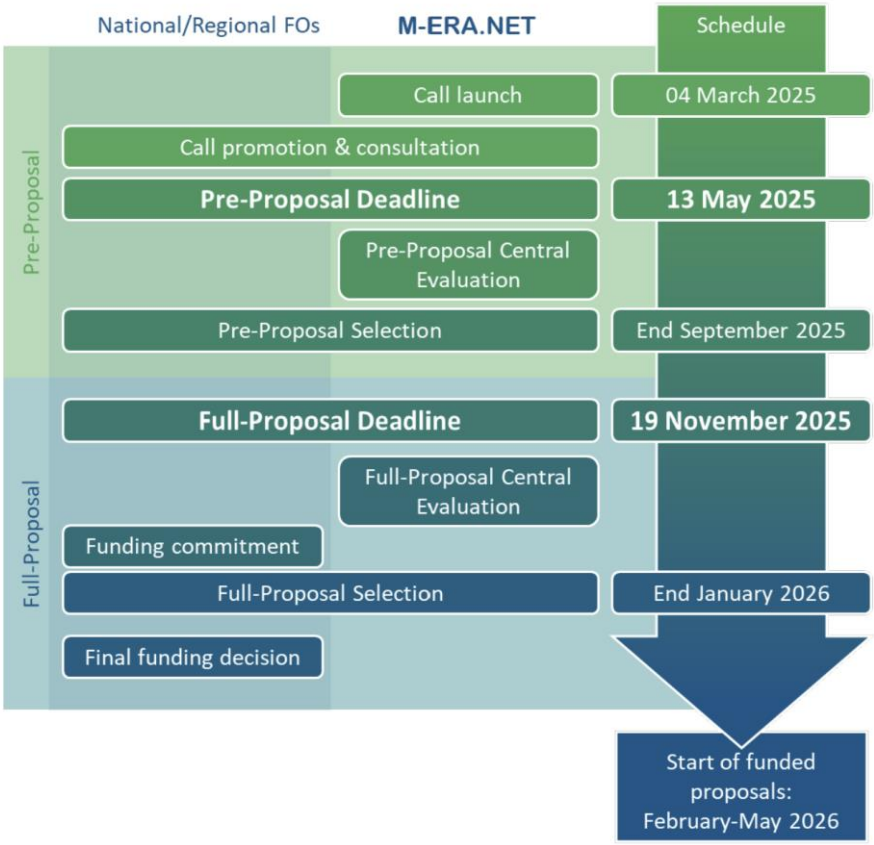
CALL FOR PARTNERS

The objective of the M-ERA.NET Call 2025 is to enable transnational R&D projects between partners receiving funding from regional/national programmes. The aim is to fund ambitious transnational RTD projects addressing materials research and innovation including materials for batteries and low carbon energy technologies. Detailed information about the 2025 call can be found here.



Problem. The agriculture and food industries generate large quantities of organic waste, which often are not recycled. Agricultural waste such as straw, rapeseed pomace or wood residues from wood processing is often not used efficiently, even though it contains valuable compounds such as lignin, which is one of the main constituents of plant fibre, giving plants structural strength and robustness. The chemical composition of lignin and the abundance of aromatic compounds make this polymer particularly promising for the production of bioplastics, glues, resins and other industrial products. Biological methods of lignin extraction use enzymes from micro-organisms, mainly fungi and bacteria, which naturally degrade lignin and separate it from cellulose and hemicellulose. The main enzymes used in this process are lignin peroxidases (LiP), manganese peroxidases (MnP) and laccase. These enzymes are effective in degrading the aromatic compounds of lignin, thus facilitating its separation.
Another issue is the environmental impact of the production of adhesives used in industry. Many conventional adhesives are made from petroleum products, which are not a renewable resource, and their production increases carbon dioxide emissions. This raises the need for sustainable, biodegradable and environmentally friendly solutions.
The aim of the project – to develop sustainable modified bio-based adhesive mixes using lignin extracted from agricultural and food organic waste and to adapt them to the production of composite materials. This aims to address both the problems of agricultural and food waste management and the use of petroleum-based adhesives, while contributing to the development of a circular economy and sustainable industry.

Solution. Project Objectives/Goals:

1. To study the composition of organic agricultural and food waste and identify the most suitable organic waste types for lignin extraction.
2. Evaluation of technologies most appropriate for lignin extraction.
3. Development and testing of different mixes of lignin and commercially available bio-based adhesives, investigating their physical and mechanical properties complying with sustainability principles.
4. Research on the production and application of composite materials made with bio-based adhesive-lignin mixes.

Expected Outcomes (after project completion)

- **Extraction of lignin from organic agricultural raw materials.** An efficient and sustainable technology has been developed to extract lignin from organic wastes such as straw, rapeseed pomace, wood waste, etc. This will increase the value of these wastes. The lignin extracted will be used as a key feedstock for the production of modified bio-based adhesives, thus contributing to the development of the circular economy.
- **Report on the existing technologies...**
- **Sustainable bio-based adhesives with lignin.** New bio-based adhesive formulations will be developed by modifying starch or animal glues with lignin or other sustainable components. The resulting adhesives will be applied to the production of composite materials. The main advantage of these adhesives is their environmental friendliness, higher resistance to environmental influences and better mechanical properties. The creativity of the project is manifested through the use of different organic wastes and an innovative approach to the development of bio-based adhesives. The integration of lignin in adhesive mixtures and their application in composite materials creates new value and the possibility of using agricultural raw materials in the production of higher added value products.
- **Manufacture of composite materials.** Development of composite products using modified adhesives made from lignin. Such materials could be widely used in the construction industry, furniture manufacturing or other areas where high quality composite materials are needed. Although the underlying technology is based on known scientific principles, the project will carry out experiments to develop optimal technologies and to test how different raw materials affect the final product. This leads to uncertain results, but with a potentially high degree of innovation.

Project Added Value (long term value)

- **Lignin extraction technology.** A practical technology for the efficient extraction of lignin from malt and other organic waste. It will cover all technological steps with focus on clean technologies, from waste preparation to optimisation of the extraction process, and will be presented as a reliable and efficient solution for the recycling of waste from the agri-food industry.
- **Modified bio-based adhesives.** Adaptation of new bio-based adhesive mixes using lignin for the production of composite materials. These adhesives will have eco-friendly properties compared to traditional adhesives made from synthetic materials.
- **Composite materials.** Composite products made with sustainable adhesives whose mechanical and thermal properties will be analysed in detail and evaluated according to industrial standards. These materials can be used in a wide range of industries as an alternative to synthetic materials.

The project will be implemented in a systematic way, with sequential research from raw material analysis to final product development. Each activity builds on the previous steps and contributes directly to the final goal of developing sustainable, environmentally friendly products. The technologies and processes developed will be readily adaptable and reproducible in other industries, as the technology base is sustainable and meets modern environmental and economic requirements. Lignin extraction and glue production can be replicated in other countries facing similar waste recycling problems.

Planned consortium: Tampere University of Applied Sciences (Finland), University of Malaga (Spain), University of Venda (South Africa), Latvian State Institute of Wood Chemistry (Latvia).

Incorporation of Sustainability and Circular Economy Principles into the Project Concept

The project is based on sustainability and circular economy principles, which are integrated into all stages of its development. The main goal of the project is to create modified, biologically-based adhesive formulations where lignin serves as the primary component. This material is extracted from agricultural and food industry organic waste, thus contributing to waste recycling and extending the life cycle of biodegradable materials.

Sustainability principles in the Project: 1) **reducing Environmental Impact** – the project aims to develop adhesive formulations that replace petroleum-based adhesives, thereby reducing dependence on fossil fuels. This will help lower greenhouse gas emissions and environmental pollution; 2) **Waste Recycling and Reuse** – Obtaining lignin as a secondary product from agricultural and food industry waste helps reduce the amount of biological waste and extend its usage cycle; 3) **use of Renewable Resources** – by utilizing bio-based raw materials such as lignin, the project reduces dependence on synthetic chemical compounds and promotes the efficient use of natural resources;

Circular Economy principles in the Project: 1) **extending the lifecycle of Materials** – the developed adhesive formulations will be adapted for composite material production, thereby extending product durability and reducing waste generation; 2) **Closed-Loop Production Cycle** – the project encourages manufacturing processes that rely on secondary raw material supply chains, thus reducing the need for new resources and enhancing resource efficiency; 3) **Product Recyclability** – the adhesive formulations will be designed to ensure that end products can be recycled, preventing additional environmental pollution at the end of their lifecycle.

Project alignment with the Horizontal Objectives for the M-ERA.NET Call 2025.

The proposed project strongly supports the Horizontal Objectives for the M-ERA.NET Call 2025, particularly in advancing sustainability, circular economy principles, and innovation in materials science.

Supporting the European Green Deal through Circular Economy

This project is a direct implementation of circular economy principles, ensuring that organic waste from the agricultural and food industries is recycled, repurposed, and reintegrated into industrial production. It addresses two major environmental challenges: the underutilization of agricultural waste and the dependency on petroleum-based adhesives. By extracting lignin from agricultural byproducts – such as straw, rapeseed pomace, and wood residues – and converting it into high-value bio-based adhesives, the project prevents valuable materials from being discarded while simultaneously reducing the use of fossil-fuel-derived industrial products.

This waste valorization approach strengthens resource efficiency and helps close material loops, ensuring that organic waste streams are transformed into valuable inputs for new industrial applications. The adhesives developed will be biodegradable, non-toxic, and recyclable, providing a

sustainable alternative to synthetic petroleum-based adhesives. Furthermore, their integration into composite materials enhances product lifespan, reusability, and recyclability, supporting the Green Deal's objectives of decarbonization and sustainable industry transformation.

By ensuring that composite materials made with bio-based adhesives can be easily dismantled and repurposed, the project prevents additional environmental pollution at the end of its lifecycle. The implementation of a closed-loop production model reduces the demand for virgin raw materials, enhances resource efficiency, and promotes waste reduction and industrial decarbonization. Additionally, the project aligns with eco-design principles by developing adhesives that contribute to longer product life cycles, enhanced recyclability, and reduced environmental impact.

This initiative directly supports the European Green Deal's vision for a climate-neutral Europe by:

- Replacing petroleum-based adhesives with bio-based alternatives, reducing carbon emissions.
- Promoting the recovery and reuse of agricultural waste, reducing landfill disposal.
- Enhancing the recyclability of composite materials, preventing additional environmental pollution.
- Lowering the overall environmental footprint of industrial manufacturing, contributing to circular and sustainable industry practices.

Supporting the Sustainable Development Goals (SDGs)

This project directly supports several United Nations Sustainable Development Goals (SDGs):

- SDG 12 (Responsible Consumption and Production): The project ensures waste recycling and resource reuse, preventing organic waste from being discarded and promoting the reuse of natural materials in industrial production.
- SDG 7 (Affordable and Clean Energy): The transition from synthetic chemical adhesives to bio-based alternatives significantly reduces fossil fuel consumption, fostering cleaner industrial processes.
- SDG 9 (Industry, Innovation, and Infrastructure): The integration of biodegradable adhesives into composite materials represents a technological breakthrough that improves manufacturing sustainability while offering a viable eco-friendly alternative to petroleum-based adhesives.

Creating Socio-Ecological Benefits through Responsible Research and Innovation (RRI)

This project is fundamentally circular—it ensures that materials are sustainably sourced, efficiently used, and designed for end-of-life recyclability. By incorporating eco-design principles, the project ensures that adhesives and composite materials are biodegradable, safe, and free from hazardous chemicals. The project's interdisciplinary and international consortium (including partners from Finland, Spain, South Africa, and Latvia) strengthens transnational cooperation and fosters knowledge exchange on sustainable materials.

Strengthening the Innovation Chain and Interdisciplinarity

The project spans the entire value chain, from waste utilization and lignin extraction to adhesive production and composite material manufacturing. This integrated approach enhances industrial sustainability by substituting petroleum-based materials with bio-based alternatives, closing material loops, and ensuring efficient use of natural resources. The involvement of research institutions and industry partners ensures that the developed technologies are both scientifically robust and industrially scalable.

To conclude, this project embodies the principles of the circular economy, demonstrating how waste can be transformed into valuable, high-performance industrial materials. By closing material loops, reducing reliance on synthetic chemicals, and promoting resource efficiency, it aligns perfectly with the M-ERA.NET Call 2025 horizontal objectives. The project not only advances sustainability and clean technology but also strengthens global research collaboration and supports the transition to a low-carbon, circular industrial model in line with EU and international environmental goals.