

Israel's Chemicals Industry: From the Desert to the Dead Sea

RAPHAEL SEMIAT
TECHNION—ISRAEL INSTITUTE
OF TECHNOLOGY
EMILY FRANGENBERG
CEP

Since Israel's independence in 1948, its chemicals industry has flourished thanks to the Dead Sea and the minerals it provides. A highly educated and skilled workforce makes this small nation a global power player in the pharmaceutical and electronics industries.

Israel is better known for its technology ventures and start-ups than for its chemicals industry. Although it has relatively few natural resources compared to nearby oil-producing countries, it is a major producer of minerals and fertilizers, bromine, refined oils and petrochemicals, pharmaceuticals, and cosmetics (1). Because the country is not rich in natural resources, it has invested heavily in technology and medicine.

The Dead Sea plays a major role in Israel's chemicals industry, because it is rich in potassium, magnesium chlorides, and bromide. Phosphate deposits extracted from the Negev, a desert region in southern Israel, are also a staple of Israel's chemicals industry.

Despite becoming independent in 1948, Israel has grown to be a world power. As of 2014, it has the 37th-largest economy in the world, with a nominal gross domestic product (GDP) of US\$303.8 billion (2). The country has a highly educated workforce, and its chemicals industry employs over 50,000 people. With a total population of over 8 million, the country has the highest standard of living of all countries in the Middle East (3).

Israel is located on the southwestern shore of the Mediterranean Sea (Figure 1). It shares its borders with Lebanon to the north, Syria to the northeast, Jordan to the east, Egypt to the south, and the Palestinian territories of the West Bank and Gaza Strip to the east and west, respectively. Israel's financial hub is Tel Aviv, and its capital is Jerusalem.

History

Before Israel became a nation in 1948, the land was known as Palestine, an old Roman name given about 2,000 years ago, and was under British control since the end of World War I, part of the land obtained from the defunct Ottoman Empire. The League of Nations gave the British a mandate that declared Palestine would become "a national home for the Jewish people." The tensions this caused with indigenous Arabs became a major source of controversy and sparked Israel's wars of independence and survival.

Early 20th century. Israel's process industries began with the first efforts to extract minerals from the Dead Sea (4). In 1930, the Palestine Potash Co. began potassium recovery at a plant on the north shore of the Dead Sea in Kalia. Potash, the salt form of potassium, helps regulate a plant's physiological functions and improves plant resilience, providing crops with protection from drought, disease, parasites, and cold weather (5). Potash is one of the main ingredients in fertilizer.

The company known today as Teva was founded in Jerusalem in 1901 as a small business that imported and distributed medications (6). A local pharmaceuticals industry was established in the 1920s and grew in the 1930s. During World War II, this industry delivered medical supplies to the British Army stationed in the Middle East.

In March 1923, Pinchas Rutenberg established the Palestine Electric Co. (7). Until that year, there had been no electric power industry in Israel; therefore, the company was a turning point for the state. The electric company built its first three power plants, in Tel Aviv, Tiberias, and Haifa, in

Note: Monetary values were converted to U.S. dollars based on the 2014-year-end rate of one new Israeli shekel = ~\$0.26.

► **Figure 1.** Israel lies on the southwestern shore of the Mediterranean Sea. The Dead Sea, to the east, provides a wealth of natural resources, including potassium, magnesium chlorides, and bromide.

1923–1925; the small diesel-powered plants produced a combined total power of about 4 MW. In 1932, the company established a hydroelectric power plant, which could produce up to 18 MW in the Jordan Valley, enabling technological expansion in Israel. By 1938, with the introduction of steam powerhouses in Haifa and Tel-Aviv, the electric company was producing 75 MW and serving over 100,000 customers.

Construction of Israel's first refinery complex began in 1938 and was completed in 1944 by British-controlled Consolidated Refineries Ltd. (CRL) (8). The refinery was located at the end of the Mosul-Haifa oil pipeline, which ran from Kirkuk, Iraq. (This pipeline ceased operation in 1948.) The refinery supplied British and American forces operating in the Middle East during World War II.

The beginning of the State (1948–1960). After Israel became independent, the government initially owned most of the nation's chemicals industry. Prior to the 1970s, the private sector owned only a small part of the chemicals industry. The move toward privatization ultimately increased the industry's capacity, but led to a reduction in research and development (R&D) spending.

Although extraction of minerals, potash, and bromine from the Dead Sea began in the early 1900s, the manufacture of potash fertilizers in Haifa did not begin until around 1946 (1).

In 1952, the new government created the Dead Sea Works, a state-owned company to mine raw materials and process their derivatives (1). In the early 1950s, several other state-owned companies were created to extract minerals from the Negev Desert and transform them into chemical products. Many of these companies were later combined to become Israel Chemicals Ltd. (ICL).

The Palestine Electric Co. suffered major setbacks during Israel's War of Independence. That spurred the government to acquire the majority of shares of the electric company, which brought the company under government ownership. In 1954, the company became the Israel Elec-

tric Co. (IEC), as it is known today. Over the next decades, additional power plants were constructed in Haifa, Tel-Aviv, and Ashdod (7), and an electricity network was established to power settlements throughout Israel.

In 1958, the British government sold Consolidated Refineries Ltd. to the State of Israel due to concerns over the



Table 1. The ten largest industrial chemical companies in Israel and their rankings among all of Israel's companies, based on sales in 2014.

Rank	Company	Sales, US\$ millions	Exports/Overseas Sales, US\$ millions	Sector
1	Teva Pharmaceutical Industries	18,336.95	17,732.15	Pharmaceuticals
2	Oil Refineries Ltd. (ORL)	9,022.58	4,392.88	Refining and Petrochemicals
3	The Israel Electric Corp.	6,914.00	–	Electricity Production and Infrastructure
4	Israel Chemicals Ltd. (ICL)	5,661.18	5,373.63	Chemicals and Minerals
8	ADAMA Agricultural Solutions	2,776.95	2,678.43	Agricultural Inputs, Herbicides, Insecticides, and Crop Protection
*	Carmel Olefins	965.95	570.65	Plastics, Rubber, and Glass
21	Keter Plastic	875.00	–	Plastics, Rubber, and Glass
*	Gadiv Petrochemical Industries	741.05	682.15	Refining and Petrochemicals
25	Taro	685.40	–	Pharmaceuticals and Cosmetics
27	Haifa Chemicals	625.00	600.0	Chemicals and Minerals

* Carmel Olefins and Gadiv Petrochemical Industries are not ranked because they are part of ORL, which ranked second.

Arab League Boycott. The company was renamed Oil Refineries Ltd. (ORL), as it is still known today. These refineries became the basis of the petrochemicals industry in Israel. This company held a monopoly over oil refining in the country until 2006, when the Paz Group acquired the refinery in Ashdod.

Israel's economy was largely based on agriculture at that time. Agan Chemical Manufacturers and Makhteshim Chemical Works both played large roles in the production of herbicides, insecticides, and fungicides.

1960 to the 1990s. In the 1960s, large-scale chemical production for export purposes began. Israel Chemicals Ltd. (ICL) was established in 1968. In 1975, ICL expanded through the consolidation of the Dead Sea Works.

After the 1970s energy crisis, the IEC began construction of two large power plants that were based on coal as a feedstock, rather than petroleum. The combined production capacity of these two plants in Hadera and Ashkelon was 4,880 MW (7).

Early 1990s to the present. In the early 1990s, the government began to privatize ICL by listing its shares on the Tel Aviv Stock Exchange (TASE) (4). In 1995, the State of Israel sold its main interest in ICL to Israel Corp., effectively privatizing the company (although the government still holds a controlling vote).

In 2004, the IEC began fueling many of its power plants with natural gas. Today, about 56% of its total power is produced using natural gas as the feedstock (7). At the end of 2013, the IEC had 63 production units that could produce up to 13,483 MW (7).

In 1997, the agricultural chemicals companies Agan Chemical Manufacturers and Makhteshim Chemical Works

merged to form Makhteshim Agan Industries. The new company was acquired by ChemChina in 2011, and its global business was later rebranded as ADAMA Agricultural Solutions.

Israel's chemicals industry today

Israel's chemicals industry can be divided into several sectors, including pharmaceuticals and cosmetics, chemicals and fertilizers, and refining and petrochemicals. Table 1 lists the country's ten largest industrial chemical companies and their rankings among all of Israel's companies, based on sales in 2014 (9).

Israel's high-tech sector is a major employer of chemical engineers and chemists. Intel Israel, a producer of semi-conductors and chips, had 2014 sales of approximately \$4 billion (9).

Extremely dry conditions and the resulting high evaporation rate near the Dead Sea have created salt and other mineral deposits in Israel. These products have spawned thriving magnesium and potash industries. Exports of Dead Sea mud and salts as cosmetic products are increasing (1). Approximately 200 quarries are currently in operation, producing 50–60 million m.t. of raw materials a year (1). Today, the Dead Sea Works (part of ICL) extracts potash, salts, and other minerals from the Dead Sea using shallow evaporation ponds (Figure 2).

ICL's bromine production plant in Sodom, near the Dead Sea, has a production capacity of 250,000 m.t./yr (1). This valuable feedstock is used to make compounds for plastics, electronics, and textiles manufacturing, and for water treatment. ICL also has a facility near Beer Sheba that uses bromine to make organic products.

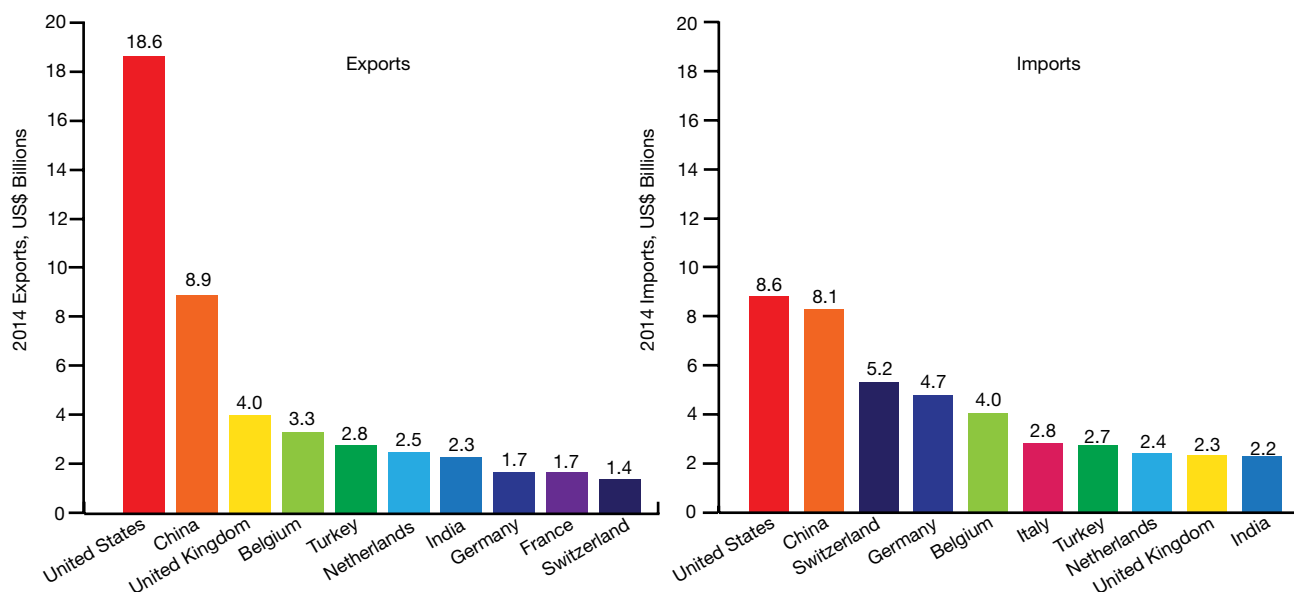
Exports and imports

Figure 3 summarizes Israel's main trading partners (10). In both the exports and imports categories, the U.S. is Israel's largest trading partner.

Figure 4 breaks down chemical-related industrial exports in 2012 by major industry segments, according to the United Nations Statistical Div.'s COMTRADE database (11). Israel's top export is pharmaceuticals, which includes medicines, antibiotics, penicillins, streptomycins, insulin,



▲ **Figure 2.** Evaporation ponds at the south end of the Dead Sea enable extraction of potash and salt via solar energy. The eastern evaporation ponds belong to the Jordanian Dead Sea Works. Source: NASA Earth Observatory.



▲ **Figure 3.** Among Israel's main trading partners in 2014, the U.S. and China ranked highest in both exports and imports. In the figure, the data for China include trade with Hong Kong, and the data for Belgium include trade with Luxembourg. Source: (10).

hormones, and alkaloids. It is also a big exporter of high-tech manufactured products, such as computers, telephones, and medical equipment. In 2012 alone, Israel exported over \$2 billion worth of refined petroleum products.

Figure 5 shows Israel's chemical-related industrial imports. The country imports massive amounts of crude and refined petroleum, as it has very little of this natural resource compared to its neighboring countries (11). Crude petroleum accounted for more than \$8.7 billion in imports in 2012. Cars, coal, and raw diamonds round out the rest of the top five imports (although Figure 5 excludes diamonds, as they are not an industrial product).

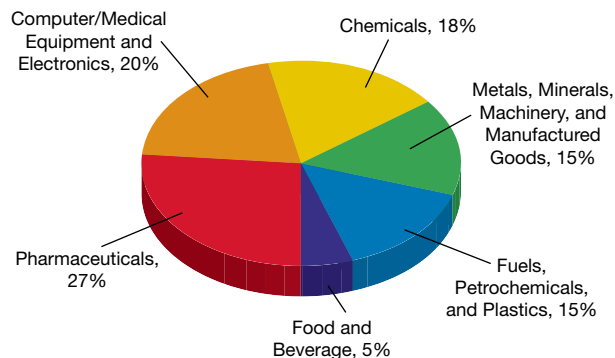
Natural gas sector

Like many countries around the world, Israel is encouraging a transition to natural gas as the primary energy source. Natural gas offers many advantages, such as lower electricity costs and greenhouse gas emissions.

The use of natural gas in Israel began in 2004, mainly by the IEC. Over the next few years, low-pressure natural gas infrastructure will be developed, which will make the gas a readily available and accessible source of energy for small industrial plants and other businesses. Vast gas reserves were recently found off the coast of Israel in the Mediterranean Sea; these are helping to encourage energy initiatives based on natural gas.

In 2008, a submerged pipeline from El Arish, Egypt, to a reception facility off the coast of Ashkelon, Israel, was constructed. Egypt and Israel agreed to a 20-year deal under which Egypt would send 1.7 billion cubic meters (BCM) of natural gas per year to Israel. In 2009, this number was

Global Outlook



▲ **Figure 4.** Israel's chemical-related exports in 2012, grouped by major industry segment. Pharmaceuticals and high-tech equipment are Israel's biggest exports. Source: Based on (11).

increased by an additional 2 BCM of natural gas a year. By 2010, the pipeline supplied approximately half of the natural gas consumed in Israel. That year, Israel consumed 5.3 BCM of natural gas, 90% of which went to electricity generation, and natural gas accounted for 40% of Israel's electricity generation.

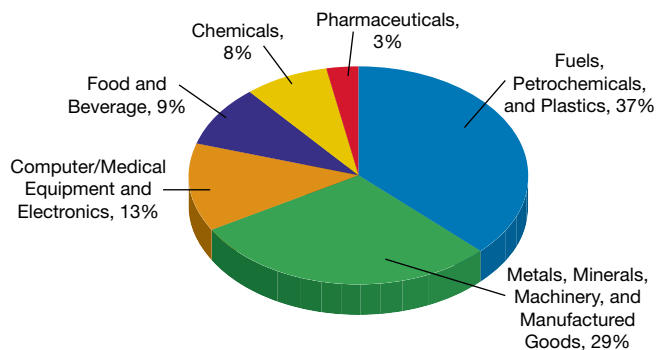
The pipeline agreement fell into disarray in 2012, with the Egyptian revolution and removal of Egypt's head of state. Since then, Egypt has been experiencing gas shortages, which raised the possibility of using the Arish-Ashkelon pipeline in the opposite direction — sending gas from Israel to Egypt. In March 2015, the firm operating the Tamar gas field reached an agreement to convert the pipeline to reverse flow and supply a private Egyptian company with 5 BCM of gas over three years.

Israeli companies have been developing the natural gas fields off the coast. Some of these fields include the Noa, Mari, Tamar, and Dalit reserves, and the large Leviathan field (Figure 1). Natural gas is extracted from gas wells and sent by pipeline to a coastal reception station offshore. There, the raw gas is processed to render it suitable for use. The gas then flows under high pressure through pipes that form the national transmission system.

Desalination industry

In 1999, the Israeli government initiated a long-term seawater reverse osmosis (SWRO) desalination program. Israel Desalination Enterprises, or IDE Technologies, built SWRO plants in Ashkelon in 2005, Hadera in 2009, and Sorek in 2013. Built for the Israeli government, each plant produces clean water from the sea at low cost. Today, the country has a total of five large-scale SWRO plants, including the Palmachim plant (GES) and the Ashdod (Mekorot) plant (which is currently undergoing commissioning).

The Sorek plant, located about 10 miles south of Tel Aviv, is the largest and most advanced SWRO plant in the world. It has the capacity to product 627,000 m³ of water



▲ **Figure 5.** Israel's chemical-related imports in 2012. The country's top import is crude petroleum, as it has very little of this natural resource. Source: Based on (11).

daily, making desalinated seawater a mainstay of the country's water supply. The Sorek plant is the first desalination plant to use pressure vessels that are 16 in. in diameter rather than 8 in. This reduces costs by requiring less piping and other hardware; costs are also minimized through the use of highly efficient pumps.

It is estimated that half of the country's water will be supplied by desalination by 2016 (12).

Higher education

Israel has six major universities with six departments of chemistry and two departments of chemical and biochemical engineering. Six chemical engineering departments exist in academic colleges. The majority of professional leaders in the process industry are graduates of the Technion-Israel Institute of Technology, which is the oldest and largest technical university in Israel. The major universities conduct R&D for industry, although some of the companies have their own R&D facilities.

Major chemical companies

Pharmaceuticals. Established in 1901, Teva Pharmaceuticals Industry is the largest company in Israel (6). The global business is divided into two segments: generic medicines and specialty medicines. Teva is the leading generic drug company in both the U.S. and the European Union. Many of its main products are related to the central nervous system, pain reduction, respiratory system, and oncology.

Fuels and petrochemicals. There are two refinery complexes in Israel — one in Haifa and one in Ashdod.

Oil Refineries Ltd. (ORL), also known as Bazan Group, operates Israel's largest oil refining and petrochemical complex. This complex is located in Haifa Bay and has a production capacity of approximately 197,000 bbl/day (13, 14). ORL and its subsidiaries produce oil products, polymers as raw materials for plastics, aromatics for chemicals and petrochemicals, and basic oils and waxes. ORL owns sev-

eral other companies that are located in the same complex in Haifa Bay, including Carmel Olefins, Gadiv Petrochemical Industries, and Haifa Basic Oils. This integration allows ORL to optimize its refining output across product and petrochemical business lines, while creating cost efficiencies through joint management and facilities. This company also supplies power and steam services to industrial customers in Haifa Bay. It is a large exporter of refined petroleum products to Eastern Mediterranean countries.

The Paz Group acquired the Ashdod oil refinery in 2006. The Paz Group is the first energy company in Israel to own a refinery. The Ashdod refinery has a capacity of 4.5 million tons of crude oil a year.

Energy. The Israel Electric Corp. (IEC) is a government-owned company that generates, transforms, distributes, and sells electricity. It employs approximately 13,000 workers and provides service to 2.58 million homes. Over the past decade, IEC invested more than \$10 billion in developing the Israeli electricity sector.

Mining and chemicals. Israel Chemicals Ltd. (ICL) produces approximately one-third of the world's bromine, and is the sixth-largest producer of potash, as well as the leading provider of pure phosphoric acid. The company is a major manufacturer of specialty fertilizers and phosphates, flame retardants, and water treatment solutions. ICL also manufactures bromine-based flame retardants, which are used to prevent fires in computers, cellphones, and other electronics. The company mines potash and phosphates that are used as ingredients in fertilizers and serve as a component in the pharmaceutical and food additive industries.

ICL is a public company whose shares are traded on the Tel Aviv Stock Exchange. The company employs about 12,000 workers worldwide (5).

Dead Sea Magnesium (DSM) is the metallurgical arm of ICL. It produces pure magnesium and magnesium alloys from the Dead Sea in one of the world's largest solar evaporation operations. DSM's products are used primarily by the aluminum, titanium, steel, and automotive industries in the U.S. and Western Europe.

Agriculture. ADAMA Agricultural Solutions is a leading global manufacturer of crop-protection solutions, such as herbicides, insecticides, and seed treatments. These products improve the quality and quantity of crop yields by providing protection from weeds, pests, and diseases. ADAMA has facilities located in Neot Hovav and Ashdod. It also has manufacturing facilities in several other countries.

The Haifa Group is a global supplier of potassium nitrate for agriculture and industry, specialty plant nutrients, and food phosphates. Haifa has two production plants in Israel, at Haifa and the Negev Center, with a combined production capacity of 454,000 m.t. of potassium nitrate annually. The company develops and produces specialty fertilizers and

potassium nitrate products. Haifa-K Solar is a technical-grade potassium nitrate used to store thermal energy in concentrated solar power (CSP) stations.

The rubber and polymers industry. The plastics and rubber sector is one of Israel's fastest growing industry segments and employs more than 20,000 workers. Companies in this sector manufacture raw materials, such as polyethylene, polypropylene, polystyrene, and polyvinyl chloride (PVC), as well as specialty compounds and consumer products (15). Products for agricultural applications — such as drip irrigation systems, sprinklers, and accessories, produced by Netafim, NaanDan, Plastro, and MetzerPlast — account for more than 20% of industry sales. Other large companies in this industry group include Keter Group, Golan Plastics, and Caesarstone. Exports by this industry amounted to about \$2.5 billion in 2014.

In closing

The future of the process industry in Israel depends on development of the new gas resources in the Mediterranean Sea, as well as exploration of shale oil deposits. A significant advancement for Israel may come through ammonia and methanol production, which may spur important developments in the organic chemicals industry.

With few oil reserves, and shaky relationships with its oil-rich neighbors, it is prudent that Israel find stable sources of energy. Advances in solar energy technology and CSP efficiency could be major advantages for the country. Israel's solar industry is centered on the Negev Desert. The desert has become the home to some of the largest solar dishes in the world, as educational and research facilities strive to take advantage of the region's sunshine. However, more research is needed before solar energy will be cost-competitive with fossil fuels. By 2020, Israel hopes to produce 10% of its energy from renewable sources (16).

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RAPHAEL SEMIAT is a professor in the Chemical Engineering Dept., Technion-Israel Institute of Technology, Haifa, Israel. He holds the Yitzhak Rabin Memorial Chair in Science, Engineering, and Management. He served as the director of the Grand Water Research Institute and is in charge of its Rabin Desalination Laboratory. He obtained his BSc degree in chemical engineering from the Technion in 1973 and his DSc on multiple-effect desalination (MED) from the Technion in 1978. He has expertise in separation processes with industrial experience in IMI, a subsidiary of Israel Chemicals Ltd., where he served as a senior research engineer and as the head of the Heat and Mass Transfer Engineering Research Dept. Semiat joined the Technion in 1990. His main research interests are process development and separation processes, with an emphasis on desalination. He has published more than 170 papers and chapters in scientific journals and books.

EMILY FRANGENBERG is an associate editor at *Chemical Engineering Progress* magazine (Email: emifra@aiiche.org, Phone: (646) 495-1347). She edits the Back to Basics articles, which cover topics ranging from distillation and heat exchange to process control and safety. She also writes the bimonthly Profile column. She received a BS in chemical engineering from Villanova Univ.

Article continues on next page

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