-0.3%	1.8%	0.6%
Alumina & Aluminum Products Manufacturing (3313)	1.0%	3.0%	3.4%	4.2%	0.9%	-0.7%	0.2%
Nonferrous exc. Aluminum Manufacturing (3314)	1.2%	3.2%	3.8%	3.9%	-1.6%	4.1%	0.7%
Foundries Manufacturing (3315)	0.4%	2.0%	2.4%	2.6%	0.4%	-2.4%	-0.8%
Fabricated Metal Product Manufacturing (332)	1.4%	2.8%	3.2%	4.8%	1.0%	0.1%	0.6%
Machinery Manufacturing (333)	0.4%	2.8%	3.3%	4.0%	0.8%	1.6%	1.1%
Computer and Electronic Product Manufacturing (334)	0.4%	1.9%	2.0%	1.7%	18.5%	7.8%	14.0%
Elec. Eq., Appliances, & Components Manufacturing (335)	0.1%	1.7%	1.7%	1.3%	-0.1%	-1.4%	-0.6%
Transportation Equipment Manufacturing (336)	0.4%	1.3%	2.1%	2.3%	2.5%	1.1%	1.9%
Miscellaneous Manufacturing (339)	0.3%	2.0%	1.6%	1.8%	3.5%	0.6%	2.3%

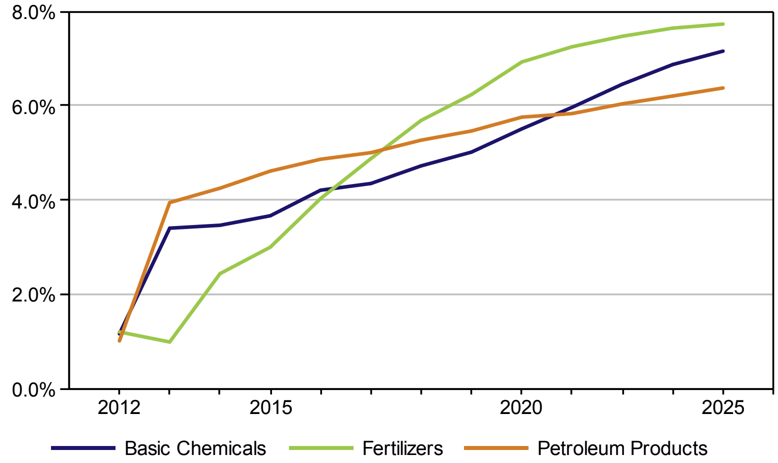
NOTES: Industries expected to realize the largest improvement in output due to the unconventional activity value chain are highlighted

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

The expected contribution from the revolution in unconventional energy varies across individual manufacturing industries. The degree and pattern of contributions in each sector depend on a few key factors, including their direct participation in unconventional energy (e.g., petroleum refining, organic chemicals, and fertilizer); their direct participation in upstream activity (e.g., primary, fabricated metals, and machinery); and their indirect participation in the supply chain. Second-order and income impacts on consumer-related sectors are also important (e.g., consumer electronics and food).

Change in Selected Non Durable Industrial Production Indices due to the Unconventional Activity Value Chain: Base Case*



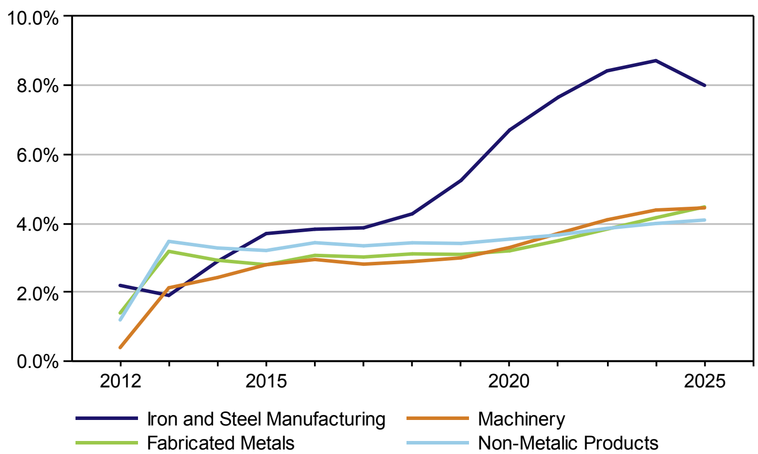
Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

The non-durable manufacturing sectors that use natural gas as feedstock are expected to benefit most from the unconventional revolution. Continued lower prices for natural gas will create opportunities to expand chemical and petroleum refining capacity and to increase production. The chart below shows the percent that the unconventional revolution will contribute to the production outlook of the basic chemicals, fertilizers, and petroleum products sectors. All three sectors' production indices were 1% higher in 2012 and are expected to be 6-8% higher in 2025.

Durable manufacturing industries are experiencing different trends. The iron and steel, fabricated metals, and machinery industries will benefit directly from increases in upstream investment activity. Some of the nonmetallic mineral products industries (e.g., glass and cement) will also benefit from lower electricity prices in their production process.

Change in Selected Durable Industrial Production Indices due to the Unconventional Activity Value Chain: Base Case*



Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

In addition to the direct impact on manufacturing, greater activity in the supply chain and the second-order economic impacts will contribute to a broader set of manufacturing sectors.

This section of the analysis assessed the economic impact that unconventional oil and natural gas activities are having on the US economy and on specific manufacturing sectors. Natural gas prices are and will continue to be substantially lower than they would have been without the unconventional revolution, generating positive immediate and medium-term contributions to GDP, employment, and real disposable income. These positive forces are reinforcing the US economy during a period of economic uncertainty and slow growth. Over the longer term, sustained improvements in industrial production are contributing to a renaissance in US manufacturing.

Low Production Case

The Base Case presented earlier in this report assumed that the revolution under way in the unconventional oil and natural gas industry would continue, reducing energy prices and delivering large economic contributions to the US economy, and to the unconventional oil and natural gas value chain and energy-related chemicals. Estimates of these economic contributions are forecast for the period 2012-2025. A second case, discussed here, is the Low Production Case for the same forecast period. In this case, IHS assumed that the unconventional oil and natural gas industry would operate in a more restrictive regulatory environment that would reduce the levels of oil and natural gas production relative to the Base Case and create more modest contributions to the US economy.

This chapter first describes the assumptions and methodology that IHS used to generate forecasts for the Low Production Case. It then describes what would be the differences in the unconventional oil and natural gas industry's economic contributions—in terms of growth, employment, disposable income, and tax revenues—between the Base Case and the Low Production Case.

Formulation of the Low Production Path

Defining the Low Production Case

The Low Production Case sets out to estimate the broader economic impacts in the event that future unconventional production is reduced by a significantly more restrictive policy and regulatory framework than that which is assumed in the Base Case. This analysis is patterned after the National Petroleum Council's Severe Restricted Supply Scenario as described in the topic papers of the 2011 National Petroleum Council (NPC) study on Prudent Development of North American Oil and Gas Resources.[33] In this scenario, the NPC said, "supply is reduced such as may occur with severe restrictions on fracture stimulation," also known as hydraulic fracturing. Specifically, the NPC assumed that "67% of shale gas/ tight gas/CBM supply is eliminated." The reliance on the previous NPC work is to ensure that this study takes into account a credible analysis that is already in the public domain. The Low Production Case quantifies manufacturing sector activity, employment and value-added contribution to gross domestic product (GDP) under the assumption that oil and natural gas production is lower than in the Base Case over the 2012-2025 forecast horizon.

Although the 2011 NPC study analyzed potential downside alternatives for production, that study did not undertake an integrated oil and natural gas market analysis with feedback loops. However, the NPC did consider restrictive regulation on fracture stimulation as the key driver potentially constraining future production. The Low Production Case in this IHS study is based on the assumption, consistent with the NPC study, that some combination of regulatory restrictions would impose significant restrictions on fracture stimulation, which would reduce the ability of the oil and natural gas industry to access, develop, and produce unconventional hydrocarbon resources in the United States.

The NPC study did not detail the exact nature of the regulatory changes that might occur, but it assumed they would be sufficiently restrictive to curtail drilling and development activity—through a 2035 outlook horizon—over large areas of the hydrocarbon resource base. This is the approach we followed in this study. Potential policies or regulations that the NPC report suggested could restrict unconventional production include:

- An extension of drilling and hydraulic fracturing moratoria, such as those in force in New York State, to other major resource basins and watersheds.

33 National Petroleum Council. (2011) Prudent Development—Realizing the Potential of North America's Abundant Natural Gas and Oil Resources Study Topic and White Papers. Paper #1-8 Onshore Natural Gas - Page B 19. http://www.npc.org/Prudent_Development-Topic_Papers/1-8_Onshore_Natural_Gas_Paper.pdf

- Limitations, in some areas, of water availability for hydraulic fracturing.
- More stringent EPA ground and surface water regulations.
- More stringent well integrity regulations addressing formation integrity and potential fracture fluid migration to groundwater sources.
- More stringent regulations that limit options for produced water discharge.
- EPA classification and regulation of high-volume, low-toxicity waste material from extraction operations as hazardous waste.
- More stringent EPA regulations on containment of produced water.
- New EPA regulations governing monitoring and levels of greenhouse gas emissions at the wellhead, as well as in processing, transmission, storage, and distribution systems.
- Extension of federal air regulations to cover new types of equipment and activities, such as pneumatic devices, compressors, well completions and workovers.
- Tightening of regulated ozone emission thresholds.
- More extensive National Environmental Protection Act reviews and a reduction of categorical exclusions related to leasing programs on federal Bureau of Land Management (BLM) land.
- More complex, time-consuming and costly front-end planning requirements for leasing on BLM lands subject to multiple uses.
- Regulatory ambiguity among federal, state and local agencies.
- Constrained regulatory capacity that slows down permitting processes.
- More stringent regulations and permitting processes governing the build-out of new gathering systems and long-haul pipelines in emerging production regions.
- Significant tax increases or tax code changes, such as the elimination of intangible drilling cost allowances, depletion allowances, unconventional fuel credits and/or research and development credits covering unconventional technology development.

The NPC Severe Restricted Supply Scenario analyzes the impact of restrictions on hydraulic fracturing, but it stops short of analyzing an outright overall moratorium on hydraulic fracturing techniques. However, given the 67% reduction in the recoverable resource base of shale gas, tight gas and coal bed methane, the North American onshore natural gas recoverable resource base is reduced by between 44% and 51%. Furthermore, the time horizon in which production can be maintained at 2010 levels before the recoverable resource base is exhausted is reduced from 50 to 90 years to only 17 to 20 years.

We looked at US production history to validate whether policy and regulations that create disincentives for drilling activity could significantly reduce available energy resources and production. We found that production fell from 22.65 trillion cubic feet (tcf) in 1973 to 16.85 tcf in 1986. Although these declines resulted from wellhead price controls, the ultimate outcome was consistent with the NPC approach in that these regulatory activities effectively excluded large segments of the resource base from being economically viable. Production began to recover when these wellhead price controls began to be lifted and the natural gas market was deregulated in the late 1980s and early 1990s.

The historical pathway of US natural gas production over this period provided valuable insight into the impact on IHS' production profile over time due to major regulatory disincentives to drilling, which played out over approximately the same time frame as the time horizon of this study. As such, it allowed us to construct a plausible profile of the impact of any restrictive hydraulic fracturing regulations that may be introduced in the near future.

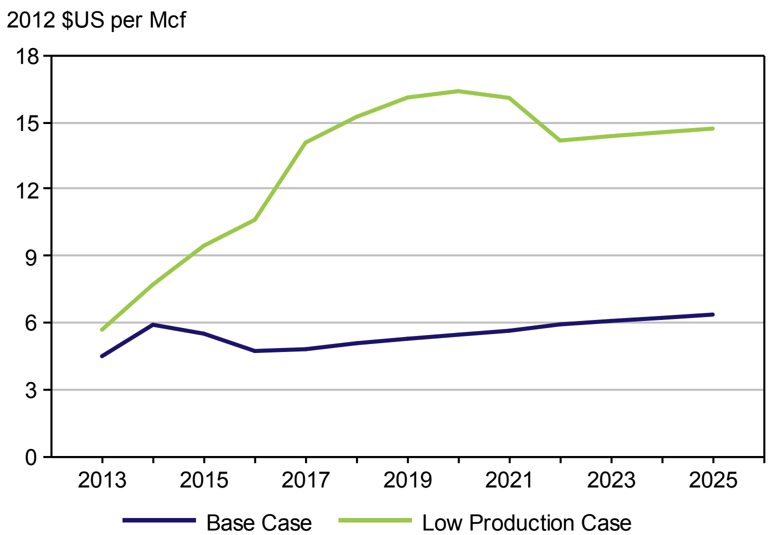
Although the nature of this historic regulatory distortion was very different from the regulatory frameworks currently being discussed (price controls vs. moratoria on hydraulic fracturing and restricted access), the impact on activity and production could be similar. This similarity would arise because both types of regulation have a direct impact on the amount of resources that can be economically recovered, creating a dampening effect on activity and production. This effect was observed in the decline of US natural gas production in the 1970s and 1980s. At a time of price, access or regulatory restrictions on the development of unconventional oil and gas, or on the technologies used to produce them, exploration and production companies shifted their capital budgets to locations—often overseas—with more accessible and economic prospects.

It is unlikely that the conventional resource base in the United States could provide sufficient additional economic opportunity to compensate for the reduction in developable unconventional resources. Before the unconventional boom, which began around 2007, periods of high oil and natural gas prices failed to spur a renaissance in conventional oil and gas production in the United States. The approach used in the Low Production analysis remains consistent with the detailed analysis in the NPC study. It gains additional credibility by using actual historical impacts from distortionary regulatory policy which, although different in rationale and design, were quite similar in the signals sent to exploration and production companies that caused them to significantly reduce their drilling activities.

Output Assumptions—Low Production Case

Just as in the Base Case, the data and assumptions required to undertake the economic impact for the Low Production Case reflected expected changes in output for upstream exploration and extraction, midstream processes, downstream elements, and energy-related chemicals. The IHS Energy team has estimated changes in output stemming from changes in capital investments. In addition, IHS Chemical estimated changes in chemical production from newly available capacity.

Henry Hub Natural Gas Price: Base Case versus Low Production Case

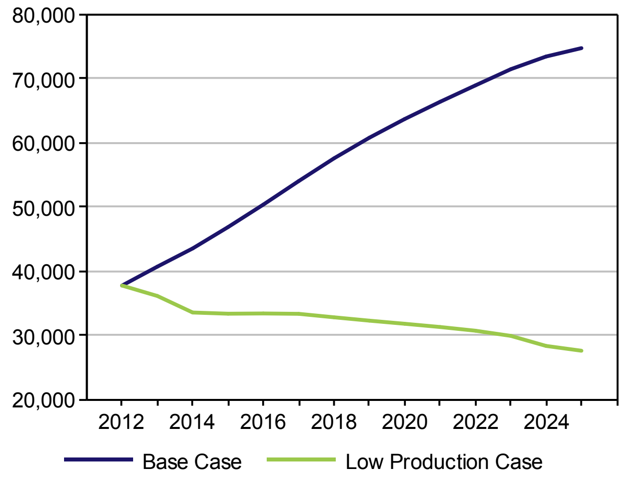


Source: IHS Model of the US Economy

The Low Production Case stemming from potential policy and regulatory restrictions that could impact unconventional oil and gas production over the next decade results in a 67% reduction in unconventional activity through 2035. This forecast will translate to a continuous decline of production over the next decade, resulting in 52% lower natural gas production than is forecast in our Base Case by 2025, the end of our forecast horizon. The ramifications of such policy and regulations will also change the outlook for the LNG market, shifting it to a more import-dependent market. Additionally, industrial and power sector demand for natural gas will experience downward trajectory. As a result of both higher LNG imports and lower domestic production, natural gas prices are projected to peak in 2020 at over $16 per thousand cubic feet (Mcf) before reaching a plateau and dropping to over $14 per Mcf.

Unconventional Natural Gas Production

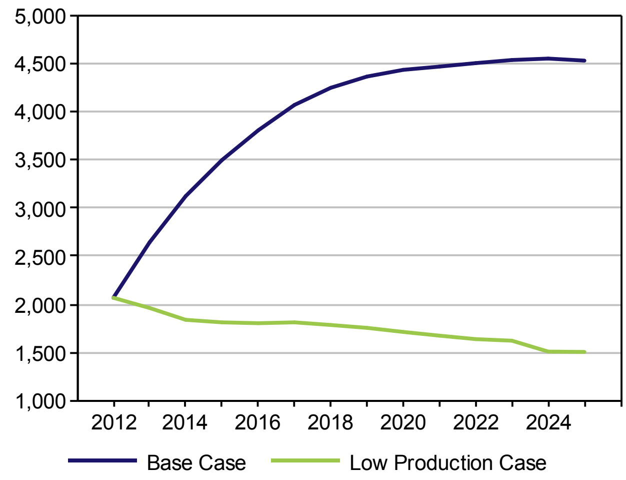
MMcf per day



Source: IHS Energy

Unconventional Oil Production

Mbbl per day



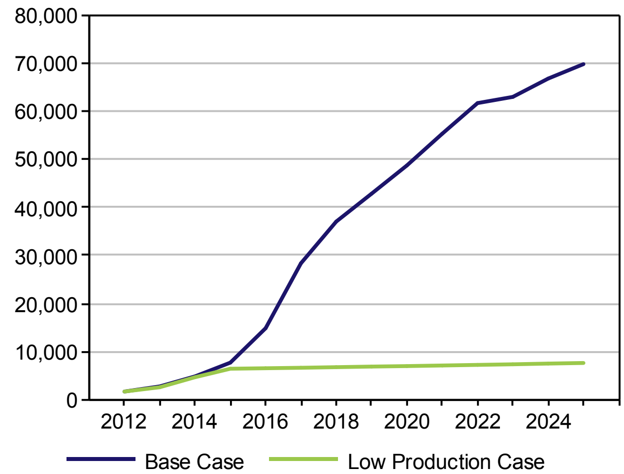
Source: IHS Energy

Both unconventional oil and natural gas production follow a similar pattern under the Low Production Case. Oil prices are projected to remain at the Base Case level.

In the Low Production Case, output from energy-related chemicals grows only at the pace of inflation. This result is in keeping with plant and capacity expansions in the Low Production Case, which is expected to end with the completion of near-term projects. In the Low Production Case, energy-related chemicals plant expansions will be undertaken up to 2014 and therefore production will stay flat over the next decade.

Energy-Related Chemicals Value of Production

Current $M



Source: IHS Energy

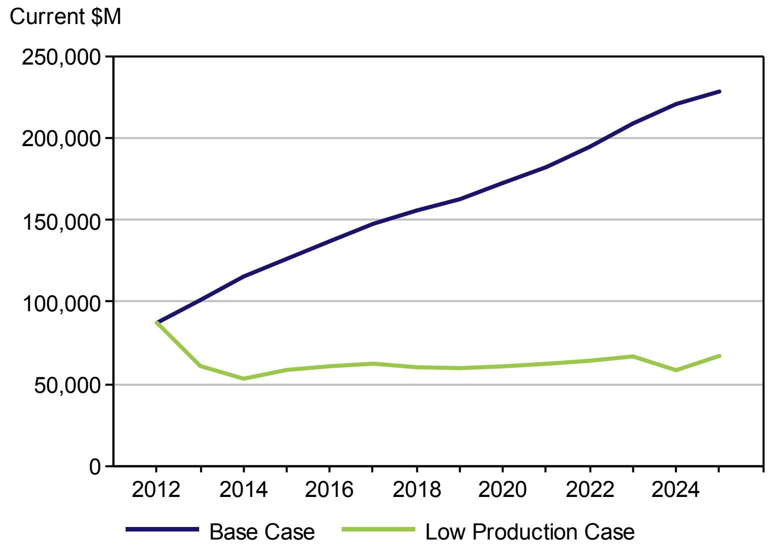
Capital Expenditure Assumptions—Low Production Case

Just as in the Base Case, the required data and assumptions to undertake the economic impact assessments in the Low Production Case include expected capital expenditures for upstream exploration and extraction, midstream processes, downstream elements, and energy-related chemicals. The IHS Energy team has researched the decrease in capital expenditures associated with the Low Production Case due to a heightened regulatory environment. IHS Chemical estimated the decreases in capital investment and capacity expansion in energy-related chemicals stemming from lower unconventional oil and natural gas production in the Low Production Case.

Using the Low Production Case's outlook for unconventional oil and natural gas, the IHS Energy team utilized a detailed supply model to estimate the required capital expenditures for upstream activity. Due to the restrictive policies and regulations in the Low Production Case, capital expenditures in this Case over the next decade are lower than in the Base Case. The chart to the right shows that upstream investment falls, then remains relatively constant (in nominal dollars) throughout the forecast period.

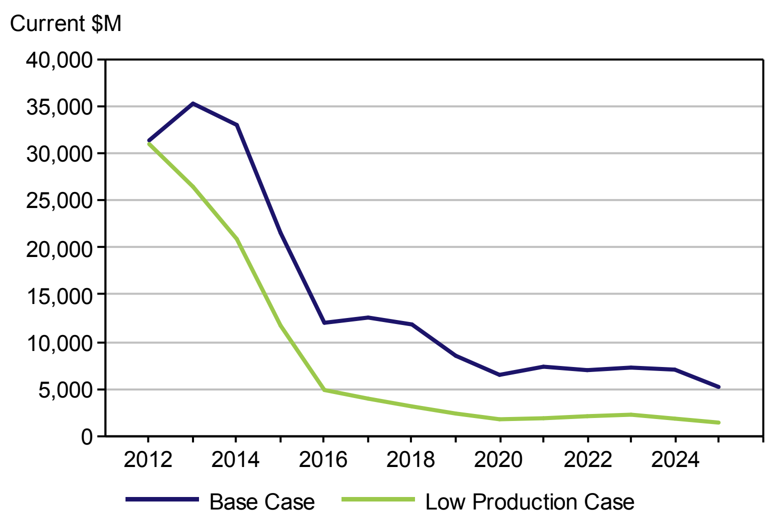
The resulting decline in capital spending for midstream and downstream energy follows a path similar to upstream oil and natural gas production, which was shown in the previous section. Over the short term, capital expenditures will decline sharply along with production. From 2015 to 2025, capital spending will be flat, eliminating the capacity expansion found in the Base Case forecast and contributing to lower midstream and downstream throughput.

Upstream Unconventional Oil and Gas Capital Expenditures



Source: IHS Energy

Midstream and Downstream Unconventional Oil and Gas Capital Expenditures

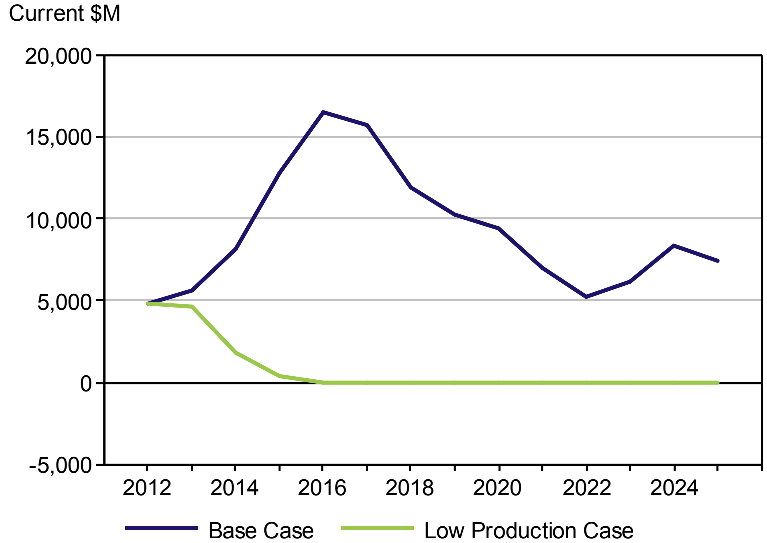


Source: IHS Energy

The next chart below shows a dramatic long-term shift downward in capital expenditures in midstream and downstream processes under the Low Production Case, similar to the downward trend in the Base Case, reflecting the lower level of activity occurring in the upstream segment under the Low Production Case. However, there is initially a surge in capital spending in the Base Case that would virtually disappear in the Low Production Case since it would be unprofitable for midstream and downstream energy sectors to expand their capacity in a heightened regulatory environment. Consequently, capital expenditures shift downward—to reflect the decline in oil and natural gas production—but maintain roughly the same trend as the Base Case, as the industry continues to build out the midstream and downstream capacity required to process these resources at the new lower level.

Finally, energy-related chemicals are expected to follow a drastically different investment path in the Low Production Case. Plans for short-term expansion projects will be completed by 2014, but the additional expansions of capacity and processes that had been forecast in later years in the Base Case to exploit the full unconventional boom will not occur. The US natural gas market in the Low Production Case will continue to be highly import-dependent for LNG, and rising natural gas prices will prevent chemical manufacturers from building additional domestic capacity. The related chemical manufacturing will shift off-shore as the US chemical manufacturers become less competitive relative to their trading partners. By 2016, no additional capacity expansion is expected to be undertaken in the United States under the Low Production Case.

Energy-Related Chemicals Capital Expenditures



Source: IHS Energy

A Comparative Analysis: Base Case versus Low Production Case

The considerable economic opportunities being unlocked by the revolution under way in unconventional oil and natural gas is a function of the pace of exploration and development. Continued exploration and development of new fields are required to find resources and develop both existing and future discoveries. For every barrel produced today, at least one additional barrel must be discovered and developed in order to maintain current production levels. However, this process is complex and costly—from leasing, seismic surveying, permitting, pad construction, well construction, hydraulic fracturing, and production to the plugging and site reclamation once a well is no longer economically viable. As previously discussed, our Base Case includes a status quo set of assumptions around the overall regulatory complexities governing this process. Changes that impact that process or alter the pace and costs of compliance with these regulatory assumptions fundamentally shift economic conditions, altering the underlying pace and scope of the exploration and development opportunities that unfold. This will have a cascading impact: upstream activity will decrease, build-out requirements for the midstream, downstream, and chemicals sectors will decrease, and the macroeconomic benefits of oil, natural gas, and energy-related chemicals to the US will decrease. The comparative analysis presented below quantifies the lost economic opportunities that result from a more restrictive supply outlook.

Comparison of Economic Contribution Results

The data required to undertake the economic contribution assessments in the Low Production Case are comprised of expected capital expenditures for upstream exploration and development, midstream processes, downstream elements, and energy-related chemicals—these are the same contributions analyzed in the Base Case and permit a comparative analysis of the two cases.

This section addresses the midstream and downstream segments of the unconventional oil and gas value chain and the energy-related chemicals. As in the Base Case, the midstream and downstream activities were combined in this analysis, while the chemical industry, which has a significantly different structure, was analyzed separately.

Rather than report the separate results for each of the two production cases, this section instead shows the differences in the various economic contributions between the Base Case and the Low Production Case. These differences, which represent foregone opportunities, demonstrate the substantial lost benefits from implementation of overly stringent oil and natural gas fracturing regulations.

The first table below presents a sample of the summary economic results (employment, value added, labor income) for four individual years included in the 2012-2025 forecast horizon. The second table presents detailed government revenue results for the same four years.

US Lower 48 Economic Contribution Summary due to the Unconventional Activity Value Chain: Difference Between Low Production Case and Base Case*				
Employment				
(Number of workers)				
	2012	**2015**	**2020**	**2025**
Upstream Energy Activity	-	(1,193,049)	(1,824,540)	(2,442,964)
Midstream and Downstream Energy Activity	-	(108,757)	(54,941)	(41,933)
Energy-Related Chemicals Activity	-	(115,069)	(247,221)	(288,613)
Total Activity	**-**	**(1,416,875)**	**(2,126,702)**	**(2,773,511)**
Value Added				
(2012 $M)				
Upstream Energy Activity	-	(100,551)	(131,166)	(249,552)
Midstream and Downstream Energy Activity	-	(13,220)	(6,660)	(5,025)
Energy-Related Chemicals Activity	-	(14,058)	(37,954)	(46,046)
Total Activity	**-**	**(127,829)**	**(175,779)**	**(300,624)**
Labor Income				
(2012 $M)				
Upstream Energy Activity	-	(84,431)	(130,449)	(172,314)
Midstream and Downstream Energy Activity	-	(7,119)	(3,577)	(2,699)
Energy-Related Chemicals Activity	-	(7,880)	(19,607)	(23,504)
Total Activity	**-**	**(99,430)**	**(153,634)**	**(198,517)**

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Economics

- **Employment**: If the Low Production Case occurs instead of the Base Case, total employment is expected to be just over 1.4 million lower in 2015 and would be nearly 2.8 lower in 2025.
- **Value Added:** Value added is expected to follow a similar path, with total forgone value added of $128 billion in 2015 and over $300 billion in 2025.
- **Labor Income:** The value of forgone labor income is expected to reach $198 billion in 2025.

Contribution to US Lower 48 Government Revenue due to the Unconventional Activity Value Chain: Difference Between Low Production Case and Base Case*

(2012 $M)

	2012	2015	2020	2025	2012-25**
Upstream Energy Activity* **					
Federal Taxes	-	(15,817)	(23,021)	(33,035)	(276,714)
Federal Royalty Payments	-	(289)	(473)	(1,218)	(6,111)
Federal Bonus Payments	-	(18)	(22)	(56)	(330)
State and Local Taxes	-	(4,991)	(3,621)	(16,754)	(84,691)
Severance Taxes	-	(947)	(1,739)	(5,382)	(22,178)
Ad Valorem Taxes	-	(465)	(861)	(2,578)	(10,895)
State Royalty Payments	-	(115)	(201)	(587)	(2,583)
State Bonus Payments	-	(55)	(70)	(186)s	(1,019)
Total Government Revenue	**-**	**(22,696)**	**(30,008)**	**(59,794)**	**(404,520)**
Lease Payments to Private Landowners	-	(472)	(712)	(891)	(8,308)
Midstream and Downstream Energy Activity					
Federal Taxes	-	(2,246)	(1,017)	(770)	(19,048)
State and Local Taxes	-	(1,387)	(659)	(498)	(11,516)
Total Government Revenue	**-**	**(3,633)**	**(1,676)**	**(1,268)**	**(30,564)**
Energy-Related Chemicals Activity					
Federal Taxes	-	(2,172)	(5,635)	(6,811)	(59,752)
State and Local Taxes	-	(1,407)	(3,708)	(4,498)	(39,192)
Total Government Revenue	**-**	**(3,580)**	**(9,343)**	**(11,309)**	**(98,944)**
Total Activity					
Federal Taxes	-	(20,235)	(29,674)	(40,616)	(355,514)
Federal Royalty Payments	-	(289)	(473)	(1,218)	(6,111)
Federal Bonus Payments	-	(18)	(22)	(56)	(330)
State and Local Taxes	-	(7,785)	(7,988)	(21,749)	(135,398)
Severance Taxes	-	(947)	(1,739)	(5,382)	(22,178)
Ad Valorem Taxes	-	(465)	(861)	(2,578)	(10,895)
State Royalty Payments	-	(115)	(201)	(587)	(2,583)
State Bonus Payments	-	(55)	(70)	(186)	(1,019)
Total Government Revenue	**-**	**(29,909)**	**(41,028)**	**(72,371)**	**(534,028)**
Lease Payments to Private Landowners	-	(472)	(712)	(891)	(8,308)

NOTES: Numbers may not sum due to rounding.

*The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

**2012-2025 represents the total for all years including those years not reported.

***Federal royalty payments, federal bonus payments, and lease payments to private landowners only apply to the upstream energy activity where land is leased from private households for drilling.

Source: IHS Economics

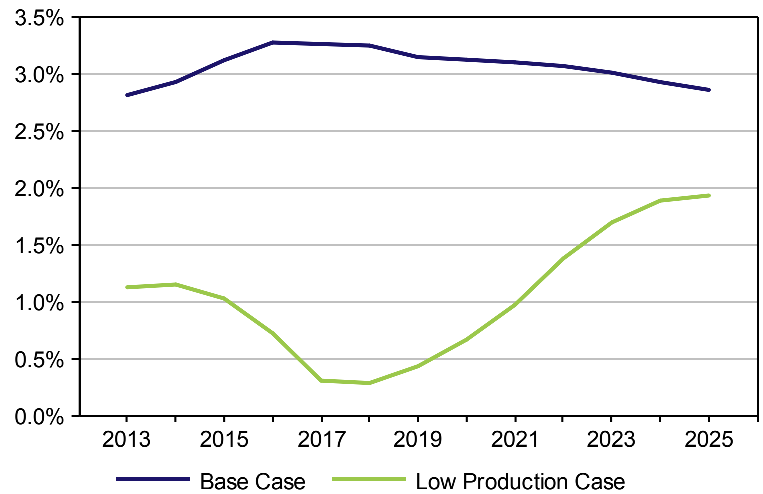
IHS estimates that annual government revenues forgone by moving from the Base Case to the Low Production Case would be nearly $30 billion in 2015, more than $41 billion in 2020, and more than $72 billion in 2025. Over the entire forecast, 2012-2025, the total sacrificed by governmental bodies would exceed $534 billion. While the majority of lost revenues would derive from reduced upstream activity, the total forgone revenue from midstream and downstream energy activity is expected to reach more than $30 billion, while lost revenue from energy-related chemicals activity is expected to reach nearly $99 billion.

Comparison of Macroeconomic Results

In order to quantify the *incremental* impacts in the two production cases at the macroeconomic level using a dynamic approach, we have assessed the results for a broad set of metrics using higher assumptions for natural gas prices. Not surprisingly, the GDP impacts stemming from the Low Production Case are well below those of the Base Case over the entire forecast horizon. The GDP impacts in the Low Production Case increase in the early years of the forecast period decrease in the intermediate years as natural gas prices rise, and rise again in the forecast's latter years. A summary of the key findings are given below:

- The contribution associated with the unconventional value chain activities ranges between 2.0% and 3.3% of GDP in the Base Case. The smaller GDP impacts associated with the Low Production Cases will not exceed 1.9% at its forecast period high.
- While employment increases in the Base Case range from 1% to 3%, the employment increases in the Low Production Case will reach just 1% in 2015, will decline to 0.4% in 2018, and will be at 1.6% in 2025.
- The net trade benefit of the Base Case peaks at $183 billion in 2022, while the benefits associated with the Low Production Case, at $92 billion, are less than half that of the Base Case.

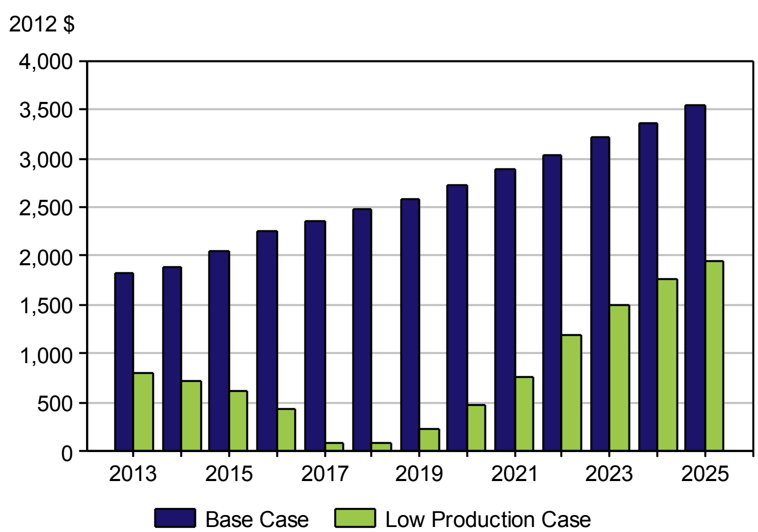
Change in Gross Domestic Product due to the Unconventional Activity Value Chain: Base Case versus Low Production Case*



Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

Change in Disposable Income per Household due to the Unconventional Activity Value Chain: Base Case versus Low Production Case*



Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

- On average, disposable personal income per household will be roughly $2,600 higher in any given forecast year in the Base Case, compared with just $800 higher in any given forecast year in the Low Production Case.
- While the contribution of unconventional oil and gas to the US industrial production index in the Base Case ranges from 1.5% to 4%, the Low Production Case's contribution will only reach 1.5% at its forecast high.

Conclusion

Unconventional oil and natural gas activity is reshaping America's energy future and bringing significant benefits to the US economy in terms of jobs, government revenues, and GDP. This study provides the foundation for a dialogue focused on the economic effects of this unconventional revolution. It does so by extending IHS' original economic assessment to include the full value-chain associated with the unconventional revolution, including the benefits to midstream and downstream energy and energy-related chemicals activities. This complete analysis reveals how these profound developments are reshaping the US macroeconomic outlook and contributing to a manufacturing renaissance brought about by greater US competitiveness in world markets.

The full economic contribution from the unconventional oil and natural gas value chain and energy-related chemical manufacturing has added 2.1 million jobs in 2012, and that contribution will increase to almost 3.1 million by the end of the decade and almost 3.9 million in 2025.

The value chain's annual contributions to GDP will nearly double, from almost $284 billion in 2012 to almost $533 billion in 2025. Government revenues will average $115 billion annually and will cumulatively grow by a total of more than $1.6 trillion from 2012 to 2025.

The revolution is also benefitting households across the country. In 2012, real household disposable income increased by more than $1,200. With 120 million households in the country, this equates to an aggregate annual boost of $163 billion. The benefits to US workers will continue to rise over the forecast horizon, from just over $2,000 in 2015 to more than $3,500 in 2025.

Equally impressive is the contribution to the manufacturing sector brought about by increasing unconventional oil and natural gas activity. This activity is making energy more affordable and abundant, creating competitive advantages for energy-intensive industries and industries that use natural gas as feedstock. And while a variety of factors have encouraged the renaissance currently under way in US manufacturing, our macroeconomic modeling demonstrates that the unconventional oil and natural gas revolution is playing a significant role.