2021 GUIDE TO THE BUSINESS OF CHEMISTRY

American Chemistry Council

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THE BUSINESS OF CHEMISTRY

BY THE NUMBERS

Chemistry is essential to our economy and plays a vital role in the creation of ground-breaking products that make our lives and our world healthier, safer, more sustainable and more productive.

American Chemistry Council

THE BUSINESS OF CHEMISTRY IS A **$486** BILLION ENTERPRISE

THE BUSINESS OF CHEMISTRY PROVIDES **529,000** SKILLED, GOOD-PAYING AMERICAN JOBS

THE BUSINESS OF CHEMISTRY SUPPORTS OVER **25%** OF THE U.S. GDP

THE BUSINESS OF CHEMISTRY ACCOUNTS FOR OVER 9% OF U.S. GOODS EXPORTS, $125 BILLION IN 2020, AND IS AMONG THE LARGEST EXPORTERS IN THE U.S.

AS THE SECOND LARGEST PRODUCER, THE U.S. CHEMICAL INDUSTRY PROVIDES **13%** OF THE WORLD'S CHEMICALS

CAPITAL INVESTMENT BY THE BUSINESS OF CHEMISTRY WAS MORE THAN **$27 BILLION** IN 2020, INCLUDING INVESTMENTS IN STRUCTURES AND EQUIPMENT

MORE THAN **96%** OF ALL MANUFACTURED GOODS ARE DIRECTLY TOUCHED BY THE BUSINESS OF CHEMISTRY

THE BUSINESS OF CHEMISTRY ACCOUNTED FOR **41%** OF TOTAL CONSTRUCTION SPENDING BY THE U.S. MANUFACTURING SECTOR IN 2020

946 MILLION TONS OF PRODUCTS WERE TRANSPORTED IN 2020, MAKING THE BUSINESS OF CHEMISTRY ONE OF THE COUNTRY'S LARGEST SHIPPERS

THE AVERAGE ANNUAL PAY IN THE BUSINESS OF CHEMISTRY IS **$90,000**

THAT'S 23% HIGHER THAN THE AVERAGE MANUFACTURING PAY

CHEMICAL COMPANIES INVESTED MORE THAN **$10 BILLION** IN RESEARCH AND DEVELOPMENT IN 2020

FOR EVERY JOB CREATED BY THE BUSINESS OF CHEMISTRY, 6.8 ARE GENERATED ELSEWHERE IN THE ECONOMY, TOTALING OVER **4.1 MILLION JOBS**

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GUIDE

TO THE
BUSINESS OF CHEMISTRY

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The American Chemistry Council acknowledges the work and research of Dr. T. Kevin Swift conducted prior to joining the American Chemistry Council and upon which this present publication draws. Permission to use this work and research is granted by Dr. Swift for this publication.

Dear Colleagues,

Following a year of historic challenges, the world has begun to emerge from the COVID-19 pandemic. The chemical industry has been a key provider of materials to combat the virus and distribute critical vaccine supplies, and it continues to produce ingredients for hand sanitizers, disinfectants, face masks, and other personal protective equipment (PPE), protective barriers, and more. The global economy has faced additional headwinds: Supply chains have been disrupted by surging pent-up demand, a winter freeze along the U.S. Gulf Coast, port congestion, blockages along key transportation routes, and ongoing shortages of logistics infrastructure and workers.

A world leader with $486 billion* in shipments, the United States is the second-largest chemical producing nation, after China. American chemistry provides more than half a million high-paying jobs, with average annual pay of more than $90,000 per year. The chemistry industry supports a vast supply chain and creates economic activity in the communities where facilities are located. For every chemical manufacturing job, nearly seven additional jobs are created elsewhere in the economy.

Despite ongoing trade tensions and COVID-related closures of national borders this past year, American chemistry remains in demand around the world. In 2020, the U.S. chemical industry was one of the world's largest exporters, at $125 billion, accounting for more than 9% of all U.S. goods exports. The industry has a large and growing trade surplus, reaching $28 billion in 2020. Trade is essential to the success of the U.S. chemical industry, and it benefits the broader economy as well. Access to global markets is critical for continued economic growth and job creation.

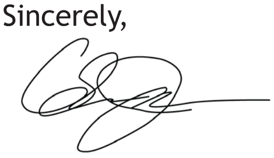
The contributions of American chemistry include the benefits provided by our products. In addition to supporting efforts to combat COVID-19, the products of chemistry enable higher living standards and are crucial to meeting the needs of a growing global population. Innovation into new materials, applications and processes is key to advances in human development. With more than $10.1 billion in R&D investment in 2020, the U.S. chemical industry is helping to expand technological frontiers. Solutions from the chemistry industry are needed to ensure a safe and plentiful food supply, clean air and water, safe living conditions, efficient and affordable energy sources, and life-saving medical treatments for people around the globe.

Our industry is committed to reducing greenhouse gas emissions in the manufacture and use of our products, and our companies are exploring, developing, and deploying a host of exciting new technologies to do so. Our products help society save energy and reduce emissions. Chemistry and plastics are used to create solutions and technologies such as energy-efficient building products; lightweight vehicle components; materials for EVs and charging stations; a variety of solutions for solar and wind power; and more.

Companies across the plastics value chain are continuing their work to develop advanced recycling systems — new technologies, innovations, and business models to recover and create value from plastic waste and help prevent it from entering the environment. In the last three years, the private sector has announced $5.8 billion in U.S. investments to dramatically modernize plastics recycling. These projects have the potential to divert more than 9.2 billion pounds of waste from landfills.

I hope our 2021 Guide to the Business of Chemistry will be a valuable resource for you and your colleagues as you explore the many ways that chemistry is essential to our economy and everyday lives.

Sincerely,



Chris Jahn
President and CEO
American Chemistry Council

* Beginning with the 2018 edition of the Guide, we publish most of our data on a chemicals (excluding pharmaceuticals) basis. We made this change in order to align our statistics with those of our global partners and the business community who view chemicals and pharmaceuticals as separate industries. The pharmaceutical industry remains a key end-use market for chemical ingredients. The decline in chemical shipments value for 2020 as compared with 2019 is due in part to downward revisions in the underlying Census data as well as lower chemical production volumes and prices due to the business and economic impacts of COVID-19.

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INTRODUCTION

The *Guide to the Business of Chemistry* is a premier source of data on the chemical industry. The publication characterizes the chemical business in ways that are familiar to the industry, as well as its observers. A number of industries, such as steel, pulp and paper, glass, and oil refining, are essentially based on chemical processes, but are not included here. The role of chemistry in these areas highlights the importance of the business of chemistry in the U.S. economy and in enhancing society's quality of life.

The *Guide to the Business of Chemistry* segments the business into several types of production: basic chemicals, specialty chemicals, agricultural chemicals, and consumer products. Each of these segments has distinct characteristics, growth dynamics, markets, new developments, and issues. In government classification systems, pharmaceuticals is also considered a segment of the chemical industry; however, ACC does not include pharmaceuticals in its definition of the chemical industry. In most segments of this publication, the data is focused on basic and specialty chemicals or chemicals excluding pharmaceuticals.

The *Guide to the Business of Chemistry* was prepared by the American Chemistry Council's (ACC) Economics and Statistics Department, which provides economic analysis of policy initiatives, business trends, and changing industry dynamics. Many of the data published herein are directly from or based on government sources. As the government revises historical data, ACC revises its data as well. For this reason, some numbers may be different from data published in previous editions of the *Guide to the Business of Chemistry*.

In addition to the data presented in the *Guide to the Business of Chemistry*, the full spreadsheet containing detailed time-series data is available to ACC members on MemberExchange (ACC member platform) or from the ACC Store at https:\\store.americanchemistry.com.

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CHAPTER 1

CHEMISTRY AND THE ECONOMY

Innovations in chemistry have created countless economic and societal benefits: longer and healthier lives through medical advancements; improved standards of living from fertilizers and water treatment; and instant access to information from anywhere, thanks to smartphones and other smart devices, to name a few. Thanks to chemistry, groundbreaking products are improving the world all around us by making it healthier, safer, more sustainable and more productive.

CHEMISTRY IN OUR LIVES

Through the science of chemistry, earth's basic building blocks, such as carbon, hydrogen and oxygen, are transformed into materials that have helped revolutionize society. The chemical industry annually transforms more than hundreds of millions of tons of natural raw materials into products that we use every day. The following are just some of the life-enhancing products made possible through chemistry:

Health Care

In March 2020, as part of the federal government response to COVID-19, the U.S. Department of Homeland Security identified the U.S. chemical industry as Essential Critical Infrastructure, an industry sector critical to public health and safety, economic and national security. From critical inputs for medical masks and personal protective equipment (PPE) to manufacturing hand sanitizer and disinfectants, the chemical industry has played a critical role in the global battle against COVID-19.

From shelf stable "plastic" blood that mimics hemoglobin to artificial skin that lets prosthetic wearers sense touch and temperature to nanotechnologies that deliver custom designed drugs based on a patient's DNA, chemisty plays a key role in the future of health care. Chemotherapy and other drugs now are delivered more accurately on plastic patches and dissolving discs; polyurethanes are used in medical applications such as catheter tubing and hospital bedding; ethylene oxide is used in the sterilization of medical supplies; and PVC is used in medical blood and intravenous bags and tubing. Polycarbonate, due to its high-impact strength and transparency, is used in a number of medical applications, including syringes, surgical instruments, clear IV components, and kidney dialysis filters. Synthetic latex gloves, sutures, bandages, splints, therapy whirlpools, and hundreds of other modern miracles of health care are all made possible by chemistry.

Modern Communications

Nearly every aspect of communication in today's society involves some sort of chemisty. From video conferencing to mobile phones (current estimates are that 61% - 68% of the global population owns a mobile phone) to Instagram, chemistry makes communication possible across a wide range of platforms. Widespread use of touch screens, enabled by plastics, adhesives and other products of chemistry are employed on cell phones, computer screens and more. LCD screens, electronic circuits, even the plastics that provide high-impact resistance, strength, and durability needed to protect these devices all rely on chemistry; indeed, chemistry is essential to information. According to the American Chemical Society, “of the 83 stable (nonradioactive) elements, at least 70 of them can be found in smartphones!”

Transportation

A typical automobile contains over $3,100 worth of chemistry, including more than 360 pounds of plastics and polymers composites, nearly 220 pounds of rubber, and 76 pounds of textiles and coatings. From the urethane foam seat cushioning to nylon airbags to windshield wiper fluids, an automobile’s performance and safety depend on thousands of products of chemistry. Supplanting steel in many automotive applications, plastics and polymer composites typically make up 50% of the volume of a new light vehicle but less than 10% of its weight, which helps make cars lighter and more fuel efficient, resulting in lower greenhouse gas emissions (*Chemistry and Light Vehicles*, American Chemistry Council). An analysis by the U.S. Department of Energy suggests a 6-8% (with mass compounding) increase in fuel economy for every 10% drop in weight. Thus, not only does the business of chemistry provide better performing and safer vehicles, it also provides solutions leading to improved sustainability.

Energy

Both renewable energy and energy-efficient technologies would not be possible without chemistry. Solar power relies on silicon-based chemistry, and innovative new plastic solar panels are poised to reach the mass residential market. Wind power turbine blades are made using plastics and chemical additives, helping deliver renewable energy to our nation’s electricity grid. Continuous rigid or spray foam plastic insulation can help achieve up to 50% energy savings. Spray foam and sealants block energy-wasting air-loss, saving on heating and cooling energy costs. Plastic housewrap and sealants can reduce the infiltration of outside air into the average home by as much as 50%, reducing energy needs. Chemistry enables compact fluorescent bulbs to “fluoresce” and to use 70 percent less energy than incandescent bulbs; LED lighting could cut global electricity demand for lighting by 30 percent. Chemistry helps save money and reduces overall energy consumption.

Residential Spaces

Chemistry has revolutionized our homes. In recent years, homes have seen a number of chemistry-enabled advancements, such as video doorbells, robot vacuum cleaners and wi-fi enabled smart plugs. Beyond smartphones, chemistry makes “smart home” possible. In the kitchen, chemistry touches nearly everything. Today, most people take for granted that they can grab a cold drink from the refrigerator or microwave a meal in minutes. Replacing an old refrigerator with an ENERGY STAR-qualified model—with improved insulation and coolant systems made possible by chemistry—saves enough energy to light an average house for nearly four months. The electronics behind the microwave are made possible from silicon chemistry (e.g., the microprocessor), as well as other chemistry that is used to create electronic circuits and protect cable and wiring, plastics that house the microwave, and polysulfone polymers offer resistance to heat, fats, oils and other elements.

Lithium Batteries

Lithium batteries use chemistry to create rechargeable batteries for electric vehicles, tablets, mobile phones, wireless headphones, and more. Lithium batteries are also used for critical military applications, including remote devices, soldier mobility and improved logistics. The strength and size of lithium batteries make them ideal for consumer use: they are in our smartphones and tablets; they power cordless drills and flashlights. On a larger scale, lithium batteries are used to power everything from wheelchairs to hybrid vehicles to jet fighters and satellites.

Protective Gear

Chemistry helps make what we wear better and safer. Football, baseball, hockey, lacrosse, skateboarding—nearly every popular sport relies on plastic pads, helmets and other protection. Plastic fibers make our workout clothing breathe and wick away sweat. Modern swimsuits help athletes glide through the water. Cyclists, skiers, hikers, mountain climbers and other outdoor enthusiasts all rely on carbon fiber-reinforced plastic gear, safety equipment and clothing, from skis to helmets to goggles to ropes to insulating fibers. At the gym, on a construction site or in the line of duty, chemistry helps to protect workers from exposures to hazardous materials, such as lead and asbestos; hard hats are made from high-density polyethylene or other resins. Fabrics coated with polyurethanes are durable and abrasion-resistant; nanotechnology allows apparel to resist stains, add UV protection and can even offer antibacterial properties. High-performance fibers from aromatic polyamides are used to make bulletproof vests. Thanks to chemistry, we are safer (and maybe even smell better).

Pharmaceuticals

Pharmaceuticals are central to human health and welfare, and chemistry is central to pharmaceuticals. Over the past century, advances in chemistry have led to groundbreaking medicines and medical treatments that have eradicated once deadly diseases. Enhanced sanitation and hygiene technologies enabled by chlorine chemistry are the most effective weapon against waterborne viruses and bacteria. Drug innovations enable individuals to live with and manage diseases; for example, diabetics readily test their blood sugar levels with a simple chemical test. Drugs have reduced and eradicated diseases around the world (e.g., smallpox, polio). Currently, scientists in the U.S. are researching how nanotechnology and nanoparticles may be used to fight many diseases, including cancer and coronavirus.

Environmental Solutions

Efforts to preserve the environment—our air, water, land and climate—are made possible in large part thanks to the innovative products of chemistry. Many environmental improvements are achieved due to the energy efficiency of innovative chemistry products; less energy used equals fewer energy-related emissions. The products of chemistry benefit the environment in many other ways: Lightweight plastic packaging allows more products to be shipped, lightening the load and producing fewer discards. After delivering the goods, many plastics can be recycled and become new packaging or long-lasting products such as plastic lumber. Absorbents, catalysts and plastic fibers in air filters for automobiles, homes and commercial buildings clean the air we breathe, and “scrubbers” at industrial facilities dramatically reduce noxious emissions to the environment and acid rain. Modern landfills are lined with industrial strength plastics to prevent toxic run off into sensitive waterways or drinking water sources. Chemistry produces fertilizers that nurture crops, new compounds that protect plants from proliferating pests and disease, water saving and delivery devices such as plastic sheeting and pipes—resulting in more food for more people.

ECONOMIC CONTRIBUTIONS OF THE BUSINESS OF CHEMISTRY

Chemistry is vital to a strong and vibrant economy. A significant contributor to the gross domestic product (GDP), the business of chemistry is essential to our economy.

The economic contributions of the chemical industry are numerous, though often overlooked in traditional analyses that consider only the direct jobs and output of the industry. The business of chemistry directly creates hundreds of thousands of jobs. In addition to the jobs created directly by the industry, additional jobs are supported by the purchases made by the chemical industry and by the subsequent expenditure-induced activity. The chemical 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 generating several rounds of economic spending and re-spending generated by the chemical industry.

Table 1.1 - U.S. Business of Chemistry Industry Snapshot, 2020

Jobs (in thousands)			Expenditures (in billions)	
Direct Jobs	529		Total Payroll	$47.7
Supplier Jobs	1,864		Benefits	$14.4
Expenditure-Induced Jobs	1,711		Total Compensation	$62.1
Total Jobs	**4,104**			
*Multiplier**	*6.8*		Value-Added	$225.5

*Each job in the chemical industry generates additional jobs in other sectors of the economy.

Data on indirect and payroll-induced jobs were calculated using the IMPLAN model.
Sources: Bureau of the Census, Bureau of Labor Statistics, Bureau of Economic Analysis, Internal Revenue Service, and American Chemistry Council analysis.

The impact of chemistry on the U.S. economy is much more extensive than standard output and job multipliers derived using input-output analysis indicate. While the former only looks at the jobs directly related to the industry, the latter primarily focuses on supplier relationships rather than downstream customer industries or final end-uses. Looking downstream, the economy depends upon chemistry at four levels:

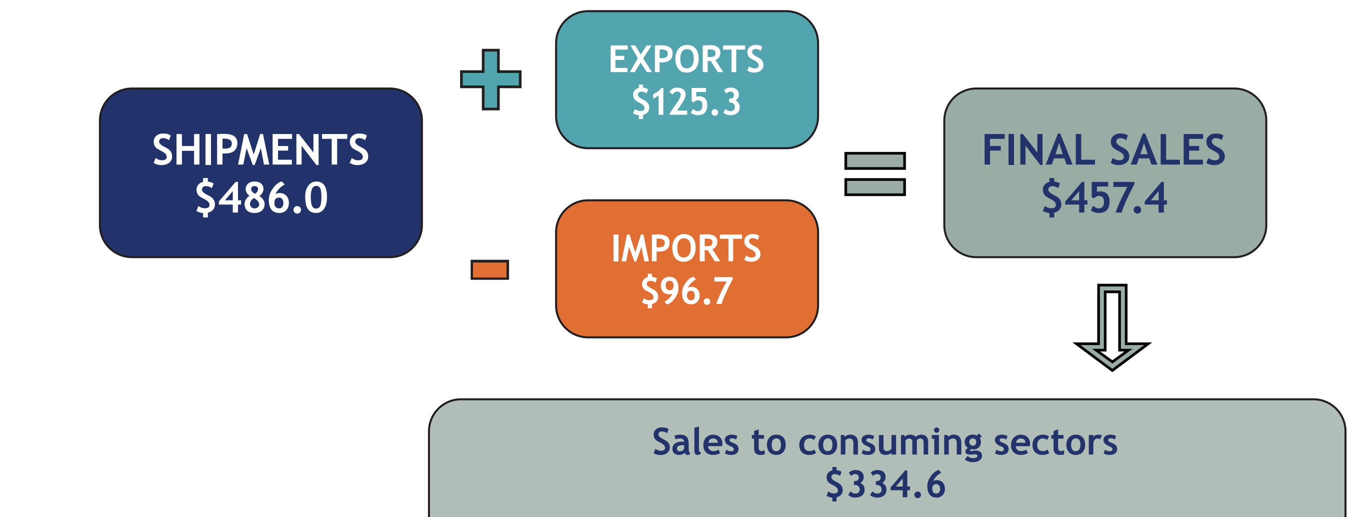
1. Actual production of chemicals;
2. Industries manufacturing products that purchase chemicals and use them to make raw materials or intermediate inputs for other industries;
3. Industries manufacturing consumer products and other final goods, which purchase chemicals directly or buy industrial parts and components based on chemistry; and
4. Wholesale, retail and service industries based on chemistry-derived products.

The robust network of relationships between the chemical manufacturing industry and the consumer is complex, but chemistry is key to a number of major consumer products, including apparel, appliances, furniture, home furnishings, light vehicles, and sporting goods, as well as agriculture and construction. Many of the products of the business of chemistry in themselves can be classified in some of these other industries. For example, pharmaceuticals and personal care products could very well be classified as industries manufacturing consumer products and other final goods, while agricultural chemicals could be classified as industries manufacturing industrial products used as intermediate inputs for other industries. Services are becoming the means by which chemistry is delivered to the ultimate consumer.

Almost every industry purchases some products and services of chemistry and, therefore, depends on the business of chemistry. Indeed, most manufactured goods are directly touched by chemistry. In addition to examining relationships among industries using the standard I-O analysis, we also examine industries which typically spend more than 5% of their material purchases on chemistry (a rough criterion for dependence).

The following flow chart presents estimates of the direct uses of the output of the U.S. business of chemistry. These estimates, based on the IMPLAN input-output model,[1] reflect purchases by the consuming industry or sector. In effect, final sales represent intra-industry sales as well as sales to industries that are consumers of chemistry.

Figure 1.1 - U.S. Business of Chemistry Flow Chart, 2020 (in billions)



Rubber & Plastic	$60.2	Transportation Equipment	$10.2
Other Manufacturing	$55.0	Fabricated Metals	$10.1
Health Care	$39.0	Construction	$10.1
Pharmaceuticals	$35.4	Food & Beverage	$6.6
Paper & Printing	$16.9	Machinery	$5.0
Agriculture	$16.8	Oil and Gas	$4.9
Computers and Electronics	$14.0	Electrical Equipment	$2.3
Textiles & Apparel	$10.6	Other Industries	$37.3

Source: ACC analysis based on data from the Bureau of the Census, and the IMPLAN model.

[1]IMPLAN is used by government agencies include the Army Corp of Engineers, U.S. Department of Defense, U.S. Environmental Protection Agency, and over 20 others, and by over 250 colleges and universities, local governments, non-profits, consulting companies, and other private sector companies.

Indirect uses of chemicals incorporated into the outputs of other industries are not included. For example, these data do not reflect the motor vehicle sector's purchase of tires from the rubber and plastics products industry, which purchases synthetic rubber to make tires. The value of this synthetic rubber is not included in the figure for motor vehicles. Thus, on a final demand basis, the total value of chemistry used in products produced by the motor vehicle industry is actually several times larger than indicated in Figure 1.1.

Table 1.2 - Industries Dependent upon the U.S. Business of Chemistry, 2020

Industry	Employment (in thousands)	Payroll (in billions)	Value-Added (in billions)
Business of Chemistry	**529**	**$47.7**	**$225.5**
Intermediate Goods			
Agriculture	814	23.9	137.7
Oil & Gas Extraction and Mining	540	59.6	100.9
Water and Sewage Treatment	53	3.5	16.8
Textiles & Fabrics	95	4.7	7.1
Engineered Wood Products	79	4.4	9.7
Paper & Paper Products	352	25.2	60.6
Petroleum Products	109	13.3	108.9
Rubber & Plastic Products	692	40.0	82.7
Nonmetallic Mineral Products	397	24.9	67.0
Aluminum	56	3.9	13.4
Windows & Doors	63	3.3	6.7
Metal Coating	127	6.8	17.4
Industrial Machinery	115	10.6	19.4
Commercial & Service Industry Machinery	87	6.9	14.4
Ventilation & HVAC Equipment	132	7.9	23.5
Semiconductors & Electronic Components	367	45.4	52.5
Electrical Equipment & Components	319	23.5	52.1
Total – Intermediate Goods	**4,396**	**$307.8**	**$790.8**
Consumer and Other Final Products			
Food, Beverage & Tobacco	1,874	100.6	273.5
Textile Mill Products	101	4.5	8.6
Apparel & Leather Products	113	5.4	9.1
Printing	375	19.5	39.0
Pharmaceuticals	314	39.6	170.0
**Book & Periodical Publishing and Software	153	22	64.7
Computers & Electronics	692	98.6	258.3
Household Appliances	62	4.1	11.4
Mobile homes	28	1.4	1.9
Light Vehicles & Parts	890	59.1	156.7
Aerospace	508	53.7	140.0
Ship & Boatbuilding	138	9.3	19.0
Furniture & Fixtures	359	17.7	30.5
Medical Equipment & Supplies	314	24.8	62
Other Miscellaneous Manufacturing	266	15.6	45.5
Total – Consumer & Other Final Products	**6,185**	**$476.3**	**$1,290.2**

Table 1.2 - Industries Dependent upon the U.S. Business of Chemistry, 2020

Industry	Employment (in thousands)	Payroll (in billions)	Value-Added (in billions)
Construction			
Residential Building Contractors	807	50.5	110.1
Nonresidential Building Contractors	788	67.0	158.6
Specialty Trade and Heavy Contractors	5,608	367.2	628.9
Total - Construction	**7,202**	**$484.7**	**$897.6**
Wholesale Distribution			
Chemical Wholesalers	144	13.5	56.7
Druggist Goods Wholesalers	235	32.6	114.1
Farm Supplies	117	7.9	18.3
Paint Wholesalers	21	1.5	3.9
Total - Wholesale Distribution	**516**	**$55.5**	**$193.0**
Services			
Testing Labs	172	14.2	25.8
Specialized Design Services	132	9.8	16.3
Scientific R&D Centers	764	119.2	127.7
Photographic Services	35	1.3	4.0
Veterinary Services	409	18.6	24.3
Facilities Support Services	154	8.3	13.7
Document Preparation Services	40	1.6	3.4
Services to Buildings and Dwellings	2,088	72.2	113.7
Waste Management & Remediation Services	443	28.5	62.7
Health Care Services	15,699	970.0	1,411.3
Auto Repair	888	28.4	83.2
Personal and Laundry Services	1,232	38.0	133.2
Total - Services	**22,056**	**$1,310.1**	**$2,019.3**
Total – Dependent Industries	**40,355**	**$2,634**	**$5,191**
Percent of U.S. Totals	29.0%	29.6%	24.8%
Total U.S. – All Sectors	**$139,107**	**$8,905**	**$20,937**

Notes. Total value-added of all sectors of the economy equals GDP.
Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Census Bureau, and American Chemistry Council analysis.

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CHAPTER 2

WHAT IS THE BUSINESS OF CHEMISTRY?

The U.S. business of chemistry is the world's second largest (after China), accounting for nearly 13% of the world's total chemical production.

The business of chemistry is the largest exporting sector in the United States, larger than aerospace products (and parts) and motor vehicles. Chemicals and related products account for nearly ten cents out of every dollar of American exports.*

Americans employed in the business of chemistry are among the most productive in the world. The increasingly complex nature of the business of chemistry requires new and more highly developed skills and better-trained and educated workers. The need for more technology skills and the increasing productivity has resulted in companies in the business of chemistry paying wages that are typically higher than those paid by manufacturing as a whole.

Table 2.1 - Business of Chemistry Summary, 2016-2020

	2016	**2017**	**2018**	**2019**	**2020**
			$billions		
Shipments	$503.4	$523.1	$548.8	$509.4	$486.0
Capital Expenditures	$31.5	$31.2	$30.7	$33.2	$27.3
Funds for Research & Development	$10.8	$10.9	$11.2	$10.5	$10.1
Exports	$121.0	$130.1	$140.1	$135.5	$125.2
Imports	$93.1	$97.1	$109.0	$101.9	$96.7
Trade Balance	$27.9	$33.1	$31.2	$33.7	$28.6
Production Index (2012=100)	95.7	99.4	103.4	103.3	99.3
Price Index (2012=100)	90.0	92.7	97.5	96.4	93.3
Employment (thousands)	526	531	538	544	529
Average Hourly Wage – Production Workers	$22.70	$23.50	$24.20	$25.40	$26.72

Sources: Bureau of the Census, Bureau of Labor Statistics, and American Chemistry Council.

*For more detailed trade information, see Chapter 4 - U.S. Trade in the Business of Chemistry.

The business of chemistry—applying science to support and enhance our quality of life—is one of the oldest American industries (*see notes at the end of the chapter*). The chemical industry is a dynamic, forward-looking, innovative industry and a keystone of the economy. The composition of the business of chemistry is ever-changing, with increasing diversification into high-technology fields such as biotechnology, nanotechnology, and advanced materials that have applications in other industries. The business of chemistry is not easily captured by traditional economic nomenclature, such as the North American Industrial Classification System (NAICS). These definitional foundations are based on the concept of related production activities. In contrast, the business of chemistry is largely market-driven. In addition to production activities, it is also important to consider marketing, distribution, intellectual property, and other capabilities that distinguish industry segments. Rather than statistical classifications, the industry is typically viewed as having four main segments: basic chemicals, specialty chemicals, agricultural chemicals, and consumer products, each with its own structure, growth dynamics, markets, developments, and issues. However, the boundaries dividing these segments are not clearly defined, and some degree of overlapping exists. For example, some specialty products like architectural coatings and packaged adhesives could be considered consumer products. Key characteristics for each segment are displayed in Table 2.2.

Furthermore, some convergence is occurring among segments, blurring the distinctions even further. For example, the next several decades will see the diffusion of biotechnology into more traditional (basic) chemistry businesses, particularly as bioscience grows in importance. Nanotechnology is used across segments, and the consumer market continues to broaden. Increasingly, the business of chemistry provides more knowledge-intensive solutions for human wants and needs.

COST STRUCTURE

The typical cost structures over the business cycle differ between the major segments of the business of chemistry. Basic chemicals are dominated by costs for feedstock and materials: combined, they can amount to more than 65% of total costs. On the other hand, consumer products spend a higher percentage on advertising, research and development (R&D), and other sales, general, and administrative (SG&A) expenditures. Profit margins for consumer products tend to be higher than specialties, which are higher than basic chemicals. For agricultural chemicals, the fertilizer business tends to reflect the cost dynamics of basic chemicals while the crop protection business more closely resembles specialties.

Table 2.2 - Characteristics of the Business of Chemistry

	Basic Chemicals	Specialties	Agricultural Chemicals	Consumer Products
Size of Business ($billion)	$345.9	$95.6	$32.5	$90.9
Product Price (per pound)†	<$0.80	>$1.75	$0.30-$1.50	>$2.00
Long-Term Growth Prospects (X GDP)	1.6	1.3	1.0	1.2
Economic Return on Capital Employed (10-Year Average)	7%	12%	5-15%	15%

†These figures represent typical ranges within chemical categories and are intended to illustrate the variations across categories.
Source: American Chemistry Council analysis.

PRODUCTION INDICES

The Federal Reserve Board (FRB) provides some 295 industrial production index measures of output in the manufacturing, mining and electric/gas utilities industries. This detailed and integrated system of output provides details along market (demand-oriented) groups and industry (supply-oriented) groups, generally all four-digit NAICS industries as well as more detailed sub-industries. These are measures of real output—that is, production, activity (on a volume basis), and the effects of price changes are not included—relative to its level in a base year (in this case, 2012). Weighting factors are published for each of the component production indices to quantify the relative importance of each segment to overall chemical manufacturing.

Table 2.3 - Industrial Production Indices, 2016-2020

	2016	2017	2018	2019	2020
			2012=100		
Chemicals	**95.7**	**99.4**	**103.4**	**103.3**	**99.3**
Basic Chemicals	95.9	97.2	100.6	100.2	98.4
Specialty Chemicals	101.2	108.2	112.6	115.4	101.1
Agricultural Chemicals	96.5	117.5	122.8	122.1	119.0
Consumer Products	91.0	93.0	98.2	96.7	94.0
Pharmaceuticals	92.7	91.7	95.3	95.8	94.2
Chemicals & Pharmaceuticals	94.7	96.6	100.4	100.6	97.4

Source: Federal Reserve Board, supplemental American Chemistry Council analysis.

PRICE INDICES

The Bureau of Labor Statistics (BLS) collects data on domestic prices for a wide variety of goods and services as provided by producers. These are commonly referred to as producer price indices, or PPI. Such measures include manufacturer rebates, incentives, and surcharges. Prices are adjusted for quality and include intra-company transfers; sales and excise taxes are not included. The indices measure the net revenue to the seller relative to its level in a base year. To make these comparable to the FRB production indices, ACC has rebased these to where 2012=100. The BLS also collects data and publishes indices on import and export prices. ACC includes these and rebases them to 2012 as well.

Table 2.4 - Producer Price Indices, 2016-2020

	2016	2017	2018	2019	2020
			2012=100		
Chemicals	**90.0**	**92.7**	**97.5**	**96.4**	**93.3**
Basic Chemicals	89.0	94.1	100.5	98.5	94.2
Specialty Chemicals	100.9	101.9	104.6	107.2	107.5
Agricultural Chemicals	85.6	84.1	90.2	90.5	85.3
Consumer Products	102.9	103.7	105.8	106.7	106.9
Pharmaceuticals	126.7	133.1	138.0	142.3	144.6
Chemicals & Pharmaceuticals	102.7	106.7	111.5	112.2	111.0

Source: Bureau of Labor Statistics, American Chemistry Council analysis.

SHIPMENT VALUE

In addition to the major segments, the business of chemistry—one of the largest manufacturing enterprises in the U.S.—consists of hundreds of sub-segments. More than one billion tons of chemicals are produced in the U.S. The value of this business is measured along the lines of the value of its shipments, as reported by the Bureau of the Census. Shipments measure the nominal value of products shipped from manufacturing establishments; they are not adjusted for price changes. *Note: these are based on non-seasonally adjusted data and, therefore, differ from data reported on a monthly basis.*

Table 2.5 - Business of Chemistry Shipments by Segment, 2016-2020

	2016	2017	2018	2019	2020
			in millions of dollars		
Chemicals	**503,404**	**523,110**	**548,807**	**509,434**	**485,992**
Basic Chemicals	302,029	319,503	340,379	302,055	288,362
Specialty Chemicals	84,782	90,333	90,652	86,660	77,197
Agricultural Chemicals	32,812	31,449	32,590	31,465	30,726
Consumer Products	83,781	81,825	85,186	89,254	89,707
Pharmaceuticals	219,868	233,299	209,256	210,744	233,858
Chemicals & Pharmaceuticals	723,272	756,409	758,063	720,178	719,850

Source: Bureau of the Census (from the ASM-1 report)

Figure 2.1 - Business of Chemistry Shipments by Segment, 2020

FINANCIAL PERFORMANCE

There are many ways to assess the financial health of an industry using metrics derived from financial statements on income, assets, and liabilities. The ratios are calculated on a company basis: that is, for statistical purposes each company is assigned to an industry group based on its largest business segment. As a result, the "company" data presented may include revenues from non-chemical business activities by companies classified as basic chemical companies. On the other hand, the chemical operations of companies not classified as chemical companies would not be included in the sample of companies assigned to other, non-chemical industries. One should note that these figures are not compatible with data presented elsewhere in this section on basic chemicals. Details on the financial performance (solvency and liquidity, profitability, cash flow, etc.), are provided in a spreadsheet of annual data, available for ACC members on MemberExchange.

Table 2.6 - Chemicals: Select Measures of Financial Performance, 2016-2020

	2016	2017	2018	2019	2020
Profitability Measures					
Operating Margin	10.8%	9.8%	16.3%	9.2%	9.5%
Earnings Before Interest, Taxes, Depreciation and Amoritization (EBITA)	20.5%	20.4%	27.4%	16.2%	16.7%
Return on Equity	14.2%	15.6%	18.5%	6.1%	6.7%
Return on Net Assets	5.7%	11.6%	18.3%	6.6%	6.5%
Cash Flow Measures					
Cash Flow as a % of Long-Term Debt	14.6%	23.2%	27.4%	13.5%	1.3%
Cash Flow as a % of Revenues	12.8%	13.7%	17.4%	8.2%	0.8%
Solvency and Liquidity Measures					
Quick Ratio	0.87	0.84	0.77	0.75	0.72
Sales/Current Assets Ratio	2.27	2.38	2.05	2.23	2.15
Current Debt/Inventory Ratio	2.76	2.79	3.09	2.82	3.10
Debt Management Measures					
Debt Ratio (Total Debt to Total Assets)	0.64	0.64	0.59	0.56	0.59
Debt/Equity Ratio	1.77	1.75	1.45	1.29	1.44
Asset Management Measures					
Inventories as a % of Revenues	13.0%	12.5%	14.4%	14.3%	14.3%
Revenues/Employee (thousands of dollars)	810	840	787	798	816
Net Income/Employee (thousands of dollars)	80,379	89,461	138,579	47,907	52,341

Sources: American Chemistry Council, based on Bureau of the Census data.

Notes: History of American Chemistry

It is difficult to ascertain the exact establishment of the U.S. chemical industry, as the is no consensus among sources. The American Chemical Society (ACS) attributes the establishment of the American chemical industry to Colonial Virginia in the early 1600s. According to ICIS, the first American chemical plant was opened in Boston in 1635. Others would argue that the chemical industry existed in America before the European settlers arrived, as Native Americans had developed methods for crop fertilization and early forms of medicine.

Sources:
American Chemical Society National Historic Chemical Landmarks. Chemistry at Jamestown, Virginia. http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/jamestownchemistry.html (accessed 6/20/2019).

"A Timeline of Chemical Manufacturing." ICIS Chemical Business. May 2008. www.icis.com/resources/news/2008/05/12/9122818/a-timeline-of-chemical-manufacturing (accessed 6/30/2021).

CHAPTER 3

CHEMISTRY 101

Chemicals are classified as one of two types, organic and inorganic, based on the raw materials used to make the chemical. Organic compounds generally include carbon. For example, organic inputs—such as oil, natural gas, and plant-based feedstocks —contain hydrocarbons, which form the backbone of final organic chemical outputs. Inorganic inputs are often compounds of two or more natural elements, and do not generally contain carbon as a principal element.

However, very few chemicals use oil and natural gas directly as raw materials. Rather, they are first processed into natural gas liquids, such as ethane and propane, or into heavier liquids, such as naphtha and gas oil. In the first stage of processing, these raw materials are refined to produce primary outputs like benzene and ethylene. Primary outputs like these are the building blocks of the business of chemistry. In subsequent stages of processing, chemicals, such as chlorine, are added to the hydrocarbon backbones to give the compounds certain desired characteristics. The final output may, for example, be nylon or polyester fiber, plastic, a pharmaceutical product, or other products. These variable outputs are generally classified into four major market-driven business segments: basic chemicals, specialty chemicals, agricultural chemicals, and consumer products.

BASIC CHEMICALS

Basic chemicals, or commodity chemicals, are produced in large volumes to chemical composition specifications that are homogeneous in nature; that is, there is no product differentiation. Basic chemicals are typically incorporated into a manufactured product or used in processing. One way to think of this segment is that producers of these chemicals are selling molecules (lots of them). Examples of basic chemicals include inorganic chemicals, bulk petrochemicals, organic chemical intermediates, plastic resins, synthetic rubbers, manufactured fibers, dyes and pigments, and printing inks.

Basic chemicals are a mature business. Primary markets include other chemicals and chemical products; other manufactured goods (textile products, automobiles, appliances, furniture, etc.) where they are incorporated into the final product or used to aid in processing (pulp and paper, oil refining, aluminum processing, etc.); and some non-manufacturing industries. Prices are highly correlated with capacity utilization levels and feedstock (or raw material) costs, resulting in low profit margins and a high degree of cyclicality. In some cases, economic returns may be less than the cost of capital.

Basic chemicals production is capital intensive. In addition to high capital costs, production of basic chemicals is typically large in scale, with high energy requirements. These factors, coupled with potential environmental liabilities, create high barriers to entry in this market. Also important is the access to hydrocarbon feedstocks, or other raw materials. Plant size (or scale) also drives economics, as well as critical mass in product. Technology requirements are moderate and continuous in nature, with more importance on process technology than product technology.

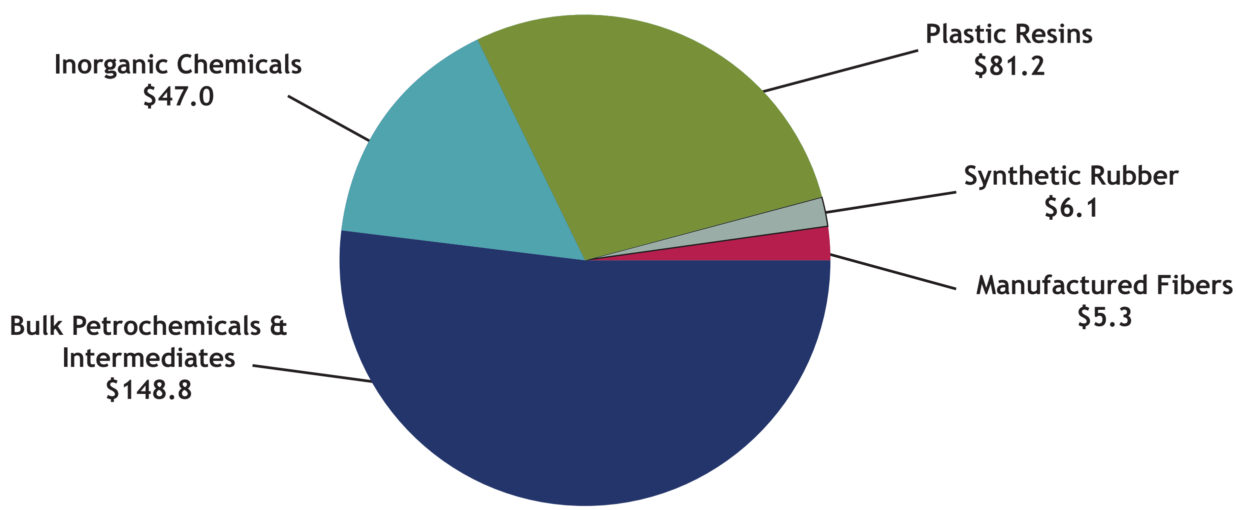
An ethane cracker utilizing hydrocarbon feedstocks would typify many basic chemicals plant operations. A new natural gas-based ethane cracker could have an annual capacity of 1.5 million metric tons or more, with a price tag in the billions of dollars. These crackers need to be located close to the feedstock, which limits the geography where facilities could be located, as well as access to distribution networks.

Distribution of basic chemicals is largely by rail and water to a limited number of large-volume customers, mostly other manufacturers or farmers (fertilizers). For many basic chemicals, typical customer accounts may generate in excess of $1 million in annual sales. Currently, an important change in focus from products to customers is underway. There has been some consolidation in basic chemicals and joint ventures have also become an important strategic vehicle as companies look to share technologies and reduce costs. A focus on core chemistry competencies has also become important and there have been de-mergers of companies into separate life science and basic industrial chemical entities. The chemical subsidiaries of oil companies, that can build upon their feedstock advantages, account for a large (and increasing) share of the total. Basic chemicals companies generally employ low-cost leadership strategies (through scale economies or proprietary process technology) and may reluctant to relinquish market share, particularly when a large number of players exists. The following chart displays a breakdown of basic chemicals shipments by major type.

Inorganic Chemicals

Inorganic chemicals are generally derived from metal and non-metallic minerals such as salt, a simple compound formed from sodium and chlorine that can be broken down by electrolysis to produce chlorine and caustic soda (sodium hydroxide). Other examples of inorganic chemicals include acids (nitric, phosphoric, sulfuric, etc.), aluminum sulfate, industrial gases (e.g., oxygen, nitrogen, argon, hydrogen), lime, soda ash (sodium carbonate), sodium bicarbonate, sodium chlorate, sodium sulfate, and sulfur, among others.

Figure 3.1 - Basic Chemicals Shipments, 2020 (billions)



Source: Bureau of the Census (from the ASM-1 report)

Inorganic chemicals serve both consumer and institutional markets. For example, chlorine, a common inorganic chemical, helps provide thousands of essential products, including clean drinking water, energy-efficient building materials, electronics, pharmaceuticals, crop protection compounds, and much more. Other industries served by inorganic chemicals include oil refining, steel, and other chemical and manufacturing industries (caustic soda is used extensively in manufacturing processes and in the production of soaps and detergents). Industrial gases, also referred to as “air separation gases,” serve major markets such steel, chemical producers, electronics, and health care.

Key economic factors of the industry include very mature demand, high cyclicality and low margins, environmental pressures, and increased consolidation. For industrial gases, in particular, key economic factors include high capital intensity, globalization, high concentration and additional consolidation, increasing service orientation, and impact of innovations in membrane separation.

Bulk Petrochemicals and Organic Intermediates

Bulk petrochemicals, also called primary petrochemicals, are monomers derived from hydrocarbon feedstocks (mostly petroleum and natural gas; small volumes are derived from coal). A distinguishing feature is the carbon molecule. These basic building blocks are used as the starting point for tens of thousands of chemical products. The foundation for a plethora of petrochemical derivatives, bulk petrochemicals include aromatics (which contain a six-carbon ring structure), olefins (short “chain” molecules of two, three or four carbons in length), and methanol (an alcohol). More than 90% of all organic chemistry is derived from seven petrochemicals: benzene, toluene, and xylene (aromatics); ethylene, propylene, and butadiene (olefins); and methanol.

Bulk petrochemicals are then chemically converted, or incorporated with other chemicals (e.g., chlorine, nitrogen or oxygen), into organic intermediates (or petrochemical intermediates). Sometimes, multiple steps are required to produce an intermediate of the desired chemical composition. Examples of bulk petrochemicals include acetic anhydride, acetone, adipic acid, cyclohexane, ethylene oxide, ethylene dichloride, ethylbenzene, cumene, formaldehyde, propylene oxide, phenol, and styrene, among others. These products, in turn, are used in downstream derivatives such as plastic resins, synthetic rubbers, manufactured fibers, surfactants, dyes and pigments, and inks, among others.

Bulk petrochemicals and organic intermediates primarily serve other chemical manufacturers and ultimately automotive, building and construction, consumer/institutional, electrical/electronic, furniture/furnishing, and packaging markets. Key economic factors include maturing demand and technology, volatile margins, environmental pressures, consolidation, globalization, overcapacity, consolidation, the increasing dominance of affiliates of oil companies, and the growing presence of Middle Eastern producers in global markets.

Petrochemical Derivatives and Other Industrial Chemicals

Organic chemicals and other chemical products are derived from bulk petrochemicals, organic intermediates, and other sources of carbon molecules. In many cases, these chemicals are compounded with inorganic chemicals and other materials. These products, in turn, are used in “downstream” derivatives such as plastic resins, synthetic rubbers, manufactured fibers, surfactants, dyes and pigments, and inks. Other products include turpentine and other wood chemicals, carbon black, explosives and other miscellaneous chemical products. Plastic resins are by far the largest segment.

Plastic resins are synthetic, long-chain compounds derived from one or more petrochemical monomers (ethylene, vinyl chloride, styrene, propylene, etc.). They offer excellent molding, mechanical, chemical resistance, and other properties. During the past several decades, the plastic resins industry has achieved remarkable growth, replacing many traditional materials such as metals, glass, and wood in packaging, automotive, building and construction, electronics, and other end-use markets. Plastic resins include commodity thermoplastics, thermosets, engineering resins, and thermoplastic elastomers.

Commodity thermoplastics are polymers that are softened by heat and hardened by cooling in their final state as a finished product. These resins can be resoftened to their original condition by heat, allowing them to be recycled. Examples of commodity thermoplastics include acrylonitrile-butadiene-styrene (ABS), polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC). (Some thermoplastics are directly polymerized from bulk petrochemicals.) Major markets for commodity thermoplastics include packaging, building and construction, consumer/institutional, electrical/ electronic, and furniture/furnishing. End-use applications include automotive trim and parts, appliance parts, grocery bags, wrap, bottles, drums and containers, toys, pipe, siding, fishing line, carpeting, wire and cable, medical disposables, egg cartons, insulation, and various other applications. Key economic factors include maturing demand, flat margins, diffusion of metallocene technology, environmental pressures, restructuring, shift of customer industries overseas, overcapacity, and consolidation.

Thermosets are polymers that, in their final state as a finished product, cannot be resoftened by heat (and, thus, cannot be recycled). Examples include epoxy, melamine, phenolic, polyester, polyurethane, and urea resins. Major markets for thermosets include building and construction, furniture/furnishing, appliances, transportation, adhesives, electrical/electronic, ink, and coatings. Thermosets are the oldest plastic resins and are used in end-use applications such as laminates, wiring devices, plywood and other structural panels, carpet, refrigerator insulation, buttons and knobs, flooring, panels, tanks, boat hulls, and shower-stalls. Key economic factors include declining and maturing demand, health of housing and construction activity, environmental pressures, consolidation, shift of customer industries overseas, and increasing scale economies.

Table 3.1 - Plastic Resins Summary, 2016-2020

	2016	2017	2018	2019	2020
Shipments (in millions)	$80,690	$90,209	$94,853	$81,673	$81,176
Production Index (2012=100)	95.2	95.7	100.7	101.8	103.5
Production (million pounds)*	112,227	112,974	119,804	119,804	119,804
Capital Expenditures (in millions)	$6,196	$6,233	$6,193	$9,516	$7,946
Price Index (2012=100)	92.9	97.6	102.3	98.1	94.6
Employment (in thousands)	57.6	57.4	58.9	58.9	58.9
Exports (in millions)	$26,704	$28,574	$32,025	$31,712	$28,875
Imports (in millions)	$12,532	$13,670	$15,586	$13,696	$11,950
Trade Balance (in millions)	$14,172	$14,904	$16,440	$18,016	$16,925

*Data for plastic resin production is reported in pounds, rather than metric tons.
Sources: Bureau of the Census, Bureau of Labor Statistics, National Science Foundation, ACC Plastics Industry Producers Statistics (PIPS) Group, and American Chemistry Council

The American Chemistry Council's Plastics Industry Producers Statistics Group (PIPS) provides relevant, timely, comprehensive and extensive business statistics on the plastic resins industry. Available for subscription on an annual basis, these statistical reports contain production and detailed sales by end use information, and capacity and inventory measures for major plastic resins. With key players and nearly the full industry in North America participating, these surveys have long been considered an authoritative, comprehensive and reliable source of information on the plastic resin industry.

Resin producers and other industry professionals use ACC's PIPS data for making a wide variety of critical business decisions. The data represents an economic indicator used by plastics processing companies, machinery manufacturers, lobbyists and other industry segments to access the business climate. Industry consultants, investment banks and securities firms rely on ACC's PIPS reports for their ongoing market research and analysis. For more information: plastics.americanchemistry.com/Jobs/EconomicStatistics/Plastics-Statistics

Engineering plastics are thermoplastic polymers that have high-performance mechanical, thermal, electrical and chemical properties. Examples include acetal, fluoropolymer, polycarbonate, polyphenylene sulfide, and other resins. Major markets for engineering plastics include automotive, electrical/electronic, and consumer. These resins are often used to replace metals in applications such as valves, faucets, zippers, wire and cable jacketing, non-stick coatings, microwave cookware, appliance and electronics housings, hair dryers, bearings, gears, and myriad other products. Key economic factors include continued supplanting of competing materials (expanding applications), maturing demand, price pressures, globalization, and consolidation.

Manufactured fibers, also known as synthetic fibers, are synthetic cellulosic and polymeric textile fibers that offer favorable, engineered attributes vis-à-vis natural fibers. Cellulosic fibers, such as acetate and rayon, are made from raw materials from plants or trees, such as wood pulp. Meanwhile, polymeric fibers such as acrylic, nylon, polyester, polyolefin, and others are derived from petrochemicals. Manufactured fibers are used in apparel, home furnishing, automotive, construction and some industrial applications. Key economic factors include intense overseas competition, mature demand, loss of apparel markets overseas, and low margins.

Synthetic rubbers are manufactured materials that exhibit a high degree of flexibility. Synthetic rubbers require vulcanization, a process that cross-links the elastomer molecules. Examples include butyl rubber, ethylene-propylene-diene monomer (EPDM) terpolymers, neoprene, nitrile rubber, styrene-butadiene rubber (SBR), and specialty elastomers. These materials are primarily used in the automotive sector and also used in the construction and consumer product manufacturing industries. Major uses are automotive bumpers and fascias. One particularly dynamic segment is thermoplastic elastomers, complex urethane-based synthetic rubbers that can be processed using injection molding and other processes used for thermoplastic resins. Key economic factors include continued supplanting of competing materials, pressures from key customers, globalization and consolidation, price pressures from OEMs, product innovations leading to longer-lasting tires, new grades, mature demand, loss of some end-use markets overseas (e.g., shoes), and low margins.

Colorants are used to impart color into other materials. These organic and inorganic chemicals include dyes (typically organic compounds and liquid in form) and pigments (generally inorganic compounds and in powder form). This segment serves the textile, paper, and plastic products markets. Key economic factors include continued mature demand, fashion trends, very low profit margins in dyes, price pressures in pigments, loss of textile markets overseas, competition from Indian and other Asian producers, environmental pressures, restructuring, and consolidation.

Inks are colored, liquid dispersions of dyes (or pigments) that are suspended in a liquid (referred to as a vehicle) and used to impart text and graphic designs onto plastics, paper, textiles, metals, and glass. This business serves the packaging, greeting card, photocopying, newspaper, book and other publishing/printing industries. Key economic factors include impact of electronic media, environmental pressures (e.g., water-soluble products), globalization, and consolidation.

Other industrial chemicals include turpentine and other wood chemicals, carbon black and explosives, as well as some other miscellaneous industrial chemical products. Key economic factors vary from segment to segment but generally include increased consolidation, declining prices, environmental pressures, and maturing demand.

SPECIALTY CHEMICALS

Specialty chemicals (also called “performance chemicals” or “specialties”) are differentiated, and often technologically advanced, products. They are manufactured in lower volumes than basic chemicals and are used for a specific purpose (e.g., as a functional ingredient or as processing aids in the manufacture of a diverse range of products). Specialties enable customers to reduce overall systems costs, enhance product performance and optimize manufacturing processing to increase yield through custom solutions. That is, they are sold for what they do, rather than for what they contain. Examples of specialty chemicals include adhesives and sealants, catalysts, coatings, electronic chemicals, institutional and industrial cleaners, plastic additives, water management chemicals, and other specialties. One feature that distinguishes specialties from basic chemicals is that specialties typically have a large customer-servicing or technical-servicing component.

Long-term growth prospects for specialties were generally more dynamic than basic chemicals but growth in latter due to shale gas has become dynamic as well. Many specialty markets exist, including manufacturing industries (automobiles, consumer products, electronics, food, foundries, lubricants, paper, plastic products, rubber products, etc.) and non-manufacturing industries such as oil recovery, construction, and electric utilities. More so than other segments, the specialty chemicals segment tends to focus along markets, many of which are maturing and becoming increasingly international.

Raw materials for specialty chemicals are derived from petrochemical intermediates and other basic industrial chemicals, which are then processed into higher value-added products. Specialty chemical prices tend to be set by “value-in-use,” as opposed to by cost, and historically their earnings are less impacted by demand pressures than other chemical segments. In general, specialty chemicals represent a small portion of a customer’s total cost, but are essential to the productivity and performance of the product. That is, the economics are driven by the value to the customer; this raises “switching costs” and offsets the bargaining power of customers. Critical mass in end-markets is also important for specialty chemicals. Traditionally, specialties have higher profit margins (and returns on equity) than basic industrial chemicals and a much lower degree of cyclicality. Earnings, on the other hand, have been less volatile. A rough rule of thumb is that most specialties are priced at more than $1.25 per pound.

Specialty chemical products are higher value-added because of their value-in-use, and they often cannot easily be duplicated by other producers due to high barriers to entry (technology, patents, market and customer knowhow, etc.). In this market, strong technical servicing, marketing, and distribution competencies are a must, as strong customer relationships are paramount. Indeed, the final price of a specialty chemical features a very high service component. Innovation is critical and specialty chemical companies typically spend 3-6% of their revenues on research and development (R&D); these innovations are growth drivers for most companies.

Though capital needs are less important and more flexible with specialty chemicals than they are with basic chemicals, they can still be relatively high. Companies typically spend 4-9% of revenues for new plant and equipment (P&E). While dedicated and continuous operations are also typical in specialties (although at a lower scale), there are also a large number of plants that are general-purpose synthesis operations (with equipment for specific unit operations such as distillation, crystallization, filtration, etc.) or formulating plants. By definition, most specialties are niche businesses and, beyond a certain size, scale does not matter.

Specialty chemical companies are generally fragmented along specialty market lines. Customers, mostly other manufacturers and some non-manufacturing operations, generally purchase relatively low volumes. In some specialty markets, typical customer accounts generate less than $50,000 in sales.

Sole-source contracts (e.g., partnership agreements) are also a factor. Consolidation and globalization are occurring, although acquisitions tend to be smaller than in basic chemicals. Motivation includes enhancing leverage from existing platforms, investing in segments that have higher growth potential, cost synergies, or filling a void in product, market, technology or geographic gaps. Alliances to provide scale and scope are becoming important.

External factors influence the specialties industry as well. The growing presence of e-commerce has had a large impact on specialties because it allows smaller firms to have greater customer reach. Government regulation is high, largely for environmental, health and safety concerns (some segments face environmental pressures, such as “green” products and processes). The Environmental Protection Agency (EPA) is the leading regulator, although the Food and Drug Administration (FDA) the more relevant regulator in some specialty markets such as cosmetics and food additives.

The following further defines types of specialty chemicals. For each of the main specialty chemical segments, a brief definition, an estimate of market size, key characteristics (economic, manufacturing, etc.), growth dynamics, developments and issues are provided.

Adhesives and Sealants
Adhesives are used to bond two surfaces together, while sealants are used to fill a gap between two objects. Included in this segment are epoxy, hot melt, glues, rubber and other adhesives as well as caulk, joint and other sealing compounds. The adhesives and sealants business is fragmented, serving major markets such as automotive, building and construction, nonwovens, office supplies, and packaging. Pricing is largely driven by raw material costs. Key economic factors include continued supplanting of mechanical fasteners by adhesives, coupled with increasing demand as durable goods shift from metals to greater use of plastics, thus necessitating more adhesives. In addition, environmental pressures (e.g. sustainable products and processes such as water-based adhesives), increasing global competition, the shifting of end-use customer industries overseas, and industry consolidation are occurring.

Catalysts
Catalysts are specialty chemicals that affect the speed of a chemical reaction without changing chemically, or being consumed. This business serves major markets such as oil refining, chemical processing, and automotive emission controls. Key economic factors include environmental regulations for removal of nitrous oxide and other pollutants, declining quality of crude oils used in refining, and an increased number of light vehicles.

Coatings
Coatings are materials applied to surfaces to protect and/or decorate. Included are alkyd, enamel, latex, oil-based, and powder; other coatings used in architectural, automotive and original equipment manufacturer (OEM) applications; and stains, varnishes, lacquers, removers, and thinners. It is a highly fragmented business serving major markets such as building and construction, OEM and other general industrial, packaging, and transportation. A large “do-it-yourself” market exists within architectural coatings. Pricing is largely driven by raw material costs, especially titanium dioxide, which is widely used in the coatings industry. Key economic factors include environmental pressures (e.g., demand for “green” products and processes such as electro-deposition, water-based coatings, etc.), the emergence of large mass retailers, globalization, and industry consolidation. Branding and distribution play important roles in this business.

Cosmetic Additives
Cosmetic additives are functional chemicals used to impart special properties (such as improved performance) in personal care products such as cosmetics, deodorants, perfume, skin care, sun care, and toiletries. Included are such chemical products as antimicrobials, antiperspirant and deodorant salts, emollients, fixative polymers, hair polymers, thickening agents, and UV stabilizers, among others. In

addition to these additives, the consumer products industry also uses fragrances, bulk surfactants, and other chemicals. Key economic factors include environmental pressures (e.g., sustainable products, organics, and product safety), globalization, consolidation, product quality and performance, and maturing growth.

Electronic Chemicals

Electronic chemicals are essential in the manufacture of semiconductors, printed circuit boards and other microelectronic devices. Among them are cleaners, developers, dopants, encapsulants, etchants, photoresists, specialty polymers, plating solutions, and strippers. This business serves major markets such as computers, telecommunications equipment, automotive, and medical devices. Long-term growth prospects are driven by the increasing proliferation of electronics in contemporary life. Key economic factors include increasingly global customers, high technological barriers to entry, device miniaturization, and shortening product life cycles. Service innovation plays a very large role in this business, as does recycling and other environmental considerations.

Fine Chemicals

Fine chemicals are undifferentiated intermediate, medicinal and aroma chemicals that are produced in low volumes—but with very high purity standards—for a small number of customers. This business serves major markets such as pharmaceuticals, crop protection, dyes, flavors and fragrances, food, and electronics. (Fine chemicals used in the latter three categories are included in relevant specialty segment.) Key economic factors include customer consolidation and price pressures, low-cost competition (particularly from Asian producers), increased outsourcing of fine chemical needs by pharmaceutical companies, demand from pharmaceutical and crop protection offsetting soft demand in dyes. Some companies have responded by controlling costs, moving to low-cost regions, and shifting to higher-growth and higher-margin products.

Flavors and Fragrances

These natural and synthetic additives are used to impart flavor and fragrance in finished food and personal care products. Included are aroma chemicals, compounded flavors, compounded fragrances, fixatives, essential oils and other natural extracts, and other odoriferous substances. This business serves major markets such as food and beverage, cosmetics, toiletries and other personal care products. Chemicals in this segment are generally used in other specialty chemical segments such as cosmetic additives and food additives. Key economic factors include environmental pressures (e.g. sustainable products, organics, and product safety), globalization, consolidation, product quality and performance, and maturing growth. It's a fairly research-intensive business. New product introduction is demanded by customers who are continually repositioning their products and is essential to maintaining growth and high margins.

Food Additives

Food additives are used to impart flavor and/or color and other properties (e.g., nutrient value, texture) in finished food products, as well as facilitate food and beverage processing. Included are acidulants (e.g., citric acid), antimicrobials, antioxidants, emulsifiers, enzymes, flavor enhancers, leavening agents, stabilizers and thickeners, artificial sweeteners, and fat replacers, among others. Within the food and beverage industry, this segment serves markets such as baked goods, confections, frozen foods, dairy products, soft drinks and beer, and other food and beverage processing. Key economic factors include environmental pressures (e.g., from "green" products, organics, and product safety), globalization, consolidation, product quality/performance, and maturing growth. The emergence of "nutraceuticals" (food-derived products that provide additional health benefits on top of those innate to the food) will play a growing role in this business.

Functional Fuel and Lubricant Additives

These functional chemicals are added to lubricating oils to impart special properties and to enhance combustion and/or reduce emissions of pollutants. Included are antiknock additives, antioxidants, antiwear additives, corrosion inhibitors, defoamers, deicers, deposit control modifiers, detergents, viscosity modifiers, and other additives. Key economic factors include maturing markets, overcapacity, customer consolidation, increased performance demands, shorter product cycles, and industry consolidation and restructuring. There is a large aftermarket for this segment, and branding can be important.

Institutional and Industrial Cleaners

As the name implies, institutional and industrial cleaners are used to clean and sanitize surfaces, equipment and other applications in institutional and industrial settings, such as food and beverage processing plants, restaurants, schools, hospitals, lodging, and laundries. Included are general-purpose cleaners, alkaline cleaners, floor waxes and polishes, strippers, dishwashing detergents, metal and other acid-type cleaners, soaps, scourers, disinfectants, solvents, hand cleaners, and other janitorial supplies. This business serves major markets such as food service, hospitality, health care, educational institutions, and food processing. Key economic factors include environmental pressures (e.g. sustainable products and food safety), globalization, consolidation, product quality/performance and reliability, and maturing growth. Other external factors, such as travel and tourism expenditures are important, as is dining outside the home. A large number of players exist, and regional fragmentation is the norm.

Oilfield Chemicals

These functional chemicals—which are used to enhance oil recovery and production—include a variety of acids, biocides, corrosion inhibitors, defoamers, dispersants, emulsions, polymers, surfactants, thickeners, viscosifiers, and other products used in cementing, well stimulation drilling, production, work-over and completion, and enhanced recovery. Key economic factors include drilling activity, globalization of customers, and increased performance demands. The recent increase in domestic chemical production, due in large part to shale gas, has stimulated the need for oilfield chemicals.

Paper Additives

Paper additives are functional chemicals used to facilitate paper manufacture or to enhance the properties of the final paper product. Examples include biocides, coagulants, defoamers, dispersants, flocculants, lubricants, sizing agents, and wet-strength agents, among others. In addition to these additives, the paper industry consumes large quantities of basic chemicals such as chlorine, caustic soda, and titanium dioxide. Key economic factors include maturing markets, customer consolidation, recycling and other environmental regulations, raw material availability, and increased performance demands. The rise of electronic communications has decreased the market for paper in some industries, particularly in the U.S., although other parts of the world are seeing an increased demand for paper and paper products.

Plastics Additives

These functional chemicals are added to plastic resin to aid or facilitate in processing or to enhance, extend or modify the final properties of plastic products. Included are antioxidants, antistatic agents, blowing agents, colorants, flame retardants, heat and other stabilizers, lubricants, plasticizers, reinforcing agents, and UV absorbers, among others. This business, by way of plastics processors, ultimately serves major markets such as light vehicles, building and construction, electronics, and consumer products. Key economic factors include maturing plastics markets in the U.S., faster growth overseas, increased performance demands in plastics, and industry/customer consolidation. As with other specialties, the increased manufacturing activity in the U.S. due to shale gas production is triggering growth in this segment.

Plastics Compounding

Plastics compounding is the physical mixing of resins with performance-enhancing additives (see above) to produce a compounded (or formulated) plastic mixture that is preferable to the base resin(s) alone (e.g., less expensive, has more favorable physical or aesthetic properties). The compounded resin product is marketed to plastic processors that manufacture a wide variety of plastic products for construction, automotive, and other applications. Plastic (or polymer) compounding is a significant market for captive resin producers, independent toll/custom compounders, and plastic processors. It serves major markets such as the plastic processing industry and ultimately light vehicles, building and construction, electronics, and consumer products, among others. Key economic factors include maturing plastics markets in the United States, faster growth overseas, increased performance demands, and industry/customer consolidation.

Rubber Processing Chemicals

These functional chemicals are used to facilitate processing or to improve the properties of the final rubber product. They include accelerators, activators, anti-ozonants, antioxidants, stabilizers, and vulcanizing agents, among others. Key economic factors include maturing markets, customer consolidation, recycling and environmental regulations, and increased performance demands. In addition to these additives, the tire and rubber products industry consumes large quantities of synthetic rubbers and of basic chemicals such as chlorine, caustic soda, and titanium dioxide.

Water Management Chemicals

Formulated and proprietary chemicals are used in the treatment of cooling and boiler water to prevent corrosion and the build-up of scale and also to prevent disease from drinking water. Included are biocides, coagulants, defoamers, flocculants, scale inhibitors, and corrosion inhibitors, among others. These specialties are also used in process water and wastewater treatment. This business serves major markets such as paper mills, chemical plants, oil refineries, and electric utilities. Key economic factors include consolidation and the rising bargaining power that customers have as they consolidate, declining real prices, the increased popularity of sole-source contracts and partnership agreements, modest account turnover, and maturing demand (largely tied to new plant construction). Additional drivers include economic development outside North America, environmental regulations and end-use customers' desire to reduce waste.

Other Specialties

A number of other diverse—and overlapping—specialty chemical segments also exist, including construction chemicals, foundry chemicals, imaging chemicals, metal plating and finishing chemicals, mining chemicals, paint additives, research chemicals, and textile specialties, among others. Some functional chemical products such as antioxidants, biocides, enzymes, flame-retardants, ion exchange resins, thickeners, and UV absorbers are also included. Growth prospects vary among segments, as do key economic factors, which generally include increased consolidation, declining prices, environmental pressures, and maturing demand.

AGRICULTURAL CHEMICALS

Although closely related to basic chemicals and specialties, a distinguishing feature of agricultural chemicals is that one end-use customer industry -- farming -- clearly dominates demand patterns. The business consists of two major segments: fertilizers and crop protection; and there are both commodity and specialty segments within this business. In addition to farming, a few other businesses, such as construction and utilities, also use agricultural chemicals, as do several institutional segments. It is likely that some undercounting occurs in this business segment; also, the value of seeds and traits based on biotechnology are not included in crop protection.

Fertilizers

Fertilizers are various combinations of three basic elements (nitrogen, phosphorous and potassium) that are added to soil to replace or supplement essential nutrients to promote plant (and especially crop) growth. Phosphorous and potassium are found in phosphate rock and potash, respectively. Fertilizers primarily serve the farm sector. Pricing is largely driven by raw material costs and key economic factors include increasing overseas demand, a high degree of seasonality, volatility in farm incomes, and potentially reduced demand arising from genetically modified crops. With the rise in natural gas resources, nitrogenous fertilizers have experienced renewed competitiveness in recent years.

Crop Protection

Crop protection products include fungicides, herbicides, insecticides, miticides, and pesticides that help control weeds, pests, and diseases, as well as disinfectants, rodenticides, and other products used to control germs. The farm sector is the primary end-use market, although household, hospital, other institutional, electric utilities, telecommunications, and industrial applications are also important. Key economic factors include growing population and the need to increase agricultural productivity, sustainable development, high regulatory barriers, high costs for product development, cost cutting, globalization, and consolidation.

The business is affected by the increased use of GMOs (genetically modified organisms) and other biotechnology innovations. The use of GM crops has increased rapidly over the past two decades; according to the USDA, "in 2012, 88 percent of the corn, 94 percent of the cotton, and 93 percent of the soybeans planted in the U.S. were varieties produced through genetic engineering." Although agricultural biotechnology offers promise for improving crops and increasing yields and potentially increasing food crop production on existing farmland—all factors which could reduce the need for crop protection products—the crop protection industry has grown in recent years.

CONSUMER PRODUCTS

The consumer products business is one of the oldest segments of the business of chemistry, dating back thousands of years (ancient Babylonians were the first recorded makers of soap). Included are soaps; detergents; bleaches; laundry aids; toothpaste and other oral hygiene products; shampoos, conditioners and other hair care products; skin care products; cosmetics; deodorants; perfume and cologne, among other personal care products. A feature that distinguishes consumer products from the other segments is that they are packaged; many companies in this packaged goods segment prefer to be viewed as “household products” companies.

Markets are segmented along distribution channels, price points, and consumer demographic lines. Points-of-sale (POS) include supermarkets, department stores, big-box stores, and specialty stores, among others. The economics of the consumer sector are largely driven by supply chain costs, although differentiation can engender widely different price points for similar products marketed to different consumer groups.

Branding aids in maintaining profit margins that are higher than that for basic chemicals. Brand loyalty is extremely important, as is management of distribution channels. In many segments, the fight for shelf space is paramount, and companies in these areas spend large resources on advertising. Because product life cycles are generally short, product development and brand extension are important. In addition, research and development expenses are rising, and many products are becoming high-tech in nature. The rise of the Internet, and ecommerce, has played a large role in how companies market their products.

Consumer products employ what is often simple chemistry and are generally formulated in batch-type operations although some products (e.g., detergents) are manufactured in large dedicated plants. Raw materials include fats, oils, surfactants, emulsifiers and other additives, and other basic chemicals. Formulating involves mixing, dispersing, and filling equipment rather than reactors for chemical conversions. Most operations, in fact, represent packaging lines. As a result, capital needs tend to be moderate as compared to basic chemicals. Government regulation is moderately high, largely in the area of product composition. The FDA is by far the leading regulator.

Consolidation and globalization are occurring as worldwide brand management continues to grow. Companies usually employ focus or product differentiation strategies, generally along brand lines. Some segments are subject to pressures from customers for environment- and animal-friendly “green” products and, despite brand importance, many consumer products are experiencing increased competition from generic products. Long-term demographic trends are important to growth prospect.

Characteristics of Pharmaceuticals

For centuries, pharmaceuticals was considered part of the broader chemical industry. While ACC no longer includes pharmaceuticals in its definition of the chemical industry, pharmaceuticals are included in the NAICS 325 definition of the broader chemical industry used in many government statistics. For this reason, we continue to include the discussion below.

An important end-use market for many chemicals, the pharmaceutical industry includes prescription and over-the-counter drugs and vitamins; in vitro (and other) diagnostics; vaccines; biological products; biotechnology; and other pharmaceutical preparations for both human and veterinary use.

Key economic factors include high regulatory barriers, high costs for new drug development, growing R&D funding requirements, the number of new products in the pipeline, globalization, consolidation, outsourcing of chemical operations, intellectual property issues, bargaining power by health care customers, rapid introduction of new products (and potential for “flops”), shorter product life cycles, patent expirations and the role of generics, other low-cost competition, consolidation trends among customers, stocking/de-stocking cycles, cost-cutting, and the impact of biotechnology. There is increasing pressure to introduce new pharmaceutical products faster, cheaper, and in greater quantity. Competition from overseas producers, as well as fewer products in development, has caused some softness in shipment activity. This comes at a time when patent expirations are rising, resulting in pricing pressures associated with an increased market share by generic drugs.

Pharmaceutical prices are often based on cost-effectiveness and value-in-use considerations vis-à-vis other alternatives. Patent and other intellectual property protection is important and development costs are high, which influence the economics of the business. As a result, pharmaceuticals have typically enjoyed higher profit margins than basic chemicals. Competition is largely based on innovation, product development and differentiation, geographical coverage, price, and customer service.

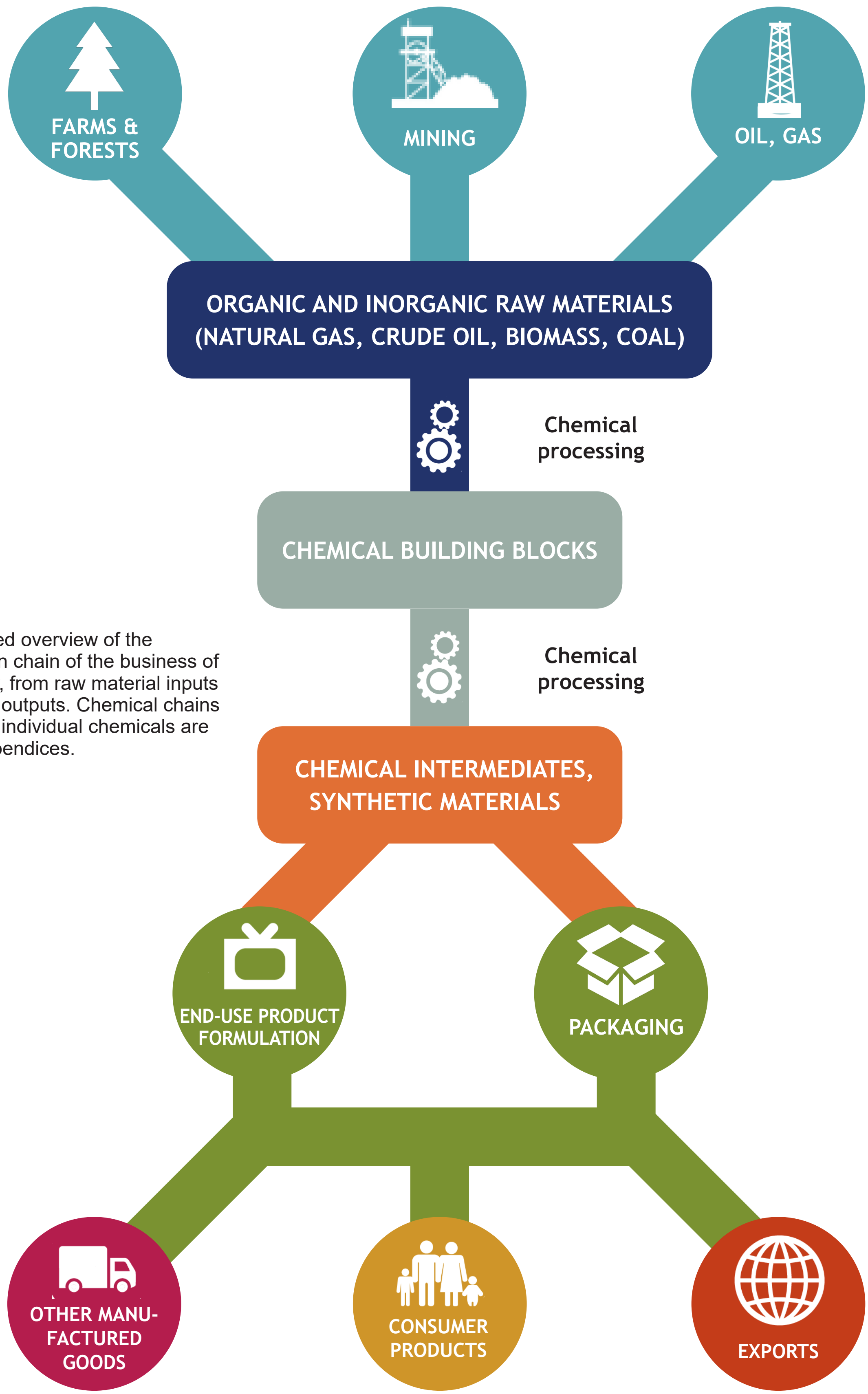
Marketing and channel management competencies are important and rising, as is advertising and branding. Sustainable product differentiation and intellectual property are significant competitive factors. To maximize revenues, it is critical to have strong distribution capabilities in every major region of the world. The rising presence of online pharmacies and business-to-business (B2B) sites is impacting supply chain dynamics.

Technology advantages are extremely important in pharmaceuticals, and there is increasing convergence between biology and chemistry as biotechnology innovations further diffuse. As a result, R&D spending in pharmaceuticals as a percent of sales is the highest among all industries. Pharmaceuticals have a high value-added component because they cannot easily be duplicated by other producers or are shielded from competition by patents. Capital needs are moderately high, but flexible. Plants are usually batch-oriented synthesis or formulating operations in which quality control and a clean environment are essential. Beyond a certain size, scale does not matter.

Government regulation (primarily the FDA) is extremely high, primarily in the area of product composition and its inherent safety. Indeed, it is a very high barrier to entry, as product approval can be a quite lengthy process.

Strategic acquisitions, alliances and research agreements, as well as investment in internal capabilities are important in pharmaceuticals. Some consolidation is occurring and industry concentration is relatively high. Optimal size in both research and marketing terms has become important, and critical mass has become paramount in a number of these activities. The biotechnology segment includes many start-up ventures and initial public offerings (IPOs).

Figure 3.2 - Business of Chemistry Chemical Chain



A simplified overview of the production chain of the business of chemistry, from raw material inputs to valued outputs. Chemical chains for select individual chemicals are in the appendices.

CHAPTER 4

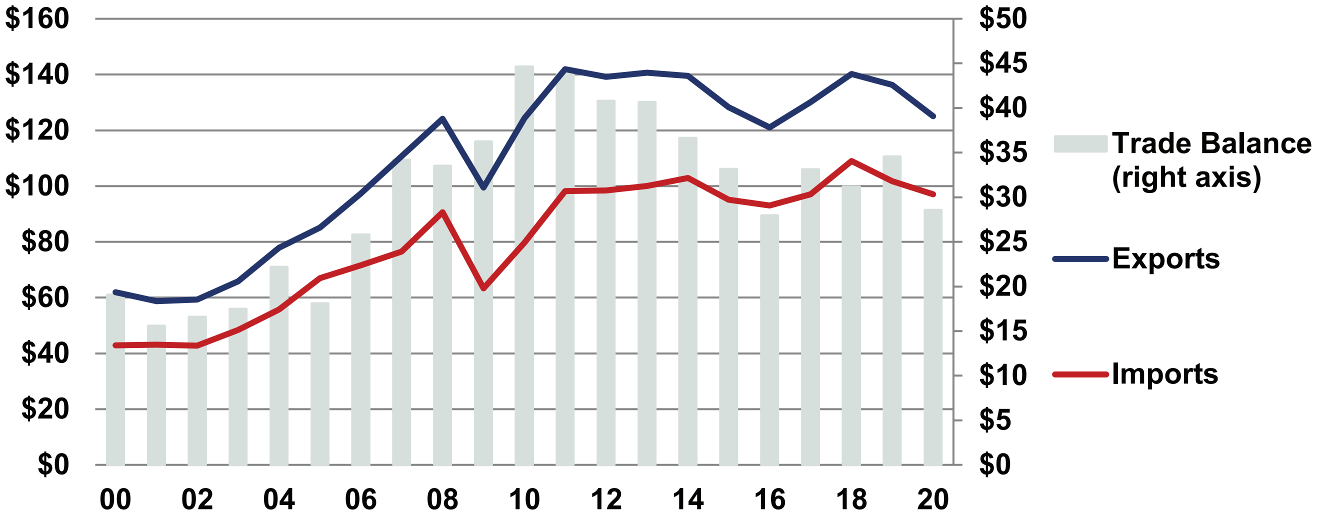
U.S. TRADE IN THE BUSINESS OF CHEMISTRY

Chemicals trade in the U.S. began with limited exports of potash and naval stores (pitch and tar) to Great Britain in the 18th century. However, with abundant natural resources and a highly skilled workforce, the U.S. chemical industry quickly became a major exporter of a multitude of chemical products to markets throughout the world. Today, the chemical manufacturing sector is one of America's top exporting industries, accounting for around 10 percent of all U.S. exports.

American manufacturers and chemical producers also import chemicals that are essential inputs to their production process. These imported inputs are an important part of competitive domestic business and represent a significant portion of U.S. trade: more than half of U.S. imports are inputs used for domestic production.

U.S. trade in chemicals (both imports and exports) has grown steadily over the years but, on balance, the U.S. chemical industry has maintained a net exporter position. Due to access to abundant and affordable shale gas, U.S. chemical manufacturers face comparatively lower production costs. The increased competitiveness of the industry will lead to a growing trade surplus especially in those segments benefitting the most from the shale gas revolution in the United States.

Figure 4.1 - U.S. Trade in the Business of Chemistry (billions)



TRADE BY COUNTRY/REGION

Table 4.1 - Top Chemicals Export Destinations, 2016-2020

	2016	2017	2018	2019	2020
			in millions of dollars		
Canada	20,473	22,024	22,618	21,750	20,894
Mexico	19,160	21,007	22,987	21,216	19,348
China	10,455	11,525	11,733	10,032	10,954
Brazil	5,979	6,695	7,743	7,314	6,636
South Korea	4,952	5,242	5,990	5,805	5,449
Japan	5,349	5,792	6,357	5,884	4,895
Netherlands	4,141	4,376	4,714	4,933	4,564
India	2,705	3,022	3,760	4,239	3,771
Germany	2,868	3,225	3,055	3,104	3,198
Singapore	3,169	3,078	3,339	3,197	2,937

Note. In descending order based on 2020 exports.

Figure 4.2 - Total U.S. Chemicals Exports by Region ($bil)

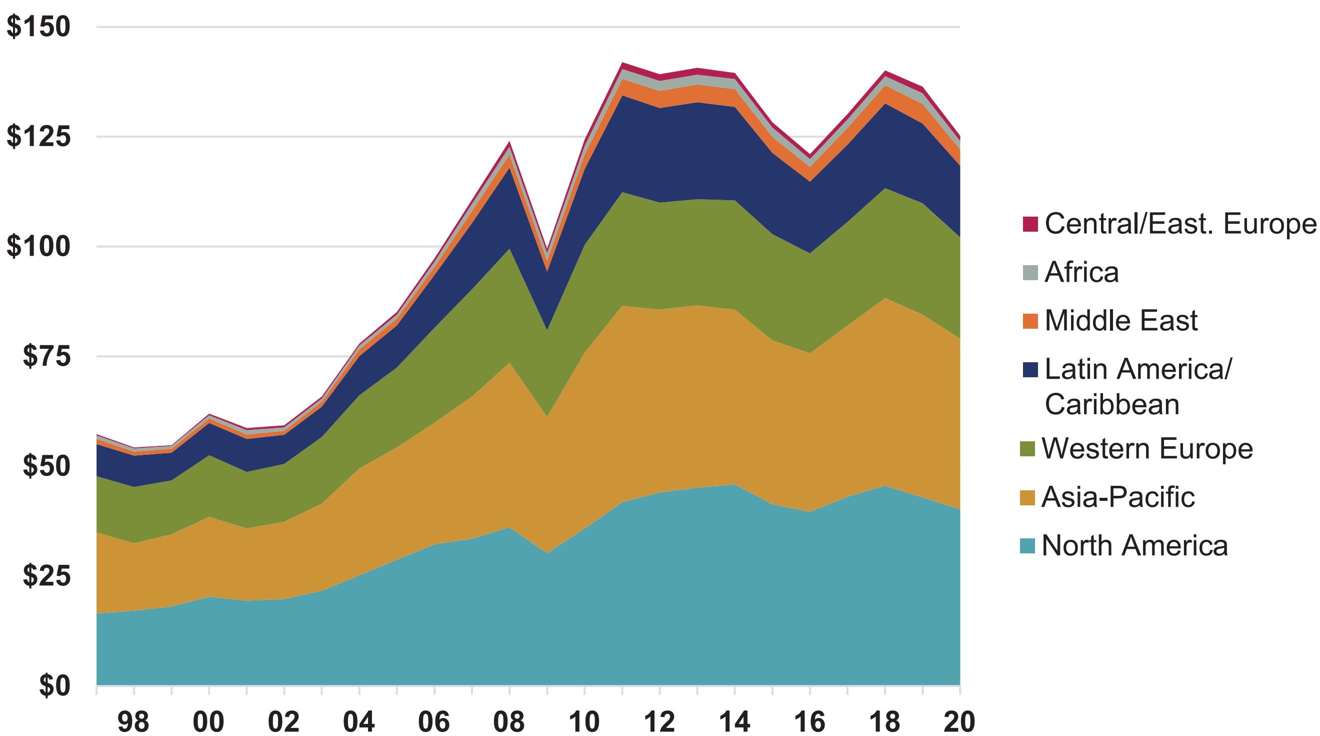
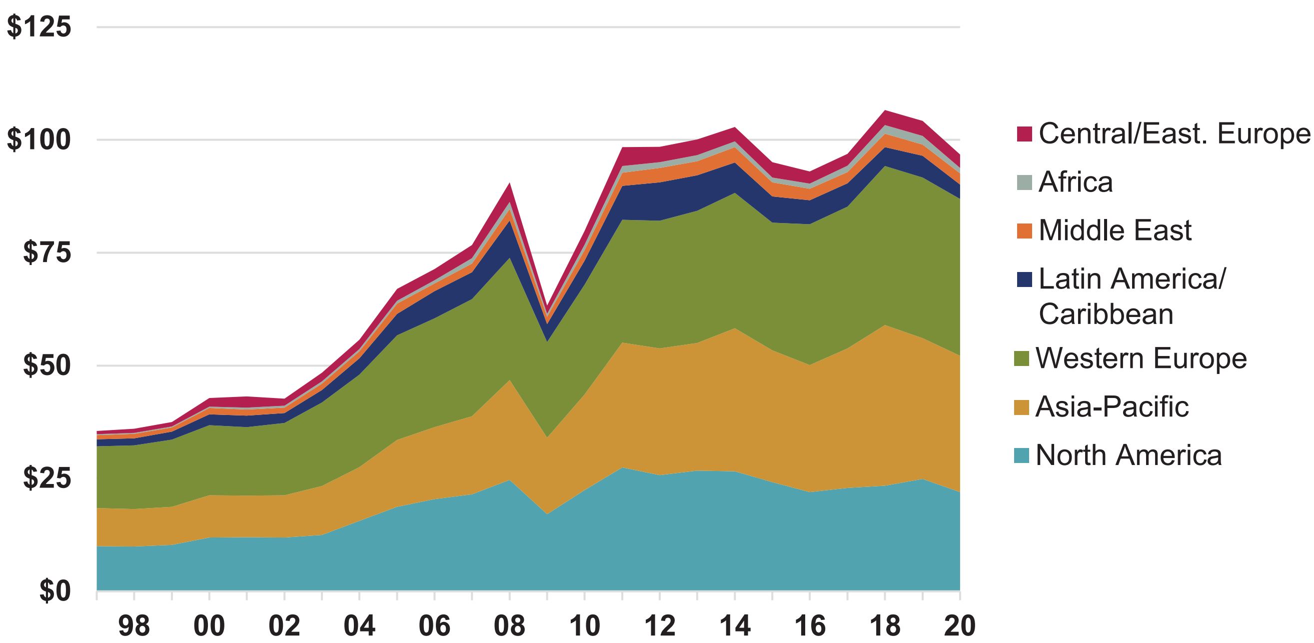


Table 4.2 - Top Chemicals Import Countries of Origin, 2016-2020

	2016	2017	2018	2019	2020
			in millions of dollars		
Canada	17,444	17,992	19,465	18,075	16,526
China	10,915	12,910	15,809	11,492	11,538
Germany	7,139	7,698	8,257	8,091	7,726
Ireland	5,608	3,902	4,839	5,530	6,619
Japan	5,576	6,003	6,732	7,094	6,345
Mexico	4,549	4,917	5,390	5,341	5,428
France	4,238	4,492	4,684	4,602	4,382
Switzerland	3,170	3,820	4,358	4,091	3,954
South Korea	2,784	3,312	3,829	3,693	3,679
India	2,594	3,026	3,393	3,733	3,528

Note. In descending order based on 2020 imports.

Figure 4.3 - Total U.S. Chemicals Imports by Region



Source for Tables 4.1, 4.2, 4.3, Figures 4.2, 4.3: U.S. Department of Commerce, American Chemistry Council analysis.

TRADE BY SEGMENT

Table 4.3 - Chemical Exports by Segment, 2016-2020

	2016	2017	2018	2019	2020
			in millions of dollars		
Chemicals	**121,001**	**130,128**	**140,053**	**135,534**	**125,249**
Basic Chemicals	81,037	87,909	95,328	92,033	84,470
Inorganics	11,918	13,573	14,811	14,598	13,351
Bulk Petrochemicals & Intermediates	35,371	38,326	41,166	39,139	36,621
Plastic Resins	26,704	28,574	32,025	31,712	28,875
Synthetic Rubber	4,813	5,275	5,186	4,560	3,948
Manufactured Fibers	2,231	2,161	2,140	2,025	1,674
Specialties	23,073	24,177	25,874	24,725	23,297
Coatings	2,600	2,654	2,777	2,764	2,486
Other Specialties	20,473	21,522	23,097	21,961	20,811
Agricultural Chemicals	6,550	7,008	7,320	7,222	6,920
Consumer Products	10,342	11,034	11,532	11,553	10,562
Pharmaceuticals	52,089	51,147	54,737	59,802	59,188
Chemicals & Pharmaceuticals	173,091	181,274	194,791	195,335	184,437
Total U.S. Goods Exports	1,386,743	1,378,818	1,374,092	1,365,252	1,358,048
Chemistry % of Total U.S. Goods Exports	8.7%	9.4%	10.2%	9.9%	9.2%

Source: U.S. Department of Commerce, American Chemistry Council analysis

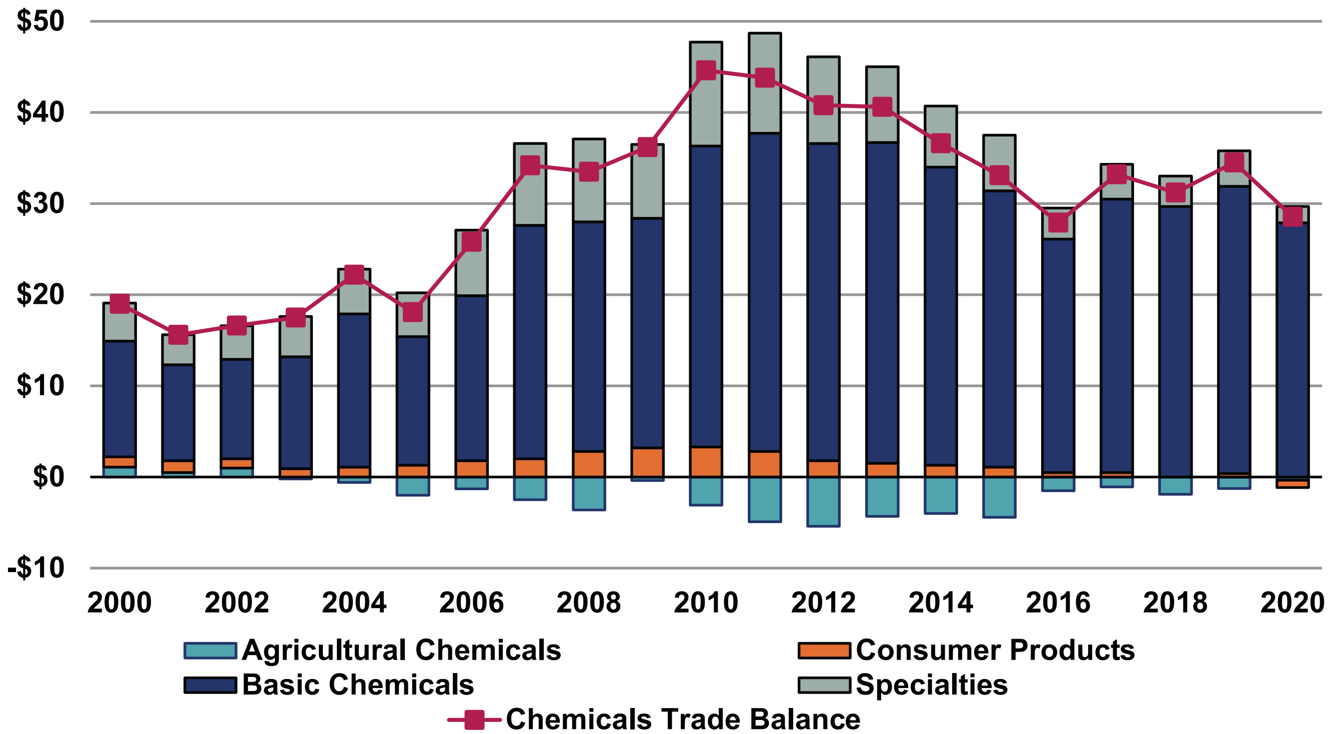
Table 4.4 - Chemical Imports by Segment, 2016-2020

	2016	2017	2018	2019	2020
			in millions of dollars		
Chemicals	**93,061**	**97,063**	**108,994**	**101,862**	**96,697**
Basic Chemicals	55,395	57,977	65,680	60,843	56,556
Inorganics	9,274	9,172	10,918	10,818	9,371
Bulk Petrochemicals & Intermediates	28,755	30,000	33,483	31,044	30,967
Plastic Resins	12,532	13,670	15,586	13,696	11,950
Synthetic Rubber	2,615	2,879	3,161	2,983	2,395
Manufactured Fibers	2,219	2,255	2,532	2,302	1,874
Specialties	19,719	20,459	22,660	21,314	21,500
Coatings	1,044	1,100	1,207	1,236	1,180
Other Specialties	18,675	19,359	21,453	20,078	20,320
Agricultural Chemicals	8,088	8,095	9,166	8,531	7,276
Consumer Products	9,859	10,532	11,488	11,174	11,365
Pharmaceuticals	113,400	112,651	135,583	151,868	167,431
Chemicals & Pharmaceuticals	206,461	209,713	244,578	253,730	264,128

Source: U.S. Department of Commerce, American Chemistry Council analysis

Table 4.5 - 2020 Top Chemicals Trade Partners (in billions)			
Canada	$37.4	France	$6.4
Mexico	$24.8	United Kingdom	$4.9
China	$22.5	Switzerland	$4.7
Japan	$11.2	Taiwan	$4.0
Germany	$10.9	Singapore	$3.5
South Korea	$9.1	Italy	$2.8
Brazil	$8.1	Malaysia	$2.2
Netherlands	$7.5	Russia	$2.1
Ireland	$7.4	Australia	$2.0
India	$7.3	Thailand	$1.7

Figure 4.4 - Chemicals Trade Balance by Segment (billions)



Given the global nature of the chemical supply chain, the implementation of industrial policies that lead to further trade liberalization will help companies reach economy of scale in sourcing and shipping of materials and products. More than 70 percent of the materials we import, and almost half of U.S. chemical exports, are intra-company, meaning one company exchanges materials with its overseas affiliate.

Note. The U.S. trade data in this section are from by the U.S. Department of Commerce and are presented by chemical segments. The entire business of chemistry is represented by NAICS 325 (Chemical Manufacturing). Exports shown in this section are domestic exports valued free alongside ship (FAS). Imports are general imports at customs value. General imports include imports that are subsequently exported (re-exports).

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CHAPTER 5

GLOBAL BUSINESS OF CHEMISTRY

Dynamic, innovative and technology-based, the business of chemistry is worldwide in scope, applying science to support and enhance the quality of life. It is a large, mature industry, with numerous suppliers and customers. Although the business is—in general—highly fragmented, for some individual products within regions, the concentration can be quite high, with only a few producers. Often, individual companies are simultaneously suppliers, customers, and competitors. Chemical manufacturers in industrialized nations typically produce a wide variety of chemicals ranging from commodity industrial chemicals to specialty chemicals. In developing nations, domestic chemical production tends to be simple chemical products such as fertilizers and inorganic commodity chemicals.

The globalization of the business of chemistry took off in the 1960s when numerous companies, based in various countries, began investing in production facilities in foreign countries, thus the development of world markets, with prices of many chemicals set by global supply and demand. World economic growth, policies that support industrial growth and competitiveness, as well as advances in technology, logistics and distribution, have fostered this globalization. Globalization of investments and markets has spread industry capital resources, technology, and managerial capabilities around the world and has resulted in a growing population of multinational chemical companies.

Although a number of large companies had foreign subsidiaries for many years, international investment by American and Western European companies grew at a particularly rapid pace during the 1980s and 1990s. Prior to that time, most developing nations had only moderate domestic chemical production. Rather, they were export markets for the chemical industries of the developed nations and provided little or no competition in other markets. By the 1990s, however, many developing nations embarked on ambitious programs to develop globally competitive chemical industries, including several of the newly industrialized countries (NICs) of Asia (Singapore, South Korea, Taiwan, Thailand) and many of the larger economies of Latin America (Argentina, Brazil, Mexico and Venezuela).

By the 2000s, the Middle East was rapidly emerging as a major player in global petrochemical markets, and U.S. chemical production (particularly Gulf Coast petrochemicals) was essentially being written off as one of the highest-cost producers. By 2010, however, shale gas production in North America caused a dramatic shift in production costs and ethane supplies in the Middle East became constrained. Today, the U.S. and Canada are among the lowest-cost producers in the world, attracting record levels of investment in new facilities and expanded production capacity over the past decade.

WORLD TRADE

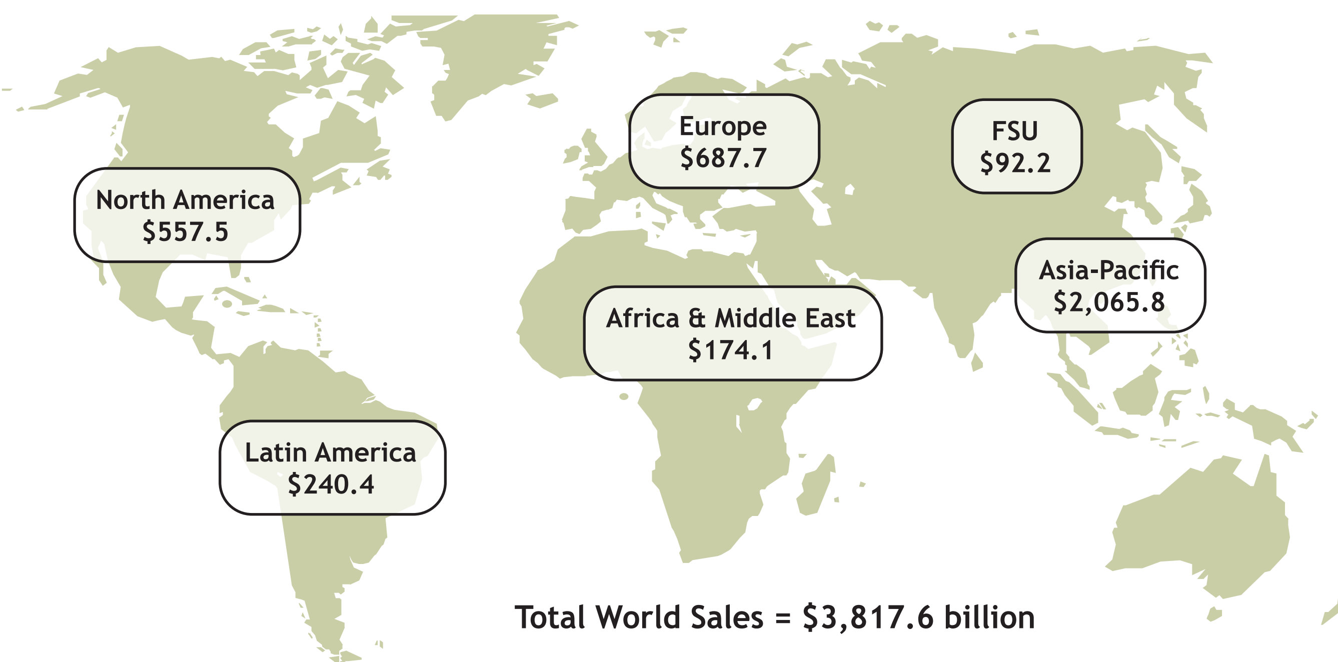
Chemical manufacturers have developed global supply chains to create and deliver the products of chemistry efficiently. International trade, including related-party trade, is essential to the global business of chemistry. Market access and minimizing tariff and nontariff barriers has been key to the globalization of the chemical industry and the fluidity of world trade.

Table 5.1 - Global Chemical Shipments by Region, 2016-2020

	2016	2017	2018	2019	2020
			in billions of dollars		
North America	577.5	603.0	633.0	589.0	557.3
Latin America	210.5	244.6	261.9	246.7	208.2
Europe	636.9	705.1	767.7	723.2	707.6
Former Soviet Union	67.7	82.4	90.4	92.6	90.3
Africa and Middle East	137.1	142.0	154.2	160.4	171.3
Asia-Pacific	2,078.5	2,049.4	2,239.4	2,147.5	2,082.9
Total Global Shipments	**3,708.2**	**3,826.5**	**4,146.7**	**3,959.4**	**3,817.6**

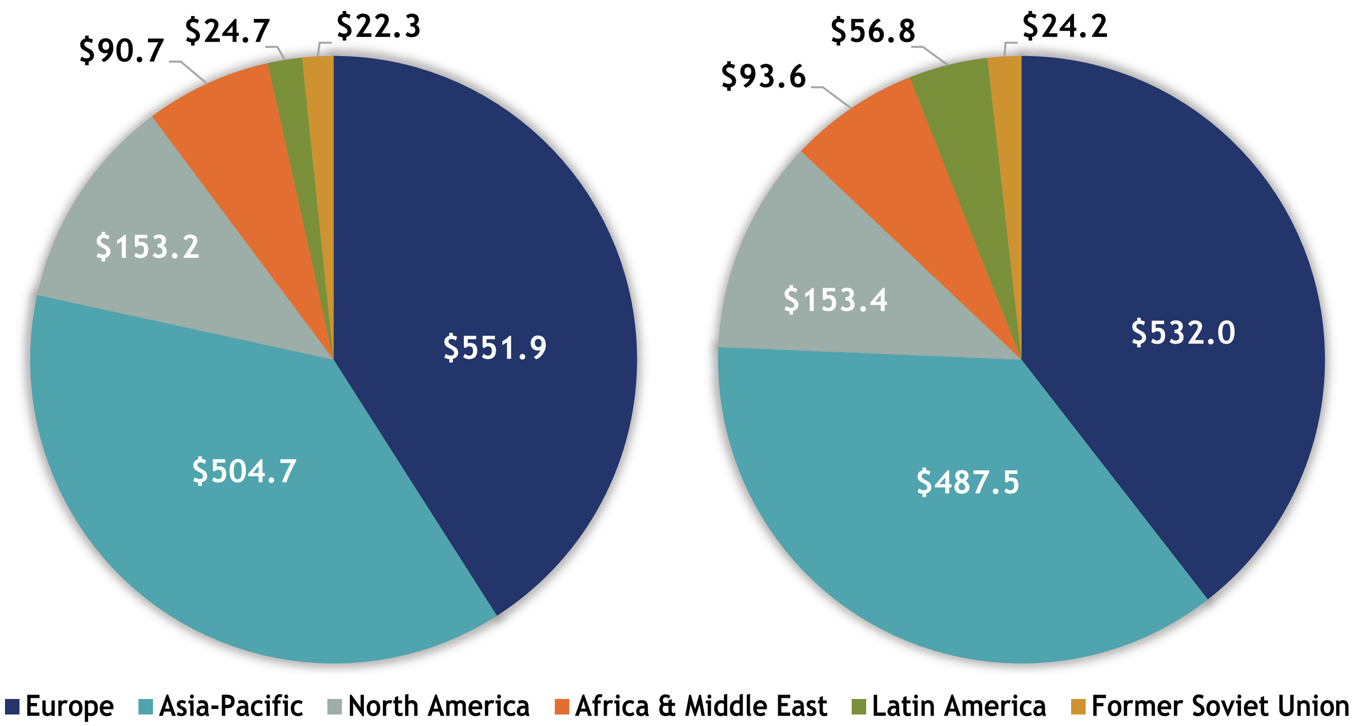
Notes. The term "shipments" is equivalent to the term "turnover," or value of output. The data are expressed in U.S. dollars, with average annual market exchange rates used to convert other currencies into U.S. dollars. ource: Bureau of the Census (from the ASM-1 report).
Sources: ABIQUIM, ANIQ, CCPA, CEFIC, JCIA, VCI, Bureau of the Census, Eurostat, IHSMarkit, Oxford Economics, Statistics Canada, United Nations, American Chemistry Council estimates

Figure 5.1 - Global Chemical Domestic Sales by Region, 2020 (billions)



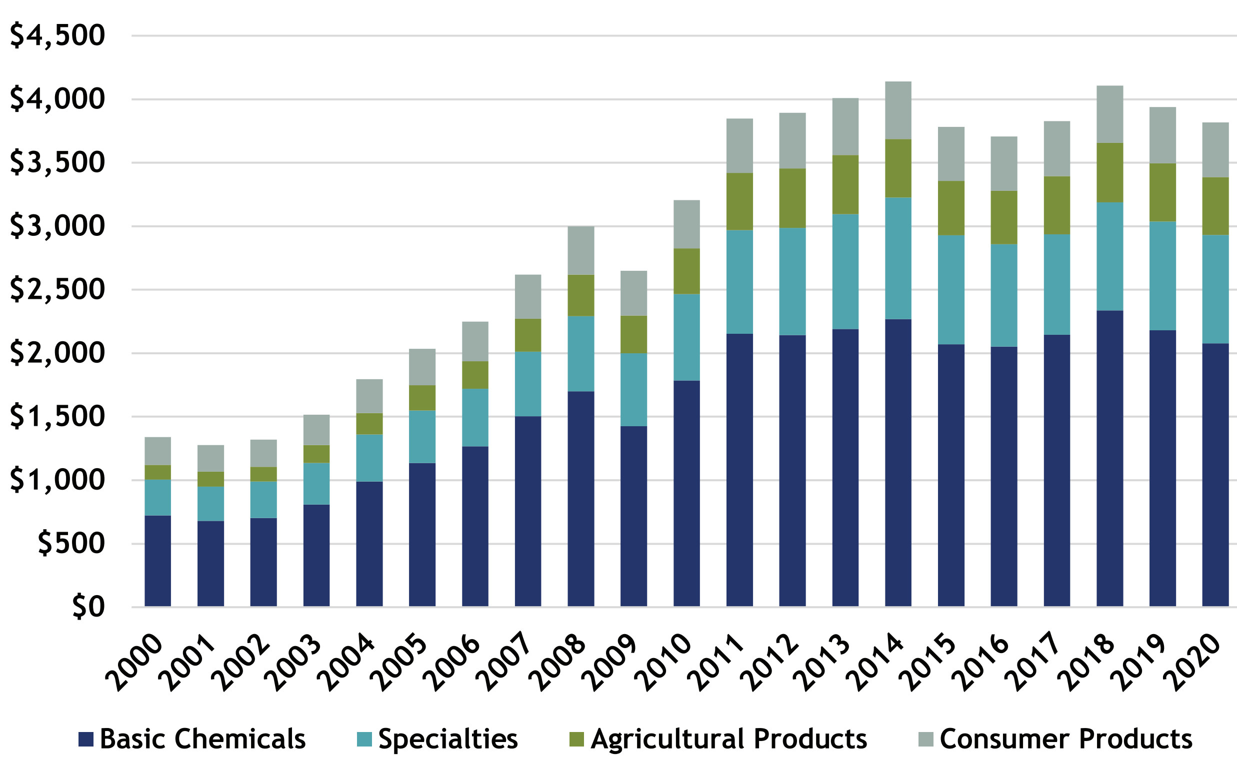
Note: Sales data is derived by subtracting shipments from exports and adding imports; it is equivalent to apparent consumption.

Figure 5.2 - Global Chemical Exports and Imports by Region, 2020 (billions)



Sources: ABIQUIM, ANIQ, CCPA, CEFIC, JCIA, VCI, Bureau of the Census, Eurostat, IHSMarkit, Oxford Economics, Statistics Canada, United Nations, WTO, American Chemistry Council estimates.

Figure 5.3 - Global Chemical Shipments by Segment (billions)

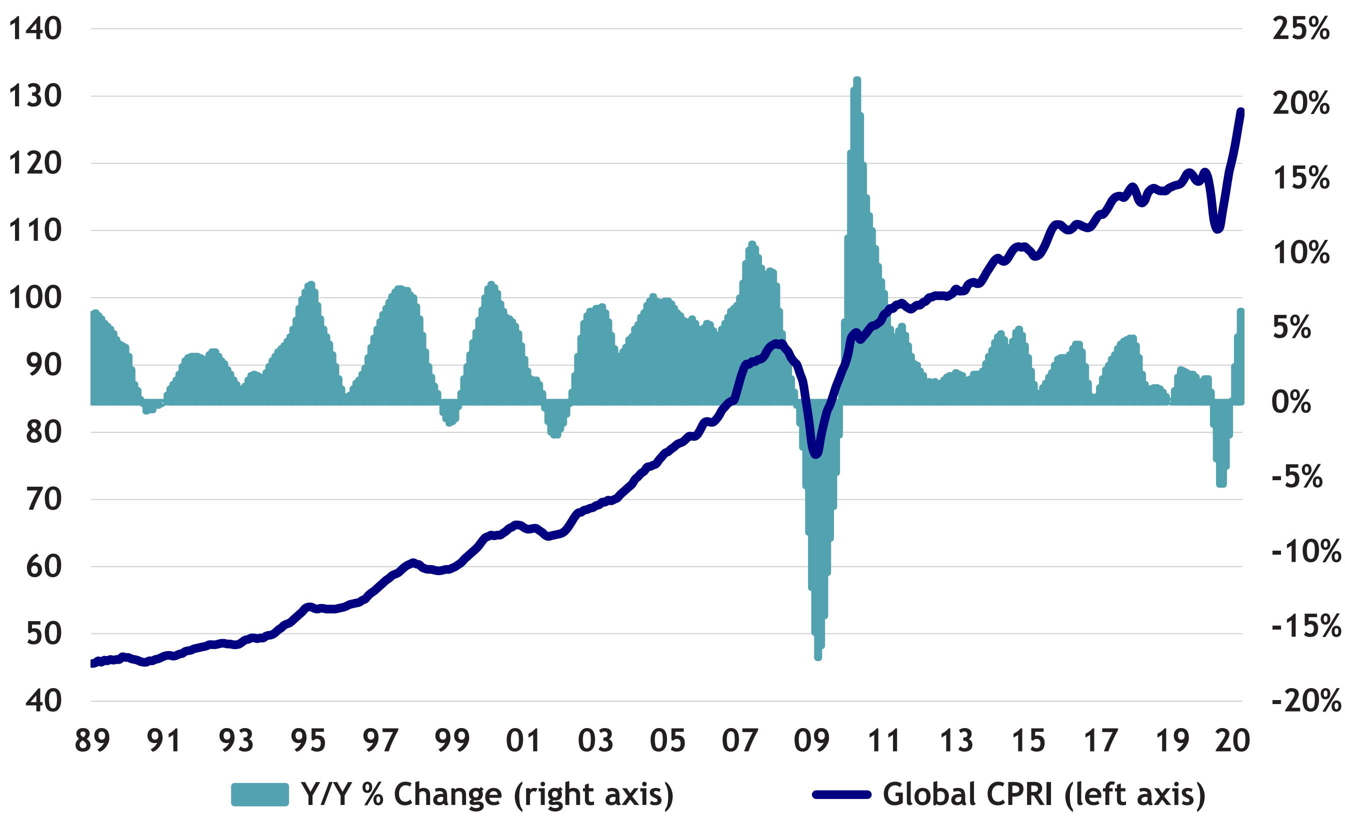


Source: American Chemistry Council estimates

GLOBAL CPRI

The ACC Global Chemical Production Regional Index (Global CPRI) measures the production volume of the chemical industry for 33 key nations, sub-regions, and regions, all aggregated to the world total. The index is comparable to the Federal Reserve Board (FRB) production indices and features a similar base year where 2012=100. This index is developed from government industrial production indices for chemicals from over 65 nations accounting for about 98% of the total global business of chemistry. Because foreign data are often non-seasonally adjusted or at best working day adjusted, ACC attempts to present the data on a seasonally adjusted basis comparable to that of the United States and Canada. As a result, it will differ from (and hopefully improve upon) official government statistics of some nations. In many cases, ACC created indices of production based on actual production data (weighted according to industry structure) and other data. The Global CPRI measures production activity generally consistent with the overall industry nomenclature of NAICS 325 (less pharmaceuticals) and the EU NACE 20 industries. That is, the index measures production of soaps and detergents, personal care products, fertilizers, and other downstream products in addition to measuring inorganic chemicals, organic chemicals, plastic resins, synthetic fibers, synthetic rubber, adhesives and sealants, coatings, and other specialty chemicals. Production of pharmaceuticals is excluded.

Figure 5.4 - Global Chemical Production Regional Index



Total world and regional, monthly, quarterly and annual time series are available back to 1987, as are detailed sub-regional data. The Global CPRI is released on a monthly basis. *Data, charts, and the monthly report are available for ACC members on MemberExchange or by email distribution. Contact ACC's Economics & Statistics Department for more information.*

CHAPTER 6

INNOVATION

A powerful engine for innovation and creativity, the business of chemistry is more than a supplier of products and solutions to other industrial sectors; it is an enabling enterprise, imparting technological innovations throughout the value chain. Innovation is found in all aspects of the chemical industry, from research and development to business processes to customer relationships and knowledge. The leading-edge products and technologies made possible by the chemistry help to improve functionalities, reduce costs, and increase productivity and contribute to a healthier, safer and more sustainable future.

A key driver of competitiveness and economic growth, innovation is at the core of value-added products and services, more efficient production processes, and improved business models. Valuation of companies is no longer equivalent to annual sales. It includes recognizing the importance of knowledge and intangible assets such as brand or corporate image, patents, customer relationships, unique skills or knowledge bases, and others. Indeed, physical assets in a number of industries are becoming commodities. It is the intangible assets—employee knowledge, brands, technology, and data and information about products, customers, and business processes, as well as more traditional intellectual property, such as patents, trademarks, and regulatory licenses— that increasingly define "real value." In an increasingly global business, companies are finding significant advantages in information, relationships, and knowledge versus physical assets.

RESEARCH AND DEVELOPMENT ACTIVITIES

The chemical industry is consistently one of the largest private-sector industry investors in research and development (R&D). R&D spending includes expeditures related to the development or improvement of a product or process. (Spending for quality control testing, advertising, market research, and other non-technological activities is excluded.) Chemists and other scientists, engineers, and technicians are constantly engaged by the business of chemistry: they develop new (and improved) process

In the 1970s, sociologist Daniel Bell was one of the first to recognize the emergence of a post-industrial society in which knowledge plays a dominant role. In his 1976 book, *The Coming of Post-Industrial Society: A Venture in Social Forecasting*, Bell cited the business of chemistry as the first of the truly modern industries, because its origin lies in the intimate linkage between science and technology.

technologies, new chemical compounds and products, and new applications for existing chemical products. And new products and processes are the driving force of the continued competitiveness of the business of chemistry, both domestically and internationally.

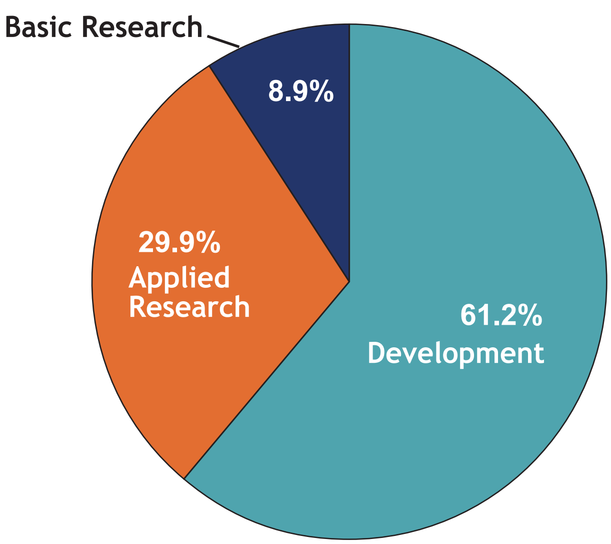
Investment in R&D is a commitment of resources in the present in exchange for an anticipated future stream of benefits. It involves allocating resources to people, as opposed to simply increasing manufacturing output. It typically involves a high degree of risk, as there is no guarantee of a return on the investment. Rates of return on successful innovations, however, can be quite high, often in the range of 20 to 30%.

There are two broad categories of research: basic and applied. Basic (fundamental) research can be defined as any planned search for unknown facts and principles of general validity, without regard to commercial objectives. It consists of original investigation for the advancement of scientific knowledge. Applied research, on the other hand, can be defined as any investigation planned with the intent of using known phenomena or substances to accomplish a particular objective. In general, the basic research of today is the foundation for tomorrow's applied research. Once the research has been conducted, the findings (or other general scientific knowledge) must be translated into a form that is designed to meet the needs of customers. This is the "development" part of R&D.

Organized industrial research in the business of chemistry began around 1900. World War I gave new emphasis to research, and marked the beginning of sizable programs. Over the last century, R&D efforts by the business of chemistry have continued to expand, and in even times of lower profit margins, chemical companies have maintained their R&D activity. In recent years, there has been a growing interest in data-driven R&D, which has become increasingly accessible in the age of digitalization. Beyond traditional researchers, companies are integrating technology, such as artificial intelligence and digital simulations, into their R&D processes.

Chemical companies allocate, on average, 2-3% of their annual sales toward R&D, although some companies may allocate as much as 8-9%. Moreover, unlike many other manufacturing industries that receive government funding for research, the business of chemistry in the U.S. typically funds its own R&D.

Figure 6.1 - Basic and Specialty Chemical Companies' R&D Spending by Type, 2020

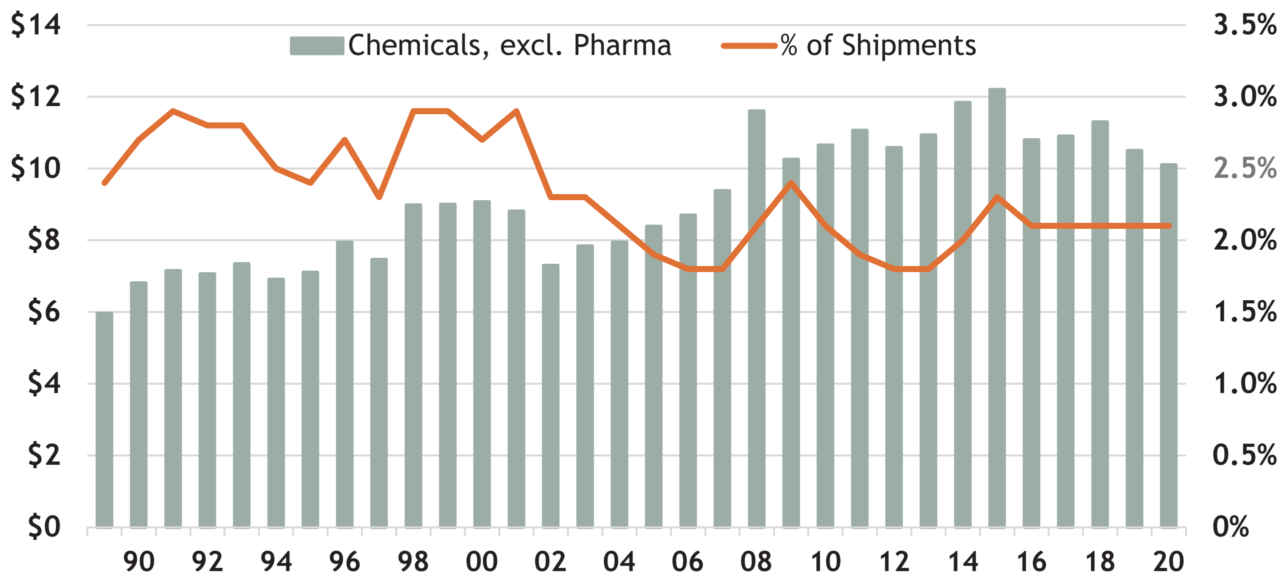


Source: National Science Foundation, ACC

Successful research in the business of chemistry requires intensive effort and major expenditures; it takes years from the time a project is conceived to the time a chemical product is brought to the marketplace. A 2013 McKinsey & Company study (*Chemical innovation: An investment for the ages*) found that it takes from two to 19 years for a chemical product to reach the market. For each project that successfully leads to a practical application, there may be as many as 100 failures. The successes must yield enough in profits to provide an adequate return on the total investment in R&D.

In R&D, a number of companies appear to be seeking critical mass via economies of scale and alliances. The role of alliances and other collaborations in innovation is achieving greater recognition as companies seek to "do more with less" in their innovative processes. Companies are adopting a more open innovation model, using more ideas from outside, including collaboration with customers and the use of Big Data. There also appears to be a more direct link between R&D efforts and commercial results, as strategic business units within many companies have become more responsible for defining R&D programs that fit their objectives. Knowledge management and innovations along the entire chemical value chain are now seen as critical areas.

Figure 6.2 - R&D Spending in the Business of Chemistry



Source: Bureau of Economic Analysis, ACC

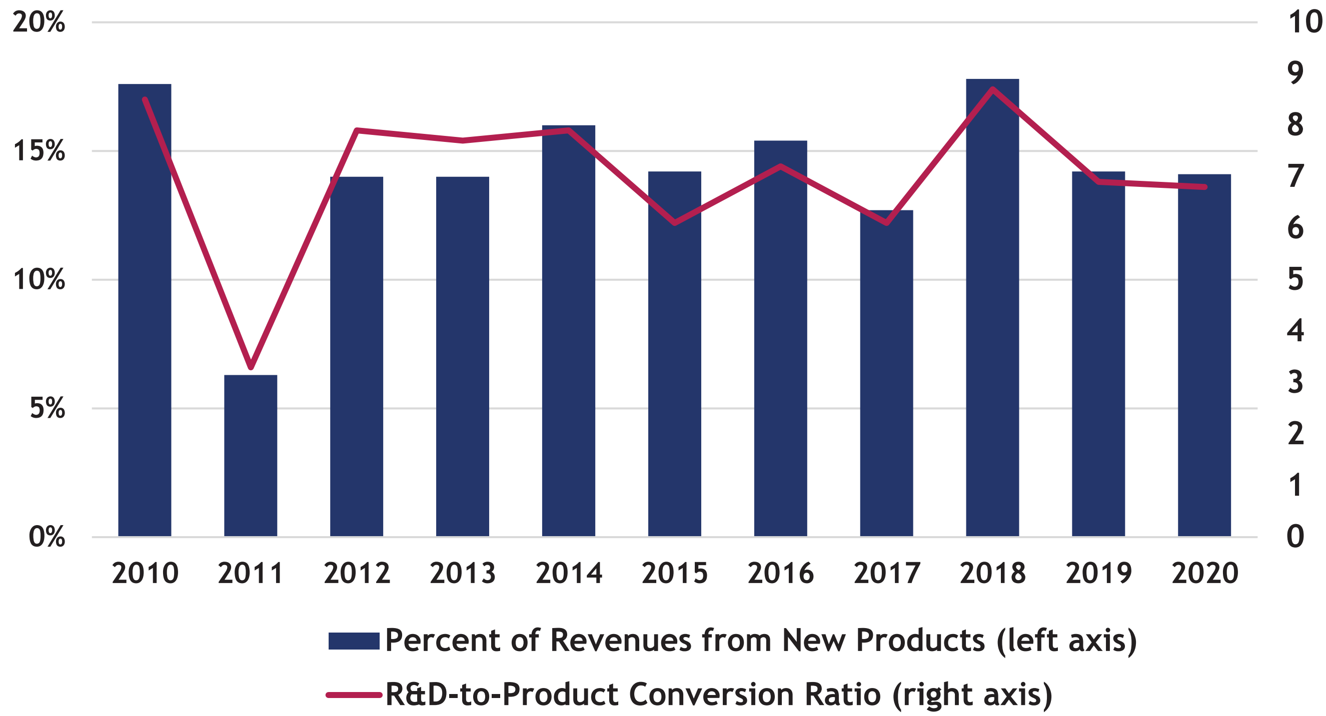
Measuring Innovation

The role of innovation is often viewed as critical to success. However, measuring innovation can be difficult. For industries and companies, many different measures of the innovation can be used such as annual R&D spending as a percent of total sales or number of patents filed. Measuring the percent share of revenues from new products and services is another metric that has found acceptance among stock analysts, academics, and others. Two professors at the Harvard Business School, Robert S. Kaplan and David P. Norton, found that a company's ability to innovate, improve, and learn is directly related to its value (part of a concept they developed called the "balanced scorecard"). That is, through the ability to launch new products and services, create additional value for customers, and improve operating efficiencies, a company can penetrate new markets and increase revenues and margins.

ACC's Economics and Statistics department collects data on the percent share of revenues from new products and services as part of its annual economic survey. Analysis of these data shows that specialty chemical companies have a slightly higher share compared to basic chemical companies. The data are not entirely comparable from year to year.

Innovation—putting ideas into action through knowledge to create new products and services to meet the needs of current and future customers—is a long-term driver of future financial performance and value creation. It provides business opportunities, as well as the sustainable foundation for continued growth. Innovation can lead to shifts in relative cost relationships, and provide sustained competitive advantages. Indeed, it is at the heart of the business of chemistry, and is crucial to economic growth and improvement in the quality of life.

Figure 6.3 - Share of Revenues from New Products



Service Innovation
Innovation is not limited to products and processes; it can include a range of endeavors that lead to enhanced value. The service intensity of many products in the business of chemistry is increasing, and service innovations are an increasingly important type of innovation. In a number of segments, companies have added management services to their portfolio, in addition to—and sometimes instead of—chemical products. Specialty chemical and advanced (performance) materials companies—which, by their nature, require extensive technical servicing components with highly-trained service and sales representatives, knowledgeable customer service problem-solvers, and EH&S professionals—demonstrate increasing innovation. Companies are looking beyond traditional technical servicing and utilizing creative solutions to adding value as service companies.

Service innovations in the business of chemistry are especially prominent in the automotive and electronics industries. Automobile manufacturers require specific properties when considering paint and coating applications (e.g., anti-corrosion properties). Rather than purchasing paint by the gallon, automobile companies are engaging with coatings manufacturers to meet individual requirements. The coatings companies are often integrated in the automotive manufacturing, running complete coatings operations at body plants. In the electronics industry, services such as “cradle-to-grave” responsibility for chemicals have become increasingly important. For example, a chemical supplier may “lease” chemicals to a semiconductor company to process the chips, so that the semiconductor company is free from the management of used chemicals. Chemical companies are taking on the role of consultant, solving problems and supplying solutions, best practices, and performance guarantees, while at the same time reducing waste and increasing cost savings.

Service innovation encompasses a new way of thinking in the business of chemistry. As a differentiation strategy, service offerings can lower coordination, transactions, and other costs incurred by the customer, as compared to if the customer were to search out and assemble various products, services and activities (chemicals, equipment, procurement, operations, maintenance, quality assurance, inventories, etc.) on their own. Service innovation allows the customer to concentrate on their core competencies and provides technological flexibility. To suppliers and innovators, these innovations engender a stream of revenues and higher added value. Innovations in service mark a shift from the value of things to the value provided by things.

Sustainability and Innovation
Chemistry is fundamental to understanding the world’s most pressing sustainability challenges, and essential to overcoming them. The chemical industry is working with experts in other business sectors, at universities and in government to develop new and innovative ways that chemistry can contribute to a sustainable future. The chemical manufacturing industry plays an integral role in reimagining the products, technologies, resources and systems that will power a circular, sustainable economy.

The chemical industry is committed to playing a key role in enhancing sustainable development and promoting the systemic transition to a circular economy, in which resources and materials are continuously cycled to eliminate waste, while creating value for all. This transition includes innovations that help improve the reuse, repurposing and recycling rates of products like plastics; technologies that recapture and repurpose chemicals used in manufacturing and break down discarded materials into their basic chemical building blocks, to extend the lifespan and create additional value for these molecules as raw materials that can be made into new products or support new industrial uses; and sustainable product design and materials selection that improves product durability, extends product lifespans and enables repurposing of product components, preserving their value and usefulness in a regenerative system.

Innovations in chemistry also contribute to the sustainability efforts of other industries. For example, in the electronics sector, chemistry is enabling the design of more durable products and the reuse and recycling of component parts. In the automotive sector, chemistry has enabled significant fuel efficiency gains through the development of lightweight, yet strong and safe materials. And thanks to chemistry, a wide range of vehicle parts can now be made from recycled plastics or can be recycled themselves.

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CHAPTER 7

INVESTMENT IN THE FUTURE: CAPITAL

The business of chemistry is a capital-intensive industry. There are numerous factors that contribute to high capital costs: the large plant capacities often needed to obtain economies of scale in producing chemicals; the intricate nature of the equipment and processes used; the high degree of process automation; the large amounts of equipment needed; technology requirements (and the rapid technological obsolescence); and depreciation of process plants.

Capital intensity (or financial resources employed per worker) is a good indicator of the adequacy of capital formation. Changes in capital formation and employment growth show up in what economists refer to as "capital endowment," that is, the average amount of capital stock that is available to each worker. Increasing levels of capital employed per worker may contribute to improved productivity, indicating that workers are equipped with the advanced resources embodied in the acquisition of new capital (and capacity). Higher productivity is, in turn, typically accompanied by higher real wages for workers. On the other hand, declining capital endowment places the labor force at a disadvantage relative to competitors. This tends to reduce real wages for workers. Among manufacturing industries, chemistry is second to petroleum refining in terms of capital employed per worker.

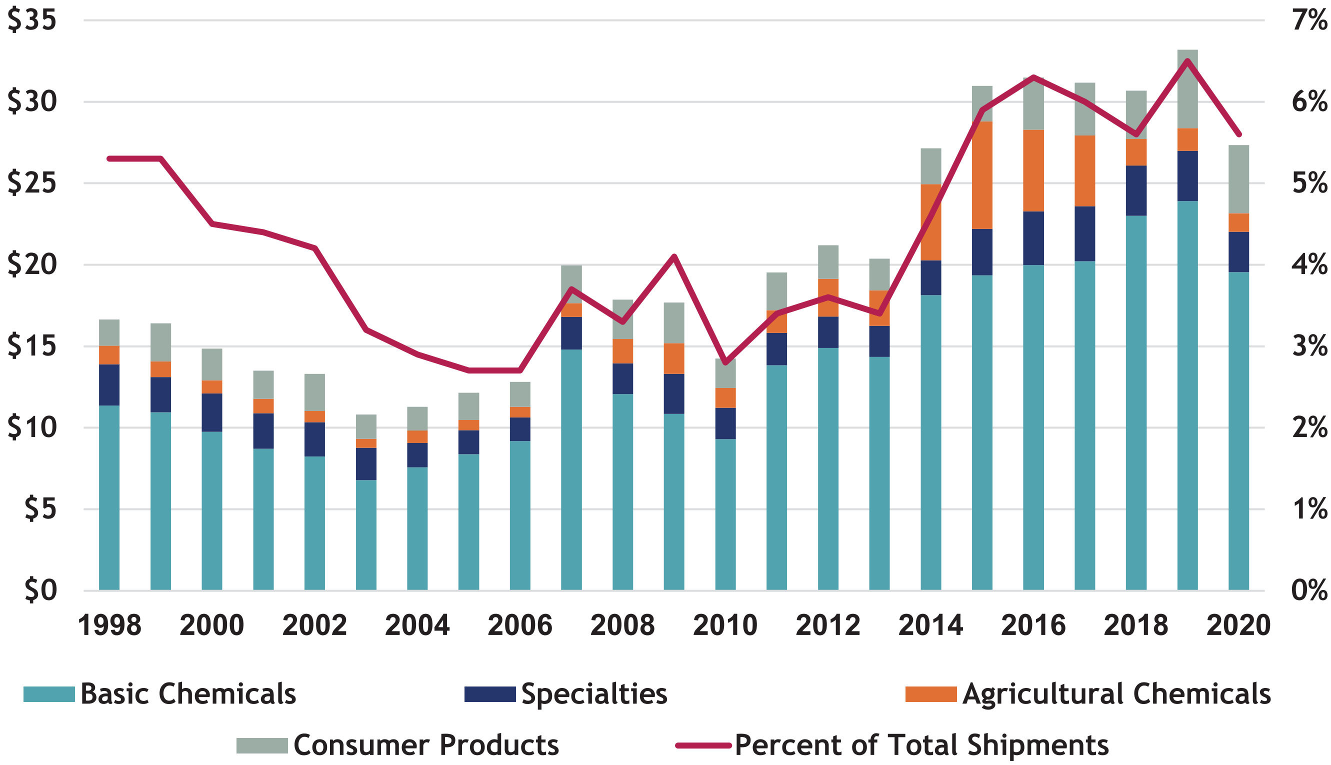
CAPITAL INVESTMENT

Capital investment (or capital spending) is comprised of two basic components: structures (e.g., buildings) and equipment. The equipment category is composed primarily of traditional process equipment such as fabricated metal products (pressure vessels, storage tanks, heat exchangers, pipe, etc.); general industry machinery (pumps, compressors, etc.); electrical transmission, distribution, and industrial apparatus; and other special industry machinery. A sizable portion of equipment spending in the business of chemistry is for instrumentation, computers, and related automation and digital technologies. To a large degree, structures in the chemical industry protect chemical processes from the elements and support process equipment. Investment in structures is mostly for industrial buildings and related structures (loading docks, terminals, etc.), but also includes some minor spending for office buildings. Of the two, equipment is notably more important to long-term growth potential for the manufacturing sector and the business of chemistry because it is essential to the production process.

The business of chemistry has consistently been one of the largest U.S. private-sector investors in new plants and equipment. In general, real (that is, adjusted for the effects of inflation) capital investment in structures (or plants) and equipment by the business of chemistry parallels overall U.S. economic activity, rising during periods of expansion and falling during periods of economic downturns.

Capital spending trends among companies differ based on their main business focus. Basic chemical companies, particularly manufacturers of plastic resins and synthetic rubber, generally allocate the largest share of their sales for capital investment, followed by consumer products and specialties. Capital spending by agricultural chemicals companies tends to fluctuate significantly based on economic conditions. Over the past ten years, spending by agricultural chemicals companies has ranged from 3.7% to 18.9%.

Figure 7.1 - Capital Investment - Chemicals



Source: Bureau of Economic Analysis and ACC analysis (based on Bureau of the Census data)

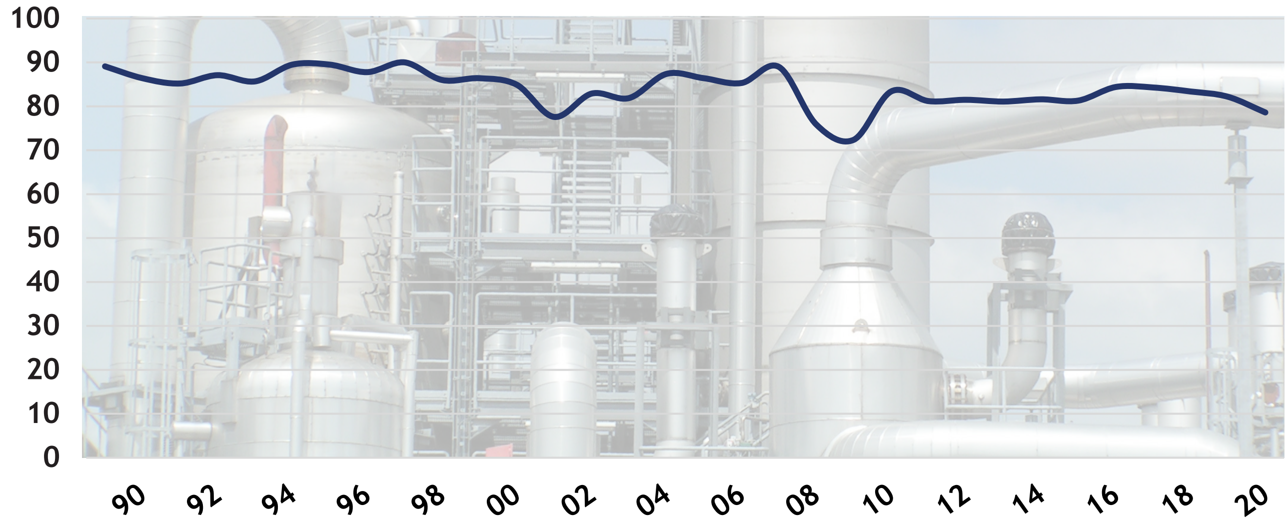
PROFITS AND OTHER DETERMINANTS OF INVESTMENT

Profit margins (and operating profits) and capacity utilization rates are key drivers for capital investment. A number of factors drive the magnitude and composition of investment in new plants and equipment, such as after-tax profits, the business cycle, long-term business expectations, taxation policies, regulatory burdens, the cost of capital, the burden of debt, the supply of credit, and mandated expenditures.

The 1990s were a period of slow and steady growth for companies engaged in the business of chemistry. In the early part of the 2000s, chemical companies were especially hard hit, as reduced capacity utilization, rising energy and other raw material costs, falling real prices, a downturn in end-use markets, and oversupply all contributed to declining margins. By 2010, the U.S. business of chemistry began to experience another wave of growth, spurred largely by developments in shale gas, which made the U.S. increasingly more attractive as a place to manufacture chemicals. However, the impacts of plant shutdowns due to COVID-19 and weather-related outages in the Gulf Coast over the past two years have negatively impacted spending. In terms of profit margins, the chemical industry can be quite volatile.

Capacity Utilization **(or operating rate) measures the extent to which the capital stock of an industry (or nation) is employed in the production of goods. Capacity utilization rises and falls with the business cycle. Historically, there has been a relationship between the capacity utilization rate and the producer price index. The Federal Reserve Board (FRB) publishes a capacity utilization number for the business of chemistry (NAICS 325). Fluctuation between 74% and 85% is typical. Industrial chemicals tend to feature higher capacity utilization rates; plastic resins are a prime example.**

Figure 7.2 - Capacity Utilization



MOTIVATION FOR CAPITAL INVESTMENT

Companies involved in the business of chemistry have a number of reasons for investing in new plants and equipment. New capital needs include expanding production capacity for both new and existing products, replacing worn-out or obsolete plant and equipment, and improving operating efficiencies. It is common for existing plants to undergo complete modernization programs that utilize the latest process technologies, often for “debottlenecking” (i.e., maximizing through-put in an existing plant). Other reasons for capital investment include energy savings, addressing changing environmental concerns, and other initiatives need to remain competitive.

Maintenance and repairs also require significant capital to keep plant operations efficient and safe. Of these expenses, about half are for labor and the other half for materials. As a share of shipments, maintenance spending tends correlate with the operating conditions of the plant: spending is low where service conditions are light and high where severe operating conditions exist. Corrosive materials and the use of special equipment, for example, tend toward higher maintenance costs. Basic chemicals engender the most maintenance and repair spending, as well as fertilizers and some specialties.

A long lead-time can be required for funding, designing, and completing chemical industry capital spending programs. This makes short-run adjustments difficult, as capital investment cannot easily be turned on and off. Given its capital-intensive nature, however, the business of chemistry is highly sensitive to the costs of capital and the level of cash flow.

INFORMATION TECHNOLOGY

The chemical sector uses information technology to streamline the delivery of products and services. Reliable information technology is key to engineering new scientific and chemical developments, managing the supply chain, executing processes in plants, maintaining productivity in offices, storing employee benefit and payroll information, and securing business and manufacturing control systems. As technology continues to advance, so will the chemical industry's use of IT to improve the way it conducts business.

Advances in information technology are improving product and process development. Supply-chain integration offers increased organizational flexibility to meet customer's changing needs, as well as increased speed of decision-making. Companies are increasingly collaborating with customers and suppliers to deliver greater value.

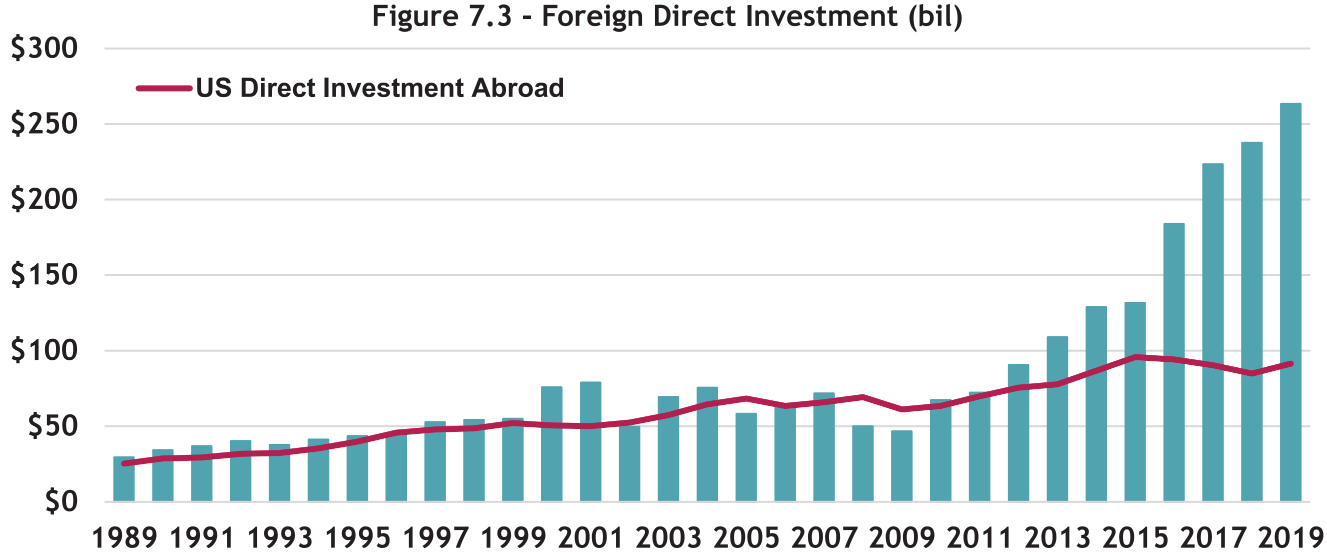
Historically, the chemical industry has not be at the forefront of digital technologies. However, the benefits of investing in new technologies, such as artificial intelligence (AI), advanced analytics and the use of Big Data, are immense. Operational disruptions due to COVID-19 also accelerated the use of digital technologies across many industries, including the business of chemistry. As many aspects of the industry worked remotely, there was an increased need in technology to conduct business, from video calls with colleagues to remote operations of plants.

FOREIGN DIRECT INVESTMENT

Foreign direct investment (FDI) is the funnel through which exports flow. In conjunction with growing exports, since the early 1980s, the business of chemistry has become increasingly global in scope, with growing U.S. investment abroad and increasing foreign investments in the United States.

American companies have a long-established presence in overseas markets. Europe accounts for around two-thirds of the overseas chemical industry investment by American companies. Canada, China, Japan, Singapore, Brazil, Mexico, and South Korea are other key destinations. Because investment positions are measured by book value, investments made by foreign companies in the United States tend to be more recent, and as a result, the position is higher than U.S. investment overseas. In terms of replacement value, however, U.S. investment overseas is higher.

Figure 7.3 - Foreign Direct Investment (bil)



Note: 2019 latest available data.

CHAPTER 8

EMPLOYMENT

Innovative, creative, and progressive, the business of chemistry is one of the most knowledge-intensive industries in the manufacturing sector. Despite a high degree of capital intensity, the business of chemistry is one of the largest U.S. industries in terms of employment. Historically, growth in the business of chemistry has been accompanied both by expanding employment and by significant gains in labor productivity (i.e., output per man-hour). Real wages have also increased. Because of the highly technical and rapidly changing nature of the industry's operations and products, R&D and technical services provided to customers are increasingly important factors in companies' ability to compete. This, together with continuing increases in the automation of production processes, has caused some decline in the production worker portion of the industry's workforce over time.

Table 8.1 - Employment in the Business of Chemistry, 2016-2020

	2016	2017	2018	2019	2020
	thousands of people				
Employees	525.8	531.3	538.4	543.8	529.0
By Occupation					
Production Workers	341.9	341.8	349.9	359.3	336.0
Other	183.9	189.5	188.5	184.5	193.0
By Sex					
Female	128.0	131.2	137.4	144.3	145.1
Male	397.3	400.1	401.0	399.5	383.9
Median Age of Workers (years)	46.1	46.0	43.9	44.6	45.9
Average Wages and Salaries/Employee	$81,677	$84,066	$85,559	$87,457	$90,125

Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, National Science Foundation, ACC analysis.

EACH JOB IN THE CHEMICAL INDUSTRY GENERATES AN ADDITIONAL 6.8 JOBS IN OTHER SECTORS OF THE ECONOMY.

TOTAL EMPLOYMENT IMPACT OF THE BUSINESS OF CHEMISTRY

The means by which an industry generates employment reaches beyond those directly employed by the industry. The true employment impact of an industry takes into consideration the following:

- **Direct Employment** — the people who work directly for the industry. For example, in the business of chemistry this includes plant operators, R&D engineers, chemists, etc.
- **Indirect Employment** — the people who works in jobs in other industries (such as supplier) that are supported indirectly by the industry being examined. For example, in the business of chemistry this could be third-party truck drivers who transport materials to/from the plant.
- **Expenditure-Induced Activity** — the jobs in the suppliers' suppliers (e.g., manufacturers of trucks needed to transport materials to/from the plant), and in those industries supported by the wages paid to employees in the communities where they live (e.g., medical facilities, coffee shops).

Table 8.2 - Total Jobs Supported by the Business of Chemistry, 2020

Industry	Direct	Supply Chain	Payroll-Induced	Total
		thousands of people		
Chemicals	529			529
Agriculture		135	31	166
Mining		56	3	59
Utilities		34	6	40
Construction		23	12	35
Manufacturing, excluding Chemicals		235	70	305
Wholesale Trade		235	46	280
Retail Trade		71	216	287
Transportation		226	83	308
Information		26	30	56
Finance and Insurance		81	145	227
Professional, Scientific, Technical Services		236	142	378
Management of Companies and Enterprises		109	21	130
Administrative and Waste Management Services		162	63	226
Health Care and Education		66	395	461
Arts, Entertainment, and Recreation		15	54	69
Accommodation and Food Services		47	208	256
Other Services		74	165	239
Government		33	19	52
Total - All Industries	**529**	**1,864**	**1,711**	**4,104**

Source: Bureau of Labor Statistics and American Chemistry Council analysis.

KNOWLEDGE WORKERS

The business of chemistry is a powerful engine of innovation and creativity. This results from the knowledge base of its employees. "Knowledge worker" is a term that was originally coined by management guru Peter Drucker, several decades ago. It refers to employees with university degrees and/or training whose principal tasks involve the development or application of specialized knowledge in the workplace. Scientists and engineers comprise about a tenth of the industry workforce. In addition, the highly technical nature of chemical manufacturing demands that production workers, technicians, and other employees have specialized skills. As a result, workers in the chemical industry earn a substantial wage premium compared to the manufacturing average.

WAGES, BENEFITS AND OTHER LABOR INDICATORS

The complex nature of the business of chemistry often demands highly-trained, skilled and educated workers. In plant operations, this has resulted in making technicians out of skilled workers (e.g., machinery operators) and skilled workers out of unskilled workers (e.g., laborers). In other areas, the need for chemists, chemical and industrial engineers, and other technically-trained personnel (from agronomists to toxicologists to zoologists) continues to mount.

In addition to high salaries and wages reflecting occupational knowledge intensity, the business of chemistry also provides excellent benefits to its employees. These include legally-mandated expenditures, as well as voluntary programs, including profit-sharing and other compensation, vacation and other leave, health and life insurance, stock purchase plans, pensions, 401(k) contributions, and others. As a share of salaries and wages, these typically add a third or more to the cost of compensation.

Driven by large investments in knowledge and in capital, the business of chemistry has achieved significant gains in productivity over the years. These productivity gains have allowed companies to restrain boosts in unit labor costs, and in some cases, even reduce them. Most plants in the business of chemistry are continuous in nature, often operating around the clock. As a result, shift-work is the norm, and the typical workweek exceeds 40 hours. The average workweek, when compared against the number of production workers, provides an excellent indicator of industry production activity.

Figure 8.1 - Labor Productivity

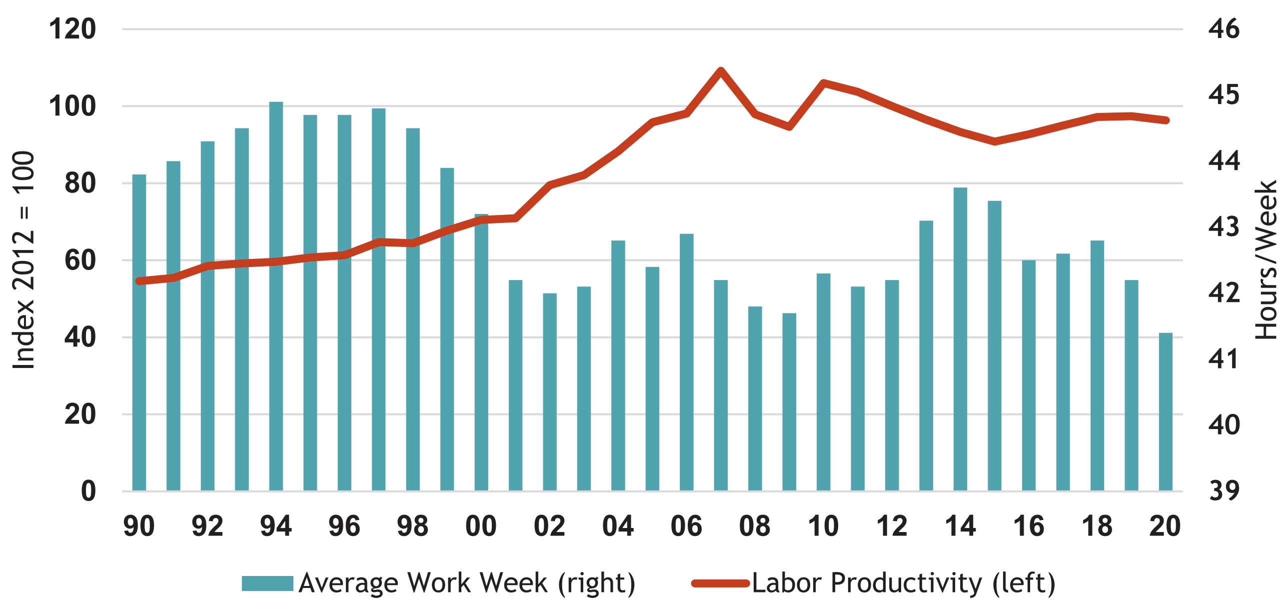
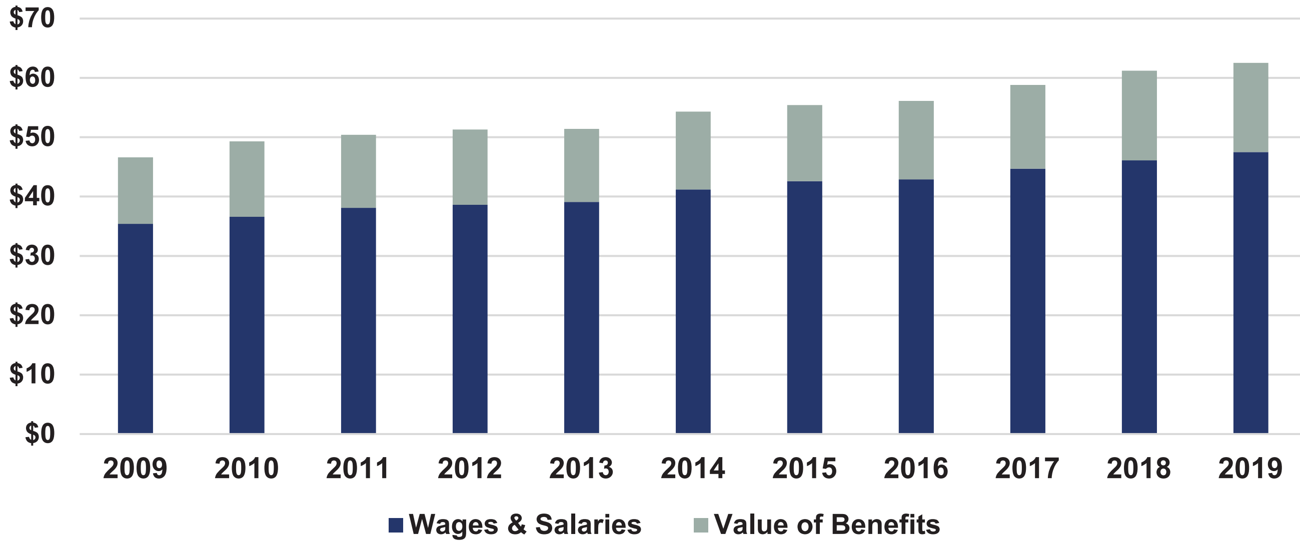


Figure 8.2 - Total Employee Compensation ($billions)



Notes on the Employment Data

The Bureau of Labor Statistics publishes two sets of data on employment by industry. The Current Employment Survey (CES) is the timeliest data available with preliminary national-level estimates available within a week of the end of the month for which data are reported. State-level estimates are usually available within three weeks of the end of the month, however, estimates at the state level are only provided for significant industries within the state. In the case of the chemical industry, the CES data only provides employment data for 21 states. The second data set is the Covered Employment and Wages (CEW) series, which collects data on employment and payroll from state claims for unemployment insurance. These data are the most accurate and detailed for employment and payroll, however, the data are not finalized for the prior year for six to nine months following the end of the calendar year. On a national level, the CES and CEW data on chemical industry employment differ slightly due to their different origins. As a result, ACC presents the CES for national-level employment. At the state level, ACC presents the CEW data, which are lagged by one year due to the fact that the Guide to the Business of Chemistry goes to print before the CEW data are released for the prior year.

Note: the industry employment data collected by the Bureau of Labor Statistics (BLS) undercounts actual employment by the business of chemistry because it does not include company management, and professional and technical services employees. As a result, actual employment is 10-15% higher than reported by the BLS Current Employment Survey (CES) data.

CHAPTER 9

ENVIRONMENT, HEALTH, AND SAFETY

***Chemistry plays an essential role in the products and technologies we use every day*,** from vital ingredients in consumer products to raw materials in manufacturing processes. These chemicals must be produced and used in ways that protect human health and the environment. The chemical industry continues to improve performance, as well as advocate for cost-effective laws and regulations that improve the nation's overall environmental performance and promote the shared national goal of a healthy environment while encouraging innovation and high-skilled, high-paying jobs in the business of chemistry.

ENVIRONMENTAL, HEALTH AND SAFETY SPENDING

Environment

Efforts to preserve the environment are made possible in large part thanks to the innovative products of chemistry. America's chemical makers create products that help protect the environment and are committed to continuous environmental improvement in their own operations. Many environmental improvements are achieved due to the energy efficiency enabled by innovative chemistry products, and less energy used equals fewer energy-related emissions. Products of chemistry are also used directly to clean and protect the environment. For example, air filters for automobiles, homes and commercial buildings use absorbents, catalysts and plastic fibers to clean the air we breathe; landfills are lined with industrial strength plastics to prevent toxic run off into sensitive waterways or drinking water sources; and new chemical compounds protect plants from proliferating pests and disease.

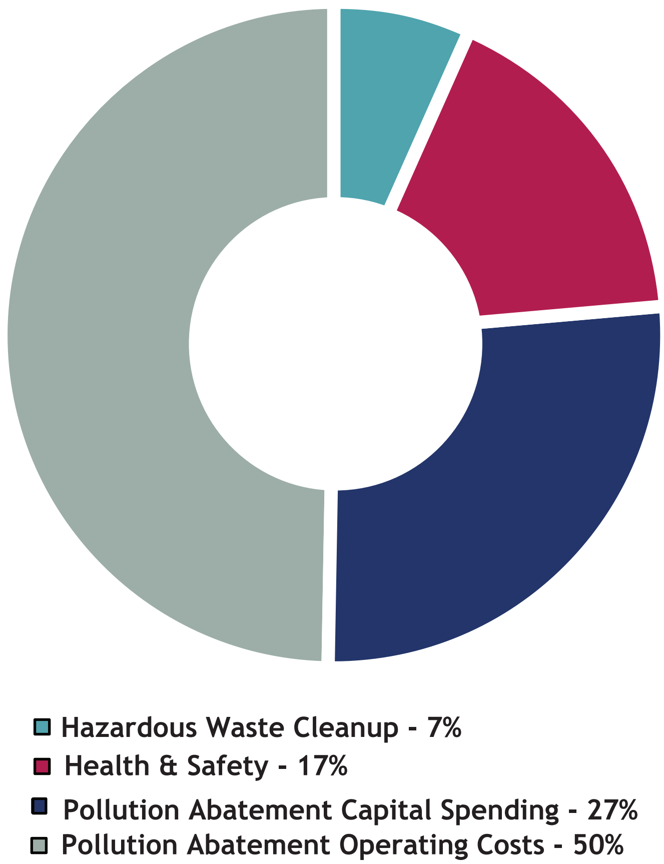
Health

Throughout our lives, chemistry plays a key role in keeping us healthy. Today we're living healthier and longer lives—more than 30 years longer over the past century—thanks in large part to innovations made possible by the business of chemistry. The products of chemistry play a key role in the quality of life for a growing global population, through improved health and nutrition, and better materials for a multiplicity of construction, consumer and industrial applications. Chemistry fosters safe food and water supplies, such as fertilizers that deliver essential nutrients to soil, and chlorine chemistry used to clean and disinfect drinking water around the world. Lifesaving medicines derived from chemistry help us combat disease and live longer.

Safety

From bike helmets to battlefield technologies, the products of chemistry continue to make the world a safer place. At the same time, it is imperative that chemicals are used both safely and responsibly.

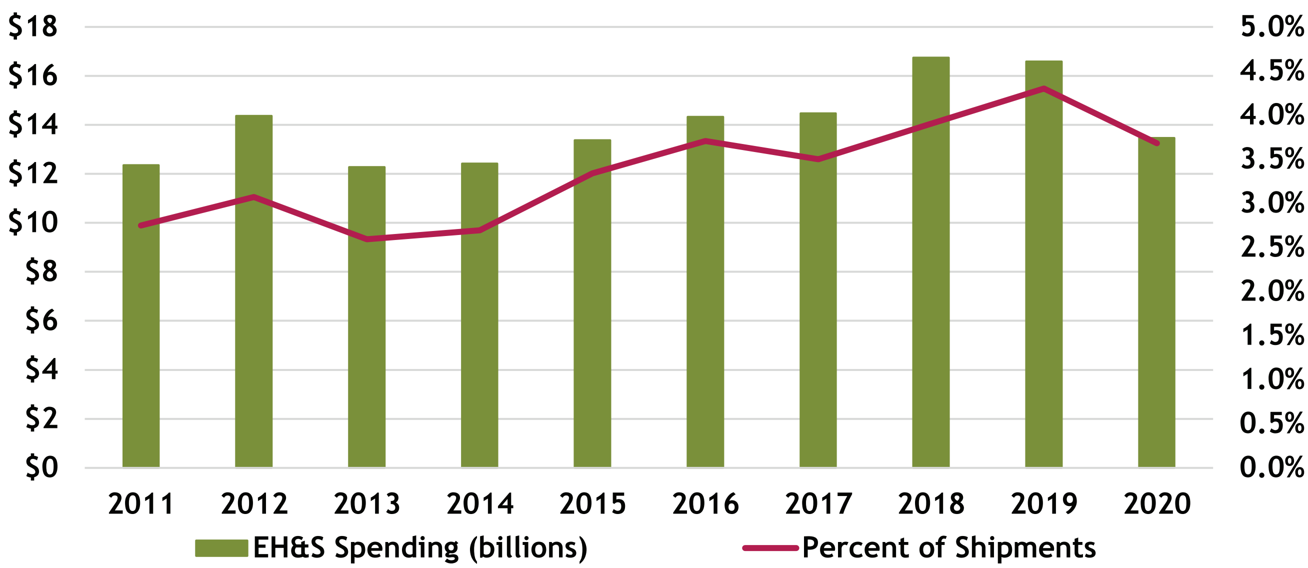
Voluntary health, safety and environmental improvement actions by the chemical industry often go beyond the minimum standards set by government regulations. For example, ACC's Responsible Care® initiative commits members to continuously improve health, safety, security and environmental performance. This commitment is demonstrated by the important contributions made by scientists and engineers in the development of products and technologies that improve health, safety and the environment, as well as the industry's commitment to continuous improvement and health and environmental research.



In recent years, Environmental, Health, and Safety (EH&S) spending as a share of shipments has declined, largely the result of more rapid gains in revenues. In addition, learning curve effects are playing a role. The period since the early 1970s witnessed increasing gross annual operating costs (depreciation, labor, material and supplies, services, etc.) for pollution abatement and control at manufacturing facilities. In addition to end-of-pipe pollution abatement activities, chemistry companies also made significant outlays for Superfund and other hazardous waste site remediation.

During the past several decades, the industry has constructed an extensive program to reduce emissions of the many types of materials that contribute to air, water, and land pollution. The industry's environmental actions have necessitated capital expenditures for pollution abatement and control that have totaled in the tens of billions of dollars since 1970.

Figure 9.2 - EH&S Spending by Basic and Specialty Chemical Producers



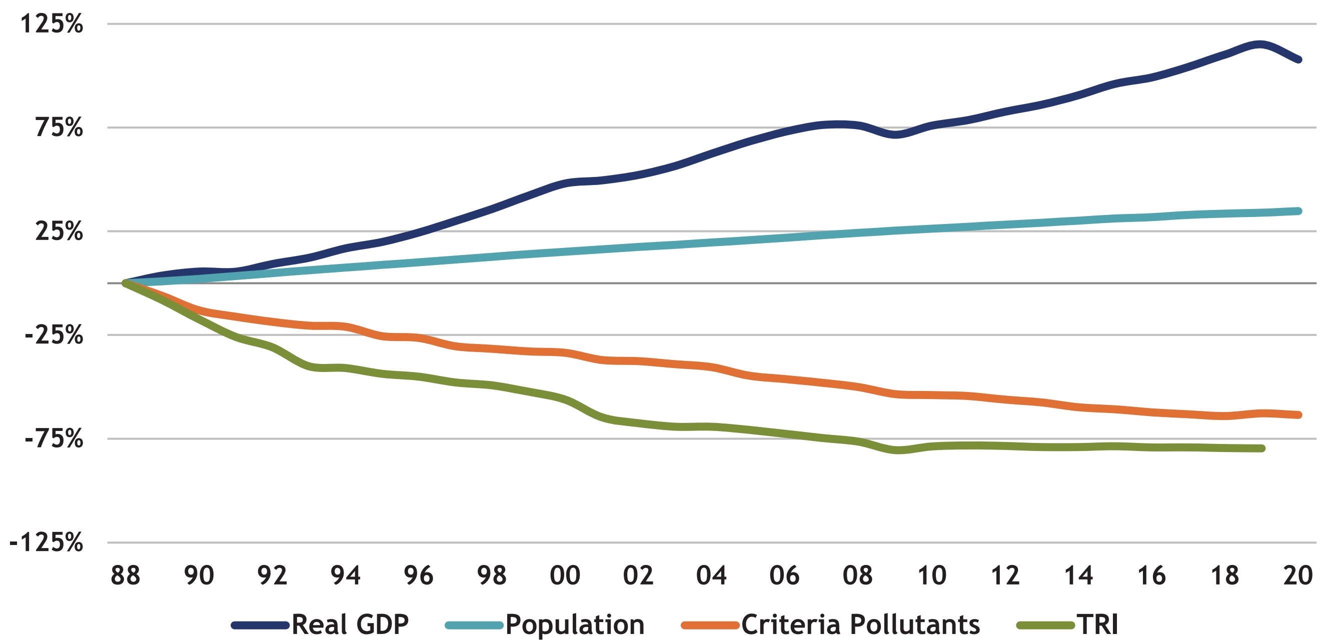
ENVIRONMENTAL PERFORMANCE

Environmental protection has been a national priority for decades. There are numerous government and industry programs that focus on environmental protection and health. One such program is the Toxics Release Inventory (TRI). Established in 1986 by the U.S. (EPA), the TRI tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. U.S. facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy recovery and treatment.

Since the 1980s, total toxic releases and air emissions of principal (or criteria) pollutants have fallen sharply. At the same time, the population and real (inflation-adjusted) gross domestic product (GDP) have grown.

Because transforming raw materials into products used by other industries can generate pollution, basic industries such as chemicals are among those most heavily regulated, particularly as it relates to the environment. The chemical industry is one of the various industry sectors required to report TRI data. Nowhere has the environmental performance of the business of chemistry been so positive than in the reduction of emissions of toxic substances. The long-term downward trend in the releases of core chemicals by the chemical industry is evidence of the industry's dramatic improvement in environmental performance. Additionally, the toxic releases and air emissions of criteria pollutants have declined, even as chemical production has increased.

Figure 9.3 - Environmental Progress and Economic and Population Growth in the U.S.



Source: U.S. Bureau of Economic Analysis (BEA), U.S. Census Bureau, U.S. EPA

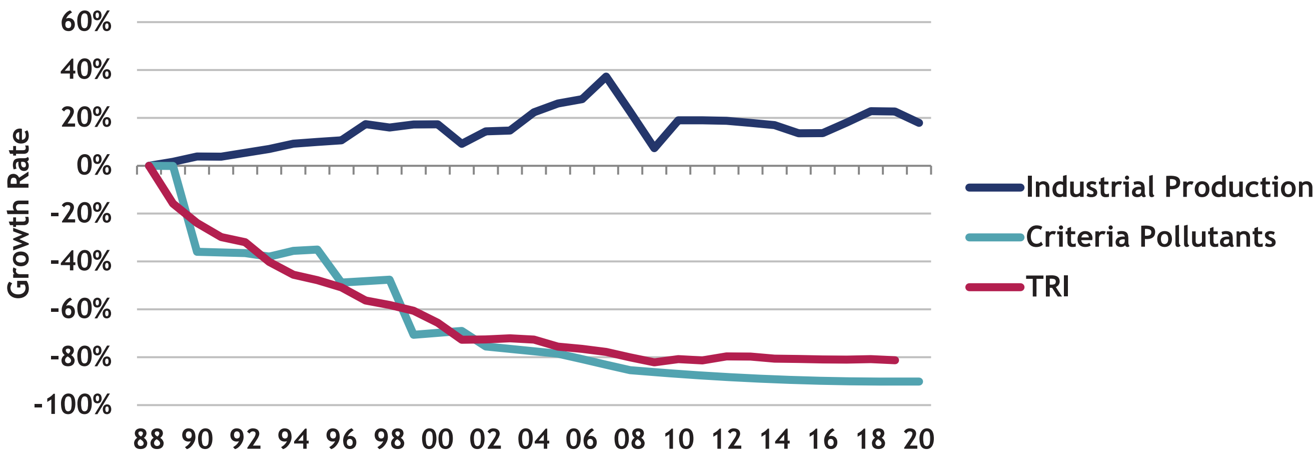
Table 9.1 shows the total emissions, as well as emissions from the chemical industry, to the air of several key pollutants. For all indicators, the business of chemistry makes up a very small percentage of total emissions.

Table 9.1 - Key Pollution Indicators: A Summary of Progress

	1988	1992	1996	2000	2004	2008	2012	2016	2020
				in thousands of short tons					
Sulfur Dioxide									
Total, All Sectors	22,693	22,082	18,385	16,347	14,571	10,324	5,079	3,204	1,962
Business of Chemistry	449	278	255	338	254	185	125	115	111
As a % of Total	2.0%	1.3%	1.4%	2.1%	1.7%	1.8%	2.5%	3.6%	5.7%
Nitrogen Oxides									
Total, All Sectors	26,074	25,261	24,787	22,598	21,331	16,909	13,879	10,304	8,228
Business of Chemistry	274	163	125	105	64	55	50	43	40
As a % of Total	1.1%	0.6%	0.5%	0.5%	0.3%	0.3%	0.4%	0.4%	0.5%
Volatile Organic Compounds									
Total, All Sectors	26,974	23,066	20,871	17,512	19,514	17,759	17,872	15,459	16,613
Business of Chemistry	982	715	388	254	240	88	81	76	75
As a % of Total	3.6%	3.1%	1.9%	1.4%	1.2%	0.5%	0.5%	0.5%	0.5%
Carbon Monoxide									
Total, All Sectors	174,418	140,895	128,858	114,467	97,147	79,655	71,758	58,904	63,271
Business of Chemistry	1,917	1,112	1,053	361	233	183	155	122	118
As a % of Total	1.1%	0.8%	0.8%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
Coarse Particulates (PM_{10})									
Total, All Sectors	42,834	27,098	22,857	23,747	21,749	21,580	19,970	16,830	16,994
Business of Chemistry	62	71	63	55	37	26	21	19	19
As a % of Total	0.1%	0.3%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%
Fine Particulates ($PM_{2.5}$)									
Total, All Sectors	n/a	7,198	6,724	7,288	5,970	6,014	5,940	5,060	5,640
Business of Chemistry	n/a	45	39	46	29	20	16	14	15
As a % of Total	n/a	0.6%	0.6%	0.6%	0.5%	0.3%	0.3%	0.3%	0.3%
Ammonia									
Total, All Sectors	n/a	4,443	4,727	4,907	4,016	4,359	3,823	3,955	4,289
Business of Chemistry	n/a	183	123	26	20	19	23	23	23
As a % of Total	n/a	4.1%	2.6%	0.5%	0.5%	0.4%	0.6%	0.6%	0.5%

Notes. Data shown in four-year increments. Business of chemistry emissions do not include emissions from fuel combustion. Particulates include condensibles.
Source: Environmental Protection Agency.

Figure 9.4 - Environmental Progress and Production in the Business of Chemistry



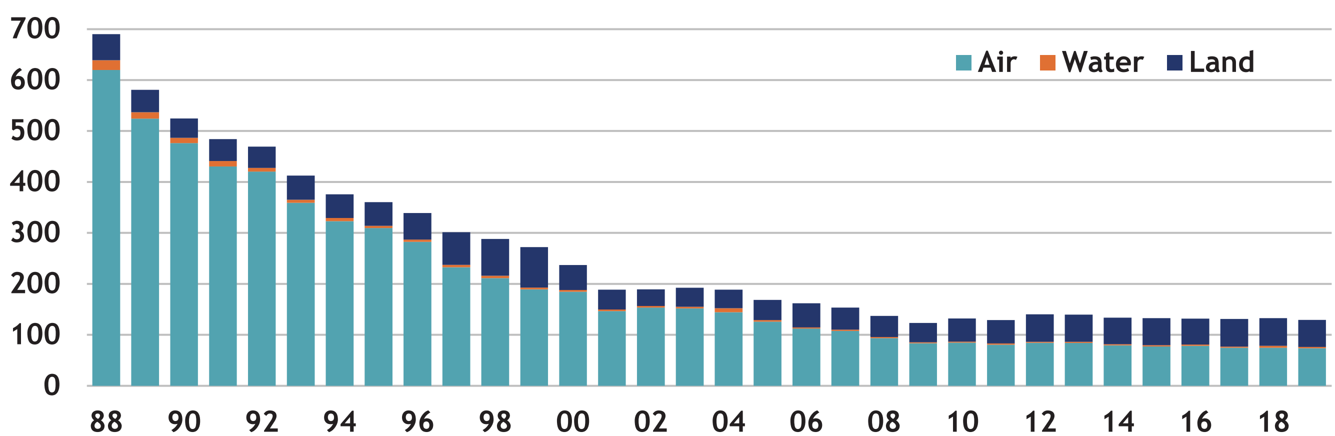
Source: U.S. EPA, ACC

Table 9.2 - Toxics Release Inventory: Business of Chemistry

	1988	1994	1999	2004	2009	2014	2019
				in million of pounds			
Total Releases*	690	376	272	189	123	134	129
Air	620	323	189	144	84	80	74
Surface Water	19	6	4	8	2	2	3
Land	51	47	79	37	38	52	53
Underground Injection	160	112	107	99	75	97	91
Off-site releases**	70	31	47	43	43	64	56

*The American Chemistry Council defines total releases to be the sum of total air, surface water, and land. Underground injections are not included in releases to the environment. Includes 1988 core chemicals only (does not include delisted chemicals; chemicals added in 1990, 1991, 1994, 1995; or aluminum oxide, ammonia, hydrochloric acid, or sulfuric acid).
**Includes metals and metal compounds transferred off-site for solidification/stabilization and for waste water treatment, including to publicly owned treatment works (POTWs).
Note: 2019 is latest available data.
Sources: Environmental Protection Agency – TRI Public Data Releases via TRI Explorer (www.epa.gov/triexplorer).

Figure 9.5 - TRI Releases by Media: Business of Chemistry (millions of pounds)



Source: U.S. EPA

WORKER HEALTH AND SAFETY

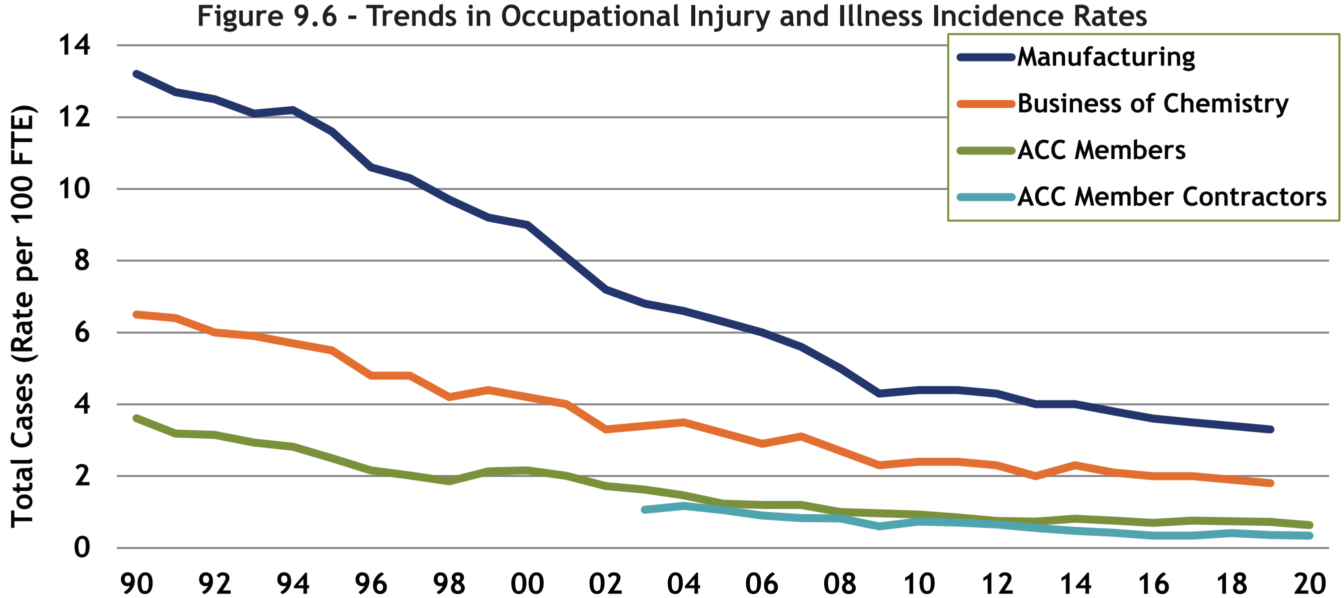
In addition to its environmental protection activities, the business of chemistry has also achieved a remarkable record of worker safety. This record has shown improvement since World War II, largely as a result of elimination of job hazards and the industry's initiatives in implementing effective safety programs. Basic and specialty chemical companies spend billions of dollars per year improving worker health and safety. The results have been nothing short of phenomenal: data from the Bureau of Labor Statistics indicate that the business of chemistry has illness and injury rates of nearly far below that of manufacturing as a whole, and one of the lowest rates across all manufacturing industries. Furthermore, illness and injury rates for American Chemistry Council member companies are nearly one-third that of the business of chemistry as a whole.

Table 9.3 - Occupational Injury and Illness Rates

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Lost workday cases rate per 100 employees										
Manufacturing											
Total OIIR Cases	4.4	4.4	4.3	4.0	4.0	3.8	3.6	3.5	3.4	3.3	n/a
Lost Workday Cases	1.1	1.1	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	n/a
Business of Chemistry											
Total OIIR Cases	2.4	2.4	2.3	2.0	2.3	2.1	2.0	2.0	1.9	1.8	n/a
Lost Workday Cases	0.7	0.7	0.7	0.5	0.7	0.6	0.6	0.6	0.6	0.6	n/a
American Chemistry Council Companies											
Total OIIR Cases	0.93	0.85	0.75	0.73	0.82	0.76	0.70	0.76	0.74	0.72	0.63
Lost Workday Cases	0.22	0.20	0.17	0.17	0.20	0.20	0.17	0.20	0.21	0.22	0.26
American Chemistry Council Company Contractors											
Total OIIR Cases	0.73	0.71	0.65	0.55	0.47	0.42	0.34	0.34	0.41	0.36	0.34
Lost Workday Cases	0.13	0.12	0.13	0.09	0.09	0.08	0.06	0.07	0.10	0.07	0.08

Sources: Bureau of Labor Statistics and American Chemistry Council

Figure 9.6 - Trends in Occupational Injury and Illness Incidence Rates



SPENDING ON SECURITY

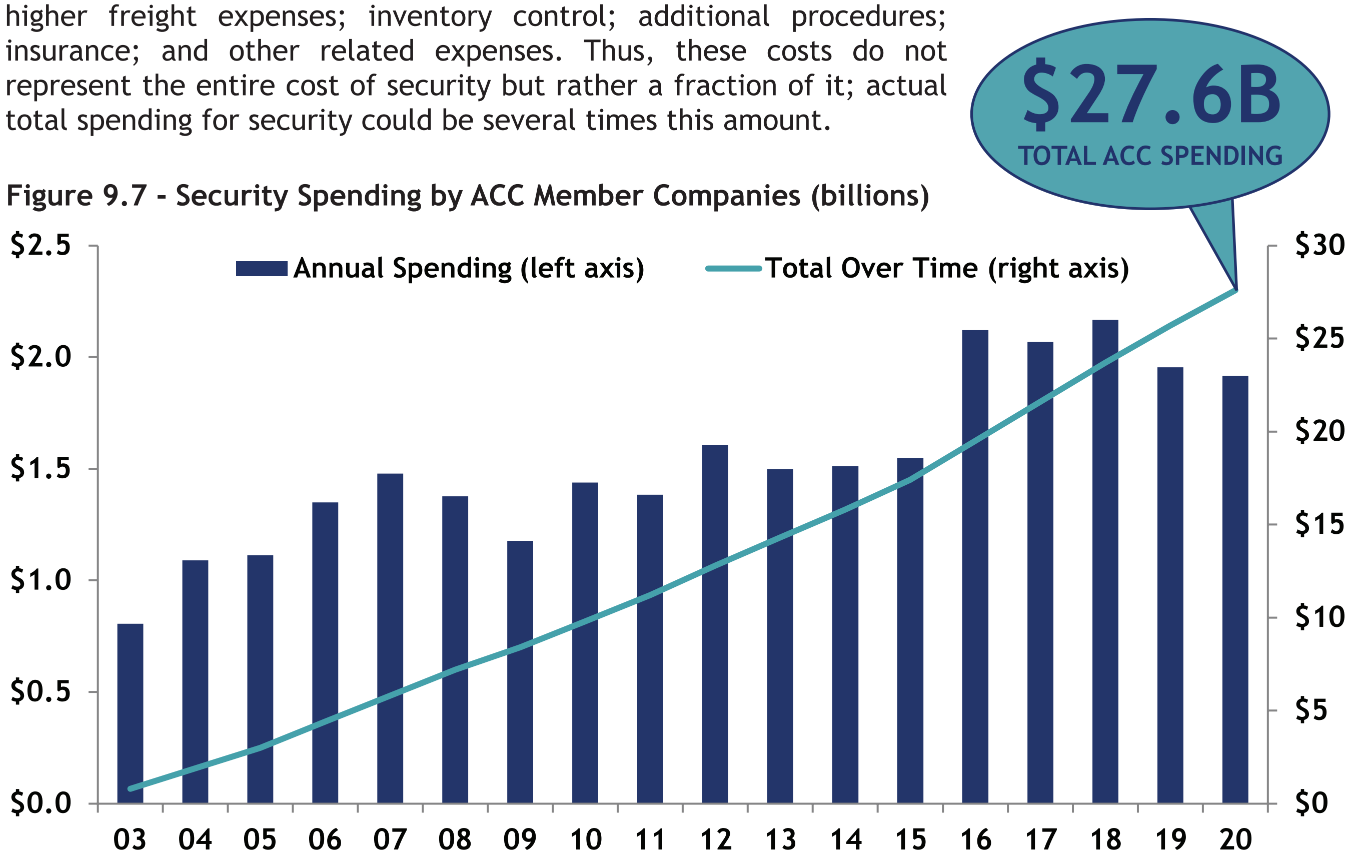
Because of its critical role to the economy, The Department of Homeland Security (DHS) has identified the chemical sector as one of sixteen “critical infrastructure sectors” (defined as “sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof”).

Facility security has long been a focus of the chemical industry, but the events of Sept. 11 led to heightened security concerns. After 9/11, members of the ACC moved aggressively to secure their facilities by adopting the highly regarded Responsible Care® Security Code.* Since then, ACC members have invested billions in transportation secutiry, facility security and cybersecurity.

Business leaders are increasingly investing in the security of their companies’ people and information, as well as process plants, equipment, technology, storage facilities and buildings. Companies must also consider the security of other assets such as tank cars and other vehicles, utilities (electric power, steam, natural gas, water, sewer, etc.), railroad lines and roads, cogeneration facilities, hazardous waste processing facilities, supplies, tools, office equipment, and even employees’ personal property.

The ACC collects data on spending for security via its annual economic survey of member companies. Some companies spend as much as 2% of their sales on security. Security spending includes guard services, electronic surveillance, remote electronic monitoring of security, other security services, and miscellaneous protective services. Security costs also include those traditionally associated with information, computer, network, and related IT security. Costs not contained in this figure include security efforts by non-security personnel (e.g., building services); costs of process safety measures; higher freight expenses; inventory control; additional procedures; insurance; and other related expenses. Thus, these costs do not represent the entire cost of security but rather a fraction of it; actual total spending for security could be several times this amount.

Figure 9.7 - Security Spending by ACC Member Companies (billions)



*For more information, visit americanchemistry.com/security

ACC'S COMMITMENT TO EHS&S

Chemistry is fundamental to understanding the world's most pressing sustainability challenges, and essential to overcoming them. Chemicals must be produced and used in ways that protect the health of people and the environment. Members of the ACC) are committed to meeting this core expectation and are helping other manufacturers and businesses along the value chain to do the same. Learn more about the industry's sustainability commitments and goals at www.ScienceBehindSustainability.org

Responsible Care® is the chemical industry's world-class environmental, health, safety and security performance initiative. For the past 30 years, Responsible Care has helped ACC member companies significantly enhance their performance and improve the health and safety of their employees, the communities in which the operate, and the environment as a whole.

Participation in Responsible Care is a condition of membership for ACC members and Responsible Care Partner companies, all of which have made CEO-level commitments to uphold the program elements. Responsible Care companies are industry leaders, playing a vital part to ensure that the business of chemistry is safe, secure and sustainable. A summary of annual performance is available at responsiblecare.americanchemistry.com

The Long-Range Research Initiative (LRI) of the American Chemistry Council (ACC) promotes innovations in chemical safety assessment. It invests in science essential for understanding the impact of chemicals on human health and the environment. With a focus on biologically-relevant exposures, LRI adopts an integrated approach to exposure and hazard characterization to promote a shift in focus away from development of safety assessments based solely on hazard or exposure data. Through integration and translation of its research outcomes, LRI transforms this information into knowledge that can inform decisions and policies about the safety of chemicals relevant to current environmental and public health challenges. Learn more at lri.americanchemistry.com

TRANSCAER® (Transportation Community Awareness and Emergency Response) is a national outreach effort. Since 1986, the organization has focused on assisting communities to prepare for and respond to a possible hazardous material transportation incident. The TRANSCAER program is led by industry professionals who volunteer their time to support our mission. Learn more at www.transcaer.com.

In 1971, responding to the growing need for timely information during chemical and hazardous materials incidents, the chemical industry created **CHEMTREC®,** a public service hotline for emergency responders. Today, CHEMTREC is the world's premier call center for hazmat emergency response coordination. CHEMTREC provides registered shippers of hazardous materials with 24/7 emergency support from our state-of-the-art call center. More than just a call center, CHEMTREC is an emergency response information provider that supports organizations throughout the process of chemical transportation. Learn more about CHEMTREC's products and services at www.chemtrec.com.

CHAPTER 10

ENERGY

The business of chemistry transforms natural raw materials from earth, water, and air into valuable products that enable safer and healthier lifestyles. Chemistry unlocks nature's potential, improving the quality of life for a growing and prospering world population by creating materials used in a multitude of consumer, industrial, and construction applications. The transformation of simple compounds into valuable and useful materials requires large amounts of energy.

The business of chemistry is energy-intensive; in fact, it is the second largest user of energy (fuel and nonfuel) in manufacturing sectors (petroleum and coal products is the largest). Within the chemical industry, this is especially the case for basic chemicals, as well as certain specialty chemical segments (e.g., industrial gases). The largest user of energy is the petrochemical and downstream derivatives business. Inorganic chemicals and agricultural chemicals are also energy-intensive.

Unique among manufacturers, the business of chemistry relies upon energy inputs, not only as fuel and power for its operations, but also as raw materials, or "feedstocks," in the manufacture of many of its products. *The term "energy" as used in this publication includes consumption for both feedstocks and as fuel and power for production processes.*

FUEL AND POWER

The business of chemistry operates by creating complex chemical reactions. Many of these reactions require large amounts of heat, pressure and/or electricity. The industry consumes energy to produce electricity and/or steam onsite and purchases electricity and some steam from electric utilities or other suppliers. The accompanying table provides details on energy consumed for fuel and power uses by the business of chemistry. This illustrates the predominant role of natural gas in meeting the industry's fuel and power needs, over half of which is provided by natural gas.

FEEDSTOCKS

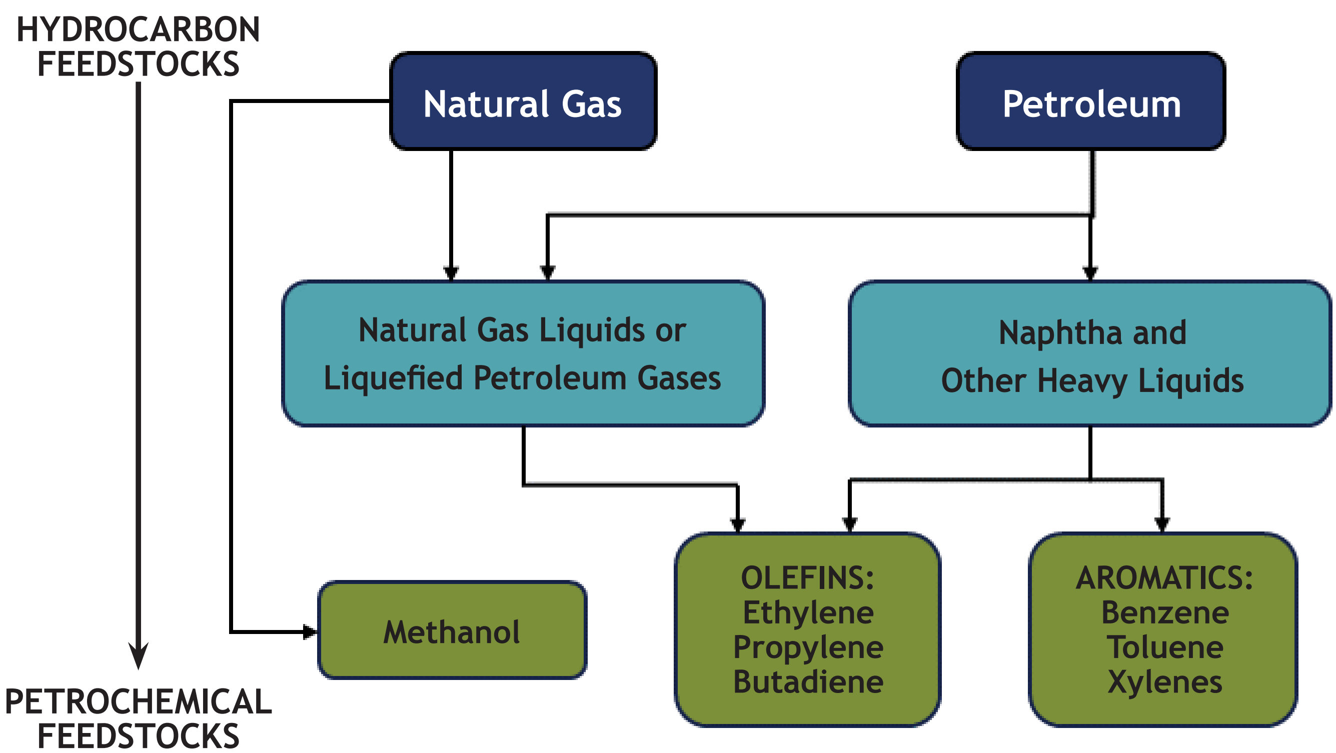
In addition to air, water, and metallic and nonmetallic minerals, the business of chemistry uses large quantities of energy such as natural gas, natural gas liquids, and naphtha as raw materials or feedstocks. (A small amount of coal is also used.) Petroleum and natural gas contain vast quantities of hydrocarbon molecules that are split apart during processing and are then recombined into useful chemistry products.

The feedstock data show that natural gas liquids (NGLs), such as ethane, play a large role in meeting the industry's feedstock needs. Combined with natural gas directly used as a feedstock, it accounts for more than half of the total. Heavy liquids, such as naphtha, also play a major role. Although coal and biomass can be used as hydrocarbon feedstocks, petroleum and natural gas account for 99% of feedstocks for the business of chemistry. Natural gas liquids are predominant, and are followed by naphtha and other heavy liquids. Besides methanol, natural gas is directly used as a feedstock for ammonia and carbon black. Once the dominant source of petrochemical feedstocks, the use of coal has dropped dramatically in the U.S. over the past century. Feedstock use is concentrated in bulk petrochemicals and in fertilizers.

There are several methods of separating or "cracking" these chains found in fossil fuels. Natural gas is processed to produce methane and natural gas liquids (NGLs). Natural gas liquids—also called liquefied petroleum gases—include ethane, propane, and butane and can be produced via natural gas processing or through the petroleum refining process. Petroleum is refined to produce a variety of petroleum products, including naphtha and natural gas liquids. Naphtha and NGLs are processed in large vessels called crackers, which are heated and pressurized to crack the hydrocarbon chains into smaller ones. These smaller hydrocarbons are the gaseous petrochemical feedstocks used to make the products of chemistry: olefins (ethylene, propylene, and butylene) and aromatics (benzene, toluene and xylenes). The seventh petrochemical feedstock, methane, is directly converted from the methane in natural gas and does not undergo the cracking process.

These petrochemical feedstocks are the foundation of chemistry of plastics, pharmaceuticals, electronic materials, fertilizers, and thousands of other products that improve the lives of a growing and prospering population. The product chains for these petrochemical feedstocks can be found in the appendices.

Figure 10.1 - Derivation of Petrochemical Feedstocks

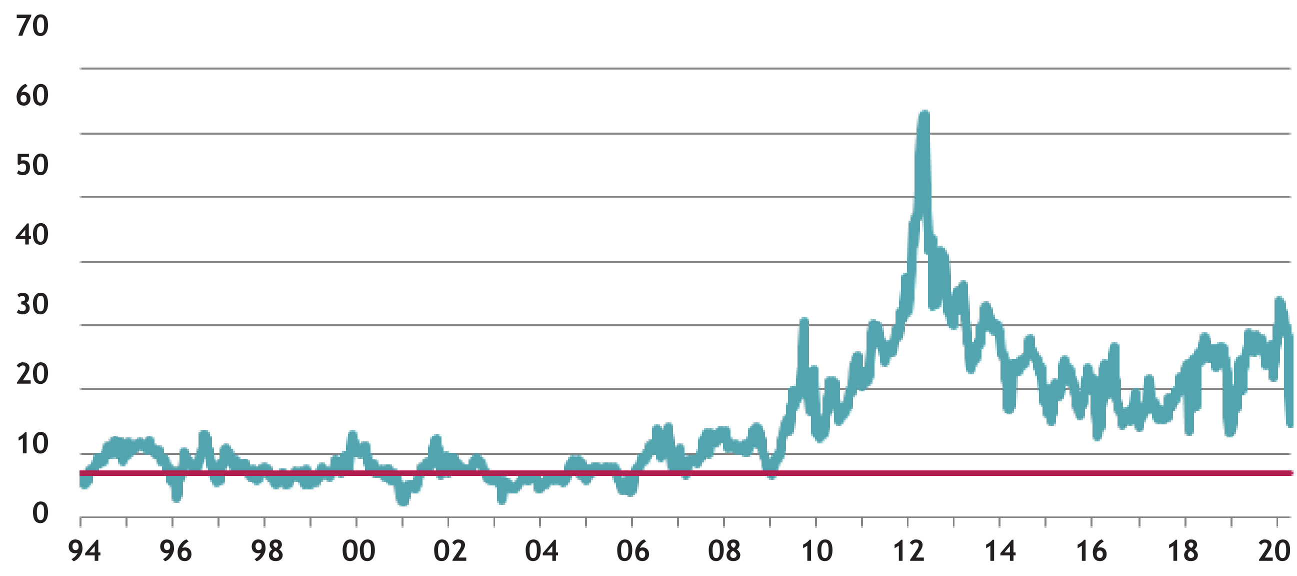


NATURAL GAS & PETROLEUM PRODUCTS

The business of chemistry is a large user of natural gas and petroleum products, The business of chemistry accounts for nearly 9% of all U.S. petroleum products consumption, including distillate and residual fuel oil for fuel and power use, natural gas liquids (or liquefied petroleum gases), such as ethane and propane, and heavy liquids (i.e., naphtha and gas oil) consumed as feedstocks. The business of chemistry is also the largest single industrial user of natural gas. Most natural gas is consumed as fuel: the majority of steam boilers and cogeneration units (units that produce both steam and electricity) are powered by natural gas. The remaining natural gas consumption is directly used as feedstocks to manufacture ammonia, carbon black, and methanol.

Due to the relative abundance of natural gas in the United States, natural gas and natural gas liquids derived from natural gas are vital to the domestic business of chemistry. Around 90% of U.S. olefins production (specifically ethylene) is based on natural gas liquids, while 70% of European and Asian petrochemical production is based on naphtha, a petroleum-based feedstock. Because petroleum is traded on the world market, all countries are subject to the same price. Natural gas markets, however, are regional; in other words, the price in North America affects only North American producers. For this reason, U.S. petrochemicals enjoy a competitive advantage when natural gas prices are low relative to oil prices. In the early 2000s, natural gas prices quadrupled, resulting in the idling or permanent shut down of about 50% of U.S. methanol capacity, 40% of ammonia capacity, and 15% of ethylene capacity, all which depend on natural gas or natural gas derivatives as feedstocks. By 2010, with the advent of abundant supplies of shale gas, the situation had reversed. Closed plants have been restarted, new plants are under construction, and substantial new investments have been announced.

Figure 10.2 - U.S. Based Petrochemical Competitiveness: Ratio of the Price of Oil (Brent) to Natural Gas (Henry Hub)



Source: Energy Information Administration and American Chemistry Council analysis.
A general rule of thumb concerning the competitiveness of U.S. petrochemical production vis-à-vis Western Europe (a primary competitor and largest exporting region) is that when the ratio between the price of oil (as measured in U.S. dollars per barrel, Brent) divided by the price of natural gas (as measured in U.S. dollars per million BTUs, Henry Hub) is above 7.0, U.S.-based petrochemicals production is generally competitive. When it is lower than 6.0, Gulf Coast petrochemicals are relatively disadvantaged. During the 1994-1999 period, the ratio averaged 8.5. As this figure shows, the ratio has been above 7.0 for since late 2009.

ENERGY CONSUMPTION

Petroleum and natural gas are important for both fuel and power in feedstock uses of energy. The following table provides a snapshot of historical perspective on energy consumption by the business of chemistry. The year 1974 represents the year of the first oil price shock, and provides a logical base-year for comparison. Similarly, 1990 represents a base-year widely used in evaluating greenhouse gas (GHG) emission trends.

Table 10.1 - Energy Consumption by the Business of Chemistry

	1974	1990	2000	2010	2016	2017	2018	2019	2020
					in trillions of BTUs				
Natural Gas	1,612	1,641	1,804	1,729	2,101	2,197	2,277	2,267	2,090
Coal and Coke	311	272	303	188	110	106	105	98	98
Fuel Oil (Petroleum)	285	77	59	17	16	16	15	14	11
Purchased Electricity	437	461	522	471	457	464	467	471	446
Other	377	650	973	767	813	824	830	832	793
Total Fuel & Power	**3,022**	**3,101**	**3,661**	**3,172**	**3,497**	**3,607**	**3,694**	**3,682**	**3,438**
NGLs/LPGs*	1,483	924	1,291	1,334	1,565	1,724	2,025	2,089	2,236
Heavy Liquids	942	1,029	1,167	943	642	699	671	630	572
Natural Gas	430	744	709	430	586	651	675	708	712
Coal	19	21	33	19	17	17	17	17	16
Total Feedstock	**2,165**	**2,718**	**3,200**	**2,726**	**2,810**	**3,091**	**3,388**	**3,444**	**3,536**

Sources: American Chemistry Council, Federal Reserve Board, Bureau of the Census, EIA
*Natural gas liquids (NGLs) and liquefied petroleum gases (LPGs) include ethane, propane, and butanes.

Figure 10.3 - Composition of Energy Requirements, 2020

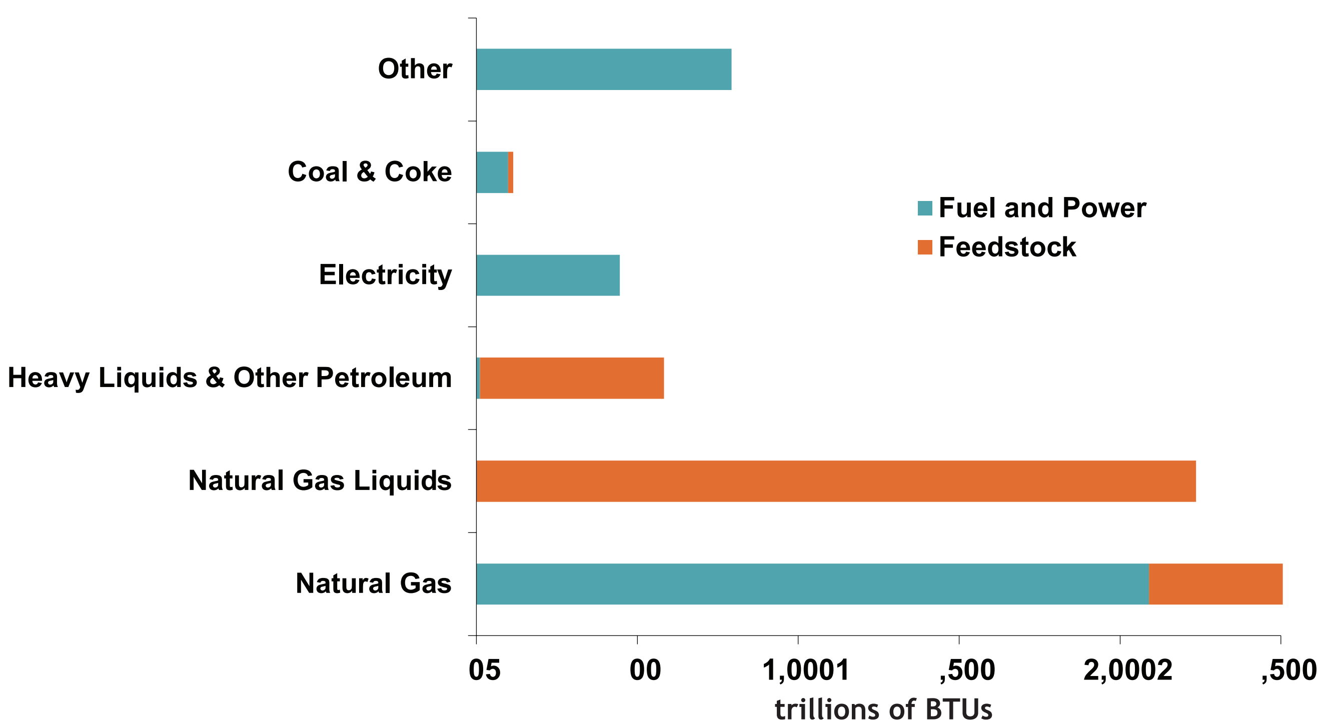
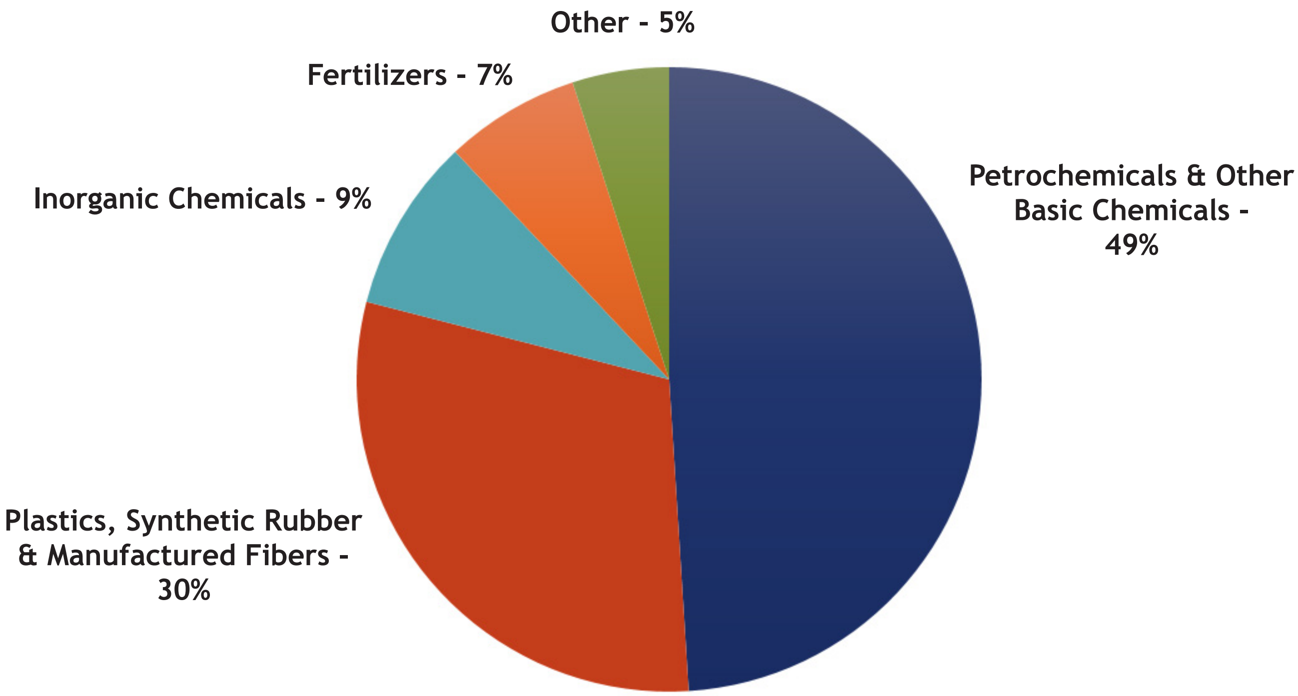
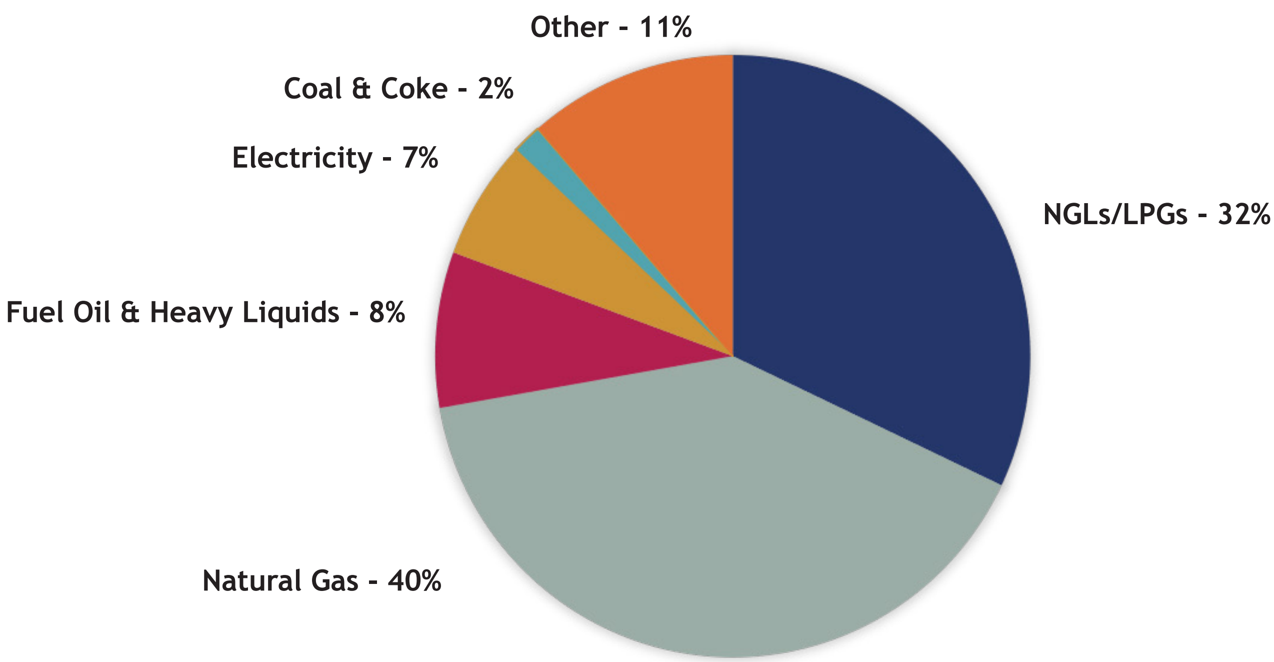


Figure 10.4 - Share of Total Energy Consumption by Segment



Source: U.S. Energy Information Administration,
Manufacturing Energy Consumption Survey (MECS)

Figure 10.5 - Share of Total Energy Consumption by Source, 2020

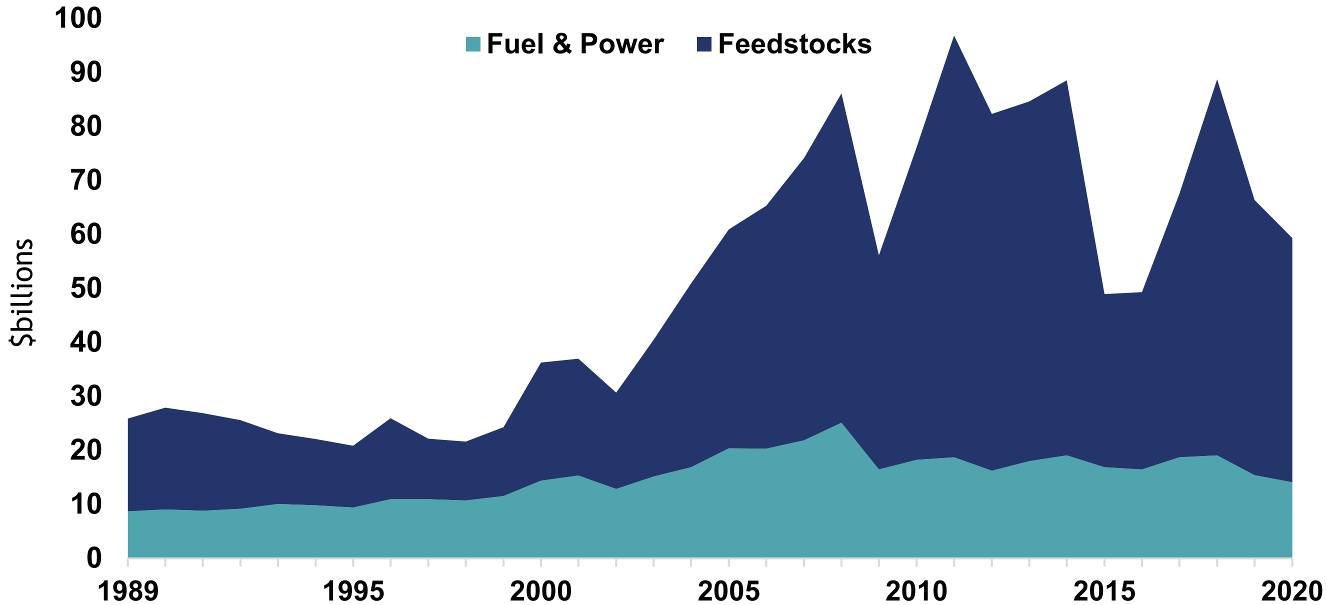


Sources: American Chemistry Council, Federal
Reserve Board, Bureau of the Census, EIA

ENERGY COSTS

Energy represents a significant share of manufacturing costs for the U.S. business of chemistry. For some energy-intensive products, energy for both fuel and power needs and feedstocks account for up to 85% of total production costs. Because energy is a vital component of the industry's cost structure, higher energy prices can have a substantial impact on the business of chemistry. Overall energy costs represent around 10% of the value of industry shipments. Moreover, value added by the business of chemistry is equivalent to five times this energy cost, which is just one of many inputs, including other raw materials and services that the business of chemistry purchases from other industries.

Figure 10.6 - Value of Energy Consumed by the Business of Chemistry



Sources: American Chemistry Council, Federal Reserve Board, Bureau of the Census, EIA

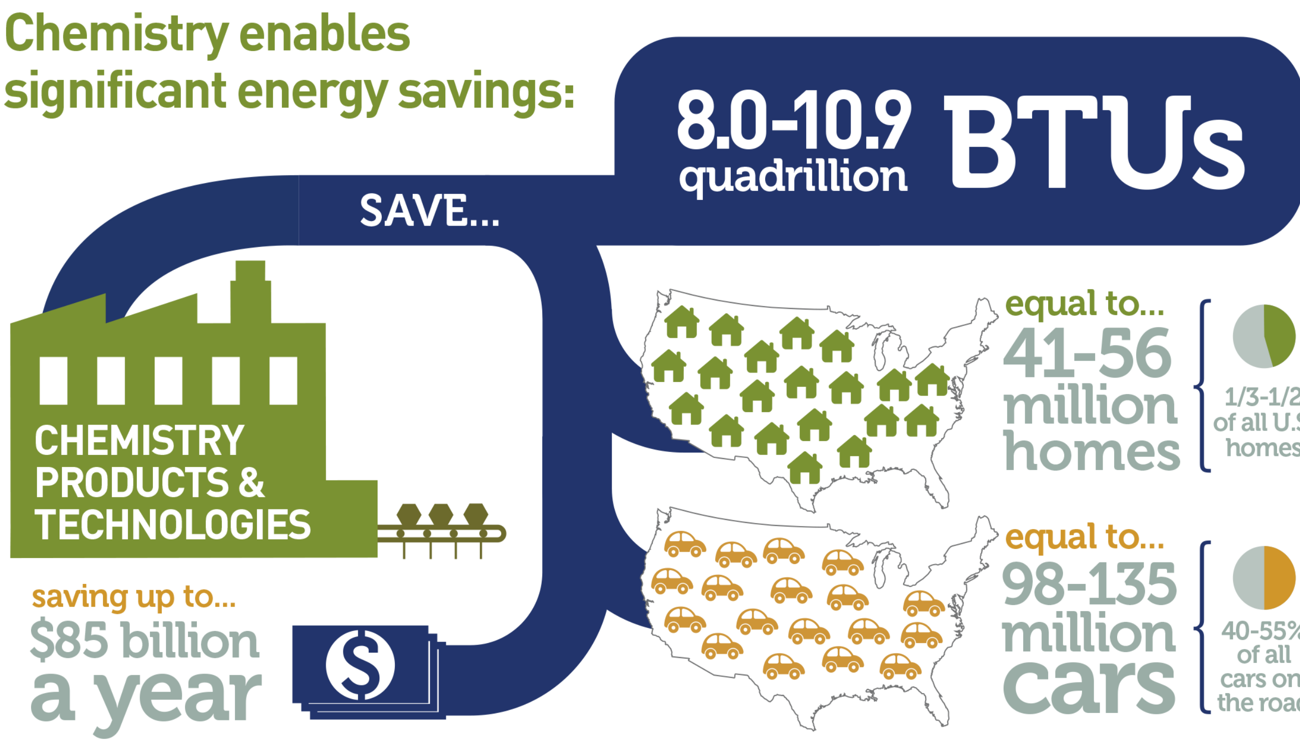
CHEMICAL INDUSTRY ENERGY EFFICIENCY

The business of chemistry in the United States has achieved significant energy efficiency gains. Since the oil crises of the 1970s, the business of chemistry began a series of energy efficiency improvements that continue today: the fuel and power energy consumed per unit of output is half that of 1974. Improvements in energy efficiency are essential for the business of chemistry to maintain its competitive edge in domestic and world markets. Since energy costs remain a major cost to the industry, providing a clear incentive for energy efficiency efforts.

One way that the business of chemistry is improving its energy efficiency is through the use of combined heat and power (CHP), also known as cogeneration. CHP is the simultaneous generation of electricity and heat from a facility that is located very close to the manufacturing facility. Because most CHP facilities use natural gas and create two forms of energy (electric power and steam) with the same amount of fuel, they are often twice as efficient as older coal-burning electric utilities. These efficiencies are boosted by the fact that the power generation is physically located close to the power consumption, thus avoiding transmission losses associated with consumption of power generated many miles away by large electric utilities. CHP by the business of chemistry accounts for nearly a third of all CHP used in manufacturing. Future federal legislation on electricity restructuring has the potential to impact the business of chemistry's cogeneration.

ENERGY EFFICIENCY FROM THE PRODUCTS OF CHEMISTRY

There are many products of the business of chemistry that help other industries and households save energy and ultimately reduce greenhouse gas emissions (foam insulation, catalysts, etc.). ACC's Economics and Statistics department estimates that the use of chemistry products in various energy-saving applications saves between 8.0 and 10.9 quadrillion British thermal units (BTUs) of energy annually. This represents 8% to 11% of total U.S. energy consumption. To put these energy savings into perspective, the annual savings of 8.0 to 10.9 quadrillion BTUs would be the equivalent amount of energy used to heat, cool, light, and power 41 to 56 million households (about one-third to one-half of all U.S. households). Alternatively, the energy savings is enough to power 98 to 135 million vehicles for a year (between 40-55% of the cars on the road today). Looking at it another way, the energy savings from chemistry products is equivalent to the amount of energy generated by 177,000 to 243,000 windmills operating under typical conditions.



GREENHOUSE GAS EMISSIONS

Radiation from the sun penetrates through the earth's atmosphere and warms its surface. Certain gases in the atmosphere, however, will trap (absorb) some of the outgoing infrared (long-wave) radiation; this radiation is then reradiated back toward Earth. This is similar to the way a greenhouse prevents heat from escaping through its glass panels. As a result, this phenomenon is called the "greenhouse effect." As concentrations of greenhouse gases (GHG) rise, the average temperature of the lower atmosphere will gradually increase. Many greenhouse gases occur naturally, including water vapor, carbon dioxide, methane, nitrous oxide, and ozone; other greenhouse gases are generated in some industrial processes, including hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF6).

There are certain human activities that add to the levels of most of these naturally-occurring gases:

- Carbon dioxide (CO_2) released into the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood or wood products are burned.
- Nitrous oxide (NO_2) emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.
- Methane (CH_4) emitted during production and transport of fossil fuels (coal, natural gas, and oil), from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.

Carbon dioxide emissions represent the majority of GHG emissions from the business of chemistry. Nitrous oxide, methane and some other gases account for the balance. Carbon emissions of the business of chemistry, including the indirect carbon value of purchased electricity, account for less than 5% of total U.S. emissions.

Per unit of output, U.S. chemical industry GHG emissions have declined significantly since 1990 due to a range of enhancements and improvements, including [one-time] process changes reducing nitrous oxide emissions; more effective catalysis; upgrades in industrial and process technologies; fuel switching (e.g., natural gas instead of coal); and education and training for employees.

There are two categories of GHG emissions: direct and indirect (or embedded). Direct emissions are emissions from sources that are owned or controlled by the company, such as on-site combustion and process emissions. Indirect (or embedded) emissions also include carbon dioxide emissions from purchased electricity. As such, there are two means of measuring CO_2 emissions: one means is to include indirect (or embedded) emissions, which presents somewhat of a life cycle approach and the other means is to exclude indirect emissions, as these emissions are generated by another sector of the economy. In order to more accurately represent the progress that the U.S. chemical industry has made in reducing its GHG emissions, we report two sets of emissions data: one including indirect emissions, and one excluding indirect emissions.

Figure 10.7 - Business of Chemistry Greenhouse Gas Emissions

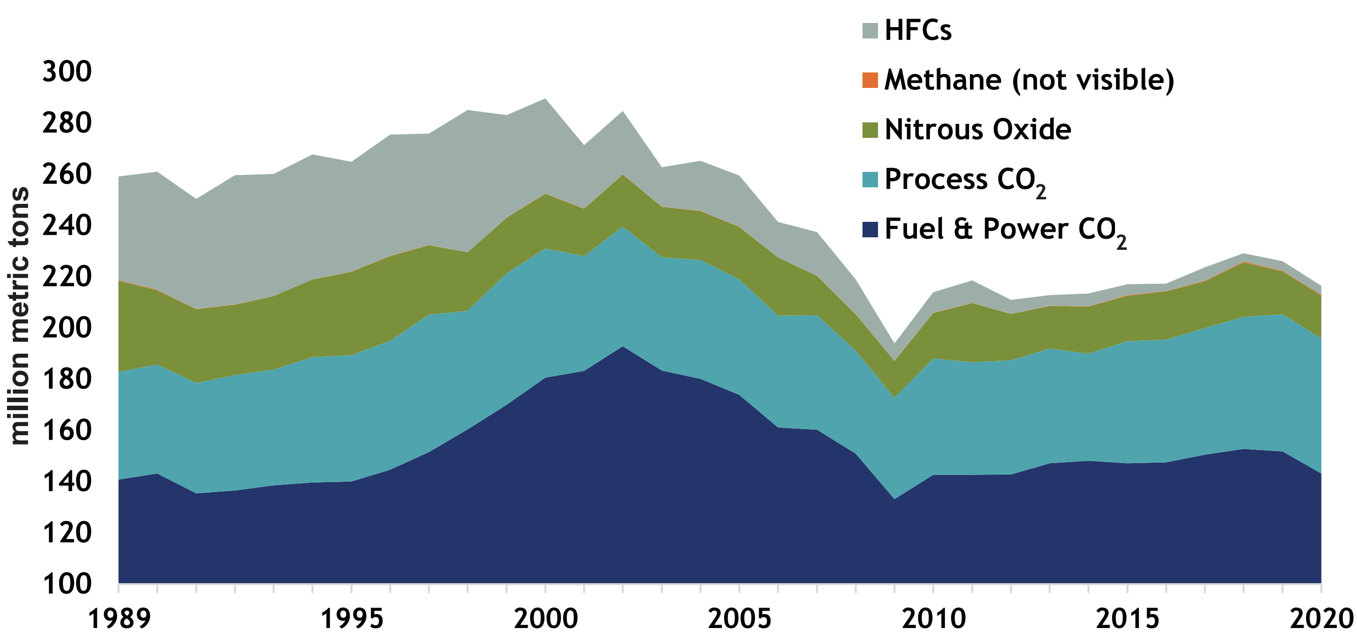


Table 10.2 - Business of Chemistry Greenhouse Gas Emissions

	1989	1995	2000	2005	2010	2016	2017	2018	2019	2020
	(in million metric tons of carbon dioxide equivalent)									
Scope 1 (Direct Emissions)*										
Fuel and Power CO_2	140.9	140.1	180.7	174.0	142.7	147.6	150.6	152.9	151.9	143.2
Process CO_2	42.0	49.3	50.5	45.0	45.5	48.0	49.5	51.5	53.5	52.8
Subtotal CO_2	*182.9*	*189.4*	*231.2*	*219.0*	*188.2*	*195.6*	*200.1*	*204.4*	*205.4*	*196.0*
Nitrous Oxide	35.7	32.6	21.3	20.5	17.7	18.8	18.2	21.3	16.7	16.7
Methane	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3
HFCs	40.5	42.9	37.1	20.0	8.0	2.8	5.2	3.3	3.7	3.5
Total Scope 1	**259.3**	**265.0**	**289.7**	**259.6**	**214.0**	**217.4**	**223.8**	**229.3**	**226.1**	**216.5**
Scope 2 (Indirect Emissions from Purchased Electricity)**										
CO_2 Emissions Embedded in Purchased Electricity	86.9	92.4	103.3	93.7	83.5	67.1	68.7	66.5	67.3	65.9
Total GHG Emissions (Scope 1 & 2)	**346.2**	**357.4**	**393.0**	**353.3**	**297.5**	**284.5**	**292.5**	**295.8**	**293.4**	**282.4**
	(Index where 1990 = 100)									
Performance Trend Indices										
Chemical Industry Output Index	97.7	106.8	121.5	138.0	127.9	119.6	122.0	126.8	127.0	123.0
Energy Efficiency Index	98.4	99.3	97.2	77.2	80.0	94.3	95.4	94.0	93.5	90.2
GHG Emissions Index - Scope 1 & 2	96.1	106.4	106.0	89.3	80.6	74.8	73.9	75.0	83.3	80.2
GHG Intensity Index - Scope 1 & 2	98.3	99.6	87.2	64.7	63.0	62.5	60.6	59.2	65.6	65.2
GHG Emissions Index - Scope 1 only	96.1	108.1	103.2	84.4	76.3	77.8	80.1	80.9	86.6	82.9
GHG Intensity Index - Scope 1 only	98.3	101.2	84.9	61.2	59.7	65.1	65.7	63.8	68.2	67.4

Notes. Process CO_2 has been revised to include emissions from phosphoric acid and other processes as well as non-fertilizer consumption of urea (e.g., urea-formaldehyde resin production). Revisions to historical data include nitric acid N_2O emissions. In 2013, EPA made revisions to its methodology to calculate process CO_2 emissions that resulted in significant upward revisions. The industrial production index (the denominator) was revised as well.
Sources: EPA, American Chemistry Council (Note: fuel and power CO_2 revised data on embedded CO_2 in purchased electricity)

Reportable GHG Scope 1 and Scope 2 Emissions

*Scope 1 Emissions: GHG emissions from sources owned or operated by the reporting company (e.g., stationary combustion, process emissions, and fugitive emissions). Scope 1 emissions includes transportation emissions from vehicles owned or operated by the reporting company.

**Scope 2 Emissions: GHG emissions from the source(s) of energy purchased by the reporting company (e.g., electricity, steam, heat). The source(s) of energy under this category are not owned or operated by the reporting company.

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CHAPTER 11

DISTRIBUTION

Although much of the U.S. chemical production is concentrated in about a dozen states, the business of chemistry has customers located throughout the United States and around the world. Thus, a large volume of chemistry products is moved within the U.S. and to foreign destinations every year, playing an important role in the transportation services industry. Chemicals are transported over the road, by rail, by water and by air, generating revenues for trucking companies, railroads, barge operators and other logistics suppliers. More than half of the tonnage of chemical products is transported less than 250 miles from the manufacturing site. This is typical of shipments of bulk, lower value-added commodity chemicals such as fertilizers and industrial inorganic chemicals. On the other hand, high value-added products such as specialty chemicals are often shipped much longer distances.

Because each individual chemical has its own unique physical properties, the transport of chemicals can present unique challenges. Some chemicals, such as chlorine, are gases at normal temperatures and must be liquefied under pressure for transportation. Others, such as hydrochloric acid, are corrosive and require special materials in construction of the shipping containers. Chemicals that require special handling tend to be shipped shorter distances, generally in large containers and high volume. Overall, the cost of transportation accounts for about 7-11% of the business of chemistry's value of shipments.

TRANSPORTATION BY MODE

Truck — Over-the-road transportation is typically lower cost than other modes, and offers more flexibility (e.g., is not reliant on set schedules, like trains or airplanes). Companies in the business of chemistry either own their own fleet of trucks, or use for-hire carriers. Shipments through third parties are either Less Than Truckload (LTL), which means that the chemical product is shipped with other products, possibly from multiple manufacturers; or Full Truckload (FT, or FTL), which means the entire truckload is one manufacturer's products, often with a single point of origin. In the business of chemistry, trucking is most widely used for small-volume packaged chemical products; it is also the most common mode of transport for industrial gases and consumer products and has increasingly been used for bulk shipments of intermediate chemicals.

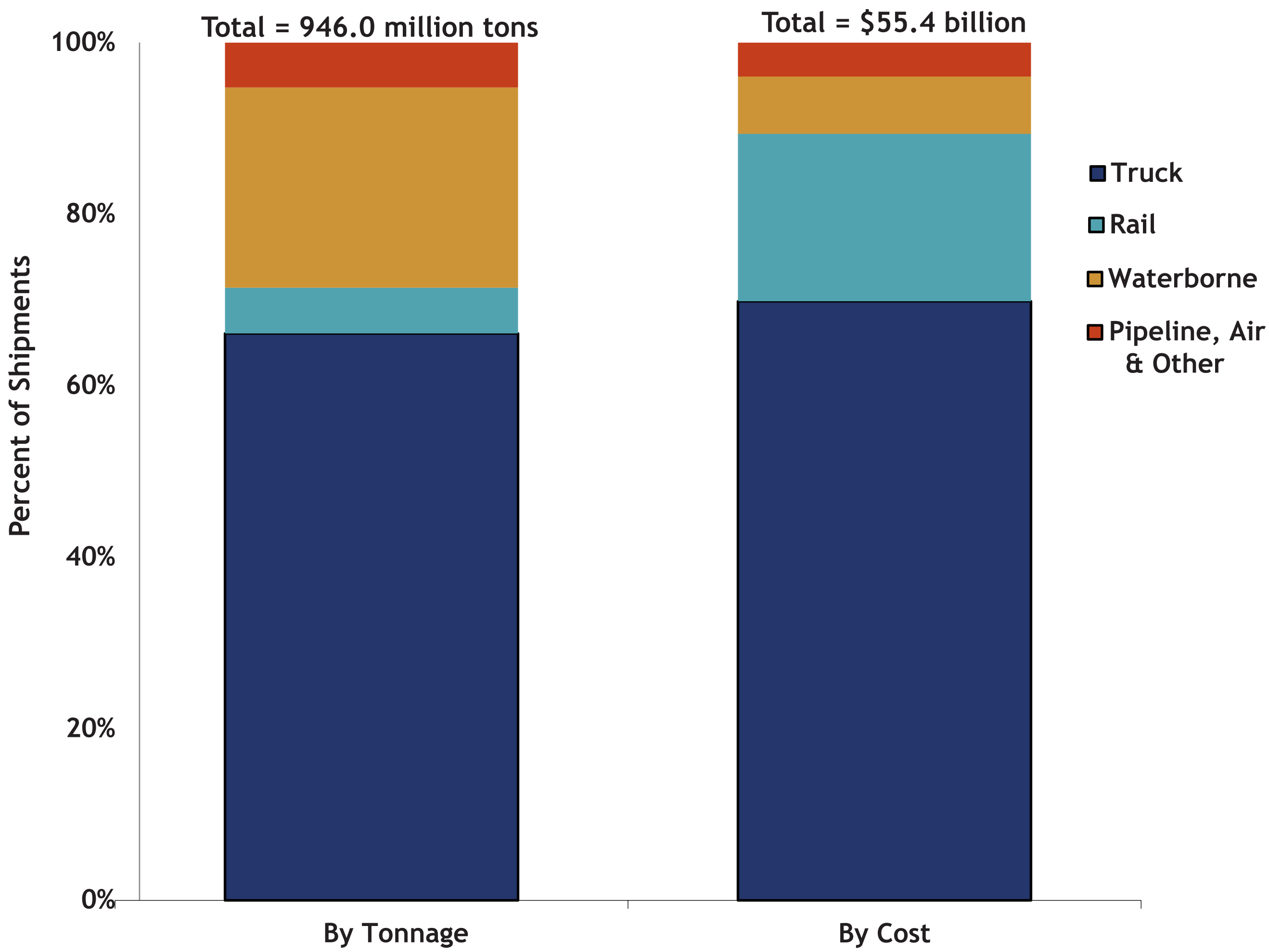
Rail — According to the U.S. Department of Transportation Federal Railroad Administration, rail transportation is "recognized to be the safest method of moving large quantities of chemicals over long distances." Chemicals are generally shipped in tank cars (liquids and liquefied gases), hopper cars (dry commodities), and some boxcars (dry bulk or packaged chemical products). According to data from the American Associations of Railroads (AAR), 174 million tons of chemicals were transported via rail (18%

of total) in 2020. The business of chemistry is also one of the top sources of revenue for the railroad industry, accounting for $11.2 billion in 2019. Ethanol is the highest-volume chemical transported by rail, followed by industrial chemicals, plastic resins, and agricultural chemicals.

Waterborne — Waterborne transport is often the least expensive method of transporting chemicals. Depending upon the product and the distance, the savings can be significant, but can only be realized by shipping large volumes and/or long distances. As a result, waterborne transport is primarily used for commodity chemicals. Domestic waterborne transport includes coastal, lake, and inland waterway transportation of goods. The vast majority of domestic waterborne transport is via towed barges. Inland waterways include the Mississippi (by far the largest), Tennessee, Ohio, and Missouri waterway systems, among others. The Ohio system and intra-costal system along the Gulf Coast are also major domestic water routes used to transport chemicals.

Other Modes of transportation include pipeline, air, and intermodal transportation (the use of multiple modes of transportation). More than three-quarters of this category includes pipeline transportation of ethylene and oxygen, usually for short distances. Small volumes of consumer products are shipped via air transportation and courier service.

Figure 11.1 - Business of Chemistry: Transportation by Mode, 2020



Sources: Association of American Railroads, Bureau of the Census, Bureau of Economic Analysis, Bureau of Labor Statistics, US Army Corps of Engineers, American Chemistry Council analysis. Data do not include pharmaceuticals.

CHAPTER 12

CHEMISTRY IN THE STATES AND REGIONS

The states (and regions) in the United States are economically interdependent. Each state's economy depends on the continuing availability of goods and services from other states and on the ability to sell its goods and services throughout the nation. This is especially true for the business of chemistry, in that every state is dependent on the products of chemistry to support its manufacturing, agricultural, service and other industries.

Nearly every state hosts some form of chemical production; however, most production of basic industrial chemicals occurs in relatively few states. Much of basic chemical production is concentrated in the U.S. Gulf Coast region, where petroleum and natural gas raw materials (or feedstocks) are more readily available than in other parts of the country. In fact, about 80% of all primary petrochemicals are produced in Texas and Louisiana. The business of converting these basic chemicals into plastics, manufactured fibers, rubber, and other chemical products is not as heavily concentrated on the Gulf Coast and tends to be more diffused. For example, the majority of total manufactured fiber production occurs in the Southeast, while production of other chemical products such as plastics, pharmaceuticals, consumer products, and fertilizers is more widely dispersed among the states.

Figure 12.1- Chemistry Shipments by State

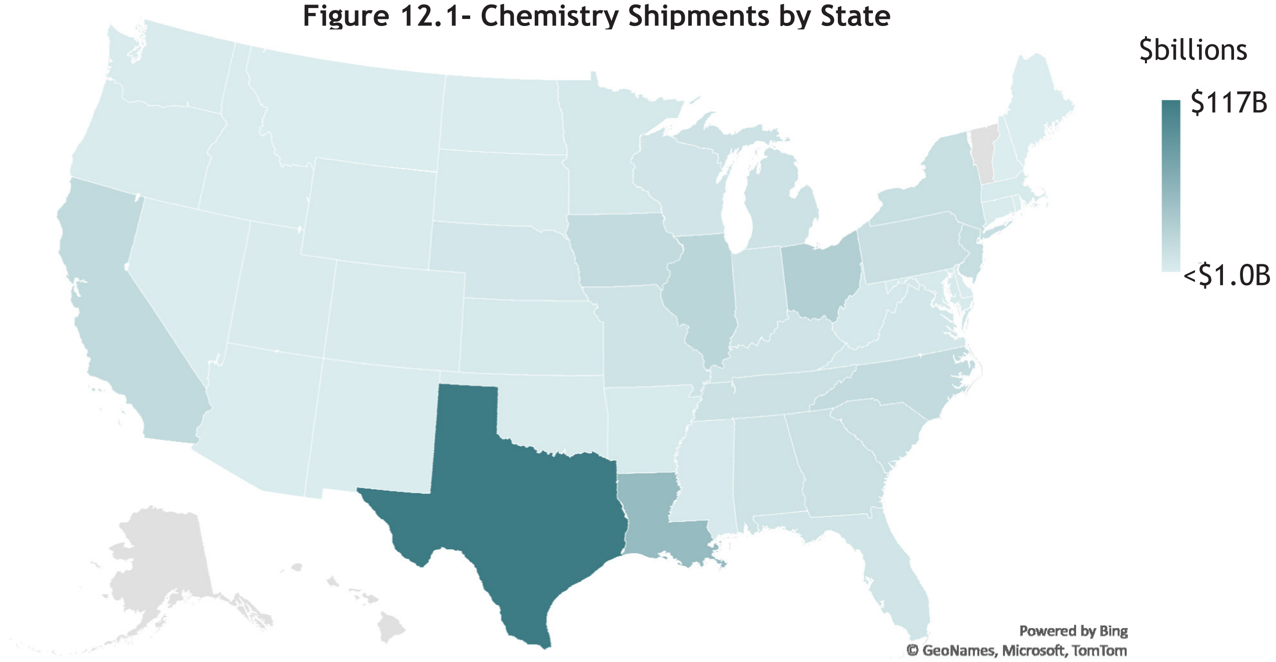


Table 12.1 - State Chemistry Statistics, 2020

State	Value of Shipments* (in millions)	Employment (in thousands)	Average Wages and Salaries ($)	Chemical Exports (in millions)
Texas	117,537	68,705	$118,292	38,208
Louisiana	51,986	26,489	$118,092	8,707
Ohio	31,263	40,088	$102,681	5,909
Illinois	24,249	24,932	$82,953	5,124
California	20,110	34,958	$82,697	6,848
Iowa	18,512	7,464	$77,927	1,372
North Carolina	18,348	19,375	$84,368	3,152
New Jersey	15,570	19,062	$101,049	7,090
New York	15,011	15,776	$85,470	3,418
Pennsylvania	14,305	22,616	$76,117	4,677
South Carolina	13,808	17,160	$75,050	2,846
Tennessee	12,965	23,453	$82,812	3,481
Georgia	12,896	18,974	$74,149	2,925
Michigan	11,123	19,427	$94,229	3,327
Alabama	10,881	9,755	$91,201	2,005
Indiana	10,396	13,087	$72,963	1,939
Missouri	10,389	14,837	$73,370	2,047
Kentucky	9,979	10,302	$78,871	2,097
Florida	8,761	14,698	$78,625	4,461
Wisconsin	8,116	14,032	$84,060	1,405
Nebraska	7,056	3,787	$67,316	588
Virginia	6,866	11,799	$79,001	1,881
Minnesota	5,713	7,805	$87,289	1,185
West Virginia	5,037	6,235	$92,473	1,341
Kansas	4,823	4,510	$72,801	604
Mississippi	3,989	4,984	$72,363	992
Massachusetts	3,794	6,114	$94,235	1,212
Arkansas	3,757	5,035	$68,402	535
Maryland	3,584	4,216	$85,222	1,147
Oregon	2,618	4,246	$67,324	1,503
Connecticut	2,458	4,730	$139,143	851
Oklahoma	2,419	2,803	$79,525	540
Wyoming	2,383	1,554	$107,971	917
Washington	2,378	3,991	$81,977	718
South Dakota	2,278	1,040	$63,828	98
Utah	2,008	2,698	$65,415	1,095
Colorado	1,892	3,425	$63,750	392
Delaware	1,833	2,022	$108,418	588
Arizona	1,716	3,886	$66,458	942

*Shipment data for 2019 (latest available). Listed in descending order based on value of shipments.
Sources: Bureau of the Census, Bureau of Economic Analysis, and Bureau of Labor Statistics.
Notes. Exports by state are reported on a NAICS basis and do not include exports from unidentified states, Puerto Rico, the Virgin Islands. As a result, they do not sum to exports referenced elsewhere in this publication.

Table 12.1 - State Chemistry Statistics, 2020

State	Value of Shipments* (in millions)	Employment (in thousands)	Average Wages and Salaries ($)	Chemical Exports (in millions)
Idaho	1,529	2,566	$64,385	292
Nevada	1,151	1,144	$71,248	148
North Dakota	977	610	$80,665	243
New Mexico	911	625	$83,851	170
Rhode Island	689	1,522	$66,773	280
Maine	423	551	$61,206	36
New Hampshire	336	758	$65,213	93
Montana	246	455	$74,610	200
Alaska	N/D	53	$40,646	6
District of Columbia	N/D	3	$52,699	13
Hawaii	N/D	401	$52,579	6
Vermont	N/D	882	$56,938	55
U.S. Total	$509,434	529,779	$90,125	$125,249

*Shipment data for 2019 (latest available). Listed in descending order based on value of shipments.
Sources: Bureau of the Census, Bureau of Economic Analysis, and Bureau of Labor Statistics.
Notes. Exports by state are reported on a NAICS basis and do not include exports from unidentified states, Puerto Rico, the Virgin Islands. As a result, they do not sum to exports referenced elsewhere in this publication.

EMPLOYMENT IMPACT OF THE BUSINESS OF CHEMISTRY

The true employment impact of an industry goes well beyond those employees it directly employs. The employment impact also includes jobs in other industries that are supported indirectly by the industry (these include jobs in industries that are in the supply chain of the industry being examined) and the jobs supported by payroll-induced activity (jobs in those industries supported by the wages paid to employees).

The business of chemistry directly employs workers as equipment operators, engineers, sales managers, scientists, safety specialists, environmental protection professionals, and in other occupations. In addition, the business of chemistry generates additional jobs in industries that supply the chemistry business with raw materials, services, equipment, and other non-labor factors of production. These suppliers include equipment manufacturers, wholesalers, contract workers, contract laboratories, engineering and construction workers, energy and raw material producers, transportation operators, etc. In addition, millions of jobs are supported through the indirect purchases of the industry's suppliers and its employees. The suppliers' suppliers and their suppliers make purchases and pay their employees the same way that the business of chemistry does. These subsequent rounds of purchasing generate additional economic activity and jobs. Businesses purchase goods and services and employees spend their wages on housing, food, clothing, furniture, utilities, and a variety of other goods and services.

The business of chemistry is a major employer in a number of states where the industry employs a significant percentage of the state's manufacturing workers. The employment contributions of the business of chemistry are discussed further in Chapter 8 - Employment.

Table 12.2 - Jobs and Payroll Generated by the Business of Chemistry by State, 2020

	in thousands				in billions of dollars			
State	Direct	Supply Chain	Payroll Induced	Total	Direct	Supply Chain	Payroll Induced	Total
Alabama	9.8	13.7	8.8	32.2	0.9	0.6	0.3	1.8
Alaska	0.1	0.0	0.0	0.1	0.002	0.002	0.001	0.006
Arizona	3.9	5.8	4.3	13.9	0.3	0.2	0.1	0.6
Arkansas	5.0	7.9	4.2	17.1	0.3	0.4	0.1	0.9
California	35.0	44.5	31.1	110.6	2.9	3.4	1.6	7.8
Colorado	3.4	4.7	3.9	12.0	0.2	0.2	0.1	0.6
Connecticut	4.7	6.7	13.1	24.5	0.7	0.3	0.2	1.1
Delaware	2.0	2.0	2.2	6.1	0.2	0.1	0.1	0.4
Dist of Columbia	0.0	-	-	0.0	0.00	-	-	0.00
Florida	14.7	20.4	16.2	51.3	1.2	1.1	0.6	2.8
Georgia	19.0	25.3	18.1	62.3	1.4	1.4	0.7	3.5
Hawaii	0.4	-	-	0.4	0.02	-	-	0.0
Idaho	2.6	4.0	2.4	9.0	0.2	0.2	0.1	0.4
Illinois	24.9	38.3	32.1	95.3	2.1	2.3	1.3	5.7
Indiana	13.1	17.4	12.6	43.1	1.0	0.9	0.5	2.4
Iowa	7.5	12.9	11.5	31.8	0.6	0.4	0.2	1.2
Kansas	4.5	8.5	5.0	18.0	0.3	0.4	0.2	0.9
Kentucky	10.3	12.9	9.6	32.8	0.8	0.6	0.3	1.7
Louisiana	26.5	81.9	47.9	156.3	3.1	4.4	1.5	9.0
Maine	0.6	1.0	0.6	2.1	0.0	0.0	0.0	0.1
Maryland	4.2	4.3	3.6	12.2	0.4	0.3	0.2	0.8
Massachusetts	6.1	6.7	6.1	18.9	0.6	0.5	0.3	1.3
Michigan	19.4	27.1	24.4	71.0	1.8	1.4	0.9	4.1
Minnesota	7.8	13.3	12.8	33.8	0.7	0.7	0.4	1.8
Mississippi	5.0	11.4	4.9	21.3	0.4	0.5	0.1	1.0
Missouri	14.8	24.3	17.7	56.9	1.1	1.5	0.7	3.4
Montana	0.5	0.6	0.4	1.5	0.0	0.0	0.01	0.1
Nebraska	3.8	7.8	5.0	16.6	0.3	0.3	0.1	0.7
Nevada	1.1	1.0	0.7	2.9	0.1	0.0	0.0	0.2

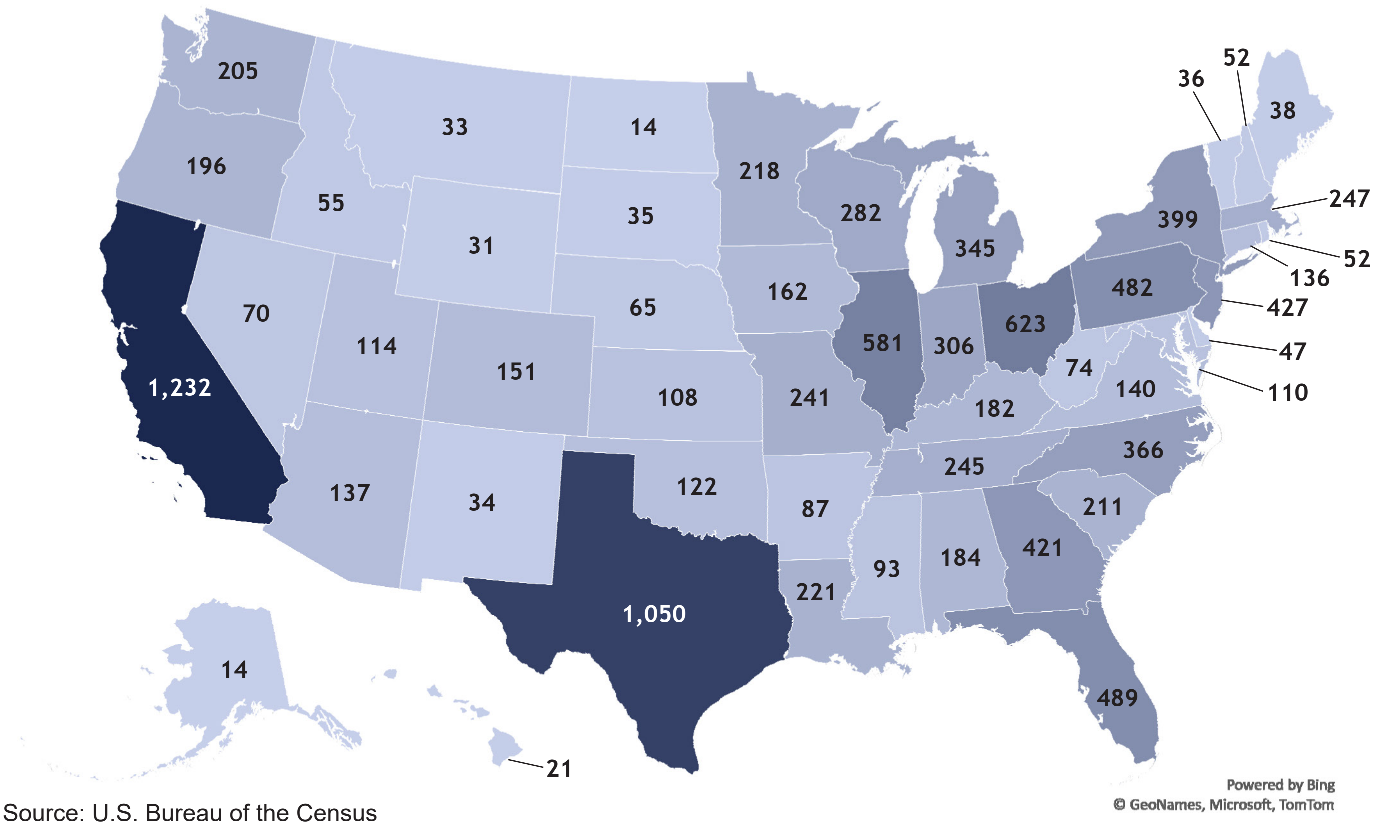
Sources: Bureau of Labor Statistics and American Chemistry Council analysis.

Table 12.2 - Jobs and Payroll Generated by the Business of Chemistry by State, 2020

State	in thousands				in billions of dollars			
	Direct	Supply Chain	Payroll Induced	Total	Direct	Supply Chain	Payroll Induced	Total
New Hampshire	0.8	0.7	0.6	2.1	0.0	0.0	0.0	0.1
New Jersey	19.1	29.4	31.9	80.3	1.9	1.6	0.9	4.4
New Mexico	0.6	0.7	0.5	1.8	0.1	0.0	0.0	0.1
New York	15.8	18.1	14.5	48.3	1.3	1.4	0.7	3.4
North Carolina	19.4	26.1	17.9	63.3	1.6	1.4	0.6	3.6
North Dakota	0.6	1.1	0.6	2.4	0.05	0.07	0.02	0.14
Ohio	40.1	53.2	51.4	144.8	4.1	3.2	1.8	9.1
Oklahoma	2.8	3.8	2.6	9.1	0.2	0.2	0.1	0.5
Oregon	4.2	6.5	4.4	15.2	0.3	0.4	0.2	0.9
Pennsylvania	22.6	31.9	32.8	87.2	1.7	1.6	1.1	4.4
Rhode Island	1.5	1.1	0.9	3.5	0.1	0.1	0.0	0.2
South Carolina	17.2	17.7	13.1	47.9	1.3	0.7	0.4	2.4
South Dakota	1.0	2.4	2.7	6.2	0.1	0.0	0.03	0.1
Tennessee	23.5	28.8	22.6	74.8	1.9	1.4	0.9	4.2
Texas	68.7	305.4	185.9	560.0	8.1	20.3	7.0	35.4
Utah	2.7	4.2	2.7	9.6	0.2	0.2	0.1	0.5
Vermont	0.9	0.8	0.6	2.3	0.05	0.04	0.02	0.1
Virginia	11.8	10.8	9.4	32.0	0.9	0.6	0.3	1.8
Washington	4.0	5.3	3.3	12.6	0.3	0.4	0.2	0.8
West Virginia	6.2	10.6	7.3	24.2	0.6	0.4	0.2	1.2
Wisconsin	14.0	19.7	17.2	50.9	1.2	1.0	0.6	2.8
Wyoming	1.6	1.8	1.1	4.5	0.2	0.1	0.03	0.3

Sources: Bureau of Labor Statistics and American Chemistry Council analysis.

Figure 12.2 - Number of Business of Chemistry Establishments by State



Source: U.S. Bureau of the Census

U.S. CHEMICAL PRODUCTION REGIONAL INDEX

The U.S. Chemical Production Regional Index (US CPRI), which tracks chemical production activity in seven regions of the United States, was developed by Moore Economics for the American Chemistry Council. The US CPRI is comparable to the U.S. industrial production index for chemicals published by the Federal Reserve and the ACC Global Chemical Production Regional Index (Global CPRI). The index is based to where 2012=100. The US CPRI is based on information from the Federal Reserve and is weighted by chemical shipments by region.

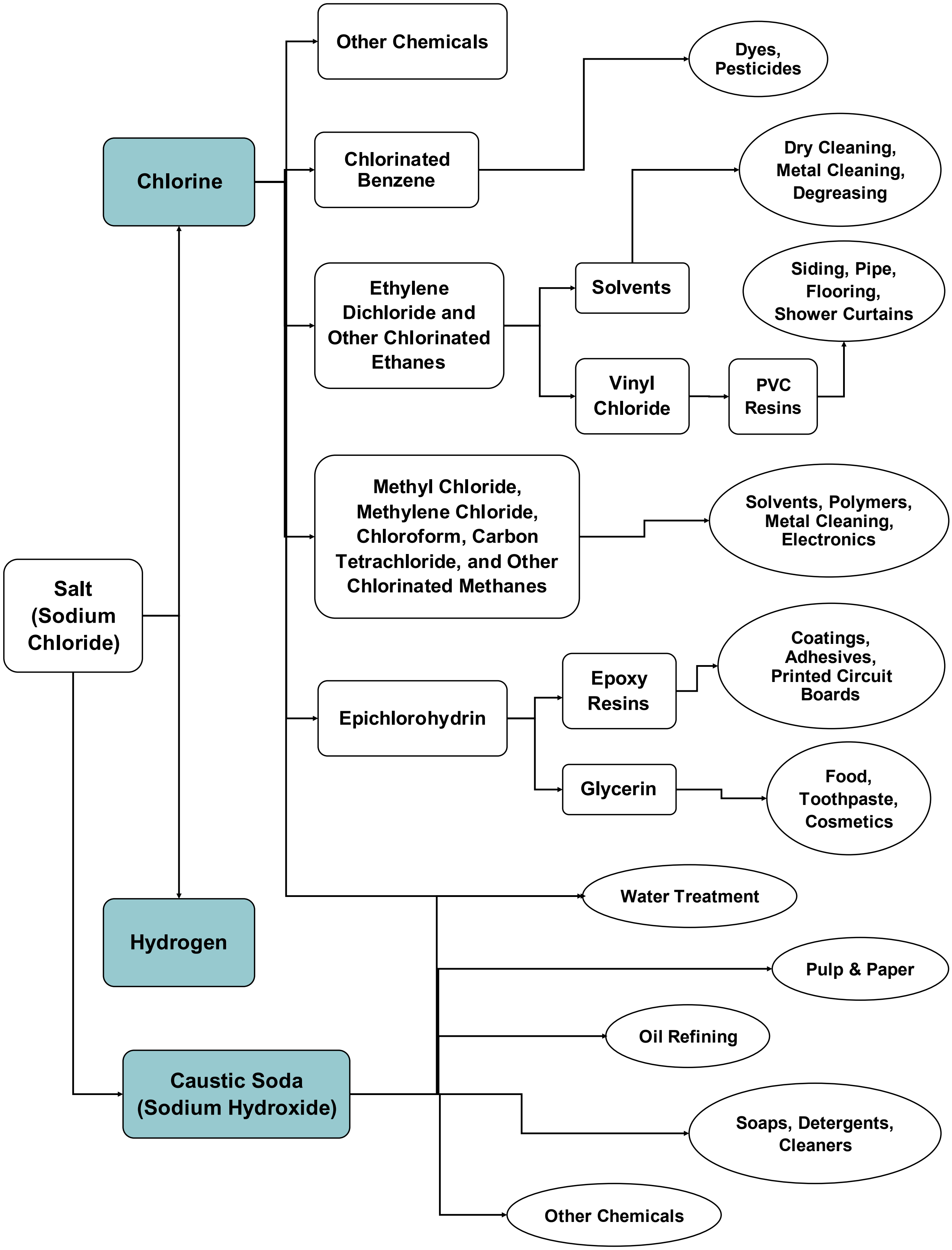
Table 12.3 - U.S. Chemical Production Regional Index, 2011-2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
					2012=100					
Gulf Coast	97.3	100.0	100.6	98.3	94.8	96.0	98.6	102.3	102.1	99.6
Midwest	99.7	100.0	100.0	99.2	96.1	96.6	101.4	105.5	105.4	100.8
Ohio Valley	101.2	100.0	98.3	98.8	96.7	96.7	100.7	105.0	104.9	99.7
Mid-Atlantic	102.5	100.0	97.5	98.6	97.0	96.7	100.7	105.0	105.0	99.3
Southeast	100.4	100.0	99.4	99.2	96.2	96.2	100.7	105.1	105.2	100.2
Northeast	103.6	100.0	97.0	98.3	96.4	95.4	99.1	103.5	104.1	98.3
West Coast	101.5	100.0	98.9	99.3	96.8	96.7	101.9	106.2	106.3	100.6

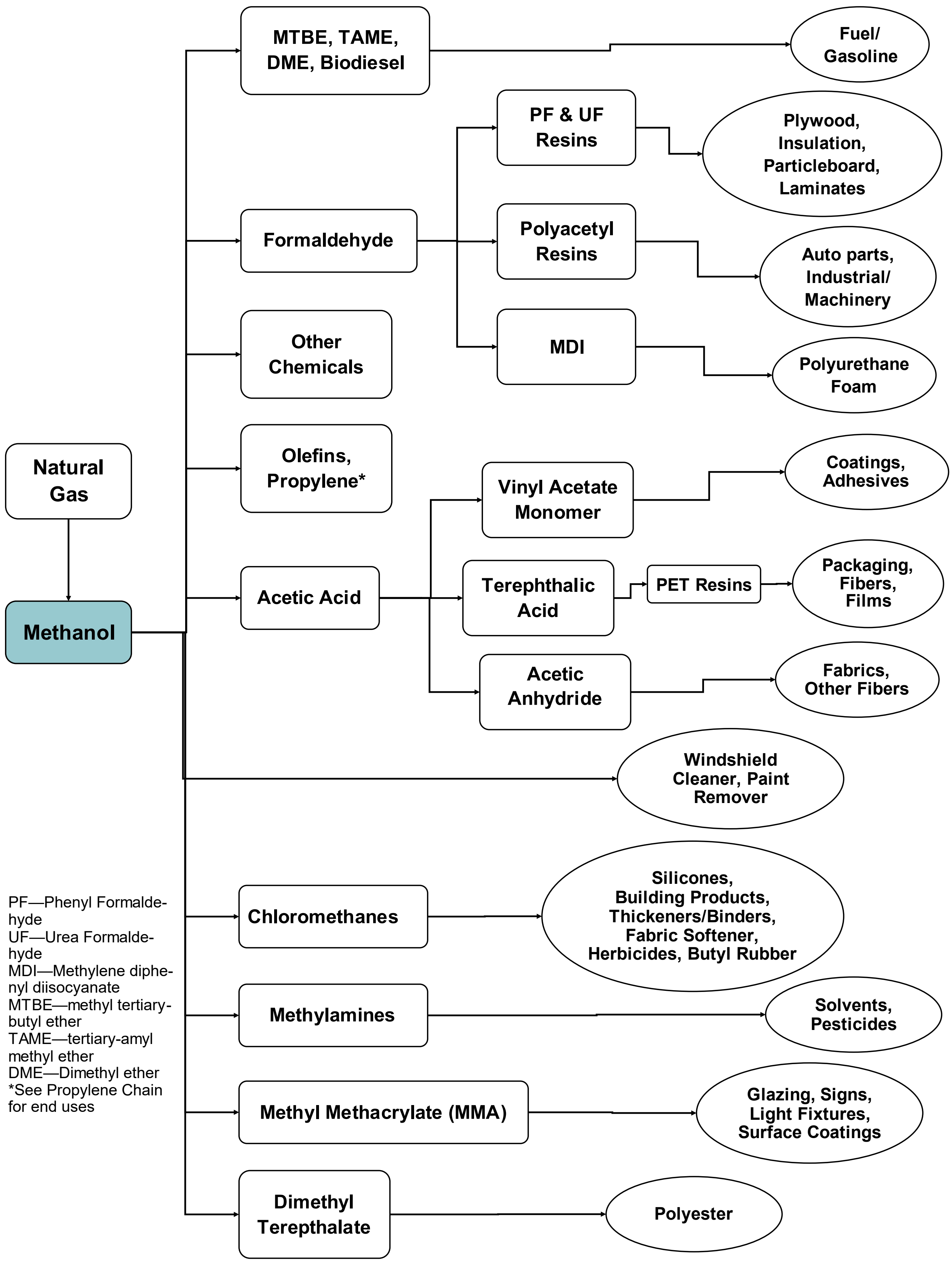
Source: American Chemistry Council

APPENDIX A: CHEMICAL CHAINS

A.1 - CHLOR-ALKALI

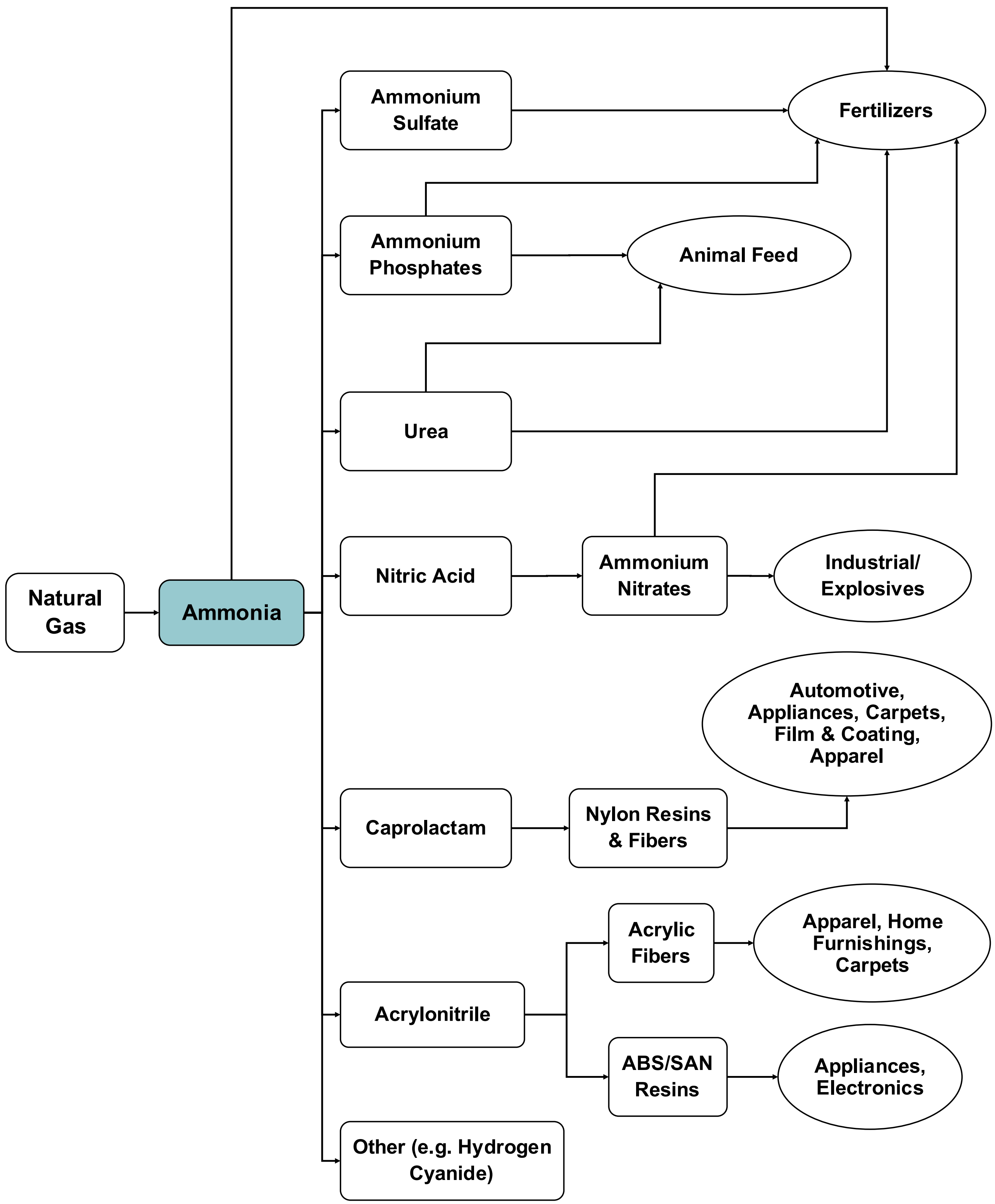


A.2 - METHANOL

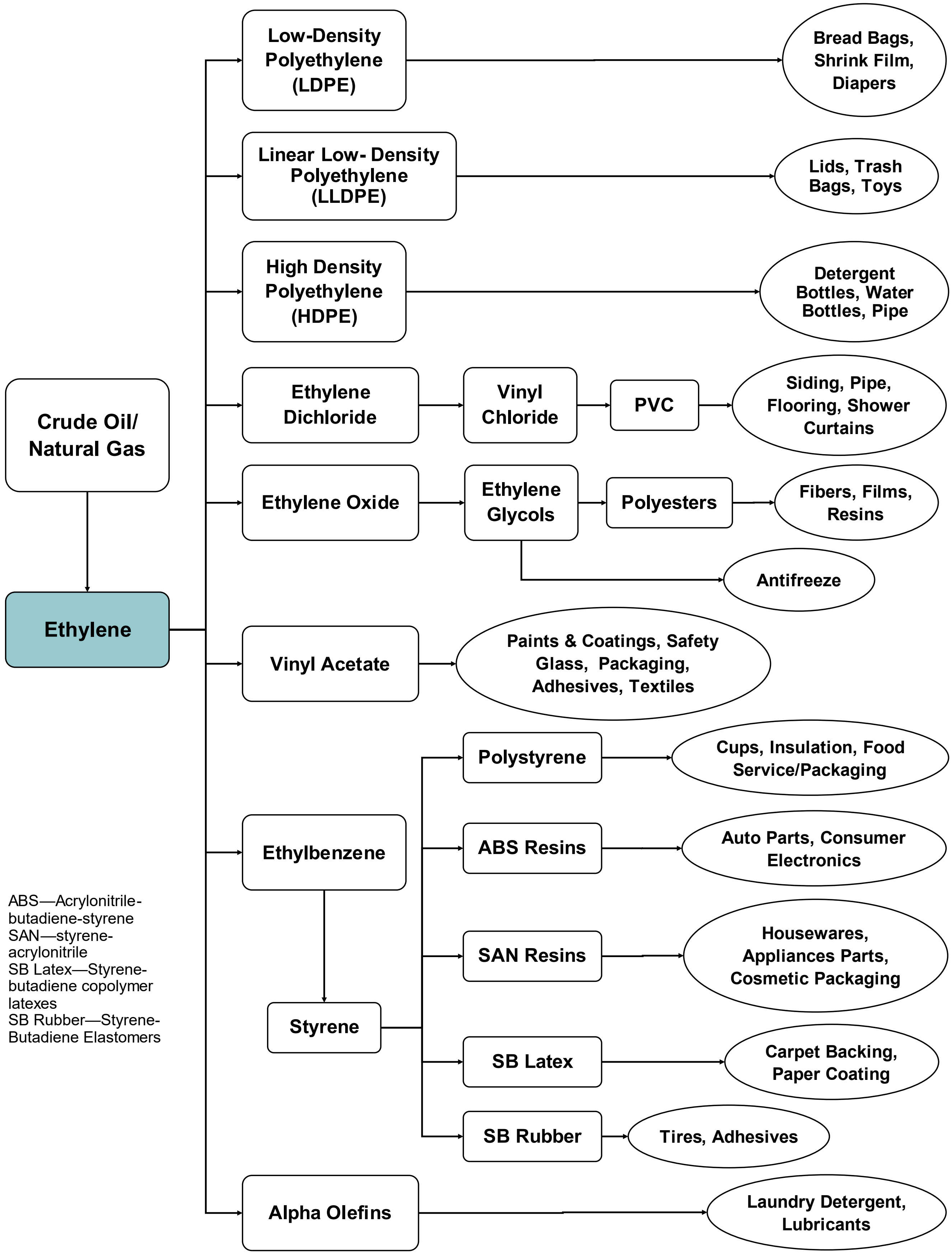


PF—Phenyl Formaldehyde
UF—Urea Formaldehyde
MDI—Methylene diphenyl diisocyanate
MTBE—methyl tertiary-butyl ether
TAME—tertiary-amyl methyl ether
DME—Dimethyl ether
*See Propylene Chain for end uses

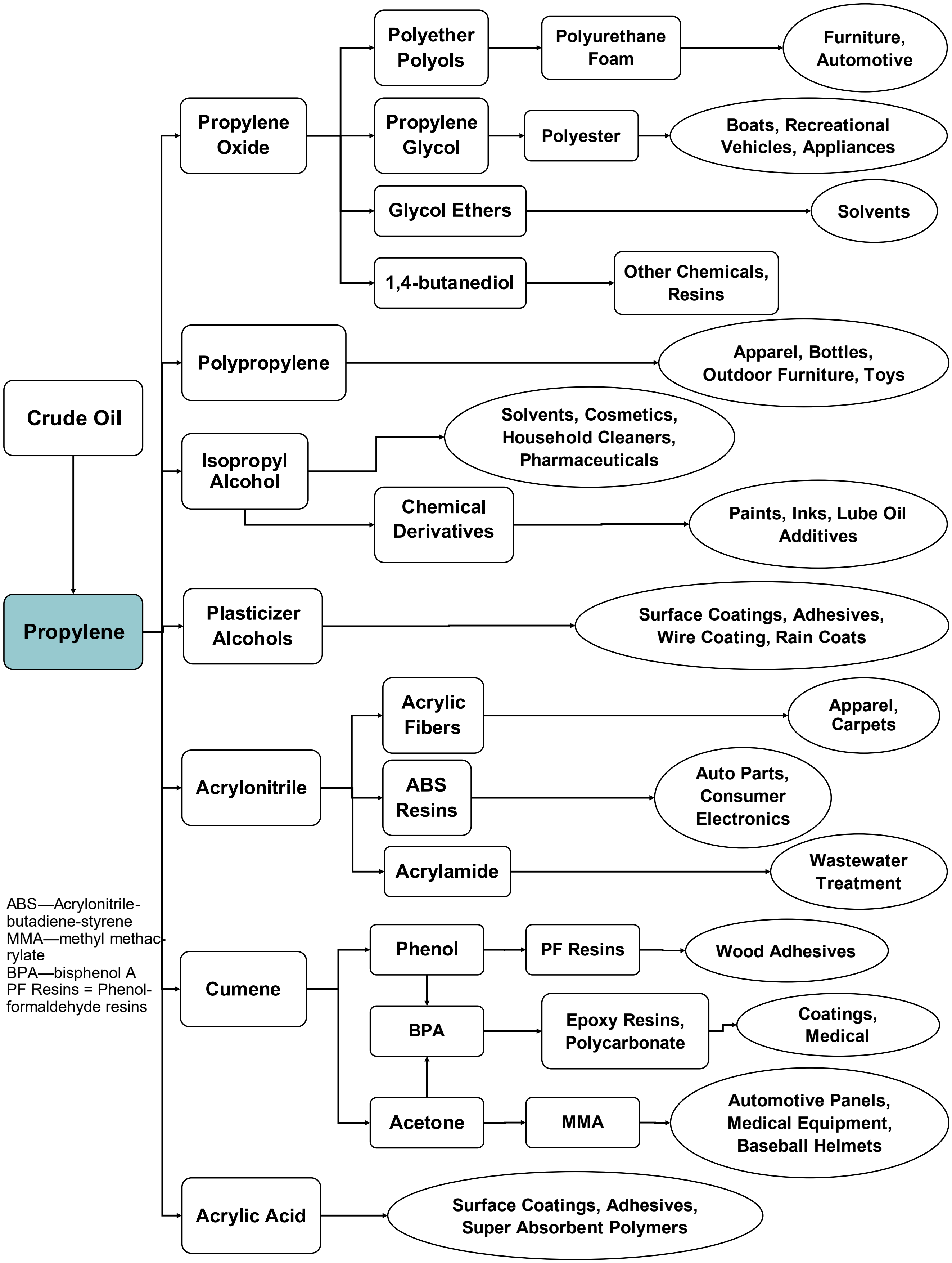
A.3 - AMMONIA


Natural Gas
Ammonia
Ammonium Sulfate
Ammonium Phosphates
Urea
Nitric Acid
Ammonium Nitrates
Caprolactam
Nylon Resins & Fibers
Acrylonitrile
Acrylic Fibers
ABS/SAN Resins
Other (e.g. Hydrogen Cyanide)
Fertilizers
Animal Feed
Industrial/ Explosives
Automotive, Appliances, Carpets, Film & Coating, Apparel
Apparel, Home Furnishings, Carpets
Appliances, Electronics

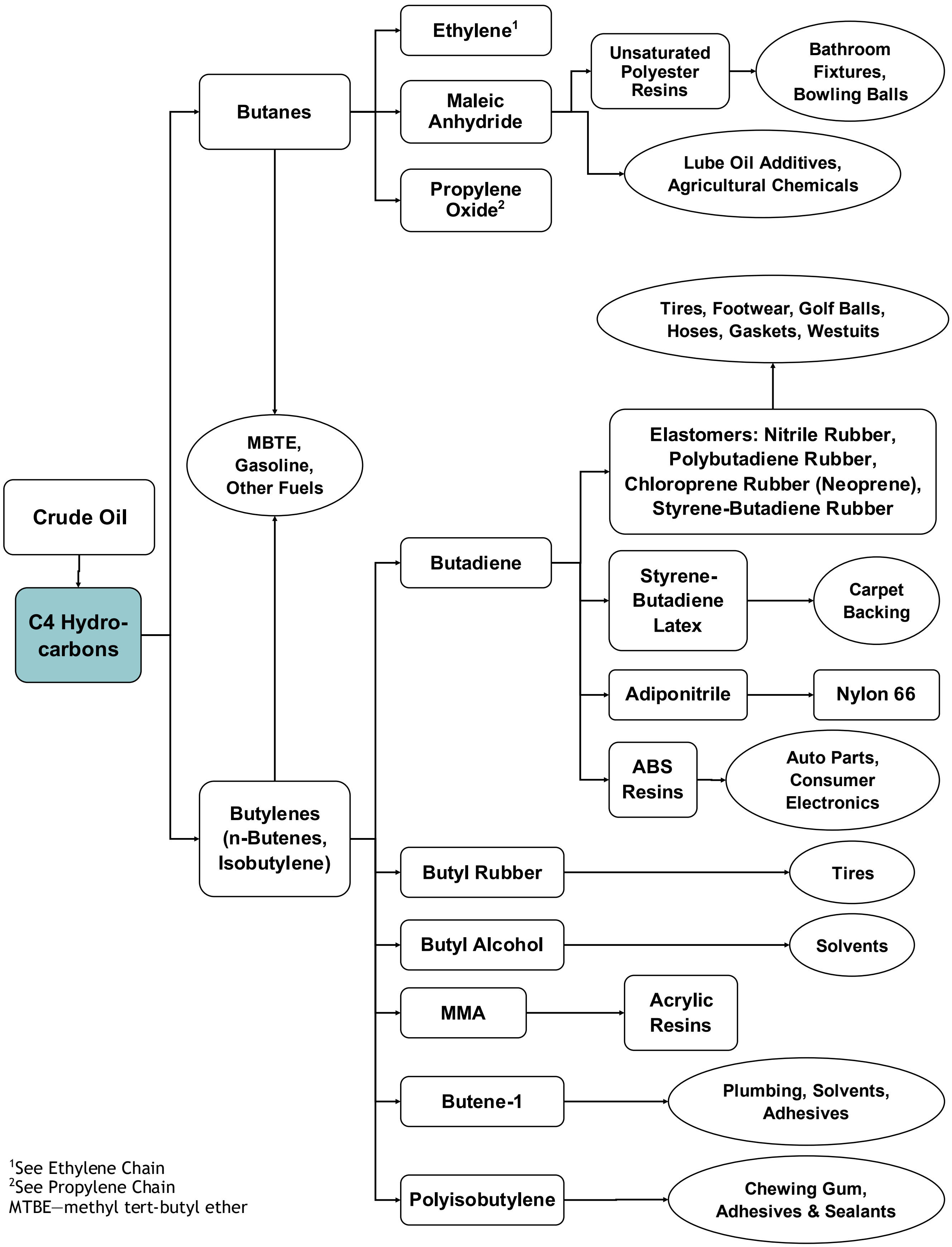
A.4 - ETHYLENE


Crude Oil/ Natural Gas
Ethylene
Low-Density Polyethylene (LDPE)
Bread Bags, Shrink Film, Diapers
Linear Low- Density Polyethylene (LLDPE)
Lids, Trash Bags, Toys
High Density Polyethylene (HDPE)
Detergent Bottles, Water Bottles, Pipe
Ethylene Dichloride
Vinyl Chloride
PVC
Siding, Pipe, Flooring, Shower Curtains
Ethylene Oxide
Ethylene Glycols
Polyesters
Fibers, Films, Resins
Antifreeze
Vinyl Acetate
Paints & Coatings, Safety Glass, Packaging, Adhesives, Textiles
Ethylbenzene
Styrene
Polystyrene
Cups, Insulation, Food Service/Packaging
ABS Resins
Auto Parts, Consumer Electronics
SAN Resins
Housewares, Appliances Parts, Cosmetic Packaging
SB Latex
Carpet Backing, Paper Coating
SB Rubber
Tires, Adhesives
Alpha Olefins
Laundry Detergent, Lubricants
ABS—Acrylonitrile-butadiene-styrene
SAN—styrene-acrylonitrile
SB Latex—Styrene-butadiene copolymer latexes
SB Rubber—Styrene-Butadiene Elastomers

A.5 - PROPYLENE

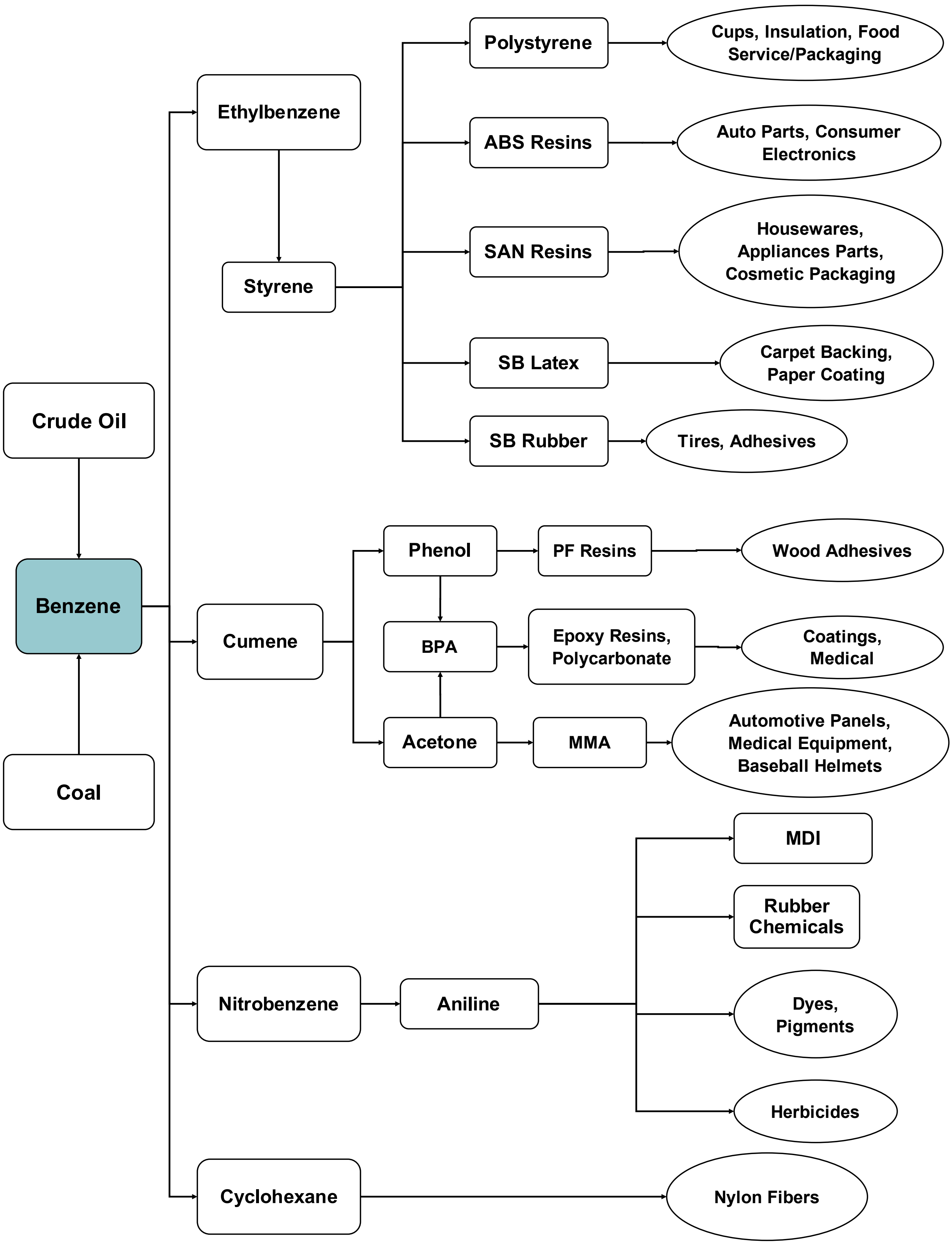


A.6 - C4 HYDROCRARBONS

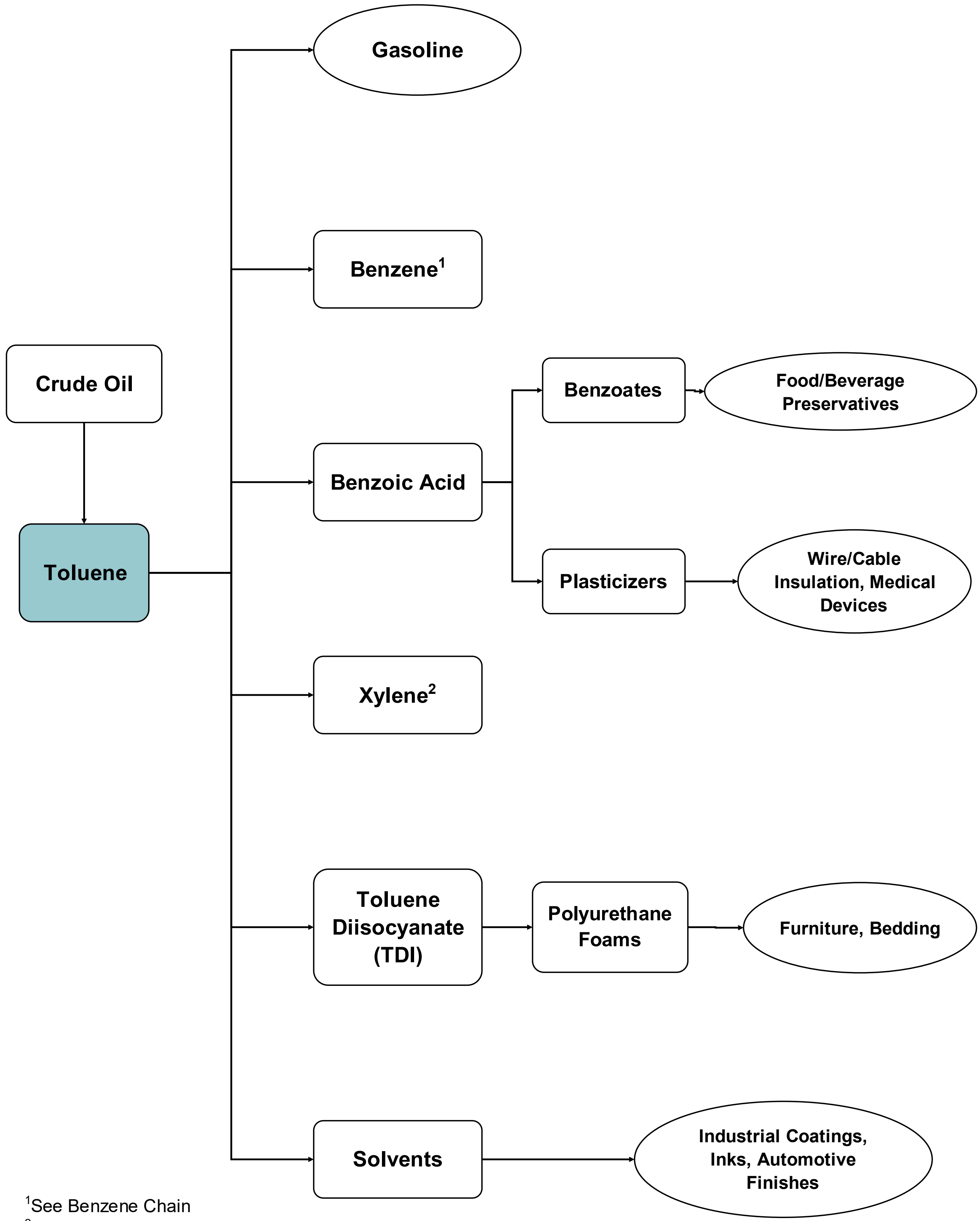


[1]See Ethylene Chain
[2]See Propylene Chain
MTBE—methyl tert-butyl ether

A.7 - BENZENE

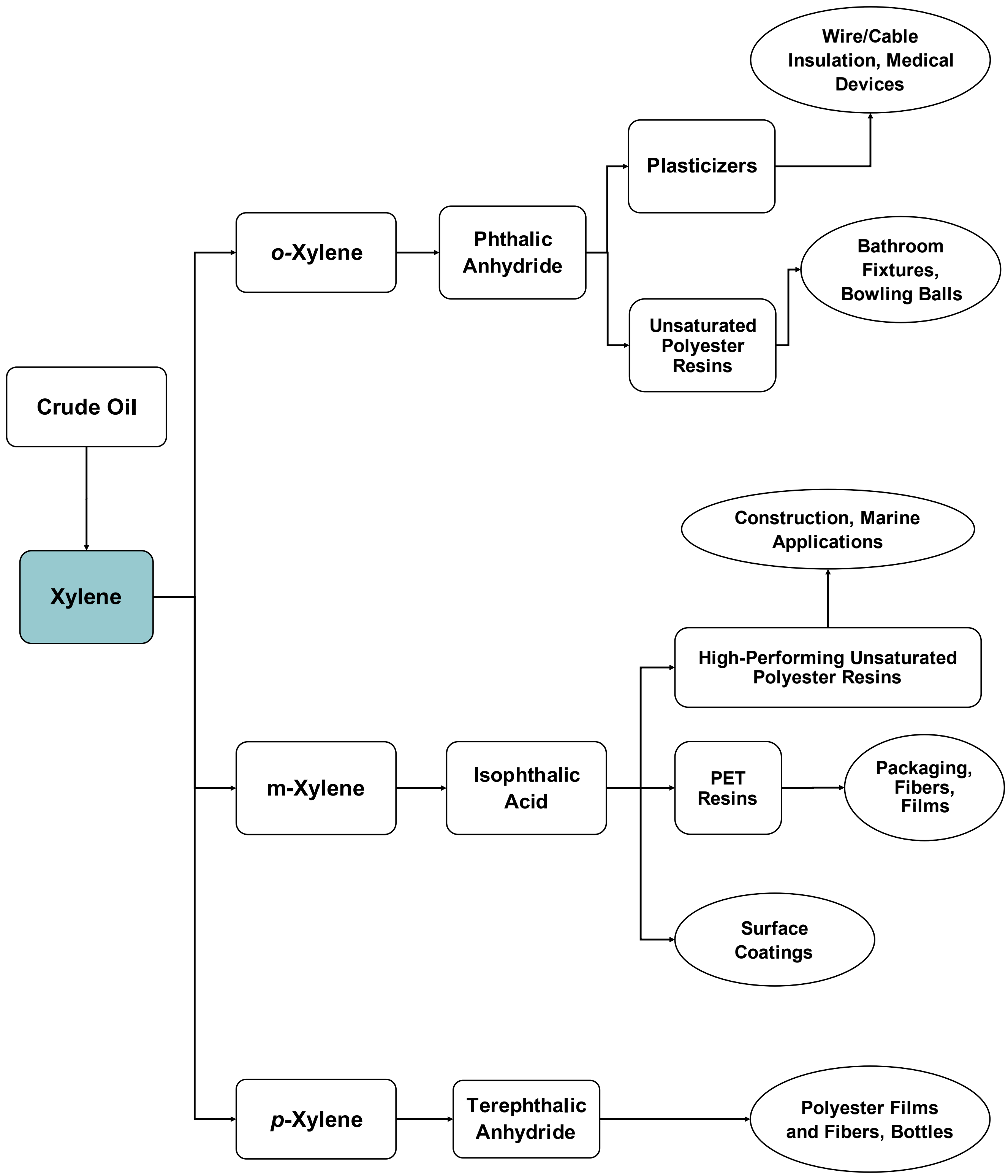

Polystyrene
Cups, Insulation, Food Service/Packaging
Ethylbenzene
ABS Resins
Auto Parts, Consumer Electronics
SAN Resins
Housewares, Appliances Parts, Cosmetic Packaging
Styrene
SB Latex
Carpet Backing, Paper Coating
Crude Oil
SB Rubber
Tires, Adhesives
Phenol
PF Resins
Wood Adhesives
Benzene
Cumene
BPA
Epoxy Resins, Polycarbonate
Coatings, Medical
Acetone
MMA
Automotive Panels, Medical Equipment, Baseball Helmets
Coal
MDI
Rubber Chemicals
Nitrobenzene
Aniline
Dyes, Pigments
Herbicides
Cyclohexane
Nylon Fibers

A.8 - TOLUENE



[1]See Benzene Chain
[2]See Xylene Chain

A.9 - XYLENE



Crude Oil
Xylene
o-Xylene
Phthalic Anhydride
Plasticizers
Wire/Cable Insulation, Medical Devices
Unsaturated Polyester Resins
Bathroom Fixtures, Bowling Balls
m-Xylene
Isophthalic Acid
High-Performing Unsaturated Polyester Resins
Construction, Marine Applications
PET Resins
Packaging, Fibers, Films
Surface Coatings
p-Xylene
Terephthalic Anhydride
Polyester Films and Fibers, Bottles

APPENDIX B: GLOSSARY

of business and technical terms and acronyms in the Business of Chemistry

ABS - Acrylonitrile-butadiene-styrene

ABSORPTION - A process in which a gaseous stream containing a separable chemical is placed in contact with a liquid solvent flowing down a column containing trays or packing. The solvent absorbs the chemical from the gas. The collection of the compound takes place inside the other substance (e.g., solvent).

ACID - A substance that produces hydrogen ions when dissolved in water.

ACID TEST - The ratio of the sum of both cash and short-term securities divided by current liabilities.

ACQUISITION - The purchase by one company of the assets and obligations of another company.

ACTIVE PHARMACEUTICAL INGREDIENT (API) - The chemical compound in a drug formulation that imparts the desired biological effect.

ADSORPTION -The adhesion of substances (e.g., gases, liquids) on the surface of solids.

ALCOHOLS - Organic compounds (usually liquids) containing a hydroxyl group (-OH), made of one oxygen and one hydrogen atom, attached to a carbon atom.

ALDEHYDES - Oxygenated organic compounds (e.g., formaldehyde, acetaldehyde) that have a tail and consisting of carbon/double-bonded oxygen and hydrogen, both attached to the same carbon atom.

ALIPHATICS - Compounds characterized by having an open-chain structure of carbon atoms.

ALKANES - Straight-chain hydrocarbon without double bonds. These contain single bonds, which makes them less reactive. The simplest alkane is methane. Also referred to as paraffin.

ALKENES - Also referred to as olefins, unsaturated hydrocarbons that contain double bonds, which make them reactive.

ALKYLATION - This process involves the reaction of hydrocarbons with an olefin by using a catalyst. This can increase the octane number of the compound.

AROMATICS - Hydrocarbons containing a 6-carbon ring structure. Benzene is the simplest aromatic. Toluene and xylenes are also aromatics.

ASSETS - Economic resources (plant, property, inventories, trademarks, patents, etc.) owned by a firm.

ATOM - The smallest, most basic unit of an element.

AVERAGE DAYS' SUPPLY IN INVENTORY - In number of days. The ratio of 365 days divided by the inventory turnover ratio. Also referred to as age of inventory.

BARREL – A standard unit of volume for crude petroleum (or oil) and petroleum products equal to 42 US gallons.

BASE - A substance that produces hydroxyl ions (OH) when dissolved in water.

BASIC EARNING POWER - Expressed as a percent, this measure is equal to income before income taxes divided by total assets.

Basic Chemicals – Chemicals produced in large volumes to chemical composition specifications that are homogeneous in nature; also called commodity chemicals.

BATCH - Chemical processing technology consisting of sequential steps (e.g., extraction) that must be repeated batch after batch. Set-up is required between each batch (versus continuous process). Capital requirements tend to be low but require greater labor input.

BENZENE - An aromatic compound in which 6 carbon atoms are structured in a ring. Used to manufacture other chemicals and an important feedstock, it is not used directly by consumers.

BLOW MOLDING – A method of processing plastic resins that uses air to conform molten plastic resin to the shape of the mold. Product examples include bottles and toys.

BPA - Bisphenol A.

BPD (BARRELS PER DAY) – A measurement of production or consumption used for petroleum and petroleum products.

BRAND EQUITY - A combination of factors such as awareness, loyalty, perceived quality, images, and emotions that customers associate with a given brand name.

BTX - Not a mountain bike brand but rather the acronym for benzene, toluene and xylenes.

BTU (BRITISH THERMAL UNIT) – A unit of heat equal to the amount of heat required to raise one pound of water one degree Fahrenheit at one atmosphere pressure.

BUSINESS CYCLE – Also called the economic cycle, it refers to sequences of alternating phases of expansion and contraction of economic activity. The cycle involves shifts over time between periods of relatively rapid growth of output (recovery and prosperity), and periods of relative stagnation or decline (contraction or recession). These fluctuations are recurring but not periodic.

BUTANE - A straight-chain hydrocarbon containing four carbon atoms.

C4 HYDROCARBONS - Hydrocarbons which contain four carbon atoms. These include the butanes, butenes, butadienes, and butylenes.

CAPACITY – The quantity of a product that can be produced in a plant or other operation.

CAPITAL EMPLOYED - Also referred to as operating assets, the dollar value of fixed capital plus the dollar value of working capital less payables. It represents the economic value of cash tied up in the business and is used to calculate economic income.

CAPITAL EXPENDITURES - Major investments in long-term assets such as process equipment, other equipment, buildings, land, etc. Also referred to as capital spending or plant and equipment (P&E) spending.

CASH FLOW - This traditional measure of financial performance is equal to net income after taxes plus depreciation and amortization plus (or minus) net change in net working capital.

CATALYST - A substance used in very small quantities to increase the rate of a desirable chemical reaction without itself being changed chemically.

CATALYTIC PROCESS - A process using a catalyst to increase the rate of a chemical reaction. This can increase overall efficiency, quality and other favorable attributes.

CIF (COST, INSURANCE AND FREIGHT) - A common term in a sales contract that may be encountered in international trading when ocean transport is used. When a price is quoted CIF, it means that the selling price includes the cost of the goods, the freight or transport costs and the cost of marine insurance.

COEXTRUSION – A process for plastic film manufacture, with two or more extruders feeding into a single die assembly. The resulting film contains several layers, with each layer having a different functionality.

COMMODITY CHEMICALS – High-volume, low-value, homogenous compounds produced in dedicated continuous plants often used in a variety of applications. These are sold on the basis of what they are (the composition), not what they do. Most specialties evolve into commodities.

COMPOUND - A substance composed of two or more different elements that are chemically bound. Water (H_2O) is an example of a compound comprised of two atoms of hydrogen (H) and one atom of oxygen (O).

COMPOUNDING – The process of mixing two materials together to obtain physical properties in a material that are different than the original materials. For example, glass fibers are sometimes added to plastic resins in order obtain greater strength, rigidity, and creep properties.

CONVERSION - The portion of raw materials in a chemical process that actually undergoes reaction. That is, the raw material that is consumed or feed that disappears in a chemical reaction. It is usually measured as a percent, primarily around a reaction step, not the whole plant.

CONVERTED PRODUCT – in the context of the plastic resins, the term used to refer to products in finished or semi-finished form, which are manufactured using virgin resins. Examples include bags, film, and injection molded parts.

COPOLYMER - A polymer of two or more different monomers.

CORE COMPETENCIES - Those functions that the organization can do as well or better than any other organization in the world.

COST OF GOODS SOLD - A measure of the cost of raw materials, supplies, purchased services, and direct manufacturing costs used for producing the product.

COST OF CAPITAL - Expressed as a percent, this measures the risk-adjusted, after-tax minimum rate of return required to compensate holders of debt and shareholders. It is based on the weighted average of the after-tax cost of debt and equity. The cost of debt is based on the yield prevailing for long-term corporate bonds of equivalent credit risk adjusted by the effective tax rate. The cost of equity is computed by adding a risk premium typical of common equities (with an adjustment for volatility) to the yield for long-term government bonds.

CRACKING - A process in which a long-chain molecule (or mixture of longer chain molecules) is broken down into smaller molecules to produce more useful chemicals. High-temperature cracking of hydrocarbons to produce olefins is referred to as steam cracking. When molecules are broken down in the presence of a catalyst, it is sometimes referred to as catalytic cracking.

CRYSTALLINITY - A property of polymers in which the molecule attract each other and line up next to the other, thus engendering strength. Crystalline polymers (polyethylene, nylon, etc.) are opaque.

CRYSTALLIZATION - A process in which a mixture of chemicals contained in a solution are separated by chilling and a filter or centrifuge are used to recover solid crystals.

CURRENT ASSETS - Those assets – cash, time and demand deposits, U.S. government and other short-term securities, trade accounts and trade notes receivable, inventories, etc. – which can be converted into cash within one year. Also referred to as working capital.

CURRENT LIABILITIES - Those liabilities – short-term loans from banks, commercial paper, other short-term debt, trade accounts and trade notes payable, etc. – which must be paid within one year. Also referred to as short-term debt.

CURRENT RATIO - Current assets divided by current liabilities. Also referred to as working capital ratio.

CUSTOM MANUFACTURING - An arrangement in which a company produces a product exclusively for a customer.

CYCLE - In chemical processing, the complete, repeating sequence of operations in a process; or in part of a process. In plastics molding, the cycle time is the period, or elapsed time, between a certain point in one cycle and the same point in the next.

DEALKYLATION - A process removing a methyl or ethyl group from an organic compound.

DEBOTTLENECKING- After some period of operating a new plant, companies learn more about the process, which allows them to remove bottlenecks in the plant, thus providing additional capacity at little incremental cost.

DEHYDROGENATION - Chemical processes removing one or more hydrogen atoms from a compound. By adding a hydrogen atom, hydrogenation is the opposite process.

DEMAND - The quantities of some good or service that consumers desire (or buy) at different prices. The relative value of the marginal unit of some good when different quantities of that good are available.

DEPRECIATION - A systematic financial write-off of the cost of a tangible asset over its estimated useful life.

DISTILLATES - High-volatility molecules separated from refined crude petroleum (or oil). These are generally isolated near the top of a fractional distillation column in an oil refinery.

DISTILLATION - Process in which two or more components of a liquid compound are separated through the use of successive vaporization and condensation. This process is employed to purify or separate the components of a mixture.

DME - Dimethyl ether.

DOWNSTREAM – The process/processes, products, or industries being fed by the process under consideration. Production of PVC resins, for example, is downstream of chlorine and ethylene production.

DYES - Synthetic or natural organic chemicals that are soluble in most common solvents, and are used to impart color to fiber, yarn or other fabrics.

EBITDA (EARNINGS BEFORE INTEREST, TAXES, DEPRECIATION AND AMORTIZATION) - this is the key profitability metric used by financial analysts.

ECONOMIC CAPACITY - In terms of scale of operations, the minimum requirement for economic operation. That is, the capacity at which producers can still operate with some profit margin.

ECONOMIC INCOME - Cash flow after taxes less a user's charge (cost of capital) on capital employed. This measures "true income" by taking into account the opportunity cost of capital. It is similar to Rutledge & Company's concept of economic profits and Stern Stewart & Company's EVA™ (economic value-added) concept. It is also similar to residual income and economic rent.

ECONOMIC RETURN ON CAPITAL EMPLOYED - Expressed as a percent, this measure of profitability (or financial performance) is equal to economic income divided by capital employed.

ELASTOMER - Synthetic polymers with rubber-like properties that can be stretched and will retract to their original form.

ELECTROCHEMICAL UNIT (ECU) – The chlor-alkali process produces chlorine and caustic soda in set ratios of one unit of chlorine and 1.1 units of caustic soda. The combination of one unit of chlorine and 1.1 units of caustic soda is an ECU.

ELECTROLYSIS - A process in which the passage of electric current through an aqueous solution causes a chemical reaction to occur.

ELEMENT - A substance that cannot be decomposed into simpler substances by any chemical or physical reaction. Elements are found on the periodic table. Hydrogen and oxygen are examples of two elements.

ENGINEERING PLASTICS - High-strength polymers that can be used to replace metals or glass. Favorable properties can include high thermal stability, good chemical and weather resistance, transparency, self-lubrication, or good electrical properties.

EQUITY CAPITAL - Funds raised from within a company or through the sale of ownership of the company.

EQUITY MULTIPLIER - The ratio of total assets divided by total shareholder's equity.

ESTER - Not your aunt, but a simple oxygenated organic compound usually formed by the chemical reaction between an acid and an alcohol.

ESTERIFICATION - A process in which an alcohol is reacted with an organic acid to produce an ester.

ETHANE - Gaseous straight-chain hydrocarbon (or alkane) containing two carbon atoms.

ETHENE - See Ethylene.

ETHYL - A chemical grouping with two carbon atoms attached to an element or group.

ETHYLENE - An olefin compound with two carbon atoms and one double bond. It is a basic "building block" for other chemicals. Also called ethene.

EXCHANGE RATE - The value of one currency relative to the currency of another nation.

EXPENSES - Costs incurred in operating a company, such as rent, utilities, and salaries. Usually is separate from cost of goods sold.

EVA COPOLYMERS – The copolymer of ethylene and vinyl acetate that approach elastomeric materials in softness and flexibility yet can be processed like other thermoplastics. It is sometimes classified as a low density polyethylene.

EXTRACTION - A process in which the component in a solution or some other mixture is separated using a liquid (typically a solvent) with selective solvent characteristics.

FACTORS OF PRODUCTION - Resources used to create wealth. Traditionally defined as land, labor and capital but it also includes knowledge and entrepreneurship.

FATTY ALCOHOLS - Primary alcohols with 6 to 40 carbon atoms. They are manufactured in a variety of ways including synthetically and from natural oils.

FEEDSTOCK – In a general sense the physical components that are combined in production to produce a product; but the term is mainly used to refer to a gaseous or liquid hydrocarbon raw material such as ethane, propane, etc. derived from natural gas or naphtha , gas oil, etc. derived from oil refining that used to manufacture petrochemicals.

FINISHED GOODS – The final product of a manufacturing operation produced for commerce.

FINE CHEMICALS – Low-volume, high-value, homogenous compounds sold on the basis of specific, high-purity composition. Generally used to produce pharmaceuticals and to a lesser extent pesticides and dyes.

FIXED CAPITAL TURNOVER - The ratio of revenues divided by net fixed capital.

FIXED COSTS - Costs and expenses that remain the same no matter what production is. These costs do not vary with output.

FOB (FREE ON BOARD) - Commonly used when shipping goods to indicate who pays loading and transportation costs, and/or the point at which the responsibility of the goods transfers from shipper to buyer. FOB shipping is the term used when the ownership/liability of goods passes from the seller to the buyer at the time the goods cross the shipping point to be delivered. FOB destination designates that the seller is responsible for the goods until the buyer takes possession. This is important in determining who is responsible for lost or damaged goods when in transit from the seller to the buyer.

FORMULATION - The mixing of chemical products by blending, emulsification or other physical means to create new chemical compounds with desired properties, or to perform a desired function.

FRACTIONATION – A chemical process by which a chemical mixture is separated. See also Hydraulic Fracturing.

FRB – Acronym for the Federal Reserve Board.

FREE CASH FLOW - This measure of financial performance is equal to net income after taxes plus depreciation and amortization less the sum of capital expenditures and dividends.

FREE TRADE - The movement of goods and services among nations without economic, regulatory or political obstruction.

GAS - Compounds in a vapor state.

GAS OIL - A petroleum distillation faction containing hydrocarbons. It is used as feedstock for steam cracking and as fuel.

GREENFIELD PLANT – Capacity added to a site where none existed. Generally includes items such as roads, sewers, utilities, and other infrastructure that do not have to be added at existing plants.

GROSS MARGIN - The financial definition of gross margin is revenues less variable costs. The chemical industry, however, uses this term slightly differently; the net sales price minus the sum of raw material costs. Byproduct credits are not included, nor are variable production costs. Gross margin is sometimes referred to as the spread over raw materials.

GROUP - Elements that make up a column in the periodic table.

HENRY HUB – Not a 1930s cartoon character but the pricing point for natural gas futures on the New York Mercantile Exchange (NYMEX). This station (located in Louisiana) connects nine interstate and four intrastate gas pipelines. The Henry Hub price is generally viewed as the primary price for the North American natural gas market. The other pricing point is the Alberta Empress.

HOPPER CARS – A rail car designed for loading and unloading of plastic resins or other powder or pellet material.

HYDROCARBONS - Compounds containing only carbon and hydrogen atoms. Hydrocarbons are the basic raw materials for petrochemicals.

HYDRAULIC FRACTURING – A type of fractionation in which liquid is used to separate chemicals from rock formations. Also calling “fracking.”

INCOME STATEMENT - The financial statement that shows a company’s profit after costs, expenses, and taxes. It focuses on a period of time, usually one year and summarizes all of the resources coming into the company (revenues), all of the resources that have left the company, and the resulting net income (or loss).

INDUSTRIAL GASES – Gases used in industrial and manufacturing processes such as steel production, semiconductor manufacture, food processing, and other industrial activities. The most common industrial gases are oxygen, nitrogen, and argon.

INFLATION - A general rise in the prices of goods and services over time caused by a prolonged rise in the supply of money.

INJECTION MOLDING – A plastic processing technique in which molten plastic resin is injected in molten form into a mold. The plastic is then cooled and solidifies. Common uses include plastic models and cups.

INTANGIBLE ASSETS - Items of value such as patents, copyrights, knowledge, and brand that have no real physical form.

INTERMEDIATE - Obtained from bulk petrochemicals as the middle step in a series of chemical reactions, intermediates can be transformed into different end products.

INTELLECTUAL CAPITAL - Knowledge that can add value. It consists of the human capital of individuals (experience, know-how, skills, and creativity) as well as intellectual assets of the firm. The latter can include codified knowledge (processes, databases, programs, methods, designs, etc.) and intellectual property.

INTELLECTUAL PROPERTY - Intellectual assets such as patents, copyrights, trademarks and trade secrets that are legally protected.

INVENTORY TURNOVER - The ratio of cost of goods sold, divided by average inventory.

ION - An atom or group of chemically bound atoms that have either a positive or negative electrical charge.

JOINT VENTURE (JV) - A partnership between companies to undertake a major project or business.

KETONES - Not a 1950s male vocal group but oxygenated organic compounds (e.g., acetone) derived from secondary alcohols. These compounds contain carbonyl groups that are bonded to alkyl groups.

LEVERAGE - Raising funds through borrowing (including issuing bonds) to raise a company's rate of return.

LIABILITIES - What a company owes to others.

LICENSING - The sale of technology to an unrelated organization using a license that allows the buyer to use the technology.

LIQUEFIED NATURAL GAS (LNG) - Natural gas that has been cooled to -259˚ Fahrenheit (-161˚ Celsius) and at which point it is condensed into a liquid which is colorless, odorless, non-corrosive and nontoxic. LNG is characterized as a cryogenic liquid and in this form can be transported via specialized tankers.

LIQUEFIED PETROLEUM GASES (LPG) – A group of hydrocarbon-based gases derived from crude petroleum (or oil) refining or natural gas fractionation. These gases include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene. For convenience in transportation, these gases are liquefied through pressurization.

LIQUIDITY – A measure of how quickly an asset can be converted into cash.

LOGISTICS - The physical movement (or distribution) of goods from producers to industrial and consumer users.

LONG-TERM DEBT & OTHER LIABILITIES - These are liabilities such as loans from banks, leases, other long-term debt, etc. that must be paid after one year.

LOSS - When a company's costs and expenses are more than its revenues.

MARKET RESEARCH - The analysis of markets to determine opportunities and challenges.

MDI - Methylene diphenyl diisocyanate

MERCHANT WHOLESALERS - Independently-owned companies that take title to (or own) the goods they handle on behalf of manufacturers.

METALLOCENE - A compound in which a metal atom is suspended between two five-membered carbon rings that are typically joined together behind the metal atom. Metallocenes are used as catalysts in the polymerization of olefins.

METHANE - A gaseous straight-chain hydrocarbon containing one carbon atom.

METHYL - A chemical grouping with one carbon atom attached to an element or group.

MMA - Methyl methacrylate.

MOLECULE - Atoms of the same element or a combination of elements that are chemically bound together in a fixed proportion.

MONOMER - A molecule or groups of molecules that may be reacted by itself or with other chemicals to form various types and molecular chains known as polymers or co-polymers. Monomers tend to be rather simple, low weight molecules.

MONOPOLY - A market in which there is only one seller. Do not pass Go.

MTBE - Methyl tertiary-butyl ether.

NAMEPLATE CAPACITY – The capacity to produce a product based on annual design capacity, excluding scheduled turnarounds and maintenance.

NAPHTHA - Derived from crude oil, naphtha is a basic building block in the petrochemical industry. In addition to being the basis for gasoline, it is used as feedstock for steam cracking.

NATURAL GAS – A gaseous mixture of hydrocarbon compounds, the primary one being methane. Other compounds include ethane, propane, and other hydrocarbons.

NATURAL GAS LIQUIDS – Those hydrocarbons in natural gas that are separated from the gas as liquids through the process of absorption, condensation, adsorption, or other methods in gas processing or cycling plants. These liquids consist of propane and heavier hydrocarbons and are commonly referred to as condensate, natural gasoline, and liquefied petroleum gases. Natural gas liquids include ethane, propane, butane, isobutene and condensate (primarily pentanes).

NET ASSETS - The value of total assets less cash and other equivalent short-term assets.

NET FIXED CAPITAL - Depreciable and amortizable fixed assets (including construction in progress), plus land and mineral rights, less accumulated depreciation. It is also referred to as fixed capital.

NET WORKING CAPITAL - Current assets less current liabilities.

NET WORTH - The value of total assets less total liabilities.

NON-OPERATING INCOME - The income (or loss) received from investments either from earnings (or loss) on the investment or from capital gains (or losses) on the investment.

NONWOVEN - Textiles which are neither woven nor knit; typically manufactured by putting small fibers together in the form of a sheet or web, and then binding them either mechanically, with an adhesive, or thermally.

NYLON - A generic name for a family of long-chain polyamides having recurring amide groups as an integral part of the main polymer chain.

OECD – Acronym for the Organization for Economic Cooperation and Development.

OEM – Acronym for Original Equipment Manufacturer.

OLEFINS - Hydrocarbons containing one double bond in its structure. Double bonds are more reactive than the than the single bonds found in most fractions of crude oil and natural gas. Ethylene is the simplest olefin, with two carbon atoms. It is followed by propylene, with three carbon atoms and one double bond and then butylenes with four carbon atoms and one double bond.

OLIGOMERS - Short chain polymers consisting of less than 10 monomer units.

OPERATING MARGIN - Expressed as a percent. This measure of profitability is equal to income (or loss) from operations (revenues less depreciation, amortization, and other operating costs and expenses) divided by revenues.

OPERATING RATE – The ratio between actual production and nameplate capacity during a certain period of time, for a chemical plant.

ORGANIC CHEMICALS - Chemical compounds that contain carbon. The petrochemical industry relies on organic chemicals.

OUTSOURCING - The practice of assigning various functions or work such as accounting or plant maintenance, to outside organizations.

OXIDATION - A chemical reaction in which a substance combined with oxygen loses one or more electrons.

PH - A measure of the acidity and alkalinity of a solution. A pH of 7 is said to be neutral. The pH decreases as the solution become more acidic. Conversely, pH will increase as the solution becomes more basic.

PATENT - A legal document giving its owner/inventor exclusive rights to the invention for 17 years.

PESTICIDES - Substances used to kill or control living things that are considered pests. Pesticides include insecticides, fumigants, fungicides, herbicides, bactericides, rodenticides, etc.

PETROCHEMICAL - Substance derived from petroleum or natural gas.

PF RESINS - Phenol-formaldehyde resins

PLASTICIZER - Chemical compounds used to make polyvinyl chloride (PVC) and other polymers flexible.

POLYETHYLENE (PE) - A plastic resin made from many ethylene molecules linked together.

POLYMER - Generally composed of smaller molecules or monomers that are linked in chains. They are derived from simple monomers and feature a higher molecular weight.

POLYMERIZATION - A process in which very large polymer molecules are formed from smaller molecules. A catalyst is generally used.

POLYOLEFINS - Polymers (or plastic resins) made from light olefins (linear unsaturated hydrocarbons). The most common polyolefins are polyethylene and polypropylene.

POLYPROPYLENE (PP) - A polymer (or plastic resin) made from many propylene molecules linked together.

POLYSTYRENE (PS) – A polymer (or plastic resin) made from polymerizing styrene. Polystyrene can form either a clear, hard, crystalline plastic as seen in CD/DVD cases, or it can be expanded into a foam product commonly seen in coffee cups used in fast food operations. Expandable polystyrene is known as EPS.

POLYVINYL CHLORIDE (PVC) - A polymer (or plastic resin) made from the polymerization of vinyl chloride, its uses include vinyl siding, pipe and fittings, conduit, window profiles, and vinyl shower curtains. Most PVC is used in building and construction applications.

PRODUCT - Any physical (or tangible) good, service or idea that satisfies a want or need.

PRODUCT DIFFERENTIATION - The creation of real or perceived differences between what are basically the same products.

PRODUCT LIFE CYCLE - A theoretical model of what happens to sales and profits for a product or class of products over time.

PRODUCTION - The creation of finished goods and services using land, labor and capital, knowledge and entrepreneurship.

PROFIT - Earnings above what a company spends on salaries, other expenses and the cost of the goods sold.

PROPANE - A gaseous hydrocarbon containing three carbon atoms and derived from natural gas and petroleum.

PROPYLENE - An olefin compound derived from cracking petroleum hydrocarbons, it has three carbon atoms and is a basic “building block” for other chemicals. Also referred to as propene.

QUICK RATIO - The ratio of total current assets net of inventories divided by current liabilities.

REDUCTION - A chemical reaction that involves the gain of electrons.

RESIN – General term for polymerized synthetics or chemically modified natural resins used in making plastics.

RESTRUCTURING - A process whereby an industry is strengthened by being reshaped into a smaller number of stronger producers. In this process, weaker players divest their positions or shut down uneconomical capacity.

RETAINED EARNINGS - Income after taxes, less the dividends paid.

RETURN ON ASSETS - Expressed as a percent. This measure of profitability is equal to net income after taxes (or loss), divided by total assets.

RETURN ON EQUITY - Expressed as a percent. This measure of profitability is equal to net income after taxes (or loss) divided by shareholders’ equity.

RETURN ON FIXED CAPITAL - Expressed as a percent. This measure of profitability is equal to net income after taxes (or loss) divided by net fixed capital.

RETURN ON NET ASSETS - Expressed as a percent. This measure of profitability is equal to net income after taxes (or loss) divided by net assets.

RETURN ON REVENUES - Expressed as a percent. This measure of profitability is equal to net income after taxes (or loss), divided by revenues.

RETURN ON WORKING CAPITAL - Expressed as a percent. This measure of profitability is equal to net income after taxes (or loss), divided by working capital.

REVENUES - The value of cash received during a year from the normal course of business. It is equivalent to net sales, receipts, and operating revenues and can include other sources.

ROTOMOLDING - A process for manufacturing plastic finished goods. The resin is first placed inside a heated mold, and as the resin melts, the mold is rotated in three dimensions. The melted resin flows over all the surfaces of the mold, coating the mold and forming a hollow plastic shape.

ROW – Acronym for Rest of the World.

SALTS - Compounds formed by the reaction of acids and bases.

SAN - Styrene-acrylonitrile.

SB LATEX - Styrene-butadiene copolymer latexes.

SB RUBBER - Styrene-butadiene elastomers.

SBU - Acronym for Strategic Business Unit.

SHAREHOLDERS' EQUITY - The value of capital stock and other paid-in capital (less treasury stock) and retained earnings. Also referred to as net worth (total assets less total liabilities).

SERVICES - Intangible products such as insurance, electronic funds transfer, and legal or strategic advice.

SHIPMENTS - The net selling values, f.o.b. plant to the customer, after discounts and allowances and exclusive of freight and taxes) of all products shipped from an establishment. Includes miscellaneous receipts. Also referred to as turnover.

SOLUTION - Homogeneous mixture of two or more components, such as a gas dissolved in a gas or liquid, or a solid in a liquid. The term is also used to refer to a low pressure polyethylene production process that can manufacture both LLDPE and HDPE polymers.

SOLVENT – A substance that dissolves another substance.

SPECIALTY CHEMICALS – Low-volume, high-value compounds sold on the basis of what they do, not what they are. That is, their performance criteria. For this reason they are often referred to as performance chemicals. These are generally blended with other compounds according to proprietary formulations.

SUPPLY CHAIN MANAGEMENT - The comprehensive process of minimizing inventory and moving goods through the channels of distribution most effectively and efficiently using information technology (IT).

SURFACTANTS - Also referred to as surface-active agents, these compounds reduce the surface tension of water or the solvents that they are dissolved or the tension at the interface between liquids or a liquid and a solid surface. Surfactants include detergents, emulsifiers, wetting agents, etc.

SYNTHETIC FIBERS – Fibers that are not of natural origin but are prepared or made artificially. Also called manufactured fibers.

SYNTHESIS GAS - Mixtures of carbon monoxide and hydrogen used for manufacturing some petrochemicals. It is generally produced by steam reforming of hydrocarbons such as methane.

TAME - Tertiary-amyl methyl ether.

THERMOPLASTICS - Long-chained polymers that soften without chemical change when heated. As a result, they can be recycled. The long chained molecules slip if pushed or pulled. They are generally more flexible than thermosets.

THERMOSETS - A type of plastic; polymers that once formed by heat and pressure, cannot be resoftened or reshaped. As a result, they aren't generally recycled.

TOLL MANUFACTURING - An arrangement in which a company produces a product for a customer using the customer's process.

TOLUENE - This liquid compound contains seven carbon atoms, is an aromatic and is a "basic building block" for industrial chemicals.

TOTAL ASSET TURNOVER - The ratio of revenues divided by total assets.

UF RESINS - Urea-formaldehyde resins.

USGC – Acronym for the United States Gulf Coast. It encompasses the states of Texas, Louisiana, Mississippi, Alabama, and Florida.

UPSTREAM – The process or processes that feeds the process, product, or industry under consideration. For example, benzene and caprolactam are all upstream of nylon. In energy operations, this refers to the exploration and production of crude oil and natural gas.

UTILIZATION RATE – The production volume as a percent of (or relative) to capacity. It is also referred to as the operating rate.

VALUE ADDED - Total revenues of a company, less the cost of raw materials, components, and services. It measures the value which the company has added to these brought-in materials and services by its productive activities.

VALUE CHAIN - The sequence of linked activities that must be performed by various organizations to move goods from the source of raw materials to the ultimate customers.

VARIABLE COSTS - Those costs that vary according to the level of production/output.

WHOLESALER - A marketing and distribution intermediary that sells to other organizations.

WORKING CAPITAL – Measured in dollars, this is equal to current assets and includes cash, time and demand deposits, U.S. government and other short-term securities, trade accounts and trade notes receivable, and inventories.

WORKING CAPITAL TURNOVER - The ratio of revenues divided by working capital (or current assets).

WORLD-SCALE PLANT - A plant the size (or designed capacity) of which achieves full economies of scale. That is, the minimum efficient scale (MES) a term used in industrial organization to denote a plant that can produce such that its long run average costs are minimized.

XYLENES - This liquid compound is an aromatic, contains 8 carbon atoms, and takes on the three following forms: para-xylene, ortho-xylene, and meta-xylene.

YIELD - The portion of raw materials in a chemical process that ends up in the prime product rather than as lower value-added by-products or waste. It’s usually measured as percent but is sometimes measured as ratio (e.g., pounds of ethylene per pound of ethane).

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