Silesian University of Technology

RESEARCH UNIVERSITY
EXCELLENCE INITIATIVE
Ministry of Science and Higher Education

Department of Thermal Technology

Hydrothermal treatment of plastic waste within a circular economy perspective

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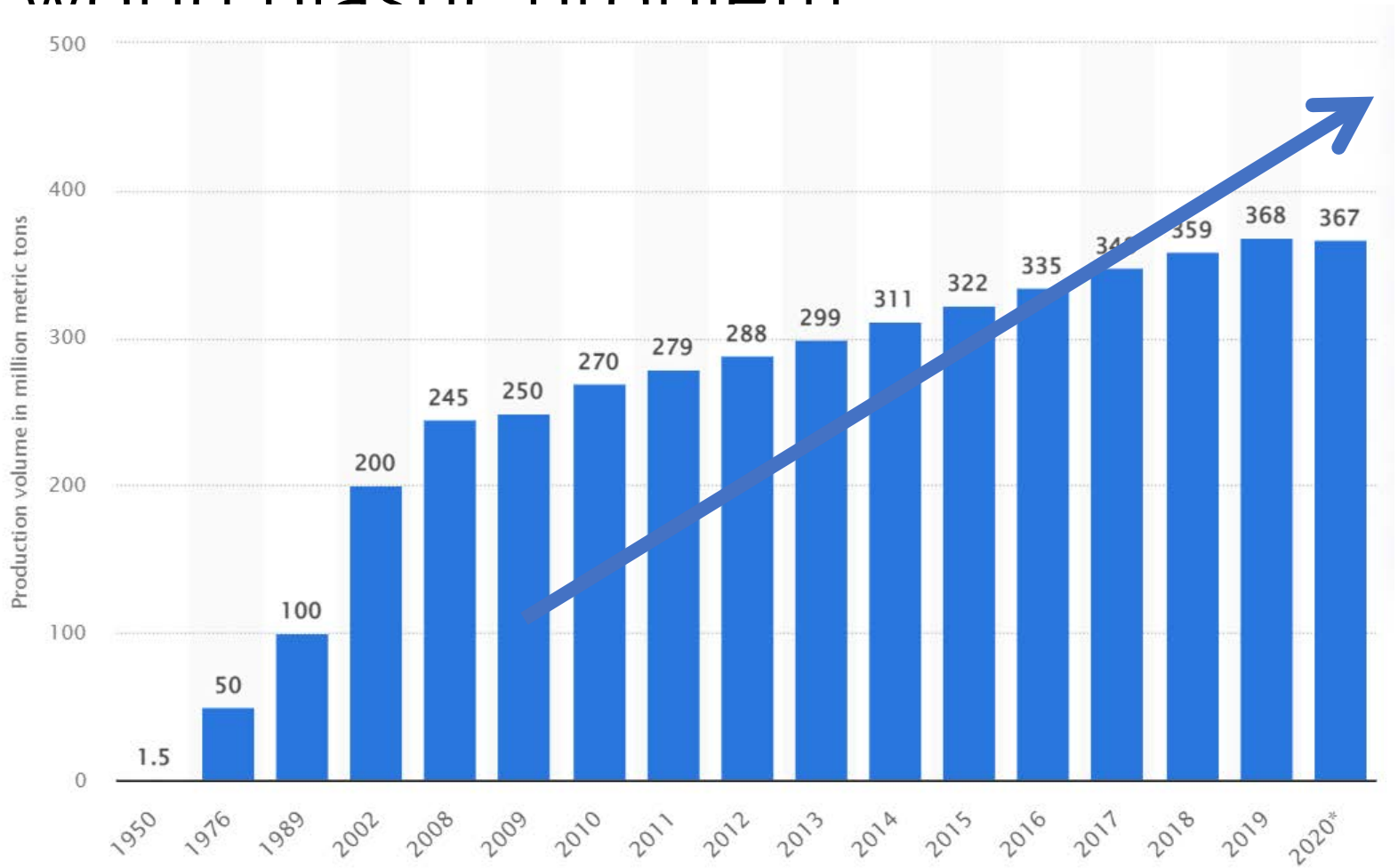
Introduction – world plastic problem

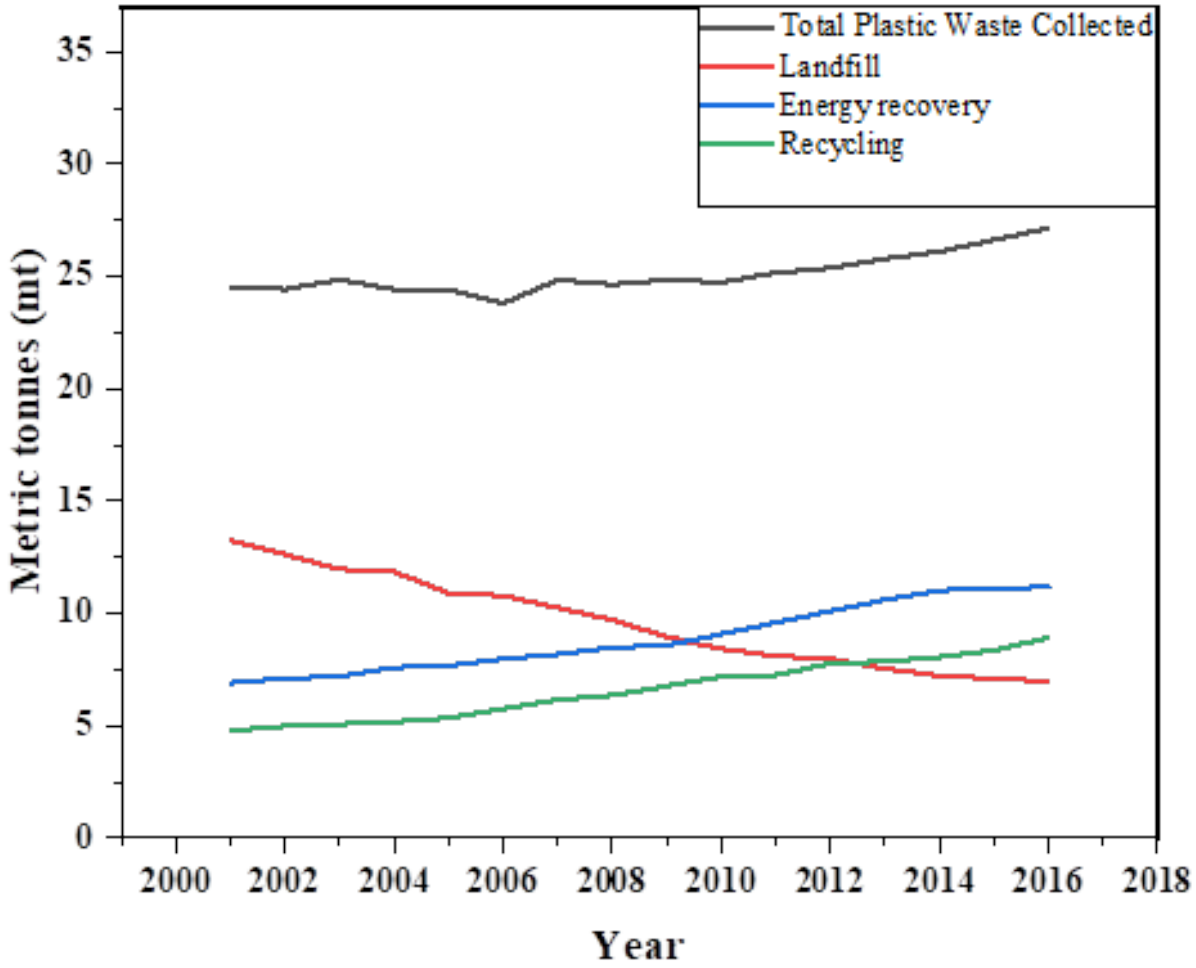
Annual production of plastics worldwide from 1950 to 2020*(in million metric tons)*



Introduction - waste management techniques

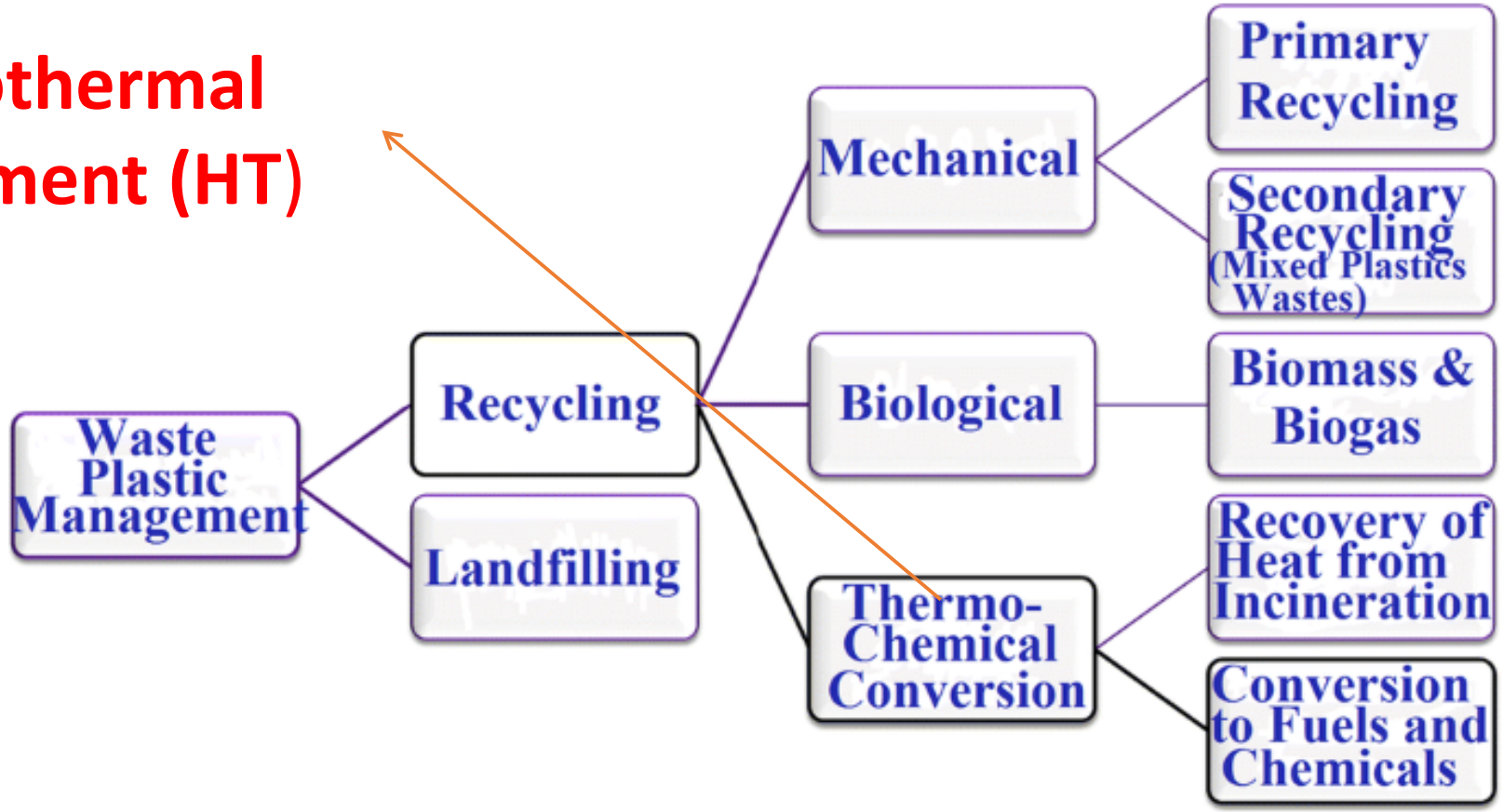
Different types of waste management techniques employed from 2001 to 2016

According to an estimation total 27 million tonnes of waste plastic was collected through out of Europe in year 2016. 31% of this total amount was recycled successfully, 42% was subjected to energy recovery purpose and remaining 28% was landfilled

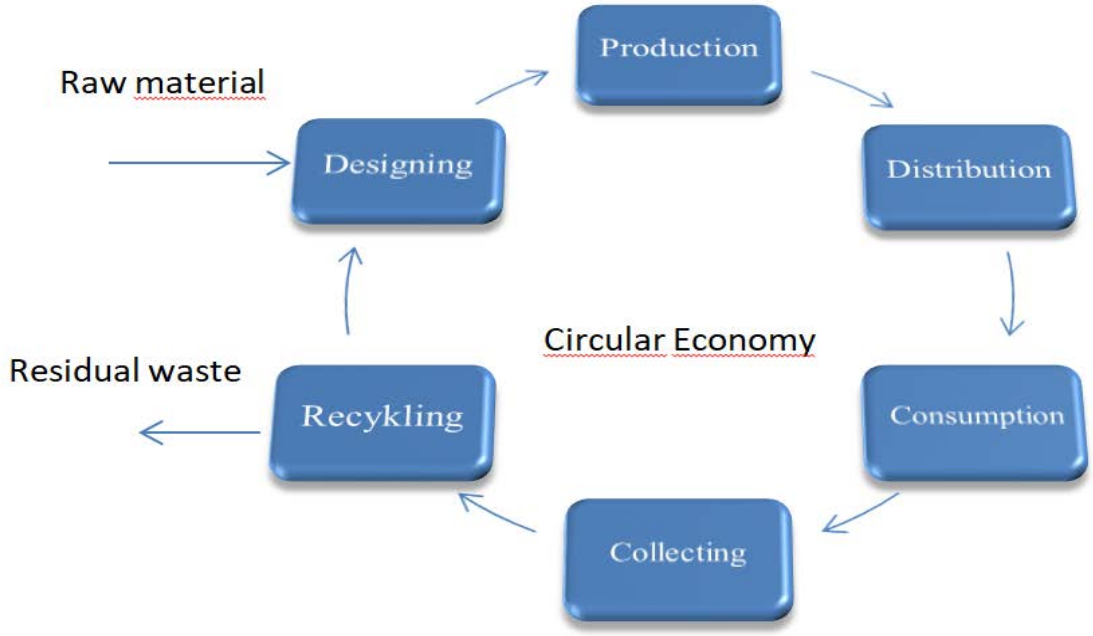


Recycling routes for plastic wastes

Hydrothermal Treatment (HT)



Circular economy



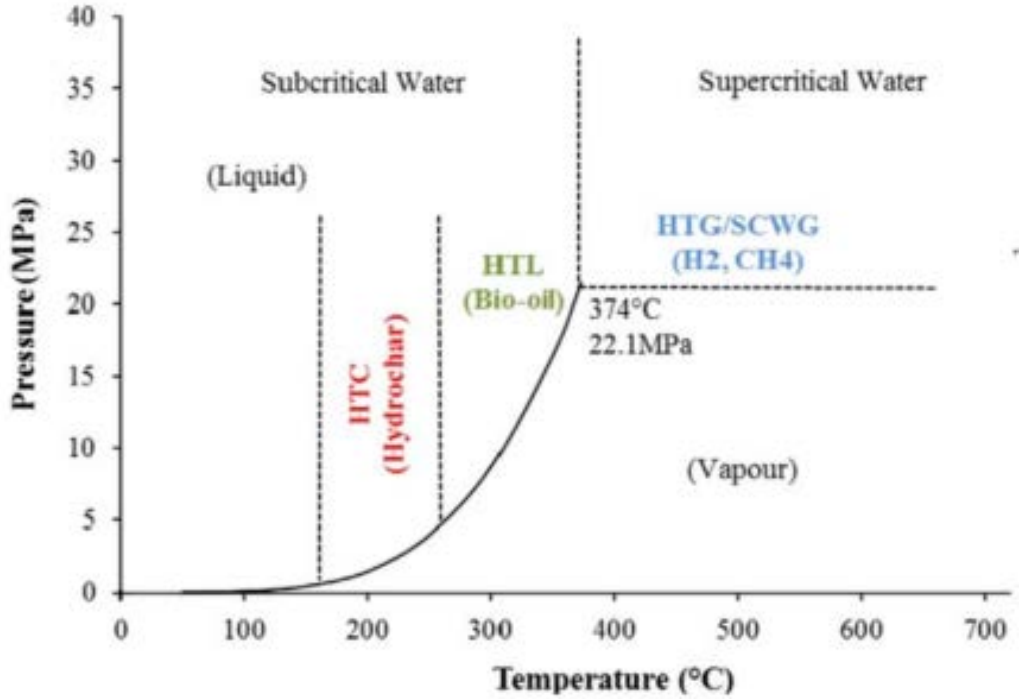
Hydrothermal Treatment (HT) processes can play a role in the transition to a circular economy

Hydrothermal Treatment (HT) - advantages

- neglecting the pre-drying process that is highly energy intensive
- the water used as a medium - the less activation energy requirements and flexibility in producing the fuels
- elimination of biological risks like pathogens existence due to autoclaving at temperature above 120°C (in the case of biomass eg.)
- products from hydrothermal treatment of waste have less moisture content and higher heating values

Hydrothermal Treatment (HT) - priniciples

- In this process the waste material is converted into useful product for energy production applications by heating it at elevated temperatures in the presence of water in high pressure.



Classification of HTP of biomass with reference to the pressure-temperature phase diagram of water

https://doi.org/10.1016/j.biombioe.2020.105479

HT processes - features

Processes	Temperature (T, °C)	Pressure (MPa)	Reaction time	Catalyst	Main products
HTC					
Low T	250	2	Several hours	Not essential	Char
High T	250–800	2	Several hours	Optional	Char
HTL					
Low T	280–370	10–25	Few seconds	Optional	Oil
High T	300–600	10–25	Few seconds	Alkaline salts: Na_2CO_3, KCl, KOH; Heterogeneous catalysts under high pressure H_2	Increasing oil yield; Improved to transport fuel by increasing C/H ratio
HTG					
Near-critical	300–500	Various	Few seconds	Metal catalyst and alkaline salts	CH_4
Supercritical	500–800	Various	Few seconds	Metal catalyst and alkaline salts	Syngas H_2 with minor CO_2, C1–C4 gases
Aqueous phase reforming	220–250	1.5–5	Several hours	Pt/Al_2O_3, Pt/ZrO_2, Rh, Ni and on SiO_2, etc.	H_2 and CO_2 with minor C1–C6 alkanes

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Reactor setup

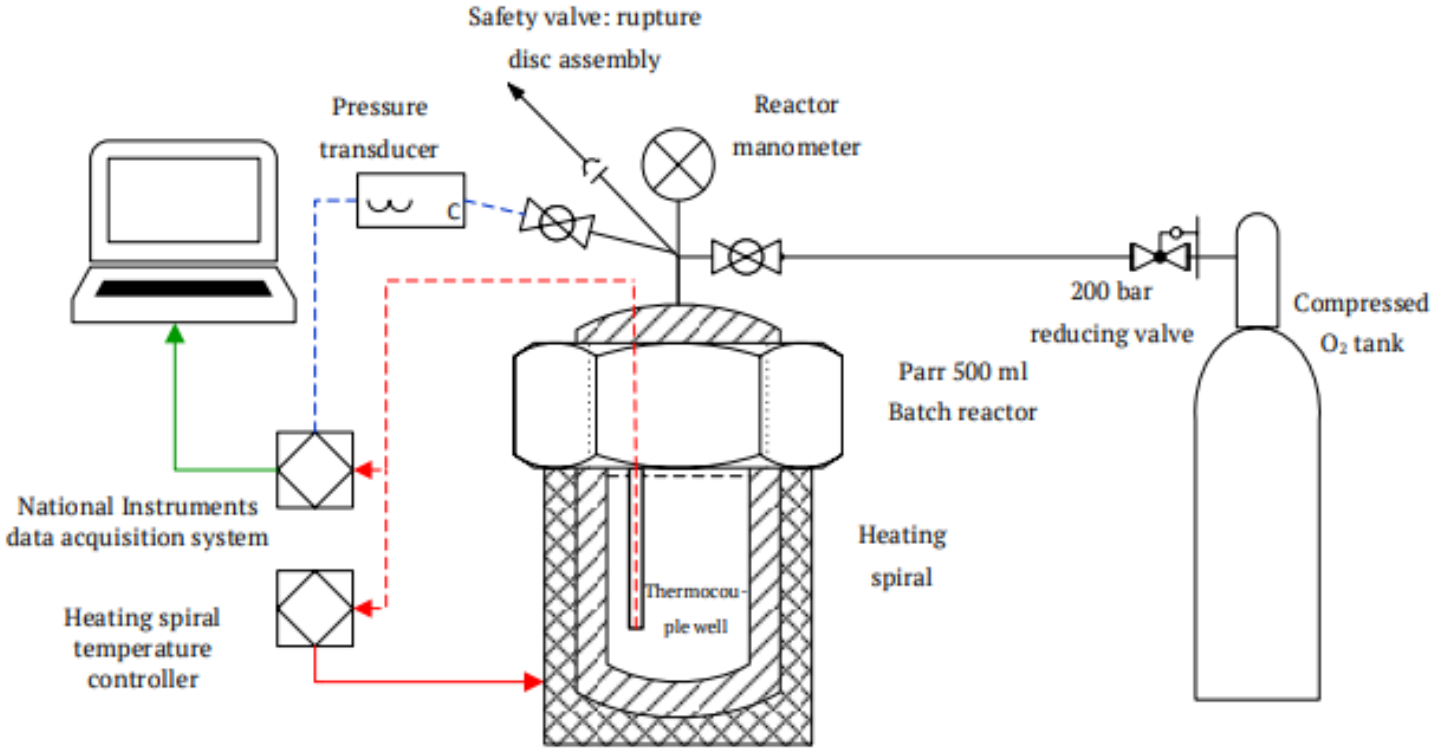
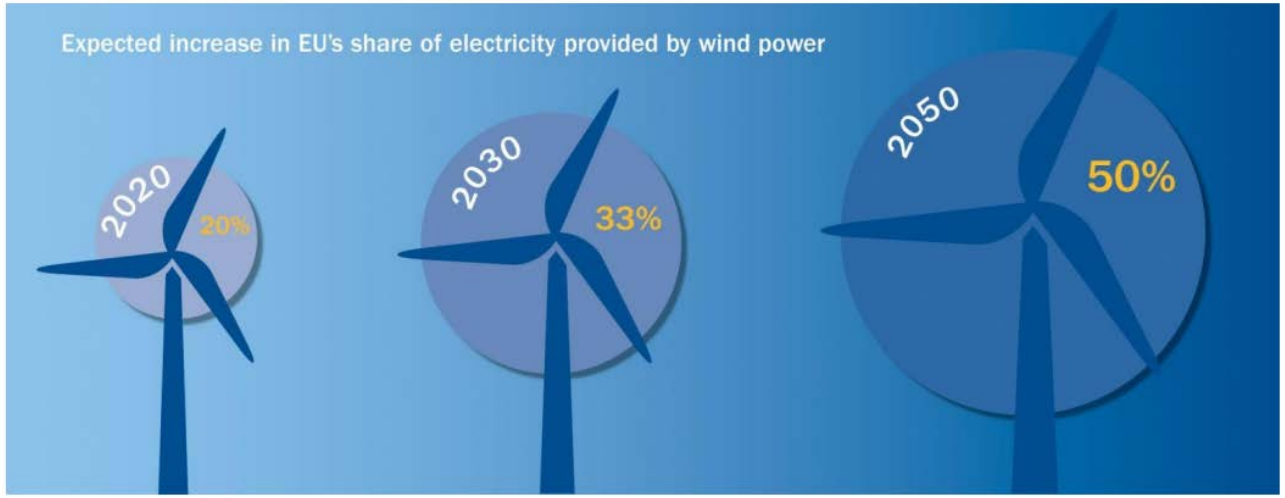


Figure 4. Parr 4650 reactor setup with NI data acquisition system for experimental investigation of the oxidative liquefaction of the plastic waste process.

Reactor setup

Wind turbine probelm

Aerial view of a turbine blade graveyard



Wind turbine probelm

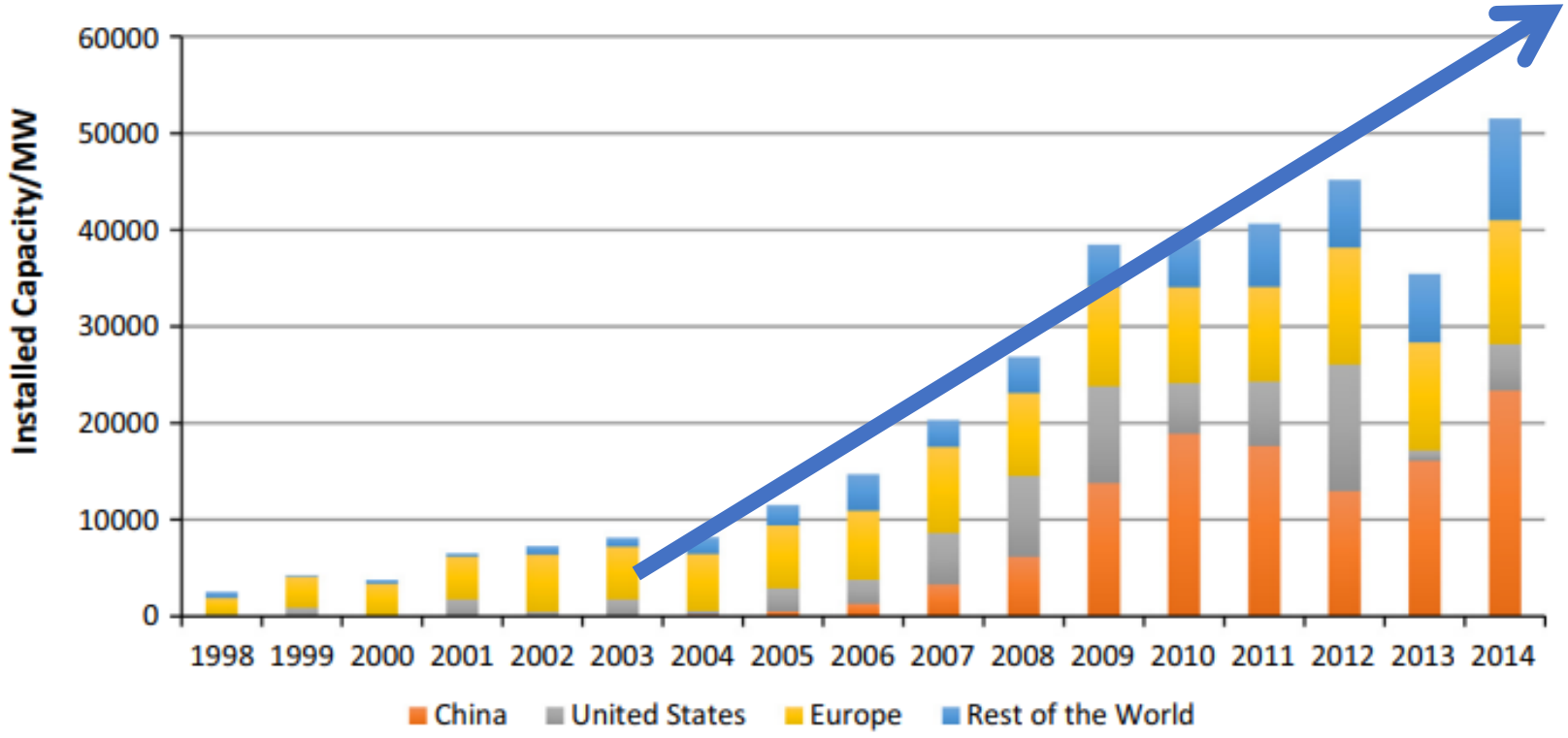


Fig. 5. Annual installed capacity by region. Source: (Liu and Barlow, 2015).

Wind turbine probelm

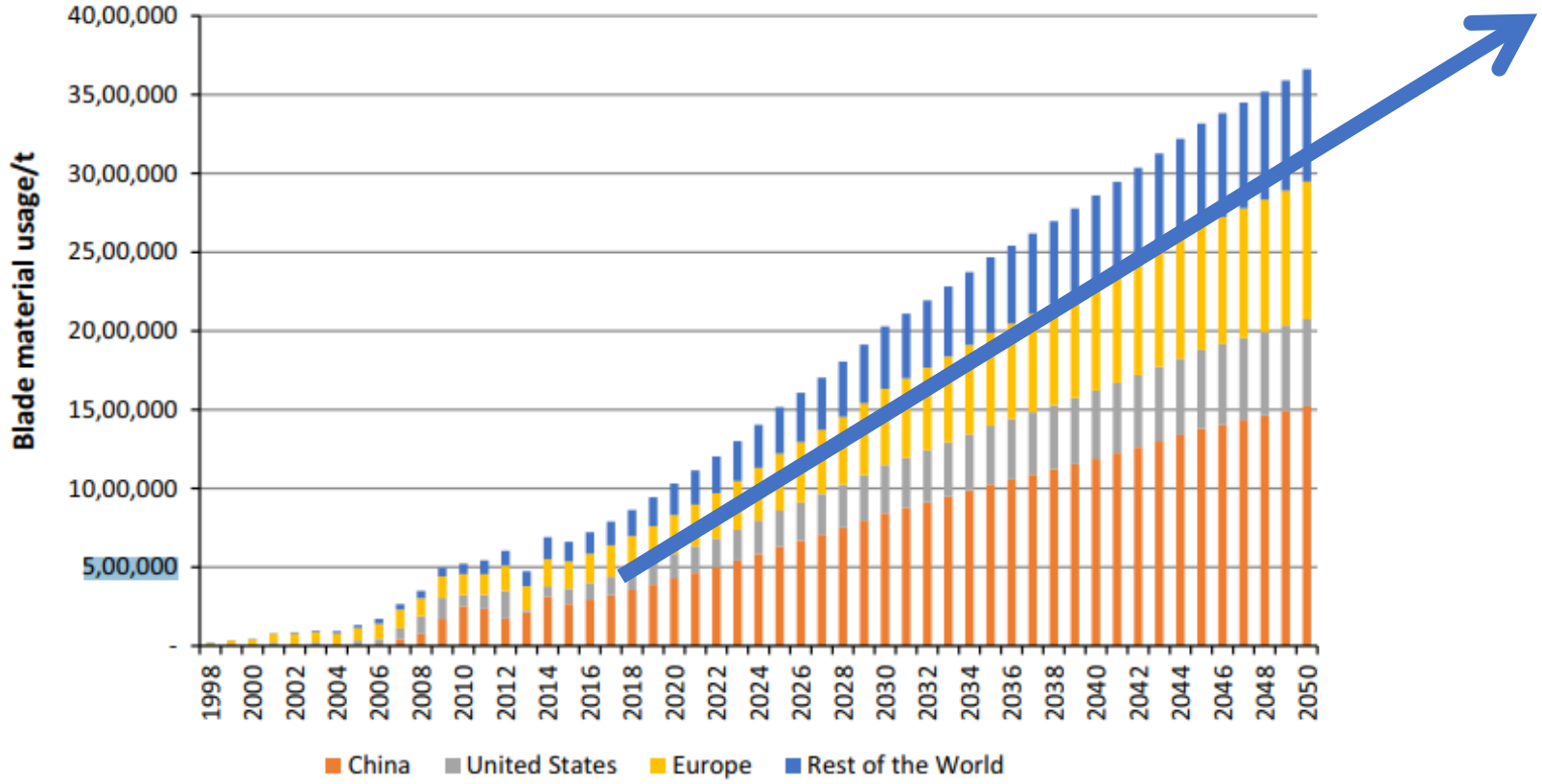
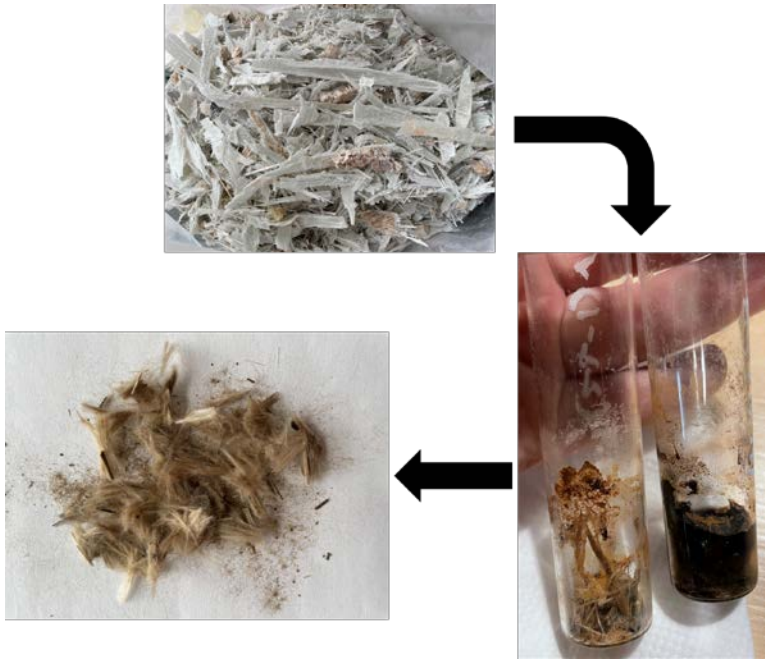


Fig. 6. Annual WTB material usage. Data after 2014 is calculated based on the moderate growth rate scenario.

HTL of wind turbine blades – 1st trials

Temperature (°C)	Pressure (Bar)	Amount of Waste (g)	Waste to liquid ratio
300	30	3	15
Residance Time (Min)			
60			



Research – projects in progress

- **Oxidative liquefaction of plastic waste. Experimental research with multidimensional data analysis using chemometric methods**

2021/41/B/ST8/01770 Departament of Thermal Technology, Silesian University of Technology, Research grant, National Science Center, 2011/03/D/ST8/04035, 2022-2024

Within the proposed project, a study on the oxidative liquefaction of waste plastics, including COVID-19 waste (PW), photovoltaic (PV) waste, wind turbine (WT) blades, and general domestic plastic waste (GDW). The project comprises experimental research on the liquefaction of various plastic waste samples in subcritical water enhanced with oxidative additives.

Research – projects in progress

- EuReComp “European recycling and circularity in large composite components”, 2022-2026;

N.	Proposer name	Country	Total Cost	%	Grant Requested	%
1	NATIONAL TECHNICAL UNIVERSITY OF ATHENS - NTUA	EL	800,250	8.99%	800,250	8.99%
2	INEGI - INSTITUTO DE CIENCIA E INOVACAO EM ENGENHARIA MECANICA E ENGENHARIA INDUSTRIAL	PT	599,900	6.74%	599,900	6.74%
3	TECHNISCHE UNIVERSITAET DRESDEN	DE	598,625	6.72%	598,625	6.72%
4	Elbe Flugzeugwerke GmbH	DE	300,000	3.37%	300,000	3.37%
5	TIRIAKIDIS BASILEIOS ANONIMI BIOMICHANIKI EMPORIKI TECHNIKI ETAIRIA AE	EL	299,375	3.36%	299,375	3.36%
6	INNOVATION IN RESEARCH & ENGINEERING SOLUTIONS	BE	371,250	4.17%	371,250	4.17%
7	HOCHSCHULE FUR TECHNIK WIRTSCHAFT UND KULTUR LEIPZIG	DE	499,987	5.62%	499,987	5.62%
8	Kunststoff-Zentrum in Leipzig gGmbH	DE	300,000	3.37%	300,000	3.37%
9	DALLARA AUTOMOBILI SPA	IT	501,250	5.63%	501,250	5.63%
10	POLITECHNIKA SLASKA	PL	404,825	4.55%	404,825	4.55%
11	INSTITUTO TECNOLOGICO DE ARAGON	ES	465,125	5.22%	465,125	5.22%
12	POLITECNICO DI TORINO	IT	350,375	3.94%	350,375	3.94%
13	ASOCIACION DE INVESTIGACION METALURGICA DEL NOROESTE	ES	649,375	7.29%	649,375	7.29%
14	PANEPISTIMIO PATRON	EL	600,000	6.74%	600,000	6.74%
15	BIOG3D MONOPROSOPI IKE	EL	380,000	4.27%	380,000	4.27%
16	EASN TECHNOLOGY INNOVATION SERVICES BVBA	BE	250,000	2.81%	250,000	2.81%
17	STRATAGEM ENERGY LTD	CY	250,625	2.81%	250,625	2.81%
18	ANTHONY, PATRICK & MURTA-EXPORTACAO LDA	PT	351,250	3.95%	351,250	3.95%
19	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	DE	432,345	4.86%	432,345	4.86%
20	CIRCULARISE BV	NL	499,075	5.61%	499,075	5.61%
21	Przedsiebiorstwo Wielobranzowe Anmet Andrzej Adamcio	PL	0	0.00%	0	0.00%
22	CG RAIL - CHINESISCH-DEUTSCHES FORSCHUNGS- UND ENTWICKLUNGSZENTRUM FURBAHN- UND VERKEHRSTECHNIK DRESDEN GMBH	DE	0	0.00%	0	0.00%
23	TILIA GMBH	DE	0	0.00%	0	0.00%
24	Industrie- und Handelskammer zu Leipzig	DE	0	0.00%	0	0.00%
25	OFFSHORE RENEWABLE ENERGY CATAPULT	UK	0	0.00%	0	0.00%
	Total:		8,903,632		8,903,632	

EUReCOMP aims to provide sustainable methods towards recycling and reuse of composite materials, coming from components used in various industries, such as aeronautics and wind energy

Preelimnary conclusions – tbc.

Hydrothermal wet oxidation of wind turbine blades is a reasonably new technique whose main objective is to reduce solid waste. This group of waste, made with composite containing plastics, are currently regarded as unrecyclable. During wet oxidation, the wind turbine blade is degraded in water under subcritical conditions of temperature (150-320°C) and pressure (20-150 bar). It is assumed that it is possible to produce a narrow group of chemical compounds such as alcohols or alkanes (C_{12}-C_{21}), aldehydes (C_6-C_{16}), ketones (C_6-C_{19}), diketones (C_6-C_{16}) and volatile fatty acids (C_6-C_{20}).

ACKNOWLEDGMENTS

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Thank you!

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