Cost Effectiveness of Technology Solutions for Future Vehicle Systems

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Reducing CO2 Footprint

- Two ways to reduce the CO2 footprint of vehicle systems
  - Efficiency Improvement
  - Alternative Fuels
- Hypothesis: Efficiency improvements always make sense and should receive the highest priority. Alternative fuels are limited by supply issues and may not always make sense.

Basic Question

- What are the economic costs or benefits for CO2 control through vehicle efficiency improvements?
  - Can the customer save money while preserving the atmosphere?

Cost Benefit of CO2 Reduction

Scope

- Information derived from ARB funded NESCCAF study, June 2004 (California)
  - Retail price & cost increase
  - CO2 savings
  - Customer Net cost effect

- SwRI study, 2008
  - Cost differences, in-house cost model
  - European Scenario
  - Update of Net cost for 2008 fuel prices

Methodology

INTERACTING TECHNOLOGIES	Multi Point Fuel injection
Multi Point Fuel injection	
λ=1 Aftertreatment	Y
Cam Phaser (In)	Y
Cam Phaser (Ex)	Y
Cam Phaser (Dual)	Y
Cam Phaser (Coupled)	Y
Variable Lift-Discrete	Y
Variable Lift-Continuous	Y
Camless-Electrohydraulic	Y
Turbocharging	Y
Elect. Assist turbo (EAT)	Y
Cylinder de-activation	Y
Variable Charge Motion	Y
GDI-λ=1	Y
GDI-Dilute	Y
SI HCCI	Y
CI HSDI	N
CI HCCI/multimode	N
HEDGE	Y

Individual Technology Identification

Price & Costing

Technology Grouping

Vehicle Performance Checks

Drive Cycle CO2

Cost/Benefit

Net Cost

Net Cost per avoided CO2

Payback Period

Correlation of US M-H combined & NEDC fuel consumptions

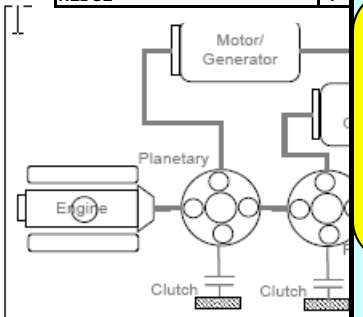
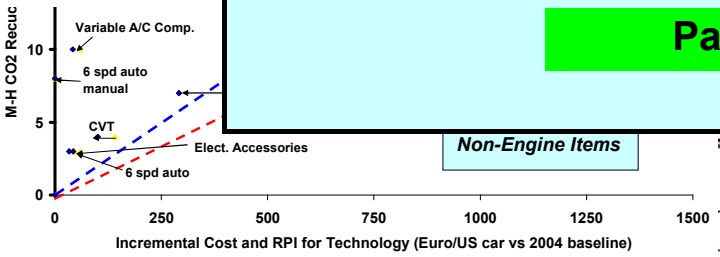
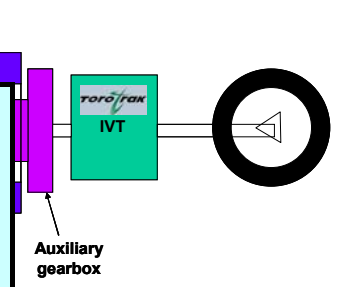
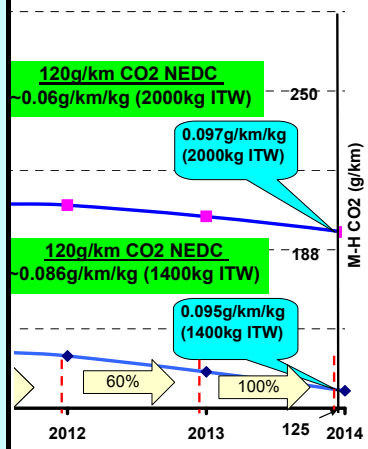


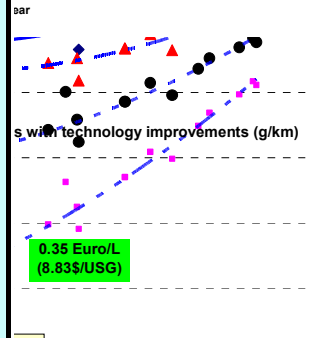
Figure 4-4: Schematic of GM-DCT



Non-Engine Items





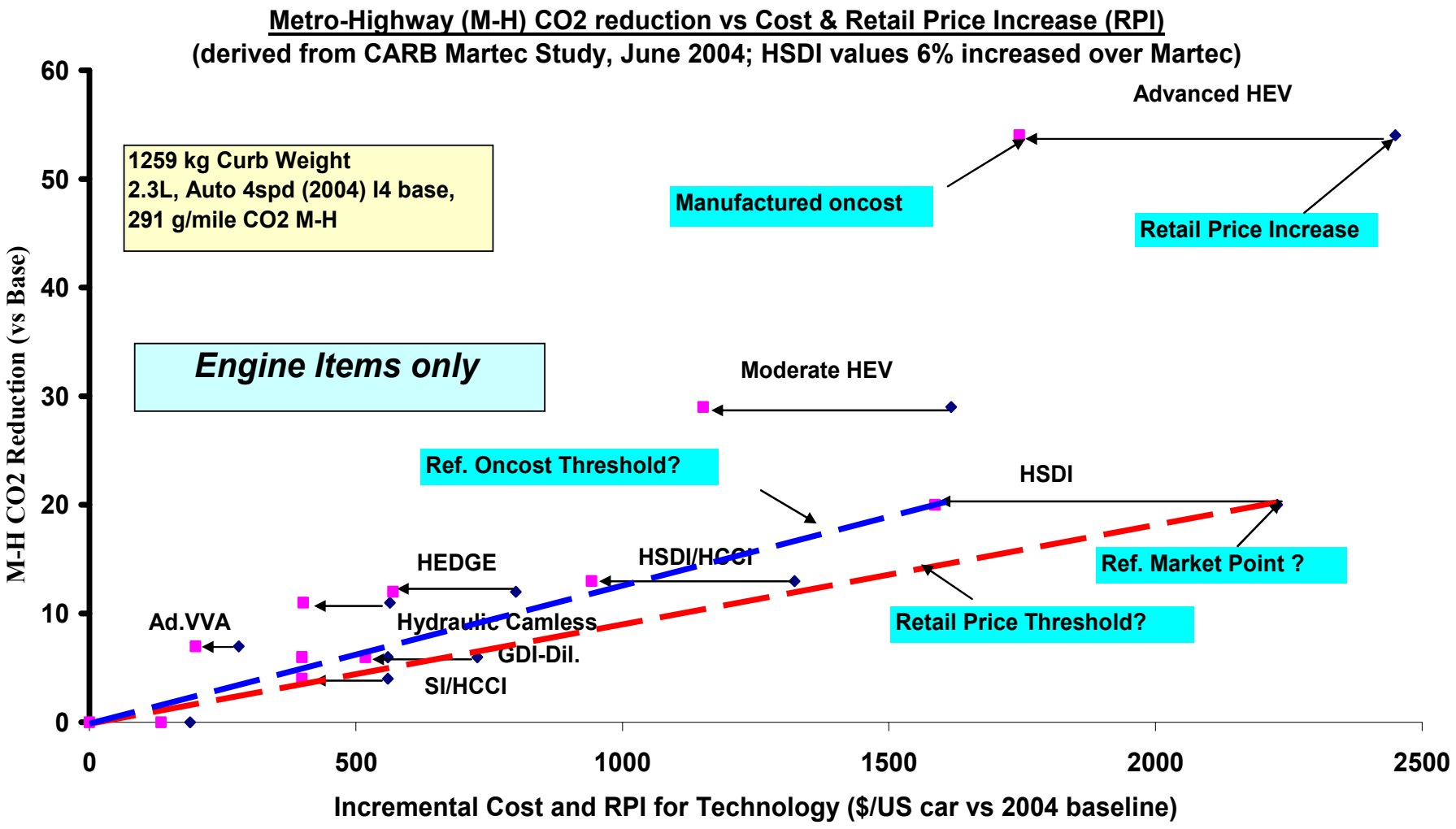


Derived Information from ARB Study

Key Aspects

- ARB (NESCCAF) study used Martec to assess price variances for technologies; *updated by SwRI cost model*
- NESCCAF deduced manufacturing cost relationship to retail price; *updated with SwRI cost model*
- AVL performed US M-H drive cycle predictions for CO_2 variances; *additional points added with correlated SwRI drive model, and transposition of M-H CO2 data to NEDC*
- Effects of individual and grouped technologies considered, but only "grouped" technologies pursued.
- Baseline is 2004MY
  - ~1600kg (curb weight) 3.2L V6, 4 speed auto with 345g/mile (215g/km) CO2
  - ~1260kg (curb weight) 2.4L I4, 4 speed auto with 291g/mile (182g/km) CO2
- Price & cost are projected for 2008 onwards

Predicted M-H CO2 Reduction vs $US Price & Cost Changes



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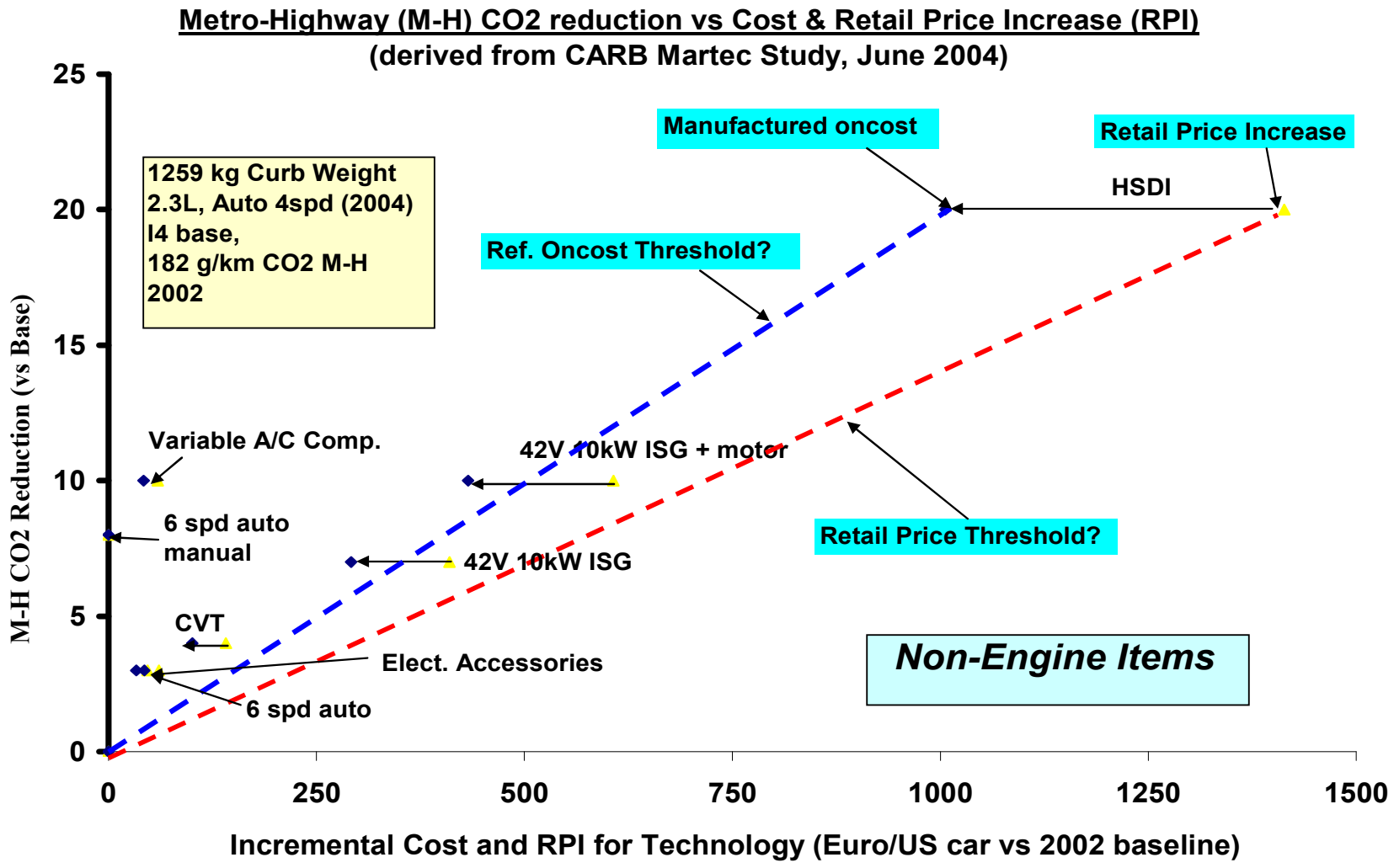

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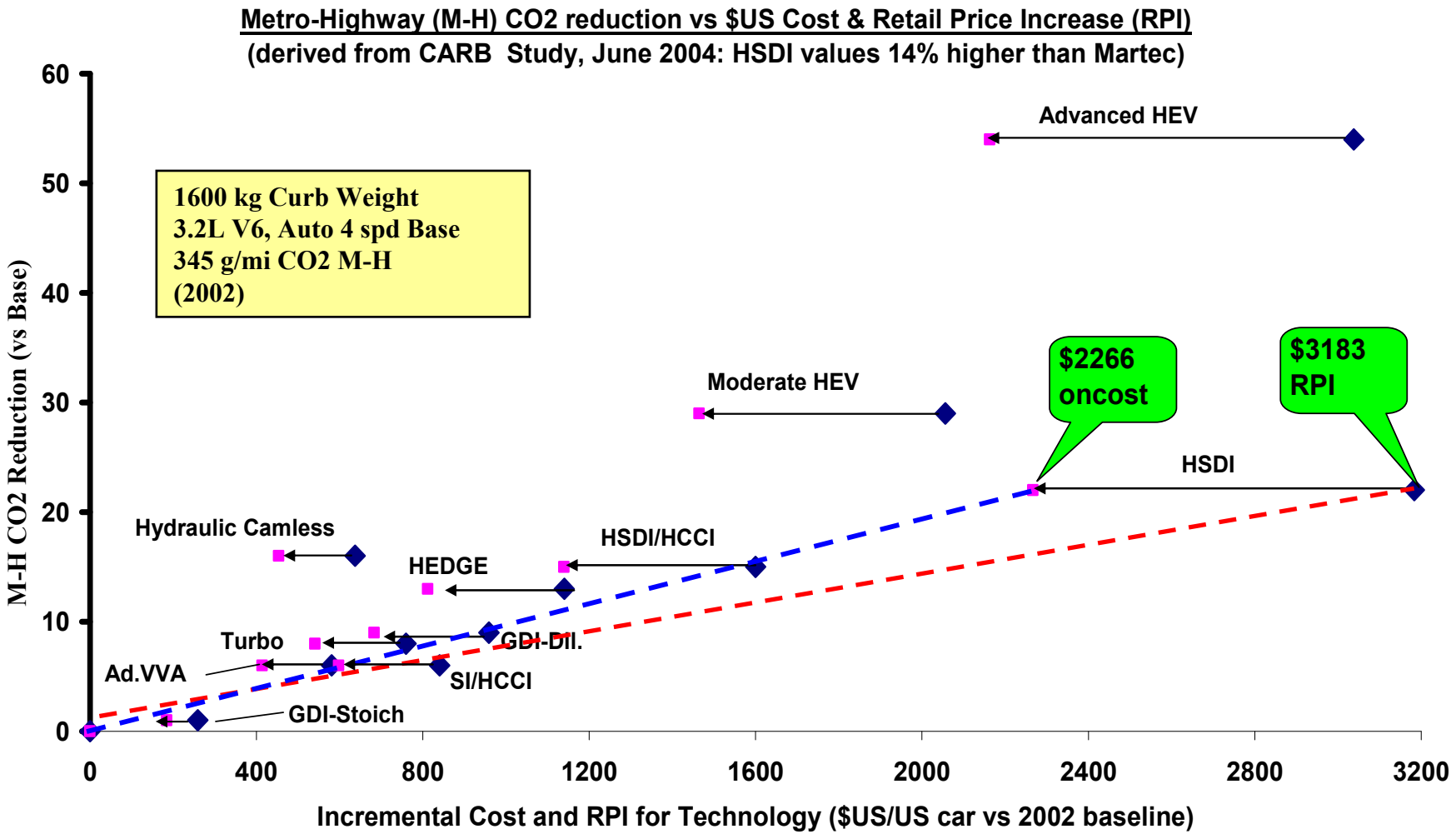


Correlations

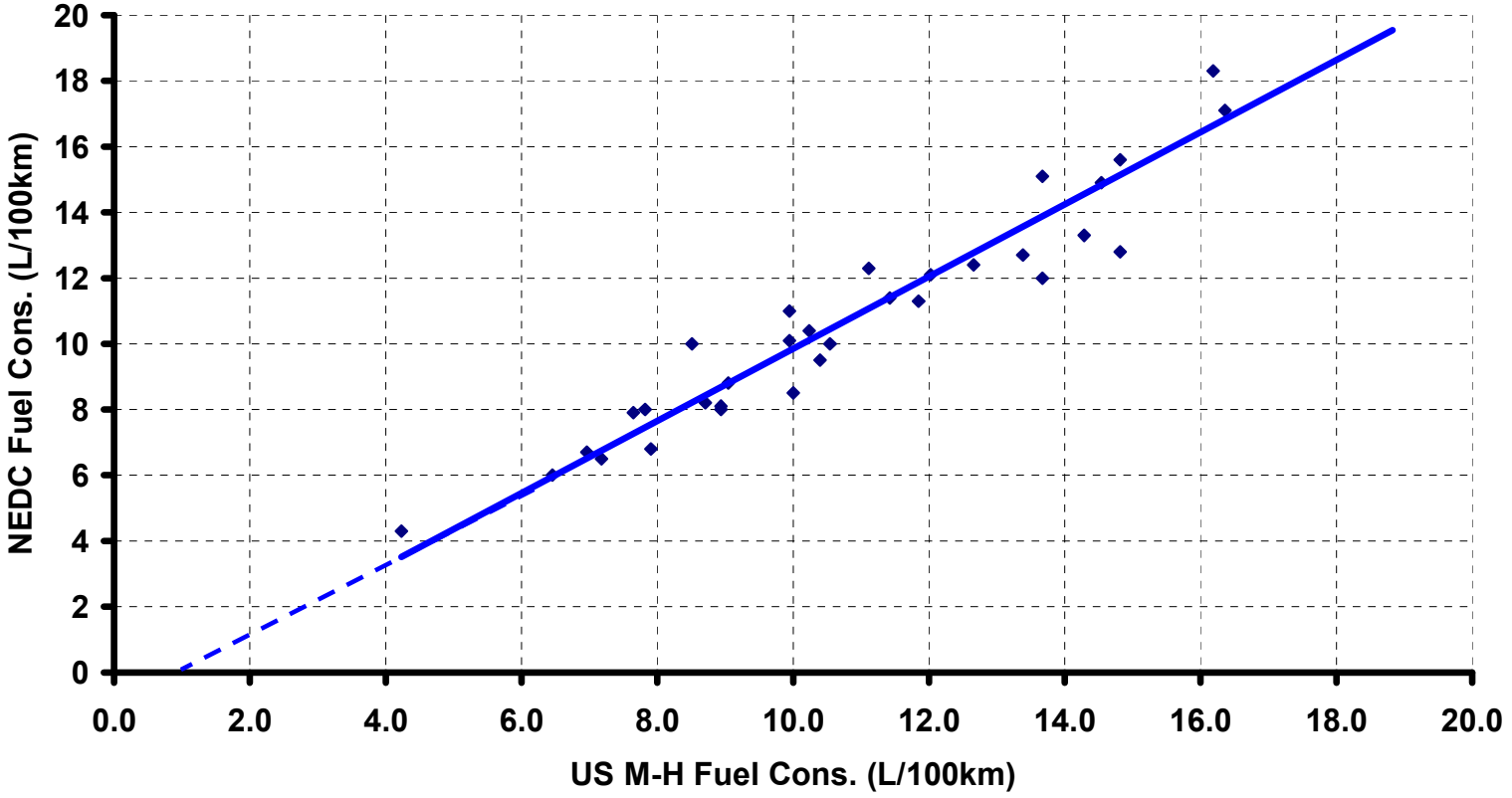
In order to transpose the previous data from the US Metro-Highway to NEDC, the following relationships are examined:

- US M-H vs NEDC fuel consumption correlation (as this is currently the most plentiful data for both markets)
- Fuel consumption vs CO2 correlation

Correlation of Metro-Highway & NEDC Fuel Consumptions

2007 US Metro-Highway & 2007 NEDC Fuel Consumption Comparisons

(Certification Data, ~30 vehicles with common USA & Europe specs.)

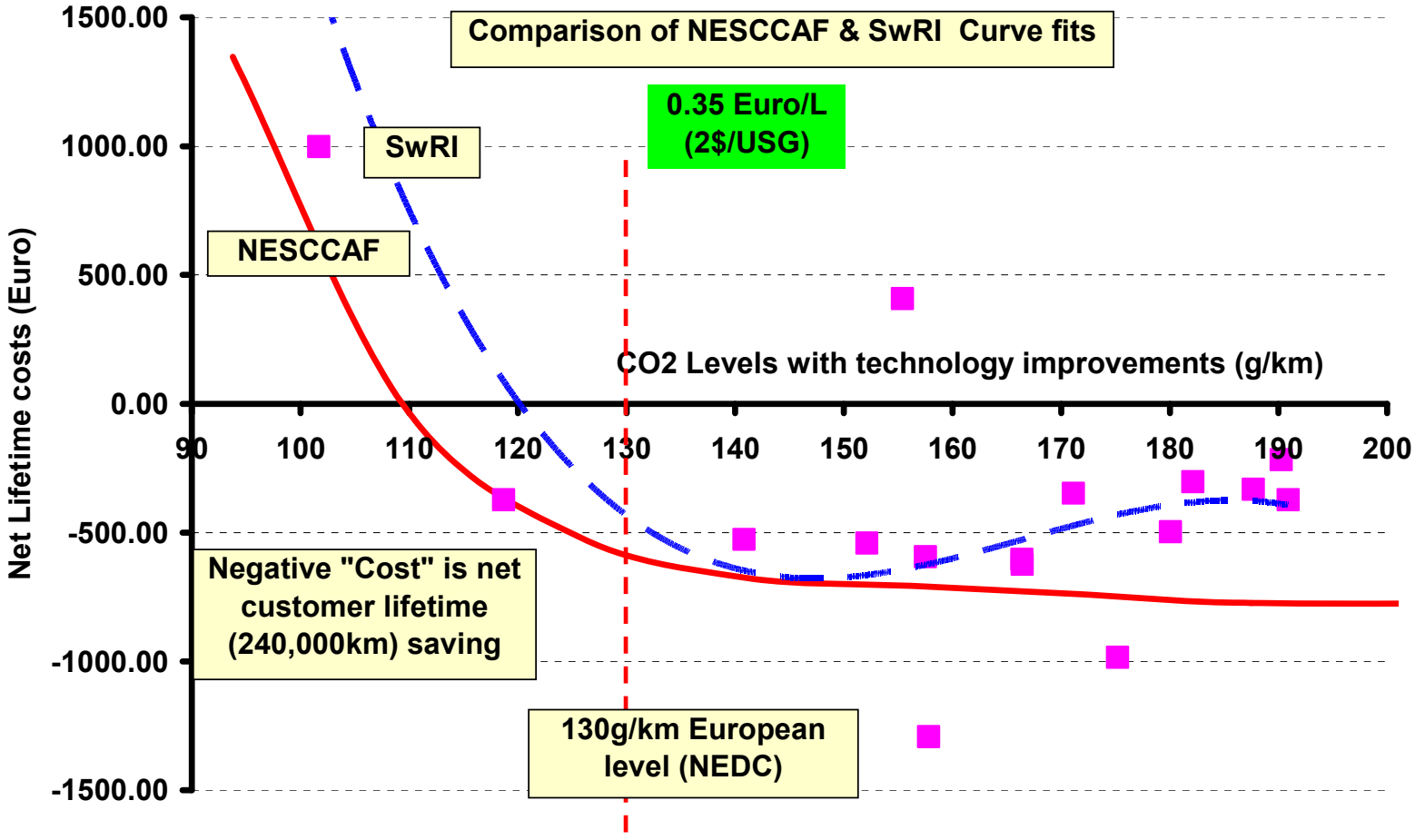


Cost of Ownership Assumptions

- 10 Years
- 240,000 km
- 5% inflation rate

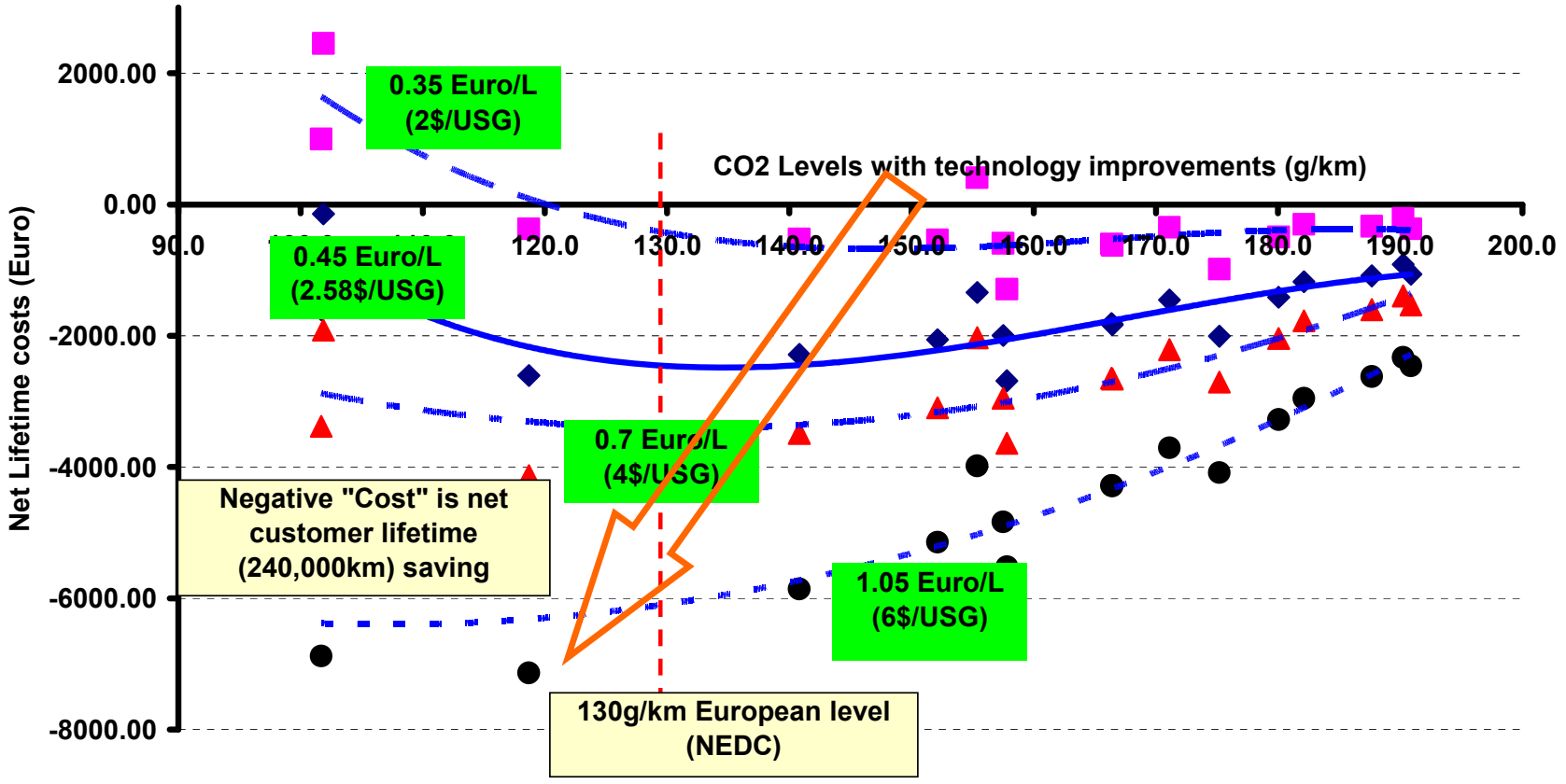
Net Cost Savings for Customer

Comparison of NESCCAF and SwRI Net Cost to Customer over 10 years, including 5% inflation/year

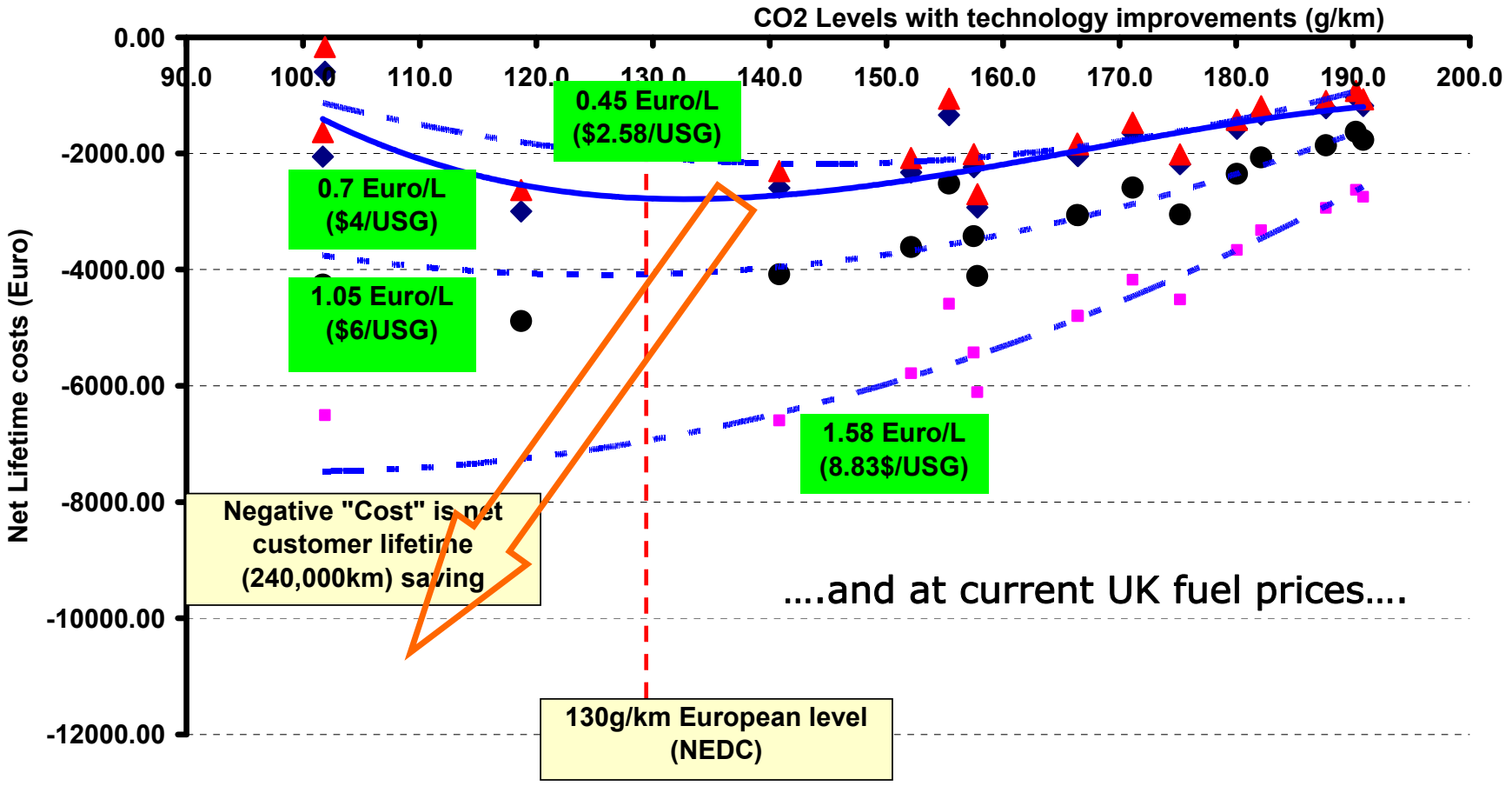


Net Cost Savings for Customer

Net costs calculated by NESCCAF method for Euro 0.35-1.05/L fuel costs, adjusted for inflation



Net Cost Savings for Customer



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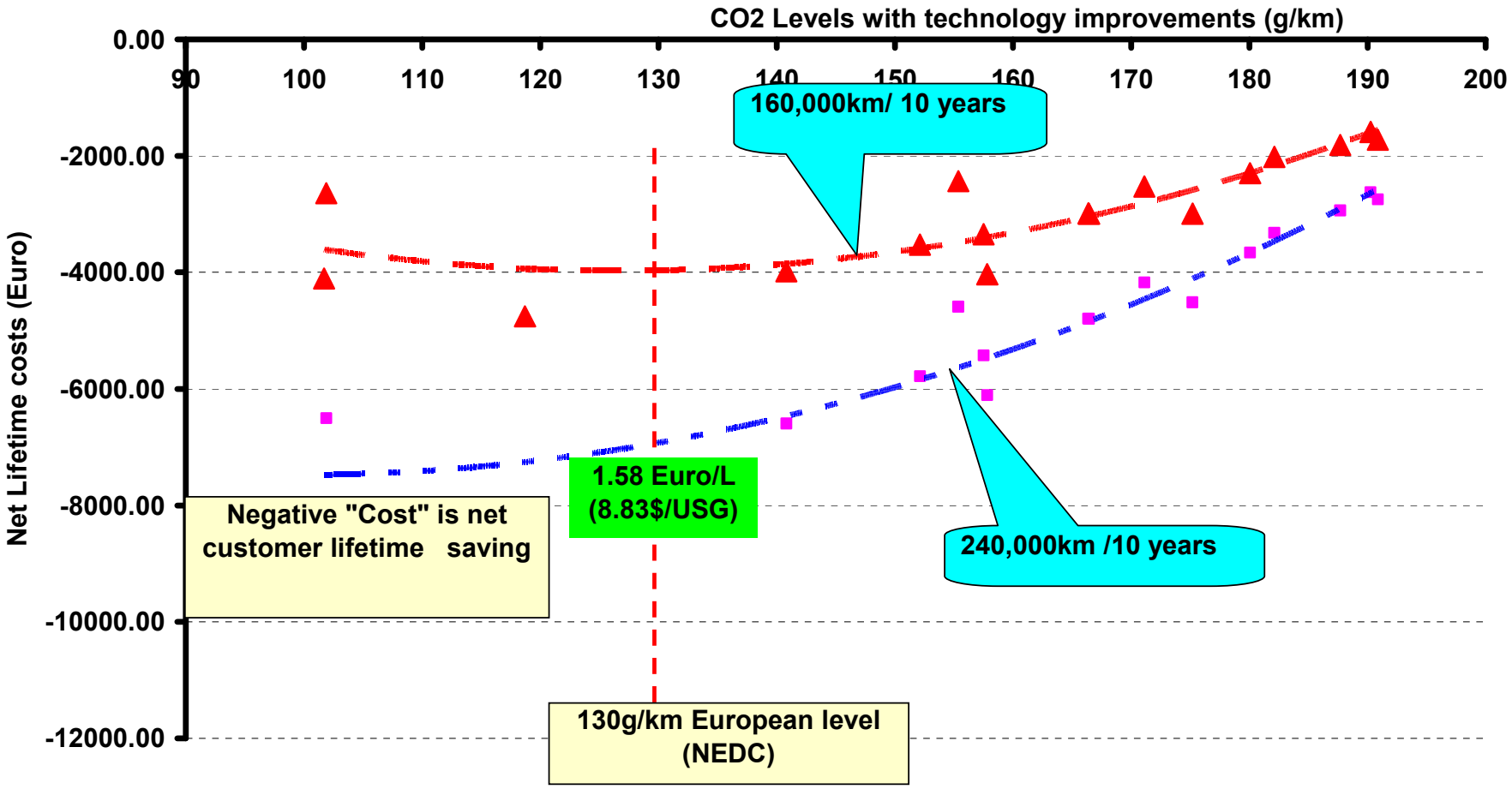
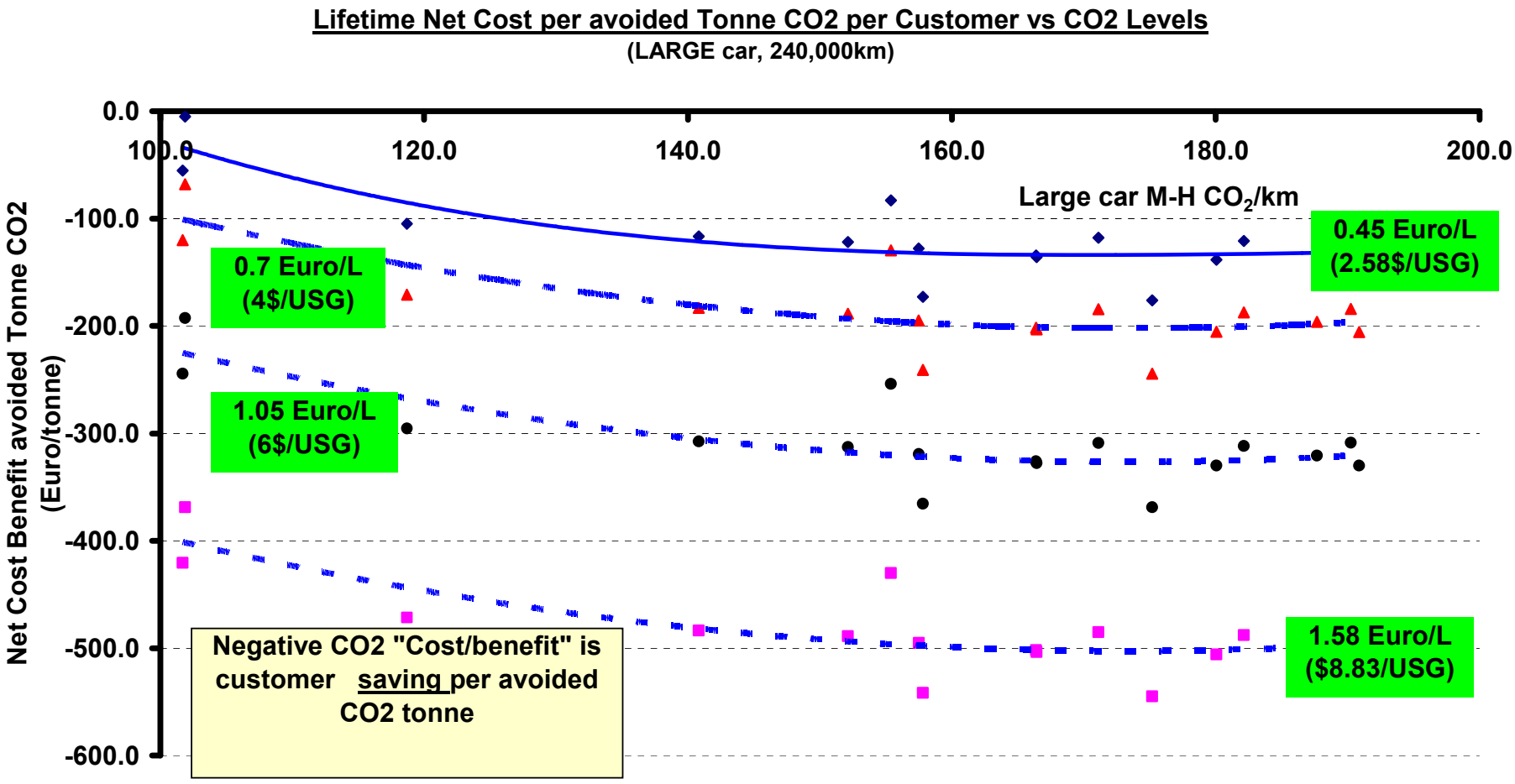


…And the effect of only 160,000km use in 10 years

Net Cost/ton avoided CO2 vs vehicle CO2 levels



At current prices, European customers will personally save > Euro 500 per tonne of CO2 avoided, at least to ~160g/km, the benefit reducing to ~Euro 450 at 120 g/km CO2

Conclusions

- The net lifetime cost of CO2 reductions by added engine technology is *negative* for current and likely future fuel pricing, *i.e. the customer benefits, as well as the climate.*

- For current fuel prices in Europe, the cost savings for the customer is 7000EU at 130 g/km CO2

Thank you

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