

# NEXT GENERATION COMPOSITE REBAR

ACMA Pultrusion Conference 2021

Aleksandar Georgiev, MBA, M.Sc.(Eng.)

KraussMaffei Technologies GmbH

# Agenda

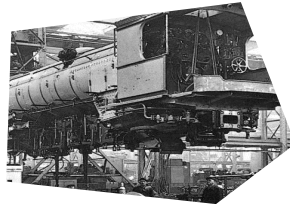
- Company and technology preface
- Introduction composite rebar
- Global market for FRP rebar
- Technical and economic background
- Technical insight GFRP amin rebar
- Executive summary
- GFRP rebar pultrusion by KraussMaffei / Pultrex

# The iconic mechanical engineering company



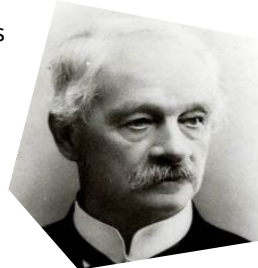
Josef Anton von Maffei  
1790 – 1870

Founding of the  
company in Munich  
**1838**



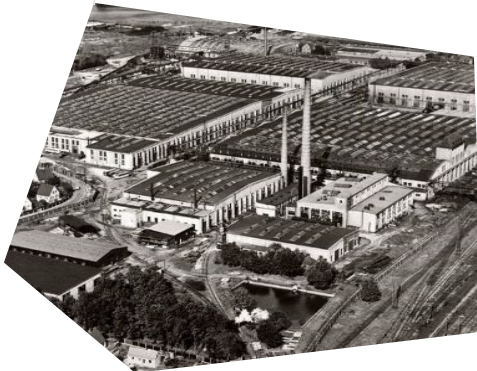
Background  
Locomotive manufacture

Georg von Krauss  
1826 – 1906



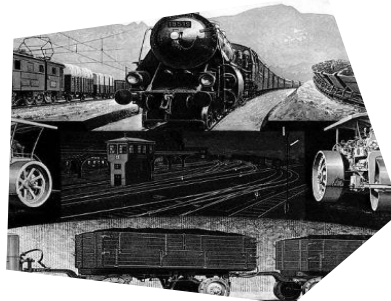
Founding of the  
company in Munich  
**1866**

Since 1931  
Headquarter  
in Munich



1945 – 1999

Mixed group within the sectors plastics  
machinery technology, traffic and  
defense technology, process  
engineering



**2016**

The Chinese chemical group China  
National Chemical Corporation  
(ChemChina) acquires the  
KraussMaffei Group.

First iBox pultrusion activities

**1999 – 2000**

The Mannesmann Group is dissolved and  
KraussMaffei specializes in plastics and rubber  
machinery.

The locomotive manufacturing division is taken  
over by Siemens and the defence technology  
division by KraussMaffei Wegmann.

**2018**

Financial pioneer

KraussMaffei opens up the  
Chinese capital market as the first  
German company.

**2019**

The KraussMaffei, KraussMaffei  
Berstorff and Netstal brands were  
combined to one strong brand:  
KraussMaffei.

Acquisition Pultrex Ltd.

# Explanation and function of rebar

## Concrete (95%)

- Strong under compression
- Weak tensile strength, brittleness

## Rebar (short for reinforcing bar, 5%)

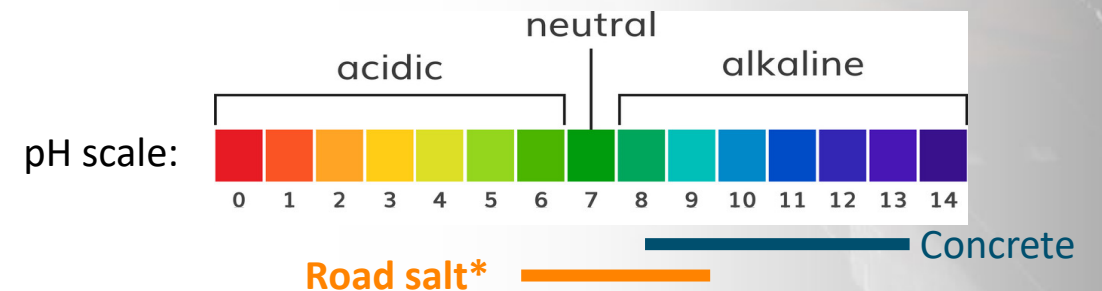
- Steel bar or mesh of steel wires with ribs, lugs indentations
- Tension device in reinforced concrete & masonry structures
- Function: Strengthening the concrete under tension

## Reinforced concrete (100%)

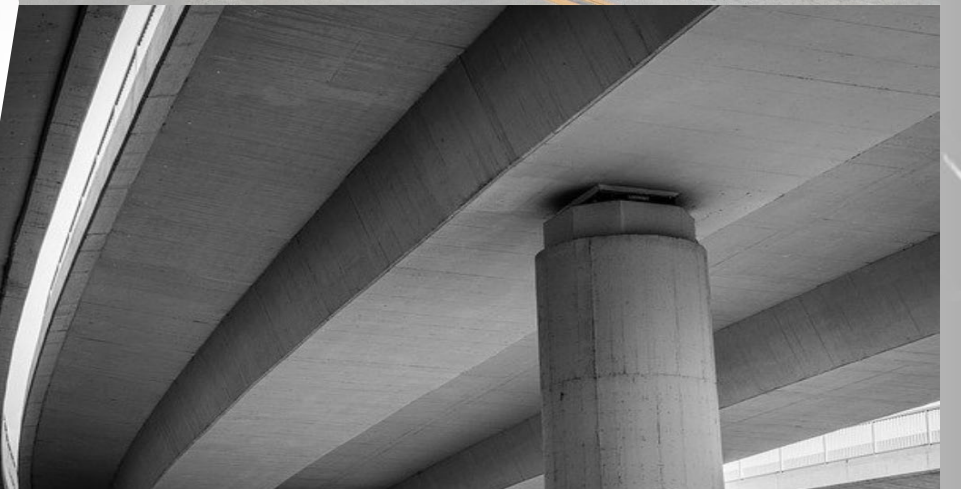
- Significantly increased tensile strength
- Problem: Corrosion



Road salt not suitable for concrete surfaces: tunnels, bridges!



# A hidden revolution in the construction sector



Source: Evonik, Pultrex



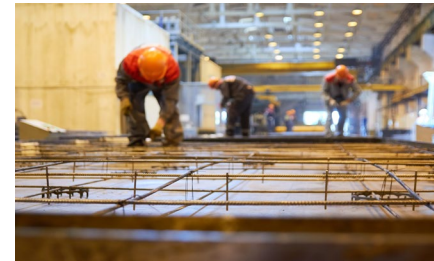
# Applications based on worldwide projects

## Concrete structures in corrosive environment / Thermal & electrical insulation / Non-magnetic structures

- **Bridges:** roadway and high-way, railway, deck
- **Underground constructions:** mining, tunneling (soft eyes), subway
- **Marine:** quays, canals, sea walls, waterfronts, shore facilities, underwater structures
- **Industrial plants:** energy, smelters, petrochemical, liquid gas, water/sewage treatment
- **Electrical insulation:** transformer pads & buildings, MRI rooms, research facilities
- **Thermal insulation:** energy efficient buildings, refrigerated warehouses
- **Other Infrastr.:** parking decks, airports (run ways, towers, compass calibration pads)
- **Precast concrete parts:** sea walls, historical buildings, gray portland cement slab
- **Other:** foundations, balconies, facades, dump sites, desert regions, dams

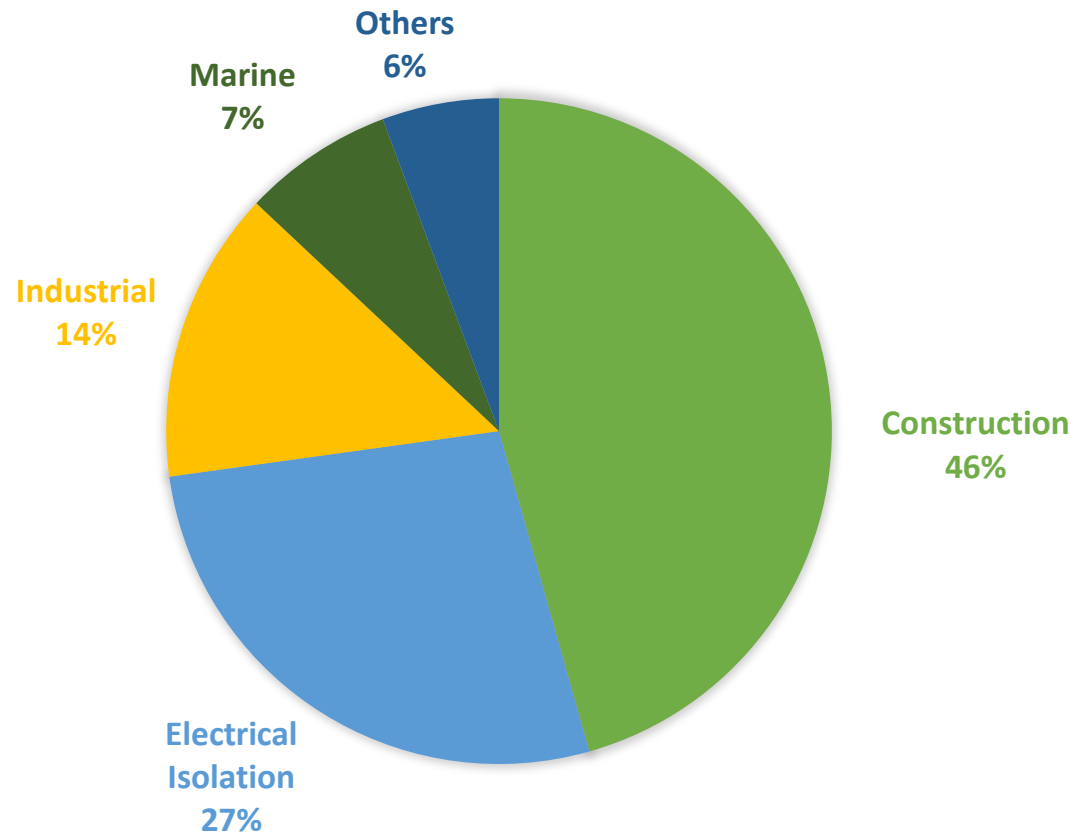


- Upcoming construction projects?
- Worldwide?



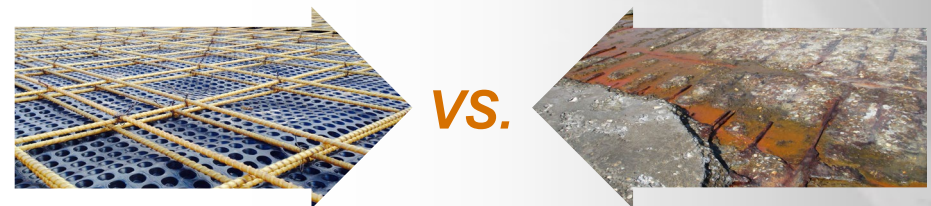
# Industrial application & general advantages

## FRP REBAR BY APPLICATIONS



## *GFRP rebar ultimate advantages*

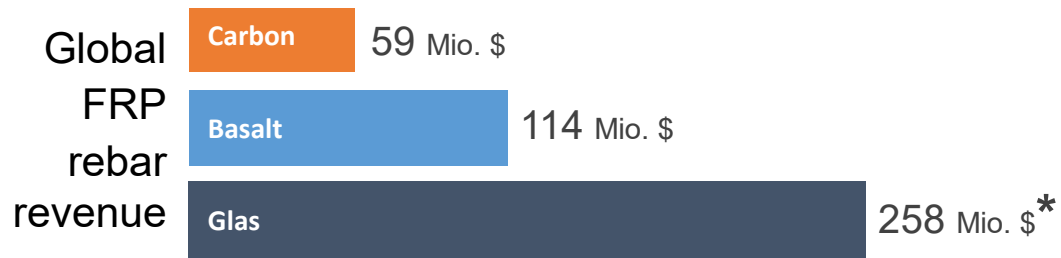
- ✓ Longer service life properties
- ✓ Extreme corrosion & alkaline resistance
- ✓ Superior tensile strength & lightweight
- ✓ Excellent fatigue resistance
- ✓ Non-magnetic & non-conductive
- ✓ Very-high chemical resistance
- ✓ Low thermal conductivity
- ✓ Easier machinability
- ✓ Lighter for transport & installation
- ✓ Long-term cost effectiveness



Source: Fior Market Research® 2020



# Insights and general market overview



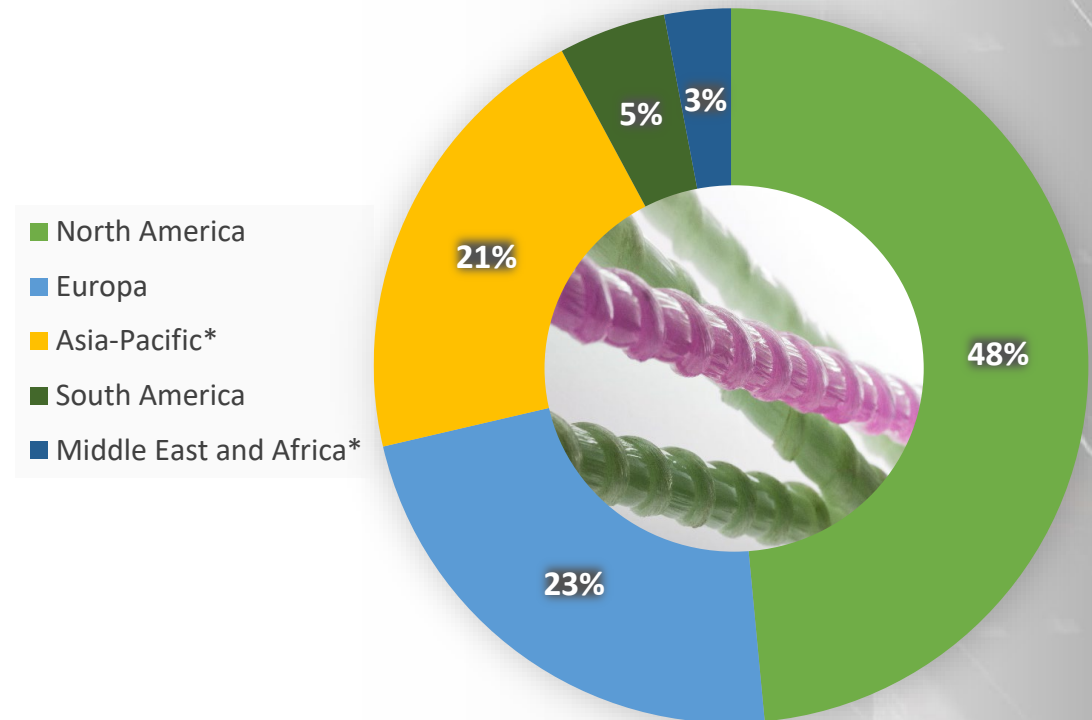
## Worldwide key indicators

**~120**  
FRP rebar  
companies

**~100K**  
output  
km/year

**+8~12%**  
CARG growth  
till 2026\*\*

## Market share by regions\*\*



Source: Fior Market Research® 2020 and KraussMaffei research

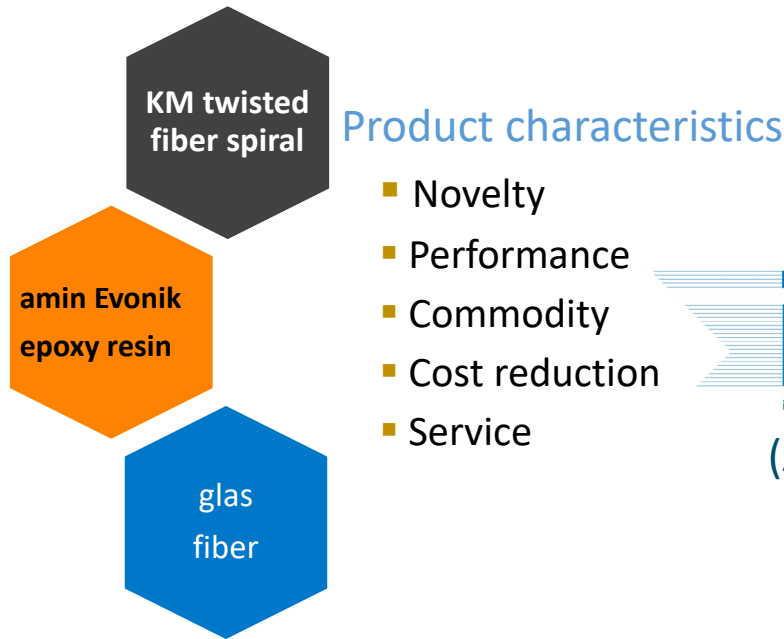


\*highest CARG 2020-2026  
\*\*2010-2020 CARG 10%+

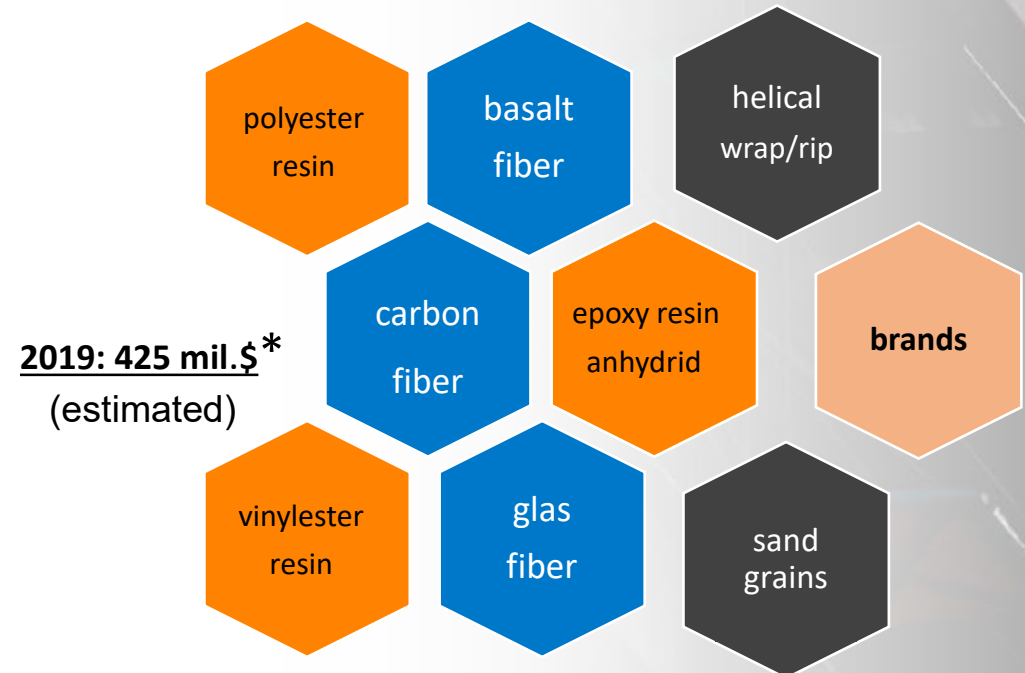


# Innovation vs. market status que in 2020

## iPul rebar market introduction



## Worldwide market for composite rebar



## Steel rebar market:

220 billion \$ in 2020 (350 bil. \$ 2025\*\*\*)

Timeline: 30 years (1990) +10 years  
 Market players: approx. 25 (of 120)  
 Ø 4 – 40(55) mm / 10-15 km/day\*\*

Source: \*KraussMaffei research, \*\*Conference paper ACI Fall Convention, US, California, 2017, \*\*\*Grandviewresearch & Marketandmarkets.com



# Fiber and resin mechanical properties

- Composite rebar: 75% fiber content + 25% resin content (Tg resin ~150°C)

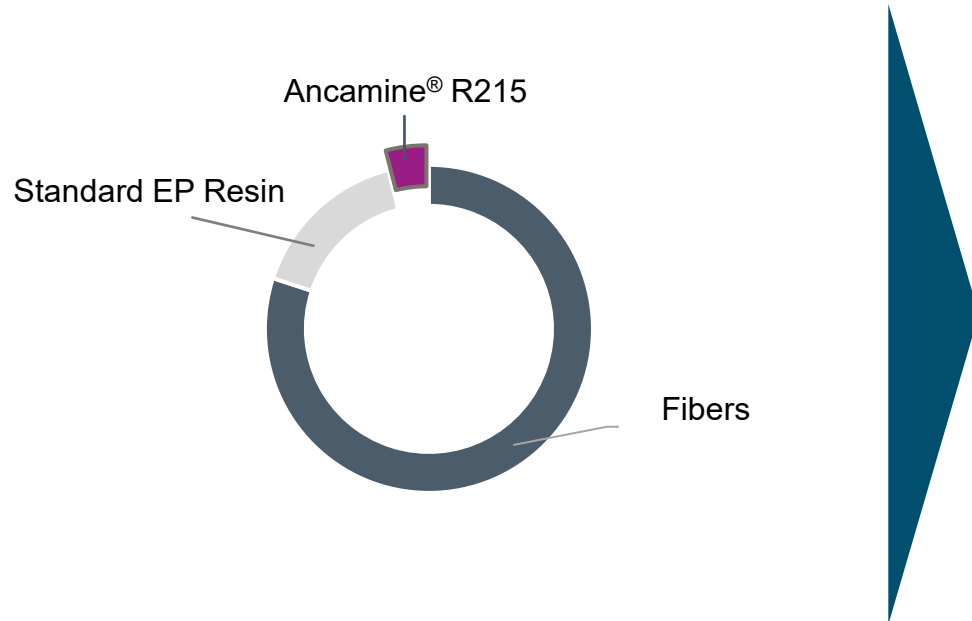
Fiber properties	Basalt	E-Glass	S-Glass	Carbon	Aramid
Density (g/cm)	2.6 – 2.8	2.5 – 2.6	2.5	1.8	1.5
Tensile Strength (GPa)	4.1 – 4.8	3.1 – 3.8	4 – 4.7	3.5 - 6	2.9 – 3.4
Elastic Modulus (GPa)	93 - 110	73 - 76	83 - 86	230 - 600	70 – 140
Elongation at break	3.1	4.7	5.3	1.5 - 2	2.8 – 3.6
Max. Service T°C	600	380	300	500	250
Price €/kg	2.5 – 3.5	1.15	13 - 20	12 - 14	10

- Resin price: **UP** resin 2 - 2.5 €/kg, **VE\*\*** 4 - 6 €/kg, Epoxy 3.5 - 6 €/kg (**Epoxy Amin** 3.5 €/kg)\*
- Alkaline resistance: **Polyester** < **Epoxy / Anhydrid** < **Vinylester\*\*** < **Epoxy / Amin**

Source: basaltfiberworld.wordpress.com, Evonik, \*Market prices stand end of 2020 – source Evonik

\*\* styrene emissions, most commonly used

# Overview over different resin technologies



	Epoxy-Amine based on R215	UPE	VE	Epoxy-Anhydride
Alkaline resistance	++	-	+	-
Mechanics	++	-	+	+
Tg	+	-	+	+
Toxicology/ Emissions	+	--	--	-
Reactivity	++	+	+	-
Material costs	0	++	0	+

- A rebar contains only 4% of Ancamine® R215 and 21% of epoxy resin
- 4% of hardener have a major impact on the final performance of the rebar product

Ancamine R215 by Evonik – small content with big impact!



# **TECHNICAL INSIGHT GFRP AMIN REBAR**

From old to sustainable solution

# Comparison of different rebar technologies

Technical characteristics	Composite reinforcement GFRP amin KraussMaffei	Composite reinforcement basalt	Carbon steel AV reinforcement	Stainless steel reinforcement
1. Tensile strength, MPa	1200	1300	550	550
2. Thermal conductivity	< 0,56	< 0,46	56	17
3. Density, g/cm <sup>3</sup>	2,24	2,0	7,85	7,85
4. Modulus of elasticity , GPa	60	59	200	200
1. Electrical conductivity	dielectric	dielectric	electrically conductive	electrically conductive
2. Magnetic characteristic	non magnetic	non magnetic	magnetic	non magnetic
3. Fire resistance, °C	Up to 150*	up to 150*	up to 600	up to 600
4. Corrosion- & chemical resistance	very high	very high	low	high

- Physical test: rebar with helical wrap – better failure behavior with concrete than sanded FRP rebar
- Physical test for carbon rebar: almost similar connecting force with concrete as GFRP rebar

Source: Rockbar (basalt fiber), Physical tests with KraussMaffei rebars at different independent German construction institutes

# Insights GFRP amin rebars

## Material Data

Epoxy curing agent	Ancamine R-215
Glasfiber	PS 4100 T30 2400 Tex
Resin	Epoxy resin



## Advantages compared to the state-of-the-art market

### GFRP amin rebar:

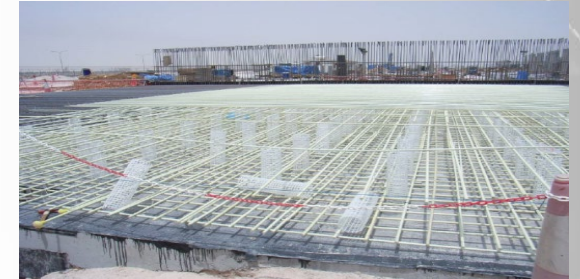
- Drastic lower overall production costs
- Turnkey solution with iBox / higher speeds
- Lower material consumption due to winding
- Characteristic values close to the best market solutions
- Decisive value: Young module is competitive
- Supreme quality product
- High end innovation
- Worldwide service network
- Longer service life

**VS.**



# From indispensable problem to a long-term solution

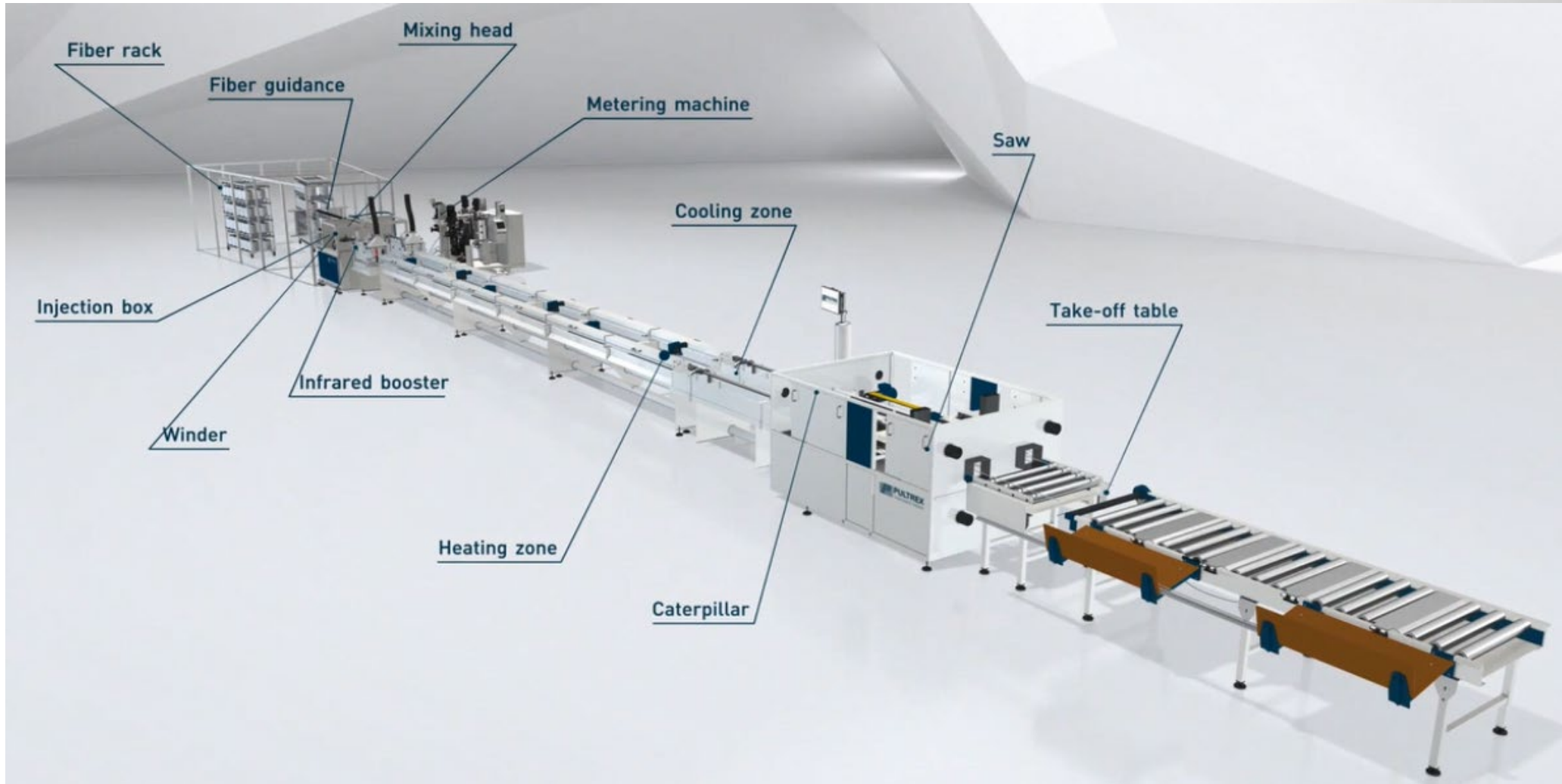
- GFRP rebar from epoxy amin – for longer life of roads, bridges and buildings
- Production technology with long term sustainable value creation – reducing CO<sub>2</sub> emissions and costs



Source: Evonik, Schöck, MMS Group



# Your 24/7 COMPOSITE REBAR PLANT - VIDEO





# ***THANK YOU FOR YOUR ATTENTION!***

For further information, please contact:

Aleksandar Georgiev

**KraussMaffei Technologies GmbH**

Krauss-Maffei-Straße 2  
80997 München

Tel.: + 49 (0)89 88 99 1683

Mobile: + 49 (0)174 8593 160

Email: [aleksandar.georgiev@kraussmaffei.com](mailto:aleksandar.georgiev@kraussmaffei.com)

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