

**Small Line Diesel Engines  
as a Winning Commercial  
and Regulatory Strategy**

*Prepared for:  
10<sup>th</sup> Annual Auto Outlook  
Symposium*

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## Premise of this paper.

### Background:

**US OEMs have reinvigorated their large (V6) diesel engine development efforts for SUV and truck applications as the promise of advanced NO<sub>x</sub> and particulate emissions control success grows.**

### Argument:

**The US OEMs should pursue small line diesels as winning CAFE, CO<sub>2</sub> and market share strategies.**

# Performance is the essential driver in the European diesel phenomenon.

## European Scenario

**Europe has embraced small diesel engines: over 50% of the market by 2010.**

- What started as an efficiency-based value proposition has transformed into a performance-driven one
- Market has been re-oriented toward low-end torque
- Diesel defines fun-to-drive (60-100 km/h) and gas is playing catch-up

**NO<sub>x</sub> and particulate standards have been more lenient in Europe, but Euro 5 standards are likely to “equalize” gas and diesel.**

- CO<sub>2</sub> supplants NO<sub>x</sub> as societal issue
- Gap to US Tier II will narrow, but still exist
- Very significant confluence of interests to make small diesels work (OEM, suppliers, environmental ministries, consumer groups)

**Small diesels have established critical scale.**

- Cost gap/price gap is narrowing
- Focused R&D efforts (Europe and Japan)
- OEM internal economics and supplier economics (fuel system, turbos, aftertreatment)

# Current US diesel development is not maximizing the existing European infrastructure.

## US Scenario

### Demand for V8 diesel engines has exceeded forecasts.

- Driven by low-end torque, not fuel efficiency
- Work-vehicles or where towing is high on customer needs
  - *In Class 2-3 pickups, diesels outsell large V8/V10 gas engines 2.5:1*
- High option price (\$5K) readily paid in this market segment/high resale
- Enhanced fuel efficiency would be plus for truck CAFE but a large percentage of this segment is over 8,500 GVW

### US manufacturers are looking at other V6 diesel scenarios (revived).

- Large SUVs and large trucks where high option price is achievable
- Some OEMs will source these engines from MD/HD suppliers (merchant or captive)
- But the Tier II emissionized cost delta on these engines represents a very significant hurdle

# US manufacturers should pursue small diesels in an optimized CAFE strategy.

## Fuel economy leadership in small cars and small trucks is vital.

- 2 standards. Unknown whether both will continue or be merged
- Shared platforms
- Small car + medium/small SUV + small PU = 44% of US market
- Large SUV and large PU = 18% of US market
- Applying a high cost solution (low manufacturing scale) in relatively few vehicles (high option price) in relatively small market segments is not a viable CAFE strategy

## Observations on Big 3 positioning in key segments:

- Small car and small SUV fuel efficiency is trailing Japanese
- Market share in small car is poor; small SUV segment increasingly crowded
- Historic efforts to compete on performance (HP) over fuel economy appear unsuccessful
  - *Optional engine penetration in small vehicles is ~ 40%\**
- US vehicle characteristics isolated vs. EU and Japan (is this tenable long term?)

\*Small trucks, small SUVs, small and midsize non-luxury vehicles

## Summary of key issues.

### **Given small diesel emission control execution is viable:**

- Impact on fleet average emissions can mirror the CAFE strategy
- High mileage segment of market has/will pay diesel premium

### **Exceptionally high diesel residuals exist in Europe and US.**

- Exceptionally low hybrid residuals in both regions
- Used diesel market in Europe supported by Eastern Europe
  - *Same true in US with Mexico*

### **Competitive activity is building:**

- 2005 Liberty with 2.8L Mercedes diesel
- 2005 Grand Cherokee with 3.0L Mercedes diesel
- 2004 E-Class diesel
- 2004 Passat 2.0L diesel
- Toyota Avensis with DPNR system has passed EPA Bin 5

### **Critical to establish diesel as a preferred technology path in US.**

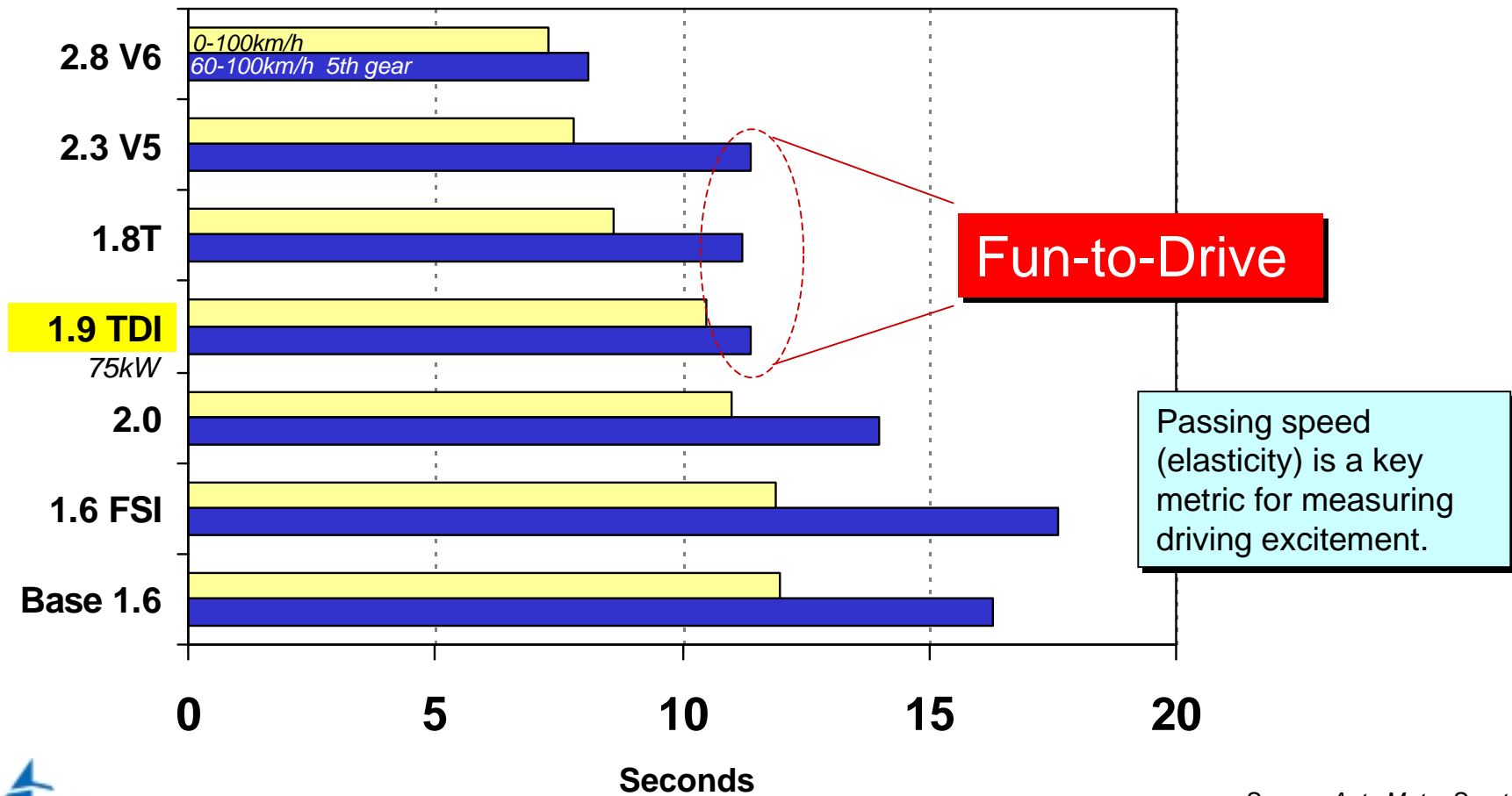
- Hybrids do not appear to be the preferred path
- Move before enviros/legislatures build more diesel/ICE barriers

# European Diesel Phenomenon

The European market has been re-oriented toward low-end torque performance.

EU

European Golf Acceleration Comparison



Fun-to-Drive

Passing speed (elasticity) is a key metric for measuring driving excitement.



Source: Auto Motor Sport

# The European New Diesel buyer values performance above fuel efficiency.

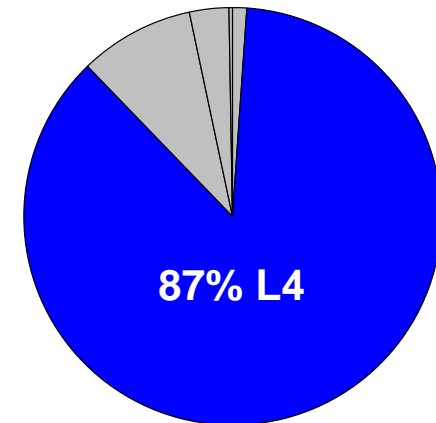
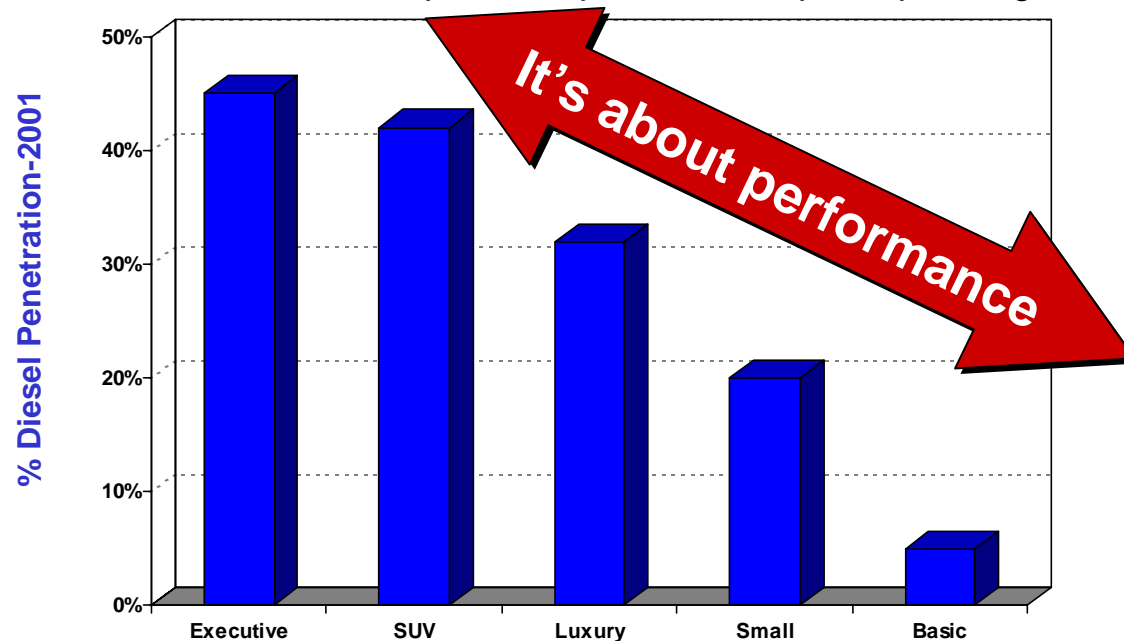
EU

## Critical Concepts of EU Diesel Market

The target EU buyer is poised to pay for a premium engine . . . .

. . . *but which one?*

- The diesel offers premium performance plus operating savings and superior residual value



**5.1M Diesel Units**

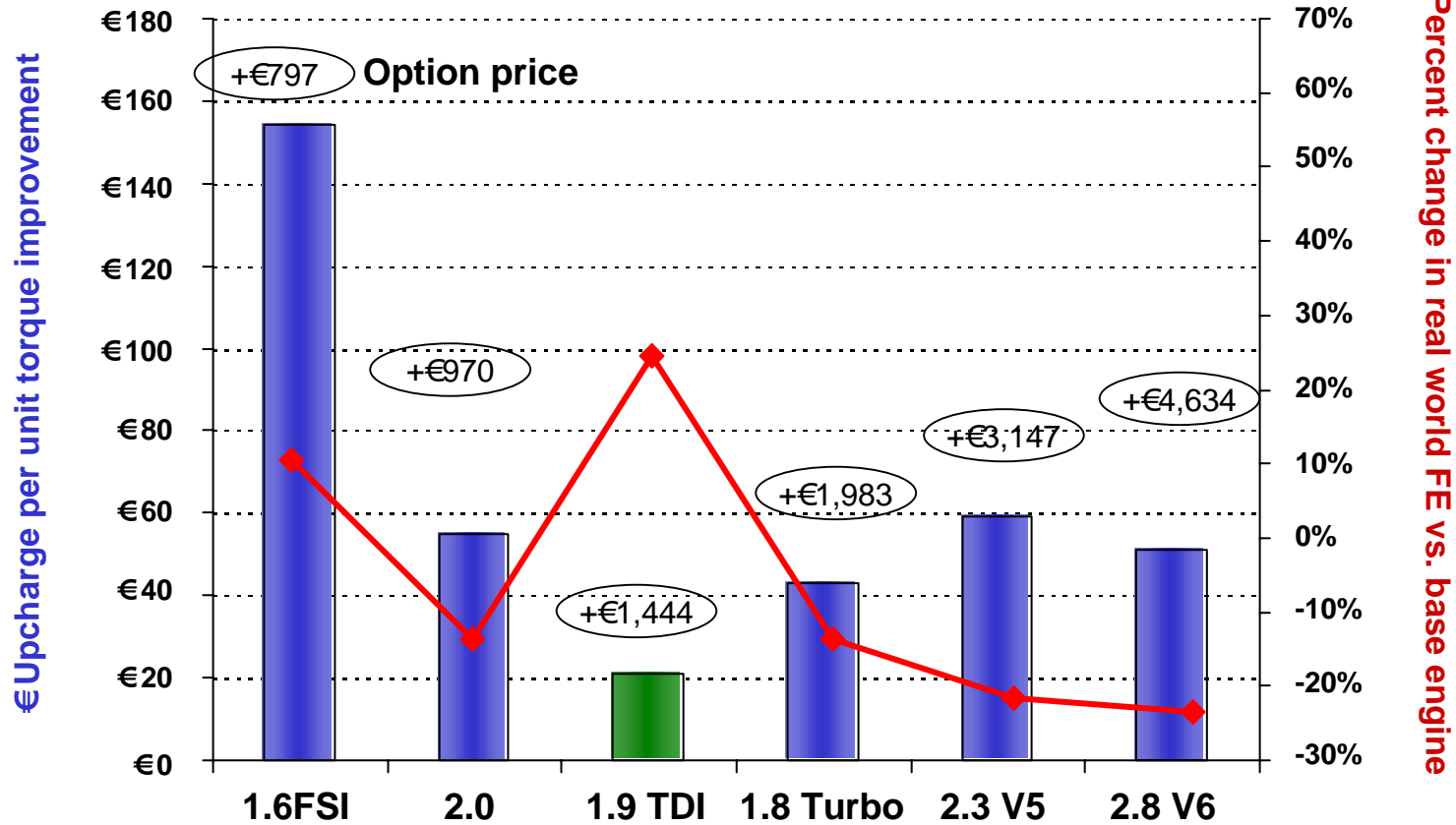
The rational EU buyer who values ownership cost above performance continues to select the base gasoline engine.

- Fuel savings do not offset the cost of the diesel option
- Used car market (economical buyers) supports this concept through high residuals on base gas engines

VW's EU diesel option price per unit of torque improvement is half that in the US; GDI is not priced attractively.

EU

VW Diesel Pricing Strategy vs. 1.6L Base



Unit torque gain → +5/5% 114lbft, +18/16% 127lbft, +68/62% 177lbft, +44/42% 155lbft, +53/49% 162lbft, +90/82% 199lbft

Based on 2002 Golf Highline retail upcharge vs. 1.6L base engine with 5-speed manual transmission.  
EU 1.9TDI = 75kW

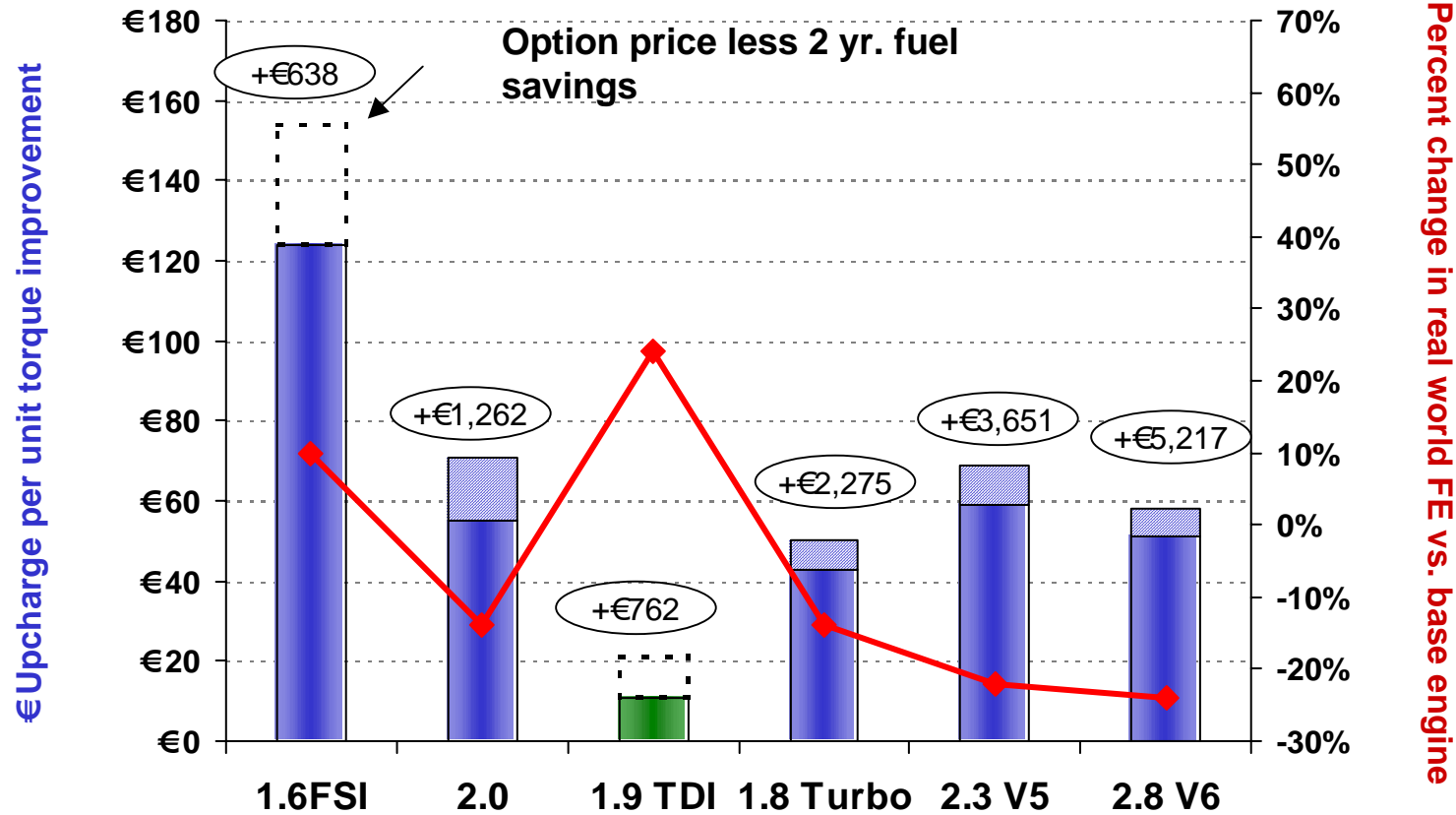
Source: Martec analysis, Auto Motor Sport



The EU driver, enjoying premium performance, pays back his diesel option in 4.2 years.

EU

VW Diesel Pricing Strategy vs. 1.6L Base



Unit torque gain	1.6FSI	2.0	1.9 TDI	1.8 Turbo	2.3 V5	2.8 V6
→	+5/5%	+18/16%	+68/62%	+44/42%	+53/49%	+90/82%
	114lbft	127lbft	177lbft	155lbft	162lbft	199lbft

Based on 2002 Golf Highline retail upcharge vs. 1.6L base engine with 5-speed manual transmission. Fuel savings based on 12,000 annual km and EU average pump prices for 8/2002.

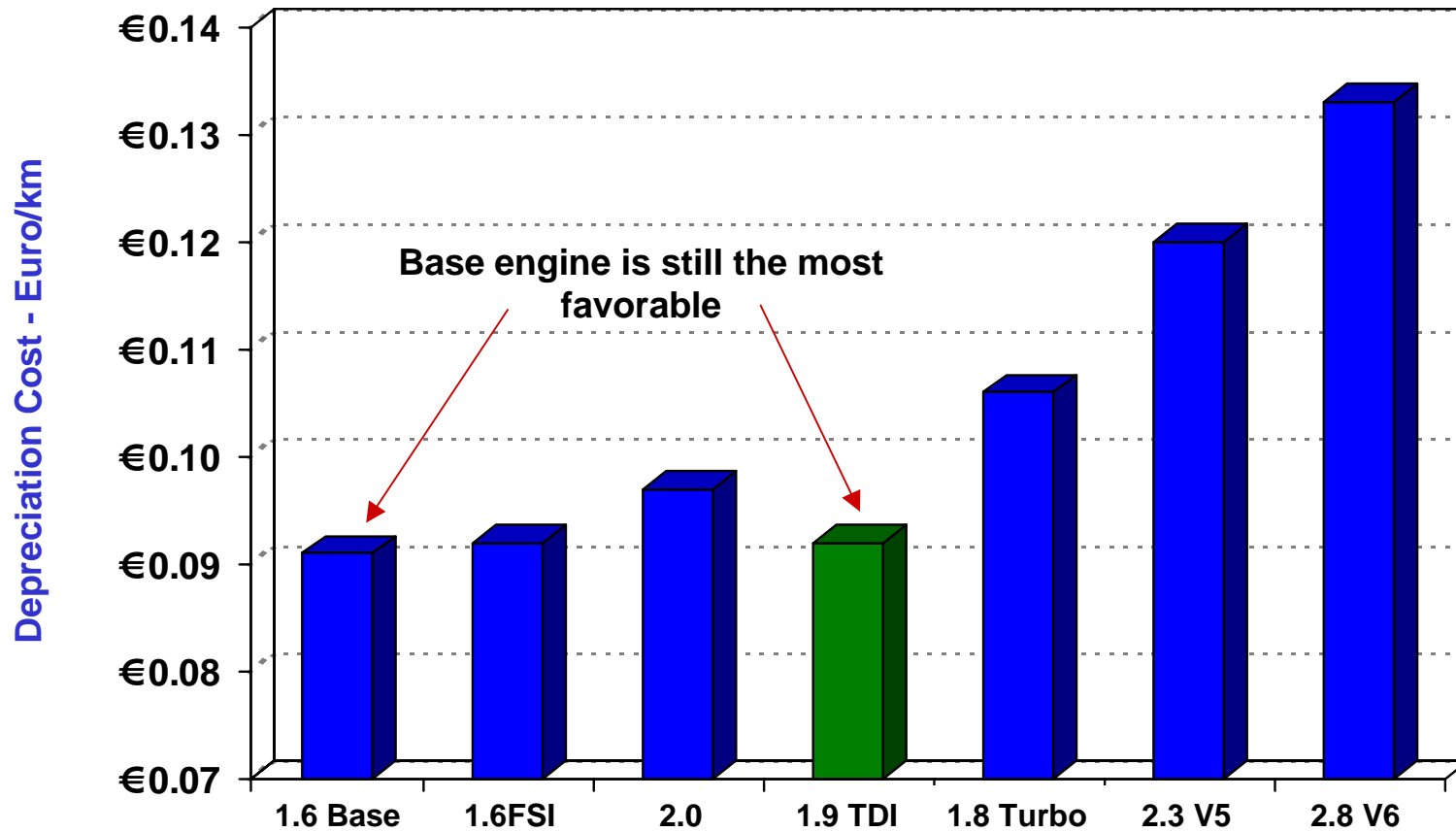
Source: Martec analysis, Auto Motor Sport



# The European diesel buyer is rewarded with high residual values: base engine depreciation/km still most favorable.

EU

VW Golf Depreciation After 3 years/54,000 km



Percent residual value	59%	61%	59%	62%	58%	55%	54%
Share of optional engines sold	-	1%	17%	65%	9%	6%	2%

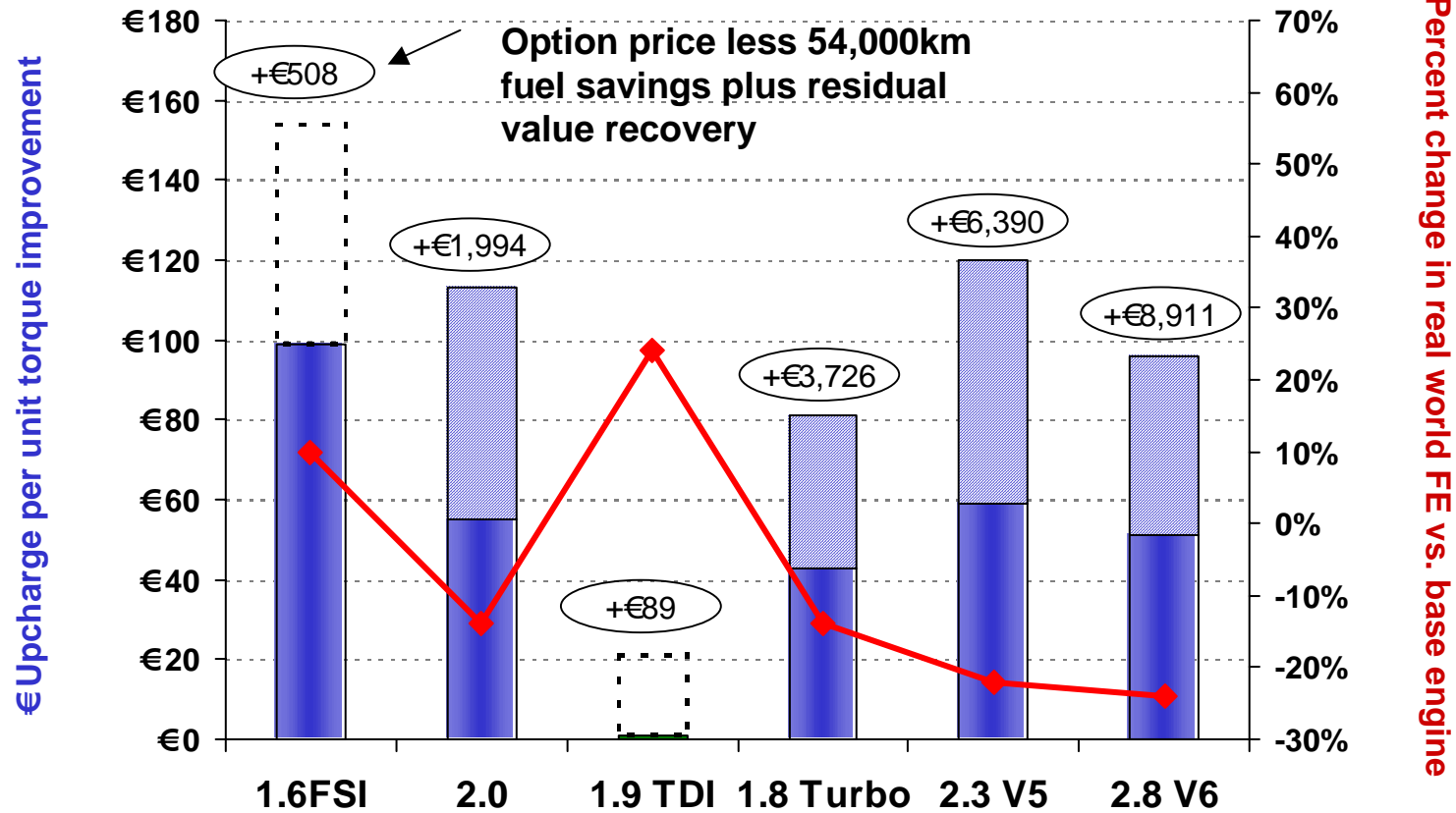
Based on 2002 Golf Highline retail prices ex-VAT. 2.8L V6 features, including 4WD, equalized to base Highline content. Residual value data available at 3 years/54,000km. Optional engine share includes 3 kW levels of 1.9 TDI engines.



After 3 years/54,000km, the effective diesel option price is ~€100.

EU

### VW Diesel Pricing Strategy vs. 1.6L Base



Unit torque gain → +5/5% 114lbft, +18/16% 127lbft, +68/62% 177lbft, +44/42% 155lbft, +53/49% 162lbft, +90/82% 199lbft

Source: Martec analysis, Auto Motor Sport



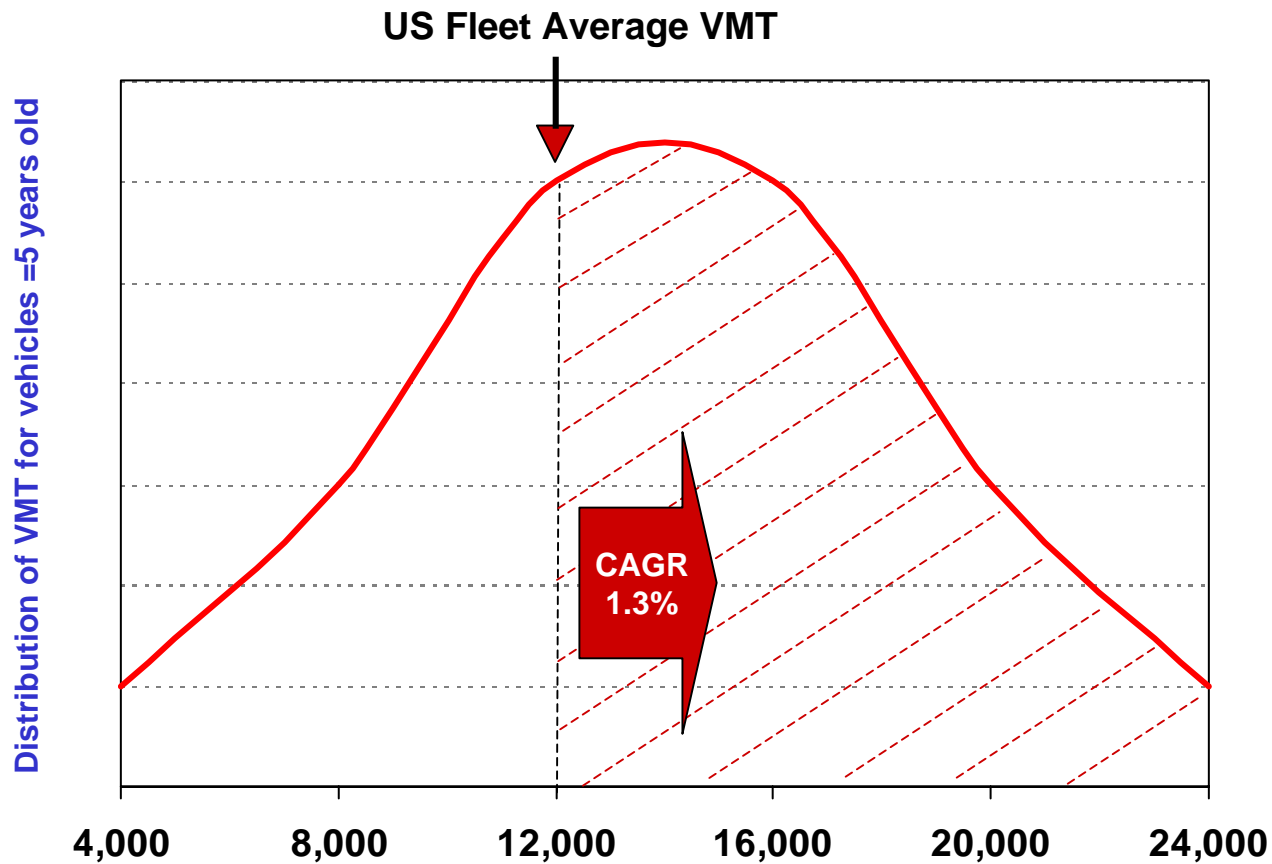
Based on 2002 Golf Highline retail upcharge vs. 1.6L base engine with 5-speed manual transmission. Fuel savings based on 54,000 km to match 3 year/54,000km available data and EU average pump prices for 8/2002.

# Small Diesel Strategy For North America

The high VMT buyer is a strong candidate for premium performance + extreme fuel economy.

North America

US VMT Distribution



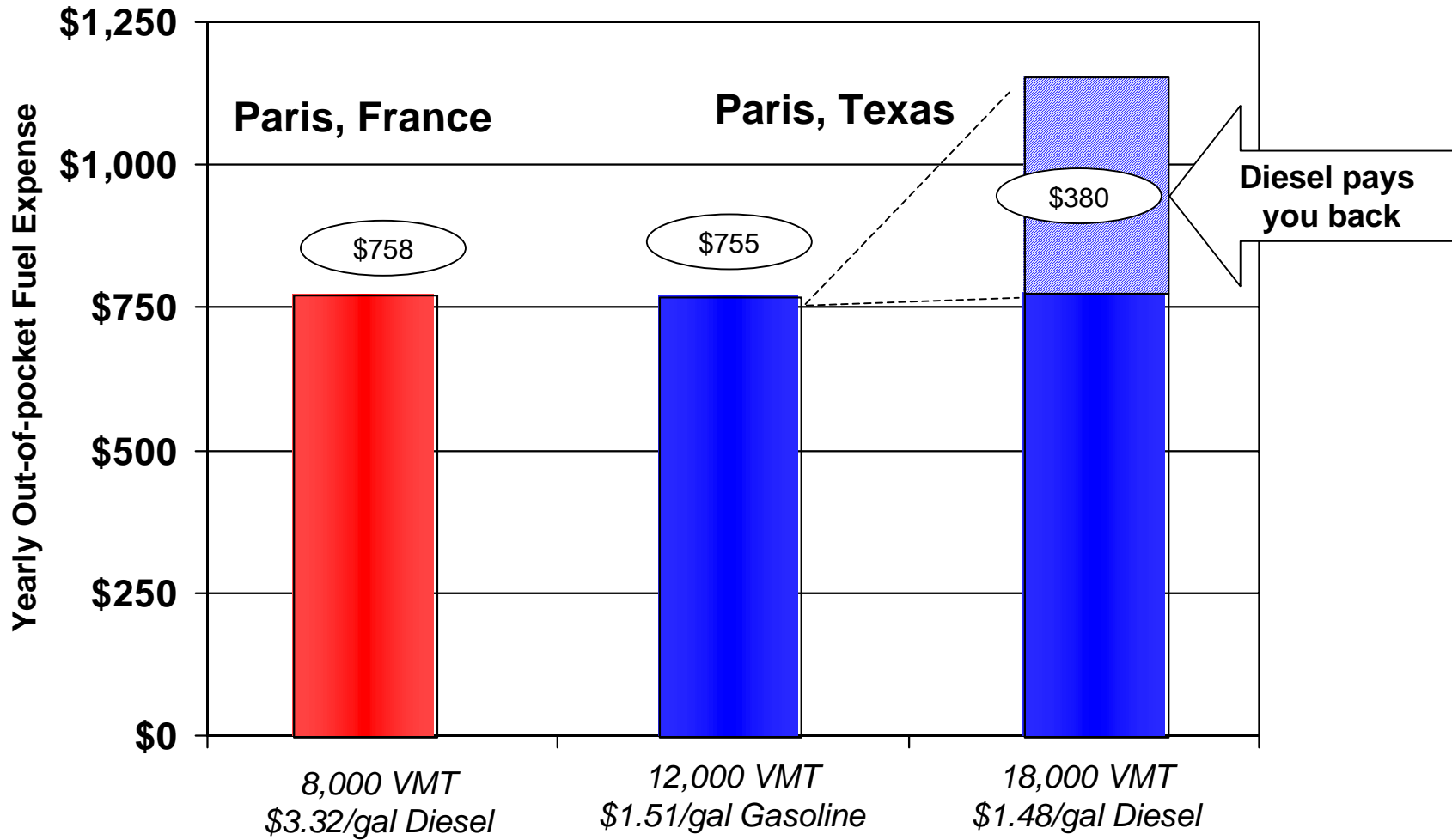
Diesel time savings vs. V6				
Fill-ups per month	1.5	2.0	2.4	2.9

Based on 2002 Jetta 1.9L TDI vs. 2.8L V6 engine with 5-speed manual transmission.



# “Diesels? Not with gas at \$1.50.”

North America



Note: Fuel price: DOE 5/5/03

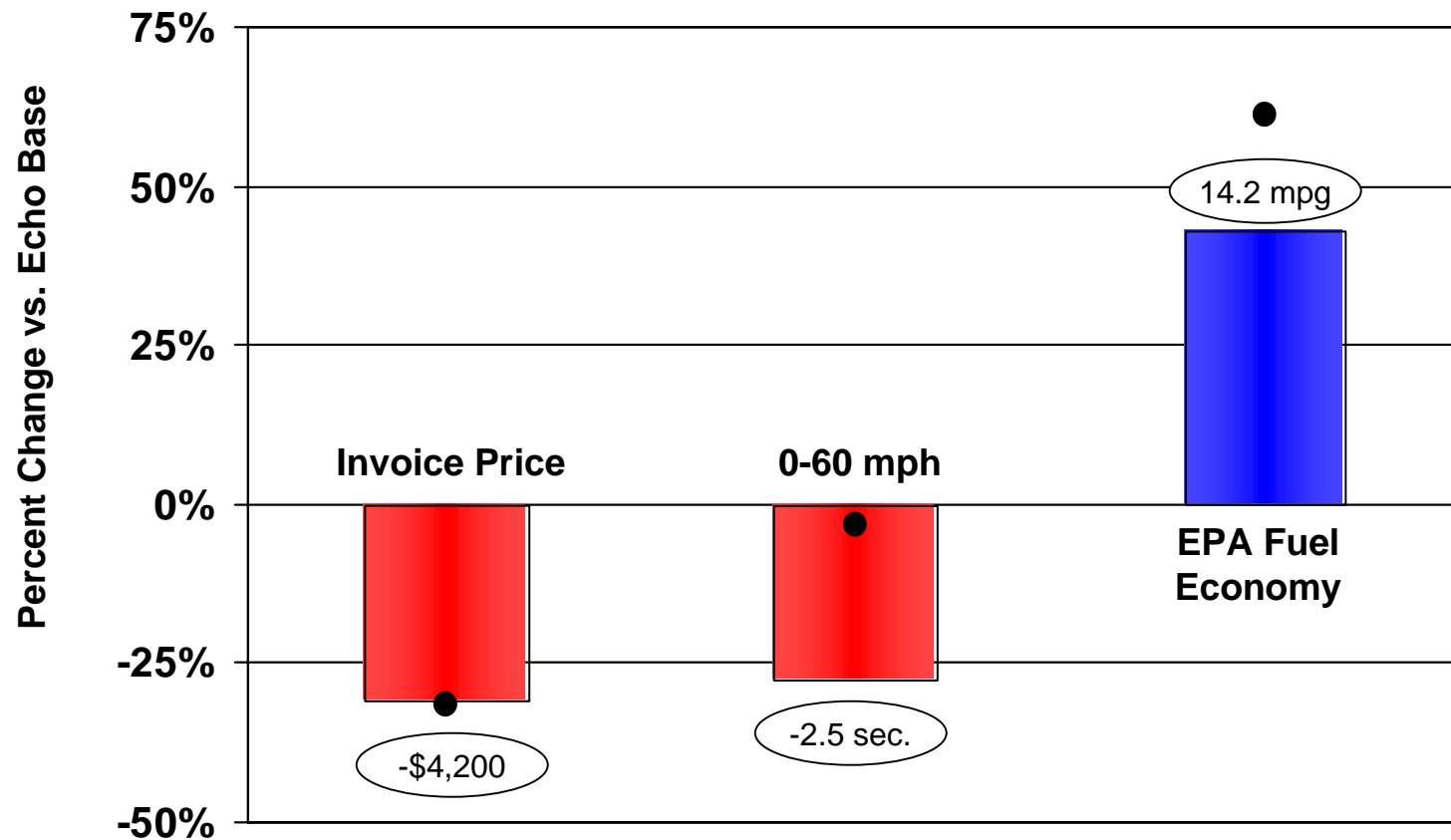


HEV vs. L4 Diesel

Unlike the diesel, the HEV consumer value proposition is solely based on fuel economy.

North America

### Toyota Prius vs. Echo Base



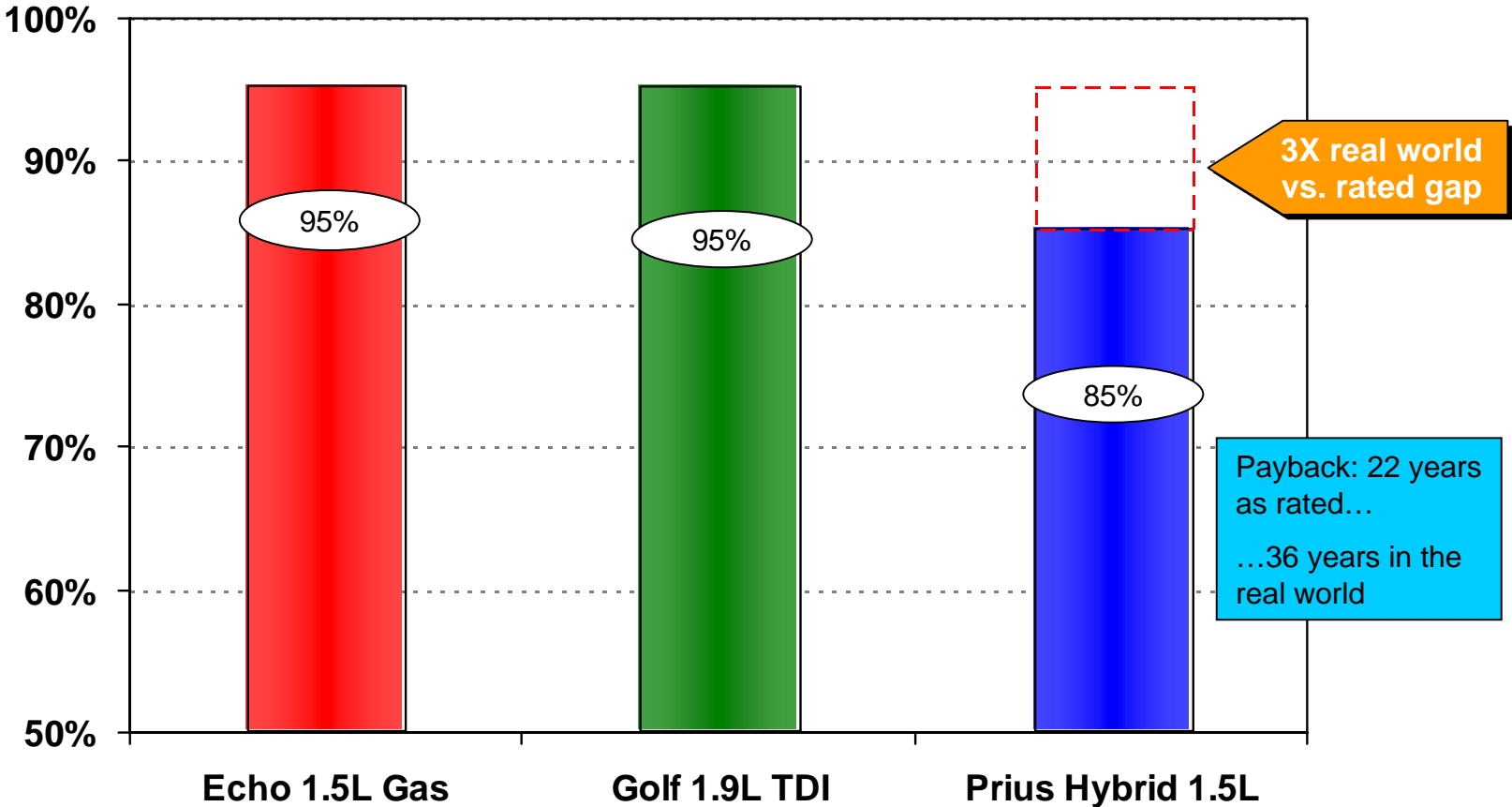
● - Estimated 2004 Prius metrics

Source: Martec analysis

# HEV fuel economy delivery falls short of promise.

North America

## Real World vs. Rated Fuel Economy



EPA 55/45 → 34.4 mpg  
 Real World → 32.7 mpg

45.2 mpg  
 42.8 mpg

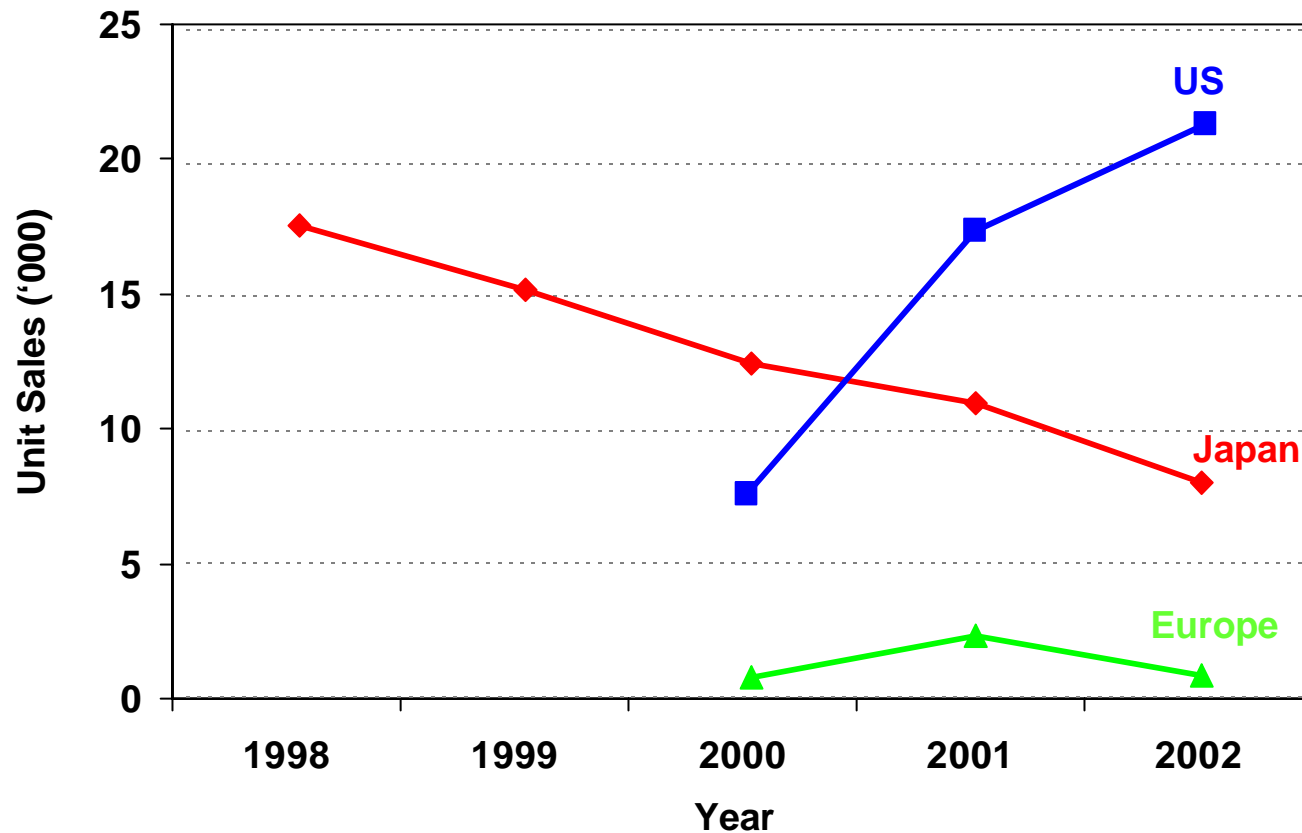
48.6 mpg  
 41.2 mpg

Source: Motor Trend, EPA



# HEV sales are not correlating to fuel price.

## Toyota Prius Sales by Region



Prius owner drives 3.75–6.25k miles per year.

Source: Toyota.jp



# Why would an OEM use HEV as a CAFE strategy . . .

North America

L4 TDI



HEV



## OEM Cost Delta vs. Gasoline Base

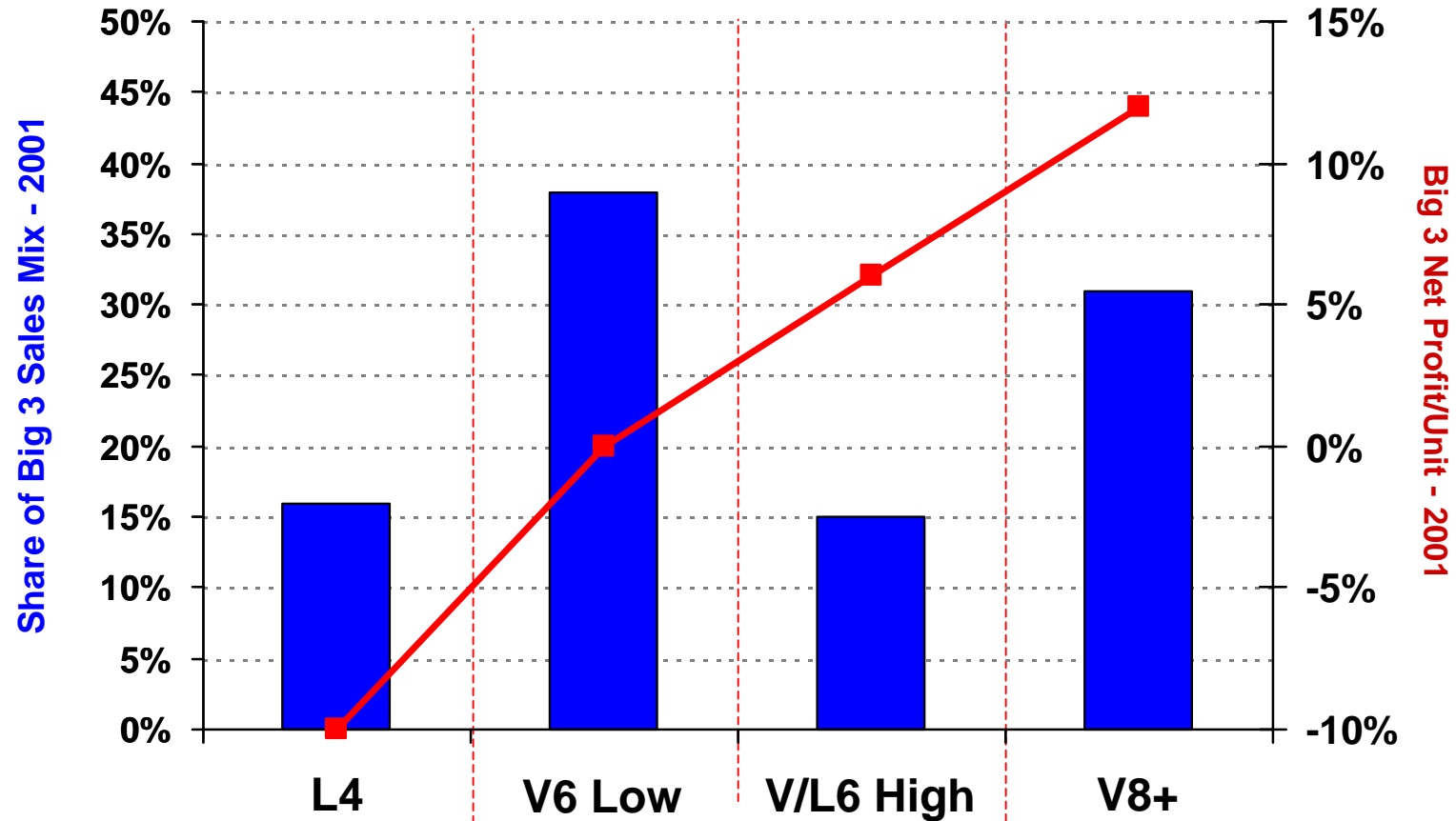
<\$1,000	Base Powertrain	\$3-5,000
<\$200	Coated DPF	\$- - -
<\$300	LNT	\$- - -
<\$1,500	Total OEM Cost ?	\$3-5,000

DPF and 80% NO<sub>x</sub> control will allow small diesel to meet Tier II Bin 5

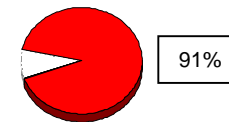
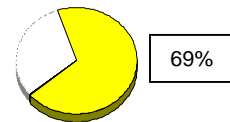
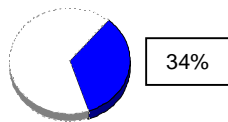
## Residual Performance vs. Gasoline Base

+2%	Residual Value at 3/36	-8%
+3%	Residual Value at 4/48	-10%

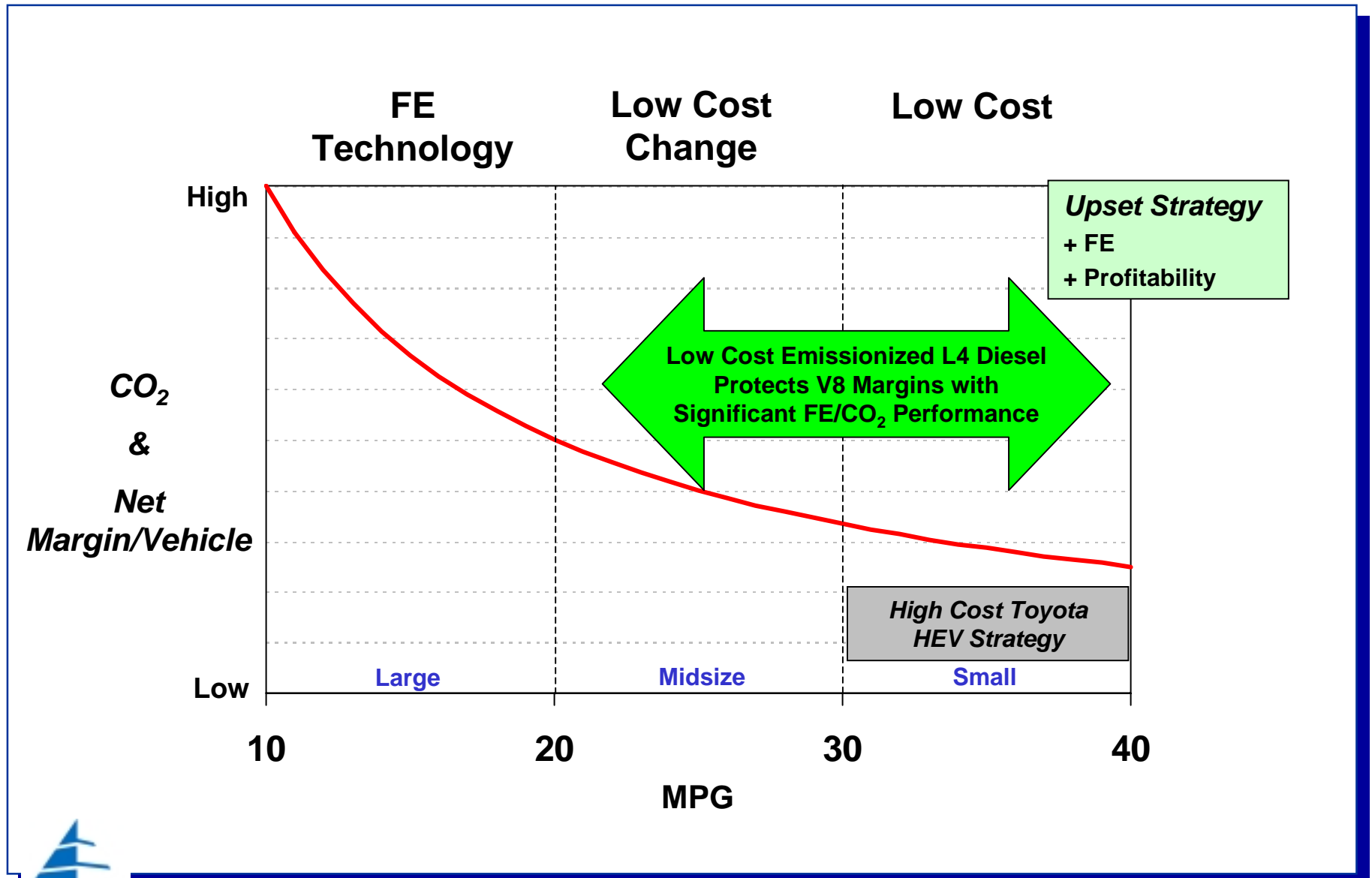
The Japanese profitably dominate the L4 market.



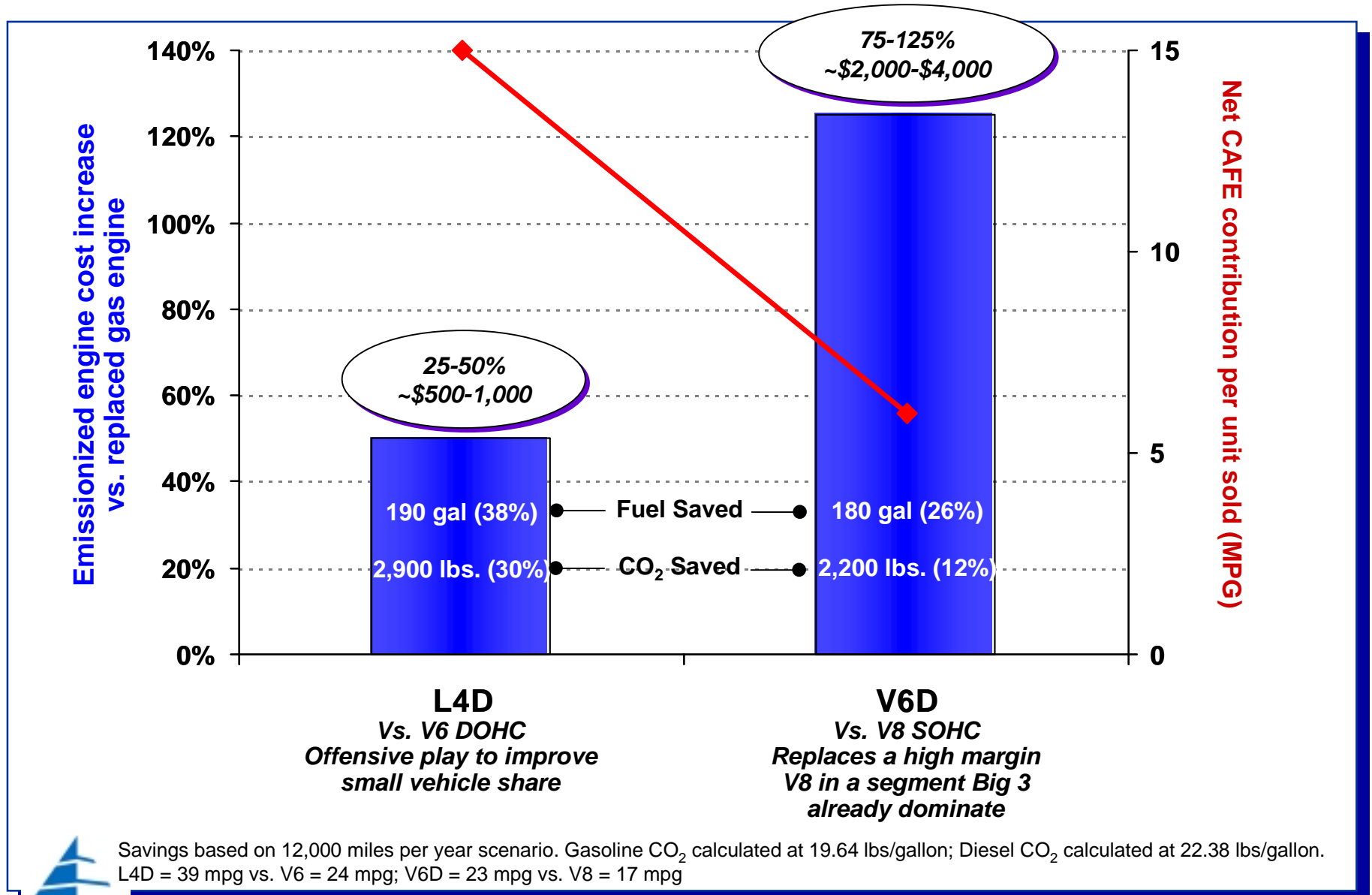
Big 3  
Share of  
Demand  
NAFTA  
2001:



Unlike their competitors, the Big 3 are being driven to introduce CAFE technologies on profit rich V8 engines.



# The small diesel strategy puts the Big 3 on the offensive.



Savings based on 12,000 miles per year scenario. Gasoline CO<sub>2</sub> calculated at 19.64 lbs/gallon; Diesel CO<sub>2</sub> calculated at 22.38 lbs/gallon. L4D = 39 mpg vs. V6 = 24 mpg; V6D = 23 mpg vs. V8 = 17 mpg



# Conclusions

- **The New Diesel delivers premium performance with exceptionally high fuel economy.**
  - The European diesel phenomenon is driven by performance
    - *Fuel economy is the differentiator that pushes the consumer away from the equally performing gas engine option*
  - The rational consumer who values overall ownership costs above performance continues to select the base gasoline engine
  - The European diesel consumer is rewarded with superior residual values vs. optional gasoline engines
- 2. **Small L4 diesels could be applied by US manufacturers in an optimized CAFE strategy.**
  - Game changing: performance coupled with cost-effective CAFE compliance
  - Strong commercial value-proposition
    - *High fuel economy with the performance US consumers want to buy*
    - *Diesel pays you back: monthly fuel bill, range, residual value*
  - High mileage segment of the US market has demonstrated a willingness to pay a diesel premium for the promise of high FE
    - *High mileage consumers are closely aligned with the European purchase decision . . . .*
    - *. . . . Gen 1 DI sales match state-of-the-art HEVs without subsidies*

## Conclusions *(continued)*

- **The small diesel strategy optimizes corporate resources.**
  - North America is positioned to take advantage of the sunk engineering, development and volume base that exists in Europe
  - The European cost structure would benefit from incremental small diesel volume in North America
  - OEM and supplier economics benefit from a multi-region small diesel strategy
    - *Emissions control technology development and cost are key elements*
    - *Full HEV is an AT-PZEV “island”. Diesel bridges all developed and developing world strategies*
  
- 4. **The HEV value proposition, as currently defined, is critically flawed.**
  - Consumer pays a steep (subsidized) premium for fuel economy benefit only
  - Real-world FE gap is 85% of rated – far below diesel/ICE
    - *This gap between promise and delivery on the primary purchase decision attribute poses a serious “trust” issue to brand decision makers*
  
- **HEVs with differentiated performance characteristics vs. ICE base are achievable.**
  - Increased performance would be traded for fuel efficiency
  - Trading high cost fuel economy for high cost performance

## Conclusions *(continued)*

6. **Why wouldn't a high performance HEV create a schism between the OEM and environmentalists?**
  - Environmentalists routinely criticize OEMs for applying ICE technology toward performance improvements vs. FE
  - If an HEV concedes fuel economy in favor of performance, where does it fit in the public policy debate?
  
- **Clean diesels can be positioned to curb the spread of ATPZEV sales mandates.**
  - Split the demand for extreme fuel economy vehicles
  - HEV is all about fuel efficiency, not about emissions
    - *An ATPZEV saves 1.5 lbs. NOx vs. a bin 5 vehicle*
    - *Federal government assigns a benefit of \$7.50/year.*
  
8. **What is blocking the small L4 diesel strategy in North America?**
  - Tier II (US06) emissions standards considered “overwhelming hurdle”
    - *Technology and cost*
  - OEMs are not capitalized for L4 diesel production in North America
  - Some OEMs do not view themselves as diesel technology leaders; are hesitant to adopt a pro-diesel stance
  - HEVs are viewed as a technology bridge to fuel cells
  - Large pockets of “old thinking” on diesels continue to exist

\* \* \*

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