Recycling Supply Tracker – Chemical

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Methodology

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Research methodology

- Online research
- Direct interviews
- Estimates

Current focus on the main process technologies: Thermal Depolymerisation, Chemical Depolymerisation, Dissolution*
Recycling Supply Tracker – Chemical (RST-C) covers projects from Engineering Design to Operating plant stages
RST-C includes both pre-commercial and commercial chemical recycling plants

** Dissolution is not a chemical recycling technology by nature as it does not alter polymers' molecular structure, but it's included into Recycling Supply Tracker – Chemical for the benefit of the customers as one of the advanced technologies complementary to chemical recycling*

Research methodology

Online Research:

- Company website
- Company report
- Press release, news articles and announcements
- Industry and market reports, research papers and journals
- Plastic recyclers directories

Direct Interviews:

- Direct contact with recycling plants: Email and phone calls
- Meeting with industry experts, conferences/events

Criteria for inclusion into Recycling Supply Tracker – Chemical:

- *Plant installed (maximum input) capacity*
  - *Pre-commercial plants:*
    - *Lab: N/A*
    - *Pilot: < 1,000 tpy*
    - *Demonstration: ≥ 1,000 tpy*
  - *Commercial plants: ≥ 15,000 tpy*
- *Project has reached Engineering Design stage*

Estimations methodology

Average process yield (output of recycling product divided by actual input):

- By process (thermal depolymerisation, chemical depolymerisation, solvent-based purification)
- By feedstock: mono-material (based on polymer type), mixed plastic, mixed waste including non-plastics
- By technology (licensor)

Average utilisation rate (actual input divided by installed capacity):

- By plant status (pre-commercial or commercial)
- By country feedstock availability (waste collection and sorting capacities)

Average recycling plant size or range:

- By region (e.g. announced North American plants tend to have larger capacities)
- By start up investment

Output products:

- By process
- By technology
- By feedstock

Additional sources (consultation with experts)

Plants that don't provide any data on their projects are not subject to the estimation methodology. Estimations are made when certain variables are available.

Maintenance and updates

Maintenance: continuous

Announcements of new plants and expansions are updated when notified, on continual basis

Update: quarterly

Plant data will be revised on a quarterly basis including direct contact with companies (where possible), industry experts and further research

Priority given to all plants announced / under construction to check on the status of the plant

Research should:

a. Confirm evolution of a project's lifecycle:
   - Announced status: confirm a plant has moved beyond Feasibility Study and reached Engineering Design stage to be featured on RST-C
   - Under Construction status: confirm a plant has moved from Engineering Design and subsequent Final Investment Decision (FID) stage to construction
   - Operating status: confirm a plant has completed commissioning, started production and is active in the selected year
b. Confirm plant status and type i.e., still pilot
c. Confirm capacity i.e., on track for annual volume entry we have in the dataset
d. Address data gaps i.e., request confirmation on estimated detail we have in the dataset – assuming these plant details can be extracted easily, and we have contact details for the site that are able to provide a response
e. Advise of market position of that site / company and supply country top ten plant listing for comment
f. Confirm licensor and investors (where detail is available)

Key chemical recycling processes

Thermal Depolymerisation / Conversion	Chemical Depolymerisation	Solvent-based Purification
• Pyrolysis • Gasification	• Glycolysis • Hydrolysis • Methanolysis	• Dissolution*

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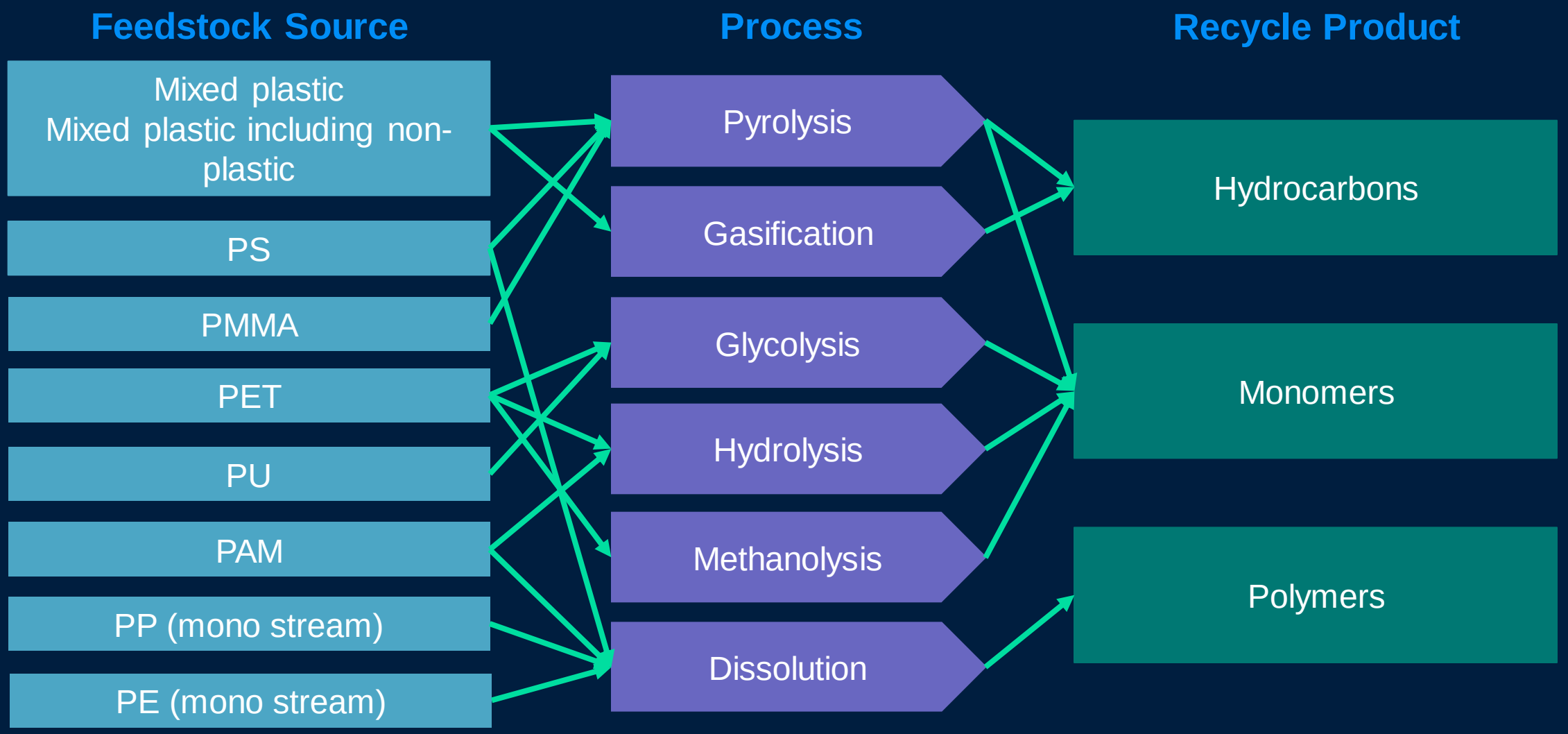
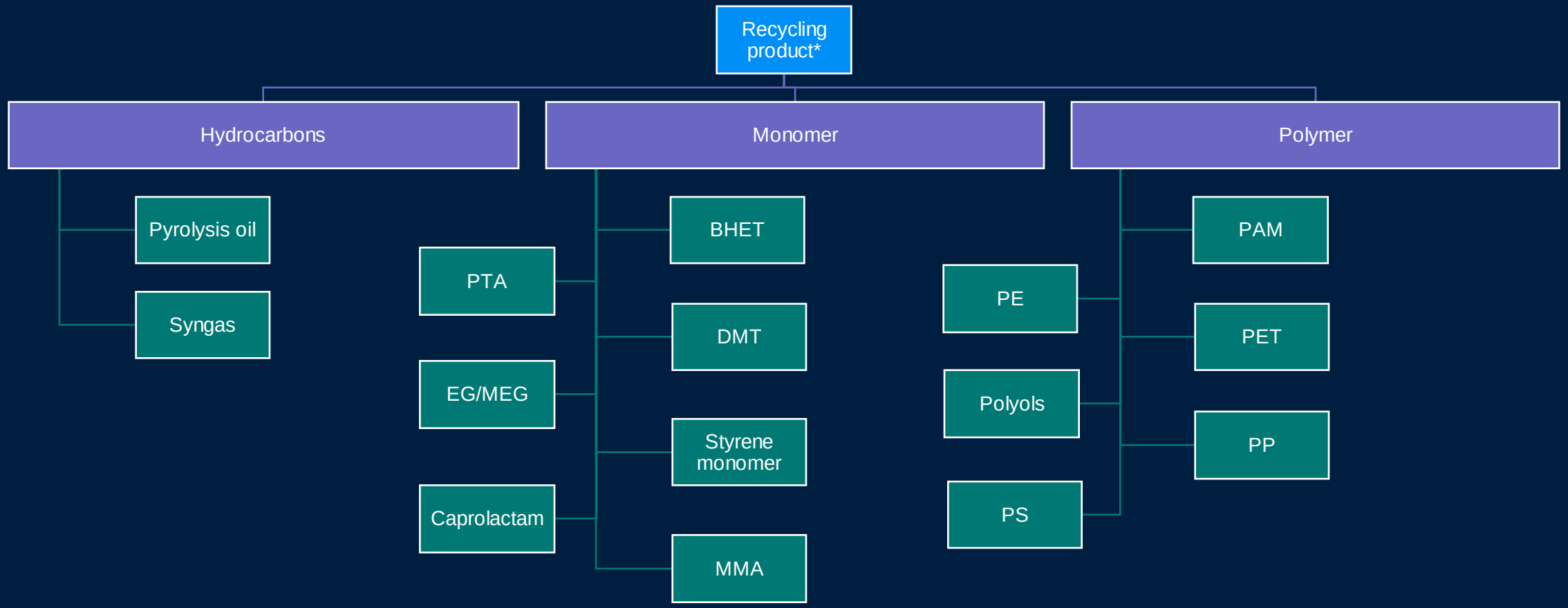
Chemical recycling flows



NB: Only those feedstocks, processes and products which are currently represented on RST-C are listed.
Chemical recycling technologies potentially can process and produce a broader range of products

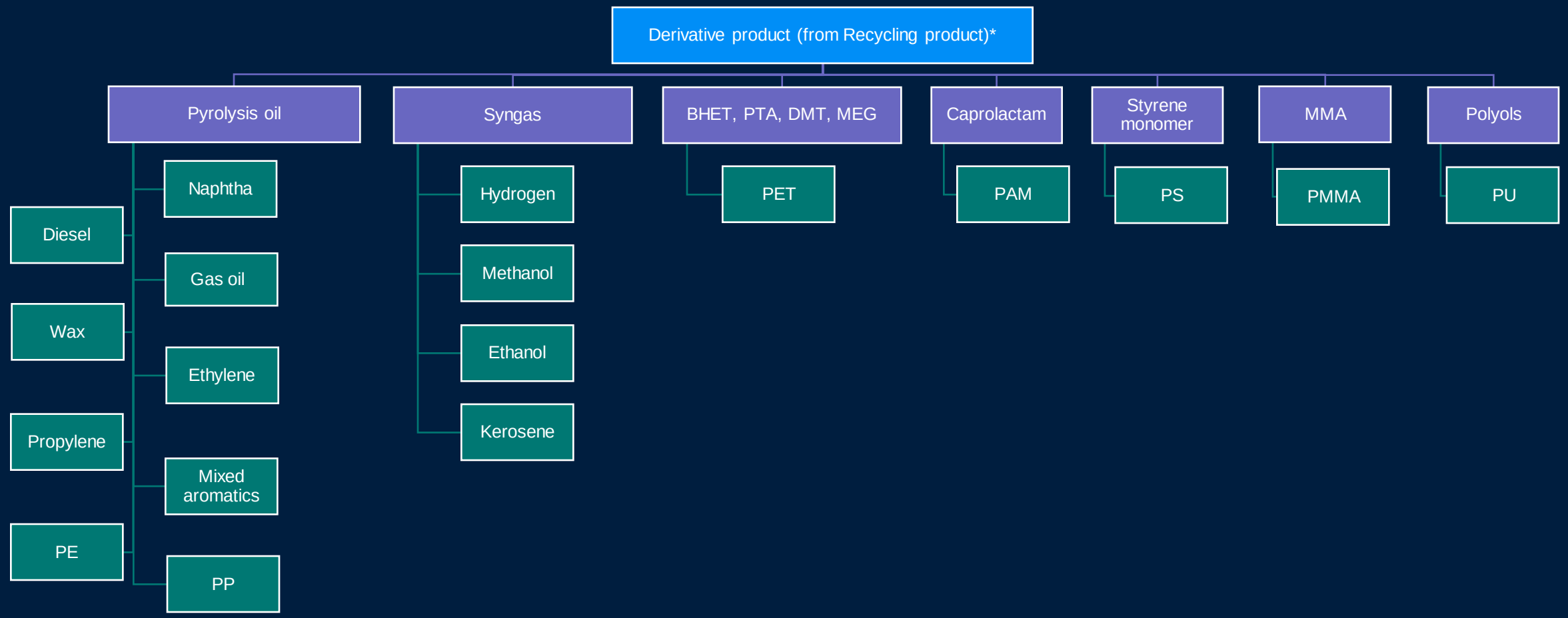
Product profile



** Recycling product is an initial output product from the processing of plastic waste feedstock using thermal depolymerisation, chemical depolymerisation or solvent-based purification recycling technologies*

NB: Only those products which are currently represented on RST-C are listed. Chemical recycling technologies potentially can produce a broader range of products

Product profile (cont.d)



** Derivative product (from Recycling product) is a product from further processing of a recycling product by the same plant/company*

NB: Only those products which are currently represented on RST-C are listed. Chemical recycling technologies potentially can produce a broader range of products

Glossary

RST-C USER INTERFACE

- FEEDSTOCK waste material used as the input material to a reprocessing line
  - MIXED PLASTIC WASTE bales can include various plastic types (HDPE, LDPE, PP, PS, PVC, PET, others), although typically they target, but will not be exclusive to, a specific polymer type. E.g. many pyrolysis-based projects primarily target bales with a minimum of 90% polyolefins content and containing no more than 0.5% PVC content.
  - MIXED PLASTIC WASTE WITH NON-PLASTIC includes all plastic types with non-plastic like organic waste.
  - PAM: Polyamide
  - PET: Polyethylene terephthalate
  - PE: Polyethylene
  - PMMA: Poly(methyl methacrylate)
  - PP: Polypropylene
  - PS: Polystyrene
  - PU: Polyurethane
- MASS BALANCE CERTIFICATIONS are approval systems for mass balance in plastic recycling which document and track recycled content through the recycling process to manufacturing end-product.
  - ISCC PLUS: International Sustainability & Carbon Certification
- PLANT STATUS
  - OPERATING STATUS includes plants which have completed commissioning, started production and is active in the selected year
  - UNDER CONSTRUCTION STATUS includes plants which have already started construction or are undergoing commissioning
  - ANNOUNCED STATUS includes plants under engineering design and plants where a final investment decision has been made but they are still awaiting start of construction
- FOOD GRADE CERTIFICATIONS are approval systems for recycled plastics in food contact applications

Glossary (cont.d)

RST-C USER INTERFACE

- PROCESS
  - THERMAL DEPOLYMERISATION / CONVERSION
    - PYROLYSIS utilises high temperatures in the absence of oxygen, typically at moderate to high temperature (300-900ºC) and at atmospheric pressure to a afford a liquid fraction – pyrolysis oil and other by-products (e.g., gas oil, wax, BTX, etc.).
      - Plasma pyrolysis utilises plasma as an energy source to reduce reaction times significantly through extremely high temperatures.
      - Microwave-assisted pyrolysis increases both temperature and reaction speed by applying microwave while providing more control of the process.
      - Catalytic pyrolysis utilises a catalyst to reduce processing temperatures and increase yields and selectivity of products.
      - Hydrothermal liquefaction, often referred to as hydrous pyrolysis, uses water as a reactant as the need of addition of hydrogen with existence of catalyst in the reaction.
    - GASIFICATION employs low volumes of oxygen to aid the degradation process, typically at high temperatures (700-1,500ºC), converting into a gaseous mixture of CO2, CO, hydrogen, methane, water, and syngas.
  - CHEMICAL DEPOLYMERISATION
    - GLYCOLYSIS is a chemical reaction using excess ethylene glycol in the presence of different simple chemicals acting as catalysts.
    - HYDROLYSIS is a chemical reaction in which water is used to break molecular bonds.
      - Enzymatic depolymerisation uses an enzyme as a catalyst to provide high product yield and selectivity.
    - METHANOLYSIS is a chemical reaction resulting from the interaction of a compound and methanol.
  - DISSOLUTION uses the principle of solubility to selectively separate plastic polymer from contaminants, like additives and non-target polymer(s).

Glossary (cont.d)

- RECYCLING PRODUCT
  - Initial output product from the processing of plastic waste feedstock using thermal depolymerisation, chemical depolymerisation or solvent-based purification recycling technologies
- DERIVATIVE PRODUCT (FROM RECYCLING PRODUCT)
  - Derivative product from further processing of recycling product by the same plant/company

Glossary (cont.d)

RECYCLING PRODUCT

- HYDROCARBON
  - PYROLYSIS OIL is synthesis oil from thermal depolymerisation, considered substitute for petroleum.
  - SYNGAS is short for synthesis gas, used to make ammonia, methanol, other industrial chemicals and fuels.
- MONOMER
  - BHET: Bis(2-Hydroxyethyl) terephthalate
  - CAPROLACTAM: An intermediate primarily used in the production of nylon 6 fibres and resins.
  - DMT: N,N-Dimethyl terephthalate
  - EG: Ethylene Glycol
  - MEG: Mono-Ethylene Glycol is one of EG (Ethylene Glycol) family
  - MMA: Methyl methacrylate
  - PTA: Purified Terephthalic Acid
  - STYRENE MONOMER
- POLYMER
  - PAM: Polyamide
  - PE: Polyethylene
  - PET: Polyethylene terephthalate
  - POLYOLS: Polyester and polyether polyols used in the production of rigid and flexible (foam) polyurethane
  - PP: Polypropylene
  - PS: Polystyrene

DERIVATIVE PRODUCT (FROM RECYCLING PRODUCT)

- PYROLYSIS OIL
  - DIESEL
  - ETHYLENE
  - GAS OIL
  - MIXED AROMATICS includes benzene, toluene and xylenes (BTX)
  - NAPHTHA is a fraction of crude composed of different mixtures of flammable liquid hydrocarbons, used either for blending into gasoline or as a petrochemical feedstock in the manufacture of olefins.
  - PE: Polyethylene
  - PP: Polypropylene
  - PROPYLENE
  - WAX refers to paraffin wax that is a mixture of hydrocarbon molecules containing between twenty and forty carbon atoms.
- SYNGAS is short for synthesis gas, used to make ammonia, methanol, other industrial chemicals and fuels.
  - HYDROGEN
  - ETHANOL
  - KEROSENE
  - METHANOL
- BHET, PTA, DMT, MEG
  - PET: Polyethylene terephthalate
- CAPROLACTAM
  - PAM: Polyamide
- STYRENE MONOMER
  - PS: Polystyrene
- MMA: Methyl methacrylate
  - PMMA: Poly(methyl methacrylate)
- POLYOLS
  - PU: Polyurethane

Thank you

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