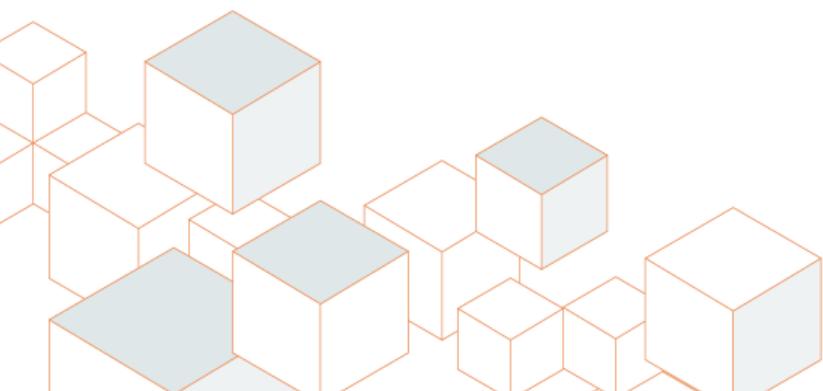


# The Rising Competitive Advantage of U.S. Plastics

Economics & Statistics Department  
American Chemistry Council

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## Executive Summary

- The surge of natural gas production from shale has reversed the fortunes of the U.S. plastics industry. Because the competitiveness of plastic resins depends on energy costs—in particular, the difference between oil and natural gas prices—shale gas development has changed the competitive landscape for U.S. plastics.
- Since U.S. producers predominantly use natural gas-based feedstocks, and European and Asian producers generally use oil-based feedstocks, the spread (difference) between feedstock prices is key to understanding the competitiveness of petrochemicals and plastics in different regions.
- Shale gas development and the abundance of natural gas liquids have shifted the competitive advantage toward the U.S. even after recent oil price declines.
- Companies are capitalizing on the U.S. shale advantage. ACC is tracking more than \$130 billion dollars of new investment in chemical manufacturing capacity that has been announced (since 2010) to be put in place over the next decade. Based on ACC's analysis:
  - Nearly \$25 billion of investments in new plastic resin capacity is expected.
  - Investments of \$2.5 billion will be made to increase capacity in plastics compounding, additives and colorants, which are used to impart specific properties to resins so they can be used to make plastic products.
  - New plastic products capacity will be built to consume plastic resin that is not exported. These investments will total \$19.6 billion.
  - The combined output from the new investments in resin, compounding and ancillary chemistries (additives, colorants, etc.) and products will be \$46.8 billion.
- Based on ACC analysis, when these investments come online over the next decade:
  - The plastics industry is expected to directly generate a total of 127,500 jobs.
  - Through supply chain impacts, an additional 172,900 indirect jobs will be supported in the industries that supply materials, utilities, parts and services.
  - Workers in the plastics industry and its supply chain will be paid \$19.1 billion which will be spent largely in local communities, supporting local employment. Thus, an additional 161,000 payroll-induced jobs will be supported from the gain in shale-advantaged plastics industry output.
  - A combined 461,800 direct, indirect and payroll-induced new jobs will be created due to shale-advantaged production.
- Many of the new investments are export-oriented. Recent work by Nexant Consulting<sup>1</sup> found that between 2014 and 2030, net plastic resin exports will more than triple, rising nearly \$15 billion from \$6.5 billion to \$21.5 billion.
- During the peak year of investment ACC's analysis found that nearly 100,000 total jobs will be supported by the build-out of the U.S. plastics industry.
  - Nearly 30,000 of those jobs will be in construction and capital equipment manufacturing industries.
  - Additionally, 29,000 supply-chain jobs and 37,600 payroll-induced jobs will be generated in local communities throughout the country.

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<sup>1</sup> See <http://www.americanchemistry.com/Policy/Trade/Fueling-Export-Growth-US-Net-Export-Trade-Forecast-for-Key-Chemistries-to-2030.pdf>

- An additional 5,100 jobs will be created in the manufacturing of plastic-making machinery, equipment and molds.

## Introduction

Shale gas development has reversed the fortunes of the U.S. plastics industry. Because the competitiveness of plastic resins depends on energy costs—in particular, the difference between oil and natural gas prices—the surge of natural gas production from shale has changed the competitive landscape for U.S. plastics. A decade ago, the U.S. was among the highest-cost producers and now it is one of the lowest-cost producers globally. As a result, there has been a flood of new investment in U.S. plastics capacity announced since 2010. New factories are being built to produce more plastic resins, and about half of that new resin production will be exported. In addition, with newly-available supplies of low-cost resin, producers of plastic products are building new production facilities. To support growing plastic products manufacturing, new capacity for plastics compounding, additives, and colorants is also under construction. As these factories become operational over the next decade, the U.S. plastics industry is expected to boost employment and spending in local communities. Additionally, while these new factories are being built and equipped, there is expected to be job growth in the construction trades, as well as increased manufacturing of capital equipment, such as specialized plastics processing equipment and injection molds. Thus, the competitive advantage shale gas production brings to U.S. plastics manufacturing is expected to generate significant economic benefits and contribute to the manufacturing renaissance that is building in the United States. And, in a virtuous cycle, as the manufacturing renaissance accelerates, demand for plastic products will be generated, reinforcing resin demand.

This analysis attempts to quantify the economic impacts associated from announced investments in shale-advantaged chemicals and plastic resins, including the expected impact on downstream plastics compounders, manufacturers of plastic products and makers of ancillary chemistries, such as plastics additives, colorants, etc. The analysis reflects announced investments through the end of March 2015. Notes on the data and analytical approach are provided at the end of the report.

## Energy: The Foundation for Plastic Resins

The raw materials for most plastic resins are found in fossil fuels, predominantly natural gas and oil resources. While an increasing share of plastic resins are made with bio-based materials from plants and algae, fossil fuels continue to provide the vast majority of hydrocarbon raw materials, called feedstocks, for plastic resins. These feedstocks are broken down to create the building blocks that are recombined into plastic resins. Nearly three-quarters of U.S. plastic resin feedstock is derived from natural gas and natural gas liquids (NGLs). Roughly a quarter of feedstock comes from petroleum-based feedstocks. Feedstocks from natural gas liquids include ethane and propane that are especially important for petrochemical (and plastic resin) manufacturing.

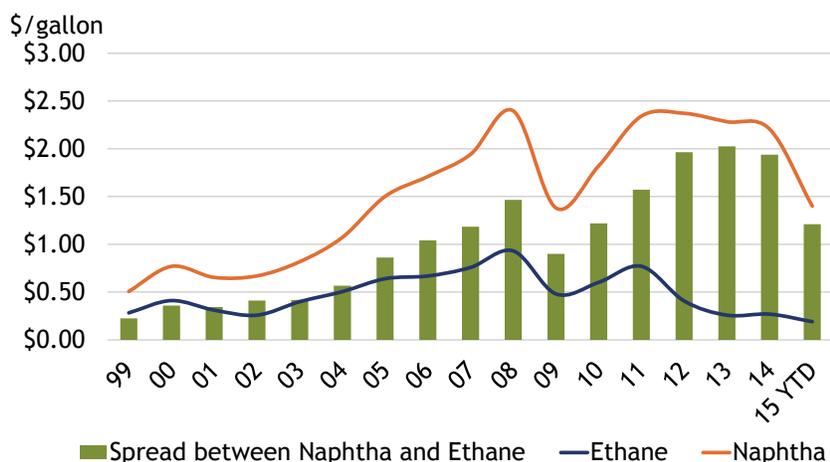
There are several key building block chemicals that are used to produce plastic resins. These building block chemicals are linked together to form long chains called polymers. Each polymer has its own portfolio of performance characteristics (i.e., strength, permeability, etc.). One of the most prevalent and largest-volume building block chemicals is ethylene. Ethylene is used to produce thousands of products, including plastic resins such as polyethylene (PE), polyvinyl chloride (PVC),

and polyethylene terephthalate (PET). In 2014, the U.S. produced nearly 25 million metric tons of ethylene, which is expected to grow in the years to come. The reason is simple: because of shale gas, it is more cost effective to produce ethylene in U.S. than just about anywhere else in the world.

Another important building block chemical for resin production is propylene. Until recently, most propylene was produced in oil refineries as a byproduct of fuel production. With shale gas, supplies of propane (a natural gas liquid) have become abundant. New technologies have emerged to convert propane into propylene which, like ethylene, has many uses, including the resin polypropylene (PP).

Because energy resources—which account for up to 70% of total costs for plastic resin producers—are the primary raw materials to make plastic resins, the price of energy feedstocks is critical to the global competitiveness of plastic resin producers. In the case of ethylene, ethane is the predominant feedstock in the U.S. In Europe and Asia, producers use naphtha, an oil-based feedstock. Ultimately, because the price of ethylene is effectively the same across the world, the competitiveness of one region over the other depends on the relative price of these feedstocks. Thus, the spread (difference) between naphtha and ethane prices is key to understanding petrochemical competitiveness, as shown in Figure 1.

**Figure 1 - Divergence between Naphtha and Ethane Prices Key to North American Petrochemical Competitiveness**



Sources: US Energy Information Administration, Chemical Week, ICIS

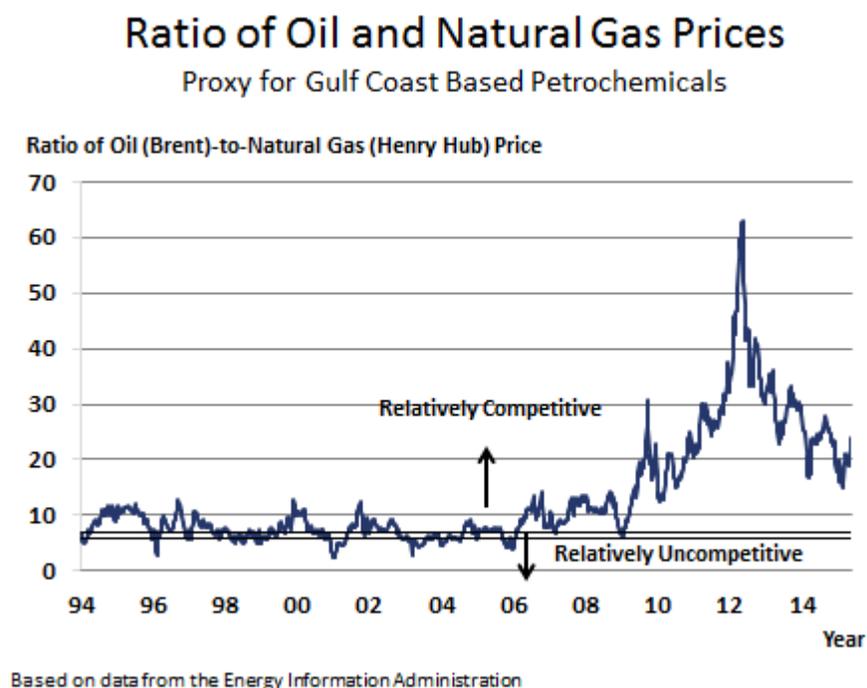
Because North American ethylene producers predominantly use natural gas-based feedstocks and European and Asian producers generally use oil-based feedstocks, the ratio of the benchmark price of oil (Brent<sup>2</sup>) to the price of natural gas (Henry Hub<sup>3</sup>) serves as a real-time proxy for competitiveness, as ethane and naphtha prices are not always readily available. As shown in Figure 2, a rough rule of thumb is when the ratio falls *below* 7, production of ethylene (and its resin derivatives) in North America is relatively disadvantaged, as was the case during much of the 2000s. When the ratio rises *above* 7, however, North American petrochemicals are relatively advantaged. Recent development of

<sup>2</sup> As oil is a globally traded commodity, Brent provides a well-known benchmark for global crude oil prices.

<sup>3</sup> The Henry Hub is a key distribution hub located in Erath, Louisiana. The trading price at the Henry Hub is a well-known benchmark for U.S. natural gas prices.

shale formations has enabled new low-cost supplies of natural gas, substantially improving the competitiveness of U.S. plastic resins compared to Europe and Asia. Despite recent lower oil prices, a competitive advantage persists: through the first quarter of 2015, the ratio of oil-to-natural gas was above 15.

Figure 2 - Proxy for U.S. Gulf Coast Based Petrochemical Competitiveness



In addition to natural gas, several large shale formations in the U.S. are rich with natural gas liquids, including the Marcellus and Utica shales in the Appalachian region and the Eagle Ford shale in Texas. The growing abundance of these liquids and the infrastructure to move them from fields to factories underlies the competitive advantage of U.S. chemical and resin producers.

## Competitive Advantage Returns to U.S. Plastics

The favorable relationship between oil and natural gas prices and the abundance of natural gas liquids has reshaped U.S. petrochemical competitiveness and, ultimately, the competitiveness of U.S. plastic resins within the global marketplace. As of early 2015, the U.S. remains the lowest cost ethylene producer after the Middle East and Canada. To capitalize on the U.S. shale advantage, more than \$130 billion dollars of new investment in chemical manufacturing capacity has been announced, including nearly \$25 billion of investments in new plastic resin capacity. For example, capacity to produce polyethylene, the most advantaged of the resins, is expected to grow by more than half over the next decade.

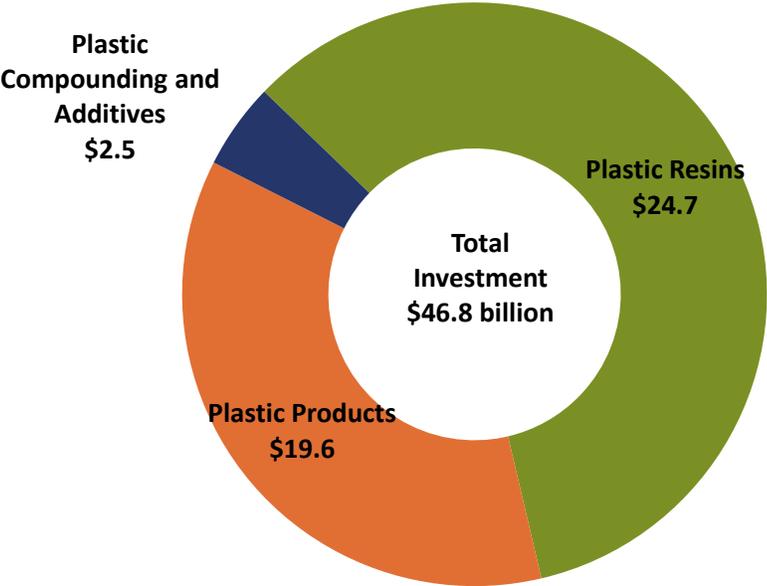
Many of the new investments in resin manufacturing capacity are export-oriented. Recent work by Nexant Consulting<sup>4</sup> found that between 2014 and 2030, net plastic resin exports (the trade surplus)

<sup>4</sup> See <http://www.americanchemistry.com/Policy/Trade/Fueling-Export-Growth-US-Net-Export-Trade-Forecast-for-Key-Chemistries-to-2030.pdf>

will more than triple, rising nearly \$15 billion from \$6.5 billion to \$21.5 billion. The report found that the gain in exports will be driven largely by polyethylene and PVC, two resins derived from shale-advantaged ethylene. The impact of lower-cost natural gas on PVC is twofold: in addition to ethylene, PVC contains chlorine, which is produced with large amounts of natural gas-generated electricity; when there is an abundance of natural gas, electricity prices decrease.

As new resin capacity comes online over the next decade, about half of the output of the new resin production is expected to be exported to foreign markets in Asia, Latin America and Europe. As a result, the trade surplus in plastic resins will continue to expand.

**Figure 3 - Announced and Expected Plastics Industry Investment Motivated by Shale Gas Advantage (\$ billions)**



### Gains to U.S. Plastics Manufacturing

While half of new resin production will be exported to foreign markets, domestic plastic processors also will benefit from expanded production of advantaged resin: more than 400 projects to build or expand plastic processing capacity in the U.S. have been announced since 2012. These announcements represent only a fraction of the new capacity that will be needed to convert advantaged resin into useful products. Over the next decade, a total of \$19.6 billion of plastic processing capacity is expected to be built to increase the capacity to manufacture plastic products from new supplies of domestically-sourced plastic resin. This is on top of the \$24.7 billion of investment to increase plastic resin capacity.

In addition, demand for plastic compounding and other chemistry used in plastic products manufacturing, such as plastic additives (e.g., plasticizers, UV stabilizers) and colorants is expected to increase: nearly \$2.5 billion in new capacity is expected from this expansion of ancillary plastics-processing chemistry. All told, nearly \$47 billion in investment is expected to be put in place over the next decade as resin producers and processors take advantage of renewed competitiveness.

## Economic Impacts of New Plastics Manufacturing Activity in the U.S.

As new production comes online over the next decade, resin producers are expected to add more than 12,000 jobs to the existing 56,000 already employed in plastic resin manufacturing, representing a 22% gain in employment levels. In addition, 5,000 jobs are expected to be generated by compounders and manufacturers of plastic additives, colorants, and other ancillary chemistry. Finally, the plastic products manufacturing industry is expected to add 110,000 jobs. Thus, the output from new investments in plastic resins, compounders/ancillary chemistry and products is expected to grow payrolls by more than 127,000 jobs (Table 1).

New production from manufacturers of plastic resins, plastic processing materials, and converted plastic products is expected to generate demand for products and services along the supply chain. Nearly 173,000 new indirect jobs are expected to be supported by suppliers (materials, utilities, parts, and services) to the plastics industry. New plastics industry workers and workers along the supply chain are expected to earn payrolls in excess of \$19 billion. Largely, these wages likely will be spent in local communities supporting jobs in health care, education, retail, services, and more. The shale-motivated build-out of the plastics industry is expected to support more than 161,000 new payroll-induced jobs across all sectors of the economy. At the end of the day, barring any regulatory disruptions or other challenges, a total of more than 460,000 new jobs will be supported by production of shale-advantaged plastic resins, plastic products and related investments. The chart below (Table 1) includes figures for jobs, payroll, economic output and investments. To eliminate the effects of inflation, dollar values are presented in 2013 dollars.

**Table 1 - Economic Impact of *Incremental* Expansion of Plastic Resins, Products and Additives Due to Shale Gas (\$2013)**

	<u>Jobs</u>	<u>Payroll</u> (\$ mill)	<u>Output</u> (\$ mill)	<u>Investment</u> (\$ mill)
<b>Direct Impacts</b>				
Plastic Resins	12,400	\$1,100	\$22,700	\$24,700
Plastic Products	110,100	\$5,200	\$41,400	\$19,600
Plastic Compounding, Additives, etc.	5,000	\$300	\$3,200	\$2,500
<b>Total Plastics Industry</b>	<b>127,500</b>	<b>\$6,600</b>	<b>\$67,300</b>	<b>\$46,800</b>
<b>Indirect Impacts<sup>5</sup></b>	<b>172,900</b>	<b>\$12,400</b>	<b>\$71,800</b>	<b>n/a</b>
<b>Payroll-Induced</b>	<b>161,400</b>	<b>\$7,800</b>	<b>\$27,800</b>	<b>n/a</b>
<b>Total</b>	<b>461,800</b>	<b>\$26,800</b>	<b>\$167,000</b>	<b>n/a</b>

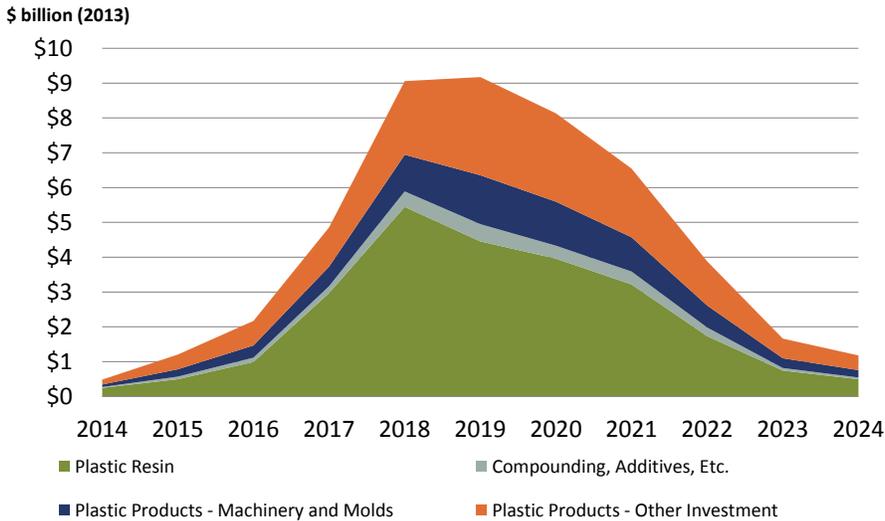
## Economic Impacts of Construction and Equipment Manufacturing

The economic activity generated during the construction phase is also significant. In the locales that build new manufacturing capacity for plastic resins, products and/or ancillary production, there are expected to be substantial, though temporary, economic impacts. Especially in the case of plastic

<sup>5</sup> Adjusted to avoid double-counting.

resin investment, these are large capital projects that require several years to plan, build and equip before production begins. Figure 4 shows the expected wave of investment in the plastics industry. The peak in plastic resin investment is expected to occur in 2018 with investment in ancillary chemistry and products manufacturing to peak in 2019. To account for the economic impact across all segments, for the purposes of this report, the “peak year” is defined as the annual average investment occurring between 2018 and 2020. See “Data and Approach” section for more details.

**Figure 4 - Anticipated Wave of Plastics Industry Investment by Segment**



During the peak year of investment activity, nearly 30,000 jobs will be supported in construction and capital equipment manufacturing across the building plastic resins, compounding and additives, and plastic products. Capital equipment manufacturing includes a variety of equipment and materials such as metal pipe, autoclaves, valves, pumps, computer equipment, transportation equipment, specialized plastics-making equipment and injection molds. During the peak year, 12,700 workers are expected to be employed in building new plastic products manufacturing capacity. Of these, 5,100 will be in the manufacture of specialized plastics-making machinery, equipment, and molds for injection-molding equipment. An additional 7,600 jobs will be supported in construction and other related capital equipment manufacturing. The supply chain of these builders and equipment manufacturers is expected to support an additional 29,000 jobs, with the wages paid to these workers supporting an additional 37,600 jobs in local communities. These impacts are shown in Table 2.

**Table 2 - Annual Economic Impact During Peak Investment Year (\$2013)**

	<u>Jobs</u>	<u>Payroll</u> (\$ mill)	<u>Output</u> (\$ mill)
<b>Direct Impacts from Investment in New Capacity</b>			
Plastic Resins	15,700	\$1,260	\$4,100
Plastic Compounding, Additives, etc.	1,500	\$110	\$400
Plastic Products	12,700	\$960	\$3,100
<i>Plastic-making machinery, equipment and molds</i>	<i>5,100</i>	<i>\$390</i>	<i>\$1,300</i>
<i>Other plastic products investment</i>	<i>7,600</i>	<i>\$570</i>	<i>\$1,800</i>

Total Direct	29,900	\$2,330	\$7,600
Indirect Impacts	29,000	\$2,000	\$7,200
Payroll-Induced	37,600	\$1,900	\$5,900
Total	96,500	\$6,230	\$20,700

## The Manufacturing Renaissance Will Increase Demand for Plastics

In addition to low-cost energy, rising wages in overseas factories, higher transportation costs, and supply chain concerns have made manufacturing in the U.S. more competitive than other parts of the world. Without access to low cost natural gas and NGLs from shale, domestic resin producers would have remained relatively uncompetitive and the higher cost of plastic resins and finished plastic products would have continued the trend of offshoring, further eroding the U.S. manufacturing base. However, that trend is being reversed. Companies that have been manufacturing abroad are returning to the U.S., and new manufacturing is increasingly being located in the U.S.

## Conclusion

The development of shale gas is enabling the U.S. to transition from a time of relatively scarce natural gas to one of abundance. The plastics industry, in particular, is poised for a revival as the U.S. has become a low-cost producer of one of the plastics industry’s chief raw materials – ethylene. The abundance of natural gas and natural gas liquids has attracted huge investments in new plastic resin capacity. And since plastic resins must be processed—and may need additives to achieve desired properties—before become a plastic product, new capacity will be needed in related industries such as plastic resin compounding, additives and colorants, in addition to plastics-making machinery, equipment and injection molds.

Significant economic benefits and job growth also are expected over the next decade, stemming from the construction of these new factories and the production of equipment that will be used in them. As the plants are built and come online, the economic activity generated by the increased output of plastic resins, compounding, additives, colorants, and plastic products will generate new employment, supporting hundreds of thousands of jobs along the supply chain and through the household spending of those workers. All told, the effects of the manufacturing renaissance on the U.S. plastics industry will be substantial and far-reaching.

## Data and Approach

### *Incremental Investment and Output*

ACC tracks chemical industry investment based on actual project announcements rather than conjecture of potential capital spending. The data are based on publicly available information, which is believed to be accurate, but have not been independently verified by ACC. Using this data, ACC estimated the amount of plastic resin investment and expected output based on expected use of monomers produced from announced investments for ethylene and propylene. About half of the incremental plastic resin production is expected to be exported, with the remaining half available to the domestic plastic products industry. Based on the relationship between resin consumption and plastic products output, an estimate of the incremental plastic products output was developed. In addition, it was assumed that incremental capacity for “ancillary chemistries” (additives, colorants, etc.) would be built to complement the resin used in the U.S. plastic products industry. With expected output gains for the plastic products and the ancillary chemistries, estimates of the value of investment were made using investment-to-output ratios derived from data from the Bureau of Economic Analysis and the Census Bureau. In the case of the investment in new plastic products capacity, the investment in plastics industry equipment and molds were separately estimated taking into account that a significant portion of these are already imported (and not made in the U.S.).

To eliminate the effects of inflation, all dollar values are presented in 2013 dollars (\$2013).

### *Economic Impacts*

To estimate the broader economic impacts, the analysis was split into two components: the economic impact from the increased output of plastic resins, products and ancillary chemistries and the economic impact that occurs during the investment phase. The former are sustained economic impacts from a rise in the level of production while the latter are temporary.

The IMPLAN<sup>6</sup> economic model was employed to estimate the indirect (supply chain) and payroll-induced impacts. The IMPLAN model also was used to develop the direct impacts during the investment phase. IMPLAN is an example of an input-output model, a quantitative economic technique that quantifies the interdependencies between different industries (or sectors) of a national economy. Although complex, input-output models are fundamentally linear in nature and, as a result, facilitate rapid computation as well as flexibility in calculating the economic effects of changes in demand. In addition to studying the structure of national economies, input-output analysis has been used to study regional economies within a nation and as a tool for national and regional economic planning. A primary use of input-output analysis is to measure the economic impacts of events, public investments or programs such as base closures, infrastructure development, or the economic footprint of a university or government program. The IMPLAN model is used by the Army Corps of Engineers, Department of Defense, Environmental Protection Agency, and over 20 other agencies, numerous government agencies in over 40 states, over 250 colleges and universities, local governments, non-profits, consulting companies, and other private sector companies.

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<sup>6</sup> [www.implan.com](http://www.implan.com)

### *Economic Impacts from Increased Output of Plastics*

The direct impacts including employment, payroll, and output were derived from 2013 and 2014 data from the Census Bureau and Bureau of Labor Statistics. Using information about growth in output estimated above and trends in productivity, estimates were made for the incremental employment gain in each segment. Indirect and payroll-induced impacts were developed using the IMPLAN model.

Because of the inherent double counting of the supply chain (and subsequently, payroll-induced impacts) between the plastic resin sector, compounding and additives, and plastic products sectors, these segments were modeled using an adjusted industry spending pattern approach where the inputs from plastic resins, compounding, and additives segments were set to 0. Thus, the cumulative results avoid double counting along the supply chain.

### *Economic Impacts during the Investment Phase*

Because these investments are taking place over a decade, modeling the impact of the full investment in a one-year period leads to misleading results. For example, imagine a hypothetical investment that will be spread out over 5 years and that investment results in one welder being employed full-time for 5 years. Modeling that investment over a one-year period will suggest enough work for 5 welders which is quite a different impact than one welder over 5 years. The peak in plastic resin investment is expected to occur in 2018 with investment in ancillary chemistry and plastic products manufacturing to peak in 2019. To examine the economic impact across all segments, the average investment occurring between 2018 and 2020 was used as the “peak year” on which to model the economic impacts during the investment phase.

The allocation of the investment to the construction and capital goods manufacturing industries used to drive the IMPLAN model was derived by using the fixed asset data through 2013 from the Bureau of Economic Analysis.

## ACC Economics and Statistics Department

The Economics & Statistics Department provides a full range of statistical and economic advice and services for ACC and its members and other partners. The group works to improve overall ACC advocacy impact by providing statistics on American chemistry as well as preparing information about the economic value and contributions of American chemistry to our economy and society. They function as an in-house consultant, providing survey, economic analysis and other statistical expertise, as well as monitoring business conditions and changing industry dynamics. The group also offers extensive industry knowledge, a network of leading academic organizations and think tanks, and a dedication to making analysis relevant and comprehensible to a wide audience. The lead author of this report was Martha Gilchrist Moore.

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