

# EXTENSION OF THE TEN GOLDEN RULES TOWARDS ASPECTS OF HOLISTIC PRODUCT DEVELOPMENT

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## ABSTRACT

The Ten Golden Rules for promoting sustainability in product development offer a simple and practical method for integrating ecological principles into the development process. This method has proven particularly successful in small and medium-sized enterprises (SMEs) and small development teams, as it provides easy-to-understand and cost-effective guidelines that can be implemented without extensive resources. In essence, the 'Ten Golden Rules' aim to minimise material consumption, avoid environmentally harmful substances, promote product longevity and improve reusability and recyclability. In this contribution, an approach is developed to take up the perspective of the Ten Golden Rules and expand on them. In order to be able to use it as an up-to-date, holistic project alignment tool to be used in the context of product development projects at the university. A central aspect of the further development of the method is the greater consideration of social sustainability. This extension ensures that not only ecological, but also ethical and social aspects of the value chain come into focus, enhancing educational dissemination. This includes fair working conditions and transparency in the supply chain. Promoting modularity and reparability is increasingly seen as key to extending product life and minimising waste. These advancements not only prepare students for real-world challenges but also pave the way for innovative and sustainable solutions.

*Keywords: Ten golden rules, design methods, sustainability*

## 1 STATE OF THE ART

The "Ten Golden Rules" (TGR) of environmentally friendly product development are guidelines designed to optimise the life cycle of a product with regard to its environmental compatibility. They were first introduced in the 1990s and serve as an aid for designers to systematically integrate ecological aspects into the design process. The rules formulated by Luttrupp and Lagerstedt cover various aspects of product development, including the selection of environmentally friendly materials, increasing energy efficiency during use and improving recyclability at the end of the product's life. The underlying philosophy of these guidelines is based on considering the entire product life cycle and understanding sustainability as an integral part of the development process [1]. (cf. [2, 3]) While the state of the art supports TGR application, the research section is brief. A deeper comparison like work on Ecodesign trade-offs (cf. [2]) could illuminate current research highlights and gaps.

## 2 TEN GOLDEN RULES

The much-cited concept for sustainable product design by Luttrupp and Lagerstedt [4] is presented in ten guidelines, which are intended to represent a generalisation of various company-specific guidelines. The guidelines are to be adapted by the developers to the context and process of the project. As a result of the deliberate adaptability, the concept has been successfully applied in companies such as Ericsson and Bombardier [4].

The TGR are structured according to the life cycle of a product. Each rule is assigned an image that visualises the respective focus of the rule (Figure 1). The example of a generic version of the TGR shows how these are structured in categories [4]:

- PRE USE:
  1. use of closed cycles for necessary toxic substances or complete avoidance of toxic substances.
  2. minimising energy and resource consumption in the production phase and during transport through improved housekeeping.
  3. using structural features and high-quality materials to minimise product weight without compromising required flexibility, strength or other functional priorities.
- USE:
  4. minimise energy and resource consumption in the use phase, especially for products with the most important aspects in this phase.
  5. promote repairs, maintenance and upgrades, especially for system-dependent products (e.g. cell phones).
  6. promoting a long service life, especially for products with significant environmental aspects outside the use phase.
  7. investing in better materials, surface treatments or structural precautions to protect products from contamination, corrosion and wear and tear to ensure lower maintenance and longer life.
- AFTER USE:
  8. provide for upgrade, repair and recycling through accessibility, labelling, modules, predetermined breaking points and manuals.
  9. promote upgrading, repair and recycling by using fewer, simple, recycled, non-mixed materials and no alloys.
  10. use as few fasteners as possible and use screws, adhesives, welded joints, snap-fits, geometric interlocks, etc. according to the life cycle scenario.

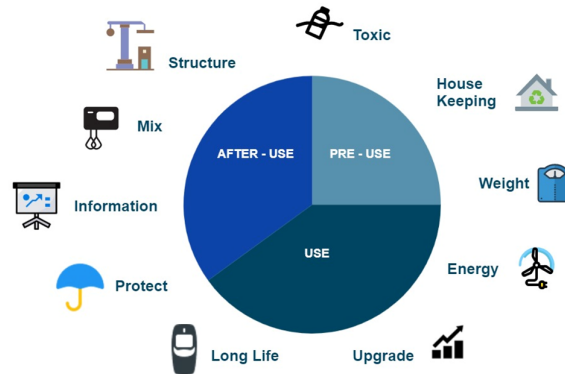


Figure 1. Overview of the Categories of the Ten Golden Rules [4]

These 10 rules are kept general so that they can be specifically and individually adapted, concretised or further developed. For the first rule of not using toxic substances, for example, it is possible to determine which toxic materials are used in the existing product and to research a non-toxic substitute that continues to meet the functional and economic requirements of the product. Furthermore, closed loops can be created or used for recycling the materials. A clear formulation of rule eight can be, for example, that the materials should be labelled and that products must be designed in such a way that they are easy to maintain. Numbers nine and ten may include the following detailed wording to generate the desired product safety objectives: Provide instructions for the disposal and recycling of toxic and scarce materials contained in the product [4].

## 2.1 Application

In the literature, TGR are described as guidelines designed to help companies minimise the environmental footprint of their products. They are used in various industries, from electronics and industries to the consumer goods sector. The focus is on a holistic view of the product and its life cycle.

### Procedure

The guidelines of TGR are first discussed in the team and the project-specific concretisations are

formulated in a context-sensitive manner. Based on this, project-specific measures and conclusions can be discussed in order to align the project with the guidelines. It is advisable to clarify the basic understanding based on the template structure proposed in the literature and then continue with the situational and individual design of the rules.

### **Limits and alternatives**

The strategies serve the qualitative project orientation. Due to the simplicity of the technique, results based on this should be additionally (quantitatively) validated.

### **Modularity and adaptability**

The high modularity and adaptability of the method in product development is due on the one hand to the low complexity of the strategies, but also to the context-sensitive adaptability of the individual strategies/guidelines. Products are designed in such a way that they can be easily modified or upgraded in order to extend their service life and enable the use of new materials or technologies. This promotes sustainability through longevity and flexibility [5].

## **2.2 SME perspective**

TGR offer numerous advantages for SMEs and small development teams. This method is well suited as it is relatively easy to use and does not require complex or costly technologies that are often difficult for smaller companies to access. Below are some conclusions from the case study as to why this method is particularly suitable in the context of SMEs and small development teams:

1. **Pragmatic and easy to implement principles** | The TGR provide a practical set of guidelines aimed at simple but effective actions. For SMEs, which often work with limited resources, these rules are easy to understand and can be implemented without extensive training or large investments. For example, SMEs can immediately start to use less materials sparingly, choose environmentally friendly materials and reduce energy consumption in production without the need for extensive research or development resources.
2. **Cost efficiency through sustainability** | Sustainability is often associated with additional costs, but the application of TGR can lead to cost reductions. By optimising the use of materials, reducing waste and saving energy, SMEs can not only reduce their environmental impact but also lower their operating costs. For example, by reducing material waste and using more durable materials, SMEs can lower their production costs while extending the life of their products, resulting in fewer complaints and lower support costs.
3. **Competitive advantage through sustainability** | More and more consumers and business partners prefer sustainable products and pay attention to the environmental responsibility of companies. For SMEs, applying the TGR can be a competitive advantage as they can position their products as environmentally friendly and differentiate themselves in an increasingly environmentally conscious market. SMEs can emphasise the sustainability of their products in their marketing and thus appeal to new customer groups who make environmentally conscious purchasing decisions.
4. **Easy integration into existing processes** | The TGR can often be integrated into existing development and production processes without drastic changes. This makes them particularly attractive for SMEs and small development teams that do not have the capacity to change their entire processes. For example, small development teams can integrate the rule “Avoid the use of environmentally harmful substances” directly into material procurement by switching to non-toxic alternatives without having to change the entire manufacturing process.
5. **Promoting creativity and innovation** | The TGR encourage development teams to find creative and innovative solutions to make their products more sustainable. This can be particularly motivating for smaller development teams, as they often have more flexibility and agility than large companies to test and implement new ideas. For example, a small development team can come up with innovative design solutions that allow products to be repaired or recycled more easily, which not only extends the life of the product but is also well received by customers.
6. **Step-by-step implementation possible** | In contrast to complex sustainability strategies that require comprehensive changes, the TGR can be implemented step by step. SMEs can start by applying one or two rules and then gradually move on to the others. This flexibility allows small development teams to start with their existing resources and continuously improve. A company can start by minimising waste during production (rule 9) and later move on to more complex rules such as design for disassembly and recycling (rule 4).

7. **Focus on durability and quality** | One of the central ideas of the TGR is to extend the lifespan of products (Rule 3). For SMEs, which often serve particular niche markets, this can be a decisive advantage, as high-quality and durable products often result in greater customer loyalty and fewer complaints. A small business that focuses on durable, repairable products can position itself as a quality provider and build customer loyalty.
8. **Improved collaboration and communication** | Applying the TGR often requires close collaboration between different departments of a company. This can be an advantage for SMEs, as small development teams often have shorter communication channels and can work together more efficiently. Implementing sustainability rules can encourage collaboration between the development team, production and sales, leading to a better overall understanding of product development.
9. **Adaptability to specific industries and products** | The TGR are deliberately kept general so that they can be easily adapted to the specific requirements and conditions of different industries and products. SMEs operating in niche markets can interpret the rules flexibly and apply them to their specific products. For example, an SME that develops electronic devices can pay particular attention to energy efficiency during use (Rule 5) and the recyclability of components (Rule 4), while a company that produces clothing can focus on material savings and environmentally friendly fabrics.

By successfully applying the TGR, SMEs can gain access to subsidies or tax benefits that are provided for companies that implement sustainable practices. The SME perspective provides valuable insights. However, including examples from other IDE projects, could strengthen the thematic relevance.

### 2.3 Interim conclusion

The sustainable principles aim to integrate sustainability aspects into the development process by providing simple and clear guidelines that describe the entire life cycle of a product. The Ten Rules cover various aspects such as choice of materials, energy consumption, durability and recyclability. It offers SMEs and small development teams a simple, flexible and effective method for integrating sustainability into product development. They help to reduce the ecological footprint, cut costs and gain a competitive edge without the need for extensive investment or conversion. For SMEs, which often work with limited resources, the TGR are a practicable approach to developing innovative and sustainable products. The high degree of adaptability makes them ideal for small development teams and SMEs for project alignment and sensitisation. However, the method does not yet reflect social sustainability. There is therefore potential for a holistic approach to expanding the method.

## 3 PROPOSAL A HOLISTIC APPROACH - THE TWELVE GOLDEN RULES

As this contribution is about expanding the view to include other solutions and usage concepts, a further category and two further “rules” are proposed, which shall be adapted to the context. The category of holistic use is intended to broaden the scope of use concepts and help to include social needs and a “function” after the actual use phase in a product development. Furthermore, the rules are reformulated to emphasise the company's responsibility and, in view of this, to raise awareness of sustainability aspects. An example of the adaptation is that the second general rule “Minimise energy and resource consumption in the production phase and during transport through improved housekeeping” becomes the rule “Use local/regional materials, recycled materials, reusable materials, select suppliers and producers”. In addition, two further rules will be added to the ten rules. The project team intends to consider the basic functionality of the product and the social orientation of the company during the project. To this end, a fourth phase in the product life cycle, “holistic use”, is being introduced.

### 3.1 Holistic Use as an extension

The extension of the TGR in the context of this work focuses on social sustainability aspects - however, like the TGR in some cases, these must be adapted to the context. For this reason, the following proposal shall only be understood as an orientation and shall serve as a basis for the application and establishment of specific project-adapted guidelines:

- PRE-USE
  1. use of closed cycles, avoidance of water poisoning or contamination, no polluting fertilisers

2. use of local/regional materials, recycled materials, reusable materials, natural materials, choice of selected suppliers and producers
3. use of lightweight materials, durability, application of lightweight design principles, standard-compliant design, simple design
- USE
  4. dismantlability, lightweight materials, suitable for transportation, energy-efficient/low-energy use, effective water storage and use
  5. maintenance-friendly, modularity, redundant arrangement, simple maintenance, use of standard parts and semi-finished products
  6. long service life during use and short decomposition phase after use, timeless design, creation of emotional attachment to the product, promotion of knowledge transfer
  7. investing in better materials, surface treatments or structural precautions to protect products from soiling, corrosion and wear, thus ensuring less maintenance and a longer service life.
- AFTER-USE
  8. provide for upgrades, upcycling, repair and recycling through accessibility, labelling, modules, predetermined breaking points and manuals
  9. promote upgrading, repair and recycling by using fewer, simple, recycled, non-mixed materials and no alloys
  10. use as few fasteners as possible and use screws, adhesives, welded joints, snap-fit joints, geometric interlocks, etc. according to the life cycle scenario, promote simple design, dismantlability
- HOLISTIC-USE
  11. social and good working conditions, promotion of a community, accessibility, promotion of intergenerational action
  12. the product must function satisfactorily

Table 1 shows the template resulting from this contribution. In it, rule formulations are sorted according to the categories and in the right-hand column, context- and project-specific measures for achieving the objectives of the formulated rule can be recorded.

*Table 1. Template for the Twelve Golden Rules*

Proposed wording			Project-specific solutions		
PRE-USE	1	Utilisation of closed cycles for necessary toxic substances or complete avoidance of toxic substances.	...	...	...
	2	Minimising the consumption of energy and resources in the production phase and during transport through improved housekeeping.	...	...	...
	3	Using structural features and high-quality materials to minimise product weight, without compromising the required flexibility, strength or other functional priorities.	...	...	...
USE	4	Minimising energy and resource consumption in the use phase, especially for products with the most important aspects in this phase.	...	...	...
	5	Promote repairs, maintenance and upgrades, especially for system-dependent products (e.g. mobile phones).	...	...	...
	6	Promote a long service life, especially for products with significant environmental aspects outside the use phase.	...	...	...
	7	Invest in better materials, surface treatments or structural precautions to protect products from contamination, corrosion and wear to ensure lower maintenance and longer life.	...	...	...
AFTER-USE	8	Provide for repair and recycling by creating accessibility, labelling, modules, (predetermined breaking points) and manuals for upgrading.	...	...	...
	9	Promote upgrading, repair and recycling by using fewer, simple, recycled, non-mixed materials and no alloys.	...	...	...
	10	Use as few fasteners as possible and use screws, adhesives, welded joints, snap-fits, geometric interlocks, etc. according to the life cycle scenario, promote simple design, dismantlability.	...	...	...
HOLISTIC-USE	11	Concerns about social and good working conditions in the pre-use phase. Promoting a communal, barrier-free and intergenerational solution.	...	...	...
	12	Ensuring satisfactory function even after the use phase.	...	...	...

While the introduction of the additional 'Holistic Use' category offers a new perspective, further research with more analysis of practical implementations within IDE could emphasise the novelty.

### 3.2 Application in Case Study

As part of the Integrated Design Engineering (IDE) master's programme at Otto von Guericke University, the TGR were applied, tested and adapted in case studies by IDE students in cooperation with a regionally based SME. However, the extended TGR were only applied in one of four case studies. A key objective was to sensitise the participating project team to sustainability, crucial in teaching sustainable product development, as well as to create a project orientation by developing context-specific guidelines and thus to provide the team with an identification and guideline to remain focused on in the development process. The implementation and development were carried out by the entire project team. In addition to the TGR, two further rules were drawn up, which deal with the functionality of the product and the ethics of the client. The time required was around three to four working hours with an additional research effort of around one hour. Consequently, the basic processing of the rules is in line with the state of the art - only the new category was integrated and the aspects falling under it were included in the product development. In view of the development task of designing a wicking bed that fulfils a wide range of requirements and also includes social aspects, it can be regarded as a decisive impulse. If the megatrend of social inclusion is considered, it can be seen that the twelve golden rules are only a logical step. The case studies within the IDE master's programme provide valuable feedback on the application of the TGR. Yet, an analysis of these results in relation to cross-sectoral applications could enhance depth. Overall, the contribution demonstrates the effect integrating guidelines into design education, paving the way for future innovations.

## 4 SUMMARY AND OUTLOOK

The TGR for promoting sustainability in product development provide a good basis for aligning development projects with sustainability aspects but also offer many opportunities to expand them. The integration of social sustainability is the first possible aspect to be included. Aspects such as circularity, modularity and regenerative approaches can also adapt these rules to today's challenges and opportunities. These extensions help not only to reduce the environmental impact, but also to promote social responsibility and at the same time develop innovative and competitive products.

In the future, it is conceivable that the established rules and their target achievement can be evaluated by means of a semantic differential by Osgood [6–8] and visualised in a spider web diagram. This makes sense in order to be able to evaluate products and product concepts during the development process on the basis of the established and adapted rules.

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