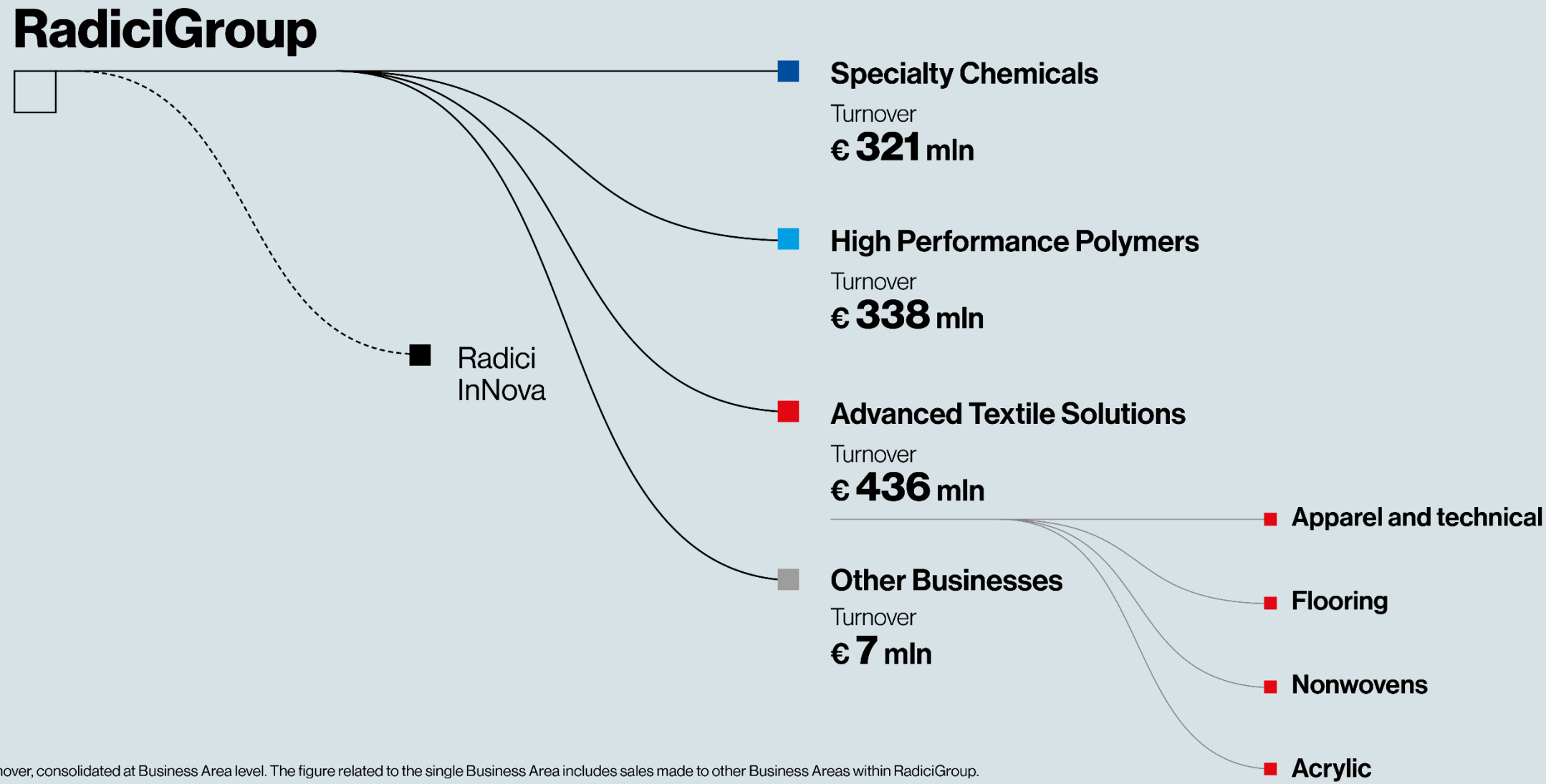
New Generation of Sustainable Materials: Technical and Environmental Performances

Riccardo Galeazzi

CAE Service Engineer, Post-consumer Product Manager

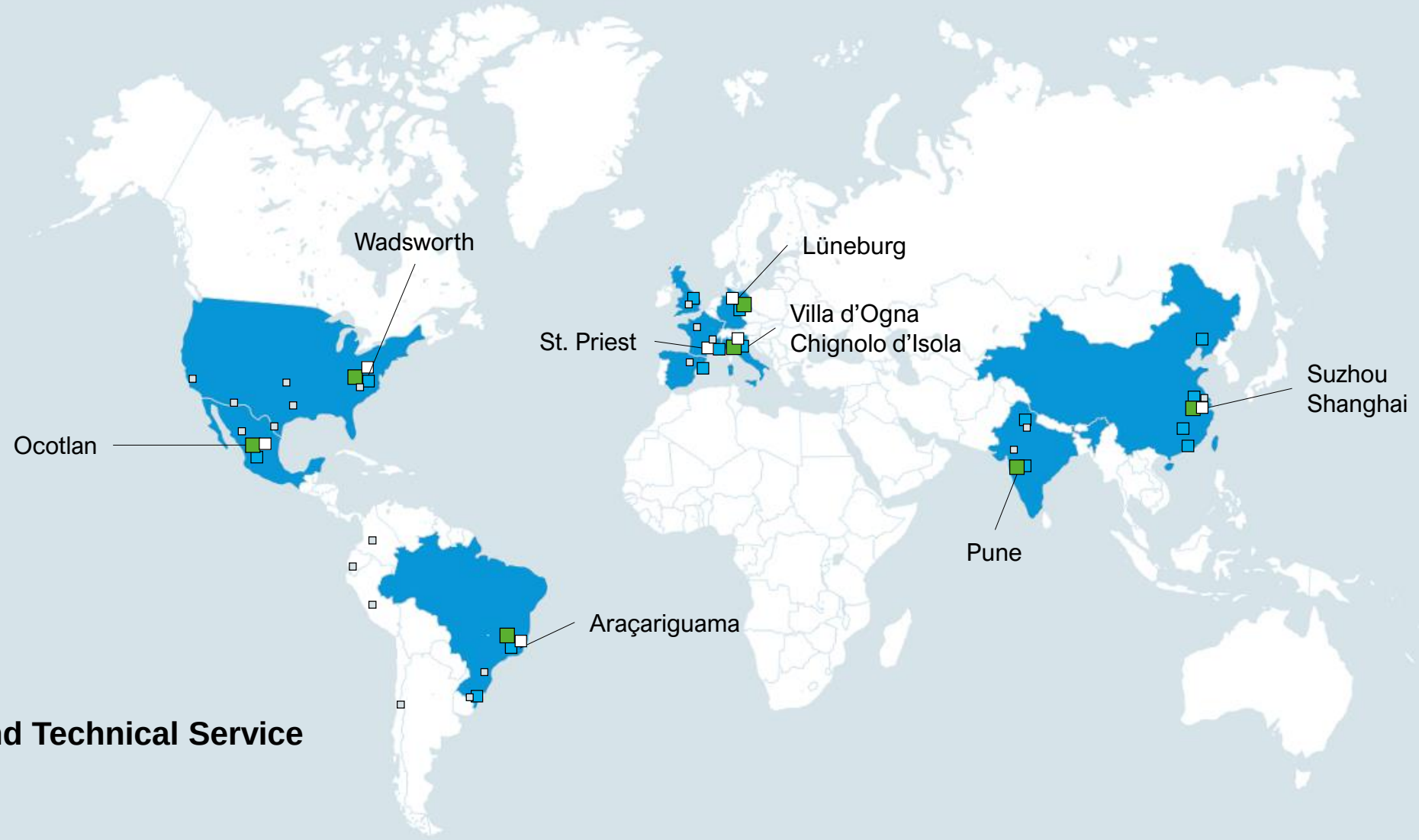
Webinar | December 1st 2021

Organizational structure



2020 turnover, consolidated at Business Area level. The figure related to the single Business Area includes sales made to other Business Areas within RadiciGroup.

High Performance Polymers - Global presence



- **Production unit**
- **Development and Technical Service**
- **Sales office**
- **Warehouse**

From RadiciGroup Vision & Mission to High Performance Polymers Facts

RadiciGroup

Vision

- **To be one of the leading chemical groups** in the polyamide, advanced textile solutions and high performance polymers production chain.

Mission

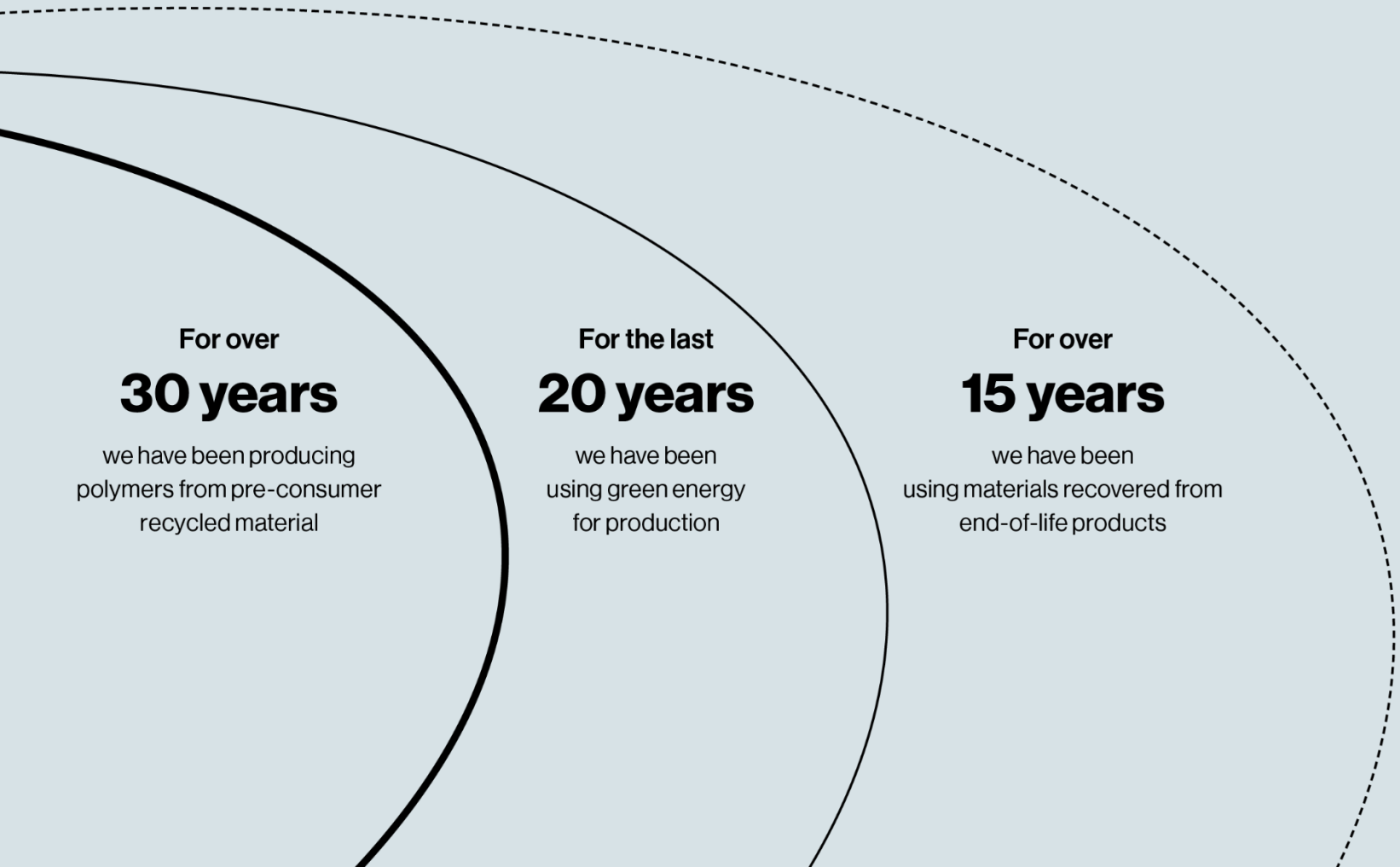
- To promote the **development of our businesses** while pursuing our Group values and culture.
- To pursue our vision by valorizing and **optimizing our resources**, **establishing alliances** and **searching for new markets**, including niche markets.
- To **embed sustainability** into new product and application **development.**

High Performance Polymers

Facts

- Growth through **innovation and sustainability** of all our processes and products.
- **Vertically integrated** polyamide production and specific **chemical know-how**.
- **Worldwide presence** with a complete range of materials and **tailored solutions**.
- Our **people's expertise** and support, offering our customers a competitive advantage.

Product sustainability comes from far back

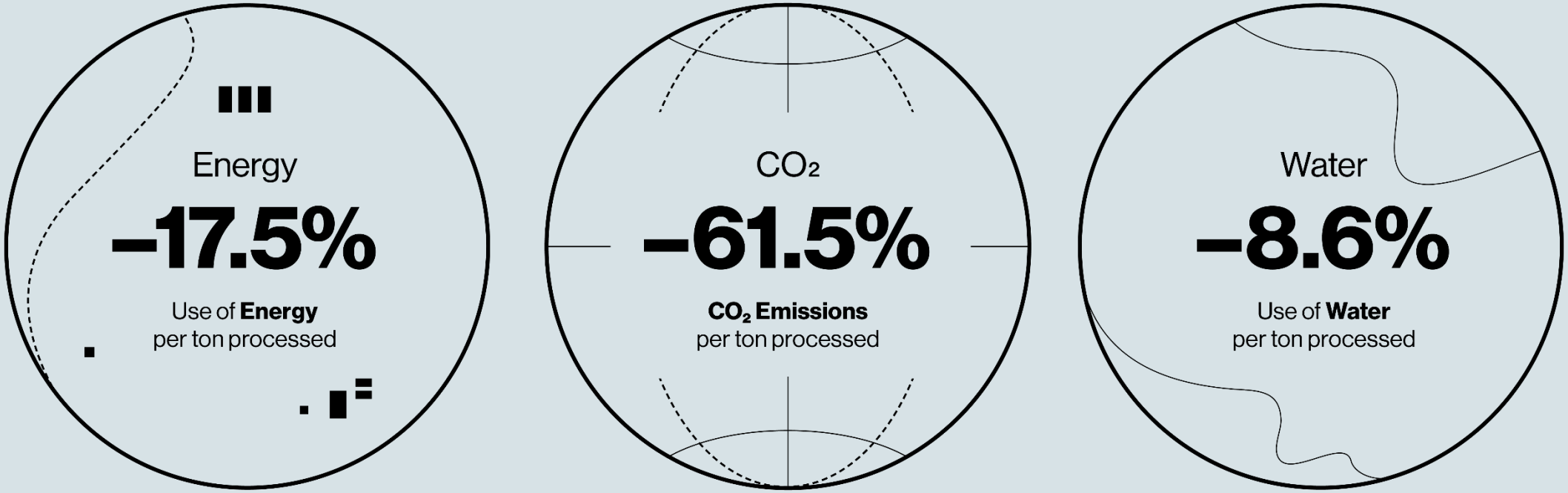


- **Innovation and ecodesign** as guidelines.
- **Measured** sustainable **performance**.
- **Optimized** production **processes.**
- **Supply chain integration**.
- **Transparent communication**.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Sustainability: Last 10 years' milestones

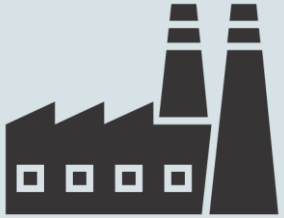


Data Source: RadiciGroup Sustainability Reports - www.radicigroup.com

Product definition by raw material source

Virgin material

This material is produced starting from the chemical precursors of the base polymers.



Post-industrial material

Material diverted from the waste stream during a manufacturing process.

Post-consumer material

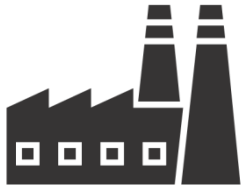
Material generated by households or by commercial, industrial and institutional facilities as end-users of products which can no longer be used for their intended purpose.

RadiciGroup High Performance Polymers,
a leader in recycled engineering polymers,
wants to express
its commitment to sustainability
through concrete action.

Our answer is….

RENYCLE®

nylon after nylon



New **sustainability**-oriented product range of **materials** from **post-industrial** and **post-consumer** sources

Lower and measurable environmental impact

Safety

Reliability

Traceability

Quality

CERTIQUALITY

ATTESTATO DI CONVALIDA
DICHIARAZIONE AMBIENTALE DI PRODOTTO
ENVIRONMENTAL PRODUCT DECLARATION
P4419

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO
DAP n. 003 H
Membro degli Accordi di Mutuo riconoscimento EA, IAF e ILAC.
Signatory of EA, IAF and ILAC Mutual Recognition Agreements.

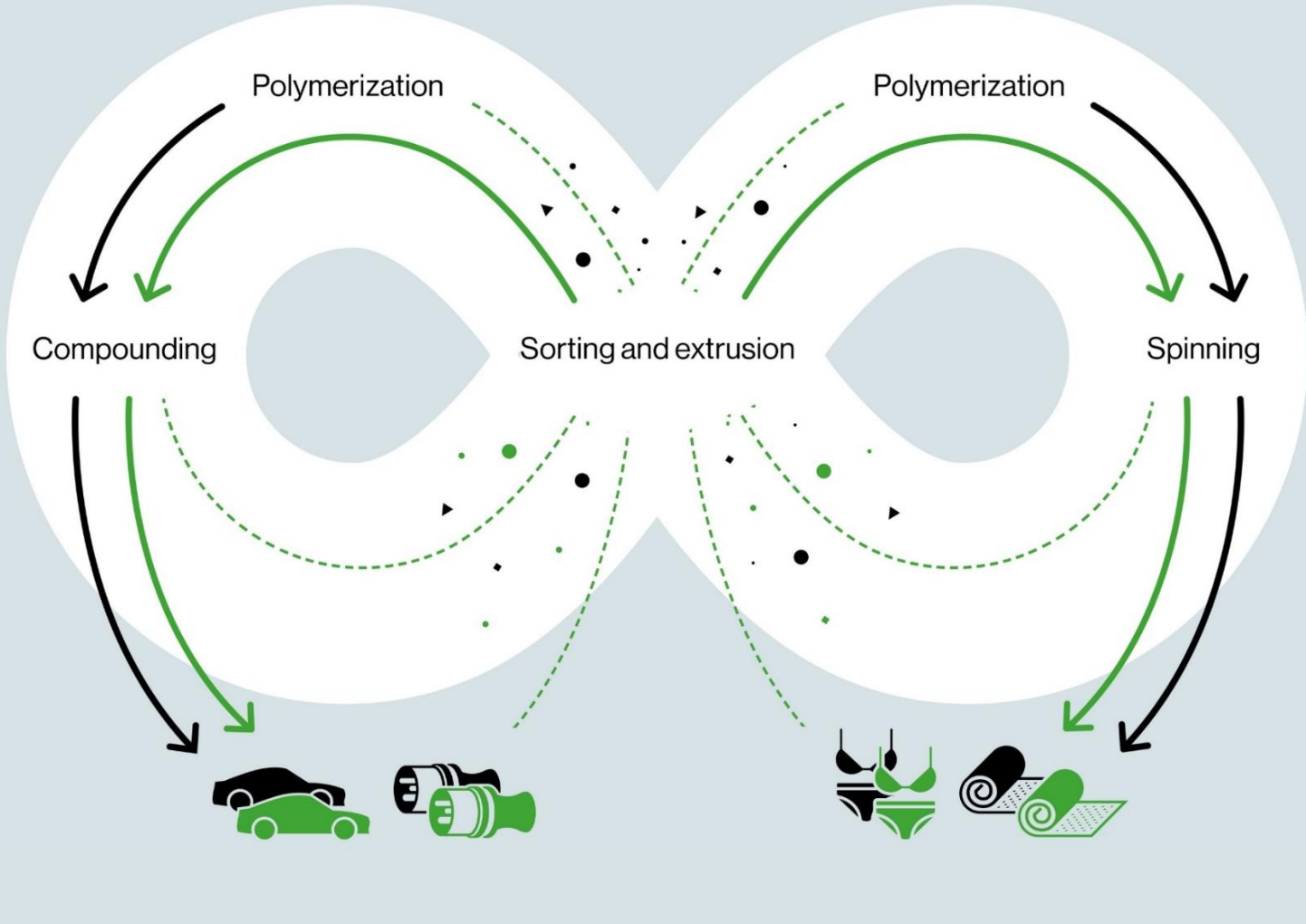
EPD®
THE INTERNATIONAL EPD® SYSTEM

RENYCLE® is the answer to:

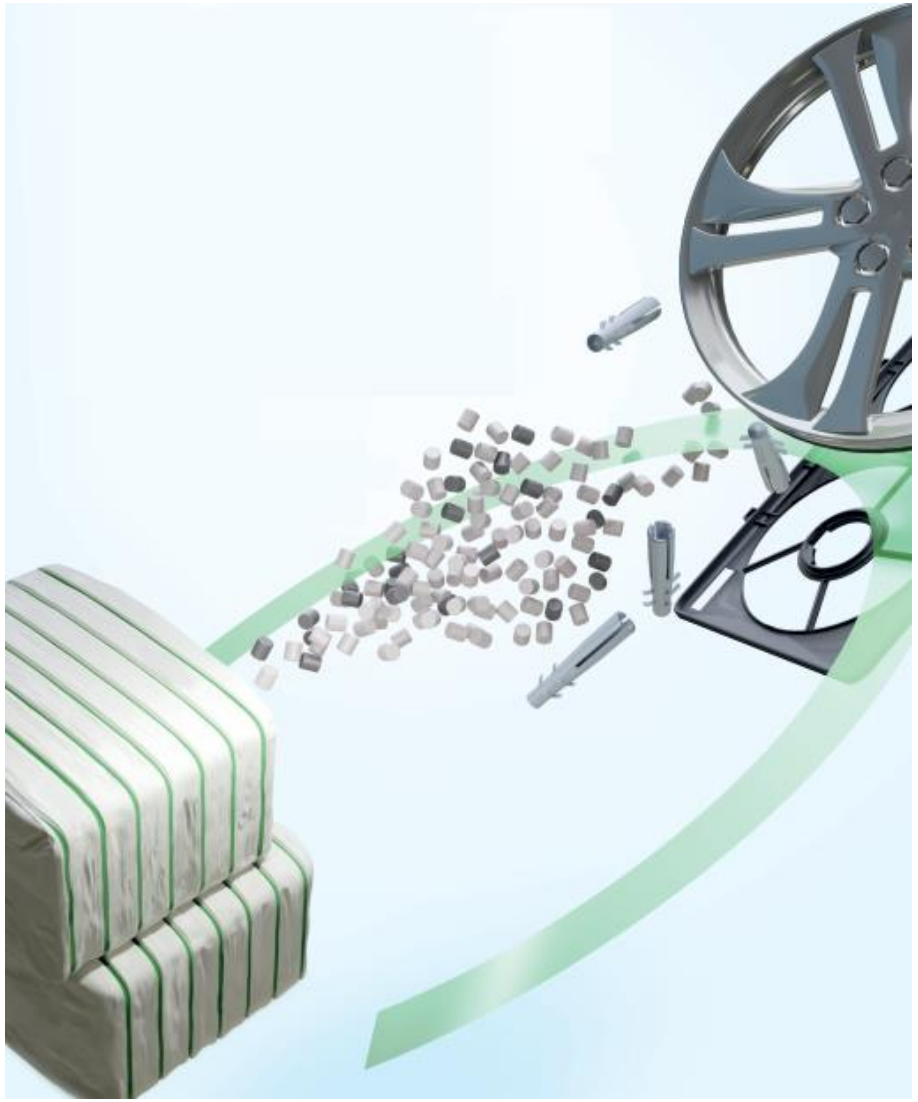
- **Customers** who want to reduce the environmental impact of their finished products and are committed to make environmentally conscious choices.
- **The evolving legislative context,** which is shifting more and more towards the reuse and recycling of materials now considered waste (so-called End-of-Life materials).
- **The need for stricter controls and standards** to guarantee the safety and traceability of the raw materials used.
- **Society** in general, which is asking industry to make a greater and more tangible commitment to sustainability.
- **Ensuring the right selection, treatment and characterization** of post-consumer and post-industrial materials.

RadiciGroup High Performance Polymers has decades of experience in the recycling field

RadiciGroup, thanks to its long-standing know-how in material formulation and recycling, is able to **convey scraps either to the same industry they came from or to a different one**.
Choosing the most sustainable solution depends on the specific characteristics of the materials and the performance expected from the final applications.



Consolidated tradition of post-industrial material production

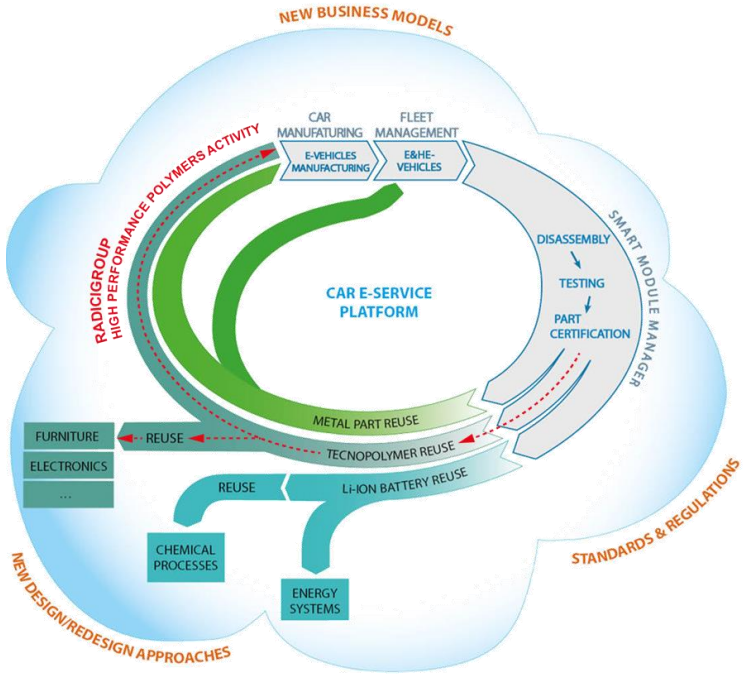


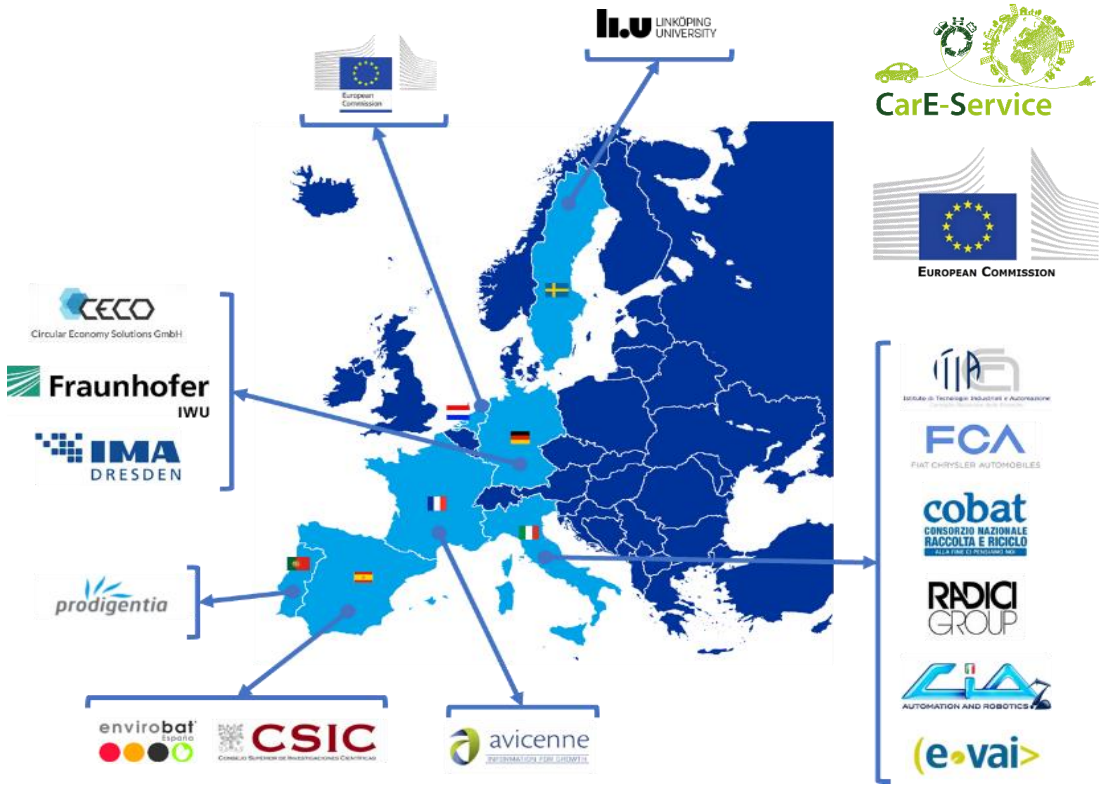
Low environmental impact PA6 and PA66 polymers made of 100% selected materials, primarily recovered from the production units of RadiciGroup High Performance Polymers Business Area.

Outstanding experience in post-consumer materials

Circular Economy Business Models for innovative hybrid and electric mobility through advanced reuse and remanufacturing technologies and services.

- **Acronym:** CarE-Service
- **Duration:** 42 Months
- **Kick Off:** 1 June 2018
- **Type:** H2020-CIRC-2017
- **15 Partners**





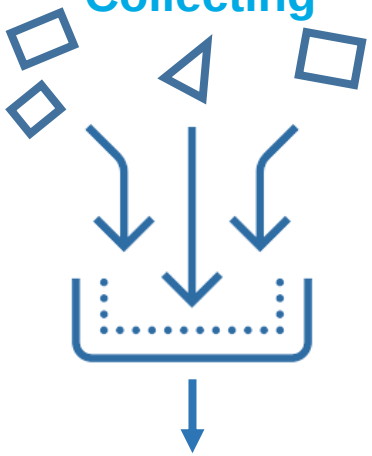
This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 776851.

RENYCLE® Production process stages

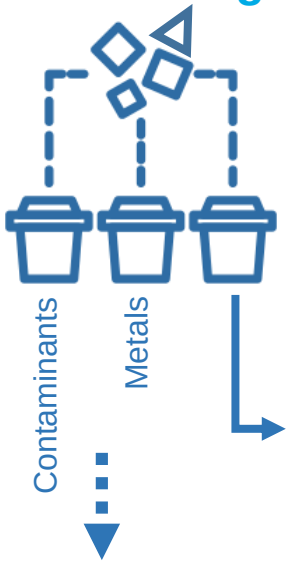
R&D 1

R&D 2

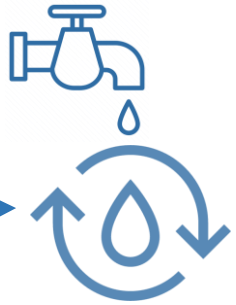
Collecting



Selecting



Cleaning



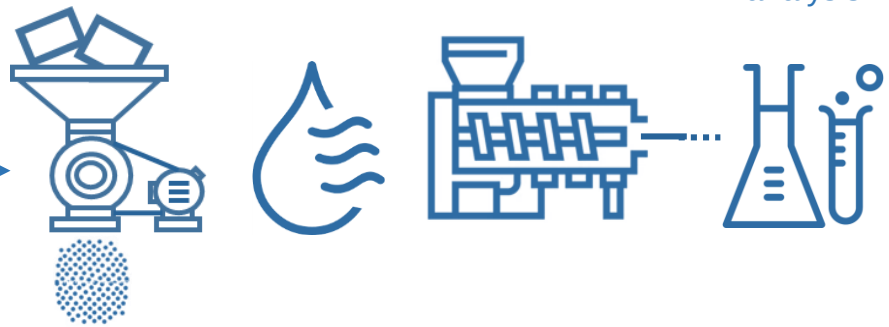
Raw material preparation

Grinding

Drying

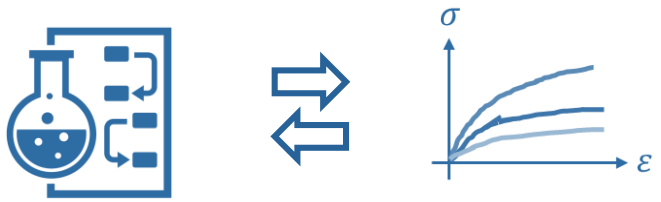
Regranulation

Chemical analysis

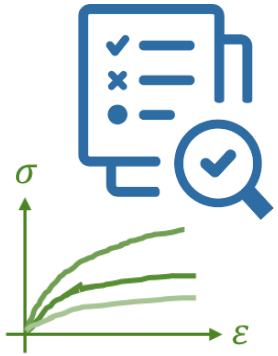


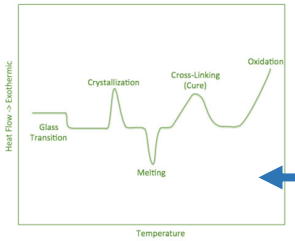
Formulation tuning

is performed to meet the requirements of our customers' applications



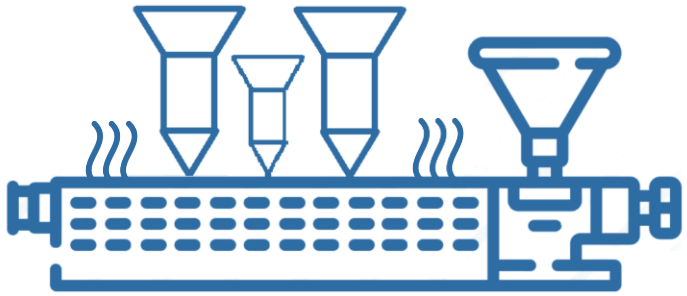
Material characterization





RENYCLE®

Production

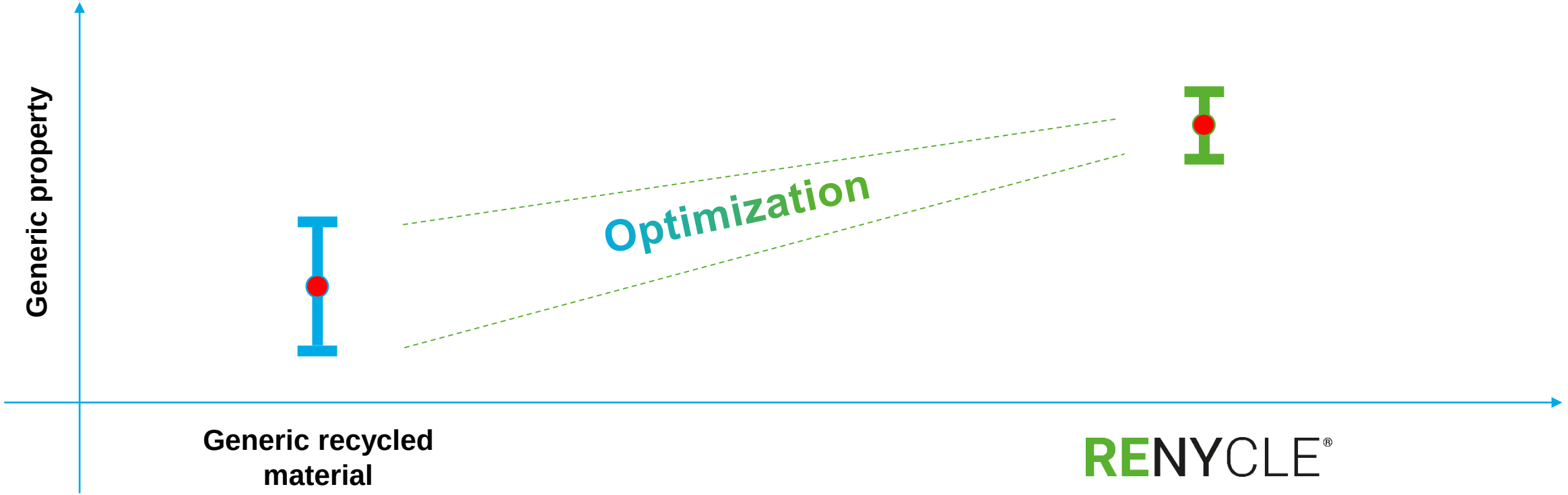


RENYCLE® Scope

Property

Variability

The experience gained in post-industrial materials production and the opportunity to participate in circular economy projects has allowed us to develop a production process that **thoroughly monitors raw material selection and treatment** in order to optimize material characteristics and variability.



RENYCLE®

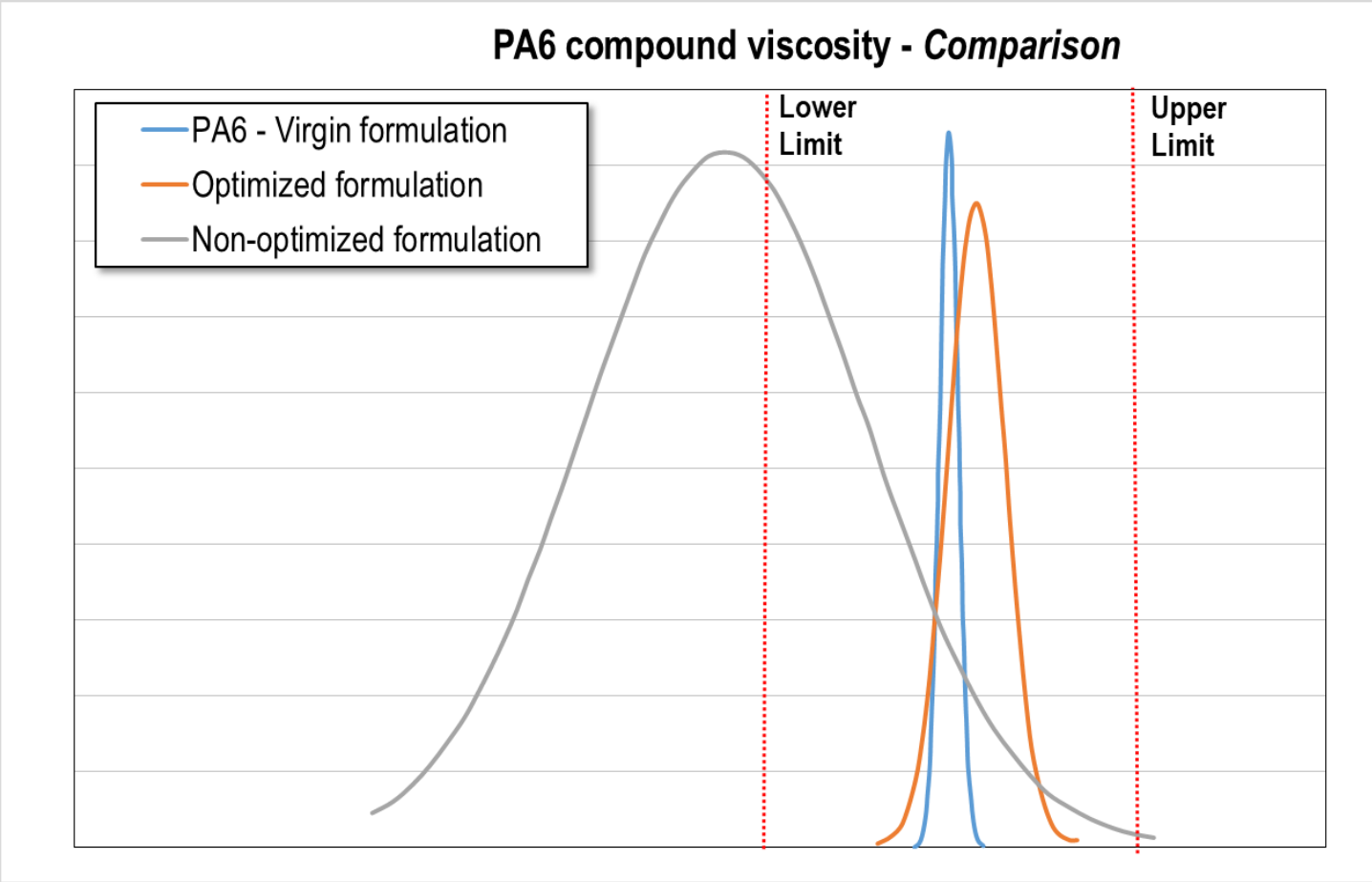
Reliable production process

- Functional performance
- Environmental performance
- Variability similar to top-grade material

Period:
March 2021 → September 2021

Property:
Viscosity

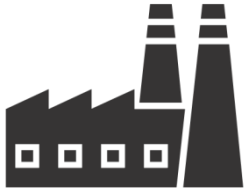
Ten lots observed.



RENYCLE® Current product offering

Post-consumer base

5 grades

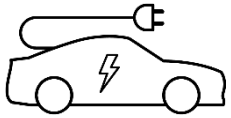


Post-industrial base

4 grades

General purpose

Automotive



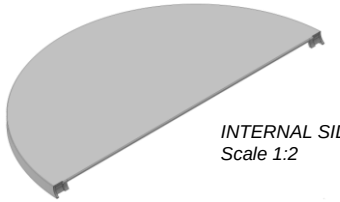
E-mobility

Electrical & Eletronics

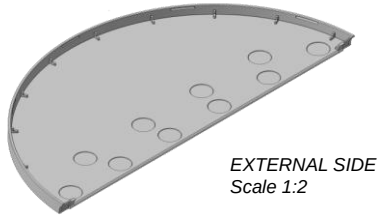
Hydrolysis resistance and flame retardancy (red phosphorus-free and halogen-free) are just some achievable properties for this new materials family.

RENYCLE® Post-consumer grades

Name	Material Description	Market
RENYCLE S GF3001K 3030 BK	PA6-GF30 heat stabilized	Auto, general purpose
RENYCLE S GF2501 HF0 3033 BK	PA6-GF25-HF FR	E&E, Auto (e-mobility)
RENYCLE S N101 3030 BK	PA6	General purpose
RENYCLE S GF3003 3033 BK	PA6-GF30	General purpose
RENYCLE S GF1501K 3030 BK	PA6-GF15 heat stabilized	Auto, general purpose



INTERNAL SIDE
Scale 1:2



EXTERNAL SIDE
Scale 1:2

Currently only available in the EU

RENYCLE®
nylon after nylon

RENYCLE® Post-industrial grades

Name	Material Description	Market
RENYCLE S GF3004K 3030 BK	PA6-GF30, 100% PIR, heat stabilized	General purpose
RENYCLE A GF3002HR 3039 BK	PA66-GF30, HR, containing a PIR%	Auto
RENYCLE A GF3502K 3033 BK	PA66-GF35, containing a PIR%, heat stab	General purpose
RENYCLE A GF3504K 3033 BK	PA66-GF35, 100% PIR, heat stabilized	General purpose

RENYCLE® Environmental and mechanical performance

Comparison (1)

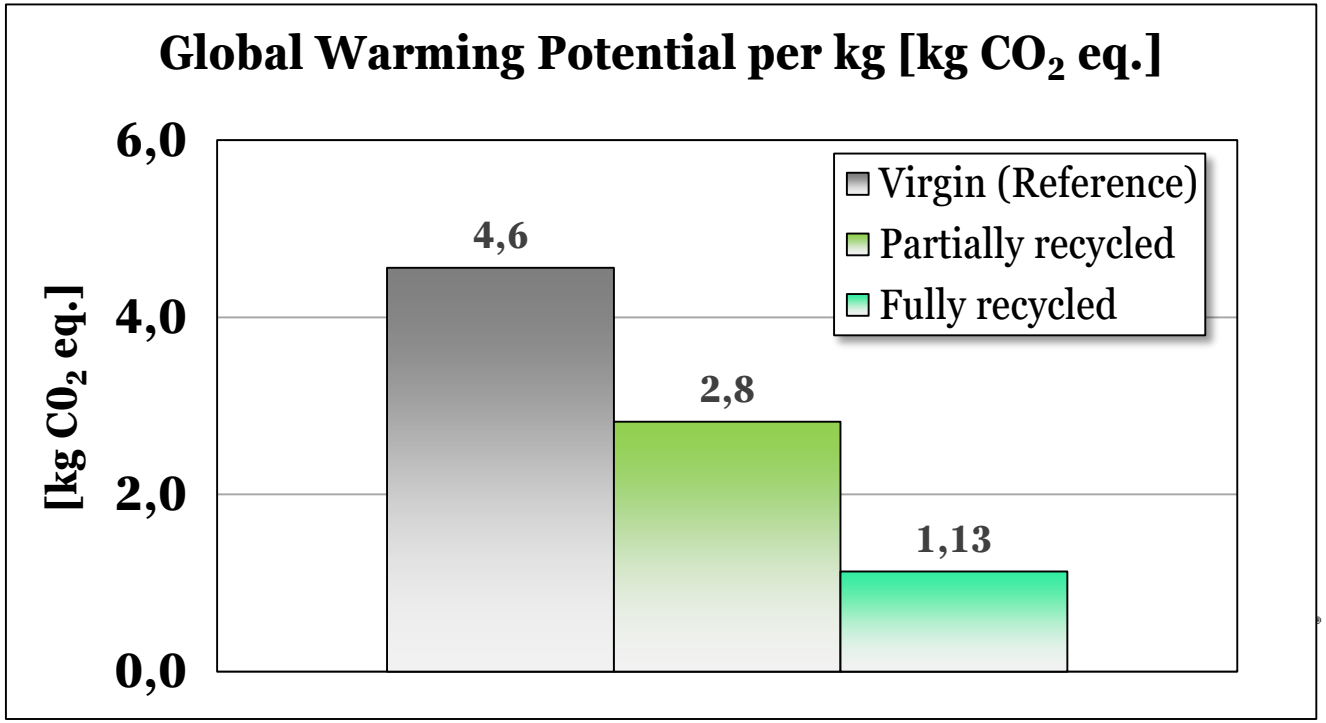
Product name	GWP [kg CO2 eq.]	Impact [kJ/m2]	E [MPa]	Stress at Break [MPa]	Strain at Break [%]
RADILON A RV350K 333 BK	4.6	80	11200	185	3
RENYCLE A GF3502K 3033 BK	2.8	58	10800	168	2.3
RENYCLE A GF3504K 3033 BK	1.13	55	11500	160	2.2

-38.2%

Partially recycled vs Virgin

-75.2%

Fully recycled vs Virgin



RENYCLE® Environmental and mechanical performance

Comparison (2)

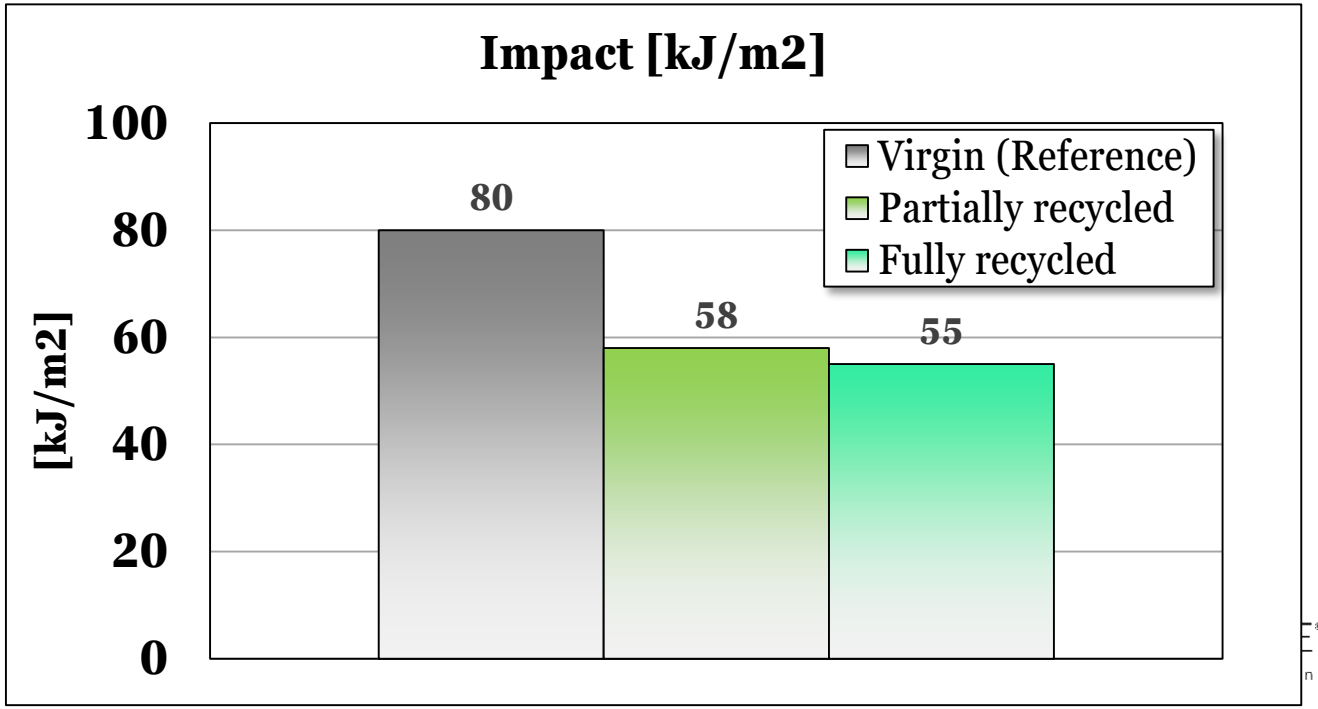
Product name	GWP [kg CO2 eq.]	Impact [kJ/m2]	E [MPa]	Stress at Break [MPa]	Strain at Break [%]
RADILON A RV350K 333 BK	4.6	80	11200	185	3
RENYCLE A GF3502K 3033 BK	2.8	58	10800	168	2.3
RENYCLE A GF3504K 3033 BK	1.13	55	11500	160	2.2

-27.5%

Partially recycled vs Virgin

-31.3%

Fully recycled vs Virgin



Why RENYCLE® ?

- Being more **sustainable** than virgin equivalents, it fuels the transition towards **climate neutrality** and **low-carbon footprint** business models.
- It allows for **waste reduction**, minimizing the amount of products sent to landfills or dispersed in the environment, and promotes a culture of **reuse and recycling.**
- It meets the needs of end-customers who are committed to make **environmentally conscious choices and support the development of a green-oriented product offering**.
- It is consistent with **the legislative context,** which is increasingly focused on the recovery of discarded materials (so-called EOL materials). Lawmakers aim to ensure **transparency, traceability** and **safety** for human health.
- It promotes collaboration with **partners that have consolidated experience** in designing sophisticated products using post-industrial and post-consumer recycled content.

HIGH PERFORMANCE POLYMERS

riccardo.galeazzi@radicigroup.com

THANK YOU

New Generation of Sustainable Materials: Technical and Environmental Performances

Susanna Caprotti

EPD (Environmental Product Declaration) Process Manager

Webinar | December 1st 2021

LCA methodology : overview and focus points

Life Cycle Assessment methodology

ISO 14040 definition of Life Cycle Assessment:
*"Compilation and evaluation of the inputs, outputs and the **potential environmental impacts** of a product system throughout its life cycle."*

Key features of the LCA methodology**:**

a) LCA assesses, in a systematic way, the environmental aspects and impacts of product systems, from raw material acquisition to final disposal, in accordance with the stated *goal and scope*;

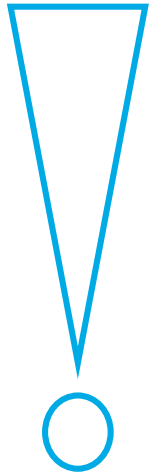
….

g) there is no single method for conducting LCA. Organizations have the flexibility to implement LCA as established in this International Standard, in accordance with the *intended application* and the requirements of the organization;

…..

To learn more: https://www.iso.org/search.html?q=14040

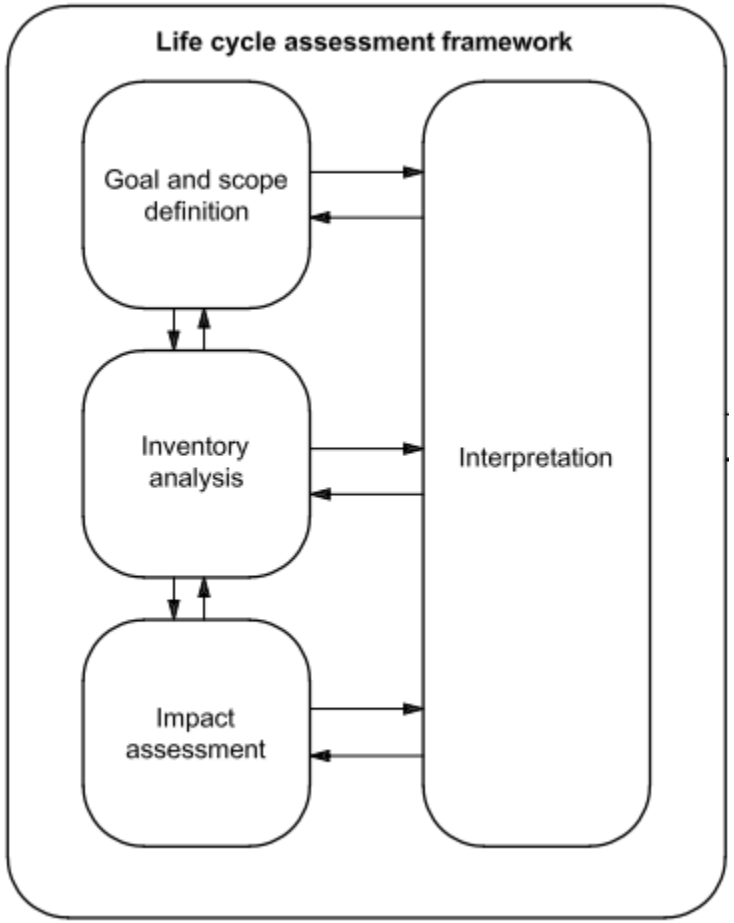
LCA focus point



It has happened to all of us to be interested in comparing the environmental footprint of a competing product to ours, or to want to choose which product to buy. So we go directly to the study page where the indicators are shown to see "how much the CO2eq is“ or other indicators are.

Already from these first definitions, we can understand that the comparison we are making could be anything but realistic!

Life Cycle Assessment methodology



Life Cycle Stages according to **ISO 14040**

- *Goal and* ***scope definition***
- ***Inventory*** *analysis*
- *Impact assessment*
- *Interpretation*

To learn more: https://www.iso.org/search.html?q=14040

Life Cycle Assessment methodology

Life Cycle Assessment : system boundaries, inputs and outputs

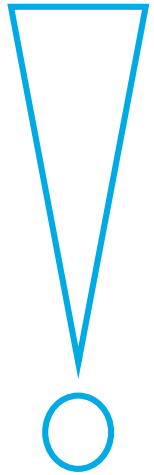
The scope, including the system boundary and level of detail, of an LCA depends on the subject and the intended use of the study.

Data used to assess each unit process (product/process) within the system boundary (starting from the extraction/cultivation of raw materials) can be classified under major headings, including

– energy inputs, raw material inputs, ancillary inputs, other physical inputs,
– products, co-products and ***waste***,
– emissions to air, discharges to water and soil, and
– other environmental aspects.

To learn more: https://www.iso.org/search.html?q=14040

LCA focus point



All the phases mentioned by ISO 14040 are obviously important, but the definition of the scope is the heart of an LCA. The scope is fundamental both to be understand the meaning of the results of a competitor's LCA we are reading, and even more so, of course, to assess our own product/process.

We must understand very well how the system works, what the functions it performs are and which measures to consider or are considered, what the inputs are, and to which output and to what extent to attribute them.

Life Cycle Assessment methodology

Some ISO Standards help the developer/reader of an LCA to identify the scope of a LCA study and the headings to assess.

Carbon Footprint (ISO 14067) and **Environmental Product Declaration** (according to ISO 14025) pre-determine the scope(s) and the figures to be assessed in studies intended for communication, in order to assure comparability among products performing the same function.

To learn more: https://www.iso.org/search.html?q=14040

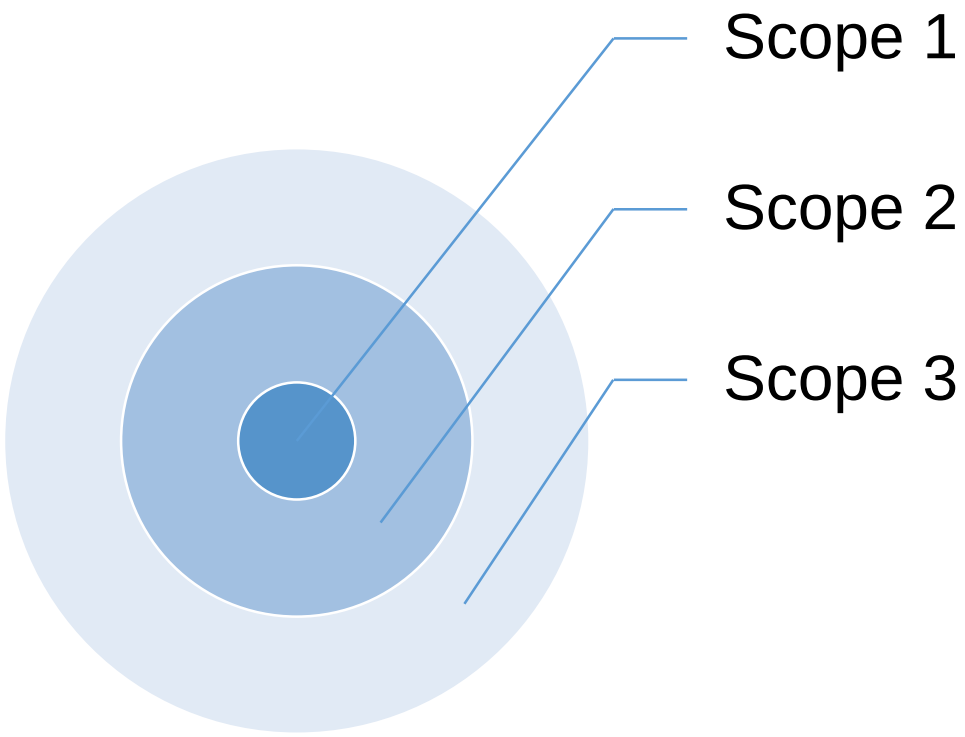
Life Cycle Assessment methodology

Carbon Footprint (ISO 14067)

Scope1 emissions are direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by an organization

Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling and are a result of the organization's energy use

Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions



To learn more: https://www.iso.org/search.html?q=14040

Life Cycle Assessment methodology

Environmental Product Declaration (ISO 14025)

Upstream impacts associate to raw materials, additives, packaging and other figures outside the company control

Core impacts associate with electricity use, waste produced, emissions, water use, inbound logistic and other the figures aimed to the production of the declared product that are under the company control

Downstream impacts associate to the delivery, use and end-of- life of the product

Upstream	Core	Downstream
• Raw materials and packaging • Ancillary inputs	• All process inputs and outputs obtained • Inbound logistics	• Outbound logistics • Use • End of Life

To learn more: https://www.iso.org/search.html?q=14040

Life Cycle Assessment methodology *& Recycling*

In environmental law, the **polluter pays principle** is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment.

The Principle applied to LCA implies that the Impact Assessment of a product is **comprehensive** of the environmental "**damage**" caused by the **waste** generated along its whole Life Cycle.

That's why the products made out of "waste" are free from the environmental burdens of raw material

Life Cycle Assessment methodology

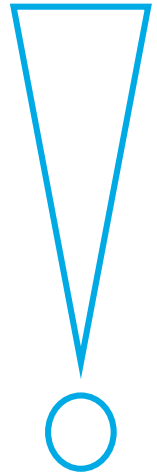
*The products made out of "waste" are **free** from the environmental burdens of **ONLY** the **raw materials**, and **NOT** from the **processes** needed to make them suitable for a new life cycle (RE-CYCLE).*

As the **new cycle** begins, a **new environmental accounting** of:

- – energy inputs, raw material inputs, ancillary inputs, other physical inputs,
- – products, co-products and waste,
- – emissions to air, discharges to water and soil, and
- – other environmental aspects.

begins as well.

LCA focus point



It is complicated to clearly identify the boundaries, the functioning, the inputs and the outputs of a product system that can count on the consistency of the raw materials, with standardized transformation phases and unequivocally qualified final products.

It is easy to imagine how much more complex it is in the case of processes, such as recovery and recycling, which, by their very nature, have a very high variability of raw materials (waste) to which the subsequent processes must “react and adapt” accordingly!

Life Cycle Assessment methodology

Outstanding experience in post-consumer materials

Circular Economy Business Models for innovative hybrid and electric mobility through advanced reuse and remanufacturing technologies and services.

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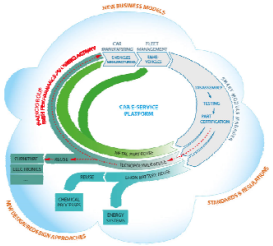
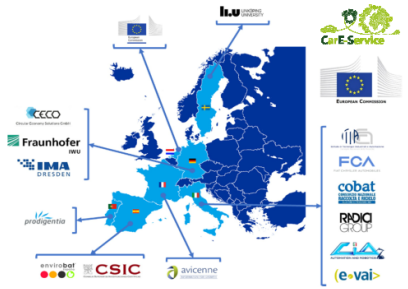
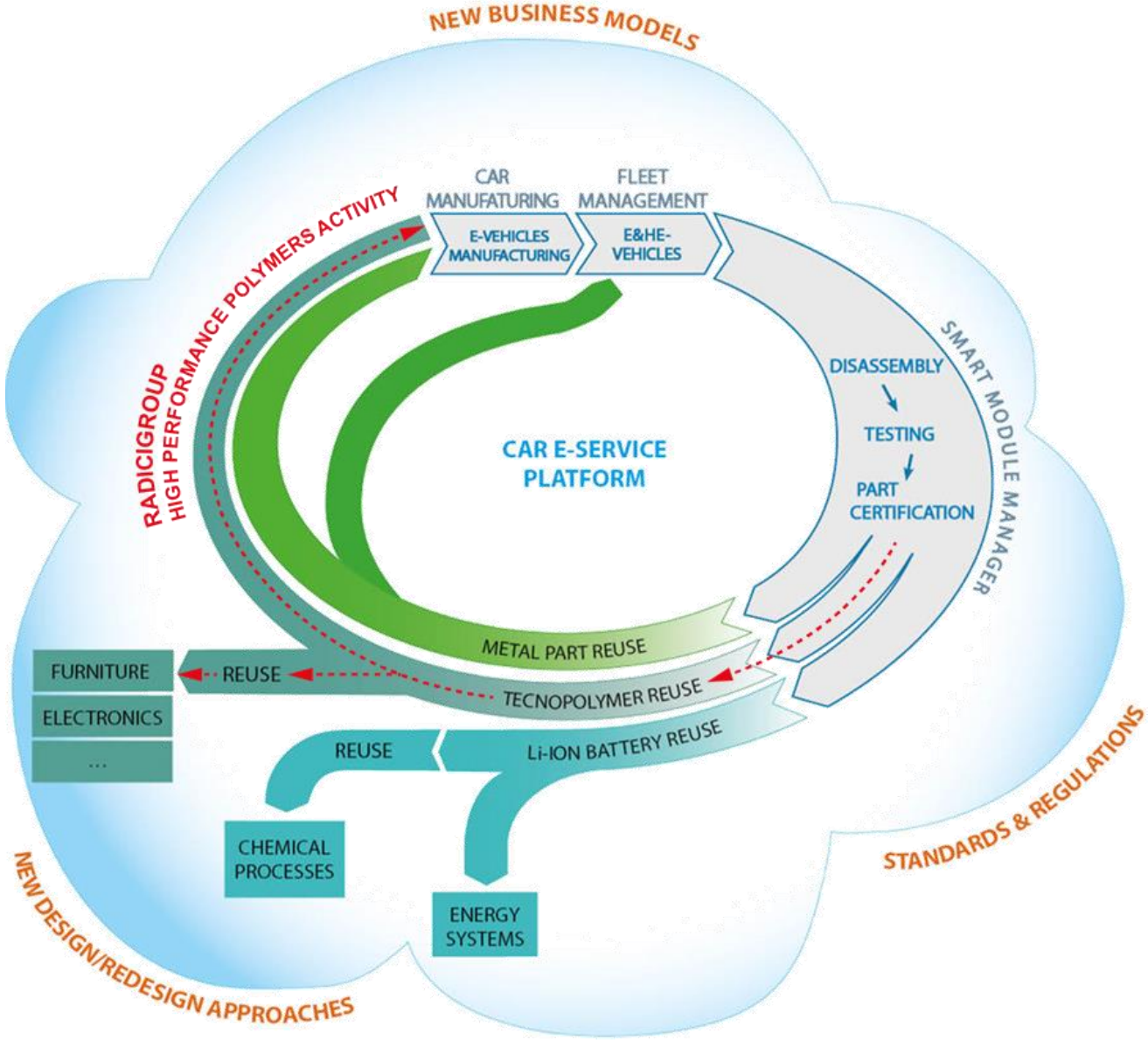
- **15 Partners**





This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 776851

Step-by-step LCA experience



Life Cycle Assessment methodology

Phase 1- Dismantling: this phase consists of the rough separation of the components: the fluids (engine oils, etc.) are sent for recycling, the components in good condition are diverted to be tested and, if possible, reconditioned, while the components that cannot be put back on the market are sorted to be prepared for recycling.

Life Cycle Assessment methodology


Figura 1

Figura 2

Figura 3

Figura 4

Figura 5

Figura 6

Figura 7

Figura 8

Phase 2 - Pre-selection: this phase consists of a rough division between similar objects (large parts made of plastic, rubber, metal, etc.) Here, larger inserts are diverted from the “main pieces” and put in a separate collection (metal wheel cover rings diverted from wheel covers and added to the metals collection, for example).

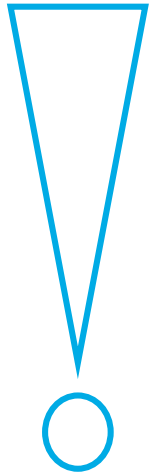
Life Cycle Assessment and Recycling

Visual technique

Phase3- Polymer selection: this phase consists of a fine division between similar objects (wheel covers in the picture) made of different plastic polymers. For high-quality recycling, which allows the material to re-enter markets that require high performance, it is essential to sort the polymers by type, as each has specific characteristics.

In the worst case, mixing the polymers inhibits recycling, in the best case, it dramatically worsens the quality of the material obtained.

LCA focus point

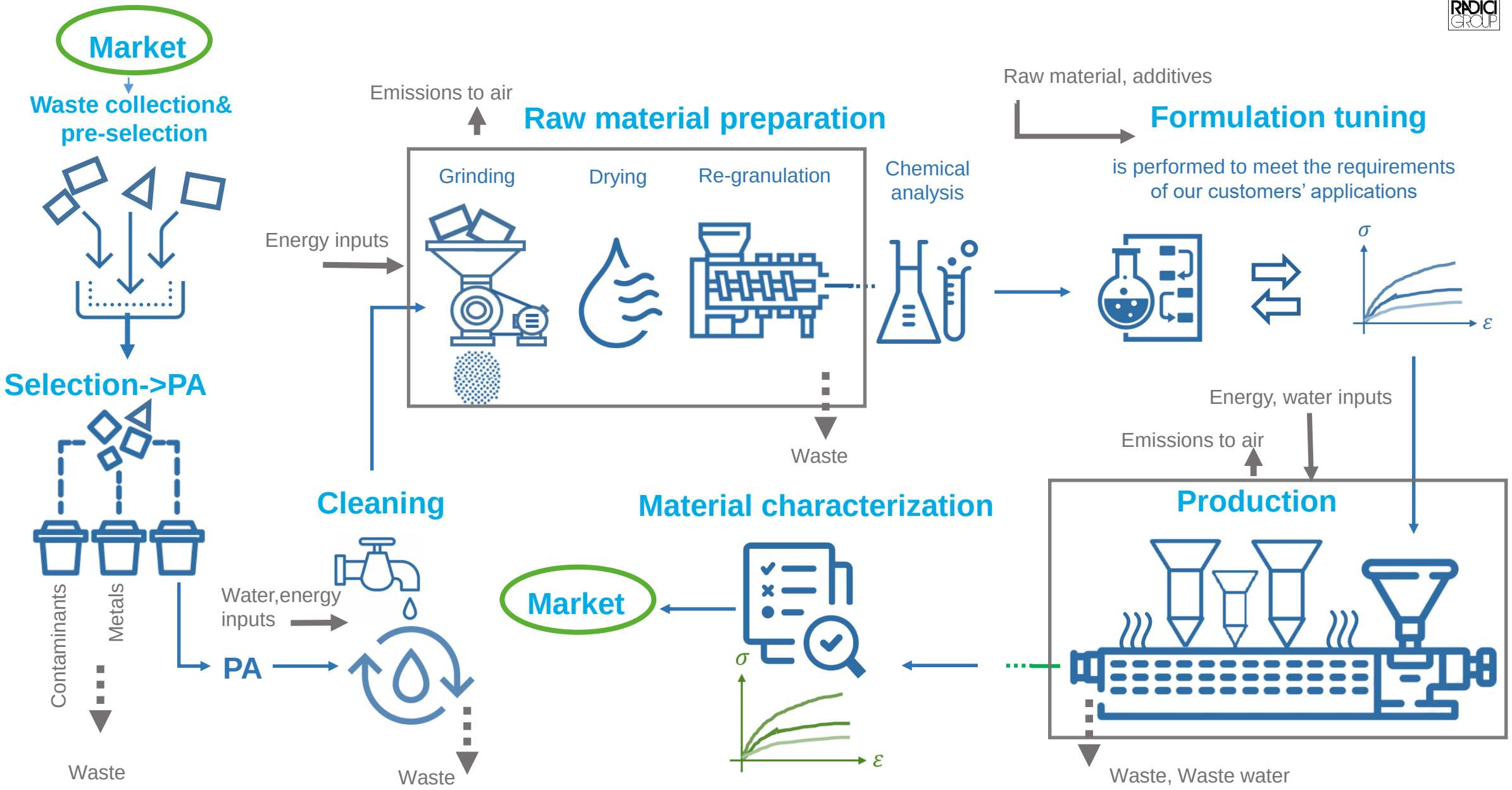


If properly sorted, the polymers used in this sector can be recycled. As illustrated, the selection consists of manual activities: excellent for LCA (no impact), but bad for large scale feasibility and economic costs.

Finally!

The material, sorted by type of polymer, is ready to enter the actual recycling process. The outcome will be an engineering polymer, with controlled technical performance, suitable for high value applications.

Life Cycle Assessment methodology



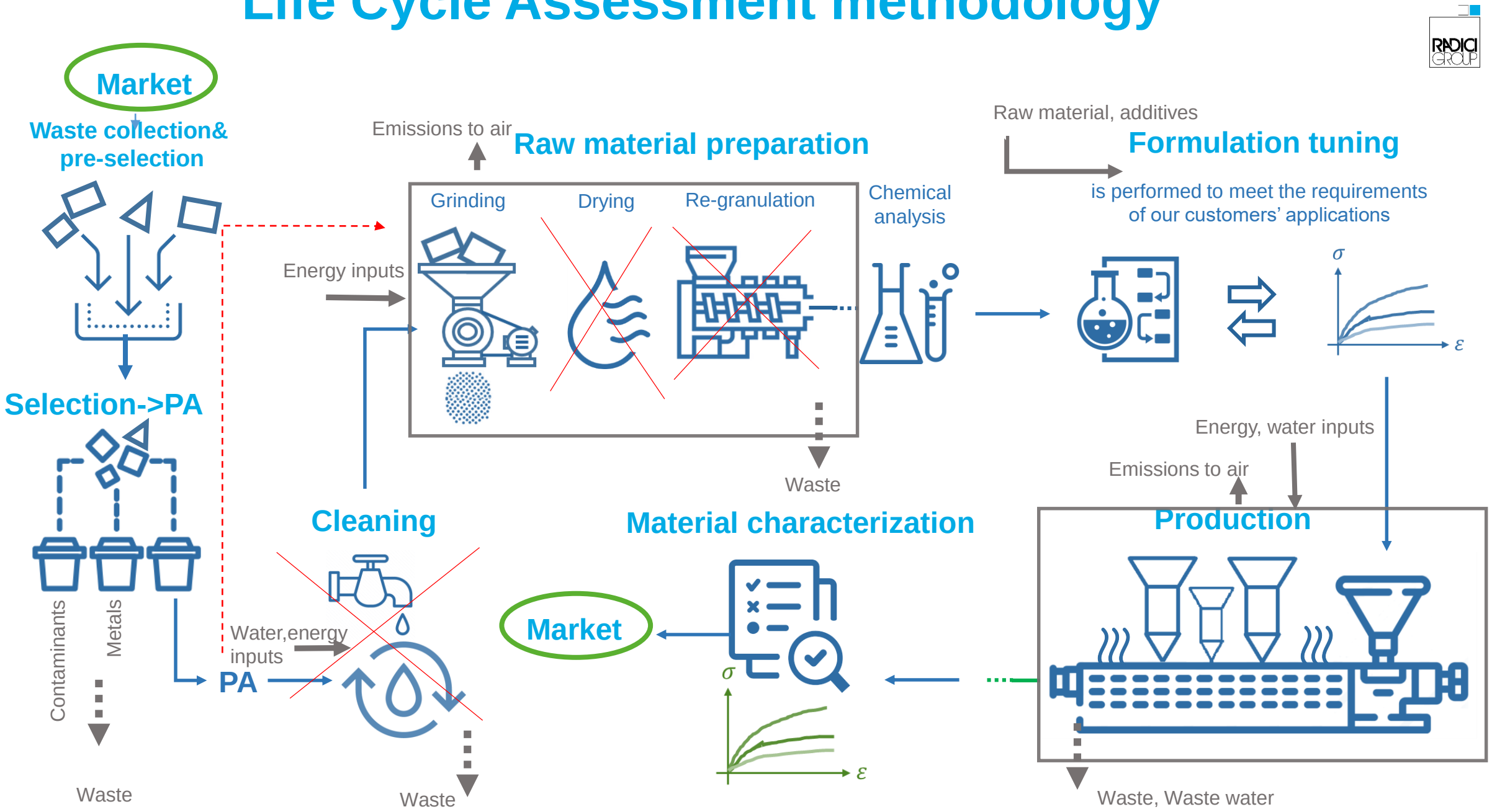
Life Cycle Assessment methodology

Once the objects are sorted according to the type of polymer, the typical and well-known recycling process starts. From this point on, the differences in the treatment process between industrial and post-consumer waste become less relevant.

Some phases of recovery are not normally carried out on post-industrial materials, which have not had a complete life cycle, especially on a car, and, therefore, have not undergone the stress and contamination of post-consumer materials.

Not only can the cleaning and drying phase (often) be avoided, but also regranulation, thus sending the ground material directly to formulation and production.

Life Cycle Assessment methodology

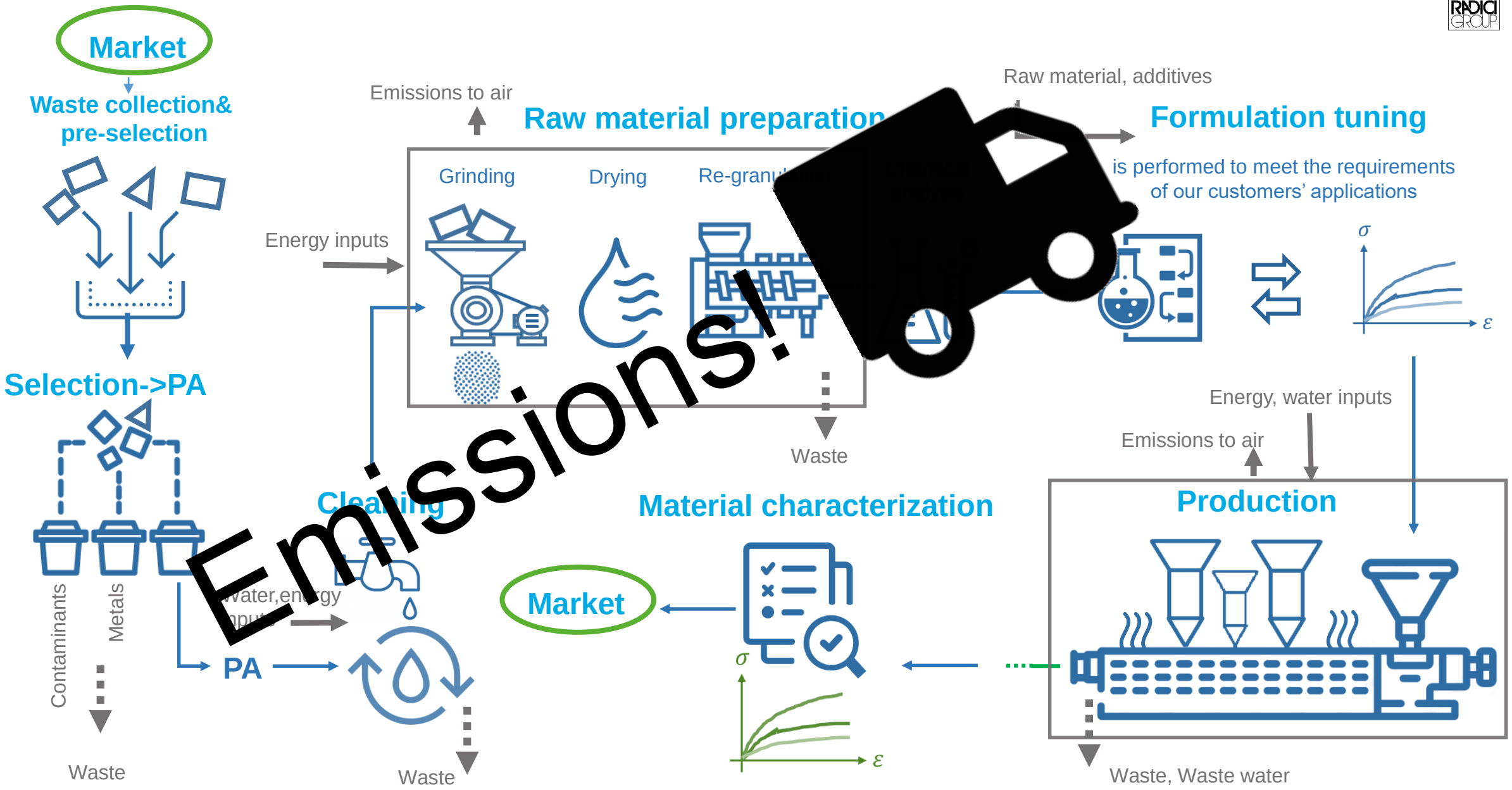


Life Cycle Assessment methodology

From everything illustrated so far, it is intuitive and inevitable that products made from post-consumer waste materials have greater environmental impacts than those from post-industrial materials. All the inputs and outputs of the additional phases necessary to recycle post-consumer materials are to be considered and obviously contribute to the impact of the final product.

And there is something I have not mentioned that has a huge bearing on the final result:

Life Cycle Assessment methodology



Life Cycle Assessment methodology

If the different phases of recycling are carried out in distant places, the transport of the material among the various recycling sites must be considered and added to the inputs that will determine the environmental impact of the recycled product.

Life Cycle Assessment methodology

Developing an efficient and effective "recycling chain" is a challenge that we face, with the very clear objectives of optimizing recycled product performance and minimizing their environmental impacts.

RENYCLE®

nylon after nylon

RENYCLE® Environmental and mechanical performance

Comparison

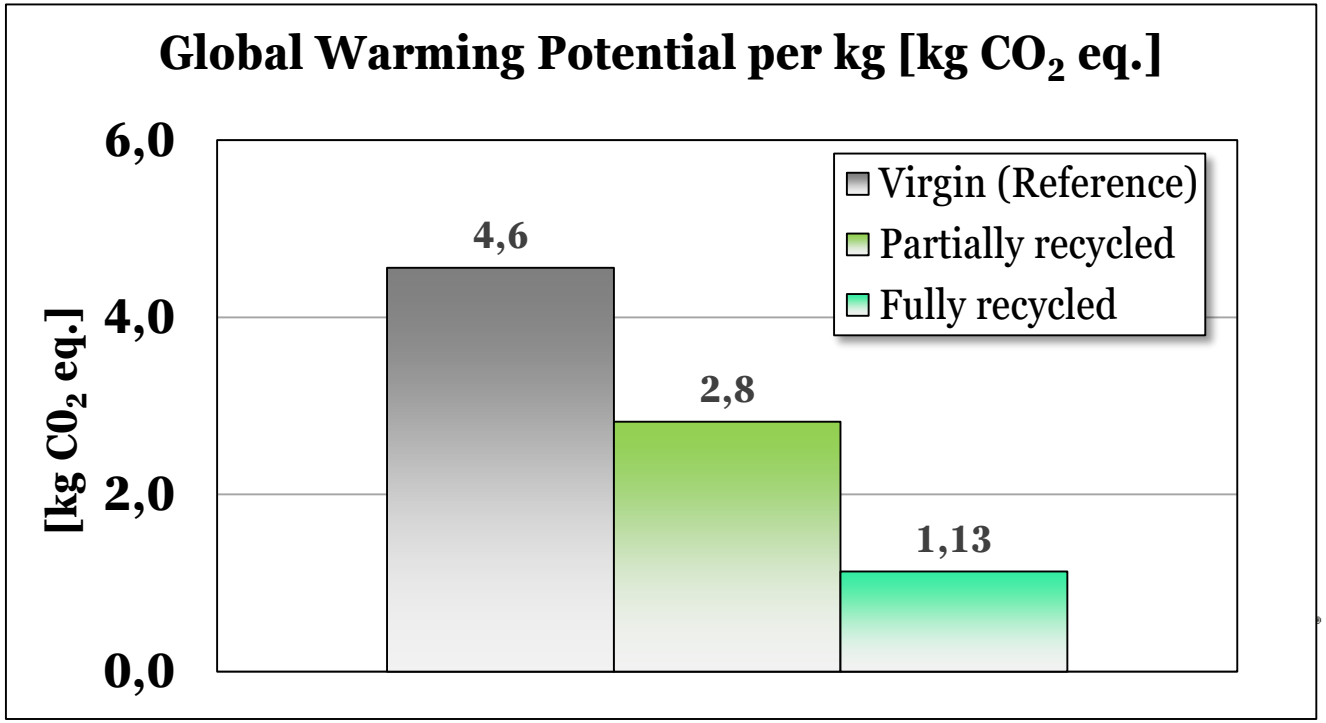
Product name	GWP [kg CO2 eq.]	Impact [kJ/m2]	E [MPa]	Stress at Break [MPa]	Strain at Break [%]
RADILON A RV350K 333 BK	4.6	80	11200	185	3
RENYCLE A GF3502K 3033 BK	2.8	58	10800	168	2.3
RENYCLE A GF3504K 3033 BK	1.13	55	11500	160	2.2

-38.2%

Partially recycled vs Virgin

-75.2%

Fully recycled vs Virgin



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THANK YOU

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Q&A