Umwelt Bundes Amt
für Mensch und Umwelt

How to make a clean Cars

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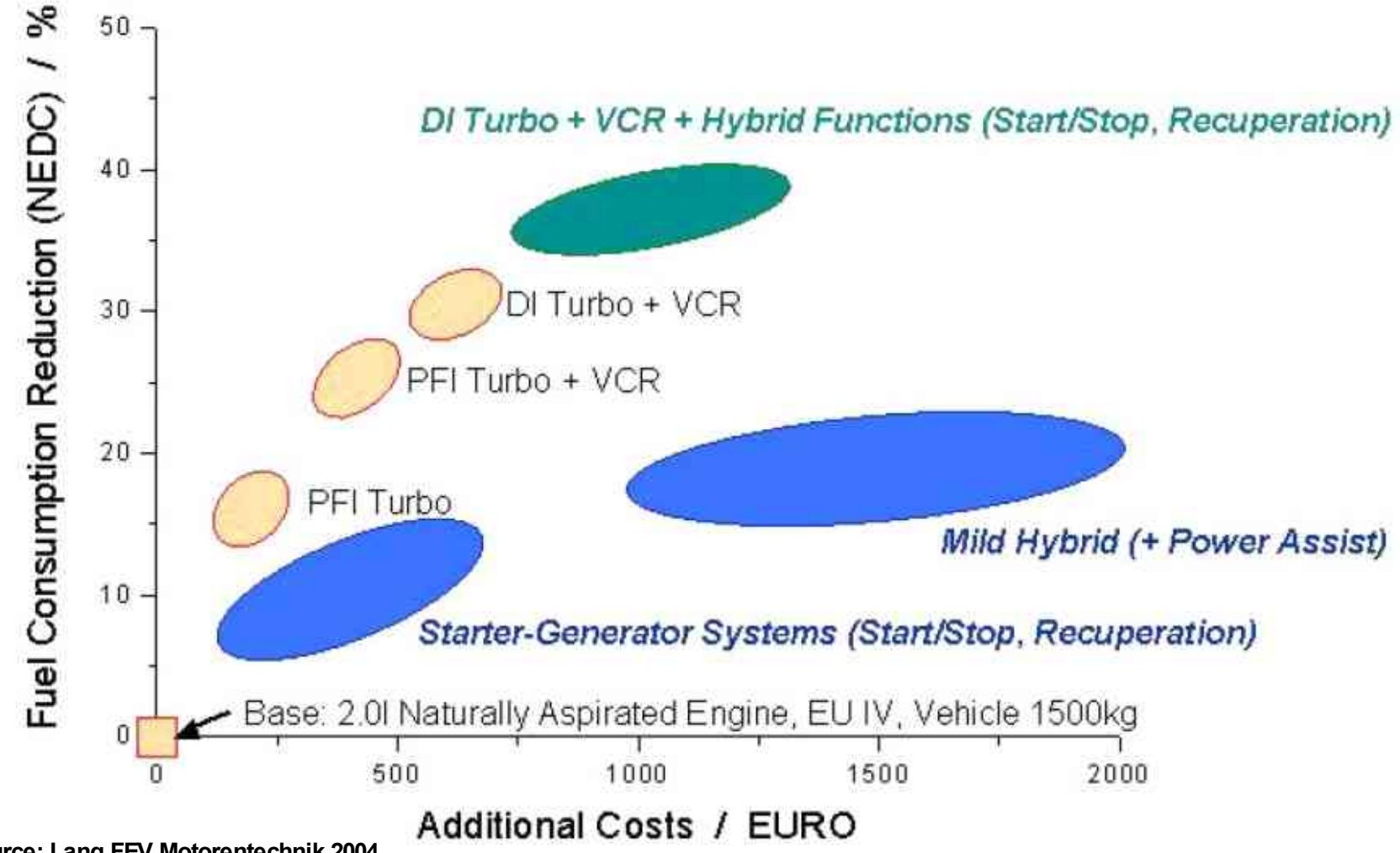
Assessment of Fuel consumption, Potential and Cost of Hybrid Concepts



Source: Lang,FEV Motorentechnik 2004

Fuel Consumption Reduction by Retrofit

Golf TSI 1,4 l 125 kW

Comparison Petrol versus Diesel

Petrol

1.4 TSI 125 kW 6- gear box

7,2 l/100km CO_2 169 g/km Price 22.700,00 €

1.4 TSI 125 kW DSG

7,2 l/100km CO_2 169 g/km Price 24.375,00 €

Diesel

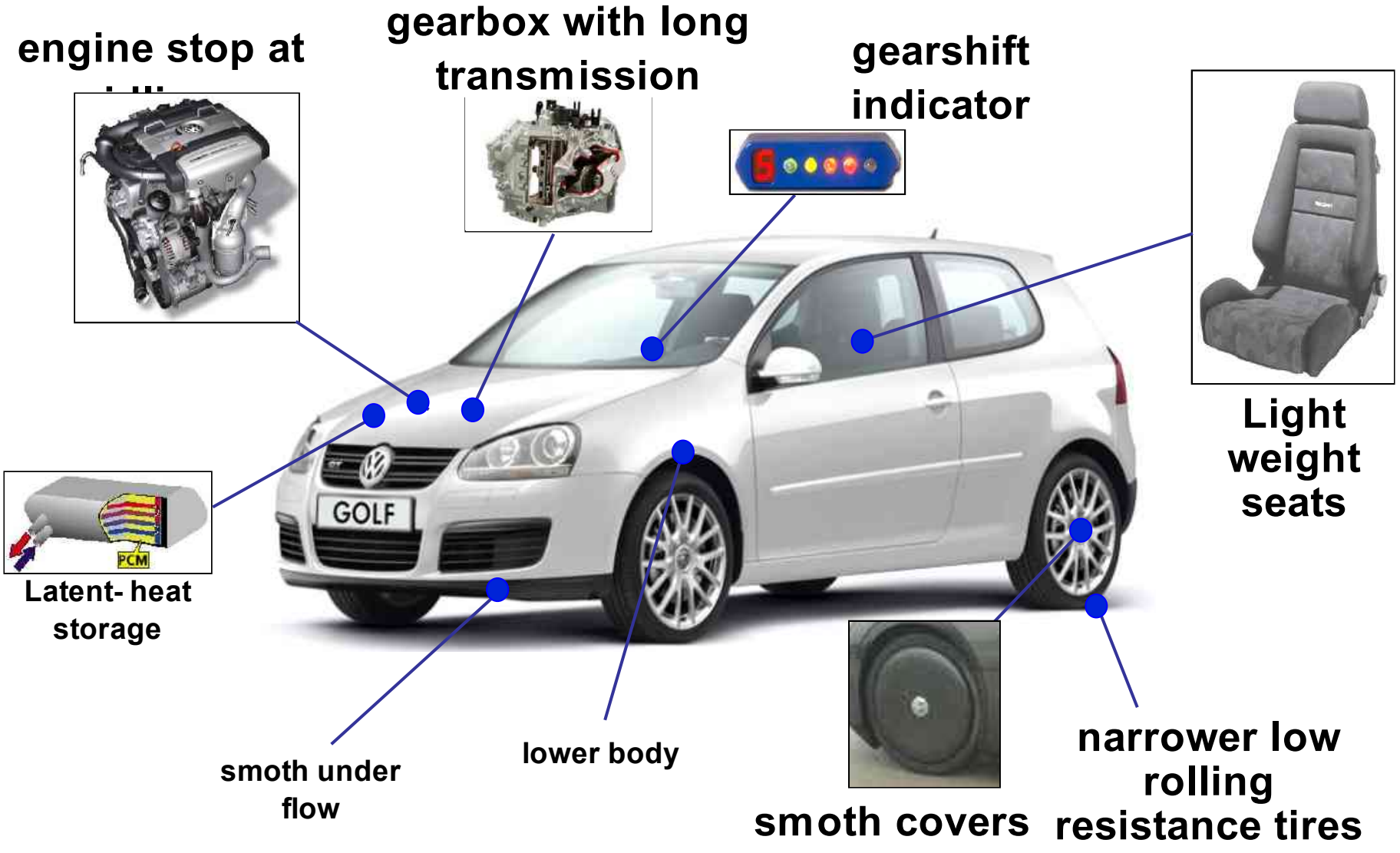
2.0 TDI DPF125 kW 6-gear box

6,0 l/100km CO_2 158 g/km Price 25.175,00 €

2.0 TDI DPF125 kWDSG

6,4 l/100km CO_2 173 g/km Price 26.850,00 €

Demonstration Car
Overview on the Fuel Saving Measures



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, 0.9*i_{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 x $m_{1\text{-Liter-car}}$)
  - total weight: 680 kg (normal), 905 kg (full loaded, 4Persons)
  - c_w-value: 0,19 (equal Mercedes Study Bionic car)
  - front area: 2 x $A_{1\text{-Liter-car}}$
  - rolling resistance: equal $f_{roll,1\text{-Liter-car}}$

Mercedes Studie Bionic car

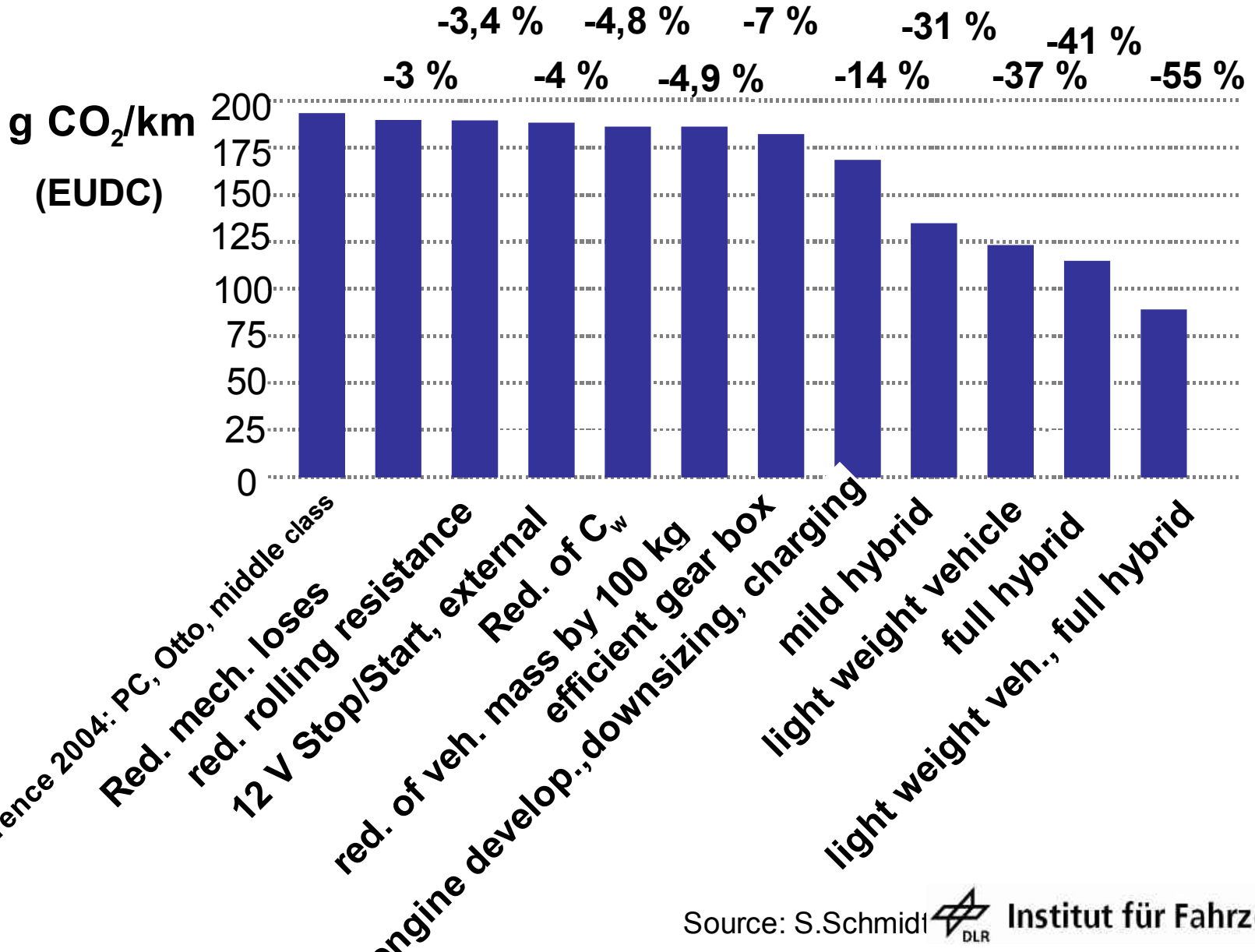
Source: ika

Simulation Results 4-Seater

vehicle:		
mass	[kg]	680 (580+100)
c_w-value	[-]	0.19
front area	[m²]	2.0
rolling restistance	[%]	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**

Source: ika

Reduction Potential Technical Measures



Source: S.Schmidt

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 %

CO_2- 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 CO_2**

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 resistence (-10 %) reduction aerodynamic drag (-5 %)	• **4.45**	• **33.3**	• **5.91**	• **17.0**

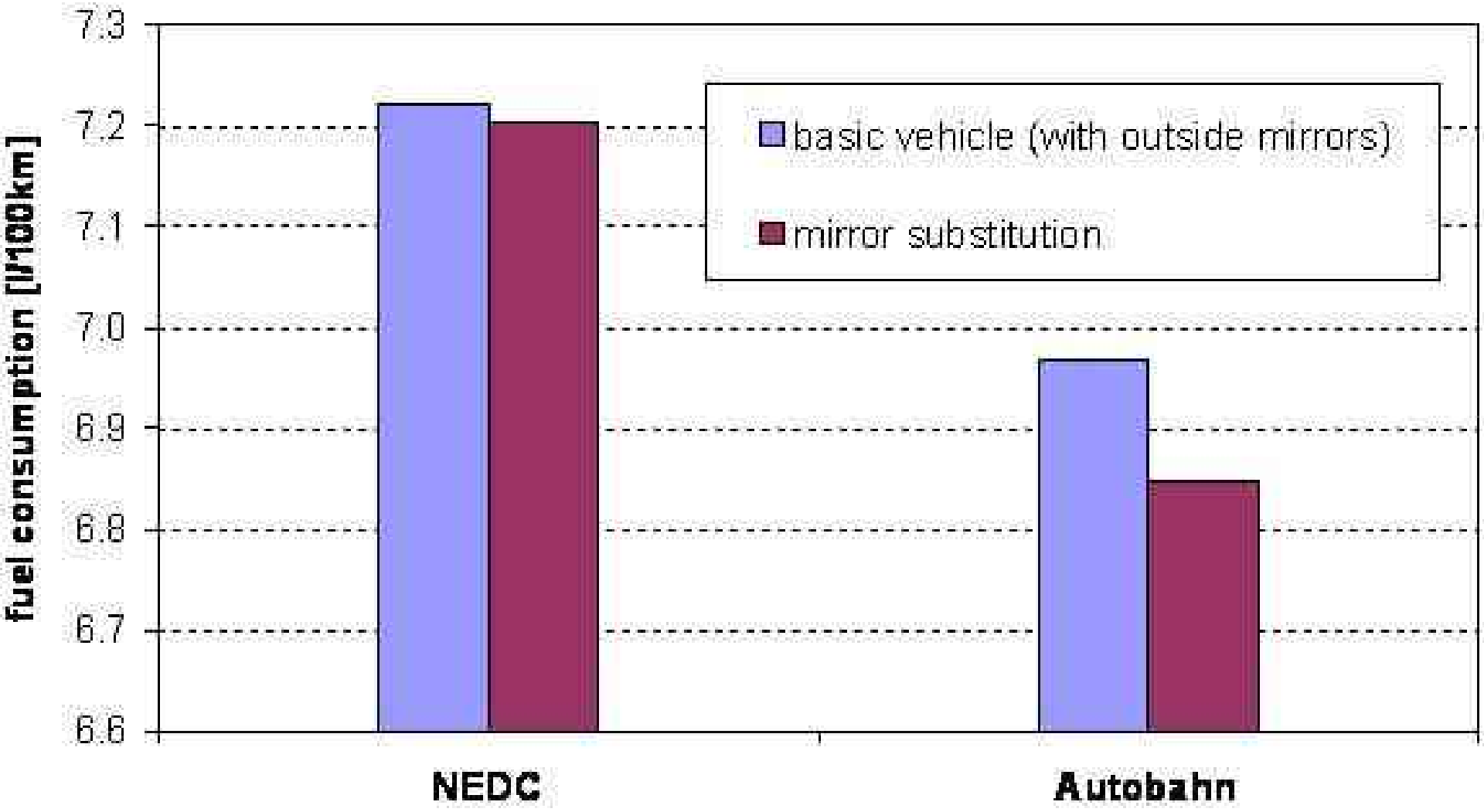
ika

Outside Mirror

Influence of the outside Mirror to c_w x A

- Golf GT: c_w x A = 0,74 m²
- Without outside mirror: c_w x A = 0,713 m²
- dc_w x A = -0,027 m²

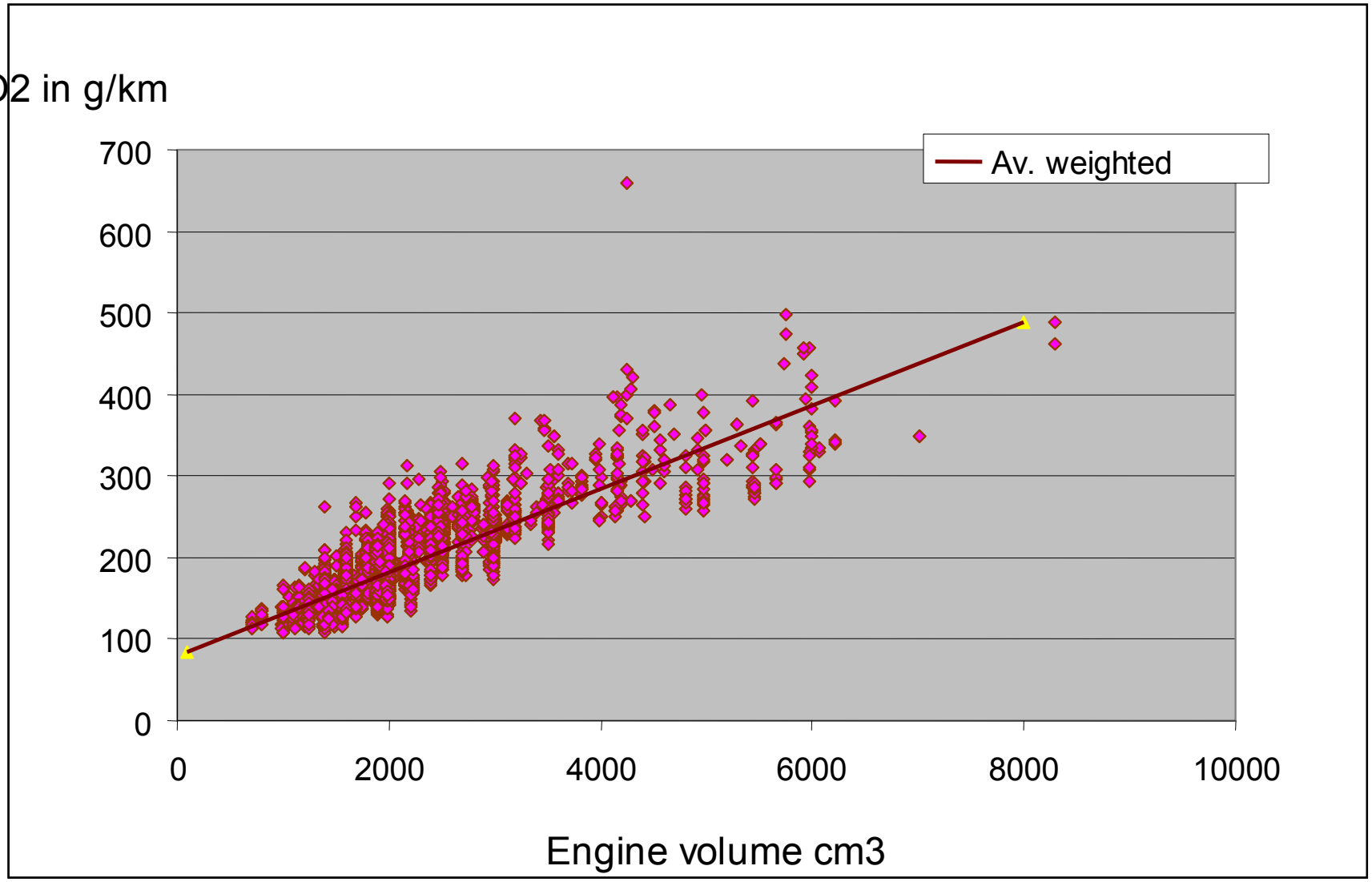
Cameras/Monitors instead of Outside Mirror



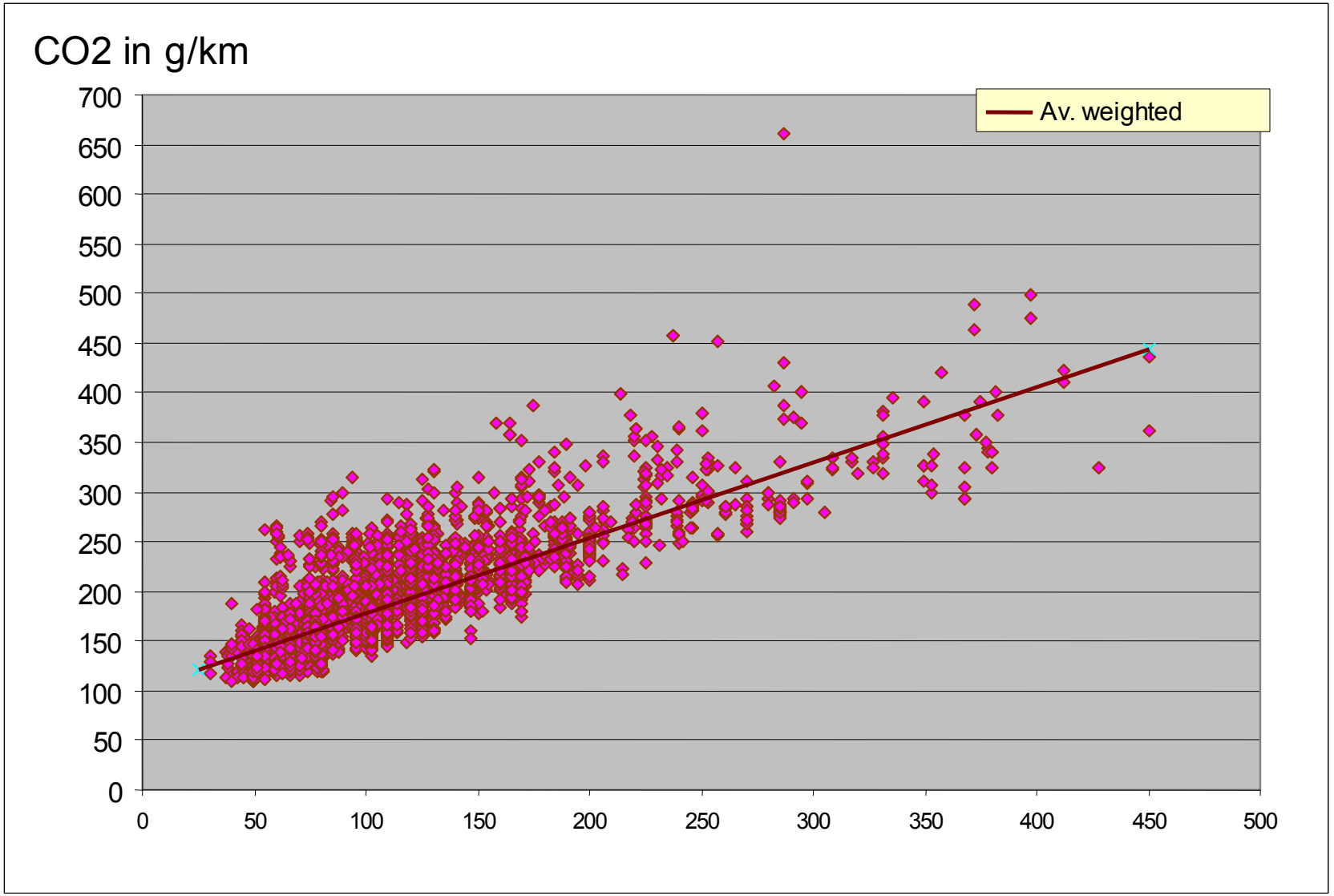
Source: ika

What Parameters for a CO_2 Limit?

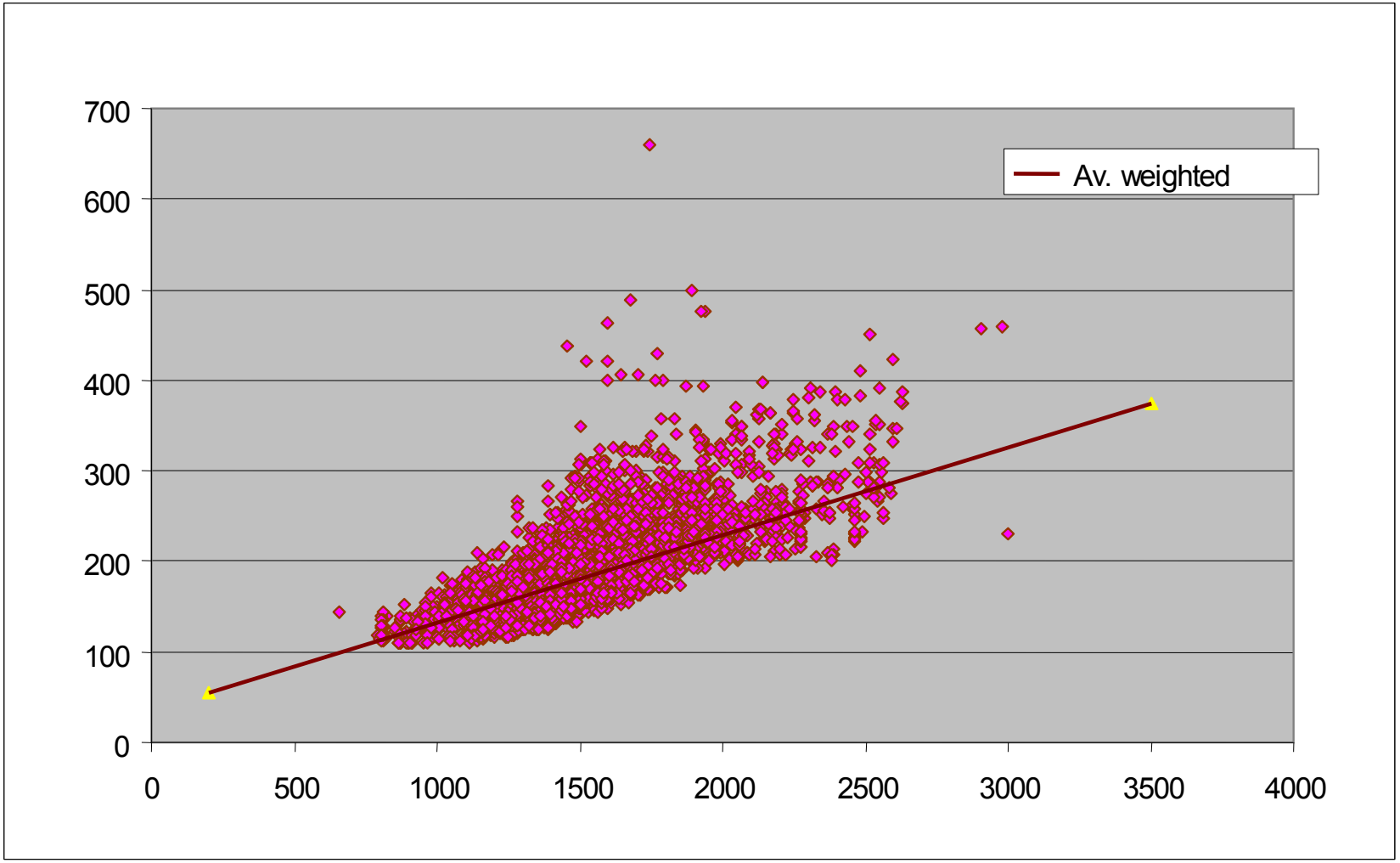
Newly registered Vehicles in Germany 2006
CO2-Emissions



Newly registered Vehicles in Germany 2006
CO2-Emissions

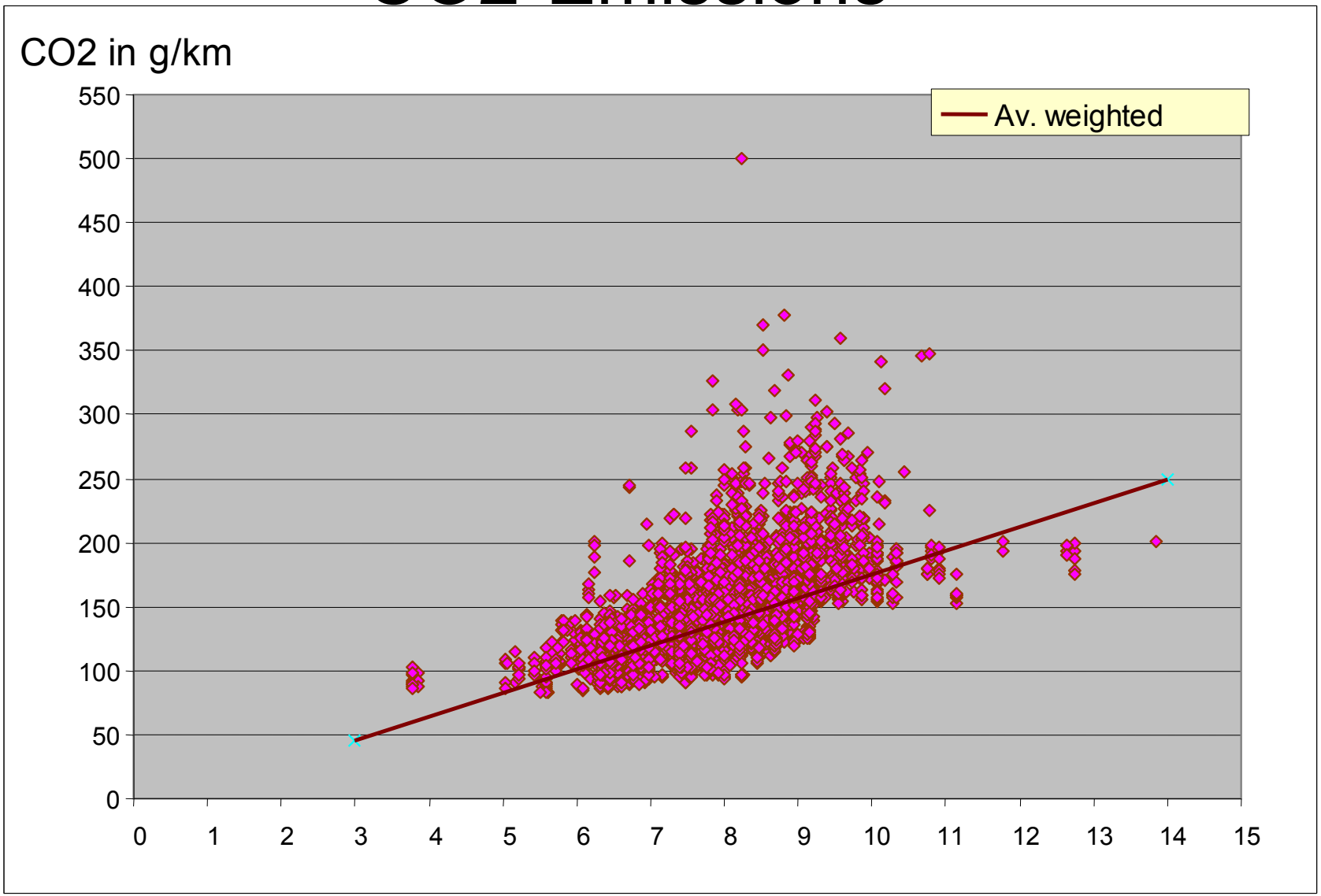


Newly registered Vehicles in Germany 2006

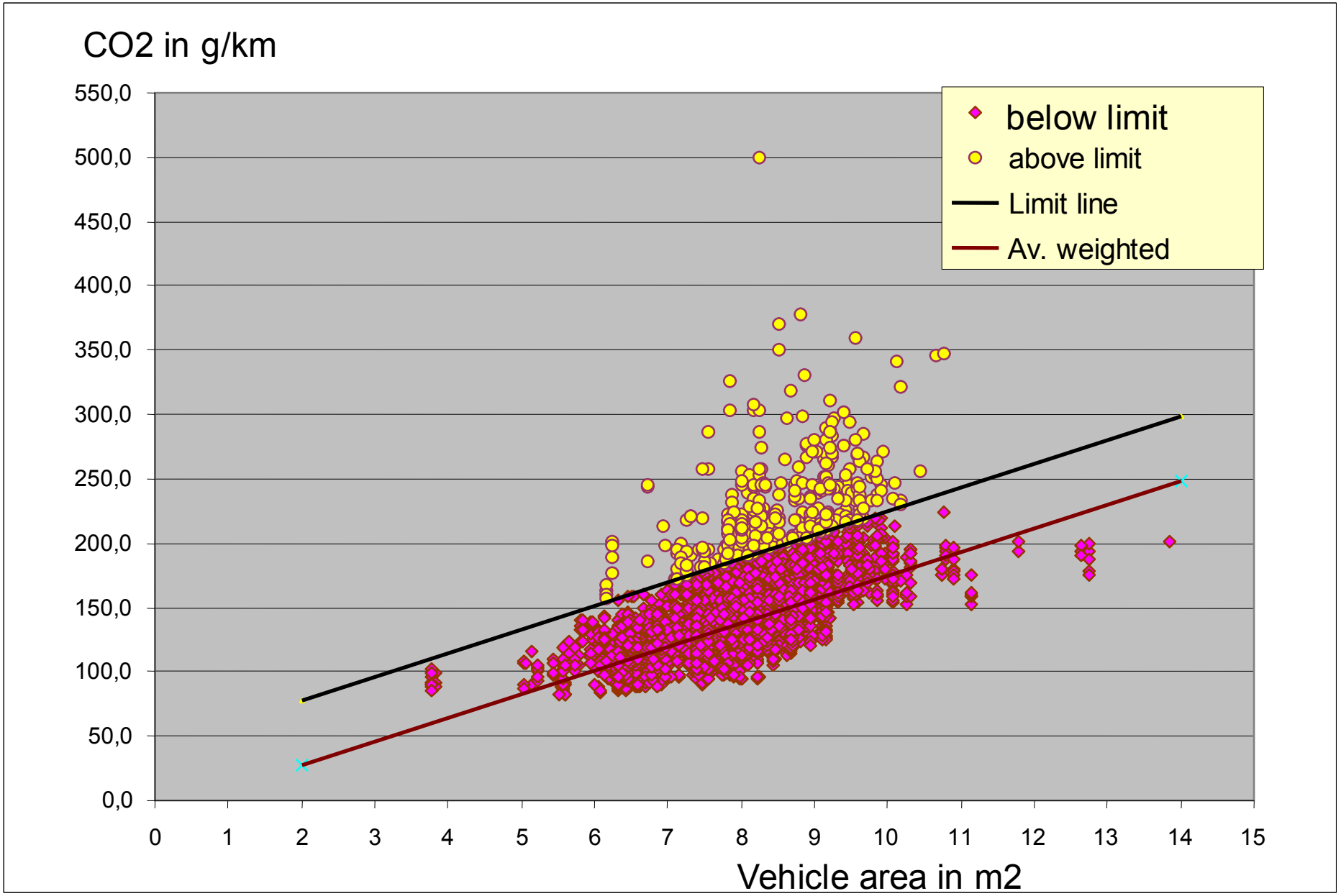


Datengrundlage: KBA 2006, betrachtet: 1.677 492 Pkw

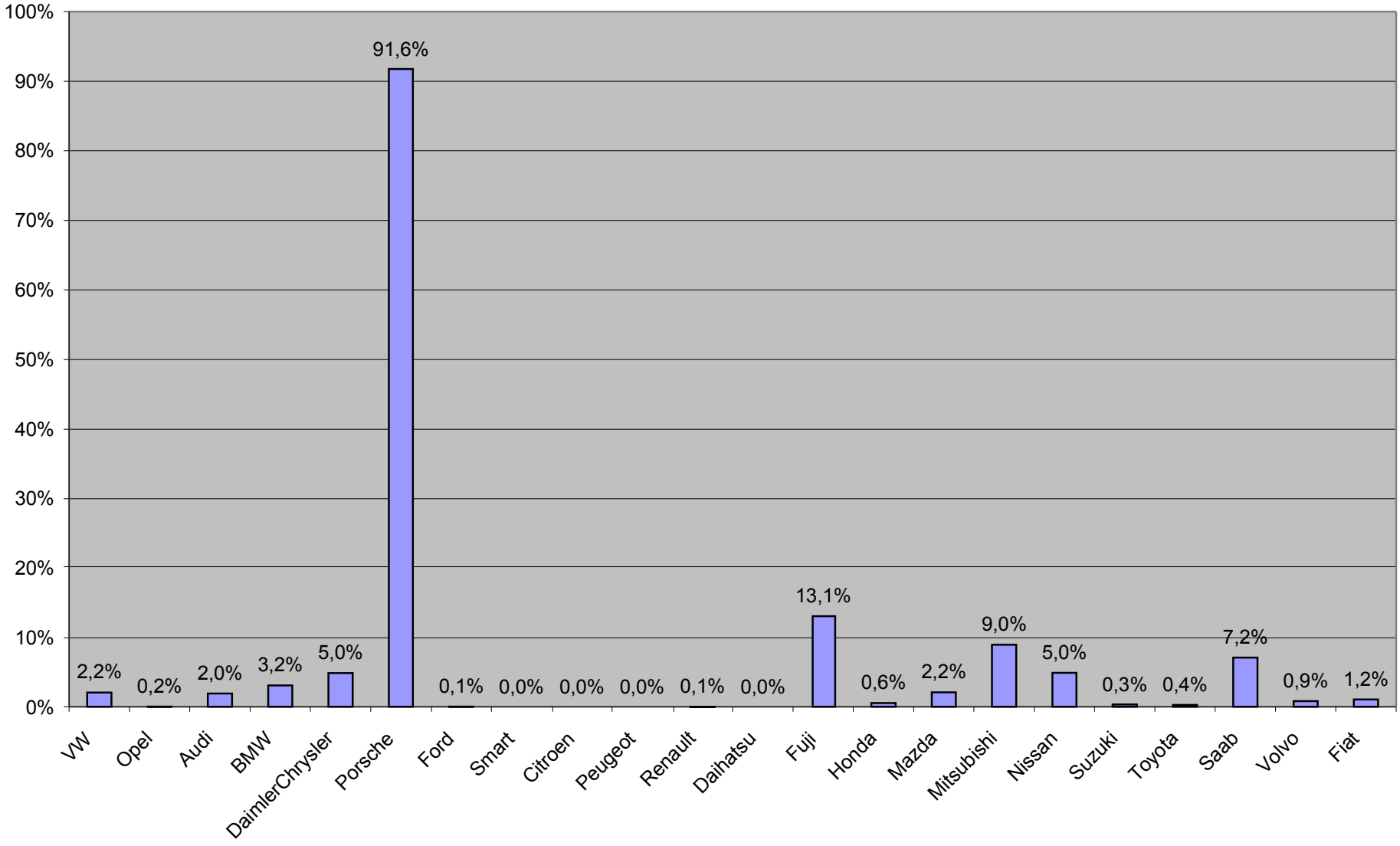
Newly registered Vehicles in Germany 2006
CO2-Emissions



Proposal for a CO_2- 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 CO_2/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 CO_2-emissions of about 50 g CO_2/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

Quelle: auto motor und sport-Redakteurin Brigitte Haschek, dpa, ecopix, teamwork

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Integrated Approach