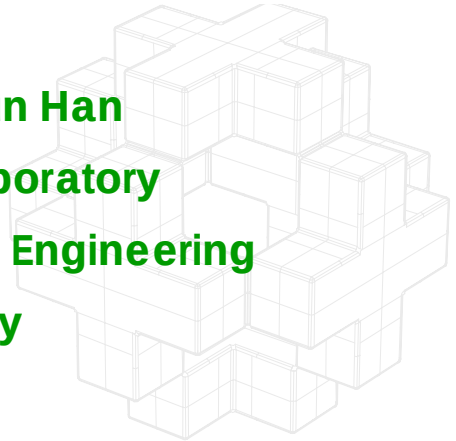
# Chemical Product Design

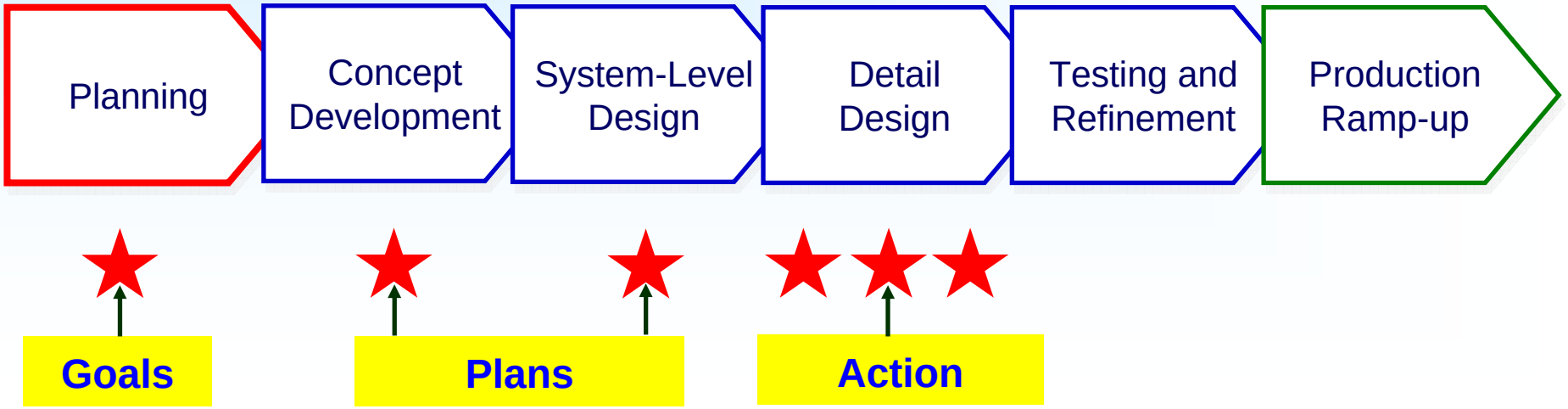
Sungwoo Cho and Chonghun Han
Intelligent Process Systems Laboratory
School of Chemical and Biological Engineering
Seoul National University



# PART X. Design for Environment

- 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 ($CO_2$)
  - 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)


HIGH-SOLIDS SOLVENT-BASED BLACK SPRAY PAINT

# Green Marketing

- **Single-issue green design encourage single-issue promotion**

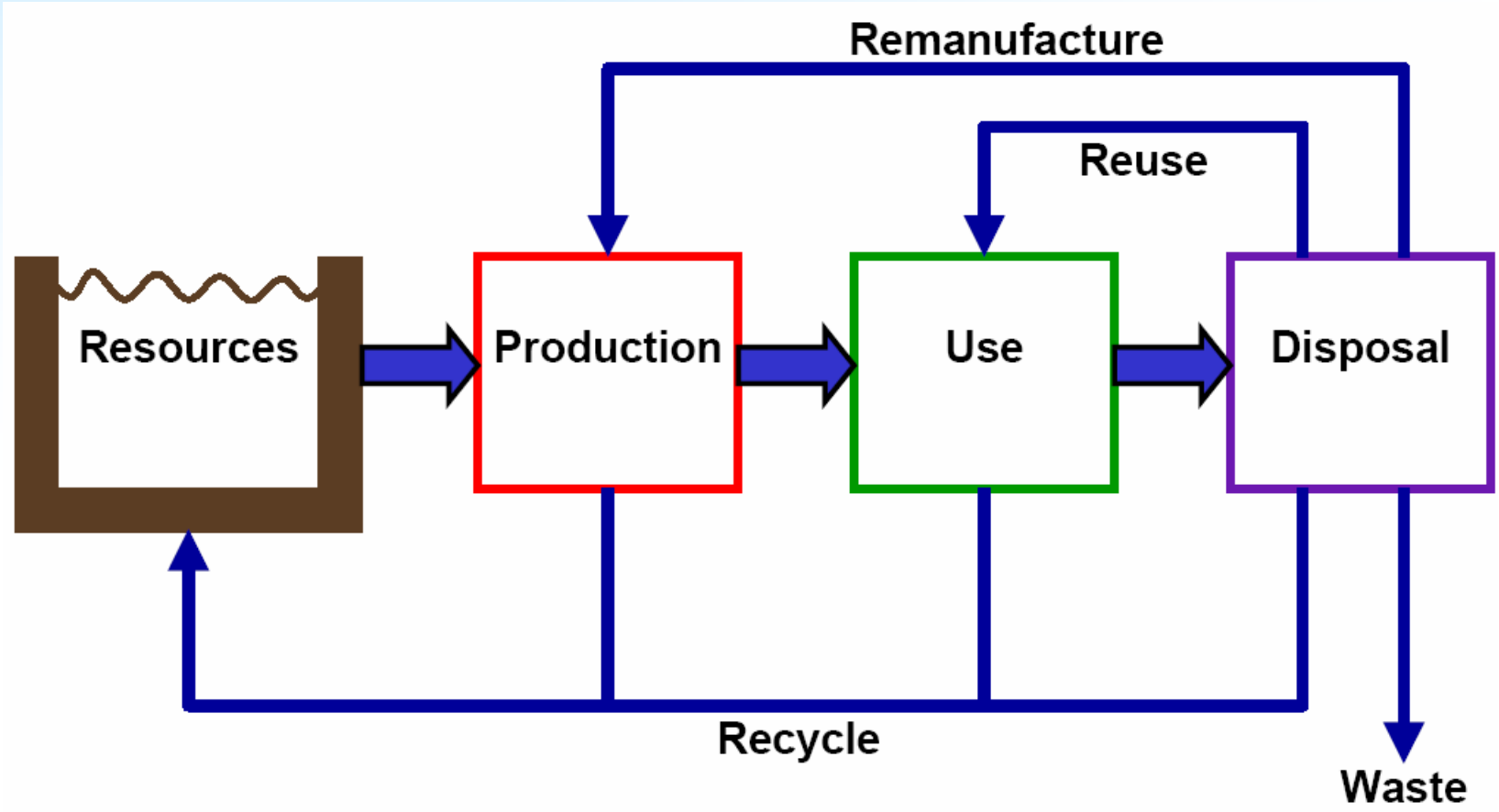
  - e.g., recyclable, low emission, all natural, ozone friendly, greener than before, compostable, etc.

  - 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



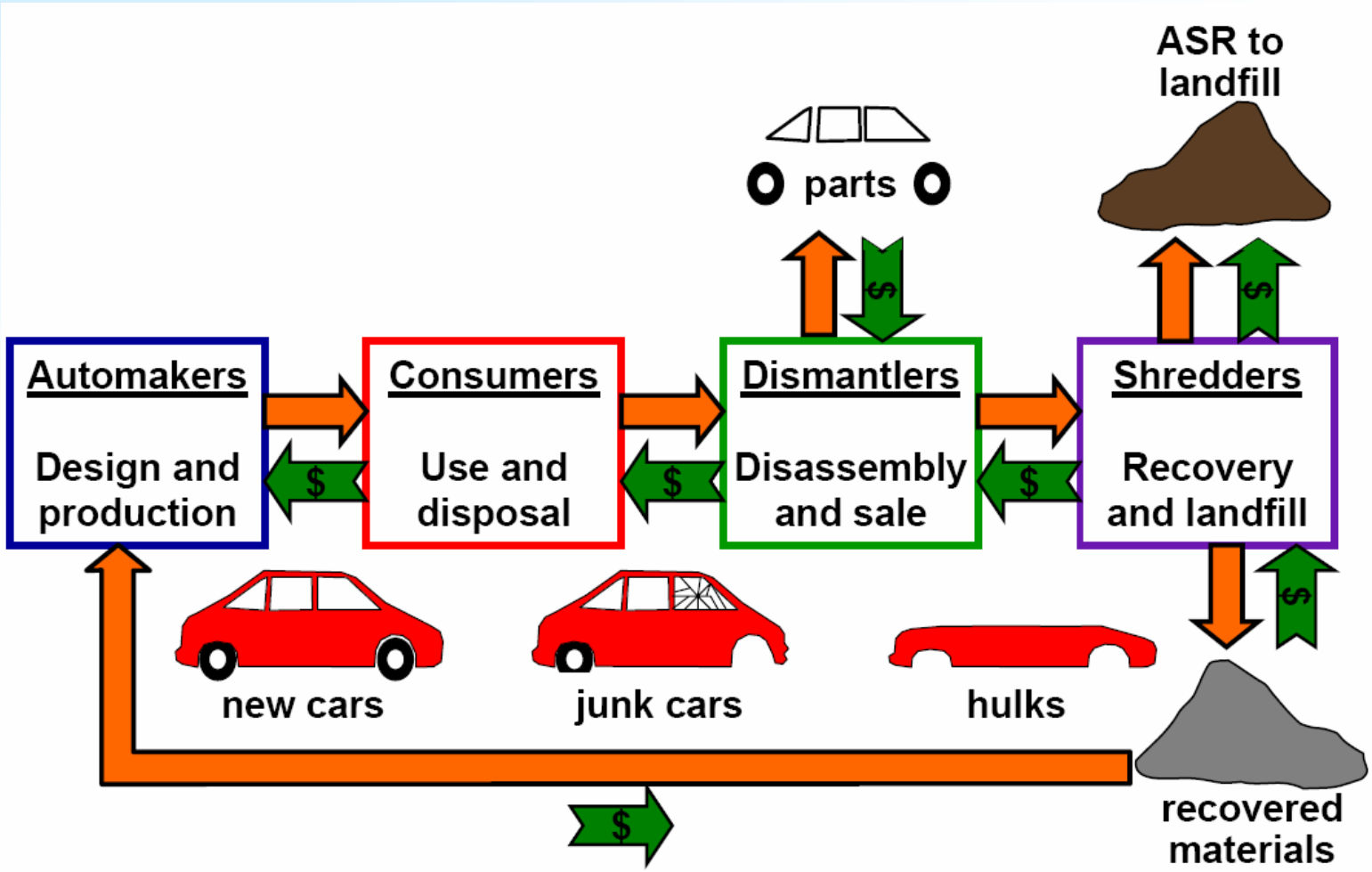

"Reduce, Reuse, remanufacture, Recycle"

# Design for Recycling Guidelines

- Use only recyclable materials
- Minimize materials variety
- Label all plastic 

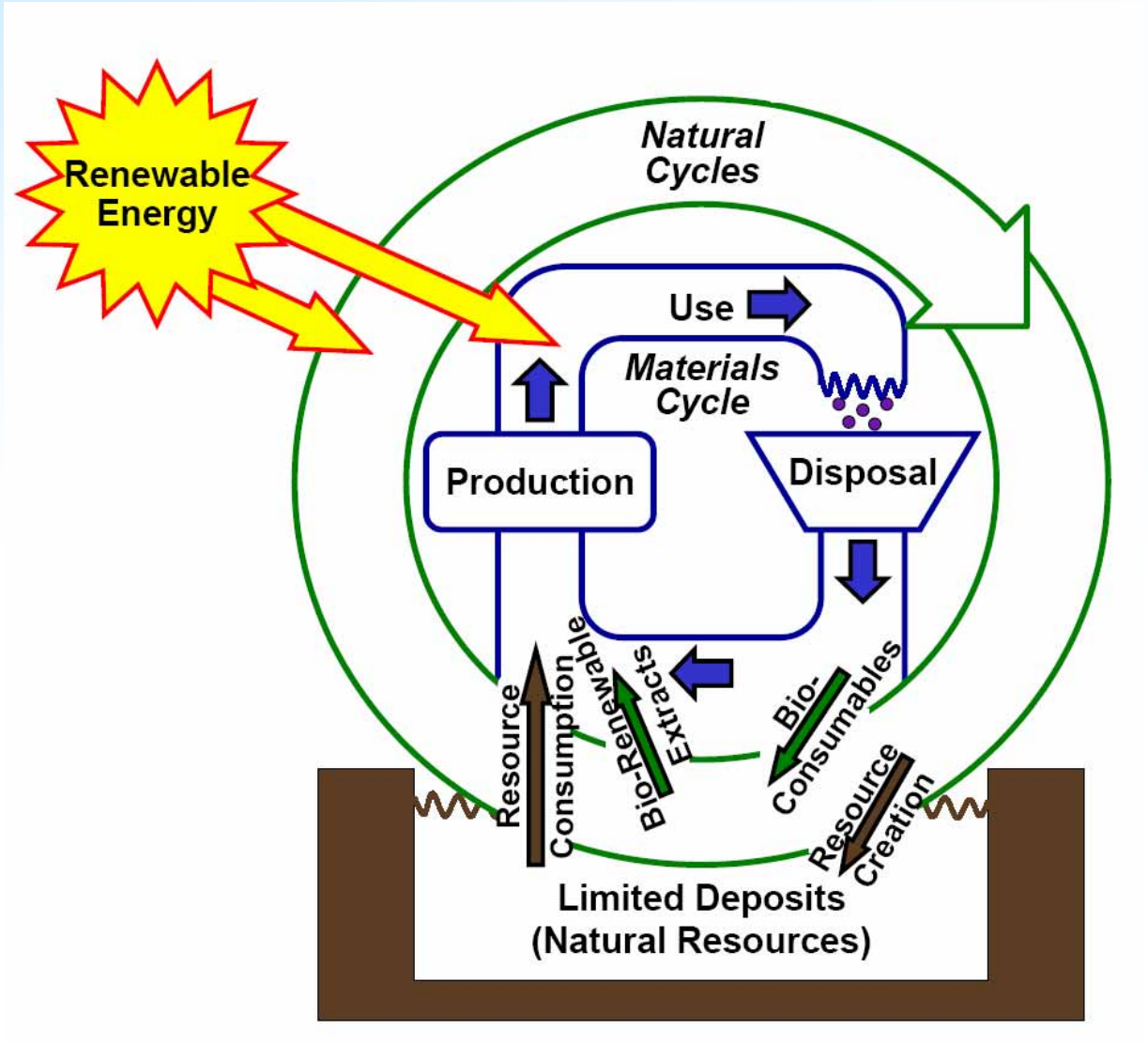
- Provide for simple disassembly (separation of materials)
- Use water-soluble adhesives
- Avoid toxic materials

# Recycling in the US Automobile Industry -




**Coupling of technical, economic, and infrastructure issues**

# Cyclical Life Cycle Model




Ref: Karl-
by Dan Frey

# “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