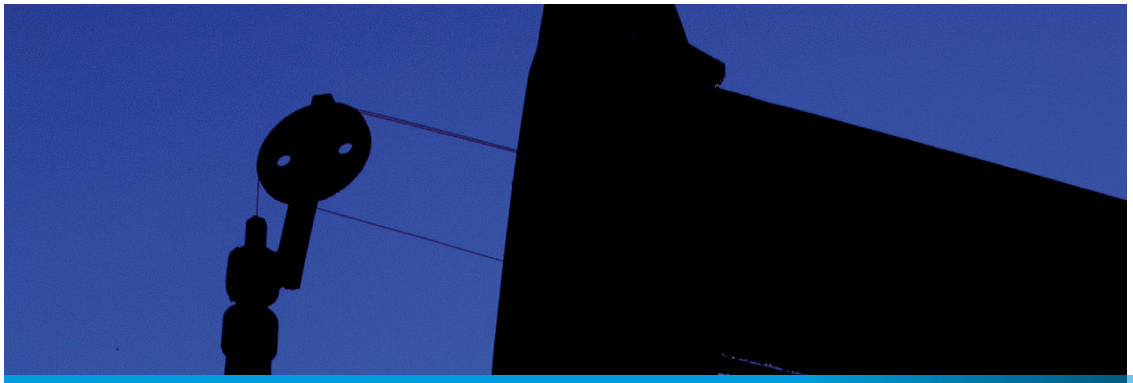


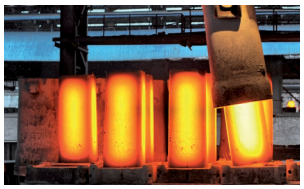
An IHS Report

September 2013

America's New Energy Future:

The Unconventional Oil and Gas Revolution and the US Economy

Volume 3: A Manufacturing Renaissance - Executive Summary



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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 the unconventional oil and gas production in promoting employment, economic growth, and energy security.

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Executive Summary

A revolution is under way in the production of unconventional oil and natural gas that is transforming America's energy future and strengthening its overall economy. In our companion study, *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy— Volume 1: National Economic Contributions,* we examined the economic contributions associated with upstream unconventional oil and natural gas production. In the current study we expand the analysis to consider a broader set of opportunities associated with the midstream, downstream, and energy-related chemicals aspects of this unconventional revolution. This study expands on our initial study through an examination and quantification of three critical areas:

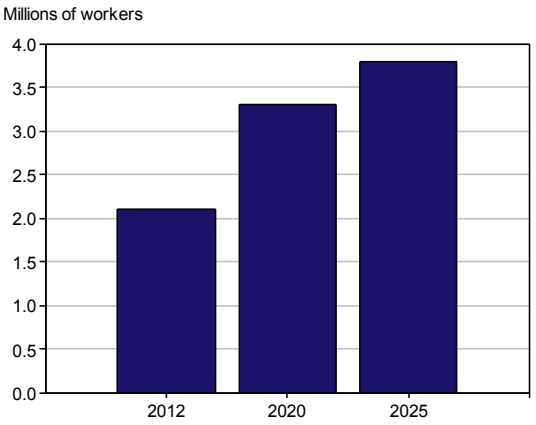
- the full set of value chains—upstream, midstream, downstream, and energy-related chemical industries—necessary to unlock unconventional oil and natural gas resources;
- the broader macroeconomic implications for the US economy; and,
- the manufacturing renaissance being driven by this new, abundant and affordable source of domestic energy.

In 2012, the full unconventional value chain—from upstream energy through energy-related chemicals—that is associated with the revolution in unconventional oil and natural gas supported 2.1 million jobs, generated nearly $75 billion in federal and state tax revenues, and contributed $283 billion to US gross domestic product (GDP). By 2020, IHS projects these economic contributions will grow to 3.3 million jobs, more than $125 billion in federal and state tax revenues, and more than $468 billion in annual contributions to GDP.[1]

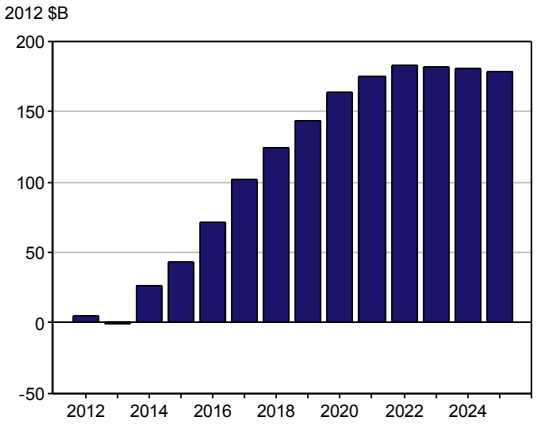
Fueling these economic contributions are massive capital investments across the full unconventional value chain.

How Will the Unconventional Oil and Natural Gas Value Chain and Energy-Related Chemicals Strengthen the US Economy?

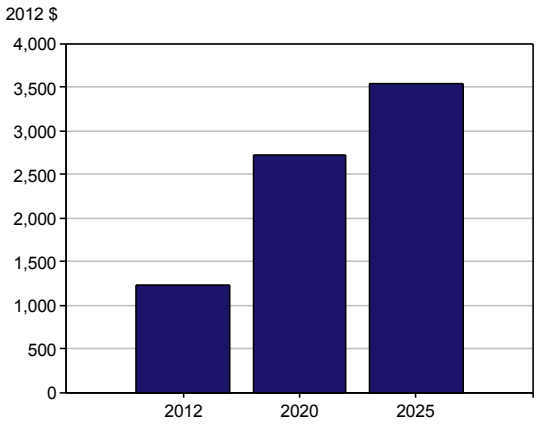
Change in Employment



Change in Net Trade



Change in Disposable Income per Household



Source: IHS Model of the US Economy

[1] Our second report, *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy*, *Volume 2: State Economic Contributions*, presented the following detailed estimates of the contributions of upstream unconventional oil and natural gas: In 2012, over 1.7 million jobs, $63 billion in federal and state taxes, and nearly $238 billion in value added to GDP; and, in 2020, 3.0 million jobs, $113 billion in federal and state taxes, and over $416 billion of value added.

Between 2012 and 2025, IHS projects a cumulative investment of nearly $346 billion across the midstream and downstream energy and energy-related chemicals value chains. Close to $216 billion of this will come in the midstream and downstream segments of the unconventional value chain, roughly half of which will be directed toward over 47,000 miles of new or modified pipeline infrastructure. The remaining midstream and downstream investments will be distributed across other critical midstream and downstream infrastructure, such as natural gas liquids (NGL) fractionation facilities, natural gas processing facilities, and natural gas liquefaction projects.

Major investments are also taking place within the energy-related chemical industries, which are also benefitting from the revolution in unconventional oil and natural gas production. More than $31 billion in new capital investments will drive the addition of more than 16 million tons of chemical capacity by 2016. Cumulative investment will grow to more than $129 billion to support nearly 89 million tons of capacity by 2025. These investments will take place in new chemical, plastics, and related derivative manufacturing facilities across the United States.

The economic benefits do not end with capital investments. The unconventional revolution is also contributing to a shift in global competitiveness for the United States by unlocking new production cost advantages for US industries benefitting from lower prices for raw materials and the energy they use. IHS has leveraged its US Macroeconomic Model to capture the benefits of lower natural gas prices and accompanying lower electricity prices on the general economy. Our analysis demonstrates that this manufacturing renaissance will increase industrial production by 3.5% by the end of this decade and by 3.9% by 2025. Output by the manufacturing sector will increase by $258 billion in 2020 and $328 billion in 2025. The US competitive advantage is particularly pronounced in energy-intensive industries, such as energy-related chemicals which in the coming years will be a primary beneficiary of lower prices for energy and feedstock. Industries such as organic chemicals, resins, agricultural chemicals, petroleum refining, metals such as iron and steel, and machinery are among the top-ranked sectors benefiting from this revolution. These sectors are expected to benefit from lower energy prices (for those that use oil and natural gas as feedstocks), lower electricity prices, and increased demand for their products as growth in overall GDP spurs domestic consumption.

And increased industrial production and exports of products to global markets will help to improve the US trade position. The benefits to US trade of the unconventional revolution will increase steadily through 2022, before plateauing at a new, higher level of $180 billion per year in additional real net trade that is above what would occur in a US trade regime that had excluded this new unconventional activity.[2]

The benefits of this unconventional oil and natural gas revolution are also reaching more than 120 million American households across the country whose incomes and consumption are rising. In 2012, average real disposable income per household increased by more than $1,200 as a result of the unconventional revolution—an aggregate financial boost to all US households of $163 billion. Real disposable income will continue to increase through the end of the forecast period, with the unconventional revolution's annual contribution to the average household growing to just over $2,700 in 2020 and to more than $3,500 by 2025.

This impact is particularly significant when it is examined against the backdrop of a historically slow economic recovery and stubbornly high unemployment. The positive forces associated with unconventional oil and natural gas activity, and the second-order gains by economic sectors that benefit from the unconventional revolution, will help the US economy to make progress in the face of steady economic headwinds.

The remaining sections of the Executive Summary present various contributions of the oil and natural gas revolution to a range of energy producers and manufacturers, as well as the US economy, from reduced

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

The terms midstream and downstream can have varying definitions within 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 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 NGLs 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; however, they have been included as they constitute the additional processing of natural gas into liquid form. For the remainder of this report, midstream and downstream energy encompasses the following seven segments: Liquefied Natural Gas (LNG) Processing; Natural Gas (NG) Processing; NG 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 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.

energy and feedstock prices. We also present the potential risks and corresponding costs associated with realizing these economic opportunities.

Unconventional Oil and Natural Gas Value-Chain Contributions

The value chain's contributions derive from the capital expenditures associated with the incremental increases in capacity required to support the growth in unconventional oil and natural gas production in a given year. The following three sets of energy-related activities are increasing their capital investments:

- Upstream energy will see continued growth in capital expenditures, as significant activity is required simply to find and replace every barrel of oil or billion cubic feet of natural gas extracted and maintain production at current levels. To increase production above current levels, significant additional capital expenditures will be required throughout the forecast horizon.
- Midstream and downstream energy activities, unlike the upstream activity, are built out in anticipation of peak production levels. The rise in production unlocked by the unconventional revolution has created considerable near-term capacity requirements—pipelines, refineries, and other infrastructure—that the industry must meet. In the near term, the midstream and downstream energy segments of the value chain will undergo significant expansion to create the necessary capacity to support production both today and in the future. Once this capital expansion is complete, lower levels of incremental capital expansion will sustain the longer term incremental increases in production expected in the later years of the forecast horizon.
- Energy-related chemicals are also built out in anticipation of peak production. However, there is some delay, because significant capital expansion cannot take place until the midstream and downstream energy expansion has been sufficiently completed and is able to supply energy-related chemicals with the necessary feedstock. As a result, capital expenditures by energy-related chemicals start modestly and expand only as the midstream and downstream energy infrastructure is completed. In the medium term, as the energy-related chemicals sector takes full advantage of the oil and natural gas resources being brought to market, capital expenditures will rise significantly to expand capacity.

$189 Billion in Annual Capital Expenditures In 2020[3]

As unconventional oil and natural gas producers expand their upstream operations over the next 25 years, the midstream, downstream, and energy-related chemical sectors will increasingly invest in infrastructure and processing capacity.

- The $87 billion in upstream capital expenditures during 2012 was accompanied by an additional $34 billion in capital expenditures from midstream and downstream energy and energy-related chemicals as these sectors rapidly expand capacity and reshore some production facilities to the United States. In total, just over $121 billion in capital expenditures occurred in 2012.
- In 2020, total capital expenditures are estimated to reach nearly $189 billion. Upstream will invest close to $173 billion. However, by this point, midstream and downstream energy and energy-related chemicals will have transitioned to incremental capacity expansion, thereby moderating their capital expenditures to almost $7 billion and over $9 billion, respectively.
- By 2025, annual capital expenditures are estimated to exceed $240 billion: $228 billion from upstream, over $5 billion in midstream and downstream, and over $7 billion in chemicals.

Over the entire forecast period 2012-2025, capital expenditures for the upstream will reach over $2.4 trillion. Midstream and downstream energy will generate over $216 billion and energy-related chemicals will add more than $129 billion.

3.3 Million American Jobs in 2020

There are three sources of economic contribution, in terms of jobs, from increased activity in the unconventional oil and natural gas value chains and in energy-related chemicals: (1) the direct contribution from the unconventional oil and natural gas value chains and energy-related chemicals activity, (2) the indirect contribution from suppliers to the unconventional oil and natural gas value chains and energy-related chemicals , and (3) the induced contribution throughout the economy as workers spend their incomes on consumer goods and services.

These employment opportunities have particular resonance at a time that reigniting job growth is one of the dominant priorities on the national agenda. A striking number of jobs will be created from unconventional oil and natural gas value chains and energy-related chemicals activities and industries that will benefit from their growth:

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

(Number of workers)

	2012	2020	2025
Upstream Energy Activity	1,748,604	2,985,168	3,498,678
Midstream and Downstream Energy Activity	323,648	73,530	56,989
Energy-Related Chemicals Activity	53,252	277,356	318,748
Total Activity	**2,125,504**	**3,336,055**	**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

- In 2012, the unconventional oil and natural gas value chain and energy-related chemicals activity supported more than 2.1 million jobs in the US lower 48 states—500,000 of these were direct jobs; almost 640,000 were indirect jobs in supplying industries; and just under 1 million were induced

[3] Estimates of the capital expenditures required to support upstream activity were discussed in detail in volume one of this report series, *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy*, *Volume 1: National Economic Contributions*.

jobs. Midstream and downstream energy and energy-related chemicals activity accounted for nearly 377,000 of these jobs.

- By 2020, we forecast that the unconventional oil and natural gas value chain and energy-related chemicals activity will support over 3.3 million jobs: nearly 685,000 direct, more than 1 million indirect, and over 1.6 million induced jobs. Midstream and downstream energy and energy-related chemicals activity will contribute nearly 351,000 of these jobs.
- By 2025, unconventional oil and natural gas value chain and energy-related chemicals activity will support almost 3.9 million jobs: over 800,000 direct, more than 1.2 million indirect, and over 1.8 million induced jobs. Midstream and downstream energy and energy-related chemicals activity will jointly contribute nearly 376,000 of these jobs.

$468 Billion in Annual Contribution to US GDP In 2020

The value-added contribution to GDP from the unconventional oil and natural gas value chain and energy-related chemicals activity totaled nearly $284 billion in 2012 alone.

- In 2012, total GDP contributions reached nearly $284 billion: the $238 billion upstream contribution to 2012 GDP was accompanied by an additional $39 billion in the midstream and downstream while energy-related chemicals sectors contributed nearly $7 billon.
- In 2020, total GDP contributions are estimated to reach $468 billion: nearly $417 billion from upstream, $9 billion in midstream and downstream, and about $43 billion in energy-related chemicals.
- And by 2025 total contributions to GDP are estimated to approach $533 billion: about $475 billion from upstream, almost $7 billion in midstream and downstream, and over $51 billion in chemicals.

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

(2012 $M)

	2012	2020	2025
Upstream Energy Activity	237,684	416,551	474,985
Midstream and Downstream Energy Activity	39,327	8,927	6,857
Energy-Related Chemicals Activity	6,766	42,949	51,041
Total Activity	**283,777**	**468,427**	**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

$125 Billion in Annual Tax Revenues to Federal and State Treasuries By 2020[4]

At a time when government budgets are also of great concern, the unconventional oil and natural gas revolution at all levels—upstream, midstream, downstream, and energy-related chemicals—is having a positive impact on federal, state and local government budgets. In 2012, the full value chain of industrial activity and employment associated with unconventional oil and natural gas contributed a total of more than $74 billion in tax receipts. Tax receipts will climb to more than $125 billion annually by the end of the decade and, by 2025, will reach $138 billion annually.

[4] These revenues include personal and corporate tax payments by the supply chain of industries, as well as tax revenues from income earned by direct and indirect employment associated with the unconventional revolution. Tax revenue includes: (1) federal corporate and personal income taxes; (2) state and local corporate and personal income taxes, state severance taxes, and state ad valorem levies; and (3) federal royalty payment for exploration on federal lands. In addition to government taxes and revenues, lease payments to private landowners are also reported.

Contribution to US Lower 48 Government Revenue due to the Unconventional Activity Value Chain: Base Case*				
(2012 $M)				
	2012	**2020**	**2025**	**2012-2025****
Contribution by Type***				
Federal Taxes	35,598	57,702	64,030	750,696
Federal Royalty Payments	1,964	3,204	2,994	39,664
Federal Bonus Payments	148	150	138	2,139
State and Local Taxes	36,732	64,484	71,233	822,137
Total Government Revenue	**74,443**	**125,540**	**138,395**	**1,614,636**
Lease Payments to Private Landowners	504	915	1,103	11,696
Contribution by Activity				
Upstream Energy Activity	63,015	112,943	124,335	1,436,294
Midstream and Downstream Energy Activity	9,750	2,168	1,665	63,133
Energy-Related Chemicals Activity	1,677	10,429	12,395	115,209
Total Government Revenue	**74,443**	**125,540**	**138,395**	**1,614,636**
Lease Payments to Private Landowners	504	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

On a cumulative basis over the entire forecast period, the tax contribution will surpass $1.6 trillion, with over $1.4 trillion generated by upstream activities, $63 billion by the midstream and downstream activities, and $115 billion by energy-related chemicals activities taking place.

Despite the fact that nearly 90% of this unconventional activity is taking place on state or private lands, rather than federal lands, there are significant fiscal implications for the federal government, as corporations and individuals pay federal taxes on earnings generated by this activity. Federal tax revenues and royalties alone currently total nearly $38 billion, with the vast majority of that—$35 billion—coming from those corporate and individual income taxes. Similarly, state and local governments are also recognizing significant tax revenues—almost $37 billion in 2012—from this activity. By 2020, total annual taxes from the full unconventional oil and natural gas value chain and energy-related activity will grow to just over $61 billion for the federal government and $64 billion for state and local governments.

Over the entire forecast period, the cumulative contribution will be $1.6 trillion, more than $792 billion being recognized by the federal government and $822 billion generated for state and local governments.

Macroeconomic Impact Assessment: the Base Case

Natural gas prices continue to remain lower than they were prior to the start of the unconventional oil and natural gas revolution in the United States and continue to trend lower than prices elsewhere in the world. The projected price for natural gas over the forecast horizon is between $4 and $5 per Mcf, which is approximately a third of the likely natural gas price faced by the United States if forced to import on a

global LNG market to meet domestic demand. These lower prices are boosting disposable income, GDP and employment—all positive forces during a period of economic uncertainty and slow growth. Over the longer term, we expect a compositional shift in the economy toward increased manufacturing due to an improvement in US international competitiveness. Lower energy and feedstock costs will lead to more manufacturing sector investment and employment, particularly in energy-related chemicals.

Three distinct first-order impacts 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 increased investment and capacity expansion in the oil and natural gas industry;
- The resulting lower natural gas prices estimated by IHS Energy Insight were incorporated into the US Macroeconomic Model;
- The increased upstream investments in capacity expansion were incorporated into the US Macroeconomic Model as part of the overall investment outlook and then, utilizing the model relationships, the model estimated investment changes in midstream and downstream energy, along with energy-related chemicals.

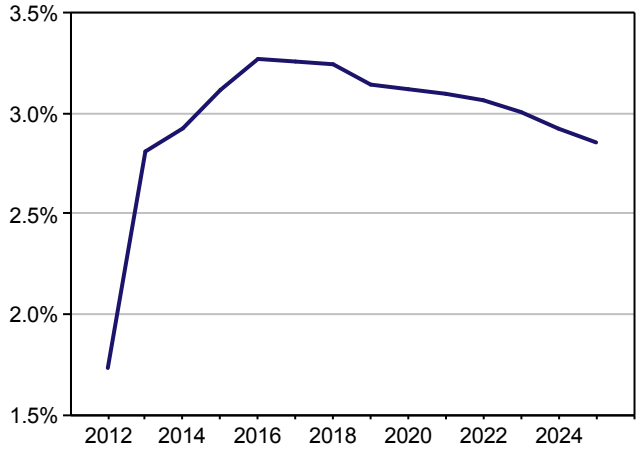
However, there are also less direct measures that will impact the broader economy and, due to its dynamic nature, the US Macroeconomic Model allows IHS to examine changes in industrial and consumer outlooks as a result of those initial first-order impacts. One important example that illustrates the nature of the model is that of electricity prices. Natural gas and oil are important inputs in the generation of electricity, so reductions in the price of natural gas will result in reductions in the price of electricity. Producers and consumers will then benefit from lower electricity bills.

The impacts are analyzed using three standard macroeconomic metrics: GDP, the net trade balance, and disposable household income.

Gross Domestic Product

The incremental boost from the unconventional oil and natural gas value chain and 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 is forecast to increase rapidly and peak in the early years. Over the short term, the impact of the unconventional oil and natural gas value chains and energy-related chemicals on the level of GDP peaks at 3.2% by 2016. In the context of a $13-15 trillion US economy, this equates to an increase in GDP of $500 to $600 billion.

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

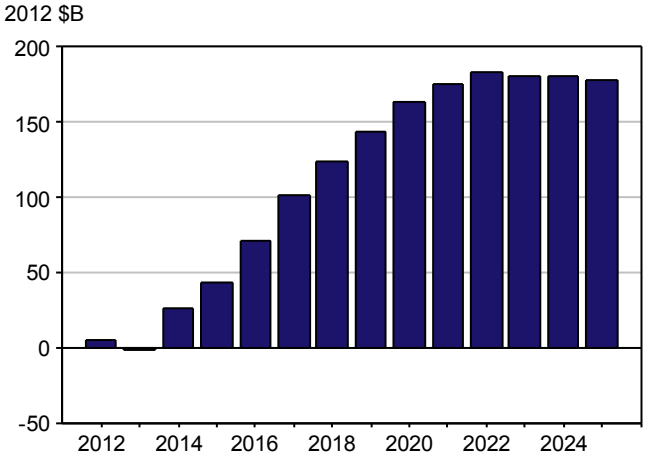
Net Trade

The unconventional revolution will also substantially improve the US net trade balance for several reasons. First, the increase in domestic energy production will allow the United States to export significant quantities of intermediate and refined

energy products such as liquefied petroleum gases and liquefied natural gas. Second, for energy products in which the United States is a large net importer, namely crude oil, each barrel of increased production cancels out an equivalent imported barrel. Third, reduced energy costs, specifically for electricity and natural gas, improve the global competiveness of energy-intensive manufacturing industries.

Despite declining domestic demand, this new competiveness will enable petroleum refiners to continue operating at high utilization rates, meeting lower domestic demand and then exporting surplus production to Latin America and Europe. The impact on US trade of the unconventional revolution is projected to increase steadily through 2022 before plateauing at a new, higher level of $180 billion per year in additional real net trade relative to a US trade regime in which there was no unconventional activity.

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



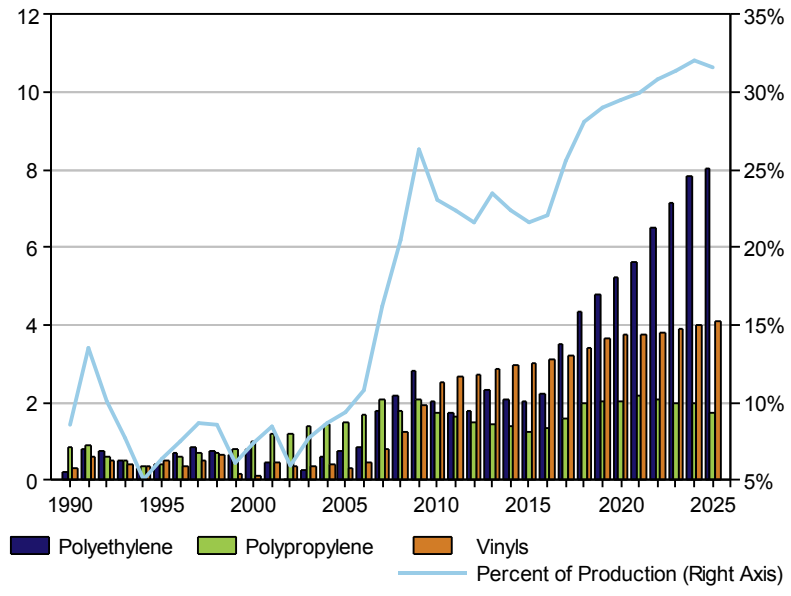
Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

This trade impact is particularly relevant for the chemical manufacturing sector. In the years immediately preceding the global recession of 2009, the chemical industry underwent an expansion in net exports.[5] This export expansion was largely driven by the widening spread between natural gas derived energy-related chemicals in the US and oil derived energy-related chemicals in other parts of the world. Over this 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 rising to $96.94 at its peak in 2008.[6] As a result, net exports as a percent of total production expanded for energy-related chemicals in the US reliant on the now relatively more affordable natural gas based feedstock.

The unconventional oil and natural gas revolution is now positioning US based energy-related chemical producers to further accelerate their net export position. Historically high oil derived feedstock prices—with oil projected to average $98 per barrel throughout the forecast horizon—will

US Net Exports for Selected Products



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

Source: IHS Chemical

[5] Net exports defined as the industries total exports minus the value of its total imports

[6] EIA Europe Brent Spot Price FOB (Dollar per Barrel).

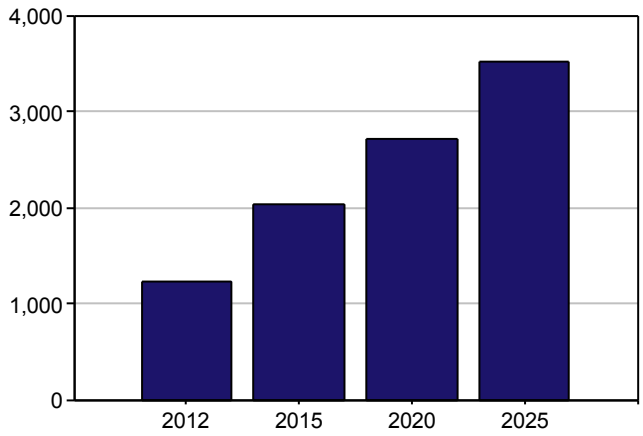
continue to place significant cost pressures on many global chemical competitors. Simultaneously, relatively affordable and abundant natural gas derived feedstock unlocked by the unconventional revolution in the US will continue to benefit natural gas based energy-related chemical producers here domestically. The chemical manufacturing industry currently stands as one of America's largest exporting industries with $198 billion in annual exports that accounted for 13% of all US merchandise exports in 2012.[7] IHS expects this export trend to continue through the forecast period as the industry continues to enjoy cost advantages relative to international competitors.

Disposable Household Income

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 increasing household wages and decreasing costs for energy and energy-intensive products. Specifically, these factors work through three primary avenues of economic growth:

- Direct consumption costs are reduced as natural gas used to heat homes and water becomes less expensive.
- Input costs for manufacturers of various consumer goods, including electricity prices, decline, reducing indirect costs for consumers.
- Wages increase as the manufacturing renaissance increases industrial activity.

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

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

These economic contributions are more significant when viewed against the backdrop of a struggling US economy, with slow growth, and an unemployment rate that hovers above 7.5%, with 12 million individuals out of work and seeking employment. IHS expects the unemployment rate to fall to 6.5% in late 2015 and reach a long-run equilibrium of 5.2% by 2025. IHS projects that the United States will experience a long, laborious recovery, with 1.8% GDP growth in 2013 and 2.9% growth in 2014.

Manufacturing Renaissance

A variety of factors have encouraged the manufacturing renaissance currently under way in the United States, including productivity gains for US workers, significant technological advances, and slower growth in hourly compensation relative to our global competitors. These factors have already helped US manufacturing rebound since the trough of the recession in 2009. Manufacturing is continuing to make important contributions to economic growth. Manufacturing's overall real value added—its contribution

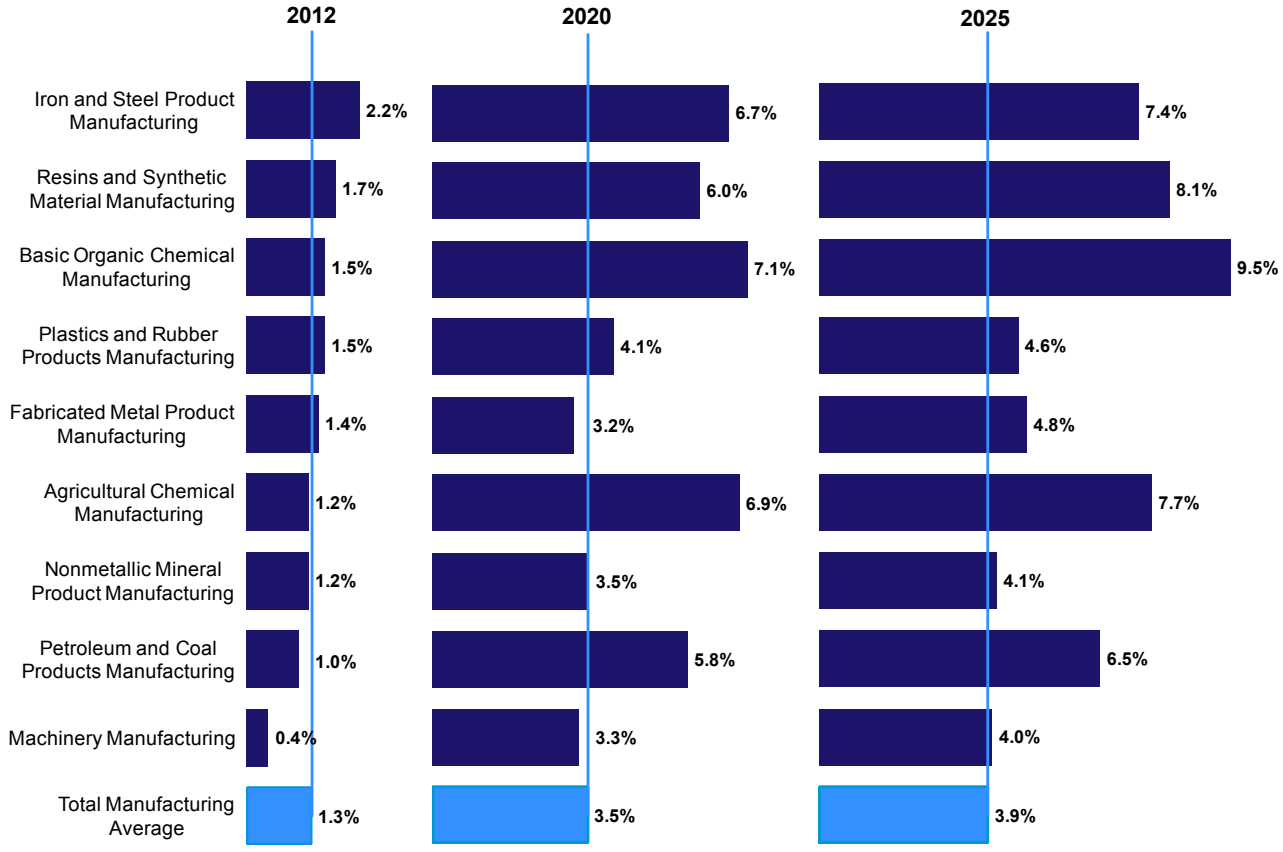
[7] United States Department of Commerce, Bureau of the Census, Foreign Trade Division

to GDP—increased 6.2% in 2012, after increasing 2.5% in 2011. This growth was led by durable-goods manufacturing, which was the largest contributor to US growth overall in 2012. The durable goods manufacturing sector has experienced significant growth for three consecutive years: 13.3% in 2010, 6.8% in 2011, and 9.1% in 2012.[8]

These factors, in combination with the profound impacts of increasing unconventional oil and natural gas production, are revitalizing critical segments of the US manufacturing base. To provide a comprehensive analysis of the economic contribution, it is critical to examine the unconventional revolution's impact on major manufacturing industries. US manufacturers are benefitting from the availability of a secure supply of low-cost natural gas, especially manufacturers in energy-intensive industries. Energy-related chemicals, petroleum refining, aluminum, steel, glass, cement, and the food industry—these are key energy-intensive sectors that are expected to invest and increase their US operations in response to declining prices for their energy inputs.

The impact of the unconventional oil and natural gas revolution in the forecast period is pronounced among energy-intensive industries. In 2012, many energy-intensive manufacturing industries outperformed the total manufacturing index average growth of 1.3%. Subsectors such as Iron and Steel Product Manufacturing and Basic Organic Chemical Manufacturing are way out in front of the overall manufacturing average in both 2020 and 2025. The same can be said for Resins and Synthetic Material Manufacturing (6.0% in 2020 and 8.1% in 2025) and Agricultural Chemical Manufacturing (6.9% in 2020 and 7.7% in 2025).

Percent Increase to Selected Industrial Production Indices due to the Unconventional Activity Value Chain



Source: IHS Economics

[8] http://www.bea.gov/newsreleases/industry/gdpindustry/2013/gdpind12_adv.htm

Beyond the unconventional oil and natural gas revolution contributions, there are a number of factors contributing to the resurgence in manufacturing placing the United States in a strong position to further expand its manufacturing base. 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 productivity levels 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.

As a result, the broad manufacturing renaissance is not purely a function of the unconventional oil and natural gas revolution. However, while it is important to recognize that these and other factors are contributing to a broad manufacturing renaissance in the US, they were not in the purview or scope of this study. The results presented in this study reflect the critical role that affordable and abundant energy is playing in the manufacturing renaissance—holding these other contributing factors constant.

The unconventional revolution's impact on US industrial production indices is captured in two ways. In what we call first-order impacts, lower natural gas prices, increased energy investment and production, and falling electricity prices have direct ramifications for many manufacturing industries that are major users of energy feedstock or are intense energy users. Major non-durable manufacturing sectors that will benefit include organic chemicals, fertilizers, resins, and plastics. Durable goods manufacturing sectors that will benefit include primary and fabricated metals, machinery and some non-metallic minerals products.

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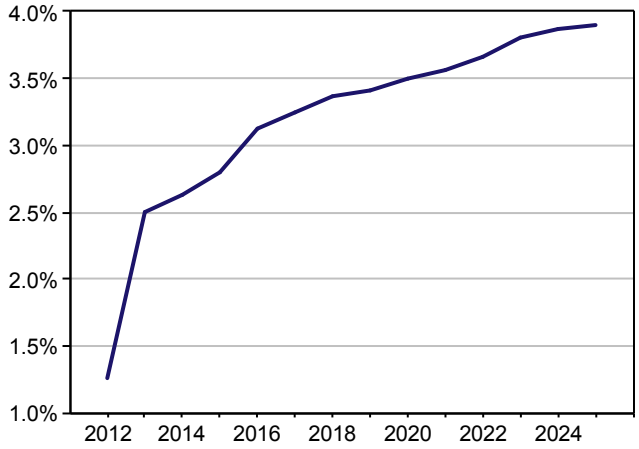
Second-order effects are captured across all manufacturing industries as the US economy continues to benefit from the unconventional oil and natural gas revolution. These effects include expansions in iron- and steel-product manufacturing and in fabricated metal-product manufacturing. Over the forecast period 2012-2025, improving cost competitiveness for domestic manufacturers will lead to increased US industrial production. The manufacturing industrial production index will be 2.8% higher in 2015 and is expected to be 3.5% higher in 2020 and 3.9% higher in 2025. In terms of value of output for the manufacturing sector, this increase is the equivalent of $258 billion in 2020 and $328 billion in 2025.

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

The dual effects of increases in aggregate demand (for example, consumers spending their higher disposable incomes on US-made products) and reductions in imports (for example, US petrochemical manufacturers increasing production) will drive increases in industrial production to a broad range of energy-intensive manufacturing industries such as organic chemicals, resins, agricultural chemicals, petroleum refining, metals, and machinery.

Risks to the Projected Economic Contributions

This study is based on a set of bottom-up resource build-outs that represent IHS Economics' current outlook for unconventional oil and natural gas production, capital expenditures, and operating expenses. It is consistent with the Base Case analysis presented in the first two volumes of this research series. The Base Case estimates the economic contributions associated with unconventional oil and natural gas activity from the 21 most significant existing or emerging unconventional oil and natural gas plays and includes both private and federal lands where drilling and extraction is taking place. However, one of the unique aspects of this unconventional revolution has been how it has unfolded predominately on state and private lands. In fact, federal lands comprise only about 10% of the resource assessment in these 21 existing or emerging unconventional oil and natural gas plays. Additional recoverable unconventional resources may exist in other onshore federal lands areas, but the inability to access a large portion of it for oil and natural gas drilling, make it impossible to fully and accurately characterize the resources base on these federal lands. It is also important to note that the analysis and resource projections assume the status quo with regard to existing policies and the regulatory framework—at a federal, state, and local level—governing unconventional oil and natural gas drilling and production.

However, there are risks as to whether the economic contributions associated with the Base Case developed for these studies will be realized. Production could be lower if regulatory or legislative changes are made to restrict unconventional oil and natural gas activity. This is particularly true despite the fact that the vast majority of this activity currently takes place on non-federal lands. Regulation at any level of oversight—by federal, state or local governments—has the potential to fundamentally alter the break-even economics of extraction, pace of development, or access to these energy resources. Therefore, to assess the potential downside risks associated with such a regulatory change, IHS developed an alternative Low Production Case. The Low Production Case estimates and then compares the broader impacts from more restrictive policies and regulatory frameworks that significantly reduce future unconventional production to the projected Base Case economic contributions.

This Low Production Case analysis is patterned after the National Petroleum Council's Severe Restricted Supply Scenario, as described in the topic papers of the 2011 US National Petroleum Council (NPC) study on Prudent Development of North American Oil and Gas Resources. In the NPC scenario, "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 Low Production Case in 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 exploration and production industry to access and develop unconventional hydrocarbon resources in the United States. 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, 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.

Low Production Case Implications

A contraction in production as a result of a Low Production Case would curtail capital expenditures and operating spending in the upstream industries. This, in turn, would flow through the entire unconventional oil and natural gas value chain, dampening its effects throughout the economy and slowing or reversing the manufacturing renaissance described in IHS' comprehensive analysis. Below we present the corresponding implications associated with a Low Production Case outcome relative to the Base Case.

The employment implications of regulatory or legislative restrictions are profound. IHS estimates that annual forgone employment—the result of moving from the Base Case to the Low Production Case—would mean more than 2.1 million fewer jobs in 2020. This reduction in employment would reach nearly 2.8 million in 2025. This would represent a 64% and 72% reduction in employment due to the unconventional oil and gas value chains and energy-related chemicals in 2020 and 2025, respectively, compared with the Base Case's employment forecasts for those years.

US Lower 48 Economic Contribution Summary due to the Unconventional Activity Value Chain: Difference between Base Case and Low Production Case*

Employment (Number of workers)	2015	2020	2025	2012-2025**
Low Production Case	1,471,343	1,209,353	1,100,904	NA
Base Case	2,888,218	3,336,055	3,874,415	NA
Difference	**(1,416,875)**	**(2,126,702)**	**(2,773,511)**	**NA**
Value Added (2012 $M)				
Low Production Case	269,170	292,647	232,260	NA
Base Case	396,999	468,427	532,884	NA
Difference	**(127,829)**	**(175,779)**	**(300,624)**	**NA**
Government Revenue (2012 $M)				
Low Production Case	74,642	84,512	66,024	1,080,608
Base Case	104,551	125,540	138,395	1,614,636
Difference	**(29,909)**	**(41,028)**	**(72,371)**	**(534,028)**

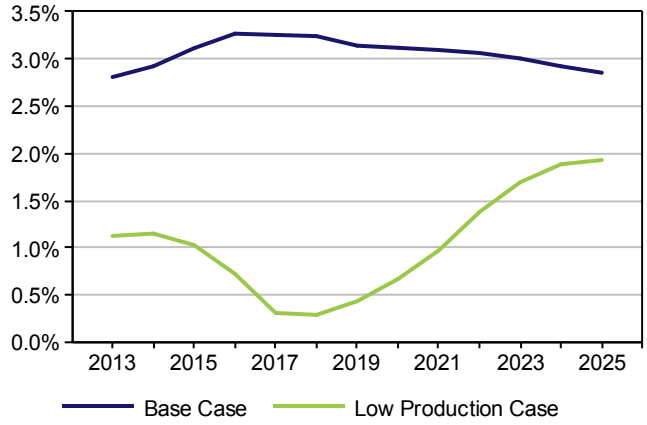
NOTES: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

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

Source: IHS Economics

IHS estimates that annual government revenues forgone by moving from the Base Case to the Low Production Case would be more than $41 billion in 2020 and over $72 billion in 2025. Over the entire forecast, governmental bodies would forgo more than $534 billion in cumulative revenues—or approximately 33% of the Base Case cumulative tax revenues. While the majority of these forgone revenues are the result of a decline in upstream activity, the cumulative forgone revenue from midstream and downstream energy activity is expected to exceed $30 billion; for the chemicals industry, forgone revenue is expected to reach $99 billion.

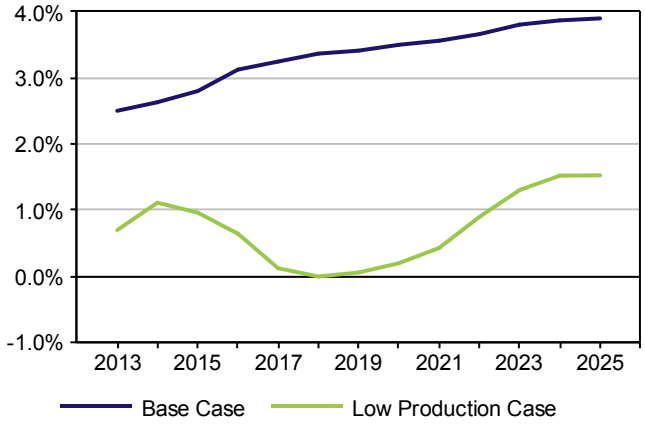
Change in Gross Domestic Product due to the Unconventional Activity Value Chain: Base Case versus Low Production Case*



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 Industrial Production Index due to the Unconventional Activity Value Chain: Base Case versus Low Production Case*

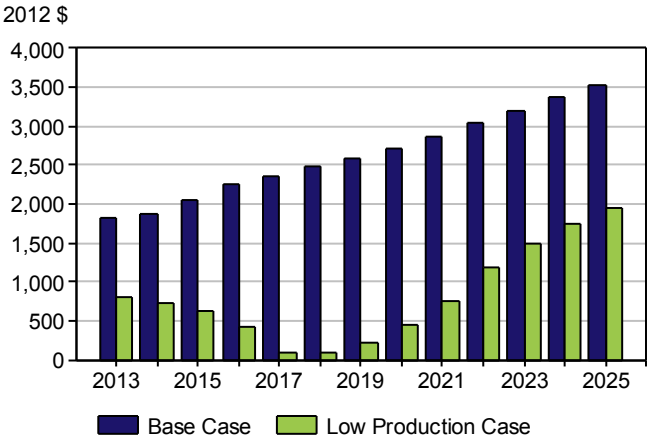


Note: *The unconventional activity value chain represents the sum of unconventional oil and natural gas value chains and energy-related chemicals.

Source: IHS Model of the US Economy

Similarly, the contribution of unconventional oil and natural gas activity to the overall economy would also contract if the Low Production Case played out. In the Base Case, the contributions to GDP peak around 3.3%, whereas under the Low Production Case contributions will not exceed 1.9%. Additionally, although the net trade benefits under the Base Case peak at $183 billion in 2022, the benefit from the Low Production Case, will peak at $92 billion—approximately half of the Base Case. While the contribution of unconventional oil and natural gas to the US industrial production index in the Base Case ranges from 1.5% to 5.0%, the Low Production Case's contribution will, at its peak, reach only 1.5%.

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

Finally, the impact on annual household disposable income is profound. Over the entire forecast interval, the average annual contribution to disposable income per household under the Base Case is roughly $2,600, whereas the average under the Low Production Case is $800—representing just 31% of the Base Case. By the end of the forecast interval in 2025, the impact on disposable income will become less pronounced as the broader economy begins to equilibrate under the new reality of the Low Production Case. Nevertheless, IHS still estimates that average annual household disposable income under the Low Production Case would be only 54% of the Base Case—$1,900 per year under the Low Production Case, versus $3,500 per year under the Base Case

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 still-evolving but transformative economic effects of this unconventional revolution. It extends our original economic assessment to include the full value-chain associated with the unconventional revolution—IHS has added the benefits from midstream, downstream, and energy-related chemicals activities to the prior upstream analysis—and explores how these profound developments are reshaping our macroeconomic outlook and contributing to a manufacturing renaissance brought about by improving 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 3.3 million by the end of the decade and almost 3.9 million by 2025. Annual GDP contributions will nearly double, from almost $284 billion in 2012 to almost $533 billion in 2025. Government revenues will average $115 billion annually and will grow by a total of more than $1.6 trillion over the 2012 to 2025 time frame.

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 per year in 2015 to more than $3,500 per year by 2025.

Equally impressive is the contribution to the manufacturing sector brought about by this unconventional oil and natural gas activity. A rapidly evolving energy landscape is unlocking in a new era of affordable and abundant energy for the US creating significant competitive advantages for both energy-intensive industries and industries that rely on natural gas derivatives as critical feedstock in production. And while a variety of factors have encouraged the renaissance under way in US manufacturing, the contributions quantified by our macroeconomic modeling demonstrate the significant role that the unconventional oil and natural gas revolution is playing in supporting this manufacturing renaissance today and in the future.