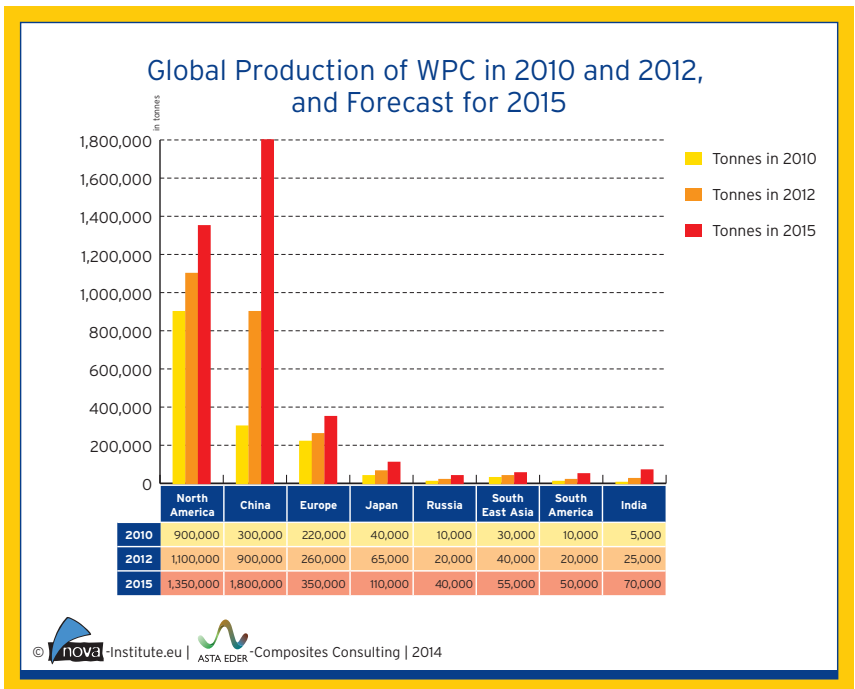


## WPC/NFC Market Study 2014-03

# Wood-Plastic Composites (WPC) and Natural Fibre Composites (NFC):

## European and Global Markets 2012 and Future Trends



Authors: Michael Carus, Dr. Asta Eder, Lara Dammer, Dr. Hans Korte, Lena Scholz, Roland Essel, Elke Breitmayer

Download this study and further nova market studies at:  
[www.bio-based.eu/markets](http://www.bio-based.eu/markets)

## Biocomposites: 352,000 t of wood and Natural Fibre Composites produced in the European Union in 2012

Authors: Michael Carus, Dr. Asta Eder

The most important application sectors are construction (decking, siding and fencing) and automotive interior parts. Between 10 and 15% of the total European composite market is covered by Wood-Plastic Composites (WPC) and Natural Fibre Composites (NFC). The study was conducted by the nova-Institute (Germany) in cooperation with Asta Eder Composites Consulting (Austria/Finland).

This market report gives the first comprehensive and detailed picture of the use and amount of wood and natural fibre reinforced composites in

the European bio-based economy. The analysis covers both Natural Fibre Composites and Wood-Plastic Composites in extrusion, injection and compression moulding in different sectors and for different applications.

To establish a reliable basic dataset, the study draws on a survey conducted in 2013 among the WPC and NFC industry, producers and customers that belong to Asta Eder Composites Consulting's and the nova-Institute's comprehensive networks. The survey included company visits, personal and telephone interviews, as well as an email questionnaire.

### Production of Biocomposites (WPC and NFC) in the European Union 2012 (in tonnes)

<b>Wood-Plastic Composites</b>	<b>260,000</b>
Decking	174,000
Automotive	60,000
Siding and Fencing	16,000
Technical Applications	5,000
Furniture	2,500
Consumer	2,500
<b>Natural Fibre Composites</b>	<b>92,000</b>
Automotive	90,000
Others	2,000
<b>Total Volume Biocomposites (WPC and NFC)</b>	<b>352,000</b>
<b>Share</b>	<b>15%</b>
Composite Production in European Union, total volume (Glass, Carbon, WPC and NFC)	2.4 Million

Table I: Production of biocomposites (WPC and NFC) in the European Union in 2012 (in tonnes) (nova 2014)

The rate of return was exceptionally high, especially for the WPC part of the study, with companies responsible for over 50% of extruded volume taking part in the survey. This means that the study covers roughly 65 European WPC extruding companies in 21 countries. In addition, more than 50 European companies using injection moulding, compression moulding and other processing technologies were included in the survey, as well as producers of WPC and NFC granulates.

### **Total production of biocomposites**

Table I summarises the results of the survey, showing all Wood-Plastic Composites and Natural Fibre Composites produced in the European Union, including all sectors, applications and processing technologies.

Decking and automotive are the most important application sectors for WPC, followed by siding and fencing. Only the automotive sector is relevant for Natural Fibre Composites (NFC) today. The share of WPC and NFC in the total composite market – including glass, carbon, wood and Natural Fibre Composites – is already an impressive 15%. Even higher shares are to be expected in the future: NFC are starting to enter other markets than just the automotive industry. WPC granulates for injection moulding are now produced and offered by global players and are becoming more attractive for clients that manufacture consumer goods, automotive and technical parts.

With increasing polymer prices and expected incentives for bio-based products (the “bio-based economy” is one of the lead markets in Europe) this trend will go from strength to strength, resulting in two-digit growth and increasing market shares over the coming decade.

### **Wood-Plastic Composites – Decking still dominant, but technical applications and consumer goods rising**

The total volume of WPC production in Europe was 260,000 tonnes in 2012 (plus 92,000 tonnes of Natural Fibre Composites for the automotive industry, see Table I). The level of market penetration of bio-based composites varies between regions and from one application field to the next. Germany leads the way in terms of the number of actors and production figures. 45% (85,000 tonnes) of European WPC production for decking, fencing and other construction applications (190,000 tonnes) was extruded by 20 German companies.

The typical production process in Europe is extrusion of a decking profile based on a PVC or PE matrix followed by PP. Increasing market penetration by WPC has meant that WPC volumes have risen strongly and Europe is now a mature WPC market. This study predicts growth, especially in the German-speaking world, on the back of a recovery in construction, particularly renovation, and a further increase in the WPC share of the highly competitive decking market. Also, variations of WPC decking models such as capped embossed solid profiles or garden fencing are on the rise across Europe.

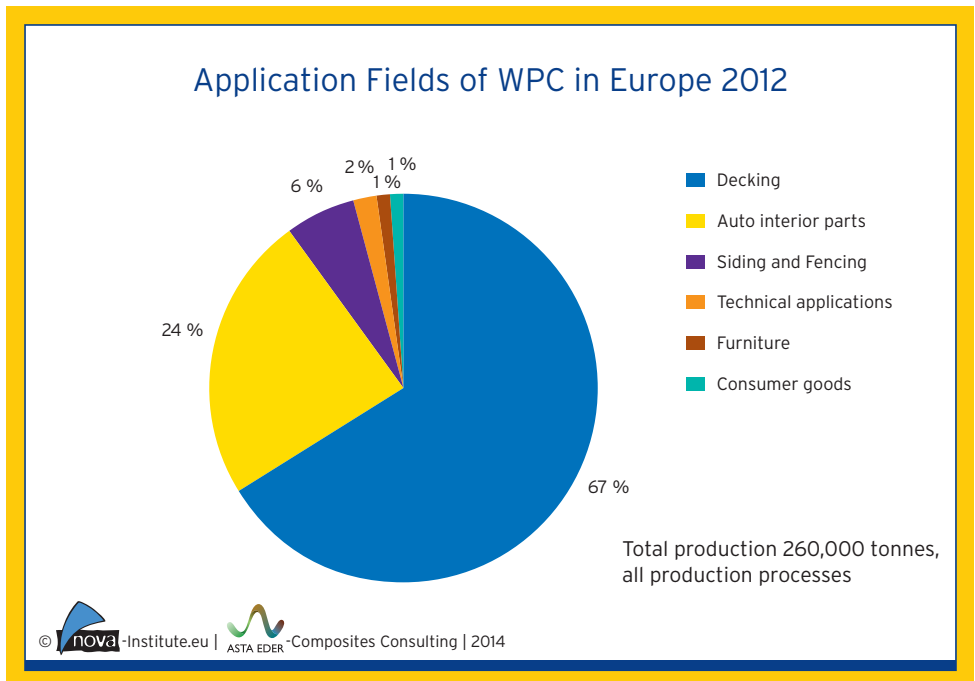
The development of the distribution across applications points to a state of affairs in which WPC is increasingly used for applications beyond the traditional ones like decking or automotive parts. For example, WPC is increasingly used to produce furniture, technical parts, consumer goods and household electronics, using injection moulding and other non-extrusion processes. Also, new production methods are being developed for the extrusion of broad WPC boards.

Figure I shows the various application fields of WPC produced in Europe. The decking market leads the way with 67% (mainly extrusion), followed by automotive interior parts with 23% (mainly compression moulding and sheet extrusion as well as thermoforming). Although they are still small, siding and fencing, along with technical applications (mainly extrusion), consumer goods and furniture (mainly injection moulding), are showing the highest percentage increases.

In the face of rising plastic prices, WPC granulates are getting more and more attractive for injection moulding, and increasingly feature in European granulate suppliers' product ranges. Three big paper companies released cellulose-based PP granulates for injection moulding between 2012 and 2013. They use a PP matrix with cellulose and have fibre shares of between 20 and 50% for new and interesting applications such as furniture, consumer goods and automotive parts.

The report also gives an overview of the latest market developments in North-America, Asia and Russia, and provides an overview of, and a forecast for, the global WPC market. Worldwide WPC production will rise from 2.43 million tonnes in 2012 to 3.83 million tonnes in 2015. Although North America is still the world's leading production region with 1.1 million tonnes, ahead of China (900,000 t) and Europe (260,000 t), it is expected that China (with 1.8 million t by then) will have overtaken North America (1.4 million t) by 2015. European production will grow by around 10% per year and reach 350,000 tonnes in 2015.

The share of WPC decking in the North American decking market is once more on the up, after a period of housing crises and WPC quality problems that led to a shakeout of the top WPC producers.



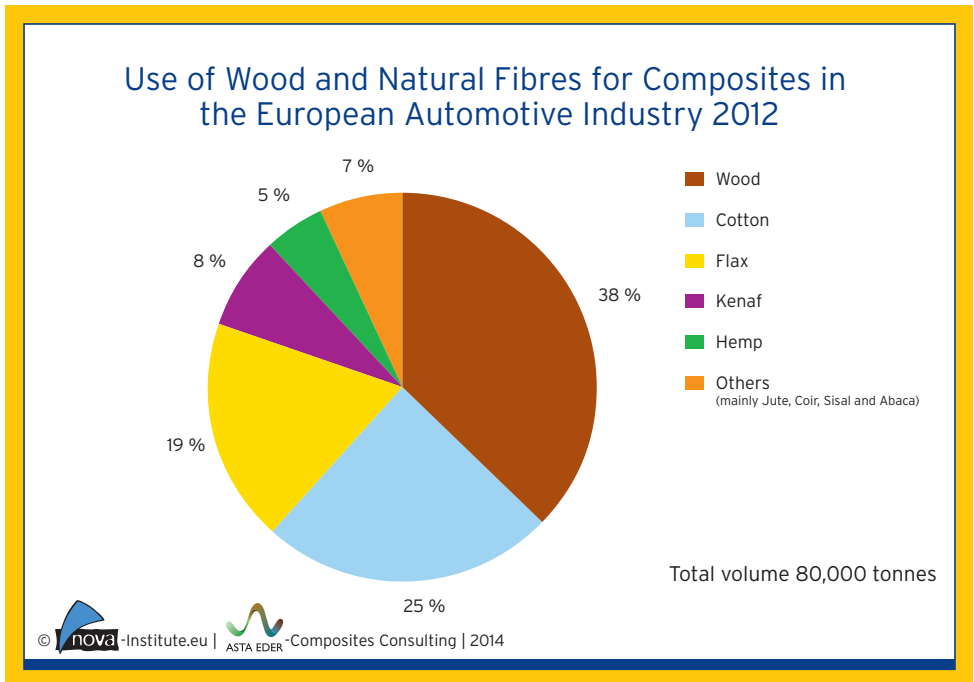
**Figure I:** Application fields of WPC in Europe in 2012 (Total production 260.000 tonnes, all production processes) (nova 2014)

In China, decking also has a larger market share than other WPC applications, mainly due to strong exports, although the domestic market has developed rapidly in recent times. China also has the largest window and door market in the world. Hence companies have lately started to produce commercial window frames using WPC, with approximately 40% wood fibre as a substitute for PVC in combination with aluminium. China produces a large variety of WPC for indoor applications. Another successful product is an extruded WPC door that is already produced by 30 companies.

### WPC and NFC in the automotive industry

Interior parts for the automotive industry is by far the most dominant use of Natural Fibre Composites – other sectors such as consumer goods are still at a very early stage. In the automotive sector, Natural Fibre Composites have a clear focus on interior trims for high-value doors and dashboards. Wood-Plastic Composites are mainly used for rear shelves and trims for trunks and spare wheels, as well as in interior trims for doors.

Figure II shows the total volume of 80,000 tonnes of different wood and natural fibres used in the 150,000 tonnes of composites for passenger cars and lorries that were produced in Europe in 2012 (90,000 tonnes of Natural Fibre Composites and 60,000 tonnes of WPC). Recycled cotton fibre composites are mainly used for the driver cabins of lorries.



**Figure II:** Use of wood and natural fibres for composites in the European automotive industry in 2012, including cotton and wood (total volume: 80,000 tonnes). “Others” are mainly jute, coir, sisal and abaca (nova 2014)

The highest market shares are for wood (of European origin), recycled cotton (from the world market) and flax fibres (of European origin). The shares of kenaf (from Asia) and hemp fibres (European origin) show the largest increases in percentage terms since the last survey for the year 2005.

Process-wise, compression moulding of wood and Natural Fibre Composites are an established and proven technique for the production of extensive, lightweight and high-class interior parts for mid-range and luxury cars. The advantages (lightweight construction, crash behaviour, deformation resistance, lamination ability and, depending on the overall concept, price) and disadvantages (limited shape and design forming, scraps, cost disadvantages in case of high part integration in construction parts) are well known. Process optimisations are in progress in order to reduce certain problems such as scraps and to recycle wastage.

Since 2009, new improved compression-moulded parts have shown impressive weight-reduction characteristics. This goes some way to explaining the growing interest in new car models. Using the newest technology, it is now possible to get area weight down to 1,500 g/m<sup>2</sup> (with thermoplastics) or even 1,000 g/m<sup>2</sup> (with thermosets), which are outstanding properties when compared to pure plastics or glass fibre composites.

Still small in volume but also strong in innovation: PP and cellulose-based granulates for injected-moulded parts were recently introduced onto the automotive market by big paper companies in Europe and the USA.

15.7 million passenger cars were produced in the EU in 2011, and an additional 2 million other motor vehicles (incl. trucks, transporters, motor bikes, etc.) were manufactured. Considering that 30,000 tonnes of natural fibres and another 30,000 tonnes of wood fibres were used in 15.7 million passenger cars, on average every passenger car in Europe contains 1.9 kg of natural fibres respectively 1.9 kg of wood fibres. Since the German automotive industry is the most important consumer of natural fibre parts within the European automotive sector and since natural fibres are more used in middle- and high-class cars, the figures of 1.9 kg for the European average and 3.6 kg for the German average match well.

From a technical point of view, much higher volumes of WPC and NFC are possible. Vehicles have been successfully produced in series for years with considerably larger amounts: 20 kg of natural and wood fibres. Market developments also depend on the political framework: any incentives for the use of natural and wood fibres in the European automotive industry could help to extend the existing volumes of 30,000 t/year each for natural and wood fibres. Such a vision could lead to an increase by a factor of up to five, which would represent 150,000 t per year and fibre type; the technologies are ready to use. Biocomposites have great potential!

## Outlook for WPC and NFC production in the EU until 2020

As just discussed, the production and use of 150,000 tonnes biocomposites (using 80,000 tonnes of wood and natural fibres) in the automotive sector in 2012 could expand to over 600,000 tonnes of biocomposites in 2020, using 150,000 tonnes of wood and natural fibres each along with some recycled cotton. Yet this fast development will not take place if there are no major political incentives to increase the bio-based share of the materials used in cars. Without incentives we forecast that production will only increase to 200,000 tonnes.

Huge percentage increases can also be expected for WPC and NFC granulates used in injection moulding for all kind of technical and consumer goods. With improved technical properties, lower prices and bigger suppliers capable of supporting their customers, we forecast a growth from the tiny amount of 15,000 tonnes in 2012 to 100,000 tonnes by 2020. Additional incentives might at least double the production. For NFC granulates we foresee only niche markets with specific demand, reaching 10% of the WPC granulate market or 10,000 t in 2020.

Extruded WPC is now well established as a material for decking, fencing and facade elements. Its market share is still growing and should reach and surpass the level of tropical wood in most of the European countries by 2020. About 190,000 tonnes of WPC were produced in Europe for the construction sector in 2012 – and this will be surely increase to 400,000 t in 2020. Unlike other sectors, political incentives will have only a small impact, because WPC are positioned against other bio-based materials and not, as in automotive or consumer goods, pitched against petrochemical plastics. Nevertheless, the whole framework of bio-based economy including green material databases will also give impetus to WPC decking.

Biocomposites	Production in 2012	Forecast production in 2020 (without incentives for bio-based products)	Forecast production in 2020 (with strong incentives for bio-based products)
<b>WPC</b>			
Construction, extrusion	190,000 t	400,000 t	450,000 t
Automotive, press moulding & extrusion/thermoforming	60,000 t	80,000 t	300,000 t
Granulates, injection moulding	15,000 t	100,000 t	> 200,000 t
<b>NFC</b>			
Automotive, press moulding	90,000 t	120,000 t	350,000 t
Granulates, injection moulding	2,000 t	10,000 t	> 20,000 t

Table II: Production of biocomposites (WPC and NFC) in the European Union in 2012 and forecast 2020 (in tonnes) (nova 2014)

## The authors of the study



**Dipl.-Phys. Michael Carus** – *nova-Institut (Germany)* physicist, founder and managing director of the nova-Institute, is working for over 15 years in the field of Bio-based Economy.

This includes biomass feedstock, processes, bio-based chemistry, plastics, fibres and composites. The focus of his work are market analysis, techno-economic and ecological evaluation as well as the political and economic framework for bio-based processes and applications (“level playing field for industrial material use”). Since 2005, Michael Carus is managing director of the European Industrial Hemp Association (EIHA).



**Dr. rer. nat. Asta Eder** – **Asta Eder Composites Consulting (Austria/Finland)** is one of the leading market experts on bio-based plastics and composites, especially on Wood-Plastic Composites. Dr. Eder did her PhD-

work on market opportunities of innovative wood composites (WPC and Thermowood) in the German speaking area. She has been conducting market research and consulting for the development of new bio-based composites and their applications for the last 15 years. Asta Eder Composites Consulting is located in Vienna, Austria. It specializes in consultation of WPC and wood composite markets; product development and launch; and marketing and sales. Since 2013 Dr. Eder also works at the nova-Institute in the field of standardisation and certification of Bio-based Composites and WPC.



**M.A. Pol. Lara Dammer** – *nova-Institute (Germany)* studied Political Science with a focus on sustainable development at Bonn University. She is a staff scientist in the field of policy

and strategy at nova-Institute. Her main focus is on framework conditions for the material use of renewable resources, national and international resource and environmental policies as well as communication and dissemination. She is active in analysing hurdles and enablers for a bio-based economy in Germany and the EU. As project manager she is currently working on a master plan for the development of the national kenaf industry with the government of Malaysia.



**Dr. rer. nat. Hans Korte** – *PHK Polymertechnik GmbH (Germany)* studied Forestry at Hamburg University and gained a PhD in Biochemistry before taking up a

post with an international chemical company, for whom he carried out R&D work on cellulose, was Head of Technical Marketing of Director of Sales of geoplastics.

Since 2000 he has worked in Wismar as a freelance consultant on process, material and product development for wood, fibres and composites. He initiates and coordinates national and international research projects, conducts market surveys and writes expert reports. In 2002 he set up, and has since run, PHK Polymertechnik GmbH in Wismar, a company that develops and markets new materials such as Rotowood, WPC for rotation sintering, and Nerolit, a hydrophobic, durable and thermally stable filling material for plastic composites.





**Dipl.-Wirtsch.-Ing. Lena Scholz**  
– *nova-Institute (Germany)* is an industrial engineer with a focus on bio-based materials, especially bioplastics and bio-composites.

Her expertise includes detailed knowledge of the global bioplastics market and she is one of the authors of the Market Study on Bio-based Polymers. Together with Michael Carus she has observing status in the CEN Committee for bio-based products representing the European Industrial Hemp Association. Since 2014, Lena Scholz is project manager at Tecnaro GmbH.



**M.Sc. agr. econ. Elke Breitmayer**  
– *nova-Institute (Germany)* studied Agricultural Economics at the University of Hohenheim, Germany with a focus on resource economics

and rural development.

In 2010 she was awarded a PhD scholarship from the DFG (German Research Foundation). She worked on the assessment of environmental impacts in intensive agricultural systems in China and as a scientific assistant at the Food Security Center at the University of Hohenheim. She joined the nova-Institute in 2013.



**Dipl.-Umweltwiss. Roland Essel**  
– *nova-Institute (Germany)* studied environmental sciences at the Universities of Trier, Edinburgh and Karlsruhe and graduated from the

University of Trier in 2010 with a thesis about the eco-efficiency of economic sectors in Europe. He started his career as a consultant for Taurus Eco Consulting GmbH as well as a research assistant at the chair of environmental accounting at the University of Technology in Dresden. Since May 2011 Roland Essel is project manager at the nova-Institute GmbH and responsible for ecological evaluation and environmental resource management.. His field of expertise covers life cycle assessment (LCA), system analysis and modelling (simulation & scenario analysis) of environmental impacts.

## nova Market Studies

- Wood-Plastic Composites (WPC) and Natural Fibre Composites (NFC): European and Global Markets 2012 and Future Trends *2014-03 – 1,000 € plus VAT*
- Bio-based Polymers in the World – Capacities, Production and Applications: Status Quo and Trends towards 2020 *2013-03 – 6,500 € plus VAT*
- Available at [www.bio-based.eu/markets](http://www.bio-based.eu/markets)

The market study “**Wood-Plastic Composites (WPC) and Natural Fibre Composites (NFC): European and Global Markets 2012 and Future Trends**” gives the first comprehensive and detailed picture of the use and amount of wood and natural fibre reinforced composites in the European bio-based economy.

**The full report covers the following subjects on 84 pages:**

## Table of Content

<b>0</b>	<b>Executive summary.....6</b>	3.3.1	VHI (Germany): Quality and Testing Specifications for Production Control for Terrace Decking made from Wood-Polymer Composites ..... 17
<b>1</b>	<b>Definition of bio-based composites, WPC and NFC ..... 10</b>	3.3.2	Austrian standard: ÖNORM CEN/TS 15534 1-3 18
<b>2</b>	<b>WPC components: plastics, wood flour and fibres, and additives ..... 11</b>	3.3.3	French standard: XP T25-501-2:2009-10 Reinforcement fibres – Flax fibres for plastics composites..... 18
2.1	Plastics ..... 11	3.4	Certification of the sustainability of wood as a raw material – FSC and PEFC ..... 18
2.2	Wood..... 13	3.5	New certification systems for sustainable biomass ..... 19
2.2.1	Wood fibres..... 13	<b>4</b>	<b>Extrusion and other processing technologies of WPC .....20</b>
2.2.2	Wood flour..... 13	4.1	Extrusion..... 20
2.2.3	Wood chips ..... 13	4.2	Compression moulding..... 20
2.2.4	Wood shavings..... 13	4.3	Injection moulding..... 21
2.3	“Other fibres” used in WPC production ..... 13	4.4	WPC profile extrusion ..... 21
2.4	Additives ..... 14	4.4.1	Counter-rotating twin-screw extruder ..... 22
2.5	Raw material costs of WPC production ..... 14	4.4.2	Co-rotating twin-screw extruder..... 22
<b>3</b>	<b>Standards, norms, certificates and labels for bio-based composites ..... 15</b>	4.4.3	Heating-cooling mixer / fluidizing-cooling mixer combination ..... 22
3.1	Example for national support structures: USDA BioPreferred® program ..... 15	4.5	Recent trends..... 22
3.1.1	ASTM D6866 Test Methods to Determine the Bio-based Carbon Content of Materials Using Radiocarbon and Isotope Ratio Mass Spectrometry ..... 15	4.5.1	Recent trends in WPC extrusion..... 22
3.1.2	ASTM D7075-04 Standard Practice for Evaluating and Reporting Environmental Performance of Bio-based Products..... 16	4.5.2	Recent trends in injection moulding ..... 24
3.2	The situation in Europe..... 16	<b>5</b>	<b>WPC markets, application fields and distribution channels in Europe in 2012 .....25</b>
3.2.1	EN 15534: Composites made from cellulose-based materials and thermoplastics (usually called wood-polymer composites (WPC) or natural fibre composites (NFC)) ..... 16	5.1	Brief history of WPC in Europe ..... 25
3.2.2	CEN/TC411 – prEN 16575 Bio-based products. 16	5.2	Wood-Plastic Composites market overview in Europe ..... 25
3.2.3	Bio-based labels in Europe ..... 17	5.3	WPC innovation trends in Europe..... 27
3.3	National (Germany, Austria and France) and European WPC and NFC standards ..... 17	5.4	European decking market trends in 2012 ..... 29
		5.5	Regional differences, decking markets and distribution ..... 29

## Order the full report

The full report can be ordered for 1,000 € plus VAT at [www.bio-based.eu/markets](http://www.bio-based.eu/markets)



<b>6</b>	<b>Global trends in Wood-Plastic Composites...32</b>	9.2.2	Hemp .....	58
6.1	Leading WPC regions: North America and China32	9.2.3	Other natural fibres .....	58
6.2	International application fields for WPC.....34	9.2.4	Conclusion .....	59
6.2.1	Materials and prices .....	9.3	Main applications of natural fibres in automotive composites.....	59
6.2.2	The Chinese WPC market .....	9.4	Volume and shares of different production techniques .....	59
6.2.3	The WPC market in Russia.....	9.5	Natural fibres per passenger car.....	60
<b>7</b>	<b>Wood and natural fibre based granulates for injection moulding and extrusion .....38</b>	9.6	Future developments.....	61
7.1	Market structure.....	9.6.1	Compression moulding – with good growth potential in lightweight construction .....	61
7.2	Technical properties of WPC and NFC in injection moulding .....	9.6.2	PP natural fibre injection moulding – still a sleeping giant or already a dead dwarf? .....	62
7.3	WPC and NFC for furniture and consumer goods.....	9.6.3	Extrusion and thermoforming .....	63
7.4	Price ranges for WPC and NFC granulates .....	9.6.4	Other processing technologies.....	63
7.5	Main WPC and NFC granulate producer and supplier.....	9.7	Political framework.....	64
<b>8</b>	<b>Production and consumption of natural fibres worldwide .....46</b>	<b>10</b>	<b>Other Applications of Natural Fibres: Non-wovens, Geotextiles and Insulation.....65</b>	
8.1	Overview: Worldwide consumption of fibres.....	10.1	Non-wovens worldwide .....	65
8.2	Natural fibres: cultivation, production and prices .....	10.2	Non-wovens in Asia.....	65
8.2.1	Jute.....	10.3	Geotextiles worldwide .....	66
8.2.2	Kenaf .....	10.4	Natural fibre insulation in Europe.....	67
8.2.3	Hemp .....	<b>11</b>	<b>Overview of life cycle assessments for Wood-Plastic Composites and Natural Fibre Composites .....69</b>	
8.2.4	Flax.....	11.1	Introduction to life cycle assessment (LCA) .....	69
8.2.5	Sisal.....	11.2	Results from recent life cycle assessments.....	69
<b>9</b>	<b>Use of wood and natural fibres in composites for the European automotive production in the year 2012 and outlook .....56</b>	11.2.1	Production of natural fibres .....	69
9.1	Natural fibres in the European automotive production – volumes and market share.....	11.2.2	Production of Natural Fibre Composites .....	70
9.2	Which developments can be expected for fibres in the coming years? .....	11.2.3	Natural Fibre Composites in comparison to biofuels .....	70
9.2.1	Kenaf .....	11.2.4	Wood-Plastic Composites .....	72
		11.3	Conclusion .....	73
		<b>12</b>	<b>References.....</b>	<b>74</b>

## Figures include:

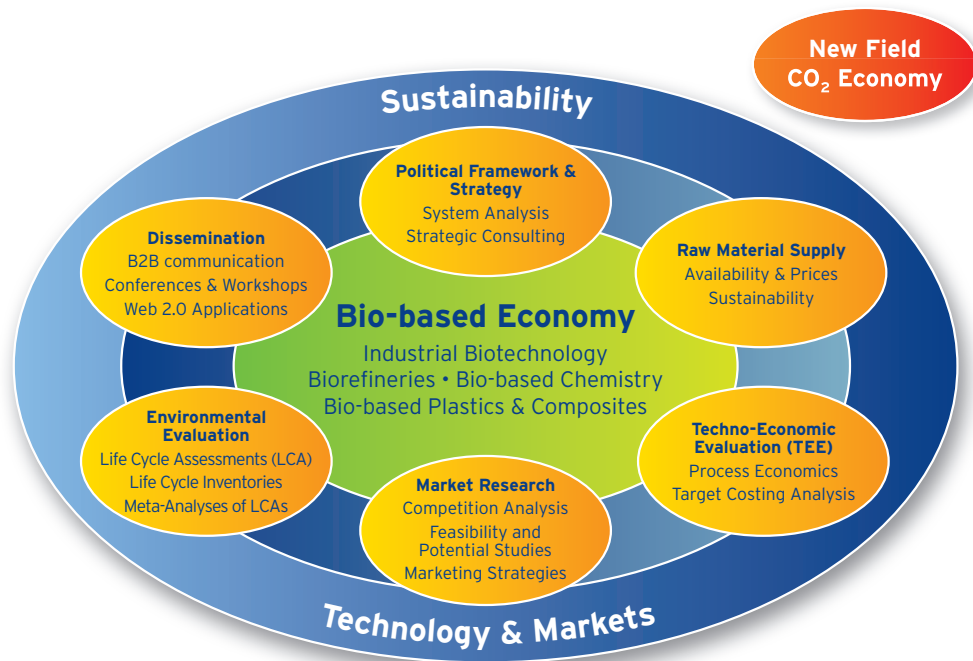
Figure I:	Application fields of WPC in Europe in 2012 (Total production 260.000 tonnes, all production processes) (nova 2014) .....7	Figure 6.1:	Development of North American multi and single family housings starts (Van Eaton 2013) .....32
Figure II:	Use of wood and natural fibres for composites in the European automotive industry in 2012, including cotton and wood (total volume: 80,000 tonnes). "Others" are mainly jute, coir, sisal and abaca (nova 2014) .....7	Figure 6.2:	Global production of WPC in 2010 and 2012, and forecast for 2015 (nova 2014).33
Figure 1.1:	Description of biocomposites (nova 2014) ..... 10	Figure 6.3:	WPC-MDF boards in India (Hardy Smith 2012).....34
Figure 2.1:	European plastics demand (PlasticsEurope 2013) .....12	Figure 6.4:	Global number of WPC-producing companies in 2012 (n=671) (nova 2014) .....34
Figure 2.2:	European plastics demand by segment and resin type in 2012 (PlasticsEurope 2013) .....12	Figure 6.6:	Main application fields of Chinese WPC products in 2012 (n=422 producers) (Song 2013).....35
Figure 2.3:	Prices of common plastics (nova 2014, based on Kunststoff Information 2013) ....12	Figure 6.7:	Development of the sales volume of the Chinese WPC industry (Song 2013).....35
Figure 4.1:	WPC production processes in Europe in 2012 (nova 2014) .....20	Figure 6.8:	Production of WPC solid decking board with capstock layer for export to North America in Ningbo Helong New Material Ltd (Picture: Eder 2012) .....36
Figure 4.2:	Polymer usage in European WPC decking (extrusion only) in 2012 (nova 2014).....20	Figure 6.9:	WPC production in Russia by type of product in 2013 (Inventra 2013) .....36
Figure 4.3:	One and two-step WPC extrusion process overview (Daniel & Kahr 2011) ...21	Figure 6.10:	Overall and WPC decking production in Russia in 2012 and 2013 (in tonnes) (Inventra 2013) .....37
Figure 4.4:	Components of a typical WPC extrusion line (Weber 2013) .....22	Figure 6.11:	Consumption of polymers for the production of WPC in 2013 – total 5,500 tonnes (Inventra 2013) .....37
Figure 5.1:	Application fields of WPC produced in Europe 2012 (nova 2014) .....26	Figure 7.1:	Value added of WPC and NFC – extrusion and injection moulding (Eder 2013) .....38
Figure 5.2:	Application fields of extruded WPC produced in Europe, 2012 (nova 2014) ....26	Figure 7.4:	Mechanical properties of different injection-moulded materials I – impact and stiffness (nova 2014) .....41
Figure 5.3:	Main countries of European WPC production of decking, fencing and other construction applications (nova 2014).....26	Figure 7.5:	Mechanical properties of different injection-moulded materials II – impact and tensile strength (nova 2014) .....41
Figure 5.9:	Polymer usage in European WPC decking (extrusion only) (nova 2014).....29	Figure 7.6:	Mechanical properties of different injection-moulded materials III – stiffness and tensile strength (nova 2014) .....41
Figure 5.10:	Price ranges per terrace surface from a survey of German decking distribution channels in 2013 (nova 2014) .....30	Figure 7.7:	Mechanical properties of different injection-moulded materials IV – shrinkage and temperature resistance (nova 2014) .....42
Figure 5.11:	Price ranges of decking from a survey of German decking distribution channels in 2013 (Asta Eder Composites Consulting 2009 and 2011, nova 2014) .....30	Figure 8.1:	World fibre consumption 1980–2012 (The Fiber Year 2013).....46
Figure 5.12:	Comparison of different profile geometries and production costs (Weber 2013) .....31	Figure 8.2:	Market shares in 2012 (The Fiber Year 2013).....46

Figure 8.3: Market shares 1965–2012 (The Fiber Year 2013).....	46	Figure 8.19: Applications for European hemp fibre from 2010 harvest (in percentage), in total 26,000 metric tonnes (nova 2014, based on EIHA 2013) .....	52
Figure 8.4: Distribution of natural fibre shares (The Fiber Year 2013).....	47	Figure 8.20: Price development of Flax and Hemp technical short fibres (suitable for non-woven and composite applications) from 2003 until 2013 (nova 2014) .....	52
Figure 8.5: Development of worldwide natural fibre production 1961–2011 (nova 2014, based on FAOSTAT 2013).....	47	Figure 8.21: Hemp cultivation area Canada 1998–2011 in tonnes (nova 2014, based on Agriculture and Agri-Food Canada 2013) .....	53
Figure 8.6: Sisal fibre production in Tanzania 1898–2006 (Tenga 2008).....	48	Figure 8.22: Top producing countries of flax fibre and tow 2011 (FAOSTAT 2013) .....	54
Figure 8.7: Market volumes of traditional fibre applications in China 1984–2009 (Mackie 2000) .....	48	Figure 8.23: Flax cultivation area in the EU, 2000–2011 (nova 2014, based on EUROSTAT 2013) ...	54
Figure 8.8: Dynamics of major fibre markets from the 1970s to 2012 (AAGR = Average annual growth rate, The Fiber Year 2013) .....	48	Figure 8.24: Development of worldwide flax cultivation area, 1993–2011 in tonnes (nova 2014, based on FAOSTAT 2013).....	54
Figure 8.9: World production of jute 2011/12 (nova 2014, based on FAO 2012) .....	48	Figure 8.25: Development of worldwide flax fibre and tow production, 1993–2011 in tonnes (nova 2014, based on FAOSTAT 2013) .....	54
Figure 8.10: World production of jute 1998–2012 in tonnes (nova 2014, based on FAO 2005, 2010, 2012).....	49	Figure 8.26: Sisal production in 2011 in most important producing countries (nova 2014, based on FAO 2012).....	55
Figure 8.11: World consumption of jute, kenaf and allied fibres 1998–2011 in tonnes (nova 2014, based on FAO 2005, 2010, 2012).....	49	Figure 8.27: Development of sisal production 2006–2011 in the most important producing countries in '000 tonnes (nova 2014, based on FAO 2012) .....	55
Figure 8.12: Accumulated cultivation area for jute, kenaf and allied fibres in India, Bangladesh, China, Myanmar, Nepal and Thailand 2000–2012 in tonnes (nova 2014, based on FAO 2005, 2010, 2012).....	49	Figure 8.28: Sisal export prices of Brazil and Tanzania 1992–2012 (nova 2014, based on Claro 2011).....	55
Figure 8.13: Price index of jute from Bangladesh 2000–2012 (FAOSTAT 2013).....	50	Figure 9.1: Use of Natural Fibres for Composites in the German Automotive Industry 2005 (total volume 19,000 tonnes, without Cotton and Wood) (nova 2014 based on Karus et al. 2006).....	56
Figure 8.14: World production of kenaf and allied fibres 2011/2012 (nova 2014, based on FAO 2012).....	50	Figure 9.2: Use of Natural Fibres for Composites in the European Automotive Industry 2012 (total volume 30,000 tonnes, without Cotton and Wood), others are mainly Jute, Coir, Sisal and Abaca (nova 2014) .....	57
Figure 8.15: World production of kenaf and allied fibres 1998–2012 in tonnes (nova 2014, based on FAO 2005, 2010, 2012).....	50	Figure 9.3: Price development of Flax and Hemp technical short fibres (suitable for non-woven and composite applications) from 2003 until 2013 (nova 2014) .....	57
Figure 8.16: Global production of hemp fibre and seed 2000–2011 in tonnes (nova 2014, based on FAOSTAT 2013) .....	51		
Figure 8.17: Global harvested area for hemp fibre, tow, waste and seed 2000–2011 in hectare (nova 2014, based on FAOSTAT 2013) .....	51		
Figure 8.18: Hemp cultivation area in the EU 1993–2012 (nova 2014, based on EIHA 2013).....	52		

Figure 9.4:	Use of wood and natural fibres for composites in the European automotive industry 2012, including bast and leave fibres, cotton and wood (total volume 80,000 tonnes), others are mainly Jute, Coir, Sisal and Abaca (nova 2014) .....57	Figure 11.4:	Cradle-to-gate energy use of hemp fibre/ epoxy door panels for the automotive industry. Data is given in percentage (Haufe & Carus 2011) .....70
Figure 10.1:	Development of production volume of non-wovens and unspun applications 2000–2012 (The Fiber Year 2013) .....65	Figure 11.5:	Greenhouse gas emissions as percentages for the production of fossil-based and hemp-based composites from a number of studies, where available showing the effect of carbon storage (Haufe & Carus 2011) .....70
Figure 10.2:	Development of non-woven fabrics production volume in Asia, 2005–2012 (ANFA 2013) .....65	Figure 11.6:	Example illustration of the methodology used (nova 2014).....71
Figure 10.3:	Most important producer countries of non-woven fabrics in Asia, 2012 (ANFA 2013).65	Figure 11.7:	Energy savings per ha (GJ/ha*a) for different Natural Fibre Composites compared to biodiesel and bioethanol from different studies (Haufe & Carus 2011) ....71
Figure 10.4:	Worldwide consumption of geotextiles by region 2002 (CFC 2004).....66	Figure 11.8:	Greenhouse gas (GHG) savings per ha and year (CO <sub>2</sub> -eq/ha*a) for different Natural Fibre Composites compared to biodiesel and bioethanol from different studies (Haufe & Carus 2011) .....71
Figure 10.5:	Worldwide consumption of natural fibre Rolled Erosion Control Products (RECP) and other RECP 2002 (CFC 2004) .....66	Figure 11.9:	Comparison of the global warming potential (GWP) of different kinds of timber and WPC decking (70% wood, 25% polymer and 5% additives) (Derreza-Greeven et al. 2013, modified)...72
Figure 10.6:	Natural fibre RECP consumed in 2002 by fibre type (CFC 2004).....66	Figure 11.10:	Greenhouse effect impact according to IPCC indicator in g CO <sub>2</sub> -eq for the stages of the life cycle (Michaud 2009) .....72
Figure 10.7:	Applications of European hemp fibre from 2010 harvest (in percentage). Total: 26,000 metric tonnes. (nova 2014, based on EIHA 2013) .....67	Figure 11.11:	Environmental impact of wood and WPC using Bilinga as a reference Abbr.: GWP = global warming potential, ODP = ozone depletion potential, POCP = photochemical oxidant creation potential , AP = acidification potential, EP = eutrophication potential, CED = cumulative energy demand (Schmid et al. 2012).....73
Figure 10.8:	Applications of European hemp fibre (without pulp & paper) from 2010 harvest. (in percentage) Total: 11,700 metric tonnes. (nova 2014, based on EIHA 2013) .....67		
Figure 10.9:	European insulation market and shares of types of materials, total 3.3 million tonnes (nova 2014, based on EUROSTAT, EIHA 2013, Amolsch & Joreau 2013, Adam et al. 2012 and EUMEPS 2009) .....68		
Figure 11.1:	Impact of different production steps on the overall greenhouse gas emissions of hemp fibre production in Europe (Haufe & Carus 2011). .....69		
Figure 11.2:	Comparison of the greenhouse gas emissions of different natural fibres (nova 2014, Ecoinvent 2010) .....69		
Figure 11.3:	Resource depletion of different materials in gigajoules per tonne (Haufe & Carus 2011) .....70		

## Tables

Table I:	Production of biocomposites (WPC and NFC) in the European Union in 2012 (in tonnes) (nova 2014) .....6	Table 9.3:	Biocomposites with natural fibres, wood fibres and recycled cotton in the European automotive production in 2012, volume of fibres, composites and shares of processing technologies (nova 2014).....60
Table II:	Production of biocomposites (WPC and NFC) in the European Union in 2012 and forecast 2020 (in tonnes) (nova 2014).....8	Table 9.4:	Typical ranges of natural fibre shares for different production techniques (nova 2014) .....60
Table 2.1:	Polymer and Fibre Use in European WPC Production in 2012 (Natural Fibre Composites are excluded) (nova 2014) ....11	Table 9.5:	Biocomposites, current automotive applications, with typical mass of natural fibre used (Ellison 2000) .....60
Table 2.2:	Additive categories used by Wood-Plastic Composites (Eder 2009).....14	Table 9.6:	Mercedes-Benz, volume and number of parts from natural and wood fibre composites (Mercedes-Benz 2007).....61
Table 2.3:	Typical material costs for WPC decking production in Europe in 2009 and 2012 (Eder 2009 nova 2014) .....14		
Table 4.1:	Producers of WPC machinery and tooling (nova 2014) .....24		
Table 5.1:	Selected large European WPC producers and their main products for construction applications (nova 2014).....27		
Table 6.1:	Global WPC production in 2010 and 2012 and forecast for 2015 (nova 2014).....33		
Table 6.2:	Number of Chinese WPC companies in 2010 and 2012 (Song 2013).....36		
Table 7.1:	Main WPC and NFC granulate producers and suppliers in Europe, 2013 (nova 2014) .....45		
Table 8.1:	Estimated annual requirement of jute, kenaf and allied fibres by sector in 2012 (JSG 2012).....51		
Table 8.2:	Value and quantity of US imports of selected hemp products, 1996–2011 (Johnson 2013; note: the authors of this report doubt the validity of the very high amount of Hemp Seed Oilcake and Other Solids supposedly imported in 2010, since compared to the development in value worth of these imports, the difference to 2009 and 2011 seems much too high – an amount of 239 metric tonnes		
Table 9.1:	Volumes of natural fibres used in the European automotive production in 2012 (nova 2014) .....56		
Table 9.2:	High (++) and important (+) share of listed materials in selected automotive interior applications (nova 2014).....59		



## nova-Institute

The nova-Institut GmbH was founded as a private and independent institute in 1994. It is located in the Chemical Park Knapsack in Huerth, which lies at the heart of the chemical industry around Cologne (Germany).

For the last two decades, nova-Institute has been globally active in feedstock supply, techno-economic and environmental evaluation, market research, dissemination, project management and policy for a sustainable bio-based economy.

### Key questions regarding nova activities

What are the most promising concepts and applications for Industrial biotechnology, biorefineries and bio-based products? What are the challenges for a post petroleum age – the Third Industrial Revolution?

#### V.i.S.d.P.:

**Michael Carus, nova-Institut GmbH**  
Industriestrasse 300, 50354 Huerth, Germany  
michael.carus@nova-institut.de | www.nova-institut.eu

## nova-Institut GmbH

Chemiepark Knapsack  
Industriestraße 300  
50354 Hürth, Germany

**T** +49 (0) 22 33 / 48 14-40  
**F** +49 (0) 22 33 / 48 14-50

contact@nova-Institut.de  
www.nova-institut.eu



## Order the full report

The full report can be ordered for 1,000 € plus VAT at  
[www.bio-based.eu/markets](http://www.bio-based.eu/markets)

