Enabling a circular economy for plastics: LCA for Eastman’s advanced recycling solution - Methanolysis

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LCM Conference 2021

Our agenda for today

- **About Eastman:** A materials innovation company
- **Eastman's Circular Economy Solutions**
- **Eastman / CE Delft LCA for Methanolysis technology**
- **Next Steps: independent analysis by Quantis**

A materials innovation company

- Celebrating more than **100 years of vital innovations that enhance people's lives every day.**
- Dedicated to **enhancing the quality of life in a material way**
- **Sustainability** is integral to who we are as a company
- A Fortune 500 company with approximately **14,500 employees and approximately 8.5 billion USD** in revenue

NEW PLASTICS ECONOMY

Global Commitment

U.S. PLASTICS PACT

ENERGY STAR AWARD 2019 PARTNER OF THE YEAR Sustained Excellence

AMERICA'S MOST JUST COMPANIES Forbes 2017

Responsible Care

WSJ 100 MOST SUSTAINABLY MANAGED COMPANIES 2020

TOP 100 BARRON'S Most Sustainable Companies 2021

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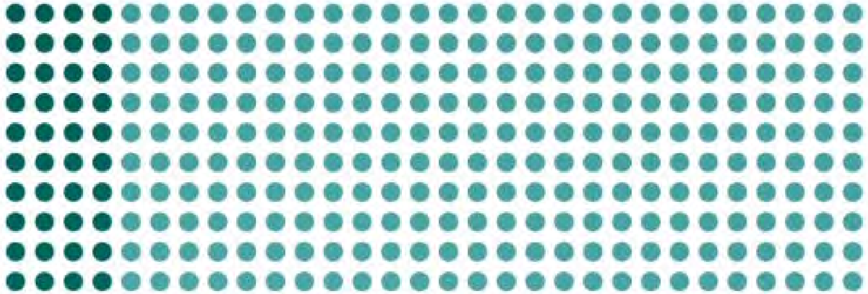
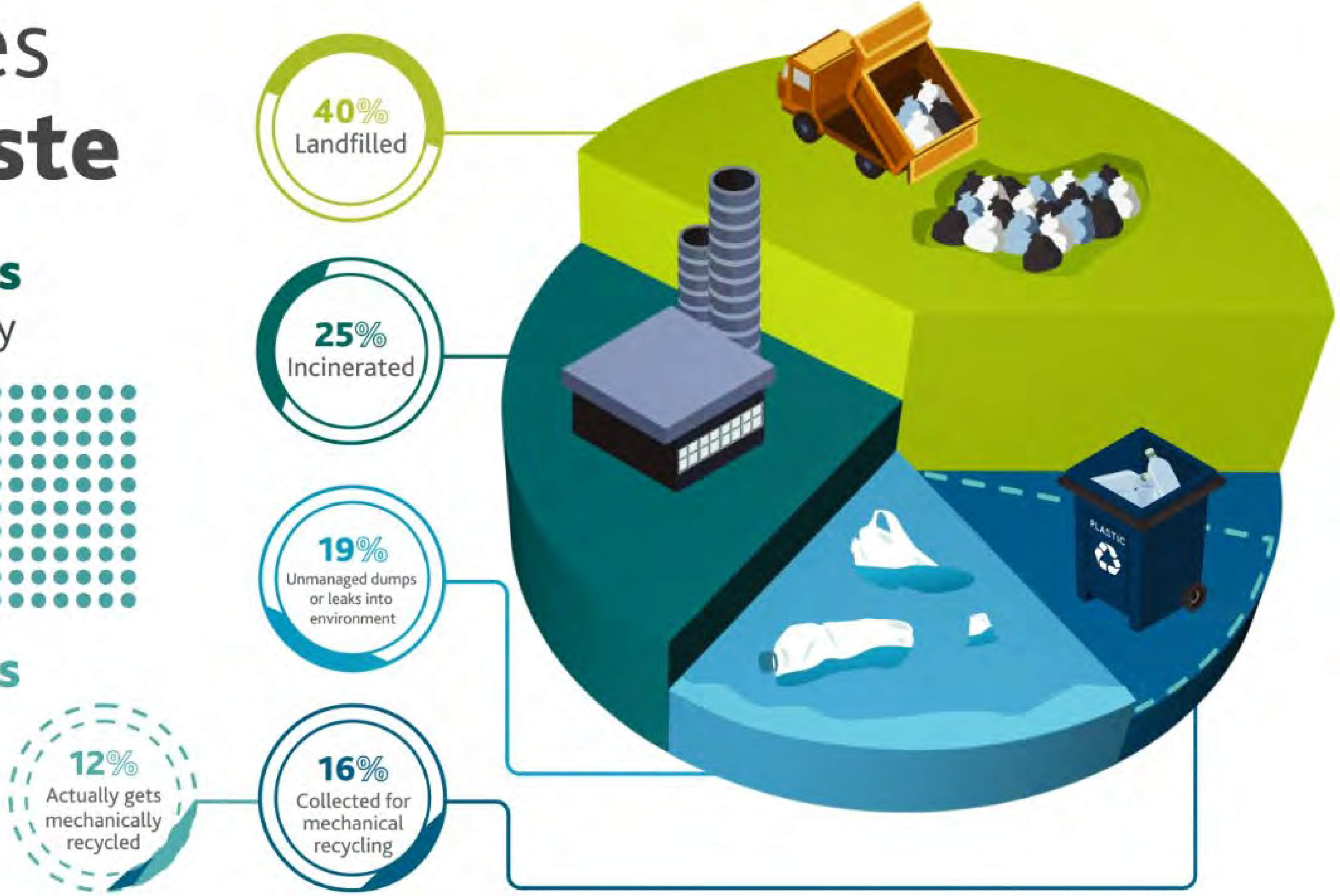
Enhancing the quality of life in a material way

Opportunities **going to waste**

300 million metric tons
of plastics are produced globally



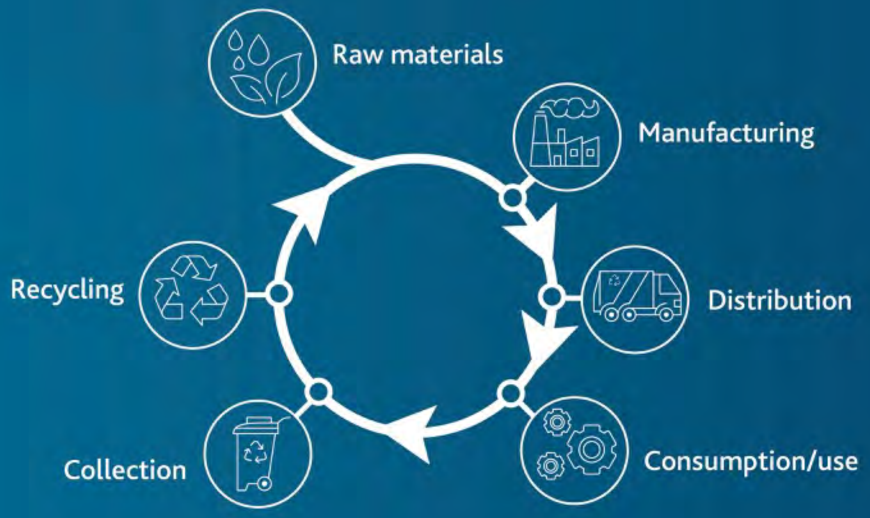
260 million metric tons
of plastics are disposed



Committed to creating change. NOW.

LINEAR ECONOMY
Where we've been

CIRCULAR ECONOMY
Where we're going



MECHANICAL AND MOLECULAR RECYCLING

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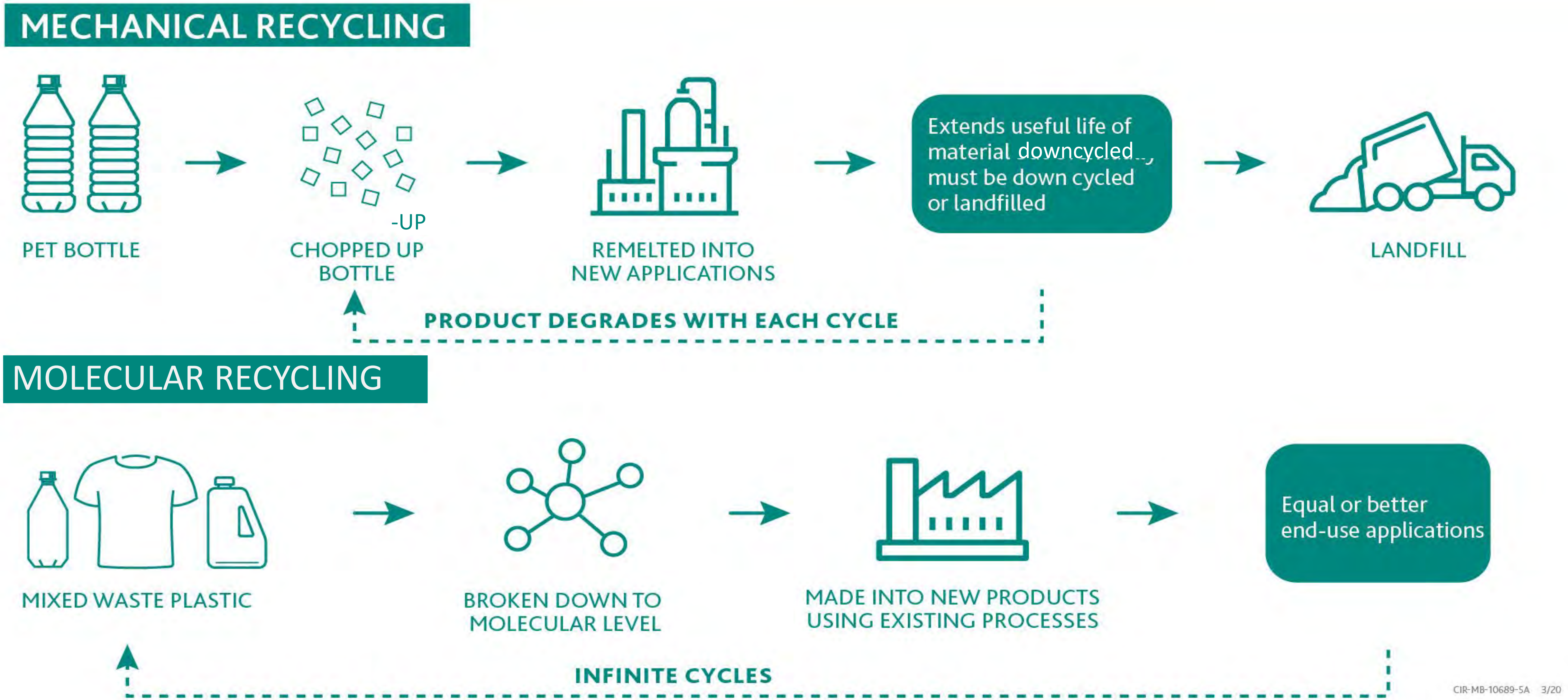
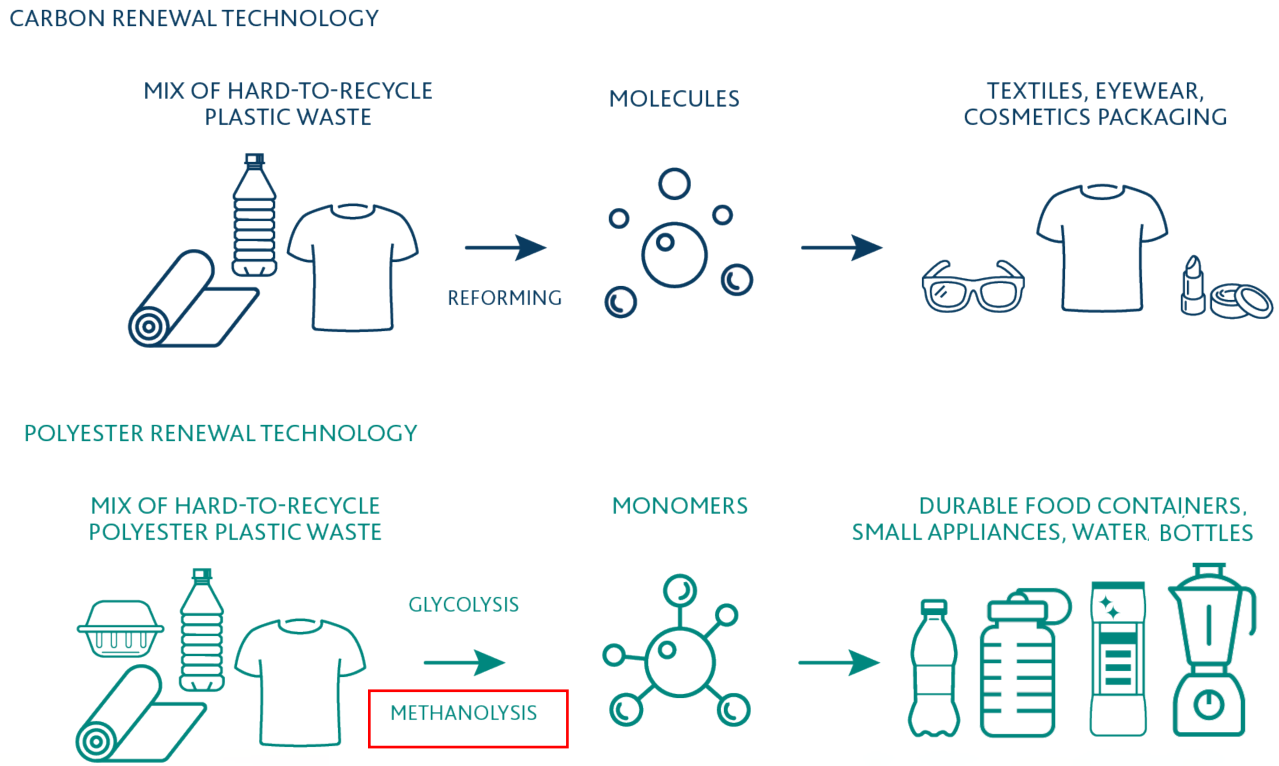


Advancing circular solutions

Already operating at scale, our Advanced Circular Recycling technologies can:

- Process up to **23 thousand tons** of waste plastics—**right now**
- Use **waste plastics as feedstock**, limiting our use of virgin materials and preserving resources
- Have a **lower footprint** than fossil-based processes



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What does 114 thousand metric tons of plastic waste look like?

114,000 metric tons of plastic waste would fill **Johan Cruijff Arena** to the top **MORE THAN TWICE.**
We will be processing this volume of plastic waste each year starting in 2023.

METHANOLYSIS

POLYESTER RENEWAL TECHNOLOGY (PRT)

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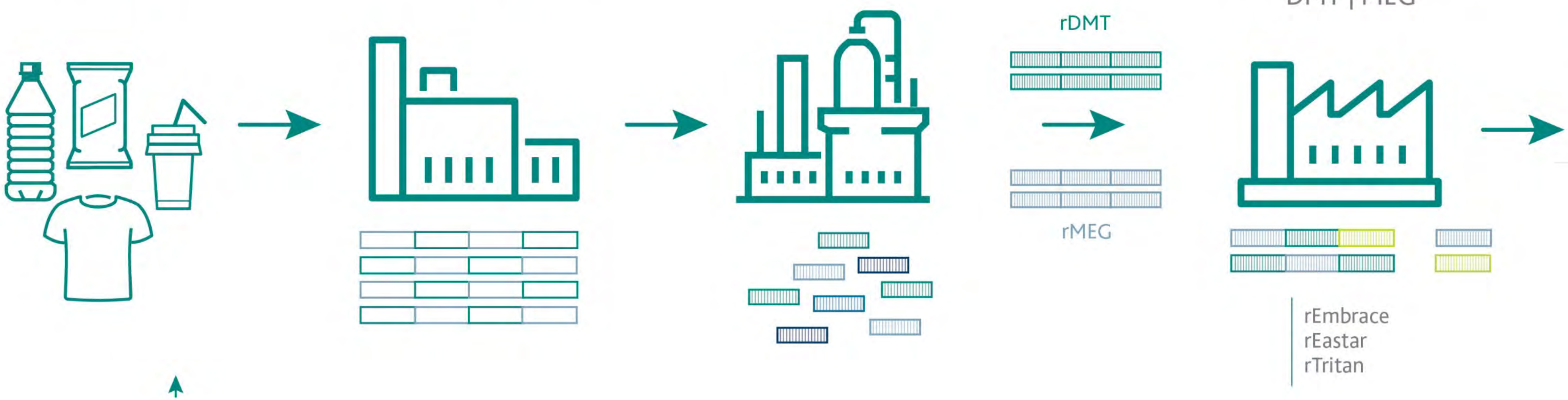
Enables a diverse variety of polyesters, including many that are difficult to mechanically recycle, to be unzipped to their monomers and reassembled into new polyesters with prime performance.

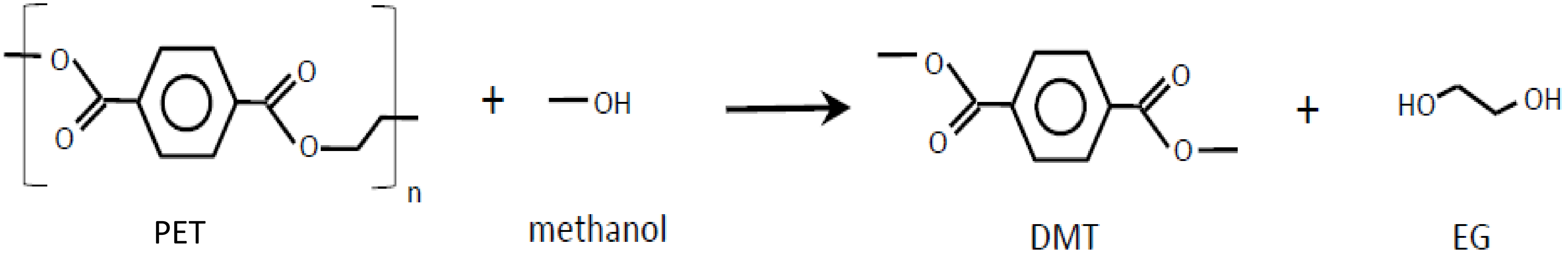
RECOVERED POLYESTER | MECHANICAL PURIFICATION PROCESS | DEPOLYMERIZATION | EXISTING SPECIALTY PLASTICS PRODUCTION

DMT | MEG



Can efficiently source feedstock that diverts waste from landfill
- or -
Create circularity via take back programs with strategic customers

Methanolysis chemistry basics

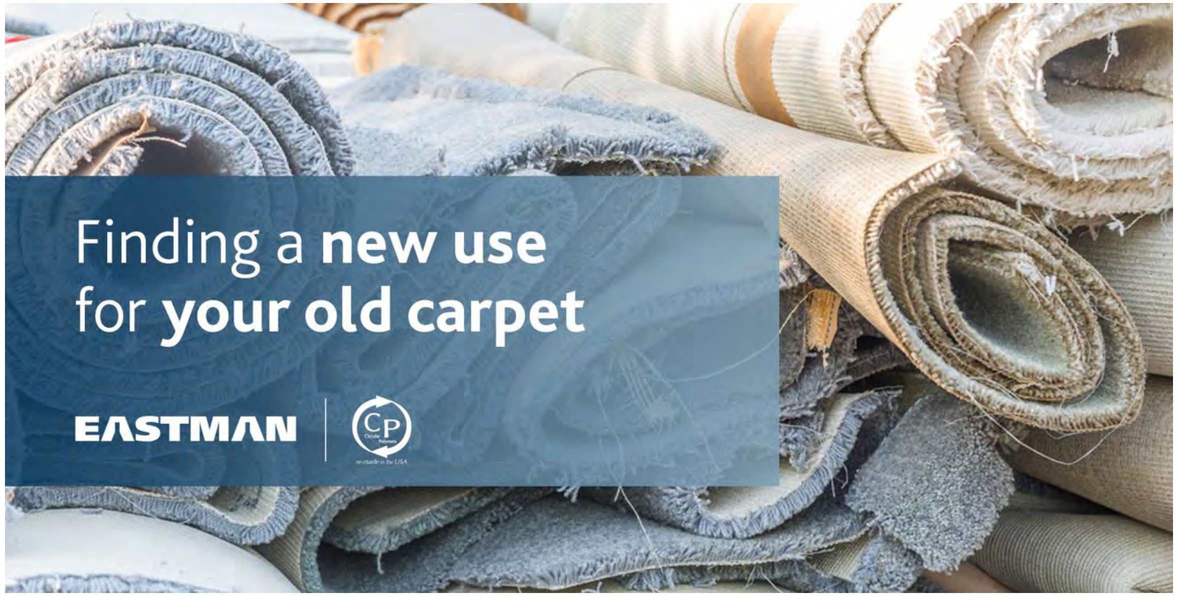


- Methanol is used to depolymerize PET into the monomers DMT & EG
- DMT, EG, and other specialty monomers are used to make specialty copolyester plastics
- When DMT is used to make polyester, it gives off methanol which is internally reused to make more DMT

Difficult-to-recycle polyester wastes

Methanolysis feedstocks will include:

- Polyester carpet fiber
- Polyester-rich fiber waste
- Residues, rejects, and waste streams from mechanical recycling processes
- Polyesters not suitable for mechanical recycling such as mixed colored materials, thermoforms, and copolymers



Colored Bottle Bales

Green Strapping

Purge Chunk Waste

PET Thermoform

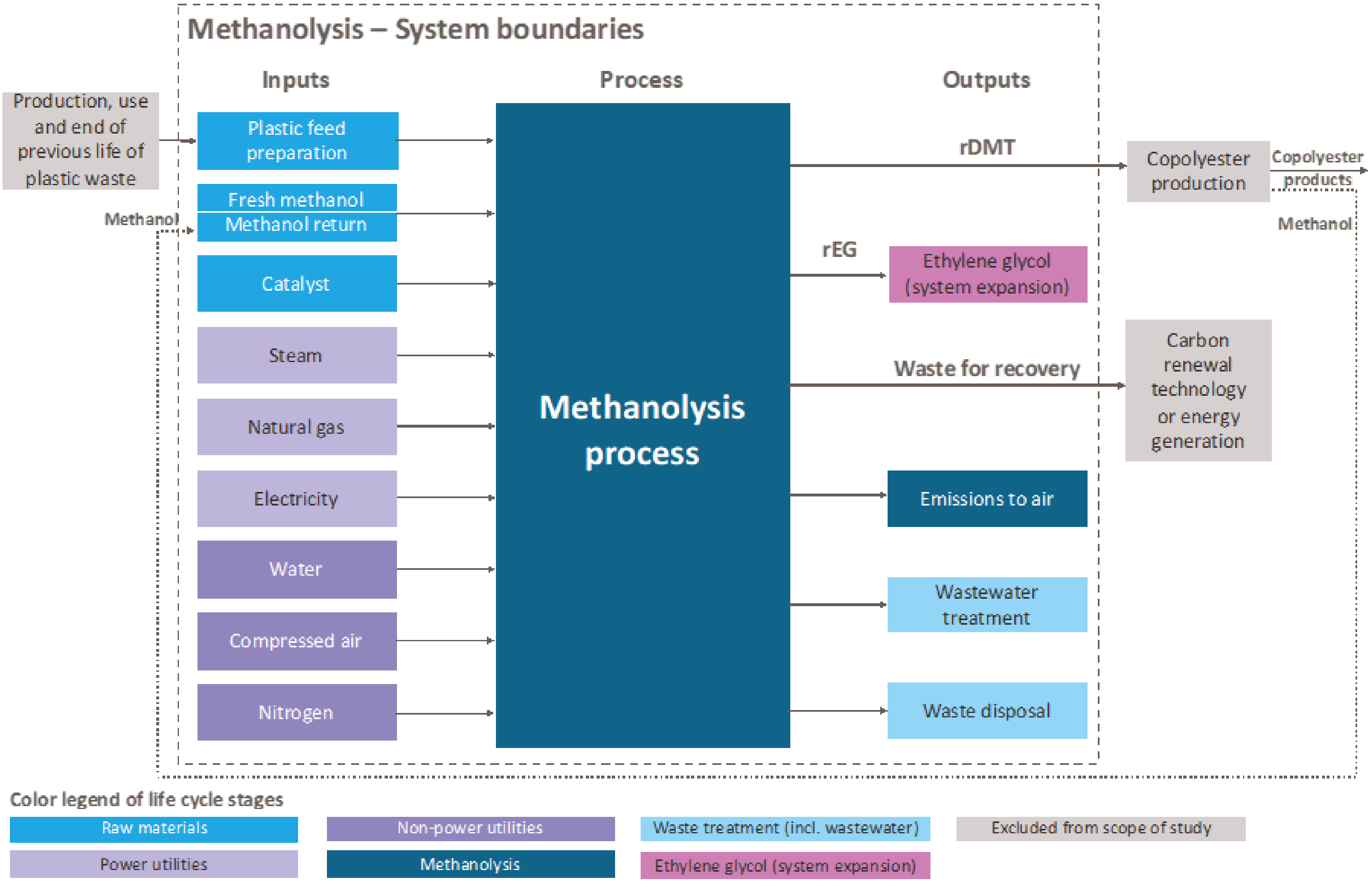
Residues & Rejects

Fibers

LCA for Eastman methanolysis

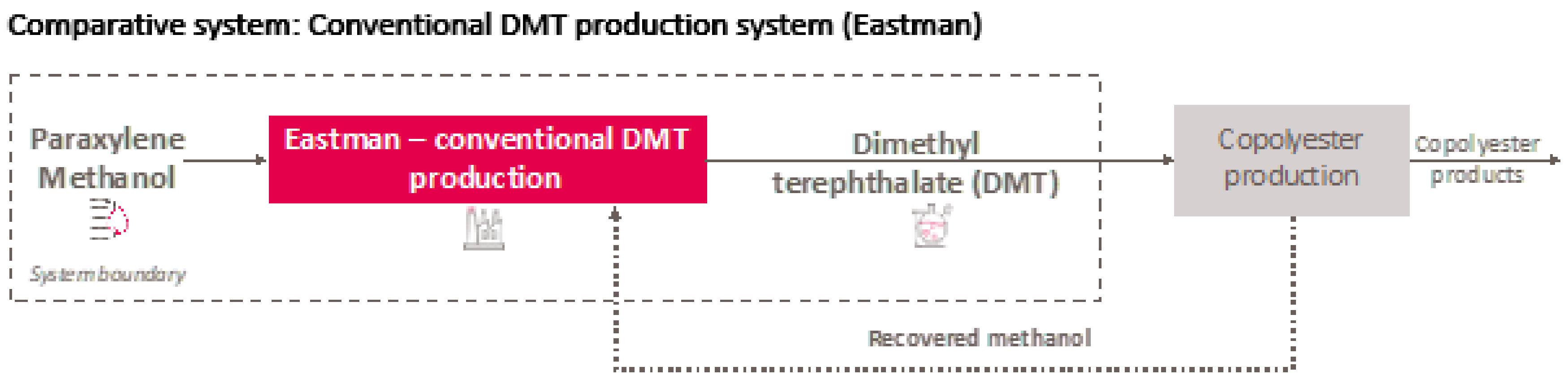
- Goal
  - ISO 14040/14044 conformant cradle-to-gate LCA of recycled dimethyl terephthalate (DMT) produced from polyester waste via Eastman's methanolysis facility (currently under construction)
  - Compare potential environmental impacts of DMT via methanolysis versus conventional DMT produced by Eastman from fossil-based paraxylene in Kingsport, Tennessee, USA
  - Establish a Life Cycle Inventory (LCI) for rDMT made from Eastman methanolysis to use as a basis for developing downstream LCA studies of copolyester products

LCA scope –methanolysis



- Scope conservatively excludes any credit for avoided landfill and incineration of waste plastic inputs
- EG co-product is addressed with system expansion

LCA scope – conventional DMT



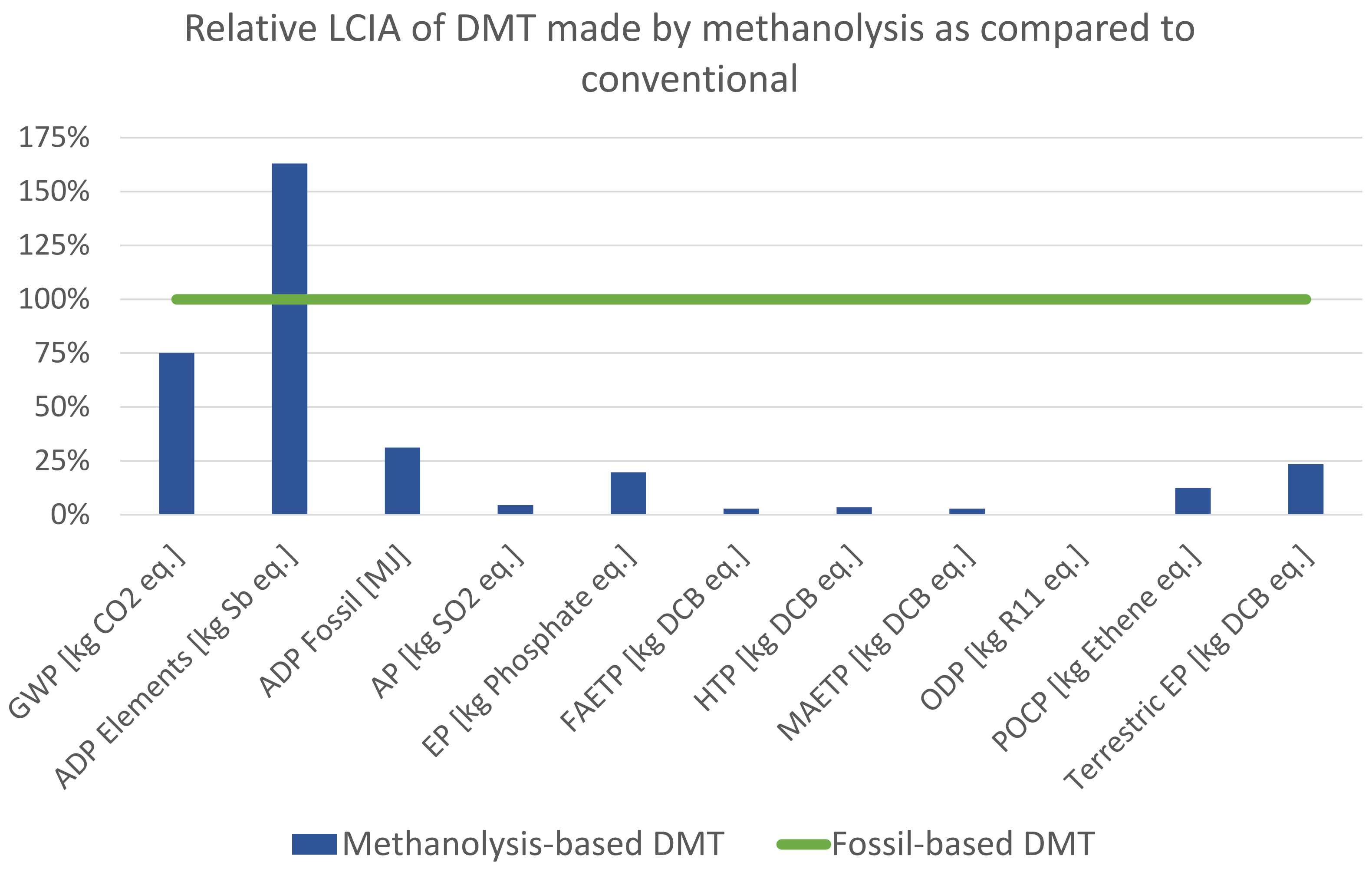
Data and calculation methodologies

- Data sources
  - Methanolysis based on final engineering design and permits for Eastman's **110,000 metric tons-per-year** plant under construction with planned completion by end of 2022
  - Conventional DMT is based on Eastman manufacturing primary data
  - Secondary data from GaBi database where possible, USLCI otherwise
- Use of secondary materials
  - "First responsibility" principle is applied. Plastic wastes carry no environmental burden from previous systems using a "cut-off" approach. Wastes accrue burden for transportation and pre-processing into a suitable form for methanolysis.
- Co-product allocation
  - Allocation between recycled DMT and EG is avoided by use of system expansion via substitution for EG

GaBi software

ISO 14040/14044

Impact assessment summary



- CML2001-Jan 2016 methodology
- Methanolysis is higher in ADP elements due to inventory gap in USLCI paraxylene dataset used in the background of conventional DMT model

Conclusions

- Eastman DMT made by **methanolysis** using waste plastic has a **substantially lower environmental footprint** than Eastman conventional DMT using fossil-based paraxylene
- Methanolysis ranks better in **10 out of 11 CML impact categories**
- The outlier result for ADP elements is questionable due to data gaps in model for conventional DMT
- Methanolysis DMT has approximately **25% lower global warming potential**

By using waste as a raw material instead of conventional fossil-based paraxylene, Eastman's methanolysis can deliver benefits for waste avoidance, climate, and other environmental impacts

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Critical review statement

"The reviewers consider Eastman's LCA of methanolysis in line with the requirements of the ISO 14040:2006 and ISO 14044:2006 standards on life cycle assessment"

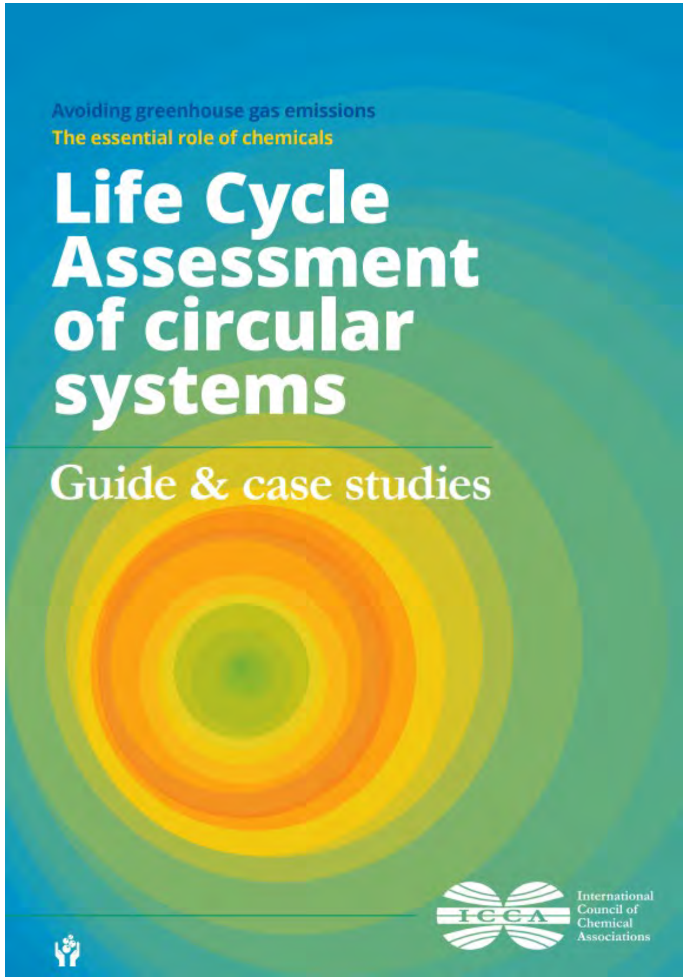
CE Delft

Limitations requested by CE Delft to mention:

- Analysis is based on the best available data from final engineering design, which may differ from operation in practice
- The main environmental claim (that rDMT from methanolysis has a 25% lower carbon footprint than conventional DMT), is based on a comparison to conventional DMT production at Eastman's Kingsport site which could differ from production on other sites or a global/regional average

Challenges with LCA for circular systems

- Allocation between co-products of multi-functional systems
  - such as waste avoidance and material recovery facilities
- Allocation between consecutive product life cycles
  - especially in open loop recycling
- Emerging circular technologies
  - potential for optimization
- Emerging waste supply chains for difficult-to-recycle materials
- Challenges in directly comparing mechanical to molecular recycling due to differences in functionality
  - performing related & complementary but different services



Coming up

- Eastman partnered with Quantis to conduct an independent re-assessment of the LCA for methanolysis

- Quantis- an internationally trusted expert known for its metrics-based approach to sustainability

- Why?
  - Improve transparency and credibility with diverse stakeholders
  - Improve robustness

What's in the upcoming study?

- Updated feedstock mix
- Scenario and sensitivity analysis including:
  - Updated feedstock mixes
  - Potential yield improvements
  - Alternative energy supply: decarbonized electricity
  - Allocation methods of multi-output system and multifunctionality
- Critical review by panel of experts
- Detailed reports summarizing findings
- Status
  - First draft report is complete and ***confirms the conclusions of Eastman's previous study***. Panel review and revision of documentation is pending.

Quantis

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Want more details?

Go to **info.eastman.com/LCA**

Read our Eastman methanolysis LCA technical summary report and get notified when the enhanced **Eastman methanolysis LCA report by Quantis** is released.

Find more resources at Eastman.com/circular