Production of Sustainable Polyethylene
based on carbon captured from industrial waste gas

Lanzatech, TotalEnergies and L'Oréal have developed an innovative solution to reduce the carbon footprint of Polyethylene (PE). They have achieved a world first in producing the very first packaging made of sustainable PE using captured and recycled carbon emissions. The aim of this project is to scale up the production of this sustainable PE and thereby reduce the amount of plastic made from fossil fuels.

Project start-up date	November 2020
Project location Site of project implementation at this stage and target geography if it is reproduced	Antwerp (BE)
Project objectives Nature of the project's climate innovation with a reminder of the problem/challenge addressed	The objective is to provide Polyethylene (PE) users with a "drop-in" solution that is a perfect substitute (in terms of mechanical performance, food safety approval, etc.) for conventional fossil fuel-based PE while reducing considerably its environmental footprint (LCA). PE carbon footprint reduction will come from substitution of fossil oil by a less carbon intensive feedstock.
Detailed description of the project	TotalEnergies' Polymers activity has fully committed to taking on this challenge by innovating to reduce the carbon footprint of its products, particularly polyethylene (PE), by using feedstocks other than fossil oil. With this in mind, TotalEnergies worked with L'Oréal and Lanzatech, both players in the value chain, to develop this ambitious project. The first major deliverable of this world premiere involved a pilot-scale proof of concept of the very first sustainable packaging produced from captured and recycled carbon emissions. The ultimate objective of this project is the industrial production of PE from ethanol, obtained via a biotech process based on the bacterial fermentation industrial waste gas. To achieve this, TotalEnergies is using an innovative dehydration process developed with IFP-EN and Axens to transform ethanol into ethylene, which is then polymerized to turn it into a PE that has all the technical specificities of its fossil fuel-based counterpart. The aim of the project is to implement a value chain, from the ethanol obtained from recycled carbon produced by a variety of sources (including waste gas from the industry) to the marketing of PE made from this feedstock. It will enable us to propose plastics that are just as effective and more sustainable than fossil fuel-based solutions, and that fit into a circular economy, including the recycling of the product obtained. The realization of the pilot-scale proof of concept was a key element, to demonstrate the technological feasibility of the dehydration process needed to transform the ethanol into polymer-quality ethylene. This innovation paves the way for carbon capture and recycling to produce materials (PE) thereby avoiding industrial waste gas and the use of fossil resources. In addition, this PE is perfectly recyclable at the end of its lifecycle via existing and well-established schemes, meaning that it fits into a complete circular value chain.
The project's main levers to reduce greenhouse gas emissions	

Reduction levers	**Clarifications on the associated aspects of the project**
☒ Energy sobriety and resources (particularly behaviors)	Decarbonization of uses and recycling of industrial emissions representing the beginnings of a new CCU chain.
☐ Energy decarbonization	
☐ Improved energy efficiency	
☒ Improved efficiency in the use of non-energy resources	Production of polyethylene from ethanol obtained via a biotech process based on the fermentation of industrial waste gas.
☐ Absorption of emissions: creation of carbon wells, negative emissions (BECCS, CCU/S, etc.)	

<table>
<tr><td>Scope(s) of emissions on which the project has a significant impact and quantification of the reduction of GHG emissions per scope</td><td>
<table>
<tr><th></th><th>Aspects of the project contributing to reducing emissions per category of emissions</th><th>Quantification of the associated GHG emissions per category of emissions

Please respect the quantification methodology used in the Afep memo.</th></tr>
<tr><td colspan="3">Reducing the company’s dependency on carbon</td></tr>
<tr><td>Scopes 1 + 2
Direct emissions generated by the company’s activity.</td><td rowspan="2">Standard ethylene production process is replaced by a process based on the dehydration of recycled carbon based ethanol.

The Fossil fuel-based ethylene coming from a naphtha cracker is replaced by the ethylene produced in a dehydration unit using recycled carbon based ethanol as a feedstock. The polyethylene production stage remains the same whatever the source of the ethylene.</td><td rowspan="2">CO_2 savings: 0.44 tCO_2/t of ethylene produced

(i.e. up to 44 $ktCO_2$/year depending on the size of the final project).
See above.</td></tr>
<tr><td>Scope 2
Indirect emissions associated with the power and heat consumed by the company.</td></tr>
<tr><td>Scope 3
Emissions induced (upstream or downstream) by the company’s activities, products and/or services on its value chain.</td><td>The polyethylene made from recycled carbon-based ethanol has a lower carbon footprint (cradle to gate) than the fossil fuel-based equivalent it is replacing.</td><td>CO_2 savings: 3.2 tCO_2/t of polyethylene

(i.e. up to 320 $ktCO_2$/year depending on the size of the final project).</td></tr>
<tr><td colspan="3">Increase in carbon wells</td></tr>
<tr><td>Emission absorption
Creation of emission wells (BECCS, CCU/S, etc.).</td><td></td><td></td></tr>
<tr><td colspan="3">GHG emissions avoided by the company on third-party sites</td></tr>
<tr><td>Emissions avoided
Emissions avoided by the activities, products and/or services of the project initiator or by financing projects to reduce emissions.</td><td>See scope 3.</td><td>See scope 3.</td></tr>
</table>
Clarifications concerning the calculation or other observations: Click here to specify
</td></tr>
<tr><td>Method of checking this quantification</td><td>Reference calculation system used (ADEME carbon base, GHG protocol, etc.) GHG protocol and internal & supplier’s LCA
Verification of the calculation (internal or external): internal</td></tr>
<tr><td>Other environmental and social benefits of the project</td><td>This project could offer an economic and circular outlet to ethanol produced by biotechnology with a twofold benefit: it helps reduce the carbon emissions of certain industrial activities (CCU approach) and it enables the polymer industry to no longer use fossil oil as a raw material to produce polymer. Owing to these prospects, a number of industries could initiate projects to produce ethanol from waste gas and TotalEnergies could use this ethanol as a substitute for conventional feedstocks obtained from fossil oil refining.</td></tr>
<tr><td>Technology Readiness Level of the project</td><td>☒ Prototype test in the laboratory (TRL 7)
☐ Test in a real environment (TRL 7-8)
☐ Pre-commercial prototype (TRL 9)
☐ Implementation on a small scale
☐ Implementation on a medium or large scale

Observations: Current TRL, the project objective being large-scale implementation</td></tr>
<tr><td>Project potential and conditions of reproducibility plus the associated potential in terms of climate impact</td><td>The project and its climate impact potential are reproducible provided that:
The polymer market for this type of offer continues to be developed and promoted
Ethanol feedstocks produced using industrial waste continue to be developed</td></tr>
<tr><td>Amount invested (in €)</td><td>> €100 M (amount estimated based on the conceptual study)</td></tr>
<tr><td>Project ROI (Return On Investment)</td><td>☐ ST (0-3 years)
☐ MT (4-10 years)
☒ LT (> 10 years)</td></tr>
</table>

	Observations: Click or press here to enter text.
Partnerships	Three partners are involved in this project: • Lanzatech captures industrial carbon emissions and transforms them into ethanol thanks to a unique biological process. • TotalEnergies uses an innovative dehydration process developed with the IFP-EN and Axens to transform ethanol into ethylene, which is then polymerized to turn it into a polyethylene that presents all the technical specificities of its fossil fuel-based counterpart. • L'Oréal then uses the polyethylene produced to make packaging that has identical properties to that of a conventional polyethylene. The three partners wish to continue working together to produce sustainable plastic on a larger scale and they welcome anyone else ready to commit to using these new sustainable plastics.
Free-text comment field for the project initiator	
For further information on the project	
Contact the project initiator	david.vandewiele@totalenergies.com
URL links for the project	Press release of October 27, 2020
Illustrations of the project	TotalEnergies polymer site, Antwerp  Lanzatech unit:  Photo of the container made by L'Oréal: