From
Idea to
Market

SME Guidelines
for the introduction of EcoDesign principles

Imprint

From Idea to Market

SME Guidelines for the introduction of EcoDesign principles

2021

BIFI - Berliner Institut für Innovationsforschung GmbH
Fürstenwalder Allee 28
12589 Berlin

+49 30 577 058 -200

contact@bifi-institut.berlin
www.bifi-institut.berlin

Commissioned by
Umweltbundesamt

Introduction of the author

The Berlin Institute for Innovation Research (BIFI), founded in 2010, is an organization dedicated to testing innovations regarding their market potential. BIFI thereby offers its clients a basis for informed decisions and successful business models.
In order to test new products and services in the context of their target group, BIFI uses research methods from the fields of social, personality, and perceptual psychology. All of our researchers have academic backgrounds and are trained in research methods with a specialization in psychology. They possess expert knowledge in the field of startups and innovations, and are experienced in researching human behavior and psychological effects.
At BIFI, we strongly believe that only products and services that add significant value to our lives will be successful. In this sense, we take on the role of the consumers' advocates. The customer is the key decisive factor for a company's success.

On behalf of the German Environment Agency and as part of the Interreg project EcoDesign Circle, the BIFI-Team authored the present guidelines. We draw from over 10 years of experience regarding target groups, viable product ideas, and sustainable business models. These guidelines are meant to help SMEs see the advantages of sustainability, so that they are able to remain or become successful both in terms of their economic and innovative power.

Table of contents

Prologue 5

1. Reasons for these guidelines 9

2. Circular economy and circular design 12

2.1. Definitions 12

2.2. Are “Circular Economy” and “EcoDesign” just fashionable terms? 14

3. Is there a market for circular design / EcoDesign products and services? 19

4. What should be considered regarding the production phase? 28

5. How to reach efficiency during the production phase 30

5.1 Change processes in production 30

5.2 How to evaluate the benefit of changing equipment 32

5.3 Shortening process chains and lowering costs 39

5.4 Reorganization of production processes 42

5.5 Reducing resource consumption through new procedures 53

5.6 How to assess costs after introduction of new products or procedures 55

5.7 Conversion from product to service 59

6. Summary and outlook 63

Prologue

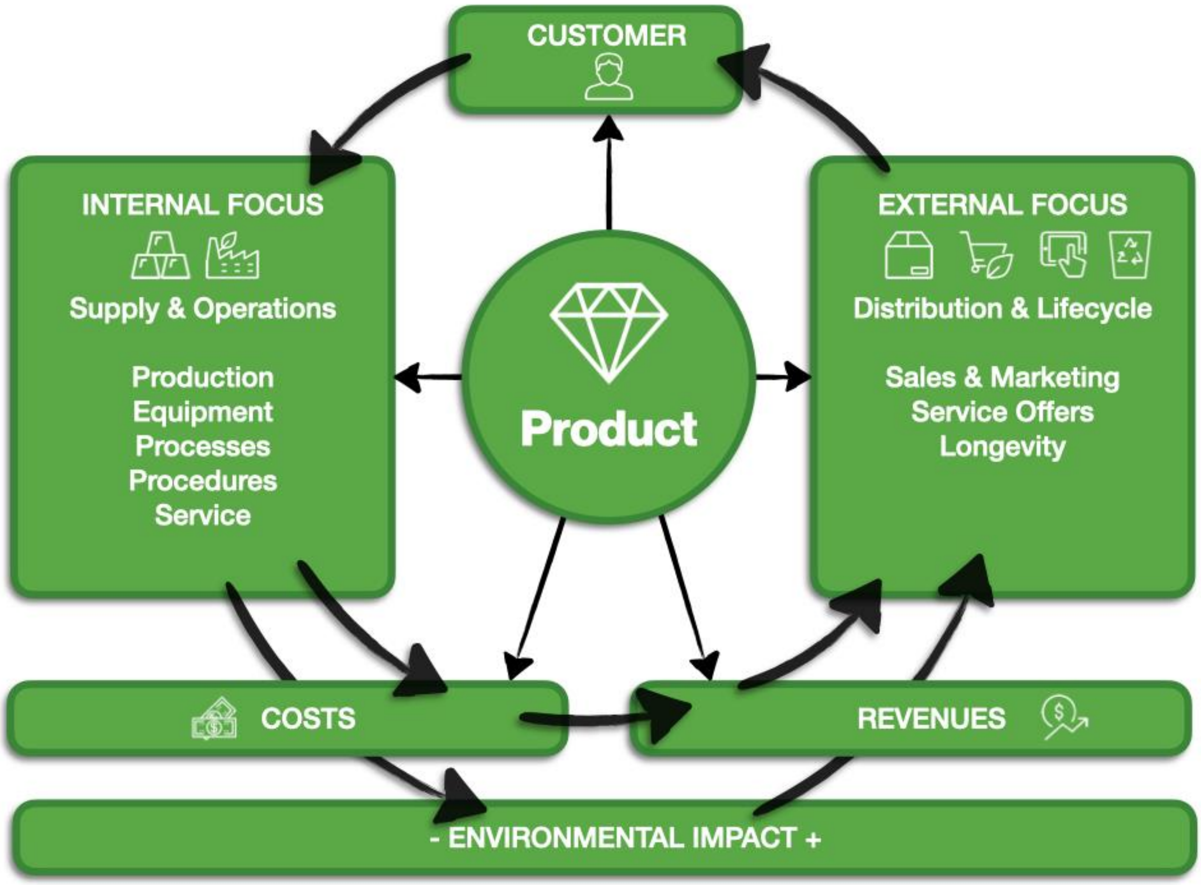

Figure A: Decision Circle 'From idea to market'

The present guidelines have the goal to accompany small and medium-sized enterprises (SMEs) on their way 'from idea to market' and are meant to support the evaluation and practical implementation of EcoDesign[1] from an economic point of view. To demonstrate the considerations, assessments, and decisions to be taken when bringing an idea to the market, we have developed a tool to help with these decisions – the Decision Circle.

Figure A – the Decision Circle – shows which topics are crucial to consider when implementing EcoDesign into a company's way of operating, while still taking economic feasibility into account. These topics will be explained further in the upcoming chapters. The chapters give an overview and introduction to the respective topics and show how to harness their potential for businesses.

In the center of the Decision Circle we have our potential idea, a ‚product' (in our case meaning material goods as well as services or product-service-combinations), as a starting point. What we are referring to in this context is the analysis of existing businesses or products, as well as the evaluation of new ideas.

[1] For definition, see Ch. 2, p. 13

The following overview and questions help to see what kind of topics should be addressed and which improvements may be useful when trying to include EcoDesign considerations in a business model. The questions are mainly aimed at these sustainable considerations:

Product

At the center of the product stands its value proposition. It is the promise and expectation regarding the value that the purchase and usage of a product will create for the consumer. Further explanations on the product design side and its ecological implications can be found within the EcoDesign frameworks.

Main Goal: Creating products that bring real value to the lives of customers

- How can a product, designed according to EcoDesign principles, contribute to the value proposition of a product?
- Can a company gain a competitive advantage by implementing EcoDesign principles during product design?
- Is there potential to officially verify the sustainability of a product, service, or business by being certified through labels or certificates?

Customer

The customer is the key decisive factor for a company's success. Considering the customer's needs is crucial when working on an idea and bringing it to market. How to segment and understand the customer better, using the persona method, is explained in chapter 3.

Main Goal: Understanding who you are solving a problem for

- How important are EcoDesign and circular economy principles to the target group?
- Can new markets be tapped into?
- Can additional target groups be reached by increasing sustainability?
- Can customer retention be increased by using EcoDesign-oriented products?

Internal Focus

Having a look at the internal structures and processes of a company - How to analyze, assess, and implement actual changes to the production process and validate them, is explained in depth in chapters 4 and 5. These topics share the goal of checking for potential changes to internal processes on the basis of EcoDesign and at the same time increasing the efficiency of them. Starting with 'oneself' is an encouraging way to reduce hesitations regarding EcoDesign – a promising and low-threshold approach to make change attractive.

Main goal: Improving efficiency in terms of materials, processes, and resource consumption

- Can a change in production equipment generate significant potential for saving energy, resources, and costs?
- Can a change in process chains generate significant potential for saving energy, resources, and costs?
- Can a change in production processes generate significant potential for saving energy, resources, and costs?
- Can a change in production processes generate higher output?
- Can adjusted production procedures generate significant potential for saving energy, resources, and costs?

External Focus

Considerations regarding more externally focused aspects of implementing EcoDesign principles into a business model, especially factors such as the usage and end-of-life phases of products are addressed in the examples of chapter 5.7.

These kinds of changes are oftentimes considered to be more difficult, as there is more uncertainty regarding their economic implications. However, they may still present a favorable way of increasing the success of a businesses.

Main goal: Improving resource consumption, opening up new revenue streams, gaining new customers, and increasing customer retention

- Can new or additional service offers generate new revenue streams while reducing environmental impact?
- Can new or additional service offers reduce production costs?
- Can digital tools be used for marketing and thus for reducing resource consumption?
- Can reputation and compliance with legal requirements be increased?

Revenues

Being aware and considering possible new revenue streams and pricing models make business modelling on the basis of EcoDesign more feasible and viable. There are many resources and tools to evaluate the revenue streams a company can generate from their ideas and products. See further reading for more information on this specific topic.

Main goal: Increasing revenues when bringing new ideas to market

- Which additional revenues can be generated?
- Can prices be adjusted when implementing EcoDesign principles into product development?
- Can longer product care lead to longer customer retention and longer-lasting income?

- Can the eligibility to further sources of income be increased, e.g., through funding programs or additional investors?
- Which revenues will changes from product to product-service-systems cause?

COSTS

Costs

Changes, innovations and the conversion towards an EcoDesign approach may lead to adjusted cost structures. Cost structures refer to the monetary cost of setting up and operating a new product, idea or business model. There are many different resources for the assessment of the costs incurred to establish and operate a new product or business. Some of them are addressed in chapter 5.6. See further reading for more information on this specific topic.

Main goal: Reducing costs through the adjustment of strategic steps

- Can costs be reduced through changes in equipment, process chains, production processes, and new procedures?
- Will additional costs be caused if sustainability is not taken into account (e.g., additional taxes, legal requirements, customer expectations)?
- Which costs do these change processes cause?
- Which costs will changes from product to product-service-systems cause?

- ENVIRONMENTAL IMPACT +

Environmental impact

Tools and strategies to analyze the environmental impact of new ideas and products can be found within the EcoDesign framework

Main goal: Reducing the environmental impact of products and services

- Which role should EcoDesign and circular economy goals play when developing new ideas and products?
- Can a change in internal processes generate significant potential for saving valuable resources, energy, and capacities?
- Can a change in the lifecycle management and corresponding service offers generate significant potential for valuable resources, energy, and resources?
- Which environmental implications does the development of new ideas and products incur?

These questions, in combination with the contemplation of a business model through other tools like the ‚business model canvas‘, are powerful methods for analyzing, creating, and validating business models that are based on EcoDesign principles.

Further reading:

- Developing business models with the Sustainable Business Canvas
- The triple layered business model canvas - A tool to design more sustainable business models

1. Reasons for these guidelines

Sustainability in companies is both a trend and an opportunity

The realization that the usage and production of products and services always come along with social and economic impacts is growing continuously. Nevertheless, establishing a mindset of sustainability is a challenge for businesses throughout the world and is accompanied by many questions. The following guidelines address this challenge by introducing the ecodesign principle for small and medium sized enterprises, which will be applied to a business context, in order to support the implementation of an ecodesign mindset from an economic point of view.

There are many reasons why socio-economic transformation is urgent:

- **Our resources increasingly deplete.**
- **We transgressed critical environmental parameters.**
- **Resulting social tensions and inequalities are growing.**

The conventional, linear way of production leads to the disposal and thereby eventually to the "devaluation" of products, their components, and materials. Instead, a circular economy and its underlying way of thinking, contributes to a usage and production with the biggest possible value preservation. For example, in biological cycles 'Cascade Use' is an option, "using residue and recycled materials for material use to extend total biomass availability within a given system" [1]. For the wood industry an example for Cascade Use is the usage of timber, which later on can be used for chipboard and in later steps for energetic use, such as in wood pellets.

The concept of 'EcoDesign' can be a determining factor here. Its conception phase includes decisions not only about the amount of future costs, but also the environmental impact throughout a product's or service's life cycle.

> „In circular design, EcoDesign strategies are combined with the aim of keeping as many resources as possible in closed loops and transferring them quickly and efficiently from a state of uselessness to a state of use." [2]

The EcoDesign guidelines – Understanding and methodological procedure

The concept of 'EcoDesign' is a holistic approach, which primarily considers ecological, but also social and economic advantages, as well as an esthetically pleasing and durable design. 'EcoDesign' by its nature promotes innovations and can foster behavioral change of manufacturers and consumers towards product-service-systems and self-sufficiency. It does not view ecological thinking as an add-on but as a part of the fundamental design process. "From idea to market" means working through a new, sustainable solution to be economically applied in a reasonable way. The 'EcoDesign Audit and Sprint approach', as developed in the EU-Interreg-project 'EcoDesign Circle' (2016-2021), can therefore be transferred to a typical procedure for the implementation of innovations. **By doing so,**

it is possible to make innovative and sustainable solutions on the basis of EcoDesign a part of the "common" business.

Merging design and sustainability: EcoDesign Audit and Sprint

EcoDesign Audits and Sprints, are approaches trying to unite the requirements of design and sustainability. Most often, they end with the introduction and discussion of the worked-out circular concepts and with an action plan for subsequent steps. After that, the company is left alone to work out the implementation and feasibility. Concepts and management decisions can lead to important changes in a company's way of doing business, its culture, and its business model. Therefore, well-founded economic support and motivation are needed in many cases.

Up until now, the offer of 'EcoDesign Audit and Sprint' is primarily requested by companies that have already progressed towards the methods of the circular economy.

The present guidelines address the question of how to evaluate different aspects of EcoDesign and access its advantages, such as economic feasibility. We would like to show that EcoDesign is not only an option for 'ecological pioneers', but for any kind of small and medium-sized enterprise (SME).

The methods of the EcoDesign Audit-Sprint approach are explained in detail in the toolkit of the Sustainability Guide. The present, execution-oriented guidelines take the aforementioned challenges into account and complement the 'EcoDesign Audit and Sprint Tools'.

The starting point is to contemplate current economic systems. Two major aspects characterize a system of products and services:

- It fulfills a certain customer request.
- It is based on the design of the stakeholder's innovative interactions, where the economic and competition-oriented interest of the supplier continually searches for environmentally and socially advantageous ethical solutions.

Economic acceptance for EcoDesign product and service solutions

The determining factor for the success of a product and/or service offer will be their practical implementation and usage. Besides moral acceptance, it is also necessary to achieve an economic acceptance of respective suggestions and solutions. Only with this acceptance, a more extensive implementation can be achieved. Even if only existing as an idea or sketch, it is important to evaluate the future benefits of new solutions in a foresighted manner. This step is about business modelling and simulation with the necessary depth.

The present guidelines specifically target small and medium-sized enterprises (SMEs) as well as relevant intermediates. By means of these guidelines, businesses are enabled to examine the economic feasibility of circular solutions and to further develop certain selected questions. To do this, the guidelines are structured along practical tasks and illustrating examples that typically occur during the implementation of innovations. They contain:

- Recommendations for companies' methodological course of action, in order to examine economic benefits and the implementation of a circular solution
- Practical instructions of how to apply usable evaluation and analysis tools, e.g., to analyze and describe the current situation compared to a new situation (costs, organization, potentials, identification of needs for in-depth evaluation and/or research activities)

The guidelines are meant to contribute to the dissemination of EcoDesign by helping new, sustainable, and economically sound offers to become market-ready and widely available, while simultaneously replacing less sustainable offers on the market.

Goals of these guidelines

- **Explaining how to evaluate different aspects of EcoDesign and access its advantages, such as economic feasibility**
- **Enabling businesses to examine the economic feasibility of circular solutions and to further develop their ideas**
- **Providing recommendations for companies' methodological course of action to examine economic benefits and the implementation of a circular solution**
- **Providing practical instructions on how to apply usable evaluation and analysis tools, e.g. to analyze and describe the current situation compared to a new situation (costs, organization, potentials, identification of needs for in-depth evaluation and/or research activities)**
- **Showing that EcoDesign is not only an option for 'ecological pioneers', but for any kind of small and medium-sized enterprise (SME)**

Further Reading

- Linking Industrial Ecology and Ecological Economics: A Theoretical and Empirical Foundation for the Circular Economy
- A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems
- Towards the Circular Economy – Economic and Business Rationale for an accelerated Transition
- EcoDesign Audit and Sprint approaches
- Sustainability Guide

2. Circular economy and circular design

2.1. Definitions

Climate change and resource scarcity are increasingly forcing businesses and the economy to rethink their ways of production and their management of resources. One prominent concept to do so is the idea of EcoDesign.

EcoDesign refers to an approach to design that – while taking into account economic requirements – tries to minimize a product's impact on the environment, by considering environmental aspects during product development and striving to keep environmental impact as low as possible throughout the product's entire life cycle [3].

EcoDesign (or ecological design) aims for:

- an intelligent use of resources
- generating optimum use for stakeholders along the value chain
- a minimum strain on the environment
- all of that under fair social conditions

EcoDesign can refer to consumer as well as investment goods, products, and services and is therefore not limited to environmental technologies or the like. For more information on the various aspects that – depending on the project – may be considered when applying EcoDesign principles, consult the criteria matrix by the Federal Environment Ministry, the Federal Environment Agency and the International Design Center Berlin.
Another important idea for a more sustainable way of managing resources in the economy is the notion of the circular economy.

The circular economy is an approach to production and consumption, based on reusing, repairing, recycling, refurbishing, sharing, and leasing materials and products, so as to extend their life-span, as well as to minimize resource extraction and environmental impact.

Four aspects are essential when considering the establishment of a circular economy [4]:

- Using products and components longer (e.g., reuse)
- Using less material and energy (efficiency)
- Using materials again (recycling, use non-toxic material)
- Using regenerative energy sources

The following guidelines explore the concepts of EcoDesign and circular economy in-depth and will provide real-life examples. The guidelines aim at giving concrete instructions, so that they can be put into practice.
The following diagram illustrates the basic features of the circular economy and how they interact.

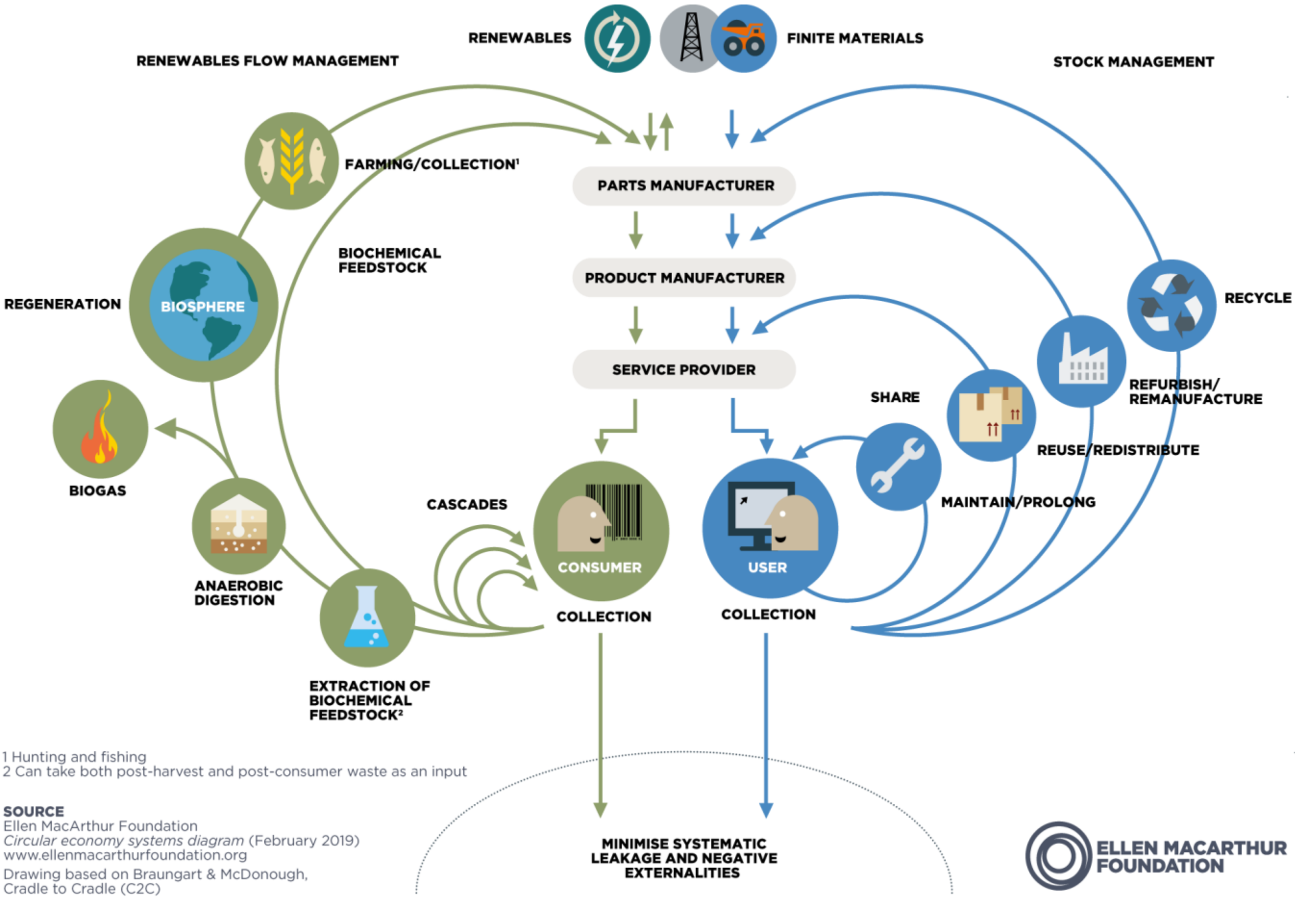

Figure 2.1: Circular economy – an industrial system that is restorative by design [5]

At the top of the diagram, resources are separated into renewable (biological nutrients) and finite materials (technical materials). The left-hand side of the diagram depicts the loop system of biological materials, which are consumed and, for the most part, regenerated. Cascades allow materials and components to be repurposed after the end of life of the product for which they were originally designed. Valuable resources and energy can be (re)-gained from procedures, such as the extraction of biochemical feedstock (post-harvest or post-consumer waste) or the production of biogas from the resulting waste products. Everything should circulate to enter the biosphere safely and restore natural capital. The right-hand side of the "butterfly diagram" shows the loops of technical materials that are used. The loop system comprises sharing, maintaining, reusing, remanufacturing, and recycling. Everything circulates with high quality without entering the biosphere. The tighter the circle, the higher is the restored value. The middle section represents the linear take (extraction of resources), make (production), use and dispose model. In the following, some important terms, referring to processes in the circular economy, will be explained.

Value-adding processes transform basic goods into goods with a higher (monetary) value. In the course of this, the increase in value (also called 'added value') is created through the activities of an organization and its employees. Services may have the advantage of generating an increase in value without the corresponding use of natural resources (dematerialization of the value chain).

When more resources than absolutely necessary are used, literature speaks of '**waste**'.
So-called **Lean Management** tries to detect and eradicate waste in all of its various forms.

Lean Production means producing only what is really needed. Lean Production stands in contrast to 'Buffered Production'. Buffered Production is done in advance, so as to create a stock or buffer in case of unpredictable disruptions. This means that resources are being used even when they are not needed.

Material services accompany the product and constitute an increase in value. Often, these are services that enable the usage of a product (e.g., personalization of products). **Immaterial services** mostly happen in connection with human beings. Products are created and accompanied by service offers (e.g., delivery services, take-back, maintenance, repair).

2.2. Are "Circular Economy" and "EcoDesign" just fashionable terms?

Or do they constitute the basic features of a concept of the future economy?
In order to work out an answer to this question, the following section will present a number of qualitative and quantitative parameters. The present guidelines are meant to inspire further engagement with the topic.

The circular economy approach allows for greater complexity in the development of products

It is estimated that up to 80% of a product's environmental impacts are determined at the design phase (see "Circular Economy Action Plan" in the "further reading" section at the end of this chapter) [6]. This would mean that effectively all organizational processes are being affected by the development and implementation of a new product or service. In order to reach ideal results, it can be helpful to put together an interdisciplinary team for the design of products and services.

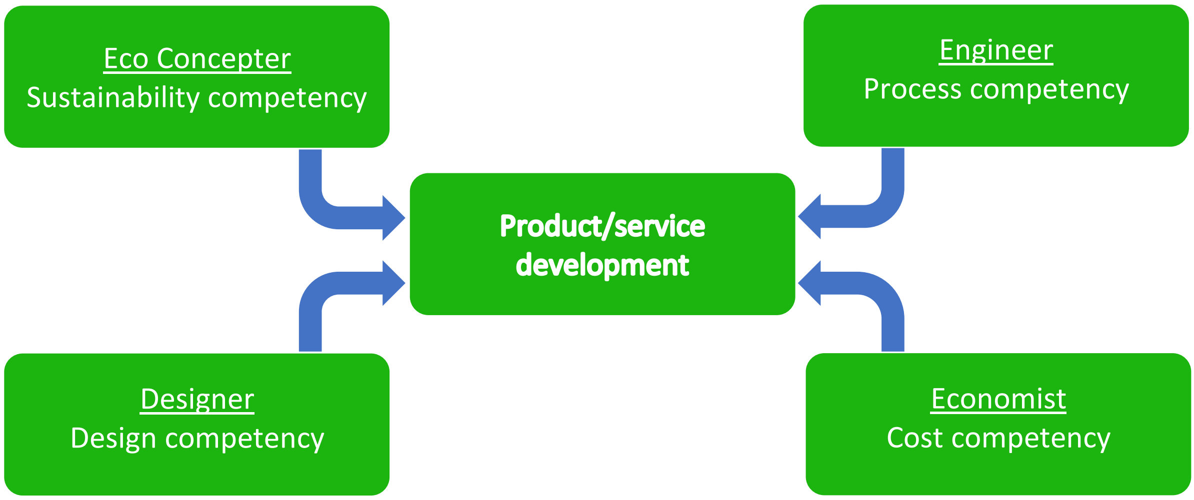

Figure 2.2: Complex and team-oriented development process. The composition of the team may vary depending on the specific product or service.

Up until now, the only two main areas that usually influence the development of products and services are design and costs.
One of the main goals of "EcoDesign" is to reduce the environmental impact throughout a product's life cycle without compromising any of the essential product criteria, like performance and costs.

Figure 2.3: The EcoDesign Circle [7]

The EcoDesign Circle shows the different life stages of a product, which need to be analyzed and presented qualitatively and quantitatively when assessing feasibility. The integration of eco-friendly, eco-efficient, and eco-innovative solutions stands at the center of the EcoDesign approach. When assuming a reduction in surplus production (as seen in the linear economy), the circular economy focuses more on individual (personalized), high-quality products and services from more regional sources (as far as possible). This approach is of particular interest for SMEs, as it requires and supports their specific traits and skills, as optimizations and adjustments might be easier to achieve for a team of 200 employees than for a team of 2.000 employees.

The circular economy and economic viability – a reduction of dependence

Circular economy, as well as the EcoDesign approach, represent a promising set of advantages for businesses. The most important aspects can be summarized below. Circular economy refers to resource-efficient production and business models. It reduces the dependence on:

- critical primary materials [8]
- monopolized and volatile raw material markets
- imports [9]

The circular economy approach can motivate to support:

- good return logistics regarding old devices, products, its components and materials
- laws and action plans that promote circular economy processes like repairing, reusing, and recycling
- an intense search for substitute materials

… and thereby make business from the European Union less dependent on imports [9].

The circular economy is more than just efficiency approaches

Nowadays, many approaches regarding economic activity are based on the **efficiency principle** which aims at **minimizing** the **use of resources** when supplying products or services [10]. Currently, efficiency considerations serve to compare the competitiveness of products, services, and value-adding processes. One important first step in reducing the use of resources and its negative consequences towards the environment, is to reduce the resource usage per produced unit. However, “the real potential of efficiency approaches” remains “limited in the face of growing consumer demands” [11]. The concept of the circular economy goes beyond resource-efficiency and productivity-approaches and positions itself between purely efficiency-based approaches and post-growth-economics, in order to achieve economical, ecological, and social change.

Post-growth-economics is a school of thought that acknowledges the limited resources available on earth and views growth as finite. It focuses on the need to decouple well-being from economic growth [12].

As a consistency strategy, the circular economy aims at the environmentally friendly design of economical systems. It strives to minimize negative impacts on the environment through qualitative transformation as well as the slowing down and closing of material cycles. In this sense, the implementation of circular economy practices is supposed to decouple the rate of economic growth from the increase of environmental impacts [13].

"**Relative decoupling** happens when the economic growth increases more than its related environmental and social consequences."
"**Absolute decoupling** only happens, when the use of resources and externalities decreases, despite continuing economic growth." [14]
An absolute "decoupling of economic growth from environmental pressures and impacts" is considered "unlikely at a global scale" as "political initiatives for a sustainable future require not only technological change but also changes in consumption and social practices." [15]

A promising future: The circular economy constitutes a significant potential for growth and innovation in Europe.

Traditional areas of the circular economy, like environmental technology and resource efficiency, are of particular interest and will remain key elements of the circular economy in the future. According to the business consultancy "Roland Berger", **the market volume for the implementation of environmental and efficiency technologies for products, procedures, and services** (incl. renewable energies and sustainable mobility) amounted to **350 billion euros** in Germany alone and to over **three trillion euros** worldwide [16]. Derived from the potential for growth and innovation in this area, profitable investment opportunities of up to 320 billion euros could arise for Europe until 2030, according to the European Mortgage Foundation [17]. A large part of these incentives is made possible or is reinforced by digital business models, such as the increasing prevalence of "mobility as a service".
Macroeconomic estimations by the OECD support these analyses: The majority of studies on the macroeconomic effects of the circular economy finds positive or at least neutral economic effects - in combination with a reduced use of primary resources, improved total costs and a tendency towards a **net positive economy** [18]. According to a study by Cambridge Econometrics, an increase in resource productivity of up to 2.5% per year until 2030 would already have a positive impact on the GDP (Gross Domestic Product) in all 28 member states of the European Union [19].

Net positive economy is a way of doing business, where businesses give more to nature, society, and the global economy than they take out [20].

Boosting the job market –The circular economy increases employment

The UN International Resource Panel (IRP) showed that the circular economy has the potential to positively impact job markets. A study on behalf of the European Commission predicted an **additional two billion jobs** as a result of the implementation of ambitious measures to increase resource productivity. Further predictions showed that the number of occupied jobs in the circular economy corresponds to the European employment rate. This is taken as evidence that a growing circular economy can potentially create jobs, including specifically in places with a regional or occupational discrepancy [21].

Ecodesign principles can be applied at any time in the production process

The question of when to implement EcoDesign principles usually comes along when thinking about the introduction of new products and services into the company. As mentioned before, the process can be accompanied by 'EcoDesign Audits and Sprints'. However, occasions for the integration of EcoDesign principles do not need to be created, it can be done at any time. Typical occasions include:

- Introduction of new products and services
- Considerations on how to attract new customers
- Considerations on how to increase the efficiency of business processes
- Considerations on cost reductions, especially in terms of material usage, work, and processing time and procedures

IMPULSE
Think of the goals for your company for the next 3 -5 years.
How could EcoDesign principles be added to those plans?
Which considerations seem most important to you?

The following life cycle phases can be considered. For each of the phases, the relevance of the criteria should be assessed (see criteria matrix of the German Ecodesign Award):

- Preliminary production stages: Creative process, planning, development, selection of materials and manufacturing techniques, raw material extraction and processing
- Production
- Distribution
- Use

Further Reading:

- Circular Economy Action Plan. For a cleaner and more competitive Europe
- German Ecodesign Award: Criteria Matrix
- Nordic Circular Economy Playbook
- Circular Economy 3.0 - Solving confusion around new conceptions of circularity by synthesising and re-organising the 3R's concept into a 10R hierarchy

3. Is there a market for circular design / EcoDesign products and services?

Since the guidelines at hand are specifically designed for the needs and experiences of SMEs, the following contemplations will be mainly carried out using the example of the biggest European market – the German market.
In 2018, 708 billion euros of the investments fell upon the consumer market (incl. building industry and intangible property) and approximately 700 billion euros upon consumption orientated sectors [22].

The question of whether there is something like the “typical buyer” of EcoDesign products is of particular interest, as well as if or how these “typical buyers” can be socially positioned. Due to their low performance capacities for their product and service offers, SME are especially dependent on customers from middle- and higher-income classes.

Distribution of the German population across income groups between 1985 and 2016

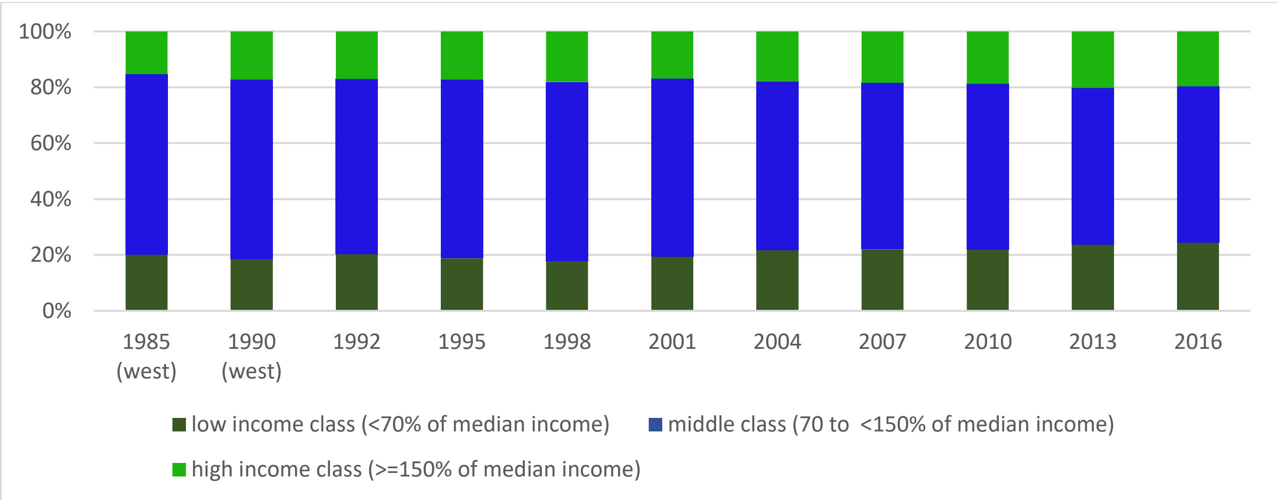

Figure 3.1: Distribution of the German population across income groups between 1985 and 2016 [23]

The German middle class has consistently shrunk between 1996 (65%) and 2016 (56%).
Simultaneously, the percentage of high-income (from 16.8% to 19.6%) and low-income population groups (from 18.4% to 24.4%) has increased by 3% and 6%, respectively [23].

The financial solvency of employers is increasing [24]. Generally, it can be noted that in Germany, educational levels and thereby labor market participation, have increased over the last two decades [25].
Regarding monetary amounts, there is evidence showing that high levels of education lead to lifelong advantages and that one's social classification remains more or less the same over an individual's life span. Though salaries of persons with different educational levels do not differ much when entering job life, differences in payment persistently grow until the middle of their careers and remain constant until entry into retirement [26].

Who has the highest affinity for organic products and EcoDesign?

The following chapter attempts to create a characterization of potential target groups for EcoDesign products based on the study "Attitudes and Consumer Profiles in Regard to Organic Products", conducted in Germany by "The Central Market and Price Reporting Agency for Products of Agriculture, Forestry, and the Food Industry". [27]

In 2001, a number of 2700 participants between the ages 18 and 75, was surveyed. 22% reported buying organic food. 13% of the participants claimed to cover their entire demand with groceries from ecological cultivations. According to the results, especially consumers between 31 and 50 years and families with two or more children buy organic food. These participants are expected to mostly belong to the middle- and upper-income classes [27].
A survey regarding the consumption of organic products from 2019 showed the following results [28]:

- Purchasing criteria: Purchasing fairly produced and regionally sourced products are most important to consumers, even more so than purchasing organic products.
- Age: One out of ten persons older than 60 reported buying only organic products
- Level of education: Not just individuals with high levels of education purchase organic products, but they do so particularly often.

Despite these findings, it is important to remember that every product and service is different and therefore aims at its own individual target group.

The importance of sustainability is increasing more and more

The results of studies of the Berlin Institute for Innovation Research (BIFI) also show that sustainability is becoming more and more important for consumers and companies.

In 2016, 68 % of the respondents of a survey, representative for Germany, claimed to buy biological fruits and vegetables regularly. At that time, sales figures told a different story, but they did continue to increase continuously [29].

It was also discovered that men and women under the age of 40 have a strong need for information on sustainability. Recyclability, Fairtrade and proportion of harmful substances in the product were considered the most important aspects of sustainability. 30 - 50-year-olds showed the greatest willingness to pay in terms of sustainable products [30].

Regarding the determining aspects of buying decisions, a ranking shows that sustainability is in third place, just after price and aesthetic aspects [31].

Age, income groups, education and purchasing criteria are some of the aspects, that can be considered when trying to determine target groups. However, they are not the only ones. It is important to remember that every product and service is different and therefore aims at its own individual target group.
The following section will give concrete instructions on how to determine a product's or service's target group.

Determination of the target group and its meaning for businesses

To determine a product's target group, the first step is to select the group of people that show interest in the product at hand. When the target group is determined, the maximum revenue with the least tax losses is generated.

> "Those who address an individual with high standards in an impersonal way, will not be successful." [32]

A successful sales department requires information about the needs, motives, experiences, and behavior of their target group. In order for customers to feel optimally taken care of, the marketing concept is built based on this information.
The determination of a distinct target group leads to the fact that the available resources are used to reach individuals who's purchase probability is the highest. Moreover, by determining and demarcating the target group, the size of the market can be identified more easily (e.g., when writing the business plan).

Attention: "Buyers" are not necessarily the same as the target group that is being determined. Instead, "influencers" need to be identified.
Example 1: Marketing to children: Parents are the ones buying, but children influence their decision and are therefore primarily targeted by marketing.
Example 2: The head of department decides that a coffee machine needs to be purchased, but the secretary determines which one [33].

How to determine the target group

Target groups are determined by market research. The determination is divided into three phases:

1. Narrow down the characteristics of customers

Initially, all potential customers are narrowed down to a smaller group of people. In order to do so, basic characteristics and criteria are used – the potential target group is kept unspecific at first.
Characteristics can be e.g., age, occupation, marital status, income, place of residence, level of education, gender etc.
At this point, the target group is broadly narrowed down but not yet specified. As a result, a description of the group without any personal targeting is created.
For this first step, information can be gathered using online research and surveys. Online research is a quick and easy way to collect information about the target group. Informative statistics are, for example, found in national statistical databases or by using marketing tools.
However sometimes, relevant statistics do not yet exist. In this case, surveys can be implemented to gather relevant data. This can, for example, be taken over by the sales department. As a result, quantitative data are collected, which do not go into depth substantially, but are able to draw a numerical picture of the target group characteristics.

2. Analyze the purchase behavior of the target group

In this second step, five basic questions regarding purchase affinity are investigated, in order to analyze the behavior of the target group in more depth:

1. **Why** does a customer purchase?
2. **When** does a customer purchase?
3. **How often** does a customer purchase?
4. **How much** is a customer willing to pay?

By answering the questions above, detailed findings about the target group can be revealed (which may, for example, concern price sensitivity and customer reach).
Qualitative methods, such as interviews, help receive a deeper understanding of the target group's needs and motives. They require more effort, but are worthwhile, as they help to obtain insights into the customers' motives.

3. Identify the psychographic characteristics of the target group

Psychographic characteristics include the life-style and interests, as well as attitudes, motives, and opinions of the target group.

Relevant personal characteristics, for example, are:
Lifestyle: How does the target group live? Where does the group live? In what way does the group strive for self-realization?
Interests: Which hobbies does the target group predominantly pursue? Is there a pattern?

Values and norms: What, according to the target group, is important in life? Do they orient themselves on something?

Special Case: Business and B2B target groups require different criteria than private individuals

If a company does not target private individuals but other businesses with their product/ service, a different set of criteria is relevant. Instead of age, lifestyle, and gender, the following criteria are recommended:

1. Location of headquarters
2. Market share
3. Number of employees
4. Type of industry

Regarding purchase behavior, the characteristics are similar:
How much does the organization spend? Where, why, and when do they purchase and how are stakeholders influenced (e.g., liquidity, supplier loyalty, time pressure)?
The business customers and their interests can be addressed by marketing accordingly. The marketing then mostly relies on rational, fact- based information.

The creation of personas is a helpful tool

The compiled information on the target group and the usage of personas enables marketing and communication activities that are tailored to the target groups. Communication with the consumer can thus be adapted to arouse the interest of the consumer.

With the help of this information outcomes, such as personas, can be developed, which present prototypical, yet fictitious ideal customers [32].

> **Personas** are simplified models of user groups involving all relevant and typical characteristics of potential users. This can include goals and interests, motivational aspects, and personality traits. A persona enables one to develop an understanding of the customer's needs [33].

By creating personas, the mindset, mental models, and shared values of the target group(s) are revealed and can be used for marketing purposes.
For a broad pre-classified system, it can be worthwhile to research the current Sinus-Milieus© of the country in question. This method divides the population into 9 different sociocultural subgroups (milieus) [34].

Consequently, definitions of the following typical personas can be deduced for the preparation of marketing and market research activities in the consumer area. Due to the social rank of this typification, it is expected that these characters make similar decisions in the working context when suitable offers are available.

Bianca Garcia

ABOUT
- Female
- 40 years old
- Married
- Kids (6 and 4 years old)

BACKGROUND
- Child and adolescent psychotherapist
- 85,000 EUR household income

IDENTIFIERS
- **Political engagement and activism, as well as a healthy social and natural environment are very important to her**
- **Values financial independence and a high-quality education**
- **Appreciates fun and joy**

GOALS
- **Making the world a better place**

CHALLENGE
- **Balancing work, political and community engagement, self-care, and family life.**

ATTITUDE TOWARDS SUSTAINABILITY
- **Grows her own organic produce and shops at the local farmers market**
- **Values sustainability when shopping for other products like clothes and make-up**

Steven Burrell

ABOUT
- Male
- 45 years old
- Married
- Kids (6 and 4 years old)

BACKGROUND
- IT specialist
- 80,000 EUR household income

IDENTIFIERS
- **Family is the most important part of his life**
- **At the same time values his career and wants to succeed**
- **Values social equality and has progressive ideas about gender roles and working hour models**

GOALS
- **A happy family life**
- **Success and self-realization at work**

CHALLENGE
- **Keeping a healthy work-life balance**

ATTITUDE TOWARDS SUSTAINABILITY
- **Buying local and organic are highly important for both, the health of his family and environmental reasons**

Lisa Smith

ABOUT
- Female
- 24 years old
- Single
- No kids

BACKGROUND
- Student
- 12,500 EUR household income

IDENTIFIERS
- **Open to new experiences and developments**
- **Needs financial independence and self-realization**
- **Focused on self-care and spirituality**

GOALS
- **Being at peace with herself by aligning body, mind, and spirit**
- **At the same time: Expressing herself in her studies and through her work**

CHALLENGE
- **Balancing studying, working and life, so that she doesn't have to sacrifice her inner peace to stress and worry**

ATTITUDE TOWARDS SUSTAINABILITY
- **Regional and organic produce are highly important to her, mainly so as to maintain a healthy diet and to take care of her body**

John Cho

ABOUT
- Male
- 55 years old
- Single
- No kids

BACKGROUND
- Content strategist
- Freelancer
- 80,000 EUR household income

IDENTIFIERS
- **Prioritizes environmentalism in his personal life and career**
- **Has ambitious ideas regarding the development of his career**
- **Needs to see a purpose in everything he does**

GOALS
- **Having a successful career, while also caring for the environment and making the world a better place**

CHALLENGE
- **Integrating sustainable choices in both his career and daily life**

ATTITUDE TOWARDS SUSTAINABILITY
- **When shopping he wants to make more sustainable choices, while also caring for his health**
- **However, he mainly focusses on financially supporting environmental organizations**

How to use personas?

- Regarding considerations on the conception and preparation of product and service offers, **the usage of personas enables these offers to be well tailored to the needs of the consumers.** Knowing which persona has which motives and reactions towards the offers helps to emphasize those aspects that are important to the specific personas.
- When the product or service is already on the market or if products and services need to be added or adjusted, **personas constitute a helpful way to constantly keep customers and their experience in mind when engaging with the product or communication with customers.**

The goal is to understand which aspects characterize potential customers and to deduce how they might behave throughout that customer journey - Taking our example personas, we could imagine that Bianca Garcia will like different aspects of an idea or product than John Cho.

It can thus be advisable to embed the usage of personas into the process of customer relationship management. Interested consumers and customer can be matched with a specific persona. In the daily communication with the consumers, this process enables marketing, sales, and service teams to decide more accurately…

- which customer approach is the most fitting one at which point in time
- which expectations the consumers have
- which offers could be relevant for which individual consumer, in terms of selling and communication.

The following checklist gives an overview of the steps that need to be taken to create and use personas in companies.

Checklist

- Determine your Target Group
    - Narrow down the characteristics of customers
    - Analyze the purchase behavior of the target group
    - Identify the psychological characteristics of the target group
- Develop your personas
- Reflect on how your personas will react to your offer(s)
- When creating a product or service offer identify if and how your product or service offer should be adjusted according to the characteristics of your personas
- Identify how your communication and marketing can be adapted according to the characteristics of your personas

Further Reading

- The Buyer Persona Manifesto

4. What should be considered regarding the production phase?

Recommendations for enhancing the production processes

It is important to remember that up to 80% of production costs are already determined in the design phase [6]. Changing the productions sequences or product design can lead to shorter processing and passing times. In the following tables and chapters possible approaches and effects will be introduced. The following tables contain a universally applicable list of steps to be considered when improving the

Reorganization of products	
Simplify the construction	Simplify the processing
Standardize construction and connections	Reduce diversity of fittings
Reduction of the diversity of geometries	Reduce the demand on storing places
Reduce the diversity of materials	Reduce cash assets obligations

Processes (catenation, appreciation)	
Simplify the construction	Simplify the processing
Catenate the work processes	Reduce work force utilization
Recognize the processing sequences	Save loading and unloading time Shorten the cycle time (lead time)
Automatize the machining processes	Reduce the work force utilization

Design and construction	
Simplify the construction	Simplify the processing
Standardize construction and connections	Reduce diversity of parts and modules
Standardize parts and modules	Increase the reparability
Standardize the connections	Increase the ability to disassemble
Offer product-service systems	Increase the material efficiency

IMPULSE
Take a typical product from your product line and generate ideas for changing the design of that product.

When bringing an idea to market and considering efficiency and reduction possibilities, it is crucial to analyze how the production process can be altered and adjusted. SMEs can profit from the adjustment of this process as it allows for significant saving potential and it can be necessary for setting up the manufacturing of new products.

For the **reorganization of products**, specific steps for simplifying construction and processing can be taken. Standardizing constructions and connections, reducing the geometry of product parts and reducing the diversity of used materials all have the goal to make the production process more efficient. Less diversity of parts and materials allows for greater flexibility in production, reducing the storage space needed and reduces the necessity of binding a lot of cash assets in materials.

Process optimization activities include analyzing processing sequences, the catenation of processes and in later steps automation of machining process. This reduces costs through more efficient work force utilization and shortens production cycle times.

The standardization of the construction process and connections may also allow for greater modularity and will simplify the transition towards greater material efficiency and reparability of products. In one of our later examples, i.e. chapter 5.4, a kitchen manufacturer has made the transition to more individually fitted kitchens. By setting up a new production process the manufacturer can significantly increase productivity. Adjustments to the production process are conceivable for any type of business. Companies from different sectors can use the steps listed in chapter 5.4 These steps can be taken in any company that is producing goods. The reflections on cycle times and efficiency can also be transferred to other sectors.

For companies, it is important to be aware of the potential and chances resulting from various possible changes to the production:

- Changes in production processes can generate significant potential for saving energy, resources and costs
- Changes in production processes may generate higher output, increase productivity and profitability
- Changes to production procedures can increase material efficiency

Further Reading

- 59 Guidelines for Eco-Improvement
- 162 Ecodesign guidelines (Check Appendix A)

5. How to reach efficiency during the production phase

Optimization of profitability of a production plant

In recent years, the development of production capacities was shaped by globalization and the resulting supra-regional sourcing, among other things. Due to high transaction efforts, this approach is only partly suitable for SMEs. SMEs are – depending on the opportunities - more oriented towards regional sourcing. A study by the Fraunhofer Society concludes that **local sourcing may present a more profitable approach** [35]:

> Excerpt:
> "Just as with the labor productivity, the real **net output ratio** positively influences the productivity of businesses in the manufacturing sector [...]. This leads to the conclusion that proprietary value creation is profitable, even more so than labor productivity. Moreover, the export rate shows a new positive effect on total factor productivity [...]. Contrary to a number of predictions, the use of global supply chains and integration into global supply chains does not seem to positively correlate with the economic development of an organization." [35]

This illustrates that an argument for local value creation is scientifically supported (using the example of Baden-Württemberg, Germany, where the supplier industry is mostly shaped by SMEs).
For a successful implementation of the results generated by EcoDesign, it is necessary to not only minimize costs and waste in relation to the product itself, but also with regard to the processes.

5.1 Change processes in production

Nowadays, one can expect all competitors to be able to achieve similar technological equipment levels. In the past, the focus was on reviews of processing time workloads.
The focus these days is increasingly shifting towards **minimal process times** (minimal operational costs per component), with a **maximum workload** (minimal machine costs per piece) and **high level of material efficiency** (minimal material costs per piece), not just from a competitive angle but also from a cost and circular economy point of view.

Determining an optimized solution, therefore, requires the definition of a local optimum under the limits of a predetermined order reserve and a (preferably low) time horizon.
The minimum possible time horizon is regimented by the procurement and delivery costs for the materials or material modules. In times of e-commerce, the order reserve can constantly change as a result of online orders. The determination of a specific planning interval leads to an established minimum delivery period.

Potential for achieving competitive advantages develops from a company structure, in which material and partial stock costs and delivery times (process times) can be minimized.

The variety of possible approaches leads to a large variety of impacts and business cases.

Oftentimes, business organizations that take a circular business model into account, differ from the classic business model in that they are motivated by the ecological and social impact. In order to bring about a business decision to implement this,

- a strategic and monetary evaluation
- management of the consequences of an innovation (i.e. its economic performance)

must replace emotionally and politically motivated arguments as the driving factors.

The result of new product or service design may lead to different tasks for the process design. Different scenarios for business organizations are imaginable: A company has a production and wants to introduce a new…

- … product and needs to change its equipment
- … product and needs to change its processes
- … service and needs to develop this service

For the above mentioned three situations, a practically applicable evaluation method is introduced and explained using the example 5.2. This evaluation assumes four steps:

Step 1:	Process decomposition / composition: Simulated prognosis for the creation of comparable states (transfer of the existing system to the parameters of the new solution)
Step 2:	Comparison of the two solutions and the costs involved, in a variety of different yield- and cost groups
Step 3:	Examination of current and future risks for the business models and their monetary evaluation
Step 4:	Investment recommendations, including the development of recommendations for a possibly adjusted procedure

This evaluation method will not be further expanded on possible cases regarding the development of new productions (Greenfield Investments[2], start-up investments), as these are projects that can often be prepared and executed by specialized planning, engineering, and design offices. In this case, the company's role is reduced to providing the necessary investment capital.

[2] The term Greenfield Investments refers to a parent company establishing operations in a foreign country that are built from the ground up. These can include a number of operations, such as manufacturing facilities or sales offices. Reasons for Greenfield Investments can be reducing production or transportation costs, being closer to and profiting from a foreign market.

For the cases mentioned, procedures and their influence on sub-processes are suggested, which are supported in the following text with specific case studies. The examples and tools used are taken from successfully tested and administered trainings for middle management in SMEs.

5.2 How to evaluate the benefit of changing equipment

How to evaluate the benefit of changing equipment can be illustrated through the reorganization of operational sequences in production. This enables automation and cost reductions. The procedures and potential savings (cost structure and revenue streams) are demonstrated in example 5.2. The example shows how assumptions can be used and how they can be obtained if there is insufficient knowledge of the specific economic value.

The example is taken from a German furniture factory. The process of analyzing and adjusting the production process can be transferred to companies from other sectors – any company can use this approach to evaluate the benefit of changing equipment. The question that arises is if and what consequences can result from possible adjustments to parts of the production, i.e. machining sequences.

Costs may be lower through the deployment of new machines and energy consumption may decrease. However, it may also be possible that certain procedures induce higher energy consumption while the energetic use during other production phases is lowered. Another advantage might be that the creation of waste through better surface quality is reduced. In the process of planning the production of new products all these aspects need to be considered. They constitute the basis for decisions in a sound development strategy.

Example 5.2: Adjustment of an existing production in 12 easy steps

Illustration of problems occurring in SMEs while transitioning towards a circular economy mindset.
Example: Replacement of equipment units in a furniture factory

This example demonstrates the necessary considerations and steps for planning the replacement of equipment units within companies. Our current example is taken from a small wood manufacturing company which is contemplating the acquisition of a new wood processing machine to increase output and reduce energy consumption as well as material waste.

Step 1: Formulate the investigative task

As part of the evaluation of the economics of solid wood working, a comparison is made with conventional carpentry machines.
The comparison is based on the state of the existing facility, which includes:

- Existing machines
- Spatial interrelations
- A production program and a typical range of orders
- The adopted volume of production

In the following section…

… the determination of the basis for decision making will be explained
… and the actual decision will be documented

Step 2: Analyze the current situation

The 10-worker plant produces all kinds of construction joinery and furniture (except windows).

For the purposes of evaluation, the individual products (orders) are…

… usually taken in the unit of time,
… divided into constituent parts,
… and calculated by capacity and geometry requirements.

To analyze this example, typical work on the production of stairs, boards for table tops, and solid wood furniture was chosen.
The power of processing for the planning and profiling of semi–finished products:

- Oak boards, 50 mm thickness (corner seat)
- Spruce boards, 50 mm thickness (stair)
- Beech board, 65 mm thickness (half-turn stair)

The annual solid wood consumption is 60 m^3. For the work of a molder, the surface that was processed by a planning machine is taken. The observance of specific standards or legal requirements has no influence on the machine capacity.

Step 3: Define the frame technology

Existing machines

- Surface planning machine (Machine 1),
- Thickness planning machine (Machine 2),
- Spindle molder (Machine 3),

The machines are less than 10 years in use. The annual duration of use is 100 hours (machine 1, machine 2) or 250 hours (machine 3). Therefore, a residual useful life of 30 years (machine 1, machine 2) or 20 years (machine 3) can be expected.

Step 4: Define technological functions

The technological possibilities allow all necessary functions for surface planning, thickness planning, and both-sided profiling.

Step 5: Determine existing capacity limits

None of the machines reach a capacity limit or are technically obsolete with running times of 100 - 250 hours per year.

Step 6: Assess electricity supply (current and maximum)

The power consumption of the 3 machines is 16 kW. The energy costs are 0,129 €/kWh.

Step 7: Analyze details of the areas (floor plans, areas, heights)

The used production area for the 3 machines is m^2. Between the machines, the processed parts are placed on a cart and moved to the respective operation. For this purpose, the area of the loaded wagon must be provided in front of the machine (task side) and next to the machine (processing side and take-off side). In addition, any roads and traffic areas are to be kept free (usually 30% of the machine area). The extraction on the machines requires 15 kW electrical power. The piping of the extraction system meets the standard requirements in terms of diameter.

Step 8: Calculate the working time

In existing technology, a board is first pushed through the planer. This is followed by a thickness calibration on the thickness planer (up to two times). On the milling machine, joining and profiling can be done in one go. Therefore, one longitudinal side is first processed. Then the parts are placed on the table trolley, the machine is converted, and the second longitudinal side is processed.

Step 9: Compile the actual costs

The current actual costs are summarized in table 5.1 according to the technological parameters.

> *Note*: The calculation of non-wage labor costs, which include all ancillary operating and administrative costs, is a common, simplistic approach in craft trades. Its aim is to show all costs in terms of machine hours and thus to obtain an easy–to–handle calculation basis. For larger projects or in larger enterprises, the real non-wage labor costs, overheads, and administrative costs should be allocated to the available/usable productive hours per job and specific non–wage labor cost rates determined.

Step 10: Formulate the target situation (technical dimensioning / technical requirements)

The machinable planning width should be extended. On the existing machines, the workpiece guidance due to wear is inadequate. The quality should correspond to industry standards

Note: Often a rough quantity planning is used as the basis for the request for offer. Capacity planning - going over the technological process in reversed order – is carried out for this purpose. The analysis is based on idealized data, which in practice are average values (e.g. area of an average furniture component $= 0{,}3\ \mathrm{m}^2$, area of an average window $= 1\ \mathrm{m}^2$). Consideration is also given to technological losses and rejects according to existing knowledge (e.g. foil utilization of membrane presses 54%, cutting machine 85%). It may also be necessary to consider technological or capacitive interim storage facilities.

10.1 Formulas for calculation

Material to be used at required output

$$E = (1 + p_v) * A \qquad (5.2.1)$$
$$Input = (1 + \text{material loss}) * output$$

with
E input,
A output,
p_v material loss

Each machine must be able to process at least the quantity E of the considered machine A.

For a plant, it is then possible to determine the losses of the overall plant p_g based on the quantities R of the first processing stage and the quantity F of the last processing stage.

$$p_g = \left(1 - \frac{F}{R}\right) * 100\% \qquad (5.2.2)$$

with
R raw material quantity
F finished product quantity

For a machine purchase, its quantity M_L must be calculated.

Average machine running time t_m

$$t_m = M_A * h_s \qquad (5.2.3)$$

with
h_s number of working hours per shift;
M_A working time of the machine minus the set-up and maintenance times

Quantity power M_L:

$$M_L = \frac{M_a}{n_A * S * t_m * 60} \qquad (5.2.4)$$

with
M_a annual production
n_A working days per year
S number of shifts

Conversion of the quantity to the material flow

$$M_{lfdm} = \frac{M_L}{A} \qquad (5.2.5)$$

with
a cross-sectional area of the passing material type

In individual cases it can happen that capacity-determining production stages can be determined, e.g., most heavily used or bottleneck production stages. All other calculations would then have to be aligned to these.

10. 2 Evaluate the requirements for running costs

The set-up times should be reduced as far as possible, in order to increase the proportion of productive hours and gain capacity for other operations. The running costs should be reduced overall.

10.3 Establish demands for environmental protection

There are many different aspects that can be considered, e.g., the generation of noise, contaminant release and usage of water and other resources should be reduced.

10.4 Develop the target specification

Based on the formulated framework conditions or, in the case of more complex technological projects (in particular investments in equipment), the supplier is handed over a specification sheet as a basis for a binding offer. The offer contains the following specifications:

1. Product information
2. Process information
3. Required machinery information
4. Additional machine information

Step 11: Evaluate and compare the variants

Within the scope of the offer comparison, the combined machine (PFM) (machine 4) was selected from the available molding machines. The machine's hourly rate is determined as a comparison criterion.

	Current situation			Goal
	Machine 1	Machine 2	Machine 3	Machine 4
Expected service life (a)	30	30	20	20
Replacement value (€ EUR)	10.000	11.000	20.000	45.000
Duration per year (h)	100	100	250	150
Calculated depreciation (EUR / a)	333,33	366,67	1.000,00	2.250,00
Imputed interest 3% (EUR)	300,00	330,00	600,00	1.350,00
Room costs (EUR / m2 * a)	50,00	50,00	50,00	50,00
Space requirement (m2)	12	12	12	20
Total room costs (EUR)	600,00	600,00	600,00	1.000,00
Fixed costs per year (EUR / a)	1.233,33	1.296,67	2.200,00	4.600,00
Fixed costs per hour (EUR / h)	**12,33**	**12,97**	**8,80**	**30,67**
Energy costs (EUR / kWh)	0,1209	0,1209	0,1209	0,1209
Power consumption of the machine (kW)	**4**	**5**	**7**	**30**
Energy costs of the machine (EUR / a)	48,36	60,45	211,58	725,40
Power consumption suction (kW)	5	5	5	8
Energy costs exhaustion (EUR / a)	60,45	60,45	151,13	181,35
Tool and maintenance costs (EUR / a)	200,00	200,00	625,00	750,00

Labor costs one-man operation (EUR / h)	12,50	12,50	12,50	12,50
Non-wage labor costs 110% (EUR / h)	13,75	13,75	13,75	13,75
Total labor costs (EUR / a)	2.625,00	2.625,00	6.562,50	3.937,50
Variable costs per year (EUR / a)	2.933,81	2.945,90	7.550,20	5.594,25
Variable costs per hour (EUR / h)	**29,34**	**29,46**	**30,20**	**37,30**
Machine hourly rate (EUR / h)	**41,67**	**42,43**	**39,00**	**67,97**

Table 5.1: Economic comparison of the offers

The **comparison** of the variants is based on the profiling costs and the amortization periods for the investment.

	Machine 1	Machine 2	Machine 3		Machine 4
Hourly rate $[EUR/h]$	41,67	42,43	39,00	1 x Machine 1; 2 x Machine 2	67,97
Power $[m/h]$	120	200	120	2 x Machine 3	200
Costs $[\boldsymbol{EUR/m}]$	**0,35**	**0,21**	**0,33**	**1,43**	**0,43**

Table 5.2: Cost per profiled meter

Annual output $\left[\frac{m}{a}\right]$	Costs [€]	Costs new [€]	Reduction [€]	Amortization $[a]$
3 000	4 290	1 020	3 270	13,7
5 000	7 150	1 700	5 450	8,3
10 000	14 300	3 400	10 900	4,1
15 000	21 450	5 100	11 350	2,8
20 000	28 600	6 800	21 800	2,1

Table 5.3: Payback periods per profiled meter

Step 12: Decide on a technically and economically meaningful variant

The comparison shows that the profiling costs are lower (67.97 EUR) on the newly considered molding machine (Machine 4) as compared to the standard machines (Machines 1-3) (123.1 EUR). However, it also shows another problem: The energy consumption of new equipment is higher (power consumption of Machine 4 = 30 kWh vs. 16kWh for Machines 1-3 combined), while it allows for a better surface quality (thinner waste) and lower energy consumption during suction. This conflict can be frequently observed in SMEs.

This example demonstrates how important it is to have a sound development strategy. Moreover, it shows that individual measures are not always sufficiently meaningful for the evaluation of development steps.

IMPULSE

Have a look at your own processes. Could there be saving potential by introducing new equipment or machines?

You can also apply the calculation in the example above as a first step.

Adjustment of an existing production in 12 easy steps

Step 1
Formulate the investigative task

Step 2
Analyze the current situation

Step 3
Define the frame technology

Step 4
Define technological functions

Step 5
Determine existing capacity limits

Step 6
Assess the electricity supply (current and maximum)

Step 7
Analyze details of the areas (floor plans, areas, heights)

Step 8
Calculate the working time

Step 9
Compile the actual costs

Step 10
Formulate the target situation (technical dimensioning/requirements)

Step 11
Evaluate and compare the variants

Step 12
Decide on a technically and economically meaningful variant

5.3 Shortening process chains and lowering costs

After looking at how to adjust existing production equipment in order to become more efficient, the following example 5.3 will shed light on how to shorten process chains and thereby reduce energy and resource usage, which in turn results in overall lower costs. The example provides concrete formulas that can be used to map time components on each processing step and figure out where there is time saving potential in the production process.

Example 5.3: How to shorten process chains and lower their costs

Cost reduction can be determined and mapped directly or through time savings.

The shortening of process chains can directly result in the reduction of energy and resource usage. When designing or adjusting the production process, the optimization of workplaces can lead to considerable improvements in the direct workplace environment.

Every operation in manufacturing (processing and helping operations, transfer, store) can be illustrated the following way. The diagram and formulas show which time components can be mapped to which processing step:

Lead Time	$T_{Processing\ time\ ij}$									
Helping time	$T_{set-up\ fixtures\ i}$			$T_{set-up\ programing\ j}$					$T_{cleaning\ time\ R}$	$T_{service\ time\ S}$
Pro-cessing			$T_{set-up\ changing\ j}$		$T_{start\ and\ operation\ ij}$		$T_{time\ to\ handle\ tools\ j}$			
Logistics time		$T_{upload\ time\ i}$				$T_{download\ time\ i}$				

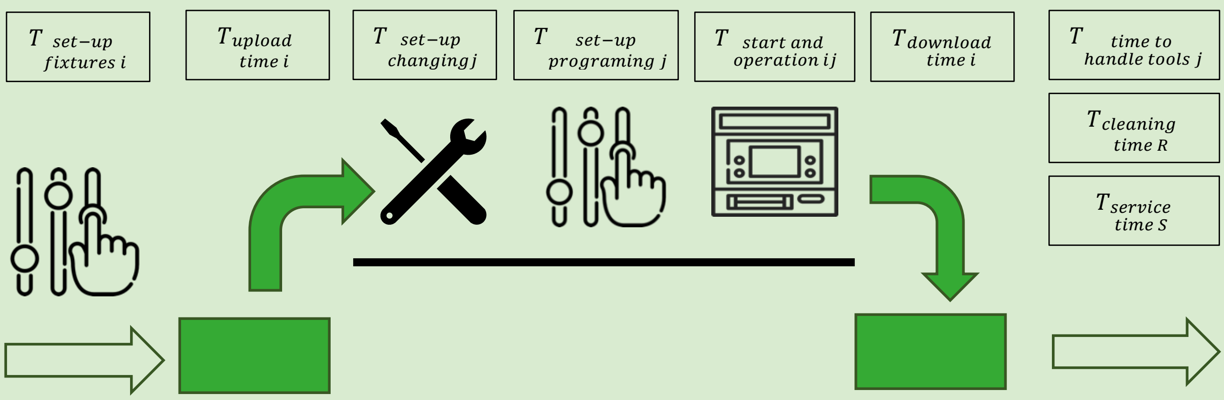

Figure 5.1: Illustration of the time components within production processes

The general formula for calculating the time needed for processing a component i with the operation j is:

$$T_{Processing\ time\ ij} = T_{set-up\ fixtures\ i} + T_{upload\ time\ i} + T_{set-up\ changing j} + T_{set-up\ programing\ j} + T_{start\ and\ operation\ ij} + T_{download\ time\ i} + T_{time\ to\ handle\ tools j} + T_{cleaning\ time\ R} + T_{service\ time\ S}$$

(5.3.1)

with $T_{set-up\ fixtures\ i}$ Set-up time of fixtures and tables for component i

$T_{upload\ time\ i}$ Upload time of component i

$T_{set-up\ changing\ j}$ Set-up time/changing time of tools for operation j

$T_{set-up\ programing\ j}$ Set-up time for programing or adjustment of limiting value for component i and operation j

$T_{start\ and\ operation\ ij}$ Start and operation time for component i and operation j

$T_{download\ time\ i}$ Download time of component i

$T_{time\ to\ handle\ tools j}$ Time to handle tools for operation j

$T_{cleaning\ time\ R}$ Cleaning time

$T_{service\ time\ S}$ Service time

In the case of machining centers, time saving potential exists in the loading and unloading process. The changing of tools and the controlling of the processing operations may be done automatically, i.e. program-controlled and therefore without labor costs.

To convert the time assessment into a cost analysis (savings for the component i), the following can be formulated:

$$E_{BKi} = \sum \Delta T_i * s \qquad (5.3.2)$$

with E_{BKi} - Expenditure for processing operations for component i

$\sum \Delta T_i$ – Reduction of the expenditure of time for the processing of component i

s – Personnel costs per time unit

At the same time, a reflection on all the necessary processing operations j for a product is possible. The data therefore can be gathered from working plans and listings of necessary parts, by considering and adding the cost savings of each operation.

$$E_{BKj} = \sum E_{BKi} \qquad (5.3.3)$$

Furthermore, it should not be forgotten that, especially for by–piece producers, a more **extensive and precise process planning procedure** needs to be undertaken. For example, …

- in process planning
- in CNC program generation
- in supply of components and, where necessary, in protective special packaging (e.g., in automated hardware assembly or feeding/charging devices)
- in adaptation of construction in accordance with the technical capabilities of the machine

Hence, the formula can be extended as follows:

Formula for calculating the times for the automatic processing of a component i with the operation j:

$$T_{ABij} = T_{Bij} + T_{AVORij} + T_{PROGij} \tag{5.3.4}$$

with

T_{Bij} –	Processing time for component i and operation j
T_{AVORij} –	Production planning time for component i and operation j
T_{PROGij} –	Program generation time for component i and operation j

Other costs to be considered and reported are e.g.,

- pro rata amortization
- energy costs (electricity, air, etc.)
- costs of auxiliary materials and facilities
- building costs and rents, lighting and heating costs
- interest costs
- further and additional costs depending on company size and sector

These costs are difficult to present as product or operation–related time.

Reduction of unit costs

The methodology of the equation for the assessment of production costs can be extended to an assessment of the process covering the total unit costs.

Unit costs cover all the costs assigned to the production of a piece (component) such as:

- *Machine costs* (depreciation, pro rata cost of financing, room and energy cost, servicing/repair costs)
- *Personnel costs* (the unit time or piece allocated pro rata to the productive and non–productive man cost)
- *Overheads* (assigned share of the overheads to the unit time or piece)

Reorganization of processes

Selective optimization of workplaces can lead to considerable improvements in the direct workplace environment. However, from an economic point of view, this effect could be lost through neighboring workplaces or the process design.

Experience shows that processes in companies grow over the years. Building on previous processes and continuously monitoring processes can lead to potential losses in redesigning (optimizing) processes to their full potential.

Experts estimate that with the existing high technological level, punctual measures of efficiency improvement may enhance the economic efficiency of a whole company by about 3%, while complex reorganization may lead to an improvement by up to 20 - 30%. This demonstrates the necessity of process-oriented thinking and acting.

Shortening routes

According to the equation

$$s = v * T \tag{5.3.5}$$

with s way
v velocity (constant)
T time

time dedicated to organizational structures can be reduced by **shortening travel/passing times** (routes) within a production (designing a linear flow of material, ideally without crossings or returns) all the way until a fully automated chain is created.

> IMPULSE
> Have a look at your own company. Where could there be time lost for carrying out certain operations or tasks?
> Where could there be time saving potential?

5.4 Reorganization of production processes

The next example 5.4 will give an in-depth, step-by-step-guide on how to reorganize production processes in order to increase efficiency. Starting with decomposing the product into production units, the example demonstrates how to determine and analyze production times, utilization, employees needed and the use of the production area. Finally, steps on how to reorganize a production after an analysis will be provided.

Example 5.4: How to reorganize production processes

Example of a kitchen furniture production after transitioning from serial production to customized built-in kitchens

This example illustrates the procedure during process reorganization and evaluation of the cost reduction by shortening distances and time. It demonstrates how SMEs can quickly and efficiently assess, plan, and implement the reorganization of their production processes, without the need for long and cumbersome planning. This reorganization can be executed and directly implemented within a short period of time.

A kitchen furniture manufacturer has shifted its production towards new, individually designable, high-quality, and individually planned fitted kitchens. Individually planned products also take an EcoDesign mindset into consideration, as they tend to be used longer and with a stronger desire for reparability and replacement of parts.

The existing production line, which aimed for large-scale production, can be further used for production.

Proposals for the transition and the production were developed in the context of a reorganization project. Additionally, the achievable production capacity had to be determined. At the time of the analysis, the company employed 18 people in the production and produced 1-2 individually fitted kitchens a day. The following figures are taken from this analysis.

More kitchens could have been sold but the production was unable to deliver more products.

The aim of the reorganization was to increase the output with customized products.

Step 1: Decompose the product into manufacturing units (parts)

The first step is to compile an overview of the manufacturing units the product can be divided into.

The following figures show what a finished product looks like (Figure 5.3) as well as the manufacturing units it can be divided into (Figure 5.4).

Step 2: Define processes and process times per part (in minutes)

The second step is to list the processes needed to manufacture each part and to assign process times for each of these parts / processing steps. The following table shows the amount of time (min) it takes to perform a certain action (e.g., cut, edge banding etc.) on various product units (e.g., sides, top panel etc.)

Example cupboard	Cut	Edge Banding	Drilling dowels	Borehole raws	Groove	Assembly	Total
Sides	2	1.5	0.5	1	1	3	**9**
Top panel/ Bottom panel	2	1.5	0.5	-	1	3	**8**
Back panel	2	-	-	-	-	1	**3**

Table 5.4: Process times per part (min)

Step 3: Compile processing times per typical products (kitchen types)

The next step is putting together the processing times for each individual product, in this case the different kitchen types and to differentiate between resting and processing times.

Type 1 *Kitchen postforming fronts with shelf*				**Type 2** *Kitchen solid wood fronts*			
Number of corpuses	15			Number of corpuses	13		
Number of shelves	8			Number of shelves	8		
Number of fixed fronts	2			Number of fixed fronts	4		
Number of doors	18			Number of doors	13		
Number of drawers	12			Number of drawers	12		
Number of sliding doors	2			Number of sliding doors	0		
Number of glass doors	0			Number of glass doors	4		
Number of fronts	34			Number of fronts	33		
CORPUS	**Pcs**	**Min/Pcs**	**Minutes**	**CORPUS**	**Pcs**	**Min/Pcs**	**Minutes**
Sides	30	9	270	Sides	26	9	234
Top panel	15	8	120	Top panel	13	8	104
Bottom panel	15	8	120	Bottom panel	13	8	104
Shelf	8	3.5	28	Shelf	8	3.5	28
Number of drawers	15	3	45	Number of drawers	13	3	39
Total			**583**	**Total**			**509**
FRONTS				**FRONTS**			
Cutting & edge banding	34	3	102	Cutting and edge banding	33	19	627
Door	18	19	342	Door	13	19	247
Drawers	12	33	396	Drawers	12	33	396
Fixed fronts	2	3	6	Fixed fronts	4	3	12
Glass doors	0	46	0	Glass doors	4	46	184
Sliding doors	2	26	72	Sliding doors	2	26	0
Total			**918**	**Total**			**918**
TOE KICK/COVER				**TOE KICK/COVER**			
Toe kick	1	38	**38**	**Toe kick**	1	38	**38**
Cover	1	38	**38**	**Cover**	1	38	**38**
			76				**76**
COUNTER TOP				**COUNTER TOP**			
Manufacturing	1	85	85	Manufacturing	1	85	85
Total			**85**	**Total**			**85**
SHELF							
Manufacturing	1	410	410				
Total			**410**				
Grand Total			**2072 min 34.53 h**	**Grand Total**			**2136 min 35.60 h**

Table 5.5: Compilation of processing times (min) per typical products

Step 4: Evaluate the utilization

The next step is to evaluate the results of the compilation of processes.

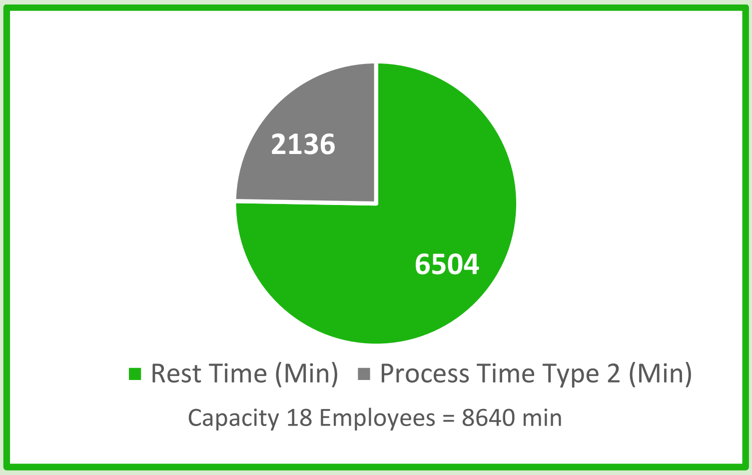

Figure 5.4: Proportion of process time (min) and rest time (min) (Numbers are based on Table 5.5. Rest times have been monitored, too)

Step 5: Analyze time and operations per product type

The following step is an analysis of the time each operation takes in a product's manufacturing process. Figures 5.5 and 5.6 depict the proportional amount of time that each step in the manufacturing process takes, for both, Kitchen 1 and Kitchen 2.

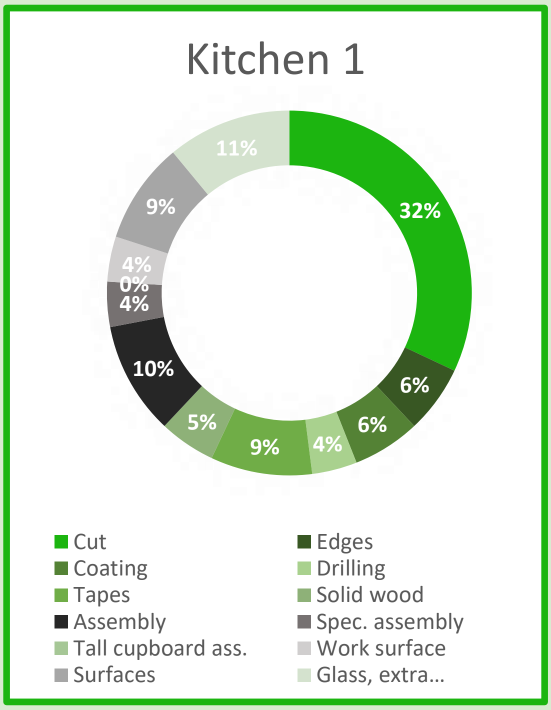

Figure 5.5: Proportional amount of time needed for each manufacturing step (kitchen 1)

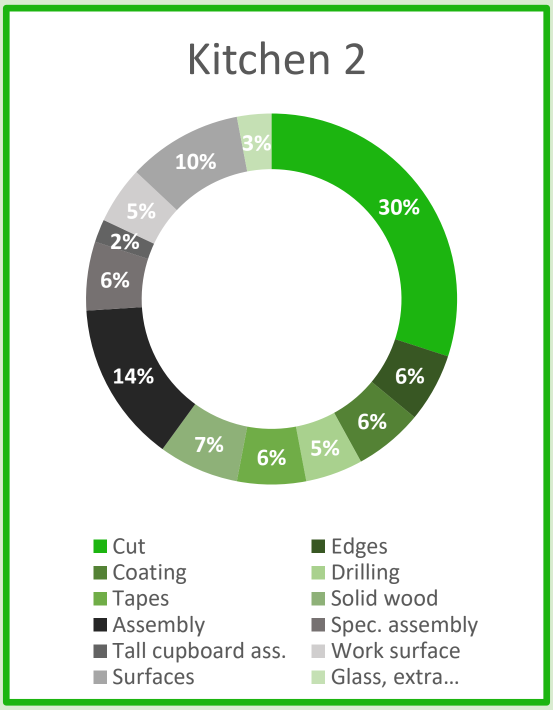

Figure 5.6: Proportional amount of time needed for each manufacturing step (kitchen 2)

Step 6: Map required employee times & their estimated mean times

One further step is the comparison of the number of employees needed for each manufacturing procedure. The employees required for the individual manufacturing tasks are depicted proportionally in Figure 5.8 and numerically in Figure 5.9, assuming 18 employees are available.

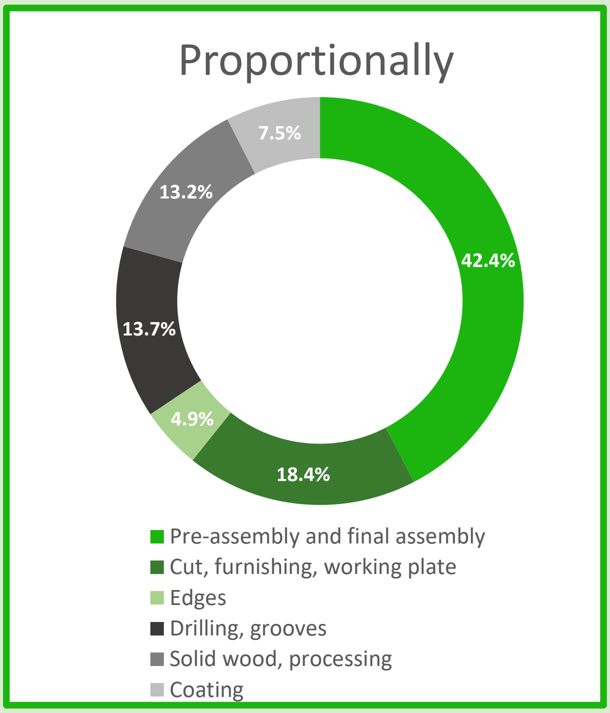

Figure 5.7: Proportion of employees needed for each task

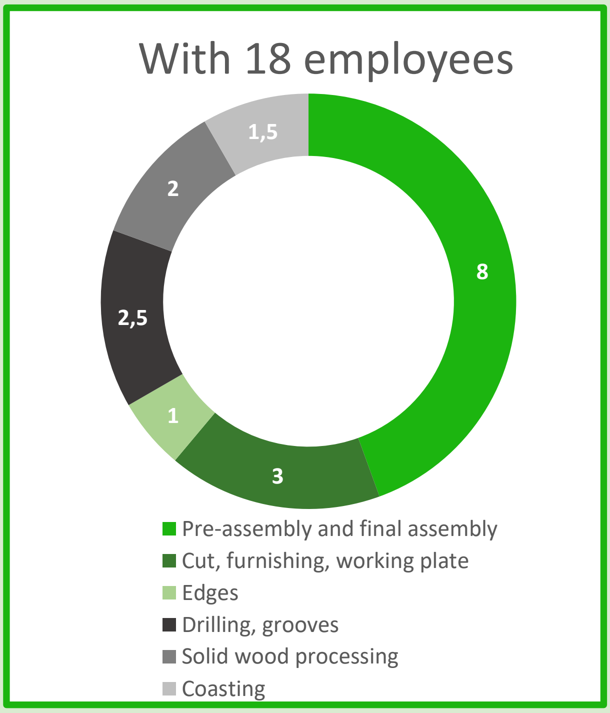

Figure 5.8: Number of employees needed for each task

Step 7: Analyze the usage of the production area

The next step is to look at the production area itself, especially its layout with regards to the location of the manufacturing parts (e.g. machines and storage units). These locations determine the distance and time required for the different operations. Red areas are storage units, blue areas are the machines, and green areas are the work stations.

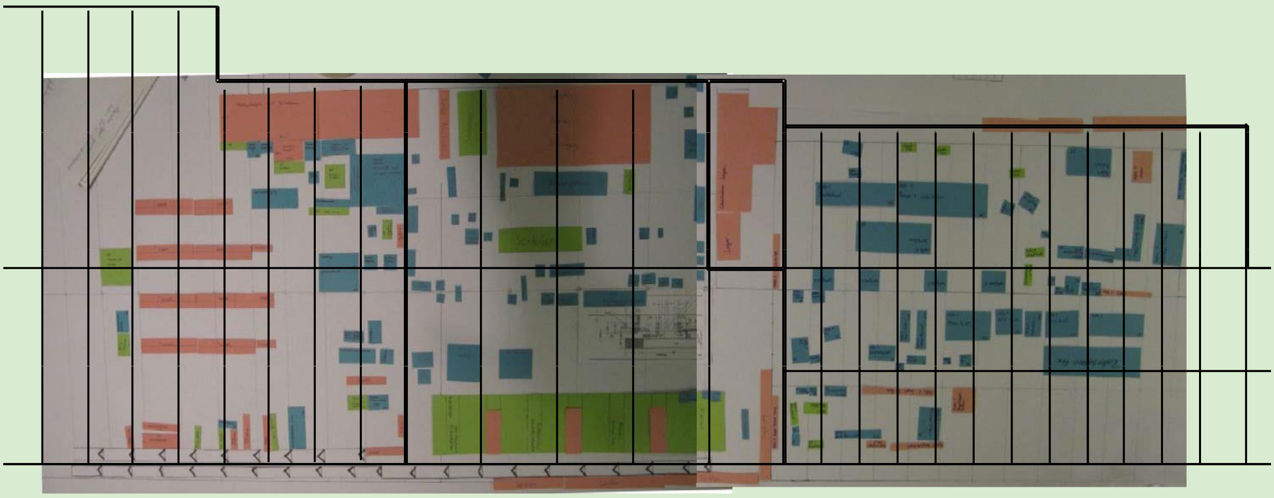

Figure 5.9: Schematic representation of the production area

➔ Area: 8`800 m^2
➔ Number of machines: 107
➔ Storage area: 1100 m^2

Step 8: What is really needed? Investigate the different operations within the production

The next step after the analysis of the production area is to conduct a breakdown of distances in order to uncover where non-productive operations are carried out. This can be done by making a draft of the distances between the different processing stations and then writing down examples of the routes of the workers for these processing operations.

8.1 Analyze the process for each part. Investigate non-productive operations (distances between the processing stations)

Fronts (with surface treatment) standard furniture	1. Cutting to size	$19m$
	2. Edge banding	$72 + 20 + 12 = 104m$
	3. Sanding	$10m$
	4. Lacquer	$10 + 10 + 35 = 55m$
	5. Drying	$35m$
	6. Intermediate sanding	$30m$
	7. Lacquer	$65m$
	8. Hinges	$100m$
	9. Handle holes	$25m$
	10. Assembly	$5m$
	11. Final inspection	$35m$
		$\approx \mathbf{470m}$

Table 5.6: Distances between processing stations

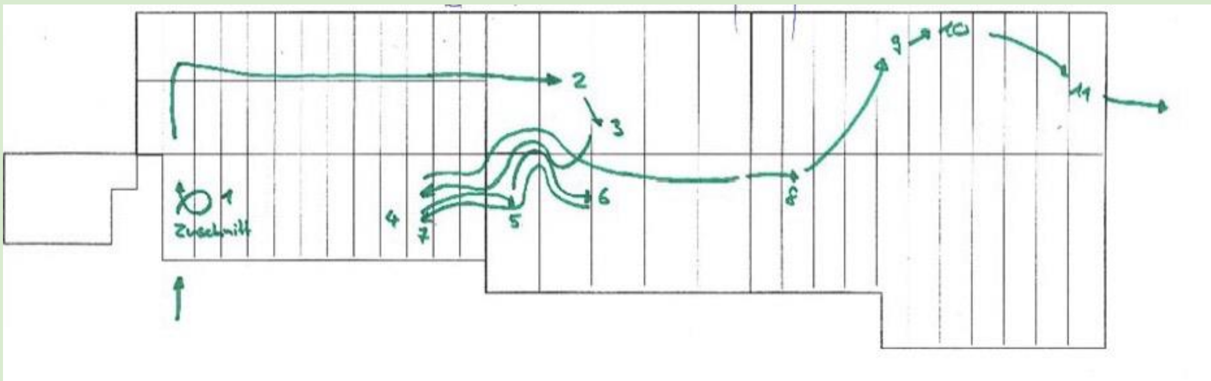

Figure 5.10: Schematic representation of the routes for the operations needed to manufacture fronts

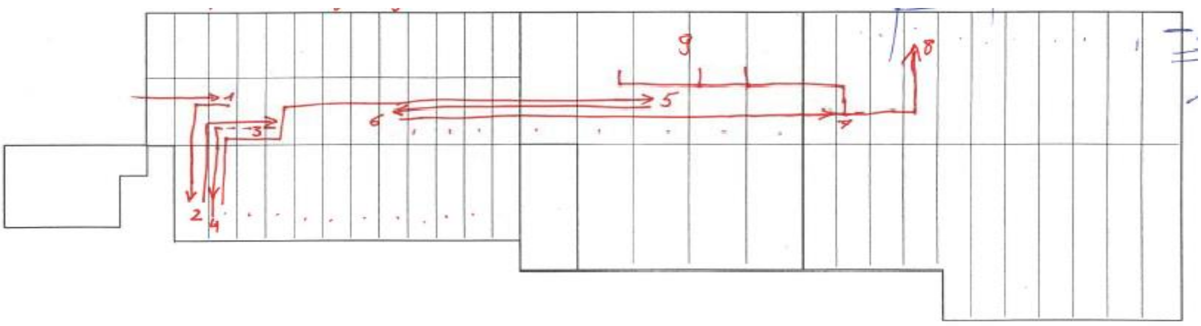

Figure 5.11: Schematic representation of the routes for the operations needed to manufacture cabinets

8.2: Record the process routes of workers

Sample: 3 employees (red, blue, green) and their itineraries

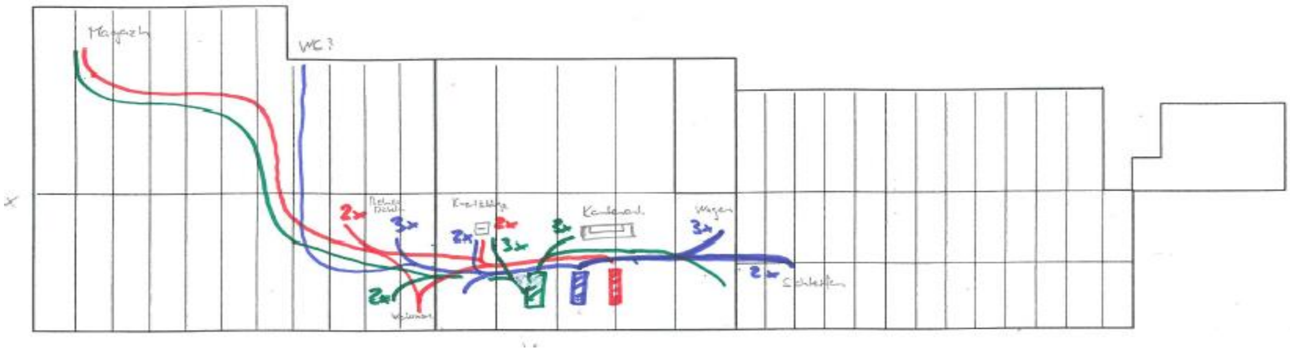

Figure 5.12: 3 employees (red, blue, green) and their itineraries

Meters (m) per hour (h) walked by three different employees (red, blue, green)

Results Red	636 m/h
Results Green	684 m/h
Results Blue	900 m/h
Calculation	→ Average 740 m/h → 5,92 km/d, with speed of 4 km/h → 1,5 h/d time on way
Result:	**1,5 h/d unproductive time (waste) per employee**

Step 9: Evaluate the results of the current situation's analysis

The next step is to compile the results of the analyses and putting them together for an evaluation of the current situation of the production. In the current example the analysis shows that employees need to cover very long walking distances from the different machines, resulting in 1,5 hours of unproductive time per employee per day. Low division of labor and large storage areas contribute to this problem.

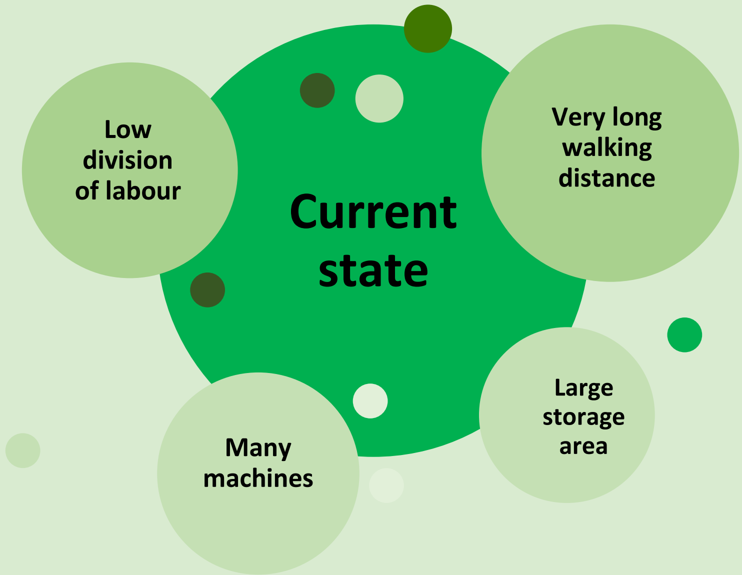

Figure 5.13: Schematic representation of the current state of the production

Step 10: Compile a reorganization strategy (release)

In a further step, the reorganization of the production area can be planned and the problems uncovered in the analysis of the manufacturing process can be tackled.
In order to do so, it is necessary to analyze the different components of the necessary equipment, followed by generating ideas on how the process flow could be altered. In our current example, two different layout variants were drafted and then compared to each other. In the original version, the entire area of the manufacturing facility was used. In the new variants, production is limited to specific areas of the manufacturing facility, thereby drastically reducing the distances and time needed by workers between the different operations. Moreover, the storage area is reduced and machines are reorganized so that they are adequately located for all necessary operations.

10.1 Define the necessary equipment

Figure 5.14 Original layout of manufacturing facility using the entire area

10.2 Reorganize the process flow

Layout variant 1

- ➔ Surface: 3300 m^2
- ➔ Number of machines: 55
- ➔ Storage area: 200 m^2

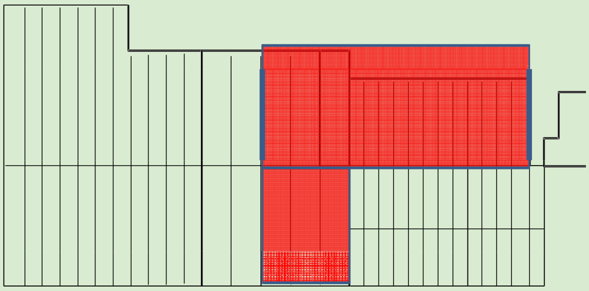

Figure 5.15: Layout variant 1

Layout variant 2

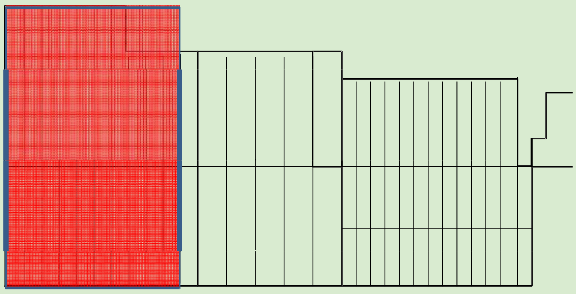

Figure 5.16: Layout variant 2

10.3 Shorten the material flow - Comparison of different versions

	Current situation	Layout V1	Layout V2
Process route for cabinets (m)	360	150	110
Route's length		**-63%**	**-70%**
Process route for coated front panels (m)	470	185	220
Route's length		**-53%**	**-60%**

Table 5.6: Comparisons of the variants

Step 11: Implement and evaluate the results

It is possible to produce up to 3 kitchens daily with 18 productive employees (before, 18 employees produced 2 kitchens per day)

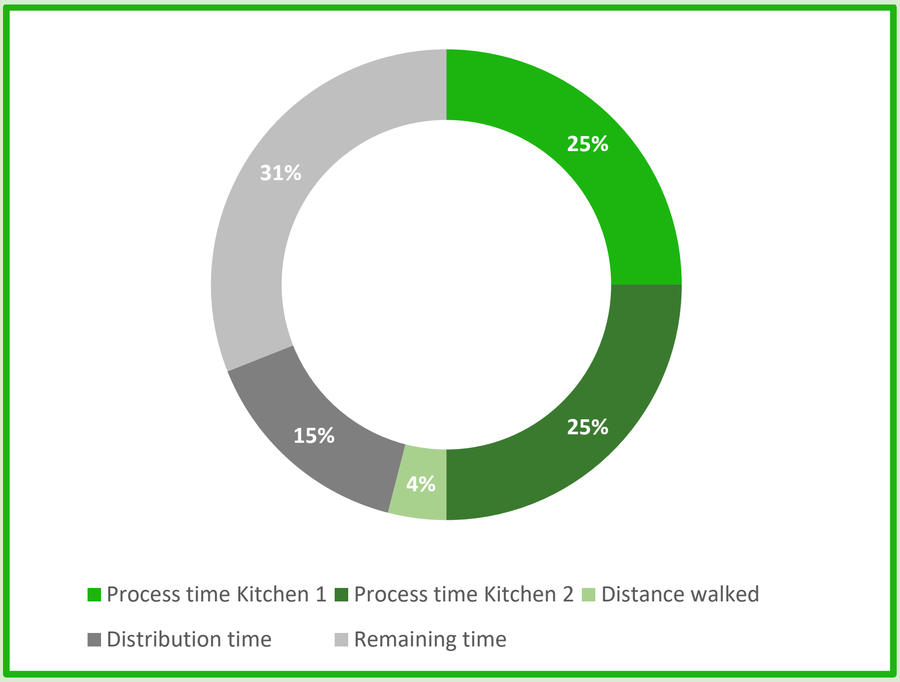

Figure 5.17: Time spent processing the kitchen's distribution, distances, and subsequent remaining time

IMPULSE

Have a look at your own company.

Where could there be time lost for carrying out certain operations or tasks?

Where could there be time saving potential?

Reorganization of production processes in 11 steps

Step 1
Decompose the product into manufacturing units (parts)

Step 2
Define respective processes and process times per part (min)

Step 3
Compile processing times per typical products

Step 4
Evaluate the processing times

Step 5
Analyze time and operations per product type

Step 6
Map required employee times & their estimated mean times

Step 7
Analyze the usage of the production area

Step 8
Investigate the different operations within the production

Step 9
Evaluate the results of the current situation's analysis

Step 10
Compile a reorganization strategy (release)

Step 11
Implement and evaluate the results

5.5 Reducing resource consumption through new procedures

Apart from reorganizing production processes, innovation can help reduce resource consumption. The next example will demonstrate this, using a case from the wood processing industry.

Example 5.5: How to reduce the resource consumption through new procedures

Innovation through procedures - Savings resulting from the development and usage of ecologically improved processing methods

Example of a wood surface smoothing tool

The sustainability-oriented development of products, processes, and services is supposed to promote an increasing impact on the conversion of existing business models towards a resource-use-lowering and energy-reducing, circular procedure. With the help of processing methods that are consistently ecologically- and sustainably-oriented, saving effects in complex processing chains can be reached.

The following example will illustrate this. The introduction of a new process (Thermo Smoothing) and a new coating technique in a wood processing plant has resulted in savings of approx. 50% in coating materials. Furthermore, energy, processing time, and storage requirements could be reduced, while at the same time, the quality of the product was increased.

'Thermo Smoothing' refers to a processing method used on medium-density fiberboards. These boards are made out of hardwood or softwood residuals, have very good milling features, and are easily processed using common woodworking methods. Thus, they have become increasingly popular as a material for facades of kitchen and corpus furniture.

The aim of the 'Thermo-Smoothing-Process' is to reduce roughness of the boards' surfaces. This is achieved by using a specific smoothing tool to machine the profiled surfaces. Using a combination of heat and pressure, upstanding material fibers are thereby smoothed out. The following illustration shows the desired effect:

Figure 5.18: Microscopic images of a milled medium-density fiberboard, unsmoothed (left) and thermally smoothed (right)

To achieve a reduction in surface roughness with common methods and without the use of Thermo Smoothing, multiple elaborate steps are necessary. These include milling, sanding, filling or priming, drying, regrinding, and multilayer application of lacquer coatings (if necessary with several intermediate drying and regrinding phases). In comparison, Thermo Smoothing saves time, effort, energy, materials, and costs, while simultaneously producing higher-quality-surfaces.

It, for instance, reduces the amount of sanding required, as well as the use of veneers for covering surfaces. Moreover, boards treated with Thermo Smoothing require only a thin layer of lamination and can be painted using powder coatings instead of liquid paint.
The use of powder coatings reduces processing time, energy/heat consumption, and required storage space. Compared to liquid coatings, the workpiece painted with powder coatings can be loaded significantly faster - after 3 min instead of 2,400 min.

Figure 5.19: Thermal smoothing tool

Overall, achieved **savings** due to Thermo Smoothing amount to **up to 50% of the originally used coating materials**. Further savings are possible depending on the type of coating, e.g. powder coatings, liquid coatings.
The example demonstrates, how a single innovative tool can replace a large number of processing steps and can greatly reduce time, energy and material costs.

5.6 How to assess costs after introduction of new products or procedures

As already mentioned in chapter 5.1 the focus in production processes is increasingly shifting towards minimal process times, maximum workloads, and high level of material efficiency. This is beneficial, not only considering competitive advantages and cost savings, but also from a circular economy point of view.

The variety of possible approaches leads to a large variety of impacts and business cases.

The variety of companies, their approaches to business, and their current economic situation leads to a number of impacts and business cases. In order to implement more circular-oriented business models, a strategic and monetary evaluation of the innovations' consequences and potential economic performance is necessary.

This may require significant investments and radical changes to production processes. The following section shows a holistic approach of determining and comparing different variants of such production processes. It can be utilized in a wide variety of sectors and company sizes.

While some enterprises chose a step-by-step-approach to change their production capacities as shown in the previous chapters, the following table shows the proceedings for more comprehensive restructuring or reorganization projects.

The goal is to determine an optimized solution amongst all the necessary choices. It requires the definition of a desired optimum within the limits of a predetermined order reserve and time horizon. The minimum possible time horizon is regimented by procurement and delivery for the materials or material modules. The order reserve may constantly change. The determination of a specific planning interval leads to an established minimum delivery period.
Potential for achieving competitive advantages develops from a company structure, in which material and partial stock costs and delivery times (process times) can be minimized.

The evaluation shown below assumes four steps that were already mentioned in chapter 5.1:

Step 1 - Process decomposition / composition: Simulated prognosis for the creation of comparable states (transfer of the existing system to the parameters of the new solution)
Step 2 - Comparison of the two solutions and the costs involved, in a variety of different yield- and cost groups
Step 3 - Examination of current and future risks for the business models and their monetary evaluation
Step 4 - Investment recommendations, including the development of recommendations for a possibly adjusted procedure

Example 5.6: Reorganization and optimization of manufacturing facilities

Reasons for the execution of a restructuring or reorganization project are generally…

- the replacement or improvement of existing production sequences
- the development of new sequences in order to adequately reduce costs

As this generally involves considerable investments, a comparison of options is done before decision making (Figure 5.20).

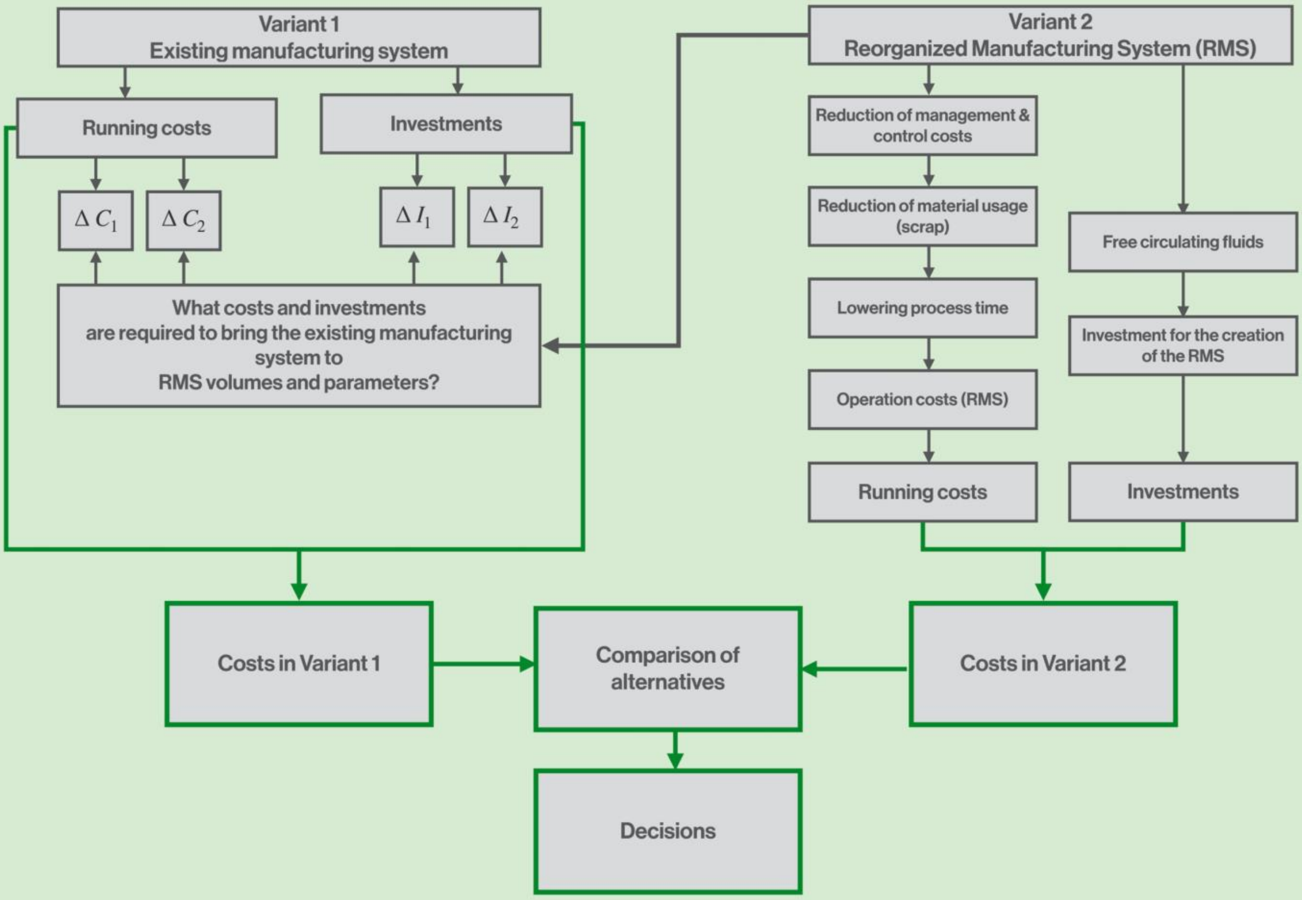

Figure 5.20: Schematic representation of the comparative approach for various options related to the benefits assessment

Figure 5.20 contains the following variables:

ΔC_1 The additional costs that would arise in the current production system if the goal is to achieve the production parameters of the automation project

$$\Delta C_1 = \sum C_{si} * \Delta N_i \qquad (5.5.1)$$

C_{si} The pro rata costs of the product i over all products

ΔN_i Increased production of product i

ΔC_2 The additional costs that would arise in the existing production system if the goal is to achieve the quality level of the new project (costs for the decrease in reject rates or use of the newest, quality-increasing, or quality-stabilizing scientific/economic solutions)

ΔI_1 The additional investments needed in the existing production system if the goal is to achieve the production parameters of the automated project

ΔI_2 The additional investments needed in the existing production system if the goal is to achieve the quality level of the new project.

The benefit of a reorganization project can be described as follows:

$$C_1 = C_{1a} + \Delta C_1 + \Delta C_2 \qquad (5.5.2)$$

with

C_1 Running costs in the existing production system taking into consideration the benefit of the achievements of the new production parameters and the new quality level

C_{1a} Running costs before the introduction

$$C_2 = C_{1a} - \sum C_i + C_B \qquad (5.5.3)$$

with

C_2 Running costs of the new system

$\sum C_i$ Sum of all cost savings

C_B Operating and service costs for the reorganized part

Accordingly, for the following investments these formulas apply:

$$I_1 = I_{1a} + \Delta I_1 + \Delta I_2 \qquad (5.5.4)$$

with

I_1 Investments in the existing production system for the achievement of the new production parameters and the new quality level

I_{1a} Investments before the introduction

$$I_2 = I_{1a} + I_{Inv} - B_{UM} \qquad (5.5.5)$$

with

I_2 Investments in the suggested improvements

I_{Inv} Sum of all investments

B_{UM} Benefit from the saving of cash assets

The benefits, i.e. the achievable savings, can be evaluated by calculating the difference between the values for the new production system and the current state.

$$B = [C_1 + (n * I_1)] - [C_2 + (n * I_2)] \quad (5.5.6)$$

with

n Coefficient of desired investment effectiveness

Overall, it becomes clear that this comprehensive approach is both meaningful and affordable for small and large companies. The approach represents the most complex form of change for businesses from the pool of all possible alterations to the operating processes. It may possibly even result in the complete adjustment of the business model. Companies can adjust their processes and procedures step by step, according to what is possible for them. If companies want to assess the possibility of an entire reorganization, the shown example can be used as an approach.

5.7 Conversion from product to service

So far, the reorganization and restructuring of processes has been introduced on a more technical level. The following real-life examples illustrate how successful conversions from products to services can look like in different organizations offering different kinds of products. The redesign of fully automatic coffee machines and vehicle components as well as a smartphone with replaceable modules are illustrated and explained as examples for durability and longevity, i.e. maintaining the product's value (and its components) for as long as possible. The idea of a virtual showroom to reduce material use and costs are explained in an additional example.

Example 5.7.1: Reparability and product lifecycle in technology: Fairphone

The Fairphone is one of the most well-known examples for business models transitioning towards more circularity within the technological sector. Founded in 2013, the company has produced a line of smartphones whose components are exchangeable and repairable.
The objectives are to keep the phones going usable for as long as possible. Throughout a phone's lifecycle, the environmental and social impact is considered and aimed to be improved. Increasing the use of fair materials and working conditions, as well as the product's lifetime and reusing recycling possibilities are the pillars of the companies' mission [36].

The businesses model and transparent approach has drawn significant public attention. The business model of the Fairphone also demonstrates the journey that companies must go through over time while working towards the sourcing, production and lifecycle management of more circular products and the tradeoffs that are necessary at some stages of a companies' or product's development.

Some consumers may be affected by some form of conflict when trying to decide whether the purchase of a more ecologically-sound product is the right choice. Consumer's expectations regarding functionality are high and a matter of course, with a variable willingness to sacrifice quality and performance, also for a certain pricing levels [37].

Nevertheless, Fairphone has more than doubled their phone sales from 2017 to 2019 which again shows the growing awareness and willingness of consumers to purchase respective products and that the company can operate in a viable and profitable way [38].

The company has also had to overcome obstacles, such as parts being out of stock or reaching their end of life due to sourcing circumstances and discontinuing the first line of Fairphones [39].
Still, they tackled the entrepreneurial challenges and are still growing their business.

A further step that is considered, is the transition of ownership towards a product-as-a-service approach in which phones may be rented to customers similar to leasing models. This makes a new approach for consumers possible as well, distributes the turnovers over the desired time period and is also a chance to coming closer to more circular technology.

Figure 5.21: Fairphone 2 modular design

Example 5.7.2: Longevity of product-service-systems and reutilization: Coffee machine

Fully automated coffee machines have become increasingly popular and are sold in a broad range of variations. The business model is based on selling the fully automated coffee machines as well as packages of coffee and coffee beans.

The condition of the machines is significantly influenced by the frequency of use, as well as the regularity of cleaning. Eventually, the machine will stop working and is then disposed. As there are many new models on the market, recycling is only possible by material decomposition.

The Swiss company "Jura" has converted its business model into a high-quality product-service-combination. Research has shown that the brewing temperature is a crucial factor for the taste of each coffee portion and does not allow for much deviation. This fact is used in order to motivate users to increase their service usage, while simultaneously integrating them in the process (logistic costs are covered by the machine's user!).

The design of the machine has been converted: Independently from their outer appearance, the machines are made up of an extendable set of standardized function modules, which have their own specified intelligence through integrated microchips. In the consumer sector, these, for example, count the number of brewed cups and signal, at a certain time, that a service time point has occurred. (In the professional sector, a corresponding signal is generated and conveyed to the service workshop via the internet, which then sends a service mechanic to fix the machine).

The customers can now visit their regional service point, at which the machine is handed over for repair. These service points are located in specified logistic hubs, centers of small towns, and shopping centers, which allow for a minimum travel distance. This makes it possible for the customers to combine their visit with other errands. Ideally, this process takes place on Saturdays (in combination with the weekly family shopping). In addition, the traditional service route via mail still exists. Customers can also receive repair information and can order spare parts for the coffee machines.

In the service sector, the submitted machine is connected to an automated diagnostic system. Here, the state of the components is diagnosed and defective components are replaced, if necessary. After about an hour, the customers can collect their retreaded machine, including the same warranty as for a new product. As a result, a life-long use of just one machine is made theoretically possible. Non-repairable damage is only expected if a serious handling error (e. g. dropping the machine), makes replacement inevitable. The service process works according to a life-long warranty service and a lasting warranty promise. At the same time, it ensures circular management of all machines and their components [40].

The extracted machine components are being repaired (or refurbished by exchanging wearing parts) in the service sector, in a separate, non-time-dependent, hierarchical process. Within the frame of this process, new machines may be assembled if needed. The components generated in this process have the quality level of new pieces and can be installed in other machines, due to the modular design. In this way, a cycle of machine use and condition warranty arises.

For the further development of this business model, an additional service step is in its implementation stage.
In the professional sector, the aforementioned internet connection to the machine can be used. This connection allows the user to:

- direct the service
- keep the machine in optimum condition
- automatically generate the order of new coffee (use is documented)

The resulting product for the user is: “fresh coffee at any time, with optimum quality”.

The first two points have also been implemented for the consumer sector, using the organization described above. A substantial part of the product are services! In order to implement a virtual ordering channel for the consumers, the possibility to order new coffee via the internet is supposed to be created. By now, a subscription service has been added, by which, e.g. through artificial intelligence, the user’s individual consumption patterns are analyzed so that orders and delivery can be automatically triggered accordingly.

This business model is vulnerable to cannibalization by emulators. If someone decides not to buy coffee at Jura, revenues from the machine and machine service are still being generated.

The amount of success this disrupted business model has, is evident by the fact that several international assembly facilities have already been erected for similar coffee machines that, under a variety of brand names and locations, offer the described product-service-combination.

Example 5.7.3: Longevity, repair and a circular system: Vehicle components

For certain safety-relevant vehicle components, very long warranty periods need to be granted (e.g., 50 years). Besides the product itself, a regular maintenance service needs to be provided.

As a consequence, the chance to create a design-initiated, circular-economy-oriented business model arises. To create such a business model, solutions that ensure the postulated functions and parameters over at least the demanded warranty period need to be developed, using research and design methods.

Usually, assembly units are used as components in the vehicle sector. These are made up of a mechanically and chemically durable casing and contain functional and wearing parts. Even when used appropriately, these internal parts have a significantly shorter life-expectancy than the casing parts.

Within the context of the designated maintenance cycles, it is possible to entirely replace these assembly units with new ones, which ensures minimal (unproductive) waiting times. This is crucial, as the economic efficiency of vehicles is determined by their product life span. The complete exchange ensures a guaranteed functional level, post maintenance.

In the context of uncoupled processes…

- the removed assembly groups can be dismounted.
- functional parts can be renewed, adjusted, or substituted.
- quality equivalent to new pieces can be obtained, and…
- the “new” assembly group can be mounted, adjusted and tested,
- which can then be installed in a new vehicle requiring maintenance.

As a result of this process, the product that was originally “only” functional, is replaced by a guaranteed warranty promise (service product) and thereby increases in value. The guaranteed durability can therefore be secure.

Example 5.7.4: The virtual showroom as a tool to reduce the material costs for the introduction and retail of new products

A virtual designer furniture salon is presented – it is localizable, customizable and variable.

For products like doors or furniture, it is common to support their market introduction and order generation by using elaborate sampling of the products in specialized showrooms. The exhibited samples can rarely cover the costs and sometimes cannot be used any further.

The integration of digital tools for product configuration and presentation can help to reduce the number of necessary physical samples and creates a new retail (business) model – retail with use of digital service tools and offers.

The use of digital tools allows new services and image factors, like…

- full digital procurement from consumer to production and assembling
- offering and using personalization services (a new product picture or "model" can be virtually composed with a photo of the consumer's living situation) from product to individual solution
- creation of retail possibilities for multi-variant products which will be produced only after signing an order (manufacturing-on-demand)

IMPULSE

Consider your own products. Is there potential for complementing or converting them to service products? Which new revenue streams could be generated from this? Which new customer groups would it attract?

6. Summary and outlook

Our last question now, is how to bring a new idea, product, or service to market. How can SMEs create products and services that, both, comply with EcoDesign principles and are still economically viable?

The analysis of economic viability and success factors for business can, again, be illustrated using the Decision Circle from chapter 0. When using this Decision Circle, as well as the topics in the respective chapters, the questions of economic viability can be answered.

The Decision circle can be used as a canvas and a process to be completed. On the next page, the topics from the Decision Circle are additionally illustrated as a checklist.

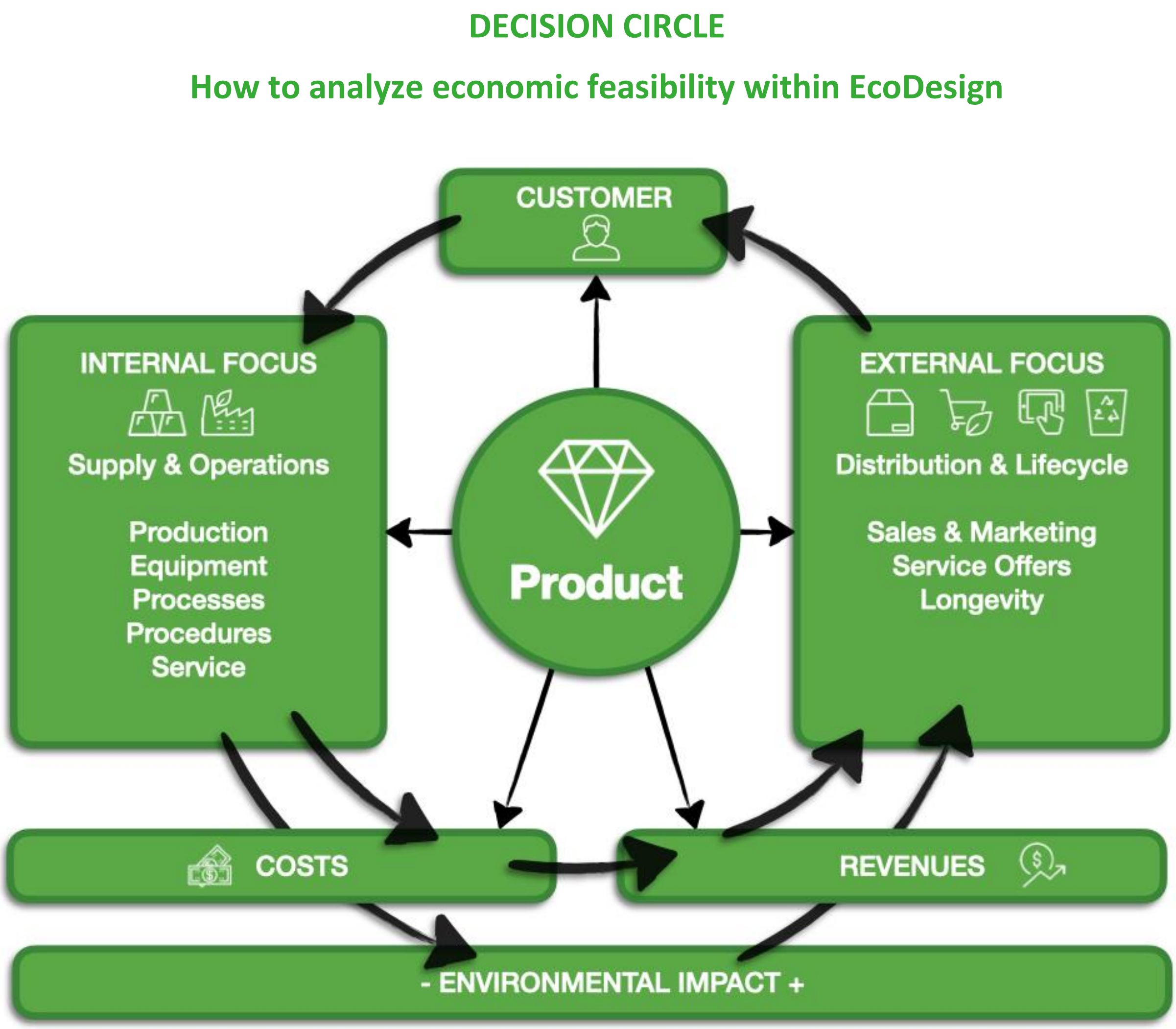

Figure 5.21 Decision Circle

Checklist of the steps within the Decision Circle

- Check if your product or service has sufficient market potential

- Check how to understand the customers to develop the best possible product for them

- Check how to set up your production:
  - Check if you need new or adjusted equipment
  - Check how to set up or adjust your processes
  - Check if you need new production procedures
- Check which service offers can be set up or added
- Remember! It increases product quality and saving potential

- Check which distribution and lifecycle aspects have which consequences in terms of costs and further expenses
- Check which service offers have which consequences in terms of costs and further expenses

- Check the revenues the product may generate
- Remember: You have the great chance to create new revenue streams, tap into new markets and increase customer retention. In this way, your product will hold its ground on the market!

- Check the costs that will incur when setting up and operating the business

- Check which environmental impacts the production and use of the product induces

What fears inhibit the implementation of more EcoDesign principles within companies?

Small and medium enterprises have the particular challenge of competing in the market. Competitors, price sensitivity and sound capacity usage are just some of the challenges they face. Regarding the shift towards more EcoDesign, there may be certain biases and fears, some of which we would like to address in short:

- Selling less: How is the increase in longevity and reparability supposed to work? Won't it result in less sales and less revenue?
- Price sensitivity: Costs for more sustainable products are higher. Is that not going to result in less sales?
- Operating costs: Are costs for the production of more sustainable products too high?

To bring an idea to market SMEs must overcome those fears and reorient themselves on the common business modelling process. It is necessary to get an unbiased picture of the actual economic potential of an idea based on EcoDesign principles and adjust one's mindset accordingly.

Furthermore, trends in the economic, societal, and regulatory framework are enhancing the chances of success and long-term growth. The way for a successful transition to more EcoDesign for product and service design is being paved and the benefit of shifting towards it is already substantial. Not only do companies have the chance to tap into new markets, but they can also gain profit along the way.

Moreover, it is important to remember that the skills needed for the described transition already exist and can be utilized. The skills, experience, and expertise on which previous lines of business were based, can be applied to the implementation, design, and management of EcoDesign-based products and services.

The motivation for this is draws strongly from the awareness of contributing to the environmental impact a company has, but also from a companies' history and the prospect of sustainable revenues and long-term growth.

References

Chapter 1:

[1] Vis, M., Mantau, U., & Allen, B. (Eds.): CASCADES: Study on the optimised cascading use of wood. No 394/PP/ENT/RCH/14/7689. Final report, Brussels, 2016.

[2] Gründl H., Heinrich V., Kellhammer, M.: Quality Standards for Circular Design - Design Criteria for Sustainable Development, Vienna, 2019.

Chapter 2:

[3] European Environment Agency: Eco-design. URL: https://www.eea.europa.eu/help/glossary/eea-glossary/eco-design.

[4] Konietzko J., Bocken N., Hultink E. J.: A Tool to Analyze, Ideate and Develop Circular Innovation Ecosystems. Sustainability, 12(1), 2020.

[5] Ellen McArthur Foundation: Infographic - Circular Economy Systems Diagram, 2019. URL: https://www.ellenmacarthurfoundation.org/circular-economy/concept/infographic.

[6] European Parliament. EXPLANATORY STATEMENT - SUMMARY OF FACTS AND FINDINGS, 2018. URL: https://www.europarl.europa.eu/doceo/document/A-8-2018-0165_EN.html

[7] Sustainablility Guide: Ecodesign, 2018. URL: https://sustainabilityguide.eu/ecodesign/

[8] acatech/Leopoldina/Akademienunion (Eds.): Raw materials for the energy transition -Securing a reliable and sustainable supply. Berlin, 2018.

[9] Angerer, G./Buchholz, P./Gutzmer, J./Hagelüken, C./Herzig, P./Littke, R./Thauer, R.K./ Wellmer, F.-W.: Rohstoffe für die Energieversorgung der Zukunft: Geologie – Märkte – Umwelteinflüsse. In: Schriftenreihe Energiesysteme der Zukunft, Munich, 2016.

[10] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB)/ Umweltbundesamt (UBA) (Eds.): Ecodesignkit, 2015. URL: https://www.ecodesignkit.de/home-willkommen/.

[11] Allwood, J.M./Gutowski, T.G./Serrenho, A.C./Skelton, A.C.H./ Worrell, E.: Industry1.61803: The Transition to an Industry with Reduced Material Demand Fit for a Low Carbon Future. In: Philosophical Transactions of the Royal Society A, 375, 2017.

[12] Wiedmann, T./Lenzen, M./Keyßer, L. T./Steinberger, J. K.: Scientists‘ warning on affluence. In: Nature Communications, 2020.

[13] International Resource Panel (IRP): Redefining Value – The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy. United Nations Environment Programme, Nairobi, 2018.

[14] International Resource Panel (IRP): Global Resources Outlook 2019: Natural Resources for the Future We Want. United Nations Environment Programme, Nairobi, 2019.

[15] European Environment Agency: Growth without economic growth, 2020. URL: https://www.eea.europa.eu/publications/growth-without-economic-growth

[16] Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU): GreenTech Made in Germany 2018. In: Umwelttechnik-Atlas für Deutschland, Berlin, 2018.

[17] Ellen MacArthur Foundation/SUN Institute/ SYSTEMIQ: Achieving Growth Within. A €320-Billion Investment Opportunity to Accelerate Europe’s Circular Economy Transition, 2017. URL: https://www.ellenmacarthurfoundation.org/publications/achieving-growth-within.

[18] McCarthy A./Dellink, R./Bibas, R.: The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches. In: OECD Environment Working Papers 130, OECD Publishing, Paris, 2018.

[19] Cambridge Econometrics: Study on Modelling of The Economic and Environmental Impacts of Raw Material Consumption. In: European Commission Technical Report, Publications Office of the European Union, Luxemburg, 2014.

[20] Forum for the Future: What is Net Positive? URL: https://www.forumforthefuture.org/net-positive.

[21] Mitchell, P. (Eurostat WRAP calculations): Economic Growth Potential of more Circular Economies, 2015.

Chapter 3:

[22] Institut der deutschen Wirtschaft Köln Medien GmbH: Deutschland in Zahlen 2020. Cologne, 2020.

[23] Bundeszentrale für Politische Bildung: Zahlen und Fakten – Die soziale Situation in Deutschland: Einkommensgruppen, 2020. URL: https://www.bpb.de/nachschlagen/zahlen-und-fakten/soziale-situation-in-deutschland/61763/einkommensgruppen.

[24] Statista: Verteilung der sozialversicherungspflichtigen Vollzeitbeschäftigten in Deutschland nach Einkommensgruppen (Bruttoeinkommen pro Monat) von 2011 bis 2019, 2020. URL: https://de.statista.com/statistik/daten/studie/577307/umfrage/verteilung-der-beschaeftigten-in-deutschland-nach-einkommensgruppen/ .

[25] Bechmann, R.: Ideenmanagement und betriebliches Vorschlagswesen. Bund-Verlag GmbH, Frankfurt, 2013.

[26] Schmillen A. / Stüber H.: Lebensverdienste nach Qualifikation: Bildung lohnt sich ein Leben lang. IAB-Kurzbericht, No. 1/2014, Institut für Arbeitsmarkt- und Berufsforschung (IAB), Nürnberg, 2014.

[27] Zentrale Markt- und Preisberichtstelle für Erzeugnisse der Land-, Forst- und Ernährungswirtschaft: Einstellungen und Käuferprofile bei Bio-Lebensmitteln. [Attitudes and Consumer Profiles in Regard to Organic Products.]. ZMP, Bonn, 2001.

[28] Bundesministerium für Ernährung und Landwirtschaft: Ökobarometer 2019: Weiter steigende Nachfrage nach Bioprodukten, 2020. URL: BMEL - Ökologischer Landbau - Ökobarometer 2019: Weiter steigende Nachfrage nach Bioprodukten.

[29] Berlin Institute for Innovation: Remote Farming – Requirements and Needs Analysis. Berlin, 2016.

[30] Berlin Institute for Innovation: Needs Analysis Recommendation & Shopping of Sustainable IT. Berlin, 2019.

[31] Berlin Institute for Innovation: Promoting sustainability through knowledge in the office and in private – An analysis of drivers for sustainable decisions. Berlin, 2020.

Chapter 5:

[32] Für-Gründer.de Redaktion: Personas: lernen Sie die Bedürfnisse Ihrer Zielgruppe kennen (inkl. Beispiel. URL: https://www.fuer-gruender.de/wissen/unternehmen-fuehren/marketing/marketingkonzept/personas/.

[33] Für-Gründer.de Redaktion: Zielgruppe; Wer kauft Ihr Angebot? URL: https://www.fuer-gruender.de/wissen/existenzgruendung-planen/idee/zielgruppe/.

[34] Sinus: SINUS-META-MILIEZS®, 2013. URL: https://www.sinus-institut.de/en/sinus-solutions/sinus-meta-milieus/.

[35] Kinkel, S./ Rieder, B./Horvat, D./Jäger, A.: Wertschöpfung lohnt - Vorteile und Notwendigkeit lokaler Wertschöpfungsketten, 2015.

[36] European Circular Economy Stakeholder Platform, Knowledge Hub, Good Practices: Fairphone created the world's first ethical, modular smartphone. URL: https://circulareconomy.europa.eu/platform/en/good-practices/fairphone-created-worlds-first-ethical-modular-smartphone.

[37] Fischer, C.. / Prieß, R. / Quack, D. / Scherf, C. / Seidl, R. / Stieß, I. Umweltbundesamt. Ökodesign als Kaufkriterium bei Verbraucherinnen und Verbrauchern stärken, 2019. URL: https://www.umweltbundesamt.de/publikationen/oekodesign-als-kaufkriterium-bei-verbraucherinnen.

[38] Fairphone Impact Report, 2019: URL: https://impact.fairphone.com/scaling-our-impact/.

[39] Fairphone Impact Report Vol. 1., 2017. URL: https://www.fairphone.com/wp-content/uploads/2018/11/Fairphone_Report_DEF_WEB.pdf.

[40] Hospitality der Zukunft: Service-Innovationen setzen neue Maßstäbe. URL: https://ch.jura.com/de/ueber-jura/coffeebreak-das-magazin/servicekonzept-interview

Further Reading

Prologue:

Tiemann, I. et al..: Developing business models with the Sustainable Business Canvas: Manual for conducting workshops. Oldenburg and Berlin, 2016.
URL: https://is.gd/U67PTv.

Joyce, A. & Paquin, R.: The triple layered business model canvas: A tool to design more sustainable business models. In: Journal of Cleaner Production, 2016. URL: https://is.gd/zLKVQG.

Chapter 1:

Bruel, A./Kronenberg, J./Troussier, N./Guillaume, B.: Linking Industrial Ecology and Ecological Economics: A Theoretical and Empirical Foundation for the Circular Economy. In: Journal of Industrial Ecology, 23(1), 2018. URL: https://is.gd/ioyQc2.

Ghisellinia, P./Cialanib, C./Ulgiati, S.: A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems. In: Journal of Cleaner Production, 114, 2016. URL: https://is.gd/G6GXmK.

McArthur E.: Towards the Circular Economy – Economic and Business Rationale for an accelerated Transition. In: Journal of Industrial Ecology, 2013. URL: https://is.gd/c7ZcEA.

EcoDesign Audit and Sprint approaches. URL: https://circulardesign.tools/.

Sustainability Guide. URL: https://sustainabilityguide.eu.

Chapter 2:

European Union: Circular Economy Action Plan. For a cleaner and more competitive Europe, 2020.
URL: https://is.gd/LEzW9E.

German Environment Agency and International Design Center Berlin: German Ecodesign Award: Criteria Matrix, 2020. URL: https://is.gd/hM53Xh.

Nordic Innovation: Nordic Circular Economy Playbook, 2021. URL: https://is.gd/Umud6Q.

Vermeulen, W./ Witjes, S.:
Circular Economy 3.0 - Solving confusion around new conceptions of circularity by synthesising and re-organising the 3R's concept into a 10R hierarchy, 2019. URL: https://is.gd/WaN86q.

Chapter 3:

Revella, A.: The buyer persona manifesto, 2011. URL: https://is.gd/PB8fN5.

Chapter 4:

Russo D. / Spreafico C.: TRIZ-Based Guidelines for Eco-Improvement, 2020. URL: ttps://is.gd/bxMcVt.

Russo, A.: VIRTUAL ECO-DESIGN: An eco-design approach driven by virtual prototyping and knowledge management to support the development of sustainable products, 2018. URL: https://is.gd/wjv5Ss.

Image Credits

Adobe Stock
j-mel / p. 1

Volha Hlinskaya / p. 24, 25

Training modules for SMEs - Bern University of Applied Sciences/GIZ / p. 42, 45 - 48

Thermo Smoothing - Bern University of Applied Science / p. 53

Innotech/BFH – dto. / p. 54

Fairphone / p. 59