OWENS CORNING®

INNOVATIONS FOR LIVING™

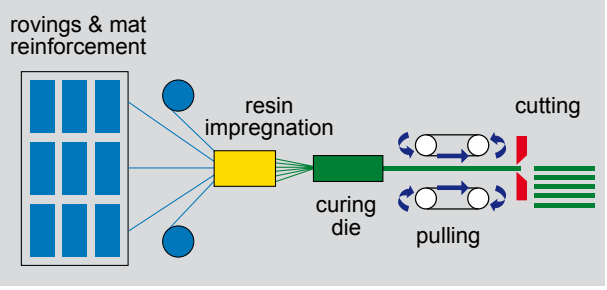
Pultrusion

Transforming the World with Advanced Solutions

PULTRUSION PROCESS

Pultrusion is a continuous process for producing constant-crosssection glass reinforced composite shapes. The process consists of pulling multiple glass fiber reinforcements through a resin bath and into a temperature controlled heated metal die to produce structural profiles of different shapes.

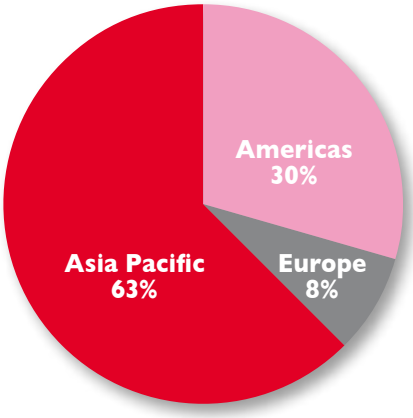
Pultruded components incorporate Single-End rovings for the high lengthwise mechanical properties of the profile, but also bulky rovings to fill in the angles, continuous filament mats and fabrics for crosswise mechanical properties and surfacing veils for a better surface appearance.



PULTRUSION MARKET*

PULTRUSION MARKET PER REGION (vol.)

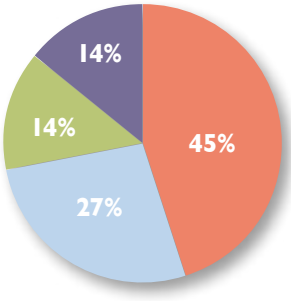
In 1960 there were about 20 manufacturers located primarily in the US, while today at least 90 pultruders are serving the main markets in US, Europe, Asia and playing in a very large variety of applications.



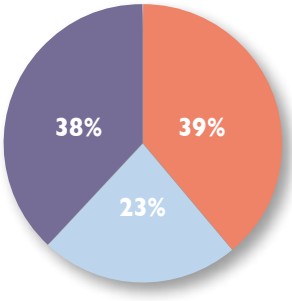
PULTRUSION MARKET BY END USE APPLICATION (vol.)

Pultruded profiles are used for many applications in the industrial, power & energy, housing and consumer goods areas. The global composites market for pultrusion is estimated over 250,000 tons with growth rate superior to 5%/year.

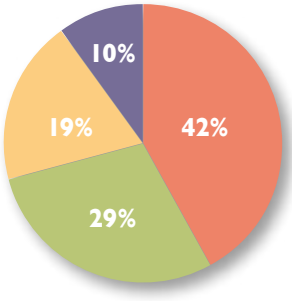
Asia Pacific

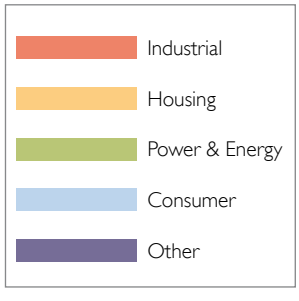


Europe



Americas

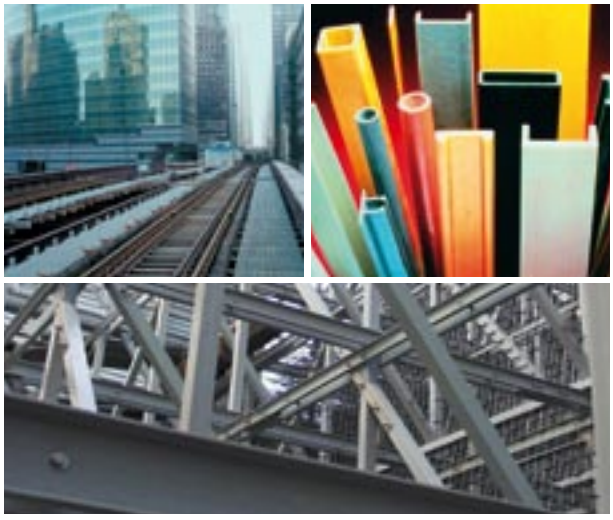




* 2011 Owens Corning proprietary database

MARKET NEEDS

- Reliable and fast processing
- Cost-effective performance
  - high strength-to-weight ratio
  - corrosion resistance
  - smoother exterior finish
  - enhanced long-term durability
  - optimize resin use
- Product customization
- Efficient design of section geometry



ADVANTAGES OF FRP(1) PROFILES VS. STEEL OR ALUMINUM

- **In a cradle-to-grave analyses of an industrial platform, FRP(1) parts can be shown to have a lessor impact on the environment compared to the same parts made of steel or aluminum(2):**
  - Less weight of materials
  - Less energy to refine, transport
  - Lower environmental burdens in many impact categories (global warming gasses, acidification of air/water, eutrophication, ozone depletion, smog).
- **An independent assessment(3) determined that finished composite parts have Life Cycle Analyses profiles that show advantages compared to the steel and aluminum alternatives.**

(1) Fiber Reinforced Plastics

(2) Comparing process; OC Sustainability Study Method TRACI/IMPACT 2002+/IPCC/Energy (Feb 09)

(3) ©European Alliance for SMC/BMC 2007, Design for Success, A Design & Technology Manual for SMC/BMC, Chapter 6 Environment.

- **Finally, FRP profiles are:**
  - Lighter (up to 70% weight reduction versus steel) with high strength
  - Maintenance free
  - Inherently thermal and electrical insulators (600 to 800 times lower thermal conductivity than metal)
  - Better in flexural strength and tension
  - Easily machined, bolted, riveted and threaded just like steel which makes joining of sections simple
  - Lower in cost due to ease of handling, light weight and lower transportation
  - Long term fatigue performant
  - Chemically and corrosion resistant
  - Heat resistant
  - Dimensional stable
  - Excellent in creep and fatigue performance

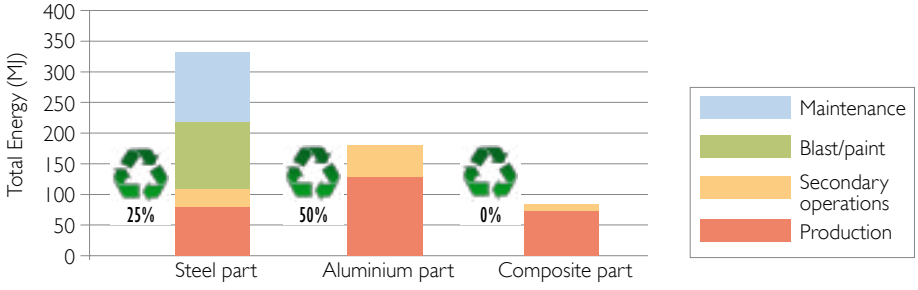
SUSTAINABILITY

Below results come from a screening or abridged version LCA conducted by Owens Corning that examined some specific pultruded parts.

For both case studies, data are based on the aggregation of various types of pultruded structural components for outdoor application such as decking and platforms

Gratings for Industrial Platforms

Composites have lowest Energy impact despite having 0 recycled content.



Case Study #1: Steel vs. Composite

Steel grating is 3.5x heavier than composite part

Energy used by Steel Part

	MJ/Kg	CRITERIA
Primary Steel Prod.	26	25% Recycle
Secondary Operation	4 to 6	Hot/Cold/Section Roll
Field Install	30 to 35	Blast & Paint
Maintenance «Use» Phase	30 to 35	Blast & Paint
Totals	90 to 106	

Total for the Steel part at 3.5 Kg = 315 to 371 MJ

Energy used by Composite Part

	MJ/Kg	CRITERIA
Primary Raw Material	70-74	Glass & Resin Mix
Secondary Operation	4 to 6	Comp. Part Mfg.
Field Install	0	Blast & Paint
Maintenance «Use» Phase	0	Blast & Paint
Totals	74 to 80	

Total for the Composite part at 1.0 Kg = 74-80 MJ

Higher specific strength of composites enables lower energy usage per component.

Case Study #2: Aluminum vs. Composite

Aluminum part is 1.2x weight of composite part

Energy used by Aluminum Part

	MJ/Kg	CRITERIA
Primary Raw Materials	101	50% Recycle
Secondary Operation	40 to 50	Extrusion or Other
Field Install	0	Blast & Paint
Maintenance «Use» Phase	0	Blast & Paint
Totals	141 to 151	

Total for the Aluminum part at 1.2 Kg = 169 to 181 MJ

Energy used by Composite Part

	MJ/Kg	CRITERIA
Primary Raw Material	70-74	Glass & Resin Mix
Secondary Operation	4 to 6	Comp. Part Mfg.
Field Install	0	Blast & Paint
Maintenance «Use» Phase	0	Blast & Paint
Totals	74 to 80	

Total for the Composite part at 1.0 Kg = 74-80 MJ

Despite a high recycled content, energy consumption in ingot & secondary operations results in giving Aluminum a disadvantage over Composites in total energy used.

OWENS CORNING PROVIDES A COMPREHENSIVE RANGE OF REINFORCEMENT PRODUCTS FOR PULTRUSION

SINGLE-END ROVINGS

Single-End rovings are generally used in all pultruded products, usually as principal reinforcement.

- Provide axial strength and stiffness
- High reinforcement content (50-80%)
- Rovings available in a range of tex values (300 to 9600 tex)
- Specifically sized for different resin systems for optimum performance

NA	LA	EMEA	AP	PRODUCT	RESIN COMPATIBILITY ● means primary compatible resin					TEX AVAILABLE
					EPOXY	POLYESTER	VINYLESTER	PHENOLIC	POLYURETHANE	
●			●	366	●	●	●		●	2000, 2200, 2400, 4400
●			●	399	○	●	○		●	4800, 8000, 8800, 9600
●				SE8400LS	●	●	●		●	4400
●			●	158B	●			●		1100, 2000, 2100
●	●			8380				●		4400
●	●	●	●	R25H	○	●	●		●	600*, 735*, 1200*, 2400, 4400, 4800,9600
●	●	●	●	SE1200	●	●	●		●	1200*, 2400, 4800

NA : North America. LA : Latin America. EMEA : Europe Middle East Africa. AP : Asia Pacific

**These tex are available for optical cable uses.*

CONTINUOUS FILAMENT MAT

CFM (Continuous Filament Mat) is also widely used in pultrusion process for better transverse mechanical properties.

- High mat tensile strength, also at elevated temperatures and when wetted with resin
- Low density
- Easy processing: both faces well bound and easy to splice
- Good compatibility with UP, UP(V), EP and acrylic resins
- Available in a full range of weights from 300g/m^2 up to 900 g/m^2
- Full width rolls and slit widths from 9 cm to 50 cm available

PRODUCT	BINDER	TENSILE STRENGHT	RESIN COMPATIBILITY				APPLICATION
			Epoxy	Polyester	Vinylester	Acrylics	
U527	Lower binder	Lower TS	●	●	●	●	Complex shapes - White parts
U528 std	Standard binder	Standard TS	●	●	●	●	Standard applications
U529	Higher binder	Higher TS	●	●	●	●	High tensile strength
M8643	Standard binder	Medium/ High TS	●	●	●	●	Standard applications good surface aspect

BULKY ROVINGS

Being filamentised to a greater or lesser extent, producing loops or filaments misaligned from the axial direction.

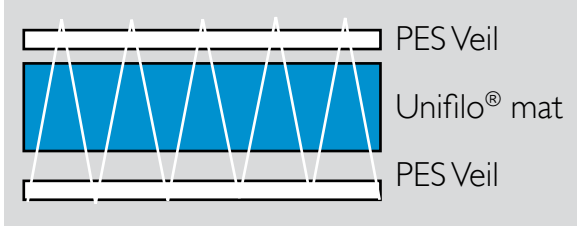
- Provides some reinforcement in the transverse direction to improve shear properties
- Produces a scouring action to clean the die and prevent lost edges in tight radii
- Easy to wet out
- 2500, 5000,10 000 tex.

NON-WOVENS

Veils are designed to create a high quality surface layer on the pultruded part

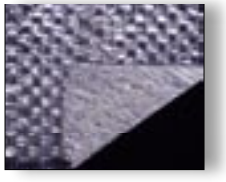
PRODUCT	M524	VL8101
Styrene solubility	Insoluble binder - M524 GC XX H/3 were the xx is the weight of the m^2	Insoluble binder
Fibre type	ECR	ECR
Fibre diameter (micron)	13	23

UNICOMPLEX® MAT



This complex is obtained by sewing a central layer of Unifilo® mat with a polyester surface veil on one or both sides. Unicomplex® C526 mat is used to improve the surface aspect and to reduce tool wear.

COMPLEXES, FABRICS, STITCHED AND NEEDLED MATS



Fabrics, complexes and mats - with sufficient tensile strength for processing through a die, and which can be impregnated with resin under operating conditions - may all be used.

DESCRIPTION	PRODUCT NAME	STANDARD PRODUCT AREA WEIGHTS - GR/M²	RECOMMANDATION FOR USE
Veil-Mat	S xxx/V xxx	S450/V035	Designed for Extra-Surface finish requirement and good process ability
Long-fibre stitched glass mat	SL xxx (L for Long fibers)	SL600	Works in similar way to Unifilo® mat, but stitching gives extra pulling strength, and long fibres give better surface finish
Woven Roving/needled mat combinations	WR xxxx/N xxx	WR0300/N300	Needling gives loft - Pushes glass into the corners of the die

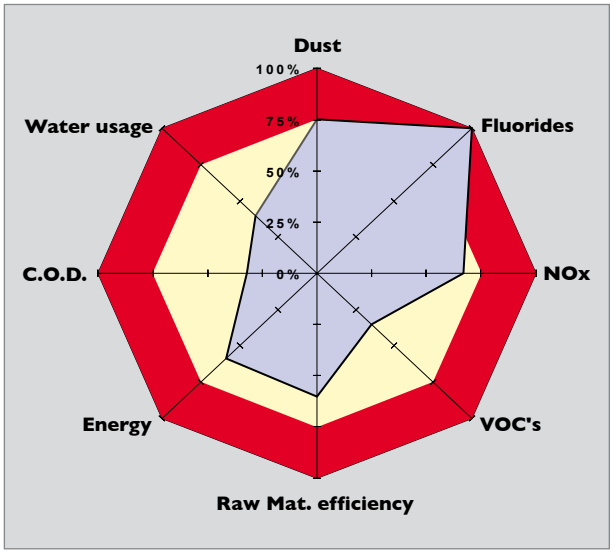
THE ADVANTAGES OF THE ADVANTEX® GLASS

- Advantex® glass offers the unique attributes of being both a boron-free E-glass and an E-CR glass in accordance with ASTM D578 and ISO 2078.
- Performing better than traditional E-glass particularly in acids and water and to a certain extent in alkaline solutions
- Allowing material savings versus E-glass
- With a excellent resistance to high temperature (higher softening-point temperature compared to standard E-glass)

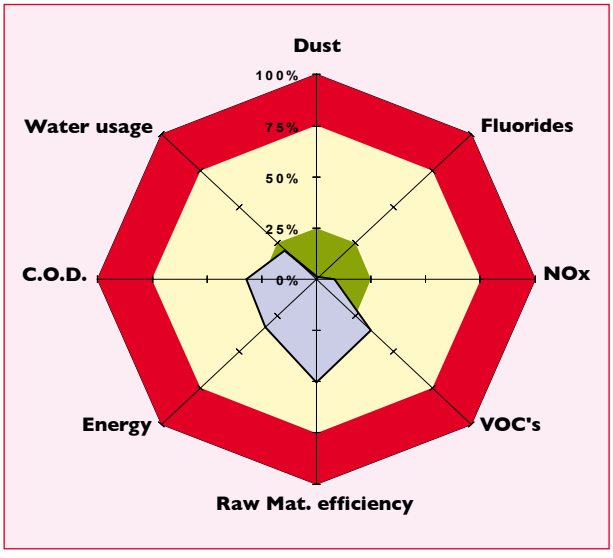
- Up to **54% higher** allowable strain in strain-corrosion resistance, in H2SO4
- Up to **50 Years** instead of 3 months lifetime for pultruded rods, in stress-corrosion in salt water (under identical conditions)
- Up to **50 Years** instead of 4 days lifetime for rods, in stress-corrosion in 1 N HCl (under identical conditions)

(Owens Corning tests; comparing to standard E glass)

Boron Traditional E-glass



Boron and fluorine-free OC® Advantex® E-CR glass



The Boron and fluorine-free OC® Advantex® E-CR glass helped Owens Corning improve our own operational performance with energy reductions and reductions of ingredients such as boron and fluorine.

The above comparison data is limited to Owens Corning own production facilities and shows an internal, Owens Corning E-glass to Owens Corning new Advantex® process comparison and is not comparing to other's E-glass production. It was typical for Owens Corning plant conversions. Actual results vary from plant to plant.

SUPPORTING OUR CUSTOMERS WHERE THE MARKET GROWS

- Supplying Materials Globally
- Advantex® /E-CR glass available around the world
- Fabrics global manufacturing and science platform delivering consistent solutions
- Matching global Thermoplastics customer locations
- Serving BRIC Countries
- Supporting Innovation and New Technologies

OWENS CORNING®
INNOVATIONS FOR LIVING™

- Headquartered in Toledo, Ohio, United States
- Operates in more than 30 plants in 15 countries
- 6 science and technology centers on 3 continents: Apeldoorn, NL, Chambéry, FR, Granville, OH, Ibaraki, Japan, Shanghai China, Zele Belgium
- 2011 Sales: $1.976 billion

composites.owenscorning.com

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