Circular business model innovation

A guidebook for practitioners

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About this guidebook

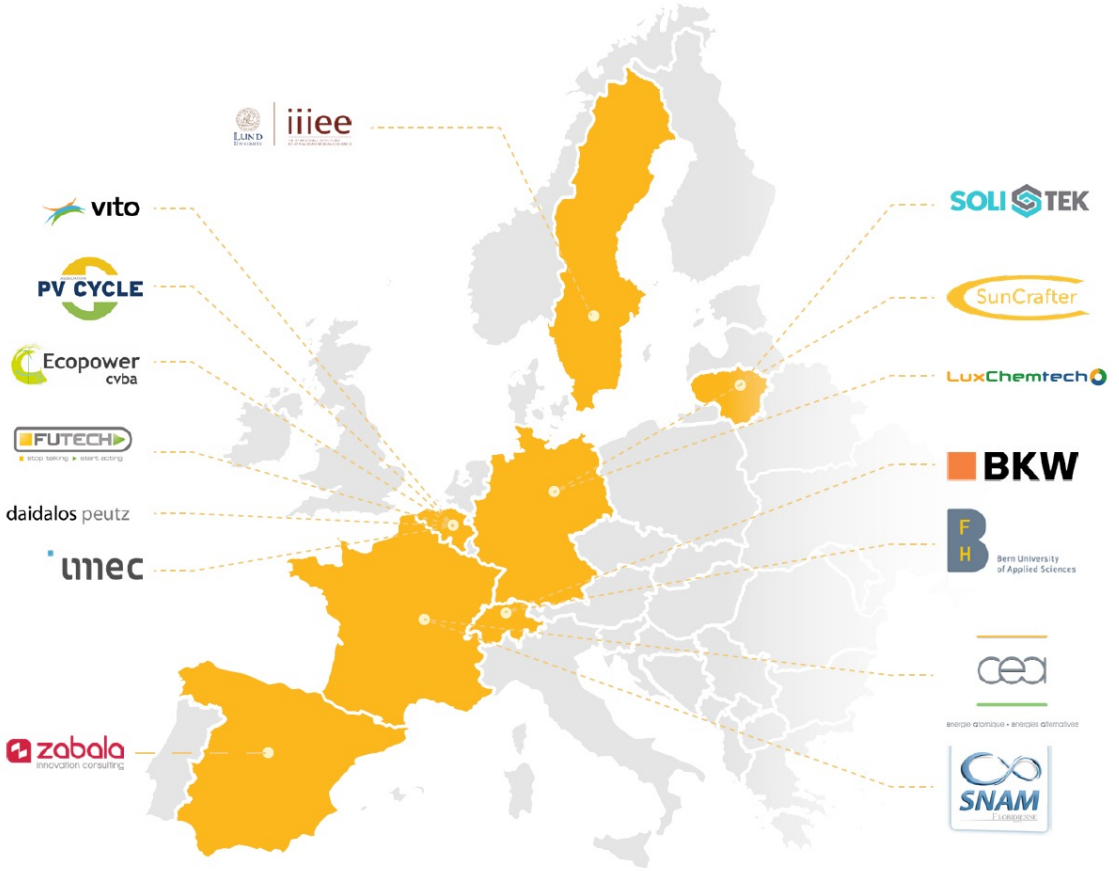
The **purpose** of this booklet is to offer easy-to-use guidelines for businesses to design and implement circularity strategies into their business model. Specifically, the booklet will provide step-by-step guidance on how to ideate, design, test, and scale novel circular business models. For each stage of this circular business model innovation (CBMI) process a selection of tools and methods will be introduced. These tools offer firms guidance and a structured approach on how to approach the CBMI process throughout the single stages.

The intended main **audience** of this guidebook are businesses in a wide range of sectors who seek for a structured technique on how to innovate their business model towards a circular economy through a collaborative and co-creative process with their stakeholders. In particular, the intended users of this method are business innovation support professionals, such as strategy and innovation units within companies, consultancy firms, incubators and accelerators, universities, institutes and NGOs working with companies in the field of circular economy business innovation.

About this guidebook

This guidebook is one of the outcomes of the **CIRCUSOL** project. CIRCUSOL (www.circusol.eu) is a Research and Innovation Action project funded by the Horizon 2020 Programme of the European Commission for the period 2018-2022. CIRCUSOL wants to unleash the full potential of service-based circular business models in the solar power industry, simultaneously delivering real environmental, economic and user benefits. The project consortium has brought together 15 partners from 7 different countries, representing research centres and universities, as well as industrial players and businesses from the solar power and battery value chains.

The circular business model innovation tools and processes compiled in this guidebook have been compiled from an extensive review of the literature from a variety of inter-related academic research fields, including business model theory, product service system concepts, business model innovation, co-creation and experimentation. Integrating several of these established tools and approaches, CIRCUSOL developed a dedicated framework to enable **circular business model innovation (CBMI)** in the solar power value chain. The framework was used and tested extensively in the CIRCUSOL project.



The CIRCUSOL project gathered 15 partners from 7 European countries

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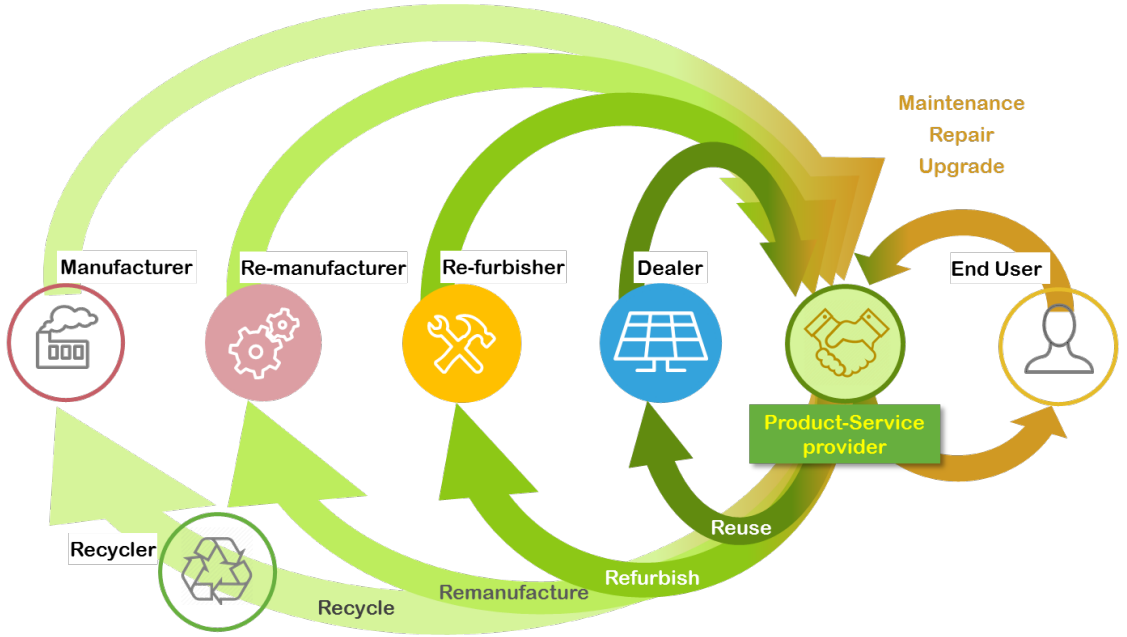
Towards a Circular Economy

The concept of Circular Economy has rapidly been gaining momentum in recent years. Governments, businesses and civil society around the world increasingly recognize the multiple benefits a Circular Economy can offer to address a number of global challenges, such as excessive resource consumption, accelerating climate change, natural system degradation, and increasing price and supply risks in global value chains.

The basic underlying principle to a Circular Economy is to **decouple value creation from resource consumption**, by enhancing resource productivity and energy efficiency, decrease waste, and ultimately lower consumption of virgin raw materials. As such, the concept departs from today's linear 'take, make, dispose' mindset, which has relied on large volumes of easily accessible materials and energy at low prices. Key building blocks of a Circular Economy are the extension of productive lifetimes, as enabled through a range of measures such as upgrade, repair, maintenance, reuse, and remanufacturing. At the ultimate end-of-life stage, when continued product use is not viable anymore, recycling of (critical) raw materials and circulating them back to the manufacturing sector will ensure that valuable resources are not wasted.

Circular Economy concepts also advocate for new modes of value generation, departing from the presently widespread ownerships model, and heading towards service-oriented and shared access models. These have the potential to further leap-frog resource productivity.



Product-service providers are the focal touchpoint between users and business firms that enable circular economy strategies.

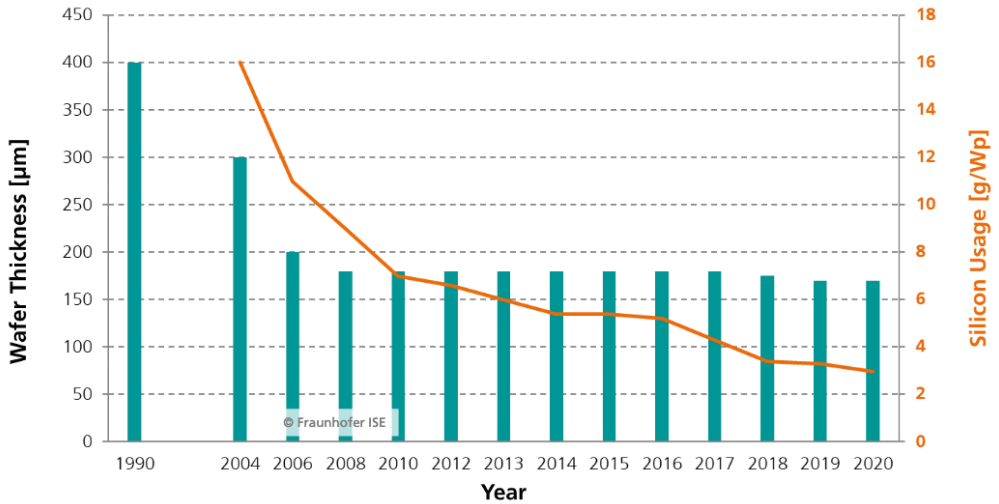
Towards a Circular Economy

For **business organisations**, a circular economy offers multiple benefits. Increasing resource productivity will typically go along with reducing the material and energy costs to manufacture a product. Reducing expenditures for waste disposal, while simultaneously gaining value from recovered materials, further enhances profit opportunities. Importantly, using less virgin material and more recycled inputs will also enhance a firm's resilience towards volatile raw material prices, supply chain disruptions, and other geopolitical risks.

Innovative business models that focus on function and service, rather than ownership, offer firms new ways to establish a longer-term relationship with customers, entailing more steady revenue streams and new business opportunities. Last but not least, a circular economy would create demand for a whole range of new business fields, such as collection and reverse logistics, product remarketers and sales platforms, as well as refurbishment and remanufacturing of products and components (EMF, 2015).

Resource efficiency in the solar power industry

One example from the solar photovoltaic (PV) industry for the circularity strategy of narrowing loops is the reduction of silicon needed per product unit. From 2004 to 2020, silicon usage per watt was reduced by about 80%, through a combination of thinner wafers and higher efficiencies. This narrowing loops strategy was critical to lower the material footprint and associated environmental impact of photovoltaic panel manufacturing. In addition, it helped to reduce raw material and manufacturing costs, thereby boosting the competitiveness of solar electricity.



Source: Fraunhofer-ISE 2022

Circularity strategies

To maximise resource efficiency, circular economy concepts often distinguish broadly between three key approaches to address this – strategies to **narrow, slow,** and **close resource loops**.

Circularity strategies	Definition	Examples from the solar power & battery sectors
Narrowing resource loops	Reducing the amount of materials needed per product or service. It is about resource efficiency, or doing more with less.	The solar power industry reduced silicon usage per watt by about 80% from 2004 to 2020. This was achieved through a combination of thinner wafers and higher efficiencies. Lowering the material footprint reduced the associated environmental impact of PV panel manufacturing and also helped to reduce raw material and manufacturing costs, thereby boosting the competitiveness of solar electricity.
Slowing resource loops	Keeping materials and products in use for a longer period. It requires to design and manufacture products that have a long life span, can easily be repaired or repurposed, and which consumers will want to use for a long time.	Life-cycle quality management enables long technical and economic lifetimes of solar power systems. This entails prevention of defects or underperformance through good operation and maintenance (O&M) practices, repair of those panels that still go defect, as well as collection of discarded functional panels and their reuse in a second-life application. In the battery sector, discarded electric vehicle batteries (EVBs) can be repurposed into stationary energy storage systems, thereby gaining a second life for the storage of, e.g., solar power.
Closing resource loops	Closing the loop and recycle. After a long lifetime and many cycles of reuse or repurpose, it entails to dismantle the product, separate materials, and recirculate these back into the manufacturing of new products.	Innovative recycling techniques enable recovery of valuable raw materials, including critical raw materials (CRMs), and avoid the mixing, or cross-contamination, of materials. Emerging concepts for eco-design and design for disassembly of solar panels will in the future further facilitate high-value recycling processes.

Key circularity strategies, illustrated with examples from the solar power and electric vehicle battery sectors

Circular business models

Implementing circularity strategies in a business context can significantly gain from taking a business model perspective. In general, a business model broadly describes 'the way business is done' by illustrating how a business proposes, creates and delivers and captures value for the business, customer and wider group of stakeholders. As such, it provides a 'systemic lens' to investigate businesses and the ways they operate.

Specifically, circular business models are designed to create, deliver, and capture value while implementing circular economy strategies, such as long-life products, reuse, repair, remanufacturing and recycling. In circular business models, product systems and value creation architectures are adjusted to retain resources at highest value for as long as possible and to close material loops at the end-of-life. Thereby, circular business models can reduce the environmental impacts embodied in products, components and materials, while simultaneously they may generate many other types of benefits, such as cost savings in production, superior customer value from, for instance, increased convenience through services or extended life times, or regional employment creation (Nußholz, 2019).

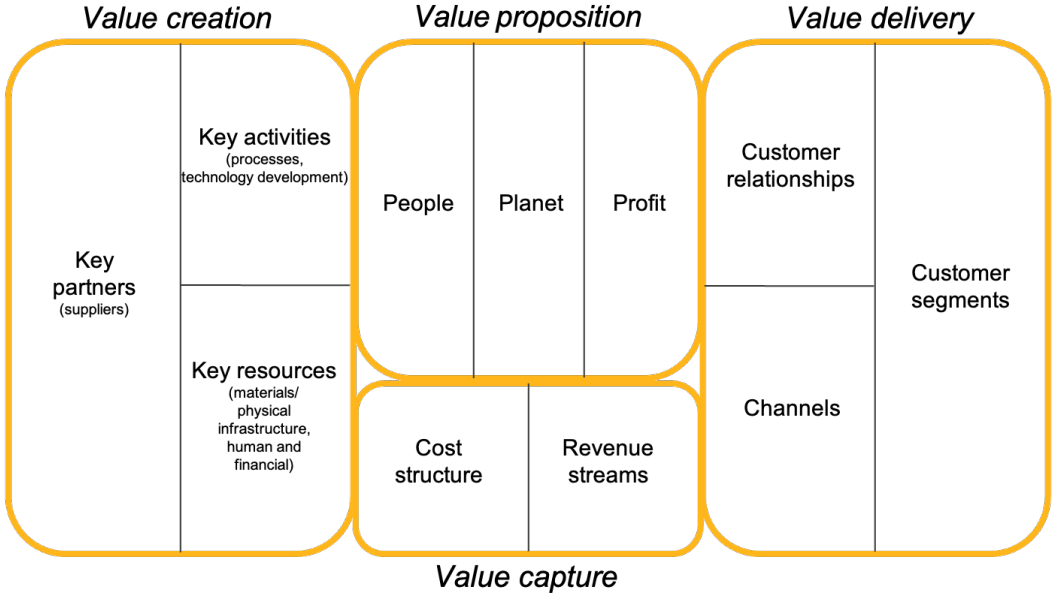
Circular business models share similarities with sustainable business models, both concepts highlighting the need for a broader understanding of value, including the benefits and costs to other stakeholders beyond the firm and its customers, specifically to society and the environment. As such, they recognize negative externalities of production and consumption practices that in today's economic system are insufficiently incorporated in prices, and they seek to exploit potential value creation opportunities that presently are often wasted, missed, or destroyed.

Business model canvas

In general, a business model consists of different elements that can be adjusted in innovative ways to enable and integrate more circularity. These elements can be structured into four dimensions:

- value proposition – describing the value provided and to whom
- value creation – specifying how value is created
- value delivery – detailing how value is delivered
- value capture – outlining how value is captured and turned into profit

The elements of a business model are tightly interlinked and define the value creation logic inherent to a firm's activities.



Adapted from: www.strategyzer.com / Osterwalder (2010)

An example of a solar firm, using a service-based business model, can be be used to illustrate how the building blocks of the business model fit together. The value creation relies on key partners, such as component suppliers and the grid operator. Key activities involve the instalment and operation of a solar system on the premises of the user. Key resources of the firm include internal know-how and skills as well as the physical products that make up a solar power system. The value proposition can be defined as the provision of green electricity, at for the user zero upfront-costs and high degree of convenience.

The customer segment comprises of commercial and industrial users, and the relationship to these customers groups is defined through long-term power-purchase and service agreements. Channels of interaction with the customers can be manifold, including channels based on existing relationships, website, campaigns, word-of-mouth communication, etc. Finally, in the value capture block, cost structure is determined by a combination of capital (CAPEX) and operating (OPEX) expenditures for the solar power system. Revenue streams comprise of recurring incomes from the sales of electricity to the user, as formalized in the service agreement.

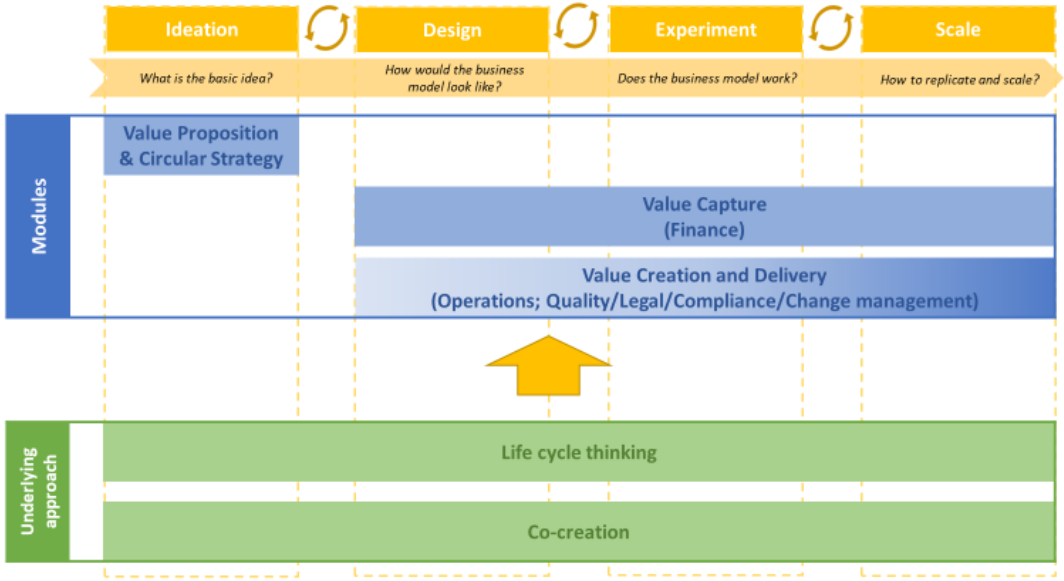
Circular business model innovation

In the the example of the business model, as described on the previous page, the key element of the value proposition is the provision of ”green” electricity”. While renewable energy generation is a key building block for the achievement of climate mitigation targets, the present business model yet lacks considerations of materials resource management and circularity.

In order to enhance circularity with the goal to preserve and utilize the embedded value in resources, updating the elements of an existing business model (or development of an entirely new business model) to embed, implement, and capitalise on circular economy strategies would be the next step. We define this process as **Circular Business Model Innovation (CBMI)**. CBMI requires rethinking how a company creates, delivers, and captures value in a holistic manner to align the value creation logic of a company with circular principles. This process of innovating the business model can be of more moderate nature (e.g. adding a new activity to an existing business model) but also of more transformative character when there is comprehensive change in various business model elements. Innovating the business model can help coordinate technological and organizational innovations, and often requires rethinking the relationships a firm has with its suppliers, other partners, and customers.

The CIRCUSOL CBMI support framework

CIRCUSOL has developed a dedicated method to support circular business model innovation. The framework integrates different tools and processes, with the aim to guide and support companies in designing and experimenting with novel circular business models in practice, and overcome common challenges. Although the solar power sector was used as a development vehicle, this framework itself is generic and is designed to be applicable for a variety of sectors.



The CIRCUSOL CBMI method combines an iterative and experimental approach with lifecycle thinking and co-creation techniques.

The CIRCUSOL CBMI support method is characterized by the following underlying approaches:

- An **iterative and experimental approach** that relies on multiple learning and innovation cycles. Iterations are common, and may even be desirable to ensure solid ground before proceeding to the next stages, which usually require increasing resource commitment and organizational change.
- A perspective of **lifecycle thinking** on the environmental and (micro-) economic impacts of circular business models. Lifecycle thinking ensures consideration of the full life of a product, from mining raw materials to the end-of-life management stage, thereby ensuring that problems are not shifted from one phase to another.
- **Co-creation** ensures a strong involvement of the firms' stakeholder network when designing novel circular business models. Co-creation brings together all stakeholders, not only in the supply chain, but also end users, civil society, public authorities, financiers, etc. This fosters the widest acceptance and support of the new business model.

Experimentation and iteration

For firms, developing circular business models entails a significant degree of uncertainty. The relative absence of circular business practices and related business models means that there are often no existing blueprints that business managers can rely on.

In this context of uncertainty, an **experimental and iterative approach** to business model innovation has been found instrumental. In practice, the innovation of a business model is rarely a linear and straightforward process in which all micro-steps are defined from the beginning. Experimentation can enable firms to test novel ideas at a small-scale and relatively low cost, and it has also been found to be a key factor that positively affects radical innovation.

An experimental approach to business model innovation is characterized by an iterative process of trial and error, that has the purpose to test assumptions in a real-live market environment. These assumptions can comprise a wide range of business model parameters, including key variables such as the value proposition, customers segment and mode of value delivery.

The Lean Startup approach

The Lean Startup approach is a specific business experimentation concept, that has been used to iteratively develop novel business models under conditions of uncertainty, and it has initially been applied by start-up firms with limited internal resources. The approach relies on the concept of business model innovation through repeated, validated experimentation with the goal to develop a minimum viable product, while holding running expenses low. Following the launch of a minimum viable business model in the market, a sequence of additional iterations in the build-measure-learn cycle can help the firm to further improve and refine the value proposition and the underlying business model mechanisms to deliver it.

A key element in the build-measure-learn cycle is *validated learning* or experimentation. Validated learning comprises of a process of testing a set of business assumptions that are empirically tested with data obtained from real customers. In fact, the involvement of users and customers in product and business development is critical in order to maximize the rate of learning. The Lean Startup methodology as a cyclical process is grounded in a set of activities in which entrepreneurs (1) map their business idea visually on the business model canvas as testable assumptions, (2) test these assumptions, and (3) evaluate the results. Invalidated assumptions are to be replaced and new assumptions are to be tested until a minimum viable business model is achieved. Emphasizing interaction and testing hypotheses with real customers to gain validation before investing heavily in development is at the core of this co-creative business model development process.

Lifecycle thinking

The second underlying approach to the CIRCUSOL CBMI support method is lifecycle thinking. In general, lifecycle thinking is about going beyond the traditional focus on production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire lifecycle, including extraction of raw materials, design and production, packaging and distribution, use and maintenance, reuse, disposal, recycling and recovery, as well as incineration and landfill. Lifecycle thinking used in the CIRCUSOL CBMI support framework mainly takes the environmental and (micro-) economic impacts into consideration. The integration of these perspectives is critical to understand synergies and trade-offs, and to ensure there is a balanced view for both economic and environmental aspects throughout the business model innovation process.

On the environmental side, **Lifecycle Assessment (LCA)** is an important tool to gain a holistic understanding of the lifecycle environmental impacts of different circular business model configurations. Thereby, LCA provides support to decision making throughout the innovation process, from identifying hotspots, screening circularity strategies, to establishing guidelines and boundaries for business model design, to monitor and assess the actual impacts. For example, LCA data can be used to compare different circularity strategies (re-use vs. recycle), and to set up guidelines for preparing-for-reuse activities.

On the micro-economic side, **Lifecycle Costing (LCC)** can provide a more holistic picture of costs and revenues across the entire lifespan of a product (or service). Ideally, cost and revenue items are assigned to a stakeholder, to enable business case analysis for different stakeholders. Understanding the financial gains and losses for each stakeholder is crucial for assessing the viability of a novel circular business model.

Circularity and the value chain

In complex value chains, transitioning from a linear model towards a circular model cannot be achieved by a single actor alone. The effective testing, implementation and scale-up of circularity strategies cut across the entire product lifecycle, from design and manufacturing, through the use phase, refurbishing and remanufacturing, and eventually recycling at the product's end-of-life stage. Collaboration of stakeholders across the value chain is critical for the development of joint circular solutions. For example, reaching a long use-phase will require manufacturers, product-service providers and refurbishers alike to have in-depth insights about end-user preferences. Similarly, understanding the needs of recyclers will enable manufacturers to design their products in a way that facilitates easy disassembly and recovery of high quality materials.

For individual firms that strive to innovate their business model towards circularity, it is critical to understand and define their position and relationships towards their upstream and downstream partners, including users.

Co-creation

Co-creation is the second key underlying approach in the CIRCUSOL CBMI support framework. Co-creation can be understood as an interactive, creative and social process between a business firm and its stakeholders that provides an opportunity for on-going interaction, with the aim to create superior value propositions – from a social, economic and environmental perspective. Co-creation can extend beyond the involvement of customers and also involve the inclusion of other stakeholders such as employees, suppliers, distributors, and regulators with the intention to develop and deliver the value proposition in close collaboration. As such, co-creation of value relies on the integration of diverse physical, human, and knowledge resources that actors in the network maintain. Co-creation has been associated with the creation of new capabilities, accelerated innovation, creation of superior value propositions, the development of new business opportunities, and sharing of risks.

Enabling a circular economy and designing circular business models can particularly benefit from co-creation that involve a variety of partners. A circular economy within any sector requires a strong interaction between all main stakeholders involved in the design, production, distribution, use-phase, and repurposing of products. In order to successfully implement circularity strategies, useful information on how products are designed and produced (e.g. ease of disassembly, estimated technical lifespan, bill and origin of materials and (semi-manufactured) products, production cost, used and managed (e.g. frequency of maintenance/repair, estimated residual service life, function, service cost), and repurposed (e.g. recyclability, reusability, next destination, residual value of components) needs to be shared within the entire value network. Trust between all main stakeholders is crucial for success.

Co-creation of innovative circular business models provides an opportunity to improve collaboration within the value network and to rethink the relationships between key actors. This can involve fundamental shifts in value chains, such as for example:

- from individual concerns toward a constructive cooperation and mutual concerns;
- from punctual communication between privileged partners towards sharing of useful information along the value network; and
- from pre-consumption-oriented businesses (with a restricted relationship between provider and end-users after purchase) towards life-cycle oriented businesses, through which responsibilities and rights are shared between (service) provider, client/end-user and post-consumption stakeholders.

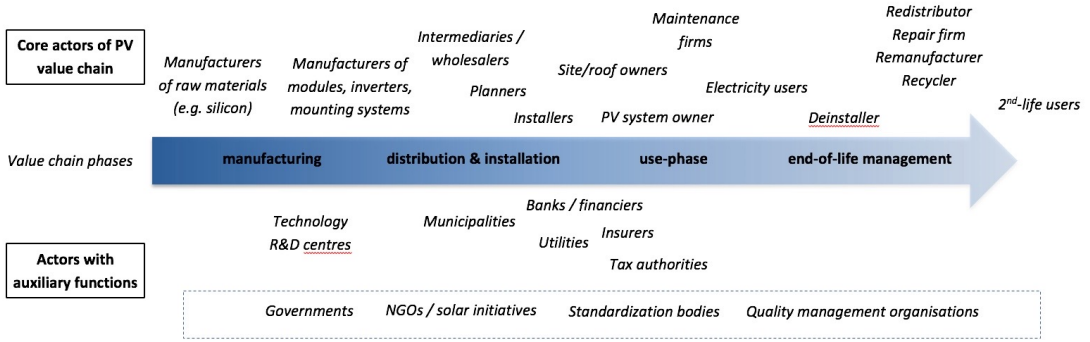
Co-creation

Co-creation in the solar power sector value chain

In the CIRCUSOL project, co-creation has been valuable to integrate knowledge and resources of various actors from the complex solar power value chain. The core of the solar power value chain comprises of manufacturers of different components, wholesalers, planners, architects, consultants, installers, and maintenance firms. Customers and users of solar power technology are a diverse group, comprising of private homes owners, municipal and commercial property owners, farmers, and utilities, amongst others. Furthermore, in a circular solar power value chain, additional actors like redistributors, repair firms, remanufacturers, recyclers as well as users of 2nd-life solar power products are critical.

In addition to the core actors of the solar power value chain, the eco-system involves a range of actors with auxiliary functions. These include utilities, banks, insurers, local authorities that play important roles for grid integration, finance, risk management, as well as permitting of compliance with local regulations and tax laws. Cross-cutting actors along the entire value chain include R&D organisations, solar initiatives, standardization bodies and quality management organisations. These actors typically do not engage in the lifecycle of individual solar power projects, however, they provide important auxiliary functions such as knowledge production, standardization, quality assurance, information provision, lobbying, as well as making and execution of relevant legislation at different administrative levels.

Engaging these core and auxiliary actors in the circular business model innovation process has been found highly valuable, by pooling resources, integrating previously fragmented knowledge resources, and co-creating novel circular business models. As such, collaboration across a multitude of stakeholders has been found critical to enable the transition towards a circular solar power industry.



The solar power ecosystem comprise of value chain actors, as well as actors with auxiliary functions

Co-creation

Overview of exemplary knowledge resources in the solar power value chain. Co-creation can integrate these knowledge resources into the circular business model innovation process.

	Actors / stakeholders	Exemplary knowledge resources to be potentially integrated in co-creation processes
Internal stakeholders of solar (service) firm (incl. planners, installers)	Management	Vision and strategy of the firm, industry knowledge, existing and potential partnerships, etc.
	Customer support	Customer needs and problems, etc.
	PV system designers / planners	Opportunities for streamlining the process of PV planning and installation
	Technicians	Opportunities for streamlining the process of PV installation, operation & maintenance, and decommissioning
	Accounting / financial staff	Cost structure of current business model, cost modelling for alternative business models
	Owners / shareholders	Requirements of capital markets in regard to ROI and risk
Core actors of PV value chain	Manufacturers of raw materials	Requirements on quality / purity of recycled raw materials
	Manufacturers of PV products (modules, inverters, mounting systems)	PV product / technology development, cost trends, regulatory and business trends in other countries
	Intermediaries / wholesalers	Opportunities for streamlining the distribution process of “circular / second-hand PV products”
	Experienced users (incl. site/roof owner, PV system owner, electricity user)	Problems, hassles, transaction costs associated with the adoption and operation of PV
	Potential users (incl. site/roof owner, PV system owner, electricity user)	Expectations towards adopting PV as a new technology, etc.
	Maintenance firms	Typical defects during use-phase, opportunities for circular PV, e.g. repair, preventive maintenance, yield optimization
	Deinstaller	Opportunities to streamline deinstallation/disassembly of PV systems
	Redistributor	Opportunities to redistribute / reuse second-hand PV products (incl. market needs, price trends, etc.)
	Repair firm	Opportunities to repair defects PV products (incl. market needs, price trends, etc.)
	Remanufacturer	Opportunities to remanufacture PV products (incl. market needs, price trends, etc.)
	Recycler	Opportunities to recycles PV products (incl. market needs, price trends, etc.)
	2nd-life users	Expectations towards adopting second-life PV products
Actors with auxiliary functions	Technology R&D centres	Long-term technology trends for various PV technologies
	Municipalities / local authorities	Status quo and trends of regulations at local level
	Financers / banks	Expectations of capital markets with regard to ROI and risk of PV projects
	Insurers	Risk management of “circular / second-hand PV products”
	Utility / DSO	Requirements for grid integration of PV, opportunities for grid management through PV, etc.
	Tax authority	Taxation rules, etc.
	Governments (regional, national, EU)	Regulatory trends at regional / national / EU level
	NGOs / solar initiatives	Independent legitimization of “circular / second-hand PV products”
	Standardization bodies	Trends concerning technology and quality standards
	Quality management organisations	Quality management of second-life PV products

The CBMI process step-by-step

Following, a step-by-step guidance will be given of how firms can approach and structure the circular business model innovation process, and for each step a section of tools will be presented that can provide support. The CBMI support framework distinguishes between four key phases in the innovation process:

(1) ideation
(2) design
(3) experimentation
(4) scaling

For each phase, several tools are available to support the circular business model innovation process. Many of the tools can be used in multiple stages. A number of tools specifically aim to aid with the identification, structuring and integration of knowledge resources from relevant actors in the business ecosystem.

It is important to note that reality is often more complex than the stylized linear process flow, as depicted in this guidebook. Real-life innovation processes will typically be characterized by a set of multiple and in many cases (partially) parallel and overlapping innovation and learning cycles.

Tools & methods	Ideation	Design	Experimen-tation	Scaling
Business model mapping	X	X	X	X
PESTEL and trend analysis	X			X
Visioning	X			X
Value chain mapping	X	X		
Value mapping	X			
Circulator tool	X			
Jobs-to-be-done approach	X		X	
Focus group methods	X		X	
Surveys	X		X	
Lifecycle assessment tools	X	X		
Lifecycle costing tools		X		X
Choice-based conjoint analysis			X	
Pilot projects			X	
Business and replication plans				X
Eco-system simulations				X

Several tools can be used in multiple phases of the circular business model innovation process

Ideating a circular business case

In the initial ideation phase, the **scope, context, vision and value proposition** for a circular business case will be explored. The purpose of the ideation phase is to understand and characterize the current business model of the organization and the context it operates in. At the start of the ideation stage there is uncertainty about which circularity strategy would be relevant for the business and which tentative value proposition could be developed.

At the end of the ideation stage, the scope and focus of the business case should be clear, by answering the following questions:

- Who are the (target) customers, what are their needs, and what could be possible ways to address these needs?
- Which circular strategies are suitable for the business? Is there a positive business case, both environmentally and financially?
- Are there significant barriers (e.g. technical, legislative or other)?
- Which synergies between the customer needs and value proposition on the one hand, and circular strategies on the other, can be identified? Which conflicts arise?

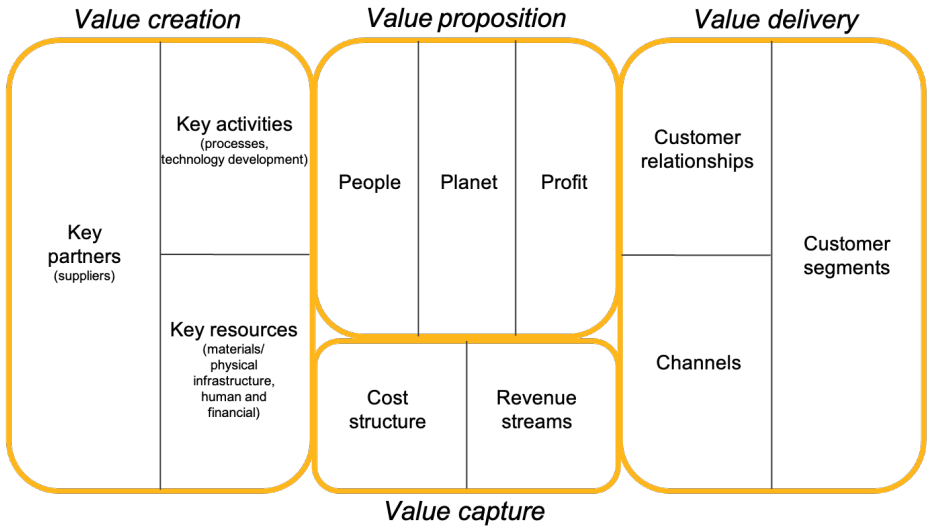
In this guidebook, the ideation phase is structured into four main steps:

1. Map the current business model
2. Understand current and future context
3. Develop a circular vision
4. Ideate novel circular value propositions

Step 1: Map your current business model

The first step in the ideation stage is to conduct a **structed analysis of the present business model**. This analysis will serve as the point of departure from where to ideate and innovate towards more circular practices.

As explained earlier, the business model canvas is an analytical tool that can support this process. It offers a shared language for describing, visualising, assessing and changing business models and describes the rationale of how an organisation creates, delivers and captures value. Mapping the current state of your business involves breaking down all activities into 11 digestible building blocks.



To map you current business model, conduct the following steps one at a time and at the given order:

- Customer segments: *Who are your customers? List the segments that (could) provide the most revenue.*
- Value propositions: *What are your products and services? What is the job you get done for your customer?*
- Revenue streams: *List your top three revenue streams. If you do things for free, add them here too.*
- Channels: *How do you communicate with your customers? How do you deliver the value proposition?*
- Customer relationships: *How does this show up and how do you maintain the relationship?*
- Key activities: *What do you do every day to run your business model?*
- Key resources: *The people, knowledge, means, and assets you need to run your business.*
- Key partners: *List the partners that you cannot do business without*
- Cost structure: *List your top costs by looking at activities and resources.*
- Social and environmental positives: *What are the key positive impacts that you have on people and planet?*
- Social and environmental negatives: *What are the key negative impacts that you have on people and planet?*

In order to identify **environmental and social positives and negatives** it is important to take a lifecycle perspective to also understand the implications of the business activities to occur beyond the direct boundaries of the firm. This requires consideration of activities upstream in the supply chain, as well as downstream among clients and in the use and end-of-life stages.

Lifecycle Assessment (LCA) is an important and widely used tool to gain a holistic understanding of the lifecycle environmental impacts of your products and services. An LCA study can provide support to decision making throughout the innovation process, from identifying hotspots, screening circularity strategies, to establishing guidelines and boundaries for business model design, to monitor and assess the actual impacts.

Lifecycle assessment in CIRCUSOL

In CIRCUSOL, lifecycle analysis (LCA) was used to identify the environmental hotspots across the lifecycle of solar power systems and evaluate different circularity strategies. Results showed that in the lifecycle of a solar power system (comprising of modules, inverters, mounting systems, and other system components), the solar modules have the highest environmental footprint and should therefore be the primary object of attention of any circularity strategy.

Furthermore, LCA was used to assess the environmental impact of different circularity strategies, including recycling, reuse and lifetime extension. Results show that at foreseeable technological innovation speeds, it is always environmentally better to extend the use lifetime of solar PV modules, but also that reuse of discarded modules in a second-life application can provide significant net environmental benefits under certain conditions.

For example, the analysis clearly revealed that transporting older solar modules even over thousands of km for reuse is still environmentally favourable than recycling them locally. This analysis provided the starting point to further explore novel circular business models that enable the reuse of solar modules.

Step 2: Understand current context

Upon completing Step 1 of the ideation stage, you have documented your present business model. Your business model does, however, not operate in a vacuum and as such is shaped and influenced by a multitude of external factors, such as policy, market and technological factors. This is often also called the **"business ecosystem"**. Before starting the process of creating new business models, it is important to have a good understanding of the existing context in which your organization operates.

By mapping the current business ecosystem and assess how it will evolve in the future, you will be able to identify opportunities and threats that arise from dynamic changes in the contextual environment in which your firm operates. By undertaking such as structured assessment of external factors that may affect your organization and its business model, it is possible to improve the firm's resilience to external threats and simultaneously identify opportunities for new (circular) business strategies.

A widely used tool to support such analysis is the **PESTEL framework.** It lists key external (macro-)influences that can affect a business' strategy and success. They are structured according to six categories, namely (1) political factors, (2) economic factors, (3) social factors, (4) technological factors, (5) environmental factors, and (6) legal factors.

For the analysis of your organization's business ecosystem, it is recommended to initially apply the PESTEL framework in a "snapshot perspective", identifying the *present* external factors that influence your business model.

PESTEL framework

Political	These factors determine to what degree the government and government policies intervene in the economy or a specific sector. This can include government policy, and political stability or instability in local as well as overseas markets, trade restrictions, fiscal incentives and taxes, labour regulations, environmental law, and so forth. Companies must be aware of, and able to respond to, current and anticipated future legislation, and adjust their business strategy accordingly.
Economic	These factors have a significant impact on the economy, which in turn impacts the profitability of a company and the way in which it can do business. Factors include the level of economic growth, employment rates, interest and exchange rates, inflation, disposable income of consumers, raw material and energy costs, and more.
Social	Socio-cultural factors determine the customers' needs and wants and are of particular interest to marketers. They include the characteristics, the shared beliefs and attitudes of the customer population. These are assessed by factors such as population demographics, education levels, general health status, lifestyles and attitudes.
Technological	Technologies change rapidly and can have a huge impact on the way products are made and marketed. Technological factors affect the way in which goods and services are produced and distributed, as well as the way in which customer communication is created and delivered. Factors include parameters such as changes in automation and robotization, and trends in digital and mobile technologies.
Environmental	These relate to the impact of ecological factors and constraints. Environmental factors have become important due to increasing environmental awareness by both governments and consumers. Concerns – and tangible impacts on businesses – related to issues such as resource scarcity, pollution, carbon footprint, and climate change are also notably influencing choices made by companies. In the context of the Circular Economy, the E for Environment parameter in the PESTEL framework is oftentimes stretched to include broader sustainability issues. One leading example is a shift towards more ethical and sustainable business policies. With more and more consumers demanding ethical and sustainably sourced products, corporate strategies that explicitly account for sustainability issues are also gaining importance.
Legal	Legal factors include parameters such as employment policies, consumer rights, health and safety standards, advertising rules, privacy, product labelling, warranties, liability, trade restrictions, and so forth. It is clear that companies need to understand the legal boundaries within which they must operate. This can become particularly challenging when a company operates on an international level, as each country has its own rules and regulations, and they often differ. There are also a range of legal issues with new forms arising related to circular economy activities – liability and intellectual property rights are just two of these.

The PESTEL framework structures key external (macro-)influences to a business' strategy and success according to six categories. Adopted from Peck et al. (2020).

Understand future context

Being complementary to the PESTEL framework, **trend analysis** involves an assessment of how the business ecosystem is likely going to evolve in the future, both in a short-, medium-, and long-term perspective. In the context of circular business model innovation, understanding future trends is particularly important to be able to identify those external factors that might drive opportunities for more circular business practices.

Building on the snapshot analysis of the present ecosystem of your firm, conducting a customized assessment of how the different external factors will evolve will provide valuable inspiration in how to innovate your business model. It is recommended to start the trend analysis with a firm-internal brainstorming, and then in an second step complement the initial findings with input and expertise of external parties. Such a co-creative approach can yield significant benefits. For companies, involving their value chain partners such as as suppliers and customers will allow for a more comprehensive, diverse and nuanced understanding of the context they operate in.

Macro-level factors driving a circular solar economy in Europe (selection)

Political	• European Commission Circular Action Plan • REPowerEU plan & EC Solar Energy Strategy
Economic	• Economic potential from reducing waste in linear economy • Price and supply risks in global value chains of solar products and (critical) raw materials • Reestablishment of solar PV manufacturing industry in Europe • Increasing consumer awareness about sustainability footprint of solar products
Social	• Job creation potential from operation & maintenance, repair, reuse, and recycling of solar power products • Low-cost second-life solar panels can meet energy and social needs in unelectrified regions in Global South countries
Technological	• Novel solar panel designs will enable repair and easy disassembly of solar panels • Novel solar panel recycling technologies will enable recovery of high value (critical) raw materials • Digitalization enabling material and product tracing
Environmental	• Natural system degradation from linear economic model • Need for urgent climate action requires massive and rapid scale-up of renewable energy, including solar power
Legal	• Emerging regulation for circular design of solar products • Emerging industry standards on preparation for reuse of solar panels

Step 3: Develop a circular vision

Following the analysis of your organization's present business model and the ecosystem it is operating in, you should have gained a good understanding of where you are starting from. The trend analysis should have provided you with further insights about evolving external factors that will determine the future context your organization will be working in. So far, however, it has not been decided which direction your organisation in this evolving environment will take.

Therefore, in step 3 of the ideation phase, you need to **establish a circular vision** so that your organisation has a clear direction of travel that is well aligned with the core principles of a circular economy. A clear vision brings focus and provides direction in everything your organisation does moving forward. A long-term vision also helps stakeholders to move away from the constraints and short-term perspective of your present day-to-day business activities. A long-term vision needs to be collectively supported, both within your organization as well as from key partners in your sector, in order to allow for systemic innovation.

Creating such a vison (or multiple ones) can take time and a lot of interactions that can be facilitated through co-creative brainstorming. This interactive process of envisioning helps stakeholders learning about each others perspectives, looking for common ground, and defining a joint agenda. A first practical step in co-creating a long-term vision is developing guiding principles that serve as a shared mental compass towards an idealised future situation.

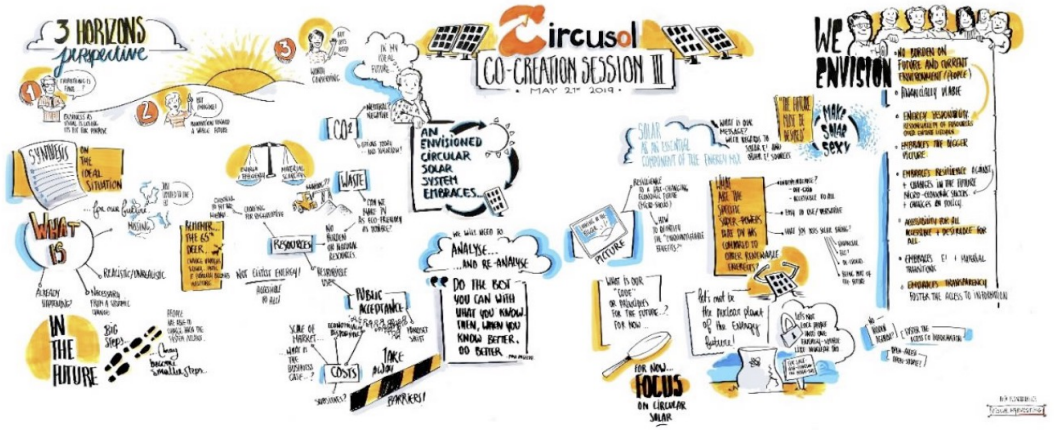
A co-developed set of guiding principles is a mental compass through which long-term objectives are translated into systemic actions on the field. These principles usually entail a positive and inspiring message. It is important that the guiding principles are shared and supported by all members of the group, in order to move towards common objectives. However, the set of guiding principles is dynamic; the content can change over time, based on new insights.

The CIRCUSOL vision and guiding principles

In CIRCUSOL, a joint vision was developed in a number of co-creation sessions. In this vision, the creation of added value for the future and the current natural & human environment was defined as the key driver for a circular solar power system. Furthermore, in the principles that guide this vision, the future circular solar power system

… embraces the bigger picture
- BY balancing economic, environmental, health, social and individual value(s) within decision-making or more specific within business definition and creation
- BY creating long-term as well as short-term benefits through circular solar power services, without any (major) trade-offs.
- BY aligning the (renewable) energy transition with the circular economy transition: this involves balancing operational energy benefits (for end users) of solar power solutions with embodied energy/resources benefits (for product/service providers).
- BY taking into account the entire life span of renewable energy solutions (such as PV and battery systems), beyond their intended application and their initial service period. This includes key life cycle stages, such as manufacturing, installation, operation, monitoring, replacement, logistics, remanufacturing, reuse and recycling.

… is resource responsible
- BY taking care – in an effective and efficient way – of natural, human and financial resources required for (solar) energy services.
- BY avoiding the use of scarce primary resources and creating zero waste within the production, remanufacturing of renewable energy product systems, including photovoltaics and (stationary) batteries.
- BY aiming for net carbon (or greenhouse gas) negative services, by using renewable energy sources in the operational phase as well as in the (re)manufacturing and logistic stages.
- BY including the entire life cycle environmental impact of energy solutions in decision-making; integrating a comprehensive set of environmental indicators, instead of only looking at climate change.



… embraces resilience towards future micro-economic shocks and policy shifts.
- BY adapting easily to social and technological evolutions, such as ‘self-sufficiency’, ‘digitalization’ and ‘smart cities’.
- BY developing robust businesses which are less or not sensitive to (modifications in) financial stimuli created by public authorities.

… is accessible and desirable for all
- BY providing affordable solar power solutions for end-users, business stakeholders and society.
- BY making circular solar power attractive for end-users, business stakeholders and society, by being service-oriented and providing short-term as well as long-term benefits
- BY deploying services that fit the needs of different types of users and operating at various scales.

… embraces transparency over the entire value network
- BY fostering the access to (non-confidential) data and useful information.
- BY sharing a diversity of knowledge within the value network (of PV and battery systems).
- BY monitoring good and bad practices, in order to share valuable lessons

Step 4: Ideate novel circular value propositions

The development of a circular vision has helped to provide strategic guidance in which direction to move to with your organisation. Based on the insights gained so far, the final step of the ideation phase is to brainstorm tentative circular value propositions. This final step of the ideation process can be guided by exploring the following points:

- How does the value chain look like? What is the flow of materials and products?
- Where in the value chain is value missed and value destroyed? Where are new value opportunities for your organization?
- What are the most suitable circularity strategies for your organization?
- What will be the product and service combination? Who are the target customer segments? What will be the key value proposition? How do customers perceive tentative value propositions?
- What will be the expected environmental benefits and business impacts? Is there a promising business case (both environmentally and financially) of the envisioned circularity strategy?

A wide range of tools can support this process of ideating circular value propositions. Following, seven approaches will be introduced:

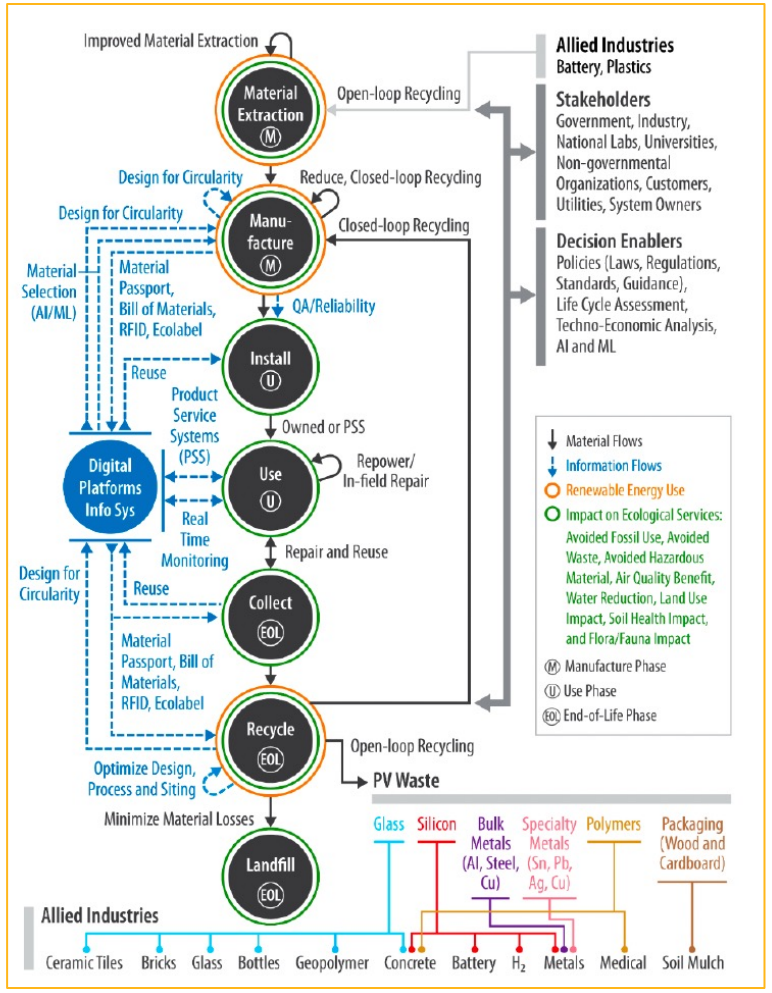
- Value chain mapping
- Value mapping
- Circulator tool
- Considering products-as-a-service strategy
- Job-to-be done approach
- Focus group method
- Survey methods

Value chain mapping details the lifecycle of products and the materials they are made from, and how actors are involved in the processes from mining and conversion of raw materials, manufacturing of more valuable products, distribution and the use phase of the product. At the end of life, when products can no longer be used and consumers dispose of them, ideally they are collected and recycled so that the material can be reintroduced into the material lifecycle.

When analysing a value chain, it is important to pay attention to what is flowing from one segment to another. While we have materials flowing, there is also money moving from one segment to the next as the materials are sold and bought. In addition to materials, products and financial flows, actors also transfer and exchange information.

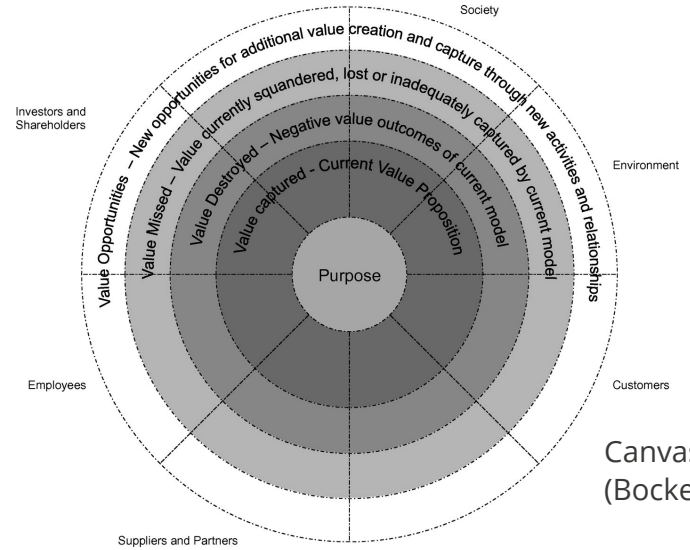
Mapping these different types of flows across the entire value chain that your organization is part of, is a critical prerequisite for gaining a holistic picture and for identifying opportunities to ideate novel circular value propositions.

The image to the right provides a simplified overview of the solar power value chain, serving as an initial overview. In reality, value chains are typically complex, multidirectional and interconnected. Hence, mapping them requires a granular approach in order to gain a holistic picture and not miss out on potential opportunities for circularity.



Value chain mapping of the solar polar sector to identify Circular Economy opportunities (NREL, 2022)

Using a **value mapping tool** is the next step in the process of ideating circular value propositions. The value mapping tool uses a multi-stakeholder perspective and explores both positive and negative forms of value creation. Building upon the analysis of your organization's current business model (see Step 1 in ideation phase), the value mapping tool provides a more nuanced perspective on the value created for different types of stakeholders, including the environment and society. As such, the tool seeks to identify and reduce conflicts and trade-offs between different stakeholder groups and assist in better aligning positive outcomes for all stakeholders (Bocken, Rana, Short, 2014).



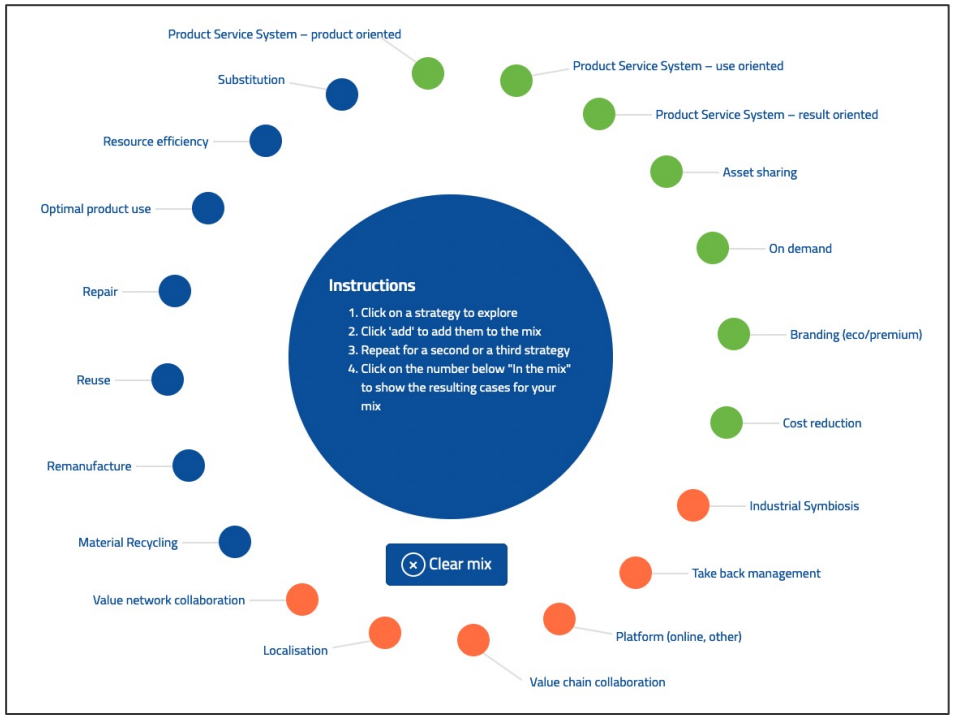
Canvas of the value mapping tool (Bocken, Rana & Short, 2014)

The tool distinguishes between multiple forms of value: (1) value captured, (2) value missed, (3) value destroyed, and (4) new value opportunities.

- *Value captured* represents the positive benefits delivered to stakeholders (i.e. the value proposition for multiple stakeholders).
- *Value missed* represents cases where stakeholders fail to capitalize on existing assets, capabilities and resources, are operating below best practice or fail to receive benefits they seek from the network. Examples of value missed are the underutilization of assets, capacity and capabilities, and the disposal of useful materials to landfill.
- *Value destroyed* is negative outcomes of the business and concerns the damaging social and environmental impacts of business.
- *New value opportunities* involves the brainstorming and search for new value creation opportunities to deliver solutions to social and environmental challenges. Here, the focus is on converting missed opportunities into positive value, delivering win-win solutions for all stakeholder groups. Collaboration with and learning from competitors, suppliers, customers or even other industries are typically important prerequisites to enhance stakeholder alignment and create positive sustainability outcomes.

Explore circular strategies with the Circulator tool

One established tool to explore a large variety of circularity strategies is Circulator (www.circulator.eu). This initiative and associated web-based tool provides an overview of the most relevant business models for the raw materials industry in the context of the circular economy. The tool allows to explore circular strategies, using the “Strategies Mixer”, and to combine them according to the user’s own preferences.



User-interface of the web-based Circulator tool (Source: www.circulator.eu)

Consider products-as-a-service strategy

For firms, providing services to the customer instead of selling the product is enable circular strategies. By keeping the ownership of the product across extended periods of its lifecycle, firms are in a position to optimize the product use from a life-cycle perspective, extend product lifetimes through repairs and multiple use-cycles, and take back the product at its ultimate end-of-life and return to to a recycling stream.

In situations where consumers are reluctant to purchase second-hand products due to concerns about performance, quality and remaining lifetime, a **Product-as-a-Service (PAAS)** offering will ensure that any perceived uncertainties will be taken care of by the firm. From the firm perspective, key benefits include long term relationships with the customer; access to the product during use, and ownership of the product that in turn allows the company to capture the value, or reuse, remanufacture or recycle.

Often a distinction is made between three fundamental types of PAAS: product-, use-, and result-oriented PAAS.

- Product-oriented PAAS: still closely resembles a conventional sales offer in that the ownership of a tangible product is still transferred to the consumer. However, it differs because there is an addition of a service offering to provide additional value to the consumer during the use phase of the product. This can include the provision of consumables linked to the product, and the performance of maintenance or repair services.
- Use-oriented PAAS: reverses the ownership model: the product is leased or rented rather than owned, in addition to the provision of similar services as in the product-oriented model. The use oriented PAAS benefits the provider as the product will generally be returned after the use contract has expired.
- Result-oriented PAAS: takes an additional step towards a service-only model: the provider assesses the need of the consumer, and decides which product or products can help her in addressing the customer's need. In such a model, the provider does not sell or lease products anymore, but the function related to those products.

Source: Peck et al. 2020

CIRCUSOL: Solar energy-as-a-service

One of the CIRCUSOL pilot project is the Cloverleaf solar power plant in Heusden-Zolder (Belgium), located at the site of a truck stop parking. The 2 MW photovoltaic plant is operated by the solar firm *Futech*. Since 2011, the solar electricity produced delivered to the truck stop via an 'energy-as-a-service' agreement with the facility owner. Under this agreement, *Futech* remains the owner of the PV plant and is also responsible for its maintenance.

In 2021, *Futech* integrated and commissioned a remanufactured battery into the system, that was originally sourced from the automotive sector. In this product-as-a-service agreement, the facility owners benefit from lower and stable electricity costs, the supply of locally produced green electricity without having made any investments themselves. Furthermore, any technical or operational risks from the operation of the solar power system and second-life battery are handled by the service provider firm *Futech*.

For *Futech*, the energy-as-a-service agreement ensures recurring incomes for 20 years and the opportunity to engage in a long-term relationship with the facility owner as their their customer.

Repurposed batteries, sourced from electric vehicles, have been installed at the Cloverleaf solar power plant. Solar firm *Futech* remains owner of the solar power plant and battery and delivers solar electricity as well as storage-as-a-service to the owner of the premises.

Jobs-to-be-done approach

Ideating value propositions can hugely benefit from interacting with users and customers, as they are in the best position to judge the value of a novel (circular) product or service. A popular tool to understand the true needs of users is the jobs-to-be-done approach. The fundamental underlying idea behind this technique is that people buy products and services to **get jobs done**.

The implication of this thinking is to stop studying the product and instead study the job that consumers are trying to get done. By making the job, rather than the product or the customer, the unit of analysis, firms are able to ideate novel (circular) value propositions that meet the true needs of customers. The approach involves finding answers to following questions:

- **Jobs-to-be-done:** What are the jobs your customer is trying to get done in work or life? These could be both functional and social. What basic needs do your customers have (emotional and/or personal)?
- **Pains:** What is annoying or troubling your customer? What is preventing him or her from getting the job done? What is hindering your customer's activities?
- **Gains:** What would make your customer happy? What outcomes does he or she expect and what would exceed their expectations? Think of the social benefits, functional, and financial gains.

Only when you have deeply explored these questions in interaction with your customers, it is time to proceed and identify products and services you can offer to them so they can get their job done, relieve them of their pains, and help them fulfil the gains. Ideation about products and services should have a clear circularity perspective in mind.

CIRCUSOL: Exploring user needs with the jobs-to-be-done approach

The Waasland co-housing project is a 22-unit co-housing site in Sint-Niklaas (Flanders, Belgium) as been one of the pilot projects in the CIRCUSOL project, that served as the testing ground to develop novel value propositions for a circular, service-based PV business model. As part of a co-creation workshop with the residents of the co-housing group, the jobs-to-be-done approach was used to identify the wants and needs of the residents of the co-housing group regarding electricity from solar photovoltaics.
At the workshop, a distinction was made between the tasks or jobs the group wants to fulfil (e.g. electricity from a sustainable source), the side-effects and risks related to these jobs (e.g. mismatch in time between production and consumption), and the benefits they expect or desire from them (e.g. grid buffering). By first writing down their individual preferences in pairs of two or three, and next discussing and clustering them in group, this exercise led to a clear overview of the co-housing group's jobs, pains and gains related to electricity from a solar power system. These findings served as input to the further development of a service-based business model through a solar service firm.

Focus group method

Another tool to ideate novel value propositions are focus groups. A focus group is a group interview involving a small number of people or participants who share some common traits or experiences. Focus group research is most commonly used to provide an in-depth exploration of a topic about which a lot of implicit knowledge and experiences are not documented. In market research, focus groups are used to grasp better people's attitudes to products or services or participants' perceptions of shared experiences.

Instead of a researcher or analyst interviewing participants individually, focus groups use group interaction to investigate and clarify participants' beliefs, opinions, and perceptions. The interactive nature of focus groups allows researchers to gather qualitative data from multiple participants at the same time and often in a relatively efficient manner.

Exploring novel market segment via focus groups

In the CIRCUSOL project, focus group methods were used explore the viability of circular value propositions for solar power in three organisational market segments: (1) non-owner residential markets, including social and private rental housing, and collective housing, (2) public and social infrastructure: including municipalities, schools, and health and social care facilities, and (3) companies and commercial real estate.

Three focus groups were organized and took place in an online meeting format, with selected representatives from the three market segments. All focus groups were moderated by two researchers, and the meetings lasted between 2 and 2.5 h. Afterwards, preliminary focus groups results were communicated again to the same set of interviewees for feedback, after which focus group participants were invited to comment on the final analysis.

The results show that organizational solar PV investments are mainly driven by lower energy costs, independence, and secured access to energy, and that the uptake of circular solar solutions mainly depends on a viable business case. Presently in most cases, a lack of market development and organizational boundary conditions limit the enabling potential of circular solar options

Survey method

Surveys are another well-established tool in market research, and as such they can provide valuable input to the ideation process. Survey questionnaires can make use of quantitative or qualitative data collection methods, or a combination of both. In quantitative surveys, researchers aim to make statistical interferences about the population being studied.

When ideating circular value propositions, surveys can enable firms, amongst others, to

- identify attitudes towards different circular strategies for selected products and services;
- detect barriers to consumer adoption of circular products and practices; and
- investigate different user and market segments that are characterized by heterogenous preferences.

Surveys can be a cost-effective means to collect data from a large number of individuals. However, like other modes of enquiry, surveys also have methodological limitations. For example, it is well-known that attitudes of individuals do not always correlate to their actions ("value action gap"). Hence, it is advisable to complement surveys with additional methods to ensure the validity of results.

Exploring user needs with surveys: Experience from CIRCUSOL

To assess the market potential of circular solar power business models in residential home-owner markets in Flanders (Belgium), CIRCUSOL researchers organized an online survey in close collaboration with the energy cooperative *Ecopower* and the solar firm *Futech*.

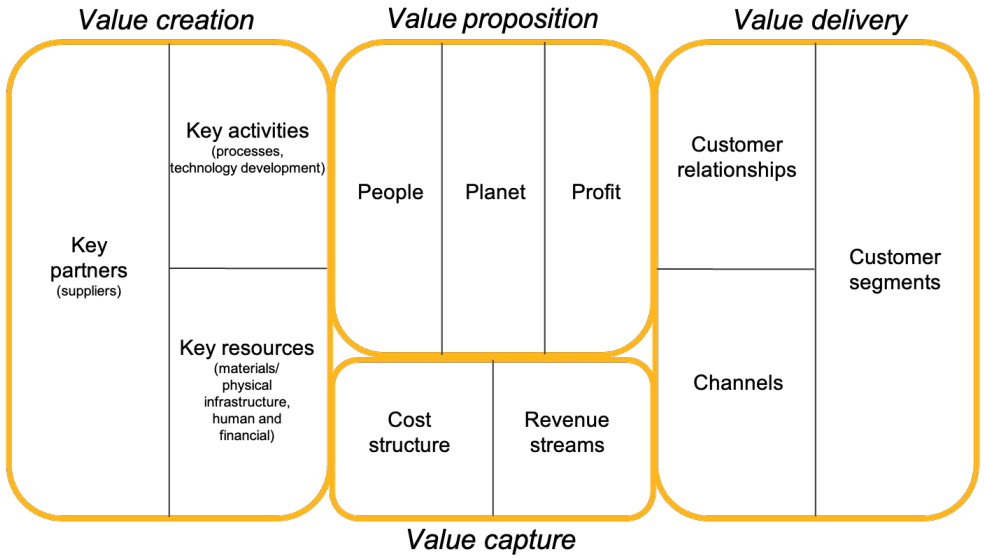
In a first stage, a questionnaire was developed and subsequently tested in the city of Eeklo (Belgium). Evaluating the quality and interpretability of these results (based on 59 responses) allowed the team to refine the questionnaire into three answer pathways for respectively (1) households with no solar PV, (2) households who own solar PV, and (3) households who already have a solar service contract.

In the second stage, the refined online questionnaire was distributed via the most important newsletters on building and reconstructing in Flanders, via direct mailings of our project partners towards their members and clients (*Ecopower* and *Futech*), and via the newsletter and social media of the research institute. The survey was online for two month in early 2022, resulting in more than 3500 full responses. Respondents were incentivized with a lottery of LED lamps. The results of the two surveys provides valuable input to the CIRCUSOL project and the ideation process of the involved partners.

Designing the circular business model

In the initial ideation phase, the scope, context, vision and value proposition for a circular business case have been explored. Yet, there is no clear view on a suitable business model that could address the customer needs and create circular value.

Designing is the second key phase of the CBMI process. The purpose of the design stage is to elaborate on the other building blocks of a circular business model: (1) value creation, (2) value delivery, and (3) value capture.



This means that at the end of the design phase, the following aspects should be clearly elaborated upon:

- Most details of an initial business model are developed.
- The key parameters and boundary conditions to deliver and increase the circularity potential are well understood.
- The necessary partners to implement the circular business model have been identified.
- A financial model has been developed with revenue and cost estimates, incorporating both the circular and the service aspects. The financial business case is positive.
- There is good understanding on how value will be created and delivered. Gaps and their possible solutions (e.g. required new partnership) are identified.
- Key assumptions are validated. Key risks are identified and mitigations are planned.

Value creation and value delivery

Designing the value creation elements of a circular business model requires rethinking about the key activities, partner networks, as well as resources resources, technologies, and capabilities needed to successfully deliver a company's circular offer. Activities need to be designed to use resources efficiently, prolong the life of products and close material loops. This might require that a company collaborates with partners that have special capabilities that it presently does not has. For example, different value networks for multiple use cycles, securing sufficient supply of secondary products, and for cycling resources at the ultimate end of life of the product need to be established.

Designing the **value creation** elements requires thinking about, amongst others, the following questions:

- What should be done with products at their end of service life? Should they be reused, refurbished, remanufactured, or recycled? How to make that decision?
- How to manage assets in a circular service-based business model in which the company retains ownership of the products?
- How to set up reverse logistics?
- What is the quality management strategy and process for second-life products (e.g. labelling, warranty, certification)?
- How to develop new supply chains?
- How to find key partners that provide provide sufficient volumes of secondary products and materials to be upgraded or reused, or that can test and certify quality of repaired products?
- How to generate engagement from internal and external stakeholders involved, and deal with resistances along the innovation process towards a circular business model?
- Which key resources are needed?

Configuring the **value delivery** elements of a circular business model involves customer segments, customer relationships, and customer channels. Designing the the value delivery elements requires thinking about, amongst others, the following questions:

- Who are the (target) customers?
- How to innovate the offer from selling ownership of a product to selling access to it (e.g. to facilitate its collection at end of life)?
- What are the distribution channels to deliver the value proposition?

Value capture

Value capture is primarily about the financial aspects of cost structure and revenue streams, and as such it is at the core of any business: how will it make money? Value capture elements in a circular business model might be adjusted to generate additional revenue by selling (essentially) the same product several times, engage in extended spare part and aftermarket services, or capitalize on environmental benefits associated with resource conservation. Besides, there are opportunities to reduce production costs via the use of lower-cost secondary materials, or to avoid expenditures for end-of-life disposal. Capturing financial value from enhanced circularity actions will require the design of separate value creation architectures may need to be designed to create value from each cycle.

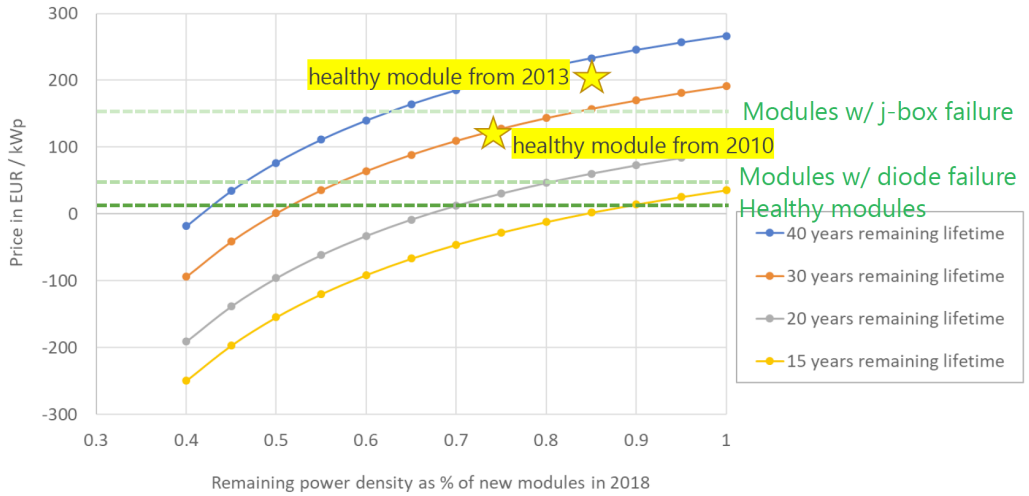
Designing the value capture elements requires thinking about, amongst others, the following questions:

- Where will the needed capital come from?
- How to reduce operational costs?
- What will be the impact of the circular business model on costs?
- What will be the impact of the circular business model on revenue? How to monetize and estimate new revenue potentials (such as residual value)?
- What needs to be done to make the circular business model more financially attractive?
- What will be the most suitable financing model for each stage?
- Which financiers may be interested in financing this new circular business business model and what they may be look for?
- What are the financial risks?
- How to capitalize on the aftermarket of products?
- How to reduce production costs through substituting primary materials with lower-priced secondary materials?

For the design of the **financial model** of a circular business case, a multitude of well-established standard tools and methods, such as Discounted Cash Flow and Net Present Value analysis, are available. For designated circular business models, these tools need to be extended in order to enable financial assessment of different circularity strategies. For example, tools need to be able to incorporate aspects like residual value calculations, savings from substituting virgin materials with secondary materials, or additional costs from collection and preparation for reuse. In sum, it is critical that financial models use **lifecycle cost analysis** methods to grasp a holistic view of the cost structure.

Lifecycle cost analysis in CIRCUSOL

In CIRCUSOL, lifecycle cost (LLC) analysis has been employed to assess the financial viability of repaired and reused PV modules. Results of the LCC analysis show that (1) financial viability of used PV strongly depends on its remaining power and lifetime, (2) transportation distance is unlikely to be a limiting factor, and (3) a testing strategy will be crucial.



Use of lifecycle cost analysis to calculate the maximum price of used modules as a function of their remaining power density and remaining lifetime.

Testing the business model in experiments

At the end of the design stage, a detailed sketch of the envisioned circular business model should have been developed. Until this point, only single aspects such as value proposition or circularity benefits may have undergone some early validation. Other elements of the business model still might be in the form of assumptions or hypotheses. At this point it is important to identify those assumptions that are vital, that is those ones that must be true for the business model to be successful.

In order to test and validate these quickly and effectively, experimentation with a number of customers and key partners is critical. Experimentation in this early phase of the circular innovation process will enable quick learning by validating (or wholly or partially invalidating) any hypotheses made in the earlier ideation and design phases. Depending on the outcomes of experiments, some hypotheses might become validated and continue to be part of the innovation process, while others will be further refined or wholly discarded. Experimentation typically involves and iterative approach and multiple learning cycles, that will gradually enable you to align and finetune your circular business model in the marketplace and business ecosystem.

Testing a business model can take place in various formats. Following, we present two types of experimentation formats that were used in the CIRCUSOL project to gather customer and end-user feedback. These are (1) web-based choice-based conjoint experiments, and (2) real-life experiments in pilot projects.

The portfolio of business model experimentation tools is much wider than can be elaborated within the scope of this guidebook. Several of the tools and methods earlier introduced in the ideation stage can equally be used as part of experiments to enable and structure learning interactions with users and customers.

Choice-based conjoint analysis

A well-established method for testing a value proposition with real-life consumers is choice-based conjoint analysis (CBC). Conjoint analysis is a technique used for measuring and weighting importance for different features of a product or service and is widely used in marketing research. Users' trade-off values for sacrificing a certain feature's level or quality in exchange for raising another can be measured and used to obtain users' preferences. The ability to estimate the trade-off is of particular interest when it comes to the development of new services as it helps to identify an optimal configuration.

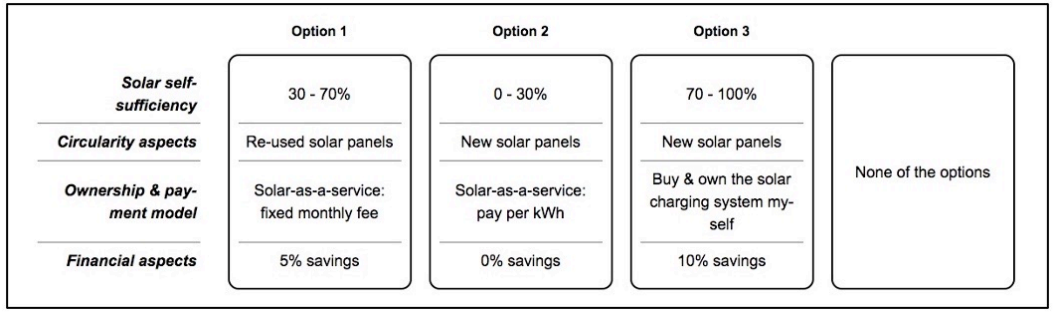
In CBC the respondents choose preferred options from a set of profiles instead of ranking or rating them as in traditional conjoint analysis. CBS thus encompasses advantages such as simplicity, requiring less cognitive effort from the respondent, as the choices made resemble an actual decision making process in which consumers typically are faced with various trade-offs.

Data obtained from CBC experiments can be further analysed for the segmentation of respondents by their preferences. This allow firms to customize their value propositions and business offer to distinct sub-groups of customers.

Experimentation with choice-based conjoint analysis in CIRCUSOL

In CIRCUSOL, a business experiment survey was used to test customer preferences for a relatively novel market segments for circular photovoltaics, namely PV systems for home-charging of electric vehicles. The experiments used the method of choice-based conjoint analysis, thereby simulating the user adoption situation in a simple format. The main part of the experiment consisted of a number of choice-based conjoint tasks that participants need to answer, in response to the question "You have the following options when choosing to charge your electric car with solar power. Which one would you choose?". In each choice task, participants could choose their preferred option between three alternatives. Each alternative was characterized by the four attributes of (1) solar self-sufficiency rate, (2) circularity aspects, (3) financial aspects, and (4) ownership and payment model. Throughout the exercise, the attribute levels are varied with different combinations being presented to the participants. Each respondent had to answer eight choice tasks.

The results of the experiment allowed to identify user preferences for the individual attributes of the value proposition. An additional segmentation analysis of users along different lines of attributes has furthermore shown a significant degree of heterogeneity in the sample, which was valuable to further customize circular value propositions towards specific customer sub-groups.



Screenshot of typical choice task that respondents had to answer in the experiment

Experimenting in pilot projects

A key building block of sustainability transitions are investments into green infrastructure, such as renewable energy technology, low-carbon heating and ventilation systems, novel mobility systems, and systems that will enable the closure of material flows. A significant share of this novel infrastructure will be located onsite or close to the premises of households, and end-users will interact with a variety of new technologies on a day-to-day basis. **Pilot projects** are commonly used for testing of technical aspects like performance and reliability of technology. In addition, pilot projects are a valuable opportunity for firms to test their business hypotheses in a real-life setting. Users and potential consumers interact first-hand with the product for extended periods, and studying these interactions can provide valuable insights to validate and finetune business value propositions, including aspects related to circularity.

It is noteworthy that in pilot projects, the installation of technical infrastructure (such as circular solar power system) can be a lengthy and costly process, inhibiting quick learning cycles with regard to the technology per se. Conversely, interactions of users with the technology can be studied through relatively low-cost experiments and in multiple cycle at a faster pace, enabling firms to gradually gain deeper insights with respect to their (circular) value propositions.

CIRCUSOL: Experimentation in a pilot project

At the CIRCUSOL Waasland co-housing pilot project, a variety of experimentation techniques were used to investigate pathways to enhance self-consumption of electricity generated by the onsite solar power systems (equipped with second-life solar panels). Techniques included the testing of a monitoring feedback tool, shifting consumption patterns, and the development of different scenarios - in collaboration with the residents - for instalment of a battery and EV charging points.

While at the outset a preliminary service-based business model was already in place, the knowledge gathered during the experiments provided valuable input to the solar service firm to update and refine their service agreement. This update encompassed the integration of second-life batteries and the accompanying installation of a larger inverter, creating a win-win situation for both the residents and the business firm.

Scaling the circular business model

The final phase in the CBMI process is scaling. At the start of this phase, a circular business model is successfully implemented at a small scale, or for a certain niche segment. The business firm is looking to further scale up or replicate the model in the market. It is envisioned that at the end of this stage, the circular business case is rolled-out at large scale.

Scaling can benefit from thinking about, amongst others, the following questions:

- Whom to partner with?
- What kind of licensing agreements could be an option to accelerate scaling?
- In which related market segment to expand to?
- In which new geographical markets to expand to?
- What sources of capital are suitable and available to finance scaling?
- What is the right pace for scaling?
- What are regulatory and markets risks to scaling?

Following we propose two methods that can be used by firms to support their decision making in relation to the scaling phase:

- Business and replication plans
- Ecosystem simulation

Business and replication plans

Upon the closure of the experimentation phase and successful demonstration of circular business case, the development of business and replication plans for wider wider roll-out of the pilot results would be the next step.

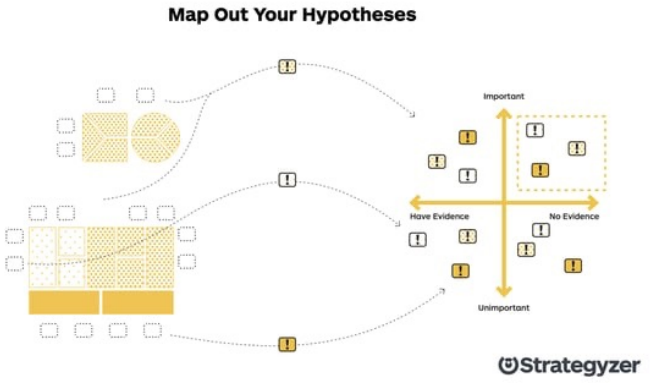
Business plans typically include the following sections: value proposition of the successful pilot business models, description of the product/service concept, market analysis, customer relationship, product life cycle management plan, financial plan including financing strategy, operational plan and legislative considerations.

In relation to the scaling potentials and pathways, as well as identification of external risks, the following questions are worthwhile exploring in the business plan:

- What is the evolution of the market, in terms of market size, competition landscape, industry trends, industry challenges, etc.?
- What are the core hypotheses regarding the desirability and feasibility of the offer? Which main assumptions is the desirability of the firm's offer based on, and how are these assumptions changing over time?

In order to assess and exploit the replication potential in other countries than the home market, the following questions are worth exploring:

- What is the market size and potential of the international market or of a specific country?
- What are the similarities and dissimilarities between the home market and the international market? Here again, the PESTEL framework can be a useful tool to organize data collection and analyse the business ecosystem.
- Which local actors in the international market can give in-depth insights into the local context?
- Which international actors to partner with in replicating the circular business model abroad?



A hypothesis map can help in organizing the underlying assumptions of a firm's business and replication plan (Source: www.strategyzer.com)

Ecosystem simulations

Simulation models of complex business ecosystems are an increasingly common tool to develop scenario studies. Such models are based on integrated **mathematical simulation techniques**, and account for the legal, social, and economic drivers and barriers of circular economic business models and services. Simulations within these models allow to explore the interplay effects between a (novel) circular business model and its respective business ecosystem.

Scenario simulations can be conducted over several decades into the future, thereby enabling firms to explore long-term trends that are critical for taking strategic decisions in relation to scaling and the mainstream adoption of circular strategies. For example, simulations can be designed to assess the long-term impacts of various kinds of changes in the ecosystem, such as a boost in user acceptance of service-based business models, increased public awareness about circularity, or changes in the market and policy environment. Through this, scenario simulations can help business managers in gaining a wider perspective, expanding beyond established modes of thinking. Scaling pathways that might seem impossible in the present context, might all of a sudden appear quite viable in the long-term view of an evolving future business ecosystem.

Since off-the shelf simulation models for circular business ecosystems are presently not available, business managers are advised to seek collaborations with the relevant research community that can support the development and use of models that suit the specific context and needs of their firms.

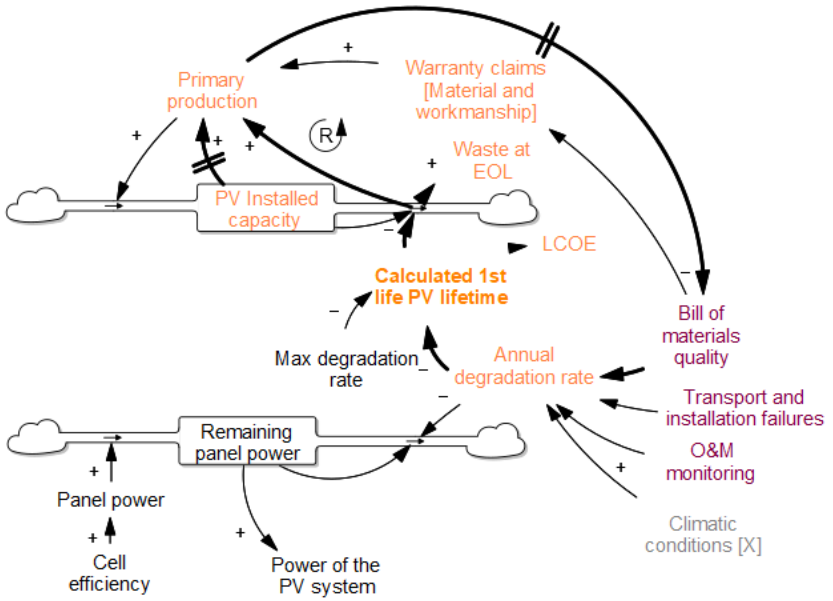


Illustration of interactions in ecosystem model as developed in CIRCUSOL

Final remarks

This guidebook offers a step-by-step guidance of how firms can approach and structure the process of innovating their business model towards circularity. The framework emphasizes the importance of collaboration and co-creation both internally within the firm and externally with stakeholder across the value chain. Particularly in established firms, the process of circular business model innovation will require setting in motion internal changes within the organisation, through engaging stakeholders.

The step-by-step guidance offered in this report can only outline a simplified process. It is important to note that reality, however, is much more complex than depicted in such an linear process flow. The boundaries between the stages, as presented in the framework, are somewhat artificial, and in reality not that clear-cut. Hence, while for each step a section of tools are be presented that can provide support, many of these tools can be of use across different stage of the process.

Given the experimental and iterative nature of the CBMI process, reality will be characterized by a set of multiple and in many cases (partially) parallel and overlapping innovation and learning cycles. The process will also depend on the type of product and sector, the circularity strategy to be pursued, and the position of the firm itself in the value chain. For every business model, depending on the circular strategies operated, or the type of product, the business model elements will be shaped differently.

Throughout the process, it is recommended to repetitively self-assess your circular business model against your present business model, the current and future context (business ecosystem), and your circular vision. Several iterations of the process might be required to ensure that the business model elements are well aligned and that they support implementation of the specific circular strategy. It is also important to reflect about the key assumptions, risks, and knowledge gaps of your circular business model.

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Abbreviations

CAPEX	Capital Expenditures
CBC	Choice-Based Conjoint Analysis
CE	Circular Economy
CMBI	Circular Business Model Innovation
CRMs	Critical Raw Materials
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
O&M	Operation and Maintenance
PAAS	Product-as-a-Service
PESTEL	Political, Economic, Social, Technological, Environmental, and Legal Factors framework
PV	Photovoltaic(s)
OPEX	Operating Expenditure

Credentials

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