



ME 450 Worksheet: Design for Environment (DfE)

ACKNOWLEDGEMENTS

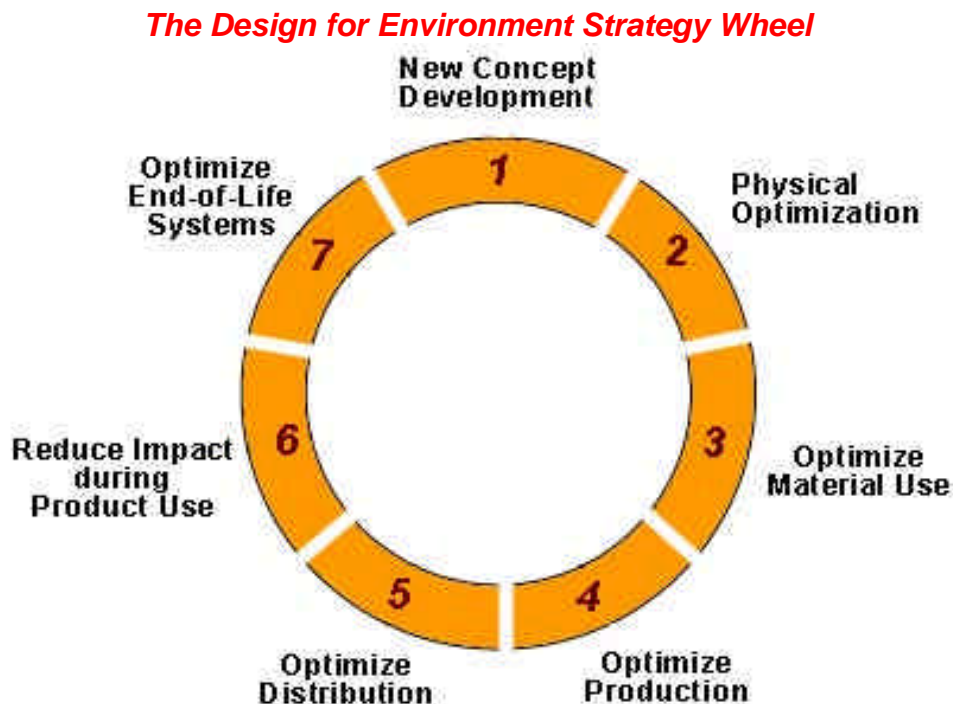
The content for this worksheet is based directly on the United Nations Environmental Program's PROMISE Manual. <http://www.unep.org/> as adapted by the National Research Council of Canada <http://www.nrc.ca/cisti/>. Modifications have been made to make the material suitable for use in ME 450 by Professor Skerlos.

OVERVIEW OF THE DfE STRATEGIES AND THE STRATEGY WHEEL

The DfE Strategy Wheel provides a basic framework that you can use systematically to review the entire life cycle of a product. It is a tool that can:

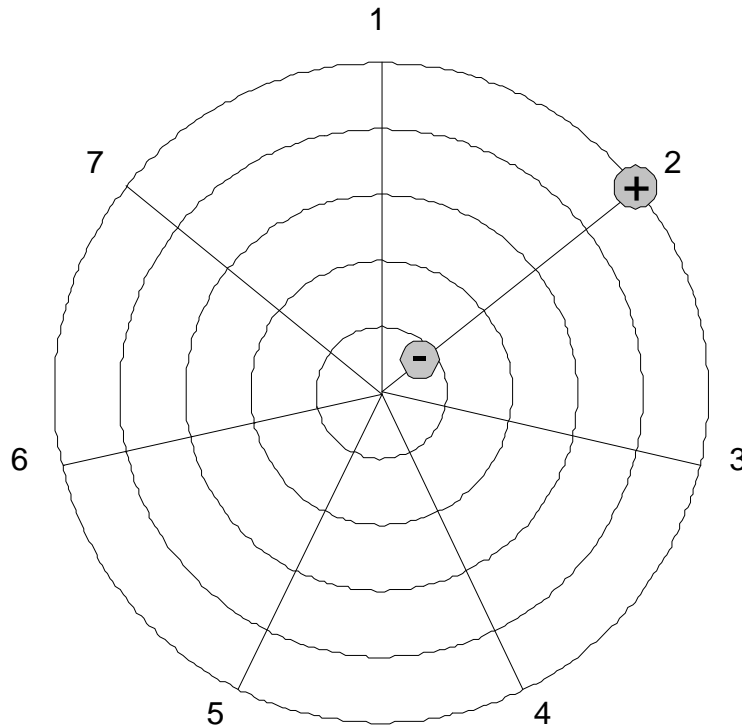
- Stimulate the creative design process.
- Assist in visualizing current environmental performance.
- Highlight opportunities for improvement.

Optimizing your product's performance will require a balance of functional, economic and environmental elements. The Strategy Wheel begins with new product concepts, and covers design, materials selection, production, distribution, and the use and end of a product's life.



Although the strategies are numbered consecutively based on a product's life cycle, you will find the sequence for implementing the strategies is not the same for every product. In other words, there is no one way to use of the strategies that is "right"; the sequencing depends on the needs of your organization and the product's production.

SPECIFIC ACTIONS CORRESPONDING TO DfE STRATEGIES



1. **New Concept Development**

De-materialization
Increase Shared Use
Provide a Service

2. **Physical Optimization**

Integrate Functions
Optimize Functions
Increase Reliability and Durability
Easy Maintenance and Repair
Design for Modularity
Promote Product-User Relationships

3. **Material Selection**

leaner Materials
Renewable Materials
Low Energy Content Materials
Recycled Materials
Recyclable Materials
Reduce Material Use (weight and vol.)

4. **Optimize Production**

Chose Alternate Production Processes
Fewer Production Steps
Lower/Cleaner Production Energy Consumption
Less Production Waste
Fewer/Cleaner Production Consumables

5. **Optimize Distribution**

Less/Cleaner/Reusable Packaging
Energy Efficient Transport Mode
Energy Efficient Logistics

6. **Product Use**

Lower Energy Consumption
Cleaner Energy Sources
Reduce Consumables
Cleaner Consumables
Reduce Consumable Waste

7. **End of Life**

Reuse of Product
Re-manufacturing / Re-furbishment of Product
Recycling of Materials
Safer Incineration
Design for Disassembly

Choosing a Starting Strategy

The table below, which compares sequencing approaches for a photocopier, a telephone and a packaging product, demonstrate how each specific product requires a different starting strategy.

- In the case of the photocopier, the reduction in the energy consumption ([6: Reduce Impact During Use](#)) should be implemented early in the development process because this has a great effect on the function of the machine. However, solutions for improving recycleability ([7: Optimize End-of-Life Systems](#)) can wait until the photocopier's detail design is being filled in.
- In the case of a package, the choice of materials ([3: Optimize Material Use](#)) is so significant to further environmental improvement that decisions must be undertaken at the earliest stage in product development.

**Sequencing of DfE Strategies
during the Design of Different Products**

	Copier	Telephone	Packaging
Idea for New Product Result: design brief	7. Feasibility study on reuse of components. 6. Structural decrease of paper consumption.	1. Consider integration with other media modes. 7. Feasibility study on recycling.	1. Optimize the product so packaging is no longer required. 7. Feasibility study on recycling.
Conceptual Design Result: several concepts	6. New principles for lower energy use. 3. Development of photo conductor with clean materials. 2. Facilitate maintenance and repair.	6. Development of zero-Watt principles to reduce energy use. 2. Optimize functions. Increase reliability / durability.	3. Development of minimal packaging. Low-impact materials. 2. Optimize functions - shipping and display.
Preliminary Design Result: preliminary design	7. Design for reuse of components. 6. Design for use of recycled paper. Optimization of energy use.	7. Optimizing electronics for recycling.	3. Selection of cleaner production techniques. Reduction of materials usage. 4. Cleaner printing processes.
Detail Design Result: product and production specification and documents	7. Design for disassembly. 3. Minimal packaging. Recyclable and clean materials.	7. Design for recycling. 4. Selection of cleaner production techniques. 3. Reduction in amount of materials. Clean and recyclable materials.	7. Design for recycling. 3. Reduction of materials usage.

Applying Strategies to One Part of the Product's Life Span

You may also find that you can apply more than one strategy to one part of a product's life span. For example, you can apply the full range of DfE strategies to a product's design process alone. The strategies take designers through a sequence of progressively demanding challenges, from the relatively simple to the highly complex. Design teams are well aware that it's usually far more difficult to achieve a viable "new concept" than a "reduction of materials."

The table below provides one sample scenario of how the different strategies could be applied during four main phases of a product's design process. Note that their logical order of use is based on design needs.

<i>Sample Scenario: DfE Strategies and A Product's Design Process</i>		
Phase	Activity	DfE Strategies
Idea for a New Product	Analyze, plan, develop scope	1. New Concept Development
Conceptual Design	Conceive, create, explore	Apply strategies that affect the entire product concept: 2. Physical Optimization 7. Optimize of End-of-Life Systems
Transition and Convergence	Evaluate, select, develop	Apply strategies that affect physical structures: 4. Optimize Production 5. Optimize Distribution 6. Reduce Impact During Use
Final Design	Define, delineate, communicate	Apply a strategy that affects components and materials. 3. Optimize Material Use

ASSIGNMENT

Perform a Design for Environment analysis on your term project using the worksheets provided on the following two pages. The first worksheet asks you to consider the Materials, Energy, and Toxics that will result from the materialization of your product design. Consider all the possible effects from metals manufacturing such as water acidification from mining, energy consumption and air pollution from steel production and casting, coolant waste and pollution from machining, heavy metals pollution from finishing, solvents from painting, etc. Note that while plastics may have "use phase" benefits, they are require energy to produce and deplete petroleum resources. Their disposal may create water pollution, and their incineration results in air pollution.

The second worksheet asks you to consider potential opportunities to improve the environmental performance of your product.

MET Matrix Worksheet

Material Cycle
(input/output)

|

Energy Use
(input/output)

|

Toxic Emissions
(output)

Production and supply of all materials and components

In-house production

Distribution

Use:

- operation
- servicing

End-of-Life system:

- recovery
- disposal

DfE Improvement Options Worksheet

<u>DfE Strategies</u>	<u>Improvement Options</u>
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1. New Concept Development

- 1.
- 2.
- 3.

2. Physical Optimization

- 1.
- 2.
- 3.
- 4.

3. Optimize Material Use

- 1.
- 2.
- 3.
- 4.

4. Optimize Production

- 1.
- 2.
- 3.
- 4.

5. Optimize Distribution

- 1.
- 2.
- 3.
- 4.

6. Reduce Impact During Use

- 1.
- 2.
- 3.
- 4.

7. Optimize End-of-Life Systems

- 1.
- 2.
- 3.
- 4.