ENVIRONMENTALLY FRIENDLY VEHICLE (EFV)

FEASIBILITY STATEMENT

0. EXECUTIVE SUMMARY

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1. INTRODUCTION

1.1. BACKGROUND

Tackling climate change and improving energy efficiency are two of the major challenges currently facing transport policymakers around the world. In this context, the development and introduction of EFV's as well as renewable fuels are the main fields of action. This issue concerns us all: the government, the industry, the research community and the consumers. Nobody can and must shirk from the responsibility for protecting health and tackling climate change especially with regard to safeguarding the life support systems for future generations.

The presentations and discussions at the 3rd EFV Conference in Dresden as well and at previous conferences in Tokyo (2003) and Birmingham (2005) as well as in WP.29 have shown that we can only jointly meet the current challenges. The presentations and the conclusion paper of the Dresden conference are available on the website of Federal Ministry of Transport, Building and Urban Affairs (http://www.bmvbs.de/g8-2007). The essential results of the 3rd EFV Conference are the following:

- The United Nations expect that between 2000 and 2030 the global vehicle population will double from 800m to 1.6 billion vehicles. Given this growth it is essential to take action now to achieve a greater use of EFV's and advanced technologies.
- In an integrated approach, all road transport players have to be involved in the reduction of CO_2 and pollutant emissions and where possible technical neutral approach should be followed. Increasing the use of environmentally friendly and sustainable alternative energy sources like for example advanced biofuels (biodiesel, bioethanol, biogas, synthetic biofuels) or renewable hydrogen and electricity are some of the essential fields of action.
- Measures to support the introduction of EFV's should be based on a common understanding. This means that we jointly should develop a globally harmonised method for evaluating the environmental friendliness of a vehicle taking into consideration regional differences.
- In developing an evaluation method, focussing solely on the vehicle will not yield the required results. Rather, the development has to be based on a holistic approach. Energy consumption and the emission of greenhouse gases have to be evaluated on the basis of an integrated ″well-to-wheels″ approach which comprises both the preceding fuel provision chain (″well-to-tank″) and the fuel use in the vehicles (″tank-to-wheels″). In the long run, the possibility of an extensive lifecycle evaluation, which also takes into account the following issues development - production - use - disposal of vehicles, should be examined as well. This should be further developed beyond the vehicle lifecycle considering also interfaces like vehicle and energy supply infrastructure, driver – vehicle interaction (e.g. ITS) and other elements in an Integrated Approach.

- It is recommended to have a close cooperation with the World Forum for Harmonisation of Vehicle Regulations (WP.29) of the United Nations in Geneva (UN-ECE).
- Future EFV Conferences is to be held every two years and should focus on the following issues:
  - status report regarding the set goals,
  - exchange of experiences with regard to ongoing measures for promoting / introducing EFV's,
  - exchange of experiences and problem analysis regarding the legal and economic framework,
  - regular status report to the G8-Leaders (according to the decision at Heiligendamm).

1.2. ISO 14021 ″ENVIRONMENTAL LABELS AND DECLARATIONS″

Section 5.3 (Terms and definitions) of ISO 14021defines:

> An environmental claim that is vague or non-specific or which broadly implies that a product is environmentally beneficial or environmentally benign shall not be used. Therefore, environmental claims such as "environmentally safe", "environmentally friendly", "earth friendly", "non-polluting", "green", "nature's friend" and "ozone friendly" shall not be used.

This point was incorporated in the international standard to avoid the misuse of unsubstantiated environmental claims for advertising and marketing purposes.

1.3. OBJECTIVE OF THE EFV

To continue a fruitful cooperation between WP.29 and the future EFV conferences, it is proposed to establish an informal group under GRPE as a parallel activity. In a first step the informal group shall prepare a review of the feasibility of the proposed EFV concept (evaluation method, holistic approach). Taking the idea of world wide harmonization into account, the applicability of the EFV concept needs to be considered for all regions of the world. Therefore following work packages are foreseen:

2.1 The available literature and concepts, including regulations and standards, shall be screened and analysed.

2.2 In a first step energy efficiency and CO_2 emissions will be considered and assessed on the basis of an integrated ″well-to-wheels″ approach.

2.3 The feasibility of the successful development of a harmonised evaluation method should be examined and assessed.

1.4. ORGANIZATIONAL STRUCTURE

The EFV concept requires an involvement of the two environmental GR groups of WP.29: GRPE (pollutant emissions, fuel consumption/CO_2) and GRB (noise). In addition assistance is needed from further experts i.e. those dealing with well to wheel aspects.

The following organisational structure is proposed:

- Establishment of an informal group under GRPE, in cooperation with GRB
- Report to GRPE and GRB
- The chair/co-chair of the informal group should rotate, in relationship to the country organising the EFV conference.

1.5. WORK PLAN AND TIME SCHEDULE

January 2008	ToR to GRPE (informal document)
February 2008	ToR to GRB (informal document)
March 2008	Request for a mandate by WP.29
April 2008	Initiation of work of informal group
2009	Documents to GRPE / GRB / WP.29 (review of the feasibility of the EFV evaluation concept)
November 2009	Conclusion by WP.29
November 2009	Presentation at 4th EFV conference in India

1.6. FEASIBILITY STATEMENT OF GRPE

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1.7. PRESENTATION ON BEHALF OF WP.29 AT 4TH EFV CONFERENCE (INDIA 2009)

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2. DEFINITIONS

2.1. ENVIRONMENTALLY FRIENDLY

The Term "environmentally friendly" shall not be used according to ISO 14021 (see 1.2).

2.2. LIFE CYCLE ASSESSMENT (LCA)

Life Cycle Assessment (LCA) is a method detailed in ISO 14040/44 to compile and evaluate inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. The life cycle consists of all processes respectively consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to final disposal. Thus the scope goes beyond a well-to-wheel approach as – for the case of vehicle LCAs – covering not only the generation of fuels to its use in vehicles but also the generation of all materials needed to produce a vehicle to its final end-of-life vehicle stage [1].

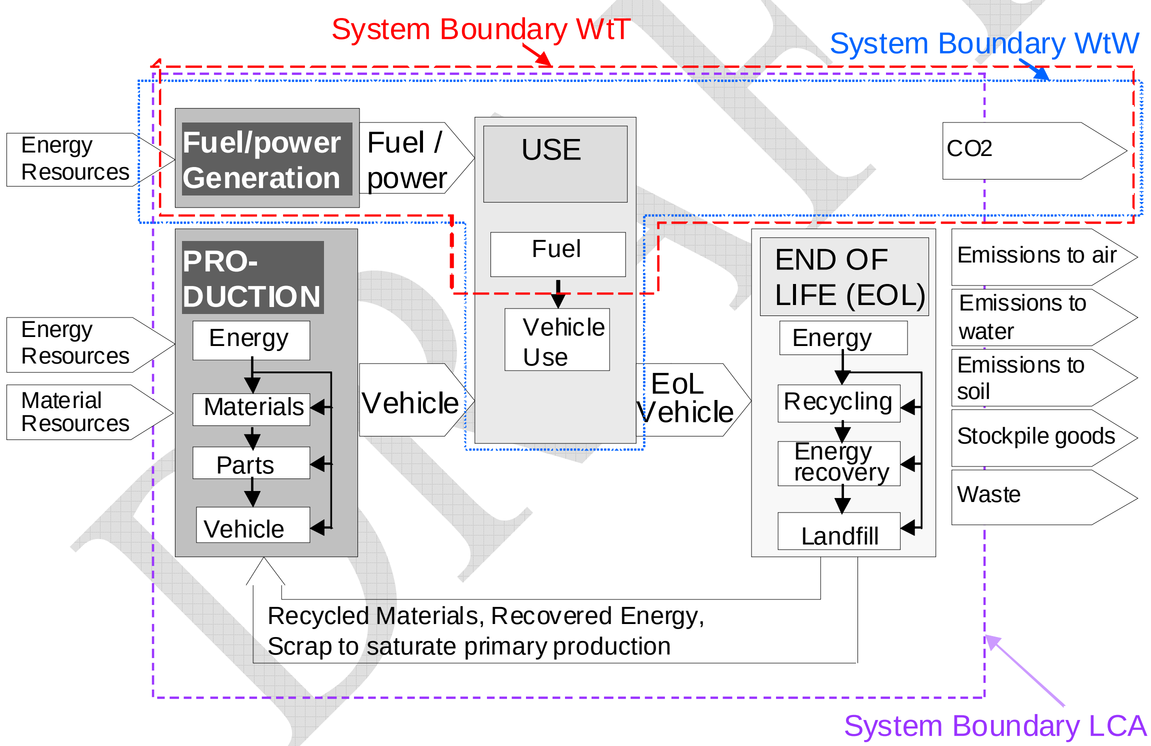


Fig. 2.2-1: Scheme of Life Cycle Assessment method. (Source: Schmidt et al, 2004)

2.3. WELL TO WHEEL (WELL TO TANK, TANK TO WHEELS)

Well to Tank (WTT) evaluations account for the energy expended and the associated GHG emitted in the steps required to deliver the finished fuel into the on-board tank of a vehicle. They cover the steps extracting, transporting, producing and distributing the finished fuel [2].

The Tank to Wheels (TTW) evaluation accounts for the energy expended and the associated GHG emitted by the vehicle in the reference driving cycle [2].

Well to Wheel (WTW) evaluations account for the energy expended and the associated GHG emitted in the steps fuel production (Well to tank) and vehicle use (tank to wheel) [2].

2.4. ENERGY EFFICIENCY

Efficiency is the ratio of the output to the input [3].

There are three explanations of energy efficiency:

- Ratio of energy output of a conversion process or of a system to its energy input [4].
- Conversion ratio of output and input energy of energy production technologies and end-use appliances. The lower the efficiency, the more energy is lost [5].
- Energy efficiency refers to products or systems designed to use less energy for the same or higher performance than regular products or systems [6].

2.5. ENERGY MIX

Energy mix is the combination of coal, oil gas, nuclear hydro biomass & waste and other renewables chosen to respond to the energy demand. As example the mix for the European energy use is shown:

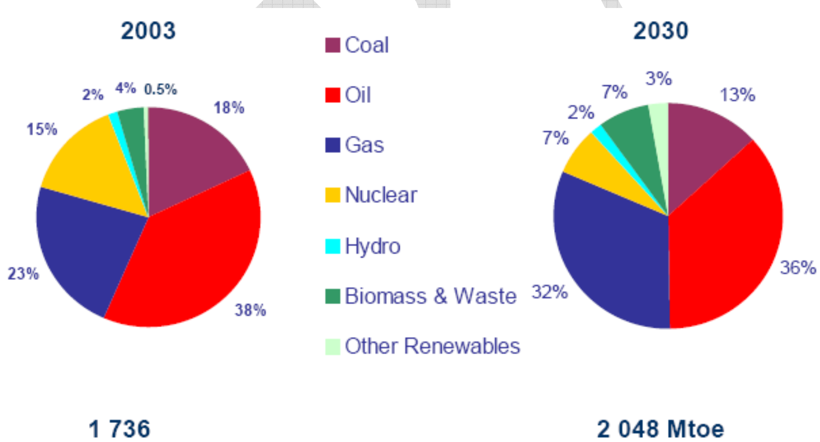


Fig. 2.5-1: Energy mix for EU.

- Resource availability is influencing the share in this combination of each energy sources.

2.6. LIFETIME; USEFUL LIFE; LIFE CYCLE

- Lifetime:
  Lifetime of a vehicle is defined as the time from start of usage until end of vehicle life. The end of vehicle life depends on the individual decision of the car owner whether the car will be sold to other persons or markets or the car will be recycled according to existing legislation. Therefore lifetime of a vehicle is always an expert guess and can not be measured or defined precisely [7, 8].

- Useful life:

	Reference	Comment
Europe	**European Union:** (EC) 692/2008 (Euro 5/Euro 6) *ANNEX VII* VERIFYING THE DURABILITY OF POLLUTION CONTROL DEVICES (TYPE 5 TEST) *ANNEX II* IN-SERVICE CONFORMITY	The whole vehicle durability test represents an ageing test of 160 000 kilometers driven on a test track, on the road, or on a chassis dynamometer. As an alternative to durability testing, a manufacturer may choose to apply the assigned deterioration factors from the following Tab.. For ISC checking vehicles are selected up to 100.000 km.
USA	**Code of Federal Regulations (CFR):** PART 86 - CONTROL OF EMISSIONS FROM NEW AND IN-USE HIGHWAY VEHICLES AND ENGINES (CONTINUED) **§ 86.1805–04**	The full useful life for all LDVs, LDT1s and LDT2s is a period of use of 10 years or 120,000 miles, whichever occurs first. For all HLDTs, MDPVs, and complete heavy-duty vehicles full useful life is a period of 11 years or 120,000 miles, whichever occurs first. This full useful life applies to all exhaust, evaporative and refueling emission requirements except for standards which are specified to only be applicable at the time of certification. Manufacturers may elect to optionally certify a test group to the Tier 2 exhaust emission standards for 150,000 miles to gain additional NOX credits, as permitted in § 86.1860–04(g), or to opt out of intermediate life standards as permitted in § 86.1811–04(c). In such cases, useful life is a period of use of 15 years or 150,000 miles, whichever occurs first, for all exhaust, evaporative and refueling emission requirements except for cold CO standards and standards which are applicable only at the time of certification.

For automotive LCA, EUCAR agreed to base the passenger car assessments on 150.000 km. However, it is good practice of OEMs to apply different mileages in different vehicle segments.

- Life cycle:
  Life cycle is defined as the consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal [9].

2.7. INTEGRATED CONCEPTS

2.7.1. TOP RUNNER APPROACH

The top runner approach is a method to set the efficiency standard higher than the energy efficiency of most efficient product currently available in the market.

- By target year, average fuel consumption must be higher than the best fuel efficiency in the base year.
- Standard will become high but reachable because target values are already achieved by actual vehicles in the base year.
- Particular types of cars such as HEVs and MT mounted cars are excluded from top runner

2.7.2. INTEGRATED APPROACH

Integrated approach means the adoption of a comprehensive strategy involving all relevant stakeholders (*i.e.* vehicle manufacturers, oil/fuel suppliers, customers, drivers, public authorities, etc.). The underlying assumption in support of such an approach is that improvements can be achieved more efficiently by exploiting the synergies of complementary measures and optimising their respective contributions rather than by focusing on improvements in car technology alone. An integrated approach would provide for:

- Greater potential for environmental benefit when more elements of the system are covered;
- Greater potential for the identification of the most-cost effective options;
- Policy coherence giving more scope for synergies and avoidance of perverse effects;
- A fair distribution of the burden between different stakeholders.

The integrated approach implies building links with other policy areas. Some of the measures which would contribute to environmental benefits also have the potential to enhance road safety. Such synergies should be exploited. The integrated approach combines further developments in vehicle technology with an increased use of alternative fuels, intelligent traffic management, changes in driving style and car use, and environmentally-related taxation. This requires partnership between the fuel industry, policy makers, drivers and the automotive industry.

2.8 SWOT ANALYSIS

The SWOT analysis combines an investigation of the strength, weakness, opportunities, and threats of a method.

For the EFV the SWOT concept is based on appropriate criteria to check whether these methods are comprehensive enough (environmental aspects covered, system boundaries) while being still applicable and realistic (data, effort for application, comparability).

3. EXISTING LEGISLATION AND ASSESSMENT CONCEPTS

3.1. REGULATIONS AND STANDARDS

3.1.1. JAPAN

3.1.1.1. TOP RUNNER PRINCIPLE

The ″Top runner approach″ has been introduced in Japan in 1998 when revising the Japanese Energy Conservation Law and consecutive government ordinances. In summary, the Japanese Top Runner uses, as a base value, the value of the product with the highest energy efficiency on the market at the time of establishing standards for such products. Standard values are set taking into account potential technological improvements leading to better energy efficiency. The producer is allowed to conform to the standard by ″average fleet″: all products should achieve this level of energy efficiency performance after a certain time frame. In case of non-compliance after expiry of the given transition period, firstly, the manufacturer of the product would be "advised" to ensure the product's compliance in a "recommendation" issued to him by the Ministry of Economy, Trade and Industry (METI). If the non-compliance continues, the manufacturer will be challenged by a system of marking poor performing products and may potentially be penalised. If penalised, such sanctions would amount up to a maximum of 1 Mio. Yen, that is some 7400 Euro. We are not aware of any penalties issued to date.

Compliant products may be labelled voluntarily under the top runner approach. Therefore, labelling can vary between products belonging to the same targeted product group. 21 product groups are targeted by the top runner in Japan including automotive applications.

The Japanese top runner focuses on the energy aspect solely. The approach does not restrict market access for any product, whether the particular product meets the target standard or not. The Japanese top runner mainly works with a "name and shame" marking scheme. Such a system may work well in Japan due to the specific enterprise culture. Serious doubts arise for adapting it to the reality of the European market that is already today open to unfair competition. Cultures and philosophies behind the European and the Japanese top runner concepts consequently differ fundamentally.

3.1.1.2. EXHAUST GAS EMISSION

Tab. 3.1.1.2-1: Exhaust Emission Limit – Gasoline and LPG fuelled vehicles.

	Test Mode [1]	Unit	CO	HC	NOx	PM [2]	New Model	All prod. / Imported veh.
New Short Term (Mean / Max)								
PC	10-15 Mode	g/km	0.67/1.27	0.08/0.17	0.08/0.17	-	Oct. 2000	Sep. 2002
	11 Mode	g/test	19.0/31.1	2.20/4.42	1.40/2.50	-		
Mini Com Veh	10-15 Mode	g/km	3.30/5.11	0.13/0.25	0.13/0.25	-	Oct. 2002	Sep. 2003
	11 Mode	g/test	38.0/58.9	3.50/6.40	2.20/3.63	-		
Light CV	10-15 Mode	g/km	0.67/1.27	0.08/0.17	0.08/0.17	-	Oct. 2000	Sep. 2002
	11 Mode	g/test	19.0/31.1	2.20/4.42	1.40/2.50	-		
Medium CV	10-15 Mode	g/km	2.10/3.36	0.08/0.17	0.13/0.25	-	Oct. 2001	Sep. 2003
	11 Mode	g/test	24.0/38.5	2.20/4.42	1.60/2.78	-		
New Long Term (Mean / Max)				**NMHC**				
PC	10-15 Mode + 11 Mode	g/km	1.15/1.92	0.05/0.08	0.05/0.08	-	Oct. 2005	Sep. 2007
Mini Com Veh			4.02/6.67	0.05/0.08	0.05/0.08	-	Oct. 2007	Sep. 2008/ Sep. 2007
LCV			1.15/1.92	0.05/0.08	0.05/0.08	-	Oct. 2005	Sep. 2007
Medium LCV			2.55/4.08	0.05/0.08	0.07/0.10	-	Oct. 2005	Sep. 2007
Post New Long Term [3] - Proposed on 8th Recommendation from the Central Environmental Counsel - Amended in November 2007 **(Mean/Max)**								
PC	JC08H + JC08C	g/km	1.15/1.92	0.05/0.08	0.05/0.08	0.005/0.007	Oct. 2009	Oct. 2009/ Sep. 2010
LCV			1.15/1.92	0.05/0.08	0.05/0.08	0.005/0.007	Oct. 2009	Oct. 2009/ Sep.
2010Medium LCV			2.55/4.08	0.05/0.08	0.07/0.10	0.007/0.009	Oct. 2009	Oct. 2009/ Sep. 2010

[1] Test mode: see pages 42-43 [2] PM limit applied to direct injection gasoline engine to which NOx absorber
[3] New PM measurement method; technically modified methods for CO and other gases

Tab. 3.1.1.2-2: Exhaust Emission Limit – Diesel vehicles.

	Test Mode [1]	Unit	CO	HC	NOx	PM	New Model	All prod. / Imported veh.
New Short Term (Mean / Max)								
PC ≤ 1265 kg	10-15 Mode	g/km	0.63/0.98	0.12/0.24	0.28/0.43	0.052/0.11	Oct. 2002	Sep. 2004
PC > 1265 kg			0.63/0.98	0.12/0.24	0.30/0.45	0.056/0.11	Oct. 2002	Sep. 2004
Light Com Veh			0.63/0.98	0.12/0.24	0.28/0.43	0.052/0.11	Oct. 2002	Sep. 2004
Med. Com Veh			0.63/0.98	0.12/0.24	0.49/0.68	0.06/0.12	Oct. 2003	Sep. 2004
New Long Term (Mean / Max)				**NMHC**				
PC ≤ 1265 kg	10-15 Mode + 11 Mode	g/km	0.63/0.84	0.024/0.032	0.14/0.19	0.013/0.017	Oct. 2005	Sep. 2007
PC > 1265 kg			0.63/0.84	0.024/0.032	0.15/0.20	0.014/0.019	Oct. 2005	Sep. 2007
Light Com Veh			0.63/0.84	0.024/0.032	0.14/0.19	0.013/0.017	Oct. 2005	Sep. 2007
Med. Com Veh			0.63/0.84	0.024/0.032	0.25/0.33	0.015/0.020	Oct. 2005	Sep. 2007
Post New Long Term [4] - Proposed on 8th Recommendation from the Central Environmental Counsel - Amended in November 2007 **(Mean/Max)**								
PC	JC08H + JC08C	g/km	0.63/0.84	0.024/0.032	0.08/0.11 [3]	0.005/0.007	Oct. 2009	Oct 2009/ Sep 2010
LCV			0.63/0.84	0.024/0.032	0.08/0.11	0.005/0.007	Oct. 2009	Oct 2009/ Sep 2010Medium
LCV			0.63/0.84	0.0240.032	0.15/0.20	0.007/0.009	Oct. 2010 [2]	Oct 2009/ Sep 2010 [2]

[1] Test mode: see pages 42-43
[2] Oct 2010 for Medium Commercial Vehicle w/ 1.7 t < GVW ≤ 2.5 t or Oct 2009 for Medium Commercial Vehicle w/ 2.5 t < GVW ≤ 3.5 t
[3] For vehicles not exceeding 1.265 kg. For vehicles > 1.265 kg: 0.15/0.20
[4] New PM measurement method; technically modified methods for CO and other gases

Other Requirements:

- From 2005:

HC is measured as NMHC
Light Weight Commercial Vehicles ≤ 1.7 t GVW (diesel and gasoline)
Medium Weight Commercial Vehicles: 1.7 < GVW ≤ 3.5 t (diesel and gasoline)
For vehicles powered by fuels other than gasoline, LPG or diesel:

- Test method is 10.15 mode + JC08C until 31 March 2011 (28 Feb 2013 for imported vehicle); after: JC08H + JC08C
- Emission limits are similar to the relevant 2009 vehicle regulation
- Application date: domestic vehicle: 01 Oct 2009; imported vehicle: 01 Sep 2010

- Test Mode:

Exhaust Emission Level will be calculated as below:
From Oct 2005: 10-15 mode hot start x 0.88 + 11 mode cold start x 0.12
From Oct 2008: 10-15 mode hot start x 0.75 + JC08 mode cold start x 0.25
From Oct 2009: JC08 mode hot start x 0.75 + JC08 mode cold start x 0.25

- Mean / Max:

Mean: to be met as a type approval limit and as a production average
Max: to be met as type approval limit if sales are less than 2000 per vehicle model per year and generally as an individual limit in series production

- Idle CO & HC – Gasoline and LPG:

Idle CO: 1per cent, Idle HC: 300 ppm

- Durability:

PC, truck and bus GVW < 1.7t: 80,000 km
PC, truck and bus GVW > 1.7t: 250,000 km
DF: 10-15 Mode: CO: 0.15; HC: 0.15; NO_x: 0.25
11 Mode: CO: 2.0; HC: 0.15; NO_x: 0.20
JC08 mode: CO: 0.11; NMHC: 0.12; NO_x: 0.21

- Evaporative Emissions – Gasoline and LPG:

Test similar to EC 2000 Evap test
(1 h hot soak at 27± 4°C + 24 h diurnal (20-35°C)),
test limit: 2.0 g/test, run on 10-15 Mode (three times).
Preparation driving cycle for EVAP:
25 sec. Idle + 11 mode x4 + ((24 sec. Idle + 10 mode x3 + 15 mode) x3)

- OBD – Diesel, Gasoline and LPG:

Current status: Vehicles to be equipped with OBD similar to EOBD requirements
OBD requirement for Passenger Cars and Commercial Vehicles with GVW ≤ 3.5 tons from October 2008

- Smoke – Diesel:

4-mode: opacity limit 25per cent; free acceleration limit 25 per cent; Max PM: 0.8 m-1
From 2009: diesel 4-mode is abolished.; Max PM: 0.5 m-1

- Fuel quality – Sulphur content:

Diesel: from Jan 2007: 10 ppm
Gasoline: current: 50 ppm; from Jan 2008: 10 ppm

NOx – PM Law:
Applicable in following metropolis: Tokyo, Saitama, Chiba, Kanagawa, Aichi, Mie, Osaka, Hyogo

	Weight category	NOx	PM
Diesel PC	-	0.25 g/km	0.026 g/km
Bus & truck	GVW ≤ 1.7 ton	0.25 g/km	0.026 g/km
	1.7 < GVW ≤ 2.5 ton	0.4 g/km	0.03 g/km
	2.5 < GVW ≤ 3.5 ton	4.5 g/kWh	0.09 g/kWh

If a vehicle does not satisfy the regulation limit it cannot be registered in the applicable area after grace period.

Grace period from 1st registration:
Diesel PC: 9 years
Small truck: 8 years
Small bus: 10 years

Local Ordinance on Diesel Vehicles – PM Emission Regulation
Applicable in whole area of Tokyo (exclude island area), Saitama, Chiba, Kanagawa

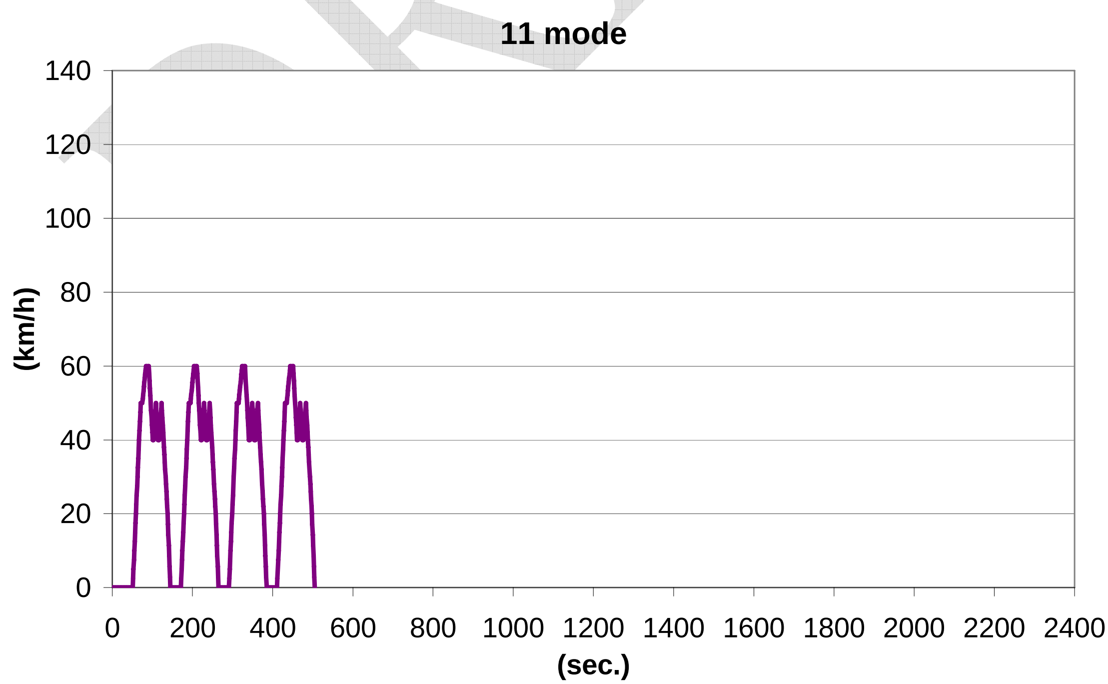
Diesel truck & bus	From Oct 2003	From April 2006*
GVW ≤ 1.7 ton	0.08 g/km	0.052 g/km
1.7 < GVW ≤ 2.5 ton	0.09 g/km	0.06 g/km
2.5 ton < GVW	0.25 g/kWh	0.18 g/kWh

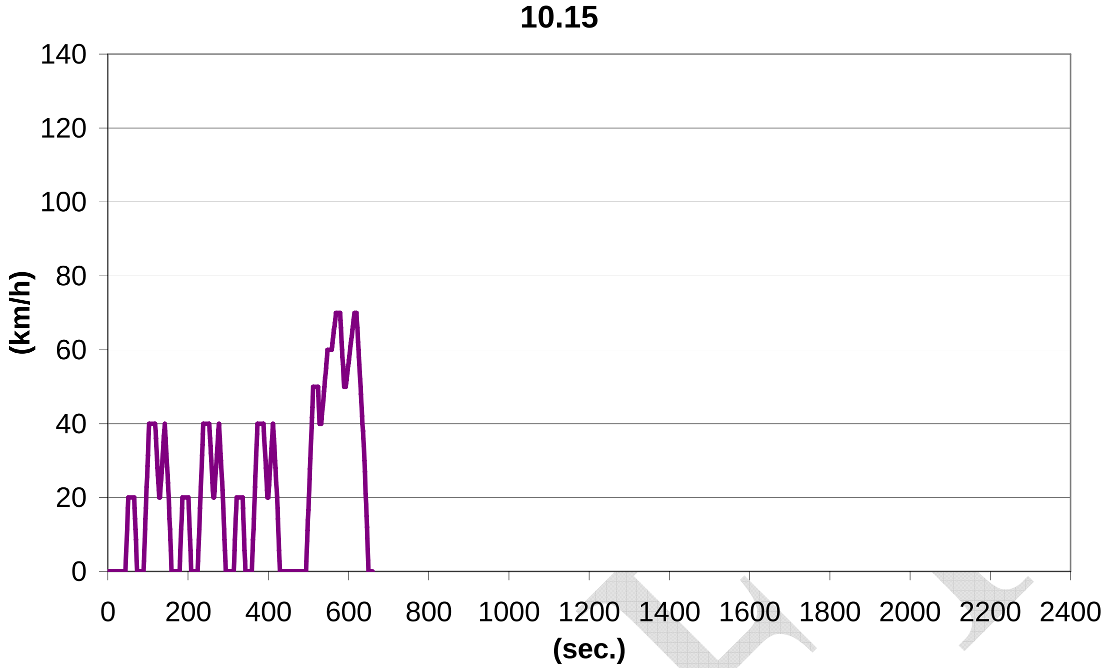
* In case of Tokyo and Saitama only

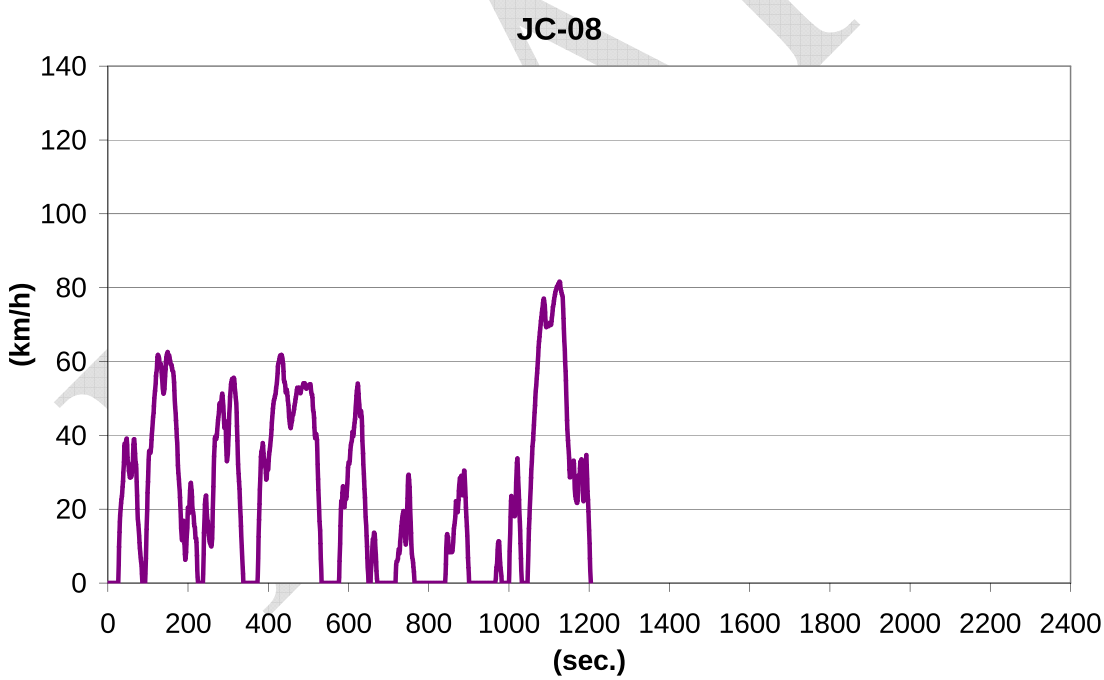
Vehicles from outside the mentioned area will not be able to operate within the cities unless of equal standard to city vehicles.

Two exemptions:
- Vehicles less than 7 years old (which must meet new vehicle emissions for 7 years from registration)
- Vehicles fitted with a PM filter

Driving Cycles:







Time (excl. soak)	1204 s
Distance	8172 m
Max. Speed	81.6 km/h
Ave. Speed	24.4 km/h
Soak	Repeated as hot test
Gear shift (man)	Fixed speeds

3.1.1.3. FUEL EFFICIENCY

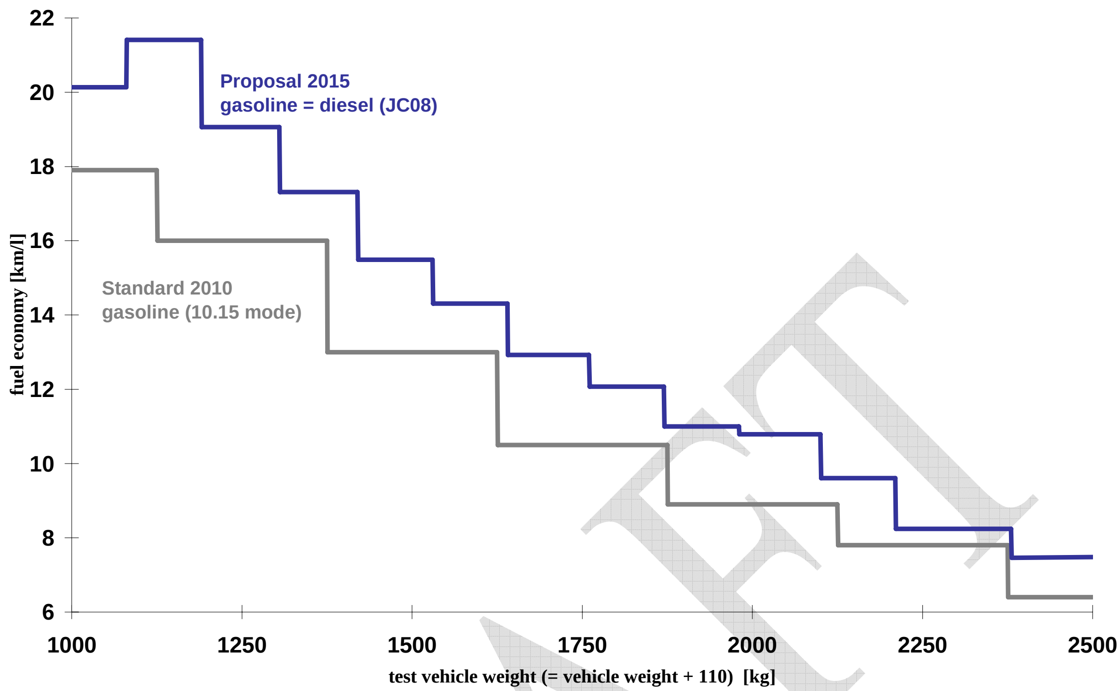


Fig. 3.1.1.3-1: Japanese fuel efficiency legislation.

3.1.1.4. NOISE

further input expected

3.1.1.5. RECYCLING

further input expected

3.1.2. USA

In the USA beside the federal regulations California deviates from this with an own system.

3.1.2.1. EXHAUST GAS EMISSION, EPA

Regulation	**Reference**	**Comment**
Auxiliary Emissions Control Devices (AECDs) & Defeat Devices	40 CFR 86.1809-01, 40 CFR 86.1803-01, 86.1844-01	This regulation requires that vehicle emissions control system effectiveness be certified in driving modes not included in the regulatory test cycles
Compliance Assurance Program (CAP 2000)	40 CFR Part 86 subpart S CAP 2000	CAP 2000 rule streamlines vehicle certification procedures and requires manufacturer funded "in-use" vehicle testing for evaporative emissions
Onboard Refueling Vapor Recovery (ORVR)	40 CFR Part 86 subparts A (prior to 2001), S (2001+), B	This rule implements new vehicle standards and test procedures for the control of emissions during refueling
US EPA MSAT Cold NMHC Exhaust Emissions Limits	40 CFR Part 86 Subpart S	US EPA requirements for PC, LDT and MDPV Cold NMHC exhaust emissions. Vehicles are required to be certified to a Cold NMHC family emissions limit (FEL) rounded to the nearest 0.1 g/mi. Sales weighted fleet average requirements of 0.3 g/mi for vehicles up to 6,000 pounds GVWR and 0.5 g/mi for vehicles over 6,000 pounds GVWR define the required mix of individaul FELs
US EPA Tier 2 Exhaust Emissions Limits	40 CFR Part 86 Subpart S	US EPA requirements for PC, LDT and MDPV exhaust emissions
Federal On-Board Diagnostics (OBD)	40 CFR, 86.094, OBD, On-Board Diagnoistics	Manufacturers are required to install an OBD system which monitors various exhaust and evaporative emission control components for malfunction or deterioration resulting in exceeding various emission thresholds and illuminates a malfunction indicator light (MIL). These requirements apply to all PCs and LDTs.
Cold Temperature CO Emission Standards	40CFR86.094-8(k) & -9(k), Cold CO for PC & LDT	The cold temperature certification CO standards at 20 oF are: · 10 g/mi for PCs
Tier 1 Exhaust Emission Standards	40CFR86.0XX-8 & -9*, Tier 1 Exhaust Emission Stds	The Tier 1 certification NMHC (nonmethane hydrocarbon), CO, NOx, and particulate matter (PM) emission standards at 50,000 and 100,000 miles, respectively, are: ·0.25/3.4/0.4/0.08 g/mi -- 0.31/4.2/0.6/0.10 g/mi for PCs,
Corporate Average Fuel Economy (CAFE)	Federal: 40 CFR, Part 600, Law: 15 U.S.C. Section 2001	Sets minimum standards for a manufacturers production-weighted average fleet fuel economy. Vehicle fuel economy is established by laboratory testing. The CAFE standards for passenger cars is 27.5 mpg.
Gas Guzzler Tax	Federal: 40 CFR, Part 600, Law: 26 U.S.C. Section 4063	For any passenger car sold in the U.S., a tax is paid if that vehicles fuel economy does not exceed a 22.5 mpg threshold. The tax increases for models with lower mpg. The tax is $1,000 if the vehicles fuel economy is between 21.5 mpg to 22.4 mpg, $1,300 for 20.5 mpg to 21.4 mpg, and increases to $7,700 if the mpg is less than 12.4 mpg.

Tier II Standard (cont'd)

Two temporary options available for MY2007-09 diesel powered vehicle:

- US06 opt: Relaxed 4k NO_x+NMHC std in exchange for 30per cent stricter composite SFTP NO_x+NMHC std.
  Also extends SFTP useful life to 150k.
- High Alt. Option; Bin 7/8 veh. Allowed in-use NO_x std of 1.2x the FTP std., when at high alt.
  In exchange, must meet Bin 5 PM std.
  Also extends the useful life to 150k for ALL FTP based tests.

New fleet average requirement for NMHC:

- Provisions for carry forward and carry-back of credits
- Prov. for carry-over programs with respect to in-use testing
- Test is on FTP cycle at 20 deg F
- Flex fueled vehicles only required to provide assurance that the same emission reduction systems are used on non-gasoline fuel as on gasoline
- LDV < 6000 GVWR:
  Meet sales weighted fleet average of 0.3 g/mi at 120k mi
  Phase in 25/50/75/100 from MY2010 - 2013
- 6000 ≤ LDV < 8500 GVWR and MDPV < 10,000 lbs
  Meet sales weighted fleet average of 0.5 g/mi at 120k mi
  Phase in 25/50/75/100 from MY2012 – 2015

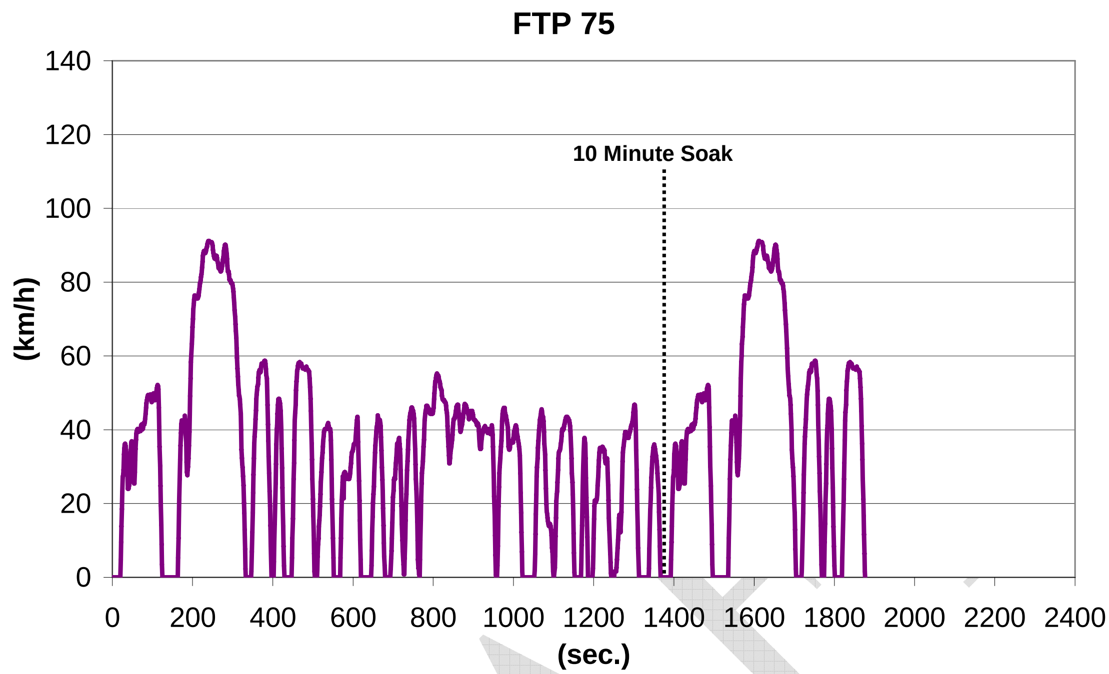
0.07 g/mi NOx fleet average

g/mi		Bin 8	Bin 7	Bin 6	Bin 5	Bin 4	Bin 3	Bin 2
NMOG	50 k	0.100	0.075	0.075	0.075			
	120 k	0.125	0.090	0.090	0.090	0.070	0.055	0.010
CO	50 k	3.4	3.4	3.4	3.4			
	120 k	4.2	4.2	4.2	4.2	2.1	2.1	2.1
NOx	50 k	0.14	0.11	0.08	0.05			
	120 k	0.20	0.15	0.10	0.07	0.04	0.03	0.02
PM	120k	0.02	0.02	0.01	0.01	0.01	0.01	0.01
HCHO	50 k	0.015	0.015	0.015	0.015			
	120 k	0.018	0.018	0.018	0.018	0.011	0.011	0.004

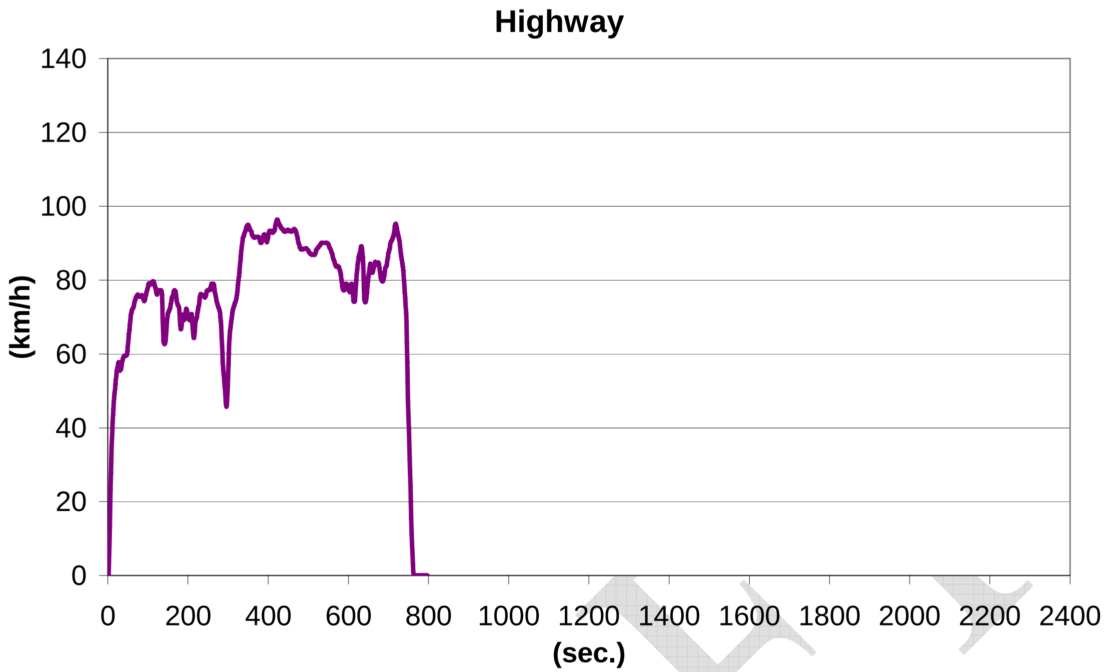
Tier II Phase-In Schedule in % (Vehicles < 6000 lbs GVWR)

%	'01	'02	'03	'04	'05	'06	'07	'08
NLEV	100	100	100					
(Interim Non-)Tier II, 0.3 NOx avg				75	50	25	0	0
Tier II, 0.07 NOx avg				25	50	75	100	100

Driving Cycles:



Time (excl. soak)	1877 s
Distance	17860 m
Max. Speed	91.2 km/h
Ave. Speed	34.2 km/h
Soak	600 s
Gear shift (man)	Specific (with evidence)



Time	765 s
Distance	16500 m
Max. Speed	96.4 km/h
Ave. Speed	77.4 km/h
Soak	N/A
Gear shift (man)	Specific (with evidence)

3.1.2.2. EXHAUST GAS EMISSION, CARB

Regulation	Reference	Comment
Enhanced Evaporative Emission Regulations	California Evaporative Emission Standards and Test Procedures for 1978 and Susequent	Regulation adds more stringent evaporative emission test procedures, longer vehicle usefull life definition, a new vehicle running loss emission standard and test procedure.
Compliance Assurance Program (CAP 2000)	California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles, CAP 2000 Impact on Enhanced Evap	CAP 2000 rule streamlines vehicle certification procedures and requires manufacturer funded "in-use" vehicle testing for evaporative emissions.
LEV II	California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles	LEV II significantly lowers evaporative emission standards from "enhanced evaporative" standards and increases the useful life definition.
Onboard Refueling Vapor Recovery (ORVR)	California Refueling Emission Standards and Test Procedures for 1998 and Subsequent Model Motor Vehicles/California Code of Regulations section 1978	This rule implements new vehicle standards and test procedures for the control of emissions during refueling
SFTP – Supplemental Federal Test Procedures	CCR Section 1960.1	The Supplemental Federal Test Procedure (SFTP) regulations add on to the current Environmental Protection Agency's Federal Test Procedure (FTP). SFTP contains two new drive cycles (a high speed and high load - US06 cycle and air conditioning on cycle - SC03) and standards. The Federal EPA and California regulations are intertwined with each other as well as the Federal National Low Emission Vehicle regulation (NLEV).
California On-Board Diagnostics II (OBD II) & Service Information	Sec.1968.2	Manufacturers are required to install an OBD system which monitors various exhaust and evaporative emission control components for malfunction or deterioration resulting in exceeding various emission thresholds and illuminates a malfunction indicator light (MIL).
California Environmental Performance Label Specification	Title 13, California Code of Regulations, Section 1965	The content of the label is specified in detail in the California regulations, including that the label must have a green border, and a smog score and global warming score printed in black type.
CARB LEV II Exh. Em.	Title 13, Division 3, Chapter 1, Section 1961	CARB requirements for PC, LDT and MDV exhaust emissions
CARB Zero Em.	Title 13, Division 3, Chapter 1, Section 1962	CARB requirements for PC and LDV exhaust & evaporative emissions, emissions warranty and advanced technology vehicles

3.1.2.3. GREENHOUSE GASES AND CAFE

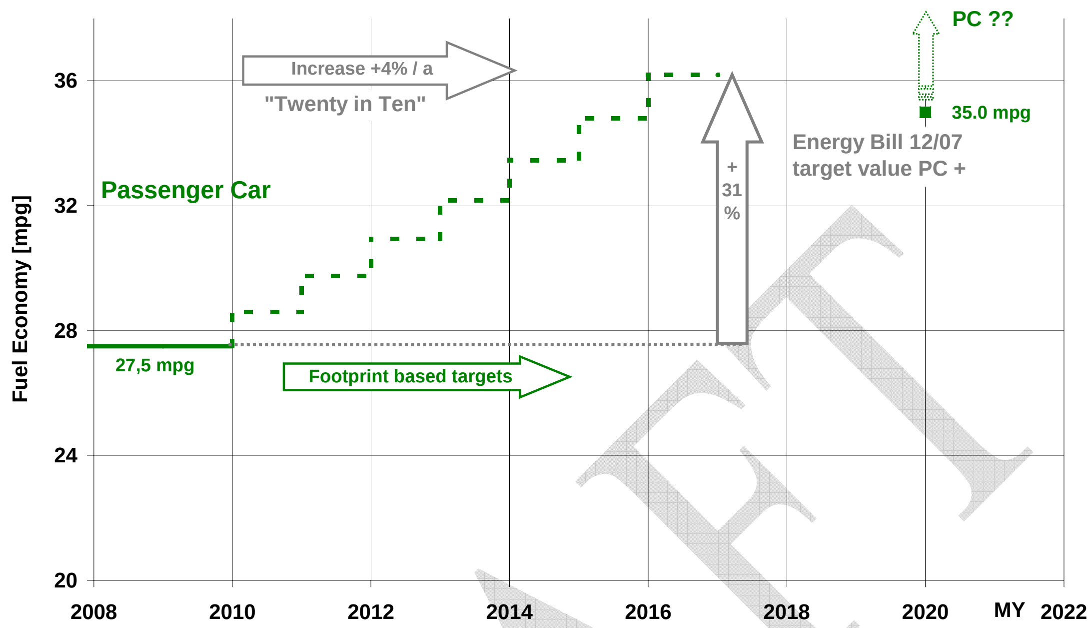


Fig. 3.1.2.3-2: CAFE (US - 50 States) „20in10“ and Energy Bill, Passenger Cars.

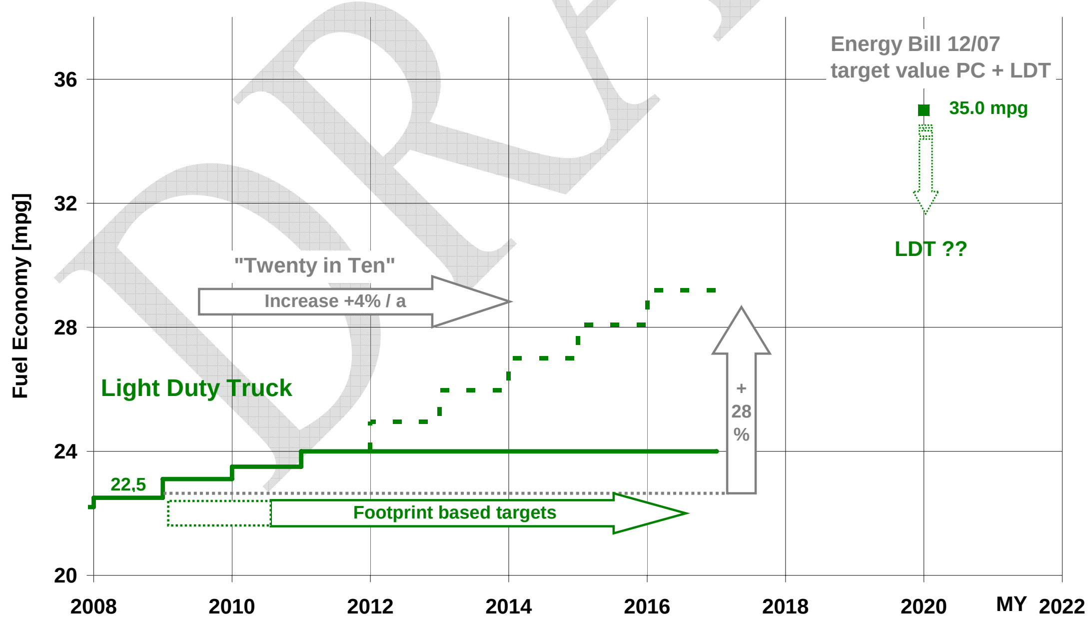


Fig. 3.1.2.3-3: CAFE (US - 50 States) „20in10“ and Energy Bill, Light Duty Trucks.

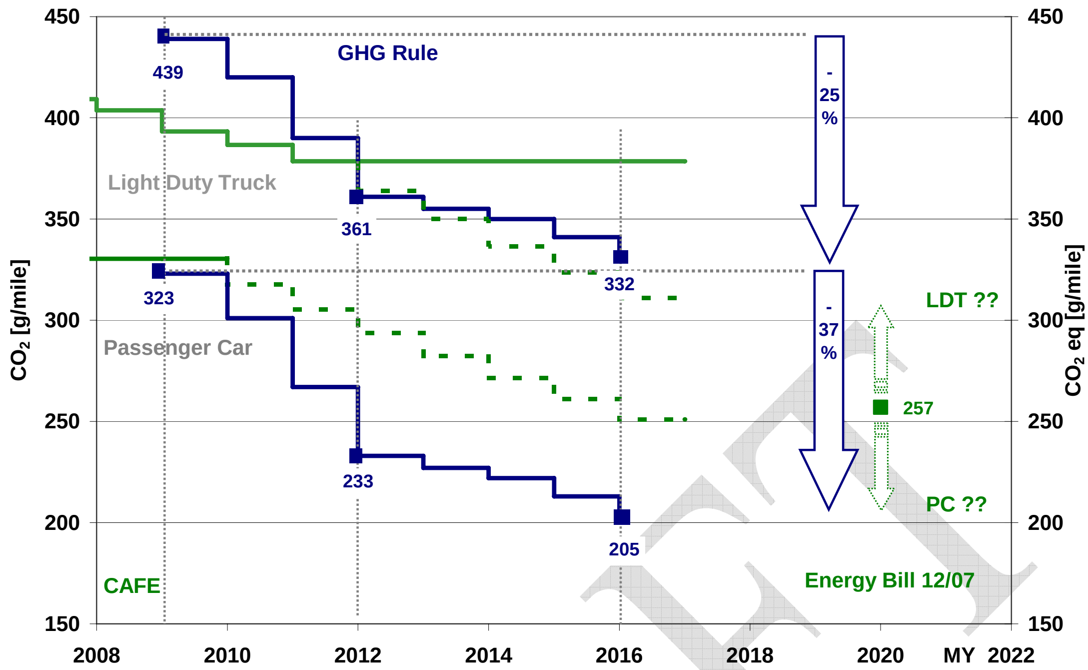


Fig. 3.1.2.3-4: GHG Rule (Cal + and Sect. 177 States) and CAFE (US – 50 States).

Tab. 3.1.2.3-1: Fleet average GHG emission standards.

Tier	MY	PC/LDT1 g mile^{-1}	LDT2/MDPV g mile^{-1}
Near-Term	2009	323	439
	2010	301	420
	2011	267	390
	2012	233	361
Mid-Term	2013	227	355
	2014	222	350
	2015	213	341
	2016	205	332

3.1.2.4. MERCURY LAW

Key Provisions of L.D. 1921; Signed into law on 10 April, 2002

1. Prohibits the use of mercury switches in all vehicles manufactured on or after 1 January, 2003;

2. Requires vehicle manufacturers to establish a system for the removal and collection of the mercury-containing parts in old cars before they are scrapped.

- Vehicle Manufacturers are required to establish and maintain authorized "consolidation" facilities geographically located to serve all areas of the state by 1 January, 2003;

- New and used car dealerships are not authorized to participate in the system;

- Manufacturers are required to pay a minimum of $1 per switch brought to the consolidation facilities;

3. Vehicles that contain mercury that apply to vehicles built on or after July 15, 2002 must have a label on the driver-side doorpost specifying which components in the vehicle may contain mercury.

4. New manufacturer reporting requirements:

- Before 1 January, 2003, vehicle manufacturers are required to submit information if they intend to levy a fee on new vehicles sold in the state, including the amount charged to customers, and the basis for charging said amount;

- By July 1, 2004, vehicle manufacturers are required to report on the number of mercury switches removed and recycled through the consolidation facilities;

3.1.3. CHINA

3.1.3.1. CHINA ENVIRONMENTAL REGULATIONS

China - Environmental Regulations				
	Regulation China nationwide	**Regulation China special areas**	**Reference**	**Comment**
CO_2/ fuel consumption standards	Fuel consumption standards applied to M1 vehicles with GVM not more than 3500kg 2 sets of fuel consumption limits for different M1 models: 1. Normal M1 (with MT and excluding the following models), 2. Special M1 (automatic transmission (AT), or 3 or more rows of seats or off-road vehicles); 2-phase implementation: Phase-1 started 07/2005 for new approval car models and 07/2006 for in-production car models, Phase-2 started 01/2008 for new approval car models and starting 01/2009 for in-production car models. The authorities are planning to issue Phase Ⅲ fuel limit in 2011 and to initiate framing in the year end.		Important Technical Standards & Legislations in China Auto Industry; Volkswagen Group China; Issue: Aug. 2008 China Automotive Technologie News; Volkswagen Group China; Issue No. 59, August 2008; Technical Development Division (Source: CATARC)	Regulation Name: Limits of fuel consumption for light duty commercial vehicles Regulation Number: GB 20997-2007
Emission control	From July 1st of 2007, the car models for new type approval must be EU 3 (without OBD) and from July 1st of 2010, the new approval car models should be EU 4. The Chinese authorities are considering to draft the national standard similar or equivalent to EU 5/ EU 6 after the official publication of EU 5/ EU 6 in Europe.	Beijing has implemented EU 4 for gasoline passenger cars since March 1st of 2008. For this implementation, Beijing Municipal Government implemented its local fuel standards of EU 4 for both gasoline & diesel fuels since January 1st of 2008. Shanghai and Pearl River Delta (Guangzhou/Shenzhen) are planning to implement EU 4 for both gasoline and diesel cars in the second half of 2009 or at the beginning of 2010.	Important Technical Standards & Legislations in China Auto Industry; Volkswagen Group China; Issue: Aug. 2008	Regulation Name: Limits Measurement Methods for Emissions From Light-Duty Vehicles (II and IV) Regulation Number: GB18352.3-2005

Emission control (heavy-duty)	From Jan. 1st of 2007 the diesel engine of heavy-duty vehicles must be EU 3. Under GB14762-2008, Phase III (equivalent to Euro III) requirements will be implemented for new gasoline engines of heavy-duty vehicles starting July 1, 2009 and Phase IV (equivalent to Euro IV) starting July 1, 2012. For new diesel engine heavy-duty vehicles the Phase IV (equivalent to Euro IV) starting July 1, 2010 and Phase V (equivalent to Euro V) starting Jan. 1, 2012.	From March 1st of 2008 the heavy-duty vehicle must be Euro 4.	Flash Report - China: New emission standard for gasoline engines in HDVS Source: International Fuel Quality Center, April 2008	Regulation Name: Limits and measurement method for exhaust pollutants from gasoline engines of heavy-duty vehicles (III, IV) Regulation Number: GB 14762-2008 Regulation Name: Limits and measurement methods for exhaust pollutants from compression ignition and gas fuelled positive ignition engines of vehicles (III, IV, V) Regulation Number: GB 17691-2005
Diesel Emissions		Because of the local air pollution problems, some special local areas beside Beijing, including Guangzhou/Shenzhen, will adopt more stringent regulations for diesel vehicles, especially more strict requirements for the particulate emissions.	Important Technical Standards & Legislations in China Auto Industry; Volkswagen Group China; Issue: Aug. 2008	
OBD Requirements	From July 1st of 2008, the OBD system will be requested on the new approval gasoline car models and from July 1st of 2009, the OBD system will be requested on all the gasoline cars registered nationwide; From July 1st of 2010, the OBD system will be requested on the new approval diesel car models and from July 1st of 2011, the OBD system will be requested on all the diesel cars registered nationwide.	Chendu started to request the OBD on the EU 3 cars from May 1st of 2008, which was one year earlier than the nationwide implementation plan.	Important Technical Standards & Legislations in China Auto Industry; Volkswagen Group China; Issue: Aug. 2008	Regulation Name: Limits Measurement Methods for Emissions From Light-Duty Vehicles (II and IV) Regulation Number: GB18352.3-2005

Vehicle Consumption Tax	The existing consumption taxation system for passenger vehicles has been in effective since April of 2006. A new policy takes effect on Sept 1, 2008. The consumption tax rate for passenger vehicles with engine displacement ranging from 3.0 L to 4.0 will be increased to 25 percent from the current 15 percent, and the tax rate for those with over 4.0 L displacement will be up to 40 percent from the current 20 percent. Contrarily, passenger cars with 1.0 or less displacement range will pay 1 percent of the consumption tax instead of 3 percent.		China Automotive Technologie News; Volkswagen Group China; Issue No. 59, August 2008; Technical Development Division (Source: MOF.gov, Aug. 13, 2008)	
Exterior Noise	The standard is formulated as per the Law of the People's Republic of China on the Prevention and Control of Environmental Noise Pollution. It is formulated in reference to the regulation of Uniform Provisions Concerning the Approval of Motor Vehicles. Having at Least Four Wheels with Regard to Their Noise Emission (ECE Reg.No.51) of the Economic Commission for Europe of the United Nations (UN/ECE) and based on the actual conditions of motor vehicle products in China.		Ministry of Environmental Protection The People's Republic of China	Regulation Name: Limits and measurement methods for noise emitted by accelerating motor vehicles Regulation Number: GB 1495-2002
Recycling and Recovery of End-of-Life Vehicles (ELV)	This Standard specifies a method for calculating the recyclability rate and the recoverability rate of a new road vehicle, each expressed as a percentage by mass (mass fraction in percent) of the road vehicle, which can potentially be - recycled, reused or both (recyclability rate), or - recovered, reused or both (recoverability rate). The calculation is performed by the vehicle manufacturer when a new vehicle is put on the market.		ISO 22628:2002	Regulation Name: Road vehicles Recyclability and recoverability — Calculation method Regulation Number: GB/T 19515-2004/ISO22628:2002

3.1.3.2. EXHAUST GAS EMISSION

Emission control – EU 3/4 nationwide

- national standard GB18352.3-2005 based on 2003/76/EC,
- published by State Environmental Protection Administration (SEPA, now Ministry of Environmental Protection, MEP) on April 15th of 2005,
- following implementation plan was stated:
  - From July 1st of 2007, the car models for new type approval must be EU 3 (without OBD) and from July 1st of 2010, the new approval car models should be EU 4;
  - From July 1st of 2008, the OBD system will be requested on the new approval gasoline car models and from July 1st of 2009, the OBD system will be requested on all the gasoline cars registered nationwide;
  - From July 1st of 2010, the OBD system will be requested on the new approval diesel car models and from July 1st of 2011, the OBD system will be requested on all the diesel cars registered nationwide.

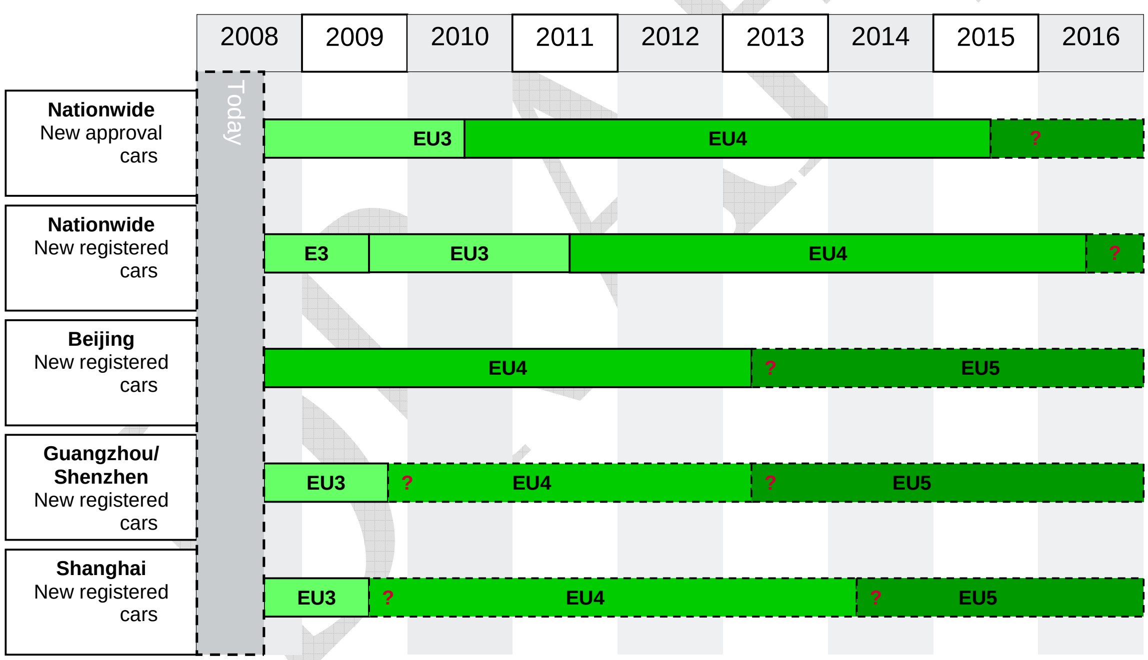


Fig. 3.1.3.2-1: Emission control for petrol passenger cars – overview and perspective.

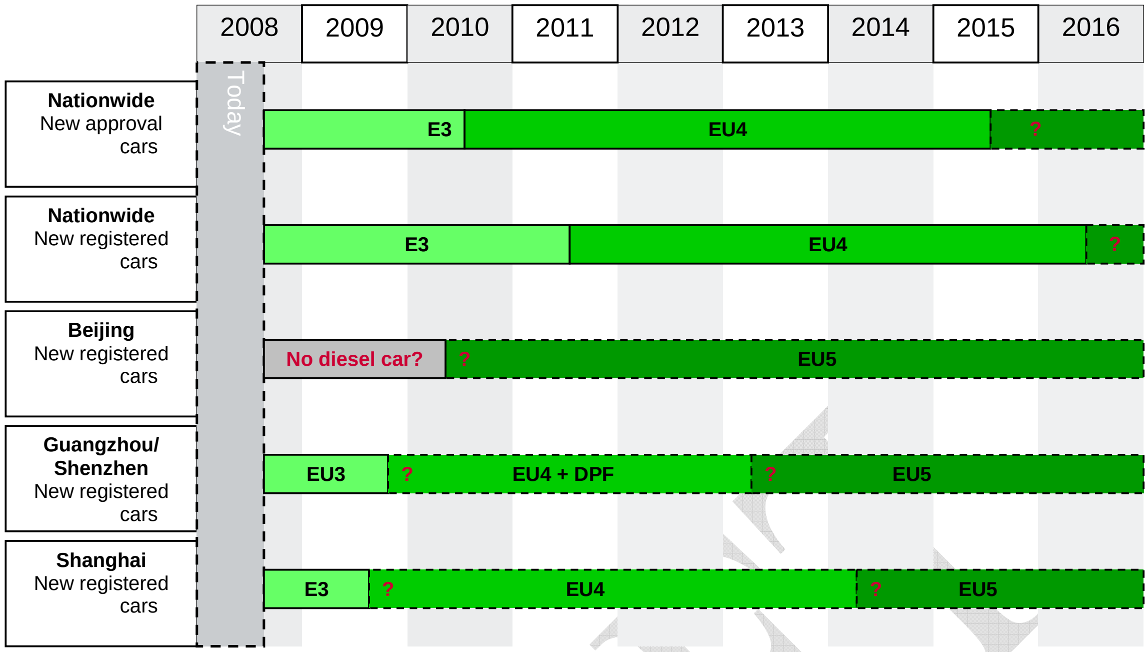


Fig. 3.1.3.2-2: Emission control for diesel passenger cars – overview and perspective.

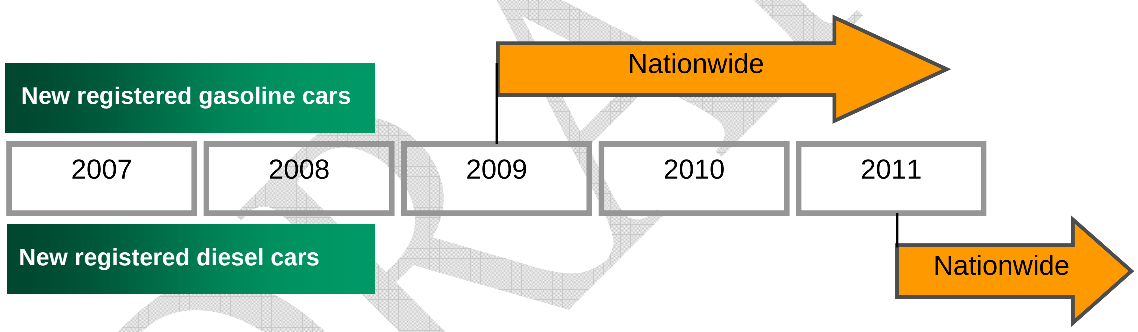


Fig. 3.1.3.2-3: OBD implementation plan China-wide.

Emission control – other specific issues

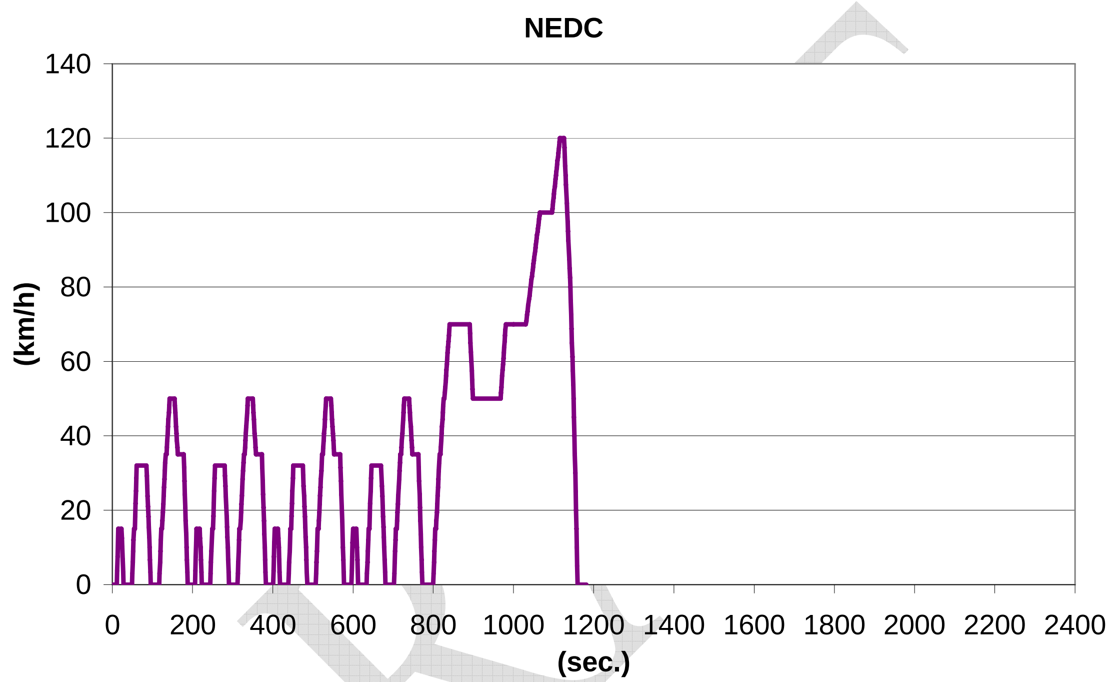
- Beijing has implemented EU 4 for gasoline passenger cars since March 1st of 2008. For this implementation, Beijing Municipal Government implemented its local fuel standards of EU 4 for both gasoline & diesel fuels since January 1st of 2008.

- In Chengdu, all the new registered Category 1 light vehicles (refer to the passenger cars with GVM not more than 2500 kg / seats not more than 6) must be EU 3 and equipped OBD since May 1st of 2008. This movement shows that more and more local areas will have the advancing implementation of the national standards.

- Because of the local air pollution problems, some special local areas beside Beijing, including Guangzhou/Shenzhen, will adopt more stringent regulations for diesel vehicles, especially more strict requirements for the particulate emissions.

- China authority is planning to draft EU 5/6 standards. Some car makers, e.g. GM China, already officially announced their development of EU 5 cars for the Chinese market.

Driving Cycles:



Time	1180 s
Distance	11007 m
Max. Speed	120 km/h
Ave. Speed	33.6 km/h
Soak	N/A
Gear shift (man)	Fixed speeds

3.1.3.3. FUEL CONSUMPTION STANDARDS FOR PASSENGER CARS

- Standards applied to M1 vehicles with GVM not more than 3500kg

- 2 sets of fuel consumption limits for different M1 models:

  - Normal M1 (with MT and excluding the following models)
  - Special M1 (automatic transmission (AT) or 3 or more rows of seats or off-road vehicles)

- 2-phase implementation:

	Phase-1	Phase-2
new approval car models	07/2005	01/2008
in-production car models	07/2006	01/2009

- The working group on phase-3 fuel consumption limits was established already. The draft limits are expected to be finished by the end of 2009.

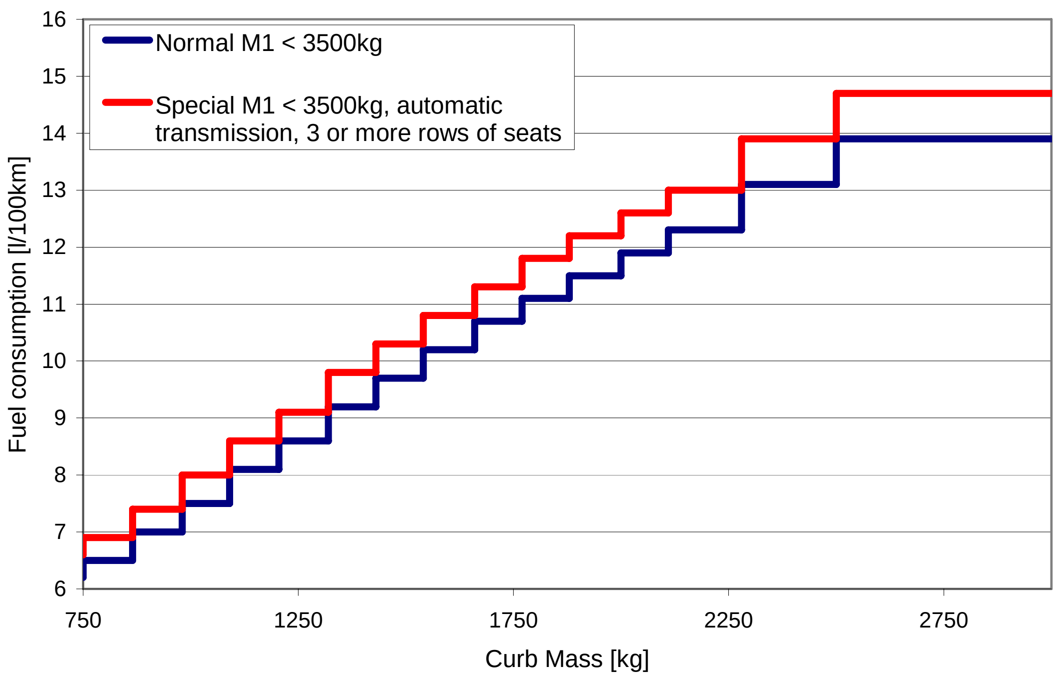


Fig. 3.1.3.3-1: Standard – Fuel consumption Phase-2 limits.

3.1.3.4. RECYCLING AND RECOVERY OF END-OF-LIFE VEHICLES (ELV)

Topics of the phase-3 research project by NDRC/CATARC：

The project is divided into three parts, which are related to management methods, banned / restricted materials and material database. The relevant working groups have been established accordingly.

- Researches on the development of the “Administrative Rules on RRR Rates of Automotive Products and Banned/Restricted Materials” and the relevant calculation methods;
- Survey / study on the banned/restricted materials in China auto industry;
- Basic researches and data collection related to China Automotive Materials Data System (CAMDS).

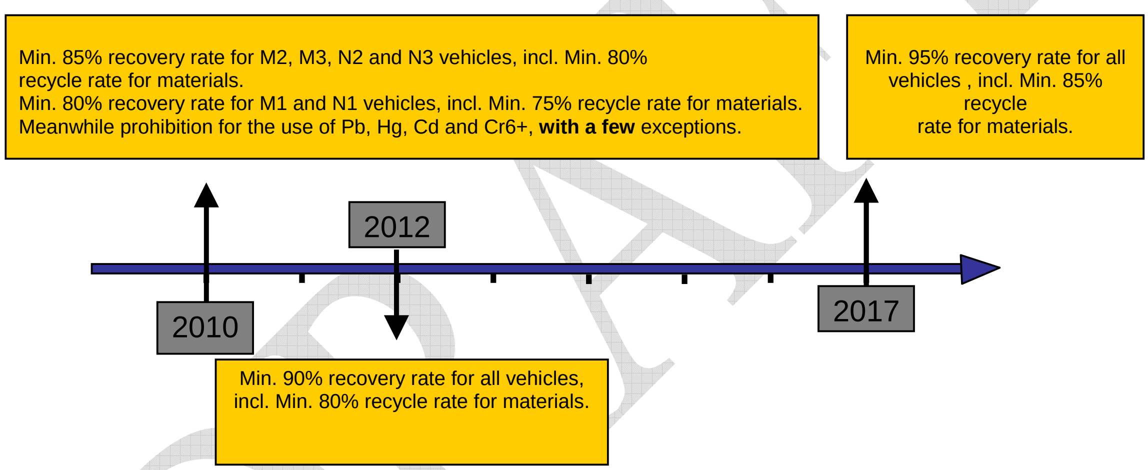


Fig. 3.1.3.4-1: 3-phase research projects.

3.1.3.5. CHINA GREEN VEHICLE

The ″Green Vehicle″certificates are based on a set of requirements. All four certificates include the evaluation factors ″Emission control (OBD)″ and ″Fuel consumption″.
Additionally they include at least one of the following criteria:

- CO_2 emission
- Curb mass
- Exterior and interior noise
- inner vehicle air quality
- ELV RRR rates, Banned materials, EMI, non-CFC materials in AC system, non-asbestos material, max. vehicle speed, acceleration and climbing ability

Often References to GB / GB/Ts given.

There would be four kinds of such certification in China:

1. ″Green Vehicle″ Certification by China National Accreditation and Certification Committee (CNCA). The relevant rule has been implemented from 01.09.2006; Camry from Guangzhou Toyota has been certified;

2. ″Green Vehicle″ Certification by National Technical Committee for Environment Management, Standardization Administration of China (SAC). The relevant national standard is under approval;

3. ″Green Vehicle″ Certification by Science & Technology and Standardization Department, State Environment Protection Administration (SEPA). The relevant rule has been implemented at the end of 2005; the so-called Green Vehicles have the priorities for ″government purchasing″ from 07.2007. The car models from FAW-VW and SVW were in the Group Procurement List jointly published by SEPA and the Ministry of Finance (MOF).

4. ″Green Vehicle″ Certification by Pollution Control Department, the State Environment Protection Administration (SEPA). The relevant rule is under discussion.

3.1.3.6. NOISE

The standard is formulated as per the Law of the People's Republic of China on the Prevention and Control of Environmental Noise Pollution. It is formulated in reference to the regulation of Uniform Provisions Concerning the Approval of Motor Vehicles Having at Least Four Wheels with Regard to Their Noise Emission (ECE Reg.No.51) of the Economic Commission for Europe of the United Nations (UN/ECE) and based on the actual conditions of motor vehicle products in China. The noise limit for vehicle in the standard is to replace that set down in the standard GB 1495-79. The noise measurement method of the standard is in reference to the Annex 3 of the Uniform Provisions Concerning the Approval of Motor Vehicles Having at Least Four Wheels with Regard to Their Noise Emission (ECE Reg.No.51/02) (1997) of the UN/ECE as well as related content of the international standard of Acoustics - Measurement of Noise Emitted by Accelerating Road Vehicles - Engineering Method (ISO362: 1998) in its technical content. The related requirements on the road surface for noise test of the standard adopt that of the stipulation in the Provisions of the Requirements of Road Surface for the Test of Noise Emitted by Road Vehicles (ISO10844: 1994) and was put into effect as of January 1, 2005. The standard is implemented in two different time periods according to the date of manufacture of the vehicle.

3.1.4. EU & UN-ECE

3.1.4.1. UN-ECE AND EUROPEAN ENVIRONMENTAL REGULATIONS

	UN_ECE Environmental Regulations		European Regulations	
Regulation	Reference	Comment	Reference	Comment
Regulated pollutants – roller bench type approval Emissions of pollutants according to engine fuel requirements	ECE R 83-05	Scope: vehicles M1, N1 with MTALW ≤ 3,5 t	Euro 5 & 6: 715/CE/2007 et 692/2008/CE	Scope: vehicles M1, M2, N1, N2 with reference mass ≤ 2610 kg (derogation possible until 2840 kg under specific conditions)
	supplement 1 to 6	- provisions for OBD; emission test procedure for periodically regeneration exhaust aftertreatment systems; provisions for Hybrid vehicles type approval; provisions for gaseous LPG/NG vehicles		implementation measure based on ECE R 83-05 except some specific requirements (limit values; deterioration factors; durability test procedure; emission at low T°C in Diesel; OBD; access to vehicle repair and maintenance information; use of reagent fort he exhaust aftertreatment system; flexfuels vehicle…)
	ongoing supplement 7	- provisions for modified particulate mass measurement procedures; - provisions for particle number measurement procedures		
Replacement Catalytic Concerters	ECE R 130-02	Scope: vehicle M1, N1	Euro 5 & 6: 715/CE/2007 et 692/2008/CE	Scope: vehicles M1, M2, N1, N2 with reference mass ≤ 2610 kg (derogation possible until 2840 kg under specific conditions) implementation measure based on ECE R 103-02 except some specific requirements

Smoke (Diesel only)	ECE R 24-03	Scope: all Diesel vehicles	Euro 5 & 6: 715/CE/2007 et 692/2008/CE	Scope: vehicles M1, M2, N1, N2 with reference mass ≤ 2610 kg (derogation possible until 2840 kg under specific conditions) implementation measure based on ECE R 24-03 except some specific requirements
Regulated pollutants – Engine bench type approval	ECE R 49-04 supplement 1	Scope: vehicles M1 with MTALW > 3,5 t; M2, M3, N1, N2, N3 (Diesel, LPG, NG) alternative procedure to roller bench type approval for category N1	2005/55/EC; 2005/78/EC 692/2008/CE	Scope: M1 > 3,5 t, M2, M3, N1, N2, N3 with Diesel or gas engine this directive can be used as an alternative procedure to roller bench type approval for Diesel or gas fuelled N1. Moreover, from Euro 5 implementation (see 715/2007/EC) the scope is modified.
Consumption and CO_2 measurement	ECE R 101 supplement 6	Scope: vehicles M1 (internal combustion engine and hybrid electric powertrain) and vehicles M1 & N1 powered by an electric powertrain the driving cycle is the one described in the UN ECE R38 (NM VEG cycle); regenerating system taken into account	Euro 5 & 6: 715/CE/2007 et 692/2008/CE	Scope: vehicles M1, M2, N1, N2 with reference mass ≤ 2610 kg (derogation possible until 2840 kg under specific conditions) - roller bench type approval implementation measure based on ECE R 101 except some specific requirements and scopes (flexfuels vehicles;…)
CO_2 regulation	nothing up to now		European project on going	Scope announced: M1 and N1 later on
ELV & recyclability End of Life Vehicles Recyclability, recovery & reuse Heavy metals	 nothing up to now		 2000/53CE 2005/64/CE Decision 2008/689/CE	 Heavy metals derogations; annex II of ELV directive
Noise	ECE R51.02	revision R51.03 towards 2013 (estimation)	2007/34/CE	

3.1.4.2. EXHAUST GAS EMISSION

Tab. 3.1.4.2-1: Euro 3 and 4 Emission Limits.

			Reference mass (RW) (kg)	Limit values						
				Mass of carbon monoxide (CO)		Mass of hydrocarbons (HC)		Mass of oxides of nitrogen (NO_x)		Mass of particulates[1] (PM)
				L_1 (g/km)		L_2 (g/km)		L_3 (g/km)		L_4 (g/km)
Category		Class		Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Diesel
Euro 3	M [2]	-	All	2,3	0,64	0,20	-	0,15	0,50	0,05
	N_1 [3]	I	RW ≤ 1305	2,3	0,64	0,20	-	0,15	0,50	0,05
		II	1305 < RW ≤ 1760	4,17	0,80	0,25	-	0,18	0,65	0,07
		III	1760 < RW	5,22	0,95	0,29	-	0,21	0,78	0,10
Euro 4	M [2]	-	All	1,0	0,50	0,10	-	0,08	0,25	0,025
	N_1 [3]	I	RW ≤ 1305	1,0	0,50	0,10	-	0,08	0,25	0,025
		II	1305 < RW ≤ 1760	1,81	0,63	0,13	-	0,10	0,33	0,04
		III	1760 < RW	2,27	0,74	0,16	-	0,11	0,39	0,06

(1) For compression ignition engines.
(2) Except vehicles the maximum mass of which exceeds 2 500 kg.
(3) And those Category M vehicles which are specified in note 2.'

Tab. 3.1.4.2-2: Euro 5 Emission Limits.

		Reference mass (RM) (kg)	Limit values											
			Mass of carbon monoxide (CO)		Mass of total hydrocarbons (THC)		Mass of non-methane hydrocarbons (NMHC)		Mass of oxides of nitrogen (NO_x)		Mass of particulate matter (1) (PM)		Number of particles (2) (P)	
			L_1 (mg/km)		L_2 (mg/km)		L_3 (mg/km)		L_4 (mg/km)		L_5 (mg/km)		L_6 (#/kg)	
Category	Class		PI	CI	PI	CI	PI	CI	PI	CI	PI(3)	CI	PI	CI
M	-	All	1000	500	100	-	68	-	60	180	5,0/4,5	5,0/4,5	-	$6x10^{11}$
N_2	I	RM ≤ 1305	1000	500	100	-	68	-	60	180	5,0/4,5	5,0/4,5	-	$6x10^{11}$
	II	1305 < RM ≤ 1760	1810	630	130	-	90	-	75	235	5,0/4,5	5,0/4,5	-	$6x10^{11}$
	III	1760 < RM	2270	740	160	-	108	-	82	280	5,0/4,5	5,0/4,5	-	$6x10^{11}$
N_2	-	All	2270	740	160	-	108	-	82	280	5,0/4,5	5,0/4,5	-	$6x10^{11}$

Key: PI = Positive Ignition, CI = Compression Ignition

(1) A revised measurement procedure shall be introduced before the application of the 4,5 mg/km limit value.

(2) A new measurement procedure shall be introduced before the application of the limit value.

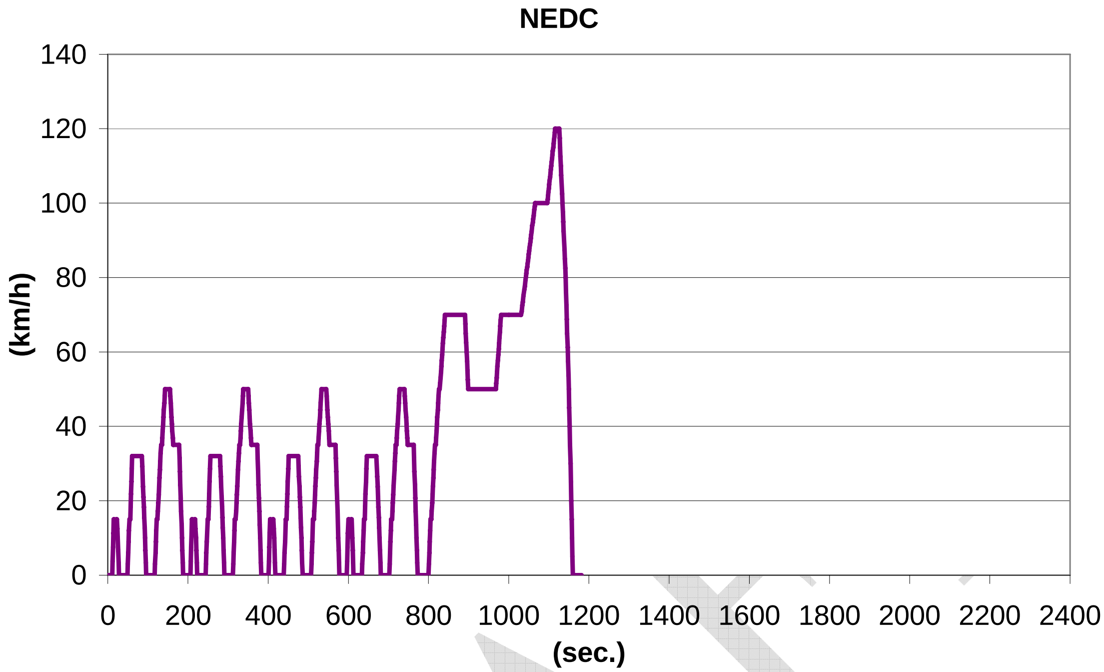
(3) Positive ignition particulate mass standards shall apply only to vehicles with direct injection engines

Tab. 3.1.4.2-3: Euro 6 Emission Limits.

		Reference mass (RM) (kg)	Limit values											
			Mass of carbon monoxide (CO)		Mass of total hydrocarbons (THC)		Mass of non-methane hydrocarbons (NMHC)		Mass of oxides of nitrogen (NO_x)		Mass of particulate matter (1) (PM)		Number of particles (2) (P)	
			L_1 (mg/km)		L_2 (mg/km)		L_3 (mg/km)		L_4 (mg/km)		L_5 (mg/km)		L_6 (#/kg)	
Category	Class		PI	CI	PI	CI	PI	CI	PI	CI	PI(3)	CI	PI(4)	CI(5)
M	-	All	1000	500	100	-	68	-	60	80	5,0/4,5	5,0/4,5	-	$6x10^{11}$
N_2	I	RM ≤ 1305	1000	500	100	-	68	-	60	80	5,0/4,5	5,0/4,5	-	$6x10^{11}$
	II	1305 < RM ≤ 1760	1810	630	130	-	90	-	75	105	5,0/4,5	5,0/4,5	-	$6x10^{11}$
	III	1760 < RM	2270	740	160	-	108	-	82	125	5,0/4,5	5,0/4,5	-	$6x10^{11}$
N_2	-	All	2270	740	160	-	108	-	82	125	5,0/4,5	5,0/4,5	-	$6x10^{11}$

Key: PI = Positive Ignition, CI = Compression Ignition
(1) A revised measurement procedure shall be introduced before the application of the 4,5 mg/km limit value.
(2) A number standard is to be defined for this stage for positive ignition vehicles.
(3) Positive ignition particulate mass standards shall apply only to vehicles with direct injection engines.
(4) A number standard shall be defined before 1 September 2014.'
(5) A new measurement procedure shall be introduced before the application of the limit value.

Driving Cycles:



Time	1180 s
Distance	11007 m
Max. Speed	120 km/h
Ave. Speed	33.6 km/h
Soak	N/A
Gear shift (man)	Fixed speeds

3.1.4.3. CO_2

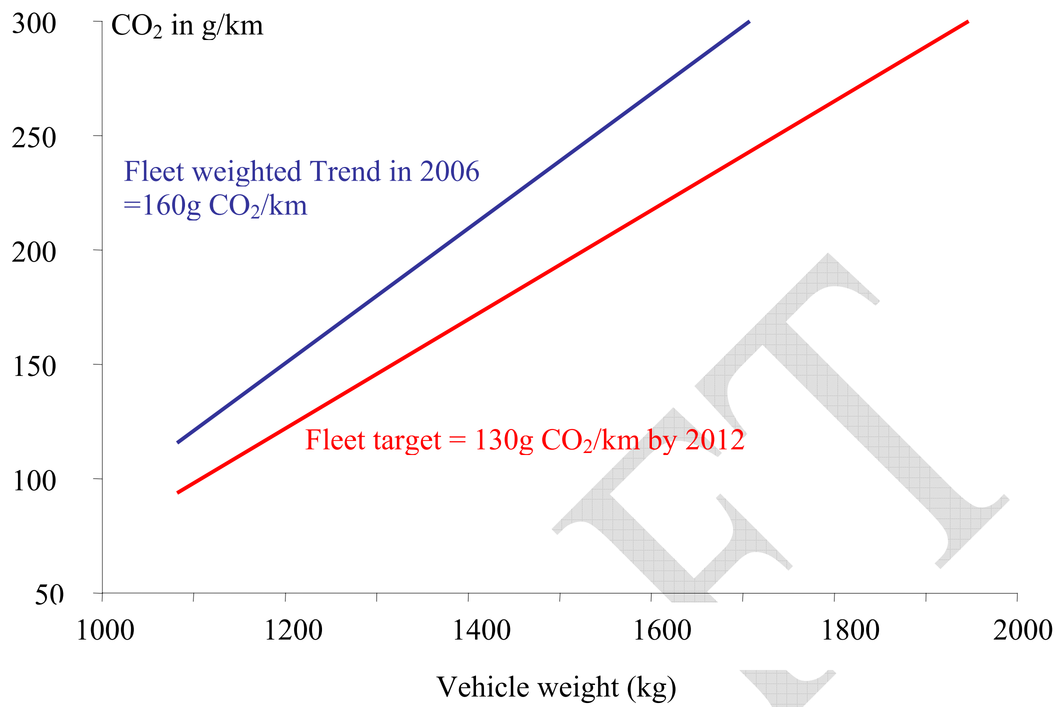


Fig. 3.1.4.3-1: Correlation vehicle weight - CO_2 for year 2006.

CO_2 Proposal on Passenger Cars: 120 g CO_2/km by 2012 (130 g CO_2/km by improvements in vehicle technology + reduction of 10 g CO_2/km by technological and biofuels).

Fig. 3.1.4.3-2: Fleet average of different manufactures and goal for 2012 (as discussed currently)

3.1.4.4. NOISE

ECE R51.02
2007/34/CE

further input expected

3.1.4.5. RECYCLING

2000/53/CE
2005/64/CE
Decision 2008/689/CE

further input expected

3.1.5. INDIA

3.1.5.1. INDIA ENVIRONMENTAL REGULATIONS

	Regulation	Reference	Comment
CO_2	Discussion ongoing. Proposals based on mass CO2 target lines affective 2010. Less stringent targets compared to EU.		SIAM presentations
HC+No_x, Co Light Duty	From April 2005, India State emissions requirements based on European Stage II with the National Capitol Region (NCR) and other cities, mandating requirements based on European Stage III. Stage III applicable to India State from April 2010. Stage IV applies to the NCR and 11 cities from Apr 2010. Both India and NCR have adopted a modified test procedure with a limit of 90 kph.	CENTRAL MOTOR VEHICLES RULES, 1989 (EXTRACTS) Latest amendment Notification No. GSR 207(E) dated April 10, 2007	Regulation Name: INDIA EMISSIONS FORECAST - LIGHT DUTY
HC+No_x, CO Heavy Duty	Bharat Stage III Heavy duty emissions is equivalent to EU Euro 3 fuel and emissions, applicable in the National Capital Region and 11 cities from April 2005 (Manufacture). Also includes diesel smoke and power testing. Bharat Stage III does not contain E-OBD and there is no information available on the timing for the introduction of OBD	The Gazette of India dated 20th October 2004. GSR-686(E), TAP 115 section D.	Regulation Name: EU Heavy Duty Euro III equivalent emissions - Bharat Stage III. Regulation Number: CMVR 2004 (TAP 115/116)
OBD Requirements	The Bharat Stage IV requirements are amended to mandate OBD. OBD is applied in 2 phases, with the OBD thresholds (identical to the European Stage III / IV thresholds) being applied at the second step. VEHICLES AFFECTED: All Light Duty Vehicles (M&N) GVM <= 3500kg	draft BS-IV, CMVR draft 2006	Regulation Name: Bharat Stage IV - proposed inclusion of OBD
Noise Requirements	Exterior noise requirements applicable from 1 Jan 2003, 1 July 2003 & 1 April 2005 maunfacture.	G.S.R.849(E), Environment SI No 56 dated 30 December 2002	Regulation Name: EXTERIOR NOISE REQUIREMENTS

Type Approvel - CNG Vehicles	Revised requirements for conversion and retro-fitment of Compressed Natural Gas (CNG) systems. Applicable from 19 May 2002.		Regulation Name: TYPE APPROVAL OF CNG VEHICLES Regulation Number: NOTIFICATION NO.853(E) 19 NOV 2001
Type Approvel	40 components (headlamps, hydraulic brake hoses etc.) and systems must meet the referenced Indian Standards (IS) or Safety Standards (SS) published by the approval agency "Automotive Research association of India" (ARAI): (All standards should be at last Research association of India" (ARAI): (All standards should be at last amended)	Central Motor Vehicle Rules (CMVR) date, Rule 124 / 1989	Regulation Name: TYPE APPROVAL REQUIREMENTS Regulation Number: SO 1365 13Dec04 amended to SO 451 30Mar05
Exterior Noise	Drive-by & static noise, equivalent to 70/157/EEC as amended but includes electric vehicles.	UN ECE WP29	Regulation Number: ECE-51.02 Suppl. 5 Regulation Name: EXTERIOR NOISE - ECE Regulation
Diesel Emissions	System type approval of vehicles equipped with diesel engines with regard to the emission of pollutants by the engine. Static steady state test used for type approval, with free acceleration test to give a reference value for in-service testing. Choice of engine component approval, plus vehicle installation approval, or in-vehicle approval. Limits (absorption coefficients) dependent on engine size. See Regulation for details. Free acceleration test result increased by 0.5-1 and marked close to vehicle VIN plate.	UN-ECE Regulation 24	Regulation Number: ECE-24 amended to ECE-24.03 Supp. 2. Regulation Name: DIESEL SMOKE EMISSIONS
Compression Ignition Vehicles Emissions	Emission approval of compression ignition (diesel, CNG or LPG) and spark ignition (CNG, LPG) engines.	UN-ECE Regulation 49 (E/ECE/TRANS?505 Rev1/Add48/Rev3)	Regulation Number: ECE-49.02 Regulation Name: HEAVY DUTY DIESEL, CNG & LPG GASEOUS & PARTICULATE EMISSIONS

Type Approval + In-Service Complience	Detailed regulations for type-approval and in-service compliance by all vehicles in India. DEFINITIONS (CMVR 2): Vehicle category definitions are as for EU and UN-ECE 1958 Agreement. Smart Cards used in driving licences, etc., must be to ISO 7816 and CMVR Annex XI.	CMVR 1989 amended to GSR 589(E) 07Oct05	Regulation Name: CENTRAL MOTOR VEHICLE RULES Regulation Number: A03198
Type Approval + In-Service Complience	The MoRTH (Ministry of Road Transport and Highways) has issued a list of amendments to the Central Motor Vehicle Rules (CMVR) based on the SIAM Road Map and GSR 172(E). Most changes introduce requirements for construction equipment and trailers.	MoRTH	Regulation Name: Amendments to the CMVR Regulation Number: S.O 589(E)

3.1.5.2. EXHAUST GAS EMISSION

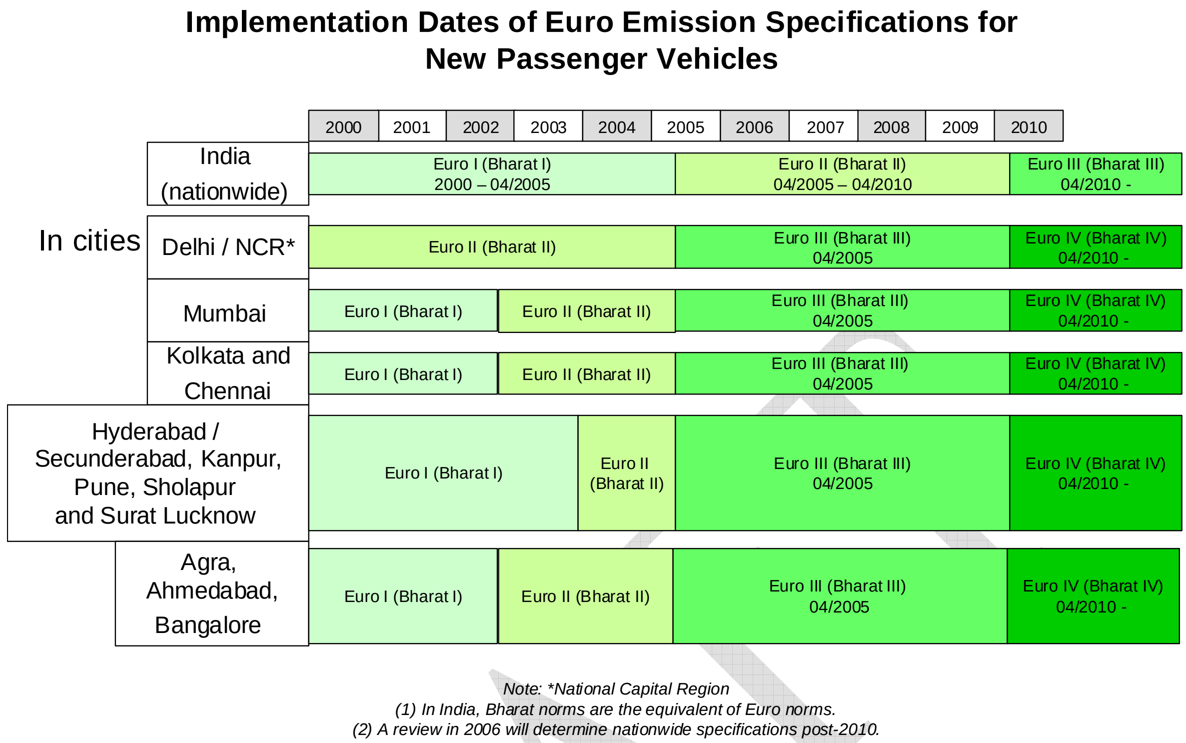
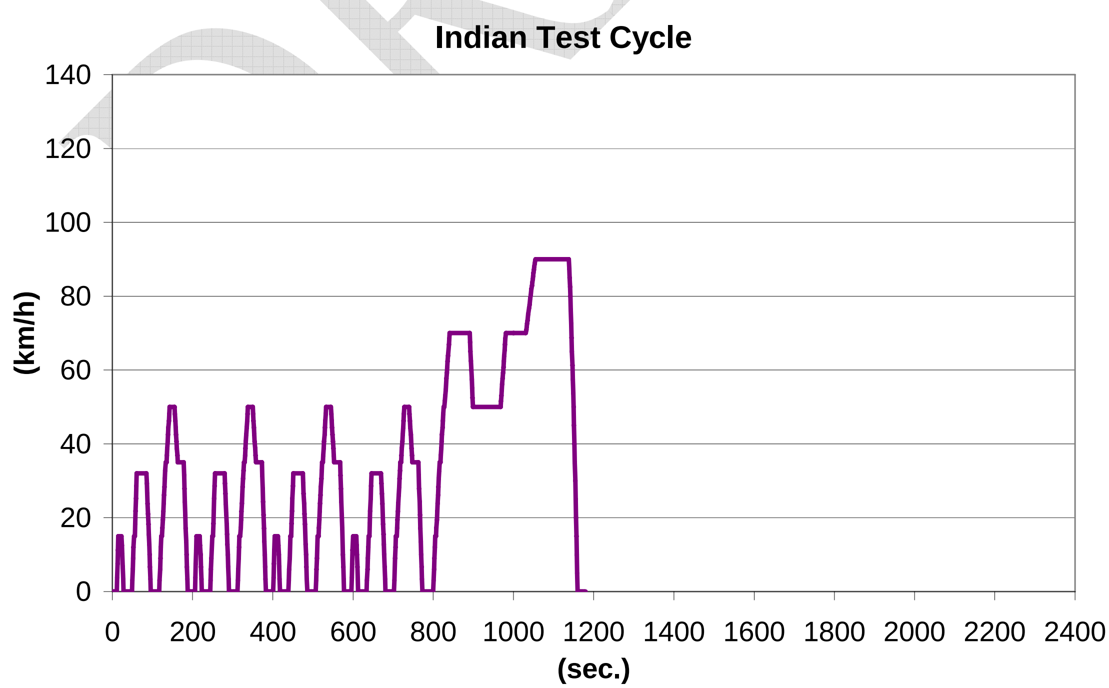


Fig. 3.1.5.2-1: Implementation Dates of Euro Emission Specifications for New Passenger Vehicles.

Driving Cycles:



Time (excl. soak)	1180 s
Distance	m
Max. Speed	90 km/h
Ave. Speed	km/h
Soak	N/A
Gear shift (man)	Fixed speeds

3.1.5.3. CO_2

further input expected

3.1.5.4. NOISE

further input expected

3.1.6. RUSSIA

3.1.6.1. EXHAUST GAS EMISSION

Since April 2006, all vehicles registered in the territory of the Russian Federation must comply with the Euro II emission standards. In terms of the next stage of requirements, a timeTab. has also been adopted with Euro III emission requirements to be introduced on January 1, 2008, followed by Euro IV emission requirements by January 1, 2010, and Euro V emission requirements by January 1, 2014:

- ECE R83/04 (Euro 2) since 1.1.2002
- ECE R83/05 (Euro 3) from 1.1.2008 - draft
- ECE R83/05 (Euro 4) from 1.1.2010 - draft
- Euro 5 from 2014 – draft

3.1.6.2. NOISE

further input expected

3.1.7. BRAZIL

3.1.7.1. EXHAUST GAS EMISSION

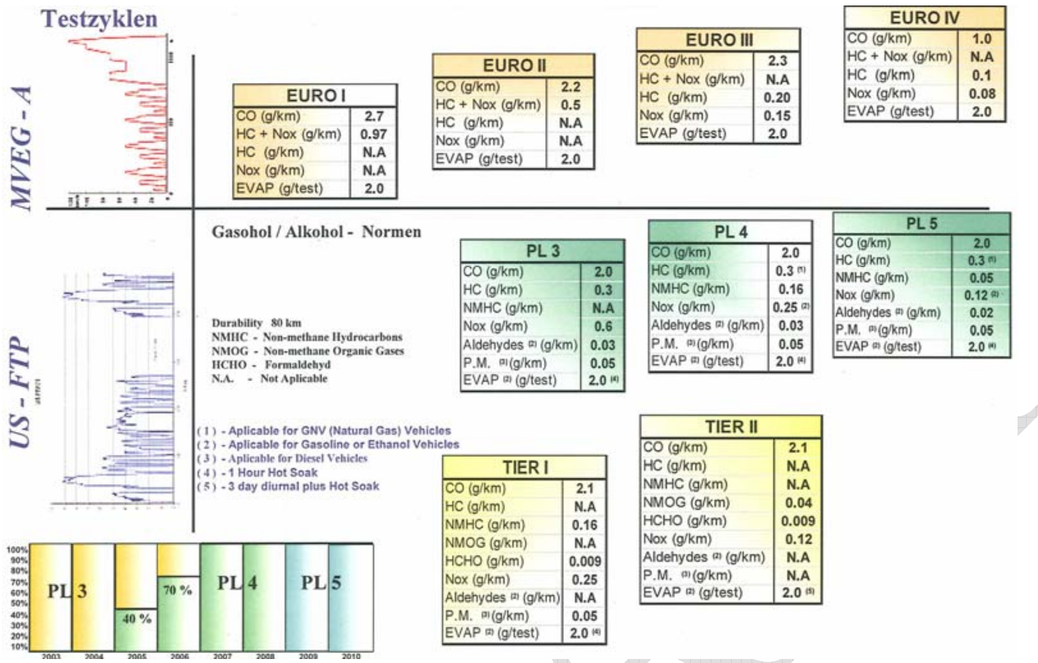


Fig. 3.1.7.1-1: Exhaust gas emission legislation.

further input expected

3.1.8. AUSTRALIA

3.1.8.1. EXHAUST GAS EMISSION

Tab. 3.1.8.1-1: ADR 79/02 Emission Control for Light Vehicles (M und N) ≤ 3,5 t gross vehicle weight.

	Date	**Date**	**Emission standard**
	New vehicles	**All vehicles**	
Gasoline	01.01.2003	01.01.2004	Euro 2
Gasoline	01.01.2005	01.01.2006	Euro 3
Gasoline	01.07.2008	01.07.2010	Euro 4
Diesel	01.01.2006	01.01.2007	Euro 2
Diesel	01.01.2006	01.01.2007	Euro 4

further input expected

3.1.9. REST OF WORLD COUNTRIES

…

further input expected

3.2. ASSESSMENT CONCEPTS

With regard to the analysis of the available literature it has to be stated that a large number of references, links and information concerning EFV can be located. Often the titles of the articles or of the websites include ambitious keywords like: 'efficiency of cars', 'global warming', 'alternative fuels', 'sustainability', 'energy consumption and the correlating emission of greenhouse gases', 'well to wheel analysis', 'lifecycle assessment' and so on. But the very most of them do not cover detailed information about the various requirements which EFV have to meet in general nor do the articles comprise concepts how to assess the environmental friendliness of cars in particular.

Since no comprehensive concept that comprises all influencing factors is available to evaluate if a vehicle is an EFV so far, the relevant issues regarding the environmental friendliness of cars have to be screened and analysed separately in order to provide the best basis for the feasibility analysis regarding the development of a holistic concept to determine and classify EFVs.

Before going into detail about the findings concerning EFV a clear distinction between the thematic priorities of the sources / literature is necessary. There are several main categories of influencing factors which affect EFVs. These categories concern particularly the energy consumption and exhaust gases emissions of EFV with regard to:

- the environmental impact of production, use and recycling of the vehicle: lifecycle considerations (LCA)
- the efficiency of fuels for road transportation: well-to-wheel (WTW) considerations

The analysis is often broken down into stages such as:
- pre-chain of the energy provisioning and supply: well-to-tank (WTT) considerations
- operation of the vehicle: tank-to-wheel (TTW) considerations

Starting from this approach it has to be taken into consideration that the findings within the literature review are addressed to different target groups. Some sources / articles are focussed on measures related to e.g. benefits for users of EFVs (for instance: reduced or no charges to enter cities (city-toll) and financial / tax incentives) and other articles pursue specific purposes of consumer information such as labelling concerns or eco-ratings. The latter take into account at least CO_2-emissions / fuel consumption or possibly even pollutant emissions and sometimes noise emissions as well. Although noise plays an important role it is not considered as a major concern within this first integrated approach.

According to the above mentioned categorisation the screened articles are listed below. With regard to the different (sub-) categories used in this structure it has to be noticed that a clear classification of the findings is not achievable always.

So occasionally it is possible that particular elements of several findings / articles could also belong to other categories.

In the context of “Environmental Friendly Vehicles” two main decisions for the concrete definition are necessary:

- On system boundaries: to focus on the energy efficiency of the vehicle (→ TTW) or of the whole system (→ WTW)
  The considerations on the system boundaries – from a pragmatic point of view – will lead in this global context clearly to a focus on the vehicle itself. The broader WTW approach would lead to a “fragmentation” in country wise, even regional or local definitions of the energy efficiency because of the specific situations of the → energy mix (especially for biofuels, hydrogen and electric power). Therefore, TTW approach is recommended.

- On the performance parameter which forms the basis for comparison in principle there are different reference (performance) parameters possible: weight, footprint, volume, load, number of seats, etc. In the light of the world wide regulatory framework, the parameter ″weight″ is the one which shows the best correlation regarding energy consumption and is most commonly used (e.g. EU, Japan, China) the best suited parameter basis for vehicle development worldwide is weight.

Additionally the problem of comparison of different energy carriers (petrol, diesel, hydrogen, LPG, CNG, electric power, etc.) has to be solved. Therefore the energy content of the energy carrier should be the basis for the definition. An international definition of the → energy content of energy carriers is necessary (e.g. LHV basis).

3.2.1. ENERGY EFFICIENCY

The definition of <u>energy efficiency</u> should be therefore:

$E_{eff} = E_{eg.}/m*d$

E_{eff} - Energy efficiency [J / (kg * km)]
$E_{eg.}$ - Energy equivalent [J]
m - vehicle curb weight [kg]
d - distance [km]

3.2.2. WELL-TO-WHEEL (WTW)

EUCAR, CONCAWE and JRC (the Joint Research Centre of the EU Commission) regularly publish a joint evaluation of the Well-to-Wheels energy use and greenhouse gas (GHG) emissions for a wide range of potential future fuel and powertrain options relevant to Europe in 2010 and beyond [2].

Study objectives:

- Establish, in a transparent and objective manner, a consensual well-to-wheels energy use and GHG emissions assessment of a wide range of automotive fuels and powertrains relevant to Europe in 2010 and beyond.
- Consider the viability of each fuel pathway and estimate the associated macro-economic costs.
- Have the outcome accepted as a reference by all relevant stakeholders.

Aside from the above mentioned main study additionally two separate special reports were published one concerning the well-to-tank concerns and one the tank-to-wheel aspects. Hence the two topics WTT and TTW of the EUCAR/CONCAVE/JRC study will be covered separately in the following.

- WTT-Report

The report identifies the potential benefits of substituting conventional fuels by alternatives.

For a well-to-tank analysis more than 100 pathways are examined regarding production, transport, manufacturing, distribution and availability of fuels on a costing basis. Two scenarios are calculated: One in which the alternative fuel was introduced or expanded in 2010-2020 and one ″business as usual″ reference scenario.

- TTW-Report

In this study the fuel consumption respectively the greenhouse gas emissions (CO_2, CH_4, N_2O) of conventional and alternative fuels as well as powertrain options were compared. But the study was not carried out with real vehicles. This was rather done on a virtual basis. For this purpose a fictitious vehicle (similar to a VW Golf model) was considered to be the vehicle of comparison. The required data were calculated by means of computer simulation on the basis of the NEDC. Taking customer preferences into account this vehicle also had to meet some minimum requirements concerning e.g. maximum speed or acceleration.

The study is mainly addressed to future development of fuel and powertrain options (as from 2010). More detailed information about the basic results of the study are summarised in the main report.

3.2.2.1. WELL TO TANK

As an energy carrier, a fuel must originate from a form of primary energy, which can be either contained in a fossil feedstock or fissile material, or directly extracted from solar energy (biomass or wind power). Generally a given fuel can be produced from a number of different primary energy sources. In the study all fuels and primary energy sources have been included that appear relevant for the foreseeable future. The following matrix summarises the main combinations that have been included.

Tab. 3.2.2.1-1: Primary energy resources and automotive fuels.

Resource \ Fuel		Gasoline, Diesel, Naphtha (2010 quality)	CNG	LPG	Hydrogen (comp., liquid)	Synthetic diesel (Fischer-Tropsch)	DME	Ethanol	MT/ETBE	FAME/FAEE	Methanol	Electricity
Crude oil		X										
Coal					X(1)	X(1)	X				X	X
Natural gas	Piped		X		X(1)	X	X				X	X
	Remote		X(1)		X	X(1)	X(1)		X		X	X
LPG	Remote(3)			X					X			
Biomass	Sugar beet							X	X			
	Wheat							X	X			
	Wheat straw							X				
	Sugar cane							X				
	Rapeseed									X		
	Sunflower									X		
	Woody waste				X	X	X	X			X	
	Farmed wood				X	X	X	X			X	X
	Organic waste		X(2)									X
	Black liquor				X	X	X				X	X
Wind												X
Nuclear												X
Electricity					X							

(1) with/without CO_2 capture and sequestration
(2) Biogas
(3) Associated with natural gas production

3.2.2.2. TANK TO WHEEL

To establish comparability a common vehicle platform representing the most widespread European segment of passenger vehicles (compact 5-seater European sedan) was used in combination with a number of powertrain options (see Tab. 3.2.2.2-1).
Key to the methodology was the requirement for all configurations to comply with a set of minimum performance criteria relevant to European customers while retaining similar characteristics of comfort, driveability and interior space. Also the appropriate technologies (engine, powertrain and after-treatment) required to comply with regulated pollutant emission regulations in force at the relevant date were assumed to be installed. Finally fuel consumptions and GHG emissions were evaluated on the basis of the current European type-approval cycle (NEDC).

Tab. 3.2.2.2-1: Automotive fuel and powertrain options covered by EUCAR/CONCAWE/JRC study.

Powertrains	PISI	DISI	DICI	Hybrid PISI	Hybrid DISI	Hybrid DICI	FC	Hybrid FC	Ref. + hyb. FC
Fuels									
Gasoline	2002 2010+	2002 2010+		2010+	2010+				2010+
Diesel fuel			2002 2010+			2010+			2010+
LPG	2002 2010+								
CNG Bi-Fuel	2002 2010+								
CNG (dedicated)	2002 2010+			2010+					
Diesel/Bio-diesel blend 95/5			2002 2010+			2010+			
Gasoline/Ethanol blend 95/5	2002 2010+	2002 2010+			2010+				
Bio-diesel			2002 2010+			2002 2010+			
DME			2002 2010+			2010+			
Synthetic diesel fuel			2002 2010+			2010+			
Methanol									2010+
Naphtha									2010+
Compressed hydrogen	2010+			2010+			2010+	2010+	
Liquid hydrogen	2010+			2010+			2010+	2010+	

PISI: Port Injection Spark Ignition
DISI: Direct Injection Spark Ignition
DICI: Direct Injection Compression Ignition
FC: Fuel cell

3.2.2.3. RESULTS OF EUCAR/CONCAWE/JCR STUDY

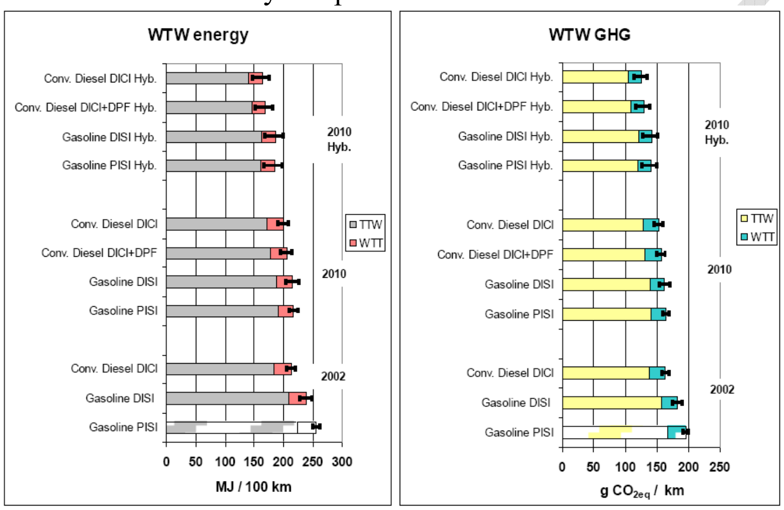
General observations

- Both fuel production pathway and powertrain efficiency are key to GHG emissions and energy use.
- A shift to renewable/low fossil carbon routes may offer a significant GHG reduction potential but generally requires more energy. The specific pathway is critical.
- Results must further be evaluated in the context of volume potential, feasibility, practicability, costs and customer acceptance of the pathways investigated.
- A shift to renewable/low carbon sources is currently expensive.
- GHG emission reductions always entail costs but high cost does not always result in large GHG reductions
- No single fuel pathway offers a short term route to high volumes of "low carbon" fuel
- A wider variety of fuels may be expected in the market
- Advanced biofuels and hydrogen have a higher potential for substituting fossil fuels than conventional biofuels.
- Optimum use of renewable energy sources such as biomass and wind requires consideration of the overall energy demand including stationary applications.

Results conventional fuels/vehicle technologies

- Developments in engine and vehicle technologies will continue to contribute to the reduction of energy use and GHG emissions.
- Within the timeframe considered in the study, higher energy efficiency improvements are predicted for the gasoline technology (PISI) than for the Diesel engine technology.
- Hybridization of the conventional engine technologies can provide further energy and GHG emission benefits.
- Hybrid technologies would, however, increase the complexity and cost of the vehicles.

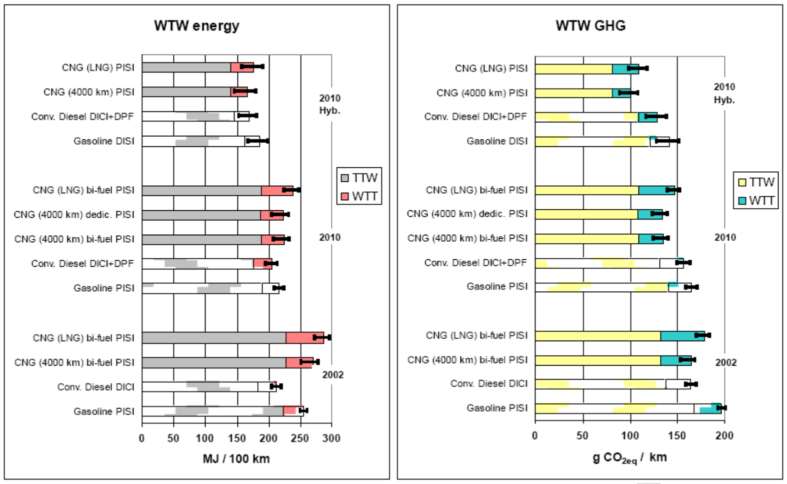
Tab. 3.2.2.3-1: WTW energy requirement and GHG emissions for conventional fuels ICE and hybrid powertrains.



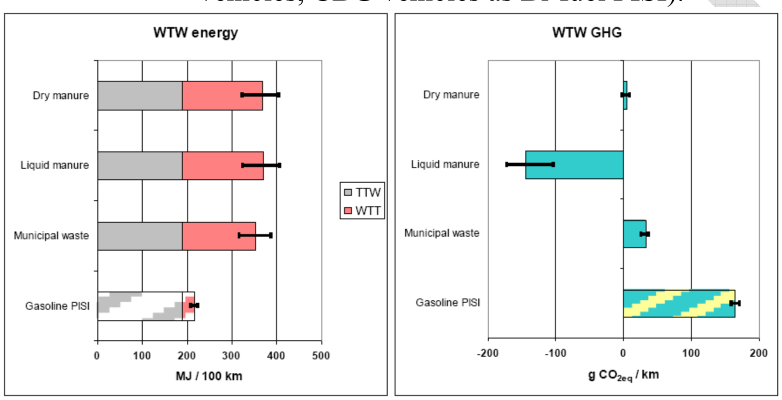
Results compressed natural gas, biogas, LPG

- Today the WTW GHG emissions for CNG lie between gasoline and diesel, approaching diesel in the best case.
- Beyond 2010, greater engine efficiency gains are predicted for CNG vehicles, especially with hybridization.
- The origin of the natural gas and the supply pathway are critical to the overall WTW energy and GHG balance.
- When made from waste material biogas provides high and relatively low cost GHG savings.

Tab. 3.2.2.3-2: WTW energy requirement and GHG emissions for conventional and CNG pathways.



Tab. 3.2.2.3-3: WTW energy requirement and GHG emissions for biogas (as CBG) (2010+ vehicles, CBG vehicles as Bi-fuel PISI).

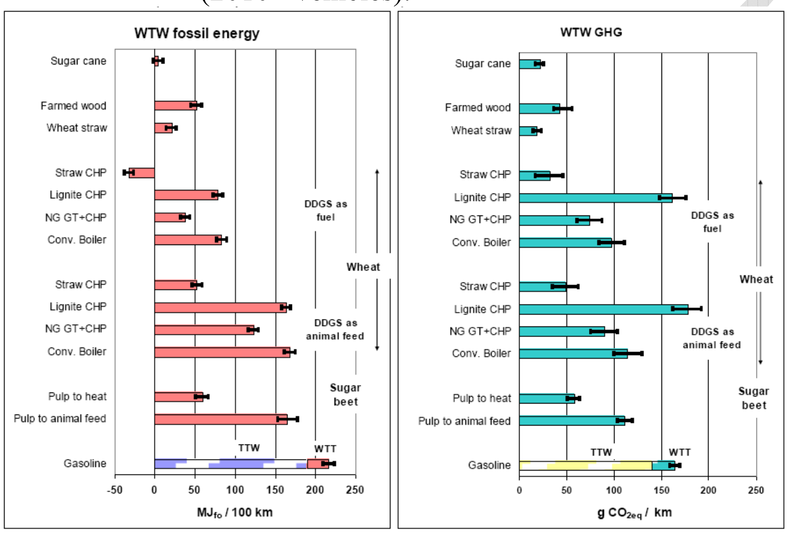


Results alternative liquid fuels

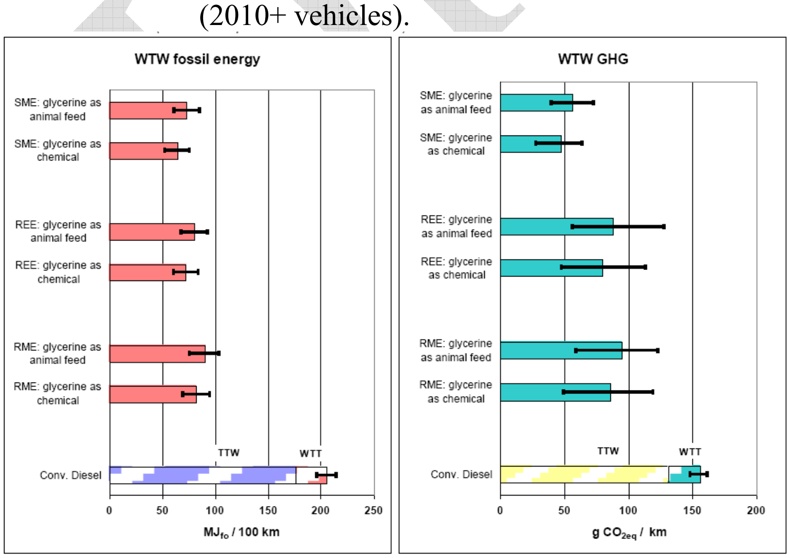
- The fossil energy and GHG savings of conventionally produced bio-fuels such as ethanol and bio-diesel are critically dependent on manufacturing processes and the fate of by-products.
- The GHG balance is particularly uncertain because of nitrous oxide emissions from agriculture.
- Potential volumes of ethanol and bio-diesel are limited. The cost/benefit, including cost of CO_2 avoidance and cost of fossil fuel substitution crucially depend on the specific pathway, by-product usage and N_2O emissions.
- The fossil energy savings discussed above should not lead to the conclusion that these pathways are energy-efficient. Taking into account the energy contained in the biomass resource one can calculate the total energy involved. Tab. 3.2.2.3-6 shows that this is several times higher than the fossil energy involved in the pathway itself and two to three times higher than the energy involved in making conventional fuels.

- High quality diesel fuel can be produced from natural gas (GTL) and coal (CTL). GHG emissions from GTL diesel are slightly higher than those of conventional diesel, CTL diesel produces considerably more GHG.
- New processes are being developed to produce synthetic diesel from biomass (BTL), offering lower overall GHG emissions, though still high energy use. Such advanced processes have the potential to save substantially more GHG emissions than current bio-fuel options .
- BTL processes have the potential to save substantially more GHG emissions than current bio-fuel options at comparable cost and merit further study.
- Issues such as land and biomass resources, material collection, plant size, efficiency and costs, may limit the application of these processes.

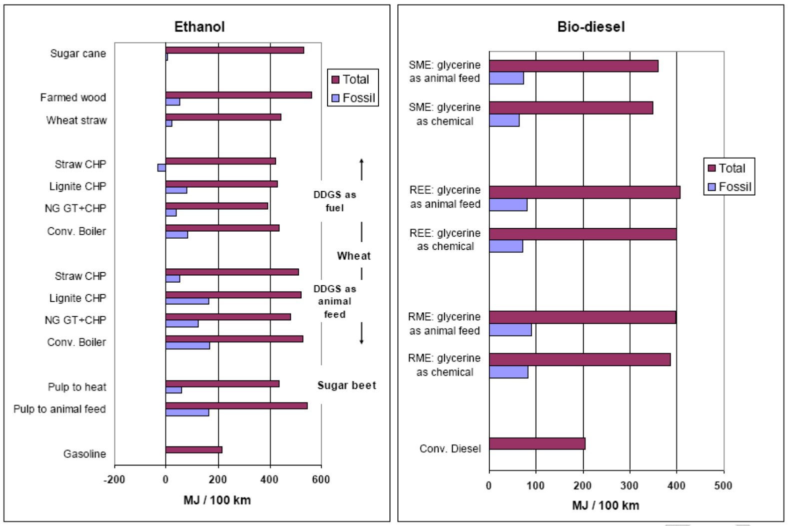
Tab. 3.2.2.3-4: WTW fossil energy requirement and GHG emissions for ethanol pathways (2010+ vehicles).



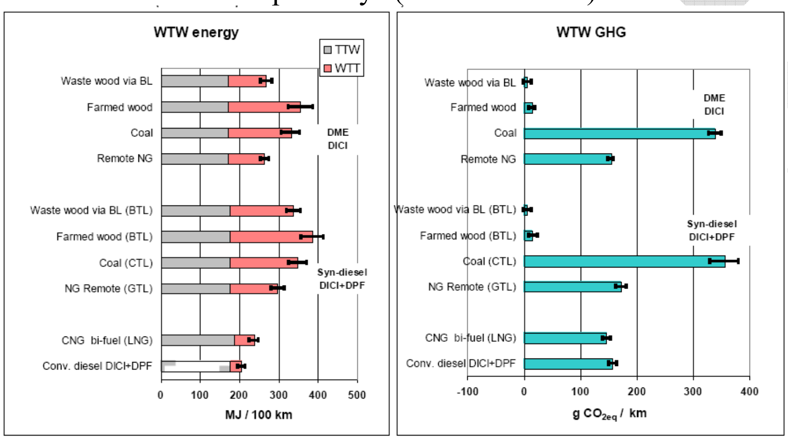
Tab. 3.2.2.3-5: WTW fossil energy requirement and GHG emissions for bio-diesel pathways (2010+ vehicles).



Tab. 3.2.2.3-6: WTW total versus fossil energy.



Tab. 3.2.2.3-7: WTW energy requirement and GHG emissions for synthetic diesel fuel and DME pathways (2010+ vehicles).



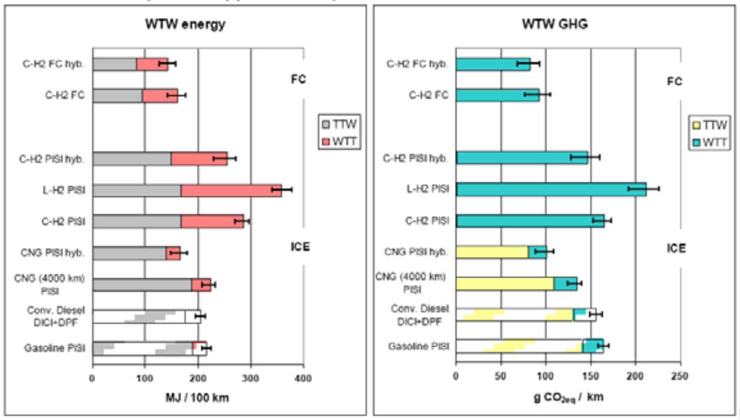
Results hydrogen

- Many potential production routes exist and the results are critically dependent on the pathway selected.

If hydrogen is produced from natural gas:

- WTW GHG emissions savings can only be achieved if hydrogen is used in fuel cell vehicles.
- The WTW energy use / GHG emissions are higher for hydrogen ICE vehicles than for conventional and CNG vehicles.
- In the short term, natural gas is the only viable and cheapest source of large scale hydrogen. WTW GHG emissions savings can only be achieved if hydrogen is used in fuel cell vehicles albeit at high costs.
- Hydrogen ICE vehicles will be available in the near-term at a lower cost than fuel cells. Their use would increase GHG emissions as long as hydrogen is produced from natural gas.

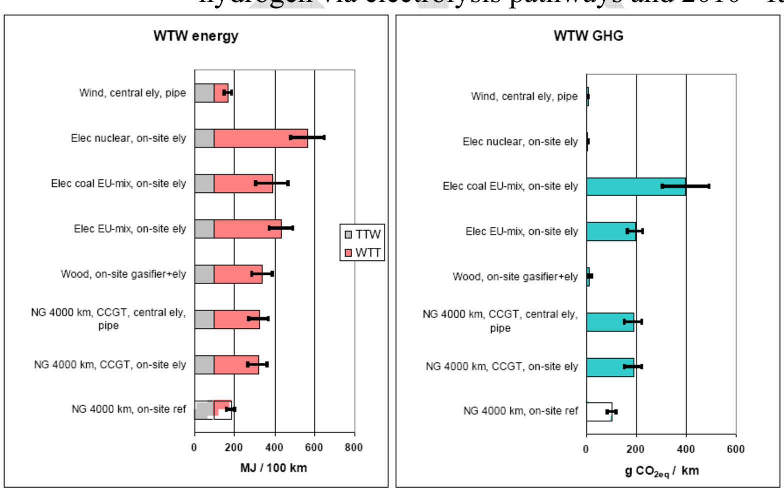
Tab. 3.2.2.3-8: WTW total energy requirement and GHG emissions for conventional, CNG and natural gas based hydrogen pathways (2010+ vehicles).



If hydrogen is produced via electrolysis:

- Electrolysis using EU-mix electricity results in higher GHG emissions than producing hydrogen directly from NG.
- Hydrogen from non-fossil sources (biomass, wind, nuclear) offers low overall GHG emissions.
- Renewable sources of hydrogen have a limited potential and are at present expensive.
- More efficient use of renewables may be achieved through direct use as electricity rather than road fuels applications.

Tab. 3.2.2.3-9: WTW total energy requirement and GHG emissions for compressed hydrogen via electrolysis pathways and 2010+ fuel cell vehicles.



Ely = electrolysis

- The technical challenges in distribution, storage and use of hydrogen lead to high costs. Also the cost, availability, complexity and customer acceptance of vehicle technology utilizing hydrogen technology should not be underestimated.

3.2.2.4. GENERAL REMARKS

It is important to recognise that:

- The model vehicle is merely a comparison tool and is not deemed to represent the European average, a/o in terms of fuel consumption.
- The results relate to compact passenger car applications, and should not be generalized to other segments such as Heavy Duty or SUVs.
- No assumptions or forecasts were made regarding the potential of each fuel/powertrain combination to penetrate the markets in the future. In the same way, no consideration was given to availability, market share and customer acceptance.
- The study is not a Life Cycle Analysis. It does not consider the energy or the emissions involved in building the facilities and the vehicles, or the end of life phase. Other environmental aspects such as HC/NO_x/CO (Summer smog / Acidification), lands use, etc. are also not addressed.

3.2.2.5. EU-PROJECT: CLEANER DRIVE
(scientific study / WTW)

The ″Cleaner Drive″-project [10] was part of a 5th FP European project. One Goal of ″Cleaner Drive″ was to develop a robust methodology for a vehicle environmental rating for the Community. Based on a well to wheels approach the ranking considers:

- Greenhouse gases (CO_2, CH_4, N_2O, O_3)
- Air Pollution (CO, NO_x, NMHC, SO_2, PM10)

Sources for the used data comprise type approval data and data from the EU-Project "MEET".

In 2004 the "Cleaner Drive" rating concept was compared with another similar rating method called "Ecoscore" [11,12]. As "Cleaner Drive" the "Ecoscore" rating is based on a scale of 0 – 100 but it was developed for the capital region of Brussels and there is a slight difference in the exhaust gas components which are ranked (e.g. the greenhouse gas component O_3 is not monitored and instead of NMHC the total HC is calculated). Moreover in the Ecoscore rating the issue noise is taken into account.
The emissions are weighted with different weighting factors. Ecoscore also uses type approval data and state-of-the-art data, based on the EU-Project "MEET".

As a result of this comparison it could be seen, that both ratings are robust and indicate similar results. In the meantime an update of the Ecoscore rating was performed.

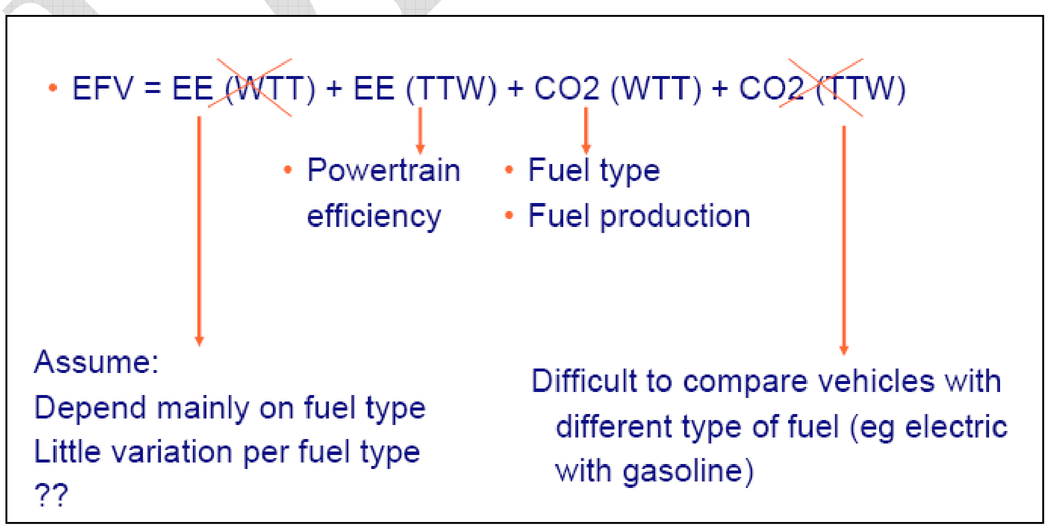
3.2.2.6. IFEU STUDY
(scientific study dealing biofuels / WTW)

In the IFEU Study [13] a wide range of results or conclusions with regard to biofuels for the transport sector is identified. The objective of this study is to get scientifically robust statements about the energy and greenhouse balances. Moreover other environmental impacts, estimations of the costs and the potentials of biofuels for the transport sector as well as the identification of needs for research are surveyed. To achieve this objective, publicly available studies were analysed and compared against each other. The inspection covers biofuels currently available on the market (e.g. pure vegetable oil, biodiesel from rapeseed, bioethanol from sugarcane or corn) as well as future biofuels which at present can not be produced on a large scale (e.g. BTL).
Ranges for the expected energy and greenhouse gas balances and the estimates of the costs for production and supply were derived for all biofuels – subdivided into the different (renewable) raw materials (e.g. bioethanol from wheat).

Possible approach to a concept for an Environmentally Friendly Vehicle from **TNO** [13a]
*(**conceptual approach / WTW** or rather WTT & TTW)*

Starting from the point that the whole chain (WTW analysis) has to be considered when vehicles are assessed concerning their environmentally friendliness this approach is focused on two key aspects: energy efficiency and CO_2-emissions which both have to be included into the assessment of EFVs. Hence the TNO concept proposes a separation of the whole chain into WTT and TTW issues what means that WTT concerns e.g. fuel production or fuel type are considered by means of CO_2 emissions. Accordingly TTW-issues are basically related to the powertrain efficiency and thus part of the key aspect energy efficiency.

In order to evaluate EFVs the two key aspects energy efficiency (EE) and CO_2 emissions are then combined according to the following equation:



With the aim to weight the importance of CO_2 versus the energy efficiency a standardisation should be performed finally. (Whereas standards could be based on e.g. average, minimum or best in class.)

$$EFV = \frac{CO_2\ [g/kWh]}{standard\ CO_2\ [g/kWh]}\ (WTT) + \frac{EE\ [\%]}{standard\ EE\ [\%]}\ (TTW)$$

3.2.3. ECO RANKING BY CONSUMER ASSOCIATIONS

Most of the screened articles of the category tank-to-wheel reflect to the purpose consumer information especially those with regard to eco-ratings. In addition much information is published with regard to the availability of consumer information on fuel economy and / or CO_2 emissions in respect of the marketing of new passenger cars (CO_2-labelling) particularly in the context with the Directive 1999/94/EC. This area of available sources especially concerning the legislation on CO_2-labelling was not examined to a great extent within this study until now.

Currently there are only few references available which give some advice how an assessment of environmentally friendly cars could be arranged on tank-to-wheel basis which are the major criteria that vehicles have to fulfil in order to score well in the corresponding lists ranking the environmental friendliness. Due to the fact that the quality level of the articles diverges very much it is beyond the question that the various assessment concepts can always be described with the same accuracy.

Promising references with suiTab. information are outlined below in detail. There one can find in many cases precise descriptions of approaches and basic requirements concerning the proposed evaluation concept for EFVs. The following findings / concepts will thus be described more detailed:

- ECO-Test from ADAC/FIA
- Environmental Ranking List from VCD
- Environmental Certificate from Öko-TREND Institute
- Environmental Performance Label from CARB
- Green Vehicle Guide (Australia)
- Green Vehicle Guide (US EPA)
- J.D. Power, Green efficiency rating
- Environmental Transport Association
- „Eco car“ concepts

However, there is no common approach available. Some ECO-rankings also include additional vehicle data (e.g. use of recycled and natural materials, noise, availability of start/stop or CO_2 calculator), others also include manufacturer aspects (e.g. availability of Environmental management system).

3.2.3.1. ECO-TEST ADAC / FIA

(consumer information/TTW)

On behalf of FIA the so-called "Eco-Test" [14, 15] was developed from the German Automobile Club ADAC. It was projected to enable the assessment of the environmental friendliness of new cars. To ensure reproducible test conditions the Eco-Test is based on driving cycle measurements on chassis dynamometers. Tests are carried out on NEDC Cold Test, NEDC Hot Test and on the ADAC Highway Driving Cycle (the latter test cycles are performed with the air conditioning switched on). Within this approach the environmental impact of passenger cars is assessed in two different categories.

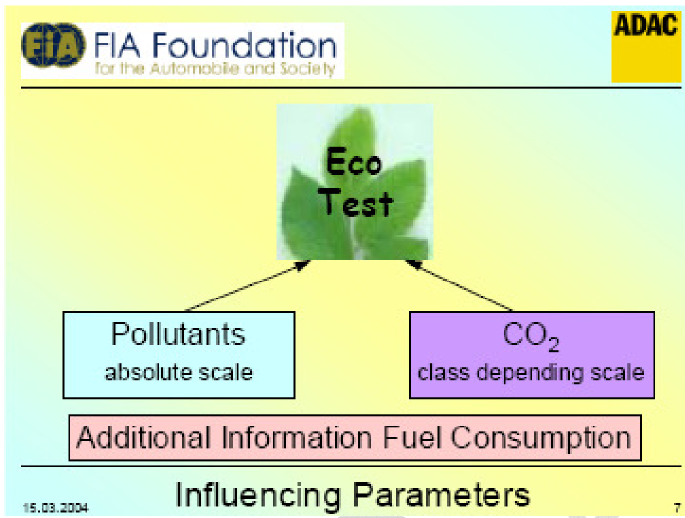


Fig. 3.2.3.1-1: Scheme of "Eco-Test" from the German Automobile Club ADAC.

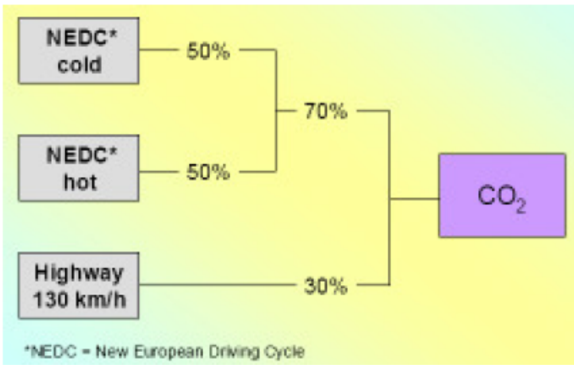
Both categories (limited pollutants on the one side and CO_2-emissions on the other side) contribute with a share of 50 per cent to the overall rating. The Eco-Test awards up to 5 stars, derived from the scores achieved for CO_2 and limited pollutants.

The rating of the CO_2-emissions rests upon relative scales on account of different vehicle classes. This allows a comparison of the results within a certain vehicle class.
Thus consumers have a direct comparing of competitors. Rating the vehicles on an absolute scale would merely indicate that large cars will have higher emissions than smaller ones.

ID	Vehicle class	Example
1	City (two seats)	Smart
2	City	Fiat , Peugeot 105, VW Lupo
3	Supermini	Fiat Punto, Peugeot 206, VW Polo
4	Small Family	Toyota Corolla, VW Golf
5	Family	BMW 3-series, Mazda 6, Opel Vectra, Toyota Avensis
6	Executive	Audi A6, BMW 5-series, Mercedes E-class, Peugeot 607
7	Luxury	Audi A8, BMW 7-series, Jaguar XJ, Mercedes S-class

Fig. 3.2.3.1-2: Ranking list ADAC.

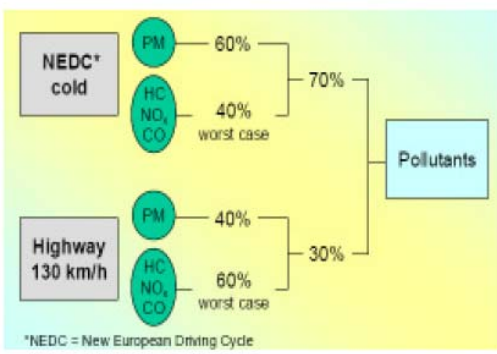
The rating of CO_2 is due to the contribution of the NEDC Cold, NEDC Hot and ADAC Highway results with different weighting factors for the involved cycles and based on seven vehicle classes each with different thresholds.



Vehicle class	★★★★★ 50 points at [g/km]	★ 10 points at [g/km]
1	60	150
2	60	150
3	70	175
4	85	205
5	105	240
6	130	280
7	160	325

Fig. 3.2.3.1-.3: Rating of CO_2 and vehicle classes.

In contrast to the class depending CO_2-rating the assessment of the limited pollutants (CO, HC, NO_X and PM) is independent of vehicle classes. Unlike in the emission legislation the same criteria and emission levels are applied to gasoline, diesel, natural gas and hybrid power trains.



	NEDC		Highway	
	★★★★★ 50 points at [g/km]	★ 10 points at [g/km]	★★★★★ 50 points at [g/km]	★ 10 points at [g/km]
HC	0.10[a]	0.20[c]	0.10[a]	0.20[c]
CO	1.00[a]	2.30[c]	1.00[a]	14.00[d]
NO_x	0.08[a]	0.50[b]	0.08[a]	1.00[d]
PM	0.005[d]	0.05[b]	0.005[d]	0.05[b]

[a]) value according to directive 98/69/EC: Euro 4 Petrol NEDC
[b]) value according to directive 98/69/EC: Euro 3 Diesel NEDC
[c]) value according to directive 98/69/EC: Euro 3 Petrol NEDC
[d]) value according to state of the art

Fig. 3.2.3.1-4: Assessment of pollutants and vehicle classes.

The rating is calculated on the basis of the performance in the NEDC cold and ADAC highway cycle. The worst results in each cycle define the pollution rating. For all cars – regardless of whether a petrol or diesel engine, with or without direct injection system – the same rating formula is applied. Although conventional petrol engines have no particle emissions detectable. by gravimetric measurement no problem emerges with this formula. As a direct consequence of the formula conventional petrol vehicles will result in the maximum score for particles.

3.2.3.2. VCD
(consumer information/TTW)

Based on an expert's report of IFEU, VCD [16, 17] publishes a ranking list for cars with regard to environmental concerns. The ranking list called ‚Auto-Umweltliste' is designed to inform the consumers. The Auto-Umweltliste addresses the environmental impact of cars to four different categories with a rating from 0 to 10 points in each case, but the four distinct categories have different shares of the overall appraisal.

The four categories affect:

- CO_2-emissions (with 10 points relating to 60 g/km and 0 points to 180 g/km; share of the overall rating: 60 per cent)
- noise (with 10 points relating to 65 dB(A) and 0 points to 75 dB(A); share of the overall rating: 20 per cent)
- human burden from pollutants (NO_X, NO_2, PM); share of the overall rating: 15 per cent
- impact on the nature; share of the overall rating: 5 per cent

The scoring of the two last mentioned categories complies with the following pattern which strongly depends on the exhaust emission stages Euro 4, Euro 5, Euro 6.

	Euro 4		Euro 5		Euro 6*
	Otto	Diesel	Otto	Diesel	Diesel
Gesundheit – NO_x	6,8	0,0	7,6	2,8	6,8
Gesundheit – NO_2	9,7	0,0	9,8	2,8	6,8
Gesundheit – Partikel	10,0	10,0	10,0	10,0	10,0
Gesamtwert für Gesundheit	9,13	5,0	9,35	6,4	8,4
Natur – NO_x	6,8	0,0	7,6	2,8	6,8
Umgerechnet in Gesamtpunkte	1,7	0,8	1,8	1,1	1,6

* Bei der Grenzwertstufe Euro 6 bleiben die Werte für den Otto-Pkw auf dem Niveau von Euro 5

Fig. 3.2.3.2-2: German VCD approach.

With regard to the category 'human burden from pollutants' is has to be mentioned that within this topic the three pollutants NO_X, NO_2 and PM have different weighting factors (NO_X: 25 per cent, NO_2: 25 per cent and PM: 50 per cent).

The applied data were taken from information from vehicle manufacturers.

3.2.3.3. ÖKO-TREND INSTITUTE
(consumer information/TTW&LCA)

Öko-TREND institute [18] awards an environmental certificate for cars. In a holistic approach the assessment is addressed to two focal points i.e. on the one side the evaluation of the vehicle (operation and equipment) which has a ratio of 55 per cent of the overall rating and on the other side the vehicle making and recycling of the vehicle with a share of 45 per cent of the overall rating.

The several evaluation categories are:

- operation / use of vehicle (contributes with 50per cent to the overall rating)
  criteria are e.g.: fuel consumption, CO_2-emission, pollutant emissions, noise emission

- equipment of the car (contributes with 5per cent to the overall rating)
  criteria are e.g.: fuel consumption indicator, stop-start automatic device

- logistics (contributes with 5per cent to the overall rating)
  criteria are e.g.: transport of new cars by ship or train

- make of vehicle (contributes with 17per cent to the overall rating)
  criteria are e.g.: expenditure of energy for producing the car, avoidance of usage of environmentally hazardous substances and manufacturing processes, waste prevention, kind of painting

- recycling (contributes with 9per cent to the overall rating)
  criteria are e.g.: usage of recycled materials in new cars, usage of renewable raw materials in new cars

- environmental management / eco-audit (contributes with 14per cent to the overall rating)
  criteria are e.g.: manufacturer's perception of ecological and social responsibility, offer of eco-trainings.

For each criterion within the several categories the vehicle will achieve points. The weighting of the different categories respectively of the criteria varies. A certificate will be awarded, if the total scoring results in more than 90 per cent of the overall points.

Fig. 3.2.3.3-1: German Auto-Umwelt-Zertifikat, Öko-Trend approach.

3.2.3.4. ENVIRONMENTAL PERFORMANCE LABEL FROM CARB
(consumer information/ TTW&WTW)

In California all new cars beginning with the 2009 model year are required to display an ″Environmental Performance″ label (EP label) [19], providing a ″Smog Score″ and a ″Global Warming Score″ – each having unique environmental impacts.
The EP label scores a vehicle's global warming and smog emissions from 1 – 10 (in each score) with the highest scores being the cleanest vehicle options.

Fig. 3.2.3.4-1: Environmental Performance.
The global warming score reflects the emissions of greenhouse gases from the vehicle's operation and fuel production. It is based on the sum of vehicle's greenhouse gas emissions which are identified as the CO_2-equivalent value. The measured emissions include Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_20) and emissions related to the use of air conditioning. The global warming score ranks each vehicle's CO_2-equivalent value on a scale of 1 - 10 (10 being the cleanest) relative to all other vehicles within the current model year. The scores are also properly adjusted to reflect the contribution of greenhouse gas emissions from the production and distribution of the fuel type used.

The corresponding Tab. shows the 10 CO_2-equivalent levels. The average vehicle available in California today will get a global warming score of 5.

Tab. 3.2.3.4-1: CO_2-equivalent levels.

Global Warming Score	CO_2-equivalent Grams per mile
10	Less than 200
9	200 – 239
8	240 – 279
7	280 – 319
6	320 – 359
5	360 – 399
4	400 – 439
3	440 – 479
2	480 – 519

1	520 and up

The Smog Score is based on the smog forming emissions from the vehicle’s operation and ranks the pollutant levels of non-methane organic gases (NMOG) and oxides of

Tab. 3.2.3.4-2: Smog Score and pollutant levels of non-methane organic gases (NMOG) and oxides of nitrogen (NO_X).

Smog Score	$NMOG + NO_x$ Gram per mile**
10	0,000
9*	0,030
8	0,030
7	0,085
6	0,110
5	0,125
4	0,160
3	0,190
2	0,200
1	> 0,356

*A smog score of 9 was given to vehicles certifying tot he California PZEV and ATPZEV standards based on the longer useful life, zero evaporative emissions requirements, and extended warranty for these vehicles compared to vehicles certifying the SULEV standards.

** Does not include upstream emissions

nitrogen (NO_X) relative to all other vehicles within the current model year. Again the scores will be on a scale from 1 – 10 with 10 being the cleanest. And again the average vehicle available in California today will get a smog score of 5.

These scores compare emissions between all vehicle classes and sizes with the average new car scoring 5 on both scales.

3.2.3.5 GREEN VEHICLE GUIDE FROM THE AUSTRALIAN GOVERNMENT (consumer information / TTW)

The Green Vehicle Guide [20] is an Australian Government Initiative and is based on tailpipe emissions. Two categories are separately weighted:

- Greenhouse Rating (weighting 50 per cent)
  The Greenhouse Rating rests upon the CO2 emission value
- Air Pollution Rating (weighting 50 per cent)

The Air Pollution Rating rests upon the Australian emission standards but a precise distinction into two stages is applied. Stage 1 covers the air pollution ratings applicable in 2004 and 2005 and stage 2 those applicable from 1 January 2006.
Due to the large sized Tab.s concerning stage 1 and stage 2 ratings only some stage 2 data are depicted below, however the logical configuration is the same in stage 1.
Tab. 3.2.3.5-1: Greenhouse ratings and CO_2 Emissions.

Greenhouse Rating	CO_2 Emissions (combined g/km)	Greenhouse Rating	CO_2 Emissions (combined g/km)
10 (0–10)	<= 60	5 (0–10)	241 - 260
9.5 (0–10)	61 - 80	4.5 (0–10)	261 - 280
9 (0–10)	81 - 100	4 (0–10)	281 - 300
8.5 (0–10)	101 - 120	3.5 (0–10)	301 - 320
8 (0–10)	121 - 140	3 (0–10)	321 - 340
7.5 (0–10)	141 - 160	2.5 (0–10)	341 - 360
7 (0–10)	161 - 180	2 (0–10)	361 - 380
6.5 (0–10)	181 - 200	1.5 (0–10)	381 - 400
6 (0–10)	201 - 220	1 (0–10)	401 - 420
5.5 (0–10)	221 - 240	0.5 (0–10)	421 - 440

Tab. 3.2.3.5-2: Stage 2 Air Pollution Ratings.

Stage 2 Air Pollution Ratings (applicable from 1 January 2006)

Air Pollution Rating	Fuel Type	Vehicle Type[i] RM = reference mass[ii] (kg)	ADR compliance	Additional GVG emissions requirements	Equivalent *Euro* Standard	Emissions Limits (g/km) HC	NOx	PM
11	Electric	All	All	-	-	-	-	-
8.5	Petrol, LPG, NG	All	ADR79/02	*Euro 4* certification and HC ≤ 0.035g/km and NOx ≤ 0.028g/km[iii]	Beyond *Euro 4*	0.035	0.028	-
	Diesel	All	ADR79/01	HC ≤ 0.035g/km and NOx ≤ 0.028g/km and PM ≤ 0.00875g/km[iv]	Beyond *Euro 4*	0.035	0.028	0.00875
6.5	Petrol, LPG, NG	Passenger Goods carrying (RM ≤ 1305)	ADR79/02	*Euro 4* certification	*Euro 4*	0.10	0.08	-
6	Petrol, LPG, NG	Goods carrying (1305 < RM ≤ 1760)	ADR79/02	*Euro 4* certification	*Euro 4*	0.13	0.10	-
5.5	Petrol, LPG, NG	Goods carrying (RM > 1760)	ADR79/02	*Euro 4* certification	*Euro 4*	0.16	0.11	-
5	Petrol, LPG, NG	Passenger Goods carrying (RM ≤ 1305)	ADR79/01	-	*Euro 3*	0.20	0.15	-
	Diesel	Passenger Goods carrying (RM ≤ 1305)	ADR79/01	-	*Euro 4*	HC + NOx ≤ 0.30	0.25	0.025
4.5	Petrol	Goods carrying (1305 < RM ≤ 1760)	ADR79/01	-	*Euro 3*	0.25	0.18	-
4	Petrol, LPG, NG	Goods carrying (RM > 1760)	ADR79/01	-	*Euro 3*	0.29	0.21	-
	Diesel	Goods carrying (1305 < RM ≤ 1760)	ADR79/01	-	*Euro 4*	HC + NOx ≤ 0.39	0.33	0.04
3	Diesel	Goods carrying (RM > 1760)	ADR79/01	-	*Euro 4*	HC + NOx ≤ 0.46	0.39	0.06
2.5	Diesel	Passenger Goods carrying (RM ≤ 1305)	ADR79/00	*Euro 3* certification	*Euro 3*	HC + NOx ≤ 0.56	0.50	0.05
2	Diesel	Goods carrying (1305 < RM ≤ 1760)	ADR79/00	*Euro 3* certification	*Euro 3*	HC + NOx ≤ 0.72	0.65	0.07
	Diesel	Passenger Goods carrying (RM ≤ 1250)	ADR79/00	-	*Euro 2*	HC + NOx ≤ 0.70		0.08
1.5	Diesel	Goods carrying (RM > 1760)	ADR79/00	*Euro 3* certification	*Euro 3*	HC + NOx ≤ 0.86	0.78	0.10
1	Diesel	Goods carrying (1250 < RM ≤ 1700)	ADR79/00	-	*Euro 2*	HC + NOx ≤ 1.00		0.12
0.5	Diesel	Goods vehicles (RM > 1700)	ADR79/00	-	*Euro 2*	HC + NOx ≤ 1.20		0.17

[i] Passenger vehicles with a maximum mass greater than 2500kg and, in the case of ADR79/00, vehicles with greater than 6 seats are, for the purposes of the emissions standards treated as goods carrying vehicles. The maximum mass of a vehicle refers to the maximum laden mass that is technically possible for that vehicle.
[ii] The reference mass of a vehicle refers to the unladen vehicle mass plus 100kg.
[iii] These HC and NOx values represent 35% of the *Euro 4* limits for a standard petrol passenger car.
[iv] These HC and NOx limits are these same as per (iii) above and the PM value is equivalent to 35% of the *Euro 4* limit for a standard diesel passenger car.

An overall star rating is generated by combining Air Pollution Score and Greenhouse Score:

Overall Rating	Combined Air Pollution & Greenhouse Score
★★★★★	combined score >= 16
★★★★½	15 <= combined score < 16
★★★★	14 <= combined score < 15
★★★½	11.5 <= combined score < 14
★★★	9.5 <= combined score < 11.5
★★½	8 <= combined score < 9.5
★★	6.5 <= combined score < 8
★½	5 <= combined score < 6.5
★	combined score < 5

Fig. 3.2.3.5-1: Overall star rating.

3.2.3.6. GREEN VEHICLE GUIDE FROM US EPA
(consumer information / WTT & WTW)

The Environmental Protection Agency (EPA) also publishes a "Green Vehicle Guide" [21, 22]: The Guide is designed for cars and trucks and provides the user with information about:

- Air Pollution
  A score from 0 to 10 reflects vehicle tailpipe emissions based on US and California emission standards:

Air Pollution Score MY 2008 & Earlier

Score	US EPA Tier 2 Emission Standard	California Air Resources Board LEV II Emission Standard
10	Bin 1	ZEV
9	Bin 2	SULEV II
8	Bin 3	--
7	Bin 4	ULEV II
6	Bin 5	LEV II
5	Bin 6	LEV II option 1
4	Bin 7	--
3	Bin 8	SULEV II lg trucks
2	Bin 9	ULEV II lg trucks
1	Bin 10	LEV II lg trucks
0	Bin 11	--

Air Pollution Score MY 2009+

Score	US EPA Tier 2 Emission Standard	California Air Resources Board LEV II Emission Standard
10	Bin 1	ZEV
9	Bin 2	SULEV II
8	Bin 3	--
7	Bin 4	ULEV II
6	Bin 5	LEV II
5	Bin 6	LEV II option 1
4	Bin 7	--
3	Bin 8	SULEV II lg trucks
2	--	ULEV II lg trucks
1	--	LEV II lg trucks
0	--	--

* Bin 9, 10, 11 phased out in MY 2009

Fig. 3.2.3.6-1: Air Pollution Score.

- Fuel Economy

Starting in model year 2008, EPA tests vehicles by running them under real world conditions. Effects of faster speed and acceleration, air conditioner use and colder outside temperatures are considered in additional driving cycles.

City: Represents urban driving, in which a vehicle is started with the engine cold and driven in stop-and-go rush hour traffic.

Highway: Represents a mixture of rural and interstate highway driving with a warmed-up engine, typical of longer trips in free-flowing traffic.

High Speed: Represents city and highway driving at higher speeds with more aggressive acceleration and braking.

Air Conditioning: Account for air conditioning use under hot outside conditions (95°F sun load).

Cold Temperature: Tests the effects of colder outside temperatures on coldstart driving in stop-and-go traffic.

- Greenhouse gases

The approach reflects the estimates, considering all steps in use of a fuel, from production and refining to distribution and final use; vehicle manufacture is excluded.

The chart (Fig. 3.2.3.6-2) shows the minimum fuel economy (combined city, highway fuel economy) for each fuel type at each Greenhouse Gas Score. The miles per gallon vary by fuel type because each fuel has a different carbon content per gallon. This means each fuel creates different levels of CO_2 emissions per gallon. The overall GHG-scoring relates to the WTW emissions.

A score from 0 to 10 reflects the amount of CO_2, N_2O and CH_4 emissions. The score is based on the methodology of the Department of Energy's GREET model. (The GREET model is explained more detailed in chapter xxx. Category Life Cycle Assessment)

Greenhouse Gas Score Criteria MY 2008 & Earlier						
		Minimum Label MPG (combined)				
GHG Score	Pounds CO2e per mile	Gasoline	Diesel	E85	LPG	CNG*
10	Less than 0.62	37	43	23	23	31
9	0.62 to <0.76	31	36	19	19	26
8	0.76 to <0.90	26	30	16	16	22
7	0.90 to <1.06	23	26	14	14	19
6	1.06 to <1.16	20	23	12	12	17
5	1.16 to <1.28	18	21	11	11	15
4	1.28 to <1.43	16	19	10	10	14
3	1.43 to <1.52	15	17	9	9	13
2	1.52 to <1.62	14	16	8	8	12
1	1.62 to <1.73	13	15	7	7	11
0	1.73 and up	1	1	1	1	1

Greenhouse Gas Score Criteria MY 2009+						
		Minimum Label MPG (combined)				
GHG Score	Pounds CO2e per mile	Gasoline	Diesel	E85	LPG	CNG*
10	Less than 0.61	39	45	24	24	33
9	0.61 to <0.74	33	38	20	20	27
8	0.74 to <0.87	28	32	17	17	23
7	0.87 to <1	24	28	15	15	20
6	1 to <1.13	22	25	13	13	18
5	1.13 to <1.25	19	22	12	12	16
4	1.25 to <1.38	18	20	11	11	15
3	1.38 to <1.51	16	19	10	10	14
2	1.51 to <1.63	15	17	9	9	12
1	1.63 to <1.76	14	16	8	8	12
0	1.76 and up	1	1	1	1	1

Fig. 3.2.3.6-2: Greenhouse Gas Score Criteria.

Vehicles, which rate 6 or better on each of the both scores (air pollution and GHG) and have a combined score of at least 13 are labelled with the SmartWay designation and vehicles, which rate 9 or better on each of the both scores are labelled with the SmartWay Elite designation.

The scores can be used to compare all vehicles and all model years against one another. The best environmental performers receive the SmartWay labels, which means the vehicles scores well on both Air Pollution and Greenhouse Gas.

3.2.3.7. J.D. POWER
(consumer information)

The J.D. Power Green Efficiency Rating (a 5-star-rating) [23][1] is based on an ″Automotive Environmental Index (AEI)″, which combines information from the Environmental Protection

[1] The sources [23] and [24] are examples for those kind of findings which are providing only some marginal information. And with respect to findings in the internet in many cases more precise descriptions about the applied ranking method or about the criteria how the assessment of the cars is

Agency (EPA) and consumers data (voice-of-the-customer) concerning fuel economy, air pollution and greenhouse gases. The top 30 environmentally friendly vehicles are listed.

3.2.3.8. ENVIRONMENTAL TRANSPORT ASSOCIATION (UK)
(consumer information)

The Environmental Transport Association (ETA) [24][1] offers an annual ″Car Buyers' Guide″. The Guide ranks the best cars in each class (Supermini, Small Family, Small MPV, City, Large Family, Sports, Executive, MPV, Off road and Luxury), the top 10 cars overall and the ten worst cars overall. The ETA 5-star-rating is based on the factors power (engine capacity), emissions (CO, HC, NO_X, PM and CO_2), fuel consumption (urban cold cycle) and noise.

Furthermore there are top 10 lists for cars with the lowest/highest CO_2 emissions and for cars with the lowest / highest fuel costs available. The result of each car is also displayed.

3.2.3.9. ″ECO-CAR″ CONCEPTS

In some countries incentives are provided for users of environmentally friendly vehicles.
The legal basis for giving special subsidies depends on regional or national action plans. The demands that such vehicles have to comply with can comprise diverse issues deriving from particularly tank-to-wheel or well-to-tank aspects as well as from LCA terms. The following concept from Sweden is an example for such a scheme
building the basis for incentives.

Example: Sweden [25]

At present (over a period from 01.04.2007 – 31.12.2009) in Sweden private persons get a subsidy of 10.000 Skr (~ 1.100 €) for registration of a new ″eco-car″ which meets certain environmental requirements. For this purpose the Swedish government provides an amount of 250 Million Skr. The definition of eco-cars is the following:

• vehicles with alternative fuels (e.g. ethanol):
energy consumption less than
  - 9,2 l fuel[2]/100 km
  - 9,7 m3 CNG/100 km
  - 37 kWh electric energy/100 km

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performed are not specified on the web-sites or in the following links related to the starting point. To get more information about the applied ranking methods considerably more effort would be needed and it is not clear if it is worth the effort involved.

[2] The fuel consumption is calculated as for operation with petrol since E85 test specifications are not available yet. The lower caloric value of E85 results in higher fuel consumption of about 30 per cent compared with the gasoline operating mode.

• vehicles with conventional fuels (including hybrids):
CO_2- emissions less than
- 120 g/km
- and additionally for diesel-engined vehicles: PM < 5 mg/km

In addition there is a reduced taxation of company cars which are running on alternative fuels or which are equipped with a particle filter in case of diesel vehicles respectively. In Stockholm such cars are exempted from congestion charges. And in some cities and communities environmentally friendly vehicles can park for free or at a reduced price (or: at a cheaper rate?) if they comply with the local requirements. In Sweden as a minimum 85 per cent of the vehicles used from public authorities must be ecocars.

Remark:
Even though more than the above mentioned action programmes are already known with regard to benefits for users of EFV (e.g. [xxx]) this part of available sources was not examined to a greater extent within this study until now.

3.2.4. LIFE CYCLE ASSESSMENT (LCA)

Background

Guidelines for performing automotive LCA were established by a dedicated LCA working group of the **Eu**ropean **C**ouncil for **A**utomotive **R** & D (EUCAR) [26]. In a EUCAR research project cofinanced by the European Commission's research program for 'competitive and sustainable growth'. This specific screening LCA project looks at '**li**ght and **re**cyclable **car**s' (LIRECAR) in a generic way, i.e. not one specific vehicle design with its specific processes.
One guiding principle of this project was the involvement of all affected Life Cycle stakeholders from the very beginning. In an advisory group all life cycle stages are virtually represented by stakeholders. This has been seen to be important for the acceptance of the study results, as well as for enabling an optimal exploitation of the study conclusions throughout the life cycle; group members included:

- Material & Part Suppliers: Plastics*Europe* (former APME), Eurometaux, European Aluminium Association (EAA), European Association of Automotive Suppliers (CLEPA), International Iron and Steel Institute (IISI), International Magnesium Association (IMA),
- Automotive Manufacturers: Adam Opel AG, Centro Ricerche Fiat S.C.p.A, DaimlerChrysler AG, Ford-Werke AG, Regienov Renault, Volvo Car Corporation, Volkswagen AG,
- Environmental Non-Governmental Organisation (NGO): Friends of the Earth,
- Research: Institute for Prospective Technological Studies, Joint Research Centre, European Commission (JRC IPTS),
- End-of-Life: European Ferrous Recovery and Recycling Federation / European Shredder Group (EFR-ESG).

The description of LIRECAR is taken from (Schmidt et al 2004)

Approach

The **goal** of the LIRECAR Project is to identify and assess lightweight design and End-of-Life options from a pure environmental point of view on a life cycle basis. The goal of the study implies a comparative assertion of these options. Any other aspects (besides life cycle, lightweight concepts and recycling issues) are out of the goal and scope of the study. In particular, changes in safety or comfort standards, propulsion improvements for CO_2 or user behavior and acceptance are out of the scope. The purpose is not to generate a general LCA/LCI data model but to answer specific questions including:

- What are the environmental impacts of lightweight design options?
- What is the importance of the EOL phase relative to other life cycle phases?
- What are the impacts of End-of-Life technology variation in the overall environmental profile?

In the LIRECAR Project, the system under consideration consists of three different sets of main vehicle scenarios. 1000 kg reference vehicles (material range of today's End-of-Life, midsized vehicles produced in the early 1990's) and 2 lightweight scenarios of 100 kg and 250 kg reduced weight (scenarios called 900 and 750, respectively) based on reference functions (in terms of comfort, safety, etc.) and vehicle concept. The scenarios represent, by their material break-down, a broad variety of theoretical lightweight strategies – in fact up to 7 vehicle concepts are aggregated in the range of one vehicle scenario. The reference vehicle scenario has been set to ELVs (End-of-Life Vehicles) of today (produced in the 1990's).
The **functional unit** is defined as follows: a European, compact-sized, five-door gasoline vehicle for 5 passengers including a luggage compartment, and all functions of the defined reference scenario with a mileage of 150,000 km over 12 years, complying with the same emission standards.
The **system boundaries** include the whole life cycle from raw material extraction to the final recycling / disposal stage (Fig. 2.2-1). However, due to the goal of LIRECAR and the complexity of the car as a system, everything is outside the system boundaries that is too company and design specific or associated with no significant environmental burden (further details in Schmidt et al 2004).

Results

In the Fig.s (Fig. 3.2.4-1), the grey part in the bottom of each column stands for the potential environmental impacts of the production phase. Within this grey colored section the part below 0 per cent represents the credits given for products of the recycling phase. So, the absolute value of both sections in total indicates the potential environmental impacts of the production phase without giving credits for EOL products (no use of recycled materials in production). Looking at the basic scenario with the extreme End-of-Life assumption of recycling for shredder residue, the positive impact of recycling (credit minus EOL emissions) remains clearly below 10 per cent (often even below 3 per cent) for all impact categories, with few exemptions, while the share of the use phase is mainly 90 per cent or higher for the basic scenario. Only for total waste is the recycling credit the dominant factor, while the use phase share is around 50 per cent. Interestingly, most of these shares are very similar for the other EOL scenarios (no recycling or energy recovery of shredder residue).

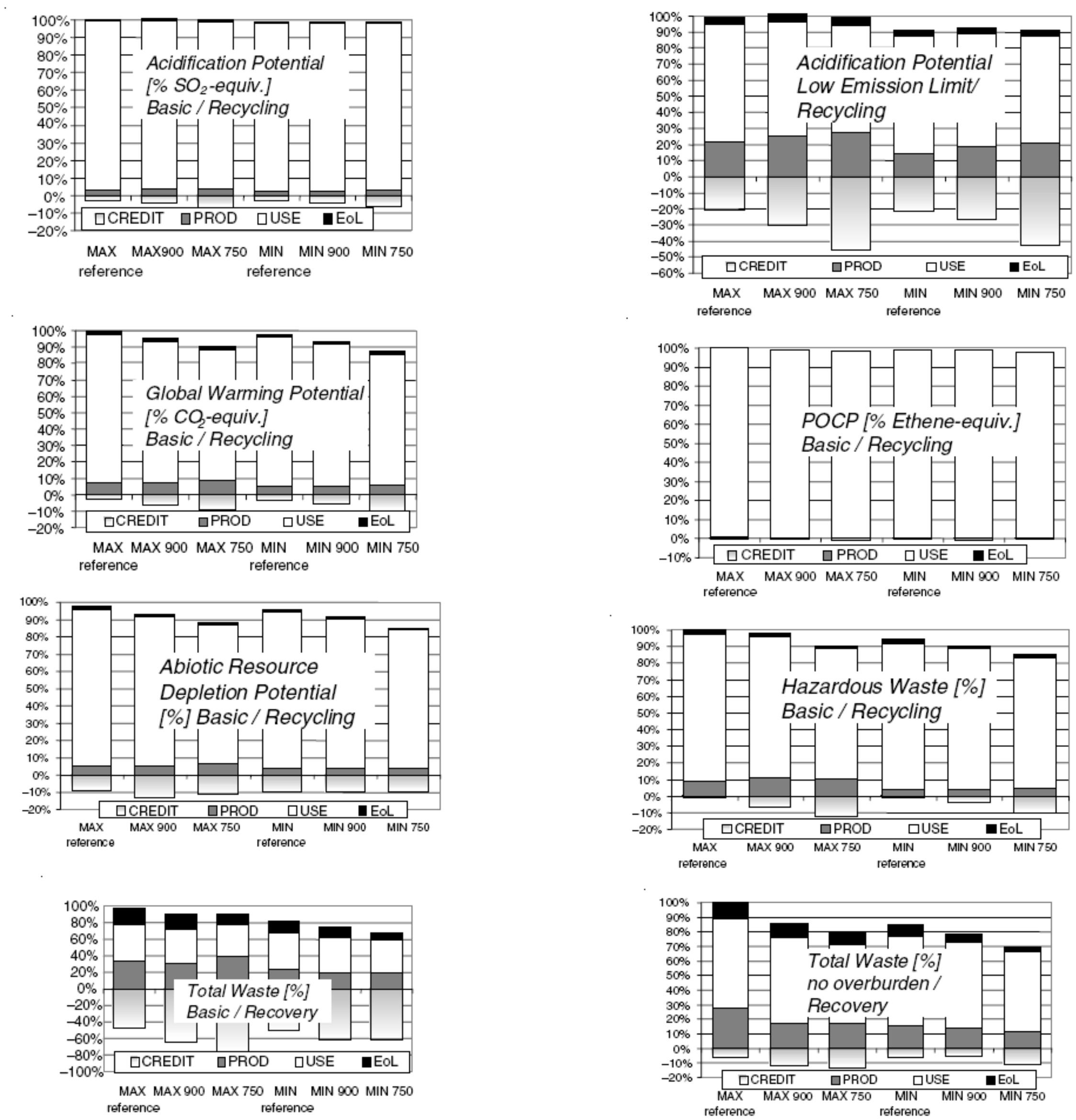

Fig. 3.2.4-1: Shares of different life cycle stages looking at different scenarios (8 examples for scenarios detailed in (Schmidt et al 2004)– other sensitivity results may show different results; minimum or maximum values for different LCIA parameters are not necessarily referring to the same vehicle composition per cent of max reference).

A major challenge of most LCA studies is to condense all available data without getting non-transparent for the individual scenarios and impact categories. Here, the objective is to determine whether the lightweight or End-of-Life technology variations are relevant for the different environmental categories. This should be only concluded where a significant difference between lightweight or End-of-Life scenarios can be found. Therefore, the question concerning which differences in the results of the lightweight and End-of-Life scenarios are actually significant has to be addressed considering relevant scenarios altering key assumptions (see Tab. 3.2.3-1 for the definition of changed key data). This is fairly difficult as there are no established statistical methods to systematically determine the significance of LCA results. As a consequence, other approaches to determine significance have to be applied. Within LIRECAR, two different criteria for a significant difference are applied – the criterion 'No overlap' between the ranges of the material scenarios and the stricter criterion 'Difference larger than material range'.

Tab. 3.2.4-1:

Scenario		AP	EP	GWP	ODP	POCP	ADP	Haz. W	Total W
Basic	Lightweight	0	0	++	++	+	++	+	0
	EOL	0	0	0	0	0	0	0	+
Low emissions limit	Lightweight	0	0	++	++	+	++	+	0
	EOL	0	0	0	0	0	0	0	+
FRV 0.5	Lightweight	0	0	++	++	++	++	+	0
	EOL	0	0	0	0	0	0	0	+
FRV 0.1	Lightweight	0	0	0	++	0	0	0	0
	EOL	0	0	0	0	0	0	0	+
No EOL credit	Lightweight	0	0	0	+	+	+	0	0
	EOL	0	0	0	0	0	0	0	0
No stockpile goods	Lightweight	0	0	++	++	+	++	+	0[1]
	EOL	0	0	0	0	0	0	0	0[1]

Criterion: 'No overlap'. A '+' in terms of 'No overlap' means that the minimum value of one vehicle weight or EOL scenario is higher than the maximum value of another weight or EOL scenario
General Note: The lines 'lightweight' and 'EOL' indicate the differences between different lightweight scenarios (with the EOL treatment being the same) or different EOL treatments (with the vehicle scenario being the same)
[1] This result refers to 'Waste to be landfilled/treated' instead of 'Total waste'

Tab. 3.2.4-2:

Scenario		AP	EP	GWP	ODP	POCP	ADP	Haz. W	Total W
Basic	Lightweight	0	0	+	++	0	+	0	0
	EOL	0	0	0	0	0	0	0	0
Low emissions limit	Lightweight	0	0	+	++	0	+	0	0
	EOL	0	0	0	0	0	0	0	0
FRV 0.5	Lightweight	0	0	++	++	+	+	0	0
	EOL	0	0	0	0	0	0	0	0
FRV 0.1	Lightweight	0	0	0	0	0	0	0	0
	EOL	0	0	0	0	0	0	0	0
No EOL credit	Lightweight	0	0	0	0	0	0	0	0
	EOL	0	0	0	0	0	0	0	0
No stockpile goods	Lightweight	0	0	+	++	0	+	0	0[1]
	EOL	0	0	0	0	0	0	0	0[1]

Criterion: 'Difference larger than material range'. A '+' means that the difference between the minimum value of one weight or EOL scenario and another weight or EOL scenario is larger than the largest range between the minimum and maximum value of one of the vehicle or EOL scenarios
General Note: The lines 'lightweight' and 'EOL' indicate the differences between different lightweight scenarios (with the EOL treatment being the same) or different EOL treatments (with the vehicle scenario being the same)
[1] This result refers to “Waste to be landfilled/treated” instead of 'Total waste'

AP – Acidification Potential
EP – Eutrophication Potential
ODP – Ozone Depletion Potential
POCP – Photochemical Oxidant Creation Potential
ADP – Abiotic Resource Depletion Potential
Haz W – Hazardous Waste

Looking at the three main questions, the following conclusions are drawn by LIRECAR:

1. What are the environmental impacts of lightweight design options?

According to the LIRECAR study, a significant difference between the different weight scenarios can be identified for GWP, ODP, POCP, ADP and hazardous waste, except for scenarios with a fuel reduction value of 0.1 or if no EOL credit is given.

This is still true (only for a theoretical 250 kg weight reduction) for GWP, ODP and ADP when applying the strict criteria 'Difference larger than material range'. For environmental interventions like AP, EP and total waste there is no significant difference between the reference and the lightweight vehicle scenarios. This shows that the quite substantial and technologically and economically challenging weight reductions assumed in the 750 kg scenarios leads to moderate or even lacking improvements in some impact categories. In addition, these improvement potentials can be only realized under well-defined conditions (e.g. material compositions with regard to specific fuel reduction value and EOL credits) based on caseby-case assessments for improvements along the life cycle.

2. What is the relative importance of the EOL phase?

Looking at the studied scenarios, the relative contribution of the EOL phase is 5 per cent or less of the total life cycle impact for most impact categories and scenarios, if the credits are not allocated to the EOL Phase. Exceptions include scenarios '900 kg vehicle, low emissions' where the EOL phase has an EP share of up to 9 per cent or up to 7 per cent for AP, respectively, as well as the impact category of total waste (EOL share of 9 per cent to 40 per cent).

3. What are the impacts of End of Life technology variation in the overall environmental profile?

Comparing the studied EOL scenarios landfill, recycling and energy recovery, there is no significant difference for the impact categories AP, EP, GWP, ODP, POCP, ADP and hazardous waste. This implies that the intended positive impact of ELV recycling on resource depletion cannot be proven in the study. The only significant difference is for total waste.

3.2.4.1. LCA CONCEPTS FROM VEHICLE MANUFACTURERS

- **Mercedes** [27]

(consumer information / LCA)

Mercedes uses Life Cycle Assessments to compare the latest models with their predecessors. These are based on ISO 14020, 14021, 14040, 14044 and 14062. The examined areas are:

• Vehicle Production
• Fuel Production
• Operation (covered distance: 150 000 km in NEDC)
• Recycling

The selected parameters are:

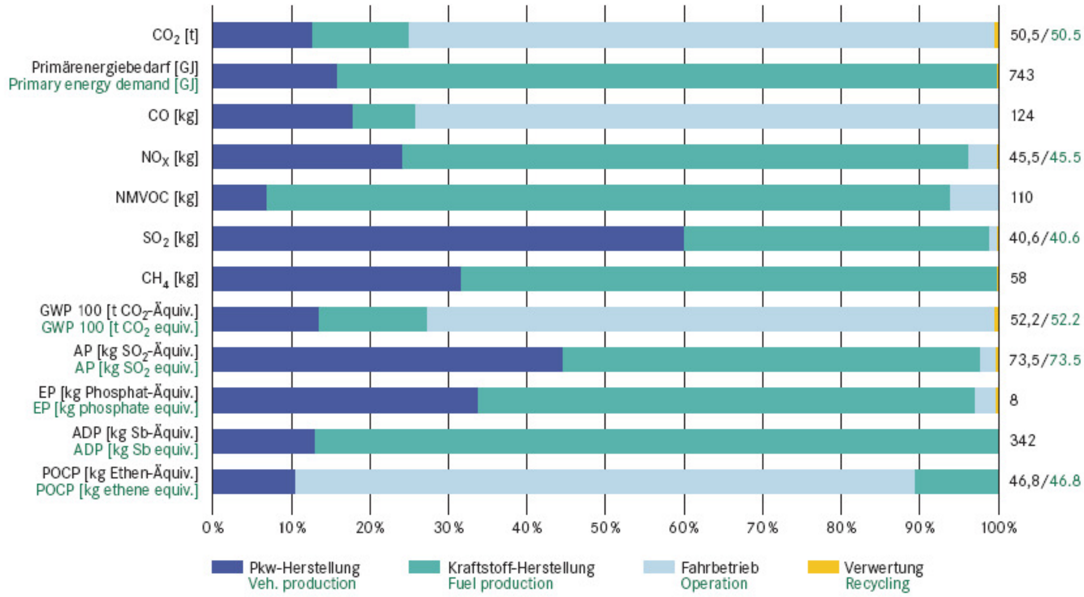

Fig. 3.2.4.1-1: Selected parameters from Mercedes LCA.

The results of the Life Cycle Assessment have been verified and certified by TÜV SÜD.

Mercedes awards its analysed cars with an Environmental Certificate (Umwelt- Zertifikat).

➢ **VW** [28]
(consumer information / LCA)

VW also uses life cycle assessments in accordance with ISO 1440/44 to compare the latest models with their predecessors. The following areas are examined:

• Engine / transmission manufacture

• Vehicle manufacture
• Fuel supply
• Driving emissions (covered distance: 150 000 km in NEDC)
• Recycling

In a Life Cycle Inventory, data is collected for primary energy demand as well as for emissions of CO_2, CO, SO_2, NO_x, NMVCO and CH_4.

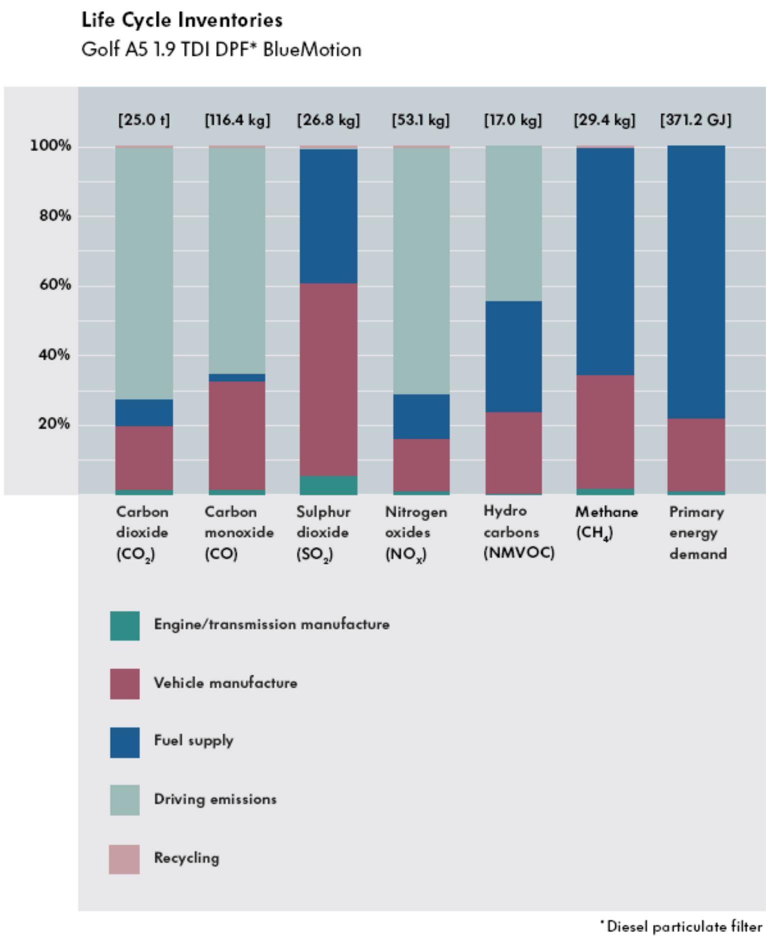

Fig. 3.2.4.1-2: Life Cycle Inventories VW.

Furthermore a Live Cycle Impact Assessment is made concerning Global Warming Potential (CO_2 equivalents), Photochemical Ozone (Ethene-equivalents), Acidification (SO_2 equivalents), Ozone Depletion (R11-equivalents) and Eutrophication (PO_4- equivalents).

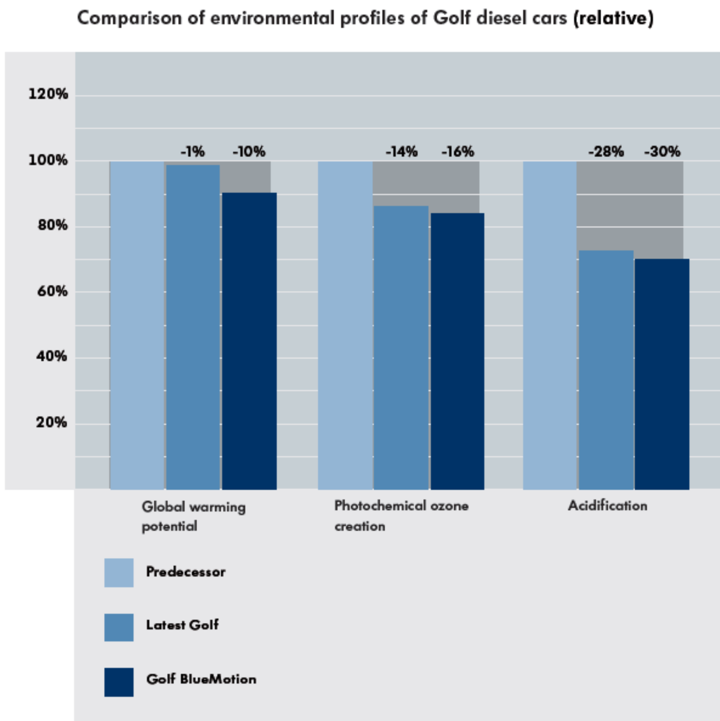

Fig. 3.2.4.1-3: Comparison of environmental profiles of golf diesel cars (relative).

The results of the Life Cycle Assessment have been verified and certified by TÜV NORD.

To provide interested parties with detailed information about the environmental performance of its vehicles and technologies, VW uses Environmental Commendations (so-called "Umweltprädikat").

➢ **Volvo Cars' Environmental Product Information** [29]
(consumer information / LCA)

Volvo Car publishes an Environmental Product Information for its vehicles. Information about environmental management, production, useful life and recycling are provided in a life cycle diagram:

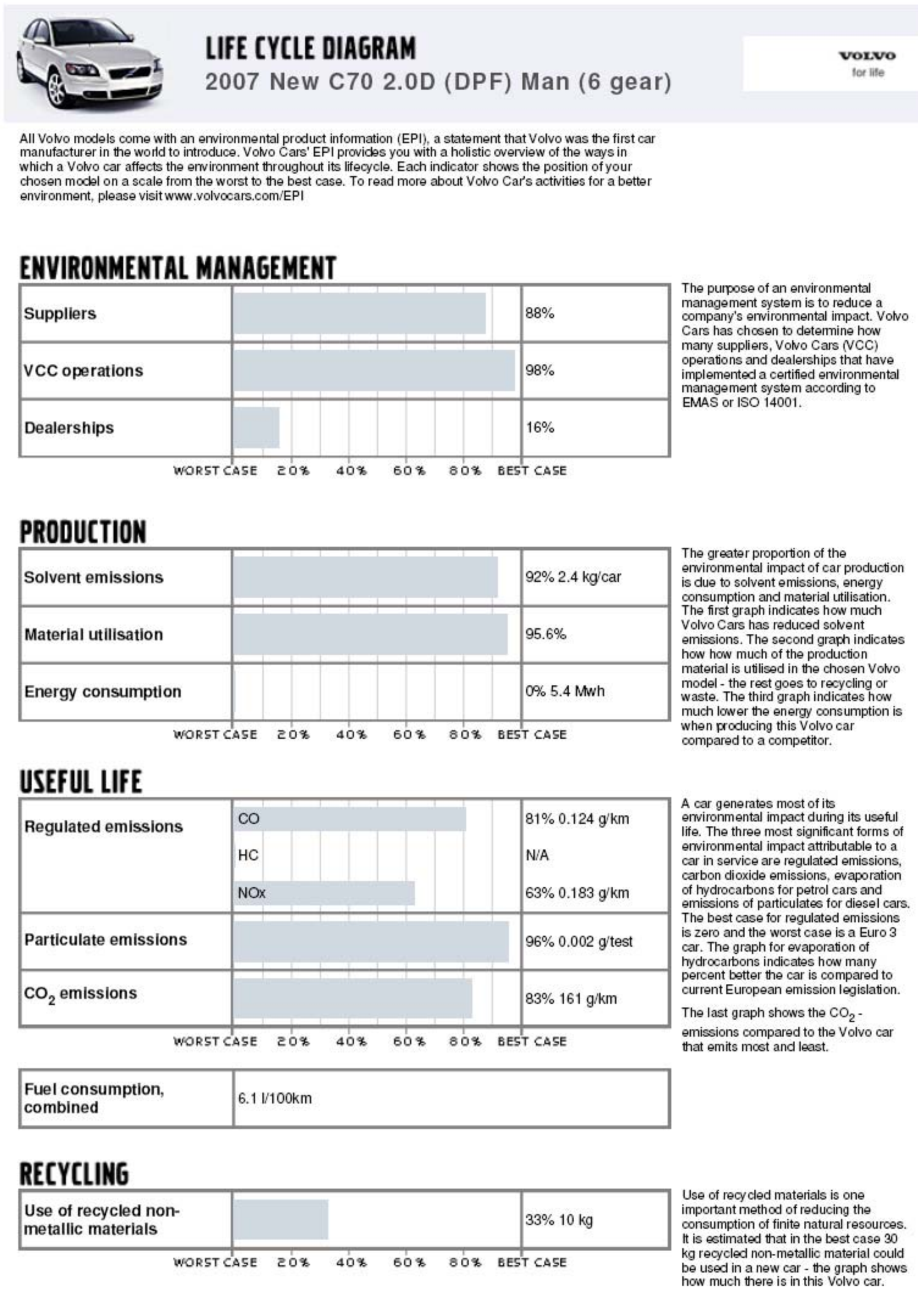

Fig. 3.2.4.1-4: Life Cycle Diagram Volvo.

3.2.4.2. LCA CONCEPTS FROM PUBLIC AUTHORITIES

- **GREET Model** (DOE USA) [30]

(researcher information / LCA)

The U.S. *Argonne* research centre has developed the ″Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET)″ sponsored by the U.S. Department of Energy (DOE). GREET considers the full life-cycle of vehicles combining two platforms:

- The fuel-cycle module (well to wheels analysis regarding resource extraction, fuel production, transport, storage, distribution and marketing and vehicle operation)
- The vehicle-cycle module (regarding the energy and emission effects associated with vehicle material recovery and production, vehicle component fabrication, vehicle assembly and vehicle disposal/recycling)

For a given vehicle and fuel system, GREET can calculate:

- Consumption of total energy (energy in non-renewable and renewable sources), fossil fuels (petroleum, natural gas and coal together), petroleum, coal and natural gas.
- Emissions of CO_2-equivalent greenhouse gases - primarily carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).
- Emissions of six criteria pollutants: volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxide (NO_X), particulate matter with size smaller than 10 micron (PM10), particulate matter with size smaller than 2.5 micron (PM2.5) and sulphur oxides (SO_X).

GREET can simulate more than 100 fuel production pathways and more than 70 vehicle / fuel systems. The GREET software is available at no charge.

- **ACEEE's Green Book** (US) [31]

(consumer information / LCA)

The **A**merican **C**ouncil for an **E**nergy-**E**fficient **E**conomy (ACEEE) publishes a ″Green Book – The Environmental Guide to Cars and Trucks, an annual consumer-oriented guide providing environmental rating information for every new model in the U.S. lightduty vehicle market″. The Green Book is based on principles of lifecycle assessment and environmental economics. Three areas are examined:

- Manufacturing of vehicle
  ACEEE uses statistics, which estimate the average emission of each pollutant per unit of vehicle weight. These are multiplied by vehicle mass (curb weight) and divided by average vehicle lifetime mileage.
- Tailpipe emissions (CO, HC, NO_x, PM)
  ACEEE adds adjustment factors to the emission standards to which a vehicle is certified, considering that emissions can be higher in real-world driving.
- Fuel economy data
  Fuel economy data include all emission rates due to fuel lifecycle.

For assessing environmental harm done by each pollutant, the associated costs to society are estimated. Adding all these results leads to an Environmental Damage Index (EDX). The EDX is converted to a Green Score on a scale of 0-100 and a fivetier class ranking is performed (Superior, Above Average, Average, Below Average and Inferior).

The vehicles are listed in the categories:

- Best of the year (greenest models in each vehicle class)
- Greenest Vehicles of the year (highest Green Scores overall)
- Meanest Vehicles of the year (worst Green Scores overall)

As a result of the used methodology, most of the diesel-powered vehicles score “Inferior” because of their amount of NO_x.

In addition to this, further findings concerning such concepts are specified in the literature list, chapter 6. Notably [32] and [33] are worth mentioning.

3.2.5. OTHERS

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4. ASPECTS FOR THE DEVELOPMENT OF AN EVALUATION CONCEPT (HOLISTIC APPROACH)

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5. ASSESSMENT OF FEASIBILITY TO INTRODUCE AN EVALUATION CONCEPT UNDER THE FRAMEWORK OF WP.29

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6. REFERENCES

[1] Schmidt et al: Life Cycle Assessment of Lightweight and End-of-Life Scenarios for Generic Compact Class Passenger Vehicles, Int J LCA 9 (6) 405 – 416 (2004).

[2] "Well-to-Wheel analysis for future automotive fuels and powertrains in the European context" by EUCAR/CONCAVE/JRC", Well-to-Wheels Reports http://ies.jrc.ec.europa.eu/our-activities/support-to-eu-policies/well-to-wheelsanalysis/well-to-wheels.html

[3] Kuchling: Physik: VEB Fachbuchverlag Leipzig 1978, p. 106.

[4] WWF Climate Glossary: http://www.wwf.org.hk/eng/conservation/cimate/glossary.php

[5] Regional Wood Energy Development Programme in Asia; http://www.rwedp.org/d_units.html

[6] Massachusetts Technology Collaborative, Renewable Energy Trust, Glossary: http://www.mtpc.org/cleanenergy/energy/glossaryefficiency.htm

[7] Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles [Official Journal L 269 of 21.10.2000], Article 2.

[8] Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste, Article 1(a).

[9] ISO 14040:2006(E).

[10] „Bewertungsmethode: Wie sauber fährt Dein Auto?", e'mobile, Schweizerischer Verband für elektrische und effiziente Strassenfahrzeuge http://www.e-mobile.ch/index.php?pid=de,2,82

[11] "The comparison of two environmental rating systems: BIM-EcoScore vs. ECCleaner Drive", ETECE Publications, Vrije Universiteit Brussel http://etecmc10.vub.ac.be/publi.php?pageNum_Recordset1=1&totalRows_Recordset1=83

[12] "Ecoscore", VITO http://www.ecoscore.be/ecoscore/EcoScoreDownloads.asp?Language=NL&vcat=M1&ExtendedSearch=Y

[13] „Studie CO2-freie Mobilität durch Biokraftstoffe", Forschungsvereinigung Verbrennungskraftmaschinen http://www.fvv-net.eu/download/plonearticle.2006-11-01.2016161066

[13a] Gerben Passier, TNO, (Working paper No. EFV-01-06, GRPE Informal Group on EFV, 1st Meeting, 6. June 2008)

[14] „5 Jahre EcoTest: Europa sucht den Umweltstar", ADAC http://www.adac.de/Tests/Autotest/Ecotest/default.asp?ComponentID=185779&SourcePageID=8447

[15] „EcoTest", FIA Foundation http://ecotest.eu/Pages/Home.aspx

[16] Lottsiepen, G.: „VCD Auto-Umweltliste 2008/2009", fairkehr, Nr. 4/2008

[17] „Auto-Umweltliste 2008", VCS http://www.verkehrsclub.ch/de/politik-kampagnen/ratgeber/auto-umweltliste.html

[18] „Auto-Umwelt-Zertifikat", ÖKOTREND-Institut http://www.oeko-trend.de/start/index.php?page=2&lang=de

[19] "DRIVECLEAN, a guide to clean and efficient vehicle technologies", California Air Resources Board http://driveclean.ca.gov/

[20] "Green Vehicle Guide, an Australian Government Initiative", Department of Infrastructure, Transport, Regional Development and Local Government http://greenvehicleguide.gov.au/GVGPublicUI/QuickCompareWebForm.aspx?CurrentTask=9531567f-c356-4427-aa1a-781891c66655

[21] "Green Vehicle Guide", EPA http://www.epa.gov/greenvehicle/

[22] "Fuel Economy", EPA http://www.fueleconomy.gov/

[23] "Green Efficiency Ratings", JDPower http://www.jdpower.com/autos/ratings/green-efficiency-ratings

[24] "Car Buyers' Guide", ETA http://www.eta.co.uk/car_buyers_guide

[25] "Eco cars", Vägverket http://vv.se/templates/page3____21943.aspx

[26] Ridge L (1998): EUCAR – Automotive LCA Guidelines – Phase 2. In: Total Life Cycle Conference and Exposition; Graz, Austria; 12/01/ 1998-12/03/1998. SAE paper 982185, 193204.

[27] "Umwelt-Zertifikat Mercedes-Benz C-Klasse", Mercedes-Benz http://www.mercedesbenz.de/content/media_library/germany/mpc_germany/de/mercedesbendeutschland/personenwagen/home/produkte/neufahrzeuge/c-klasse/cklasse_limousine/umweltzertifikat_de.object-Single-MEDIA.download.tmp/Umweltzertifikat.pdf

[28] "The Golf, Environmental Commendation Background Report", VW http://www.volkswagen.com/vwcms_publish/etc/medialib/vwcms/virtualmaster/de/Unternehmen/mobilitaet_und_nachhaltigkeit/downloads/umweltpraedikate.Par.0017.File.pdf

[29] "Environmental Product Information", VOLVO http://www.volvocars.com/intl/corporation/FactsandFig.s/EnvironmentalProductInformationEurope/Pages/default.aspx

[30] "The GREET Model", Argonne http://www.transportation.anl.gov/modeling_simulation/GREET/

[31] "guide to green", ACEEE http://greenercars.org/guide.htm

[32] "Lifecycle Emissions Analysis", University of California, Institute of Transportation studies http://www.its.ucdavis.edu/people/faculty/delucchi/index.php#LifecycleEmissions

[33] "GHGenius, a model for lifecycle assessment of transportation fuels", Natural Resources Canada http://www.ghgenius.ca/reports.php

[34] "Informal working group on EFV, working papers", UNECE http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/efv01.html

Also screened:

[100] Schindler, J., Weindorf, W.: „Einordnung und Vergleich biogener Kraftstoffe – „Well-to-Wheel“- Betrachtung“ http://www.itas.fzk.de/tat0up/061/scwe06a.pdf

[101] “Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems – North American Analyses –“, GM, Argonne, BP, ExxonMobil, Shell“ http://www.transportation.anl.gov/pdfs/TA/163.pdf

[102] “Top 10 Green Cars 2008”, Autotropolis http://autotropolis.com/wiki/index.php?title=Top_10_Environmentally_Friendly_Cars_for_2008

[103] “Green Center”, yahoo autos http://autos.yahoo.com/green_center/

[104] „Clean Vehicles“, Union of Concerned Scientists http://www.ucsusa.org/clean_vehicles/

[105] “Environmental Performance Labels for Vehicles: Context and Findings of Market Research for the U.S. Environmental Protection Agency”, ACEEE http://www.aceee.org/pubs/t071.htm

[106] “DEVK Versicherungen und ACV verleihen Umweltpreis an die Autoindustrie“, ÖkoGlobe 08 http://www.oeko-globe.de/

[107] Gruden, D.: „Umweltschutz in der Automobilindustrie“, ATZ/MTZ-Fachbuch, 1/2008

[108] Gordon; D.: “Fiscal Policies for Sustainable Transportation: International Best Practices”, A Report Prepared for The Energy Foundation and The Hewlett Foundation, 03/2005

[109] http://www.iea.org/

[110] http://www.umweltbundesamt.de/verkehr/index.htm

[111] http://www.bmu.de/allgemein/aktuell/160.php

[112] http://www.duh.de/

[113] http://www.ifeu.org/

[114] http://www.dlr.de/

[115] http://www.bund.net/

[116] http://www.fh-gelsenkirchen.de/fb11/homepages/CAR/index.htm

[117] http://www.sugre.info/Vorlage.phtml?id=487&sprache=en

[118] http://www.fia.com/

[119] http://www.ace-online.de/

[120] http://www.avd.de

[121] http://www.tcs.ch

[122] http://www.vcoe.at/

[123] http://www.oica.net/

[124] http://www.vda.de/

[125] http://www.opel.de/

[126] http://www.bmw.de/

[127] http://www.audi.de/

[128] http://www.ford.de/

[129] http://www.renault.de/

[130] http://www.peugeot.de/home/

[131] http://www.citroen.de/CWG/

[132] http://www.toyota.de/

[133] http://www.nissan.de/

[134] http://www.marutisuzuki.com/
[135] http://siamindia.com/
[136] http://autos.sify.com/
[137] http://www.araiindia.com/

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