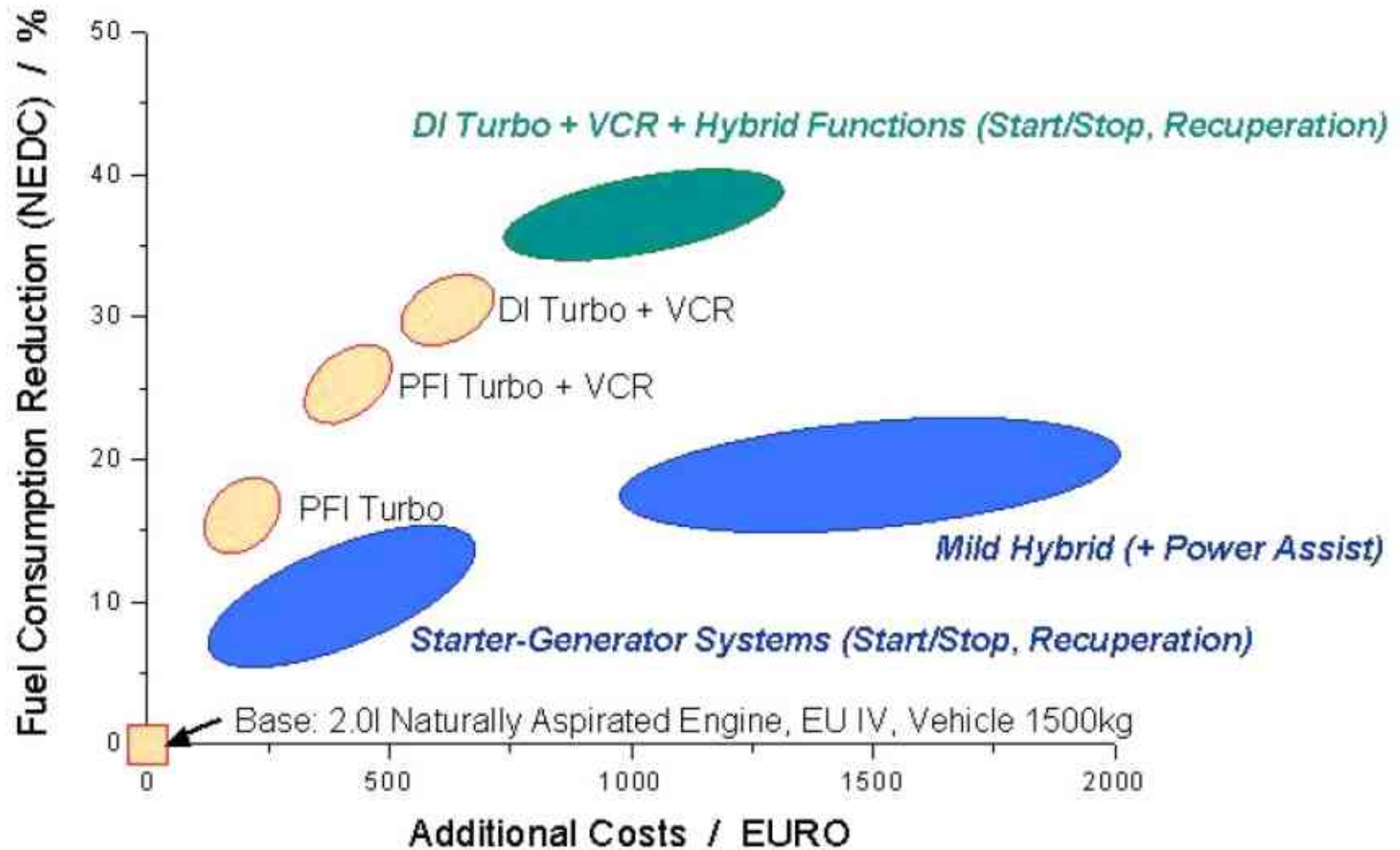


How to make a clean Cars

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Assessment of Fuel consumption, Potential and Cost of Hybrid Concepts



Fuel Consumption Reduction by Retrofit

Golf TSI 1,4 I 125 kW



Comparison Petrol versus Diesel

Petrol

1.4 TSI 125 kW 6- gear box

7,2 l/100km CO₂ 169 g/km Price 22.700,00 €

1.4 TSI 125 kW DSG

7,2 l/100km CO₂ 169 g/km Price 24.375,00 €

Diesel

2.0 TDI DPF125 kW 6-gear box

6,0 l/100km CO₂ 158 g/km Price 25.175,00 €

2.0 TDI DPF125 kW DSG

6,4 l/100km CO₂ 173 g/km Price 26.850,00 €

Demonstration Car

Overview on the Fuel Saving Measures

engine stop at



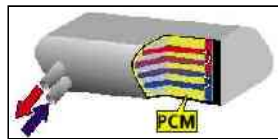
gearbox with long transmission



gearshift indicator



Light weight seats



Latent-heat storage

smooth under flow

lower body



smooth covers resistance tires

narrower low rolling

resistance tires



Reduction Potential in the Simulation

Single Measures in the EUDC

	NEDC			
	Consump. [l/100km]	CO ₂ [g/km]	Reduction [l/100km]	Reduction [%]
Basic car				
Golf 1.4l TSI	7.24	173.7	0.00	0.0
Single measure				
c_w=0.28	7.11	170.6	0.13	1.8
f_R=0.9%	6.89	165.5	0.34	4.7
2.0l-TDI-gear box	6.57	157.6	0.67	9.3
2.0l-TDI-gear box, 0.9th Achse	6.56	157.5	0.68	9.3
m=1250kg	7.05	169.2	0.19	2.6
Start-Stopp	6.90	165.6	0.34	4.7
Gearshift Indicator	6.62	158.9	0.62	8.5
warm start	6.65	159.7	0.58	8.1

Reduction Potential in the Simulation combined Measures in the NEDC

	NEDC			
	consumption [l/100km]	CO ₂ [g/km]	reduction [l/100km]	reduction [%]
Basic car				
Golf 1.4l TSI	7.24	173.7	0.00	0.0
combined measures				
c_w=0.28, f_r=0.9%, m=1250kg 2.0l-TDI-gear box, start-stop	5.58	133.8	1.66	22.9
c_w=0.28, f_r=0.9%, m=1250kg 2.0l-TDI-gear box, GSI start-stop,	5.44	130.6	1.80	24.8
c_w=0.28, f_r=0.9%, m=1250kg 2.0l-TDI-gear box, GSI Start-Stop warm	4.85	116.5	2.38	32.9

Basis Data for a 4-Seater

Motor + Starter-Generator:

Basic engine maps as for the 1-liter-car, scaled to twice the power

- Hybrid strategy:
 - equivalent to 1-Liter-car
- car data:
 - gross weight: 580 kg (equal $2 \times m_{1\text{-Liter-car}}$)
 - total weight: 680 kg (normal), 905 kg (full loaded, 4Persons)
 - c_w -value: 0,19 (equal Mercedes Studie Bionic car)
 - front area: $2 \times A_{1\text{-Liter-car}}$
 - rolling resistance: equal $f_{\text{roll},1\text{-Liter-car}}$

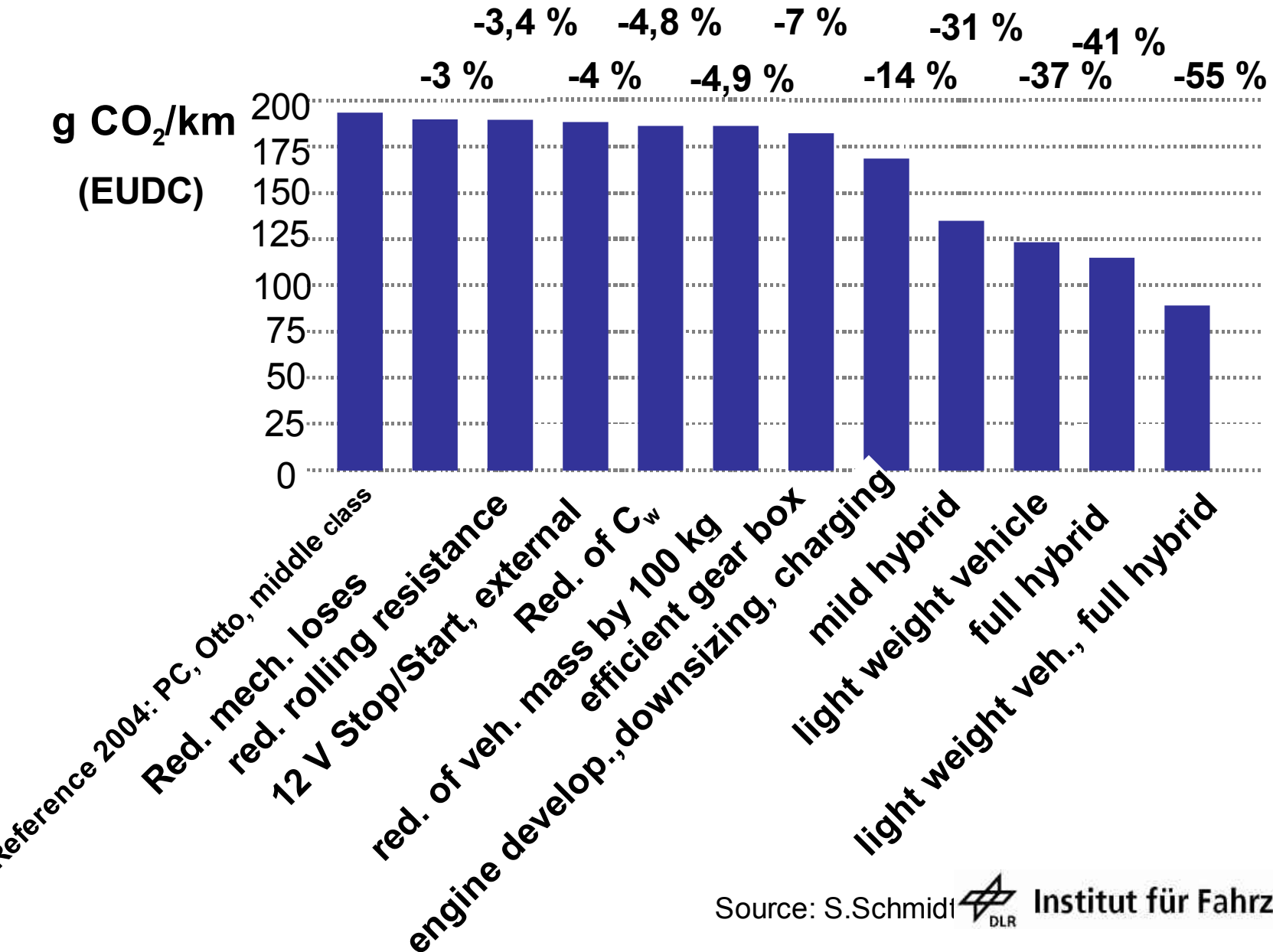


Mercedes Studie Bionic car

Simulation Results 4-Seater

vehicle:		
mass	[kg]	680 (580+100)
c _w -value	[-]	0.19
front area	[m ²]	2.0
rolling resistance	[%]	0.8
engine:		
fuel		Diesel
max. power	[kW]	12.6
at	[U/min]	4000
max. torque	[Nm]	38.2
at	[U/min]	1800 - 2800
starter-generator:		
max. power	[kW]	•5
fuel consumption:		
NEDC	[l/100km]	1.78
NEDC (full loaded	[l/100km]	2.08
Hyzem 905kg)	[l/100km]	3.04
Hyzem (full loaded 905kg)	[l/100km]	3.42

Reduction Potential Technical Measures



Simulation Results Engine Downsizing

Task and Procedure

Estimate the fuel consumption reduction potential of a Golf V by limiting the maximum velocity 160 km/h.

- Starting with the basis engine (1,4l TSI, 125 kW) and scaling down to $v_{\max}=160$ km/h. The new engine power is 50 kW.
- As a result of the lower max speed the car can be equipped with smaller tires, which reduces the vehicle weight and additionally the aerodynamic drag. The smaller engine has also a positive effect for the vehicle mass.
- To estimate the impact the following assumption are made for the simulation:
 - Reduction of the vehicle weight by 100 kg
 - Reduction of the rolling resistance by 10%
 - Reduction of the aerodynamic drag by 5 %

CO₂- Emission Reduction by Downsizing

Basic vehicle:	156 g/km CO ₂
Engine Downsizing (direct effects)	113 g/km CO ₂
Vehicle (indirect effects)	105 g/km CO₂

Reduction Potential

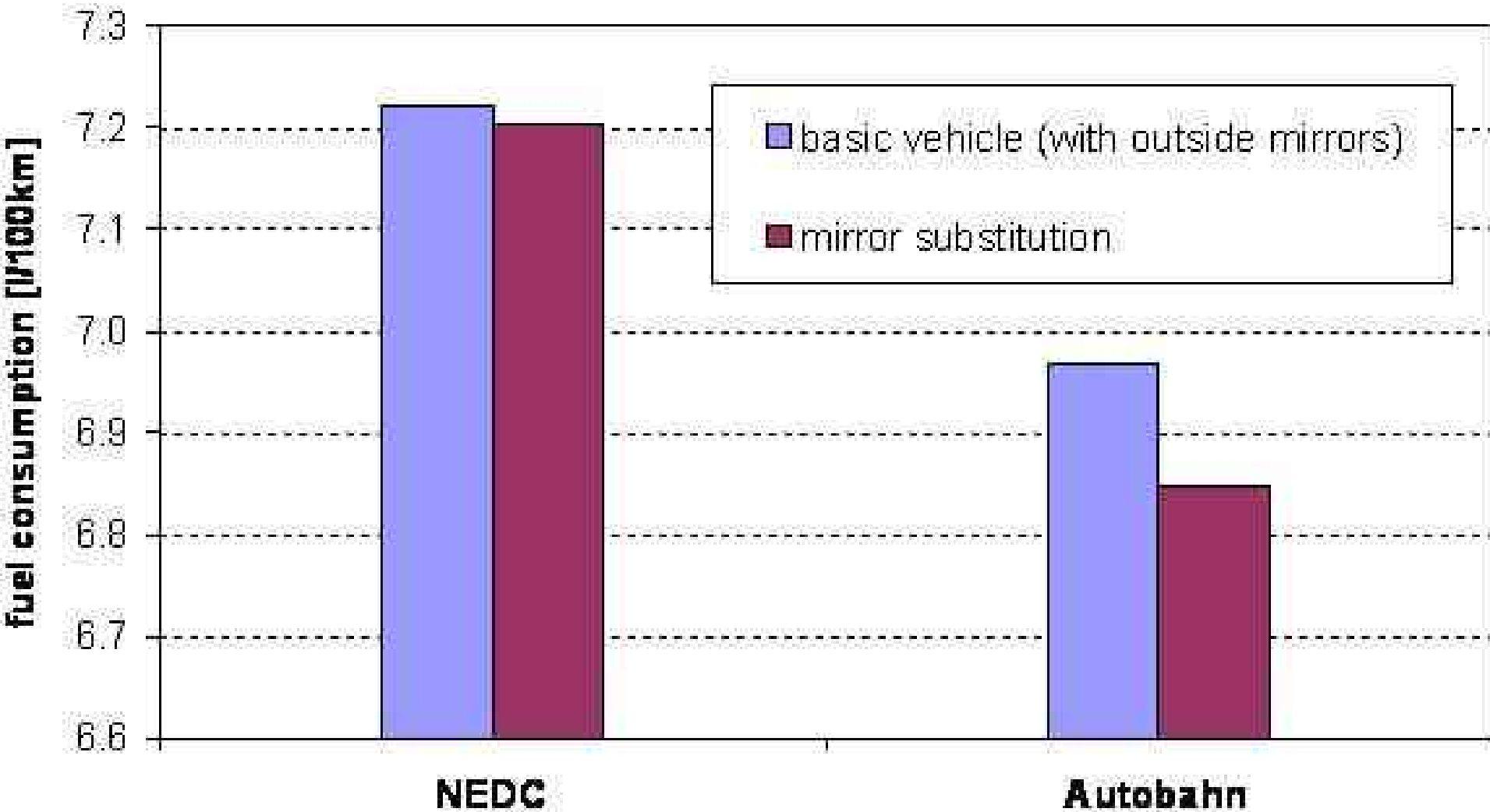
	• NEDC (warm start)		• Autobahn cycle	
	Consumption • [l/100km]	Reduction • [%]	Consumption • [l/100km]	Reduction • [%]
Basic vehicle Golf GT 1,4l TSI	• 6.66	• -	• 7.13	• -
Engine downsizing: • Design of the engine to 50 kW	• 4.81	• 27.8	• 6.42	• 10.0
Subsequent impacts: weight reduction (-100 kg), reduction rolling resistance (-10 %) reduction aerodynamic drag (-5 %)	• 4.45	• 33.3	• 5.91	• 17.0

Outside Mirror

Influence of the outside Mirror to $c_w \times A$

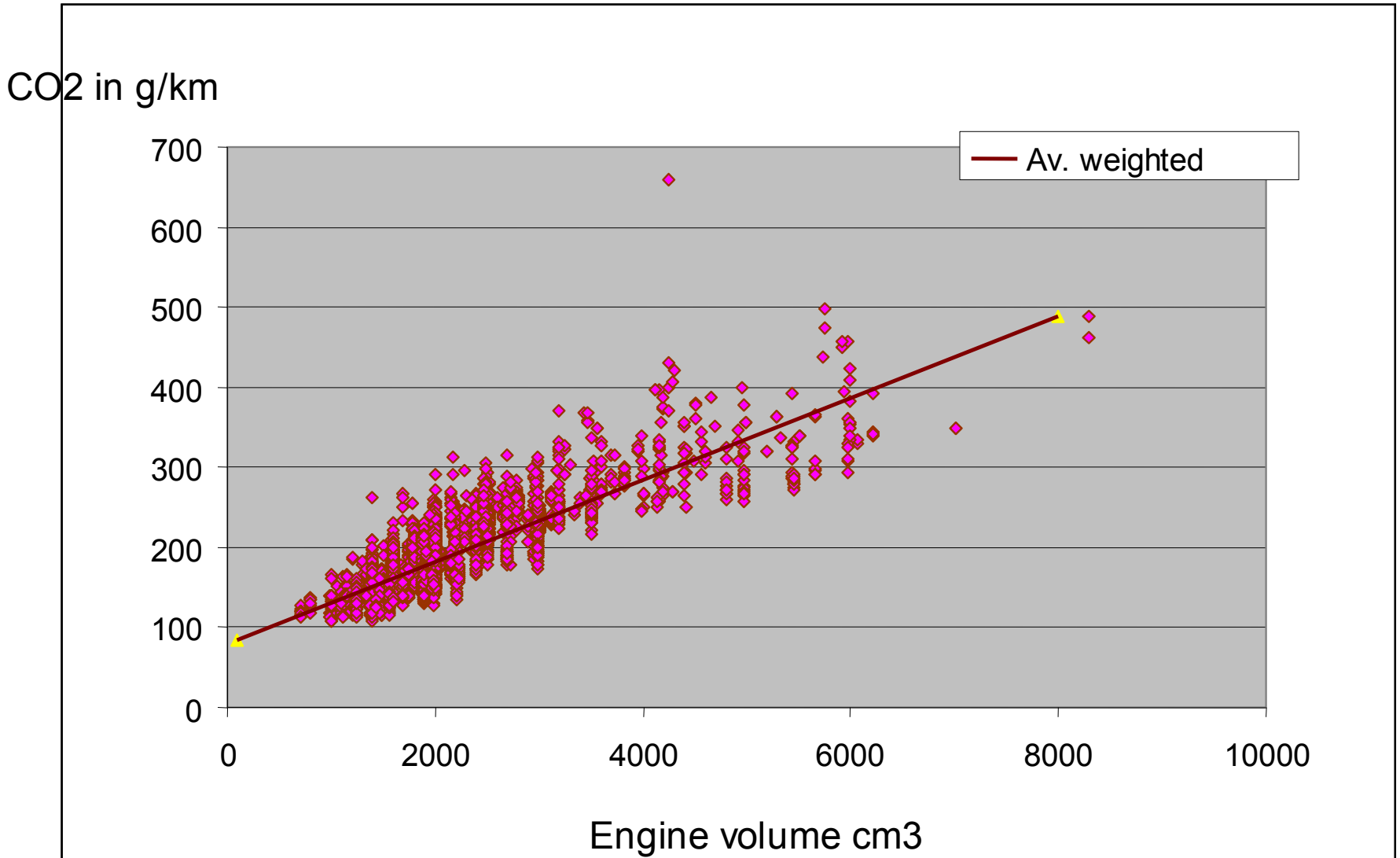
- Golf GT: $c_w \times A = 0,74 \text{ m}^2$
- Without outside mirror: $c_w \times A = 0,713 \text{ m}^2$
- $dc_w \times A = -0,027 \text{ m}^2$

Cameras/Monitors instead of Outside Mirror



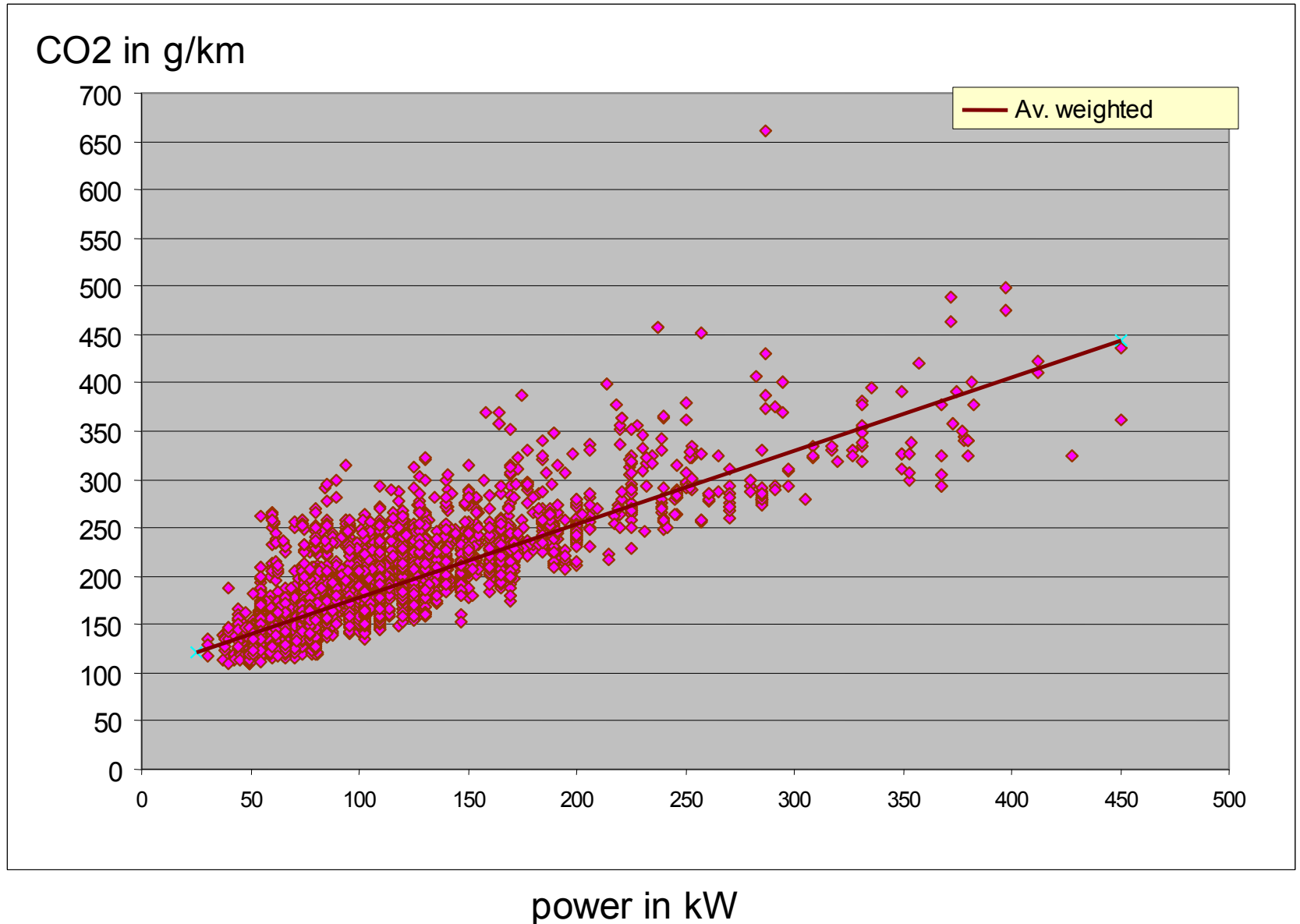
**What Parameters for a CO₂
Limit?**

Newly registered Vehicles in Germany 2006 CO2-Emissions

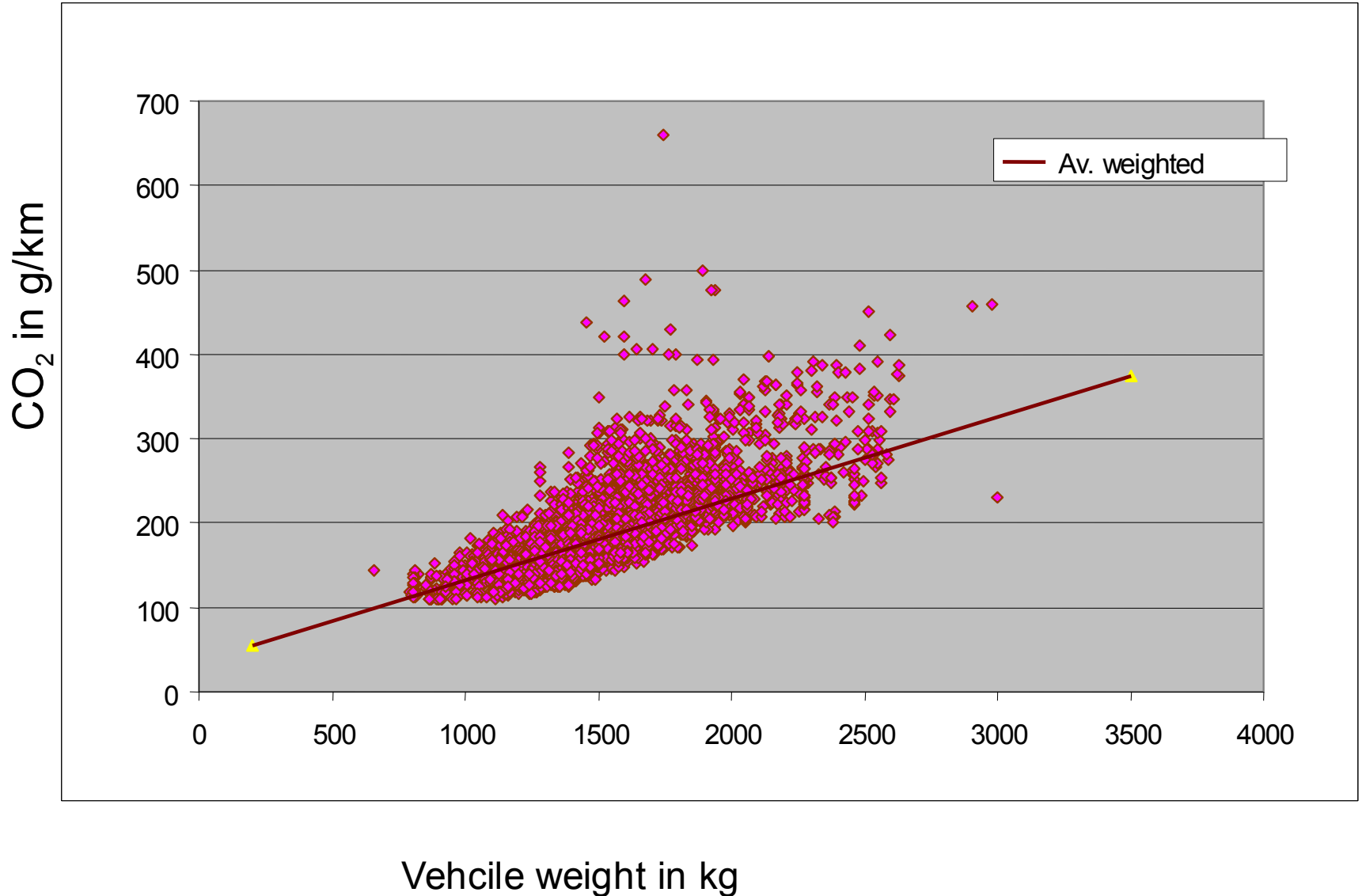


Newly registered Vehicles in Germany 2006

CO2-Emissions

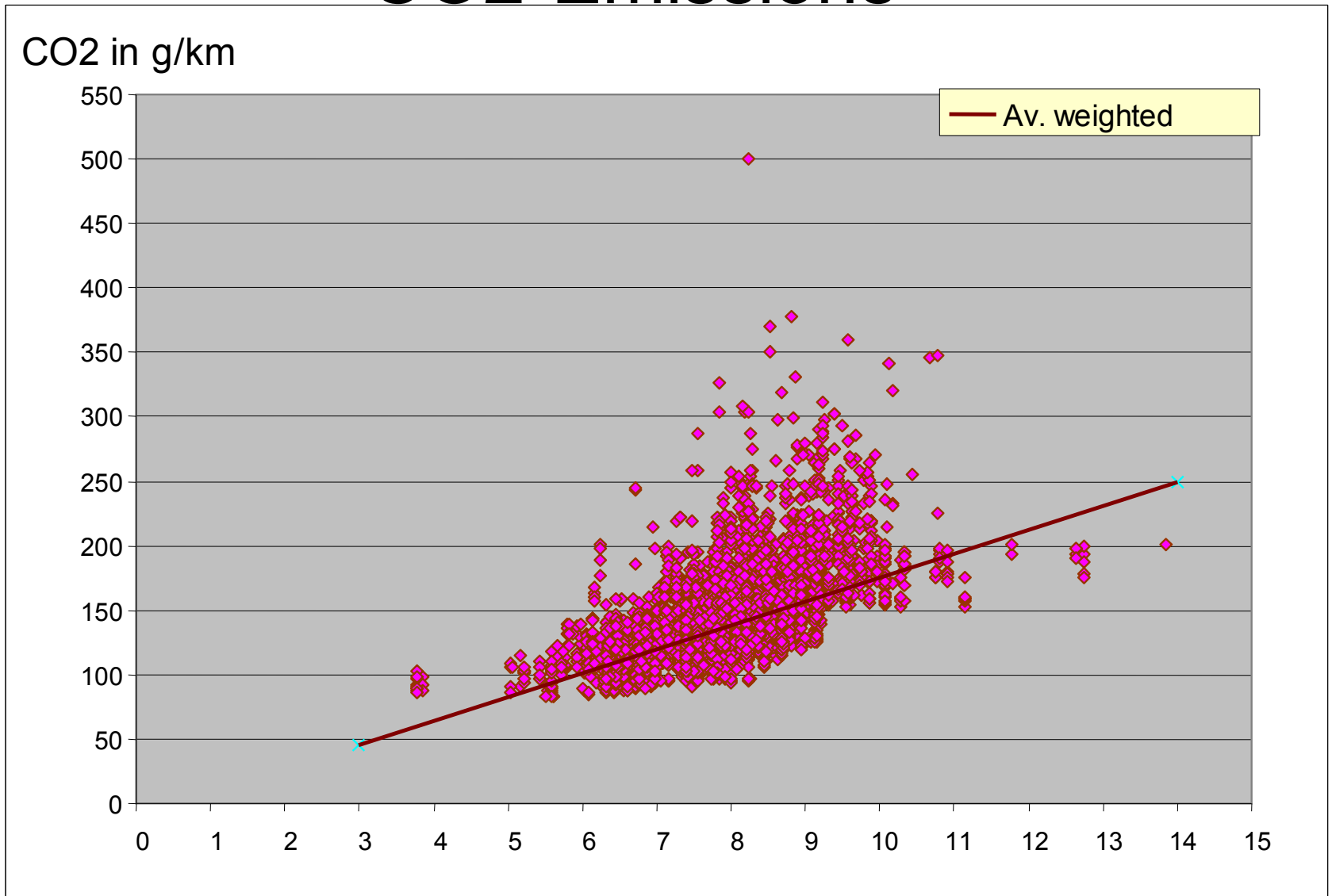


Newly registered Vehicles in Germany 2006



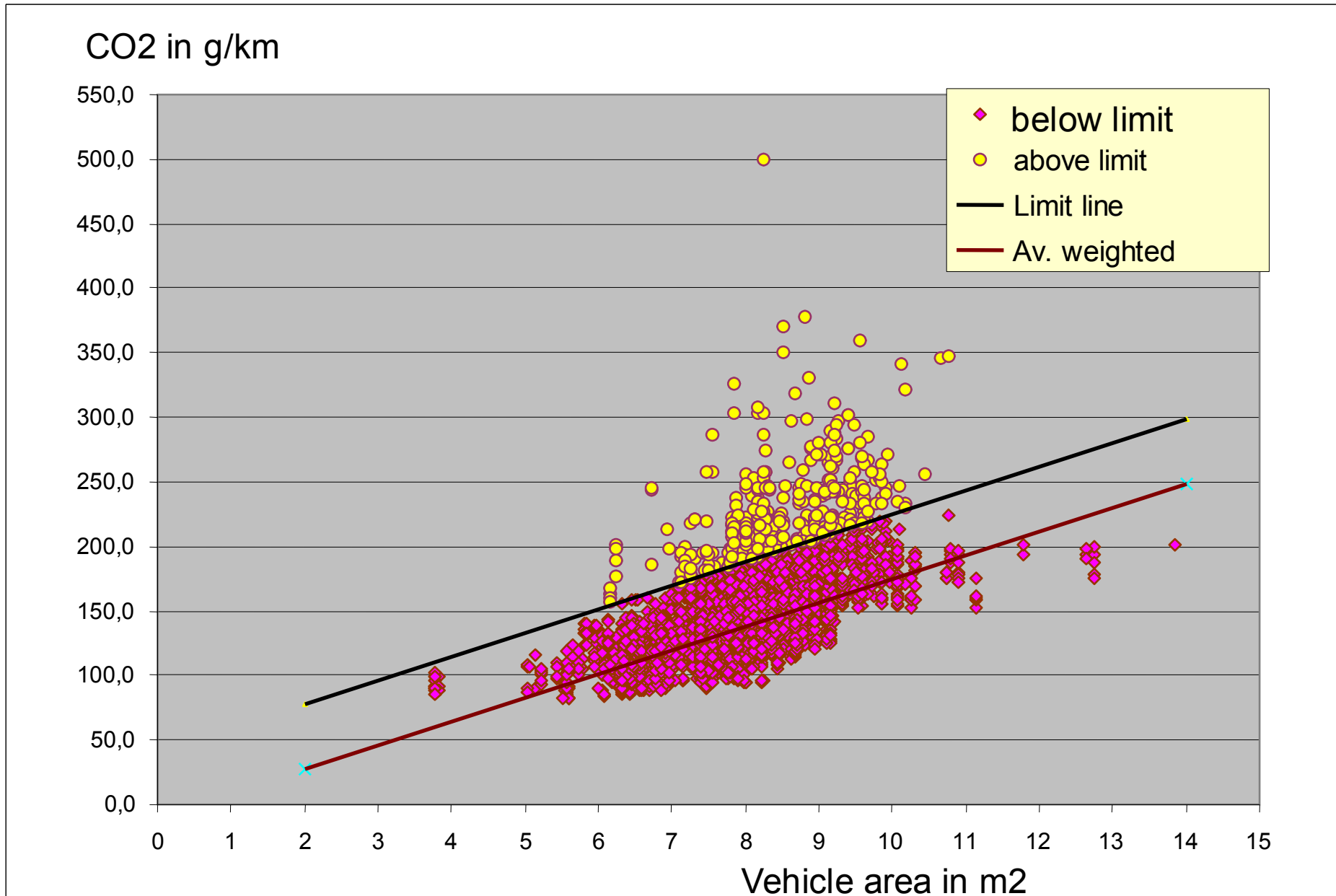
Newly registered Vehicles in Germany 2006

CO2-Emissions

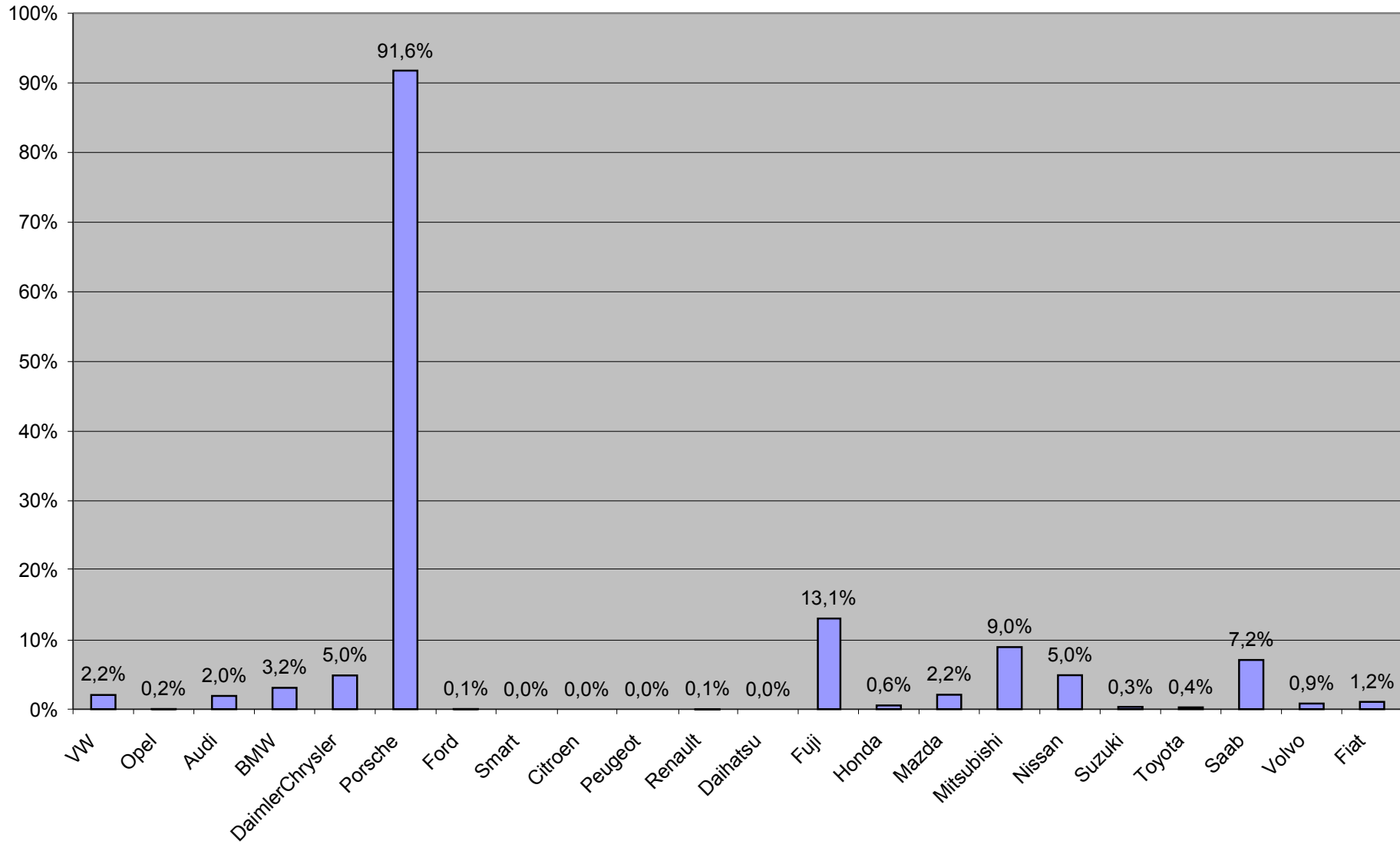


Vehicle area in m²

Proposal for a CO₂ Limit



Share of Vehicles above the Limit Line



Conclusions

For the further development of conventional vehicles technical measures are foreseen, which allows under the condition of a consequent enforcement until the year 2050 a reduction of the average fuel consumption to 3 liter/100 km, which is a reduction of the GHG-Emissions to 70 g CO₂/km (-58% compared to 2004). The technologies the reduction of the energy consumption are widely available. A considerable reduction of the vehicle mass and improved combustion engines in combination the hybrid allows such low fuel consumption.

The additional costs for more efficient vehicles compared to the reference vehicle are about 400 to 700 Euro per vehicle in the year 2008 and 2000 to 5000 Euro in the year 2050 for high efficiency vehicles. But this vehicles have due to the very low fuel consumption much lower running costs.

Conclusions (2)

By further efforts (new propulsion concepts and additional requirements for the reduction of the vehicle mass, C_w value and rolling resistance), it is possible in a efficiency scenario to reduce the average fuel consumption below 2 Liter/100km, equivalent to CO₂-emissions of about 50 g CO₂/km. Under the assumption of increasing oil prices and modest additional costs compared to the reference vehicle it is possible to achieve with this efficiency strategy in total cost reductions.

EU- Enterprise Commissioner Günther Verheugen
on the Future of the European Automotive Industry
and the EU- Environment Strategy:

Gas guzzlers can't be privileged anymore



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Integrated Approach

