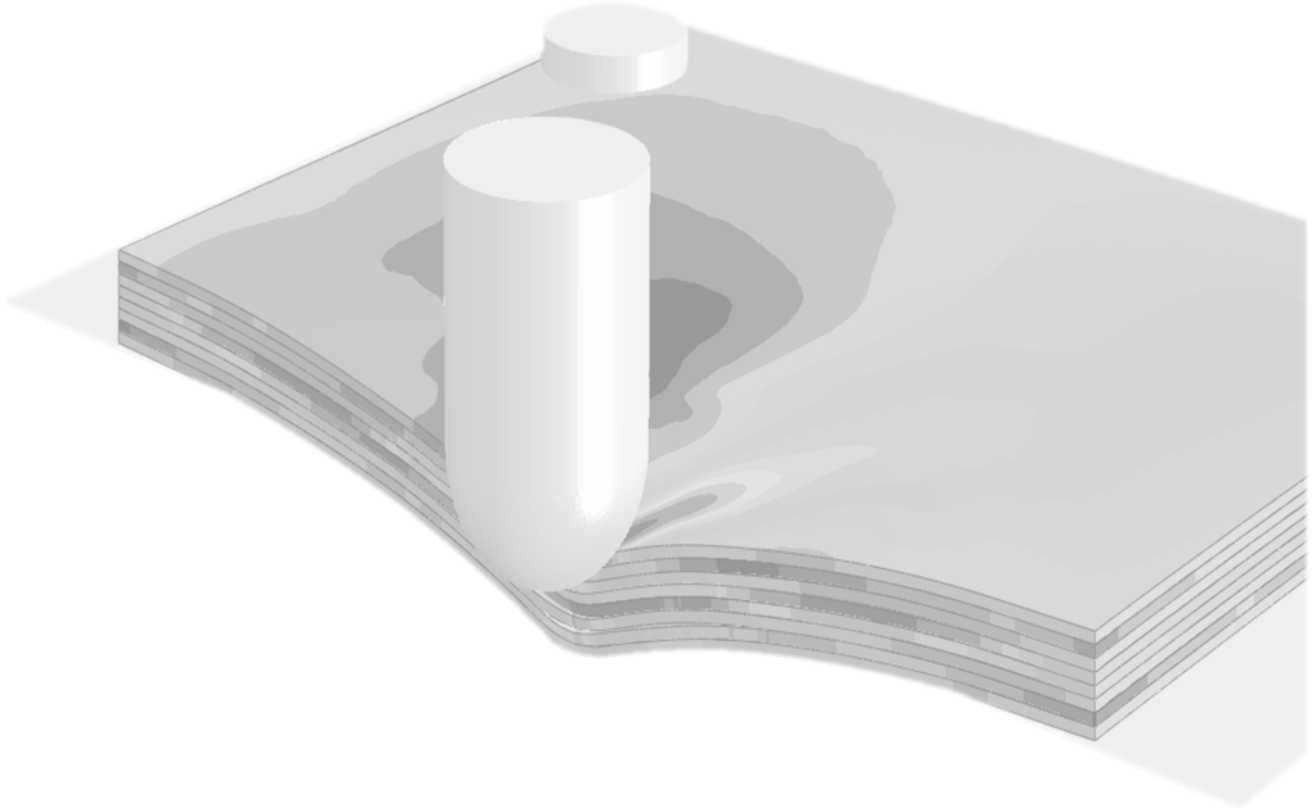


AMADE's sight on sustainability

AMADE Day

Josep Costa
Girona, July 15th, 2022

AMADE
ANALYSIS AND ADVANCED MATERIALS
FOR STRUCTURAL DESIGN

Two comments before entering into the topic

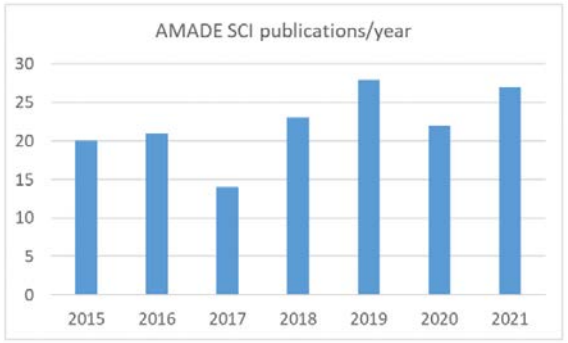
COMPTEST

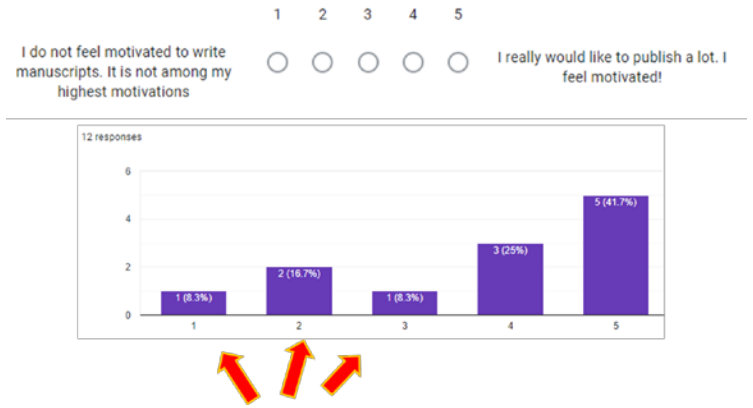
- AMADE will host an international conference, COMPTEST, in 2023

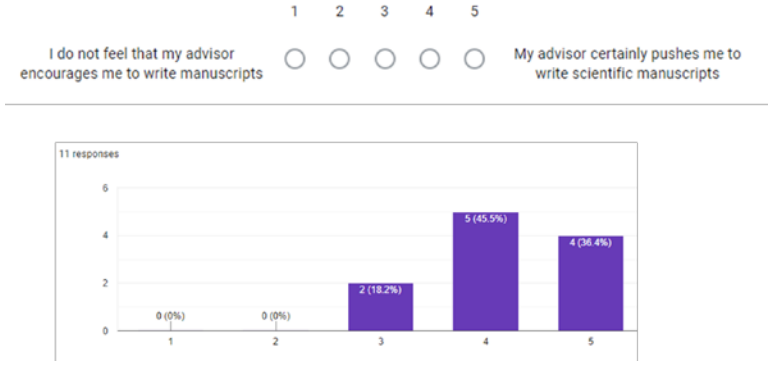
Three will be tasks for everyone! We count on you!

Survey results

- The results of the survey to PhD students on
  "**How to improve scientific productivity**"
  are being processed by the AMADE's council and will be presented and discussed soon.







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AMADE's sight on sustainability

What does **sustainability** mean?

- In 1987, the United Nations Brundtland Commission defined sustainability as:

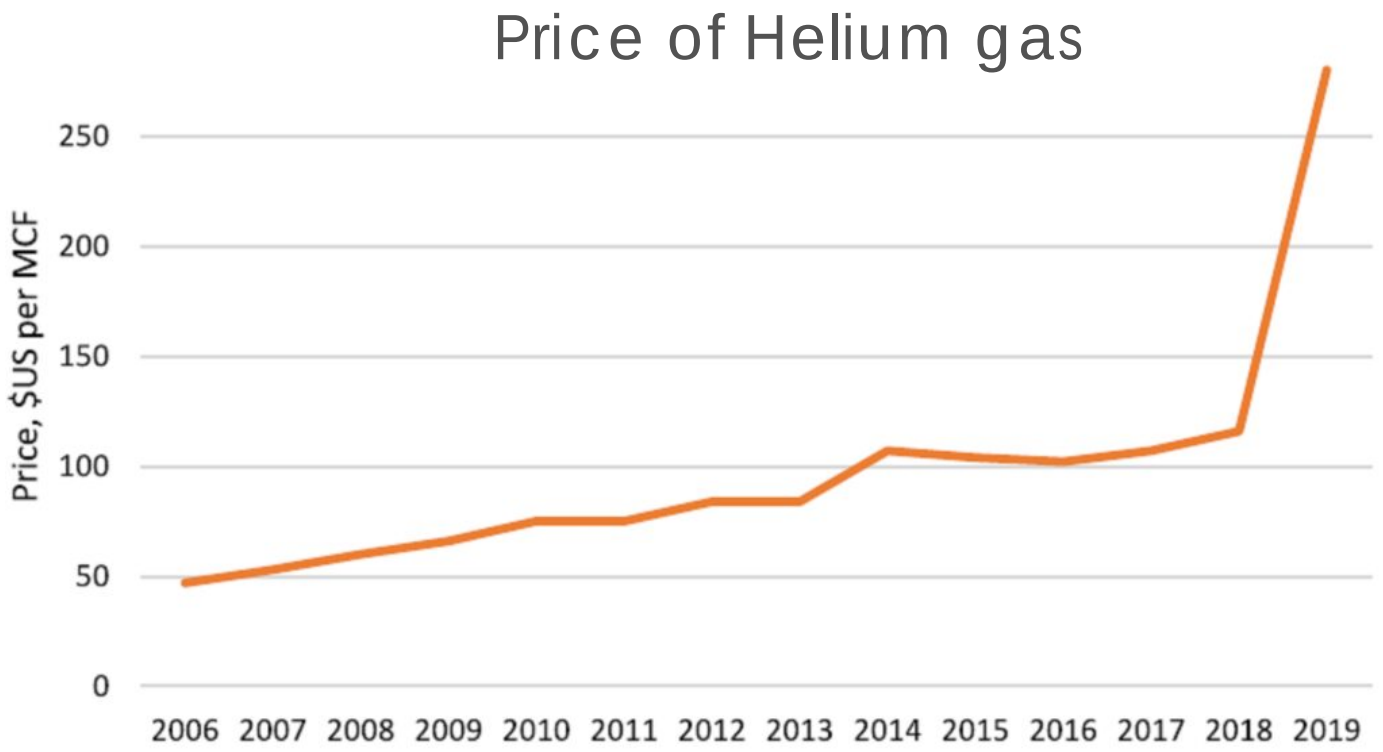
“meeting the needs of the present without compromising the ability of future generations to meet their own needs.”

What's non-sustainable?

- Exhaust natural resources that are finite
- Pour to the environment harmful substances for living beings
- Use of energy – climate change

What's non-sustainable?

- Use of natural resources that are finite (fossil fuels, etc.)



What's non-sustainable?

- Pour to the environment harmful substances for living beings

Up to 51 trillion plastic particles, weighing between 93,000 to 236,000 metric tons, are estimated to be floating on the surface of the oceans.

https://www.globalseafood.org/advocate/what-threat-do-microplastics-a-k-a-ocean-hitchhikers-pose-to-aquaculture/

93 percent of the world's children breathe toxic, polluted air each day

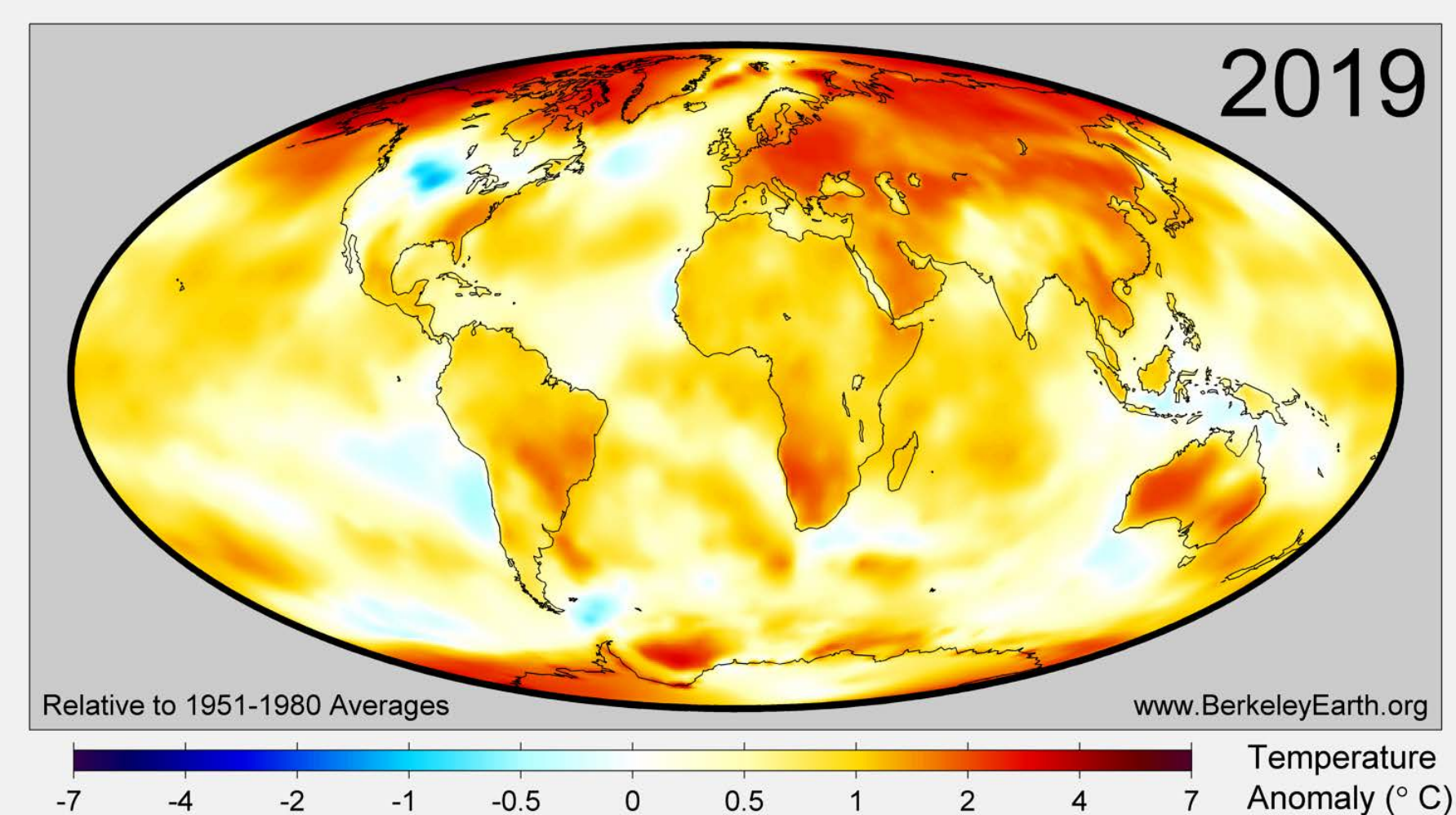
https://www.earth.com/news/children-breathe-toxic-air/

There are approximately 3 million potentially polluted sites in the European Economic Area and the West Balkans.

https://reliefweb.int/report/world/soil-pollution-hidden-reality

What's non-sustainable?

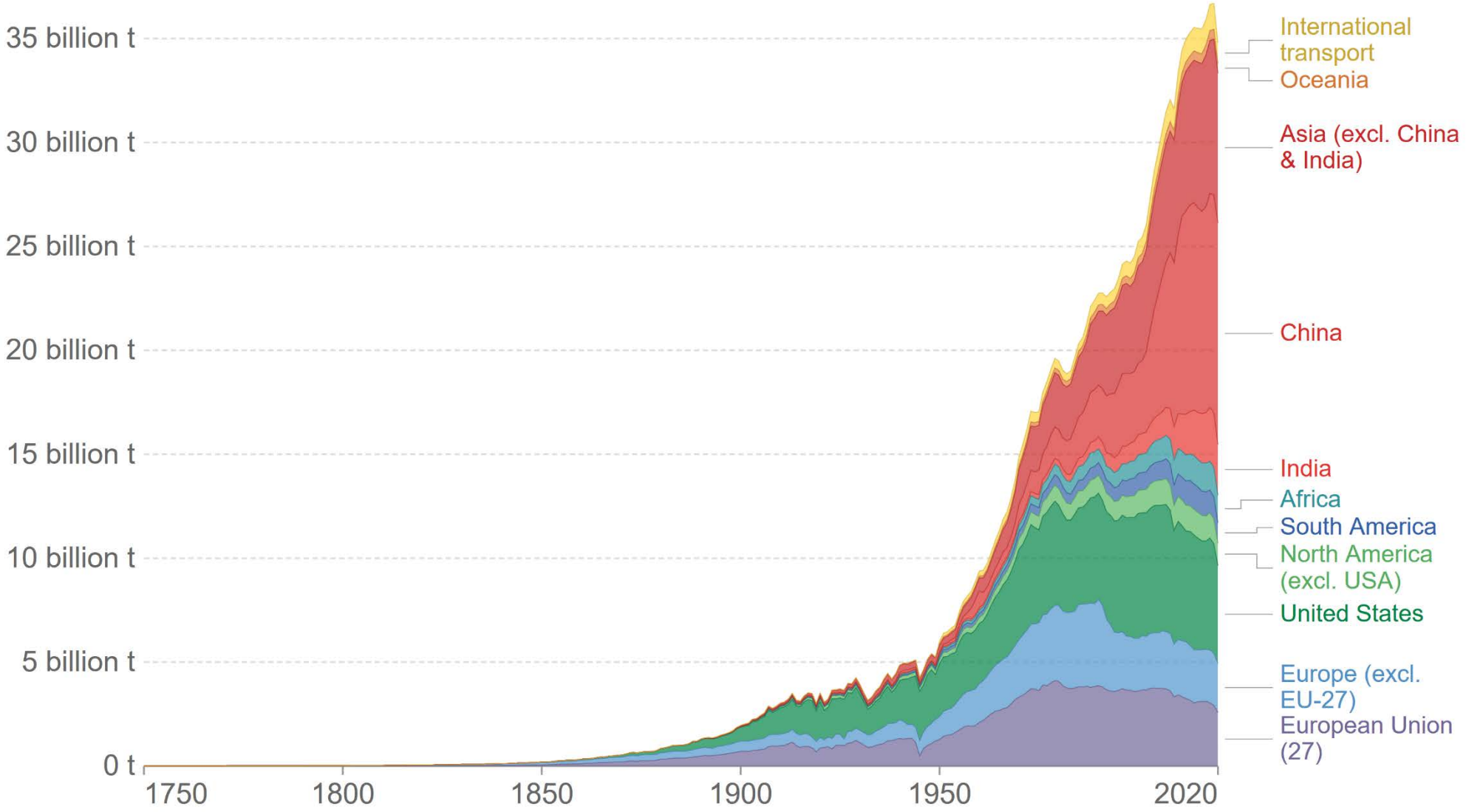
- Use of energy (greenhouse gas emissions)



Annual CO_2 emissions from fossil fuels, by world region

Our World in Data

5th, 2022

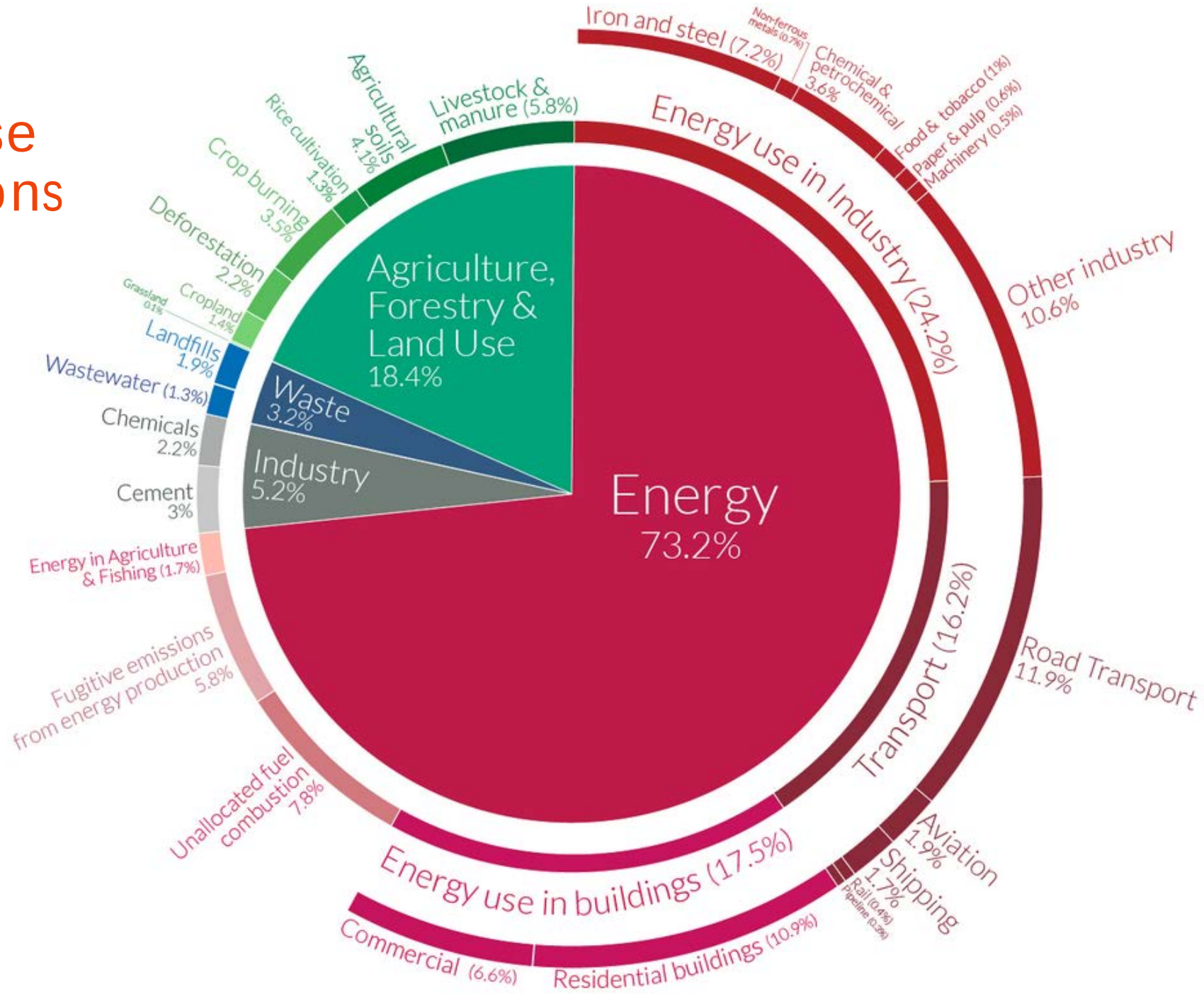


Source: Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Note: This measures CO_2 emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.

Greenhouse gas emissions by sector



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Current composites and sustainability
The material

Current composite materials and sustainability

- Use of natural resources that are finite:

  Carbon fibres and current thermoset matrices derive from fossil fuels

- Pour to the environment harmful substances for living beings

- Use of energy

Composite materials and sustainability

- Use of natural resources that are finite
- Pour to the environment harmful substances for living beings
- Use of energy (the embodied energy in composite raw materials is huge)

Material	Energy Content (MJ/Kg)
Carbon Fibre	183-286
Glass Fibre	13-32
Polyester resin	63-78
Epoxy resin	76-80

Embodied energy of cement (a badly reputed material) is 3.3 MJ/kg)

Composite materials and sustainability

- Use of natural resources that are finite
- Pour to the environment harmful substances for living beings
- Use of energy (current composite processing is energy intensive)

The primary energy intensity of manufactured CFRP composites with 50% fiber volume fraction is roughly 800 MJ/kg, whereas that for conventional steel is only 50 MJ/kg

Composite materials and sustainability

- Use of natural resources that are finite
- Pour to the environment harmful substances for living beings
- Use of energy (current composite processing is energy intensive)

The embodied energy of ONLY the composite parts of one Boeing 787 Dreamliner (32000 kg), 25.6 TJ, is equivalent to the electricity consumption of 3000 homes in one year.

Composite materials and sustainability

- Use of natural resources that are finite:

- Pour to the environment harmful substances for living beings

Composite materials and sustainability

- Use of natural resources that are finite:
- Pour to the environment harmful substances for living beings

A total of **43 million tons of blade waste will be accumulated worldwide by 2050**, 25% of them in Europe.
Each megawatt of installed capacity corresponds to 12 to 15 tons of composite waste.

Composite materials and sustainability

- Use of natural resources that are finite:
- Pour to the environment harmful substances for living beings

Recycling carbon fibers is feasible (5-40* MJ/kg vs 200 MJ/kg).
Recycling glass fibers is not (5-40 MJ/kg vs 13-20 MJ/kg).

- Use of energy

* pyrolisis.

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Then, why do we use them !?
The function

Composites contribution to sustainability

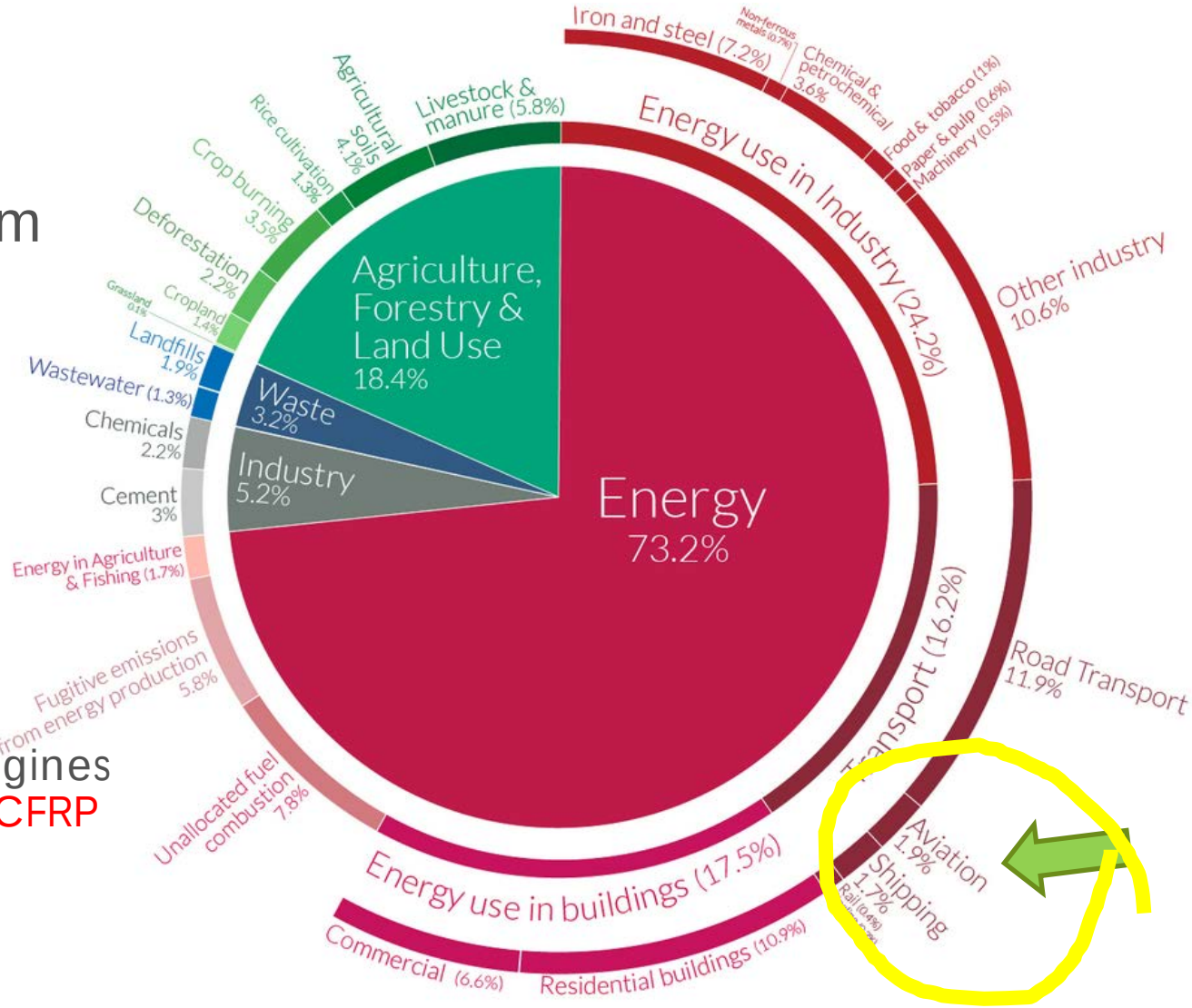
Use of energy

Energy consumption per km

Boeing 747: 417.6 MJ/km
Boeing 787: 208 MJ/km

A car: 2,5 MJ/km

More modern engines
Intensive use of CFRP



Composites contribution to sustainability

Use of energy

Energy consumption per km of the Boeing 787: 208 MJ/km

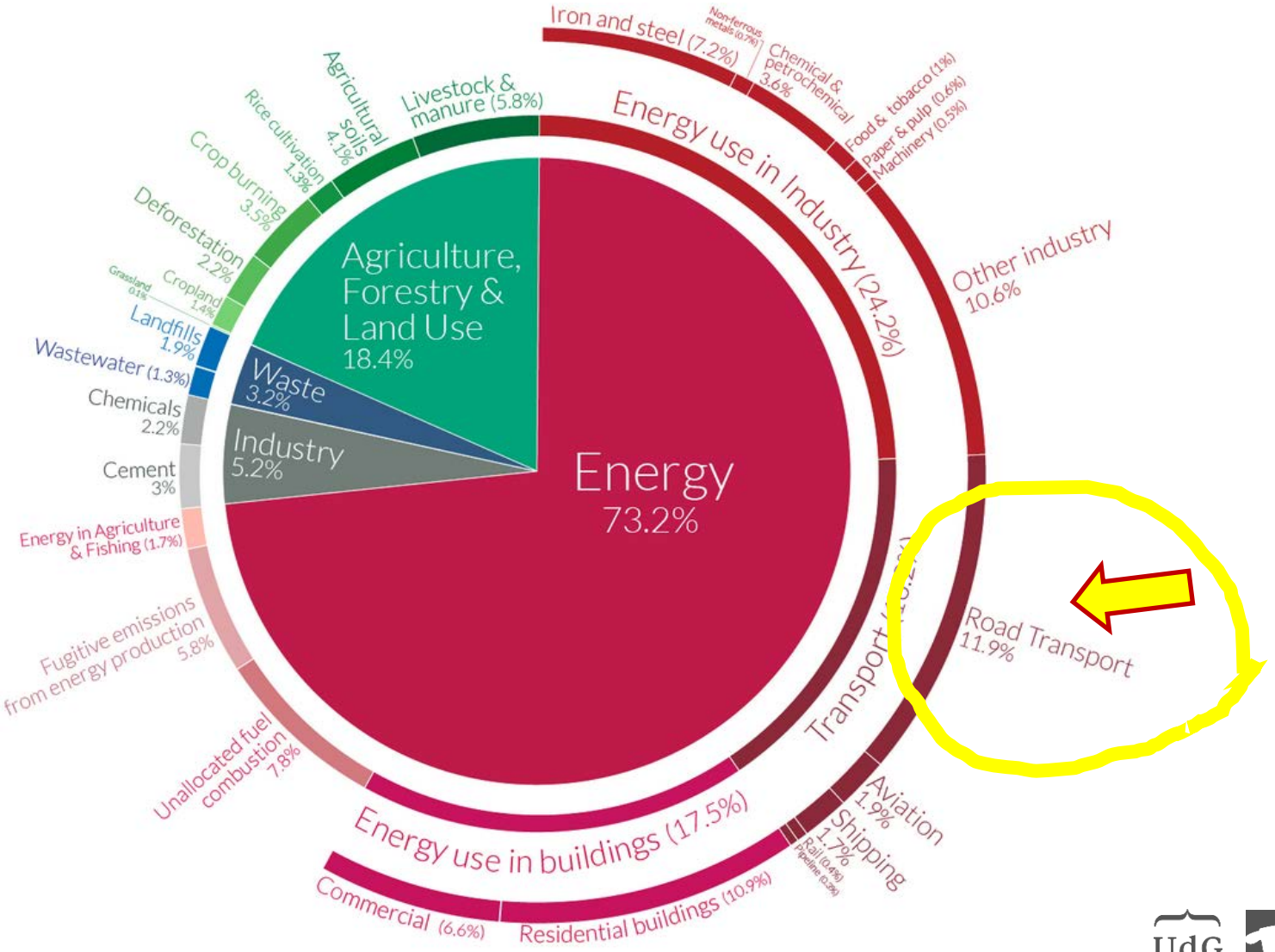
Expected life: aprox 100 milions of km (2300 turns around earth)
Energy consumed during life: 19.000 TJ
Embodied energy of CFRP in the aircraft: 25.6 TJ
Ratio of embodied energy vs consumed energy during life: 0.13%

Embodied energy in the components is not relevant when compared with operational savings

Composites contribution to sustainability

Use of energy

Impossible unless the material becomes sustainable (recyclable, non-harmful waste)



Composites contribution to sustainability

- Use of natural resources that are finite

Repair of buildings instead of demolition + construction

Longer lifetime of civil structures in corrosive environments

- Pour to the environment harmful substances for living beings

- Use of energy

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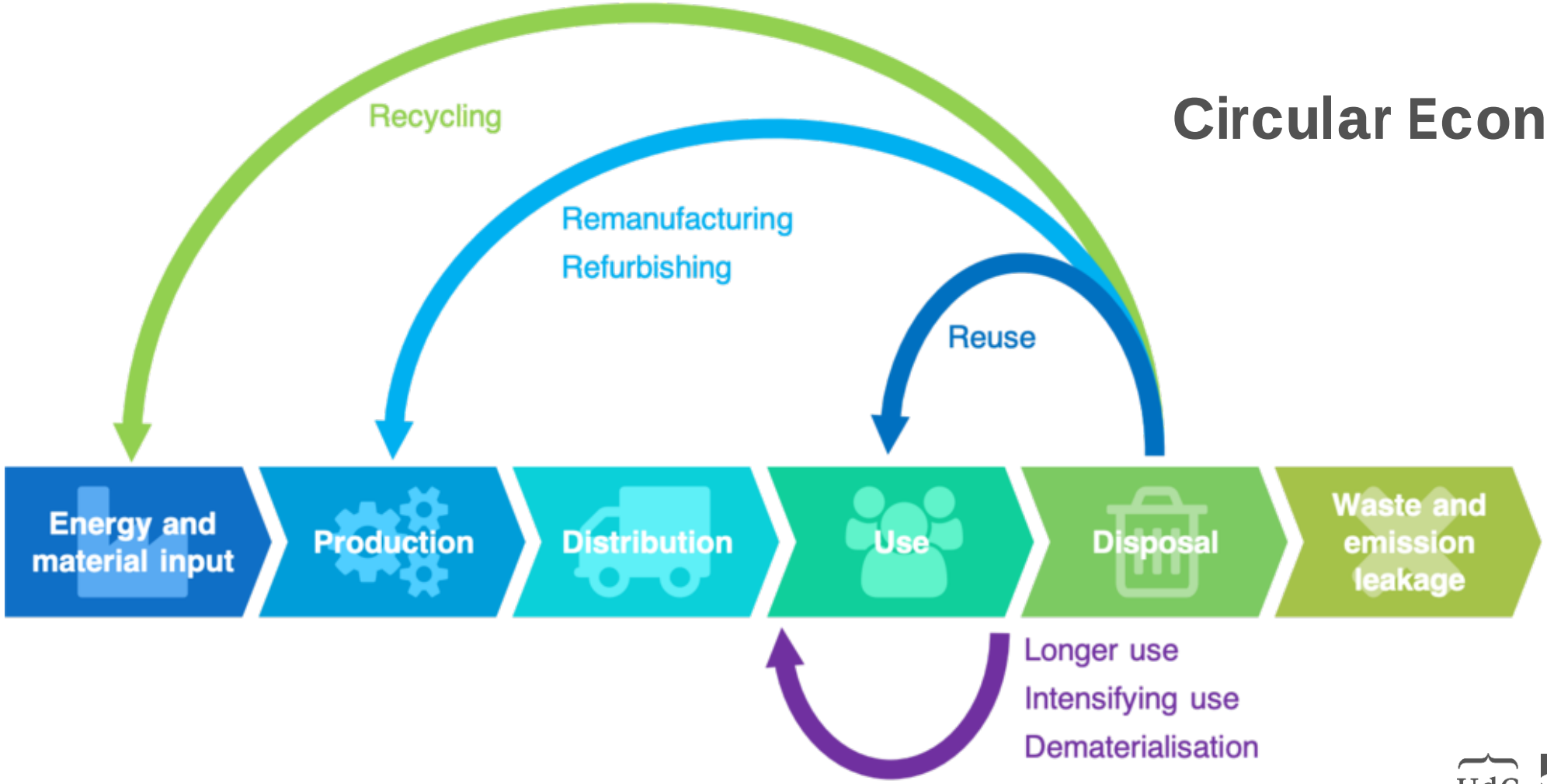
How to mitigate current composites' non-sustainability

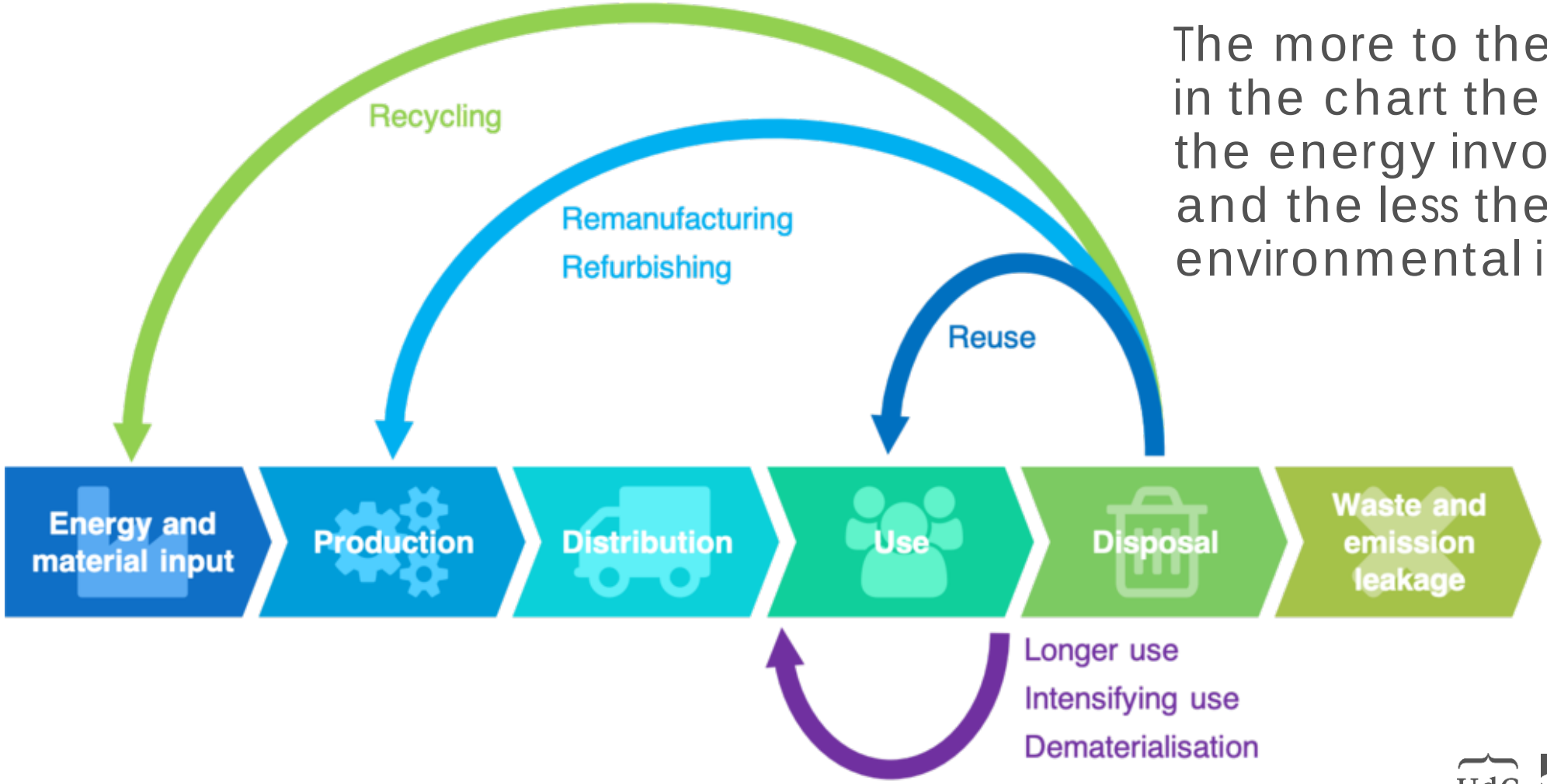
What to do with current composite components at the end of life

Reuse - Refurbish - Recycle



Circular Economy

Reuse - Refurbish - Recycle



The more to the right in the chart the less the energy involved and the less the environmental impact

AMADE's actions – COM2BUILD

Call: CL4-2021-RESILIENCE-01-01

COM2BUILD

Not funded

COM2BUILD

Boosting circularity of composite materials from wind energy and aeronautics to construction. Acronym: COM2BUILD

Nº	Partner name (acronym)	Type	Country
1	UNIVERSITAT DE GIRONA (**UDG**)	HE	ES
2	ONYRIQ LABS, SL (**ONY**)	SME	ES
3	UNIVERSIDADE DO MINHO (**UMIN**)	HE	PT
4	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V. (**FH-IWES / FH-IWM**)	RO	DE
5	GURIT LIMITED (**GUR**)	IND	UK
6	INSTITUT FUR KREISLAUFWIRTSCHAFT AN DER HOCHSCHULE BREMEN GMBH (**IEKRW**)	RO	DE
7	INSTITUT JOZEF STEFAN (**JSI**)	RO	SI
8	BRANDS & VALUES GMBH (**B&V**)	SME	DE
9	RECICLALIA, SL (**RECI**)	SME	ES
10	VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V. (**VITO**)	SME	BE
11	CLEVER REINFORCEMENT IBERICA (**S&P**)	IND	PT
12	UNIVERSITÉ CATHOLIQUE DE LOUVAIN (**UCL**)	HE	BE
13	SCHLAICH BERGERMANN PARTNER GMBH (**SBP**)	SME	DE

HE: higher education institutions; SME: small and medium enterprises; RO: research organization; IND: large industry

AMADE's actions - COM2BUILD

Figure 1. *Example of the COM2BUILD approach: composite components from aircrafts, a), can be easily sliced in flat patches, bars or T-shapes, b), then reused for the repair of buildings as external reinforcement, d), or near-surface-mounted, c) and e).*

AMADE's actions - COM2BUILD

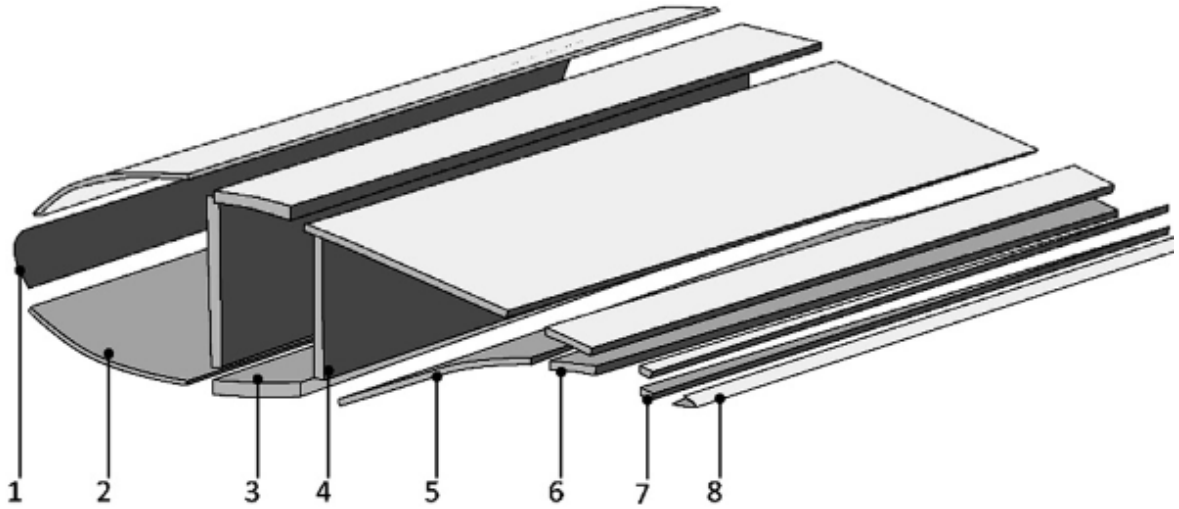


Fig. 6. Structural segmentation of the blade.

AMADE's actions - AIR2BUILD

TITLE OF THE COORDINATED PROJECT (ACRONYM): Boosting circularity of composite materials: from aeronautics to construction (AIR2BUILD)

Submitted

AIR2BUILD

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Towards sustainable composites

How to reach sustainable structural composites?

Inherently recyclable matrices

- The very high embodied energy of carbon fibres asks for reusing it.
  This objective requires matrices that can be solved or melted easily.

Thermoplastic matrix composites
(prospect of structural performance: PEEK, PAEK, etc.)

Thermoset matrix composites
(covalent adaptative networks – CANs; vitrimers)

Bio-based / Bio-degradable constituents

- Matrices derived from natural products.

Table 1 Bases of natural and synthetic bio degradable polymer matrices (Source: Stevens, 2002)

Natural	*Synthetic*
1. Polysaccharides	**1. Poly(amides)**
Starch	**2. Poly(anhydrides)**
Cellulose	**3. Poly(amide-enamines)**
Chitin	**4. Poly(vinyl-alcohols)**
2. Proteins	**5. Poly(vinyl-acetate)**
Collagen / gelatine	**6. Polyester**
Casein	Polyglycolic acid
Albumin	Polylactic acid
Fibrogene	Polycaprolactones
Silk	Poly ortho esters
3. Polyesters	**7. Poly(ethylene-oxides)**
Polyhidroxyalkanoates	**8. Polyphosphates**
4. Other polymers	
Lignin	
Lipids	
Shellac	
Natural rubber	

- Natural fibres (flax, hemp, etc.)

AMADE's actions - RESCUE

Call: CL4-2021-TWIN-TRANSITION-01-05 CONFIDENTIAL RESCUE – Part B

RESCUE

REcyclable and **S**ustainable **C**omposites for **U**se in **E**conomic solution for industry

N°	Participant organisation name (acronym)	Type	Country
1	INSTITUT NATIONAL DE LA RECHERCHE POUR L'AGRICULTURE, L'ALIMENTATION ET L'ENVIRONNEMENT (INRAE)	RE	France
2	INRAE TRANSFERT SAS (IT)	OTH	France
3	AiRCaDs GmbH (AiRCaDs)	SME	Germany
4	Howa-Tramico SAS (HT)	IND	France
5	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V. (IFAM)	RE	Germany
6	KATHOLIEKE UNIVERSITEIT LEUVEN (KUL)	RE	Belgium
7	NOVA-INSTITUT FUR POLITISCHE UND OKOLOGISCHE INNOVATION GMBH (NOVA)	SME	Germany
8	RISE SICOMP AB (RISE)	RE	Sweden
9	New Zealand Forest Research Institute LTD (SCION)	RE	New Zealand
10	SOPREMA (SOPREMA)	IND	France
11	TUCO YACHT VAERFT APS (TUCO)	SME	Denmark
12	UNIVERSITY OF BRISTOL (UBRIS)	HE	UK
13	UNIVERSITE DE BRETAGNE SUD (UBS)	HE	France
14	UNIVERSITAT DE GIRONA (UDG)	HE	Spain
15	PANEPISTIMIO PATRON (UPAT)	HE	Greece
16	ONYRIQ LABS (ONYRIQ)	SME	Spain
17	Bitrez Limited (BITREZ)	IND	UK
18	SOUDAL (SOUDAL)	IND	Belgium

Not funded

Similar to a previous proposal, BIORECOMP, not funded

AMADE's actions - RESELECT

Call: HORIZON-CL4-2022-RESILIENCE-01-11 – Advanced lightweight materials for energy efficient structures

RESELECT:

RECYCLABLE **S**USTAINABL**E** **L**IGHTW**E**IGHT **C**OMPOSI**T**ES TOWARD STRUCTURAL RESOURCE EFFICIENCY

Submitted

List of participants:

N°	Participant short name	Participant full name	Type	Ctry
1	INRAE	Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement	RE	FR
2	IT	INRAE TRANSFERT SAS	OTH	FR
3	AIRCaDs	AiRCaDs GmbH	SME	DE
4	HT	Howa-Tramico SAS	IND	FR
5	IFAM	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	RE	DE
6	KUL	KATHOLIEKE UNIVERSITEIT LEUVEN	RE	BE
7	NOVA	NOVA-INSTITUT FUR POLITISCHE UND OKOLOGISCHE INNOVATION	SME	DE
8	RISE	RISE SICOMP AB	RE	SE
9	SCION	NEW ZEALAND FOREST RESEARCH INSTITUTE LTD	RE	NZ
10	TUCO	TUCO YACHT VAERFT APS	SME	DK
11	UBRIS	UNIVERSITY OF BRISTOL	HE	UK
12	UBS	UNIVERSITE DE BRETAGNE SUD	HE	FR
13	UDG	UNIVERSITAT DE GIRONA	HE	ES
14	UPAT	PANEPISTIMIO PATRON	HE	EL
15	ONYRIQ	ONYRIQ LABS	SME	ES
16	BITREZ	Bitrez Limited	IND	UK
17	SOUDAL	SOUDAL	IND	BE

AMADE's actions - REPOXYBLE

HORIZON-CL4-2022-RESILIENCE-01-11 - Advanced lightweight materials for energy efficient structures (RIA)

REPOXYBLE, 1

Depolymerizable bio-based multifunctional closed loop recyclable epoxy systems for energy efficient structures

REPOXYBLE

Submitted

List of participants

Participant No	Participant organisation name (short name)	Type	Country
1 (Coord.)	AVANZARE INNOVACION TECNOLOGICA SL (AVA)	SME	ES
2	COMPOSITES EVOLUTION LTD (COMPEVO)	SME	UK
3	FUNDACIÓN GAIKER (GAIKER)	RTD	ES
4	ONYRIQ LABS SL (ONY)	SME	ES
5	TEMAS SOLUTIONS GmbH (TEMASOL)	SME	CH
6	UNIVERSITY OF PATRAS PANEPISTIMIO PATRON (UPATRAS)	HE	GR
7	UNIVERSITY OF LJUBLJANA (UL)	HE	SI
8	DISTRETTO TECNOLOGICO AEROSPAZIALE DELLA CAMPANIA (DAC)	RTD	IT
9	OFFICINE MECCANICHE IRPINE SRL IT (Affiliated to DAC)	SME	IT
10	UNIVERSITAET FUER BODENKULTUR WIEN (BOKU)	HE	AT
11	ASSOCIAZIONE ITALIANA PER LA RICERCA INDUSTRIALE (AIRI)	RTD	IT
12	SATURNTECH UNIPESOAL LD (SAT)	SME	PT
13	RIVERSIMPLE MOVEMENT LTD (RIVERS)	SME	UK
14	GURIT (UK) Limited (GURIT)	LE	UK
15	UNIVERSITAT DE GIRONA (UDG)	HE	ES
16	UNIVERSITY OF BATH (UBAH)	HE	UK

AMADE's actions - SUCCESSBLADE

Submitted

- SUstainable and CirCular Economy SyStem for wind BLADE
  (SUCCESS BLADE)

  - Spanish Council for Scientific Research Polymer Composite Group (ICTP-CSIC)
  - The Centre for Energy, Environment and Technology Research - CIEMAT
  - AMADE

New thermoplastic resin with very low viscosity before polymerization, AKELITE

AMADE's actions - SUBHYCO

Awarded
9/2022-9/25

- In search of sustainable, bio-based, hybrid, long-fibre reinforced composites for structural applications (SUBHYCO)

  - Spanish Council for Scientific Research Polymer Composite Group (ICTP-CSIC): Bio-based matrices
  - CIDETEC (technological centre from the Basque Country): Vitrimers
  - AMADE

Use of natural fibres. Hybridization with glass and recycled carbon fibres

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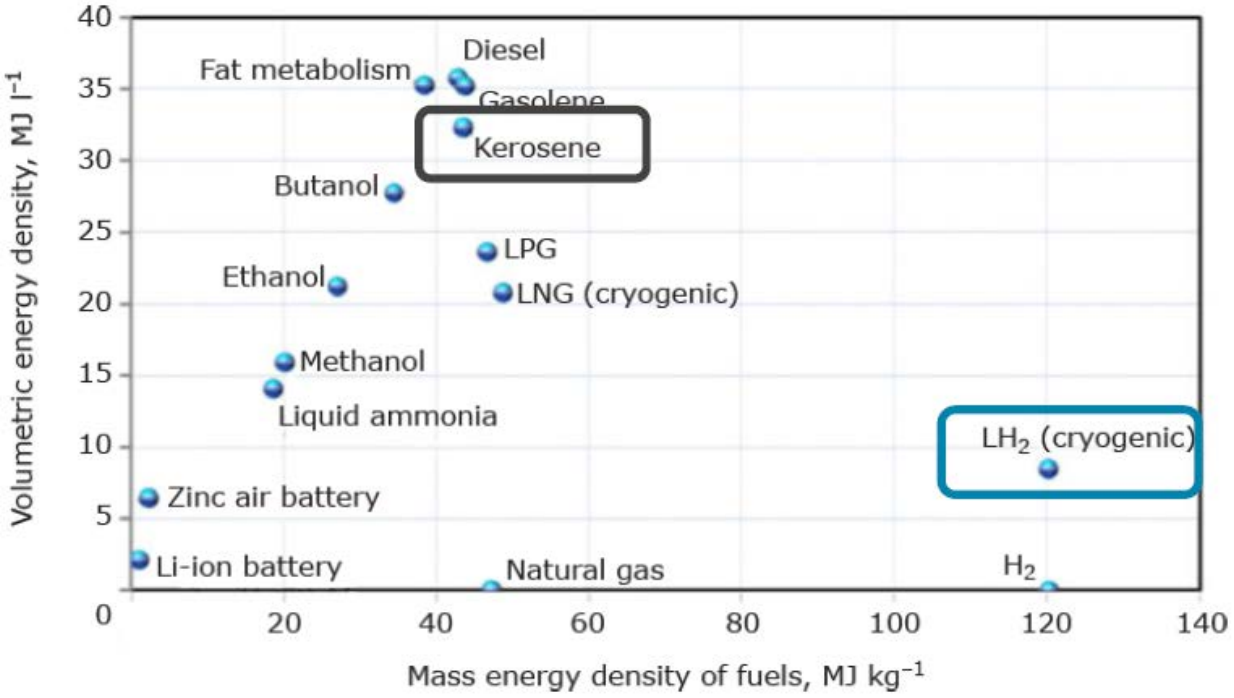
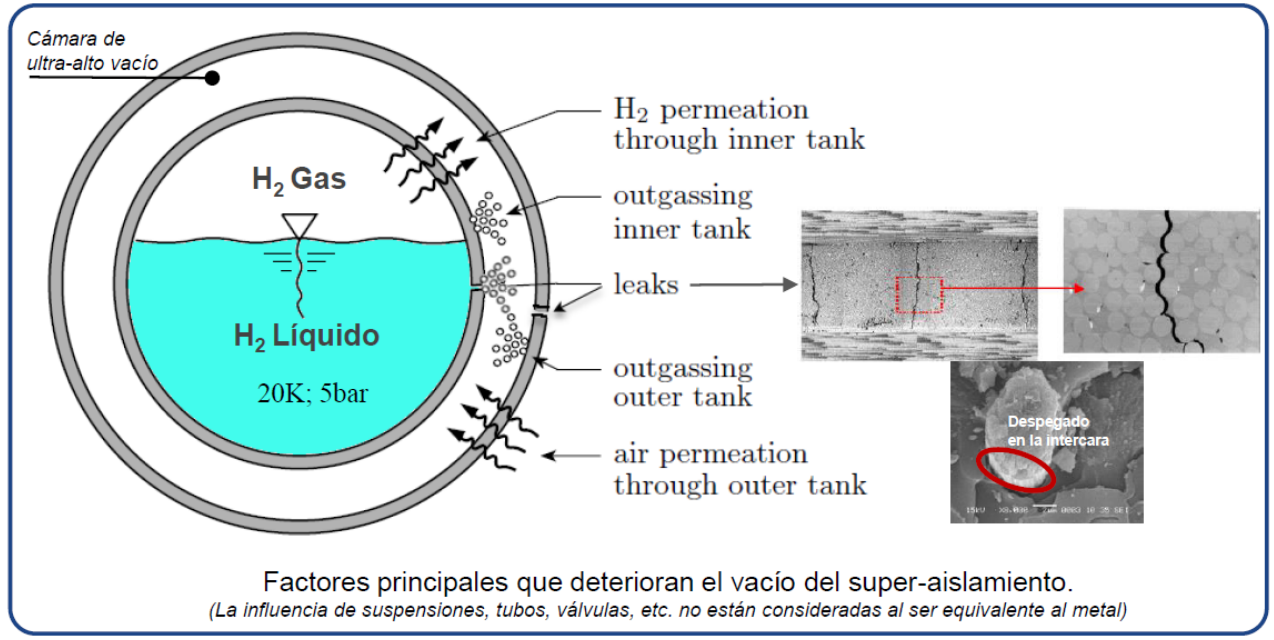
Improving composites contribution to sustainability

Zero emission vehicles

- Liquid Hydrogen tanks represent a scientific-technical challenge





Factores principales que deterioran el vacío del super-aislamiento.
(La influencia de suspensiones, tubos, válvulas, etc. no están consideradas al ser equivalente al metal)

AMADE's actions – Jordi Renart's next talk....

- CRYFTO
- OVERLEAF
- FASTER
- FIDELITY

Multifunctional structures

- DeVelopment of a multifunctional rEinforcement system for self-poweReD CONcrete structures (CONVERD)

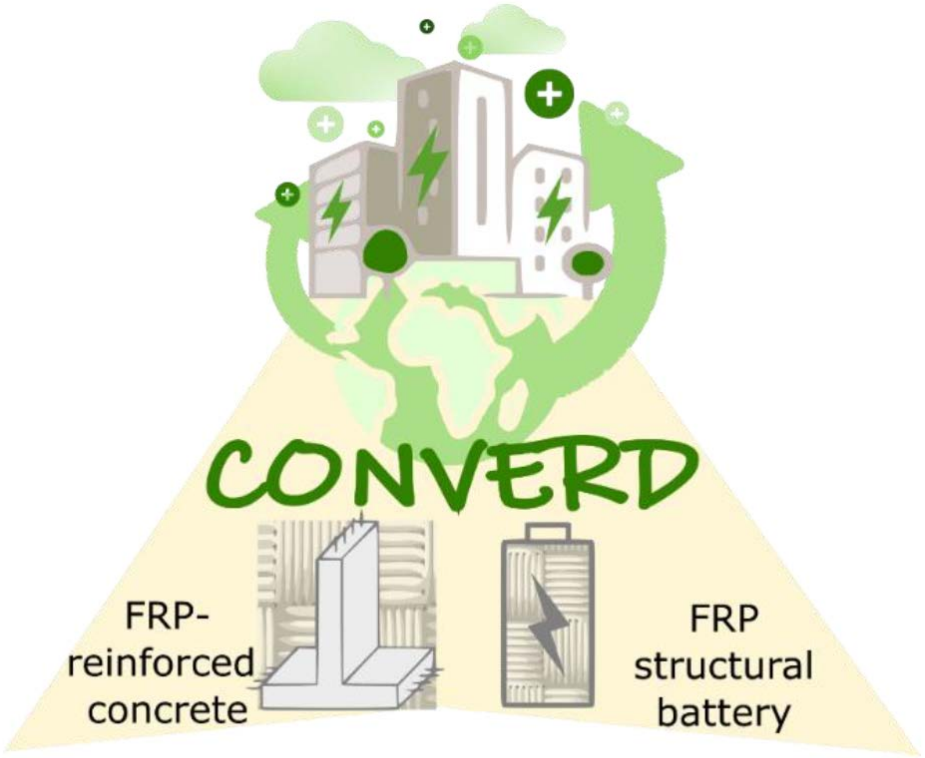


Figure 1. CONVERD technologies for self-powered concrete structures.

Submitted

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Small contributions add up

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Small contributions add up

Turn off lights, screens, PC's, aircons,...
Take public transport, bike...
Reduce the energy consumption of your activities
Reuse before throwing away

...Just do a good job in AMADE

http://amade.udg.edu

testlab.amade@udg.edu

Universitat de Girona

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