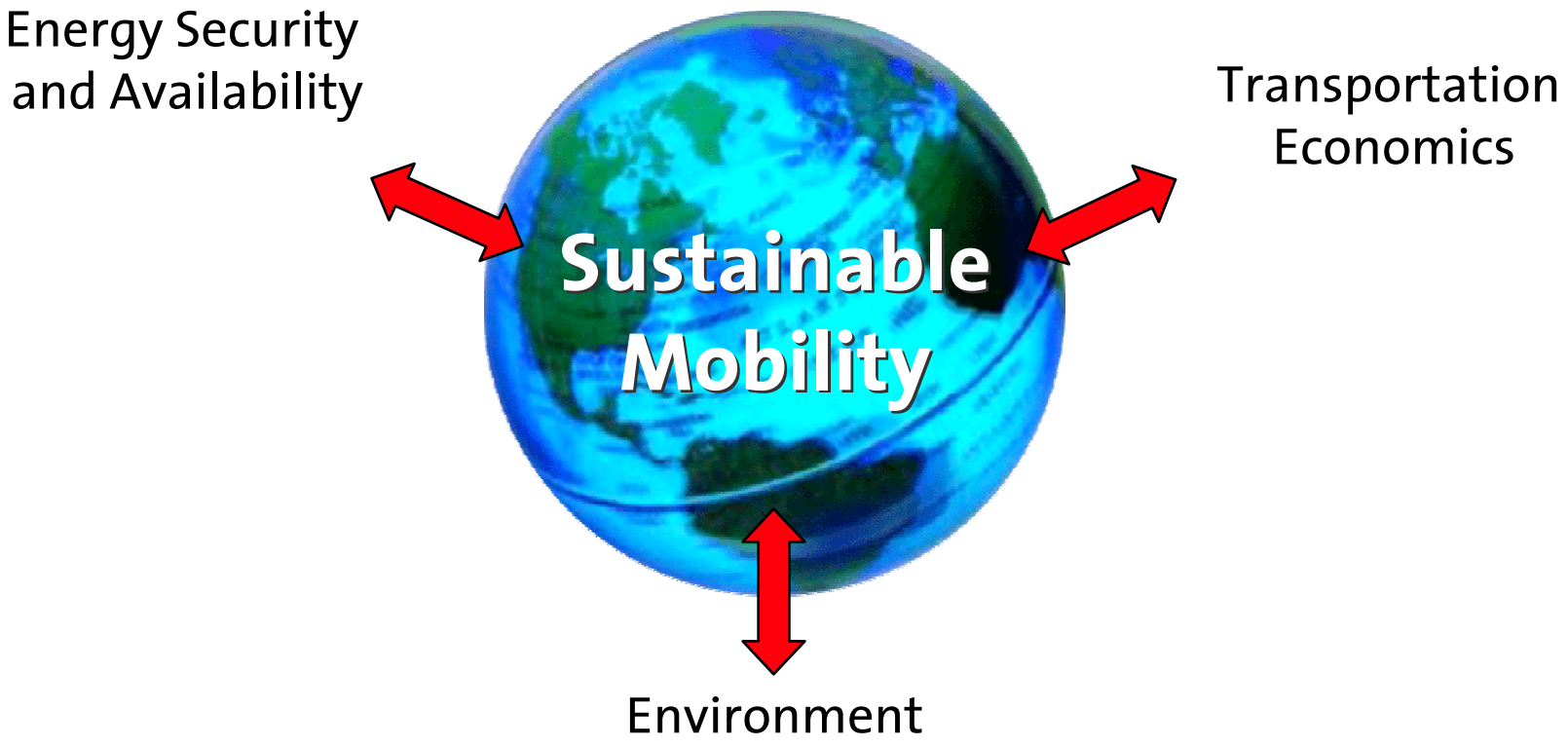
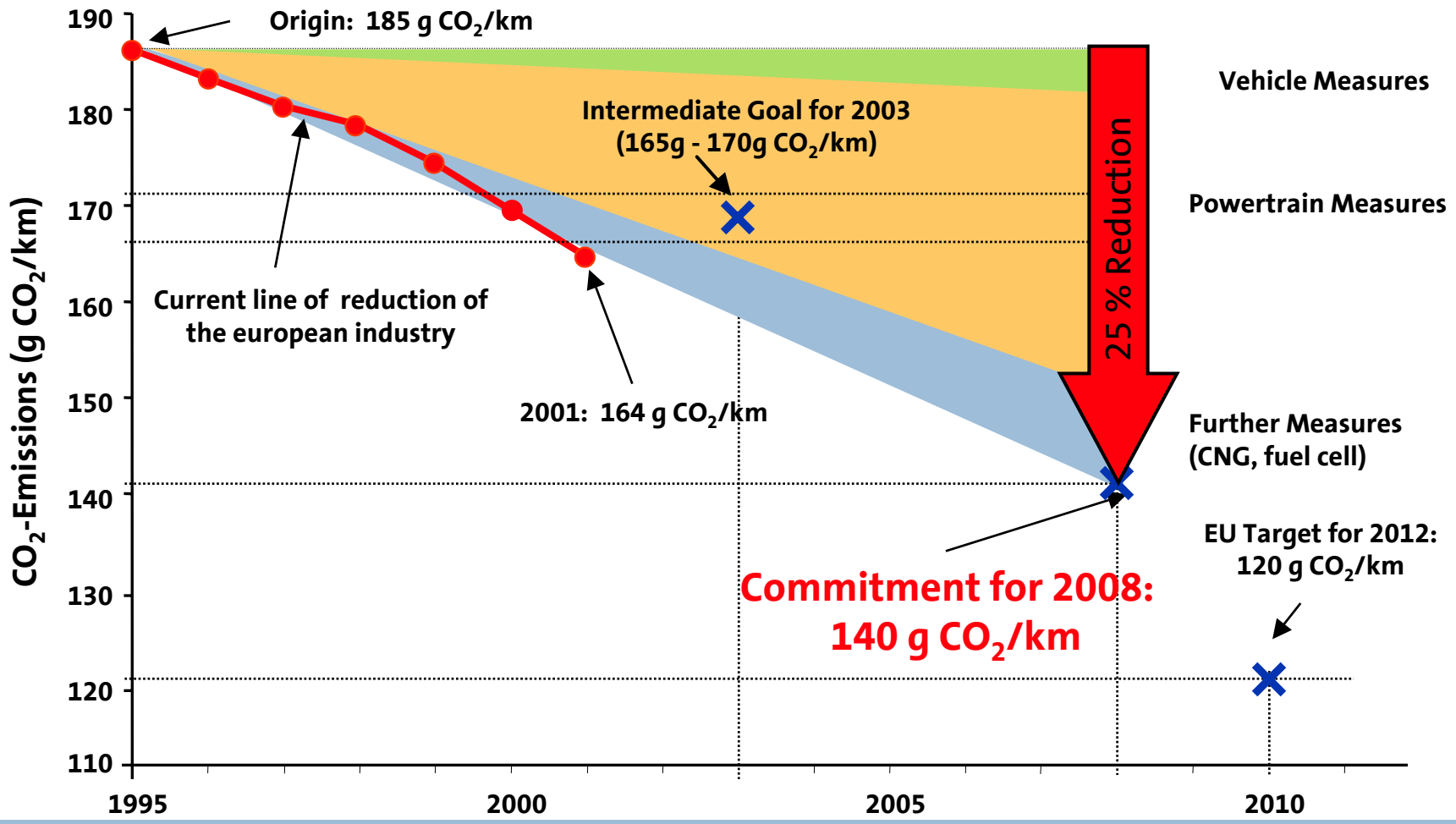
General Motors/Opel Fuel Cell Activities

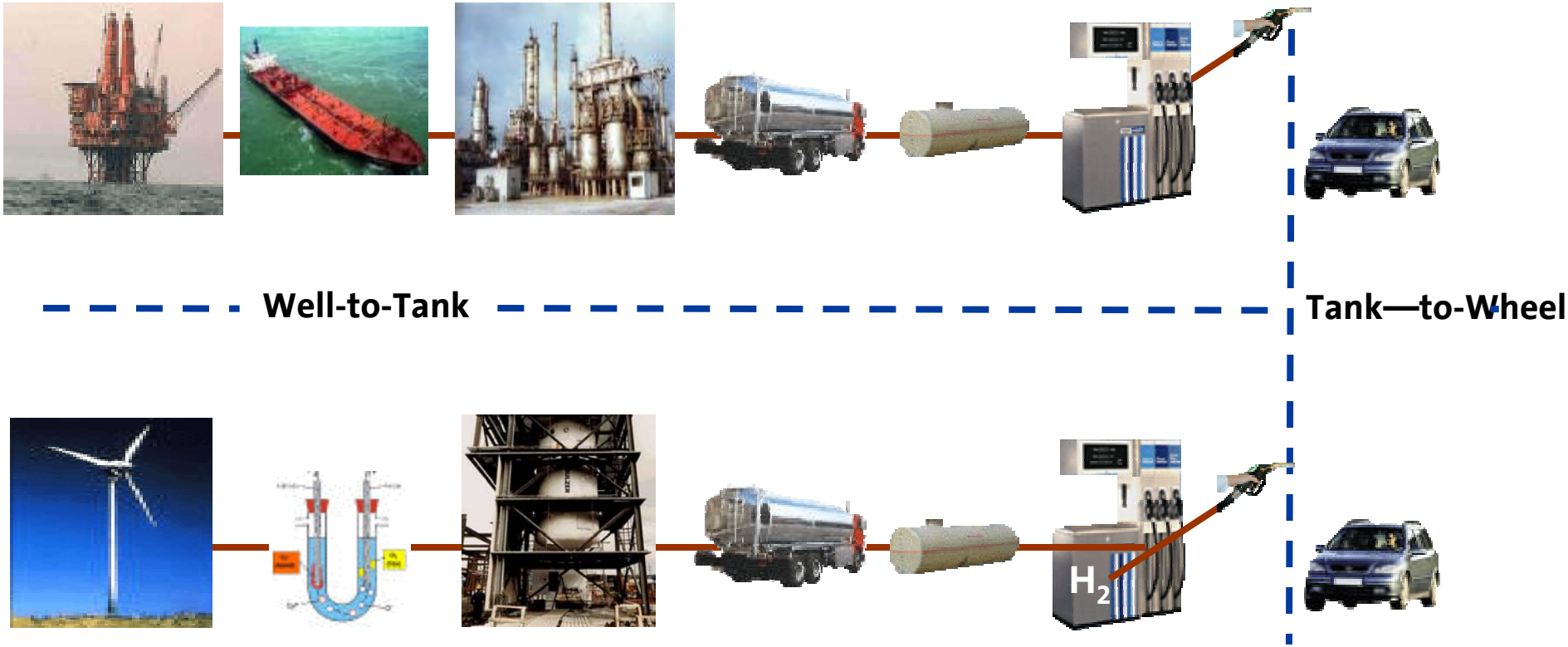
Global Perspectives Require Balanced Solutions



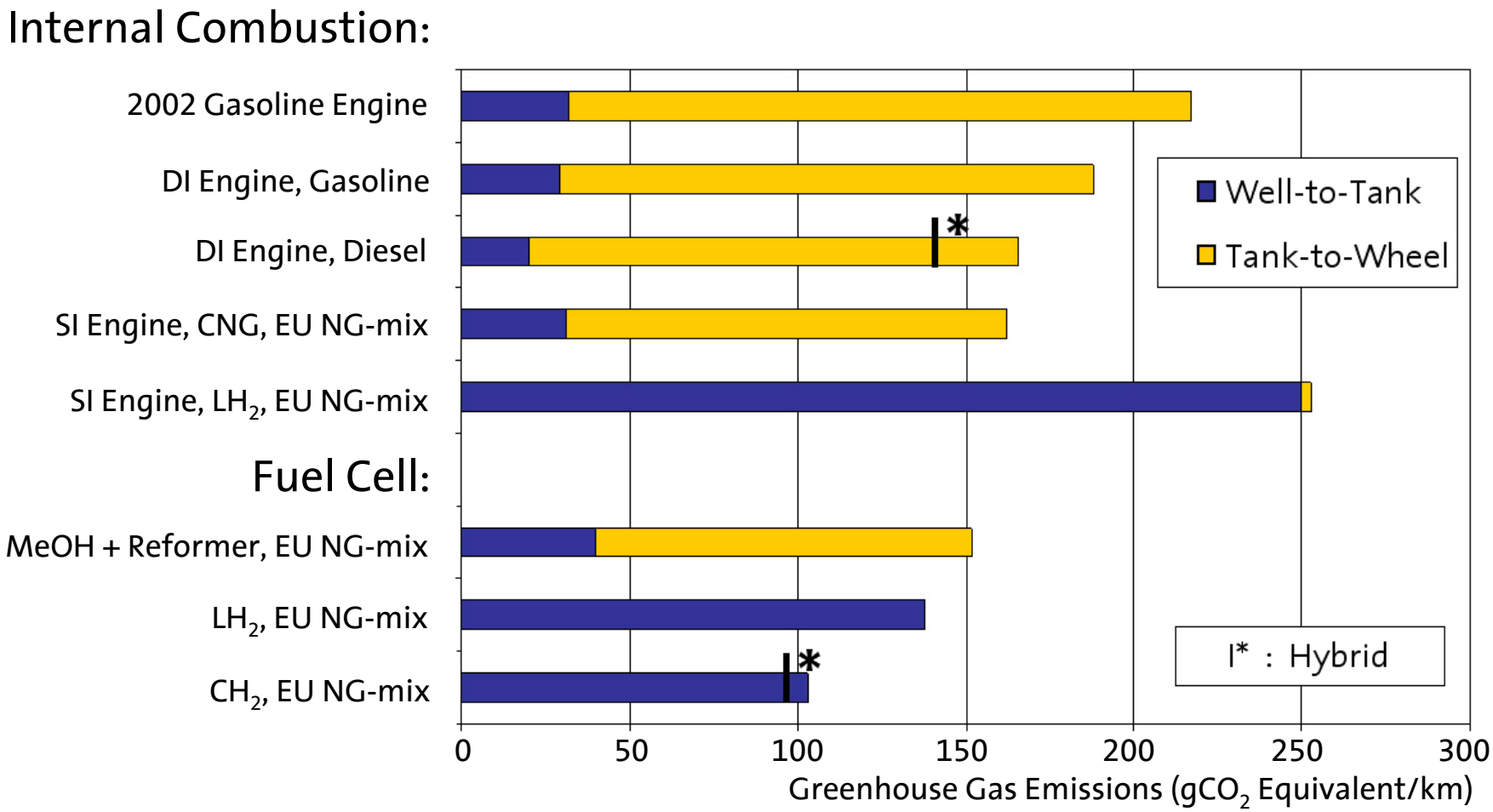
Commitment of the European Automotive Industry about the reduction of CO_2-Emissions



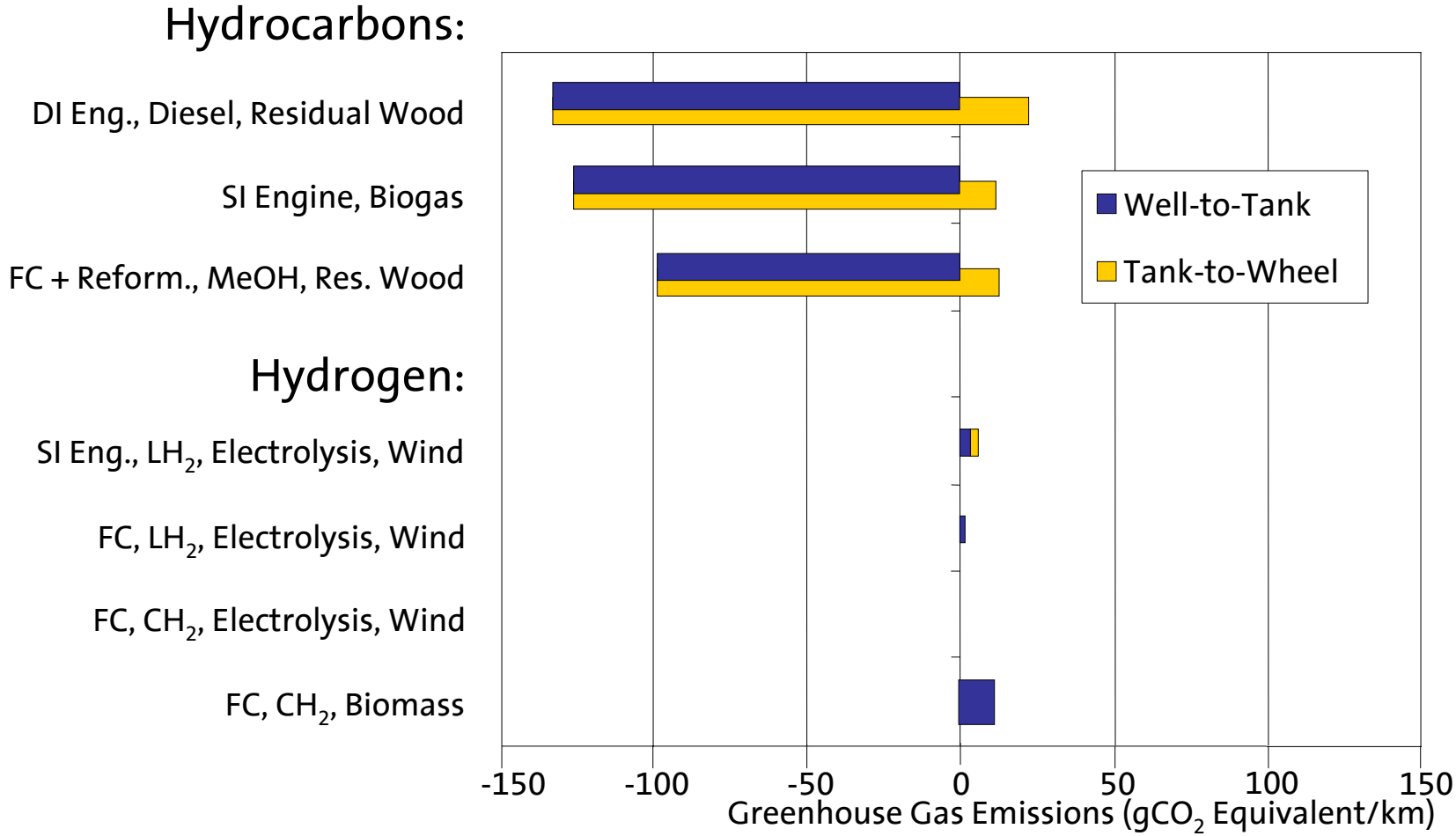
Well-to-Wheel Pathways – Traditional and Renewable Feedstocks



Well-to-Wheel Greenhouse Gas Emissions Using Fossil Fuels



Well-to-Wheel Greenhouse Gas Emissions Using Renewable Fuels



Conclusions of the Study

On a Well-to-Wheel basis, several pathways offer improved greenhouse gas emissions and energy consumption:

- Advanced ICE powertrains using conventional diesel and biofuels
- Fuel cell powertrains using hydrogen

Long term, fuel cells and hydrogen from renewable sources are the most attractive option due to:

- Fuel economy
- Local and global emissions
- Feed stock diversity / security of supply

GM Fuel Cell Activities

Warren
(MI, USA)

Rochester
(NY, USA)

Mainz-Kastel
(Deutschland)

Torrance
(CA, USA)

Tokyo
(Japan)

Fuel Cell Vehicle “HydroGen1”

- Fuel Cell Stack (200 cells):

  Power: 80 kW

  Start-up: 30 s at -20° C
- Elektromotor: 55 kW
- Top speed: 140 km/h
- Fuel: 5 kg LH_2
- Range: 400 km (EDC)

Michelin Challenge Bibendum 2001

Great success for “HyroGen1”at competition for alternative propulsion vehicles:

- Only fuel cell passenger vehicle to cover the whole distance
- Best scores in disciplines emissions, handling, noise
- Design trophy for outstanding integration of fuel cell system

Milestones achieved with “HydroGen3”

Improved performance and day-to-day practicality compared to “HydroGen1”:

- No high-performance buffer battery
- Increased fuel cell unit power density, no external humidification devices
- Compact propulsion module
- Air conditioning system, diagnostic system
- Same loading space as production model

“HydroGen3” – Liquid and Compressed

- Fuel cell stack (200 cells):

  Power: 94 kW

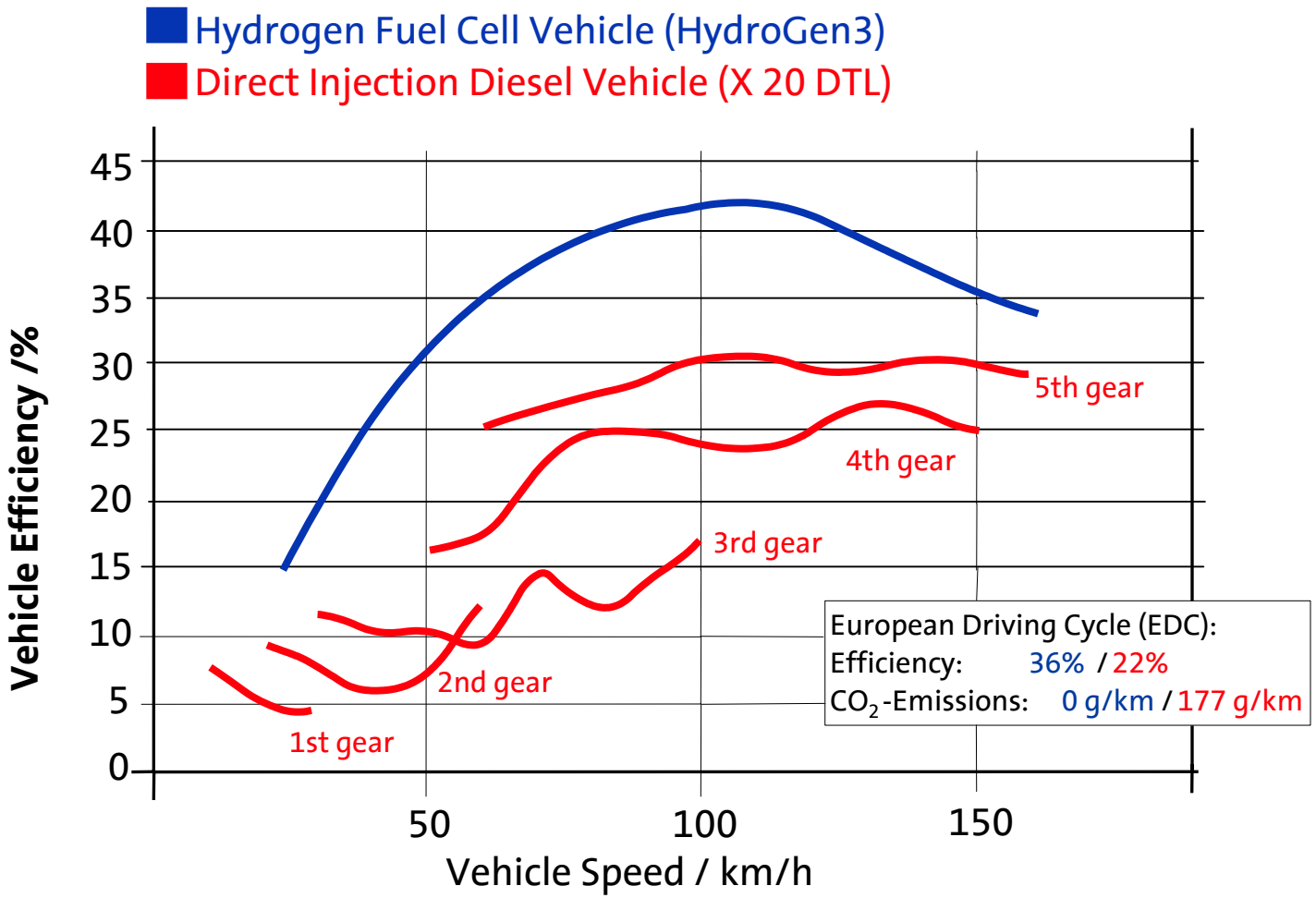
  Start-up: 30 s at -20° C (-4° F)
- Electric motor: 60 kW
- Top speed: 160 km/h (100 mph)
- Fuel: 4.6 kg LH_2 or 3.1 kg CH_2
- Range: 400 or 270 km (EDC)

  250 or 170 miles (EDC)

Detroit Motor Show 2002: Presentation of “GM AUTOnomy”

Concept vehicle with “skateboard”-chassis developed based on advantages of fuel cell and “x-by-wire technology”

Efficiency Comparison



Fuel Cell Technology Outlook

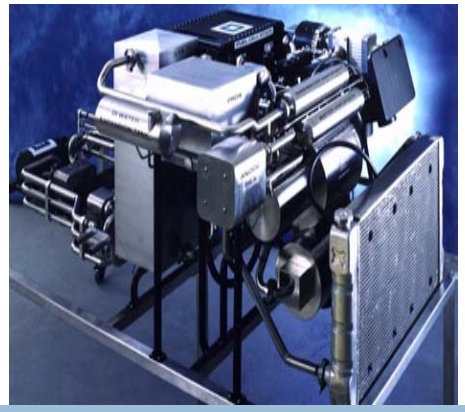
Fuel Cell Technology will be competitive with internal combustion engine powertrains:

- Fuel cell system performance superior to internal combustion engine
- Vehicle integration is feasible
- No functional vehicle restrictions for customers

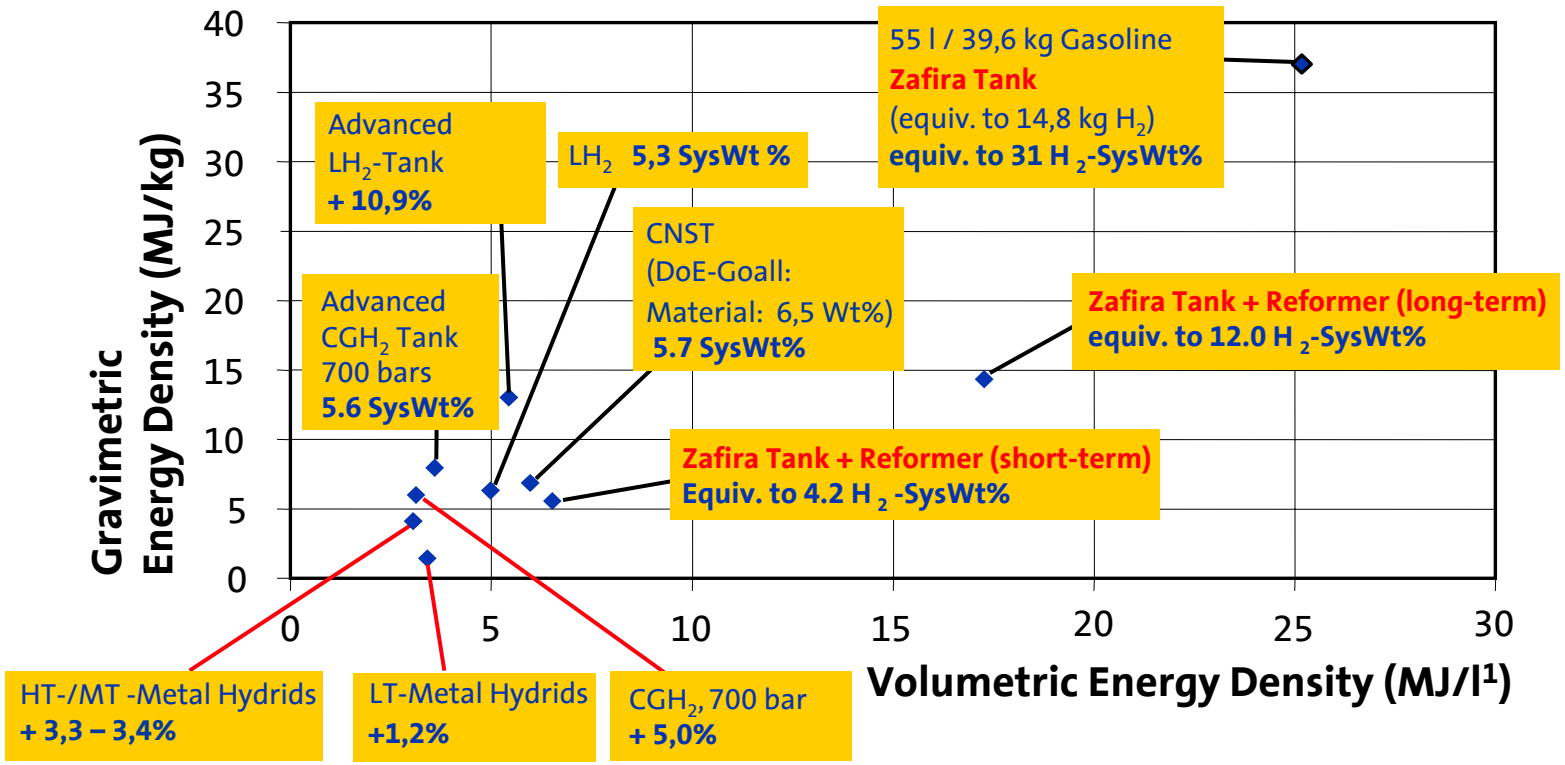
  → "Fun to drive"

Key Challenges for Commercialization

- Fuel cell system cost
- High performance hydrogen storage system
- Infrastructure Development
- Fuel processing



Energy Storage Comparison

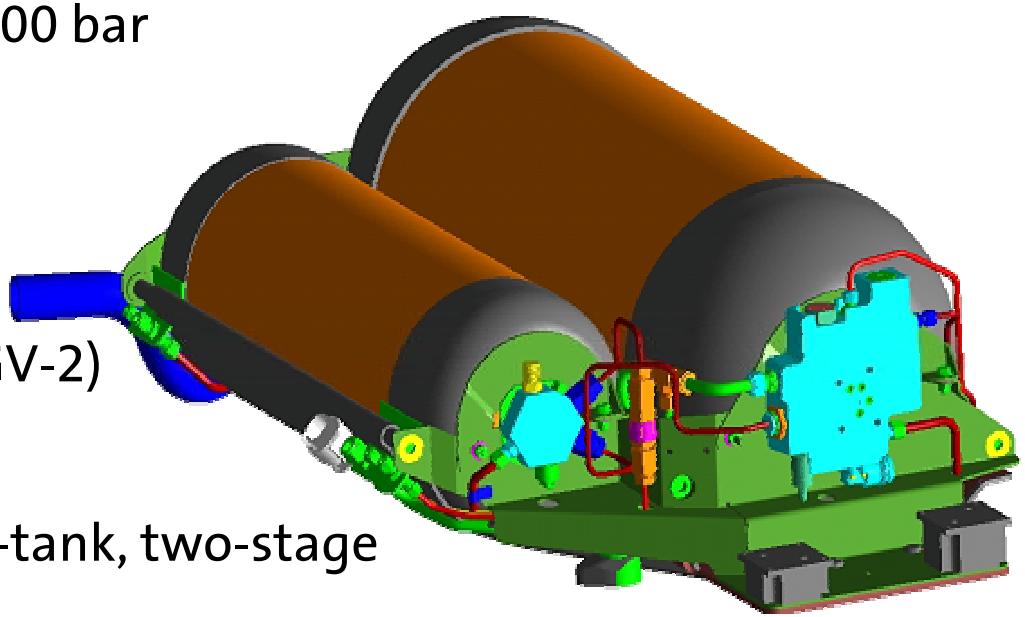


Liquid Hydrogen Storage – Challenges

- Mechanization
- Costs
- Design / package
- Parking / boil-off:
  - heat transfer into tank leads to H_2 losses (boil-off)
  - cannot be prevented completely
  - boil-off Hydrogen converted into water

HydroGen3 Compressed Hydrogen Storage System

- Capacity: 3.1 kg H_2 at 700 bar
- Weight: 95 kg
- Service life: 2.5 years
- Certification: TÜV
  (EIHP "Draft No. 7"; NGV-2)
- Carbon fiber: T1000
- Pressure regulation: in-tank, two-stage



Hydrogen Infrastructure

- Automotive companies cannot develop hydrogen infrastructure alone
- Strong support, commitment and leadership are required from energy companies and governments to jump-start the infrastructure buildup
- Potential of hydrogen economy must be considered under economic aspects and perspectives of energy security

GM Takes Leading Steps towards Hydrogen Economy

GM is in discussions with all stakeholders in various regions and actively participating in:

- California Fuel Cell Partnership (CaFCP)
- Transport Energy Strategy (VES), Germany
- Clean Energy Partnership (CEP)
- European Integrated Hydrogen Project (EIHP)
- National Hydrogen Association of U.S. (NHA)
- International Hydrogen Infrastructure Group (IHIG)
- International Standards Organization (ISO)
- Society of Automotive Engineers (SAE)
- Japan Hydrogen and Fuel Cell Demonstration Projekt (JHFC)

Conclusions (I)

- Goal is to take automobile out of environmental debate
- Hydrogen from renewables is the future fuel
- Fuel cell system offers best propulsion system for hydrogen
- Hydrogen storage technology has key function
- Activities to develop hydrogen infrastructure must be significantly increased

Conclusions (II)

- Automotive industry is engaged in developing solutions, but needs active support from governments and energy companies
- On-board fuel processing could offer interim solution, but should not hinder implementation of hydrogen economy
- All activities must be accompanied by encouragement of customer acceptance with regard to new product “fuel cell vehicle” <u>and</u> new retail fuel “hydrogen”