

January 2024



COMPOSITES RECYCLING STUDY

IKK

*IKK –
Institute for Plastics and
Circular Economy*

AVK

*AVK –
Industrievereinigung
Verstärkte Kunststoffe e. V.*

January 2024



COMPOSITES RECYCLING STUDY

Authors

IKK

*Hans-Josef Endres,
Madina Shamsuyeva
IKK - Institute of Plastics and
Circular Economy of the
Leibniz University Hannover
An der Universität 2
30823 Garbsen
kontakt@ikk.uni-hannover.de*

Publisher

AVK

*AVK- Industrievereinigung
Verstärkte Kunststoffe e. V.
Am Hauptbahnhof 10
60329 Frankfurt
069 271077-0
info@avk-tv.de
www.avk-tv.de*

Partner

CU
COMPOSITES
UNITED

*Composites United e. V.
<https://composites-unity.com/>*

Distribution partner

ITA
GmbH

*AVK is a partner in the ITA project
“Supply Chain for Recycling of
Composite Materials and Parts”*

ISBN 978-3-00-076437-0



9 783000 764370

Selling price

399,00€ plus VAT for members of AVK and Composites
United (Price incl. VAT 19% 474,81€)
799,00€ plus VAT for non-members
(Price incl. VAT 19% 950,81€)



AVK – Federation of Reinforced Plastics

AVK, the German Federation of Reinforced Plastics, is the professional German association for fibre-reinforced plastics and composites. It represents the interests of manufacturers and processors both in Germany and at the European level.

Its range of services includes specialised workgroups, seminars and conferences as well as the provision of market-specific information.

In Germany, AVK is one of four support organisations of GKV, the General Association of the Plastics Processing Industry. Within Europe, it is a member of the European umbrella association for composites, EuCIA (European Composites Industry Association).

AVK is a founding member of Composites Germany.



Follow us at LinkedIn

AVK | Am Hauptbahnhof 12 | 60329 Frankfurt | +49 69 27010770
info@avk-tv.de | www.avk-tv.de



IKK

Institut für Kunststoff-
und Kreislauftechnik

In its research work, the IKK – Institute of Plastics and Circular Economy at Leibniz Universität Hannover considers the entire life cycle of bio-based and conventional plastics, from material development and component manufacture through to End of Life scenarios such as mechanical recycling or aquatic degradability.

The IKK supports the industry in the development of recycling-friendly product design solutions and product-specific recovery strategies, the practical implementation and optimisation of recycling processes, compounding and material development as well as plastics processing and sustainability assessment of processes and materials.

Extensive destructive and non-destructive material testing as well as chemical analysis and software systems for sustainability assessment accompany the entire development process.



IKK – Institute of Plastics and Circular Economy
Hannover Centre for Production Technology of Leibniz Universität Hannover
An der Universität 2 | 30823 Garbsen | <https://www.ikk.uni-hannover.de/de/>

Table of contents

Table of contents	I
List of figures	VIII
List of abbreviations.....	XI
1. Introduction.....	14
1.1. Purpose of the study	14
1.2. Scope of the study	18
2. Composites markets worldwide, Europe and Germany.....	19
2.1. Market overview according to application area.....	28
2.1.1. (Wind) energy and construction	31
2.1.2. Transport incl. aerospace	34
2.1.3. Consumer goods incl. sports and leisure as well as marine.....	36
2.1.4. E&E	37
2.1.5. Others.....	38
2.2. Market overview by process and semi-finished products	39
2.3. Market overview of thermoset composites.....	39
2.3.1. RTM process	40
2.3.2. SMC and BMC manufacturing processes	41
2.3.3. Hand lay-up and fibre spraying	42
2.3.4. Centrifugal casting and winding processes	43
2.3.5. Pultrusion and continuous processing	44
2.3.6. Market overview of thermoplastic composites	44
2.3.7. Extrusion/Compounding	46
2.3.8. Injection moulding.....	47
2.3.9. Hot pressing	47
3. Terms, definitions and legal bases relevant to composites recycling.....	49
3.1. General regulations, directives and ordinances: European Waste Framework Directive and German Closed Substance Cycle Waste Management Act.....	51
3.1.1. European Waste List.....	55
3.1.2. German Landfill Ordinance	58
3.2. European and German application-specific laws and regulations.....	60
3.2.1. End of Life Vehicles (ELV) Ordinance.....	60
3.2.2. Electrical and Electronic Equipment Act.....	65
3.2.3. Commercial Waste Ordinance	69
3.2.4. Requirements for the dismantling of wind turbines.....	71
3.2.5. Regulation on the recycling of ships	75
3.3. New European Action Plan for the Circular Economy	77

4.	Standardisation for composites recycling	78
4.1.	ISO 20819-x – Wood-plastic recycled composites	78
4.2.	DIN SPEC 91446 – Classification of recycled plastics by Data Quality Levels for use and (digital) trading	78
4.3.	DIN SPEC 4866 – Sustainable dismantling, disassembly, recycling and recovery of wind turbines	78
4.4.	German Circular Economy Standardisation Roadmap.....	79
4.5.	DIN SPEC 91481 – Classification of recycled plastics of polyamides by Data Quality Levels for use and (digital) trading.....	79
5.	Composite waste quantities according to the application areas.....	81
5.1.	Post-consumer composite waste	84
5.2.	Post-industrial/pre-consumer composite waste.....	87
5.3.	Production and post-consumer waste.....	90
5.4.	(Wind) energy and construction	91
5.4.1.	Wind energy	91
5.4.2.	Energy and construction	98
5.5.	Transport.....	98
5.5.1.	End of Life vehicles.....	98
5.5.2.	Aircraft	104
5.6.	E&E	110
5.7.	Consumer goods incl. sport and leisure as well as marine.....	112
6.	Recycling technologies for composites.....	114
6.1.	Mechanical recycling	121
6.2.	Physical or solvent-based recycling	123
6.3.	Chemical recycling	124
6.3.1.	Solvolysis.....	125
6.3.2.	Pyrolysis	129
6.3.2.1.	Microwave-assisted pyrolysis (or thermolysis)	130
6.3.2.2.	Fluidised bed pyrolysis.....	131
6.4.	Cement clinker route.....	133
6.5.	Carbide route.....	135
6.6.	Recovery in metallurgical processes.....	135
6.7.	Comparison of different recycling processes	135
7.	Recycling companies and example processes as lighthouse projects in the field of composite recycling.....	144
7.1.	Mechanical recycling.....	146
7.2.	Solvolysis	148
7.3.	Pyrolysis.....	150
8.	State of research	153
9.	Summary of the study and outlook	156