Converting composite plastic waste into circular recycled **Materials and Products**

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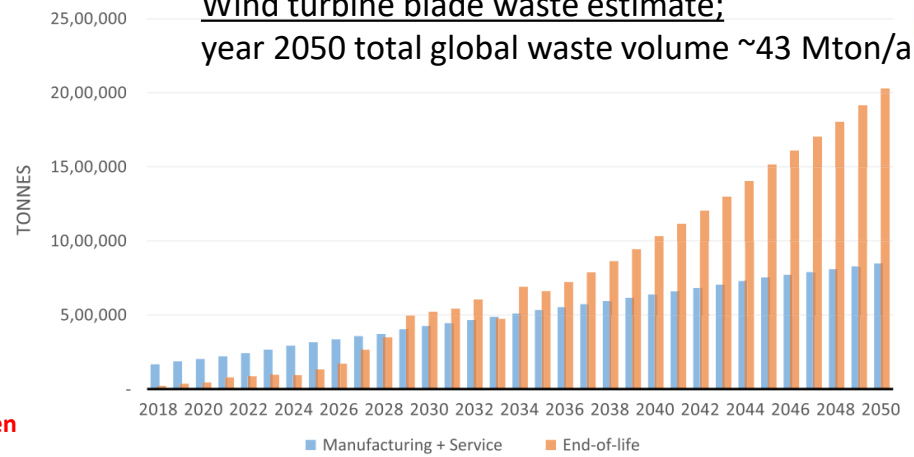
Problem

Glass- and carbon <u>fibre reinforced plastics (FRP)</u> from wind turbines, marine, automotive, infrastructure etc. <u>are not recyclable</u> and create a massive global environmetal problem and total waste of resources

<u>Wind turbine blade waste estimate;</u>
year 2050 total global waste volume ~43 Mton/a



Zu geringe Recyclingkapazitäten für Rückbau von Windenergieanlagen
UBA-Studie betrachtet Umweltaspekte des Recyclings alter Windenergieanlagen
https://www.umweltbundesamt.de/presse/pressemitteilungen/zu-geringe-recyclingkapazitaeten-fuer-rueckbau-von

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Blade recycling is a top priority for the wind industry

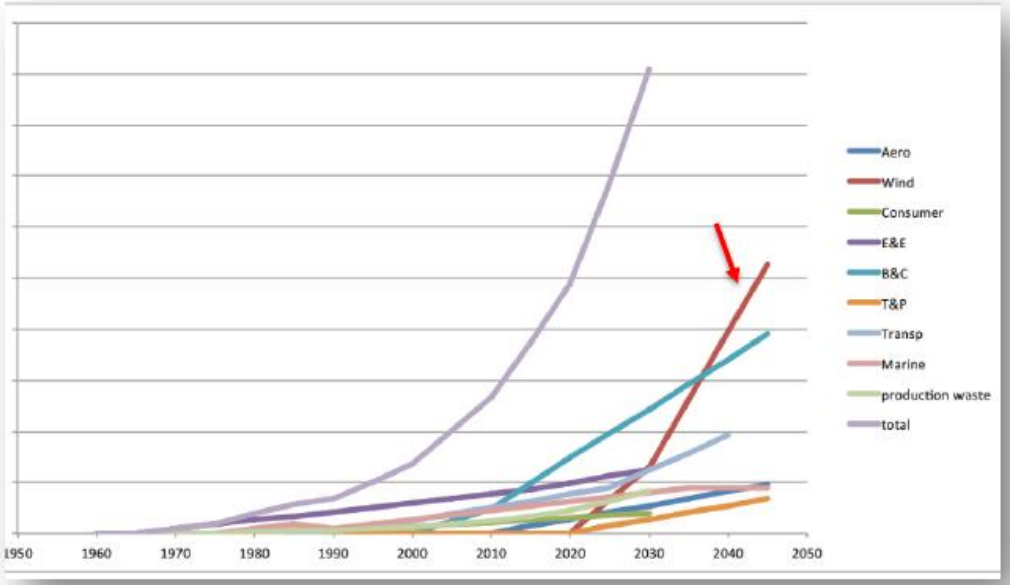
News from Wind Europe
12 February 2020

https://windeurope.org/newsroom/news/blade-recycling-a-top-priority-for-the-wind-industry/

Making turbines 100% recyclable is an important task for the wind industry as the EU heads towards a circular economy.

But turbine blades represent a specific challenge. Wind turbine blades are made up of composite FRP-materials that boost the performance of wind energy by allowing lighter and longer blades. Today 2.5 million tonnes of composite FRP-material are in use in the wind sector globally.

The Problem is not only with the blades..



Many other industries face the same problem how to recycle annually rapidly growing amounts in millions of tons GFRP-waste sustainably ;

- Aero
- Marine
- Construction
- Consumer goods
- others

EuCIA
European Composites Industry Association

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”Recycling” with thermosets is not a solution

❖ GFRP-waste is not recyclable “ as is” because of its crosslinked polymer chain matrix which makes the material cured thermoset in contrast with thermoplastics which can be recycled and re-molded several times into new products

➢ Re-manufacturing technologies utilizing virgin thermoset resins e.g. polyester, epoxy, polyurethane are not solving the GFRP-waste recycling but are creating another even bigger and much more complex recycling problem for the next generations which is totally non-acceptable

✓ Equally as recent developments in creating a circular thermoplastic based GFRP materials like Elium® by Arkema, the current GFRP-waste problem from the past materials must become recycled sustainably with recycled thermoplastics e.g. PE/PP that are circular materials

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Disposal in cement kiln is not recycling

Ref. SusChem; Polymer Composites Circularity – White Paper http://www.suschem.org/publications

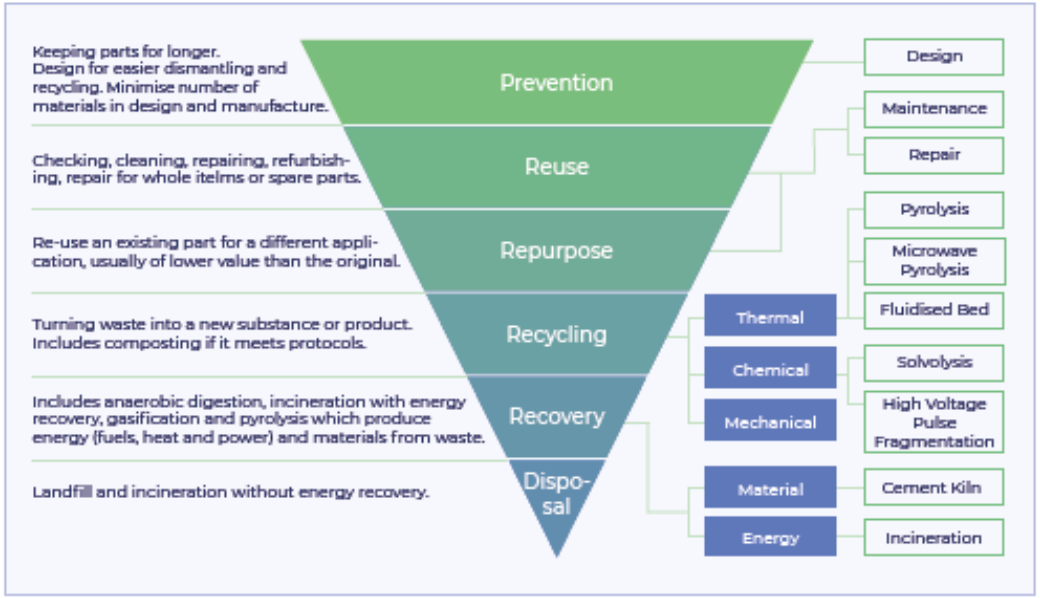

Figure 4. Waste management categories hierarchy

Waste management hierarchy

Disposal of GFRP-waste in cement kiln is a co-process for energy and material recovery.

The outcome is not circular.

Solution – ReGenerating FRP-waste

Patented low cost agglomeration technology to utilize FRP-waste as reinforcement in circular composite construction materials and products

stop landfilling

photo by Bloomberg Green (USA), 2020

ReGenerating FRP-waste

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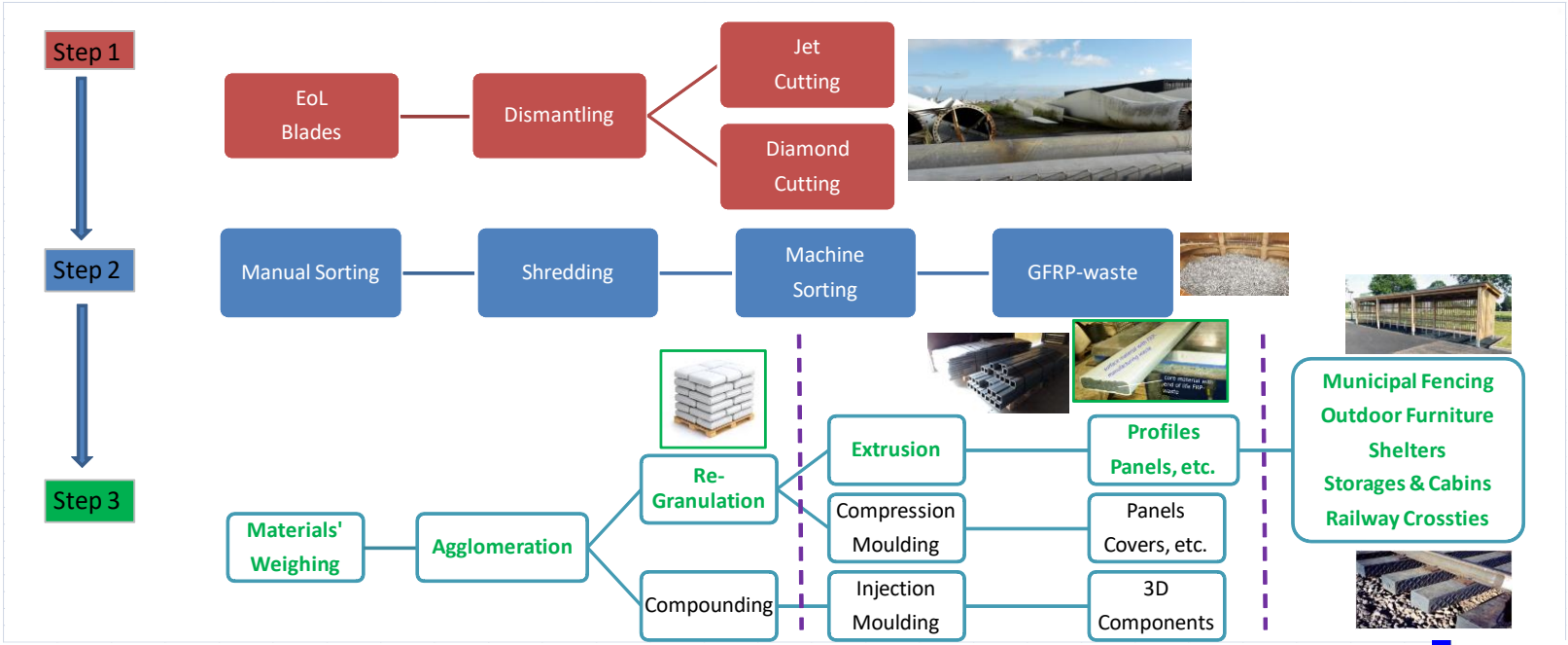
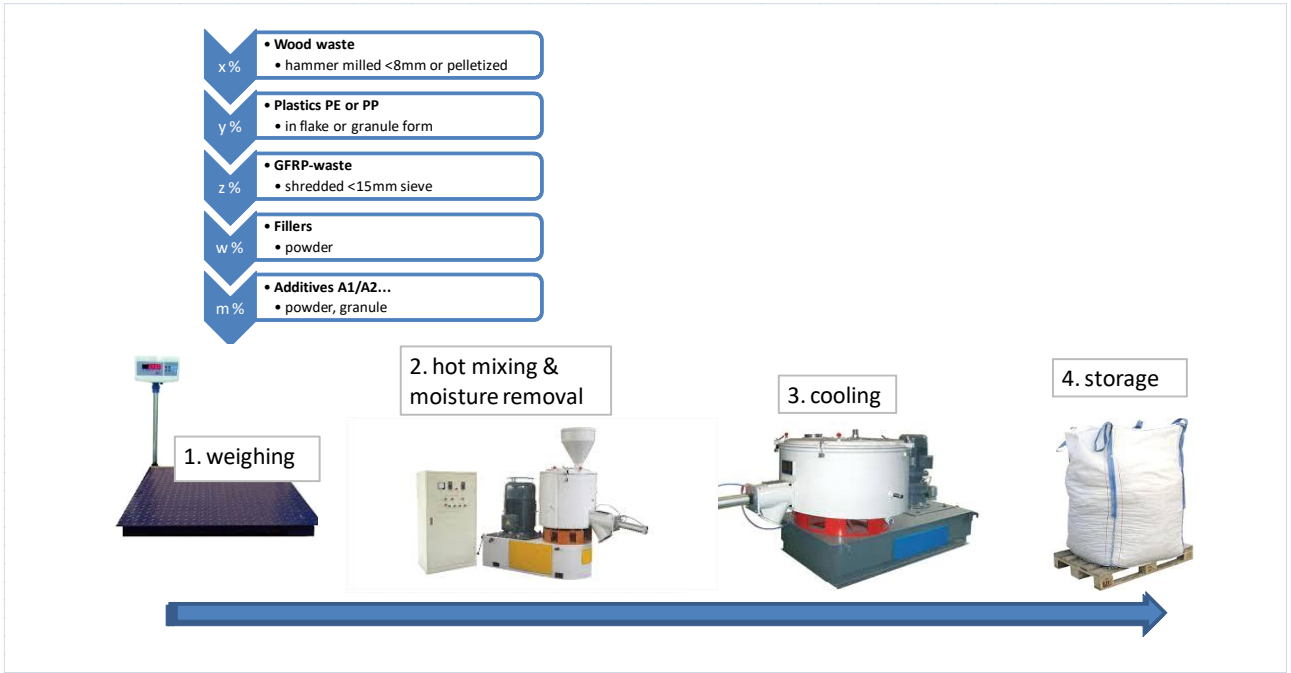
Processing Steps w. EoL Blades

Patented low cost agglomeration technology to utilize FRP-waste as reinforcement in circular composite construction materials and products



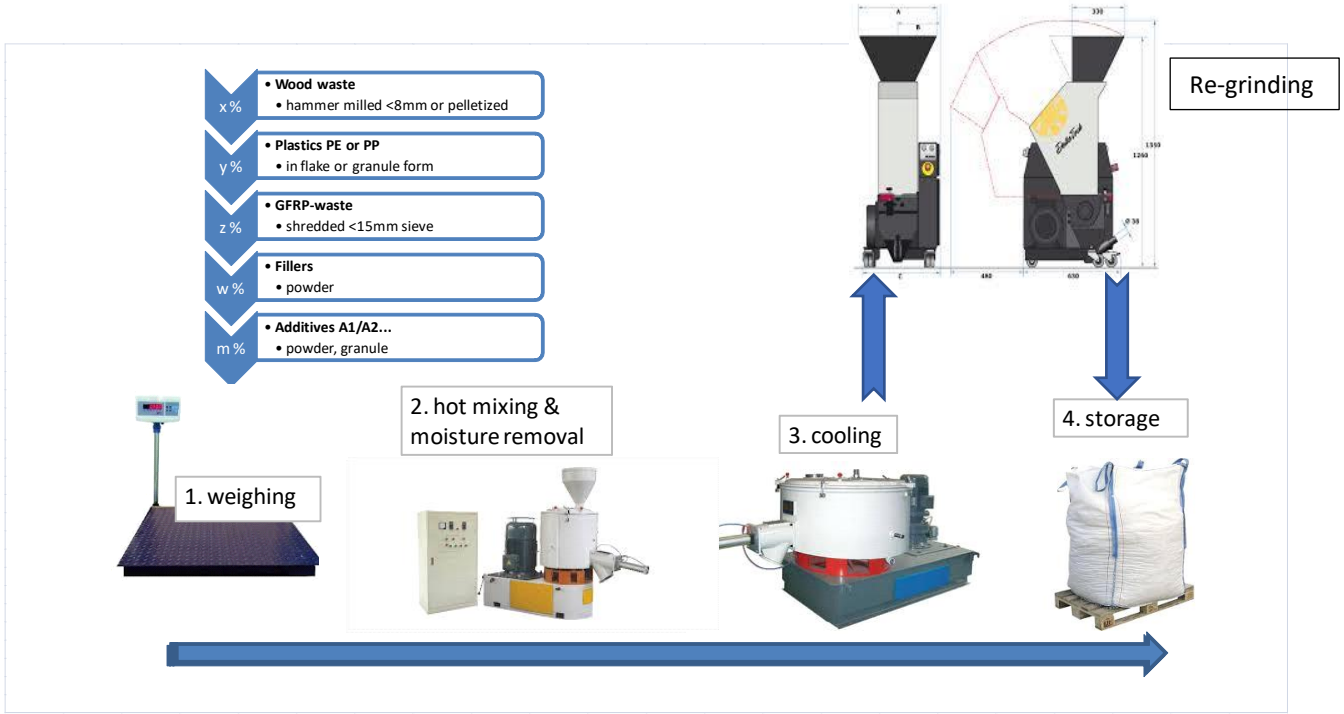
The Agglomeration Process

”Produce random sized thermoplastic agglomerates with FRP-waste”



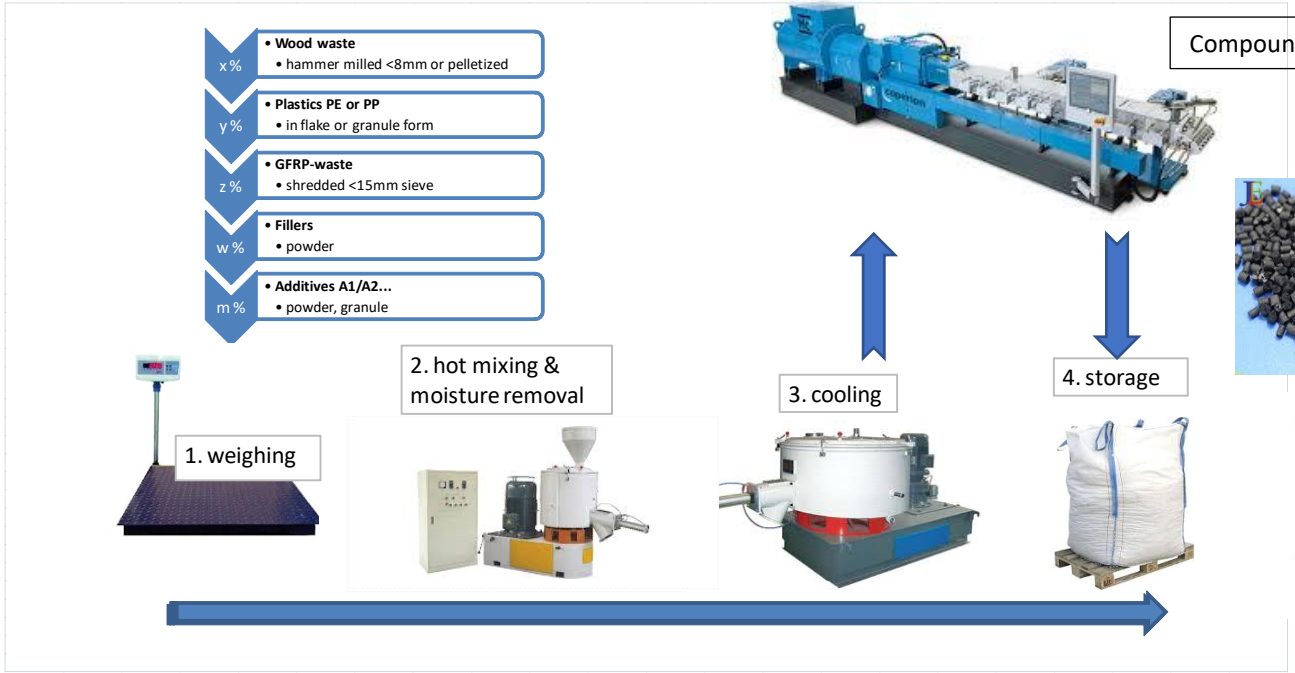
Re-grinding Agglomerates

”Produce 90% dust free molten lumps and re-grind small”



Compounding Agglomerates

”Produce dust free homogenous standard sized granules/pellets”



Strategic partnerships

European Patent on the Agglomeration Process EP 3159127 B1

Europäisches Patentamt
European Patent Office
Office européen des brevets

Manufacturing

- Agglomerates
- Re-grinded agglomerates
- Agglomerates compounded in pellets

Business Strategy

Market entry in collaboration with selected plastic processing equipment manufacturers for GFRP-waste shredding companies enabling their new business with added value raw materials

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International Patents – Material Processing

Canada – granted
(CA 2994054)

USA – granted
(US 10,843,382)

China – granted
(CN ZL201810132572.3)

International Patenting – Multilayer Products

Following the material processing patent, another **product patent** application WO 2020/148484 A1 filed January 13th 2020;

”MULTILAYER PRODUCT AND METHOD OF FORMING A MULTILAYER PRODUCT”

WIPO | PCT
The International Patent System

”A multilayer product, c h a r a c t e r i z e d in that the multilayer product has at least two layers, at least one of which consists of End of Life waste of fibre reinforced thermosetting plastic or discarded production waste of fibre reinforced thermosetting plastic combined into a thermoplastic matrix, …”

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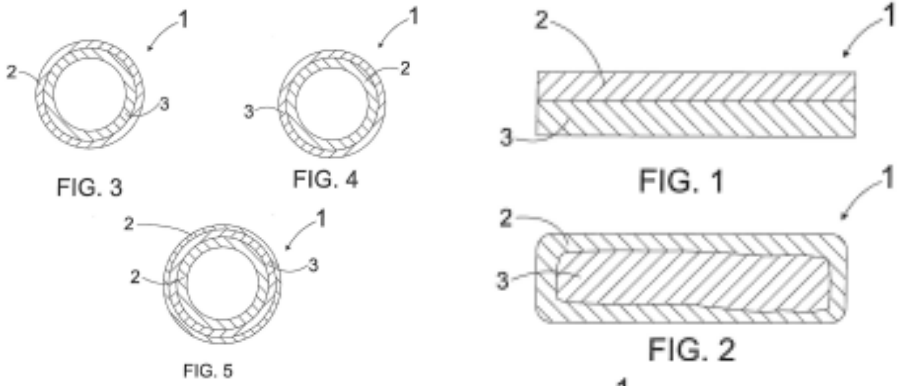
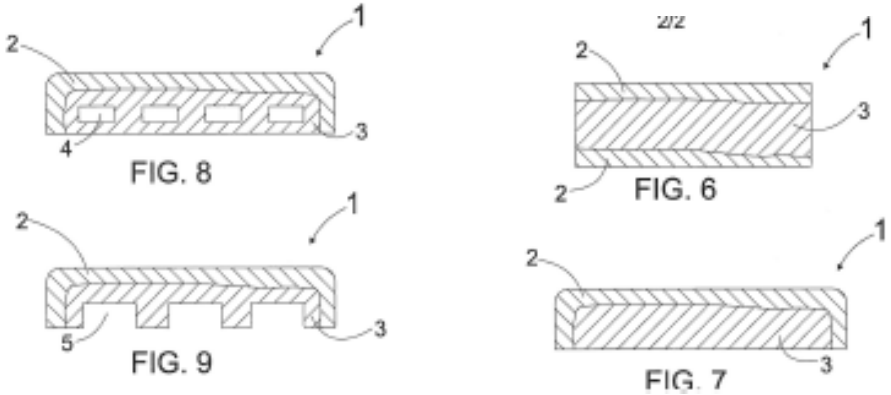
Multilayer Product Structures (*pct application*)

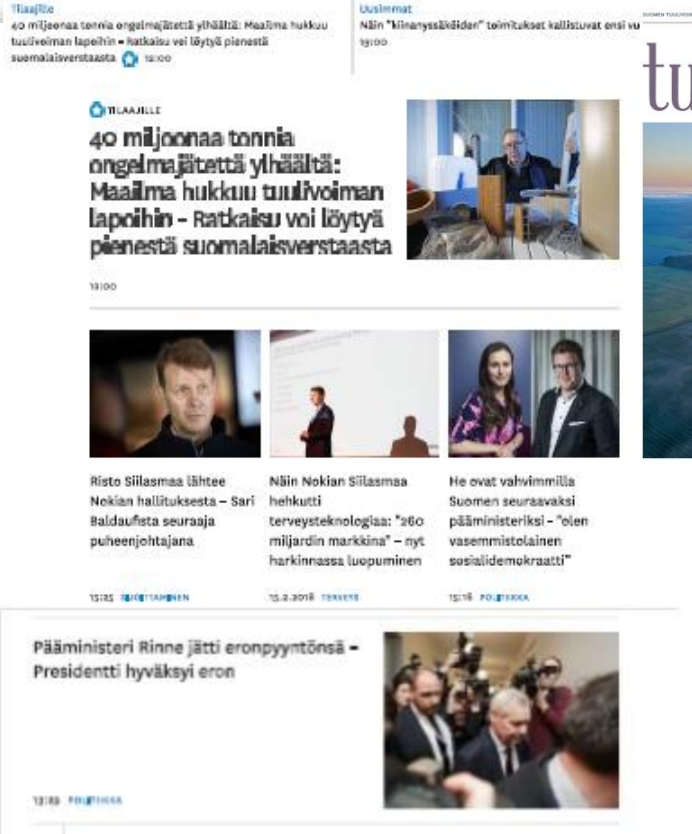


Illustrations of various shapes of multilayer product structures with FRP-waste…



in Finnish Media

Head line news at Tekniikka&Talous 3.12.2019 Internet version



https://yle.fi/uutiset/3-9923884

https://www.delete.fi/deletelehti/artikkelit/kierrattamalla-uusiomateriaaliksi/suomen-vanhin-tuulivoimalapuisto-purettiin-ja-materiaalit-kierratettiin?origin=item6

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Presentations at wind industry conferences

Wind Turbine Blade Manufacture, Dusseldorf, Germany

- year 2018 presentation
- year 2019 presentation

International Energy Agency (IEA), Rome, Italy

- presentation 2019

+ News in international press, WMW, 2018-03-20

https://waste-management-world.com/a/european-circular-economy-project-researches-wind-turbine-blade-recycling

WASTE MANAGEMENT WORLD®

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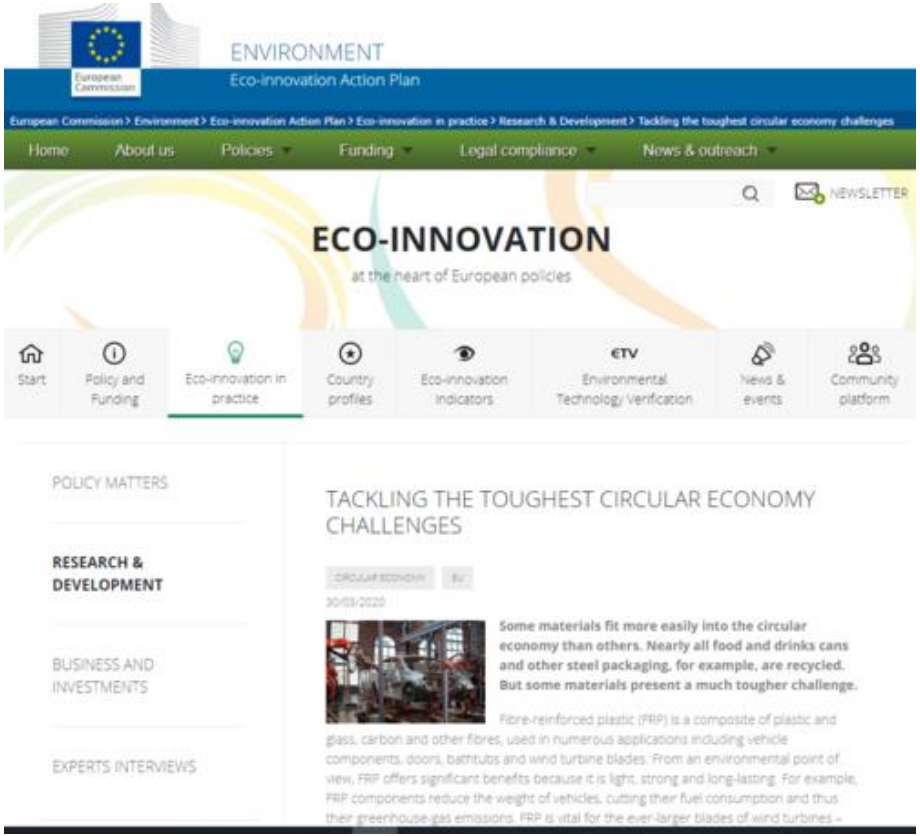
ECO-INNOVATION in the EU Environment Action Plan



enterprise europe network

[Conenor offering in Enterprise Europe Network (EEN)]

https://ec.europa.eu/environment/ecoap/about-eco-innovation/research-developments/tackling-toughest-circular-economy-challenges_en

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Awards – Enel Green Power

EGP's Sustainable Challenge: New Life for Wind Turbines Opened on Wednesday, 12 December 2018

ma 20.5.2019 19.35
- Markku Vilkki;
- ENEL Open Innovability Challenges <enelopeninnovabilitychallenges@innocentive.com>

Dear Markku,
It gives me great pleasure to let you know that the review of your submission *Reinforced thermoplastic material from GFRP-waste* to the Enel Open Innovability Challenge *Recycle and Reuse of Wind Turbine Blades* led to a favorable evaluation. You will be awarded $10,000!

AN IMPORTANT NOTE: The final award for this Challenge is contingent upon satisfactory completion of the verification process. A member of InnoCentive's operations team will be in touch with you shortly to assist you through the verification, solution transfer and payment processes.

Congratulations, and thank you for your participation on this Enel Open Innovability Challenge!
Sincerely,
Renato

Renato Vasconcelos, *PhD*
Senior Principal, Challenge Design and Development
InnoCentive

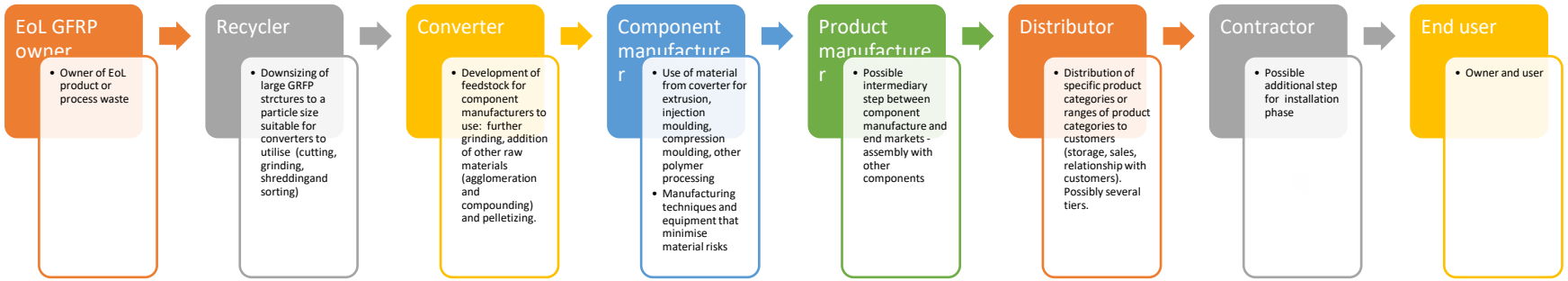
https://www.enelgreenpower.com/media/news/d/2018/12/recyclabe-wind-turbine-thanks-innovation-and-circular-economy

Conenor role and offering in value chain

Technology Provider & Licensor to Converters and Component Manufacturers

- materials, additives, formulations
- process technique
- equipment purchase
- product design and properties
- start-up training

In collaboration with chosen process Equipment Manufacturers worldwide



Material characteristics with 35-45%-w. GFRP-waste

Analysis of GFRP-waste containing products

Analysis of the Conenor developed GFRP-waste reinforced circular composite PE/PP-materials and extruded products have been undertaken within ECOBULK by CNR in Italy, Muovipoli Ltd in Finland and through a Masters research project at University of Eastern Finland (UEF):

- ✓ **Compared to quality commercial WPC decking boards**: ECOBULK hollow boards (140x28mm) with GFRP-waste are stronger and stiffer vs. quality commercial WPC decking boards in dry as well as wet conditions
- ✓ **Compared to commercial plywood panels:** ECOBULK composite panels 390x10mm with GFRP-waste remain stronger and stiffer vs. quality commercial plywood panels when getting into contact with water (EN-water soaking test method)

Typical material values:

- density 1.2 - 1.4 g/cm^3
- moisture absorption & dimensional swelling (28d water soaking) +/- 0%
- surface hardness Brinell (HBS 10/3000) 60-100
- flexural strength (MOR) 30-50 MPa
- flexural modulus (MOE) 3-5 GPa
- EN fire rating class B-d0-s2 (optional)
- no rotting, no mould growth, no leaching, pesticide free, formaldehyde free

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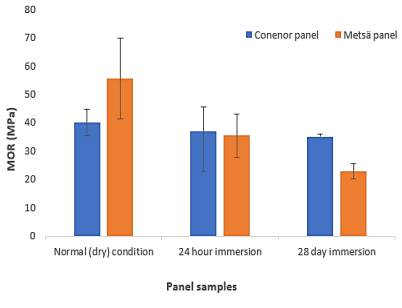
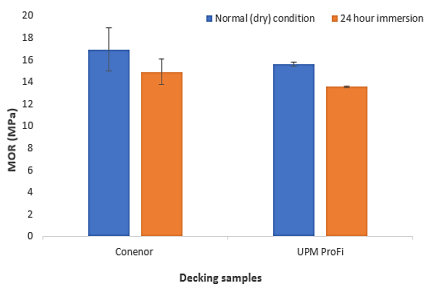
Materials and products for moist conditions

Master thesis by Mr. Ramji Pandey at University of Eastern Finland (UEF)

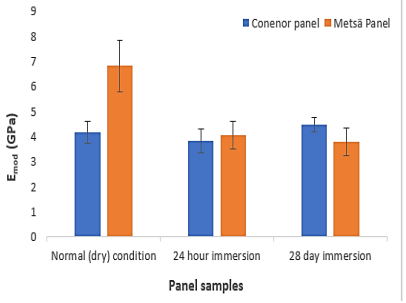
MOR



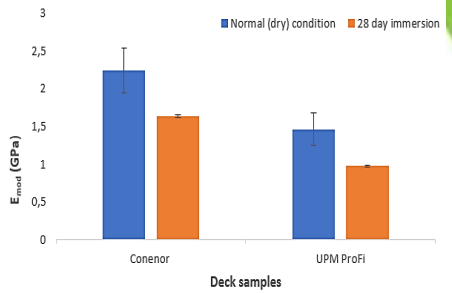
MOR



MOE



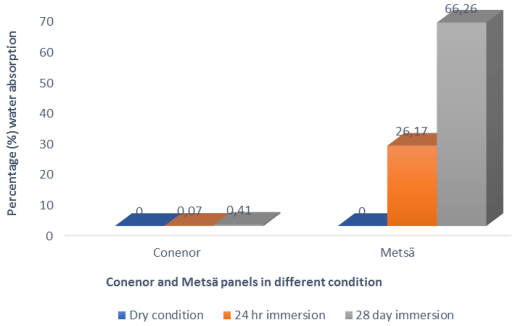
MOE



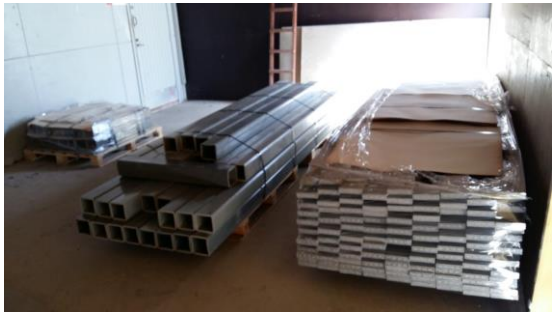
Main outcome:

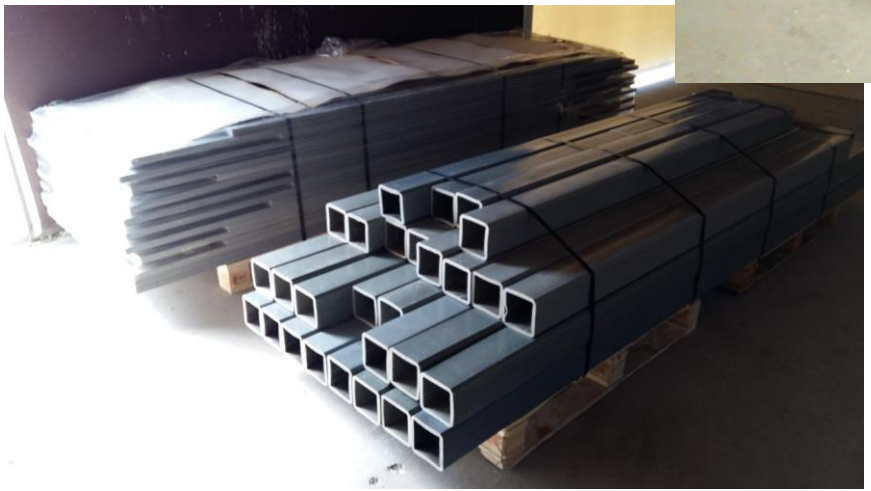
✓ Ecobulk hollow boards (140x28mm) with FRP-waste **are** stronger and stiffer vs. quality commercial WPC decking boards in dry as well as wet conditions

✓ Ecobulk composite panels 390x10mm with FRP-waste **become** stronger and stiffer vs. quality commercial plywood panels when getting into contact with water (EN-test method)



Volume scale piloting with GFRP-waste in FI/UK/PT





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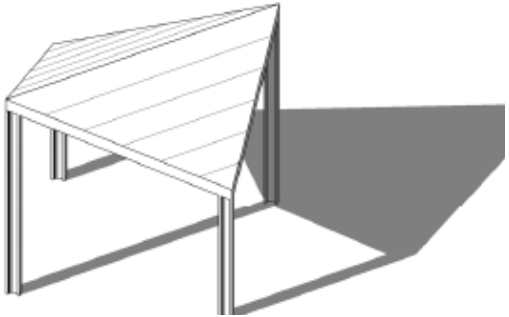
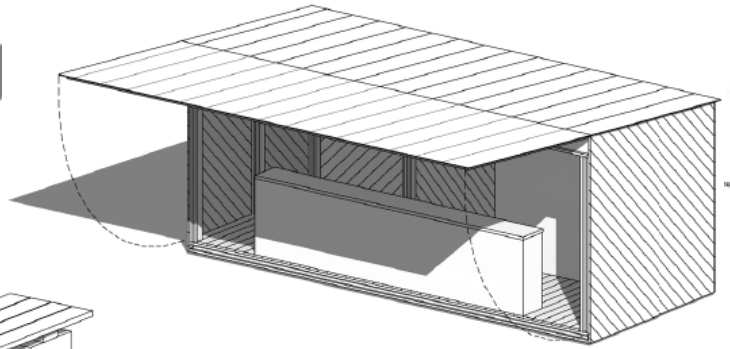
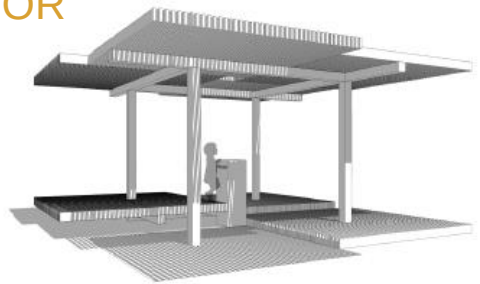
User applications being demonstrated

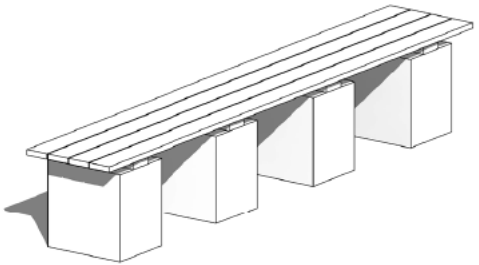
H2020 project **ECOBULK** demos in WP4; FIN-UK-FRA-POR





axonometry





Bench, axonometry

www.ecobulk.eu

https://www.ecobulk.eu/wp-content/uploads/2018/12/D4.4-Demonstration-plans.pdf

Programme under Grant Agreement No. 730456 – WP4 Task Leader Conenor

User applications at LIPOR park in Portugal

Construction

Drinking fountain

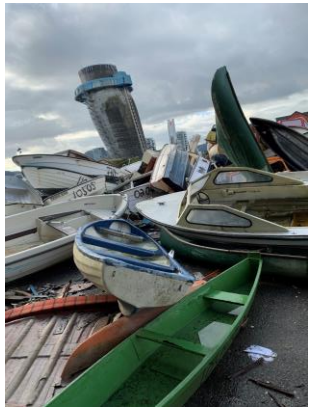
Recycling bin shelter

Rest place around a tree

User applications at Warwick University UK

Gazebo

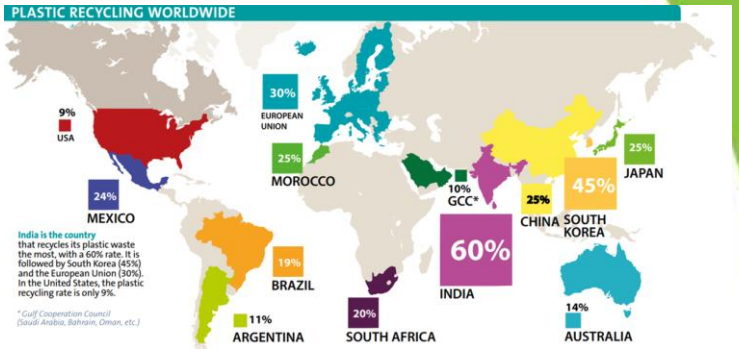
User applications w. boating waste in NOR



Enhancing PE/PP plastics recycling

Stronger and stiffer composite materials at lower cost

- reinforcement in mechanical properties from glass fibres
- stronger and stiffer thermoplastic recyclates
- can be used in higher added value structural applications where they are today non-compatible
- specific characters e.g. fire retardancy applicable
- new reinforced and low cost plastic material from waste enables profitable new volume business in constructions



The European Green Deal Investment Plan

SUSTAINABLE FINANCE

Major private and public investments are needed to transform the EU economy to deliver on climate, environmental and social sustainability goals, including the Paris Agreement and the UN Sustainable Development Goals (SDGs). Sustainable Finance is an important component of the European Green Deal.

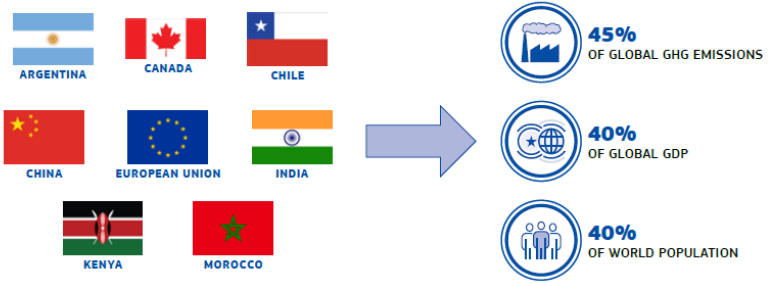
!

Sustainable finance makes sustainability considerations part of financial decision-making. This means more climate neutral, energy- and resource-efficient and circular projects. Sustainable finance is needed to implement the Commission's strategy towards achieving the SDGs.

Integrating sustainability considerations will mitigate the impact of natural disasters as well as environmental and social sustainability issues that can affect the economy and financial markets.

OTHER ONGOING INITIATIVES

INTERNATIONAL PLATFORM ON SUSTAINABLE FINANCE
Platform to exchange and disseminate information to promote best practices in environmentally sustainable finance.



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