Ecology of the Automobile

Challenges and Research Methods in Sustainable Vehicular Materials Usage

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Outline: Ecology of the Automobile

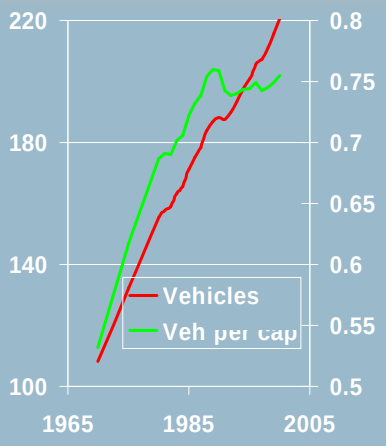
- **Why care about the auto?**
  - **Impacts of the automobile**
  - **Auto materials usage**
- **Materials Flows for The automobile**
  - **Challenges**
- **Current Research: Identifying Solutions**
  - The challenge of design
  - Addressing the materials system

Why consider AUTOMOBILES in a discussion of SUSTAINABILITY?

Materials

Why Care About the Automobile? – Magnitude

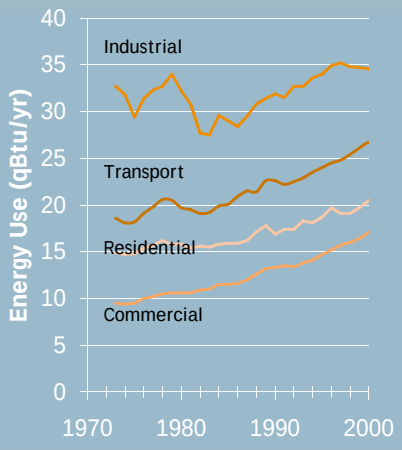
- There really are a lot of cars out there
- US in 2000
  - >220 million light vehicles
  - 0.75 per capita
- World
  - ~ 700 million
  - 0.12 per capita



Source: S.C. Davis and S.W. Diegel, Transportation Energy Data Book", v23, DOE, ORNL-6970, 2003

Why Care About the Automobile? – Energy Use & Impacts

- **Autos are a major consumer of energy**
- **US in 2005 for driving**
  - **28 quadrillion Btu**
  - **14 million barrels of oil per day**
- **Autos are a major source of emissions**
  - **2003: 1875M mtons of CO2**



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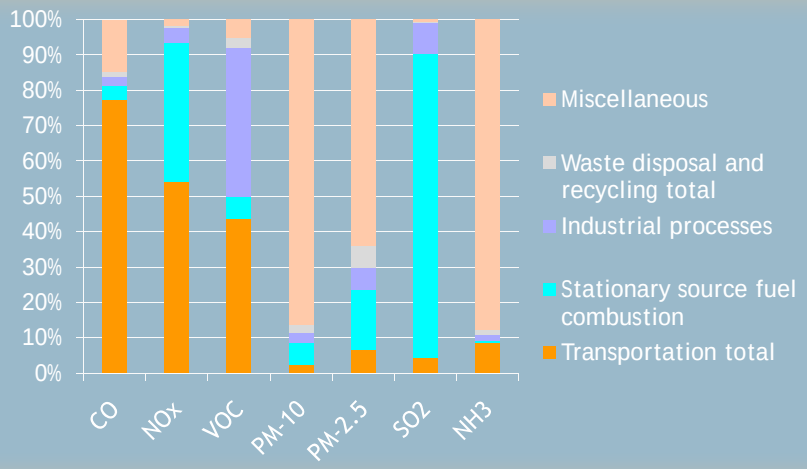
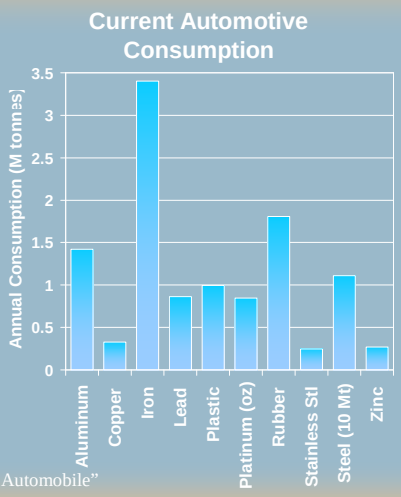
Why Care About the Automobile? – Emissions



Source: S.C. Davis and S.W. Diegel, Transportation Energy Data Book", v23, DOE, ORNL-6970, 2003

Why Care About the Automobile? –
Magnitude of Materials Consumption

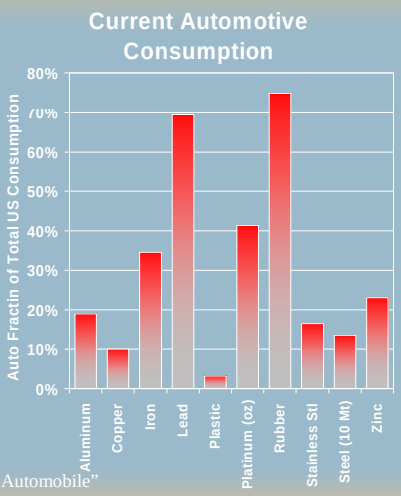
- **Autos are significant consumers of resources**
  - **Aluminum 1400kt**
  - **Lead 840kt**
  - **Platinum 850koz**
  - **Rubber 1800kt**
  - **Iron 3400kt**
  - **Steel 11000kt**



Sources: USGS & Keolian, Industrial Ecology of the Automobile"

Why Care About the Automobile? –
Magnitude of Materials Consumption

- **Autos are significant consumers of resources**
  - **Aluminum 19%**
  - **Lead 70%**
  - **Platinum 41%**
  - **Rubber >60%**
  - **Iron 35%**
  - **Steel 14%**



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Material Flows for the Automobile

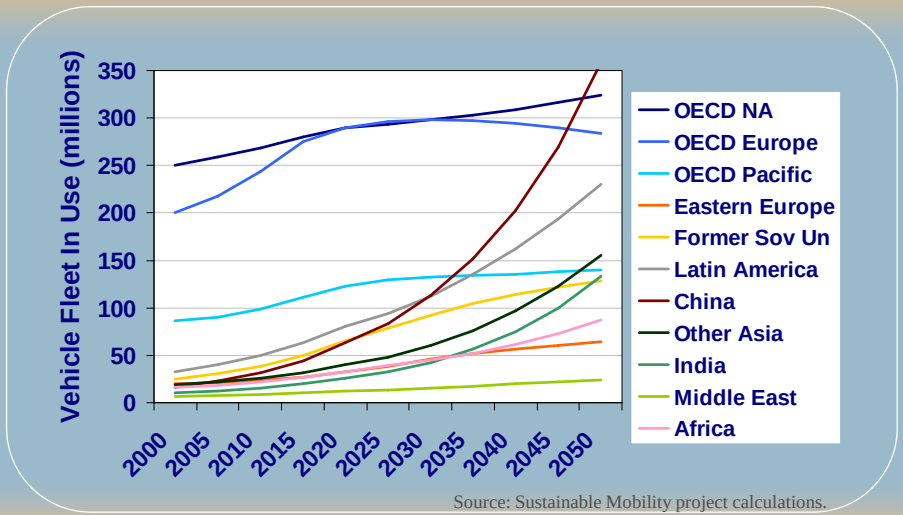
Projecting Future Materials Usage:
Sustainable Mobility 2030

- **Sponsor:**
  - **World Business Council on Sustainable Development**
- **Goals**
  - **Characterize the performance of current mobility**
  - **Project future sustainability characteristics**
  - **Recommend goals for improvement**
  - **Chart possible paths for achievement**
- **MIT Team**
  - **Project long-term materials flows for vehicle production**

Scope of Analysis

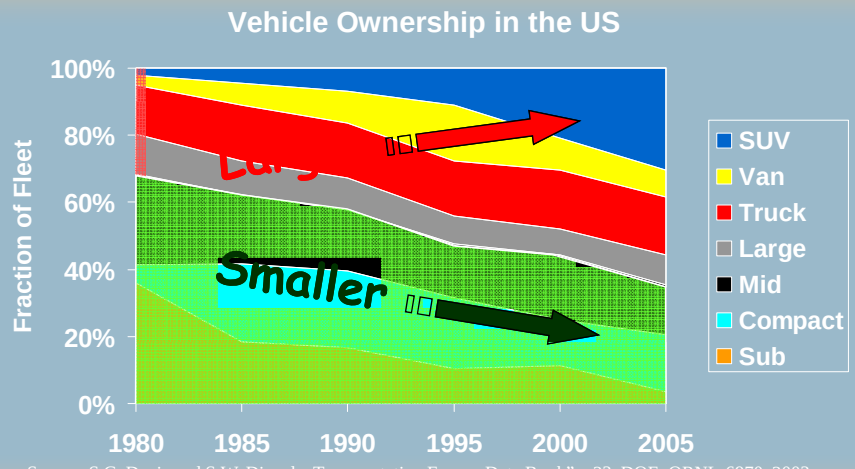
- **Materials Considered**
  - Ferrous metals
  - Aluminum
  - Other Non-Ferrous (Cu, Pb, Ni, Mg)
  - Platinum Group (Pt & Pd)
  - Plastics & Rubber
  - Glass
- **Vehicles Considered**
  - Autos & Light Trucks
    - Gasoline & hybrid
    - Diesel & hybrid
    - CNG/LNG hybrid
    - Fuel cell
  - Large passenger buses
  - Delivery and Class 8 trucks
- **Regions Considered**
  - OECD North America
  - OECD Europe
  - OECD Pacific
  - Former Soviet Union
  - Eastern Europe
  - China
  - Other Asia
  - India
  - Middle East
  - Latin America
  - Africa

Projected Vehicle Population



Source: Sustainable Mobility project calculations.

Examining Demographic Trends:
Increasing Vehicle Size



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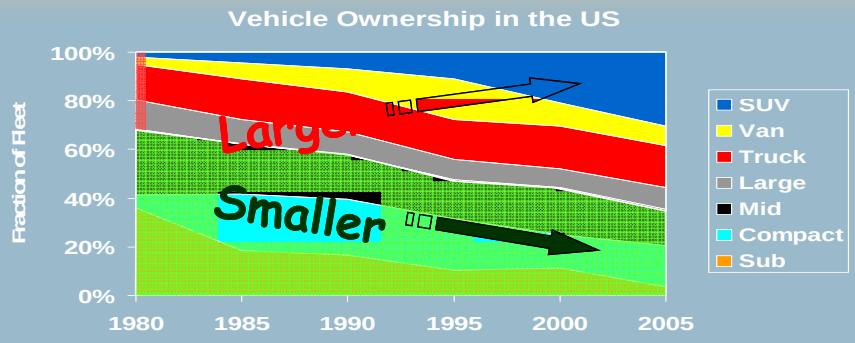
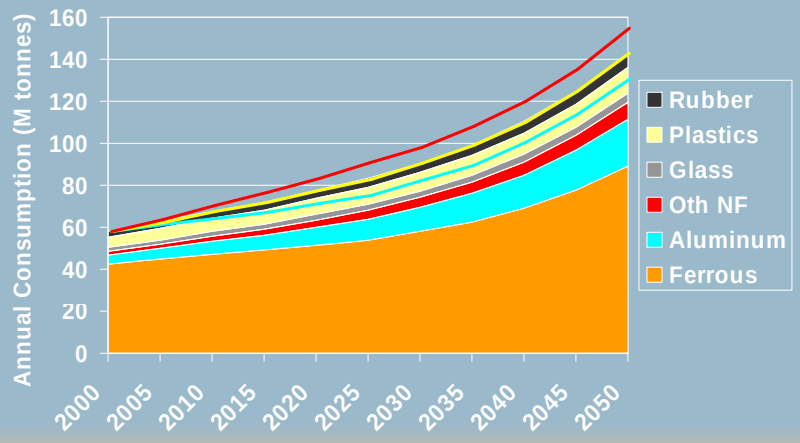
Examining Demographic Trends:
Increasing Vehicle Size



- **Data is scarce for non-OECD locales**
- **Projection assumes slow shift in vehicle mix -- increasing average size for 20 years in non-NA markets**

Projected Global Automotive Materials Consumption



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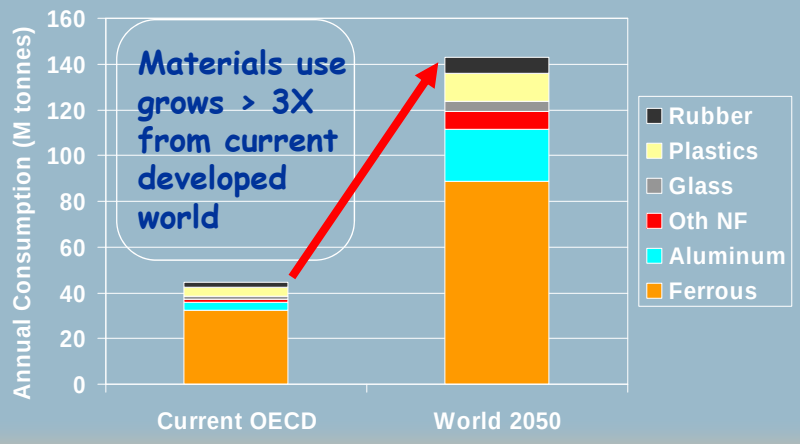
Issues of the Auto: Slide 19

Putting Consumption Into Perspective:
Compared to Current Consumption



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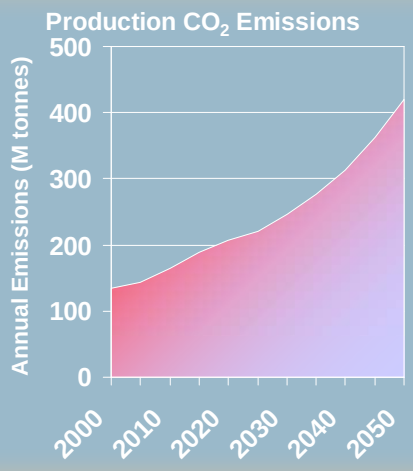
Issues of Concern:
Attendant Effects of Production

- **Energy Consumption**
  - **Aluminum** **185** MJ/kg
  - **Copper** **100** MJ/kg
  - **Steel** **40** MJ/kg
  - **Polyester** **96** MJ/kg
  - **Glass** **30** MJ/kg

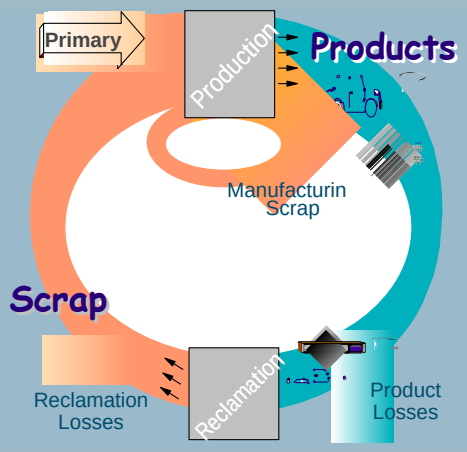
- **CO2 Emissions**
  - **Primary Aluminum** **10 – 15** kg/kg
  - **Secondary Aluminum** **1.0** kg/kg
  - **BOF Steel** **1.3-1.5** kg/kg



Opportunities to Improve Auto Materials Sustainability

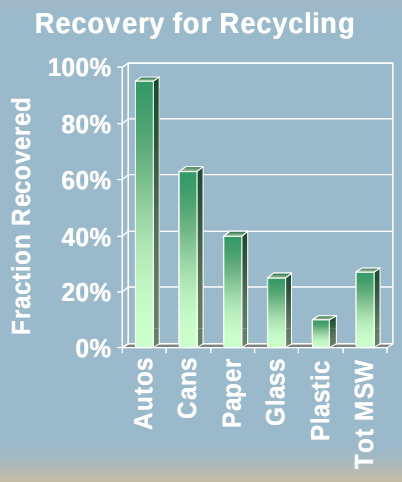
Opportunities to Improve Sustainability

- **Where are the opportunities to improve cyclicity?**
  - **Collection**
  - **Reclamation**
  - **Recycling**
  - **Design**



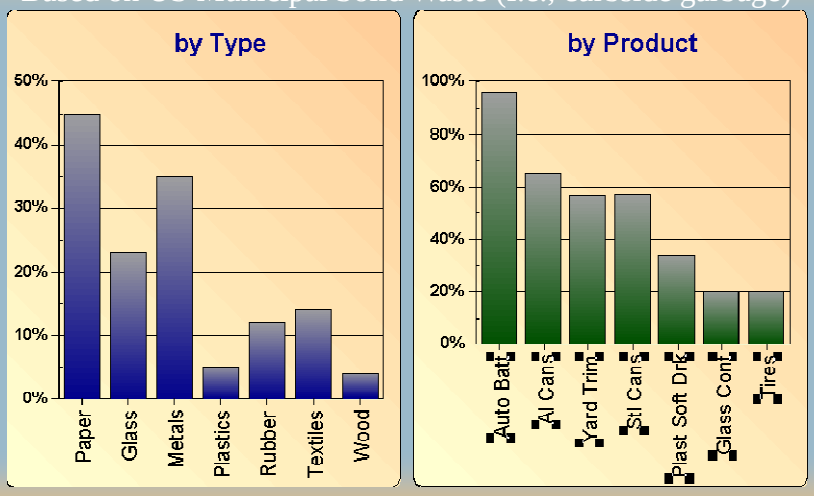
Why Care About the Automobile?
Contribution to Materials Recovery

- **Vehicle reclamation rates > 90%**
- **Material recovry rate > 75%**
- **In US, currently returns:**
  - **Steel 13 M tons**
  - **Nonferrous 0.8 M tons**
  - **Rubber 1.6 M tons**
- **Compare to:**
  - **Total recycling industry ~ 100 M tons**
  - **Total MSW ~ 200 M tons**



What Are We Recycling?

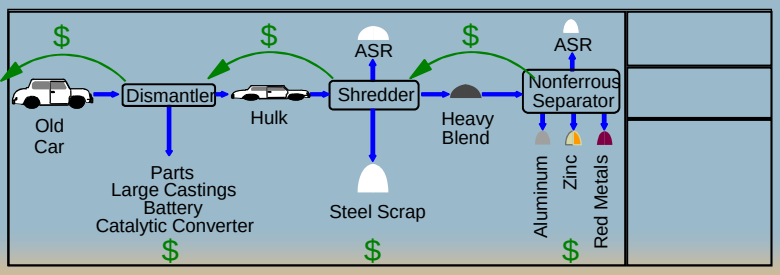
Based on US Municipal Solid Waste (I.e., curbside garbage)



Examining Automobile Recycling

- **Key elements**
  - **Dismantling**
  - **Shredding**
  - **Separation**
- **Generally, functions without regulatory intervention**

- **Key material flows**
  - **Ferrous -- $$**
  - **Non-ferrous -- $$**
  - **Auto-shredder residue -- $$**



Examining the Impact of Materials Technology Decisions on Materials Recovery

- **Material reuse (recyclability) is effected by:**
  - **Design decisions**
    - Product designers
    - Material producers
  - **Processing decisions**
    - Recovery infrastructure
- **Method needed which examines choices throughout system**