U.S.-Saudi Business Council
مجلس الأعمال السعودي الأمريكي

October 2022
www.ussaudi.org

Economic Brief

Saudi Petrochemical Sector 2022 Review

Overview

Saudi Arabia is among the world's leading producers of petrochemicals. Saudi Basic Industries Corporation (SABIC), now majority owned by Saudi Aramco, is the largest chemical company in Saudi Arabia and a global leader in the production of petrochemicals and plastics. Enabled by low feedstock costs and large-scale capacity expansion in recent decades, the petrochemical sector is the second pillar of the Saudi economy. Chemical exports, of which petrochemicals command the largest share, represent 35 percent of non-oil exports. However, potential for growth remains significant as a large share of Saudi domestic production consists of basic chemicals while more advanced specialty products are produced in other markets. Government investments in technology, production capacity, and gas exploration in line with Vision 2030 have supported broad growth in both feedstocks and downstream production.

As the sixth largest natural gas producer in the world, Saudi Arabia benefits from a high level of proven reserves, competitive extraction costs, and a well-developed basic chemical industry. Further gas exploration remains critical as population growth and rising global energy demand has driven concerns over supply shortages. In 2021, Saudi Aramco awarded more than SAR38 billion ($10 billion) in contracts for subsurface exploration of the vast Jafurah unconventional gas field. The reliable supply of natural gas for both domestic energy use and economic diversification remains a core priority of the Kingdom.

Domestic production of petrochemicals with extracted natural gas or naphtha represents an important economic diversification vehicle for Saudi Arabia. Petrochemicals are used in numerous manufacturing industries such as plastics, pharmaceuticals, automotive parts, agrinutrients, and textiles. Major international firms will remain integral to further developing advanced and specialty petrochemical products through joint ventures (JVs), which enable knowledge and technology transfer. A U.S.-Saudi joint venture valued at SAR75 billion ($20 billion) between Dow Chemical and Saudi Aramco, Sadara Chemical Company, represented the largest investment in the Saudi petrochemicals industry. Petrochemical projects remain well-financed in Saudi Arabia, representing the largest share of lending from the Saudi Industrial Development Fund (SIDF). The petrochemical sector benefits from favorable incentives and lower taxation compared to regional competitors. Business opportunities for industry leaders include research, technology, and JVs across the sector's value chain.

Albara'a Alwazir
Director, Economic Research
alalwazir@ussaudi.org

Jacob Dichter
Research Analyst
jdichter@ussaudi.org

Petrochemical Sector Background

Petrochemicals are an integral part of the modern global economy and can be found across a vast range of consumer and industrial products. The International Energy Agency (IEA) estimates that petrochemical feedstocks account for 12 percent of global oil demand. This share is expected to increase in the near term as demand for plastics, fertilizers, and other associated products continues to grow. Demand for plastics continues to outpace the demand growth for any other bulk material such as steel, cement, or aluminum. IEA forecasts the demand for petrochemicals will account for over a third of the growth in oil demand through 2030.

Produced from petroleum, petrochemicals can be classified as olefins or aromatics. Olefins include ethylene, propylene, and butadiene, which are raw materials for making plastics, resins, fibers, elastomers, and lubricants. Aromatics include benzene, toluene, and xylene which are raw materials for making dyes and synthetic detergents. Methanol is a primary petrochemical used for a variety of purposes including as a precursor to producing a range of commodity chemicals such as acetic acid, methyl benzoate, anisole, peroxyacids, and formaldehyde. These chemicals can also serve as base materials in acrylic plastics, synthetic fabrics, adhesives, paints, fertilizers, and pharmaceuticals.

Primary feedstocks for the production of petrochemicals include natural gas, liquified natural gas (LNGs), and petroleum liquid feedstocks (primarily naphtha). Naphtha is a product of crude oil refining. When processed, naphtha yields both olefins and aromatics (both basic chemicals). Globally, naphtha is a costlier feedstock than natural gas. Naphtha comprises only 11 percent of the Kingdom's petrochemical feedstock. Ethane accounts for 53 percent of Saudi Arabia's petrochemical feedstock. The most common natural gas inputs for the refinement process are ethane, propane, and butane. Propane accounts for 32 percent of Saudi Arabia's petrochemical feedstock.

Production Process

Basic Petrochemicals

Through refinement such as cracking, six basic petrochemicals are produced: ethylene, propylene, butadienes, benzene, toluene, and xylene. Ethylene and propylene are important sources of industrial chemicals and plastics products. Butadiene is used in making synthetic rubber. Aromatics like benzene is used for dyes and synthetic detergents, and benzene and toluene can produce inputs that are used in the production of polyurethane. Xylenes are typically used to produce plastics and synthetic fibers.

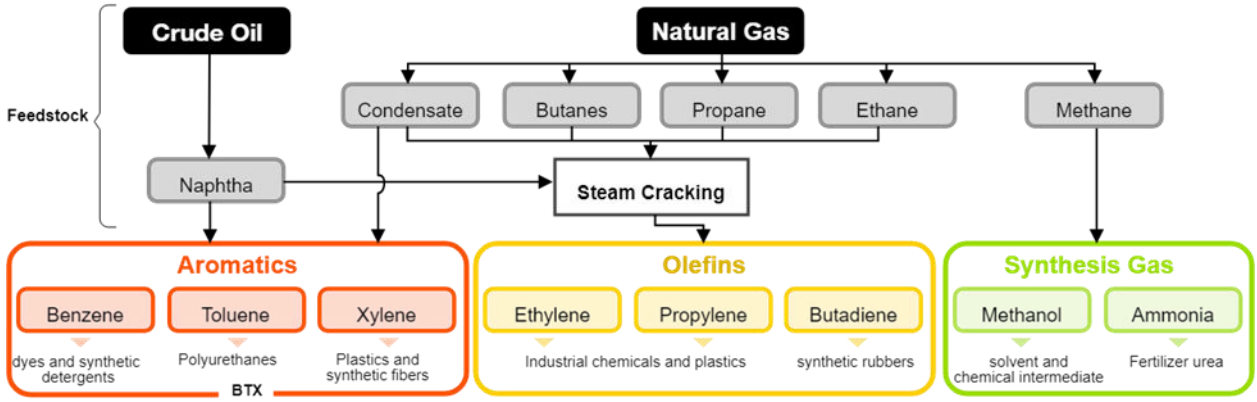
Synthesis gas and steam crackers are important components in the production of methanol and other chemicals. Steam crackers are different than steam reforming plants that are used to produce hydrogen for ammonia production. Ammonia is used to make the fertilizer urea and methanol is used as a solvent and chemical intermediate.

Intermediate & Advanced Petrochemicals

Intermediate products are produced by chemical conversion of basic petrochemicals to form more complicated derivative products that are either sold commercially to end users or further used as inputs to manufacture consumer and industrial products. Common petrochemical intermediates include vinyl acetate (for paint, paper, and textiles), vinyl chloride (for PVC), ethylene glycol (for polyester textiles), and

styrene (for rubbers and plastics). As Saudi Arabia diversifies its exports and further develops its petrochemical refining and plastics manufacturing capacity, the share of intermediate and advanced product exports is expected to increase.

Petrochemical Supply Chain



Source: SafeRack

Saudi Petrochemical Market

The chemical sector is a key pillar of Saudi Arabia's economy. According to the General Authority for Statistics (GAStat), chemical products represented 35 percent of the Kingdom's non-oil exports during the second quarter of 2022. If plastic and rubber products, which heavily depend on petrochemical inputs are included, the share of total exports rises to 65 percent.

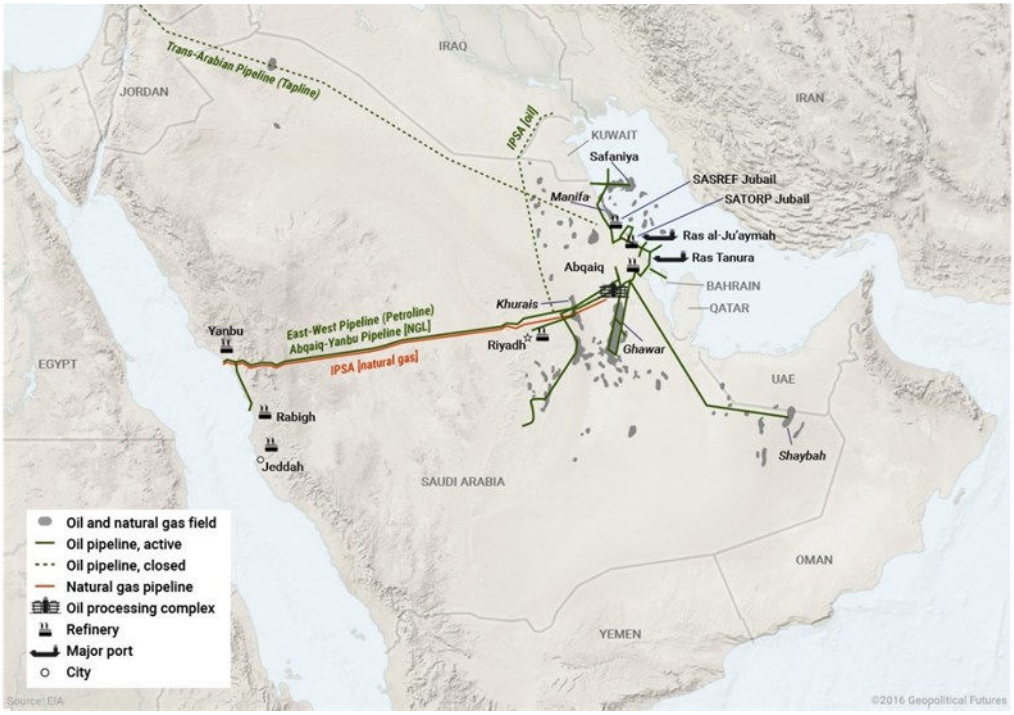
Feedstock

Saudi Arabia's chemical industry began in the 1970s with the construction of the master gas system (MGS) that enabled large quantities of previously unutilized natural gas to be transported for processing. Initial investments were concentrated in the methane industry for which feedstock was abundant and key products included methanol, ammonia, and urea. The expansion of natural gas pipeline infrastructure and the formation of SABIC in the following decade further developed the industry. Presently, the Kingdom's gas system has over 60 gas-oil separation plants in Khurais, Safaniya, Ghawar, and Zuluf.

Saudi Arabia has proven natural gas reserves of 333 trillion cubic feet (tcf) and ranks fourth in the world behind China, the U.S., and Russia, according to the Energy Information Administration (EIA). The bulk of Saudi gas production is extracted from associated gas. According to the EIA, Saudi Arabia's production of non-associated gas has grown from 13 percent in 2010 to 46 percent of total gas production in 2020. Despite the large quantities produced and Saudi Arabia's high rank in global gas production, the Kingdom does not meet domestic market needs with its existing production. The pricing of natural gas below global market values has supported the industry to the present but will not remain economically viable over the long-term as energy demand continues to grow and the share of non-associated gas accounts for the majority of production.

In 2020, Saudi Arabia announced SAR412.5 billion ($110 billion) in new investments to develop its unconventional gas reserves in Jafurah field, which are estimated to hold some 200 trillion cubic feet of wet gas. Production from Phase 1 of the Jafurah field development is expected to commence commercial production by 2026 with a projected 2.2 billion cubic feet of natural gas and 425 million cubic feet of ethane. Unconventional natural gas supplies the phosphate plant linked to Saudi Arabian Mining Co. (Ma'aden) industrial city Waad Al Shimal City for Mining Industries.

Saudi Arabia Major Oil & Gas Infrastructure



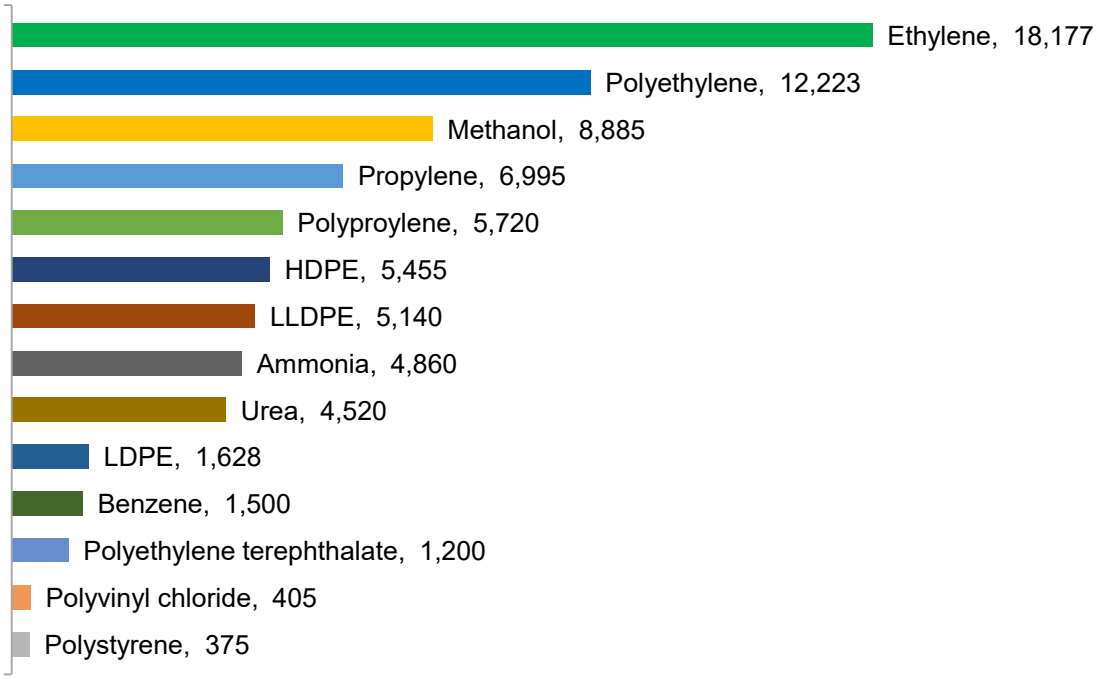
Source: EIA, Geopolitical Futures

The main source of current Saudi feedstock is ethane which, along with methane, is naturally found in associated gas. Other significant feedstocks include liquid petroleum gas (LPG) derivatives propane and butane. The heavy use of ethane and LPG as feedstocks mean Saudi chemical production is skewed towards olefin production - primarily ethylene, proplylene, and methanol. Olefins have traditionally accounted for a strong majority of Saudi chemical output compared to aromatics and methanol.

Production

Petrochemical production in Saudi Arabia is dominated by ethylene and polyethylene. Saudi ethylene production was estimated at 18.2 million tonnes per year while polyethylene production was estimated at 12.2 million tonnes per year, according to Fitch Solutions. In October 2022, SABIC began commercial operations at a new monoethylene glycol plant in Jubail, adding a further 700K metric tonnes of annual production. Propylene capacity in Saudi Arabia is estimated at 7 million tonnes, supporting the production of polymer derivatives such as polypropylene. Other major polymer production segments include polyvinyl chloride (405K tonnes) and polystyrene (375K tonnes).

Saudi Petrochemical Annual Capacity
(Thousand tonnes per year)



Source: Fitch Solutions, 2020

Major Players

SABIC is the national champion of Saudi Arabia's petrochemical industry and a global market leader in key products such as ethylene, ethylene glycol, methanol, methyl tert-butyl ether (MTBE), polyethylene and various plastics. The company posted annual revenues of SAR175 billion ($46.6 billion) in 2021 and currently employs more than 33,000 people in 50 countries. In 2019, Saudi Aramco acquired a 70 percent stake in the company for SAR259 billion ($69 billion), representing a major shift in the sector and a consolidation of Aramco's energy dominance in the Kingdom.

SABIC developed Saudi Arabia's chemical industry through joint ventures with foreign partners and served as a holding company for several plants producing petrochemical products that were then marketed by their international partners. Other major Saudi chemical firms include Sipchem (owned by Zamil Group), Petro Rabigh (formed as a Saudi-Japan JV), Saudi Industrial Investment Group (SIIG), SAFCO (now SABIC Agrinutrients), and Saudi Kayan. ExxonMobil, Chevron, Shell, Dow and other international investors have joint ventures with Saudi Aramco and SABIC in large-scale petrochemical plants. SABIC is the operating partner of ExxonMobil in two longstanding joint ventures, Kemya and Yanbu Petrochemical Company (Yanpet). Other notable major U.S. investors in the Saudi chemical industry include Air Products and Ecolab. Dow Chemical Company and Saudi Aramco's SAR75 billion ($20 billion) joint venture, Sadara, created the world's largest integrated petrochemical production complex. Combined with its majority acquisition of SABIC, Saudi Aramco is now the leading company in

both crude and chemicals industries in the Kingdom. Sadara Chemical Company represents the most significant U.S.-Saudi downstream investment in recent years. The facility began commercial operations in 2017 and posted its first profit in 2021 after the completion of key feedstock pipelines to neighboring PlasChem Park, an industrial base for Sadara customers. Sadara has three main types of petrochemicals – polyethylene, EO/PO derivatives, and polyurethanes.

International Activity

As a global leader in the chemical industry, SABIC has significant international partnerships including major U.S. investments (Motiva, others). SABIC has its Americas headquarters in Houston, TX along with other U.S. locations that include a major resin manufacturing plant in Selkirk, NY. SABIC acquired GE Plastics in 2007 for SAR43.5 billion ($11.6 billion) and subsequently moved the resin plant operations to Selkirk, NY in 2017. SABIC further built on its foothold in the U.S. market with a major SAR38 billion ($10 billion) joint venture with ExxonMobil to form Gulf Coast Growth Ventures (GCGV). The Texas-headquartered JV produces ethylene and the derivatives polyethylene and ethylene glycol. The company announced mechanical completion of its monoethylene unit and two polyethylene units in 2021, supporting 600 permanent U.S. jobs.

Regulatory

Presently, foreign firms are restricted from investing in the upstream hydrocarbon sector, but foreign investment is highly sought in the downstream energy sector which includes the refining process and production of petrochemicals. In September 2022, the government introduced a new draft law affecting the petrochemical sector (“Draft Law on Petroleum and Petrochemical Materials”). The new law will replace the current law on Trading Petroleum Products enacted in October 2017 and broadened the definition of “petrochemical operations” to engagement in producing, processing, selling, purchasing, distributing, transporting, storing, importing, or exporting petrochemical materials, or operating a petrochemical plant.

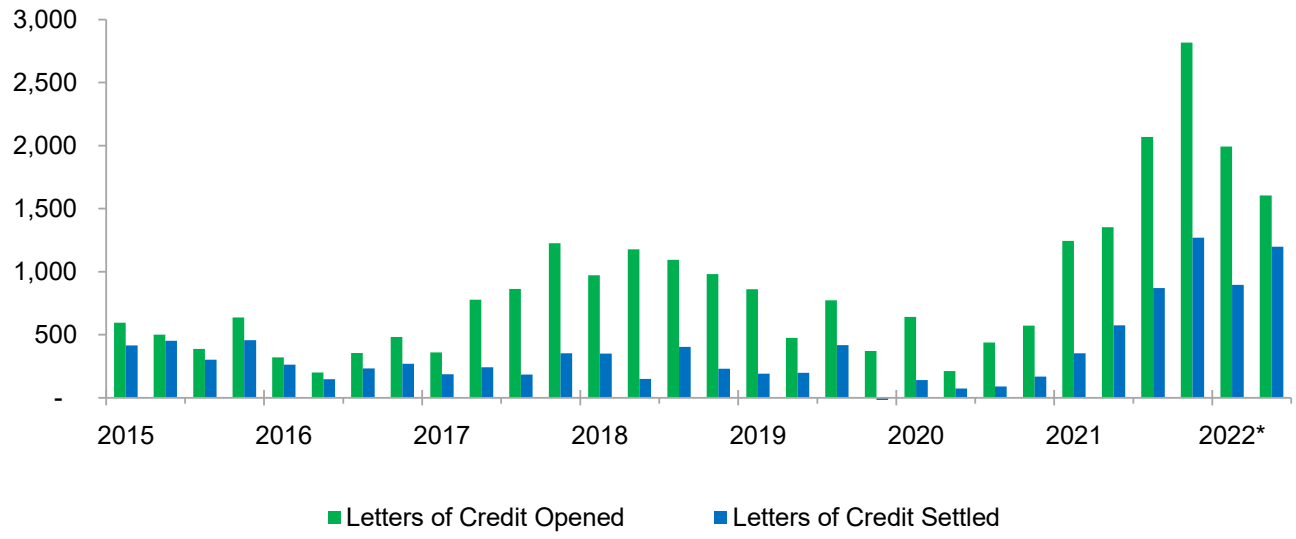
Financing

Petrochemical project financing in Saudi Arabia is supported by a range of products including the Saudi Industrial Development Fund (SIDF) which offers up to 75 percent project financing. SIDF was established to support medium and long-term lending facilities for private sector industrial projects in Saudi Arabia. The chemicals industry ranks as the top recipient of SIDF loans. Lending rates under the SIDF typically fall into three categories depending on location, project size, and commercial viability: 1) a 15-year loan up to 50 percent financing, 2) a 20-year loan up to 60 percent financing, and 3) a 20-year loan up to 75 percent financing. SIDF offers Land & Loan facilities in partnership with the Saudi Authority for Industrial Cities and Technology Zones (MODON) with incentives that include lease discounts up to 15 percent and reduced or delayed fee scheduling. Land & Loan facilities are aimed at promoting investment in Saudi Arabia’s industrial areas and economic cities such as KAEC or Yanbu Industrial City. International companies engaged in joint ventures with local firms are permitted to apply and obtain SIDF facilities, providing a strong incentive for MNCs to find a local Saudi partner before investing.

Petrochemical projects also benefit from special export facilities from the Saudi EXIM bank. Saudi EXIM lending activity is expected to grow as Saudi non-oil export activity expands. The EXIM Bank approved credit facilities of SAR9.4 billion ($2.5 billion) in the first nine months of 2022 across a range of industrial products including petrochemicals, plastics, and fertilizers. Local companies have used a combination of SIDF facilities, Islamic banking facilities (Murabaha) with local and regional banks, EXIM bank facilities, foreign export credit agencies, and conventional commercial facilities

The chemical industry accounted for SAR15.2 billion ($4.1 billion) in approved SIDF loans in 2020, constituting 86 percent of the total value of financing. Recent major financing deals with SIDF include Petro Rabigh's SAR3.6 billion ($960 million) facility for its ongoing Phase II expansion and Advanced Petrochemical's SAR3 billion ($800 million) facility for the construction of propane and polypropylene plants. In 2021 and 2022, commercial bank lending has grown sizably and has accounted for at least 25 percent of commercial lending for six consecutive quarters. These levels are closer to the percentages seen during the 2000s period of rapid expansion for the Saudi chemicals industry. The well-established national industry, competitive feedstock prices, and the range of available investment opportunities has made the sector highly attractive for investors.

Commercial Bank Financing of Chemicals & Plastics Exports
(USD Million)



Source: SAMA
* Through Q2 2022

Sector Strategies

Vision 2030 aims to boost manufacturing contribution to national GDP and the government has consequently implemented policies guiding the development of relevant domestic value chains. The development of Saudi Arabia's petrochemical sector is guided by major strategic initiatives including the National Development & Logistics Program (NIDLP), the Industrial Clusters Program, and Saudi Aramco's In-Kingdom Total Value Add (IKTVA) Program. The focus of both the government and private sector is

currently downstream petrochemicals to diversify the economy, create domestic jobs, and attract knowledge and technology transfer for industry leaders.

The formation of industry-themed clusters (known as Industrial Clusters) is a key strategy for achieving economic diversification, facilitating the horizontal and vertical expansions of firms in a competitive and efficient manner. This includes clustering chemical production with gas extraction and processing, refining, and identifying linkages between existing minerals, plastics, and other downstream industry supply chains. Saudi Arabia aims to export a greater amount of both natural gas and petrochemicals as its industrial base expands. The recently launched Global Supply Chain Resilience (GSCRI) aims to attract SAR40 billion ($10.6 billion) to establish integrated industrial economic zones and comprehensive transport and logistical services, building on the principles of NIDLP.

The petrochemical sector is well-established compared to other emerging industries such as mining or basic metals manufacturing and is therefore less directly emphasized in Vision 2030 and related strategic programs. However, its dominance in the Kingdom's export portfolio positions the sector as a pillar of non-oil economic diversification. Two of the primary objectives of the Kingdom's Vision 2030 is to boost non-oil exports and establish Saudi Arabia as a global logistics hub. Both objectives will be heavily supported by the Kingdom's petrochemical industry. Further, many of the targeted industries such as biomedical, agrinutrients, plastics, and automotive are reliant on various petrochemical feedstocks.

With the emergence of Saudi Aramco as the dominant natural gas and chemicals entity in addition to its oil preeminence, the IKTVA localization program will achieve even greater importance for partnering firms. IKTVA is a framework for Aramco suppliers and a key vehicle for securing local content and domestic jobs alongside the commercial expansion of its key business sectors. Demand for specialty chemicals tends to exhibit lower price volatility than crude oil or natural gas alone and will therefore also buffer the economy against oil and gas price volatility. Other relevant programs include the National Transformation Plan 2025 and the Made in Saudi initiative.

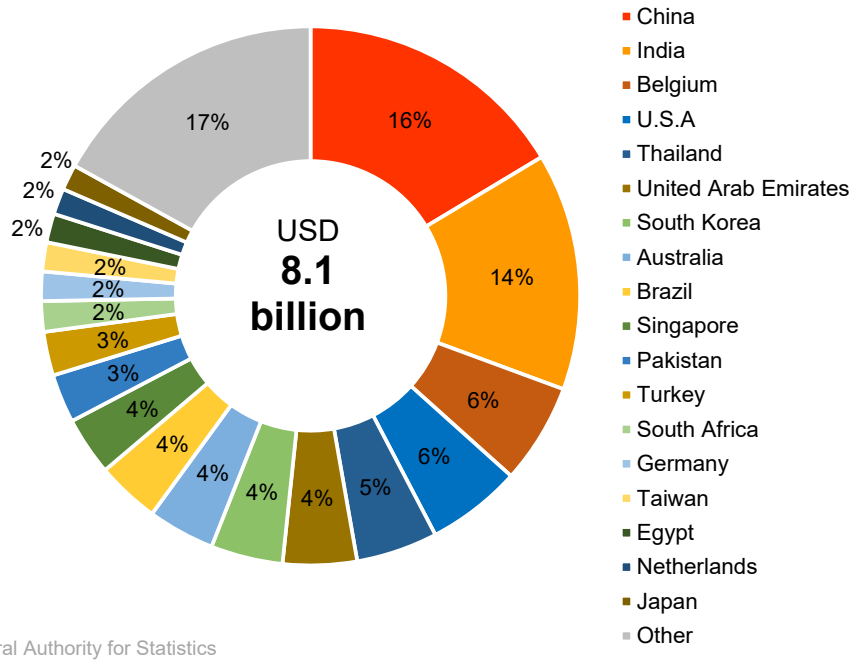
Saudi Petrochemical Exports

Global demand for petrochemicals is driven by growth in both China's manufacturing base and the consumer sector. In Q2 2022, China represented 16 percent of Saudi Arabia's chemical exports. The U.S. was the fourth largest destination for Saudi chemical products, representing SAR1.8 billion ($486 million) in Q2. China is currently the world's largest consumer of ethylene and represents a growing export market for Saudi Arabia along with several other Asian economies. Saudi Arabia supplies China with 12 percent of its petrochemical imports and is the fifth largest petrochemical export partner.

U.S.-Saudi Trade

The overall value of basic chemicals exported from Saudi Arabia to the U.S. has trended lower in recent years but the value of intermediate and advanced products such as agrichemicals, resins, and rubbers has grown. Notably, 2021 saw a large spike in U.S. chemical imports from the Kingdom. Minnesota was a top U.S. importer of phosphate fertilizers and polypropylene from Saudi Arabia and was a leading driver of higher chemical imports from the Kingdom last year. Minnesota was the sixth biggest U.S. importing state

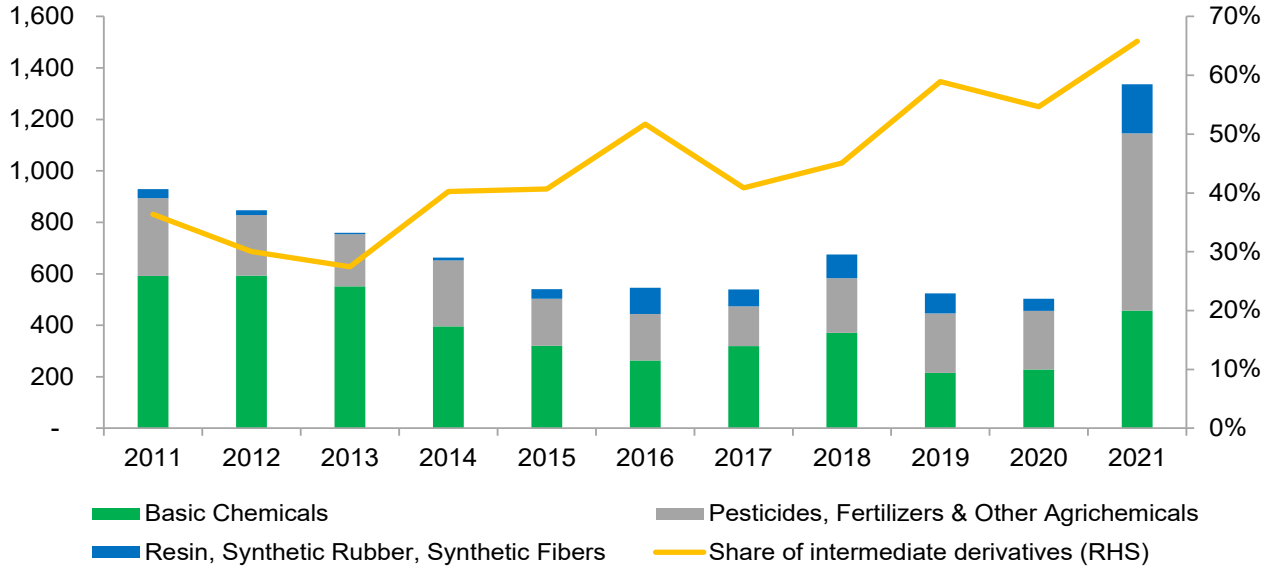
Saudi Chemical Exports by Destination
(Q2 2022)



Source: General Authority for Statistics

from Saudi Arabia in 2021, totaling SAR359 million ($96 million) in goods. Fertilizers accounted for SAR349 million ($93 million) of the state's imports. More broadly, basic chemicals represented roughly a third of U.S. imports of Saudi petrochemicals in 2021 compared to approximately 64 percent in 2011. The share of intermediate derivatives such as resins, fibers, and fertilizers exported to the U.S. grew from 36 percent in 2011 to 66 percent in 2021 as domestic manufacturing in Saudi Arabia expanded.

Saudi Chemical Exports to the U.S.
(USD Million)



Source: U.S. Department of Commerce

Major Projects

Saudi Arabia has an estimated SAR18.8 billion ($5 billion) in chemical projects currently in execution, according to MEED Projects. Projects expected to be completed in 2022 include Ma'aden's Ammonia III plant in Ras Al Khair, which will add 3,300 tons of daily ammonia production. The Kingdom also has SAR35 billion ($9.3 billion) in chemical products currently under study which include ethylene, propylene, polyisobutylene, polyethylene terephthalate (PET) plants among others. According to MEED Projects, the largest petrochemical project currently under construction in the Kingdom is Pan-Asia Saudi's SAR4.5 billion ($1.2 billion) contract to build an integrated polyethylene terephthalate (PET) and purified terephthalic acid (PTA) production complex. Other petrochemical projects currently under construction include U.S.-Saudi joint venture Air Products Qudra's construction of a fully integrated, SAR900 million ($240 million) industrial gases hub in Jubail City and Advanced Petrochemical Company's (APC) SAR1.9 billion ($500 million) contract with Maire Tecnimont to build a large-scale polypropylene plant.

Major Petrochemical Projects Under Execution

Project	Capacity	Units	Completion
Petrokemya - Nexlene Project in Jubail	1	LDPE (ton per day)	2027
SATORP – Amiral Complex: Mixed Feed Cracker : Mixed Feed Cracker: Package 1	4,110	Ethylene (ton per day)	2026
SATORP – Amiral Complex: Mixed Feed Cracker : Mixed Feed Cracker: Package 1	1,370	Propylene (ton per day)	2026
NGHC - Ammonia Storage Tanks at NEOM	2	Tank (unit)	2026
NGHC – NEOM City: Helios Green Fuels Project: Ammonia and Hydrogen Plants	192	Hydrogen (ton per day)	2026
MCC - Technical-Grade Ammonium Nitrate (TAN) plant	822	Ammonia (ton per day)	2025
Pan-Asia Saudi - Petrochemical and Chemical Fiber Integrated Project	7	Purified Terephthalic Acid (ton per day)	2024
Pan-Asia Saudi - Petrochemical & Chemical Fiber Integrated Project: Phase-1	3,425	Purified Terephthalic Acid (ton per day)	2023
Saudi Bio Acids Company - Citric Acid Plant at Jeddah	88,000	Development area (square meter)	2022
Maaden - Ammonia III in Ras Al Khair	3,300	Ammonia (ton per day)	2022

Source: MEED Projects

In Focus:

Key Insights from Moosa Al Moosa, President of Dow Saudi Arabia

Dow has a longstanding commercial presence in Saudi Arabia that includes several major joint ventures and billions of dollars in investments. How has Dow's business relationship with Saudi Arabia evolved, particularly over the past decade?

Dow has longstanding ties to the region, and to Saudi Arabia in particular. We have been present in Saudi Arabia since 1976, entering the market through distribution partnerships. Today, Dow is one of the largest foreign investors in the country's petrochemical sector.

The Sadara Chemical Company, which was established in 2011 as a joint venture between Saudi Aramco and Dow, is the world's largest integrated chemical facility and the largest ever built in a single phase. It reached full commercial operation in 2017. This partnership, and the tremendous impact it has in the community through job creation and engagement, and overall support to domestic manufacturing, are a testament to Dow's unwavering commitment to the Kingdom.

In 2016, Dow became the first international company to receive a trading license from the government of Saudi Arabia, allowing 100 percent ownership in the country's trading sector. This next phase of partnership expands Dow's local engagement through delivering high-value, innovative products in the areas of sustainable development, energy-efficiency, oil and gas, alternative energy and water, and all in support of Vision 2030. Dow works as a strategic partner to customers across the Kingdom, supporting not only with chemical inputs but technical expertise to innovate.

In 2018, Dow became a founding member of the KAUST Industrial Collaboration Program, which helps commercialize research into practical applications. The Dow Middle East Innovation Center "MEIC'' is located at KAUST and develops innovative, science-based solutions for modern-day challenges in the energy, energy efficiency, and infrastructure industries. Most importantly, the Center creates an opportunity for Saudi students to develop hands-on critical expertise to build meaningful careers. Dow supports the University's vision to drive economic development by investing in R&D with strategic relevance to the Saudi market. Within the MEIC is the Digital Marketplace Center "DMC,'' which innovates digital solutions to support regional growth while enhancing customer experience. Through these various partnerships, joint ventures, and investments, it is clear that Dow supports the Kingdom's diversification objectives while also ensuring the development of local capabilities and talent. From 2017 to 2022, Dow Saudi Arabia has received certification from the Top Employers Institute—the global authority on recognizing excellence in people practices—as one of the 'best places to work.'

The Sadara Chemical Company joint venture between Saudi Aramco and Dow represents the largest ever joint venture in the Kingdom's petrochemical sector. How has Sadara and related projects such as the PlasChem Park in Jubail impacted the competitiveness of Saudi Arabia's petrochemical sector?

Saudi Arabia has been focused on increasing its share in the global petrochemicals market for decades. The industry is of vital importance to the country's economy. In terms of value, chemical products were amongst the most important non-oil export in the first quarter of 2022, comprising 34.2 percent of total non-

oil merchandise exports. From a global standpoint, Saudi Arabia is an important player in both ethylene and ethylene derivatives, accounting for approximately 9 percent of the world's ethylene production capacity. The Sadara Chemical Company is one such example of how the Kingdom is prioritizing steady organic growth through new domestic projects and expansions. As the world's largest integrated chemicals complex built in a single phase, it produces more than 3 million mt/year of high value plastics and chemical products.

The investment has brought new technologies to the Kingdom and generated high quality jobs through building technical expertise to a new generation of the workforce. Prior to the completion of Sadara, Dow had trained over a thousand Saudi nationals at different sites and facilities worldwide. Sadara is also a critical component of developing local raw materials and chemical inputs that are part of value-creation for downstream manufacturing – turning intermediate products into lightweight auto parts, recyclable food packaging and energy efficient building & coating materials.

How does Dow see its role in expanding localization over the next decade, in line with objectives such as the Industrial Cluster program or Saudi Aramco's in-Kingdom Total Value Add (IKTVA) initiative?

Earlier in July this year, Dow and the Al-Hejailan Group signed a Memorandum of Understanding (MoU) to form a joint venture to design, build and operate a methyl diethanolamine (MDEA) plant in the PlasChem Park in Jubail, Kingdom of Saudi Arabia. The joint venture will enable Dow and Al-Hejailan to meet growing demand for natural gas purification in Saudi Arabia and in the broader Middle East region. In addition to the joint venture, Dow will also build a Dow-owned downstream manufacturing facility which will source raw materials from the new JV. This new facility will expand capacity of the Company's MDEA-based high performance UCARSOL™ products and will also blend Dow's ACCUTRACE™ fuel markers for the region. This investment will position Dow to further enable local solutions for the energy transition, including delivery of industry leading gas treating, carbon capture, and fuel additive technology to the region. The facility is expected to come online in late 2024.

How has domestic chemical R&D within Saudi Arabia progressed in recent years? What role does Dow play in R&D and knowledge transfer in the Saudi petrochemical industry?

Earlier this year, Saudi Arabia's H.R.H. Crown Prince Mohammed bin Salman Al Saud launched a new program for the research, development and innovation (RDI) sector which aims to add $16 billion to the country's GDP by 2040. Given that chemical products are amongst the most important non-oil exports, we can expect that boosting R&D in this sector will be a major focus for the Kingdom going forward.

In launching the Dow Middle East Innovation Center at King Abdullah University of Science and Technology (KAUST) in 2018, Dow has demonstrated its commitment to promoting localized research and providing advanced digital solutions within the Kingdom. The Center, which was LEED certified earlier this year, houses our Digital Marketplace Center and our R&D facilities. The Center utilizes technologies to develop and test scientific applications for customers allowing them to virtually pilot solutions from sustainable coating to oil and gas technology solutions for energy efficiency. By leveraging technology, Dow is supporting Saudi customers to develop and commercialize key applications rapidly for the growing consumer market. Beyond providing research and innovation, the Center also serves as a hub for direct knowledge exchange and talent development between KAUST and Dow. Through mutual collaboration including internships and research experience for KAUST students, postdocs and researchers, to opportunities for further academic pursuits and training of Dow's employees, the Center will be key in continuing to shape and drive Saudi Arabia's intellectual ecosystem.

In addition to the innovation center, Dow has engaged in several partnerships with notable local entities to launch numerous initiatives and innovative solutions in the past three years. These solutions allow for industrial diversification and R&D acceleration in the following strategic fields:

- Renewable energy
- Recyclable initiative for plastics (Paving roads with recyclable plastic)
- Water desalination
- Coatings and constructions polymers
- Insulations and Energy efficiency

What market factors will have the biggest impact on the Kingdom's downstream sector over the next five years?

Market factors poised to support developments over the coming decades are growth in the area of renewables, sustainability, decarbonization and infrastructure. Saudi Arabia has committed to have 50 percent of its power come from renewable sources by 2030 and to reach net zero 2060. As such, we can expect petrochemical players in Saudi Arabia and around the world to increasingly prioritize sustainability measures in the years to come. While there are various roads to increased sustainability, they can each bring about substantial value-creating opportunities, including premium pricing for sustainable materials and access to high-growth, high-margin markets.

U.S.-Saudi Business

U.S. companies have played an integral role in the development of Saudi Arabia's industrial chemical sector. Several established U.S. entities have created major JVs with Saudi entities in recent years. U.S. energy firm Baker Hughes signed an agreement with Saudi Industrial Investments Company (Dussur) in October 2022 to form an oilfield and industrial chemicals joint venture in the Kingdom. The joint venture will be majority-owned by Baker Hughes and include existing assets such as its chemical blend plant in Dammam and manufacturing facility in Jubail's PlasChem Park. Halliburton announced a major oilfield specialty chemical manufacturing facility in March 2022 at the PlasChem Park as part of a more than SAR3.8 billion ($1 billion) commitment to Saudi Arabia through 2030. Sadara's 26-unit manufacturing facility is one of the world's largest integrated chemical facilities and the largest ever built in a single phase. Sadara operates four polyethylene plants and supply pipelines carrying ethylene oxide & propylene oxide (EO/PO) to Jubail's PlasChem Park. Dow Chemical also has joint ventures with Juffali & Brothers and owns a joint venture stake in Saudi Acrylic Monomer Company.

Sector Challenges

Ethane scarcity

The historically lower cost of ethane compared to crude oil has created a cost advantage to the Kingdom. This advantage was heightened during the runup of global oil prices between 2010 and 2014 when crude prices hit record levels. However, population growth and economic development has led to greater quantities of ethane diverted to power plants for use as consumer and industrial electricity generation. Consequently, the availability of gas supply for petrochemical manufacturers has been reduced.

The ethane supply crunch also presents a major challenge to the Kingdom's ability to leverage cheap gas and diversify the economy. Producers have turned to the higher priced propane and naphtha feedstocks to replace ethane. Supply increases will need to be concurrent with the growth in gas demand or a greater percentage of Saudi energy production will have to be diverted to meet local needs. Additionally, the rising use of non-associated gas, which is more expensive will alter the commercial viability of current structural incentives.

Skilled Labor Demand

Saudi Arabia's chemical industry was developed through collaboration with leading international players in the chemical industry, allowing the transfer of knowledge and technology necessary for petrochemical production. As the Kingdom builds its intermediate and specialty chemical capacity, the need for highly skilled labor will increase. Specialty chemicals have unique and complex formulations and the ability to produce them depends heavily on technological capacity and research and innovation. Foreign firms may benefit from recently relaxed Saudization requirements to attract foreign direct investments, in addition to local content requirements.

Sector Opportunities

Saudi Arabia's petrochemical sector stands to benefit strongly from growing global demand for plastics, and a range of products dependent on chemical derivates. Several high-growth sectors such as minerals, metals, automotive, packaging, home appliances, and solar panels require polymers that depend on ethylene and propylene inputs. The Kingdom has organized a range of industrial clusters to centralize production and supply chains that will further incentivize domestic investment.

The multi-billion-dollar PlasChem Park and the associated Sadara production facilities highlight the advantages of Saudi Arabia's integrated development model. The cluster benefits from proximal access to raw material from gas extraction and refining sites as well as planned, completed infrastructure specialized for commercial chemical production. The PlasChem Park highlights a range of investment opportunities for international firms in consumer goods (films, furniture, mattresses, paints), home use (detergents, emulsifiers, cleaning fluids, surfactants), construction (adhesives, sealants, plasticizers, insulation), medical (sheaths, tubes, catheters), and automotive (brake fluids, adhesives, tires, linings). The U.S.-Saudi JV Sadara Chemical is still adding additional production capacity and announced in May 2022 the full operation of its EO/PO pipeline transportation system to the adjacent PlasChem Park.

Saudi Aramco's positioning as a petrochemical leader is supported by major investments in liquid-to-chemicals projects, carbon capture technology, and gas exploration. Development of more non-associated natural gas, including unconventional resources, and further expansion of natural gas reserves with new reservoirs near existing fields will help meet growing domestic demand. The government has also recently announced the discovery of five major conventional and unconventional gas fields located in the Kingdom's central region, the Empty Quarter, the Northern Borders region, and the Eastern Province. The newly discovered fields are estimated to support production of an additional 104 million cubic feet of natural gas per day. The Kingdom's sizable proven natural gas reserves can support a globally competitive chemicals industry for the foreseeable future. IEA projects an additional 56 billion cubic

meters of natural gas will be consumed by 2030 at which point Saudi Arabia aims to be a natural gas exporter. Business opportunities include research, technology, and joint ventures across the petrochemical value chain.

Appendix: Investment Opportunities in The Saudi Petrochemicals Sector

Opportunity	Stated Investment Size (USD)	Plant Capacity (KMT)
Ultra-high-molecular-weight polyethylene fiber	$477 million	20-30
Ultra-high-molecular-weight polyethylene	$58 million	20-30
Polytetrafluoroethylene-(Ptfe)	$862 million	38
2-Propylheptanol	$267 million	100
Polyvinylidenefluoride Pvdf	$212 million	5
Hydrogen Fluoride	$176 million	40-45
Precipitated Silica	$147 million	20-25
Formic Acid	$107 million	40-45
Maleic Anhydride	$100 million	30
Phosphorous Trichloride	$85 million	30
Polyvinyl Acetate	$85 million	45
Polycarboxylate Ethers-(Pce)	$75 million	40-50
Propionic Acid	$68 million	30
Trioctyltrimellitate (Totm)	$63 million	50
Dioctylterephthalate (Dotp)	$63 million	50
N Propanol	$50 million	20
Poly-Alpha-Olefins-(Pao)	$30 million	32
Polyaluminum Chloride (Pac)	$27 million	30
Methyl Styrene	$13 million	20-30
Carbon Fiber	$5 million	3
Refrigerant Grade Isobutane (R-600a)	$3 million	5

Source: InvestSaudi, Ministry of Investment