

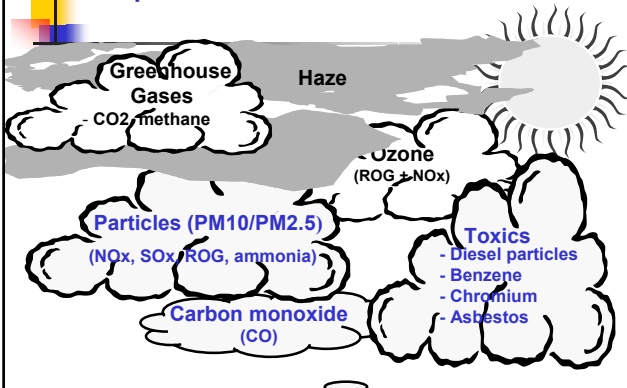
# A Comparative Assessment of Vehicle Technologies and Fuels: Diesel, CNG or Hybrid

CAI Latin America  
Lima, Peru  
May, 2003

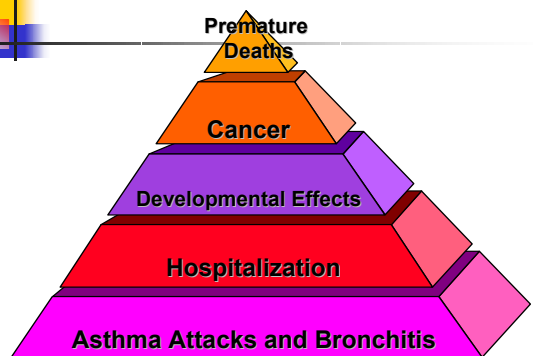
## Summary

- Why We Are Interested
- Diesel Pro & Con
- CNG Pro & Con
- Hybrid Pro & Con
- Conclusions

## What pollutants are of concern?



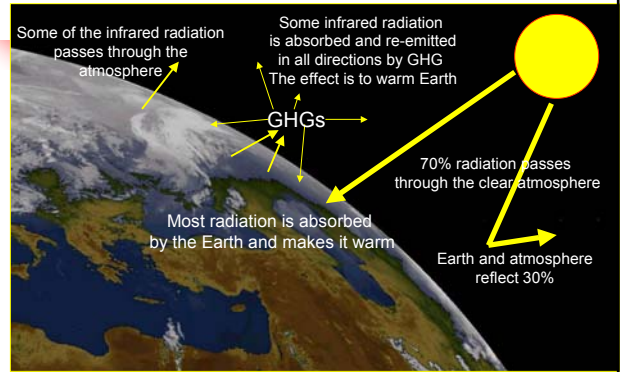
## Health Impacts of Air Pollution



## Health Effects

- Different Pollutants have Different Effects
  - Carbon Monoxide - circulatory system, heart
  - Ozone - respiratory system, lung
  - Nitrogen Dioxide – respiratory system
  - PM - lung, potential effects on heart
  - Diesel, Air Toxics - cancer, respiratory effects
- There are potential effects of the Mixture
- Some Populations more sensitive than others
  - elderly
  - people with heart and lung disease

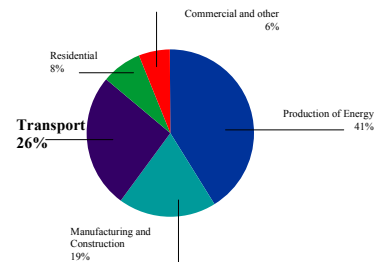
## Greenhouse Gas Effect



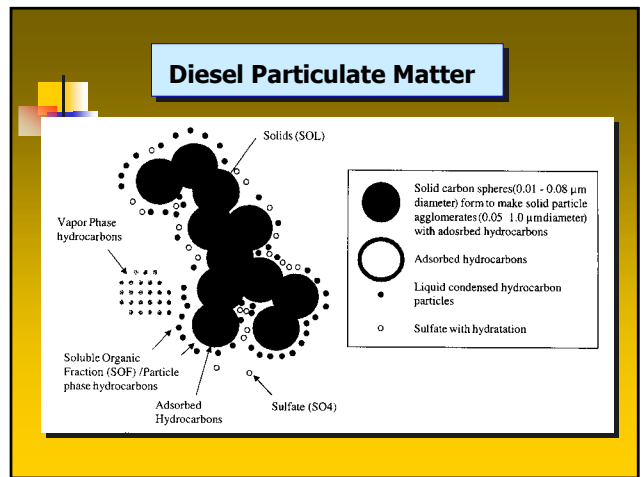
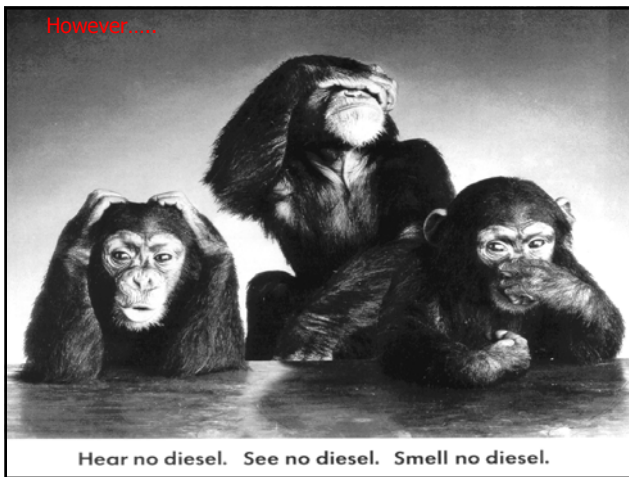
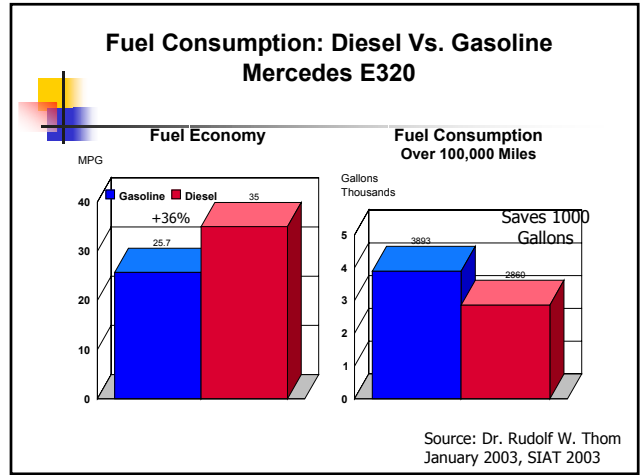
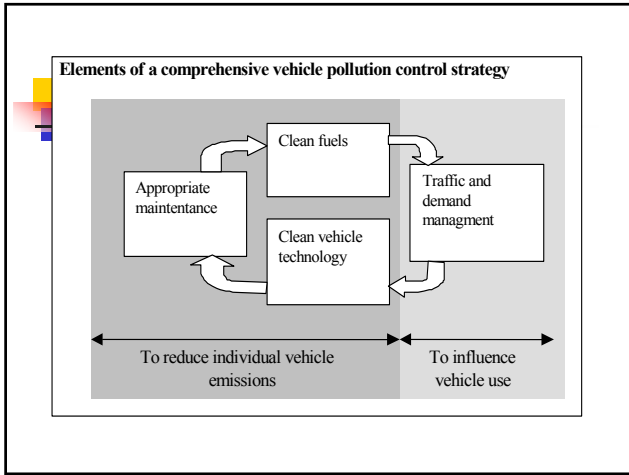
## Global Warming Concerns

- IPCC - 1995
  - ▶ "the balance of evidence suggests a discernible human influence"
- IPCC - 2000
  - ▶ "there has been a discernible human influence on global climate"

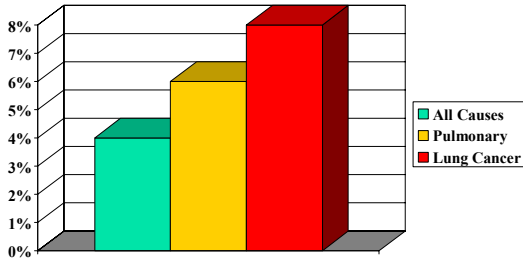
## Share of worldwide CO<sub>2</sub> emissions from the combustion of fuel, by sector -- 1998



Source: IEA 2000a.

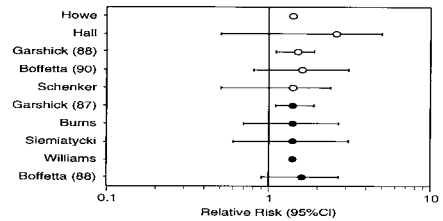


## Increased Risk of Premature Mortality Due To $10\mu\text{g}/\text{m}^3$ $\text{PM}_{2.5}$



JAMA, March 2002

## Cancer Studies in Railroad Workers HEI, 1995



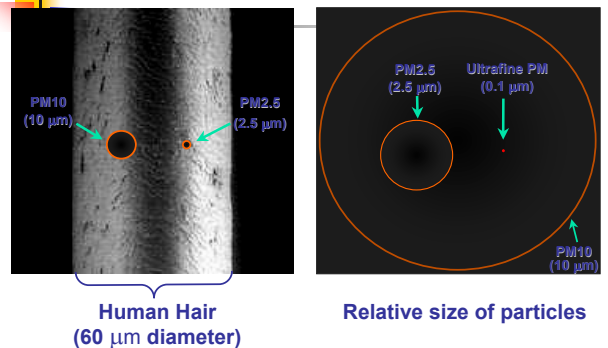
## Health Impacts of Diesel in California

### Impacts Of Diesel $\text{PM}_{2.5}$

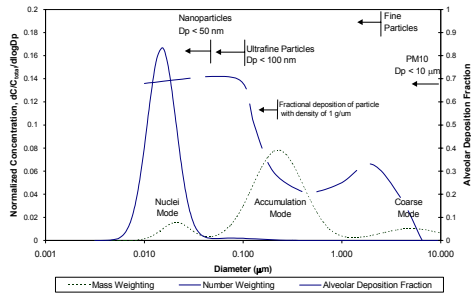
Deaths	2,900
Chronic Bronchitis	2,590
Hospital Admissions	2,790
Lower Lung Symptoms	95,400
Loss of Days Work	621,000

Annual

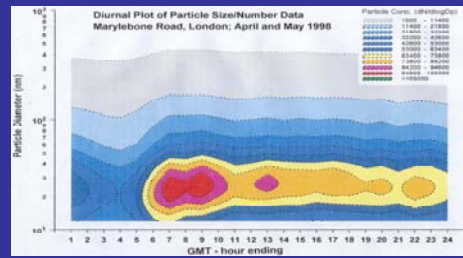
## Comparison of $\text{PM}_{10}$ , $\text{PM}_{2.5}$ , and Ultrafine $\text{PM}$



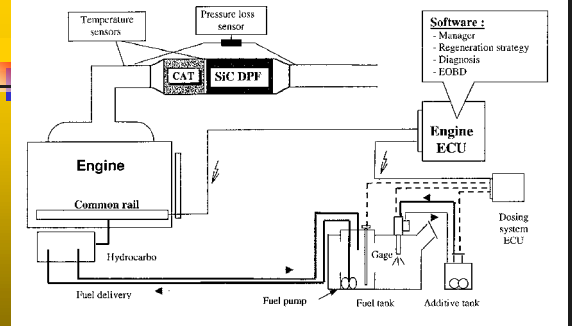
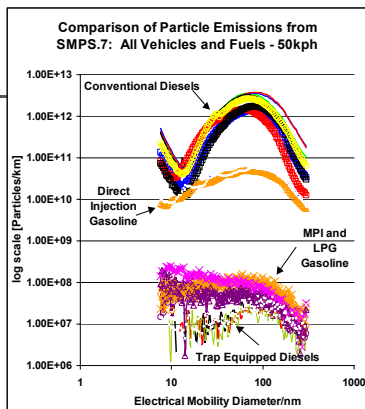
## Typical engine exhaust mass and number weighted size distributions shown with alveolar deposition



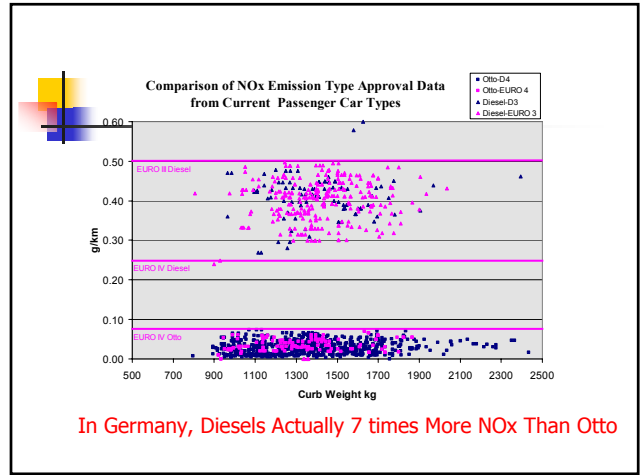
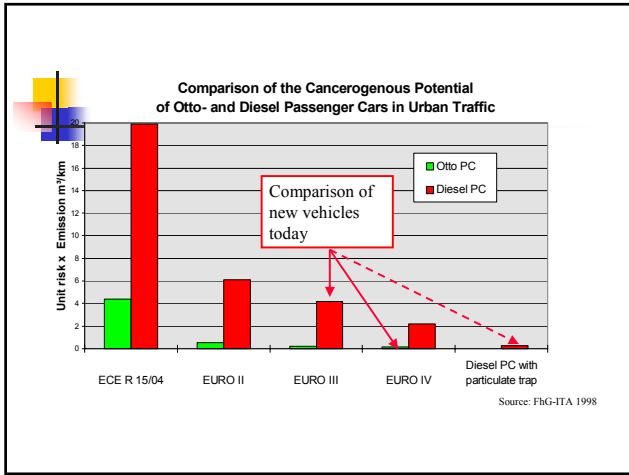
## Vehicles Are A Major Source of Ultrafine Particles



A PM Solution Exists!



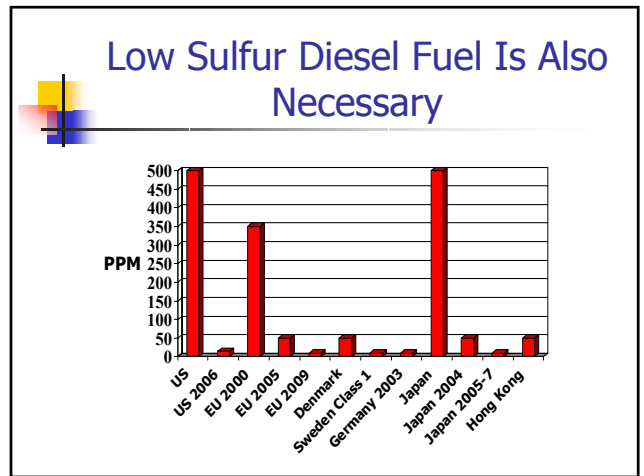
**PSA's DPF System for Diesel Passenger Cars**

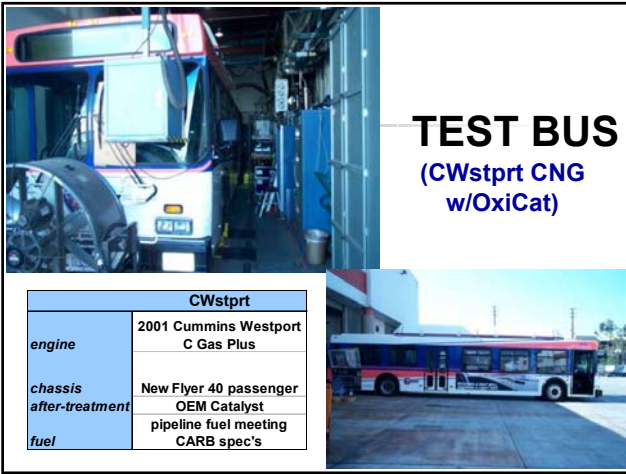


### Emission Performance Light-duty Diesels

Model	NO <sub>x</sub>	PM
	g/mile	
CA VW 1.9 / Jetta	0.7	0.053
US Mercedes 3.0 / E300	0.8	0.08
EU Peugeot 607 <sup>1</sup>	0.6	0.0005
Toyota Avensis <sup>1</sup> Prototype	0.05	0.006

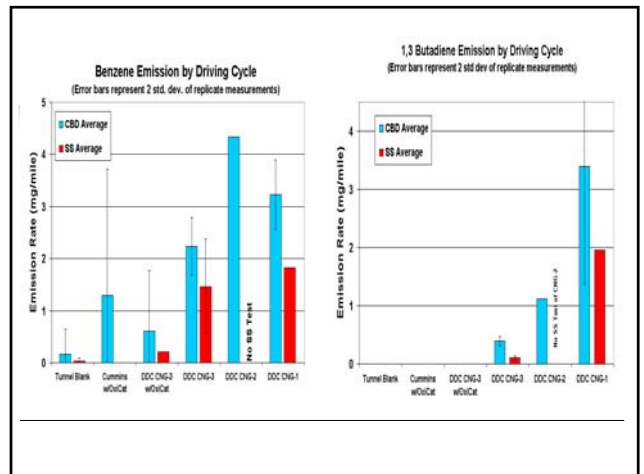
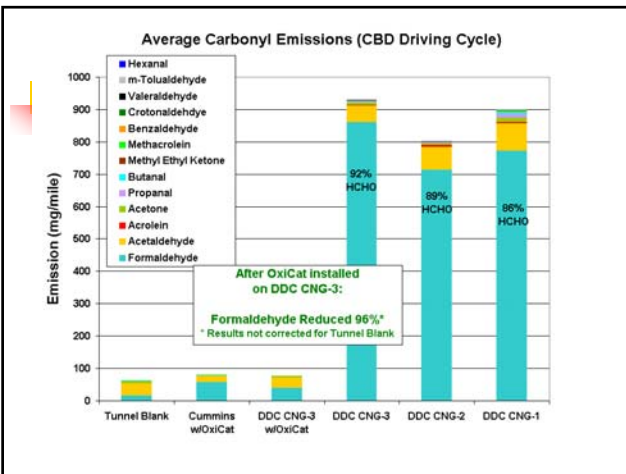
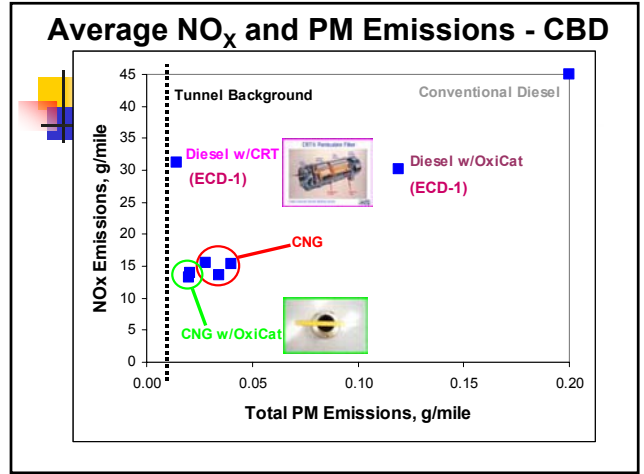
<sup>1</sup> Low mileage









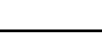


## TEST BUS (CWstprt CNG w/OxiCat)

CWstprt	
engine	2001 Cummins Westport C Gas Plus
chassis after-treatment	New Flyer 40 passenger OEM Catalyst
fuel	pipeline fuel meeting CARB spec's



## Hybrid Vehicle Commercialization

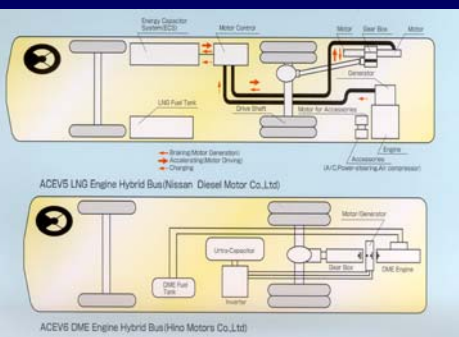
Toyota Prius	Small car	2000	
Honda Civic	Small car	2002	
Ford Escape	Small SUV	2003	
Dodge Durango	Large SUV	2003	
GM Sierra	Large Pickup	2004	
GM	Medium SUV	2004	
Toyota	Minivan	?	

## Hybrid Vehicles Developed and Sold in Japan

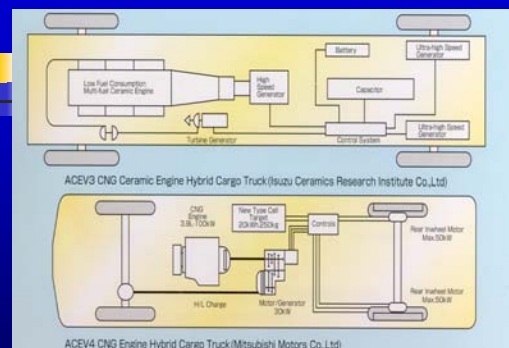
Source: JEVA, 2002

Type	Size	Name	Maker	Range	Battery	Motor/System
PC	Compact	Prius	Toyota	31 km/L	Ni-MH	AC Synch/ P/S
		Insight(MT)	Honda	35	Ni-MH	AC Synch/ P
		Insight(AT)	Honda	32	Ni-MH	AC Synch/ P
	Medium	CIVIC-H	Honda	29.5	Ni-MH	AC Synch/ P
		(Tino-H)	Nissan	20	Li-ion	AC Synch/ P
Truck (3.5 t)	Estima-H	Toyota	18	Ni-MH	AC Synch/ P/S	
	Crown(Mild)	Toyota	15	Lead	AC Synch/ P	
Bus	Micro	Ranger	Hino	8 (60km/h)	Lead	AC Induct/ P
	Coaster	Toyota	5.3	Lead	AC Induct/ S	
Bus	Transit	Blue Ribbon city	Hino	30% ↑	Ni-MH	AC Induct/ P

Note: Micro hybrid PCs and HD hybrid trucks are being developed by Japanese automakers



Advanced Clean Energy Buses with Hybrid Systems (NEDO)



Advanced Clean Energy Trucks with Hybrid Systems (NEDO)



## Highest-Mileage Vehicles in U.S. (2003)

### Manual Transmission

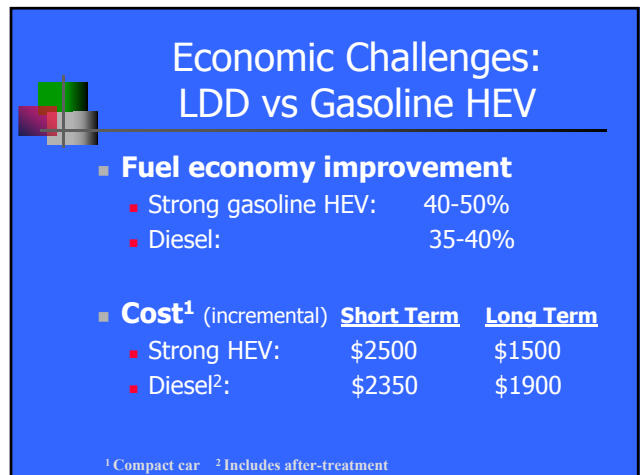
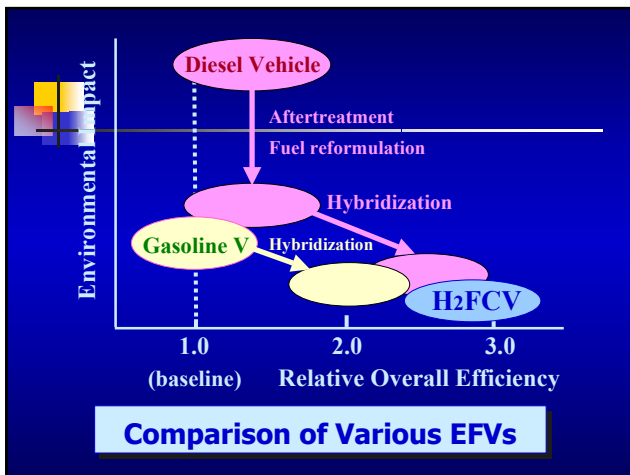
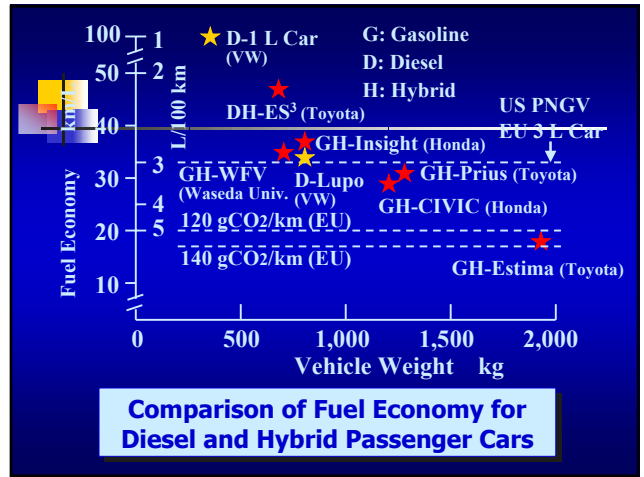
Vehicle	Energy source	Avg. mpg	CO <sub>2</sub> (g-C/km)	CO <sub>2</sub> (g-C/km) trap+filter
Honda Insight	Gas/electric	64.5	23.0	
Honda Civic	Gas/electric	48.5	30.6	
VW Golf, Jetta	Diesel	45.5	37.8	39.7
Honda Civic	Gas	40	37.1	
Toyota Echo	Gas	39	38.0	

### Automatic Transmission

Vehicle	Energy source	Avg. mpg	CO <sub>2</sub> (g-C/km)	CO <sub>2</sub> (g-C/km) trap+filter
Honda Insight	Gas/electric	56.5	26.2	
Toyota Prius	Gas/electric	48.5	30.6	
Honda Civic	Gas/electric	39.5	37.5	
VW Golf, Jetta	Diesel	39.5	43.5	45.7

→ Gasoline/electric hybrids emit less CO<sub>2</sub> than the best diesel vehicles in U.S.

Mark Jacobson, Haagen Smit 2003





## Conclusions

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- Diesel, CNG & Hybrids Each Have High Potential
- Stringent Performance Standards Necessary To Obtain Full Potential
- Major Challenges
  - Diesel – PM, NO<sub>x</sub>
  - CNG – Aldehydes, Infrastructure
  - Hybrids - Cost