National Petrochemical Company (NPC)

Ethylene

Introduction, application, value chain, review of Iran's production status and global market analysis

1. Introduction

Ethene (C2H4), commonly known as **ethylene** and recognized as the simplest alkene, is a hydrocarbon primarily derived as a petrochemical monomer. It serves as a key feedstock in the production of plastics, fibers, and various organic chemicals. This colorless gas is flammable and emits a faint, sweet-musky aroma in its pure form. When cooled below -50°C, it transitions into a pressurized cryogenic liquid, with vapors lighter than air. Although non-toxic, it acts as a simple asphyxiant. Prolonged exposure to fire or extreme heat can cause containers to rupture violently. The compound exhibits a melting point of -169.2°C and a boiling point of -103.7°C, with a density of 1.178 kg/m³ at 15°C. Beyond its industrial uses, ethylene plays a vital role in fruit ripening processes. It aids in the transformation of fruit coloration and promotes the development of sweetness by converting stored starches and acids into sugars.

2. Production methods

The main routes of ethylene production are:

2.1 Hydrocarbon Steam Cracking

- Steam cracking accounts for 95% of global ethylene production.
- Core stages: Pyrolysis, compression, and cryogenic separation.
- Feedstock impact: Lighter feeds (e.g., ethane) yield fewer byproducts than heavier feeds (e.g., naphtha).
- Technological advancements: Enhanced efficiency via advanced process control and reduced residence time.
- Future goals: Achieving higher feedstock flexibility, improved energy efficiency, and net-zero emissions.

2.2 Ethylene from Coal and Methanol

• **Main Processes:**

- **Coal-to-Ethylene (CTO):** Uses Fischer-Tropsch reactions on coal-derived syngas. Ethylene is recovered from byproduct gases or through steam cracking coal-derived naphtha. Example: Sasol (South Africa) employs this method.
- **Methanol-to-Olefins (MTO):** Syngas → Methanol → Olefins (ethylene/propylene) via catalytic conversion. Widely adopted in China to utilize domestic coal reserves.

2.3 Ethanol Dehydration

• **Main Process:** Catalytic ethanol dehydration is employed for ethylene production. Economically viable mainly in countries with abundant fermentable feedstocks (e.g., sugarcane, sugar beets) that enable low-cost ethanol production.

• **Technical and Economic Challenges:**

- Lower yield: Produces only 60% ethylene (compared to 95% from ethane steam cracking).
- Water byproduct: Generates significant amounts of water as a process challenge.

• **Market Advantages and Opportunities:**

- Current attractiveness: Rising oil and gas prices enhance the cost-effectiveness of plant-based ethylene.
- Value-added products: Bio-ethylene is utilized in green polyethylene (e.g., Braskem) and ethylene dichloride (e.g., Solvay), commanding premium market prices.

2.4 Refinery Gases

• Ethylene is produced as a byproduct of Fluid Catalytic Cracking (FCC) operations.

• **Typical Yield:** 0.6–1.2 weight percent, depending on feed and operating conditions.

• **Economic Considerations:** Recovery is only viable at large refineries (capacity of +100,000 barrels/day). Smaller refineries generally lack sufficient quantities for commercial recovery.

• **Limitations:**

- Limited by FCC off-gas availability.
- Not all refinery configurations are suitable for economic ethylene recovery.

2.5 Ethylene from Natural Gas

• **Main Process:** Oxidative Coupling of Methane (OCM): A method to produce ethylene directly from methane (natural gas).

• **Key Advantages:**

- Utilizes low-cost methane feedstock (natural gas).
- Offers potential for a simpler process compared to steam cracking.
- Still in pilot/demonstration phase.

3. Ethylene Derivatives and Industrial Applications

• Global ethylene demand in 2023 was primarily driven by polyethylene production, which accounted for a 63% share, particularly in HDPE, LDPE, and LLDPE varieties.

• The second-largest application was ethylene oxide (14%), primarily utilized in the production of ethylene glycol for PET manufacturing.

• Other significant uses included EDC for PVC production, as well as applications in ethylbenzene and vinyl acetate.

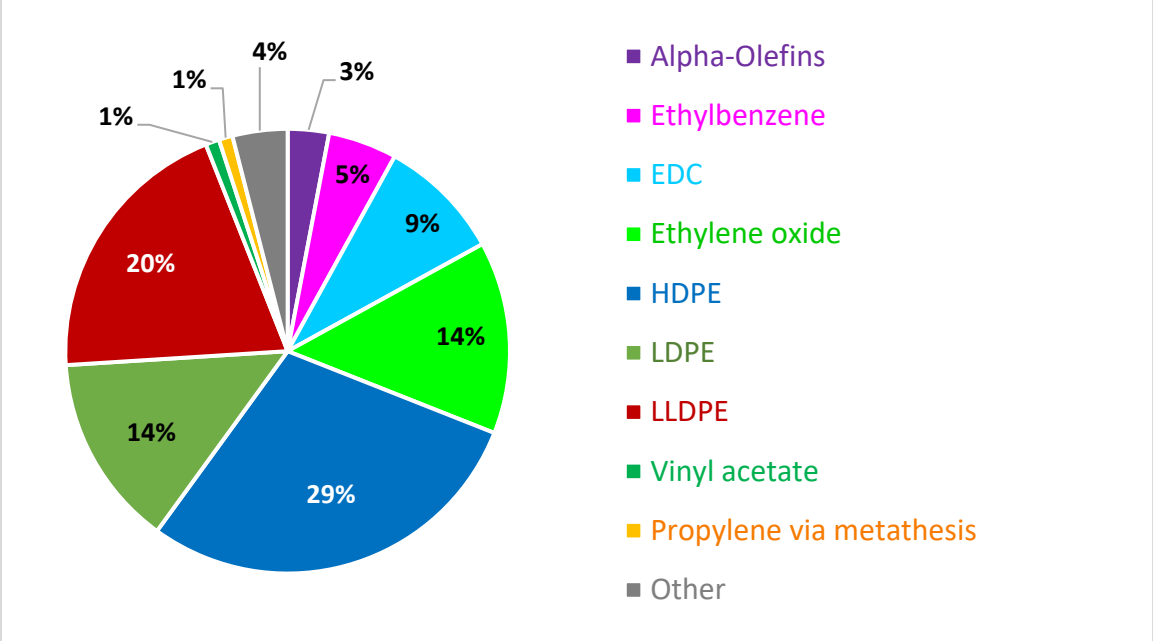

Figure 1- World Consumption of ethylene by end use (2023)

4. Global Market Analysis and Industry Economics

Global ethylene capacity reached 223.1 million metric tons in 2023, with North America (23%), China (22%), and the Middle East (16%) as the leading regions. From 2018 to 2023, capacity grew at an annual rate of 4.9% (a total increase of 46.6 million tons), with North America (+12M tons) and China (+25M tons) contributing 79% of this expansion. Other Asian regions contributed smaller shares (8% and 5% respectively), while Europe experienced capacity reductions due to aging infrastructure and competitive challenges.

China's ethylene demand has continued to grow, despite recent economic slowdowns, driven by domestic chemical needs. The Middle East has capitalized on its abundant, low-cost ethane feedstock to establish highly competitive ethylene production, primarily for export-oriented polymer manufacturing. This ethane advantage has positioned the region as the global cost leader in ethylene production.

The ethylene sector faced challenges in 2023, with operating rates declining to 79% due to capacity expansions and softer market conditions. However, demand growth is projected to rebound from 2024, supported by a strengthening global economy. Looking ahead, operating rates are expected to hit their lowest point post-2029, as China continues to add new capacity. Although capacity growth is slowing, a gradual market tightening is anticipated, pushing utilization rates to 85% by 2032.

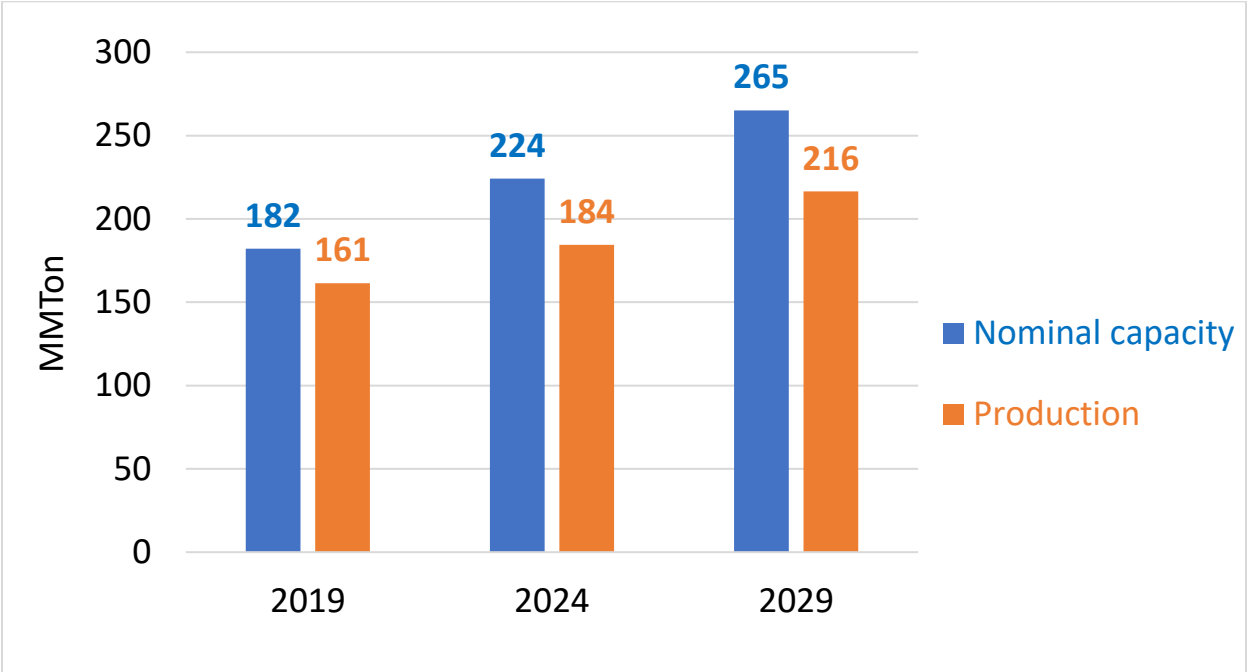

Figure 2- Global nominal capacity and production of ethylene in 2019, 2024 and 2029

5. Overview of ethylene production in Iran

- Petrochemical Complexes Producing Ethylene in Iran

By the beginning of 2025, Iran has eleven operating ethylene production plants with a total nominal capacity of 8.9 million tons. The major Ethylene-producing companies in Iran include:

No.	Logo	Petrochemical Complex	Production Capacity (KTons/Year)	License	Year of Operation	Web site
1		Amir Kabir Petrochemical Company	520	Linde	2005	https://www.akpc.ir/en/home
2		Ilam Petrochemical Company	458	Stone & Webster	2020	https://en.ilampetro.com/
3		Arya Sasol Company	1100	Technip	2007	https://www.aryasasol.com/
4		Tabriz Petrochemical Company	136	TPL (Italy) KTI (Netherlands)	1996	https://www.tpco.ir/en-US/DouranPortal/1/page/Home
5		Jam Petrochemical Company	1320	Technip	2007	https://jpcomplex.ir/
6		Shazand Petrochemical Company	306.6	TPL, KTI	1993	https://arpc-ir.com/

7		Bandar Imam Petrochemical Company	411	Lummus	1993	https://bipc.ir/en/faravaresh1/
8		Kavian Petrochemical Company	2000	Technip	First phase: 2012 Second phase: 2016	https://petrokavian.com/
9		Marun Petro Chemical Group	1100	Linde (Germany)	2006	https://mpc.ir/english
10		Morvarid Petrochemical Company	500	Technip	2010	https://www.morvaridpc.ir/
11	-	Gachsaran Petrochemical Company	1000	Technip (France)	2023	https://www.gpetroc.ir/

- Ethylene petrochemical complexes under construction

No.	Logo	Petrochemical Complex	Production Capacity (K Tons/Year)	Year of Operation (prediction)	Web site
1		Kangan Olefin (Kangan Petrochemical Development)	1000	2024	-
2		Badr-e-Shargh Petrochemical Complex (BSPC)	248	2026	-
3		Parsian Star petrochemical Company	20	2026	https://setarehparsian.com/
4		Petrofarhang Oil, Gas and Petrochemical Holding	20	2030	http://petrofarhang.com/
5		Kian Petrochemical Company	1260	2025	-
6		Bushehr petrochemical Company	1000	2025	https://bupc.ir/en
7		Almas Mahshahr petrochemical Company	-	2026	https://www.almpc.ir/en/home
8		Dehloran petrochemical company	630	2028	https://dehloranpetro.com/
9		Hormoz Persian Gulf Petrochemical	-	2025	https://hormozpc.ir/en/home

10	PEDC	Soroush Energy Paydar-GTO	300	2027	https://www.pedc.ir/fa/our-businesses/downstream/soroush-energy-paydar
11	-	Sina Chemical Industry Development	225	2030	https://www.pedc.ir/our-businesses/downstream/sina-chemical-industry-development
12	-	Arghavan Vista Energy	900	2025	https://veapc.ir/