



Project title	Empowering bioeconomy projects by deploying Technical, Business, Regulatory and Social assistance services		
Project acronym	ToBeReal		
Project number	101181799		
Project start date	01/11/2024	Duration	60 months

D4.5 – OPEN REPORT: REGIONAL ANALYSIS OF BIOECONOMY POTENTIAL (INCLUDING POLICY BRIEF)

Due date	28/10/2025	Delivery date	31/10/2025
Work package	WP4		
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Type	Report		
Dissemination level	Public (PU)		

VERSION AND AMENDMENTS HISTORY

Version	Date (MM/DD/YYYY)	Created	Changes
1	21/10/2025	Thanasis Lampropoulos	V1
2	24/10/2025	Thanasis Lampropoulos	V2





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LIST OF ABBREVIATIONS

Abbreviation	Definition
AD	Anaerobic Digestion
AFIR	Alternative Fuel Infrastructure Regulation
CAP	Common Agriculture Policy
CBAM	Carbon Border Adjustment Mechanism
EfW	Energy from Waste
ESR	Effort Sharing Regulation
ETS	European Trading System
EU	European Union
GHG	Greenhouse Gas
LULUCF	Land Use Land Use Change and Forestry
NZIA	Net-Zero Industry Act (EU)
RED	Renewable Energy Directive (EU)
RRF	Recovery and Resilience Facility
SAF	Sustainable Aviation Fuel
CSA	Coordination and Support Action
RIA	Research and Innovation Action
IA	Innovation Action
TRL	Technology Readiness Level
BRL	Business Readiness Level
RRL	Regulatory Readiness Level
SRL	Social Readiness Level
ESG	Environmental, Social, and Governance
EIB	European Investment Bank
KPI	Key Performance Indicator
NGO	Non-Governmental Organisation
SME	Small and Medium-sized Enterprise
VC	Venture Capital
IPO	Initial Public Offering
M&A	Mergers and Acquisitions
PE	Private Equity
R&D	Research and Development
DD	Due Diligence
SDG	Sustainable Development Goal
CAPEX	Capital Expenditure
UNPRI	United Nations Principles for Responsible Investment
NCP	National Contact Point





AI	Artificial Intelligence
Ainia	Ainia
ALE	Adaptative Laboratory Evolution
ANB	Agentschap Natur & Bos
ARTP	Atmospheric Room-Temperature Plasma
B2BE	Business-to-BioEconomy
B4C	Bioeconomy for Change
BAU	Business-As-Usual
BBEPP	Bio Base Europe Pilot Plant
BBSRC	UK's Biotechnology and Biological Sciences Research Council
BCRS	The Maltese Beverage Container Refund Scheme
BDC	UK's Biorenewables Development Centre
BEC	Bioeconomy Cluster
BFR	Biofuel Region BFR AB
BGE	Biodiversity Genomics Europe
BIC	Biobased Industries Consortium
BioMADE	Bioindustrial Manufacturing and Development Ecosystem
BRCGS	British Retail Consortium Global Standards
BSG	Brewer's Spent Grain
CAGR	Compound Annual Growth Rate
CBD	Cannabidiol
CBE JU	Circular Bio-Based Europe Joint Undertaking
CBP	Consolidated Bioprocessing
CCIS	Chamber of Commerce and Industry of Slovenia
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CEAP	Circular Economy Action Plan
CEE	Central and Eastern Europe
CEN	European Committee for Standardisation
CERTH	Greek Centre for Research and Technology
CHP	Combined Heat and Power
CLUBE	Cluster of Bioeconomy and Environment of Western Macedonia
CoLABs	Collaborative Laboratories
CPI	UK's Centre for Process Innovation
CREA	Council for Agricultural Research and Economics
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CSTR	Continuous Stirred Tank Reactors
DEFRA	UK's Department for Environment, Food and Rural Affairs
DESNZ	UK's Department for Energy Security and Net Zero





DIH	Digital Innovation Hub
DM	Dry Matter
DNA	Deoxyribonucleic acid
DSIT	UK's Department for Science, Innovation and Technology
EAB	Electroactive Bacteria
EFI	European Forest Institute
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
ERDF	European Regional Development Fund
ERGA	European Reference Genome Atlas
ETIS	Estonian Research Information System
EUDR	European Union Deforestation Regulation
EV ILVO	Eigen Vermogen Van Het Instituut Voor Landbouw – En Visserijonderzoek
FAB FVG	Fondazione Agrifood & Bioeconomy FVG
FAIR	Findable, Accessible, Interoperable and Reusable
FAME	Fatty Acid Methyl Ester
FDCA	2,5-Furandicarboxylic acid
FDE	Environmental and Sanitary Declaration Forms
FO	Forward Osmosis
FSC	Forest Stewardship Council Certification
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GMO	Genetically Modified Organisms
GPS	Global Positioning Systems
GVA	Gross Value Added
HRT	Hydraulic Retention Time
HVO	Hydrotreated Vegetable Oil
IBioIC	UK's Industrial Biotechnology Innovation Centre
ICEADR	Romanian Institute of Agricultural Economics and Rural Development
IFPEN	French Institute of Petroleum – Energy nouvelles
ILUC	Indirect Land-Use Change
IMTA	Integrated Multitrophic Aquaculture
INECP	Bulgarian Integrated National Energy and Climate Plan
INRAE	French National Institute for Agriculture, Food and Energy
IoT	Internet of Things
ISO	International Organisation for Standardisation
ISPRA	Italian Institute for Environmental Protection and Research
JRC	Joint Research Centre
LCA	Life Cycle Assessment





LIAK	Latvian Industry Development Confederation
LNG	Liquefied Natural Gas
MAPA	Spanish Ministry of Agriculture, Fisheries and Food
MASE	Italian Ministry for the Environment and Energy Safety
MCAST	The Malta College of Arts, Science & Technology
MD	Membrane Distillation
MEC	Microbial Electrolysis Cell
MLSP	Malta Life Sciences Park
MOFs	Metal-Organic Frameworks
MSW	Municipal Solid Waste
MT	Metric tonne
NBMs	Nano-enabled Bio-based Materials
NECP	Cypriot National Energy and Climate Plan
NETIS	Hungarian National Environmental Technology Innovation Strategy
NFI	Swedish National Forest Inventory
NGOs	Non-Governmental Organisations
NGS	Next-Generation Sequencing
NNFCC	NNFCC Limited
NPPC	Slovak National Agricultural and Food Center
OFMSW	Organic Fraction of Municipal Solid Waste
OPEX	Operational Expenditure
OSRO	Organic Solvent Reverse Osmosis
PDI	Pilot and Demonstration Infrastructures
PLA	Polylactic acid
PNO ES	PNO Innovation SL
PNO PT	PNO Innovation Unipessoal LDA
PRTR	Spanish Recovery, Transformation and Resilience Plan
PV	Pervaporation
R&I	Research and Innovation
RDF	Refuse-Derived Fuel
RE2020	Revised Thermal Regulation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RED I	Renewable Energy Directive I
RED II	Renewable Energy Directive II
RED III	Renewable Energy Directive III
RES	Renewable Energy Sources
RTFO	Renewable Transport Fuel Obligation
S3	Smart Specialisation Strategy
SCP	Single-Cell Protein





SFE	Supercritical Fluid Extraction
SmF	Submerged Fermentation
SMR	Small Modular Reactor
SRC	Short Rotation Coppice
SRF	Short Rotation Forestry
STEP	Strategic Technologies for Europe Platforms
SusBioMM	UK's Sustainable Bio-based Materials and Manufacture
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TACR	Technology Agency of the Czech Republic
THC	Tetrahydrocannabinol
TNO	The Netherlands' Organisation of Applied Scientific Research
TRUST	Transparency, Responsibility, User focus, Sustainability and Technology
TTOs	Technology Transfer Offices
UK	United Kingdom
VAM	Vinyl Acetate Monomer
VFA	Volatile Fatty Acid
VITO	Vlaamse Instelling Voor Technologisch Onderzoek N.V.
VoB	Volume of wood over Bark
WP	Work Package





1 EXECUTIVE SUMMARY

This executive summary presents the purpose, scope, method, core results, and practical implications of D4.5, the synthesis deliverable that converts the evidence gathered in WP4 into comparable country and regional SWOT analyses and an EU-level SWOT. Unlike D4.1–D4.4, which each examined a single pillar of the bioeconomy (technologies and feedstocks, the policy and permitting environment, financing and instruments, and social innovation aspects), D4.5 does not generate new primary data. Instead, it assembles only what is already documented in those deliverables and in the ToBeReaL questionnaire into a single, structured assessment that policymakers and implementers can use to prioritise actions by geography and theme. The result is a traceable, side-by-side picture of strengths to build on, weaknesses to fix, opportunities to capture, and threats to manage—first for each country (with regional detail where the sources allow), then for Europe as a whole.

Methodologically, D4.5 is defined by three guardrails. First, it restricts sources to D4.1–D4.4 and the ToBeReaL questionnaire, with no extrapolation beyond those texts or the aggregated survey signals. Second, it works from a five-pillar baseline for each country—technology maturity and process performance, feedstock stability and quality, regulatory clarity and permitting speed, availability of finance for scale-up, and social acceptance and collaboration—constructed exclusively from those sources. Third, it applies the same inclusion rule across all geographies: a SWOT item appears only if it can be traced to D4.1–D4.4 or to the questionnaire; regional details are included only where a region is explicitly mentioned in those sources. This ensures comparability across countries and a verifiable audit trail from the SWOT back to the underlying evidence.

Inclusion criteria followed three guardrails: evidence-first, triangulation of policy/finance/social data, and an explicit audit trail. Stakeholder questionnaires served only to validate observed patterns, not to substitute documentary evidence. The questionnaire is used in a deliberately conservative way: only the first 88 responses are drawn on, and only in aggregate, to confirm and refine patterns already visible in the deliverables. Those responses broaden coverage across Central, Southern, and Northern Europe and help locate regional clusters such as Východné Slovensko, Central Macedonia, Comunitat Valenciana, Galicia, Canarias, Lazio, Pays de la Loire, and Limburg, where respondents reported active R&D and early deployment. The same responses reinforce the mid-TRL profile of ongoing work (a centre of gravity between TRL 4 and TRL 6, with fewer activities beyond TRL 7), the salience of scale-up economics and regulatory friction, and the need for stronger brokerage among innovators, investors, and public authorities—signals that align with the technical, regulatory, finance, and social findings already recorded in D4.1–D4.4.





The country and regional SWOTs converge on a consistent set of messages across the pillars. On the technology and feedstock side, the inventory in D4.1 shows a substantial pipeline of processes and value chains validated at pilot and demonstration levels, with recurring bottlenecks around process efficiency, integration, and scale-up feasibility; these appear as strengths (a strong R&D base, accessible pilot infrastructure) and weaknesses (limited FOAK deployment, integration risk) in multiple geographies. The questionnaire's TRL distribution and barrier selections confirm that picture and help locate it spatially where the underlying deliverables already cite regions. These same signals feed the EU-level SWOT: Europe's aggregate strength is its depth of research and testing capacity; its aggregate weakness is the thin bridge from demonstration to commercial scale.

On policy and permitting, the national sections in D4.2 document both enabling frameworks and persistent fragmentation: bioeconomy strategies exist in many Member States, but permitting remains complex and timelines uncertain, particularly for projects that cross sectoral or waste/product interfaces. These appear as opportunities (where strategies and targeted instruments are in place) and threats (where administrative risk depresses investment appetite). The questionnaire's average rating of the regulatory environment and the qualitative emphasis on harmonised standards corroborate those themes and explain why developers and investors discount timelines and prefer familiar jurisdictions.

On finance, D4.3 maps a layered architecture—EU grants and partnerships (e.g., Horizon Europe Cluster 6, LIFE, Missions), national and regional programmes that provide co-financing and local anchoring, and private capital instruments ranging from venture debt to project finance. In SWOT terms, this appears as an opportunity (diverse routes to de-risk early stages) and a weakness/threat at the point of TRL 6–8, where non-recourse project finance and offtake-backed models remain difficult without clearer permitting, stable feedstock contracts, and qualified offtake agreements. The questionnaire results reinforce this, with “economic feasibility,” “regulatory barriers,” and “scalability” the most frequently cited obstacles, and with respondents naming blended public–private models and regional green funds as high-impact enablers. The EU-level SWOT therefore underlines that financing solutions exist, but their effectiveness depends on earlier pillars: predictable permits, bankable feedstock, and capable project sponsors.

On social innovation and collaboration, D4.4 records moderate collaboration among research organisations, clusters, and companies, but weaker ties with investors, authorities, and consumers; it also points to gaps in long-term vision, skills, and data sharing. The questionnaire's mean collaboration rating ($\approx 3/5$) and low awareness of scale-up and





matchmaking platforms confirm these frictions. In the SWOTs, these appear as weaknesses that lengthen time-to-permit and time-to-market, and as opportunities where regional ecosystems have active clusters, living labs, and testbeds that can be scaled or replicated.

What D4.5 offers, beyond any single prior deliverable, is a stitched-together view that keeps every statement tied to its source while making the evidence usable for decisions at country, regional, and EU scales. It translates hundreds of pages of thematic analysis into a compact, comparable matrix of where each geography stands, why, and what that implies for action. In practice, that means a policymaker can see, for example, that a country with strong feedstock baselines and active pilot assets (from D4.1) but with slow cross-sector permitting (from D4.2) and limited access to demonstration finance (from D4.3) should focus on permit streamlining and targeted guarantees; or that a region with moderate collaboration (from D4.4) and mid-TRL strength (from D4.1) would benefit most from brokerage and shared demonstration facilities. Because each item is sourced, the logic chain from recommendation back to evidence is transparent.

Three findings illustrate the cross-validation the synthesis achieves. First, the mid-TRL bottleneck: D4.1 documents the maturity profile of priority technologies; the questionnaire quantifies where respondents actually are; D4.3 explains why capital intensity and risk allocation at TRL 6–8 remain hard without off-take certainty; and D4.2 shows how fragmented permitting multiplies that risk. All four point to the same message: improve demonstration de-risking and permitting coherence to shorten the path from pilot to flagship. Second, the policy-finance handshake: D4.2 identifies where bioeconomy strategies, standards, and one-stop-shop processes are clearer; D4.3 shows that these jurisdictions attract blended finance earlier and at lower cost; the SWOTs capture this as a geography-specific opportunity. Third, the ecosystem effect: D4.4 highlights the value of clusters, skills, and data-sharing; the questionnaire confirms that where these exist, collaboration scores and opportunity optimism are higher; D4.1 shows those same regions hosting more diverse technology trials. In each case, the country SWOTs line up with the EU-level SWOT, because they are built from the same, cross-checked evidence.

The mapping of ongoing projects, where referenced in earlier deliverables, further grounds the analysis by indicating where replication is plausible and where gaps remain. D4.3's overview of financial pathways and national/regional mechanisms, for instance, provides a ready set of instruments that align to the weaknesses and opportunities surfaced in the SWOTs, from grant-first de-risking to venture debt and offtake-backed project finance for late-stage scale-up. The policy brief attached to this report then condenses the cross-





regional patterns into practical steps: clarify and streamline permits at the interfaces of waste, product, and energy regulation; align standards for bio-based products; pilot green public procurement windows for early demand; and expand regional funds and guarantees that specifically target the TRL 6–8 gap in less-developed and transition regions.

In sum, D4.5's contribution is to integrate, not to speculate. It delivers a disciplined methodology that keeps to the evidence; a comparable set of country and regional SWOTs that reflect that evidence; and an EU-level SWOT that captures the patterns common to many geographies. It shows that Europe's bioeconomy in the assessed regions is rich in research capacity and pilots, constrained in scale-up economics and permitting, variably served by funding instruments that work best when policies are predictable, and under-connected across stakeholder groups that must broker projects from benches to plants. By connecting the dots across D4.1–D4.4 and the questionnaire—and only where those dots are actually present—D4.5 equips WP5 and WP6 to target capacity-building, brokerage, and demonstration support where they are most likely to change outcomes, and it gives national and regional actors a clear, sourced baseline against which to plan their next moves.





2 INTRODUCTION

This chapter defines the purpose, scope, and structure of D4.5 in relation to prior deliverables, consolidating evidence from D4.1–D4.4 into a single baseline for decision-making by public authorities, clusters, and investors.

Europe's underdeveloped and transition regions sit at the heart of the continent's shift to a climate-neutral, circular bioeconomy. These territories—often rural, industrially restructured, or peripheral—hold abundant but underused biomass (agriculture, forestry, fisheries, food-industry side streams) and a dense fabric of SMEs, cooperatives, and municipal services. Converting these assets into higher-value bio-based products, fuels, and materials can simultaneously cut emissions, reduce import dependence, diversify farm and forest income, and revitalise towns that have seen jobs move away. The transition also addresses structural challenges that are felt most acutely outside the big hubs: dispersed and seasonal feedstocks, legacy infrastructure, skills gaps, and uneven access to risk capital. By steering investment toward modular pre-processing near origin, continuous bioprocessing with efficient downstream steps, and verified circular uses of residues and wastes, the bioeconomy offers a practical route to deliver the European Green Deal, the Circular Economy Action Plan, the Biodiversity Strategy, and REPowerEU at ground level. Horizon Europe priorities around systems innovation, sustainable food and bio-based industries, and mission-driven R&I provide the science and demonstration backbone, while green public procurement, extended producer responsibility, and carbon-pricing signals can pull markets toward certified bio-based alternatives. Geographic and temporal coverage follow the project's Description of Action and the datasets referenced in D4.1–D4.4; where coverage differs across sources, the most conservative interpretation is applied, and limitations are stated explicitly in the relevant sections.

At the same time, these regions face real constraints that explain why promising technologies often stall at pilot scale: mid-TRL maturity for key routes (fractionation, advanced fermentation, novel separations), variable biomass quality that depresses yields, permitting and end-of-waste determinations that differ by jurisdiction, and the hardest financing gap precisely at TRL 6–8 where grants taper and commercial debt is still cautious. Social licence also matters: communities want visible local benefits (jobs, revenue sharing, lower energy bills via heat recovery), tight controls on odour, traffic and water use, and credible life-cycle evidence for biodiversity, soil and air. D4.5 treats these realities as design constraints for bankable projects rather than afterthoughts, focusing on execution levers—near-origin stabilisation of feedstock, integrated heat/water loops, digital QA/QC and traceability, early certification and standards mapping, and blended finance that pairs grants with concessional loans and offtake commitments—to shorten the path from research to first-of-a-kind plants.





Within this context, D4.5 pursues three concrete objectives. First, it diagnoses the barriers that most consistently hold back deployment across territories: technology and process gaps, feedstock stability and logistics, the clarity and timing of permits and standards (including end-of-waste and product certification), availability and suitability of funding for pilots, demonstrations and first plants, and the quality of cooperation and social acceptance. Second, it identifies enablers and repeatable strengths that countries and regions already demonstrate—such as open-access pilots, cluster governance, smart-specialisation focus areas, regional development funds that co-finance equipment and utilities, and buyer signals from green procurement or sector mandates—and distils them into patterns that others can adopt. Third, it converts the evidence into practical, prioritised recommendations for policy makers, clusters, developers and financiers: streamline and sequence rules that bottleneck first-of-a-kind assets; standardise data, LCA and mass-balance claims to unlock procurement; and structure financing stacks that blend national/regional grants, EU instruments and patient debt with early offtake to de-risk cash flows. Readers should use the evidence maps and annexed source lists to trace each analytical statement to its originating documents, ensuring that conclusions are interpreted within their data boundaries and assumptions. The chapter is structured to move from scope and definitions to the analytical approach, followed by an orientation for navigating the subsequent country and regional assessments.

D4.5 is intentionally a synthesis and decision-support step inside WP4, not a new data collection exercise. It integrates the technology and feedstock signals from D4.1, the regulatory and permitting landscape from D4.2, the financing pathways and instruments from D4.3, and the social acceptance and collaboration findings from D4.4, complemented by the ToBeReal questionnaire in aggregate form. Using this shared evidence base ensures traceability: every item in the EU-level SWOT and in the country SWOTs is grounded in the earlier deliverables or in aggregated stakeholder responses. Where the earlier work or the questionnaire clearly points to a region (for example, coal-transition territories, blue-bio coastal economies, or forest-industry corridors), D4.5 localises the national picture to reflect those place-based realities—funding envelopes, permitting practice, existing industrial sites, logistics, and skills.

This alignment with WP4 also ensures continuity across the project. The cross-regional insights extracted here - common strengths to build on, weaknesses to mitigate, opportunities opened by EU and national policy, and external threats to manage—feed directly into the EU-level SWOT and the policy brief that follows. Those outputs are designed to be immediately useful for WP5 and WP6: they point to system-wide levers (e.g., harmonised end-of-waste pathways, shared certification services, open pilot networks, digital traceability baselines) and to investment-ready actions (e.g., regional pre-treatment hubs, heat-integration retrofits, biomethane and digestate valorisation, brownfield





biorefinery siting near ports or mills). They also help partners coordinate instruments and timing: when to use regional ERDF for site utilities, when to apply national innovation grants to core process equipment, when to call on EU programmes or Just Transition envelopes, and how to structure offtake pools with public buyers or value-chain anchors.

Finally, D4.5 frames the bioeconomy as both an industrial and a social project. It treats skills and inclusion as core to bankability—embedding training modules and apprenticeships with funded pilots, building municipal and cooperative capabilities for feedstock contracting, and ensuring that benefits are visible where inputs come from. By centring execution detail—what it takes to move a lab-validated route to stable multi-month operation with lender-grade data—and by connecting policy, finance, technology and community acceptance in one narrative, this deliverable gives policy makers and practitioners a clear, evidence-based line of sight from today’s regional realities to investable, scalable, and socially robust bio-based value chains that advance EU climate and circularity goals.





3 METHODOLOGY

This deliverable (D4.5) synthesises—not generates—evidence. It draws exclusively on D4.1–D4.4 and the ToBeReal questionnaire to produce SWOT analyses; no new primary data are created. The rationale is to apply prior findings consistently at country level, and—only where earlier deliverables or the questionnaire explicitly reference a location—at regional level. The analytical workflow begins by constructing a baseline for each country across five pillars covered in D4.1–D4.4: technology/process performance and maturity, feedstock stability and quality, regulatory clarity and permitting speed, financing availability for scale-up, and social acceptance and cooperation. Where the source material or questionnaire clearly points to a specific region, those signals are used to localise the baseline without extrapolating beyond documented evidence.

The assessment applies an evidence-first principle: only claims supported by identifiable, dated sources are retained. Evidence includes policy and regulatory acts, programme documentation, financial instruments and guidance, project data, and socio-economic indicators. Triangulation reduces single-source bias. Policy, finance, and social datasets are cross-checked; where sources conflict, precedence goes to the most recent official or statistically robust source. Material discrepancies are noted in the evidence map. On that foundation, two SWOT layers are prepared. First, an EU-level SWOT distils the strengths, weaknesses, opportunities, and threats that recur across multiple countries and therefore represent system-wide levers or risks. Second, a country SWOT is produced for every nation treated in the earlier deliverables, refined with regional details only when those details are explicitly present in D4.1–D4.4 or in the questionnaire. Each SWOT item is limited to points that can be traced back to those sources; brief notes on ongoing projects are included only if the projects are already cited in earlier deliverables. A cross-country narrative then identifies patterns and outliers that inform the policy brief. Quality assurance comprises internal consistency checks (terminology, units, cross-references) and an explicit audit trail that links each analytical statement to one or more source identifiers in the annexed evidence map.

Data handling is deliberately conservative. Sources are restricted to D4.1 (technologies and feedstocks), D4.2 (policies and permitting), D4.3 (financing and instruments), D4.4 (social acceptance and collaboration), and the ToBeReal questionnaire. Questionnaire inputs are limited to the first 88 responses, used only in aggregate to confirm or refine signals already present in the deliverables; no disaggregated or identifying information is used. Processing consists of extracting relevant statements from D4.1–D4.4, grouping them by country, and





cross-checking them against the aggregated questionnaire results. Only clear, source-backed items are admitted to the SWOTs; if a point cannot be traced to the deliverables or to the questionnaire, it is excluded. This approach ensures traceability, comparability across countries, and methodological discipline in translating existing evidence into actionable SWOTs and an EU-level synthesis.

Stakeholder questionnaires and interviews are used strictly to validate patterns observed in documents; they do not substitute for documentary evidence. Where stakeholder input diverges from the documentary record, it is flagged and treated as a hypothesis until corroborated. Comparability across countries and regions is ensured by common inclusion criteria and a standard coding schema for strengths, weaknesses, opportunities, and threats. Where comparability cannot be guaranteed, results are presented qualitatively with an explicit limitation note that prepares the reader for the detailed country/region sections below.





4 COUNTRY/REGIONAL BIOECONOMY ANALYSIS

4.1 OVERVIEW OF REGIONS/ TECHNOLOGICAL ROADBLOCKS/ DEMAND-SIDE BARRIERS/ REGULATORY AND FUNDING CHALLENGES/ SOCIAL INNOVATION FACTORS:

4.1.1 Overview of regions

SWOT items are derived from triangulated evidence and coded against a shared schema to preserve comparability across countries and regions. Each point is traceable to one or more sources listed in the evidence map. Table 24 (see Annex Section) compiles the countries and regions exactly as provided by partners in the shared list used for earlier work. Names are kept in their original form, including local spelling and accents. Most entries match NUTS-2 units; some are provinces, metropolitan areas, or planning regions supplied by partners. Where a region is marked “Less developed” or “Transition,” the label comes directly from the partner list. If no label was given, it appears as “Unspecified.” No edits, conversions, or reclassification were made. The table shows only the territories covered by partners. It is not a full EU register and may include local naming or grouping choices. Duplicate names from multiple partner inputs were consolidated where identical; clear alternates were kept as written. Use the table for quick orientation, to see which territories are in scope, and to understand how partners framed their regional focus.

4.1.2 Technological roadblocks

Across countries the technical picture is consistent. Many bio-based processes remain batch-heavy and energy-intensive, which lowers yields and raises unit costs. Integration across fermentation, separation, and downstream operations is incomplete, so variability propagates through plants and reduces uptime. Pilot and demonstration capacity is scarce in several countries, which slows learning and makes the jump to first-of-a-kind plants risky. Certification and product testing routes are not always clear, which delays market entry for higher-value materials. Digitalisation is uneven: few facilities run robust online analytics, soft-sensors, model-predictive control, or LCA-linked data pipelines. This makes quality control and bankability harder. Circularity levers are underused where residue capture, separate collection of biowaste, and pre-treatment infrastructure are incomplete. Typical examples include: residue mobilisation gaps in agricultural regions in Southern and Eastern Europe; scale-up and continuous-processing gaps in Central Europe; and limited high-TRL biorefinery assets outside established hubs. The net effect is a TRL concentration in the 4–6 range and slow progression to FOAK deployment.





4.1.3 Demand-side barriers

Strengths and opportunities are retained only when enabling mechanisms—policy instruments, infrastructure, finance, or capabilities—are identifiable; weaknesses and threats are included when a credible constraint, risk, or uncertainty is evidenced. Three demand frictions dominate. First, feedstock at the right quality, price, and location remains decisive. Variability in moisture, contaminants, and seasonality adds pre-treatment cost and risk. Second, market pull and offtake. Buyers need reliable specs, standards, and labels to switch from fossil inputs at scale. In packaging, construction materials, and chemicals, certification and performance data drive purchasing. Third, end-user and citizen perception. Awareness of bio-based benefits is uneven and sensitive to food vs. materials vs. energy trade-offs. In several regions this affects planning, siting, and procurement unless projects show clear value, low nuisance, and credible climate benefits. Countries with strong public procurement pilots or recognised eco-labels progress faster; where these are absent, offtake remains bespoke and narrow.

4.1.4 Regulatory and funding challenges

Permitting, standards, and multi-level governance are the main regulatory hurdles. Even where national strategies are in place, the path from lab to pilot to FOAK crosses multiple authorities and timelines. Differences between national and regional rules add time and cost. Standardisation for new materials is still maturing, which slows acceptance in construction and consumer goods. On funding, the landscape is layered. Early R&D is covered by EU and national grants. The critical gap is TRL 6–8. Projects need blended packages that pair grants with loans or guarantees, link disbursements to milestones, and align with offtake. Where regions control instruments (e.g., Belgium’s regional schemes; Italian and Spanish regional OPs; Bulgaria’s Just Transition territories; Swedish regional innovation funds), bankability improves if permitting is clear and sites have utilities and logistics. Where execution of national plans lags, public co-funding is delayed and private capital waits.

4.1.5 Social innovation factors

Social factors are decisive for siting and speed. Public understanding of bio-based products varies and can be low, which increases sensitivity to cost and land-use debates. Engagement is often limited to government–academia–industry, while farmers, SMEs, citizens, and financiers join late. Skills gaps appear in digital operations, bioprocess engineering, and maintenance. Data-sharing is weak across actors, so social and environmental performance is hard to verify. Practical responses work best when they are simple: early and open engagement led by trusted intermediaries; training and reskilling





aligned with local employers; clear, public dashboards for environmental and social metrics; and pilots that bring benefits where the feedstock comes from. Regions with clusters, innovation hubs, or Just Transition platforms have natural venues to run these actions.

Section 4 provides the map. It locates the countries and regions that matter to this project, and it defines the common issues on technology, demand, regulation and finance, and social dynamics. Section 5 uses this map to write short country summaries and then builds SWOTs. Where the earlier deliverables or the partner list mention a region, that regional detail is carried forward into the summary and into the SWOT items. No new sources are introduced.

4.2 QUESTIONNAIRES APPLIED TO TOBEREAL ANALYSIS

The ToBeReal questionnaire provides a coherent, system-wide snapshot of Europe's bioeconomy from the perspective of actors operating across underdeveloped and transition regions, and its signals align closely with D4.1–D4.4. In total, 283 valid responses were gathered, with the largest country cohorts in Slovakia, Spain, Czechia, Sweden, Belgium, Italy, Slovenia and Greece, and smaller samples from the Baltics and the Western Balkans. Many respondents also reported multi-country operations—especially in Spain, Slovakia, Czechia, Poland, Sweden, Slovenia, and Portugal—indicating that even smaller or peripheral ecosystems are embedded in cross-border value chains rather than isolated local markets. Regional self-identification repeatedly referenced Východné Slovensko, Central Macedonia, Comunitat Valenciana, Galicia, Canarias, Lazio, Pays de la Loire and Limburg, which points to active R&D and cluster activity in territories that mirror D4.5's emphasis on less-developed and transition NUTS-2 regions. The organisational mix is balanced: universities, research and technology organisations, clusters and networks, SMEs, and a smaller set of large firms and public authorities. Roles concentrate in research and development, project and innovation management and technology development, which is consistent with the pre-commercial profile of most initiatives captured. This composition matters for interpretation: it reflects the vantage point of those doing hands-on development and early deployment rather than late-stage financiers or mass-market buyers. Where quantification is feasible, indicative ranges are reported rather than single-point estimates to reflect heterogeneity across regions and data vintages. Unquantified items remain when qualitative evidence is strong and consistent.

Technological maturity sits mainly at mid-TRL. Across the full and early subsamples, the centre of gravity is TRL 4–6, with relatively few activities beyond TRL 7 and only isolated first-of-a-kind deployments. This confirms the “valley of demonstration” identified in D4.1: promising routes in bioconversion, separations, and multi-feedstock processing are validated in labs and pilots but struggle to prove multi-month stability, consistent





specifications and lender-grade datasets. The technical pain points that respondents highlighted—process efficiency, integration of unit operations, automation and digital control, energy consumption and operational stability—map directly to the reasons pilots stall: heterogeneous feedstock drives variability; batch-heavy configurations keep utilities high; and limited inline analytics, soft sensors and advanced control slow troubleshooting and depress yields. In short, the innovation pipeline is populated and active, yet still transitioning from pilot to robust demonstration.

Regulatory and policy experience is rated “moderate” on average. The dominant frictions are fragmented and lengthy permitting, inconsistent end-of-waste and product-certification pathways, and uneven coherence between national bioeconomy ambitions and EU-level directives. Respondents in Southern and Eastern member states report these hurdles more acutely, often citing administrative iteration and limited local implementation capacity. This is consistent with D4.2 and helps explain why otherwise viable TRL 6–8 projects face long lead times: rules intended to safeguard environmental performance are necessary, but inconsistent interpretation, unclear documentation templates, and late LCA or mass-balance work add costly loops that small developers struggle to absorb. Harmonising certification and clarifying evidencing requirements earlier in project development would remove a disproportionate share of the friction for first-plants.

Finance emerges as a binding constraint for moving from TRL 6 to 8. Respondents rely heavily on EU and national grants (ERDF/CF, Horizon, CBE JU, LIFE), sometimes complemented by service revenue or small private contributions, while private risk capital and project debt are sparse at the moment, scale-up is needed. Bureaucratic complexity of calls and match-funding requirements add to the burden for SMEs and rural projects. In parallel, market pull is perceived as “stable to gradually growing,” strongest around agri-food residues, organic waste valorisation and bio-based packaging; yet price competition with fossil incumbents and limited consumer awareness mute demand signals for differentiated bio-materials. Together, these conditions produce a familiar pattern: weak offtake visibility and high perceived technology risk increase the cost of capital just when plants must lock EPC and long-lead equipment. Respondents consistently see public–private co-financing, regional green funds, and dedicated demonstration grants as the highest-impact enablers—especially where they are paired with early offtake arrangements from public buyers or value-chain anchors to stabilise cash flows.

Collaboration and social-innovation signals are mixed. Cross-sector collaboration averages about 3/5, with strong ties between research institutions and technology developers but weaker engagement with investors, regional authorities and end-users. Only about one in five respondents knew of pilot-brokering or scale-up platforms (e.g., open-access testbeds), suggesting that many actors are still discovering where to take a process for continuous trials, certification testing or pre-commercial tolling. This under-use of brokerage





infrastructure reinforces the mid-TRL bottleneck: without easy pathways to pilots, shared separations and certification services, projects remain trapped in one-off rigs and cannot produce the datasets that reduce lender and buyer risk. The social dimension—acceptance, benefit sharing, and visible local gains—appears as a secondary but persistent constraint: respondents note that siting is easier when projects codify odour/traffic/water safeguards, return value to feedstock providers, and connect with municipal services (e.g., heat networks, waste contracts).

Across the sample, respondents converge on a common opportunity set. Scaling sustainable production through modular pre-processing near origin, circular business models that valorise residues and biowaste, development of novel bio-based materials with clearer end-of-life routes, and the integration of AI and automation for process control are viewed as the most actionable moves. Regions with strong R&D clusters—Belgium, Spain, Sweden and others—report higher readiness and innovation optimism, largely because they already combine test assets, certification capacity and cluster governance with funding instruments that can be stacked. When mapped back to D4.1–D4.4, the questionnaire therefore validates four pillars that structure D4.5's SWOT work: strengths in science, clusters and cross-border networking; weaknesses in TRL maturity, fragmented regulation and thin late-stage finance; opportunities in digitalisation, circularity and policy-aligned market creation; and threats from administrative inertia, feedstock variability and price exposure to fossil incumbents. The implication for policy and practice is direct: shorten and standardise permitting and certification for first-plants; invest in shared pilots and separations tied to regional feedstocks; blend grants with concessional loans and early offtake to cross TRL 6–8; and build brokerage and capacity-building so that SMEs can actually use these assets. This is the evidential bridge from the questionnaire to the EU-level and country-level SWOTs that follow, and it sets a practical agenda for WP5 and WP6 actions.

4.2.1 Connection and validation against D4.1–D4.4

The technology and feedstock picture in the survey matches D4.1. The report states that many bio-based processes remain suboptimal in efficiency and energy use and that integration of enabling technologies is necessary to reach scalable and sustainable operation. It details automation challenges in batch bioprocessing, data scarcity from complex biological systems, and barriers to digital integration in legacy plants. The survey's counts on process efficiency, energy intensity, technology integration, and automation confirm these pain points and the need for robust sensors, advanced control, and interoperable digital platforms. The same D4.1 chapters stress continuous operation, integration across biotechnology, thermochemical, and digital layers, and the role of logistics





for stable feedstock quality. The survey's emphasis on feedstock variability and supply fits this diagnosis and supports D4.1's prescription to invest in process control, integration, and digital transformation to stabilise yields and costs.

The regulatory signal in the survey aligns with D4.2. The D4.2 structure maps the European Green Deal frame and then lists "Biggest challenges" by country. Those national snapshots document uneven strategy maturity, fragmented permitting, and standardisation gaps that slow market access. The high frequency of "regulatory barriers" in the questionnaire is therefore expected. The D4.2 layout allows D4.5 to link each NUTS-2 SWOT threat to a country-specific challenge statement and to extract concrete asks for streamlining, such as clearer end-of-waste criteria or aligned certification roadmaps for bio-based products. The country chapters for the Czech Republic, Slovakia, Spain, Sweden, and the United Kingdom are directly relevant to the largest respondent cohorts and should anchor the regional write-ups.

Finance and scale-up findings in the survey mirror D4.3. Respondents point to de-risking gaps between TRL 6 and 8 and to the difficulty of financing pilots and first-of-a-kind plants. D4.3 sets out the staged pathway and instruments. It shows where EU grants and partnerships cover TRL 2–5 and 5–8, where national and regional instruments add co-financing and technical assistance, and where EIB instruments such as direct investment loans, framework loans, project finance, venture debt, and multi-beneficiary intermediated loans can carry demonstrations and early deployment once offtake and cash-flow certainty are in place. The survey's reliance on EU and national programmes and the low visibility of private capital in this subset confirm D4.3's conclusion that blended approaches and advisory support are needed to close the demonstration gap. These elements can be lifted into D4.5's policy brief as a standard finance stack for regions.

Social and collaboration patterns in the survey validate D4.4. D4.4 identifies low citizen understanding of bioeconomy, scepticism toward bioplastics and novel foods, the dominance of the government–academia–industry triad, and the need for broader stakeholder inclusion. It also notes weak social data, limited monitoring frameworks, and education gaps. The moderate collaboration score in the survey and the listing of social acceptance as a barrier fit that profile. The D4.4 section on capacity-building translates well into D4.5 actions: early engagement, co-creation, brokerage via clusters and digital innovation hubs, and transparent communication linked to local contexts. These measures can raise the collaboration score above neutral and support the uptake of circular projects that the respondents favour.





The geographic distribution in the first eighty-eight rows also aligns with the WP4 evidence base. D4.1's executive summary and introduction map the technology and socio-economic barriers and tie them to partner-assigned regions and feedstock realities. D4.2's country chapters then provide the regulatory and policy texture. By combining the two, D4.5 can justify regional SWOT entries that are both data-driven and policy-aware. For example, a Slovak region that reports scalability and regulatory barriers in the survey can be paired with D4.2 Slovakia "Biggest challenges" and D4.1's notes on process integration and feedstock logistics. The same method applies to Spain, Sweden, the Czech Republic, and the United Kingdom, which are well represented in the survey.

In conclusion, the first eighty-eight questionnaire responses and the WP4 deliverables tell a coherent story. The system has a mid-TRL pipeline with clear technical bottlenecks in efficiency, integration, and automation. It faces regulatory fragmentation and permitting complexity that vary by country. It lacks scale-up finance fit for TRL 6–8 without public de-risking and structured offtake. It needs stronger social engagement and broader collaboration. D4.1 offers the technical levers to stabilise processes and valorise feedstocks. D4.2 offers the map to target regulatory streamlining by country. D4.3 offers the finance stack to cross the demonstration gap. D4.4 offers the social and capacity levers to raise acceptance and accelerate coordination. D4.5 can therefore remain an operationalisation document that applies these levers to SWOTs and a short policy brief without new primary research beyond targeted validation.





5 SWOT ANALYSIS

5.1 COUNTRY/REGIONAL SWOT PROFILES:

Analytical statements in this chapter are tied to the documented evidence base via the annexed evidence map, enabling readers to retrace each claim. This section turns the earlier evidence into clear choices for action. It uses only what has already been produced in D4.1–D4.4 and what stakeholders reported in the ToBeReal questionnaire. It does not add new sources. For each country, and for any region that is explicitly mentioned in the previous deliverables or in the questionnaire, it prepares a short executive summary and a focused SWOT. The executive summary brings together four angles: technologies and feedstock, policy and regulation, finance and investment, and social factors and collaboration. The SWOT then distils this material into strengths and weaknesses within the country/region, and opportunities and threats coming from outside. The section's proposals are grounded in the documented evidence base and linked to the audit trail to ensure transparency from recommendation to source.

The approach is simple and traceable. First, the analysis gathers the relevant statements from D4.1–D4.4 for the country. Where the earlier deliverables or the questionnaire provide clear regional signals, the text highlights them. Second, the analysis checks that the survey responses support or refine these signals. Third, the section writes a short narrative that a policymaker or investor can read in minutes. Fourth, the section lists the SWOT items in a compact form. Every point used in the SWOT comes from the cited deliverables or from the aggregated questionnaire, and no gap is filled with assumptions.

Granularity follows the sources. If only country-level material exists in the earlier deliverables, the analysis stays at that level. If a region is named and described in those deliverables or in the questionnaire, the text brings that regional detail forward. This keeps the section faithful to the evidence and avoids introducing new claims.

5.1.1 Belgium

Belgium's bioeconomy is built on a productive but finite biomass base and on region-led governance. Primary biomass output was about 16.1 Mt dry matter in 2020. Crop agriculture provides 86% of this, with roughly two-thirds channelled to animal feed; forestry and landscape management supply the remaining 14%, with most forest resources located in Wallonia. Despite high domestic productivity, Belgium imports significant volumes of soy and oilseeds, which raises exposure to external markets. The bioeconomy accounts for about 20.8% of apparent biomass use, dominated by forestry-based products that exceed





70% of the bioeconomy share. Established applications include construction materials, chemicals, textiles, biogas, and biofuels.

Demand is set to grow much faster than domestic supply. Scenario work to 2050 indicates a 260–430% rise in total biomass demand versus 2018, driven by the full substitution of fossil feedstocks in chemicals, large uptake of bio-based materials in construction, and targeted use of bioenergy for hard-to-electrify segments in industry, buildings, and maritime transport. Composition shifts matter: solid biomass demand declines by about 58%, while biogas rises by about 333% and biofuels by about 90%. Supply is expected to stabilise or edge down even after land-use changes, diet shifts (including lower meat consumption), food-waste reduction, and reduced synthetic fertiliser use. The structural gap implies higher import dependence, sharper competition between food, materials, and energy uses, and sensitivity to global trade constraints.

Policy and regulation are split between federal measures and the three regions—Flanders, Wallonia, Brussels-Capital—which run their own climate, energy, circularity, and bioeconomy frameworks. Flanders' Material Decree and Bioeconomy Policy Plan emphasise prevention, reuse, recycling, and new value chains. Regional climate and energy plans target efficiency, grid reinforcement, and renewable heat. Transport biofuel blending rules add sector-specific demand. This multi-level setting enables tailored action but raises coordination costs across jurisdictions and timelines, which directly affects permitting and standards.

Financing is also regional. Flanders channels grants for R&D and green transition through VLAIO and offers equity via public investors; Wallonia combines feasibility grants, guarantees through SOWALFIN, and equity or loans through SRIW, with advisory help to access EU programmes. The country hosts key scale-up assets, notably an open-access pilot plant that supports process demonstration and de-risking, and strong cluster platforms such as Catalisti and GreenWin. These assets shorten time to pilot and help align projects with regional smart-specialisation priorities, but first-of-a-kind economics remain tight and often require blended support and clear offtake.

Social factors shape deployment speed. Public understanding of bio-based products is uneven, and farmer protests have highlighted affordability and burden-sharing concerns. Stakeholder inclusion differs by region and project type, and data-sharing across actors can be improved. Targeted capacity-building, early engagement, and consistent communication are needed to maintain acceptance while executing land-use reform, cascading use, and circularity measures.





Overall, Belgium combines strong know-how, dense infrastructure, and active regional instruments with real constraints on domestic biomass and complex governance. Near-term progress depends on closing the demand–supply gap through efficiency and circularity, prioritising bioenergy to essential uses, standardising and streamlining permitting across authorities, and using regional finance to move proven technologies from pilot to first-of-a-kind with credible market pathways.

Table 1 Belgium SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Productive biomass base with established agro and forest sectors	Structural demand–supply gap for biomass toward 2050	Growth in bio-based chemicals and construction materials	Rising import dependence and externalised impacts
Mature bioeconomy niches in construction, chemicals, textiles, bioenergy	Reliance on imported feedstocks (e.g., soy, oilseeds)	Valorisation of residues and side-streams; stricter cascading	Global competition for sustainable biomass and trade volatility
Strong regional policies on circularity and climate	Fragmented governance across three regions	Region-level grants, guarantees, and equity to de-risk pilots and demos	Social pushback on affordability and environmental measures
High-quality scale-up assets and clusters; open-access pilot plant	High production costs at demo/FOAK scale	Alignment with EU programmes to crowd-in capital and offtake	Climate risks to forest productivity and supply stability
Skilled R&D and industrial biotech base	Limited public understanding and uneven stakeholder inclusion	Process efficiency and digital control to stabilise yields and costs	Competition between food, materials, and energy for the same feedstocks
Active investor and advisory ecosystem at regional level	Coordination burden for permitting and standards	Circular business models and design-for-recycling to ease supply pressure	Policy uncertainty across jurisdictions slowing execution





5.1.2 Bulgaria

Bulgaria holds strong biomass potential in agriculture and forestry, yet the bioeconomy remains constrained by technology gaps and limited scale-up capacity. Process efficiency is low in many facilities due to outdated, batch-centric operations and high energy use. Continuous processing, advanced fermentation, and real-time control are scarce, which depresses yields and raises unit costs against fossil alternatives. Scale-up infrastructure is thin: pilot and demonstration plants are limited, certification and sustainability labelling are underdeveloped, and many promising lines in lignocellulosics and algae stall before industrialisation. Logistics further reduce efficiency, with feedstock losses along agricultural chains and weak mobilisation of residues.

Digital adoption lags. AI-assisted process control, traceability tools for biomass, and data platforms for biorefining and logistics are the exception, not the rule. This slows learning cycles, keeps OPEX high, and makes projects harder to finance. Circularity remains an untapped lever: substantial agro-forestry and food-processing waste streams are under-valorised due to missing biogas capacity, limited composting, and few waste-to-bio products and biochar plants, especially in rural areas.

Policy ambition is clear. Bulgaria's CAP Strategic Plan, Agricultural Strategy to 2030, National Climate Change Adaptation Strategy, Aquaculture Plan, Integrated Energy and Climate Plan 2021–2030, and Energy Strategy to 2050 point to modernisation of primary sectors and a stronger role for bioenergy and advanced materials. Forest legislation and the wood industry plan aim to reshape forest management and wood use. The Vision is supported by smart specialisation (S3 2021–2027), which puts innovation and digitalisation at the centre.

Financing instruments exist but must be better connected to bioeconomy scale-up. At national level, the National Innovation Fund supports R&D for SMEs and research actors; the National Recovery and Resilience Plan (RRP) sets out green and digital investments (publicly communicated envelope ~€6.3 b; earlier government-EU agreement ~€5.5 b subject to milestones); the Competitiveness and Innovation Programme 2021–2027 targets clean tech and sustainable industry; Cohesion Fund and Programme "Environment" 2021–2027 back environmental infrastructure; EIB loans co-finance large projects; and the Just Transition Fund allocates ~€1.2 b to coal-dependent regions (Stara Zagora, Kyustendil, Pernik). Regional development is organised through Level-2 planning regions (North West, North Central, North East, South East, South Central, South West) with a 2021–2027 programme aimed at balanced growth. Early examples of bioeconomy awards include RRP support to insect-tech scale-up activity (~€2.5 m). Execution risk remains material: milestone





slippage has already affected RRP disbursements, which makes bankability and co-financing harder precisely where first-of-a-kind projects need it most.

Social aspects mirror the technological and investment picture. Public understanding of bio-based options is uneven; local acceptance hinges on affordability, land-use effects, and visible benefits. Collaboration across government, academia, industry, farmers, and financiers is improving but still moderate. Early engagement, skills support, and transparent communication are needed to build durable coalitions, especially in rural areas and in Just Transition territories where new value chains must replace high-carbon activities.

Overall, Bulgaria's opportunity is to turn abundant biomass and rural capacity into higher-value products by closing the technology and scale-up gaps, accelerating digitalisation, and building circular value chains. Near-term wins include targeted pilots in residue valorisation and biogas, certification and labelling to unlock markets, Just Transition-linked demonstrators in coal regions, and tighter links between national funds, RRP, EIB instruments, and private co-investment.

Table 2 Bulgaria SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large agricultural and forestry resource base with significant rural capacity	Outdated batch processes and high energy use reduce yields and raise costs	RRP, Cohesion, and Programme "Environment" funds to modernise plants and infrastructure	RRP milestone slippage risks delayed public funding and weaker crowd-in of private capital
Emerging lines in essential oils, biofertilisers, bio-based textiles; growing biopharma know-how	Sparse pilot and demo plants; limited industrial biorefining capacity	Just Transition Fund (~€1.2 b) for Stara Zagora, Kyustendil, Pernik to host flagship demos and reskilling	Competition from lower-cost fossil products and imported bio-based goods
Clear policy direction across agriculture, climate, energy, forestry, and S3 2021–2027	Weak certification and sustainability labelling slows market uptake	EIB loans and blended finance to support TRL 6–8 projects with offtake	Feedstock losses and logistics inefficiencies; rural infrastructure gaps
National Innovation Fund and Competitiveness & Innovation	Limited industry–academia commercialisation pathways	Residue and waste valorisation (biogas, compost, biochar) in rural regions and	Regulatory and permitting complexity; uneven





Programme support R&D and clean tech		Level-2 planning regions	execution across administrations
Level-2 regional development programme for balanced growth	Slow adoption of digital tools for process control and traceability	Digitalisation for process stability, traceability, and bankability; data-driven logistics	Social acceptance risks if affordability and land-use concerns are not addressed
Established forest and wood-processing policy framework	Under-mobilisation of agricultural residues and food-processing by-products	Clustered projects in coal regions to anchor new value chains linked to JTF	Climate and drought risks affecting biomass availability and quality

5.1.3 Croatia

Croatia's bioeconomy is at an early stage but has strong natural assets across agriculture, forestry, fisheries, and aquaculture. In the Adriatic economy of Jadranska Hrvatska (HR03), fisheries, aquaculture, and food processing generate steady blue-biomass side streams such as fish offal, shells, and algae. Tourism creates seasonal biowaste flows near ports and coastal towns. Universities and ports give access to skills and logistics. However, there are few pilot or demonstration plants able to process marine-derived feedstocks into biopolymers, ingredients, or advanced materials. Production remains largely batch-based and energy-intensive. Certification and testing routes for marine materials are not routine, which slows offtake.

Inland, Panonska Hrvatska (HR02) is the agricultural heartland with crop and livestock residues, wood processing, and food-industry side streams. Rail and highway links and brownfield industrial areas support new siting, but integrated pre-treatment near farms and processors is limited. Many lines lack continuous operation and robust downstream integration, which keeps yields modest and costs high. Anaerobic digestion and biochar options are underused, and residue variability increases pre-processing costs. In both regions, digital adoption is slow. Plants rarely run online analytics, soft sensors, or model-based control. Traceability systems are uncommon. This keeps quality variability high and weakens the case for finance at TRL 6–8.

Policy intent is clear. Climate, energy, waste, biodiversity, agriculture, aquaculture, forestry, and smart specialisation documents all support modernisation and circular use of resources. The execution gap is practical: siting, permitting, standardisation, offtake building, and blended finance for pilot and first-of-a-kind assets. National instruments exist for research and SME innovation through HAMAG-BICRO and the Croatian Science Foundation, while commercialization support is available through BICRO-type programmes. Primary sector





innovation can draw on EIP-AGRI. Cross-border and regional programmes can de-risk first projects. In Jadranska Hrvatska (HR03), Interreg Italy–Croatia, including the BIOBASED initiative, can fund blue bioeconomy pilots and knowledge transfer between labs and producers. In Panonska Hrvatska (HR02), the Interreg Danube Programme can back transnational networks, residue mobilisation, and demonstration sites.

Social factors will influence speed and siting. Public familiarity with bio-based products is mixed. Acceptance depends on affordability, local jobs, visible benefits, and management of odour, noise, and traffic. Collaboration improves when clusters, chambers, cooperatives, and universities act as neutral brokers and when value returns to the communities that provide feedstock. Skills gaps appear in plant operations, maintenance, and digital tools. Targeted training and reskilling can raise reliability and investor confidence.

Near-term priorities are the same in both regions but differ in implementation. In Jadranska Hrvatska (HR03), coastal residue hubs with cold-chain and pre-treatment should be placed near landing sites and ports to stabilise marine feedstocks. Pilot lines for chitin and chitosan, collagen and gelatin, and PHA or other biopolymers from marine streams can be attached to these hubs, paired with fast testing and labelling routes for packaging and marine-grade materials. In Panonska Hrvatska (HR02), residue hubs should be co-located with mills, cooperatives, and processors, with modular drying, size reduction, and densification to cut transport costs. Pilot lines for lignocellulosic sugars and fibre-reinforced biocomposites can anchor inland clusters, while anaerobic digestion and digestate valorisation and biochar can create near-term revenue and soil services. In both regions, digital control and traceability should be introduced in candidate plants to reduce variability and support financing. Blended finance stacks that combine national grants, Interreg support, and loans or guarantees can back TRL 6–8 projects once early offtake is signed. These steps will compress the path from lab to first-of-a-kind and convert Croatia's biomass into bankable products.

Table 3 Croatia SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Diverse biomass base across agro-forestry and the Adriatic blue economy	Batch, energy-intensive operations; limited continuous and integrated processing	Interreg Italy–Croatia in Jadranska Hrvatska (HR03) for blue pilots and knowledge transfer	Permitting complexity and evolving standards prolong time-to-project
Broad policy alignment on climate, energy, waste, agriculture,	Thin pilot/demo capacity; few industrial biorefinery sites	Interreg Danube in Panonska Hrvatska (HR02) for residue valorisation and demo networks	Competing fossil and imported bio-based products undercut price and delivery





aquaculture, forestry, S3			
National instruments for R&D and SME innovation (HAMAG-BICRO, HRZZ, BICRO)	Underdeveloped certification, testing, and eco-labelling for materials and chemicals	Blended finance stacks (national + Interreg + EIB-type loans/guarantees) for TRL 6–8	Logistics inefficiencies and feedstock losses reduce competitiveness
Strong blue bioeconomy potential: algae, fish-processing side streams, marine biopolymers	Weak industry–academia commercialisation pathways	Digitalisation for process stability, traceability, and LCA-ready data	Investor caution without offtake contracts and stable policy signals
Growing demand for sustainable packaging and construction inputs	Slow uptake of AI/automation; limited data infrastructure	Residue hubs near farms and processors; pre-treatment to cut transport costs	Climate and drought risks affecting biomass yield and quality
Cross-border value chains with Italy, Slovenia, Hungary, Danube region	Uneven rural infrastructure; limited utility access at candidate sites	Standardised certification routes to speed market entry in construction/packaging	Community pushback if siting, odour, or transport impacts are not managed

5.1.4 Cyprus

Cyprus has strong science capacity in biotechnology, environmental engineering, and circular economy, but the industrial base for bio-based production is thin. Most plants operate in batch mode with high energy use. Multi-step, integrated processing is rare, so yields are modest and unit costs are high versus fossil benchmarks. Access to modern enzymatic and microbial conversion platforms is limited, and there are few pilot or demonstration hubs to validate processes before committing capital. Certification and sustainability labelling are not routine, which slows market entry for bio-based materials in packaging, construction, and specialty chemicals. Waste valorisation is underused: agro-





food residues and municipal biowaste lack modular pre-treatment, and anaerobic digestion capacity is limited, so feedstock ends up under-valued or exported in low-value forms.

Scale-up is the core bottleneck. Promising university results seldom reach TRL 6–8 because there is no stable pathway from lab rigs to pilots with continuous operation and robust downstream steps. That raises OPEX uncertainty and makes offtake negotiations difficult. Digital transformation lags. Few facilities run online analytics, soft sensors, or model-based control; traceability and data rooms for lenders are uncommon. This keeps variability high and bankability low. As an island system with a single NUTS-2 territory (CY00), logistics are compact, but water scarcity and heat stress constrain biomass choices and plant operations, so projects must prioritise low-water processes and robust summer operation.

Policy intent is clear and aligned with EU goals. Energy and climate plans prioritise renewables and efficiency; waste and low-carbon strategies promote circular resource use; sector policies cover forests, aquaculture, agriculture, and biodiversity. Funding instruments are material and near-term. The Recovery and Resilience Plan totals about €1.2 billion through 2026, structured into 133 investments and reforms and 35 grant schemes. Public sources report several live calls at any time (about five open under National Grant Schemes and about five under Co-Financed Programmes), plus additional RRP calls (about three open). The Research and Innovation Foundation finances start-ups, SMEs, and collaborative R&D. Cohesion instruments and Just Transition mechanisms offer co-funding for infrastructure, skills, and green investment. The gap remains TRL 6–8. Projects need blended packages that pair grants with loans or guarantees, link disbursements to milestones, and anchor financing with early offtake.

Social factors shape siting and speed. Public familiarity with bio-based products is uneven. Acceptance depends on affordability, land- and water-use constraints, odour and traffic management, and visible local benefits. Early engagement with municipalities, waste operators, farmers, and hospitality chains improves outcomes. Skills shortages in bioprocess operations, maintenance, and digital tools slow ramp-up; targeted training raises reliability and lender confidence.

Near-term moves are practical and fundable within existing envelopes. Stand up a multiproduct pilot and testing hub that can run continuous fermentation, separation, and downstream steps; include shared analytics, certification support, and a lender-ready data room. Add modular pre-treatment for biowaste and agro-food residues near collection points; stabilise feedstock with drying, size reduction, and hygienisation. Expand anaerobic digestion where feedstock is steady and valorise digestate into biofertilisers fit for local agronomy. Formalise certification routes for bio-based materials and eco-labels used by public buyers. Roll out basic digital control, soft sensors, and end-to-end traceability in candidate plants to cut variability and shorten troubleshooting. Use the €1.2 billion RRP, National Grant Schemes, and Co-Financed Programmes to seed TRL 6–8 lines, then crowd in bank finance once initial offtake is secured.





Table 4 Cyprus SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Strong university and R&D base in biotechnology and circular economy	Batch, high-energy operations; limited integrated multi-step processing	RRP ~€1.2 bn with 133 investments and 35 grant schemes through 2026	High unit costs versus fossil alternatives in a small market
Compact logistics within a single NUTS-2 territory (CY00)	Few pilot/demo hubs; weak industry–academia transfer; slow certification and labelling	Multiple live national/co-financed calls (≈5 each) and additional RRP calls (≈3)	Water scarcity and heat stress constrain biomass and operations
Clear policy direction across energy, climate, waste, agriculture, aquaculture, forestry, biodiversity	Limited AD capacity and modular pre-treatment for residues and biowaste	Cohesion/JTF and RIF funding to build testing hubs and residue valorisation	Import dependence for key inputs; exposure to price shocks
Growing circularity demand from tourism, food, and packaging chains	Slow digital adoption; scarce traceability and lender-grade data rooms	Blended finance (grants + loans/guarantees) tied to milestones and offtake	Permitting complexity and small industrial base delay FOAK rollout
Active national innovation agency (RIF) and access to EU programmes	Small number of industrial offtakers; bankability gap at TRL 6–8	Fast-track standards and eco-labels to open public procurement markets	Social pushback if costs rise or benefits are not local and visible
Island scale eases coordinated pilots and procurement	Fragmented datasets; limited LCA and performance evidence	Modular pre-treatment + AD, biofertiliser, compost to close loops	Climate variability affecting feedstock stability and energy demand

5.1.5 Czechia

Czechia has a wide biomass base across agricultural residues, industrial hemp, forestry wood, food-processing side streams, and dedicated energy crops. Conversion into higher-value products is held back by technology maturity, weak pre-treatment near the source, variable feedstock quality, scarce pilot and demonstration capacity, and limited use of



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continuous processing with integrated downstream steps. Many priority routes sit at technology readiness level 4 to 6, so yields for anaerobic digestion, pyrolysis, and enzymatic hydrolysis fall when inputs are heterogeneous. Energy use is high where heat recovery, water reuse, and nutrient recycling are incomplete. Digitalisation is thin across logistics and plants; sensors, advanced control, and plant-level simulation are rare, which keeps quality variability high and lowers lender confidence.

These constraints appear differently by region and investment line. In the coal transition territories of Karlovy Vary (CZ041), Ústí nad Labem (CZ042), and Moravian-Silesian (CZ080), the Just Transition Fund can underwrite multi-feedstock pre-treatment hubs, anaerobic digestion with heat recovery linked to district systems, and first-of-a-kind demonstration plants on brownfield sites with rail and grid access. Cross-border programmes expand options for joint pilots and supplier networks. Bavaria–Czechia covers Karlovy Vary and South Bohemia (CZ031). Saxony–Czechia covers Karlovy Vary, Ústí nad Labem, and Liberec (CZ051). Austria–Czechia covers South Bohemia, Vysočina (CZ063), and South Moravia (CZ064). Slovakia–Czechia covers South Moravia, Zlín (CZ072), and Moravian-Silesian. Czechia–Poland covers Liberec, Hradec Králové (CZ052), Pardubice (CZ053), Olomouc (CZ071), and Moravian-Silesian. These programmes can fund research–industry pilots, circular economy projects, skills, and participation by small and medium-sized enterprises, with high co-funding rates under European Regional Development Fund rules. In South Moravia and Vysočina, feedstock specifics matter: hop residues and brewery streams in South Moravia; hemp and mixed straw streams in Vysočina. Both need modular pre-treatment (drying, size reduction, densification) and flexible conversion to stabilise specifications. Central Bohemia (CZ020) shows straw potential close to Prague’s research base but needs certification and testing routes to move beyond heat and simple biogas into materials, packaging, or chemicals. South Bohemia, Plzeň, Liberec, Hradec Králové, Pardubice, and Olomouc combine forestry and food-processing residues; smaller circular projects—anaerobic digestion, nutrient recovery, biochar, and fibre composites—fit regional and cross-border calls.

Policy gives direction but remains generic for bioeconomy execution. The Strategic Framework 2030, the Innovation Strategy 2019–2030, the Circular Economy framework, the Wastes Act, the Packaging Act, and the National Energy and Climate Plan set targets for resource efficiency, renewable energy, and waste hierarchy. The Common Agricultural Policy Strategic Plan 2023–2027 lists ninety-two interventions for agriculture, food, forestry, and rural development that can finance residue mobilisation, storage, and cooperative pre-treatment. For capital expenditure, the Operational Programme Environment offers grants up to ninety-five percent of eligible costs and in selected measures up to one hundred percent for energy efficiency, renewable energy, water, circular economy, nature, and pollution. The National Programme Environment fills gaps with continuous calls. The New Green Savings Programme supports energy savings in buildings up to fifty percent, and up to sixty percent for lower-income households when combined with boiler subsidies; this can complement bioenergy and heat integration at sites. The Modernisation Fund finances electrification, energy storage, and efficiency upgrades in first-of-a-kind plants. The National





Recovery Plan and the RepowerEU component add calls for green and digital upgrades, permitting simplification, and skills. The Operational Programme Technologies and Applications for Competitiveness targets productivity, research and development, digitalisation, low-carbon transitions, and resource efficiency and suits equipment, controls, and pilot-line upgrades for small and medium-sized enterprises. Cross-border and transnational Interreg lines fund joint pilots, certification collaborations, and supplier development. Combining these instruments lets regions assemble tailored finance: Just Transition Fund plus Operational Programme Environment plus Modernisation Fund for coal-region utilities and first-of-a-kind plants; Interreg plus Operational Programme Technologies and Applications for Competitiveness plus Common Agricultural Policy for inland residue hubs; Interreg plus Operational Programme Environment for forestry and food circular projects in border regions.

Commercial bottlenecks are consistent nationwide: build pre-treatment close to producers to tame variability; run continuous operation with integrated separations to raise yields; generate lender-grade data, certification, and life-cycle assessment to open public and private procurement; and install digital control and traceability to stabilise quality. Addressing these with region-specific finance stacks is the fastest route to bankable technology readiness level 6 to 8 projects and to shift from heat and low-value outputs into materials, chemicals, and verified circular products.

Table 5 Czechia SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Wide biomass base: straw, manure, wood, hemp, food-processing residues; region-specific streams such as hop residues in South Moravia, hemp in Vysočina, straw in Central Bohemia	Many routes at technology readiness level 4–6; few pilots with continuous operation and integrated downstream steps	Operational Programme Environment grants up to ninety-five to one hundred percent for circular, energy, and water upgrades and pilot utilities; Common Agricultural Policy with ninety-two interventions for rural logistics	High energy intensity; limited low-carbon power raises operating costs
Dense funding mix: Operational Programme Environment, National Programme Environment, New Green Savings Programme,	Limited certification, testing, and life-cycle assessment; products remain in lower-value markets	Just Transition Fund in Karlovy Vary, Ústí nad Labem, and Moravian-Silesian to finance multi-feedstock hubs, demonstrations, and skills on brownfields	Investor caution at technology readiness level 6–8 without offtake and validated specifications





Modernisation Fund, National Recovery Plan with RepowerEU, Operational Programme Technologies and Applications for Competitiveness, Common Agricultural Policy, and Interreg programmes			
Cross-border reach via Interreg with Austria, Slovakia, Poland, Bavaria, and Saxony; high co-funding under European Regional Development Fund rules	Fragmented biomass and performance data; few open platforms for decision support	Flexible, multi-feedstock lines; digital control and traceability to stabilise quality and improve bankability	Permitting complexity slows first-of-a-kind timelines
Industrial sites, rail, and grids in transition regions; universities and sector institutes near key feedstocks	Circular links underdeveloped; residues often treated as waste rather than inputs	Certification and eco-labels to access construction, packaging, and export markets	Competition from fossil and imported bio-based products
Supplier proximity in Germany, Austria, and Switzerland and in Central and Eastern Europe	Manual logistics and storage; low adoption of sensors and plant-level simulation	Stacked finance: Interreg plus Operational Programme Technologies and Applications for Competitiveness plus Common Agricultural Policy inland; Just Transition Fund plus Operational Programme Environment plus Modernisation Fund in coal regions	Climate variability and water constraints affecting feedstock stability and operations

5.1.6 Estonia



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Estonia's bioeconomy pairs rich biomass (forests cover about half the land; arable land per person is high) with strong research bases in Tallinn and Tartu, yet conversion capacity lags potential. Much wood still flows to low-value mechanical uses; continuous fractionation and integrated separations remain scarce outside pilots, and mid-TRL scale-up lacks bankable multi-month runs. Pre-treatment near origin is limited, so wet and bulky feedstocks move long distances with variable moisture and contamination, raising costs and depressing yields. Plant digitalisation is uneven: sensors, advanced control, inline QA/QC, and simple digital twins are not standard in farms or processing lines. Productivity signals this gap: value added per bio-sector worker is roughly €23–25k vs ~€61k European Union average. Logistics and dispersion amplify the issue; quality stabilisation (drying, sizing, densification) close to producers is the highest-leverage fix. Sustainability requirements are tightening across circularity, soil, biodiversity, and climate—life-cycle assessment and certification must be designed in from the start or market access will stall. Within the single NUTS-2 region, specialisation patterns matter: Tallinn–Harju and Tartu corridors suit TRL6–8 pilots, certification, and supplier depth; coastal and island counties align with aquaculture and marine by-product valorisation; South-East Estonia targets small and medium enterprise equipment, pre-treatment hubs, and job creation using dedicated regional lines.

Regulatory direction is clear and supportive. National roadmaps on circular bioeconomy, waste, and energy-climate targets align with European Union objectives and push higher resource efficiency, cascading use, and safeguards for soils and biodiversity. Implementation is distributed across ministries and municipal actors; obligations are rising on proof (traceability, LCA, biodiversity impact) and on process integration (water reuse, heat recovery, nutrient cycling). County strategies and city programmes translate high-level aims into utilities, waste systems, and shared infrastructure that projects can plug into. For developers this means early permitting engagement, data rooms for compliance evidence, and budget lines for monitoring, verification, and certification.

Investment pathways are practical and stackable from lab to first plant. Company-led research and development is co-funded by the Applied Research Programme (typical co-fund 20–75%; awards up to ~€1.9m observed for scale-up) and Smart Specialisation grants (€20k–€3m) to build continuous pilots, separations, and control. Equipment and site utilities are eligible under the European Regional Development Fund through 2027 for pilot lines, shared labs, and cluster infrastructure. Circularity capex is covered by the Grant for Circular Production and Consumption (round budget €2m; ≥€0.8m ring-fenced outside Tallinn and Tartu; company match ≥30%) and municipal Circular Economy Pilots (grant intensity up to 85%) to install heat-recovery networks, water reuse, nutrient recovery, and by-product valorisation. First commercial units combine the Large-Scale Investment Grant (minimum €100m project; ≥30 new jobs; high self-finance) with ERDF and national co-financing for LIFE, Horizon, or Innovation Fund awards to complete capital stacks. Regional funding adds precision: South-East Estonia entrepreneurship support covers up to 60% of SME equipment and pilot costs (≥40% applicant co-financing), County Development Strategy Support finances shared utilities and enabling works up to 85%, and the Environmental Investment Centre's Co-financing Programme bridges national matches for EU-backed





projects. Rural LEADER calls via local action groups fund community-led logistics, small civil works, and micro-equipment across all counties. Coastal investments can blend the European Maritime, Fisheries and Aquaculture Fund with Central Baltic Programme grants (co-financing up to 80%) for joint pilots, market access, and shared certification with Finland and Sweden. The Estonia–Latvia Programme funds cross-border pilots, supplier pooling, and skills with co-financing up to 80%. For early work, Development Vouchers (to €35k, 70% intensity) and Innovation Vouchers (to €7.5k, 80% intensity) pay for feasibility, analytics, standards mapping, and LCA scoping. Sequencing that works: vouchers for feasibility and certification pathways; Applied Research + Smart Specialisation to build continuous pilots; ERDF to install equipment and utilities; Circular grants to close loops; large-scale and EU instruments for first plants. Every application should show near-origin stabilisation, inline QA/QC, digital traceability, third-party LCA, and a skills plan with universities and vocational providers.

Social factors shape execution. Acceptance rises when projects co-design with municipalities and local action groups, publish verified environmental performance, and deliver visible benefits: jobs, lower energy bills via heat recovery, better waste services, and upgraded public infrastructure. Skills are a binding constraint across operations, automation, and quality; training modules and apprenticeships tied to funded projects should be mandatory work packages. Governance clarity and shared data reduce friction between authorities, companies, and communities; embedding these in grant milestones improves delivery.

Table 6 Estonia SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Abundant, diverse biomass: extensive forests, strong agri-food and wood side streams; high arable land per person.	Mid-TRL bottleneck: few continuous pilots and demonstrations; low value added per worker; fragmented research efforts.	Upgrade from mechanical wood uses to fractionation and biochemicals; replicate flagship biorefineries with certified specs and offtake.	Tightening sustainability and market standards; lagging LCA and certification can delay sales and permitting.
Universities and start-ups concentrated in Tallinn and Tartu; active municipalities and local action groups	Limited near-origin pre-treatment; high logistics for wet/bulky biomass; variable quality without stabilisation.	Finance stack to de-risk scale-up: Applied Research, Smart Specialisation, ERDF, Circular grants, municipal pilots, national co-financing.	High energy and transport costs if plants lack heat recovery, water reuse, and local pre-processing.





enable local circular loops.			
Clear policy signals on circularity, biodiversity, climate; county and city instruments to implement.	Patchy adoption of sensors, advanced control, and plant-level simulation in farms and plants.	Coastal blue bioeconomy via EMFAF + Central Baltic; South-East SME pre-treatment hubs with 60% grants; Estonia–Latvia cross-border supplier pooling.	Community pushback where benefits are unclear; contested forestry practices and competing land uses.
Broad access to national, regional, and EU instruments; national co-financing available for EU-backed projects.	Limited bankable multi-month pilot data; scarce shared spec databases and certification pipelines.	Digital QA/QC and traceability to stabilise quality and improve bankability; embedded skills pipelines through universities and vocational centres.	Climate and water variability affecting feedstock; investor caution at mid-TRL without long-term offtake.

5.1.7 France

France's bioeconomy combines a large and diverse biomass base with deep research and engineering capacity, but conversion into scalable, higher-value plants is uneven. In bio-based molecules, industrialisation is slowed by contamination-prone fermentations, enzyme immobilisation complexity, and limited use of artificial intelligence for strain design and structure–activity prediction; downstream processing remains energy- and solvent-intensive. In bio-based materials, performance gaps versus fossil comparators persist (mechanical/barrier properties, thermal resistance), and composites are hard to disassemble or recycle; some biopolymers still lack robust end-of-life options in real conditions. Food and feed scale-up is difficult for novel proteins and cultivated meat; characterising and functionalising plant proteins and anchoring flavour–texture–nutrition remain active work, alongside the need to re-introduce and breed varieties like lentils and faba beans. On bioresources, year-round supply is challenging for seasonal streams; lignocellulosic fractionation is energy-intensive and pre-treatments are costly; algae production faces harvesting and energy constraints; tighter coupling with urban and industrial biowaste can raise utilisation. In bioenergy, enzyme and microbial robustness for lignocellulosic ethanol, conversion efficiency for advanced fuels, limited digestate valorisation, and smarter grid integration for biomethane are recurrent issues. Cross-cutting, many plants still struggle to adapt processes to variable feedstock moisture/quality, to





deploy digital twins and predictive control, and to evidence environmental performance with harmonised life-cycle data.

Regulatory and market drivers are generally supportive but demanding. The national low-carbon pathway and the bioeconomy and biomass-mobilisation strategies prioritise residue- and waste-based inputs, cascading uses, and traceability. Packaging, waste, air-quality and biodiversity rules tighten the floor on environmental performance, pushing projects toward integrated water reuse, heat recovery and credible life-cycle assessment from day one. Regional biomass schemes and soil artificialisation controls are being localised to reflect territorial realities; this favours regions that can show aligned land-use, biodiversity safeguards and grid access. Cluster capacity is strong but uneven: Grand Est couples forests and agri-residues with gas-grid proximity; Hauts-de-France advances agri-materials and biomethane under a dedicated regional strategy; Auvergne–Rhône-Alpes concentrates green chemistry and separation know-how; Île-de-France anchors finance, certification and analytical services; Occitanie adds blue-bio links; Normandy and Nouvelle-Aquitaine channel S3 funds into circular/agri-food upgrades.

Investments blend large national envelopes with regional instruments and EU funds. The France 2030 plan sets a €54 billion top-down frame for strategic value chains. Typical company-facing tickets include: innovation grants that can cover up to ~50–70% of eligible research and development; start-up creation support with subsidies up to ~€0.6 million; single-partner innovation competitions co-financing 35–45% of €1–5 million projects (60% subsidy/40% recoverable advance mix); and industrial decarbonisation calls offering ~30–60% grants for projects cutting at least ~1,000 tCO₂ per year, with ~€3–30 million award ranges. A national “industrial territories in ecological transition” line offers up to ~80% funding with minimum awards around ~€0.4 million for structuring green-industry projects. Materials circularity calls can finance diagnostics at ~€50–100 thousand and investments up to roughly €0.8–2.5 million depending on the stream. Eco-design lines in textiles and cross-sector studies commonly fund ~€5 thousand to €100 thousand (and up to ~80% of eligible costs). On regional instruments, the i-demo programme operates in most NUTS-2 regions (for example, Grand Est, Hauts-de-France, Île-de-France, Occitanie, Auvergne–Rhône-Alpes), typically backing €1–4 million collaborative projects at up to ~60%. The Just Transition Fund is available in coal- and carbon-intensive NUTS-2 areas such as Hauts-de-France, Grand Est, Normandy, Pays de la Loire, Auvergne–Rhône-Alpes and Provence–Alpes–Côte d’Azur, with grant rates commonly ~30–40% (up to ~70% in specific cases) and minimum aids around ~€0.2 million. Grand Est maintains continuous calls for agri-food modernisation (10–40% up to ~€0.8 million) and large-company research and innovation (typically up to ~€0.25 million per file), plus a dedicated i-demo window for bio-based molecules and materials (€0.5–2 million). Nouvelle-Aquitaine runs an innovation springboard (~€7.8 thousand for feasibility) and biodiversity actions (grants up to ~€50 thousand). Île-de-France supports forest-wood companies (up to ~€0.5 million at 50%) and innovative projects for forests and biobased materials (up to ~€0.1 million at 50%). These are commonly stacked with ERDF (often 40–60% for site utilities, water/heat loops) and Interreg (€0.8–2.5 million consortia) where cross-border value chains apply.





Social readiness is mixed but improving. Rural and industrial communities expect tangible local benefits (jobs, farmer income stability, heat networks, odour/noise control), transparent risk management, and credible biodiversity safeguards. Skills gaps persist in automation, fermentation operations, analytical quality control and life-cycle assessment; regions with strong technical colleges and cluster academies (for example, Auvergne–Rhône-Alpes, Hauts-de-France, Grand Est) have an advantage. Acceptance rises where projects co-govern feedstock standards with cooperatives, publish monitoring dashboards, valorise digestate or lignin locally, and dedicate budgets to workforce upskilling and inclusion.

Table 7 France SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Extensive and diverse biomass (forestry, crops, residues)	Scale-up bottlenecks from lab/pilot to demo/first-of-a-kind	France 2030 and national schemes for industrialisation	Global competition from lower-cost fossil and imports
Mature agri-food, forestry, and fermentation know-how	High OPEX in downstream separation and purification	Regional i-demo windows; targeted calls in Grand Est, Hauts-de-France, Île-de-France	Policy instability and changing eligibility rules
Strong innovation ecosystem (IAR, Axelera, Bioeconomy HDF)	Limited continuous processing lines and shared pilots	Rapid biomethane growth; grid access and tariff support	Feedstock variability from climate stress and seasonality
Robust research base and testing/certification capacity	Fragmented tech transfer to SMEs; slow TRL progression	Public procurement for biobased, eco-design and recycling mandates	Local siting constraints; permitting delays and opposition
Good logistics, gas grid, and industrial sites for co-location	Inconsistent quality specs for lignocellulosics and organics	Industrial symbiosis in chemical basins and ports	Energy price volatility raising operating costs
Established LCA expertise and sustainability monitoring	Under-valorised side streams (digestate, lignin, CO ₂)	High-value niches: biopolymers, green solvents, nutraceuticals	Tight biodiversity, water, and land-use constraints
Regional depth: Grand Est (biomaterials), Hauts-de-France (proteins, starch), Auvergne-Rhône-Alpes	Skills gaps in operations, QC, and digital process control	Cross-border value chains with Belgium, Germany, Spain, Italy	Supply-chain fragility for specialised





(chemistry), Île-de-France (wood/biobased construction)			enzymes and equipment
Active gas and waste operators enabling bioenergy plays	Low deployment of AI/digital twins in plants	Brownfield conversion and JTF areas for decarbonised industry	Investor caution on first-of-a-kind risk profiles
Strong standards and traceability culture	Limited market pull for premium biobased vs. fossil	Carbon pricing and EPR to improve biobased competitiveness	Slow recycling infrastructure for complex composites
Finance mix (Bpifrance, ADEME, ANR, regions)	Long payback for heavy CAPEX biorefineries	Port/rail hubs for export of biobased materials and fuels	Talent competition with other deep-tech sectors

5.1.8 Greece

Greece's bioeconomy is sizable and underexploited. It already generates roughly €27 billion in turnover and around 500,000 jobs, anchored in agriculture (about 40% of land) with plentiful side streams from olives, vines, cotton and dairy, plus strong blue-bio potential from fisheries and algae. Yet industrialisation lags: few biorefineries, limited pilot-to-plant scaling, manual and batch operations, weak technology transfer, and incomplete sustainability metrics constrain competitiveness. Policy momentum is real—the National Circular Economy Strategy and Action Plan, a strengthened National Energy and Climate Plan (targeting ~81% renewable power by 2030 and pathways to ~4.65 TWh biomethane and ~20.9 TWh hydrogen), and Smart Specialisation all point in the right direction—but the absence of a dedicated national bioeconomy strategy and slow permitting dilute impact. Investment capacity is significant and multi-layered: the National Recovery and Resilience Plan (~€35.95 billion), the NSRF 2021–2027 (~€26.2 billion) including the “Competitiveness” programme (~€3.9 billion), the Development Law 4887/2022 (13 aid schemes with tax relief and grants), CAP/LEADER instruments, and the Just Transition Fund (~€1.63 billion) for Western Macedonia, Megalopolis and island grids. All thirteen NUTS-2 regions deploy Regional Operational Programmes that channel European Regional Development Fund and European Social Fund resources into innovation, low-carbon infrastructure and SME upgrading—Western Macedonia prioritises energy transition and industrial symbiosis; Central Macedonia emphasises research-business links; Attica targets innovation, eco-design and waste systems; Crete and the Aegean regions push resource efficiency and resilient water-energy systems. Socially, the bioeconomy aligns with rural revitalisation and





youth employment but requires skills upgrading in process operations, digital manufacturing and quality control, plus stronger community engagement for new facilities. Priority actions are to launch a national bioeconomy strategy with clear sector roadmaps, stand up demonstration and first-of-a-kind plants for bioplastics, biochemicals and biomethane, digitise biomass collection and processing, standardise life-cycle assessment and certification, and use public procurement and regional funds to create stable demand and bankable project pipelines.

On the technical side, Greece's bottlenecks cluster around process efficiency, scalability and digitalisation. High moisture and heterogeneity in agricultural residues depress conversion yields; batch configurations dominate biogas and fermentation, raising energy and labour costs; pre-treatment capacity is sparse, so cascading valorisation is rare and side-streams are under-used. Many promising outputs (olive-mill waste biopolymers, dairy by-product fertilizers, algal ingredients) stall at pilot because demonstration assets and first-of-a-kind financing are limited. Automation, in-line analytics, digital twins and AI-driven control are not yet standard in fermentation, separation or logistics; biomass traceability and quality grading remain manual, and precision-ag adoption is uneven. Priority fixes include regional pre-processing hubs, multi-feedstock pre-treatment (steam explosion, organosolv, hydrothermal), modular AD and gas upgrading for biomethane, continuous fermentation with in-situ product removal, and robust downstream separations with heat-integration and water reuse. Standardised life-cycle assessment, digestate valorisation (biofertiliser specs, pelletisation), and certified compost/biochar pathways would close carbon and nutrient loops while improving bankability.

From a regulatory and policy perspective, Greece has strong anchors but lacks a single bioeconomy framework to knit them together. The National Circular Economy Strategy and Action Plan set horizontal levers on waste prevention, recycling and secondary raw materials; the National Energy and Climate Plan elevates renewable gases and advanced biofuels; the Development Law 4887/2022 provides tax relief, grants, leasing subsidies and employment incentives through 13 schemes; CAP Strategic Plan and LEADER/CLLD sustain primary-sector modernisation. What is still needed are streamlined, time-bound permits for biowaste-to-bioprocess plants, harmonised product standards for digestate and compost, clear sustainability criteria and certification for bio-based products, and green public procurement targets (e.g., minimum bio-based content or recycled nutrients in municipal purchasing). Aligning tariffs and grid codes for biomethane injection, simplifying waste-shipment rules for regional feedstock pooling, and ring-fencing a share of public tenders for certified bio-based alternatives would materially accelerate market creation.

Investment is deep and multi-tiered across national and regional lines, with clear tickets and co-financing rates. At national level: Greece 2.0 (Recovery and Resilience Plan) mobilises ~€35.95 billion to 2026 for green and digital projects; NSRF 2021–2027 totals ~€26.2 billion, including the “Competitiveness” programme (~€3.9 billion) that backs SME innovation, decarbonisation and scale-up; the Development Law earmarks ~€150 million per scheme per year offering tax exemptions, cash grants, leasing subsidies and employment support;





TEPIX III Loan and Guarantee Funds ease SME finance (blended or guaranteed loans, interest subsidies of ~2–3% for two years), while the Microcredit Fund provides small tickets with mentoring; the Just Transition Fund allocates ~€1.63 billion to Western Macedonia, Megalopolis and islands for clean energy, circular economy and skills; the Green Fund co-finances environmental infrastructure; CAP/LEADER supports rural innovation and processing. Regionally (NUTS-2), the thirteen Regional Operational Programmes shape pipelines and co-funding: Central Macedonia ~€1.40 billion, Attica ~€1.20 billion, Crete ~€1.00 billion, Thessaly ~€553.9 million, Western Greece ~€491.0 million, Eastern Macedonia & Thrace ~€639.1 million, Epirus ~€325.8 million, Western Macedonia ~€330.7 million, Peloponnese ~€800 million, Sterea Ellada ~€190.1 million, South Aegean ~€400 million, North Aegean ~€300 million, Ionian Islands ~€250 million. These programmes typically cover SME modernisation, research–industry collaboration, renewable energy and water–waste systems. Practically, this means a biomethane hub in Western Macedonia can blend JTF grant with ROP and Development Law support; an agri-bioplastics demo in Central Macedonia can stack Competitiveness R&D funding with the region's innovation axis; a blue-bio ingredients line on Crete can pair ERDF with CAP processing measures; and island waste-to-energy or nutrient-recovery projects in the Aegean can combine ROP green priorities with the Green Fund.

Social implications are material and two-sided. On the opportunity side, bioeconomy projects can stabilise rural incomes, create skilled jobs in regions with out-migration, and support youth and women entrepreneurs through microcredit, TEPIX and LEADER. Just Transition funding underwrites reskilling from lignite to bio-process operations, maintenance, laboratory QA/QC and digital production. Community-benefit sharing (e.g., fee rebates, farmer premiums, municipal revenue-sharing) and cooperative feedstock contracts strengthen local acceptance, as do transparent odour, traffic and noise mitigation plans for new plants. On the risk side, fragmented farm structures increase transaction costs; skills gaps in automation, fermentation, utilities and EHS can slow start-up; and siting concerns (landscape, water use, transport) trigger delays without early engagement. A systematic approach—regional skills academies, dual vocational programmes with plant internships, standard contracts and price formulas for residues, and citizen panels tied to permitting milestones—keeps projects investable and socially durable.

Table 8 Greece SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large agricultural base (~40% land), diverse residues	No dedicated national bioeconomy strategy; fragmented governance	National Recovery and Resilience Plan (~€36 billion)	Climate stress: droughts,





(olive, vine, cotton, cereals)		catalysing green industry	fires, yield volatility
Strong agri-food culture and SMEs; high rural participation	Small, fragmented farms (avg. <7 ha) hinder scale and logistics	Just Transition Fund (€1.63 billion) for Western Macedonia, Megalopolis, islands	Competition from mature EU bioclusters (Germany, Netherlands, Nordics)
Marine assets: aquaculture, algae, fisheries	Limited biorefineries; few FOAK/demo plants	NECP: higher 2030 RES targets; biomethane (~4.65 TWh) and hydrogen (~20.9 TWh) pathways	Fossil price swings and high energy costs impacting OPEX
Active universities and institutes (CERTH, AUA, NTUA)	Weak tech transfer and pilot-to-market pipeline	NSRF 2021-2027 (€26.2 billion) and "Competitiveness" OP (€3.9 billion)	Policy uncertainty and slow permitting
Abundant agri-industrial side streams (olive mill waste, whey, pruning)	Low automation; batch processing; limited digital twins	Development Law 4887/2022: tax/cash incentives, sector schemes	Social acceptance risks for new plants and waste facilities
Strong circular economy policy base and waste-to-value potential	Logistics gaps: collection, drying, pre-treatment	Regional Operational Programmes across 13 NUTS 2 regions (multi-fund)	Water scarcity and biodiversity constraints on biomass
Growing biomethane/biogas interest; existing gas grid interconnects	Incomplete sustainability metrics/LCA use	CAP/LEADER funding for biomass hubs, precision ag, young farmers	Feedstock seasonality; quality variability
Tourism brand and gastronomy support biobased packaging/ingredients	Limited quality standards for lignocellulosics and organics	Olive/by-product valorisation (biopolymers, bioactives, biofertilisers)	Import dependence for enzymes, equipment,





			specialty inputs
Strong diaspora and start-up scene in cleantech/bio	Skills gaps in process ops, QC, maintenance	Blue bioeconomy: algae, marine collagen, fish side-stream valorisation	Market pull still weak vs. fossil equivalents
Brownfield sites from lignite phase-out for co-location	Data fragmentation; scarce open platforms	Industrial symbiosis in Western/Central Macedonia, Thessaly, Attica	Long paybacks for heavy CAPEX bioplants
Rich biodiversity and endemic crops for high-value extracts	Limited recycling/upcycling of composites and bioplastics	Public procurement for biobased, eco-design, and green construction	Fragmented land tenure complicates biomass contracting
Active municipal networks and local action groups	Slow standardisation/certification of biobased products	Cross-border projects (Balkan, Med) to build export value chains	Brain drain in advanced biotech and digital skills

5.1.9 Hungary

Hungary's bioeconomy sits on strong primary resources and central-European logistics, but commercialization is held back by fragmented policy execution, modest industrial assets, and slow technology transfer. Abundant agricultural residues from wheat, maize and sunflower, plus forestry by-products and emerging lignocellulosic and algal options, could underpin high-value biochemicals, biomaterials, advanced biofuels and circular agro-inputs. The main technical pinch points are supply-chain inefficiencies (collection, drying, densification), limited pre-treatment capacity, batch-heavy operations with high energy use, and uneven automation and in-line quality control. Pilot results often stall because demonstration plants and first-of-a-kind financing are scarce, and academia–industry links remain thin. On the regulatory side, Hungary has many relevant strategies, but coherence is uneven; permitting can be slow; market pull for bio-based products is weak without standards, green procurement or stable offtake. Sustainability risks—soil organic matter loss, water constraints, and waste-management gaps—require robust safeguards, LCAs and nutrient-loop closure. Socially, the opportunity is meaningful rural income diversification,





skills and jobs around pre-processing hubs and biogas/biomethane, but it needs farmer cooperatives, transparent feedstock pricing, community benefits, and targeted reskilling in process operations, maintenance, digital manufacturing and EHS.

Investment capacity exists at national and regional levels but needs sharper targeting to scale assets. National research and innovation are supported by the National Research, Development and Innovation Fund (grants for bio-based R&D and scale-up; typical awards can range roughly €0.3–3 million with 40–70% co-financing, depending on call), and by the Hungarian Scientific Research Fund for foundational work. Commercial deployment can leverage Hungarian Development Bank debt (investment and working-capital loans; tickets commonly from low single-digit to several tens of millions of euros, maturities aligned to industrial CAPEX), blended with project equity. European Regional Development Fund and Cohesion Fund resources flow via regional programmes and can co-finance 50–85% of eligible costs depending on measure and region. Practically, biomass pre-processing and AD/biomethane clusters in Northern Great Plain and Southern Great Plain can combine ERDF grants with MFB loans; wood-based biochemicals or fibre materials in Transdanubia can pair NRDI grants with Cohesion-funded utilities; Budapest–Pest can back biotech process scale-up, pilot lines, and digital/QA infrastructure. As an order of magnitude, a regional biogas-to-biomethane hub or a multi-feedstock pre-treatment line typically closes at €5–20 million CAPEX, while FOAK biopolymer/biochemical demos often require €20–60 million; grant components at 30–60% substantially improve bankability. Across NUTS-2 regions, priorities differ: Northern/North-Eastern regions can emphasise agri-residue logistics, AD and nutrient recovery; Great Plains can develop cooperative feedstock pools and modular biorefineries; Transdanubia can focus on forestry residues and engineered wood by-products; Budapest–Pest can host shared pilot infrastructure, GMP/food-grade processing and analytics. Stitching these into coherent value chains with standardised LCAs, quality specs for digestate/compost, and green procurement (bio-based packaging, recycled nutrients for public landscaping) would create predictable demand and accelerate private investment.

Table 9 Hungary SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, reliable agricultural residue base (wheat, maize, sunflower) and	Few demonstration/first-of-a-kind biorefineries; limited pre-	Regional feedstock hubs for collection, drying, pelletisation; modular anaerobic	Climate variability affecting yields; soil organic matter loss if residues over-removed





forestry by-products	treatment/densification capacity	digestion/biomethane with CO ₂ capture	
Strong agri/biotech research base; established biogas know-how	Batch-heavy, energy-intensive processes; uneven automation and in-line quality control	Lignocellulosic sugars to platform chemicals, fibres, and biopolymers	Competition from low-cost fossil and imported bio-products
Central CEE location and logistics; access to EU markets	Fragmented policy execution; slow, complex permitting	Industrial symbiosis in food/wood/paper parks; heat/water reuse and circular nutrient recovery	Financing gaps for FOAK plants; capex inflation and supply-chain risk
Availability of national R&D instruments and development-bank debt; ERDF/Cohesion eligibility	Weak market pull (limited standards, green procurement, labels); low consumer awareness	Digital twins, soft sensors, real-time analytics to raise yields/OEE	Local opposition if odour/traffic/water impacts not mitigated
Growing SME ecosystem around circular economy	Limited long-term offtake agreements; immature product certification	Green public procurement, guarantees of origin for biomethane, certified digestate/biofertilisers	Policy instability or delayed adoption of EU-aligned standards
Existing industrial parks suitable for shared utilities	Skills gaps in process operations, maintenance, EHS, and data/automation	Blended finance stacks (30–60% grants + concessional loans + equity); cooperative SPVs with farmers	Water constraints for certain processes (e.g., algae, cooling) and tightening environmental limits

5.1.10 Italy

Italy's bioeconomy sits on a strong policy backbone (Next Generation/PNRR, Plan for Ecological Transition, National Smart Specialisation, National Strategy for the Circular Economy) and a powerful agri-food, forestry, chemicals and machinery base, but it is constrained by SME fragmentation, high energy/process costs, uneven digital uptake and a



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shortage of pilot/demonstration assets that slows scale-up. Technically, process efficiency can improve via heat-integration, electrification of unit ops, advanced enzymes/biocatalysis and multi-product cascading; many plants remain batch-heavy with sub-optimal yields and high utilities intensity. Scalability is hampered by CAPEX risk, limited FOAK facilities and supply-chain dispersion; modular biorefining, shared utilities in eco-industrial parks, and consortia with farmer co-ops can de-risk. Product development and differentiation require adapting to variable feedstock (seasonality, moisture, lignin/protein content) and tightening specs; stronger TRL6-8 pilots and standardized QA, certification and ecolabels would accelerate market entry. Process innovation is slowed by the paucity of demo sites and SME reluctance to adopt automation; targeted brownfield retrofits (inline analytics, APC/soft sensors, digital twins) and vendor OPEX models can lift OEE quickly. Digital transformation still lags in SMEs despite PNRR incentives; priorities are MES/LIMS rollout, end-to-end traceability, predictive maintenance and farm-to-plant IoT for quality and logistics. Circularity and waste management are a national focus, yet infrastructure gaps persist (organics treatment, hazardous/complex fractions, regional disparities); higher capture of organics, biochar/biogas/compost valorisation, nutrient recovery and design-for-recycling in biopolymers are near-term wins. Environmental performance can advance through renewable electrification, water reuse, solvent swapping, low-temperature separations and robust LCAs; consistent monitoring and scale-appropriate BAT guidance will help SMEs. The regulatory environment is broadly supportive but administratively complex; streamlining permits for waste-to-resource projects, harmonising end-of-waste criteria and fast-tracking demo plants would improve execution. Socially, acceptance is high when projects show local value—jobs in rural areas, odour/traffic controls, fair feedstock pricing, and tangible co-benefits (soil health via digestate/biochar); skills gaps remain in operations, EHS and data/automation, calling for regional training academies tied to clusters.

Investment needs are material and layered. At national level, instruments include Development Contracts–Net Zero (typical project sizes $\geq$ €20m; blended packages combining subsidised loans, grants and equipment subsidies), Green New Deal R&D (eligible €3–40m; ~60% soft loans + up to 15% grants for R&D and 10% for equipment), Circular Economy R&D (€0.5–2m; ~50% soft loans + 10–20% grants), Industrial Transition Fund (€3–20m; non-repayable contributions prioritising decarbonisation), STEP schemes in less-developed regions (subsidised financing ~50% plus grants up to 35–60% depending on entity/size), and the venture-backed Green Transition Fund (~€250m). For illustration, a 50–80 kt/y biopolymer or advanced fertiliser FOAK would typically require €60–120m CAPEX; a 100–150 kt/y industrial organics biogas/biomethane hub with CO₂ valorisation €35–70m; modular lignocellulosic sugar platform pilot-to-demo €8–25m. Regionally (NUTS-2), ERDF/ESF+ Programmes across all 21 regions finance innovation, pilot lines, energy





efficiency and circularity—often with 30–60% grant rates for SMEs—and several regions explicitly prioritise STEP-related deep tech/biotech and clean tech. Southern regions (Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia) additionally earmark ≥40% of national instruments’ envelopes and run Interreg cross-border calls that can co-fund transnational pilots. Practically, projects should stack: regional ERDF (30–50%) + national soft loan/grant (e.g., Green New Deal 60% loan + 10–15% grant) + sponsor equity, aiming for public leverage of ~1.5–2.5× on private capital. SMEs can start with €0.5–2m Circular Economy R&D, then step to €3–10m demo with Green New Deal, and finally to €20m+ with Development Contracts–Net Zero or supply-chain Development Contracts; cluster-level shared utilities (steam, wastewater, labs) reduce per-project CAPEX by 10–20%.

Table 10 Italy SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, diverse agri-food and forestry base; strong chemicals/materials know-how	Fragmented SME landscape; scarce pilot/demo plants; slow permitting	Scale shared-infrastructure bioclusters and eco-industrial parks with common utilities	Input price/energy volatility and capex inflation squeezing FOAK economics
Robust policy stack (PNRR, circular economy, S3); broad funding mix (grants, soft loans, VC)	High energy and utilities intensity; batch-heavy processes; variable yields	Modular biorefineries, cascading valorisation, carbon-smart products (biochar, CO ₂ use)	Feedstock competition and seasonal variability; logistics costs for dispersed residues
Strong equipment/machinery and automation vendors; applied R&D capacity	Patchy digital adoption in SMEs; skills gaps in data/APC/EHS	Digital twins, inline analytics, traceability boosting OEE, quality and market access	Regulatory complexity and uneven end-of-waste implementation across regions
Established markets and brands for premium	Limited long-term offtakes, certification and	Green public procurement, ecolabels and	Public opposition if odour/traffic/water impacts not





bio-based foods/materials	standardisation for new bioproducts	certification to unlock demand	mitigated at site level
Multiple regional ERDF Programmes and Interreg channels; STEP focus in South	Regional disparities in waste/organics treatment and recycling infrastructure	Blended finance stacks (30–60% support) to de-risk FOAK and crowd-in private capital	Water stress and tightening environmental limits affecting siting and operations

5.1.11 Latvia

Latvia's bioeconomy is anchored in abundant forests (~50% land) and a solid agri-base (~30%), with a fast-maturing biorefinery and startup scene. Policy direction is clear (LIBRA 2030; carbon-neutrality by 2050) and recent measures (Biorefinery MoU, circular economy plan) push biomass valorisation, biomethane, and export growth (bioeconomy exports ~€7.9bn in 2023). Industrial cooperation is strengthening (LIAK), and there are tangible process-innovation outcomes (high-yield wood bioproducts, bio-polyols, algae-based wastewater systems, biomass trading platform).

Latvia's bioeconomy operates under LIBRA 2030 and the 2050 Carbon-Neutrality Strategy, with 2030 –65% GHG targets. ERDF 2021–27 (Ministry of Interior) and **REPowerEU/RRF** drive digitisation, circularity, and **biomethane** (grid access, guarantees of origin, self-consumption). **RED II/III** sustainability rules are transposed for bioenergy; waste law tightens via EPR schemes, rising landfill taxes, organics collection, and Single-Use Plastics curbs; forestry follows sustainable management and road-access plans. **CAP** supports on-farm investments and nutrient recovery; **Green Public Procurement** is expanding to pull bio-based products. Key gaps: slow FOAK permitting, unclear **end-of-waste/by-product** status, uneven GPP uptake, and grid interconnection/off-take certainty for biomethane.

Key constraints are SME capital scarcity, dependence on EU funds, fragmented farm structure, forest road deficits, uneven digital skills/connectivity, and gaps in waste/circular infrastructure. Execution bottlenecks (permitting, end-of-waste clarity, long-term offtakes) slow scale-up from lab/pilot to FOAK/demo. Near-term gains come from efficiency retrofits, modular biorefineries, nutrient/CO₂ recovery, organics capture, and end-to-end digital traceability. De-risking finance (stacking ERDF/RRF/Interreg with VC/mezzanine), public procurement for bio-based products, and targeted skills programs will accelerate commercialization while meeting climate and competitiveness goals.





Table 11 Latvia SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, renewable biomass base (forestry, agriculture)	High reliance on EU funds; limited domestic risk capital for FOAK/demo	Modular biorefineries; cascading use (lignocellulose → chemicals, materials, energy)	Feedstock competition/price volatility; climate & pest risks in forests
Growing biorefinery ecosystem; proven pilots (wood biomaterials, biopolyols, algae wastewater)	Fragmented farming; logistics inefficiencies; forest road shortfall	Biomethane scale-up; nutrient recovery, biochar, CO ₂ valorisation	Regulatory/permitting delays; end-of-waste uncertainty
Strong startup culture; VC/mezz/mechanisms available; supportive schemes	Skills gaps in digital/ICT; sub-EU digital skill levels; 5G/gigabit gaps	Digitalisation of mills/plants (APC, inline analytics, traceability); biomass marketplaces	Public acceptance risks (siting, odour/traffic); NIMBY
Clear strategies (LIBRA 2030; carbon-neutrality); export momentum	Waste/circular infrastructure uneven; organics capture below potential	Green public procurement; certification/labels to pull demand	External energy shocks; capex inflation; small market size
Cross-industry coordination via LIAK	Limited long-term offtakes; SME balance-sheet constraints	Interreg/ERDF/RRF stacking to de-risk scale-up; regional clusters	Talent scarcity in process, EHS, and automation

5.1.12 Lithuania



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Lithuania has strong biomass fundamentals (agriculture, forestry) and clear policy scaffolding—NECP 2021–2030, CAP Strategic Plan, Smart Specialisation 2021–2027, the Circular Economy Roadmap to 2035, and sectoral rules on water, forests, waste, chemicals, and ag-biotech—while a **new National Bioeconomy Strategy** is in consultation. Yet high production costs, limited domestic processing/biorefinery capacity, modest market pull, and a thin tech-transfer pipeline keep value creation low and exports raw-material-heavy. To unlock growth, Lithuania should prioritise first-of-a-kind and demo biorefineries, targeted tax/loan incentives, stable offtake (e.g., green public procurement, advanced biofuels quotas), and stronger university–industry consortia and clusters. Regionally, tighter Baltic supply-chain integration (feedstock pooling, shared labs, biomethane corridors) can lift scale and competitiveness, while strict environmental safeguards keep expansion aligned with circularity and biodiversity goals.

Table 12 Lithuania SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, reliable agri & forestry feedstock base	High production/energy costs for bio-based processing	New National Bioeconomy Strategy to align instruments & funding	Competition from Western EU bioindustries with larger scale
Established NECP, CAP Plan, Circular Economy Roadmap	Limited biorefinery/demo infrastructure	EU funds for FOAK/demo (RRF/ERDF), green state aid flex	Policy/funding volatility; reliance on EU instruments
Strong life sciences/biotech footprint (smart specialisation)	Fragmented tech transfer; weak academia–industry links	Green Public Procurement to create market pull for bio-based	Tightening sustainability criteria raising compliance costs
Solid forestry management & certification base	Underdeveloped product differentiation/branding	Biomethane/advanced biofuels in transport; waste-to-value	Feedstock price swings; cross-border biomass competition





Good logistics to Nordics/Baltics/EU markets	Small domestic market; low demand for premium bio-products	Baltic clustering for shared pilots, testing, and scale	Brain drain; talent gaps in bioprocess/digital skills
Clear environmental acquis (water, waste, chemicals)	Capital scarcity for scale-up; risk-averse finance	Digitalisation of mills/farms; precision & LCA-driven design	Public acceptance/permitting risks for new plants
Growing startup support via Innovation Agency calls	Limited downstream processing capacity; export of raw biomass	Agro-waste valorisation (lignocellulose, manure, sludge)	Supply-chain disruptions; energy price volatility
Forestry & ag residues with circular potential	Gaps in stable offtake (PPAs, GO schemes, GPP uptake)	Cross-border corridors (biomethane, green corridors)	Climate & biodiversity constraints on biomass availability

5.1.13 Malta

Malta's bioeconomy is nascent but strategically aligned with the island's circular-economy, biodiversity, and climate agendas. Policy direction is clear: the National Energy and Climate Plan (2019, updated 2025) prioritises renewable deployment and efficiency while integrating sustainable biowaste pathways; the Long-Term Waste Management Plan 2021–2030 and the 2023 Waste Framework Regulations modernise collection, harmonise practice, and build treatment capacity; and the 2024 National Biodiversity Strategy embeds nature protection across land and sea uses. The Common Agricultural Policy Strategic Plan steers investment toward sustainable farming and resource efficiency, complemented by sectoral statutes on fisheries, trees and woodlands, and environmental protection. Within this framework, Malta's primary constraints are structural—limited land, high urbanisation, reliance on imports, and small firm size—which suppress economies of scale, slow digital adoption, and fragment R&D effort. Yet these same constraints create a clear opportunity space for compact, modular, digitally enabled bioprocessing focused on high-value niches such as organics valorisation, marine and algal products, precision aquaculture, and bio-based materials that dovetail with waste reduction and energy diversification.

Financing is shaped for lab-to-pilot progression and cross-border collaboration rather than heavy capex builds. PRIMA Section 2 awards up to €500,000 per project for water–



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farming–agro-food R&I, M-ERA.NET 2025 offers up to €300,000 per Malta participant for circular and energy-relevant materials, and national instruments such as the Technology Development Programme LITE (up to €200,000), Access2 Partnerships (up to €100,000), and Xjenza Malta–TÜBİTAK (up to €100,000) underwrite prototyping and international teaming, with micro-seed from Xjenza Malta–CNR (up to €12,000) to catalyse consortia. In practical terms, a Malta-led pilot can combine €300,000–€500,000 from PRIMA or M-ERA.NET with €100,000–€200,000 from A2P or TDP-LITE to fund TRL 4–7 work, digital instrumentation, regulatory readiness, and LCA. Over a 12–24 month horizon, this mix can realistically support three to five pilots at €100,000–€300,000 each, two digital traceability or LCA implementations covering at least a quarter of targeted organic streams, and at least one transnational award channeling €300,000 or more to Malta-based work packages. The policy scaffolding, waste-system upgrades, and right-sized funding tickets position Malta to de-risk modular bio-based solutions, reduce import dependence in selected value chains, and convert urban organic residues into energy and bioproducts, provided skills development, data systems, and SME-oriented incentives continue to deepen.

Table 13 Malta SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Clear policy scaffolding (NECP, NBSAP, Waste Plan/Regulations, CAP)	Very limited land/biomass; economies of scale hard to reach	Niche, small-footprint biorefineries (food waste, organics, algae)	Import dependence, global price shocks
Existing infrastructure steps (ECOHIVE, BCRS)	Fragmented ecosystem; weak institutionalised knowledge transfer	Green Public Procurement to create demand for bio-based goods	Tight sustainability/compliance raising costs for SMEs
Strong EU alignment; access to EU programmes	Skills & digital gaps in SMEs; slow uptake of automation/IoT	Cross-border valorisation chains with Med/EU partners	Space/permits constraints for new plants
High tourism/services—steady organic waste streams	Limited R&D capacity and demo/pilot sites	Funding windows: Xjenza Malta, PRIMA, A2P, TDP-Lite, M-ERA.NET	Climate/water stress; biodiversity pressure





Compact geography enables fast policy roll-out	Missing robust CE/bioeconomy indicator framework	Aquaculture & marine biotech; high-value specialty products	Public acceptance risks for new facilities
Strong regulatory base in primary sectors (fisheries, trees, environment)	Market pull for bio-products still weak	Digital waste-tracking, LCA-based standards, circular labelling	Competition from larger EU producers

5.1.14 Poland

Poland's bioeconomy sits at a crossroads: sizeable biomass resources, strong industrial capabilities and an expanding policy toolkit collide with structural barriers that still mute scale and speed. The country lacks a formal, dedicated national bioeconomy strategy and has not pledged economy-wide carbon neutrality, yet it has embedded circularity and decarbonisation themes within broader frameworks such as the 2019 Circular Economy Roadmap, the Strategy for Responsible Development and energy strategies extending to 2040. On the ground, progress is uneven. Productivity in agriculture is low, innovation diffusion is slow, and linkages across primary producers, processors, logistics and services remain weak. Fragmented value chains and under-industrialised research outputs drive high unit costs—especially for energy and feedstock—while the absence of large demonstration assets constrains technology validation and investor confidence. Addressing these issues requires a double track: clear, stable rules and incentives that lower early-stage risk, paired with targeted technology transfer into low-energy pre-treatment and conversion routes matched to Poland's most competitive feedstocks. A national bioeconomy strategy, empowered cluster organisations, and a pipeline of proof-





of-concept, demo and first-of-a-kind plants would tighten research–industry hand-offs, crowd in private capital and speed market entry. At the same time, Poland must defend share against better-capitalised neighbours by focusing on cost-effective, replicable pathways—biogas and biomethane from agri-residues and MSW organics, advanced bio-materials from forestry and food by-products, and bio-inputs for food and aquaculture—where domestic feedstock, logistics and market access align.

The financing landscape is deep and multi-layered, with national envelopes for green transition complemented by substantial NUTS-2 regional programmes. At the centre sits the National Recovery and Resilience Plan (KPO), a PLN 268 billion package of 57 investments and 54 reforms that channels grants, loans and financial instruments into resilience, green energy and digitalisation—an umbrella under which circular economy plants, industrial symbiosis, waste-to-biogas and biomethane, and enabling digital infrastructure can be banked. The European Funds for a Modern Economy 2021–2027 add competitive calls across four pillars—entrepreneur support, an innovation-friendly environment, “greening of enterprises” and technical assistance—blending co-financing with guarantees and green credit lines suitable for R&D, piloting and industrialisation of bio-based processes. For capital-intensive decarbonisation, the EU Modernisation Fund—operated nationally by the National Fund for Environmental Protection and Water Management—finances priority programmes spanning renewable generation (including renewable hydrogen), energy efficiency in industry and buildings, storage and grids, and zero-emission mobility; awards mix non-repayable and repayable support, allowing project stacks that combine grants with concessional debt. The FENIKS programme (European Funds for Infrastructure, Climate, Environment 2021–2027) layers in grants and financial instruments for circular economy infrastructure, waste and wastewater upgrades, and logistics that directly de-risk bioeconomy feedstock and product flows. Sectoral strategic programmes managed by NCBR—New Energy Technologies (TRL 8–9), BIOSTRATEG for environment–agriculture–forestry, TECHMATSTRATEG for modern materials, and mission-oriented initiatives like NEON (decarbonised refining, biomass processing, circularity) and NUTRITECH (sustainable, health-oriented food systems with circular practices)—provide sizable R&D tickets, typically from PLN 1–10 million per project in NUTRITECH and higher in technology programmes, to push pipelines from lab to pre-commercial pilots. Together, these sources can fund a full TRL ladder: early validation via BIOSTRATEG or TECHMATSTRATEG, pilot and demo under European Funds for a Modern Economy or NCBR strategic calls, and commercial scale with FENIKS and Modernisation Fund, topped up by KPO windows.





At NUTS-2 level, regional programmes are both numerous and material for bioeconomy deployment. Silesia commands the largest allocation among EU regional programmes and, alongside its Just Transition Fund envelope, targets research infrastructure, biodiversity, renewable energy and remediation of post-industrial sites—ideal conditions for siting circular plants and bio-based manufacturing while addressing legacy coal assets. Wielkopolska couples climate-neutral advisory systems with renewable uptake and a designated Just Transition plan for the Konin subregion, explicitly supporting companies withdrawing from traditional industries; its scope includes circular production and resource-efficient logistics, and infrastructure for charging and refuelling zero-emission fleets that serve bio-feedstock movements. Łódzkie integrates Greener Europe priorities with Just Transition support around the Bełchatów complex, opening a path for waste-to-bioenergy, biomethane injection and bio-based materials to anchor replacement value chains. Eastern Poland's dedicated programme accelerates less-developed regions—Lublin, Podlaskie, Podkarpackie, Świętokrzyskie and Warmińsko-Mazurskie—through SME innovation, clean energy, waste management and transport connectivity, which together reduce feedstock frictions and expand regional market access. Within individual voivodeships, additional detail matters for pipeline building: Lublin earmarks over €1.0 billion equivalent across research and innovation, environment and climate, energy efficiency and mobility, with named lines for circular economy and municipal waste; Kujawsko-Pomorskie reserves about €440 million for clean energy and environmental protection and a further €233 million for innovation and SME competitiveness, including support for waste management and circularity in SMEs; Lubuskie, Małopolskie, Pomorskie and Pomorze Zachodnie each blend grants and financial instruments for RES, energy efficiency and circular economy actions; Podlaskie explicitly finances technology transfer and green transition modules with mixed grant–debt packages to scale start-ups; and Opolskie, Warmia-Mazury and Świętokrzyskie invest in biodiversity, water and climate adaptation while backing digitisation and SME R&D. These regional envelopes typically cover 50–85% of eligible costs depending on location and measure, enabling realistic capital stacks where a mid-sized biogas-to-biomethane upgrade or an organics biorefinery can combine, for example, a 40–60% NUTS-2 grant with Modernisation Fund debt and an innovation grant for process optimisation, while KPO or European Funds for a Modern Economy finance digital traceability, LCA and market development.

In practical terms, Poland can convert this architecture into bankable bioeconomy outcomes by prioritising three steps. First, codify a national bioeconomy strategy that aligns permitting, sustainability criteria and incentives with EU taxonomy and state-aid rules, giving investors visibility and compressing time-to-FID for pilots and first-of-a-kind plants. Second, stand up a coordinated demonstration network in coal-transition and





Eastern regions—Silesia, Konin, Bełchatów, Lublin, Podlaskie—so that TRL 6–8 assets have local feedstock, off-take and skills, while using regional funds to bridge capex gaps to 50–70% coverage. Third, empower cluster organisations to broker cross-sector value chains, standardise feedstock specs, and package projects that match regional calls and national windows, ensuring that publicly funded R&D is industrialised quickly. If Poland executes on these levers with disciplined cost focus on domestically advantaged feedstocks, it can close the innovation–industrialisation gap, build competitive bio-based value chains in priority NUTS-2 regions, and capture a meaningful share of EU green growth without sacrificing affordability or speed.

Table 14 Poland SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, diverse biomass base (agri-residues, forestry, OFMSW).	No dedicated national bioeconomy strategy; no carbon-neutrality pledge.	Scale biogas/biomethane from agri-residues & OFMSW; grid injection and transport use.	Faster-moving neighbour ecosystems capturing capital and markets.
Strong industrial capabilities and logistics footprint.	Low agricultural productivity; weak farm-industry-services linkages.	First-of-a-kind biorefineries; advanced biomaterials from forestry/food by-products.	Coal reliance slows transition; risk of missing EU targets and higher compliance costs.
Broad policy scaffolding (Circular Economy Roadmap, energy strategies).	Slow innovation diffusion; few demo/FOAK plants.	Stackable funding (regional grants + Modernisation Fund +	Feedstock price/availability volatility; competing





		innovation grants) to de-risk CAPEX.	biomass uses.
Deep multi-layer finance: KPO (PLN 268bn), Modernisation Fund (NFOŚiGW), FEnIKS, EF for a Modern Economy, NCBR (BIOSTRATEG/TECHMATSTRATEG/NEO N/NUTRITECH).	High unit costs for energy/feed stock; fragmented value chains; elevated investor risk perception.	Just Transition in Silesia & Konin to repurpose sites, workforce and grids for bio-industry.	Permitting delays; social acceptance issues near new facilities.
Strong NUTS-2 programmes with 50–85% co-financing (e.g., Silesia JTF, Wielkopolska/Konin, Łódzkie/Bełchatów, Eastern Poland).	Permitting/policy uncertainty; uneven regional execution capacity.	Digital traceability/LCA and industrial symbiosis backed by EU/NCBR calls.	Macroeconomic and power-price shocks undermining project bankability.
Growing export channels and cluster potential.	Under-industrialised research outputs; weak tech-transfer pathways.	Cross-border value chains (Interreg, Eastern Poland, Baltic) and public-procurement pull.	Sustainability constraints on biomass sourcing; stricter ESG and taxonomy alignment risk.

5.1.15 Portugal

Portugal remains a Moderate Innovator, performing at roughly 83.5% of the EU average. Total R&D outlays have risen to about 1.70% of GDP in 2023, still below the EU's ~2.22% benchmark, and this under-investment shows up in weak technology transfer, limited patenting (PCT filings per capita ~55% of the EU level), modest high-tech export intensity (medium/high-tech goods ~59% of the EU average; knowledge-intensive services ~38%), and scarce risk capital (VC ~51% of the EU norm). These structural headwinds are most



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visible in the bioeconomy scale-up chain, where Portugal's shortage of open-access pilot and demonstration capacity widens the "valley of death" between lab results and market deployment. The policy scaffolding is strong and getting sharper—carbon-neutrality is now targeted for 2045 under the Basic Climate Law, with the Integrated National Energy and Climate Plan aiming for a 55% GHG cut by 2030 and a 51% renewables share in final energy (including ~93% renewable electricity). The 2020 Blue Bioeconomy Roadmap and the Sustainable Bioeconomy Action Plan – Horizon 2025 layer sectoral priorities on top of this trajectory, while a growing network of interface institutions (35 CoLABs, e.g., B2E) and industry-backed research centres (e.g., RAIZ, with 12 PCTs in 2024 and a €14.6 million forest-bioeconomy R&D programme) demonstrate the upside when finance, talent, and industry pull align.

Financially, Portugal's bioeconomy can tap a blended stack of tax incentives, grants, and regionally allocated EU funds. At national level, SIFIDE allows corporate tax deductions up to 82.5% of eligible R&D spend, creating predictable, scale-agnostic relief that is well-suited to multi-year RD&I pipelines. Grant finance under COMPETE/Portugal 2030 includes SITCE—open 01/03/2025–30/07/2025—covering energy-efficiency, decarbonisation and green-innovation CAPEX with non-refundable support of up to 100%, directly de-risking first-of-a-kind retrofits and clean-process integration. SICE Productive Innovation runs two complementary lines to back industrial scale-up and 4.0 transitions: the Low-Density Territories window (Alentejo, Centro, Algarve, Norte) and the Other Territories window (nationwide excluding the low-density carve-out), both open 01/04/2025–30/04/2026 with non-refundable co-financing; exemplar projects like WoodShape 4.0 indicate readiness for advanced manufacturing themes that overlap with bio-based materials. Critically for NUTS-2 execution, the seven regional operational programmes—NORTE 2030, CENTRO 2030, LISBOA 2030, ALENTEJO 2030, ALGARVE 2030, plus the autonomous regions AÇORES 2030 and MADEIRA 2030—channel PT2030 envelopes into place-based priorities such as smart specialisation, business innovation, decarbonisation and capacity building. Although regionally tailored, these are nationally consistent and can be layered with SIFIDE, SITCE and SICE to build bankable finance stacks, especially in Norte and Centro's industrial belts, Alentejo's low-density bio-resource plays, Algarve's blue-economy niches, and the islands' circular resource and waste-to-value schemes. The combination of tax relief, 100% grants for decarbonisation pivots, co-financed productive innovation, and territorially focused NUTS-2 programmes gives Portugal a workable capital pathway to address its two binding constraints—TRL scale-up and private-sector RD&I intensity—provided calls continue to fund pilot/demo assets and proof-of-concepts that bring university outputs to investable TRLs.





Table 15 Portugal SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Clear decarbonisation pathway (2045) with ambitious 2030 energy targets; coherent blue and sustainable bioeconomy roadmaps.	R&D intensity ~1.70% of GDP and weak private RD&I; VC ~51% of EU; patenting and high-tech exports below EU averages.	Stackable finance: SIFIDE (up to 82.5% R&D deduction), SITCE (up to 100% grants), SICE co-financing, plus NUTS-2 PT2030 programmes (Norte, Centro, Lisboa, Alentejo, Algarve, Açores, Madeira).	Fragmented R&I governance and limited pilot/demo infrastructure risk prolonging the “valley of death.”
Growing interface capacity (35 CoLABs; RAIZ with 12 PCTs in 2024 and €14.6 m programme) linking firms and academia.	Limited open-access pilot and demonstration plants; slow industrial uptake and tech transfer bottlenecks.	Blue bioeconomy leadership and forest-based value chains; regional smart-specialisation to cluster FOAK bioprocesses.	Wildfire risk undermining forest sinks and bio-feedstock reliability; macro uncertainty and energy-price volatility.
Strong policy alignment and improving GHG performance (-43.9% since 2005).	Innovation concentrated in public institutes; SME skills gaps; risk-averse culture slows collaborations.	Combine regional OPs with national incentives to finance TRL 6–8 pilots, LCA/traceability digitalisation, and circular biowaste valorisation.	Competition for capital and talent from higher-intensity EU ecosystems; tightening sustainability criteria for biomass.

5.1.16 Romania

Romania has committed to carbon neutrality by 2050, with an interim ambition of a 78% emissions reduction by 2030, and has embedded circularity objectives across fourteen



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priority sectors through its national circular economy strategy. Building on these pillars, the country's bioeconomy opportunity sits at the intersection of extensive agricultural and forestry resources, established bioenergy assets, and regionally tailored smart-specialisation agendas. Yet structural barriers persist: highly fragmented, smallholder agriculture limits feedstock aggregation and market integration; ageing rural demographics and weak producer cooperation reduce supply-chain efficiency; and gaps in pilot, demonstration and industrial-scale processing capacity hinder large-scale investments and slow innovation uptake. Unlocking potential therefore hinges on coordinated investments in advanced biorefineries and logistics, stronger industry–academia interfaces, and targeted incentives that de-risk first-of-a-kind projects.

Financially, Romania can assemble robust, blended capital stacks that combine EU, national and guarantee instruments. At national level, the forthcoming State Aid Scheme for Advanced Biofuels dedicates €500 million to new domestic capacity, offering direct grants up to 45% of eligible investment, capped at €45 million per bioethanol plant and €91.25 million per SAF/HVO plant, a scale suitable to crowd in private co-investment for flagship assets. The IMM Invest programme complements capex grants with bankability support: state guarantees can cover up to 90% of loan principal, interest subsidies can reduce rates to 0% for an introductory period, and certain sub-programmes (e.g., AGRO IMM INVEST) add a non-reimbursable component up to 10% of the loan amount, easing early cash-flow constraints for SMEs in agri-food and rural bio-based ventures. Research and testing capacity is strengthened through METROFOOD-RO, which channels non-repayable ERDF and national grants into food quality, safety and traceability infrastructure, and through broader NextGenerationEU windows supporting green and digital transitions. Sectoral investment continues via AFIR's EAFRD-backed measures for processing, livestock, irrigation and generational renewal, while the EU Innovation Fund offers competitive grants for low-carbon technologies relevant to advanced biofuels, hydrogen and process electrification. For transnational collaboration and technology diffusion, Interreg Danube provides grant rates up to 92% (with the ERDF contribution capped at 80% of total costs), facilitating cross-border pilots in areas such as plastics reduction, renewable systems and micro-pollutant management.

Regional financing at NUTS-2 level is material and increasingly aligned with bioeconomy priorities. The North-West Regional Programme 2021–2027 totals about €1.437 billion, of which €1.194 billion is EU funding and €242.67 million is national co-financing, and it targets innovation, sustainable mobility and education—key enablers for bio-based scale-up and skills. Within the same NUTS-2 region, the AgroTransilvania Cluster mobilises Horizon-linked calls and cluster grants to upgrade agri-food processing and short supply





chains, while providing access to research infrastructure and international partnerships. Just Transition Fund envelopes in Sud-Vest Oltenia, Centru and Sud-Muntenia prioritise clean technologies and new industrial models that can host advanced bioprocessing, with complementary innovation ecosystem and SME instruments active in Nord-Est and Nord-Vest. These NUTS-2 programmes can be layered with national schemes—pairing, for example, JTF or regional ERDF co-financing with the advanced biofuels state-aid grant and an IMM Invest guarantee—to create bankable, milestone-based structures from TRL 6–8 pilots to commercial deployment. Together, this multi-tiered mix of grants, guarantees and regional co-financing directly addresses Romania’s key bottlenecks by lowering weighted average cost of capital, underwriting first-plant risk, and funding the logistics, testing and skills infrastructure that feed reliable bio-based value chains.

Strategically, the policy and finance architecture now in place enables a pragmatic roadmap: use Interreg and regional smart-specialisation to seed proofs of concept in priority NUTS-2 regions; channel METROFOOD-RO and Innovation Fund support into standards, LCA and low-carbon process integration; deploy the €500 million advanced biofuels scheme to anchor first-of-a-kind biorefineries; and scale SMEs through IMM Invest guarantees and EAFRD productivity upgrades. If accompanied by producer-group formation, targeted feedstock aggregation, and streamlined permitting, Romania can convert its dispersed biomass base into bankable industrial projects, advancing both national growth and EU bioeconomy goals.

Table 16 Romania SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Extensive agricultural & forestry resource base; established local bioenergy assets	Highly fragmented smallholder farming; weak producer cooperation and aggregation	Build advanced biorefineries (bioethanol, SAF/HVO, biomethane) and upgrading hubs	Competitive pressure from faster-moving EU neighbours and global players
Clear policy pillars: carbon neutrality 2050	Limited pilot/demo and scale-up	Blendable funding: €500m Advanced Biofuels state-aid	Biomass price/availability volatility; sustainability





target; national circular economy strategy	infrastructure; “valley of death” from TRL 6–8	(≤45% capex), IMM Invest guarantees (≤90% loan cover, interest relief), EAFRD/AFIR, Innovation Fund, Interreg Danube	constraints and stricter LULUCF rules
Strong regional levers: NUTS-2 programmes (e.g., North-West €1.437bn total incl. €1.194bn EU + €242.67m national); JTF envelopes in Sud-Vest Oltenia, Centru, Sud-Muntenia	Logistics inefficiencies for feedstock collection; rural infrastructure gaps	Regional smart specialisation + clusters (e.g., AgroTransilvania) to aggregate feedstock, professionalise value chains, and attract FDI	Policy or permitting delays; administrative burden slowing project pipelines
Growing R&I assets: METROFOOD-RO, university labs, cross-border networks	Limited industry uptake of R&D; tech transfer and skills gaps in bioprocessing	Waste and residue valorisation (agri, forestry, OFMSW); precision ag and digital traceability to raise yields and bankability	Climate risks (drought, fires, pests) affecting feedstock reliability and insurance terms
Ability to stack finance across national, EU and regional instruments	Ageing farming demographics; out-migration from rural areas	Market pull from EU decarbonisation (RED III, ReFuelEU, green public procurement)	Market risks for novel bio-products (price parity vs fossil, offtake uncertainty, changing EU taxonomy/standards)

5.1.17 Slovakia



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Slovakia's bioeconomy potential is strong—rooted in abundant agricultural and forest feedstocks and anchored by climate-neutrality and circular-economy commitments—but commercial uptake is throttled by low-TRL technologies, scarce pilot/demo capacity, heterogeneous feedstock logistics, weak product differentiation, and interoperability gaps with legacy farm/forestry equipment. Policy direction is established through the Low-Carbon Strategy (to 2050), Vision & Strategy 2030, the National Forestry Programme (2025) and the CAP Strategic Plan (2023–2027), yet actionable scaling levers and regulatory enablers—such as cooperative use of manures/slurries across holdings—remain underdeveloped, limiting economies of scale and slowing market entry for higher-value biochemicals, materials and biofertilisers.

The near-term unlock is financial. Programme Slovakia 2021–2027 consolidates EU and national cohesion funding under “Greener” and “Smarter” priorities, opening continuous calls that can co-finance R&D, demonstration, renewable heat/power integration, energy-efficiency retrofits and sustainable urban mobility; award levels vary by call but typically blend grants with required applicant co-financing. The Environmental Fund adds year-round grant windows for air/water protection, waste and circularity, environmental R&D, rural green infrastructure and education, plus a loan line for water, waste and efficiency—useful for CAPEX where grant intensity is lower. Its Modernisation Fund window channels EU ETS proceeds to RES generation, district heating decarbonisation and public-building efficiency, enabling large-ticket bioenergy interconnections or process heat replacements in mills and food plants. CAP instruments provide direct payments and project calls for short supply chains, irrigation and water-retention, climate adaptation/mitigation and AKIS/EIP-AGRI operational groups—well suited to farmer-led pilots, cooperative preprocessing hubs and on-farm digestate upgrading. The Recovery and Resilience Plan, reinforced by REPowerEU, layers green-economy, R&D/innovation, education and digitalisation investments that can finance first-of-a-kind bioprocess equipment, grid connections and skills, while the Just Transition Fund targets three coal-affected NUTS2 territories—Nitra (SK023), Banská Bystrica (SK032) and Košice (SK042)—with grant finance for clean-tech reindustrialisation, SMEs and workforce up/re-skilling, a natural fit for wood-residue valorisation, modular AD and low-carbon construction materials. Integrated Territorial Development then channels ERDF to all eight NUTS3 regions via territorial strategies, supporting cross-sector projects such as biowaste collection and separation, flood/retention measures and cross-regional innovation partnerships that de-risk feedstock aggregation and preprocessing near source.

Cross-border programmes are a second pillar of capital. Interreg Danube and Central Europe fund transnational pilots and policy uptake across innovation and green priorities,





typically covering up to 80% of ERDF-eligible costs (with some schemes allowing total public support up to ~92% depending on beneficiary type). At the borders, SK–AT (Bratislava SK010, Trnava SK021) and SK–CZ (Trnava SK021, Trenčín SK022, Žilina SK031) favour smart/green cooperation and education; PL–SK (Žilina SK031, Prešov SK041) prioritises nature-friendly infrastructure; HU–SK (SK010, SK021, SK023, SK032, SK042) funds “Green cooperations”; and the NEXT HU–SK–RO–UA window (Prešov SK041, Košice SK042) dedicates €83 million to resilient and green border projects—ideal for shared biomass logistics, traceability pilots and harmonised quality specs. Taken together, these instruments can be sequenced: early TRL pilots via Interreg or CAP EIP-AGRI; scale-up/demonstration via Programme Slovakia and RRP; grid/heat integration via the Modernisation Fund; territorial deployment via Integrated Territorial Development; and industrial conversion and re-skilling via the JTF in the three priority NUTS2 regions.

Financially, the path to bankability hinges on blending and staging. A typical sequence for a €8–10 million demo plant can use a 60–80% grant share across Interreg/Programme Slovakia/JTF depending on location and call, with the residual covered by Environmental Fund loans or commercial debt; operating-expenditure support can be partially offset by CAP results-based schemes and municipal gate-fees for biowaste. Where ERDF grant rates cap below project needs, stacking with national Environmental Fund grants is possible if state-aid ceilings and cost-allocation rules are respected, while Modernisation Fund tranches can underwrite large energy-system components (e.g., biomass boilers, heat networks) that sit alongside the core biorefinery. For farmer- and SME-led consortia, CAP measures and EIP-AGRI operational groups reduce match-funding pressure and create paid collaboration structures; in coal-transition counties, JTF calls further lift aid intensities and favour local employment outcomes, easing equity requirements. Across Interreg lines, ERDF typically reimburses a fixed percentage of eligible costs, simplifying cash-flow planning but requiring robust partner consortia and transnational deliverables that directly support Slovak deployment.

To turn this finance into outcomes, projects should anchor in place: in SK023/SK032/SK042, pair JTF grants with Modernisation Fund heat projects for sawmill residues and municipal biowaste; in SK031/SK041, use PL–SK Interreg to co-design mountain-area collection and modular preprocessing; in SK010/SK021, leverage SK–AT for smart-logistics and quality standards; and in SK021/SK022/SK031, use SK–CZ to mainstream climate-smart construction materials. Priorities for spend should include open-access pilot and demo lines tuned to Slovak feedstock heterogeneity; mobile/modular units for marginal terrains; digital tracking and forecasting platforms for biomass supply; side-stream valorisation (digestate upgrading, lignin applications) backed by LCA and eco-





labelling; and targeted regulatory refinements enabling cooperative manure/slurry pooling and equipment retrofits. With disciplined use of the available grant/loan mix and territorial instruments, Slovakia can compress the TRL-to-MRL gap, crowd-in private co-financing and convert its resource base into competitive, higher-value bio-based outputs while advancing rural incomes and regional resilience.

Table 17 Slovakia SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, diverse biomass base (forests, straw, dung, grassland, hemp, SRC; strong agri-forestry tradition).	Low TRL for many processes (AD, composting, torrefaction, HTC); limited pilot/demo capacity; sub-optimal conversion with heterogeneous feedstocks.	Programme Slovakia 2021–2027 (green, smart priorities) and Just Transition Fund in Nitra SK023, Banská Bystrica SK032, Košice SK042 to co-finance bio-based upgrades and new plants.	Climate risks (drought, pests, fires) impacting forest/agri feedstock reliability and insurance/costs.
Clear long-term policy vision (carbon neutrality 2050; Vision & Strategy 2030; S3 on circular bioeconomy; National Forestry Programme; CAP SP).	Fragmented, largely private small forest plots; outdated equipment; poor interoperability between farm/forestry machinery and new bioprocesses.	Environmental Fund grants/loans + Modernisation Fund for RES, efficiency, and circularity; CAP SP tools (EIP-AGRI, AKIS, short chains) to professionalise value chains.	Regulatory frictions (e.g., ban on cross-farm manure/slurry mixing) may persist; permitting/admin burden delays projects.
Active research base (SUA Nitra, NPPC), cross-border	Weak tech transfer and industry uptake; few locally adapted, modular/mobile	Interreg VI-A SK–AT (SK010, SK021), SK–CZ (SK021, SK022, SK031), PL–SK (SK031, SK041), HU–	Competition from neighbouring bioeconomy players moving faster on scale-up and





positioning (Danube/Central Europe corridors), growing circular-economy agenda.	solutions for mountain/marginal areas; risk-averse culture, scarce transparent pilots.	SK (SK010, SK021, SK023, SK032, SK042), and NEXT HU–SK–RO–UA (SK041, SK042) to fund cross-border pilots, logistics, and circular hubs.	certification; market price pressure vs fossil alternatives.
Existing local bioenergy assets and by-products (digestate, pellets, compost) as a base to upgrade.	Low product differentiation; limited certification/branding reduces market credibility; sparse LCA/eco-labelling use.	Digitalisation push: build GIS/blockchain biomass tracking, IoT for process control, smart logistics; integrated valorisation of side-streams (lignin-rich residues, digestate) for biofertilisers/biochemicals.	Feedstock price/availability volatility; sustainability/taxonomy tightening; rural out-migration and skills gaps slow adoption.
Strong regional instruments at NUTS3 via Integrated Territorial Development (all 8 regions) to bundle projects across R&I, decarbonisation, waste, water.	Poor circular integration of municipal/food biowaste; insufficient waste-to-bio conversion capacity; limited service ecosystem for integration/retrofitting.	Stacking finance with Recovery & Resilience Plan + REPowerEU chapters; leverage public procurement and cluster models to de-risk first-of-a-kind plants.	Financing crowd-out if private capital remains hesitant; fragmented ownership and logistics raise transaction costs and hinder bankability.

5.1.18 Slovenia



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Slovenia's bioeconomy is underpinned by a coherent green-transition vision (Slovenian Development Strategy 2030; Transition to a Green Economy framework) and policy tools that champion circularity, industrial symbiosis, and governance-model innovation. The Sustainable Smart Specialisation Strategy (S5) prioritises sustainable food systems, bio-based materials and circular value chains, with public bodies explicitly tasked to coordinate with industry and research. Progress is visible in cross-sector collaboration and the use of EU territorial instruments, yet the country still lacks a dedicated, operational bioeconomy action plan that translates strategy into measurable deployment, tighter academia–industry coupling, and faster scale-up of pilot and demonstration capacity.

Financially, Slovenia offers a layered mix that can bankability-stage projects from TRL pilots to commercial rollout. Nationally, the Slovene Enterprise Fund provides grants, seed/co-investment and guarantees for start-ups and SMEs; the Slovenian Regional Development Fund supplies loans, guarantees, subsidies and pre-financing for regional bio-based investments; SID Bank adds patient debt, guarantees and export finance for scale and internationalisation; CAP/EIP-AGRI instruments fund farmer-led innovation groups and short supply chains; and Horizon Europe can underwrite higher-risk R&I. Regionally and transnationally, Interreg Slovenia–Austria (SI01) and Italy–Slovenia (SI02), plus Danube and Alpine Space programmes, finance cross-border pilots, cluster building, smart/circular infrastructure and policy uptake—typically grant-funding a large share of eligible costs and well suited for open-access pilots, biomass logistics digitalisation and certification/standards work. Practically, early pilots can be co-funded via Interreg/Horizon and EIP-AGRI; demonstration and first-of-a-kind equipment can blend SRDF/SID Bank finance with national grants; and market rollout can leverage SEF instruments and export-oriented SID facilities, with SI01 (Vzhodna Slovenija) and SI02 (Zahodna Slovenija) calls used to align with regional smart-specialisation priorities. This stack allows Slovenian consortia to de-risk scale-up, crowd-in private capital, and move from research outputs to competitive bio-based products while maintaining circularity and environmental performance objectives.

Table 18 Slovenia SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
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Compact geography eases regional coordination; mature wood and agri-food processing base; strong tradition of cooperative models; high-quality utilities and logistics for a small market.	Small domestic market limits scale; fragmented biomass holders; limited open-access pilot/demo lines; underused industrial symbiosis outside flagship sites.	Cross-border operating models with AT/IT for shared pilots and toll processing; cluster-led O&M playbooks for bioprocess uptime; eco-industrial parks linking wood, pulp, food and waste utilities.	Competition from larger EU operators with cheaper unit costs; supply shocks from forestry pests/fires or import dependencies.
Good applied R&D culture under S5; niche excellence in wood, packaging, and process control; universities experienced in EU projects.	Gaps at TRL 6–8 (pilot/demo) for biochemicals, biopolymers, nutrient recovery; sparse PoC funds for scale-up; limited test bays for multi-feedstock flexibility.	Joint pilot assets with Interreg (Danube/Alpine, SI–AT, IT–SI); modular, mobile units for mountain/rural feedstocks; digital twins/advanced control to stabilise heterogeneous inputs.	Faster-moving hubs (DE, NL, FI, AT, IT) lock standards and IP; technology lock-in to imports not tuned to local biomass.
Strong design/brand culture; wood-based materials and green construction demand rising; tourism/food brands can absorb premium bio-based SKUs.	Low product differentiation beyond pellets/compost/basic packaging; few ecolabels/EPDs to support premiums; limited local offtake for advanced biochemicals.	High-margin niches: bio-adhesives, lignin/hemicellulose derivatives, circular packaging, nutraceuticals from side streams; green public procurement to create anchor demand.	Price competition from fossil incumbents and scale players; buyer risk aversion without long-term specs and certification.
Coherent green-transition scaffolding	No dedicated, measurable national Bioeconomy Action	Fast-track permitting for pilots; harmonised standards with AT/IT;	Policy drift or budget re-prioritisation;





(SDS2030, Green Economy Framework, Circular Economy Roadmap); S5 smart specialisation; active PPP culture.	Plan; permitting not yet streamlined for first-of-a-kind bioprocesses; standards/certification pathways fragmented.	expansion of green procurement and carbon criteria; single-window advisory for bio-based projects.	EU state-aid/taxonomy changes affecting eligibility; tightening sustainability criteria outpacing local readiness.
Multi-instrument stack: SEF grants/co-investment, SRDF loans/guarantees, SID Bank debt/export finance; strong Interreg access; Horizon Europe track record.	Early-stage VC shallow; limited ticket sizes for demo plants; complex stacking/admin burden for SMEs; OPEX support scarce.	Blending SRDF/SID with Interreg/Horizon for 60–80% capex cover; CAP/EIP-AGRI for farmer-led hubs; green bonds/ESG lending for scale; export finance for Italy/Austria offtake.	Rising capex/interest costs; state-aid caps constrain stacking; competition for EU envelopes; FX and energy price volatility impacting bankability.
Dense road/rail to AT/IT corridors; modern waste management baseline; district heating footholds for bioheat.	Biomass aggregation costly in mountainous areas; few pre-processing hubs (drying, size-reduction, densification); limited CO ₂ /LCA data infrastructure.	Territorial hubs near sawmills/food plants; shared preprocessing with neighbours; digital traceability (GIS/IoT/blockchain) to cut logistics risk; waste-to-resource upgrades.	Weather/disaster risks to forestry; cross-border haulage constraints; competition for feedstock from energy uses.
Strong engineering and design talent; universities engaged in EU consortia; bilingual	Shortage of bioprocess scale-up, regulatory, and QA/QC specialists; SME bandwidth thin for EU admin; limited technician	Upskilling via CoVE/ERASMUS+/Interreg; industry-embedded MSc/apprenticeships; shared pilot sites doubling as training centres.	Brain drain to larger hubs; wage competition from neighbouring countries;





workforce easing cross-border ops.	training on modular plants.		ageing workforce in forestry/agri SMEs.
High environmental ambition; strong forestry stewardship; circular mindset gaining traction; good baseline for LCA adoption.	Limited systematic LCA/EPD use; biodiversity/fire resilience investments still evolving; nutrient recycling from biowaste underexploited.	Premium eco-labels and EPDs to unlock price; nature-positive forestry and fire-resilient value chains; nutrient recovery (struvite, organo-mineral fertilisers).	Harsher climate impacts (drought, pests, fires); tighter EU biodiversity rules increasing compliance costs if not anticipated.
Vzhodna (SI01) and Zahodna (SI02) benefit from Interreg SI-AT, IT-SI, Danube, Alpine Space; proximity to anchor markets/offtakers.	Regional disparities in pilot access; coordination friction across programmes.	Joint certification, pilot and logistics platforms with AT/IT; export-led bioproduct plays using SID export finance.	Neighbouring regions capture projects if timelines/permits slip; cross-border policy shifts affect pipelines.

5.1.19 Spain

Spain's bioeconomy is sizable (~€75 bn turnover) and policy-anchored (Bioeconomy 2030; Circular Economy 2030), but scaling is uneven: R&D is fragmented, pilots/demos are scarce, biowaste is under-valorised, and rural connectivity gaps slow digital adoption. The near-term unlock is financial blending and regional execution: use strong national lines (CDTI—R&D loans plus high-intensity Misiones/TransMisiones/NEOTEC; Incentivos Regionales for plant CAPEX; PERTE/IDAE for circularity, biogas/biomethane; Fundación



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Biodiversidad for industrial circularity) stacked with agile regional grants to push TRL 5–7 pilots into TRL 8–9 deployment.

Catalonia is the most investment-ready: its Bioeconomy Strategy 2030, BIOHUBCAT, and active sandboxing (plus ACCIÓ's NUCLIS for circular economy) create a bankable path from pilot to first-of-a-kind. Priorities are fourth-gen biorefineries, precision irrigation/soil inputs, and biowaste valorisation; gaps are grid/heat interconnections and limited number of operational biohubs (3 of 15), so projects should pair ACCIÓ grants with CDTI Misiones and IDAE capex for utilities. Andalusia is biomass-rich (olive groves, 2.3 Mt+ annual residues) and policy-driven (Circular Bioeconomy Action Plan in agri-food; S4). The investment thesis is distributed preprocessing (drying, pelletising, extraction) near orchards, advanced AD/biomethane, and high-value co-products (polyphenols, biofertilisers). Use Innterconecta STEP for cooperative R&D, Incentivos Regionales for plant build-outs, and IDAE/biogas prefeasibility lines to de-risk site selection and grid injection.

The Basque Country offers deep industrial integration and high approval rates for R&D: SPRI's HAZITEK (industrial research/experimental development) and Fast Track Innobideak (TRL 7–9) suit process-intensive biochemicals, advanced bio-materials and waste-to-chemistry. Projects benefit from dense supplier networks and port/logistics; main risks are space constraints and strict permitting—mitigate with early environmental screening and port-adjacent brownfield siting. Valencian Community is scaling through IVACE+I (PIDI-CV, PIDCOP-CV, INNOVA-CV) with strong food/packaging value chains. Best-fit investments are bioplastics from agro-residues, enzymatic depolymerisation, and smart biowaste collection with IoT routing. Pair regional R&D grants with CDTI LIC/LICA for near-market equipment and PERTE circular calls for recycling/re-use lines; Valencia's Urban Sandbox can accelerate pilots in city services and public procurement.

Asturias and Galicia are strong for forest and mixed agro-marine feedstocks but need CAPEX help and clustering. Asturias' SEKUENS (CIR circular-industry grants, PID R&D, PIE investment) supports industrial symbiosis (steel/cement + biochar, digestate upgrading) and biomethane for heavy transport; pair with IDAE biomethane studies and Incentivos Regionales for plant equipment. Galicia's IGAPE INNOVA and corporate investment grants suit pulp side-streams, seaweed/aquaculture valorisation, and biobased packaging—stack with CDTI TransMisiones for cross-regional consortia. Castilla-La Mancha and Castilla y León are scale plays: abundant cereal straw and forest residues, plus CLM's Biomethane Plan under consultation. Investment focus is modular preprocessing hubs (baling, steam-explosion, HTC) feeding regional biogas/biochemicals, and drought-resilient precision inputs. Use Incentivos Regionales for greenfield builds, CDTI LIC for production-line





upgrades, and CAP/EIP-AGRI to organise farmer co-ops and pay for on-farm pilots. Aragon, Extremadura and Murcia can specialise in arid-zone bio-inputs (biostimulants, biofertilisers), lignocellulosic sugars and insect/bio-protein; bankability improves via water-efficient processes and co-locating with solar/biogas hybrids, combining CDTI R&D with PERTE-circular windows and regional investment aids, and locking offtake through public procurement in water utilities and school catering chains.

On the technical side, Spain needs to close a set of repeatable gaps that hold pilots at TRL 5–6. Anaerobic digestion and gas-upgrading perform below EU averages due to variable feedstock quality and heat integration losses; bankable designs should include front-end quality control (NIR sorting, moisture normalisation), hybrid thermal + biological trains (e.g., HTC for wet streams; torrefaction for dry fines) and guaranteed utilities islands that recover low-grade heat into drying and upgrading. Fourth-generation biorefineries require modular pretreatment blocks tuned to Spanish residues (olive pomace, grape marc, straw, pruning) with flexible downstream routes (C5/C6 sugars, lignin, lipids). Digital layers should standardise data across farm/plant with open APIs, edge sensing where connectivity is weak, and simple decision dashboards to overcome low digital literacy; where 5G is spotty, design for store-and-forward telemetry and LoRa backhaul rather than assuming continuous broadband. Grid and gas interconnections are a hard constraint—early utility studies and standardised skids for biomethane grid-injection and medium-pressure heat loops reduce schedule risk, while urban pilots should pre-engineer containerised units that fit municipal footprint and noise limits.

Regulatory enablers need tightening and alignment to accelerate first-of-a-kind. Projects should structure by-product and End-of-Waste determinations early to avoid classifying valuable side streams as “waste” all the way to the buyer; align biofertiliser specifications with the EU Fertilising Products Regulation so digestate-derived products can move cross-border; and ensure RED sustainability criteria and mass-balance systems are embedded from day one for advanced biofuels eligibility and guarantees of origin for renewable gas. Spain’s separate collection obligations for biowaste and landfill-diversion incentives are tailwinds, but municipalities vary in readiness—bankability improves when developers pair offtake with municipal service contracts (gate-fees) and Green Public Procurement, rather than relying solely on spot commodity sales. Permitting runs through EIA/IPPC and water abstraction/discharge; early scoping with regional authorities, biodiversity screening for olive and forest landscapes, and pre-agreed monitoring plans reduce iteration. For digital and sandboxed innovations, leverage regional testbed regimes (Catalonia BIOHUBCAT, Valencia’s Urban Sandbox) to pilot data-sharing and automated compliance reporting that can later be scaled nationally. On aid-stacking, respect state-aid ceilings and cumulation





rules by cleanly allocating costs between ERDF-backed assets (core process) and national lines (utilities/heat networks), and use CAP/EIP-AGRI frameworks to formalise farmer cooperatives and pay for on-farm trials without overburdening the SPV.

Across regions, a pragmatic financing sequence is unchanged: CDTI/regionally funded pilots → Misiones/TransMisiones scale-up → Incentivos Regionales for core CAPEX → IDAE/PERTE for utilities and (bio)gas injection → municipal gate-fees and green-procurement offtake to stabilise OPEX. Immediate cross-cutting priorities are open-access pilot lines tuned to local residues, 6–8 preprocessing/logistics hubs to cut transport and standardise quality, shared LCA/PEF protocols and eco-labels to unlock price premia, and targeted national tweaks to speed TRL 8–9 permitting and clarify industrial symbiosis rules. Done in sequence, this compresses the TRL-to-market gap and converts Spain's diverse regional feedstocks into higher-value chemicals, materials and bio-inputs while lifting rural incomes and resilience.

Table 19 Spain SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
National frameworks in place (Bioeconomy 2030, Circular Economy 2030); strong regional leadership (Catalonia, Andalusia, Basque Country, Valencia, Galicia, Asturias); active sandboxes (BIOHUBCAT, Valencia Urban Sandbox).	National bioeconomy strategy not regularly updated; policy misalignment centre–region; permitting complexity for FOAK bioprocesses.	Refresh national strategy with TRL7–9 scale-up levers; fast-track permitting for pilots; inter-regional standards for residues, specs, LCA and data.	Fragmentation slows scaling; shifting state-aid/taxonomy rules; biodiversity/water regulations tighten without aligned incentives.
Dense grant stack: CDTI (Misiones/TransMisiones/NEOTEC/Innterconecta/LIC/LICA), Incentivos Regionales, PERTE/IDAE, Fundación	Early-stage VC thin; administrative burden	Blend 60–85% capex via Misiones/Trans Misiones +	Interest-rate and capex inflation;





Biodiversidad; ECBF VC presence; strong regional agencies (ACCIÓ, SPRI, IVACE+I, IGAPE, SEKUENS).	high for SMEs; OPEX support scarce; grid/connection costs underfunded.	Incentivos Regionales + regional grants; IDAE for biogas/biomethane; green procurement and CfD-style pilots for offtake; export scaling via Basque/Catalan equipment makers.	competition for EU envelopes; later-stage bias in ECBF; co-financing gaps for SMEs.
Strong university/tech-centre base; Catalonia targeting 4G biorefineries; Basque/Valencian manufacturing & automation prowess.	TRL6–8 gap (few open pilots/demos); underperforming AD (~65% utilisation); limited grid/heat integration at sites.	Regional pilot network (15 Catalan biohubs plan), shared demo lines; modular/mobile pretreatment for dispersed feedstocks; digital twins & advanced control to stabilise heterogeneous streams.	Competing EU hubs set standards/IP; lock-in to imported tech not tuned to Spanish residues.
Very large, diverse biomass base (olive, forestry, fisheries, citrus, livestock); strong ports & agri-supply chains.	Low-density/fragmented streams (Asturias livestock); limited preprocessing	Territorial hubs near mills/coops; densification & drying nodes; IoT/GIS traceability to cut risk; by-	Drought/fire/pests; competing energy uses; transport cost volatility.





	ng hubs; biowaste under-valorised (≈61% industrial, ≈17% municipal).	product swaps via industrial symbiosis.	
National push on ag-digitalisation; urban sandboxes accelerate IoT use cases.	≈43% low digital literacy among farmers; ≈53% ag land reliable broadband; siloed farm-software/data.	Targeted connectivity (5G/FWA) in bioeconomy corridors; common data model & APIs; remote O&M and predictive quality for feedstock.	Cyber/privacy concerns slow adoption; rural broadband delays increase OPEX.
Food/tourism brands support premium bio-based SKUs; growing demand for circular packaging and construction biocomposites.	Limited product differentiation beyond energy/low-value outputs; certification/EPD not systematic.	High-margin plays: phenolics from olive, biopolymers/adhesives, nutraceuticals from fish/fruit, organo-mineral fertilisers, biochar-based materials; green public procurement to anchor demand.	Fossil parity pressure; buyer risk aversion without warranties/specs; imports from scale players.
Catalonia: funding depth, BIOHUBCAT, industry base. Andalusia: massive agro-residues,	Disparate readiness and	Region-tailored specialisation and cross-	“Race to the cheque” among





sun/land. Basque Country: engineering scale-up, Hazitek/Fast Track. Valencia: RIS3-CV, Urban Sandbox. Galicia: fisheries/forestry, IGAPE. Asturias: circular-capex intensity via SEKUENS. CLM: biomethane roadmap, forest biomass.	timelines; hub delays (only 3/15 Catalan biohubs active).	region corridors (e.g., Andalusia residues → Basque equipment → Catalan processing).	regions; projects migrate to faster-permitting neighbours.
Strong conservation ethos in strategies; rising circularity focus; scope for climate-positive labels.	Monoculture risks (e.g., olive); biodiversity loss; limited real-time monitoring; low biochar/CCU efficiency.	Stewardship incentives, ecological corridors; bio-inputs (bio-pesticides/fertilisers); verified LCA/EPD to monetise premiums; higher-efficiency pyrolysis/CCU pilots.	Stricter biodiversity/water rules raise costs if unprepared; social licence risks in intensive zones.

5.1.20 Sweden

Sweden's bioeconomy is anchored in world-class forest industries, very high process efficiency built over a century, and an enabling climate policy stack (Carbon Tax since 1991, EU ETS, 2017 Climate Policy Framework targeting net-zero by 2045). The opportunity now is to convert this depth into diversified biorefineries, digital forestry services and carbon-smart products; the binding constraints are weak industrial absorptive capacity for "new to mill" value chains, limited pilot-to-demo scale-up inside incumbent pulp/paper assets, and policy uncertainty from overlapping EU files (EUDR/deforestation, LULUCF, Nature Restoration, RED) that could depress harvests and raise admin costs. Circularity remains low (3.4% material circularity), driven by extractive waste and geographically remote flows,



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so deployment models must privilege co-location with existing mills/CHPs and logistics hubs to keep unit costs down while meeting strict environmental baselines (66% of productive forest land already FSC/PEFC certified; mills have sharply reduced emissions and eliminated elemental chlorine bleaching).

The financing path is clear and stackable. Use Vinnova, Formas and BioInnovation for TRL 2–6 research/consortia; move to Swedish Energy Agency thematic calls for pilots and to Industriklivet for first-of-a-kind decarbonisation inside industry (incl. Bio-CCS, process electrification, biogenic CO₂ capture and reuse). For pure CAPEX that cuts GHGs, Klimatklivet can fund up to 50% of eligible investment (biogas/biomethane, charging/H₂, low-carbon fuel use). At regional level, Tillväxtverket (ERDF) provides up to ~40% co-financing via eight NUTS-2 programmes, useful for demo lines, cluster infrastructure and SME scale-ups; complement with regional foundations (e.g., Northern Sweden foundations for equipment) and Interreg (Baltic Sea Region/Europe/Nordic cross-border) at up to 80% for transnational pilots and policy uptake. Typical bankable sequencing: Vinnova/Formas → Energy Agency pilot → Industriklivet (scale, FOAK) + Klimatklivet (site utilities) → Tillväxtverket co-financing for anchor region → Interreg for cross-border logistics/standards, while securing mill-site offtake and service contracts to stabilise cashflows. Aid-stacking must respect state-aid ceilings: ring-fence ERDF-financed shared assets (logistics hubs, testbeds) from nationally funded process units; attribute OPEX-saving climate measures to Klimatklivet and emissions-abatement innovation to Industriklivet.

Regionally, deployment should mirror industrial footprints rather than greenfield sprawl: (i) Mill-adjacent northern and mid-Sweden corridors—co-site lignin/tall-oil upgrades, hemicellulose sugar platforms, and Bio-CCS on recovery boilers/CHPs; (ii) Chemistry and port clusters—drop-in biochemicals, SAF intermediates using biogenic CO₂, with ready export logistics; (iii) Sawmill belts—engineered wood, biochar from fines, resin substitutes, and circular adhesives; (iv) Agri/biogas pockets—upgrading, CO₂ liquefaction and digestate-to-biofertiliser. Digital forestry is investment-ready: Sweden's long runway with GIS, LiDAR/airborne laser scanning, harvester-data standards and applied AI (e.g., Mistra Digital Forest) enables scalable products in inventory prediction, harvest planning and biodiversity safeguards; business models should bundle edge sensing + store-and-forward comms for low-coverage areas and monetise via mill service contracts and certification compliance (automated EUDR due-diligence dossiers). Technically, FOAKs should emphasise modular lignocellulosic pretreatment tuned to Swedish feedstocks, integrated heat cascades (recovering low-grade heat into drying/upgrading), hybrid trains (e.g., torrefaction/HTC for side-streams), and by-product valorisation routings (lignin resins, bio-based binders, carbon materials). On the regulatory side, bankability hinges on early End-of-Waste determinations,





RED mass-balance readiness, robust LCA/PEF dossiers, and biodiversity monitoring consistent with national Forestry Act practice; developers should pre-agree monitoring plans and due-diligence data pipelines with authorities and buyers to compress permitting cycles. With disciplined use of Industriklivet/Klimatklivet/Tillväxtverket and mill-site co-location, Sweden can overcome the TRL-to-MRL gap, crowd-in private capital, and defend global leadership in high-value wood-based materials, fuels and digital forest services.

Table 20 Sweden SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
~70% land forested; large, reliable feedstock base	Limited absorptive capacity for novel biorefinery chains in incumbents	Stackable public finance (Industriklivet, Klimatklivet, Energy Agency, ERDF, Interreg) to de-risk CAPEX	Overlap of EU files (EUDR, LULUCF, Nature Restoration, RED) may constrain harvests
Century-long pulp/paper know-how; high process efficiency	Slow pilot→demo→FOAK scaling; few large demo assets	Mill co-location for lignin/tall-oil upgrades and hemicellulose platforms	Policy uncertainty on formal national bioeconomy strategy
Strong climate-policy stack (carbon tax, EU ETS, 2045 net-zero framework)	Path dependency on legacy profit streams; risk-averse investment	Bio-CCS at recovery boilers/CHPs; CO ₂ -to-fuels/chemicals	Commodity price volatility (pulp, energy) hits project cashflows





Extensive certification (FSC/PEFC ~66% of productive forest)	Cost gap vs fossil incumbents for many biomaterials	Digital forestry (GIS/LiDAR/harvester data, AI) for EUDR due-diligence services	Local acceptance risks near sensitive habitats/biodiversity areas
Mature logistics, ports, export orientation	Limited market differentiation for some novel bioproducts	Side-stream valorisation (biochar, resins, adhesives, nutrients)	Skilled labour/contractor bottlenecks for FOAK deployments
Advanced CHPs and industrial symbiosis at mills	Low overall circularity (~3.4%) driven by extractive waste	Hybrid pretreatments (steam explosion/HTC/torrefaction) to widen feedstock window	Permitting timelines and administrative burden increase
Strong R&D fabric (Vinnova, Formas, Energy Agency, BioInnovation)	Fragmented demo support; partial focus on early-stage R&D	Heat-cascade integration to cut OPEX and improve IRR	Competing international incentives attracting projects abroad
Early digitalisation leadership in forestry	Limited internal talent for new business models in incumbents	Green public procurement and eco-labels to pull biobased demand	Feedstock competition (energy vs materials) during tight markets
Stable institutions; public-private collaboration culture	Legacy equipment interoperability limits for new processes	Regional funds (Tillväxtverket, foundations) for SME pilots	Sustainability scrutiny on clear-cuts and habitat impacts
High environmental performance	Commercial focus on incremental upgrades over new lines	Cross-Nordic partnerships for shared pilots/testbeds	Grid capacity constraints for electrified/CCS processes





in mills (air/water)			
Strong safety and quality standards	Conservative financing norms for tech risk	Export premium on verified low-carbon materials	Supply chain disruptions (storms, pests, fires) affecting wood flows
Established district heating networks	Limited domestic venture scale for late-stage rounds	Demand growth in construction, packaging, textiles for bio-alternatives	Long asset lifecycles locking in incumbency, slowing rotation to new tech

5.1.21 UK

The UK bioeconomy mixes deep scientific strength with uneven commercial scale-up. On the technical side, capabilities span advanced feedstock pretreatment, fermentation, and bioprocess control (strong university/Catapult base), but production remains constrained by costly, seasonal, and regionally concentrated feedstocks; incomplete food-waste segregation; and limited open-access pilot/demo infrastructure, which keeps many platforms marooned at TRL 5–6. Supply chains remain fragmented across agriculture, waste and chemicals, with weak logistics planning and heterogeneous data standards; this raises working-capital needs, depresses plant utilisation, and increases delivered feedstock costs versus EU/US competitors. Digital traceability and common quality specs are emergent but not yet pervasive, and LCA/end-of-life labelling inconsistency undermines buyer confidence for biomaterials.

The policy pull is strengthening but not yet fully coherent. The 2023 Biomass Strategy commits to expanding sustainable domestic biomass while deferring hard prioritisation across materials, chemicals, fuels and power—leaving investors uncertain about future hierarchy and carbon accounting. Transport provides the clearest demand signal: the Sustainable Aviation Fuel (SAF) mandate (from 2025) and a prospective Low-Carbon Fuels Strategy create offtake visibility for biogenic fuels (alongside waste-to-fuels pathways), while maritime low-carbon fuel measures are tightening. Engineering biology remains a priority under the National Vision for Engineering Biology, aligned with the Net Zero Strategy, but cross-departmental frictions (Defra vs. DESNZ/DfT/DSIT) can slow standards, permitting and market-creation reforms (e.g., delayed universal food-waste collections, uneven





recycling labelling, variable definitions of recyclable/compostable). A national bioeconomy roadmap that fixes feedstock hierarchy (materials → chemicals → fuels/power), harmonises LCA/claims, and clarifies BECCS/CCU revenue stacking would materially improve bankability.

Finance is available but dispersed. UKRI/Innovate UK provide early- to late-stage instruments—sLoLa for large bioscience teams; cooperative KTPs; thematic Innovate UK competitions (Smart-style when active); Innovation Loans for near-market CAPEX/OPEX; and Launchpads that channel grant funding into regional clusters. DESNZ/DfT streams (e.g., SAF support) and Innovate UK Business Connect/Growth Hubs help assemble consortia and offtakes. Yet first-of-a-kind (FOAK) plants still face equity gaps and conservative project debt. Practical structures that work: stack grant (Launchpad/Innovate UK) + Innovation Loan for EPC/commissioning, add offtake pre-pays (airlines/brands), and layer revenue-support (e.g., mandates, certificates, or CfD-style price floors for fuels/BECCS) to bring WACC into investable range. Standardised LCA and end-of-life claims are pivotal for unlocking green public procurement and retailer Scope-3 offtakes in packaging, textiles and construction materials.

Regional deployment is increasingly place-based. Scotland's IBioIC anchors industrial biotech with pilot lines, workforce programmes and brand offtakes; it is a natural locus for engineered biology ingredients, lignocellulosics and waste-to-chemicals, and benefits from the "Biobased Manufacturing in Scotland" Launchpad. Teesside and the Liverpool City Region, proven in earlier Launchpad pilots, can host FOAK waste-carbon and SAF projects via shared utilities, hydrogen/CO₂ handling and port access. Eastern England's AgriTech & FoodTech cluster suits biowaste valorisation, precision fermentation inputs and controlled-environment side streams, while South-West Wales' Net-Zero Industry Launchpad aligns with co-located heavy industry for biocarbon/biomaterials integration. Priorities across these hubs: (1) expand open-access pilot/demo (continuous, sterile and solids-handling lines) tied to local feedstocks; (2) implement digital feedstock marketplaces with quality/spec contracts; (3) create buyer clubs/offtake pools (airlines, FMCG, construction) to lift MRLs; and (4) streamline permitting with unified LCA/data rules. With those enablers and blended finance, the UK can convert scientific advantage into competitive bio-based fuels, chemicals and materials at scale.





Table 21 UK SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
World-class life sciences and synthetic/engineering biology base (universities, Catapults).	Fragmented supply chains between agriculture, waste, chemicals; seasonal, geographically concentrated feedstocks.	SAF mandate from 2025 and low-carbon fuels policy create bankable offtake for biogenic fuels.	International competitors with cheaper feedstock/energy undercut UK bio-products.
Strong policy pull from Net Zero Strategy; cross-departmental collaboration channels exist (UKRI with DESNZ, DfT, Defra, DSIT).	Underinvestment in open-access pilot/demo assets; TRL 5–6 stall and “valley of death”.	Innovate UK/UKRI tools (Launchpads, Innovation Loans, KTPs, sLoLa) to blend grant+loan and de-risk scale-up.	Policy misalignment/changes (departmental priorities, budget cycles) depress investor confidence.
Active start-up ecosystem and accelerator support; Growth Hubs and Innovate UK Business Connect.	High biomass and energy costs; competition for feedstocks with bioenergy; tight food-waste supply.	Regional cluster plays (IBioIC in Scotland; Teesside/Liverpool; Eastern England AgriTech) for place-based deployment.	Prolonged delays to segregated food-waste collections constrain biowaste feedstock growth.
Strong academic–industry partnering mechanisms	Inconsistent LCA methods, end-of-life labelling and data standards	Standardised LCA/data and eco-labels can unlock procurement and export markets.	Import exposure for key biochemicals/materials; FX/energy price shocks.





(KTPs, Catapults).	undermine market trust.		
Technical depth in pretreatment, fermentation, and bioprocess control.	Limited late-stage risk capital; conservative project finance for FOAK plants.	Corporate PPAs/offtakes and CfD-style models for fuels/BECCS to improve bankability.	Feedstock competition and land-use constraints elevate costs and public scrutiny.
Established blue-chips in chemicals, aerospace, and retail to anchor offtake.	Disconnected waste generators vs. downstream users; weak logistics planning.	Industrial symbiosis at chemical parks (e.g., Teesside) to integrate waste-to-chemicals hubs.	Sustainability/permitting challenges and local opposition to new plants.
Mature standards/governance culture; strong QA/regulatory science.	Skills gaps for bioprocess scale-up, operations, and QA in regions outside major hubs.	Green public procurement to pull bio-based packaging, textiles, construction materials.	Carbon policy uncertainty for BECCS/CCU revenue stacking.
Transport decarbonisation targets (aviation/maritime) align with bio-based fuels.	Fragmented R&D spend; duplication and slow tech transfer.	UK export positioning on engineered biology toolkits and low-carbon materials.	Tight grid capacity for electrified processes at key industrial sites.
IBiolC provides pilot lines and workforce programs in Scotland.	Limited national bioeconomy strategy coherence (prioritisation still evolving).	National roadmap with clear feedstock hierarchy (materials→chemicals→fuels/power) to guide investment.	EU/US incentive asymmetry (IRA, EU IF) diverts late-stage projects abroad.





Launchpads channel funds to local clusters and SMEs.	Modest domestic demand signals for some bio-materials vs. fossil incumbents.	Retail/brands' scope-3 commitments to co-fund transitions.	Macroeconomic headwinds raising WACC and capex costs.
Large potential to valorise biowaste and agri-residues with improved segregation.	Logistics and inventory integration for biomass chains still immature.	Digital traceability and quality specs to stabilise feedstock contracts.	Extreme weather affecting biomass yields and supply reliability.
Established innovation loans mechanism for near-market tech.	Lack of consistent offtake/price-stabilisation for chemicals/materials.	Long-term offtake pools and buyer clubs to lift MRL and enable project finance.	Rapid tech cycles outpacing regulatory updates and standards.

5.2 CROSS-REGIONAL INSIGHTS

Across countries, the European bioeconomy shows a consistent pattern: strong primary resource bases and deep scientific capacity coexist with mid-TRL bottlenecks, scarce open-access pilots/demos, and fragmented value chains. Heterogeneous, seasonal feedstocks and under-developed pre-treatment near origin drive variability and cost, while many plants remain batch-heavy with limited digital control, depressing yields and bankability. Where continuous operation, integrated separations, and digital QA/traceability are deployed, performance and financing readiness improve markedly. Statements in this section are tied to the documented evidence base and mapped to the audit trail to ensure transparency from conclusion to source.

Policy scaffolding is broad and generally supportive (climate, circularity, CAP/S3, waste and energy frameworks). Yet execution gaps persist—permitting complexity, uneven standards (LCA, end-of-waste, bio-labels), and unclear feedstock prioritisation across materials, chemicals, fuels, and power. Funding is material at EU, national, and regional levels, but





instruments are often biased to early R&D; first-of-a-kind (FOAK) assets still struggle to assemble blended stacks and long-term offtake. Social acceptance hinges on visible local benefits, fair feedstock contracts, and credible environmental safeguards; skills gaps in operations, QA/QC, and digitalisation are widespread.

Across Europe, funding is abundant but uneven. Most countries combine EU envelopes (ERDF/CF/JTF, RRF/REPowerEU, Innovation Fund, Interreg), national grant/loan schemes (e.g., industrial transition/green-deal lines, innovation loans), and regional OPs tied to smart specialisation. Northern/Western regions typically move faster with mature clusters, co-location sites and match funding; several Central/Eastern and Mediterranean regions have large grant rates (often 40–80%) but slower execution (permitting/admin load, TRL 6–8 gaps, limited offtake). Common pain points: FOAK equity/debt gaps, fragmented end-of-waste/LCA rules that stall bankability, under-provision of open-access pilots/demos, and OPEX exposure to energy/interest-rate volatility. What works: blended stacks (grant + innovation loan/guarantee + buyer pre-pays), place-based co-financing via regional OPs/JTF, and demand anchors (GPP, mandates/quotas, buyer clubs) to lift projects from pilot to FOAK.

The system-level levers are clear: (1) expand shared pilot/demo capacity tuned to local feedstocks; (2) standardise LCA, certification, and end-of-waste pathways; (3) co-locate with existing industrial sites and utilities to cut CAPEX/OPEX; (4) digitise feedstock logistics and plant control for quality stability; and (5) use place-based finance plus demand instruments (green public procurement, mandates/quotas, buyer clubs) to lift FOAKs from TRL 6–8 to market. Measures are framed for implementers with references to enabling instruments and delivery responsibilities, leading into the content that follows.

Table 22 EU-level SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Large, diverse biomass base (agri, forestry, blue); established primary sectors/logistics.	Mid-TRL/FOAK bottlenecks; scarce open-access pilots/demos; batch-heavy plants; limited	Scale modular, multi-feedstock biorefineries; residue/biowaste valorisation (biogas/biomethane, biofertilisers, biochar);	Global incentive asymmetries and cheaper inputs abroad; energy/interest-rate volatility eroding IRR.





	integrated downstream.	lignin/hemicellulose derivatives; engineered biology.	
Deep science/engineering, clusters, testing/certification; strong standards culture.	Fragmented value chains/data; variable feedstock quality; little near-origin pre-treatment → higher costs.	Harmonised LCA/EPD, certification and eco-labels to unlock procurement and price premia; digital traceability for bankability/EUDR.	Tightening biodiversity/water/climate constraints raising compliance costs or limiting biomass.
Broad policy scaffolding (climate, circularity, CAP/S3, RED); multi-tier finance (EU/national/regional).	Permitting/admin complexity; uneven end-of-waste/product standards; inconsistent LCA/labeling.	Place-based deployment: co-locate at mills/ports/industrial parks; use JTF/ERDF/Interreg to de-risk regional hubs.	Feedstock competition across food/materials/energy; climate shocks (drought, fires, pests) destabilising supply.
Mature industrial sites for co-location; ports/grids/CHPs enabling symbiosis/export.	Weak market pull for some bioproducts; few long-term offtakes; conservative project finance.	Blended finance playbooks (grant + innovation loans/guarantees + offtake/buyer clubs; CfD-style floors for fuels/BECCS).	Permitting delays/policy drift; end-of-waste uncertainty; social pushback without local co-benefits.
Rising buyer demand: companies cutting supply-chain (Scope 3) emissions and governments buying more green products.	Skills gaps in operations, QA/QC, maintenance, automation/digital; uneven social acceptance.	Digitisation: inline analytics, advanced control, digital twins, biomass marketplaces to stabilise quality/costs.	Lock-in to imported tech not tuned to EU feedstocks; talent leakage to larger ecosystems.





Cross-border programme depth and cluster networks (Interreg, S3/EIT; dense equipment vendors).	Patchy organics capture/recycling ; low circularity in extractive sectors; incomplete food-waste segregation.	Product passports & carbon accounting (ESPR/DPP) to reward verified low-carbon/biobased content and enable secondary markets.	Standards divergence with US/Asia and trade remedies; compliance burden falling hard on SMEs.
Abundant brownfields with utilities/ports and district heat for FOAK co-location; robust QA/regulatory science.	Limited late-stage risk capital and FOAK equity; conservative lenders; complex aid-stacking ceilings.	De-risk finance via CfDs/guarantees, green bonds, public development banks; aggregated buyer clubs for offtake.	Grid/CO ₂ transport capacity constraints and permitting queues for electrification/CCS; extreme-weather disruption to supply chains.

5.3 CURRENT BIOECONOMY PROJECTS MAPPING

Across the countries and regions assessed, a clear map of current bioeconomy activity emerges if we follow the money, the feedstocks, and the places where pilots are graduating into bankable assets. At the EU level, the largest engine knitting these projects together is the Circular Bio-Based Europe Joint Undertaking, which now runs a roughly €2 billion public–private programme under Horizon Europe with three tiers of awards—from Research and Innovation Actions to medium Innovation Actions and “IA-Flagship” demonstrators—backing close to two hundred projects and more than fifteen hundred partners. That portfolio has become the connective tissue for many of the initiatives we see on the ground: it pays for the science and the first serious engineering, it standardises environmental baselines with life-cycle metrics, and—crucially—it nudges consortia to include institutions from less represented countries so that capability spreads beyond the usual hubs. In practice, when a regional cluster in, say, the Baltics or the Balkans moves from feasibility to equipment orders, there’s a decent chance a CBE-JU work package funded the early data, shared the test methods, and pre-agreed the certification routes that local lenders now ask to see. This same “EU spine, regional muscle” pattern repeats in national and sub-national finance. Sweden’s two-handed model illustrates it well: Klimatklivet covers up to half the CAPEX for





investments that cut greenhouse gases—typical references include farm-scale biogas at Fröstorp, hydrogen refuelling, and fast-charging networks that close the loop on green logistics—while Industriklivet, run by the Swedish Energy Agency, takes on first-of-a-kind industrial decarbonisation inside mills and chemical sites, including Bio-CCS and the Project AIR synthesis route. Those two lines are then braided with regional growth funds (Tillväxtverket) and, where relevant, cross-border Interreg envelopes so projects can finance not just the core unit operations but also the enabling heat loops, water reuse, and shared utilities that make the numbers work for municipalities and SMEs. Sweden's example matters for replication because it shows that dispersed, heterogeneous biomass can be industrialised when investment covers pre-treatment near origin, continuous operation at plant, and the district or port-side connections that monetise by-products and low-grade heat. In the UK, the Launchpads programme plays a similar role for clusters: it funds dozens of R&D-to-commercialisation projects in places that already have supplier depth and offtakers—Biobased Manufacturing in Scotland anchored by IBiolC's pilot lines and brand demand, Net Zero Industry in South-West Wales where heavy industry and ports absorb biocarbon and fuels, and AgriTech & FoodTech in Eastern England where waste streams are dense and logistics tight. Launchpads then stack with Innovate UK's "Future Economy" Innovation Loans for near-market equipment and commissioning, giving FOAK plants a blended package with both grant and debt features rather than relying on scarce equity alone; the explicit design is to push firms over the TRL-6/7 hump into continuous, lender-grade runs so offtake pre-pays can close. On the continent, the same stacking logic is visible in the Interreg family of programmes, which routinely underwrite 70–80% of eligible costs for transnational pilots, standard-setting, and supplier pooling. Baltic Sea Region and Europe-wide calls have become practical bridges between university rigs and the multi-month, multi-feedstock pilots that SMEs in Estonia, Latvia and Lithuania need to win industrial customers; they also pay for the unglamorous pieces—road access to forest plots, digital traceability and QA systems, harmonised end-of-waste determinations—that decide whether a project can ship product across a border without getting stuck in waste or customs rules. In Central Europe and the Danube space, Interreg and Just Transition windows are doing similar work for coal-transition counties, financing preprocessing hubs, brownfield conversions, and training programmes so that demonstration plants in Czechia, Slovakia, Poland, Romania and Hungary can hire operators, prove specifications, and write the first commercial contracts with local construction, packaging, or fuel buyers. Where Southern Member States lean on tourism and agri-food, regional programmes in Spain, Portugal, Italy and Greece co-finance residue hubs near orchards, mills and ports, build modular anaerobic digestion with biomethane upgrading, and co-site pilot lines for lignocellulosic sugars, marine biopolymers and phenolics; here again, EU-level instruments such as CBE-JU supply the technical spine, while national and regional funds supply the place-based muscle





to buy kit, connect to the grid or gas network, and certify outputs for public procurement. Statements in this section are tied to the documented evidence base and mapped to the audit trail to ensure transparency from conclusion to source.

Zooming in by territory, the project map groups into repeatable “archetypes” that can be lifted and placed elsewhere with minor adaptation. Coastal and island systems—Croatia’s Adriatic regions, Cyprus, Malta, the Spanish and Portuguese Atlantic and Mediterranean belts—are converging on compact blue-bio and organics valorisation lines: cold-chain and pre-treatment at landing sites, collagen and chitin pilot runs, PHA and other biopolymers routed quickly through certification, and anaerobic digestion plus digestate valorisation where organic flows are steady. These are relatively low-footprint, high-value plays that match constrained land and water; they are also good candidates for Interreg coastal corridors and CBE-JU Innovation Actions that can carry the same package between ports with minimal design change. Inland agricultural heartlands—Flanders in Belgium, Central and Eastern Czechia, the Great Plains of Hungary, Castilla-La Mancha and Castilla y León in Spain, Western Macedonia in Greece, Romania’s North-West and Poland’s Lublin and Konin subregions—cluster around multi-feedstock preprocessing (drying, size reduction, densification), modular AD/biomethane with CO₂ capture and use, lignocellulosic sugar platforms and fibre-reinforced composites, all tied to regional gas and heat infrastructures. These projects work when logistics are digitised, moisture and contaminants are stabilised at source, and digestate or lignin is certified to meet local agronomy and construction standards so more value stays local. Industrial forestry belts—Sweden’s mill corridors, Latvia’s and Estonia’s forest regions, France’s Grand Est and parts of Central Europe—are moving from mechanical to hybrid biorefinery models: hemicellulose sugar extraction, tall-oil and lignin upgrade lines, bio-adhesives and resins, and bio-CCS on recovery boilers. This “brownfield-plus” pattern hinges on mill co-location, heat-cascade integration, and buyer-ready EPDs; it scales when national decarbonisation funds pay for the emissions-cutting utilities and EU or regional innovation lines pay for the new process units. Urban and peri-urban zones—Catalonia, the Basque Country, Valencia, Île-de-France, parts of Belgium and the Netherlands though not covered here in depth—are focusing on biowaste capture and advanced recycling of biopolymers, with municipal offtake and gate-fees stabilising revenue; in these areas, grid and water constraints are often bigger obstacles than technology, so early utility studies and pre-approved modular skids for gas injection or heat loops save months on timelines and are directly replicable. In every archetype, digital layers—edge sensors, soft-sensing and model-based control, simple digital twins for troubleshooting, end-to-end traceability—raise yields and reduce downtime; they are also increasingly a condition for finance because they shorten the time it takes to build a lender-grade data room with multi-month performance and quality evidence.





Several flagship or near-flagship examples anchor this map and show how capital stacks are assembled. In Sweden, Klimatklivet's references to farm-scale biogas (Fröstorp), hydrogen refuelling and fast-charging corridors capture the enabling-infrastructure side that lets low-carbon logistics and waste-to-value chains run profitably, while Industriklivet funds heavier industrial transitions such as Bio-CCS and the Project AIR route for low-carbon chemicals; together with the Swedish Energy Agency's R&I calls and regional growth funds (Tillväxtverket), they span feasibility, pilots, and plant CAPEX in a way SMEs and municipalities can actually absorb. Those same projects typically report into national climate-neutral city initiatives or sector roadmaps—Skellefteå's 2030 neutrality programme is a typical anchor—which strengthens offtake and planning certainty for lenders. In the UK, Launchpads have already distributed tens of millions across eleven clusters, with Scotland's biobased manufacturing theme and South-West Wales' net-zero industry theme pushing dozens of SME projects toward market; when paired with Innovate UK's Innovation Loans, those consortia finance continuous runs, QA/traceability and the first commercial tools and utilities that turn a promising unit operation into a sellable SKU. At EU scale, CBE-JU's 2024 batch of thirty new consortia adds to an existing network of nearly two hundred projects, with IA-Flagships typically receiving around €20 million and medium IAs and RIAs around €14 million and €7 million respectively—ticket sizes that are large enough to build serious pilot or demo assets, yet small enough to stay close to regional feedstocks and buyers. Cross-border Interreg corridors then pay for supplier pooling, interoperable specifications and joint certification work so those assets can trade across regions without reinventing legal and logistics baselines. The result is a pipeline where blue-bio pilots on the Adriatic can be cloned in the Central Baltic, where inland residue hubs in the Danube programme lift copy-and-paste modules from Spain's olive and pruning chains, and where mill-adjacent lignin and hemicellulose plays tested in Sweden can be adapted for French or Baltic mills with similar fiber lines and grid connections. These are not paper synergies—they are showing up in procurement plans, buyer clubs and municipal tenders, which is why we recommend treating Interreg, regional ERDF lines and national decarbonisation funds as a single orchestration platform rather than separate pots.

Opportunities for replication and scaling are therefore less about inventing new technology than about institutionalising a playbook that travels. The first rule is to co-locate preprocessing at or near the feedstock source so variability is tamed and logistics are de-risked; here, Programme-type grants (regional ERDF or cohesion windows), municipal contributions, or climate-oriented national lines like Klimatklivet are the most appropriate instruments because they fund shared assets that no single SME will carry on its balance sheet. The second rule is to secure continuous, digitally controlled pilot time for 6–12 months so lenders and offtakers can see stable yields and specifications; CBE-JU IA or IA-Flagship, national innovation grants and Launchpad-style cluster money are designed for this





evidence-building phase. The third is to lock standards, certification and end-of-waste status early, ideally through cross-border projects that make the paperwork portable; this is what Interreg, Baltic Sea Region and Europe calls have funded well, and it saves months when a plant seeks offtake across borders. The fourth is to finance utilities and grid/gas interconnections as climate-abatement CAPEX through national decarbonisation lines (Industriklivet, climate-investment funds) and city or regional programmes; separating these “platform” costs from process equipment makes state-aid rules easier to respect and lowers weighted average cost of capital. The fifth is to create market pull with municipal gate-fees, green public procurement, and buyer clubs in construction, packaging and fuels so that first-plants enter with a blend of commodity and contract revenue rather than spot-only exposure. Finally, all replicable models now embed digital QA/traceability and lender-grade data rooms from day one—this is increasingly a screening criterion in calls and a central element in due diligence. When these rules are applied, capital stacks assemble quickly and repeat reliably across regions, which is why we consistently see Sweden’s Klimatklivet/Industriklivet pair, the UK’s Launchpads and Innovation Loans, the CBE-JU tiers, and the Interreg corridors appearing together in the projects most likely to graduate to flagship status. In sum, Europe’s bioeconomy project map already contains the templates for scaling: coastal blue-bio with modular pilots and fast certification; inland residue hubs feeding modular AD and lignocellulosic platforms; mill-adjacent brownfield conversions for high-value wood chemistry and Bio-CCS; and urban biowaste and biopolymer loops anchored by municipal services. The finance architecture to replicate these—EU spine plus national climate funds and regional ERDF, topped up with cluster-level loans and grants—is in place; the work now is to keep tightening the interfaces between instruments, standardise digital and certification baselines, and move more pilots into the multi-month, continuous-run class that lenders and offtakers trust. Measures are framed for implementers with references to enabling instruments and delivery responsibilities, leading into the content that follows.

Table 23 Indicative Table of different bioeconomy projects (incl. Flagship) across EU.

Country/Region	Project / Initiative	Type & Focus	Status / Scale	Main Funding / Backers	Replication notes
Sweden	Project AIR	First-of-a-kind low-carbon chemicals route integrated with the existing industry	Demo/early deployment	Swedish Energy Agency programs incl. Industriklivet	Brownfield co-location with shared utilities shortens time-to-market





Sweden	Bio-CCS at pulp/paper mills	Carbon capture on recovery boilers/CHPs	Pilots moving to scale	Industriklivet + mill operators	Transferable to Nordic/Baltic mills with similar assets
Sweden	Fröstorp Biogas	Farm-scale biogas upgrading and utilisation	Commissioned investment	Klimatklivet (up to 50% CAPEX support)	Replicable cluster model for agri regions
Sweden (national)	Hydrogen refuelling & fast-charging corridors	Enabling infrastructure for low-carbon logistics	Rolling deployments	Klimatklivet + regional co-funding	De-risks biofuel/biogas logistics across regions
Sweden	Mistra Digital Forest	Digital forestry (GIS/LiDAR, harvester data, AI)	Multi-year R&I platform	Research foundations + partners	Tooling travels well to other forest economies
Interreg Baltic Sea Region	BioBoosters	Cross-border SME acceleration for bio-based pilots	Ongoing	Interreg BSR (≈80% co-financing)	Template for cluster-to-cluster scaling
Interreg Baltic Sea Region	Blue Supply Chains	Blue-bio logistics and value-chain pilots	Ongoing	Interreg BSR	Replicable in Adriatic/Atlantic corridors
Interreg Baltic Sea Region	Best Ace	Innovation collaboration on circular/clean tech	Ongoing	Interreg BSR	Helps standardise specs/LCA across borders
Interreg Europe / BSR	Cinurgi	Transnational circular-	Ongoing	Interreg	Good for shared certification/e





		bioeconomy pilots			end-of-waste work
Croatia & Italy (Adriatic)	BIOBASED (Italy–Croatia)	Blue-bioeconomy pilots (e.g., marine biopolymers)	Active consortium	Interreg Italy–Croatia	Port-adjacent, modular set-up suits other coasts
UK (Scotland)	“Biobased Manufacturing in Scotland” Launchpad	Portfolio of SME scale-ups using IBioIC pilots	Multiple projects in flight	Innovate UK Launchpad + Innovation Loans	Cluster model ties pilots to offtake and skills
UK (South-West Wales)	Net Zero Industry Launchpad	FOAK integration in a heavy-industry/port cluster	Multiple projects in flight	Innovate UK + regional partners	Industrial symbiosis model for other ports
Spain (Catalonia)	BIOHUBC AT network	Biohubs for 4G biorefineries and packaging	Hubs operational (growing)	ACCIÓ + CDTI + regional ERDF	Standardised utilities/skids speed replication
Portugal	RAIZ Forest-Bioeconomy R&D Programme	Advanced wood-based materials/chemicals	Active (multi-year)	Industry + national RD&I (e.g., SIFIDE)	R&D-to-demo pathway for forest regions
Latvia (national)	Biorefinery MoU & LIAK coordination	Platform to scale wood/agri pilots and exports	Active	National programmes + ERDF	Governance template for SME pipelines

5.4 POLICY BRIEF

5.4.1 Key Recommendations



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Policymakers should lock in a predictable, scale-up-friendly framework that moves projects from lab and pilot to first-of-a-kind (FOAK) plants. The first priority is regulatory clarity: adopt uniform end-of-waste and by-product determinations for the most common bio-streams (digestate, compost, lignocellulosic fractions, CO₂ from biogenic sources) and a single market-wide approach to LCA, mass balance, and eco-labelling. One compliance pack must open all Member State markets; anything less inflates legal cost, slows sales, and scares off financiers. In parallel, establish time-bound permitting service levels for pilots, demos, and FOAK assets with single-window coordination across environment, water, energy, and planning authorities. Early scoping on biodiversity, air, and water—paired with a standard monitoring plan—shortens cycles without diluting safeguards.

Demand signals need to be stronger and simpler. Expand green public procurement to include verified biobased materials, recycled nutrients, and renewable gases with clear specifications and default templates for contracting, warranties, and performance data. Require large public buyers to publish forward purchase calendars, allowing suppliers to raise capital against a predictable offtake. On the supply side, co-fund near-origin pre-treatment hubs (drying, sizing, densification, hygienisation) so heterogeneous residues arrive at plants with stable moisture and contamination levels; this single step lifts yields, cuts OPEX, and de-risks logistics.

Finance architecture must be stitched into an explicit “ladder.” Research grants should hand off to mid-TRL pilot/demonstration instruments that pay for continuous operation, utilities, and digital QA/QC; FOAK plants should combine grants with innovation loans or guarantees and, where relevant, revenue support (mandates, certificates, or floor-price contracts) so projects can carry bank debt. Aid-stacking rules should be pre-explained with model term sheets, and programme managers should accept milestone-based drawdowns (e.g., mechanical completion, performance test, first commercial run) to align disbursements with project risk. Finally, invest in people: tie public funding to operator training, safety and quality certifications, and data skills so plants reach stable utilisation quickly and stay bankable.

5.5 ACTIONABLE STRATEGIES:

Within 12–24 months, publish a concise “how to finance and permit a bioplant” playbook for regions and sponsors. It should map each TRL/MRL step to the correct instrument (research → pilot/demonstration → FOAK) and explain legal cumulation, eligible costs, and typical award sizes. Include standard documentation for lender-grade data rooms: feedstock contracts with quality specs, process guarantees, commissioning plans, and monitoring protocols. Require any publicly supported pilot or demo to run for multi-month campaigns with continuous operation, integrated separations, energy/water recovery, and digital





traceability—yield stability proven at pilot is the single best predictor of FOAK bankability. Prioritise measures by materiality of impact, feasibility within existing mandates, cost-effectiveness, and time to effect; each strategy directly targets a binding constraint evidenced in the analysis. Streamline permitting through a single point of contact, standardised application packages, and service-level agreements with defined timelines and escalation paths, delivered via a digital portal.

Stand up an EU-wide network of open-access certification and test bays for biobased materials, biomethane, and bio-inputs. Let SMEs validate performance once (mechanical, barrier, compostability, and agronomic value) and use the same certificate across markets. Couple this with national “fast lanes” for pilots: fixed timelines, standard permit conditions, and early joint site visits by all authorities. Where municipalities fund biowaste systems, make support conditional on contamination control, quality-assured outlets (biogas/compost/biofertiliser), and simple guarantee-of-origin schemes that underpin revenues. Secure feedstock by adopting standard contract templates, a regionally maintained feedstock map (availability, quality, logistics, competing uses), and clear data governance for updates. Achieve bankability for TRL 6–8 by combining non-dilutive grants with risk-sharing debt/guarantees (e.g., InvestEU-type) and targeted state-aid; condition support on credible feedstock and offtake contracts.

Create place-based deployment corridors that match feedstocks, infrastructure, and skills. In forestry regions, co-site biorefineries at pulp/paper and sawmill hubs and prioritise heat-cascade integration, lignin/hemicellulose valorisation, and Bio-CCS readiness. In agriculture-dense regions, fund modular pre-processing near cooperatives and standardise digestate specifications so biofertilisers move easily into local markets. In coastal and blue-bio regions, anchor pilots at ports with shared utilities and fast testing routes for marine-grade materials. Everywhere, require digital twins or advanced control on supported lines, plus end-to-end traceability that can generate due diligence dossiers automatically. Create demand signals using advanced market commitments, targeted green public procurement, and recognised product labelling to reward verifiable sustainability performance. Scale collaboration through cluster and testbed models that coordinate permitting, feedstock contracting, and offtake development; replicate proven structures across less-developed and transition regions.

Finally, build a durable market pull. Expand public procurement targets for biobased construction materials, packaging, and recycled nutrients; encourage “buyer clubs” that aggregate corporate demand under common specs; and pilot simple price-stabilisation tools (e.g., volume-limited contracts with indexation bands) for early FOAK output. Tie these to





transparent performance dashboards—energy use, emissions, water, biodiversity measures—so communities see benefits and acceptance rises.

5.6 EU POLICY ALIGNMENT

These measures operationalise the European Green Deal’s twin aims of decarbonisation and competitiveness by turning dispersed biomass into certified, tradable materials, chemicals, and renewable gases. They directly advance the Circular Economy Action Plan by pushing higher-value cascading uses, improving secondary raw-material quality, and closing nutrient loops. They also complement energy-security and industrial-policy goals by fast-tracking renewable gas interconnections, electrified process heat, and carbon-smart products, while keeping biodiversity and water safeguards intact through standardised monitoring and due diligence.

Critically, the brief aligns EU-level funding with regional execution. Recovery and cohesion instruments can underwrite pilot lines, shared utilities, and grid/heat connections; modernisation and transition funds can convert brownfields and coal regions into bio-industrial hubs; and national innovation loans and guarantees can close the FOAK financing gap. Harmonised standards and fast-track permits reduce administrative drag, while expanded procurement and coordinated corporate demand create predictable revenue for early plants. Together, these steps turn today’s fragmented pilots into investable, cross-border value chains—raising productivity, strengthening rural and coastal economies, and accelerating the shift to a climate-neutral, circular European bioeconomy.

5.7 CONCLUSIONS AND RECOMMENDATIONS

This deliverable adds value by stitching together three strands of evidence—the country chapters in D4.1–D4.4, the EU-level synthesis in our consolidated SWOT, and the ToBeReal questionnaire—into one consistent message about where Europe’s bioeconomy stands and what will actually move it forward. Across sources, the same pattern repeats. On the “S” side of the SWOT, strengths show up as a deep and reliable biomass base and long industrial experience in forestry, agri-food, pulp and paper, and chemicals (e.g., Sweden’s century-honed mill efficiency; France’s clusters coupling green chemistry with strong





testing/certification; Italy's machinery and processing know-how). D4.1's process notes and D4.2's policy scans both underscore that many countries already have the sites, utilities and logistics to host biorefineries and circular hubs; the questionnaire reinforces this with a broad geographic footprint and cross-border intent. On "W", weaknesses are practical and repeated: most pipelines still sit at TRL 4–6, with very few first-of-a-kind plants; feedstock variability and seasonality raise costs without near-origin pre-treatment; batch-heavy unit ops and energy-intensive downstream steps depress yields; and digital control, inline QA/QC and end-to-end traceability remain uneven. These points are visible in D4.1 (efficiency and scale-up gaps), D4.3 (late-stage finance scarcity), and D4.4 (moderate collaboration), and they are echoed by the questionnaire's barrier profile where economic feasibility, regulatory complexity, scalability and feedstock risk dominate responses. On "O", opportunities converge on the same few levers in every source: modular, multi-feedstock pre-treatment near farms, forests and ports; converting obvious batch steps to continuous and integrating separations with heat and water reuse; early, harmonised LCA and certification to unlock procurement; and disciplined use of existing public finance to de-risk TRL 6–8. You can see these openings in the national funding maps (e.g., Sweden's Industriklivet/Klimatklivet stacks; Poland's KPO, Modernisation Fund and strong NUTS-2 envelopes; Spain's CDTI + regional programmes; Greece's RRP and JTF; Estonia's applied research/circular grants), and the questionnaire's "emerging opportunities" list (digital control, circular business models, novel materials) points to the same direction. On "T", threats line up as policy overlap or drift that can slow permits or shift eligibility; input and energy price volatility; climate stress on biomass quality and yields; and global competition from ecosystems that scale faster or subsidise deeper. These risks are visible in country chapters (e.g., Sweden's uncertainty from overlapping EU files; Spain's grid/connection constraints; Poland's risk of slower standards alignment), and surfaced again in stakeholder comments about administrative inertia and offtake uncertainty. The analysis converges on four binding constraints: (1) permitting lead time and predictability; (2) feedstock logistics and contracting; (3) bankability of TRL 6–8 demonstrations; and (4) uneven collaboration capacity across regions.

The convergence is clearest when you track a few concrete examples from analysis to SWOT and back to the survey. Sweden's section in D4.1 describes high core process efficiency but weak industrial absorptive capacity for new value chains and a very low material circularity rate; that becomes a "strength + weakness" pair in the SWOT and is mirrored by survey responses that put "economic feasibility" and "scalability" ahead of technical novelty. Spain's country synthesis flags a TRL 5–6 stall, under-performing anaerobic digestion and scarce open pilots/demos; those sit in the "weaknesses" column and are exactly the mid-TRL bottlenecks respondents reported (few projects beyond TRL 7, moderate collaboration, fragmented standards). Belgium's governance split across three





regions appears in D4.2 and is reflected in the SWOT as both an asset (tailored regional action, strong clusters and pilot plants) and a liability (coordination burden for permitting and standards); in the survey, regulatory fragmentation scores as a top-three barrier. Greece's funding architecture (large RRP/NSRF envelopes, Development Law, JTF in Western Macedonia) shows up under "opportunities" and is the kind of blended finance the survey says SMEs need to cross TRL 6–8. Estonia's stack (applied research, smart specialisation, circular production grants, municipal pilots) maps directly onto "opportunities" for continuous pilots and circular utilities, while its low value-added per worker and thin near-origin pre-treatment feed the "weaknesses" list. Poland's absence of a formal bioeconomy strategy and few FOAK assets land squarely in "weaknesses", even as its very deep financing mix populates "opportunities"—a tension the questionnaire captures as "funding exists, but late-stage and administrative gaps persist." Latvia's coordinated biorefinery push (MoUs, export momentum) sits in "strengths/opportunities" but is moderated by SME capital scarcity in "weaknesses," again consistent with survey feedback on risk capital.

With that triangulation, the recommendations stay close to what the evidence supports. For policymakers, three narrow fixes will yield outsized gains. First, standardise the basics: pre-publish document packs and time limits for permits; harmonise end-of-waste and by-product determinations for common streams; and accept a small set of LCA/PEF templates across agencies so project teams don't re-prove the same points. This directly addresses the questionnaire's regulatory pain point and D4.2's fragmentation. Second, point a portion of existing envelopes at continuous pilots and FOAK equipment, not just R&D: for example, ring-fence regional ERDF for shared utilities and pilot halls, use national climate/industry lines (e.g., Industriklivet, Modernisation Fund) for core process units, and reserve Interreg for cross-border logistics/standards and supplier pooling. This is exactly where D4.3 shows capacity and where the questionnaire flags the TRL 6–8 finance gap. Third, require a few bankability anchors in calls: near-origin stabilisation (drying, sizing, densification), inline QA/QC and traceability, and letters of intent from offtakers. These are the items D4.1 ties to process efficiency and the survey highlights under "process optimisation," "automation," and "scale-up feasibility."

For industry, the dependable route is operational rather than speculative. Co-locate with mills, CHPs, ports or chemical parks to share utilities and shorten permits; install modular pre-treatment at the source to tame variability and cut transport; convert the clearest batch steps to continuous and integrate separations with heat/water reuse; and implement basic inline analytics and traceability from day one. Several country chapters (France, Italy, Czechia) show that these decisions immediately lift yields and OPEX, and they also generate the lender-grade datasets the survey respondents say are missing. Plan certification and LCA early so procurement and export markets open without last-minute redesigns; that's a recurring "opportunity" in the SWOT and a known bottleneck in





D4.2/D4.4. For academia, RTOs and clusters, keep pilots practical and long-running (multi-month continuous campaigns), publish lender-usable data, and broker early offtake so specifications are set before equipment is purchased. The questionnaire's "moderate collaboration" score and the thin awareness of matchmaking platforms show there is immediate value in visible brokerage, applied standards help and shared data rooms.

Finally, the hand-off to the next work packages is direct. WP5 can lift the consolidated SWOT into short, operational playbooks: minimum viable configurations for residue hubs; a "continuous pilot" checklist (unit ops, sensors, data, LCA pack); template document sets for permits and end-of-waste; and example finance stacks that combine the national and regional instruments catalogued in D4.3. WP6 can focus capacity-building where the survey says it is needed most: permitting packs for SMEs and municipalities; buyer clubs and offtake pools in packaging, construction and fuels; cross-border standards work (residue specs, digestate/biofertiliser, RED mass-balance) that unlock replication; and targeted digital/operations training to close the skills gaps flagged in D4.4. The consolidated SWOT is not a promise of rapid transformation; it is a disciplined baseline that all sources agree on: strong biomass and know-how, mid-TRL and permitting bottlenecks, clear process and certification upgrades that pay back, and external risks that must be managed. By keeping to that common signal—and backing it with the examples above—this deliverable gives the project, regions and operators a realistic, shared starting point for the actions that now follow.





Annexes

Annex I: Number of underdeveloped bioeconomy regions from partners

			Less developed	Transition regions
	Total regions to include in the study of ToBeReal	154	41	45
Country Partners	NUTS2-level region https://ec.europa.eu/eurostat/web/nuts/overview	Nº of NUTS2	NUTS 2 - Less developed regions according to CBE Widening Strategy	NUTS 2 - Transitions regions according to CBE Widening Strategy
Spain	Galicia	19	5	7
	Principado de Asturias			
	Cantabria			
	País Vasco			
	Comunidad Foral de Navarra			
	La Rioja			
	Aragón			
	Comunidad de Madrid			
	Castilla y León			
	Castilla-La Mancha			
	Extremadura			
	Cataluña			
	Comunitat Valenciana			
	Illes Balears			
	Andalucía			
	Región de Murcia			
	Ciudad de Ceuta			
	Ciudad de Melilla			
	Canarias			
Slovenia	Vzhodna Slovenija	2	2	
	Zahodna Slovenija			
Slovakia	Bratislavský kraj	4	4	
	Západné Slovensko			
	Stredné Slovensko			
	Východné Slovensko			
Greece	Αττική	13	13	
	Βόρειο Αιγαίο			
	Νότιο Αιγαίο			
	Κρήτη			
	Ανατολική Μακεδονία, Θράκη			
	Κεντρική Μακεδονία			
	Δυτική Μακεδονία			
	Ηπειρος			
	Θεσσαλία			
	Ιόνια Νησιά			
	Δυτική Ελλάδα			
	Στερεά Ελλάδα			
	Πελοπόννησος			



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			Less developed	Transition regions
Total regions to include in the study of ToBeReal		154	41	45
Country Partners	NUTS2-level region https://ec.europa.eu/eurostat/web/nuts/overview	Nº of NUTS2	NUTS 2 - Less developed regions according to CBE Widening Strategy	NUTS 2 - Transitions regions according to CBE Widening Strategy
Sweden	Stockholm	8		1
	Östra Mellansverige			
	Småland med Gärna			
	Sydsverige			
	Västsverige			
	Norra Mellansverige			
	Mellersta Norrland			
	Övre Norrland			
Italy	Piemonte	21	7	3
	Valle d'Aosta/Vallée d'Aoste			
	Liguria			
	Lombardia			
	Abruzzo			
	Molise			
	Campania			
	Puglia			
	Basilicata			
	Calabria			
	Sicilia			
	Sardegna			
	Provincia Autonoma di Bolzano/Bozen			
	Provincia Autonoma di Trento			
	Veneto			
	Friuli-Venezia Giulia			
	Emilia-Romagna			
	Toscana			
	Umbria			
	Marche			
	Lazio			





			Less developed	Transition regions
Total regions to include in the study of ToBeReal		154	41	45
Country Partners	NUTS2-level region https://ec.europa.eu/eurostat/web/nuts/overview	Nº of NUTS2	NUTS 2 - Less developed regions according to CBE Widening Strategy	NUTS 2 - Transitions regions according to CBE Widening Strategy
France	Ile-de-France	28		20
	Centre — Val de Loire			
	Bourgogne			
	Franche-Comté			
	Basse-Normandie			
	Haute-Normandie			
	Nord-Pas de Calais			
	Picardie			
	Alsace			
	Champagne-Ardenne			
	Lorraine			
	Pays de la Loire			
	Bretagne			
	Aquitaine			
	Limousin			
	Poitou-Charentes			
	Languedoc-Roussillon			
	Midi-Pyrénées			
	Auvergne			
	Rhône-Alpes			
	Provence-Alpes-Côte d'Azur			
	Corse			
	Guadeloupe			
	Martinique			
	Guyane			
	La Réunion			
	Mayotte			
Belgium	Région de Bruxelles-Capitale/ Brussels Hoofdstedelijk Gewest	11	1	4
	Prov. Antwerpen			
	Prov. Limburg (BE)			
	Prov. Oost-Vlaanderen			
	Prov. Vlaams-Brabant			
	Prov. West-Vlaanderen			
	Prov. Brabant Wallon			
	Prov. Hainaut			
	Prov. Liège			
	Prov. Luxembourg (BE)			
	Prov. Namur			





			less developed	Transition regions
	Total regions to include in the study of ToBeReal	154	41	43
Country Partners	NUTS2-level regions https://ec.europa.eu/eurostat/web/nuts/overview	Nº of NUTS2	NUTS 2 - Less developed regions according to CBE Widening Strategy	NUTS 2 - Transitions regions according to CBE Widening Strategy
Portugal	Norte	7	7	
	Algarve			
	Centro (PT)			
	Área Metropolitana de Lisboa			
	Alentejo			
	Região Autónoma dos Açores			
	Região Autónoma da Madeira			
UK	Tees Valley and Durham	41	2	16
	Northumberland and Tyne and Wear			
	Cumbria			
	Greater Manchester			
	Lancashire			
	Cheshire			
	Merseyside			
	East Yorkshire and Northern Lincolnshire			
	North Yorkshire			
	South Yorkshire			
	West Yorkshire			
	Derbyshire and Nottinghamshire			
	Leicestershire, Rutland and Northamptonshire			
	Lincolnshire			
	Herefordshire, Worcestershire and Warwickshire			
	Shropshire and Staffordshire			
	West Midlands			
	East Anglia			
	Bedfordshire and Hertfordshire			
	Essex			
	Inner London — West			
	Inner London — East			
	Outer London — East and North East			
	Outer London — South			
	Outer London — West and North West			
	Berkshire, Buckinghamshire and Oxfordshire			
	Surrey, East and West Sussex			
	Hampshire and Isle of Wight			
	Kent			
	Gloucestershire, Wiltshire and Bristol/Bath area			
	Dorset and Somerset			
	Cornwall and Isles of Scilly			
	Devon			
	West Wales and The Valleys			
	East Wales			
	North Eastern Scotland			
	Highlands and Islands			
	Eastern Scotland			
	West Central Scotland			
	Southern Scotland			
	Northern Ireland			





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Annex II: Indicative results from the TobeReal Questionnaires

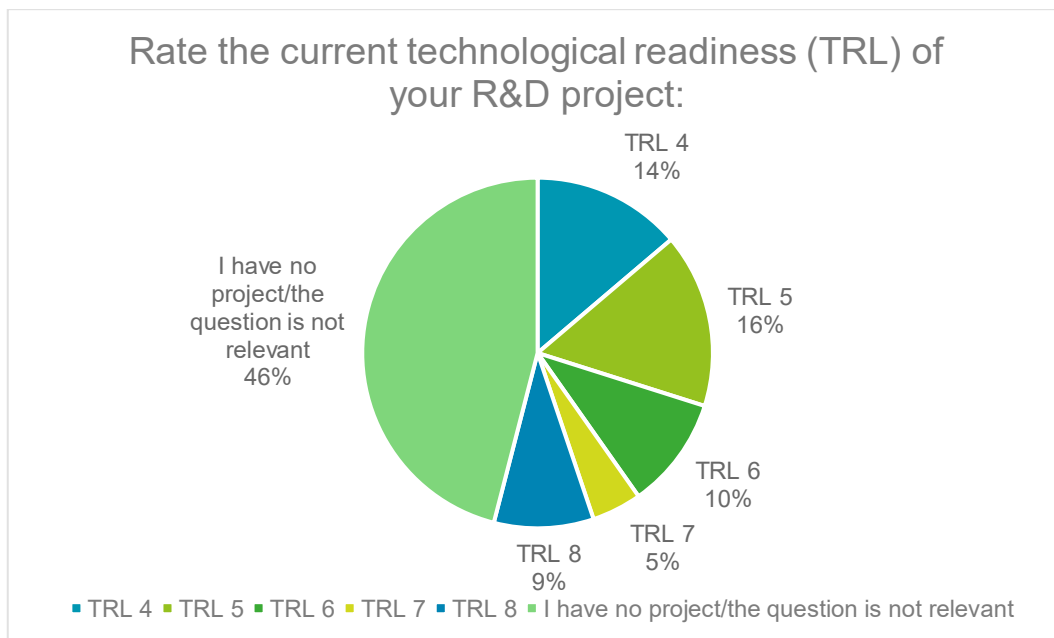


Figure 1

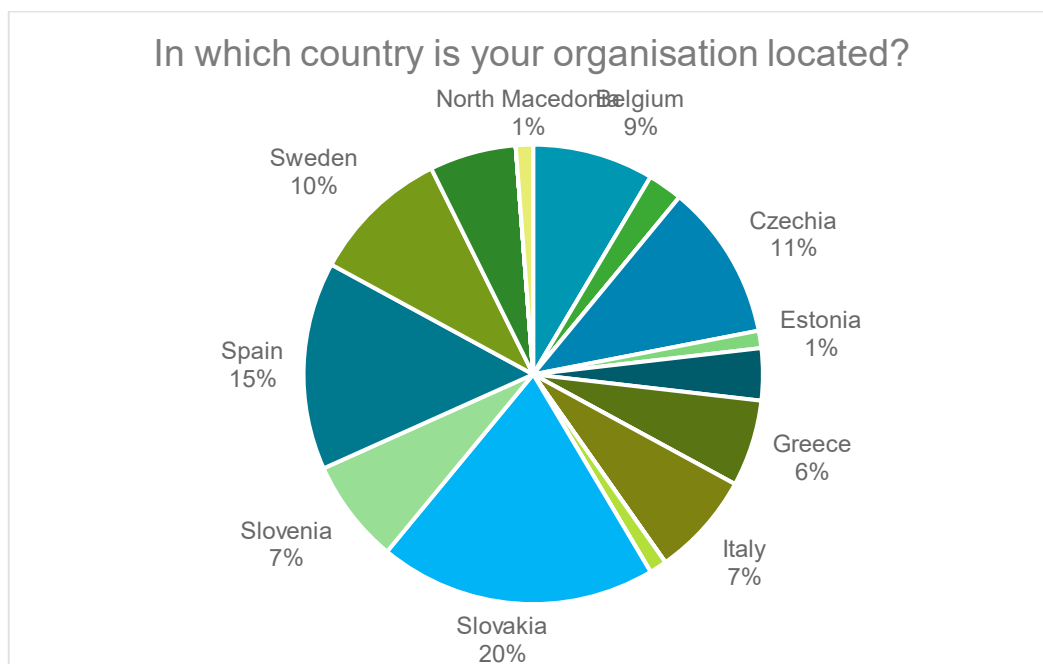


Figure 2





Figure 3

