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The Future of Plastics: Scaling Innovation & Investment for a Circular Economy

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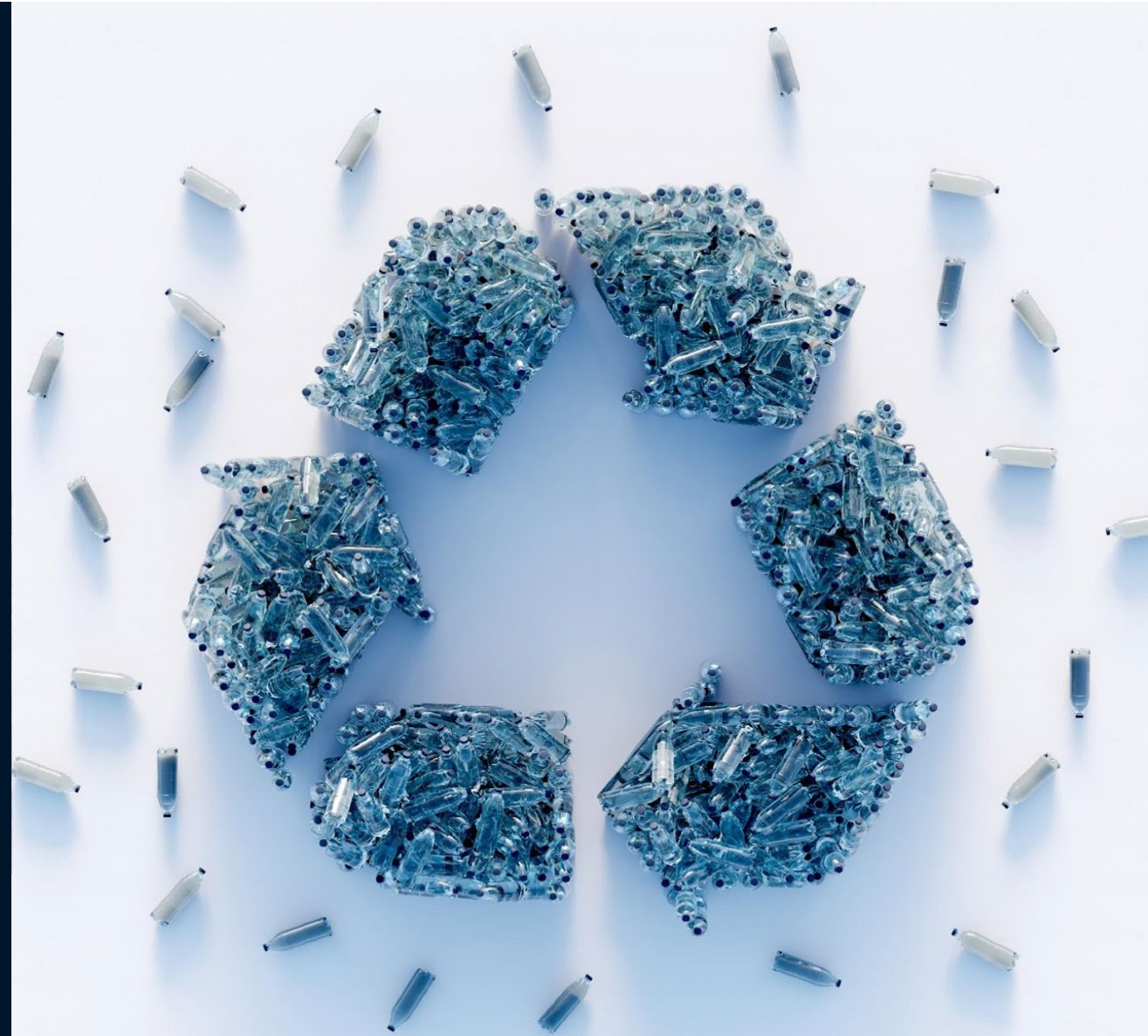


APIC
2025

Asia Petrochemical Industry Conference
Bangkok, Thailand

Agenda

- Recycling technologies
 - Mechanical
 - Chemical
- New business models
- Impact on polyolefins demand



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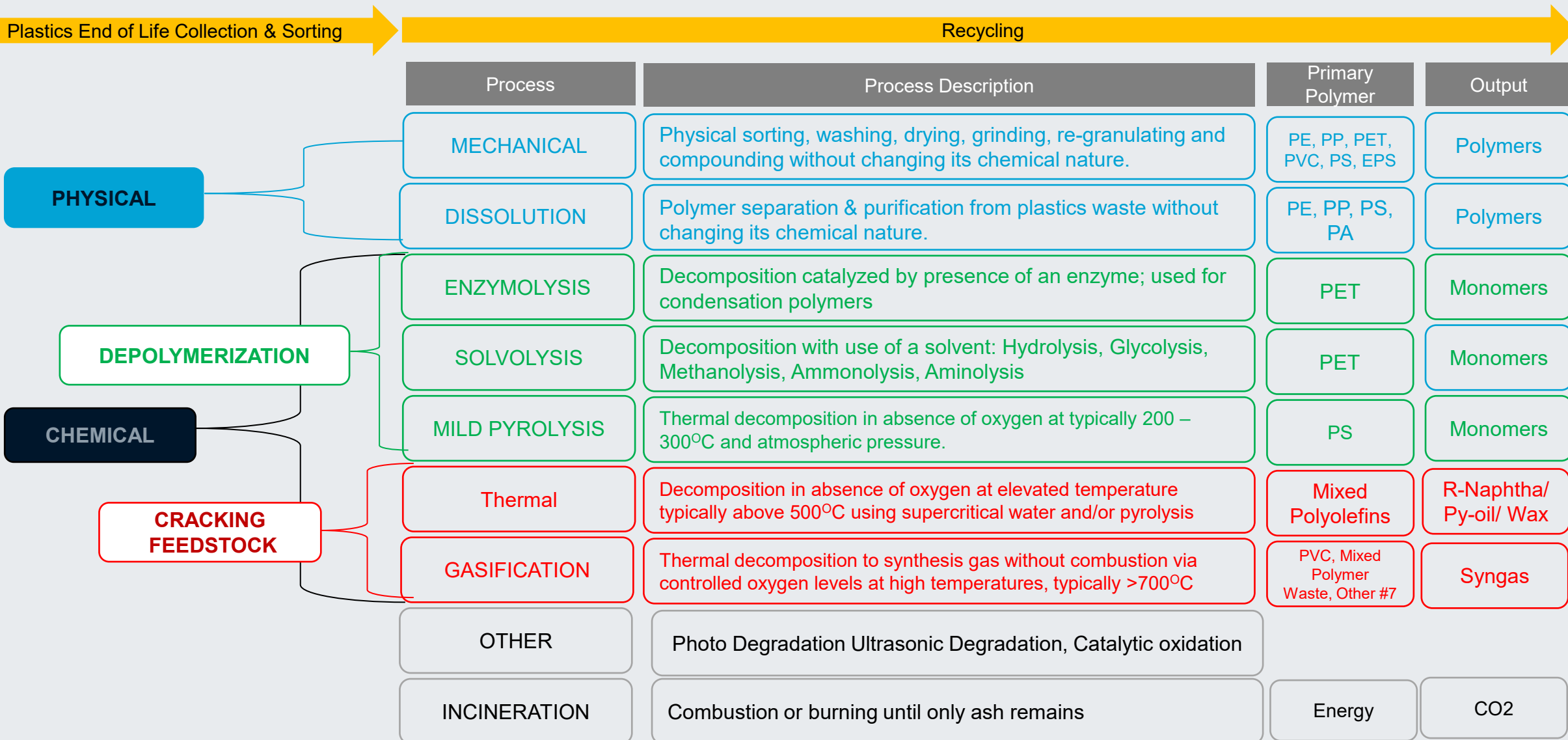
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Sustainability from the technology perspective



Many investments in various recycling options



Despite being the most established process, mechanical recycling has its challenges

Economic

- High cost of collecting, sorting and processing
- Fragmented

Technical

- Poor collection infrastructure
- Inconsistent feedstock
- Contamination

Environmental

- Competition from incineration
- Safety risk from additives

Regulatory

- Lack of enforcement
- Insufficient proper waste collection systems

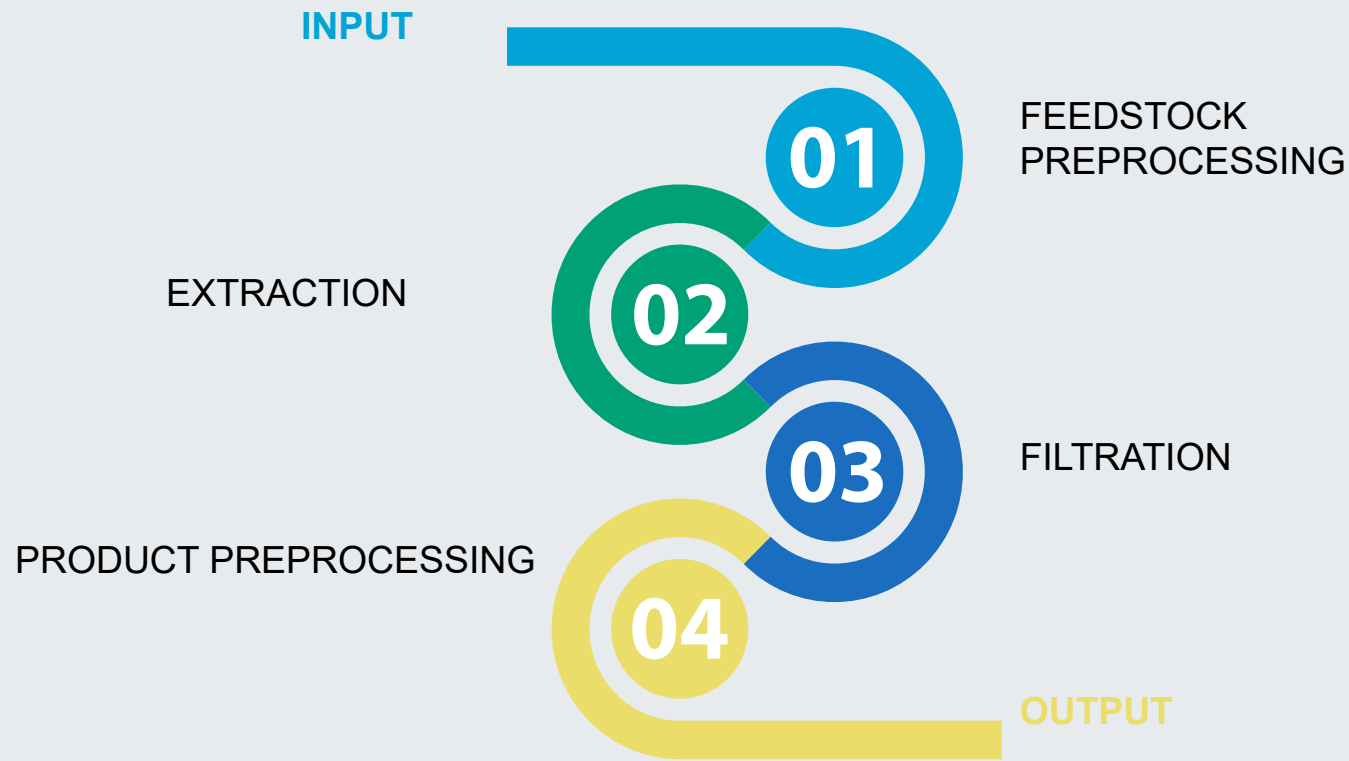
Developing Solutions

- Harmonize waste collection systems
- Segregate waste stream collection



Dissolution is one of the latest developments of physical recycling

A wildcard for virgin demand risk?

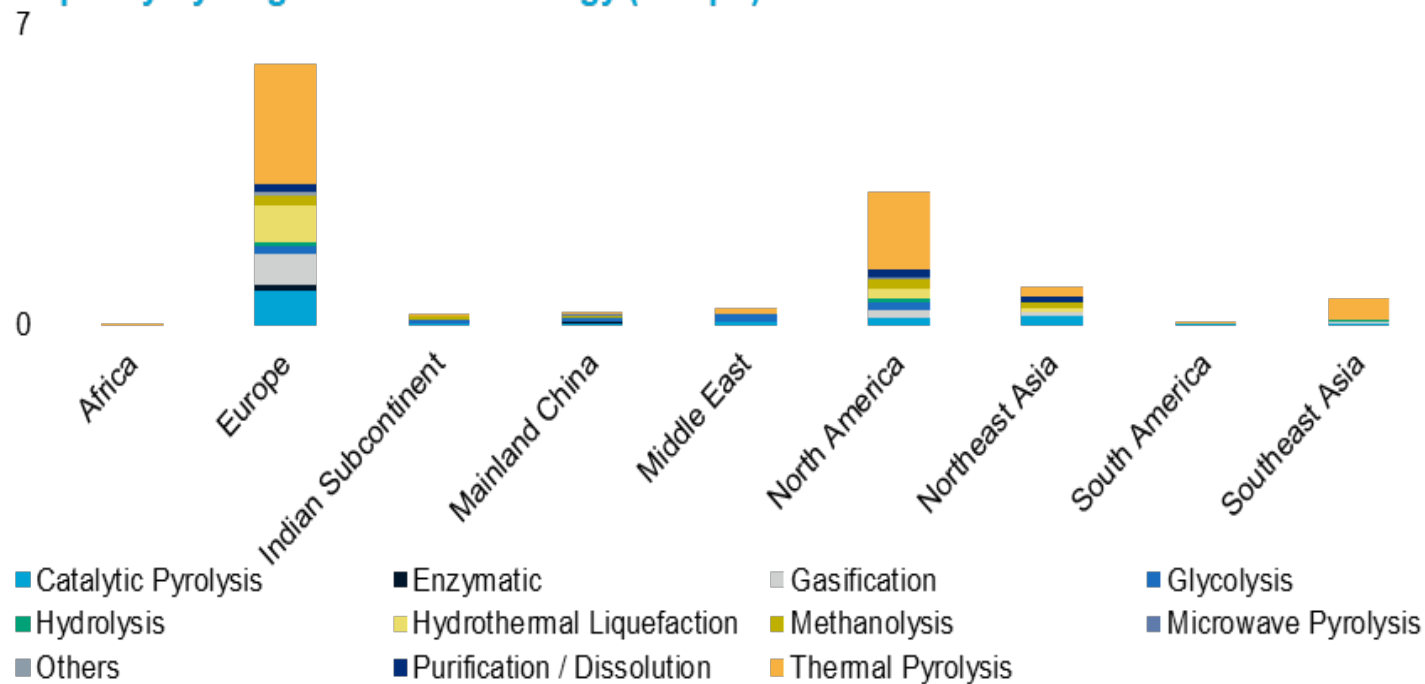


- Solvents dissolve waste polymers for separation
- Dissolution recycling starts with plastic waste sorting
- Use heat and solvents to dissolve plastic into solution
- Additives are separated before recovering polymers from solution
- Structure of polymer is not altered
- Finally, additives are added to polymers to produce new recycled plastic
- Recycled resin has the same quality as virgin resin

Investments in chemical recycling have been growing

- North America and Europe accounts for at least 75% of the global chemical recycling capacity
- Current capacity is about 1.7 million tons/year
- More investments in thermal pyrolysis
 - Catalytic pyrolysis improves efficiency
- Challenges
 - Higher investment cost
 - Some companies already faced bankruptcy

Capacity by Region and Technology (MMtpa)

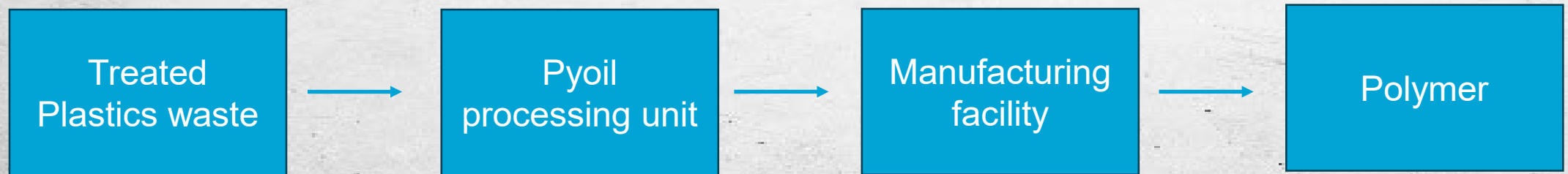


Note: Includes all years, i.e. Operational, Under construction, and Under feasibility.
Source: Chemical Market Analytics by OPIS

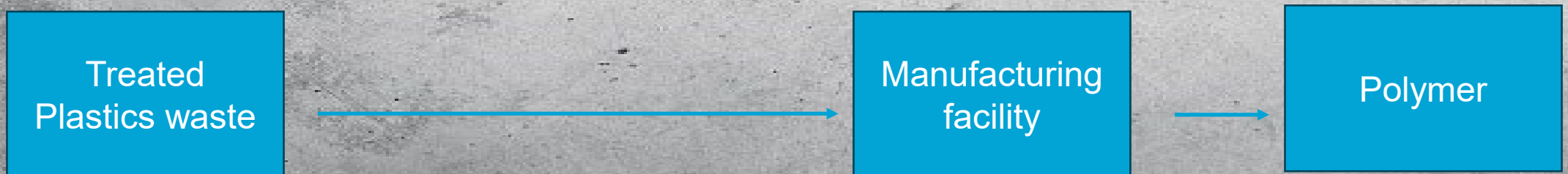
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Chemical recycling technologies continues to evolve

Pyrolysis



Co-processing



Comparison between Mechanical and Chemical Recycling

	Mechanical Recycling	Chemical Recycling
Investment cost	Low	High
Quality of product	Generally lower, depending on feed	Same as virgin
Technology	Established. Further developing.	Non matured. Developing.
Emissions impact	Low	High
Scalability	Low	High

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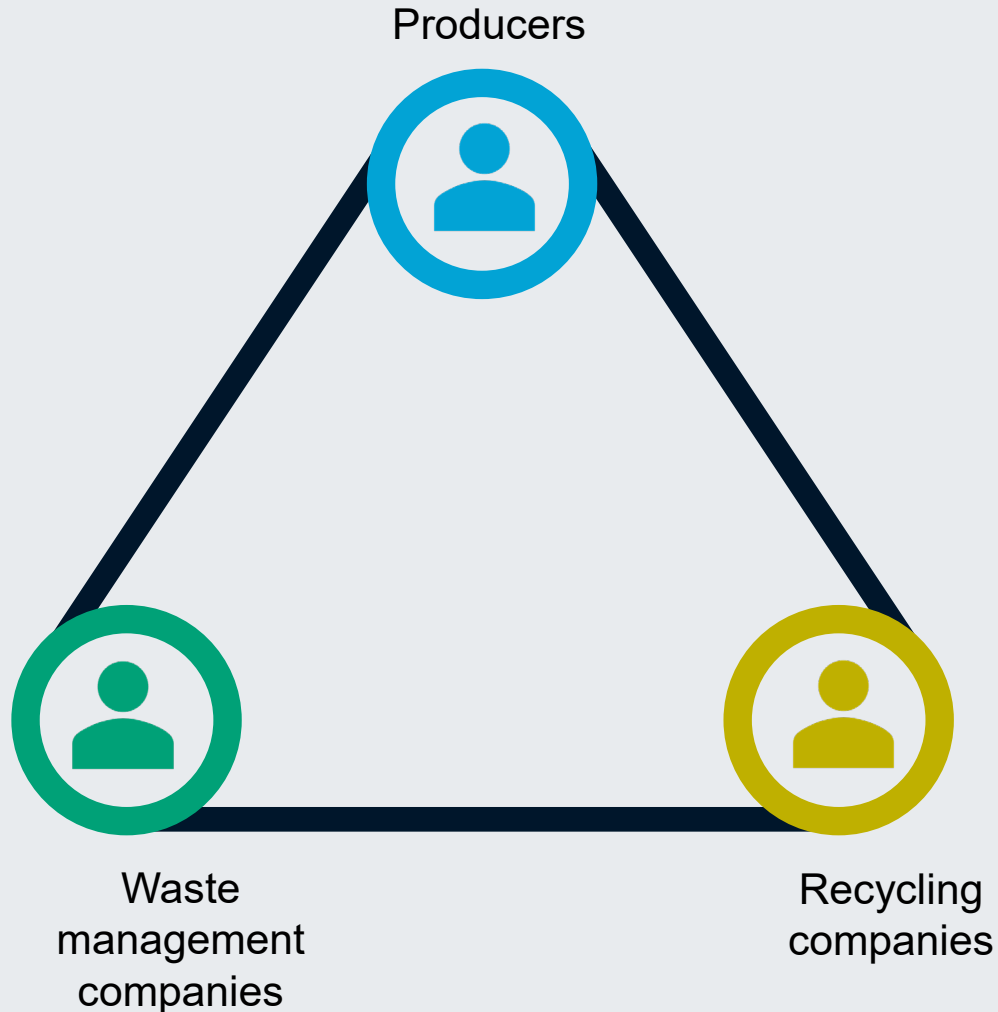
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New business models



New business models are emerging from transition to circular economy



The Houston Collaborative

- Cyclyx International, ExxonMobil and LyondellBasell have signed an agreement to advance development of a first-of-its-kind plastic waste sorting and processing facility in the Houston area.
- The Cyclyx Circularity Center is unique among plastic recovery facilities, producing feedstock for both mechanical and advanced recycling
- The facility is designed to produce 150,000 metric tons of plastic feedstock per year, supplying ExxonMobil's and LyondellBasell's advanced recycling projects, as well as mechanical recycling markets.
- Total investment for the first circularity center is estimated to be \$100 million.

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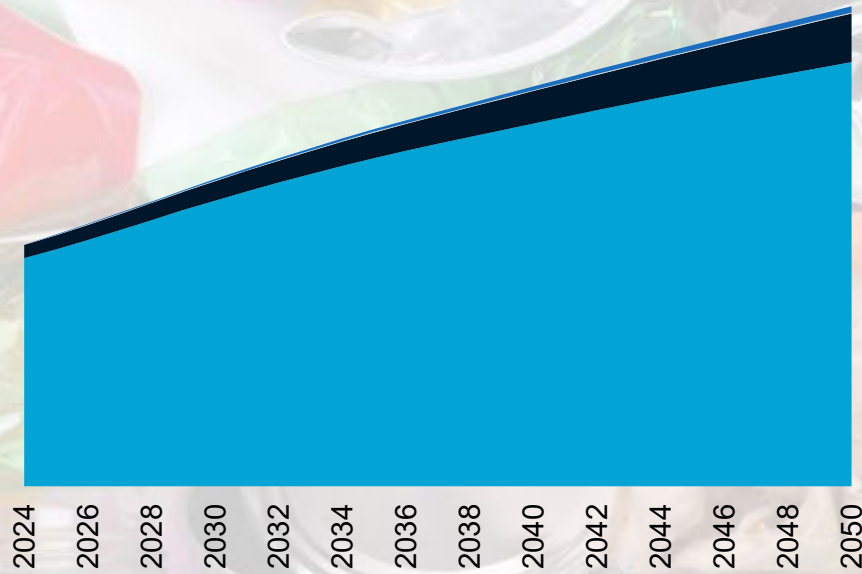
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Sustainability from the polyolefins perspective

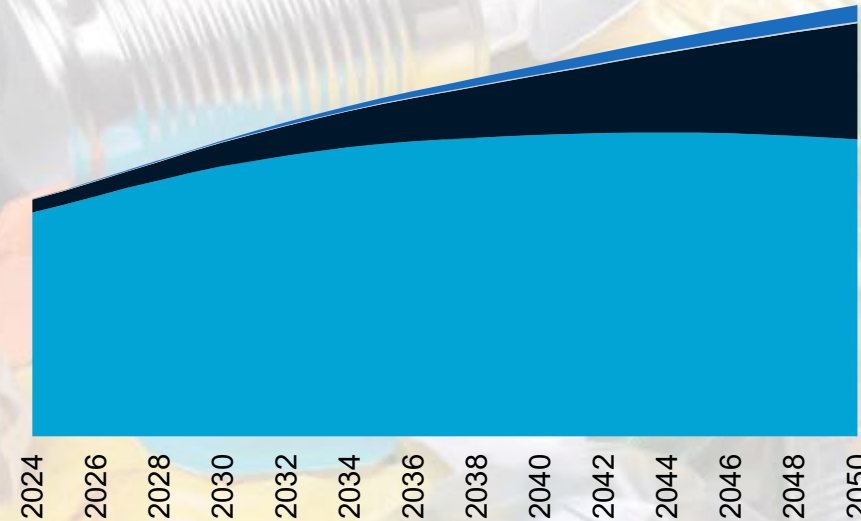
Global Polyolefins virgin demand peaks in 2033-35 timeframe

- By 2050, recycling technologies can contribute to 30-35% of the total plastics demand
- Mechanical recycling would account to 25-30% of the total plastics demand
- Due to yield losses in converting waste to plastics, chemical recycling would only account about 5% of the total plastics demand

Base Case - PO



Green Case - PO



Source: Chemical Market Analytics by OPIS

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■ Chemical ■ Bio ■ Mechanical ■ Fossil

Recycling is challenged in today's environment



Waste collection



High yield loss from converting waste to feedstock



Oversupply of virgin material



Lack of quality feedstock

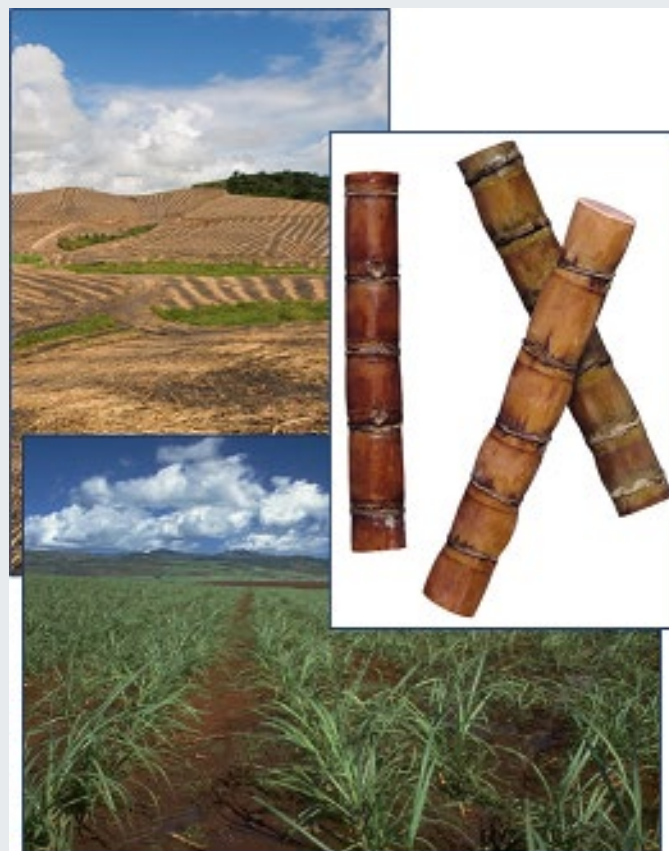


High cost of production

Green PE is an alternative to recycled resins



Braskem in Brazil is Leading the Effort in Green Ethylene via Sugar Cane



Conventional Route to "Synthetic" Ethanol:

Ethylene + H₂O

—————> Ethanol

New (old) Route to Ethylene

Bioethanol

—————>

Ethylene + H₂O

↑

"Green"

Braskem Siam signed letter of intent with Mitr Phol Bio Fuel. Latter will supply green ethanol for SCGC to produce green PE.

Capacity: 200,000 tons/year

High cost will limit the growth of bio PE



Pros

- Reduce carbon footprint of plastics production.
- Same characteristics as virgin PE.



Challenges

- Concerns of insufficient availability/supply of bio-feedstock such as sugar cane and corn, waste oil, Agri-oils.
- Ethanol is gaining popularity as the basis for SAF (sustainable aviation fuel), and bio-PE producers will have to compete with the aviation industry for ethanol volumes.



Outlook

- High bio-PE prices relative to virgin will limit demand growth
- Market segments for bio-based PE will focus on packaging applications used by brand owners
- Penetration for bio-PE is expected to be less than 5% by 2050

Main applications



Beverages



Cleaning products



Cosmetics



Food



Agriculture and industry



Coating



Retail

Circularity does not mean total displacement of PE grades

Move towards multi layer mono material packaging



Increased mLLDPE demand with more PCR in core layers



Conclusion

- Each recycling option has its own merits and challenges
- Recycling technologies are still developing and not matured yet



- Oversupply in virgin polyolefins to limit demand growth for recycled

- Collection of waste an issue, but solutions can increase demand for some PE grades
- Bio-based PE an alternative to recycled resins

CMA's circular plastics offerings address both clients' long-term strategic and short-term tactical needs

Moving to a plastics circular economy

- Transition away from the 'produce, use and dispose' linear model
- Strive to extract maximum value by keeping materials in use as long as possible and recovering and regenerating valuable materials at each end of use
- Complex transition reflecting the broad, long-term energy transition shifts and the near-term ebb and flow of the plastics industry business cycle
- Increased plastics demand risk profile
- Balancing emissions with structural changes for a successful transition

CMA's Circular Plastic offerings:

CPS

Circular Plastics Service
Data and analyses to support strategic long-term planning
Combination of forward-looking models, databases & insights covering: capacity, supply, demand, waste generation & disposition, technoeconomic & emissions analytics, and price & margin forecasts
PE (HD, LLD, LD), PP, PET, PS, EPS, PVC
Global coverage (10 regions)

GRPR

Global Recycled Plastics Service
Tactical tool for managing circular plastics business functions
Monthly report with price discovery & forecasts and coverage of issues shaping market dynamics as well as directories of mechanical & chemical recyclers
r-PE, r-PET, r-PP
Focused coverage on U.S., West Europe, China Mainland markets

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