Sustainability and Single-Use Systems: From Vision to Action

Magali Barbaroux, Sustainability Committee Chair
Vachette, Elisabeth - Sartorius
Narendar, Yeshwanth – Saint Gobain
Mitchel, Matt - Avient

ECI SUT VI

2023 Sept. 10-13

Boston MA

Hyatt Regency Hotel

Single-Use Technologies :
Established, Emergent, Agile, Sustainable ?

REGISTRATION IS OPEN

https://engconf.us/conferences/biotechnology/single-use-technologies-vi/

Conference Chairs

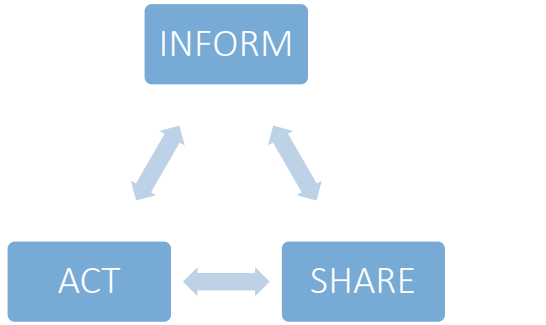
Magali Barbaroux (Sartorius)

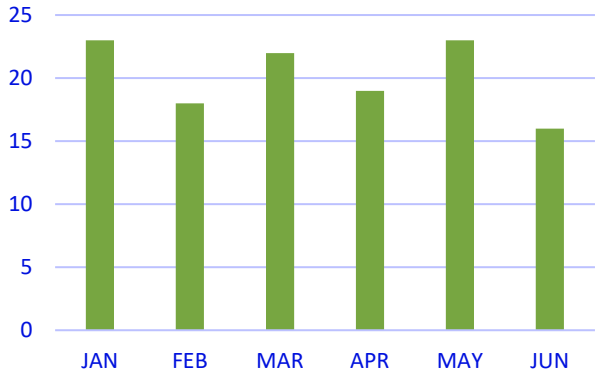
Sheryl Kane (Takeda)

Seongkyu Yoon (U-Mass Lowell)

BPSA Sustainability (technical) Committee

Board Sponsor : Brian Chung, Solvay | *Committee chair :* Magali Barbaroux, Sartorius





Attendance 2023

Mission

- Provide members information on how **SUT support biomanufacturing call for sustainability** & takes actions to prove BPSA seriously tackle sustainability concerns.
- Allow members to be informed on environmental sustainability tools and trends in the biomanufacturing and polymer industry, to share ideas and good practices.

Members

- Approx. 42 active members (attended at least one monthly meeting) (33 in 2022)
- Average of 20 attendees | meeting (18 in 2022)

Objectives

INFORM, SHARE & ACT

- [ ] Monthly opening sustainability spotlights
- [ ] 1-2 webinars
- [ ] Publications, E-book, glossary, LinkedIn
- [ ] Create and clearly state an industry message inside and outside linked to SDGs goals

Thank you

- Baillie, Megan - Barrentine, Robert - Bogen, Jon - Calmels, Caroline - Chen, Joy - Chung, Brian - Clark, Chris - Cook, Hubert - Collins, Francois - Cormier, Bryce - Cousin, Olivier - Daumke, Ralph - Ettie, Derek - Flanagan, Shannon - Grube, Kallee - Hanson, Colin - Heiler, Dianne - Horowski, Brian - Horst, Kendall - Jarmey-Swan, Claire - Jermyn, Christian - Kamph, Evan - Kuyl, Pierre - Love, Calum - Mariner, Amanda - McCool, Jeanette - Miles, Merete - Mitchell, Matt - Narayanan, Ravi - Narendar, Yeshwant - Ouellette, Matthew - Petrich, Mark - Roalandt, Elke - Shih, Cherry - Snyder, Mitchell - Springael, Sabine - Strohben, Bill - Tan, Chor Sing - Vachette, Elisabeth - Young, Don

Active contributors :

- Avient, Burkert, Corning, Cytiva, Daikin, DPS, DuPont, Entegris, GSK, GEA, Gore, High Purity England, , ILC Dover, KrystalBio, NewAge, Nordson Medical, Meissner, Pfizer, PendoTECH, Qosina, Repligen, RubiusTherapeutics, Saint-Gobain, Sartorius, Sealed Air, Solvay, ThermoFisher, Watson Marlon, Wood

Sustainability and Single-Use Systems: From Vision to Action

Content :

- Context and ideality
- Case studies, illustrations
- Q&A

The UN's sustainable development goals context

- Triple bottom line: People ● Planet ● Profit
- 17 Interconnected goals
- Corporate Challenge
  - Identify THE driving goal
  - As we can, contribute to others
  - Activities must be transparent
  - Can't be achieved alone

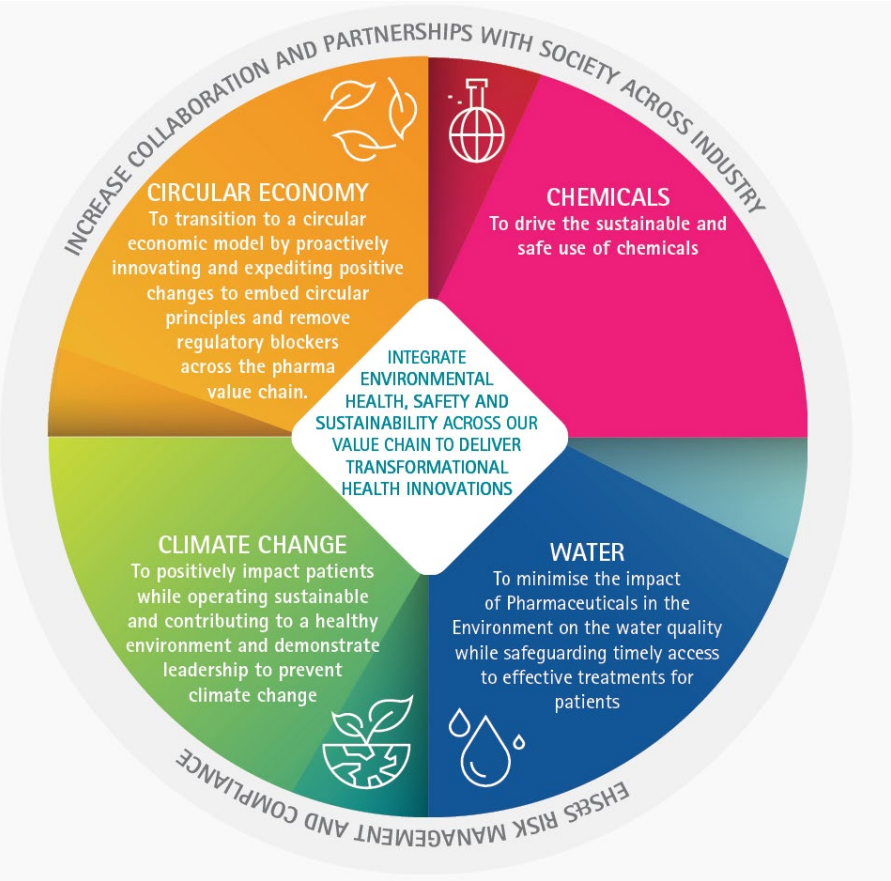
Pharma driving goal

Collaboration imperative

Reasons for Industry Adoption of SU Technologies

- Improved consistency in manufacturing processes
- Flexibility to design a purpose-built facility and the ability to amend SU technologies as needed
- Fast process deployment and changeover
- Less initial investment in fixed equipment enabling significant cost-savings
- Reduced water use due to the elimination of steaming and cleaning procedures
- Smaller facility footprint reduces the requirement for HVAC, the most significant factor for energy usage in the facility

Biotech industry environmental landscape

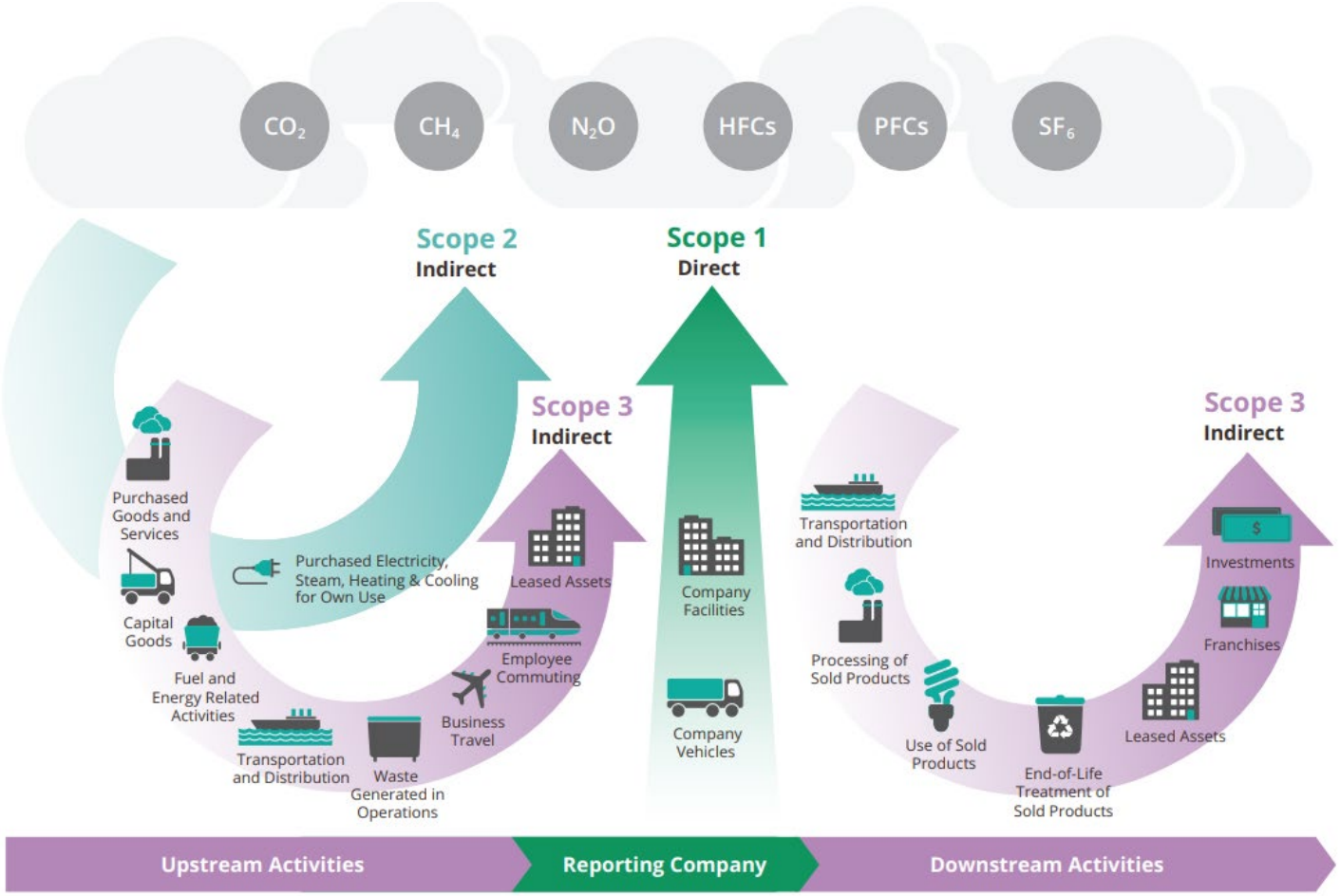


European Federation of Pharmaceutical Industries and association
PIE = pharmaceutical in environment -https://www.efpia.eu/about-medicines/development-of-medicines/regulations-safety-supply/environment-health-safety-and-sustainability/

- A 2019 study found that the climate footprint of healthcare was representing 4.4% of total global emissions (1)
- Total amount of carbon emitted | year by public companies in the biotech and pharma industry is more than the semiconductor or forestry and paper industry sector.(2)
- Fast-growing global biotech and pharma industry = significant contributor to climate change but beginning to move in the right direction, with some of the largest companies demonstrating leadership on emissions reductions(3)

(1) https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_090619.pdf
(2) https://www.mygreenlab.org/blog-beaker/my-green-lab-measures-carbon-impact-of-biotech-and-pharma
(3) The Carbon Impact of Biotech & Pharma, October 2022 (mygreenlab.org)

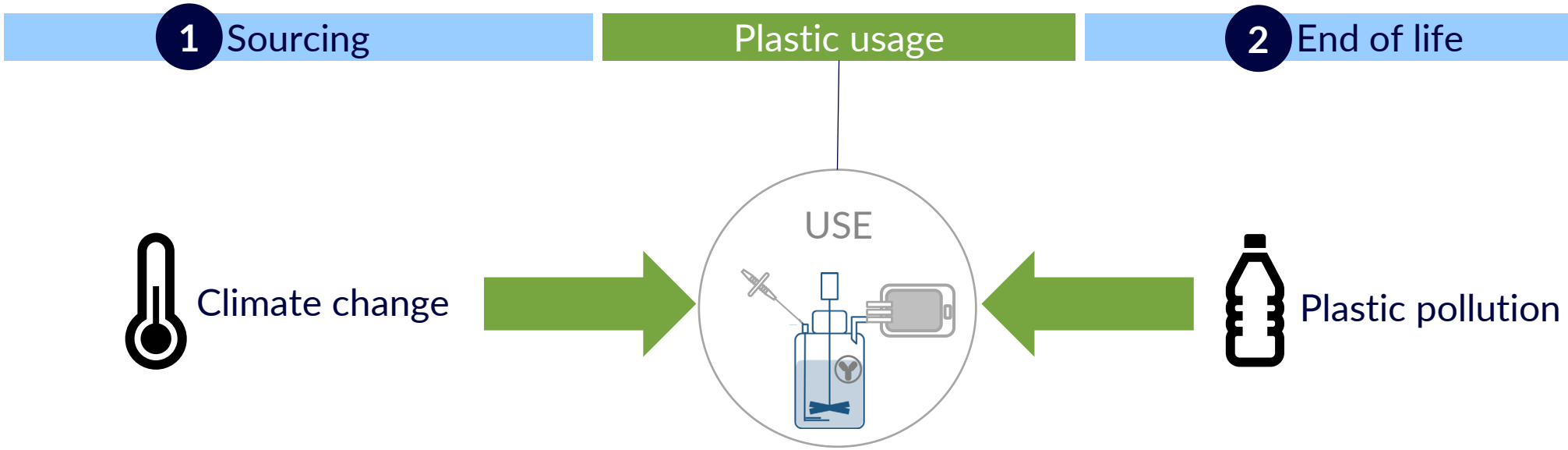
Toward Carbon Neutrality



Credit: Greenhouse Gas Protocol — Corporate Value Chain (Scope 3) Accounting and Reporting Standard

- For most industries — biotech and pharma is no exception — scope 3 emissions are significantly larger than scope 1 and 2 combined.
- To understand the true carbon impact of an industry, critical to evaluate the entire carbon footprint, including scope 3 emissions in the upstream and downstream value chain

Toward (Plastic) Circularity



Decouple plastic from fossil feedstock

Minimize amount of plastic (products and packaging) - efficiency

Recycling plastic

(1) Derived from Carbone 4 slide – consulting firm for low carbon stategies

References*

1. Aseptic Virtual conference, March 2021, Upstream Cell-based Vaccine Production: Improving the Environmental Footprint, Whitford, Barbaroux
2. World Economic Forum 2016 – The New plastic Economy
3. UNEP SINGLE-USE PLASTICS - A Roadmap for Sustainability
4. Medical plastic market is estimated to 7.7 million tons in 2020 (www.grandviewresearch.com/industry-analysis/medical-plastics-market) for a global market of 400 million de tons, e.g.1,9%.
5. Health-care waste (who.int)
6. www.nationalgeographic.com/science/2019/10/can-medical-care-exist-without-plastic/
7. www.the-scientist.com/news-opinion/ucl-to-phase-out-single-use-plastics--including-pipette-tips-66637
8. Whitford, William; Petrich, Mark; Flanagan, William. "Environmental Impacts of Single-Use Systems." Single-Use Technology in Biopharmaceutical Manufacture, 2nd Edition, edited by Regine Eibl and Dieter Eibl, John Wiley & Sons, 2019, 271-285.
9. J. Ignacio, From Single-Use to Re-Use in the MedecineMaker, June 2018
10. BPSA "The Green Imperative" series - BioProcess Intl 2020 and 2021
11. W. Flanagan, "Single-use and sustainability: quantifying the environmental impact," BioProcess Online, 2016.
12. European Commission : A circular economy for plastics, Insights from research and innovation to inform policy & funding decisions
13. K. Budzinski, et al., "Introduction of a process mass intensity metric for biologics," New BIOTECHNOLOGY 49 (2019) 37-42.
14. Kristi Budzinski *et al.* Streamlined life cycle assessment of single use technologies in biopharmaceutical manufacture. *New Biotechnology*, 2022.
15. Luu, D and al, Recycling of Post-Use Bioprocessing Plastic Containers—Mechanical Recycling Technical Feasibility. Sustainability (Switzerland) 2023
16. Sartorius - Driving Environmental Sustainability in the Biopharmaceutical Industry White Paper Environment | Sartorius

*Last access to web sites – July 7th 2023

SARTORIUS

Simplifying Progress

Examples of circularity initiatives

Elisabeth Vachette

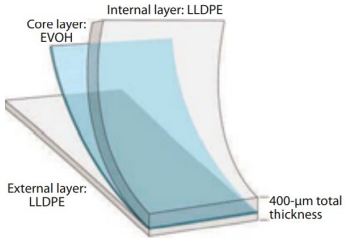
Initiatives to improve packaging

- Same Safety, Less Waste: new Packaging For MaxiCaps Sterile Filters
- Smaller, lighter, and recyclable with no compromise on quality – more complicated that what it looks !

Eva Schäfers presents the old (left) and new packaging (right).

Initiatives to improve waste management (Aubagne)

Enhanced film recyclability(1) > **Reduced film consumption** > **Improved waste collection and sorting** > **Increased waste recycling**



Sorting is a critical success factor for recycled polymer value, especially for color
“Plastics packaging waste recycling rates are 80x higher (and plastics waste 13x higher) when collected separately compared to mixed waste(2)

(1) Figure taken from: Vachette, Elisabeth & Fenge, Christel & Cappia, Jean Marc & Delaunay, Lucie & Greller, Gerhard & Barbaroux, Magali. (2014). Robust and convenient single-use processing: The superior strength and flexibility of flexsafe bags.

(2) Plastics - the Facts 2022 • Plastics Europe

Collaboration in recycling post use non biohazardous film

Working group : Sanofi, Sartorius and Veolia.

Objective :

Challenge widespread thought that SUTs cannot be recycled in standard waste streams for plastics(1) and collaboratively answer the following questions :

- Is there any application where post used bags are not considered bio-hazardous ?
- How to technically recycle a SUT bag, composed of a mechanically recyclable film(2) (sorting strategy) ?
- What will be the quality of the recycled content(3) ?
- What impact on environmental profiles of SUT end of life ?

Identified opportunity : bioprocessing bags used for media and buffer preparation and storage

- Still represent the largest amount today.
- Most buffers and media are not hazardous fluids.
- Flexsafe® Bag chamber designed to be recyclable | biggest weight contributor in simple bags.
- Materials for the constitution are well known and characterized.

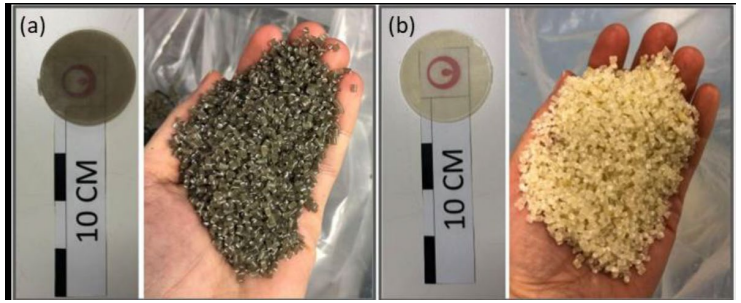
Order of magnitude “Simple” bag mass distribution (measured)
Bag chamber 43,7 %
Plastic packaging 14,1 %
Carboard packaging 31,9 %
Connectors & tubes 10,3 %

(1) most frequent objections : mixed plastic, multilayer films, bio-hazardous post-use products, recycling has a higher footprint than waste to energy.)
(2) Recommended recycling option in the recycling hierarchy
(3) Laboratory scale on representative

Methodological approach

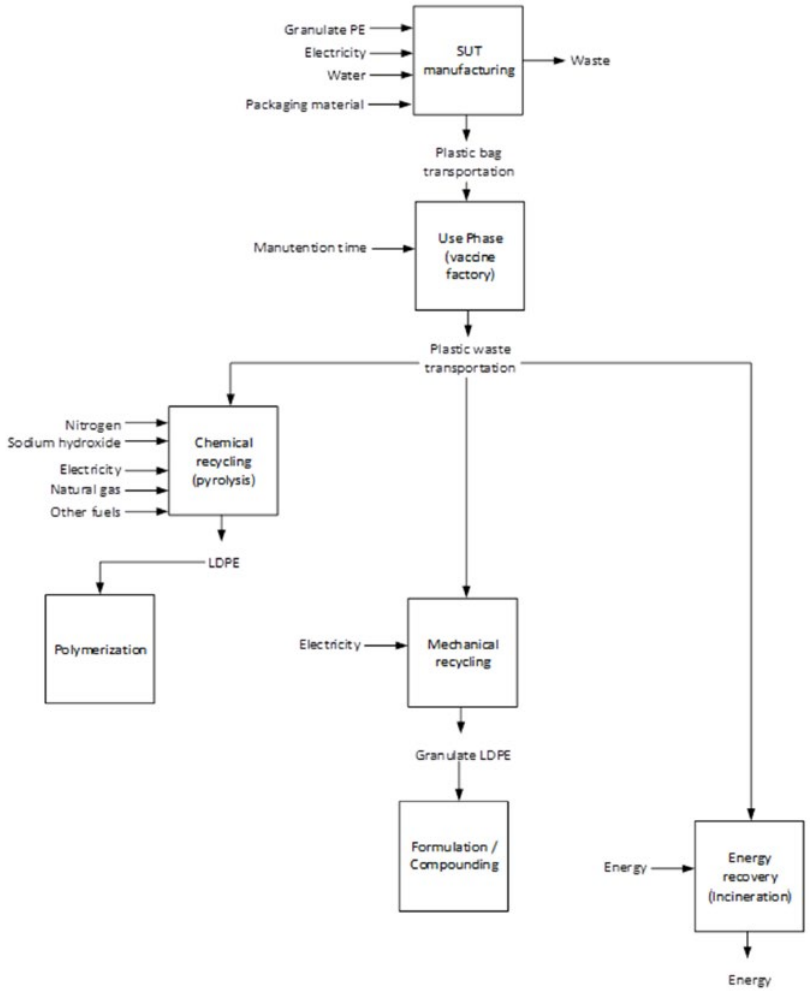
Post-use | Manual dismantling | Cutting | Shear Crushing #1 | Shear Crushing #2 | Grinding | Extrusion | Injection Molding

- Quantitative physical | mechanical tests and analysis (FTIR, DSC, TGA, density, MFI, color, tensile, flexural, and Charpy choc)
- Results show that recycled PE can go to applications with similar performance requirements than the one of virgin material (films, bags, pipes and fittings, profiles, and flexible sheets)
- Confirmed that sorting is a critical success factor for recycled polymer value, (color doesn’t impact mechanical properties, but negative impact on value)



On the left, cable ties mixed.

Theoretical Environmental Profiles of Different End of Life Scenarios



Comparative LCA[(1)] (theoretical framework), shows mechanical recycling for end of life presents the advantage of keeping material in the loop without a significant statistical difference compared to incineration with regards to the climate change indicator.

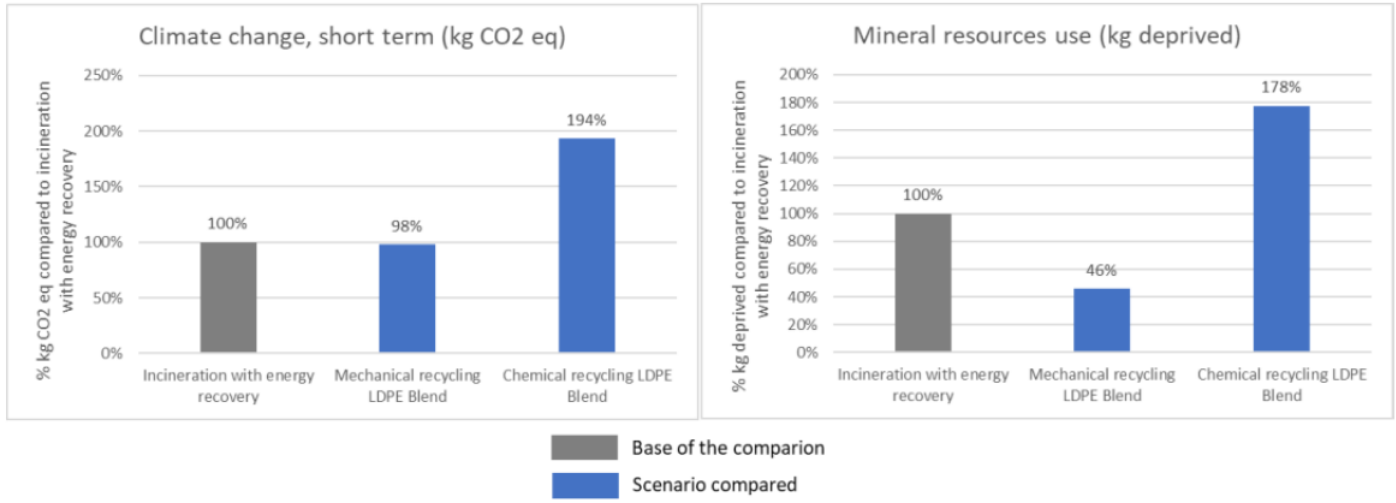


Figure 10. Comparative LCA results of mechanical treatment vs. incineration vs. chemical treatment for 1 kg of SUA treated, for two mid-point indicators, climate change short term and mineral resources use (IMPACT World + Midpoint V1,01).

[(1)] Data assumptions available for upload : https://www.mdpi.com/article/10.3390/su142315557/s1.

Conclusion

- Recycled Flexsafe® bag chambers could technically be used for films, bags, pipes and fittings, profiles, and flexible sheets provided an appropriate sorting and massification solution is identified.
- The comparative LCA, based on a theoretical framework, shows that mechanical recycling for end of life presents the advantage of keeping material in the loop without a significant statistical difference compared to incineration with regards to the climate change indicator.
- Several challenges remain
  - Trade-off between the quality and quantity of the recycled plastic needs to be further evaluated.
  - Cost and efficiency of sorting is another area that needs to be addressed.
  - Lack of accurate data (e.g., production volume, energy consumption, quantities of emissions) related to the emergence of this new circular scheme product limits the value of the LCA*
- Published in open-source Sustainability 2022, 14, 15557

*A whole environmental impact assessment, with different logistic scenarios to ensure the economic viability from a cost perspective, would require a more detailed cradle-to-cradle LCA, with more accurate data (raw materials, SUA production, location use, waste treatment streams), with relevant stakeholders, when the recycling scheme at scale will be defined.

CIRCULARITY AT SAINT-GOBAIN
Case study from Ceramics used in Glass Production

Yeshwanth Narendar
Vice-President R&D and Innovation
Saint-Gobain Life Sciences

TOGETHER, WE CREATE A BETTER LIFE

SAINT-GOBAIN

SAINT-GOBAIN – OPERATES ACROSS MULTIPLE MARKETS

Materials based solutions across our markets

LIFE SCIENCES

- BIOPROCESS SOLUTIONS
- MEDICAL COMPONENTS
- INDUSTRIAL AND CONSUMER SOLUTIONS
- ELECTRONICS

CONSTRUCTION INDUSTRY

- VETROTEX
- INDUSTRIAL FABRICS EUROPE
- CONSTRUCTION PRODUCTS EUROPE
- CONSTRUCTION INDUSTRY AMERICAS

CONSTRUCTION CHEMICALS

- CEMENT
- CONCRETE
  - Precast
  - Ready-mix concrete
  - Decorative Concrete
  - Screed
  - Gypsum
- SPECIALTY BUILDING MATERIALS

MOBILITY

- SEKURIT ORIGINAL EQUIPMENT MANUFACTURER (OEM)
- AUTOMOTIVE GLASS REPLACEMENT
- SEKURIT TRANSPORT
- AEROSPACE
- ENGINEERED COMPONENTS
  - Bearings
  - Joints Automobile Polymer Solutions
  - Omniseal Solutions

SURFACE SOLUTIONS

- ABRASIVES
  - Europe, Middle-East, Africa
  - North America
  - Latin America
  - Asia-Pacific
  - India
- ADHESIVES AND SEALANTS
- COMPOSITE SYSTEMS
  - Tape Solutions
  - Composite Solutions
  - Thin Films

CERAMICS

- GLASS REFRACTORIES
- ZIRCONIA
- PERFORMANCE CERAMICS AND REFRACTORIES
- QUARTZ
- CATALYST SUPPORTS
- SPECIALTY POWDERS
- VALOREF - RECYCLING

CIRCULARITY KEY TO ACHIEVE ENVIRONMENTAL OBJECTIVES

➢ Saint-Gobain Objectives

2017 Reference

2030
-33% CO_2 (Scopes 1 & 2)
-16% CO_2 (Scope 3)
- 30% new raw material
- 80% waste reduction

2050 Carbon neutrality

Circular economy – Inorganic Materials

Industries
Glass, abrasives..

Sale

Collect Waste

Shaped products
Glass Refractory blocks
Abrasives

Valoref WMS
WASTE MANAGEMENT SERVICES

Recycling

Manufacturing
New + Recycled raw materials

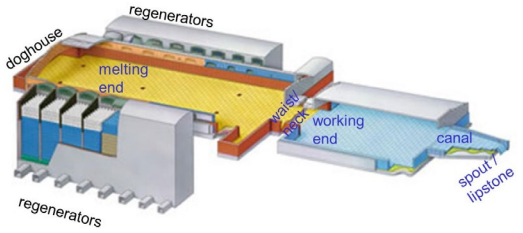
Saint-Gobain ceramic companies

Scope 1: Company Direct Emissions (e.g. energy & plant process)
Scope 2: Company Indirect Emissions (e.g. electricity for power used in plants)
Scope 3: Indirect value chain emissions (e.g. raw materials, transport, use, end-of-life

RECYCLING APPROACH FOR GLASS REFRACTORIES

Glass Furnaces

- Building flat glass
- Automotive glass
- Containers (incl. Pharma)
- Glass wool & fibers (insulation)



1000s of tons of ceramics used
Furnace Life span of 10-20 years

*"**Valoref** started to recycle ceramics used for glass furnaces: Production waste to post use"*

3 SERVICES

Valorwaste™

→ **Punctual waste collection**

→ **Furnace demolition operation**
- Dedicated team on-site

Valorbox

→ **Regular waste collection**

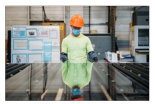
Valorstock™

RECYCLING PROCESS

GROW & IMPACT

1. Industrial use

MARKET


GLASS INDUSTRY


TECHNICAL CERAMICS INDUSTRY


ABRASIVES INDUSTRY

87%
Recycled in 2021

6 PRODUCT RANGES
VAL
VALMAG
VALORCHROM
VALORGAL
VALORZAC
ZIRCOVAL

2. Waste collection

Valoref WMS
WASTE MANAGEMENT SERVICES

3 SERVICES
Valorwaste
Valorbox
Valorstock

20,000 tons
Per year

Revalorization > 85%

3. Waste sorting

Sorting line – operators

Sorting:
- the material type
- level of contamination

4. Crushing

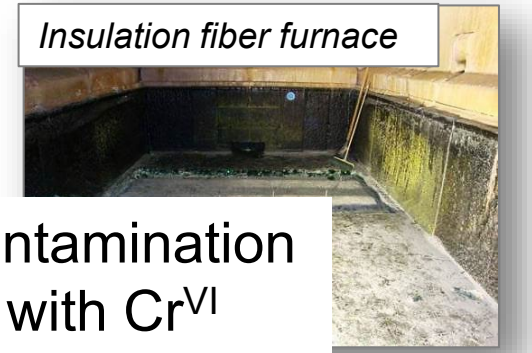
5. Resale

Valoref RRM
RECYCLED RAW MATERIALS

SAINT-GOBAIN

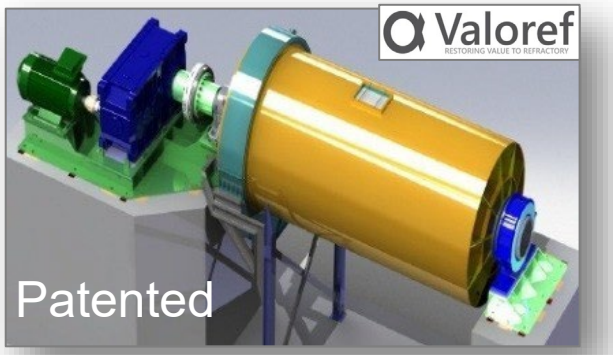
UNIQUE PROCESS TO VALORIZE CR(VI) CONTAMINATION

Insulation fiber furnace



Contamination with Cr^{VI}

Waste treatment



→ **100% of recycling**

Cr^{III}-based slurry

New refractory blocks

DISCUSSION POINTS FOR SUT

Engineered Products “fused”/connected together in a glass furnace ->
Separate product into raw materials to enable recycling

Contamination is a common issue ->
Develop economical decontamination process to enable recycling

Glass furnace ceramics need to work for 15+ years ->
Some recycled raw materials are used for less demanding applications

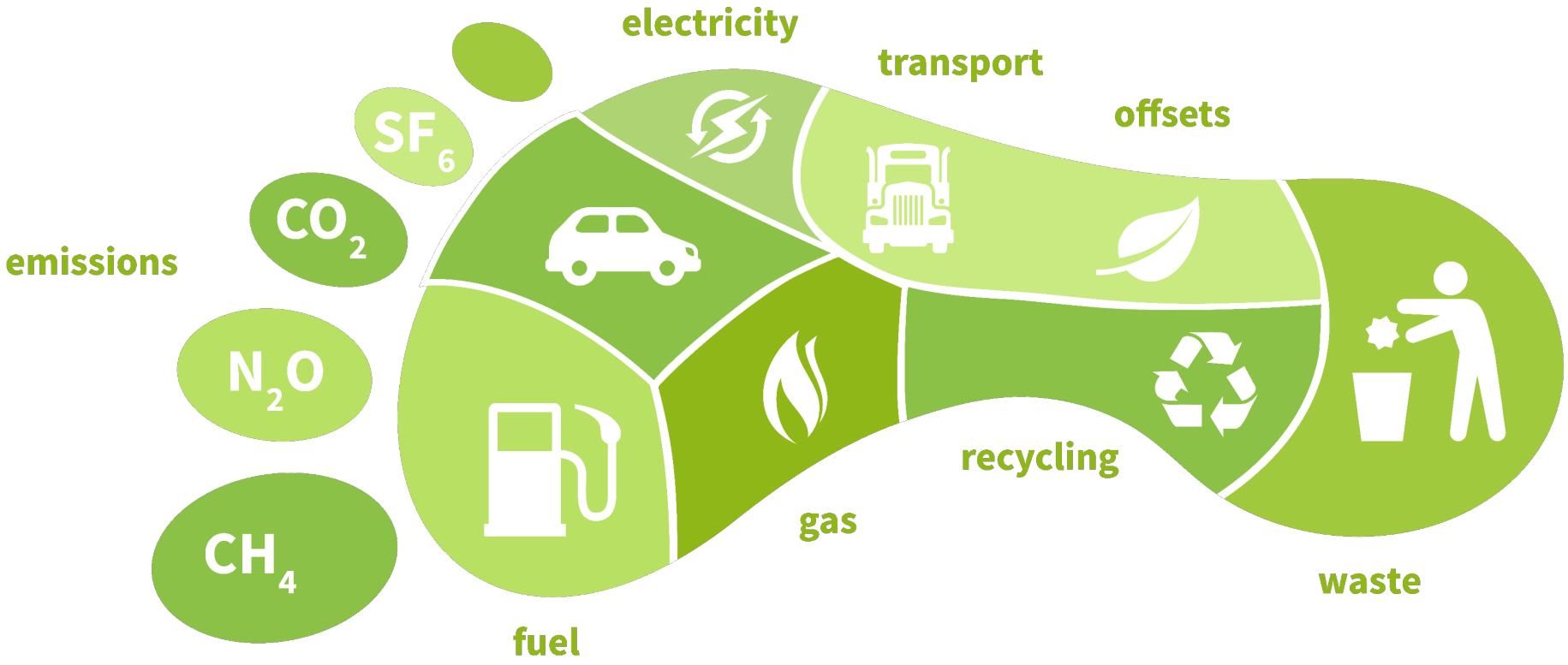
Testing feasibility of single use plastics recycling
-> leveraging Saint-Gobain’s presence in Life Science, Industrial and Construction

PRODUCT CARBON FOOTPRINT

AVIENT

WHAT IS CARBON FOOTPRINT?

A carbon footprint describes the total climate change impact – greenhouse gas (GHG) emissions – that a product, action, or person has.



AVIENT

CARBON EMISSIONS DATA

- CO_2 emissions have increased by about 90% over the past 50 years[2]

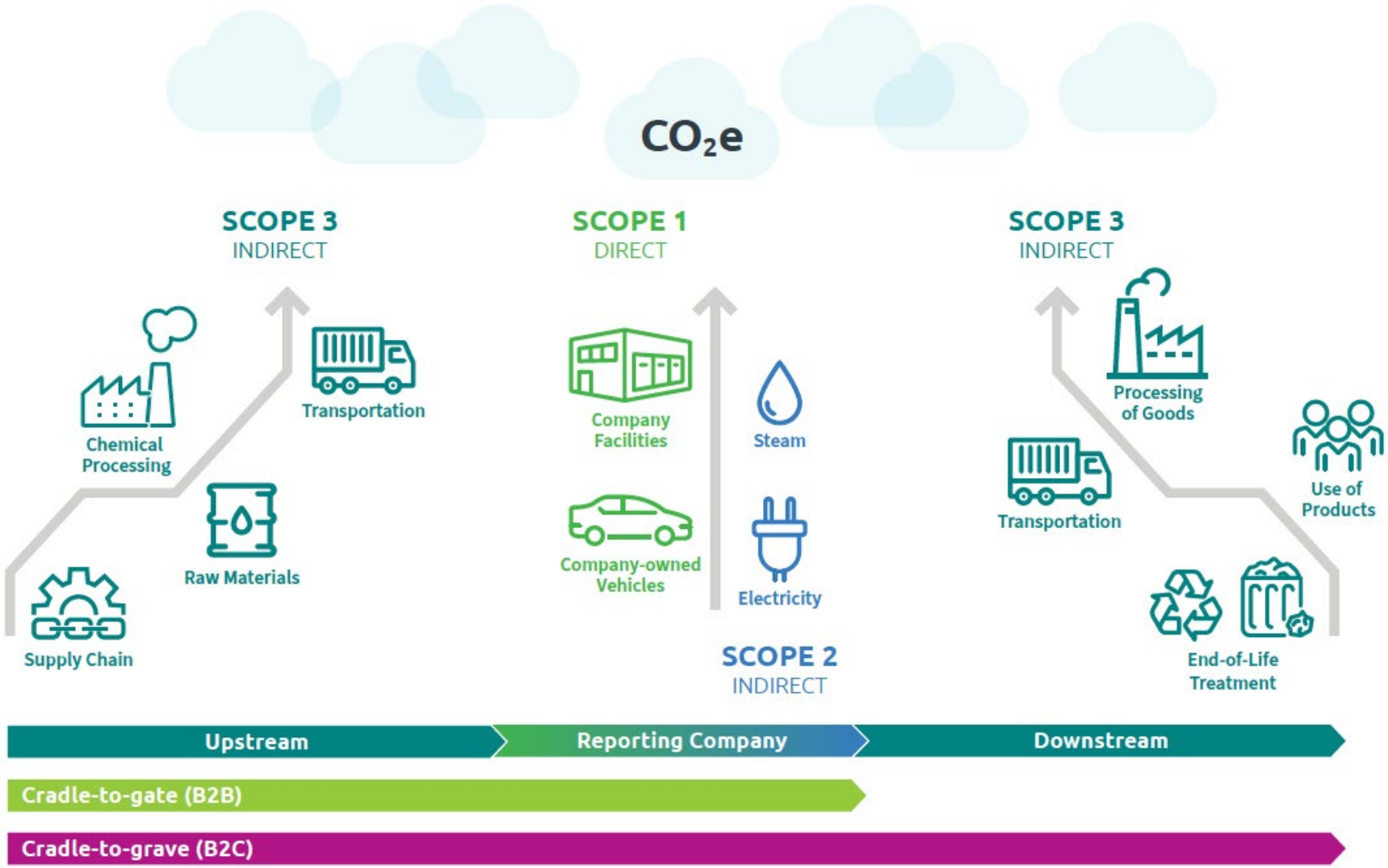
2500 companies have set emission reduction targets[3]

70% of countries have net zero targets[3]

1740+ companies set net zero commitments[3]

Source 2: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data
Source 3. https://sciencebasedtargets.org/companies-taking-action

UNDERSTANDING PRODUCT CARBON FOOTPRINT



METHODOLOGY

- Follows **ISO 14067:2018** Carbon Footprint of Products
  - Specifies principles and guidelines for the quantification and reporting of the carbon footprint of a product

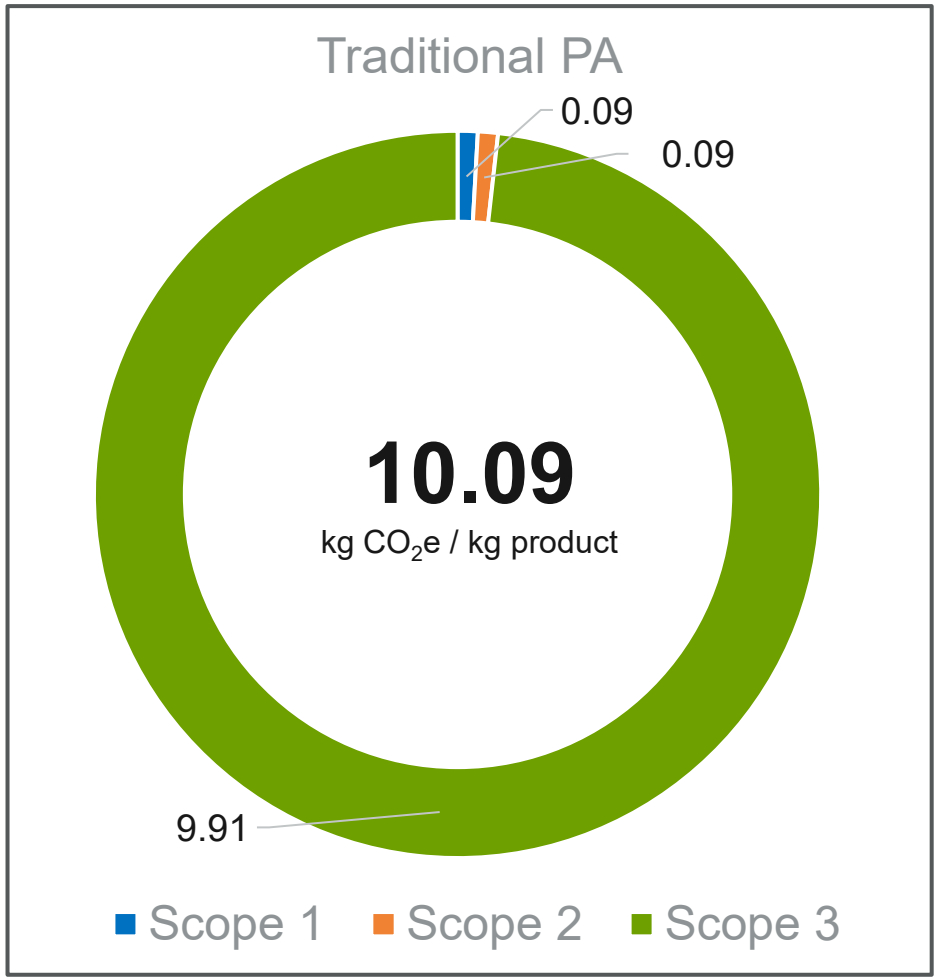
- Third-Party **Certified by TUV**
  - Certificate confirms that a product meets defined criteria and defined safety-relevant aspects

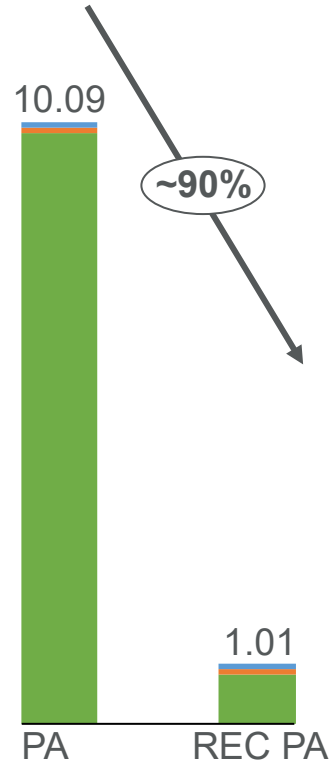
CERTIFICATE

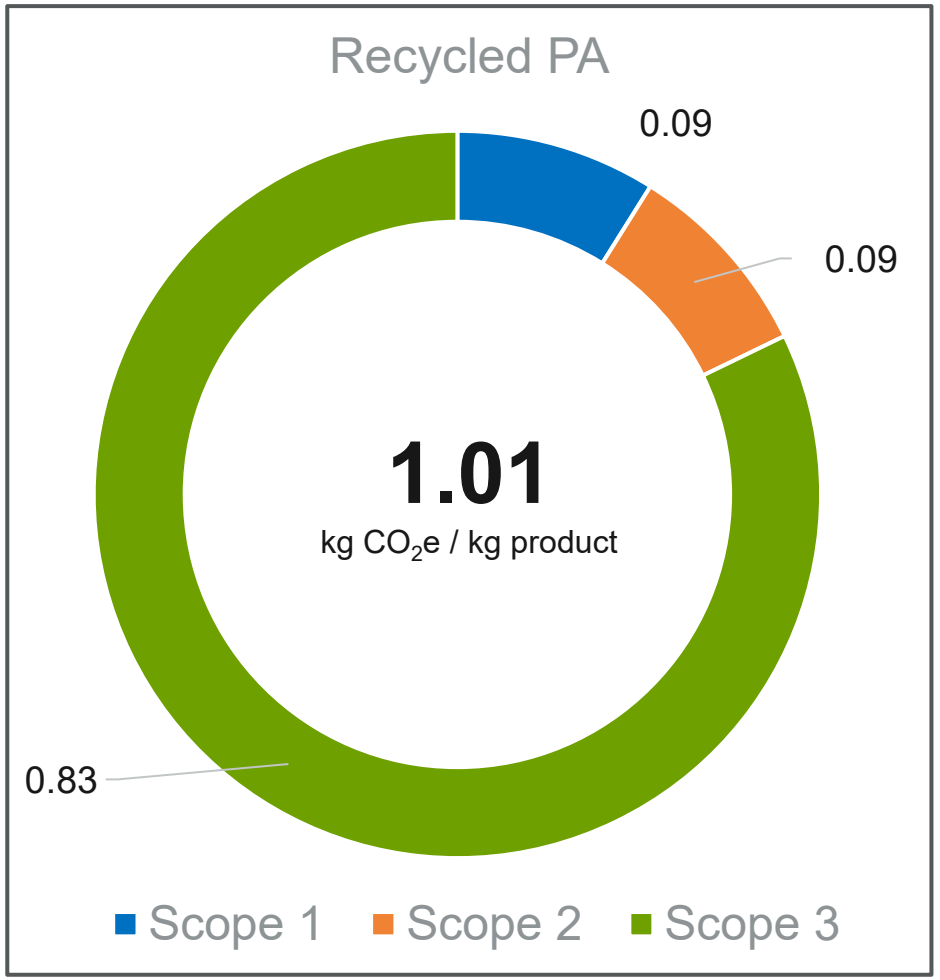
Certificate ID:	C01-2023-03-21257059
Certificate for:	**Review of Product Carbon Footprint Method of Avient Corporation**
Certified:	Avient Corporation 33587 Walker Road, Avon Lake OH 44012, United States
Accounting Scope:	Methodology for assessing the potential climate change effects for plastics in primary pellet forms, such as color and additive masterbatches, and compounds with reinforced fillers
Applied Standard:	ISO 14067: 2018 which is based on ISO 14040:2006 + A1:2020 /ISO 14044:2006 + A1:2018 + A2:2020
Review Report:	CF-2023-03-21257059
Valid until:	March 31st 2024

IMPACT OF RAW MATERIAL

TRADITIONAL PA VS. RECYCLED PA



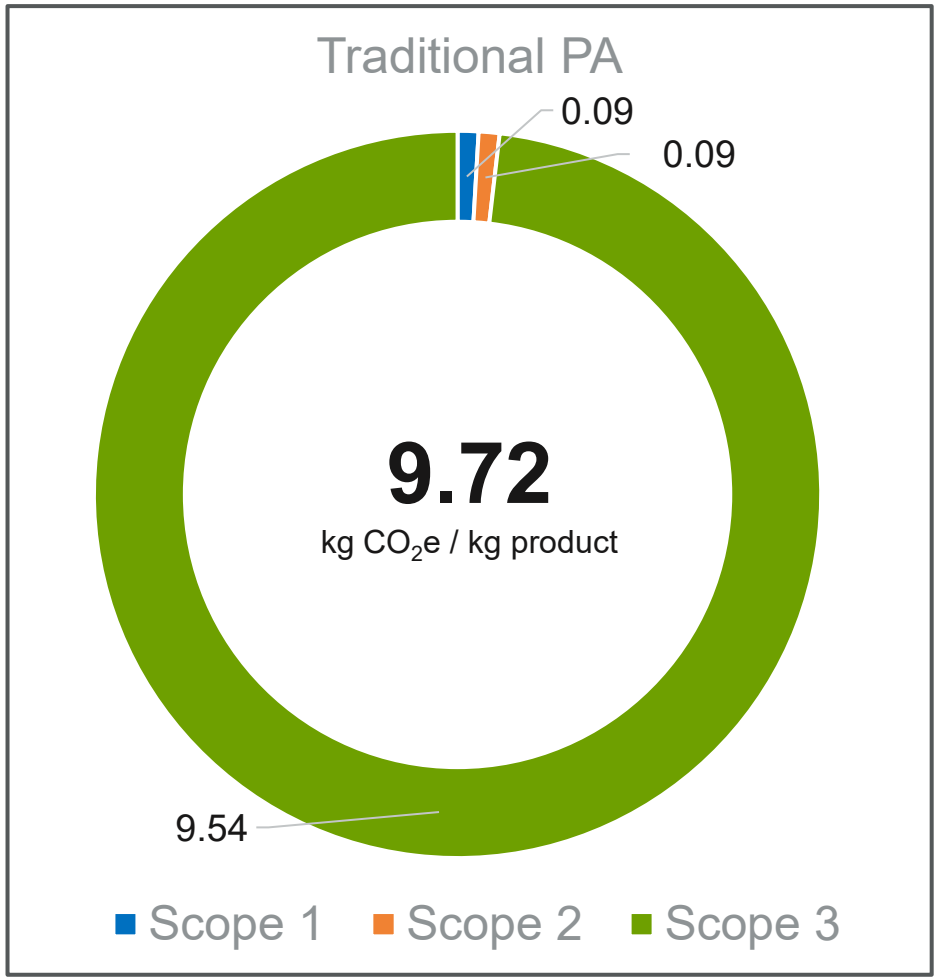


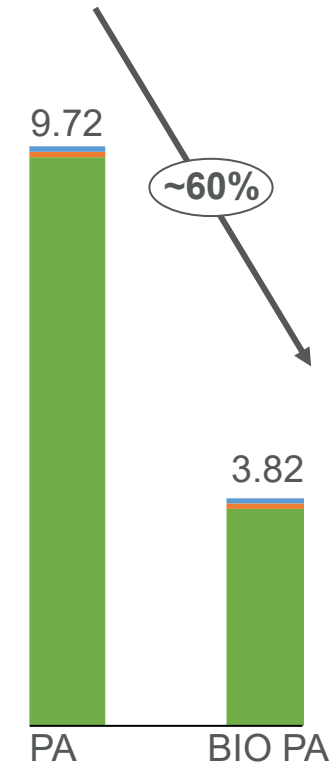


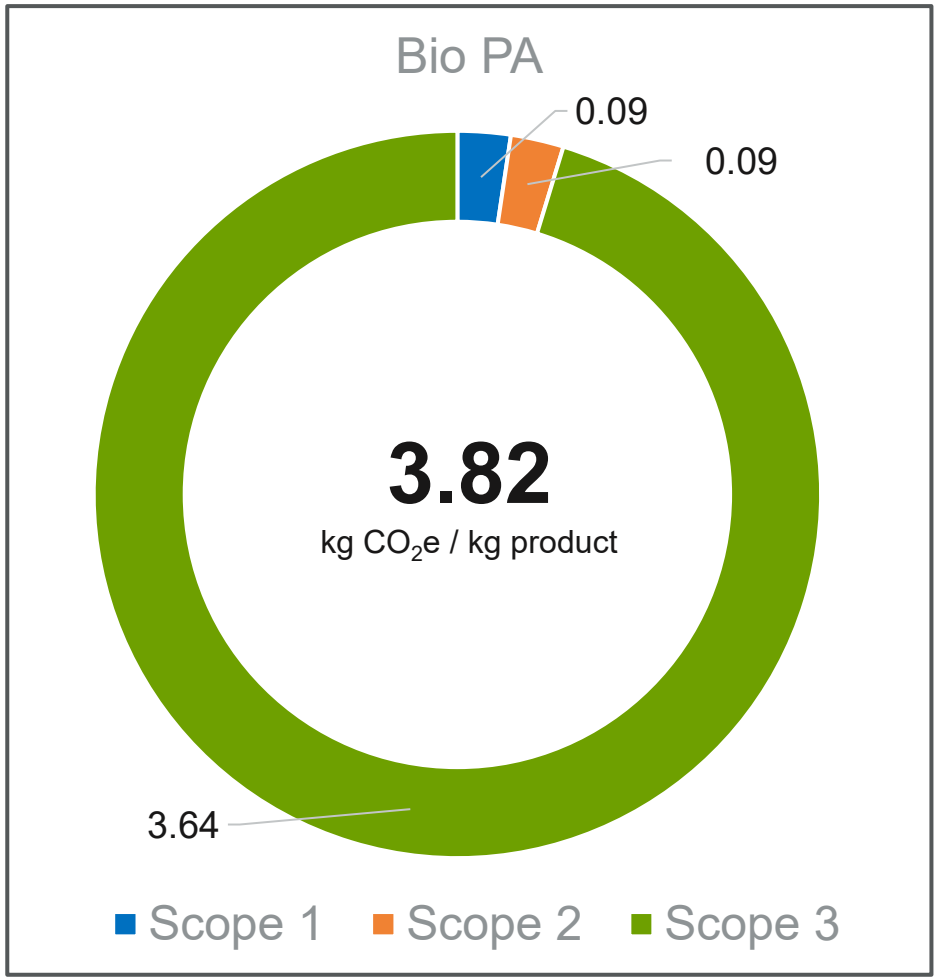
AVIENT

IMPACT OF RAW MATERIAL

TRADITIONAL PA VS. BIO PA

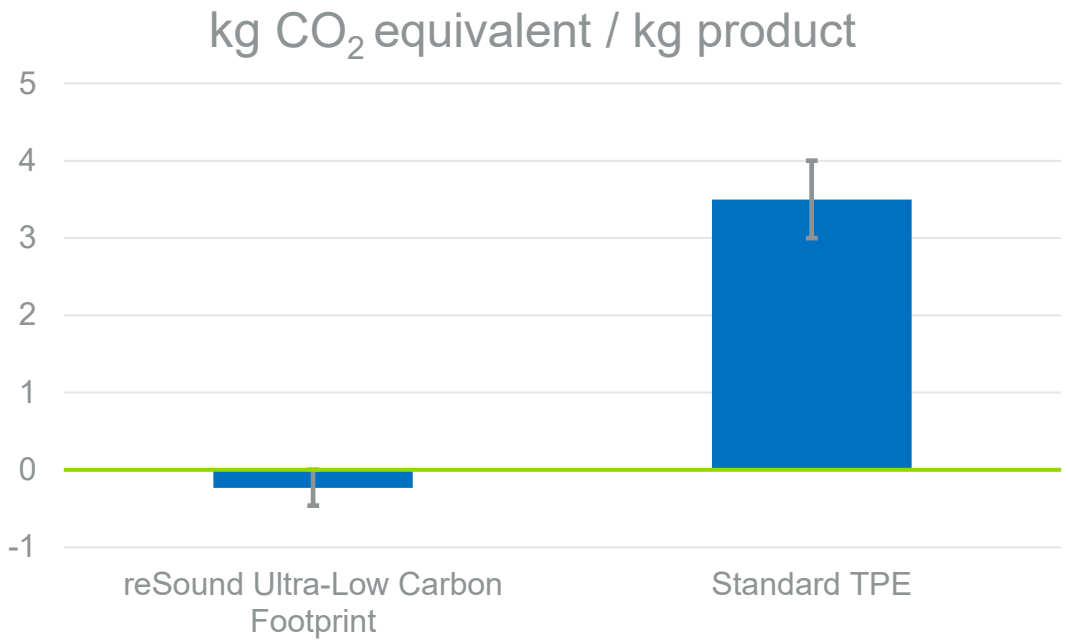






SUSTAINABLE SOLUTIONS

INDUSTRY-FIRST NEUTRAL PCF TPES



- Comparable performance
- Globally available