



# RENEWABLE OPTIONS OF FUTURE MOBILITY: BEYOND OIL

**Dr. Sanjay Kaul**  
Professor  
*Fitchburg State University*  
*Fitchburg, MA*



## RENEWABLE OPTION OF FUTURE MOBILITY: BEYOND OIL

Conventional Oil reserves are concentrated in OPEC areas (>70%).  
The production maximum is expected within the next two decades

- Transportation contributes to energy consumption and greenhouse emissions
- Sustainable mobility requires reduction in both areas
- A Significant share of energy consumption is due to rising transportation activities. Today, the mobility sector is completely dependent on crude oil derivatives



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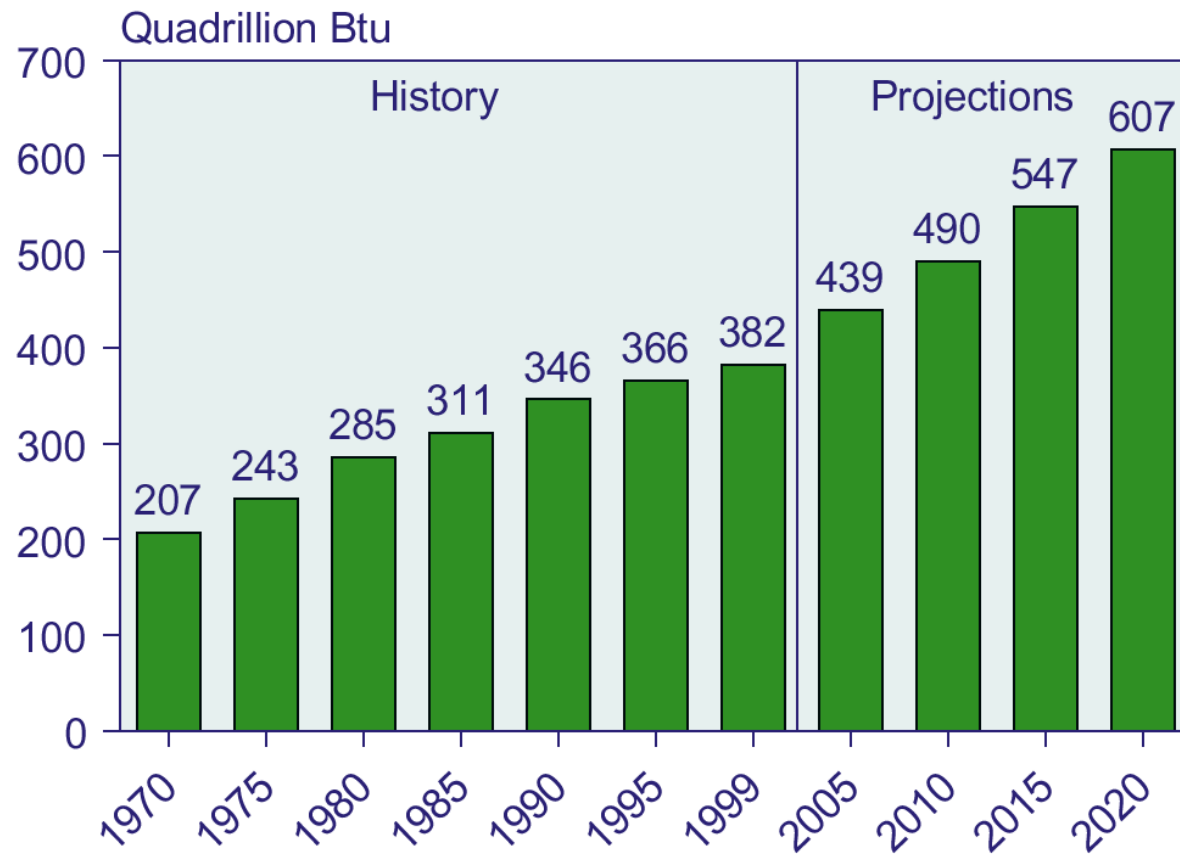
## World Natural Resources

- World Oil
  - Production  $P \sim 21 \text{ Bbl/year}$
  - Reserves  $R \sim 649 \text{ Bbl}$
  - Ratio( $R/P$ ) =  $649/21 \sim 31 \text{ year}$
- World natural gas
  - Production  $P \sim 48 \text{ TCF/Year}$
  - Reserves  $R \sim 2,470 \text{ TCF}$
  - Ratio( $R/P$ ) =  $2,470/48 \sim 52 \text{ years}$
- World Coal
  - Production  $P \sim 2.45 \text{ Bmt/year}$
  - Reserves  $R \sim 663 \text{ Bmt}$
  - Ratio( $R/P$ ) =  $663/2.45 \sim 270 \text{ years}$



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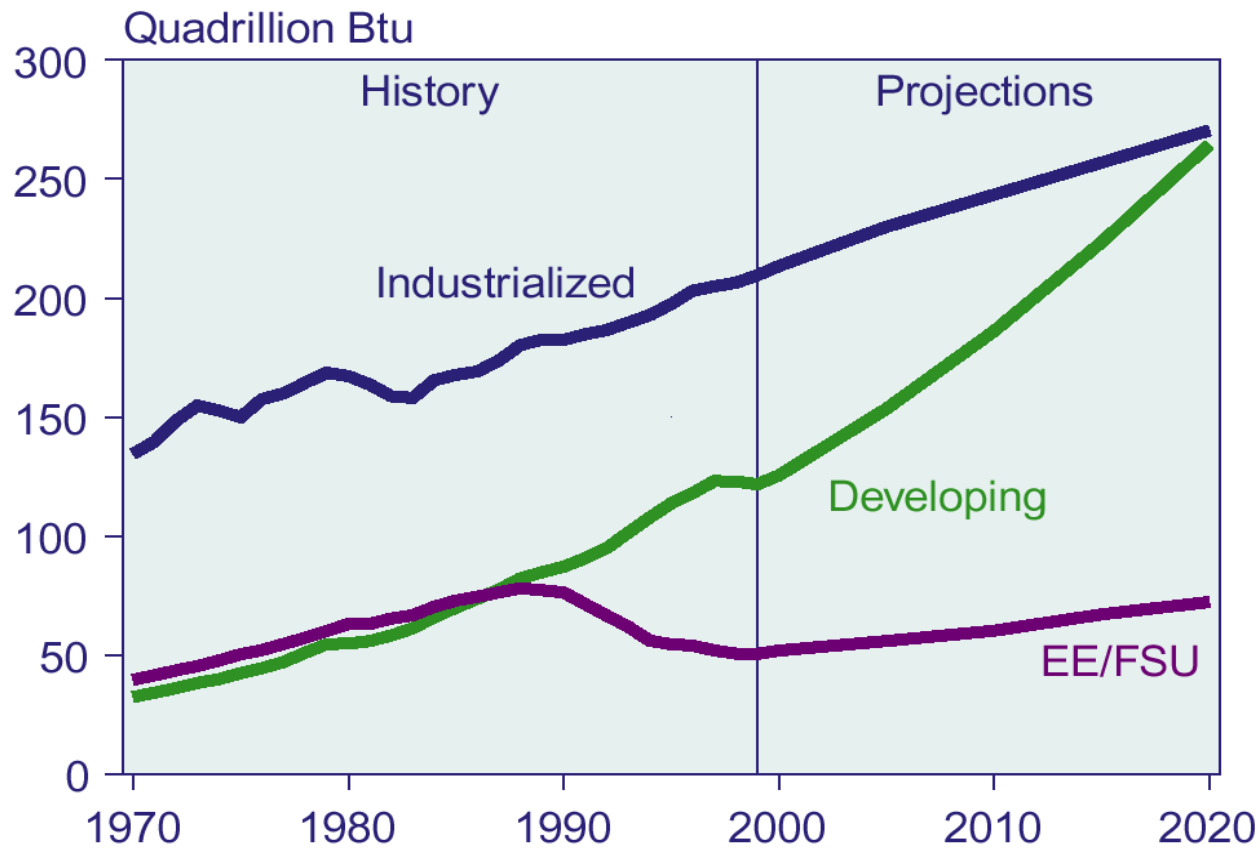
## World Energy Consumption 1970-2020





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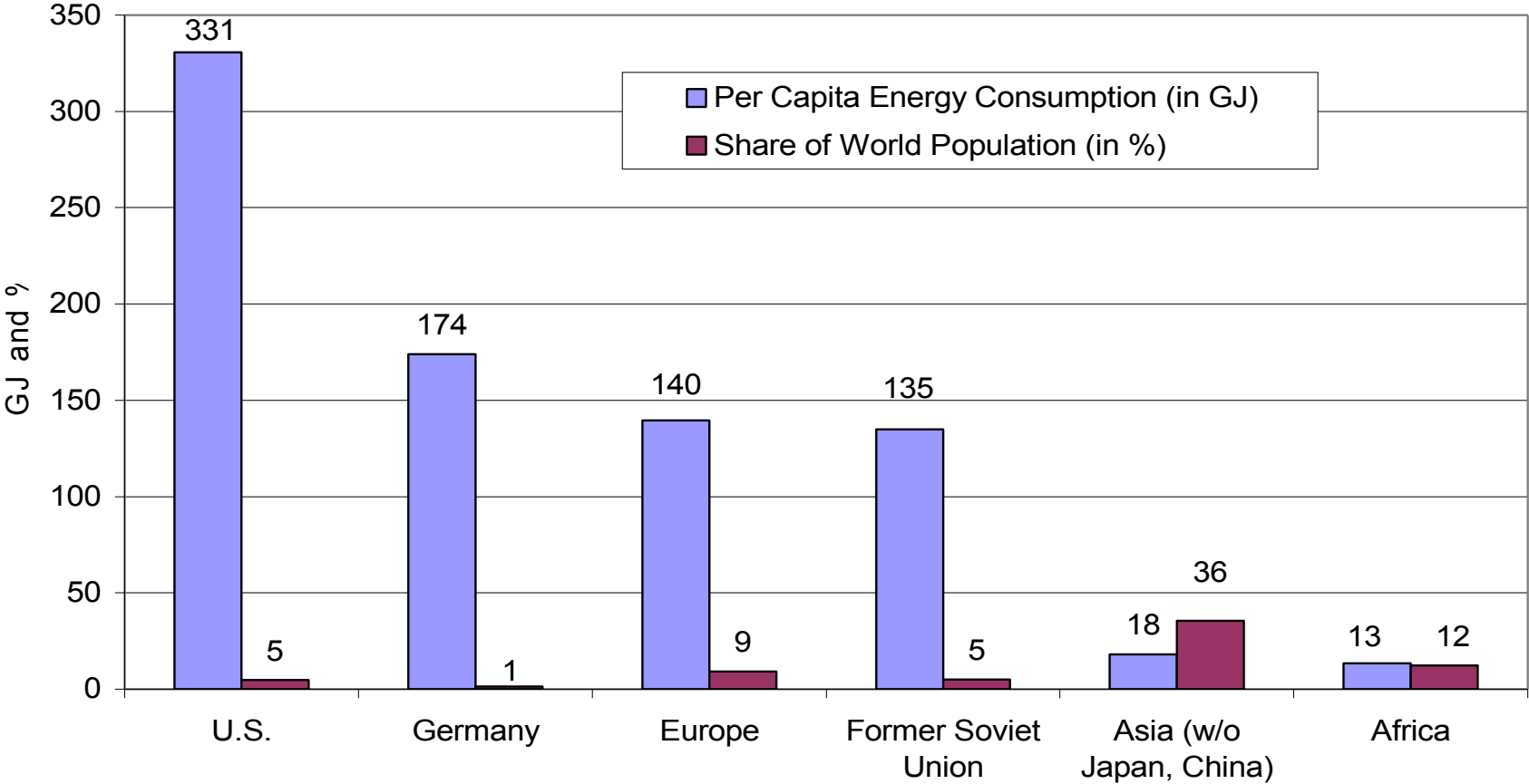
## World Energy Consumption by Region (1970-2020)





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# Per Capita Energy Consumption and Share of World Population (1998/1999 data)

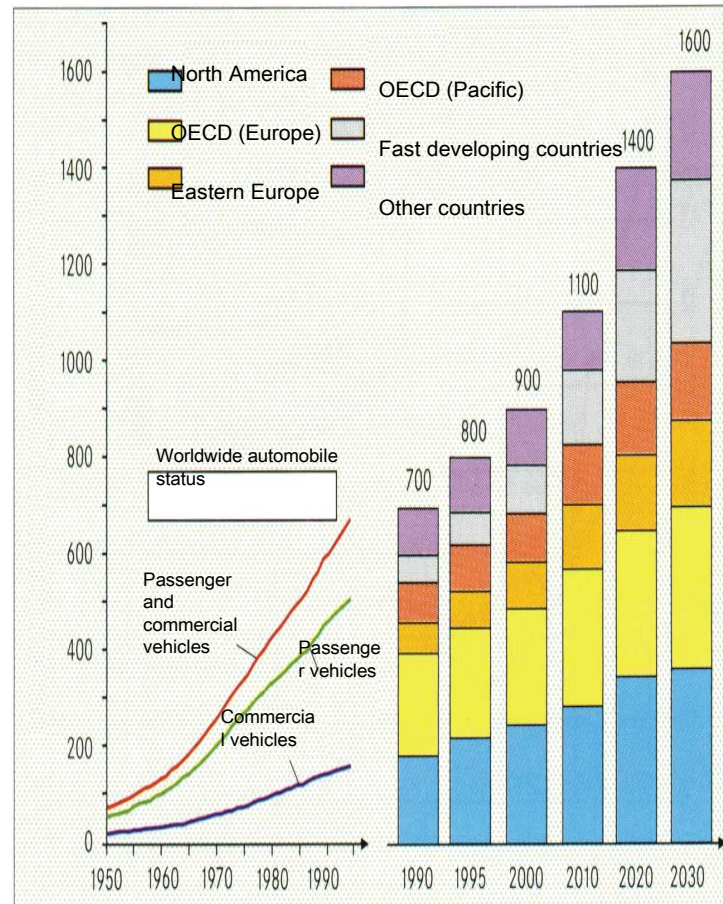
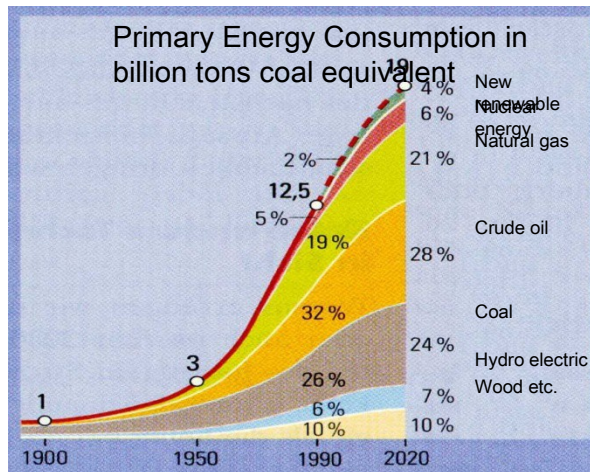
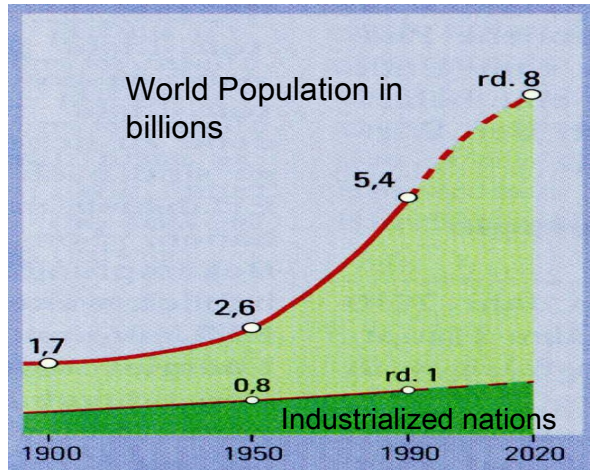






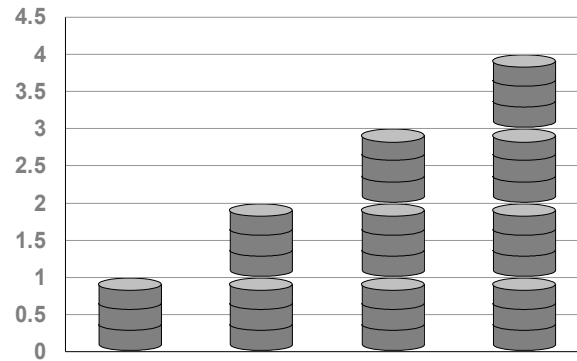
## RENEWABLE OPTION OF FUTURE MOBILITY: BEYOND OIL

- Long term trends**
- Continuous growth of population and energy needs
    - Ongoing demand for mobility resulting in increasing number of cars

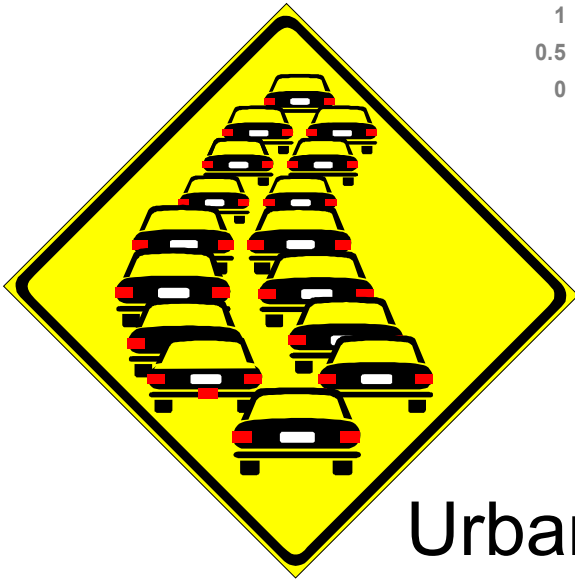




## The Challenges Facing Us...



Growing  
Petroleum  
Consumption

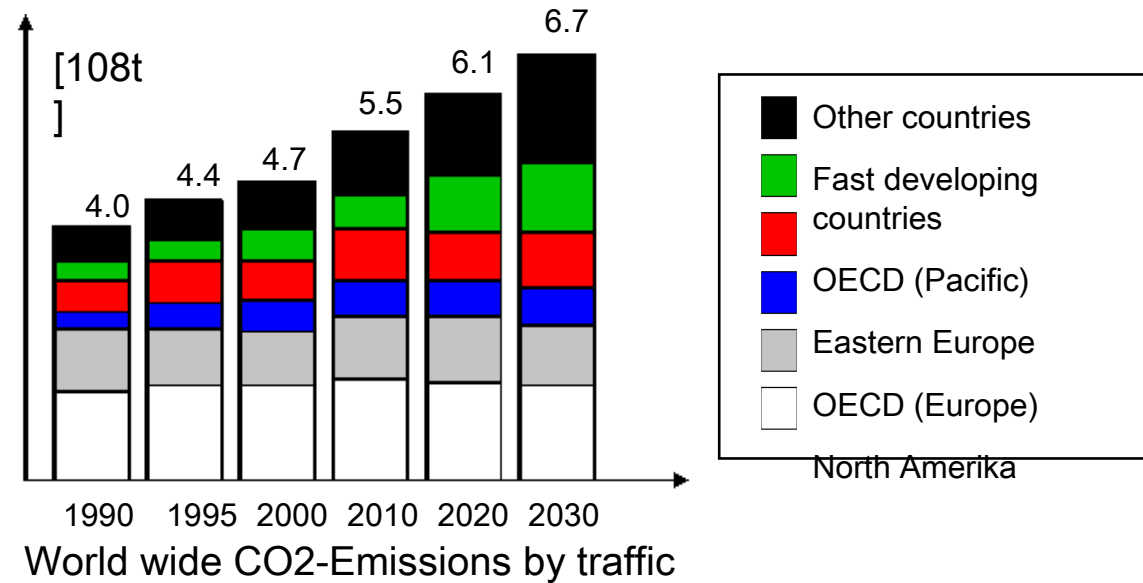






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### Environmental aspects



- Global climatic changes are expected by steadily increasing CO<sub>2</sub>.
- CO<sub>2</sub>-Emissions will be limited or fined by future legislation.
- Toxic emissions (NO<sub>x</sub>, Hydrocarbons, Particulates etc.) from vehicles will be further restricted.

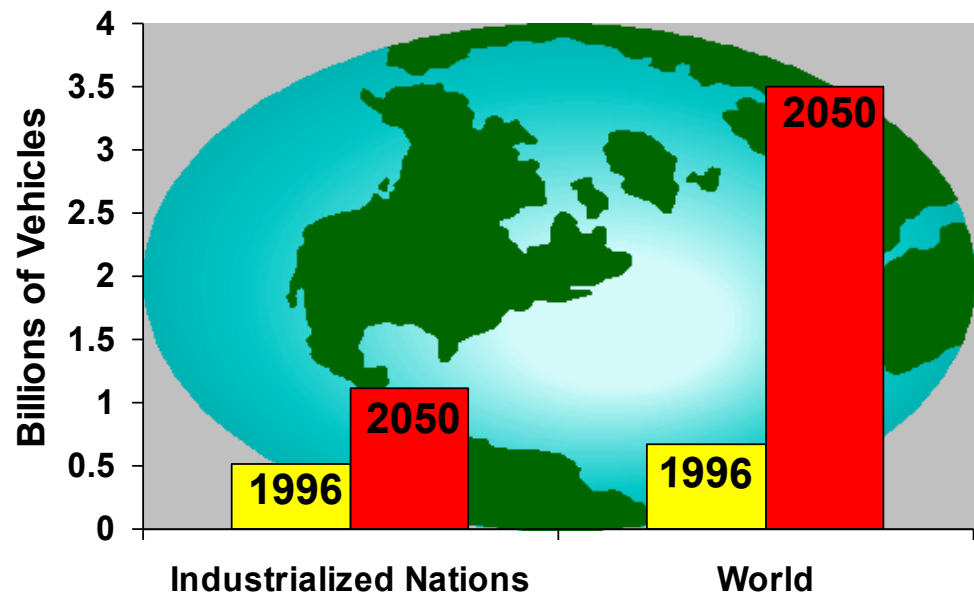


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## Projected Growth in Vehicle Population Intensifies Challenges

### Projected Growth in Light-Duty Vehicle Registrations

***Currently, U.S. Transportation uses 5,800 gallons of Petroleum a second***



Source: Program Analysis Methodology; Office of Transportation Technologies, Quality Metrics 2000, Office of Transportation Technologies



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## “Sustainable Development” Approach Required

- “**Sustainable development**” is broadly defined as economic growth that will benefit present and future generations without detrimentally affecting the resources or biological systems of the planet.\*
- Government and Industry share responsibility.

**We must approach the transportation challenge from a “sustainable development” perspective.**

\*Page 149, Linking Science and Technology to Society’s Environmental Goals, Policy Division National Research Council, National Academy Press, Washington D.C.



## RENEWABLE OPTION OF FUTURE MOBILITY: BEYOND OIL

Fuels from renewable energies help to achieve the climate goal in the long run

Shell predicated according to scenario analyses, that after 2050, there will be 50% renewable resources in our portfolio

With today's technology, we are able to produce various fuels from renewable resources such as hydropower, wind, solar energy or biomass.

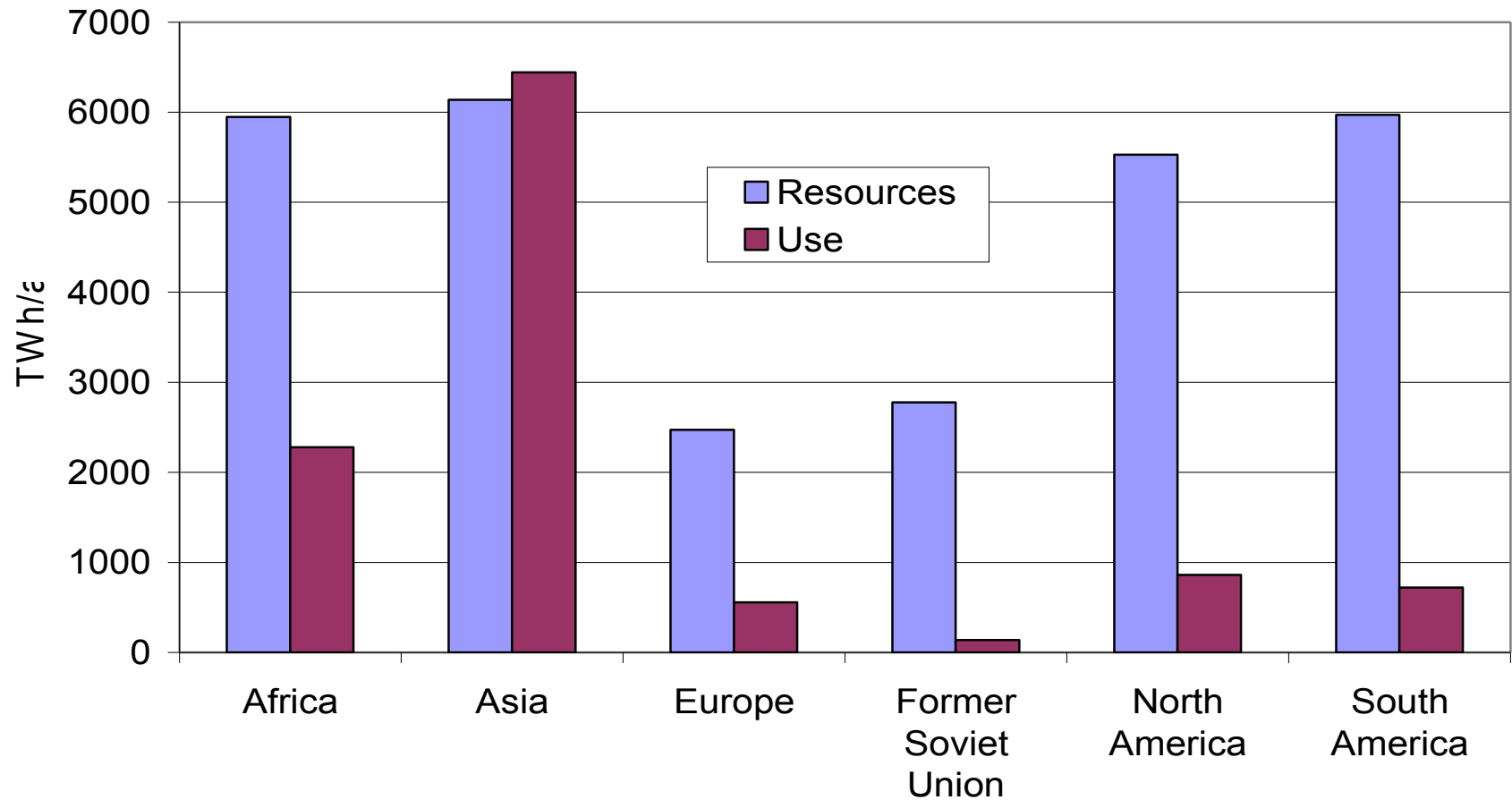
Methanol (as well as ethanol, dependent on the local biomass situation ) and hydrogen are exceptionally well suited for production from  $\text{CO}_2$  neutral or  $\text{CO}_2$  free sources and may be used in internal combustion engines as well as fuel cell vehicles





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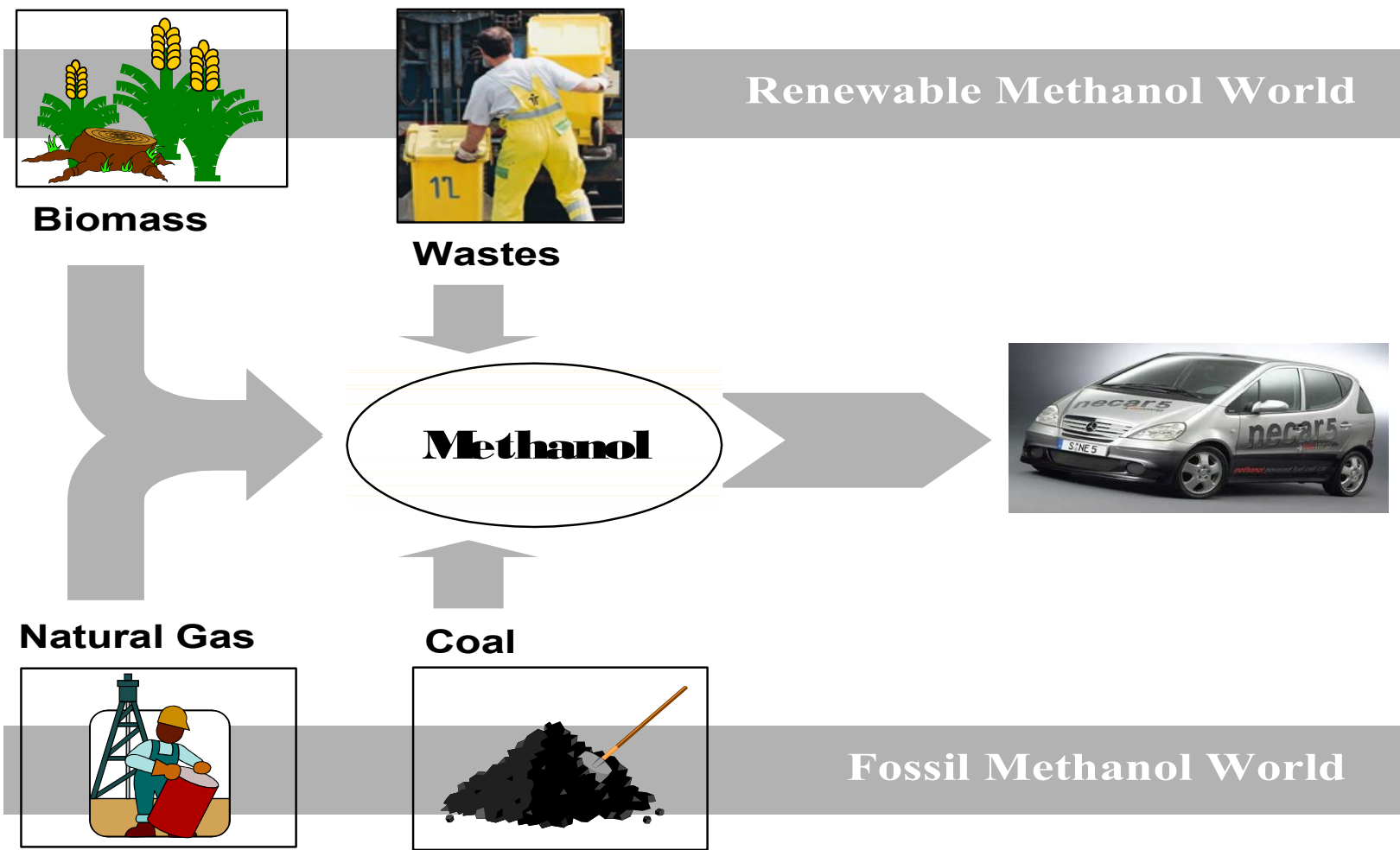
## Global Biomass Use & Resources





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# Renewable and Fossil Methanol Production





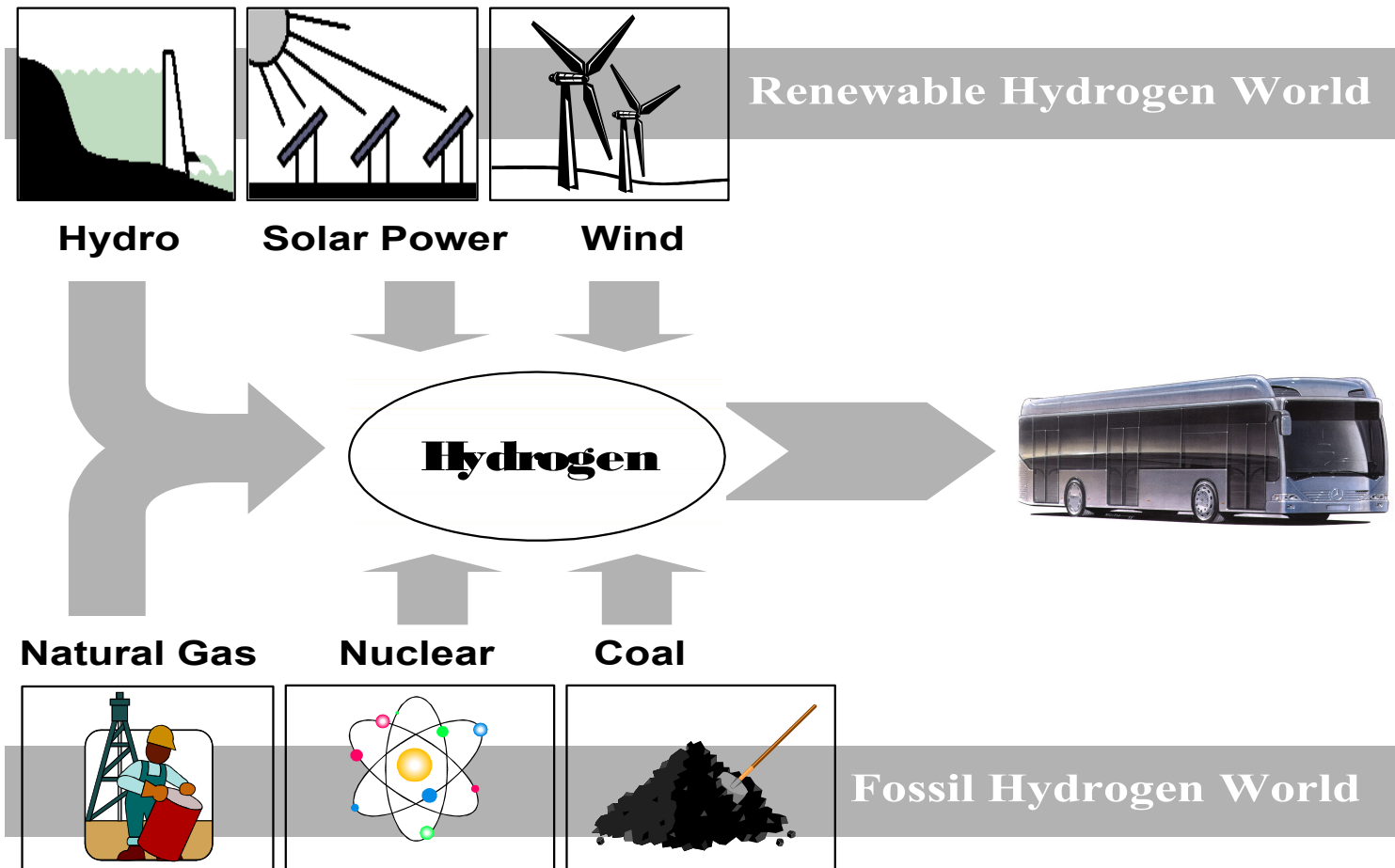
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The previous picture explains that the fuel methanol can be produced from fossil fuels such as Coal and natural gas , thus increasing  $\text{CO}_2$  concentration in the atmosphere. Methanol can also be produced from  $\text{CO}_2$  free or  $\text{CO}_2$  neutral sources such as wood and other biomass sources, fast growing energy crops otherwise be deposited on waste disposal sites. Using these resources as an intermediary step for fuel production reduces the consumption of primary fossil fuel



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## Renewable and Fossil Hydrogen Production







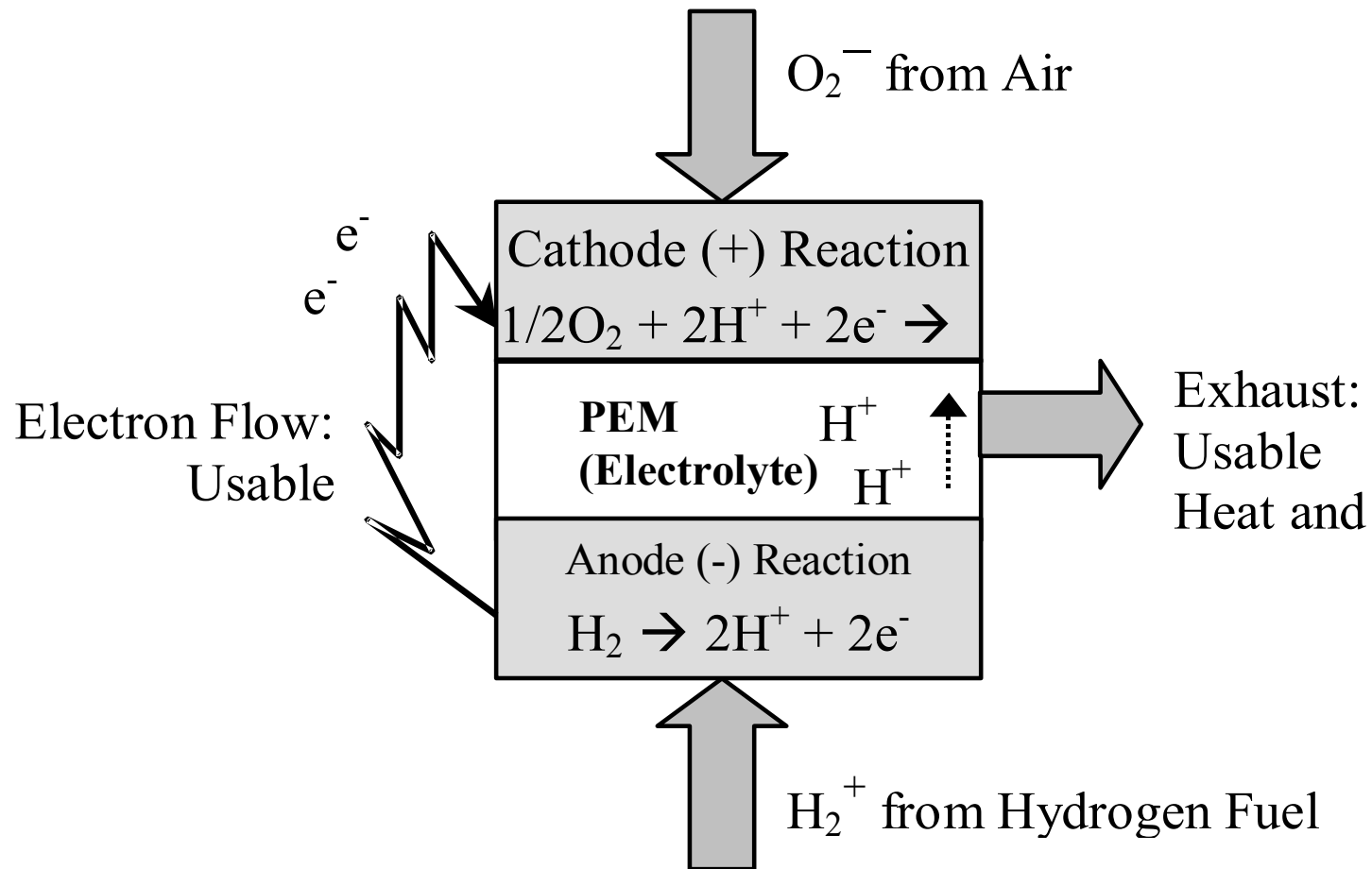
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The slide seen explains that the same logic holds true for a hydrogen based fuel system. In the public and political debate, it is often neglected that hydrogen is not a energy source itself but merely and energy carrier with zero carbon content. For the atmosphere it is irrelevant whether carbon dioxide is produced at the combustion location of the car or at the fuel production site. Hydrogen produced through electrolysis using renewable electricity is an option of greenhouse gas free production



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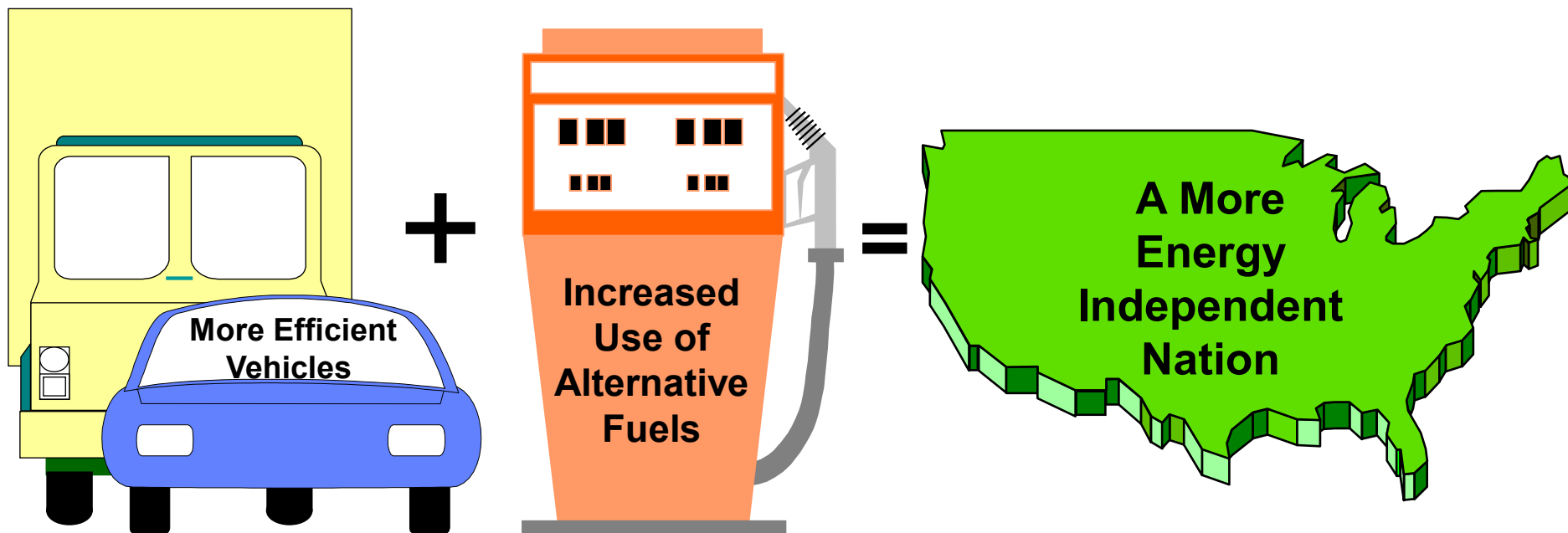
## Electrochemical Processes in the Proton Exchange Membrane (PEM) Fuel Cell





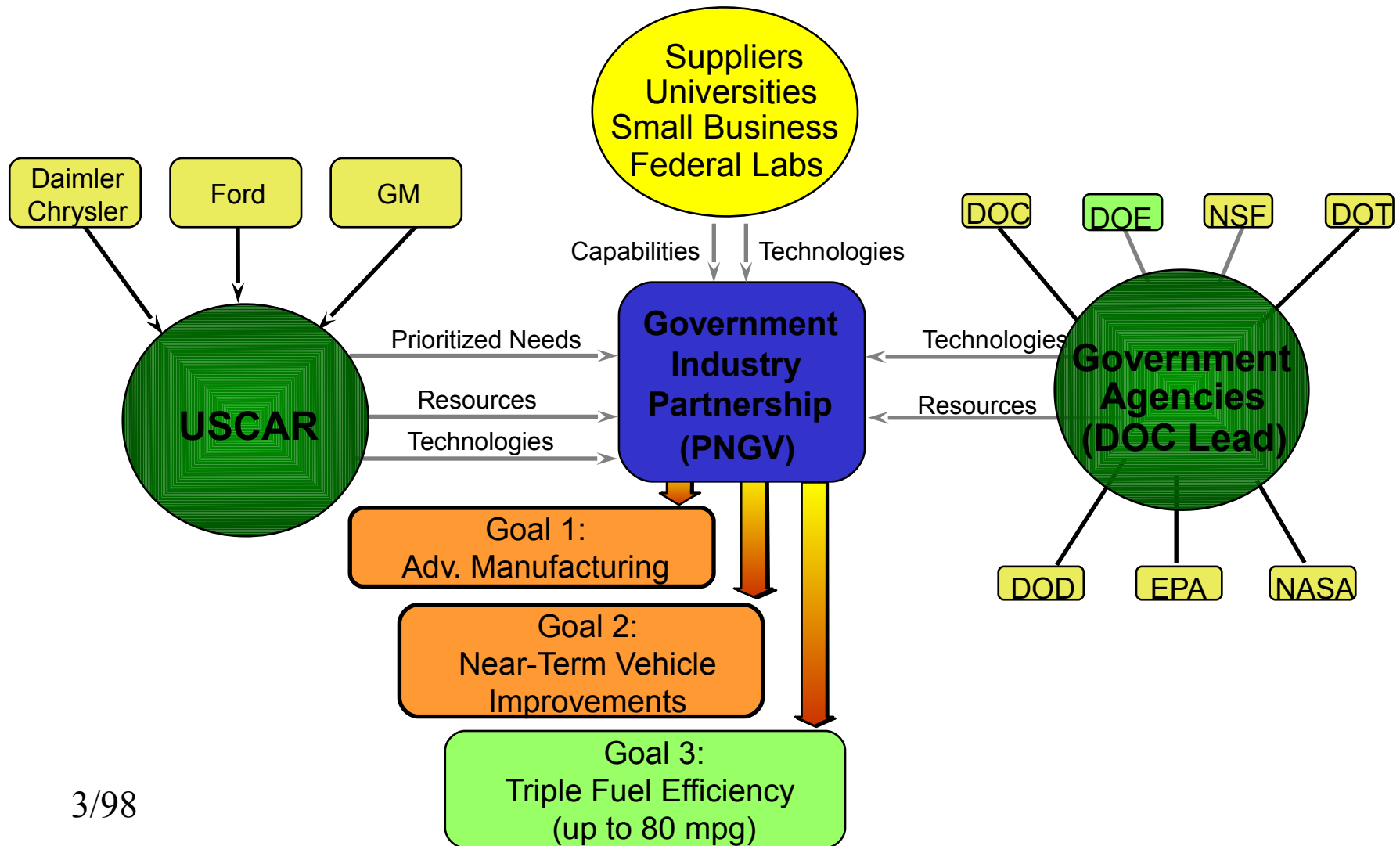
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DOE's Transportation Technologies Program:  
*Driven by a Simple Equation*





## Key Elements of the Partnership for a New Generation of Vehicles







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## PNGV Technology Selection Completed on Schedule

1993

### Candidates for Development:

- Hybrid Vehicles
- Fuel Cells, Fuel Reformers
- CIDI Engines, Turbines
- Low Emissions Technologies
- New Materials
- Advanced Design Simulations
- Efficient Electronics and Electrical Devices
- Advanced Batteries
- Ultra-Capacitors and Flywheels

Focus and Accelerate

1997

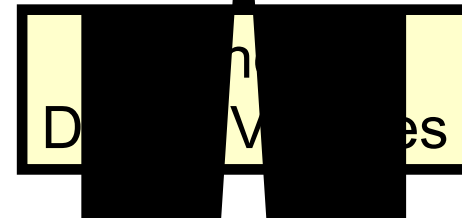
2000

2004

**Three  
Concept  
Cars**

**Three  
Production  
Prototype  
Cars**

**Technology Selection  
Decisions Completed**





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## Results of Technology Selection Process

Focus R&D on:

- Most promising technology areas:
  - hybrid-electric vehicle drive
  - **fuel cells**
  - direct injection engines
  - lightweight materials
- Overcoming top technical barriers





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## Top Technical Barriers

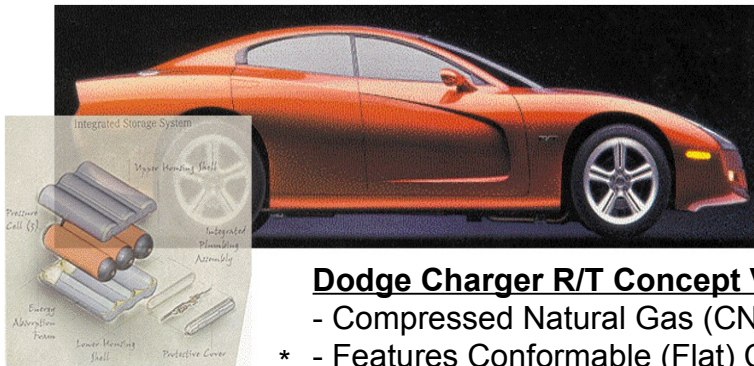
- NO<sub>x</sub> and particulate emissions from CIDI engine systems
- Compact, high-efficiency fuel-flexible fuel processor for PEM fuel cell
- Thermal management for lithium battery systems
- Commercial production costs:
  - Lamination material and processing for motor rotors and stators
  - Aluminum sheet, carbon fiber for structural applications, and magnesium
  - Power electronic building blocks and liquid coolants
  - High pressure fuel injector and pump
  - Electrode materials and fabrication processes for batteries and fuel cells



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## Advanced Automotive Technologies Displayed at International Auto Shows

### 1999 Detroit Auto Show



#### Dodge Charger R/T Concept Vehicle

- Compressed Natural Gas (CNG) Fueled
- \* - Features Conformable (Flat) CNG Storage System
- Reduces CO2 emissions by 25%

### 1999 Detroit Auto Show



#### Ford P2000 Hybrid Electric Vehicle

- \* - Aluminum 1.2L DIATA Diesel Engine
- \* - High-power nickel metal hydride battery
- \* - Light-weight aluminum intensive body
- \* - Automatically shifted manual transmission

### 1998 Paris Auto Show



#### GM Zafira Fuel Cell Concept Vehicle

- \* - On-board reforming of methanol into hydrogen
- Batteries capture braking energy and assist acceleration
- Twice the fuel economy of gasoline engine minivan
- Reduces CO2 emissions by 50% and NOx by 100%

\* DOE supported technologies





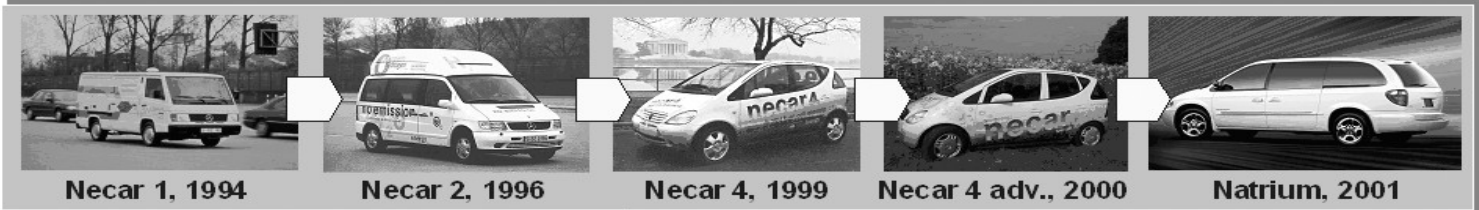
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# DaimlerChrysler Fuel Cell Vehicle Development Program

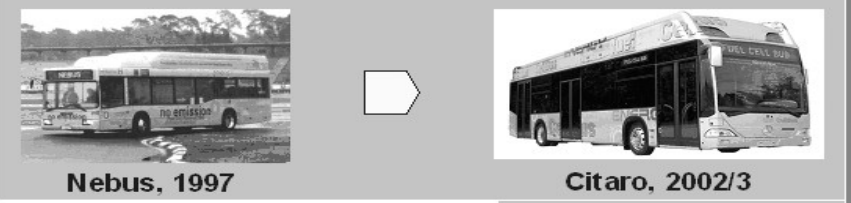
Cars



Methanol



Buses



Hydrogen

Transporter





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## Transportation Technologies Program: *Ambitious Goals for Highway Vehicles*

