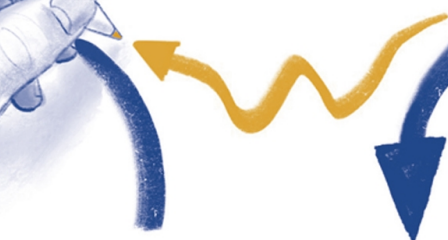


Karine Van Doorselaer  
Rudolf J. Koopmans

# Ecodesign

A Life Cycle Approach for  
a Sustainable Future



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Van Doorselaer / Koopmans  
**Ecodesign**



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Rudolf J. Koopmans

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A Life Cycle Approach  
for a Sustainable Future

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*With 30 years in this field I have learned that:*

- ✓ *We are too slow, too late, and do too little, we rediscover the same solutions and give them new names, but we still use them too late, too slowly, too sparsely.*
- ✓ *In our short-sightedness we overreact to crises but muddle through at high pains and costs.*
- ✓ *Business, while lucid about the risks and publicly vocal for change and innovation, largely undermines reasonable transition policies for its short-term comfort and gains.*

*Yes, it sounds bitter and pessimistic.*

*Yet I keep pushing and getting results in my direct sphere of influence.*

*Everyone can do it. It will add up!*

**From a 2020 exchange with Claude Fussler,  
author of *Driving Eco-Innovation* (1997) and *Raising the Bar* (2004)**





# Acknowledgments

In 1995, I taught the course “Ecodesign” for the first time. In those days, among consumers, “ecodesign” was perceived to relate to products made out of biomaterials or to making art out of discarded products. For companies, implementing ecodesign in the design process was considered a time- and money-consuming effort, bringing benefits for other stakeholders in the value chain. For example, the “design for recycling” guidelines favor the recycling companies, but do not provide any benefit to the company producing a product.

Now, 25 years later, ecodesign is considered as a key to success for the transition to a circular economy model in which the development of new business models and close value chain stakeholder collaboration is the challenge. The notion that the environmental impact and circularity of products are particularly determined during the design phase, the phase in which numerous choices are made, has pervaded.

The hope is that in the next 25 years we can look back on a successful transition period to a sustainable, livable society with respect for fauna, flora, and all the natural resources.

The reset of the economy worldwide after the Corona pandemic, now in 2020, is the perfect opportunity to invest in industries and business models based on the principles of sustainability and circularity. Governmental actions already have been taken by the EU, with, for example, the “European Green Deal”. Growing environmental concerns of consumers support the economic and industrial shift towards a sustainable world.

Special thanks to the co-author of this book, Prof. Dr. Rudolf Koopmans. He proposed to translate and rework the Dutch-language book *Ecodesign*. He broadened the scope of the book by inserting extra interesting information. He also took care of the enormous editorial work, so I could concentrate on the content of the book. We have learned from

each other. The intense collaboration was my invitation to describe and articulate the ecodesign theory very carefully, so that no misunderstandings may arise.

Furthermore, I would like to thank my colleagues from the Department Product Development of the University Antwerp, Belgium. Many thanks to Mr. Wim Maes for making the nice figures according to the house style of the book; Prof. Dr. Alexis Jacoby, for his contribution on the state-of-the-art information concerning the design methodology; and Prof. Dr. Ingrid Moons, for the explanation of some economic themes.

Many thanks go to Simon De Meulenaer, the cartoonist of the book. His beautiful cartoons give an extra look to the book.

I also would like to thank the graduates of the Department Product Development of the University Antwerp in Belgium for their presentation of their master's theses: Frederik Carette, Laure Herweyers, Thomas Roscam, Nicholas Van Beylen, and Robrecht Vandekerkhove.

And finally, I would like to thank those responsible at the publishing house Carl Hanser Verlag for giving us the opportunity to spread our knowledge about ecodesign.

*Karine Van Doorselaer* – Antwerp, Belgium – October 2020

The future is unpredictable as unplanned events can change the course of history. In 2017, having been invited by the European Commission to participate in a team of experts for writing up what the R & I (research and innovation) state of play of plastics was (A Circular Economy for Plastics – 2019), I first met Prof. Dr. Karine van Doorselaer. Her interest in and passion for sustainability was so stimulating that I invited her to give a talk on the topic at our PICC – Plastics Update Conference in November 2019 in Fribourg, Switzerland. During our joint dinner, the same evening she mentioned having written a book, *Ecodesign*, in Dutch and promised to send me a copy. She did and I read the book in a few days. The book was so inspirational that I asked her about an English version to reach a larger audience. When I said I would do the translation and spend the time needed, Karine agreed to go for the English version as suggested. So I set off on a challenging journey that quickly became more than “just me translating” and resulted in conceiving together a new book. On March 15, 2020, the Corona pandemic forced us to stay home, which actually enabled me to finish the job. In the endeavor I also got some help from my native-speaking English/American friends, who were kind enough to read the first version and provide some insightful suggestions as well as some spelling improvements. Thank you, Malcolm, thank you, Bob!

Overall for me, it was a rewarding experience in which I learned a lot. The available information (and some disinformation) on the topic of sustainability and associated themes is so overwhelming, it becomes difficult to see the forest for the trees. And I think I can speak for Karine and me: this book is a good starting point to see the forest and find a path through the trees. Enjoy!

*Rudy Koopmans* – Halle, Germany – October 2020



# Reading Guide

This reading guide aims at bringing a better understanding of the book's structure. It provides a brief summary of the topics addressed in the different chapters. Chapters can be read as self-standing units or read consecutively or in any desired order, with the exception of Chapter 1, which needs to be read first.

This book addresses three main themes that may guide designers, organizations, governments, and companies or anybody who seeks to understand the role of ecodesign in a circular economy model and with an interest in finding a path towards a sustainable future. The first theme explains ecodesign for what it is and how ecodesign is related to the circular economy model. It draws attention to ecodesign as a product life cycle approach for developing sustainable products with the least possible ecological impact but also to ecodesign as a system approach for preserving a healthy and sustainable society (Chapters 1, 2, 3). The second theme looks into the details of implementing ecodesign in a product development process including the use of ecodesign tools and how this design approach can be stimulated for use (Chapters 4, 5, 6, 7). The third theme elaborates on the transition towards a sustainable society within a circular economy model as the responsibility of all citizens. It exemplifies the impact of the ecodesign approach on major stakeholders such as companies, governments, and consumers (Chapters 8, 9, 10).

*Chapter 1* introduces the book with general information on design and ecodesign; “why, what, and how”. It is important to read this chapter first to get the right picture of what industrial design and ecodesign stand for and what is the role of the designer. After reading this chapter all concepts are explained, so that there is no confusion regarding the definition and meaning of the terms and specific words used in this book.

*Chapter 2* frames the need to implement ecodesign in the design process within the environmental problems that current and future generations will be confronted with. In

this chapter information is provided on the explosive growth of the world population, the rate at which resources are depleted, and the ecological footprint of humanity. A brief historical overview shows some milestones and initiatives that have triggered awareness and action relating to the many environmental issues.

*Chapter 3* gives a clear overview of the many concepts, models, and approaches that have the ambition to create a society with respect for the people and the planet, from “sustainable development” to “a circular economy model”. The reader gets insight into the relevance of the different approaches, their similarities and differences, and their relationship with ecodesign.

*Chapter 4* presents all the “design for X” guidelines. The X stands for the different stages in the life cycle of a product. Ecodesign stands for life cycle thinking, in which the designer strives to minimize the ecological impact of each stage of the life cycle and to optimally close the product and material cycles. The ecodesign rules of thumb guide the designer as they are clustered according the life cycle stages. The “design for X” guidelines are the basis for the qualitative ecodesign tools.

*Chapter 5* elaborates on the different tools the designer can use to implement ecodesign in the development process. A distinction is made between strategic tools, relating to a sustainability strategy development as a business policy, and the tools used to evaluate and verify the ecological impact of a product. The latter tools focus on the opportunities to minimize the ecological impact of products and to optimally integrate the principles of the circular economy model into the design. These tools are based on the product life cycle thinking concept. Two categories of tools are distinguished: the quantitative tools and the qualitative tools. In the former case, the estimated ecological impact is expressed in quantitative numbers. In the latter case, the “design for X” rules of thumb are applied as qualitative ecological impact evaluation tools. The possibilities and limitations as well as the advantages and disadvantages of both types of tools are discussed so the choice and use of the tools can be done in a well-considered manner.

*Chapter 6* describes in detail how ecodesign is implemented in the product development process. Depending on the expected and desired degree of innovation, the implementation of ecodesign is relatively simple to very complex. With a low degree of innovation, the implementation of ecodesign is limited to include ecological criteria in the product requirements. With highly innovative design challenges, ecodesign can be considered as system design with a very high complexity.

*Chapter 7* gives a brief overview of disciplines that can stimulate ecodesign solutions, in particular, learning from nature and learning from the past.

*Chapter 8* describes the drivers and challenges for industry to implement ecodesign in a business operation and in the product development process. The integration and adoption of sustainability at different organizational levels are discussed: company leadership, operational level, product level.

*Chapter 9* discusses the role of governance in the transition to a sustainable and circular economy model. Relevant standards, guidelines, legislation, and labels related to eco-

design are discussed. A brief overview is presented on the possibilities that governing bodies have to stimulate ecodesign via public procurements and investments.

*Chapter 10* gives a brief insight into sustainable consumption. A good understanding of exactly how environmentally conscious present and future consumers are is essential for comprehending the role of ecodesign in promoting sustainable consumption. Some international studies are discussed to get an indication of the consumers' behavior in relation to their attitudes and environmental consciousness. Some governments' instruments like the ecolabel are discussed to steer the consumer towards a more sustainable behavior.

*Chapter 11* concludes the book with a summary of ecodesign as an essential approach and methodology to address the main challenges and hurdles on the path towards a sustainable future as first expressed in "Our Common Future" by the Brundtland commission in 1987.



# About the Authors

Prof. Dr. **Karine Van Doorselaer** (born in Belgium in 1965) graduated in 1986 from the University of Ghent, Belgium, as industrial engineer in chemistry with specialization in plastics. In 1990 she finalized the program “Human Ecology” at the University of Brussels, where in 1999 she obtained her PhD in human ecology.

Between 1986 and 1990, Karine worked in the technical laboratory “Polymers” of Exxon Chemical. In April 1990 she switched to the academic world and started as assistant in the polymer laboratory at the department Product Development of the University of Antwerp, Belgium, later being promoted to lecturer (in 1995) and senior lecturer (in 2016). Since 1995 she teaches the course “Materials Science, Selection of Materials and Production Techniques”. In that same year, she set up the course “Ecodesign”. For a quarter of a century, Karine has been guiding future designers into the world of materials and on how they can design products that fit in a sustainable and circular economy. She is often invited to various educational institutions and companies to provide knowledge and advice on ecodesign, and has worked on numerous government projects to integrate ecodesign into policies.



Prof. Dr. **Rudolf (Rudy) J. Koopmans** fosters creative thinking that stimulates innovative science and technology, and advances application development that contributes to a sustainable society. Presently, he is Director of the Plastics Innovation Competence Center (PICC – [www.picc.center](http://www.picc.center)), Director of the Institute of Applied Plastics Research, and Professor at the University of Applied Sciences and Arts of Western Switzerland (HES-SO–HEIA-FR) in Fribourg (FR). As owner of Koopmans Consulting GmbH, located in Zürich, Switzerland, he provides industry consultancy on innovation and sustainability challenges. As a former R&D Fellow at The Dow Chemical Company, he brings more than 35 years of experience in the plastics industry. As a PhD graduate in physical and macromolecular chemistry (University of Antwerp – Belgium) and Master in Business Administration (KU Leuven – Belgium / INSEAD – France), he combines deep technical knowledge with business metrics to advance evolutionary and disruptive innovation.



At ETH Zürich (Switzerland), he lectures at the Department of Materials Sciences, where he also received the Staudinger-Dürer Medal for excellence in Materials Science. He is member of the Wetenschappelijke Advies Raad of Catalisti for advising on R&D projects for the Region of Flanders (Belgium). In addition, he is board member of the Swiss Plastics Cluster, Kunststoff Ausbildungs und Technologie Zentrum (KATZ) (Switzerland), expert evaluator for the EU Research and Innovation Framework Programmes, and assembly member of the Horizon Europe Mission Healthy Oceans, Seas, Coastal, and Inland Waters.

He has published more than 70 papers in international journals, contributed several book chapters, wrote or co-wrote four books, presented multiple keynotes at international conferences, and is holder of 22 patents.

The cartoons at the beginning of each chapter and on the cover of this book are the work of **Simon De Meulenaer**. Simon graduated in 2015 with a Master in Product Development from the University of Antwerp, Belgium.



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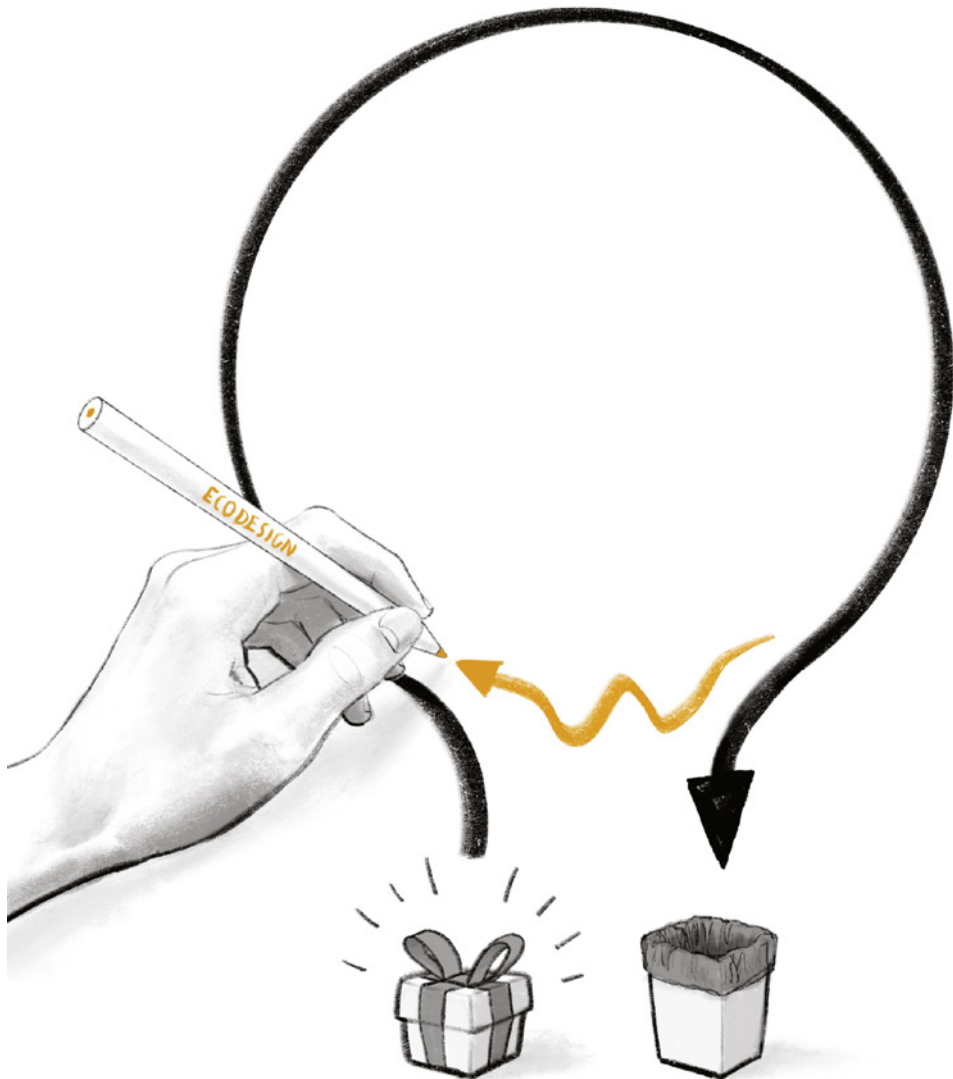
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# 1

## Introduction





*Fight for the things that you care about,  
but do it in a way that will lead others to join you.*<sup>1</sup>

Ruth Bader Ginsburg, American lawyer and jurist (1933–2020)

All manufactured products are the result of a design process. However, a distinction needs to be made between industrial design and craft-based design. The former stands for a process of design applied to products that are to be manufactured through techniques of mass production. The production of products is a repetitive act, often automated, for generating large quantities at the lowest possible cost. The objective of large-volumes production thus impacts the product design criteria because the products need to fit the techniques enabling mass production. In a craft-based design, in contrast, the actual design and manufacturing of a product are closely integrated. The craft-based designer defines the product and the manufacturing, which are often a creative act. In this book, the focus is on industrial design. Here, the word “design” does not relate to the development of creative products by artists and craftsmen, where the focus is mainly on the aesthetics [1, 2].

Typically, the products developed by the designer are divided into three groups: consumer products (e. g., toys, packaging, household products), industrial products (e. g., air compressors, medical scanners), and products for public services (e. g., railcars, bus stop shelters). The designer works independently on behalf of companies or as part of the design team of a company. As individuals, they often work on small-scale product designs such as toys and kitchenware. As part of a larger team the designer may contribute to the design of complex systems such as city centers, industrial products, or bus cockpits. An industrial designer does not design engines, electrical circuits, or gearboxes; that is the job of engineers. However, the designer may impact the technical aspects through considerations on the usability and form relationships. For example, a car engine needs to be constructed such that it fits into a comfortable, functional vehicle for use with an appealing form that consumers are willing to buy.

---

<sup>1</sup> Speech at Radcliffe Medal event, 29 May 2015, Harvard University, USA.

The role of an industrial designer is to create and execute design solutions for problems of form, function, usability, physical ergonomics, brand development, sustainability, marketing, and sales. The industrial designer is educated to develop a product that fulfills all the economic, technical, and human-related requirements by following a design methodology. In addition, the designer must have knowledge of all economic, technical, societal, and environmental product-related aspects. The designer is a generalist and not a specialist in a single product-related aspect. As needed, the designer is therefore assisted by specialists; for example, engineers, graphic designers, marketeers, material specialists, environmental experts, economists. The design process is mostly conducted by the designer supported by a team of specialists. It combines intuitive creativity with calculated scientific decision-making. The process is influenced by product design requirements that touch upon topics as varied as materials, production processes, business strategy, social, commercial, and human-centered product use criteria [3].

In the transition towards a sustainable society and a circular economy model, the designer will have a critical role by implementing environmental criteria in the design process. It is estimated that the ecological impact of all products is up to 80% settled already in the design phase [4]. In addition, in the design phase equal thought must be given to find opportunities for closing the product loop according to the principles of the circular economy model.

Ecodesign is the discipline that guides the designer to implement the ecological impact of products in the design process. The whole life cycle of the product is considered, starting from the mining of the raw materials over the production of the materials and the products until the use of the product. After the use phase, the aim is to close the cycles by encouraging the reuse of the products and the recycling of the materials. By implementing ecodesign in the product development process the designer can influence the environmental impact of products concerning the complete life cycle. Ecodesign is much more than just selecting a bio-based material for the product. It is a major fallacy that bio-based products are the ultimate solution to address environmental problems. Maybe unfortunately, but presently the use of biomass as a raw material is not without its ecological impact. For example, the production of biomass leads to soil pollution and a reduction of biodiversity through the use of pesticides, high water consumption, and eutrophication through over-fertilization. Moreover, the possibilities for composting or recycling bio-based material are limited. Today, for example, packaging made out of compostable plastic such as polylactic acid (PLA) disrupts the industrial composting process; the consequence is that the packaging needs to be sorted out and is eventually incinerated together with all other non-compostable material. The compostable plastics can cause also contamination in the recycling stream of non-compostable plastics when not presorted. As a result, compostable plastics in packaging cause more hassle and problems than their originally intended purpose. Optimization of sorting techniques and composting processes can be a future development target for recycling compostable plastics to tackle the current problems.

Ecodesign is about “sustainable use of materials”, as there exist no “sustainable materials”. The materials should fulfill the optimal criteria for the complete life cycle of the

product in combination with a low ecological impact, e. g., low energy consumption for converting feedstock to materials, low weight for reducing transport energy during distribution, being technically robust for a long usage phase, being recyclable.

Ecodesign is also much more than making art from discarded products, such as making lampshades or fruit bowls from LPs, or chairs made of bathtubs cut in half.

The challenge for the designer is to implement the holistic approach of ecodesign. The ecological impact of the product life cycle may differ from region to region or continent to continent. It is not about a one-size-fits-all but about adapting the product life cycle to the prevailing ecological system. The product that fulfills a required function, e. g., the ability to drink water, can be conceived differently to achieve its full sustainable conception depending on the context. A solution for Europe may not be a proper solution for any other part of the world. While polyethylene-terephthalate (PET) drinking bottles can be 100% collected, recycled, and kept very long in a loop with a very low ecological impact in Europe when having the proper infrastructure, this product may not be a solution for other places on Earth where no such infrastructure exists. The systems are different.

The current global economic model is based on the linear concept in which raw materials are extracted, mined, or harvested and converted into products that are mainly burned or landfilled after use. This is the so-called “take-make-waste economy” [5]. This economic model is not sustainable because of the depletion of raw materials, the faster consumption of renewable resources than can be grown, and the negative impact on the total environment. This all relates to the increased demand for products from an increasing number of world citizens and the corresponding increased affluence for many.

Certainly, for Europe, a new approach is imperative, as there are virtually no raw materials on the European continent, making the European economy and society increasingly dependent on other continents. The answer to this critical situation by the European Commission is the “European Green Deal”, a new growth strategy that aims to transform the EU into a fair and prosperous society. The ambition is a modern, resource-efficient, and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use [5]. The motor of this ambitious plan of the European Commission is the transition to a circular economy model. The essence of the circular economy is to preserve the value of products built up through the value chain for as long as possible by reusing products and materials as much as possible. This has inspired new business models such as “product as a service” (PaaS), in which services are offered to meet needs of consumers while the products that provide these services remain the property of the producing company. Ecodesign and the designer have a very prominent role to play in this transformation. For example, the business model “product as a service” will only be successful when the products that remain the property of the company are very robust, repairable, easy to disassemble, and the materials are recyclable. The implementation of the ecodesign rules of thumb (Chapters 4 and 5) in the product development process is essential.

A key to success in the circular economy is collaboration between all the stakeholders of the value chain, e. g., material suppliers, marketeers, retailers, recycling companies,

investors, technology providers. As ecodesign is based on life cycle thinking, the designer needs the expertise from all those stakeholders. For example, should the designer decide to select a recyclable material for the product under development, the designer needs to get information from the materials suppliers on whether the material is recyclable, and from the collection and recycling companies on whether there are recycling programs for that specific material to recycle it effectively. The designer has a key role in this necessary value chain collaboration.

Not only the stakeholders of the value chain should work together, but also all stakeholders in society should participate and engage. To create a sustainable future, governments, industry, investors, and, last but not least, consumers – essentially all citizens – need to align themselves. There is an important interaction between all these stakeholders. For example, legislation can steer industry to reduce the environmental impact, which can benefit the quality of life of citizens. The designer can steer the consumer towards a sustainable behavior by integrating the “human-centered design” approach. Human-centered design applies human factors, ergonomics, usability knowledge, and techniques to interactively develop systems that aim at making products usable and useful by focusing on the users’ needs and their functional requirements [6]. By integrating the “design for sustainable behavior” rules of thumb, ecodesign is not only focusing on the environmental impact of products but also on the social aspects, such as sustainable behavior.

The ease or difficulty of implementing ecodesign depends on the desired level of innovation. For example, in relation to the specifications for a redesign, it is relatively easy to use the ecodesign rules of thumb and some appropriate ecodesign tools. The design process does not change more drastically than the additional inclusion of ecological design criteria in the design brief. When striving to design products with a high degree of innovation, the design context becomes quite complex, so that one speaks of system design. System thinking is a scientific approach that takes a holistic look at the whole instead of focusing on the individual components. System thinking is a quite new approach within design in general. A small range of tools is already developed to steer this complex design approach.

In summary, ecodesign is a design approach that focuses on minimizing the ecological impact over the complete life cycle of products and supports the strategies of the circular economy model. The designer will integrate the ecodesign rules of thumb in an optimal way in relation to the economic, social, and human product requirements. The implementation of ecodesign is supported with specific tools, which can be used at the different stages of the design process. The ease or difficulty for integrating ecodesign depends on the desired level of innovation: the higher the level, the more complex the process gets, with the ultimate challenge in which ecodesign is considered as system design.

Ecodesign is a broad discipline with actionable methodologies at different levels – product and system – to guide the designer in developing sustainable products.