



Circular Plastics: Options, Threats and Opportunities for the European Petrochemicals and Plastics Industry



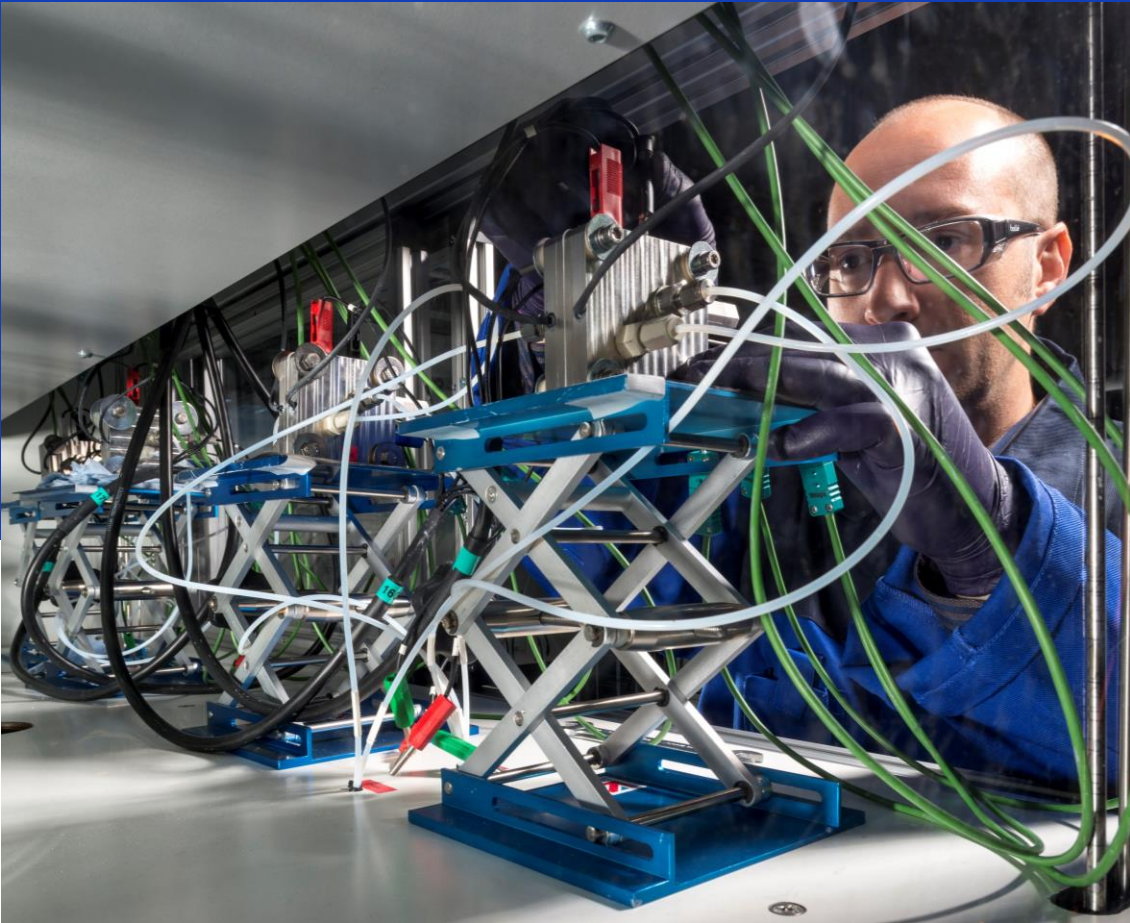
Keynote Address: Rajesh Mehta

**Senior Consultant, Energy and Materials Transition,
TNO, The Netherlands**

World Waste-to-Wealth Summit & Expo-2024

1-2 August 2024, New Delhi, India

Talk Outline



1. Introduction TNO
2. TNO Circular Plastics Program
3. Megatrends & Long-Term Outlook
4. European Chemical & Plastics Industries
5. Risks, Options, Opportunities
6. Technology Pathways
7. 2030 Scenario
8. Summary

Netherlands Organisation for Applied Scientific Research



Connecting people and knowledge



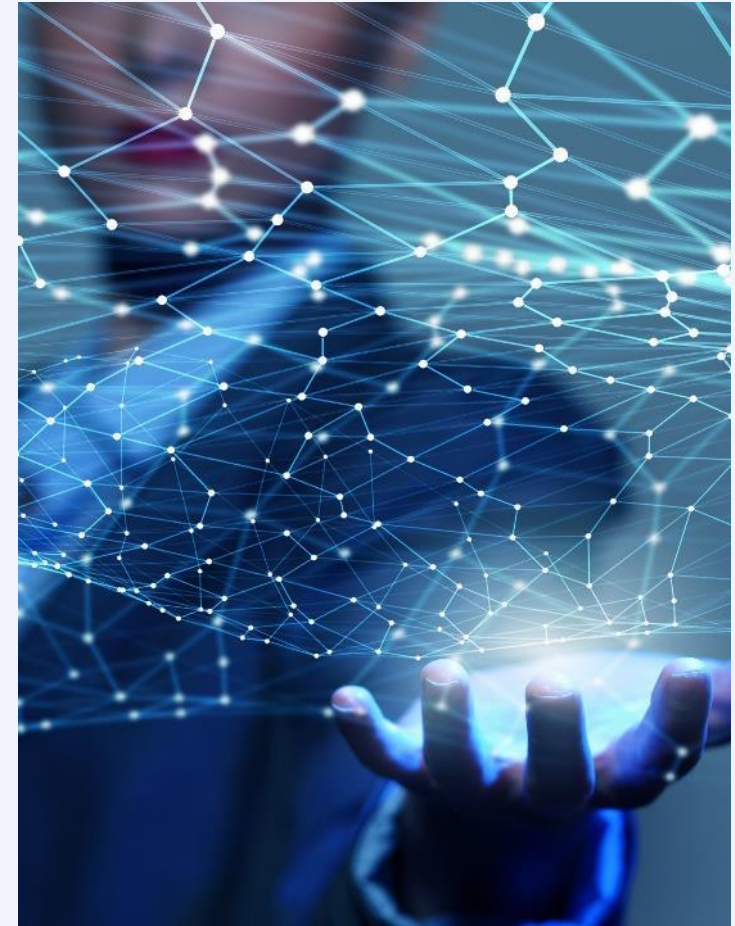
Creating innovations



Sustainably strengthening
business competitiveness



Sustainably strengthening
well-being across society





TNO key figures 2022

3897

Number of
employees

1,000

Public-private
partnerships

42

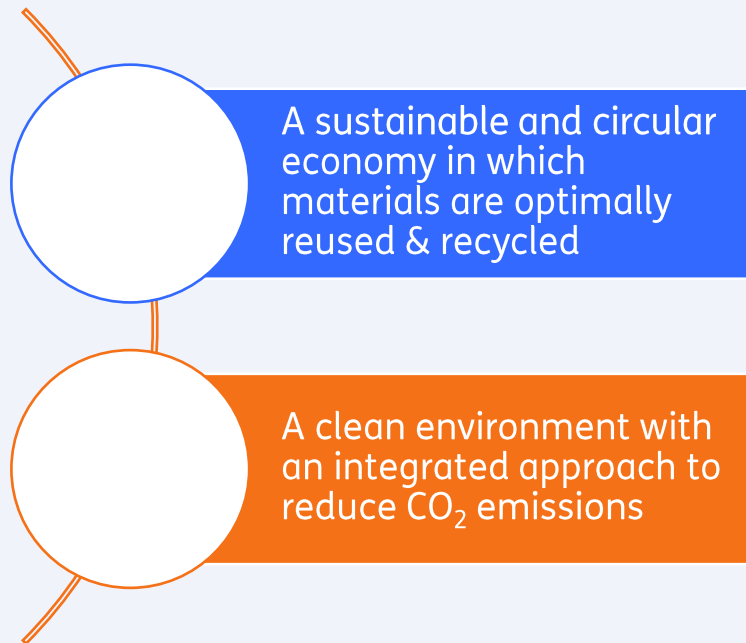
Lecturers professors

876

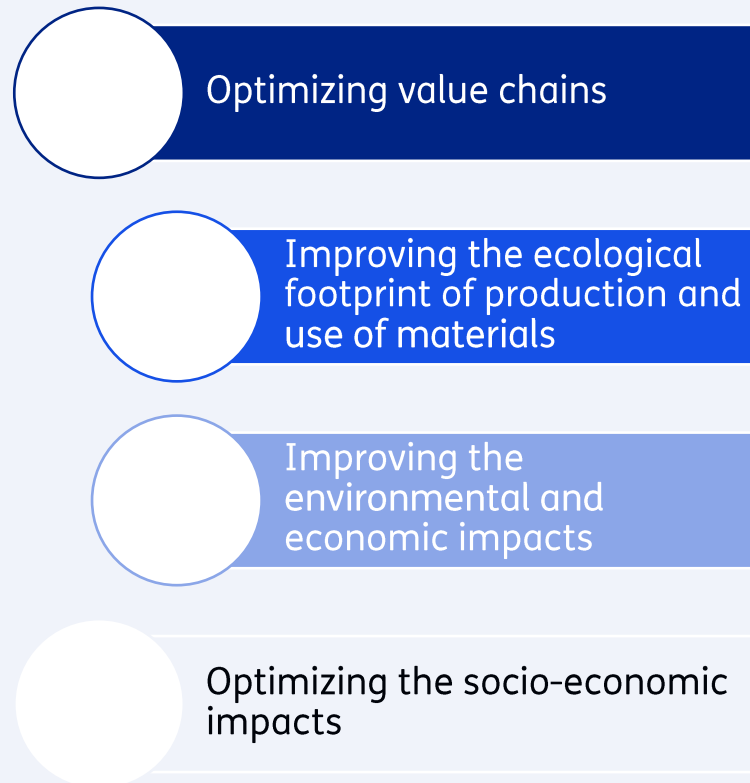
Patents

TNO Vision, Mission and Strategy on Circular Economy

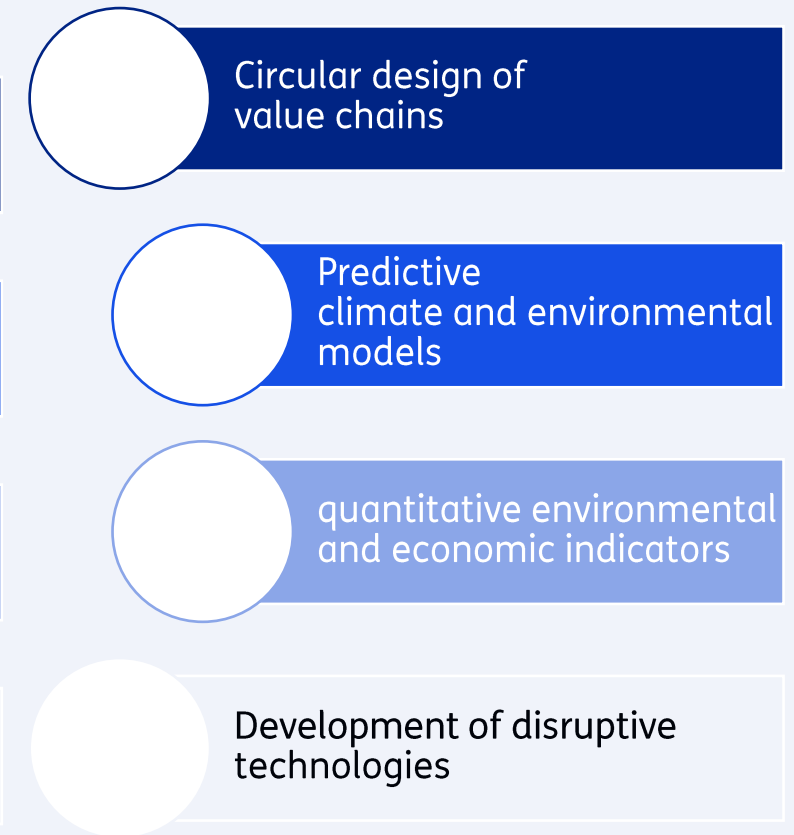
Vision



Mission



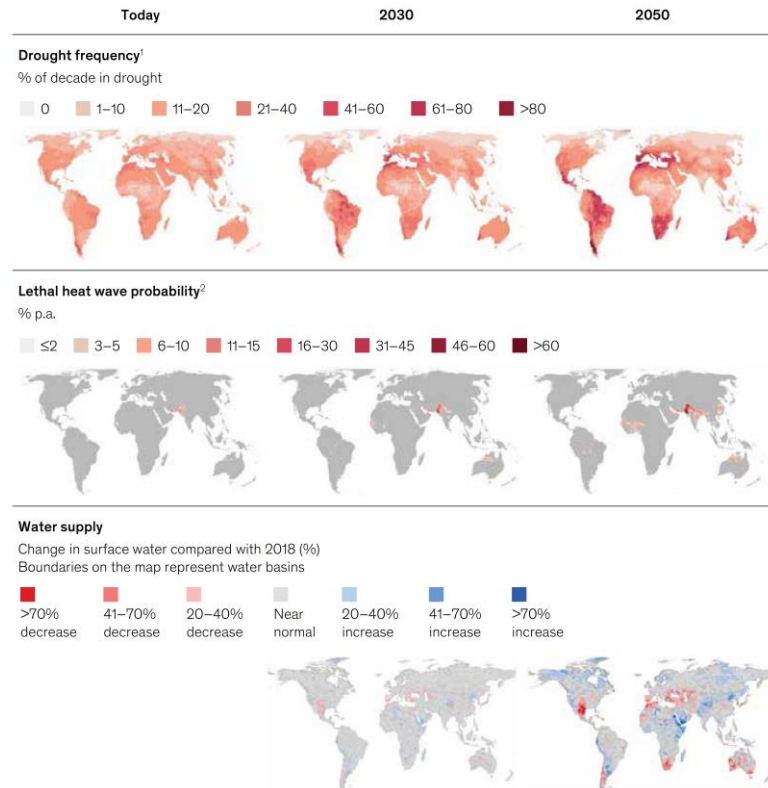
Strategy



The Core Issues and Direction

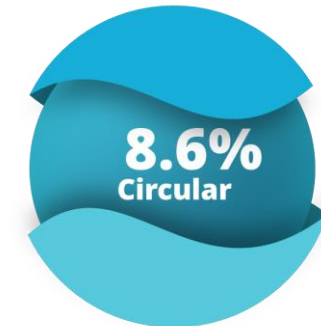
Decarbonization and circular economy

CLIMATE CHANGE



ECOSYSTEM DAMAGE AND LINEAR ECONOMIC SYSTEM

THE WORLD AT PRESENT



REFERENCE: "THE CIRCULARITY GAP REPORT 2020", CIRCLE ECONOMY
GLOBAL NET ZERO COVERAGE



The Two Megatrends: Climate and Circular Economy



a long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels

to aim to limit the increase to 1.5°C

on the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries

2050



Aiming for a reduction in virgin plastic products and packaging of at least 20% (by weight) by 2025

half of the 20% reduction coming from an absolute reduction of plastics

Achieving an average of at least 30% recycled plastics (in weight) in plastic product and packaging range

2025



Single-use plastic products and packaging will be 100 per cent recyclable

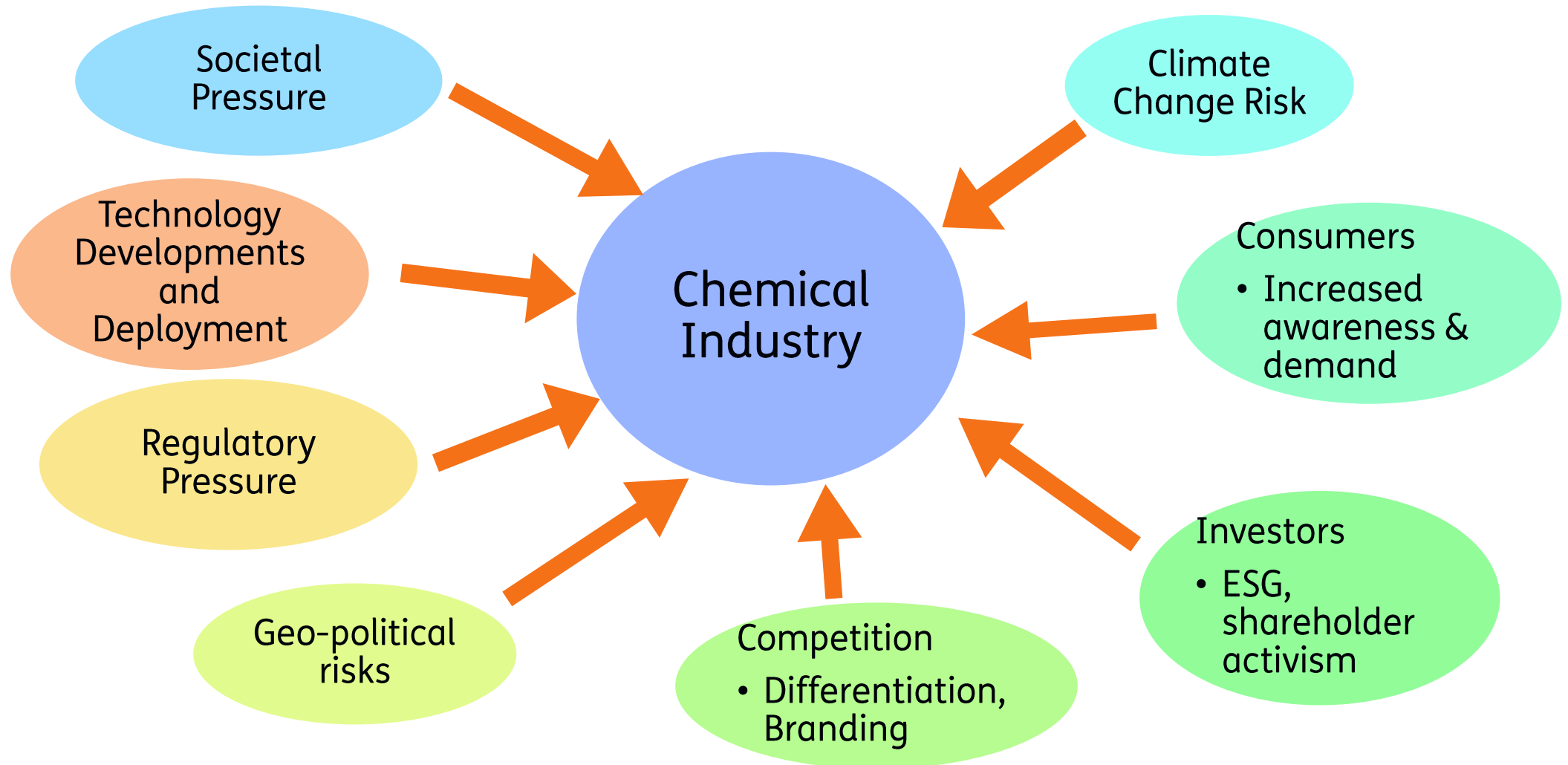
20% less plastic packaging through, among other things, greater reuse

at least 70% of single-use products and packaging will be recycled

Packaging products will comprise at least 35 per cent recycled plastic

2025

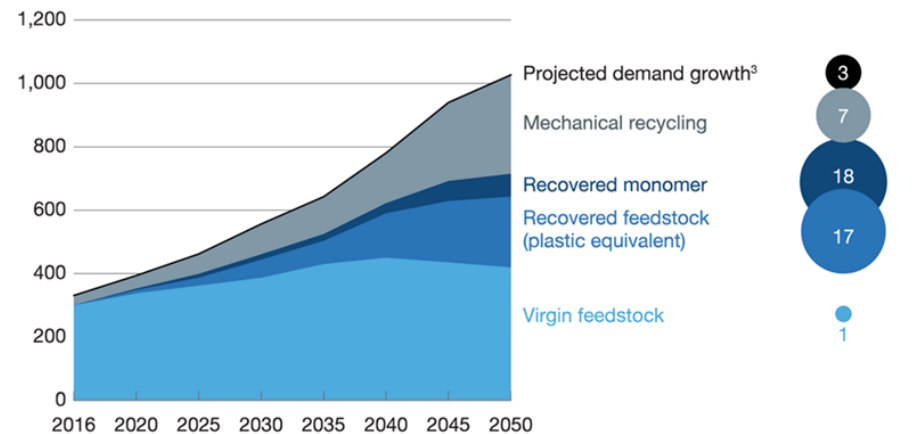
Forces Driving Circular Economy In Chemical Industry



2050 Outlooks

By 2050, nearly 60 percent of plastics production could be based on plastics reuse and recycling.

Global polymer demand 2016–50 and how it could be covered, millions of metric tons¹



¹Scenario based on a multi-stakeholder push to boost recycling, regulatory measures to encourage recycling, consistent progress on technologies, and \$75-per-barrel oil price.

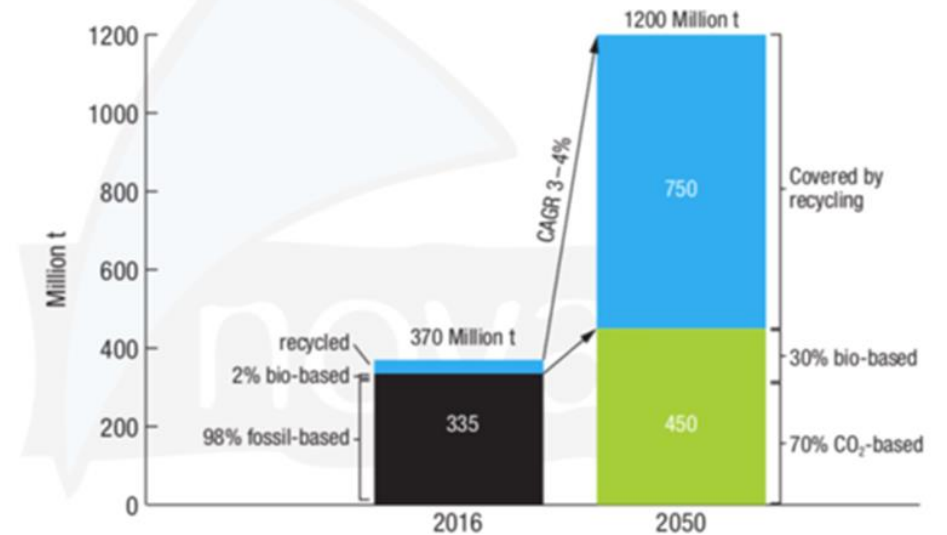
²Compound annual growth rate. Mechanical recycling limited by downcycling and applicable materials, monomerization limited by applicability to condensation polymers only, pyrolysis limited by likely rise in input costs.

³After demand reduction, assuming annual global GDP growth of 3.1%.

McKinsey&Company

Ref: 1) Mckinsey & Company report, December 2018

World Plastic Production and Carbon Feedstock in 2016 and Forecast for 2050 (in Million tonnes)



The virgin plastic production of 335 Million t in 2016 will increase to 450 Million t in 2050, completely based on renewable carbon. The total demand for plastics of 1,200 Million t in 2050 will be mainly covered by recycling.

© NOVA Institute.eu | 2018

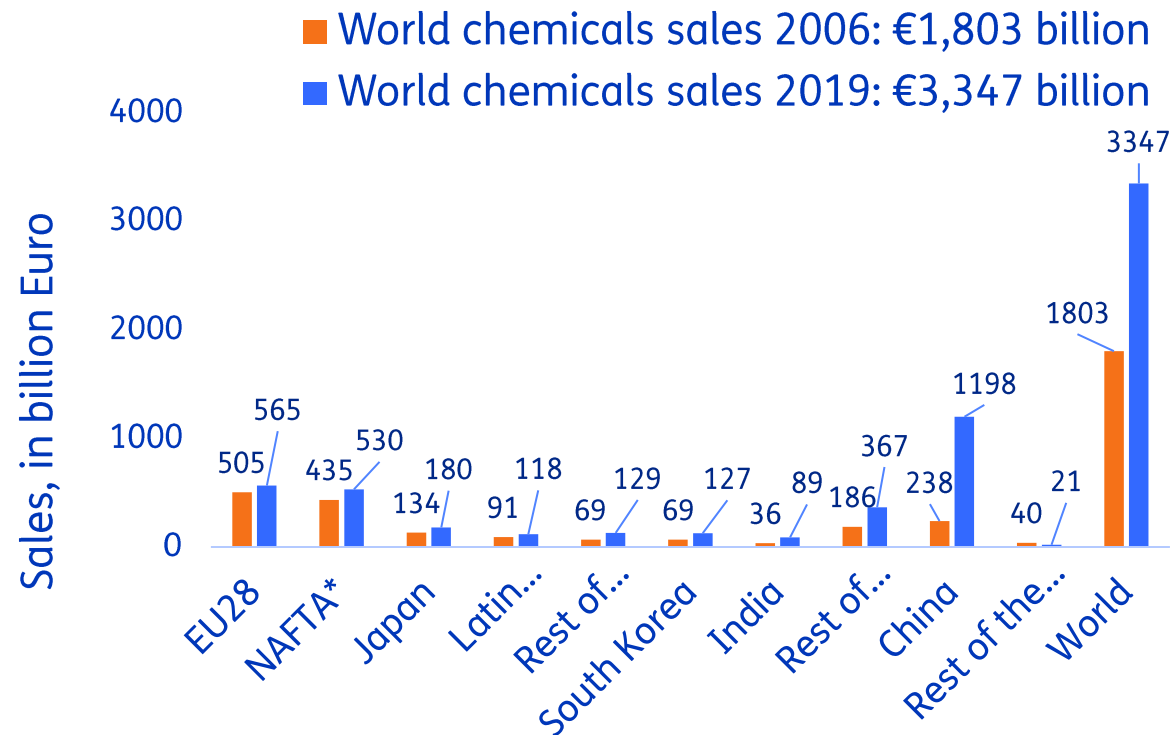
Ref: Nova Institute Report, 2019

Different Assessments - Similar Narrative
Momentum shift towards Circular Economy and Decarbonization

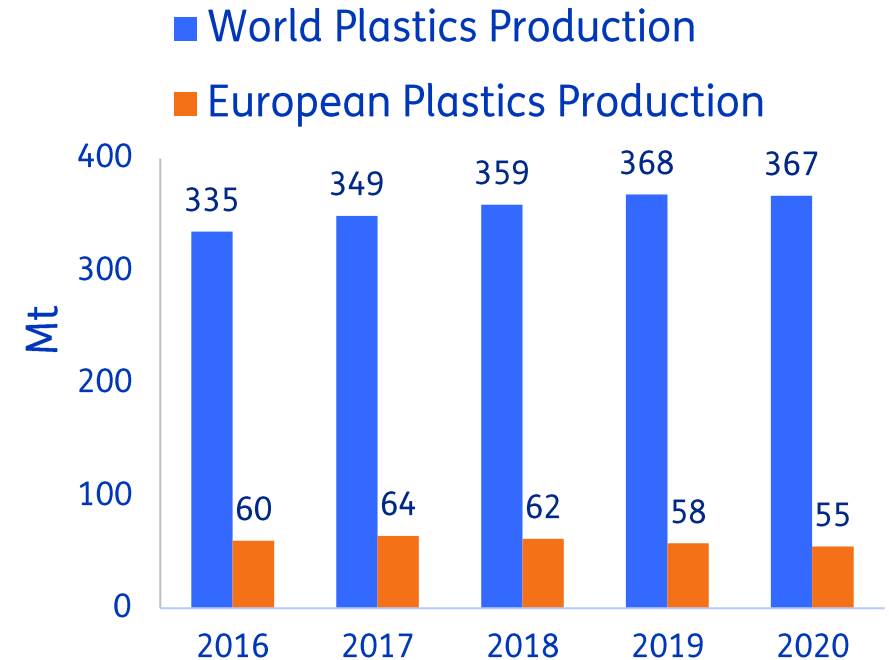
World Chemical and Plastics Statistics

Long Term Trend → One Direction

WORLD CHEMICAL SALES BY REGION

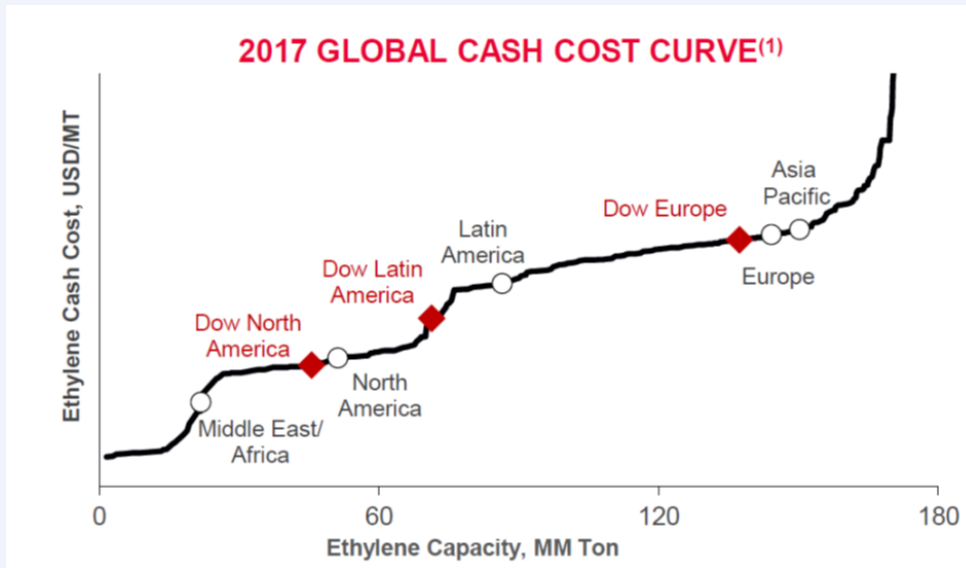


WORLD AND EUROPEAN PLASTICS PRODUCTION



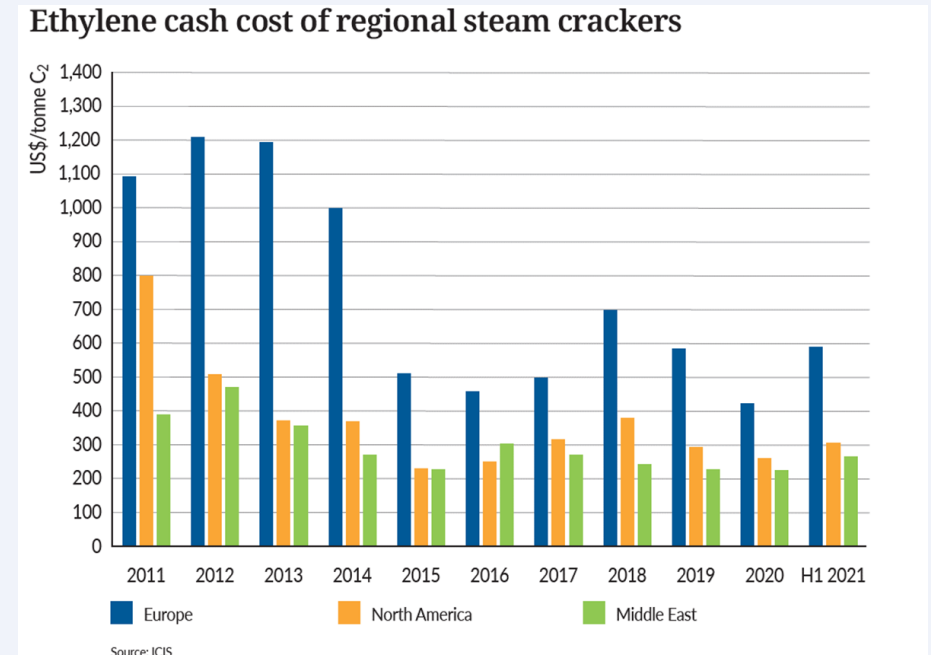
Shift of chemicals and plastics production to Asia

Ethylene Cash Cost Curve



- European crackers are on the right side of the cost curve
- Middle East & US have low-cost feedstock (Ethane) advantage with additional new capacities planned/under construction
- European Plastics industry will be threatened by cheaper imports from the US

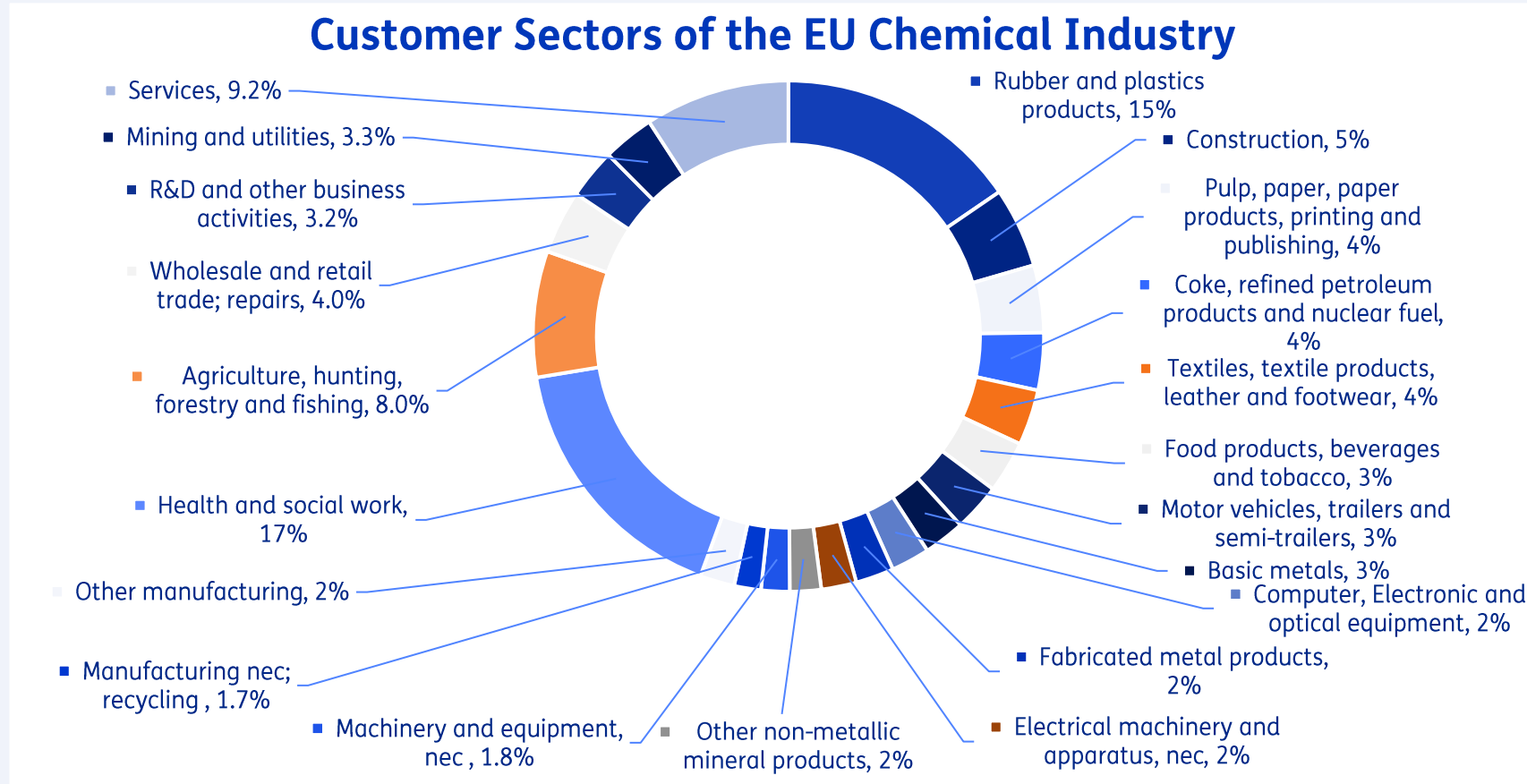
Need for European Plastics Industry to Differentiate



References: 1) "New DOW", PRE-SPIN INVESTOR ROADSHOW Presentation, March 2019.

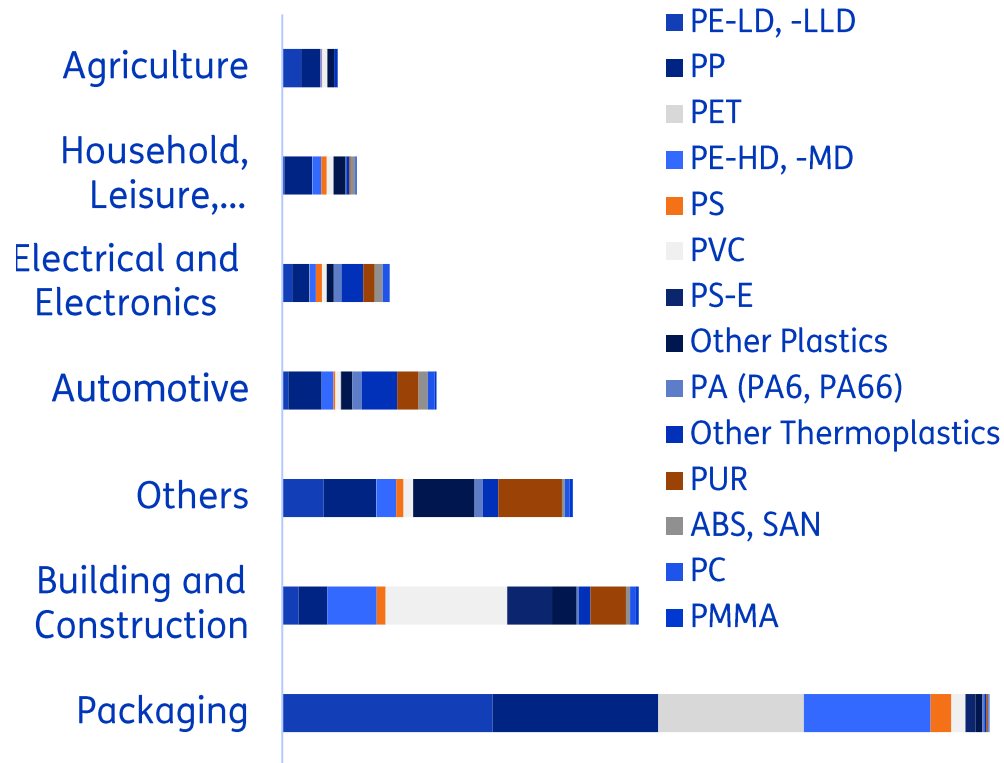
2) ICIS Chart on ethylene cash cost of regional steam crackers.

Complex Customer and sectoral mix



- Extremely hard to provide niche circularity solutions to every customer segment
- Complex supply chains per customer sector leads to challenges on establishing cost effective circular solutions

European Plastics Demand



- PlasticsEurope report that almost 40% of the European plastics demand goes into packaging, followed by B&C, and Automotive.
- Agriculture applications such as greenhouse films accounts for 3.4% of the plastics demand.
- The complexity of plastics entering the waste stream will continue to increase as more consumer products such as packaging take advantage of material innovations

- Extremely hard to provide niche circularity solutions to every product; high product development costs
- Need for segment/sector based approach to deliver accelerated results and lower costs for change for the value chains

Circular Economy

Risks

Opportunities

Business Model

Redesigning the business around a circular approach

Business model and supply chain redesign

Regulations, Geopolitical

Geopolitical tensions & limited regulatory support
Low carbon price/carbon tax
Plastics to fuel

Regulatory support on CE
High carbon price/carbon tax
Scope 3 GHG savings credit?

Market

Import of chemicals/plastics into EU
Cost competitiveness, supply chain,
Competition with biofuels

High crude oil prices
Differentiation / Premium
Growing demand
Low barriers for entry

Technology

Many technologies under development
Long technology development time
Winning technologies?
Product quality, food grade applications

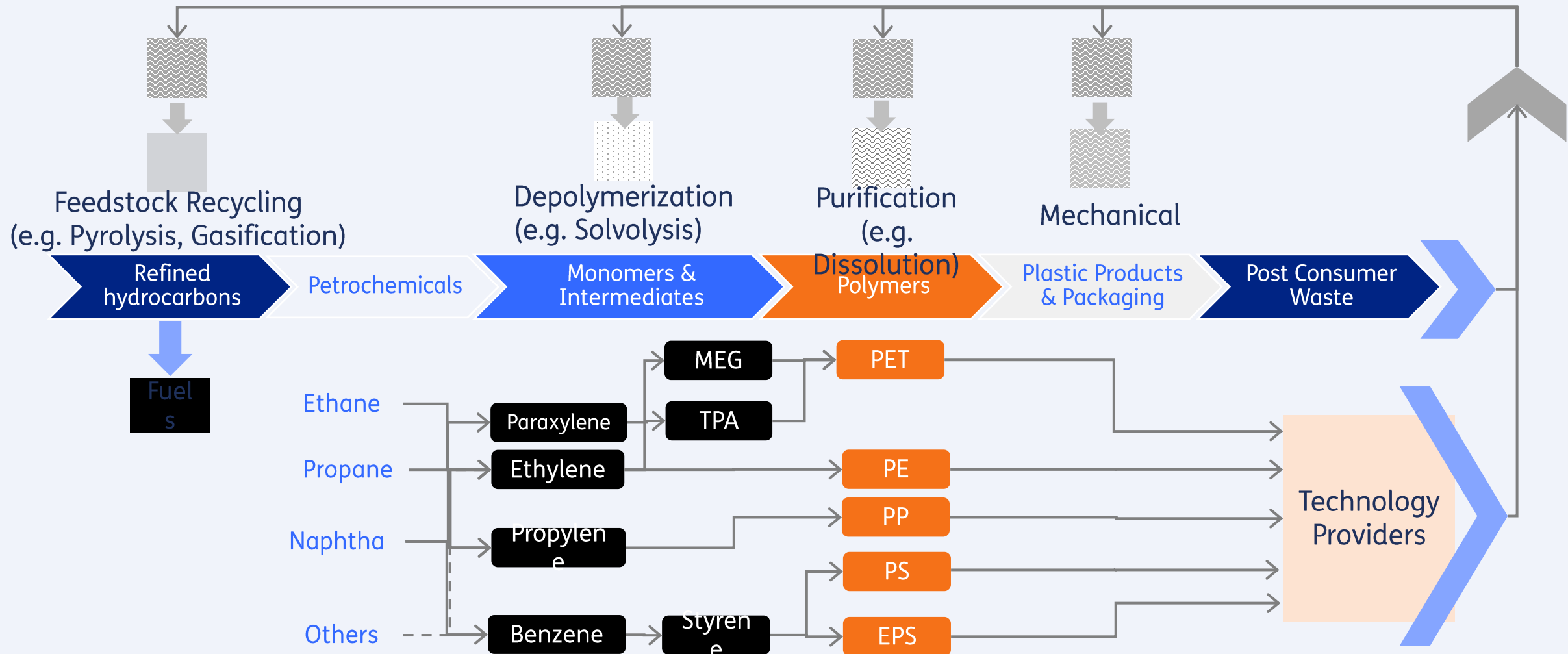
New Product/Process development
Design
Supply chains
Digitization

Cultural

Lack of awareness/willingness/agility to engage with CE

Demonstrate leadership

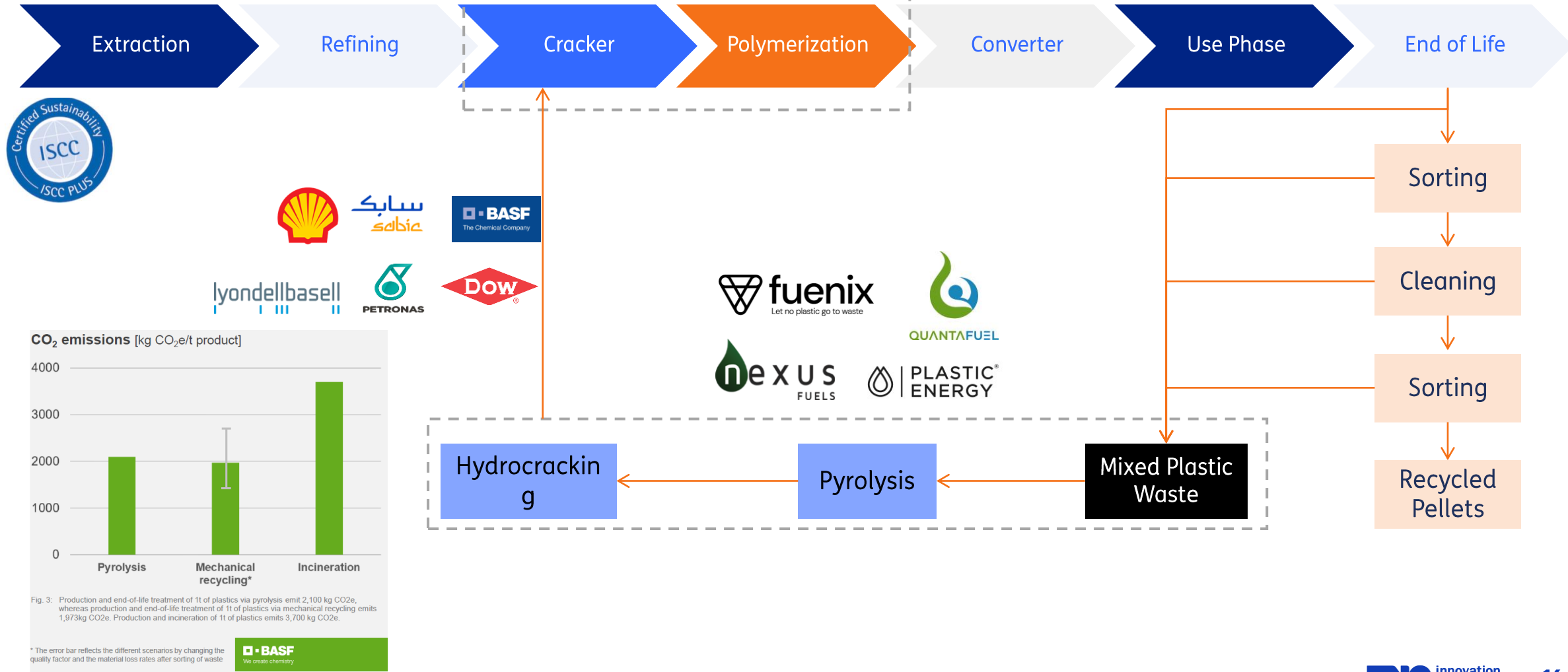
TECHNOLOGY PATHWAYS FOR CIRCULAR PLASTICS



Reference: "ACCELERATING CIRCULAR SUPPLY CHAINS FOR PLASTICS", CLOSEDLOOPPARTNERS"

Example – THERMAL CONVERSION (Pyrolysis)

Mixed plastic waste streams to chemicals, plastics value chain



Platforms for bio-chemicals production

8 platforms

Pyrolysis oil

Bio-Mass Balance Approach

CO2 Platform

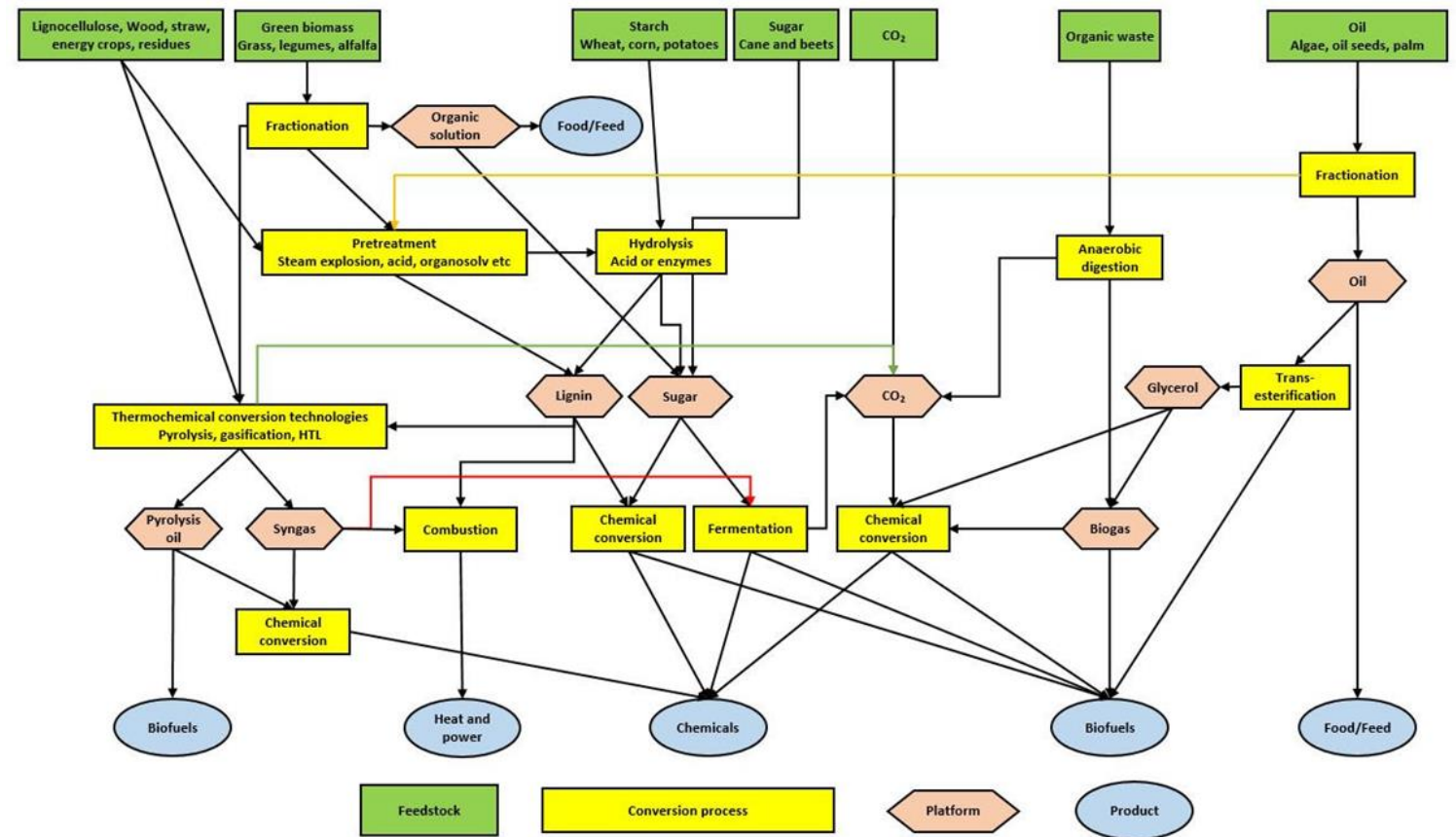
Syngas Platform

Sugars

Lignin

Bio-Oil Platform

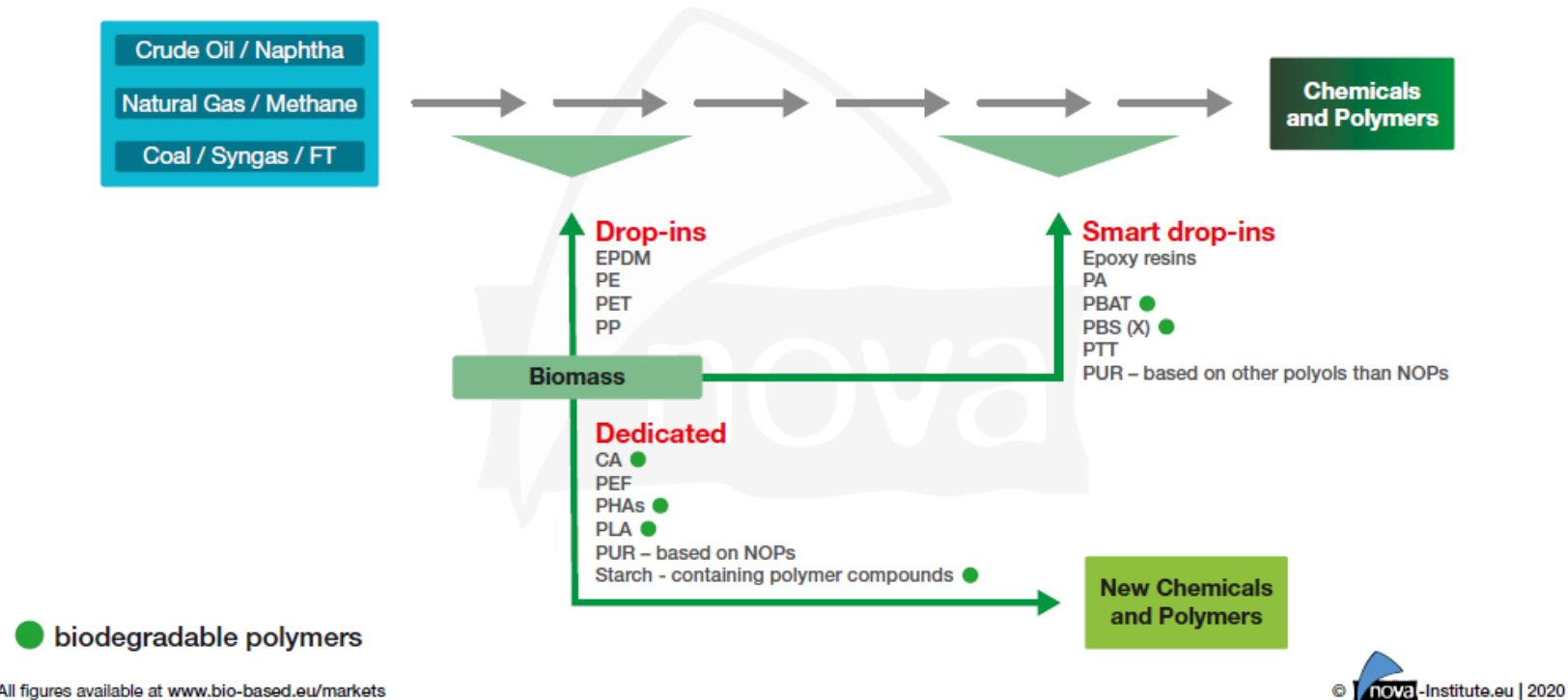
Organic Solution Platform



8 Platforms | Multiple Pathways | High Complexity & Risks For Placing Bets On Winning Technologies

All possible pathways need attention by the industry

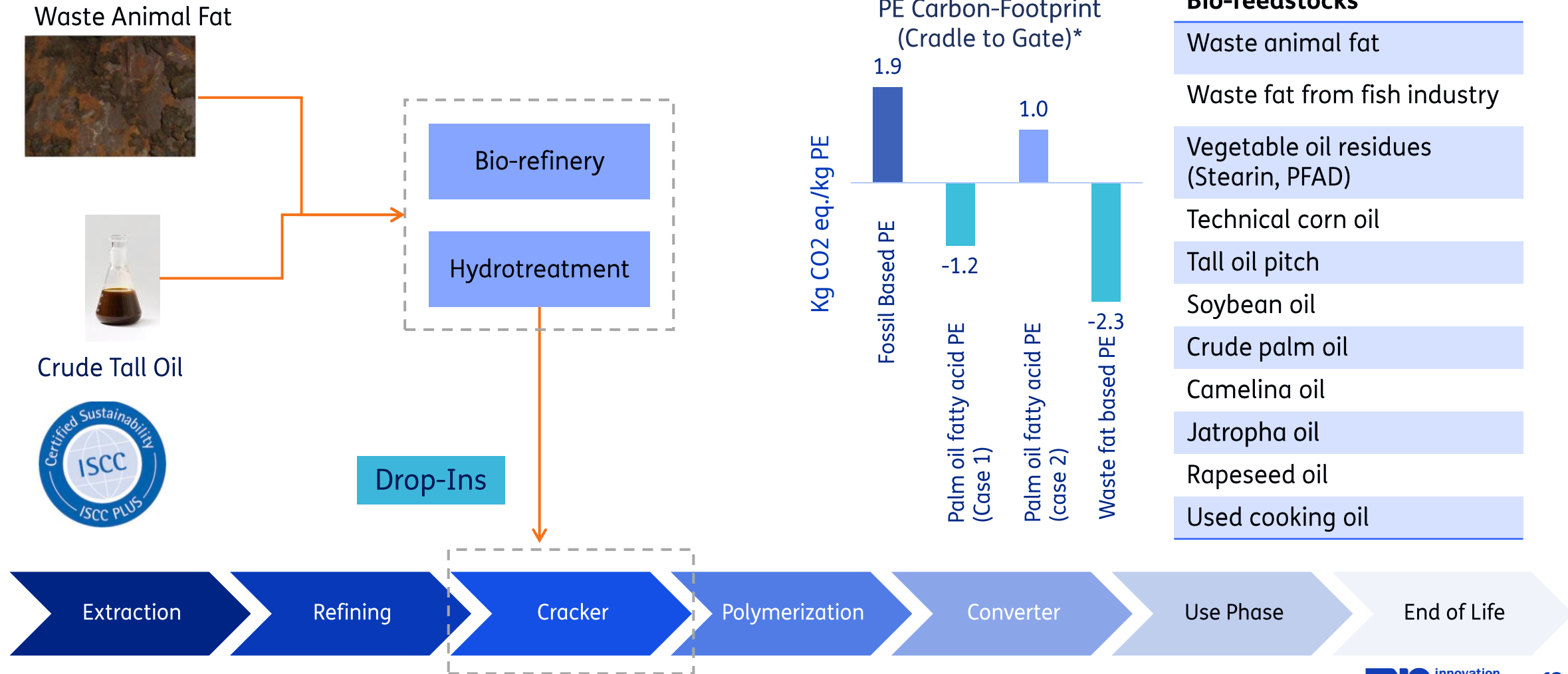
Schematic differentiation of pathways of drop-in, smart drop-in and dedicated bio-based chemicals and polymers



- Smart drop-ins need business development and market pull
- Dedicated bio-based pathways need technology development

Example – biobased drop-ins

Bio-polyethylene from waste animal fat or crude tall oil

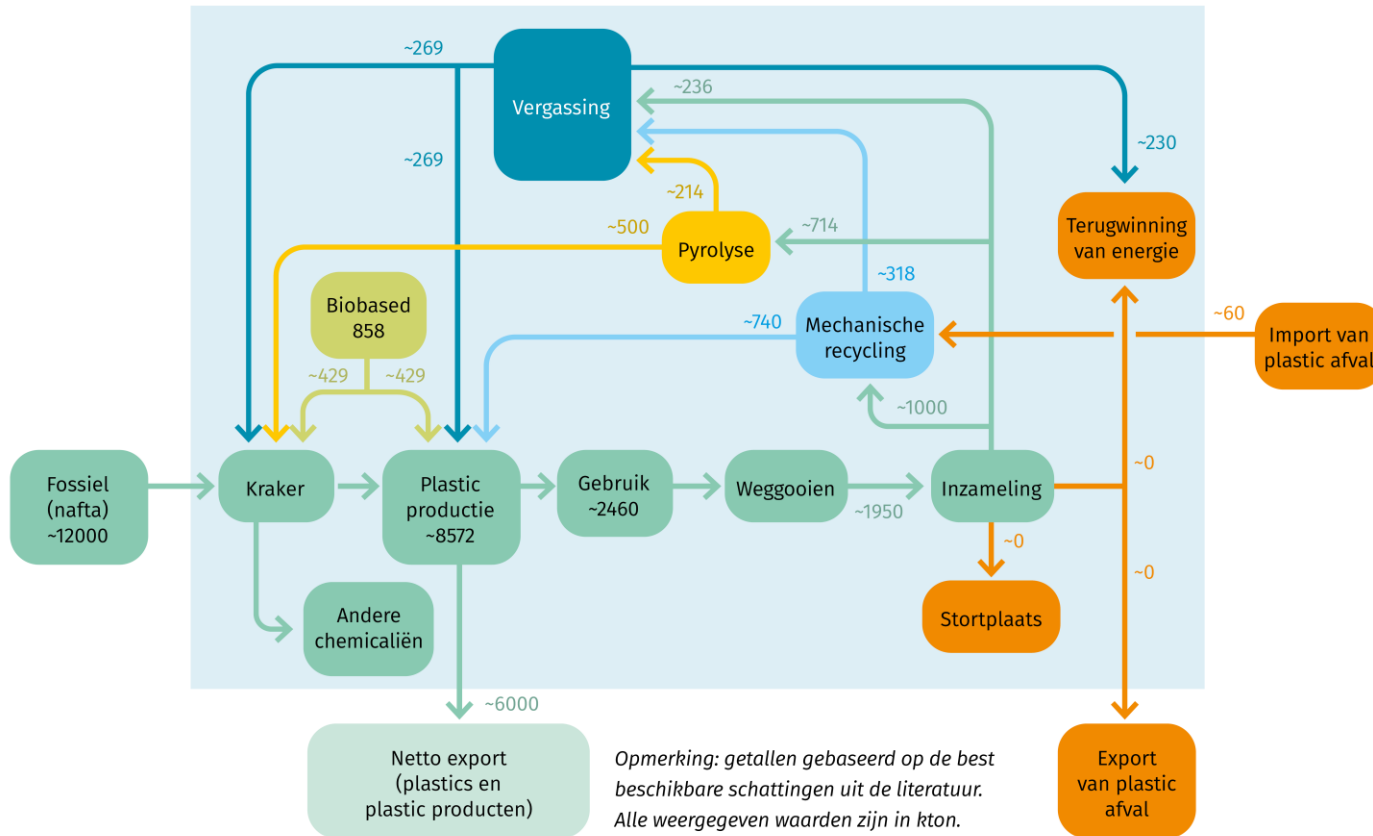


*Literature Report, ICCA Avoided Emissions Case Studies Report, 2017.

Plastics Flows In The Netherlands

2030 Scenario | No Imports Of Waste Plastic Feedstock

Afbeelding 4: Vereenvoudigd schema van de voor 2030 verwachte plastic-stromen in Nederland¹³.



Note: Numbers based on the available estimates from the literature. All displayed values are in kton.

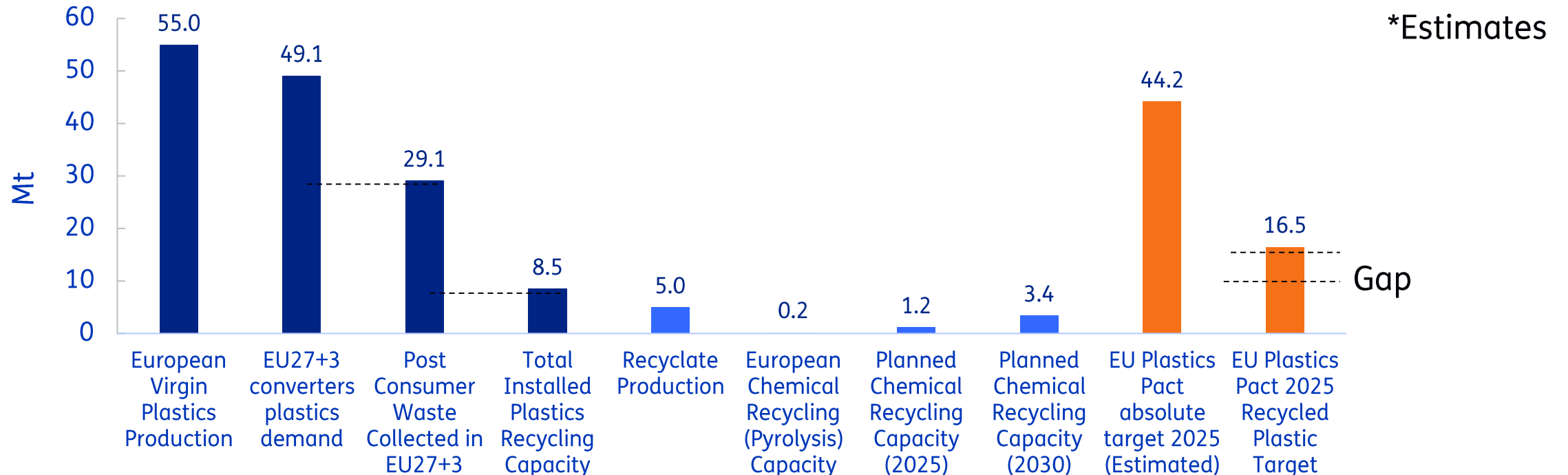
- Efforts to meet circularity targets will contribute towards climate change goals
- However, meeting 2030 circularity goals will likely not be sufficient to meet climate goals for the Dutch petrochemicals industry

Opportunity Size Assessment | The Netherlands

2030 Scenario | No Imports Of Waste Plastic Feedstock

Recycling Technology	Polymers	Existing capacity (Kt)	Maximum opportunity (Kt)	Number of Plants
Mechanical	PP, PP, PS,PET	250-300 (120 HDPE/PP)	700-1000	10-15
Dissolution	PP, PP, PS,PET	-	20-50	1-3
Depolymerisation	PET	20-40	200-400	4-8
Pyrolysis	PP, PP, PS,PET	Demonstration scale	700-1000	4-8
Gasification	PP, PP, PS,PET	Pilot		10-15

Recycled plastics Demand, Capacity Mismatch



- European reprocessing and mechanical recycling have room to scale up significantly.
- Additional recycling capacity is being added rapidly and several announcements have been made for new recycling plants in Europe- mechanical, depolymerization, and pyrolysis.
- However, most of these announcements are for investments after 2025 and 2030 (pyrolysis, depolymerisation, dissolution). Therefore, short to medium term the recycled plastics market will continue to be tight.
- Risk of xx% idle virgin plastic (& cracker) production capacity in Europe by 2030.

Summary

“It is not the strongest, nor the most intelligent species that survive, but the one most responsive to change”
- Charles Darwin

Theme name

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Thank you