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CHEMICAL MARKET ANALYTICS
BY OPIS, A DOW JONES COMPANY

Impact of EPA's Proposed Asbestos-Diaphragm Chlor-Alkali Rulemaking

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Acronyms

AD	Asbestos Diaphragm
Cl_2	Chlorine
ECU	Electrochemical Unit
EDC	Ethylene Dichloride
kMT	Thousand Metric Tons
MDI	Methylene Diphenyl Diisocyanate
MM	Merchant Market
MMT	Million Metric Tons
NAM	North America
NaOH	Sodium Hydroxide
PCB	Polycarbonates
POX	Propylene Oxide
PVC	Polyvinyl Chloride
ROI	Return on Investment
TDI	Toluene Diisocyanate
TiO_2	Titanium Dioxide
US	United States
VCM	Vinyl Chloride Monomer
WEP	West Europe
W/WWT	Water / Wastewater Treatment

Definitions

Captive Consumption

The amount of any chemical that is produced and consumed by the same facility.

Merchant Market

Any chemical quantity that is metered and commercially transferred from its production facility to a buyer.

Units of Measure

All data are provided in metric tons, and Sodium Hydroxide units are dry metric tons.

FOB Price

Cash cost (excluding transportation) plus margin realized by the producer.

Water Treatment (WT)—Elemental Chlorine

Chlorine consumed for direct elemental chlorination in municipal water treatment facilities for potable water and wastewater treatment.

Water Treatment (WT)—Others

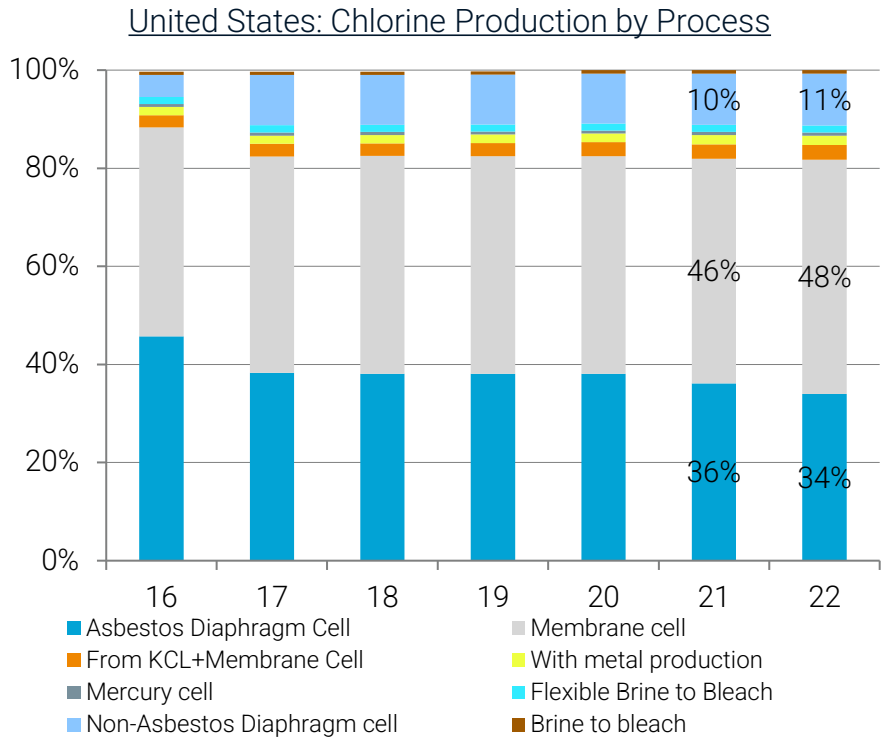
Chlorine consumed for sodium hypochlorite, calcium hypochlorite, ferric chloride, chlorinated isocyanurates, chlorine dioxide, and other water treatment chemicals produced from chlorine.

Production vs. Capacity

Production is the portion of installed capacity that is producing product at an average operating rate. Capacity is the maximum production capacity for an operating rate of 100%.

Total US Market

Total US AD Chlorine Production

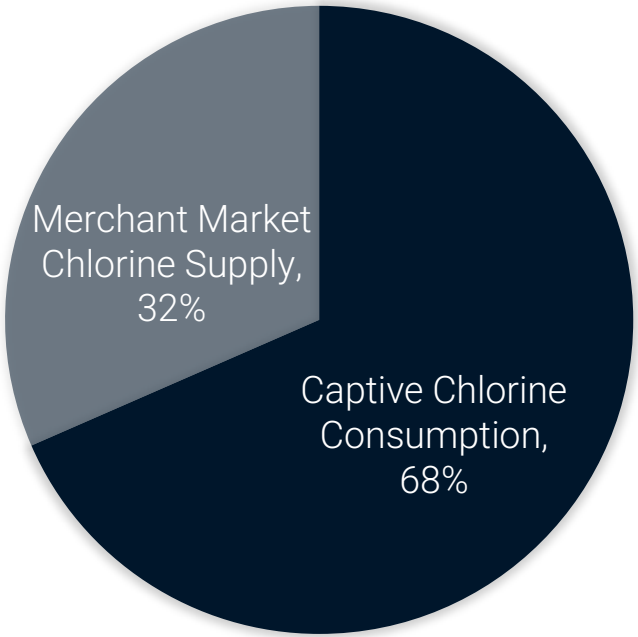


- In 2021, 36% (4.0 MMT) of chlorine production in the US was produced utilizing AD technology.
- In 2022, approximately 34% (3.9 MMT) of chlorine production in the US will be produced utilizing AD technology.
  - In 2021, 559 kMT of AD chlorine capacity closed.
  - In late 2021, 245 kMT of membrane capacity started up.

Total Captive and Merchant Market US Chlorine Production

7.8 MMT of total US chlorine production in 2022 is expected to be captive.

3.6 MMT of total US chlorine production is expected to be sold on the US MM in 2022.



2022 US Chlorine Production Forecast = 11.4 MMT

Barriers for Captive Chlorine Transition to MM

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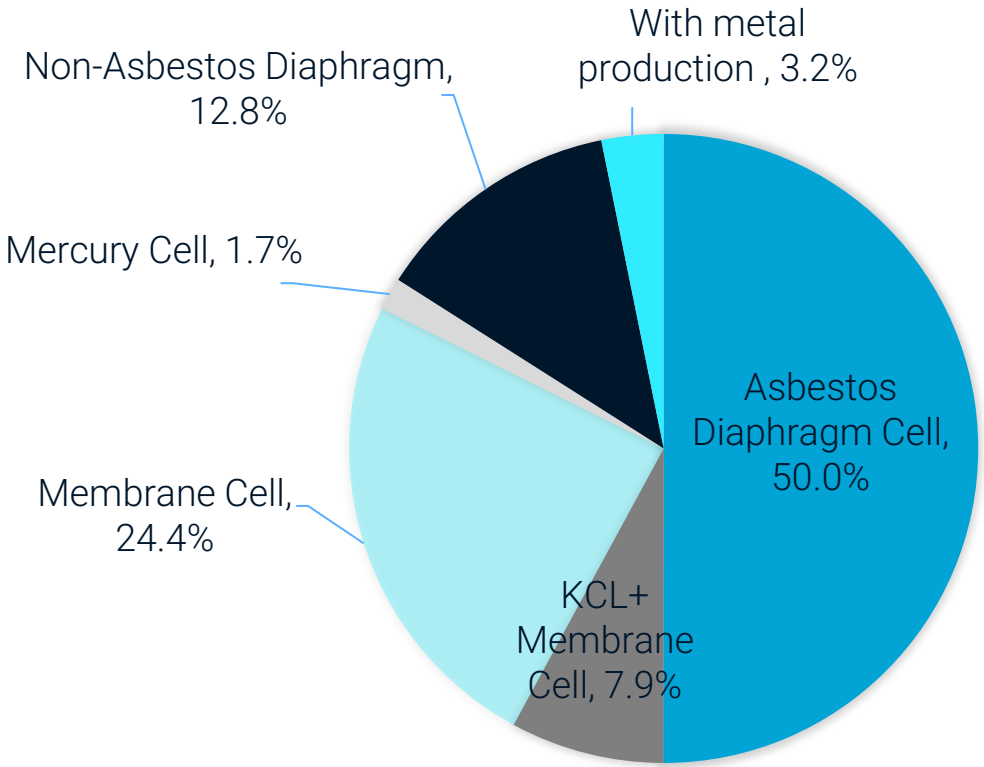
Railcar loading	There is insufficient railcar loading capacity at some non-asbestos production facilities to offset potential production closures. Increasing railcar loading capacity would require capital investment and time and may not be possible in some plants due to space constraints.
Railcar unloading	Some merchant pipeline buyers do not have unloading infrastructure to switch to alternate supply by rail. Some locations have insufficient space to add railcar unloading facilities.
Railcar availability	Elemental chlorine railcars are currently available to supply uses in W/WWT. Chlorine derivatives are mostly supplied via pipeline. Railcar manufacturers indicate that steel supply has increased railcar production cost, but steel is not a bottleneck on railcar production. Chlor-Alkali producers are transitioning from 500lb to 600lb chlorine railcars cars by the end of 2027. As a result, 500lb railcars are available to lease.
Railcar leases	As railcar production costs have increased, railcar lease costs have increased for all cars. New chlorine railcar capital leases will contribute significant cost to producers, who will subsequently pass the cost through to chlorine buyers. The minimum lease term is 7-10 years for new railcars, but shorter leases are available for older cars. Railcars leased to an operator with asbestos diaphragm capacity may need to be transferred to another producer with loading capacity. Railroad contracts have limits on maximum cars that can be shipped.
Rail transit routes	Chlorine transit routes require pre-approval, which may not be attainable in 2 years. New transport routes may be less freight logical resulting in higher costs for chlorine consumers, more railcars required (slower railcar turnover) and increased carbon emissions.
Rail infrastructure	Rails are challenged with current freight movement. Shifting additional chlorine movement to rail will increase rail congestion.
Chemical Properties	Chlorine must be liquified to ship by rail. Facilities that supply chlorine via pipeline may have insufficient chlorine liquefaction capacity to ship by rail, thereby exacerbating shortages.
Product Specifications	Chlorine specifications may be interchangeable, but buyers will need time to qualify a new supplier.

1.8 MMT of US MM chlorine is expected to be produced with AD technology in 2022.

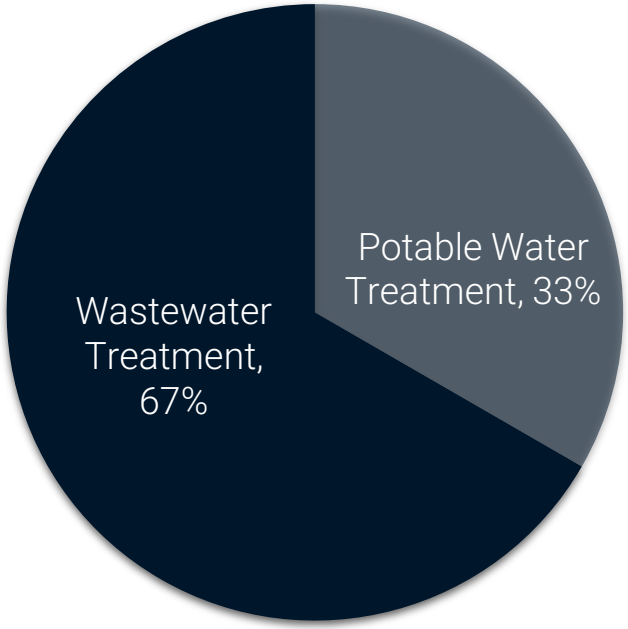
Market discovery indicates that facilities with both AD and other technologies supply the MM with AD chlorine and captively consume other chlorine production.



2022 US Merchant Chlorine Production by Technology

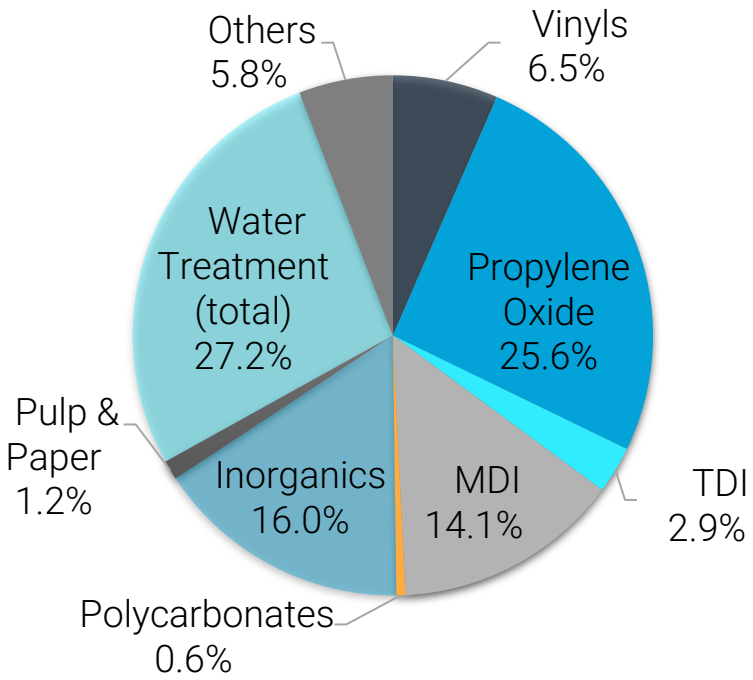
209 kMT of elemental chlorine is used for direct chlorination in municipal potable water treatment in 2022.

Excludes elemental chlorine used for industrial water treatment applications.



2022 US Elemental Chlorine Forecast for Water Treatment = 628 kMT

US Merchant Market Chlorine Uses



2022 US Merchant Chlorine Demand by Sector

Merchant Chlorine Demand Sectors	2022 US MM Chlorine Demand (kMT)
Water Treatment (Total)	1039
Pulp & Paper	46
Water Treatment (Total) includes WT (elemental chlorine) and WT (others). For sectors below, see page 12 for details on merchant chlorine applications.	
Propylene Oxide	979
Inorganic Chemicals	609
Vinyls	250
MDI	539
TDI	112
Polycarbonates	21
Others	223
United States Total	3818

Merchant Chlorine Demand Sectors – Consumer and Industrial End Products Dependent on Merchant Chlorine Derivatives

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Propylene Oxide (POX) 2022 Demand Sectors

- Propylene oxide is used to produce propylene glycol, which is used for antifreeze and aircraft deicers.
- Other consumer products include food, pharmaceuticals, personal care, flavors, fragrances, liquid detergents, animal food and health products.

Polyvinyl Chloride (PVC) 2022 Demand Sectors

- Medical grade PVC is used for tubing (IV & ventilator), bags (blood & IV), masks, gloves, catheters, drip chambers, and other disposable applications.
- PVC is a preferred material for potable water and wastewater infrastructure due to its durability, ease of maintenance, and low susceptibility to corrosion.
- Consumer-oriented PVC products include wall coverings, flooring, fencing, and artificial leather.

Methyl Diphenyl Diisocyanate (MDI) 2022 Demand Sectors

- MDI is an intermediate used to produce polyurethanes. Polyurethane elastomers are used in automotive components such as bumper covers, trim, spoilers, body panels, mechanical parts, gaskets, and seals.
- MDI is used in electric vehicles (EVs) for its strong, lightweight properties. MDI consumption per EV is expected to trend upward.
- Wind turbine blades use polyurethane adhesives as the material choice for its lightweight and high lap shear strength in outdoor conditions.
- Insulation products like cold-chain storage and protective packaging use MDI to ensure the quality, supply, and shelf life of food products.
- Polyurethanes are used in internal combustion engines (ICE) to reduce fuel consumption via weight reduction.

Inorganic Chemicals 2022 Demand Sectors

- Titanium dioxide (TiO_2) is the major pigment constituent of paints, plastics, and surface coatings where opacity or UV light protection is desired.
- TiO_2 is also used for self-cleaning glass, electronics, and in cosmetics to provide sunscreen protection.
- Clear brine fluids like calcium, zinc, and sodium bromides are used by the oil and gas industry for high-density, clear drilling completion, packer, and workover fluids
- Brominated hydantoins and sodium/ammonium bromides are used in water treatment for swimming pools, cooling towers, paper mills, household and industrial dishwashing/cleaning products.
- Environmental use of bromine compounds includes mercury (Hg) removal at coal-fired power stations.

Toluene Diisocyanate (TDI) 2022 Demand Sectors

- TDI is an intermediate used to produce polyurethanes. TDI is used in urethane coatings for architectural applications, and for primers and wood coatings.
- Polyurethane adhesives and sealants are used in automotive, shoes, and wood binders.
- TDI is used in electric vehicles (EVs) for its strong, lightweight properties. TDI consumption per EV is expected to trend upward.

Polycarbonates (PCB) 2022 Demand Sectors

- Polycarbonate(PC) films are used automotive instrument panels, instrument displays, and medical laboratory equipment.
- PC is used for both prescription and non-prescription eyewear, protective helmets, and personal electronic devices (laptops, monitors, cameras).

2021 US Chlorine Supply vs. Key US Supply Chains

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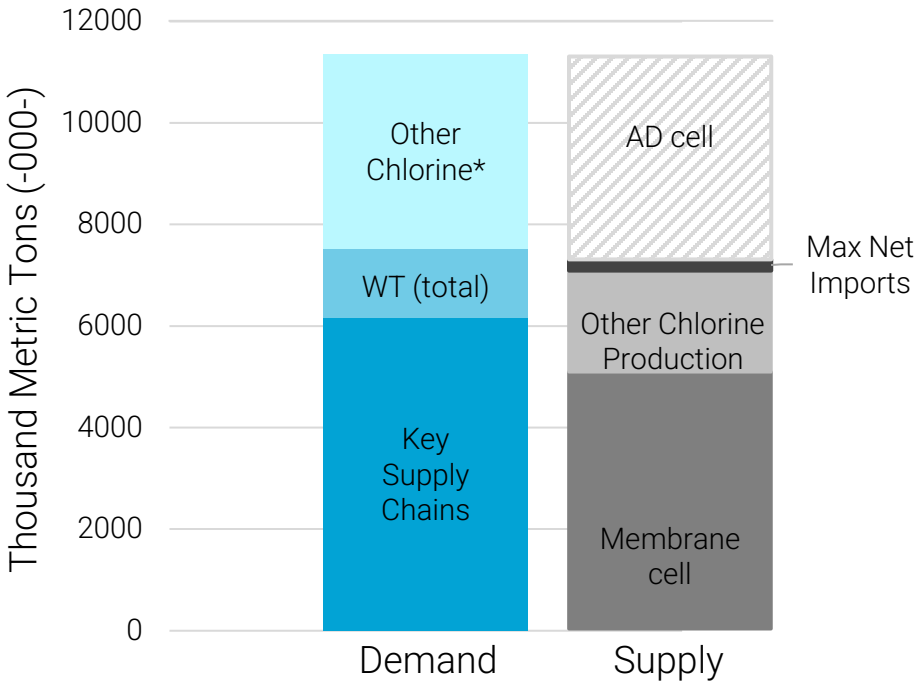
2021 US Chlorine Supply & Demand



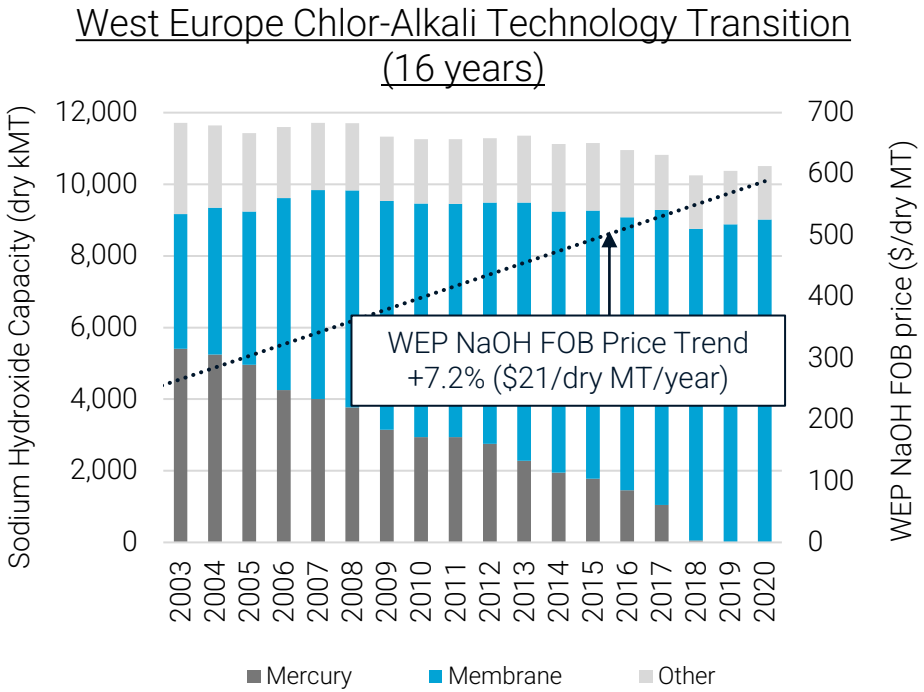
*see page 12 for Other Chlorine demand sector details

2021 Chlorine Demand for Key US Supply Chains

5290	kMT of chlorine demand is estimated for use in US construction applications in 2021.
50.2	kMT of chlorine demand is estimated for use in US medical devices such as blood bags, gloves, tubing and oxygen masks in 2021.
23.7	kMT of chlorine demand is estimated for use in US semiconductors in 2021.
426	kMT of chlorine demand is estimated for use in US oil & gas production in 2021.
328	kMT of chlorine demand is estimated for use in US agriculture applications in 2021.
46	kMT of chlorine demand is estimated for use in US pulp & paper in 2021.

- Although the US chlorine market is influenced by macroeconomic conditions and global events, US chlorine market dynamics are less influenced by global events compared to the sodium hydroxide market. In general, changes to domestic chlorine supply have a direct impact on the domestic market with some second-order effects on the global market.
- Between Q3 2020 and Q2 2022, the US quarterly chlorine nameplate capacity declined by 156 kMT, quarterly chlorine production increased by 174.5 kMT, and the effective chlorine operating rate went from 86.5% to 97.1%, which is an unsustainable rate over prolonged periods. As a result, the US chlorine FOB price increased by 353% ($686/MT) between Q3 2020 and Q2 2022.
- According to this trend, the US chlorine FOB price could reach $3,600/MT if all AD capacity were removed from the US market by 2025 without time for an equivalent capacity increase via non-AD technology. In this scenario, the US chlorine FOB price could increase by approximately 102% on average each year over the course of two years.
- As a result of a tight supply/demand balance in 2022, North American chlorine market prices have reached record highs. Derivatives such as EDC and HCl are also exhibiting the same price trend. Although US chlorine demand has remained strong, discovery indicates that the rapid and significant elevation of merchant chlorine prices over the past year may be reaching a tipping point that threatens demand erosion. Chemical Market Analytics by OPIS has confirmed that at least one merchant chlorine consumer producing chlorine derivative chemicals has suspended operations as a result of chlorine prices exceeding the limit that enables profitable operation.

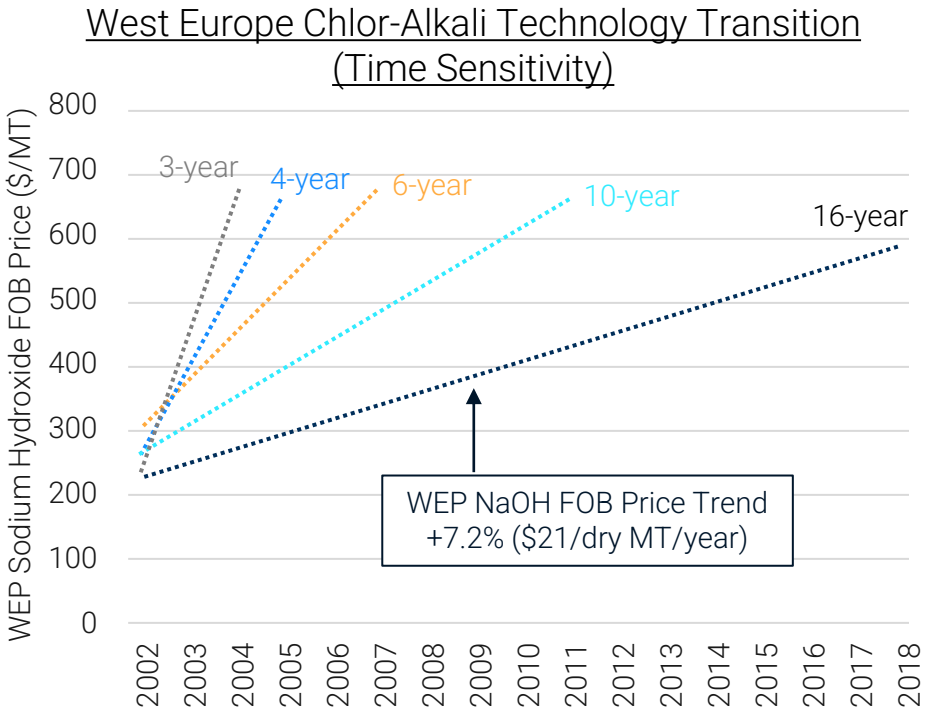
- Historically, the US price trend for sodium hydroxide is defined by the supply/demand balance and domestic cash costs. Inasmuch, recent global events have led to global market tightness, which has resulted in prices rising to the highest cash cost region, consistent with fundamental economic principals,— the highest cash cost region is Europe. In the US, recent NaOH price trends are influenced by the domestic capacity rationalizations and the benchmark set by Europe.
- Between Q3 2020 and Q2 2022, the US quarterly sodium hydroxide nameplate capacity declined by 170 kMT, quarterly NaOH production increased by 208 kMT, and the effective NaOH operating rate went from 87.5% to 98.7%, which is an unsustainable rate over prolonged periods. As a result, the US NaOH FOB price increased by 85% ($375/MT) between Q3 2020 and Q2 2022.
- According to this trend, the US sodium hydroxide FOB price could reach $2,200/MT if all AD capacity were removed from the US market by 2025 without time for an equivalent capacity increase via non-AD technology. In this scenario, the US NaOH FOB price could increase by approximately 65% on average each year over the course of two years.
- This estimate for FOB price increase is conservative. Approximately 24% of US NaOH production goes to the export market. If the US AD capacity were removed from the market, no other country or region could offset the loss, which could trigger a much higher price level than the one provided.



Note: European sodium hydroxide contract structure mirrors US contract structure therefore Europe is a good proxy for the US sodium hydroxide market.

- In 2001, the European chlor-alkali industry made a voluntary commitment to phase-out mercury cell technology by 2020. However, the transition became legally mandatory, and all mercury-based chlor-alkali production was ordered to cease by 2017.
- Over the course of 16 years, the European industry converted 5.4 MMT of mercury-based sodium hydroxide capacity with an average capacity conversion rate of 3% per year. During this transition period (2001-2017), the total European capacity declined by 326 kMT. Meanwhile, domestic demand for sodium hydroxide in Europe continued to grow each year by an average of 0.02%, and the domestic NaOH FOB price increased each year by an average of 7.2%.
- For an AD technology conversion in the US (5.1 MMT of AD NaOH capacity) with a similar annual conversion rate of 3% of capacity per year, the US NaOH FOB price could increase by approximately 5% on average each year over the course of 15 years. This estimate assumes that total US capacity remains constant during conversion.

- In the US, an AD technology conversion would impact 5.1 MMT of NaOH capacity and 4.7 MMT of chlorine capacity. The rate of conversion would impact the time it takes to transition from AD to non-AD technology, and the time it takes to transition would impact the rate of US FOB price increase for both chlorine and sodium hydroxide.
- For example, if the US were to follow an average technology conversion rate of 3% per year (similar to West Europe), the impact to NaOH FOB price is an average annual increase of 5% over the course of 15 years. In this scenario, the impact to chlorine FOB price could result in an average annual increase of 10-20% over the same period.
- The impact on chlorine price is more significant than the impact on NaOH price due to the nature of elemental chlorine compared to sodium hydroxide. Elemental chlorine is not easily stored or transported. As a result, any lost chlorine production is permanent and cannot be recovered. For sodium hydroxide, lost production in the domestic market can be supplied by shifting export volumes away from the export market and toward the domestic US market. Furthermore, lost NaOH production in the domestic market can be supplied by NaOH imports to the extent of available export capacity in other countries. In the case of chlorine, only Canada and Mexico can supply chlorine imports the US. Currently, Canada and Mexico lack spare capacity to increase chlorine exports to the US.



- The 16-year technology transition in Europe is associated with an average NaOH FOB price increase of 7.2% per year or $21/dry MT per year.
- As illustrated in the chart, the timing of Europe's technology transition had a direct impact on the domestic sodium hydroxide FOB price. If the conversion in Europe were implemented over 10 years instead of 16 years, the potential average increase in NaOH FOB price is 12.6% per year or $44.6 /dry MT per year.
- Although this example only shows the impact to the domestic NaOH FOB price in Europe, the technology transition in Europe effected both domestic and global sodium hydroxide prices. In general, a longer transition period can reduce the rate at which prices increase both at the domestic and global level.
- Aside from transition timing, the market conditions at the start of a technology transition period can also influence prices. If the domestic or global supply/demand balance is tight at the start of transition, then prices have the potential to reach a higher threshold.

Equivalent Price Increase for Chlorine and Sodium Hydroxide Derivatives used in Water Treatment

Water Treatment Chemicals	Δ $1 Cl_2	Δ $1 NaOH
Hydrochloric Acid [HCl]	+$0.95	n/a
Ferric Chloride [$FeCl_3$]	+$0.49	n/a
Aluminum Chloride [$AlCl_3$]	+$0.80	n/a
Methyl Chloride [CH_3Cl]	+$0.70	n/a
Chloramines [NH_2Cl],[$NHCl_2$], [NCl_3H_2O]	+$0.02	n/a
Bromine [Br_2]	+$0.44	n/a
Chlorine Dioxide [ClO_2]	+$0.53	n/a
Sodium Hypochlorite [NaClO]	+$0.95	+$1.08
Calcium Hypochlorite [$Ca(ClO)_2$]	+$0.99	+$0.56

Market behaviors indicate water treatment chemical producers will pass through the incremental cost of feedstocks onto their customers.

- A US shortage of chlorine and sodium hydroxide can impact the cost of water treatment chemicals. HCl is a feedstock for some chlorine derivatives used in water treatment such as ferric chloride and aluminum chloride. For example, a $1 increase in chlorine price translates to a $0.95 increase in HCl price and a $0.49 increase in ferric chloride price.

Global Impact, including US

2021 US Chlorine, Sodium Hydroxide and Derivative Trade

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Chlor-Alkali Chemicals	2021 Imports	2021 Exports	Net	Global Trade	%US Export supply for Non-US Global Demand
Sodium Hydroxide	550	2946	2396	8694	4.2%
Sodium Chlorate	400	45	-355	732	1.6%
Alumina	1522	70	-1452	32051	0.1%
Chlorine	263	43	-220	482	0.1%
EDC	0	813	813	2296	2.1%
VCM	0	1182	1182	3527	2.8%
PVC	273	1978	1705	9624	4.6%
MDI	386	248	-138	2957	4.0%
TDI	73	86	13	1234	4.0%
Titanium Dioxide	236	497	261	3481	7.8%
Perchloroethylene	2	25	23	121	6.8%
Trichloroethylene	2	8	6	36	2.2%
Methylene Chloride	9	46	37	364	2.7%
Epichlorohydrin	35	36	1	326	2.2%
Chloroform	1	12	11	55	1.0%
Propylene Oxide	0	160	160	804	2.0%
Methyl Chloride	11	14	4	35	0.8%
Bromine	0	2	1	98	0.3%
Chlorobenzene	65	0	-65	170	0.0%
Carbon Tetrachloride	22	0	-22	23	0.0%

Thousand Metric Tons (-000-MT)

- US sodium hydroxide exports supply a significant proportion (roughly 4.2%) of sodium hydroxide demand in other world regions. For example, US sodium hydroxide exports supply approximately 83% of South American sodium hydroxide demand. Similarly, the US supplies 48% of sodium hydroxide demand in Mexico, 28% of demand in Canada, and 24% of demand in Australia. If all US AD cell sodium hydroxide were removed from the market in 2025 while domestic US sodium hydroxide demand remained constant, the US domestic market could be short approximately 240kMT of sodium hydroxide supply with no spare capacity to supply the export market.
- Elemental chlorine does not trade intercontinentally, and chlorine is primarily traded as chlorine equivalents (Cl2 EQ) in chlorine-containing derivatives. Only Canada and Mexico supply the US with elemental chlorine imports. Canada and Mexico currently lack spare capacity to increase chlorine exports to the US. Canada's chlor-alkali operating rates are near max, and Mexico is limited by railcars.

Example: Indirect Impact of a US Shortage

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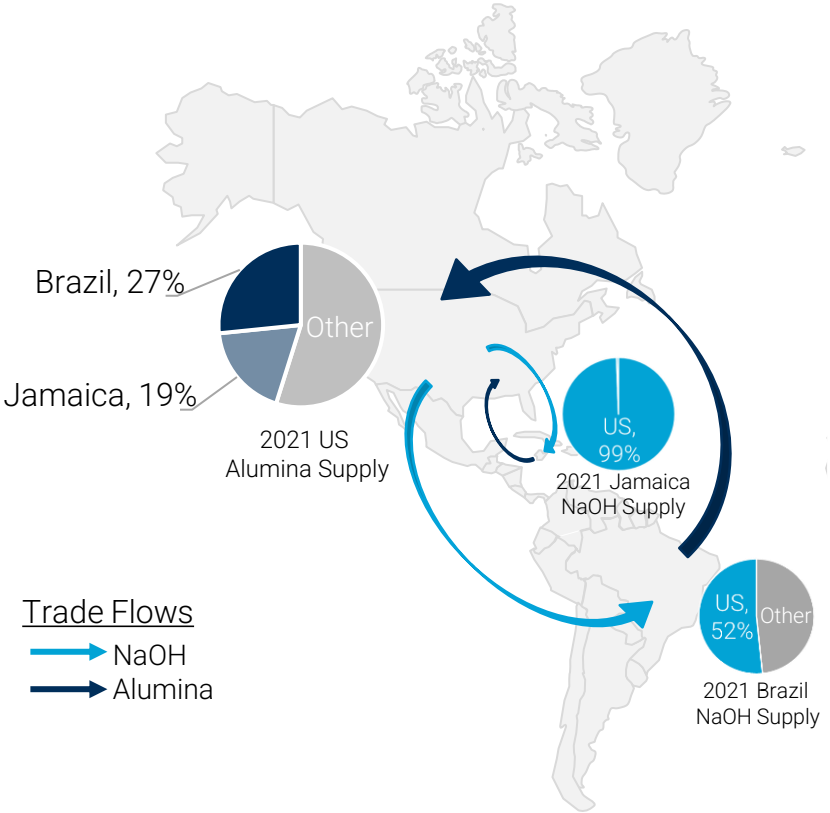

- Sodium hydroxide (NaOH), chorine, and derivative products are used as feedstocks for a wide range of applications with larger economies that cannot be defined with precision. Alumina is the raw material for all aluminum production. An aluminum supply chain disruption is one example of an indirect impact that could occur in the event of a US NaOH shortage. If the US NaOH market is short, a decline in US exports could result in higher costs for alumina and/or a global shortage of alumina which would in turn translate to higher prices and/or a global shortage of aluminum. As a major global consumer of aluminum, the US NaOH shortage could directly impact national security.
- The US imports roughly 70% of its alumina demand each year due to limited domestic smelting capacity. Jamaica and Brazil supply 19% and 27% of US demand for alumina, respectively. However, US NaOH exports supply 99% of Jamaica's demand for NaOH and 52% of Brazil's demand for NaOH. If the US NaOH market is short, alumina manufacturers in Brazil and Jamaica would have to import NaOH from other, high-cost regions with available export capacity. As a result, the cost of alumina imports to the US could increase.

- Chemical Market Analytics by OPIS analysis indicates that taking all asbestos-diaphragm cell capacity out of service for rapid conversion would reduce sodium hydroxide production in the US to significantly reduce or effectively eliminate US exports for an extended period while the US rebuilds capacity via non-AD technology.
- The US is the world's largest supplier of export sodium hydroxide. A significant reduction or temporary halt in sodium hydroxide exports from the US to prevent egregious domestic supply shortage could cause average operating rates in the balance of the world to rise by approximately 2.9%. In that situation, incremental global sodium hydroxide demand for net importing countries that depend on sodium hydroxide to produce important fundamental commodities such as aluminum, paper and carton products would have to source sodium hydroxide from higher cost regions.
- The fully fungible nature of sodium hydroxide causes prices to equilibrate globally. Therefore, price increases outside the US are expected to quickly translate back to the US domestic market. Based on our econometric models, and assuming 2025 economics, we project that sodium hydroxide prices in world markets could rise by at least 25% based on the relative cash costs of the next highest potential export region. Sodium hydroxide prices could more double if the highest cash cost region increased exports to compensate for the global sodium hydroxide supply deficit created by the US AD capacity closure. Additionally, we would expect global prices of chlorine derivatives produced from merchant chlorine, including (but not limited to) TiO2, MDI and TDI, to also increase. We would further expect higher prices for sodium hydroxide and chlorine derivatives to be passed through to end-product producers, and therefore to consumers.

Global Impact, Simulation

In order to quantify the global and domestic impact of a total US AD chlor-alkali capacity shutdown, we've simulated a total US AD shutdown within our global chlor-alkali supply/demand balances (World Analysis—Chlor-Alkali). The following pages include details on the simulation method and results.

Simulation Timeline

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April 2022

"EPA is proposing pursuant to TSCA section 6(a) to prohibit manufacture (including import), processing, distribution in commerce, and commercial use of chrysotile asbestos in bulk for or as part of chrysotile asbestos diaphragms used in the chlor-alkali industry… these prohibitions would take effect two years after the effective date of the final rule." <https://www.federalregister.gov/documents/2022/04/12/2022-07601/asbestos-part-1-chrysotile-asbestos-regulation-of-certain-conditions-of-use-under-section-6a-of-the>

November 2023

Final Rule

November 2025

Total shutdown of 4.67 MMT of US chlorine capacity

2025 US Shortage Simulation—Impact on US Trade

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Simulation: US Trade Impact for total US AD Shutdown in 2025						
	Before AD Shutdown		After AD Shutdown			Export Markets
Chlor-Alkali Products & Derivatives	2025 US Exports	2025 US Net Exports	2025 US Production Loss	2025 US Exports	2025 US Net Exports	Major Import Sources*
Chlorine	50	(160)	(4,451)	0	(312)	Canada, Mexico
Sodium Hydroxide	3,899	3,361	(4,896)	398	(140)	CHI, MDE, WEP
EDC	1,330	1,330	(1,814)	0	0	MDE, WEP, Thailand
VCM	1,424	1,424	(1,134)	290	290	N/A
PVC	3,500	3,230	(1,134)	2,366	2,096	CHI, MDE, WEP
POX	245	245	(698)	0	(8)	CHI, SAM, WEP
EPI	40	(5)	0	40	(5)	CHI, WEP
TDI	150	43	(17)	133	26	CHI, WEP, MDE
MDI	295	20	(85)	205	(70)	CHI, WEP
PCB	380	266	(36)	343	229	CHI, WEP
TiO_2	508	266	(125)	383	141	Russia, CHI, Japan
Bromine	2	1	(20)	-	(19)	MDE, Japan
Chlorinated Intermediates	94	48	(73)	48	(40)	CHI, WEP, India, Japan

Thousand Metric Tons (-000- MT)
*See next page for description of regional acronyms

2025 US Shortage Simulation—Impact on Global Markets

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Global Approach:	If all US AD production were removed from the market in 2 years (2025), only countries with both spare chlor-alkali capacity and spare chlorine-derivative capacity can ramp up to compensate for US sodium hydroxide export losses. Elemental chlorine does not trade intercontinentally due to logistical challenges and liability concerns. Instead, chlorine is primarily traded as chlorine equivalents (Cl2 EQ) in chlorine-containing derivatives.
Global Results:	If all US AD production were removed from the market in 2 years (2025), a global NaOH shortage of 846 kMT could occur due to insufficient spare capacity to produce chlorine into chlorine-derivatives. This analysis assumes global NaOH demand in 2025 remains constant with zero global demand destruction. In this scenario, the global average chlor-alkali operating rate would increase to a 38-year high of 86%.
North America (NAM)	Canada lacks spare chlor-alkali capacity. Mexico lacks spare derivative capacity but can theoretically increase elemental chlorine exports in 2025 by 150 kMT if loading capacity and railcars are available. If Mexico can increase chlorine exports by 150 kMT, the US market could still be short by 4.3 MMT chlorine in 2025.
South America (SAM)	Only Brazil and Argentina can increase chlorine production by a total of 80 kMT into POX, vinyls, and TDI.
West Europe (WEP)	WEP can increase chlorine production by 252 kMT into vinyls, POX, MDI, and chlorinated intermediates.
Central Europe (CEP)	Operating rates in CEP are near-max. Only Poland can increase chlorine production by 9 kMT into POX and TiO2.
CIS & Baltic States (CIS)	Russia can increase chlorine production by 2 kMT into chlorinated derivatives. Russia can also increase TiO2 production by 50 kMT via the sulfate route (uses NaOH not chlorine) to compensate for US TiO2 export losses.
Middle East (MDE)	MDE countries can increase chlorine production by 427 kMT into vinyls, inorganics, and MDI.
Africa (AFR)	Only Egypt has capacity to increase chlorine production in Africa by 176 kMT into vinyls.
Indian Subcontinent (ISC)	India can increase chlorine production by 133 kMT into vinyls, POX, and chlorinated intermediates.
Northeast Asia (NEA)	NEA, outside CHI, can increase chlorine production by 27 kMT into POX, chlorinated intermediates, & inorganics.
Southeast Asia (SEA)	SEA lacks spare chlor-alkali and chlorine derivative capacity but can increase non-chlorine production for POX.
Mainland China (CHI)	China can increase chlorine production by 1.6 MMT into vinyls via acetylene-carbide technology, POX, PCB, chlorinated intermediates, and TiO2. China accounts for 60% of the global chlor-alkali production increase.
United States (US)	Total US domestic chlorine production loss is 4.5 MMT and sodium hydroxide production loss is 4.9 MMT in 2025.

2025 US Shortage Simulation—Impact on Global Markets

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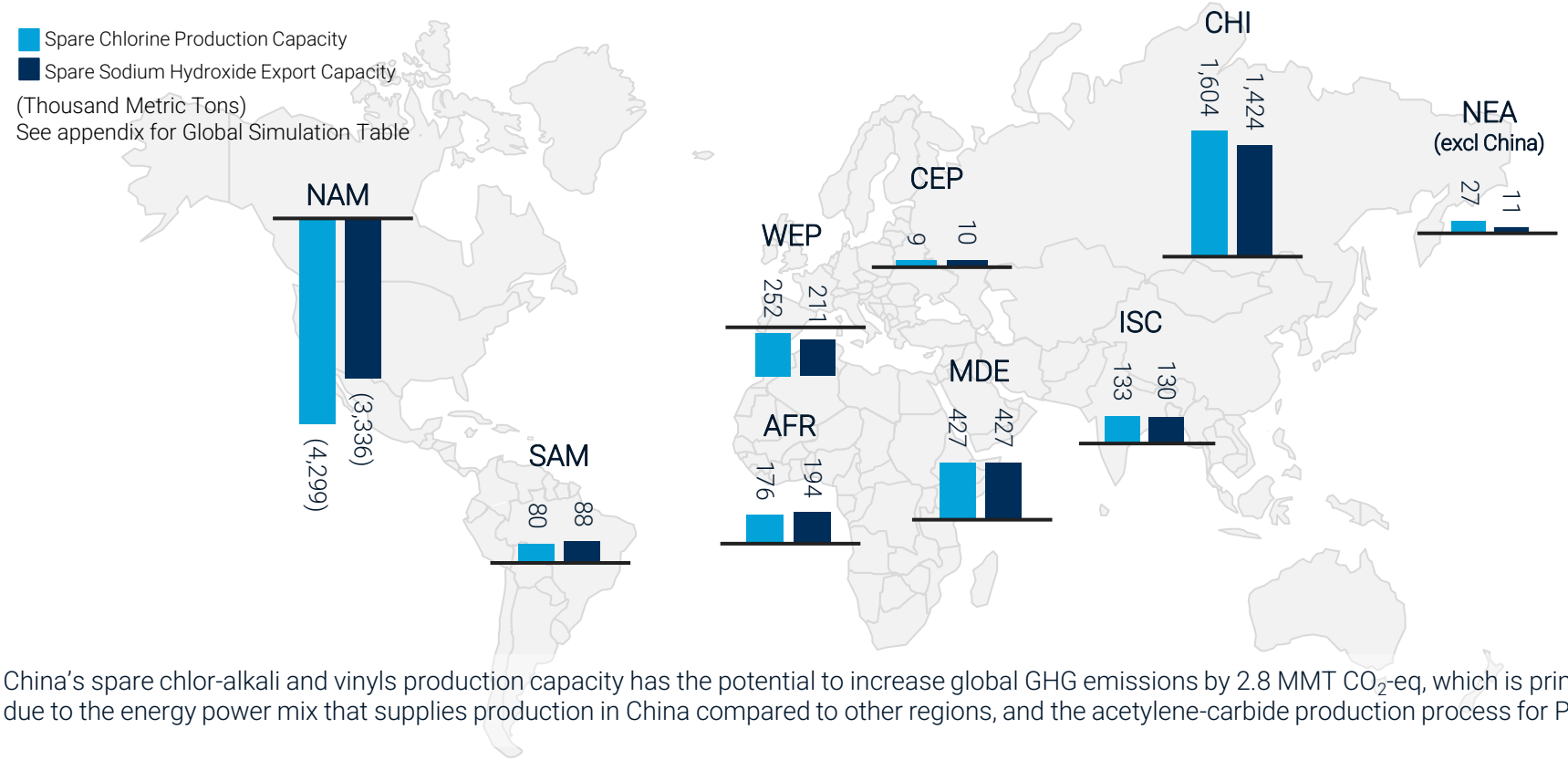

China's spare chlor-alkali and vinyls production capacity has the potential to increase global GHG emissions by 2.8 MMT CO_2-eq, which is primarily due to the energy power mix that supplies production in China compared to other regions, and the acetylene-carbide production process for PVC.

Appendix

2022 Chlorine Derivative Demand Sector Breakdown

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Propylene Oxide (POX) 2022 Demand Sectors	
Butanediol	2.4%
Polyether Polyols	59.3%
Propylene Glycol	21.7%
Others	16.7%

Polyvinyl Chloride (PVC) 2022 Demand Sectors	
Rigid Applications	
Pipe & Fittings	46.0%
Rigid Profiles	19.0%
Rigid Film & Sheet	8.0%
Bottles	0.1%
Flexible Applications	
Wire & Cable	3.0%
Flexible Film & Sheet	5.0%
Flexible Tubes & Profiles	2.2%
Floorings	2.0%
Coatings	2.0%
All Others	12.8%

Methyl Diphenyl Diisocyanate (MDI) 2022 Demand Sectors	
Rigid Polyurethane Foam	53.5%
Construction	40.9%
Appliances	7.1%
Transportation	1.1%
Others	4.4%
Flexible Foam	8.1%
Transportation	6.1%
Furniture	0.8%
Bedding	0.8%
Others	0.5%
CASE	14.3%
Coatings	3.6%
Adhesives	2.9%
Sealants	2.3%
Elastomers	5.6%
Binders	24.0%
Wood Composites	20.6%
Others	3.4%

Inorganic Chemicals 2022 Demand Sectors	
Titanium Dioxide	
Paints & Coatings	62.9%
Plastics	23.9%
Paper & Cardboard	6.5%
Others	6.7%
Bromine	
Brominated Flame Retardants	28.8%
Clear Brine Fluids	42.8%
Water Treatment	9.6%
Environmental	9.9%
Butyl Rubber	2.5%
Terephthalic Acid (TPA)	2.5%
Methyl Bromide	0.4%
Pharmaceutical	1.1%
Other	2.5%

Toluene Diisocyanate (TDI) 2022 Demand Sectors	
Flexible Foam	89.2%
Transportation	2.0%
Furniture	23.2%
Bedding	50.8%
Others	13.2%
CASE	10.8%
Coatings	3.6%
Adhesives	3.6%
Sealants	0.0%
Elastomers	3.6%

Polycarbonates (PCB) 2022 Demand Sectors	
Sheet/Film	30.1%
Automotive	21.8%
Optical Media	2.6%
Appliances/Housewares	6.3%
Electronics/Electrical	19.0%
Medical/Opthalmic	7.4%
Cons./Sports/Recreation	4.4%
Packaging	4.7%
Other	3.6%

Global Simulation Table

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Global Trade Impact for Total US AD Shutdown in 2025						
	Before AD Shutdown			After AD Shutdown		
World Regions	Average Chlor-Alkali Operating Rate (%)	Chlorine-Equivalent Net Exports* (kMT)	Sodium Hydroxide Net Exports (kMT)	Average Chlor-Alkali Operating Rate (%)	Chlorine-Equivalent Net Exports* (kMT)	Sodium Hydroxide Net Exports (kMT)
North America (NAM)	82	3,180	2,794	84	289	(542)
South America (SAM)	76	(1,254)	(1,726)	79	(1,169)	(1,638)
West Europe (WEP)	83	1,208	(299)	85	1,427	(88)
Central Europe (CEP)	87	(305)	118	88	(296)	128
CIS & Baltic States (CIS)	84	(254)	201	84	(245)	196
Middle East (MDE)	65	109	263	76	518	690
Africa (AFR)	62	(1,150)	(676)	80	(920)	(482)
Indian Subcontinent (ISC)	81	(3,136)	(71)	83	(3,004)	59
Northeast Asia (NEA) excl CHI	86	2,415	2,056	86	2,452	2,067
Southeast Asia (SEA)	85	(1,576)	(3,318)	85	(1,508)	(3,318)
Mainland China (CHI)	85	768	658	88	2,305	2,082
United States (US)	84	4,251	3,361	86	1,360	(140)

*Chlorine equivalent (Cl_2 EQ) net exports is chlorine trade in the form of chlorine derivatives, which are converted to an equivalent chlorine value

	Asbestos-Diaphragm	Non-Asbestos Diaphragm	Membrane
NaOH Strength, wt%	10-15	10-15	25-35
Range of Electrolyzer Energy use (AC kWh/MT Cl2)	2450-3100	2300-2900	2200-2800
Steam consumption (MT/MT Cl2) to reach a NaOH strength of 50wt%	2.75-5	2.75-5	0.5-1.7

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Impact of EPA's Proposed Asbestos-Diaphragm Chlor-Alkali Rulemaking

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