Collaborative Engineering

Design for Environment

- Environmental Impact
- Design for Environment
- 3 'R' concept
- DFE Examples

OrthoCAD Lab, I.I.T. Bombay

Environmental Impact

Environmental Impact

Copiers and laser printers produce ozone and volatile organic compounds (VOCs) that cause lung irritation and breathing problems.
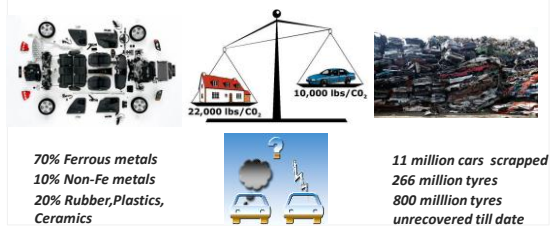
Materials in drum and toner are known to be carcinogens.

Other electronic devices, including laptops & batteries cause metallic pollution of cadmium, mercury and lead.


WE'RE HERE TO SERVICE THE PHOTOCOPIER!

Environmental Impact

Environmental impact during:

Product manufacture	Product use & service	Product disposal
⬇	⬇	⬇
Material consumption	**Energy consumption**	**Pollution or waste**

22,000 lbs/CO₂   10,000 lbs/CO₂

70% Ferrous metals
10% Non-Fe metals
20% Rubber,Plastics, Ceramics

11 million cars scrapped
266 million tyres
800 milllion tyres unrecovered till date

Environmental Impact

Raw Material Extraction

End of Life

Processing

Product Use

Manufacturing

Assembly
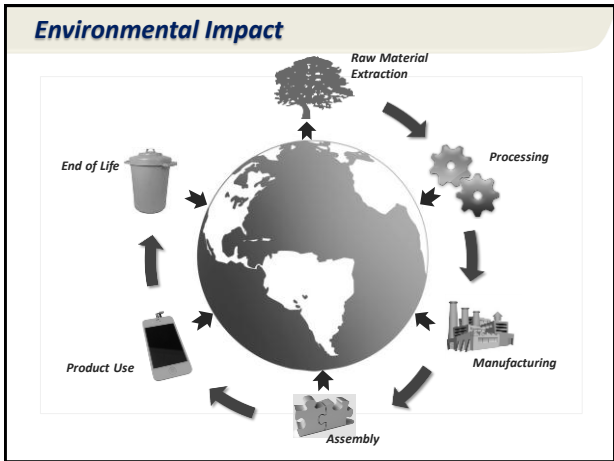
Product End-of-Life

- End of life: obsolete functionality / irreparable / no buyers.
- Consumers can not just 'dump' the product anymore
- Regulations to make manufacturers responsible for EOL.
- Forces manufacturers to rethink design strategy
- DFE becoming a functional requirement, not just constraint!

Design for Environment - Response

POLICY/ETHOS
No policy
Mission statement
Environment policy
Environ-Director

PRESSURE
Government
Regulatory bodies
Consumers
Competitors

MFG
FIRM

TECHNOLOGICAL
No response
'End-of-Pipe'
Process change
Clean technology

STRATEGIC
Non-compliance
Compliance (defensive)
Compliance-plus (offensive)
Leading-edge (innovative)
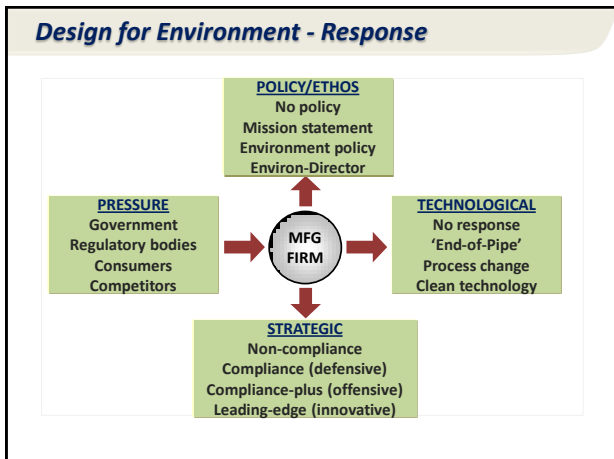
Design for Environment - Definition

- **Definition: Anticipating and eliminating negative impact of the lifecycle of a product on environment.**

- **Also referred to as *Green Design!***

- Negative impact on the environment:
  - Material and energy consumption
  - Generation of gaseous, liquid and solid wastes

- Life cycle of a product w.r.t. environment:
  - Raw material processing and manufacturing
  - Product distribution, use and service
  - Demanufacturing at the end of product life

Design for Environment - 3 R's

- **Reduce: Design products and processes to reduce**
  - Raw material use – shape optimization
  - Waste generation – less packaging
  - Energy consumption – efficient power packs

"Syreen": Cambridge Consultants

Material: Cyclic Olefin Polymer (COP)
Sheds the need for secondary packaging
Syringes can be clipped together
Eliminates the need for wasteful
fillers such as cardboard and styrofoam,
reducing the packaging weight by 30% and
volume by 50%

Design for Environment - 3 R's

- **Reuse: Design products for disassembly and reuse of parts**
  - In same products – often more reliable
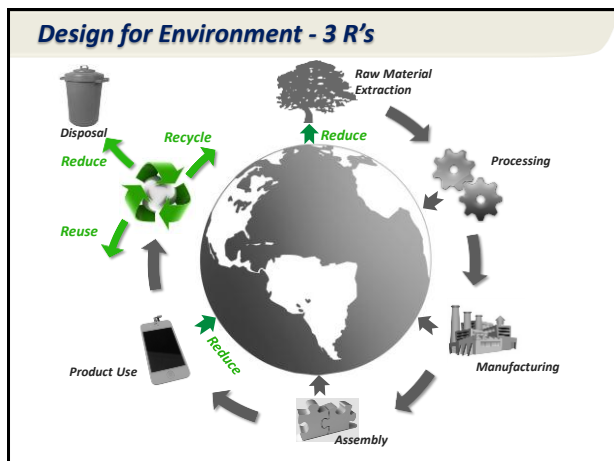 - Secondary products – lower demanding (properties)

Regular skate decks reused and turned into a sustainable skate bench.

Design for Environment - 3 R's

- **Recycle: Design products for ease of material separation and recycling the materials for other applications**
  - Plastics, metals, ceramics
  - Use of mono materials

"Syreen": Cambridge Consultants

The chair is up to 94% recyclable itself (36% aluminum, 31% steel, 31% plastic) and made from 62% recycled materials
Takes just 2 hours to disassemble
Returnable/Recyclable package (cardboard box and plastic)

Design for Environment - 3 R's

Disposal

Recycle

Reduce

Reuse

Reduce

Raw Material
Extraction

Reduce

Processing

Manufacturing

Assembly

Product Use

Reduce

Design for Environment - 3 R's : Overall Imapct

Design for Environment - Materials

- Avoid materials that:
  - Contaminate ground water
  - Generate toxic gases when burned

Nichola Coleman of the University of Greenwich, UK

Ground up glass into tobermorite: a compound that sucks up toxic materials from groundwater like Lead and cadmium

- Minimise use of all materials, especially scarce materials.
- Minimise or replace material use through technology.
- Minimise different types and volume of packaging.

Design for Environment - Materials

- Use recycled or easily recyclable materials:
  - metals better than plastics without loosing properties
  - but metals use more energy in manufacturing
- Use bio-degradable materials.

Green Street Cooking Tools: Robinson Home Products

Made from recycled plastic water bottles that were turned into flakes, compressed, and shaped with the assistance of wind power Heat resistant to 425 degrees

Material Recycling: Plastics

Material Recycling: Aluminium
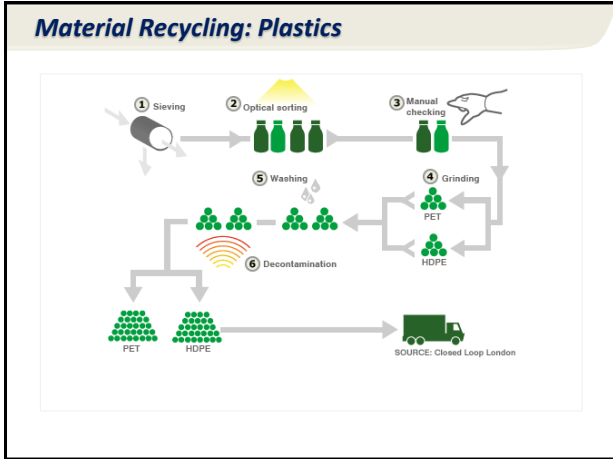
Design for Disassembly

- **Definition**: Design products so they can be taken apart without any damage, so that they can be reused or recycled in other products.
- Disassembly by reverse assembly or brute force.
- Influenced by part value / disassembly cost.
- Proper documentation and procedure essential.

Low-cost floss container

Simple to assemble and disassembled.
Easy to open, free of glues, screws, or heat stakes.
Main component's material is clearly labeled
Parts are quickly separated. (10 sec)

Design for Disassembly

DFE Examples – Nissan Automobile
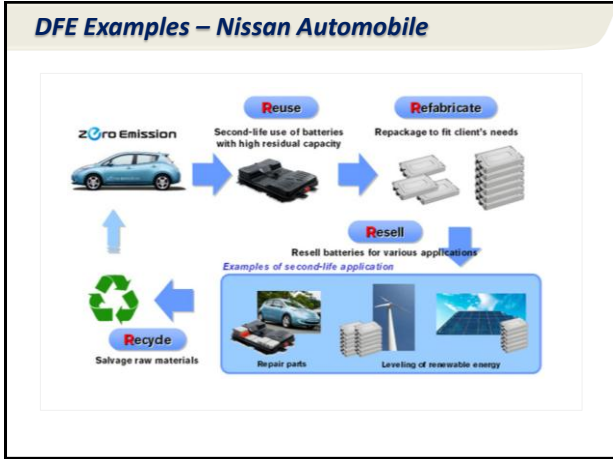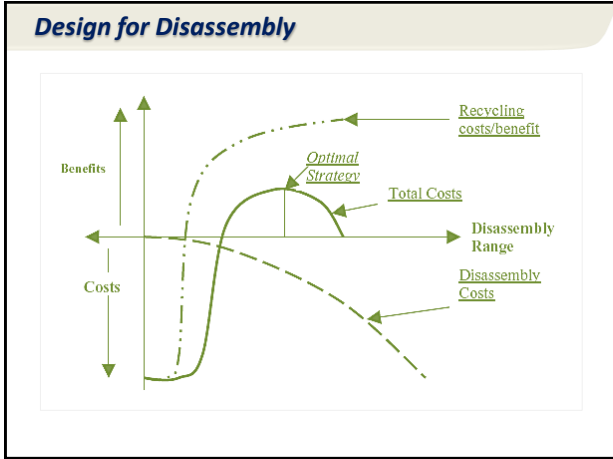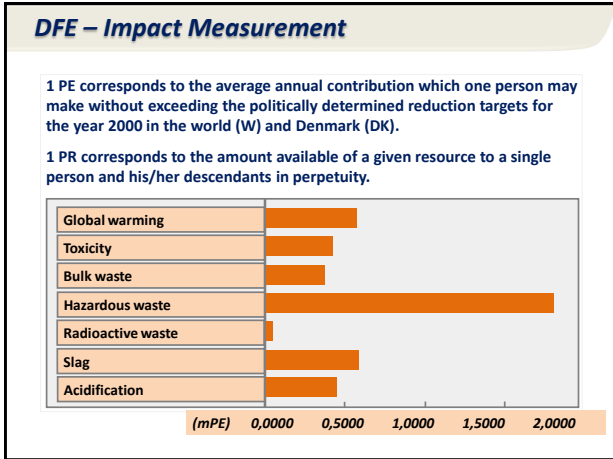

DFE more Examples

- Kodak has converted disposable cameras to recyclable ones. Now 87% of the cameras are either reused or recycled.

- HP recycles up to 65% of print cartridges by weight. Remaining non recyclable parts are disposed of in an environmentally responsible manner.

- Vehicle Recycling Development Center (joint venture of GM, Chrysler, Ford) finding is ways to recycle automobiles, and to disassemble them more cost-effectively.

DFE Challenges in Medical Products

- Regulations: limitations in design
- Virgin Materials: Molded parts should come from pure virgin pellets
- Sterilization: Material compatibility for sterilization
- Bio-Compatibility: Limits the material choice
- Single Use: Single use disposables

SABIC innovative plastics: high quality eco friendly

- Design for Reuse: Reduce no. of disposable components
- Molding: Optimizing tools for less sprues, gating and flash in molding
- Design for Sterilization: New engineering plastics withstand temperatures
- Material Selection: Select a material requiring less energy
- DFA for less energy: Fastner, adhesive, snap-fit

DFE – Impact Measurement

1 PE corresponds to the average annual contribution which one person may make without exceeding the politically determined reduction targets for the year 2000 in the world (W) and Denmark (DK).

1 PR corresponds to the amount available of a given resource to a single person and his/her descendants in perpetuity.

SUMMARY

- Environmental impact in whole product lifecycle from materials to disposal
- Design for environment and 3R concept motivates designers for innovative solutions good for environment
- Industries are now aware and giving importance to design for environment and product lifecycle issues
- Medical products have a great impact in environment and also challenge in design for environment