Chlorine and Building Materials
A Global Inventory of Production Technologies and Markets

Phase 2: Asia • Including Worldwide Findings

BY HEALTHY BUILDING NETWORK
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## Phase 2 (Asia) and Global Findings

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EXECUTIVE SUMMARY & INTRODUCTION
Executive Summary

This Healthy Building Network (HBN) report is the second of a two-part project, Chlorine and Building Materials: A Global Inventory of Production Technologies and Markets. It is a landmark effort: a globe-trotting, plant-by-plant accounting of the production and use of chlorine, a key feedstock for a wide range of chemicals and consumer products. Phase 1, completed in July, 2018, included Africa, the Americas, and Europe. Phase 2, covered in this report, examines Asia.

Demand from manufacturers of building and construction products drives the production of chlorine, especially in the region covered by this report: Asia. Chlorine is the key ingredient of polyvinyl chloride (PVC) used in pipes, siding, flooring, roofing membranes, and more.

This report focuses on chlorine production and PVC production. Chlorine is produced in chlor-alkali plants where sodium chloride (brine) is split into chlorine and sodium hydroxide in an energy intensive process. Four different technologies are used in chlor-alkali plants:

- mercury cell;
- asbestos diaphragm;
- per- and polyfluoroalkyl substances (PFAS) diaphragm; and
- PFAS-coated membrane

The chlorine can then be used to make the vinyl chloride monomer (VCM) which is in turn used to generate PVC. Two different technologies are used in VCM production:

- acetylene route (uses coal and a mercury-based catalyst); and
- ethylene route (uses ethylene from natural gas or oil)

Phase 2 of this project provides details about 60 chlor-alkali plants and 52 PVC plants in Asia. This review resulted in three types of resources that can help manufacturers make informed decisions about their supply chain and have productive conversations with their suppliers.

These resources include:

This report containing:
- The key findings both in Asia and globally.
- An inventory of plants that produce chlorine and PVC in Asia.

HBN Chlor-Alkali Inventory Maps
HBN Chlor-Alkali Inventory Spreadsheets

These resources are accessible on HBN’s Chlorine and Building Materials project page, https://healthybuilding.net/reports/20-chlorine-building-materials-project-phase-2-asia-including-worldwide-findings.

Asia Production

Cheap coal, labor, and technology allowed China to become Asia’s biggest producer for both the chlorine market and the PVC market, generating half of Asia’s chlorine and one-third of the world’s PVC. Production of PVC continues to grow in Asia, driven largely by India’s growing population that has demanded a sixfold increase in supply over the past 20 years. The rate of increase in production in China has slowed due to a slower rate of building and construction in that country. PVC production in East Asia is contracting. For example, production in Japan declined 14% in the past decade (see Japan Overview for further details).
Asia Chlor-Alkali Production Technology

In Asia, almost all chlorine (we estimate 94%) produced in the 60 plants covered in this report comes from PFAS-coated membrane technology. Our preliminary research on over 500 plants in Asia did not identify any facilities with at least 100,000-ton-per-year chlorine production capacity that still use mercury cells to produce chlorine. This is due to the Minamata Convention and the collapse of site-specific end uses — such as chlorinated pesticides and chlorine pulp bleaching — for chlorine plants that previously used mercury cells.

Asia VCM/PVC Production Technology

The PVC industry in Asia has traded reliance on one form of mercury for another. As stated above, mercury cell use in chlorine production is declining. However, due to the low cost of coal, the acetylene route of PVC production (which uses coal and mercury) is growing. This is especially true in China, where we found that 83% of PVC capacity uses the acetylene route. In Asia as a whole, we estimate that 63% of PVC capacity uses the acetylene route.

Global Production

We estimate that PVC production consumes about 48% of the chlorine produced worldwide. The largest producers of PVC are China (we estimate 34% of the global PVC production capacity) and the United States (we estimate 20%).

PVC and chlor-alkali production in most of the world is plateauing or even declining. Even China has struggled with overcapacity in the face of a slowing economy, and has become increasingly export-oriented, as has the United States. (See China overview in this report’s Inventory, and the findings in our Phase 1 report).

Global Technology

Mercury, asbestos, or PFAS is used in 100% of PVC production.

*The following figures add up to over 100% because some PVC produced using the acetylene route contains chlorine from non-mercury chlor-alkali technologies and so is counted in two categories.*

- 12% of PVC contains chlorine produced using diaphragms coated in asbestos.
- 29% of PVC contains chlorine produced using mercury cells or VCM produced using mercury catalyst in its production.
- 87% of PVC contains chlorine produced using PFAS-coated membranes or diaphragms.

Moving Forward

While environmentalists, building owners, architects and designers, and building-product manufacturers differ in their opinions on avoiding PVC, there is widespread and growing support for the elimination of pollution from the supply chain of PVC and of other chlorine-based products. A public global inventory of chlorine and PVC producers is a necessary first step for taking action.

HBN is providing this report, and accompanying online materials, spreadsheets, and map, as full open-access content. This data can help manufacturers to avoid chemicals derived from toxic technologies, and scientists to fill gaps in understanding the material flow of pollutants like mercury, PFAS, and carbon tetrachloride.

*When we know better, we can do better.*
About HBN

Healthy Building Network (HBN) envisions a future in which all people and the planet itself thrive in an environment that is free of hazardous chemicals. HBN’s mission is to advance human and environmental health by improving transparency about hazardous chemicals and by inspiring product innovation. As a non-profit organization, our work broadly benefits the public, especially children and the most marginalized communities, who suffer disproportionate health impacts from exposure to toxic chemicals.

Since 2000, HBN has defined the leading edge of healthy building practices that increase transparency in the building-products industry, reduce human exposure to hazardous chemicals, and create market incentives for healthier innovations in manufacturing. We are a team of researchers, engineers, scientists, building experts, and educators, and pursue our mission on three fronts:

1) Research and policy — uncovering cutting-edge information about healthier products and health impacts;
2) Data tools — producing innovative software platforms that ensure product transparency and that catalog chemical hazards; and
3) Education and capacity building — fostering others’ capabilities to make informed decisions.

We work to reduce toxic-chemical use, minimize hazards, and eliminate exposure, especially to those chemicals of concern which fail to improve product performance. We promote the development of affordable green chemistry solutions that support a healthy, successful, circular economy.

About HBN Subscription Research

Healthy Building Network prides itself on independent and unbiased research. Our partners and stakeholders rank our independence and impartiality as a key value proposition in their decision to work with us. Our analysis of chemical hazards, industry trends, supply chains, and market structures, and of the health, social, and environmental impacts of product manufacture is widely respected for its depth and rigor.

HBN has launched a “crowd-funded” research model to allow several interested parties to jointly participate in funding support for select research projects. HBN develops the goals, conducts the research, and publishes the results. Subscribers receive research updates and have pre-publication access to research findings.

Eligibility: There are no restrictions on the types of organizations eligible to apply for the subscription research services. HBN reserves the right to accept or decline subscribers on a case-by-case basis. Subscription rates and limits, if any, are determined project by project, at the sole discretion of HBN.

Transparency: The names of all subscribers will be listed in research products to which their subscription fees contributed.
Introduction

This report is the second of a two-part plant-by-plant accounting of the production and use of chlorine, a key feedstock for a wide range of chemicals and consumer products. Phase 1, completed in July, 2018, covered Africa, The Americas and Europe. Phase 2, in this report, covers Asia.

The production of three plastics — PVC, epoxies, and polyurethane — consumes most of the world’s chlorine. This report focuses on chlorine production and PVC production. Chlorine is produced in chlor-alkali plants, where sodium chloride (brine) is split into chlorine and sodium hydroxide. This energy intensive process relies upon asbestos, mercury, or PFAS to separate chlorine and sodium hydroxide. To make PVC, chlorine is combined with a carbon source. Coal and mercury are used in the acetylene method of PVC production. Natural gas or oil is the basis for the ethylene route.

This Healthy Building Network report establishes basic facts concerning chlorine production: Who is producing chlorine? Who is producing PVC? Where? How much? And with what technologies? What products use the chlorine made in each plant?

PVC products, especially those used in building and construction, are dominant end uses of chlorine. But other chlorine derivatives, especially chemicals key to epoxy and polyurethane production, are of increasing importance. This project identifies which of these industries each plant serves and, plant by plant, examines the markets, capacities, and technological evolution of chlor-alkali and PVC production in Asia. It includes details about 60 chlor-alkali and 52 PVC plants.

Worldwide, between the two phases of this project, HBN provides vital information about 146 chlor-alkali plants and 113 PVC plants, including their capacities, owners, technologies, and markets.

The Findings section synthesizes key data, mostly from this Phase 2 report. It also summarizes our findings from both phases of our research for a global view of production technologies. In addition to this report’s long-form Inventory and detailed Appendices, essential data also is available in online companion resources, including the HBN Chlor-Alkali Inventory Maps and the HBN Chlor-Alkali Inventory Spreadsheets. The maps and spreadsheets are available on the homepage for HBN’s Chlorine and Building Materials project, https://healthybuilding.net/reports/20-chlorine-building-materials-project-phase-2-asia-including-worldwide-findings.

Chlorine and Building Materials: A Global Inventory of Production Technologies, Markets, and Pollution is a prerequisite to understanding the origins and life-cycle impacts of high-volume building materials such as polyvinyl chloride, polyurethane, and epoxies. This is open-access content, available online at www.healthybuilding.net, free of charge. All text, charts, graphs, tables, spreadsheets, and maps, may be re-used without restriction except for required attribution to Healthy Building Network as the source.

Methodology

This project establishes a baseline understanding of the global chlorine industry. Chlorine and Building Materials: A Global Inventory of Production Technologies, Markets, and Pollution is not an insider’s view of the industry, but rather an outsider’s accounting of the industry as revealed by its own data.

To complete this project, HBN scoured many thousands of sources, spanning over a century, to establish facts and draw conclusions. Our research is derived from resources on hand or available online during the time this report was researched (August 2018 to February 2019). For each source, we provide full citations, including links where available. Sources include annual corporate reports, technical literature, trade databases, industry news and press releases, reports, directories, news articles, and government and chemical industry archives. Google’s automated translation service was used for many sources from countries where the government owns most of the industry and has published very little information in English; this is particularly true for sources written in Chinese.

There are many more smaller chlor-alkali plants in operation than those detailed in this report. We conducted preliminary research on over 500 locations in Asia, many of which have closed.
THE FINDINGS
Phase 2 (Asia) and Global Findings

This is Phase 2 of a global inventory of chemical plants that produce chlorine and PVC. It is intended to establish a public domain accounting of the technologies used to make chlorine and related products.

Phase 2 of this project provides details about 60 chlor-alkali plants and 52 PVC plants in Asia. (Chlor-alkali plants produce chlorine and caustic soda.) The plants in this report represent an estimated 56% of Asia’s chlorine capacity and 67% of its PVC production capacity in 2017.¹

The Phase 1 report provides details for 86 chlor-alkali plants and 61 polyvinyl chloride (PVC) in the rest of the world. Combined, these two phases of HBN’s Chlorine & Building Materials project researched 146 chlor-alkali and 113 PVC plants. These represent an estimated 73% of the world’s chlorine production capacity², and 72% of global PVC production capacity.³

Findings are summarized below, beginning with a look at Asia’s chlorine markets and production technologies, followed by global findings. Additional data and analysis are found elsewhere in this report, and in online companion spreadsheets and maps.⁴

Asia Findings

Markets

- Since 2000, chlor-alkali production in the Middle East, China, and Southeast Asia has increased sharply as domestic and regional demand for PVC products has risen. PVC is by far the leading consumer of chlorine from the chlor-alkali industry in Asia, especially China. “Spurred by rapid economic growth and fast urbanization in the People’s Republic of China (PRC), demand for PVC more than doubled between 2001 and 2007 and grew by 54.4% more between 2007 and 2013 to reach a total of 15.5 million metric tons⁵ in 2013. Capacity growth outpaced demand growth from 2001 to 2013,” reported the Asian Development Bank.⁶

- PVC resin manufacturing consumes an estimated 64% of all the chlorine produced by the plants in the scope of our Phase 2 study (Asia). The production of a kilogram of PVC requires an estimated 0.61 kilograms of chlorine. This is based on the chemical composition of PVC (which is 57% chlorine by weight) plus releases of chlorine that occur through the production chain.⁷ The installed capacity of chlor-alkali plants in Asia that we researched is an estimated 21.6 million tons. The 52 PVC plants that receive chlorine from these facilities have an estimated combined capacity of 22.8 million tons, which requires an estimated 13.9 million tons of chlorine, or 64% of Asia’s chlorine capacity.

- All but one of the 27 largest chlor-alkali plants in China produce PVC or vinyl chloride monomer (VCM, the monomer used to produce PVC) on-site. We estimate that nearly three-quarters (74%) of the chlorine produced at these plants in China is used to make PVC.⁸ The PRC’s PVC production now accounts for more than one-third of global production.⁹

- Three of the world’s four largest PVC plants are located in inner China. Each uses the acetylene route of VCM production.

- In other Asian countries, chlor-alkali production is more frequently tied to non-PVC supply chains. In India, four of the seven largest chlorine producers do not appear to supply PVC plants. In Japan, chlorine from four of nine plants support industries other than PVC. The chlor-alkali plants covered in our Phase 2 report supply chlorine feedstocks for non-PVC products such as isocyanates, chlorinated paraffins, carbon tetrachloride, chloroform, methylene chloride, epichlorohydrin, and hydrochlorofluorocarbons.
In East Asia, where the pace of industrialization, building, and construction has subsided, PVC production has become export-oriented. South Korea produces more than twice the PVC it consumes, exporting over one-third of its production to India.\(^\text{10}\) Taiwan, with the capacity to produce 1.93 million tons of PVC, has a domestic demand of just 700,000 tons, resulting in the world’s highest overcapacity of PVC. A reported 43% of Taiwan’s PVC is sold in India.\(^\text{11}\) In Japan, PVC production is 20% below peak values and is not expected to recover. Producers from Japan are shifting and expanding capacity to less expensive overseas locations such as Indonesia and Vietnam.

As building and construction take off, India is the main destination of PVC exports from other Asian countries. PVC demand in India increased sixfold in the past 20 years.\(^\text{12}\) Net consumption of PVC (factoring in imports and exports) increased 79% between 2009-10 and 2016-17, from 1.82 million tons to 3.25 million tons.\(^\text{13}\) The Indian chemical industry anticipates PVC demand to exceed 5 million tons by 2020.\(^\text{14}\)

### US IMPORTS FROM CHINA

In 2017, about 85% of all PVC floor, wall, and ceiling coverings entering the United States came from China. The rate of flooring shipments accelerated in 2018. Despite an escalating trade war, the United States remained a major market for PVC building materials, especially floor coverings, made in China. According to shipping records, in just one recent month (December 2018) over 2,000 shipping containers arrived in the US from China containing PVC building materials, including:

- 119,026 tons of PVC floors;
- 1,096 tons of PVC moulding;
- 927 tons of PVC window blinds and shades;
- 782 tons of PVC windows;
- 706 tons of PVC fence;
- 162 tons of PVC slat walls;
- 125 tons of PVC pipes, valves, and fittings;
- 119 tons of PVC ceiling tiles; And,
- 88 tons of PVC rails.\(^\text{15}\)

If all the PVC flooring products shipped to the United States from China in December 2018 were luxury vinyl tile (LVT), there would be enough to cover about 139,000 homes with 2,000-sq-ft floor plans.\(^\text{16}\)

On September 24, 2018, the US government imposed 10% tariffs on imported PVC floor coverings from China. LVT flooring shipments spiked in anticipation of tariffs that were due to increase to 25% on January 1, 2019. This increase was delayed 90 days and reduced to an incremental 15% tariff; however, Floor Daily reported in January 2019, this still had LVT importers “nervous.”\(^\text{17}\)
Chlor-Alkali Production Technology

- The 60 chlor-alkali plants in Asia researched for this report, combined, can produce an estimated 21.6 million tons of chlorine per year. About half of Asia’s chlor-alkali capacity is in China.
- Four industrial processes create chlorine gas. The oldest technologies use either mercury or asbestos. Two newer technologies (introduced in the 1970s) use diaphragms or membranes coated with per- and polyfluoroalkyl substances (PFAS). In Asia, almost all chlorine (an estimated 94%) produced in plants listed in this report comes from PFAS-coated membrane technology.
- Five of the 60 plants in our Phase 2 study use asbestos diaphragm technology along with PFAS membrane cells to produce chlorine. One of these five is in Saudi Arabia. The other four operate in China, where asbestos diaphragms were the most common chlor-alkali technology until the 2000s.
- Our preliminary research on over 500 plants in Asia did not identify any facilities with at least 100,000 tons per year of chlorine production capacity that still use mercury cells to produce chlorine. Scores of smaller mercury cell chlor-alkali plants have closed (but not all) in recent years due to the implementation the Minamata Convention (see Phase 1 report for further details) and due to the collapse of site-specific end uses, such as chlorinated pesticides and chlorine pulp bleaching.
- The coal-mining region of inner China provides Asia’s least expensive source of energy. Coal also serves as chemical feedstock for PVC production through the acetylene process. Through the 1990s, much of the chlor-alkali and PVC industry in China was concentrated in the east coast, where ethylene was the primary fossil fuel used to make VCM. Production shifted north and west in the last 15 years, as chlorine-to-PVC plants proliferated in the vast and remote coal regions, especially the Xinjiang Uyghur and Inner Mongolia Autonomous Regions. The continent’s capacity is heavily concentrated in China’s coal-mining regions.

VCM/PVC Production Technology

- The 52 PVC plants in Asia reviewed in this report have a combined capacity to produce about 22.8 million tons of PVC per year.
- Half of the plants documented in Phase 2 are in China; these 26 plants have an estimated combined capacity of 14.3 million tons per year or 63% of Asia’s PVC production reviewed in this report. Recent estimates of China’s total PVC capacity range from 16.3 million tons to 23.9 million tons. Based on these estimates, this report covers plants that account for about 60-88% of China’s PVC capacity.
- The PVC industry has traded reliance on one form of mercury for another. The use of liquid mercury in chlor-alkali production is dwindling; however, the use of mercury is rising rapidly in the acetylene route of production of VCM in China. VCM is the precursor to PVC. The Royal Society of Chemistry explains that the industry is exploiting China’s “vast coal resources, turning coal into calcium carbide and from there acetylene. Producers then get VCM by reacting acetylene and hydrogen chloride gas using a mercury (II) chloride catalyst supported on activated carbon.”
- 83% of China’s PVC production chain uses the acetylene route. This estimate is based on our research into the 21 largest PVC producers in China (11.8 million out of the 14.3 million tons of capacity). The result is similar to a United Nations estimate for the whole of China. In 2016, the United Nations Industrial Development Organization estimated that the acetylene method accounted for 14 million out of 16.3 million tons of VCM production.
- Three of the world’s four largest PVC plants are located in inner China. Each uses the acetylene route of VCM production.
- The use of mercury in the production of VCM by the acetylene route is growing rapidly. The United Nations Environment Programme estimates that the global VCM industry (mainly China) consumed around 1,200 tons of mercury in 2015. This is roughly double what it consumed in 2005.
- VCM production may consume more mercury than the other primary remaining use, the artisanal and small-scale gold-mining industry (ASGM). UNEP estimates that the ASGM industry consumes between 872 and 2,598 tons of mercury worldwide.\\(^{23}\)

- Some PVC resin factories using the acetylene route produce building materials that are directly exported to North America. For example, Yibin Tianyuan Group Co. (Inventory Code: ASIACHN22) shipped over 2,291 tons of PVC floors to the United States and Canada in 2018.

- In Asia, 37% of PVC is made using the ethylene route. In this method, ethylene made from natural gas or crude oil is the carbon source for PVC. Ethylene is reacted with chlorine to create ethylene dichloride (EDC). In the next step, EDC is “cracked” at high temperatures and broken down into the simpler molecule, VCM.

- Many ethylene-route PVC resin producers in Asia depend upon imported feedstocks — ethane, ethylene dichloride (EDC) and/or vinyl chloride monomer (VCM) — from the Middle East, Indonesia, or, increasingly, the United States. Reliance Industries of India imports ethane from the United States to make EDC. It also owns the world’s first fleet of Very Large Ethane Carriers (VLECs). These ships started delivering ethane in 2016. India quickly became the leading destination for ethane exported from the United States.\\(^{24}\) Other PVC producers in Asia, import EDC from the US Gulf Coast. China, South Korea, Japan, India, and Taiwan are the top five destinations for EDC exported from the United States.\\(^{25}\) Within Asia, the Middle East and Indonesia are the cheapest sources of ethylene; there, export-oriented EDC and VCM factories supply PVC producers in other countries.
XINGJIANG ZHONGTAI IN URUMQI, XINJIANG UYGHUR AUTONOMOUS REGION, CHINA: THE PROTOTYPICAL PRODUCER IN ASIA

In many ways, the largest PVC plant in Asia — and in the world — is the industry’s prototypical operation. The Xingjiang Zhongtai chemical plant in Urumqi (ASIACHN26) has a PVC production capacity of at least 1,530,000 tons per year, higher even than Shin-Etsu’s Shintech plant in Freeport, Texas, USA (by far the largest PVC plant identified in Phase 1 of our research).

Energy is a major factor in the industrial geography of chlorine and PVC production. Chlor-alkali plants consume vast quantities of fossil fuels. These fuels power the chlor-alkali process and are a carbon-based feedstock necessary to turn chlorine into PVC. In the United States, that cheap energy comes from fracking for natural gas. In China, it comes from coal. In the last two decades, the Chinese government and related companies have built several of the world’s largest chlorine-to-PVC plants in the heart of the country’s coal-mining region. Of the four plants in the world that can produce more than one million tons of PVC per year, three are located in China’s coal belt.

Most of these plants have some degree of government ownership and are integrated with coal-mining operations. In this case, two of the four leading shareholders in 2016 were state-owned: Xinjiang Zhongtai (Group) and Urumqi Huan Peng Co., Ltd., which is a coal-mining operation.28

Some of the coal is burned to power the chlor-alkali plant. The Urumqi complex, for example, obtains its energy from an on-site 900 megawatt (MW) coal-fired plant. The rest of the coal is heated and, from coke, begins the acetylene route of VCM and PVC production. The plant is new (built since 2004) and uses PFAS membrane technology for the chlor-alkali process.

Xinjiang Zhongtai has directly shipped PVC resin to North America for use in building materials. There is not much direct resin export to the United States, but there is a significant rise in the export of PVC building materials, especially flooring, to the United States.
Reliance Industries, India's largest private company, now owns fracking sites in the US and the world's first fleet of Very Large Ethane Carriers, including the Ethane Crystal pictured here, to deliver feedstock from the US to its PVC plants in India.

Global Findings

Summary Results of the Global Inventory of Chlor-Alkali Plants

This Healthy Building Network research project began with some basic questions: Where does the chlorine used in the production of PVC (and other plastics) come from? Which of those plants use mercury, asbestos, or other potentially toxic technologies?

This Inventory provides the answers to those questions for 146 chlor-alkali plants around the world, with a combined estimated capacity of 51.2 million tons of chlorine per year. We believe this includes all of the world’s operating chlor-alkali plants with at least a 300,000-ton-per-year capacity.

Our research project identifies the chlorine sources for 112 PVC plants worldwide, with a combined estimated capacity of 41.8 million tons per year of resin. We believe this includes all of the world’s operating PVC plants with at least a 250,000-ton-per-year capacity, of which there are 74.

Summary tables of all 146 chlor-alkali plants and 113 PVC plants are available in the Appendices to this report. Further details are found in on-line spreadsheets, maps, and the Phase 1 report available at https://healthy-building.net/reports/20-chlorine-building-materials-project-phase-2-asia-including-worldwide-findings.
Our reports document important shifts in the industrial geography of chlor-alkali and PVC production since the 1990s. Large-scale mercury cell production of chlorine has been nearly fully replaced by PFAS technology (with several notable exceptions). However, the use of mercury in the next step of the PVC supply chain – VCM production – is rising alongside the development of massive chlorine-to-PVC plants in the coal-mining regions of China. The chlor-alkali industry is fading in older industrialized regions, especially where production was dependent upon obsolete markets or is burdened with high energy costs. Production is surging where fossil fuels and brine abound, especially the US Gulf Coast and inner China. And, more than ever, PVC demand is driving these trends.

These are the main findings of our report:

**Markets**

- We estimate that PVC production consumes about 50% of the chlorine produced worldwide. The 113 PVC plants in this study have a combined estimated capacity of 41.8 million tons per year. This requires the consumption of 25.5 million tons per year of chlorine, which is 50% of the estimated capacity of this study’s 146 chlor-alkali plants.

- Global chlorine and PVC production is increasingly concentrated in low-cost energy regions. The relationship of chlor-alkali and PVC production is closest in China (where we estimate 74% of chlorine is used to make PVC) and the United States (54%). China accounts for over a third of the PVC produced worldwide, according to the Asian Development Bank. Our study arrived at a similar result: China accounts for 34% of the global PVC production capacity. We found that the United States accounts for 20% of the capacity, leaving a balance of 46% in the rest of the world.

- The chlorine and PVC resin production chain is increasingly global. The United States is the largest exporter of PVC resins, and all the feedstocks that go into their production, including ethane, ethylene dichloride, and VCM. Production within the United States is also globalizing: Mexichem (Mexico), Formosa Plastics (Taiwan), and Shin-Etsu (Japan) are major players in the US chlorine/PVC chain. India’s Reliance Industries invests in fracking sites in Pennsylvania and Texas, and owns a fleet of ships to deliver ethane to its PVC plants in India. The globalization of the PVC production chain extends to Europe, where companies from the Americas and China are supplying and buying chemical plants, and companies from Belgium and China are investing in Russian producers. There is one area where globalization has taken little hold: China’s coal-mining region, where the government and related companies control all of the production.
Chlor-Alkali Technology

Among the plants in our report:

- An estimated 79% of the world’s chlor-alkali capacity is based on PFAS membranes or diaphragms, 18% on asbestos diaphragms, and 3% on mercury cells.
- The mercury percentage likely would be revealed to be higher if we researched more plants under a 100,000-ton-per-year capacity.
- Production by asbestos diaphragm is heavily concentrated in the United States, where 11 plants use this technology. We estimate that 67% of the world’s chlor-alkali production by asbestos diaphragm occurs in the United States (6.1 million of 9 million tons per year of capacity).

PVC/VCM Technology

Worldwide, we estimate that:

- 100% of PVC uses mercury, asbestos, or PFAS in its production. (The following figures add up to over 100% because some PVC is produced using the acetylene route with chlorine from non-mercury chlor-alkali technologies and so is counted in two categories.)
  - 12% of PVC has asbestos diaphragm technology origins.
  - 29% of PVC has mercury cell or acetylene origins.
  - 87% of PVC has PFAS origins.
- Larger plants are more likely than smaller ones to produce PVC with origins in either the acetylene route of VCM production or the asbestos diaphragm method of chlorine production.
  - Seven of the 10 largest PVC plants in the world rely upon feedstocks produced with either asbestos or mercury.
○ Among the top 50 PVC plants, 15% of the production capacity is tied to asbestos diaphragm-based chlorine and 37% comes from acetylene-based VCM. They account for 85% of the asbestos diaphragm-based chlorine production and 91% of the acetylene-based VCM capacity of plants in our global inventory.

○ Among the 63 smaller PVC plants we researched, 6% of the capacity comes from asbestos-based chlorine, and 8% from acetylene based-VCM.

- PVC and chlor-alkali production in most of Europe and East Asia is declining as export-oriented production surges in the United States and China. Combined, China and the United States control half of the world’s chlorine production capacity, and 54% of global PVC production capacity. In 2018, the chemical industry news site, ICIS, predicted a growing US influence on world chlor-alkali markets. “As the US becomes a larger global supplier, prices are likely to continue upward as US plants churn at near capacity, and any production upset will ripple through markets around the world.\(^\text{28}\)

### Ten Largest PVC Producers in the World

<table>
<thead>
<tr>
<th>RANK</th>
<th>OWNER</th>
<th>LOCATION</th>
<th>PVC CAPACITY (1,000 TONS/YR)</th>
<th>CHLORINE TECH.</th>
<th>VCM TECH.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Xinjiang Zhongtai Chemical</td>
<td>Urumqi, XUAR, China</td>
<td>1,530</td>
<td>PFAS</td>
<td>Acetylene</td>
</tr>
<tr>
<td>2</td>
<td>Shin-Etsu</td>
<td>Freeport, Texas, USA</td>
<td>1,450</td>
<td>PFAS</td>
<td>Ethylene</td>
</tr>
<tr>
<td>3</td>
<td>Tianye Group</td>
<td>Shihezi Development Zone, XUAR, China</td>
<td>1,200</td>
<td>PFAS</td>
<td>Acetylene</td>
</tr>
<tr>
<td>4</td>
<td>Shaanxi Coal and Chemical Industry Group</td>
<td>Shenmu County, Shaanxi, China</td>
<td>1,100</td>
<td>PFAS</td>
<td>Acetylene</td>
</tr>
<tr>
<td>5</td>
<td>Occidental</td>
<td>Pasadena, Texas, USA</td>
<td>898</td>
<td>Asb/PFAS</td>
<td>Ethylene</td>
</tr>
<tr>
<td>6</td>
<td>Mexichem</td>
<td>Altamira, Tamaulipas, Mexico</td>
<td>876</td>
<td>Asbestos</td>
<td>Ethylene</td>
</tr>
<tr>
<td>7</td>
<td>Westlake</td>
<td>Plaquemine, Louisiana, USA</td>
<td>861</td>
<td>Asbestos</td>
<td>Ethylene</td>
</tr>
<tr>
<td>8</td>
<td>Formosa</td>
<td>Point Comfort, Texas, USA</td>
<td>816</td>
<td>PFAS</td>
<td>Ethylene</td>
</tr>
<tr>
<td>9</td>
<td>Inner Mongolia Junzheng Energy &amp; Chemical Group</td>
<td>Wuhai City, Inner Mongolia, China</td>
<td>800</td>
<td>PFAS</td>
<td>Acetylene</td>
</tr>
<tr>
<td>10</td>
<td>LG Chemical</td>
<td>Yeosu City, South Korea</td>
<td>750</td>
<td>PFAS</td>
<td>Ethylene</td>
</tr>
</tbody>
</table>

Note: Chlorine and VCM technologies are based upon either on-site or suppliers’ production methods.
### PVC Production Chain Technologies Worldwide

<table>
<thead>
<tr>
<th>CHLOR-ALKALI TECHNOLOGY</th>
<th>VCM ROUTE</th>
<th>GLOBAL CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>Mercury</td>
<td>PFAS</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
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<td>✓</td>
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<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>–</td>
<td>✓</td>
<td>–</td>
</tr>
</tbody>
</table>

Note: This table summarizes the technologies used to produce the chlorine and VCM used by 113 PVC plants worldwide. Total is less than 100% due to rounding.

### PVC Production Chain Technologies (by plant size)

<table>
<thead>
<tr>
<th>PVC PLANTS - SOURCE TECHNOLOGIES</th>
<th>CHLORINE SOURCE TECHNOLOGY</th>
<th>VCM SOURCE TECHNOLOGY</th>
<th>PVC Resin Capacity (total)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asbestos</td>
<td>Mercury</td>
<td>PFAS Membrane or Diaphragm</td>
</tr>
<tr>
<td>World’s 50 Largest PVC Plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000 tons per year</td>
<td>4,417</td>
<td>0</td>
<td>25,171</td>
</tr>
<tr>
<td>No. of PVC plants</td>
<td>11</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>% of production capacity</td>
<td>15%</td>
<td>0%</td>
<td>85%</td>
</tr>
<tr>
<td>All PVC Plants in the HBN Inventory (Phase 1 and Phase 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000 tons per year</td>
<td>5,181</td>
<td>410</td>
<td>37,170</td>
</tr>
<tr>
<td>No. of PVC plants</td>
<td>5</td>
<td>5</td>
<td>102</td>
</tr>
<tr>
<td>% of production capacity</td>
<td>12%</td>
<td>1%</td>
<td>87%</td>
</tr>
</tbody>
</table>

Note: This table summarizes the technologies used to produce the chlorine and VCM used by 113 PVC plants worldwide, including the 50 largest ones. Some PVC plants obtain feedstocks from multiple chlorine sources. These have been apportioned as follows: When chlorine comes from both on-site and off-site sources, it is assumed that all the on-site chlorine is used for PVC production on-site and the remainder PVC production is covered by the off-site chlorine. When chlorine comes from multiple off-site sources, it is assumed that the chlorine is evenly distributed amongst the sources.
COUNTRY: CHINA

OVERVIEW

In the 2000s, as China’s booming building and construction sector demanded more and more PVC, the country became the world’s largest chlorine producer. China also became the world’s largest PVC producer in 2006, and has kept growing since then. The industry has grown so large that “Chinese production and consumption dominates (the) global market structure,” reported Ana Lopez, an industry analyst at IHS Markit. Chlorine-to-PVC plants have proliferated in the coal belt of China, especially in the Xinjiang Uyghur Autonomous Region (XUAR), where an estimated 40% of the country’s PVC capacity is located. Three of the four largest PVC plants in the world are located in the heart of China’s coal mining region (see ASIACHN15, ASIACHN24 and ASIACHN26 below).

Cheap coal, labor, and technology created the perfect conditions for the industry’s rapid expansion in the 2000s. In 2005, coal cost as little as $10 per ton at the mine, reported ICIS. “The acetylene route seemed destined to disappear entirely, but it has had a remarkable renaissance in China in the last few years. The reason is the extreme cheapness of coal, as low as RMB70-100 per ton [roughly US$10-15] at the minehead in some of the remote provinces of the country, such as Nei Mongol [Inner Mongolia] or Ningxia, where labour costs are low. This in turn allows production of electricity as cheaply as Rmb120-150 [$18-23] per MWh. The calcium carbide is made near to the coal mines and can be used locally to make acetylene, which is then combined with HCl from a local chlor-alkali plant to make VCM and then PVC.” Furthermore, “the production chain from calcium carbide to VCM requires much less capital investment than the ethylene route.”

For this report, we concentrated on plants with greater than 250,000-ton capacity. The 27 Chinese PVC plants that we researched have a combined capacity of 16.4 million tons per year. The plants in this inventory account for between 67% and 80% of what industry analysts say is the country’s total estimated capacity.

Market research estimates of its total PVC capacity range between 20 and 24.3 million tons. At the end of 2017, according to researchandmarkets.com, China had the capacity to produce “over 20 million tons.” The China National Chemical Information Center (CNCIC) reported that China’s PVC production capacity was 22.8 million tons in 2017, from 62 plants. The Federation of Indian Chambers of Commerce and Industry (FICCI) said China had another estimate placing capacity at 24.3 million tons in 2016. Some of these estimates may include inflated plant capacity sizes or plants that are not currently operating. Plants have closed in eastern China as the government shifts some heavily polluting industries away from coastal population centers. Others have closed due to explosions. In November 2018, for example, VCM leaked and exploded at ChemChina’s Hebei Shenghua chlorine-to-PVC plant in Zhangjiakou, Hebei Province. The accident killed 24 people and injured 21. This was an acetylene-based unit.

The PVC industry’s pace of expansion in China correlated with the growth of building and construction. This pace slackened in recent years. In 2016, FICCI said China’s PVC capacity exceeded domestic demand by 9,500,000 tons. “Growth of Chinese capacity addition has decreased [dramatically] and capacity is expected to be at 25,200,000 tons in 2020,” the FICCI report predicted.

Still, there are expansions underway in the coal-mining regions as the industry becomes more export-oriented. PVC resin production that exceeds domestic demand is shipped mainly to India, Russia, Malaysia, and other countries on mainland Asia.

Excess production, and exports, may decline. After the past 15 years of rapid growth, “the risk of Chinese capacity coming down is very real,” adds the FICCI report. The Indian industry federation (FICCI) is concerned about how this could impact India, which relies upon imported PVC. The risk comes from China’s dependence upon the acetylene method of VCM manufacturing, it said. “This process has come under pressure on account of air pollution, mercury pollution, international conventions on mercury and depletion of mercury resources in China.”
These factors "bring into doubt not only the exportable surplus of PVC that would be available in China but also the ability of the local manufacturers to meet domestic demand, thereby providing manufacturers based in Taiwan and Korea a market closer than India to offload their surplus."\(^{37}\)

**INVENTORY CODE: ASIACHN01**

- **Plant Name**: Anhui Huasu (also spelled Anhui Hwasu)
- **Owner**: Government of China. Five state-owned enterprises own shares of Anhui Huasu Co., Ltd.: Huaibei Mining (Group) Co., Ltd. (58% share); China Chengda Engineering Co., Ltd. (12%); Ma Steel (Group) Holding Company (holding 10%); Anhui Investment Group Co., Ltd. (10%) and Zhongyan Dongxing Salt Chemical Co., Ltd. (10%).\(^{38}\)
- **Location**: Luquiaozhen, Dingyuan County, Chuzhou, Anhui Province, China.
- **Process**:
  - Chlor-alkali: membrane.\(^{39}\)
  - PVC: acetylene.
- **Year Opened**: 2013.\(^{40}\)
- **Capacities** (tons per year):
  - 290,000 tons of chlorine (2013).
  - 560,000 tons of calcium carbide (2013).
  - 460,000 tons of PVC (2017, acetylene route).\(^{41}\)
  - 600 MW coal-fired power plant (2013).\(^{42}\)
- **Capacity Rankings**: Not among the largest 33 chlor-alkali plants in Asia. 18th largest PVC plant in Asia. 29th largest PVC plant in the world.
- **Technology Conversions**:
  - According to the company’s website, the plant reduced its consumption of calcium carbide, per ton of PVC, from 1.42 tons to 1.38 tons.\(^{43}\)
  - In March 2018, Anhui Huasu announced it planned to raise 920 million yuan (about $133 million) to build phase two of the plant. This expansion, according to Platts, "will increase production capacities to 1 million mt/year of PVC, 1.4 million mt/year of calcium carbide and 760,000 mt/year of caustic soda."\(^{44}\)
  - A test run of the expanded capacity is planned in 2019.\(^{45}\)
- **Markets**:
  - The plant’s PVC resins are sold domestically and worldwide.\(^{46}\)

**INVENTORY CODE: ASIACHN02**

- **Plant Name**: Tangshan Sanyou Chlor-alkali Co.
- **Owner**: Tangshan Sanyou Chlor-Alkali / Tangshan Chlor-Alkali.
- **Location**: NanPu Development Zone, Tangshan, Hebei Province, China.
- **Process**:
  - Chlor-alkali: membrane.\(^{47}\)
  - PVC: acetylene
- **Year Opened**: 2005.\(^{48}\)
- **Capacities** (tons per year):
  - 455,000 tons of chlorine (2016).
  - 400,000 tons of PVC (acetylene route, 2017).\(^{49}\)
- **Capacity Rankings**: Tied as the 14th largest chlor-alkali plant in Asia and 27th largest chlor-alkali plant in the world. Tied as 20th largest PVC plant in Asia and 37th largest PVC plant in the world.
**Technology Conversions:**
- In 2002, the plant had the capacity to produce 100,000 tons of PVC, which is planned to double. Existing and planned capacities were acetylene-based.\(^{50}\)
- It installed a membrane-based 91,000-ton-per-year chlorine capacity chlor-alkali plant in 2005.\(^{51}\)
- In 2012, Tangshan Sanyou increased its PVC and caustic soda capacities by 100,000 tons, to 400,000 tons each.\(^{52}\)
- In 2016, the company planned to increase the plant’s production capacities from 500,000 tons per year of caustic soda to 530,000 tons, and from 400,000 tons per year of PVC to 435,000 tons.\(^{53}\)

**Markets:**
- It exports a reported 50,000 tons of PVC resin (brand name: Sanyou) per year.\(^{54}\) The company says its “products sell well all over the country and are exported to more than 20 countries and regions such as Asia, Europe and America.”\(^{55}\)
- Tangshan Sanyou Chemical sells other chlorinated products, including liquid chlorine, hydrochloric acid, calcium chloride, and sodium chloride.\(^{56}\)
- In 2002, it entered into a joint venture with General Chemical (Canada) to “produce, market and sell calcium chloride for the Asian market and for export to Europe, Africa, and the Middle East. Under the agreement, which would give 60% of the ownership to General Chemical and 40% to Tangshan Sanyou, the plant will be located at the existing Tangshan Sanyou soda ash facility in Tangshan, Hebei province,” according to the Journal of the Electrochemical Society.\(^{57}\)

**INVENTORY CODE: ASIACHN03**
- **Plant Name:** Heilongjiang Haohua Chemical
- **Owner:** ChemChina (China National Chemical Corporation), via China Haohua Chemical (Group). According to a 2016 ChemWeek article, “ChemChina ranks among the top three producers of PVC in China, but the company’s production is coal-based.”
- **Location:** Ang’angxi Industrial Park of the Harbin-Daqing-Qiqihar Industrial Corridor, Heilongjiang Province, China.
- **Process:**
  - Chlor-alkali: membrane.\(^{58}\)
  - PVC: acetylene.
- **Year Opened:** 2008.\(^{59}\)
- **Capacities (tons per year):**
  - 300,000 tons of chlorine (2012).
  - 300,000 tons of PVC (2012).\(^{60}\) PVC production is by acetylene-VCM route.\(^{61}\)
- **Capacity Rankings:** Tied as the 32nd largest chlor-alkali plant in Asia and 62nd largest chlor-alkali plant in the world. Tied as 33rd largest PVC plant in Asia and 57th largest PVC plant in the world.
- **Technology Conversions:**
  - In 2005, ChemChina bought Qiqihar Chemical Group and shut down its plant (45,000 tons per year of chlorine, 80,000 tons per year of PVC capacities) in the industrial park three years later. It replaced it with a new plant in the same vicinity, although the old devices remained onsite in 2012.\(^{62}\)
- **Markets:**
  - In addition to PVC, the plant’s chlorinated products include chlorine and hydrochloric acid.\(^{63}\)

**INVENTORY CODE: ASIACHN04**
- **Plant Name:** Haohua Yuhang
- **Owner:** ChemChina, via China Haohua Chemical Corporation subsidiary.\(^{64}\)
Healthy Building Network  I  Chlorine and Building Materials, Phase 2: Asia

- **Location**: Qinyang Chemical Industrial Park, Xinyang, Henan, China. (Haohua Chemical also operates a 91,000-ton-per-year chlorine and 100,000-ton-per-year PVC plant in Jiaozuo, Henan province.\(^{65}\))
- **Process**:
  - Chlor-alkali: asbestos diaphragm and Membrane.\(^{66}\)
  - PVC: acetylene.
- **Year Opened**: 1969.\(^{67}\)
- **Capacities** (tons per year):
  - 400,000 tons of chlorine (82,000 tons by asbestos diaphragm and 318,000 tons by membrane).\(^{68}\)
  - 400,000 tons of PVC per year (acetylene process, 2014).\(^{69}\)
  - 115 MW coal-fired power plant.\(^{70}\)
- **Capacity Rankings**: Tied as 21st largest chlor-alkali plant in Asia and 39th largest chlor-alkali plant in the world. Tied as 20th largest PVC plant in Asia and 44th largest PVC plant in the world.
- **Technology Conversions**:
  - In 2008, Haohua Yuhang expanded PVC production capacity (acetylene route) from 180,000 tons to 200,000 tons per year.\(^{71}\)
  - In 2009, the plant had the capacity to produce 82,000 tons of chlorine per year using asbestos diaphragm and 100,000 tons by membrane technology, with an expansion of capacity by membrane underway.\(^{72}\)
- **Markets**:
  - Chlorinated products include chlorine, barium chloride, PVC calendered film and sheet, PVC artificial leather, and hydrochloric acid.\(^{73}\)
  - Carbide slag from the operation is used in cement sold by Beijing Building Materials Group.\(^{74}\)

**INVENTORY CODE:** ASIACHN05

- **Plant Name**: Jilantai Salt Chemical (Group) Co., Ltd.
- **Owner**: China National Salt Industry Corporation (CNSIC).\(^{75}\)
- **Location**: Wusital, Alashan Economic Development Area, Alxa Zuoqi, Alxa Left Banner, Inner Mongolia China.
- **Process**:
  - Chlor-alkali: membrane.\(^{76}\)
  - PVC: acetylene.\(^{77}\)
- **Year Opened**: 2008.
- **Capacities** (tons per year):
  - 273,000 tons of chlorine.\(^{78}\)
  - 400,000 tons of PVC (2018).\(^{79}\)
  - 270 MW coal-fired power plant.\(^{80}\)
- **Capacity Rankings**: Not among the 33 largest chlor-alkali plants in Asia. Tied as 20th largest PVC plant in Asia and 37th largest PVC plant in the world.
- **Technology Conversions**:
  - In September 2007, the Jilantai Salt plant, with PVC production capacity (acetylene route) of 200,000 tons, was completed.\(^{81}\) It was the first phase of a planned 400,000-ton-per-year complex.\(^{82}\)
  - From 2008 to 2010, the company expanded membrane-based chlorine production by 182,000 tons in 2009 and 2010, to feed its growing PVC unit.\(^{83}\)
  - On December 2, 2010, an acetylene converter explosion at the plant killed three workers. According to ICIS News, the explosion “caused a feedstock snag” and a PVC plant shutdown until the end of the month.\(^{84}\)
• Chlorine production capacity in 2012 was 273,000 tons.\(^{85}\)
• The company plans to reach a PVC production capacity of 1,000,000 tons per year.\(^{86}\)

● **Markets:**
  • Most of the “company’s PVC cargoes are sold… on the spot market,” according to *ICIS News*.\(^{87}\)
  • According to the company’s website, PVC and other products are exported around the world.\(^{88}\)
  • A 2011 survey of 13 plants in China found that China Salt Jilantai offered the lowest price for PVC.\(^{89}\)
  • Additional chlorinated products include liquid chlorine, hydrochloric acid, calcium chloride, perchlorate, and tetrachloroethylene.\(^{90}\)
  • In 2017, the National Development and Reform Commission, a Chinese government authority, accused China Salt Jilantai Salinization Group Co., Ltd. of price-fixing practices.\(^{91}\)

**INVENTORY CODE: ASIACHN06**

● **Plant Name:** *Baotou Haipingmian (alternatively Baotau Haiping) Polymer Industry Co., Ltd.*
  Also called *Baotou Haipingmian Macromolecule Industry Company*

● **Owner:** East Hope Group.\(^{92}\)

● **Location:** Hope Industrial Park, Baotou Rare Earth High-tech, Baotou, Inner Mongolia, China.

● **Process:**
  • Chlor-alkali: membrane.\(^{93}\)
  • PVC: acetylene.\(^{94}\)

● **Year Opened:** 2010.\(^{95}\)

● **Capacities (tons per year):**
  • 291,000 tons of chlorine.
  • 400,000 tons of PVC.
  • 600,000 tons of calcium carbide.\(^{96}\)

● **Capacity Rankings:** Not among the 33 largest chlor-alkali plants in Asia. Tied as 20th largest PVC plant in Asia and 37th largest in the world.

● **Technology Conversions:**
  • The Baotou Haipingmian project, planned since 2002, opened in 2010 with the capacity to produce up to 400,000 tons per year of PVC.\(^{97}\)
  • In December 2018, Baotou Haipingmian reported that control measures reduced mercury emissions by half, on a per-unit PVC resin basis, as compared to 2010.\(^{98}\)

● **Markets:**
  • PVC resin produced at this plant is sold on the spot market.\(^{99}\)
  • In 2017, the National Development and Reform Commission fined the company for establishing a PVC price monopoly agreement with Dezhou Shihua Chemical.\(^{100}\)

**INVENTORY CODE: ASIACHN07**

● **Plant Name:** *Inner Mongolia Yili Chemical Industries Inc.*

● **Owner:** Elion Resources Group, via Inner Mongolia Yili Energy, of which it was the controlling shareholder in 2013. Inner Mongolia Yili Energy was named Inner Mongolia Yili Science & Technology Industry Co. until 2008.\(^{101}\) Elion Resources and Shanghai Huayi Group launched this 52:48 joint venture in 2005.\(^{102}\)

● **Location:** Dalat Banner Industrial Park, Erdos City, Inner Mongolia, China.

● **Process:**
  • Chlor-alkali: membrane.\(^{103}\)
  • PVC: acetylene.\(^{104}\)
● **Year Opened:** 2006.

● **Capacities (tons per year):**
  - 364,000 tons of chlorine (2013).\(^{105}\)
  - 500,000 tons of PVC (2017, acetylene-based).\(^{106}\)
  - 640,000 tons of calcium carbide (2013).
  - 800 MW coal gangue-fired power plant (Shenhua Yili).\(^{107}\) Coal gangue is mainly waste rock from mining operations.\(^{108}\)

● **Capacity Rankings:** Tied as the 23rd largest chlor-alkali plant in Asia and 44th largest in the world. Tied as 15th largest PVC plant in Asia and 24th largest in the world.

● **Technology Conversions:**
  - Started up in 2006 with a 159,400-ton-per-year chlorine production capacity by membrane electrolysis.\(^{109}\)
  - Expanded in 2007 to 328,000 tons per year of chlorine capacity.\(^{110}\)

● **Markets:**
  - Sells PVC resin on the spot market. In 2017, the National Development and Reform Commission fined the Elion Resources Group and 17 other PVC producers for price fixing. “The 18 companies involved in the case have increased the price of PVC sales and actual sales in accordance with the agreed price or price increase of the monopoly agreement,” reported the NDRC.\(^{111}\)
  - PVC pipe manufacturing in China consumes a significant amount of resin made at this plant.\(^{112}\)

**INVENTORY CODE: ASIACHN08**

● **Plant Name:** *Inner Mongolia Yidong Group Dongxing Chemical Co., Ltd.*

● **Owner:** Inner Mongolia Yidong Resources Group Co., Ltd.

● **Subsidiaries - Inner Mongolia Yidong Dongxing Chemical Co., Ltd. / Inner Mongolia Dong Xing International Trade Co., Ltd. Largest shareholder is Xie Dongsheng.*\(^{113}\)

● **Location:** Qixiaying Industrial Park, Ulan Qab City, Inner Mongolia, China.

● **Process:**
  - Chlor-alkali: membrane.\(^{114}\)
  - PVC: acetylene.

● **Year Opened:** The company was founded in 2006.\(^{115}\)

● **Capacities (tons per year):**
  - 291,000 tons of chlorine.
  - 400,000 tons of PVC (including 100,000 tons of emulsion PVC), by acetylene route.\(^{116}\)
  - 600,000 tons of calcium carbide.
  - 30,000 tons of trichloroethylene.\(^{117}\)

● **Capacity Rankings:** Not among the 33 largest chlor-alkali plants in Asia. Tied as 20th largest PVC plant in Asia and 37th largest in the world.

● **Technology Conversions:**
  - In 2014, the plant’s PVC production capacity was 300,000 tons.\(^{118}\)

● **Markets:**
  - In addition to PVC, the plant exports other chlorinated products, including calcium chloride and magnesium chloride.\(^{119}\)
  - The company also runs a 100,000 ton-per-year capacity emulsion PVC plant in Erdos, Inner Mongolia, China. It opened the plant in 2013.\(^{120}\)
INVENTORY CODE: ASIACHN09

- **Plant Name:** Inner Mongolia Junzheng Chemical Co., Ltd.
- **Owner:** Inner Mongolia Junzheng Energy & Chemical Group (also referred to as Junzheng Group). In 2016, Forbes magazine listed its owner, Du Jiangtao, as China’s 76th richest person. He fell to #208 in 2018. Du ranked #965 on Forbes’ worldwide Billionaires 2018 list.
- **Location:** Wudai Industrial Park, Wuda District, Wuhai City, Inner Mongolia, China.
- **Process:**
  - Chlor-alkali: membrane.
  - PVC: acetylene.
- **Year Opened:** 2008.
- **Capacities (tons per year):**
  - 500,000 tons of chlorine.
  - 800,000 tons of PVC. The company also is developing a large-scale (planned 600,000-ton capacity) integrated chlor-alkali/PVC plant in Erdos (Erdos Junzheng).
  - 200 MW coal-fired power plant (Junzheng Chemical Power Plant).
- **Capacity Rankings:** The 13th largest chlor-alkali plant in Asia and 24th largest in the world. 4th largest PVC plant in Asia and 9th largest in the world.
- **Technology Conversions:**
  - Construction on the first phase of the PVC plant began in 2007.
  - PVC production capacity reached 400,000 tons in 2012 after a 300,000-ton overhaul. Actual production for the year was 314,000 tons.
  - In 2012, the company shut down an old 55,000-ton PVC unit and two original calcium carbide furnaces.
- **Markets:**
  - The largest customers for the plant’s PVC resin in 2012 were state trading companies.
  - In addition to PVC, chlorine, and caustic soda, the plant sells hydrochloric acid, ferrosilicon, calcium carbide, limestone, and cement clinker.

INVENTORY CODE: ASIACHN10

- **Plant Name:** Inner Mongolia Wuhai Chemical Plant
- **Owner:** Hongda Xingye Co., Ltd., via its subsidiary, Inner Mongolia Wuhai Chemical Co., Ltd; Hongda Xingye acquired this plant — then called Wuhai Temple Chemical Plant — in 2004.
- **Location:** Haihua Industrial Park, Wuda District, Wuhai City, Inner Mongolia, China.
- **Process:**
  - Chlor-alkali: membrane.
  - PVC: acetylene.
- **Year Opened:** 2007.
- **Capacities (tons per year):**
  - 267,000 tons of chlorine (2013).
  - 500,000 tons of calcium carbide (undated).
  - 600,000 tons of PVC (2017).
  - 400 MW coal-fired power plant.
- **Capacity Rankings:** Not among the largest 33 chlor-alkali plants in Asia. Tied as 8th largest PVC plant in Asia and 16th largest in the world.
- **Technology Conversions:**
○ In 2007, Wuhai Chemical said it was partnering with Asahi Kasei (Japan) to install a new membrane chlor-alkali plant (109,000-ton-per-year chlorine capacity). “Wuhai Chemical has said it would start up its 300,000 tonnes/year polyvinyl chloride (PVC) plant at the same time as the membrane caustic soda plant this year,” reported ICIS.\textsuperscript{142}

○ PVC production began on April 28, 2007.\textsuperscript{143}

○ Wuhai Chemical acquired Inner Mongolia Menghua Haibowan Power Generation Co., Ltd. in 2013. This company has a 400 MW coal-fired power plant, which is integrated with the site’s chlor-alkali and PVC production.\textsuperscript{144}

○ In 2015, the plant’s PVC capacity was reported as 300,000 tons per year.\textsuperscript{145}

● **Markets:**
  ○ In addition to PVC (“Tianhu” brand), the company sells other chlorinated products, including liquid chlorine and hydrochloric acid.
  ○ The company says its products are sold domestically and “are exported to South Africa, Russia, Canada, Bangladesh, Sudan, Korea, Vietnam, Mongolia, and other countries.”\textsuperscript{146}
  ○ In addition to chlorinated products, it sells soda ash, caustic soda, cement, slag, and other raw materials.\textsuperscript{147}

**INVENTORY CODE: ASIACHN11**

● **Plant Name:** Shingpu Chemicals Ltd.

● **Owner:** SP Chemical Holdings (Cayman Islands/Singapore), via SP Taixing subsidiary.\textsuperscript{148}

● **Location:** Taixing, Jiangsu Province, China.

● **Process:**
  ○ Chlor-alkali: membrane.\textsuperscript{149}
  ○ PVC: ethylene.

● **Year Opened:** 1998.\textsuperscript{150}

● **Capacities (tons per year):**
  ○ 660,000 tons of chlorine
  ○ 500,000 tons of VCM (2018).\textsuperscript{151}
  ○ 160 MW coal-fired power plant.\textsuperscript{152}

● **Capacity Rankings:** The 7th largest chlor-alkali plant in Asia and 14th largest in the world.

● **Technology Conversions:**
  ○ The first chlor-alkali operations began in 1998 with the capacity to produce 36,000 tons of chlorine per year.\textsuperscript{153}
  ○ In 2006, it embarked upon an expansion plan.
  ○ It added a VCM production line (200,000 tons per year) in 2007.
  ○ In 2008, SP Chemical expanded the plant’s chlorine production capacity from 264,000 to 396,000 tons and its aniline capacity from 90,000 tons to 135,000 tons.\textsuperscript{154}
  ○ In June 2008, SP Chemicals imported EDC from the United States (10,500 tons), Saudi Arabia (4,998 tons), and Taiwan (5,065 tons).\textsuperscript{155}
  ○ SP Chemical is located on the Yangtze River, where it operates a shipping terminal. In 2019, SP Chemicals and partner INEOS plan to launch the largest ethane carrier in the world. The ship will deliver shale gas ethane from the United States to the Taixing plant.\textsuperscript{156} The ethane will be used as feedstock for the production of EDC and VCM.

● **Markets:**
  ○ “SP Chemicals’ customer base in the PRC [People’s Republic of China] spans the Jiangsu, Zhejiang and Shandong provinces, as well as Shanghai. In 2004, the Company also started exporting its products to the US, Japan, Korea and Taiwan,” read a company press release in 2004.
Its customers included Akzo Nobel Basic Chemical Solutions, BASF, Dow Chemical, Tomen, and Yantai Wanhua.\footnote{157}

- In 2008, SP Chemical noted that it sells VCM “on a spot basis.”\footnote{158}
- Other products include aniline, chlorobenzene, and nitrochlorobenzene.\footnote{159} Aniline is a feedstock for isocyanate production. Chlorobenzene is a solvent used in pesticides, paints, and other products. Nitrochlorobenzene is a chemical intermediate used in the production of dyestuffs, insecticides, rubber chemicals, and oil additives.\footnote{160}
- Local customers of this plant’s chlorine and VCM included:
  - Taiwan UPC Group, which has the capacity to produce 450,000 tons of PVC per year\footnote{161};
  - Solvay (100,000 tons per year epichlorohydrin capacity)\footnote{162}; and,
  - Akzo Nobel (60,000 tons per year of monochloroacetic acid).\footnote{163}

**INVENTORY CODE: ASIACHN12**

- **Plant Name:** Jiangsu Meilan. Formerly known as *Taizhou Electrolysis Chemical Factory*\footnote{164}
- **Owner:** Jiangsu Meilan Chemical (established 1996).\footnote{165}
- **Location:** Taizhou, Jiangsu Province, China.
- **Process:**
  - Chlor-alkali: asbestos diaphragm\footnote{166} and membrane\footnote{167}.
  - PVC: ethylene.
- **Year Opened:** By 1969.\footnote{168}
- **Capacities** (tons per year):
  - 293,000 tons of chlorine (2013); of which, an estimated 232,000 tons are from membrane cell production and an estimated 61,000 tons are by asbestos diaphragm.\footnote{169}
  - 400,000 tons of PVC (2004, ethylene route).\footnote{170}
  - 240,000 tons of methylene chloride (2016).\footnote{171}
- **Capacity Rankings:** Not among the 33 largest chlor-alkali plants in Asia. Tied as 20th largest PVC plant in Asia and 37th largest in the world.
- **Technology Conversions:**
  - In 2002, the plant stopped producing CFC-113, a potent ozone-depleting substance.\footnote{172}
  - In 2003, the plant produced 3,395 metric tons of carbon tetrachloride. It consumed 76,348 tons of chlorine, according to a United Nations Environment Programme report.\footnote{173}
  - In 2004, the plant installed 133,000 tons per year of chlorine production capacity by membrane cell technology.
  - In 2005 and 2006, the plant added 99,000 tons per year of chlorine production capacity by membrane cell technology.\footnote{174}
- **Markets:**
  - In addition to PVC and methylene chloride, the plant produces HCFC-22, carbon tetrachloride, and chloroform, all of which are ozone-depleting substances.\footnote{175}
  - In 2005, the World Bank agreed to purchase Carbon Finance Emissions Reduction credits from the plant and provide technical assistance in exchange for the installation of an HFC-23 incinerator. The World Bank reported, “At this site, Jiangsu Meilan produces a variety of chemical products (e.g. caustic soda, aniline, organic silicon, polytetrafluoroethylene, KFM, and PVC) and chemical intermediates (such as chlorine, hydrochloric acid, hydrofluoric acid, anhydrous hydrogen fluoride, methylene chloride, chloroform, HCFC-22, tetrafluoroethylene, perfluorpropene, chloroethylenes).”\footnote{176}
  - According to a list of registered pesticides in Pakistan, Jiangsu Meilan produces the pesticide, trichlorfon, which targets mango and melon fruit flies.\footnote{177} Trichlorfon also is used in veterinary medicine and a lawn-grub pesticide product.\footnote{178}
A 2017 company report suggested that “both the sale of large EDC [ethylene dichloride] and hydrochloric acid should be done.”

INVENTORY CODE: ASIACHN13

- **Plant Name:** Hangjin - Huludao
- **Owner:** Hangjin Technology Co., Ltd. The company was named Fangda Jinhua Chemical until April 2018. The Shenzhen Stock Exchange-listed corporation also produces military electronics.
- **Location:** Huludao, Liaoning Province, China. Huludao was known as Jinxi until 1994.
- **Process:**
  - Chlor-alkali: membrane
  - PVC: acetylene
- **Year Opened:** 1941. Originally named Jinhua [or Jin Hua] Chlor-Alkali.
- **Capacities** (tons per year):
  - 354,000 tons of chlorine (2018).
  - 40,000 tons of PVC (by acetylene method).
  - 200,000 tons of propylene oxide (2014).
  - 100,000 tons of polyether polyols.
- **Capacity Rankings:** The 27th largest chlor-alkali plant in Asia and 52nd largest in the world.
- **Technology Conversions:**
  - In 1989, the plant added a nonylphenol production plant. It also had the capacity to produce 114,000 tons per year of chlorine, 20,000 tons of propylene oxide, 20,000 tons of polyether polyols, and 20,000 tons of chlorobenzene.
  - In 1998, the plant (then called Jinhua Chemical) replaced “obsolete and highly polluting mercury and diaphragm cells for caustic soda production with ion exchange membrane cells, according to the ADB, which financed the conversion (73,000 tons per year chlorine capacity).”
  - In 2003, the company built another chlor-alkali unit with membrane technology (109,000 tons per year of chlorine capacity). The Japan Bank for International Cooperation supported this project with supplier’s credit.
  - In 2009, it reported, the Huludao plant produced 168,000 tons of chlorine, 45,084 tons of propylene oxide, 10,318 tons of polyether polyols, and 17,205 tons of chlorobenzene.
  - In 2012, according to industry analysts at ICIS, “the company’s 2012 production output more than doubled year on year.” It reported producing 309,000 tons of chlorine, 119,550 tons of propylene oxide, and 55,793 tons of polyether polyols.
- **Markets:**
  - According to a Reuters Company Profile, the company “distributes its products in the domestic and overseas markets.”
  - Hanjin Technology’s PVC resins are used to produce “cable sheaths, various types of films, sheets, profiles, pipes, pipe fittings, transparent sheets, etc. in the fields of industry, agriculture, military and health medicine.”
  - Hanjin’s website says it serves “China’s major military industrial groups and subordinate units, private military enterprises and other domestic key weapons and equipment manufacturing enterprises, especially in the high-end fields such as military industry and aerospace.”
  - Propylene oxide and polyether polyols produced by this plant are used in the production of polyurethane.
  - It also supplies chlorine to a phosgene plant, Liaoning Hongshan Chemical Co., in Kazuo County, Liaoning Province. Phosgene, the leading nerve gas used in the First World War, is used in the manufacture of pesticides and polyurethane. It is made from the reaction of chlorine with carbon monoxide.
According to Hanjin Technology, the plant’s chlorobenzene “is mainly used in the production of sulfur dyes and azo dyes, as well as in the synthesis of DDT, nitrochlorinated benzene, phenol, aniline, pyrochloric acid and organic solvents.”

**INVENTORY CODE: ASIACHN14**

- **Plant Name**: Ningxia Jinyuyuan Chemical Group Co, Ltd.; also called Ningxia Jinhaoyuan Chemical Group, Ltd.; formerly called Qingtongxia Resin Factory
- **Owner**: Ningxia Jinyuyuan Chemical Group Co. Ltd. Also called Ningxia Jinyuyuan Chlor-Alkali Co, Ltd.
- **Location**: Qingtongxia Town, Wuzhong City, Ningxia, China.
- **Process**:
  - Chlor-alkali: membrane.
  - PVC: acetylene.
- **Year Opened**: 1991.
- **Capacities** (tons per year):
  - 455,000 tons of chlorine.
  - 700,000 tons of PVC.
  - 1.6 million tons of calcium carbide slag.
  - 600 MW coal-fired power plant.
- **Capacity Rankings**: Tied as the 14th largest chlor-alkali plant in Asia and 27th largest in the world. 7th largest PVC plant in Asia and 12th largest in the world.
- **Technology Conversions**:
  - In 2001, Ningxia Jinyuyuan completed a renovation that increased its production capacity to 91,000 tons of chlorine, 100,000 tons of PVC, and 100,000 tons of calcium carbide. This collaboration with Shanghai Chlor-Alkali Chemical (SCAC) was, at the time, the largest chlor-alkali operation in Northwest China. The government of China (through the Huayi Group) is the largest shareholder of SCAC.
  - From 2005 through 2007, the plant added a 71,000-ton-per-year chlorine production capacity.
  - In 2010, ICIS News reported that a project to add 400,000 tons of carbide-based PVC production capacity was delayed. In 2011, this project was envisioned as an additional output of 291,000 tons of chlorine, 400,000 tons of PVC, 600,000 tons of calcium carbide, and 800,000 tons of cement, to be constructed in two phases.
  - In 2011 it reported capacities of 120,000 tons of caustic soda, 150,000 tons of PVC resin, 200,000 tons of calcium carbide, 40,000 tons of hydrochloric acid, and 5,000 tons of liquid chlorine.
  - In 2016, a 240,000-ton expansion in PVC capacity was planned to start.
  - The project to add 400,000 tons of carbide-based PVC production capacity was completed in 2018. The company reported expanding its resin production production to 700,000 tons of PVC, or “more than 70 times” the plant’s opening capacity in 1991.
- **Markets**:
  - According to the company’s website, its leading products are general purpose suspension PVC resins used in electrical insulating materials, membranes, agricultural films, pipes, pipe fittings, and profiles.
  - It sells PVC resin on the spot market. In 2017, the National Development and Reform Commission fined Ningxi Jinyuyuan and 17 other PVC producers for price fixing. “The 18 companies involved in the case have increased the price of PVC sales and actual sales in accordance with the agreed price or price increase of the monopoly agreement,” reported the NDRC.
INVENTORY CODE: ASIACHN15

- **Plant Name:** Shaanxi Beiyuan Chemical Industry Group Co.
- **Owner:** Shaanxi Coal and Chemical Industry Group (state owned), via Beiyuan Group subsidiary.\(^{212}\)
- **Location:** Jinjie Industrial Park, Yulin, Shenmu County, Shaanxi Province, China.
- **Process:**
  - Chlor-alkali: membrane.\(^{213}\)
  - PVC: acetylene.\(^{214}\)
- **Year Opened:** 2010.\(^{215}\)
- **Capacities** (tons per year):
  - 800,000 tons of chlorine.
  - 1.1 million tons of PVC (acetylene route).
  - 500,000 tons of calcium carbide.
  - 500 MW coal-fired power plant.\(^{216}\)
- **Capacity Rankings:** The 5th largest chlor-alkali plant in Asia and 11th largest in the world. 3rd largest PVC plant in Asia and 4th largest in the world.
- **Technology Conversions:**
  - Construction was started in 2008 and the first phase was completed in 2010, with the capacity to produce 82,000 tons per year of chlorine and 100,000 tons of PVC.\(^{217}\)
  - By 2011, the plant’s capacity expanded by 364,000 tons of chlorine and 500,000 tons of PVC.\(^{218}\)
  - In 2014, the plant produced 801,000 tons of chlorine. At the time, it ranked as the third largest chlorine producer in China and planned further expansion.\(^{219}\)
  - In the first half of 2018, according to the company’s website, “the company produced 558,800 tons of PVC, 387,700 tons of caustic soda, 784,300 tons of cement, 219,900 tons of calcium carbide, and 1.782 billion kWh of electricity.”\(^{220}\) By the end of the year, it achieved its goal of producing 1.1 million tons of PVC resins per year.\(^{221}\)
- **Markets:**
  - The main customers of the PVC produced here are domestic.\(^{222}\) The company says that “it can convert 1.35 million tons of raw salt and 8 million tons of raw coal directly and indirectly, which will drive the rapid development of local chemical, building materials, transportation, service and other related industries, which is of great significance to boost local industrial economic growth and catch up with development.”\(^{223}\)

INVENTORY CODE: ASIACHN16

- **Plant Name:** Dezhou Shihua Chemical Co. Ltd., (DSC), formerly Shandong Dezhou Petrochemical General Factory
- **Owner:** ChemChina, via its China Hoahua Chemical Group subsidiary. ChemChina acquired the plant in 2007.\(^{224}\)
- **Location:** Tianqu Industrial Park, north of Dezhou City, Shandong Province, China.
- **Process:**
  - Chlorine: membrane.\(^{225}\)
  - PVC: acetylene.
- **Year Opened:** 1971. Moved from the city to 8 kilometers north of the city in 2011.\(^{226}\)
- **Capacities** (tons per year):
  - 364,000 tons of chlorine (2015).
  - 360,000 tons of PVC resin (2015).
  - 182 MW coal-fired power plant (2015).\(^{227}\)
- **Capacity Rank:** Tied as 23rd largest chlor-alkali plant in Asia and 44th largest in the world. Tied as 27th largest PVC plant in Asia and 46th largest in the world.
● **Technology Conversions:**
  - The chlor-alkali and PVC plant moved to its current location in 2010 and restarted in 2011 with a capacity to produce 218,000 tons of chlorine and 300,000 tons of PVC resin. A report by the Asian Development Bank (ADB) explains, “Before 2011, the DSC manufacturing facility was located in Dezhou City. However, as a result of a government policy to relocate heavy industries out of [the] city boundary, DSC moved its facility to the current location, which is [on the] outskirts of Dezhou City, 8 kilometers (km) north of the city center. The construction of the DSC facility started in 2011 and since December 2012, the DSC has been operating the current facilities.”
  - In 2015, the Asian Development Bank approved a loan to demonstrate a new way of producing VCM using calcium carbide. The method intends to reduce energy consumption and replace the use of mercury catalysts with barium chloride. According to an ADB environmental impact assessment, in this new process, “acetylene and EDC are reacted in a fixed bed reactor and produce VCM. In this reaction, barium chloride is used as a catalyst and nitrogen-doped coal-based activated carbon is used as a carrier of the catalyst.” This technology is called the Jiang-Zhong process. It “passed expert review” in 2014, according to ChemChina.
  - In 2017, the ADB noted that “with this demonstration project, ChemChina and the government intend to pave the way for a complete elimination of mercury in the PRC’s PVC industry.”
  - ChemChina is installing up to 400,000 tons of PVC production capacity using the process backed by the ADB. The first mercury-free VCM production units financed by the ADB loan were under construction in 2018.
  - According to a 2018 industry survey, in addition to the new production using the Jiang-Zhong process, DSC is also planning to install another 100,000 tons of PVC capacity using the conventional calcium carbide route.

● **Markets:**
  - In 2017, China’s National Development and Reform Commission accused Dezhou Shihua Chemical of establishing a PVC price monopoly agreement with Baotou Haipingmian.
  - In addition to PVC, the plant produces hydrochloric acid (100,000-ton capacity per year), liquid chlorine (120,000 tons), trichloroethylene (40,000 tons) and hydrogen peroxide (100,000 tons).

**INVENTORY CODE:** ASIACHN17

- **Plant Name:** Shandong Yangmei Hengtong Chemical Co., formerly Shandong Hengtong / Hengtong Chemical
- **Owner:** Yangmei Group.
- **Location:** Linyi City Tancheng, Shandong, China.
- **Process:**
  - Chlor-alkali: membrane.
  - PVC: ethylene.
- **Year Opened:** 2011.
- **Capacities (tons per year):**
  - 364,000 tons of chlorine.
  - 300,000 tons of PVC.
  - 200 MW coal-fired power plant.
- **Capacity Ranks:** Tied as 23rd largest chlor-alkali plant in Asia and 44th largest in the world. Tied as 33rd largest PVC plant in Asia and 46th largest in the world.
- **Technology Conversions:**
  - The Shandong Yangmei Hengtong Chemical plant opened in 2011 with the capacity to produce 182,000 tons of chlorine per year via membrane cells, which it doubled in 2012.
  - In February 2015, the company started up a methanol-to-olefins (MTO) plant, with capacities
to produce 120,000 tons of ethylene and 180,000 tons of propylene per year.\textsuperscript{244} A company source informed ICIS that “the plant’s ethylene output will be fed into the company’s downstream 300,000 tonne/year PVC unit at Tanchen in the same province, while the propylene produced will be for commercial sales.”\textsuperscript{246}

- The methanol is derived from coal. As of June 2016, Shandong Yangmei Hengtong Chemical’s complex was one of 9 active coal-to-chemicals projects in China, and the only one directly connected to PVC production.\textsuperscript{246} Honeywell, which supplied the technology for this project, said, “The two most widely used components to make plastics are ethylene and propylene, and both have traditionally been derived from crude oil. Regions such as China that lack domestic sources of crude oil have turned to MTO [methane-to-olefin] technology to take advantage of alternative feedstocks such as coal and natural gas.”\textsuperscript{247}

- **Markets:**
  - In addition to PVC, caustic soda, propylene, and ethylene, Shandong Yangmei Hengtong Chemical can produce 200,000 tons of hydrogen peroxide, 80,000 tons of phosphorus trichloride (which is mainly used in pesticides manufacturing), 20,000 tons of bleaching powder, and 80,000 tons of hydrochloric acid.\textsuperscript{248}

**INVENTORY CODE: ASIACHN18**

- **Plant Name:** *Qilu Petrochemical*
- **Owner:** China Petroleum & Chemical Corporation (Sinopec), via its subsidiary, Sinopec Qilu Petrochemical Corporation.\textsuperscript{249}
- **Location:** Zibo, Shandong Province, China.
- **Process:**
  - Chlor-alkali: diaphragm and membrane.\textsuperscript{250}
  - PVC: Ethylene.\textsuperscript{251}
- **Year Opened:** 1966.\textsuperscript{252}
- **Capacities** (tons per year):
  - 410,000 tons of chlorine (2012).\textsuperscript{253} Estimated 230,000 tons by asbestos diaphragm and 180,000 tons by membrane technology (see below).
  - 600,000 tons of VCM (2004).
  - 600,000 tons of PVC (2017).\textsuperscript{254}
  - 800,000 tons of ethylene (2012).\textsuperscript{255}
- **Capacity Rank:** 20th largest in Asia and 37th largest in the world. Tied as the 8th largest PVC plant in Asia and 16th largest in the world.
- **Technology Conversions:**
  - In 2000, Qilu Petrochemical’s chlorine production capacity in Zibo increased to 230,000 tons per year.\textsuperscript{256}
  - In 2004, a plant expansion increased chlorine, VCM, and PVC production capacities to their current (2018) tonnages. The expansion incorporated membrane cell technology.\textsuperscript{257}
  - In 2005, its PVC production capacity of 600,000 tons per year was the largest of four plants in China that produced PVC from on-site chlorine and ethylene.\textsuperscript{258}
- **Markets:**
  - In addition to PVC (including chlorinated PVC) resins, the plant produces epichlorohydrin and epoxy resins.\textsuperscript{259}

**INVENTORY CODE: ASIACHN19**

- **Plant Name:** *Shandong Xinfa Chemical Co. Ltd.*
  Also called *Shandong Xinfa Huayu and Chiping Xinfa PVC Co. Ltd.*
• **Owner:** Xinfa Group.
• **Location:** Liaocheng, Shandong Province, China.
• **Process:**
  - Chlor-alkali: membrane.\(^{260}\)
  - PVC: acetylene.\(^{261}\)
• **Year Opened:** 2007.
• **Capacities** (tons per year):
  - 510,000 tons of chlorine (2014).\(^{262}\)
  - 600,000 tons of PVC (2017).\(^{263}\)
• **Capacity Rank:** 12th largest chlor-alkali plant in Asia and 23rd largest in the world. Tied as the 9th largest PVC plant in Asia and 16th largest in the world.
• **Technology Conversions:**
  - The first chlor-alkali plant - using membrane cells with the capacity to produce 182,000 tons of chlorine per year - was completed in 2007.\(^{264}\)
  - By 2013, after a series of expansions starting in 2009, the plant’s PVC production capacity reached 600,000 tons.\(^{265}\) It added more chlor-alkali capacity in 2013 (273,000 tons of chlorine).\(^{266}\)
• **Markets:**
  - The company’s website markets PVC resins to “countries in South Asia (which) have an urgent need to build infrastructure.”\(^{267}\) Its exports are handled by Ningbo Grand International Trading Company Limited, upon which the Indian government has imposed anti-dumping duties.\(^{268}\)

**INVENTORY CODE: ASIACHN20**

• **Plant Name:** *Shanghai caustic soda and PVC project,*\(^{268}\) also called *Tianyuan Chemical Plant*\(^{269}\)
• **Owner:** Joint venture of Shanghai Tianyuan (Group) Corporation, through its subsidiary, Shanghai Tianyuan Huasheng Chemical Co Ltd.; Shanghai Chlor-Alkali Chemical Co. (SCAC); and, Shanghai Coking Co.\(^{270}\) The government of China (through the Huayi Group) is the largest shareholder of SCAC.\(^{271}\)
• **Location:** Shanghai Chemical Industry Park, Caojing, Shanghai Province, China
• **Process:**
  - Chlor-alkali: membrane.
  - PVC: ethylene.\(^{272}\)
• **Year Opened:** 2005.\(^{273}\)
• **Capacities** (tons per year):
  - 655,000 tons of chlorine.
  - 720,000 tons of PVC.\(^{274}\)
• **Capacity Rank:** 8th largest chlor-alkali plant in Asia and tied as 15th largest in the world. 6th largest PVC plant in Asia and 11th largest in the world.
• **Technology Conversions:**
  - In the first phase of this project, the owners built a chlor-alkali plant (328,000-ton-per-year chlorine production capacity) and a 280,000-ton-per-year EDC plant, followed by a 300,000-ton VCM/PVC plant. The EDC unit startup coincided with the Shanghai Secco cracker project started by BP in the same complex. Construction of the 1.2-million-ton-per-year ethylene cracker began in 2002, was completed in 2005, and expanded in 2009.\(^{275}\) Ethylene from Shanghai Secco is combined with byproduct hydrogen chloride from the nearby isocyanate consortium to make EDC.
  - In 2012, the company increased its chlorine production capacity from 491,000 tons to 655,000 tons per year, and doubled the capacity of the EDC unit to 720,000 tons.\(^{276}\)
In 2016, SCAC closed its chlor-alkali and PVC units in the Wujing Zone and “transferred the production center of gravity to Caojing Chemical Zone,” according to its annual report.277

Markets:

- In addition to PVC production, the chlor-alkali plant supplies chlorine to Shanghai Lianheng Isocyanate Co. Ltd., (SLIC), a US$1.12 billion isocyanates production complex that opened in 2006. The operation was launched as a joint venture of SCAC, BASF, Huntsman, Shanghai Huayi (Group) Company, and Sinopec Shanghai Gao Qiao Petrochemical Corporation. Its initial capacities were 240,000 tons per year of methyl diisocyanate (MDI) and 160,000 tons per year of toluene diisocyanate (TDI). At the time, China’s demand for isocyanates was an estimated 1 million tons per year.278 In 2014, Huntsman and SCAC announced plans to double their joint venture’s MDI production capacity to 480,000 tons by 2017.279 As of 2017, the MDI plant’s capacity was 370,000 tons, with full scale expansion expected by early 2018.280 Huntsman (US) owned 70% of the joint venture, and SCAC owned the remaining 30%.281
- Chlorine from the plant is feedstock for a bisphenol A (BPA) plant run by a joint venture of Mitsui (Japan) and Sinopec (or China Petroleum & Chemical Corporation).282 The plant has the capacity to produce 120,000 tons of BPA per year.283
- Covestro is another chlorine consumer located in the Shanghai Industry Chemical Park. It produces polycarbonate plastics and isocyanates. The plant opened in 2006 as a partnership between Bayer (Germany) and SCAC. In 2013, Bayer and SCAC planned to increase the plant’s polycarbonate capacity to 400,000 tons, and reached this target in 2016. By 2016, the Covestro plant in Caojing had capacities to produce up to 500,000 tons of MDI, 300,000 tons of TDI, and 500,000 tons of hexamethylene diisocyanates (HDI), according to an ICIS report. In 2018, it planned to add, by 2022, up to 140,000 tons of MDI and 200,000 tons of polycarbonate capacity in Caojing.284

INVENTORY CODE: ASIACHN21

- **Plant Name:** Sichuan Jinlu Resin
- **Owner:** Sichuan Jinlu Group (also called Jinlu Group).
- **Location:** Deyang City, Sichuan, China.
- **Process:**
  - Chlor-alkali: membrane.
  - PVC: acetylene.
- **Year Opened:** 2004.
- **Capacities** (tons per year):
  - Chlor-alkali: 200,000 tons.
  - PVC: 300,000 tons.285
- **Capacity Rank:** Not among 33 largest chlor-alkali plants in Asia. Tied as 33rd largest PVC plant in Asia and 57th largest in the world.
- **Technology Conversions:**
  - In March 2018, the Sichuan provincial government announced that it would close nine chemical plants and move others - including Sichuan Jinlu - away from cities. It gave the Jinlu Group until the end of 2025 to relocate.286
- **Markets:**
  - The plant produces general purpose suspension PVC resins and PVC paste.287
  - In 2017, the National Development and Reform Commission, a Chinese government authority, accused Sichuan Jinlu Group of price-fixing practices.288
  - Sichuan Jinlu High-tech Materials Co., Ltd., a subsidiary of the Jinlu Group, produces PVC artificial leather used in interior finishes, toys, gloves, and other consumer products. It sells PVC “wall leather” that it claims to be “environmentally friendly, moisture-proof, flame-retardant, flexible,
sound-absorbing, easy to clean, and resistant to aging.” The factory has the capacity to produce 8 million yards of artificial leather per year.\(^{289}\)

**INVENTORY CODE: ASIACHN22**

- **Plant Name:** Yibin Hai Feng Herui Co., Ltd.
- **Owner:** Yibin Tianyuan Group Co., Ltd. (Tianyuan Group, state owned), via its Yibin Hai Feng Herui Co. subsidiary which operates the chlor-alkali plant.\(^{290}\) The Shanghai municipal government formed the Tianyuan Group in 1996.\(^{291}\)
- **Location:** Yibin, Sichuan Province, China.
- **Process:**
  - Chlor-alkali: asbestos diaphragm and membrane.
  - PVC: acetylene.\(^{292}\)
- **Year Opened:** 1944. This is “one of the earliest chlor-alkali manufacturers in China,” according to a Tianyuan Group website.\(^{293}\) It was originally called the Yibin Branch of Tianyuan Electrochemical Plant.\(^{294}\)
- **Capacities** (tons per year):
  - 437,000 tons of chlorine (estimated 146,000 tons from asbestos diaphragm and 291,000 tons from membrane).
  - 500,000 tons of PVC (2014).\(^{295}\)
- **Capacity Rank:** 19th largest chlor-alkali plant and 33rd largest in the world. Tied as 15th largest PVC plant in Asia and 24th largest in the world.
- **Technology Conversions:**
  - Installed membrane cell technology with 11,000-ton-per-year capacity in 1991.\(^{296}\)
  - In 2005, the plant produced 252,000 tons of PVC from 320,000 tons of capacity.\(^{297}\)
    - In 2008, the plant had 320,000 tons of PVC production capacity, with a 180,000-ton expansion underway.\(^{298}\)
  - In 2009, the plant had 273,000 tons of chlorine production capacity (half asbestos diaphragm and half membrane technology) and a 137,000-ton expansion underway (membrane).\(^{299}\)
  - The plant’s PVC production capacity reached 500,000 tons in 2009, at which time it ranked as China’s 4th largest PVC plant.\(^{300}\)
- **Markets:**
  - The Tianyuan Group sells PVC resin under the “Jiangshui” brand name. It also sells plastic pipes under the “Tianyuan” brand name.\(^{301}\)
  - The Tianyuan Group produces vinyl floors in this same location, through its recently formed subsidiary, Yibin Tianyi New Material Technology Co., Ltd. Flooring types include luxury vinyl tile (LVT), stone plastic composite (SPC), and wood plastic composite (WPC).\(^{302}\) From May to December 2018, this factory shipped over 2,291 tons of SPC and PVC floors to the US and Canada.\(^{303}\)
  - Other PVC building and construction materials made by the Tianyuan Group include water supply pipe, drain pipe, and wire and cable sheathing.\(^{304}\)
  - The Tianyuan complex also can produce 30,000 tons per year of trichloroethylene and 1.2 million tons of 600,000 tons per year of cement.\(^{305}\)
  - It also sells tetrachloroethylene, liquid chlorine, and hydrochloric acid.\(^{306}\)

**INVENTORY CODE: ASIACHN23**

- **Plant Name:** Tianjin LG Bohai Chemical Co., Ltd.
- **Owner:** LG Chem (Korea).\(^{307}\)
- **Location:** Lingang Industrial Area, Tanggu, Tianjin Province, China.
● **Process:**
  ○ Chlor-alkali: membrane,
  ○ PVC: ethylene.
● **Year Opened:** 2007.
● **Capacities (tons per year):**
  ○ 218,000 tons of chlorine (2007)
  ○ 350,000 tons of VCM (2007).
● **Capacity Rank:** Not among 33 largest chlor-alkali plants in Asia.
● **Technology Conversions:**
  ○ In 2005, LG Chem, Ltd., broke ground on a new chlor-alkali and VCM/EDC plant in the Lingang Industrial District. The new plant had planned capacities of 218,000 tons of chlorine, 300,000 tons of EDC, and 350,000 tons of VCM.
  ○ The plant opened in 2007.
  ○ According to an ICIS report, the LG Bohai EDC plant consumed “a significant proportion” of the ethylene produced in LG Chem’s naphtha cracker in Daesan, South Korea.
● **Markets:**
  ○ In 2005, LG said it selected the Lingang Industrial District site in Tianjin due to the proximity to its LG Dagu PVC plant located 10 kilometers away. The Dagu plant became one of the world’s largest PVC producers, with a capacity of 800,000 tons per year. It also produced doors and windows. However, in 2016, Business Korea reported, the Dagu plant was closed, and its production “absorbed” by the Tianjin LG Bohai plant. The article attributed the closure to “an expanding worldwide PVC glut.” LG reported that its LG Dagu and LG Bohai subsidiaries merged in 2015. It reported that the two subsidiaries, combined, lost over 105 billion Korean won that year, or the equivalent of over US$100 million. The 800,000-ton-per-year Dagu plant is in the process of being relocated next to the LG Tianjin chlor-alkali plant, in part in response to a city government initiative to move chemical plants from the urban center to the Naning Industrial Zone along the coast. It has been located in the Tianjin Bohai Chemical Group complex, which is the site of China’s first chlor-alkali plant. In 2015, a chemical warehouse explosion in Tianjin killed at least 179 people. In 2017, Morimatsu of Japan was awarded the contract to relocate the 800,000-ton-capacity plant.
  ○ According to a government of Pakistan National Tariff Commission analysis in 2018, LG Bohai sells PVC grades TL 700, TL 800, and TL 1000, some of which it exports to Pakistan through Bohai Chemical (HK) Ltd. The analysis found that “100 percent of domestic sales were below cost to make and sell.” The commission imposed 20% anti-dumping duties.

**INVENTORY CODE: ASIACHN24**

- **Plant Name:** Xinjiang Tianye Co. Ltd.
- **Owner:** Tianye Group, through its subsidiary, Xinjiang Shihezi Zhongfa Chemical Co.
- **Location:** Shihezi Development Zone, Xinjiang Uyghur Autonomous Region (XUAR), China.
- **Process:**
  ○ Chlor-alkali: membrane,
  ○ PVC: acetylene.
- **Year Opened:** 1995.
- **Capacities (tons per year):**
  ○ 910,000 tons of chlorine (2016).
  ○ 1.2 million tons of PVC (2017).
  ○ Xinjiang Tianye had the world’s 8th largest reported PVC production capacity in 2016.
40% of China’s PVC capacity is in XUAR.\textsuperscript{327}

1,800 MW coal-fired power plant.\textsuperscript{328}

- **Capacity Rank:** 4th largest chlor-alkali plant in Asia and tied as 9th largest in the world. 2nd largest PVC plant in Asia and 3rd largest in the world.

- **Technology Conversions:**
  - The plant opened in 1995 with the capacity to produce 3,000 tons per year of chlorine and 6,000 tons per year of PVC.\textsuperscript{329}
  - By 2002, the plant’s capacities reached 41,000 tons of chlorine and 60,000 tons of PVC.\textsuperscript{330}
  - In 2008, the plant’s PVC production capacity was 320,000 tons per year, and the company was adding another 200,000 tons of capacity.\textsuperscript{331}
  - By 2010, the Xinjiang Tianye plant’s production capacity reached 546,000 tons of chlorine and 720,000 tons of PVC, with another 273,000 tons of chlorine and 400,000 tons of PVC capacity under construction.\textsuperscript{332}
  - In 2013, *ICIS News* reported that the plant’s production levels were far below its reported capacities. “In 2013, Xinjiang Tianye produced 293,200 tonnes of PVC resin and 213,700 tonnes of liquid membrane caustic soda, up from 3.1% and 2.5% respectively from 2012,” it said. “Xinjiang Tianye posted a net loss of yuan (CNY) 216m ($34.8m) for 2013 because of softer caustic soda and polyvinyl chloride (PVC) prices amid oversupply in the domestic chlor-alkali market, the producer said.”\textsuperscript{333}

- **Markets:**
  - Much of the plant’s PVC is consumed on-site in the production of agricultural irrigation pipes.\textsuperscript{334} The company also exports PVC resins to neighboring countries. It was the largest exporter of suspension grade PVC to Russia in 2007.\textsuperscript{335}
  - In 2017, the National Development and Reform Commission, a Chinese government authority, accused Xinjiang Tianye of price-fixing practices.\textsuperscript{336}
  - In 2018, Xinjiang Tianye and four other companies sought anti-dumping measures against imported PVC resin imports from the United States, Japan, South Korea, and Taiwan.\textsuperscript{337}

**INVENTORY CODE: ASIACHN25**

- **Plant Name:** *Xinjiang Shengxiong Energy Co.*\textsuperscript{338}

- **Owner:** Xinjiang Zhongtai Chemical (often abbreviated to Zhongtai Chemical).\textsuperscript{339} Two of the four leading shareholders in 2016 were state-owned: Xinjiang Zhongtai (Group) and Urumqi Huan Peng Co., Ltd., which is a coal-mining operation.\textsuperscript{340} Xinjiang Zhongtai ranked as the world’s 7th largest PVC producer in 2016, according to a Mexichem report.\textsuperscript{341}

- **Location:** Shengxiong Industrial Park, Alehui Town, Toksun County, Turpan Prefecture, Xinjiang Uyghur Autonomous Region (XUAR), China.

- **Process:**
  - Chlor-alkali: technology not found, but assumed to be membrane.
  - PVC: acetylene.\textsuperscript{342}

- **Year Opened:** 2016.\textsuperscript{343}

- **Capacities** (tons per year):
  - 200,000 tons of chlorine (2016).
  - 250,000 tons of PVC (2016).
  - 600 MW coal-fired power plant (2016).\textsuperscript{344}

- **Capacity Rank:** Not one of the 33 largest chlor-alkali plants in Asia. 41st largest PVC plant in Asia and tied for 73rd largest in the world.
● Technology Conversions:
  ○ In 2006, Xinjiang Shengxiong Energy Co. said it planned to build a 3,000,000-ton PVC plant on this site.\textsuperscript{345}
  ○ Upon opening the first phase of the plant in 2016, the company said it plans to increase production capacities to 637,000 tons of chlorine and 900,000 tons of PVC.\textsuperscript{346}
  ○ The company also plans to double its coal-fired power production capacity to 1200 MW. However, according to the Center for Media and Democracy, “Due to new restrictions announced during 2016 by the National Energy Administration and the National Development and Reform Commission, further [coal-fired power plant] capacity expansions at this location appear to be on hold or cancelled.”\textsuperscript{347}

● Markets:
  ○ See Xinjiang Huatai Heavy Chemical below.

**INVENTORY CODE: ASIACHN26**

● Plant Name: Xinjiang Huatai Heavy Chemical

● Owner: Xinjiang Zhongtai Chemical (often abbreviated to Zhongtai Chemical). Two of the four leading shareholders in 2016 were state-owned: Xinjiang Zhongtai (Group) and Urumqi Huan Peng Co., Ltd., which is a coal-mining operation.\textsuperscript{348}

● Location: Urumqi, XUAR, China.

● Process:
  ○ Chlor-alkali: membrane.\textsuperscript{349}
  ○ PVC: acetylene.\textsuperscript{350}

● Year Opened: 2006.

● Capacities (tons per year):
  ○ 1,000,000 tons of chlorine (2016).
  ○ 1,530,000 tons of PVC (2016) (see below)
  ○ 900 MW coal-fired power plant.\textsuperscript{351}

● Capacity Rank: 3rd largest chlor-alkali plant in Asia and 7th largest in the world. Largest PVC plant in Asia and the world.

● Technology Conversions:
  ○ The VCM plant started up in early 2006 with the capacity to produce 120,000 tons per year of PVC.\textsuperscript{352}
  ○ In 2010, the plant had capacities to produce 218,000 tons of chlorine and 300,000 tons of PVC.\textsuperscript{353}
  ○ The site’s production capacities in 2011 reached 582,000 tons of chlorine and 740,000 tons of PVC after Xinjiang Zhongtai completed the installation of 273,000 tons of chlorine and 360,000 tons of new PVC production capacities.\textsuperscript{354}
  ○ According to a 2014 MRCPlast report, “In 2012, Xinjiang Zhongtai began a trial run of the third plant for suspension PVC production with the capacity of 900,000 tonnes per year in Fukang (China). The launch of the third unit of Xinjiang Zhongtai will allow to increase the total production capacity of acetylene PVC up to 1,600 thous. tonnes and, thus, become a major producer in Northern China and surpass the company Xinjiang Tianye, the total annual capacity of which makes 1,300 thous. tonnes.”\textsuperscript{355}
  ○ In its 2016 annual report, Xinjiang Zhongtai Chemical said its production capacities reached 1,000,000 tons of chlorine and 1,530,000 tons of PVC.\textsuperscript{356}
  ○ Also of note: In 2018, Xinjiang Zhongtai and Jinhui Zhaofeng Energy announced a partnership “to build a million-ton polyvinyl chloride plant in Baicheng county, Xinjiang [Uighur] Autonomous Region,” reported the Chinese news service, Yicai Global.\textsuperscript{357}
• Markets:
  ○ In 2003, Xinjiang Zhongtai sold about 30% of its PVC to markets in eastern China. 358
  ○ A 2010 Russian PVC market report describes Xinjiang Zhongtai as a “major supplier of imported PVC.” 359
  ○ In 2015, it exported 17 tons of PVC resin to Emballage Sefaco Inc., a manufacturer of fences, ramps, garden accessories, and lattice, in Quebec, Canada. 360
  ○ In 2017, the National Development and Reform Commission (NDRC), a Chinese government authority, accused Xinjiang Zhongtai of price-fixing practices. 361 The NDRC fined the company 71 million yuan (about US$10 million). 362
  ○ In 2018, Xinjiang Zhongtai and four other companies sought anti-dumping measures against imported PVC resin imports from the United States, Japan, South Korea, and Taiwan. 363

**INVENTORY CODE: ASIACHN27**

- **Plant Name:** Ningbo Wanhua
- **Owner:** Wanhua Chemical Group Co., Ltd. 364
- **Location:** Wanhua Industrial Park, Ningbo Daxie Development Zone, Ningbo, Zhejiang Province, China.
- **Process:**
  ○ Chlor-alkali: membrane.
- **Year Opened:** 2010.
- **Capacities** (tons per year):
  ○ 455,000 tons of chlorine (2015) 365
  ○ 1,200,000 tons of methylene diisocyanate (MDI, 2018).
  ○ 250 MW coal-fired power plant. 366
- **Capacity Rank:** Tied as 14th largest chlor-alkali plant in Asia and 27th largest in the world.
- **Technology Conversions:**
  ○ In 2003, Wanhua Chemical began construction of the project in Ningbo. 367
  ○ In 2010, the Wanhua Chemical (then called Yantai Wanhua Polyurethanes) opened a new chlor-alkali and MDI plant. According to an ICIS news report, “The new complex houses a 300,000 tonne/year MDI plant, a 240,000 tonne/year formaldehyde unit, a 360,000 tonne/year aniline facility and a 150,000 tonne/year caustic soda plant.” 368
  ○ By 2017, Wanhua Chemical was operating two MDI plants at Ningbo. One had 400,000 tons per year capacity; the other, 800,000 tons. 369
  ○ In 2018, Wanhua said it would increase total MDI capacity to 1.5 million tons by 2021. 370
- **Markets:**
  ○ Wanhua’s Ningbo chemical complex is the largest MDI plant in the world. 371
  ○ Overall, “Wanhua Chemical (WHC) is the biggest global methylene diphenyl diisocyanate (MDI) producer with a 24% market share,” according to a 2017 market analysis by Deutsche Bank. 372
  Wanhua Chemical also produces MDI in Yantai, China (600,000 tons per year of MDI capacity), and Kazincbarcika, Borsod-Abaúj-Zemplén, Hungary (240,000 tons see Inventory Code EU-RHU01 in Phase One report). The plant in Yantai dates to 1980. It is also building a polycarbonate (70,000-ton-per-year capacity) plant in Yantai, and considering starting an isocyanates plant in the U.S. Gulf Coast. 373
  ○ According to a Chemical & Engineering News report in 2016, “About two-thirds of Wanhua’s sales are to customers in China.” The US also is a major market. 374
COUNTRY: INDIA

OVERVIEW

The Indian chlorine industry has almost eliminated the use of mercury cell technology. In 1991, 80% of India’s chlorine production capacity used mercury cell technology. PFAS-coated membrane and PFAS diaphragm technology both held 10% shares. By 2008, 23 out of 32 plants in India were using only PFAS-coated membrane technology. The largest plants have since converted to PFAS-coated membrane and expanded capacity, while many of the smaller mercury cell plants have closed.

India has ratified the Minamata Convention, which prohibits the use of mercury cell technology by 2025. However, this treaty does not yet ban the use of mercuric catalysts in VCM production. The DCM Shriram plant in Kota, Rajasthan (ASIAIND04) uses the acetylene route of VCM/PVC production and its owners have not announced any plans to convert to ethylene-based production.

India’s building and construction sector is in the midst of long-term growth, and PVC materials – especially pipes – are a big part of that growth. According to a 2016 report published by the Federation of Indian Chambers of Commerce and Industry (FICCI), 73% of the PVC consumed in the country was used in pipes and fittings, which compares to a global rate of 43%. It also uses more PVC in flooring than reflected in global averages (8% versus 3%).

In the 2016-17 fiscal year (which runs from July to June), India produced 1.46 million tons of PVC, up from 1.11 million tons in 2009-10. It is producing PVC at near full capacity (97.9% in 2016-17). Almost all of the PVC was consumed domestically. Net consumption of PVC (factoring in imports and exports) increased 79% between 2009-10 and 2016-17, from 1.82 million tons to 3.25 million tons. PVC demand in India increased sixfold from 1996 to 2016.

The Indian business community expects demand to accelerate. In 2016, FICCI “estimated that annual demand growth for PVC will be at least 13% in the next five years. Demand is expected to cross 5 million tons in 2020.”

Since the 2014-15 fiscal year, India imported more PVC resin than it produced domestically (see chart).

According to FICCI, the leading sources of imported PVC resin are Taiwan, South Korea, Japan, China, and Iran. The industry group worried that these countries might not be “able to meet the demand in India in the future, thereby making capacity addition in the domestic industry an absolute must.”

Most PVC supply-chain imports have been in the form of PVC resins; however, India’s largest producer has installed multi-billion-dollar ethane crackers at three locations to provide feedstock for EDC/VCM/PVC production. The producer, Reliance Industries, is in three joint ventures in the US to produce shale gas from fracking. It also owns a fleet of ships dedicated to delivering ethane from the US to its PVC plants in India.
In addition to the chlor-alkali producers listed below, India’s third and fourth largest producers of PVC resins rely upon imported feedstocks. Chemplast Sanmar (Cuddalore, Tamil Nadu, 270,000-ton-per-year PVC resin capacity) imports 200,000 tons per year of VCM that it manufactures in Port Said, Egypt. Finolex Industries (Ratnagiri, Maharashtra, 260,000-ton- per-year PVC resin capacity), imports EDC from Southeast Asia and Middle Eastern producers.

**INVENTORY CODE: ASIAIND01**
- **Plant Name:** Grasim Industries - Vilayat
- **Location:** Vilayat, Gujarat, India.
- **Process:**
  - Chlor-alkali: PFAS membrane.
  - PVC: Ethylene.
- **Year Opened:** 2013.
- **Capacities** (tons per year):
  - 150,000 tons of chlorine (2013). Aditya Birla owns five chlor-alkali plants in India. In addition to the new Vilayat operation, it owns plants in Nagda (Madhya Pradesh, listed below), Renukoot (Uttar Pradesh, listed below), Rehla (Jharkhand, 90,000-ton chlorine capacity), Veraval (Gujarat, 84,000 tons), and Karwar (Karnataka, 60,000 tons).
- **Capacity Rank:** 4th largest chlor-alkali plant in India. Not among the largest 50 plants in Asia. Largest epoxy producer in India.
- **Technology Conversions:** None.
- **Markets:**
  - Alongside the new chlor-alkali plant in Vilayat, Grasim (now owned by Aditya Birla) opened a 123,000-ton-per-year-capacity epoxy production unit in Vilayat in 2014. The epoxy resins are sold worldwide under the brand name Epotec.
  - The US imported over 14,000 tons of Epotec from Aditya Birla, mainly from Thailand, in a recent one-year period (October 25, 2017 to October 24, 2018). Aditya Birla produces epoxy resins at its chlor-alkali complex (71,500 tons per year chlorine capacity) in Map Ta Phut, Thailand.

**INVENTORY CODE: ASIAIND02**
- **Plant Name:** Grasim Industries - Nagda
- **Location:** Nagda, Madhya Pradesh, India
- **Process:** PFAS membrane. Converted from mercury.
- **Year Opened:** 1972.
- **Capacities** (tons per year):
  - 245,000 tons of chlorine.
- **Capacity Rankings:** 2nd largest chlor-alkali plant in India. Not among largest 33 plants in Asia.
- **Technology Conversions:**
  - In 1989, the plant’s chlorine production capacity was 74,000 tons per year.
  - In 1993, the capacity was 82,000 tons of chlorine per year. The company announced it would convert to membrane technology.
  - By 1995, the plant had converted from mercury cell to membrane technology. The new capacity totalled 91,100 tons of chlorine per year.
Markets:
- In 2016, Aditya Birla reported that 55% of its chlorine was sold on the open market (merchant chlorine).
- According to Aditya Birla, “Grasim set up a rayon grade caustic soda unit at Nagda in 1972 with the intention of achieving a reliable and economical supply of rayon grade caustic soda, an important raw material in VSF [viscose staple fibre] production.” Grasim produces VSF in Nagda and at two other sites. Oceana reported in 2007 that Grasim was the world’s leading source of rayon (23% of the global market share), and that India supplied 20% of the United States’ imports of rayon.
- Grasim’s chlorinated products include hydrochloric acid, bleaching powder, poly aluminum chloride, aluminum chloride, and chlorinated paraffins. From July 2015 to June 2016, Aditya Birla, over all of its plants, produced over 157,000 tons of PAC, 47,000 tons of chlorinated paraffins, 36,000 tons of aluminum chloride, and 94,000 tons of bleaching powder.
- “It also supplies chlorine to Gwalior Chemical Industries Limited’s chemical complex at Nagda,” reported ICIS in 2007. Lanxess AG of Germany purchased Gwalior in 2009. The Lanxess Gwalior complex in Nagda produces specialty chemicals, including benzyl chloride, benzotrichloride, thionyl chloride, sulfuryl chloride, and sulfur dichloride.

INVENTORY CODE: ASIAIND03

- **Plant Name:** Renukoot Chemical Division (RCD)
- **Owner:** Aditya Birla Chemicals, which acquired the plant from Kanoria Chemicals & Industries (KCIL) in 2011.
- **Location:** Renukoot, Uttar Pradesh, India.
- **Process:** PFAS membrane. Converted from mercury cell.
- **Year Opened:** 1965.
- **Capacities (tons per year):**
  - 117,000 tons of chlorine.
  - 50 MW coal-fired power plant.
- **Capacity Rankings:** 6th largest chlor-alkali plant in India. Not among largest 33 plants in Asia.
- **Technology Conversions:**
  - In 1995, Kanoria Chemicals converted part of its capacity (9,000 tons of chlorine per year) from mercury to PFAS membrane technology and increased its overall capacity from 30,000 tons of chlorine to 44,000 tons.
  - In 2004, KCIL announced plans to expand its chlorine production capacity by 35,000 tons, to a total of 75,560 tons per year. The International Finance Corporation supported this expansion with a $20 million loan. The new PFAS membrane based unit was built adjacent to its existing mercury cell-based plant; the company planned to continue operating the mercury cell unit until 2012.
  - In September 2011, the mercury cell operations “permanently stopped,” according to a company filing.
  - In 2013, the company reported that it expanded chlor-alkali production in Renukoot by 43,000 tons per year. It said it accomplished this “despite the pressure of increasing input costs for power, coal and other raw materials and the unstable supply of power from the grid.”
- **Markets:**
  - The Renukoot complex makes a variety of chlorinated products, including bleaching powder, chlorinated paraffins, poly aluminum chloride, and aluminum chloride.
INVENTORY CODE: ASIAIND04

- **Plant Name**: Shriram Vinyl & Chemical Industries (SVCI), Kota
- **Owner**: DSCL (DCM Shriram) / Shriram Fertilizers & Chemicals / Shriram Chem. The related PVC compounding business, Shriram Axiall, is a 50:50 joint venture with Westlake (formerly Axiall Corporation) of the USA.\(^{421}\)
- **Location**: Kota, Rajasthan, India.
- **Process**:
  - Chlor-alkali: PFAS membrane.\(^{422}\) Converted from mercury cell.
  - PVC: Acetylene. It is the only plant in India to use the acetylene route of PVC production.\(^{423}\)
- **Year Opened**: 1964.\(^{424}\)
- **Capacities** (tons per year):
  - 103,000 tons of chlorine (2016).\(^{425}\) Expansion planned (see below).
  - 70,000 tons of PVC resin (2016).
  - The Shriram Axiall PVC compounding operation has a capacity of 32,564 tons per year.\(^{426}\)
  - 133 MW coal-fired power plant.\(^{427}\) Expansion planned.
- **Capacity Ranking**: 7\(^{th}\) largest chlor-alkali plant in India. Not among largest 33 plants in Asia.
- **Technology Conversions**:
  - In 2003, the Kota complex had the capacity to produce 34,000 tons per year of PVC resins.\(^{428}\)
  - In 2005, DCSL expanded its calcium carbide capacity from 62,700 to 112,200 tons per year, and its PVC capacity from 37,950 to 57,750 tons per year.\(^{429}\)
  - Also in 2005, it announced it had converted from mercury cell to membrane technology for producing chlorine, and that it would expand this chlorine production capacity from 75,000 to 93,000 tons per year.\(^{430}\)
  - In 2016, the company proposed increasing the plant’s chlorine capacity from 103,000 tons per year to 173,000 tons.\(^{431}\)
- **Markets**:
  - DSCL’s subsidiary, Fenesta, manufactures UPVC (unplasticized PVC) windows and doors. The products are extruded in the Kota complex.\(^ {432}\)
  - In 2014, Shriram entered into a joint venture, with Axiall (now Westlake) Corporation. Shriram Axiall operates in the Kota complex. It makes PVC polymers used in medical and healthcare products such as IV tubing and blood bags.\(^ {433}\) Compounded PVC made by the Shriram Axiall is sold worldwide. It also is used in wire and cable sheathing, pipes, and other applications.\(^ {434}\)
  - The company also sells calcium carbide to other industrial users in India.\(^ {435}\) In addition to its primary use in acetylene-route PVC production, calcium carbide is a feedstock for acetylene used in oxyacetylene welding. It also is a feedstock for manufacturing calcium cyanamide, organic solvents, and, in the steel industry, desulfurization blends.\(^ {436}\)

INVENTORY CODE: ASIAIND05

- **Plant Name**: Shriram Alkali & Chemicals, Bharuch
- **Owner**: DSCL (DCM Shriram).
- **Location**: Jhagadia, Bharuch District, Gujarat, India.
- **Process**: PFAS membrane.
- **Year Opened**: 1996.\(^ {437}\)
- **Capacities** (tons per year):
  - 284,000 tons of chlorine (2017).\(^ {438}\)
  - 110 MW coal-fired power (2017), from imported coal.\(^ {439}\)
• **Capacity Rankings:** Largest chlor-alkali plant in India. Not among largest 33 plants in Asia.

• **Technology Conversions:**
  - In 2005, the plant’s reported chlorine production capacity was 57,000 tons per year.\(^{440}\)
  - In 2016-2017, DCM Shriram expanded its chlorine production capacity in Bharuch to 284,000 tons per year. It also added a 60 MW captive power plant.\(^{441}\)

• **Markets:**
  - In 2017, DCM Shiram reported that the major use of chlorine from the plant is in the production of PVC.\(^{442}\)
  - DCM Shirram planned to start a 19,800-ton-per-year unit to produce anhydrous aluminum chloride by June 2018.\(^{443}\)

**INVENTORY CODE: ASIAIND06**

• **Plant Name:** Dahej Complex

• **Owner:** Reliance Industries Limited (RIL). Formerly Indian Petrochemicals Corp. Ltd., which merged with RIL in 2007.\(^{444}\) Reliance is the largest private company in India.\(^{445}\)

• **Location:** Dahej, Bharuch District, Gujarat, India.

• **Process:** PFAS membrane.

• **Year Opened:** 1996.\(^{446}\)

• **Capacities** (tons per year):
  - Chlorine: 141,200 tons (2016)
  - EDC: 498,960 tons
  - VCM and PVC: 315,000 tons each.\(^{447}\) A major expansion is under way (target is 1.2 million tons per year of PVC).
  - Reliance also has the capacity to import and store 650,000 tons of ethane and produce 500,000 tons per year of ethylene.
  - 270 MW coal-fired power plant and 195 MW gas-fired power plant.\(^{448}\)

• **Capacity Rank:** 5th largest chlor-alkali plant in India. Not among the largest 33 chlor-alkali plants in Asia. 34th largest PVC plant in Asia.

• **Technology Conversions:**
  - This salt-to-PVC production complex opened in 1996 with capacities to produce 115,000 tons per year of chlorine, 170,000 tons of VCM, 150,000 tons of PVC. It was powered by a 65-MW captive power plant.\(^{449}\)
  - In 2000, a second phase of development added a 300,000-ton-per-year ethylene cracker.\(^{450}\)
  - By 2003, the plant’s PVC capacity expanded to 180,000 tons per year.\(^{451}\)
  - In 2014, Reliance planned to replace its existing 142.5 MW gas-fired power plant with a 270 MW coal-fired power plant.\(^{452}\)
  - In 2016, Reliance proposed expanding the Dahej complex’s capacities to 187,000 tons per year of chlorine, 700,000 tons ethylene, 588,000 tons of ethylene dichloride, 360,000 tons of VCM, and 360,000 tons of PVC. It also envisioned a new 1.2-million-ton VCM/PVC plant using mostly using imported EDC.\(^{453}\)
  - This major expansion is relying upon ethane shipments from the USA. RIL is building six “Very Large Ethane Carriers” (VLECs). The first two — Ethane Crystal and Ethane Emerald — launched in 2016.\(^{454}\)
  - In December 2016, Reliance Industries began importing ethane from the USA. In 2017, according to the U.S. Energy Information Agency, it imported 20.8 million barrels of ethane. India became the leading destination for US ethane exports.
  - Reliance has invested heavily in replacing naphtha with ethane from the USA. These investments
include stakes in gas fracking joint ventures, including two in Pennsylvania (with Chevron and Carrizo Oil & Gas) and one in Texas (Pioneer Natural Resources Co.).

- In April 2017, Reliance announced the completion of its project to receive ethane from the USA. This project included “securing ethane refrigeration capacity in the US Gulf Coast; delivery of dedicated Very Large Ethane Carriers (VLECs) to carry ethane from the US Gulf Coast to the West Coast of India; construction of ethane receipt and handling facilities; laying pipelines and upgrading crackers (to receive ethane) at Dahej, Hazira and Nagothane Manufacturing Facilities,” according to a company press release.

- Also in April 2017, Reliance secured government approval for its planned expansion of PVC production capacity. According to a plastics industry website, Plastemart, the company’s plans are influenced by erratic feedstock supplies, and the “adequate supply of shale gas ethane from the US.”

- Markets:
  - Reliance sells several grades of PVC resins under the Reon brand name. Typical applications for these resins include pipes, bottles, flooring, wire and cable sheathing, shoe compounds, and medical blood bags.

INVENTORY CODE: ASIAIND07

- **Plant Name:** Hazira Complex
- **Owner:** Reliance Industries (RIL).
- **Location:** Hazira, Gujarat, India.
- **Process:**
  - Chlor-alkali: PFAS membrane.
  - PVC: Ethylene.
- **Year Opened:** 1993.
- **Capacities** (tons per year):
  - 198,000 tons of chlorine.
  - 360,000 tons of PVC.
  - 372 MW of coal-fired power.
- **Capacity Rankings:** 3rd largest chlor-alkali plant in India. Not among the largest 33 chlor-alkali plants in Asia. Tied for 33rd largest PVC plant in Asia.
- **Technology Conversions:**
  - From 1991 to 1995, Reliance built a $2.5 billion petrochemical complex in Hazira, including chlor-alkali and PVC units. It features a cracker that converts naphtha from its Jamnagar Complex to ethylene, propylene, and butene. ICIS reported “the PVC plant will rely on ethylene dichloride imports halving the amount of ethylene that would normally be required. Other products include polyethylene, polypropylene, polyester, and polyethylene terephthalate (PET).
  - By 1996, the plant’s PVC capacity reached 270,000 tons. Reliance planned to further expand capacity to 300,000 tons per year, representing nearly half of India’s PVC production capacity in 1998.
  - In 2014, the steam cracker at Hazira had the capacity to produce 790,000 tons per year ethylene.
  - By 2016, the plant’s PVC capacity reached 360,000 tons.
  - In April 2017, Reliance announced the completion of its project to receive ethane from the USA. This project included “securing ethane refrigeration capacity in the US Gulf coast; delivery of dedicated Very Large Ethane Carriers (VLECs) to carry ethane from the US Gulf Coast to the West Coast of India; construction of ethane receipt and handling facilities; laying pipelines and upgrading crackers (to receive ethane) at Dahej, Hazira and Nagothane Manufacturing Facilities,”
according to a company press release.\textsuperscript{470} The move to import 1.5 million tons of ethane per year from the US was projected to save Reliance $450 million per year.\textsuperscript{471}

- In 2018, Reliance proposed installing several new pipelines to feed production at Hazira, including lines to deliver ethylene (at a rate of 2,500 tons per hour) and EDC (125 tons per hour) from the port of Adani to the chemical complex. It plans to begin operating the pipelines in 2019.\textsuperscript{472}

- **Markets:**
  - Reliance sells several grades of PVC resins under the Reon brand name. Typical applications for these resins include pipes, bottles, flooring, wire and cable sheathing, shoe compounds, and medical blood bags.\textsuperscript{473}

### COUNTRY: INDONESIA

**INVENTORY CODE:** ASIAIDN01

- **Plant Name:** PT Asahimas Chemical (PT ASC)
- **Owners:** AGC Inc. (formerly named Asahi Glass Corporation) owns 52.5% shares of P.T. Asahimas Chemical. Additional major shareholders are PT Rodamas (Indonesia, 18%), Benny Suherman or Ableman Finance (Indonesia, 18%), and Mitsubishi Corporation (Japan, 11.5%).\textsuperscript{474}
- **Location:** Cilegon, Banten province, Indonesia.\textsuperscript{475}
- **Process:** PFAS membrane.\textsuperscript{476}
- **Year Opened:** 1989.\textsuperscript{477}
- **Capacities** (tons per year):
  - 636,000 tons of chlorine, 800,000 tons of VCM, and 550,000 tons of PVC (2016).\textsuperscript{478}
  - 300 MW on-site coal-fired power plant planned for 2018 opening.
  - Receives ethylene from the nearby Chandra Asri Petrochemical Complex.\textsuperscript{479}

- **Capacity Rankings:** 10th largest chlor-alkali plant in Asia. 29th largest chlor-alkali plant in the world. 11th largest PVC plant in Asia. 20th largest PVC plant in the world. This is the "biggest integrated chemical production site in Southeast Asia," according to the *Jakarta Post*.\textsuperscript{480}

- **Technology Conversions:**
  - Opened in 1989 with a 118,000-ton-per-year chlorine production capacity.\textsuperscript{481}
  - In 1996, the plant expanded capacity to 281,000 tons of chlorine per year and planned to increase it further to 409,000 tons.\textsuperscript{482}
  - In 2015, Asahimas Chemical announced it planned to add on-site power plants and further expand its manufacturing capacity.\textsuperscript{483}
  - In 2016, Kawasaki Heavy Industry announced it was selected to install two 150- MW coal-fired power plants at the Cilegon chemical complex.\textsuperscript{484}
  - The company planned to increase VCM capacity from 800,000 to 900,000 tons in 2018.\textsuperscript{485}

- **Markets:**
  - VCM feedstocks are used in PVC production on-site and in AGC’s Phu My Plastics and Chemicals PVC plant in Vietnam (150,000 tons per year of PVC capacity).\textsuperscript{486}
  - An estimated 80% of Asahimas’ products are consumed domestically, with the balance exported.\textsuperscript{487}
  - In addition to the AGC PVC resin plant (run by its Phu My Plastic and Chemicals subsidiary) in Vietnam, Asahimas exports VCM and PVC resins to Australia, Malaysia, Singapore, Saudi Arabia, and Turkey.\textsuperscript{488}
INVENTORY CODE: ASIAIDN02

- **Plant Name:** PT Sulfindo Adiusaha
- **Owner:** According to Moody’s Investors Service, Sulfindo Adiusaha “is owned by entities controlled by Debora Wahjutirto Tanoyo. The company has been owned and controlled by Ms. Tanoyo’s family since 2001.”483 Previously owned by the Salim Group.480 Known as PT Indo Chlor Prakarsa Industries before 1995.
- **Location:** Merak, Banten Province, Indonesia.
- **Process:** PFAS membrane.
- **Year Opened:** 1987.491
- **Capacities (tons per year):**
  - 300,000 tons of chlorine, 320,000 tons of EDC, 130,000 tons of VCM, and 95,000 tons of PVC (since 2012).492
  - The plant receives its ethylene by pipeline from Chandra Asri Petrochemical.493
  - Sulfindo operates two 60-MW coal-fired power plants on-site.494
- **Capacity Rankings:** 33rd largest chlor-alkali plant in Asia. 50th largest PVC plant in Asia.
- **Technology Conversions:**
  - In 1998, converted from mercury cell to membrane technology.495
  - In 1998, completed expansion to a 193,000-ton chlorine capacity.496 At the same time, Sulfindo Adiusaha shut down its 82,000-ton-per-year mercury cell plant.497
  - In 2004, ICIS reported the complex had the capacity to produce 195,000 tons of chlorine, 265,000 tons of EDC, 100,000 tons of VCM (through Satomo Indovyl Monomer, SIM), and 80,000 tons of PVC (through Satomo Indovyl Polymer, SIP).498 The PVC plant restarted after being idle since 2002.499
  - In 2008, Sulfindo reported its production capacities were 238,000 tons of chlorine per year, 295,000 tons of EDC, 100,000 tons of VCM, and 80,000 tons of PVC.500
  - In 2012, Sulfindo reported these capacities as 300,000 tons per year of chlorine, 320,000 tons of EDC, 130,000 tons of VCM, and 95,000 tons of PVC. These figures remained unchanged in 2018.501
  - In September 2018, Sulfindo signed a Memorandum of Understanding with Hyundai Engineering to expand the plant’s VCM- and PVC-production capacity. The expansion would be supported by loans from the Korean Export-Import Bank.502
- **Markets:**
  - According to PT Sulfindo Adiusaha, infrastructure developments “in the region has led to a growing demand for PVC products such as pipes and cables. The changing lifestyles of consumers also demand high quality of PVC products such as leather for furniture, film for food packaging, PVC doors, profile for housing and others.”503
  - “Sulfindo is a commodity-chemical producer and distributor of caustic soda, ethylene dichloride (EDC) and PVC, which accounted for approximately 45%, 25% and 29% of revenue during the nine months ended 30 September 2017. The balance of sales are from hydrochloric acid and sodium hypochloride,” reports Moody’s Investors Service.504
  - According to a 2012 ICIS report, “Sulfindo is the sole exporter of EDC in Southeast Asia.”505
COUNTRY: IRAN

OVERVIEW

In 2014, the Iranian government reported a national PVC production capacity of 745,000 tons per year. In addition to the Arvand Petrochemical Company plant listed below, major Iranian PVC producers include:

- Abadan Petrochemical Company (110,000 tons of PVC per year, some of which is exported to Iraq, Afghanistan, Pakistan, Azerbaijan, Turkey, and Armenia);  
- Ghadeer Petrochemical Company (150,000 tons of VCM and 120,000 tons of PVC);  
- Hamedan Petrochemical Industry Company (48,000 tons of medical grade PVC); and  
- Qadir Petrochemical Company (Khuzestan Province, in 2018 planned to increase production from 120,000 to 160,000 tons of PVC).

INVENTORY CODE: ASIAIRN01

- **Plant Name:** M/s Arvand Petrochemical Co. (APC Complex)  
- **Owner:** Islamic Republic of Iran, via Iranian Petroleum Ministry and the National Petroleum Company.  
- **Location:** Special Economic Zone, Bandar Emam, Iran.  
- **Process:** PFAS membrane.  
- **Year Opened:** 2009.  
- **Capacities** (tons per year):
  - 585,000 tons of chlorine.  
  - 890,000 tons of EDC.  
  - 343,000 tons of VCM.  
  - 340,000 tons of PVC (2016).  
- **Capacity Rankings:** 11th largest chlorine plant in Asia. 20th largest chlorine plant in the world. 30th largest PVC plant in Asia. 50th largest PVC plant in the world.
- **Technology Conversions:**
  - In 2002, the Iranian National Petrochemical Company contracted with Uhde of Germany to build the integrated chlor-alkali-to-PVC plant.  
  - In 2006, the plant was producing 175,000 tons per year of PVC.  
  - In 2014, the Iranian government was considering a second-phase expansion of its PVC capacity.  
  - In 2015, the plant reached its planned initial capacity of 340,000 tons per year of PVC.
- **Markets:**
  - Arvand Petrochemical produces PVC for domestic and overseas markets, particularly China and India. Destinations include Afghanistan, Azerbaijan, Iraq, Italy, India, Iraq, Kuwait, Pakistan, Turkey, and the United Arab Emirates.  
  - The plant opened with the intention of supplying 186,700 tons of chlorine gas and 339,300 tons of EDC to other plants in the area.  
  - Some of this plant’s outputs feed production at the 110,000-ton-per-year Abadan Petrochemical Company PVC plant.
**COUNTRY: JAPAN**

**OVERVIEW**

The chlor-alkali industry in Japan was the first to fully convert from mercury cell to PFAS membrane cell technology. The first PFAS membrane cells producing chlorine and caustic soda were introduced in Japan in 1975. The country, reacting to the mercury-poisoning tragedy of Minamata Bay, quickly converted and closed all mercury cell plants. Japan completed its conversion to ion-exchange processes by the late 1980s.  

Chlor-alkali and PVC production in Japan is contracting. In 2017, there were 30 chlor-alkali plants in Japan with a combined production capacity of 3.7 million tons of chlorine, down from 31 plants and 4.3 million tons capacity in 2008.

For decades, Japan has been "haunted" by oversupply of PVC, as ICIS described the situation in 2000. In announcing that it would close its Osaka plant by 2020, Taiyo Vinyl, recently said, "The domestic PVC business environment continues to be plagued by oversupply. And given other market factors such as Japan's declining population and the forecast for a decrease in new housing, the market is expected to remain sluggish." AGC (formerly Asahi Glass) is focused on "expansion of production capacity in overseas markets, which show potential for growth in the Chlor-Alkali business."

According to a 2016 report published by the Federation of Indian Chambers of Commerce and Industry (FICCI), Japan's 2,090,000 tons of PVC capacity exceeded domestic demand (1,450,000 tons) by 640,000 tons.

**INVENTORY CODE: ASIAJPN01**

- **Plant Name:** Chiba Plant
- **Owner:** AGC Inc. (formerly Asahi Glass).
- **Location:** Ichihara City, Chiba, Japan.
- **Process:** PFAS membrane. Formerly mercury cell and asbestos diaphragm.
- **Year Opened:** 1959.
- **Capacities (tons per year):**
  - 182,000 tons of chlorine (2017).
- **Capacity Rankings:** Not among top 33 chlor-alkali plants in Asia.
- **Technology Conversions:**
  - In 1975, AGC’s Chiba plant converted from mercury cell to asbestos diaphragm technology.
  - In 1986, it converted from asbestos diaphragm to ion exchange PFAS membrane technology.
  - In 2004, AGC announced the “world’s first” “practical application” of chlorofluorocarbon resin recycling.
- **Markets:**
  - The Chiba plant produces carbon tetrachloride, chloroform, and methylene chloride (also called dichloromethane). Volatile organic compounds (such as dichloromethane) produced by Asahi Glass are widely used as raw materials for the making of chemical products, cleaning solvents, reaction solvents and so forth,” states a 2001 company report.
  - It also produces fluorinated resins, and intermediates for pesticides and pharmaceuticals.

**INVENTORY CODE: ASIAJPN02**

- **Plant Name:** Kashima Plant (AGC)
- **Owner:** AGC Inc. (formerly Asahi Glass).
Healthy Building Network  | Chlorine and Building Materials, Phase 2: Asia

- **Location**: Kamisu Town, Kashima, Ibaraki, Japan.
- **Process**: PFAS membrane.
- **Year Opened**: 1975.\(^{534}\)
- **Capacities (tons per year)**:
  - 318,000 tons of chlorine (2017).\(^{535}\)
- **Capacity Rankings**: 30th largest chlor-alkali plant in Asia. 59th largest chlor-alkali plant in the world.
- **Technology Conversions**:
  - In 1975, AGC converted the Kashima plant from mercury cell to asbestos diaphragm technology (146,000 tons per year of chlorine capacity).\(^{536}\)
  - In 1989, AGC converted the Kashima plant from asbestos diaphragm to ion exchange PFAS membrane technology.\(^{537}\)
  - In 1994, the plant’s chlorine production capacity was 251,000 tons per year.\(^{538}\)
  - On March 11, 2011, the Kashima industrial complex “suffered major earthquake and tsunami damage (although for the most part buildings remained intact),” according to an *Environmental Health Perspectives* journal article by Elizabeth Grossman and Winifred Bird. "As cleanup continues in the disaster area, questions remain about the fate of chemical contaminants released by these damaged industrial facilities and other sources, and the environmental health hazards they might pose to the hundreds of thousands of people living and working in this area."\(^{539}\)
- **Markets**:
  - AGC’s Kashima plant has the capacity to produce 110,000 tons of propylene oxide per year.\(^{540}\)
  - Propylene oxide is manufactured in two primary ways: the chlorohydrin and hydroperoxidation processes. The chlorohydrin route is typically integrated with chlor-alkali plants such as this. Nexant, a global consultant to the energy and chemical industries, says the chlorohydrin process “suffers from environmental liabilities and large capital investment requirements. Also, inexpensive electric power must be available for the integrated chlor-alkali facility.”\(^{541}\)
  - The plant also sells epichlorohydrin.\(^{542}\)

**INVENTORY CODE: ASIAJPN03**

- **Plant Name**: Kashima Plant (Shin-Etsu)
- **Owner**: Shin-Etsu Chemical Co. Ltd., via Kashima Chlorine & Alkali Ltd. (including Kashima VCM. Shin-Etsu is the majority shareholder. Mitsubishi Chemical holds a minority stake.\(^{543}\) Asahi Glass, Adeka, and Kaneka were shareholders until 2012.\(^{544}\)
- **Location**: Kashima, Ibaraki, Japan.
- **Process**: PFAS membrane. Converted from mercury cell.
- **Year Opened**: 1968.\(^{545}\)
- **Capacities (tons per year)**:
  - 364,000 tons of chlorine.
  - 600,000 tons of VCM (2012).\(^{546}\)
  - 550,000 tons of PVC (2011).\(^{547}\)
- **Capacity Rankings**: 26th largest chlor-alkali plant in Asia. 47th largest chlor-alkali plant in the world. 13th largest PVC plant in Asia. 22nd largest PVC plant in the world.
- **Technology Conversions**:
  - The plant converted chlorine production technology in July 1983 from mercury cell to PFAS membrane technology.\(^{548}\)
  - In 1987, the plant’s PVC production capacity was 200,000 tons per year.\(^{549}\)
  - In 1994, the plant’s chlorine production capacity was 281,000 tons per year.\(^{550}\)
The March 11, 2011, Great East Japan Earthquake halted plant operations for several weeks. The company reported "some damage" to its chemical production facilities and "heavy damage" to electrical and water supplies in the Kashima industrial complex.

- **Markets:**
  - PVC is the main product of this factory, Shin-Etsu’s largest in Japan; Shin-Etsu is also the world’s largest PVC producer.

**INVENTORY CODE: ASIAJPN04**

- **Plant Name:** Miyazaki Chemical Center
- **Owner:** Asahi Kasei Corporation, via subsidiary, Asahi Kasei Chemicals Corporation (AKCC).
- **Location:** Nobeoka City, Miyazaki, Japan.
- **Process:** PFAS membrane. Converted from mercury cell.
- **Year Opened:** 1923.
- **Capacities (tons per year):**
  - 141,000 tons of chlorine (1994).
- **Capacity Rankings:** Not among the 33 largest chlor-alkali plants in Asia.
- **Technology Conversions:**
  - A 1949 US Army chemical industry inspector found that the Asahi “Nobeoka Plant… at the southern part of Kyushu, has a small mercury cell caustic plant, part of a large chemical plant – as a unit practically useless to anyone else. To move that for reparations would, [the inspector was] informed, throw eight hundred men out of work. In that case the caustic and chlorine to be used in the main plant must be brought in from plants located at a distance.”
  - In 1975, the Asahi Kasei began producing chlor-alkali using perfluorocarboxylic acid (PFAS) membranes, with chlorine production capacity of 80,000 tons per year. According to the 1976 report of the electrolytic industries, “initially, commercial testing was done with DuPont’s Nafion membranes but more recently a perfluorocarboxylic acid membrane developed by Asahi Chemical is being substituted for the DuPont membranes.” The Asahi Kasei PFAS membrane technology has since become “employed in plants with a total production capacity of over 25 million tons of caustic soda per year,” according to Asahi Kasei. It was the first plant in the world to convert directly from mercury to PFAS membrane technology (most of the 1970s conversions were to asbestos diaphragm technology).
  - In 1982, the Journal of the Electrolytic Industries reported that the company “plans to replace the remaining mercury cells at Nobeoka with ion exchange membrane technology.”
  - In 2012, Asahi Kasei opened a wood biomass power plant in the Nobeoka complex.
- **Markets:**
  - This chemical complex produces polyvinylidene chloride (PVDC) resin and latexes. Applications include: Saran Wrap (PVDC) film; paper coating; polyurethane coating; binder for PVDC or PVC fiber; and flame retardant fabric, paper, and leather. In 2012, Asahi Kasei said it held a 20% share of the global PVDC market. This equals 40,000 tons of a worldwide PVDC production capacity of 200,000 tons.
  - Other chlorinated products include sodium hypochlorite and PAC (poly aluminum chloride).
  - The Nobeoka plant also produces toluene diisocyanate, which uses chlorine as a feedstock.

**INVENTORY CODE: ASIAJPN05**

- **Plant Name:** Takasago Plant Kanevinyl
- **Owner:** Kaneka Corporation (previously Kanegafuchi Company), through its subsidiary Toagosei Corporation.
- **Location:** Takasago, Hyōgo, Japan.
Healthy Building Network  | Chlorine and Building Materials, Phase 2: Asia

- **Process**: PFAS membrane.\(^{570}\)
- **Year Opened**: 1960.\(^{571}\)
- **Capacities** (tons per year):
  - 270,000 tons of chlorine (1998).\(^{572}\)
  - 400,000 tons of VCM (2012).\(^{573}\)
  - 290,000 tons of PVC (2012).\(^{574}\)
- **Capacity Rankings**: Not among the 33 largest chlor-alkali plants in Asia. 39th largest PVC plant in Asia. 67th largest PVC plant in the world.
- **Technology Conversions**:
  - In 1971, the Takasago plant’s vinyl chloride production capacity was 115,000 tons per year.\(^{575}\)
  - In 1974, the plant’s owners converted its production technology from mercury cell to asbestos diaphragm.\(^{576}\)
  - In 1989, it converted the plant to PFAS membrane technology.\(^{577}\)
  - In 1994, the plant’s chlorine capacity was 181,000 tons per year.\(^{578}\)
  - By 1998, its chlorine production capacity grew to 270,000 tons per year.\(^{579}\)
  - In 2008, Kaneka stated that it had “appointed a consultant and uncovered issues at our Takasago Plant, which has high energy consumption compared to our other plants.”\(^{590}\)
  - In 2010, Kaneka’s total PVC capacity in Japan (including Takasago and another plant, at Kashima, Ibaraki) was 430,000 tons per year.
- **Markets**:
  - In 1960, Takasago was “the exclusive producer of vinyl chloride in Japan.”\(^{581}\)
  - The primary chlorinated products of the Takasago plant are VCM, PVC, and sodium hypochlorite.\(^{582}\)

**INVENTORY CODE: ASIAJPN06**

- **Plant Name**: Mizushima Plant
- **Owner**: Osaka Soda, through its Daiso Co. subsidiary, and in turn, Daiso’s Okayama Chemical subsidiary.\(^{583}\)
- **Location**: Mizushima, Kurashiki, Okayama, Japan.
- **Process**: PFAS membrane. Converted from mercury.
- **Year Opened**: 1968.\(^{584}\)
- **Capacities** (tons per year):
  - 126,000 tons of chlorine (1994).\(^{585}\)
  - 60,000 tons of epichlorohydrin (2015).
- **Capacity Rankings**: Not among the 33 largest chlor-alkali plants in Asia.
- **Technology Conversions**:
  - In 1986, the plant’s production technology was converted from mercury cell to PFAS membrane.\(^{586}\)
  - “In 1971, we expanded into the Mizushima chemical complex and built a system for integrated production of AC [allyl chloride] and EP [epichlorohydrin],” reported Osaka Soda.\(^{587}\) Allyl chloride is a feedstock for epichlorohydrin production.
  - In 2003, the plant’s epichlorohydrin production capacity was 33,000 tons per year.\(^{588}\)
  - In 2015, Osaka Soda said, “In Epichlorohydrin, we expanded [the] production capacity of Mizushima Plant to pursue market share expansion aggressively, making [the] AC/EP chain more competitive globally by enhancing [its] low-cost position.”\(^{589}\)
• Markets:
  ○ Osaka Soda is Japan’s largest producer of epichlorohydrin.\(^{590}\)

**INVENTORY CODE: ASIAJPN07**

- **Plant Name:** *Tokuyama Soda*
- **Owner:** Tokuyama Corporation. Formerly known as Nihon Soda Kogyo Co.
- **Location:** Tokuyama, Yamaguchi, Japan.
- **Process:** PFAS membrane. Converted from mercury cell and asbestos diaphragm.
- **Year Opened:** 1952.\(^{591}\)
- **Capacities** (tons per year):
  ○ 445,000 tons of chlorine (2018).\(^{592}\)
  ○ 330,000 tons of VCM (2012).\(^{593}\)
- **Capacity Rankings:** 18th largest chlor-alkali plant in Asia. 31st largest chlor-alkali plant in the world.
- **Technology Conversions:**
  ○ In 1975, the plant converted from mercury cell to asbestos diaphragm technology.
  ○ In 1983, the plant converted from asbestos diaphragm to PFAS membrane technology.\(^{594}\)
- **Markets:**
  ○ Tokuyama Group’s subsidiary, Shin Dai-ichi Vinyl Corporation, uses VCM produced at this plant.\(^{595}\) It uses the PVC mostly for "building materials such as pipes, wallpaper, and flooring tiles; film sheets."\(^{596}\) In 2011, the Shin Dai-Ichi Vinyl Corporation plant in Tokuyama had the capacity to produce 145,000 tons per year of PVC.\(^{597}\)
  ○ Tokuyama Group uses chlorine from this plant to produce propylene oxide, which is a feedstock for isocyanate and then polyurethane production.\(^{598}\)
  ○ The company also produces the solvent methyl chloride.\(^{599}\)

**INVENTORY CODE: ASIAJPN08**

- **Plant Name:** *Nanyo Complex*
- **Owner:** Tosoh Corporation. Formerly named Toyo Soda.
- **Location:** Shin-Nanyo, Yamaguchi, Japan.
- **Process:** PFAS membrane.
- **Year Opened:** 1936.\(^{600}\)
- **Capacities** (tons per year):
  ○ 1,022,000 tons of chlorine (2017).\(^{601}\)
  ○ 850,000 tons of VCM (2015).\(^{602}\)
  ○ 400,000 tons of methylene diisocyanate (MDI) (2016).\(^{603}\)
- **Capacity Rankings:** 2nd largest chlor-alkali plant in Asia. 6th largest chlor-alkali plant in the world.
- **Technology Conversions:**
  ○ In 1975, the plant converted from mercury cell to diaphragm technology.\(^{604}\)
  ○ In 1998, the plant’s chlorine production capacities were 148,000 tons by diaphragm technology, and 384,000 tons by PFAS membrane.\(^{605}\)
  ○ In 1999, according to Tosoh, the plant replaced its remaining asbestos diaphragm production units with ion exchange PFAS membranes.\(^{606}\)
- **Markets:**
  ○ Tosoh is the largest producer of VCM in Japan and uses it to produce PVC in Japan and overseas.\(^{607}\) In Japan, Tosoh operates PVC factories in Takaishi (Osaka, 158,000 tons), Ichihara
Chlorine and Building Materials, Phase 2: Asia

Overseas operations include Tosoh Guangzhou Chemical Industries (Guangdong Province, China), P.T. Standard Toyo Polymer (Indonesia), and Philippines Resins Industries (Makati City, Bataan, Philippines).

- The MDI produced in Nanyo is used in a wide range of products, including artificial leather, spandex, shoe soles, coatings, adhesives, spray foam, integral skin foams, elastomers, flexible foam, and automobile parts.
- The plant also produces calcium hypochlorite for water disinfection and sterilization.

**INVENTORY CODE: ASIAJPN09**

- **Plant Name:** Yokkaichi Complex
- **Owner:** Tosoh Corporation. Formerly named Toyo Soda.
- **Location:** Yokkaichi, Mie, Japan.
- **Process:** PFAS membrane
- **Year Opened:** 1971.
- **Capacities** (tons per year):
  - 115,000 tons of chlorine (2017).
  - 260,000 tons of VCM (2015).
  - 310,000 tons of PVC (2018).
  - 527,000 tons of naphtha cracker (2016). Ethylene produced by the cracker feeds ethylene dichloride/VCM production, as well as on-site lines to produce polyethylene and ethylene-vinyl acetate.
- **Capacity Rankings:** Not among the 33 largest chlor-alkali plants in Asia. 32nd largest PVC plant in Asia. 56th largest PVC plant in the world.
- **Technology Conversions:**
  - In 1976, the plant had 64,000 tons per year of chlorine production capacity using asbestos diaphragm technology.
  - The plant converted to PFAS membrane technology in 1983.
  - In 2017, Tosoh announced a project to expand its naphtha-cracking furnace, which it expected to complete by mid-2019.
- **Markets:**
  - Tosoh PVC resins are used in rigid plates, extruded sheets, injection molding, pipes, window frames, food films, wire and cable sheathing, agricultural films, and other applications.

**COUNTRY: PAKISTAN**

**INVENTORY CODE: ASIAPAK01**

- **Plant Name:** Engro Polymer and Chemicals (EPCL)
- **Owner:** Engro Corporation. EPCL was formerly Engro Asahi Polymer and Chemical, established in 1997 as a joint venture between Engro Chemical (50%, Pakistan), Asahi Glass Company (30%, Japan) and Mitsubishi Corporation (20%, Japan).
- **Location:** Port Qasim, Baluchistan, Pakistan.
- **Process:** PFAS membrane.
- **Year Opened:** 1999 (PVC), 2007 (chlor-alkali, EDC, VCM).
- **Capacities** (tons per year):
96,000 tons of chlorine (2015)
195,000 tons of VCM and PVC (2018). The VCM plant uses imported ethylene, 90-95% of which comes from Qatar Vinyl (ASIAQAT01 below).
65 MW gas-fired power plant.


Technology Conversions:
Opened in 1999 with a 100,000-ton-capacity PVC plant.
In 2009, EPCL expanded PVC capacity to 150,000 tons per year, and added chlor-alkali, EDC, and VCM production units to the complex.
In 2010, EPCL added a 65 MW natural-gas-fired power plant.
In 2013, a debottlenecking process increased the Port Qasim complex’s PVC capacity to 178,000 tons.
In 2016, ICIS reported that EPCL “will conduct debottlenecking works at its polyvinyl chloride (PVC) plants in 2018.”
In December 2017, The Express Tribune reported that EPCL was going to “add a new PVC plant with a capacity of 100,000 tons (taking total capacity to 295,000 ton per annum) and increase production of VCM (the raw material) by 50,000 tons through debottlenecking of the existing plant by the third quarter of 2020.”
According to a 2018 environmental impact assessment, an EDC import pipeline will supply the new VCM and PVC plant. At an October 25, 2018, hearing on the assessment, residents and environmentalists raised concerns about contaminated groundwater, air pollution, the destruction of mangrove swamps, and discharges into the ocean.
In August 2018, EPCL stated that it is partnering with Tianchen Corp China on the plant expansion. Tianchen will supply the plant and machinery.
In November 2018, EPCL announced that it obtained $35 million in financing from the International Finance Corporation (part of the World Bank Group) in support of its planned expansion.

Markets:
EPCL sells four grades of PVC, with the brand name Sabz. It says 55% of its resin is used to make PVC pipes; other consumers include artificial leather, shoes, hoses, windows, and doors.
In 2016, ICIS reported that “PVC demand in Pakistan currently stands at around 200,000 tonnes/year and is growing at an annual rate of 16%.”
The Express Tribune reported that EPCL produced 73% of the PVC consumed in Pakistan in 2017.

COUNTRY: QATAR

INVENTORY CODE: ASIAQAT01

Plant Name: Qatar Vinyl Company Ltd. (QVC)
Owner: Government of Qatar through shareholders. Shareholders in 2015 were Mesaieed Petrochemical Holding Company (55.2%), Qatar Petrochemical Company (Qapco, 31.9%) and Qatar Petroleum (12.9%). Total (France) owns 20% of Qapco.
Location: Mesaieed Industrial City, Al Wakrah Municipality, Qatar.
Healthy Building Network  I  Chlorine and Building Materials, Phase 2: Asia

- **Capacities (tons per year):**
  - 336,000 tons of chlorine, 470,000 tons of EDC (of which 180,000 tons is sold overseas), and 360,000 tons of VCM (2017).  
  - An ethane cracker located in the Mesaieed petrochemical complex provides 220,000 tons of ethylene to QVC (2017, ICIS).
  - 110 MW gas-fired power plant.
- **Capacity Rankings:** 28th largest chlor-alkali plant in Asia. 56th largest chlor-alkali plant in the world.
- **Technology Conversions:**
  - Qatar Vinyl Co. was launched in 1999 as a joint venture of the government of Qatar, Norsk Hydro (Norway, which divested its petrochemical business in 2007), and Elf Atochem (France, now Arkema, which sold its shares in QVC in 2013). The venture planned to have the capacity to produce 290,000 tons of chlorine, 175,000 tons of EDC, and 230,000 tons of VCM. According to Qatar Petroleum, “QVC was established to produce intermediates in the PVC industry.”
  - In 2003, the plant’s capacities were 260,000 tons per year of chlorine, 368,000 tons of EDC (175,000 tons for sales, 193,000 tons for VCM unit), and 230,000 tons of VCM.
  - In 2006, QVC postponed plans to double chlorine and EDC production.
- **Markets:**
  - QVC exports EDC and VCM to PVC manufacturers. In 2004, the Gulf Industry newsletter reported that “the entire production of both EDC and VCM is exported while some 10,000 tonnes of caustic soda is consumed within Qatar itself. Among the export markets for caustic soda are GCC states UAE and Oman. QVC’s major market is South-east Asia, the Far East, Australia and the Indian Subcontinent. Small quantities are sold in Europe and the US as well as South Africa. The company works through the marketing network of its European shareholders in various countries.”
  - It supplies Engro Polymer & Chemical in Pakistan with 90-95% of its imported VCM.

COUNTRY: SAUDI ARABIA

INVENTORY CODE: ASIASAU01

- **Plant Name:** Saudi Petrochemical Co. (SADAF) Complex/SABIC
- **Owner:** Saudi Basic Industries Corporation. (SABIC), via its SADAF subsidiary. SABIC is "owned 70% by the Saudi government and 30% by private investors from the six GCC countries," according to a 2018 ICIS report. SADAF had been a 50/50 joint venture with Shell since its inception, but Shell sold its stake to SABIC in 2017.
- **Location:** Jubail Industrial City, Al-Jubail, Saudi Arabia.
- **Process:** Asbestos diaphragm and PFAS membrane.
- **Year Opened:** 1987.
- **Capacities (tons per year):**
  - 645,000 tons of chlorine (2016). Estimated 342,000 tons by asbestos diaphragm and 303,000 by membrane technology.
  - 840,000 tons of EDC.
  - 500,000 tons of VCM.
  - 400,000 tons of PVC (2008).
  - The Sadaf complex also includes an ethylene cracker, a salt plant, styrene and MTBE plants, and a power plant. The ethylene is produced from ethane, a co-product of Saudi Aramco’s crude oil production.
• **Capacity Rankings:** 9th largest chlor-alkali plant in Asia. 23rd largest PVC plant in Asia. 17th largest chlor-alkali plant in the world.

• **Technology Conversions:**
  - In 1985, the Shell/SABIC joint venture began production. It used asbestos diaphragm cell technology capable of producing 342,000 tons per year of chlorine. It also opened with the capacity to produce 454,000 tons of EDC.
  - In 1996, SADAF installed a PFAS membrane chlor-alkali plant with a 221,600-ton-per-year chlorine capacity.
  - In 2000 and 2004, the plant’s chlorine production capacity was reported as 609,000 tons per year.
  - In 2006, ICIS reported that “Sabic is looking to increase PVC capacity by 450,000 tonnes/year to 850,000 tonnes/year and VCM feedstock capacity by 500,000 tonnes/year to 950,000 tonnes/year.” However, as of 2018, this does not appear to have been implemented.
  - In 2017, SABIC’s board planned to replace the chlor-alkali plant’s asbestos diaphragms with membrane cell technology by the end of 2018. The board reported in 2017 on the “SADAF project in Al-Jubail Industrial City to convert the DIVRAM cell lines, which contains the banned asbestos material to membrane cell technology to eliminate environmental problems and problems related to industrial health.” The conversion was schedule for completion by Q4 2018. No confirmation of this conversion had been announced on SABIC’s website through the end of 2018.

• **Markets:**
  - When the plant opened in 1987, the Saudi government planned to export chlorine to Japan and Taiwan. “Saudi chlorine appears to be replacing 10,000 tons per year of market that had been exported to the Far East by U.S. producers,” reported the 1987 Report of the Electrolytic Industries. In 2004, Oil and Gas News Worldwide reported, “The main customers for Sadaf’s products are in Asia, Australia, Europe and the US. Hence, basically, the Sadaf Business Unit markets its products in four continents. The main market for caustic soda is in Australia, where it is an important ingredient in the bauxite refining process to produce alumina - the raw material used to make aluminum. Caustic soda is also being sold in other markets in Asia and the Americas…. EDC is supplied to major customers in Asia, who manufacture VCM and PVC, mainly in Taiwan, Japan, Malaysia and China.” A major customer, it said, is the Taiwan VCM (TVCM) Corporation, part of the USI Group. The Taiwan VCM (TVCM) plant in Kaohsiung, Taiwan, had a capacity of 330,000 tons VCM production in 2006.
  - According to TVCM, “major clients in Taiwan are China General Plastics Corporation, CGPC Polymer Corporation, and Ocean Plastics Corporation. We also export VCM to mainland China, South East Asia and India etc.”

**INVENTORY CODE: ASIASAU02**

- **Plant Name:** Sahara & Ma’aden Petrochemicals (SAMAPCO)
- **Owner:** SAMAPO is a 50/50 joint venture between Sahara Petrochemicals and Saudi Arabian Mining Co (Ma’aden) and Sahara Petrochemicals. The Saudi government owns 50% of Ma’aden. In October 2018, the Saudi International Petrochemical Company (Sipchem) agreed to purchase Sahara Petrochemicals.
- **Location:** Jubail Industrial Complex, Al-Jubail, Saudi Arabia.
- **Process:** PFAS membrane.
- **Year Opened:** 2014.
- **Capacities (tons per year):** 227,000 tons of chlorine, 300,000 tons of EDC (2014).
- **Capacity Rankings:** 2nd largest chlor-alkali plant in Saudi Arabia. Not among the largest 33 chlor-alkali plants in Asia.
- **Technology Conversions:** None.
- **Markets:**
Healthy Building Network | Chlorine and Building Materials, Phase 2: Asia

- All of the caustic soda from this plant supplies an alumina refinery owned by Ma’aden, in Ras Alkair.
- EDC produced by this plant is consumed domestically and exported, on the wholesale and retail markets.\(^{682}\)
- SABIC is the “prime marketer” for this plant’s EDC.\(^{683}\)

### COUNTRY: SOUTH KOREA

There is an excess amount of caustic soda in South Korea, leading at least one plant to convert to a technology to produce caustic potash, instead, as a co-product of chlorine production.\(^{684}\)

High electricity costs, and overseas competition, also are constraining production of chlorine. For example, in 2018, Hanwha, a leading producer, "reduced operating rates for 3 chlor-alkali lines out of the 5 lines owing to poor export prices and high electricity cost during peak hours."\(^{685}\)

Supply also exceeds domestic demand for PVC, and much of the country’s industry has become export-oriented, especially to India. In 2017, *Sisa Journal* reported, "PVC, which makes pipes, is classified as an oversupply item in Korea and is subject to restructuring, but exports to India are steadily increasing. PVC exports to India amounted to 500,000 tons by November last year. Exports to India account for more than one-third of the total PVC production of 1.5 million tons in Korea and more than half of PVC exports in Korea. LG Chem and Hanwha Chemical are in charge of PVC production in Korea and the market is also divided. LG Chem and Hanwha Chemical produce 900,000 tons and 600,000 tons respectively."\(^{686}\)

According to a 2016 report published by the Federation of Indian Chambers of Commerce and Industry (FICCI), South Korea’s capacity of 1,470,000 tons of PVC exceeded domestic demand (700,000 tons) by 770,000 tons. FICCI said that 52% of South Korea’s 575,000 tons of exports were shipped to India.\(^{687}\)

### INVENTORY CODE: ASIAKOR01

- **Plant Name:** *Ulsan CA Plant.*
- **Owner:** Unid Co. Hanwha Chemical sold the chlor-alkali unit to Unid in 2016.\(^{688}\) Formerly known as Daehan Plastic Industry.\(^{689}\)
- **Location:** Ulsan, South Korea.
- **Process:** PFAS membrane.\(^{690}\)
- **Year Opened:** 1966.\(^{691}\)
- **Capacities** (tons per year):
  - 182,000 tons of chlorine.\(^{692}\)
  - 300,000 tons of PVC.\(^{693}\)
  - The EDC plant receives its ethylene from Yeochun NCC (YNCC), a naphtha cracker in which Hanwha holds a 50% stake. YNCC has a capacity of 1.9 million tons of ethylene per year.\(^{694}\)
- **Capacity Rankings:** Not among the largest 33 chlor-alkali plants in Asia. 36th largest PVC plant in Asia.
- **Technology Conversions**:
  - The first VCM plant was set up in 1972.\(^{695}\)
  - A PVC paste-resin plant was added in 1977.\(^{696}\)
  - In 2011, Hanwha listed plant capacities as 176,000 tons of chlorine, 385,000 tons of EDC, 247,000 tons of VCM, and 305,000 tons of PVC.
  - In 2016, Hanwha sold the chlor-alkali production unit in its Ulsan complex to Und Co. Unid planned to convert the plant to produce caustic potash rather than caustic soda. According to the
business news site, *Pulse*, Hanwha will continue to receive chlorine from the plant to produce PVC.\(^{697}\)

- In 2016, Hanwha began building a new chlorinated polyvinyl chloride (CPVC) plant in Ulsan, with a planned 30,000-ton capacity.\(^{698}\)
- In January 2018, Unid began production at the new chlor-alkali unit.\(^{699}\)

**Markets:**

- CPVC produced in Ulsan is used in fire sprinkler systems, hot-water and specialty industrial pipes.\(^{700}\)
- Hanwha’s subsidiary, Hanwha L&C, processes PVC resins into flooring, tiles, and automotive parts.\(^{701}\)
- Hanwha exports PVC resins made in Ulsan, including to India.\(^{702}\)

**INVENTORY CODE: ASIAKOR02**

- **Plant Name:** Yeosu Plant - Hanwha
- **Owner:** Hanwha Chemical (formerly Hanyang Chemical).
- **Location:** Yeosu City (formerly Yeochon), South Korea.
- **Process:** PFAS membrane.
- **Year Opened:** 1980.\(^{703}\)
- **Capacities** (tons per year):
  - 782,000 tons of chlorine\(^{704}\)
  - 430,000 tons of EDC (2012).\(^{705}\)
  - 360,000 tons of VCM (2014).\(^{706}\)
  - 290,000 tons of PVC (2015).\(^{707}\)
- The EDC plant receives ethylene from the nearby Yeochun NCC (YNCC) naphtha cracker. Hanwha holds a 50% stake in this cracker. YNCC has a capacity of 1.9 million tons of ethylene per year.\(^{708}\)
- **Capacity Rankings:** 6th largest chlor-alkali plant in Asia. 12th largest chlor-alkali plant in the world. 38th largest PVC plant in Asia. 68th largest PVC plant in the world.

**Technology Conversions:**

- In 1992, the naphtha cracker began operating at the Yeosu chemical complex.\(^{709}\)
- In 2008, the plant’s chlorine production capacity was 500,000 tons per year.\(^{710}\)
- In 2017, the plant’s chlorine production capacity expanded by 118,000 tons.\(^{711}\)

**Markets:**

- Hanwha Chemical is South Korea’s second-largest epichlorohydrin producer, according to *ICIS*.\(^{712}\)
  In 2009, it had the capacity to produce 25,000 tons of epichlorohydrin per year.\(^{713}\)
- Hanwha’s subsidiary, Hanwha L&C, processes PVC resins into flooring, tiles, and automotive parts.\(^{714}\)
- Chlorine also is consumed on-site in the KPX Fine Chemical isocyanates plant, which can produce 150,000 tons per year of toluene diisocyanate (TDI).\(^{715}\) Hanwha Chemical acquired KPX Fine Chemical in 2014. KPX is one of three isocyanates producers in South Korea (the others are BASF and OCI).\(^{716}\)

**INVENTORY CODE: ASIAKOR03**

- **Plant Name:** Yeosu Plant - LG; originally called “Lucky Vinyl Ltd.”\(^{717}\)
- **Owner:** LG Chemical.
- **Location:** Yeosu City (formerly Yeochon), South Korea.
• **Process:** PFAS membrane.

• **Year Opened:** 1962.

• **Capacities (tons per year):**
  - 454,000 tons of chlorine, 575,000 tons of EDC, and 750,000 tons of VCM and PVC (2012).\(^{718}\)
  - The EDC plant receives ethylene from LG’s on-site Yeosu naphtha cracker. This cracker expanded in 2010. It can produce 1.15 million tons of ethylene per year. In 2018, LG announced that it will invest over $2.4 billion to expand cracker and polyolefin capacity.\(^{719}\) LG, like other cracker operators in Asia, purchases naphtha from the global market.\(^{720}\)

• **Capacity Rankings:** 17th largest chlor-alkali plant in Asia. 30th largest chlor-alkali plant in the world. 5th largest PVC plant in Asia. 10th largest PVC plant in the world.

• **Technology Conversions:**
  - In 1976, the first PVC paste-resin plant was opened; it was expanded in 1982.\(^{721}\)
  - In 1997, LG complete expansion of the chlor-alkali, EDC, and VCM operations.
  - In 2012, LG added 245,000 tons of chlorine capacity and 300,000 tons of EDC capacity. It expanded the EDC plant to 575,000 tons per year.\(^{722}\)

• **Markets:**
  - LG exports PVC resins made in Yeosu, including to India.\(^{723}\)
  - LG is a vertically integrated producer of PVC products. In Cheongju, South Korea, its LG Hausys subsidiary produces PVC profiles, windows, tile flooring, carpet, wood polymer composites, and coated fabric.\(^{724}\)
  - The USA is a major importer of PVC products made by LG Hausys in South Korea.\(^{725}\)

**INVENTORY CODE: ASIAKOR04**

• **Plant Name:** Lotte Fine Chemical

• **Owner:** Lotte Group. Originally Korea Fertilizer Industries, which was founded in 1964 and nationalized in 1967. It was later privatized, then became Samsung Fine Chemical, part of the Samsung Group, in 1994. Samsung sold the plant to the Lotte Group in 2016.\(^{726}\)

• **Location:** Ulsan, South Korea.

• **Process:** PFAS membrane.

• **Year Opened:** 1994.\(^{727}\)

• **Capacities (tons per year):** 318,000 tons of chlorine (2015).\(^{728}\)

• **Capacity Rankings:** 31st largest chlor-alkali plant in Asia. 60th largest chlor-alkali plant in the world.

• **Technology Conversions:**
  - Korea Fertilizer industries added a methyl chloride plant to the Ulsan complex in 1991.\(^{729}\)
  - In 1998, Samsung installed a waste incinerator.\(^{730}\)
  - In 1999, it built an epichlorohydrin plant.\(^{731}\)

• **Markets:**
  - The plant produces, for domestic and global customers, numerous chemicals including epichlorohydrin, chloroform, tetramethylammonium chloride (TMAC), methylene chloride, and methyl chloride.\(^{732}\)
  - The plant’s epichlorohydrin production capacity is 120,000 tons per year.\(^{733}\)
  - TMAC, according to Lotte, is “a core chemical material used in semiconductors for electronic devices and LCD circuit boards for TVs, smartphones and similar devices. Fueled by the continuing growth of semiconductor, LCD, OLED and other display-related industries, the product has maintained a solid growth trend, and the area of applications has been broader.”\(^{734}\)
COUNTRY: TAIWAN

According to a 2016 report published by the Federation of Indian Chambers of Commerce and Industry (FICCI), Taiwan has the world’s highest proportion of excess PVC capacity. It estimated that Taiwan’s 1,930,000 tons of PVC capacity exceeded domestic demand (700,000 tons) by 1,230,000 tons per year. FICCI reported that 43% of Taiwan’s 751,000 tons of exports are shipped to India.

INVENTORY CODE: ASIATW01

- **Plant Name**: Jen-Wu (or Kaohsiung) Plant
- **Owner**: Formosa Plastics Corporation.
- **Location**: Jen-Wu (or Jenwu or Renwu) District, Kaohsiung City, Taiwan.
- **Process**:
- **Year Opened**: 1957
- **Capacities** (tons per year):
  - 400,000 tons of chlorine (2007)
  - 540,000 tons of VCM (2015). Formosa imports EDC from its US Gulf Coast plants.
  - 550,000 tons of PVC (2007).
- **Capacity Rankings**: 22nd largest chlor-alkali plant in Asia. 40th largest chlor-alkali plant in the world. 12th largest PVC plant in Asia. 21st largest PVC plant in the world.
- **Technology Conversions**:
  - Formosa Plastics Corporation started producing plastics in 1957, with the opening of a PVC plant in Kaohsiung City with a capacity of just four tons per day, the world’s smallest. It delivered PVC resins to outgoing ships by ox-towed carts.
  - In 1972, a larger PVC plant opened with a 28,800-ton-per-year capacity.
  - In 1975, a chlor-alkali plant opened using mercury cell technology, with a 175,000-ton-per-year capacity. It also began producing VCM, with a 240,000-ton-per-year capacity.
  - In 1988 the Jenwu (Renwu) plant converted to ion-exchange membrane technology.
- **Markets**:
  - The plant’s chlorinated products include VCM, PVC resin, chloroethylene, chloromethanes, and hydrochlorofluorocarbons (HCFCs).
  - According to ICIS, “Most of the VCM produced by FPC is for captive uses in producing polyvinyl chloride (PVC).”
  - It supplies PVC resins to the global market, mostly India and China.
  - Formosa’s plants in Kaohsiung and Miaoli, Taiwan, supply VCM to the company’s 300,000-ton-per-year PVC plant in Ningbo, Zhejiang Province, China.
  - In 2010, after authorities discovered VCM pollution in groundwater, manufacturers feared the plant would be shut down, and thus increase PVC prices in India. “FPC is a major PVC exporter to India. A shutdown of its Jenwu plant would have definitely sent PVC prices rocketing,” an Indian PVC buyer told ICIS. Hundreds of villagers marched on the site and demanded a shutdown of the plant.

INVENTORY CODE: ASIATW02

- **Plant Name**: Mailiao Chlor-Alkali Plant
Owner: Formosa Plastics Co.
Location: Mailiao, Taiwan.
Year Opened: 1998 (PVC plant) and 1999 (chlor-alkali and VCM plant).

Capacities (tons per year):
- 1,209,000 tons of chlorine (2014).
- 1,650,000 tons of EDC.
- 800,000 tons of VCM (2018).
- 500,000 tons of PVC (2011).

Capacity Rankings: Largest chlor-alkali plant in Asia. 4th largest chlor-alkali plant in the world. 11th largest PVC plant in Asia. 26th largest PVC plant in the world.

Technology Conversions:
- The Mailiao PVC plant opened in 1998 with a capacity of 420,000 tons.
- Added chlor-alkali plant (300,000-ton chlorine production capacity) and VCM plant (600,000 tons per year) in 1999.
- Expanded from 600,000 tons to 750,000 tons of chlorine production capacity in 2003.

Markets:
- In addition to the VCM and PVC products, Formosa Plastics produces 100,000 tons of epichlorohydrin in Mailiao. One of Formosa's subsidiaries, Nan Ya Plastics Corp., produces 160,000 tons of epoxy resins. Another subsidiary, called Formosa Chemicals and Fibre Corp., produces 200,000 tons of polycarbonate resins, which are also dependent upon chlorine feedstocks.
- Formosa's Mailiao plant exports PVC resin to the USA and other countries.

INVENTORY CODE: ASIATW03

Plant Name: TCI
Owner: Taiwan Chlorine Industries (TCI), a joint venture between Westlake Chemical (60%) and PPG (40%). PPG acquired its share from China Petrochemical Development Corporation (CPDC of Taiwan) in 2016.
Location: Lin Hai industrial area, Kaohsiung City, Taiwan.
Year Opened: 1988
Capacities (tons per year): 120,000 tons of chlorine.
Capacity Rankings: Not among largest 33 chlor-alkali plants in Asia.
Technology Conversions:
- In 1988, the plant converted from mercury cell to membrane technology. The new plant opened with the capacity to produce 103,000 tons of chlorine per year.

Markets:
- TCI's only chlorinated products are chlorine and hydrochloric acid (hydrogen chloride). It also provides sodium hydroxide and liquid caustic soda to China Petrochemical Development Corporation.
- It markets these products "within the country... for the development of chlorine derivatives with high added-value."
COUNTRY: THAILAND

INVENTORY CODE: ASIATH01

- **Plant Name**: ACTH Rayong Plant; previously called Thasco (Thailand Asahi Chemical Company)
- **Owner**: AGC Group (formerly named Asahi Glass) through its subsidiary, AGC Chemicals Thailand (ACTH), since 2007.
- **Location**: Map Ta Phut (also translated as Mab Ta Phut), Rayong, Thailand.
- **Process**: PFAS membrane.
- **Year Opened**: 1997.
- **Capacities (tons per year)**: 146,000 tons (2003).
- **Capacity Rankings**: Not among largest 33 chlor-alkali plants in Asia.
- **Technology Conversions**:
  - In 1997, Asahi Glass provided membrane technology with the capacity to produce 115,000 tons of caustic soda per year.
  - In 1999, the plant added 40,000 tons of caustic soda capacity.
  - In October 2018, AGC announced plans to build a pipeline between its two chlor-alkali plants (ACTH and Vinythai) in Map Ta Phut.
- **Markets**:
  - Chlorine from the plant is sold to nearby chemical producers in Map Ta Phut.
  - Customers include polycarbonate producers (Bayer [now Covestro] and Thai Polycarbonate).

INVENTORY CODE: ASIATH02

- **Plant Name**: Vinythai
- **Owner**: AGC Group (formerly named Asahi Glass Co., Japan), through its Vinythai Public Company Ltd. subsidiary. AGC holds a 58.8% share of Vinythai; PTT Global Chemical of Thailand owns 25%. AGC acquired its stake from Solvay in 2017.
- **Location**: Map Ta Phut, Rayong, Thailand.
- **Process**: PFAS membrane.
- **Year Opened**: 1992.
- **Capacities (tons per year)**:
  - 336,000 tons of chlorine, 320,000 tons of EDC, 560,000 tons of VCM, and 280,000 tons of PVC (2016).
  - Vinythai imports EDC and VCM as needed.
  - It receives ethylene from Thai Olefins.
- **Capacity Rankings**: 29th largest chlor-alkali plant in Asia. 57th largest chlor-alkali plant in the world. 40th largest PVC plant in Asia. 69th largest PVC plant in the world.
- **Technology Conversions**:
  - Solvay opened the PVC plant in 1992, using VCM imported from the global market.
  - In April 1996, Solvay added chlor-alkali and VCM production. It used ethylene from the new NCP 2 cracker, and salt from a joint venture - Pimai Salt Company - that it shared with two Thai companies.
In 2012, the company began producing epichlorohydrin in the Vinythai Map Ta Phut complex.\(^7\) In October 2018, AGC announced plans to increase PVC production at the Vinythai plant to 860,000 tons per year, VCM to 830,000 tons, and chlorine to 536,000 tons. It also plans to connect its two chlor-alkali plants (ACTH and Vinythai) in Map Ta Phut by pipeline.\(^4\)

**Markets:**
- Vinythai markets VCM and PVC resins, the latter under the trademark "SIAMVIC®." In 2017, it exported over 1,400 tons of PVC resins to the USA.\(^5\)
- A Vinythai division, Advanced Biochemical (Thailand) Co. Ltd, makes epichlorohydrin on-site. ABT markets its Epicerol\(^6\) epichlorohydrin as "bio-based."\(^7\)

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**COUNTRY: TURKEY**

**INVENTORY CODE: ASIATUR01**

- **Plant Name:** Petkim Aliaga
- **Owner:** Petkim Petrokimya Holding AS/ SOCAR Turkey Enerji A.Ş.
- **Location:** Aliaga, Izmir Province.
- **Process:** PFAS membrane.\(^8\) Converted from mercury cell in 2000.\(^9\)
- **Year Opened:** 1985.\(^0\)
- **Capacities** (tons per year):
  - 100,000 tons of chlorine.
  - 152,000 tons of VCM.
  - 150,000 tons of PVC.\(^1\)
  - This complex includes an ethane cracker with the capacity to produce 585,000 tons of ethylene per year.\(^2\)
- **Capacity Rankings:** Not among the largest chlor-alkali or PVC plants in Asia.
- **Technology Conversions:**
  - The chlor-alkali plant opened in 1985 using De Nora mercury cell technology.
  - In 1995, the company added ethylene, VCM, and PVC production units; by 2003, production capacity had reached 520,000 tons of ethylene, 152,000 tons of VCM, and 150,000 tons of PVC.\(^3\)
  - In 2000, all mercury cells in the chlor-alkali plant were replaced with PFAS membranes.\(^4\)
- **Markets:**
  - Markets for the plant’s PVC include “pipe, window shades, cable, bottles, building materials, packaging film, floor tiles, serum bags,” according to the company’s 4Q 2017 financial report.\(^5\)
THE APPENDICES
### APPENDIX A
### GLOBAL INVENTORY OF CHLOR-ALKALI PLANTS

<table>
<thead>
<tr>
<th>RANK</th>
<th>INVENTORY CODE</th>
<th>PARENT COMPANY</th>
<th>LOCATION</th>
<th>TOTAL TPH (est.)</th>
<th>PFAS TPH</th>
<th>ASBES TPH</th>
<th>MERC TPH</th>
<th>CHLORINE USES</th>
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<tbody>
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<td>1</td>
<td>AMUSA16</td>
<td>Olin</td>
<td>Freeport, Texas, USA</td>
<td>3,030</td>
<td>1,450</td>
<td>1,580</td>
<td>Chlorinated solvents and epoxy resins (on-site); PVC (Shintech, adjacent); Isocyanates (Dow, adjacent).</td>
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<td>EURDE09</td>
<td>DowDuPont</td>
<td>Stade, Lower Saxony, Germany</td>
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<td>550</td>
<td>1,030</td>
<td>PVC (through EDC sales); polycarboxylates, chlorinated polyethylene, epoxies, perchloroethylene, trichloroethylene, and carbon tetrachloride (on-site).</td>
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<td>AMUSA22</td>
<td>Westlake</td>
<td>Lake Charles / Westlake, Louisiana, USA</td>
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<td>PVC (off-site: Westlake, Aberdeen, Mississippi, and Certainteed, Lake Charles).</td>
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<td>ASIATW02</td>
<td>Formosa Plastics</td>
<td>Mailiao, Taiwan</td>
<td>1,209</td>
<td>1,209</td>
<td></td>
<td>PVC (on-site and through VCM sales), epichlorohydrin (on-site).</td>
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<td>AMUSA19</td>
<td>Shin-Etsu</td>
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<td>PVC (on-site and Addis, Louisiana).</td>
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<td>6</td>
<td>ASIAJPN08</td>
<td>Tosoh Corp. (formerly Toyo Soda)</td>
<td>Shin-Nanyo, Yamaguchi, Japan</td>
<td>1,022</td>
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<td>PVC (on-site and overseas through VCM exports).</td>
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<td>ASIACHN26</td>
<td>Xinjiang Zhongtai Chemical</td>
<td>Urumqi, Xinjiang, China</td>
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<td>Merchant PVC (on-site).</td>
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<td>Carbon tetrachloride, epoxies, perchloroethylene (on-site); Merchant EDC; PVC (Shintech, off-site).</td>
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<td>Epichlorohydrin, isocyanates and PVC (on-site).</td>
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Notes
PFAS = Per- and polyfluoralkyl substances that coat membranes or diaphragms used in chlor-alkali production.
Asbes = Asbestos diaphragms. Merc = Mercury cells.

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<tr>
<th>RANK (SIZE)</th>
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<td>SP Chemical Holdings</td>
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<td>On-site: chlorobenzene, nitrochlorobenzene. Off-site, nearby: PVC (Taiwan UPC Group); epichlorohydrin (Solvay), monochloroacetic acid (AkzoNobel).</td>
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<td>Caojing, Shanghai, China</td>
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<td>PVC (on-site). Off-site (in chemical park): isocyanates (Shanghai Lianheng Isocyanate Co.,); bisphenol A (Mitsui/Sinopec); polycarbonate and isocyanates (Covestro).</td>
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<td>ASIASAU01</td>
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<td>Jubail Industrial City, Saudi Arabia</td>
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<td>PVC (on-site and nearby Abadan Petrochemical Company).</td>
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<td>PVC (OxyChem, Pasadena, Texas).</td>
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<td>Covestro</td>
<td>Dormagen, North Rhine-Westphalia, Germany</td>
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<td>Isocyanates (on-site).</td>
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<td>Tangshan Sanyou Chlor-alkali Co.</td>
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<td>Wuzhong City, Ningxia, China</td>
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<td>Ningbo, Zhejiang, China</td>
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<td>ASIAJPN07</td>
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<td>Tokuyama, Yamaguchi, Japan</td>
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<td>PVC (off-site in nearby plant owned by subsidiary).</td>
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<td>Blowing agents, carbon tetrachloride, chlorinated solvents (on-site); PVC (off-site).</td>
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<td>ASIACHN22</td>
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<td>Yibin, Sichuan, China</td>
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<td>PVC, tetrachlorethylene, liquid chlorine, hydrochloric acid (on-site).</td>
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<td>Carbon tetrachloride, chloroform, methylene chloride, and perchloroethylene (on-site); merchant chlorine.</td>
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<td>AMBRA05</td>
<td>DowDuPont Inc.</td>
<td>Candeias, Bahia, Brazil</td>
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<td>Propylene dichloride for isocyanates used in polyurethane.</td>
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<td>Sinopec</td>
<td>Zibo, Shandong, China</td>
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<td>Maceió, Alagoas, Brazil</td>
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<td>PVC, chloroethylene, chloromethanes, and HCFCs (on-site).</td>
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</table>

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<tr>
<td>41</td>
<td>EURDE06</td>
<td>Covestro</td>
<td>Leverkusen, North Rhine-Westphalia, Germany</td>
<td>390</td>
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<td>Isocyanates (on-site). Also supplies chlorine for nearby producers of benzyl chloride, chlorobenzene, chlorotoluene mixtures, methyl chloride, chloroaniline, chloronitrobenzene, dichlorobenzene, and titanium dioxide.</td>
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<td>Isocyanates, trichlorethylene, alcoholates (on-site).</td>
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<td>PVC (through VCM supplied to subsidiaries in France and the Netherlands).</td>
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<td>PVC, hydrochloric acid, merchant chlorine, trichloroethylene (on-site).</td>
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<td>PVC (through VCM supplies to related plants in France and Spain); ferric chloride (on-site).</td>
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<td>PVC (on-site and through EDC sales); epichlorohydrin, caustic soda, chloromethanes, and allyl chloride (on-site).</td>
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<td>Unipar Carbono</td>
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<td>PVC, propylene oxide, chlorobenzene (on-site), phosgene (off-site, Liaoning Hongsan).</td>
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<td>EDC sold to off-site PVC manufacturers.</td>
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</table>

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<td>Meraised Industrial City, Qatar</td>
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<td>Propylene oxide; epichlorohydrin.</td>
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<td>Epichlorohydrin, chloroform, tetramethylammonium chloride, methylene chloride, and methyl chloride (on-site).</td>
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<td>PVC, trichloroethylene, calcium chloride, magnesium chloride (on-site).</td>
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</tbody>
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<td>Aluminum chloride (on-site); Merchant chlorine.</td>
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<td>PVC (on-site and off-site through VCM sales).</td>
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<td>Marl, North Rhine-Westphalia, Germany</td>
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<td>83</td>
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<td>Olin</td>
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**Notes**

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<td>Merchant chlorine, poly aluminum chloride, chlorinated paraffins (on-site); benzyl chloride, benzotrichloride, thionyl chloride, sulfuryl chloride, and sulfur dichloride (off-site, Gwalior in Nagda).</td>
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<td>Natrium (New Martinsville), West Virginia, USA</td>
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<td>ASIASAU02</td>
<td>50:50 joint venture between Sahara Petrochemicals and Saudi Arabian Mining Co.</td>
<td>Jubail Industrial City, Saudi Arabia</td>
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<td>JSC Bashkirskaya Khimiya</td>
<td>Steritamak, Bashkortostan, Russia</td>
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<td>84</td>
<td>134</td>
<td>PVC (on-site and through EDC exports).</td>
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<td>Sibur and Solvay (JV)</td>
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<td>Ulsan, South Korea</td>
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<td>Ichihara City, Chiba, Japan</td>
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<td>Carbon tetrachloride, chloroform, and methylene chloride (on-site).</td>
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<td>Titanium dioxide (DuPont, adjacent).</td>
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<td>AMARG01</td>
<td>Unipar Carbocloro</td>
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<td>PCC Rokita</td>
<td>Brzeg Dolny, Poland</td>
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<td>Hydrochloric acid, chlorobenzene, and trichloroethylene.</td>
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<td>Alcoholates (on-site); Cyanuric chloride (nearby related plant).</td>
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<td>Local producers of ethylene amine, chlorinated PVC, and mono-chloroacetic acid.</td>
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<tr>
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<td>AMMEX02</td>
<td>Cydsa</td>
<td>Allende, Veracruz, Mexico</td>
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<td>ASIAPAK01</td>
<td>Engro Corporation</td>
<td>Port Qasim, Baluchistan, Pakistan</td>
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<td>96</td>
<td></td>
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</tr>
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<td>EURRU02</td>
<td>EuroChem Group</td>
<td>Novomoskovsk, Tula region, Russia</td>
<td>91</td>
<td>91</td>
<td>PVC, sodium hypochlorite, hydrochloric acid, calcium chloride (on-site).</td>
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<tr>
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<td>AMCAN02</td>
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<td>AkzoNobel</td>
<td>Ibbenbüren, North Rhine-Westphalia, Germany</td>
<td>75</td>
<td>75</td>
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<td>Chloromethanes (on-site).</td>
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<td>AMBRA02</td>
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<td>AFEGY01</td>
<td>Misr Chemical Industries</td>
<td>Alexandria, Egypt</td>
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<td>68</td>
<td></td>
<td>Merchant chlorine.</td>
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<td>AFMOR01</td>
<td>Ynna Holding</td>
<td>Mohammedia, Morocco</td>
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<td>68</td>
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</tbody>
</table>

Notes
PFAS = Per- and polyfluoroalkyl substances that coat membranes or diaphragms used in chlor-alkali production.
Asbes = Asbestos diaphragms. Merc = Mercury cells.

Continued on next page
### Chlorine and Building Materials, Phase 2: Asia

<table>
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<tr>
<th>RANK (SIZE)</th>
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<th>PARENT COMPANY</th>
<th>LOCATION</th>
<th>TOTAL</th>
<th>PFAS</th>
<th>ASBES</th>
<th>MERC</th>
<th>CHLORINE USES</th>
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<td>Ashtabula, Ohio, USA</td>
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<td>Titanium dioxide (Cristal, adjacent).</td>
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<tr>
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<tr>
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<td>Quimpac</td>
<td>Paramonga, Lima, Peru</td>
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<td>27</td>
<td></td>
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<td>Merchant chlorine.</td>
</tr>
</tbody>
</table>

| No. of Plants | 146 | 127 | 24 | 14 |
| Shares of capacity | 79% | 18% | 3% |

| Technology, Estimated Capacity (1000 tpy, est.) | 51,218 | 40677 | 9011 | 1530 |

**Notes**
- PFAS = Per- and polyfluoroalkyl substances that coat membranes or diaphragms used in chlor-alkali production.
- Asbes = Asbestos diaphragms.
- Merc = Mercury cells.

Rankings are not included for chlor-alkali plants under 300,000 tons per year capacity because this Inventory does not include some operating plants with capacities in this range.

This Phase 2 report contains additional details about chlor-alkali plants in Asia. Details about plants in the rest of the world are available in the Phase 1 report. These reports provide sources for data in this Appendix.

Phase 1 and Phase 2 reports, and related spreadsheets and maps, are available on the homepage for HBN’s Chlorine and Building Materials project, [https://healthybuilding.net/reports/20-chlorine-building-materials-project-phase-2-asia-including-worldwide-findings](https://healthybuilding.net/reports/20-chlorine-building-materials-project-phase-2-asia-including-worldwide-findings).
## APPENDIX B
### GLOBAL INVENTORY OF PVC PLANTS

<table>
<thead>
<tr>
<th>RANK</th>
<th>OWNER</th>
<th>LOCATION</th>
<th>PVC CAPACITY (1,000 TONS/YR.)</th>
<th>CHLORINE SOURCE</th>
<th>CHLORINE SOURCE TECHNOLOGIES</th>
<th>VCM SOURCE TECHNOLOGY</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Xinjiang Zhongtai Chemical</td>
<td>Urumqi, Xinjiang, China</td>
<td>1,530</td>
<td>ASIACHN26 (on-site)</td>
<td>PFAS membrane</td>
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<tr>
<td>2</td>
<td>Shin-Etsu</td>
<td>Freeport, Texas, USA</td>
<td>1,450</td>
<td>from AMUSA16</td>
<td>PFAS membrane</td>
<td>Ethylene</td>
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<tr>
<td>3</td>
<td>Tianye Group</td>
<td>Shihezi Development Zone, Xinjiang, China</td>
<td>1,200</td>
<td>ASIACHN24 (on-site)</td>
<td>PFAS membrane</td>
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<tr>
<td>4</td>
<td>Shaanxi Coal and Chemical Industry Group</td>
<td>Shenmu County, Shaanxi, China</td>
<td>1,100</td>
<td>ASIACHN15 (on-site)</td>
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<tr>
<td>5</td>
<td>Occidental</td>
<td>Pasadena, Texas, USA</td>
<td>898</td>
<td>from AMUSA06 and AMUSA14</td>
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<td>Ethylene</td>
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<tr>
<td>6</td>
<td>Mexichem</td>
<td>Altamira, Tamaulipas, Mexico</td>
<td>876</td>
<td>from AMUSA07 and AMMEX01</td>
<td>Asbestos diaphragm</td>
<td>Ethylene</td>
</tr>
<tr>
<td>7</td>
<td>Westlake</td>
<td>Plaquemine, Louisiana, USA</td>
<td>861</td>
<td>AMUSA20 (on-site)</td>
<td>Asbestos diaphragm</td>
<td>Ethylene</td>
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<tr>
<td>8</td>
<td>Formosa</td>
<td>Point Comfort, Texas, USA</td>
<td>816</td>
<td>AMUSA03 (on-site)</td>
<td>PFAS membrane</td>
<td>Ethylene</td>
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<tr>
<td>9</td>
<td>Inner Mongolia Junzheng Energy</td>
<td>Wuhai City, Inner Mongolia, China</td>
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<td>ASIACHN09 (on-site)</td>
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<td>10</td>
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<td>Yeosu City, South Korea</td>
<td>750</td>
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<td>Government of China</td>
<td>Caojing, Shanghai, China</td>
<td>720</td>
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<tr>
<td>12</td>
<td>Ningxia Jinyuyuan Chemical</td>
<td>Wuzhong City, Ningxia, China</td>
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<td>Calvert City, Kentucky, USA</td>
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<tr>
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<tr>
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<td>Botlek-Rotterdam, Netherlands</td>
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<tr>
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<td>(tie) Shin-Etsu</td>
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<tr>
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<td>(tie) Xinfa Group</td>
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<tr>
<td>RANK</td>
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<td>PVC CAPACITY (1,000 TONS/YR.)</td>
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<td>CHLORINE SOURCE TECHNOLOGIES</td>
<td>VCM SOURCE TECHNOLOGY</td>
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<td>CHLORINE SOURCE TECHNOLOGIES</td>
<td>VCM SOURCE TECHNOLOGY</td>
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<td>International Chemical Investors Group</td>
<td>Wilhelmshaven, Netherlands</td>
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<td>Hazira, Gujarat, India</td>
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<td>ASIAIND07 (on-site)</td>
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<td>Ethylene</td>
</tr>
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<td>Occidental</td>
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<td>from AMUSA05 and AMUSA14</td>
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<tr>
<td>49 (tie)</td>
<td>Islamic Republic of Iran</td>
<td>Special Economic Zone, Bandar Emam, Iran</td>
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<td>PKN Orlen</td>
<td>Wloclawek, Poland</td>
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<td>Sibur and Solvay (JV)</td>
<td>Kstovo, Russia</td>
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<tr>
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<td>Rheinberg, Germany</td>
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<td>Dahej, Bharuch District, Gujarat, India</td>
<td>315</td>
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<td>55</td>
<td>Tosoh Corp. (formerly Toyo Soda)</td>
<td>Yokkaichi, Mie, Japan</td>
<td>310</td>
<td>ASIAJPN09 (on-site)</td>
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<td>56 (tie)</td>
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<td>Heilongjiang, China</td>
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<td>PFAS membrane</td>
<td>Acetylene</td>
</tr>
<tr>
<td>56 (tie)</td>
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<td>Balan, France</td>
<td>300</td>
<td>from EURFR02 and EURFR03</td>
<td>PFAS membrane</td>
<td>Ethylene</td>
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<tr>
<td>RANK</td>
<td>OWNER</td>
<td>LOCATION</td>
<td>PVC CAPACITY (1,000 TONS/YR.)</td>
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<td>CHLORINE SOURCE TECHNOLOGIES</td>
<td>VCM SOURCE TECHNOLOGY</td>
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<td>Sanmar Holdings</td>
<td>Cuddalore, Tamil Nadu, India</td>
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<td>PFAS membrane</td>
<td>Ethylene</td>
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<tr>
<td>56</td>
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<td>VCM SOURCE TECHNOLOGY</td>
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<td>122</td>
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<td>P.T. Sulfindo</td>
<td>Merak, West Java, Indonesia</td>
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<td>ASIAIDN02 (on-site)</td>
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<td>Chateau-Arnoux-Saint-Auban, France</td>
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<td>Mohammedia, Morocco</td>
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Notes:
Rankings are not included for chlor-alkali plants under 250,000 tons per year capacity because this Inventory does not include some operating plants with capacities in this range.
This Phase 2 report contains additional details about PVC plants in Asia. Details about plants in the rest of the world are available in our Phase 1 report. These reports provide sources for the data in this Appendix.
See also the spreadsheets and map on HBN’s Chlorine and Building Materials project page, https://healthybuilding.net/reports/20-chlorine-building-materials-project-phase-2-asia-including-worldwide-findings.
Endnotes


Our estimated percentage of coverage is based on an average of these two industry estimates.


5. Where the term “tons” appears, it refers to metric tons, into which reported weights have been converted for consistency. See the Glossary of Notes in our Phase 1 report for further details of this and other technical terms.

6. We estimated that chlorine is lost in these reactions, we have taken the amount of chlorine that is required for the overall reaction (0.61 kg Cl / kg PVC) and subtracted the amount of chlorine that ends up in the PVC (0.5672 kg Cl / kg PVC) to arrive at 0.04 kg Cl lost / kg PVC produced. In other words, 7% of the chlorine used by this method is released into the environment or subsumed by by-products, and 93% ends up in PVC.

8. We estimate that the PVC plants that are associated with chlor-alkali plants we researched in China have a combined capacity of 14.1 million tons per year. This requires the consumption of 8.6 million tons of chlorine. This is 74% of the estimated chlorine capacity (11.7 million tons) of the 27 chlor-alkali plants in China that we researched for this report.


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78 Ibid.
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Chlorine and Building Materials: A Global Inventory of Production Technologies and Markets

Phase 2: Asia

Healthy Building Network Mission

To advance human and environmental health by improving hazardous chemical transparency and inspiring product innovation.

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