ONTO-DESIDE

Guide 1

Value chain design, development & innovation

For a circular and regenerative economy

Funded by
the European Union

In collaboration with:

Circularity Thinking
Innovating for systemic circular solutions

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Acronyms/ terminology

CE = circular economy
CEON = Circular Economy Ontology Network
MFM = Multi-Flow Method
OCP = Open Circularity Platform

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This guide—how it came to be, who it's for, and how to use it

Why this guide? The Onto-DESIDE project.
The Onto-DESIDE project aimed to accelerate the transition to a circular economy (CE) where materials, components, and products are reused to reduce waste and retain value. At the moment, circular value networks are difficult to design and scale because it is difficult to make sense of such systems as a whole. Second, industries struggle to form circular value networks due to inconsistent terminology, lack of semantic clarity, and limited tools for secure, automated data exchange.

To address this, Onto-DESIDE combined conceptual and technical innovation, by 1) creating innovation capacity for circular value chains, and 2) addressing key technical barriers to data sharing across industries. It developed the Multi-Flow Method (MFM), which integrates resource, energy, value, and information flows into a systemic view of circular value chains, using generative tensions to explore root causes to barriers and find ways to improve functioning and robustness. The project also introduced technical solutions: ontologies to model materials, products, actors and processes, ensuring vertical (within domains) as well as horizontal (across domains) semantic interoperability, together with a decentralised collaboration platform where data can be exchanged. However, a crucial aspect of supporting transformation is to provide guidance in using these new tools: the aim of this guide.

What was done and how
Onto-DESIDE applied a transdisciplinary and iterative methodology to develop the new tools and technologies for circular value networks. Academia and practice came together, using three diverse real-world industry use cases selected for their diversity and complexity—construction, electronics, and textiles—as testbeds to derive needs and validate the within- as well as cross-sector applicability of the solutions.

The project, running from June 2022 to November 2025, was structured into multiple work packages. One focused on the creation of the innovation method, a second on ontology development, and a third on the data-exchange platform. Each used their own methodology and domain-specific expertise, respectively, design science methods; agile ontology engineering practices including eXtreme Design (XD) resulting in the Circular Economy Ontology Network (CEON); and the application of mature open web standards to create a secure and decentralized interoperable data sharing infrastructure dubbed the Open Circularity Platform (OCP). Collaboration across these tasks makes them comprehensive and integrated. In uniting top-down research and standards analysis with bottom-up learning from use cases, the project created a solid and actionable foundation for advancing the circular economy.

Guide 1: *Circular value chain design, development & innovation*

Guide 2: *Decentralised sharing of data & information*

How to use the guides

There are two guides: one which focuses on circular value chain development and innovation, and a second technical guide that is dedicated to setting up a decentrally organised data-sharing infrastructure in such a way the data is interoperable and compatible.

Both guides focus on the practical steps to take towards better functioning circular value chains. Each guide discusses the relationship with the other, so it is clear where they connect. Depending on your needs and circular maturity level, you can drive straight into the technical parts, or you can first spend a moment thinking about the functioning of your circular value chain and how to design or improve it. It is up to you to decide what you need and where to start. Together, both parts of the Onto-DESIDE project outputs support the planning and automation of management and execution of circular value networks at scale, contributing to Europe's digital and green Twin Transition.

For more details, or more technical descriptions as well as templates, explainer videos, and other supplementary materials go to our website.

Please visit:
www.ontodeside.eu

ONTO-DESIDE

Ontology-based Decentralised Sharing of Industry Data in the European Circular Economy

- 12 partners, 7 countries:
  - Linköping University (SE)
  - *Interuniversitair Micro-Electronica Centrum (BE)*
  - *Concular Ug Haftungsbeschrankt(DE)*
  - *+Impakt Luxembourg Sarl (LU)*
  - *Circularise Bv (NL)*
  - *Universität Hamburg (DE)*
  - *Circular.Fashion Ug (DE)*
  - *Lindner Group Kg (DE)*
  - *Ragn-Sells Recycling Ab (SE)*
  - *Texon Italia Srl (IT)*
  - *Rare Earths Industry Association (BE)*
  - *Prague University of Economics & Business (CZ)*
- June 2022-November 2025
- Funding: Horizon Europe
  - *Grant agreement #101058682*

Three use case domains:

- Textile industry
- Electronics industry
- Construction industry

Funded by the European Union

Who the guides are for

Both of our guides are aimed at anyone who wishes to engage in circular oriented innovation. That is: anyone who wants to explore new or better circular value chains as well as get practical about data and information sharing to enable this in practice. Each guide is meant as an entry point into their respective topics, and they each target different roles—with an emphasis on the role and contribution of these different roles to the various steps in the process. Mainly these two guides provide an overview and explain what to expect whilst on this journey. In this, we focus on how different roles can work together. To this end at the top of each section, you find an indication of what roles are typically involved or who is needed to provide input to complete a step successfully. Of course, these roles can be different people, or be one and the same. Organising the guides around roles clarifies responsibilities and interfaces across the process, supporting structured collaboration, aligned expectations, and deliberate progress in circular-oriented innovation.

Guide 1—*The guide in front of you now:*
Value chain design, development & innovation:

This guide has a strategic focus, and explores what currently shapes the value chain dynamics and how circular strategies can be (better) supported. The following roles are needed to successfully complete the process:

- *Project lead:* Coordinates the overall process in which the method is applied. Ensures the right people are involved, aligns the method with the project's goals, and takes responsibility for follow-up after sessions and working groups.
- *Facilitator:* Guides the group through the Multi-Flow Method. Ensures the process is structured, that flows, tensions, and patterns are captured in a way the group can work with, and that different perspectives are heard.
- *Decision maker(s)*: Stakeholder representatives with the authority to shape the value chain configuration or influence (strategic) decisions. To ensure relevance and actionability, the process should include different perspectives (e.g., suppliers, customers, recyclers, logistics providers).
- *(Flow) Experts:* Bring (technical and practical) knowledge of specific flows (material, information, value, energy). They explain how flows operate in practice and support the group in understanding constraints, dependencies, and opportunities.

Guide 2—See: www.ontodeside.eu
Decentralised sharing of data & information:

This guide focuses on the technical side. It explains how to set up a decentralised, secure and automated data-sharing infrastructure that supports a chosen value chain configuration and the collaborations between the actors involved. The steps involved in setting up this infrastructure needs the involvement of different types of roles in the involved organisations. We identify 4 such roles:

- *Decision Maker*: May be the value chain manager, coordinating the setup of the whole value chain, or merely the internal manager in charge of ensuring the participation of a specific actor in the value network configuration. Additionally, a decision maker may be a CTO or CIO making decisions about the IT infrastructure setup and investments.
- *Data Steward*: Any role that produces, manages or maintains the data that is to be shared and used in order to make the value chain configuration work.
- *Developer*: Either an information architect/ data modeller, or a software developer/IT specialist. These are the roles that will do the practical work of modelling and transforming the data, as well as setting up the actual infrastructure and configuring it.
- *End-User*: The roles within the value chain organisations that hold the needs for receiving or sharing the data. For instance, this could be a person at a recycling facility, needing the information about incoming used materials in order to make decisions regarding where to dispatch a certain batch or container.

Why, what and how of Circular Economy

"Take-make-use-*lose*"

Our global economy operates largely on a linear model: extract, produce, consume, and dispose —repeat. This system assumes unlimited access to resources and an infinite capacity for waste absorption. But our planet can provide neither: we are rapidly depleting finite resources and are overwhelming natural systems with waste and emissions. Even recycling, often seen as a solution, only addresses a very small part of the problem and fails to fundamentally transform how we use resources. What's more, this extractive system entrenches inequality, undermines livelihoods, and worsens living conditions for many.

For example, resource extraction has already more than tripled since 1970 and is projected to rise another 60% by 2060 if the current path is followed, accounting for over 60% of global greenhouse gas emissions and 40% of pollution-linked health impacts[1]. Such scale places enormous pressure on ecosystems and communities. No wonder that the linear economy is sometimes also referred to as "Take-make-use-*lose*"[2].

Instead…

Our economies will have to change their extractive practices to sustainable and regenerative ones. Circular Economy (CE) offers one path through the application of Re-strategies like *re*think, *re*duce, *re*tain, *re*use, *re*pair, *re*furbish, *re*manufacture, *re*cycle—and a range of related strategies like composting & industrial symbiosis. The aim is to better meet the needs of the whole system–planet, people and businesses–and thereby encourage different ways of handling waste and resources, improving resource conservation, efficiency and productivity. Or: how can we live comfortably - without costing people and the planet?

CE is no longer optional, but a must-have

Mounting resource scarcity, increasingly volatile supply chains and resource prices, intensifying legislative and regulatory pressure, and rising stakeholder expectations mean that CE is no longer optional—it's essential for business resilience, compliance, innovation, and competitiveness[3,4,5]. Companies that continue to rely on a take-make-dispose model expose themselves to higher costs, operational disruptions, and reputational risks, while those that adopt circular strategies can secure materials, stabilize supply, and strengthen their license to operate. Thus, CE is becoming a key driver of both risk management and value creation.

Likewise, finance and investors are intensifying the shift of capital toward businesses that demonstrate circular strategies, recognizing them as lower-risk, future-fit, and better positioned to deliver long-term value[6]. Capital markets are increasingly embedding sustainability and circularity metrics into lending, investment, and valuation models, rewarding companies that proactively align with emerging standards. Those who fail to adapt may face shrinking access to capital, higher borrowing costs, and reduced investor confidence, while circular leaders stand to attract investment, partnerships, and preferential market positioning.

The Challenge

But… 'going circular' is complex. It requires systems thinking to understand how and why materials flow, where and why waste originates, and how circular strategies interact. It requires moving beyond simplistic models and truly solving problems—not shift them elsewhere or create new ones. And: not all circular strategies work at every scale or in every context, and some may even compete or create trade-offs. For example, choosing highly

durable composites can hinder recyclability, and remanufacturing may initially require more materials—not less. And so on. The challenge is to design and operate sets of circular strategies that resolve, go around or balance these tensions and deliver real benefits. Doing so requires the right mix of competition and collaboration, clear and easily accessible data, and adaptive management across the value entire chain.

For this reason, circular innovation differs fundamentally from linear or 'business-as-usual' innovation. It involves creating virtuous loops—feedback mechanisms where resources re-enter the value chain—and generating emergent properties like sustainability and resilience. These benefits arise not from isolated actions but from how the entire system behaves.

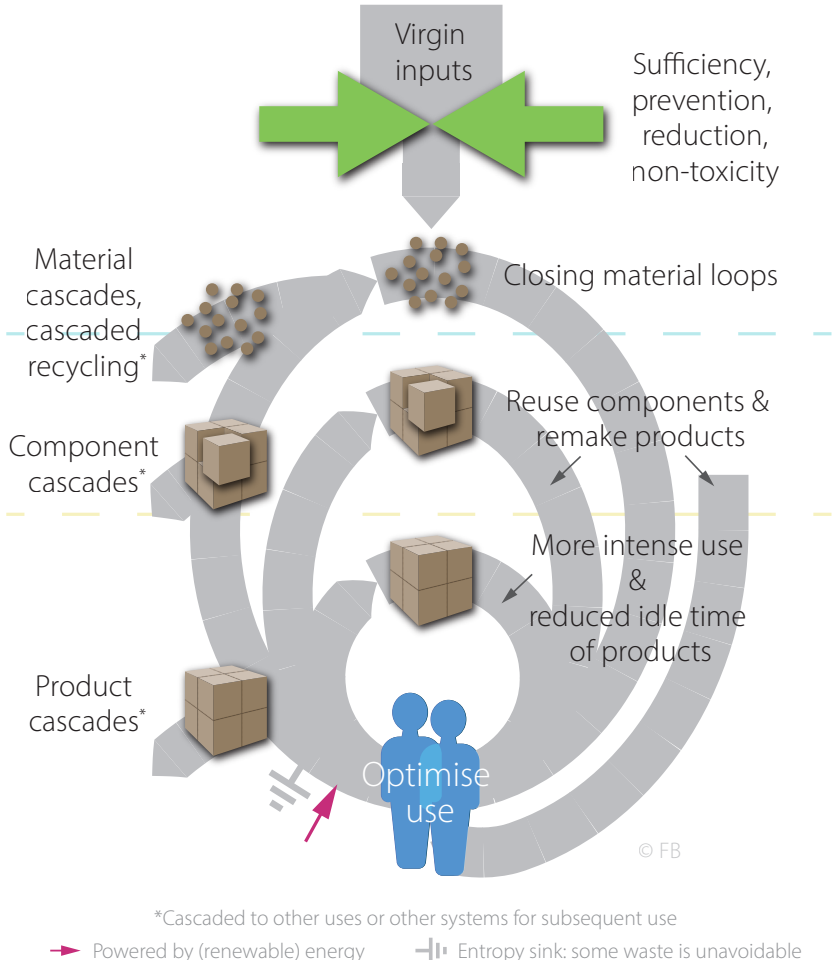


Figure: **Circular strategies in the use phase, and for products, components and materials.**

From a linear to a circular mindset

All this means that a different mindset is needed when engaging in circular oriented-innovation. Crucially: it means creating systems where multiple circular strategies operate synergistically—where, through collaboration, all actors benefit. Circularity Thinking helps cultivate this new circular mindset.

1. Flow Structure: One-Way vs. Feedback Loops

- Linear mindset: Resources flow in a straight line—extraction, production, use, disposal—with minimal interaction between processes.
- Circular mindset: Resources circulate and regenerate through feedback loops, re-entering the system several times (as products, components, and materials) and influencing upstream and downstream decisions over time.

2. Value Creation: Localized vs. Emergent

- Linear mindset: Value is created and captured at specific points in the chain (e.g. sales, production)—with opposing and conflicting interests, resulting in value conflicts.
- Circular mindset: Value is emergent, arising from how the entire system functions—through resilience, sustainability, and shared innovation. Both the whole and the parts benefit equally.

3. Problem Solving: Fragmented vs. Systemic

- Linear mindset: Problems are solved in isolation, often within departmental or disciplinary silos. This leads to displacement and the creation of new problems.
- Circular mindset: Problems are addressed systemically, considering interdependencies, long-term effects, and cross-sector dynamics.

4. Strategy Use: Selection vs. Configuration

- Linear mindset: Strategies are chosen individually—reuse or recycling, efficiency or durability—as they benefit one actor, often without considering their interactions.
- Circular mindset: Strategies are combined into configurations, designed to work together synergistically and allowed to evolve over time, seeking the addition of more circular strategies through continuous improvement.

5. Innovation Process: Execution vs. Iteration

- Linear mindset: Innovation follows a fixed plan—analyse, design, implement—assuming predictability and with limited flexibility.
- Circular mindset: Multiple innovation modes operate alongside each other, where innovation also incorporates processes that are iterative, involving experimentation, learning, and the ability to pivot when assumptions prove incorrect.

6. Responsibility: Compliance vs. Stewardship

- Linear mindset: Responsibility is often limited to meeting regulations or minimizing costs.
- Circular mindset: Responsibility includes stewardship—ensuring that circular strategies address real problems and no new ones are created elsewhere in the system. And: that the needs of all parts of the system are served.

Value-, resource- & information-flows

Therefore, to design, improve, and operate a circular way of working it is essential to adopt a *value chain* perspective - sometimes also called a *value network*. This is because circularity cannot be achieved in isolation—materials, components, products, as well as benefits and impacts flow across multiple actors and stages. Only by seeing how decisions in one part of the chain affect others can businesses understand how shared benefits can be created and value captured and to design circular strategies that synergistically reinforce each other. This perspective also highlights trade-offs and tensions that must be managed collectively, rather than pushed onto individual actors, if the system is to function. *Data and information* play a critical role in this: they *provide the transparency needed* to track resource flows, identify where waste and inefficiencies occur, and coordinate action across suppliers, partners, and customers. Without accurate, shared and frictionless access to information, circular value chains cannot be designed effectively or operated at scale.

This guide

To help with this, the **Onto-Deside** project created the following guidance and support for:

- *Value chain design, development & innovation:* gaining insight into the root causes of barriers and enablers that shape the behaviour of value chains, and examining how this dynamic can (better) support circular flows.
- *Decentralised sharing of data & information:* understanding data needs and availability, formats, and aligning the data to a shared domain model, the Circular Economy Ontology Network (CEON), setting up an Open Circularity Platform (OCP)—data-sharing such that data becomes interoperable, but where control over what to share with who and when remains with the data owners.

The guide in front of you covers:

- *Value chain design, development & innovation.*

Please find the other guide at:
>>> www.ontodeside.eu

For all circular strategies—from recycling to repair, from reuse to remanufacturing

To make the guidance concrete, we introduce four short circular-strategy scenarios that we'll revisit throughout this guide, with the reuse case treated in more depth. Their role is to illustrate that they all benefit from strategic thinking about your value chain: where value is lost, which resource states to preserve, and how strategies interact as a configuration rather than in isolation. Although the scenarios (A–D) pursue different priorities, they surface common needs—clear roles, aligned incentives, and to have healthy value chain patterns. This provides a foundation for deriving data requirements, providing the basis for designing your data infrastructure. See more: *Guide 2 Decentralised sharing of data & information*.

(A) Beginning-of-life: using recycled input
What: Cross-sector recycling of apparel waste into feedstock for floor tiles.
Why: To unlock circular business models, and help to find the right recycled feedstock through product passports and secure data exchanges.

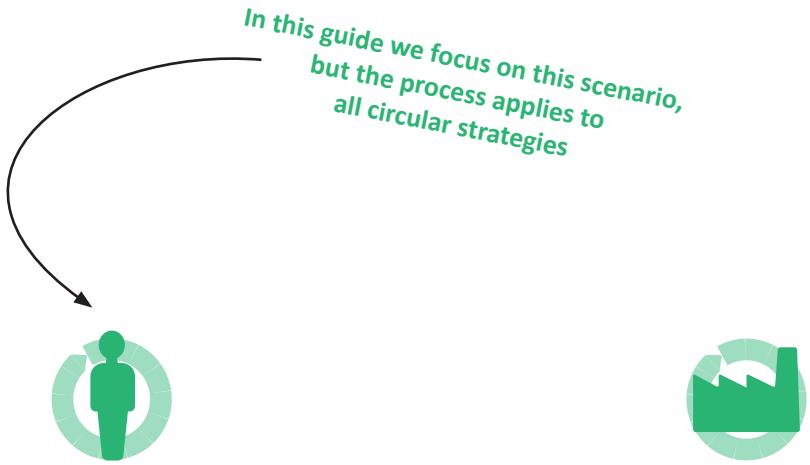
A *product manufacturer* creates a performance shoe using inputs from various *material suppliers*, each contributing data to a shared platform for product passports using standardized formats. Once the shoe reaches end-of-life, a *recycling operator* disassembles it, guided by digital instructions, and extracts the rubber outsoles and textile laces that are made into bulk materials.

These recovered materials are listed on a *digital marketplace*, enriched with a certificate and metadata including composition, condition, and recycled content. Next, a *materials processor* identifies suitable batches and requests pricing via the platform. After purchase, the recycled inputs are turned into materials that an *interior outfit company* uses for acoustic floor tile layers. Certificates and material data travel along, and a new product passport is generated for the product.

(B) Middle-of-life: repair
What: Repair of an audio system through access to reliable spare parts and instructions.
Why: Automating sustainable asset management through digital tools to enable easier data management, whilst protecting sensitive data.

A *building owner* identifies a malfunction in the installed audio system. Using a data exchange platform they access repair instructions and discover that the *original equipment manufacturer* offers a repair service. The component is sent for repair, and the manufacturer replaces the faulty speaker with a newer model containing a higher amount of recycled content.

The repaired unit is reinstalled, and updated product data is published and added to the *building's digital twin*, including material composition and sustainability attributes. Digital product passports record both original and repaired versions, tracking components and their environmental impact—including recycled content, origin, and certifications—automating the management of building information.



(C) End-of-life: reuse

What: Reuse and resale of a door for use in other building projects.

Why: Linking supply & demand through a digital market place for second-life parts & components.

A *building owner,* preparing for demolition, assesses the reuse potential of installed elements, such as doors, for repurposing through resale. This information is used by the *demolition contractor* to negotiate a fair price for the building's demolition, and sets the frame for what demolition methods will be used.

To find a new use, the building owner lists the components, including the doors, on a *digital marketplace*—provided by an *intermediary* for sale to *construction companies* for reuse in new projects. Metadata such as dimensions, condition, and installation history are shared, and enriched with images, enhancing buyer confidence. Pricing information is managed securely via decentralized data pods, ensuring only authorized parties can access commercial terms and optimising the value for the building owner. Planning considerations are automatically taken into account.

(D) End-of-life: remanufacturing

What: Take-back of the floor tiles by the manufacturer for remanufacturing.

Why: Enabling manufacturers to take-back their products, ensuring access to future feedstock.

At the end-of-life stage of a building, a *building owner* initiates a demolition plan and assesses reuse and recovery options for installed components. Among these, the acoustic floor tiles—originally made with recycled feedstock from apparel waste—are identified as having high reuse potential, but not in their current condition.

The owner contacts the *original tile manufacturer,* who offers a take-back program. Through a data exchange platform—facilitated by an *intermediary*—the manufacturer provides pricing and logistics information for reclaiming the tiles. The tiles are returned, inspected, and remanufactured into new flooring systems, integrating both recovered and new materials. This process reduces raw material demand and preserves embedded value.

Innovating for a circular economy—an overview of the what, why & how of Circularity

A structured approach to systemic innovation
Circular-oriented innovation touches on many aspects: material choices, product design, business models and capabilities, customer and supplier relationships, as well as other value chain capabilities that may be needed but cannot be provided in-house. When juggling all this alongside the daily demands of any organisation, it is easy to lose sight of the bigger picture and it can be difficult to make sense of the many interactions. And when—on the rare occasion—there is time to engage with these matters, it can be hard to navigate the wealth of existing approaches and to choose the right tool, card set, method, framework, or software.

In practice, what is often missing is a structured approach that acts as a red thread through this complexity: one that makes it easier to apply a circular mindset through a systemic approach, connects the dots between problems and solutions, and weaves separate tools into a coherent whole. Without this, businesses risk partial solutions, wasted effort, and unintended consequences. A method for designing and managing circular innovations can provide this missing structure by offering clarity, focus, and coordination.

Circularity Thinking (CT) is designed to do exactly this. It is a structured, systems-based method that supports circular economy innovation by forcing a careful look at the *problem space* before jumping to solutions. Rather than starting with a favourite circular strategy or technology, CT first helps clarify what really needs to be addressed: where resources are wasted, where value is lost, and which actors and constraints shape the system. Only then does it link this problem space to the *solution space*—showing how circular strategies can be effectively applied—and help identify and unpack the key system dynamics that any successful innovation must take into account.

A focus on relationships and the *in-between*
In CE innovation, focusing solely on local optimisation—such as improving the recyclability of a single product or reducing waste in one department—can obscure deeper systemic issues. Waste often originates not at the point where it becomes visible, but elsewhere in the system, driven by decisions made upstream or downstream. For example, designed obsolescence in product development may lead to premature disposal, which also increases manufacturing waste due to replacement purchases. Without a systemic lens, these interdependencies remain hidden, and interventions risk treating symptoms rather than root causes.

The "in-between"—the spaces between processes, departments, companies, and life cycle stages—is often where many obvious and less obvious forms of waste reside. These gaps represent value loss and value destruction, yet they are often overlooked because they fall outside the scope of individual actors or tools. Circularity Thinking helps make these invisible zones visible by mapping flows for complete life cycles and identifying where *waste has a ripple effect*. Or: where waste creates more waste. The method enables seeing how processes interact. This relational view is essential for designing circular configurations that are coherent, scalable, and resilient—and don't lead to circularity for circularity's sake, but enable circular strategies to address real problems.

Moreover, no single actor can implement circularity alone; it requires coordinated action

across supply chains, sectors, and communities. By focusing on relationships—who needs to do what, when, and with whom—organisations can identify gaps, align incentives, coordinate processes and build the partnerships necessary for circular systems to function.

Circularity Thinking provides the tools to map actor configurations, explore systemic dynamics and align innovation modes to ensure that circular strategies are not only technically viable but also organisationally feasible.

Figure: **Waste loves company and has a ripple effect.**

A red thread, not a replacement of existing tools
Importantly, CT does not replace existing tools. Instead, it acts as a conceptual red thread that connects and enhances them. Whether you're working with product design guidelines, business model tools or lifecycle assessment (LCA) or other tools, CT helps you apply these methods more effectively by clarifying what's at stake and what needs to be achieved. It provides a common language and structure that supports interdisciplinary collaboration and decision-making. For example:

- ***Product Design***
  CT helps design teams understand how circular product features (e.g. modularity, durability, material choices) can support different circular strategies across a resource's life cycle. It enables designers to anticipate how design decisions affect the system as a whole, including downstream processes and user behaviour.

- ***Business Model Development***
  CT distinguishes between anchor strategies (those addressing key structural wastes) and supporting strategies (those enhancing or enabling the anchor). This allows for phased implementation and continuous improvement, helping organisations build circular business models that are both viable and scalable.

- ***Impact Assessment (LCA & others)***
  CT supports the definition of functional units and system boundaries by identifying relevant circular strategies and their implications. It helps organisations assess trade-offs, avoid rebound effects, and interpret LCA results in a way that reflects systemic impact rather than isolated metrics.

Circularity Thinking "follows the flows"
It continually asks where something comes from, where it goes next and why, and what effects this has. It is grounded in life-cycle and systems thinking. Each step uses a similar template but examines different aspects of the problem and solution spaces. Together, these steps form a suite of tools, each developed through a scientific process—sometimes in collaboration with a range of actors, sometimes first tested within a single company. Over time, CT has been shaped with companies of different sizes and maturity levels, and across many sectors: e.g. the built environment, fashion and textiles, electronics, furniture, fast-

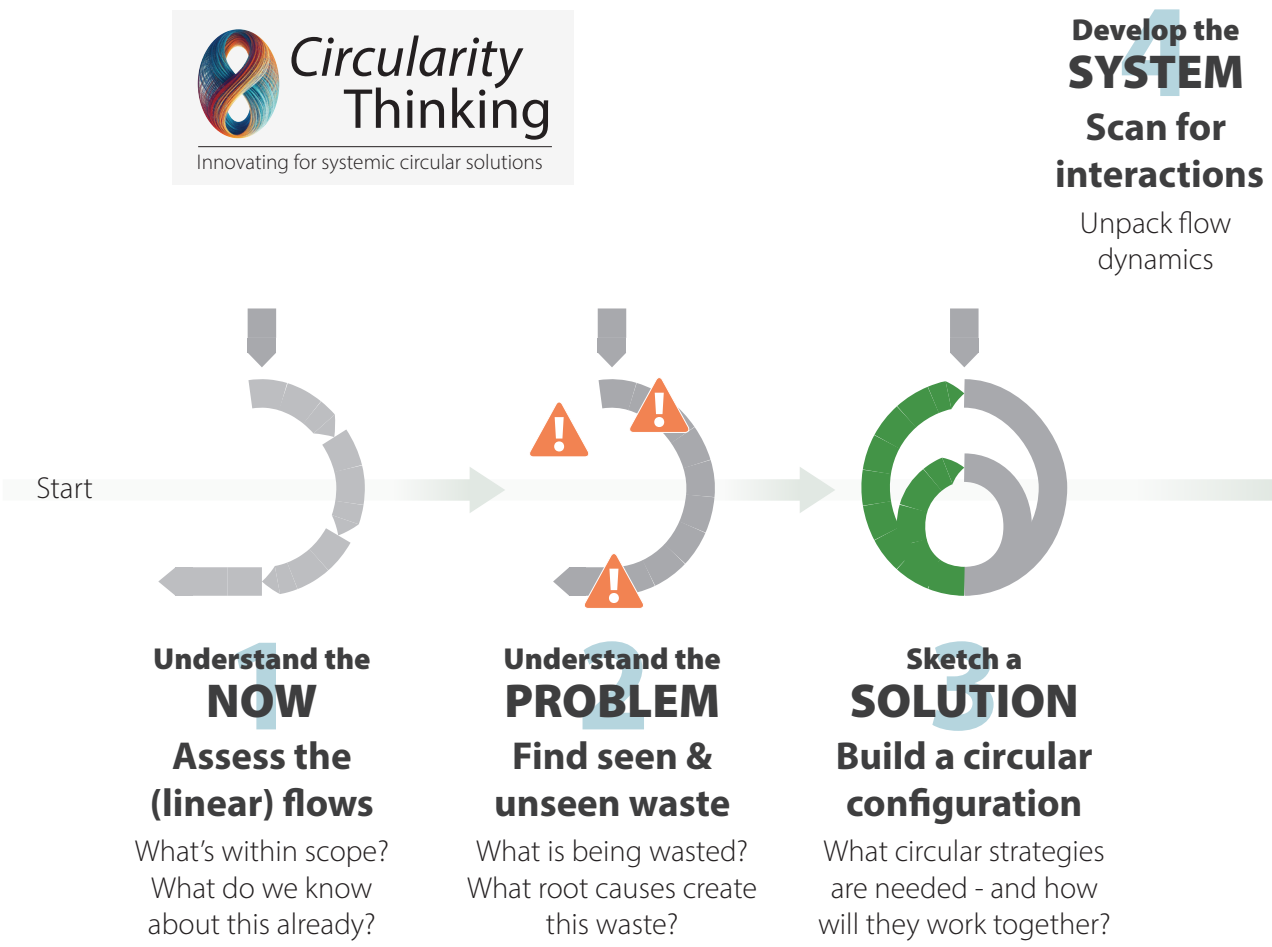
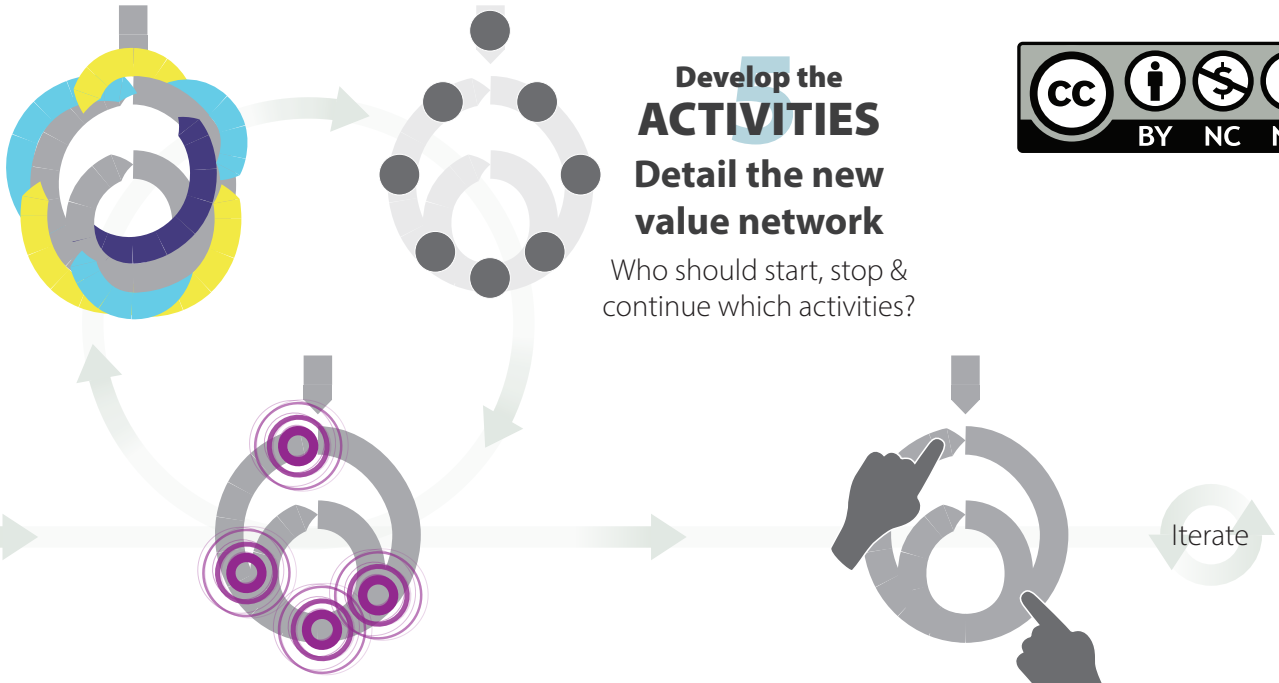


Figure: **The Circularity Thinking process, step 1-6. This guide explains about step 1-4. Note Ci**
The (purposefully low) fees for commercial use are reinvested

moving consumer goods and capital goods. These companies have acted both as case studies and as test beds for different parts of the methodology, allowing the approach to mature. It continues to evolve as we learn more about how to bring circular and regenerative practices to scale. Today, Circularity Thinking is used by a wide network of users—from Spain to Norway, from Finland to Germany, from Italy to Romania, and from the Maldives to Japan. It has also been applied in education, and in work with local, regional and national governments. The following sections describe a selection of steps in more detail.

This guide covers Steps 1 to 4 - for the remainder please consult: >>> www.circularitythinking.org



How to use? Always a good starting point.
As Circularity Thinking consists of a suite of tools, you may not need all tools all the time. Depending on the scope, what is investigated and the remit for change, different tools may be used.

However, a good starting point, no matter the project, is to 'understand the now' combined with a 'waste hunt' followed by the 'configuration builder.' The first provides an overview of the life cycle and where different types of waste are located—and how they are related. The second explores the possible set of circular strategies that is needed to address this. This gives you insight into where the problems really are, and the nature and scope of the available solution space. With this foundation, you can further deepen insights and develop solutions in subsequent steps.

Foreground and backstage tools
If you are working with a group of people, inside or outside your organisation, consider how to best use the tools. It may be good to organise a workshop where you convene different actors and use the Circularity Thinking tools to facilitate the conversation. Such *foreground use* helps build a shared picture of what's going on and allows drawing from different types of expertise. But it may not always be needed to organise big workshops. You can also pre-fill the templates and further develop, expand or validate your analysis by asking input from others in 1-on-1 sessions. However, do make sure that before getting a response, that everyone is on the same page regarding the objective, scope of the question and how to navigate the templates. In other cases it may be sufficient to use the tools to structure your own thinking or that of a few key decision makers—and only share the outcomes of this with the group. Such *backstage use* ensures you think through decisions and justify them appropriately.

Use Circularity Thinking to:

Diagnose
- Make hidden wastes visible by mapping flows across the value chain.
- Highlight how waste arises in-between actors, processes, and life-cycle stages.
- Connect the problem space (why waste occurs) with the solution space (what circular strategies to use).

Prioritise
- Distinguish which wastes matter most: large in volume, small but toxic, or strategically critical.
- Compare and weigh different wastes to identify interventions with the highest systemic impact.

Design
- Translate problems into targeted circular solutions (e.g. repair, cascade, recycling).
- Balance interdependencies: account for synergies, trade-offs & competition between strategies.
- Ensure feasibility by considering costs, risks and path dependencies.
- Leave room for continuous improvement and innovation through adaptable system design.

Align
- Clarify roles and responsibilities across actors in the system.
- Identify gaps, overlaps & collaboration opportunities.
- Provide shared understanding and common language across disciplines and organisations.

Justify
- Ground circular strategies in real problems instead of "circularity for circularity's sake."
- Build strong business cases anchored in cost savings, risk reduction, compliance, and sustainability outcomes.

Resources & Waste—two central concepts

Circular economy is about changing how we handle resources and waste. But what counts as resource and what is waste is not always obvious. Where, how, and why a resource becomes waste shifts with context, use, and perception. Today's waste can become tomorrow's feedstock, and vice versa. This makes it hard to know whether two people mean the same thing when discussing circular strategies. For example, one might say "recycling" when referring to product reuse, while another might say "reuse" to describe recycling. Circularity Thinking offers clarity through a shared language to explore where waste occurs and why. Two frameworks are used: Resource States and Structural Wastes.

What is a *resource*? Introducing *Resource States.* Simply put, a resource is the *physical "stuff"* that flows through the economy. But: as resources flow, they take different forms on their journey:

- Particles (materials) – elements, substances, molecules or bulk materials (e.g. metal sheets, plastic pellets, cotton bales).
- Parts (components) – intermediate forms created from materials through manufacturing (e.g. gears, motors, casings, zippers).
- Products (finished goods) – fully assembled items that deliver utility to end users (e.g. kettles, phones, cars, clothes).

These three states reflect increasing levels of order (organisation of matter), so we refer to them as three *resource states*. The more organised something is, the more effort, technology and labour has gone into creating it—and therefore the more value is at stake if that order is lost. That is: value lies not only in the raw material itself, but also in how it is structured. A steel beam, a car engine and a laptop all contain metals, but dismantling them back into metals destroys much of the invested value in design, precision, assembly and distribution.

Resource states describe what is transformed and also who does this: the different actor *tiers.* Tiers indicate suppliers' position relative to the final manufacturer. Materials such as sheet metal, cotton bales or plastic pellets typically map to Tier 3 suppliers (extraction and basic processing); components such as motors or zippers typically map to Tier 2 suppliers (manufacturing and technical know-how); finished products such as clothes or cars sit with the final manufacturer, who is supplied directly by Tier 1 (finished or near-finished parts, modules or products). In this way, resource states align with tiers and highlight distinct knowledge and competencies at each level.

Circular strategies aim to preserve the order created in each resource state for as long as is feasible and desirable. But resources are not static; their value comes from how they are transformed, structured and maintained over time. Organising this journey using the resource states gives us the *Circularity Compass* - see Figure.

***Why* is something a resource?**
Even more important than *what* it is, is perhaps the question of *why* a resource is even thought of as a resource. Resource-ness is not an inherent property, but emerges when people, organisations, or societies decide it is useful.

Resource-ness is shaped by:
- Practices (what we do with things).
- Expectations (what we think (will) matter).
- Cultural values (what we all care about).
- Institutional framing (what is allowed, supported, or incentivised).

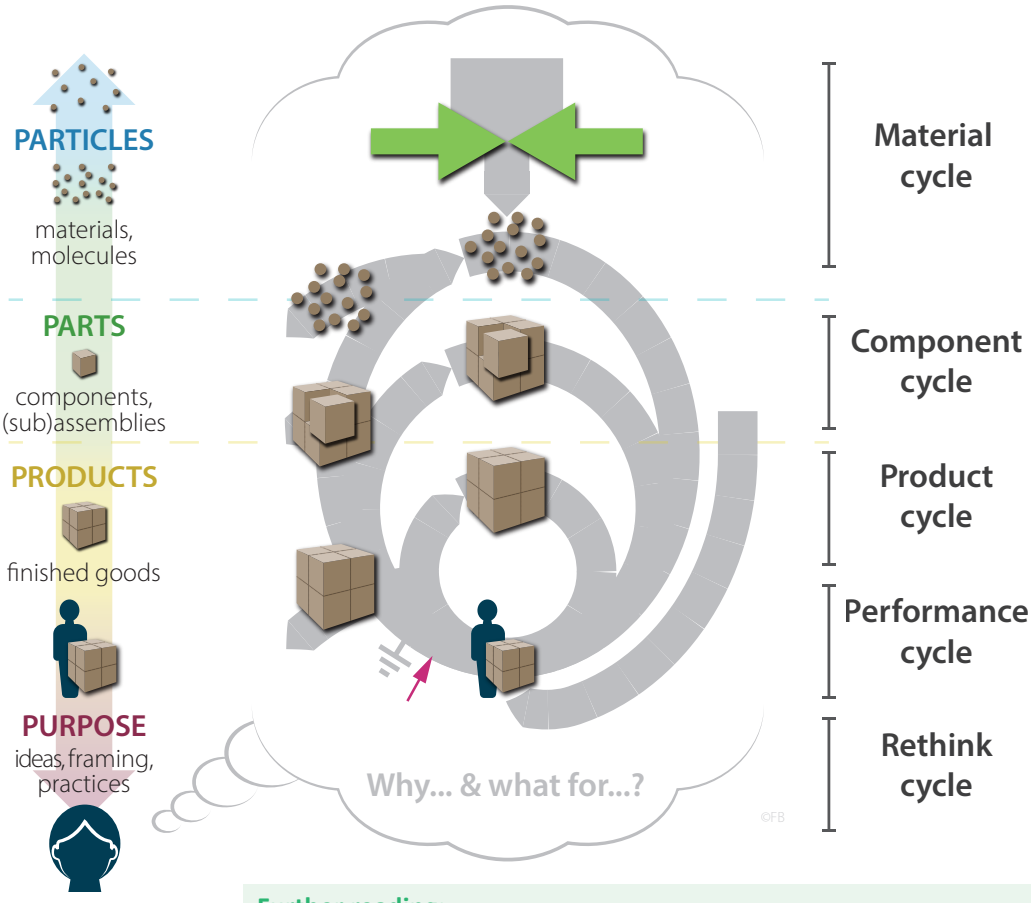
This means the same item can be a waste stream in

one context and a valuable resource in another—food surplus, CO_2 or old textiles are all familiar examples. Recognising this dynamic creates leverage: by shifting perceptions, redesigning practices or changing incentives, it becomes possible to turn waste into resources.

In other words, "resource" is a relational concept: something is only a resource if people attribute value and utility to it. Making the underlying purpose explicit and reflecting on current practices opens up space to rethink how things are done and to make more deliberate choices about how needs are served.

The Circularity Compass captures this by combining the three resource states with a fourth, interpretive layer that interrogates why something is seen as a resource, providing a shared frame for organising discussions and guiding decisions.

Figure: **The Circularity Compass**



Further reading:

- *Blomsma and Tennant (2020)[16] & Blomsma, Tennnant & Ozaki (2023)[17].*

What is waste? On *Structural Waste*.

In everyday language, waste is usually understood as what we throw away or is incinerated—the leftovers, scrap, or rubbish that is no longer useful to us. But this narrow view hides a much bigger issue: the *loss or destruction of value*. This type of waste also occurs when products fail too early, when resources are underused, when more is consumed than necessary or this has a toxic effect. To capture these less visible forms of value loss, we use the term *structural waste*. This gives a more technical definition to the concept of waste: it highlights the patterns in how value leaks out of systems, making it possible to spot and address them systematically through circular strategies. This gives circular strategies a clear 'why'—and prevents circularity for circularity's sake.

How to look for structural waste

To make looking for structural waste easy, it is grouped into three core categories, each highlighting a distinct way value is lost across systems. These categories are not just technical—they reflect recurring patterns across industries and life cycles. They reveal where resources are not renewed, left unused, or consumed in ways that cause harm. By naming these patterns—*premature end-of-life*, *premature end-of-use*, and *excess or harm*—and locating them within each resource state, we can better understand the nature of waste and match it with targeted circular strategies that restore and extend, or that prevent waste—making circularity purposeful and effective. In doing this analysis you gain clarity on where interventions matter most, how to prioritise them, and unlock value. This reduces blind spots, helps ensure strategies address root causes rather than symptoms, and aligns departments and partners around a shared understanding of the problem and the options to address it.

Structural waste patterns

1. Premature End-of-Life

- Problem: A resource stops functioning because its performance is not renewed, even though it could be restored.
- Waste pattern: Life cycles are cut off unnecessarily; value is lost because resources are abandoned instead of rejuvenated.
- Response: *Re-establish performance* by renewing or restoring quality/functionality.

2. Premature End-of-Use

- Problem: A resource's functional capacity is underused; it stops being useful in one context even though it still has value in another.
- Waste pattern: Value is lost due to partial use of resources instead of fully 'used up'.
- Response: *Optimise functional life* by redirecting, cascading, or sharing resources to maximise their use potential.

3. Excess or Harm

- Problem: Resources are used unnecessarily, inefficiently, or in damaging, toxic ways.
- Waste pattern: Overuse, inefficiency, or harmful design choices.
- Response: *Prevent excess or harm* by reducing inputs, choosing benign alternatives, or designing for sufficiency.

Structural waste and resource states

Structural waste patterns span all resource states: premature end-of-life occurs when materials, parts, or products aren't renewed; premature end-of-use arises when their functional capacity of these resources remains underused; excess or harm results from unnecessary or damaging consumption, reducing efficiency and sustainability system-wide. We can use these patterns to create a waste-matrix: the *Big 5 Structural Wastes*—see Figure.

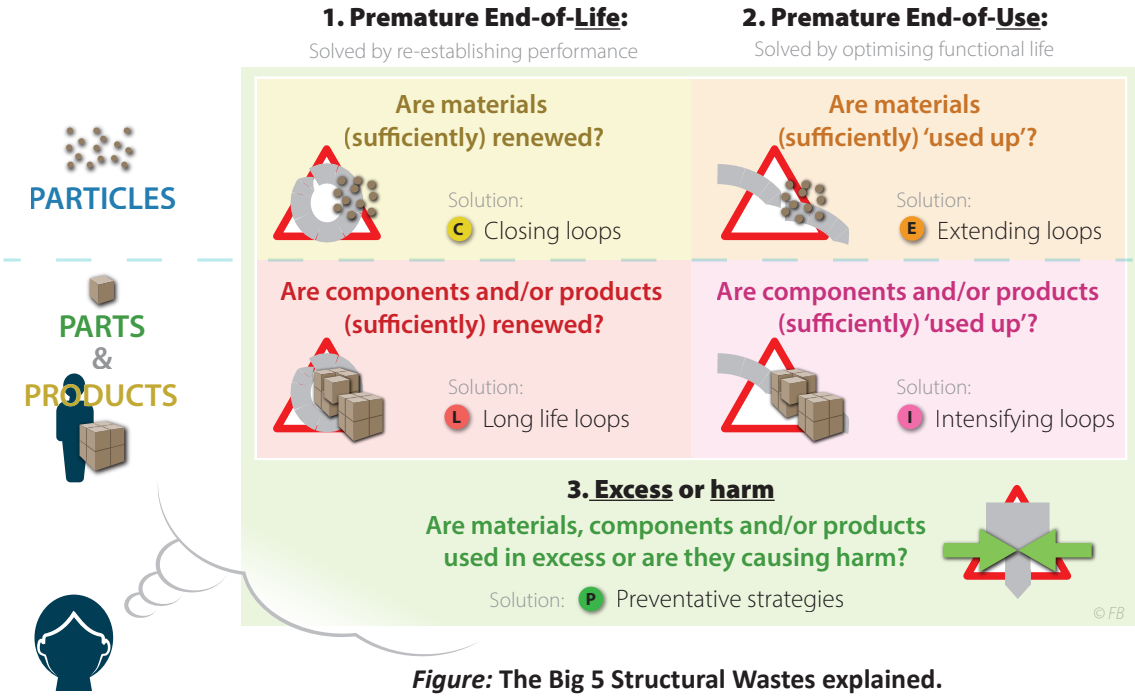


Figure: **The Big 5 Structural Wastes explained.**

Using the "Big Five"
The Big Five can be used to answer the following questions, which is the foundation for exploring what circular strategies can and should be used:

What waste is found?
Use the Circularity Compass to scan each resource state for structural wastes. This gives an overview of what is going on.

Where does it originate? The "in-between".
Waste often doesn't occur in obvious places: it is hidden in-between processes, departments, and actors when incentives are misaligned, coordination breaks down, data is not shared, or responsibilities are unclear. These gaps, usually invisible to conventional reporting, often represent the biggest untapped opportunities for value creation. Be critical in examining this.

Why does it originate? Purpose & practices.
Similar to what is seen as a "resource" what counts as a "waste" is not fixed but shaped by practices, expectations, cultural values, and institutional framing. What ideas and assumptions around purpose and practices lead to waste?

Which wastes are connected?
Waste in one part of a system often triggers further waste elsewhere. For example, poor design can cause production scraps, difficult repairs & shorter product lives. These connections make that waste multiplies across processes.

The answers to these questions together explain what waste is present and why.

Further reading:
- *See also: Blomsma (2018)[7].*

Why is all this needed?

By now, it may be clear that Circularity Thinking takes a different approach to circular strategies compared to other circular strategy frameworks such as the *waste hierarchy* ("reduce, reuse, recycle"), the *9R framework*[8] or "closing, slowing, narrowing"[9]. For one, Circularity Thinking avoids a fixed ranking of circular strategies. After all, it may not always be preferable to recycle a material or to reuse a product. For example, recycling low-grade plastics into food packaging can risk contamination, and reusing an old, inefficient refrigerator may waste more energy than replacing it. Instead, Circularity Thinking asks: "How can this whole system be optimised in context?"

A clear language

Other circular strategy frameworks can be useful as shorthand, but—as discussed—they often blur what exactly is being preserved. The *Resource States* (particles, parts, products) provide a clearer language to distinguish whether a strategy is preserving materials, components, or whole products, while the *Big Five* clarifies which types of waste are at play. Together, they make it easier to build a shared picture of where interventions are needed, and what kind of circular strategies are appropriate.

A clear 'why' for circular strategies

Another shortcoming of other circular strategy frameworks is that circular strategies are presented unconnected to specific underlying problems. This risks creating "circularity for circularity's sake" by ticking boxes. Instead, using the Big Five critically and examining what waste occurs where in the system allows for focusing on systemic impact. This makes for a shift into a problem-driven rather than solution-driven approach, which grounds circular strategies more firmly in a rationale for doing them. This furthermore supports strategic prioritisation. Instead of asking "Which R should we use?", Circularity Thinking asks: "Which kinds of waste do we need to address—and how can circular strategies help with this?"

Circular Configuration: a circular strategy portfolio

Another common shortcoming of other circular strategy frameworks is that they tend to present circular strategies as a list of which you, after some reflection, can pick and choose a preferred option. But this ignores a simple fact: circular strategies interact. Some strategies are synergistic with each other: using a bio-waste as an input can also create a compostable material at the end-of-life. Others may compete or represent trade-offs: such as design-for-remanufacturing, which may mean having to use more materials for the first cycle.

For this reason, Circularity Thinking approaches circular strategies by putting their interactions at the centre, recognising that these interactions—both positive and negative—are the rule rather than the exception[10]. Instead of looking at individual circular strategies in isolation, it is more useful to think in terms of **circular configurations**: situations where two or more strategies interact. The aim is to maximise positive, synergistic interactions and to minimise or manage negative ones. As with any portfolio, circular strategies are best considered as a set, not as stand-alone measures.

Adopting this perspective not only means that it is easier to spot the "in-between" of processes, departments and actors discussed earlier, but it also means that already at an early stage effects like displacement—moving impacts to other parts of the system—and rebound—when circular gains trigger extra consumption that cancels out the intended benefits—can be explored by critically examining how the set or portfolio of circular

strategies will interact with each other.

Unpack the 'black-box' of circular business models

In addition, Circularity Thinking also provides a way to unpack what is actually circular about circular business models. On the surface, different models may look similar—for example, product-service systems based on renting, leasing or pay-as-you-go access—but their underlying circular strategies can differ significantly. It becomes possible to ask: does the model only change the use phase, or is it backed up by additional circular strategies such as maintenance, repair or remanufacturing? This makes it easier to see to what extent resource conservation, efficiency and productivity are supported by the circular strategies embedded in a given business model.

Anchor- & support strategies, sequences

Another part of this is how to distinguish between the circular strategies that form the backbone of a business model and those that enhance it. *Anchor strategies* are those directly linked to the most pressing structural wastes a business model seeks to address. They represent the primary intervention and form the foundation of a circular configuration. *Supporting strategies* complement these anchors by enhancing them, or mitigating remaining wastes. A sharing model anchored in intensification, for instance, may first launch as a basic access model, then be improved over time with durable design, spare parts provision, and predictive maintenance. Thinking in terms of roll-out sequencing makes circular business models more flexible, adaptive, and capable of evolving and maturing.

Continuous improvement

A roll-out mindset also highlights the importance of continuous improvement. Without clarity on the ambition—the broader set of strategies a business model is working towards—initial choices may unintentionally foreclose including more circular strategies later. For example, selecting composite materials to extend product life might make future recycling impossible, or prioritising downcycling could undermine opportunities for high-quality recycling. Trade-offs and competition between strategies mean that implementing one in isolation can create lock-ins that limit systemic circularity. By sequencing with the bigger picture in mind—see figure, circular business models remain open to adaptation and the integration of additional strategies over time.

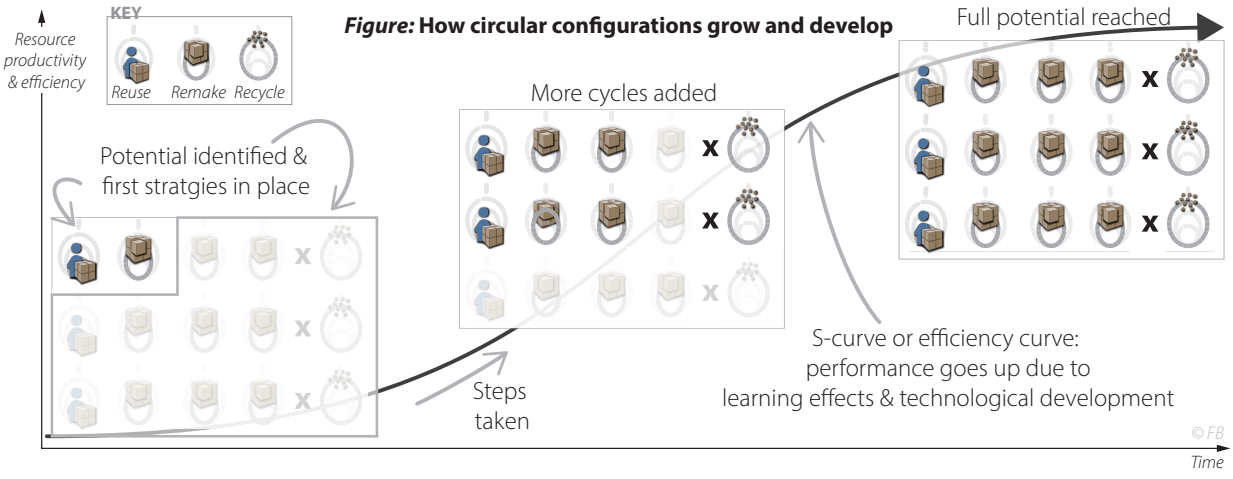


Figure: **How circular configurations grow and develop**

Step 1—Understand the present: mapping resource flows

Responsible role: Project lead (to ensure scope and purpose is set right). **Participants:** Flow Experts, Decision

Before looking at waste and what (other) circular strategies are needed, it is necessary to understand the current value chain—from start to finish. This may already involve circular strategies or it may not—but chances are, there is plenty to improve and circular strategies can either be strengthened or added.

1.1 Set the scope: your unit-of-analysis

First, set the scope of the analysis. What material, component, product or product group will be examined? The Circularity Compass can accommodate all these different *units-of-analysis*. Just adjust the granularity or resolution of your analysis: if your case encompasses more variety and complexity, you will have to simplify and group smartly.

Are you not certain what to focus on? It may be helpful to make an exploratory draft mapping: as you go through the different life-cycle stages and examine the different flows, you may have a clearer picture afterwards. Also note that, when you go through the different steps, you may need to amend and further clarify your unit-of-analysis later on. It's ok to take an iterative approach.

1.2 Make a resource inventory

Make a *list and description* of what materials are present in a system: what they are, in what quantities they are used, and how important they are for the functioning of the value chain. In the case of rare-earth metals, for example, only a small fraction of the weight typically comes from these materials—but they are incredibly important for the functioning of electronic devices and equipment. Similarly, toxins can be present in small quantities, but have a large impact. However, in the first instance, don't make it too detailed—examining 3-5 different materials or materials groups will already get you a lot of insights. After you've also done a Waste Hunt (Step 2) and Configuration Build (Step 3) it will be clearer where you need more depth and detail—and you can return to this step, if needed.

1.3 Resource flow mapping

Next, map the life-cycle of the resources from beginning to end-of-life: what materials are extracted, how are they processed, where and how do they get to a user, how are they used, and what happens post-use? Essentially, you are making a variation on a formal method that is called a material-flow analysis, or MFA—where, in this version, you do not yet have to worry so much about mass-flow balance or precise quantification. Treat this as a storytelling exercise of the resource journey, capturing the key stages.

<u>Start at the top and move clockwise</u>

Using a different colour for each resource (group), map how the resources flow through the different resource states. Where does *stuff* come from: is a virgin resource being used—and if so, is it a renewable or non-renewable material? Or: is a material already being recycled within this system, or is a waste stream from another system used here as an input?

Complete the journey all the way to end-of-life. Trace how and when materials are turned into components, and then into products, noting any important intermediate processing steps such as cutting, gluing, painting, etc. Along the way, note what comes into the system, how it is transformed, and what leaves the system. At this stage, the aim is not yet to identify structural waste—the focus is on mapping flows and processes. If circular strategies are already present, include those as well. Ask: do they function well, or is there room for improvement?

Maker(s), Faciliator.

Get a sense of quantities - where you can

If you don't have detailed information, use rules of thumb (like the "70-fold waste upstream for every unit of finished product") to highlight magnitudes. Find out what these rules of thumb are for the system or industry under examination. At this stage, estimates are enough—the aim is to create visibility, grasp relative scales and hotspots. Indicate this by matching the relative thickness of the lines to each other.

Include everything

Include everything that is bought, sourced, or outsourced, even if a firm does not directly handle it—these activities still shape the system's footprint. This means considering upstream sourcing, manufacturing, logistics, use, and end-of-life. Cutting things out would miss the point of doing this analysis: to get an overview of what impacts are created in the system.

Note blind spots and knowledge gaps

Use publicly available sources where needed, even if it just helps to get an initial indication. Mark blind spots and knowledge gaps openly—noting where information is uncertain or unavailable is just as important as mapping what you know. This creates a roadmap for where deeper investigation is needed: maybe a colleague or another value chain partner can help you get answers.

From qualitative to quantitative

Begin qualitatively to capture the system's logic and flows; later, if needed, you can translate this into a formal and quantitative MFA with data, balances, and validation. This first qualitative mapping helps frame the system before committing to detailed (and often time-consuming and costly) data collection—and this initial step often reveals more than expected.

When is it finished?

You have completed your mapping when you have reached the end-of-life for all the (main) flows you have decided to include in your analysis and feel confident that you have addressed important blind-spots.

How to: Resource-flow mapping

Complexity/ difficulty: It can be simple to start with, adding more complexity as your analysis progresses. Consider making a separate analysis for packaging and production inputs that are not part of the final product.

Time plan: A rough first version can usually be made in about an hour of brainstorming and consulting publicly available resources. A more detailed version and filling in any blind-spots or knowledge gaps will take longer.

Who to involve: It is helpful to involve different parts of the organisation, as they may have different perspectives and complementary knowledge. Where you can, discuss where it is sufficient to make educated assumptions. Where you feel you cannot do this, involve other parts of the value chain.

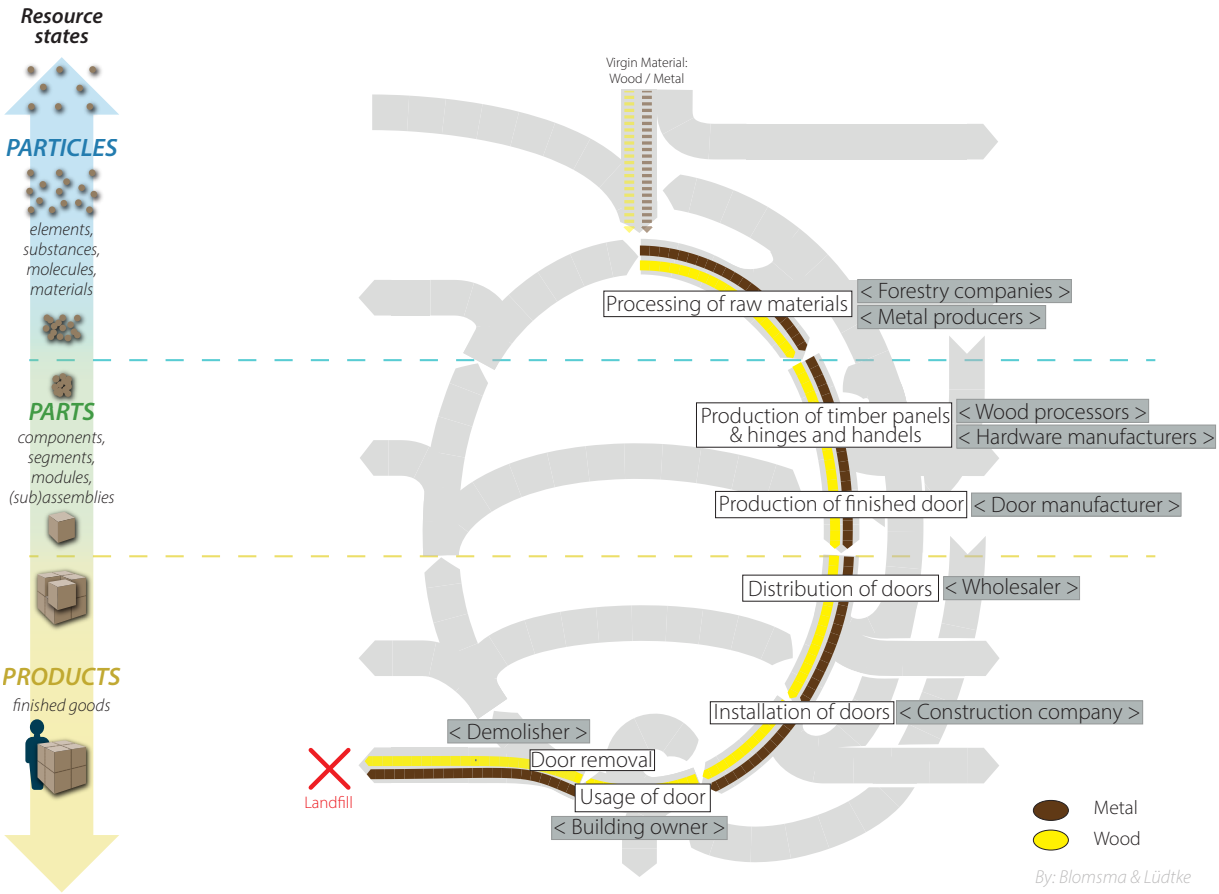
Circularity Thinking materials:

- One the Circularity Compass available as a shared workspace (large print or digital).

Other materials needed:

- Post-its, different coloured pens (if using a pen-and-paper analysis).
- Permissions to edit for contributors (if using a digital workspace).

***Figure:* Building doors** – Resource Flow Mapping



Example resource flow mapping building door

In the current resource flows of doors, wood from forestry companies and metal from producers are processed into panels, hinges, and handles by manufacturers, before being assembled into finished doors and distributed via wholesalers to construction companies. These doors are installed and used in buildings until demolition, when the demolisher removes them. At this point, most doors are simply sent to landfill, as this is the cheapest and fastest route. The flows therefore move in a largely linear fashion from virgin input through to disposal, with little effort made to recover or extend the value of materials.

The dominance of landfill stems from cost and convenience: demolition contractors are incentivised to remove doors quickly, rather than dismantle them carefully for reuse, refurbishment, or recycling. To enable alternative outcomes, such as reuse through marketplaces or refurbishment by brokers, the flows would need to include extra steps like assessing door condition, selective dismantling, and arranging logistics. Because these steps are usually skipped, both the material value in wood and metal and the potential for further use are lost, locking the system into a disposal pathway and limiting opportunities for circularity.

Step 2—"Waste Hunt": identify *structural waste*

Responsible role: Facilitator. **Participants:** Flow Experts, Decision Maker(s).

After mapping the resource flows, the next step is to trace where waste appears in the system. The Waste Hunt uses the Big Five to make potential value leaks and losses visible on the resource flow mapping, so that you can later decide how to address them. The key is not to measure every gram of waste—some forms of waste will in fact be very hard to quantify and measure, but to identify where in the life cycle resources are *prematurely lost, underused*, or handled *inefficiently* or *harmfully*.

2.1 *What* waste is found? Scan along the flows.
Take your resource flow map and move step by step through the resource states and the lifecycle stages—from extraction and processing, to use, to end-of-life. At each resource state: consider whether the resources are being renewed (or does premature end-of-life occur?) and fully used (or does premature end-of-use-occur?). Can you detect any excess or harm? Answer the Big Five questions as best you can. This means:

- For every out-flow: What type of waste is this?
- For every arc: Is it done in the most efficient way possible? What harm occurs?

And don't forget:

- For every in-flow: Is a waste from a previous life-cycle stage or from another system already being used?

By systematically checking each resource state—and crucially, the transitions between them—you ensure that you don't only capture visible discards, but also the less obvious inefficiencies in use, processing and design. Name and mark where current flows fall short and identify the types of waste that are present.

A Waste Hunt is best done in dialogue. As you map, check with colleagues or partners: Do we all agree this is a waste point? Is this really a hotspot, or only a minor issue? The aim is to build a shared understanding of where the system is leaking value. Use colour-coding, symbols, or sticky notes to make it clear which waste points belong to which resource flow.

It's almost inevitable that during the discussion you will already touch upon the circular strategies you may want to use. This is ok, but try and bring it back to discussing what structural wastes exist across the value chain until this is fully exhausted. Of course, other issues, such as biodiversity loss, slave or child-labour, poor health and safety conditions, etc: indicate these too—there's no reason you cannot strengthen the argument for 'going circular' with these elements included

2.2 *Where* does it originate? The "in-between".
Remember: the *in-between*—the spaces between processes, departments, companies, and life cycle stages—is often where many obvious and less-obvious wastes reside. This means that where waste appears is not necessarily where it originates. For example, a broken component can be the result of design choices. Similarly, a wasted material can be due to the lack of coordination between processes or value chain partners. To understand better where the cause of the waste lies, trace it back to its origin: *where* in the system is it created or caused? Discuss this and note it on the diagram.

2.3 *Which* wastes are connected?
Waste loves company. This is because once resources are wasted at one stage (like products being designed to wear out early), it forces more production, more by-products, and more end-of-life disposal—so the waste initially identified is actually part of a chain reaction of wastes, where one form of waste drives others elsewhere in the system.

For this reason it is important to ask: which wastes are connected? Which wastes create more wastes? Identify any chain-reactions and group or cluster these wastes.

2.4 *Why* does it originate? Purpose & practices.
Now that you know *what* wastes originate *where* in the value chain and *which* are connected it is time to critically examine *why* this is the case. Ask: what expectations and assumptions about this resource cause it to become waste at this point? What is the role of our practices, ideas and framing in this? Examining this shifts the focus from symptoms to root causes, enabling smarter and more effective interventions.

2.5 Identify magnitudes and hotspots
What hotspots are there? At this stage, estimates are enough—you do not need exact figures. Use rough indicators of scale to highlight the biggest issues. The waste groups or clusters you made earlier help with this. For example, make the icons bigger for large wastes, or use simple tags like “high”, “medium”, “low” on your post-its. Also note where a small flow may still represent a big impact (for example, critical raw materials or toxic substances). This helps later when you need to prioritise.

2.6 Capture uncertainties
Just as with the resource mapping, do not hide blind spots. If you are unsure about the fate of a certain flow, mark it with a question mark. If you suspect waste occurs but lack data, write it down anyway. These uncertainties are part of the Waste Hunt and create a roadmap for further investigation.

All along: challenge, challenge & challenge again
Sometimes spotting waste requires a fresh perspective and to see your own context with new eyes: to, like a fish, become aware of the water you are swimming in. For example, cars have become more efficient, but also heavier through the years. Over time, their current weight has become an accepted norm or standard—in part due to car manufacturers not carrying the cost for driving it. Thus, reducing total-cost-of-ownership is not a strong motivator for innovation across manufacturers and suppliers. This means that the weight of cars is really an unseen structural waste. As is the fact that cars only last a decade or so before they often end up in countries with poor end-of-life infrastructure.

The same is true in many situations, even if the causes differ. Awareness may be lacking of alternative processes—for example, using closed-cycle CO_2 instead of water to dye textiles[11], or machining aluminium parts in protected atmospheres so that scraps can go straight into extrusion without being remelted[12]. Or: it may have to do with what is considered the ‘core business’ of a company: if the main mission is shifted from producing sugar to ‘making the most of our flows’ it becomes possible to also produce tomatoes in greenhouses using the residual heat and CO_2 from the sugar-refining process[13]. Therefore, critically examine the role of ‘givens’, of assumptions, and of the *but-we-have-always-done-it-this-ways*. Discuss these, how fixed are they, really? For inspiration, it may be helpful to look at other industries or innovative startups. Include in this not only successes, but also failures: after all, the idea may have been sound, but other circumstances may not have been and maybe it’s an idea whose time has come.

Don’t be tempted to narrow the scope
It may be tempting during the Waste Hunt to focus on the part you, at this time, have control over or influence in. But because circular strategies impact each other across the value chain, it is important to first establish a complete overview.

You may uncover opportunities that are available through collaborations and partnerships. And: having a good overview of the problems will also make the circular configuration you will build (in Step 3) more robust. After all, someone else may soon spot problems that you exclude now—and their solution may make yours obsolete. So, for now, thoroughly explore the problems.

When is this step finished?

You have completed the Waste Hunt when your resource flow map clearly shows where waste occurs, both visible and hidden. Waste points are annotated, relative magnitudes are indicated, and uncertainties are marked (which may need further investigation). You have thoroughly explored and discussed not only what waste occurs, but also where it really originates and how the wastes—likely you have uncovered quite a few—are connected. Most importantly, the team has reached agreement on the 2–3 most important hotspots to carry forward. These priorities will form the starting point for Step 3, where you will explore which circular strategies could address it. And because you have discussed wastes deeply and thoroughly explored the problem space, you are now ready to build towards an effective circular configuration—knowing *where innovation is most needed*.

How to: Waste Hunt

Complexity/ difficulty: It can be simple to start with, adding more complexity as your analysis progresses.

Time plan: A rough first version can usually be made in about an hour of brainstorming and consulting publicly available resources. A more detailed version, incl. the why and which wastes are connected can take longer. Filling in any blind-spots or knowledge gaps can also take additional time.

Who to involve: A Waste Hunt is best done in dialogue. As you map, check with colleagues or partners from the value chain. Consider organising a workshop to gather different perspectives, or consult people 1-on-1.

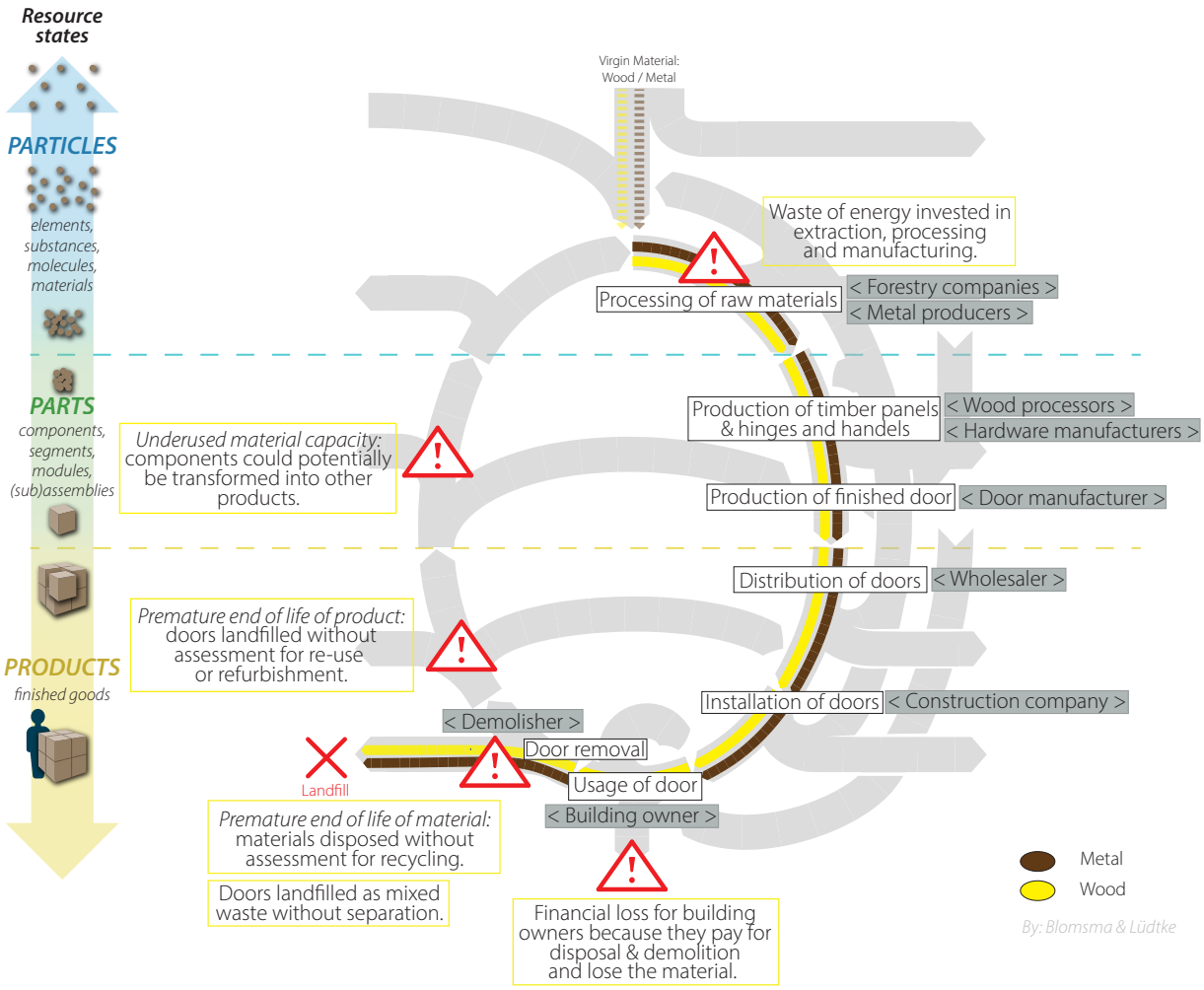
Circularity Thinking materials:

- One the Circularity Compass available as a shared workspace (large print or digital).

Other materials needed:

- Post-its, different coloured pens (if using a pen-and-paper analysis).
  - Consider using different coloured stickers for the the different wastes (5x different colours).
- Permissions to edit for contributors (if using a digital workspace).
  - Use ready-made icons that can be easily drag-and-dropped onto the workspace

***Figure:* Building doors** – Waste Hunt



Example Waste Hunt for building door

The Waste Hunt for the door scenario reveals multiple losses across the value chain. Energy invested in extraction, processing, and manufacturing are wasted due to inefficiencies at the beginning of the value chain during raw material processing. As doors are mostly sent to landfill after one use and both the product and material reach their end-of-life prematurely (they are neither "renewed" nor "used-up"), with no evaluation of whether the product could be reused or its materials recycled. Likewise, underused material capacity occurs as metal components that could have been reused also end up in landfill. The process of disposing of the doors results in a direct financial loss for building owners, who pay for disposal and demolition while losing the material value. The key waste hotspot appears after use, during demolition and disposal.

Step 3—Configuration Builder: sketching a set of circular strategies

Responsible role: Project lead (to make sure it aligns with scope). **Participants:** Flow Experts, Decision Maker

Once you have identified where waste occurs, the next step is to design possible solutions. A well-functioning circular configuration consists of a set of circular strategies that work together and reinforce each other to address the waste hotspots you have identified. Think of them as the circular strategies portfolio of the value chain. The aim of this step is to go from the wide range of circular strategies that are on offer, to a short-list of those that are applicable to the situation under investigation. You will explore and sketch a first configuration that makes sense for your system and that will be refined later.

3.1 Explore *anchor strategies*

Whilst some circular strategies may have already been discussed in the previous step, here you will explore more systematically which circular strategies make the most sense.

Start from your waste priorities

Look back at and review the 2–3 critical waste hotspots identified in the Waste Hunt. Each one points to an important place in the system where value is leaking out. Start your configuration design by asking: which circular strategies could best address these wastes? For example, if products fail prematurely, durability, repair or refurbishment strategies may be most relevant. If crucial materials are lost, recycling or cascading may play a key role. Keep your focus on the priorities you have chosen—and acknowledge you cannot fix everything.

What are central circular strategies?

Many circular strategies fall under the circular economy umbrella: rethink, reuse, repair, remanufacturing, recycling, cascading, redistribution, sharing, performance optimisation, and more. For each hotspot, explore several strategies and ask: what would it look like if we applied this here? At this stage, it is useful to sketch multiple pathways, even if some are not yet feasible. This helps to identify interactions and trade-offs. Which set of strategies would optimise circularity, sustainability and value capture—and do away with the structural wastes you identified?

The set of circular strategies you short-list to address the key structural wastes are the basis for your *anchor strategies*.

3.3 Combine into a *circular configuration*

Next, starting with your short-list, consider how different circular strategies could be combined so that they work together. Be mindful of trade-offs—making a product highly durable may complicate recycling later, or how lightweighting can reduce longevity. Try to design combinations where strategies positively reinforce or support each other. The goal is to create a set that is synergistic rather than fragmented.

Do support strategies need adding?

Once you have a synergistic set of anchor strategies, branch out to identify support strategies. These are strategies that further enhance your anchor strategies and that address the remaining structural wastes. For instance: reuse can be strengthened by repair services, which in turn can make recycling more effective.

Take the long-view

Envision which circular strategies the value chain would contain when fully mature and operating efficiently. This may not be short- or even medium-term. But the goal is to establish a vision to work towards, and to think about what would be optimal. This is crucial for developing a set of circular strategies that works well together.

(s), Faciliator.

3.4 Are any new wastes created?
As all resource transformations require resource inputs, ask if any chosen circular strategies also create new wastes: whether through transport, residual or extra materials, stock, buffers, or other unintended by-products that may undermine circular benefits. Discuss whether these can be managed or addressed—perhaps by adding supporting strategies or redesigning specific steps in the system to avoid unnecessary losses.

Circular rebound
It may be useful as well, to take a moment to consider unintended consequences in the form of circular rebound. Circular strategies can reduce resource demand in one place, but also stimulate additional consumption elsewhere, offsetting or even outweighing the intended benefits[14]. For example, extending product lifetimes may lower sales volumes in the short term, but can encourage firms to push more products into the market or lead consumers to spend their savings in other resource-intensive ways.

Circular initiatives should be judged by their net systemic impact, not just immediate efficiency gains. Use this point in the process to surface new wastes and rebound risks, explore side effects, and question assumptions. Even in a qualitative mapping exercise, such reflection can uncover hidden dynamics, highlight trade-offs, and reveal leverage points that shape how the system works in practice and over time.

With potential new wastes and rebound effects in mind, reassess whether the chosen set of circular strategies truly addresses the structural wastes identified. Adjust the circular configuration as needed, and stay open to adding, adapting, or combining strategies as new insights and opportunities emerge.

3.5 Who and what makes it possible?
Circular strategies require business capabilities and activities to implement them. As you sketch your configuration, ask:

- Do different materials need to be used? Does the product design need to change in some way? Does the user need to be supported differently?
- Do changes to the business model need to be made (e.g. product-as-a-service, take-back schemes)?
- What other activities or capabilities are needed—and which department or which partner can provide them?
- What logistics, infrastructure, or information flows are needed?
- What other relationships need to change? Are new collaborations needed? Is there anyone who will 'lose out'?
- Is there a logical sequence to how the circular strategies will need to be 'rolled-out'?

In other words: what are the practical implications of your proposed circular configuration? The aim is to surface assumptions, dependencies, and enabling conditions early, so you can see what might be required without yet deciding how exactly to deliver it. This reflection is not only about feasibility, but also about timing, priorities, and sequencing—what needs to come first, what can follow later, and where dependencies between actors might create challenges or opportunities. This serves to understand what you are really asking of the partners involved—internal and external.

Use this, again, to iterate the circular configuration accordingly, and remain open to adding, adapting, or combining strategies as new insights and opportunities develop.

When is this step finished?
Think of the configuration as an initial vision of how the system could become more circular—not a finished blueprint. The aim is not to capture every detail, but to create a sketch that is already useful for reflection, iteration, and discussion. It is "enough for now" when it makes visible the key enabling conditions, assumptions, and gaps, without pretending the picture is final or fixed.

At this stage, the reflections are exploratory and indicative: they sketch possibilities rather than lock in firm commitments or detailed plans. Be explicit about the assumptions you are making and the uncertainties that remain: what is still unknown about costs, user behaviour, or technical feasibility? At this moment, it's too early to say whether these areas of uncertainty could weaken the configuration; at present, they highlight areas for investigation, learning, testing, and adaptation.

Keep iterating until the picture feels sufficiently complete for the moment, knowing it will evolve as new insights, partners, and opportunities appear. If crucial enablers or barriers remain unclear, investigate them before moving on. Subsequent steps of Circularity Thinking will help to deepen this sketch into more detailed flows, clarify actor roles and responsibilities, and translate the configuration into practical plans, partnerships, and pilots.

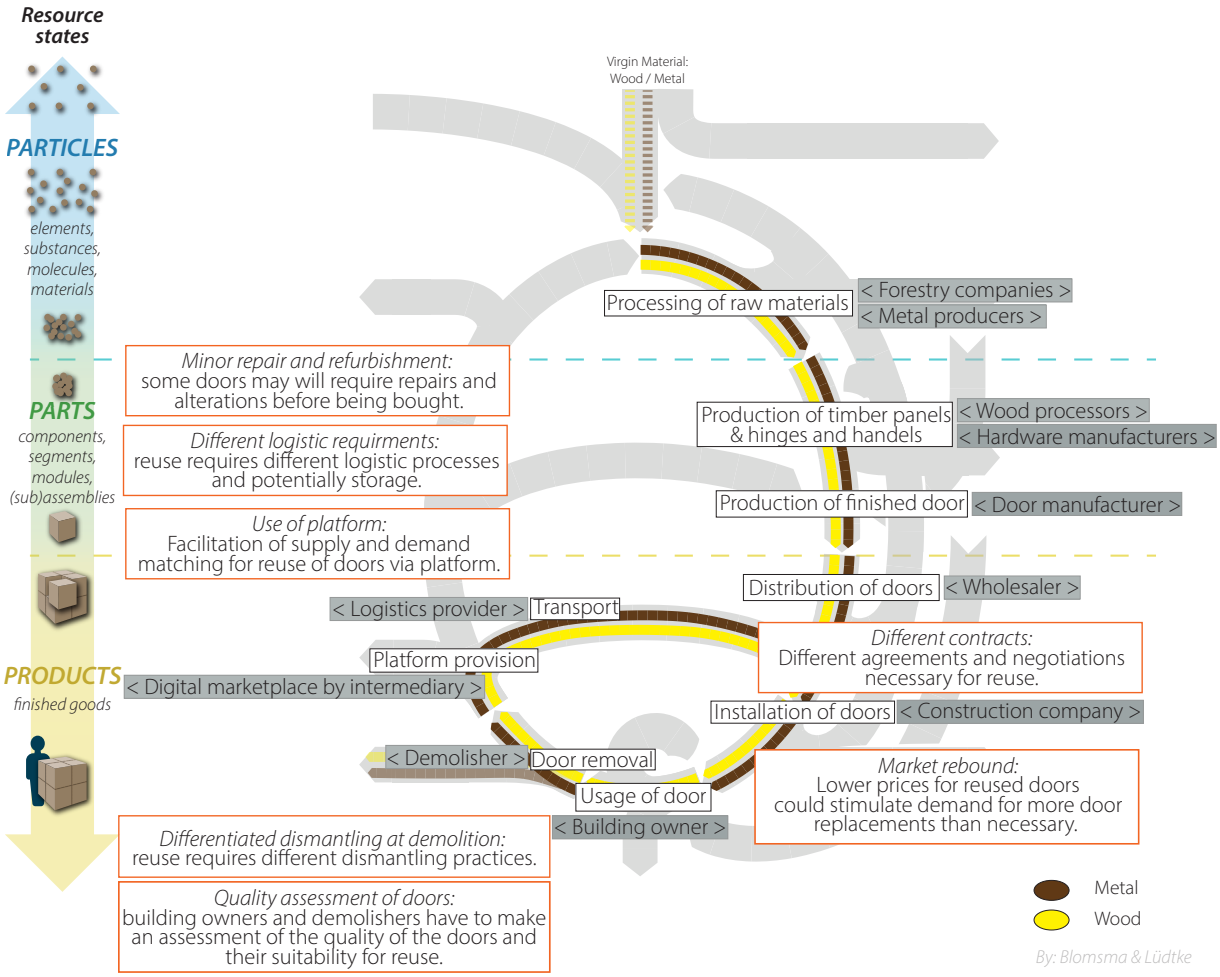
How to: Configuration Builder
Complexity/ difficulty: It can be simple to start with, focusing on only 2-3 circular strategies, adding more complexity as your analysis progresses and you add more strategies to the configuration.
Time plan: A rough first version can usually be made in about an hour of brainstorming and consulting publicly available resources. A more detailed version and filling in any blind-spots or knowledge gaps will take longer.

Who to involve: Same as before: a configuration sketch is best developed in dialogue. As you map, check with colleagues or partners from the value chain. Consider organising a workshop to gather different perspectives, or consult people 1-on-1. But also consider: there may not be a place for everyone in the new configuration. For example, if you aim to have more direct contact with customers, dealers or retailers may not have a large role to play in the new configuration. Involving these stakeholders, or involving too many stakeholders too soon, may block the development of your configuration.

Circularity Thinking materials:
- One the Circularity Compass available as a shared workspace (large print or digital).

Other materials needed:
- Post-its, different coloured pens (if using a pen-and-paper analysis).
- Permissions to edit for contributors (if using a digital workspace).

***Figure:* Building doors**– Circular Configuration



Example of Circular Configuration analysis

The Waste Hunt already identified demolition and disposal as key waste hotspots for building doors. The central circular strategy chosen to address these hotspots is to reuse them, as it is expected that building waste will be more strictly regualted in the future and building materials are getting more difficult to come by. To enable this, quality assessments by building owners and demolishers will be necessary to evaluate the condition and reusability of each door. If doors pass this initial quality check, different dismantling procedures will be required compared to those used for disposal. New logistics and potential storage solutions are needed to facilitate reuse, along with possible repair work. In addition, new contracts and negotiations will be required, as a reuse strategy depends on different agreements between parties. Finally, the need for a digital re-sale platform to match supply and demand is highlighted as a critical support function.

Step 4—Multi-Flow Method: what forces shape how all the flows flow?

After sketching a circular configuration, the next step is to explore its feasibility and robustness. Resource flows do not stand alone—they rely on flows of value, information, and energy. The Multi-Flow Method (MFM) allows you to map these flows and their interactions, and it helps to unpack the forces that shape them. It uncovers what is important, but usually goes unseen: revealing the systemic shifts that are needed to make a circular configuration work.

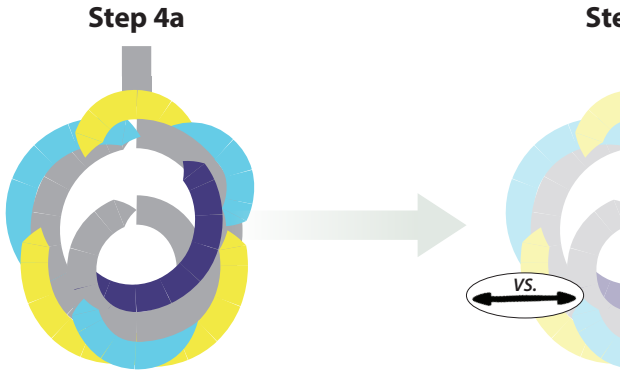
Why the Multi-Flow Method matters

But MFM does more than trace materials: it shows how value chains function in practice. By integrating multiple flows, it reveals the structural conditions that enable or block circularity, exposing deeper pressures and interdependencies rather than just listing seemingly unconnected barriers and enablers. For example, recycling, reuse, repair or take-back schemes may look straightforward on paper, but they depend on financial incentives for users, timely data on the condition of the resources and clean and affordable energy for reverse logistics and processing. Without alignment across these conditions, even promising strategies stall or collapse in practice.

This focus on relationships and conditions complements, rather than replaces, quantitative approaches to circularity such as Material Flow Analysis (MFA) or Life Cycle Assessment (LCA). These methods are excellent at quantifying inputs and outputs. They can tell us how much material enters a system, how much is wasted, and what environmental impacts are associated with these flows. However, they stop short of explaining why certain circular opportunities succeed while others fail, and they struggle to capture the complex interactions needed for systemic implementation. This means that numbers alone may give a sense of efficiency and impact, but they cannot reveal the social, economic, and organisational factors that determine whether a strategy is workable.

This is because materials do not move on their own. They are extracted, processed, used, and disposed of by actors making decisions. Those decisions are shaped by value flows—who gains, who pays, and where profits or losses are created. They are also shaped by information flows—who knows what, and whether actors are able to coordinate effectively. They are further shaped by energy flows, since people decide which processes to use, what sources to rely on, and whether renewables are prioritised. In short: *people make flows flow*—or not[15].

A recycling process may be technically feasible, but if demolition contractors are paid to landfill rather than recycle, it will not be used. A reuse scheme may be available, but if building owners

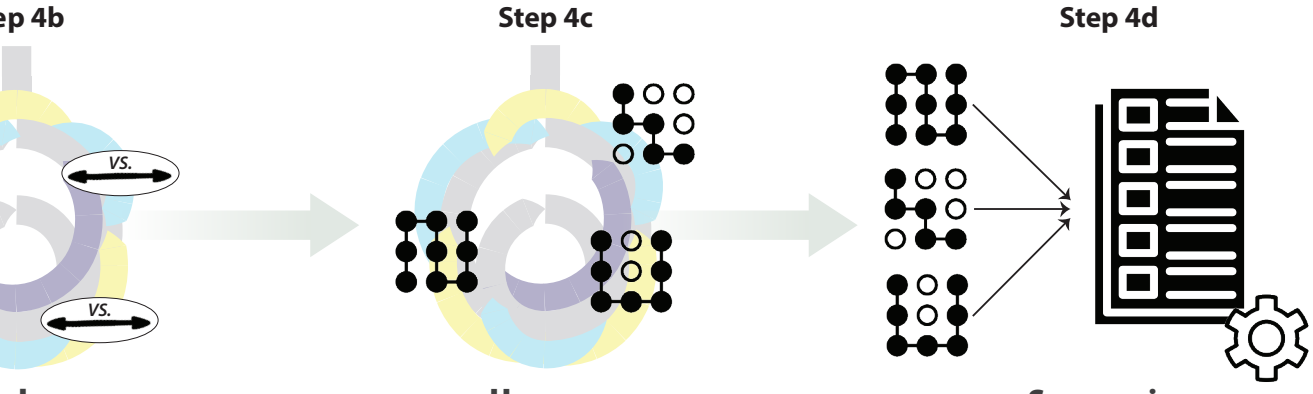


or architects are unaware of it, products will still be discarded. Circular strategies fail not only because of technical limits, but also because of incentives that misalign, knowledge that never reaches the right actors, or energy choices that make one option easier or cheaper than another.

The Multi-Flow Method was developed to make these dynamics visible. It provides a structured way to map not only material flows, but also the financial, informational, and energy relationships that surround them. By doing so, it pinpoints where tensions, bottlenecks, and reinforcing patterns arise, helping to interrogate how the system as a whole behaves and where interventions can be most effective. This means MFM does not just highlight obstacles but also uncovers leverage points—places where small adjustments in incentives, data sharing, or energy sourcing can unlock circular outcomes that can outperform linear solutions.

When to use the MFM

Application of the MFM is most valuable when surface-level tools are not enough—when listing barriers and enablers, or mapping resource flows, leaves the real dynamics unexplained. Its unique contribution is to uncover the tensions and recurring patterns that shape behaviour, helping actors look beyond isolated issues to the deeper forces driving them. This makes it especially useful where collaboration across complex value chains is required, but incentives, power, or roles are misaligned. If the context is simple, actors aligned, or barriers straightforward, the MFM may be unnecessary; but where systemic misalignments dominate it provides insights other tools cannot. Think of it this way: mapping a flow is like drawing a river—you see where the water goes, but not why it sometimes floods or runs dry. The MFM looks at the forces behind that river: the weather, the terrain, the climate, and how people manage water, to explain *why* the flow behaves as it does.



plore
VE TENSIONS

he key insights
he flows?

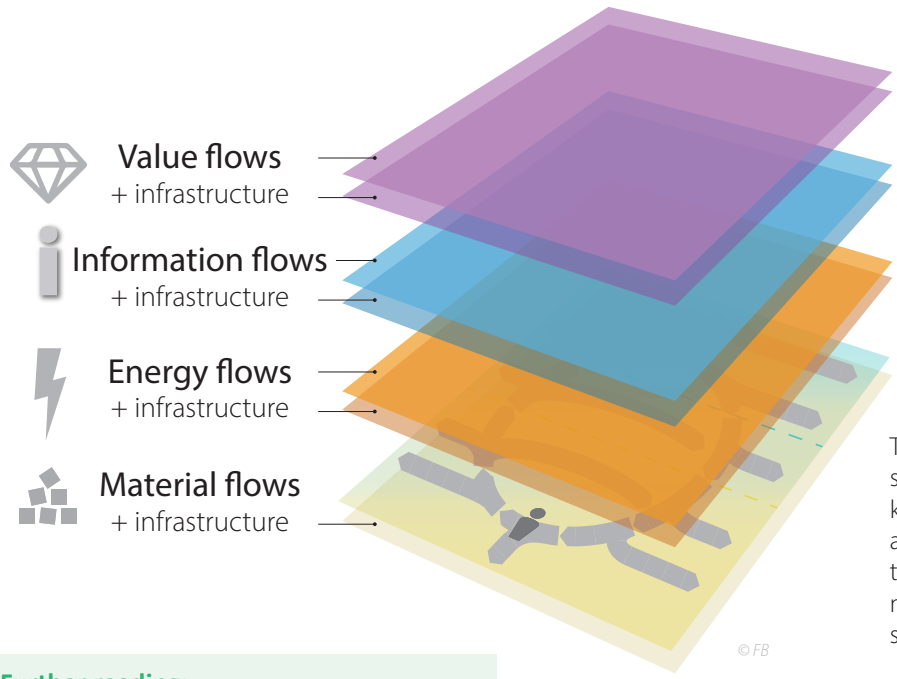
Uncover
PATTERNS

What existing patterns shape the system? What desired patterns could enable change?

Summarise
ECOSYSTEM REQUIREMENTS

What can be built on? What is still missing?

Figure: **Multi-Flow Model**



The 'layers' of the industrial system: each layer depicts a key 'flow' incl. its infrastructure and technology that are vital to transitioning from one metabolsim state (linear) to a second (circular) one.

Further reading:

- *Blomsma, Tennnant and Ozaki (2023)*[18].

Theoretical roots of MFM

The Multi-Flow Method was first developed by observing what circular-oriented innovators actually do in practice across a wide variety of cases[10]. These recurring patterns did not emerge in a vacuum: they echo and are deepened by several strands of existing theory. From systems thinking, it takes the insight that behaviours emerge from interactions, not from isolated actors. From complexity theory, it borrows the idea that tensions and paradoxes are generative forces, not always obstacles to be removed and that progress often depends on navigating rather than resolving them. From institutional theory, it highlights the role of rules, norms, and power in shaping flows of value and information. And from socio-technical transitions research, it recognises that industries evolve through the alignment and misalignment of technologies, markets, and institutions. Together, these perspectives make the MFM both a conceptual lens and a practical tool. It translates abstract insights into workable processes where participants can map flows, discuss tensions, and co-create visions of new patterns. It reflects the shared insight that change arises not from isolated actions but from the interplay of structures, relationships, and dynamics across the system. By connecting practice-based observations with these theoretical perspectives and further developing it as a tool with practice partners, the method bridges academic insight and real-world application, enabling systemic thinking to inform practical interventions.

The flows

At the heart of the method are three flows—resources, value, and information—with energy sometimes added as a fourth when it plays a critical role.

- ***Resource flows*** are the most tangible: materials, components, and products moving through their lifecycle. They show where extraction takes place, how processing and manufacturing occur, how products are used, and what happens at the end of life. For example, apparel waste can be recycled into feedstock for acoustic floor tiles. Here the flow of recovered materials runs from one sector to another, extending the lifecycle of resources that would otherwise be discarded. In Step 1 such a resource flow map was already made.

- ***Value flows*** trace the exchange of money, incentives, and costs. They reveal who pays whom, who benefits financially, and where value is lost. These flows often move in the opposite direction to materials. For example, in the reuse of doors from demolition projects, a building owner can negotiate directly with demolition contractors and buyers through a digital marketplace. Value is retained when components are sold for reuse, rather than lost when they are sent to landfill at additional cost.

- ***Information flows*** capture the movement of knowledge, data, and communication. They include location, quantity, and 'health' but also design specifications, contracts, quality standards, or even informal practices and expectations. But also relevant stakeholder information: what capabilities someone has for processing, for example. Without adequate information flows, even technically feasible circular solutions may fail to materialise. For example, repair of a building's audio system depends on reliable data: digital product passports and instructions enable owners and manufacturers to coordinate repair, while updated product information feeds into a building's digital twin, ensuring transparency over recycled content and sustainability attributes.

- ***Energy flows*** become important when energy demand plays a critical role in the system, such as in energy-intensive industries or where energy costs shape decision-making. The type and amount of energy required may determine whether a product is refurbished, remanufactured, or replaced and recycled instead. For example, in the remanufacturing of acoustic floor tiles, energy use in transport, processing, and production determines whether the take-back program is viable, and whether it delivers real environmental gains compared to sourcing new inputs.

Each flow depends on its own enabling infrastructure—logistics networks to move recovered resources, financial systems and marketplaces for pricing and payment, digital platforms and standards for product information, and energy grids to power processes. Infrastructure sets the conditions for what flows can move, how they move, and at what scale. Together, infrastructure and technology shape the system's possibilities and limits. As they evolve, so do the flows—and it is their interaction that determines whether new solutions can take hold.

When mapped together, the flows and their infrastructure form a more complete picture of the system. Resource flows are the foundation, showing how materials, components, and products move, but on their own they give only a partial view. Adding value, information, and energy flows makes visible the incentives, knowledge, and conditions that ultimately decide whether circular strategies succeed in practice.

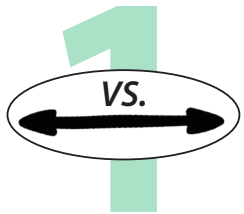
More than flows: uncovering patterns

The Multi-Flow Method is not just about mapping flows. While flow mapping reveals how a system operates, it does not explain *why* certain problems persist or why dynamics keep repeating. To address this, the method moves the focus beyond analysing flows or listing persisting barriers and enablers, and instead asks why these dynamics occur. It aims to uncover *patterns*: the recurring dynamics that explain why the value chain functions as it does. Patterns reveal the underlying pressures, trade-offs, and forces that shape behaviour across the system.

To explore such patterns, the method works with three recurring tensions that appear across most value chains and most flows. These tensions may not be problems to be permanently resolved, but forces that must be balanced, navigated, or worked around. The tensions serve as a lens, a practical tool for uncovering why certain dynamics endure and where opportunities for change lie.

From current to desired ecosystem patterns

Three tensions are used to explore both existing and desired patterns. Existing patterns show how the value chain currently functions—the misalignments, incentives, and structures that hold the system in place and make circular strategies difficult. Desired patterns, by contrast, describe how the system should function for circularity to succeed—for example, through upstream coordination, fairer value distribution, or more adaptive contracts. Examining how existing patterns might be transformed into desired ones reframes tensions and problems as opportunities for redesign. In this way, patterns go beyond barriers and enablers: they reveal the deeper mechanisms and forces that shape behaviour across the value chain as a whole.

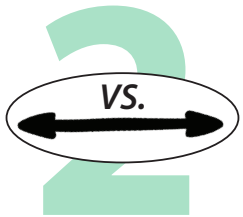


Individual versus Collective interest

- When unmanaged: On the one hand, when individual goals dominate, actors optimise for their own short-term advantage, at the expense of collaboration. On the other hand, when collective goals dominate, the system may neglect the needs and constraints of individual organisations.
- Therefore: Balancing the benefits for individual actors with the shared value of the whole system is essential. In circular value chains, circular strategies can only succeed when all parties are willing to contribute, collaborate, and invest in shared outcomes.

Examples of patterns:

- Existing pattern: Building owners prioritise short-term cost savings (e.g., demolition, disposal) over collective benefits such as reuse, leaving components underutilised.
- Desired pattern: Pricing and incentives align individual gains with collective outcomes, so returning materials (e.g., tiles) becomes financially attractive and supports circular strategies.

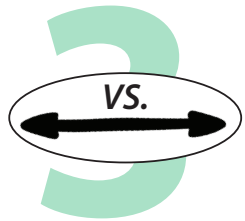


Robustness versus Adaptability

- When unmanaged: Too much robustness creates rigidity and resistance to change; conversely, too much adaptability causes fragility and lack of reliability.
- Therefore: it is necessary to find the right balance between stability and flexibility in value chains. Circular systems depend on stable contracts, processes, and relationships to secure continuity, but also require adaptability to deal with crises, shifting markets, or new technologies. Without some adaptability, solutions quickly become outdated. Without a degree of robustness, trust and reliability erode.

Examples of patterns:

- Existing pattern: Fixed contracts and rigid processes provide stability but restrict the integration of new data, partners, or recovery options, leaving the system slow to adjust and vulnerable to more innovative competitors.
- Desired pattern: Contracts and data systems combine reliability with flexibility, maintaining trust and continuity while enabling adaptation to changing feedstocks, evolving data standards, and emerging technologies, enabling the solution to remain competitive.



Concentration versus Distribution

- When unmanaged: Too much concentration gives control and benefits to a few dominant players; and too much distribution can lead to fragmentation and weak coordination.
- Therefore: Managing how power, organisational resources, and information are shared across the system is a central challenge. In circular transitions, large players often dominate decision-making and capture most of the value, but broad participation is essential to unlock innovation and ensure fairness. Effective systems balance strong leadership with inclusive collaboration and distributed influence.

Examples of patterns:

- Existing pattern: Large manufacturers and platforms control access to data and value, while smaller actors struggle to participate and benefit equally.
- Desired pattern: Marketplaces distribute access and benefits more widely and fairly, enabling contractors and intermediaries to participate while still ensuring coordination.

From insight to impact: identifying new ecosystem requirements

After examining the current and desired patterns, ecosystem requirements can be defined. These describe what the system must provide to make the desired patterns possible, by asking: what can be built on, and what is still missing? This may involve scaling existing practices, collaborations, capabilities, and infrastructures, or introducing new ones. Making these requirements clear moves the process from analysis to getting ready for planning action.

Ecosystem requirements provide the foundation for concrete steps and interventions, which are developed in a subsequent step of Circularity Thinking. The MFM facilitates moving from flows to patterns—first existing, then desired—and finally to ecosystem requirements, using tensions throughout as a lens to interpret system dynamics. This reveals not only what is technically possible but also what is systemically necessary for circular strategies to succeed.

Working with multiple flows

The following pages present each step of the Multi-Flow Method in detail. Each step is introduced with its overall logic, followed by guiding questions for the different flows. Each step includes guidance for all flows—resource, value, information, and, where relevant, energy—but not all will apply in every case. This structure allows the method to be followed step by step, while focusing only on the flows that are relevant in a given context.

Further reading on the development of MFM:

- *Blomsma and Lüdtke (2023)*[19].
- *Blomsma and Lüdtke (2024)*[20].

How to: Multi-Flow Method

When to use: The Multi-Flow Method is most useful when value chains are complex and traditional tools don't explain why problems persist. Its strength lies in revealing recurring patterns that drive behaviour, making it valuable where incentives, power, or roles are misaligned.

Pre-work: Draw on the outputs from earlier Circularity Thinking steps. Either a resource flow map of the current system (Steps 1–2) or a configuration sketch from Step 3 can serve as the starting point.

Complexity/ difficulty: The method does not require technical expertise but does demand persistence and willingness to address ambiguity. Participants must move beyond mapping flows to recognising dynamics, patterns, and tensions, which may feel unfamiliar at first. The main challenge lies less in technical detail and more in helping participants think systemically rather than reverting to barrier–enabler lists.

Time: Time requirements vary depending on the complexity of the case, the number of flows explored, and the tensions considered. Workshops with many participants benefit from pre-mapping in a smaller core group to provide a concrete starting point. Allow time for participants to get used to thinking in patterns and for the analysis to go deep. If you remain at the level of barriers and enablers you risk not getting to actionable insights.

Who to involve: Ensure the right people are involved: at minimum a facilitator, a project lead, and decision makers or stakeholder representatives with relevant perspectives. Flow experts can be invited where technical input on materials, energy, information, or value is needed.

Iterative process: The method works iteratively. While flows are mapped one at a time, new insights will often emerge that require revisiting earlier steps. This back-and-forth is an essential part of connecting across flows.

Practicalities: Use different colours to distinguish flows, patterns, and tensions—whether with post-its and pens in physical workshops or digital equivalents online. We suggest assigning colours to specific flows (e.g. purple for value, blue for information, orange for energy, red for losses), but the key is that participants share a clear understanding of what each colour represents.

Circularity Thinking materials:

- Several Circularity Compasses available as a shared workspace (large print or digital): one for each flow you are examining.

Other materials needed:

- Post-its, different coloured pens (if using a pen-and-paper analysis).
- Permissions to edit for contributors (if using a digital workspace).

See also:
Onto-Deside or Circularity Thinking websites.

Step 4a—Extend beyond resource flows

Responsible role: Project lead (to set focus on additional flow). **Participants:** Flow Experts, Decision Maker(s)

With a picture of the current flows (Step 1) or a first configuration sketch in place (Step 3), the MFM now extends the focus beyond resource flows. This step builds on the resource flow mappings and expands the view by exploring the value, information and energy flows.

Getting started

The mapping created in earlier steps provides the foundation for this stage. If a configuration sketch has already been developed, it is best to start there: the MFM can then be directed toward exploring what is needed to realise this specific circular setup. If only a resource flow map of the current situation is available, that can also serve as a starting point. In this case, the MFM analysis will be more exploratory, focusing on what is not working and what possible solutions could address these issues.

Whichever starting point is chosen, additional flows can then be layered step by step—value, information, and, where relevant, energy. Begin with the flow that appears most critical either for realising the new configuration or for deepening understanding of the current situation. Although it is simplest to focus on one flow at a time, expect connections to other flows to surface naturally. Capture these links as you go with brief notes on the corresponding Circularity Compass template so they are not forgotten, but return to examine them in depth later. The method is iterative, and understanding strengthens as flows are revisited and integrated.

If working on paper, use a clean Circularity Compass template for each new flow: sketch the resource flow outline, then add the new flow using the mapping steps. Digitally, copy the resource flow template and draw the new flow on top. Keeping flows on separate templates helps maintain clarity, also once patterns & post-its accumulate.

Keep a system-wide perspective

When extending the map, focus on system-wide relationships, not just a single organisation. Look beyond your own operation and ask: Who else needs to be involved for this flow to work? What other actors, processes, or infrastructures interact with it, even if they are outside your immediate suppliers or customers?

4a.1: Mapping value flows

Goal: Make visible how money, incentives and benefits move across the value chain—and who bears the cost or investment.

Why this matters: Circular strategies succeed only when actors are incentivised to participate. Mapping value flows shows who gains, who pays, and where value losses occur, revealing whether incentives enable or block circular goals.

To do this, focus on the financial relationships and transactions across the system. Use (purple) post-its to capture payments, costs, or incentives (e.g. “contractor pays for landfill disposal”). For each one, ask: *Who pays or invests—by how much? Who receives or benefits—by how much? What is needed for the value flows to flow—and who provides this?*

Place the notes next to the relevant actor or step in the chain and draw arrows to show the direction of money or incentives. To make the mapping clearer, use two different colours for arrows: one colour (e.g., blue) to indicate value exchanges—where resources are exchanged for money, such as a building owner paying for the purchase of a reusable door—and another colour (e.g., red) to indicate value losses—where

resources and financial value are both lost, such as paying for disposal of building material.

Tip: Include both formal mechanisms, such as contractual payments, subsidies, or disposal fees, and informal mechanisms, such as verbal agreements or goodwill-based exchanges. And: financial flows are always a good starting point, but of course other types of value can be added, too, such as easier processes, or environmental and social benefits.

4a.2: Mapping information flows
Goal: Make visible what information needs to move across the value chain for the system to function effectively.

Why this matters: Information connects different parts of the system. Knowing what data is needed, by whom, at what point in time, in what format and what level of detail helps coordinate actions and put the right processes in place.

Focus on the knowledge, data, and communication that move across the system. Use (blue) post-its to capture key pieces of information needed for the value chain to function. For each one, ask: *What information is required? Who needs it? Who is withholding it? When and where in the chain is it needed?*

Place the notes next to the relevant actor or step and draw arrows to indicate where this information comes from or should come from.

Tip: Capture both digital and non-digital exchanges, such as automated sensor data versus a phone call from a supplier.

4a.3: Mapping energy flows
Goal: Make visible where energy is required, consumed, or recovered along the value chain—and indicate the type and quantity.

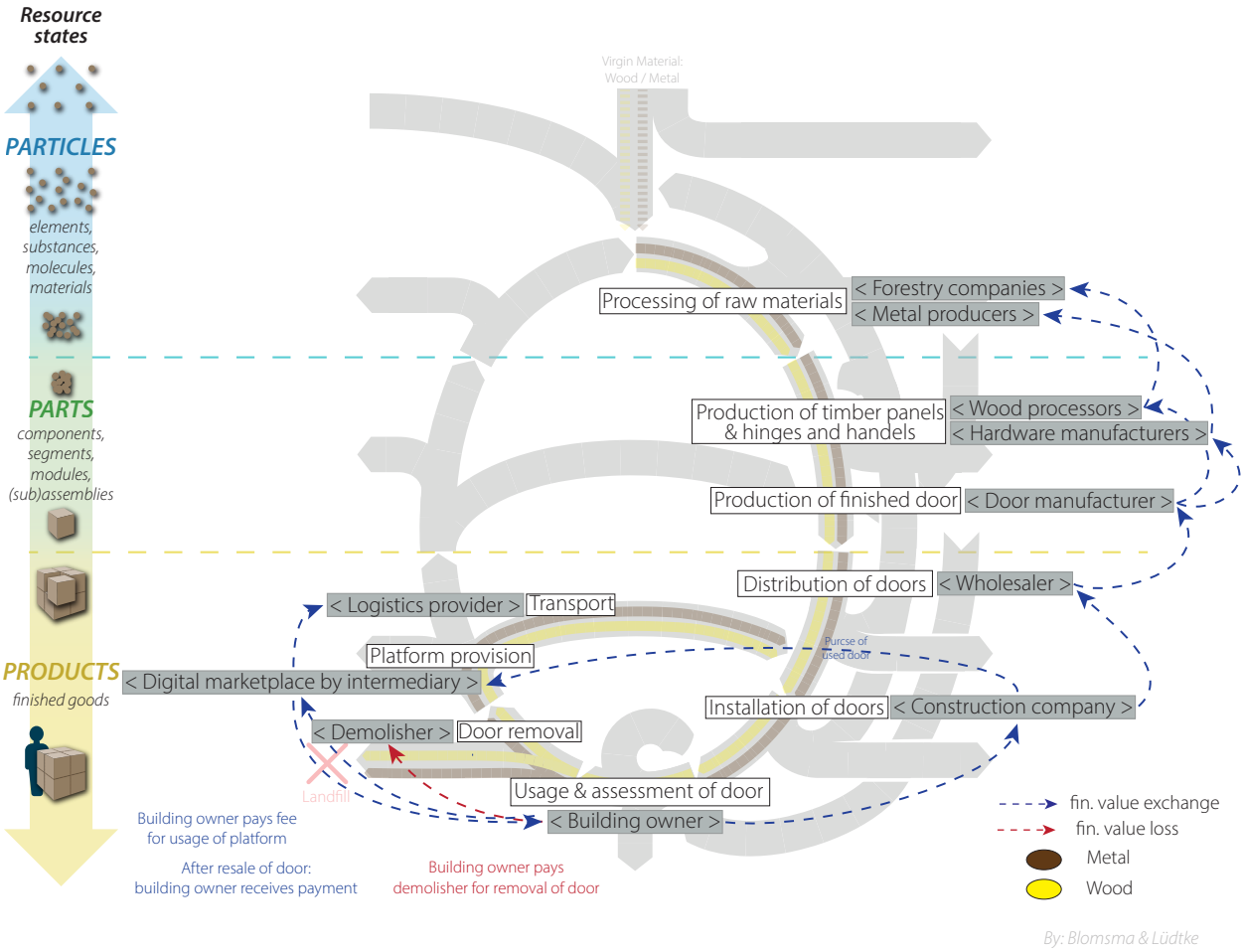
Why this matters: Energy can be a key enabler of circular practices. Mapping energy flows helps identify where demand creates barriers and where opportunities exist for recovery, substitution, efficiency or sustainability gains.

Focus on where energy is needed across the system—at each stage of the value chain, such as processing, transportation, or remanufacturing. Use (orange) post-its to note different types of energy demand and their scale. For each one, ask: *Where is energy required, and for which activity? What type of energy is used (e.g., electricity, heat, fuels)? How much energy is needed—high (H), medium (M), or low (L)? Where does the energy come from? And is any energy wasted, lost, or left unused — and could it be recovered or repurposed?*

Place the notes next to the relevant process or actor and draw arrows to show energy movement or exchanges between stages.

Tip: Where possible, distinguish between different forms of energy (e.g., electricity for machinery vs. heat for drying processes). Noting these differences helps reveal where energy is critical to the system and where alternatives, efficiencies, or substitutions might be possible.

***Figure:* Reuse of building doors** – Value Flow Mapping



Example value flow mapping for door reuse

In the case of reusing doors, the mapping shows how value moves between multiple actors: the building owner pays the demolition contractor for removal but can also generate revenue from the marketplace intermediary through the resale of the door. Buyers, such as construction companies, pay for the reused doors, while the marketplace operator earns a commission or service fee. At the same time, disposal fees for doors that cannot be reused represent a value loss for the building owner, as the building owner pays for landfill and loses the material value. Mapping these exchanges in blue for value creation and red for value loss highlights where incentives align with reuse and where they still push materials toward disposal. While downstream exchanges are relatively straightforward—raw materials, components, or doors are traded for money—the more revealing value dynamics appear in the end-of-life stage, where demolition, reuse, or disposal create sharper contrasts between value gains and value losses.

When is this step finished?
This step is complete when the flow mappings feel sufficiently mature to serve as a basis for exploring patterns. In most cases, at least two flows in addition to the resource map should be included—value and information almost always surface in discussions, while energy can be added when needed. The aim is not to capture every detail but to ensure that all major steps of the process are represented, that there is sufficient detail for critical issues or gaps to become visible, and that the flows reflect system-wide dynamics rather than isolated perspectives.

The maps should be "enough for now": clear enough to inform the next step, but it can remain open for refinement later. If discussions risk circling without progress, move on once the major flows and key issues are visible—the following steps will deepen the analysis. Also remember that this is not yet an analysis, just a mapping. Analysis follows in the next step.

As always, documenting uncertainties or assumptions at this stage is useful, as these will often point to areas for learning or testing. Remember that this mapping step is not about final answers, but about creating a shared picture that can evolve as new insights and actors come into play.

How to: Step 4a - Extending beyond resource flows
Pre-work: Access the outputs from Steps 1 – 3. Either the resource flow map of the current system or the configuration sketch can be used as a starting point: the configuration sketch provides a more directed discussion, while the resource map allows for a more exploratory one.

Time plan: Mapping additional flows can take 60 to 90 minutes per flow, depending on complexity. All three flows can usually be covered within a half-day workshop, if discussions are kept focused.

Circularity Thinking materials:
- Several Circularity Compasses available as a shared workspace (large print or digital): one for each flow you are examining.

Materials needed:
- Post-its in multiple colours (for resources, value, information, energy).
- Pens or markers, ideally colour-coded according to post-its.

Facilitator tip:
Encourage participants to capture connections to other flows whenever they surface, but keep the active discussion focused on one flow at a time. Emphasise that circling back to refine or add detail later is expected—the method builds through iteration rather than aiming for a perfect map in one go.

Step 4b—Explore tensions: discuss the influence of opposing forces

Responsible role: Facilitator. **Participants:** Project lead, Decision Maker(s).

Mapping flows alone does not explain why circular systems behave as they do. To fully understand what drives the system, it is necessary to identify patterns—the recurring dynamics that explain why the value chain functions as it does. Patterns highlight the deeper mechanisms, trade-offs and forces that shape behaviour across the system.

How it works

To uncover these patterns, the Multi-Flow Method works with three recurring tensions as interpretive lenses. Tensions are not problems to be permanently solved but forces that must be balanced, navigated, or sometimes worked around. They help explain why certain dynamics persist and where opportunities for change might lie. By using the guiding questions linked to each tension, the discussion explores how opposing forces shape flows, surfaces key insights, and opens up possible explanations for system behaviour. Later, these conversations will be refined into explicit patterns in Step 4c.

Applying tensions as lenses

Goal: The purpose of this step is to create space to explore how the tensions appear in the system and to use them as a way to spark conversation about what usually goes unseen. The step is deliberately divergent: it deepens dialogue and brings forward interdependencies, gaps, and issues, so the outlines of patterns that explain how the system behaves begin to emerge.

Why this matters: Tensions expose pressures and trade-offs—real or perceived—that shape value chains. They move analysis beyond surface issues, revealing forces that enable or block circular strategies, sparking discussion, and clarifying recurring patterns in system behaviour.

Individual versus collective interest

This tension explores how the needs of individual actors relate to the needs of the system as a whole. The key questions are:

- *What is the goal of the individual actors*—and can they reach it*?*
- *What is the goal of the value chain as a whole*—can it be reached*?*
- *How do these relate: are both individuals and the collective taken care of?*

This lens shows where flows—resources, value, information, or energy—support both the individual and the collective, and where mismatches make circular strategies harder to realise.

4b.1 How to make sense of the flow mappings?

Start by revisiting the flow mappings from Step 4a. The aim now is to unpack these by asking what forces might explain why the flows take their current shape. Begin by choosing one flow where issues surfaced during the mapping or which feels most urgent to explore. Then, with the help of the key questions provided in the boxes above, select one generative tension that seems most pressing to examine. For more detailed questions for each flow, see the table below.

For example, in the case of the reuse of doors, whilst the overall goal may be reuse, demolition contractors may prioritise disposal because it is quicker and cheaper, suggesting a potential misalignment between individual and collective interests. Once a flow and tension have been chosen, look up the respective set of questions in the table below to spark discussion. These questions serve as prompts for reflection, not a checklist—so choose only those most relevant to your case.

Robustness versus adaptability

This tension examines how stability and flexibility are balanced in the system. The key questions are:

- *Where is the system robust?*
- *Where is the system adaptable?*
- *How do these relate: is the balance right?*

This lens helps identify where flows are supported by stability, where flexibility is needed, and where an imbalance undermines circular strategies. It also highlights the trade-offs between reliability and responsiveness that shape how value chains evolve over time.

Concentration versus distribution

This tension looks at how resources, influence, and responsibilities are shared across the system. The key questions are:

- *Where is value/power/information/… concentrated?*
- *Where is it distributed?*
- *Is the balance right?*

This lens helps reveal how flows are governed and accessed, and whether their concentration or distribution supports or hinders circular strategies.

4b.2 What are the key insights?

As you discuss the questions exploring tensions, write down your main takeaways on post-its and place them on the canvas at the point in the flow where they apply. Each post-it should contain one clear insight phrased as a short cause-effect statement. Avoid simply writing barriers such as “reuse is too expensive”; instead be as descriptive as you can to capture the underlying cause, for example: “current pricing structures make disposal cheaper than reuse.” The goal is to move beyond surface observations and to begin to see what drives the system. Therefore, focus on causes rather than symptoms.

Ask yourself:

- What important insights or observations stand out from this discussion?
- What underlying reasons or misalignments seem to explain why flows take their current shape?
- What consequences do these dynamics create for actors or for the system as a whole?

When is this step finished?

This is an intermediary, exploratory step aimed at surfacing the most important underlying forces—in essence a guided brainstorm. The focus is breadth rather than precision: the goal is to open discussion and make visible the different ways tensions shape the system. This step is complete once the main dynamics are surfaced and better understood. It is not necessary to cover every flow under every tension—what matters is to generate meaningful insights about the forces driving behaviour. A good sign is when participants can articulate a handful of key dynamics that explain why the system functions as it does. Remember: tensions are the interpretive lenses that help surface dynamics, while patterns are the recurring dynamics themselves. In the next step, these insights will be organised and refined into explicit patterns. If discussions start circling without new input, move on—the following step will capture patterns more explicitly.

Figure: **Key insights from mapping**

Key insights from exploring tensions

In the case of value flows for door reuse, several key insights emerge across the three tensions. Under the tension of individual versus collective interest, demolition contractors opt for fast disposal because it is cheaper for them, even though the system as a whole loses recoverable value. Building owners who invest in careful dismantling are often under-compensated, since the benefits accrue to buyers or brokers instead. Under robustness versus adaptability, standard demolition contracts reinforce the misalignment by locking in fixed prices and timelines, leaving little room to adapt when reuse opportunities arise. Together, these insights show how incentives and rules nudge behaviour toward disposal rather than recovery. Other findings highlight how power and trust issues play out under the tension of concentration versus distribution. Buyers hesitate to commit to reused doors because price and supply reliability are less certain compared to new products, which limits uptake. At the same time, value capture is uneven: large demolition firms dominate recovery because they hold the contracts, have the necessary equipment, and can operate at scale, while smaller refurbishers struggle to access opportunities. Digital marketplaces add another layer of concentration: they centralise transactions and fees, which can create efficiency but also risk excluding smaller brokers and narrowing access. These insights underline how systemic imbalances across incentives, contracts, and market structures determine whether reuse becomes viable or remains marginal.

How to: Step 4b - Exploring tensions

Pre-work: Flow mappings from Step 4a should be available as a reference. These provide the basis for discussing how tensions shape the system.

Time plan: The time required varies with the level of detail. Covering all tensions for one flow can take around 90 minutes. A focused session of about 3 hours is often sufficient to provide a solid basis for the next step, though not all flows and tensions need to be addressed, and additional time can be added if needed.

Materials needed:

- Post-its to note key insights.
- The guiding questions for each tension.

Facilitator tip:

Encourage the group to treat tensions as interpretive lenses, not checklists. Guide participants to capture insights on post-its at the points in the flow where they apply, and to focus on underlying dynamics rather than surface observations.

Table: **Flow-specific guiding questions for the different generative tensions**

	Resource Flows	Value Flows
Individual vs. Collective Interest	• Are actors incentivised to maximise their own short-term use of resources, or to preserve shared long-term availability? • Who benefits from discarding or extracting resources, and who bears the costs of loss or scarcity? • Do current arrangements reward collective recovery of resources, or reinforce individual disposal practices?	• Where do some actors bear costs that benefit others, and how does this affect participation? • Do current value exchanges encourage collaboration across the system, or pull actors in different directions? • When value is created, does it stay with the actor who generated it, or does it spill over to benefit others in the system?
Robustness vs. Adaptability	• Do existing supply contracts and standards provide security, or restrict flexibility when resource quality or availability changes? • Can the system adjust when disruptions occur (e.g. shortages, impurities), or is it too dependent on fixed supply chains? • Does stability in resource flows build confidence, or reduce the space to experiment with circular alternatives?	• Do financial arrangements (e.g. contracts, pricing models) provide security, or lock actors into rigid paths? • When conditions change, can value flows adapt — or are they too fixed to respond? • Does stability in value exchange build trust, or prevent experimentation with new circular practices?
Concentration vs. Distribution	• Is access to key resources concentrated in a few actors, or spread more widely across the system? • Does concentration create efficiency and control, or vulnerability to bottlenecks and dependency? • Would more distributed access to resources enhance resilience, or complicate coordination?	• Is value capture concentrated in the hands of a few actors, or distributed more widely across the system? • Does concentration of financial power create efficiency, or dependency and exclusion? • Would broader distribution of value strengthen resilience, or complicate coordination?

Information Flows	Energy Flows
• Are organisations rewarded for keeping information to themselves / sharing information with the value chain? • What are they gaining/ losing by sharing/ not sharing? • What risks emerge from not sharing/ sharing wrong/ unintentionally sharing?	• Do actors optimise energy use mainly for their own operations, or in ways that benefit the system as a whole? • Are savings from efficiency or recovery kept within single firms, or shared across the value chain? • Does competition over energy costs hinder collaboration on shared energy solutions?
• Is the way information moves in this system rigid? Or flexible when things change? • What happens when unexpected things happen? • Does the system rely on fixed routines? Or can it adjust when things change?	• Are energy supply arrangements (e.g. contracts, infrastructure) providing stability, or locking the system into rigid paths? • When disruptions occur, can the system shift to alternative energy sources, or is it too dependent on one option? • Does reliance on stable but carbon-intensive energy provide short-term security at the cost of long-term adaptability?
• Is access to information concentrated among a few actors, or broadly shared across the system? • Who controls the key information needed to make decisions, and who is left dependent on them? • Does concentrating information in a few hands make the system more efficient, or more vulnerable?	• Is access to affordable energy concentrated in a few hands, or distributed fairly across actors? • Does centralised energy provision create efficiencies, or make the system vulnerable to bottlenecks and disruptions? • Would distributed and decentralised energy models increase resilience, or add coordination challenges?

Step 4c—Uncover patterns: identify the main dynamics

Responsible role: Facilitator. **Participants:** Project lead, Decision Maker(s).

In the previous step, the system was examined through the lens of tensions, surfacing deeper forces that shape how flows behave. Now the focus shifts from broad exploration to convergence: refining and prioritising the key insights and organising them into patterns. Patterns are the recurring dynamics that explain why the system functions as it does. They emerge from the interplay of flows and actor decisions, shaped by the tensions identified earlier, and move the focus beyond isolated issues to reveal the structures, incentives, and behaviours that drive outcomes across the value chain.

Patterns should always describe systemic dynamics, not single actions. For example, instead of writing 'provide spare parts,' frame it as 'repair becomes the default option because spare parts and knowledge are consistently accessible.' This ensures the discussion captures recurring behaviour, not isolated fixes.

Goal: The aim of this step is to identify and organise the systemic patterns that explain how the system currently functions, while filtering and prioritising the most important ones. These patterns then serve as the basis for imagining how the system could function differently. The step involves making existing patterns explicit and then defining desired patterns that show how tensions could be resolved, worked around, or embraced.

Why this matters: By stepping back to identify and organising patterns, the analysis shifts from listing problems to understanding why they persist. Patterns reveal what is really shaping flows across the system and highlight where change is possible. Distinguishing between existing and desired patterns makes it clear which dynamics currently block circular strategies and what alternative dynamics could support them.

Start from what was discussed

Look back at the post-its developed in Step 4b that highlight where tensions exist in the system. Use the key insights from 4b as the starting point for discussion. You may choose to begin with a particular flow or with an issue that has proven especially pressing.

4c.1. What existing patterns shape the system?

The goal here is to capture what happens across the value chain—not one-off incidents, but recurring behaviours. In the previous step, the focus was on discussing flows to reveal where tensions influence the system. These may have appeared as isolated issues; now the task is to look for common patterns and dynamics that explain how the system functions.

To explore possible patterns, discussions can build on participants' own reflections or draw on the guiding questions provided for each flow—see table below. These questions are not a checklist to be completed but prompts for reflection—choose the ones most relevant to your case. Capture 2–3 concise statements of recurring dynamics on post-its and place them in a shared repository.

For example, in the case of audio equipment repair, an existing pattern is that repair is discouraged because spare parts are hard to access and manufacturers often push replacement over repair. This reflects the tension between individual versus collective interest, as manufacturers prioritise sales over system-wide value retention. Observing this opens up the possibility of rethinking how the manufacturer can (also) benefit from repair, aligning individual and collective interests.

4c.2. What desired patterns could enable change?
After defining the existing patterns in the previous step, now consider how these could be transformed into desired patterns that support circular strategies. Go through the existing patterns one by one and ask: *what new dynamics would resolve, work around, or embrace the tensions that were identified?* Rephrase barriers into opportunities or describe new dynamics that would enable change.

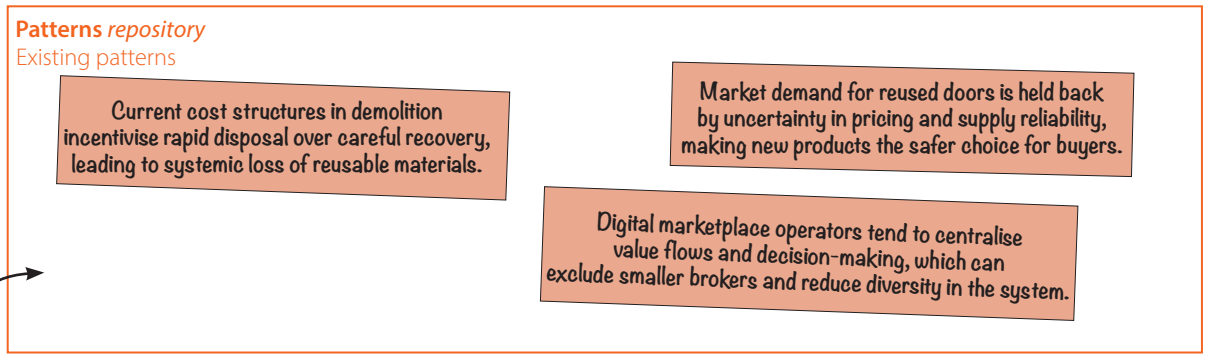
Use the provided guiding questions as inspiration for your discussions. Desired patterns should be formulated as systemic dynamics rather than single actions, so that they describe how the system could behave differently. Write down each desired pattern as a concise statement on a post-it and add it to the respective repository.

For example, in the case of audio equipment repair, a desired pattern could be that reliable spare parts and clear repair instructions are consistently available. Rather than stating this as a one-off action like "provide spare parts," it is better phrased as: "repair is the default option because spare parts and knowledge are consistently accessible." This formulation highlights the systemic shift, showing how new dynamics can reframe repair from an exception to a standard practice.

When is this step finished?
This step is complete once a set of existing patterns has been captured and paired with corresponding desired patterns that show how the system could behave differently. It is not necessary to identify patterns for every flow, but there should be enough to explain the key dynamics that block or enable circular strategies.

A good rule of thumb is 2–3 patterns per flow or for the issues that proved most pressing in earlier discussions. At this point, individual barriers and enablers should be understood as connected rather than separate issues, and attention should also be given to patterns that cut across multiple flows.

The patterns should be formulated clearly enough to serve as inputs for the next step, where they will be translated into ecosystem requirements. If discussions risk becoming repetitive, move on once both the main existing dynamics and at least some promising alternatives are visible.

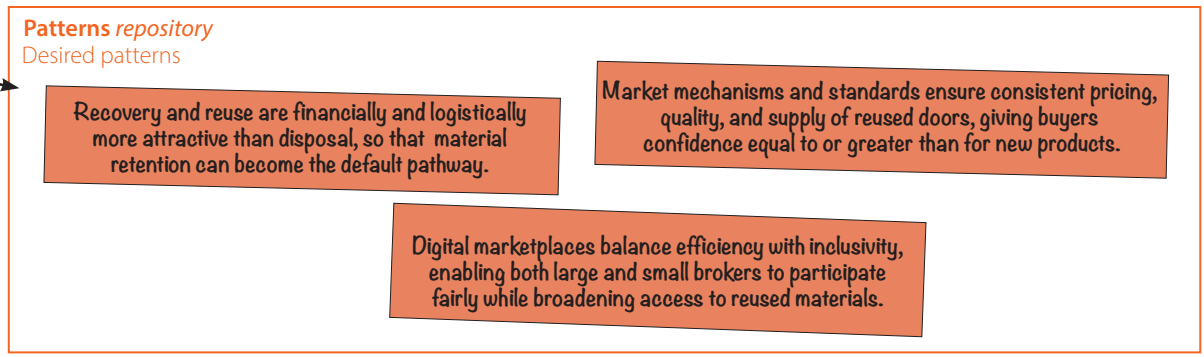


Example of existing patterns in the reuse of doors

Based on the analysis of value flows in the reuse of doors, three systemic patterns stand out. Current cost structures incentivise demolition contractors to prioritise fast disposal over recovery, even though this results in a collective loss of valuable materials. Buyers remain cautious about reused doors, as uncertain prices and supply reliability make new products the safer option. Marketplace operators tend to centralise transactions and fees, which risks excluding smaller brokers and narrowing participation. Together, these patterns highlight how misaligned incentives, demand uncertainty, and platform control combine to hold back reuse at scale.

Example of desired patterns in the reuse of doors

Based on the analysis above, three desired patterns illustrate how the system could function differently. First, recovery and resale need to be financially and logistically more attractive than disposal, making reuse the default pathway rather than the exception. Second, market mechanisms and standards should ensure consistent pricing, quality, and supply, giving buyers the confidence to choose reused doors without hesitation and to plan with them reliably. Third, marketplace structures should combine efficiency with inclusivity, enabling both large and small actors to participate fairly while broadening access to reused materials. Together, these desired patterns highlight how systemic shifts can align incentives, build trust, and open access, creating the conditions for reuse to succeed at scale.



How to: Step 4c - Uncovering patterns

Pre-work: The key insights from Step 4b should be available on post-its, capturing how tensions surfaced in the flows and what dynamics they revealed. These serve as the starting point for identifying recurring patterns.

Time plan: Allow 30 – 60 minutes per flow, though less time may be needed if Step 4b already provided in-depth insights. In total, plan for around 90– 120 minutes.

Materials needed:

- Post-its in two colours (existing vs. desired patterns)
- Repository for clustering existing and desired patterns
- Guiding questions for each flow

Facilitator tip:

Encourage participants to phrase patterns as concise, systemic statements rather than long lists of barriers or enablers. Pair each existing pattern with a desired one to keep the discussion constructive and forward-looking.

Table: **Flow-specific guiding questions to support pattern-finding**

	 Resource Flows	 Value Flows
Questions to uncover ***existing*** *patterns*	● Where are resources consistently wasted, downcycled, or lost from the system? ● How do current sourcing, production, or disposal practices reinforce linear rather than circular use? ● Which dependencies on specific materials, suppliers, or processes repeatedly create risks or bottlenecks?	● How do current incentives and costs shape behaviour across the system? ● Where is value consistently lost, concentrated, or overlooked? ● How do existing financial arrangements (e.g. contracts, subsidies, fees) reinforce or block circular practices?
Questions to uncover ***desired*** *patterns*	● How could design and sourcing practices prioritise reuse, repair, remanufacturing, or recycling? ● What new routines or standards could reduce leakage and keep resources circulating longer? ● How could dependencies on scarce or high-impact materials be reduced through substitution, redesign, or cascading use?	● What incentives or exchanges would make circular practices the preferred option? ● How could contracts, pricing, or financing balance stability with adaptability? ● What would fairer distribution of value look like across different actors in the system?

Information Flows	Energy Flows
• Where does information routinely get lost, delayed, or distorted? • How do current information practices influence trust and coordination? • Which recurring habits or structures limit access to relevant knowledge?	• Where does energy demand create recurring barriers or dependencies? • How do current energy practices affect costs, risks, or vulnerabilities in the system? • Which opportunities for efficiency, recovery, or reuse are repeatedly missed?
• How could information sharing be structured to improve reliability and coordination? • What practices or standards would build trust and transparency across the system? • How might feedback loops help decisions adapt to real-time information?	• How could energy recovery, reuse, or efficiency become standard practice? • What role could decentralised or renewable energy provision play in strengthening resilience? • How might energy use be redesigned to both meet demand and reduce environmental impact?

Step 4d—Summarise ecosystem requirements

Responsible role: Project lead. **Participants:** Flow Experts, Decision Maker(s), Faciliator.

Desired patterns describe how the system should behave in the future. The next step is to identify what the ecosystem must provide to make those patterns possible. While patterns describe how the system tends to behave, ecosystem requirements describe the conditions that make such behaviour possible. Think of patterns as 'what should happen' and requirements as 'what the system must provide to allow it to happen.' Ecosystem requirements translate visions into practical conditions by showing both what can already be built upon and what still needs to be created. This step also offers a chance to condense similar desired patterns into broader, system-wide requirements that cut across multiple flows.

Start from your desired patterns

Begin with the set of desired patterns developed in the previous step. Review them one by one and look for overlaps or common themes across different flows. Where several patterns point to the same underlying condition, condense them into a single requirement. Be careful not to oversimplify—similarities can be combined, but important nuances should not be lost.

Goal: Translate desired patterns into clear ecosystem requirements by identifying offerings that can be built upon and needs that must be developed. Offerings and needs are not patterns themselves—they are the systemic conditions, resources, or infrastructures that either already exist (offerings) or still need to be created (needs) to enable the desired patterns.

Why this matters: Systemic change does not always start from scratch. Often, existing resources, infrastructures, and practices can be scaled or adapted rather than reinvented. At the same time, naming what is absent makes gaps visible and actionable. This step is therefore a crucial part of the overall process: it moves the Multi-Flow Method beyond analysis and prepares the ground for concrete action by specifying what the ecosystem must deliver for circular strategies to succeed.

Review desired patterns

Look for overlaps between desired patterns from different flows and condense them where appropriate. Be careful not to oversimplify—the aim is to identify shared requirements without losing important nuances.

4d.1. What can be built on?

Look for offerings—tools, practices, infrastructures, or relationships — that are already in place and can help realise the desired patterns in order to strengthen the system's circularity. Ask: *Which practices or routines already work well? What resources, infrastructures, or partnerships are available to build on? Where does the system already show strengths that can be scaled?*

Write down each offering as a concise statement on a post-it and place it in the repository under *Offerings*.

4d.2. What is still missing?

Identify the needs—capabilities, infrastructures, or connections—that are currently absent but would be required to make the desired patterns a reality. Ask: *Which capabilities or resources are not yet in place? Where are the gaps or bottlenecks that hold the system back? What critical elements are needed but currently unavailable?*

Capture each need as a concise statement on a post-it and place it in the repository under Needs. Keep requirements specific and actionable.

For example, in the case of audio equipment

repair, the desired pattern was that spare parts and clear repair instructions are readily available, in an effort to make repair the default option instead of replacement. To realise this, one offering might already exist in the form of repair manuals for newer product lines. A critical need, however, could be a platform that ensures consistent availability of spare parts across multiple generations of products. Identifying such needs makes clear what additional elements the ecosystem must provide to make the desired pattern work in practice.

When is this step finished?
This step is complete when offerings and needs have been defined for the desired patterns. Aim to cover as many patterns as is useful given their number and relevance—the exact breadth depends on how many patterns were identified—while prioritising those that matter most. As a general guideline, the most pressing patterns should each have at least one offering and one need recorded. Requirements should be specific and actionable, clearly linked back to the patterns, yet remain open to refinement. A good sign of maturity is when it's clear what the ecosystem already provides and where the critical gaps are.

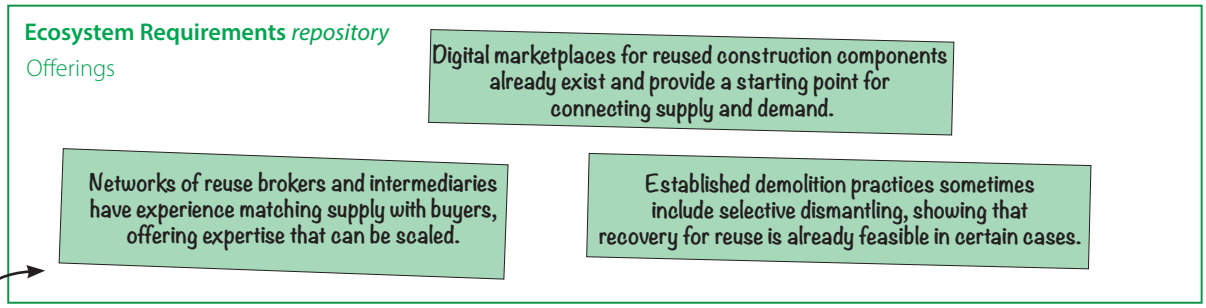
This marks the end of the Multi-Flow Method: the process has moved from flows to tensions, from patterns to requirements, leaving a clear picture of what the ecosystem must deliver for circular strategies to succeed. The next steps for translating these requirements into action fall outside the scope of this guide, but you can find more on this in the remainder of the Circularity Thinking process.

How to: Summarising ecosystem requirements
Pre-work: Desired patterns from Step 4c should be available as post-its. These form the basis for defining what the ecosystem must provide.

Time plan: Plan for 60 – 90 minutes, depending on the number of desired patterns carried over from the previous step. Allow extra time if overlaps need to be reviewed and distilled into clear, systemic requirements.

Materials needed:
- Repository divided into "Offerings" and "Needs"
- Post-its in two colours, markers or digital equivalents

Facilitator tip:
Encourage participants to phrase requirements in systemic and actionable terms. Remind them that the aim is not to design detailed solutions but to specify what the ecosystem must provide for circular strategies to succeed. Highlight that this step produces the final result of the Multi-Flow Method — a clear picture of what already exists and what is still missing in the ecosystem.



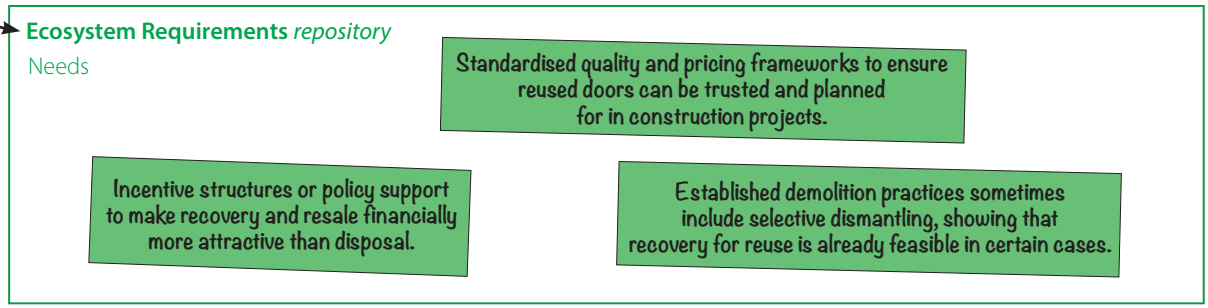
Example of ecosystem offerings for the reuse of doors

In the reuse of doors, several elements already exist that can be built upon. Digital marketplaces for reused construction components already exist and provide a starting point for connecting supply and demand, even if their scale and adoption vary between regions. Established demolition practices sometimes include selective dismantling, showing that recovery for reuse is already feasible in certain cases, and that practical know-how exists in the industry. Networks of reuse brokers and intermediaries also have experience matching supply with buyers, offering expertise that can be scaled and transferred to new contexts.

Together, these offerings illustrate that reuse is not an entirely new practice but one with a foundation to build on. The challenge is less about invention from scratch and more about strengthening, expanding, and aligning these existing initiatives to make them effective across the system.

Example of ecosystem needs for the reuse of doors

To make the desired patterns a reality, additional needs must be addressed. Standardised quality and pricing frameworks are essential to ensure reused doors can be trusted and planned for in construction projects, providing consistency for architects, contractors, and clients. Incentive structures or policy support, such as disposal levies or tax breaks, are needed to make recovery and resale financially more attractive than disposal, shifting the economic balance in favour of circular practices. Inclusive platform design and governance must also be ensured, so that smaller brokers and contractors can access marketplace opportunities alongside larger firms. Without these measures, existing efforts risk staying fragmented or being captured by dominant players, rather than enabling a systemic transition.



A starting point for next steps for all circular strategies

In this guide we focus on *Value chain design, development & innovation* to map the current as well as the desired circular flows: resources, value, energy (if needed) and, of course, information flows—who moves what, who benefits, with which evidence. This shared picture is then examined through the lens of recurring tensions—Individual vs. Collective Interest, Robustness vs. Adaptability, Concentration vs. Distribution—so that real bottlenecks surface. This enables targeting the highest-leverage frictions rather than symptoms. For our four example circular strategies, we illustrate below what insights can be used to kick-start the development of new data and information sharing infrastructures, which serves as input for Guide 2 *Decentralised sharing of data & information*.

(A) Beginning-of-life: using recycled input
What: Cross-sector recycling of apparel waste into feedstock for floor tiles.

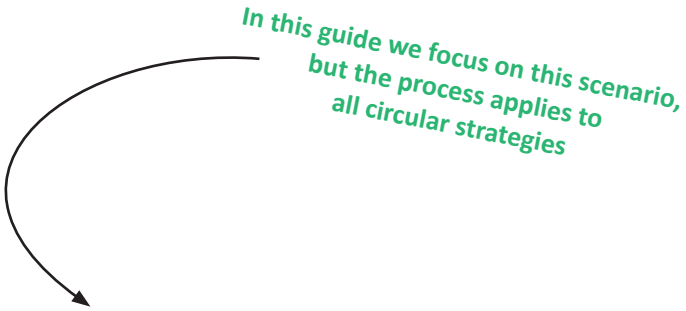
Current undermining tension—Individual vs. Collective Interest: Each actor optimizes for self-protection. Suppliers upload batch "proof" as PDFs with metadata at different levels of confidence and granularity ("rubber≈20%"), but keep sensitive fields—phthalates, heavy metals, formulations—offline. Recyclers list vague tags ("post-consumer, clean"); processors and buyers can't verify claims such as "≤0.1% phthalates" or binder compatibility without seeing company secrets. Suppliers won't risk exposure; buyers won't risk non-compliance. Deals fail not for technical reasons, but because evidence can't be shared selectively.

Improvement opportunity for data flows: Apply governed, selective disclosure. Certificates become machine-readable and are mapped to shared terms; sensitive results are issued as verifiable credentials with field-level, purpose-bound access and audit trails. A supplier can prove "Batch X meets limit Y" without revealing spectra or recipes. Predefined queries check compliance across decentralized stores, preserving ownership. With accountable, granular sharing, trust rises and qualified recycled batches can flow—opening trade across sectors. It is decided to create this.

(B) Middle-of-life: repair
What: Repair of audio system through access to reliable spare parts & instructions.

Current undermining tension—Concentration vs. Distribution: Repair data, diagnostics, and spare-part info are locked behind OEM portals and contracts. Access to repair guides, compatibility, and pricing is controlled by OEMs, while building owners must scrape PDFs or call helpdesks, and updating a building's digital twins is cumbersome. This erodes trust, invites errors, and tilts decisions toward replacement: unable to verify "fit-for-use," and nudged by warranties and liability, owners replace rather than repair—driving premature end-of-life and extra cost.

Improvement opportunity for data flows: Apply governed, selective disclosure. That is: encode diagnostics and compliance as verifiable credentials; grant time-limited, purpose-bound access to repair data; and automatically sync updated composition and sustainability attributes to the digital twin or product passport after repair. This aligns incentives—owners get proof, OEMs keep control—ensuring access to reliable parts and streamlined data updates, letting repair outcompete replacement. Creating this capability develops into the focus of the next nine steps in the process.



(C) End-of-life: reuse

What: Reuse and resale of a door for use in other building projects.

Current undermining tension—Robustness vs. Adaptability: Ahead of demolition, doors are assessed and listed, but rigid, document-based formats can't capture real-world variability. Key fields—dimensions, swing, interfaces, material, glazing, ratings, condition, and install history—are missing or incomparable so buyers can't test fit for new projects. Planning constraints aren't linked, and commercial terms sit in scattered PDFs. "Robust" formats (reports, photos) are too static to support confident pricing for reuse, so building owners accept conservative offers or default to disposal.

Improvement opportunity for data flows: Enable machine-readable door passports with geometry, interfaces, ratings, condition, provenance, images, and location, using shared vocabularies and verifiable credentials. Sync planning constraints automatically and manage contracts decentrally so only authorized parties can access them. Interoperable APIs let marketplaces and builders auto-check fit and code, improving negotiation with the demolition contractor and enabling confident resale into new projects. Putting this in place becomes the main concern of the project that follows.

D) End-of-life: remanufacturing

What: Take-back of the floor tiles by the manufacturer for remanufacturing.

Current undermining tension—Individual vs. Collective interest (Take-back): At end-of-life, owners and demolition crews optimise for speed and lowest cost, while the OEM needs predictable, quality-controlled returns to plan remanufacturing. Crucial evidence—lot IDs, composition/binder, contamination risk, install zones, uninstall technician, custody—sits in PDFs or isn't captured. With incentives split and proof missing, tiles are cherry-picked or downcycled, and OEMs can't secure stable and reliable feedstock for remanufacturing.

Improvement opportunity for data flows: Use governed, selective disclosure. Issue machine-readable passports with lot/composition/binder/condition; attach verifiable credentials for "fit-for-return" and chain-of-custody. Publish reverse-logistics slots and price bands via decentralized pods (with commercials only to authorised parties). Predefined queries in planning tools auto-route eligible tiles to the OEM, aligning incentives and making take-back predictable and scalable. Enabling these solutions is what the next steps are about.

Closing words

Looking back, this guide has taken you on a journey from understanding flows and resource states, to mapping waste, sketching sets of circular strategies and exploring how structural patterns can be turned into actionable strategies. Along the way, we have shown how tools and frameworks can turn abstract circularity ambitions into practical steps. The key insight is that waste is not inevitable—it can be prevented, reduced, or transformed when organisations see the bigger system and act with intent.

Of course, circularity is not a one-off project but a continuous process. As you learn from the first circular strategies you implement, conditions change, technologies evolve, and partnerships expand, there is always room to refine, adapt, and improve. Keep testing your assumptions, strengthening your practices, and updating your strategies. Each iteration brings you closer to unlocking new value, building resilience, and delivering impact at scale.

This guide also sets the stage for the next step: data and information sharing. By identifying flows, and value chain patterns, you have clarified where information matters most. These insights form the foundation for designing data infrastructures, where transparency and interoperability help organisations coordinate more effectively and scale circular practices - see Guide 2 *Decentralised sharing of data & information.*

At the same time, what you have explored here is just part of the pathway into Circularity Thinking. Other steps of the toolkit, but also other methods, and perspectives—whether focused on business models, governance, or cultural change—can further strengthen your approach. Use them to complement what you have learned, and let them inspire new directions. Good luck on your circular journey—we wish you curiosity, persistence, and success in putting these ideas into practice!

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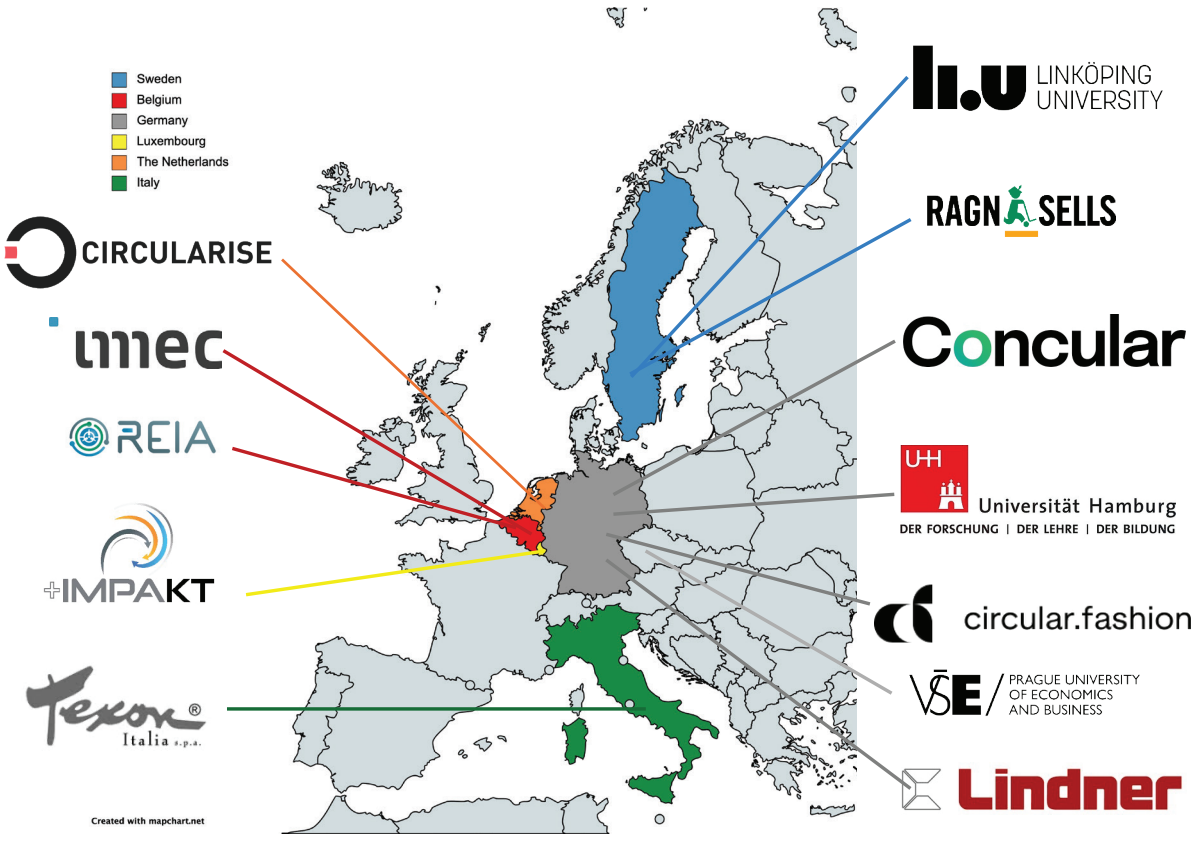
ONTO-DESIDE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