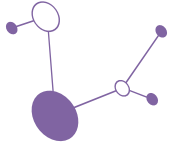


New Methodology for Strengthening Value Chain Development





Deliverable	D.1.5.3
Output	O1.1 – New Methodology for Strengthening Value Chain Development
Coordinating Partner	PP4-CCB – Chemie-Cluster Bayern GmbH
Output Indicator	RCO116_2.3 – Jointly developed solutions
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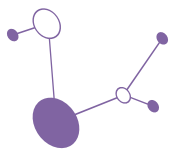
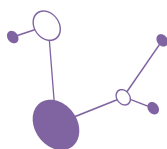
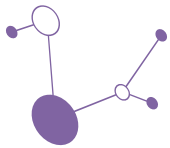


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1. INTRODUCTION

1.1 Description of the Document

The TeBiCE project - Territorial Biorefineries for Circular Economy - was established to demonstrate how regions across Central Europe can systematically transform underutilised biomass by-products and agri-food waste into viable circular value chains. Co-funded under Interreg Central Europe 2021-2027 (Specific Objective SO2.3), the project brought together nine project partners from six countries: Italy, Slovenia, Germany, Poland, Austria and Slovakia.

This Deliverable 1.5.3 presents the final version of the Methodology for Strengthening Value Chain Development. It constitutes the concluding step of Activity 1.5 and represents the completion of an iterative development and validation process conducted jointly by all TeBiCE partners.

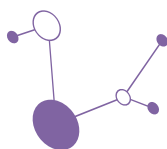
Further information about the TeBiCE project - including partner profiles, pilot action results, project deliverables, and news - is available on the official project website:

<https://www.interreg-central.eu/projects/tebice/>

1.2 Objective of the Document

Central Europe generates significant volumes of biomass from primary production and agri-food processing sectors that remain largely underutilised. This is not primarily a technical problem - valorisation options exist for most streams. The core challenge is one of fragmented information and structural barriers. Companies lack practical tools to identify suitable valorisation technologies, to compare alternative chain configurations on consistent criteria, and to connect with potential partners across regional and national borders. The creation of circular value chains is further hindered by technological barriers, market barriers, regulatory barriers, and cultural barriers.

The Methodology for Strengthening Value Chain Development is a transnational, data-driven decision-support framework enabling business support agencies and companies —



in particular, SMEs in the primary production and agri-food processing sectors – to identify, assess and pursue circular value chains from such underutilized by-products and waste.

The TeBiCE project (2019-2024) developed and evaluated this framework with fifteen pilot actions across six countries to design and launch circular value chains.

This guide shares that methodology and implications for implementation.

Note on software-based operationalization and tool independence

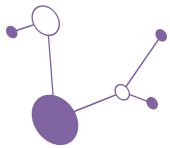
During the TeBiCE project, parts of the methodology were operationalized with the support of the Value Chain Generator (VCG), a digital matching platform developed in the predecessor project AlpLinkBioEco. The VCG provided a structured interface for entering biomass stream data, querying technology matches, and generating candidate value chain configurations. Its use in the early analytical phases contributed to the systematic, data-driven approach that is documented in this guide.

The present guide describes the methodology as it was implemented across TeBiCE partner regions – in a form that is fully independent of the VCG or any other proprietary software tool, and directly replicable using standard analytical and facilitation capabilities.

Organizations applying this methodology are not required to use any specific software. All steps can be carried out with standard tools (e.g., spreadsheets, database applications, GIS). Where available, purpose-built digital solutions may support individual steps – in particular biomass data collection and assessment, technology matching, and scenario modelling – and their use is encouraged where it adds efficiency and rigor. Any such tool should be evaluated against the methodological criteria set out in this guide.

1.3 Target Audience

The Methodology for Strengthening Value Chain Development provides a practical framework for facilitators - clusters, business support organisations (BSOs), regional development agencies and research institutions - who accompany companies through the value chain development process. It also provides reference material for the companies themselves and for policy actors seeking to understand what conditions enable or hinder circular bioeconomy transitions:



- **Small and Medium-Sized Enterprises (SMEs):** For organizations that produce or process agricultural and agri-food by-products, this guide provides a structured methodology for systematic evaluation.
- **Business Support Organizations (BSOs),** regional development agencies, Clusters and other facilitators who accompany companies through the value chain development process. It also provides reference material for the companies themselves and for policy actors seeking to understand what conditions enable or hinder circular bioeconomy transitions. This guide outlines dialogue structuring approaches, tool applications, and evidence-based interventions for common implementation challenges.
- **Policy Decision-Makers:** This guide documents factors that enable or constrain circular economy development. Use it to inform standards, incentives, and regulatory clarity.

2. CONCEPTUAL FRAMEWORK

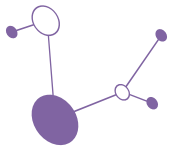
2.1 Analytical Pillars

The methodology rests on three analytical pillars that together constitute the transnational knowledge base underpinning all subsequent analytical steps. Each pillar was jointly developed by the full TeBiCE partnership, drawing on regional expertise from six countries:

■ **Pillar 1: Biomass Characterization**

Regional and transnational datasets on by-products and waste from primary production and agri-food processing, characterised at compound level: quantities, seasonality, physic-chemical composition, current management route, and the producing actors. For supply-side users, this pillar answers: what do I have? For demand-side users, it answers: what is available in my territory that could serve as feedstock for my process?

■ **Pillar 2: Technology Assessment**



A benchmarked catalogue of processing technologies applicable to the biomass streams in scope, assessed using Material Flow Analysis (MFA), Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) indicators, and classified by Technology Readiness Level (TRL). This pillar identifies which technologies can convert a given stream and maps which streams are compatible with an existing technology – and under what process conditions.

■ Pillar 3: Market Readiness Assessment

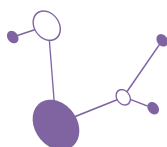
A transnational assessment of market demand for products derivable from biomass streams, covering demand sources, price dynamics, relevant drivers and barriers, and a PESTEL analysis of the market environment. This pillar identifies where the market is and informs the pricing and competitive position of a product produced from selected feedstocks.

These three pillars were populated through the coordinated efforts of all partner organisations, each contributing regional biomass data, technology benchmarks, and market intelligence for their respective territories. The result is a transnational knowledge base that enables both regional application and cross-border comparison.

2.2 Compound-Level Biomass Analysis

The single most important methodological innovation of the TeBiCE approach is the treatment of residual biomass at compound level rather than at product level. Conventional approaches categorise by-products generically - 'apple pomace', 'dairy whey', 'hemp shive' - and match them to an equally generic set of valorisation uses. This product-level framing systematically underestimates the valorisation potential of most biomass streams.

The TeBiCE methodology instead characterises each biomass stream in terms of its constituent chemical compounds: pectin, polyphenols, organic acids, proteins, lignocellulosic fractions, fatty acids, minerals, and so on. This compound-level characterisation has two decisive consequences:

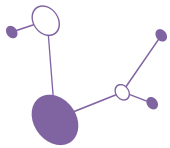


- It expands the set of valorisation options identified. A residue characterised as 'apple pomace' may have two or three obvious uses. Characterised as a source of pectin (food-grade gelling agent), quercetin and chlorogenic acid (nutraceuticals), dietary fibre (functional food ingredient), and organic acids (fermentation substrates), the same stream may match with ten or more potential downstream industries.
- It enables more precise matching between biomass supply and market demand. When both supply and demand are described at compound level, the matching procedure can identify partners and chain configurations that product-level analysis would miss entirely.

2.3 Multi-Criteria Sustainability Assessment Framework

The methodology integrates technical, environmental, economic and social evaluation criteria into a single sustainability assessment framework. This is not a sequential exercise - the criteria are applied in parallel across the analytical pillars and throughout the implementation phases. The framework comprises four assessment dimensions:

Assessment dimension	Methods and indicators applied
Technical	Technology Readiness Level (TRL 1-9); material efficiency (yield per unit of input); scalability to available volumes; compatibility with existing infrastructure.
Environmental	Material Flow Analysis (MFA): mass balances tracking material flows and losses across the value chain; Life Cycle Assessment (LCA): carbon footprint, primary energy demand, water consumption, and waste generation across the full life cycle; comparison with baseline (current disposal route).
Economic	Life Cycle Costing (LCC): capital expenditure (CAPEX) and operating costs (OPEX) over the operational lifetime; revenue projections based on target product price and volume; added



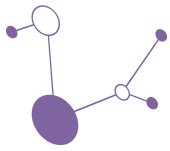
	value ratio (product value relative to input cost); sensitivity analysis on key assumptions.
Social	Stakeholder analysis: employment effects, community engagement, equity of value distribution across chain actors; alignment with UN Sustainable Development Goals.

The combination of MFA, LCA, and LCC in Pillar 2 ensures that the technology catalogue provides a standardized, comparable basis for evaluating alternative chain configurations. MFA quantifies material efficiency at each process stage and identifies where losses occur. LCA places these material flows in a life-cycle environmental context. LCC translates the physical flows into cost structures. Together, they enable a comparison of chain configurations that are simultaneously rigorous on environmental and economic grounds.

Why all four dimensions are required

Focusing on economic criteria alone produces value chains that may be profitable but environmentally counterproductive or socially inequitable. Focusing on LCA alone may favor chains that are environmentally optimal but economically unviable at the available scale. The TeBiCE multi-criteria framework reflects the programme objective (SO2.3 - Taking circular economy forward in Central Europe): value chains must be circular, sustainable, and economically viable.

In practice, the framework does not require a full quantitative assessment of all four dimensions at every stage. Phase 1 operates with qualitative or indicative data; the full quantitative assessment is the domain of Phase 4 (pre-feasibility studies).



2.4 Four-Phase Implementation Process

The three pillars provide the knowledge base. The four-phase process describes how that knowledge base is built, how companies are selected and engaged, and how the methodology is applied to produce actionable value chain proposals.

PHASE 1 | Territorial Knowledge Base

Build the three analytical pillars for the territory: biomass potential assessment at compound level, technology benchmarking using MFA/LCA/LCC, market readiness analysis, and transnational actor matching. Output: ranked priority value chains with identified supply, technology and demand conditions.

PHASE 2 | Company Selection and Engagement

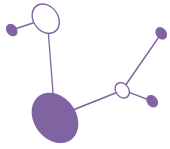
Identify and rank companies whose by-product streams align with the priority chains. Formalize their participation and establish the working relationship needed for Phase 3 data collection. Output: committed pilot companies with signed participation declarations.

PHASE 3 | Pilot Implementation and Current State Analysis

Collect primary data from pilot companies. Characterize current by-product management. Identify and categorize bottlenecks. Validate findings against existing virtuous chains (Activity 1.6). Output: evidence-based assessment of valorization potential, barriers, and validated chain configurations.

PHASE 4 | Feasibility Assessment

Develop technological scenarios, apply the Triple-Layered Business Model Canvas, and conduct pre-feasibility studies for the highest-potential chains. Facilitate preliminary chain agreements between interested actors. Output: Go/No-Go decision basis and, where applicable, signed preliminary chain agreements.



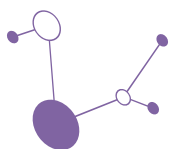
The phases are sequential in design but iterative in practice. Insights from Phase 3 frequently require revisiting Phase 1 conclusions. Phase 4 feasibility findings may require reconfiguring the chain options considered in Phase 3.

2.5 How to use this Guide

The guide follows the four phases. Each phase chapter contains: a description of the purpose and sequence of activities; practical guidance for facilitators and for companies; structured decision tools (checklists, matrices, templates); common pitfalls from TeBiCE implementation experience; and references to relevant TeBiCE deliverables.

Further information about the TeBiCE project - including partner profiles, pilot action results, project deliverables, and news - is available on the official project website:

<https://www.interreg-central.eu/projects/tebice/>



3. PHASE 1 - TERRITORIAL KNOWLEDGE BASE

Phase 1 constructs the three analytical pillars for the territory in question. It produces a ranked shortlist of priority value chains and a preliminary map of the key actors who would need to participate in those chains. This knowledge base directly guides all subsequent phases.

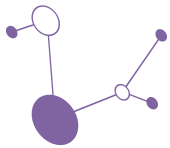
3.1 Step 1: Define the Scope of Investigation

The first step establishes which sectors, by-product categories and geographic area are in scope for the analysis. The methodology accommodates distinct starting positions:

Entry point	Starting condition and direction of search
Supply-side	A company, sector or region generates by-products or waste streams and seeks valorization options. The analysis starts from Pillar 1 (what streams are available) and moves toward Pillar 3 (where market demand is and what products can be sold). The question is: what can be made from what we have, and who needs it?
Demand-side	A company holds a processing technology, a product formulation, or a production process that requires residual biomass as a secondary raw material input. The analysis starts with the feedstock specification and moves into Pillar 1 (which regional by-products or waste streams meet those specifications) and Pillar 2 (whether those streams are technically compatible). The question is: what can we source regionally, from which suppliers, and does it meet our process requirements?

Both entry points use the same pillars and the same four phases. The difference lies in the direction of search through the pillar data. In many applications, both entry points are active simultaneously: the facilitator identifies supply-side companies with surplus streams and demand-side companies with compatible processing technologies, which can be connected through the matching procedure.

Once the entry point is established, define the scope of the analysis. For supply-side entries, identify at least three by-product or waste streams from the relevant sectors. For demand-side entries, specify the feedstock requirements of the technology or process in scope. For each stream or requirement, determine:



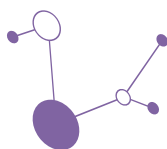
- Whether a value chain already exists (improvement scenario) or must be newly developed (new chain scenario). In the improvement scenario, the assessment focuses on the differential between current practice and the proposed change.
- At which tiers the assessment will be conducted: at production sites, at potential processing sites, and/or at potential end-use sites.
- Whether a transnational dimension is relevant: are similar streams available in partner regions, and would aggregation across territories help reach critical mass?

3.2 Step 2: Biomass characterization

For each identified stream, apply the scoring matrix applied in *D.1.2.3 Report on existing state-of-the-art value chains in target Central Europe* available on the project website to assess its economic and environmental valorization potential. The matrix applies eleven weighted criteria and produces a comparative score enabling benchmarking across streams and, where applicable, across regions.

The following data must be collected or can be sourced from D.1.2.3 where applicable:

- Chemical composition at compound level: identify the specific valuable compounds present (e.g. pectin, flavonoids, proteins, lignocellulose fractions, fatty acids, organic acids). Do not characterise by-products only at the product category level.
- Available quantities: annual volumes (t/year) at territorial level, derived from production statistics or direct company surveys.
- Supply continuity: whether production is continuous, seasonal, cyclical or occasional. Specify the relevant period.
- Current fate: current management route and associated economic outcome (disposal cost, low-value sale price, or existing valorisation income).
- Actor landscape at territorial level: which companies produce the stream, in which localities, and in what quantities.



The compound-level characterization should be carried out analogously and with the support of the TeBiCE dataset. For streams not yet covered, reference compositions from comparable streams in D.1.2.3 may be used as proxies at screening stage. Direct analytical data should be obtained for any stream that advances to Phase 4.

Biomass potential assessment - readiness checklist

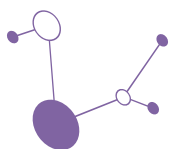
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| ☐ | Scope defined: at least three by-product/waste streams identified |
| ☐ | Sector and production process documented for each stream |
| ☐ | Annual volumes estimated or sourced from D.1.2.3 |
| ☐ | Supply continuity characterized (monthly or quarterly profile) |
| ☐ | Chemical composition at compound level documented or referenced |
| ☐ | Current disposal route and associated cost/income documented |
| ☐ | Actor landscape (producers, current processors, potential end-users) mapped |
| ☐ | Scoring matrix completed and streams ranked |

3.3 STEP 3: Technology Assessment

For each high-ranking stream, catalogue the valorization technologies applicable to the proposed conversion pathway and benchmark them using the multi-criteria sustainability assessment framework (Section 2.3).

Each technology should be assessed against three analytical tools:

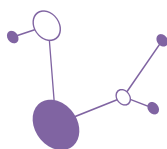
- **Material Flow Analysis (MFA):** Construct a mass balance for the conversion pathway. Map all input flows (feedstock, water, energy carriers, auxiliary materials) and output flows (target product, by-products, waste streams,



emissions). Identify the material efficiency coefficient (kg of target product per kg of feedstock input). MFA at this stage can be simplified to the key input/output flows; a full quantitative MFA is part of Phase 4.

- **Life Cycle Assessment (LCA):** Apply LCA indicators to each candidate technology. Key indicators: carbon footprint (CO₂-eq per functional unit), primary energy demand (MJ per functional unit), and material efficiency. These indicators provide the environmental basis for comparing value chains and for establishing the environmental benefit relative to the current disposal baseline.
- **Life Cycle Costing (LCC):** Assess CAPEX and OPEX ranges for each technology at the scale relevant to the available territorial volumes. The Technology Readiness Level (TRL) provides a proxy for cost uncertainty: TRL 7-9 technologies have more reliable cost data; TRL 4-6 technologies carry higher uncertainty and should be assessed with wider ranges.

Assessment criterion	Relevant question and data source
TRL (1-9)	Is the technology proven at commercial scale (TRL 7-9) or in development (TRL 4-6)?
MFA: material efficiency	What fraction of input biomass is converted to target product? Where are the main losses?
LCA: carbon footprint	What are the net GHG emissions (or savings) vs. current baseline?
LCA: energy demand	What is the primary energy demand per unit of output? Is waste heat recovery feasible?
LCC: CAPEX range	What is the indicative capital investment at the relevant production scale?
LCC: OPEX structure	What are the key operating cost drivers (feedstock, energy, labor, waste)? (→ D.1.3.1, D.2.4.1)



Scalability	Can the technology handle available territorial volumes? What is minimum viable scale? (→ D.1.2.3)
By-product management	Does the technology generate secondary waste streams? How are they managed? (→ D.1.3.1)

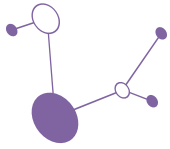
3.4 STEP 4: Market Readiness Analysis

A technically feasible chain is only viable if there is genuine market demand for its products at a price that sustains the chain economics. Step 4 characterizes the market environment based on the transnational market readiness assessment in D.1.4.1 and the market foresight report in D.3.1.2 of the TeBiCE project. The analysis covers demand sources, price dynamics, barriers and drivers. A PESTEL analysis (Political, Economic, Social, Technological, Environmental, Legal) provides the organizing framework:

- Demand sources: which industries currently purchase or could purchase products derivable from the stream, at what volumes and under what quality conditions.
- Price dynamics: market prices for target products and their relationship to virgin material equivalents. Secondary materials typically trade at a discount; the magnitude of that discount is a key variable in the chain economics.
- Policy drivers: EU Circular Economy Action Plan, national bioeconomy strategies, End-of-Waste criteria, public procurement requirements, and available financial support instruments.
- Barriers: regulatory complexity (waste classification, cross-border rules), market concentration, consumer acceptance, competing substitutes. Distinguish structural barriers (requiring policy intervention over multi-year timelines) from situational barriers (resolvable operationally within the pilot).

3.5 STEP 5: Actor Matching

Steps 2-4 generate the three-pillar knowledge base for the territory: available biomass streams at compound level (Pillar 1), benchmarked conversion technologies (Pillar 2), and market conditions



for derivable products (Pillar 3). Step 5 applies a structured matching procedure that cross-references these pillars in both directions to identify viable value chain configurations and the actors needed to realize them.

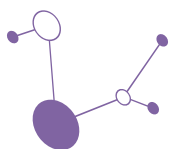
The matching procedure runs along two parallel paths that converge on the same output: a set of candidate value chain configurations, each with an identified supply actor, a technology pathway, and a market or demand actor.

Path A - Forward matching (supply-side)

1. Compound-level supply screening: For each by-product stream in Pillar 1, identify its constituent compounds (e.g. pectin, polyphenols, proteins, lignocellulose fractions). For each compound, identify from Pillar 3 the downstream industries, products and demand actors that use or could use that compound as a raw material. This produces a matrix of supply-demand pairings at compound level, which is systematically broader than a product-level matrix.
2. Technology filtering (forward): For each supply-demand pairing, identify from Pillar 2 the conversion technologies that could perform the required transformation. Filter by TRL (minimum TRL 5 for pilot candidates), material efficiency (MFA), and LCA/LCC indicators. Retain only pairings for which a technically viable and economically plausible conversion pathway exists.
3. Demand-side actor identification: For each viable pairing, identify the concrete demand-side actors: companies or industries that purchase or process the target compound or product. Cross-reference with market data and partner networks. Document their volume requirements, quality specifications, and indicative price ranges.

Path B - Reverse matching (demand-side)

1. Feedstock specification: The starting point is a technology, process, or product formulation that requires a secondary raw material. Define the feedstock specification at compound level: which compounds are needed, at what minimum purity or concentration, in what annual volumes, with what seasonality tolerance, and under what logistical constraints (e.g. maximum transport distance, required pre-treatment state).
2. Supply-side screening in Pillar 1: Search the Pillar 1 biomass dataset for streams whose compound-level profile matches the feedstock specification. For each candidate stream, document: the producing companies and their geographic location, available volumes and

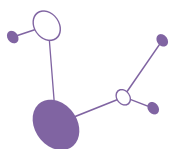


their seasonal distribution, and the current management route (which determines the likely supply price). Where no match is found in the regional dataset, extend the search to transnational partner territories using D.1.2.3 data.

3. Technology compatibility check: Verify from Pillar 2 whether the conversion technology already held by the demand-side company is compatible with the identified supply streams, or whether pre-treatment steps are required. Identify any gap between the current state of the feedstock (as generated by the supplier) and the input specification of the technology. Document whether that gap is bridgeable by pre-treatment (logistical/operational solution) or requires technology adaptation (investment).

The two paths are not mutually exclusive. In the most productive applications, the matching procedure runs both simultaneously and identifies chain configurations where a supply-side actor and a demand-side actor are compatible - companies that hold, respectively, the stream and the process, but have not previously connected. The facilitator's role is to make this connection visible and to provide analytical evidence that motivates both parties to engage.

Output element	Supply and demand side perspective
Primary question	Supply: What can we valorize from our by-product stream, and to whom? Demand: What regional feedstock streams can our process or technology use?
Starting point in pillars	Supply: Pillar 1 (supply) → Pillar 2 (technology) → Pillar 3 (demand) Demand: Pillar 2 (technology need) → Pillar 1 (compatible supply) → Pillar 3 (product market)
Pillar 1 output	Supply: What compounds are in our stream? What downstream applications exist? Demand: Which regional producers have streams matching our feedstock specification?
Pillar 2 output	Supply: Which technologies can convert our stream to target products?



	Demand: Is our existing technology compatible with the available side streams?
Pillar 3 output	Supply: Where is the market for the products we could make? Demand: What is the market value of the products we would produce from this feedstock?
Actor identified	Supply: buyers, processors, downstream industries Demand: by-product producers, waste generators in territory

Transnational matching

The transnational dimension of TeBiCE is a methodological asset. Where regional biomass volumes are insufficient to reach critical mass for a given conversion pathway, aggregation with similar streams in partner regions may make the chain viable. Where processing technology is not available in the territory, a transnational supply arrangement (or a regional technology investment plan) may be more practical than foregoing the chain entirely.

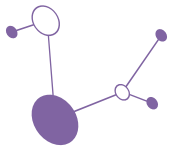
Facilitators should document which chain configurations are viable at regional level and which require transnational cooperation. This distinction is relevant both for Phase 2 company selection and for the policy interface activities of WP3.

3.6 STEP 6: Validation against Existing Virtuous Chains

Before finalizing the Phase 1 chain selection, the identified configurations are validated against existing commercially operational chains that successfully valorize comparable biomass streams. This iterative validation step serves two purposes: it tests the realism of the simulated configurations, and it identifies best practices that can be directly incorporated.

The validation procedure involves:

- Identification of virtuous chains: For each priority configuration, identify one or more existing commercial chains that valorize the same or a comparable biomass stream using the same or a closely related conversion pathway. Sources include *the Book of Good Examples* (D.2.6.1), and partner networks.

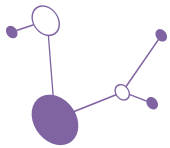


- **Structural comparison:** Compare the simulated configuration with the virtuous chain on the following parameters: biomass input volumes and composition, conversion technology and TRL, material efficiency (MFA), product portfolio and price positioning, actor structure and governance model, and regulatory requirements. Identify where the simulated configuration departs from the virtuous chain and assess whether those departures are improvements, neutral differences, or risk factors.
- **Feedback integration:** Where the comparison reveals unrealistic assumptions in the simulated configuration (e.g. overestimated yields, underestimated CAPEX, inaccessible end markets), revise the configuration before proceeding to Phase 2. Where the virtuous chain reveals a better or more efficient approach to the same valorisation objective, incorporate that learning.

The validation step is iterative: as pilot data from Phase 3 becomes available, the comparison with virtuous chains can be updated to reflect real-world performance rather than modelled estimates. This integration of pilot feedback into the methodology is explicitly described in the O1.1 output definition as a defining innovative element.

Output of Phase 1

A ranked shortlist of priority value chain configurations for the territory, each supported by: Pillar 1 (biomass supply at compound level), Pillar 2 (technology options with MFA/LCA/LCC benchmarks), Pillar 3 (market readiness and actor landscape), validated against at least one comparable virtuous chain. The shortlist feeds directly into Phase 2 company selection.



4. PHASE 2 - COMPANY SELECTION AND ENGAGEMENT

Phase 1 identifies which value chains are most promising for the territory. Phase 2 identifies which companies are most suitable to engage as pilot actors in those chains, formalizes their participation, and establishes the working relationship needed for Phase 3 data collection.

4.1 Selection Criteria and Ranking

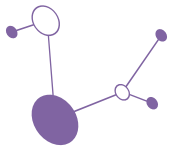
Two distinct actor types are suitable for engagement as pilot companies: supply-side actors (primary producers and agri-food processors generating by-product or residual biomass streams) and demand-side actors (companies with existing processing technologies or innovations seeking upstream feedstock or residual biomass as a production input). Both actor types may participate as pilots, and where feasible, at least one of each should be engaged per partner region to allow end-to-end chain verification.

For supply-side actors, company selection is governed by the following criteria:

- **By-product availability:** Does the company generate one of the priority streams identified in Phase 1? In what volumes? With what supply continuity? Companies whose streams match the compound-level profile of priority configurations are ranked highest.
- **Sustainability potential:** Does the current management of the by-product represent a meaningful improvement opportunity in economic or environmental terms? Companies currently paying for disposal or receiving negligible income from high-value streams are priority candidates.

For demand-side actors (technology holders and processors seeking biomass input), selection is governed by an analogous set of criteria:

- **Feedstock need and process readiness:** Does the company have an operational or near-commercial technology that requires a specific biomass fraction or compound as input? Is the process sufficiently mature ($TRL \geq 5$) that supply sourcing is the primary constraint?



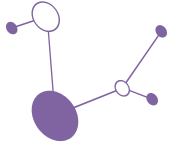
- **Regional sourcing potential:** Does the Phase 1 territorial knowledge base indicate that the required feedstock type exists within reach of the company? A mismatch between feedstock demand and available supply disqualifies a candidate at this stage.
- **Supply chain leverage:** Is the company of sufficient scale or sectoral significance that its successful integration as a demand-side actor would activate or stimulate supply-side actors (producers, collectors, pre-processors) in the region?

Additional considerations include: the company's capacity to participate (time, personnel, data availability), openness to external collaboration, and the absence of state aid constraints that would prevent the provision of support services. Coordination with the company selection processes of other partner regions is recommended to avoid duplication and to enable transnational matching where relevant.

4.2 Engagement Workflow

TeBiCE experience demonstrates that trust is the precondition for data sharing, and data sharing is the precondition for meaningful analysis. The engagement workflow is designed accordingly:

1. Initial contact and project introduction. Explain the TeBiCE methodology and the specific benefits of participation. Clarify that the company receives a structured analysis of its by-product situation as a value-added service. Identify the most effective contact person: a technical profile (agronomist, environmental or sustainability specialist, process engineer, R&D professional) or senior manager.
2. SME readiness survey. Circulate a brief questionnaire to assess the company's current circular economy awareness, willingness to collaborate, and perceived barriers. This also creates a baseline for measuring the methodology's impact.
3. Presentation of Phase 1 findings. Present the territorial value chain analysis in terms directly relevant to the company's sector and by-product streams. Make the connection between the transnational evidence base and the company's specific situation concrete.
4. Formalization of participation. Once sufficient interest is confirmed, conclude a participation declaration establishing the terms of engagement, data confidentiality arrangements, and the expected working schedule.



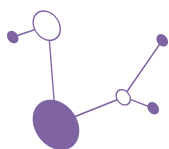
5. Establishment of a regular working rhythm. Agree on periodic meetings - in-person where possible - to maintain engagement, collect data, and provide ongoing technical support. Monthly contact during the active data collection phase is recommended minimum.

State aid

Activity 2.2 is a state aid-relevant activity. Partners providing technical support services to companies for which a market exists must ensure compliance with applicable state aid rules before beginning. Obtain legal confirmation at the outset of Phase 2.

Company engagement - formalization checklist

- | | |
|--------------------------|--|
| ☐ | Company identified and eligibility against selection criteria confirmed |
| ☐ | Key contact person identified (technical or senior management level) |
| ☐ | SME readiness survey completed |
| ☐ | Phase 1 findings presented in company-relevant terms |
| ☐ | Participation declaration signed; data confidentiality agreed |
| ☐ | State aid eligibility confirmed |
| ☐ | Working meeting schedule agreed (minimum monthly during data collection) |



5. PHASE 3 - PILOT IMPLEMENTATION AND CURRENT STATE ANALYSIS

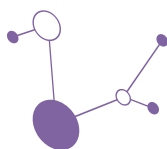
Phase 3 collects primary data from the pilot companies, characterizes current by-product management practices, and identifies the barriers that prevent or constrain valorization. It also integrates pilot findings with the Phase 1 analysis, updating the chain configurations considering real-world data.

5.1 Data Collection Methodology

A structured data collection checklist guides the information-gathering process. The checklist is differentiated by actor type. For supply-side actors, the focus is on characterizing the by-product stream and current management practice. For demand-side actors, the focus is on characterizing feedstock requirements and process compatibility. Both checklists share a common core on company profile, regulatory context, and investment signals.

Supply-side data collection checklist:

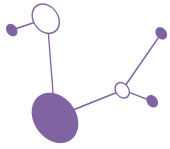
Category	Data collected
Company and operational unit	Size, sector, location, production volumes, key processes generating by-products
By-product streams	Types, quantities (t/year or kg per ton of primary product), seasonal availability profile, current management route
Compound-level composition	Specific chemical constituents; if not directly measured, reference proxy data (e.g. D.1.2.3) and document assumption
Economic data	Current disposal or sale income/cost per ton; logistics costs; any existing valorization contracts
Regulatory constraints	Applicable waste classification; permits held; country-specific requirements for valorization



Actor relationships	Existing upstream and downstream relationships; openness to new partnerships
Investment signals	Indicative willingness to invest; available co-financing; existing infrastructure

Demand-side data collection checklist:

Category	Data collected
Company and technology profile	Size, sector, location; description of the conversion process or innovation; current production scale and TRL; existing feedstock sourcing arrangements
Feedstock specifications	Target biomass fraction or compound (e.g. lignocellulose, pectin, plant proteins); required purity, moisture content, particle size, and absence-of-contamination standards; acceptable feedstock forms (fresh, dried, pre-processed)
Volume and continuity requirements	Annual feedstock demand (t/year); minimum batch size; required supply continuity and tolerance for seasonal variation; maximum acceptable distance from source to processing site
Process compatibility constraints	Critical parameters: pH sensitivity, heavy metal thresholds, presence of inhibitors, microbiological standards; pre-treatment steps the company can perform vs. must receive pre-treated
Economic parameters	Maximum acceptable feedstock cost (€/ton) at delivery point; indicative product value and margin to determine feedstock budget; any existing off-take agreements that define price benchmarks
Regulatory and certification requirements	Required input certifications (e.g. organic, food-grade, ISCC); country-specific import or transport restrictions for biomass materials; relevant end-product quality standards



Investment signals	Capacity for upstream investment or co-financing of collection/pre-processing infrastructure; interest in long-term supply partnerships or preliminary chain agreements
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Data collection should combine direct dialogue with company representatives, document review (sustainability reports, procurement records, process specifications), and at least one site visit. Quantitative data should be cross-checked against reference figures and technology profiles of the territorial knowledge base developed in phase 1 to confirm that characterized regional streams fall within the company's acceptable input range. All data must be treated as confidential in accordance with the participation declaration.

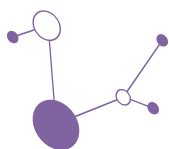
5.2 Current By-Product Management Assessment

The primary analytical output of Phase 3 is a characterization of how the by-product or waste streams are currently managed and an assessment of the gap between current practice and the valorization potential identified in Phase 1. The assessment documents:

- Actual composition and quantity of each stream, including seasonal variation and inter-annual variability.
- Current economic outcome: disposal cost, low-value sale, or established valorisation income.
- Environmental outcome of current practice: GHG emissions, landfill burden, resource losses.
- Any partial or existing valorisation efforts and their effectiveness.
- The company's own assessment of the primary constraints.

This assessment is also the basis for calculating the environmental and economic improvement potential that the proposed chain configurations would deliver relative to the baseline. This baseline comparison is required for the LCA and LCC components of Phase 4.

5.3 BOTTLENECK Identification and Categorisation



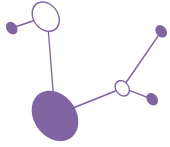
Systematic bottleneck identification is essential to realistic phase planning. The TeBiCE bottleneck analysis identified four constraint categories, which consistently co-occurred across pilot territories:

Category	Key constraints observed across TeBiCE pilots
Logistical	Perishability requires rapid processing; inadequate storage infrastructure; geographical scattering of producers; mismatch between supply continuity and processing schedules; high transport costs for wet or low-density biomass.
Regulatory	Ambiguity in waste/by-product classification; limiting or absence of applicable End-of-Waste criteria; lack of harmonized standards for cross-border valorization; absence of inter-professional coordination mechanisms.
Economic	Competition from low-cost disposal routes (energy recovery, landfill); uncertain market value; high upfront investment; limited access to public finance for small producers or early-stage innovations.
Technical	Limited availability of proven technologies for specific biomass types; insufficient local technical expertise; process complexity; yield uncertainty for novel conversion pathways.

Bottlenecks should be categorized as structural (requiring policy-level responses and multi-year timelines) or situational (addressable operationally within the pilot). This distinction directly influences the chain configurations selected for Phase 4 and the recommendations made to policy actors.

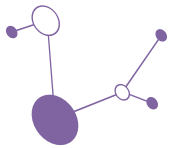
5.4 Validation Update

As Phase 3 primary data becomes available, the comparison with virtuous chains initiated in Phase 1 (Step 6) should be updated. Actual company data on volumes, composition, and current costs replace the modelled estimates used in Phase 1. Where the updated comparison reveals significant divergences from the Phase 1 assessment, the chain configuration and the shortlist of priority options should be revised accordingly before committing to Phase 4 investments.



Phase 3 - data and analysis completeness checklist

- | | |
|--------------------------|---|
| ☐ | All major by-product streams identified and volumes documented |
| ☐ | Compound-level composition documented or referenced from D.1.2.3 |
| ☐ | Seasonal availability profile mapped (monthly or quarterly) |
| ☐ | Current disposal route and economic baseline documented |
| ☐ | Regulatory constraints for the territory identified |
| ☐ | Site visit conducted and operational observations recorded |
| ☐ | Bottlenecks identified and categorized (logistical / regulatory / economic / technical) |
| ☐ | Structural vs. situational bottlenecks distinguished |
| ☐ | Validation update: Phase 1 chain configurations revised using actual data |



6. PHASE 4 - FEASIBILITY ASSESSMENT

Phase 4 translates the combined analytical work of Phases 1-3 into a structured feasibility assessment of the highest-potential value chain configurations. It culminates in a Go/No-Go decision and, where the decision is affirmative, in a preliminary chain agreement between the relevant actors.

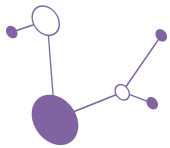
6.1 Technological Scenario Development

A technological scenario is a detailed process description that provides the technical specification for the MFA and LCA/LCC assessment. Each scenario covers:

- Input by-product: type, composition at compound level, volume, and seasonal availability.
- Conversion pathway: the sequence of unit processes (pre-treatment, extraction, separation, conversion, finishing), described with process conditions, equipment type, and key operating parameters.
- Mass balance (MFA basis): inputs, outputs, by-products and residues at each stage. Specify the material efficiency coefficient (kg target product per kg feedstock). Document where process losses occur and how secondary waste is managed.
- Energy balance: heating, cooling, and electrical energy requirements; recovery opportunities.
- Target product specifications: purity, form, packaging, TRL of the production process.

Scenarios should be based on existing process descriptions from scientific literature, technology providers, and comparable commercial examples. The facilitator prepares the technological scenario for its selected high-value chain. External technical expertise may be contracted where required.

6.2 Multi-Criteria Assessment: Triple-Layered Business Model Canvas

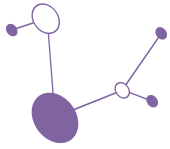


Each scenario is assessed using the Triple-Layered Business Model Canvas (TLBMC). The TLBMC provides a rapid, structured evaluation of the sustainability dimensions of the proposed business model innovation, identifying major risks or weaknesses in any of the three layers before committing to a full pre-feasibility study.

Layer	Focus and key sustainability questions
Economic layer	How does the innovation create, deliver and capture economic value? Key variables: value proposition, customer segments, revenue streams, cost structure, key partnerships. Does the business model generate sufficient surplus for all chain actors at the available scale?
Environmental layer	What environmental impacts and benefits does the innovation generate across its full life cycle? Drawing on the MFA (material efficiency) and LCA (carbon footprint, energy demand) from Step 3, assess net environmental performance relative to the current baseline. A formal full LCA is not required; alignment with ISO 14040/44 principles is recommended where data permit.
Social layer	What social value does the innovation generate? Apply a stakeholder perspective: who benefits, who bears risk, what employment and community effects arise? Alignment with UN Sustainable Development Goals should be noted. This layer often reveals social equity issues in value distribution that economic analysis alone misses.

The TLBMC must be completed with active company involvement. Their input is indispensable for the economic layer (actual cost and revenue data) and provides important grounding for the environmental and social layers.

TLBMC in TeBiCE



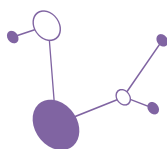
The reference academic text is Joyce and Paquin (2016), 'The triple layered business model canvas: A tool to design more sustainable business models.'

D.2.4.1 documents the TLBMC outputs for all TeBiCE pilot chains and serves as a reference for the expected level of detail and format.

6.3 Pre-Feasibility Study

The pre-feasibility study provides a techno-economic evaluation sufficient to support a Go/No-Go decision on proceeding to pilot investment. It builds directly on the technological scenario (Section 6.1) and is complementary to the TLBMC outputs (Section 6.2). Its outputs are:

- Full mass balance and energy balance, based on the technological scenario.
- CAPEX estimate (range): capital investment for equipment, infrastructure and commissioning.
- OPEX estimate (range): annual operating costs including feedstock, energy, labour, maintenance, and waste management.
- Revenue projection: estimated annual revenue based on product volume, market price, and assumed penetration rate. Include a comparison with the economic baseline (current by-product management cost/income).
- Environmental performance summary: net carbon footprint and material efficiency relative to the baseline, drawing on LCA indicators from Pillar 2 and the MFA developed in the technological scenario.
- Sensitivity analysis: model the impact of $\pm 20\%$ variation on the two or three assumptions that most affect the economic outcome (typically: feedstock cost, product price, and process yield).
- Go/No-Go recommendation: a structured conclusion with explicit reasoning. 'No-Go' decisions are valid and valuable outcomes - they prevent investment in non-viable configurations and generate documented learning for the territory.



Pre-feasibility study - output completeness checklist

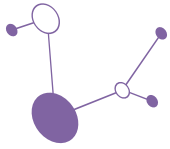
- | | |
|--------------------------|---|
| ☐ | Technological scenario documented and validated with pilot company |
| ☐ | TLBMC completed for all three layers; company input confirmed |
| ☐ | Full mass balance (MFA) and energy balance developed |
| ☐ | CAPEX and OPEX ranges estimated; data sources documented |
| ☐ | Revenue projection prepared; market price sources cited |
| ☐ | Environmental performance (LCA summary) relative to baseline documented |
| ☐ | Sensitivity analysis conducted for at least two key assumptions |
| ☐ | Go/No-Go recommendation documented with explicit reasoning |
| ☐ | Report shared with pilot company; company feedback recorded |

5.4 Preliminary Chain Agreements

Where the pre-feasibility study supports a Go decision, the facilitator moves to secure preliminary chain agreements between the relevant actors. A preliminary chain agreement is a formal expression of intent by two or more actors to proceed with the development of the identified value chain. It is not a binding commercial contract; it is a documented commitment that makes the pilot action credible and sustains partner engagement through the investment preparation phase.

A preliminary chain agreement should specify:

- The parties: biomass provider(s), processor(s), and end-buyer(s).
- The chain configuration: which biomass stream, which conversion pathway, which target product.

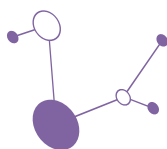


- The indicative volumes and timeline for the pilot phase.
- The conditions under which the parties would proceed to a binding commercial arrangement.
- The data sharing and confidentiality terms governing the collaboration.

The facilitator plays a central brokering role in securing these agreements: facilitating introductions, providing the analytical evidence from the pre-feasibility study as a shared reference, mediating on terms, and maintaining momentum through the often-extended negotiation period. TeBiCE experience indicates that the period from first actor introduction to a signed preliminary agreement may take several months.

Output of Phase 4

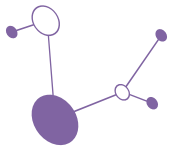
For each chain assessed: a Go/No-Go decision with documented reasoning, a completed pre-feasibility study, and - where the decision is affirmative - a signed preliminary chain agreement between the relevant actors.



6. CRITICAL SUCCESS FACTORS AND TRANSFERABILITY

6.1 Critical Success Factors

Critical success factor	Explanation
Committed facilitating organization	Phases 1-4 require sustained investment of time, expertise and relationship capital. Organizations with a primary mandate for industry support (clusters, BSOs, research centers) are better positioned than general-purpose public agencies.
Compound-level biomass data	The quality of the Phase 1 analysis depends directly on the depth of biomass characterization. Facilitators who invest in compound-level data - even for a subset of priority streams - generate significantly richer chain options and more credible pre-feasibility studies than those who work only at product level.
MFA/LCA/LCC rigor in technology assessment	Technology selection based solely on TRL, or cost estimates misses critical environmental trade-offs. The multi-criteria framework (MFA + LCA + LCC) is the basis on which chains can be compared and on which environmental claims can be substantiated to both investors and policy actors.
Early actor alignment	Chains initiated with the active engagement of key actors at both the supply and demand end from Phase 1 onwards are significantly more likely to reach a preliminary agreement. Facilitators should identify potential end-buyers and processors as early as Phase 1.
Realistic timeline expectations	From first company contact to a completed pre-feasibility study with a signed preliminary agreement: 12-18 months is realistic. Partners and companies should be informed of this at the outset to maintain commitment through the analytical phases.
Active policy interface	Where regulatory barriers are identified in Phase 3, facilitators should channel that evidence into policy interfaces. Pilots that identified structural barriers and documented them for policy purposes generated systemic

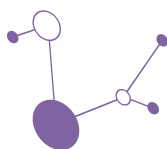


impact beyond the individual company. The policy interface is not a separate activity - it is integral to the methodology.

6.2 Transferability

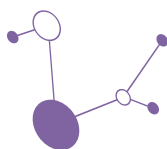
The methodology was developed and tested across six Central European countries, ten agri-food sectors, and more than fifteen pilot companies. This breadth provides a robust evidence base for transferability. Organizations outside the original programme area should note the following:

- The three-pillar framework and the four-phase process are fully transferable. The specific data content of D.1.2.3 and D.1.3.1 is TeBiCE-specific, but the framework for building equivalent datasets in other regions is fully transferable based on the information based in this guide and within the respective documents.
- The multi-criteria sustainability assessment framework (MFA/LCA/LCC/TLBMC) is a standard, internationally recognised set of methods. No proprietary tools are required.
- The compound-level biomass characterisation approach can be applied to any biomass-generating sector using standard analytical methods and publicly available reference databases.
- The regulatory impact analysis is specific to the six TeBiCE partner countries. Equivalent national regulatory analysis will be required for other jurisdictions, particularly regarding End-of-Waste criteria and cross-border waste classification.
- The Book of Good Examples (D.2.6.1) provides a curated set of virtuous chain references applicable to regions beyond the programme area, particularly for wine, dairy, fruit and vegetable, and hemp chains.

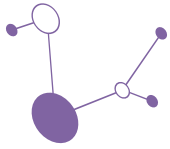


GLOSSARY

Term	Definition
By-product	A residue from a production process that is currently economically valorized or has the potential to be.
CAPEX	Capital expenditure: the upfront investment required for processed equipment, infrastructure, and related assets.
Compound level	The characterization of biomass in terms of its specific constituent chemical compounds rather than at the category level of the feedstock product.
Critical mass	The minimum annual feedstock volume required to sustain each actor in a value chain configuration at a viable economic level.
End-of-Waste (EoW)	A regulatory status by which a residue or waste stream ceases to be classified as waste and may be traded as a commodity, provided defined criteria are met (Article 6, EU Waste Framework Directive).
Facilitator	The partner organization - cluster, BSO, or research institution - that guides companies through the methodology and coordinates value chain development.
LCA	Life Cycle Assessment: a method for quantifying the environmental impacts of a product or process across its full life cycle.
LCC	Life Cycle Costing: an economic assessment of the total cost of a process over its operational life, including CAPEX and OPEX.
MFA	Material Flow Analysis: a quantitative method for tracking material flows and stocks through a defined system, identifying conversion yields and losses at each stage.
OPEX	Operating expenditure: recurrent costs of running a process including feedstock, energy, labor, and maintenance.



Pilot action	A small-scale, structured trial of a value chain configuration designed to validate technical and economic assumptions before full-scale investment.
Preliminary chain agreement	A formal expression of intent between two or more chain actors to proceed with the development of an identified value chain configuration; not a binding commercial contract.
Sensitivity analysis	A method for testing how the outcome of a quantitative model changes when key input assumptions are varied, typically by $\pm 20\%$, to identify the assumptions that most affect the result.
TLBMC	Triple-Layered Business Model Canvas: a framework extending the standard BMC with environmental and social layers for comprehensive sustainability assessment of a business model innovation.
TRL	Technology Readiness Level: a scale from 1 (basic principles observed) to 9 (system proven in operational environment) indicating technology maturity.
Value chain	The set of processes, actors and relationships that convert a by-product or waste stream into a product of greater economic or environmental value.
Virtuous chain	An existing, commercially operational value chain successfully valorizing a comparable biomass stream, used as a validation reference for simulated chain configurations.
Waste	A residue not yet economically valorized, assessed under the methodology for its potential to become a by-product input to a new value chain.



CONTACT

Questions regarding this methodology or its application may be directed to the TeBiCE project partnership. The coordinating partner for Output O1.1 is PP4-CCB - Chemie-Cluster Bayern GmbH.

Further information on the project, its partners, deliverables and pilot results are available at:

<https://www.interreg-central.eu/projects/tebice/>