

ME290

**Global Engineering Professional
Seminar**

Impact of Engineering Solutions

Lecture-2

Economic, Environmental, and Societal Issues in Materials Science and Engineering

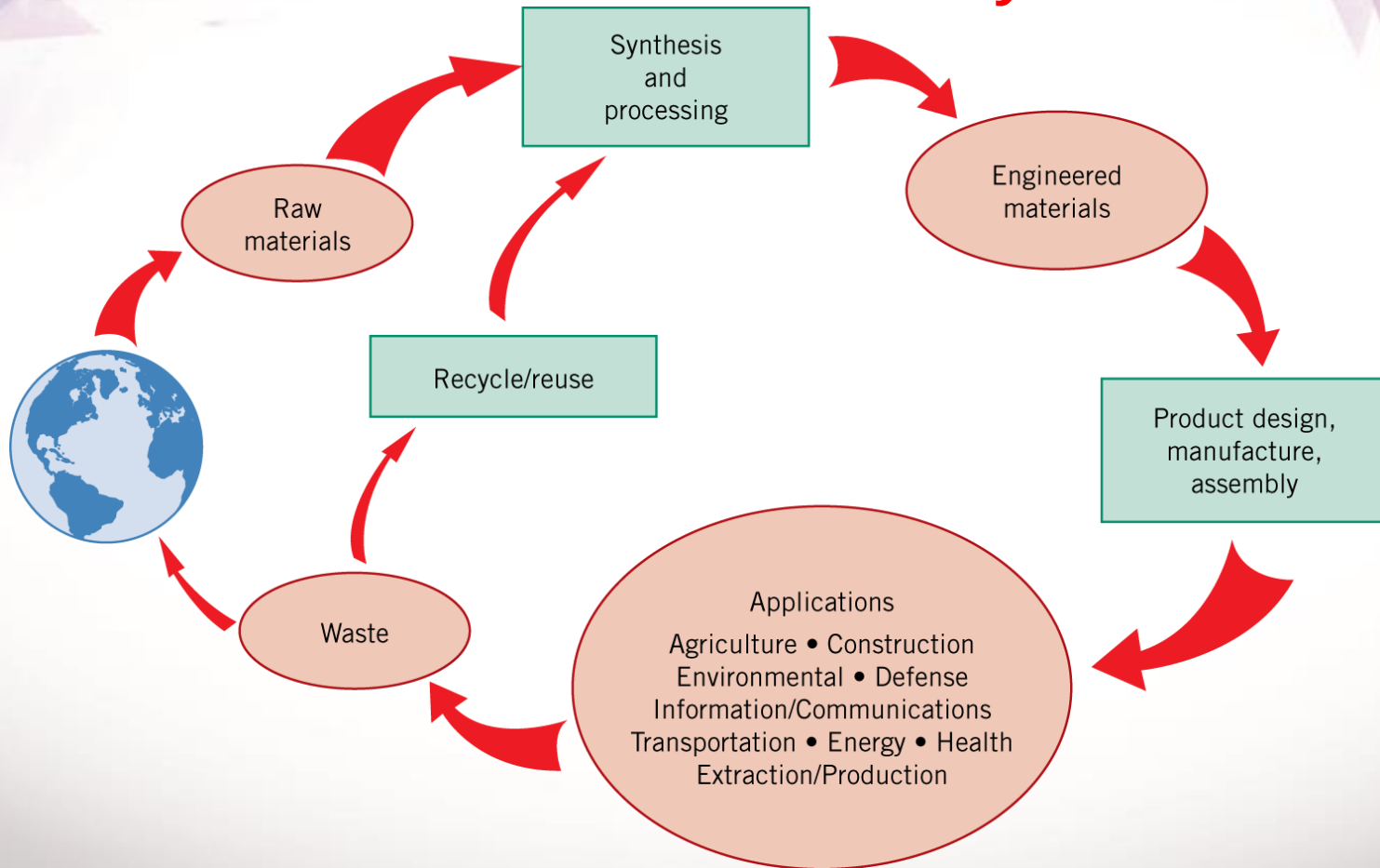
ISSUES TO ADDRESS...

- What factors affect product cost?
- What factors determine the overall environmental impact of a product?
- For which materials is recycling a viable option?
- What is “green design”?

Economic Considerations

- A product must make economic sense:
 - the price must be attractive to customers
 - it must return a sustainable profit to the company
- To minimize product cost materials engineers must consider three factors
 - component design
 - material selection
 - manufacturing techniques
- Other significant factors include labor & fringe benefits, insurance, and profit

Total Materials Cycle



Total Materials Cycle Steps: raw material extraction, synthesis/processing, engineered materials, product design/manufacture, application, and waste disposal

Components Of “Green Design”

- **Reduce** – redesign the product to use less material
example: PET bottles with thinner walls
- **Reuse** – fabricate the product of a material that can be reused
example: refillable bottles and shipping containers
example: grind up old tires for use as mulch
- **Recycle** – reprocess the material into a new product
example: convert PET bottles to carpet fibers



Benefits of Recycling

- Reduces the amount of waste sent to landfills
- Conserves natural resources such as timber, water and minerals
- Prevents pollution by reducing the need to collect new raw materials
- Saves energy
- Increases economic security by tapping a domestic source of materials
- Helps create jobs in the recycling and manufacturing industries



Recycling Of Metals

- **Aluminum** is the most commonly recycled metal
- Compared to refining raw ore, **reprocessing metals**
 - is more energy efficient
 - produces less waste (pollution)
- Difficult to recycle metals that are susceptible to **Corrosion**
- **Toxic metals** (e.g., Cd and Hg):
 - must be handled as hazardous waste
 - are difficult to reprocess
 - should not be added to landfills



Recycling Of Glass

- Glasses are the most common commercial ceramics
- Little economic incentive to recycle glass
 - raw materials inexpensive
 - relatively dense - expensive to transport
 - must be sorted by
 - color – clear, amber, green, brown
 - type – plate vs. container
 - composition – soda-lime, leaded, borosilicate



Johnny Greig/iStockphoto



Recycling Polymers

- **Thermoplastic polymers** easily recycled
 - grind into pellets, melt, and extrude or mold into new product
 - must be sorted by polymer type – polyethylene, polystyrene, PET, etc.
 - properties degrade in each reuse
- **Thermosetting polymers** more difficult to recycle
 - can be ground up and use as filler
 - depolymerize to make monomer
- Polymers are combustible so they can be burned to reclaim fuel value

Recycling Composites

- **Difficult to recycle** because they contain an intimate mixture of materials – difficult to separate
- Some composites are recyclable
- Components must be separated by shredding or dissolution

Biodegradable Polymers

- Biodegradable polymers are designed to degrade upon disposal by the action of living organisms (**microbes**)
 - **Example:** plastic tableware, beverage containers, golf tees
 - **Example:** degradable mulch films
 - retain heat and moisture
 - after harvesting crop
 - plow the film into the soil
 - decomposes into nutrients
- Long shelf life at ambient conditions
- Decomposes in months in commercial composting operations



Biodegradable Polymers

How can biodegradable polymers help the environment?

Biodegradable polymers can reduce Plastic Pollution which is the accumulation of plastic objects and particles (e.g. plastic bottles, bags and microbeads) in the Earth's environment that adversely affects wildlife, wildlife habitat, and humans.



Summary for Materials

- Important for materials engineers to consider in design(and related laws & regulations):
 - materials selection
 - manufacturing process
- Environmental and societal impacts of production are significant engineering design issues
- Cradle-to-grave life cycle assessment of products involves:
extraction, synthesis/processing, product design/manufacture, application, disposal
- Recyclability and disposability issues are important in materials science and engineering. Ideally, a material should be at best recyclable, and at least biodegradable or disposable



AUM

American University Of The Middle East

Regulations



**"Of course there are more bureaucrats than field workers!
It's more fun to create regulation, than to actually enforce it!"**

Regulations

Reducing CO2 emissions from passenger cars

Policy

Documentation

Studies

Faq

Why do we need Emission Regulations for cars?

The environmental impact of cars is significant because they burn fuel. This produces air pollution and greenhouse gases such as carbon dioxide, nitrous oxides and particulates which have negative consequences for climate change and health.

Regulations



Regulatory Information by Topic



- [Acid Rain](#)
- [Drinking Water](#)
- [Mold](#)
- [Asbestos](#)
- [Small Business](#)
- [Toxics Release Inventory](#)

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Laws

Laws written by Congress provide the authority for EPA to write regulations.

- [Clean Air Act](#)
- [Clean Water Act](#)
- [Toxic Substances Control Act](#)
- [More Law Summaries](#)

Regulations

Regulations explain the technical, operational, and legal details necessary to implement laws.

- [Get Involved](#)
- [Regulatory Reform](#)
- [Deregulatory Actions](#)
- [More about Regulations](#)

Regulatory Information by Sector



- [Agriculture](#)
- [Automotive](#)
- [Construction](#)
- [Electric Utilities](#)
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Compliance & Enforcement

EPA helps regulated entities meet federal requirements, and holds entities legally accountable for environmental violations.

- [About Compliance](#)
- [EPA's Enforcement Website](#)

Policy & Guidance

EPA issues policy and guidance documents to assist the public and regulated entities.

- [Significant Guidance Documents](#)
- [More guidance resources](#)

Regulations



Toxic Substances Control Act

Purpose of the Toxic Substances Control Act:

The Toxic Substances Control Act (TSCA) was enacted in 1976 to regulate commerce and protect human health and the environment by requiring testing of and establishing use restrictions on certain potentially hazardous chemicals.

- EPCRA Section 302 Extremely Hazardous Substances
- CERCLA Hazardous Substances
- EPCRA Section 313 Toxic Chemicals
- CAA 112(r) Regulated Chemicals for Accidental Release Prevention

These Substances should not be used in product designs or use with some limitations as explained in regulations

NAME	CAS/313 Category Codes	Section 302 (EHS) TPQ	Section 304 EHS RQ	CERCLA RQ	Section 313	RCRA CODE	CAA 112(r) TQ
Arsenic Compounds	N020			&	313		
Barium Compounds	N040				313		
Beryllium Compounds	N050			&	313		
Cadmium Compounds	N078			&	313		
Chlorinated Phenols	N084			&	313		
Chlorophenols	N084			&	313		
Chromium Compounds	N090			&	313		
Cobalt Compounds	N096			&	313		
Copper Compounds	N100			&	313		
Cyanide Compounds	N106			&	313		
Diisocyanates (includes only 20 chemicals)	N120				313		
Dioxin and dioxin-like compounds (includes only 17 chemicals)	N150				313		
Ethylenebisdithiocarbamic acid, salts and esters	N171				313		
Glycol Ethers	N230			&	313		
Lead Compounds	N420			&	313		

Summary

- Engineering solutions must be evaluated in the following terms:
 - Environmental
 - Economical
 - Societal
- Try to implement sustainable and greener designs
- Always check **laws & regulations** before implementing a solution