The role of Chemical recycling of plastic waste

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Chemical recycling hype

Chemical Recycling Hype

Über OMV Businesslösungen

Fra

BASF
We create chemistry

WWF

„Chemisches Recycling“

HINTERGRUND // JULI 2020
Chemisches Recycling

Für Mensch & Umwelt

Umwelt Bundesamt

Von Kur

ieses Dokument enthält keine Empfehlungen für bestimmte
chen Recyclings. Es definiert vielmehr Umsetzungsprinzipien
und Natur für den Fall, dass die Technologien in die Anwendung
sollten als Entscheidungshilfe dienen und Akteure unterstützen,
führung von Kunststoffen voranzutreiben. Positionierung und
er internationalen WWF-Netzwerkposition.

ft zu etablieren, in der Materialien wiederverwendet und Abfälle
tstehen, muss der Vermeidung und Wiederverwendung Vorrang
aterialien und Produkte, die gebraucht und nicht durch Mehrweg-
nen, müssen Recyclingfähigkeit und Rezyklateinsatz im Vorder-
er Kunststoff deponiert und verbrannt wird oder in der Natur

g ist die heute verbreitetste Form des Recyclings. Es umfasst die
(Sortieren, Waschen und Trocknen, Zerkleinern, Mahlen und
laterial. Das chemische Recycling bezieht sich im Bereich der
thermochemische und Verbrennungsprozesse, bei denen Kunst-

einer

Chemical Recycling Hype

Introduction

EU Taxonomy Environmental Delegated Act
Annex II: Transition to a circular economy

1. MANUFACTURING

1.1. Manufacture of plastic packaging goods

Description of the activity

Manufacture of plastic packaging goods.

….

1. The activity complies with one of the following criteria:

(a) design for reuse: ….

(b) use of circular feedstock: at least 65% of the packaging product by weight consists of mechanically recycled post-consumer material for non-contact sensitive packaging and at least 50% for contact sensitive packaging[2]. Where producing mechanically recycled material is not technically feasible or economically viable, the product may consist of at least 65% of chemically recycled material;

(c) use of bio-waste feedstock: ….

Definition of Chemical recycling

Definition of Chemical recycling

Expert group of UBA* project on Chemical recycling

- Chemical recycling of plastics refers to process chains in which polymers are completely or partially broken down into their components and subsequently used as a feedstock, to produce new polymers or other substances, and – apart from by-products or residual materials – are not used for energy recovery.

European Coalition for CR [initiative by Cefic and PlasticsEurope]

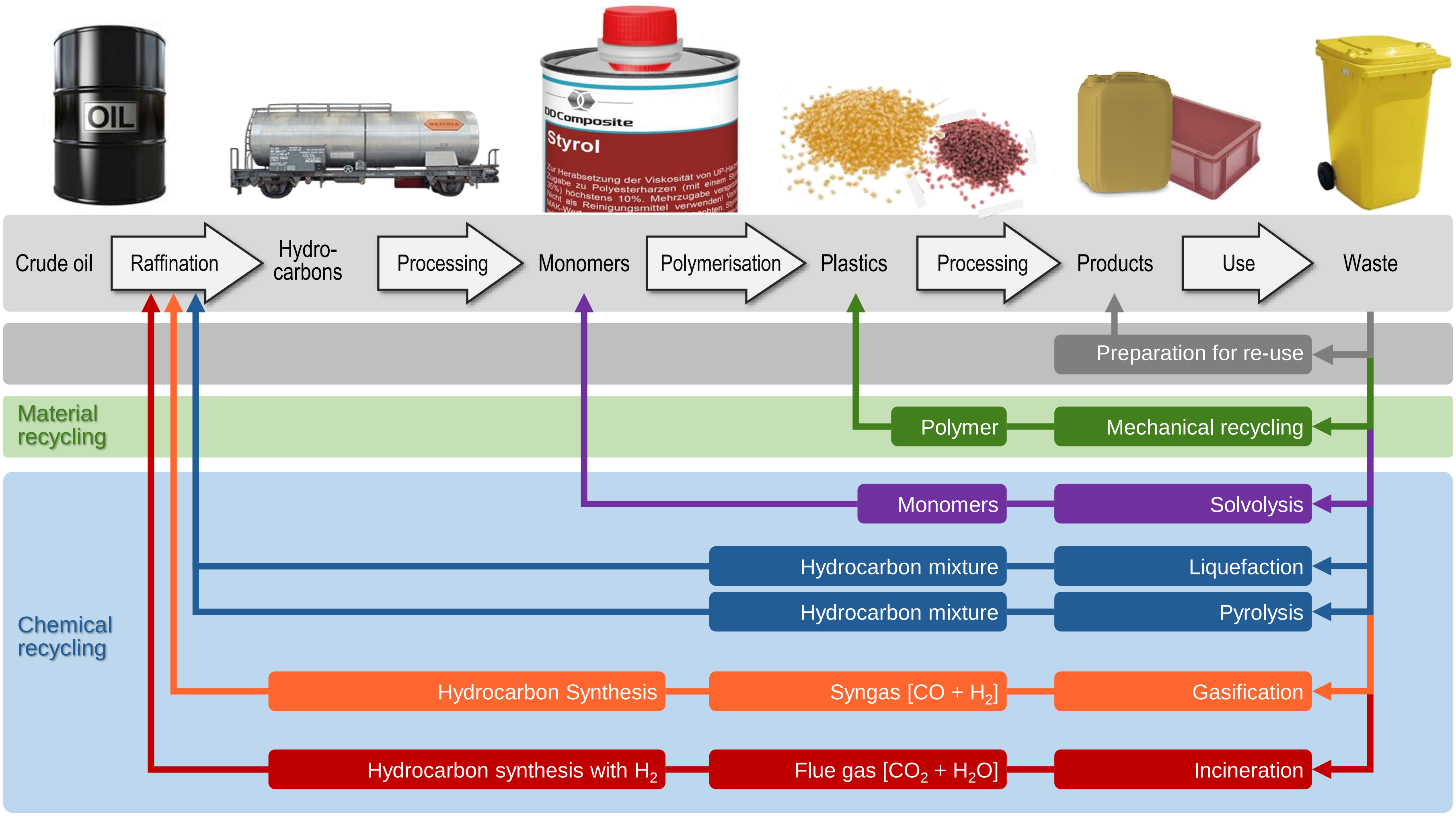
- Chemical Recycling converts polymeric waste by changing its chemical structure to produce substances that are used as products or as raw materials for the manufacturing of products. Products exclude those used as fuels or means to generate energy.

- …

* UBA = Umweltbundesamt = German Federal Environmental Agency

Options for waste plastics utilization

Options for waste plastics utilization

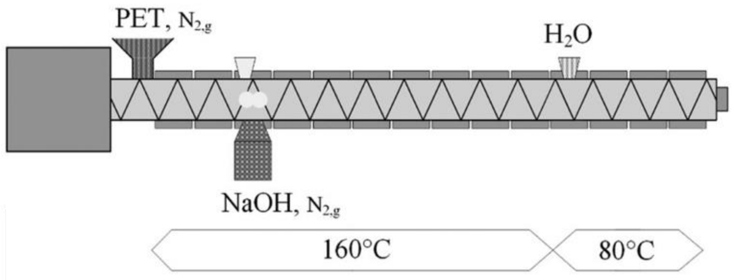


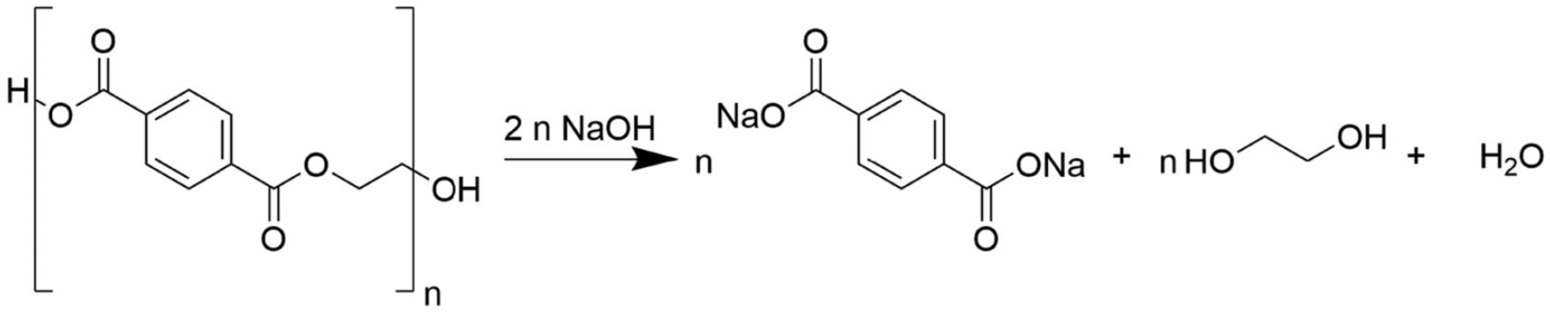
Solvolysis

Solvolysis

Example revolPET – RITTEC

- Continuous PET depolymerization by alkaline hydrolysis in a twin-screw extruder
- Input: bilayered plastics waste (PET/PE)
- Products (97 % depolymerization degree):
  - Terephthalic acid
  - Ethylene glycol
  - PE layer keeps inert and is separated by filtration





Quelle: Biermann et al. 2021

Solvolysis

revolPET – RITTEC

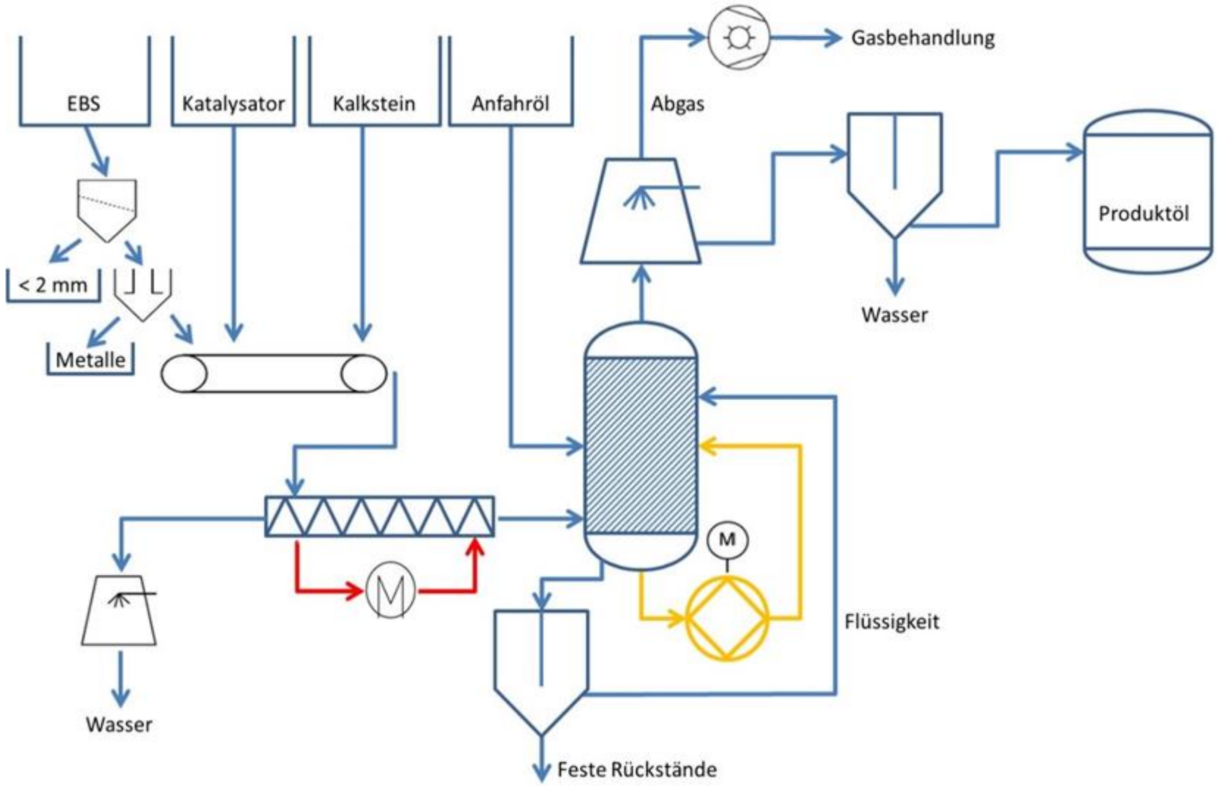
- Pilot plant

Liquefaction

Liquefaction

Depolymerisation

- Carboliq, formerly known as Dieselwest
  - Conversion in liquid phase (starter oil)
  - 320-350 °C
  - 3 min residence time
  - Additives: Catalyst Neutralizor lime Fe_2O_3 for sulfur fixation



Liquefaction

Depolymerisation

- Carboliq, formerly known as Dieselwest
  - Pilot plants

Ennigerloh

Barrie, Kanada

Liquefaction

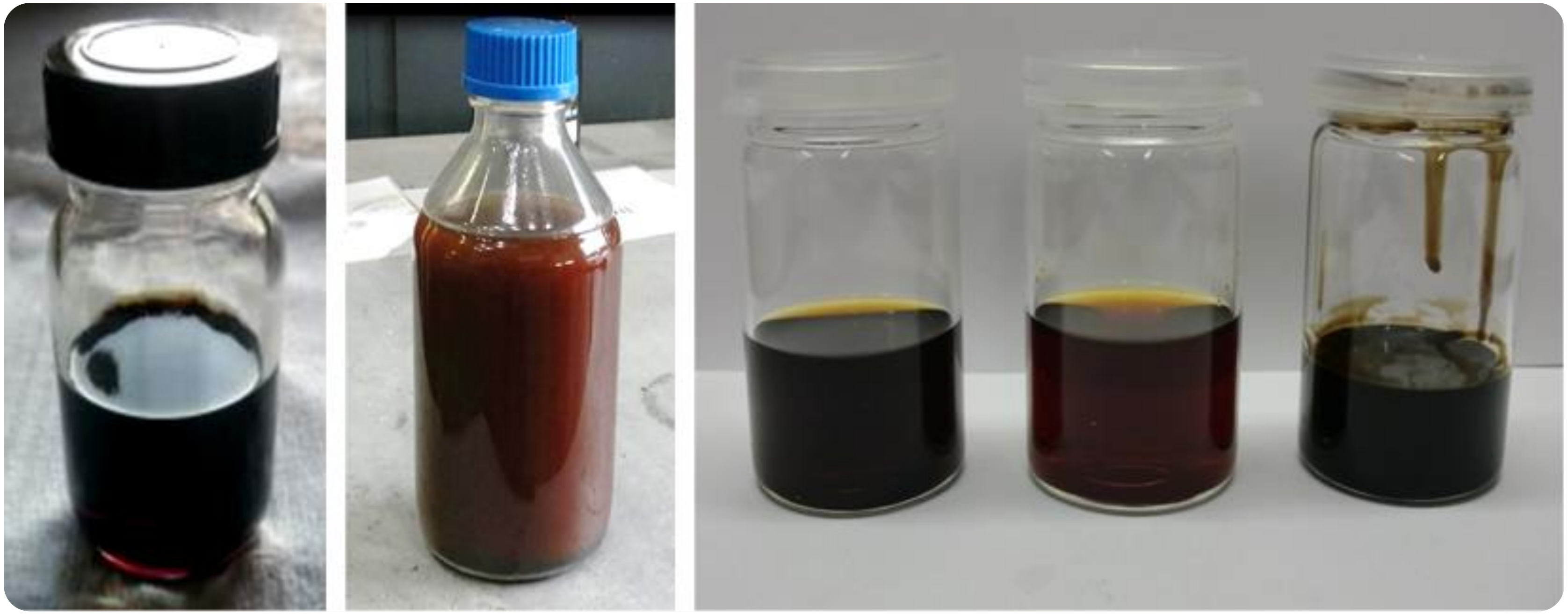
Depolymerisation

- Carboliq, formerly known as Dieselwest
  - Pilot plant Enigerloh

Liquefaction

Depolymerisation

- Carboliq, formerly known as Dieselwest
  - Products



Depolymerisation

- Carboliq, formerly known as Dieselwest
  - Products

Parameter	Einheit	Produktanalysen Dieselwest					Diesel DIN EN 590
		EBS		EBS	Kunststoff		
		roh	behandelt		Granulat	Folien	
Cetanzahl		**43**	57	**37**	**31**	57	> 51
Cetanindex		49	67	**42**			> 46
Dichte [15 °C]	[kg/m³]	**850**	832	**850**	**903**	843	820-845
PAK	[Ma-%]	3,1	2,0	2,7	4,1	2,2	< 8,0
Schwefel	[mg/kg]	**1240**	< 5	**1400**	**980**	**1170**	< 10,0
Mangan	[mg/l]	< 1					< 2,0
Flammpunkt	[°C]	**31,5**	**36**	**< 20**	**< -20**	**22**	> 55
Koksrückstand	[Ma-%]	**1,26**	< 0,01	0,20	**0,36**	**1,50**	< 0,30
Aschegehalt	[Ma-%]	0,004	< 0,001	**0,024**	**0,045**	0.008	< 0,010
Wassergehalt	[Ma-%]	**0,080**	0,0025	**0,21**	**0,38**	**0,143**	< 0,020
Gesamtverschmutzung	[mg/kg]	**161**	8,5	**698**	**987**	**147**	< 24
Kupferkorrosion	Rating	Class 1		**Class 2**	Class 1	**Class 2**	Class 1
Viskosität [40 °C]	[mm²/s]	3,5	**4,7**	2,18	4,46	4,39	2-4,5

Pyrolysis

Pyrolysis

Technology

- Typical operation conditions
  - 450 – 600 °C, ambient pressure
  - Application of additives
- Typical reactor types
  - Rotary kiln
  - Screw reactors
  - Fludized bed
- Products
  - One or more liquid fractions

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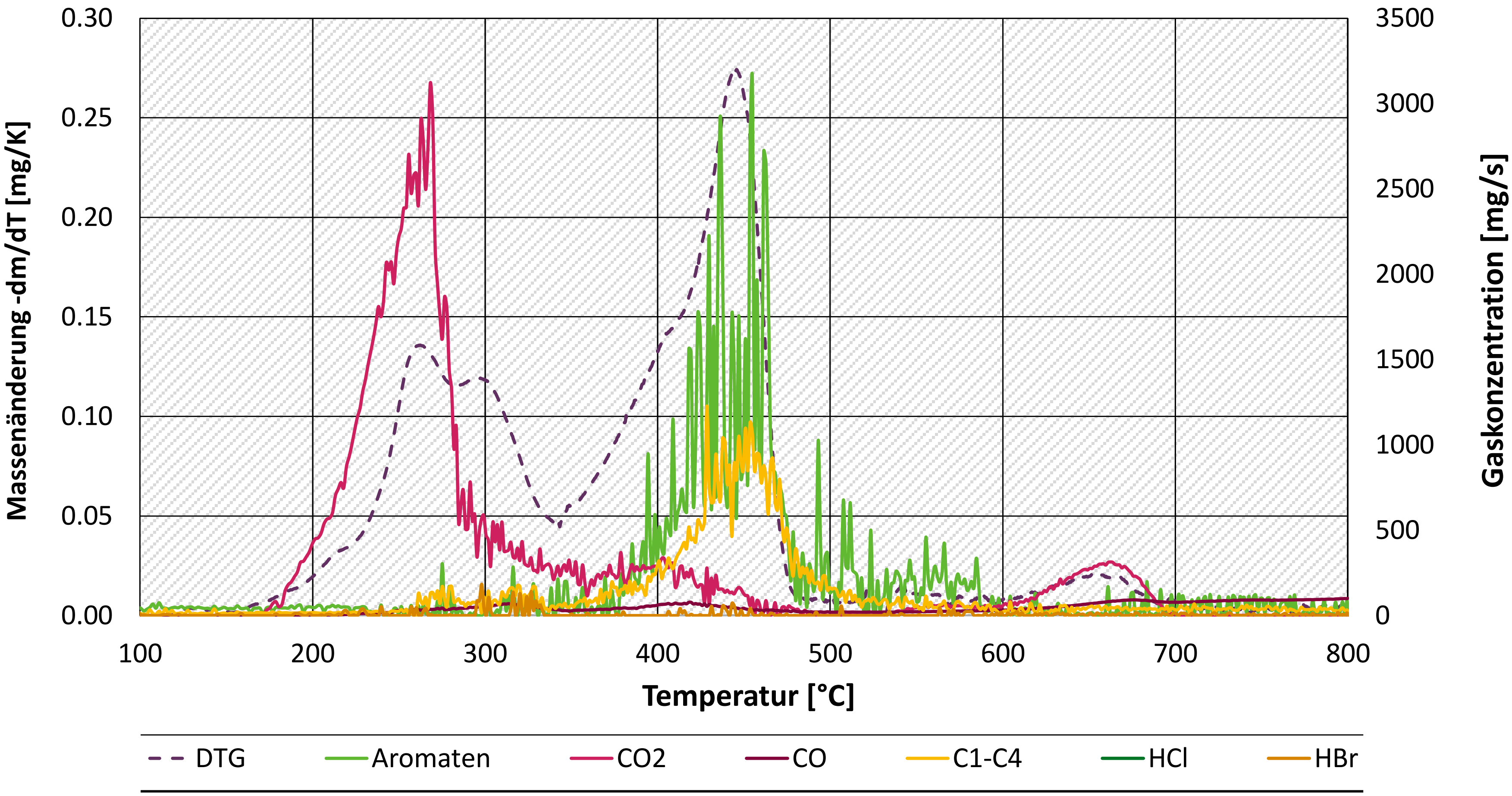
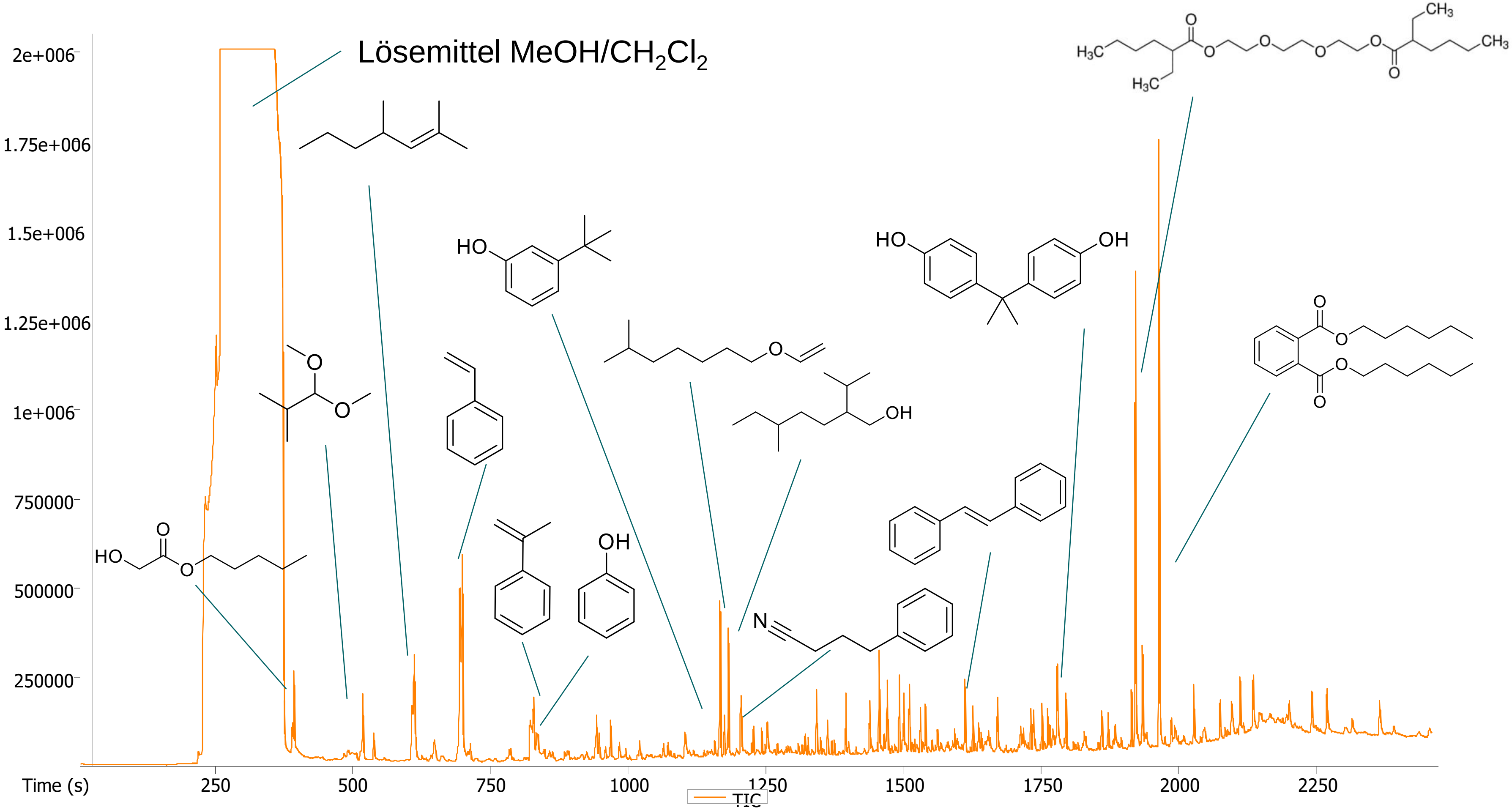
Pyrolysis

Product composition example RDF



Product composition example RDF



Pyrolysis

Technology

- Typical operation conditions
  - 450 – 600 °C, ambient pressure
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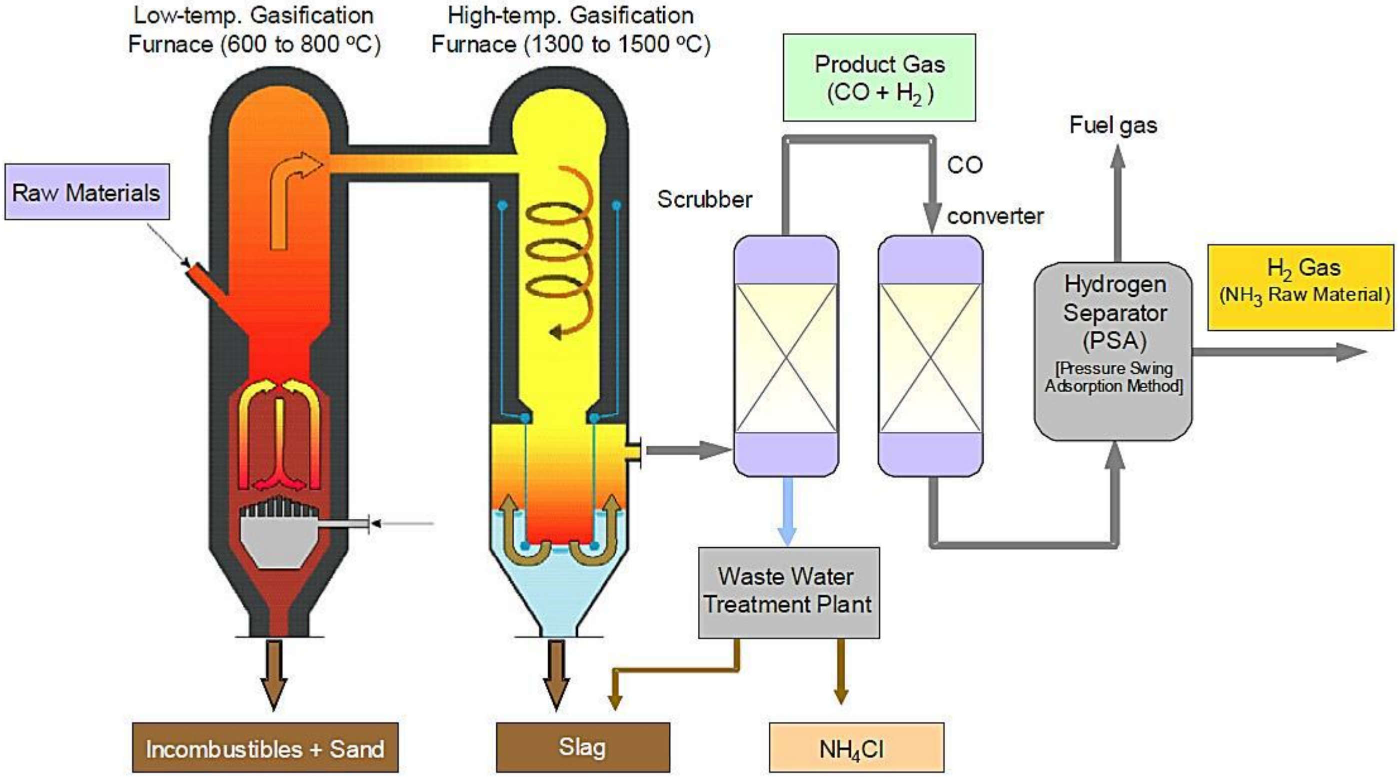
- Typical reactor types
  - Rotary kiln
  - Screw reactors
  - Fludized bed
- Products
  - One or more liquid fractions
  - Permanent gas
  - Solid residue

Gasification

Gasification

Ebara | Showa Denko in Kawasaki

- Plastics gasification and NH_3 production
- 5-15 bar



Gasification

Ebara | Showa Denko

- Plastics gasification and NH_3 production

Gasification

Ebara | Showa Denko

- Input waste plastics

Gasification

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- Input waste plastics

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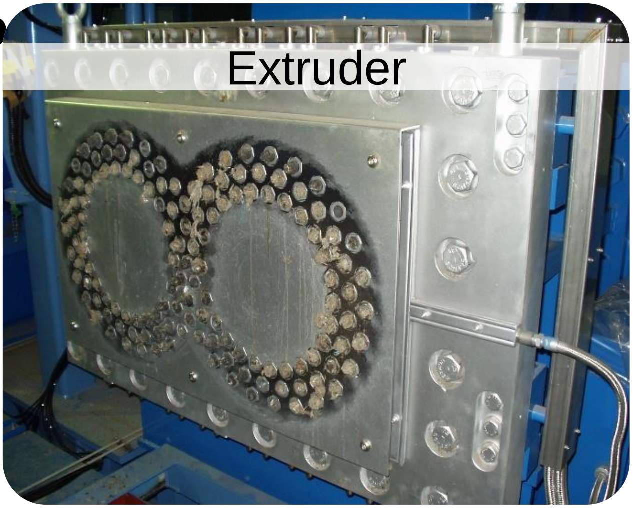
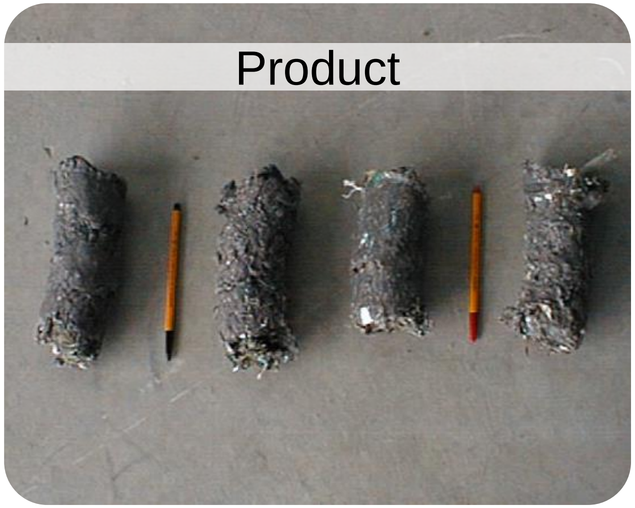
- Pre-pocessing of input material

Gasification

Ebara | Showa Denko

- Pre-pocessing
  of input material

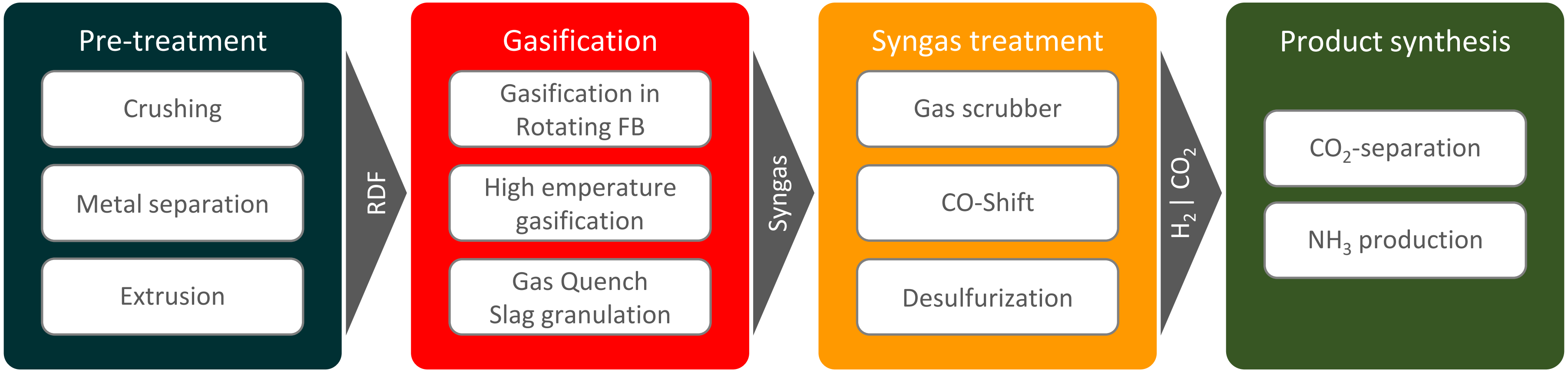




Chemical waste plastics recycling by gasification

Ebara | Showa Denko

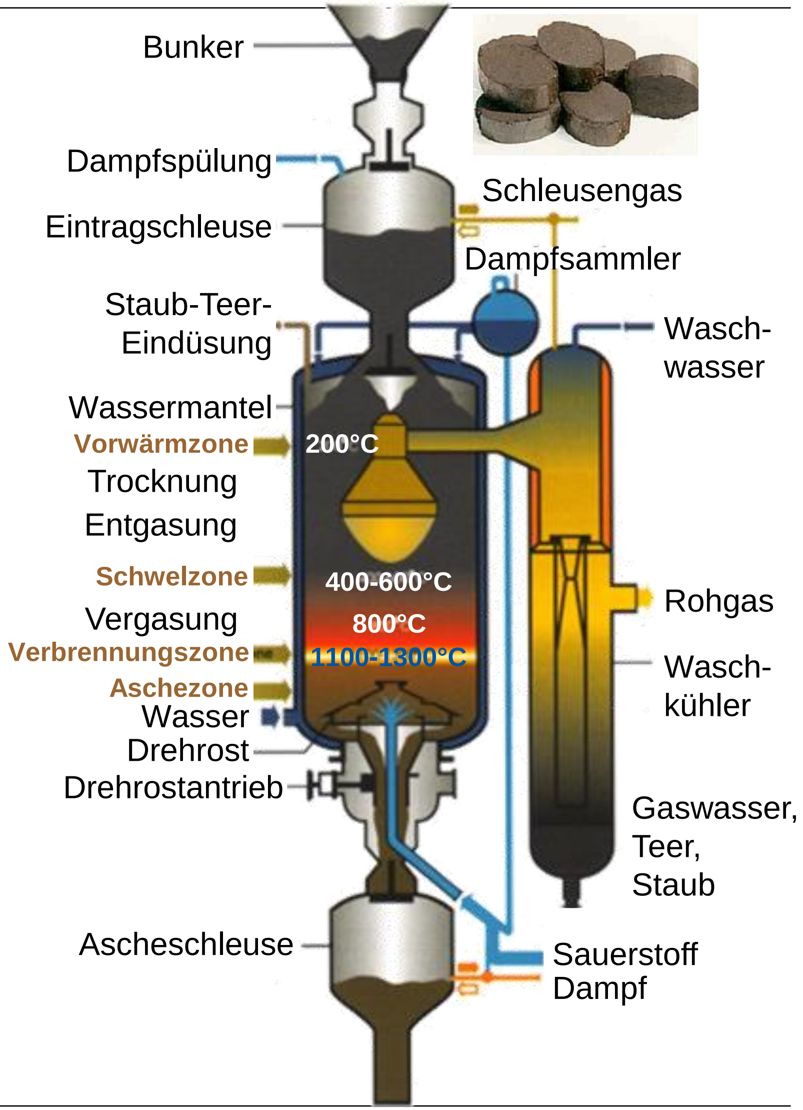
- Ebara | Showa Denko
  - 7000-7500 h of operation each year
  - Slagging problems in both reactors
  - Residues (metals, sulfur, slag) are disposed of, due to low quality
  - 1 Mg Plastics + 1,4 Mg O_2 + 1,2 Mg Steam + ? Mg N_2 + ? Mg H_2
    → 0,9 Mg NH_3 + 0,1 Mg Residues



Gasification

SVZ Schwarze Pumpe Germany

- Fixed bed gasification in 6 reactors
  - 25 bar | 800-1.300°C

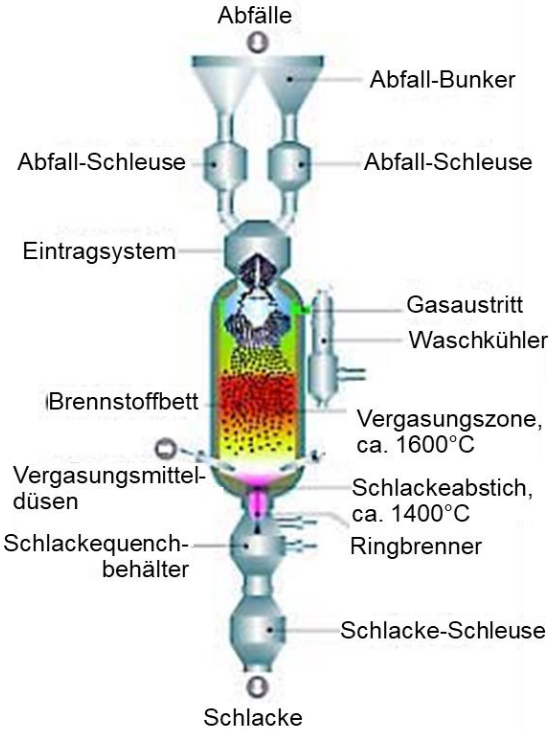


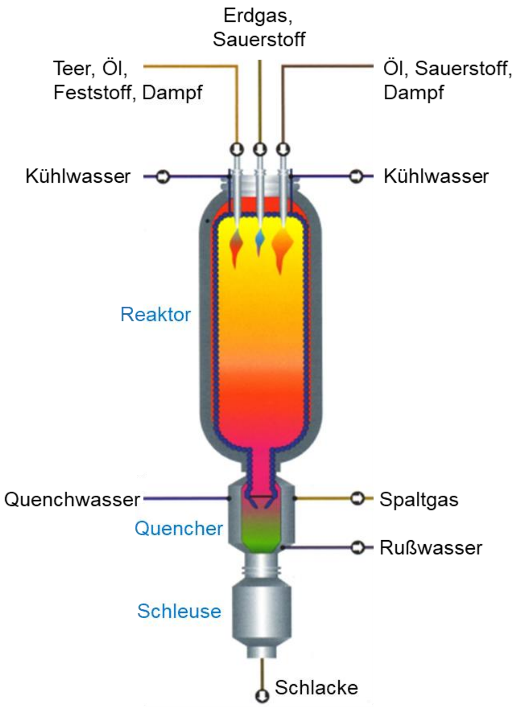
Gasification

SVZ Schwarze Pumpe Germany

- Entrained flow gasification
  - (25 bar | 1.600-1.800°C)

- BGL-Schlackebadvergaser
  - (25 bar | 1.600°C)





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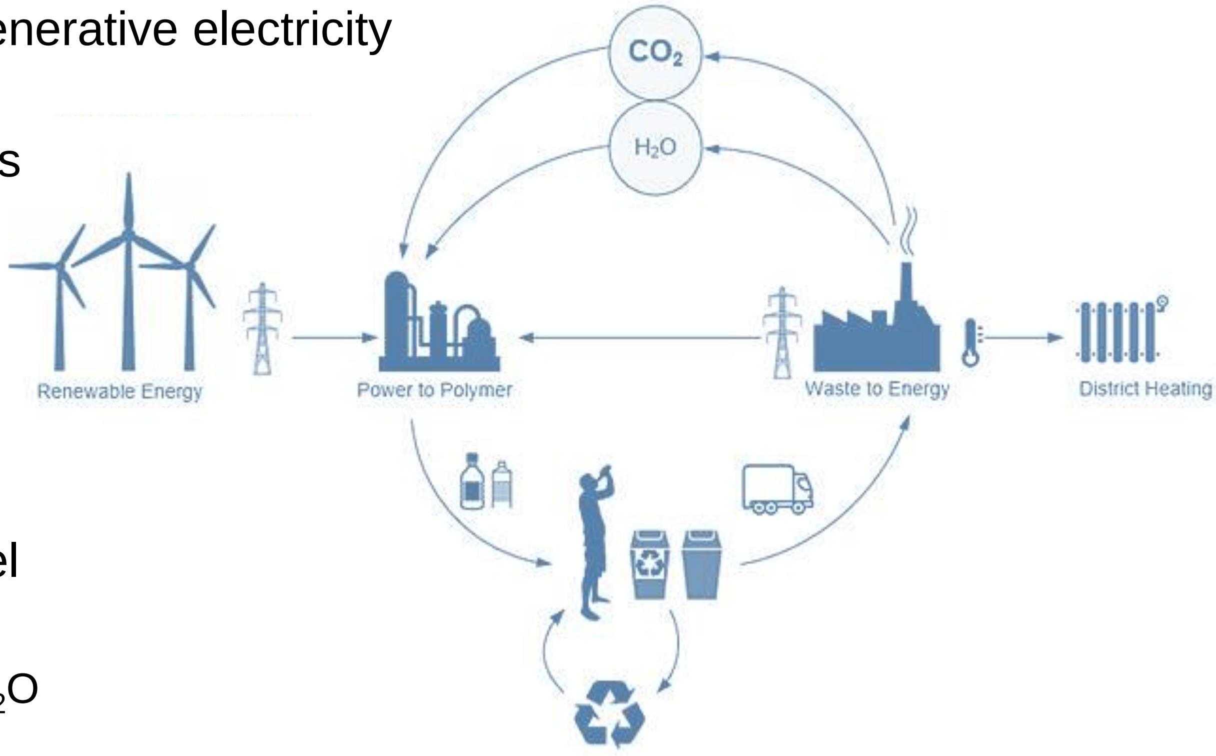
Incineration and CCU

Incineration nan CCU

Power & CO_2 to Hydrocarbons

- CO_2-separation from combustion gases
- H_2O-electrolysis with regenerative electricity → H_2
- Synthesis of hydrocarbons



- Option:
  Combustion with Oxy-Fuel
  (O_2 from electrolysis):
  $-(CH_2)-_n + O_2 \rightarrow CO_2 + H_2O$

Source: Prof. Rainer Bunge

The role of the input material

Introduction

Most important: Quality of input material

uelle: www.kloepfel-engineering.com; www.plastverarbeiter.de, www. … enespa.eu

Conclusion

Conclusion – Technologies

- **Incineration**
  Tolerates almost everything | in combination with CCU very costly in infrastructure and operation
- **Gasifiction**
  Limited in feed composition | technically very complex | gas upgrading costly and complex | Syngas ($CO + H_2$) high quality product | quality of residues?
- **Pyrolysis & Liquefaction**
  Low quality products | very low quality of residues
- **Solvolysis**
  high effort with chemical solvents | high quality products | very selective restrictions in feed composition | problems with “real waste”

Conclusion

- **Status Quo**
  - Only few technical facilities including downstream are realized
  - Most of almost 200 processes are still „under development“
  - Big technical facilities are in planning and under construction (e.g. ÖMV)

- **Perspective**
  - Chemical recycling facilities will be established, due to public/political pressure
  - Limitations in input composition and output quality have to be managed
  - Stand alone plants (including downstream) only expected for solvolysis
  - Co-processing of oils and gases in (petro-)chemical facilities after pre-treatment

- **Need for clarification**
  - Which routes for chemical recycling will be accepted by administration?
  - Is chemical recycling the ecological better alternative, compared to combustion and energy recovery?

Thank you!

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www.teer.rwth-aachen.de