Rethinking material impact with Luminy PLA and Luminy® rPLA Life Cycle Assessment

Considering PLA from sugarcane and from recycled material

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Luminy®
PLA bioplastics

What is Luminy® PLA?

Polylactic acid

100% Biobased

Made from annually harvested renewable sugarcane plants

Compostable

Industrially composts faster than banana peels

Recyclable

Mechanically and chemically

Versatile

Used anywhere conventional plastics are used

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How is Luminy® PLA made?

Sugarcane is the starting point for Luminy® PLA. The sugar extracted from the sugarcane is fermented using microorganisms to produce lactic acid, an organic acid also produced by the human body.

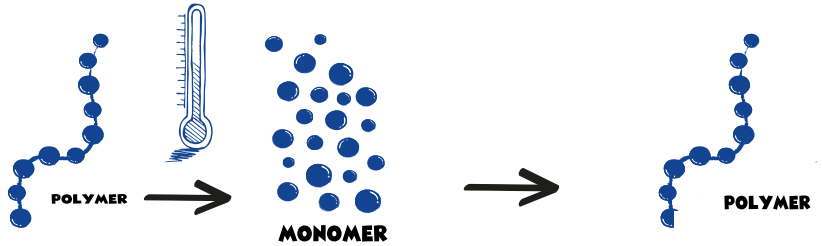
Greenhouse gas capture → **Sugarcane farming** → **Raw sugar** → **Lactic acid production** → **Polylactic acid (PLA) production**

At TotalEnergies Corbion we produce via two routes

Virgin Luminy® PLA

Sugarcane is the starting point for PLA.
Sugar obtained from sugarcane is fermented by microorganism producing lactic acid which is then polymerized into PLA.

Recycled Luminy® PLA



PLA is the starting point for PLA
Depolymerizing PLA via hydrolysis produces lactic acid which is then purified and repolymerized offering the same properties as virgin PLA.

What is the environmental impact of PLA's production process?

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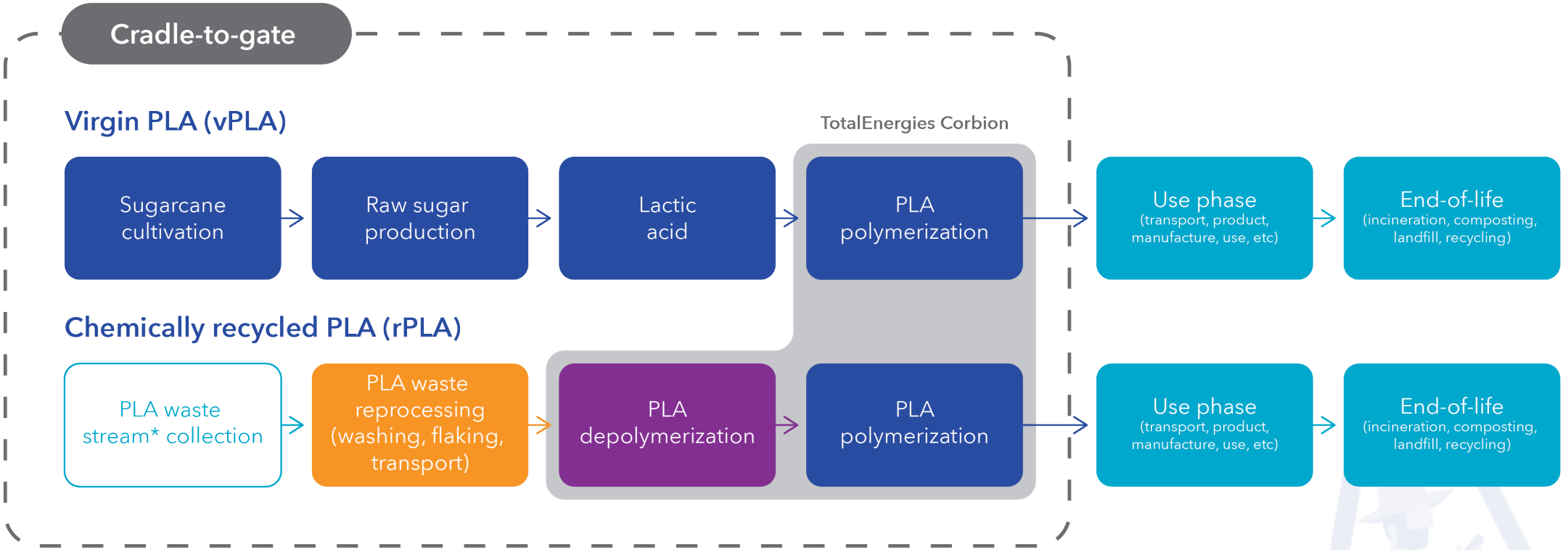
Our Life Cycle Assessment (LCA)

SCAN ME

- **Objectives**
  Quantify the environmental impact of PLA from TEC produced in Thailand from virgin and recycled lactic acid and identify potential improvements
- **Scope**
  Cradle-to-gate (covering the production process as it was in 2024)
  For recycled PLA incoming waste are Post-Consumer Waste (PCW) from Asia and Post-Industrial Waste (PIW) from Europe.
- **Functional Unit**
  1kg PLA or rPLA
- **Datasets**
  Corbion LCA 2022, TEC data 2024, Literature, Ecoinvent 3.10, Agrifootprint v6
- **Products**
  Virgin PLA, , rPLA 100%, rPLA 30%, rPLA 20%, Circular lactic acid PLA.
- **Compliance verified according to**
  ISO14040, ISO14044, ISO14067, ISO14071

Production process in scope



*Waste stream: Post-industrial and post-consumer closed-loop waste, assume no environmental burden

Life Cycle Inventory (LCI) (2025)

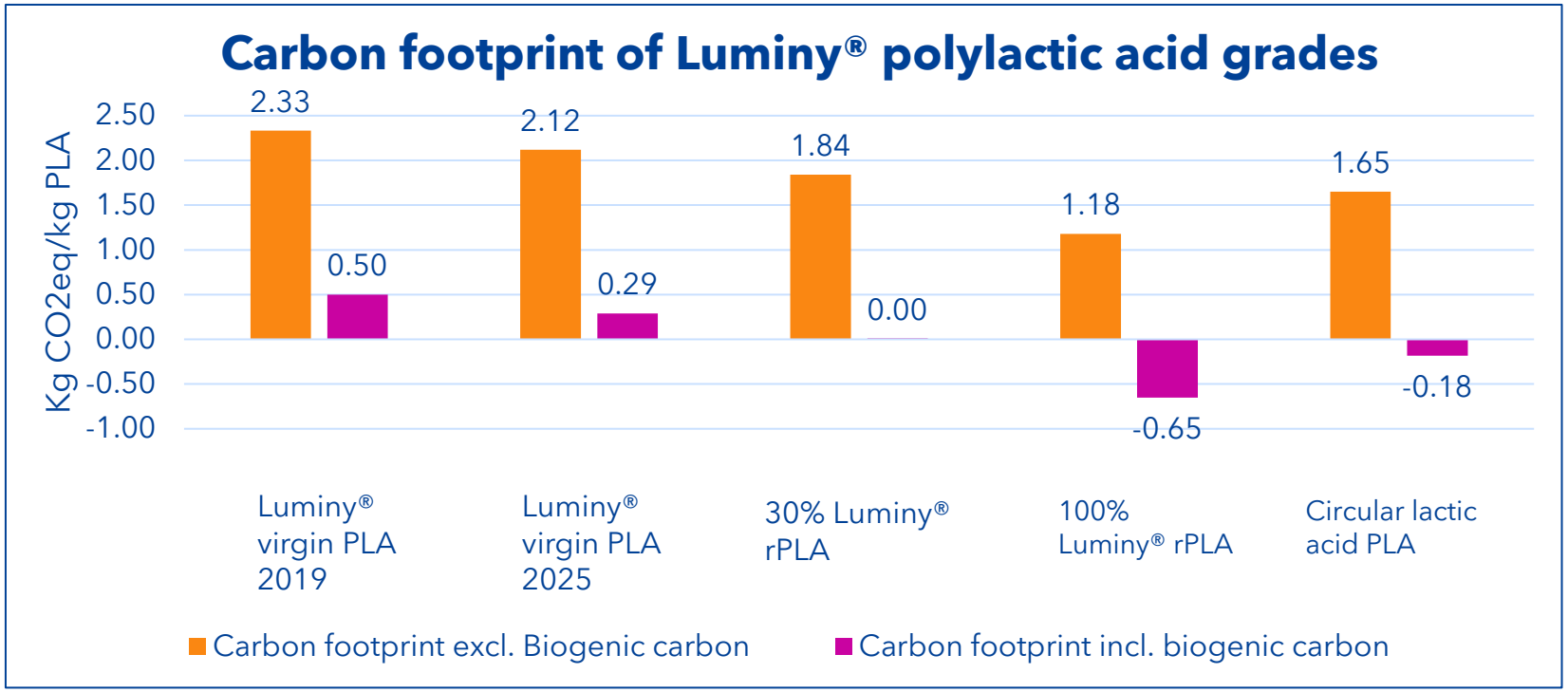
Assume same use phase and end-of-life for virgin and recycled PLA

New process from TotalEnergies Corbion LCI 2025

Literature

Climate change impact

Carbon footprint



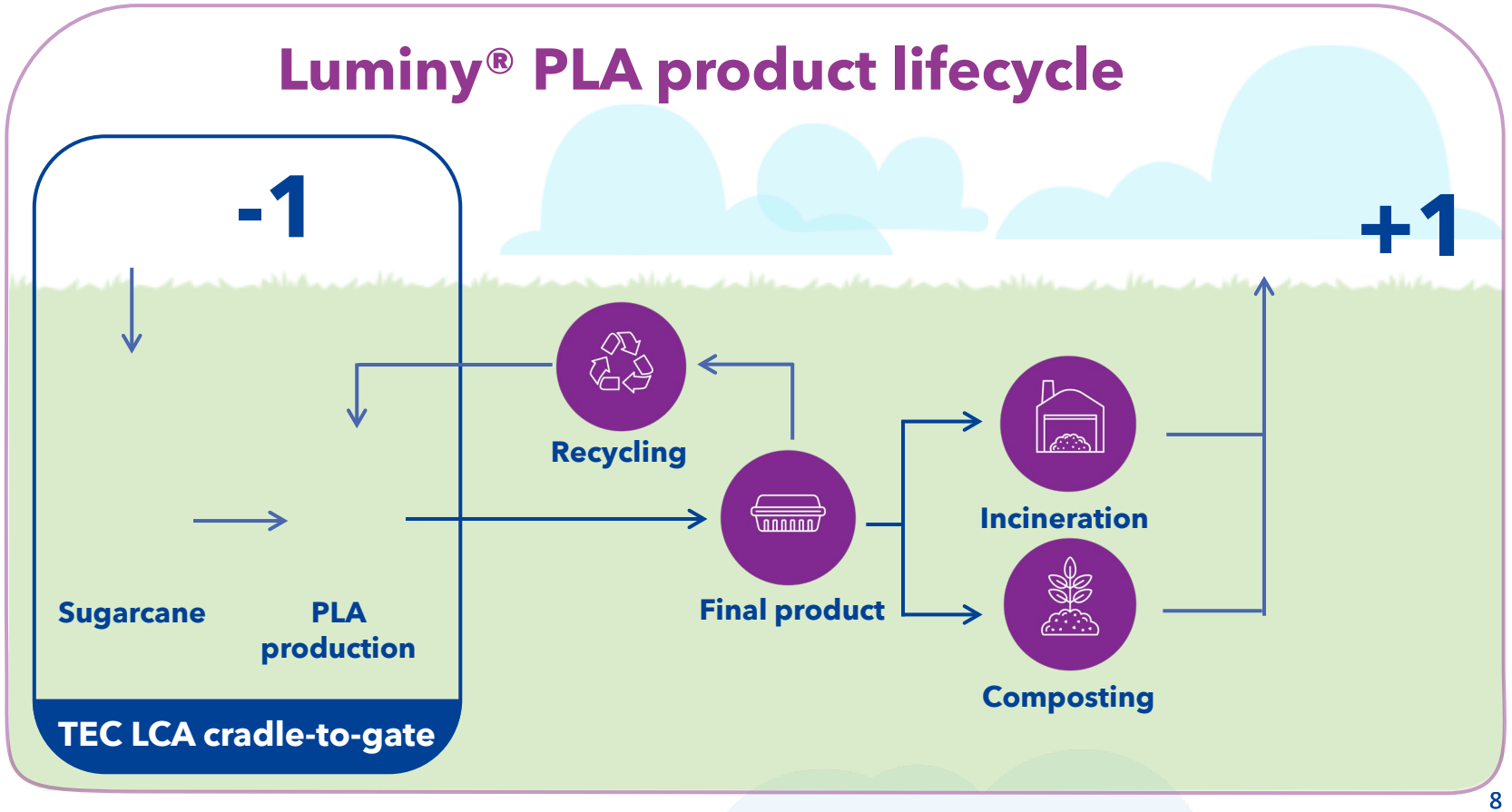
- 200kgCO_2eq/ton PLA reduction compared to 2019 (0,5 – 0,3).
- **Carbon neutrality reached for 30% Luminy® rPLA**
- **Negative carbon footprint reached for 100% Luminy® rPLA**
- Carbon neutrality will be reached using the circular lactic acid.

Biogenic carbon accounting

The industry approach allowed by ISO

What is the -1/+1 approach?

- A transparent approach showing the atmospheric carbon captured in the product and then released at EOL.
- In cradle to grave (incineration or composting), the biogenic carbon footprint is 0.
- If we stop at cradle-to-gate (polymer or product), the benefits of biobased products are demonstrated.
- The atmospheric carbon temporarily stored in the product is recognized.



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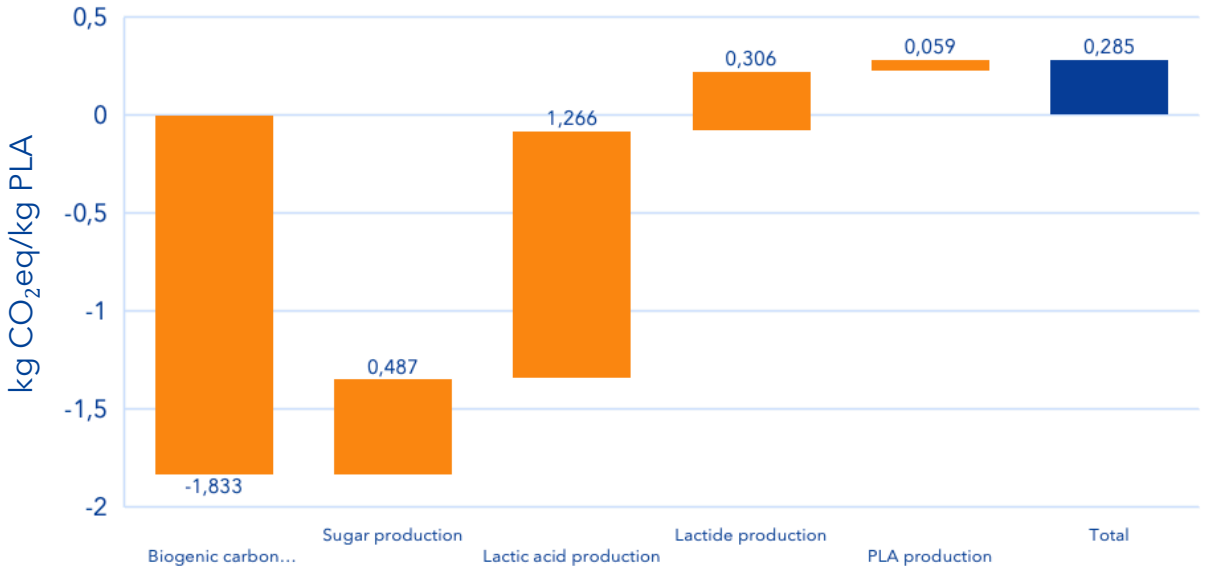
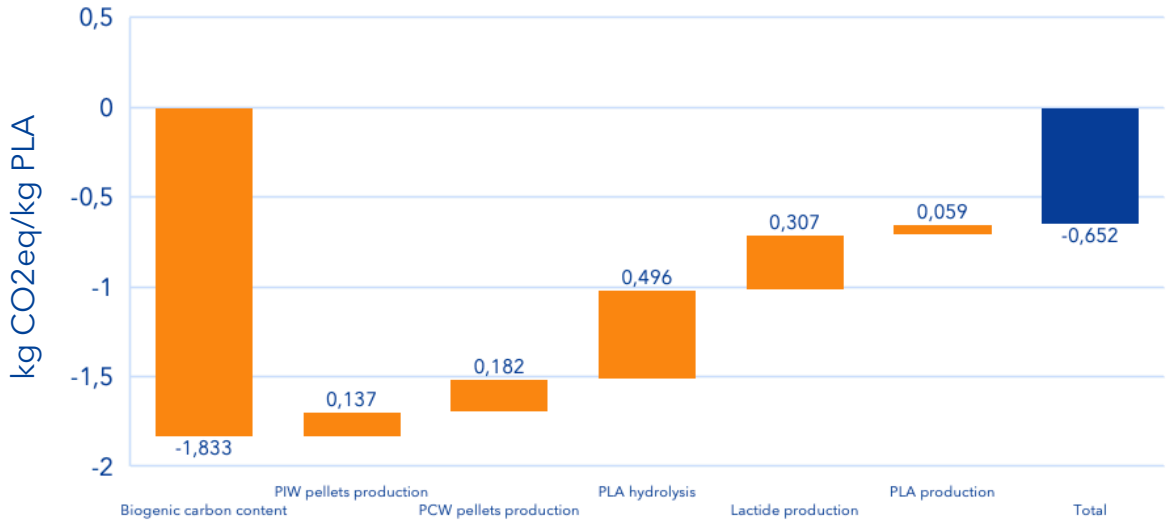
Split of Climate change impact

Climate change impact of Luminy® PLA (including biogenic carbon)



- 42% from hydrolysis
- 27% from waste preparation
- 26% from lactide production

Climate change impact of Luminy® 100% rPLA (including biogenic carbon)



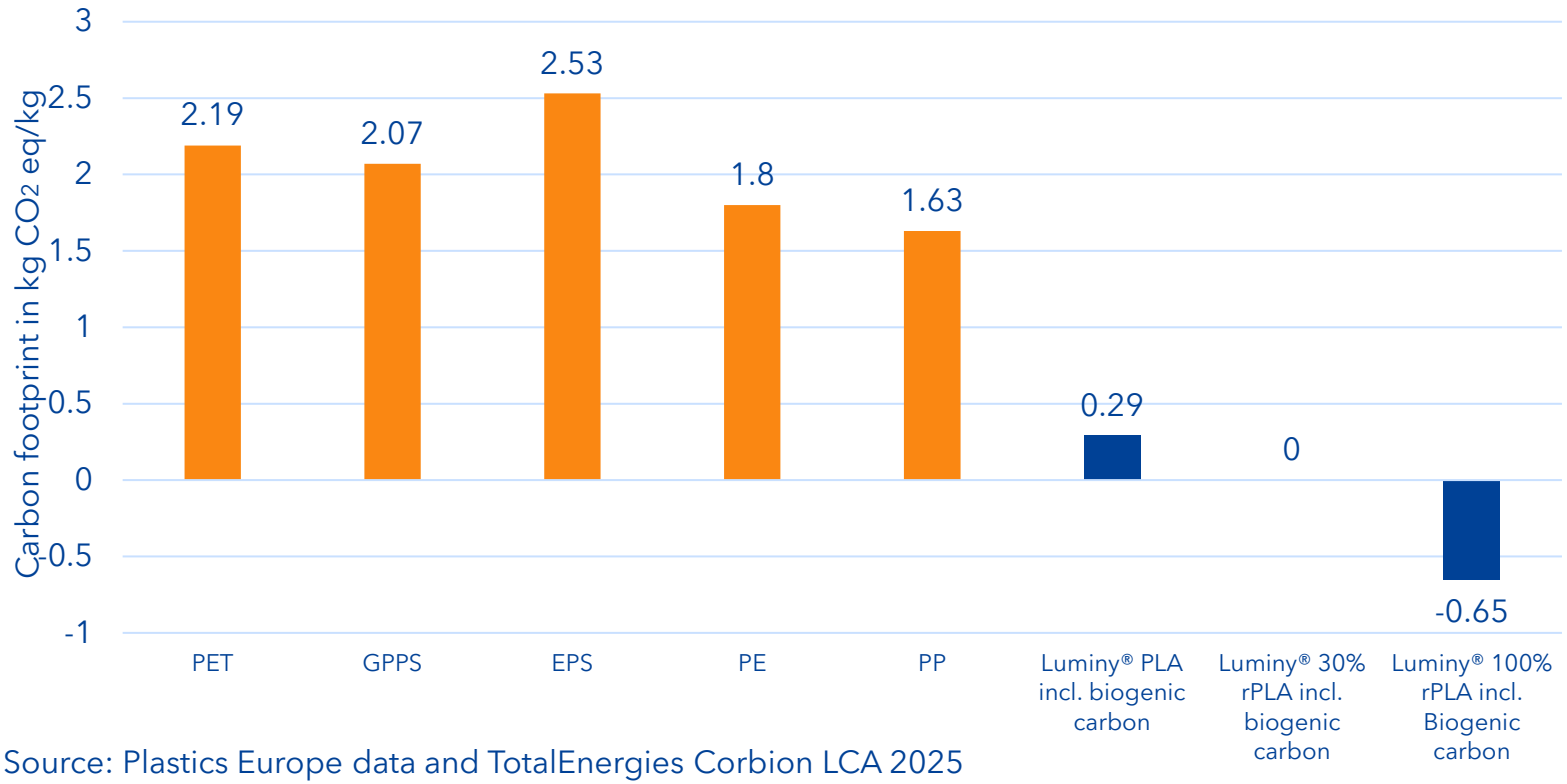
- 60% GWP from lactic acid production
- 23% from sugar production

How Luminy® compares

Low Global Warming Potential compared to conventional materials

85% Carbon footprint reduction with Luminy® PLA

Cradle to Gate Carbon Footprint for various polymers kg CO_2 eq/kg polymer



Source: Plastics Europe data and TotalEnergies Corbion LCA 2025

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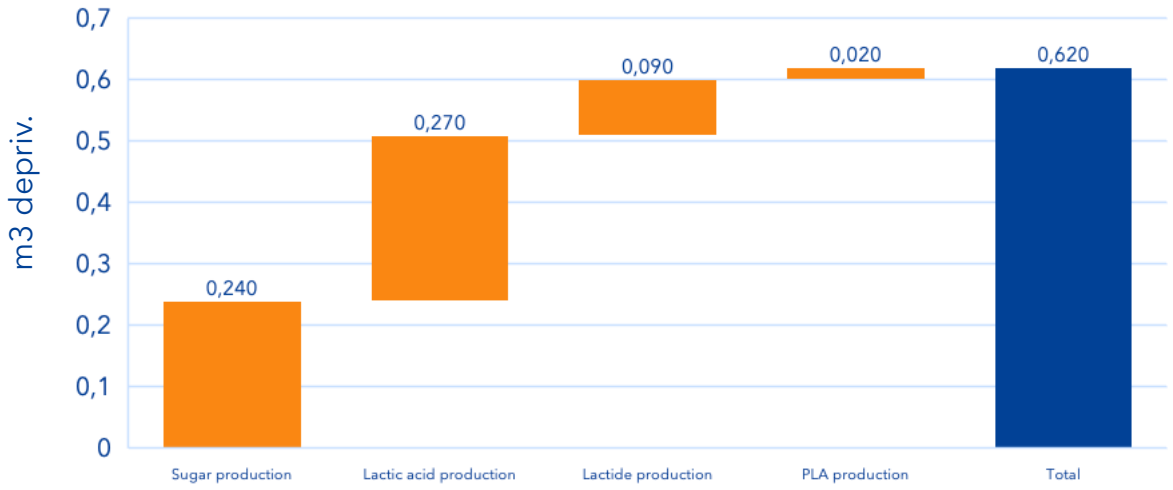
Water impact (deprived water)

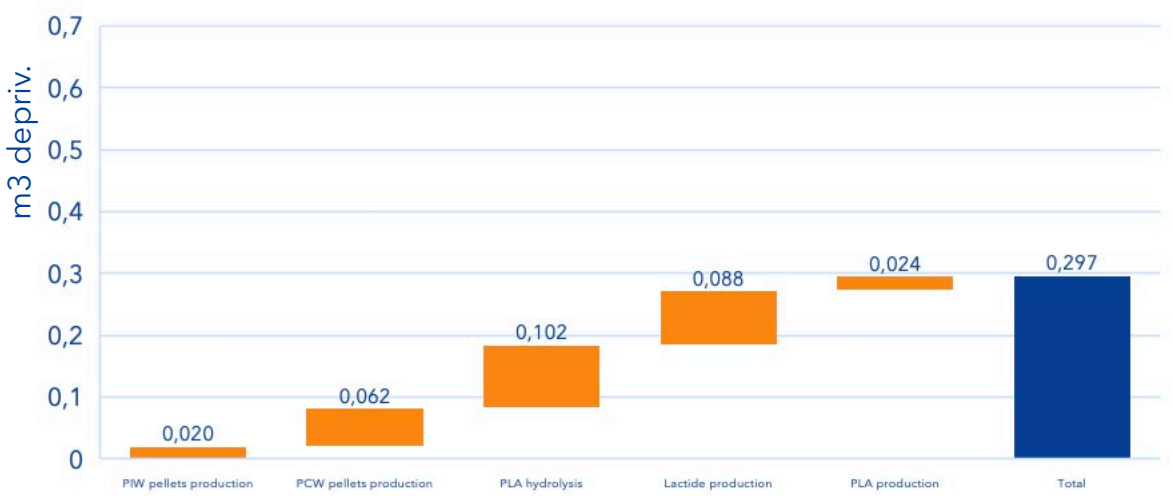
Water is not a relevant category (not in the 80%) but important to be assessed for a biobased material.

Water use for Luminy® PLA per production stages



- 43% from lactic acid production (chemicals)
- 39% from sugar production (farm)

Water use for Luminy® 100% rPLA per production stages



- 35% from hydrolysis
- 30% from lactide production
- 20% from PCW preparation

Results

rPLA scores lower in all relevant impact categories

Impact Category	Unit/kg PLA	Virgin PLA	100% Luminy rPLA	
Climate change	kg CO2 eq	2.12	1.18	↙ -44%
Climate change including biogenic carbon	kg CO2 eq	0.29	-0.66	
Photochemical ozone formation	kg NMVOC eq	7.79E-03	5.29E-03	↙ -28%
Particulate matter	disease inc.	3.76E-07	0.29E-07	↙ -93%
Acidification	mol H+ eq	4.28E-02	0.69E-02	↙ -84%
Eutrophication, marine	kg N eq	1.70E-02	0.23E-02	↙ -86%
Eutrophication, terrestrial	mol N eq	0.13	0.02	↙ -86%
Land use	Pt	212.24	15.13	↙ -93%
Water use	m3 depriv.	0.62	0.30	↙ -52%
Resource use, fossils	MJ	18.72	14.38	↙ -23%
Resource use, minerals and metals	kg Sb eq	1.10E-05	0.43E-05	↙ -61%

Future scenario

Use of circular lactic acid

- The major impact reduction is due to the elimination of lime and sulfuric acid in the process. The production of these chemicals is very intensive as well as treatment of the byproducts.
- The new lactic acid process however requires more natural gas use.
- The values are based on design data.

Impact Category	Unit/kg PLA	Virgin PLA	PLA future scenario	
Climate change without biogenic carbon	kg CO_2 eq	2.12	1.65	↙ -22%
Particulate matter	disease inc.	3.76E-07	3.04E-07	↙ -19%
Acidification	mol H+ eq	4.28E-02	3.54E-02	↙ -17%
Eutrophication, terrestrial	mol N eq	0.13	0.13	↙ -4%
Eutrophication, marine	kg N eq	1.70E-02	1.59E-02	↙ -6%
Resource use, fossils	MJ	18.72	19.43	↗ 4%
Land use	Pt	212.24	200.39	↙ -6%
Water use	m3 depriv.	0.63	0.46	↙ -26%

Conclusions

- The main environmental hotspots for Luminy® virgin PLA are the **production of sugar and lactic acid**, particularly the use of chemicals, steam, and energy-intensive.
- **Luminy® recycled PLA** uses PLA waste as feedstock instead of sugar avoiding the most environmentally impacting steps fo the PLA production. In **all relevant** impact categories, it has a **lower impact.**
- When including the biogenic carbon, **Luminy® virgin PLA has a carbon footprint of 0.29 kgCO_2e/kg**, while **Luminy® 100% recycled PLA achieves -0.65 kgCO_2e/kg**, confirming **carbon neutrality and even negative carbon footprint**.
- Switching to a new **circular lactic acid** input can further **reduce the environmental impact** including **climate impact reduced by 22%.**
- The results of this newly updated and third-party verified LCA for Luminy® PLA demonstrates that the **biobased industry** is **evolving** and constantly working towards **reducing its environmental impact**.
- There is a need for **harmonization** in LCA methodology especially in **biogenic carbon accounting** which is even more crucial for recycled biobased materials.

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