

FROM BY-PRODUCT TO VALUE: UNLOCKING LIGNIN'S POTENTIAL

In many industrial processes, by-products are still seen as the end of the value chain. They are often used for low-value applications such as energy recovery or simply treated as waste streams to be managed.

But this perception is changing. Across industries, and especially in the bioeconomy, by-products are increasingly recognised as valuable resources that can be upgraded into higher-value products. This shift is not only driven by sustainability goals, but also by economic opportunity.

The pulp and paper industry offers a clear example of this transformation. Pulp mills generate large quantities of lignin as part of the kraft process. Today, most of this lignin is burned on-site to produce energy. This is efficient and essential for mill operation, but it represents a low-value use of a complex and potentially valuable molecule.



At the same time, industries such as food, cosmetics, rubber, fuels and lubricants rely heavily on additives like antioxidants, which are still predominantly fossil based.

This creates a gap with on one side, an abundant bio-based resource (lignin) and on the other, a demand for functional molecules with specific properties. Bridging this gap is at the core of lignin valorisation.



Valorisation means going beyond traditional uses and unlocking new functionalities from existing streams. In the case of lignin, this involves transforming a heterogeneous polymer into targeted fractions with defined properties. The ZEBRA-LIFE project explores this pathway by converting lignin into bio-based antioxidant additives. Instead of being used only as a fuel, lignin is upgraded into products that can replace fossil-derived ingredients in multiple sectors. This shift from energy use to material use

significantly increases the value generated per tonne of lignin and supports the transition towards a circular and bio-based economy.

One of the key challenges in by-product valorisation is not only the transformation itself, but how it fits within existing industrial systems. ZEBRA-LIFE has been designed with this in mind. The process is integrated

close to pulp mills, allowing lignin streams to be valorised locally while maintaining the operational balance of the mill. Side streams are managed in a way that supports circularity, including energy recovery and chemical reuse where possible. This approach ensures that valorisation does not disrupt existing processes but rather adds a new layer of value on top of them.

Lignin is just one example of a wider trend. Across industries, by-products are being reconsidered as part of a broader strategy to reduce waste and emissions, improve resource efficiency, create new revenue streams, and decrease dependence on fossil-based inputs. Valorisation can take many forms such as internal reuse (energy or process integration), transformation into new materials or chemicals or collaboration with external value chains. The key is to move from a linear view of production to a system-based approach, where each output stream is evaluated for its highest potential value.



By-product valorisation plays a central role in building a competitive and sustainable European bioeconomy. It aligns industrial performance with environmental objectives, supporting both decarbonisation and resource efficiency. In the case of ZEBRA-LIFE, lignin valorisation demonstrates how an existing industrial by-product can become a platform for new bio-based products, contributing to the replacement of fossil-derived additives and opening new market opportunities. As industries continue to evolve, the question is no longer whether by-products can be valorised, but how far their potential can be taken.

About ZEBRA-LIFE

ZEBRA-LIFE is a project co-funded by the European Union under the LIFE Programme. It focuses on developing lignin-based antioxidants as sustainable alternatives to fossil-derived additives. The consortium brings together CENER (project coordinator), Smurfit Kappa Navarra, ASINCAR, Centro Tecnológico Riojano, Roka Furadada, Repsol, Bioquochem and Inveniam Group.

Contact

Email: zebralife@cener.es

Website: <https://zebra.bio2c.es/>