



# Vehicle Fuel Economy Improvements

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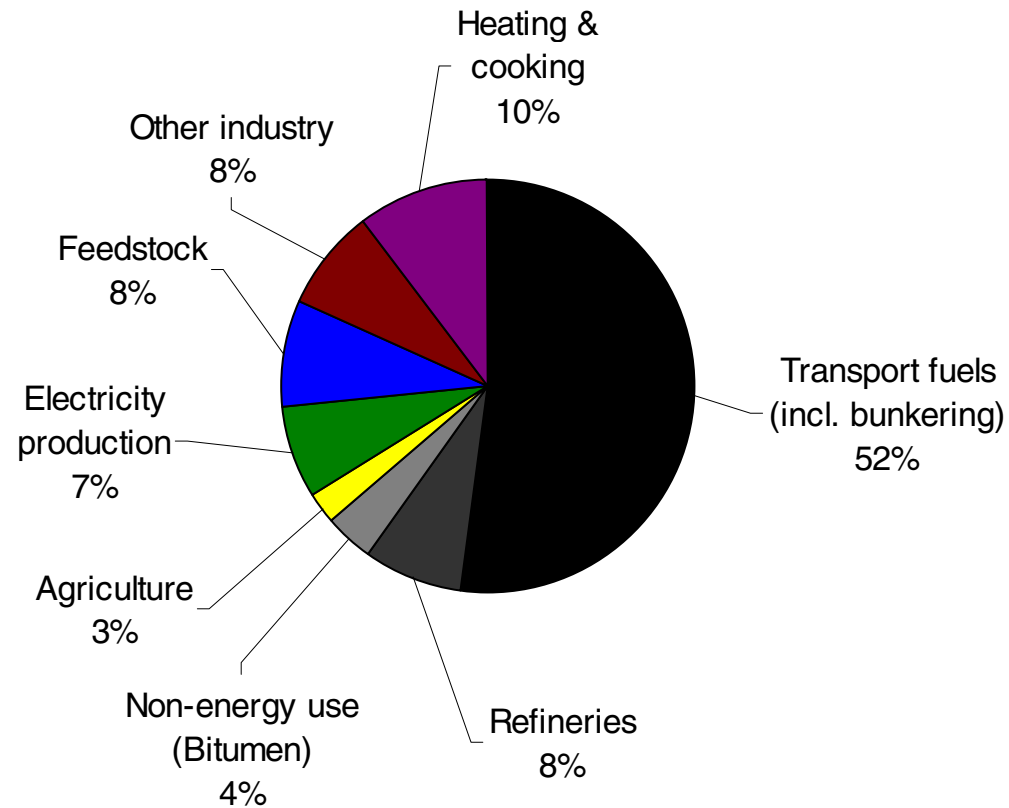


# Key Facts and Trends



# Oil Demand: 84 mb/d in 2005

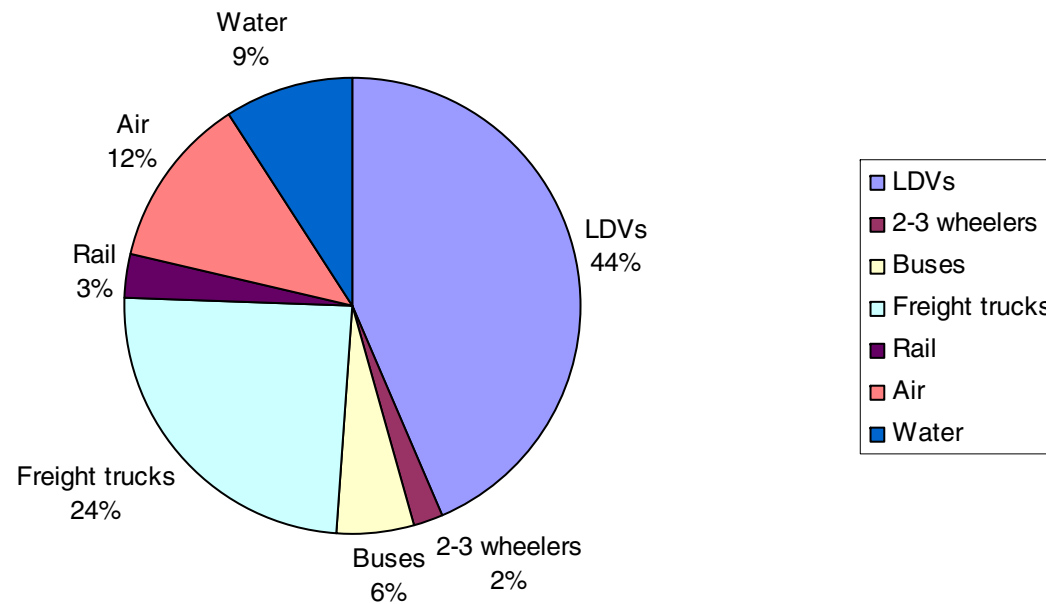
2/3 is transport related





# Global transport energy demand by mode, 2005

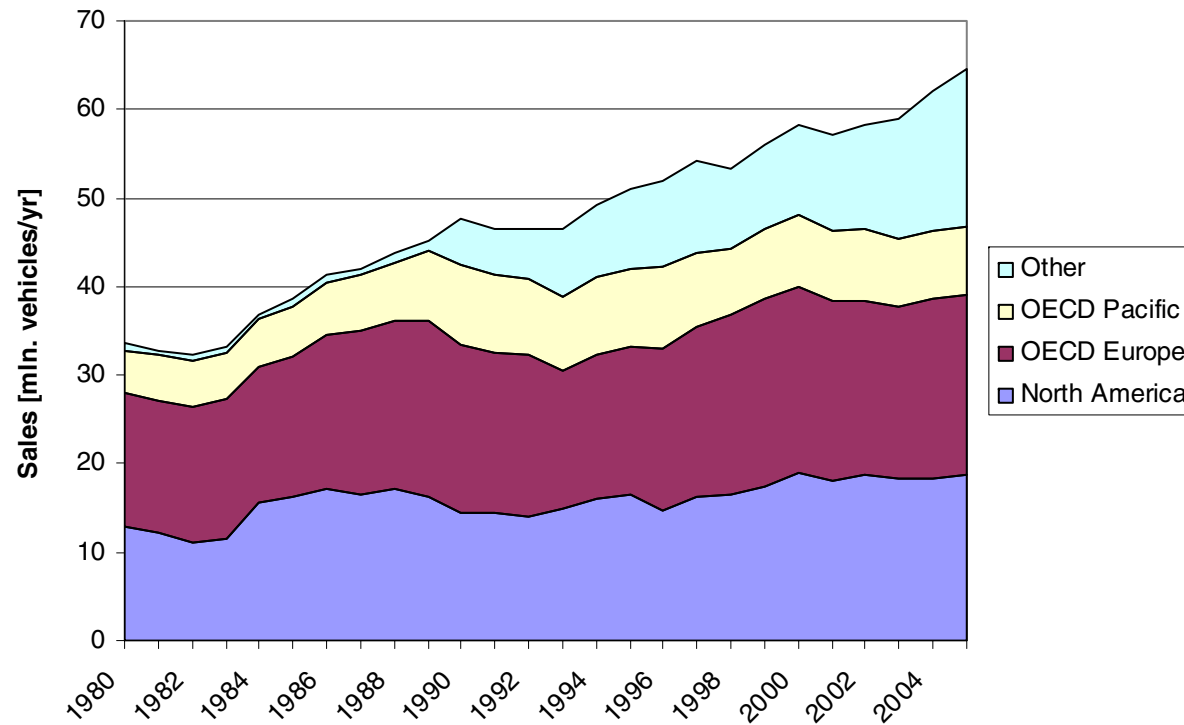
Light duty vehicles (LDV) use nearly half of it





## New LDV sales

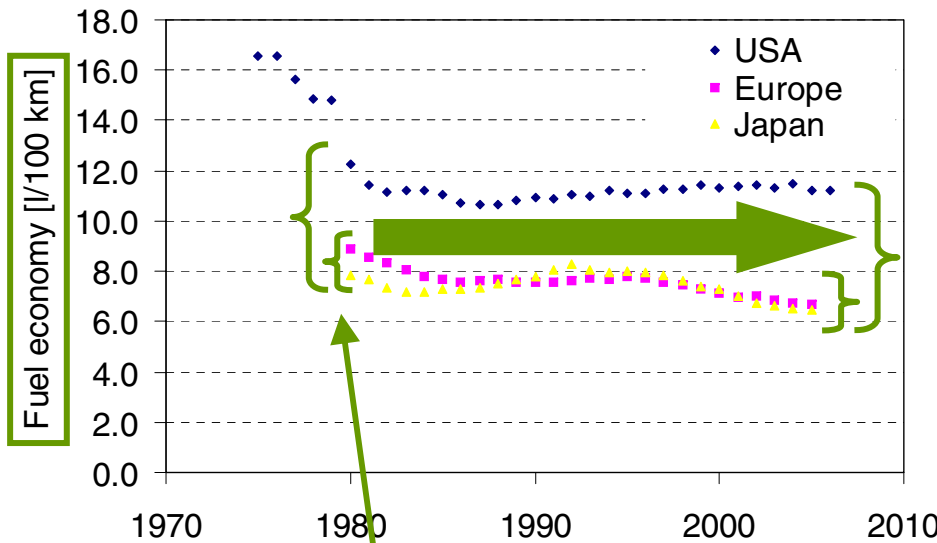
Sales have almost doubled in 25 years; the OECD region is still dominant, but most of the growth is in non-OECD





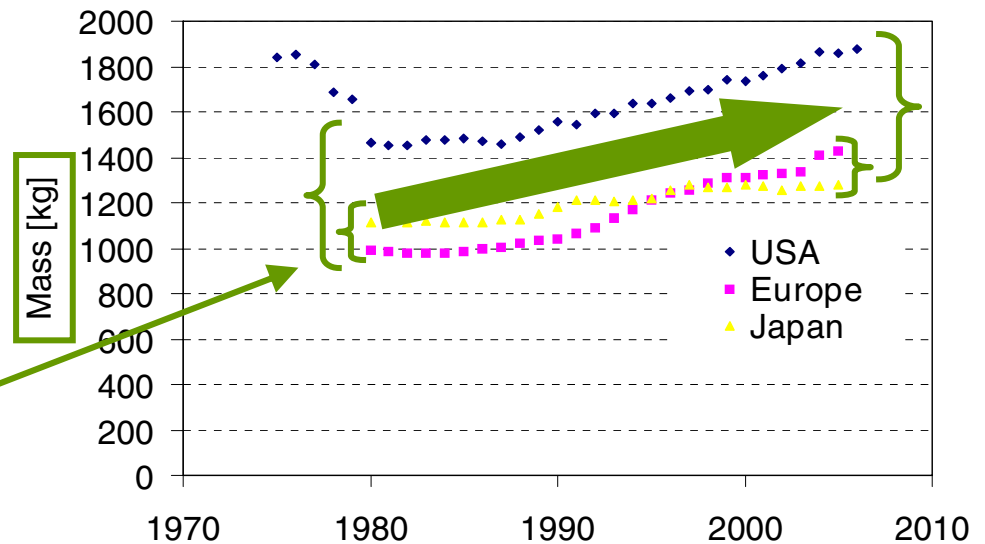
# New vehicles sales

## Fuel economy and vehicle mass



- Relatively steady fuel economy since 1980
- Increasing weight (and power)

Weight (often associated with size and often correlated with power) explains most of the differences amongst OECD regions

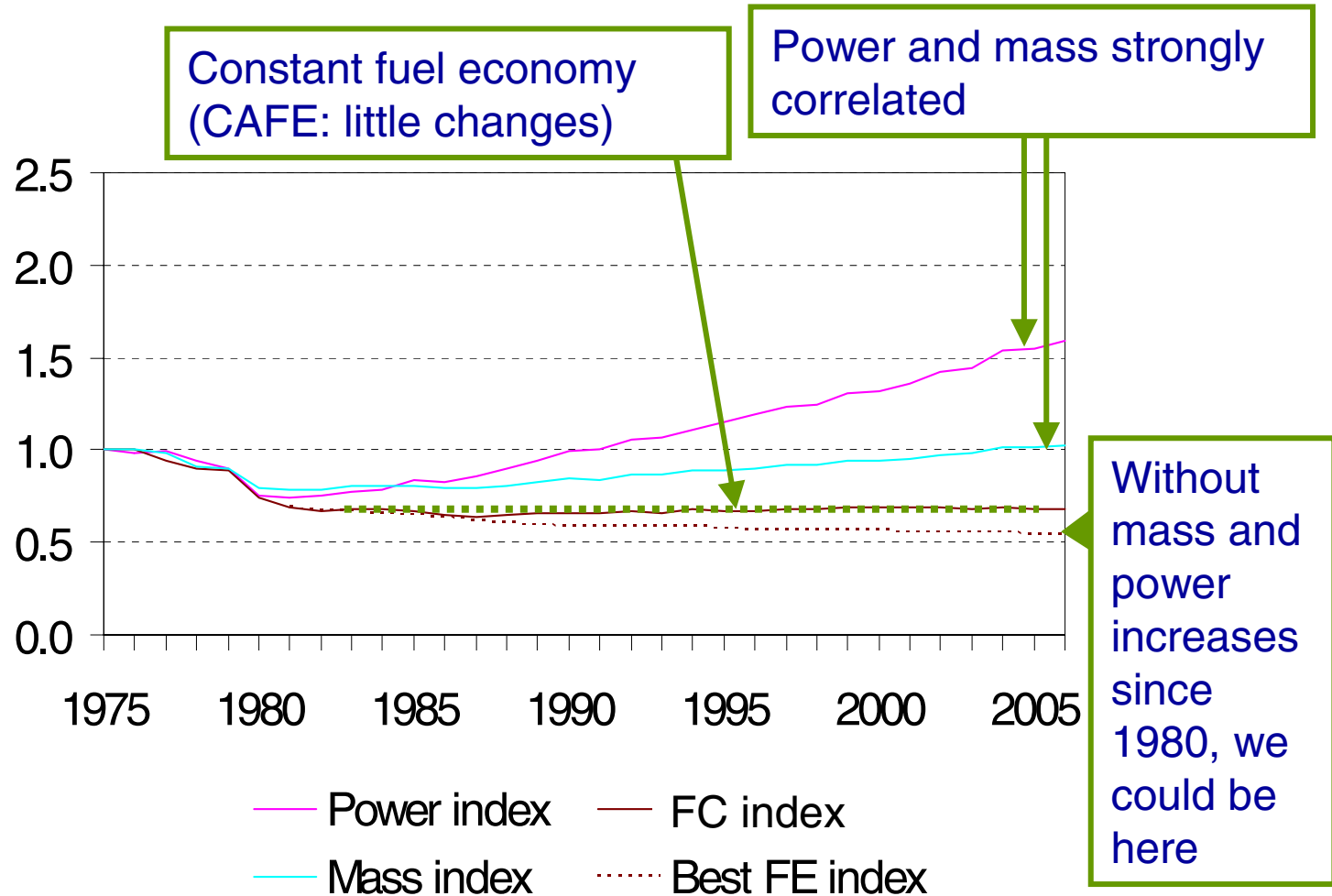




# USA, new vehicle sales

## A closer look

Model Year	Passenger Cars		Light-Duty Trucks	
	CAFE	CAFC	CAFE	CAFC
1977				
1978	18.0	13.1		
1979	19.0	12.4	17.2	
1980	20.0	11.8	-	
1981	22.0	10.7	-	
1982	24.0	9.8	17.5	
1983	26.0	9.0	19.0	
1984	27.0	8.7	20.0	
1985	27.5	8.6	19.5	
1986	26.0	8.6	20.0	
1987	26.0	8.6	20.5	
1988	26.0	8.6	20.5	
1989	26.5	8.6	20.5	
1990	27.5	8.6	20.0	11.8
1991	27.5	8.6	20.2	11.6
1992	27.5	8.6	20.2	11.6
1993	27.5	8.6	20.4	11.5
1994	27.5	8.6	20.5	11.5
1995	27.5	8.6	20.6	11.4
1996	27.5	8.6	20.7	11.4
1997	27.5	8.6	20.7	11.4
1998	27.5	8.6	20.7	11.4
1999	27.5	8.6	20.7	11.4
2000	27.5	8.6	20.7	11.4
2001	27.5	8.6	20.7	11.4
2002	27.5	8.6	20.7	11.4
2003	27.5	8.6	20.7	11.4

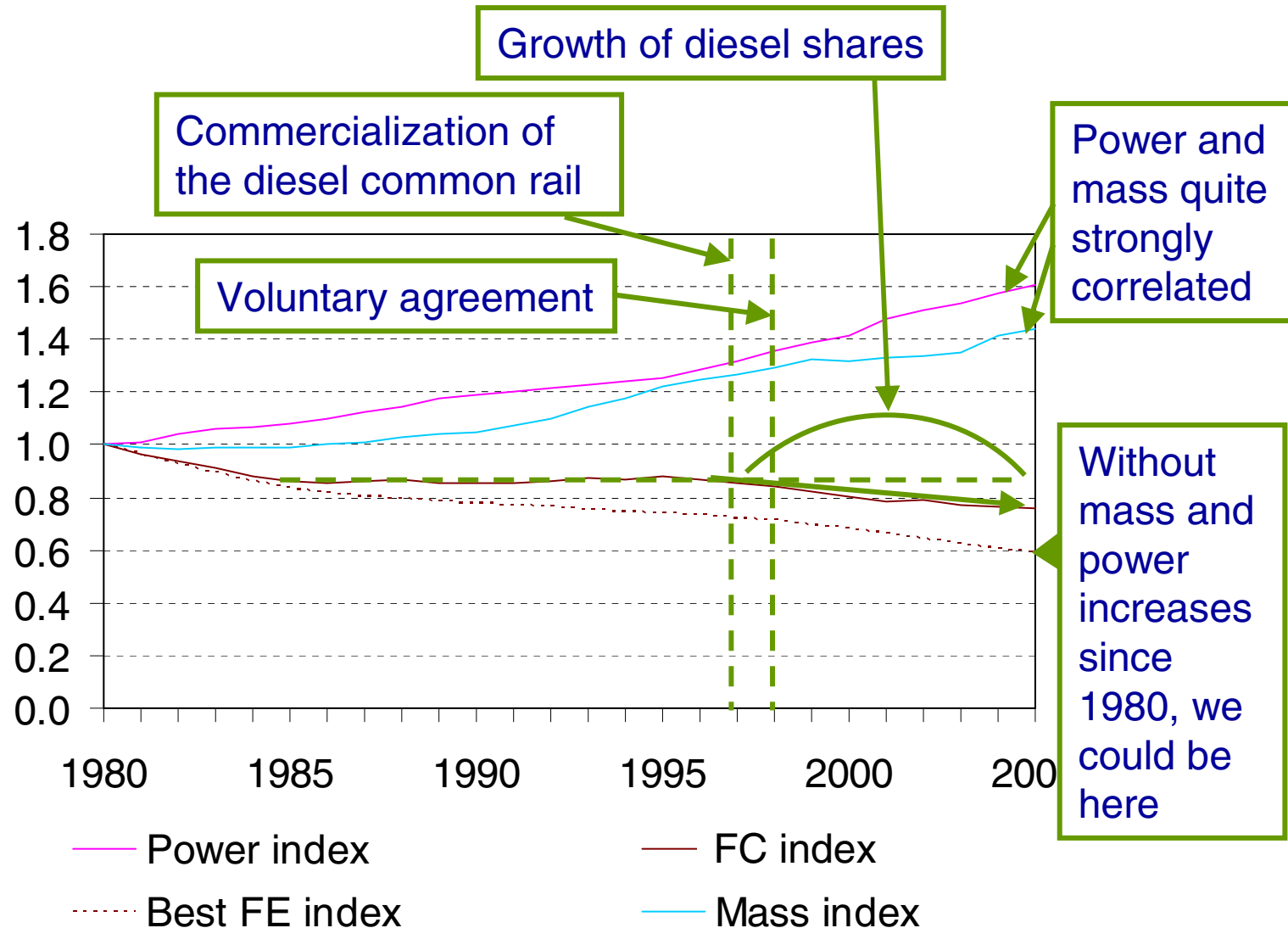


Sources: EPA, IEA estimates



# Europe, new vehicle sales

## A closer look

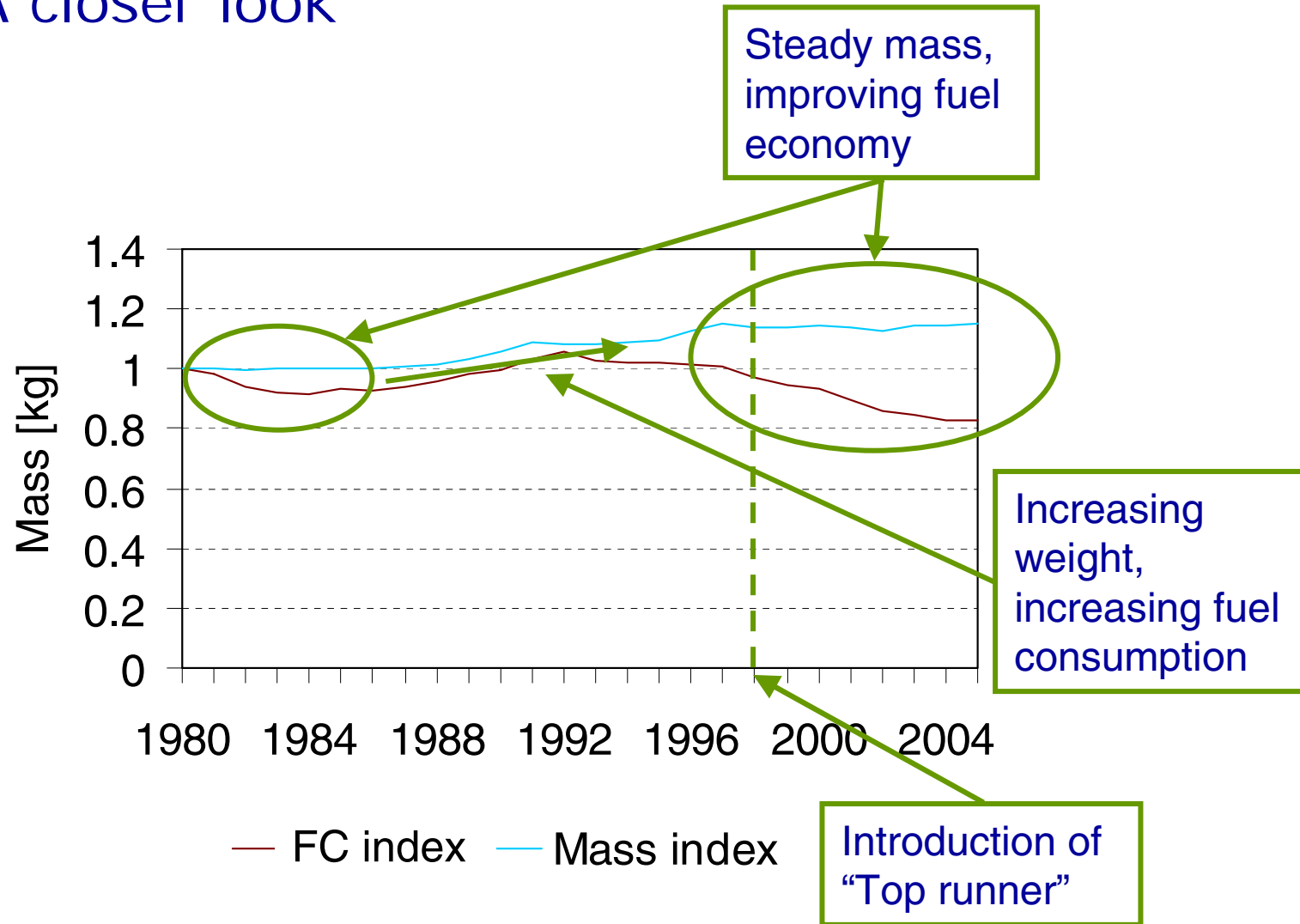


Sources: ACEA, ECMT, Odyssee, IEA estimates



# Japan, new vehicle sales

## A closer look





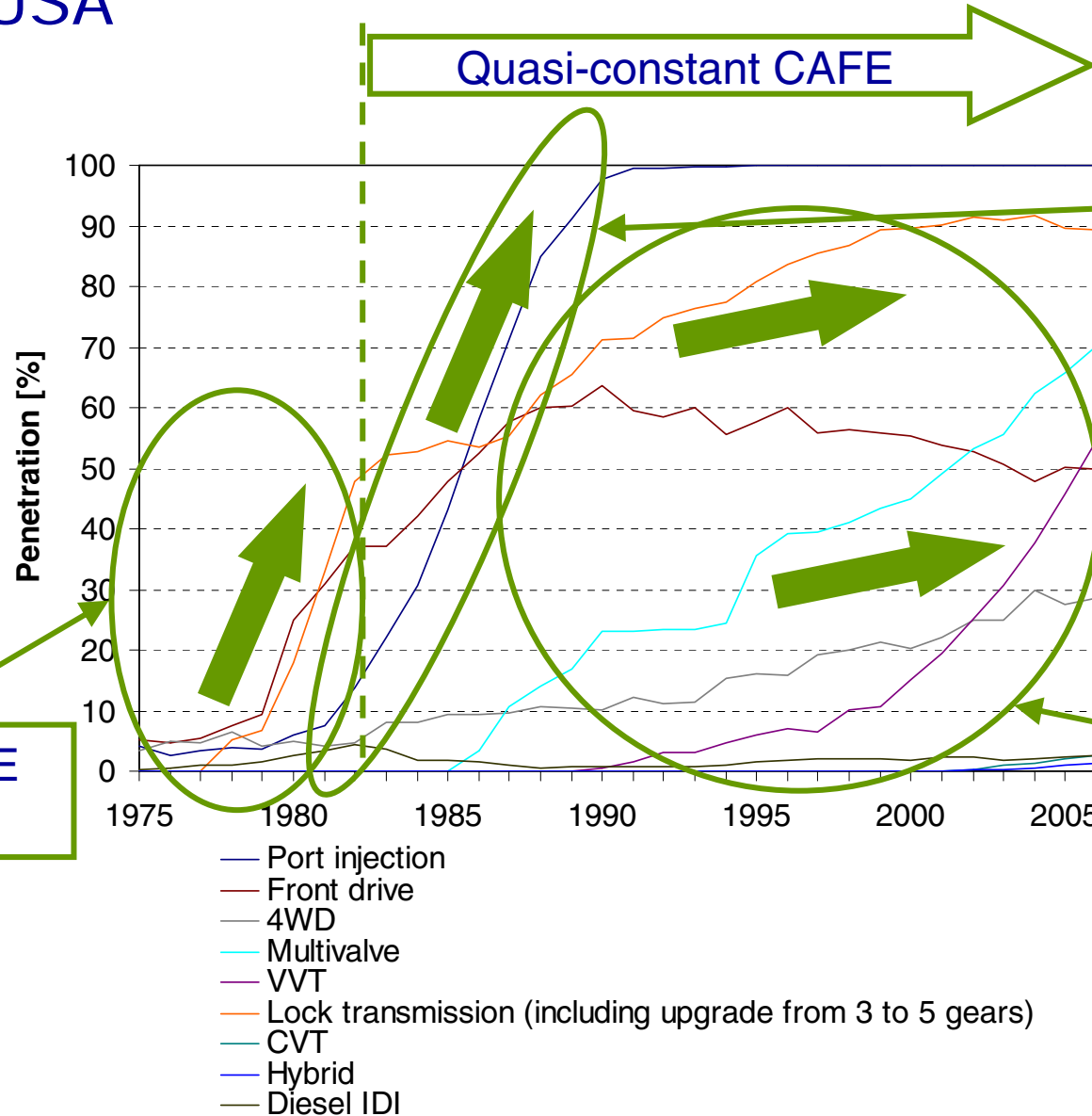
## Issues

- Will the weight increase continue?
- Will other regions follow OECD trends?
- Stopping the growth of vehicle mass and power is a key element to exploit technology potentials for better efficiency



# Technologies and policies

USA



Strong CAFE incentives

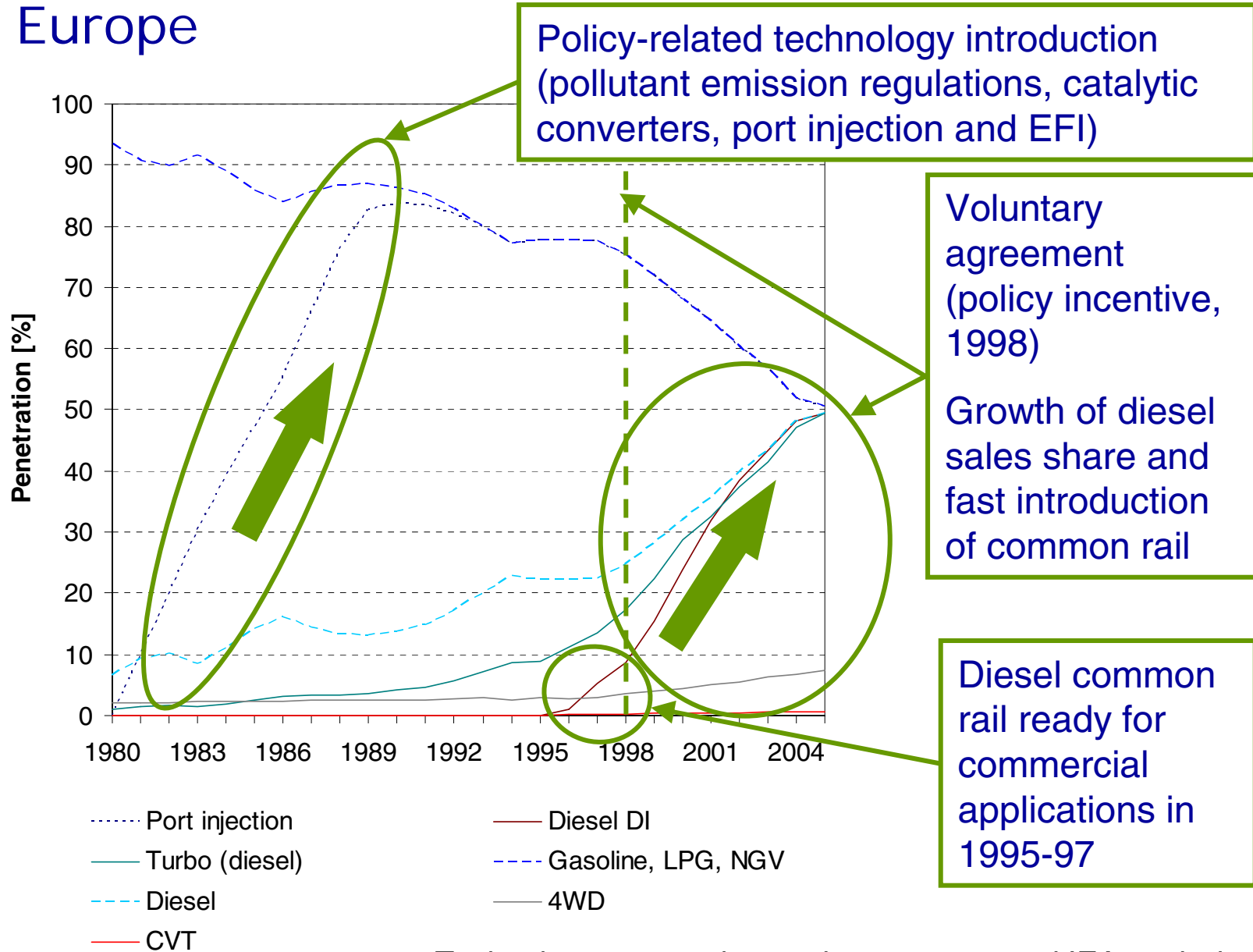
Policy-related technology introduction (Pollutant emission regulations, introduction of catalytic converters, port injection and EFI)

Little policy incentives



# Technologies and policies

## Europe



Technology penetration: various sources and IEA analysis



# Issues

- Is the commercial introduction of new technologies related to fuel prices?
- Is there a technology potential left?
- When will it be effective?
- Cost barriers: how to overcome them?

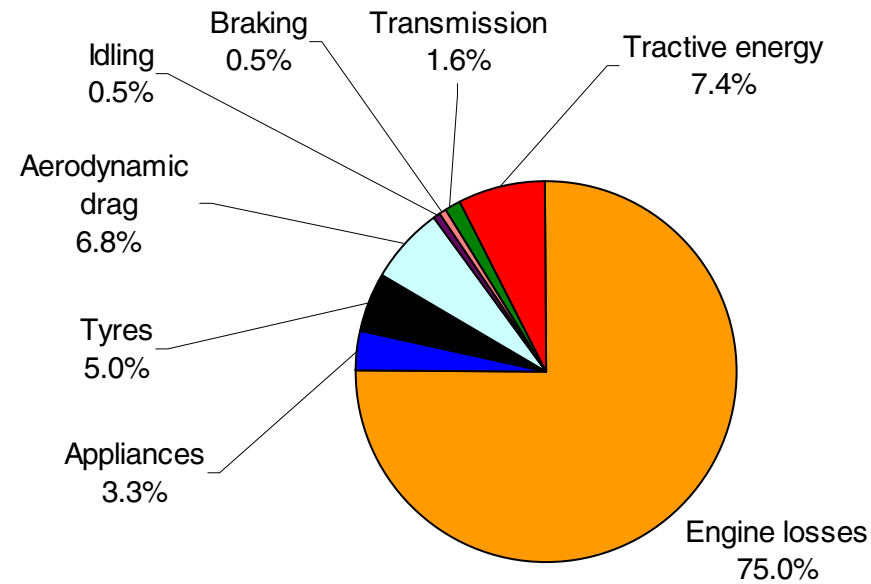


# Efficiency options



# Use of the energy in a vehicle

## Conventional gasoline





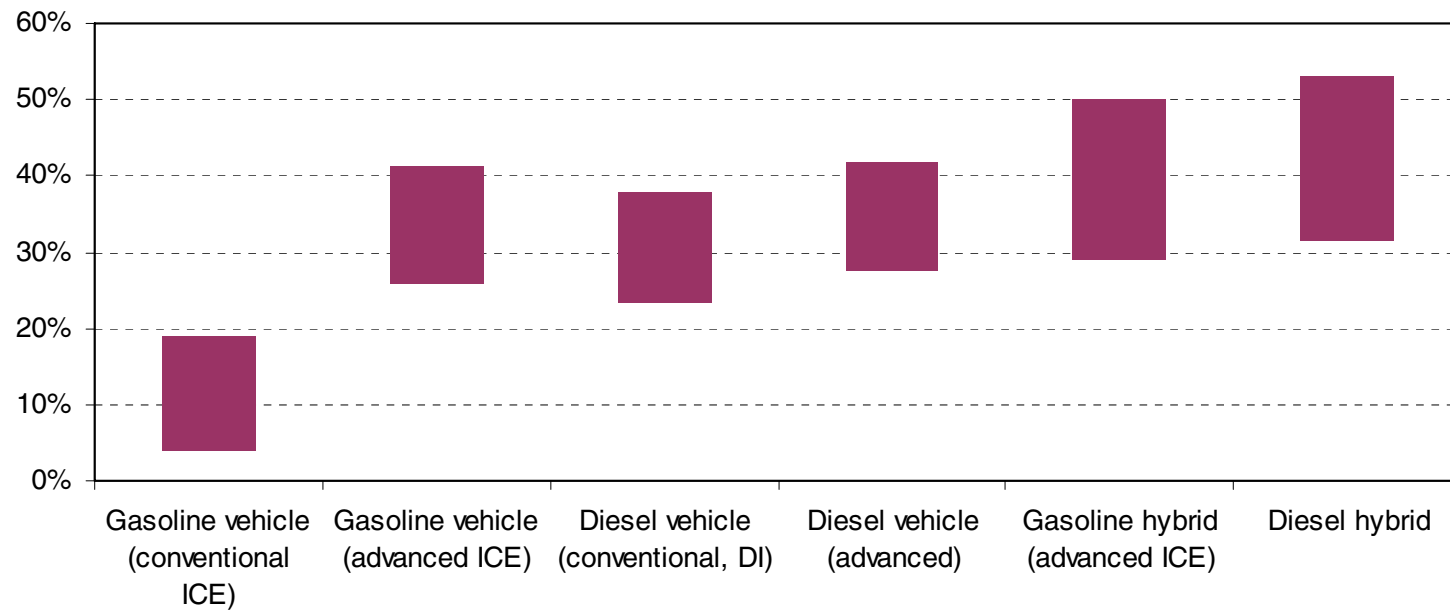
# Options to improve efficiency...

- Improved ICEs
  - ◆ Relying heavily on electronics, more and more since EFI
  - ◆ ICE operating closer to optimum conditions for longer times (thanks to electronic controls)
  - ◆ Gasoline engines potentially applying modified diesel technologies
- Non-engine options
  - ◆ Not considered in test cycles, therefore somewhat neglected
  - ◆ Account for 10-15% of the energy delivered by the engine to the shaft
- Hybrids
  - ◆ Different levels of hybridization possible
  - ◆ Proven technology, but not (yet?) widespread amongst vehicle manufacturer
  - ◆ Relying also heavily on electronics
  - ◆ ICE operating closer to optimum conditions
  - ◆ Recuperate energy lost in braking



# Efficiency potentials

## Including engine and non-engine options



Options	Fuel Efficiency Improvement [%]	Technology cost per vehicle [USD]
Variable valve lift and timing, enabling Miller cycles	5 to 7	350
Turbocharging & downsizing	10 to 15	470
Lightweighting	10	500-1000
Improved aerodynamics	2 to 4	0
Low rolling resistance tyres	2 to 4	100-200
improved A/C systems	2 to 3	100

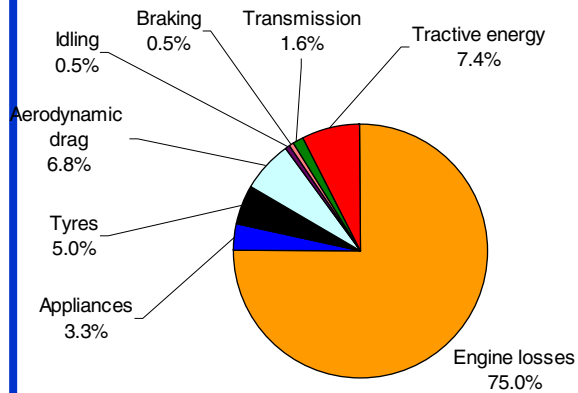
Ranges are associated to the degree of engine downsizing associated to the implementation of non-engine options

Driving cycles can influence these figure significantly

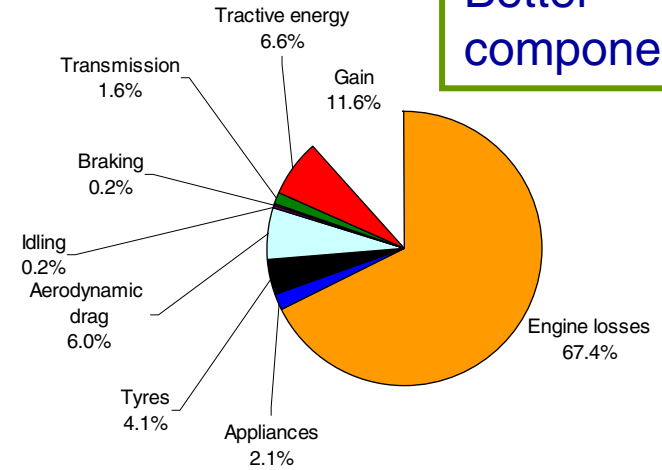


# Energy use in different configurations

## Gasoline ICEs

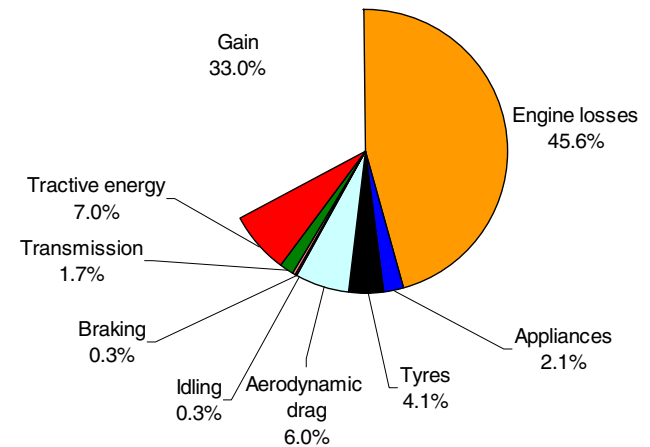


Gasoline today



Better components

Advanced gasoline ICE and better components

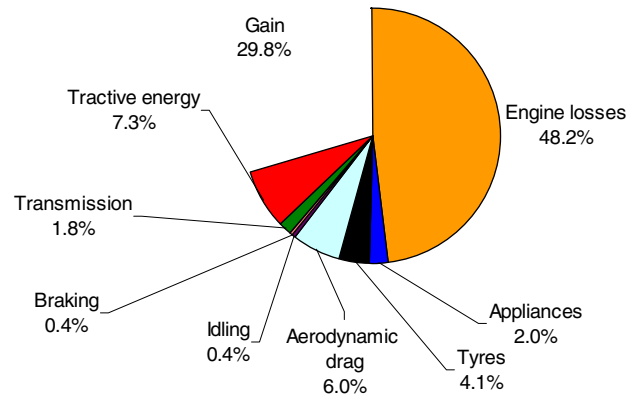




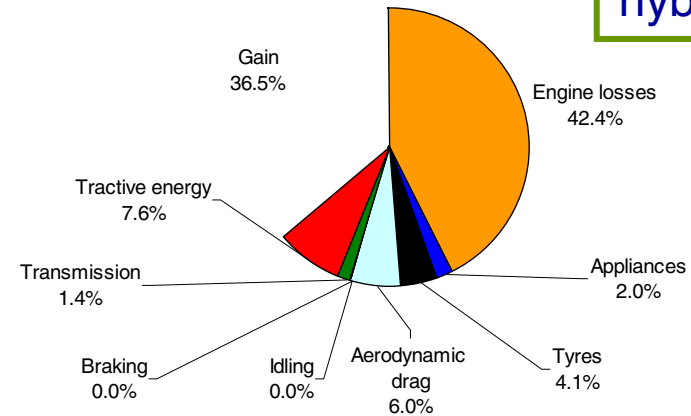
# Energy use in different configurations

Other powertrains mentioned

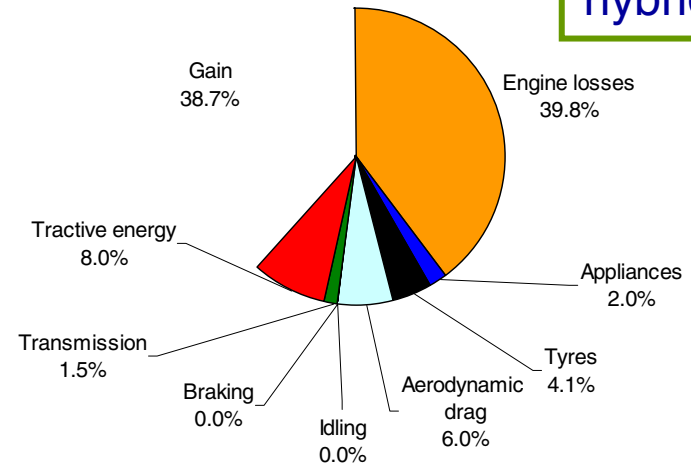
Diesel ICEs today



Gasoline hybrid



Diesel hybrid





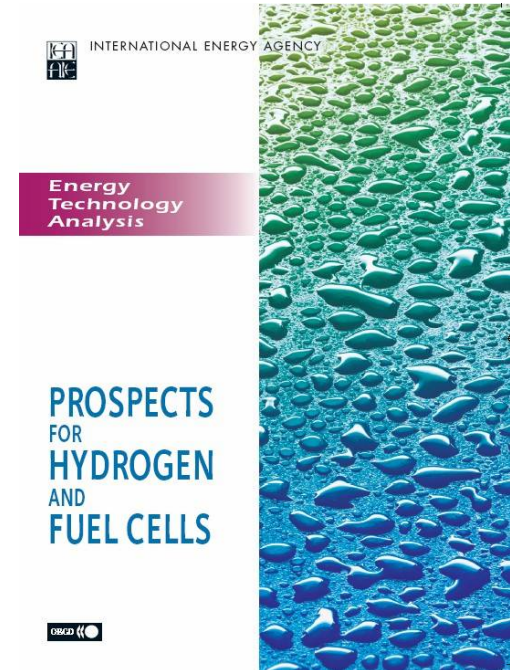
# Plug-in hybrids

- A hybrid with a larger battery
- Rapid improvements in Li-ion polymer batteries (claims):
  - ◆ Rapid loading
  - ◆ Explosion safety
  - ◆ Use of cheaper electrode materials
  - ◆ Longer life span for deep cycling
- ⇒ Can all these features be combined into one battery?
- Cost-effectiveness depends on oil & CO2 price, mileage and future battery cost.



# Fuel cell vehicles

- Efficiency gain factor 2-3 compared to advanced ICE
- Cost is a challenge (today \$2000/kW; <100 \$/kW drive system needed)
- Technology is not ready
- Long-term option
- Policy support needed



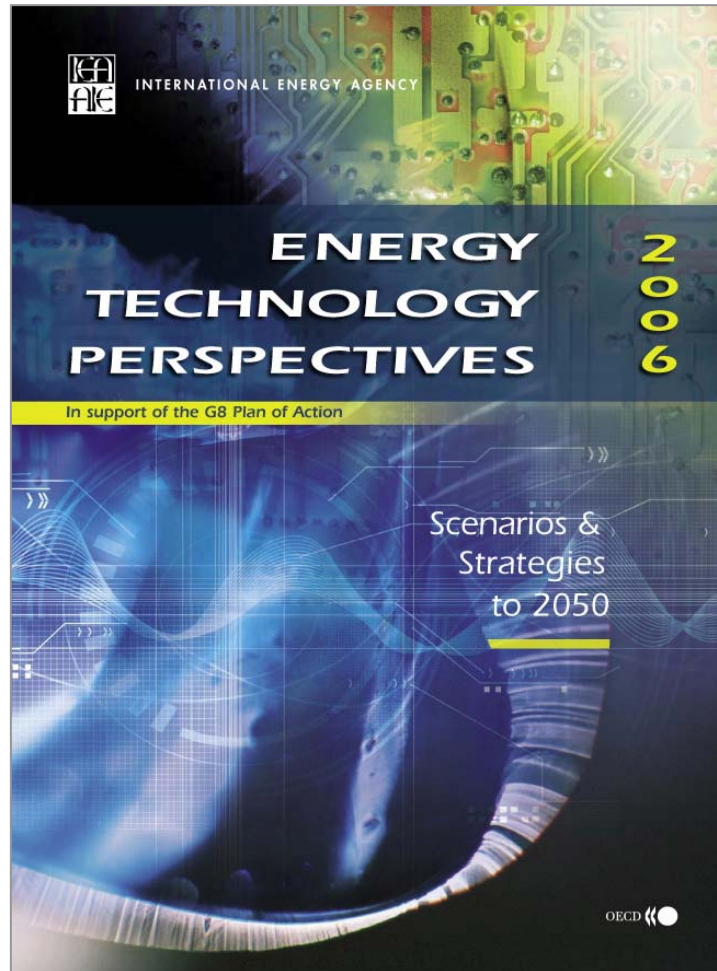


# Conclusions

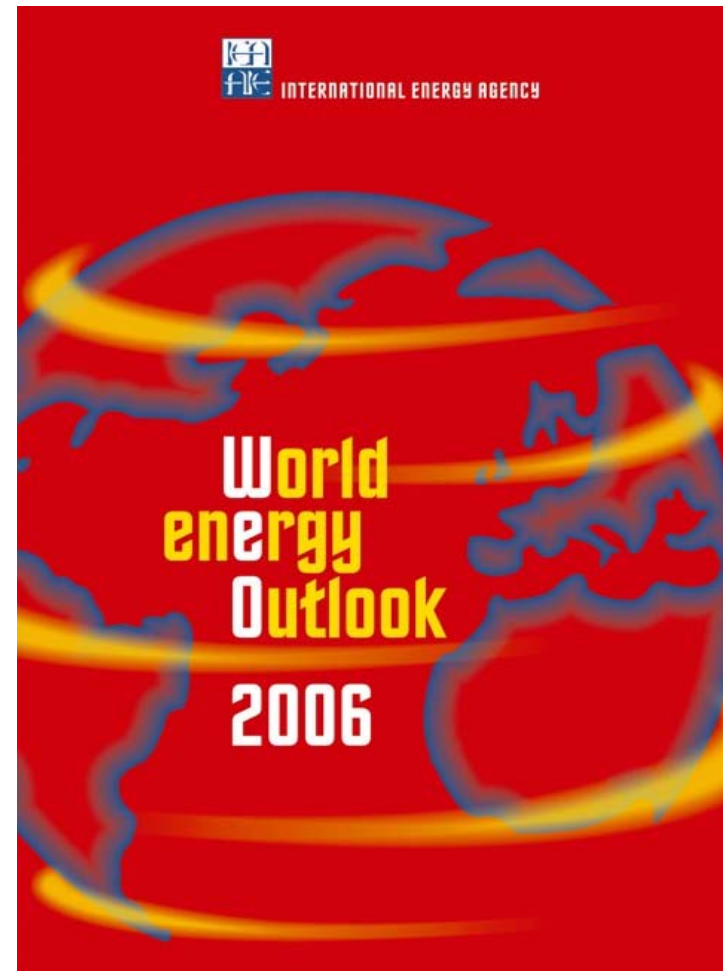
- Incremental fuel economy measures keep being introduced
  - ◆ They gain larger market shares with **policy incentives for improved fuel economy**
  - ◆ They are generally cost effective and first introduced on more expensive models
  - ◆ The risk is to lose the potential benefit they offer by exploiting it elsewhere (mass, power)
- Hybrids
  - ◆ Not (yet?) cost effective, need incentives (feebates, for instance)
  - ◆ Technically, they are a “natural” evolution of the increase use of electronics in cars
  - ◆ Plug-in hybrids follow from hybrids and can allow significant fuel switching. Battery technology still requiring improvements. Relatively low infrastructure cost, compared to fuel cells
- Fuel cell
  - ◆ Significant “revolution”
  - ◆ large infrastructure costs
  - ◆ Costs are still very high



Thank you  
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