CAFE Standards and Trends for U.S. Cars and Light Duty Trucks

Feng An, Ph.D.
International Transportation Consultant

Sponsor: Environment Program, The William and Flora Hewlett Foundation

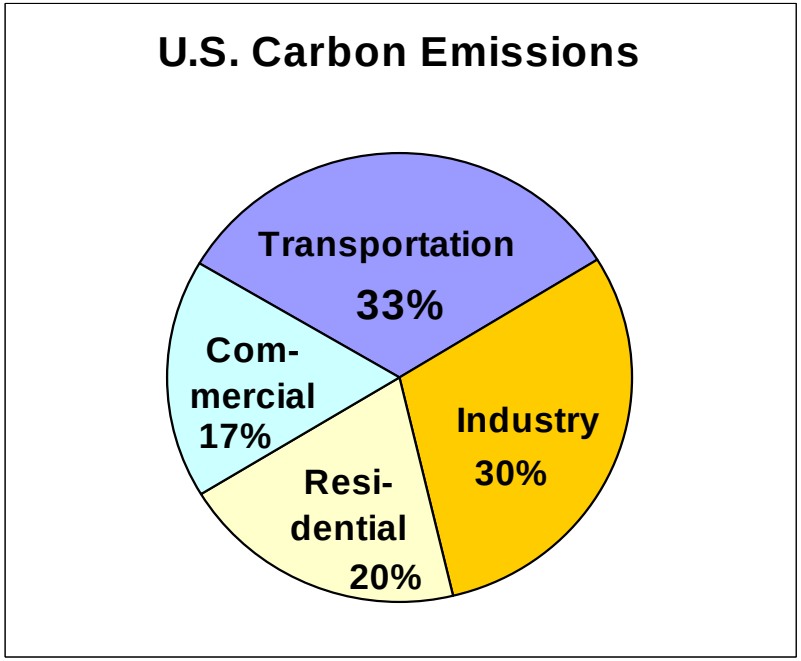
March 15, 2004
Mexico City, Mexico

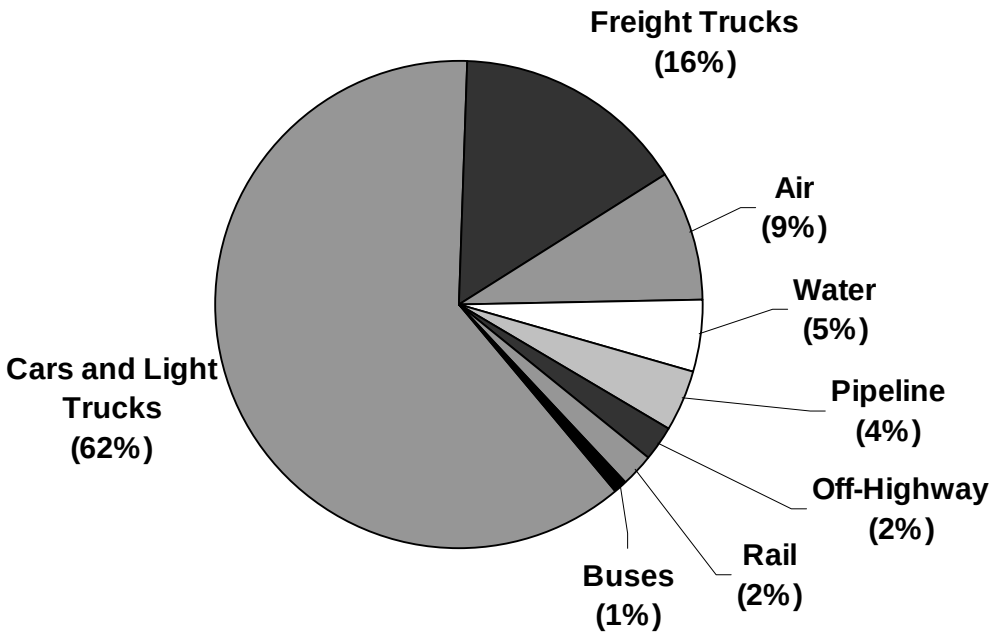
Outline

- Benefits of Improving Vehicle Fuel Economy
- How CAFE is Determined
- Recent Fuel Economy Trends in US
- CAFE Reform and California GHG Regulation
- Fuel Economy Standards of EU, Japan, China
- Technical Potential for Cars and Light Trucks Fuel Economy improvements by 2010–15
- Advanced Vehicle Technologies

In 2000, US transportation sector contributes one third of total carbon emissions, and among them, 62% is from automobiles.

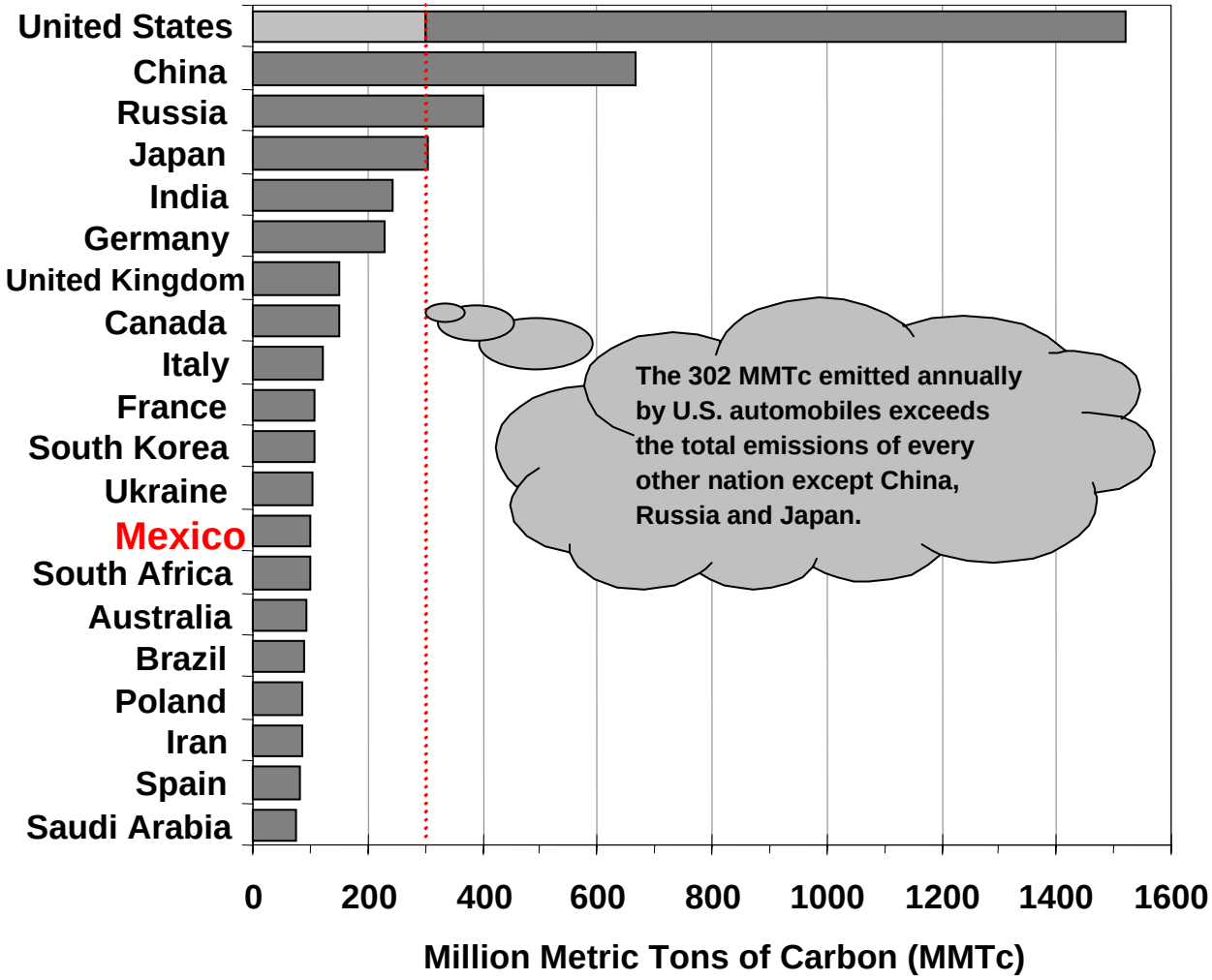
(What is the breakdown for Mexico?)





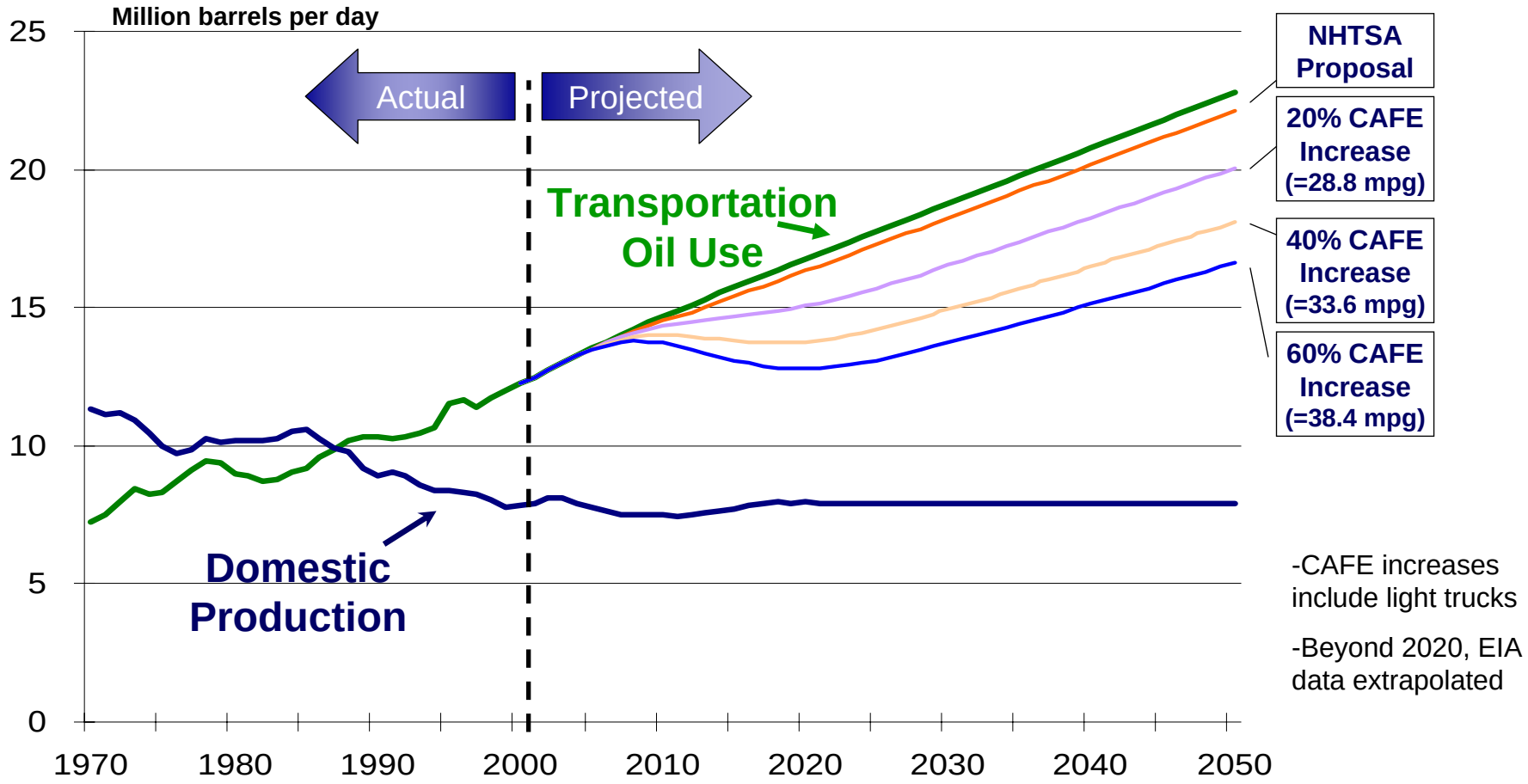
Carbon Emissions from U.S. Automobiles vs. Nations of the World

– Mexico ranks among top 20



The US Oil "Gap" Is Growing

– Dramatic actions are required, but no solutions in sight



-CAFE increases include light trucks

-Beyond 2020, EIA data extrapolated

Feng An

Relationship of Vehicles Sales to Per Capita Income – Large potential for Mexico

The Oil Imbalance

– Will Mexico become a net-importer?

	Nations that **HAVE** oil		Nations that **NEED** oil	
64%	Saudi Arabia	26.4%	U.S.	24.9%
	Iraq	11.5%	Japan	7.3%
	Kuwait	9.8%	China	6.4%
	Iran	9.6%	Germany	3.7%
	UAE	6.3%	Russia	3.4%
	Russia	5.4%	S. Korea	2.9%
	Venezuela	4.7%	Brazil	2.9%
	Libya	3.0%	France	2.7%
	China	3.0%	India	2.7%
	Mexico	**2.7%**	Canada	2.6%
	Nigeria	2.4%	Italy	2.5%
	U.S.	2.2%	**Mexico**	**2.5%**

Source: EIA International Petroleum Information, December 2002. Data for 2000

Benefits of Improving Vehicle Fuel Economy (and relevance to Mexico ✓)

- Reducing Energy Consumption ✓
- Reducing GHG Emissions ✓
- Improving Air Quality ✓
- Reducing Dependence of Imported Oil
- Improving Energy Security
- Improving Trade Balance ✓
- Promoting Energy Efficient Technologies
- Increasing Competitiveness of auto industry

Vehicle Fuel Economy Standards of US

Corporate Average Fuel Economy (CAFE)

- CAFE standard for Cars: 27.5 mpg
- CAFE for Trucks: currently 20.7 mpg, proposed 21 mpg in 2005, 21.6 in 2006, and 22.2 in 2007, representing a 7% increase over three years
- Actual average MPG ratings (2002) for Cars - 28.5, Trucks - 20.3, fleet average - 23.8 mpg, lowest level since 1985

Definitions of "Cars" and "Trucks"

- Car class include:
  - Cars
  - Wagons
- Truck class include:
  - Pickup trucks
  - Sports Utility Vehicles (SUVs)
  - Minivans
  - less than 6500 lb.
- Rapid rising of crossover vehicles
- GM hot selling Hummer is not a "light-duty" vehicles

Hummer is not a "light-duty" truck

Crossover Vehicles – Cars or Trucks?

2003 Subaru Outback
Hatchbacks/Wagons/SUVs
"2003 as car, 2004 as truck"

2003 DCX PT Cruiser
Small Wagon/SUV
"Truck"

2003 Pontiac Vibe
Hatchbacks/Wagons/SUVs
"Car"

How CAFE is Determined
(and difference from "Real-World" MPG Rating)

- CAFE is determined based on separate City and Highway driving cycles
- CAFE Rating (Unadjusted, Lab MPG) – 55% of City Driving, 45% of HWY Driving

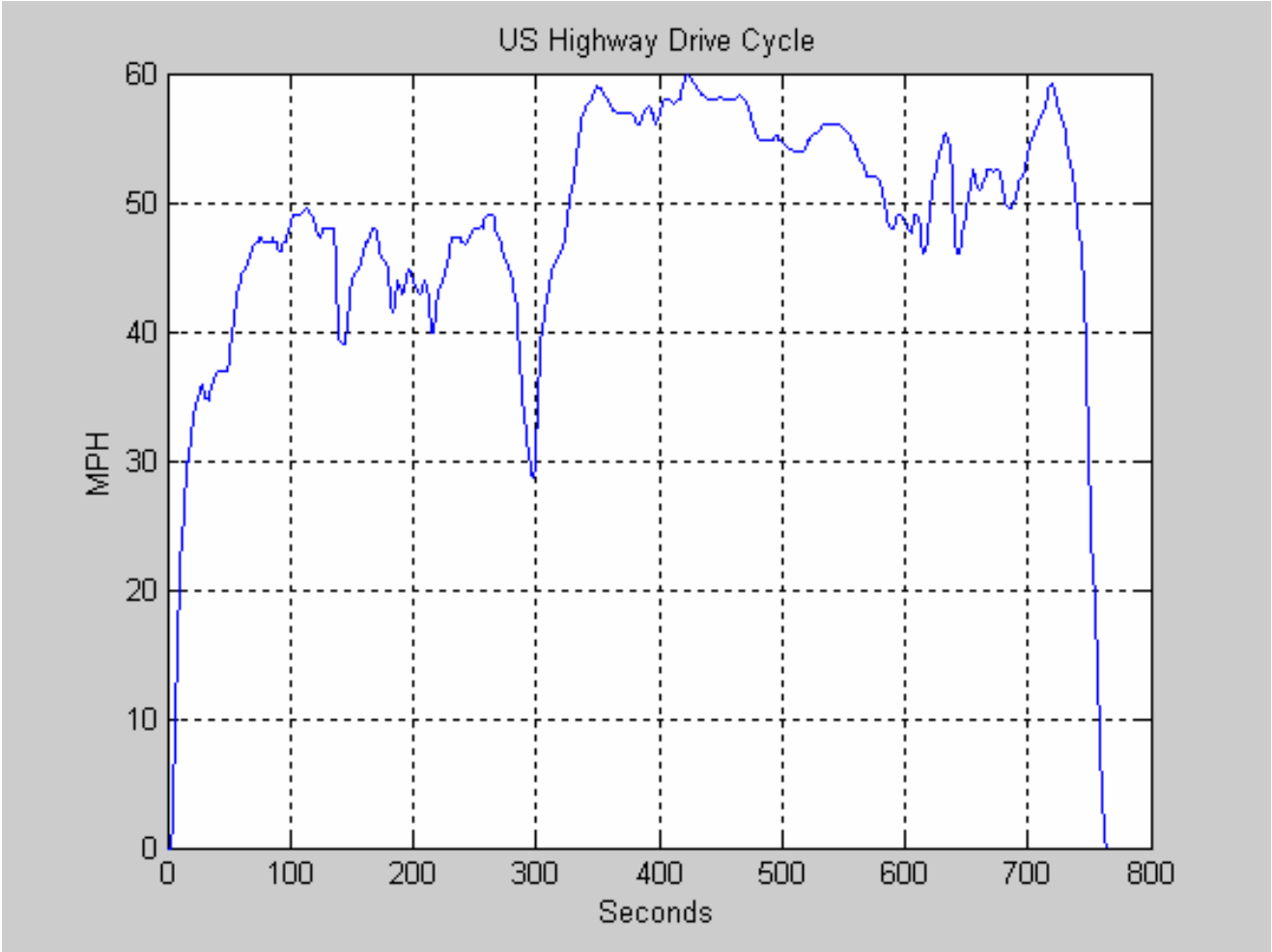
$$\frac{1}{MPG_{CAFE}} = \frac{0.55}{MPG_{CITY}} + \frac{0.45}{MPG_{HWY}}$$

- "Real-World" or "Sticker" MPG Rating at new vehicle showroom: The adjustment factors are 0.9 to convert the FTP mpg to consumer "city" mpg, and 0.78 to convert the EPA highway mpg to consumer "highway" mpg.

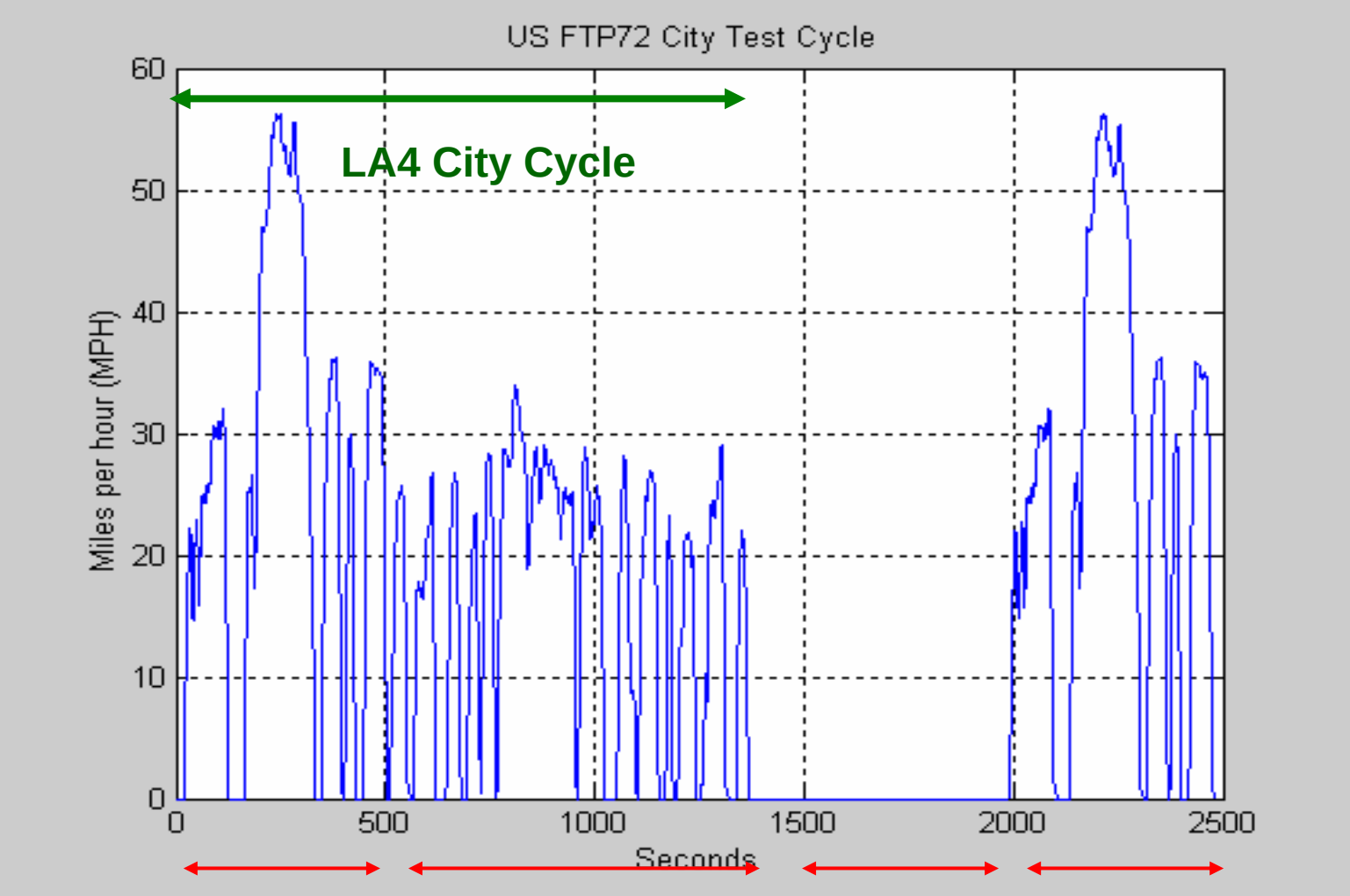
$$MPG_{Sticker} \approx 0.85 * MPG_{CAFE}$$

US EPA Highway Drive Cycle

- 10.26 miles long, average speed of 48.2 mph, peak speed of 60 mph



US Federal Urban Drive Schedule (FUDS, or City Cycle) has a complicated structure

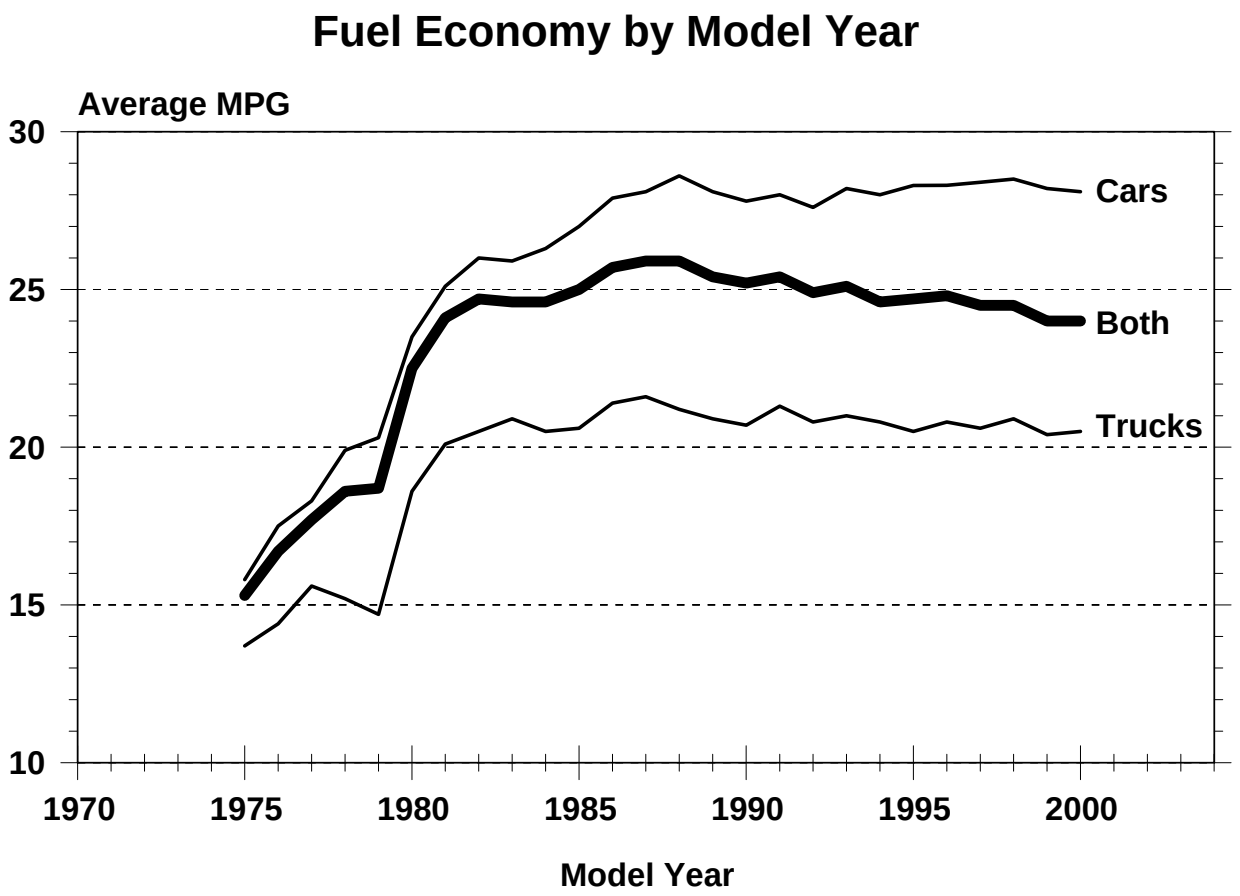


City (FUDS) Fuel Economy Calculation
- Breakdown Cold and Warm Starts

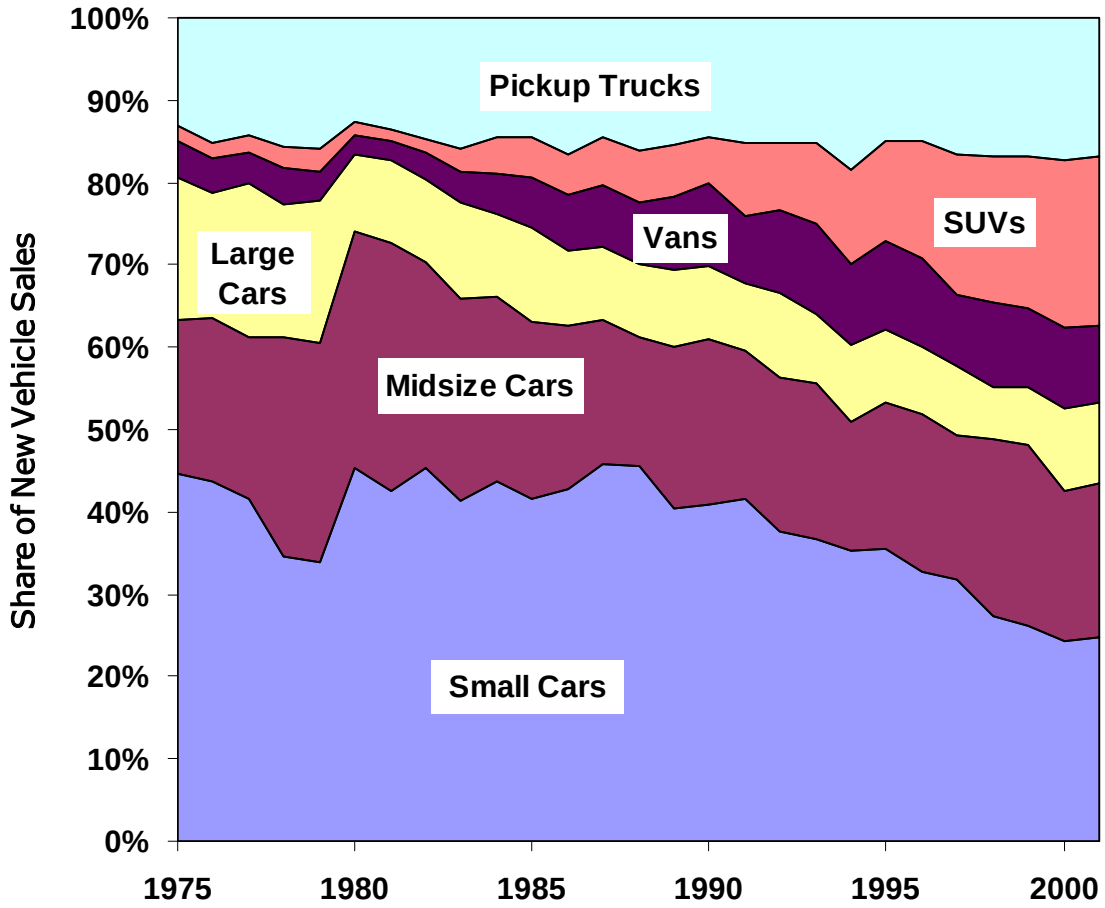
- FUDS = LA4 (Bag 1 + Bag 2) + 10 min. Soak + Bag 3 (Warm Bag 1)
- LA4 Cycle - 7.45 miles long, average speed of 19.6 mph, peak speed of 56.7 mph.
- Assuming 43% of cold start and 57% of warm start
- Distance weighted

$$\frac{1}{MPG_{City}} = \frac{0.207}{MPG_{bag1}} + \frac{0.518}{MPG_{bag2}} + \frac{0.275}{MPG_{bag3}}$$

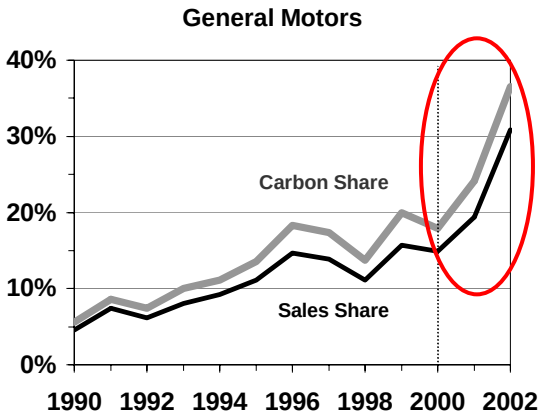
US Vehicle Fleet Average Fuel Economy Nearly Doubled between 1975 and 1985, but Has Been Declining Since

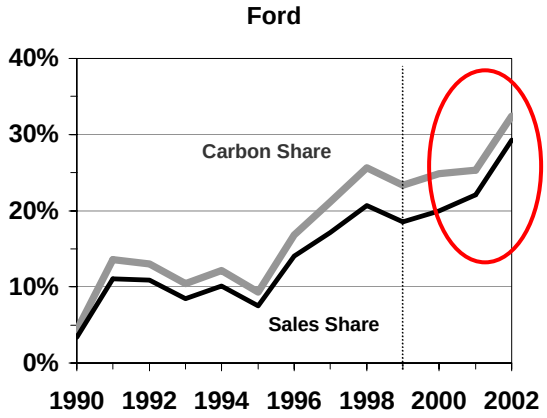


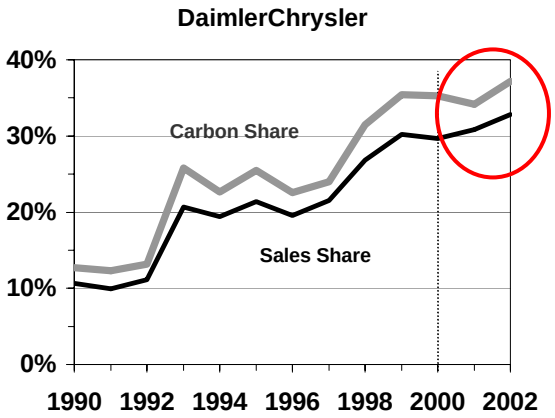
In 2003, for the first time the new truck sales surpassed the new car sales. The SUV share reached 27% in 2002

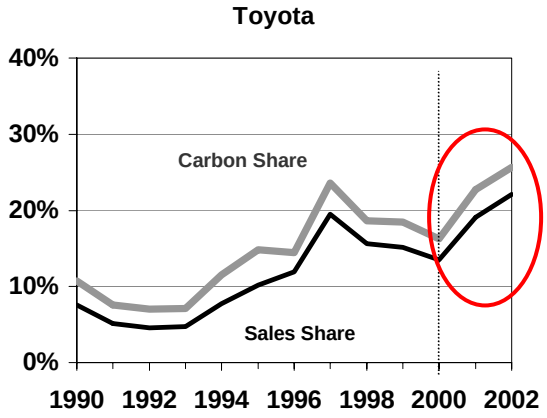


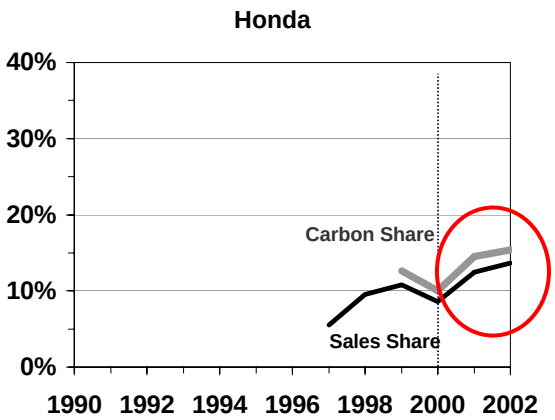
Feng An

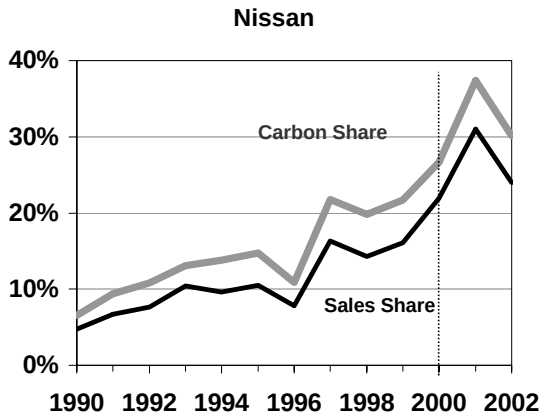










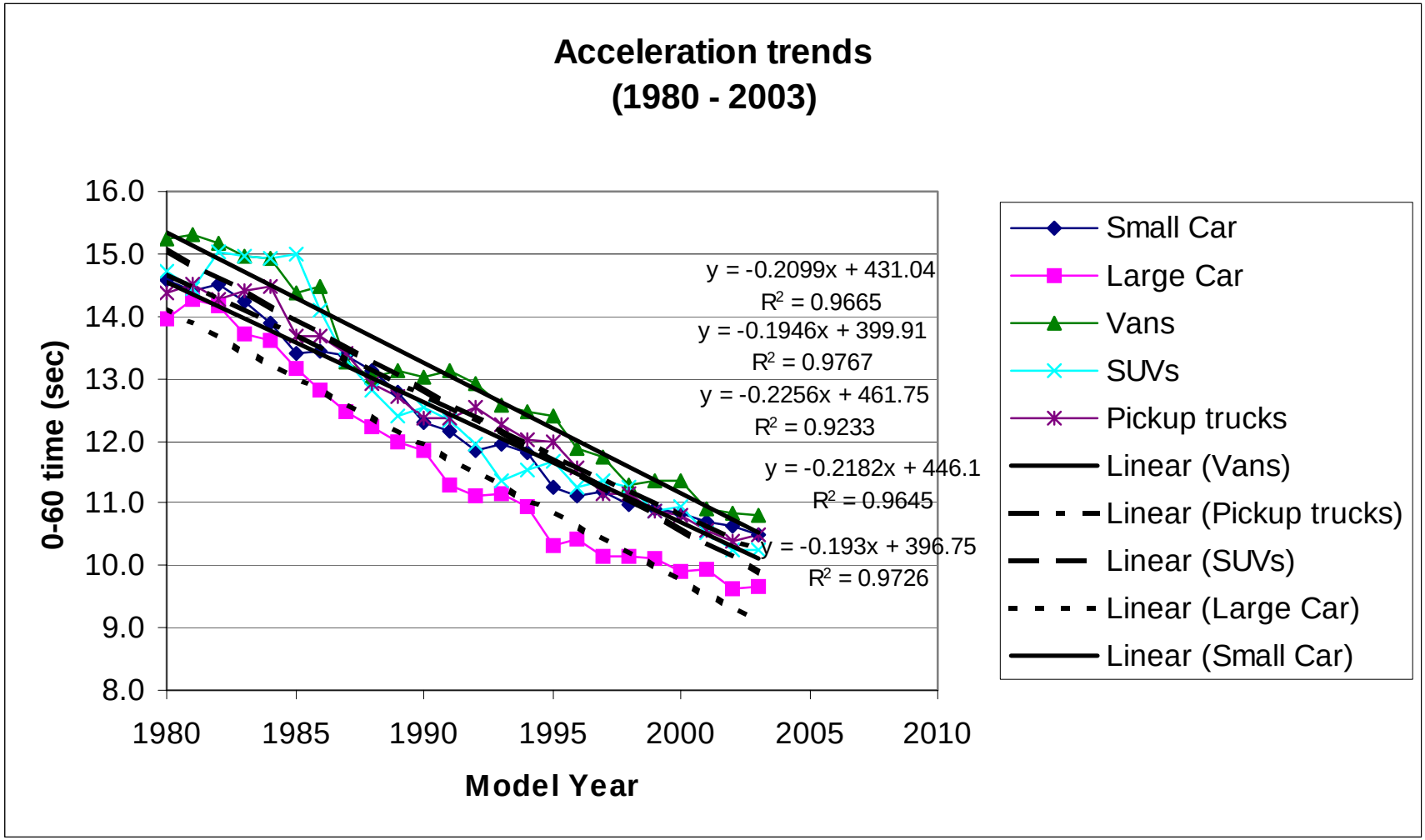


SUV market share of Big Five surged between 2000 to 2002

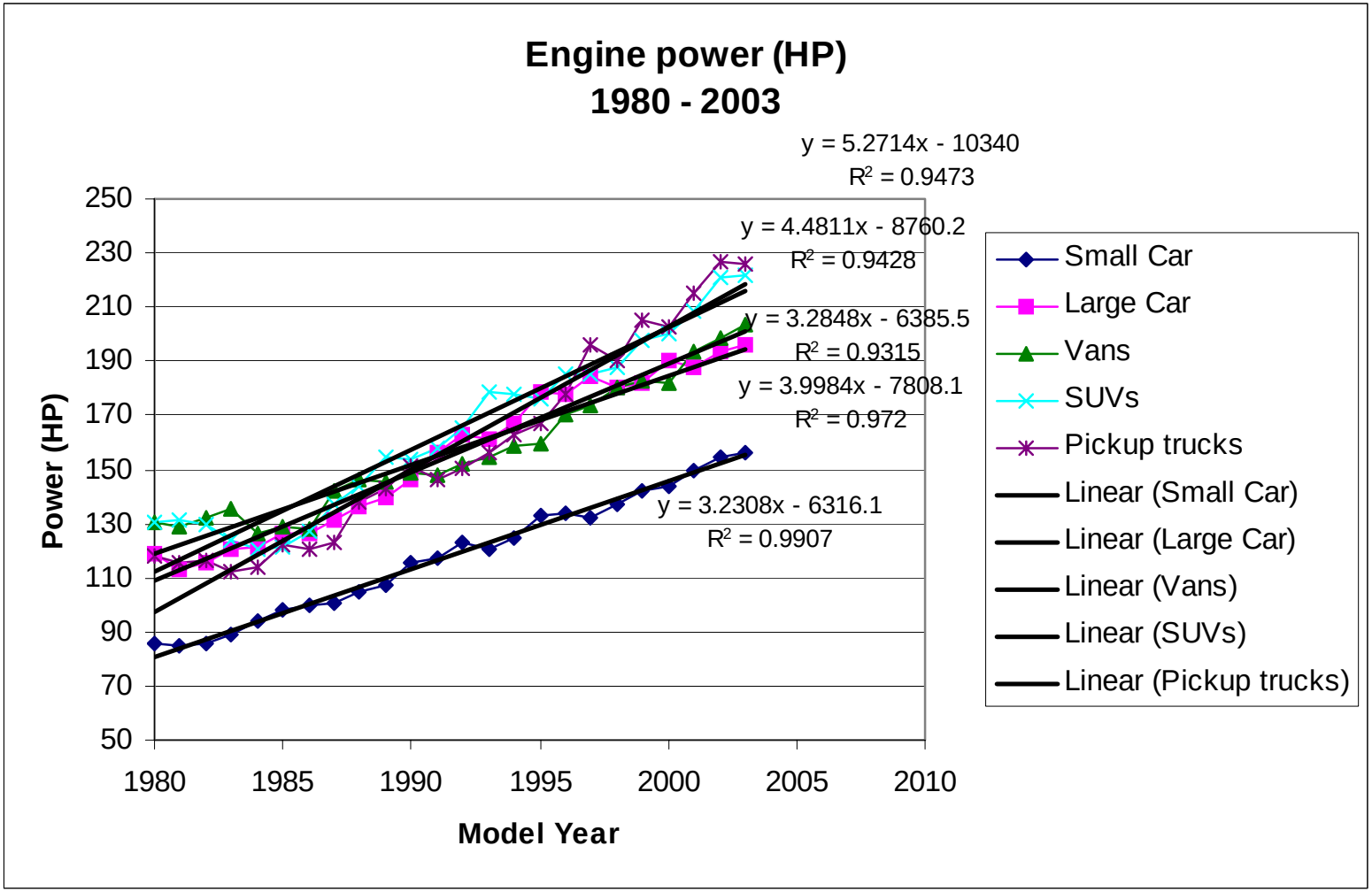
Technologies are not used to further improve vehicle fuel economy

- Technologies have become much more advanced since mid 1980s
- Many individual vehicle models are much more fuel-efficient than the average
- Great potentials exist to improve SUV's fuel economy
- Advanced technologies are emerging (hybrid electric-drive, PNGV super cars and fuel-cell vehicles)
- However, in today's market place, fuel-efficient technologies are used to increase engine power to boost performance

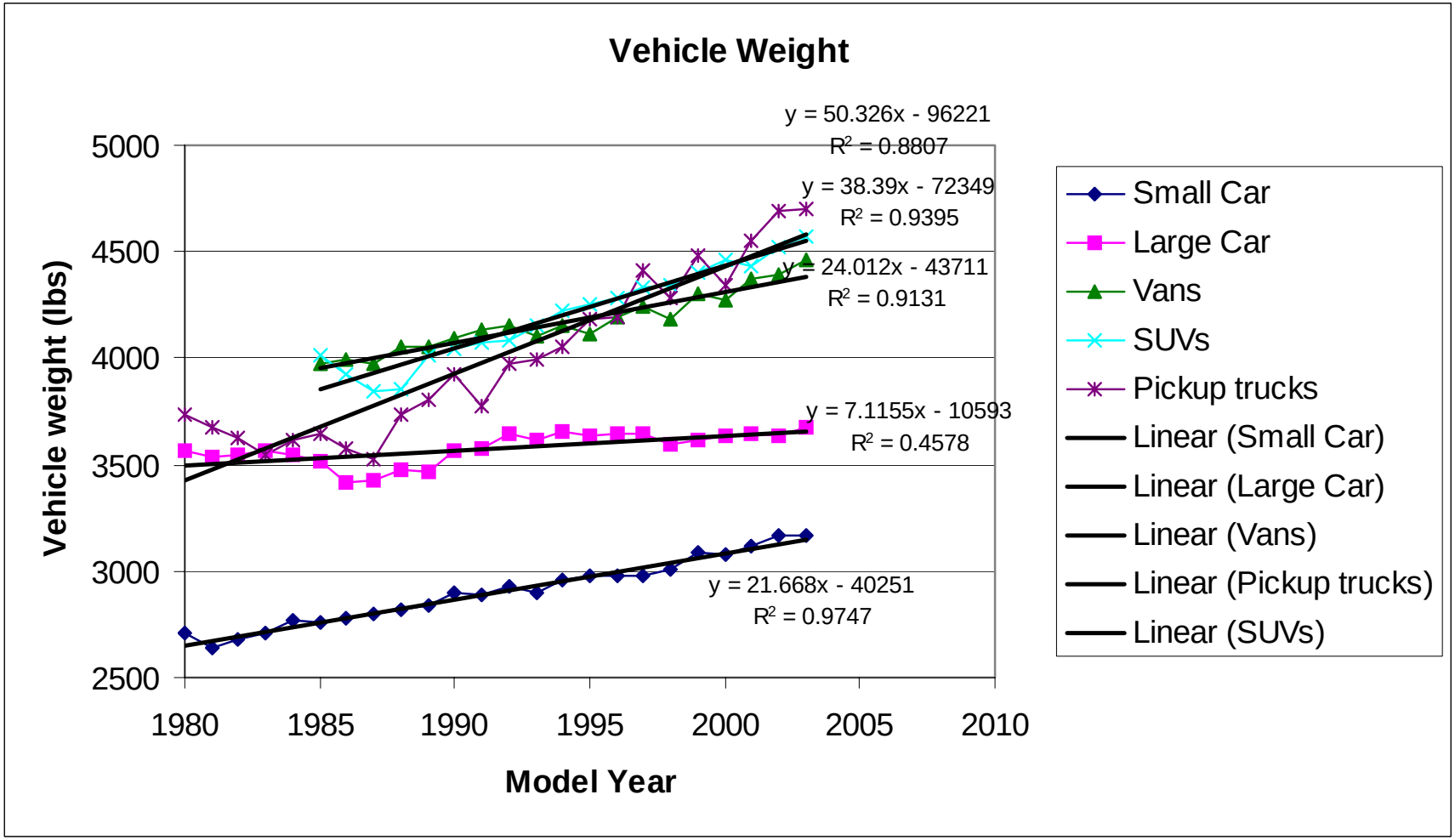
Vehicle 0-60 Acceleration Rate Continues to Drop at a rate of about 2 sec. per decade



… and no limit on engine power is in sight

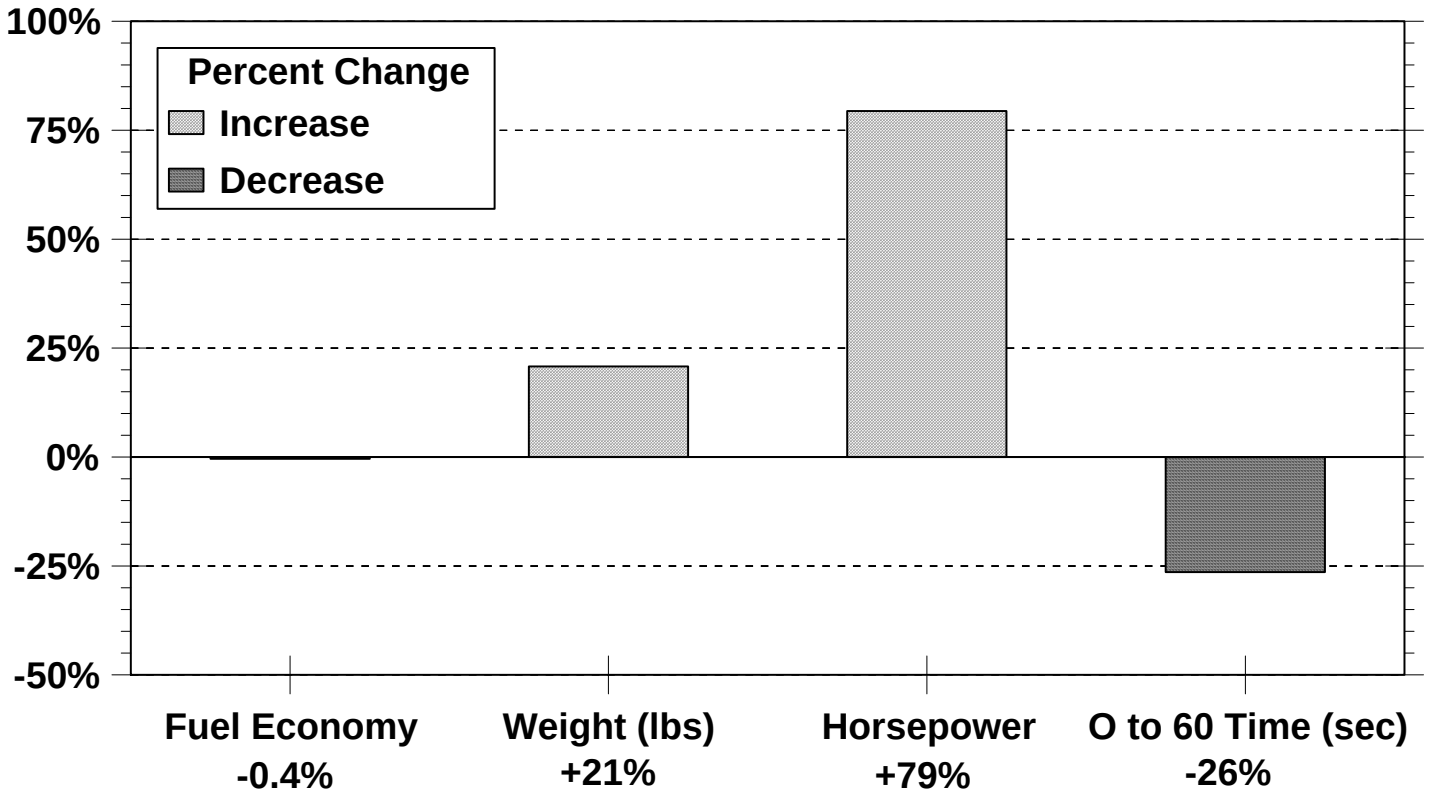


Vehicle Weight Continues to Increase



As results, Fuel Economy is Being Traded for Weight, Power and Performance for the US market

Percent Change from 1981 to 2000
in Average Vehicle Characteristics



US Gas Guzzler Tax

collected on the sale of new model year vehicles whose fuel economy fails to meet certain statutory levels. The gas guzzler tax applies only to cars (not trucks).

Unadjusted MPG	*GAS GUZZLER Tax ($)*
at least 22.5	No tax
at least 21.5, but less than 22.5	$1000
at least 20.5, but less than 21.5	$1300
at least 19.5, but less than 20.5	$1700
at least 18.5, but less than 19.5	$2100
at least 17.5, but less than 18.5	$2600
at least 16.5, but less than 17.5	$3000
at least 15.5, but less than 16.5	$3700
at least 14.5, but less than 15.5	$4500
at least 13.5, but less than 14.5	$5400
at least 12.5, but less than 13.5	$6400
less than 12.5	$7700

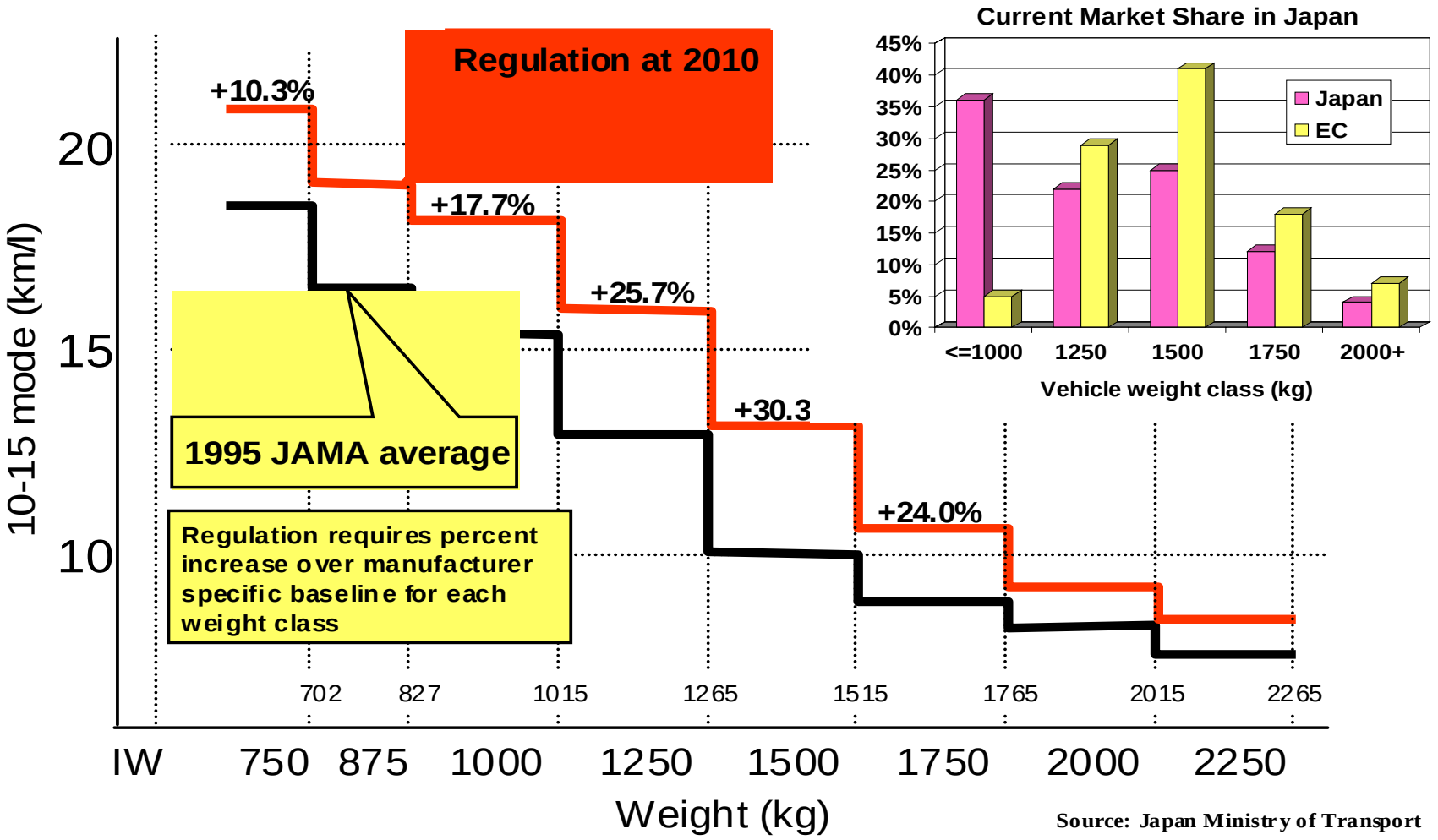
CAFE reform is a hot topics now

- Increase CAFE
  - To fleet average 40 MPG (from current 24 MPG)
  - Increase LDT CAFE to 21 mpg in 2005, 21.6 in 2006, and 22.2 in 2007
- Close CAFE SUV loopholes
  - Treat car-based SUVs as Cars
- Weight-based Formula
  - Set MPG target based on weight class
- Size-based Formula
  - Interior volume, wheelbase length, wheelbase * track width
- Uniform Percentage Increase
  - x% increase for all models, Penalizing leaders, rewarding laggers

California Climate Change Regulation AB1493

- To achieve the maximum feasible and cost-effective reduction of climate change emissions from cars and trucks in California
- Must be adopted by January 1, 2005, and may not take effect before Jan. 1, 2006, would apply to 2009 and later model year vehicles
- Strong support by new governor
- The regulation can not
  - Impose additional fees and taxes
  - Ban the sale of any vehicle categories such as SUVs and LDTs
  - Require reduction in vehicle weight
  - Limit or reduce speed limit
  - Limit or require reduction in vehicle miles traveled

New Japanese Fuel Economy Regulations



Source: Japan Ministry of Transport

Feng An

European Union Voluntary Commitment

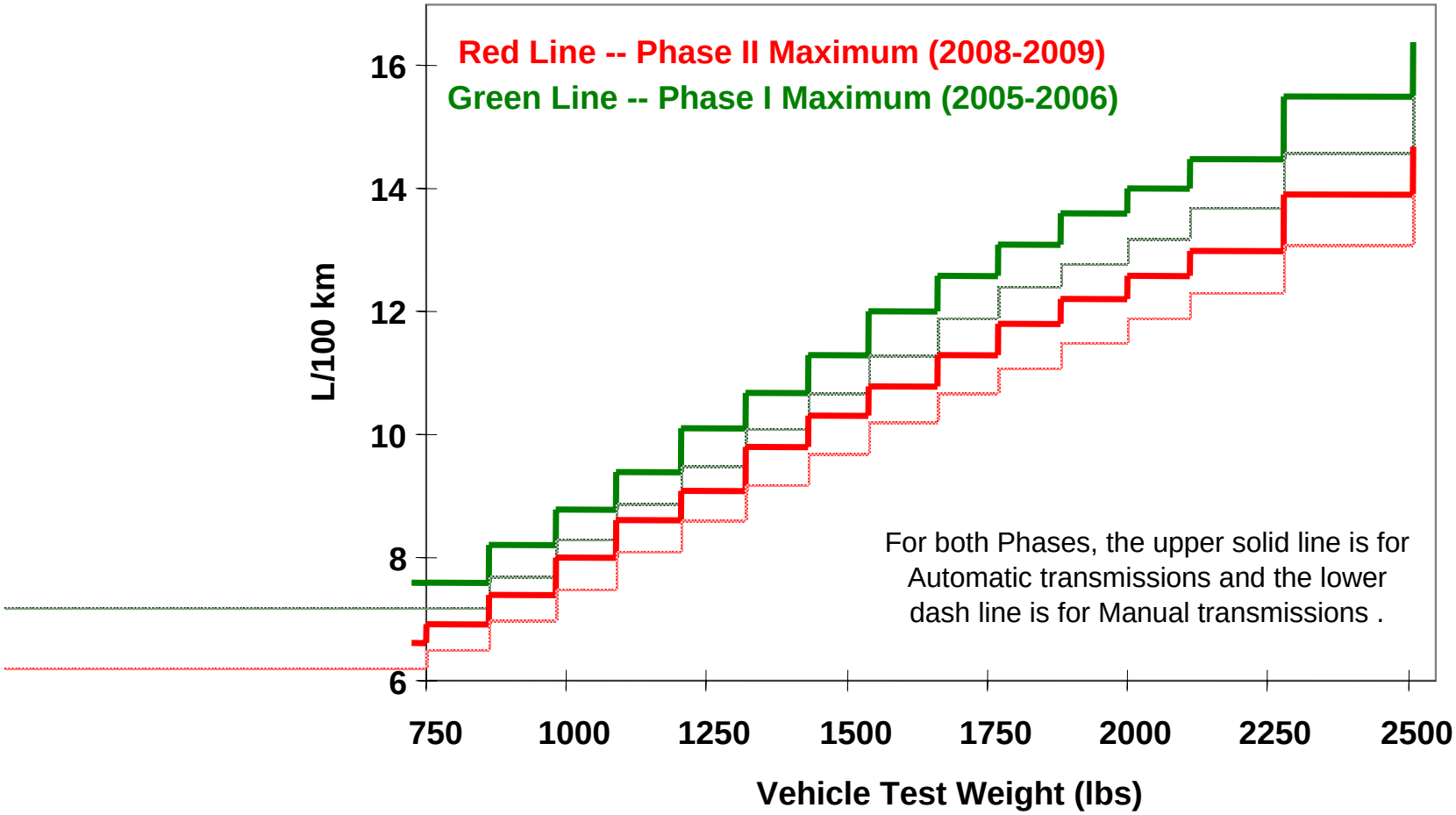
- 2012 Fleet target of 120 g CO_2/km
- 2008 Fleet target of 140 g CO_2/km (~41 mpg gasoline)
- 25% reduction from 1995 average of 187 g/km (~30 mpg)
- collective target, not target for each company
- Contingent on:
  - 2005 clean fuels availability (30 ppm S)
  - Protection against unfair competition
  - Regulatory cease-fire
  - Unhampered diffusion of technologies
  - Escape hatch for “detrimental” effects

Highlights of Chinese Motor Vehicle Fuel Consumption Standards

- M1 and M1G type vehicles (EU classification), including passenger cars, SUVs and MPVs less than 9 seats
- Two separate sets of standard for:
  - passenger cars with manual transmission
  - passenger cars with automatic transmission, SUVs and MPVs with 3+ rows (all transmission types)
- Weight-based, 16 classes (based on EU emission wt. categories)
- Based on European Test Cycle (NEDC)
- Liters/100 km
- Maximum fuel consumption level for individual vehicle models within each wt. class, instead of average value associated with each wt. class

China Light-duty Vehicle Fuel Consumption Standards

	New models	Continued models
Phase I	7/1/2005	1/1/2006
Phase II	7/1/2008	1/1/2009



An ACEEE Study to Assess Technical Options to Improve Vehicle Fuel Economy in Short- to Mid- Term

- **Technical potential for car and light truck fuel economy improvements by 2010–15**
- **Cost Effectiveness**
- **Fleet-wide Impacts**

Methodologies used in the study

- Choose baseline vehicles from five vehicle classes
  - Small cars (GM Cavalier, *changed to Focus for an updated UCS study*)
  - Midsize cars (Ford Taurus, *changed to Camry for updated study*)
  - Sport Utility vehicle (SUV, Ford Explorer)
  - Minivan(Dodge Caravan)
  - Pickup truck (GM Silverado)
- Four technology packages:
  - Moderate
  - Advanced
  - Mild Hybrid
  - Full Hybrid
- Use a vehicle system simulation model, the Modal Energy and Emissions Model (MEEM)

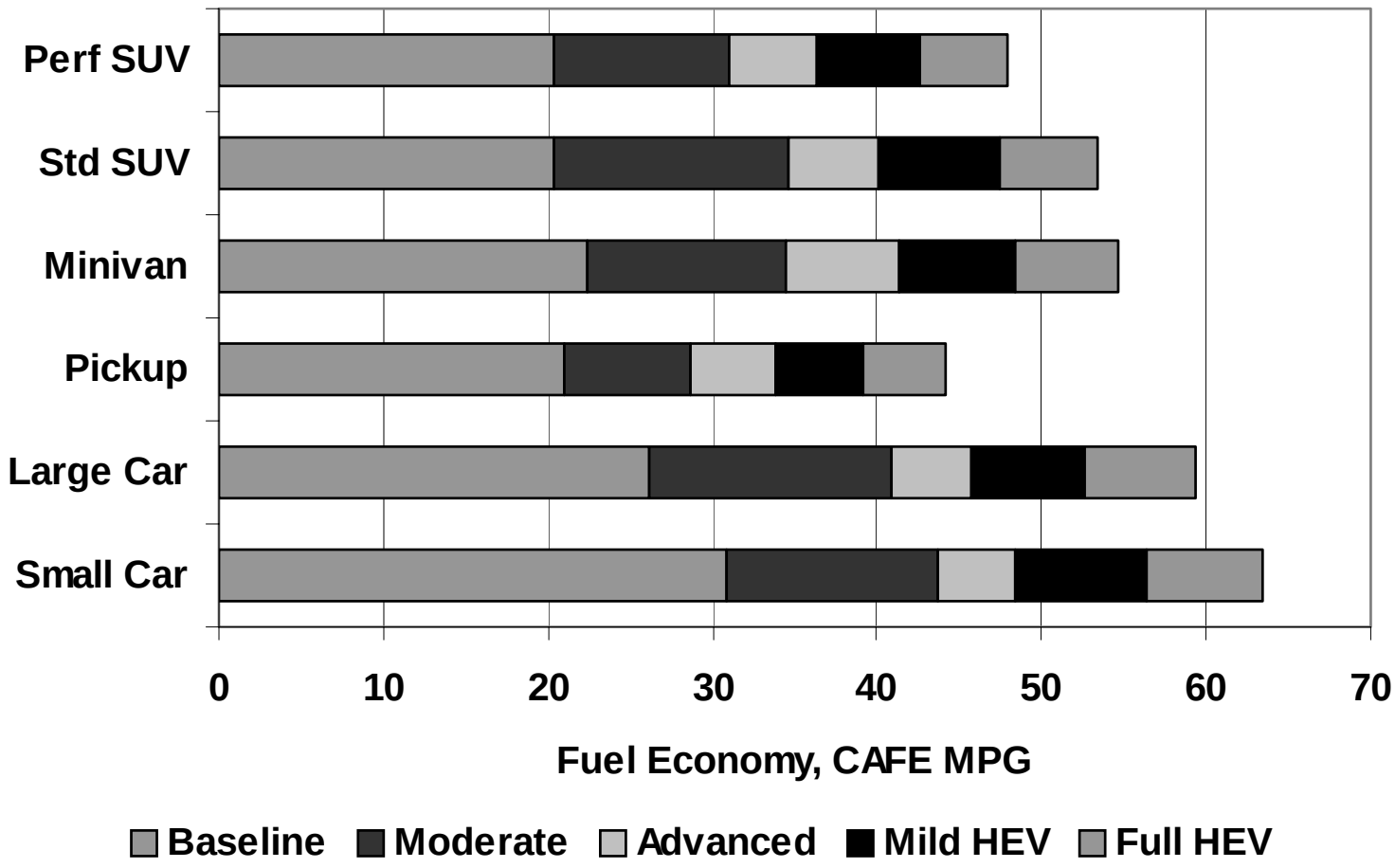
Moderate Package

- Streamlining, lower tire rolling resistance, and more efficient accessories
- High-efficiency, lightweight, low-friction, gasoline engine (Honda VTEC-like)
- Integrated starter-generator with 42-volt system and engine start/stop capability
- Improved transmissions: CVT for cars, 5-speed automatics for light trucks *(changed to 6-speed for updated study)*
- Mass Reduction Lowest for Cars, Highest for Trucks
  - 0% for Small Cars
  - 10% for Midsize Cars
  - 20% for Trucks

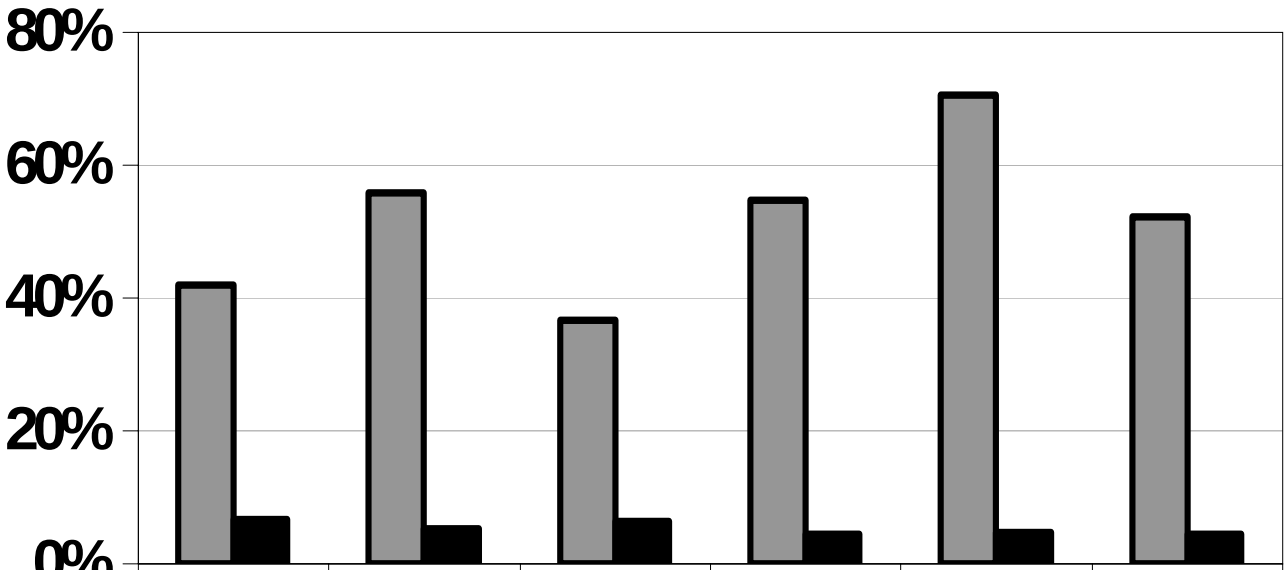
Modeling Results Show that Fuel Economy Gains Range from 37-70% by Vehicle Class for the Moderate Package. Even Greater Potential for More Advanced Technology Packages

Vehicle	Fuel Economy (MPG) and Improvements over Baseline *(%)*								
	Baseline	Moderate		Advanced		Mild HEV		Full HEV	
Small car	30.8	43.7	*42%*	48.4	*57%*	56.3	*83%*	63.5	*106%*
Midsize car	26.2	40.8	*56%*	45.8	*75%*	52.6	*101%*	59.3	*126%*
Full size pickup	21.0	28.7	*37%*	33.8	*61%*	39.2	*86%*	44.2	*110%*
Minivan	22.3	34.5	*55%*	41.3	*85%*	48.4	*117%*	54.6	*145%*
Standard SUV	20.3	34.6	*70%*	40.1	*98%*	47.4	*133%*	53.4	*163%*
Performance SUV	20.4	31.0	*52%*	36.3	*78%*	42.5	*109%*	48.0	*135%*

Summary of Fuel Economy Estimates by Vehicle Type and Technology Package

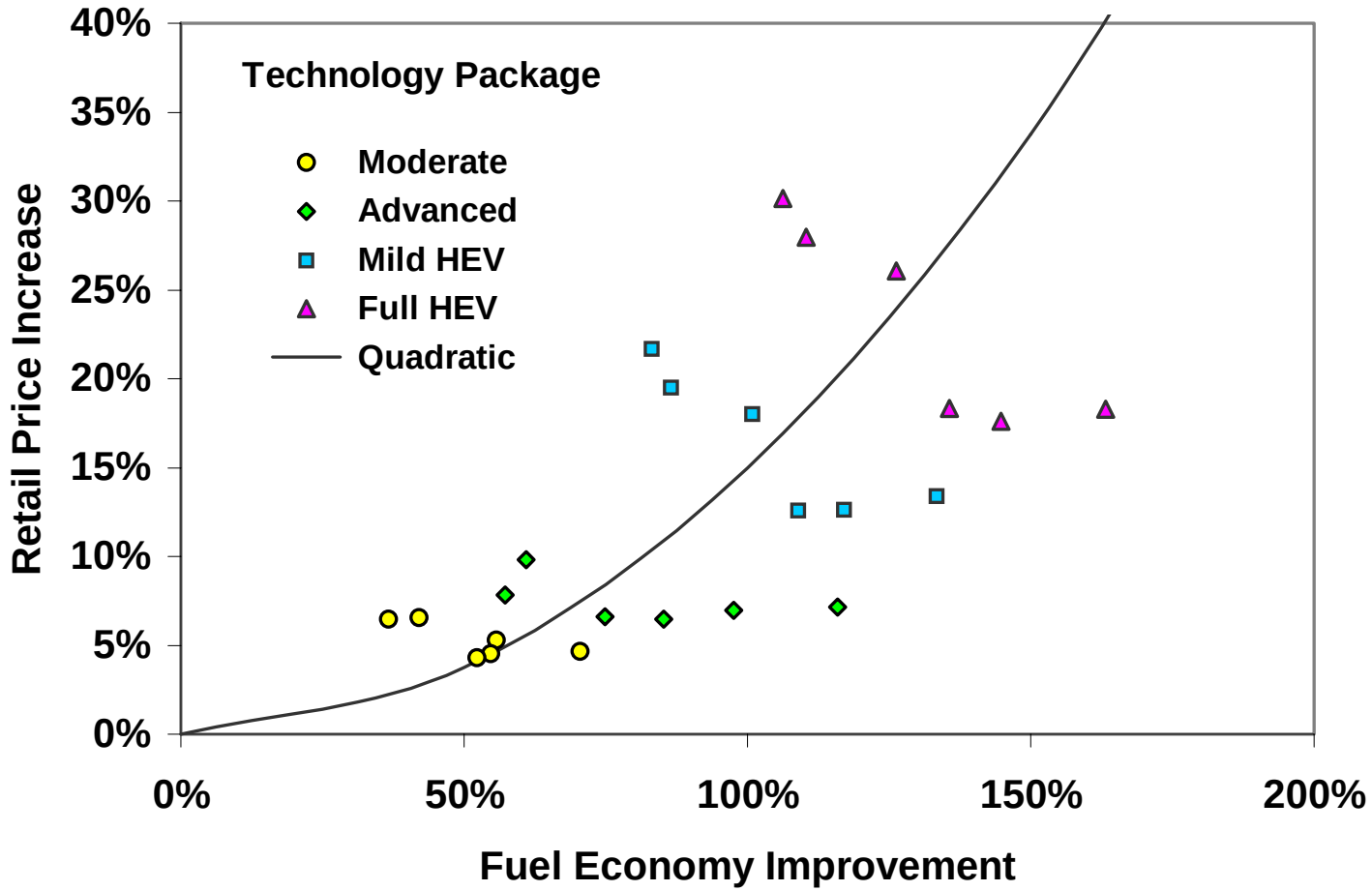


Retail Price Impacts of Implementing Moderate Technology Package Amount to 4%-7%

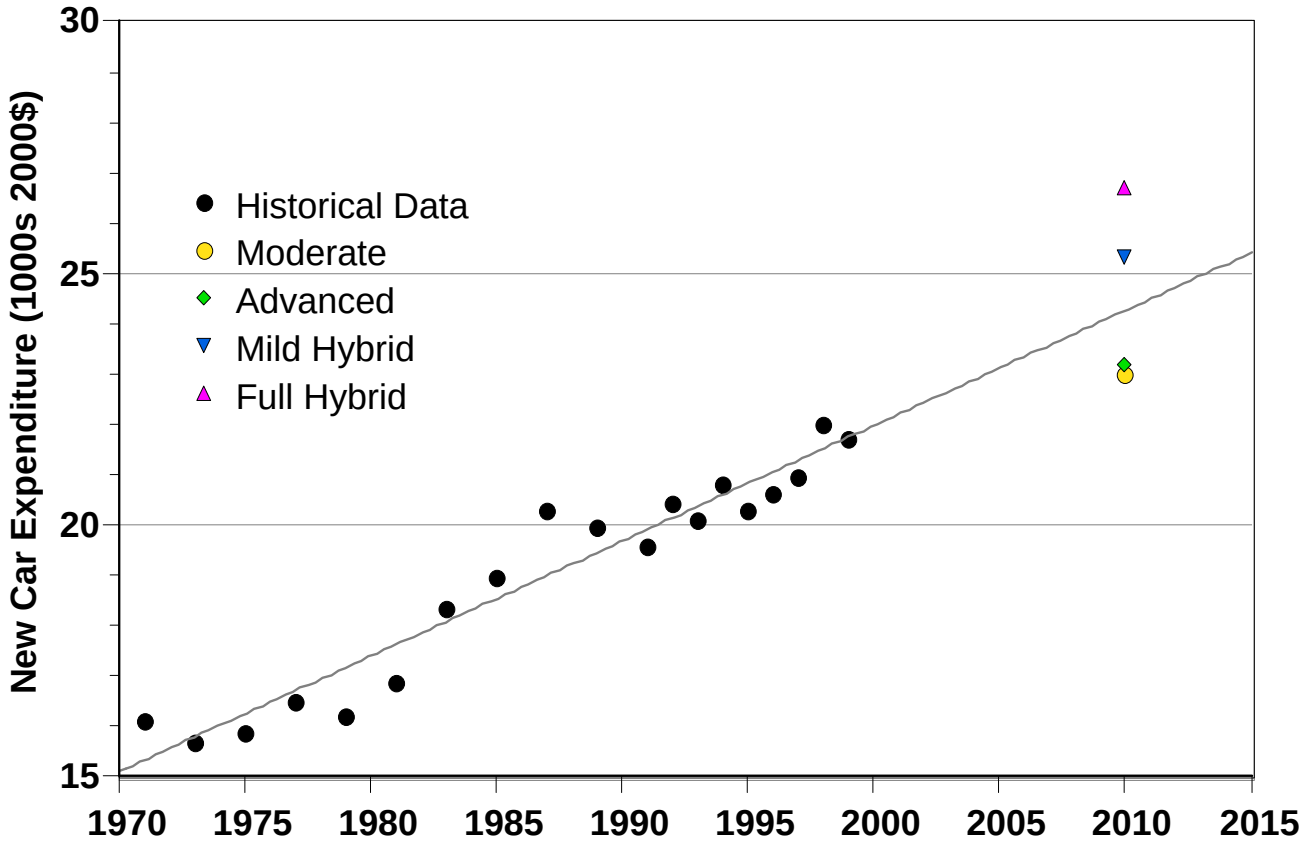


	Small Car	Midsize Car	Full-Size Pickup	Minivan	Standard SUV	Perform-ance SUV
MPG increase	42%	56%	37%	55%	70%	52%
Price increase	6.6%	5.3%	6.5%	4.5%	4.7%	4.3%

Retail Prices Increase as Fuel Economy Gains Increase

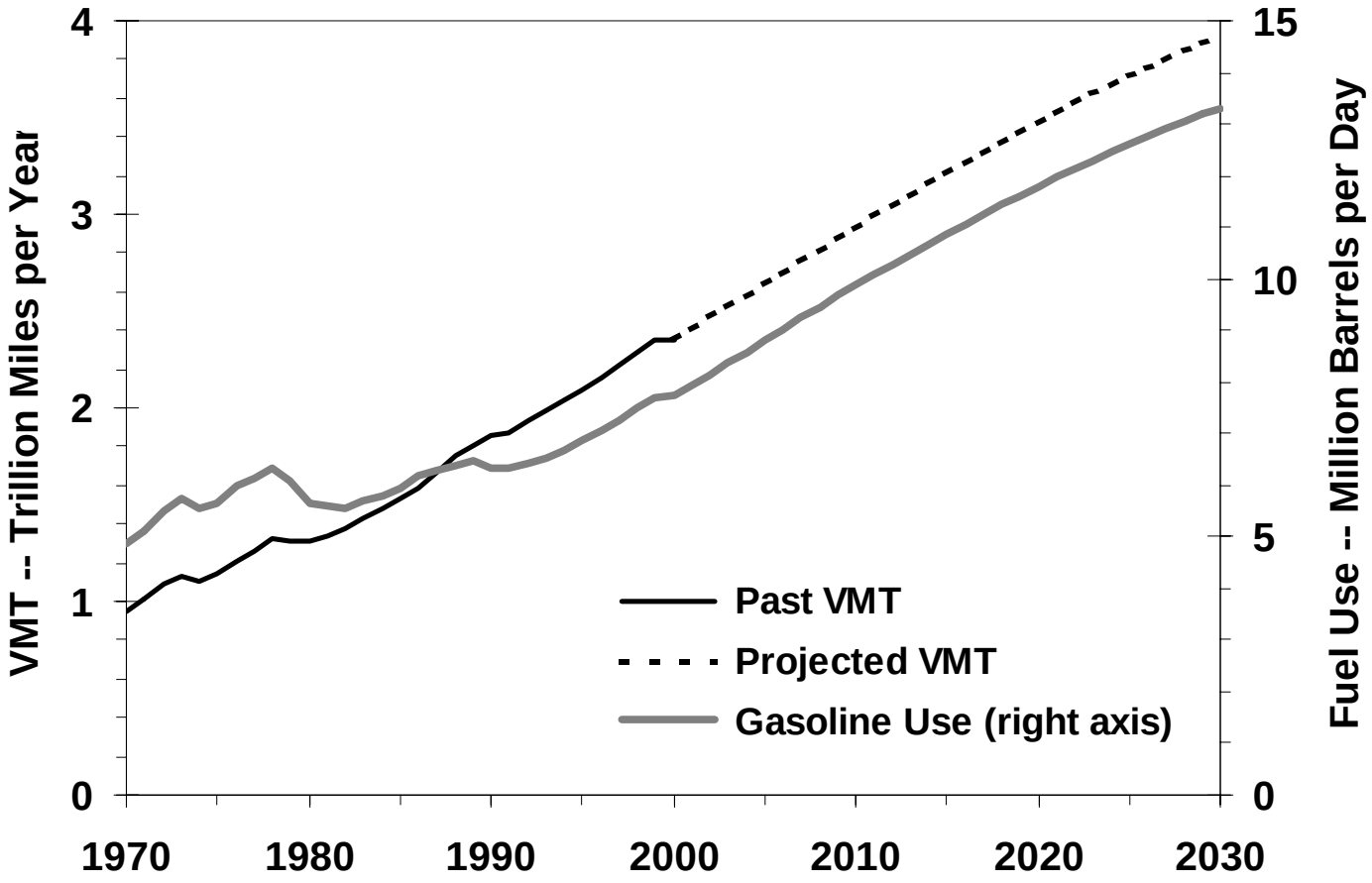


However, Price Increases for Moderate and Advanced Packages are within Historical Car Price Trends

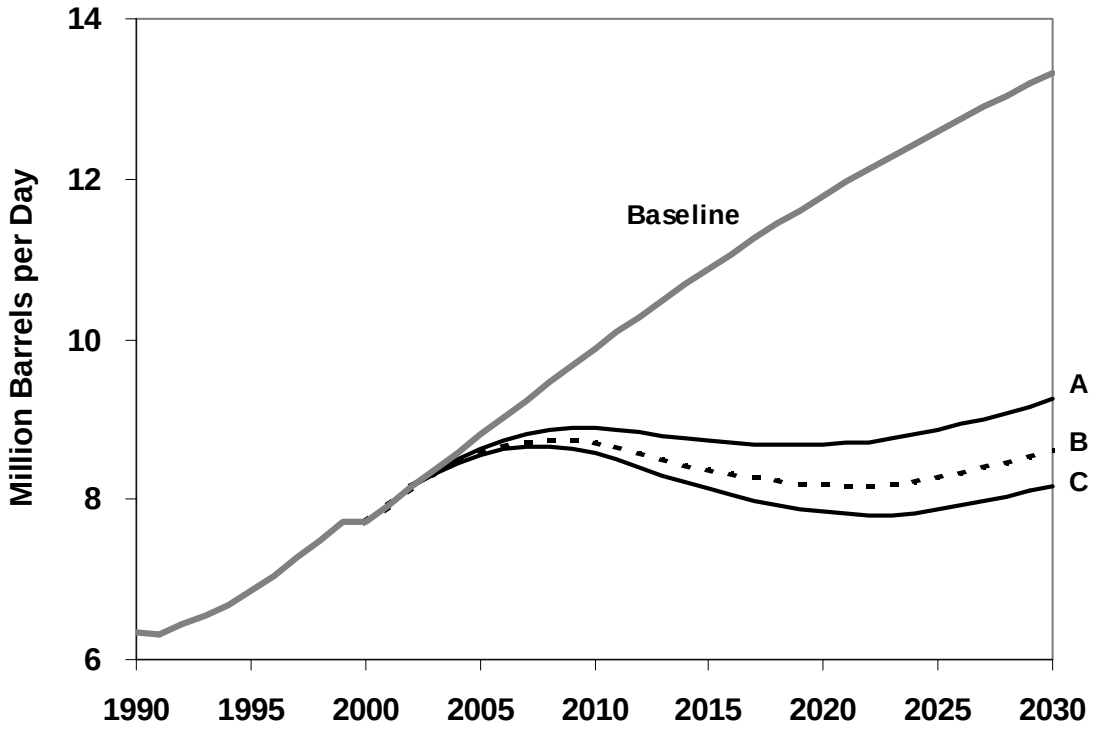


Source: Historical statistics from Ward's inflated to 2000$; trend fit is: Price (2000$) = $15,130 + ($229/yr)(Year - 1970)

Past and Projected Nationwide Light Duty VMT and Fuel Use



U.S. Light Vehicle Fuel Consumption by Technology Scenario



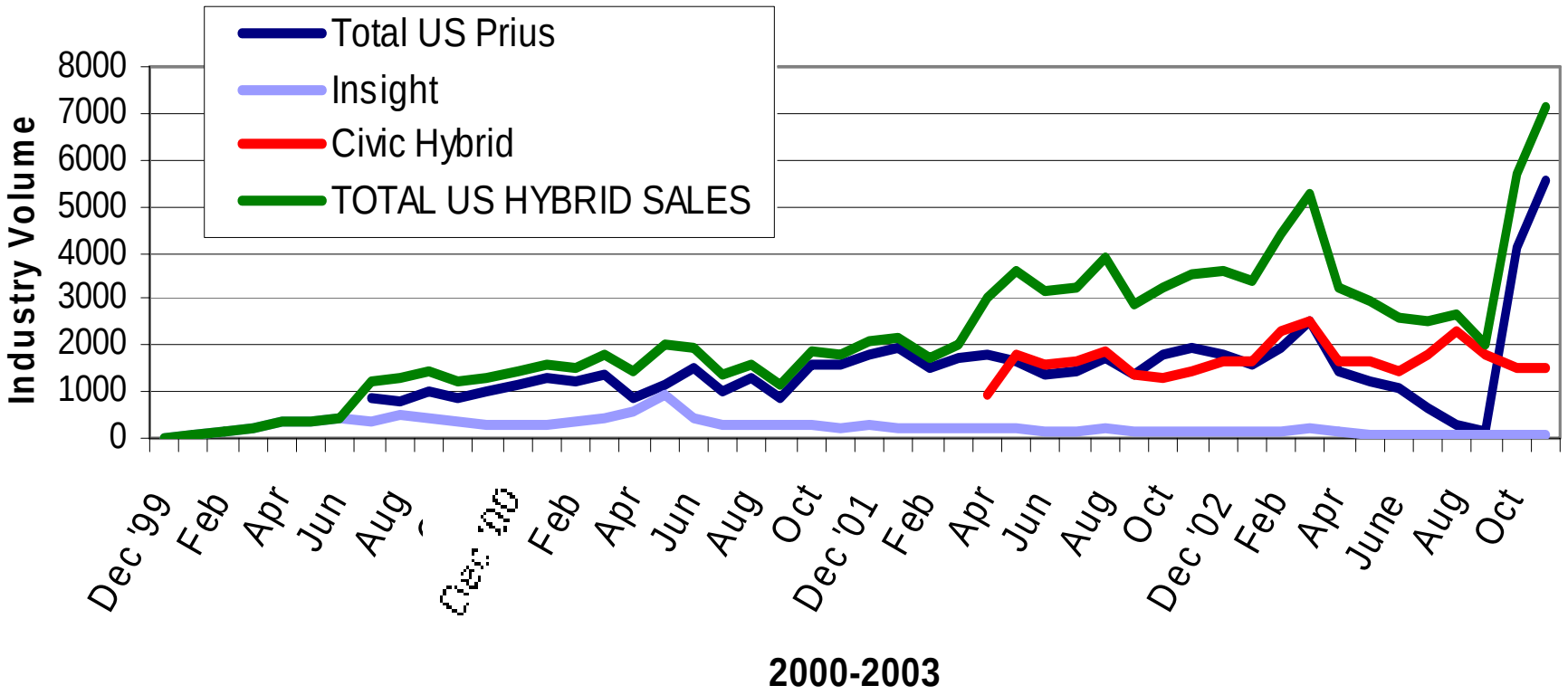
Fleet fractions by technology level	*A*	*B*	*C*
Moderate	98%	47%	0
Advanced	0	47%	98%
Average Hybrid	2%	6%	2%

Commercial Hybrid Electric Vehicles (HEVs) in US Market

Prius $20,510, 65 MPG

Civic Hybrid $19,650, 57 MPG

US Hybrid Sales History

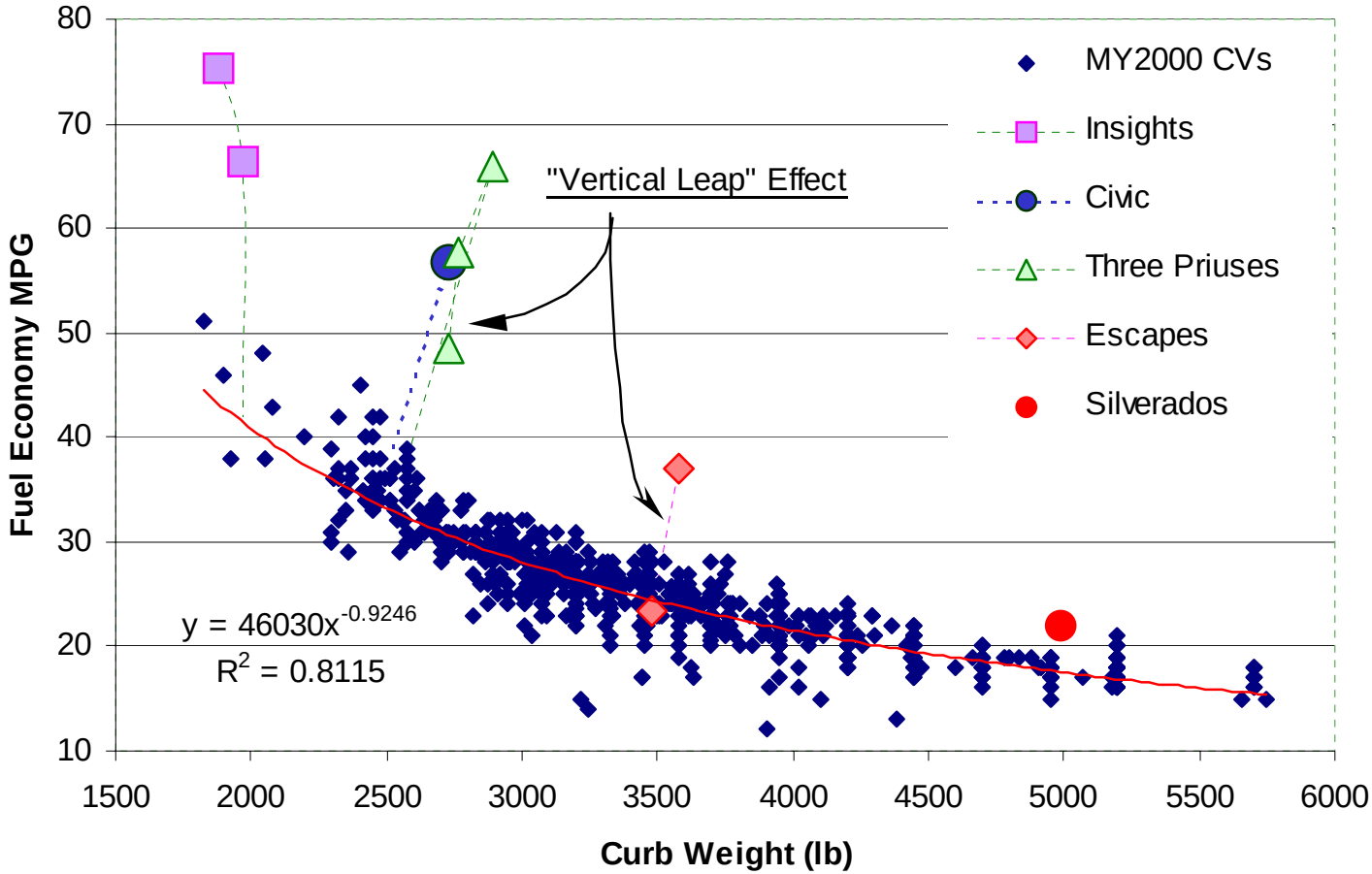


Total US Hybrid Sales 2004 CYTD:

Prius – 65,865, Insight – 11,921, Civic – 35,354

Total – 117,431 (source: Toyota)

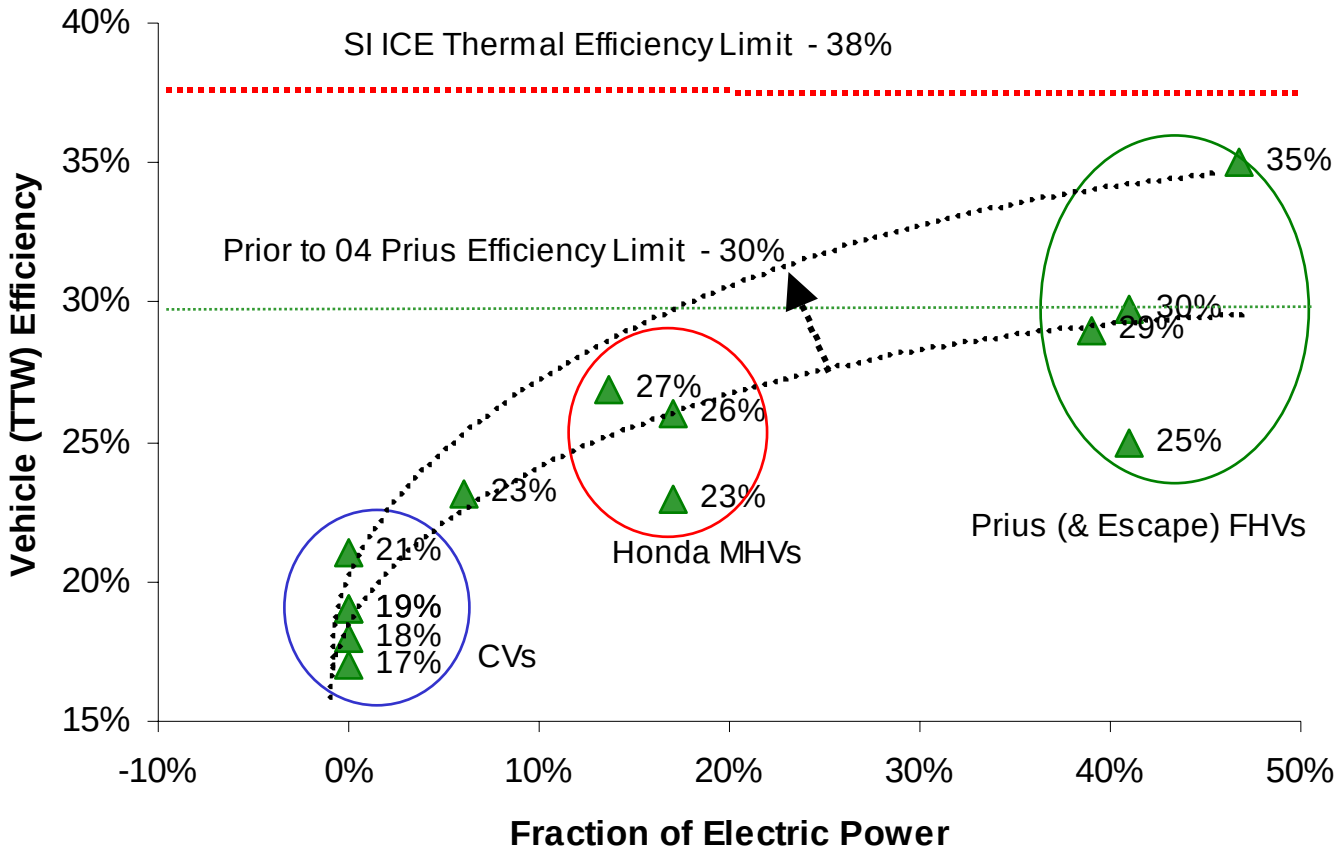
Hybrid Electric Vehicles Show Great Improvements in Fuel Economy



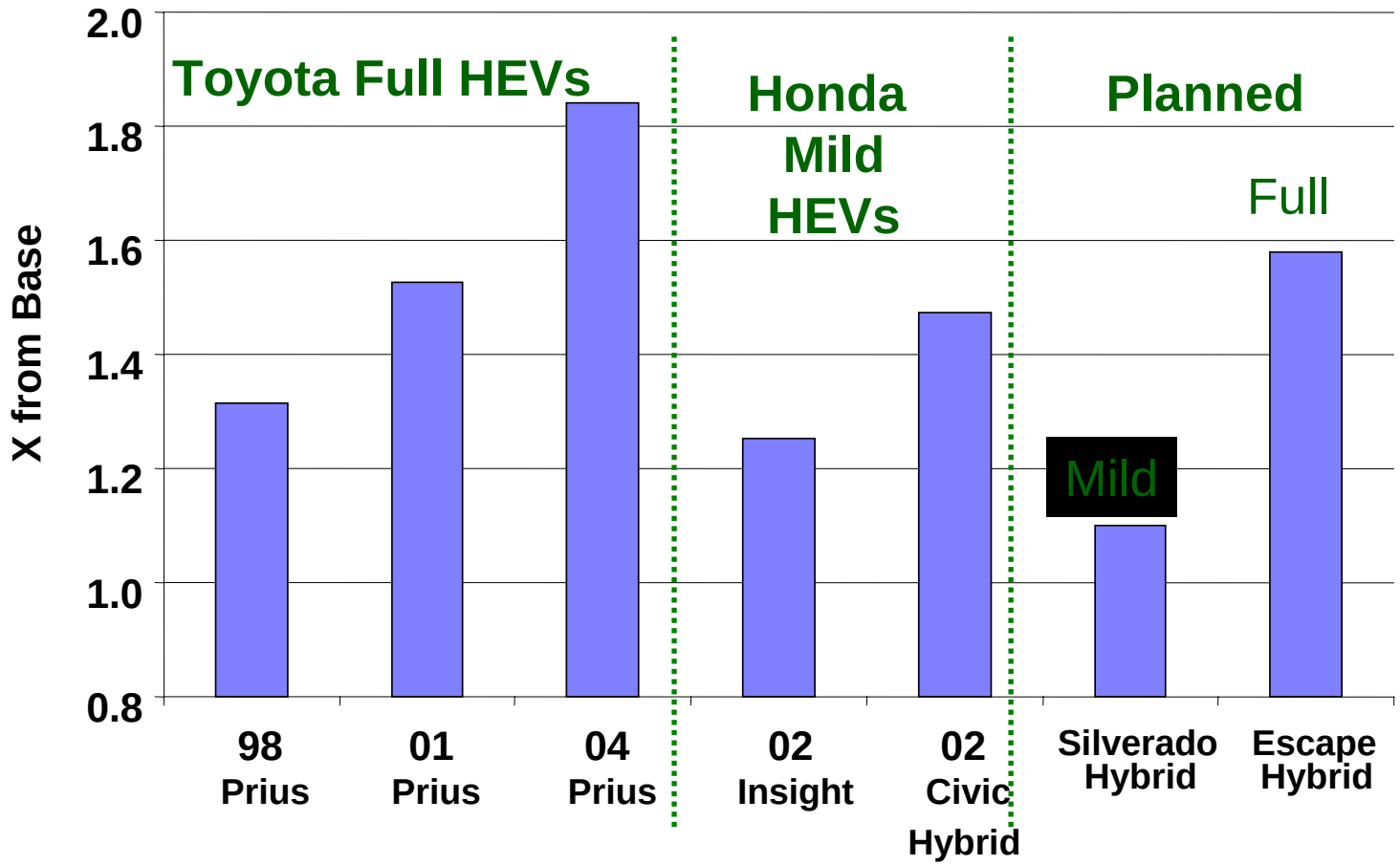
MPG of Hybrids vs. All MY 2000 Conventional LDVs, by Curb Weight

Vehicle Efficiencies vs. Fraction of Electric Power (Peak Motor Power)

– Hybrid Efficiency is positively correlated with fraction of electric power



Toyota & Honda Show Improvements in HEV Efficiencies for Multiple Generations



Estimated "Comparable Glider" CAFE Efficiency Multipliers for 7 HEVs

Conclusions

- CAFE nearly doubled vehicle fuel economy between 1975 and 1985
- However, CAFE stagnation and loopholes stalled the FE progress in the last 20 years
- New actions are under way to combat auto energy and emission problems
- Many studies demonstrated a capability to affordably improve average U.S. car and light truck fuel economy by 50%–70% over the coming decade.
- The technology packages would add 6%–8% to average vehicle price, but the fuel economy increases are cost effective if viewed from a societal perspective over a vehicle lifetime
- Hybrid electric drive technologies show great market and fuel saving potentials.