



## PRINCIPLES OF DESIGN FOR THE LIFE-CYCLE

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**Abstract:** *The industrial Revolution was devastating in its environmental impact. As greater environmental concerns arose, designers, scientists, governments and eventually industrialists initiated efforts to address these problems. These efforts led to the creation, adoption and practice of life-cycle engineering and design for environment programs.*

**Key words:** *design, life-cycle, sustainable development*

### 1. INTRODUCTION

The purpose of DfLC is to create products that positively affect the environment, thus decreasing ecological damage. This is a broader aim than the elimination, reduction and prevention of waste. Each product life-cycle stage has its own guidelines or principles that come together to achieve this goal. Trade-offs among these stages, as well as between DfLC principles and other design objectives, must be balanced so that products are optimized for environmental performance over the entire life-cycle. DfLC principles can act in concert to better environmental performance; addressing one aspect of product efficiency can lead to efficiency improvements in other aspects.

### 2. PRODUCT DESIGN PRINCIPLES

The product design process cements many details of a product and hence determines many of the possibilities for how other life-cycle design principles can be applied (Tab. 1.). During the product design stage, designers must measure environmental performance iteratively and make design decisions accordingly. The cost of a product throughout its life-cycle must be predicted, including environment-related expenditures. Lastly, by increasing the useful life of a product with appropriate technical and aesthetic life spans in mind, designers can attain many environmental benefits (Kutz, 2007).

WHO APPLIES			
	Explanation	Principles	Example
<b>Measure Environmental Performance</b>	Assess resource use and risks	Design team	Use life-cycle assessment to identify and benchmark environmental impacts
<b>Consider All Costs</b>	Determine all product life-cycle costs	Design team	Employ life cycle costing to capture all costs incurred by a product
<b>Minimize and Eliminate</b>	Choose design that facilitates recycling	Design team	Upgrade the technology in a product, improve product durability, or employ aesthetics that people will enjoy long-term

Tab.1. Product Design Principles

### 3. PACKAGING DESIGN PRINCIPLES

The design of the product includes the design of packaging. Following environmentally responsible design principles such as those in Tab. 2. is an important step toward achieving environmentally benign packaging. Besides the product covering and marketing materials, all transportation packaging must be considered as well. (Mihok & Liberikova, 2005) A good way to reduce packaging needs is for design and transportation engineers to communicate about product concerns and design packaging to fit both points of view. Setting up a deposit or refund for packaging or some type of return system between supplier, retailer, and user encourages packaging reuse.

WHO APPLIES			
	Explanation	Principles	Example
<b>Choose Sustainably Harvested Materials</b>	Ensure that renewable resources remain available and viable	Design team	Pick materials that meet sustainable certification requirements, like wood with the Forest Stewardship Council label
<b>Choose Recyclable Materials</b>	Extend the life of materials through several cycles	Design team	Avoid using composites; instead choose materials with economically viable recycling markets
<b>Choose Recycled Materials</b>	Ensure that recyclable materials have a market	Design team	Keep recycled material quality high for multiple uses, use recycled materials in their original colors and textures
<b>Avoid Hazardous Substances</b>	Ensure that products are safe for human and environmental health	Design team	Choose materials that cause no health or legal concerns

<b>Reduce Material Process Energy</b>	Account for material production effects in the environmental impact of a product	Material producers and design team	Consider the energy and impact differences for producing materials at a facility instead of outsourcing the finished substances before making manufacturing changes
<b>Eliminate Material Waste</b>	Decrease the amount of material that becomes waste during production	Design team	Design products to make manufacturing offcuts as small as possible
<b>Dematerialize</b>	Remove materials from a product	Design team	Reduce the weight and volume of materials in a product
<b>Simply Products</b>	Eliminate the material waste of overdesign	Design team	Eliminate features that are not essential or necessary for a product to function or combine features
<b>Choose Cleaner Production Processes</b>	Select the production processes with least environmental impact	Manufacturers	Employ lean manufacturing techniques to remove inefficiencies and waste from production and choose suppliers that use the most benign methods
<b>Choose Clean Power Sources</b>	Utilize power sources that create the least pollution	Manufacturers	Use renewable energy like wind power to generate needed electricity

Tab.2. Material Design Considerations

#### 4. PRODUCT USE DESIGN PRINCIPLES

The use phase of a product can also contribute significantly to its impact. Designers are responsible for improving the energy efficiency of products. However, ensuring that products are safe for users and their environment is also important for meeting DfLC principles. The principles in Tab. 3. highlight some of the general do and don'ts that a product designer can control with respect to the environmental impact of product use.

	WHO APPLIES		
	Explanation	Principles	Example
<b>Reduce Product Energy Use</b>	Improve product energy efficiency to reduce waste and emissions	Design team	Fix leaks or energy losses and inform consumers how to best use products
<b>Keep Products Clean</b>	Create products that do not emit pollutants	Design team	Substitute materials used in adhesives to stop product off-gassing

Tab. 3. Product Use Design Principles

#### 5. PRODUCT END-OF-LIFE DESIGN PRINCIPLES

At the end of a product's useful life, end-of-life systems for the collection of broken or unwanted products must be initiated in place. Designing for product take-back and establishing a unique product take-back system increases the chances of a product being reused, remanufactured or recycled. Sometimes users discard the whole product when only one component fails, so designing all product components to fail at the same time can create less waste. Many end-of-life options exist for products; each has its own advantages and disadvantages.

#### 6. CONCLUSION

There are additional principles that lead to radically new ways in which DfLC can be realized. These principles fit in several broad categories. Using nature as inspiration for product design can lead to reduced environmental impact. Users can also enjoy the function of a product without possessing an object, reducing the necessary production volume while increasing utilization. Designing in multiple life-cycles or industrial ecosystems is another worthy goal (Muransky & Badida, 2005). Designing for sustainability incorporates DfLC principles as well as social and economic concerns, a challenge that corporations and designers recognize as designing for the triple bottom line. All of these product design principles stretch the generally held body of thinking behind DfLC.

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