OVERVIEW OF THE GLOBAL COMPOSITES MARKET 2018-2023

CONTINUING GROWTH

JEC GROUP

Table of contents

01

About

JEC GROUP

Developing the composites industry worldwide through Knowledge, Networking & Innovation

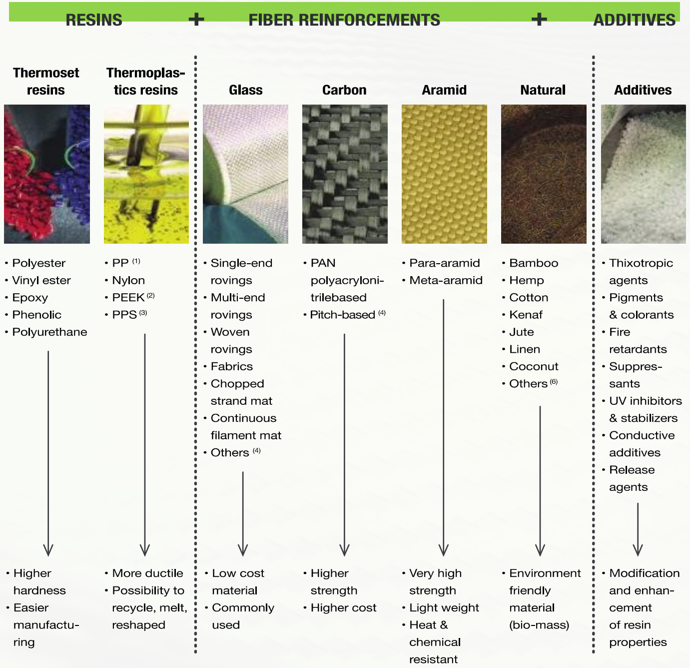
JEC Group is the world's leading company dedicated entirely to the development of information and business connections channels and platforms supporting the growth and promotion of the composite materials industry.

Building on their international reach, JEC Teams and their network source and highlight advanced materials & technologies, organize exhibitions & events, provide information & data, publish on- & offline media, and drive international programs.

02
Perimeter and definition

Composites materials consists of resins, fiber reinforcements and additives. They usually bring stronger physical properties and lighter weight to final applications

Definition of composites materials



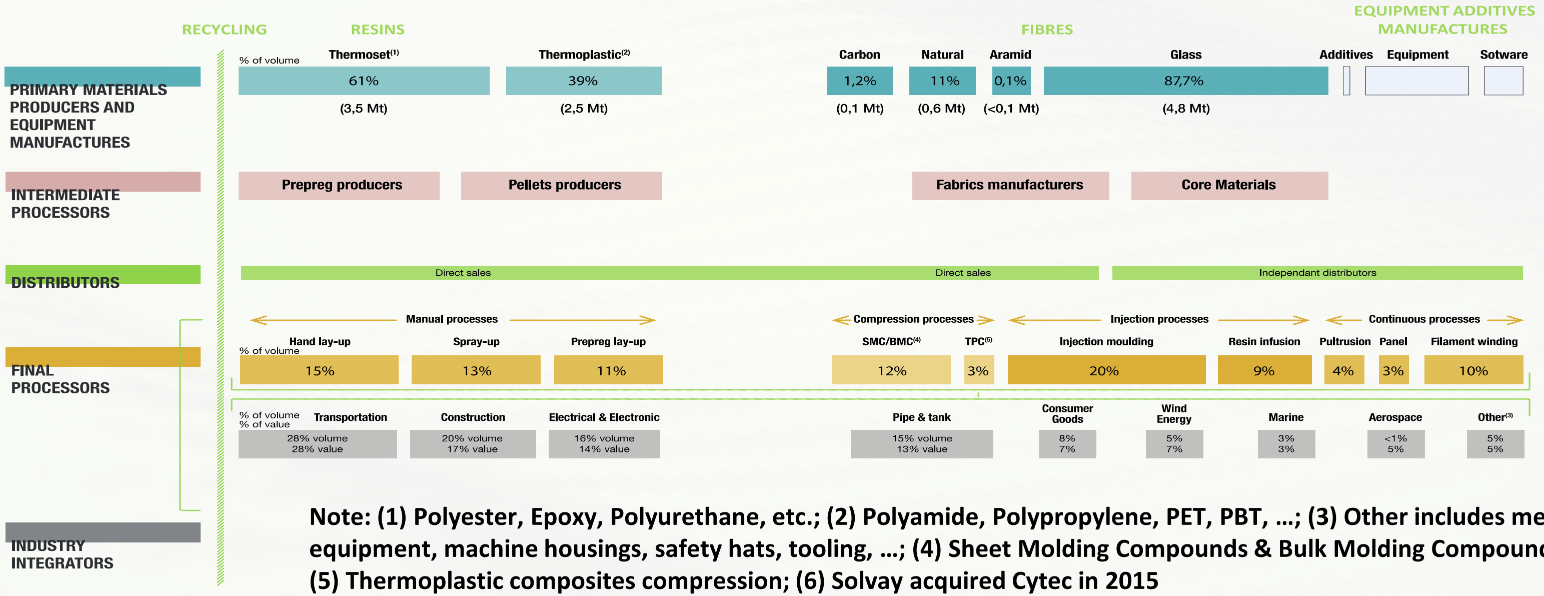
Note: (1) Polypropylene; (2) Polyetheretherketone; (3) Polyphenylene sulfide; (4) Including chopped strands, veils; (5) pitch is a viscoelastic material that is composed of aromatic hydrocarbons; (6) Including banana leaf fibers, wheat straw… Source: Lucintel, Estin & Co interviews, analysis and estimates

03

Composites industry value chain

The composites industry value chain – volume and value

Mapping of segment -2018



Note: (1) Polyester, Epoxy, Polyurethane, etc.; (2) Polyamide, Polypropylene, PET, PBT, …; (3) Other includes medical equipment, machine housings, safety hats, tooling, …; (4) Sheet Molding Compounds & Bulk Molding Compounds; (5) Thermoplastic composites compression; (6) Solvay acquired Cytec in 2015

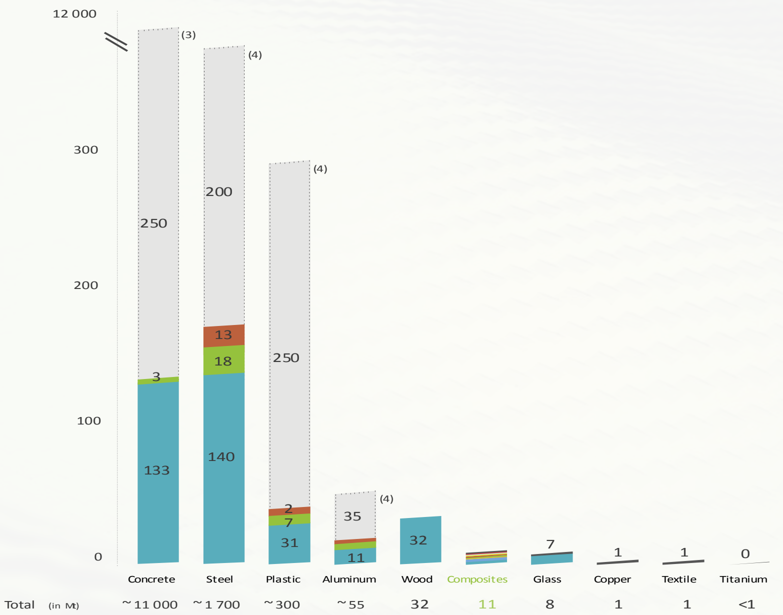
Source: Lucintel, Estin & Co interviews, analysis and estimates

Composites materials are niche materials compared to the main other competing materials such as concrete, steel and plastic

Total materials volume by applications - 2018

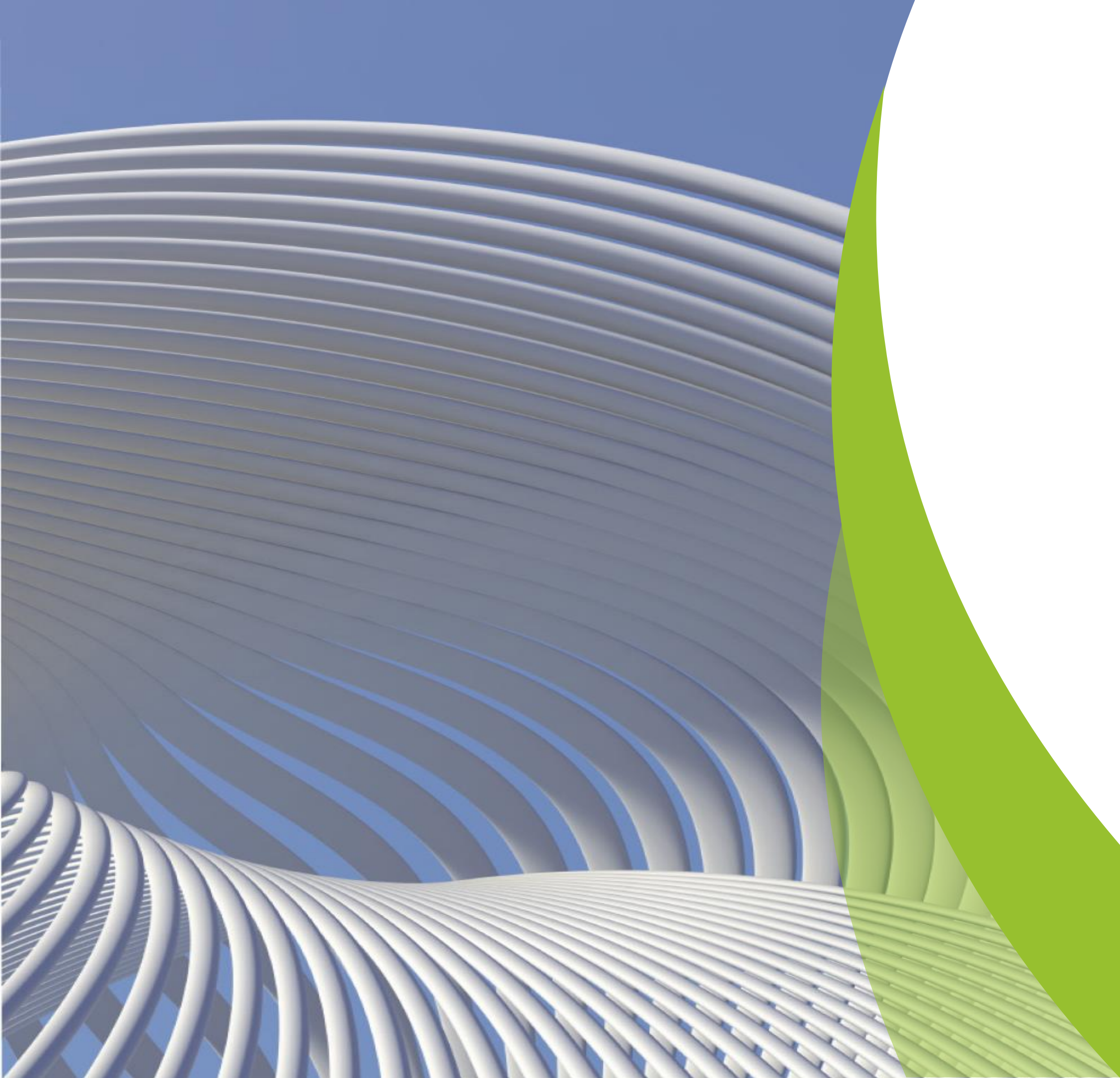
- Other
- Aerospace
- Marine
- Wind energy
- Consumer goods (1)
- Pipe & Tank
- E&E
- Construction (2)
- Transportation

Material volume (in Mt)



Note: (1) Ma" "ion only (bridge, highway, ...), excluding residential construction; (3) Material used in other construction projects; (4) Material used in other construction projects and other industries (e.g. other consumer goods, industrial equipment, healthcare, ...)

Source: Lucintel, ICF, OICA, Euromonitor, Azo Materials, Composites Manufacturing, Composites World, Estin & Co interviews and analysis"



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Key figures of the global composites industry in 2018

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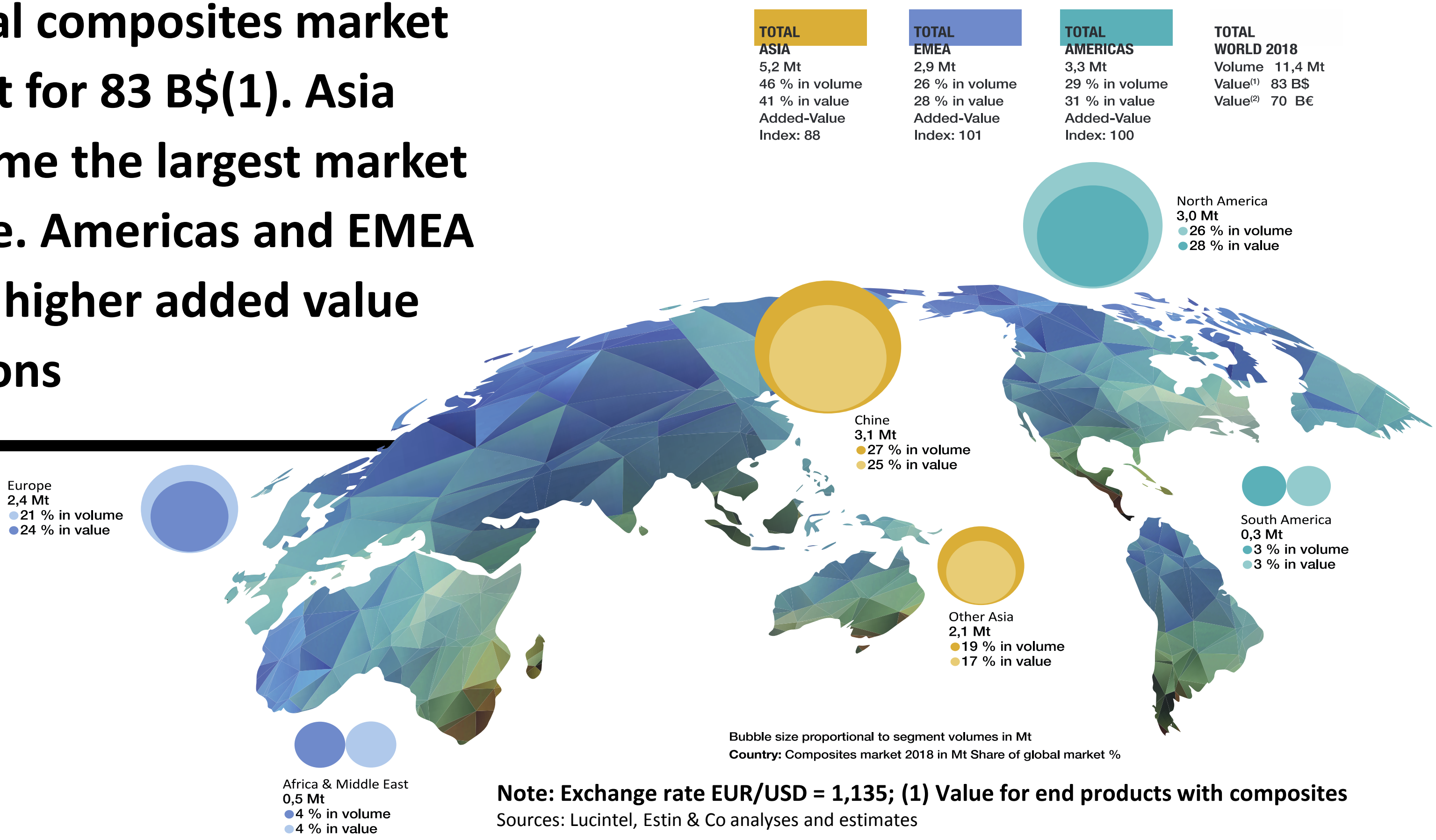
The global composites market is 11,4 Mt for 83 B$(1). Asia has become the largest market in volume. Americas and EMEA still have higher added value applications

2018

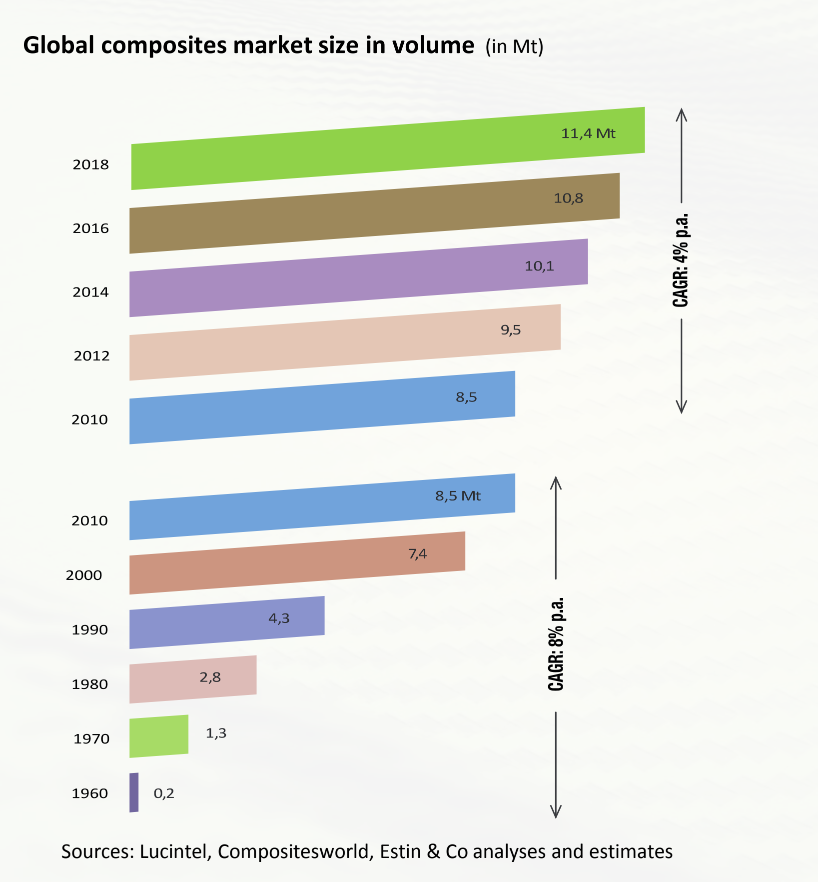


Note: Exchange rate EUR/USD = 1,135; (1) Value for end products with composites

Sources: Lucintel, Estin & Co analyses and estimates

The global composites market has grown at 8% p.a. over 1960 to 2010, and 4% p.a. since 2010

Evolution of composites market – 1960-2018 – Global – In volume



After a period of high growth until 2010, the composites industry is in a maturing phase

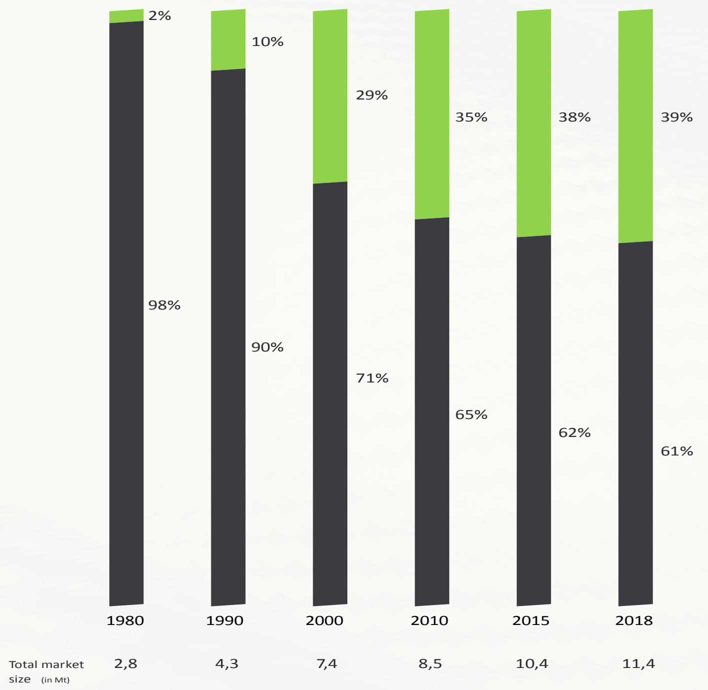
Thermoplastic resins started developing in the 80s, and have reached around 40% of total resins for composites so far

Evolution of composites market – By resin type – 1980-2018 – In volume

" Thermoplastic resins are gaining share against thermoset resins. Thermoplastic molecules do not crosslink and therefore, they are flexible and able to be reformed. They also can be welded together, making repair and joining of parts more simple than for thermosets. Therefore thermoplastic is being widely used for complex components in industries such as automotive and aerospace."
General manager, Ningbo Hibel

	Delta 1980-2018	Cost index 2018(1)
Thermoplastic • Main applications include automotive, aerospace, … • High flexibility, high environmental tolerance, light weighting, lower cost and possibility to recycle	**+37 pts**	**1,0**
Thermoset	**-37 pts**	**1,2**

Market breakdown by resin type (in volume)



Note: (1) Price index of thermoplastic as 1
Sources: Lucintel, interviews, Estin & Co analyses and estimates

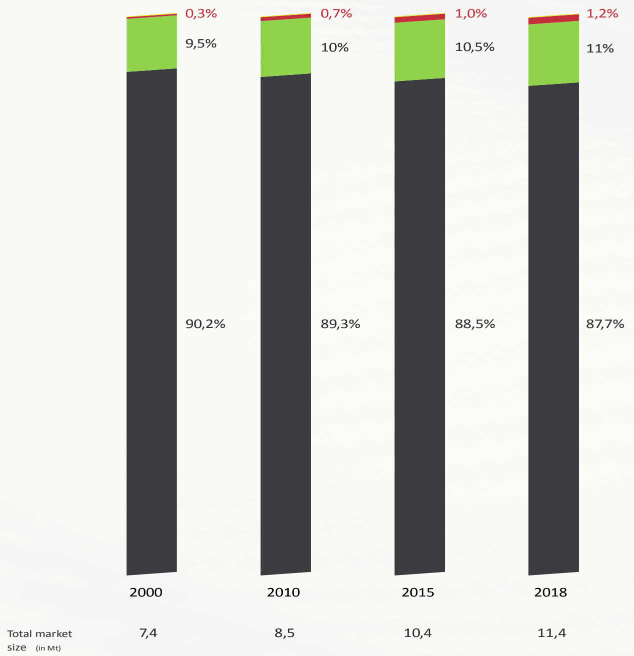
Carbon fibers and aramid fibers keep developing for high added value applications in aerospace, wind energy, sports goods…

Evolution of composites market – By fiber type – 2000-2018 – in volume

“ Advanced reinforcements, such as carbon fiber and aramid fiber, are substituting glass fiber in certain areas. Carbon fiber is lighter, and has higher strength. However, the much higher cost also limits the wide commercial use of carbon fiber. Nowadays, cost-intensive markets such as aerospace, defense, sports, racing and luxury cars have great interest of using carbon and aramid fibers.”
Regional director, CPIC

	Delta 2000-2018	Cost index 2018(1)	Share in value 2018(2)
Aramis fiber • Example of main applications - Consumer goods(1) – Aerospace	+0,1 pt	20,3	1%
Carbon fiber • Example of main applications - Aerospace - Wind energy – Consumer goods(1) – Automotive	+0,9 pt	20,7	23%
Natural fiber	+1,5 pt	1,0	8%
Glass fiber	2,5 pt	1,0	68%

Market breakdown by reinforcement fiber type
(in volume)



Note: (1) High performance sports goods like snow boards, sail clothes, protective gloves & helmets, …; (2) Price index of fiberglass as 1
Sources: Lucintel, interviews, Estin & Co analyses and estimates

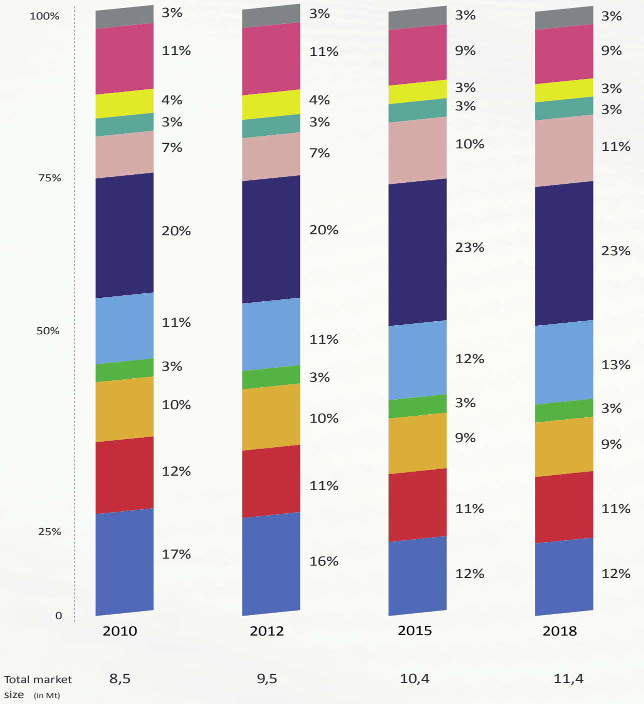
Modern injection and compression processes are gaining market shares against traditional manual and continuous processes

Evolution of composites market –
By manufacturing process – 2010-2018 – In volume

	Delta 2010-2018
Other (1)	0 pt
Continuous processes	**-3 pt**
Filament winding	-2 pt
Panel manufacturing	-1 pt
Pultrusion	0 pt
Injection processes	**+7 pt**
Resin Infusion	+4 pt
Injection molding	+3 pt
Compression processes	**+2 pt**
SMC/BMC	+2 pt
TPC Compression	0 pt
Manual processes	**-6 pt**
Pre-preg lay-up	-1 pt
Spray-up	-1 pt
Hand lay-up	-5 pt

"Injection and compression processes are the dominant manufacturing processes for making thermoplastic composite parts. Therefore they are gaining share against manual and continuous processes."
Marketing and sales manager, Solvay

Market breakdown manufacturing process (in volume)



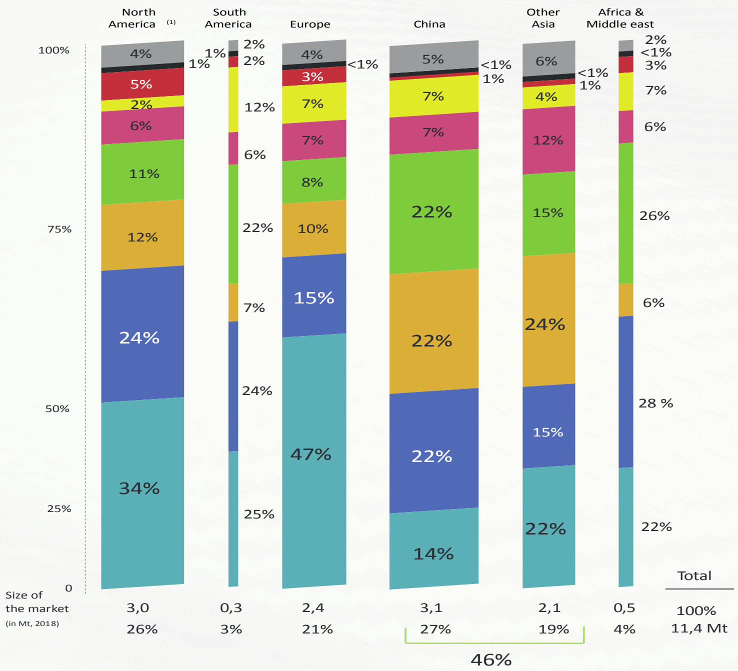
Note: (1) Other include blow molding, bladder molding, diaphragm forming
Source: Lucintel, interviews, Estin & Co analyses and estimates

In volume, Asia takes up nearly 50% of the global market. Application in transportation and construction have the largest shares in most geographies

Market size by region and by application Global – 2018 – In volume

	Total weight (%)
Other	5%
Aerospace	<1%
Marine	3%
Wind energy	5%
Consumer goods	8%
Pipe & Tank	15%
E&E	16%
Construction	20%
Transportation (Automotive, trucks & buses)	28%

Market breakdown by region and by application (in volume, 2018)



Note: (1) Includes United States, Canada, and Mexico; (2) Other includes medical equipment, machine housings, safety hats, tooling

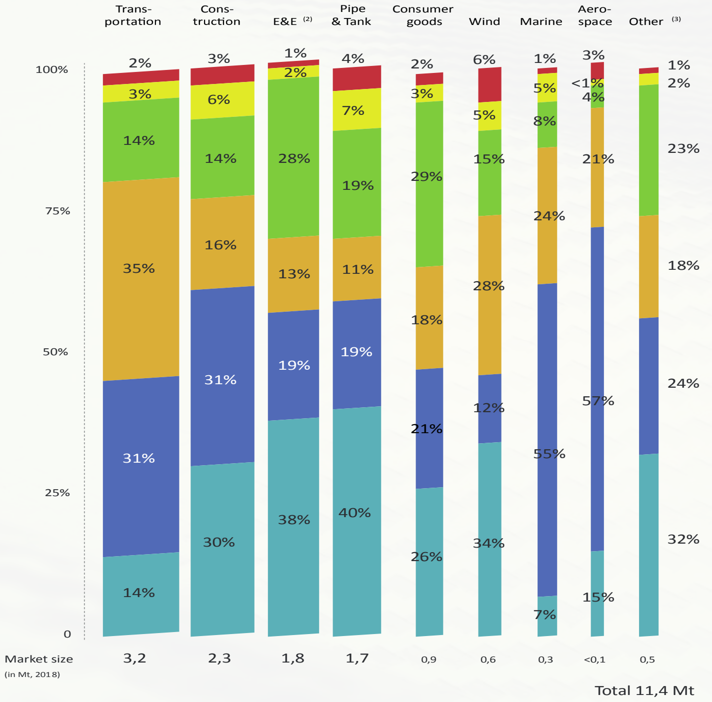
Sources: World Bank, IMF, Global Insight, Oxford Economic Forecasting, USDA, Lucintel, Estin & Co interviews, analysis and estimates

Transportation, construction and E&E represent the top 3 application industries that have the largest weight in volume

Market size by region and application – Global – 2018 – In volume

	Total weight (%)
South America	3%
Africa & Middle East	4%
Other Asia	19%
Europe	21%
North America (1)	26%
China	27%
Total	**100%**

Market breakdown by region and by application (in volume, 2018)



Note: (1) Includes US, Canada and Mexico; (2) Electrical appliances and electronics; (3) Other includes medical equipment, machine housings, safety hats, tooling

Sources: Lucintel, interviews, Estin & Co analysis and estimates

05

Market dynamics of composites industry by geographies 2018-2023

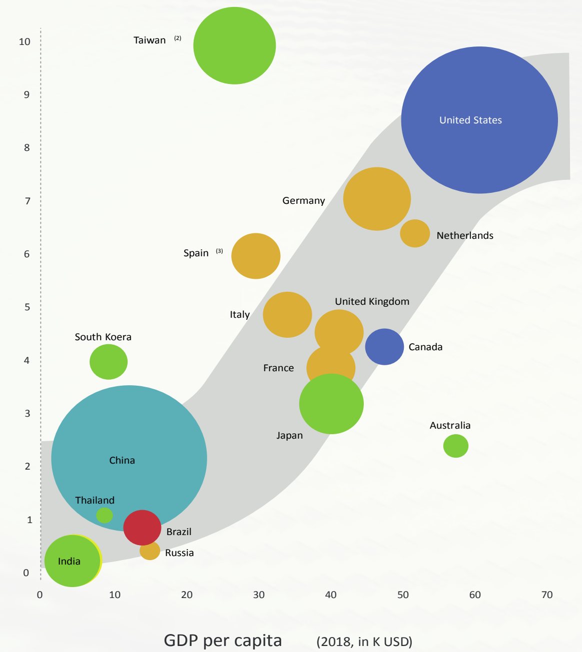
Composites markets follow the curve of economic development. Emerging Asia has still strong potential to grow. Europe has the risk of remaining fragmented by country

Development curve – 2018 – In volume

- North America
- South America
- Europe
- Africa & Middle East
- China
- Other Asia

Size proportional
To market 0,2 Mt

Composites markets in volume[1] per capita (2018, in kg per inhabitant)



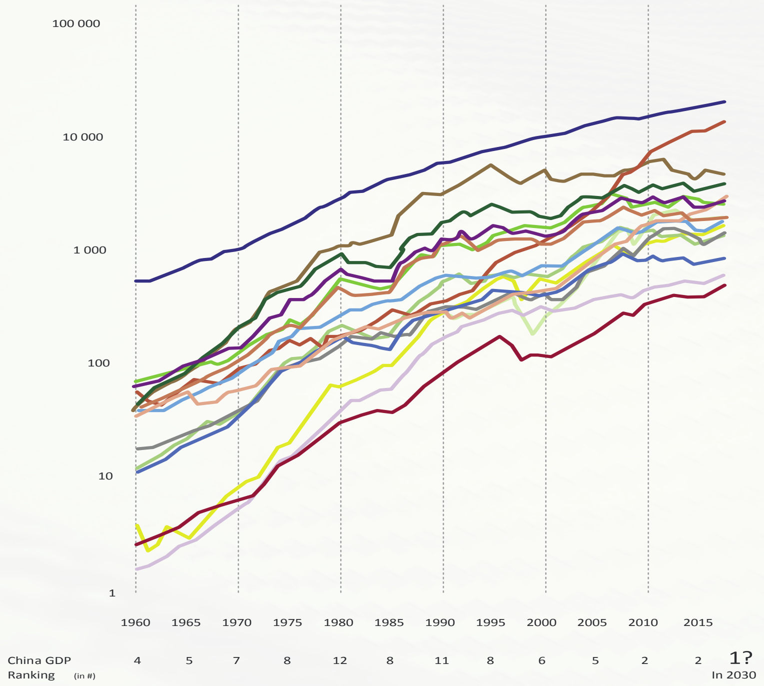
Note: (1) Domestic consumption of composites; (2) 29kg/inhabitant composites consumption, high penetration of composites due to strong electronic industry; (3) Impact of strong consumption from automotive industry
Sources: World Bank, IMF, Global Insight, Oxford Economic Forecasting, USDA, Lucintel, Estin & Co interviews, analysis and estimates

China has become the 2nd economy in the world and is challenging the long term economic leadership of the USA

GDP evolution by country – 1960-2018 – In constant currency

	CAGR 1960-2010	CAGR 2010-2018
USA	7%	4%
China	10%	10%
Japan	10%	-2%
Germany	Na	2%
India	8%	8%
France	8%	0%
UK	7%	1%
Brazil	11%	1%
Italy	8%	-1%
Russia	Na	3%
Canada	8%	1%
South Korea	12%	5%
Australia	9%	3%
Spain	10%	0%
Netherlands	9%	1%
Taiwan	12%	4%
Thailand	10%	5%

Historical GDP evolution (in Bn$) (1)

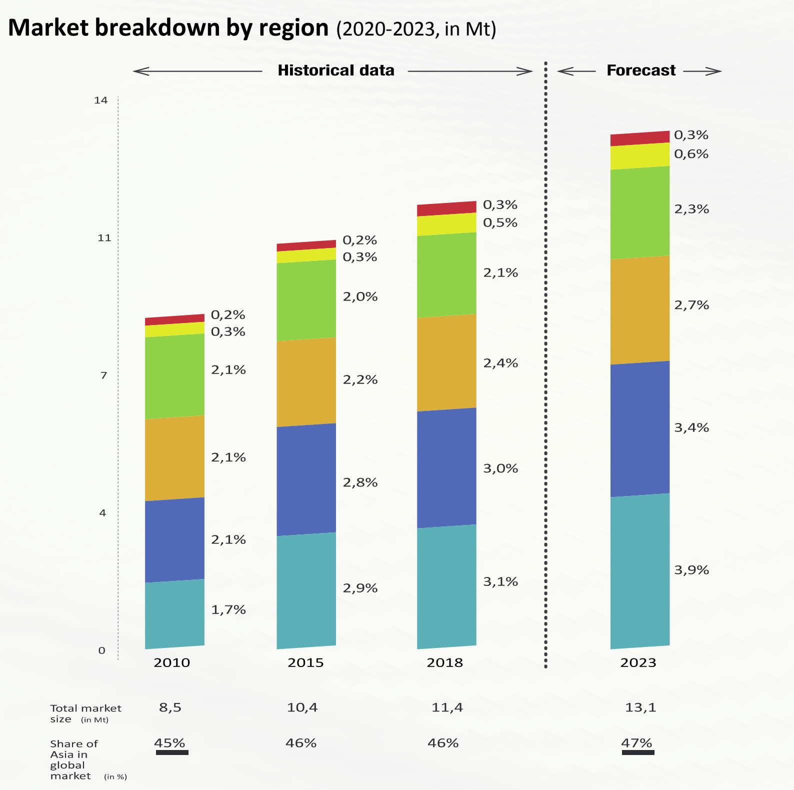


"Note: (1) In constant 2010 USD
Sources: Worldbank, Estin & Co analyses and estimates

Overall, the global composites industry should continue to grow over 2018-2023 at 3% p.a., with China representing almost half of the global growth

Market growth – 2010-2023 – In volume

	CAGR 10-18	CAGR 18-23	Share of growth 18-23
South America	7%	4%	3%
Africa & Middle East	7%	4%	6%
Other Asia	0%	1%	8%
Europe	2%	2%	13%
North America	5%	3%	24%
China	8%	5%	**46%**
Total	**4%**	**3%**	**100%**



Sources: Lucintel, Estin & Co interviews, analysis and estimates

06

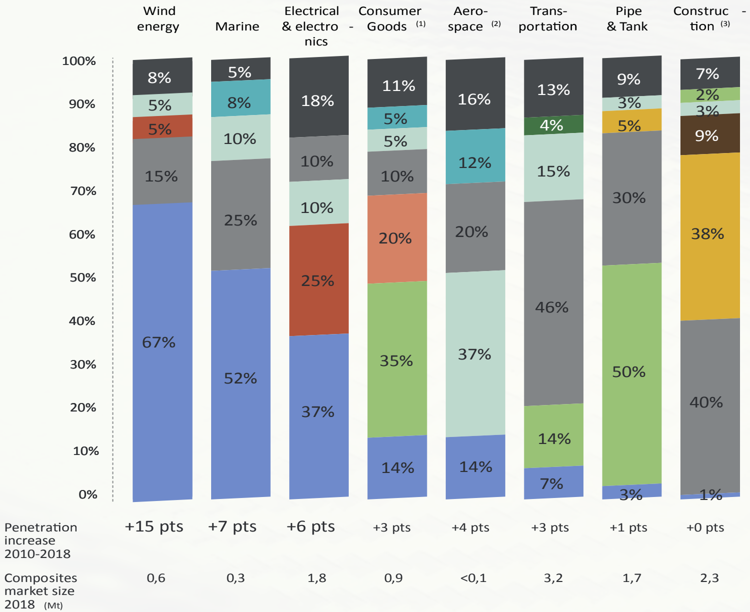
Market dynamics of composites industry by “end user” industry

The industries where composites have increased their penetration rates over the past ten years are wind energy, marine, and electrical & electronics

Composites penetration by application – Global – 2018 – In volume

- Other materials
- Textile
- Copper
- Plastic
- Concrete
- Sand
- Wood
- Titanium & alloys
- Glass
- Aluminum & alloys
- Steel
- Composites

Penetration of composites per industry in 2018 (in volume, in %)



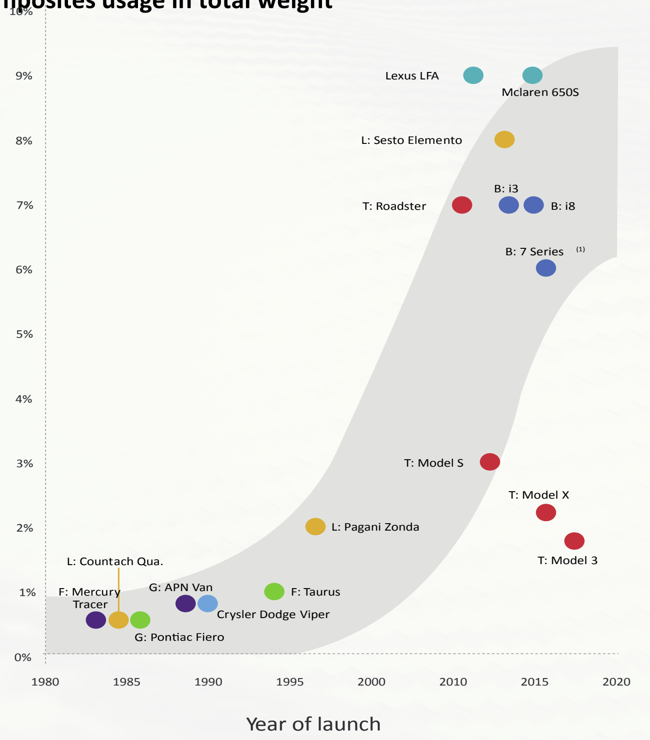
Notes: (1) Mainly sports and sportive equipment; (2) "Fly-weight" for aerospace; (3) Infrastructure construction only (bridge, highway...), excluding residential construction; (4) Composites price for construction as base index = 100 Sources: Lucintel, ICF, OICA, Euromonitor, Azo Materials, Composites Manufacturing, Composites World, Estin & Co interviews and analysis

The penetration rate of composites in luxury and high-end cars have increased over the past 40 years

Automotive – Composites penetration – 1980-2020

- BMW
- Tesla
- Lamborghini
- Ford
- General Motors
- Others

% of composites usage in total weight



Notes: (1) BMW 7 Series, the 6th generation

Sources: BMW, Tesla, Lamborghini, Ford, General Motors, Estin & Co Interviews & analysis

The penetration rate of composites and plastics is increasing in the automotive industry, mainly against steel

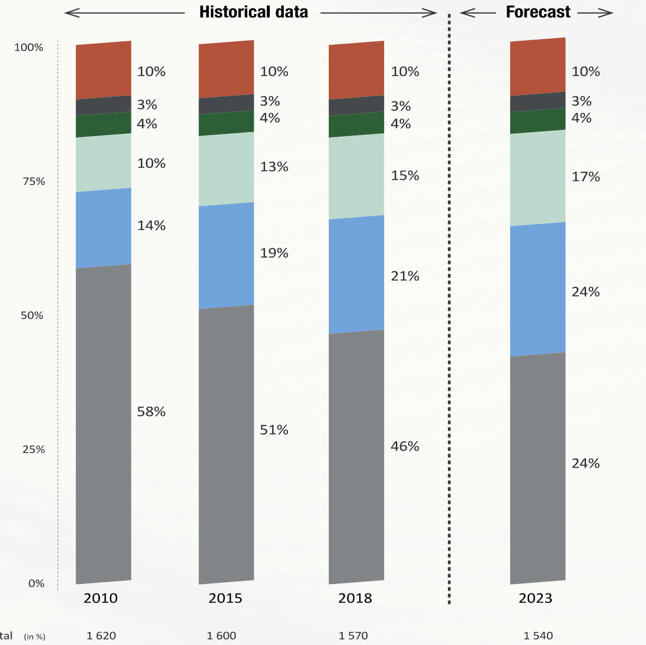
Automotive – Weight distribution by material – Europe – 2010-2023 – In %

	Delta 2010-2023
Other Materials	+0 pt
Other Metals	+0 pt
Glass	+0 pt
Aluminium	+7 pts
Composites and plastics	+10 pts
Steel	-16 pts

"There is strong demand for light vehicles in the recent years. Composites materials, having high stiffness to weight ratio, has greatly contributed to vehicles, weight reduction. Composites will de nitely increase penetration in car production in the future."
Head of Central Researching Institute, BYD

Average weight distribution of a car by material
(in %)

- CAVEAT -
Vision of automotive manufacturers



Source: Organisation Internationale des Constructeurs d'Automobiles (OICA), Estin & Co analysis and estimates

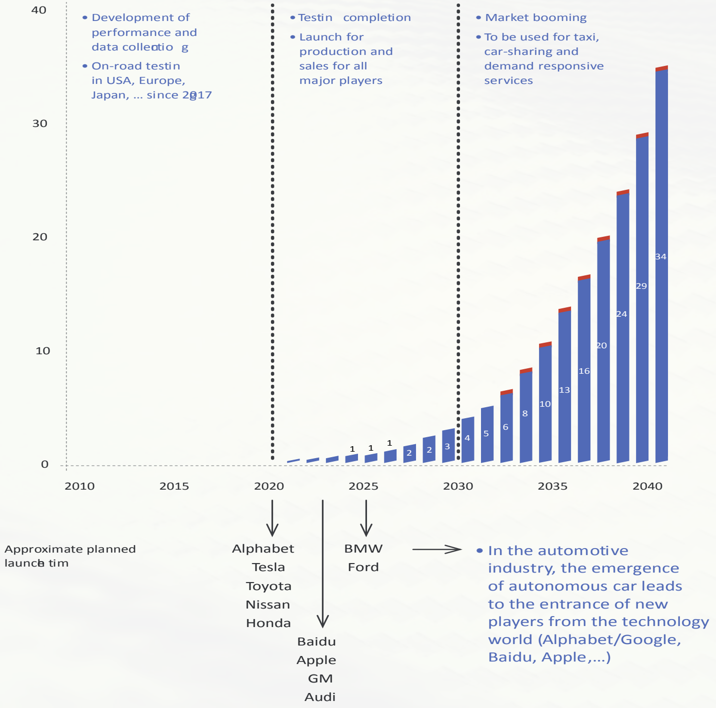
Forecasted growth of autonomous cars will drive the growth for composites in the automotive industry, due to signal & data transmission key states

Autonomous cars – 2010-2040

Estimated penetration for autonomous vehicles (in %)

Sales volume for autonomous vehicles (in M units)

Sales volume for autonomous vehicles (in M units)

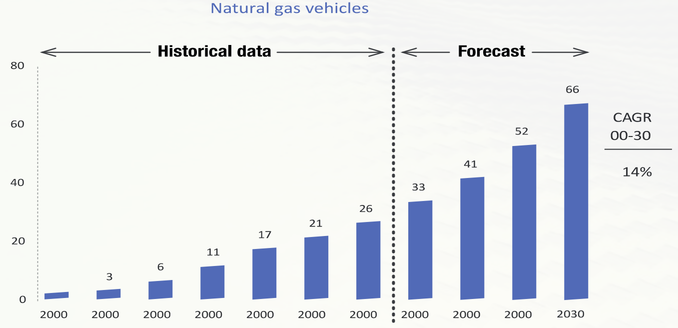


Source: IHS Markit, Protiviti, Statista, Market Watch, press release, Estin & Co Interviews & analysis

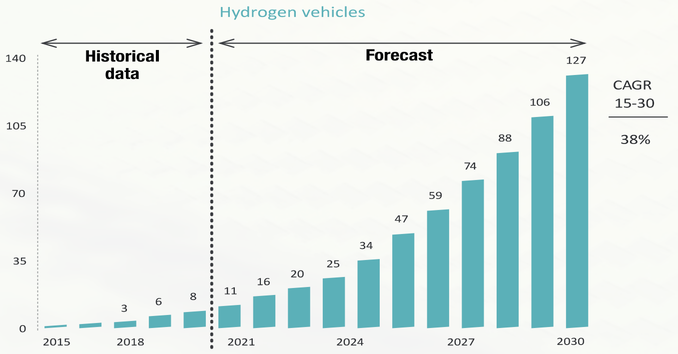
The growth for composites in the automotive industry will be driven by the growth of natural gas & hydrogen vehicles, with compressed vessels made in composites

Natural gas & hydrogen vehicles – 2000-2030

Global natural gas vehicles in operation (in M€)



Global annual hydrogen vehicles production (in M€)



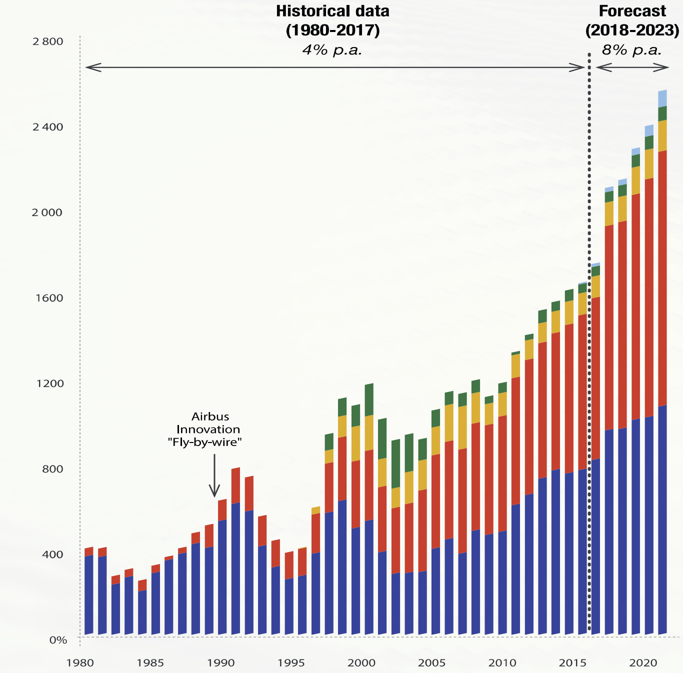
Source: IHS Markit, Statista, press release, Estin & Co Interviews & analysis

Aircrafts manufacturing is growing worldwide, with manufacturing sites in Europe (France, Germany, UK, Spain), the USA and China

Aerospace – Commercial Aircraft delivery – 1980-2023

	CAGR 2018-2023	Major Production sites
COMAC[(1)]	38%	China
Bombardier	7%	Canada (5), Mexico, UK, USA, Morocco
Embraer	7%	Brazil (4), Portugal, USA
Airbus	10%	France, Germany, Spain, USA
Boeing	5%	USA (6)
Total	**8%**	

Annual commercial aircraft deliveries (in units)



Note: The 2018-2022 projections are based on production targets set by Boeing, Airbus and COMAC and a normative growth rate for Embraer and Bombardier; (1) COMAC belongs to AVIC.

Sources: Airbus, Boeing, Estin & Co analysis and estimates

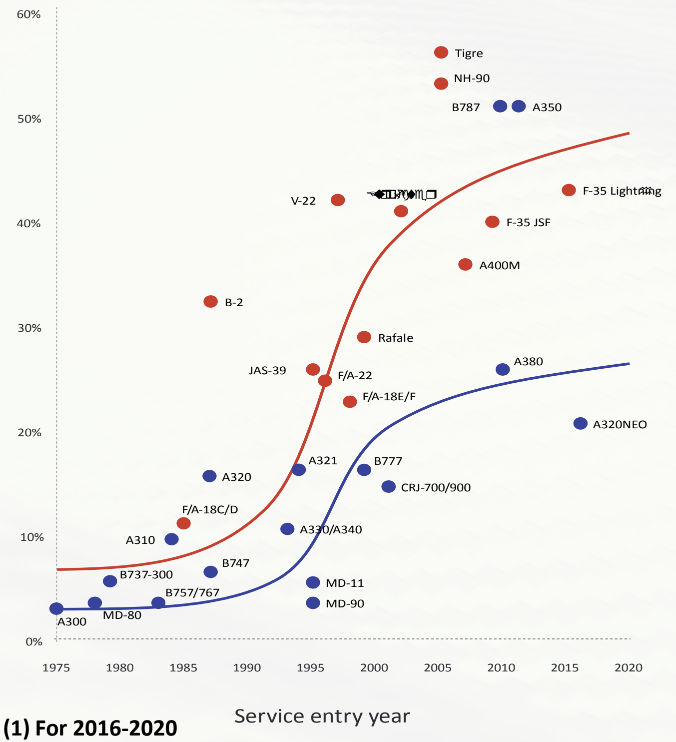
The penetration rate of composites in aircrafts has strongly increased over the past 30 years, both for military and commercial applications

Aerospace – Composites penetration – 1975-2020

Military
Commercial

"Penetration for composites materials is increasing for aircrafts. The major advantage of using composites is energy saving due to weight reduction. Besides, composites also have high sti ness, high strength, high structural damping and excellent fatigue performance."
General manager, Sunwardtech

% of composites usage in total weight
(excluding engine weight)

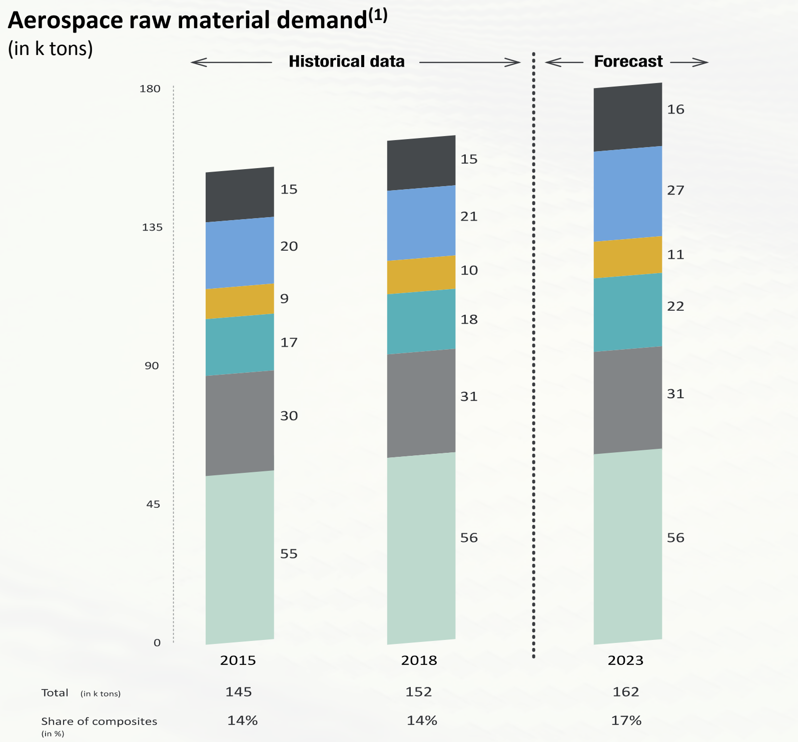


Note: (1) For 2016-2020
Sources: Airbus, Boeing, Estin & Co analysis and estimates

Composites are growing faster than other raw materials in the aerospace industry and have reached a penetration rate of around 15%

Aerospace – Raw material demand – 2015-2023 – In volume – Fly weight

	CAGR 2018-2023
Other materials	1%
Composites	**5%**
Super alloys	1%
Titanium alloys	4%
Steel alloys	0%
Aluminum alloys	0%
Total	**1%**



Note: (1) "Fly-weight" listed above. Assuming Buy-to- y ratios of 6 for aluminum, 5 for steel, 5 for titanium, 7 for super alloys, 2 for composites, 3 for other materials Sources: ICF, Boeing, Estin & Co analysis and estimates

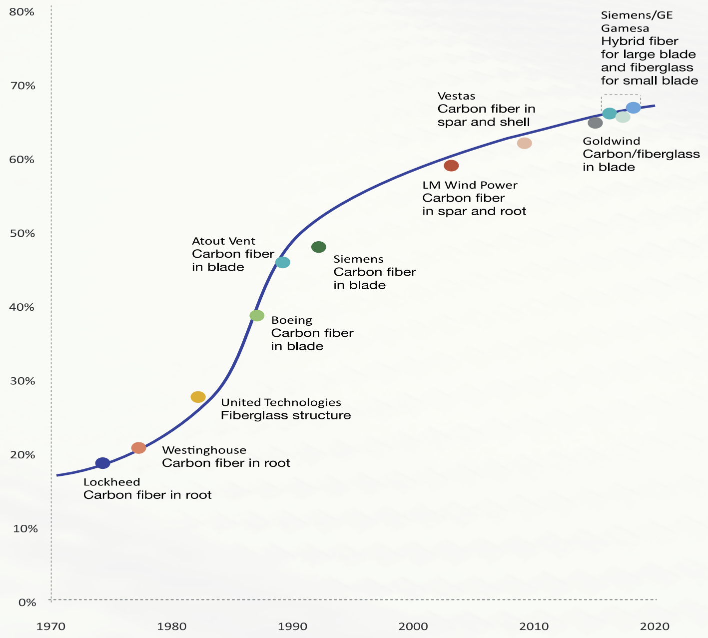
The penetration rate of composites in wind turbine blades has increased by ~40 pts over the past 40 years

Wind energy – Composites penetration – 1970-2020

- Lockheed
- Westinghouse
- United Technologies
- Boeing
- Atout Vent
- Siemens
- LM Wind Power
- Vestas
- GE
- Goldwind
- Gamesa

"The current wind turbines are developing in the direction of large-scale and lightweight. The current blade diameter has exceeded 190m, and the extra- long blade puts higher demands on the strength and rigidity of the material. Composites materials , especially carbon ber composites, will further increase penetration and to play an important role in the wind energy industry."
Head of blade engineering center, Goldwind

% of composites usage in blade weight
(excluding engine weight)



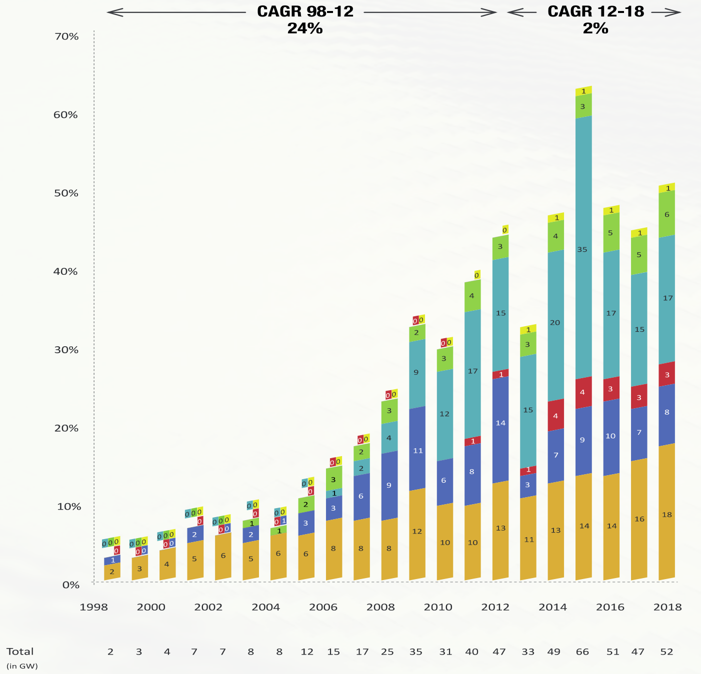
Sources: WindPACT, GWEC, Estin & Co Interviews & analysis

The annual new capacity for global wind energy is stable since 2012

Wind energy – Annual new capacity by region – 1998-2018

	CAGR 98-12	CAGR 12-18
Africa & Middle East	34%	21%
Other Asia	31%	10%
China	50%	1%
South America	29%	24%
North America	26%	-10%
Europe	16%	5%
Total	**24%**	**2%**

Annual new capacity by region (in GW)



- The growth of composites driven by the wind energy industry could be challenged

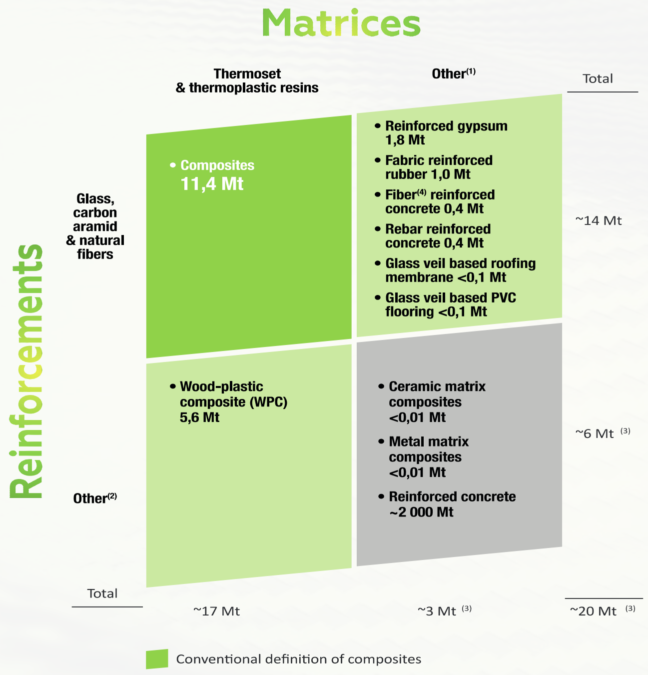
Sources: BP Outlook, IRENA, Global Wind Energy Council, Navigant Consulting and national sources, Estin & Co analyses and estimates

07

Focus: Composites adjacent markets

Composites in a broad definition represent a market that is twice as large in volume as the one of core composite materials

Market segmentation – Broad definition of composites



Note:
(1) Concrete, rubber, gypsum, ceramics, textile, ...; (2) Steel, ceramic ber, metal, textile, ...; (3) Total market size excludes reinforced concrete ; (4) Or grid

Sources: Lucintel, interviews, Estin & Co analyses and estimates

Composites in a broad definition represent a market that is twice as large in volume

Adjacent markets

Composites = Blend of 2 (or more) materials with superior properties than the simple addition of them

	Name	Matrix	+ Reinforcement	Volume 2018 (Mt)	Application industries	Example of companies
	Composites materials	Thermoset & thermoplastic resins	Glass, carbon, aramid & natural fibers	11,4 Mt	Transportation, construction, E&E, ...	Olin, Owens Corning, Solvay , Toray ...
	Materials with similar matrix as composites					
1	Wood-plastic composite (WPC)	Thermoplastic resins	Wood fiber, wood flour, cardboard...	5,6 Mt	Construction, automotive	CRH, Axion, Trex, …
	Materials with similar reinforcement as composites					
2	Reinforced gypsum	Gypsum	Glass fiber	1,8 Mt	Construction	Owens Corning, Saint Gobain, USG, …
3	Fabric reinforced rubber	Rubber	Glass fiber, carbon fiber, textile, metal, aramid	1,1 Mt	Pipe & tanks, automotive, marine	Trelleborg, ContiTech, Freudenberg, …
4	Carbon-fiber cloth reinforced concrete	Concrete	Carbon fiber	0,4 Mt	Construction	Chomarat, Porcher, SGL Carbon, …
	Different matrix and reinforcements					
5	Reinforced concrete	Concrete	Steel	~2 000 Mt	Construction	LafargeHolcim, Cemex, CRH, …
6	Ceramic matrix composites	Ceramics	Ceramic fiber, carbon fiber, metal	<0,01 Mt	Aerospace, automotive, E&E	3M, GE, SGL Carbon, …
7	Metal matrix composites	Metal	Ceramic fiber, carbon nanotubes, graphite	<0,01 Mt	Aerospace, automotive	Materion, 3M, Santier, …
	Total (3)			~20 Mt (3)		