HUNFALVY JÁNOS KÉT TANÍTÁSI NYELVŰ KÖZGAZDASÁGI TECHNIKUM LÁTOGATÁSA

Múlt a nehéz, a könnyű jövő

Szabó Rudolf

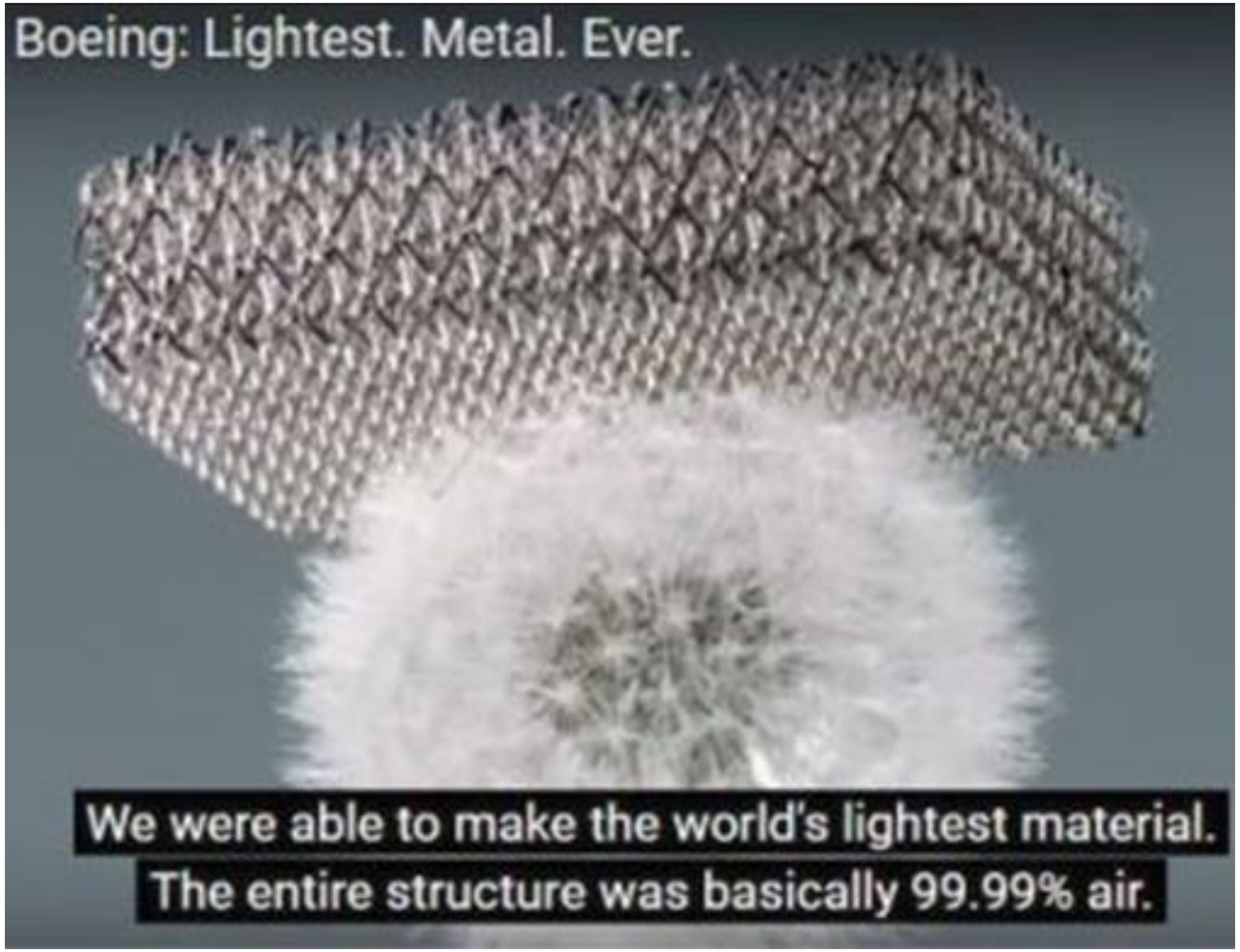
Rejtő Sándor Pro Technológia Alapítvány

2024. március 11.

Paradigm Change

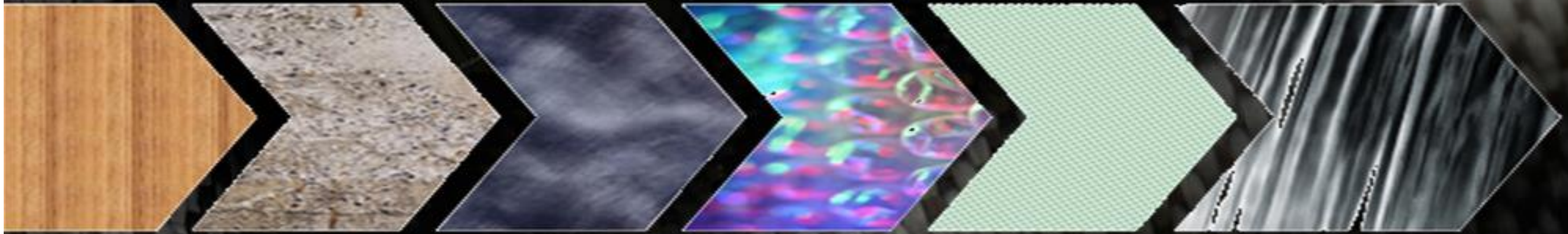
The lighweigt is the future

- Sustainability
- Material
- Fiber structures
- Carbon fibers,
- graphene,
- nano Tube
- Lightweight structural materials
- Renewable energy
- Electrification
- Energy storage
- 3D printing



Materials Evolution, changes in energy sourse

The Pursuit of Higher Performing Materials...



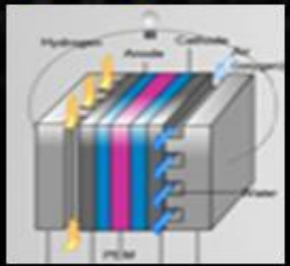
Wood	Stone & Concrete	Metals	Plastics	Glass Fiber Composites	Carbon Fiber Composites	CFRP + Graphene, Nanotube
Biomass	Biomass	Coal	Oil	Gas	Fossil	Renewable
Renewable		Fossil			Renewable	Hydrogen

Commercialization...

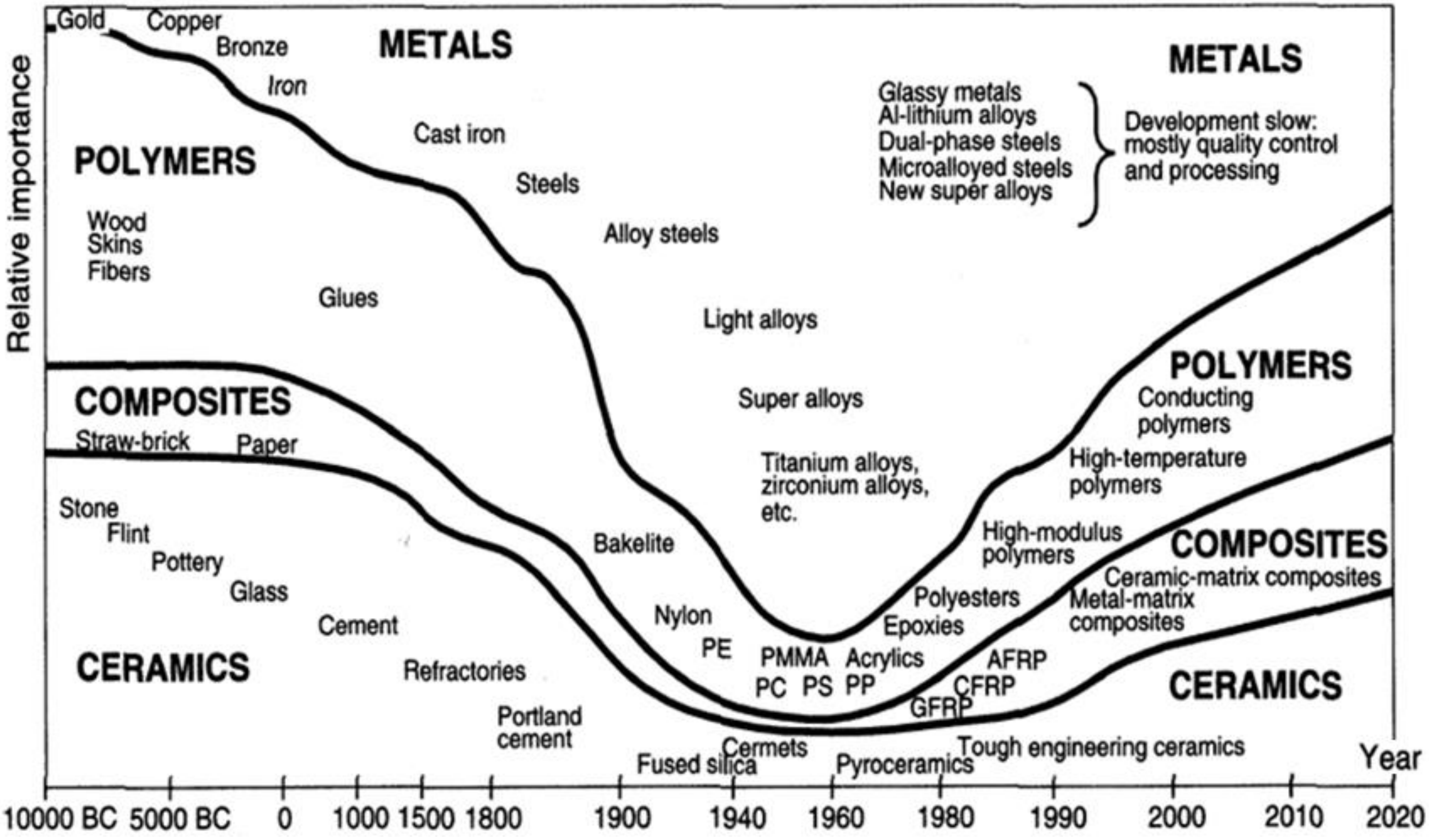






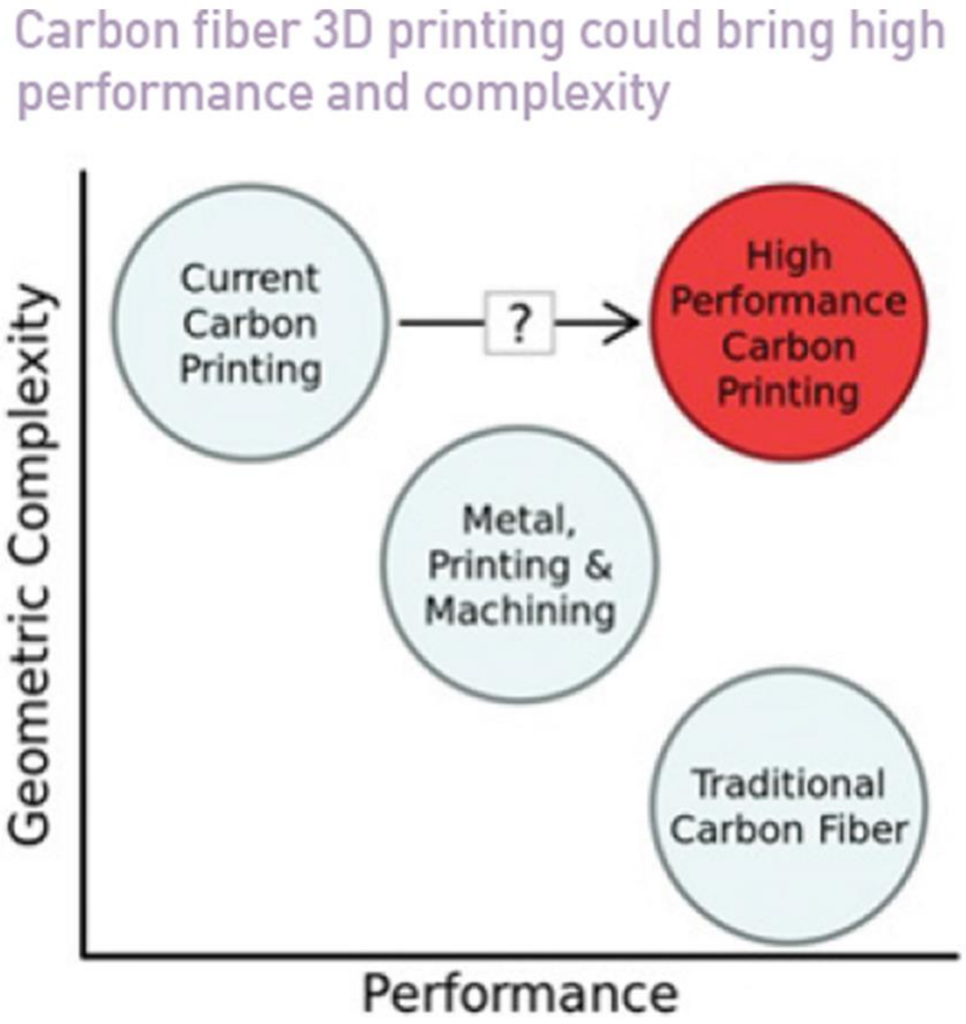




Relative importance of material development through history



Stone

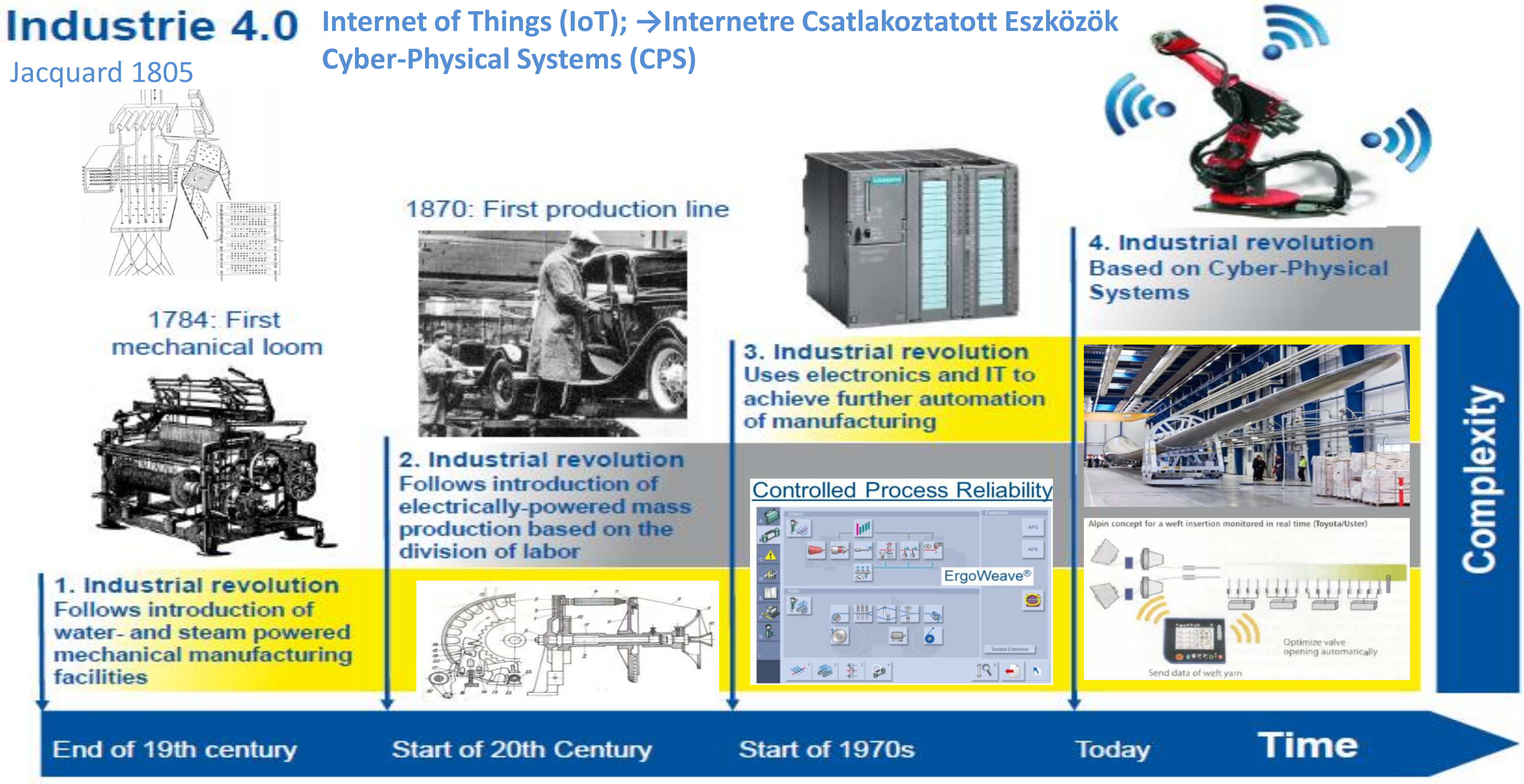
3D printing



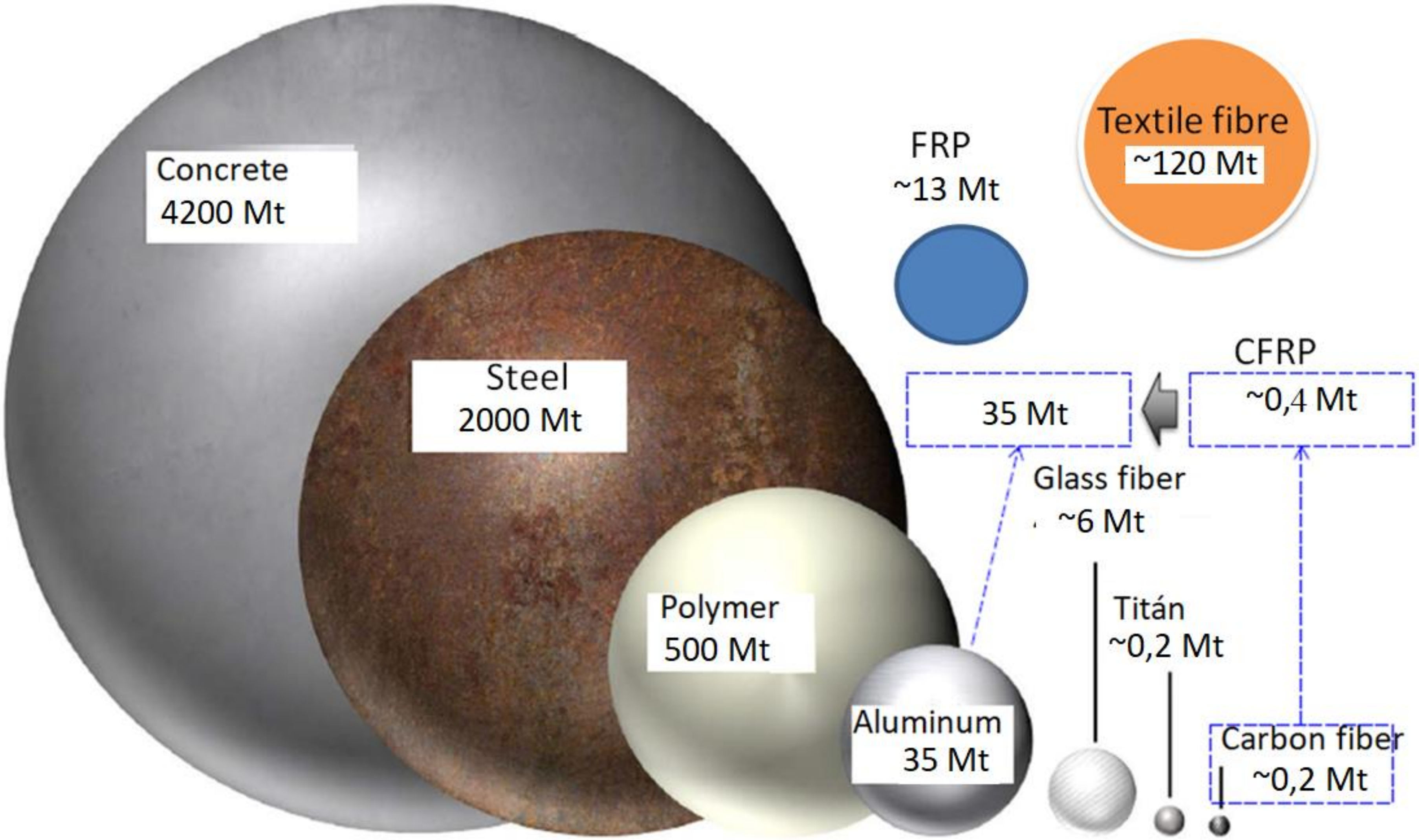
Industrial revolution

Internet of Things (IoT); →Internetre Csatlakoztatott Eszközök
Cyber-Physical Systems (CPS)

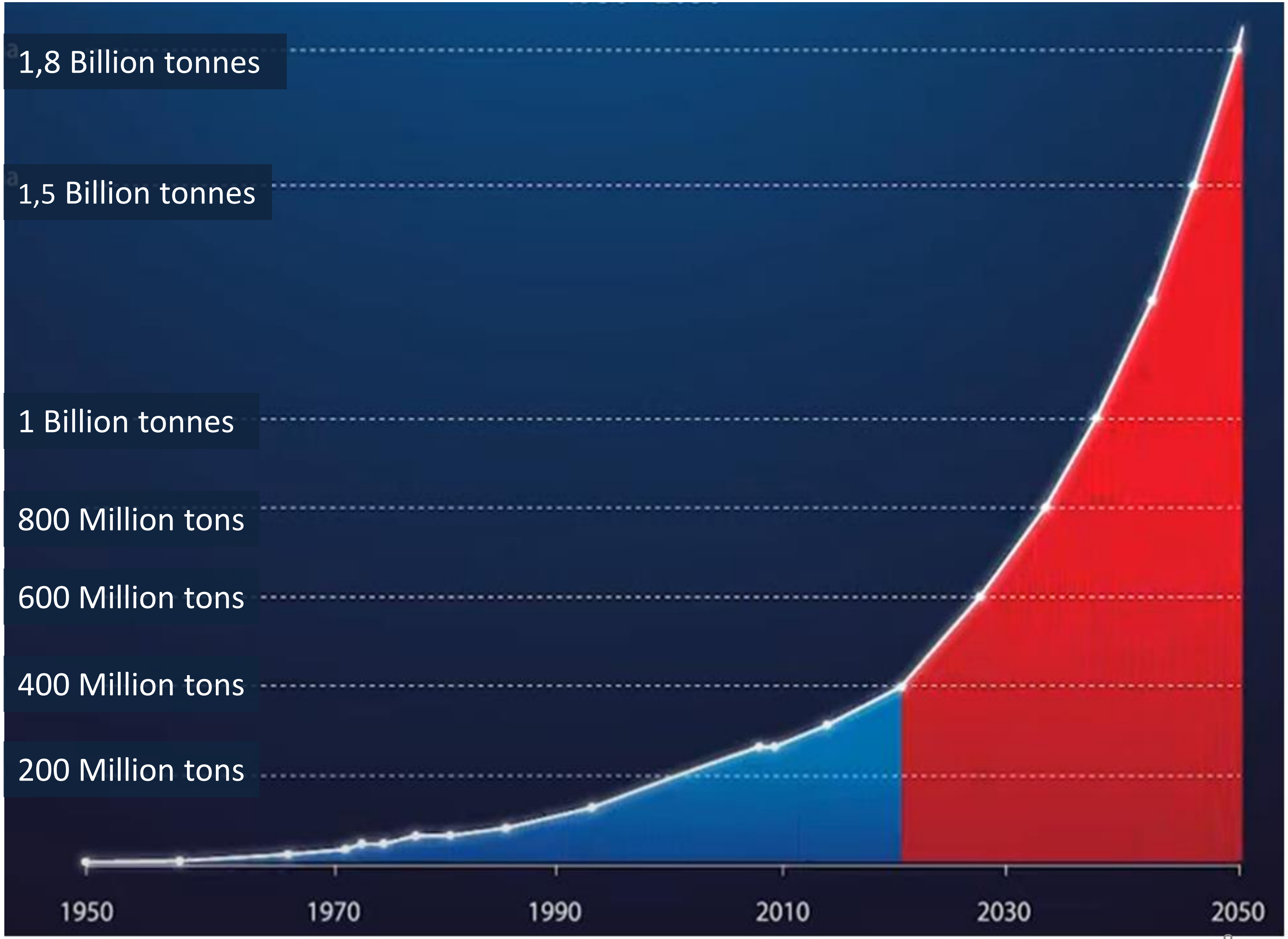
Jacquard 1805



The distribution ratio of structural materials is carbon fiber resp. comparison of CFRP and aluminum in 2023

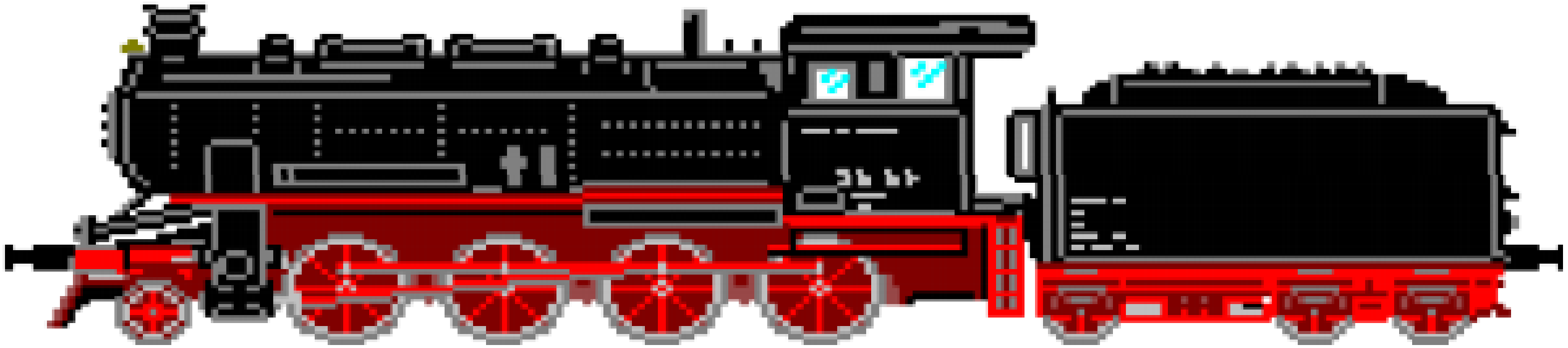


Global plastic production 1950-2050

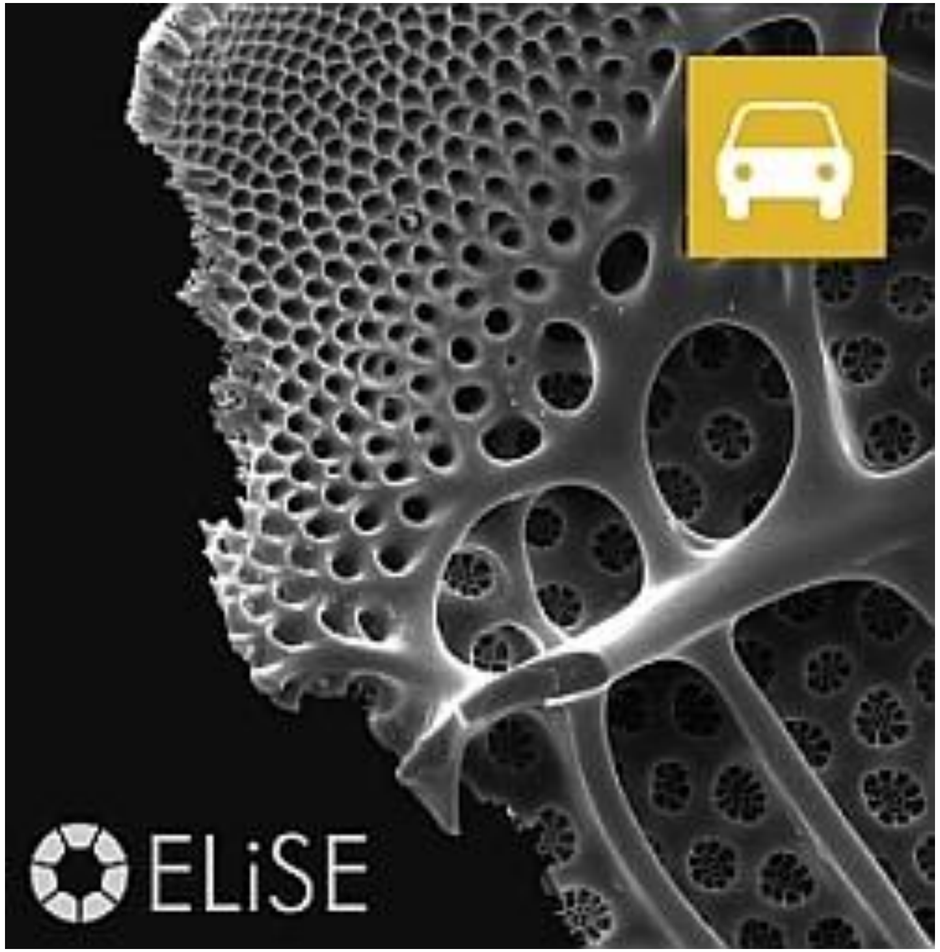


Definition Innovation

- An innovation is understood of the first commercial use, or the first commercial application of inventions to the achievement of corporate objectives.
- An innovation surrounds the Invention, the commercial development and market introduction.

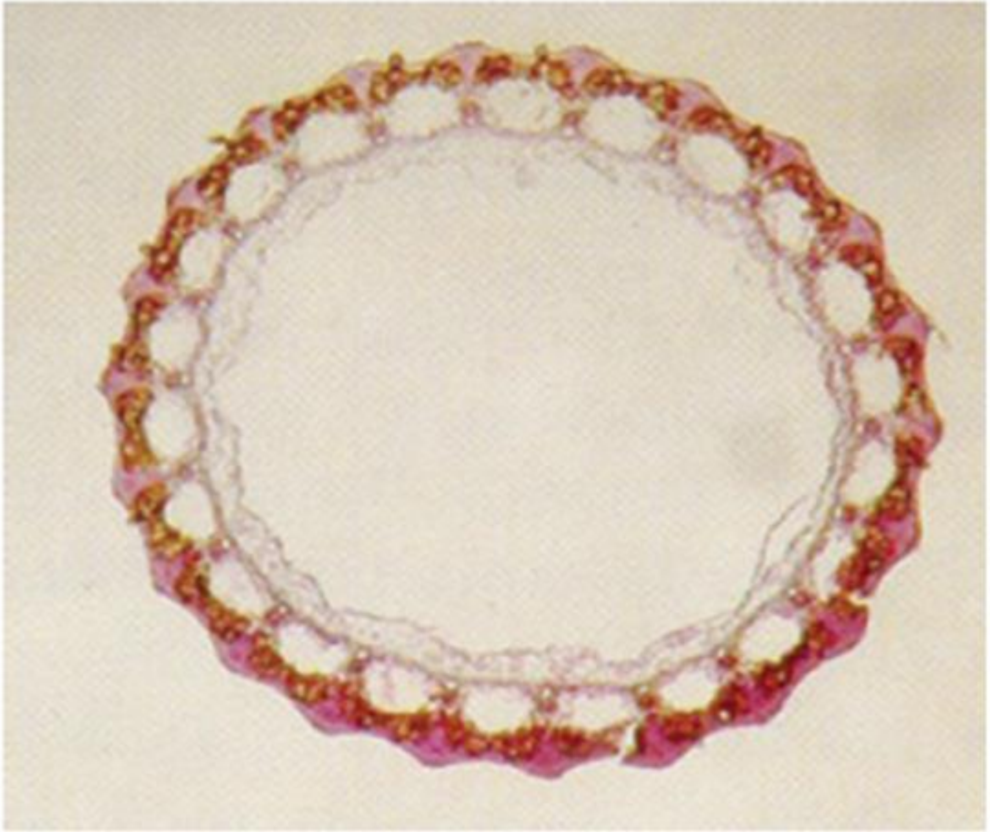


BIONIC DESIGN: The future of lightweight structures



Bone structure of birds

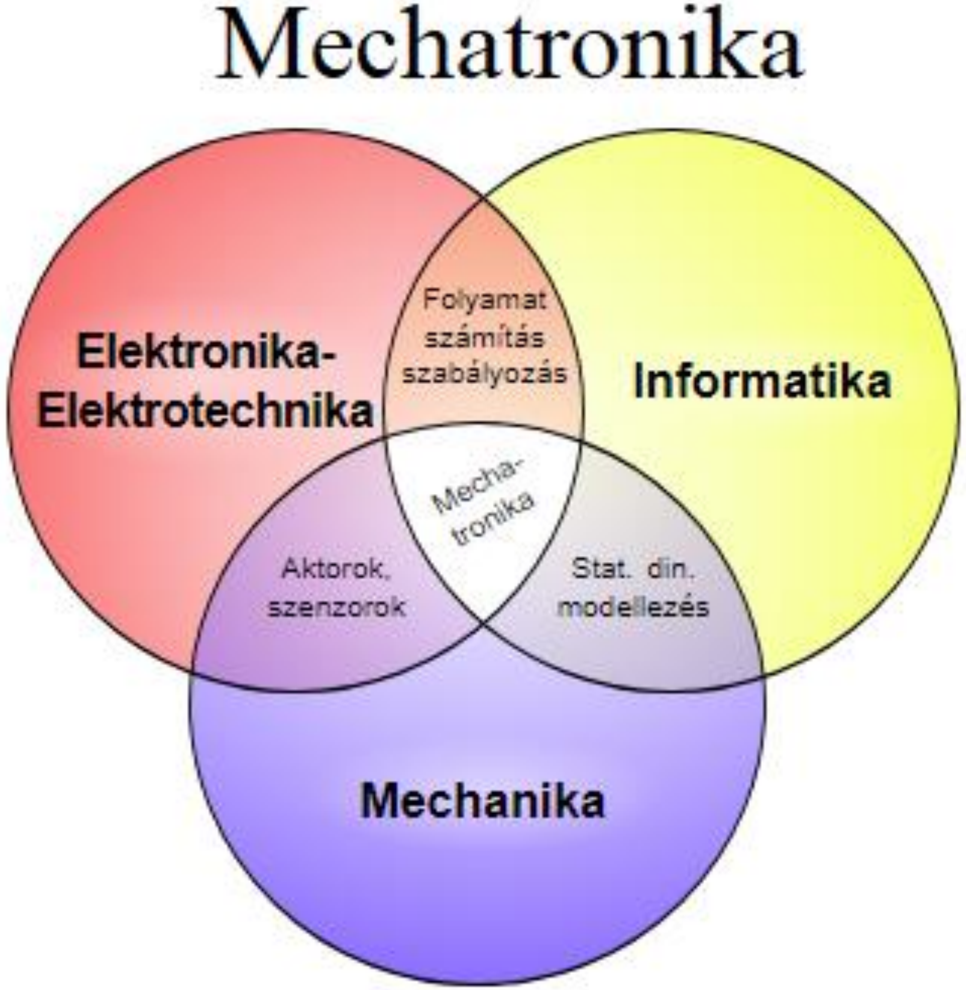
Cross section of plant stem (hemp) and technical (composte) stem



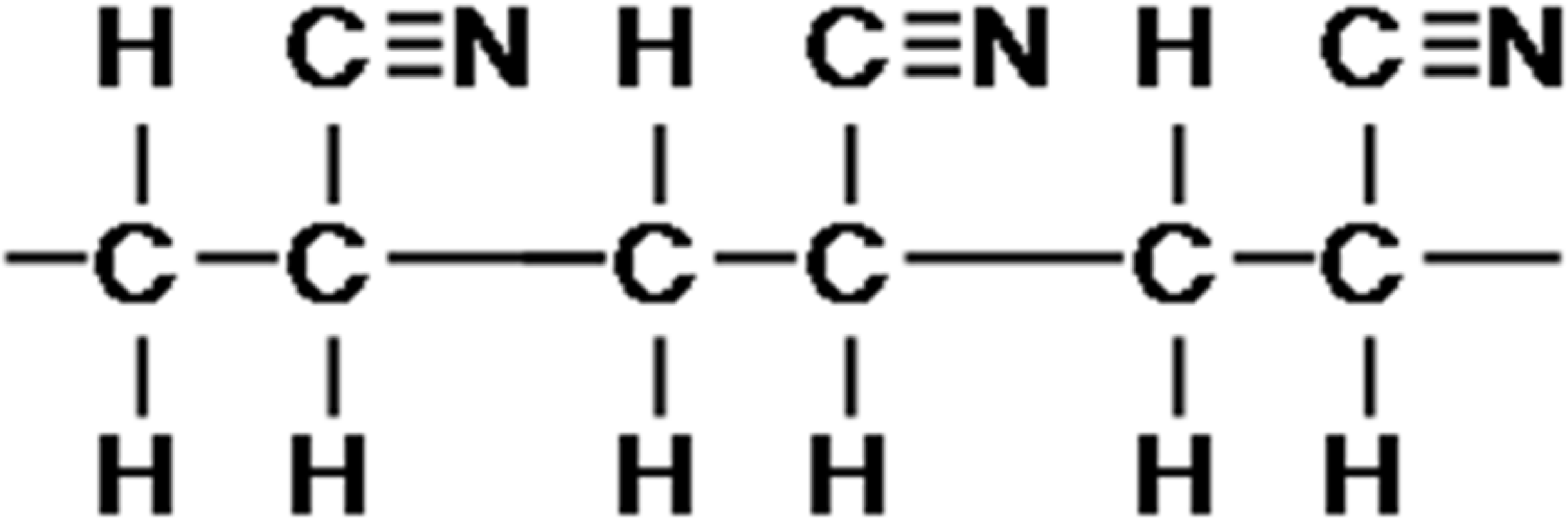
Cross-section of plant stem

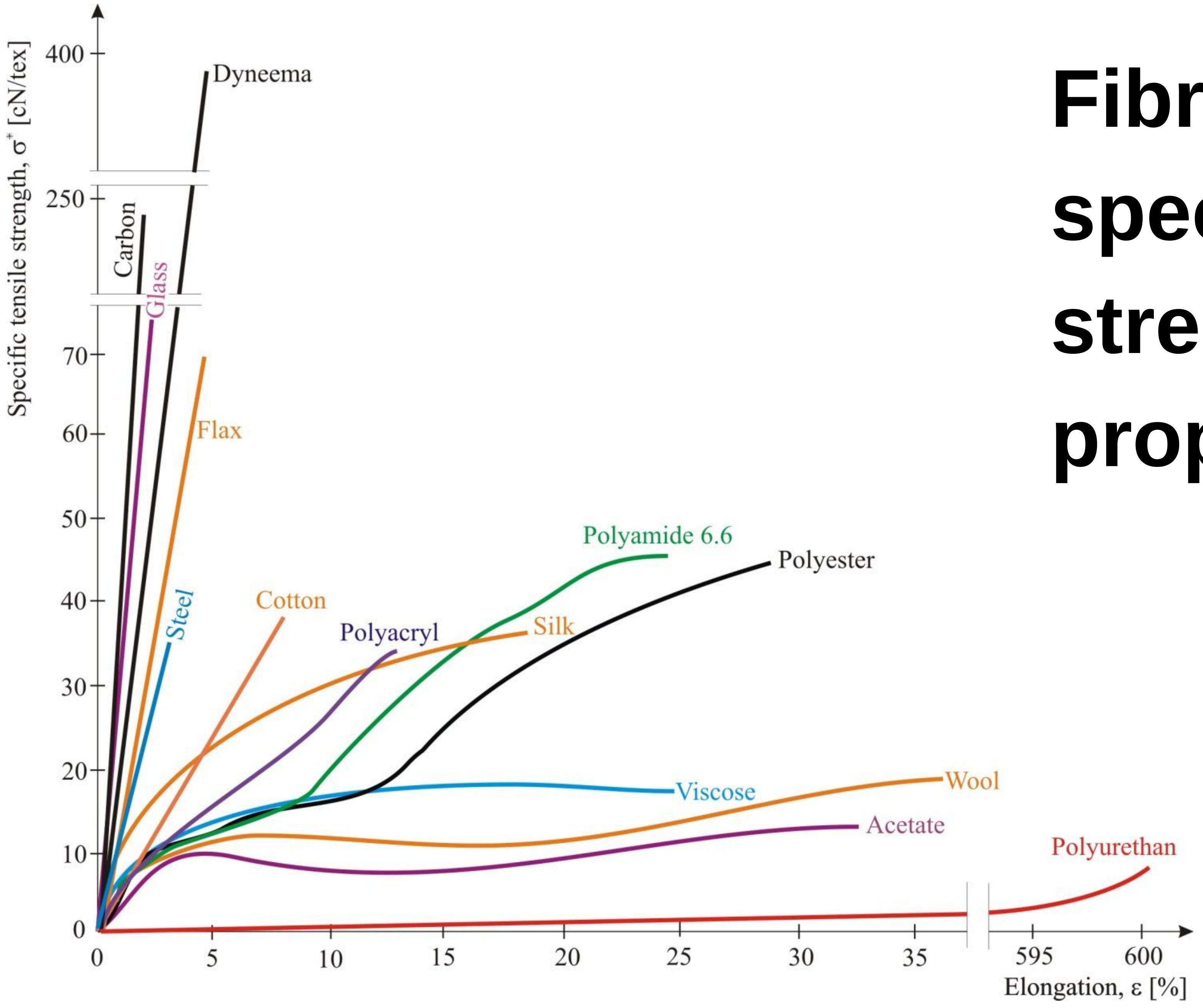
Technical „plant" stem

Microprocessing system



Polyacrylonitrile chain molecule



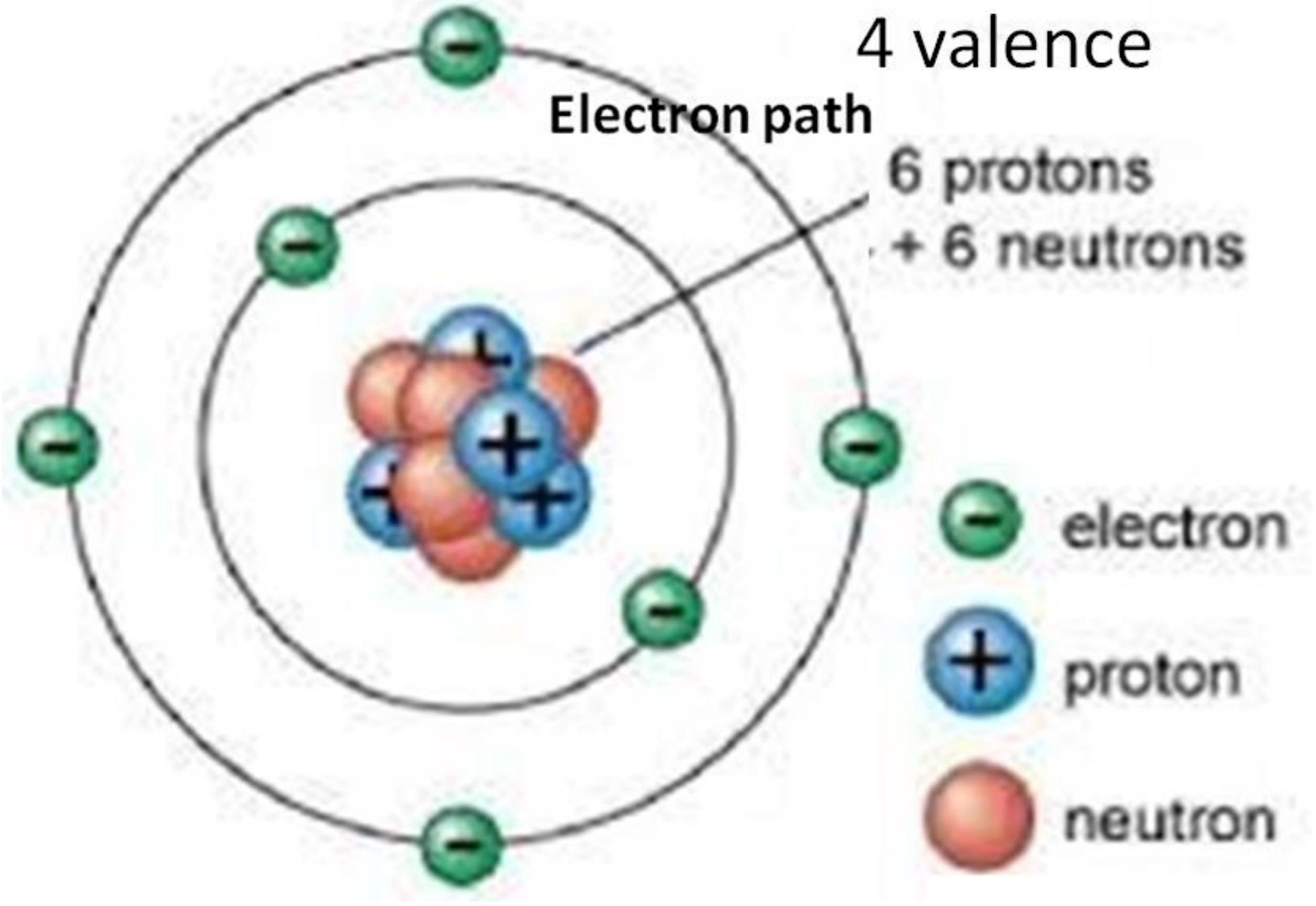


Fibre elongation-specific tensile strength properties

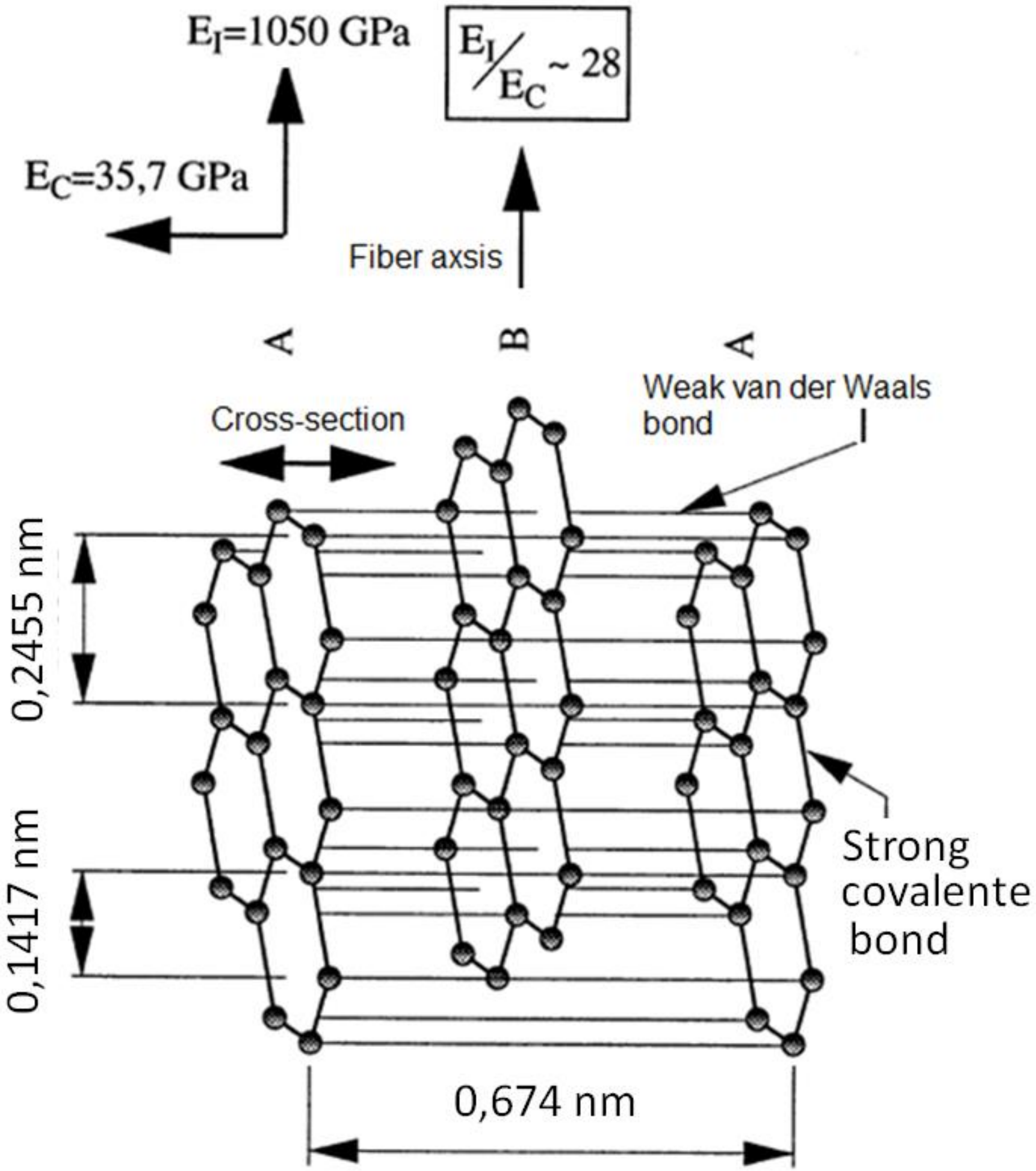
Carbon atom

Carbon atom is linked to a variety of other compounds

4 valence

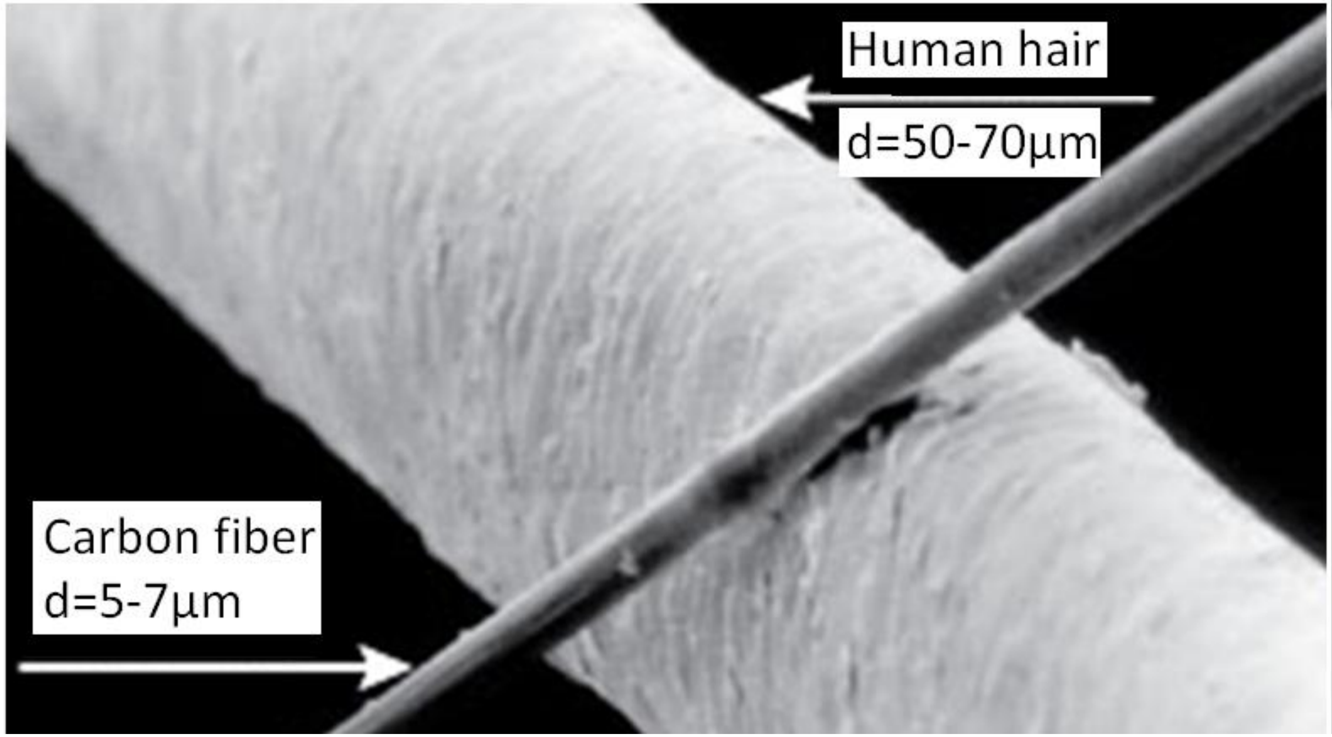


Atomics structure of carbon fiber

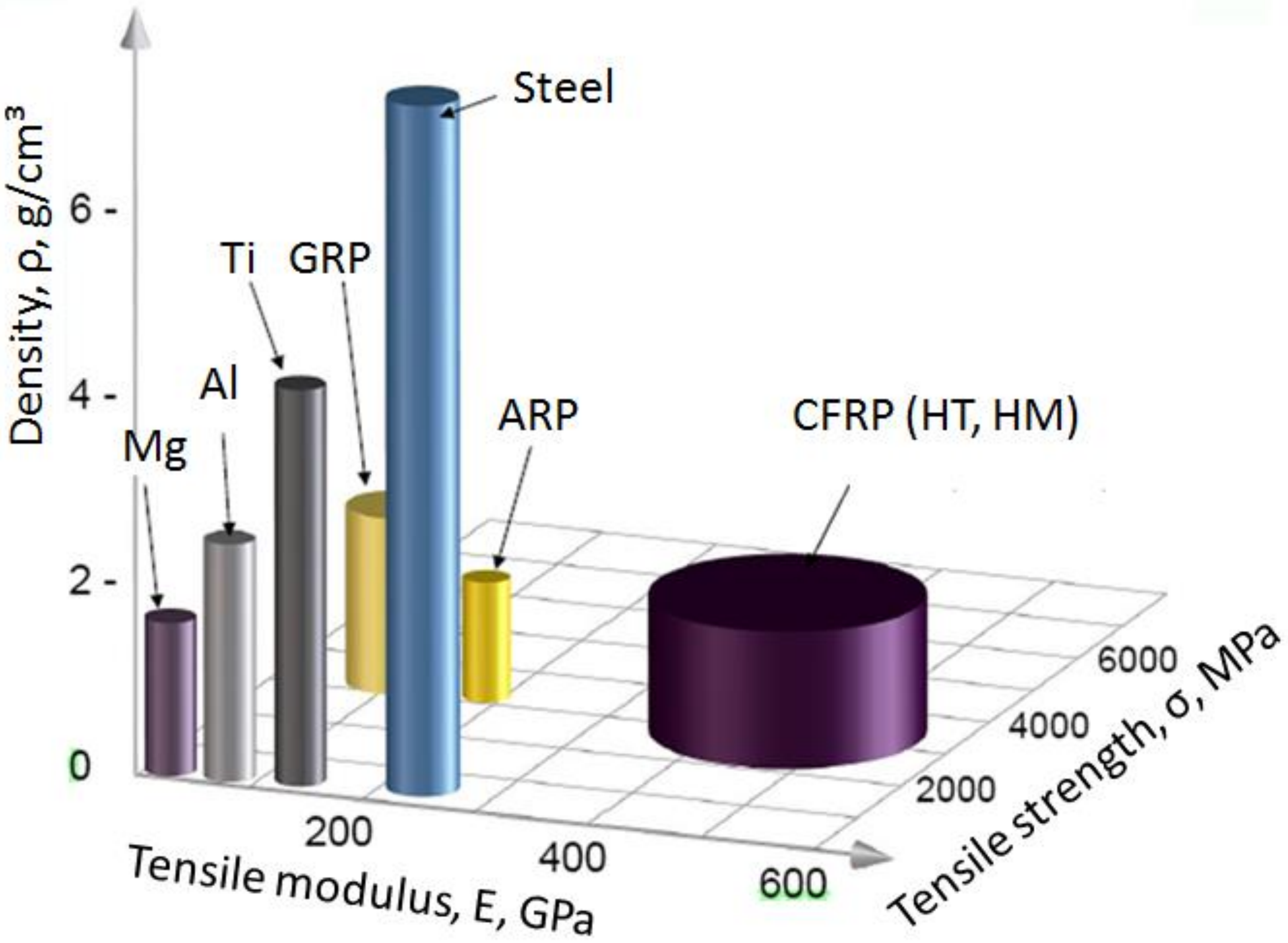


Features of carbon fiber

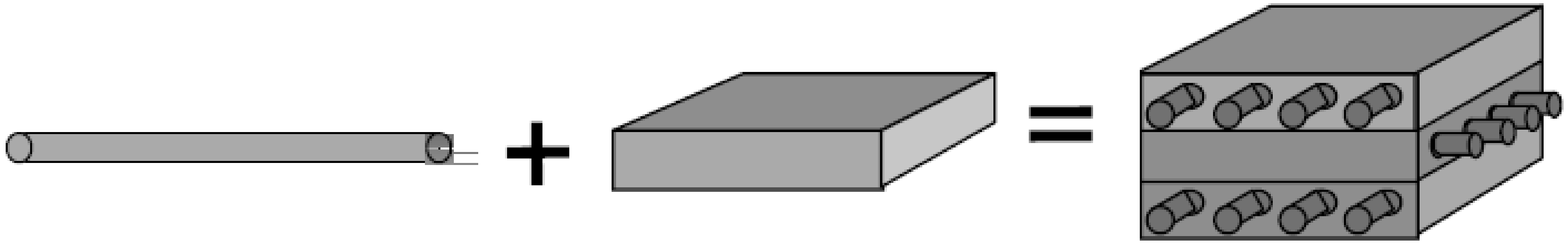
- Carbon fibers are extremly fine fiber (d= 5-7µm, ~0,7 dtex)
- Consisting mostly of carbon atoms (>0,95%)
- Carbon fiber is mostly used to reinforce composite matrials: CFRP- carbon fiber reinforced polymers, C&C, C-SiC ....
- Carbon fibers are produced in tow (bundles or yarns) ranging 1000 filaments (1k): Small tow: 1k, 3k, 6k, 12k, 24k
  Large tow: 48k, 50k, 60k ...



Mechanical properties of important structural materials

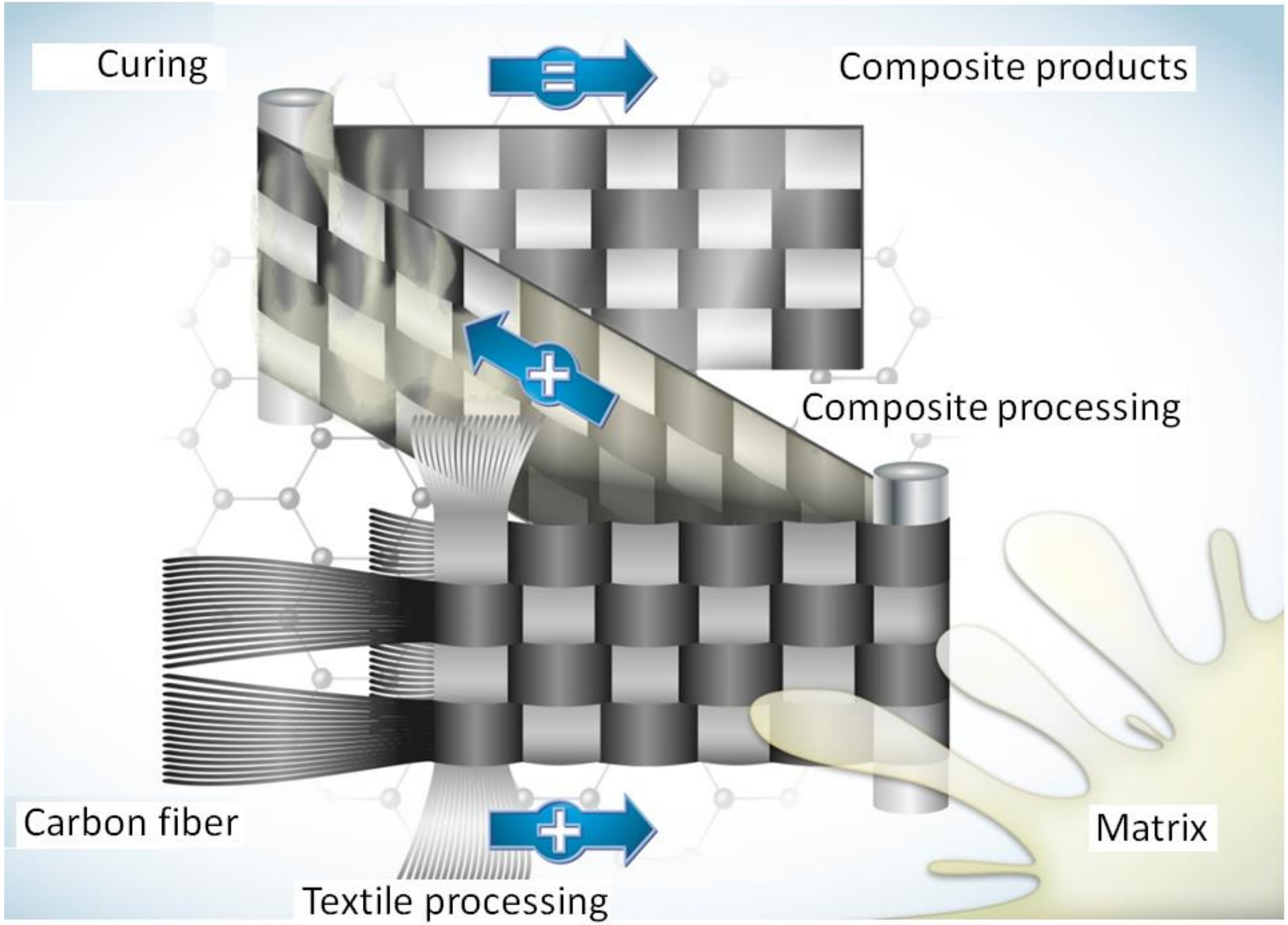


Composition of Composites

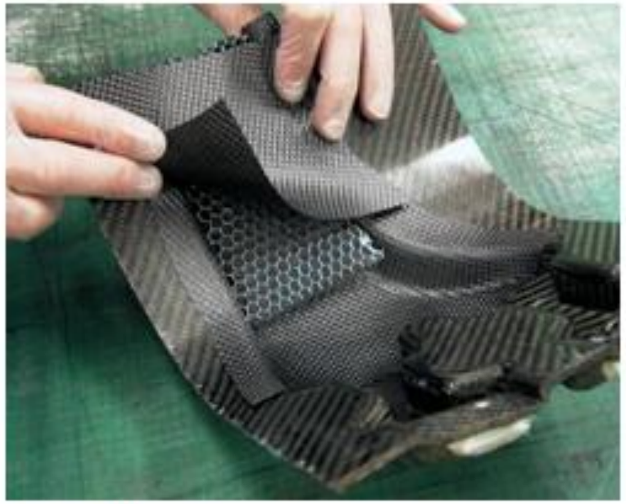


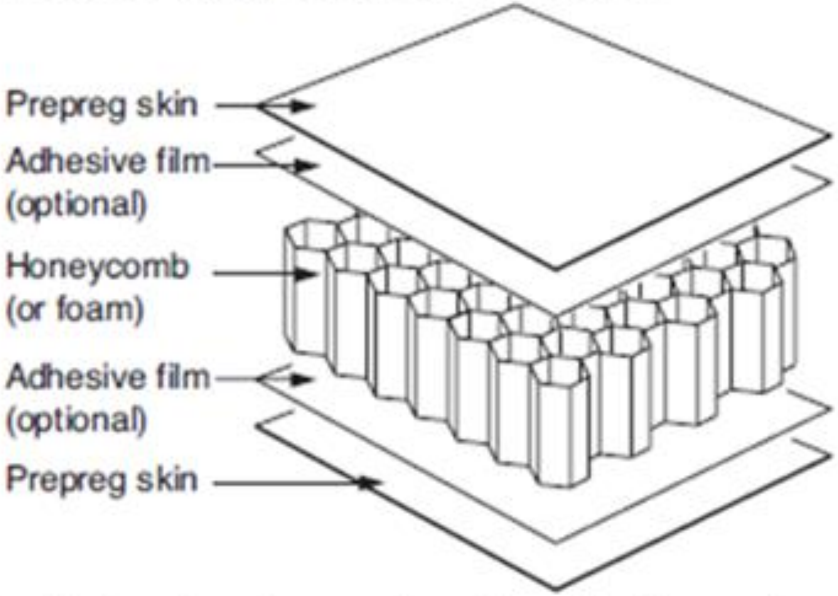
Fiber/Filament Reinforcement	Matrix	Composite
• High strength	• Good shear properties	• High strength
• High stiffness	• Low density	• High stiffness
• Low density		• Good shear properties
		• Low density

Manufacture of carbon fiber reinforced composites (CFRP)



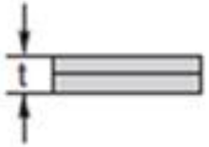
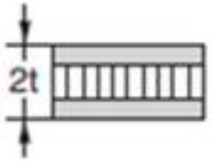
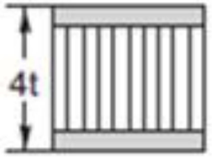
HONEYCOMB SANDWICH WITH PREPREG SKINS





Advantages :
very low weight, high stiffness, durable, design freedom, reduced production costs.

What are the properties of a sandwich construction ?

Properties	Solid material	Core thickness t	Core thickness 3t
			
E I, Flexural rigidity	1.0	7.0	37.0
σ, Flexural strength	1.0	3.5	9.2
m, mass/weight	1.0	1.03	1.06

Design Freedom,
Aesthetics & Flexibility

Lightweighting

Resistance
& Resilience

Strength
& Stiffness

Part Count Reduction
& Functions Integration

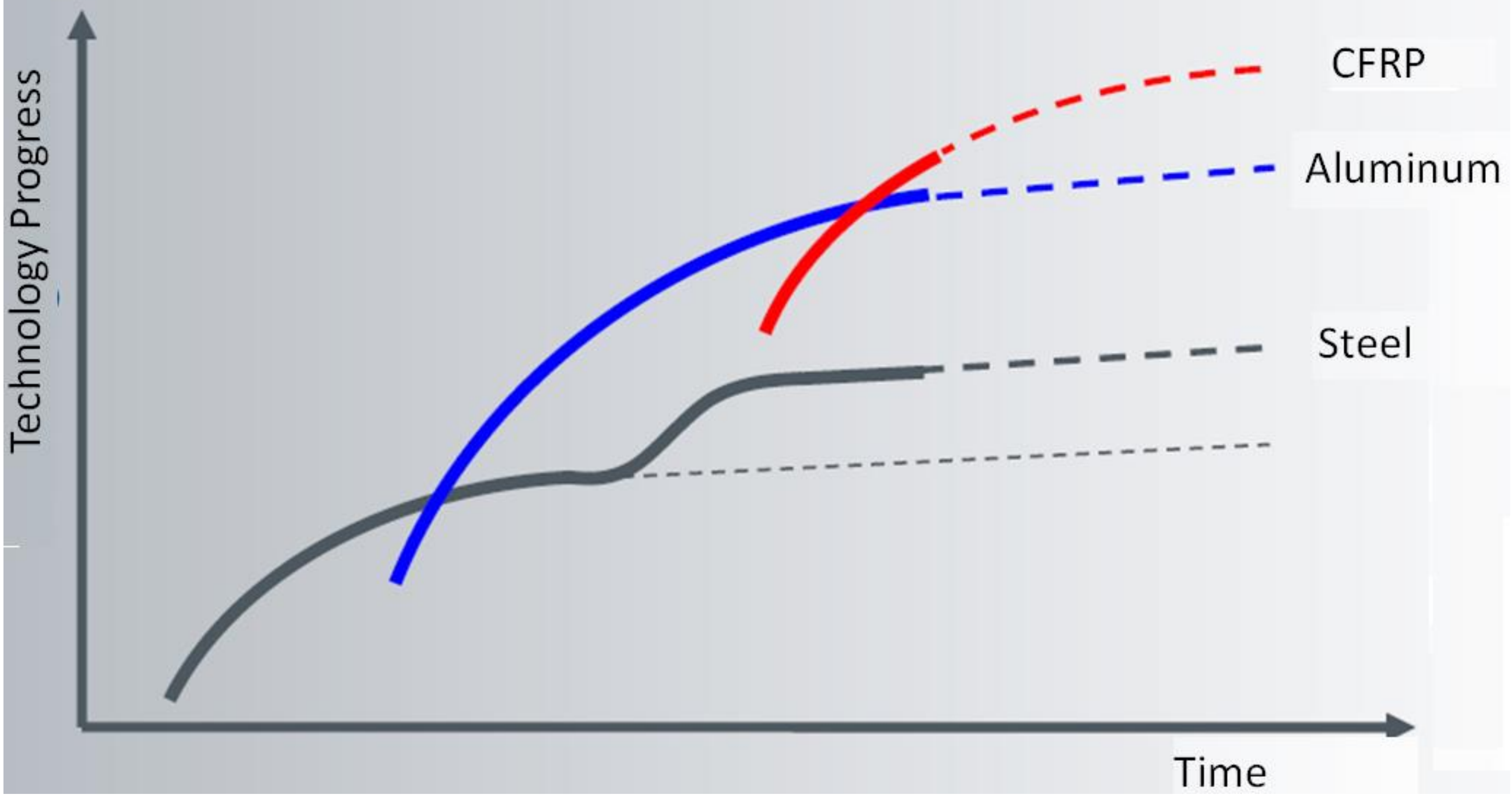
Hybridization & Bonding
with other Materials

Corrosion Resistance

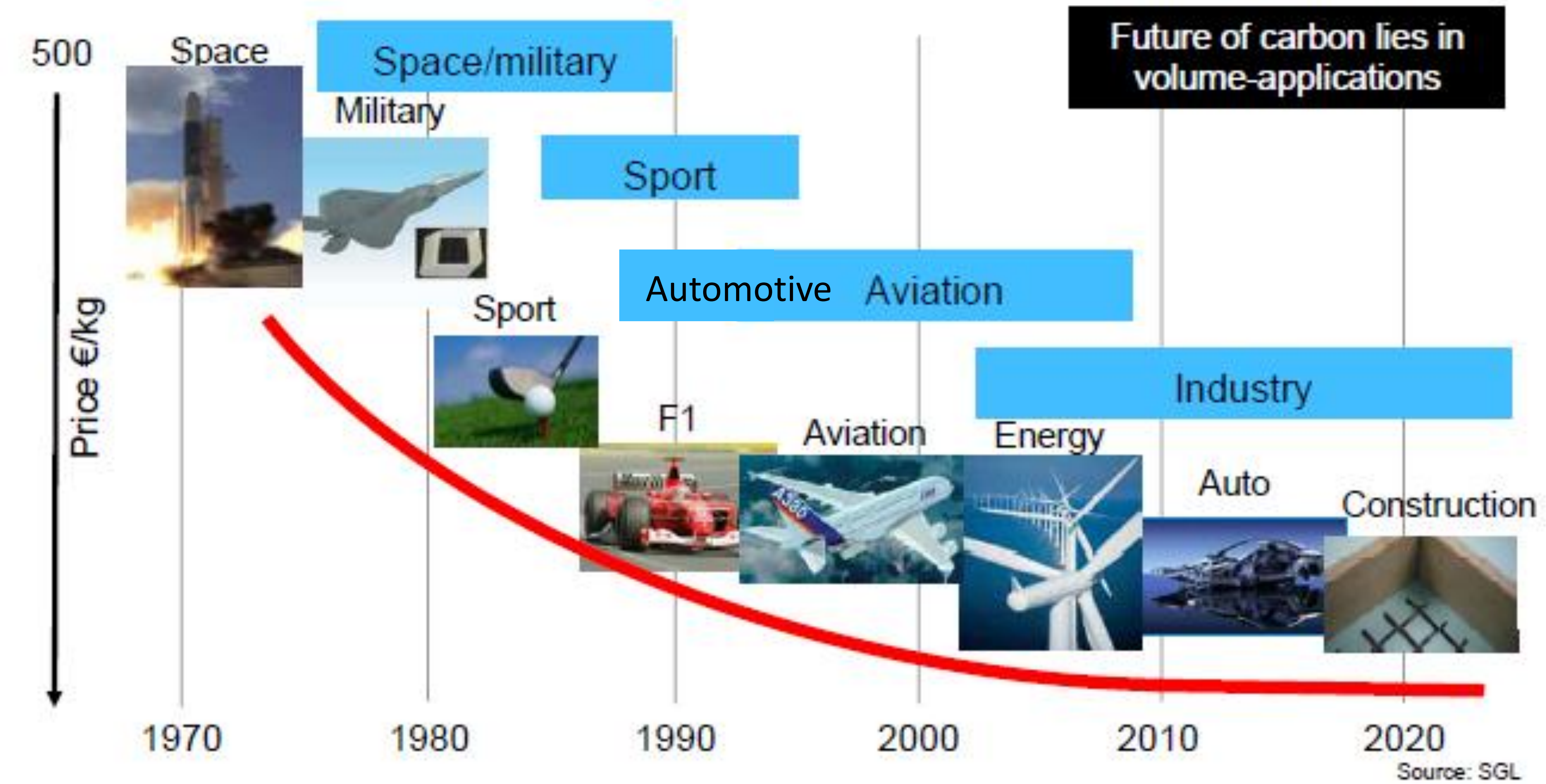
Durability

High
Strength-to-Weight Ratio

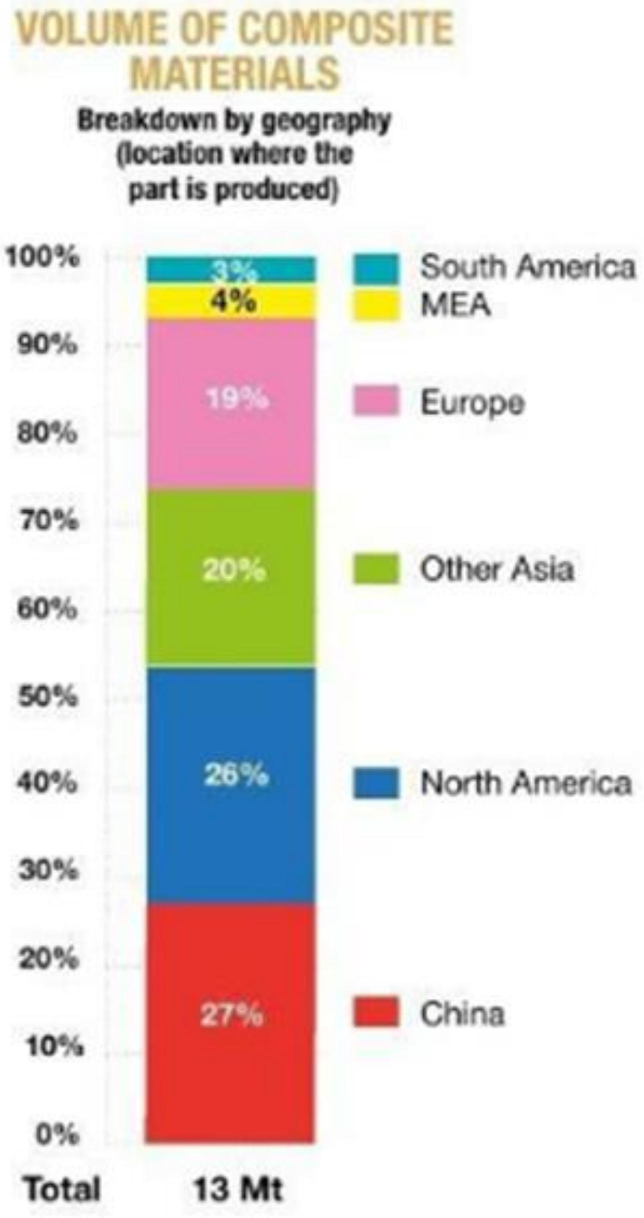
Cycles of technology developments

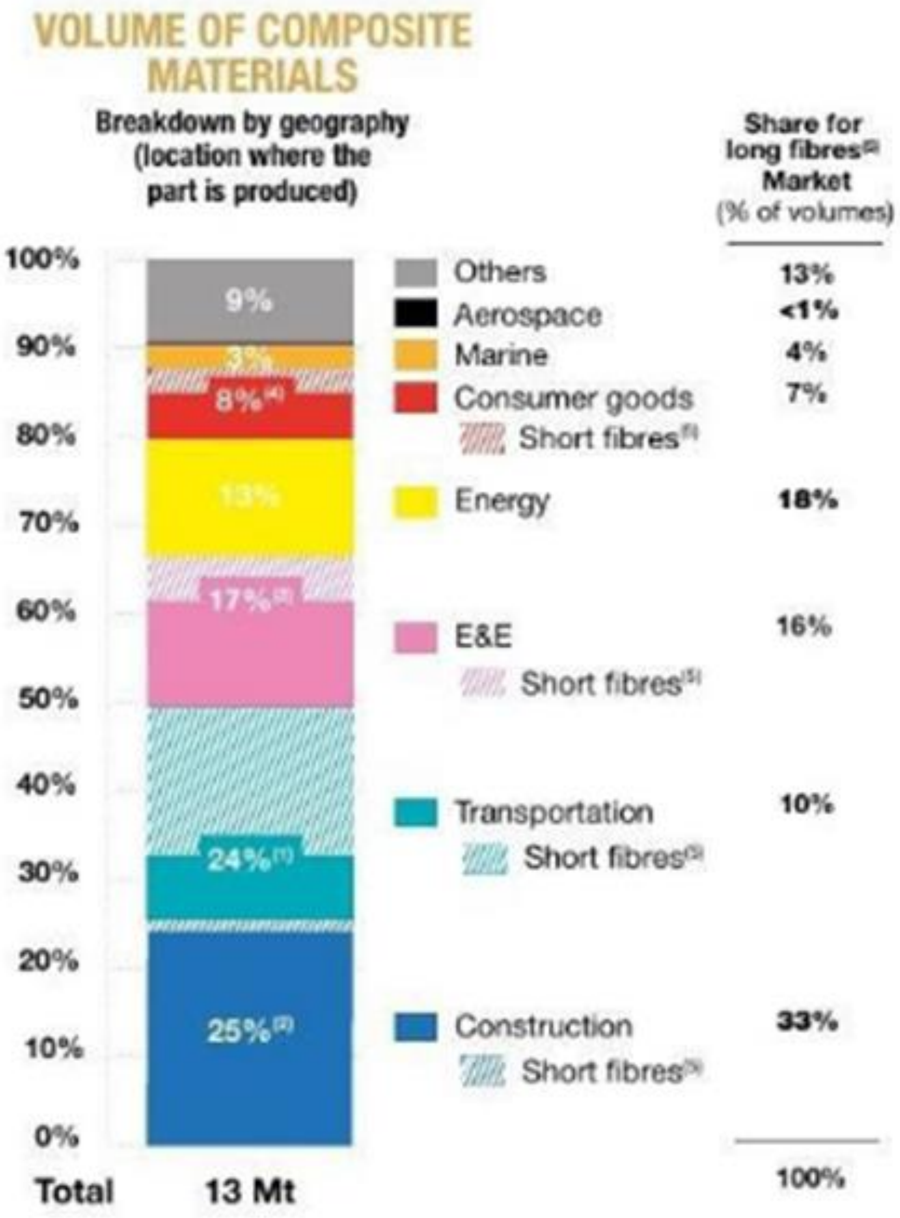


Carbonfiber – evolution of prices



In volume





In 2023, the global market for composites material is estimated at 13 Mt

Solutions and innovations for all markets

Some example of FRP applications

Aerospace

Rockets, satellites, military,
commercial airplane

Sport Goods

Ski poles, snowboards,
golf shafts, bycicle, race cars

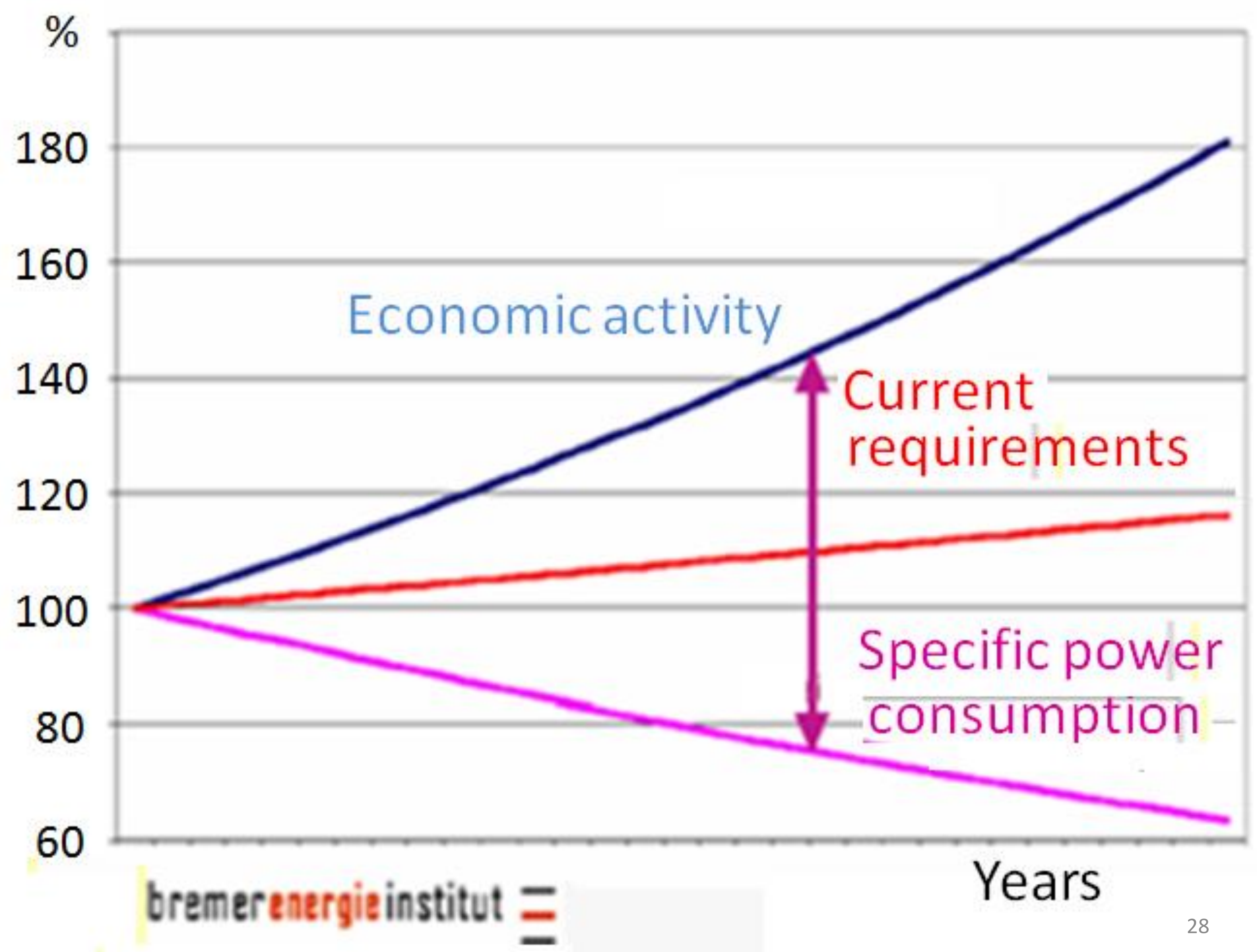
Transportation

Cars, trains, buses,
marine, boats

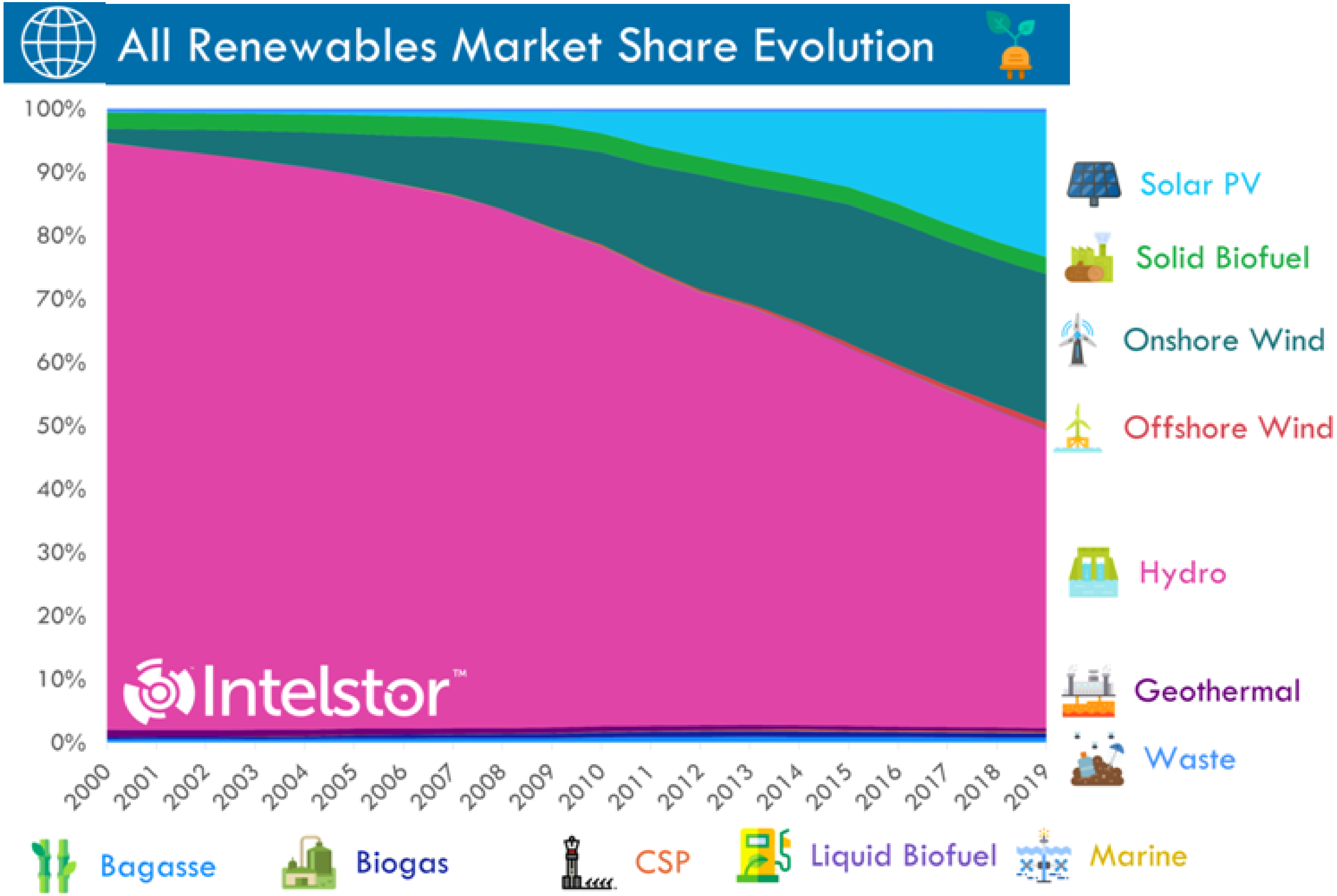
Energy, chemistry industry

Wind turbine, oil exploration,
tubes, pressure vessels

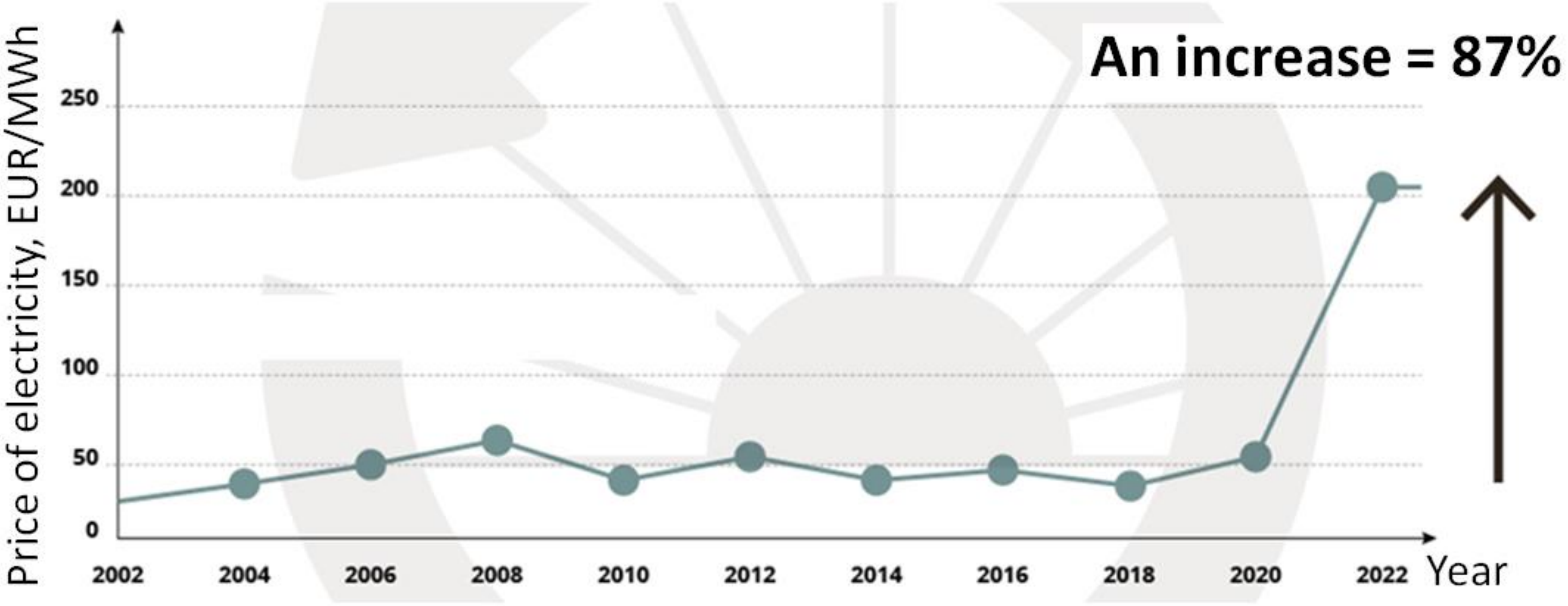
Development of electricity demand



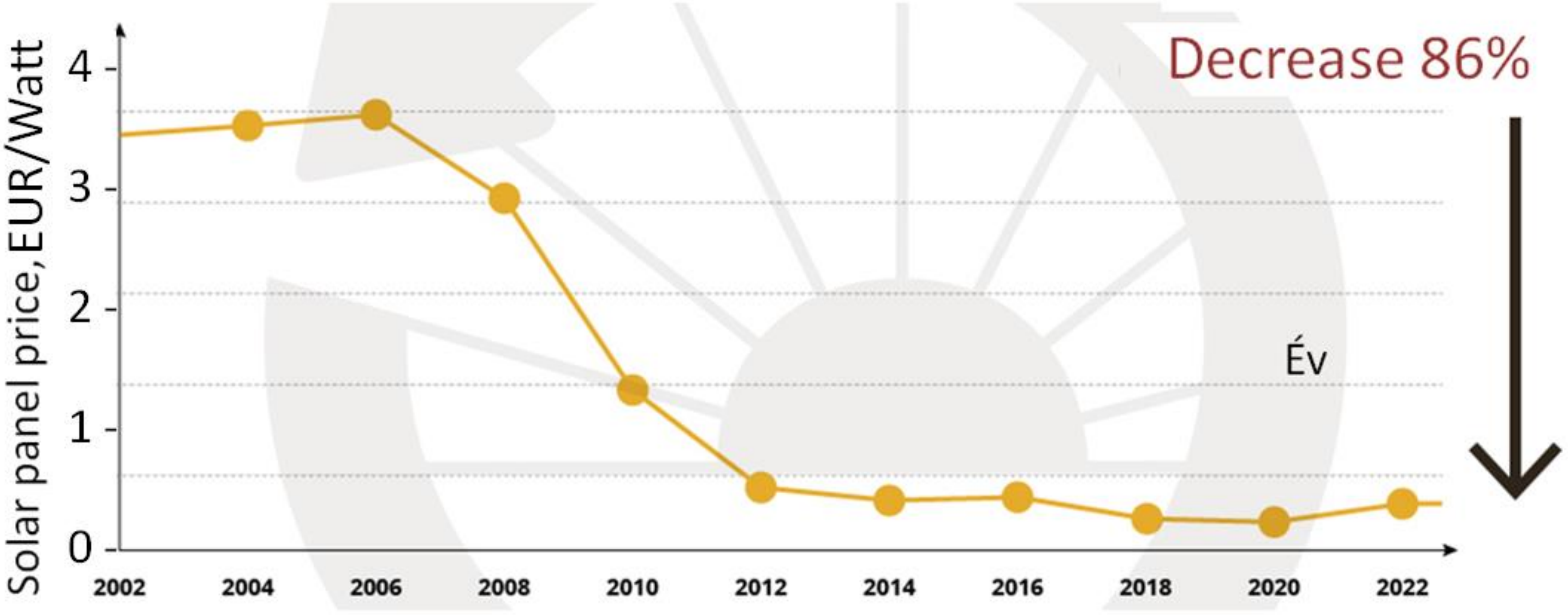
Yet with 20W of energy, it consumes around of 20% an individual's basal metabolic rate


All Renewables Market Share Evolution
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Intelstor™
Solar PV
Solid Biofuel
Onshore Wind
Offshore Wind
Hydro
Geothermal
Waste
Bagasse
Biogas
CSP
Liquid Biofuel
Marine

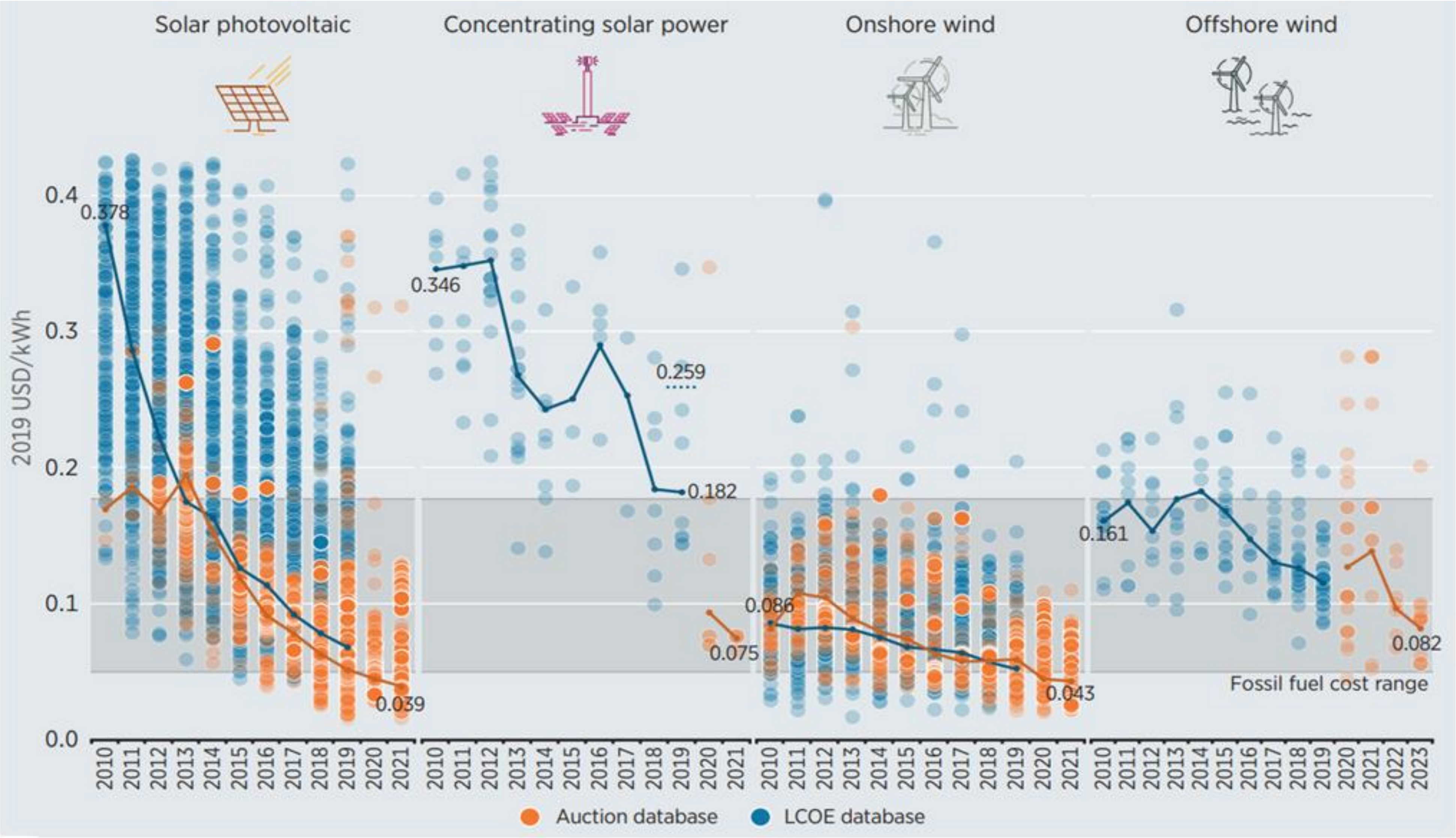
Evolution of lectricity price in Europe, EUR/MWh



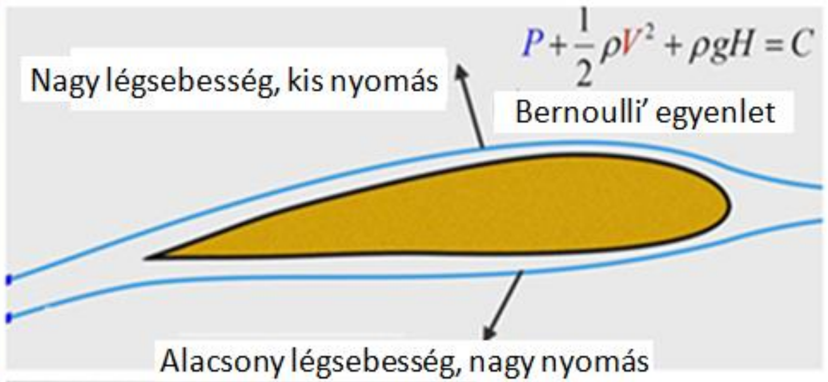
Evolution of the price of solar panels in Hungary,
EUR/Watt

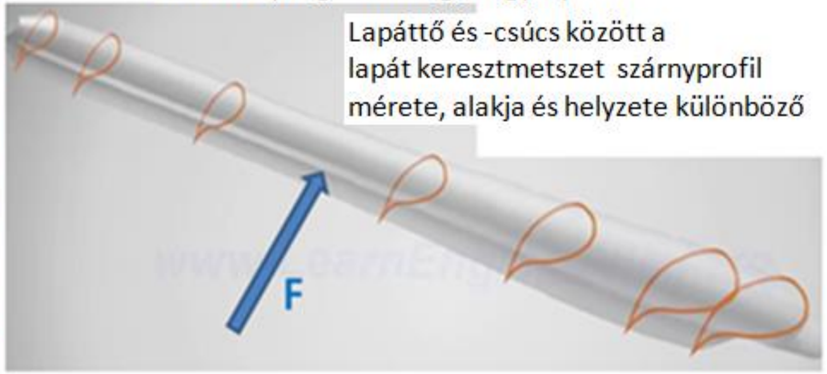


Global average cost of wind, solar technologies



Madárszárny elv (madár, repülő, szélmalom, szálturbina

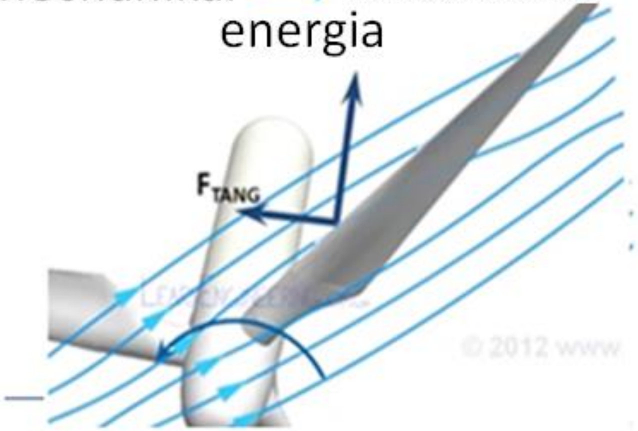




Szélmalom

Szélturbina

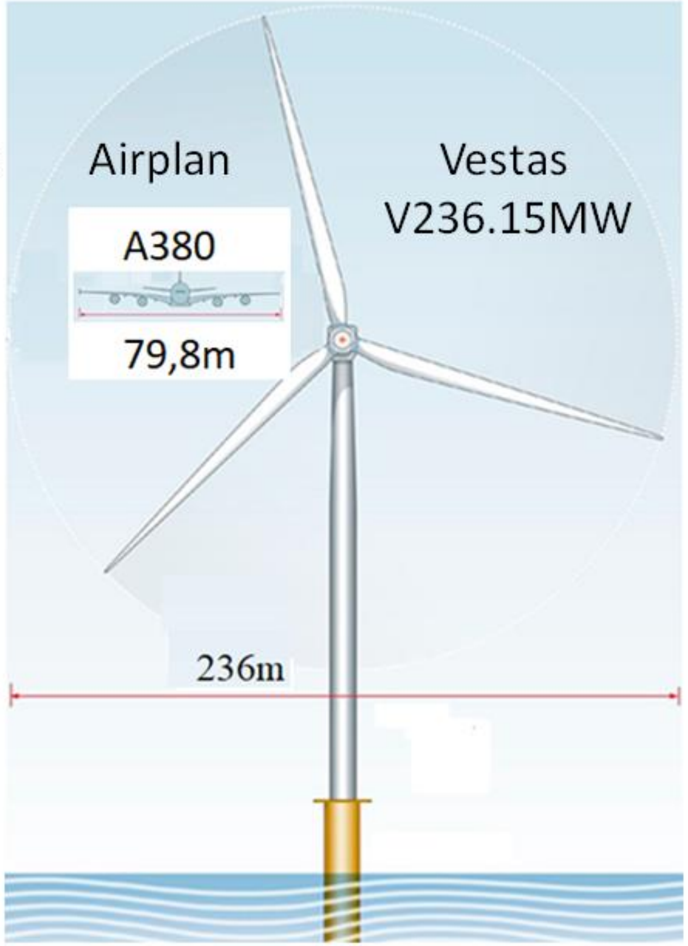
Mechanikai → Elektromos energia



Fiber technologies → From small to gigantic structures

Flying starlings form

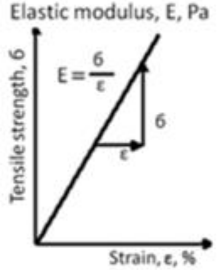
1-1 billion carbon fibers
to stiffen the wind blade
Blade length, l=115,5 m,
Blade mas~70 t
Wind speed, v= 15m/s
Performance, P=15MW



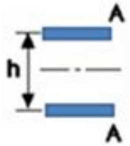
High bending stiffness CFRP spar caps with UD fiber orientacio

Bending stiffness (E I)
Flexural rigidity

E – elastic modulus



I – area moment of inertia



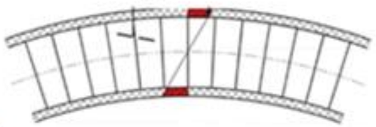
$$I_x = 2A\left(\frac{h}{2}\right)^2$$

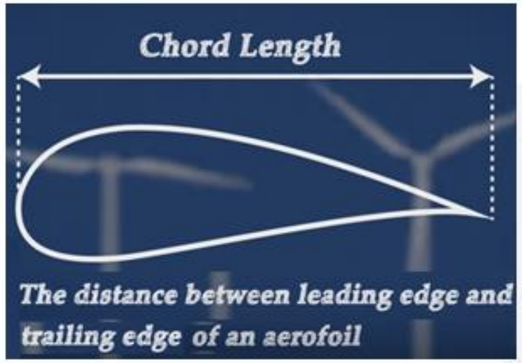
E I – bending stiffness

E I = M R

M – the moment about the natural axis

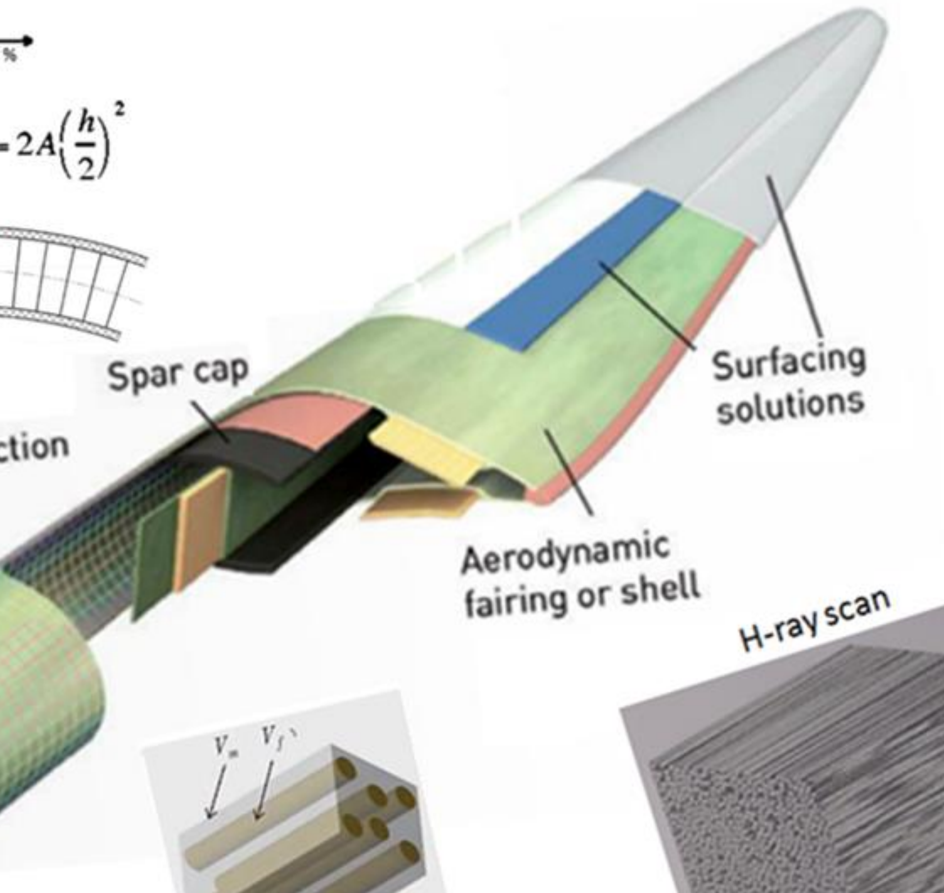
R – radius of curvature of the structure

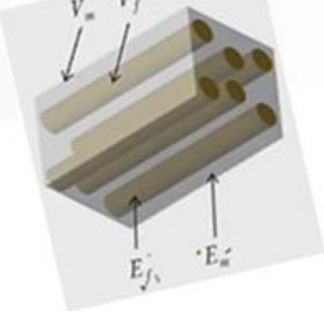


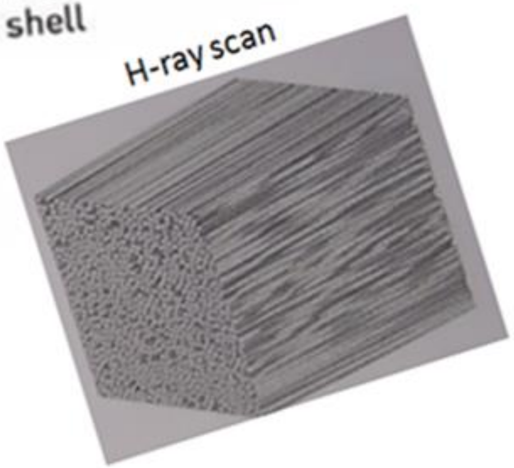


1 mm² ~ 15 000 carbon fiber

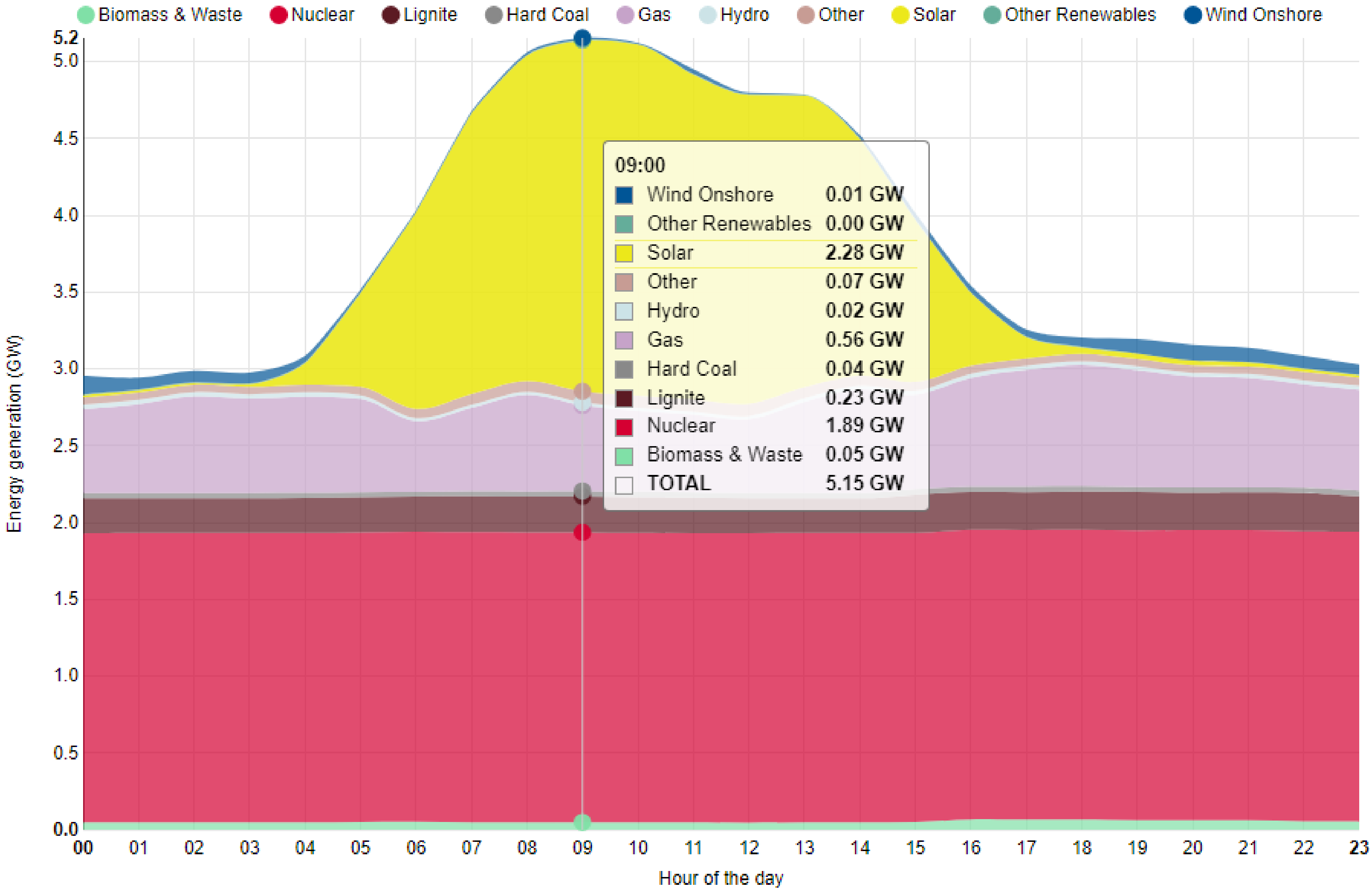
0,1 m² ~ 1,5 billion carbon fiber







Hungary


Biomass & Waste
Nuclear
Lignite
Hard Coal
Gas
Hydro
Other
Solar
Other Renewables
Wind Onshore
Energy generation (GW)
5.2
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of the day
09:00
Wind Onshore 0.01 GW
Other Renewables 0.00 GW
Solar 2.28 GW
Other 0.07 GW
Hydro 0.02 GW
Gas 0.56 GW
Hard Coal 0.04 GW
Lignite 0.23 GW
Nuclear 1.89 GW
Biomass & Waste 0.05 GW
TOTAL 5.15 GW

Importance of lightweight in vehicle construction

Reduction of emissions

Impact of the car weight on CO_2 Emission:

Weight reduction of 100 kg effects:

CO_2 Emission - 8.8* up to - 12.5** gr./km

Reducing cost of ownership

Impact of the car weight on fuel consumption:

Weight reduction of 100 kg effects:

Fuel consumption - 0.35* up to -0.5** l/100 km

Increasing performance

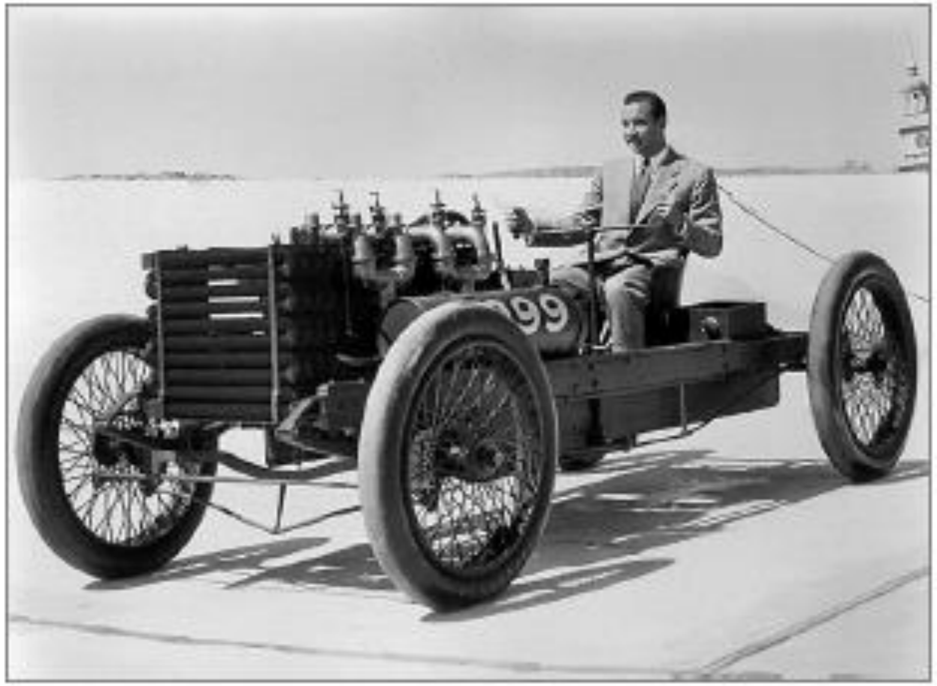
Impact of the car weight on driving performance:

Weight reduction effects generally:

+ Longitudinal / transversal dynamics
+ Axle load distribution

(Quelle: Audi)

TECHNOLOGY: THE CONNECTION BETWEEN SPEED AND SAFETY



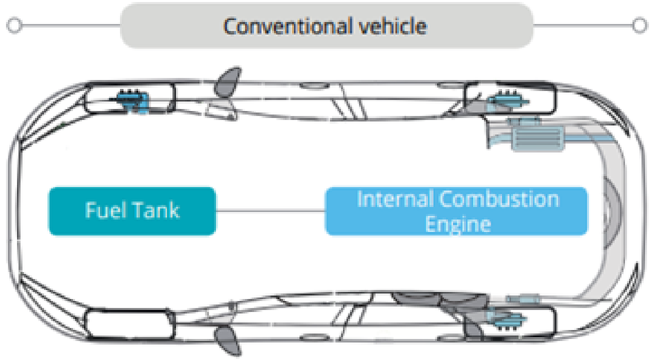
Low speed - High risk

High speed - Low risk

"It is all about probabilities. You can never make it safe. F1 is not safe but you can do a lot of work to reduce the probability of somebody getting hurt."

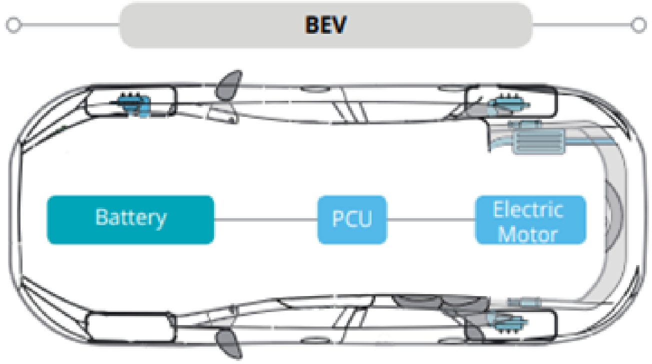
Max Mosley
Former FIA President

Propulsion system of vehicles



-- Internal-combustion engine

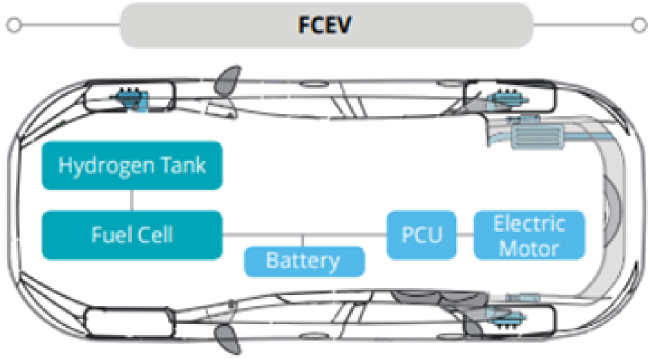
to burn petroleum-based fuel, generate heat, and push pistons up and down to drive the transmission and the wheels.



-- **(BEVs - Battery Electric Vehicles**

100% electric without any other power source. The main drawbacks of these vehicles are

- their price (mainly due to the battery cost),
- the long charging time and
- their limited range (150 to 300 km).



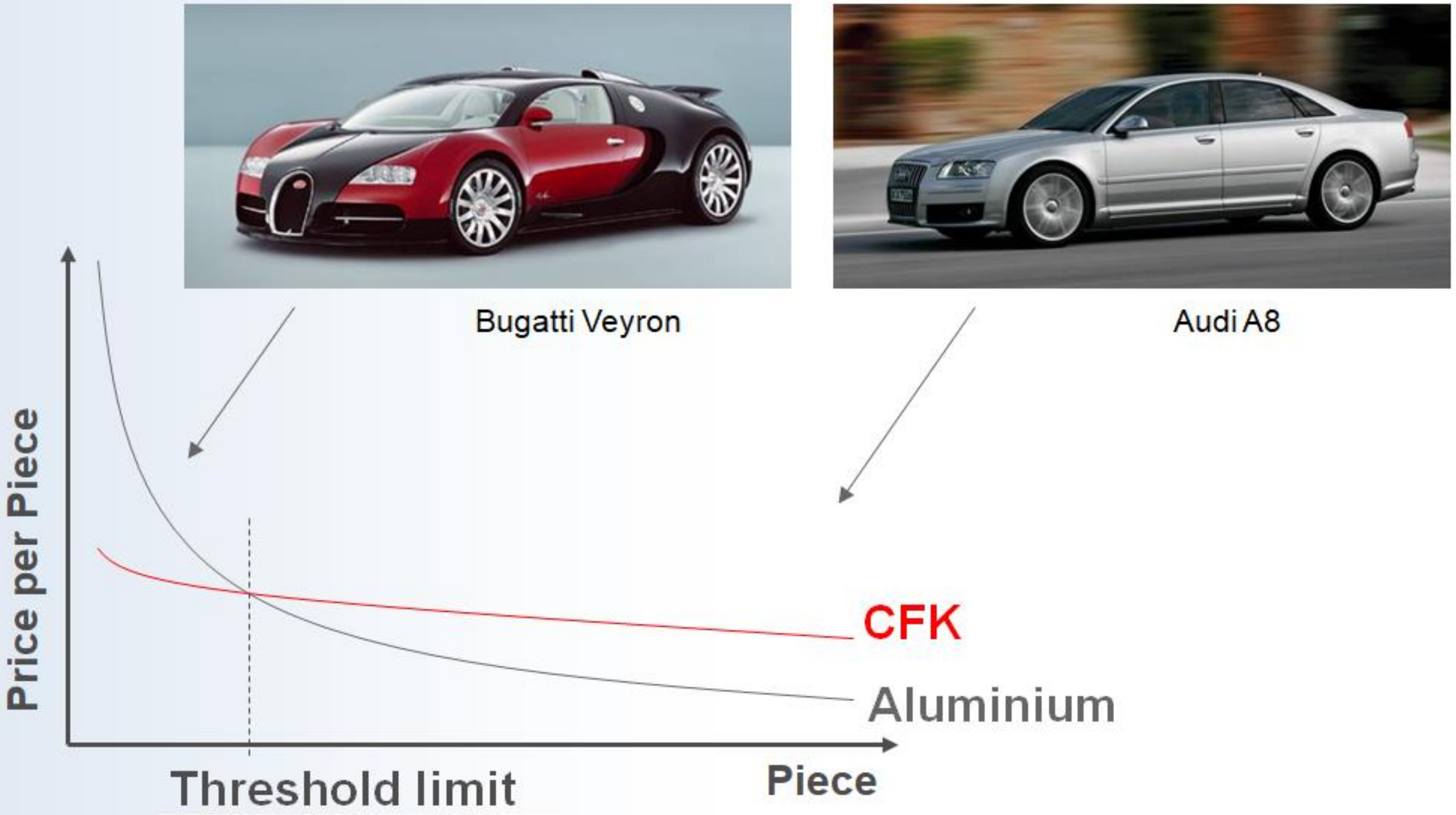
-- FCEVs - Fuel Cell Electric Vehicles

This technology is promising, but market development is a major challenge:

- economical production of hydrogen by hydrolysis of renewable energies,
- development of efficient fuel cells,
- high pressure (700 bar) tanks and
- in the field of refueling the gas station network.

Why Composit in Car Production?

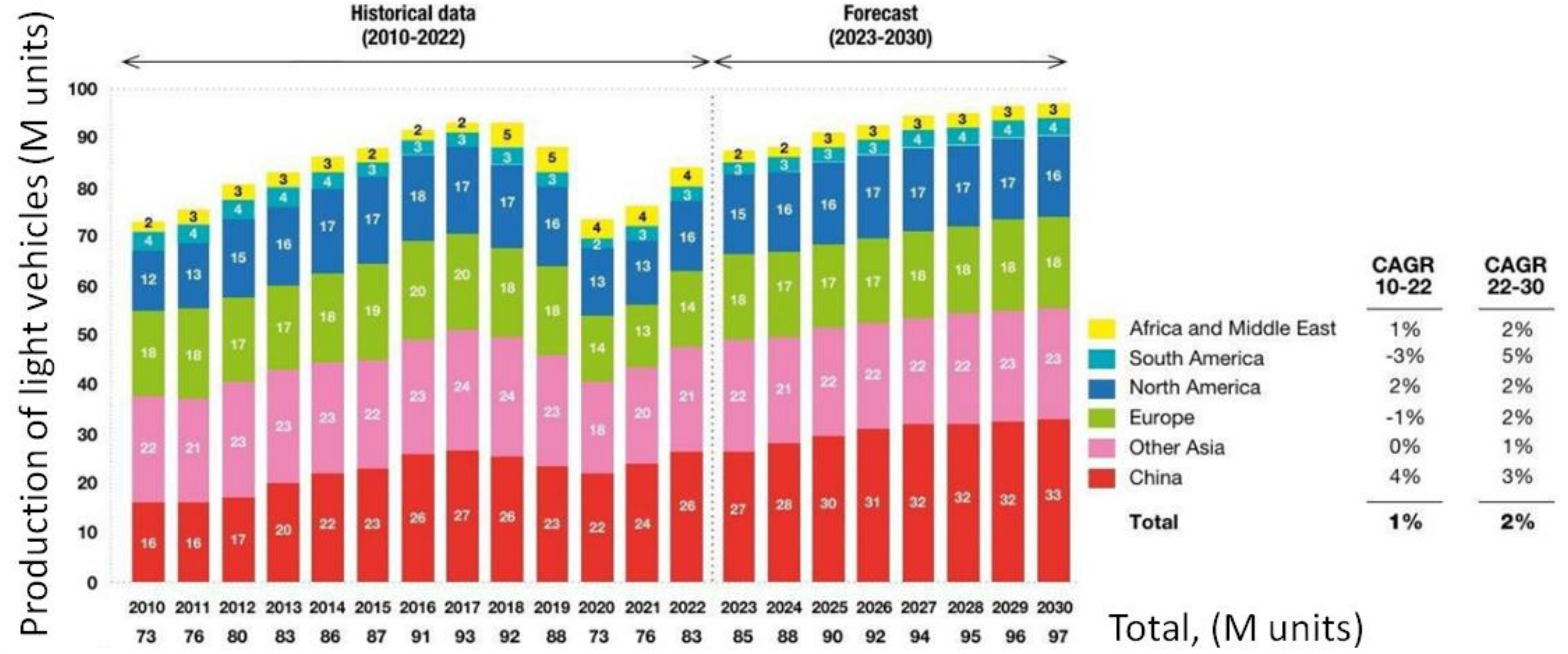
However composit has a higher price compare to metall, it is cheaper under a certain amount of production




Carbon fiber composite material
40% lighter than aluminium
60% lighter than steel

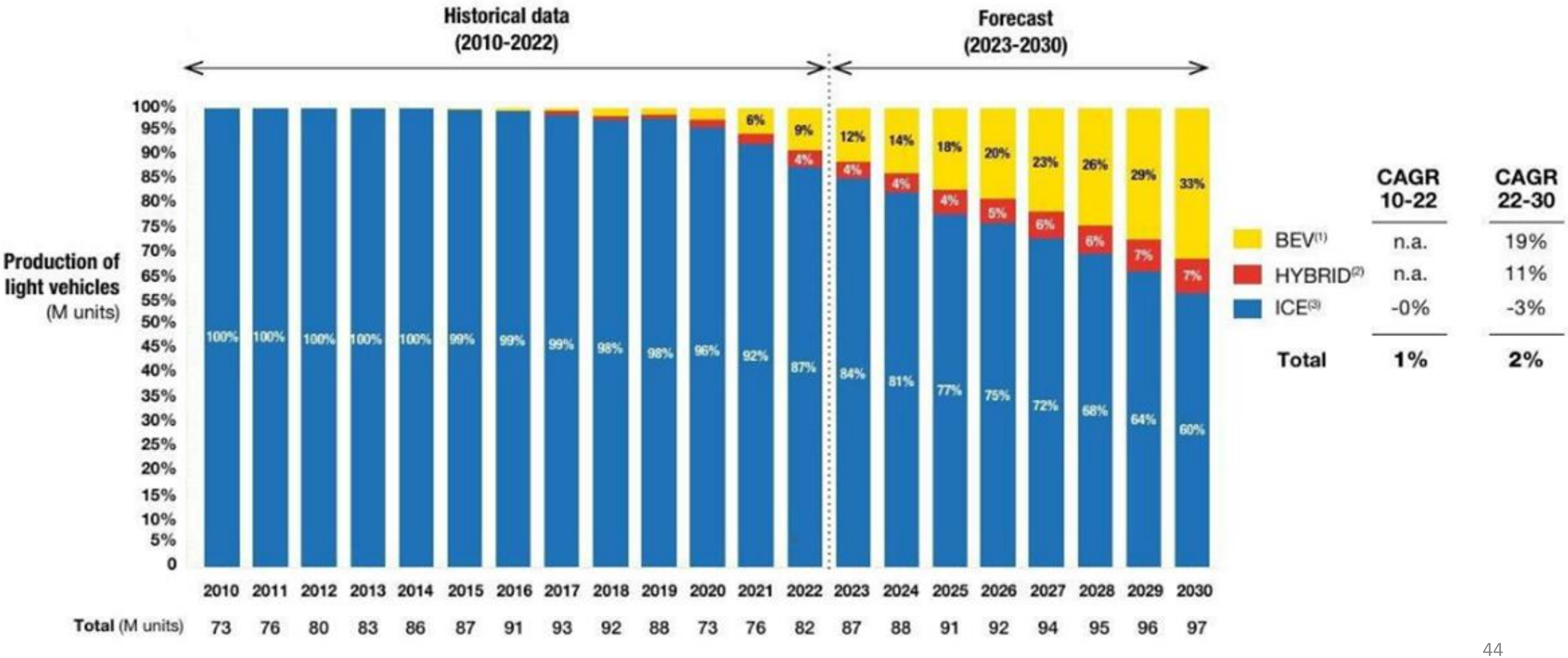
In automotive, the shortage of semiconductors and the Covid crisis have negatively impacted production.

They industry recovery should take around 2026.

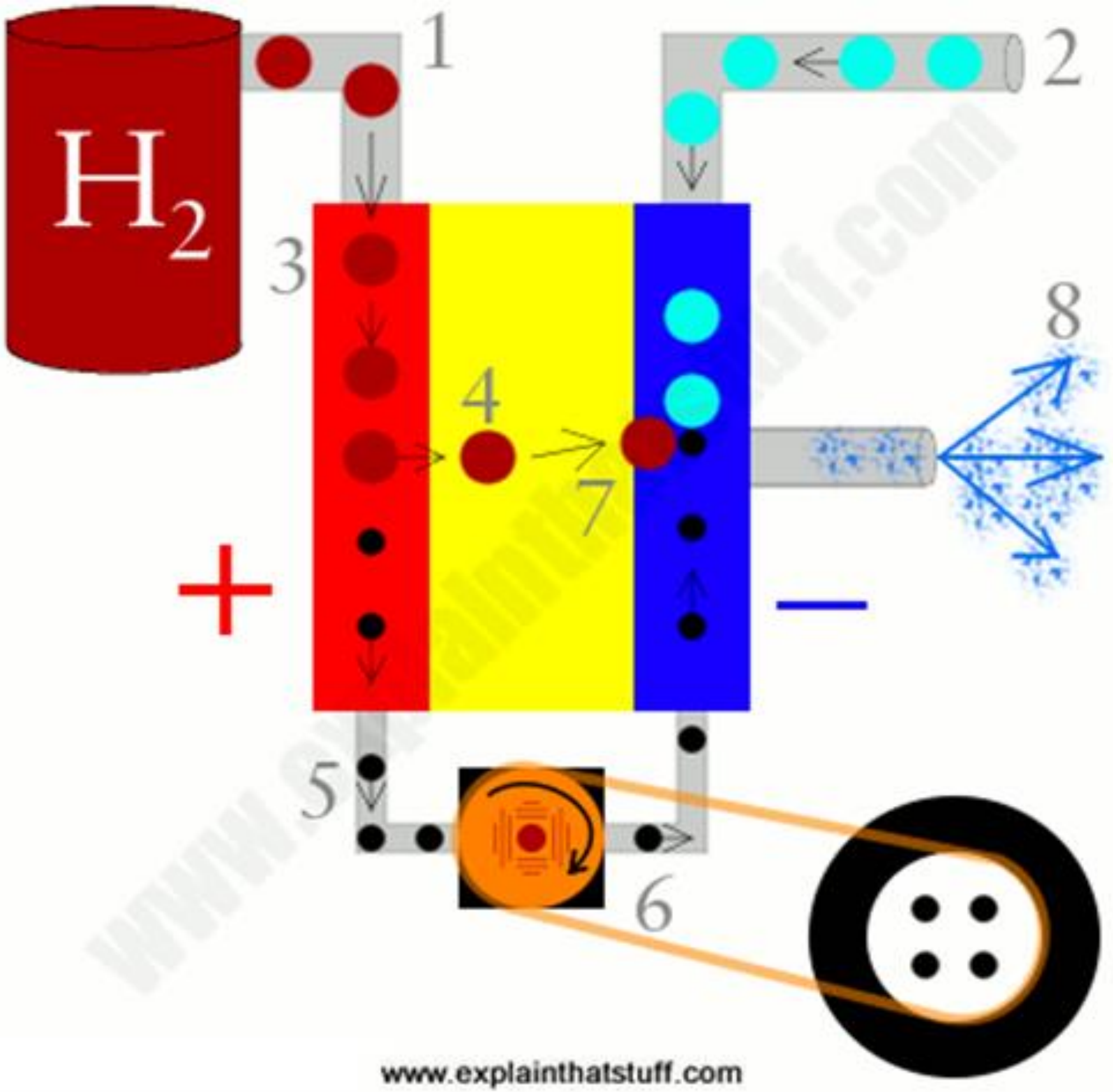


Globally, the **production of electric vehicles**

(composites intensive) is expected to reach ~30% at the 2030 horizon



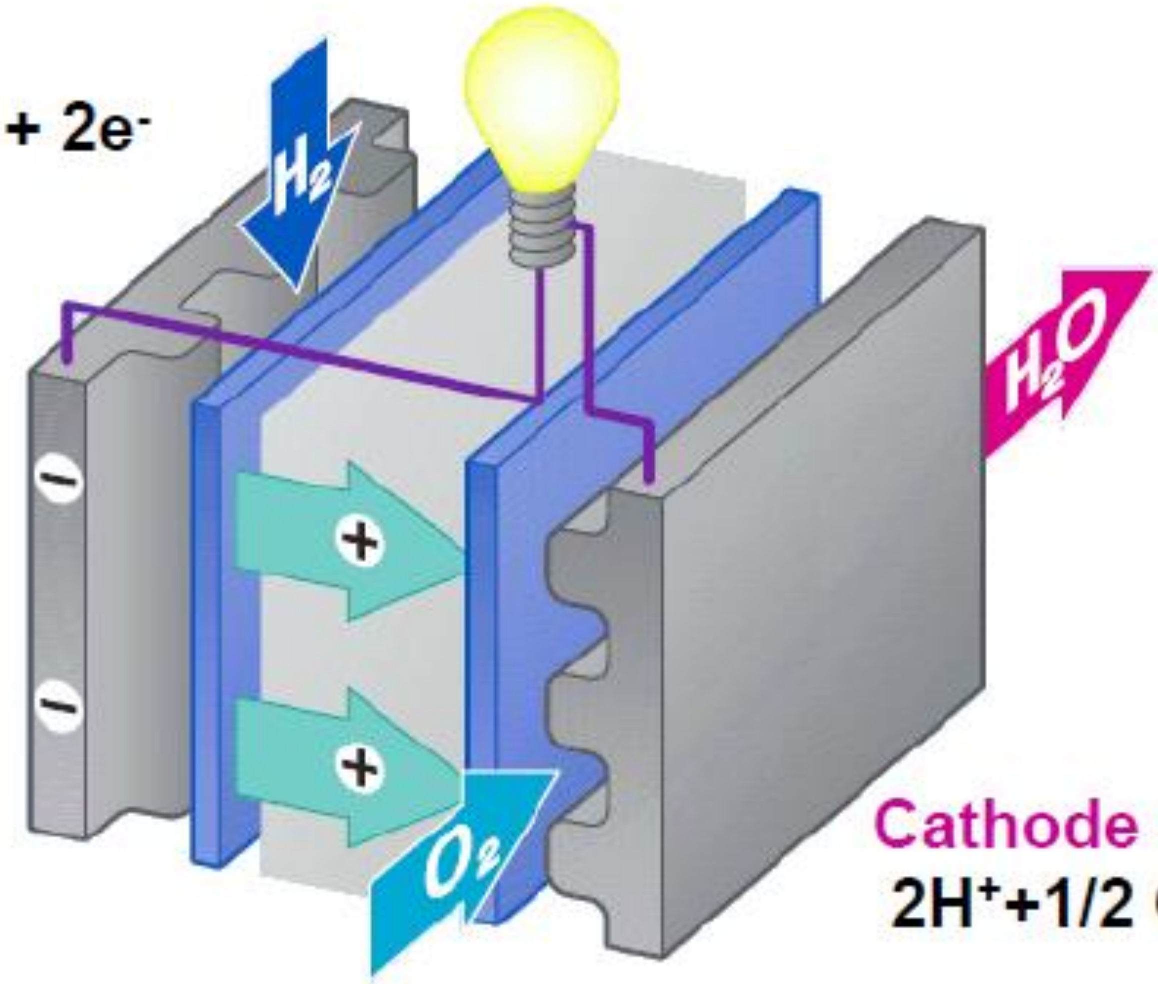
Schematic diagram of hydrogen drive



Fuel Cell Basics (2)

Anode

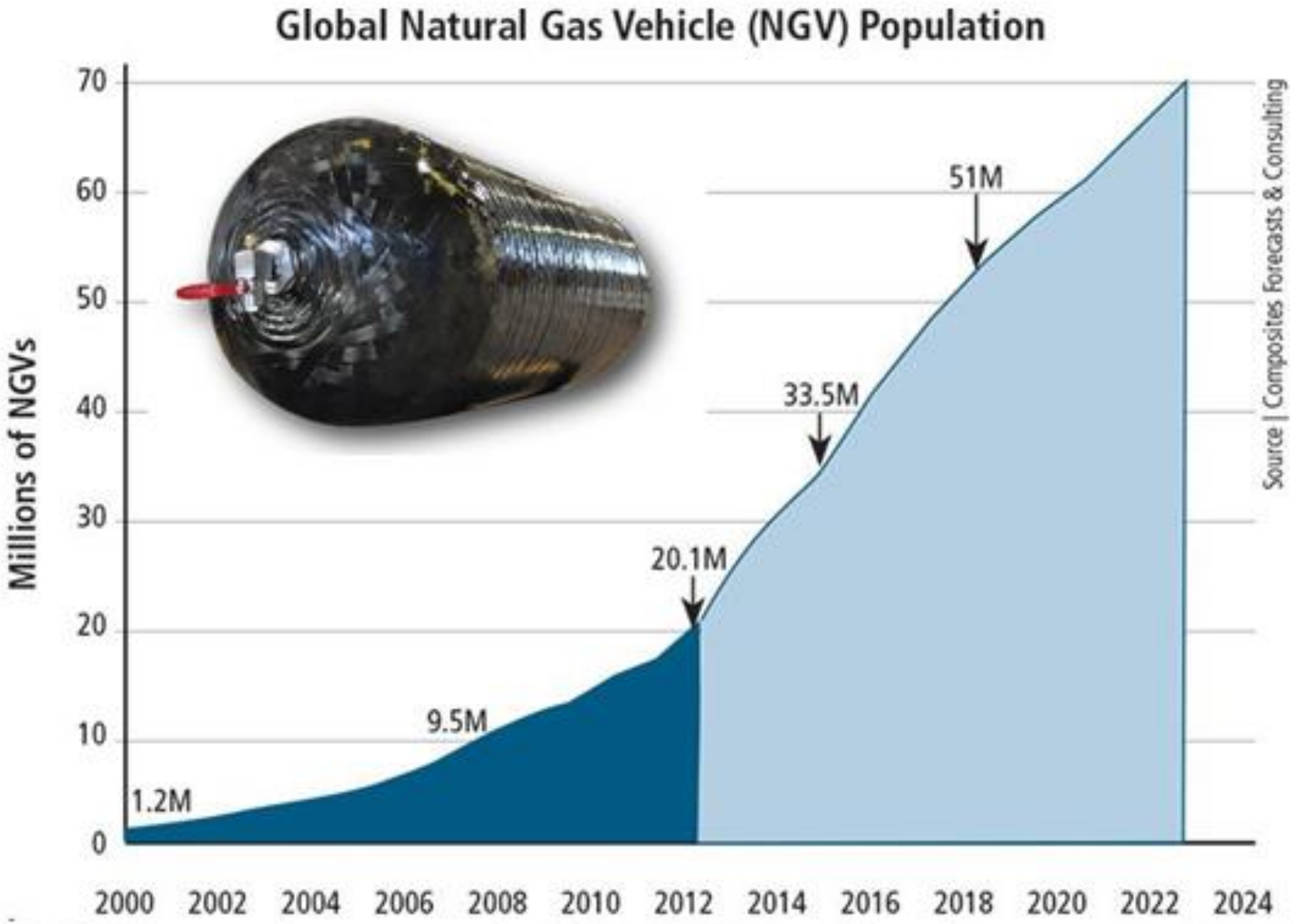
$H_2 \rightarrow 2H^+ + 2e^-$



Cathode

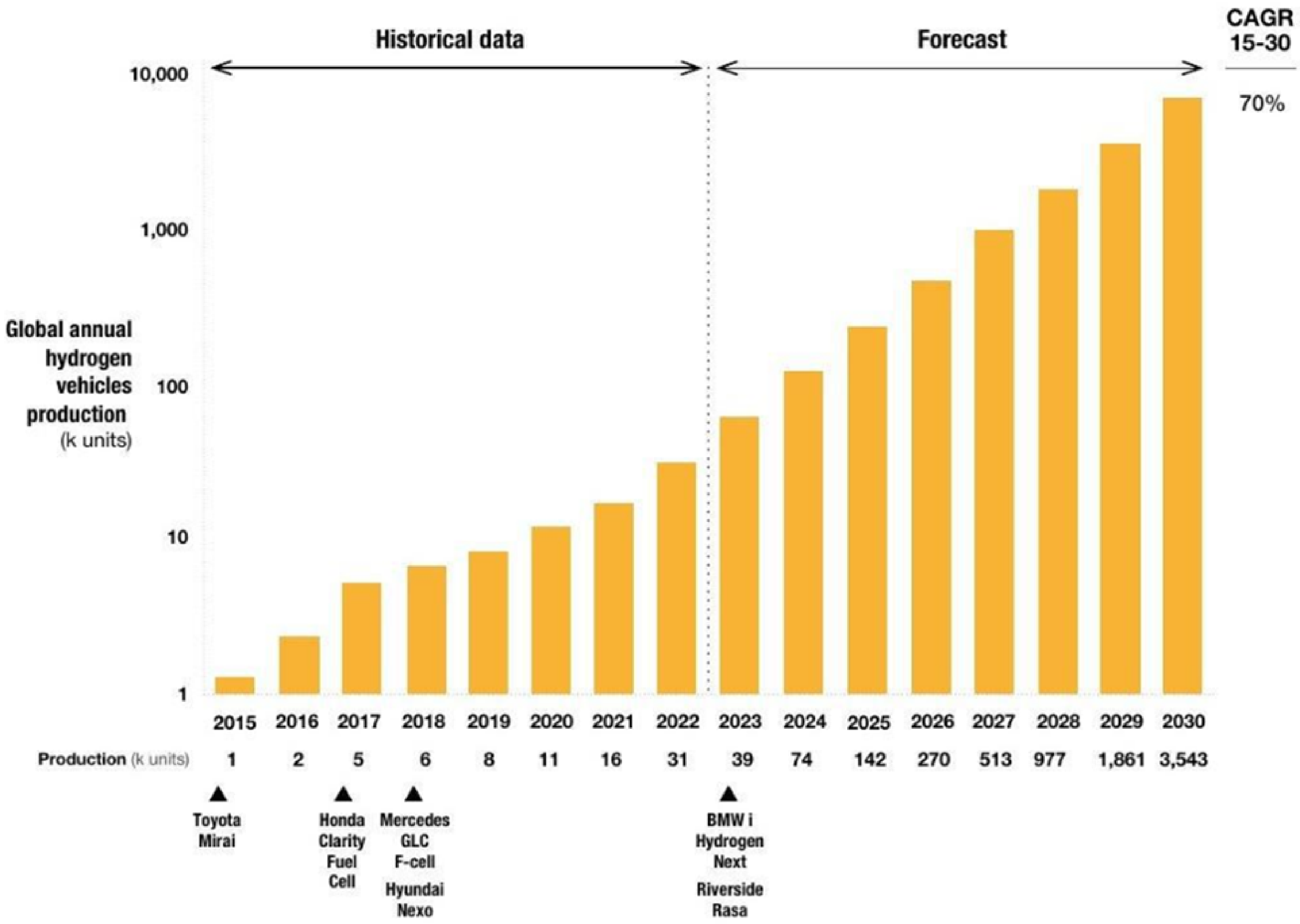
$2H^+ + 1/2\ O_2 + 2e^- \rightarrow H_2O$

$H_2 + ½\ O_2 \rightarrow H_2O + heat$

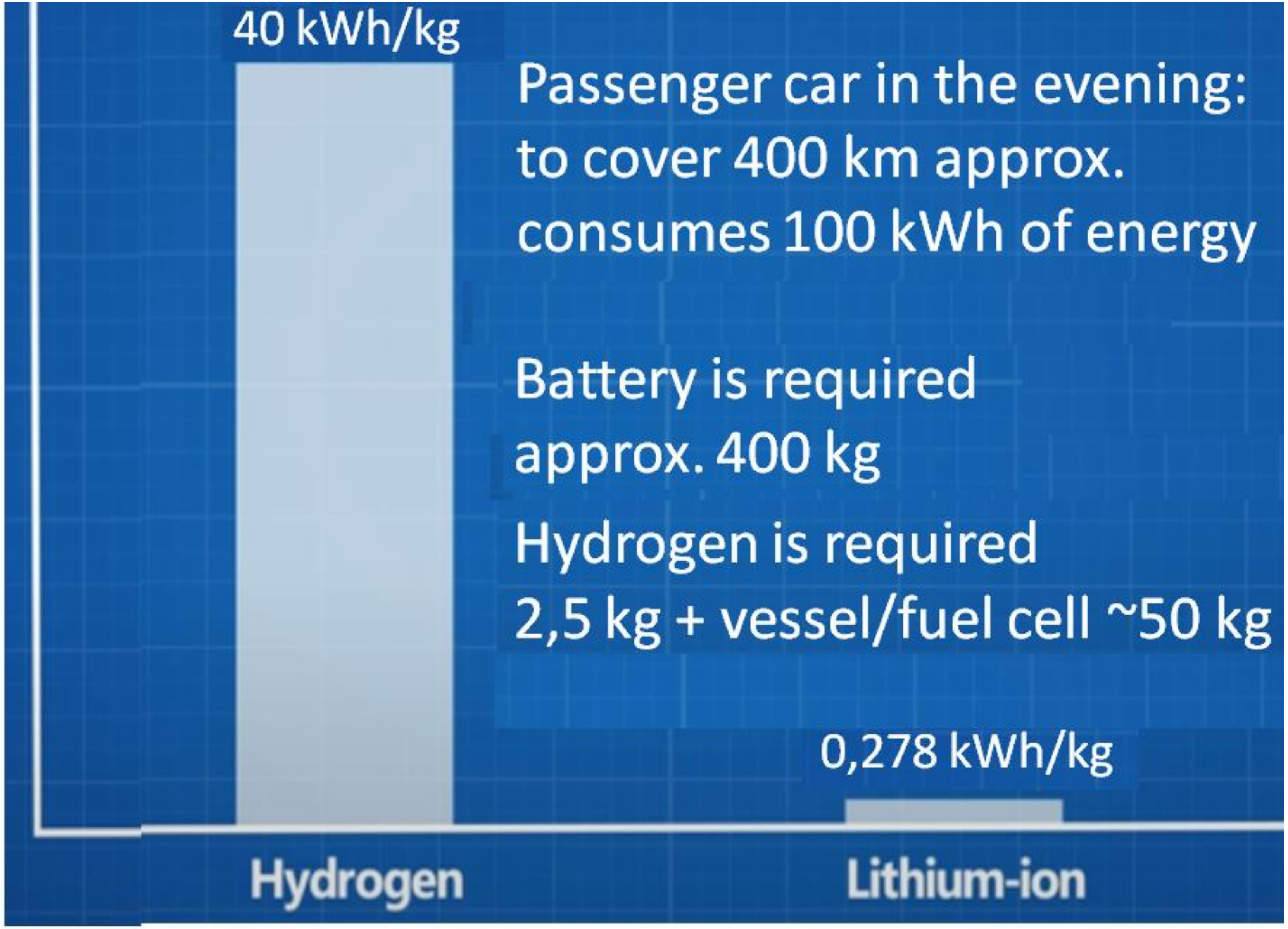


By 2023, natural gas-powered vehicles (NGVs) could number more than 65 million

Production of hydrogen cars is expected to grow strongly over the next decade



Specific energy of hydrogen and lithium-ion battery, W [kWh/kg]



Medical equipments

X-ray equipments, operation parts, protheses, wheelchairs

Present and future of electric mobility

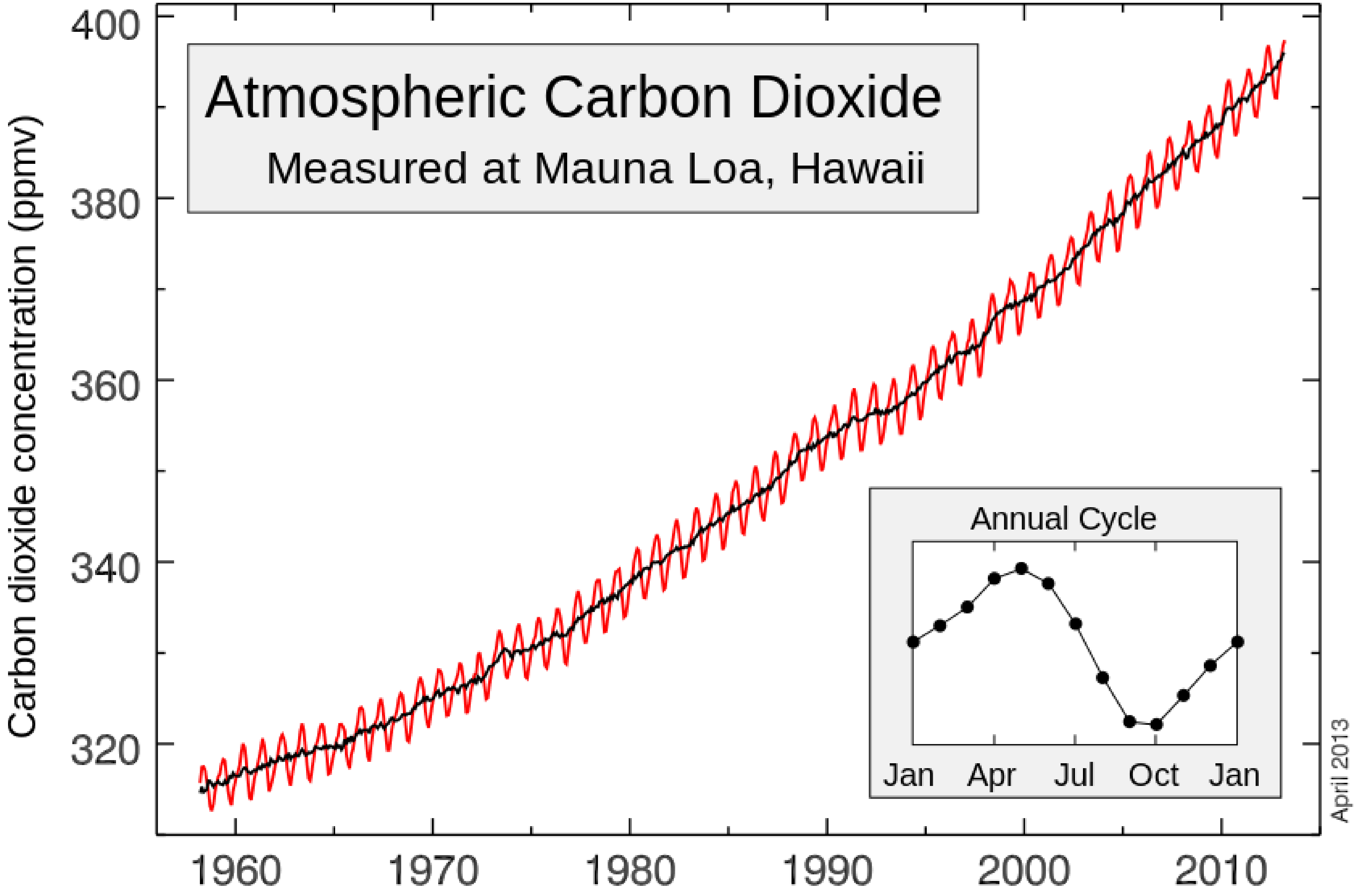
Electric skateboard

e-Bike

Hoverboard

e-Roller

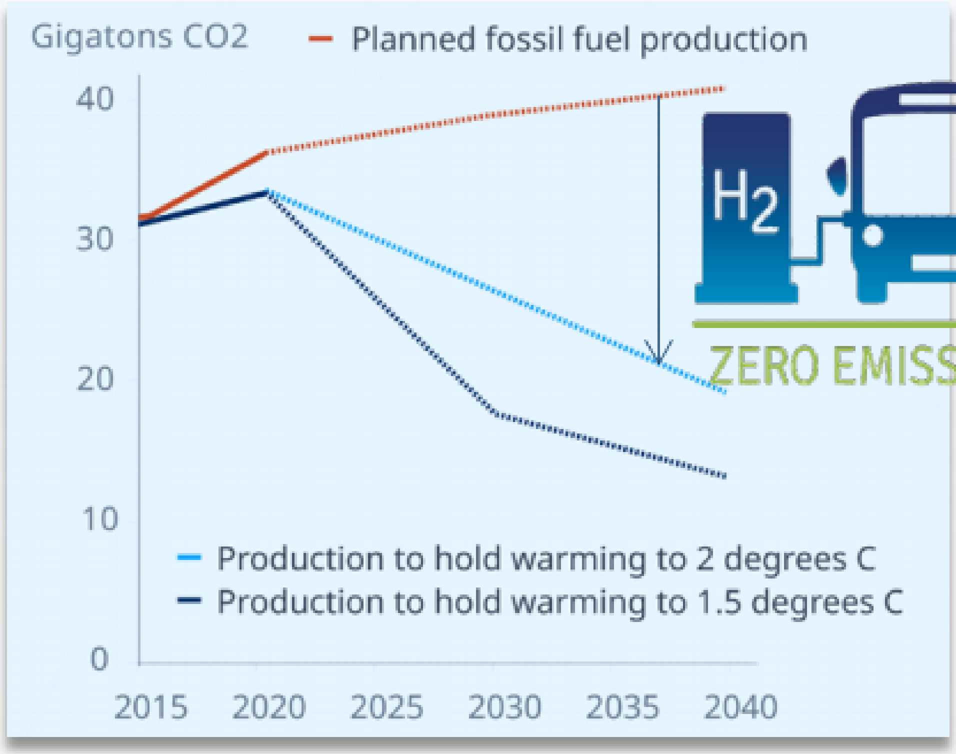
Segway



Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii
Carbon dioxide concentration (ppmv)
400
380
360
340
320
1960
1970
1980
1990
2000
2010
Annual Cycle
Jan
Apr
Jul
Oct
Jan
April 2013

What is the Hydrogen Economy?

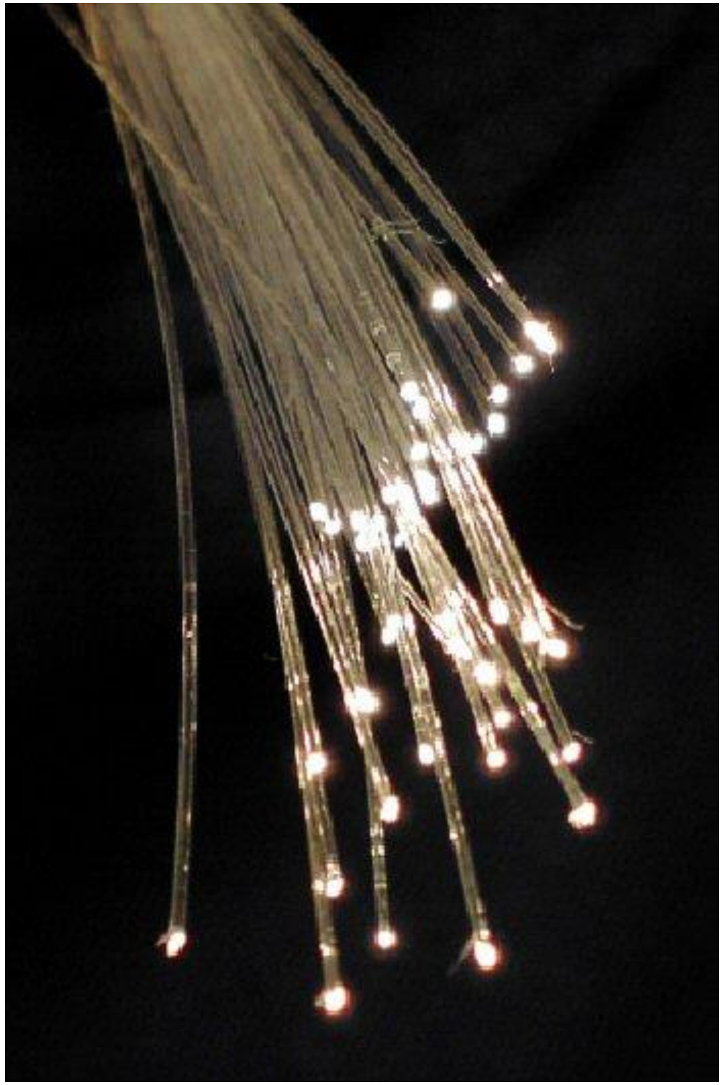
- To limit global warming to 2°C vs. 2010 levels, world CO_2 emissions must drop > 60%/yr until 2050.
- H_2 offers sustainable decarbonization



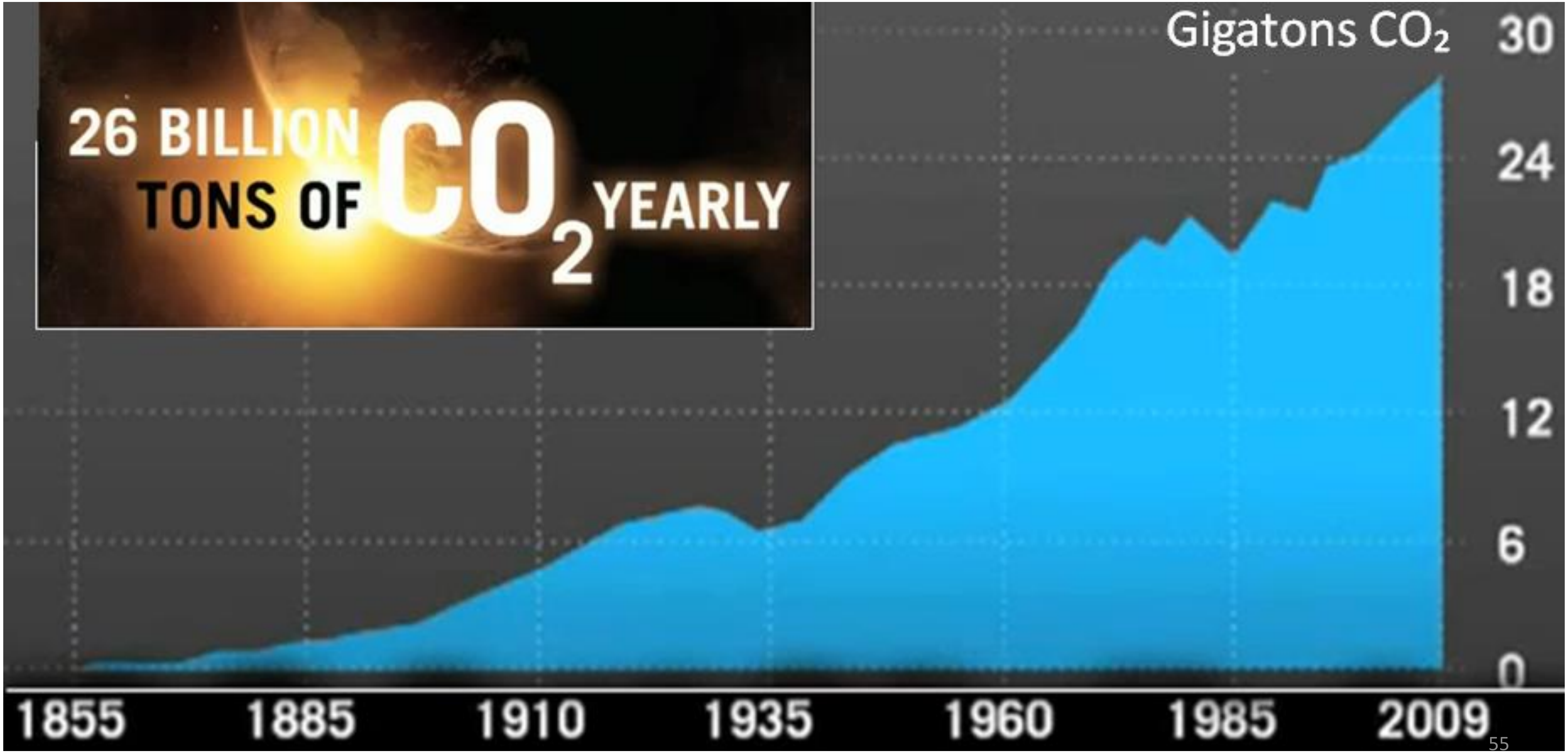
Source | The Production Gap Report 2019

Source | Hydrogen Scaling Up, 2017

LiTraCon – Light-transmitting Concrete (info@litracon.hu)

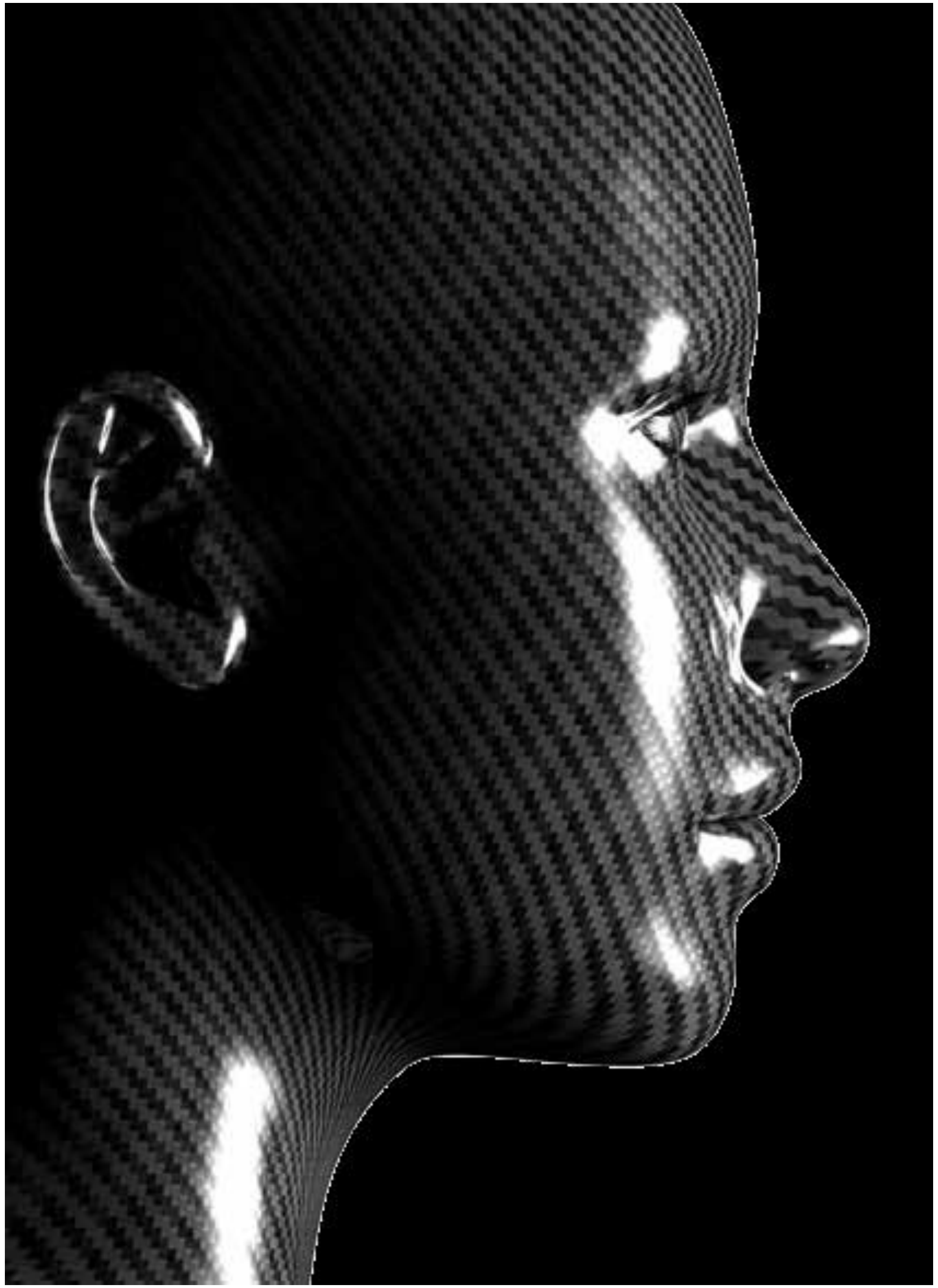


Global Carbon Emissions from Energy Production



OCEAN PLASTIC

CLOSED LOOP CONCEPT



Köszönöm
a figyelmet!