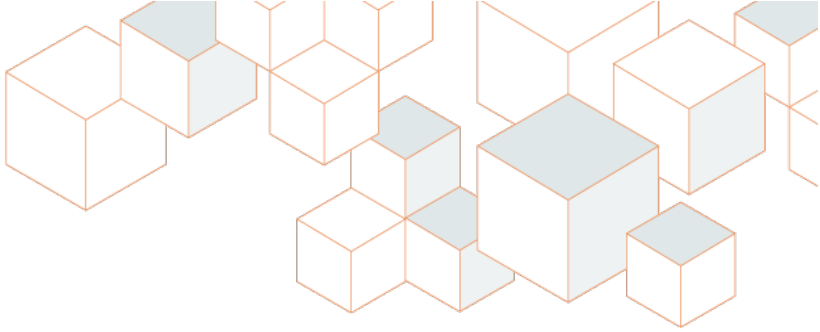

The Economic Benefits of Industrial Gases

Economics & Statistics Department
American Chemistry Council
December 2015

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EXECUTIVE SUMMARY

The American industrial gas industry provides essential products to manufacturers, innovators and service providers that help drive the U.S. economy. Using advanced technologies, industrial gas companies supply gases like oxygen, nitrogen and hydrogen to industries such as manufacturing, health care and transportation. Industrial gases enable us to have safe drinking water, cleaner fuels for our cars, and efficient energy production.

From fuel in NASA's space shuttles to filling up balloons at a child's birthday party, industrial gases constitute a very significant industrial sector of the U.S. economy. The industry directly contributes to the U.S. economy with $12.2 billion in shipments (output), more than 60,000 jobs, and an annual payroll of $5.6 billion.

The contributions of the industrial gas industry go well beyond its direct economic footprint. Looking upstream at suppliers, the economic output of the industrial gas industry fosters indirect economic activity through its purchases and through the payrolls paid by the industry itself and its suppliers. This, in turn, leads to induced economic output as well. As a result, each job in the industrial gas industry generates an additional 2.1 jobs elsewhere in the U.S. economy, and $24.3 billion in additional upstream output.

Moreover, the economic contributions of industrial gases extend downstream to customers. Industrial gases are essential to a multitude of industries, most significantly health care and manufacturing. The industrial gas industry supports over $4 trillion in downstream economic output – a quarter of U.S. GDP - and over 115 million workers in downstream customer industries.

Table 1 - Economic Impact of Industrial Gases

	Employment	Payroll ($ billion)	Output ($ billion)
Direct	61,200	$5.6	$12.2
Indirect	49,100	$3.4	$11.8
Induced	78,500	$3.9	$12.5
Total	188,800	$12.9	$36.5

THE U.S. INDUSTRIAL GAS INDUSTRY

Industrial gases include elements that are all around us, most notably in the air we breathe. Two key industrial gases— nitrogen and oxygen— together make up nearly 99% of the earth's atmosphere. Other atmospheric gases include argon (less than 1%) and very small quantities of krypton, neon, and xenon. In addition to atmospheric gases, industrial gases include gases that are produced via synthesis or separation from other materials. These so-called process gases include acetylene, nitrous oxide and carbon monoxide, as well as hydrogen, carbon dioxide and helium which, while they are found in air, do not occur in sufficient quantities and must be produced from other sources. Flourocarbon gases, which are used as refrigerants and as precursor chemicals to fluoropolymers, are included in some definitions of industrial gases. However, these gases, along with fuel gases, such as propane and butane are not manufactured by ACC's Industrial Gases Panel members and have therefore been excluded from this analysis.

While evidence shows that humans have been using industrial gases for years, these gases were not identified until the late 18th and early 19th century. The industrial gas industry took hold nearly a century later with the advent of air separation technologies which allowed atmospheric gases to be isolated and extracted in pure form. The earliest commercialized used of industrial gases was in refrigeration and ice production, as well as in beverage carbonation.

Today industrial gases remain essential to the food and beverage industry: modern refrigeration still relies on industrial gases. However, industries gases play a pivotal role in a multitude of other industries and products either directly or indirectly. From watching television—industrial gases are used in plasma TV screens—to getting a CAT (Computed Axial Tomography) scan, industrial gases are critical to modern life.

Production

Industrial gases can be produced in a variety of ways, each with its own technology and market dynamics. Atmospheric gases are produced via air separation, a suite of technologies to separate the constituent gases in the air we breathe (this is why industrial gases are also referred to as "air separation gases"). The largest volumes of atmospheric gases are produced from cryogenic distillation of air, a process in which compression and temperature are used to change the air into a liquid state, allowing the elements to be separated. Non-cryogenic processes, such as membrane separation or adsorption technologies, are also used, generally to produce smaller, less pure quantities.

Some industrial gases, such as hydrogen and acetylene, are produced from hydrocarbon feedstocks (e.g., liquefied petroleum gas, methane, naphtha). Gases are also produced as by-products of other chemical processes. Again, hydrogen is an example as it is co-produced with chlorine production and catalytic reforming processes in refineries. Some gases, such as helium, come from the mining sector where they a component in some natural gas deposits.

The industrial gas industry is one of the most capital-intensive in the chemical industry. While air, the primary feedstock, is free and available in abundance there are substantial energy costs associated with an air separation plant. Industrial gas manufacturing is concentrated among five

large companies (listed alphabetically), Air Liquide, Air Products and Chemicals, Linde, Matheson Tri-Gas and Praxair.

Distribution

In addition to manufacturing, the distribution of industrial gases contributes significantly to the industry's economic footprint. Transportation of industrial gases can be expensive and the physical properties of industrial gases often need specialized shipping containers. Some industrial gas manufacturers offer storage and distribution as part of their business, while there are also non-manufacturing companies that specialize in distribution.

Industrial gases are distributed via various transportation channels, depending on the physical properties of the gas, like critical temperature and pressure, and the quantity of product. Most distribution is either over-the-road or by pipeline. Distribution is generally regionally focused, due both the cost as well as the nature of some products. As such, there is limited international trade in the industrial gas market (most imports and exports are between the U.S. and neighboring countries).

Some large customers take delivery of industrial gases that have been compressed into liquid form (thus saving space) and transported in large cylinders by truck or rail. To serve smaller customers, industrial gases are filled into smaller cylinders and distributed to customers in the health care, retail, and welding markets. For industries that consume large volumes of industrial gases, such as manufacturing and health care, air separation units may be co-located with the customer site, or very close to the site of consumption and linked by pipeline. On-site production is also useful for gases, such as acetylene, that are hazardous to transport in large quantities.

End-Use Markets

Industrial gases are primary inputs in the processes and products of many industries and, as such, contribute significantly to the U.S. gross domestic product (GDP). Table 2 highlights select end-use markets of the industrial gases.

Table 2: Select End-Use Markets of Industrial Gases

Research & Development

The chemical industry in the United States is consistently one of the largest private-sector industry investors in research and development (R&D). R&D spending includes research in the sciences, engineering and the design and development of prototype processes and products. (Spending for product testing, technical servicing, market research, and other non-technological activities is excluded.)

Industrial gas companies invest more than $100 million each year on R&D to develop new and improved methods to produce and distribute industrial gases. In addition, industrial gas companies perform R&D to develop new applications and markets for their products. R&D activities are critical to the continued competitiveness of companies is the industrial gas industry.

Capital Expenditures

Industrial gas manufacturing in extremely capital intensive, in that it requires large and sophisticated pieces of equipment to separate, purify, and store industrial gases. The industry spends nearly $1 billion per year on new plant and equipment. This pace of investment is set to increase in the years ahead as new industrial gas capacity has been announced in response to new capacity in petrochemical manufacturing to take advantage of shale gas in the U.S. At the end of 2015, at least 20 new or expanded air separation units have been announced.

Electricity Consumption

In addition, the industry uses tremendous amounts of electricity to cool and/or heat gases for separation and purification, and storage. One of the most electricity-intensive industries, industrial gas manufacturers annually purchase 20 billion kilowatt hours of electricity to fuel their processes. Electricity purchases amount to nearly $1.1 billion and represent a significant cost to industrial gas manufacturers.

ECONOMIC SNAPSHOT OF THE INDUSTRIAL GAS INDUSTRY

The industrial gas industry is a significant contributor to the U.S. economy. In 2014, the industrial gas industry produced and distributed more than $12.2 billion industrial gas products. The manufacturing segment employed 17,100 while another 36,800 were engaged in wholesale and distribution activities. Finally another 7,300 industrial gas employees were engaged in management and research and development activities. Together, the industry generated $5.6 billion in payrolls spent in local communities.

In addition, the industrial gas industry made significant investments in both physical capital (i.e., plants and equipment) and innovation. Capital expenditures to expand capacity and replace equipment totaled nearly $1 billion. The industry invested around $100 million in research and development to improve manufacturing processes and develop new applications for industrial gases.

The industrial gas industry also contributed to government tax revenues through a variety of mechanisms, including income taxes, payroll taxes, property taxes, sales and use taxes, etc. At the Federal level, these tax revenues amounted to $1.5 billion. At the state and local level, the industrial gas industry contributed $1.3 billion in tax revenues.

Table 3 – Economic Snapshot of the Industrial Gas industry

	Employment	Payroll ($ billion)
Industrial Gas Manufacturing	17,100	$1.8
Distribution/Wholesale	36,800	$2.9
Management/R&D	7,300	$1.0
Total	**61,200**	**$5.6**

	($ million)
Industry Shipments/Output	12,216
Federal Tax Revenues	1,452
State & Local Tax	1,284
Capital Expenditures	950
R&D Spending	100
Electricity Purchases	1,096

ECONOMIC CONTRIBUTIONS OF THE U.S. INDUSTRIAL GAS INDUSTRY

Upstream Economic Impact

The economic contributions of the U.S. industrial gas industry are numerous, extending well beyond the direct jobs and output of the industry. In addition to the jobs created directly by the industry, additional jobs are supported by industrial gas industry and by the subsequent expenditure-induced activity (i.e., "upstream impact"). The industrial gas industry paid its employees' wages and salaries and purchased supplies and services (including transportation, contract workers, warehousing, maintenance, accounting, etc.); these supplier businesses, in turn, made purchases and paid their employees. Thus, the industrial gas industry generates several rounds of economic spending and re-spending.

In addition to the direct effects of the U.S. industrial gas industry, the indirect and induced effects on other sectors of the economy can also be quantified. The economic impact of an industry includes:

Direct Impacts

- Employment, wages and output of the industry being analyzed; in this case, the manufacture and distribution of industrial gases.
- Also included are associated company management and research and development activities.

Indirect Impacts

- Jobs, wages and output created by the businesses that provide goods and services essential to the industry.
- These businesses range from manufacturers (who make goods) to wholesalers (who deliver goods) to janitorial firms who clean the buildings.

Induced Impacts

- The result of the spending of wages and salaries of the direct and indirect employees on items such as food, housing, transportation and medical services.
- This spending creates induced employment in nearly all sectors of the economy, especially service sectors.

The economic contributions of the industrial gas industry were analyzed using an economic input-output model, IMPLAN.[1] This method estimates the total contributions of an industry to the economy at the state and national levels for a given year. The economic contributions analyzed in this report are employment, payroll and output in the U.S. for the year 2014. For the purpose of this analysis, the industrial gas industry includes both manufacturing and distribution.

[1] IMPLAN (IMpact analysis for PLANning) is a complete economic assessment package providing economic resolution from the National level down to the zip code level; MIG Inc. is the sole licensor of IMPLAN.

The output and employment directly generated by the businesses that manufacture and distribute industrial gases are significant. These businesses directly employed more than 61,000 workers, with $5.6 in payroll, and $12.2 billion in annual output.

Upstream, the businesses that produce and distribute industrial gases purchase raw materials, services, and other supplies throughout the supply chain. Thus, an additional 49,000 jobs are supported by the industrial gas industry supply chain. Finally, the wages earned by workers in the industrial gas industry and those throughout the supply chain are spent on household purchases and taxes generating more than 78,000 payroll-induced jobs. All told, the $12.2 billion in output of the industrial gas industry generates an estimated $36.5 billion in output to the economy and nearly 190,000 jobs in the United States, with a payroll of $12.9 billion. In addition, the industrial gas industry directly contributes $1.5 billion in Federal tax revenues and another $1.3 billion at the state and local level.

Table 4 – Upstream Economic Impact of Industrial Gases

	Employment	Payroll ($ billion)	Output ($ billion)
Direct	61,200	$5.6	$12.2
Indirect	49,100	$3.4	$11.8
Induced	78,500	$3.9	$12.5
Total	188,800	$12.9	$36.5

Downstream Economic Impact

Industrial gases support the U.S. economy, not only through the economic activity generated by their business activities, but in the value added to the economy by industries that depend on industrial gases to produce products and services. Consumers of industrial gases include a large and diverse portfolio of industries in the U.S. and the applications in which industrial gases are used are manifold. Since each industrial gas is used for its specific physical and chemical properties, they impart unique chemical properties to various processes and products and thus, cannot be easily substituted.

Table 5 - Economic Contributions of Industrial Gas Customer Industries

	Employment (thousands)	Payroll ($billions)	Value-Added ($billions)
Manufacturing	**9,897**	**656.3**	**1,857.4**
Chemicals	800	74.3	345.7
Computers & electronics	1,047	111.0	255.1
Food, beverage & tobacco	1,695	76.0	235.0
Petroleum products	110	12.0	169.7
Motor vehicles & parts	879	52.9	151.1
Machinery	1,121	74.8	144.6
Fabricated metal products	1,449	77.5	139.9
Other transportation equipment	682	58.8	136.5
Plastic & rubber products	673	33.3	73.4
Primary metals	398	25.6	63.6
Paper	372	23.8	51.9
Electrical equipment	290	16.0	50.6
Nonmetallic mineral products	382	20.3	40.3
Health Care Services	**14,443**	**704**	**1,093.0**
Construction	**5,819**	**309.3**	**619.9**
Mining	**813**	**79.8**	**439.4**
Utilities	**549**	**53.9**	**276.7**
Other Services	**1,290**	**109.4**	**191.5**
Architectural, engineering , R&D	915	89.5	148.7
Waste management services	375	19.9	42.8
Total Industrial Gas Customer Industries	**32,811**	**$1,912.7**	**$4,477.9**
Total U.S.	**115,569**	**$5,928.0**	**$16,768.1**
% of Total U.S.	28.4%	32.3%	26.7%

Together these downstream industries generate more than $4 trillion in value-added and contribute significantly to more than 25% of GDP.[2] In addition, these industries generate nearly one-third of total U.S. payroll. Industrial gases are primary inputs in the processes and products of these industries and thereby essential to the economic contributions of the customer industries.

The following highlights some of the major end-use applications of industrial gases in major customer industries:

[2] The concept "value-added" represents the contributions that firms make to the economy when they transform raw materials into new products or services. It is calculated as revenues less cost of brought-in raw-materials, components, and services. Value-added is used to measure the value that firms add to these brought-in materials and services during their production process.

Chemicals Manufacturing

Industrial gases play an integral role in petrochemical and fertilizer production, particularly oxygen (used in oxidation reactions) and nitrogen (used in blanketing, purging, and other processing applications). Other examples include carbon monoxide, which is used in the production of esters, glycols, ketones and other chemicals. In recent years, access to vast, new supplies of natural gas from previously untapped shale deposits has bolstered the U.S. chemical industry. As chemical companies from around the world build and expand their shale-advantaged capacity in the U.S., industrial gas companies are building air separation units to support the new production. Some of these new facilities are dedicated plants, while others will provide products to a wide range of chemical industry customers. As of August 2015, ACC is tracking 246 announced chemical industry projects representing $155 billion in investment. At least 20 new or expanded air separation units have been announced, most of which are either complete or under construction, and as more chemical projects move into the construction phase the industrial gas industry will continue to come online.

Steel Manufacturing & Metal Fabrication

Industrial gases play key roles in primary and fabricated metals production, including steel manufacturing and metal fabrication. Steel is essential to almost all industrial sectors including automotive, construction and defense. Oxygen has a very important role in the steel manufacturing process: it is a primary raw material for making steel. In fact, oxygen is crucial in the two dominant steel making technologies in the U.S.: the basic oxygen process (BOP) and the electric arc furnace. In addition, argon is used in conjunction with oxygen in a common technology for refining stainless steel.

Industrial gases also have important applications in metal fabrication. For instance, acetylene is used for welding and metal cutting and argon is used as a shielding gas for the electric arc welding of nonferrous and specialty metals. Nitrogen is used in heat-treating and metalworking for products such as metal sheeting, rods, wires, and castings.

Health Care & Medical

Oxygen is crucial to human life and, therefore, crucial to the health care and medical industry. The health care industry (including hospitals and home health care) is the largest consumer of liquid oxygen, with over one-third of total consumption. According to the American Hospital Association, there are nearly 70 million hospital admissions each year, many of which require some level of oxygen therapy or supplementary oxygen. Patients suffering a range of chronic and acute medical conditions require additional oxygen, either pure or in a mixture, such as such as emphysema, asthma, pneumonia, and COPD (chronic obstructive pulmonary disease). Numerous other industrial gases are also used in the health care field: xenon and liquid helium are used in MRI (magnetic resonance imaging) scanners, xenon is also used in CAT scanners; krypton can be used in brain x-rays; and liquid argon is used in cryosurgery, to target cancer cells.

Electronics

Industrial gases, particularly nitrogen, are used in a variety of electronic applications, one of the most significant being semiconductor manufacturing. The use of industrial gases is so critical in that

market that many industrial gas companies are integrated with semiconductor manufacturers, either through subsidiaries or suppliers. In addition to semiconductor applications, nitrogen is used in circuit board manufacturing, chemical storage, and military applications among others. Industrial gases are also used in flat panel displays, solar panels, and lighting (e.g., LED, incandescent lamps, headlights).

Food & Beverage

Since the first days of commercial refrigeration, industrial gases have played a major role in the food and beverage sector. Carbonation, another early use of industrial gas (carbon dioxide), remains in use today; in fact, carbonated beverages (soft drinks and beer) make up about 70% of total beverages manufactured in the U.S.[3]

Industrial gases are used in both food preservation and shipments: argon is used in wine preservation (and other beverages); hydrogen is used in the hydrogenation of vegetable and animal oils; oxygen is used in transporting live seafood products; and liquid nitrogen is to freeze foods such as meat patties, shrimp and berries. As the field of molecular gastronomy has become increasingly mainstream, the use of liquid nitrogen has risen in restaurants, as a way to quickly freeze food and to add visual effects, such as vapor, in food presentations.

Water Treatment

Industrial gases, primarily oxygen and carbon dioxide, are used in wastewater and drinking water applications, as well as in treating streams, lakes and other bodies of water. These gases are used in disinfection, lowering pH levels (carbon dioxide is a safer alternative to other mineral acids that are often used), sterilization, desalinization and demineralization. Ozone (O_3) is used to disinfect drinking water, as well as to control color, taste and odor. Oxygen has also become increasingly important in aquaculture (e.g., fish farming), to ensure proper oxygen levels for the health and growth of farm-raised fish and seafood.

CONCLUSION

The economic contributions of the industrial gases sector are many and wide-ranging. Industrial gases are critical to certain segments of the economy including, health care, clean water, space exploration, and industrial processes for chemical, fuel, electronics, metals, etc. The use of industrial gases supports a diverse set of industries; these industries account for roughly a quarter of U.S. GDP. In addition to the contributions from the use of industrial gases, the industry itself contributes to the economy by providing employment for more 60,000 workers directly in manufacturing and distribution of industrial gases, in addition to corporate management and research and development activities. The industrial gases industry also stimulates economic activity along its supply chain. Also, the wages paid to workers in the industrial gases industry and their suppliers supports another tranche of economic activity. At the end of the day, the U.S. industrial gases industry supports nearly 190,000 U.S. jobs. These jobs and their payrolls support local communities throughout the U.S.

[3] According to data from U.S. Census Bureau's Annual Survey of Manufacturers, 2013.

Appendix – Economic Impact for Selected States

	Direct Jobs	Indirect & Induced Jobs	Direct Payroll ($ mill)	S&L Tax ($ mill)	Fed Tax ($ mill)	Selected Customer Industry Jobs*	Hospital Admissions (mill)
California	4,800	8,200	$420	$132	$184	356,000	3.4
Florida	1,500	2,700	$110	$34	$40	75,000	2.5
Illinois	2,400	4,400	$220	$64	$56	193,000	1.5
Indiana	1,800	2,400	$130	$47	$34	123,000	0.7
Louisiana	2,100	4,800	$200	$97	$29	62,000	0.6
Michigan	1,800	2,500	$160	$39	$37	129,000	1.2
New York	4,300	6,600	$420	$137	$116	119,000	2.5
Ohio	2,700	4,900	$230	$67	$54	194,000	1.5
Pennsylvania	7,300	12,300	$750	$188	$113	181,000	1.8
Texas	6,400	17,200	$700	$260	$89	291,000	2.6

* Selected customer industries include food and beverage, steel, glass, basic industrial chemicals, and fabricated metal products.

NOTES ON DATA AND METHODOLOGY

Industrial Gases Industry

Data on industrial gas manufacturing is based on NAICS 32512 adjusted to exclude fluorocarbon gases. Estimates of the economic output and employment of industrial gas wholesaling distribution are based on average wholesale margins for industry sectors from the Census Bureau and employment estimates were made using data on average wages from the Bureau of Labor Statistics (BLS). National totals for distributors were allocated to each state by the relative presence of consuming industries (mining, manufacturing, and hospitals). Estimates of employment of corporate management (HQ) and research and development activities were developed through input from market research databases (i.e., Dun & Bradstreet), annual reports, and input panel members. BLS was the source of data for average wages and payroll. Data on capital expenditures is from the Census Bureau and represents an average from 2012-2013. Data on electricity consumption and purchases are also from the Census Bureau. Estimates of research and development expenditures was developed using company annual reports.

Upstream Economic Impacts

As described above, the IMPLAN model was used to estimate the indirect (supply chain) and payroll-induced impacts of the industrial gas sector. The IMPLAN uses industry spending patterns and output-labor ratios to estimate these impacts. Estimates of tax revenues generated from the economic activity of the industrial gases sector are also from IMPLAN.

Customer Industries

Data on employment and payroll were from the Bureau of Labor Statistics while data on value-added came from the Census Bureau and the Bureau of Economic Analysis. Data on hospital admissions was from the Kaiser Family Foundation.

INDUSTRIAL GASES PANEL

The Industrial Gases Panel of the American Chemistry Council (ACC) serves as the voice of the industrial gases sector participating in public policy initiatives that impact the industry and communicating advocacy positions for industrial gases. The panel is comprised of leading manufacturers of industrial gases in the United States:

Air Liquide

The Linde Group

Matheson Tri-Gas

Praxair, Inc.

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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.

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