INSTITUTE FOR HOMELAND SECURITY

Sam Houston State University

TEXAS CRITICAL INFRASTRUCTURE SUPPLY CHAIN PROTECTION

REACHING THE CHEMICAL INDUSTRY

Institute for Homeland Security

Sam Houston State University

Scott Lynn

December 2, 2022

Table of Contents

INTRODUCTION

The Homeland Security Institute of Sam Houston State University commissioned this paper as part of a series of papers regarding to help in marketing the need for Supply Chain *Preparation, Response, Resilience and Recovery* to the four Texas Critical Industries (Health Care, Energy, Chemical and Transportation).

Supply chain disruptions have occurred and will continue to do so – it is only a question of "when." They may come from natural disasters, industrial accidents, internal or external attackers, but they will come. Preparing for them is the best way to help Texas Critical Infrastructure stay online, in operation and prepared to serve the people of the state.

The purpose is to identify:

1) Texas Chemical Supply Chain requirements.
2) Chemical Supply Chain vulnerabilities and threats.
3) Typical sizes of Texas chemical facilities and sizes.
4) Resources to plan for Supply Chain Disruptions.
5) Existing resources available to the energy industry for supply chain protection.

Notes about this paper

1. We expect that large chemical plants are of sufficient size to have their own internal resources to protect their supply chains. Therefore, this paper is intended to be a general introduction to supply chain disruptions and their prevention, while providing resources smaller businesses may not be aware of.

2. Cyberattacks are perhaps the newest and most vibrant threat to chemical facilities. While (as an introduction) this document does not focuses extensively on them, the effect of cyberattacks should in no way be minimized.

SUPPLY CHAIN REQUIREMENTS AND VULNERABILITIES

What Are Supply Chains?

A useful definition of supply chain is a "linked set of resources and processes… that begins with the sourcing of products and services and extends through the design, development, manufacturing, processing, handling, and delivery of products and services to the acquirer.[1]

The goal of this paper is to alert readers to possible supply chain disruptions in the chemical industry - disruptions which might affect their ability to produce and supply finished goods. Therefore (in this document) the supply chain "definition" extends beyond input and output chemicals and includes aspects such as energy, equipment, people, and even the maintenance without which chemicals cannot be made. Therefore, for the purposes of this paper, the supply chain description is expanded to include both purchased goods and other process inputs required for operation. These include:

- Raw materials
- Chemicals used as catalysts or components to create finished goods
- Equipment
- Facilities
- Spare parts
- Maintenance
- People
- Information Systems
- Operational Technology (plant controls)

If a company's particular needs require it, the definition could be further expanded to include virtually anything needed to ensure business operation.

Supply Chain Requirements

Virtually all supply chain definitions include movement between various stages and linking them into an overall system. Chemical (and petroleum) plant supply chains require:

- Large volumes of product movement
- Deliveries timed to ensure balanced plant operation without excess storage requirements.
- End-to-end product tracking
- Consistent product quality
- Protection from product tampering
- Data security

[1] Risk Management Framework for Information Systems and Organizations; A System Life Cycle Approach for Security and Privacy, National Institute of Standards and Technology Special Publication 800-37 Revision 2, https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-37r2.pdf

THE TEXAS CHEMICAL INDUSTRY AS CRITICAL INFRASTRUCTURE

The petroleum and chemical industries are separate but inextricably linked. Most of the chemical industry supply chain relies on Texas oil and gas drilling (and imports from other states and countries). Oil & gas drilling is separate from but feeds both the petroleum and chemical manufacturing industries.

When the word "petrochemical" is used in this paper, it refers to chemicals obtained from petroleum or natural gas base products. "Chemical" products include both petroleum and non-petroleum-based products.

Texas Petroleum and Chemical Magnitude

After China, the United States is the second largest chemical manufacturer in the world. And Texas is far and away the largest US manufacturer of both petroleum and chemical products. For example:

- Texas is the top crude oil- and natural gas-producing state in the nation. In 2021, Texas accounted for 43% of the nation's crude oil production and 25% of its marketed natural gas production.

- Texas has the largest number of crude oil refineries and the most refining capacity of any state. The 31 petroleum refineries in Texas can process a combined total of almost 5.9 million barrels of crude oil per calendar day— 32% of the nation's refining capacity as of January 2021.[2]

- Texas leads the nation in energy consumption across all sectors and is the largest energy-consuming state in the nation. The industrial sector, including the state's refineries and chemical plants, accounts for more than half of the state's energy consumption and for 23% of the nation's total industrial sector energy use.

Economic Importance of the Chemical Industry

The 2017 total value of manufactured goods in Texas was approximately $575 billion. Petroleum refinery and chemical output for that same period was at $285 billion. Therefore, chemical manufacturing makes up almost half (49.6%) of total Texas manufacturing output.

NAICS Code	NAICS code description	Texas Shipment Values x ($1,000,000)	% of all Texas Mfg. Values
324	Petroleum and coal products	$155,628	27.1%
325	Chemical manufacturing	$129,235	22.5%
	Total revenues:	$284,863	49.6%

[2] US Energy Information Administration, Texas State Energy Profile, https://www.eia.gov/state/print.php?sid=TX

In 2017, Texas supplied nearly one-third of all of US petroleum and coal product manufacturing and 18% of all US chemical manufacturing.[3] Thus Texas petroleum and chemical production is also critical to the state and the entire country.

NAICS Code	NAICS code description	US Shipment Values x ($1,000,000)	Texas Shipment Values x ($1,000,000)	Texas % of US Values
324	Petroleum and coal products	$543,450	$155,628	28.60%
325	Chemical manufacturing	$735,936	$129,235	17.60%
	Total revenues:		$284,863	

Downstream Economic Effects Of Chemical Production

Downstream of actual manufacturing, the economy depends upon chemistry at four levels:

1. Actual production of chemicals themselves.
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.
4. Wholesale, retail and service industries based on chemistry-derived products. [4]

The values above include only the value of the petroleum and chemical products themselves. Additionally, many chemicals are part of manufacturing downstream products. In fact, the value that downstream customers are enabled to create by chemical industry sales has been estimated to multiply their initial value twenty-fold.[5]

Chemical Industry Employment

Chemical industry importance extends to Texas employment. In 2017, Chemical manufacturing employed over 90,000 people, approximately 12% of all Texas manufacturing jobs.

NAICS Code	NAICS code description	Texas Employees
324	Petroleum and coal products	23,669
325	Chemical manufacturing	68,268

[3] Economic Census, 2017: ECN Core Statistics Summary Statistics for the U.S., States, and Selected Geographies, 2017, https://data.census.gov/cedsci/

[4] 2022 Guide to The Business of Chemistry, p. 8.

[5] 2022 Guide to The Business of Chemistry, p. 11

Export and Import Trade

Petroleum and chemical products were the top two 2021 Texas exports.[6]

NAICS Code	NAICS Code Description	2021 Texas Exports (x $1,000)	2021 Rank
324	Petroleum and coal product	$55,748,095	1
325	Chemical manufacturing	$51,693,124	2
334	Computer & Electronic Products	$50,490,593	3

Imports from other countries through Texas were also significant, though lower in ranking.

NAICS Code	NAICS Code Description	2021 Texas Imports (x $1,000)	2021 Rank
324	Petroleum & Coal Products	$12,317,520	7
325	Chemicals	$15,639,947	5

This data indicates that chemical transportation in and out of Texas ports is also critical to both the Texas and US economies.

Summary

These numbers lead to three significant conclusions:

1. On a stand-alone basis, Chemical manufacturing are critical to both Texas' and the US economy and employment.

2. Chemical products are critical to virtually every manufacturing process.

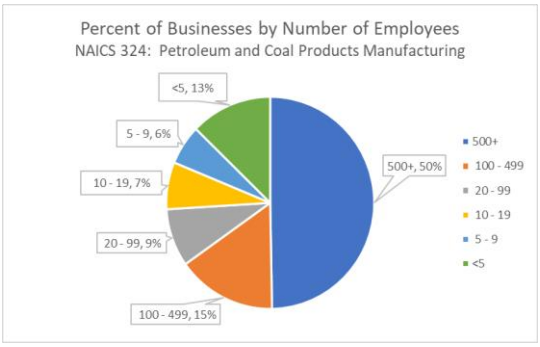
3. Because fuels are derived not just from wells but as a byproduct of refinery processing, losing US petroleum refining and chemical manufacturing would be disastrous to the economy.

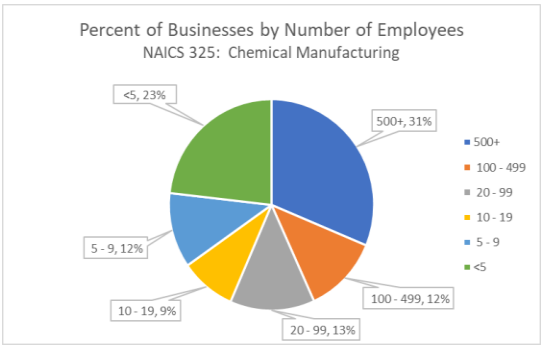
To describe Texas petroleum and chemical supply chains as "Critical Infrastructure" in Texas is no overstatement.

[6] US Census Bureau, USA Trade Online, accessed 11/10/2022

Chemical Business Sizes

From a “number of employees” perspective it appears there are more small businesses (with fewer than 500 employees) than large ones. Only 50% of petroleum and 31% of chemical manufacturers are large businesses.

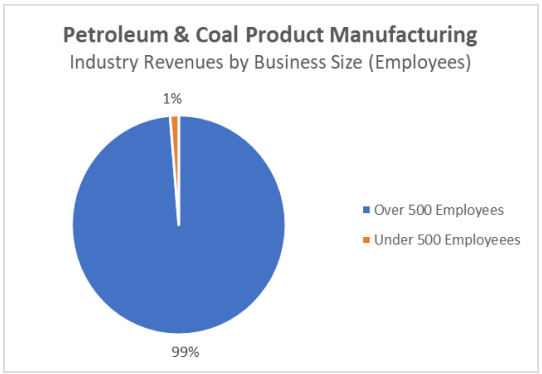


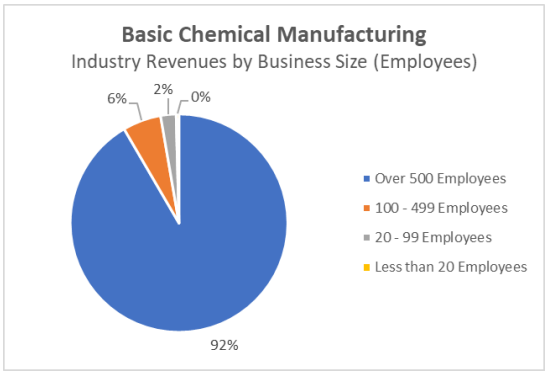


Number Of Petroleum and Chemical Manufacturing Businesses by Size

However, the requirements of sophisticated process equipment, capital investment and high production volumes lead chemical plants to be physically large size and to employ a large number of people.

Almost all (99%) petroleum refining revenues and 92% of chemical manufacturing revenues come from large businesses with over 500 employees. Large companies are the driving force of the chemical industry.





Petroleum and Chemical Manufacturing Revenues by Business Size

CHEMICAL ORIGINS AND USES

Organic Chemicals

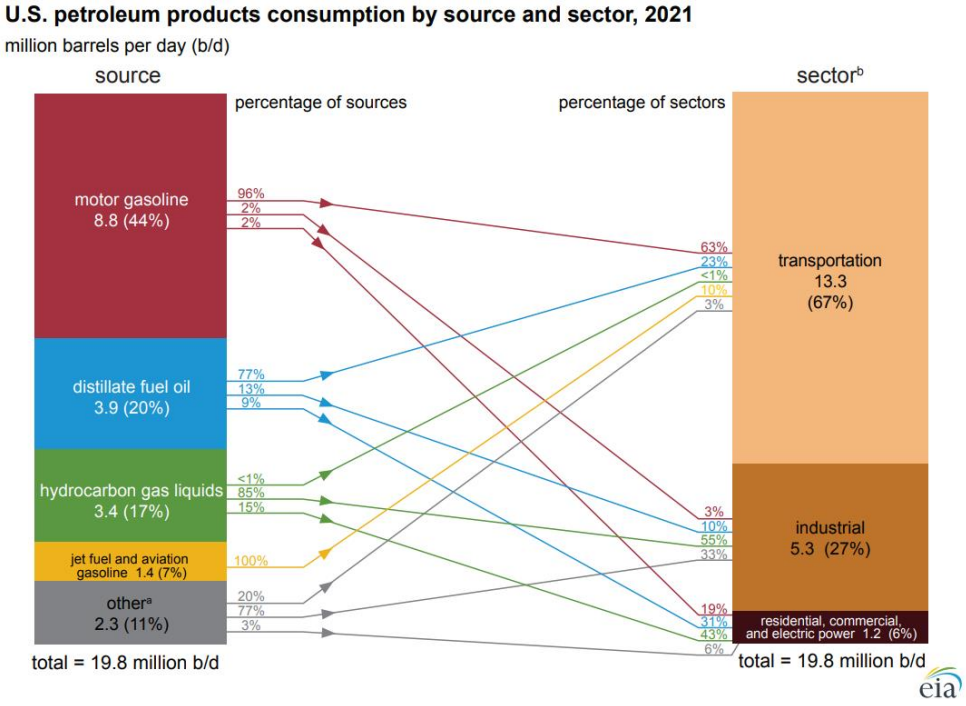
These are typically derived from petroleum products. In Texas, wells typically generate oil and natural gas.

As might be expected, the bulk of Texas chemical production has its roots in petroleum products. Gasoline, diesel fuel and heating oil are the top three uses, amounting to over 80% of petroleum product uses. These end uses of these products (below) show the importance of ensuring their supply chains are secure and the end products remain available. [7]

Finished motor gasoline*	44%
Distillate fuel oil (diesel fuel and heating oil) *	20%
Hydrocarbon gas liquids (HGLs)	17%
Kerosene-type jet fuel	7%
Still gas	3%
Asphalt and road oil	2%
Petrochemical feedstocks	1%
Lubricants	1%
Other (coke, aviation gas, waxes, kerosene, etc.) *	4%
Total	100%

* Includes biofuels in gasoline and in distillate fuels.
** Includes other liquids not included in the table.

The illustration below shows how petroleum products are consumed in the United States. [7]



[7] Oil and Petroleum Products Explained, US Energy Information Administration, https://www.eia.gov/energyexplained/oil-and-petroleum-products/use-of-oil.php, accessed 12/2/2022

Inorganic Chemicals

A related sector is inorganic chemicals (chemicals not made up of carbon atoms). In Texas, this industry is much smaller than the petroleum industry. In addition to other inorganically based products, Texas produces around 20% of basic inorganic chemicals in the United States.

Some inorganic products include:

- Gases: Hydrogen, chlorine, nitrogen, and oxygen, used for medical and industrial purposes, or to create other substances.
- Chlorine: This element is used to manufacture chemicals for water treatment, plastics such as PVC (polyvinyl chloride), fertilizers, insecticides, pharmaceuticals, and cleaners / sterilizers.
- Ammonia: Made of hydrogen and nitrogen, about 80% - 85% of ammonia is used to make nitrogen-based fertilizers. This makes it one of the widest chemical uses worldwide.
- Dyes: Along with pigments, these are used to color other materials or substances. *Note however that not all dyes and pigments are inorganic*.
- Others: Nitric, phosphoric, and sulfuric acid, lime, sodium bicarbonate, sulfur, etc.

It is important to note that organic chemicals are often used to create inorganic ones, and vice-versa. For instance, ammonia is made up of hydrogen and nitrogen. The hydrogen used to make ammonia typically comes from natural gas (an organic chemical).

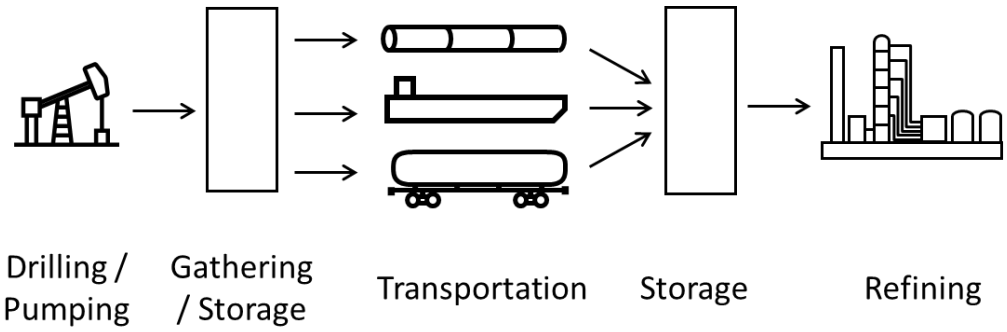
CHEMICAL INDUSTRY SUPPLY CHAINS

Chemical manufacturing may only require a few “ingredients”, but they typically require them in high volumes, and the many uses of chemicals lead to highly complex supply chains.

The chemical industry supply chains may be described as upstream and downstream supply chains.

Both require storage, transportation, and related logistics to deliver products from their start points to end points. Each of these steps creates its own unique security requirements to protect the product and its supply, security, purity, and traceability.

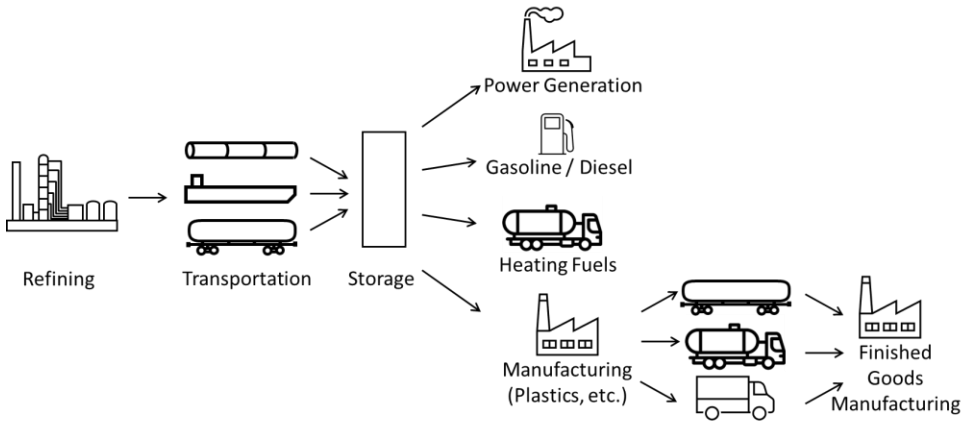
Upstream chemical Supply Chain (using petroleum as feedstock)



The upstream supply chain involves the acquisition of crude oil, and includes exploration, production, and delivering crude oil from wells to refineries. Typically, refineries create chemicals from crude oil, whether for other use in manufacturing or fuels for transportation and heating use.

Downstream chemical supply chain

The downstream side is more complex. Chemicals have many paths they might take in route to a final product. Depending on the process, the downstream supply chain can involve transportation, direct consumption, further refining, or processing to create “raw materials” for other manufacturing, and storage and transportation.



CHEMICAL INDUSTRY SUPPLY CHAIN VULNERABILITIES

As described above, Texas petroleum and chemical manufacturing are critical to the United States. This makes any event disrupting their supply chains a major security concern to the entire country.

These concerns are magnified by the geographic density of Texas chemical manufacturing. While much of Texas petroleum production is statewide and in rural areas, most refining and production capability is grouped around the Houston area. Therefore, geographically widespread events can dramatically affect the industry. These can include weather, power grid, or physical attacks using weapons of mass disruption (nuclear, chemical, or biological weapons)

Of all 1,259 basic chemical manufacturing companies in Texas, 618 are grouped around Houston. These represent 44% of US base petrochemical capacity.[8] Likewise, two of 12 LNG Import Terminals for the country are with 60 miles of Houston[9] This renders a significant amount of Texas petroleum and chemical manufacturing vulnerable to a area-wide disruptions.

Note that other areas of the chemical industry one might not wish disrupted include:

- Plastic packaging materials
- Pharmaceuticals and medicines
- Paint
- Soaps
- Plastic pipe and fittings
- Toilet preparations
- Adhesives
- Polystyrene and urethane foams
- Industrial gases
- Pesticides
- Plastic bottles
- Fertilizers
- Explosives

The availability of many of these items are taken for granted. But as can be imagined, disruption in their supply chains, leading to unavailability of the products, will have significant effects on the ordinary lives of people.

---

[8] Chemical Industry Overview, Chemical Industry Overview, Greater Houston Partnership, 4/26/21, https://www.houston.org/houston-data/chemical-industry-overview.

[9] https://www.cisa.gov/sites/default/files/publications/2019-CSSS-USCG-Hazard-Cargo-508.pdf, p. 19

Sources of Supply Chain Disruptions

For purposes of this paper, the following supply chain vulnerabilities are generally divided into Natural Disasters, "Bad Actors", and Economic.

Natural Disasters

For purposes of this paper, this list includes pandemics in the category.

Natural disasters historically have caused most disruptions to the chemical supply chain. Examples include:

1. Polypropylene and polyethylene are used to make food packaging, appliances, car parts and a plethora of other items – including N95 masks.

   Covid lockdowns started reducing polypropylene and polyethylene production. Then a hurricane shut down 10% to 15% of us PE and PP production. The combined effect was reduced supplies of raw materials and finished goods, and increased prices for both.

2. In 2017, Hurricane Harvey impacted Texas chemical manufacturing.[10]

   a. 54% of ethylene production and 36% of ethylene consumption went off-line.
   b. Flooding limited BASFs ability to restore operations in Port Arthur and Freeport.
   c. BNSF Railway reporting flood-related outages from the hurricane.

3. In February 2021, Winter Storm Uri cut the state's production of natural gas by nearly half, with olefins – essential chemical building blocks – by 80 percent.[1] The Gulf Coast's chemical manufacturing industry was disrupted for months.[11]

Bad Actors

The chemical supply chain is a major target for potential "bad actors." They know attacks on the supply chains can result in:

- Fuel and other Shortages
- Explosions
- Loss of products required for health purposes
- Economic disruptions
- Toxic releases / pollution / Unsafe environments

While there have been no

Cyberattacks

The primary source of attacks on the chemical industry, cyberattacks have become a "catch-up" issue for chemical manufacturers. Targets have included manufacturing processes,

---

[10] Houston's Chemical Industry Rebounds From Harvey, Chemical & Engineering News, Melody Bomgardner, Alex Tullo, September 7, 2017, https://cen.acs.org/articles/95/i36/Houstons-chemical-industry-rebounds-Harvey.html

[11] https://comptroller.texas.gov/economy/economic-data/supply-chain/2021/chem.php

products, and information. Supply chains in multiple industries have been attacked repeatedly. Examples of successful supply chain cyberattacks (not necessarily chemical) include:[12],[13]

1. In 2008, US investigators found that "A large amount of Lenovo laptops were sold to the U.S. military that had a chip encrypted on the motherboard that would record all the data that was being inputted into that laptop and send it back to China."

2. In 2013, a data breach at Target, led to the theft of data on 40-million credit and debit cards. It is believed that a Heating, Cooling and Air Conditioning (HVAC) vendor supplied equipment to Target with internet connectivity. The idea was for the vendor to be able to provide better service by monitoring Target's HVAC systems. Target network connection information was stolen from the vendor, allowing the thieves to access Target's HVAC system then move from there into payment systems.

3. In 2015, the Federal Bureau of Investigation warned multiple companies those Chinese operatives had concealed an extra chip loaded with backdoor code in servers ordered by a US manufacturer.

4. The Colonial Pipeline ransomware attack in April 2021 led to a halt in pipeline flow for several days on a line supplying 45% of US East Coast fuel. Several other recent cyberattacks have focused on IT security providers with huge, multinational client lists.

5. In 2022 Russian cyberattacks hit plants in Saudi Arabia and Ukraine, disrupting petroleum supplies and electricity deliveries.

6. In February 2022, Toyota had to suspend operations in all 14 of their Japan plants after a cyberattack on their supplier Kojima Industries and their order management system.

Physical Attacks on Plants and Carriers

Physical attacks can occur during refining, storage, or transportation, causing human casualties, physical destruction, and supply chain disruption.

Several physical attacks on petroleum plants and carriers have been documented, particularly targeting Saudi Arabia and Ukraine.

Petroleum companies ship or transport by other means a great deal of hazardous products. Supply chain partners must be aware of the locations of each shipment at any point in time. Transportation vulnerability points exist across all supply chain points, including: [14]

---

[12] The Long Hack: How China Exploited a U.S. Tech Supplier, Jordan Robertson and Michael Riley, Bloomberg, February 12, 2021, https://www.bloomberg.com/features/2021-supermicro/?leadSource=uverify%20wall

[13] A 'Worst Nightmare' Cyberattack: The Untold Story Of The SolarWinds Hack, Dina Temple-Raston, April 16, 2021, https://www.npr.org/2021/04/16/985439655/a-worst-nightmare-cyberattack-the-untold-story-of-the-solarwinds-hack

[14] Chemical Supply Chain (CSC) https://www.cisa.gov/sites/default/files/publications/2019-CSSS-Risk-Theft-Diversion-508.pdf, p. 9.

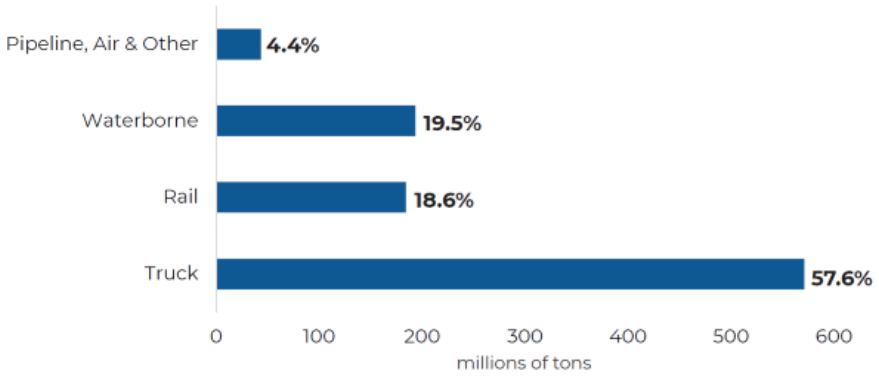
Pipelines Often remote and unprotected.

Rail lines Also often remote and unprotected.

Ships Many Middle Eastern attacks have occurred on ships whether at sea or in port. The Houston Ship Channel has long been considered a primary target for terrorists wanting to attack the United States. An explosion or chemical release here could have horrific effects.

Truck As can be seen in the chart below, most chemicals are ultimately moved via truck, creating (again) and unprotected opportunity.[15]

Figure 12.1 - Transportation by Mode (Volume of Chemical Shipments), 2021



While truck attacks may not have the same widespread impact as a larger target, they still can affect larges areas, especially if the cargo is highly toxic or if the attack occurs in or near an urban area.

Economic Supply Chain Threats

Note: Greenhouse gas reduction is listed here because moving away from greenhouse gases will dramatically affect both the Texas petroleum and chemical industries and their supply chains.

Greenhouse Gas Reduction

US and international "decarbonization" efforts offer an existential threat to Texas largest manufacturing industries. Those efforts require changes in feedstocks, manufacturing processes, energy consumption, and other areas. Decarbonization will lead to dramatic restructuring of the industry, creating fundamental shifts to the Texas economy.

Whether one subscribes to the effects of greenhouse gases on the environment, the concern over the chemical industry's contribution to their generation is valid.

---

[15] 2022 Guide to the Business of Chemistry, p. 84.

- Per Deloitte, LLP, the "chemical industry produces millions of metric tons of energy-intensive products, relying almost exclusively on fossil hydrocarbons as inputs."

- Ten percent of all fossil fuels produced are consumed by the chemical industry.

- With demand growth increasing, emissions are expected to double by 2050 unless abated.

- Over 200,000,000 metric tons of carbon dioxide equivalent (4% of total US emissions) come from either chemical industry direct emissions or indirectly from purchased electricity and steam.[16]

Navigating the reduction in demand for fossil fuels will require tremendous readjustment of the Texas economy.

Environmental Regulation

Per the Texas comptroller's office, "The environmental impact of the chemical industry is under greater scrutiny than ever before." "…oil and gas and the chemical industry will face new supply, shipping, and quality control constraints as they keep up with evolving regulations around the world." [17]

Trade Disputes

In 2018, plastic and chemical shipments were caught up in the trade battle between the United States and China, with many substances getting hit with 25 percent tariffs for several months.

Energy consumption

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).[18]

International Supply chains

As might be imagined, international supply chains raise questions of security, economics and port congestion, which can be expected to continue, with effects on costs and lead times.[19]

Domestic Supply Chains

While not typically considered, "locally" acquired items such as energy, water, and maintenance parts should be recognized as critical to plant operation.

---

[16] For the Chemical Industry, a Path to Lower Emissions and Sustainable Growth, Linda Holland, Deloitte Insights in the Wall Street Journal, July 20, 2022, https://deloitte.wsj.com/articles/for-the-chemical-industry-a-path-to-lower-emissions-and-sustainable-growth-01658336034?mod=djemclimate

[17] Chemical Manufacturing Supply Chain, https://comptroller.texas.gov/economy/economic-data/supply-chain/2021/chem.php, accessed November 29, 2022

[18] 2022 Guide to The Business of Chemistry, p. 93.

[19] The State Of The Chemical Industry—It Is Getting More Complex, November 10, 2020, https://www.mckinsey.com/industries/chemicals/our-insights/the-state-of-the-chemical-industry-it-is-getting-more-complex

PLANNING FOR SUPPLY CHAIN DISRUPTIONS

Risk Assessment and Prioritization

Note: With the apparent rapid growth in threats, it is tempting to try to address the most recent ones found in the news. A good security program will ensure both traditional and new threats are dealt with, assessing the risk associated with each.

Resilience Planning begins with Leadership determining to act on threats to a company and its supply chains. It then extends to assessing the risk posed by various threats, then deciding what to do about them. Finally, a company must implement any actions they decide to take.

Leadership

Implementing a network-wide security program requires not only top-down leadership, but ensuring the message is commonly understood at all levels of a company.

Different sub-organizations or division have discrete needs, wants, vulnerabilities and interest in protecting the greater organization. Therefore, leadership must drive not only the message of Preparedness, Responsiveness and Resiliency, but ensure the various divisions or departments understand how their actions contribute to the security of the entire organization.

In a presentation to the 2019 CISA Chemical Sector Security Summit, Gary Davis identified several key steps in helping alert international companies regarding protecting their supply chains.[20] Some of those identified the importance of:

- Ensuring each department leader understands the security needs of their area or department.
- Ensuring leadership understands feedback from employees reflecting their concerns regarding supply chains or security.
- When "top-down" messages are created, communicate them in language employees understand. Leadership must speak the "language" of their employees, or ensure the employees understand the language used by leadership.

It is also important to remember that business leadership is responsible to protect bottom line profitability. This should be remembered when proposing security plans. If solutions are more costly than their risk prevention value, they are unlikely to be implemented without outside incentives (financial or regulatory).

---

[20] Presentation: International Supply Chain Protection Challenges and Solutions, CISA Chemical Sector Security Summit 2019, https://www.cisa.gov/sites/default/files/publications/2019-CSSS-Intl-Supply-Chain-Challenges-508.pdf

Supply Chain Risk Assessment

Generally, risk assessment includes three factors shown in a general (and simple) equation used by the Federal Emergency Management Agency (FEMA): [21]

Risk = Asset Value x Threat Rating x Vulnerability Rating

Asset Value	=	The value of what you are trying to protect.
Threat Rating	=	The probability or likelihood that an attack or disruption will occur.
Vulnerability Rating	=	An assessment of how vulnerable the organization is to a threat.

A supply chain risk assessment evaluates supply chain vendors, internal processes and customers, and the effect disruptions at each step might have on the business. For example:

Asset value

"Assets" include raw materials, production equipment, information and finished goods. They also include sales revenue and reputation. To protect these, one must understand and quantify their value. One must also understand how supply chain disruptions will affect them.

Threat rating

With each vulnerability, how likely are any of these threats to occur? Is each a high, medium, or low probability?

Vulnerability rating

- Are vendors reliable to deliver what they promised?
- Are international suppliers in countries potentially hostile to the United States?
- Do vendors require access to company data infrastructure (some companies use customer networks to monitor equipment or consumables they supply)?
- Are vendor systems protected?
- Is data available for customer ordering separate from company data systems?
- Is vendor-supplied software secure from other parties which might corrupt it?

With an analysis complete, an organization should then be able to prioritize what threat or threats to address first.

Several tools are available to help organizations evaluate risk to their operation. Some of them, along with references to different regulating or advisory agencies, are referenced in Appendix 1.

---

[21] Building Design for Homeland Security, Unit V, Risk Assessment, Risk Management; Federal Emergency Management Agency; accessed November 30, 2022 https://www.fema.gov/pdf/plan/prevent/rms/155/e155_unit_v.pdf

Acting on Risks

An organization may or may not choose to act on each threat. It might:

- Act to protect itself.
- Decide not to act and let insurance will take care of it
- Accept that the threat could happen and accept the consequences.

Regardless of the action taken, internal and external communication to understand how to implement risk reduction is important.

Departments preparing for resilience cannot work in isolation and expect their actions to work well for the rest of the organization. It is understood that each department will have its own security concerns. Examples include:

- Finance will want to ensure assets are protected and properly accounted for.
- Legal may focus on ensuring regulatory issues regarding purchased or sold products, liability for products, and ensuring contract terms will be met.
- IT must balance providing data security with ordering information sent to suppliers and making inventory data available to customers.
- Human Resources must ensure employees are properly screened and trained as are vendor personnel working on a company's site.

It is important to ensure the various departments work together to develop practices that don't adversely affect others or develop new practices when necessary. Ideally, security solutions can be developed that protect both company security and departmental needs.

But again, training employees to understand how their actions affect the needs of other departments (and the company) will help provide both smooth business operation and help ensure employee accountability for security.

APPENDIX 1: SECTOR RESOURCE WEB SITES

Texas Commission on Environmental Quality

Homeland Security Office

"The TCEQ has regulatory authority over several of the federal and state identified critical infrastructures and key resources (CI/KR), including water supply systems, wastewater treatment plants, chemical plants, low level radioactive waste, refineries, and dams."
The site is primarily focused on natural disasters and includes links to appropriate resources.
https://www.tceq.texas.gov/response/security

Department Of Homeland Security

Disaster planning

DHS planning for resilience to natural disasters.
https://www.dhs.gov/topics/disasters

Terrorism prevention

Links to DHS pages providing information on terrorism prevention, including Weapons of Mass Destruction (WMDs), Improvise Explosive Devices (IEDs) and related topics.
https://www.dhs.gov/topics/preventing-terrorism

Resilience

DHS home page for information regarding putting resilience to disruptions into practice
https://www.dhs.gov/topics/resilience

Cybersecurity & Infrastructure Security Agency (Cisa)

CISA is a federal agency tasked specifically with protecting US infrastructure. They administer several chemical industry-specific programs as shown below.

CISA Site (chemical-specific):

https://www.cisa.gov/chemical-security

Chemical Sector Resources

A listing of CISA resources regarding Chemical Security
https://www.cisa.gov/chemical-sector-resources

Chemical Facility Anti-Terrorism Standards (CFATS)

CFATS is a regulatory program focused specifically on terrorism security at high-risk chemical facilities.
https://www.cisa.gov/chemical-facility-anti-terrorism-standards

Chemlock
A voluntary, no-cost program to provide facilities possessing dangerous chemicals "services and tools to help them better understand the risks they face and improve their chemical security posture in a way that works for their business model."
https://www.cisa.gov/chemlock

Chemical Security Assessment Tool (CSAT)
CSAT is an online portal to surveys and applications facilities must submit to CISA to determine which facilities are considered high-risk under CFATS.

https://www.cisa.gov/chemical-security-assessment-tool

Unmanned Aircraft
"Protecting Against the Threat of Unmanned Aircraft Systems" This document discusses "best practices" for protection against UAVs.
https://www.cisa.gov/sites/default/files/publications/Protecting%20Against%20the%20Threat%20of%20Unmanned%20Aircraft%20Systems%20November%202020_508c.pdf

Cybersecurity
CISA Home page for Cybersecurity.
https://www.dhs.gov/topics/cybersecurity

Surface Transportation Cybersecurity Toolkit
CISA "collection of documents designed to provide cyber risk management information to surface transportation operators who have fewer than 1,000 employees."
https://www.tsa.gov/for-industry/surface-transportation-cybersecurity-toolkit

Transportation Security Agency (TSA)

Surface Transportation Security Training
TSA requires "owner/operators of higher-risk freight railroad carriers… to provide TSA-approved security training to employees who perform security-sensitive functions."
https://www.tsa.gov/for-industry/surface-security-training-rule

Intermodal Security Training and Exercise Program (I-STEP)
This is a training and risk-assessment program developed by the TSA. It is a cross-industry platform to help public and private sector entities plan security and develop exercises to evaluate it. The Exercise Information System (EXIS) tool helps users plan these exercises.

I-STEP
https://www.tsa.gov/for-industry/intermodal-security-training-and-exercise-program

Exercise Information System (EXIS)
https://www.tsa.gov/for-industry/exercise-information-system

US Coast Guard

This web page provides access to US Coast Guard Ports and Cargoes regulations.
https://www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Inspections-Compliance-CG-5PC-/cgfac/

Training And Education

Sam Houston State University

SHSU offers Masters and Bachelors level programs in homeland security.

Master of Science (in person or online)
https://www.shsu.edu/programs/graduate/homeland-security-studies/
Bachelor of Arts / Bachelor of Science (online)
https://www.shsu.edu/programs/bachelor-degree-in-homeland-security-studies/

Texas A&M

The Texas A&M Homeland Security program provides a variety of degree and certificate programs.
https://teex.org/homeland-security/

APPENDIX 2: NAICS DEFINITIONS

The North American Industry Classification System, or NAICS, is published in the United States by the Office Of Management And Budget. These classifications are included to help better understand the breadth of the chemical industry and identify potential targets to protect. Following are 2022 definitions as found online at:

Lookup by topic or NAICS number:
https://www.census.gov/naics/

PDF for view or download
https://www.census.gov/naics/reference_files_tools/2022_NAICS_Manual.pdf

Four-Digit NAICS Categories

3241 Petroleum and Coal Products Manufacturing

3251 Basic Chemical Manufacturing
This industry group comprises establishments primarily engaged in manufacturing chemicals using basic processes, such as thermal cracking and distillation. Chemicals manufactured in this industry group are usually separate chemical elements or separate chemically defined compounds.

3252 Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing
This industry group comprises establishments primarily engaged in one of the following: (1) manufacturing synthetic resins, plastics materials, and non-vulcanizable elastomers and mixing and blending resins on a custom basis; (2) manufacturing non-customized synthetic resins; (3) manufacturing synthetic rubber; (4) manufacturing cellulosic (e.g., rayon, acetate) and non-cellulosic (e.g., nylon, polyolefin, polyester) fibers and filaments in the form of monofilament, filament yarn, staple, or tow; or (5) manufacturing and texturizing cellulosic and non-cellulosic fibers and filaments.

3253 Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
This industry group comprises establishments primarily engaged in one or more of the following: (1) manufacturing nitrogenous or phosphatic fertilizer materials; (2) manufacturing fertilizers from sewage or animal waste; (3) manufacturing nitrogenous or phosphatic materials and mixing with other ingredients into fertilizers; (4) mixing ingredients made elsewhere into fertilizers; and (5) formulating and preparing pesticides and other agricultural chemicals.

3254 Pharmaceutical and Medicine Manufacturing

3255 Paint, Coating, and Adhesive Manufacturing
This industry group comprises establishments primarily engaged in one or more of the following: (1) mixing pigments, solvents, and binders into paints and other coatings; (2) manufacturing allied paint products; and (3) manufacturing adhesives, glues, and caulking compounds.

3256 Soap, Cleaning Compound, and Toilet Preparation Manufacturing
This industry group comprises establishments primarily engaged in (1) manufacturing and packaging soaps, detergents, polishes, surface active agents, textile and leather finishing agents, and other sanitation goods or (2) preparing, blending, compounding, and packaging toilet preparations.

3259 Other Chemical Product and Preparation Manufacturing
This industry group comprises establishments primarily engaged in manufacturing chemical products (except basic chemicals; resins, synthetic rubber, cellulosic and non-cellulosic fibers, and filaments; pesticides, fertilizers, and other agricultural chemicals; pharmaceuticals and medicines; paints, coatings, and adhesives; soaps and cleaning compounds; and toilet preparations).

Five-Digit NAICS Categories

32411 Petroleum Refineries
See industry description for 324110.

32412 Asphalt Paving, Roofing, and Saturated Materials Manufacturing
This industry comprises establishments primarily engaged in (1) manufacturing asphalt and tar paving mixtures and blocks and roofing cements and coatings from purchased asphaltic materials and/or (2) saturating purchased mats and felts with asphalt or tar from purchased asphaltic materials.

32419 Other Petroleum and Coal Products Manufacturing
This industry comprises establishments primarily engaged in manufacturing petroleum products (except asphalt paving, roofing, and saturated materials) from refined petroleum or coal products made in coke ovens not integrated with a steel mill.

Illustrative Examples:
Biodiesel fuels not made in petroleum refineries and blended with purchased refined petroleum
Coke oven products (e.g., coke, gases, tars) made in coke oven establishments
Petroleum brake fluids made from refined petroleum
Petroleum briquettes made from refined petroleum
Petroleum jelly made from refined petroleum
Petroleum lubricating oils and greases made from refined petroleum
Petroleum waxes made from refined petroleum
Re-refining used petroleum lubricating oils

32511 Petrochemical Manufacturing
See industry description for 325110.

32512 Industrial Gas Manufacturing
See industry description for 325120.

32513 Synthetic Dye and Pigment Manufacturing
See industry description for 325130.

32518 Other Basic Inorganic Chemical Manufacturing
See industry description for 325180.

32519 Other Basic Organic Chemical Manufacturing
This industry comprises establishments primarily engaged in manufacturing basic organic chemicals (except petrochemicals, industrial gases, and synthetic dyes and pigments).

Illustrative Examples:
Biodiesel fuels not made in petroleum refineries and not blended with petroleum
Carbon organic compounds, not specified elsewhere by process, manufacturing
Cyclic intermediates made from refined petroleum or natural gas (except aromatic petrochemicals)
Enzyme proteins (i.e., basic synthetic chemicals) (except pharmaceutical use) manufacturing
Fatty acids (e.g., margaric, oleic, stearic) manufacturing
Gum and wood chemicals manufacturing
Organo-inorganic compound manufacturing
Plasticizers (i.e., basic synthetic chemical) manufacturing
Silicone (except resins) manufacturing
Synthetic sweeteners (i.e., sweetening agents) manufacturing

32521 Resin and Synthetic Rubber Manufacturing
This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing synthetic resins, plastics materials, and non-vulcanizable elastomers and mixing and blending resins on a custom basis; (2) manufacturing non-customized synthetic resins; and (3) manufacturing synthetic rubber.

32522 Artificial and Synthetic Fibers and Filaments Manufacturing
See industry description for 325220.

32531 Fertilizer Manufacturing
This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing nitrogenous or phosphatic fertilizer materials; (2) manufacturing fertilizers from sewage or animal waste; (3) manufacturing nitrogenous or phosphatic materials and mixing with other ingredients into fertilizers; and (4) mixing ingredients made elsewhere into fertilizers.

32532 Pesticide and Other Agricultural Chemical Manufacturing
See industry description for 325320.

32541 Pharmaceutical and Medicine Manufacturing
This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing biological and medicinal products; (2) processing (i.e., grading, grinding, and milling) botanical drugs and herbs; (3) isolating active medicinal principals from botanical drugs and herbs; and (4) manufacturing pharmaceutical products intended for internal and external consumption in such forms as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

32551 Paint and Coating Manufacturing
See industry description for 325510.

32552 Adhesive Manufacturing
See industry description for 325520.

32561 Soap and Cleaning Compound Manufacturing
This industry comprises establishments primarily engaged in manufacturing and packaging soaps and other cleaning compounds, surface active agents, and textile and leather finishing agents used to reduce tension or speed the drying process.

32562 Toilet Preparation Manufacturing
See industry description for 325620.

32591 Printing Ink Manufacturing
See industry description for 325910.

32592 Explosives Manufacturing
See industry description for 325920.

32599 All Other Chemical Product and Preparation Manufacturing
This industry comprises establishments primarily engaged in manufacturing chemical products (except basic chemicals, resins, and synthetic rubber; cellulosic and non-cellulosic fibers and filaments; pesticides, fertilizers, and other agricultural chemicals; pharmaceuticals and medicines; paints, coatings, and adhesives; soaps, cleaning compounds, and toilet preparations; printing inks; and explosives).

Illustrative Examples:
Activated carbon and charcoal manufacturing
Antifreeze preparations manufacturing
Custom compounding (i.e., blending and mixing) of purchased plastics resins
Electronic cigarette vapor refills manufacturing
Industrial salt manufacturing
Matches and matchbook manufacturing
Photographic chemicals manufacturing
Pyrotechnics (e.g., flares, flashlight bombs, signals) manufacturing
Sugar substitutes (i.e., synthetic sweeteners blended with other ingredients) made from purchased synthetic sweeteners
Swimming pool chemical preparations manufacturing
Writing inks manufacturing

Six-Digit NAICS Categories

324110 Petroleum Refineries
This industry comprises establishments primarily engaged in refining crude petroleum into refined petroleum. Petroleum refining involves one or more of the following activities: (1) fractionation; (2) straight distillation of crude oil; and (3) cracking.

324121 Asphalt Paving Mixture and Block Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing asphalt and tar paving mixtures and blocks from purchased asphaltic materials.

324122 Asphalt Shingle and Coating Materials Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) saturating purchased mats and felts with asphalt or tar from purchased asphaltic materials and (2) manufacturing asphalt and tar and roofing cements and coatings from purchased asphaltic materials.

324191 Petroleum Lubricating Oil and Grease Manufacturing
This U.S. industry comprises establishments primarily engaged in blending or compounding refined petroleum to make lubricating oils and greases and/or re-refining used petroleum lubricating oils.

324199 All Other Petroleum and Coal Products Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing petroleum products (except asphalt paving, roofing, and saturated materials and lubricating oils and greases) from refined petroleum and coal products made in coke ovens not integrated with a steel mill.

Illustrative Examples:
Biodiesel fuels not made in petroleum refineries and blended with purchased refined petroleum
Coke oven products (e.g., coke, gases, tars) made in coke oven establishments
Petroleum briquettes made from refined petroleum
Petroleum jelly made from refined petroleum
Petroleum waxes made from refined petroleum

325110 Petrochemical Manufacturing
This industry comprises establishments primarily engaged in (1) manufacturing acyclic (i.e., aliphatic) hydrocarbons such as ethylene, propylene, and butylene made from refined petroleum or liquid hydrocarbons and/or (2) manufacturing cyclic aromatic hydrocarbons such as benzene, toluene, styrene, xylene, ethyl benzene, and cumene made from refined petroleum or liquid hydrocarbons.

325120 Industrial Gas Manufacturing
This industry comprises establishments primarily engaged in manufacturing industrial organic and inorganic gases in compressed, liquid, and solid forms.

325130 Synthetic Dye and Pigment Manufacturing
This industry comprises establishments primarily engaged in manufacturing synthetic organic and inorganic dyes and pigments, such as lakes and toners (except electrostatic and photographic).

325180 Other Basic Inorganic Chemical Manufacturing

This industry comprises establishments primarily engaged in manufacturing basic inorganic chemicals (except industrial gases and synthetic dyes and pigments).

Illustrative Examples:
Alkalis manufacturing
Aluminum compounds, not specified elsewhere by process, manufacturing
Carbides (e.g., baron, calcium, silicon, tungsten) manufacturing
Carbon black manufacturing
Chlorine manufacturing
Hydrochloric acid manufacturing
Potassium inorganic compounds, not specified elsewhere by process, manufacturing
Radioactive isotopes manufacturing
Sulfides and sulfites manufacturing
Sulfuric acid manufacturing

325193 Ethyl Alcohol Manufacturing

This U.S. industry comprises establishments primarily engaged in manufacturing non-potable ethyl alcohol.

325194 Cyclic Crude, Intermediate, and Gum and Wood Chemical Manufacturing

This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) distilling wood or gum into products, such as tall oil and wood distillates; (2) distilling coal tars; (3) manufacturing wood or gum chemicals, such as naval stores, natural tanning materials, charcoal briquettes, and charcoal (except activated); and (4) manufacturing cyclic crudes or cyclic intermediates (i.e., hydrocarbons, except aromatic petrochemicals) from refined petroleum or natural gas.

325199 All Other Basic Organic Chemical Manufacturing

This U.S. industry comprises establishments primarily engaged in manufacturing basic organic chemical products (except aromatic petrochemicals, industrial gases, synthetic organic dyes and pigments, gum and wood chemicals, cyclic crudes and intermediates, and ethyl alcohol).

Illustrative Examples:
Biodiesel fuels not made in petroleum refineries and not blended with petroleum
Calcium organic compounds, not specified elsewhere by process, manufacturing
Carbon organic compounds, not specified elsewhere by process, manufacturing
Enzyme proteins (i.e., basic synthetic chemicals) (except pharmaceutical use) manufacturing
Fatty acids (e.g., margaric, oleic, stearic) manufacturing
Organo-inorganic compound manufacturing
Plasticizers (i.e., basic synthetic chemicals) manufacturing
Silicone (except resins) manufacturing
Synthetic sweeteners (i.e., sweetening agents) manufacturing

325211 Plastics Material and Resin Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing resins, plastics materials, and non-vulcanizable thermoplastic elastomers and mixing and blending resins on a custom basis and/or (2) manufacturing non-customized synthetic resins.

325212 Synthetic Rubber Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing synthetic rubber.

325220 Artificial and Synthetic Fibers and Filaments Manufacturing
This industry comprises establishments primarily engaged in (1) manufacturing cellulosic (e.g., rayon, acetate) and non-cellulosic (e.g., nylon, polyolefin, polyester) fibers and filaments in the form of monofilament, filament yarn, staple, or tow or (2) manufacturing and texturizing cellulosic and non-cellulosic fibers and filaments.

325311 Nitrogenous Fertilizer Manufacturing
This U.S. industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing nitrogenous fertilizer materials and mixing ingredients into fertilizers; (2) manufacturing fertilizers from sewage or animal waste; and (3) manufacturing nitrogenous materials and mixing them into fertilizers.

325314 Fertilizer (Mixing Only) Manufacturing
This U.S. industry comprises establishments primarily engaged in mixing ingredients made elsewhere into fertilizers.

325320 Pesticide and Other Agricultural Chemical Manufacturing
This industry comprises establishments primarily engaged in the formulation and preparation of agricultural and household pest control chemicals (except fertilizers).

325411 Medicinal and Botanical Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing uncompounded medicinal chemicals and their derivatives (i.e., generally for use by pharmaceutical preparation manufacturers) and/or (2) grading, grinding, and milling uncompounded botanicals.

325412 Pharmaceutical Preparation Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing in-vivo diagnostic substances and pharmaceutical preparations (except biological) intended for internal and external consumption in dose forms, such as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

325413 In-Vitro Diagnostic Substance Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing in-vitro (i.e., not taken internally) diagnostic substances, such as chemical, biological, or radioactive substances. The substances are used for diagnostic tests that are performed in test tubes, petri dishes, machines, and other diagnostic test-type devices.

325414 Biological Product (except Diagnostic) Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing vaccines, toxoids, blood fractions, and culture media of plant or animal origin (except diagnostic).

325510 Paint and Coating Manufacturing
This industry comprises establishments primarily engaged in (1) mixing pigments, solvents, and binders into paints and other coatings, such as stains, varnishes, lacquers, enamels, shellacs, and water-repellent coatings for concrete and masonry, and/or (2) manufacturing allied paint products, such as putties, paint and varnish removers, paint brush cleaners, and frit.

325520 Adhesive Manufacturing
This industry comprises establishments primarily engaged in manufacturing adhesives, glues, and caulking compounds.

325611 Soap and Other Detergent Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing and packaging soaps and other detergents, such as laundry and dishwashing detergents; toothpaste gels and tooth powders; and natural glycerin.

325612 Polish and Other Sanitation Good Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing and packaging polishes and specialty cleaning preparations.

325613 Surface Active Agent Manufacturing
This U.S. industry comprises establishments primarily engaged in (1) manufacturing bulk surface active agents for use as wetting agents, emulsifiers, and penetrants and/or (2) manufacturing textile and leather finishing agents used to reduce tension or speed the drying process.

325620 Toilet Preparation Manufacturing
This industry comprises establishments primarily engaged in preparing, blending, compounding, and packaging toilet preparations, such as perfumes, shaving preparations, hair preparations, face creams, lotions (including sunscreens), and other cosmetic preparations.

325910 Printing Ink Manufacturing
This industry comprises establishments primarily engaged in manufacturing printing and inkjet inks and inkjet cartridges.

325920 Explosives Manufacturing
This industry comprises establishments primarily engaged in manufacturing explosives.

325991 Custom Compounding of Purchased Resins This U.S. industry comprises establishments primarily engaged in (1) custom mixing and blending plastics resins made elsewhere or (2) reformulating plastics resins from recycled plastics products.

325992 Photographic Film, Paper, Plate, and Chemical Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing sensitized film, sensitized paper, sensitized cloth, sensitized plates, toners (i.e., for photocopiers, laser printers, and similar electrostatic printing devices), toner cartridges, and photographic chemicals.

325998 All Other Miscellaneous Chemical Product and Preparation Manufacturing
This U.S. industry comprises establishments primarily engaged in manufacturing chemical products (except basic chemicals, resins, and synthetic rubber; cellulosic and non-cellulosic fibers and filaments; pesticides, fertilizers, and other agricultural chemicals; pharmaceuticals and medicines; paints, coatings and adhesives; soaps, cleaning compounds, and toilet preparations; printing inks; explosives; custom compounding of purchased resins; and photographic films, papers, plates, and chemicals).

Illustrative Examples:
Activated carbon and charcoal manufacturing
Antifreeze preparations manufacturing
Electronic cigarette vapor refills manufacturing
Industrial salt manufacturing
Lighter fluids (e.g., charcoal, cigarette) manufacturing
Matches and matchbook manufacturing
Pyrotechnics (e.g., flares, flashlight bombs, signals) manufacturing
Sugar substitutes (i.e., synthetic sweeteners blended with other ingredients) made from purchased synthetic sweeteners
Swimming pool chemical preparations manufacturing
Writing inks manufacturing

INSTITUTE FOR HOMELAND SECURITY

Sam Houston State University

The Institute for Homeland Security at Sam Houston State University is focused on building strategic partnerships between public and private organizations through education and applied research ventures in the critical infrastructure sectors of Transportation, Energy, Chemical, Healthcare, and Public Health.

The Institute is a center for strategic thought with the goal of contributing to the security, resilience, and business continuity of these sectors from a Texas Homeland Security perspective. This is accomplished by facilitating collaboration activities, offering education programs, and conducting research to enhance the skills of practitioners specific to natural and human caused Homeland Security events.

Institute for Homeland Security
Sam Houston State University

Lynn, S. (2022). **Texas Critical Infrastructure Supply Chain Protection: Reaching the Energy Industry** (Report No. IHS/CR-2022-2031). The Sam Houston State University Institute for Homeland Security. https://ihsonline.org/Research/Technical-Papers/Texas-Critical-Infrastructure-Supply-Chain-Protection-Reaching-the-Energy-Industry