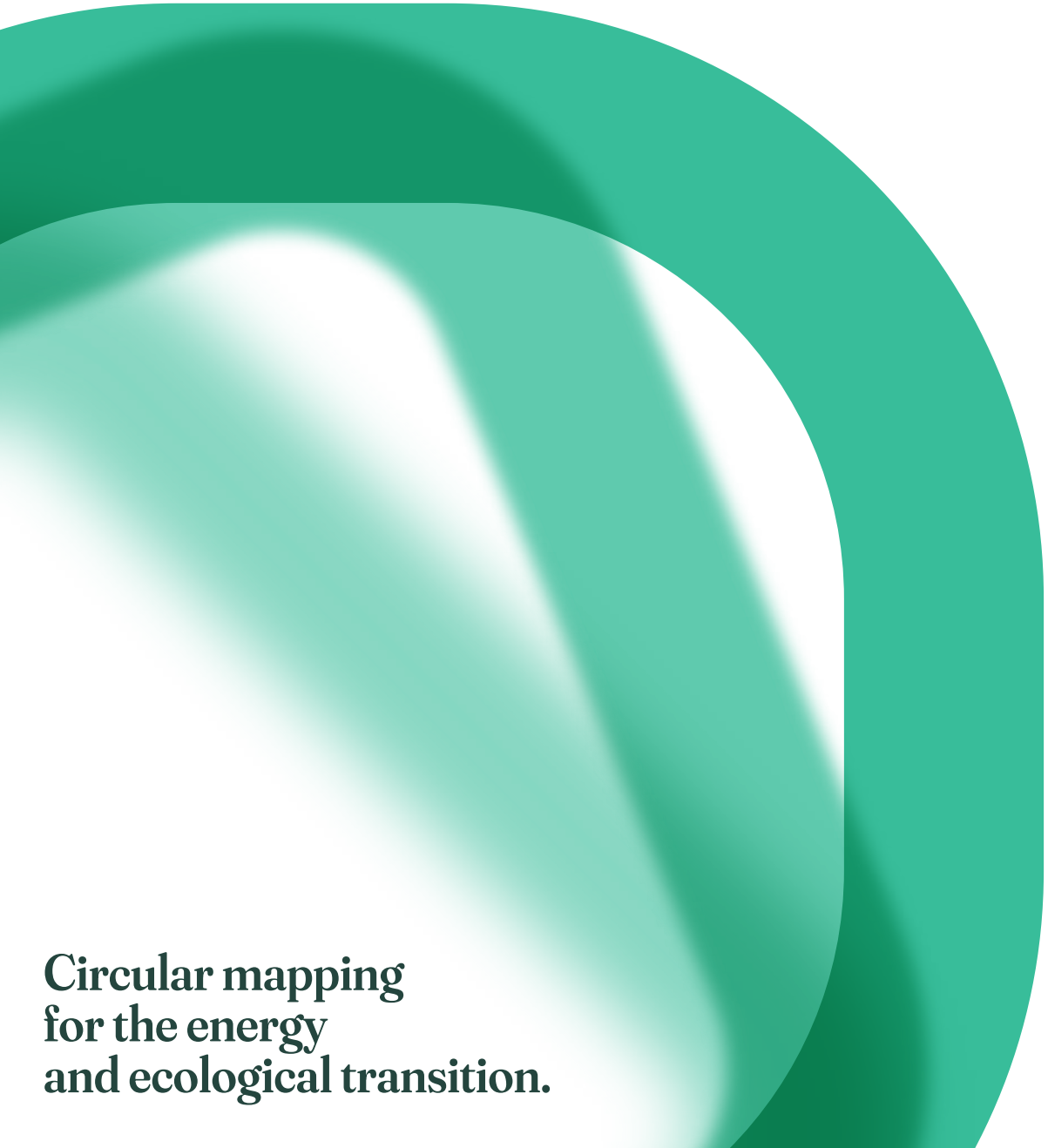
# mactee

## planning the recovery.



**Circular mapping
for the energy
and ecological transition.**

# A new dependency

*Regulatory and economic scenario*

The energy transition does not eliminate dependence on foreign sources. It shifts it from fossil fuels to metals. Today, the European Union meets a large portion of its demand for critical raw materials through imports from outside the EU, concentrated in a small number of supplier countries. The Critical Raw Materials Act (EU Regulation 2024/1252, in force since April 2024) sets four thresholds for 2030.

# 10%

of the EU's annual consumption
of strategic raw materials
to be extracted within the Union

# 40%

of annual demand
to be processed within the EU

# 65%

maximum threshold for dependence
on a single non-EU country,
for each strategic material

# 25%

of the EU's annual consumption
of strategic raw materials to be met
through recycling by 2030

*Source: Regulation (EU) 2024/1252 on the Critical Raw Materials Act.*

*Transition technologies are largely made of these same materials. A wind turbine is **86%** metal by composition. By 2030, demand for silver in photovoltaic production will exceed **30%** of total global demand, despite improvements in material-use efficiency.*

*Source: IEA, "The Role of Critical Minerals in Clean Energy Transitions" (2021); IEA, "Global Critical Minerals Outlook 2025".*

When a photovoltaic system, a wind turbine or a battery energy storage system (BESS) reaches the end of its life, these materials do not simply disappear: they remain in decommissioned facilities, unmapped, unquantified and not scheduled for recovery. The cost of recycling a photovoltaic panel is currently estimated at €12–39, against €1–4 for landfill disposal*: a gap that, in the absence of an organised collection and treatment supply chain, fuels improper disposal and ineffective storage instead of recovery.

MACTEE addresses this data gap: where the material is located, when it will be available, how much it will cost to recover it.

*Source: IEA, "Recycling of Critical Minerals" (2024); data reported in the MACTEE Development Plan.*

* These figures reflect estimates from international literature (NREL; IEA, "Recycling of Critical Minerals", 2024), which indicate a global reference range of $15–45 for recycling a module and $1–4 for landfill disposal. Within the European Union, landfilling photovoltaic panels is prohibited under the WEEE Directive (2012/19/EU): the gap therefore describes a global market benchmark, not a legal option within the EU, and explains the economic incentive behind illegal supply chains and improper storage in the absence of planned recovery.

# The MACTEE project

*Making recovery predictable*

MACTEE — Circular mapping for the energy and ecological transition — is a digital system that identifies, locates and quantifies the recovery potential of critical and strategic raw materials, projecting their availability over time.

It covers photovoltaic plants, wind turbines, storage systems (BESS), buildings, and civil and industrial technological networks.

Planning recovery requires precise answers: where the facilities are located, what materials they contain, when they will reach end of their life, how much it will cost to recover them, and what economic value they can generate. Today, this information is scattered across various sources: grid operators, land registries, permits, and technical facility data. MACTEE brings it together on a single platform.

*The prototype has a regional scope: **Puglia** serves as the testing ground for a methodology designed, from the outset, to be replicated on a national scale.*



# Why Puglia

*The region with the most plants to map*

*Puglia ranks second among Italian regions in terms of installed photovoltaic capacity (**3,627 MW**, behind Lombardy) and first in terms of energy produced, with **4,639 GWh** in 2024 — **12.9%** of the national total. It also has **110,307** active systems, with the highest average size among Italian regions (**33 kW**).*

*Source: GSE, Photovoltaic Solar Statistical Report 2024.*

A large, dense network of systems, mostly small and medium in size: this is precisely the scenario in which knowing the location of each system, and what it contains, makes the difference between a planned recovery and an improvised one.

# What the platform does

*The four functions*

## 1 Map

Locates facilities and the critical materials they contain.

## 2 Estimate

Calculates the theoretically and actually recoverable quantities.

## 3 Evaluate

Compares recovery costs with the market value of the materials.

## 4 Correlate

Integrates the constantly evolving data.

# Integrated collaboration between research and innovation

## *Laser Romae and CINIGeo*

**MACTEE stems from the collaboration between Laser Romae,** an innovative SME specializing in the development of advanced digital solutions, **and CINIGeo**, a research organization with established expertise in georesources engineering. **This partnership has made it possible to combine experimentation and technological innovation** within a multidisciplinary approach, fostering the sharing of expertise, the coordination of activities and the integrated development of project solutions.

**The project combines complementary technological and scientific expertise**: Laser Romae contributes its experience in developing digital technologies, data processing and intelligent systems; CINIGeo brings its specialized know-how in the analysis of georesources, as well as the characterization and valorization of raw materials. **MACTEE represents the outcome of a structured partnership between diverse areas of expertise**, leading to the development of innovative tools for understanding, mapping and enhancing the value of critical and strategic raw materials.

### ***Laser Romae***

*Innovative SME*

**Laser Romae is an innovative SME** active since 2013 in the **Information and Communications Technology** sector, with offices in Rome, Milan and Monopoli. Each year, the company invests around **15% of its revenue in a comprehensive Research & Development** program focused on areas related to Artificial Intelligence and Machine Learning, the Circular Economy, and indoor and outdoor positioning.
Over the years, Laser Romae has developed **proprietary technologies and participated in numerous research and innovation projects** in collaboration with leading national and international research organizations, including CNR, ENEA, the European Space Agency and Mercator Ocean International.
As a part of the MACTEE project, **Laser Romae contributes its expertise** in process digitalization, data processing, integration and utilization, artificial intelligence, and the design and development of advanced technology platforms.

### ***CINIGeo***

*Research Organization*

**CINIGeo** — National Interuniversity Consortium for Georesource Engineering — **is a research organization founded in 1988**, active in promoting and coordinating scientific activities in the field of georesources. Its areas of expertise include **geotechnologies, environmental assessment, the characterization and recovery of mineral resources**, territorial analysis and sustainable development, with experience in the study and utilization of raw materials.
CINIGeo has developed expertise in mapping critical and strategic raw materials and in technologies for resource recovery and valorization, participating in initiatives and projects in collaboration with MASE and ENEA in the fields of industrial symbiosis and the valorization of technological waste.
Within MACTEE, **CINIGeo contributes scientific, methodological, and specialized expertise in the analysis, qualification, quantification, and mapping of critical and strategic raw materials,** complementing the technological and digital capabilities of Laser Romae.

LASER ROMAE
INNOVATION COMPANY

CINIGeo

# The scale of the problem

*Solar and wind power from 2025 to 2050*

## 140 million

non-subsidized photovoltaic panels at the end of their life cycle in Italy by 2050

## 260,000 t/year

of estimated photovoltaic waste in Italy by 2050

## €762 million

estimated total management cost for the period 2025–2050

*Source: REF Ricerche Laboratory, "La gestione del rifiuto fotovoltaico non incentivato in Italia" [Managing non-incentivised photovoltaic waste in Italy] (2025).*

*The Italian figure refers solely to non-subsidized panels, i.e. those outside state incentive programs. At the European level, including all photovoltaic systems, the European Commission's Joint Research Centre estimates a waste volume of between **21 and 35 million** metric tons by **2050**. During the same period, the number of end-of-life wind turbines will rise from approximately **42,500** in **2030** to **86,000** in **2050**, surpassing photovoltaics as the primary source of renewable-energy waste by mid-century.*

*Source: Joint Research Centre, "Circular Economy Strategies for the EU's Renewable Electricity Supply".*

Every unmapped facility, at end of its life,
represents a missed opportunity for recovery.
Planning the recovery starts here.

*This brochure is printed on Shiro Echo paper: made from 100% recycled fibres, recyclable and biodegradable, FSC®–certified, and with zero CO2 emissions thanks to carbon credit offsets.*

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