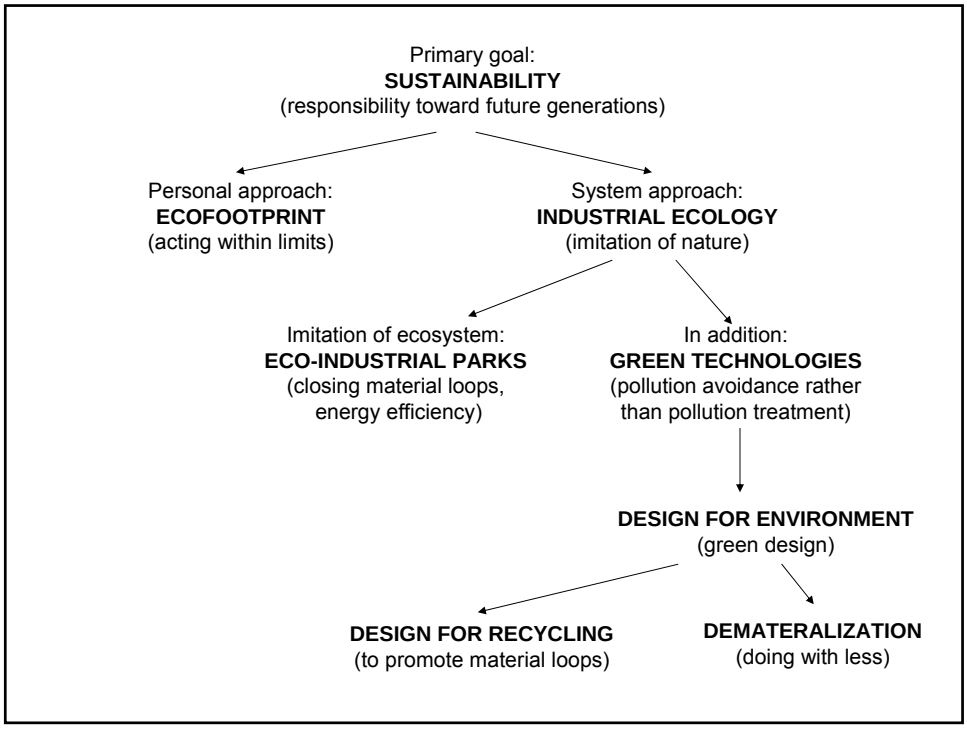


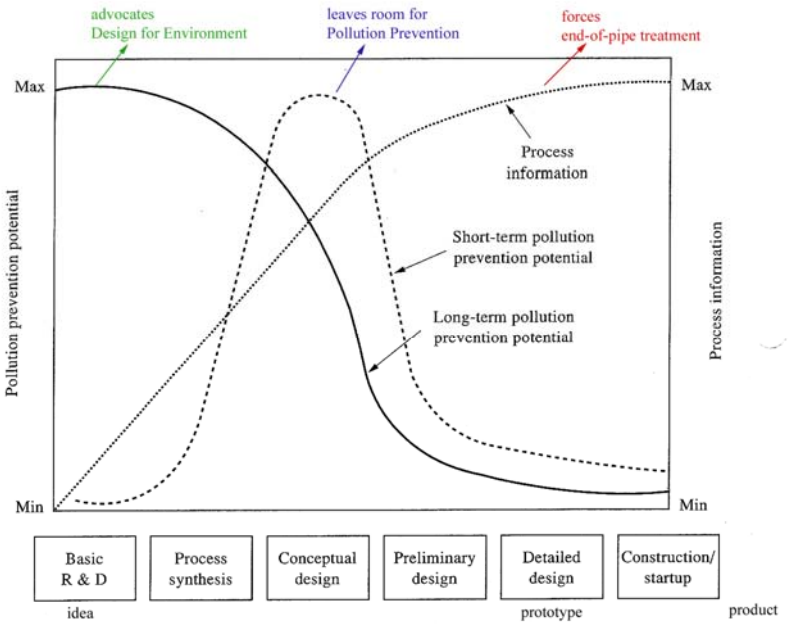
THE IMPORTANCE OF DESIGN:

70% of costs of product development, manufacture and use
are decided in early design stages
(1991 Nat'l Research Council Report titled "Improving Engineering Design")

Examples:

GM truck transmissions: 70% of costs decided at design stage

Rolls Royce: 80% of costs decided at design stage,
as determined from an average among 2000 parts



Pollution prevention potential in the design process. (Adapted from Hertz, 1995; Taken from Bishop, 2000)

The various levels of **DESIGN**

DFM	Design for Manufacturability	So that the product can be made easily and at reasonable cost
DFL	Design for Logistics	So that all production activities are well orchestrated
DFT	Design for Testability	So that the quality of the product may be conveniently checked
DFP	Design for Pricing	So that the product will sell
DFSL	Design for Safety & Liability	So that the product is safe to use and the company is not held liable
DFR	Design for Reliability	So that the product works well
DFS	Design for serviceability	So that service after sale can be offered at a reasonable cost to the company

etc. etc.

Now to be added:

DFE	Design for Environment	To reduce or eliminate environmental impacts from cradle to grave

The various sub-levels of **DESIGN for ENVIRONMENT**:

DFMa	Design for Manufacturability	To enable pollution prevention during manufacturing For less material For fewer different materials For safer materials and processes
DFEE	Design for Energy Efficiency	For reduced energy demand during use For flexible energy use
DFSe	Design for Serviceability	For ease of repairs → longer life For recapture of used/broken parts
DFMo	Design for Modularity	To ease upgrading → Delay replacement To ease serviceability
DFD	Design for Disassembly	To promote re-use of components For quicker and cheaper disassembly For more complete disassembly
DFR	Design for Recycling	For greater materials recovery For easier materials identification For safer disposal of non-recyclables
DFER	Design for Energy Recovery	For composting of organic residues For safe incineration of residues
DFC	Design for Compliance	To meet regulations more easily To prepare for future regulations

What to consider in
DESIGN FOR ENVIRONMENT

1. <u>Product or process?</u>

Make the same product in a different way
ex: as to minimize energy consumption or generation of by-products

Make the essentially the same product, but with different materials

Make a different product that fulfills the same function

2. <u>At which level?</u>

Microscale: Part of a product
A unit of production

Mesoscale: The entire product
The entire factory

Macroscale: Meeting the function (service) in a new way
Rethinking the industry-environment relation (social concerns)

Redesign of PROCESSES versus redesign of PRODUCTS

PROCESSES

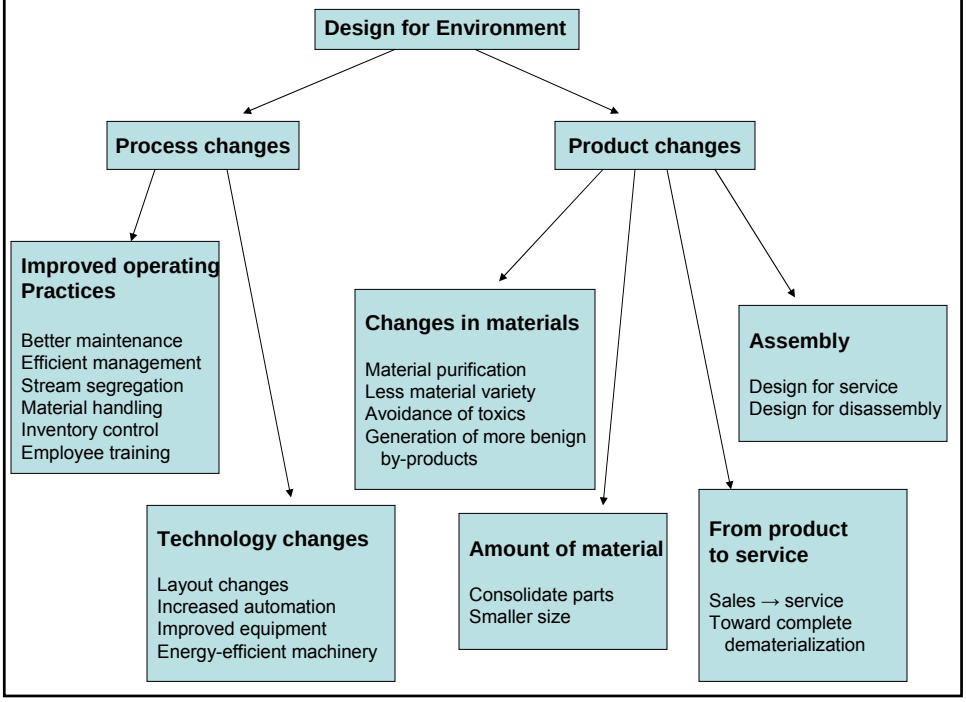
Many times the only way to approach the redesign (*ex*. paper, steel)
Rethink the way the product is made
Rethink what enters the manufacturing (entry materials, needed machinery)
Rethink technology of specific processes (*ex*. solvents)
Consider what goes out besides the product itself (by-products or waste?)

Barriers: - Technological (alternative is not technically feasible)
- Cost of research and development (R&D)
- Risk associated with the unknowns – apprehension, fear
- Corporate inertia ("*Don't mess with success!*")

PRODUCTS

Consider function rather than the object:
Can this function be met with a smaller product, with a more benign product?
Or, at the limit, could it be met as a service without any material product?
Do not forget to also rethink the packaging of the product.

Barriers: - Technological (alternative is not always technically feasible)
- Ergonomic, Safety (alternative may be a misfit or unsafe)
- Societal (people may not be prepared for the alternative)



Example of Design for Environment applied to a manufacturing process

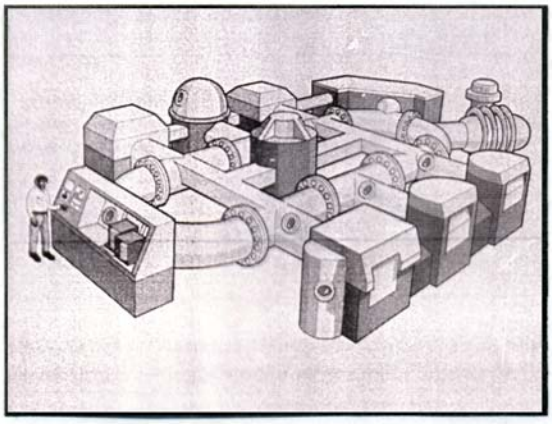
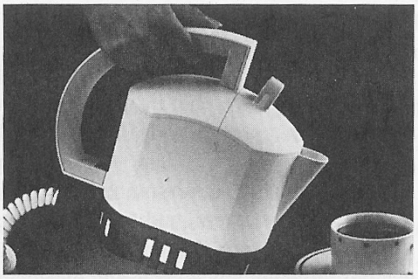
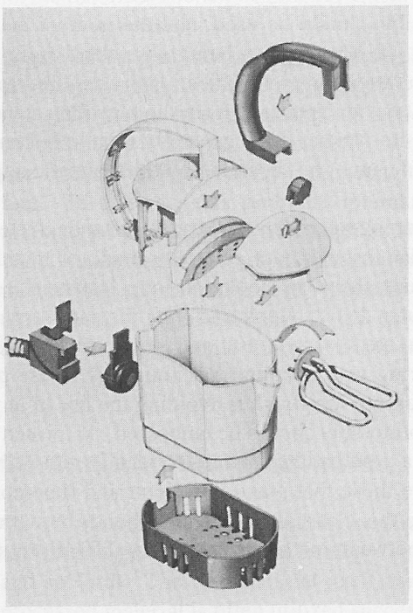


Figure 23.4 A concept for the manufacture of electronic circuits by "cluster processing" techniques. (Courtesy of C. K. N. Patel, University of California, Los Angeles.)

Advantages: - Less air to be dust-free and less chance of dust intrusion;
- In the absence of personnel inside the controlled volume, one can also take advantage of an oxygen-free (pure nitrogen) atmosphere to reduce oxidation or other undesirable side effect.



Teapot designed for disassembly
by Polymer Solutions, Inc.
for British Kettles, Ltd.
(Courtesy of Fitch, Inc,
Columbus, Ohio.
also in *Industrial Ecology*, by
T. Graedel & B. Allenby, 1995)



The story of Ray Anderson and Interface, Inc.

Ray C. Anderson: Founder, Chairman and CEO of Interface, Inc.

Company founded in 1973
Aims to become a sustainable corporation by 2020

Carpet by the square

LEVELS OF DESIGN FOR ENVIRONMENT

From tinkering at the margin to the social revolution!

Example: Automobile

1. Re-design of parts:
   - Aluminum or plastic radiator cap
   - Longer-lasting tires and batteries
   - Aluminum or steel engines
2. Re-design of assembly:
   - Eco-friendly painting
   - Facilitating disassembly
   - Recycling of plastics
3. Re-design of automobile itself:
   - Alternative fuels (ex. ethanol, methanol)
   - Alternative powertrains (hybrids, fuel cells)
4. Re-design of transportation systems:
   - Smart highways
   - Public transportation
5. Re-thinking the need for mobility:
   - Virtual office (telecommuting)
   - Community layout

ELEMENTS OF DESIGN for ENVIRONMENT

At a minimum:

Compliance with all applicable (federal, state and local) environmental regulations

Compliance with existing permit requirements for discharge and emissions

Process loadings not to exceed existing treatment facilities

Going beyond mere compliance:

Procurement of renewable resources and/or recycled materials

Energy-efficient, low-waste manufacturing

No toxics during manufacture or inside product

Energy-efficient product

Long-lasting product

Dematerialized product

Maximization of recycling after product use