A European vision on chemical recycling

Workshop PSYCHE INTERREG PROJECT

Charleroi - 8 May 2019

PlasticsEurope
Association of Plastics Manufacturers

Who is PlasticsEurope ?

PlasticsEurope
Association of Plastics Manufacturers

PlasticsEurope is a pan-European organisation (with more than 100 member companies) representing plastics manufacturers at European, regional and national level

HEADQUARTERS – Brussels, Belgium

NORTH
London, UK

- Denmark
- Estonia
- Finland
- Ireland
- Latvia
- Lithuania
- Norway
- Sweden
- UK

MEDITERRANEAN
Milan, Italy

- Bulgaria
- Croatia
- Cyprus
- Greece
- Italy
- Malta
- Romania
- Turkey

CENTRAL
Frankfurt, Germany
Warsaw, Poland
Vienna, Austria

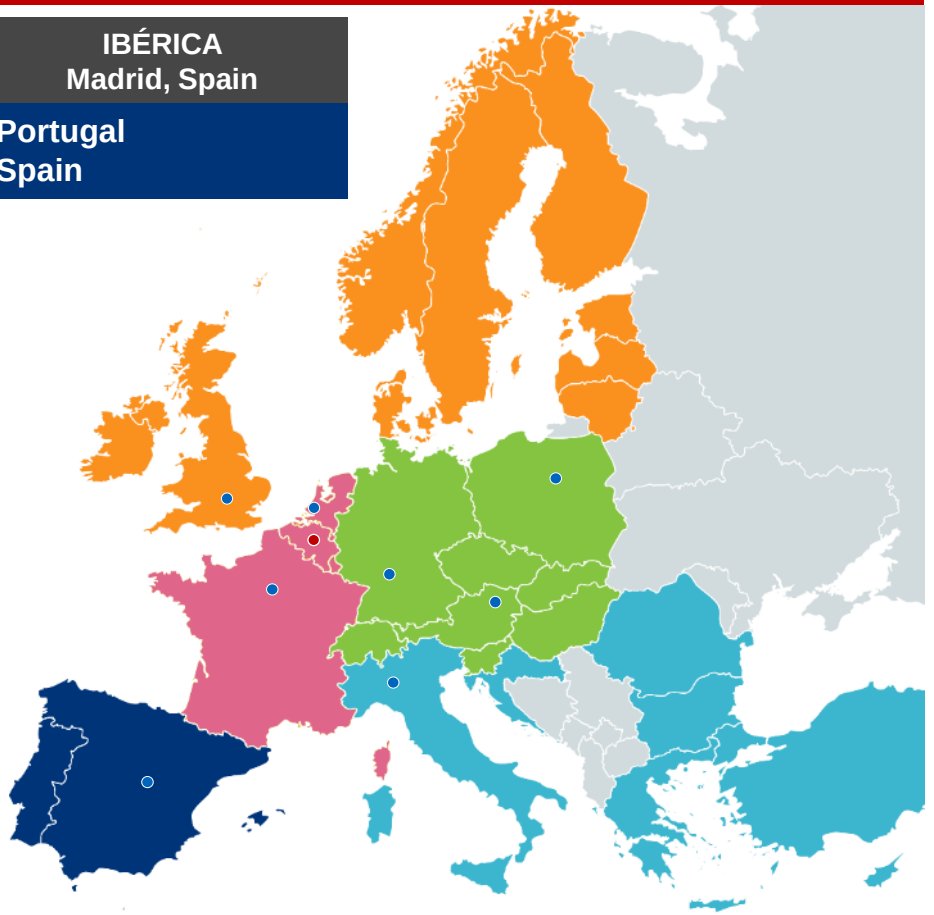
- Austria
- Czech Republic
- Germany
- Hungary
- Poland
- Slovakia
- Slovenia
- Switzerland

WEST
Paris, France
The Hague, Netherlands

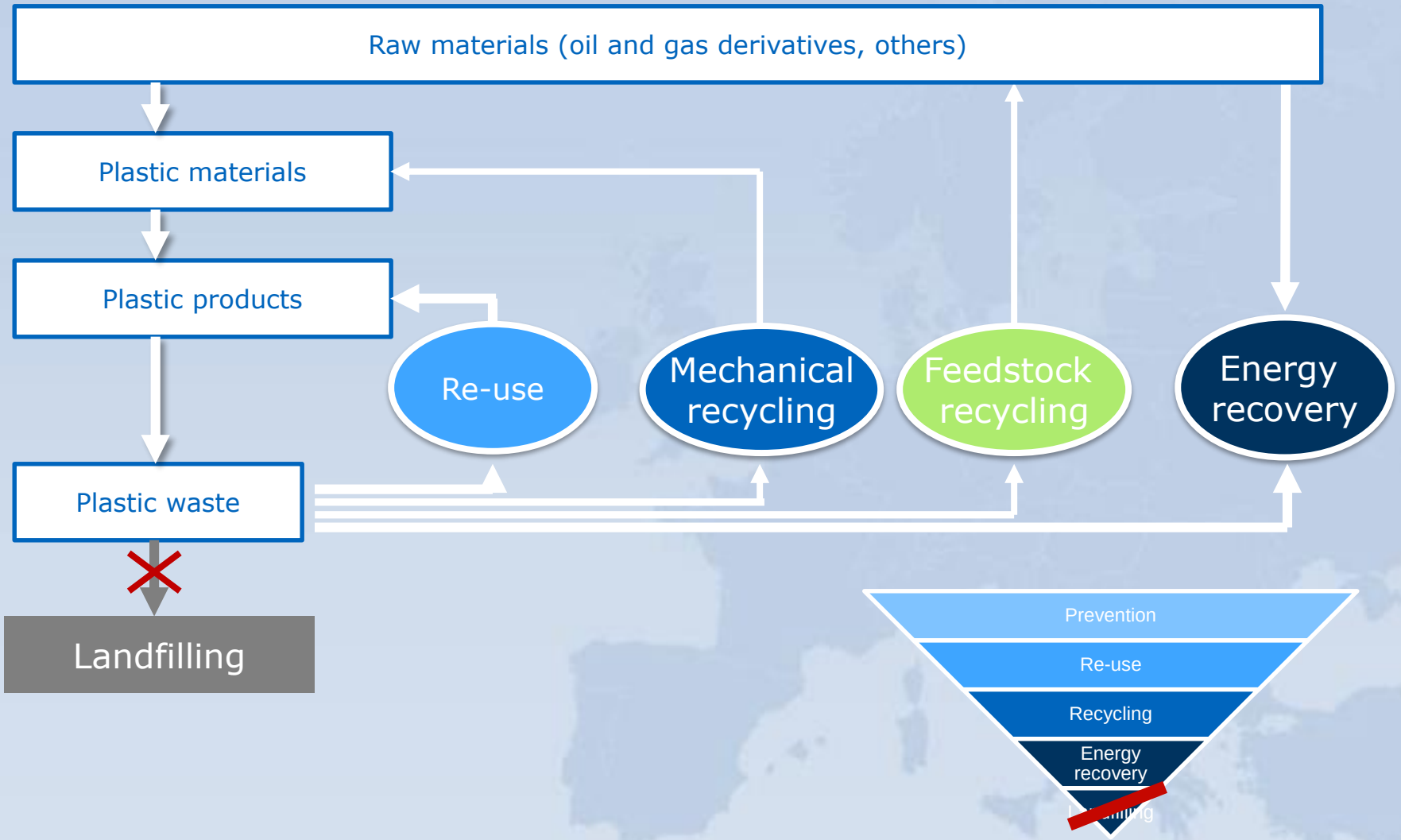
- France
- Belgium
- Luxembourg
- Netherlands

IBÉRICA
Madrid, Spain

- Portugal
- Spain



Recovery options of plastic waste



Management of post-consumer plastic waste in Europe (UE 28+2) in 2016

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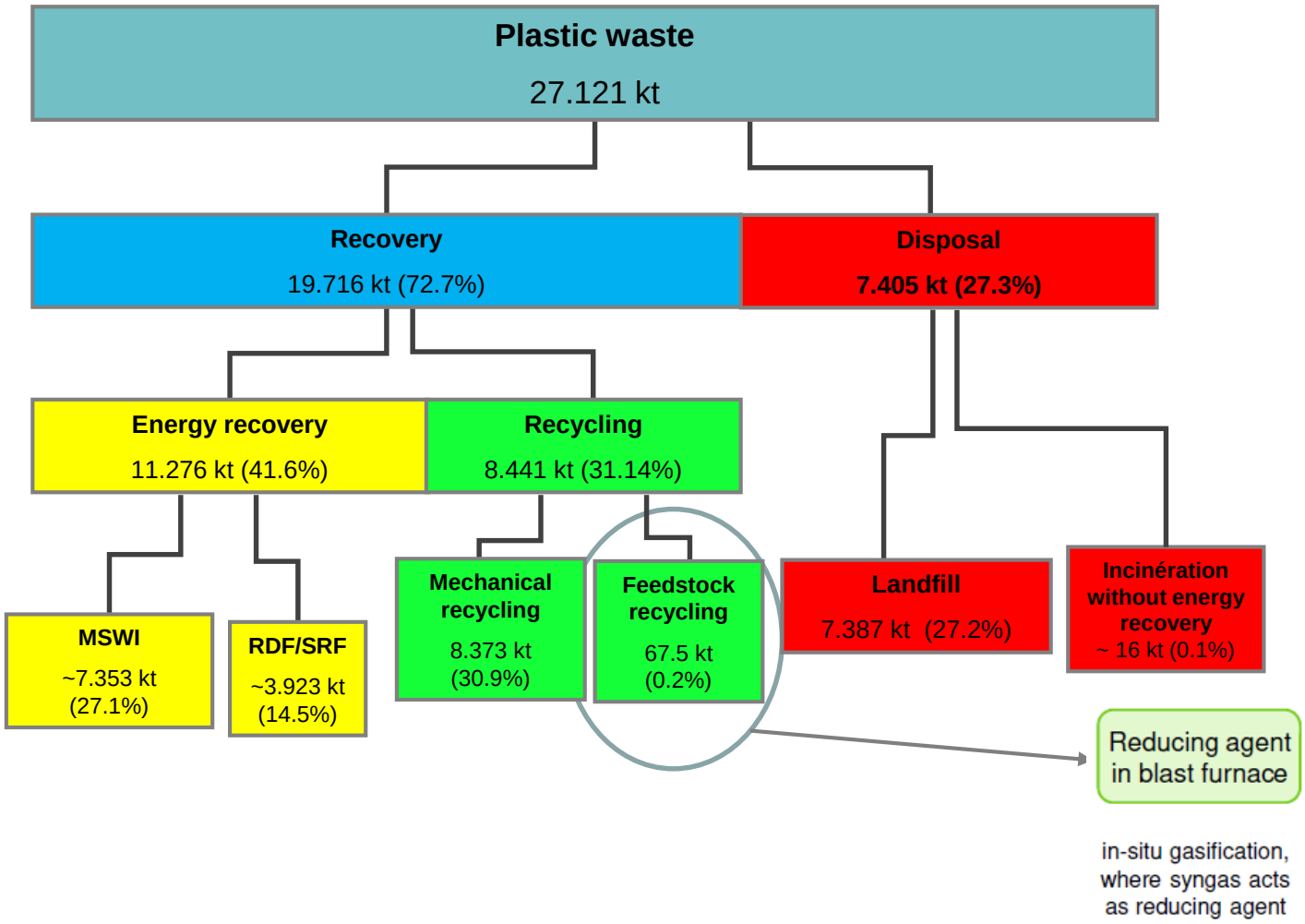

Source: Conversio Market & Strategy GmbH

Plastic cycle in Europe (2016)

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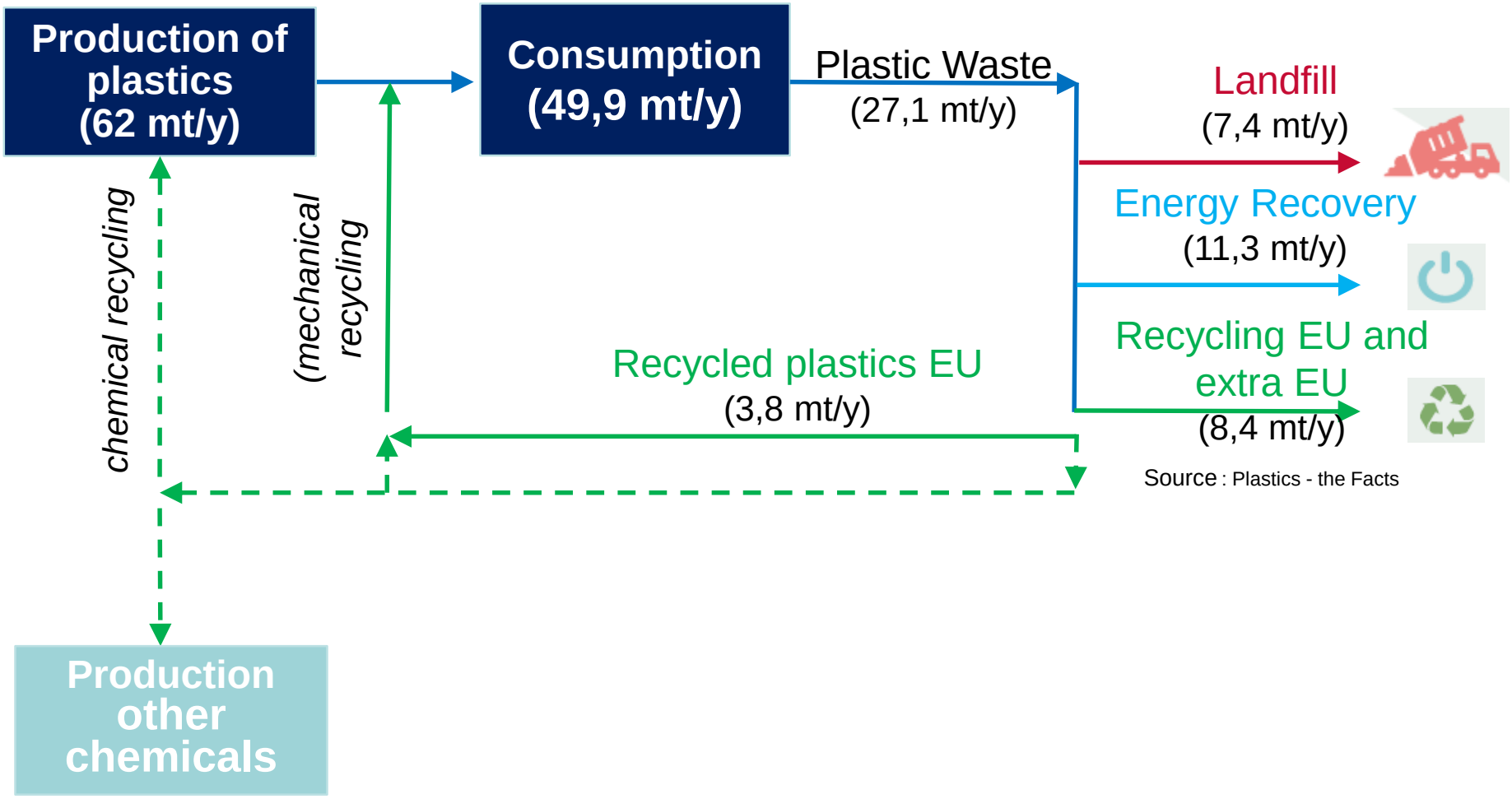

Source : Plastics - the Facts

New challenging targets for the management of plastics waste in Europe

PlasticsEurope
Les producteurs de matières plastiques

- Regulatory targets of the recently revised waste directives
  - ➢10% max landfilling of municipal waste by 2035
  - ➢50% recycling of plastic packaging by 2025 and 55% by 2030
- Aspirational targets of the European strategy for plastics in a circular economy
  - ➢50% plastic waste recycled by 2025
  - ➢10 Mt of plastic recyclate used in Europe by 2025
- Voluntary target of our industry (Plastics 2030)
  - ➢60% plastic packaging reused and recycled by 2030

Speeding up innovation and industry collaboration are key

Definition of feedstock / chemical recycling

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ISO 15270 Plastics – Guidelines for the recovery and recycling of plastics waste

"**conversion to monomer or production of new raw materials by changing the chemical structure of plastics through cracking, gasification or depolymerisation, excluding energy recovery or incineration**"

- → It implies a change of the chemical structure of the polymer and its cracking into base molecules (e.g. monomer, syngas, oils)
  This definition does not cover other technologies, of a more physical nature, such as dissolution
- → It excludes cases where plastic waste is converted into fuels used for energy purposes (it is also the regulatory status set by the Waste Framework Directive)

Recycling Processes for plastic waste

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Physical / Mechanical processes
- Polymer

Chemical processes
- New chemical

Mechanical

Dissolution (solvent extraction)

Solvolysis
- Monomer

Depolymerisation
- Monomer

Pyrolysis
- Syncrude

Gasification
- Syngas

For sorted / defined polymer waste (PET, PS, PA, etc)

For mixed / soiled plastic containing waste

Study on feedstock recycling thermal processes (pyrolysis, gasification)

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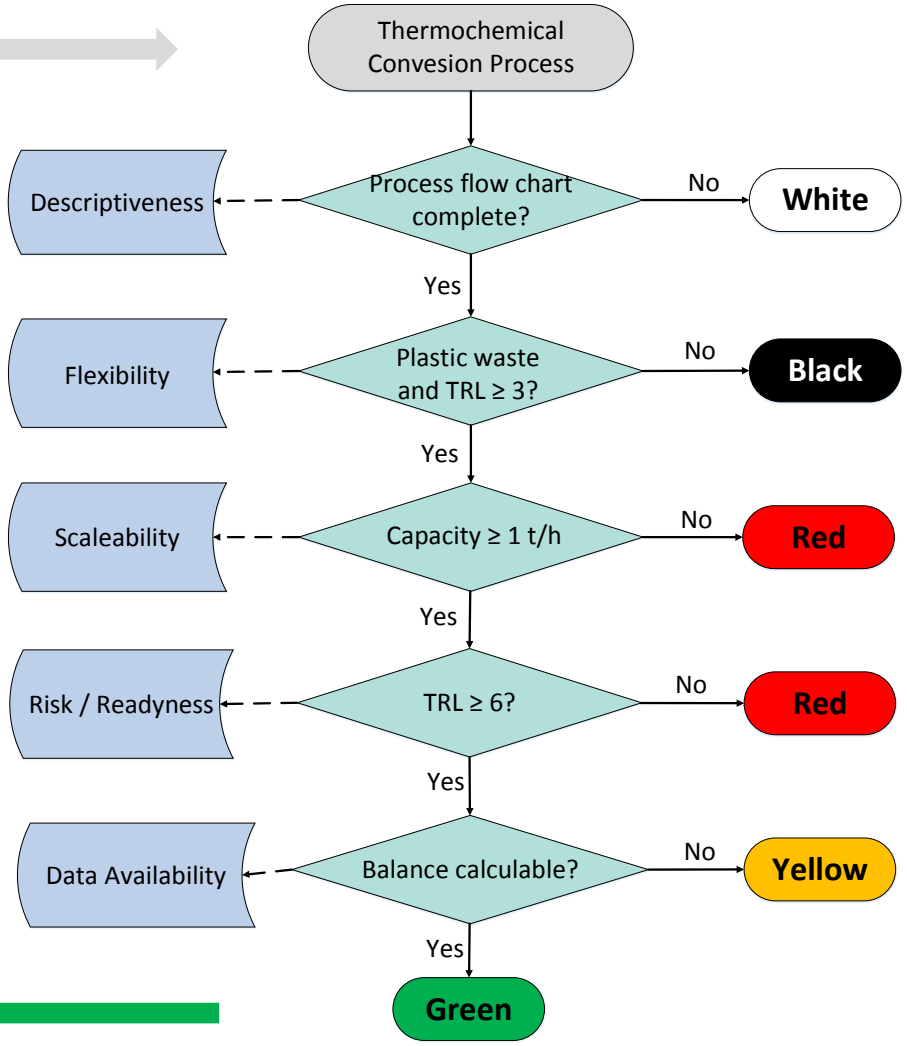
- Inventory and evaluation of the existing available thermal processes Selection of the most suitable ones (flexible, scalable, ready to be evaluated) and definition of the required input quality
- Determination of the composition (quantity, quality) of possibly 5 relevant waste streams, in several countries including Germany
  a. Residual household waste
  b. Sorting residues (plastics household packaging separate collection)
  c. Shredder residues E+E (small appliances)
  d. Shredder residues from large shredders (ELV & E+E large household appliances, excl. fridges)
  e. Construction waste, incl. EPS/XPS (high calorific mixed waste, excl. minerals)
- Evaluation of the pre-treatment operations and related costs applicable to German waste streams to be used as input into selected feedstock recycling processes
- Economic assessment of the treatment costs of the most suitable processes for the relevant waste streams generated in Germany

Selection of Processes Suitable for Plastic Waste

Criteria, procedure, results

35	Gasification Processes
4	Gasification & Melting Processes
6	Metallurgical Processes
4	Plasma Processes
29	Pyrolysis Processes
6	Liquefaction Processes



3 (4) Gasification Processes:

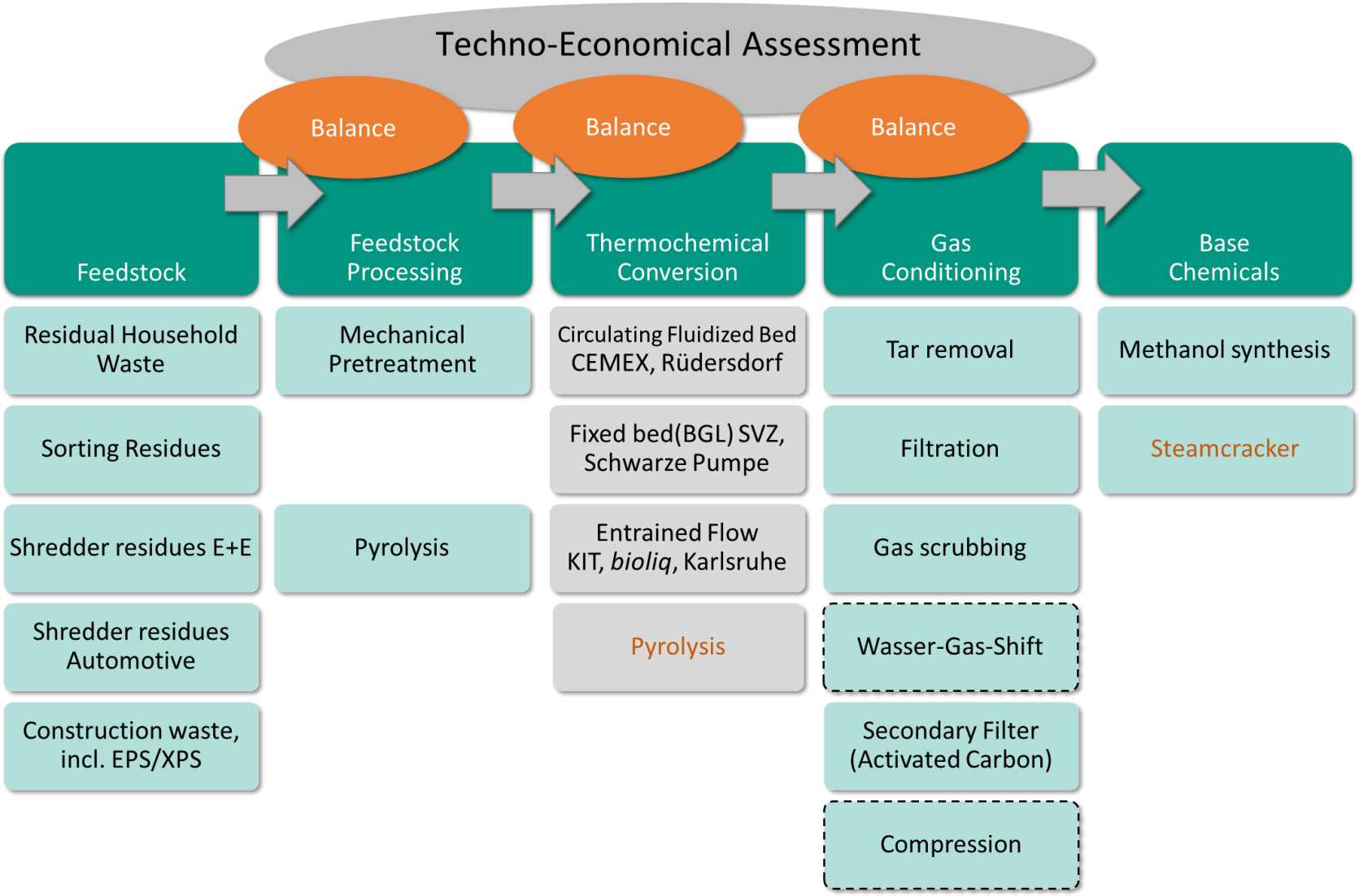
British-Gas Lurgi (BGL)
SVZ (Schwarze Pumpe, Germany)

Circulating Fluidized Bed
CEMEX (Rüdersdorf, Germany)

bioliq Entrained Flow
KIT (Karlsruhe, Germany)

Project Scope Overview

Waste-to-chemicals process chains



Process Overview:

Technology availability and Risk

Process	Pretreatment Feedstock	Conversion	Upgrading Rawgas / crude	Product utilization
Fixed Bed Gasification (BGL)	9	8	7	MeOH-Synthesis
Fluidized Bed Gasification (CFB)	9	8 - 9	7	MeOH-Synthesis
Entrained Flow Gasification (EFG)	5 - 6	6	9	MeOH-Synthesis
Pyrolysis	9	5 - 6	3	Steamcracker

- TRL 3: applied research
- TRL 5: large scale prototype
- TRL 6: prototype system
- TRL 7: demonstration system
- TRL 8: first of a kind commercial system
- TRL 9: full commercial application

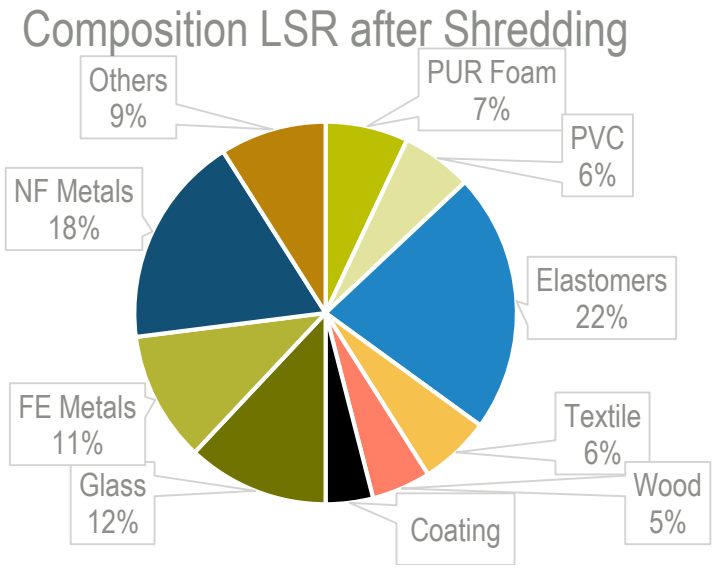
Pyrolysis & Gasification Technology

- BGL, CFB gasifier:
  - Key technical issue:
    - Optimization and reliable operation of syngas post-processing unit (Tar removal, plugging, etc.)
- EF gasifier:
  - Key technical issue:
    - Waste pretreatment for feed-in (e.g. by pyrolysis)
- Rotary kiln pyrolysis unit:
  - Key technical issues:
    - Design, optimization and reliable operation of a product condensing system (Plugging, polymerization, etc.)
    - Cost of pyrolysis product post-treatment systems
    - Optimization of a pyrolysis unit that assures multiproduct quality (organic condensate as cracker feedstock, solids quality) in line with required feedstock flexibility

Analysis Waste Streams:
d) Shredder Residues from Large Shredders (ELV & large E+E Appliances, excl Fridges)

- Residues from large shredders, processing ELV and large household appliances after separation of precipitable fractions (e.g. metal).
- Plastics account for about 35% of SLF
- Calorific value ~ 13 MJ/kg

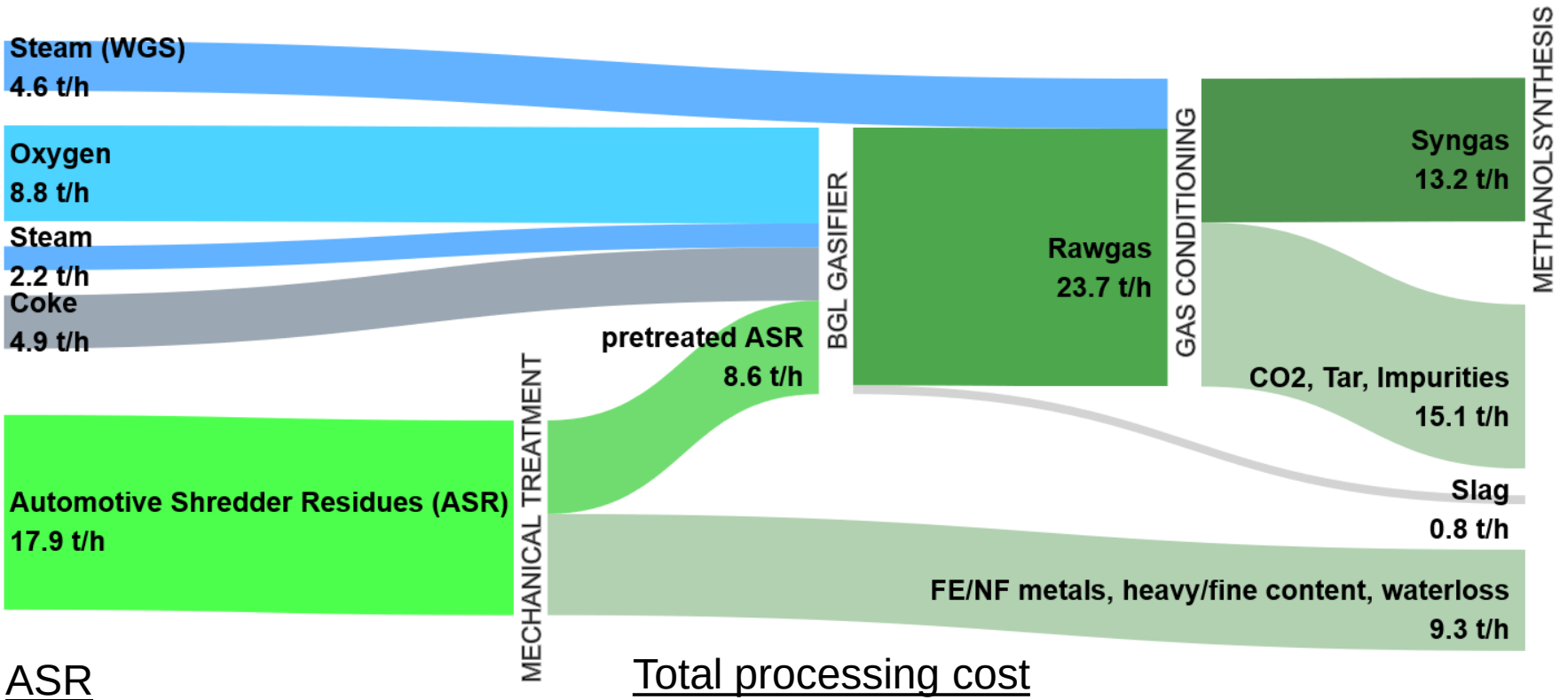
Country total quantity (2015)	**451 kt** (Large shredder residues)
Price FOB (2016, €)	150 €/t



Particle Size [mm]		Proximate analysis (M-%)			Ash melting point (°c)	HHV (MJ/Kg)		Ultimate analysis: Sulphur (M-%)		Trace elements: Chlorine (M-%)		Trace elements: Mercury (M-%)	
Mean	Type	Moisture Content	Volatile matter	Ash content	Mean	Mean	S.Deviation	Mean	S.Deviation	Mean	S.Deviation	Mean	S.Deviation
10-80	Fine-grained	6.7	50.8[10)]	53	n/a	13	6	0.6	0.1-1.4	1.8	0.5-3	0.005	0.001-0.0001

10) GKS-Datenbank (Stand: 2018)
15) BMU; Jahresbericht über die Altfahrzeug-Verwertungsquoten in Deutschland im Jahr 2015
18) Background Study on the Content of Shredder Residue, 2014

Gasification of ASR in a BGL-Gasifier



ASR

$m_{C,\ total}$ 4.9 t/h

Plastic Fraction ~ 35 wt.-%

$m_{C\ from\ Plastic}$ ~ 3.8 t/h*

Coal

$m_{C,\ total}$ 3.3 t/h

Total processing cost

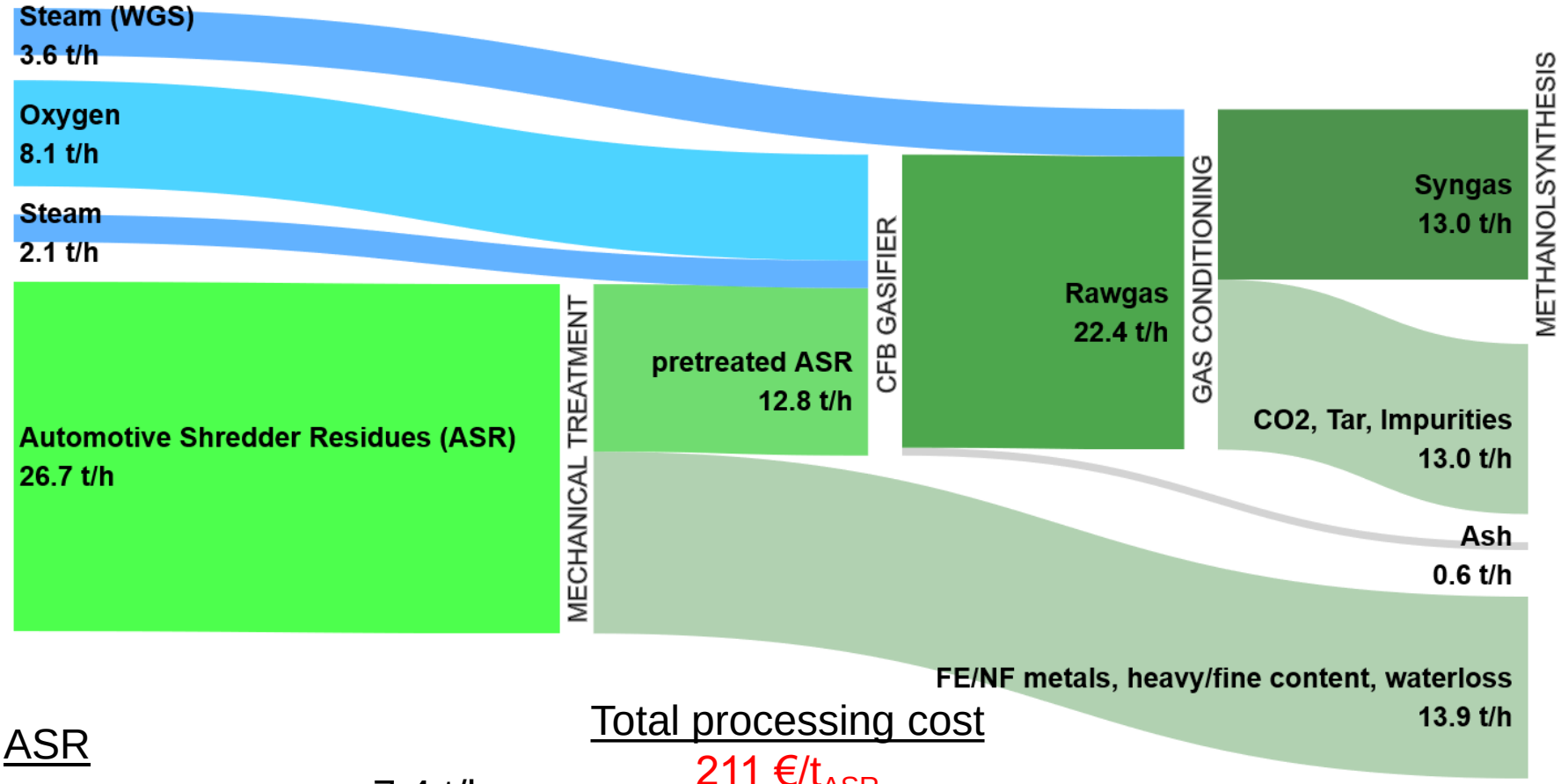
275 €/t_{ASR}

*without composites, compounds, …

Syngas

$m_{C,\ total}$ 4.9 t/h

Gasification of ASR in a CFB-Gasifier



Total processing cost

211 €/t_{ASR}

ASR

$m_{C,\ total}$ 7.4 t/h

Plastic Fraction ~ 35 wt.-%

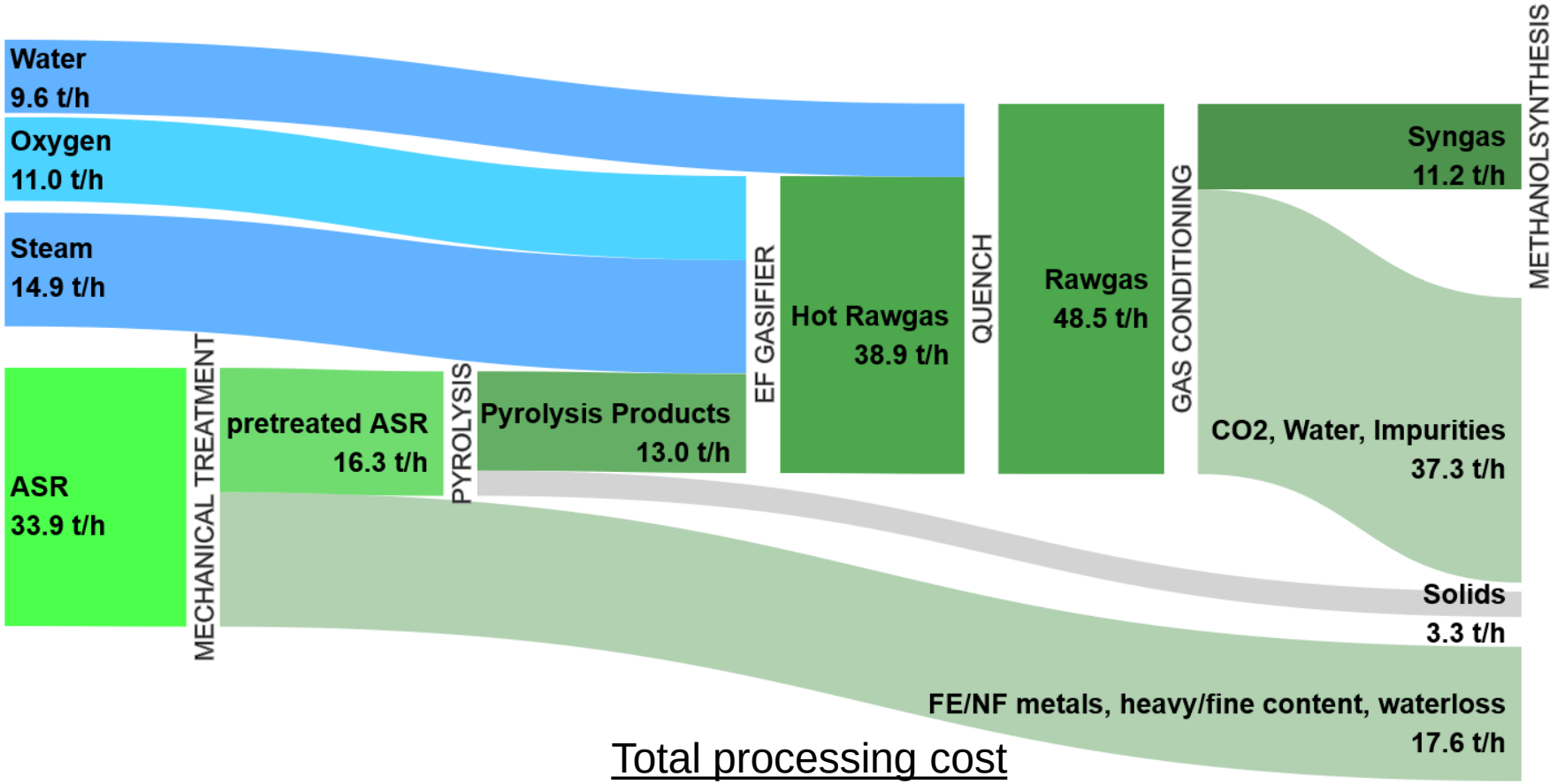
$m_{C\ from\ Plastic}$ ~ 5.6 t/h*

*without composites, compounds, …

Syngas

$m_{C,\ total}$ 4.8 t/h

Gasification of ASR in an EF-Gasifier



Total processing cost

189 €/t_{ASR}

ASR

$m_{C,\ total}$ ~ 9.2 t/h

Plastic Fraction ~ 17.7 wt.-%

$m_{C\ from\ Plastic}$ ~ 3.6 t/h

Syngas

$m_{C,\ total}$ 4.1 t/h

Process Overview: Economics*

Shredder Residues large Shredders (ASR)

Process	Pretreatment Feedstock [€/t_{ASR}]	Conversion [€/t_{ASR}]	Upgrading Raw Syngas [€/t_{ASR}]	Total processing cost [€/t_{ASR}]	Revenues** [€/t_{ASR}]
BGL	-28	208	95	275	
CFB	-28	112	127	211	- 97
EFG	-28	154	63	189	
Pyrolysis	-28	152		124	- 86

*) unit size ca. 100 MW / ca. 15 t/h of pretreated waste

**) Syngas @ 200 €/t
Naphta @ 500 €/t

Net processing costs in the range of incineration market gate fees

Cost estimate accuracy : +/- 30%

Economical attractiveness versus technology readiness

Views of PlasticsEurope on feedstock recycling

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Feedstock recycling is a complementary emerging technology next to traditional mechanical recycling.
It is foreseen that it will be needed to divert from landfill and energy recovery certain plastic waste which cannot be sustainably recycled by mechanical processes. Suitable streams for feedstock recycling can include, for instance, mixed or contaminated plastic streams.

In parallel to developments in dissolution technologies (APK, PSLoop, PureCycle, Total, etc), we see an increasing number of initiatives in feedstock / chemical recycling (BASF, Sabic, Enerkem, Agylix, etc)

Further innovation, funding and adequate regulatory framework is still needed to make feedstock recycling technically and economically a reality in the future.

Plastics

The Material for the 21st Century