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D2.2 Measuring the transition towards circular supply chains across plausible futures

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Table of contents

1. Introduction

The circular economy (CE) has emerged as a dominant paradigm in sustainability discourse, offering the promise of reconciling economic activity with ecological boundaries by closing resource loops and extending product lifecycles (Korhonen et al., 2018). Yet, beneath its growing appeal lies a conceptual ambiguity: the CE is not a unified model but a contested space, shaped by diverse, and often contradictory, visions of what constitutes value, progress, and justice (Corvellec et al., 2022). As Lowe and Genovese (2022) argue, the transition to circularity is not a neutral, technocratic process, but one that necessarily invokes political, social, and economic assumptions about how societies ought to function.

This deliverable (D2.2) engages directly with this ambiguity by treating CE scenarios not as static visions of the future but as value-articulating institutions (VAIs) (Vatn, 2009), which represent institutional arrangements that define what is considered valuable, who gets to decide, and how outcomes are measured. Different circular futures embody different governance regimes, technological trajectories, and normative goals. They are underpinned, often implicitly, by distinct theories of value: neoclassical, biophysical, institutionalist, or deliberative (Lowe and Genovese, 2022). These theories do not simply inform measurement; they structure the very notion of what *performance* means in a given context.

Building on the scenario framework included in D1.4, and on the analysis of supply chain configurations across four plausible circular futures on D2.1, this deliverable shifts the focus to measurement. It asks: *how can we assess the performance of circular supply chains when the criteria for success are inherently scenario-dependent?* What should be measured in a techno-optimistic, growth-oriented future led by multinationals differs profoundly from what matters in a community-led, sufficiency-based transition pathway, which needs to prioritise wellbeing and local resilience.

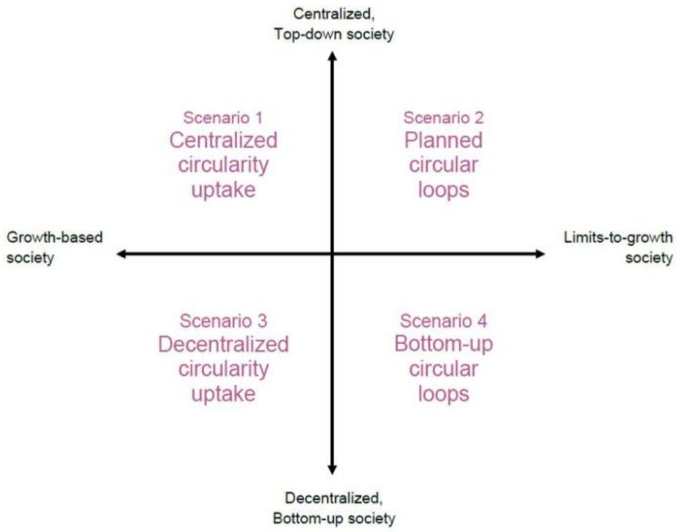
The mainstream approach to indicator development, often typified by single dashboards or universal key performance indicators (KPIs), presumes that progress can be assessed through objective, comparable metrics. Yet, as Purvis et al. (2025) contend, such an approach is inherently linked to an underlying epistemological reductionism. As already pointed out by Gasparatos (2010), indicators are not value-neutral tools, but they reflect embedded assumptions about what counts, what can be known, and what is worth striving for. As such, the desire for universal, consensus-based indicators may lead to the marginalisation of qualitative, contextual, and justice-oriented dimensions of performance (Purvis and Genovese, 2023).

This deliverable therefore explicitly rejects one-size-fits-all approaches to circular supply chain performance measurement. Instead, it offers scenario-specific indicator frameworks that align with the governance logics, value theories, and performance priorities of the four distinct futures which have been introduced in D1.4 (Figure 1.1).

- *Centralised Circular Uptake*: a high-tech, growth-led pathway driven by multinational enterprises and global policy regimes. D2.2 named this supply chain configuration MNEs integrated global supply chain configuration
- *Planned Circular Loops*: a state-led, limits-to-growth model focused on resource sufficiency, equity, and regulatory control. Reshoring production and sourcing for local supply chains.

- *Decentralised Circular Uptake*: an entrepreneurial, innovation-oriented future enabled by platforms, peer-to-peer systems, and flexible governance. Peer-to-peer platforms for green supply chains
- *Bottom-Up Circular Loops*: a community-driven, low-tech transition prioritising local resilience, regenerative practices, and social cohesion.

Figure 1.1 – Each of the 4 scenarios explores different pathways towards circularity, shaped by varying levels of governance and growth priorities.



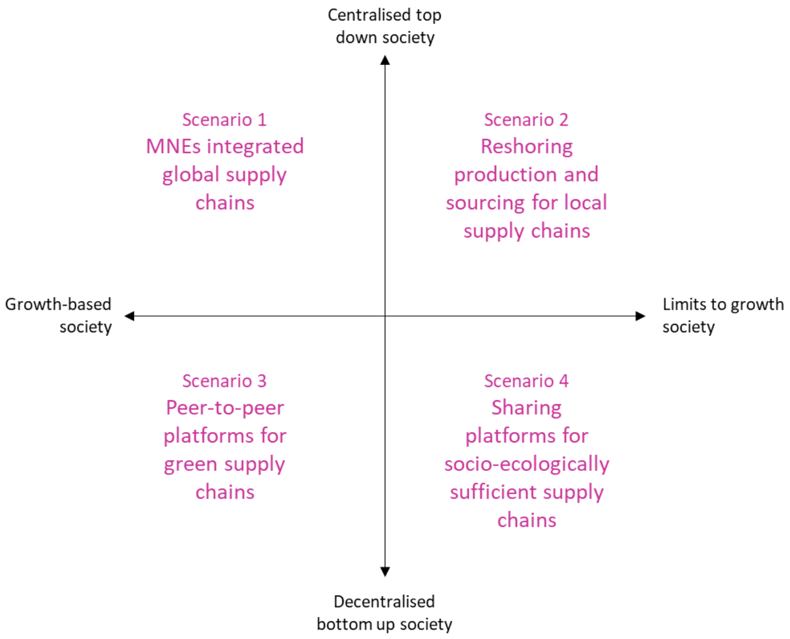
In D2.1, these four circular futures were illustrated through concrete examples of how supply chains might be configured under each scenario (Figure 1.2). Below, the corresponding supply chain configurations are summarised:

- *MNE-Integrated Global Supply Chains*: Supply chains are tightly coordinated by multinational enterprises using advanced technologies to maximise efficiency, traceability, and material recovery across international operations.
- *Reshored Production and Local Supply Chains:* Production and sourcing are relocated closer to end-use regions, enabling state-regulated circular districts and simplified loops aligned with ecological limits.
- *Peer-to-Peer Platforms for Green Supply Chains*: Digital infrastructures support decentralised actors in dynamically configuring supply chains, enabling flexibility, innovation, and circular coordination at multiple scales.
- *Sharing Platforms for Socio-Ecological Sufficiency*: Community-managed networks organise local, low-tech production and distribution systems, prioritising resilience, mutual aid, and regenerative material flows.

In this deliverable, we recognise that each scenario requires its own logic of evaluation. For instance, indicators that emphasise innovation, scale, and efficiency may be relevant for Centralised Circular Uptake, but inappropriate for assessing success in a Bottom-Up Circular Loops scenario, where participatory governance, social return, and biophysical sufficiency are more salient.

To this end, the indicator frameworks developed in D2.2 are grounded in a pluralistic methodology. They integrate both quantitative and qualitative dimensions, spanning inputs, processes, outcomes, and transformational logics, and draw on existing frameworks (e.g., Circulytics, CTI, GRI) while adapting them to the specific institutional and normative contexts of each future.

Figure 1.2 – Taxonomy of Supply Chain Configuration in different Circular Futures



The structure of this deliverable reflects this intent:

- *Chapter 2* outlines the methodological foundation, including selection criteria, typologies, and performance dimensions.
- *Chapters 3 to 6* present tailored indicator frameworks for each scenario.
- *Chapter 7* compares and contrasts performance priorities across futures, highlighting tensions and trade-offs (e.g., growth vs sufficiency, efficiency vs equity).
- *Chapter 8* explores the practical application of these frameworks in policy, business strategy, and participatory processes.

Ultimately, this report makes the case that measuring circular transitions requires more than technical rigour. As argued by Purvis and Genovese (2023), such a process demands theoretical clarity and political honesty. Circular supply chains cannot be meaningfully assessed using universal tools which are detached from context. Only by acknowledging that circular futures are embedded in very different theoretical assumptions, conceptualisation of value and power structures we can develop indicators that can realistically support just transitions.

2. Methodological Framework

As stated in the previous section, the development of performance indicators for circular supply chains cannot be approached as a purely technical or neutral task. As Lowe and Genovese (2022) argue, the identification and definition of circular futures is inseparable from the articulation of value: each future scenario enacts a particular worldview about what matters, what should be measured, and how systems ought to evolve in transitional dynamics. These futures are, in essence, value-articulating institutions (VAIs), structures that embed specific assumptions about the purpose of economic activity, the role of technology and governance, and the metrics of success (Vatn, 2009). Consequently, any effort to evaluate circular performance must begin by acknowledging the plurality of value theories underpinning alternative visions of the circular economy.

Rather than seeking universal, one-size-fits-all indicators, this deliverable adopts a scenario-based methodology, grounded in the recognition that performance assessment must be contextually anchored in the normative, institutional, and techno-economic conditions of each future. This chapter lays out the framework that guided the construction of the indicator sets presented in Chapters 3–6. It does so in five parts: (2.1) indicator selection criteria, (2.2) performance dimensions, (2.3) the typology of indicators, (2.4) alignment with existing indicator frameworks, and (2.5) integration with the scenario logic established in D1.4 and D2.1.

2.1 Indicator Selection Criteria

Selecting individual indicators is a key aspect in assessing the performance of circular supply chains for each CE future (Purvis and Genovese, 2023). Five core criteria guided the process of selecting appropriate indicators:

- *Relevance*: Indicators must reflect the key priorities and value systems of the specific circular future in question. What constitutes “good performance” varies depending on the underlying governance mode, technological paradigm, and theory of value.
- *Measurability*: While some indicators can be quantified directly, others require qualitative assessments. This framework accepts both forms of evidence, provided they are grounded in transparent methods and produce actionable insights.
- *Comparability*: Where appropriate, indicators were selected to allow for intra-scenario benchmarking or cross-scenario dialogue, without assuming that such comparisons are always meaningful or desirable.
- *Data availability*: Indicators were prioritised if they can be informed by data that is theoretically accessible through public or private sources, such as firm disclosures, statistical agencies, or stakeholder processes.
- *Responsiveness*: Indicators must be sensitive to change, being able to reflect the effects of interventions, structural shifts, or behavioural adaptation over time.

These criteria were applied not as rigid filters, but as heuristic tools for navigating the complexity and contestation inherent in CE performance measurement (Purvis et al., 2025). In line with Lowe and Genovese’s (2022) critique of reductionism, this framework was applied separately to the four different CE futures, resisting collapsing diverse futures into a singular evaluation model.

2.2 Performance Dimensions

The performance of circular supply chains must be understood as multi-dimensional (MahmoumGonbadi, 2021). Drawing from existing sustainability literature and CE practice (Calzolari et al., 2021), four core dimensions were applied consistently across all scenarios:

- *Environmental*: Captures biophysical impacts and ecological flows, including resource use, emissions, circularity of materials, and alignment with planetary boundaries.
- *Operational*: Relates to the structural and functional characteristics of supply chains, such as integration, modularity, traceability, localisation, and technological configuration.
- *Economic*: Focuses on value creation, cost structures, investment in innovation, and resilience. Notably, the definition of economic value varies significantly across scenarios, from neoclassical notions of utility and price to institutionalist views of collective provisioning.
- *Social*: Encompasses equity, participation, access, labour conditions, and distributional effects. This dimension is particularly sensitive to the scenario's normative orientation, with some futures (e.g., Bottom-Up Circular Loops) emphasising social cohesion and autonomy over growth or efficiency.

These dimensions are not discrete silos, but overlapping spheres of value articulation. For example, a given indicator (such as *CE employment share*) may reflect both economic and social performance, depending on the scenario's framing; also, in most of the CE-related literature and practice, the operational dimension is treated as a sub-set of the economic one, according to a triple-bottom line logic.

2.3 Typology of Indicators

Following best practice in sustainability assessment, indicators were categorised using a four-part typology:

- *Input indicators*: Capture resource and energy flows entering the system (e.g. percentage of recycled inputs, renewable energy share).
- *Process indicators*: Reflect internal dynamics and institutional practices (e.g. supplier certification rates, stakeholder engagement mechanisms).
- *Outcome indicators*: Measure the direct results of CE interventions (e.g. reduction in emissions, increase in product life).
- *Transformational indicators*: Capture deeper shifts in values, behaviours, and structural conditions (e.g. changes in ownership models, prevalence of commons-based governance).

This typology enables a layered understanding of performance, distinguishing between surface-level change and systemic transformation. The inclusion of transformational indicators responds to the call for greater attention to the underlying logics of production, valuation, and reproduction within CE futures (Lowe and Genovese, 2022). Indicators included in the recent reviews provided by Calzolari et al. (2021), MahmoumGonbadi et al. (2021) and Verma et al. (2025) were employed as a first set of potential measures to be evaluated for their adherence to specific futures. Where adequate measures were not immediately available, further rounds of ad-hoc literature searches were performed.

2.4 The need to overcome existing frameworks

To ensure that the scenario-based indicators are both novel and policy-relevant, a series of widely used CE and sustainability assessment tools were also consulted:

- *Circulytics* (Ellen MacArthur Foundation): Provides corporate-level CE metrics, particularly for input and process indicators.
- *CTI* – Circular Transition Indicators (World Business Council of Sustainable Development): Focuses on material flows and circularity performance at the organisational level.
- *GRI* (Global Reporting Initiative) and *SDGs* (Sustainable Development Goals): Offer broader sustainability metrics, including social and governance aspects.
- *ISO 14040* (Life Cycle Assessment standards): Informs the environmental dimension, especially in outcome and input indicators.

However, these frameworks often presume a growth-oriented, technocratic, and firm-centric model of circularity. They tend to select metrics based on data availability and perceived relevance for business strategy, which may overlook or devalue elements critical to post-growth or community-driven futures. Where necessary, the indicators proposed here were adapted or extended to accommodate non-market forms of value and collective, participatory governance structures present in decentralised or limits-to-growth scenarios. This allows for a more plural and inclusive interpretation of circular performance.

2.5 Integration with Scenario Logic

The indicator frameworks developed in this deliverable are deeply embedded in the scenario typology established in D1.4 and elaborated in D2.1. Each scenario reflects a distinct configuration of two key axes: the degree of centralisation in governance and the orientation toward growth versus sufficiency. These configurations implicitly align with different theories of value, which in turn shape what is deemed measurable, meaningful, and desirable.

This linkage between scenario, governance, growth orientation, and value theory is central to the methodological framework. It ensures that the indicators are not just operational tools, but reflections of the broader epistemic and normative structures in which CE transitions are embedded. Table 2.1 summarises these relationships, showing how each scenario combines a specific governance mode and growth orientation with an indicative theory of value, which together inform the rationale behind scenario-specific indicators.

Table 2.1 - Typology of circular futures by governance, growth orientation, and underlying value theory

Scenario	**Governance**	**Growth Logic**	**Indicative Value Theory**
Centralised Circular Uptake	Centralised	Growth-driven	Neoclassical
Planned Circular Loops	Centralised	Post-growth	Biophysical / Institutional
Decentralised Circular Uptake	Decentralised	Growth-enabled	Neoclassical / Institutional
Bottom-Up Circular Loops	Decentralised	Sufficiency-based	Socio-cultural / Deliberative

2.6 Conclusion

The framework outlined in this chapter provides a theoretically informed, pluralistic foundation for the scenario-specific indicator sets that follow. It recognises that indicators are never neutral; they are shaped by, and in turn shape, the futures we seek to bring into being. By integrating insights from value theory and acknowledging the politics of measurement, this approach offers a more reflexive and context-sensitive way of evaluating circular supply chains, not as isolated technical systems, but as socially embedded configurations of value, governance, and transformation.

3. Centralised Circular Uptake

3.1 Scenario Summary

The Centralised Circular Uptake scenario envisions a future where the transition to a circular economy is initiated by the state but primarily driven by market forces, all within a continued pursuit of economic growth. National governments, supranational institutions, and multinational enterprises (MNEs) form strategic alliances to secure resources, reduce environmental impacts (particularly GHG emissions), and maintain global competitiveness amid geopolitical and ecological challenges.

The CE is framed as an industrial strategy, underpinned by high-tech solutions such as artificial intelligence, robotics, blockchain, and advanced recycling systems. Circularity is deployed at scale, particularly in resource-intensive sectors such as electronics, automotive, and construction. Policies incentivise CE adoption through tax breaks, R&D funding, and trade agreements, with private-sector actors leading implementation.

In this scenario, large MNEs are the primary agents of circular implementation (Bauwens et al., 2020). They respond to institutional pressures from governments, markets, and industry groups to adopt CE practices and secure their legitimacy (Calzolari et al., 2023). The only viable pathway for operationalising CE principles across expansive global supply chains is through tighter control and integration, achieved by coordinating and monitoring suppliers and customers across the supply chain (Calzolari et al., 2025). This results in highly centralised, standardised, and traceable supply chains where decision-making is concentrated in a few powerful corporate and institutional nodes.

In this scenario, circular supply chains are global, digitally integrated, data-rich, and highly automated. MNEs deploy advanced technological infrastructure to ensure visibility, control, and optimisation of circular flows at every stage.

Supply chain integration is achieved through real-time data exchange, contractual alignment, and technological coupling across multiple supply chain tiers. MNEs build high levels of coordination both upstream (with suppliers and material recovery actors) and downstream (with customers and service platforms) ensuring circular processes such as reverse logistics and remanufacturing are tightly managed. Some of the key technologies and associated tools that enable circularity in this scenario are:

- Robotics and AI to power automated disassembly, material sorting, and predictive maintenance systems.
- Blockchain to ensure immutable traceability of materials, compliance documentation, and lifecycle data.

- Digital Product Passports to track circular value across the entire product lifecycle, enabling warranty management, repair, reuse, and recycling.
- Advanced recycling facilities are strategically located and scaled to handle vast material flows, operating with minimal downtime and maximum resource recovery.
- Centralised platforms support global coordination, offering MNEs the ability to monitor supply chain performance, emissions, material efficiency, and CE-specific KPIs in real time.

3.2 Performance Priorities

In the *Centralised Circular Uptake* scenario, performance is aligned with a growth-oriented industrial strategy that leverages high-tech solutions to achieve circularity at scale. Here, the concept of performance extends beyond traditional economic metrics to include circularity-specific outcomes embedded within globalised and centrally coordinated supply chains.

The dominant actors, including national governments, supranational institutions, and multinational corporations, define what "good performance" looks like, favouring metrics that emphasise scale, control, and innovation. Key performance priorities are then CE throughput efficiency and recovery rates, economies of scale, CE driven innovation, compliance and traceability and standardisation of metrics and certifications.

a) *CE throughput efficiency and recovery rates*: In this scenario supply chains aim to maximise throughput efficiency through CE practices, by extracting the greatest value from material and energy flows, while minimising waste. *Recovery rates* of materials and components, particularly in sectors like electronics and automotive, are essential indicators of systemic circularity performance.
b) *CE economies of scale*: scale is a central performance criterion and is seen as both a measure of technical success and a market imperative, reinforcing centralised power structures. They apply to both the forward supply chain and to the reverse supply chain.
c) *CE-driven innovation for global competitiveness*: Innovation is a means of maintaining competitive advantage. Performance in this domain is assessed via corporate R&D intensity, the share of CE-aligned products and services, and the development of proprietary circular technologies. Success is defined by the ability of firms and nations to lead global markets in CE solutions, particularly in critical raw materials recovery, product-as-a-service models, and closed-loop manufacturing systems.
d) *Compliance and traceability*: Regulatory compliance and supply chain traceability are central to the governance logic of this scenario. CE performance is evaluated through metrics such as supplier certification rates, audit compliance scores, and the integrity of digital product passports. These tools are not only for risk management but serve to legitimise corporate CE claims and reassure stakeholders, investors, regulators, and consumers of systemic accountability.
e) *Standardisation of metrics and certification*: Performance is also defined by the extent to which circular practices can be codified and standardised. CE maturity is tracked through harmonised reporting tools (e.g. Circulytics, CTI), and third-party certifications. These standards provide the backbone for benchmarking and enforcing circularity, enabling cross-sector comparability and regulatory scalability.

3.3 Key Indicators

The following indicators are proposed to assess the performance of supply chains under the *Centralised Circular Uptake* scenario. They are structured according to the Triple Bottom Line (TBL) framework (Table 3.1).

Table 3.1 – Triple Bottom Line indicators relevant to Centralised Circular Uptake

Category	Indicators	Description
Environmental	Percentage of secondary raw materials in production	*Share of total inputs sourced from recycled or reclaimed materials, reflecting the system's ability to loop materials at scale.*
	GHG emissions per unit of output	*Tracks carbon efficiency across the supply chain, incentivising emission reduction through technological and logistical optimisation.*
Economic & Operational	Investment in Circular Economy R&D	*Level of corporate or sectoral commitment to CE innovation through research, development, and digitalisation.*
	Share of revenue from circular products or services (as % of Revenue):	*degree to which businesses are generating economic value through CE-aligned offerings (e.g., remanufactured goods, leasing models).*
	Supplier compliance with CE standards	*Proportion of upstream supply chain actors adhering to formal CE certifications or internal corporate sustainability protocols*
	Global Circular Integration Index	*A composite measure reflecting the extent to which supply chains are globally connected and coordinated to support circular loops (e.g., take-back systems, cross-border recovery).*
Social	Employment in CE-Enabled sectors	*Job creation or transformation within industries linked to CE practices such as recycling, advanced manufacturing, reverse logistics, and eco-design.*
	CE skills penetration rate	*Workforce readiness by measuring access to training, certification, and education in CE-relevant domains (e.g., repair skills, material science, digital CE platforms).*

In terms of environmental indicators, the focus is on throughput efficiency and recovery performance across global supply chains. Metrics such as material footprint and carbon intensity reflect efforts to maximise value extraction from resource flows while minimising waste, in line with priorities around CE recovery rates and large-scale systemic efficiency.

In terms of economic indicators, the emphasis is on scaling circular models and fostering innovation to sustain global competitiveness. Indicators assess the penetration of CE-aligned services, infrastructure efficiency, and localisation within global systems, reinforcing the importance of economies of scale, reverse logistics, and proprietary CE technologies as drivers of market leadership.

In terms of social indicators, performance relates to compliance, traceability, and legitimacy. Employment metrics and public perception scores help capture how CE governance frameworks, underpinned by audits, certifications, and digital tracking, shape stakeholder confidence and institutional accountability in the transition.

3.4 Data measurement considerations

Primary data are going to be obtained through firm-level reporting (ESG disclosures, annual reports), trade registries, compliance databases. Secondary data might be obtained from different sources including: OECD, Eurostat, WEF Circularity Gap Reports, CDP corporate datasets. Key challenges might include:

- Lack of harmonisation in CE performance reporting across global operations.
- Risk of greenwashing in unverified CE claims by large actors.
- Difficulty in capturing material flows in non-transparent or informal parts of the supply chain.

3.5 Discussion and Relevance

In contrast to other CE futures, this scenario relies on vertical integration, market incentives, and global governance to scale circularity. It reflects a continuation of existing capitalist dynamics, just reconfigured to accommodate environmental pressures.

Value is captured and concentrated by key actors, often using proprietary technologies and certification schemes, which may limit transparency and participation. Performance indicators are designed to serve regulatory compliance, investor communication, and competitive positioning, rather than ecological sufficiency or democratic governance.

This makes the scenario efficient and scalable, but potentially fragile in terms of social legitimacy and ecological coherence. From a policy standpoint, it raises questions about power asymmetries, data ownership, and innovation justice.

The *Centralised Circular Uptake* scenario is closely aligned with a neoclassical theory of value. In this framework:

- Value is equated with price, utility, and productivity, rooted in firm-level performance.
- Circularity is valuable insofar as it reduces costs, secures inputs, or enables new markets.
- Efficiency and innovation are the main levers for achieving environmental and economic outcomes.

While environmental externalities are internalised through regulations or incentives, ecological limits are not treated as hard constraints, but rather as challenges to be managed through technological advancement. To a limited extent, a biophysical value theory may be acknowledged, particularly in material flow assessments or lifecycle costing, but always subordinated to market-based optimisation.

4. Planned Circular Loops

4.1 Scenario Summary

The Planned Circular Loops scenario envisions a future in which the transition to a circular economy is driven by national governments and supranational institutions, operating under centralised governance. In this scenario, a strong limits-to-growth orientation is hypothesised. In response to escalating ecological crises, these actors implement binding regulations and system-wide planning to reshape economic activity within planetary boundaries.

Circularity is framed not as a market opportunity but as a public mandate, executed through technocratic planning, legal enforcement, and long-term sustainability targets. Policies include carbon caps, material quotas, product bans, and extended producer responsibility. Public procurement and investment are strategically used to reduce material throughput, extend product lifespans, and shift consumption from ownership to shared-use models such as *Product-as-a-Service*.

The principal agents of implementation are public authorities and large enterprises under regulatory control, tasked with delivering access to essential goods and services through cooperative or publicly managed systems. Consumption is shaped by rationing mechanisms, durability standards, and behavioural shifts toward sufficiency. Innovation is directed toward efficiency, modularity, and reuse rather than product differentiation or market expansion.

Supply chains are restructured to support national and regional self-sufficiency, with global sourcing deemed environmentally and geopolitically unviable. Instead, circular districts or eco-industrial clusters emerge, coordinated by planning authorities. These localised systems prioritise closed material loops, infrastructure resilience, and industrial symbiosis through territorial circularity.

Supply chain integration is achieved via state-mandated data sharing, harmonised standards, and regional coordination. Public agencies and regulated enterprises collaborate to ensure emissions are reduced, materials are reused locally, and access is equitable. Key enabling technologies and associated tools include:

- Lifecycle Assessment Systems to align products with environmental thresholds and durability standards.
- Public Resource Registries to monitor and allocate materials within circular districts.
- Digital Twin Models to simulate and optimise resource use within ecological limits.
- Repair and Remanufacturing Hubs embedded in public infrastructure.
- Circular Planning Platforms to coordinate production, compliance, and performance across supply networks.

4.2 Performance Priorities

In the Planned Circular Loops scenario, performance is aligned with ecological sufficiency, social equity, and public accountability. Circularity is deployed through regulatory mandates and systemic planning, not through market incentives. As such, the concept of performance is shaped by biophysical limits, redistributive aims, and infrastructural resilience, rather than efficiency or competitiveness. The state and supranational institutions define what constitutes “good performance,” favouring metrics that emphasise material reduction, territorial self-sufficiency, and equitable access.

Key performance priorities include: material and energy throughput reduction, regional self-reliance, design standardisation, equity of access, and regulatory compliance.

a) *Material and energy throughput reduction*: Performance is measured by the capacity of supply chains to drastically reduce resource extraction and energy input. Indicators focus on total material footprint, fossil fuel phase-out, and lifecycle resource intensity, reflecting a broader commitment to operate within planetary boundaries.
b) *Regional resilience and self-sufficiency*: Circular supply chains are expected to function within national or regional loops, minimising dependence on global inputs. Performance is assessed by localisation ratios, infrastructure autonomy, and supply stability under constraint. Regional self-sufficiency becomes a strategic objective of circular planning.
c) *Design for durability and recyclability*: Standardisation of product design is a cornerstone of planned circularity. Performance is evaluated through metrics such as average product lifespan, modularity rates, and recyclability indices, ensuring that goods remain in circulation longer and can be efficiently processed at end-of-life.
d) *Equitable Access to Circular Services*: A core priority in this scenario is the fair distribution of circular benefits. Indicators include access equality scores, public provisioning coverage, and service affordability, particularly for essential goods such as appliances, housing, and mobility. Performance reflects how circular systems contribute to social inclusion.
e) *State Accountability and Regulatory Compliance*: Governance structures are responsible for delivering planned outcomes. Performance is measured through compliance with sustainability mandates, procurement quotas, and policy delivery metrics. Tools such as public dashboards, lifecycle audits, and compliance registries are used to track progress and maintain transparency.

4.3 Key Indicators

The indicators associated with the *Planned Circular Loops* scenario should reflect ecological sufficiency, governance control, and social equity. Table 4.1 is a proposed set, structured by performance dimension.

In terms of environmental indicators, the emphasis is on measuring throughput reduction and carbon efficiency across centralised loops. Indicators target material footprint, circular input use, and lifecycle emissions, aligning with priorities around planetary boundaries, fossil fuel phase-out, and standardised recovery systems.

In terms of economic indicators, the focus is on regional resilience and infrastructure optimisation. Metrics reflect progress in localising supply chains, scaling *Product as a service* models, and maximising shared asset use, core to reducing global dependencies and enabling efficient, planned circulation.

In terms of social indicators, performance is assessed through equitable access and state accountability. Indicators track distributional fairness, circular employment share, and public trust in CE governance, highlighting the scenario's aim to align system efficiency with social legitimacy.

4.4 Data and Measurement Considerations

Primary data are going to be obtained by national statistics agencies, government procurement platforms, and public service providers, which are playing a major role in the implementation of CE strategies in this scenario. Secondary data might be obtained from sources, including: Eurostat (e.g., material flow accounts), OECD, UNEP Resource Panel.Key challenges might include:

- Limited availability of social equity data disaggregated by access model.
- Need for harmonised lifecycle methodologies to track carbon and material intensity under planned production regimes.

Where possible, indicators should be aligned with existing international benchmarks (e.g., Sustainable Development Goals, Circular Economy Monitoring Framework by Eurostat) to enhance comparability and integration into policy frameworks.

Table 4.1 – Triple Bottom Line indicators relevant to Planned Circular Loops scenario

Category	**Indicators**	**Description**
Environmental	Material footprint per capita (kg/capita/year)	*Total raw material extraction needed to satisfy domestic consumption. A critical metric for evaluating the success of material reduction goals.*
	Circular material use rate (%)	*Share of material input sourced from recycled or reused content.*
	Carbon intensity of supply chains (kg CO_2e/unit output)	*Lifecycle-based assessment of carbon emissions per product or service delivered.*
Economic & Operational	Localisation ratio (% of supply chain operating within national/regional boundaries)	*Degree to which supply chains have been restructured to operate within planned loops.*
	Product-service penetration rate (% of products accessed via Product-as-a-Service models).	*Diffusion of alternative ownership models that favour long product lifespans.*
	Infrastructure utilisation rate (%)	*Efficiency in the use of shared logistics, warehousing, recycling, and remanufacturing facilities.*
Social	Access equality index (normalised score)	*Measures distributional equity in access to circular goods and services (e.g., appliances, mobility, housing)*
	CE employment share (% of workforce in CE-relevant roles)	*Job creation or transformation in sectors such as repair, reuse, recycling, remanufacturing.*
	Public acceptance score (survey-based)	*Measures citizen satisfaction and trust in the planned CE governance model.*

4.5 Discussion and Relevance

This set of indicators highlights how performance in a planned circular economy must be evaluated through a systems lens, emphasising sufficiency, control, and social justice. Unlike market-based CE models, this scenario's indicators stress collective outcomes over individual firm performance.

By decoupling from the neoclassical understanding of value, this scenario repositions supply chains as instruments of collective provisioning rather than mechanisms for profit optimisation. Value becomes a function of material stewardship, social access, and governance legitimacy. This shift necessitates the development of new forms of accounting, such as material flow accounts and social value metrics, capable of capturing both biophysical constraints and social objectives. It also calls for policy tools that can allocate resources fairly, such as rationing systems or formal access rights, and the creation of institutions that embody ecological and social values, including circular authorities and commons-based organisations.

The measurement framework must therefore embed biophysical accounting principles and social equity metrics, fundamentally challenging conventional cost-benefit analysis and productivity-based KPIs. Indicators such as localisation, access equality, and material throughput reflect a paradigm shift: success is no longer measured by output or profit, but by resilience and fairness within planetary limits. Consequently, traditional performance metrics like return on investment (ROI) and time-to-market lose relevance, underscoring the need for new, governance-centric performance frameworks.

5. Decentralised Circular Uptake

5.1 Scenario Summary

The Decentralised Circular Uptake scenario envisions a circular economy shaped by bottom-up, entrepreneurial, and digitally enabled dynamics. In this future, platforms, start-ups, local networks, and digitally empowered citizens emerge as the main drivers of circular innovation, challenging traditional models of production and consumption. Supply chains become modular, decentralised, and adaptive, configured around flexible partnerships, community enterprises, and peer-to-peer exchanges.

The role of the state is largely facilitative, focused on providing enabling infrastructure, open data standards, and incentives for experimentation. Regulatory frameworks are lightweight and adaptive, designed to support interoperability and innovation rather than impose strict controls. Public actors invest in connectivity, open-source tools, and decentralised data governance to empower a diversity of actors.

Circularity in this scenario is not mandated from above, but emerges through distributed agency: users become co-producers, prosumers, and service providers. Digital platforms coordinate resource flows across local and trans-local networks, enabling rapid scaling of repair, reuse, redistribution, and product-as-a-service models. Innovation thrives in niches and ecosystems, fuelled by hackerspaces, fab labs, and circular start-ups responding to local conditions and user needs.

Global supply chains are supplemented or replaced by regionalised, digitally orchestrated loops, where materials and products circulate through local recovery systems, modular repair services, and platform-mediated redistribution. These systems are resilient and responsive, often bypassing incumbent corporate infrastructures through softwarebased interoperability and data sharing.

Supply chain integration is achieved through open protocols, digital commons, and participatory governance mechanisms. Collaboration happens via transparent platforms, distributed ledgers, and smart contracts, which enable traceability and trust without central oversight. Key enabling technologies and associated tools include:

- Decentralised platforms that host product-as-a-service models, second-hand markets, and tool-sharing schemes.
- IoT and sensor networks embedded in products to track usage, predict maintenance needs, and facilitate return logistics.
- Digital Product Passports designed for peer access and interoperability, enabling repair histories and material traceability.
- Open APIs and data marketplaces allowing actors to plug into regional CE ecosystems, exchanging information on supply, demand, and surplus.
- Tokenisation and blockchain tools to facilitate decentralised coordination, incentivise participation, and manage reputational systems.

5.2 Performance Priorities

In the Decentralised Circular Uptake scenario, performance is aligned with entrepreneurial innovation, modular scalability, and user-driven circular models. Circularity is not mandated by regulation nor orchestrated by central authorities, but emerges from experimentation, distributed coordination, and the rapid evolution of platform-based ecosystems. Here, *good performance* is defined by adaptability, opportunity creation, and the ability of diverse actors to self-organise and interoperate effectively. Key performance priorities include flexibility and innovation, value generation through new business models, decentralised coordination, and systemic risk management:

a) *Flexibility, innovation, and user-driven models*: Performance is measured by the capacity of supply chains to adapt quickly, accommodate diverse actors, and facilitate continuous innovation. Indicators include rates of business model experimentation, modular system integration, and user participation in circular activities such as co-design, repair, and redistribution.
b) *Economic opportunity through new business models*: Circularity is a competitive space for new entrants and local entrepreneurs. Performance is tracked through metrics such as the number of circular start-ups, growth in peer-to-peer services, and the economic share of circular platforms. Success reflects how effectively the ecosystem supports inclusive innovation and decentralised value creation.
c) *Agile coordination and interoperability*: Decentralisation demands high levels of coordination without central command. Performance is evaluated by the presence of open APIs, data-sharing protocols, and plug-and-play compatibility across actors and services. Indicators also assess the responsiveness of platforms to shifting local needs.
d) *Risk management in distributed systems*: Without central oversight, systems must self-regulate and mitigate risks collaboratively. Performance indicators include governance participation rates, dispute resolution effectiveness, and resilience metrics across decentralised nodes. Trust and transparency mechanisms, such as blockchain, audit

trails, and community feedback systems, are essential to maintaining performance integrity.

5.3 Key Indicators

The indicators in this scenario reflect a flexible, entrepreneurial, and digitally networked CE system, where innovation and participation are key metrics of success. Below, they are grouped using the TBL framework (Table 5.1).

In terms of environmental indicators, the focus is on capturing the environmental trade-offs and recovery performance within decentralised, user-driven systems. Metrics such as average transport distance and platform-enabled material recovery rate reflect the scenario's emphasis on agility and the ability of distributed actors to coordinate reuse and reverse logistics without central control.

Table 5.1 – Triple Bottom Line indicators relevant to Decentralised Circular Uptake scenario

Category	Indicator	Description
Environmental	Average transport distance per product lifecycle	*Tracks the physical movement of products in distributed systems to assess environmental trade-offs of decentralisation.*
	Platform-enabled material recovery rate	*Measures the effectiveness of digital platforms in facilitating reuse, recycling, and reverse logistics.*
Economic & Operational	Share of GDP from CE-aligned SMEs and start-ups	*Contribution of entrepreneurial activity to the CE transition.*
	Number of active users on circular platforms (per capita)	*Scale of engagement with digital CE services such as sharing, renting, or peer-to-peer exchange.*
	Platform interoperability index	*Extent to which different CE platforms can share data, resources, and services, a proxy for ecosystem efficiency.*
	Transaction trust score (Reputation-based)	*Reliability and accountability of users in P2P exchanges, critical for self-governed networks.*
Social	Participation rate in local circular initiatives	*Measures citizen engagement in local or grassroots CE efforts facilitated by digital tools.*
	Platform accessibility score	*Evaluates inclusiveness across income groups, languages, age, and digital literacy.*
	Transparency and data governance index	*Assesses how openly platforms share information about transactions, material flows, and governance rules.*

In terms of environmental indicators, the focus is on capturing the environmental trade-offs and recovery performance within decentralised, user-driven systems. Metrics such as average transport distance and platform-enabled material recovery rate reflect the scenario's emphasis on agility and the ability of distributed actors to coordinate reuse and reverse logistics without central control.

In terms of economic and operational indicators, performance is defined by innovation, entrepreneurial dynamism, and system interoperability. Indicators track the economic contribution of CE-aligned SMEs and platforms, as well as their ability to scale flexibly through digital ecosystems. Measures of interoperability and transaction trust reflect the scenario's priority on decentralised coordination and the smooth integration of diverse, independently operated nodes.

In terms of social indicators, success is linked to inclusive participation, self-regulation, and transparency. Metrics such as local initiative participation and platform accessibility capture how effectively citizens engage in shaping CE outcomes. Data governance and transparency indicators address the need for trust and accountability in the absence of top-down oversight, ensuring resilience and legitimacy across decentralised circular networks.

5.4 Data and Measurement Considerations

Primary data are going to be obtained through platform analytics, user engagement statistics, blockchain-based transaction data, regional SME registries. Secondary data might be acquired from sources including: open innovation datasets, circular economy innovation indices, local government open data portals. Challenges linked to the operationalisation of this set of indicators might include:

- Ensuring data privacy while maintaining transparency.
- Quantifying informal and unregistered circular activity (e.g., community sharing, DIY repair).
- Differentiating true circularity from platform-enabled consumption rebound effects.

5.5 Discussion and relevance

The *Decentralised Circular Uptake* scenario reflects a CE future rooted in innovation ecosystems, entrepreneurial action, and decentralised agency. It favours speed, experimentation, and user-centric solutions over central planning or large-scale infrastructure. Rather than relying on central planning or large-scale infrastructure, this pathway favours speed, experimentation, and user-centric solutions enabled by digital platforms, peer-to-peer (P2P) networks, and localised innovation.

In this scenario, traditional performance metrics often fall short. New, more intangible and dynamic forms of value emerge, which are not easily captured through conventional accounting or efficiency-based KPIs. Instead, proxies for circular performance take the form of reputation systems, user access rates, platform interoperability, and patterns of digital engagement. These metrics reflect an economy where value is co-created through participation, connectivity, and digital trust infrastructures.

Environmental and social safeguards, however, may be more difficult to ensure. The decentralised structure can lead to fragmentation, coordination challenges, and variability in standards enforcement. Moreover, there is an increased risk of rebound effects and widening digital divides, particularly if access to platforms or technical infrastructure is unevenly distributed. Consequently, to put the Decentralised Circular Uptake scenario into practice, governance-by-design principles become essential, incorporating trust mechanisms and ethical data stewardship to maintain equity and sustainability within decentralised systems.

This scenario aligns primarily with a neoclassical theory of value in its entrepreneurial and user-driven logic. Value is understood as emerging through voluntary exchange, market innovation, and the dynamics of network effects. The CE is conceived as a flexible and opportunity-rich domain where businesses and individuals can differentiate themselves and extract value through new forms of interaction and service models. Efficiency remains relevant, but value increasingly derives from engagement, convenience, and the utility of platform-based interactions.

At the same time, elements of institutionalist and socio-cultural value theories are also present. Trust, reciprocity, and reputation systems are fundamental to enabling decentralised cooperation across diverse actors and contexts. Value, in this scenario, is not solely captured by firms but is co-produced through collaborative dynamics involving users and communities. This points to an embedded recognition of social capital and collective agency as vital sources of value.

In contrast, ecological or sufficiency-based value logics are less emphasised. While the reduction of waste and the extension of product lifespans remain key performance goals, they are pursued primarily as outcomes of market innovation rather than as normative ends. This distinction marks a meaningful divergence from post-growth or degrowth perspectives and underscores the scenario's dependence on market-driven change mechanisms rather than collective restraint.

6. Bottom-Up Circular Loops

6.1 Scenario Summary

The Bottom-Up Circular Loops scenario envisions a radically decentralised, post-growth transition to circularity, led by local communities, civil society networks, and grassroots initiatives. Governance is participatory, place-based, and grounded in deliberative democracy, with decisions emerging from community assemblies, regional councils, and federated cooperatives rather than central authorities or market actors.

The circular economy in this future is not an industrial strategy but a mode of collective provisioning, designed to satisfy essential needs while respecting ecological thresholds. Economic activity is oriented around sufficiency, wellbeing, and local resilience, rather than profit or competitiveness. The CE is embedded in broader transformations toward social justice, degrowth, and ecological restoration.

Supply chains are short, regenerative, and community-managed, often organised around commons-based approaches to production, maintenance, and distribution. Ownership is collective or cooperative; value is shared. Activities such as repair, reuse, food sharing, mutual aid, urban gardening, tool libraries, and maker spaces are commonplace. These networks form local loops of resource use and care, reducing dependence on extractive systems and global markets.

Technology plays a minimalist or frugal role, focused on enabling autonomy rather than optimisation. Instead of high-tech infrastructures, the emphasis is on convivial tools, traditional knowledge, manual skills, and materials sourced from nearby environments. Digital systems, where used, are open-source, democratically governed, and support transparency and knowledge sharing across peer networks.

Supply chain integration is achieved through community-based coordination, informal networks, and federated structures that prioritise trust, transparency, and mutual support. Unlike data-intensive or corporate-led systems, these supply chains rely on low-tech and convivial technologies that are accessible, adaptable, and locally maintainable. Key enabling technologies and associated tools include:

- Frugal and modular tools designed for local repair, reuse, and remanufacturing, often produced through open-source hardware initiatives.
- Community-managed platforms supporting coordination of shared resources, surplus redistribution, and peer-to-peer exchange.

- Low-energy digital infrastructure (e.g., mesh networks, offline servers) facilitating local connectivity and data sovereignty.
- Open-source knowledge hubs documenting repair techniques, ecological practices, and community innovations.
- Participatory mapping tools used to visualise local assets, material flows, and needs for planning circular interventions.

6.2 Performance Priorities

In the Bottom-Up Circular Loops scenario, performance is aligned with a post-growth orientation that prioritises community wellbeing, local autonomy, and ecological regeneration over throughput, competitiveness, or innovation. Supply chains are evaluated not for their scale or productivity, but for how well they support social cohesion, biophysical limits, and democratic participation. Indicators in this context must accommodate slow, qualitative, and often place-based dimensions of performance. Key performance priorities include: local resource sovereignty, ecological sufficiency, participatory governance, solidarity-based exchange, and regenerative low-tech practices.

a) *Local resource sovereignty*: Performance is measured by the ability of communities to meet needs through local, renewable, and reused materials, reducing dependency on external inputs. Indicators include local sourcing rates, reuse intensity, and self-provisioning capacity within bioregional loops.
b) *Ecological sufficiency*: Success is defined by staying within local ecological limits. Metrics focus on per capita material use, carbon and nutrient cycling, and alignment with biocapacity. Circularity is about maintaining ecosystem balance, not extending throughput through efficiency.
c) *Community participation and collective ownership*: Governance is participatory and grounded in local deliberation and shared responsibility. Performance is tracked through indicators such as co-management structures, participatory budgeting, and inclusion in supply chain decisions, particularly for marginalised groups.
d) *Social and solidarity economies*: Performance includes the extent to which circular activities support mutual aid, non-monetary exchange, and inclusion. Indicators may include participation in time banks, community currencies, and cooperative ownership of supply infrastructure.
e) *Low-tech regeneration and cultural resilience*: Innovation is low-impact, rooted in place-based knowledge, traditional skills, and regenerative cycles. Metrics include the presence of community repair spaces, composting networks, agroecological practices, and transmission of local know-how.

6.3 Key Indicators

The following indicators have been developed to assess performance in the Bottom-Up Circular Loops scenario, structured using the *TBL* framework (Table 6.1).

In terms of environmental indicators, the focus is on local resource sovereignty and ecological sufficiency. Metrics such as local sourcing rates, land use for regeneration, and ecological balance reflect the scenario's priority on bioregional self-reliance and staying within natural limits, rather than maximising circular throughput.

In terms of economic and operational indicators, performance centres on solidarity-based value retention and affordability within local systems. Indicators assess how well communities retain economic value through reuse and mutual aid, while supporting low-cost access to goods and services. The presence of local repair hubs signals the importance of low-tech, community-rooted infrastructure for enabling everyday circularity.

In terms of social indicators, success is defined by participatory governance, collective ownership, and inclusion. Metrics track levels of community involvement, the social value generated by circular activities, and the degree of democratic control over enterprises. These reflect a shift away from market-driven metrics toward cultural resilience, shared stewardship, and social cohesion as the basis for circular performance.

Table 6.1 – Triple Bottom Line indicators relevant to Bottom-Up Circular Loops scenario

Category	Indicator	Description
Environmental	Local resource self-sufficiency rate (% of materials sourced locally)	*Extent to which material inputs are derived from within the bioregion, supporting reduced reliance on external supply chains and lowering transport-related impacts.*
	Ecological footprint vs. biocapacity (EF/BC ratio)	*Assesses whether the total ecological demand of the community or initiative exceeds the regenerative capacity of the local environment.*
	Regenerative land use share (% of land under regenerative or circular use)	*Extent of land actively contributing to soil health, biodiversity, and resource renewal through agroecology, permaculture, or circular forestry.*
Economic & Operational	Local circular value retention index	*Proportion of economic value retained within the community through local exchange, reuse, repair, and mutual aid networks.*
	Relative cost of circular goods (compared to linear alternatives)	*Assesses the affordability and accessibility of circular products relative to new, mass-produced items.*
	Number of community repair hubs per 10,000 inhabitants	*Reflects the infrastructural support for repair, reuse, and skills sharing at the local level.*
Social	Community participation rate in circular initiatives (% of population engaged)	*Measures active involvement in repair cafés, reuse cooperatives, tool libraries, and other grassroots circular systems.*
	Social return on circular initiatives (SROI)	*A qualitative or monetised measure of the broader social benefits delivered by circular activities (e.g., inclusion, skill-building, cohesion).*
	Democratic ownership ratio (% of circular enterprises under cooperative or commons-based ownership)	*Degree of participatory control over production and resource flows.*

6.4 Data and Measurement Considerations

Primary data are going to be obtained through community-level surveys and participatory mapping, along with local government records and cooperative registries, project-level reporting by NGOs and citizen groups. Secondary data might be acquired from sources including: environmental footprint calculators (e.g. Global Footprint Network), academic case studies and ethnographic research, citizen science data platforms. Key challenges in this scenario include:

- Lack of standardised data across informal or non-institutionalised initiatives
- Tension between quantification and the inherently qualitative nature of many performance aspects (e.g., trust, care, empowerment)
- Risk of over-burdening community actors with reporting obligations

Where feasible, indicators in this scenario favour process transparency and participatory evaluation over rigid measurement. Reflexive, co-created monitoring methods (e.g., storytelling, participatory scoring, community audit tools) are encouraged.

6.5 Discussion and Relevance

The Bottom-Up Circular Loops scenario departs most radically from mainstream visions of the circular economy. It rejects the premise that circularity must be driven by technological innovation or market logic. Instead, it positions circularity as a lived practice of care, sufficiency, and local provisioning, a fundamentally socio-political shift grounded in alternative theories of value.

In line with Lowe and Genovese (2022), this scenario reflects a socio-cultural and deliberative theory of value, where worth is constituted through collective processes, situated knowledge, and interdependence with the natural world. Value emerges not from price or productivity, but from mutual aid, environmental reciprocity, and the capacity to meet needs without externalising costs.

From a policy and institutional perspective, this scenario raises critical questions about the role of the state, the nature of economic incentives, and the capacity of existing governance structures to support diverse, grassroots circularities. It also challenges the epistemic assumptions of conventional indicator frameworks: that progress is linear, that indicators must be comparable, and that success can be universalised.

Ultimately, performance in this scenario must be assessed on its own terms, through frameworks that privilege relationality, self-determination, and ecological balance. While such a model may not scale in the conventional sense, it offers a compelling vision of circularity grounded in justice, humility, and regeneration.

7. Comparative analysis

The scenario-based indicator frameworks developed in this deliverable reveal that performance in circular supply chains is deeply contingent on context. Each scenario enacts a distinct configuration of governance, technological agency, value orientation, and institutional logic. These differences manifest not only in which indicators are used, but in what those indicators are meant to represent, who they serve, and what kinds of futures they aim to enable or foreclose.

7.1 Contrasting performance logics

Each of the four circular economy futures carries its own internal logic of performance assessment. These logics are not simply technical or operational, they are grounded in fundamentally different value theories that shape what counts as success, who defines it, and how it is measured. The scenarios thus act as value-articulating institutions, each aligning with distinct assumptions about economic, ecological, and social priorities (Lowe & Genovese, 2022). Table 7.1 summarises these contrasting logics across four key dimensions: value theory, performance priorities, and dominant indicators.

- *Centralised Circular Uptake* focuses on scale, efficiency, and innovation within a high-tech, growth-oriented framework. Indicators reflect compliance, throughput optimisation, and market competitiveness. This scenario aligns with neoclassical value theory, where circularity is instrumentalised to secure inputs and reduce externalities.
- *Planned Circular Loops*, by contrast, prioritises sufficiency, standardisation, and social equity. Performance is gauged in terms of ecological constraint adherence and public provisioning. Indicators reflect national or regional self-sufficiency, access equality, and carbon intensity. The value logic here is biophysical and institutionalist, with the state playing a strong planning and redistributive role.
- *Decentralised Circular Uptake* privileges entrepreneurial dynamism, digital coordination, and user engagement. Indicators capture platform activity, innovation diffusion, and trust in peer-to-peer networks. Value emerges from network effects, reputation systems, and rapid iteration, drawing on neoclassical and institutionalist hybrids.
- *Bottom-Up Circular Loops* rejects the primacy of scale and market logic altogether, focusing instead on community wellbeing, ecological harmony, and democratic participation. Indicators reflect social return, local material cycles, and non-monetised value creation. This is rooted in socio-cultural and deliberative theories of value, where worth is co-constructed and contextually embedded.

These scenarios are not variations on a single model; they represent ontologically distinct pathways for how circularity might be imagined, designed, realised, institutionalised, and evaluated.

Table 7.1 – Contrasting performance logics across circular economy scenarios

Scenario	Value Theory	Performance Logic	Indicators Emphasised
Centralised Circular Uptake	Neoclassical	Efficiency, innovation, compliance	Throughput optimisation, CE investment
Planned Circular Loops	Biophysical / Institutionalist	Sufficiency, equity, resilience	Carbon intensity, localisation rate
Decentralised Circular Uptake	Neoclassical / Institutional	Innovation, trust, engagement	Platform activity, P2P diffusion
Bottom-Up Circular Loops	Deliberative / Socio-cultural	Wellbeing, ecological harmony	Non-monetised value, local material cycles

7.2 Divergence and trade-offs

While some indicators appear across multiple scenarios, such as material circularity rate, CE employment, or access to CE goods and services, their meaning and normative weight diverge significantly across value regimes. This reflects a broader challenge of indicator ambiguity: the same metric can support radically different interpretations depending on the assumptions embedded in each scenario. For example:

- A high recovery rate is seen as a marker of innovation, scale, and profitability in *Centralised Circular Uptake*, yet in *Bottom-Up Circular Loops*, it may be irrelevant, or even problematic, if it masks unsustainable throughput or legitimises extraction from the commons.

- CE employment share is a central policy target in *Planned Circular Loops*, reflecting goals of redistribution and state-led transformation. In *Decentralised Circular Uptake*, it is interpreted as a market-based success indicator of entrepreneurial vitality.
- Carbon intensity per unit of output, a staple of CE metrics, has different implications depending on the scenario. In growth-oriented futures, reducing intensity is seen as progress in terms of efficiency. In post-growth or sufficiency models, such as *Planned* or *Bottom-Up Circular Loops*, what matters is absolute reduction, not efficiency per unit.

These examples illustrate a core insight: indicators do not carry inherent meaning. Their significance arises from the institutional and normative context in which they are used. As such, comparability is not guaranteed by the metric itself, but depends on the underlying value theory and logic of evaluation. Circular supply chains, understood as value-articulating institutions, therefore require scenario-sensitive metrics to avoid misinterpretation or false equivalence.

Table 7.2 – Diverging Meanings of Shared Indicators across Circular Futures

Indicator	Centralised Circular Uptake	Planned Circular Loops	Decentralised Circular Uptake	Bottom-Up Circular Loops
Recovery Rate	Benchmark of efficiency, technological leadership, and ROI	Means to meet material quotas and reduce dependence on extraction	Business opportunity in recycling innovation	May obscure overconsumption; secondary to reducing demand
CE Employment Share	Economic diversification via CE industries	Strategic goal for state-led redistribution and just transition	Evidence of entrepreneurial dynamism and market uptake	Proxy for community resilience, autonomy, and self-provisioning
Carbon Intensity (per unit)	Performance indicator for eco-efficiency	Transitional tool; ultimate goal is absolute reduction	Branding tool for green business models	Insufficient; only absolute, territorial reductions are meaningful
Access to CE Goods/Services	Customer satisfaction and market expansion	Equity and universal provisioning ensured by public or cooperative models	Inclusion metric for platform reach and user adoption	Indicator of community stewardship and mutual aid
Material Circularity Rate	Industrial performance KPI for CE optimisation	Compliance with state-mandated resource efficiency norms	Indicator of product and material innovation	Relevant only if aligned with bioregional cycles and sufficiency

7.3 Universal vs. scenario-specific indicators

While the previous section explored how the meaning of shared indicators diverges across scenarios, this section takes a step further by distinguishing between truly universal (or 'boundary') indicators and those that are scenario-specific by design.

Very few indicators are truly universal across all futures. However, several may function as boundary objects, metrics that enable dialogue across perspectives while allowing for localised interpretation, as reported in the following Table 7.3.

Table 7.3 – Boundary indicators

Potential Boundary Indicators	Interpretation Depends On...
Material Circularity Rate	Whether loops are global/centralised vs. local/closed
CE Employment Share	Job quality, wage structure, and sectoral distribution
Access to CE Products or Services	Equity of access vs. market uptake
GHG Emissions per Unit Output	Absolute vs. relative reduction, and policy context

Most indicators, however, are scenario-specific, particularly in domains like governance, ownership models, digital platform trust, and community participation. For example:

- Digital interoperability is critical in Decentralised Uptake, but irrelevant in Planned Loops.
- Democratic ownership is a key performance indicator in Bottom-Up Loops, but not meaningful in Centralised Circular Uptake.
- Product-as-a-service penetration features in both Planned and Decentralised futures but with radically different implications.

7.4 Trade-offs and incommensurability

The diversity of indicators across circular economy futures reflects not just methodological variety, but deeper normative tensions and political trade-offs. These are not technical inconveniences to be optimised away, they are constitutive of how different futures define progress, justice, and viability. Some of the most salient trade-offs include:

- *Efficiency vs. Equity*: Indicators focused on material throughput, innovation, or cost reduction may obscure how benefits and burdens are distributed. A supply chain optimised for circular efficiency might displace environmental harms or undermine local livelihoods, especially in regions without power in global governance structures.
- *Scale vs. Resilience*: Large-scale, integrated systems offer visibility, standardisation, and control, yet they can become fragile and path-dependent. Conversely, decentralised and community-based systems often trade efficiency for adaptability and social cohesion, resisting easy quantification.
- *Growth vs. Sufficiency*: Market-based indicators often assume expansion and optimisation as inherent goods. In contrast, post-growth scenarios prioritise thresholds, limits, and wellbeing over throughput. Here, “less” may be better, but this clashes with traditional performance metrics tied to GDP, productivity, or shareholder value.

These tensions lead to incommensurability, situations where performance cannot be meaningfully compared across scenarios because the underlying value theories, goals, and assumptions are incompatible (Martinez-Alier et al., 1998). An efficient circular supply chain in one scenario may be seen as extractive or illegitimate in another.

Ultimately, these trade-offs are not neutral. They signal whose interests are being served, whose voices are elevated or ignored, and what kinds of circular futures are rendered measurable, governable, or even imaginable. As both Lowe and Genovese (2022), and

Gasparatos (2010) argue, indicators are never just technical tools, they are expressions of institutionalised value systems and embedded worldviews.

7.5 Toward reflexive indicator design

The comparative analysis across scenarios reveals that indicator frameworks are not just technical artefacts, but deeply performative and normative instruments. Indicators do not merely describe the world, they shape it, by directing attention, legitimising particular actors, and reinforcing specific value systems. This recognition calls for a more reflexive approach to indicator design, one that embraces pluralism, contextual sensitivity, and deliberative governance.

In their contribution to Ecological Economics, Purvis and Genovese (2023) ask whether CE indicators should be made *better or different*. Their response (*both*) emphasises that improving indicator systems must go beyond refining technical methods or expanding coverage. It requires confronting the epistemological and ontological assumptions embedded in current frameworks. Indicators should not simply reflect what is easily measurable, but must interrogate what ought to be measured, and why. They are not neutral mirrors of reality, but value-articulating tools that help construct circular futures in particular ways. Building on this insight, our proposal for better indicators across circular economy scenarios includes the following key principles:

- *Align indicators with scenario logic and value theory*. Indicators must be explicitly anchored in the governance model, normative priorities, and theory of value underlying each circular future. A metric that fits Centralised Uptake may be irrelevant, or even misleading, in Bottom-Up Loops. Reflexivity begins with recognising this contextual embeddedness.
- *Design modular, narrative-based dashboards.* Rather than enforcing a single set of KPIs across contexts, we advocate for flexible dashboards that can accommodate different indicator logics. These should include not just quantitative scores, but narrative dimensions that explain trade-offs, uncertainties, and local interpretations. Modularity also allows for hybrid configurations, where boundary indicators can facilitate dialogue without imposing homogenisation and give more space to the understanding of qualitative factors.
- *Integrate participatory and deliberative processes.* Indicator selection and interpretation should not be the domain of experts alone. In line with deliberative theories of value, communities, workers, and marginalised actors must have a voice in defining what counts as performance. This includes not only selecting indicators, but shaping how they are used in decision-making and accountability.
- *Include transformational indicators*. In addition to inputs, processes, and outcomes, indicator frameworks should capture deep, systemic shifts, such as changes in ownership models, governance arrangements, or cultural norms. These indicators are often qualitative, but are essential for evaluating whether a circular transition is not just efficient, but just and regenerative as well able to account for ongoing or potential transformation processes.
- *Embrace pluralism and incommensurability.* Instead of seeking a universal "circular score", better indicators should reflect the plurality of pathways, acknowledging that not all futures can be assessed through a single lens. Reflexive indicators accept the presence of incommensurable goals, such as growth vs. sufficiency, and create space for transparency and contestation rather than false precision.

In sum, designing better indicators requires a shift from measurement as control to measurement as dialogue and reflection. Reflexive indicators do not erase conflict or ambiguity, but help make them visible, so that they can be navigated openly and democratically. As circular economy transitions unfold, our ability to evaluate them must evolve accordingly, grounded in value theory, informed by context, and accountable to the futures we wish to build.

8. Conclusions and Next Steps

This deliverable has developed a novel approach to measuring the performance of circular supply chains by embedding indicators within distinct scenario logics. Building on the scenario architecture from D1.4 and the supply chain configurations explored in D2.1, this report has demonstrated that performance cannot be meaningfully assessed without reference to the institutional, technological, and normative contexts that shape a given circular future.

Each of the four circular economy scenarios articulated in this work, *centralised circular uptake, planned circular loops, decentralised circular uptake, and bottom-up circular loops,* represents a coherent but divergent vision of how circularity could unfold. These futures are not simply technical pathways, but value-articulating institutions (Lowe and Genovese, 2022), embedded in distinct theories of what is desirable, valuable, and just. As such, they demand their own performance priorities and evaluation frameworks.

By developing scenario-specific indicator sets grounded in these contextual logics, this deliverable challenges the prevailing assumption that circular performance can, or should, be assessed through a universal dashboard. Instead, it offers a pluralistic, reflexive approach to evaluation, one that acknowledges the epistemic and political dimensions of measurement (Purvis et al., 2025). This approach enables stakeholders to assess not just whether circularity is being achieved, but what kind of circularity is being pursued, by whom, and to what ends.

8.1 Key contributions

This deliverable makes several important contributions to the evolving field of circular economy evaluation.

First, it presents a comprehensive methodological framework for designing performance indicators that are context-sensitive and theoretically grounded. By integrating value theory, governance typologies, and performance dimensions, the framework enables a more nuanced approach to assessing circular supply chains, one that recognises their embeddedness in broader institutional and normative structures.

Second, the report develops four distinct sets of performance indicators, each tailored to a specific circular economy future. These indicator sets span environmental, economic, social, and operational dimensions, and reflect the unique priorities and assumptions of each scenario. Rather than applying a uniform measurement template, this reports rejects one-size-fits-all approaches and respects the diversity of circular transition pathways and the varied criteria by which success may be judged.

Third, the comparative analysis carried out in this report illuminates areas of both convergence and divergence across scenarios. It identifies potential boundary indicators that can support cross-scenario dialogue, while also highlighting irreducible trade-offs and sites of incommensurability. This analysis provides a richer understanding of how circularity is valued and measured differently across governance models and societal visions.

Finally, the deliverable offers critical reflection on the epistemological and political implications of measurement itself. It challenges the notion of indicators as neutral tools, emphasising instead their performative role in shaping what becomes thinkable, governable, and desirable. In doing so, it contributes to ongoing theoretical and policy debates about reflexivity, legitimacy, and the politics of sustainability assessment.

8.2 Next steps

The indicators and frameworks developed here are intended as foundational tools for further research, policy design, and foresight experimentation. The following steps are proposed:

- *Operational testing and piloting*: Future work should focus on piloting these indicators in real-world contexts, using both quantitative and qualitative methods to test their validity, relevance, and usability. Pilots could take place in diverse organisational and geographic settings, aligned with the different scenario logics.
- *Integration into foresight and policy design*: The indicator frameworks can serve as inputs for policy simulation, strategic foresight workshops, and participatory scenario testing in WP3. Their use can support anticipatory governance and help explore the implications of different pathways for specific sectors or regions.
- *Stakeholder co-production*: A critical next step is to engage stakeholders (including businesses, municipalities, civil society organisations, and citizens) in co-producing and refining these indicators. Participatory processes can surface blind spots, localise metrics, enhance legitimacy, and foster social transformation processes.
- *Linking to broader policy and reporting frameworks*: Further alignment with global sustainability frameworks (such as the SDGs, EU Green Deal indicators, and ISO standards) can increase policy uptake and bridge local experimentation with institutional decision-making.
- *Exploring systemic and transformational indicators*: Continued work is needed to advance transformational indicators that go beyond surface-level outputs and reflect deeper shifts in values, structures, and behaviours, particularly in post-growth and community-led scenarios.
- *Building a reflexive monitoring toolkit*: To support adaptive learning and reflexivity, the development of a modular, scenario-based indicator toolkit is recommended. Such a toolkit would allow users to explore different combinations of indicators suited to their context and ambitions, while making underlying assumptions explicit.

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