

# Circular Product Design Strategies

## *A guideline framework*

**Goal:** To (re)design the product as such that the user of this product will feel personally attached to it, encouraging him or her to be careful with it and postpone replacement of this product. In this way, the product's lifetime will be extended.

### Design for Product Attachment & Trust

User is personally attached to product

- Emotional product value
- *Narrative*
- Social product value
- Product personalization

User trusts product

- Product quality
- Product safety

User is personally detached from product

- Lack of emotional product demand
- Lack of product expectation

Product's design is attractive to user

- Attractive, fashionable, personalized
- Well-aging materials and surface

Product triggers curiosity

- Product innovativeness
- Product upgradability and adaptability

Product is 'conscious'

- Product-user interaction
- Comfort of product use

Product has favorable economy of use

- Product profitability

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**Goal:** To (re)design the product as such that this product will last as long as possible. Key in this is to guarantee and improve the product's reliability of use.

## Design for Product Durability

Enhanced product durability

- Degradation-resistant materials
- Ruggedization of product

Pre-use processes optimized

- Manufacture process optimized
- Assembly process optimized
- Installation process optimized

Simplified product

- Less complex product use
- Less complex product components

Specified product

- Product use mechanisms improved
- Product components improved

Product replacement potential

- Easily accessible product components
- Easy-to-replace materials

Reduced product variability

- Limited material variability
- Standardized product components

Understressed product use

- Product components designed for understressed use

Product redundancy

- Crucial product components duplicated
- Product components and subsystems used in parallel

Post-purchase services professionalized

- Maintenance services
- Ease of inspection

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**Goal:** To (re)design the product as such that this product will be capable of “performing in harmonious or congenial combination with different parts” (Succi et al., 1998, p. 140) or different products.

## Design for Product Standardization & Compatibility

Product compatibility may be achieved through standardization, meaning that products or product components are designed and produced in a defined and uniform way (i.e. according to **standards**), or through developing adapters between incompatible parts of this product.

1.

### Determining whether product compatibility is desirable

- Is interchangeability of product components or systems favorable?
- Is there a sufficiently interesting opportunity to become a ‘leader’ within the market by introducing a compatible product?
- How innovative is the new technology that will be introduced?
- Is mass production and mass customization desirable for this product from financial and/or market share perspective?
- Is ease of communication among users in the same product network or system favorable?
- How large and promising is the current *installed base* of the product for which a compatible product or component would be designed?

2.

### Determining the type of product compatibility

- What kind of compatible product or product component is most favorable?
  1. New product as a whole
  2. New product component as a whole
  3. Product component that can be added to an already existing product system of the producer
  4. Product component that can be purchased and combined so as to form a product system; this involves components of more than one producer

3.

### Determining the most optimal way to obtain product compatibility

- How can this compatible product or product component best be obtained?
  - Designing product or product component in such way that it is compatible with existing production standards (figure 1)
  - Designing product or product component in such way that it is directly compatible with other products or product components
    1. Compatibility through similarities of inherent product or product component characteristics (figure 2)
    2. Compatibility through integration of a convertor in the product or product component (figure 3)
    3. Compatibility through an external converter between the products or product components that are to be made compatible (figure 4)
- Use of product modularity

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**Goal:** To (re)design the product as such that it is easy to maintain and repair by its user. This prolongs product quality and will postpone the need for product replacement, thereby allowing for a longer lifetime of this product.

### Design for Ease of Product Maintenance & Repair

#### General design guidelines

- Unambiguity with regard to product use, maintenance and repair activities
- Predictability of product performance and maintenance
- Safety of product
- Testability of product performance
- Monitoring ability inherent to product
- Standard interface of product

#### Product handling & access

- Maintenance points appropriately located and designed
- Access points appropriately located and designed
- Maintenance activities understandable and easy to perform

#### Modules & joining mechanisms

- Modularized components and systems
- Fasteners practical and compatible with regard to maintenance and repair activities

#### Components & materials

- Standardized, universal components
- Modularized components
- Ease of component and material handling
- Practical location of components
- Component usability and tolerance range

# Circular Product Design Strategies

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**Goal:** To (re)design the product as such that it can be upgraded to perform different functions and satisfy different user needs in future product generations (i.e. **upgradability**) and/or that the product in its current form can be adjusted to improve its current functions and to satisfy user needs more appropriately (i.e. **adaptability**).

## Design for Product Upgradability & Adaptability

This will foster product flexibility and eliminate the need for purchasing a new product when new technologies are available or advances are made, thereby lengthening the product's lifetime.

1.

### Defining long-term *upgrade-and-adapt* plan for various product generations

- Determining product functions of current product
  - Sequence: List major product functions; function decomposition; selection of physical features
- Determining *scenarios of future product change*
  - Input: Information on product use and product-user interactions, technological developments, and societal developments
- Determining product functions that are to be upgraded or adapted per product generation

2.

### Determining upgrading and adaptation operations for each product generation

- Functional upgrading – determining how the product can be upgraded through altering its functions
  - Making functions independent of the product
  - Making functions insensitive with regard to the product
- Parametric upgrading – determining how the product can be upgraded through altering its performance
  - Making functions independent of the product
  - Making functions insensitive with regard to the product
- Functional adaptability – enhancing the extendibility of product functions
  - Designing existing parts with versatile functions
  - Adding or replacing parts and assemblies
- Customized and operational adaptability – determining the ease of adaptability
  - Customizability of product components
  - Operationability of the product

3.

### Determining the product platform and *upgrade-and-adapt* modules of product

- Distinguishing between the product platform and the *upgrade-and-adapt* modules of the product
  - Components with high plausibility of being involved in upgrading or adaptation operations: integration into product platform
  - Components with low plausibility of being involved in upgrading or adaptation operations: isolation from product platform as *upgrade-and-adapt* modules
- Delayed selection of components
- Standardization and modularization of product components and *upgrade-and-adapt* modules

# Circular Product Design Strategies

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**Goal:** To (re)design the product as such that it can be easily disassembled and reassembled without its various components losing their initial function due to damage or deformation.

As the original product components can be reassembled after disassembly, there is no need for replacing the current product with a new one. In this way, the product's lifetime is extended.

### Design for Product Dis- & Reassembly

Less disassembly work

- Minimize material and component variability
- Combine elements of same material
- Use standardized and compatible components and materials
- Modularize related components
- Provide easy access for harmful, valuable, reusable components
- Provide easy access to joining points

Predictable product configuration

- Avoid ageing and corrosive material combination
- Protect subassemblies against soiling and corrosion

Easy disassembly

- Use standardized and modularized components
- Accessibility of key components
- Simplicity of joining mechanisms
- Uniformity of fasteners
- Linear and unified disassembly direction
- Avoid turning operations
- Enable simultaneous separation and disassembly
- Base-part product structure with key elements
- Avoid metal inserts in plastic parts

Easy handling

- Surface available for grasping
- Avoid non-rigid parts
- Seal and modularize harmful substances
- Parts easy to store and transport

Easy separation

- Use standardized and modularized components
- Avoid secondary finishing
- Labelling of different materials

Variability reduction

- Use standardized and modularized components
- Limit number of materials and fasteners