

A little foggy: Improved downstream activity will boost demand

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IBISWorld Industry Report 32512 Oxygen & Hydrogen Gas Manufacturing in the US

June 2017

Stephen Morea

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About this Industry

Industry Definition

This industry manufactures organic and inorganic industrial gases in various forms, including compressed, liquid and solid (i.e. dry ice). Examples of industrial gases include oxygen, hydrogen, helium,

nitrogen and carbon dioxide. These gases are then supplied to a diverse range of customers, including industrial and medical users. Key inputs for the industry include electricity and natural gas.

Main Activities

The primary activities of this industry are

Manufacturing industrial organic gases

Manufacturing industrial inorganic gases

Hydrogen manufacturing

Oxygen manufacturing

Helium manufacturing

Nitrogen manufacturing

Carbon dioxide manufacturing

Acetylene manufacturing

Fluorocarbon gases manufacturing

The major products and services in this industry are

Acetylene

Argon and hydrogen

Carbon dioxide

Fluorocarbon gases

Nitrogen

Oxygen

Other gases

Similar Industries

22121 Natural Gas Distribution in the US

This industry manages gas distribution systems consisting primarily of gas mains and meters that transport gas to end users.

32511 Petrochemical Manufacturing in the US

This industry manufactures ethane and butane gases made from refined petroleum or liquid hydrocarbons.

32518 Inorganic Chemical Manufacturing in the US

This industry manufactures a variety of basic inorganic chemicals.

45431 Fuel Dealers in the US

This industry sells heating oil, propane and other fuels directly to end users.

About this Industry

Additional Resources

For additional information on this industry

www.cganet.com

Compressed Gas Association

www.iomaweb.org

The International Oxygen Manufacturers Association

www.eia.gov

US Energy Information Administration

IBISWorld writes over 1 000 US industry reports, which are updated up to four times a year. To see all reports, go to www.ibisworld.com

Industry at a Glance

Oxygen & Hydrogen Gas Manufacturing in 2017

Key Statistics Snapshot

Revenue

\$7.6bn

Profit

\$1.5bn

Annual Growth 12-17

-1.1%

Exports

\$544.1m

Annual Growth 17-22

1.8%

Businesses

87

Market Share

Praxair Inc.

39.8%

Air Products and Chemicals Inc.

25.9%

The Linde Group

18.4%

Air Liquide

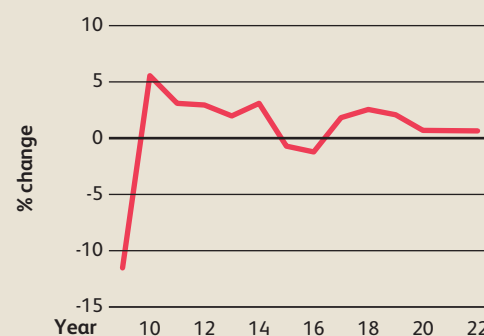
12.4%

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Revenue vs. employment growth

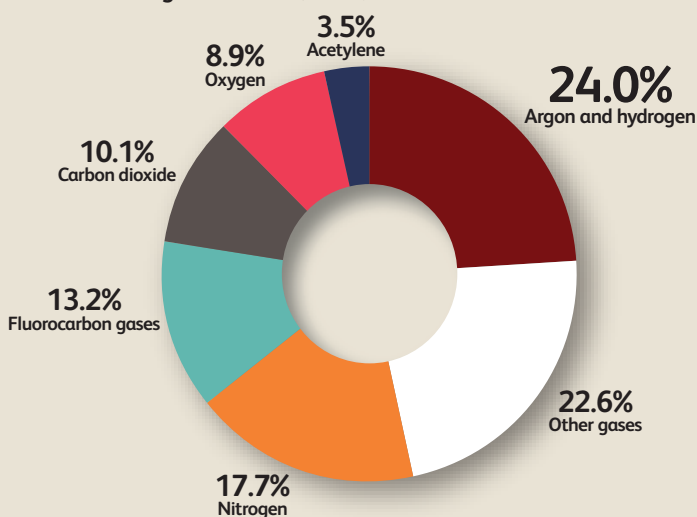


Industrial production index



SOURCE: WWW.IBISWORLD.COM

Products and services segmentation (2017)



SOURCE: WWW.IBISWORLD.COM

Key External Drivers

Industrial production index
Consumer spending
Demand from oil and gas extraction
Demand from primary metal manufacturing

p. 5

Industry Structure

Life Cycle Stage

Mature

Revenue Volatility

Medium

Capital Intensity

High

Industry Assistance

Low

Concentration Level

High

Regulation Level

Medium

Technology Change

Low

Barriers to Entry

High

Industry Globalization

Medium

Competition Level

Medium

FOR ADDITIONAL STATISTICS AND TIME SERIES SEE THE APPENDIX ON PAGE 34

Industry Performance

Executive Summary | Key External Drivers | Current Performance
Industry Outlook | Life Cycle Stage

Executive Summary

The Oxygen and Hydrogen Gas Manufacturing industry produces gases that are used as inputs in a variety of consumer and industrial products. Industrial gases are essential to various downstream sectors, including chemical manufacturing, metal manufacturing and oil refining. Metal manufacturers use nitrogen in steel production to improve steel's resistance to corrosion, while oil refineries use hydrogen to remove sulfur from crude oil. Consumer products also rely on industrial gases, such as carbon dioxide, which is used to carbonate

and chemical manufacturers sharply declined due to plummeting oil, gas and commodity prices. However, industry revenue is expected to increase modestly in 2017, as rebounding commodity prices and slowly increasing US manufacturing activity will facilitate 4.5% projected industry revenue growth in 2017.

The Oxygen and Hydrogen Gas Manufacturing industry is highly concentrated and dominated by a handful of global industrial gas manufacturers, including Praxair, Air Products and Chemicals, Air Liquide and The Linde Group. These large companies with greater economies of scale are more capable of developing robust distribution networks and negotiate long-term contracts with major markets. Moreover, the industry's major players have engaged in a series of strategic acquisitions during this period.

In the five years to 2022, industry revenue is projected to increase at an annualized rate of 1.8% to \$8.3 billion. Key buying industries' production levels are expected to be in full swing, as an anticipated increase in consumer spending will drive demand for oxygen, hydrogen, nitrogen and various industrial gases. In addition, rebounding global demand for oil and natural gas will increase demand for hydrogen, which is used for refining heavier, sulfur-laden fuels.

Increased demand from key downstream markets will boost revenue

beverages and, in its dry ice form, to keep perishables cold. Therefore, gas manufacturers are dependent on manufacturing activity, industrial output and consumer demand. While international trade does not directly influence industry revenue, industrial gas sales are, in turn, impacted by overseas demand for US manufactured products.

Consequently, industry revenue is expected to decrease steadily at an annualized rate of 1.0% to \$7.6 billion over the five years to 2017. During this period, demand from highly cyclical markets, such as energy producers, metal

Key External Drivers

Industrial production index

The industrial production index (IPI) is a broad measure of the level of output in the manufacturing, mining and utility sectors, all of which are consumers of industrial gases. Manufacturers, ranging from electronics producers to pulp and paper manufacturers, use industry goods to enhance their products and remove hazardous vapors from equipment. Generally, as the IPI increases, so does

demand for oxygen and hydrogen manufactured gases. The industrial production index is expected to slowly increase in 2017; any potential decline will represent a threat to the industry.

Consumer spending

Consumer spending indirectly affects oxygen and hydrogen gas manufacturers. The industry relies on food and beverage manufacturers, the healthcare sector and

Industry Performance

Key External Drivers continued

electronics manufacturers to purchase its products. For example, downstream users purchase nitrogen to cool soft or heat-sensitive materials so manufacturers can grind them, a process used to create products like medicines and spices. These key buying industries are dependent on consumer spending for their own demand. Therefore, as consumer spending rises, end-user industries buy more industrial gases. Consumer spending is expected to increase in 2017, representing a potential opportunity for this industry.

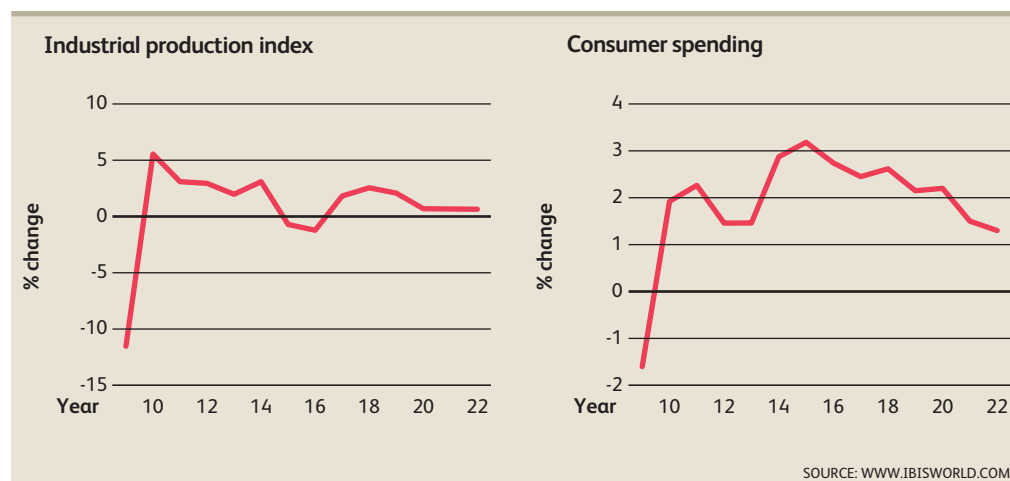
Demand from oil and gas extraction

Hydrogen is a key product in oil refining used to remove sulfur from crude oil. As

the demand for oil extraction, production and refining increases, demand for hydrogen also increases. Demand from oil and gas extraction is expected to increase in 2017.

Demand from primary metal manufacturing

Metal manufacturers purchase a variety of industrial gases including oxygen, acetylene, nitrogen, argon and hydrogen. As the demand for metal manufacturing and refining increases, demand for industrial gases sold by the Oxygen and Hydrogen Gas Manufacturing industry also increases. Demand from primary metal manufacturing is expected to increase in 2017.

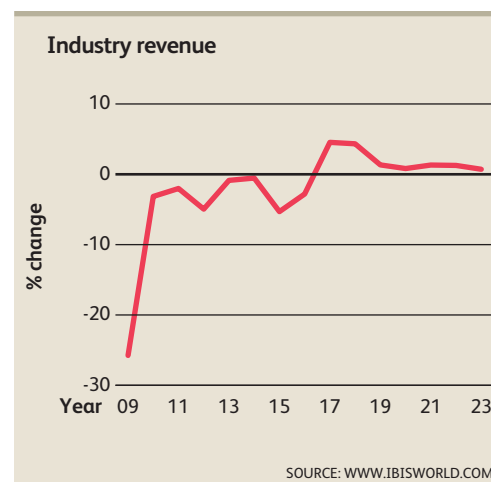


Industry Performance

Current Performance

Over the five years to 2017, Oxygen and Hydrogen Gas Manufacturing industry revenue is expected to decrease at an annualized rate of 1.0% to \$7.6 billion. During this period, a sharp decline in global commodity prices led to a swift contraction in demand for industrial gases, especially from energy, metal refining and manufacturing sectors.

However, the industry is expected to modestly rebound in 2017, as global economic growth, increasing commodity prices and steady US industrial and manufacturing output will increase demand from key buyers of industrial gases, such as chemical manufacturers. These factors will help



facilitate a 4.5% projected increase in industry revenue in 2017.

Vacillating demand from buying markets

Despite a range of uses for industrial gases, the industry relies heavily on demand from a few downstream markets, including metals manufacturing, chemical manufacturing and natural gas and petroleum refining. Any shift in production from these downstream industries directly affects demand for industrial gases.

The energy refining industry is a key buyer of industry products, and primarily purchases hydrogen, which is used to remove sulfur from crude oil in gasoline production. From 2011 through 2014, an expanding US economy, persistently high oil prices and tensions in the Middle East pressed the need for domestic oil and gas exploration. As a result, the United States entered a boom in oil and natural gas extraction, encouraged by technological improvements, such as hydraulic fracturing, horizontal drilling and other enhanced recovery procedures, which spiked natural resource refining and production in the Appalachian Basin and Bakken regions. This, in turn, led to stronger demand for hydrogen, which is used for refining heavier, sulfur-laden fuels native to these US regions.

However, a rapid drop in the price of crude oil has reduced demand from this vital downstream market in 2015 and 2016, as oil and gas refiners opt to scale back production in response to near-term concerns of lower global demand and an oversupply of oil. Similar to oil and gas, a slowdown in economic growth in emerging countries like China precipitated a swift decline in the price of other commodities, including steel, iron ore and copper over the past several years.

Metal manufacturers comprise an estimated 13.5% of industry sales. This downstream market uses oxygen and acetylene in welding and cutting, as well as nitrogen to improve ductility and corrosion resistance of steel. Metal manufacturers experienced a slight decline in demand over the past five years, causing a reduction of industrial gas purchases. For example, demand from the metal stamping and forging market is expected to decrease at an annualized rate of 1.8%, as a tempered US industrial production diminished sales of roll form metal and pressed metal sheets, particularly in 2015 and 2016.

Industry Performance

Vacillating demand from buying markets continued

Thus, a significant portion of industry revenue remains dependent on the capital expenditures of oil, gas and metal producers as well as petrochemical manufacturers, which are tightly aligned with the performance of the energy markets. As oil and gas prices remained low throughout for most of the past five years, demand from these sectors gradually diminished.

Moreover, the Oxygen and Hydrogen Gas Manufacturing industry also relies on the electronics industry, which commonly uses argon and nitrogen, as well as helium, which is a critical component for flat panel display production, in semiconductor production. Over the past five years, as electronic manufacturers increasingly moved their productive facilities overseas, demand for gases like argon and helium has leveled off over the past five years.

Costs and profit

Lower demand for industrial gases led to stagnant industry margins, as slower global economic growth tempered sales to vital downstream manufacturing and energy markets. Average industry profit, which is measured as earnings before interest and taxes, decreased marginally from 19.8% of revenue in 2012 to an expected 19.5% in 2017. While rapidly declining energy prices are expected to constrain industry revenue growth, falling oil and gas prices will actually support profit margins through 2017. Energy is one of the largest costs in the production of industrial gases. Moreover, industrial byproduct gases are created through the chemical breakdown of natural gas, petroleum or other inputs. Consequently, the recent decline in energy prices help support industry margins.

Energy is one of the largest costs in the production of industrial gases

However, the main energy resource for gas manufacturers is electricity. Therefore, as the price of electricity fluctuates, the industry's production costs follow suit. In the five years to 2017, the price of electric power is expected to increase at an annualized rate of 1.5%, according to data sourced from the US Department of Energy and IBISWorld estimates. To maintain stable margins, industry operators will need to increase their selling prices to help offset the rising input costs.

Consolidation

The Oxygen and Hydrogen Gas industry experienced consolidation over the past five years. Over the five years to 2017, the number of industry operators is expected to increase marginally at an annualized rate of 0.7% to 87 companies. Slow growth caused industry employment to decline slowly over the past five years, as operators remained hesitant about the industry's stability. Consequently, in the five years to 2017, employment is expected to decrease at an annualized rate of 0.3% to 10,058 workers.

During this period, many major companies have also used acquisitions to gain market share and improve efficiency. Industry major players have pursued vertical integration strategies as part of their business strategy, expanding into the wholesale distribution of carbon dioxide, oxygen, hydrogen and other industrial gases.

For example, in November 2012, industry major player Praxair acquired Acetylene Oxygen Company, an independent gas and welding products

Industry Performance

Consolidation continued

distributor operating in the southern United States. In March 2013, Praxair completed the \$1.1 billion acquisition of NuCO₂ Inc., the largest provider of fountain beverage carbonation in the United States. NuCO₂ supplies carbon dioxide that is added to fountain soda and draft beer and provides delivery services to restaurant chains, convenience stores and entertainment locations.

These acquisitions pale in comparison to Air Liquide's \$10.3 billion acquisition of Airgas, which was completed in May 2016. The acquisition vastly expanded Air Liquide's industry-relevant operations in the United States, as Radnor, PA-based Airgas was one of the largest distributors and manufacturers of industrial and specialty gases in North America.

Industry Outlook

The Oxygen and Hydrogen Gas Manufacturing industry is expected to expand in the five years to 2022, with industry revenue estimated to increase at an annualized rate of 1.8% to \$8.3 billion. Industry revenue will be largely driven by higher US manufacturing and industrial output as well as a modest projected rebound in domestic energy refining, which will increase demand for industrial gases like hydrogen and nitrogen.

Throughout this period, product prices are anticipated to rise as the price of energy increases. In the near-term, oxygen and hydrogen gas manufacturers will be able to pass along price increases, as demand from vital downstream markets remains high and stable. However, if demand in customer markets weakens, industrial gas price hikes may deter purchases and could drive down industry revenue.

Downstream markets

Industrial output, as measured by the industrial production index (IPI), is expected to increase at an annualized rate of 1.4% over the next five years. The industry's key downstream markets will also benefit from higher manufacturing activity. Increased manufacturing and construction will facilitate greater demand for chemically manufactured products like adhesives and paints. Since chemical manufacturers use industrial gases in their refining and production processes, sales for oxygen and hydrogen gas manufacturers will likely increase. In addition, metal manufacturers will increase their purchases of industrial gases as commercial building construction rises. Commercial construction will likely expand rapidly, with the value of private nonresidential construction expected to increase at an annualized rate of 4.6% over the next five

Increasing refining activity will yield a greater need for industrial gases, benefiting the industry

years. Steel is a common component of commercial construction and, because steel producers use nitrogen, higher demand for new buildings will heighten the need for industry products.

Over the past 10 years, the US government has become more concerned with harmful gas emissions. Federal officials have enacted regulations to reduce the amount of greenhouse gases produced by many industries and products. For example, in 2004, the Environmental Protection Agency's (EPA) Tier 2 Gasoline Sulfur program reduced the sulfur content in gasoline by

Industry Performance

Downstream markets continued

up to 90.0% from 340 parts per million (PPM) to 30 PPM. These new standards led to a significant increase in demand for hydrogen to remove sulfur from gasoline products over the past five years and will continue to boost industry sales in the five years to 2022. Moreover, the EPA's Tier 3 Gasoline Sulfur program aims to lower vehicle emission standards by 2017, which includes

lowering the sulfur content in gasoline to 10 PPM. Therefore, the Oxygen and Hydrogen Gas industry will experience steady demand growth from the petroleum refining markets through 2022. Increasing refining activity will naturally yield a greater need for industrial gases, such as hydrogen, benefiting the Oxygen and Hydrogen Gas Manufacturing industry.

Rising costs

Since energy is the largest cost associated with industrial gas production, any changes in electricity or natural gas prices significantly affect the industry. The price of electricity is expected to modestly rise over the five years to 2022 at an average annual rate of 3.2%. As a result of steadier costs, operators are expected to incur less volatile input prices. In addition, healthy demand from key buying industries will enable operators to pass along modest price increases to downstream customers, which will continue to purchase gases from the industry due to high demand for their own products.

Over the next five years, profit margins are expected to increase marginally. As industry revenue rises, so will employment and wage costs, tempering

As a result of steadier costs, operators are expected to incur less volatile input prices

industry profit expansion. Oxygen and hydrogen gas manufacturers have invested in labor-saving technologies over the past decade, but certain service-oriented positions, such as maintenance and delivery workers, will need to increase to keep pace with greater industrial gas demand. As a result, in the five years to 2022, industry employment is expected to increase at an annualized rate of 1.1% to 10,617 workers, with total wages expected to increase at an average annual rate of 1.5% to \$847.5 million.

Continued consolidation

Despite rises in demand, many companies are projected to consolidate to help increase production and improve efficiency. The number of companies is forecast to decline at an annualized rate of 0.7%, as the industry is expected to

comprise just 84 enterprises in 2022. Larger companies will likely complete more acquisitions to increase market share, while others will enter the market as demand for industrial gases continues to rise.

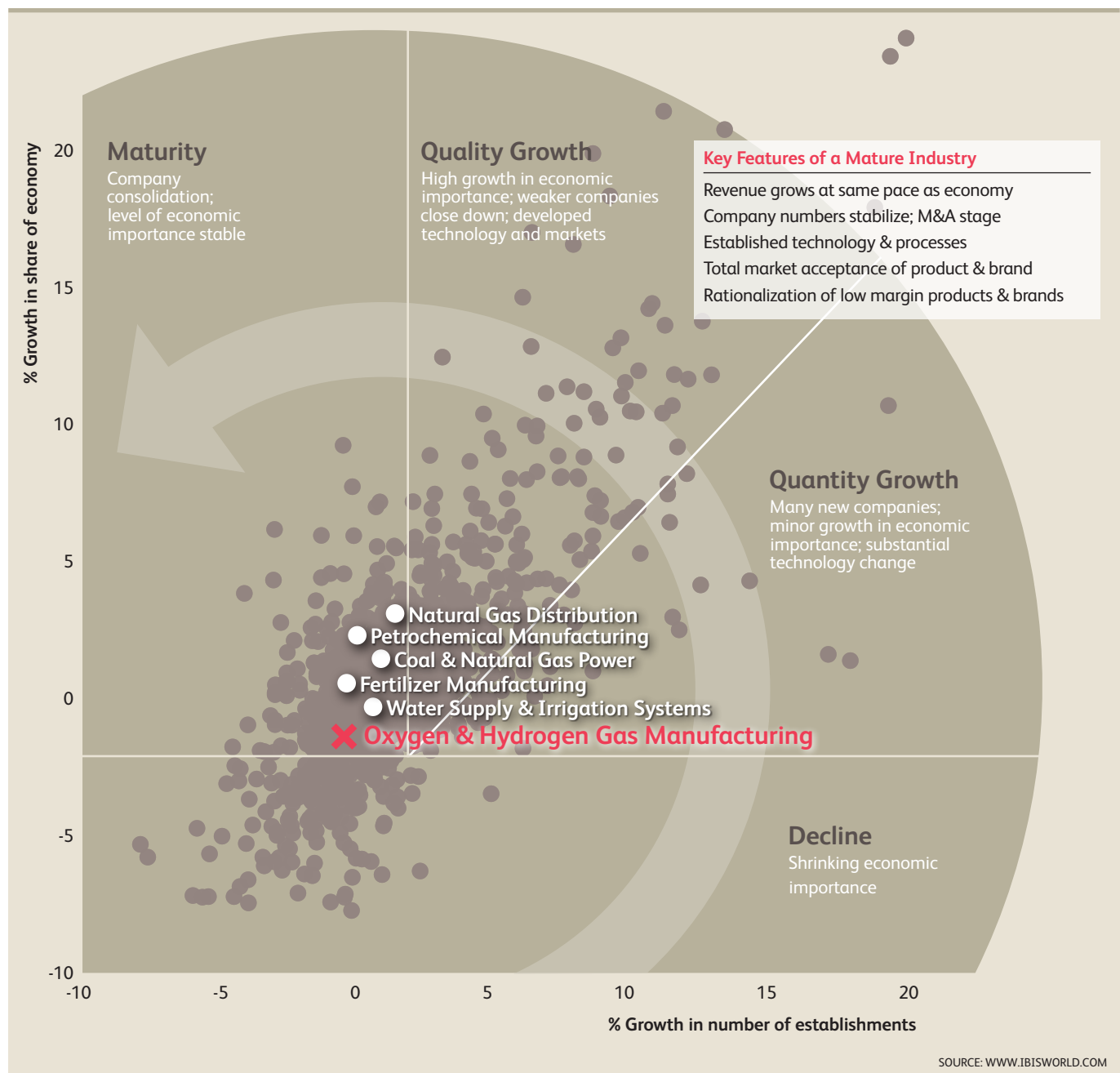
Industry Performance

Life Cycle Stage

The industry has experienced consolidation among its largest companies

Industry value added is expected to grow at a slower pace when compared to GDP

No new products are expected to come to market in the near future



Industry Performance

Industry Life Cycle

This industry
is **Mature**

Industry value added, which measures the industry's contribution to the overall economy, is expected to increase at an average annual rate of 0.4% from 2012 to 2022, which is slower when compared to national GDP, which is expected to grow at an annualized rate of 2.0% during the same period, indicating that the Oxygen and Hydrogen Gas Manufacturing industry is in the mature phase of its life cycle. Moreover, the industry has experienced product saturation and consolidation activity.

The existence of clearly segmented product groups and user industries, along with the fairly stable nature of industry products, are also indicative of the

industry's mature phase. No significant new products are appearing to boost the industry to a growth stage. The industry's key buying markets remain in the manufacturing sector.

The industry is also consolidating, which is indicative of a mature industry. Over the 10 years to 2022, the number of companies is expected to remain unchanged. Larger players have been acquiring small- and medium-sized enterprises to expand market share and customer base. For example, Air Products and Chemicals acquired EPCO Carbon Dioxide Products in 2013, the largest independent US producer of liquid carbon dioxide, expanding the company's merchant gas segment.

Products & Markets

Supply Chain | Products & Services | Demand Determinants
Major Markets | International Trade | Business Locations

Supply Chain

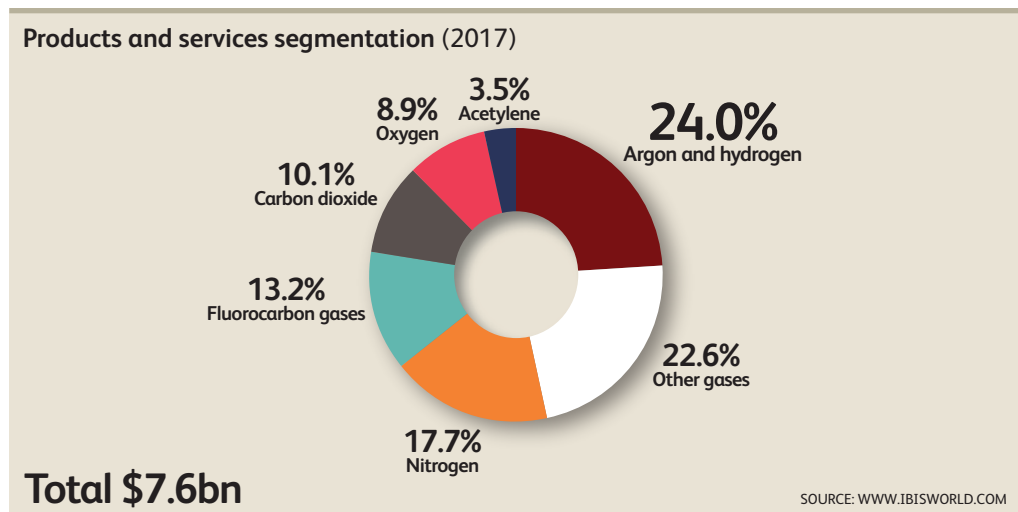
KEY BUYING INDUSTRIES

22131	Water Supply & Irrigation Systems in the US Water treatment industries use a range of industrial gases, such as oxygen.
23	Construction in the US The construction sector uses liquid nitrogen, liquid carbon dioxide and dry ice in various applications, including freezing soil and cooling concrete.
32411	Petroleum Refining in the US The Petroleum Refining industry buys hydrogen from industry operators.
33441a	Semiconductor & Circuit Manufacturing in the US The Semiconductor and Circuit Manufacturing industry uses nitrogen, hydrogen and halogen gases.
62	Healthcare and Social Assistance in the US The Healthcare and Social Assistance industry uses a range of industrial gases, including oxygen, helium and carbon dioxide.

KEY SELLING INDUSTRIES

22111a	Coal & Natural Gas Power in the US The Coal and Natural Gas Power industry supplies electricity to industry operators.
22121	Natural Gas Distribution in the US Natural gas is an important input in the production of various gases.
32531	Fertilizer Manufacturing in the US The Fertilizer Manufacturing industry supplies inputs, such as ammonium nitrate, to industry operators.

Products & Services



The Oxygen and Hydrogen Gas Manufacturing industry manufactures various industrial gases, which are: derived from the air by a process of separation; processed from natural gas or petroleum; or produced by chemical synthesis (i.e. the construction of

complex chemical compounds from simpler ones).

Nitrogen, oxygen and other air-separated gases

Common air-separated gases include key industry products such as oxygen and

Products & Markets

Products & Services continued

nitrogen. Nitrogen, which represents an estimated 17.7% of total industry revenue, has a variety of uses, ranging from preserving packaged foods by stopping the oxidation process to producing electrical parts like transistors and integrated circuits. Cryogenically cooled nitrogen can be used to flash-freeze certain food products. In heavy manufacturing, nitrogen acts as a complement to oxygen, behaving as a blanketing agent that slows down combustion and chemical reactions. When used in conjunction with oxygen, nitrogen helps control the rate at which chemical reactions occur. Nitrogen can also be used to produce ammonia, a key component of agricultural fertilizers and a building block of many plastics and chemicals.

Oxygen, which accounts for an estimated 8.9% of industry revenue, is used in a variety of industries, ranging from healthcare, food and beverage to heavy industrial, steelmaking and welding. Pure oxygen gas is sold to healthcare facilities as a breathing gas; for industrial applications, oxygen is used to intensify the rate of combustion. Over the five years to 2017, demand for air-separated gases, including oxygen and nitrogen has fluctuated in line with demand for downstream users.

Other gases produced through the fractional distillation of normal air include noble gases such as neon or krypton. These gases are extensively used in healthcare, electronics manufacturing, light bulbs and for scientific research.

Argon and hydrogen

Argon and hydrogen combined account for an estimated 24.0% of industry revenue in 2017. Argon, the third-most abundant gas, is a byproduct of the production of oxygen and nitrogen. Present in only small quantities, the gas is used for lighting, preserving documents and preserving paints and varnishes. Argon is also used for arc welding and steel-making.

Hydrogen, the most consumed industrial gas within the United States, is a colorless, odorless and tasteless gas that is slightly soluble in water. It is primarily used by oil and chemical industries to upgrade crude oil through desulfurizing and hydro-cracking processes. Over the past five years, demand for hydrogen has decreased as refining activity for heavier, sulfur-laden fuels has declined due to a rampant drop in oil and commodity prices from 2014 through 2016.

Industry byproduct (process) gases

Unlike air-separated gases, industrial byproduct gases are created through the chemical breakdown of natural gas, petroleum or other inputs. Key products in this category include carbon dioxide (CO₂), which accounts for an estimated 10.1% of industry revenue in 2017 as well as carbon monoxide (CO) and trace amounts of helium. Similar to hydrogen, CO and CO₂ are the direct byproducts of steam-reformed natural gas, whereby natural gas and water are combined chemically to produce a gas mixture known as syngas. Syngas is then further processed into separate streams of CO and CO₂ gases. In contrast, helium is not a direct byproduct of this chemical reaction, but is rather extracted from syngas in ways similar to air-separated gases.

CO₂, CO and helium also have numerous applications in manufacturing, agriculture and medicine. CO₂ in solid form, better known as “dry ice”, is commonly used to flash-freeze fresh foods to preserve flavor. CO₂ in compressed gas form is also used to carbonate beverages or as a plant supplement in greenhouses. Although a very poisonous gas, CO is an integral building block for several plastics, industrial alcohols and other chemicals. In addition, CO and hydrogen blends are used by oil refineries to break down heavy crude oil into lighter petroleum products.

Products & Markets

Products & Services continued

Because of its extremely low liquefaction temperature, helium is used extensively in scientific and medical research to cool Magnetic Resonance Imaging (MRI) machines, superconductive magnets and other technical equipment. Helium is also a lifting agent, most commonly used in party balloons or airships.

Other gases

This miscellaneous category includes specialty refrigerant and propellant gases such as chloro- or hydro-fluorocarbons, welding gases such as acetylene and advanced technical gases such as phosphine or radon. Chlorofluorocarbons or fluorocarbons account for an estimated 13.2% of total industry revenue in 2017. Introduced in the 1930s, fluorocarbon gases are used as refrigerants, solvents and in the production of foam. Demand for this segment has declined over the past five years, as regulatory limits have capped the production of new fluorocarbons, like R-22, a common industrial refrigerant.

Examples of other gases include: acetylene, a colorless flammable gas, used in oxy-acetylene torches use in welding and construction. Welding gases such as acetylene have also shrunk as a share of industry revenue in recent years. Mainstream adoption of electrical arc welding, which uses high-current, low-voltage electricity in place of an acetylene-oxygen fuel mixture, has significantly reduced demand for acetylene production by construction and heavy industrial customers.

This industry does not include the production or distribution of simple hydrocarbon gases such as methane, ethane and propane, which are all derived from natural gas or petroleum. Sales from these products are included in the Organic Chemical Manufacturing industry and Oil Drilling and Gas Extraction (IBISWorld reports 32519 and 21111, respectively). This industry also does not include the production of elemental chlorine gas or hydrochloride gas; these products are discussed in the Inorganic Chemical Manufacturing industry (IBISWorld report 32518).

Demand Determinants

Industrial gases are used by different industries, ranging from metals production and petroleum refining to electronics and chemical manufacturing. Accordingly, demand for industrial gases is determined by economic activity, developments in downstream user industries and environmental regulations. Most industry end-users are sensitive to economic conditions. For example, industrial gases are used extensively in metal product manufacturing, which, in turn, is affected by volatile markets, such as construction and machinery and equipment manufacturing. Therefore, when demand for construction drops, demand for metals also falls.

Developments in major user industries can also influence demand. In particular, technological developments and changes in the production levels of major end-user industries can significantly affect demand. New applications for industrial gases in existing end-user markets continue to be developed, which is helping drive demand. For example, enhanced oil recovery (EOR) techniques use vast amounts of pressurized gasses, such as carbon dioxide to loosen the oil trapped in rock formations within wells. From 2011 through 2014, persistently high global crude oil prices have boosted demand for EOR drilling, subsequently increasing demand for industrial gases. However the expedient decline in oil

Products & Markets

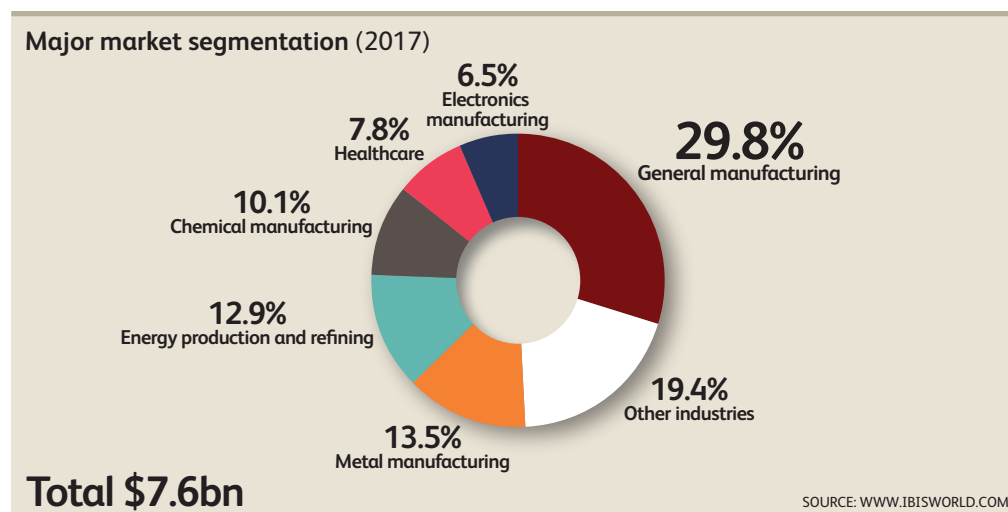
Demand Determinants continued

prices from 2014 through 2016 has depressed demand from this burgeoning market, as crude oil has been increasingly supplied from less expensive global sources.

Last, environmental pressures are becoming an increasingly important demand determinant. Mounting environmental concerns and increasing calls for cleaner burning fuels (relative

to the more traditional fossil burning fuels) have tended to benefit the industrial gas industry. For example, demand for hydrogen from the petroleum refining market segment is expected to grow in line with the need for clean-burning, low-sulfur gasoline and diesel fuels as per new Environmental Protection Agency regulations regarding sulfur limits.

Major Markets



General Manufacturing

A diverse array of manufacturers including: packaged goods makers, materials manufacturers, non-residential construction equipment makers and industrial equipment manufacturers, use industrial gases as part of their productive process. In 2017, sales to this market accounted for an expected 29.8% of total industry revenue. Over the five years to 2017, sales to this segment rebounded as increased consumer spending and higher manufacturing activity increased demand for this industry's gases.

Metal manufacturers

The metal manufacturing market accounts for an expected 13.5% of total industry

revenue in 2017. Metal manufacturers purchase a variety of industrial gases including: oxygen and acetylene for welding and cutting activities; nitrogen, which is used in steel production to improve wear resistance; argon, which prevents oxidation in molten steel and is a key component in stainless steel refining; and, hydrogen, which is also used to prevent oxidation in the heat treatment of metals. In the five years to 2017, demand from this market has fluctuated in-line with US industrial output and manufacturing activity, increasing for most of this period. However, demand from this market declined from 2015 onward, due to a slowing economic growth in emerging economies like China as well as a sharp decline in commodity prices

Products & Markets

Major Markets continued

Energy production and refining

Sales of gases to the energy industry is expected to account for 12.9% of industry revenue in 2017. Hydrogen is commonly used in petroleum refining, specifically in the hydro-cracking of heavier, sulfur-laden types of crude oil. Over the past five years, tighter mandates for low-sulfur gasoline and diesel levels set by the Environmental Protection Agency have increased demand for hydrogen. While demand for industrial gases from this market steadily increased from 2012 through 2014, a rapid decline in global crude oil led to a slowdown in oil production and refining activity in 2015 through 2017.

Chemical manufacturers

In 2017, chemical manufactures are expected to comprise 10.1% of total industry sales. Chemical industries such as petrochemicals, plastics and agrichemicals use industrial goods in the refining and production. Chemical manufacturers also purchase industry gases such as nitrogen to clean equipment that releases dangerous vapors. This market segment experienced strong growth in early over during the five-year period, as downstream buyers of chemicals, such as the transportation and construction industries, increased their purchases. However, similar to the oil, gas and energy markets, as global economic growth stalled and commodity prices declined, chemical manufacturing revenue declined. Consequently, sales of industrial gases to this segment decreased slightly in the past few years.

Healthcare

The healthcare market will account for an estimated 7.8% of total industry sales in 2017. The healthcare sector uses oxygen

in medical procedures and in life support. The sector also uses various industrial gases for a variety of applications, including nitrous oxide as a base anesthetic, nitrogen in tissue freezing and storage, and carbon dioxide as a breathing stimulant. Demand from the healthcare sector has risen slightly over the past five years.

Electronics manufacturers

In 2017, sales to electronic manufacturers are expected to generate 6.5% of total industry revenue. Gases like argon and nitrogen are commonly used in semiconductor production and helium is a critical component for flat panel display production. Electronic manufacturers also use specialty gases supplied by the industry such as silane, arsine, silicontetrafluoride, nitrogen trifluoride, carbon tetrafluoride, hexafluoroethane and tungsten hexafluoride. Over the past five years demand from this market segment has remained low due to the high level off-shoring of electronics manufacturing facilities.

Other

The other segment contains sales to merchant, consumer, defense, aerospace and government markets. In total, sales of this industry's products to other markets comprise an estimated 19.4% of total industry revenue in 2017. Among the largest subcategories within this segment is food and beverage manufacturers. Demand from food and beverage manufacturers, which historically accounts for more than 6.0% of total industry sales, has increased over the past five years. The industry increasingly relies on nitrogen for processing frozen foods and refrigeration purposes. It also requires carbon dioxide for beverage carbonization and chilling.

Products & Markets

International Trade

Level & Trend
Exports in the
industry are
Medium and Steady

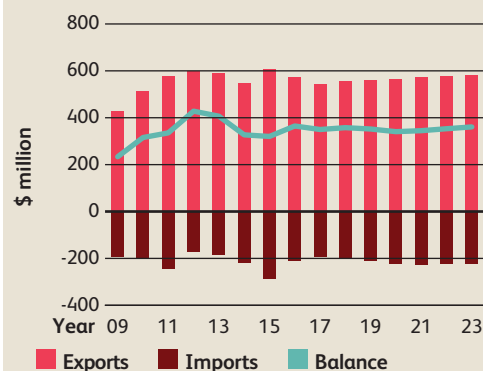
Imports in the
industry are **Low**
and Increasing

Imports

Canada, Qatar, the Ukraine and China are the industry's largest sources of imports, jointly accounting for more than 75.0% of the industry's imports in 2017.

Nevertheless, international trade in the Oxygen and Hydrogen Gas industry is very low. For example, imports are expected to account for only 2.7% of domestic demand in 2017. In this industry there is a proportionally high cost of transport relative to the value of industrial gases. The majority of gases need to be stored and distributed under great pressure, which requires them to be carried in heavy and bulky cylinders, or at extremely low temperatures in specially insulated tankers, which limits the distance they can be transported. The limited international trade that does occur often involves particular gases that are not produced domestically. For example, helium, which is extracted from natural gas deposits, is one of the few gases that is traded extensively on the international

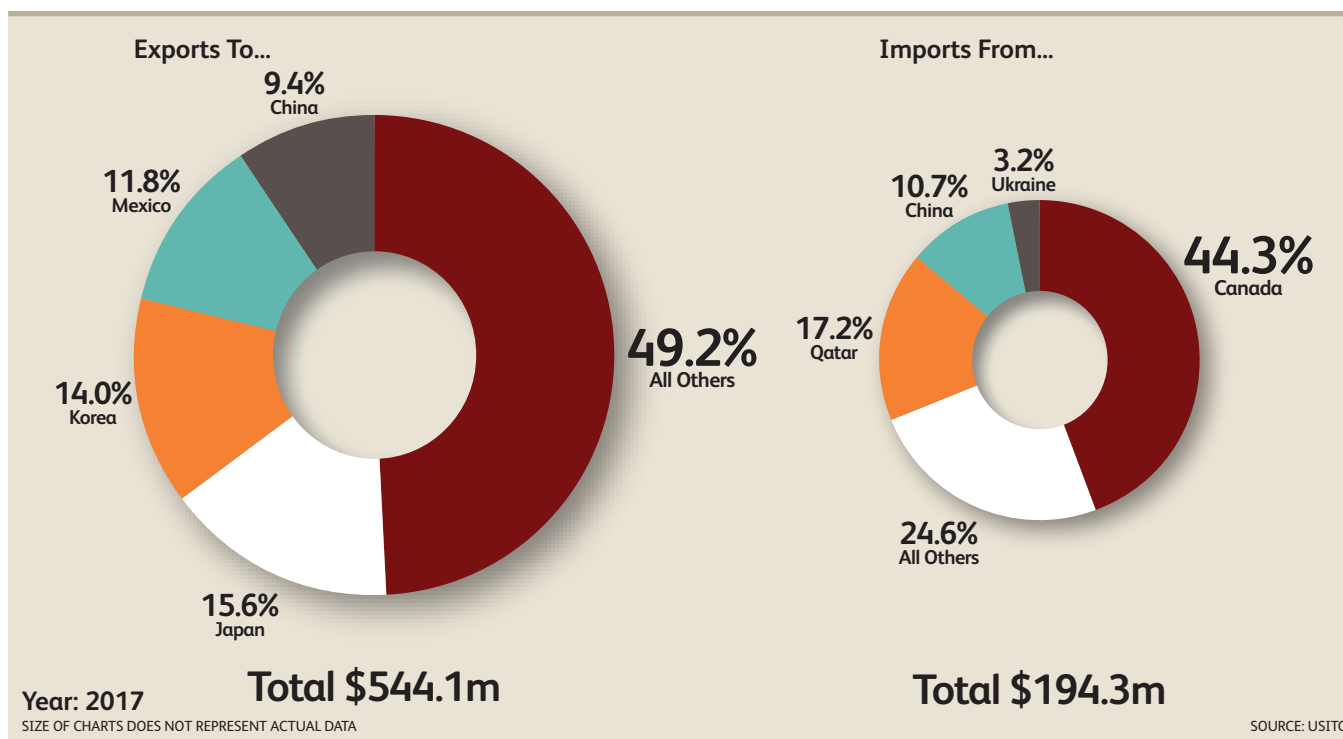
Industry trade balance



SOURCE: WWW.IBISWORLD.COM

scene. It also tends to be undertaken by the small number of global players that dominate the world stage.

Imports, are expected to rise at an annualized rate of 2.4% to \$194.3 million over the past five years. Much of this growth was driven by a stronger US dollar, which made goods produced overseas relatively less expensive in the



Products & Markets

International Trade continued

United States. However, ample domestic supplies of industrial gases and the relative costliness of shipping has constrained and will continue to limit significant import growth.

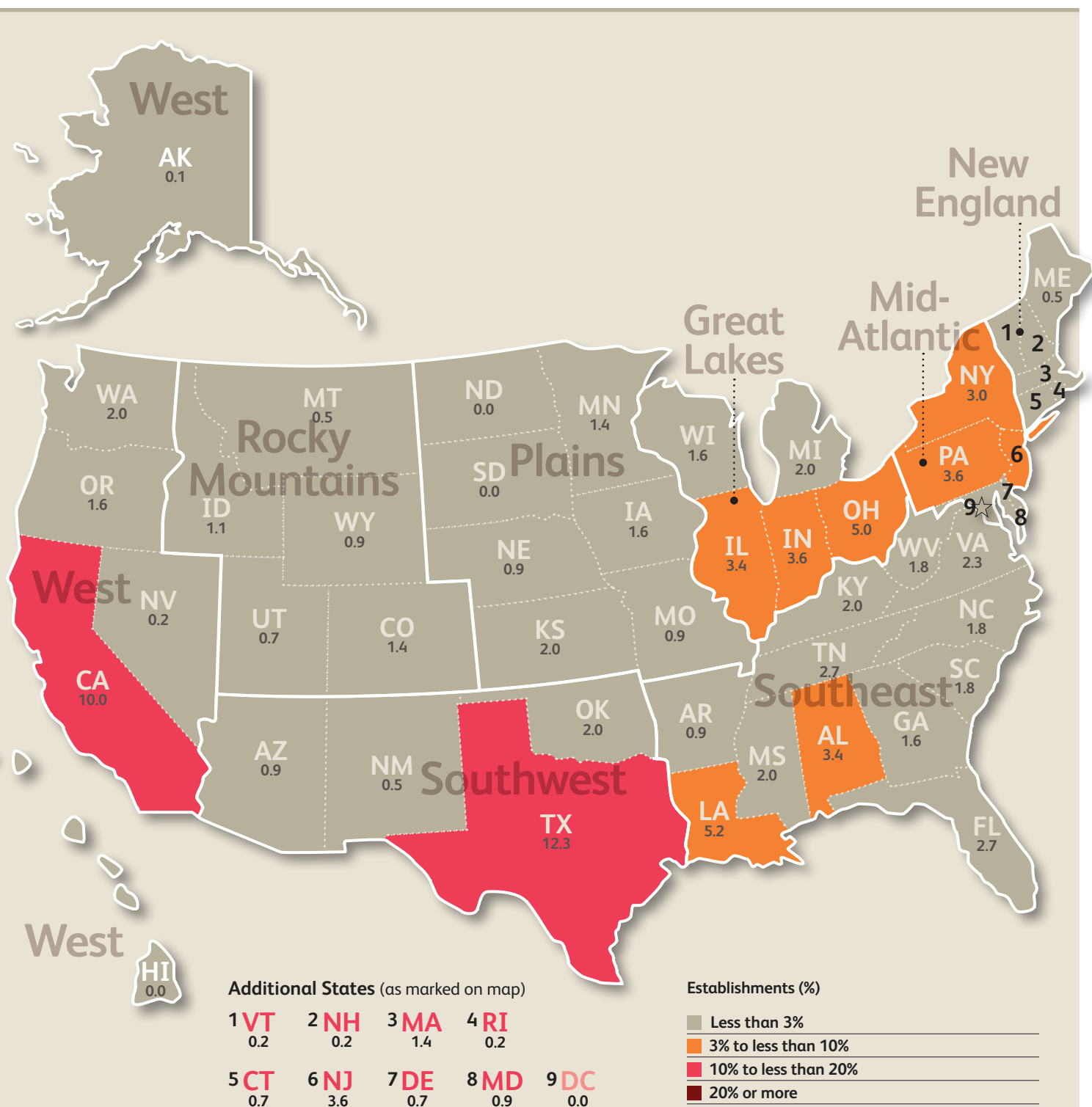
Exports

In the five years to 2017, exports are expected to decrease at an annualized rate of 2.0% to \$544.1 million. Earlier in the decade, industry exports were supported

by greater industrial growth and higher disposable income levels in emerging nations, which boosted sales of industrial gases. However, export growth stalled in 2016 and 2017 due to a slowdown in emerging market growth and a stronger US dollar. Industry exports are also concentrated within the North American Free Trade Agreement (NAFTA) regions. In 2017, Mexico are expected to account for 11.8% of industry exports.

Products & Markets

Business Locations 2017



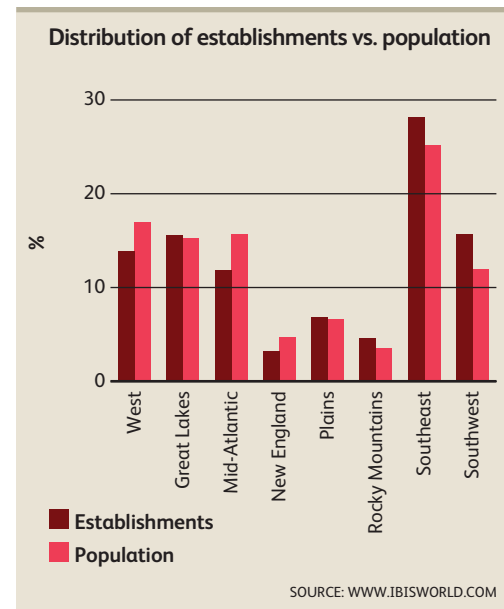
SOURCE: WWW.IBISWORLD.COM

Products & Markets

Business Locations

Oxygen and Hydrogen Gas Manufacturing industry establishments are primarily located in the Southeast, which comprise an estimated 28.3% of industry establishments, West (13.9%), Great Lakes (15.6%) and Southwest (15.7%). Manufacturers in this industry tend to be located near raw material inputs and end-user industries, such as manufacturers and domestic energy producers. For example, the tonnage gas division of industry major player Air Products and Chemicals, Inc., has facilities located in proximity to chemical, energy and metal manufacturing establishments, delivering hydrogen, oxygen and other gases via short-distance pipelines to customer factories.

States with the highest proportion of industry establishments includes Texas, which has an estimated 12.3% of industry establishments, and, California, which has an estimated 10.0% of establishments. A number of the states



with the highest concentration of industrial gas producers, including Texas, are among the top 10 chemical producing states, according to IBISWorld estimates.

Competitive Landscape

Market Share Concentration | Key Success Factors | Cost Structure Benchmarks
Basis of Competition | Barriers to Entry | Industry Globalization

Market Share Concentration

Level
Concentration in
this industry is **High**

The Oxygen and Hydrogen Gas Manufacturing industry has a high level of market share concentration. In 2017, the top four players are expected to account for more than 90.0% of industry revenue. Given the high level of concentration,

industry players are using acquisitions to increase market share. Concentration is expected to remain high over the next five years as operators improve efficiencies and grow market share by acquiring competing companies and production facilities.

Key Success Factors

IBISWorld identifies 250 Key Success Factors for a business. The most important for this industry are:

Effective cost controls

Competitive manufacturing and distribution infrastructure is essential to reducing costs and increasing efficiency.

Having contacts within key markets

Strong relationships with customers are important given the homogeneity of the products offered. A number of these customers operate on a global scale, using the same industrial gas producer throughout the world.

Access to highly skilled workforce

Technical expertise among the workforce can provide a competitive advantage, particularly within niche market segments and in the provision of value-added services.

Provision of superior after-sales service

The ability to provide superior after-sales service to customers is important due to the homogeneity of industry products.

Cost Structure Benchmarks

Profit

Profit, which is measured as earnings before interest and taxes, are relatively high for this industry since oxygen, hydrogen and other merchant gases are necessary in many downstream industries, such as manufacturing, electronics and energy refining. Over the past five years, profit margins have decreased marginally from 19.8% in 2012 to an estimated 19.4% in 2017. Industry margins slightly contracted over the past five years, as slower global economic growth tempered sales to vital downstream manufacturing and energy markets. Moreover, many of the industry's largest players will continue to incur high capital costs related to the construction of on new productive facilities and pipelines for gas transmission.

Purchases

Purchases make up the industry's largest expense, averaging 29.2% of total revenue for industry manufacturers in 2017. Similar

to other manufacturers, companies are susceptible to changes in the cost of input materials, given that they form the largest component of expenses. The largest cost item for most industry operators is related to the purchase and procurement of natural gas, which is reformed via a chemical reaction with steam to form syngas and trace amounts of helium. In turn, the syngas is further processed to extract hydrogen, carbon monoxide and other process gases.

Utilities

Industry participants are substantial users of electrical power, which is used in large quantities to drive compressors, pumps and other equipment. Air separation plants tend to be particularly energy intensive, with a unit making 2,000 tons-per-day of oxygen consuming some 20.0 megawatts of electricity to run its compressors. As a result, utility or electricity related costs in this industry are high and account for an estimated 17.2% of industry revenue in

Competitive Landscape

Cost Structure Benchmarks continued

2017. This share is relatively higher among operators whose primary products are oxygen or nitrogen. In the case of nitrogen gas, energy costs comprise about half of the total production costs. Although industry operators have invested heavily in making their equipment more energy-efficient in recent years, electricity consumption remains among the largest components of operating costs.

Wages

Wage costs are estimated to account for 10.4% of industry revenue in 2017. Wages' share of industry revenue has increased over the past five years, as stable industry profit has curtailed cost-cutting strategies, such as reducing wages, as a means to offset lower revenue from 2012 through 2017.

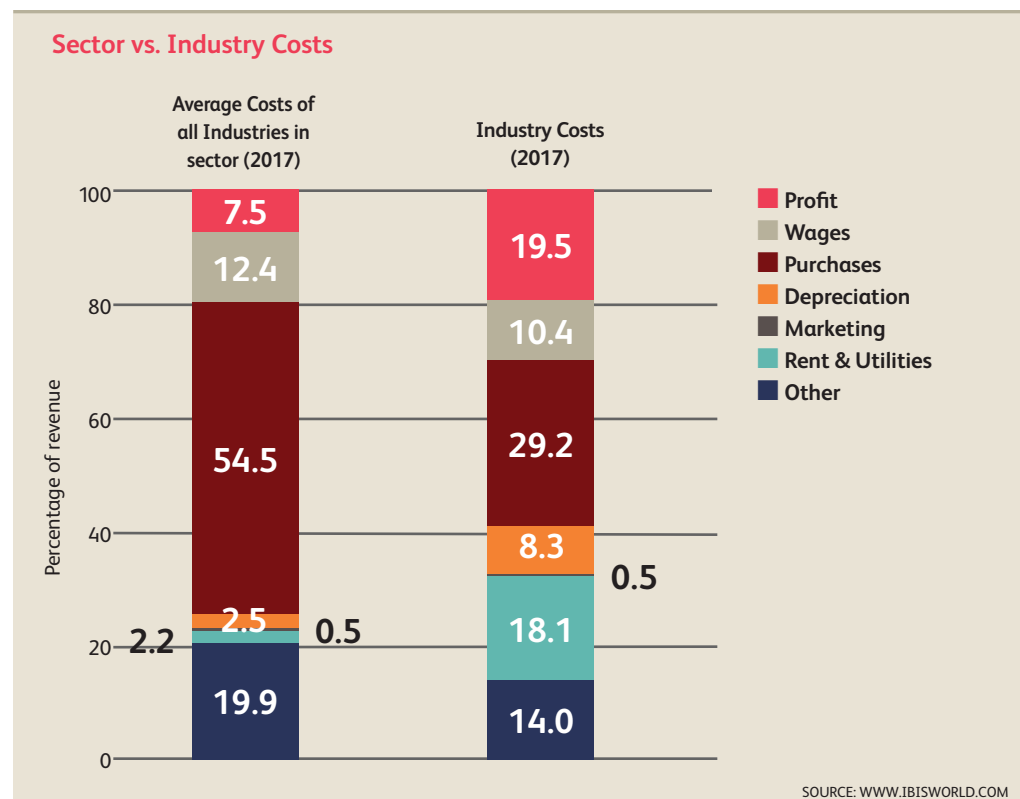
Depreciation

Depreciation rates for this industry are high, accounting for an estimated 8.3% of

industry revenue in 2017. Most of this industry's depreciation costs are associated with the construction and operation of industrial gas pipelines, which supply downstream energy and manufacturing markets with oxygen, hydrogen, nitrogen and other gases. For industry operators, pipeline costs may be particularly substantial during the initial years of operation. Moreover, ongoing pipeline construction, maintenance and expansion of existing pipelines also significantly increases depreciation charges. Lastly, machinery and equipment necessary for industrial gas production is expensive to purchase or lease, which also bolsters industry depreciation costs.

Other

Other costs include outsourced professional fees for accountants, lawyers and other business professionals as well as marketing, insurance, warehousing,



Competitive Landscape

Cost Structure Benchmarks continued

transportation and interest-related costs. Rental costs account for an estimated 1.1% of industry revenue, as

many of the industry's largest companies opt to own as opposed to rent productive facilities.

Basis of Competition

Level & Trend
Competition in this industry is **Medium** and the trend is **Steady**

The industry experiences a moderate and increasing level of competition. Because of the homogeneity of industry products, competition is primarily based on price, distribution and service. This is particularly the case with the likes of nitrogen, oxygen and carbon dioxide, all of which are low-cost commodities that can be produced at large-scale, air-separation plants or at on-site facilities.

Moreover, supply chain management has become increasingly important as

industry operators must be able to supply industry products through various modes including cylinders, pipelines or on-site cryogenic and non-cryogenic plants. The use of delivery tracking systems and telemetry to monitor tank volumes and schedule deliveries and ensure safer filling, are becoming increasingly important. The speed and reliability of fulfilling customer orders, which are often time-sensitive, can be a basis of differentiation among competitors.

Barriers to Entry

Level & Trend
Barriers to Entry in this industry are **High** and **Steady**

Given the highly concentrated nature of the industry, barriers to entry are high. It is difficult for new entrants to gain revenue as many of the established operators have strong relationships with key buyers and have established multi-year contracts with many of their customers. Moreover, the major industry operators have a strong influence over the pricing of key products including nitrogen, oxygen and hydrogen. Many of these large companies can lower the price of their goods because of their bulk production. Lower prices can crowd out smaller producers who are unable to lower their prices without enduring a financial loss.

Additionally, high capital costs and specialized technical requirements can further pose substantial barriers. Oxygen and hydrogen gas manufacturing is

Barriers to Entry checklist

Competition	Medium
Concentration	High
Life Cycle Stage	Mature
Capital Intensity	High
Technology Change	Low
Regulation & Policy	Medium
Industry Assistance	Low

SOURCE: WWW.IBISWORLD.COM

extremely capital intensive. New entrants will need to be able to fund the large upfront capital costs. New companies must also comply with regulations regarding the production process, including statutes on toxic emissions. Nonetheless, despite these barriers, entry opportunities in niche segments, including the production of specialty gases, exist.

Competitive Landscape

Industry Globalization

Level & Trend
Globalization in this industry is **Medium** and the trend is **Increasing**

The level of globalization within the Oxygen and Hydrogen Gas Manufacturing industry is moderate and will continue to increase over the five years to 2022. A number of industry operators compete on

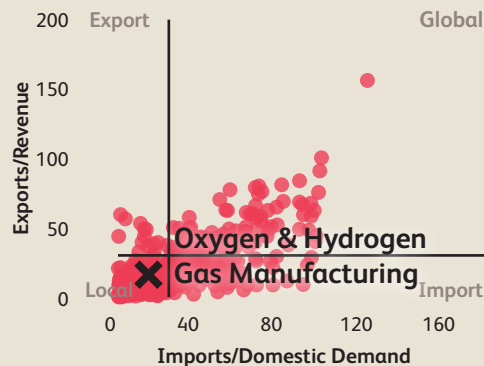
a global scale. US-based, Praxair, for example, has operations in roughly 50 countries. Similarly, The Linde Group, a German-headquartered company, has operations in nearly 100 countries.

International trade is a major determinant of an industry's level of globalization.

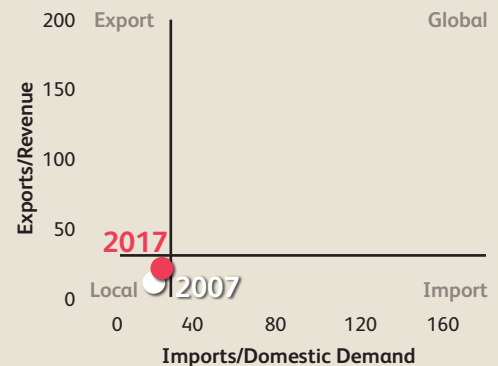
Exports offer growth opportunities for firms. However there are legal, economic and political risks associated with dealing in foreign countries.

Import competition can bring a greater risk for companies as foreign producers satisfy domestic demand that local firms would otherwise supply.

Trade Globalization



Going Global: Oxygen & Hydrogen Gas Manufacturing 2007-2017

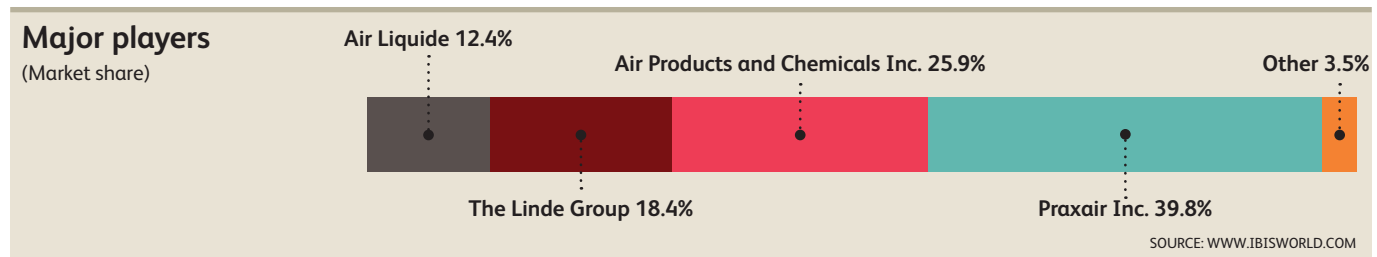


SOURCE: WWW.IBISWORLD.COM

Major Companies

Praxair Inc. | Air Products and Chemicals Inc.

The Linde Group | Air Liquide



Player Performance

Praxair Inc.
Market share: 39.8 %

Founded in 1907 and headquartered in Danbury, CT, Praxair is one of the largest global industrial gases companies, employing 26,498 people, 10,182 of which work in the United States. Praxair produces atmospheric gases (e.g. oxygen, nitrogen and argon), processed gases (e.g. carbon dioxide, helium and hydrogen) and various specialty gases, such as electronic gases. The company serves 25 industry segments, including: metals; food and beverages; aerospace; chemicals; healthcare; energy; manufacturing; electronics; water treatment; and petroleum refining. In 2016, Praxair's global revenue totaled \$10.5 billion.

Proximity to downstream markets is essential to Praxair's business, as transportation relative to product costs are high in this industry and industrial gases are often directly shipped from manufacturer to consumer via pipeline. For example, in June 2014, the company

announced the startup of an air separation unit in Memphis, TN, which will supply liquefied oxygen, nitrogen and argon largely to steel and energy refineries in the surrounding area. Later that month, Praxair announced the startup of a new packaged gas fill plant located in Bismarck, ND, designed to increase cylinder gas capacity to refiners in the Bakken shale oil formation region. Moreover, in March 2015, Praxair announced an up to 180-tons-per-day contract with Owens-Illinois (OI), a leading global glass manufacturer. Praxair will supply OI's Muskogee, OK factory with gaseous oxygen.

In addition, Praxair has engaged in a series of strategic acquisitions in the five years to 2017. As a global corporation, Praxair operates in more than 30 countries and derives roughly 56.0% of its sales outside of the United States. Over the past five years, the company has

Praxair Inc. (industry-specific segment) - financial performance*

Year	Revenue (\$ million)	(% change)	Operating Income (\$ million)	(% change)
2012	2,747.7	N/C	722.3	N/C
2013	3,069.2	11.7	768.8	6.4
2014	3,296.2	7.4	812.4	5.7
2015	3,003.8	-8.9	801.0	-1.4
2016	2,864.1	-4.7	735.7	-8.2
2017	3,004.4	4.9	772.5	5.0

*Estimates

SOURCE: IBISWORLD

Major Companies

Player Performance continued

expanded its presence overseas. In June 2016, Praxair acquired Yara International ASA's (Yara) European carbon dioxide business, which supplies liquid CO₂ and dry ice primarily to food and beverage markets across Europe.

Over the past five years, the company has also pursued vertical integration strategies, expanding into the wholesale distribution of carbon dioxide, oxygen, hydrogen and other industrial gases. In November 2012, Praxair acquired Acetylene Oxygen Company, an independent gas and welding products distributor operating in the southern United States. In March of 2013, Praxair completed the \$1.1 billion acquisition of NuCO₂ Inc., the largest provider of fountain beverage carbonation in the United States. NuCO₂ supplies carbon dioxide that is added to fountain soda and draft beer and provides delivery services to restaurant chains, convenience stores and entertainment locations. In February 2014, Praxair fully acquired its distribution joint venture Praxair Distribution Mid-Atlantic, which operates in 51 facilities and has sales in excess of \$220.0 million. In 2016, Praxair acquired three independent distributors of industrial and specialty packaged gases with operations in Indiana, Illinois and Arizona. As a fully integrated manufacturer and distributor of industrial gases, Praxair can better control costs and potentially achieve higher margins. In December 2016, Praxair announced plans

to merge with industry major player The Linde Group. Combined, these companies would become the largest global manufacturer of oxygen, hydrogen and other industrial gases, with global revenue of roughly \$30.0 billion.

Financial performance

Over the five years to 2017, Praxair's industry-specific revenue is expected to increase marginally at an annualized rate of 1.8% to \$3.0 billion. This revenue expansion was driven by acquisitions. However, company revenue declined 8.9% and 4.7% in 2015 and 2016, respectively, as slow economic growth in Asia and a stronger US dollar depressed overseas sales. Moreover, slightly weaker US industrial activity led to lower demand from domestic metals, chemicals and manufacturing markets.

Meanwhile, Praxair's profit margins marginally declined in recent years due to lower sales volumes. Additionally, increased capital expenditures will likely pressure company margins during this year. For example, in June 2015, Praxair announced plans to build a new air separation unit (ASU) to support its industrial gas pipeline operations in Michigan and the Great Lakes region. Although construction of this facility will raise costs in the near term, the new ASU plant, which will begin operations in 2017, will help meet growing demand for industrial gases and bolster company revenue in the five years to 2022.

Player Performance

Air Products and Chemicals Inc.

Market share: 25.9 %

Air Products and Chemicals Inc. is a global supplier of industrial and specialty gas products and claims to be the world's largest supplier of hydrogen and helium. Founded in 1940, Pennsylvania-based Air Products has more than 18,600 employees, roughly 6,800 of which work in the United States. The company operates in 50 countries through four

business segments: merchant gases, tonnage gases, electronics and performance materials, and equipment and energy. In 2016, Air Products' global revenue totaled \$9.5 billion.

Air Products operates in this industry primarily through its tonnage gas division, which provides hydrogen, nitrogen, oxygen and other gases

Major Companies

Player Performance continued

principally to energy production, chemical and metal industries located in proximity to Air Product's facilities and delivered via pipeline. The company is the world's largest producer of hydrogen, which is commonly used by oil refiners to lower the sulfur content in gasoline and other diesel fuels.

Additionally, the company's merchant gases division manufactures oxygen, nitrogen, argon, hydrogen, helium and certain medical and specialty gases. However, a majority of revenue from these operations are captured as industrial gas distribution and not manufacturing revenue. Moreover, the United States accounts for slightly more than 35.0% the company's sales.

Over the past five years, Air Products has acquired global industrial gas manufacturing and distribution companies. In May 2013, Air Products acquired EPCO Carbondioxide Products, the largest independent US producer of

liquid carbon dioxide, expanding the company's merchant gas segment. In addition, Air Products continues to exploit growth opportunities in emerging markets. To expand to rapidly developing regions, the company has recently engaged in strategic acquisitions.

Financial performance

Over the five years to 2017, industry-specific revenue marginally decreased at an estimated annualized rate of 2.3% to \$2.0 billion. While the company has experienced increased North American demand for other industrial gases, such as oxygen, nitrogen and argon, which are used in manufacturing, food production and healthcare markets, The company's stagnant financial performance was offset by lower per unit prices charged for hydrogen due to falling oil and natural gas prices. Furthermore, a stronger US dollar has negatively impacted company exports over the past five years.

Air Products and Chemicals Inc. (industry-specific segment) - financial performance*

Year	Revenue (\$ million)	(% change)	Operating Income (\$ million)	(% change)
2012	2,195.9	N/C	369.5	N/C
2013	2,392.9	9.0	382.4	3.5
2014	2,409.9	0.7	369.6	-3.3
2015	2,182.7	-9.4	369.6	0.0
2016	1,901.1	-12.9	409.3	10.7
2017	1,956.2	2.9	421.7	3.0

*Estimates

SOURCE: IBISWORLD

Player Performance

The Linde Group
Market share: 18.4 %

Headquartered in Germany, the Linde Group has more than 59,700 employees and operations in more than 100 countries, including the United States, where the company has more than 4,000

employees. Linde operates in this industry through its gases division, which produces and distributes a range of compressed and liquefied gases, including oxygen, nitrogen, argon, carbon

Major Companies

Player Performance continued

dioxide and monoxide, hydrogen, acetylene and electronics gases. Furthermore, Linde's gases are used in a variety of downstream markets, such as steel production, chemical manufacturing, food processing, glass production and healthcare. Lastly, the company is a leading global player in the development of environmentally friendly hydrogen technology. In 2015, Linde's global revenue totaled \$19.2 billion.

In the United States, Linde has more than 30 air separation plants and 24 carbon dioxide liquefaction plants. From these facilities, Linde generally supplies its North American customers with industrial gases through pipeline or through the delivery of gases in tankers and cylinders. Over the past five years, the company expanded its manufacturing footprint in the United States. For example, in 2014, Linde opened a new nitrogen liquefaction plant in Delta, OH. Moreover, in 2014, Linde opened a new specialty gas

production plant in Hammond, IN, which will manufacture industrial and medical gases for customers in the food and healthcare industries.

Financial performance

In the five years to 2017, industry-specific revenue is expected to increase at an annualized rate of 3.4% to \$1.4 billion. Over the past five years, the company increased its reliance on supplies from on-site facilities or via pipeline for high-volume customers, as opposed to the traditional delivery method of cylinders and tanks. For example, in 2014 and 2015, Linde invested roughly \$250.0 million for the installation of a new gasification train, in its existing synthesis gas complex in La Porte, TX. This new fully-integrated site for the production of air gases and syngas products is the company's largest facility of this type in the United States and will help ensure Linde's long-term gas supply contracts with its petrochemical customers.

The Linde Group (industry-specific segment) - financial performance*

Year	Revenue (\$ million)	(% change)	Operating Income (\$ million)	(% change)
2012	1,175.9	N/C	294.3	N/C
2013	1,354.3	15.2	346.3	17.6
2014	1,380.1	1.9	335.0	-3.3
2015	1,386.9	0.5	347.3	3.7
2016	1,324.9	-4.5	334.0	-3.8
2017	1,389.8	4.9	349.7	4.7

*Estimates

SOURCE: IBISWORLD

Player Performance

Air Liquide
Market share: 12.4 %

Air Liquide Inc. operates in 80 countries employing roughly 67,000 workers and generated more than \$19.0 billion in net sales globally. The company operates through four main business segments.

The company's large business line manufactures all classes of industrial gases for distribution via direct pipeline or on-site production facilities to large manufacturing or heavy industrial users.

Major Companies

Player Performance continued

Air Liquide's industrial merchant business line manufactures and distributes products via rail or tanker to smaller manufacturing, food and beverage and construction users. The healthcare segment produces medical gases, such as oxygen gas USP or ultra-pure helium, for medical use. Lastly, the electronics segment produces a wide selection of carrier gases such as ultra-pure nitrogen or specialty gases for technical manufacturing industries. Globally, the company's revenue totaled roughly \$17.5 billion in 2015.

In May 2016, Air Liquide vastly expanded its industry-relevant operations in the United States with the acquisition of Airgas, one of the leading suppliers of industrial gases in North America. Prior to the purchase of Airgas, Air Liquide had more than 5,000 employees, 140 industrial gas plants and 2,000 miles of gas pipeline. The acquisition will create a widespread multichannel distribution network in the United States, as Air Liquide will absorb Airgas' national distribution network of more than 1,100 branches, retail stores, cylinder fill plants, distribution and manufacturing facilities throughout the country. Combined, the newly formed company will have more than 20,000 US employees.

Financial performance

In the five years to 2017, industry-relevant revenue at Air Liquide is expected to increase at an annualized rate of 4.9% to \$936.9 million. However, much of this growth was driven by the acquisition of Airgas in 2016. Over the past five years, US demand for Air Liquide's industrial merchant gases have largely been driven by domestic oil and gas exploration activity. For example, in 2014, the company benefited from its new North Dakota plant, which was designed to supply nitrogen to energy projects in the surrounding states. Moreover, in the United States, Air Liquide's on-site gas production and pipeline-delivered operations services the refining, natural gas, chemical and metal manufacturing industries.

From 2014 through 2016, a rapid decline in energy and commodity prices significantly reduced demand from these vital downstream markets in recent years. In 2015, Air Liquide reported a slowdown in North American industrial merchant gas sales due to a slowdown in oil and gas production as well as metal fabrication industries. These trends are expected to turnaround in 2017, as demand from downstream energy markets will likely improve due to higher global commodity prices.

Air Liquide (industry-specific segment) - financial performance

Year	Revenue (\$ million)	(% change)	Operating Income (\$ million)	(% change)
2012	736.5	N/C	68.1	N/C
2013	759.0	3.1	70.0	2.7
2014	783.7	3.3	73.5	5.0
2015	785.6	0.2	77.4	5.4
2016	893.1	13.7	86.54	11.8
2017	936.9	4.9	90.8	4.9

*Estimates

SOURCE: ANNUAL REPORT AND IBISWORLD

Operating Conditions

Capital Intensity | Technology & Systems | Revenue Volatility
Regulation & Policy | Industry Assistance

Capital Intensity

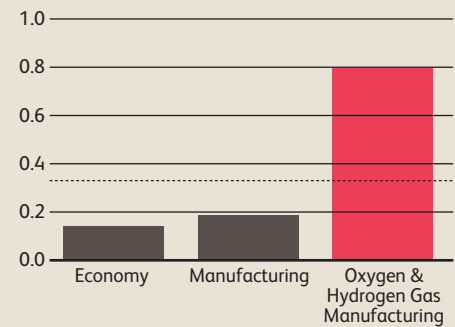
Level

The level of capital intensity is **High**

The Oxygen and Hydrogen Gas Manufacturing industry is capital intensive, with industry operators spending about \$0.80 on capital for every dollar spent on labor. To effectively compete, industry operators require large scale production units and distribution networks, which demand substantial capital investments. In addition, plants tend to be highly automated, requiring limited on-site labor. Major players, such as Praxair, Air Products and Chemicals, and The Linde Group are currently engaging in vast capital expenditures, of which a large part is dedicated to the construction of new facilities or transport pipelines.

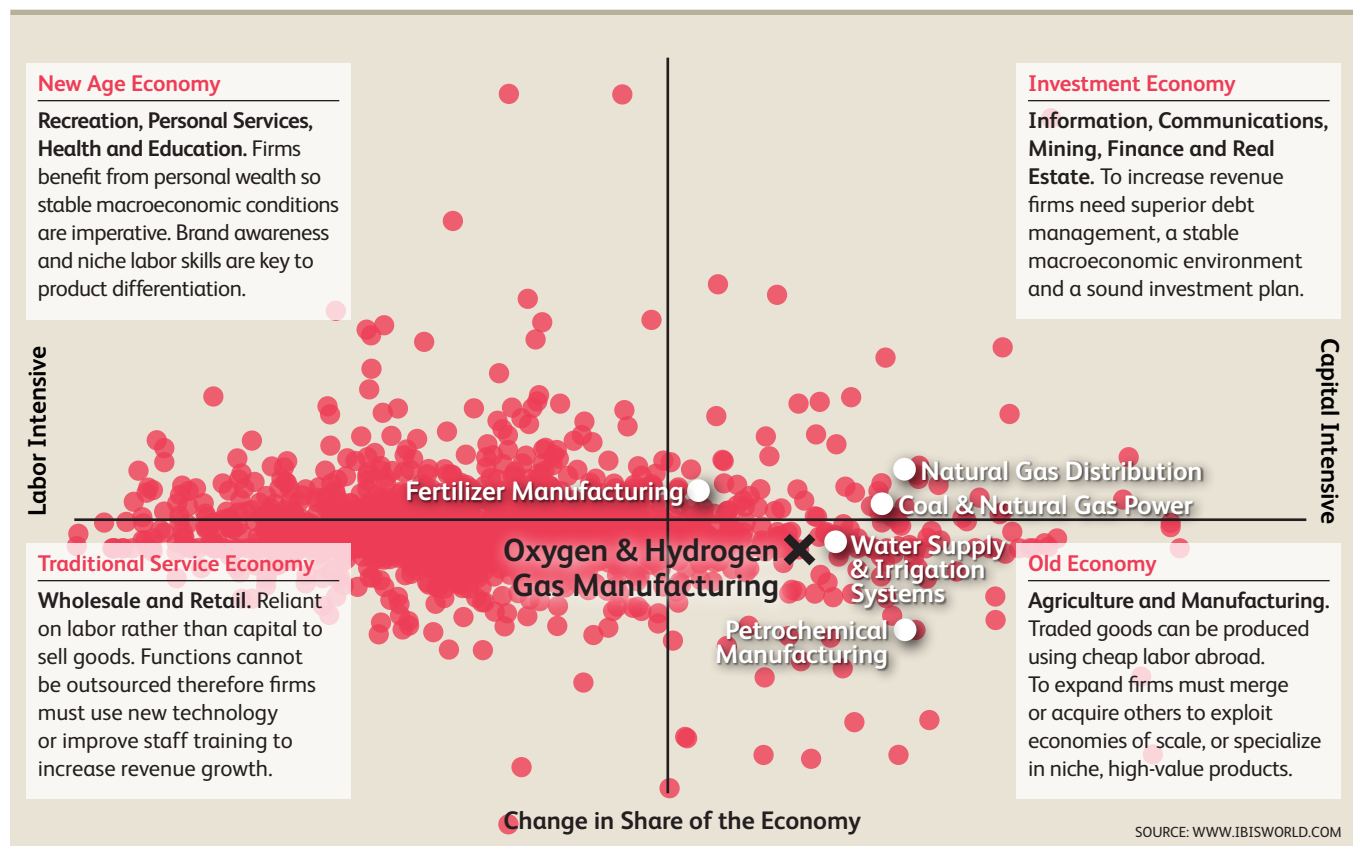
Capital intensity

Capital units per labor unit



SOURCE: WWW.IBISWORLD.COM

Tools of the Trade: Growth Strategies for Success



Operating Conditions

Technology & Systems

Level

The level of Technology Change is **Low**

The Oxygen and Hydrogen Gas Manufacturing industry has a low level of technological change. Industry operators are increasingly using integrated supply chain management systems. Industrial gas manufacturers use technology to manage orders, track product shipments and monitor tank volumes, helping to ensure a timelier and safer delivery of industrial gases to customers.

The production process of industrial gases has not changed significantly over the past decade. The manufacture of industrial gases includes two separate industrial gas extraction processes: cryogenic and noncryogenic. First developed over a century ago, cryogenic techniques involve liquefying air under pressure at low temperatures and allowing the air to return to its gaseous form under controlled conditions. Cryogenic systems are most suitable for large tonnage users, low temperature applications and high purity gas requirements.

Developed in the 1970s, non-cryogenic techniques are becoming increasingly important for smaller and less demanding on-site applications. Today there are three primary forms of noncryogenic separation methods: pressure swing adsorption (PSA), vacuum-pressure swing adsorption and membrane diffusion. While noncryogenic techniques are cheaper and simpler than conventional cryogenic technology, they do not produce the same level of gas purity.

Cryogenic air separation accounts for between 80.0% and 85.0% of oxygen and nitrogen production. However, noncryogenic PSA and membrane diffusion methods are continuing to take a larger share of these markets. The comparatively less expensive noncryogenic production is also shifting demand away from the merchant bulk and cylinder markets.

Revenue Volatility

Level

The level of Volatility is **Medium**

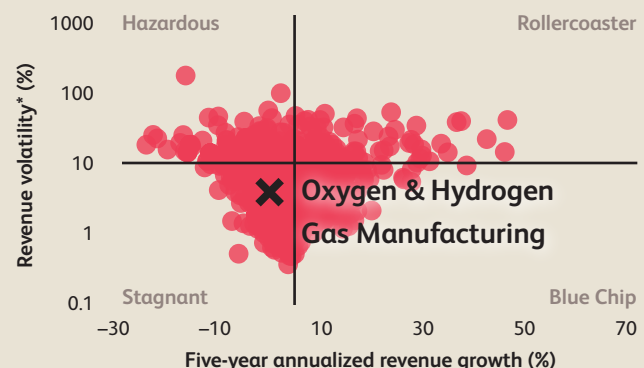
The Oxygen and Hydrogen Gas Manufacturing industry has a moderate level of volatility, thanks to the cyclical nature of its downstream users like the chemical industry. Industry revenue

declined in four of the past five years due to decreased demand in buyer markets. However, sales for oxygen and hydrogen gas manufacturers are expected to slowly recover in 2017, as rising commodity prices,

A higher level of revenue volatility implies greater industry risk. Volatility can negatively affect long-term strategic decisions, such as the time frame for capital investment.

When a firm makes poor investment decisions it may face underutilized capacity if demand suddenly falls, or capacity constraints if it rises quickly.

Volatility vs Growth



* Axis is in logarithmic scale

SOURCE: WWW.IBISWORLD.COM

Operating Conditions

Revenue Volatility continued

economic growth and healthy demand from downstream customers will provide the impetus for industry revenue growth.

Accordingly, revenue volatility is expected to decrease over the next five

years, as greater demand from vital industrial gases customers, like chemical manufacturers and energy refiners, will lead to increasing gas sales, ultimately aiding industry revenue growth.

Regulation & Policy

Level & Trend
The level of Regulation is **Medium** and the trend is **Increasing**

Participants in the Oxygen and Hydrogen Gas Manufacturing industry are subject to regulations that vary between gases. For example, because gases such as nitrogen and carbon dioxide are nontoxic, regulations affect transportation and usage. On the other hand, regulations are more extensive for gases like hydrogen, which is a fire and explosion hazard. Industry operators are also subject to the Occupational Health and Safety Act, the Hazardous Materials Transportation Act and the Clean Air Act. Enforced by a number of regulatory authorities, including the Environmental

Protection Agency and state and regional air quality agencies, the Clean Air Act sets requirements for airborne emissions from a number of sources, including stacks and processing tanks.

Industrial gas manufacturers are further subject to various environmental regulations, including the Comprehensive Environmental Response, Compensation and Liability Act and the Resource Conservation and Recovery Act, which governs the handling, storage, treatment and disposal of hazardous and solid non-hazardous waste and underground storage tanks.

Industry Assistance

Level & Trend
The level of Industry Assistance is **Low** and the trend is **Steady**

While the Oxygen and Hydrogen Gas Manufacturing industry receives little in the way of governmental assistance, a number of products are protected by import duties which will vary depending on the originating country. For example, imports of oxygen, nitrogen, hydrogen, argon and helium are subject to a

general tariff of 3.7%, but can rise as high as 25.0% when imported from Cuba, Laos or North Korea. However, products imported under various free trade agreements, such as the North American Free Trade Agreement or the Generalized System of Preferences, are not subject to tariffs.

Key Statistics

Industry Data

	Revenue (\$m)	Industry Value Added (\$m)	Establishments	Enterprises	Employment	Exports (\$m)	Imports (\$m)	Wages (\$m)	Domestic Demand	Consumer spending (\$b)
2008	11,884.3	3,910.0	547	95	11,159	462.4	285.1	970.1	11,707.0	10,007.2
2009	8,823.7	2,620.5	493	86	9,865	426.9	193.3	785.7	8,590.1	9,847.0
2010	8,545.8	2,750.9	491	86	9,891	514.8	199.2	769.5	8,230.2	10,036.3
2011	8,373.3	2,762.9	475	87	10,160	579.0	243.6	791.4	8,037.9	10,263.5
2012	7,958.7	2,993.3	450	84	10,189	600.6	172.6	780.5	7,530.7	10,413.2
2013	7,889.9	2,928.7	453	81	10,182	592.8	186.2	762.2	7,483.3	10,565.4
2014	7,847.8	2,959.8	449	86	9,433	547.7	220.7	743.0	7,520.8	10,868.9
2015	7,431.3	2,837.9	466	89	9,538	608.3	288.1	746.7	7,111.1	11,214.7
2016	7,223.0	2,756.5	458	88	9,755	574.5	209.7	754.0	6,858.2	11,518.5
2017	7,550.9	2,888.0	455	87	10,058	544.1	194.3	785.0	7,201.1	11,823.7
2018	7,878.3	3,042.2	453	87	10,315	555.1	197.4	811.8	7,520.6	12,125.2
2019	7,983.5	3,072.2	449	86	10,434	561.1	209.2	825.1	7,631.6	12,310.1
2020	8,048.8	3,076.0	444	85	10,469	563.1	222.5	830.3	7,708.2	12,503.3
2021	8,154.6	3,106.0	439	84	10,512	571.7	226.9	836.1	7,809.8	12,691.7
2022	8,257.4	3,108.2	438	84	10,617	578.1	225.0	847.5	7,904.3	12,924.5
Sector Rank	170/436	127/435	181/436	301/436	239/436	197/399	288/399	209/436	183/399	N/A
Economy Rank	827/1707	719/1568	1215/1707	1456/1707	1192/1707	233/524	344/524	1061/1707	219/524	N/A

Annual Change

	Revenue (%)	Industry Value Added (%)	Establishments (%)	Enterprises (%)	Employment (%)	Exports (%)	Imports (%)	Wages (%)	Domestic Demand (%)	Consumer spending (%)
2009	-25.8	-33.0	-9.9	-9.5	-11.6	-7.7	-32.2	-19.0	-26.6	-1.6
2010	-3.1	5.0	-0.4	0.0	0.3	20.6	3.1	-2.1	-4.2	1.9
2011	-2.0	0.4	-3.3	1.2	2.7	12.5	22.3	2.8	-2.3	2.3
2012	-5.0	8.3	-5.3	-3.4	0.3	3.7	-29.1	-1.4	-6.3	1.5
2013	-0.9	-2.2	0.7	-3.6	-0.1	-1.3	7.9	-2.3	-0.6	1.5
2014	-0.5	1.1	-0.9	6.2	-7.4	-7.6	18.5	-2.5	0.5	2.9
2015	-5.3	-4.1	3.8	3.5	1.1	11.1	30.5	0.5	-5.4	3.2
2016	-2.8	-2.9	-1.7	-1.1	2.3	-5.6	-27.2	1.0	-3.6	2.7
2017	4.5	4.8	-0.7	-1.1	3.1	-5.3	-7.3	4.1	5.0	2.7
2018	4.3	5.3	-0.4	0.0	2.6	2.0	1.6	3.4	4.4	2.6
2019	1.3	1.0	-0.9	-1.1	1.2	1.1	6.0	1.6	1.5	1.5
2020	0.8	0.1	-1.1	-1.2	0.3	0.4	6.4	0.6	1.0	1.6
2021	1.3	1.0	-1.1	-1.2	0.4	1.5	2.0	0.7	1.3	1.5
2022	1.3	0.1	-0.2	0.0	1.0	1.1	-0.8	1.4	1.2	1.8
Sector Rank	125/436	148/435	325/436	221/436	151/436	146/399	84/399	157/436	158/399	N/A
Economy Rank	579/1707	629/1568	1384/1707	1138/1707	811/1707	209/524	117/524	762/1707	208/524	N/A

Key Ratios

	IVA/Revenue (%)	Imports/Demand (%)	Exports/Revenue (%)	Revenue per Employee (\$'000)	Wages/Revenue (%)	Employees per Est.	Average Wage (\$)	Share of the Economy (%)
2008	32.90	2.44	3.89	1,065.00	8.16	20.40	86,934.31	0.03
2009	29.70	2.25	4.84	894.45	8.90	20.01	79,645.21	0.02
2010	32.19	2.42	6.02	864.00	9.00	20.14	77,798.00	0.02
2011	33.00	3.03	6.91	824.14	9.45	21.39	77,893.70	0.02
2012	37.61	2.29	7.55	781.11	9.81	22.64	76,602.22	0.02
2013	37.12	2.49	7.51	774.89	9.66	22.48	74,857.59	0.02
2014	37.72	2.93	6.98	831.95	9.47	21.01	78,766.03	0.02
2015	38.19	4.05	8.19	779.13	10.05	20.47	78,286.85	0.02
2016	38.16	3.06	7.95	740.44	10.44	21.30	77,293.70	0.02
2017	38.25	2.70	7.21	750.74	10.40	22.11	78,047.33	0.02
2018	38.61	2.62	7.05	763.77	10.30	22.77	78,700.92	0.02
2019	38.48	2.74	7.03	765.14	10.34	23.24	79,078.01	0.02
2020	38.22	2.89	7.00	768.82	10.32	23.58	79,310.34	0.02
2021	38.09	2.91	7.01	775.74	10.25	23.95	79,537.67	0.02
2022	37.64	2.85	7.00	777.75	10.26	24.24	79,824.81	0.02
Sector Rank	60/435	341/399	273/399	72/436	335/436	319/436	68/436	127/435
Economy Rank	727/1568	440/524	358/524	228/1707	1396/1707	573/1707	366/1707	719/1568

Figures are in inflation-adjusted 2017 dollars. Rank refers to 2017 data.

SOURCE: WWW.IBISWORLD.COM

Provided to: University of California - Berkeley (2127291013) | 13 October 2017

Industry Financial Ratios

	Apr 2012 - Mar 2013	Apr 2013 - Mar 2014	Apr 2014 - Mar 2015	Apr 2015 - Mar 2016	Apr 2015 - Mar 2016 by company revenue		
					Small (<\$10m)	Medium (\$10-50m)	Large (>\$50m)
Liquidity Ratios							
Current Ratio	1.8	1.9	2.2	2.1	2.4	1.9	2.1
Quick Ratio	0.9	1.0	1.3	1.2	1.5	1.1	1.3
Sales / Receivables (Trade Receivables Turnover)	10.2	9.6	9.4	9.4	8.2	8.2	12.2
Days' Receivables	35.8	38.0	38.8	38.8	44.5	44.5	29.9
Cost of Sales / Inventory (Inventory Turnover)	8.8	8.2	7.6	7.8	8.2	5.3	10.2
Days' Inventory	41.5	44.5	48.0	46.8	44.5	68.9	35.8
Cost of Sales / Payables (Payables Turnover)	15.6	13.4	13.8	14.3	14.2	11.1	19.3
Days' Payables	23.4	27.2	26.4	25.5	25.7	32.9	18.9
Sales / Working Capital	12.6	9.7	7.4	7.4	5.9	7.7	7.8
Coverage Ratios							
Earnings Before Interest & Taxes (EBIT) / Interest	4.7	10.0	14.0	12.8	4.7	19.7	13.8
Net Profit + Dep., Depletion, Amort. / Current Maturities LT Debt	3.4	4.6	5.5	4.6	n/a	5.2	4.5
Leverage Ratios							
Fixed Assets / Net Worth	1.0	0.8	0.7	0.7	0.7	0.6	0.8
Debt / Net Worth	1.1	1.0	0.8	0.7	0.7	1.1	0.5
Tangible Net Worth	42.7	43.6	45.5	48.1	36.5	43.1	54.8
Operating Ratios							
Profit before Taxes / Net Worth, %	13.8	24.0	31.7	17.9	12.1	28.2	14.2
Profit before Taxes / Total Assets, %	6.1	11.4	14.4	9.5	6.5	9.6	9.9
Sales / Net Fixed Assets	4.8	5.7	5.3	4.5	5.8	9.1	3.7
Sales / Total Assets (Asset Turnover)	2.0	2.0	1.9	1.7	1.9	2.1	1.6
Cash Flow & Debt Service Ratios (% of sales)							
Cash from Trading	18.0	24.6	25.8	25.6	43.5	30.2	19.9
Cash after Operations	5.9	9.2	11.7	9.6	12.2	6.4	10.5
Net Cash after Operations	5.8	8.8	10.3	9.3	9.5	6.7	10.6
Cash after Debt Amortization	0.9	2.9	4.2	2.1	1.7	1.9	2.7
Debt Service P&I Coverage	2.0	3.9	4.6	4.0	3.2	3.4	6.7
Interest Coverage (Operating Cash)	7.3	13.9	18.5	17.5	9.9	13.0	21.9
Assets, %							
Cash & Equivalents	7.5	9.4	11.4	11.6	16.1	8.4	12.3
Trade Receivables (net)	20.0	20.0	19.9	19.0	22.0	26.4	13.6
Inventory	20.7	19.9	19.9	18.1	18.0	25.3	13.8
All Other Current Assets	2.5	2.5	2.5	2.2	1.0	2.5	2.5
Total Current Assets	50.6	51.9	53.7	51.0	57.1	62.5	42.1
Fixed Assets (net)	39.9	36.1	33.8	36.7	32.2	25.6	44.9
Intangibles (net)	4.8	6.3	6.2	6.0	2.9	6.6	6.5
All Other Non-Current Assets	4.8	5.8	6.2	6.3	7.8	5.3	6.5
Total Assets	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Assets (\$m)	20,323.1	17,297.6	20,230.0	18,315.8	232.1	1,868.9	16,214.8
Liabilities, %							
Notes Payable-Short Term	6.4	6.0	6.0	6.1	9.8	8.3	3.6
Current Maturities L/T/D	3.4	3.6	2.6	2.7	3.1	3.1	2.3
Trade Payables	11.9	12.3	11.1	10.5	10.4	15.5	7.6
Income Taxes Payable	0.4	0.4	0.4	0.2	n/a	0.5	0.2
All Other Current Liabilities	7.1	6.8	8.3	6.7	9.1	6.4	6.1
Total Current Liabilities	29.3	29.2	28.4	26.2	32.5	33.7	19.8
Long Term Debt	17.3	14.5	14.4	13.5	17.3	11.1	14.0
Deferred Taxes	0.8	0.9	0.8	0.9	0.4	1.1	1.0
All Other Non-Current Liabilities	5.2	5.5	4.8	5.1	10.5	4.5	4.0
Net Worth	47.5	49.9	51.7	54.1	39.4	49.7	61.3
Total Liabilities & Net Worth (\$m)	20,323.1	17,297.6	20,230.0	18,315.8	232.1	1,868.9	16,214.8
Maximum Number of Statements Used	351	319	341	315	49	101	165

Source: RMA Annual Statement Studies, rmahq.org. RMA data for all industries is derived directly from more than 260,000 statements of member financial institutions' borrowers and prospects.

Note: For a full description of the ratios refer to the Key Statistics chapter online.



Jargon & Glossary

Industry Jargon

AIR SEPARATION The process of separating atmospheric air into nitrogen, oxygen and other gases.

ARGON A by-product of the production of oxygen and nitrogen.

TONNAGE USERS Large-volume users that typically receive the gas in question via direct pipeline from an on-site production facility.

IBISWorld Glossary

BARRIERS TO ENTRY High barriers to entry mean that new companies struggle to enter an industry, while low barriers mean it is easy for new companies to enter an industry.

CAPITAL INTENSITY Compares the amount of money spent on capital (plant, machinery and equipment) with that spent on labor. IBISWorld uses the ratio of depreciation to wages as a proxy for capital intensity. High capital intensity is more than \$0.333 of capital to \$1 of labor; medium is \$0.125 to \$0.333 of capital to \$1 of labor; low is less than \$0.125 of capital for every \$1 of labor.

CONSTANT PRICES The dollar figures in the Key Statistics table, including forecasts, are adjusted for inflation using the current year (i.e. year published) as the base year. This removes the impact of changes in the purchasing power of the dollar, leaving only the “real” growth or decline in industry metrics. The inflation adjustments in IBISWorld’s reports are made using the US Bureau of Economic Analysis’ implicit GDP price deflator.

DOMESTIC DEMAND Spending on industry goods and services within the United States, regardless of their country of origin. It is derived by adding imports to industry revenue, and then subtracting exports.

EMPLOYMENT The number of permanent, part-time, temporary and seasonal employees, working proprietors, partners, managers and executives within the industry.

ENTERPRISE A division that is separately managed and keeps management accounts. Each enterprise consists of one or more establishments that are under common ownership or control.

ESTABLISHMENT The smallest type of accounting unit within an enterprise, an establishment is a single physical location where business is conducted or where services or industrial operations are performed. Multiple establishments under common control make up an enterprise.

EXPORTS Total value of industry goods and services sold by US companies to customers abroad.

IMPORTS Total value of industry goods and services brought in from foreign countries to be sold in the United States.

INDUSTRY CONCENTRATION An indicator of the dominance of the top four players in an industry. Concentration is considered high if the top players account for more than 70 % of industry revenue. Medium is 40 % to 70 % of industry revenue. Low is less than 40 %.

INDUSTRY REVENUE The total sales of industry goods and services (exclusive of excise and sales tax); subsidies on production; all other operating income from outside the firm (such as commission income, repair and service income, and rent, leasing and hiring income); and capital work done by rental or lease. Receipts from interest royalties, dividends and the sale of fixed tangible assets are excluded.

INDUSTRY VALUE ADDED (IVA) The market value of goods and services produced by the industry minus the cost of goods and services used in production. IVA is also described as the industry’s contribution to GDP, or profit plus wages and depreciation.

INTERNATIONAL TRADE The level of international trade is determined by ratios of exports to revenue and imports to domestic demand. For exports/revenue: low is less than 5 %, medium is 5 % to 20 %, and high is more than 20 %. Imports/domestic demand: low is less than 5 %, medium is 5 % to 35 %, and high is more than 35 %.

LIFE CYCLE All industries go through periods of growth, maturity and decline. IBISWorld determines an industry’s life cycle by considering its growth rate (measured by IVA) compared with GDP; the growth rate of the number of establishments; the amount of change the industry’s products are undergoing; the rate of technological change; and the level of customer acceptance of industry products and services.

NONEMPLOYING ESTABLISHMENT Businesses with no paid employment or payroll, also known as nonemployers. These are mostly set up by self-employed individuals.

PROFIT IBISWorld uses earnings before interest and tax (EBIT) as an indicator of a company’s profitability. It is calculated as revenue minus expenses, excluding interest and tax.

VOLATILITY The level of volatility is determined by averaging the absolute change in revenue in each of the past five years. Volatility levels: very high is more than $\pm 20\%$; high volatility is $\pm 10\%$ to $\pm 20\%$; moderate volatility is $\pm 3\%$ to $\pm 10\%$; and low volatility is less than $\pm 3\%$.

WAGES The gross total wages and salaries of all employees in the industry. The cost of benefits is also included in this figure.

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