Fueling Transportation in the 21st Century

Aspen Global Change Institute

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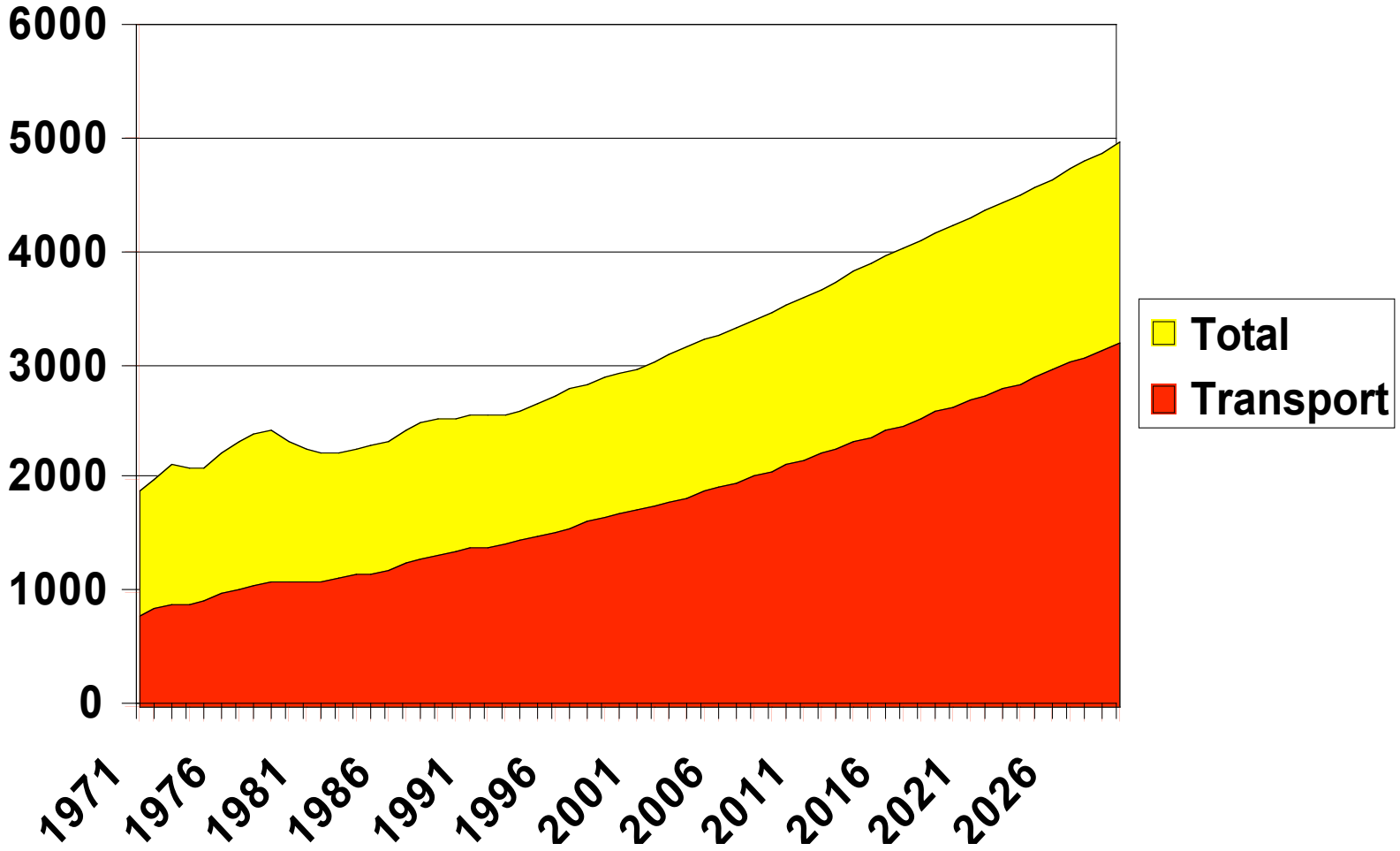
International Energy Agency

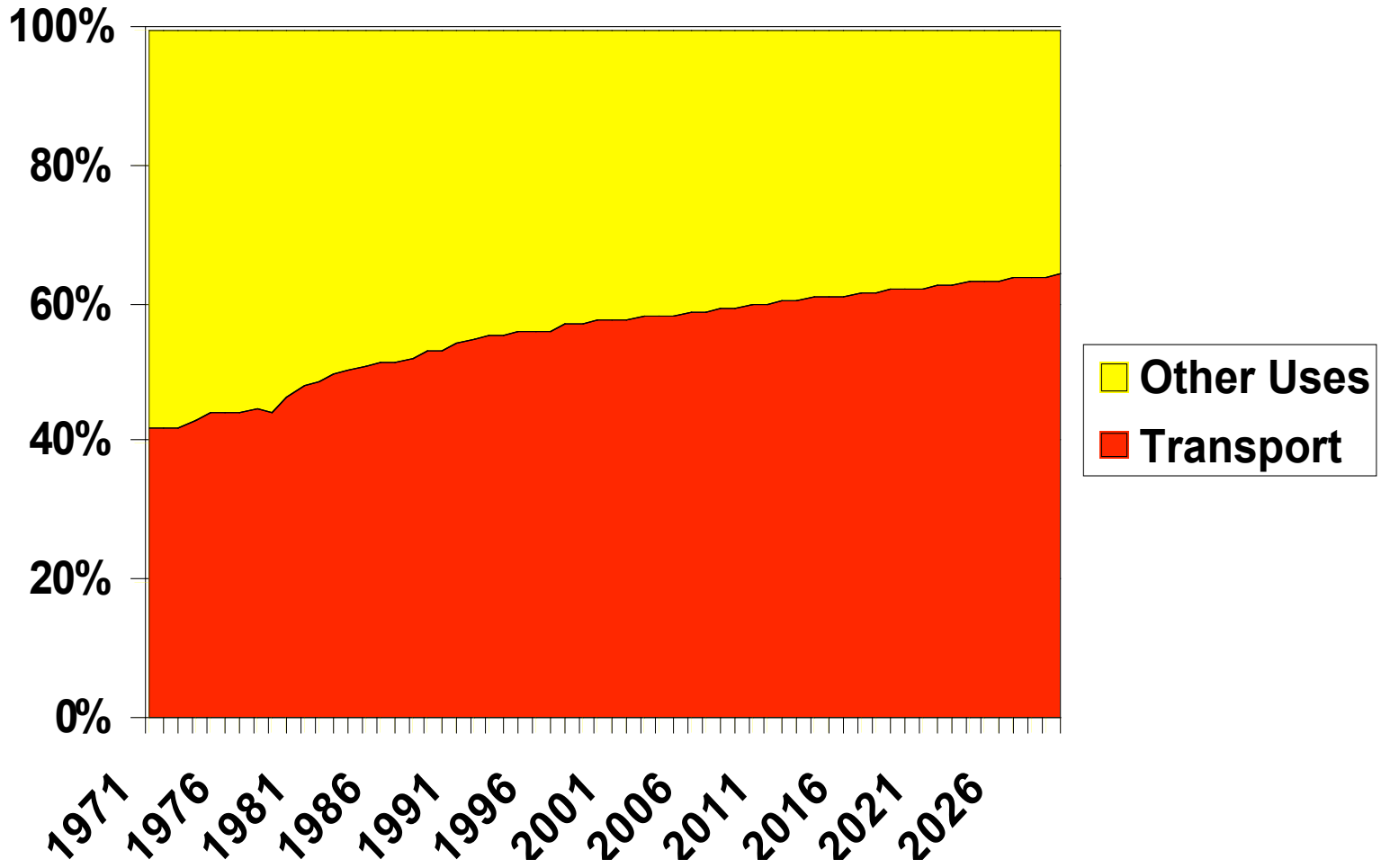
World Oil Consumption 1971-2030

(Final Consumption - Mtoe - Historic Data + WEO 2002)



Transport's Share of World Oil Consumption - 1971-2030

(Historic Data + WEO 2002)



Transport Challenges Over Time

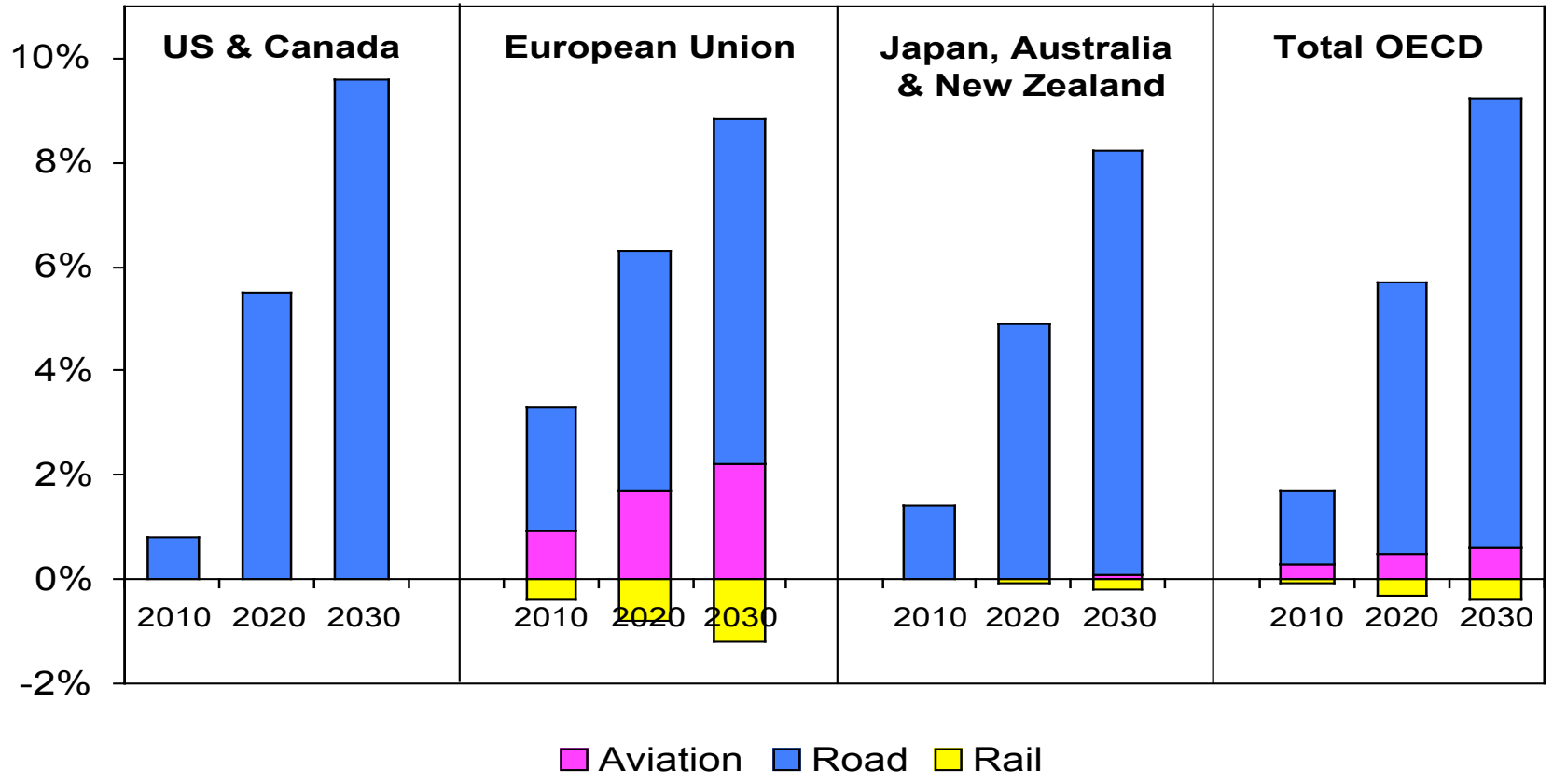
- **Near term** - through 2010 - implement policies to slow the growth rate of oil use and CO_2 as much as possible.
- **Long-term** - move toward a more sustainable transport system, featuring near-zero CO_2 emissions and secure sources of energy supply.

Near Term Actions
WEO 2002 Alternative Policy Scenario

Policy aim	Programme/measure	Impacts
Improved vehicle fuel efficiency	Increased CAFE/vehicle efficiency standards (US and Canada) Increased voluntary agreement targets (EU) Top Runner programme and equivalents (Japan, Australia and New Zealand)	New car and light truck efficiency improves
Increased use of alternative fuels and vehicles	Increased R&D and tax credits (US and Canada) Alternative fuel targets (EU) Green tax for clean fuel vehicles (Japan)	Increases the use of hybrid, natural gas, and fuel cell powered vehicles and alternative fuels
Reduced travel demand growth and switch to less energy-intensive modes	Urban road pricing, expansion of high-speed rail and freight initiatives (Japan) White Paper on transport-package of policies (EU)	Suppress growth in passenger and freight transport and foster modal shift from road and aviation to rail and bus.

Near-Term Actions Still Require a Long Time to Have an Impact

Reduction in Emissions Compared to Reference Scenario



Long-Term Options

- Three clearly established possibilities for near-zero CO_2 emission energy carriers for transport:
  - hydrogen
  - electricity
  - biofuels
- Each fuel has its own set of limitations and technical challenges, however,
- Hydrogen is increasingly seen as the next generation of motor vehicle technology.

"Hydrogen" is Not a Single Technology

- There are a variety of hydrogen supply and end-use technologies that have different full fuel chain impacts CO_2 emissions and energy resource use.
- Many of these offer significantly reduced emissions compared to conventional vehicles.

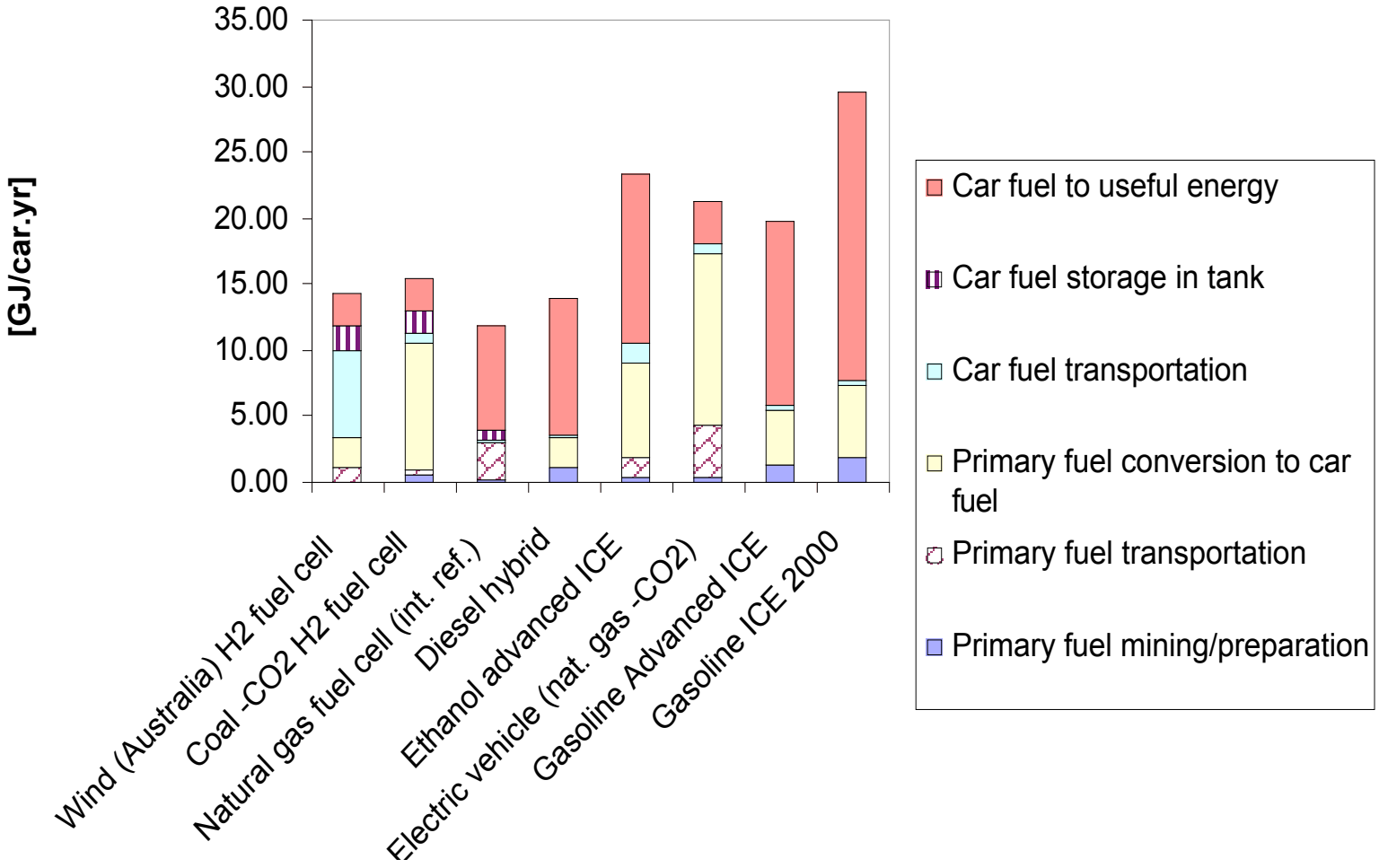
Alternative Hydrogen Transport Technologies

- **Alternative Sources of Hydrogen**
  - Coal with & without CO_2 capture & storage
  - Gas with & without CO_2 capture & storage
  - Electrolysis of water with CO_2-free electricity
  - Co-generation in HTGR
  - Biomass production
- **Vehicle Technologies**
  - Advanced ICE optimised for H_2
  - Hybrid ICE optimsed for H_2
  - Fuel Cell

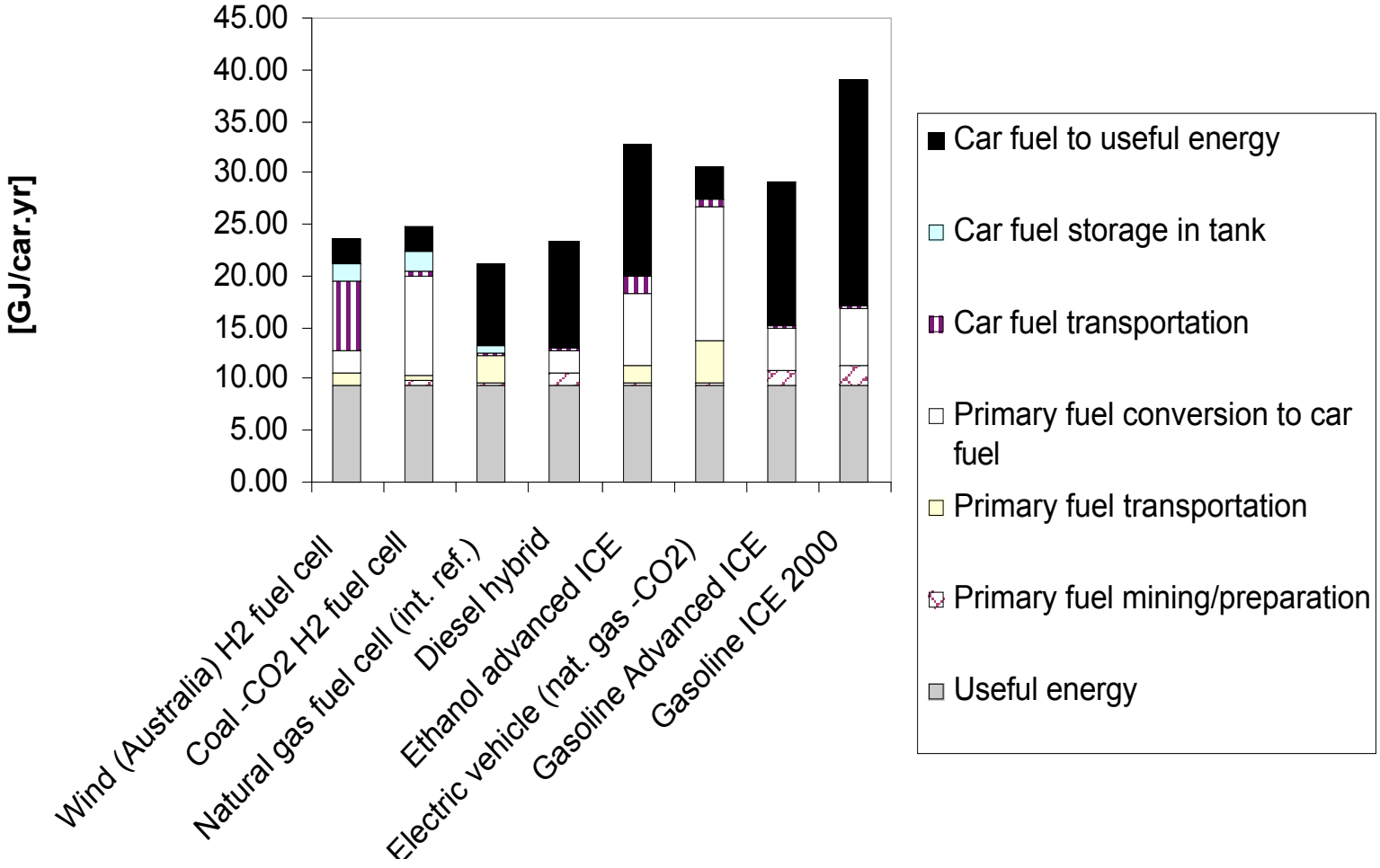
Energy Use

- Energy use can occur at every step in the “full-fuel-cycle” chain:
  - primary fuel mining and preparation
  - primary fuel transport
  - conversion to car fuel
  - car fuel transportation
  - car fuel storage
  - conversion of car fuel to useful energy

Well-to-Wheel Energy Losses



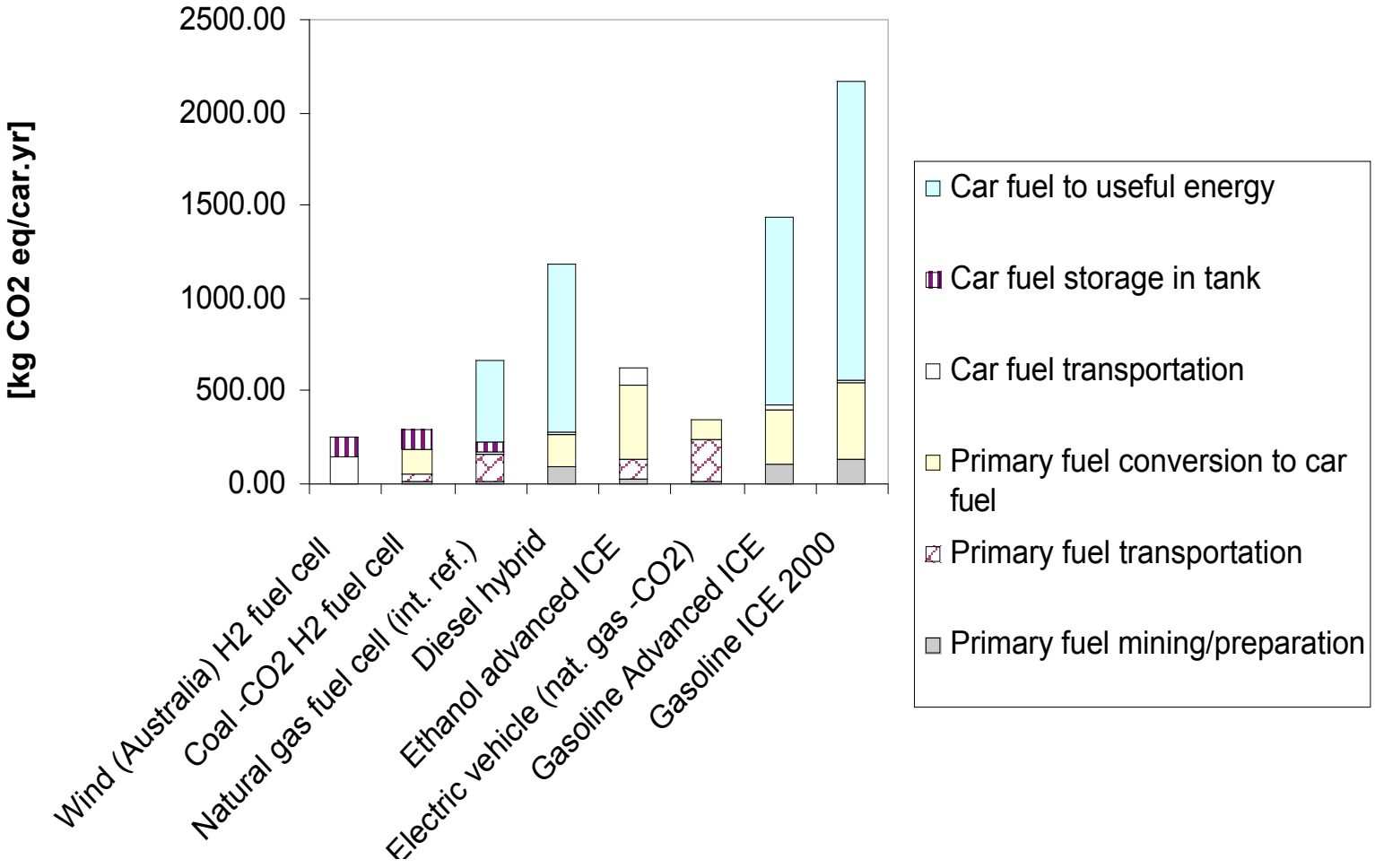
Well-to-Wheel Energy Use



Observations - Energy Use

- Fuel cells and electric vehicles provide large improvements in the efficient use of car fuel.
- These savings are partly offset by increased energy use in primary fuel transportation, conversion to car fuel and on-board storage.
- Natural gas fuel cells (on board reforming) and diesel hybrids both have very low well-to-wheel energy losses.

Well-to-Wheel GHG Emissions



Observations - CO_2 Emissions

- "Zero-Emissions" do not exist but very low CO_2 emissions are attainable.
- "Near Zero" CO_2 emissions are achieved with hydrogen & electric cars .
- Advanced ethanol and natural gas/fuel cell cars offer significant reductions.
- While far from "near-zero", hybrid vehicles and advanced ICE vehicles can provide important savings.

Future Transportation Fuel Cost Comparisons

ProductProduction cost[$/GJ]Gasoline/diesel5-7Natural gas2	

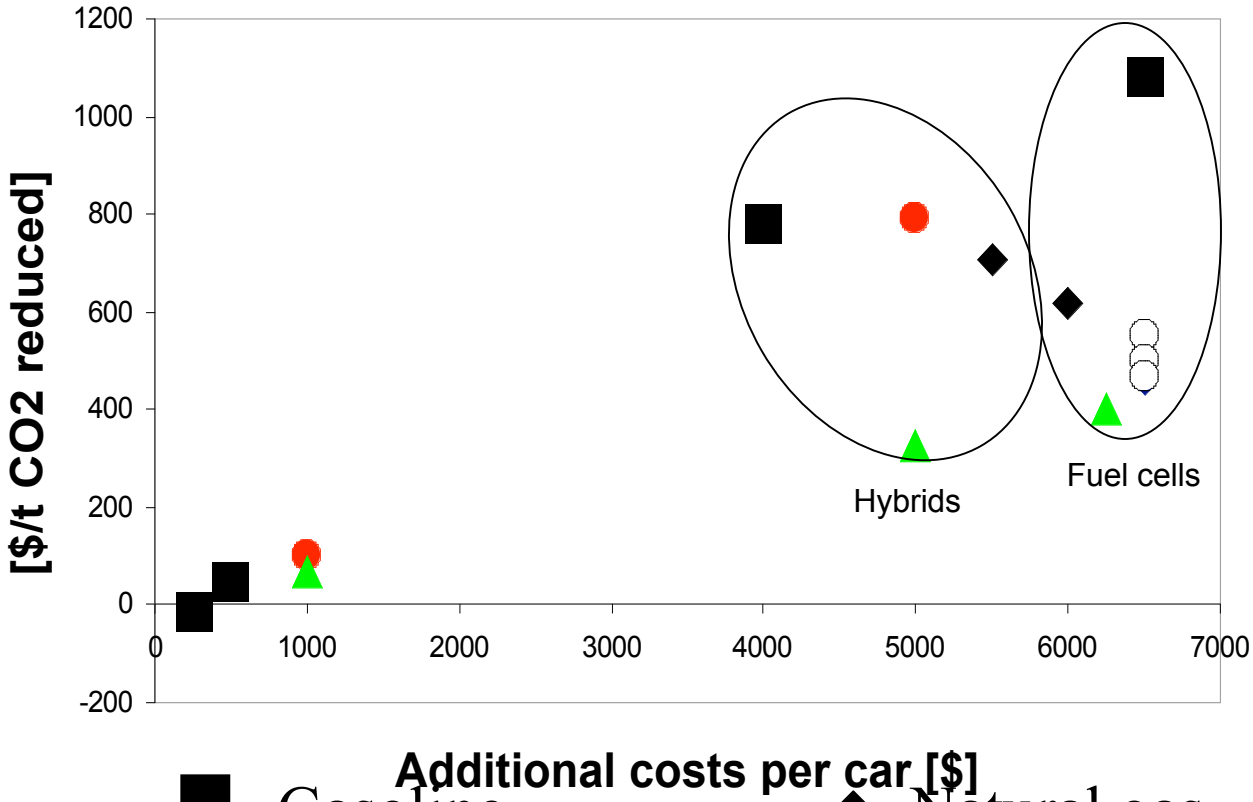
Future Vehicle Cost Comparisons

(Added Cost Over Current ICE)

Vehicle typeAdditional cost[$/car]Advanced ICE0-1,000Hyb	

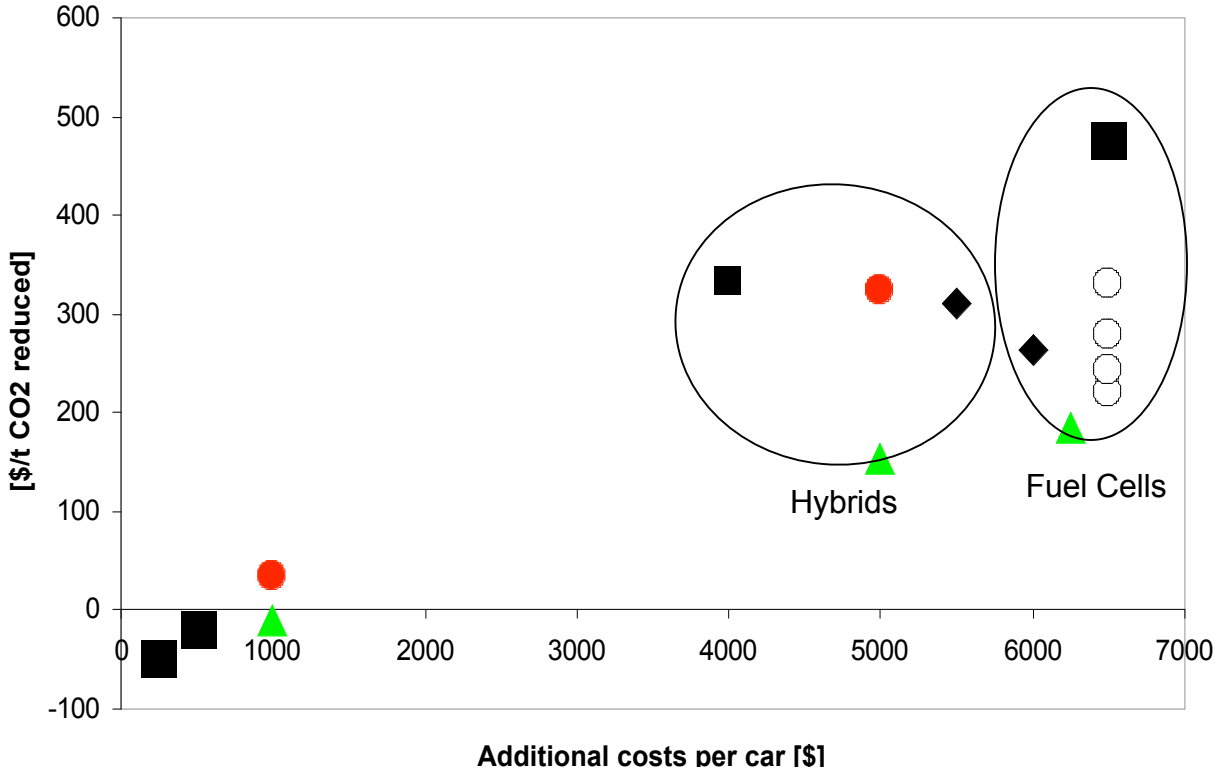
Cost of Reduced CO_2 Emissions

(cost relative to current ICE: Euro-Japan travel)



Cost of Reduced CO_2 Emissions

(cost relative to current ICE: US travel)



Sensitivities

- The most important data affecting cost per ton estimates in order of relative importance are:
  - future hybrid or fuel cell costs,
  - driving cycle (urban vs. highway miles),
  - kilometres travelled, and
  - regional fuel costs.

Observations
CO_2 Abatement Costs

- Neither hybrid or fuel cell vehicles would likely come about as a result of any carbon abatement incentives that are now anticipated as a result of Kyoto.
- In addition, much higher costs will be incurred to achieve the assumed technology learning and due to the poor economics of retail hydrogen distribution during a transition phase.
- However,
  - eventually, atmospheric GHG stabilisation may require that these costs be incurred, and
  - energy security concerns alone could justify the increased costs.

Current H_2 Challenges

- Competing uses of low-emission energy?
- Where does a hydrogen strategy fit in with other opportunities to reduce transport oil use and emissions? Multiple technologies and policies?
- Time horizon needed to develop needed technologies to support low-emission hydrogen system.
  - Fuel cells
  - CO_2 capture & storage technologies
  - Nuclear
  - Renewables

Needed Information

- Costs and availability of renewables, nuclear and fossil fuels with carbon capture & storage to:
  - reduce electricity sector CO_2 emissions *and*
  - reduce transport sector CO_2 emissions.
- Costs and benefits of alternative approaches to reduce transport sector CO_2 emissions.
- Interactions among power-generation, transportation, and fuel markets.
- CO_2 emission and resource use implications of these interactions.