



D11.4 Benchmarking and RMIS

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Prepared by	ISMC
Partners involved	ISMC
Authors	Laura Quijano, David Sanjuan, María José Marqués
Reviewers	IDE team
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ABBREVIATIONS

CRM	Critical Raw Materials
CRMA	Critical Raw Materials Act
DPP	Digital Product Passport
DG REGIO	Directorate-General for Regional and Urban Policy (European Commission)
ECA	European Clusters Alliance
ECCP	European Cluster Collaboration Platform
ECF	European Competitiveness Fund

EIP	European Innovation Partnership
EMRIE	European Mining Regions Innovation Ecosystems
EU	European Union
EURMKB	European Union Raw Materials Knowledge Base
GMP	Good Manufacturing Practice
I3	Interregional Innovation Investments (Instrument)
ISMC	Iberian Sustainable Mining Cluster
JRC	Joint Research Centre
KPI	Key Performance Indicator(s)
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
NdFeB	Neodymium-Iron-Boron
REE	Rare Earth Element(s)
RMIS	Raw Materials Information System
RMKG	Raw Materials Knowledge Gateway
S3	Smart Specialisation
S3 CoP	Smart Specialisation Community of Practice
S3P	Smart Specialisation Platform(s)
S3P-IM	Smart Specialisation Platform for Industrial Modernisation
SME	Small and Medium-sized Enterprise(s)
TSSP	Thematic Smart Specialisation Partnership
WEEE	Waste Electrical and Electronic Equipment

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Executive summary

This deliverable (“D11.4: Benchmarking and RMIS”) sets out the strategy, plan and activities that NEO-CYCLE will implement to: benchmark where the most credible adoption corridors exist across Europe; structure clustering with relevant regional and sector ecosystems; and package and organise project evidence so it can be shared through RMIS as a long-lasting EU knowledge channel.

In line with this logic, the deliverable introduces an internal NEO-CYCLE Regional Ecosystems Scoreboard to assess and compare regional readiness and to convert mapping into decision-ready engagement priorities.

Across the three phases, the consortium will:

- **M1–M18 (Task 11.4):** launch S3P and cluster interactions, produce an initial benchmarking baseline, initiate contributions linked to cluster intelligence (e.g., European Cluster Observatory-related outputs), and start collecting/organising data to feed RMIS.
- **M19–M36 (Task 12.4):** deepen and stabilise cooperation with priority regions and clusters, maintaining continuity with the partnerships initiated in the first period.
- **M37–M48 (Task 13.4):** consolidate outcomes into a Portfolio of Investment Ideas for future integration into relevant S3P-Industry thematic areas, supporting post-project scale-up and replication.

Through this approach, NEO-CYCLE aims to strengthen awareness and engagement around critical raw materials circularity, reduce adoption friction for industrial stakeholders, and support credible pathways for scaling sustainable NdFeB magnet upcycling solutions across EU territories.

1. Introduction

NEO-CYCLE operates in a value chain where scaling depends on coordinated adoption conditions. The project is foreseen to demonstrate technical performance in rare-earth recovery and in the upgrading of secondary magnet materials into circular catalyst products, but replication at the European level also requires enabling infrastructures: trusted traceability, sustainability evidence that can be compared across actors, and credible industrial validation pathways.

NEO-CYCLE is fully aligned with EU priorities on **Critical Raw Materials (CRM) resilience**, the **twin green and digital transition**, and Europe's industrial competitiveness.

The project delivers innovative and clean-technology solutions by upcycling **NdFeB permanent magnets** into valuable products for green applications, while building the enabling conditions that make circular routes **credible, comparable, and adoptable at scale** (traceability, sustainability evidence, and industrial validation pathways).

This deliverable supports that wider replication logic. It provides a benchmarking synthesis of the external ecosystems that can act as multipliers for uptake. The replicability and transferability are overarching goals in NEO-CYCLE: impact is not limited to the consortium but depends on reaching multiple regions and industrial ecosystems across Europe through structured clustering and coordinated uptake corridors.

In this context, benchmarking is treated as a practical tool to identify where adoption platforms exist, which intermediaries can mobilise industry, and which interaction formats can convert interest into traceability.

The benchmarking synthesis is built on two complementary multi-criteria evaluation frameworks derived from cluster excellence literature, S3P methodologies, and European cluster assessment tools. The framework examined governance maturity, innovation capacity, industrial strength, international networking and support services.

In parallel, NEO-CYCLE partners are committed to structured knowledge transfer through **RMIS**, treated as a persistence channel that keeps NEO-CYCLE evidence visible and reusable after the project.

This includes sharing concise, updated information packages that external adopters and intermediaries can consume and reuse, such as process and performance evidence from recovery/upcycling routes; Digital Product Passport (DPP) and traceability logic; sustainability and socio-economic evidence; and downstream validation requirements that shape adoption decisions.

Through these actions, NEO-CYCLE will strengthen awareness among regions, clusters, industry, and the wider public about the strategic importance of Critical Raw Materials and about practical circular solutions that can improve resilience while remaining consistent with EU sustainability expectations, supporting trust, acceptability, and real-world uptake of sustainable CRM value chains across EU territories

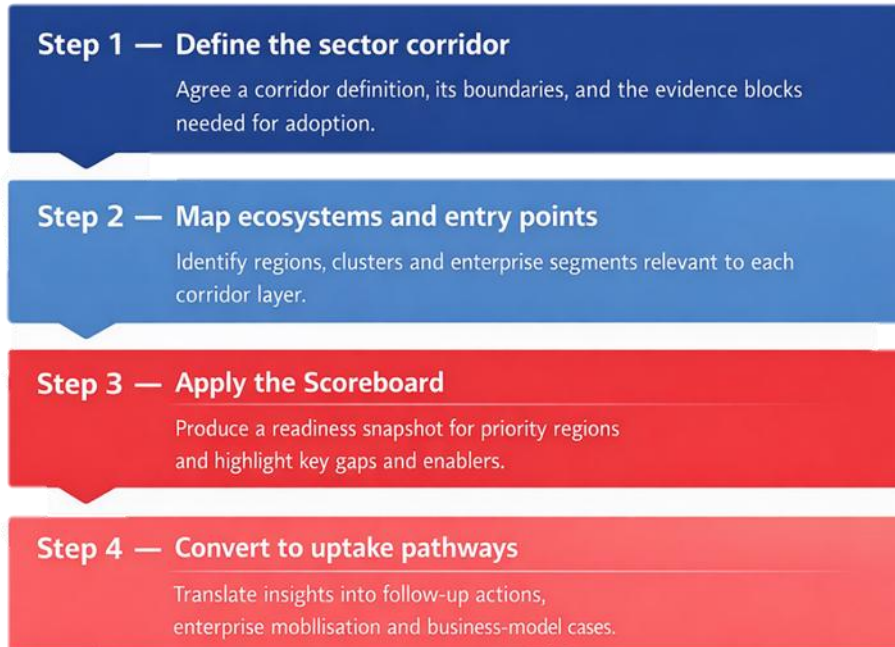
2. NEO-CYCLE regional ecosystem scoreboard

Based on the analysis of Smart Specialisation Platforms (S3P) and European Cluster instruments, the deliverable proposes the implementation of a **NEO-CYCLE Regional Ecosystems Scoreboard**.

This internal analytical tool is designed to bridge the gap between high-level mapping and concrete operational action, making the strategic reasons for engaging with specific regions both explicit and comparable.

The scoreboard functions not merely as a registry but as a dynamic framework to structure regional dialogues and validate assumptions, ensuring that the project's internal assessment of external territories is rigorous and evidence based.

The operational methodology for this scoreboard follows a systematic four-step sequence.



First, the project maps broadly to identify the widest potential ecosystem landscape. Second, it applies a selection filter to narrow down priority targets. Third, the lightweight scoreboard is used to assess specific regional readiness. Finally, the insights gained are converted into reusable outputs, including sector notes, scoreboard updates, enterprise network entries, and business-model briefs.

This process ensures that the Priority Sector Report defines the sector clearly enough to be measurable while explaining its critical role in competitiveness and resilience.

Crucially, this internal analysis recognises that permanent magnet circularity is a cross-sector corridor rather than a single industry label, requiring description through connected capability layers.

For the project, the scoreboard evaluates how effectively a region links circular feedstocks, recovery and purification, and advanced materials to downstream industrial users. To move beyond abstract mapping, NEO-CYCLE applies a lightweight scoreboard methodology that evaluates regional potential through specific maturity levels for the dimensions criteria.

This assessment framework transforms qualitative insights into actionable strategy, ensuring that engagement is calibrated to the actual readiness of the territory:

Maturity scale	Meaning
MEDIUM	Relevant as a secondary corridor or for downstream deployment narratives; requires targeted use cases (e.g., specific niche applications) to be productive.
HIGH	Strong corridor to adoption discipline, scale-up readiness, or traceability/sustainability evidence governance; exhibits high conversion potential for specific technological outputs.
VERY HIGH	High-value benchmark for circular materials governance and uptake logic; offers transferable frameworks for quality stability, due diligence, and evidence packaging that support comparability between sectors.
CRITICAL	Strong intermediation: corridor conditions are in place; ecosystem can mobilise implementation actors.

2.1 Using the scorecard for internal benchmarking and replication planning

This internal scorecard is designed to translate S3P and cluster mapping into a repeatable benchmarking method. It supports two practical decisions: **where NEO-CYCLE should invest engagement effort and what type of evidence package is needed to convert initial interest into a credible replication pathway.**

The scorecard combines two layers of evaluation:

- **Strategic leverage (S3P / cluster positioning):** how well a region is connected to EU-level multiplier channels—S3P partnerships, active cluster organisations, and conversion-oriented formats such as *Clusters Meet Regions*.
- **Operational maturity (regional readiness):** how strong and mobilisable the corridor conditions are across the maturity scale described above.

Scores must be supported by short, verifiable evidence notes (one to three lines each). Typical sources include S3 priorities, S3P partnership activity, ECCP cluster profiles and services, regional programmes, and relevant funding instruments.

The method converts qualitative mapping into comparable numerical scores. In practice, S3P valuations (e.g., **CRITICAL / VERY HIGH/ HIGH / MEDIUM**) are used first as a selection filter. Regions strongly linked to CRITICAL or VERY HIGH corridors—such as mining regions, chemicals, traceability & Big Data, and efficient and sustainable manufacturing—are assessed first.

The scorecard then checks whether strategic relevance is matched by operational readiness. To remain useful, it must be maintained as a living tool. WP11 should run an update cycle **at least every six months and** after major interaction events (e.g., clustering workshops, *Clusters Meet Regions*).

3. (S3) context and relevance

Smart Specialisation (S3) is the European Union's core place-based methodology for driving industrial transformation. It functions as a strategic tool that enables regions to focus their resources on a limited number of priority domains, defined by regional strengths, capabilities, and realistic market opportunities (Rakhmatullin et al., 2020).

Within the analytical framework of NEO-CYCLE, S3 is more than a funding framework; it serves as a critical operational tool. The structural barriers that affect scaling-up are largely governed at the regional level, where S3 provides a governance space connecting public authorities, cluster organisations, companies, and research institutions (European Commission, DG REGIO, n.d.-a). This is particularly relevant for circular economy value chains, where magnet circularity is not only a technical challenge but also a coordination challenge involving actors across the entire value chain.

Achieving magnet circularity requires synchronised action among collection and dismantling operators, recyclers, chemical processors, downstream users, and data or compliance entities. S3 engagement provides a structured environment where these actors can jointly address implementation barriers and enabling conditions, not just technical feasibility (European Commission, DG REGIO, n.d.-b).

Consequently, the project integrates S3 principles to bridge the gap between scientific feasibility and industrial implementation, using the following axes to structure regional engagement and value chain integration:

- **Governance for circular value chains:** Magnet circularity presents a coordination challenge that goes beyond pure technology. It requires the alignment of fragmented actors across the value chain. S3 acts as a governance interface that convenes the quadruple helix of innovation actors (public authorities, cluster organisations, private industry, and research bodies) enabling structured collaboration on operational issues such as data sharing, regulatory alignment, and standardisation (Rakhmatullin et al., 2020).
- **Operational implementation of policy priorities:** From an implementation perspective, S3 strategies link NEO-CYCLE's scalability with regional and national policy priorities related to the circular economy, critical raw materials, and advanced materials, ensuring alignment with mandates and instruments supporting industrial uptake (European Commission, 2019; European Parliament and Council of the European Union, 2024a).
- **Knowledge transfer:** NEO-CYCLE contributes structured, reusable evidence to regional transition strategies, including benchmarking-ready process documentation, Digital Product Passport (DPP) design logic, and sustainability evidence based on Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), supporting risk reduction and investment justification (European Commission, 2025a; European Commission, JRC, 2019).

Together, these mechanisms align NEO-CYCLE with the objectives of the European Green Deal and the S3P Industrial Modernisation framework, ensuring scalability and integration into Europe's circular industrial transition (European Commission, 2019).

Building on this operational approach, NEO-CYCLE's engagement with the S3 ecosystem is not limited to project-level cooperation. It extends into the structured European environment where regional authorities, innovation agencies, and industrial stakeholders collaborate to translate Smart Specialisation strategies into real investment actions.

This strategic interface is critical for turning regional experimentation into interregional scale-up, connecting NEO-CYCLE's circular magnet solutions with policy platforms that sustain learning, replication, and industrial uptake across EU territories.

3.1 The S3 Community of Practice and S3P Industrial Modernisation

At the European level, interregional innovation cooperation under Smart Specialisation (S3) is coordinated through the Smart Specialisation Community of Practice (S3 CoP), managed by the European Commission (DG REGIO) (European Commission, Directorate-General for Regional and Urban Policy, n.d.-a).

The S3 CoP acts as a collective support mechanism for regions implementing or updating their S3 strategies. It provides capacity-building tools, expert guidance, peer-learning initiatives, and structured collaboration spaces to help territories strengthen policy design and align innovation investments with European priorities such as the Green Deal, circular economy, and twin transition.

The S3 CoP is not only a policy framework but also a practical gateway to regional and interregional cooperation. It creates an institutional environment where partners can efficiently engage with regional authorities, intermediaries, and thematic clusters—reducing the cost of partner discovery and improving the quality of collaboration. Embedding NEO-CYCLE within this framework ensures that its outcomes are visible, policy-relevant, and aligned with Europe's ongoing industrial transformation initiatives.

Within S3 CoP, the Smart Specialisation Platform for Industrial Modernisation (S3P-IM) is particularly relevant to NEO-CYCLE's objectives. It supports regions aiming to modernise their industrial base through cooperation projects in advanced materials, resource efficiency, sustainable manufacturing, and circular economy models (European Commission, Directorate-General for Regional and Urban Policy, n.d.-b).

The platform operates through Thematic Smart Specialisation Partnerships (TSSPs), recurring cooperation environments rather than one-off projects. These partnerships enable continuous collaboration across policy cycles, strengthening learning loops and replication capacity, which are essential for long-term impact and scalability.

A TSSP provides structure and continuity to interregional collaboration. It offers coordination mechanisms for regular interaction between regional actors and intermediaries, alignment tools for refining evidence models and enabling conditions, and conversion pathways that turn shared knowledge into tangible interregional projects or investment-oriented initiatives, for example through the Interregional Innovation Investments (I3) Instrument.

Beyond coordination and alignment, a TSSP also provides visibility with purpose. It ensures that pilot results and innovations are not seen as isolated activities but as contributions to Europe's broader industrial transformation and regional resilience.

These platforms create a European cooperation space where regions, clusters, and innovative actors align their strategies and invest roadmaps around shared industrial priorities:

- **Industrial Modernisation (S3P-Industry):** The largest and most relevant platform for NEO-CYCLE, hosting partnerships on Mining, Chemicals, Advanced Materials for Batteries, and Efficient and Sustainable Manufacturing. Its mandate is to build investment pipelines that modernise European industry through digitalisation, circularity, and technological convergence.
- **Energy (S3P-Energy):** Focuses on Hydrogen Valleys and Sustainable Buildings, essential for NEO-CYCLE's downstream applications (e.g. catalysts for green ammonia production).
- **Agri-Food (S3P-AgriFood):** Includes the Traceability and Big Data partnership, a methodological benchmark for NEO-CYCLE, where advanced traceability principles developed for food supply chains are being adapted to the Digital Product Passport (DPP) for critical raw materials.
- **Sustainable Blue Economy:** Established in 2022 to target marine resources and blue growth. While its direct relevance to NdFeB magnet recycling is limited, potential future links with marine mining and biotechnology merit exploratory interest.

For NEO-CYCLE, participation in an S3P TSSP creates a bridge between research-driven activities and the long-term Smart Specialisation strategies of participating regions. This integration supports the replication and mainstreaming of circular industrial solutions through a stable EU cooperation structure that combines peer learning, policy experimentation, and investment mobilisation.

To translate this cooperation logic into practical decision-making, the table below identifies and prioritises S3P partnerships with the highest replication leverage. The goal is to avoid ad hoc engagement and focus on environments where interaction can realistically generate reusable outputs and sustained follow-up actions. The model remains lightweight, ensuring that all partners can apply it easily and consistently.

Evaluation combines thematic relevance with interaction readiness. A partnership may be highly relevant to NEO-CYCLE's objectives but not yet ready for active cooperation, while another—focused on enabling fields such as digitalisation or advanced manufacturing—can still provide strong value for evidence alignment and traceability. Work Package 11 (WP11) therefore uses a multidimensional evaluation approach rather than a single thematic filter.

The interaction focus defined below is operationalised in the subsequent partnership descriptions, which explain how each focus area supports replication and benchmarking decisions

Table 1. Principal S3P thematic platform partnerships

S3P thematic platform	Partnership	Leading partner(s)	Priority	Synergies
Industrial Modernisation (S3P-Industry)	Mining	Lapland (FI), North Karelia (FI), Andalusia (ES)	CRITICAL	Direct policy/territorial corridor for CRM resilience and deployment conditions; strong overlap with regional raw materials governance and investment framing (incl. mining-region innovation ecosystems).
Industrial Modernisation (S3P-Industry)	Advanced Materials for Batteries	Andalusia (ES), Castile & Leon (ES), West Slovenia (SI)	VERY HIGH	High-value benchmark for circular materials governance (quality stability, due diligence, evidence packaging) that can be transferred to magnet circularity; supports comparability and uptake logic
Industrial Modernisation (S3P-Industry)	Efficient & Sustainable Manufacturing	Lombardy (IT), Catalonia (ES)	HIGH	Strong corridor for process maturity, industrialisation logic and repeatability evidence (scale-up credibility; quality assurance across variable feedstocks).
Agri-Food (S3P Agri-Food)	Traceability & Big Data	Andalusia (ES), Emilia Romagna (IT)	HIGH	Provides the methodological framework for Digital Product Passports (DPP) . Essential for certifying the "green" status of recycled NdFeB and catalysts, transferring agri-food best practices to mining (recycled content / responsible sourcing).
Industrial Modernisation (S3P-Industry)	Chemicals	Lombardy (IT), Limburg (NL)	HIGH	Direct relevance to the output of NEO CYCLE (catalysts for ammonia/polymers). Connects the project with end-users in the chemical industry needed REE sources.

Industrial Modernisation (S3P-Industry)	SME Integration to Industry 4.0	Slovenia (SI) Tuscany (IT)	HIGH	Supports the digitalization of the recycling plants (Digital Twins). Helps regional SMEs adopt the advanced technologies developed by NEO CYCLE for WEEE processing.
Industrial Modernisation (S3P-Industry)	Hydrogen Valleys	Aragon (ES), Auvergne-Rhône-Alpes (FR) Normandie (FR), Northern Netherlands (NL)	MEDIUM	Connection via the "Ammonia" use case (Green Hydrogen to Ammonia). Potential niche application for REE catalysts in electrolyzers or hydrogen storage.
Energy (S3P Energy)	Sustainable Buildings	Andalusia (ES) North Great Plain/Észak-Alföld (HU), North West Croatia (HR)	MEDIUM	Peripheral to magnets, but useful as a benchmark for structured regional deployment approaches and "quadruple helix" engagement models; as secondary corridor, not a primary feedstock stream.

Table 2. Interaction focus by priority partnership

Thematic platform	Interaction focus	Key points to benchmark
Mining Regions	Best corridor for territorial feasibility: benchmark feedstock governance, permitting, and regional enabling instruments (applies to circular value chains to).	<ul style="list-style-type: none"> - Circular CRM corridor design: link collection, pre-processing, recovery, markets across territories. - Benchmark sustainability & traceability expectations in CRM ecosystems (regional/authority expectations). - Identify cluster organisations/agencies that can mobilise actors quickly. - Understand regulatory readiness constraints (waste status, shipment constraints, permitting).

		<ul style="list-style-type: none"> - Benchmark feedstock security & social licence (narratives/evidence for local acceptance).
Chemicals	Corridor where adoption discipline is strongest: translates “technical result” into an industrial product with clear requirements and risk logic.	<ul style="list-style-type: none"> - End-user requirements & validation pathways for circular catalysts (specs, performance windows, quality stability) - Traceability as procurement infrastructure. - Bankability: evidence that reduces risk for adoption/investment decisions.
Advanced Materials for Batteries	Strong benchmarking reference: mature governance around secondary materials; transferable evidence/governance model for magnet circularity.	<ul style="list-style-type: none"> - Comparability & uncertainty handling for circular materials. - Traceability & due diligence logic (selective sharing, interoperability constraints). - Lessons on communicating maturity & bankability for secondary routes. - Identify strong regional ecosystems for circular materials deployment.
Efficient and Sustainable Manufacturing	Strengthens process maturity and industrialisation credibility: better evidence of repeatability/readiness (not a new tech).	<ul style="list-style-type: none"> - Process maturity benchmarking & scale-up readiness criteria. - Quality management & repeatability evidence across variable feedstocks. - Industrial conventions & critical control points used by manufacturers. - Identify manufacturing intermediaries & technical centres supporting industrialisation.
SME Integration for Industry 4.0	Ensures feasibility: DPP/digital evidence won't scale if SMEs can't implement with reasonable effort.	<ul style="list-style-type: none"> - Feasibility of traceability & data sharing implementation in SMEs. - Interoperability constraints & realistic data governance models. - Selective sharing & confidentiality handling in real settings

<p>Hydrogen Valleys</p>	<p>Useful for deployment logic: tests how sustainability/traceability claims affect procurement and investment decisions.</p>	<ul style="list-style-type: none"> - Deployment requirements & procurement logic for catalysts/process technologies. - Evidence requirements for market readiness (esp. sustainability & traceability). - Bankability narrative & investment-oriented pathways beyond pilots. - Cross-sector links with process industries, clusters, policy intermediaries.
<p>Traceability and Big Data</p>	<p>Strongest governance benchmark for DPP interoperability is validating feasibility and trust architecture (not copying a sector model).</p>	<ul style="list-style-type: none"> - Interoperability & data governance models for heterogeneous sources. - Cybersecurity-aware exchange patterns & trusted data intermediaries. - Selective data sharing that protects commercial confidentiality. - Trust architecture patterns: responsible sourcing, recycled content, certification logic.
<p>Sustainable Buildings</p>	<p>Secondary benchmark for how regions organises deployment: strengthens engagement design and continuity.</p>	<ul style="list-style-type: none"> - Regional deployment pathway design (milestones, actor roles). - Multi-helix engagement methods that sustain continuity beyond events. - How sustainability evidence is integrated into procurement & public support schemes.

S3P Mining Regions: institutional and policy benchmarking for CRM resilience

S3P Mining Regions is highly relevant for NEO-CYCLE because it sits at the centre of the EU debate on Critical Raw Materials resilience and on how the Critical Raw Materials Act (CRMA) is implemented in territories. Even when regional agendas focus on primary extraction, the enabling conditions are closely aligned with circular value chains: access to material streams, permitting and governance constraints, sustainability expectations, and the ability to coordinate actors from pilots to real deployment. For this reason, S3P Mining Regions is essential not only for benchmarking but also for practical conversion because it gathers regional authorities, raw materials agencies and cluster organisations that can convene and mobilise implementation actors.

In practice, this partnership offers a structured space to test whether NEO-CYCLE's replication assumptions hold at the regional level. It helps clarify how feedstock streams can be secured, what evidence is needed to justify circular investment pathways, and how regional instruments can be aligned with project outputs. In this sense, NEO-CYCLE's contribution is to position NdFeB magnet circularity as a CRM resilience instrument and to provide reusable evidence blocks that regions can adopt across strategies, rather than treating circular magnets as a stand-alone technical niche.

A key policy reference in this corridor is the EMRIE initiative (Interreg Europe, running until 2029), which provides a structured learning roadmap for mining regional innovation ecosystems. For NEO-CYCLE, the value is methodological: staged diagnosis and iterative alignment help connect technical innovation to regional decision cycles. This matters for replicability because scaling is often limited by governance alignment, missing intermediaries, or unclear deployment conditions, not by technology alone.

S3P Advanced Materials for Batteries: evidence and governance benchmarking for circular materials

This partnership is valuable because it combines CRM relevance with mature circularity governance. Even where the material scope differs, the adoption logic is similar: secondary materials require stable quality, due diligence, traceability and credible sustainability evidence. Battery ecosystems also act as a recognised benchmark for comparing circular approaches across sectors.

For NEO-CYCLE, engagement should focus less on technical similarity and more on evidence convergence. The goal is to make NEO-CYCLE evidence easier to interpret and reuse by external adopters (regions, clusters and industry), especially where comparability, uncertainty handling and governance models are critical.

S3P Efficient and Sustainable Manufacturing: process maturity and industrialisation corridor

This corridor matters because replication requires process maturity and operational credibility. A circular route can be technically valid but still not adoptable if evidence cannot demonstrate repeatability, quality assurance and stable operation, particularly when feedstocks vary.

This partnership provides a useful environment to benchmark how industrial communities assess scale-up readiness and how maturity is checked in real manufacturing settings. A practical output here is a simple maturity/readiness checklist that can also strengthen investor-facing and replication discussions later in the project.

S3P Traceability and Big Data: governance and interoperability benchmarking for DPP

Although the sectoral context is different, Traceability and Big Data is one of the most useful S3 partnerships for NEO-CYCLE as a methodological benchmark. It provides mature experience in digital governance, interoperability, cybersecurity-aware data exchange and large-scale stakeholder coordination. This matters because, in CRM circularity, traceability is often not perceived as the headline innovation; it is the enabling layer that makes circular routes comparable, credible and adoptable at scale.

For NEO-CYCLE, this partnership is best used to test what a realistic traceability model looks like, how selective data sharing can work in practice, and how trust architectures (certification, responsible sourcing, and recycled content) can be aligned with emerging regulatory expectations. It also provides a reference model for stable interregional cooperation over time.

S3P Chemicals: downstream validation corridor for circular catalysts

The Chemicals partnership matters because it connects directly to NEO-CYCLE's downstream objective: circular catalysts and industrial validation. Replication depends on end-user uptake. Even strong recovery performance will not scale if industry cannot integrate outputs into processes, if specifications remain unclear, or if safety and compliance requirements are not addressed in an adoption-ready way.

This corridor is valuable because process industries use clear decision criteria: performance, safety, compliance, cost, reliability and procurement risk. That discipline helps NEO-CYCLE package evidence in a form that external adopters can trust and reuse. It also provides access to industrial

associations and cluster organisations that can mobilise multiple end-users, accelerating the move from general interest to concrete validation pathways.

S3P SME Integration for Industry 4.0: feasibility corridor for DPP and traceability

This partnership is important because traceability and the Digital Product Passport will only scale if SMEs can implement them. Many SMEs have limited capacity for data management and reporting. Engagement here helps NEO-CYCLE avoid designing evidence requirements that are unrealistic and supports the refinement of templates into SME-friendly formats.

The most useful replication output is practical and lightweight: a minimal data-field map plus a short note on selective data sharing and confidentiality. These can be reused by clusters and regions to support real implementation, and they reduce friction for SME participation in circular value chains.

S3P Hydrogen Valleys: deployment corridor and investment logic for uptake

Hydrogen Valleys are deployment-orientated ecosystems linking industrial demonstrators, regional strategies and investment logic. For NEO-CYCLE, the main value is that adoption conditions are explicit: procurement expectations, credibility of sustainability claims and practical maturity constraints. Even when the topic is not magnet recycling directly, valley ecosystems often depend on catalysts and process technologies, which makes them relevant for circular catalyst narratives and validation expectations.

Engagement should stay specific and evidence-led: one evidence package and one clear deployment question focused on what would reduce end-user risk.

S3P Sustainable Buildings: secondary benchmarking corridor for deployment models

This corridor is not directly linked to NdFeB magnet recovery, but it can still support NEO-CYCLE as a benchmarking space for *how regions organise deployment at scale*. Sustainable Buildings partnerships typically work with structured approaches to implementation: multi-actor coordination, public-private investment logic, and measurable performance frameworks for sustainability outcomes.

For NEO-CYCLE, the value is therefore methodological rather than material: it provides reference practices on how to structure regional adoption pathways, how to frame evidence in a way that is

understandable for non-specialist decision-makers, and how to maintain continuity across authorities, industry and citizens.

It is best treated as a secondary corridor where NEO-CYCLE can test communication and evidence-packaging approaches that improve uptake readiness, while also learning from “quadruple helix” engagement models that combine public authorities, industry, research, and civil society in real deployment context.

3.2 How to engage with S3P in NEO-CYCLE practice

This approach will be implemented through the NEO-CYCLE clustering workshop format, taking the first event held in Seville as a practical reference case. The first clustering workshop, organised in hybrid mode by ISMC and ECOCastulum, served as an early demonstration of how to connect NEO-CYCLE’s internal evidence packages (covering technical data, traceability requirements, and adoption narratives) with external communities capable of validating, refining, and reusing them.

The workshop format transforms S3P cooperation from a one-off exchange into a repeatable engagement cycle. The participatory methodology of first clustering workshop, alongside upcoming regional events, shows how local and interregional actors can jointly test evidence and identify cooperation pathways. The session also facilitated dialogue with relevant S3P thematic platforms and corridor logics, including Advanced Materials for Batteries, Mining, and Traceability and Big data, illustrating how policy communities can directly interact with the project’s technical outputs.

Outreach design focuses on the intersection between transfer relevance and interaction feasibility. By combining on-site moderation with remote participation, NEO-CYCLE ensures that regional experts, clusters, and policymakers can contribute meaningfully while keeping exchanges structured and traceable.

The experience follows a consistent logic that makes the S3P engagement cycle operational in practice, with connections established through S3P partnership coordinators and cluster organisations already active in the ecosystem with structured sessions for key assumptions, including feed-stock governance, regulatory compliance, interoperability, and evidence requirements.

Evaluation remains straightforward and consistent with S3P adoption logic, focusing on practical results. This structure makes the clustering workshop a scalable cooperation model, one that systematically links NEO-CYCLE's evidence production with real-world policy and industrial adoption environments across different regions for the next reporting periods.

4. EU Networking Platform and Cluster-based uptake pathways

EU cluster instruments are the main multiplier channel for industrial mobilisation. They complement S3 engagement by providing access to cluster managers and to large SME networks.

In this context, cluster instruments matter because replication is not achieved by publishing results. It is achieved by creating low-friction adoption pathways for companies and by providing evidence packages that intermediaries can reuse.

This position fits the direction of EU competitiveness policy, where clusters are increasingly treated as implementation infrastructure for industrial transition. Under the European Competitiveness Fund (ECF) debate, the emphasis shifts from supporting isolated innovations to building delivery capacity: mechanisms that can mobilise companies quickly, connect them across borders, and move them from interest to adoption with fewer administrative and coordination barriers (European Commission, 2025a; European Commission, 2025b; European Cluster Collaboration Platform, 2025).

For NEO-CYCLE, that is the core replication challenge: circular NdFeB solutions will only scale if intermediaries can bring the right firms into the same corridor (feedstock holders, processors, digital/traceability enablers, and downstream users) and if the project's outputs are packaged in a form that these corridors can reuse.

From a benchmarking perspective, this EU architecture creates a clearer impact logic for clustering. Cluster instruments provide a practical setting for this because cluster organisations already operate with a portfolio mindset: meeting screen needs, matching supply and demanding, and helping members structure credible pathways to market. That is why NEO-CYCLE's benchmarking focus should explicitly include how clusters structure adoption decisions (European Expert Group on Clusters, 2021).

The ECF context also strengthens a second opportunity for NEO-CYCLE: cross-border value-chain building as a policy objective. In a competitiveness framing, clusters are expected to help identify strategic gaps, connect suppliers and buyers, and accelerate industrial ecosystems in targeted domains (European Commission, 2025a; European Commission, 2025b).

For NEO-CYCLE, this is directly usable as a replication architecture: magnet circularity is not a single process but a chain that requires territorial coordination (collection and dismantling), process maturity (recovery/upgrading), evidence infrastructure (traceability and sustainability), and downstream pull (catalyst validation and end-user requirements). EU cluster instruments can act as the “connector layer” that makes those interfaces operational across regions.

A third opportunity is that competitiveness-orientated cluster policy brings investment and scale-up considerations closer to the clustering agenda. This matters because many replication barriers are economic rather than technical: uncertainty about costs, risk perception, lack of bankable demand signals, and unclear compliance pathways (European Commission, 2025b).

Cluster ecosystems often sit close to finance-facing channels (regional development instruments, investor networks, scale-up support services) and can help translate technical evidence into decision-ready narratives. In NEO-CYCLE terms, this strengthens the rationale for producing reusable “evidence packages” that are not only scientifically correct but also adoption-ready: comparable KPIs, clear assumptions, repeatability indicators, and traceability/sustainability documentation that can be used in procurement and due diligence contexts.

Importantly, this EU architecture also supports **benchmarking as a method**, not only as a policy goal. For NEO-CYCLE, EU cluster instruments provide a structured way to compare how different industrial ecosystems frame circularity: what they treat as a credible claim, which KPIs are considered meaningful, how standards and compliance expectations are interpreted, and where maturity thresholds sit for real uptake. This is a practical input to WP11 because it reduces guesswork and helps the consortium adapt engagement formats and messages to what drives adoption, without diluting technical integrity.

Finally, the competitiveness framing opens a clear route to connect clustering to do that at scale; new opportunities under the EU benchmarking and competitiveness architecture reinforce a simple implementation rule for NEO-CYCLE: use cluster intermediaries as the multiplier network that can carry those blocks into multiple regions, companies, and replication corridors.

In this context, the relevant point for NEO-CYCLE benchmarking is that the EU cluster architecture is not a single tool; it implies:

- a **collaboration platform** (ECCP) that helps find and approach cluster organisations and events.

- a **territorial validation format** (Clusters Meet Regions) that links clusters with regional authorities and investment priorities.

4.1 ECCP: how to promote the connections to uptake NEO-CYCLE results

The **European Cluster Collaboration Platform (ECCP)** is the main EU-level entry point to identify cluster organisations, follow cluster-driven events, and access matchmaking formats connected to EU industrial ecosystem priorities. Its value increases when it is used consistently, with a clear selection logic. For NEO-CYCLE, the purpose is to find intermediaries that can connect the project to implementation actors and reuse NEO-CYCLE outputs packages in their own channels.

A practical way to avoid ad-hoc outreach is to apply a corridor-based search. This keeps engagement aligned with what replication needs: upstream feedstock mobilisation, midstream processing and quality logic, downstream adoption conditions, and the enabling evidence infrastructure (traceability, reporting, interoperability).

In concrete terms, ECCP covers a wide range of clusters, selectivity depends on looking for the right intermediary types rather than only matching keywords.

The table below provides a practical guide to the main intermediary categories that can accelerate replication in each corridor layer.

NEO-CYCLE layer	Intermediary types	Replication
Feedstock and dismantling (WEEE, motors, HDDs)	WEEE recycling clusters; electronics/manufacturing clusters with dismantling members; compliance scheme networks; repair/remanufacturing networks	For validating realistic feedstock access, pre-treatment constraints and quality boundaries, and can mobilise SMEs that handle real streams.
Recovery and processing (chemical / electrochemical routes)	Process industry clusters; metal-lurgy/materials clusters; pilot/scale-up intermediaries; technical centres linked to clusters	Stressing test scale-up assumptions, safety/compliance expectations, and process maturity evidence needed for industrialisation.
Traceability and DPP evidence infrastructure	Digitalisation / Industry 4.0 clusters; data spaces and interoperability initiatives; cybersecurity and trusted data intermediaries	Ensuring that DPP logic is feasible for SMEs and compatible with selective data sharing and confidentiality constraints.

Downstream validation (circular catalysts / end-users)	Chemical clusters; energy/process transition clusters; application networks (ammonia, pharma, green chemistry)	Clarifying end-user requirements, procurement logic and validation steps that decide adoption.
Deployment and investment framing	Clusters connected to transition programmes; regional cluster associations; innovation agencies working with clusters	They technology evidence to funding pipelines, procurement channels and regional instruments.

After this guide to prioritising technical outputs to end users, potential clusters that can *connects companies*, not only for involving in NEO-CYCLE events.

In practice, the strongest targets are clusters that provide services, have recurring activity (events, calls, working groups), and (sit in multi-helix environments (industry–research–public actors), for that, it’s necessary to:

1. **Define concrete layer objective:** Decide which corridor is targeted (feedstock/recycling; process scale-up; traceability/DPP; downstream validation; deployment).
2. **Search by keywords:** Use sector and technology keywords aligned with the corridor (e.g., WEEE, recycling, circular materials, chemicals, Industry 4.0, traceability, digital passport).
3. **Filter for active convening power:** Prioritise clusters that show frequent activity: events, services, newsletters, working groups, open calls, or strong member bases.
4. **Prioritise multi-helix connectors:** Select clusters connecting SMEs with large industry and authorities (innovation agencies, regional bodies).

4.2 Clusters Meet Regions: how to enable validation, public matchmaking and conversion

Clusters Meet Regions is a commission-backed format designed to connect cluster organisations with regional and national authorities around industrial ecosystem priorities. It is highly compatible with NEO-CYCLE’s replication logic because it merges two conditions that often block scale-up when treated separately: **industrial mobilisation** and **policy/enabling conditions**.

For NEO-CYCLE, this format is valuable because it creates a structured space to test territorial feasibility. Regions can confirm whether upstream streams exist, whether industrial capabilities and infrastructure are present, and whether downstream users can be mobilised. Cluster managers can indicate whether companies are ready for follow-up.

In this sense, special value has the matchmaking layer because it forces focus. Participants register with profiles, state objectives, and can request targeted meetings.

This structure supports replication because it compresses the “search cost” for adopters: instead of open networking, the project can organise short meetings around specific transfer questions (feedstock constraints, quality requirements, evidence needs, and adoption barriers).

Table 4. ECCP-linked events with high thematic fit for NEO-CYCLE

Year	Event	Date / Place	Thematic focus	What it unlocks for NEO-CYCLE (value-chain)
2024	Clusters Meet Regions Milan (IT)	26–27 Mar 2024, Milan	Strong twin transition framing (green and digital) applied to industrial competitiveness, with a clear emphasis on clusters as deployment intermediaries and on regional industrial ecosystems	Useful for testing how magnet circularity is received as an industrialisation case (not only a recycling topic): what evidence convinces companies, what regional instruments support adoption, and how to position traceability/DPP as a risk-reduction layer rather than a compliance add-on.
2025	Clusters Meet Regions Palma (ES)	14–15 May 2025, Palma	Explicit focus on transition from linear to circular regional models, with clusters positioned as drivers of circular deployment (materials, waste streams, value-chain coordination).	High relevance for NEO-CYCLE’s upstream replication narrative: how to secure and govern secondary streams, how to align circular routes with regional priorities, and how to package “replication conditions” (feedstock + evidence + intermediaries) in a way regions can reuse.
2025	Clusters Meet Regions Vaasa (FI)	24–25 Sep 2025, Vaasa	Strong green transition / energy-industry ecosystem identity, with a practical	Valuable for strengthening the downstream deployment story: how circular catalyst outputs and sustainability evidence can be framed for

			emphasis on industrial transformation environments (real deployment settings, technology ecosystems, regional scale-up logic).	industrial transition ecosystems, and how adoption requirements are expressed in energy-intensive regional contexts.
2025	Cluster Meets Regions (Navarra (ES)	12–13 Nov 2025, Pamplona	Distinctive emphasis on regional industrial transition under EU competitiveness and net-zero logic, with clusters used as coordination instruments (skills, re-industrialisation, resilience, circularity as an enabling condition).	Strong corridor for identifying which enabling conditions are missing (business models, standards, governance capacity), and which cluster intermediaries can translate NEO-CYCLE evidence into company-facing uptake pathways.

5. RMIS action plan

For the project, synchronising with RMIS is a strategic step to ensure **continuity**. By treating RMIS as a persistence channel, NEO-CYCLE ensures that its core outputs, specifically the logic for up-cycling magnets into catalysts, remain accessible through an EU-facing repository even after project websites and campaign cycles decline.

The project validates the recycled output in four distinct industrial sectors, creating a robust demand portfolio for RMIS:

1. **Ammonia Synthesis:** Using Nd as a promoter in catalysts for the Haber-Bosch process. This is critical for the "Green Ammonia" economy, where efficiency improvements directly translate to energy savings in hydrogen storage.
2. **Polymers (Rubber):** Producing Neodymium Versatate catalysts for the polymerization of butadiene. This creates High-Cis Polybutadiene Rubber (Nd-BR), essential for "Green Tires" that reduce fuel consumption in vehicles.
3. **Pharmaceuticals:** Using REEs as Lewis acid catalysts in the synthesis of complex organic molecules (APIs). This demonstrates the ability to reach extremely high purity levels required by GMP standards.

4. **Fertilizers:** Applying REEs as micronutrients or process enhancers, providing a high-volume sink for lower-purity fractions.

To understand the significance of the NEO-CYCLE contribution to RMIS, the clustering and benchmarking activities will continuously identify and activate cooperation opportunities with European and international ecosystems. This includes structured interaction with the **Raw Materials Information System (RMIS)** and, where relevant, the wider European raw materials knowledge community, ensuring that NEO-CYCLE results remain visible, accessible, and reusable beyond the consortium.

The cooperation with RMIS and related clustering actions pursue the following objectives:

- **Increase the visibility** of NEO-CYCLE results among a broad set of stakeholders (industry, clusters, regions, policy and research communities).
- **Identify synergies** with other European and international initiatives, projects and organisations that are relevant to circular critical raw materials and permanent magnet value chains, supporting stronger coordination and complementarity across EU-funded actions.
- **Strengthen project-to-project interaction**, especially with other Horizon-funded projects, to accelerate learning, avoid duplication, and promote replication pathways.

To achieve this, NEO-CYCLE will implement a set of practical actions:

- **Create and maintain a dedicated project workspace in RMIS** (within the Raw Materials Knowledge Gateway), including selected public information and updateable evidence packages (e.g., key results, public deliverables, guidance-oriented outputs, and summaries).
- **Maintain regular contact with RMIS and relevant communities** to follow up on potential synergies and joint visibility opportunities.
- **Participate in RMIS workshops and relevant EU clustering events**, contributing project insights and connecting with key intermediaries (regions, clusters, innovation agencies).
- **Organise targeted meetings** (virtual and/or face-to-face) with projects and organisations featured in these EU databases, focusing on concrete cooperation angles (replication, traceability/DPP alignment, sustainability evidence, or value-chain integration).

- **Engage in external events and workshops** hosted by other Horizon projects and stakeholder platforms where NEO-CYCLE can exchange lessons learned and build replication momentum.

Until the end of the project, NEO-CYCLE will also consolidate evidence from these interactions into dedicated reporting outputs, capturing: the cooperation activities with RMIS and related platforms carried out across the project lifetime, and a structured summary of clustering events, outcomes, and follow-up opportunities generated through these actions.

5.1. Plan for Protocols to Cooperate with the RMIS and EURMKB

To support the international dissemination of project information, NEO-CYCLE will establish cooperation protocols with the **Raw Materials Information System (RMIS)** and the **European Raw Materials Knowledge Base (EURMKB)**.

The project will provide the required data, covering general characteristics, objectives, new technologies, and main results, for inclusion in both systems:

- Areas most relevant for the project.
- Overview related to activities on raw materials and statutory and IPR issues.
- Raw material knowledge on value chain(s); environmental and social sustainability; economics and trade, secondary raw materials & circular economy; monitoring raw materials sectors, data accessibility and research and Innovation

The Raw Materials Information System (RMIS) serves as the European Union's central gateway for knowledge on primary and secondary raw materials. Developed and maintained by the Joint Research Centre (JRC), RMIS 2.0 was officially launched in November 2017.

It supports the collection, organisation, storage, and dissemination of raw materials information and, to some extent, of related products and value chains. RMIS 2.0 is structured in thematic sections, one of which is the **Raw Materials Knowledge Gateway (RMKG)**, a key component offering a single access point to curated knowledge from national, European, and international sources.

Through the RMKG, a wide network of knowledge providers contributes to the continuous enrichment of the RMIS. This collaboration both strengthens the EU's knowledge base and increases the visibility of each partner's data, information, and results among relevant stakeholders in policy, research, and industry. The RMIS also facilitates knowledge coordination and harmonisation, creating opportunities for joint activities and data integration.

Within this framework, NEO-CYCLE contributes actively to the consolidation of European knowledge on raw materials by sharing project-specific insights and innovations related to digital, sustainable quarrying. A first data template will be prepared to the RMKG, including direct links to the project website. A dedicated project webpage will be created within the RMIS environment to display relevant knowledge outputs. This space can be freely configured by the project team, allowing the inclusion of visual identifiers (logo, images) and thematic descriptions structured by specific knowledge areas.

Future updates will be coordinated in collaboration with the RMKG team, following JRC guidance for data exchange and publication formats (see: <https://rmis.jrc.ec.europa.eu/>). Knowledge contributions are expected to evolve over time, structured at both national and European levels, ensuring coherence with existing datasets and policy frameworks. Close interaction between the RMIS coordination team and NEO-CYCLE partners will continue throughout the project's duration to maintain up-to-date and interoperable information in the European raw materials knowledge ecosystem.

The European Union Raw Materials Knowledge Base (EURMKB) forms an integral part of the European Innovation Partnership (EIP) on Raw Materials Strategic Implementation Plan ([link](#)). Its mission is to function as a one-stop platform for all information on raw materials within the European Union.

In cooperation with EU Member States, the EURMKB collects, stores, maintains, updates, analyses, and disseminates comprehensive information on both primary and secondary raw materials. This consolidated knowledge base serves as a strategic information resource for industry, policymakers, and research institutions, supporting evidence-based decision-making and fostering sustainable resource management across Europe.

The EURMKB is structured around three main building blocks:

- **Data collection:** Aggregating data and information from a wide range of sources, including EUROSTAT, the Joint Research Centre (JRC), national geological surveys, European agencies, other international organisations, and European research projects and industrial programmes.
- **Primary and secondary raw material information:** Integrating and showcasing data on material sources, production, use, and recycling.
- **Expertise and supporting knowledge:** Providing insights, reports, and best practices developed by EU projects, institutions, and networks.

Building on the clustering activities and stakeholder engagement outcomes reported in Deliverable D11.3, this deliverable translates those interactions into a structured benchmarking and knowledge-integration framework that supports exploitation and long-term uptake. The benchmarking logic and RMIS integration developed in D11.4 provide a foundation for post-project scale-up by identifying adoption-ready regional and sectoral corridors, clarifying enabling conditions, and packaging project evidence in a form that can be reused by regions, clusters and industrial stakeholders.

Beyond the project lifetime, these outputs are expected to support follow-up actions and investment-oriented initiatives, including potential interregional cooperation and deployment instruments such as Interregional Innovation Investments (I3), Interreg programmes, or complementary EU and national funding mechanisms, thereby contributing to sustained replication and impact of NEO-CYCLE results across European territories.

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