Lurederra centro tecnológico · FERVER · MINERALI INDUSTRIALI · Warrant Hub TINEXTA GROUP

SUNRISE

POLYVINYLBUTYRAL (PVB): A BOOST IN THE RECYCLING

An innovative approach of the Sunrise project

Presentation of the SUNRISE project

Angélica Pérez

ECOMONDO
The green technology expo.

Funded by the European Union

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Speaker presentation

Angélica Pérez
Lurederra Technological Centre
angelica.perez@lurederra.es

Angélica Pérez, distinguished Chemical Engineer, began her journey with Centro Tecnológico Lurederra in 2009.

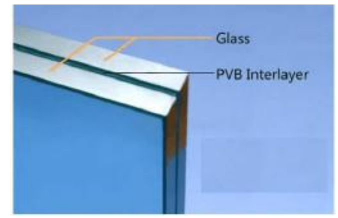
Starting as a technical researcher, Angélica progressed to managing numerous national and international projects related with nanomaterials production and recycling. By 2015, she advanced to the role of European Project Manager at Lurederra.

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958243”.

SUNRISE

What is laminated glass?

Laminated glass is obtained by bonding glass layers using a polymeric interlayer. **Polyvinyl Butyral (PVB)** is used as interlayer in laminated glass and their use in construction components is growing, therefore the end-of-life should be addressed.



The waste, the problem

Laminated glass wastes from construction and automotive origin are recycled by glass recyclers around Europe. However, the target is to recover the glass, **PVB is is considered a waste** in the glass recycling process. Up to now, most of the **post-consume PVB** material in laminated glass is incinerated/landfilled, and **only a 9 % is recycled in secondary uses**.

Up to 1 250 352 tons/year of laminated glass wastes

More than 125 000 tons of PVB wastes

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

ECOMONDO
The green technology expo.

PVB, challenges for circular recycling in laminated glass

1st) Glass content in re-PVB will result in haze and turbidity

2nd) Aging of laminated glass and PVB (exposure of waste at outdoor conditions) is an extended practice in glass recycling, facilitating the separation of the glass from the PVB

3rd) Variability of PVB interlayer compositions, blending PVBs with different compositions can result in haze and turbidity

- Plasticizer types and contents
- Different interlayer functions: acoustic, solar control, uv blocking…
- Different configurations: monolayer, multiple layer

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

SUNRISE –THE PROJECT

MultiSensor sorting tools in a circular economy approach for the efficient recycling of PVB interlayer material in high-quality prodUcts from laminated glass coNstRuction and demolItion waStEs

Project data:

STARTING DATE: 1st June 2021

TOTAL DURATION: 42 MONTHS

PARTNERS: 20

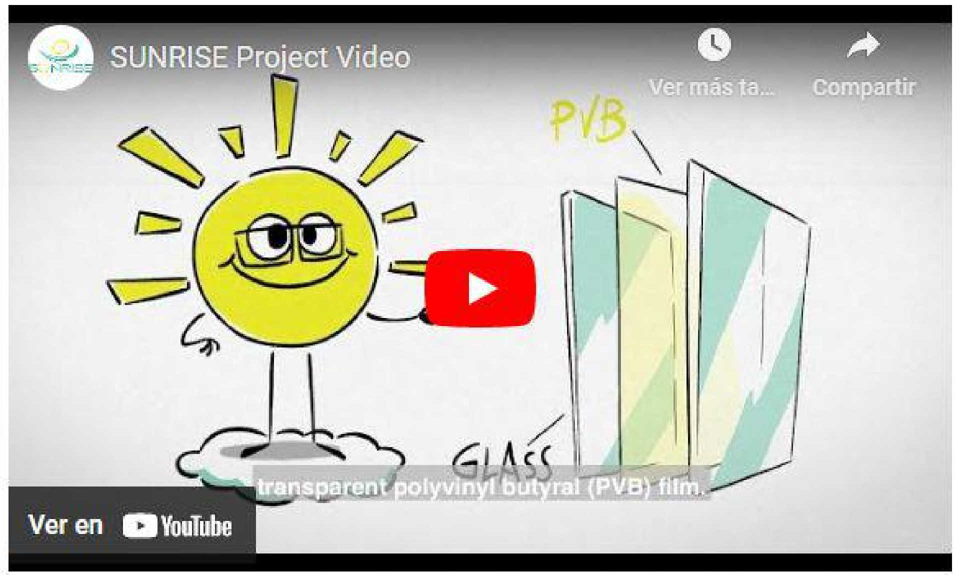
GLOBAL BUDGET: 9 499 371.25 €

EC CONTRIBUTION: 8 040 302.51 €

TOPIC: CE-SC5-07-07-2020

COORDINATOR:

Lurederra centro tecnológico

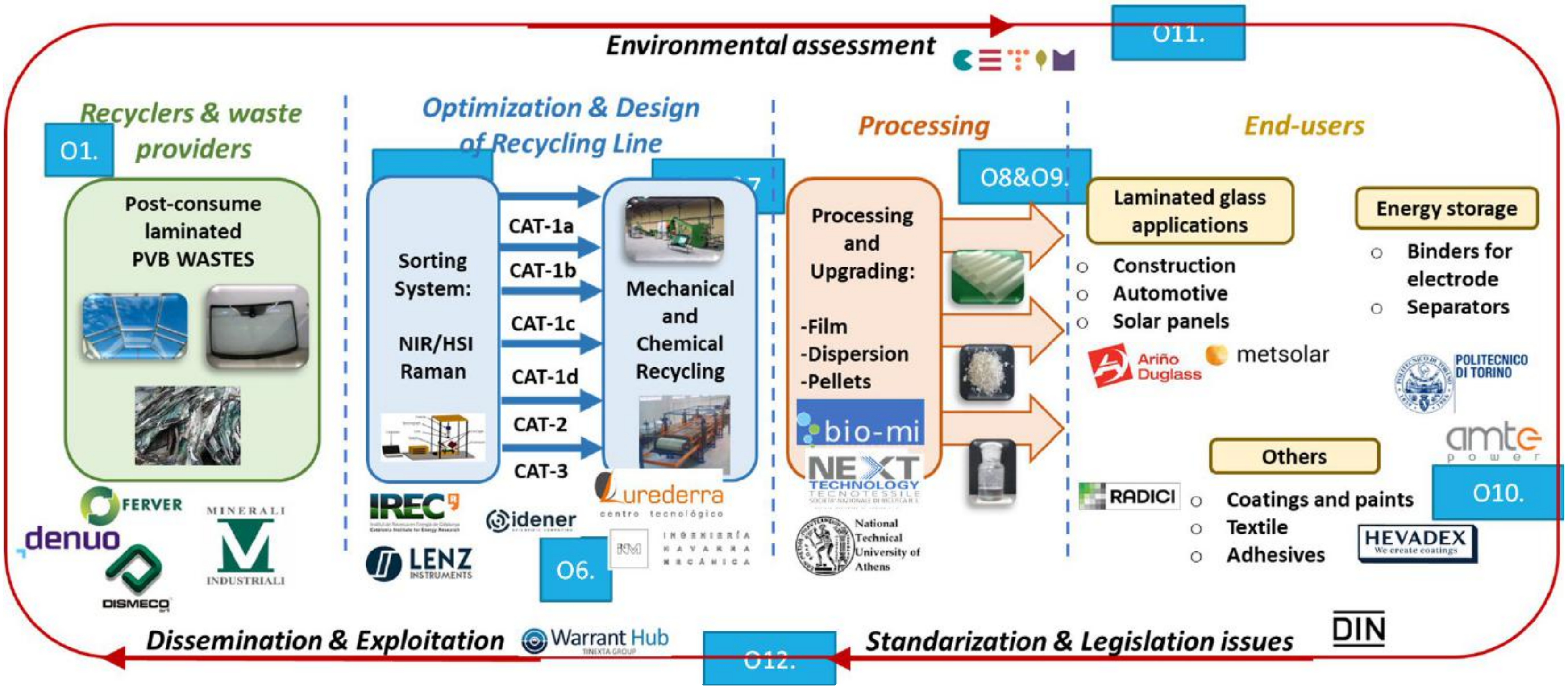


“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958243”.

ECOMONDO The green technology expo.

Structure and Objectives

SUNRISE

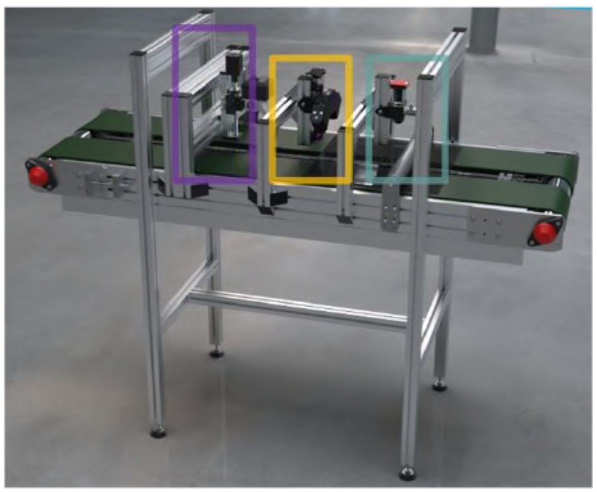


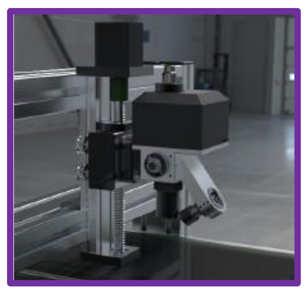
"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

ECOMONDO
The green technology expo.

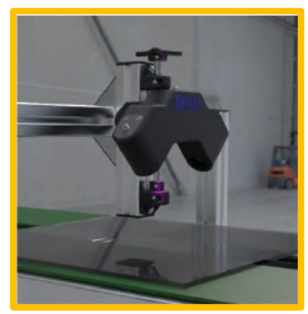
Development of the Multisensor tool

- **Multisensor sorting** system based on advanced characterization spectroscopic techniques (**Raman, NIR and transmittance).**
- The prototype tool allows fast inspection (33 seconds for whole area inspection), allowing a **sorting capacity higher than 100 laminated glass/hour.**
- Haze measurement method allow to detect the haze value with accuracy ±1 % points





Raman probe head

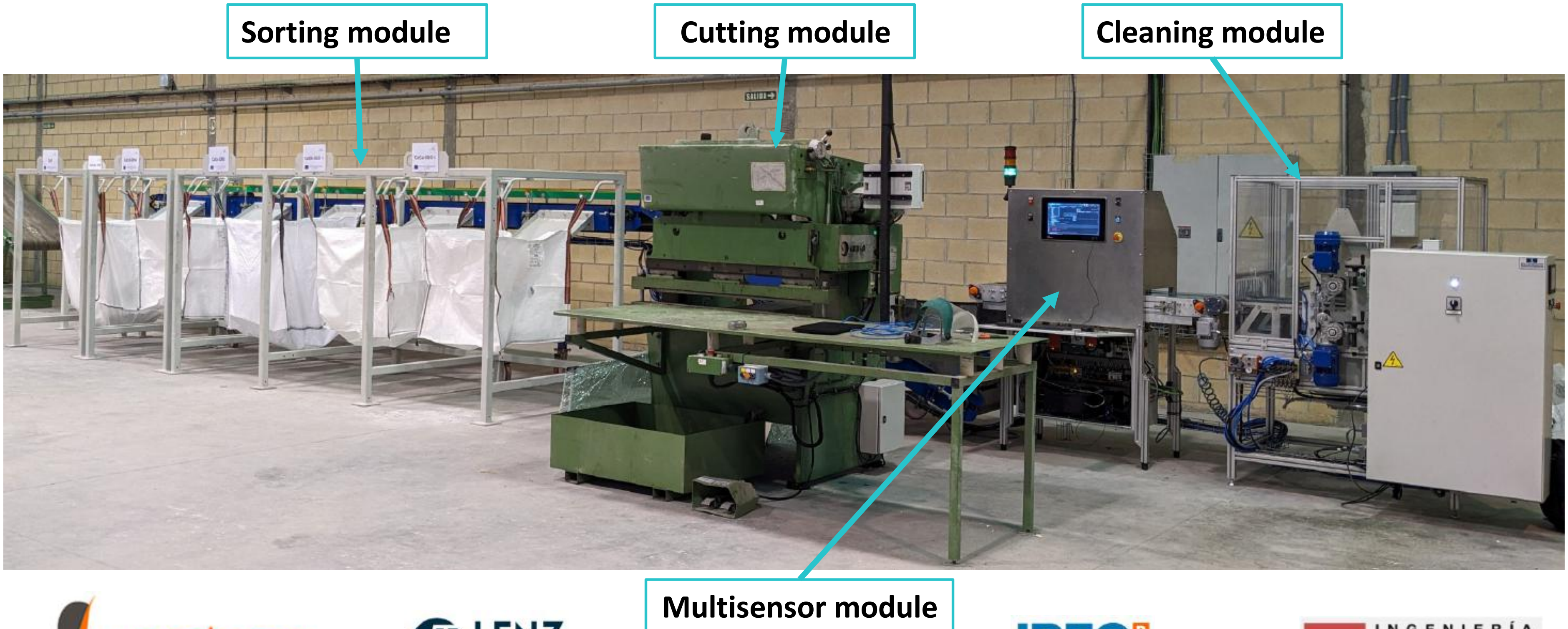


NIR probe head

Integrated probe head

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Implementation of the full sorting system



"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Sorting categories

AI algorithms has been used for real time assessment of the laminated glass wastes by correlating the spectral data with the target properties and for sorting the laminated glass wastes in qualities and pre-defined compositions for recycling.

Category	Subcategory	Description	Critical parameter to evaluate
Cat1	High quality interlayer laminated glass waste-only PVB		Low degradation level according to haze and yellowness
	Cat1a	Plasticizers of ethylene glycol oligo-esters chemical class (plasticizer content <32%)	Additional identification of plasticizer type
	Cat1b	Plasticizers of ethylene glycol oligo-esters chemical class (plasticizer content >32%)	
	Cat1c	Plasticizers of dibutyl sebacates chemical class	
	Cat1d	Plasticizers of dihexyl adipate chemical class	
Cat2	N/A	Low quality interlayer laminated glass waste-only PVB	Higher degradation level according to haze and yellowness
Cat3	N/A	Rejection. Non-classified and non-PVB	

- NIR and Raman are equally sensible to identify PVB from non PVB and also in identifying the presence of 3GO as plasticizer
- Discrimination between DBS and DHA plasticizers is better with Raman data
- Prediction of quantification of plasticizer content is more complex (more data are needed)

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Mechano-chemical treatment

SUNRISE

Previous sorting module has been integrated together the mechano-chemical pilot line with a capacity to produce 360 Kg/h (544 tons/year) of recycled PVB capable to remove the 98% of glass and obtain a PVB with a moisture < 2%.

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958243”.

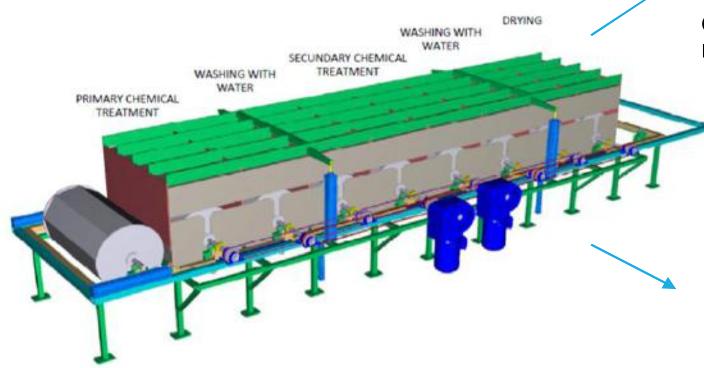
Mechano-chemical treatment

To integrate previous sorting module to a mechano-chemical pilot line with a capacity to produce 360 Kg/h (544 tons/year) of recycled PVB capable to remove the 98% of glass and obtain a PVB with a moisture < 2%.

Inorganic content of various samples of PVB from automotive glass waste.

Batch number	Category	Inorganic content after mechanical	Inorganic content after chemical
1	Waste mix	2.06	0.48
2	Cat 1b	1.59	0.57
3	Cat 1b	1.45	0.31
3´	Cat 1b	1.44	0.29
5	Cat 1b	1.36	0.27

INPUT: PVB FLAKES
(< 5% glass)



OUTPUT: CLEAN PVB FLAKES

Waste (Glass powder)

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Processing of re-PVB- Thermal re-stabilization

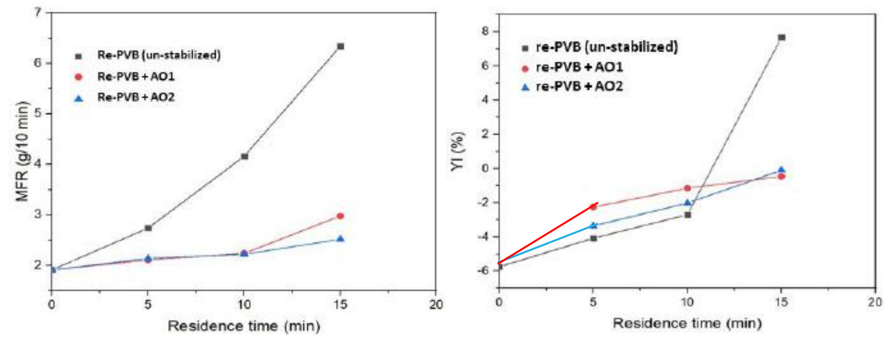
NATIONAL TECHNICAL UNIVERSITY OF ATHENS

bio-mi SUSTAINABLE SOLUTIONS

SUNRISE

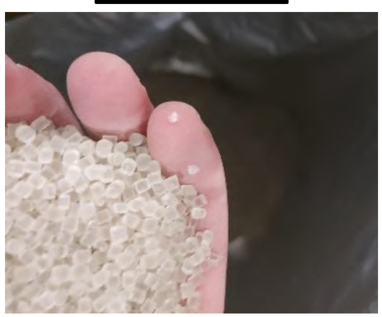
FLAKES

Lab scale screening of AOs in the Internal Mixer



AOs "cure" degradation of PVB (retention of MFR) and inhibit yellowing

PELLETS



Results:

- Reprocessing of PVB → thermo-oxidative degradation → Increase of MFR and yellowness
- AO additives studied in the range of 0.1 to 0.5 wt % → inhibition of degradation → Processing Stability
- Selection of best performing additives in terms of degradation inhibition, yellowness control and transparency
- Adoption of in the pilot scale confirmed AO protect the material during its second life cycle, limiting degradation and yellowness

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

ECOMONDO The green technology expo.

Film production and lamination

To ensure the circular economy concept in the project by demonstrating the production of recycled PVB film for laminated glass applications with high optical and mechanical properties

PELLETS

FILM

Results:

- Lurederra re-PVB materials results in much clearer film than currently benchmarked one
- Mixtures of virgin/re-PVB are being processed to fulfill requirements
- Films are being tested in laminated glass for construction sector and for solar applications

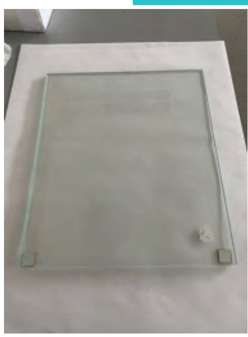
"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Film production and lamination

SUNRISE

Validation by end-user companies including the production of prototypes of laminated glass for construction sector and solar panels

LAMINATES



	Virgin film reprocesed	Mixture virgin/recycled
Transmittance, %	85.8	83.7
Haze, %	1.45	2.49
Yellownes index, %	8.7	9.3
Inorganic content	N/A	0.27 %

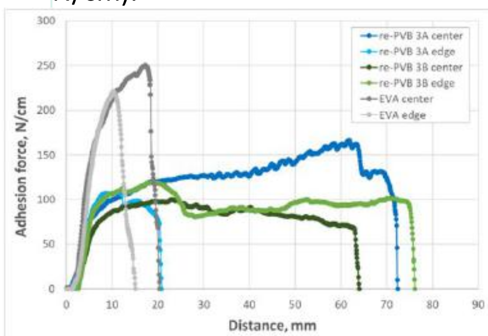
Ariño Duglass

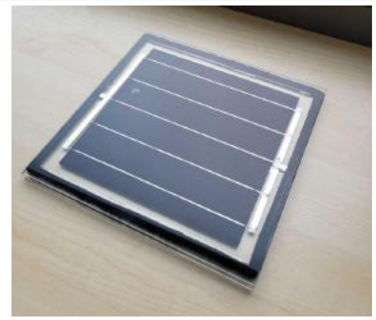
PV PANELS

Encapsulant:	Average transmittance:
100% recycled PVB	68.71%
Commercial PVB	68.37%
EVA	70.24%

met.

Laminated glass samples with EVA had higher adhesion strength (from 128.0 to 176.2 N/cm) compared to PVB (from 81.4 to 123.8 N/cm).





"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

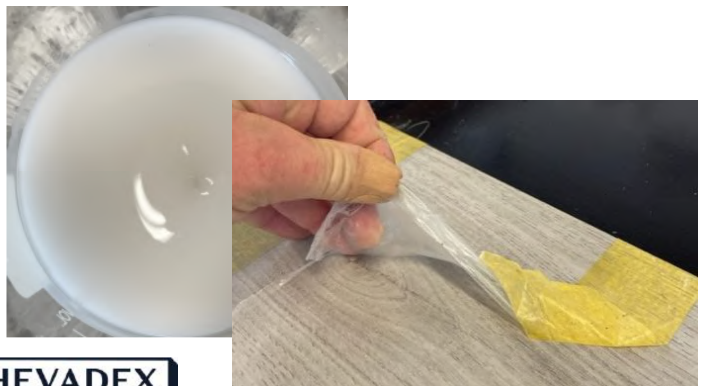
ECOMONDO
The green technology expo.

Other applications

DISPERSION/DISOLUTIONS

SUNRISE

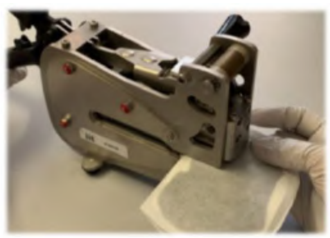
To revalorise other PVB fractions by the production of dispersions and solutions for coatings, carpets and high-value products in energy storage sector such as binder for electrodes processing for batteries

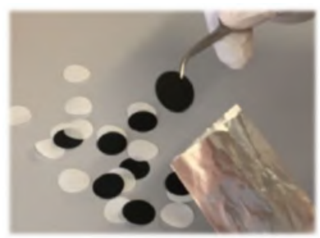


HEVADEX
We create coatings

NEXT TECHNOLOGY TECNOTESSILE
SOCIETÀ NAZIONALE DI RICERCA R. L.

RADICI





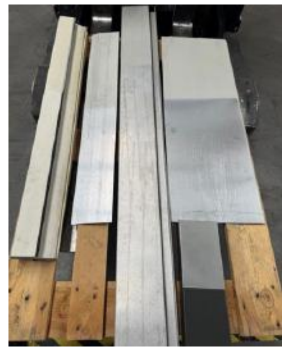
Politecnico di Torino
1859

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

ECOMONDO
The green technology expo.

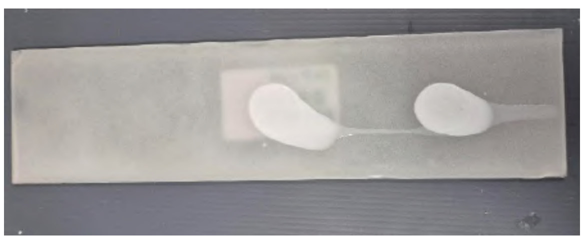
Peelable coatings for construction



Applied by airless spray equiment on glass, aluminium, pvc

PARAMETER	VALUE
Density	1.01 kg/L
pH	9.8
Brookfield Viscosity @ 20°C	20rpm = 5030 mPas 50rpm = 8840 mPas 100rpm = 17900 mPas
Tensile strength	9.8 MPa
Elongation	183 %
Light Transparency of coating	Translucent
Peelability	Easily peelable on most substrate
Spray test with airless	Easily sprayable
Drying time (20°C & 52% RH @ 800µm wet-film thickness)	3hr:09min



Maximising water/weather resistance

Characteristics:

- Sprayability (airless)
- UV resistance
- Rain resistance
- Early water repellency
- Light transparency

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Coatings on textile sector

Re-PVB coating on textiles for UV-protection

Steps of Spray coating:
- ✓ Spraying of the re-PVB (5 %w) dispersion containing a crosslinker on the synthetic textile,
- ✓ Drying in the oven at 160 °C for 6 min.

- ✓ Rapid technique of application,
- ✓ Homogeneous, colourless and durable coating,
- ✓ Flexible textile.

Use of organic and inorganic UV-absorbers in combination with re-PVB

Sample	UPF mean value	Transmittance (%) UVA–UVB
Uncoated fabric	236 ± 14	2 – 0.2
Re-PVB (5 %w) dispersion + crosslinker	666 ± 34	0.9 – 0.1
Re-PVB (5 %w) dispersion + crosslinker + Organic UV-absorber	1248 ± 57	0.5 – 0.1
Re-PVB (5 %w) dispersion + crosslinker + Inorganic UV-absorber	1005 ± 31	0.6 – 0.1

Standard test method UNI EN 13758-1:2007

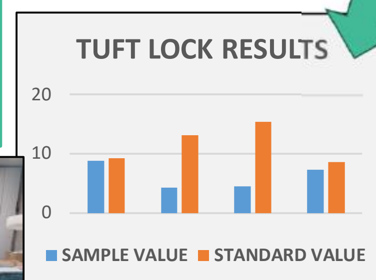
Application of re-PVB in carpet production

Re-PVB flakes

Dissolution of re-PVB (17%)

Re-PVB latex product

- ✓ Re-PVB latex is used to fix the pile to the backing structure of the carpet.
- ✓ Laboratory tests on different fibers (natural and synthetic) and carpet backing (action and felt).



Performance analyses on the samples: comparison with standard latex carpets

Laboratory test

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958243”.

ECOMONDO The green technology expo.

PVB application in Li- and Na-ion batteries

PVB as Innovative Polymeric Binders

- The substitution of a fraction of standard polymer binders (PVdF or PAA) with pure PVB can be effective for both Li- and Na-ion batteries up to 20-50%.
- Recycled PVB can be used as well, displaying excellent specific capacity and C-rate capability, but with a low initial coulombic efficiency during the first cycles due to secondary reaction of plasticizers/contaminants (to be optimized).

PVB as Innovative Polymeric Separators

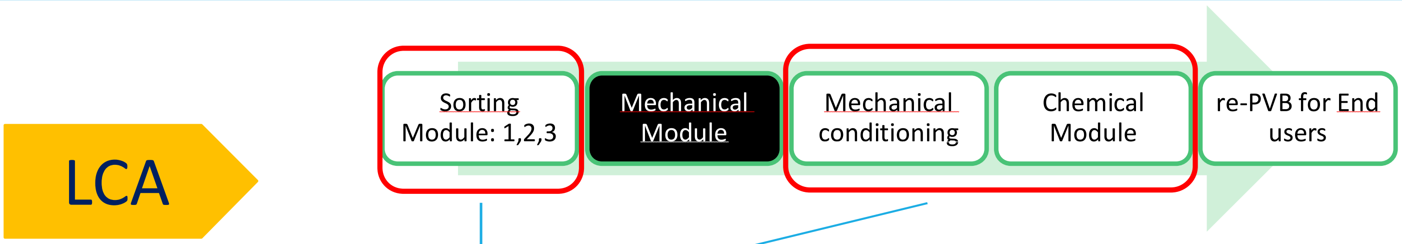
- Light and thin PVB-based membranes were prepared by cross-linking reaction with a diisocyanate.
- The membranes were successfully tested as electrolyte separators in Li-ion batteries (electrolyte uptake as high as 221%, electrochemical stability up to 4.7 V).
- To prepare the membrane with recycled PVB the procedure was optimized, thus forming a dense elastomeric membrane, compatible with metal Li and stable upon cycling.

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958243”.

Environmental outcomes

SUNRISE

To evaluate positive techno-economic and environmental outcomes of the PVB recycling solution in SUNRISE. These impacts will be compared to current end-of-life scenarios and to virgin production of PVB.



SCENARIO	Carbon footprint per FU (kg CO_2 eq.)	% carbon reduction achieved by SUNRISE (target: 80%)
S1 (SUNRISE with reprocessing)	**1453**	----
S2 (WtE)	4351	67%
S3 (Landfill)	2953	51%
*PVB conventional production (*GaBi*) without waste PVB management	4804	70%

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

ECOMONDO
The green technology expo.

Techno-economic outcomes

SUNRISE

To evaluate positive techno-economic and environmental outcomes of the PVB recycling solution in SUNRISE. These impacts will be compared to current end-of-life scenarios and to virgin production of PVB.

LCC

Sorting Module: 1,2,3

Mechanical Module

Mechanical conditioning

Chemical Module

re-PVB for End users

Lurederra centro tecnológico

S1) PVB recycling

- 1 t PVB recycled as in SUNRISE
- Added sorting and mechano-chemical steps
- Different formats and prices

S2) PVB incineration

- 1 t PVB disposed in WtE facility
- 65-150 €/ton.

S3) PVB landfilling

- 1 t PVB disposed in landfill
- 35- 175 €/ton

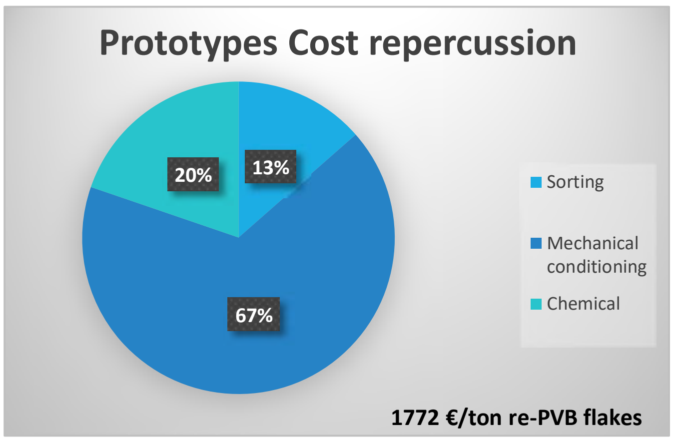
“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958243”.

ECOMONDO The green technology expo.

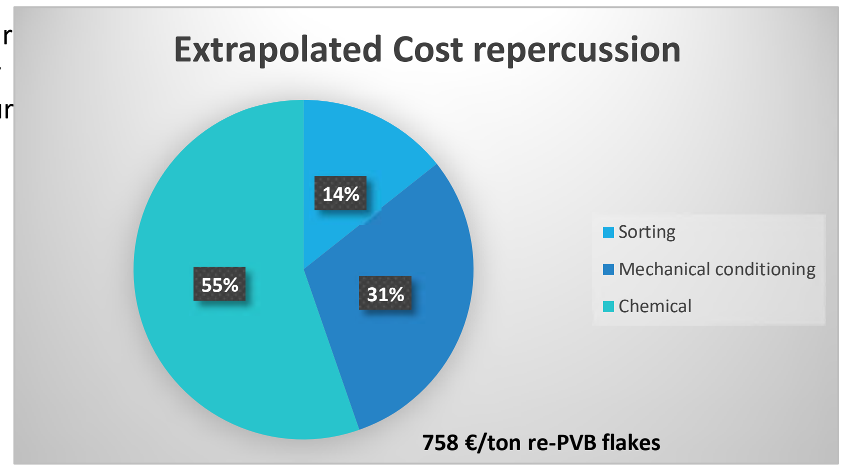
Techno-economic outcomes

To evaluate positive techno-economic and environmental outcomes of the PVB recycling solution in SUNRISE. These impacts will be compared to current end-of-life scenarios and to virgin production of PVB.

LCC



Economy of scale:
Sorting: 300units/hour
Mechan.: 400kg/hour
Chemical: 365 kg/hour

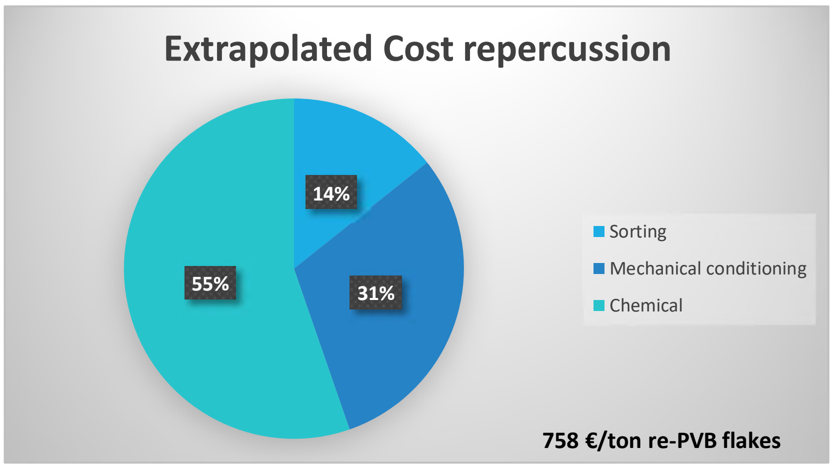


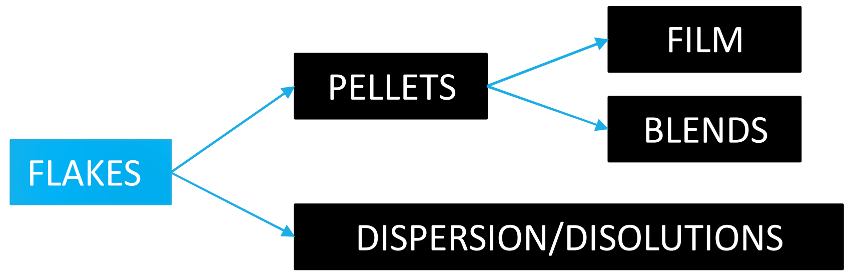
"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

Techno-economic outcomes

To evaluate positive techno-economic and environmental outcomes of the PVB recycling solution in SUNRISE. These impacts will be compared to current end-of-life scenarios and to virgin production of PVB.

LCC



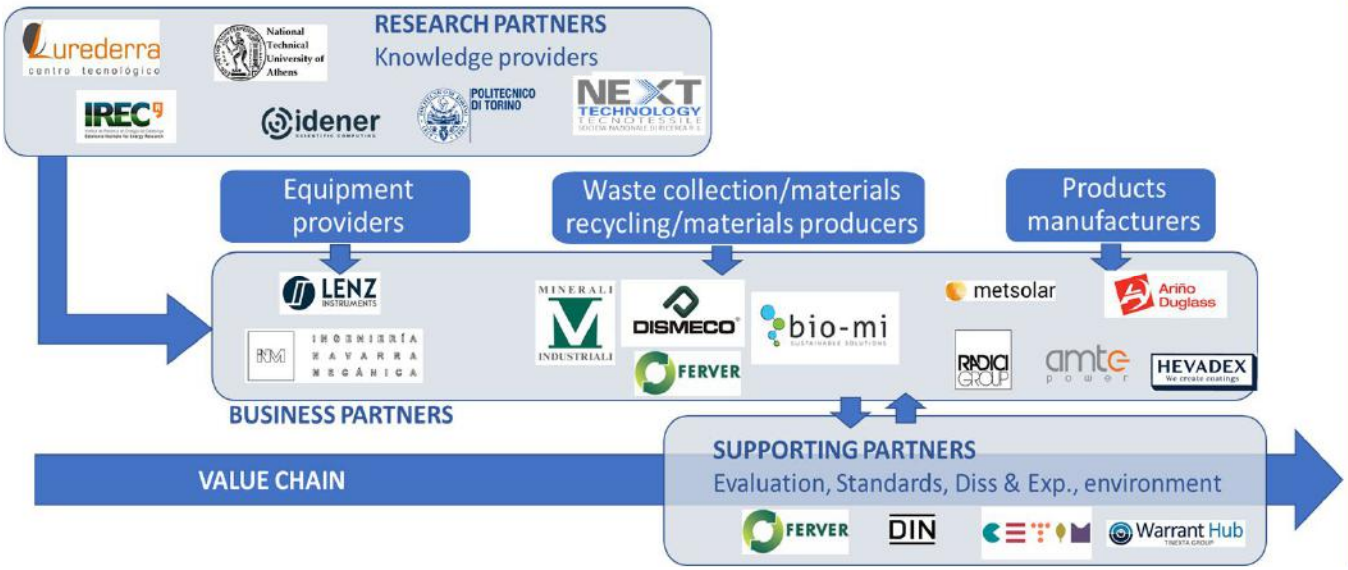


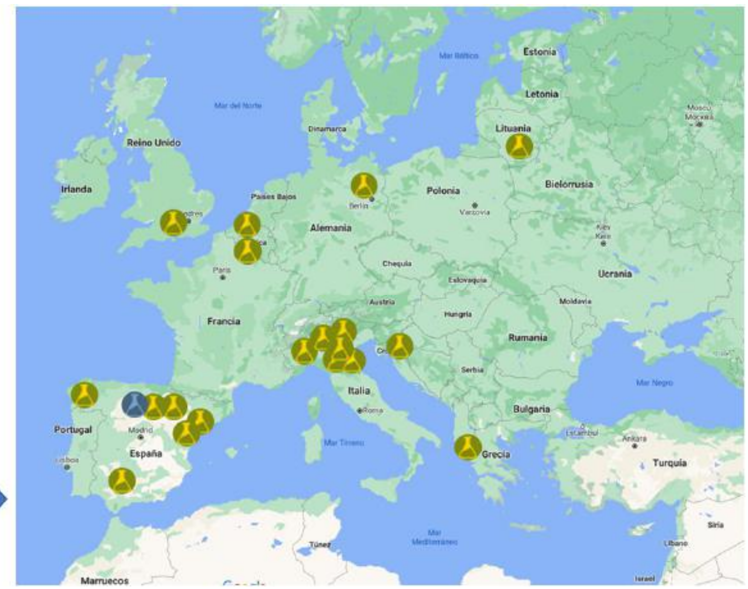
Market Prices

Re-PVB	Price
Re- Foil PVB	270-430 €/ton
Re- PVB flakes	1000 €/ton
Granulated Re-PVB	1200 – 1600 €/ton

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

SUNRISE TEAM





"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".

ECOMONDO
The green technology expo.

SUNRISE

POLYVINYLBUTYRAL (PVB): A BOOST IN THE RECYCLING

An innovative approach of the Sunrise project

Thanks for your attention!

ECOMONDO
The green technology expo.

Funded by the European Union

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958243".