Karlsruhe Institute of Technology

THINKTANK INDUSTRIELLE RESSOURCEN-STRATEGIEN

Chemical Recycling of Mixed Plastic Wastes

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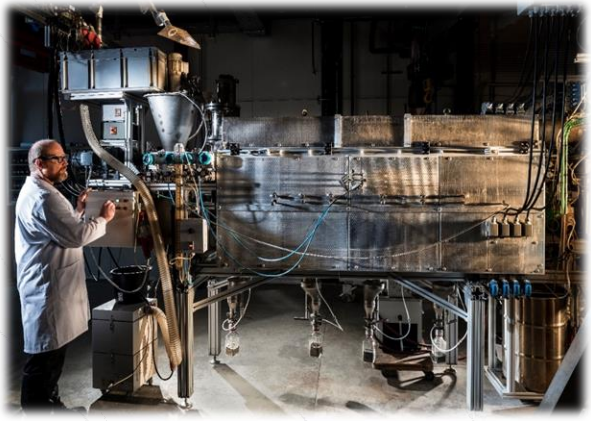
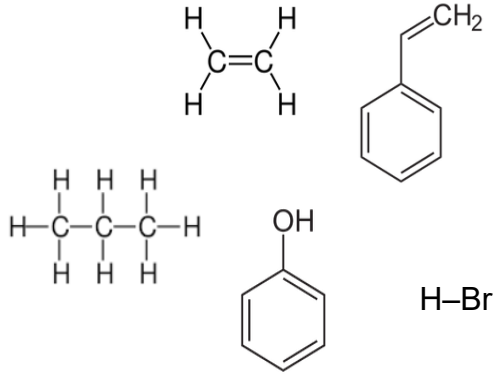


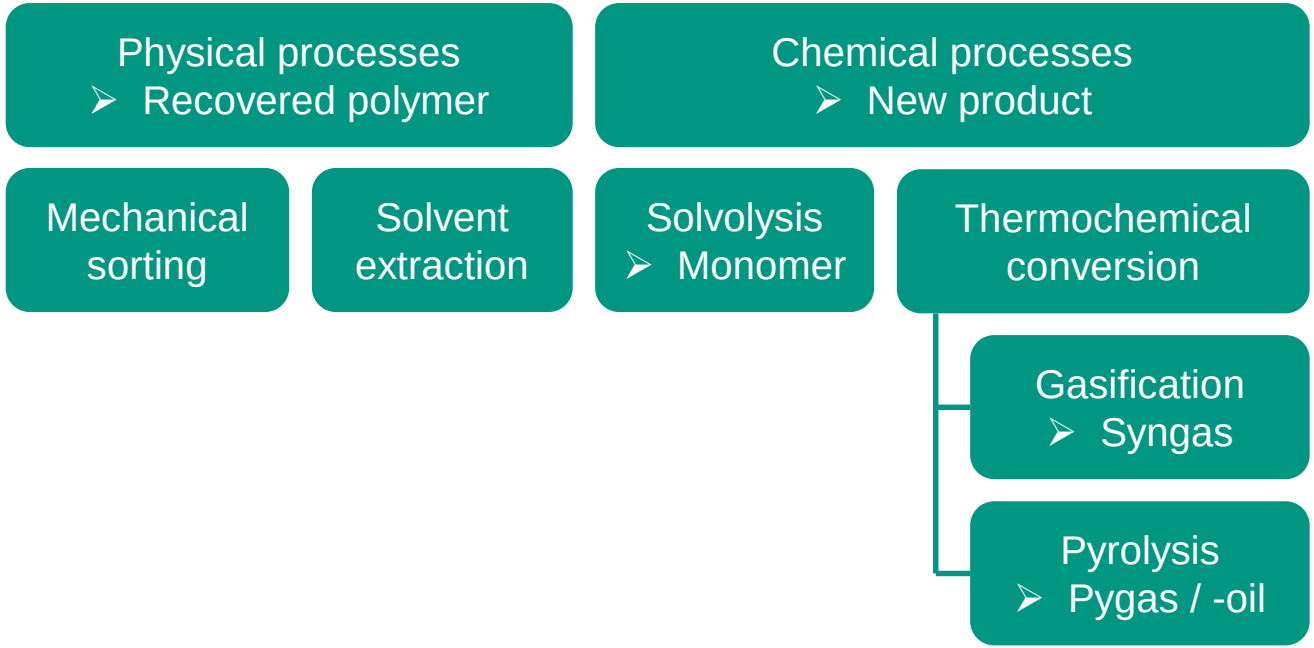


Plastics Production and Plastics Waste Generation

[million t / a]	EU 28+2*	Germany**
Plastics production	61.8	19.9
Plastics consumption	51.2	12.6
Plastic waste	29.1	6.2
- Landfill	7.2	< 0.1
- Energy recovery	12.4	3.2
- Recycling	9.4 (export 1.8)	2.9 (export: 0.6)

*) Lindner,C. et al.: Circular Economy of Plastics 2018 EU-28+2, Conversio Market & Strategy GmbH, Mainaschaff (2019)
**) Lindner,C., Schmitt, J.: Stoffstrombild Kunststoffe in Deutschland 2017, Conversio Market & Strategy GmbH, Mainaschaff (2018)

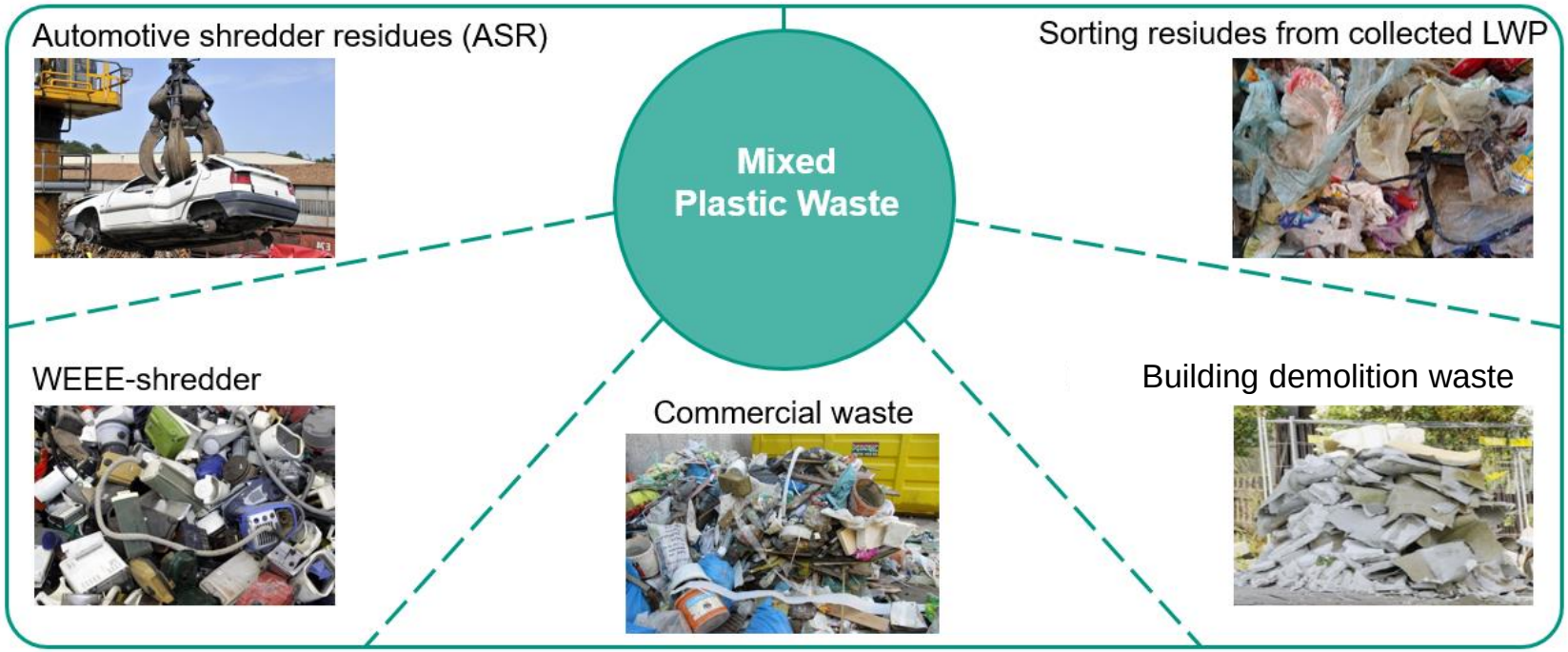
Recycling Processes for Plastic Waste and Key Products



applied to:

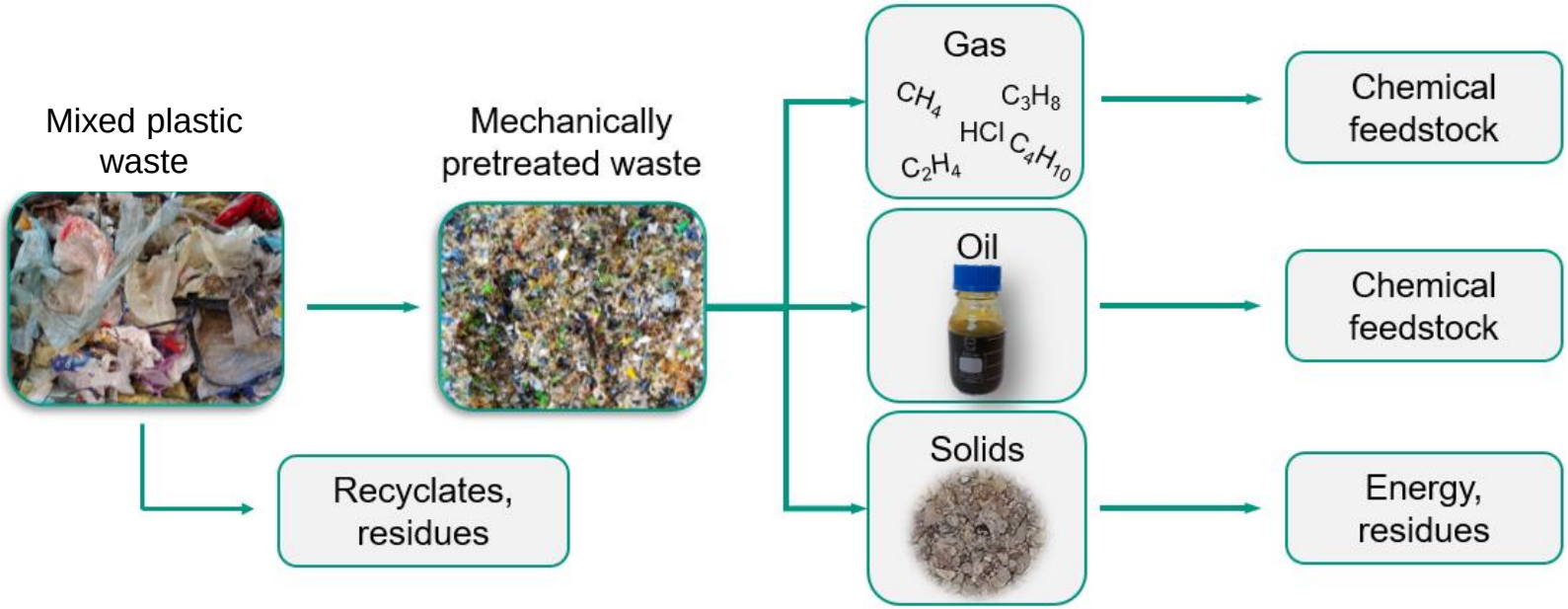
- ➢ standard thermoplastics
- ➢ Pure polymers
- ➢ Polycondensates
- ➢ Mixed wastes, composite materials

Examples of Plastic Waste Produced

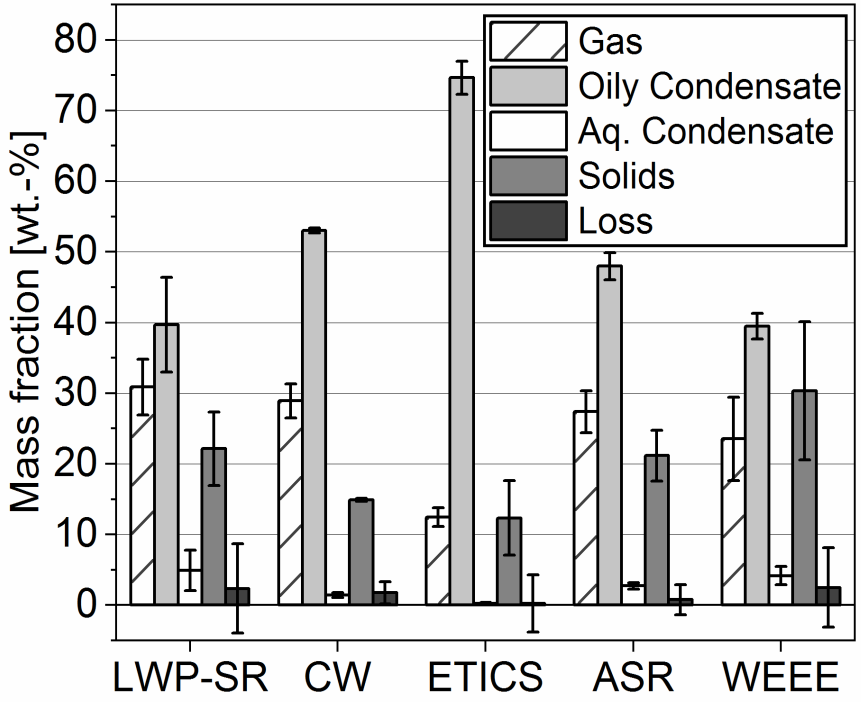


WEEE = Waste of Electrical and Electronic Equipment
LWP-SR = Sorting Residues from Light Weight Packaging Waste collected
ETICS = Thermal Insulation Compound System

Recycling of Collected Plastic Waste - The Pyrolysis Value Chain Example



Pyrolysis Mass Balances



Zeller, M., et al.: Chemical recycling of mixed plastic wastes by pyrolysis. Chem. Ing. Tech. 2021, 93 (11), 1-9. https://doi.org/10.1002/cite.202100102

Carbon Recovery

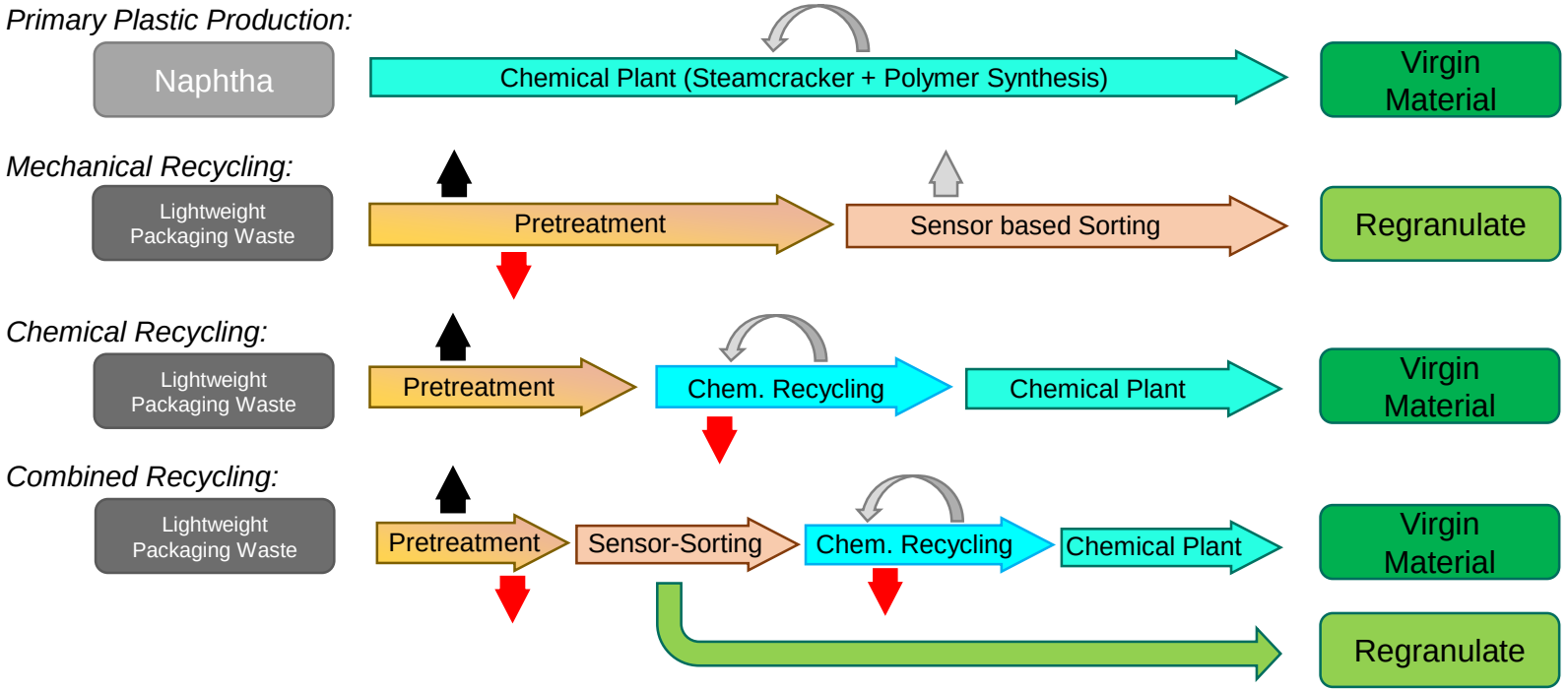
Feedstock	Fraction of C-feed found back in oily condensate
	[wt-%]
LWP-SR	51.1
CW	60.0
ETICS (XPS)	74.6
ETICS (EPS)	72.9
ASR	57.5
WEEE	60.5

Pyrolysis Energy Balance

Feedstock	Energy demand for heating, melting, thermal degradation, evaporation
	[% of feedstock higher heating value]
LWP-SR	5.1
CW	5.2
XPS	4.9
ASR	5.4
WEEE	3.7

Case: Recycling of Collected LWP-Waste

Comparison of Recovery Routes



Extracted metals via sorting

Heavy contents / Mineral residues that are landfilled

Residues that are used energetically

LWP Waste Recycling Routes Compared to Primary Plastics Production of HDPE

Recycling scenario	Cost [€/kg_{Input}]	CED [MJ/kg_{Input}]	GWP [$kgCO_2e/kg_{Input}$]	Overall Carbon Recycled
Mechanical, 42% yield	-0.16	-18.1	0.2	42%
Mechanical, 22% yield	-0.08	-6.9	0.6	22%
Chemical recycling	-0.24	-15.9	0.3	59%
Combined recycling, mech. 42%	-0.29	-30.1	-0.2	74%
Combined recycling, mech. 22%	-0.25	-23.1	0.0	66%

Volk,R., et al.: Techno-economic Assessment and Comparison of Different Plastic Recycling Pathways - a German Case Study, Journal of Industrial Ecology, 2021, 1-20. https://doi.org/10.1111/jiec.13145

Conclusions

Technical assessment of combined mechanical and chemical recycling

Comparison of the production of plastics from fossil raw materials with the combined mechanical / chemical recycling of post-consumer waste, taking into account energy recovery

- **Costs:** Economic attractiveness of both, large scale mechanical and chemical recycling
- **Energy:** Mechanical and chemical recycling perform similar; advantageous over crude oil based products
- **CO_2 emissions**: Mechanical and chemical recycling perform similar; at high recycling rates advantegous over crude oil based products, today already
- **Technology readiness:** Scale-up and demonstration of feedstock recycling / virgin material recovery from mixed plastic wastes

Acknowledgement

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