Global Olefins and Polyolefins Outlook
Navigating Energy Transition in Highly Competitive and Dynamic Markets
Agenda

State of the Olefins and Polyolefins industry

- New capacity
- Impacts on markets
- Cost competitiveness

Energy transition and long-term Impacts

Takeaway
The olefin and polyolefin markets have experienced a variety of challenges over the past few years. Despite holding up well during the 2020 COVID shutdowns compared to other commodities, ethylene's demand growth weakened in 2022

**Ethylene demand growth compared to GDP and energy / chemical commodities**
Most recent incremental ethylene capacity has been added in China or the USA

Ethylene Capacity vs. Demand Increases

- Global Demand Change
- Central and Eastern Europe
- Northeast Asia ex-China
- North America
- Central and South America
- Russia and CIS
- Mainland China
- Africa
- Middle East
- Western Europe
- Middle East
- Southeast Asia
- South Asia
- Operating Rate

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Huge propylene capacity vs demand build up across ‘20-24. Operating rates will remain low until early 2025.
Polyethylene capacity additions led by China and the US has over-paced demand growth across in ‘20-23.

### Capacity vs. Demand Increase for Global PE

- **Global Demand Change**
- **Middle East**
- **Western Europe**
- **South Asia**
- **Mainland China**
- **Northeast Asia**
- **Russia and CIS**
- **Southeast Asia**
- **North America**
- **Other**
- **Africa**
- **Operating Rate**

### Polyethylene Capacity Additions (2020-2024)

<table>
<thead>
<tr>
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<th>Capacity (MT)</th>
<th>(%)</th>
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</thead>
<tbody>
<tr>
<td>China</td>
<td>12.9</td>
<td>56%</td>
</tr>
<tr>
<td>North America</td>
<td>4.7</td>
<td>20%</td>
</tr>
<tr>
<td>Northeast Asia</td>
<td>2.2</td>
<td>10%</td>
</tr>
<tr>
<td>India &amp; Subcontinent</td>
<td>1.3</td>
<td>6%</td>
</tr>
<tr>
<td>ROW</td>
<td>1.8</td>
<td>8%</td>
</tr>
</tbody>
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Source: S&P Global Commodity Insights.
Middle East & North America continue as largest exporters of polyethylene; China remains the largest importer

Total PE net trade by region (MMT)

- Middle East exports 85% of its production
- North America exports 55%
- Russia exports 47%
- China's self-sufficiency stands at 65%, projected to increase to 71% by 2026

Source: S&P Global Commodity Insights

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Ethane Based Producers retain cost advantage on a “Delivered Cost basis to China”

Delivered Cost of Polyethylene to China - 2023

Delivered Cost of Polyethylene to China - 2025

Platts | CERAWeek | Chemical Week

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Polypropylene industry is currently going through the peak of a unprecedented capacity wave in ‘20-24

World : PP capacity growth by region (Million Metric Tons)

- Mainland China
- Southeast Asia
- South Asia
- Americas
- Europe
- Middle East
- Africa
- Northeast Asia

<table>
<thead>
<tr>
<th>Region</th>
<th>Capacity Addition Share (2020-26)</th>
</tr>
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<tbody>
<tr>
<td>Mainland China</td>
<td>64%</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>13%</td>
</tr>
<tr>
<td>South Asia</td>
<td>10%</td>
</tr>
<tr>
<td>Americas</td>
<td>5%</td>
</tr>
<tr>
<td>EMEA</td>
<td>4%</td>
</tr>
<tr>
<td>Europe</td>
<td>4%</td>
</tr>
<tr>
<td>Africa</td>
<td></td>
</tr>
<tr>
<td>Northeast Asia</td>
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</tbody>
</table>
The ongoing wave of capacity expansion in China is being propelled by deregulation of refinery-petrochemical industry and the central government's efforts to enhance self-sufficiency.
Energy Transition: Olefin value chain’s long-term disrupter

Examples affecting olefin value chain
- Peak refined products demand
- Evolution of natural gas demand
- Process heating
- Rate of decarbonization
Ethane continued to gain share of total ethylene feedstocks. However, naphtha remains to be critical to olefin industry.

**Ethylene Production by Feedstock**  
*(2019 inner/ 22 outer)*

- Ethane: 38%
- LPG: 15%
- Other: 7%
- Naphtha: 38%

**Ethylene Production by Feedstock**  
*(Ethylene, million t/a)*

- Ethane
- LPG
- Naphtha
- Other

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If naphtha yields / refinery throughputs underperform, ethylene feedstock slates would need to fundamentally change

Incremental Naphtha Requirement for Ethylene vs Refinery Scenarios (Naphtha, Million t/y)

- Blue: Naphtha requirement from ethylene forecast (trendline post 2032)
- Orange: Naphtha from refining, assuming increasing naphtha yield
- Purple: Naphtha from refining, same throughput but constant naphtha yield
E-furnaces in crackers can potentially remove ~1 million tons per year of CO₂ emissions per world scale cracker*

- Ethane crackers emit ~0.85 metric tons CO₂ / ton ethylene
- Mostly in flue gas of furnaces (~97%)
- Two strategies to trim carbon emissions
  - Electrification – still in pilot testing phase, partial or whole replacement of NG with H₂
  - CCUS – more mature and commercialised technology
- No commercial installations yet
  - Pioneers: BASF / SABIC / Linde, Dow / Shell, Technip / Siemens

* Assume 1.5 million ton per year ethane cracker; Scope 1 and Scope 2 emissions

Photo source: BASF, SABIC and Linde started construction of the world’s first demonstration plant for large scale steam-cracker furnace (chemengonline.com)
E-furnaces in steam crackers can potentially reduce CO₂ emissions by 90%, but CAPEX rises to ~1.33x

- Variations of process to reduce total CO₂ emissions
  a. Conventional ethane cracker (base case)
  b. Conventional cracker + carbon capture from flue gas
  c. Cracker with furnace fuelled by blue hydrogen
  d. E-Furnace, electricity via NET Power™ system (NG to clean energy through oxy-combustion process)

Comparisons for a 1.5 MM tpy Ethylene Cracker

- Total fixed investments
- Production cost
- CO₂ emissions

Source: IHS Markit PEP Report 2022-04, Low Carbon Ethylene Production via E-furnace Powered by NET Power Cycle

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On-purpose propylene production share will become important as energy transition will cause FCC source of PGP/CGP to decline.
Hydrogen co-product from PDH creates opportunities in hydrogen economy aligned with China’s energy and fuel cell industry

- Provides low-cost, low-carbon source of hydrogen, easily integrated into existing infrastructure and supply chains
- Aligned with China’s energy and fuel cell industry
  - For example, Dongguan Grand in Pearl River Delta China, is plugged into the Hydrogen Energy Integrated Plan
- Demand for hydrogen refilling from this source is small and it has a long way to go (at least 5-10 years).
  - Only ~3% of total domestic hydrogen supply

19.3 MMT PDH capacity in China (2023) → 1.1 MMT of usable hydrogen → ~3% of total domestic hydrogen supply

Source: S&P Global Commodity Insights
Resilient demand in 2021 supported margin of olefin value chain, but **2022 was trough year**

2023 likely worst year of trough; margin recovery by 2026 with capacity discipline

**Energy Transition** efforts already impacting olefins & polyolefins markets

- Refinery yield structure will change feedstock slates – and costs
- Decarbonization rate a key factor