# Transforming digestate into high-value bioproducts for Europe's circular bioeconomy

## The EU-funded Pathfinder ReWoW project explores how digestate can become a key resource for Europe's sustainable future

**ANAEROBIC DIGESTION** (AD) is expanding rapidly across Europe. Biogas has become a strategic and flexible resource, driven by the need to strengthen energy sovereignty, reduce reliance on fossil fuels, and accelerate the transition to renewable energy systems. It can convert organic waste into heat, electricity, and transport fuels, while also providing an efficient way to manage diverse organic residues. This dual role positions AD as a cornerstone of Europe's circular bioeconomy. As policies and investments continue to support its growth, biogas production is expected to play a growing role in Europe's renewable energy mix.

However, this success also brings a new challenge: the growing volume **of digestate**. As AD expands, so does the volume of this residual output. Although digestate is **commonly used as a fertiliser**, this application only captures **part of its value**. Its variability, together with regulatory constraints and limited valorisation routes, has led to its underutilisation.

Yet, within this challenge lies a significant opportunity. Rather than being seen as waste to be managed, **digestate can be reimagined as a versatile feedstock for high-value bio-based products**. Unlocking this potential is at the core of the ReWoW project.

### A new paradigm: Modular Adaptive Fermentation (MAF)

The core innovation of ReWoW is the development of the **Modular Adaptive Fermentation (MAF)**, a new approach to managing the complexity of digestate valorisation. Unlike traditional bioprocesses, which are tailored to single feedstocks, MAF handles the high variability of digestate by breaking the process into modular units that target specific transformations. This modularity enables adaptation to variations in feedstock, different biological and process routes, and flexible configurations based on the desired outputs. MAF integrates multiple disciplines within a coordinated framework, allowing simultaneous process optimisation. This approach aims to transform digestate from being used for low-value applications into serving as a raw material for producing high-value bioproducts such as **aroma compounds, biosurfactants, and enhanced soil amendments**. MAF shifts the focus from fixed-input processes to adaptive systems that can learn, evolve, and respond to complex resources. This positions digestate as a key feedstock in next-generation circular bioeconomy systems.

### Integrating valorisation with artificial intelligence

A key element of ReWoW is its capacity to integrate multiple areas of knowledge into a unified, coherent framework. Digestate valorisation is a complex challenge that involves microbiology, engineering, environmental science, and economics. The project proposes customised artificial intelligence (AI) tools to connect and interpret data from these different disciplines.

At the heart of this approach lies a double-layered AI-driven system that integrates data from experiments, literature, and process monitoring. It is designed to identify optimal process conditions across different scenarios, predict the performance of alternative fermentation configurations, and support decision-making throughout the entire value chain.

Crucially, this system is based on the continuous interaction between experimentation and data analysis. Laboratory work generates real data, which is used to train and refine the models. In turn, these models guide new experiments, creating a dynamic feedback loop. This iterative learning process helps ReWoW deepen its understanding of digestate behaviour and adapt to variability rather than be constrained by it.

### From technology to system: Enabling real-world adoption

Developing new processes is only part of the challenge. For innovation to succeed, it must be effective in real-world conditions, within industries, markets, regulatory frameworks, and society.

ReWoW addresses this by adopting a system-level approach from the outset. The project is developed



within a Safe and Sustainable by Design (SSbD) framework, ensuring that safety, environmental performance, and sustainability are integrated at every stage of development.

This means tackling key questions early. Can these solutions compete economically? Are they aligned with existing regulations? Will the industry adopt them? How will society perceive them?

To answer these questions, the ReWoW project combines technical development with sustainability assessment, economic modelling, policy analysis, and stakeholder engagement. By linking these dimensions, the project ensures that its solutions are not only technically sound but also feasible, acceptable, and scalable. In doing so, ReWoW goes beyond innovation at the laboratory scale. It paves the way for technologies that can be implemented, adopted, and scaled up to deliver tangible impact within Europe's circular bioeconomy.

## Why does this matter for Europe?

Europe is moving towards a more sustainable and resilient economic model, but the challenges are significant. Reducing environmental pressures, securing access to resources, and strengthening industrial competitiveness must all be addressed simultaneously. By converting digestate into high-value products, ReWoW aims to help reduce dependence on fossil-based materials, improve resource efficiency, create new value streams for the bioenergy and waste sectors, and strengthen local, resilient value chains.

This shift from linear waste management to resource-efficient value chains is key to Europe's long-term sustainability. It enables existing infrastructure, such as biogas plants, to generate additional value while supporting regional development. For industry, this means new opportunities to innovate and diversify. For policymakers, it offers practical pathways to align environmental and economic goals. For society, it marks a step towards a more sustainable future.

## Building collaborative ecosystems

ReWoW is driven by an interdisciplinary consortium combining expertise in biotechnology, engineering, artificial intelligence, environmental assessment, and policy. This diversity enables the project to address challenges from multiple perspectives and develop solutions grounded in real-world needs. Beyond the consortium, ReWoW will engage with industry, research initiatives, and policy platforms. These connections ensure that knowledge is shared, solutions are validated, and pathways to implementation are strengthened.

By linking stakeholders, disciplines, and applications, ReWoW contributes to a broader ecosystem of innovation that can accelerate the transition towards a circular bioeconomy across Europe.

ReWoW points towards a future in which waste is no longer treated as an endpoint, but as the beginning of new value cycles that can support a more resource-efficient and circular bioeconomy in Europe that produces, consumes, and thrives.

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