Chem/ESPM/PH 234 Class 2
Energy Systems and the Role of Biofuels

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The structure and complexity of energy systems

The role of biofuels in energy systems

Class exercise

An overview of biofuels and their impacts/benefits

Discuss group projects

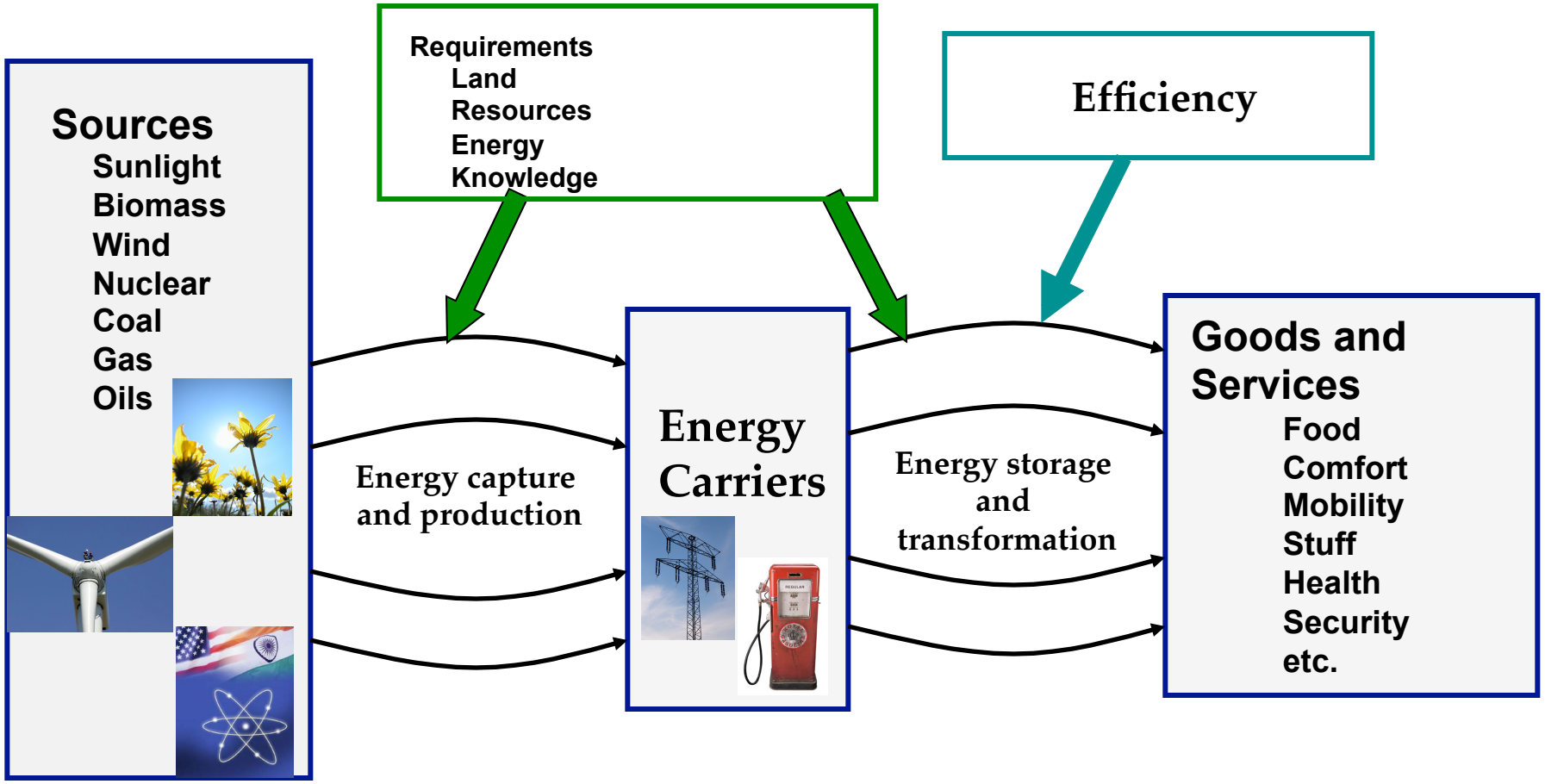
Energy Systems

Energy and Power

- What is energy?
- How do we measure energy?
- What is power?
- How do we measure power
- How much energy do we use in the US?
  - For all sectors?
  - For transportation?

Energy Systems Components

- Feed stocks (fossil fuels, uranium, biomass, water, etc.
- Feed-stock storage and transport
- Feed-stock transformation
- Storage, transport and distribution
- Energy use



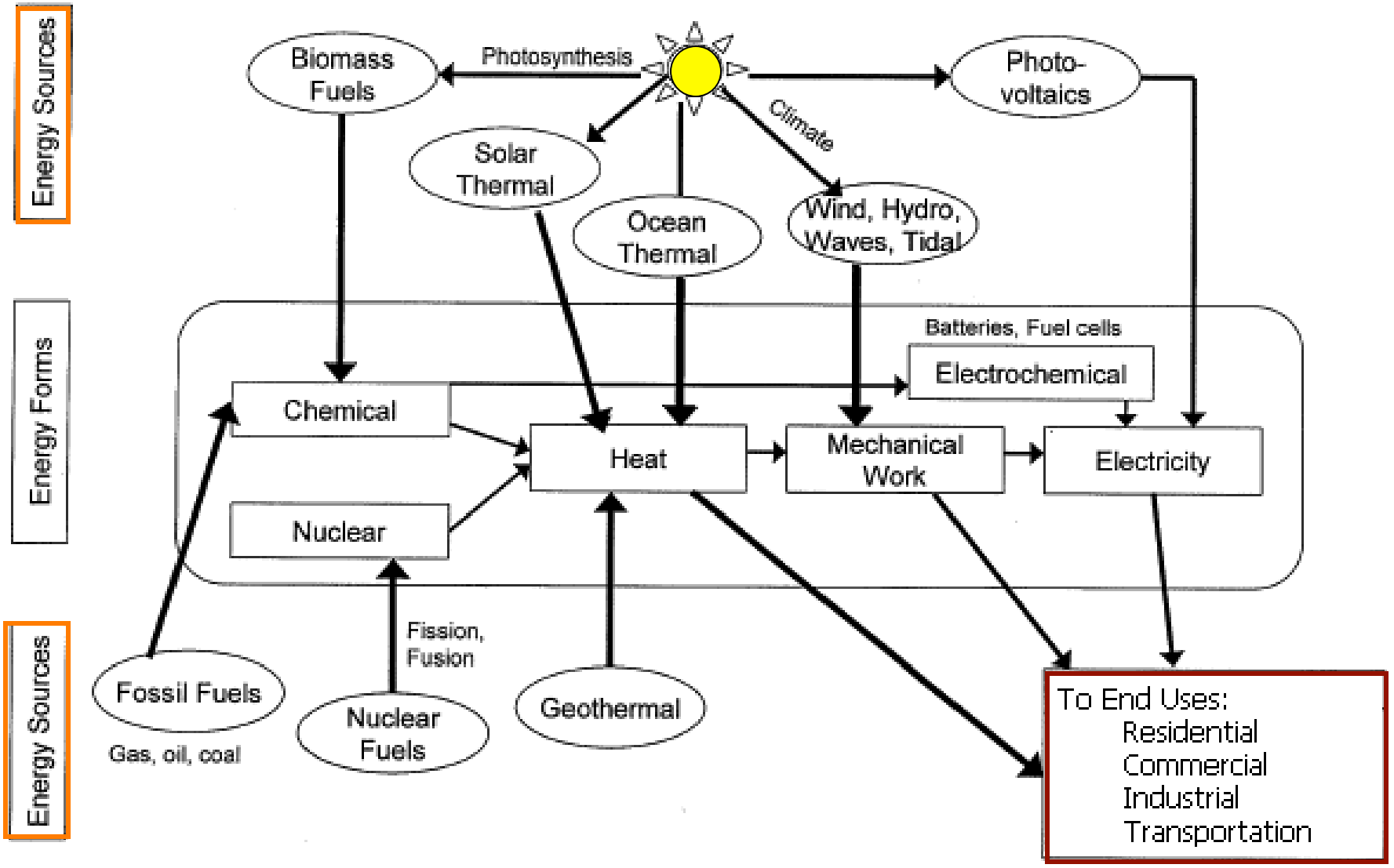
Energy Content MJ/kg:

Gasoline 45 Ethanol 30 Diesel 45 LNG 55 Hydrogen 120

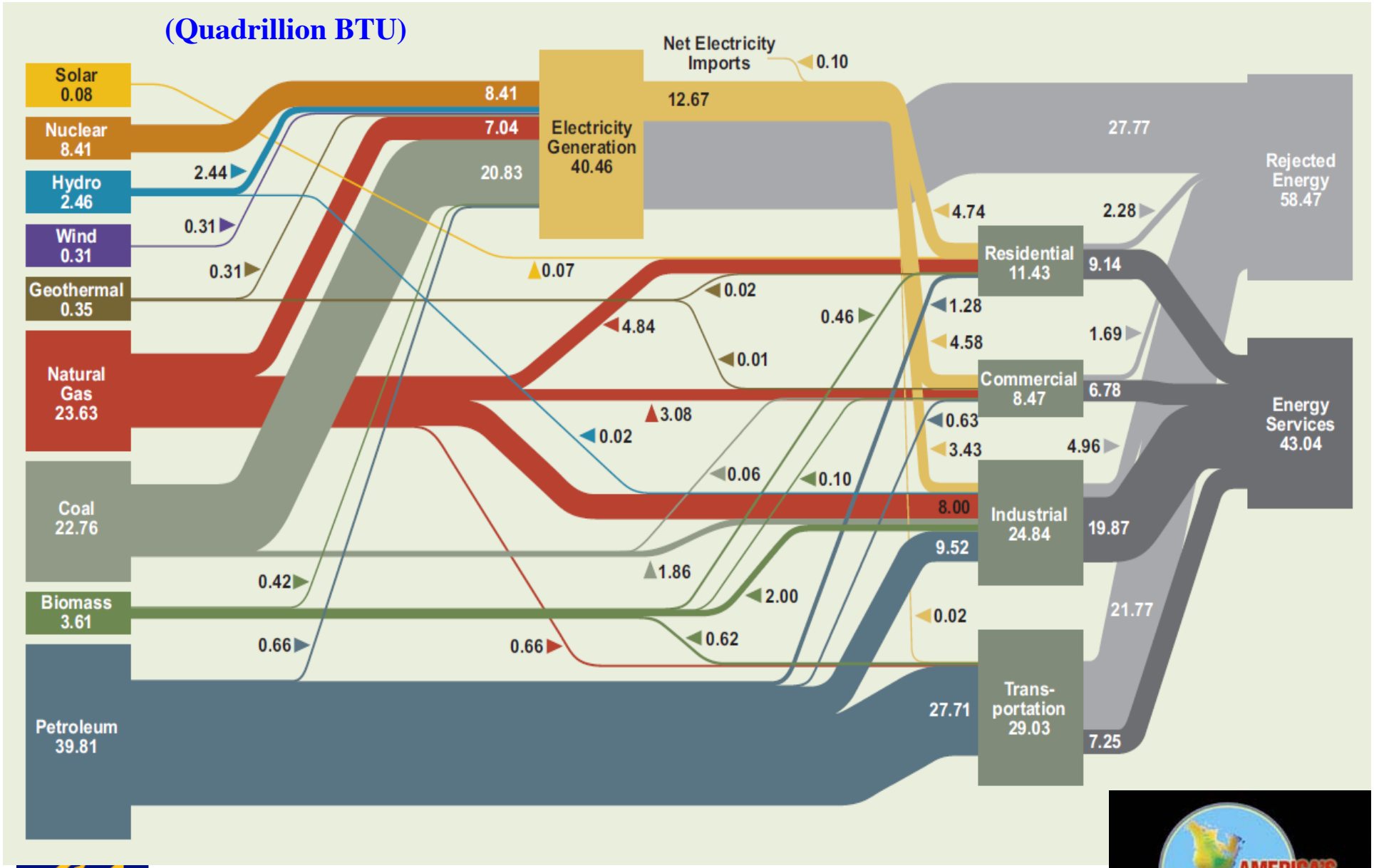
Uranium use in fission 77,000,000

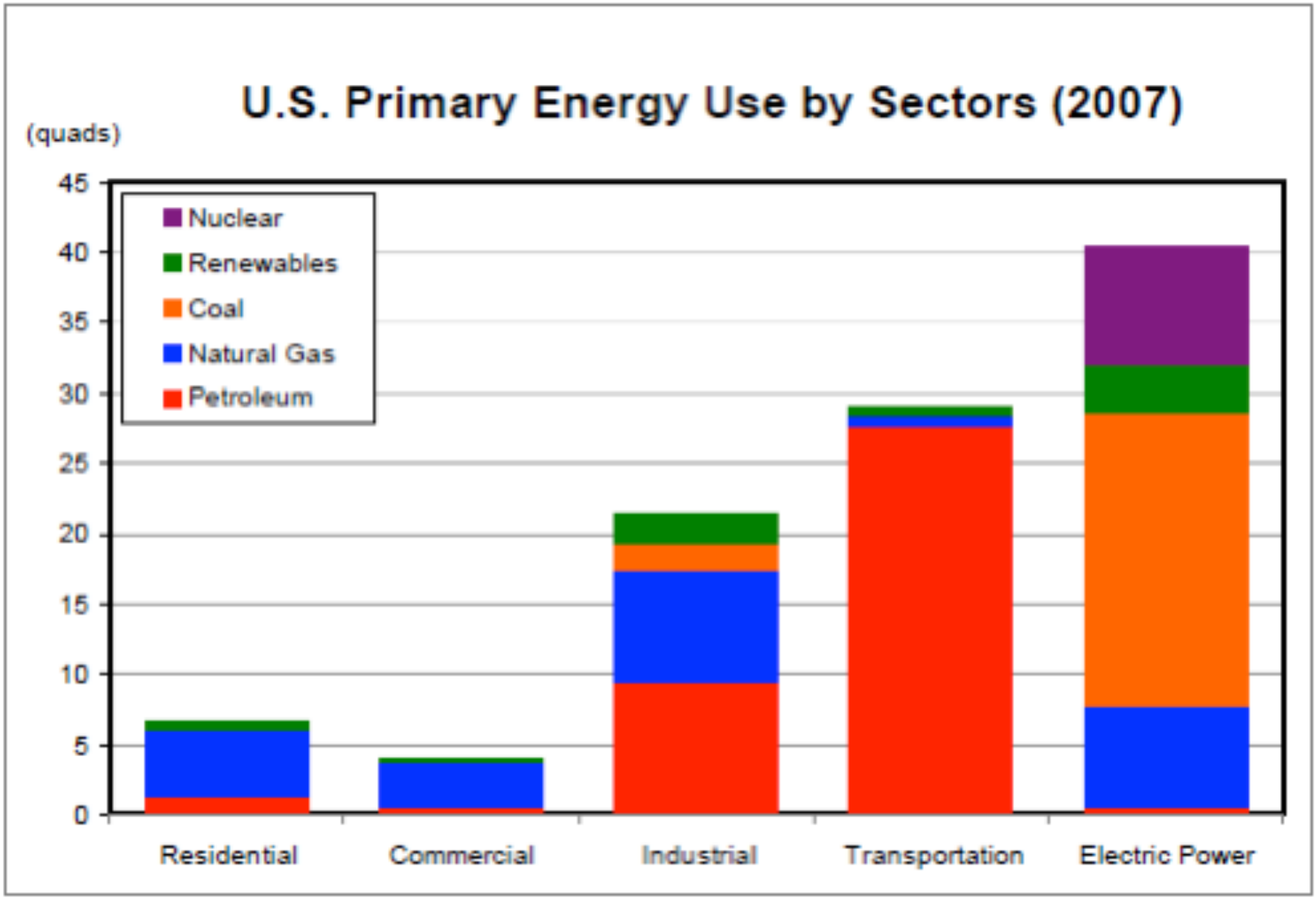
Lithium ion batteries ~0.5 to 1

Sources and Forms of Energy

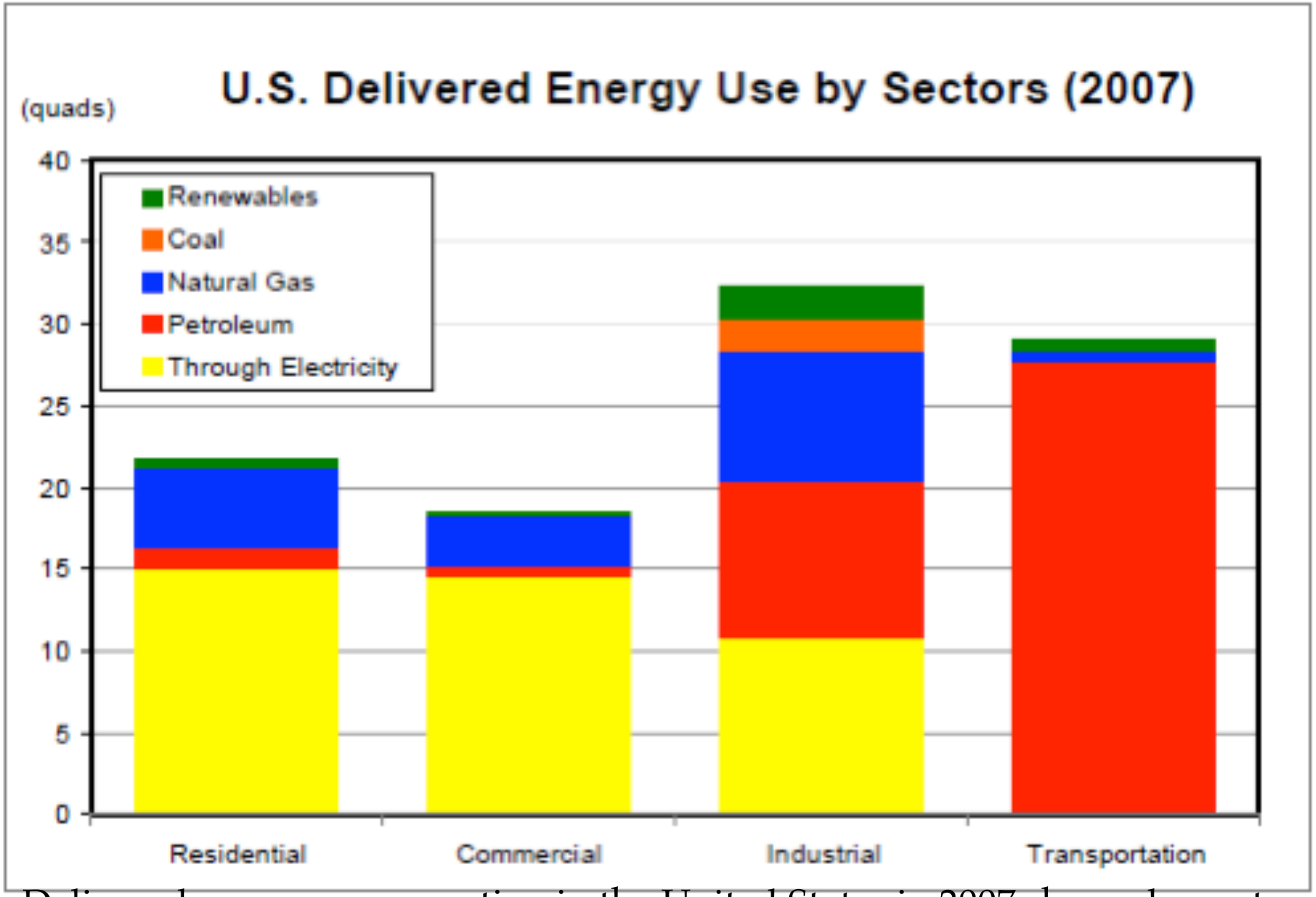


Energy Flows in the U.S. Economy, 2007





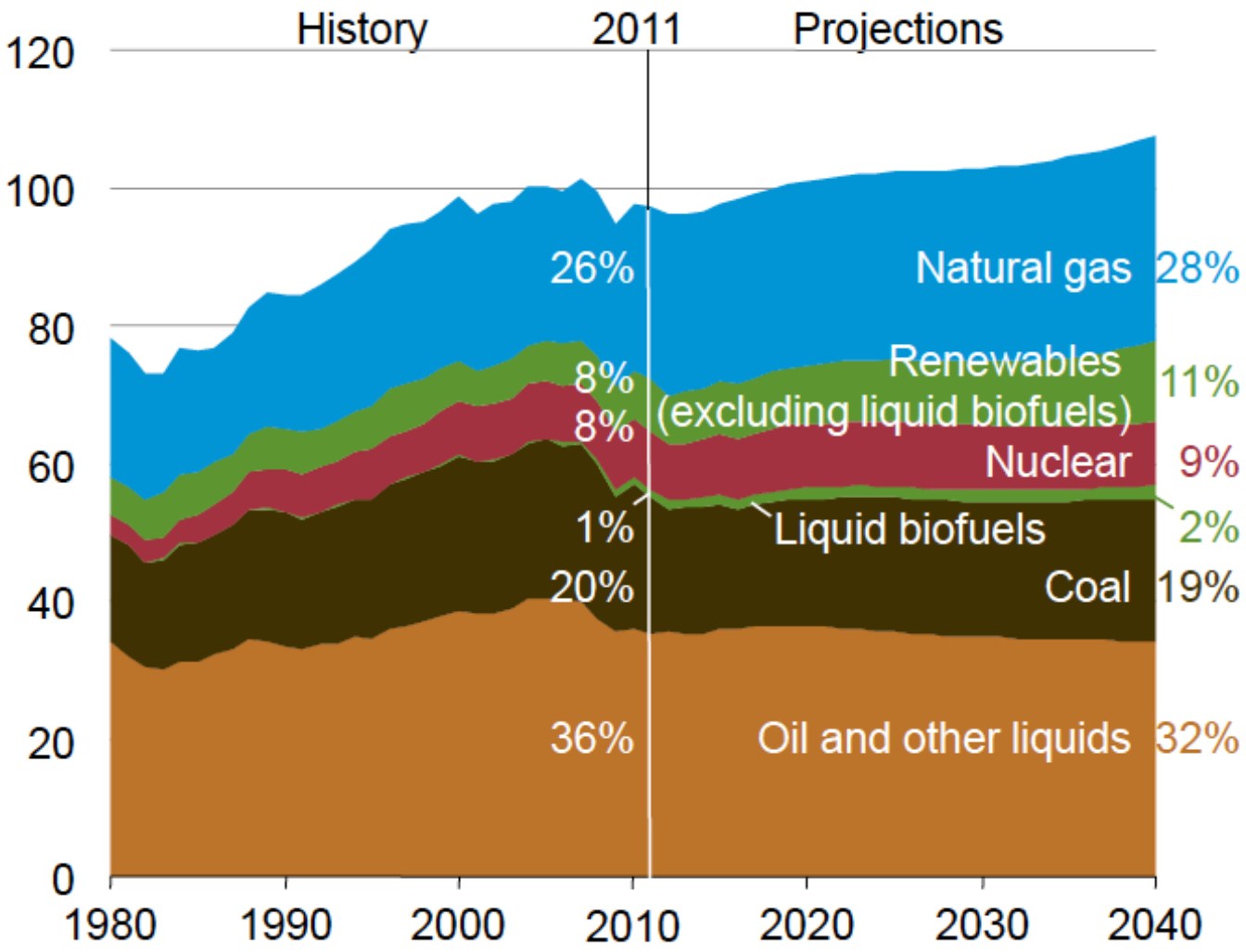
Primary energy consumption by sector and fuel type in the United States in 2007. Energy consumed by the electric power sector is used to produce electricity consumed by the end-use sectors.



Delivered energy consumption in the United States in 2007 shown by sector and by fuel type. Delivered energy consumption assigns primary energy sources consumed to produce electricity to the appropriate end-use sector

Projections: More Domestic Sources, Not Much Biofuel

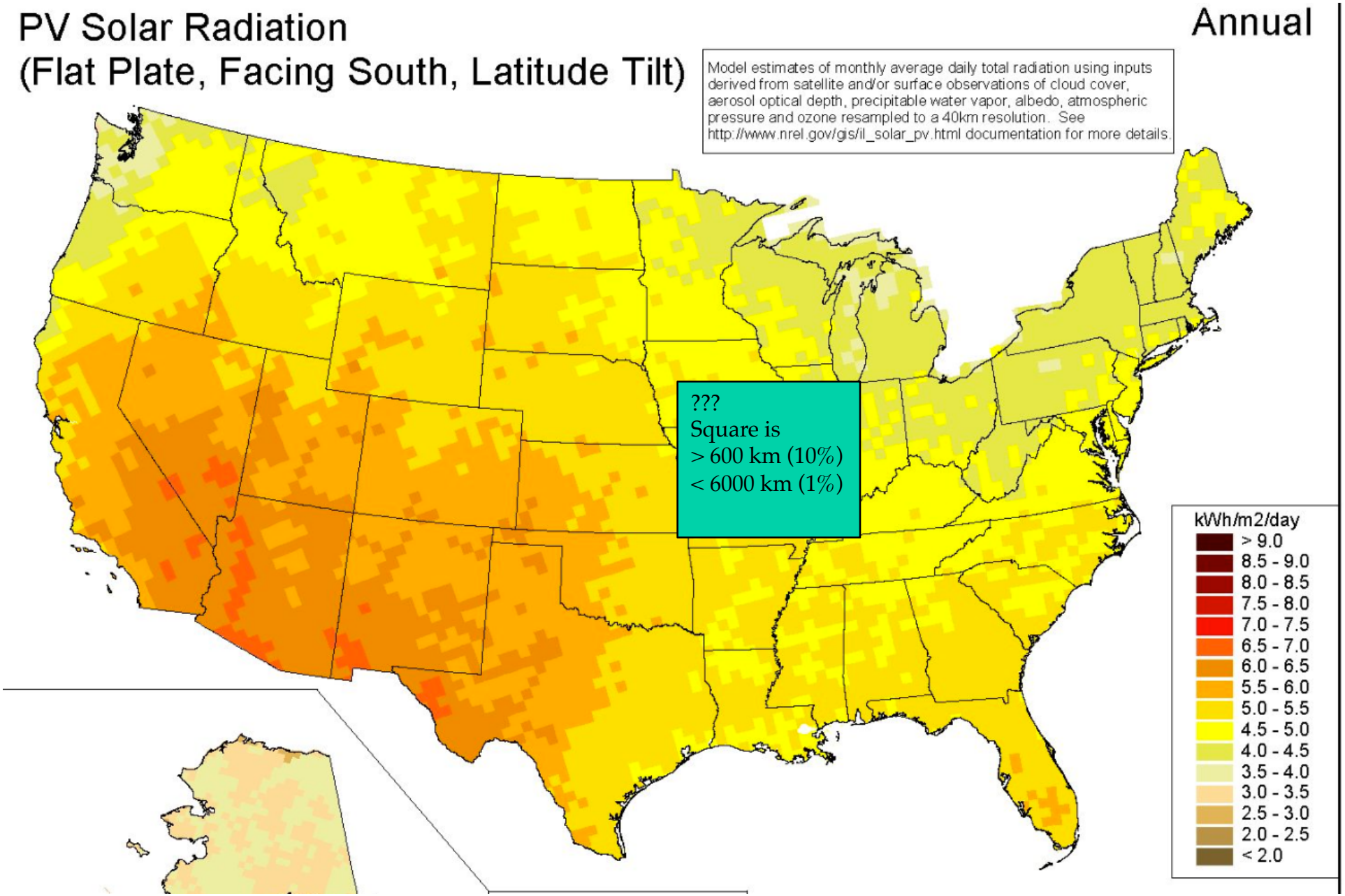
Figure 7. U.S. primary energy consumption by fuel, 1980-2040 (quadrillion Btu per year)



Source:

US Energy Information Agency (2012)

Energy Conversion Efficiency



Biomass Production

Conversion and processing to make fuel

Storage, transport, and distribution

Combustion and use

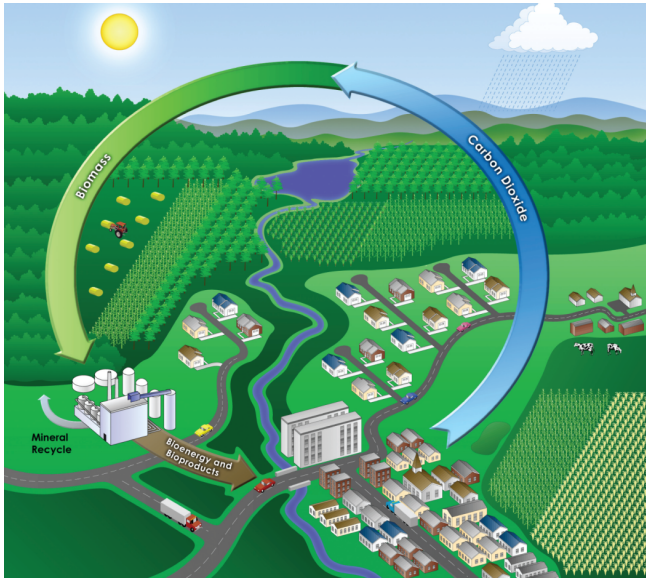
Overall Human health and ecosystem impacts

Energy Biosciences Institute

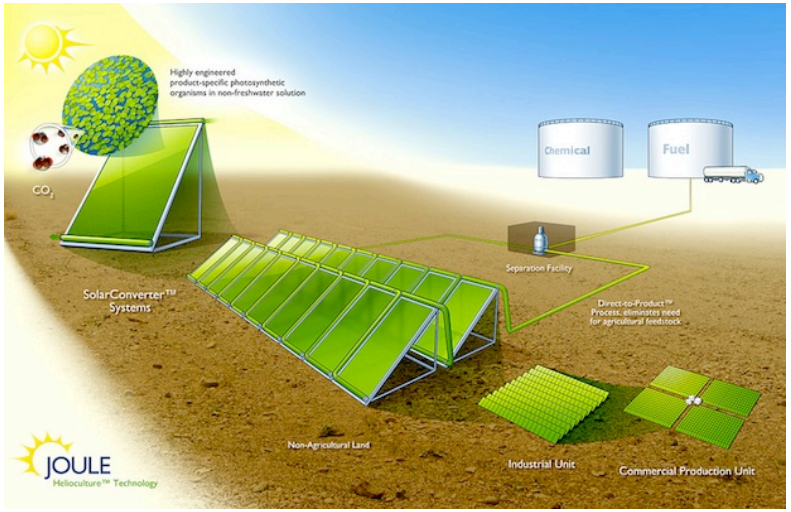
Exercise

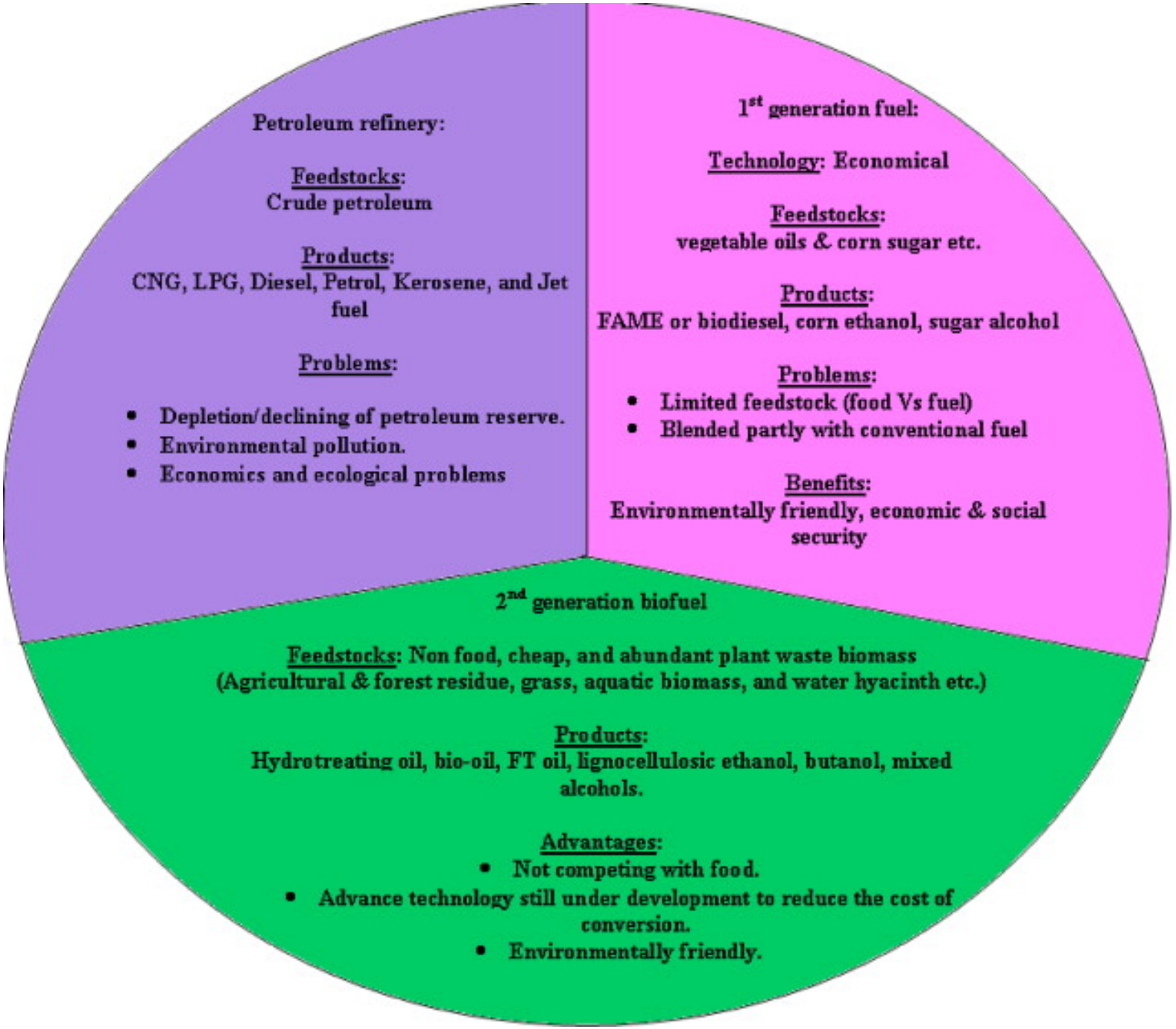
- **Consider that we want to double the contribution of biofuels in transportation from 8% to 16% by the year 2020.**
- **For each of the life stages of biofuel production—from feed stock production through fuel production, distribution, and use:**
  - **What infrastructure changes will be required in the US to address this increase (land changes, transport, piping, etc)?**
  - **Identify some potential impacts of these changes on (a) greenhouse-gas emissions, (b) land, (c) water resources, ecosystems, (d) human health, and (e) economic welfare**

Biofuels: Generations



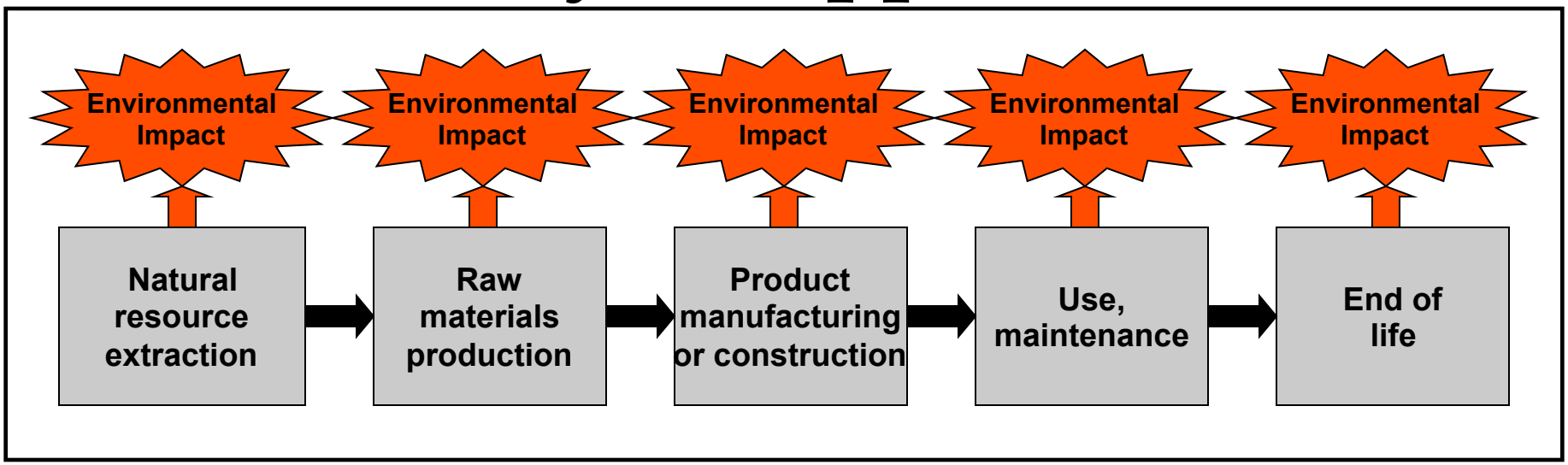
- First-generation or conventional biofuels are made from sugar, starch, or vegetable oil—basically from edible plant components
- Second-generation biofuels are produced from cellulose, hemicellulose or lignin. Examples of 2nd-generation biofuels are cellulosic ethanol and Fischer-Tropsch fuels.
- Third-generation biofuel includes advanced algae-based biodiesel
- Fourth-generation biofuels are created using petroleum-like hydroprocessing or advanced biochemistry



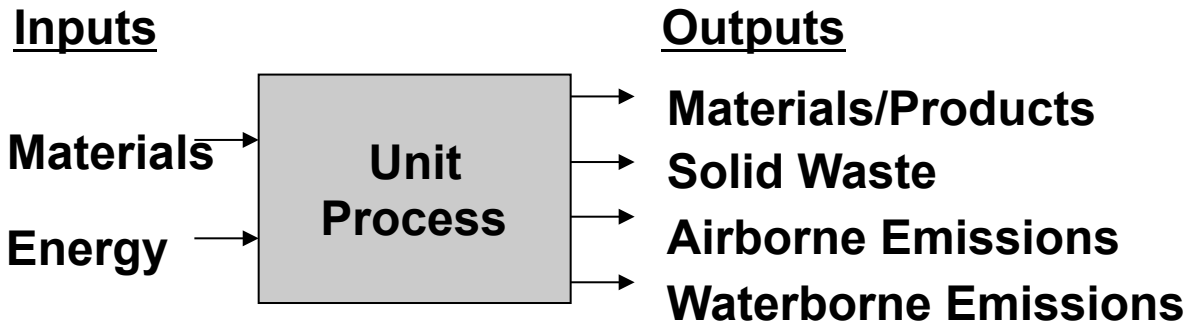

Petroleum refinery:
Feedstocks:
Crude petroleum
Products:
CNG, LPG, Diesel, Petrol, Kerosene, and Jet fuel
Problems:
• Depletion/declining of petroleum reserve.
• Environmental pollution.
• Economics and ecological problems
1st generation fuel:
Technology: Economical
Feedstocks:
vegetable oils & corn sugar etc.
Products:
FAME or biodiesel, corn ethanol, sugar alcohol
Problems:
• Limited feedstock (food Vs fuel)
• Blended partly with conventional fuel
Benefits:
Environmentally friendly, economic & social security
2nd generation biofuel
Feedstocks: Non food, cheap, and abundant plant waste biomass
(Agricultural & forest residue, grass, aquatic biomass, and water hyacinth etc.)
Products:
Hydrotreating oil, bio-oil, FT oil, lignocellulosic ethanol, butanol, mixed alcohols.
Advantages:
• Not competing with food.
• Advance technology still under development to reduce the cost of conversion.
• Environmentally friendly.

Life-Cycle Impact Assessment

Life-cycle Approach

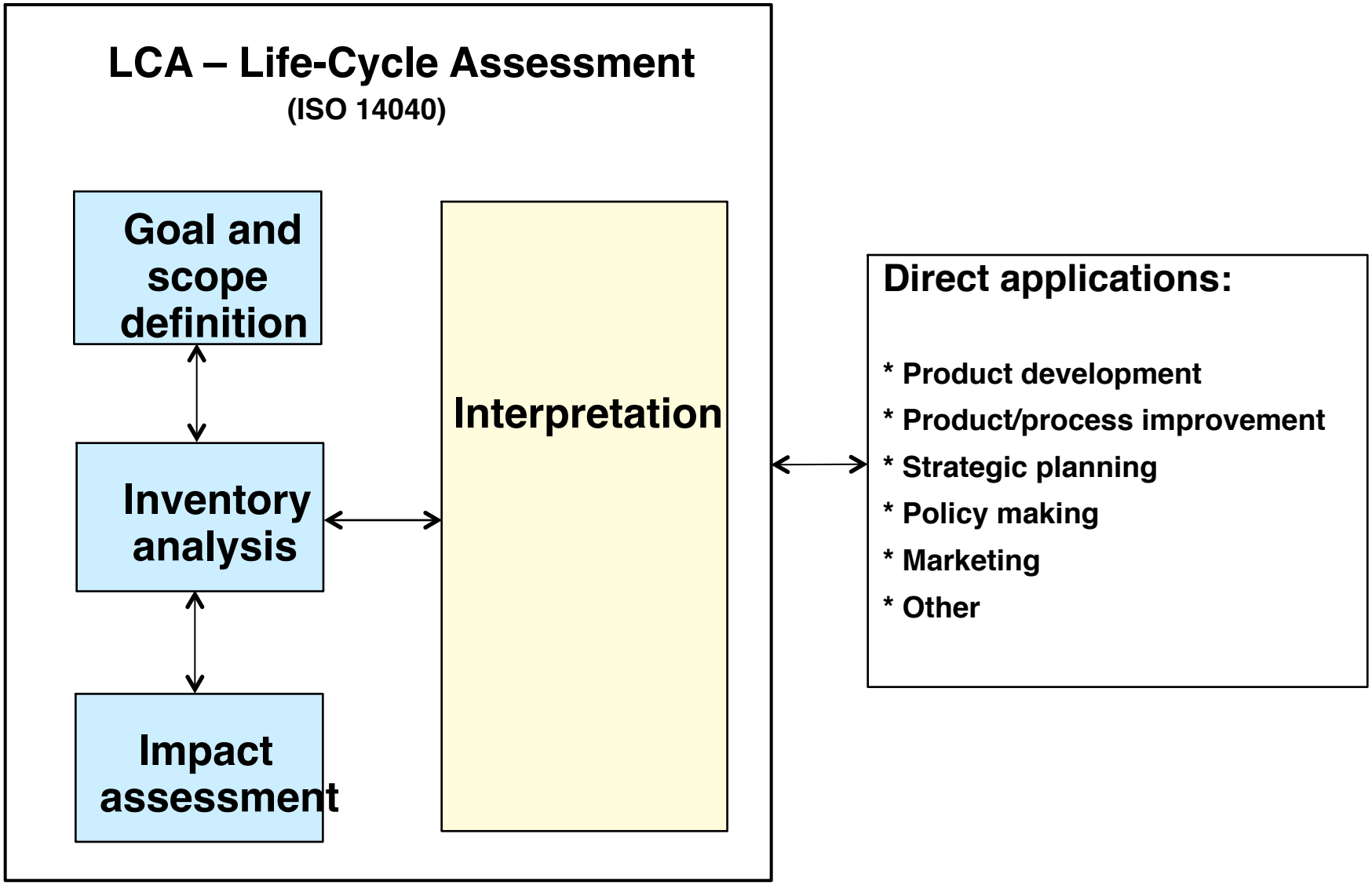


System boundary

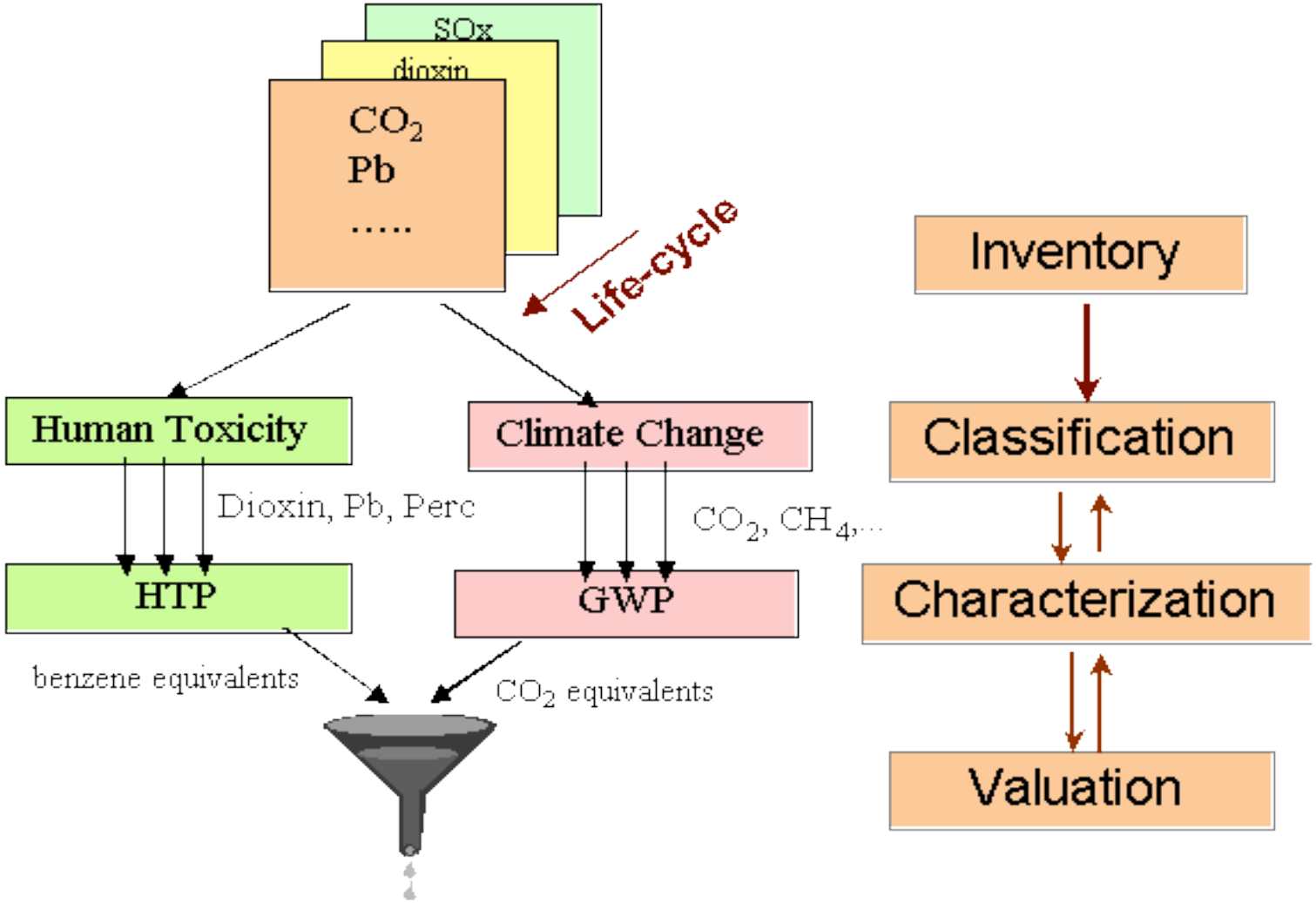


LCA: A concept and methodology to evaluate the environmental effects of a product or activity holistically, by analyzing the whole life cycle of a particular product, process, or activity (U.S. EPA, 1993).

LCA Methodology – ISO 14040



Life-Cycle Impact Assessment



Overall Environmental Preference

Biofuel
Life Cycle Assessment

REQUIREMENTS / INPUTS

- Climate
- Land and soil resources
- Plant geno/phenotypes
- Microbes
- Water
- Nutrients
- Energy as fuels
- Materials
- Capital
- Labor skills
- Existing and new infrastructure
- Information resources

Agricultural system

Conversion and processing to make fuel

Storage, transport, and distribution

Combustion and use

IMPACTS

Climate Forcing
- Greenhouse gases
- Albedo, latent/sensible heat
- Aerosols

Water quality and quantity
- Ground-surface water pollution
- Eutrophication
- Diversion and consumption

Ecosystem Sustainability
- Pollution stress
- Biodiversity and Habitat
- Soil quality and nutrient cycling

Human health
- Community health - air, water
- Occupational health
- Drinking water

Waste streams
- Wastewater
- Solid waste
- Hazardous waste

Social & Economic
- Adapting to new infrastructure
- Food prices/Fuel prices
- Efficiency demands

Spatial considerations: Local Regional National Global

Temporal considerations: Short-term (5-10 yr) Mid-term (10-25 yr) Long-term (>25 yr)