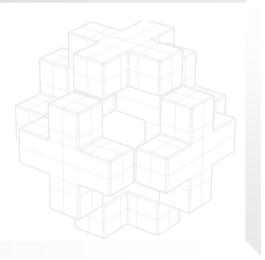
Chemical Product Design

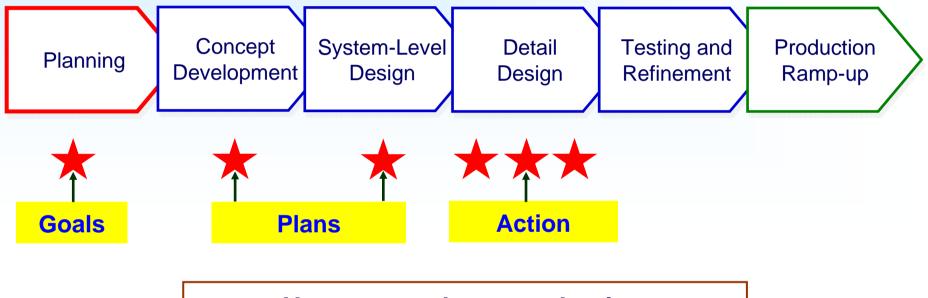
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PART X. Design for Environment





Design for Environment in the Product Development Process



How can we best emphasize environmental impact of products during the product development process ?

Dimensions of Environmental Impact

"Limitless potential to confuse consumers"

Resource Depletion

- non-renewable energy (fossil fuels)
- natural resources (water, wood, minerals)

Human Toxic Exposure

- carcinogens
- other health hazards

Environmental Impact – air, water, solid

- ozone depletion (CFCs)
- greenhouse gas emission (CO₂)
- smog-producing chemicals (VOCs)
- acid rain chemicals (sulfides)
- eutrophication [oxygen depletion] (nitates, phophates)
- eco-toxics (heavy metals) & solid waste (landfill)

Paper vs. Polystyrene Cups

	Paper Cup	Polyfoam Cup
Raw Materials (per cup)		
wood	33 g	0
petroleum	4.1 g	3.2 g
Utilities (per metric ton)		
steam	10,000 kg	5,000 kg
power	980 kWh	150 kWh
cooling water	50 m ³	154 m ³
Water Effluent (per metric unit)		
suspend solids	50 kg	trace
BOD	40 kg	0.07 kg
organochlorines	6 kg	0
metal salts	10 kg	20 kg
Air Emissions (per metric unit)		
chlorine	0.5 kg	0
chlorine dioxide	0.2 kg	0
reduced sulfides	2.0 kg	0
Recycle Potential		
after use	low	high
Ultimate Disposal		
incineration recovery	20 MJ/kg	40 MJ/kg
mass to landfill	10.1 g	1.5 g
biodegradable	yes	no

Life Cycle Assessment (LCA)

Quantifies environmental impact of a product

Steps in LCA

- Identify raw materials and energy sources used
- Identify outputs and waste streams
- Continue for product's entire life cycle Production, transportation, use, recycling, disposal
- Quantify impacts of each material, energy, waste
- Aggregate impact into categories for comparison Normalize by reference materials for each use

 Generally requires specialized training (in materials and chemical engineering) and LCA software

Needs to be integrated with process development process

Life Cycle Assessment (LCA)

Environmental Report Card

Burdens from production, distribution, use and disposal.

TYPE OF BURDEN	PRODUCT & PACKAGING:			WORSE HEAVIER BURDENS	
RESOURCE DEPLETION		LOWER BURDENS	-	I I I I I I I I I I I I I I I I I I I	
WATER	35 kg				
W000	230 g				
OIL GAS (non-fuel)	0.4 g				
MINERALS	120 g				
ENERGY USE	A DESCRIPTION OF		ALC: AND		
TOTAL ENERGY USED	23 MJ	and the second se	100 100	and the second	
AIR POLLUTION	And in case of the local division of the loc		1.00		
CARBON DIOXIDE	1.2 kg		100 C		
CARBON MONOXIDE	5 g		1000		
SULFUR OXIDES	19 g		Concerned in the	In the second second	
NITROGEN OXIDES	7 g	and the second se	1 (C) (C)		
HYDROCARBONS	240 g				
PARTICULATES	3 g				
UNCLASSIFIED	0.008 g			100	
HAZARDOUS	500 m.g	And in case of the local division of the loc		1.1	
OZONE LAYER DEPLETER	IS 0 mg				
WATER POLLUTION					
TOTAL SOLIDS	15 a	and the second se			
OXYGEN DEPLETERS	0.1 g				
TOXIC	77 mg		And in case of the local division of the loc		
SOLID WASTE					
UNCLASSIFIED	260 g	the second se		1773	
HAZARDOUS	3 9			2	
	10000	10			
6 M		10x 100x	1 000		
FOR INFORMAT	TION CALL	TINGA	1,000x	10,000	
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TM 1"000"LUU	MUID	* PLASTI-KOTE® HIGH SOLIDS SO	LVENT-BASED BLACK	SPRAY PAINT	

HIGH-SOLIDS SOLVENT-BASED BLACK SPRAY PAINT

Green Marketing

Single-issue green design encourage single-issue promotion

- e.g., recyclable, low emission, all natural, ozone friendly, greener than before, compostable, etc.

- http:// www.eco-directory.com/

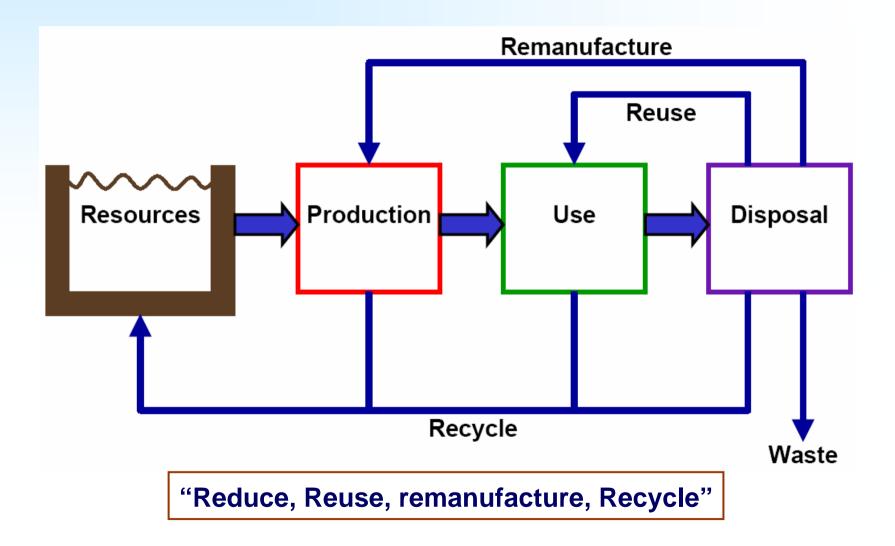
Consumers prefer green products but will generally not pay more for them





Products from recycled jeans, newspapers, money:

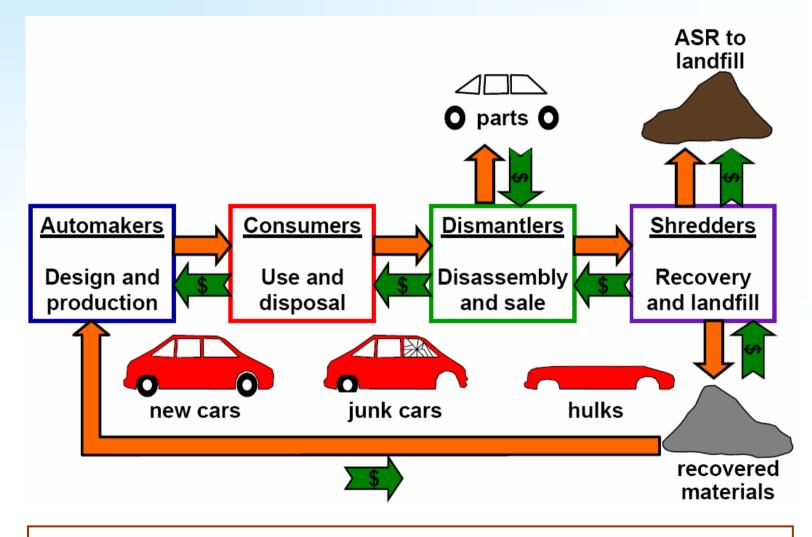
Product Life Cycle



Design for Recycling Guidelines

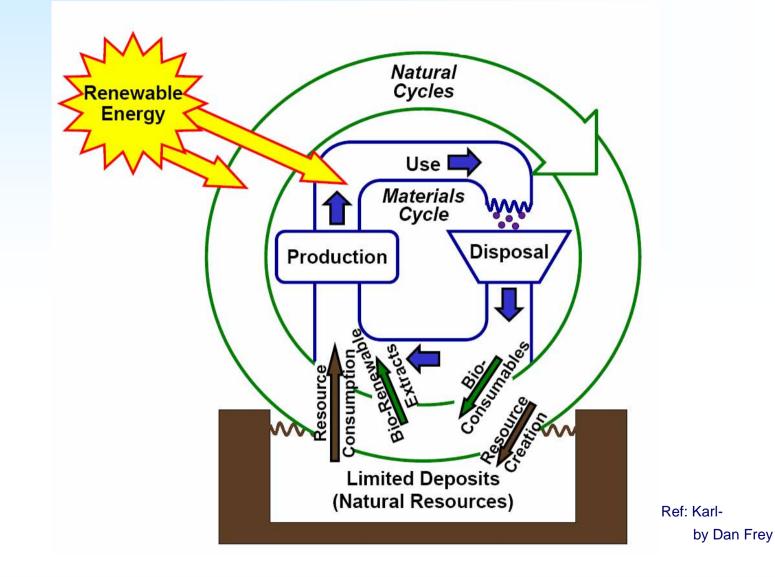
- Use only recyclable materials
- Minimize materials variety
- Label all plastic
- Provide for simple disassembly (separation of materials)
- Use water-soluble adhesives
- Avoid toxic materials

Recycling in the US Automobile Industry -



Coupling of technical, economic, and infrastructure issues

Cyclical Life Cycle Model



"Conditions" for Sustainability

 Consider the earth as a closed system with limited solar input and natural bio cycles.

 Solar energy and other renewable fuels are sustainable energy sources

Resource usage must balance to the rate the earth creates each

resource (e.g., rate at which earth creates fossil fuels)

 Toxic wastes heavy metals, radiation, and other "molecular garbage"must be eliminated because they are not part of the bio cycle

More Discussion Point

- How we come very far yet in terms of environmental awareness?
- How can sustainability (ever) be achieved
- What is the role of each party?
 - Consumers
 - Industry
 - Government

What high-leverage solutions make sense to you ?

- Regulation
- Targets
- Technology
- Partnerships
- Education