Transmitted by the
GRPE informal group on EFV

Informal document No. **GRPE-58-02**
(58th GRPE, 9 - 12 June 2009,
agenda item 8.)

Background document regarding the Feasibility Statement for the development of a methodology to evaluate Environmentally Friendly Vehicles (EFV)

CONTENTS

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 a technical neutral approach should be followed. Increasing the use of environmentally friendly and sustainable alternative energy sources like for example advanced biofuels (biodiesel, bioethanol, biomethane, 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 may 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. OBJECTIVE OF THE EFV INFORMAL GROUP

To continue a fruitful cooperation between WP.29 and the future EFV conferences, as parallel activity an informal group under GRPE was established. In a first step the task of the informal group is to 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:

- The available literature and concepts, including regulations and standards, shall be screened and analysed.
- In a first step mainly energy efficiency and CO_2 emissions is considered and assessed on the basis of an integrated ″well-to-wheels″ approach.
- The feasibility of the successful development of a harmonised evaluation method should be examined and assessed.

At this stage of the EFV project (feasibility study) the scope is limited to passenger cars (vehicles of category 1-1 / Special Resolution No. 1).

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.

1.3. PREPARATION OF A FEASIBILITY STATEMENT

The main part (chapter 3.) of this background document regarding the EFV feasibility statement contains a compilation of existing legislation, tools for holistic approaches and assessment concepts (status 2008). The available literature and concepts, including regulations and standards, is screened and analysed. The result of this exercise is an overview about a lot of varying approaches dealing with different environmental aspects. All these regulations, standards, assessment concepts and ranking systems are based on different principles, structures, conditions and timelines.

These tools needs to be assessed whether these approaches can be used for the development of a holistic evaluation concept. This assessment (chapter 4.) needs also to first anticipate the foreseen target groups and the purpose(s) for applying an EFV concept. Another step is to analyse and list all environmental aspects which are relevant for an EFV concept. Additionally tool evaluation criteria are specified to describe the dimensions and applicability of regulations, concepts and tools. A table shows an evaluation of the main existing different regulations, concepts and tools against the environmental criteria and the tool evaluation criteria.

Based on this overview of tools versus criteria, an analysis of potential approaches of an EFV concept is possible. The conceptual idea rests upon the so-called SWOT analysis. The idea of this concept depends on the four issues: **S**trength, **W**eakness, **O**pportunity and **T**hreat which should be taken into consideration when various approaches with regard to the assessment of the environmental friendliness of vehicles are analysed. The SWOT analysis was used for several of the existing tools.

This assessment in chapter 4. shows in example that with an analysis of environmental aspects and tool evaluation criteria plus a following SWOT analysis an assessment of the existing tools and approaches is possible and reasonable.

Based on the compilation of tools and approaches in chapter 3. and the SWOT analysis in chapter 4. the feasibility to introduce an evaluation concept under the framework of WP.29 is discussed in chapter 5. This requires a consideration of the potential target groups and purposes of an EFV concept.

The conclusion and final feasibility statement is included in a separate informal document to GRPE, that also contains an executive summary of this background document.

2. DEFINITIONS

2.1. ENVIRONMENTALLY FRIENDLY VEHICLE

- Common definition of EFV does not exist.

- The term EFV as well as EEV (see 3.1.4.9.), green vehicle, eco-car, etc. is often used in the context of regulations, assessment concepts and environmental measures.

- The Term ″environmentally friendly″ shall not be used according to ISO 14021 (see 3.9.). 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.

  The reason for this ISO rule is that environmentally friendly is a very comprehensive and bold statement that is not likely to be justifiable. It might be the case that e.g. a vehicle has lower NO_x emissions than another vehicle during its life-time. However, 'environment' is much more than NO_x emissions and need to take into consideration also other relevant items as for example CO_2 emissions or heavy metals. In consequence, a vehicle having lower CO_2 emissions might be identified as a low-CO_2-emission-vehicle but not necessarily "environmentally friendly". ISO requires a specific, not misleading terminology.

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].

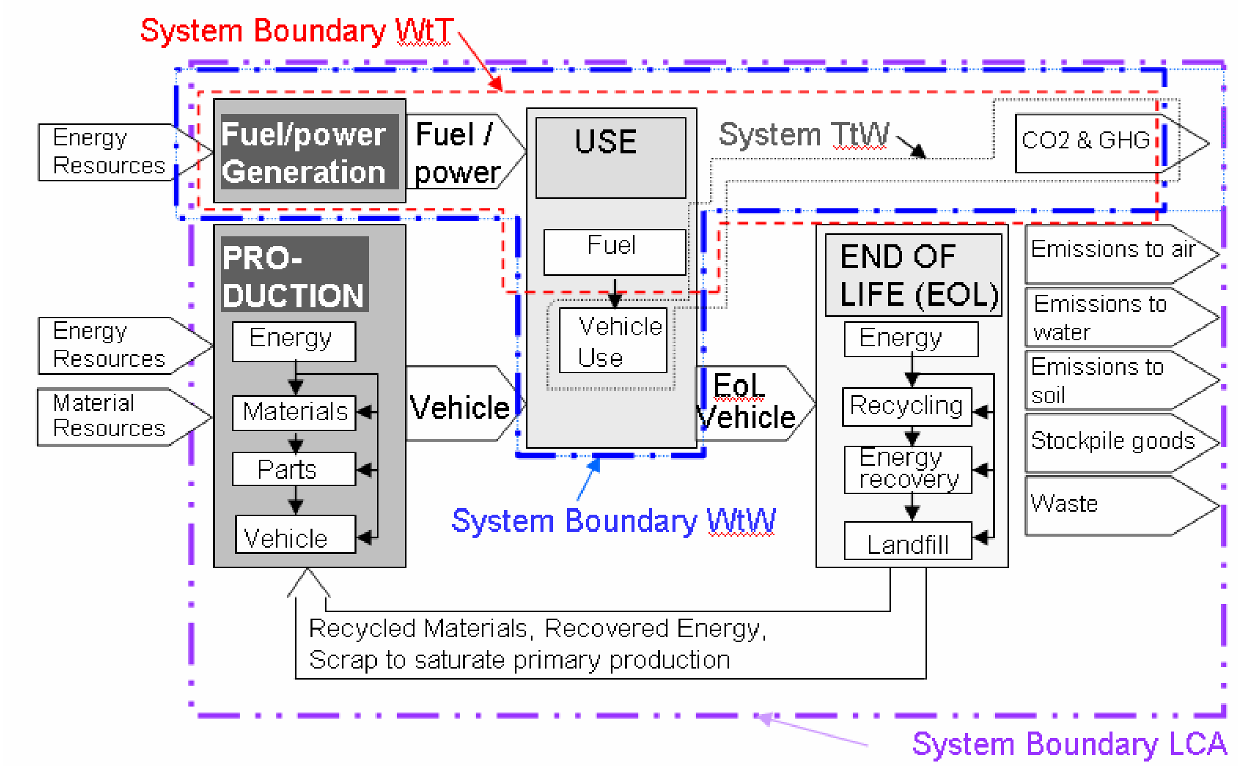


Fig. 2.2-1: Scheme of Life Cycle Assessment method.

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/fuel combination 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) and forms the essential basis to assess the impact of future fuel and power-train options [2].

2.4. ENERGY EFFICIENCY

Efficiency is the ratio of the output to the input [3]. Examples of definitions for Energy efficiency are:

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

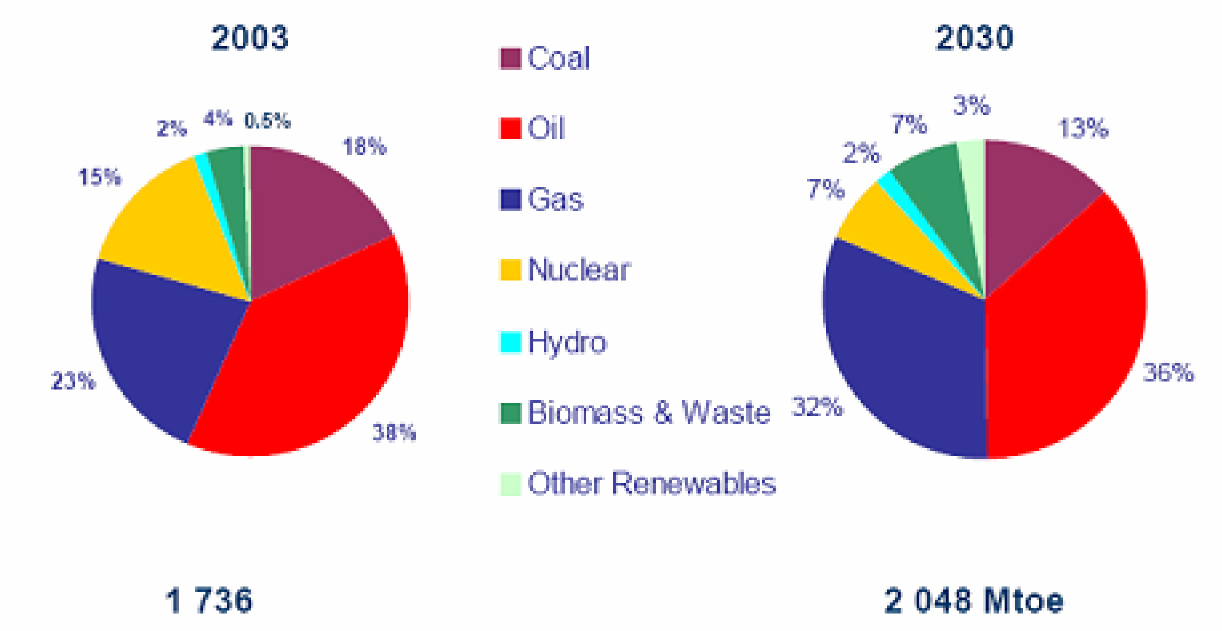


Fig. 2.5-1: Energy mix for EU.

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

For Example: Energy for Electricity Generation

Energy for generation of electricity is primarily supplied by the fossil fuels of coal, oil and natural gas, nuclear energy, hydro electric power, and more recently, the emergence of large wind and multi megawatt scale photovoltaic applications. Political and economic drivers are the forces that have determined what mix of these energy sources we utilize.

Electricity generation worldwide is currently dominated by the combined energy from the fossil fuels coal, oil and natural gas (Figure 2.5-2). Replacing these sources with sustainable sources is an enormous challenge. Sustainable options are hydro power, wind, and solar, either as solar thermal power plants or as photovoltaic power. At present wind energy is a rapidly growing contributor to electricity generation with annual installed capacity figures still increasing by about 30% per annum. Total world installed wind generation capacity exceeded 100,000 MW in the summer of 2008, but even this leaves wind as a small although important and growing overall contributor. As oil and coal prices increase, the economics of wind power improve and the wind industry will continue to grow at high rates for the foreseeable future. Some regions of Germany have 20% to 30% of their electricity production from wind machines. Wind power production will become a larger and larger player in world electricity generation, and wind's present growth rate is limited by the number of manufacturers and their annual production capacity. The percentage of wind generation that a grid can support is also limited by conventional grid designs, but with pumped storage and other reactive power controls, wind penetration into grids could be increased.

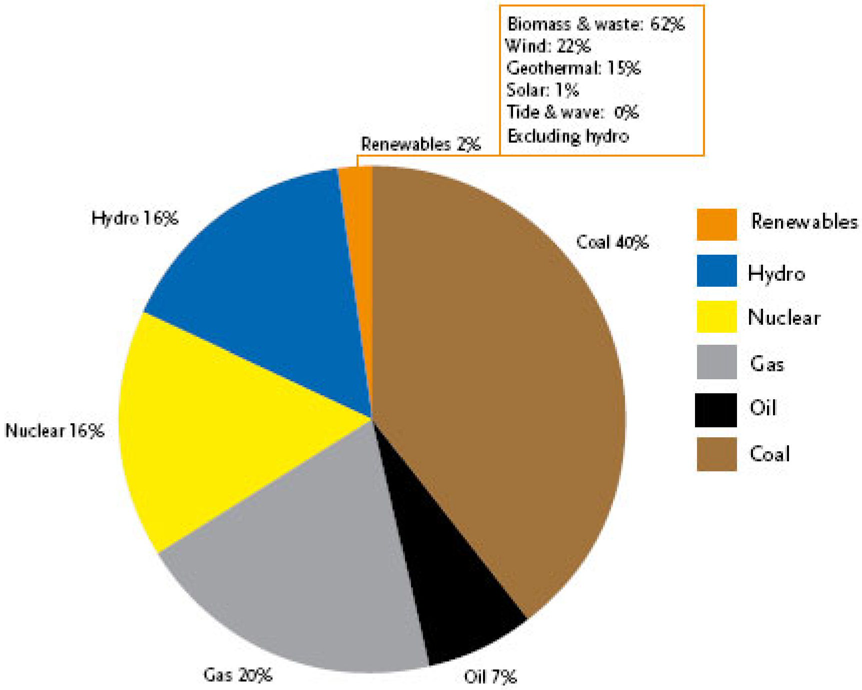


Fig. 2.5-2: World electricity by energy source (IEA 2004).

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 or 5 years.
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 common 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 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 purpose to develop an EFV evaluation method, the SWOT concept can be used. SWOT 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, TOOLS FOR HOLISTIC APPROACHES AND ASSESSMENT CONCEPTS (Status 2008)

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 in each weight class″: the manufacturers should produce all vehicles falling into a class to meet this level of energy efficiency performance in average though shortage can be compensated by overachievement gained in another weight class. 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) or Ministry of Land, Infrastructure, Transport and Tourism (MLIT). 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. The Japanese top runner mainly works with a "name and shame" marking scheme.

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 credit system above mentioned keeps diversity of makers by giving makers flexibility in the achievement of objectives. In addition, the Japanese top runner cooperates with some other measures, such as labelling, tax incentives, and subsidiary, and achieves a good effect.

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; NOx: 0.25
  11 Mode: CO: 2.0; HC: 0.15; NOx: 0.20
  JC08 mode: CO: 0.11; NMHC: 0.12; NOx: 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

- NO_x – PM Law:

Tab. 3.1.1.2-3: NO_x – 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

Tab. 3.1.1.2-4: 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:

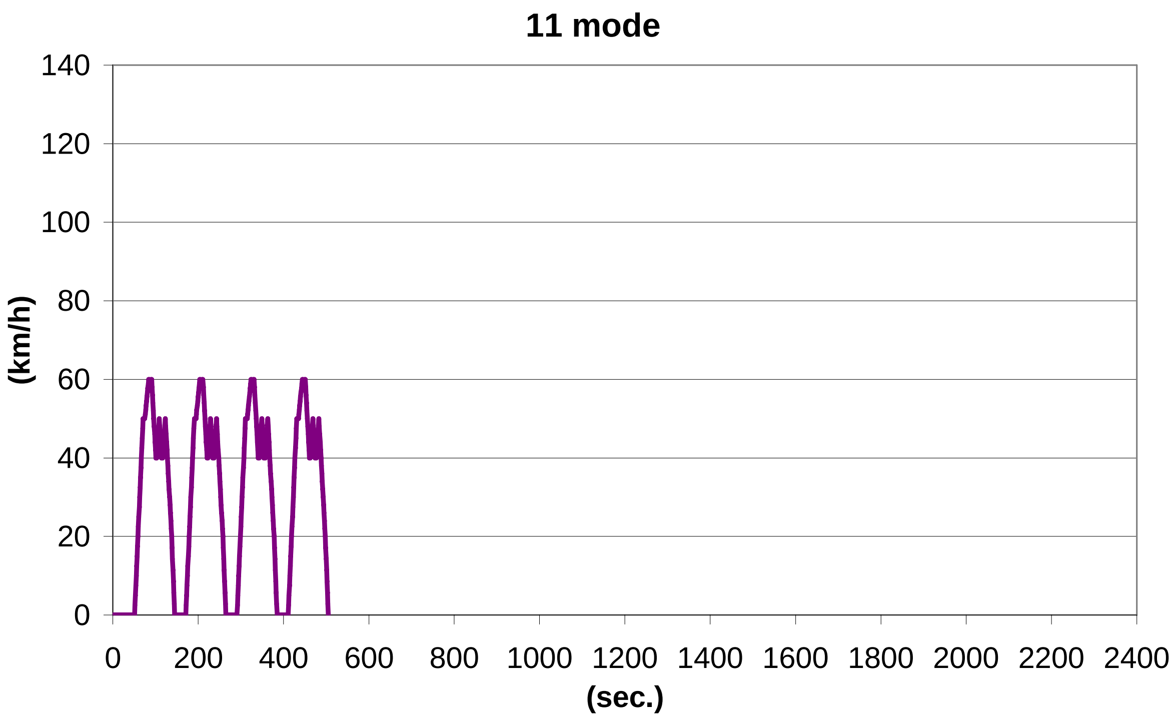


Fig. 3.1.1.2-1: Driving Cycle Japan 11 mode cold cycle.

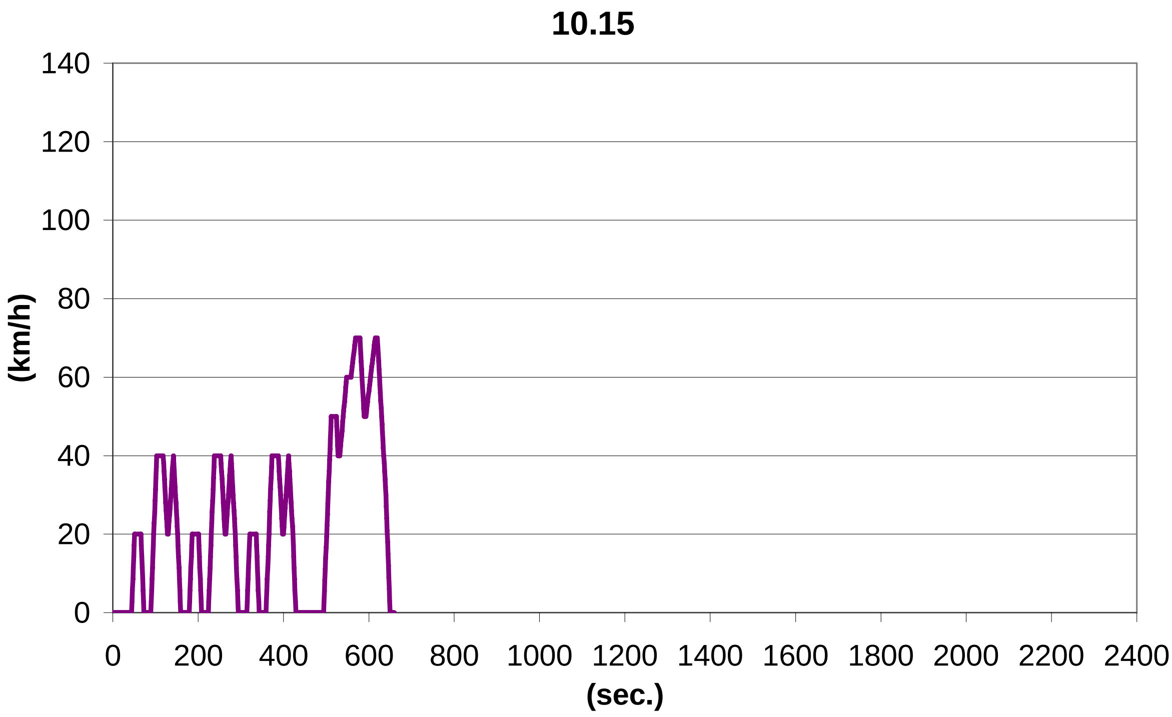


Fig. 3.1.1.2-2: Driving Cycle Japan 10.15 mode hot cycle.

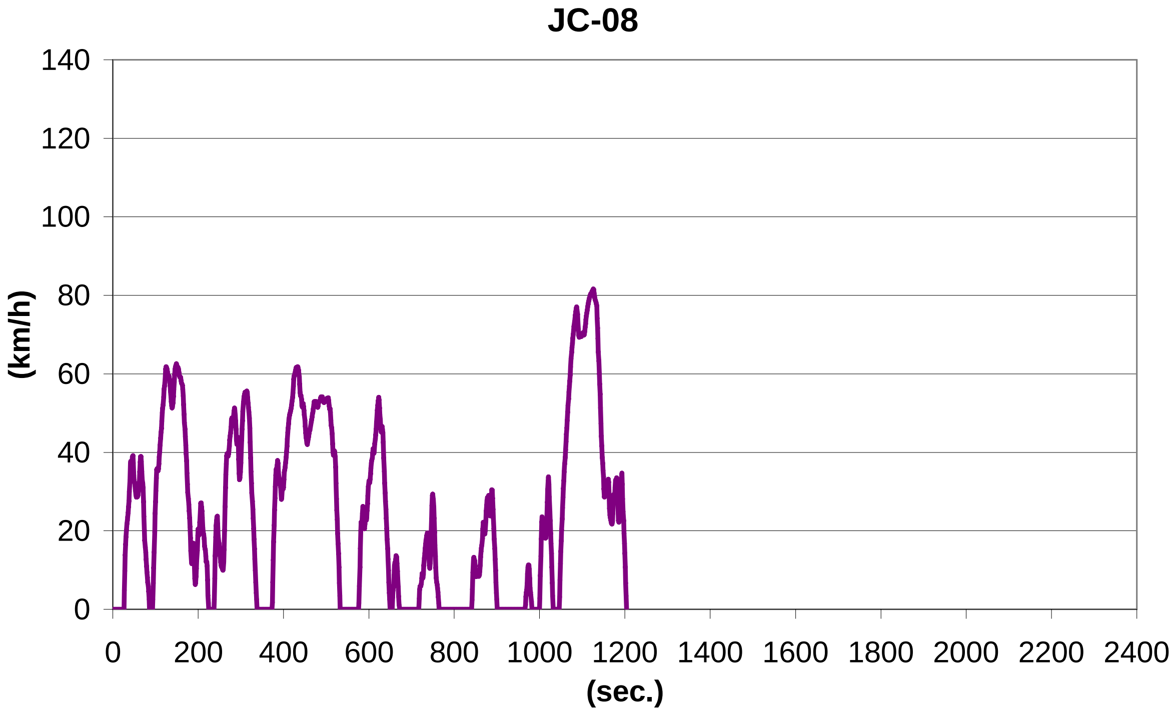


Fig. 3.1.1.2-3: New Driving Cycle Japan JC 08.

Tab. 3.1.1.2-5: Driving cycle summary.

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 AND EFV APPROACH IN JAPAN

Further information is available in Working paper No. EFV-02-04.

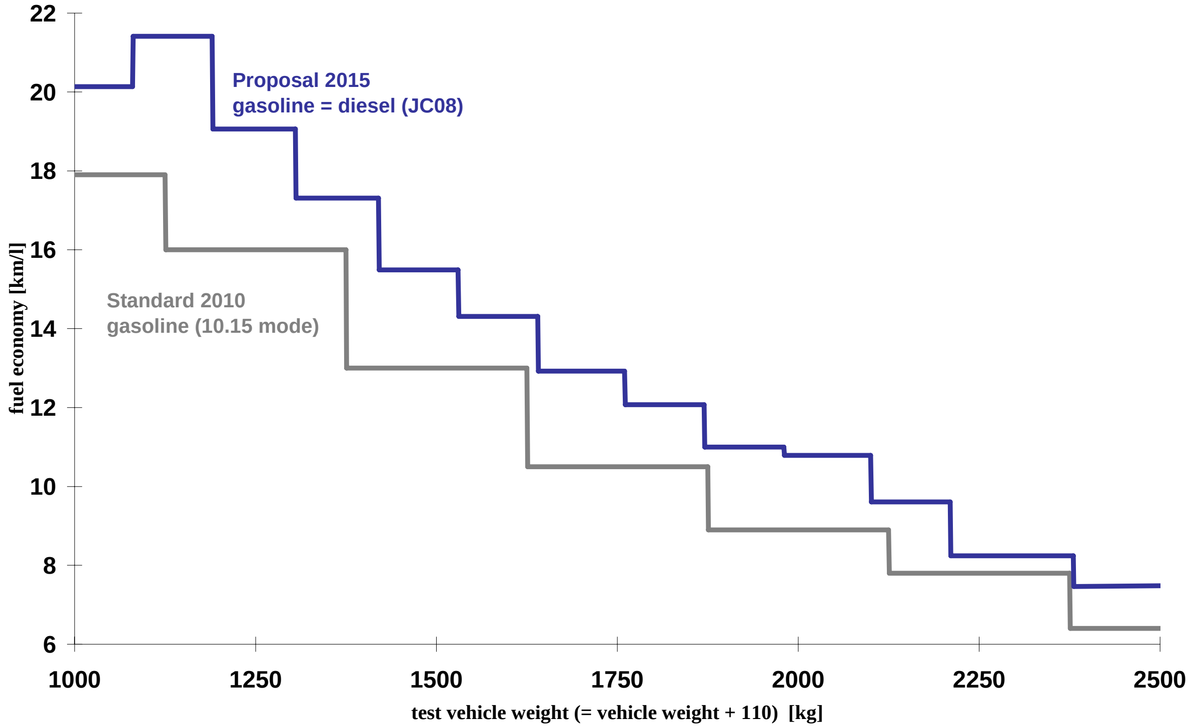


Fig. 3.1.1.3-1: Japanese fuel efficiency legislation.

3.1.1.4. NOISE

Reducing Automobile-Emitted Noise [10]:

Reducing motor vehicle and road traffic noise constitutes a major environmental issue. Automobiles generate various kinds of noise, including the noise emitted by the engine, the intake system, the drivetrain, the cooling system, and the exhaust system. In addition, tires generate tire/road noise. Automotive noise in Japan is regulated by standards—on accelerated running noise, steady running noise, and stationary exhaust proximity noise—which have become progressively more stringent, requiring automobile manufacturers to develop the technologies necessary for compliance. All motor vehicles manufactured as of September 2003 comply with the latest noise standards.

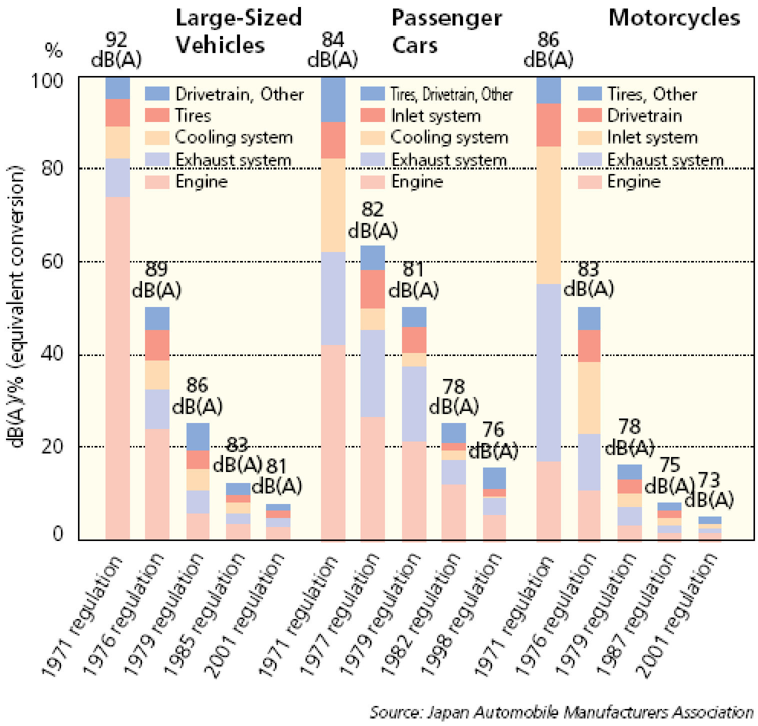


Fig. 3.1.1.4-1: The progress in motor vehicle noise reduction (accelerated running noise).

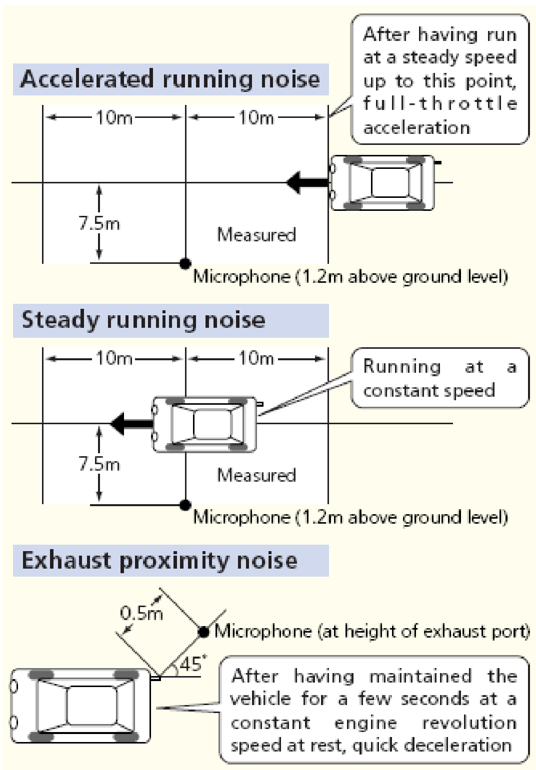


Fig. 3.1.1.4-2: Testing motor vehicle noise levels.

Tab. 3.1.1.4-1: Overview of japan’s motor vehicle noise regulations (for accelerated running noise).

Vehicle Type				Regulation 1971	1976-1977	1979	1982-1987	1998-2001
Large-Sized Vehicles	Vehicles with GVW=over 3.5 tons and maximum engine output=over 150 kW	4WD vehicles, etc.		92	89	86	83	82
		Trucks						81
		Buses						81
Medium-Sized Vehicles	Vehicles with GVW=over 3.5 tons and maximum engine output=up to 150 kW	4WD vehicles, etc.		89	87	86	83	81
		Trucks						80
		Buses						80
Small-Sized Vehicles	Vehicles with GVW=up to 3.5 tons	Other than mini-vehicles	GVW=Over 1.7 tons	85	83	81	78	76
			GVW=Up to 1.7 tons					76
		Mini-vehicles	“Bonnet” type					76
			Cab-over-engine type					76
Passenger Cars	Vehicles exclusively for the transport of passengers, with up to 10-passenger occupancy	Over 6 occupants		84	82	81	78	76
		6 occupants or fewer						76
Motorcycles	Small-sized motorcycles (over 250cc) and mini-sized motorcycles (126cc-250cc)	Small-sized		86	83	78	75	73
		Mini-sized		84				73
Motor-Driven Cycles	Class 1 motor-driven cycles (50cc & under) and Class 2 motor-driven cycles (51cc-125cc)	Class 2		82	79	75	72	71
		Class 1		80				71

Notes: 1. In pre-1987 regulations, “150 kW” reads “200 horsepower.” 2. “4WD vehicles, etc.” includes 4WDs, tractors, and cranes. *Source: Ministry of the Environment*

3.1.1.5. RECYCLING

Vehicle Recycling and Waste Reduction [10]:

Under Japan’s End-of-Life Vehicle (ELV) Recycling Law which entered into force in January 2005, automobile manufacturers and importers are responsible for recovery, recycling and appropriate disposal with respect to fluorocarbons, airbags, and automobile shredder residue (ASR). Compliance with the law will enable ASR to be recycled at a rate of 70% by 2015, resulting in an automobile recycling rate of 95% (by vehicle weight) as compared with the 80% rate prevailing prior to the introduction of the law. Japan’s vehicle recycling infrastructure as mandated by its ELV Recycling Law is the first in the world to administer the entire process of auto recycling - from ELV recovery to final disposal - on the basis of electronic “manifests” (or compliance checklists). JAMA itself played a central role in the development and implementation of this advanced vehicle recycling system. It also provided financial support for related software development and continues to help finance system maintenance and improvements. In line with national efforts to “reduce, reuse, recycle,” Japan’s automakers are also striving to design vehicles using lightweight materials that are easy to dismantle and recycle, and to reduce and recycle designated waste products generated in the manufacturing process. In 2006 the total volume of auto plantgenerated waste destined for landfill disposal dropped to 6,000 tons, a decrease of 98% from the 1990 level, already largely exceeding the 2010 target of 11,000 tons.

Tab. 3.1.1.5-1: Industry measures in line with national legislation.

	Law for the Promotion of Effective Utilization of Resources (3R Law)		Distribution, Service and Consumption	End-of-Life Vehicle Recycling Law
	Product Design	Waste Management		ELV Recycling
"Reduce" initiatives	For designated products: - Weight reduction/ Downsizing - Longer product life	For designated industries: - Reduction/recycling of designated waste products generated in vehicle manufacturing operations: 1) Scrap metals 2) Casting sand residue		
"Reuse" initiatives	For designated products: - Use of recyclable materials - Ease of dismantling - Ease of sorting - Safe recyclability - Materials identification			- Recovery and recycling of: 1) ASR 2) Airbags 3) Fluorocarbons Note: Motorcycles are not covered by the ELV Recycling Law.
"Recycle" initiatives		- Total waste volume*: 1990 (baseline): 350,000t ↓ 2006: 6,000t (a 98% reduction from 1990) JAMA target: 11,000t by FY2010 *For landfill disposal, including scrap metals, casting sand residue, and other waste.		

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 standard 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.
  lso 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

Tab.3.1.2.1-1: NO_x fleet average 0,07 g/mi.

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

Tab. 3.1.2.1-2: 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:

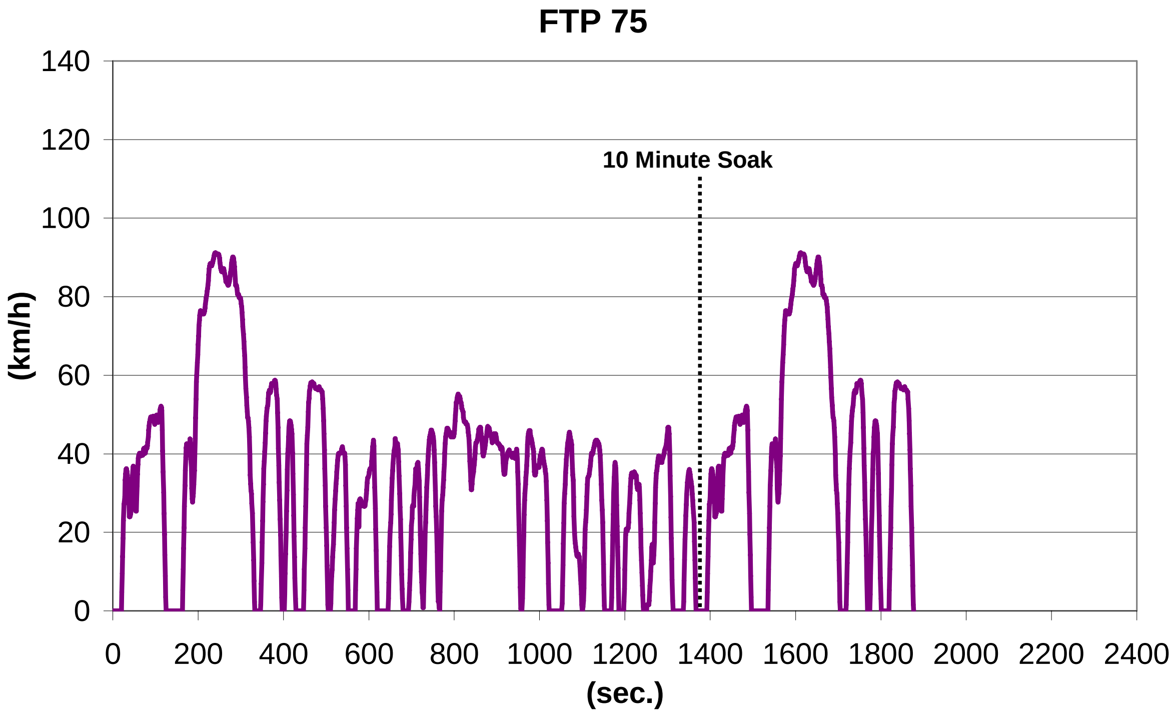


Fig. 3.1.2.1-1: Driving cycle FTP 75, EPA III (also known as: city cycle).

Tab. 3.1.2.1-3: Driving cycle summary.

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)

Fig. 3.1.2.1-2: Highway cycle (also known as: Highway Fuel Economy Test-HWFET).

Tab. 3.1.2.1-4: Driving cycle summary.

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 Subsequent	Regulation adds more stringent evaporative emission test procedures, longer vehicle useful 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
California Low Carbon fuel Standard Regulation	Draft	LCFS applies to all California transportation fuels. Starting January 1, 2010 the carbon intensity standard should be reduced by 10% by 2020.

3.1.2.3. GREENHOUSE GASES AND CAFE

Since the 1970s, NHTSA has promulgated CAFE standards for passenger cars and light trucks to address the goal of reducing oil consumption in the United States. Figure 3.1.2.3-1 shows the historical CAFE levels for 1978 to present.[1,2] The EPA has been working on responses consistent with the decision of the Supreme Court in Massachusetts v. EPA and EPA's recent proposal to find that emissions of GHGs from new motor vehicles and motor vehicle engines cause or contribute to air pollution that may reasonably be anticipated to endanger public health and welfare [46].

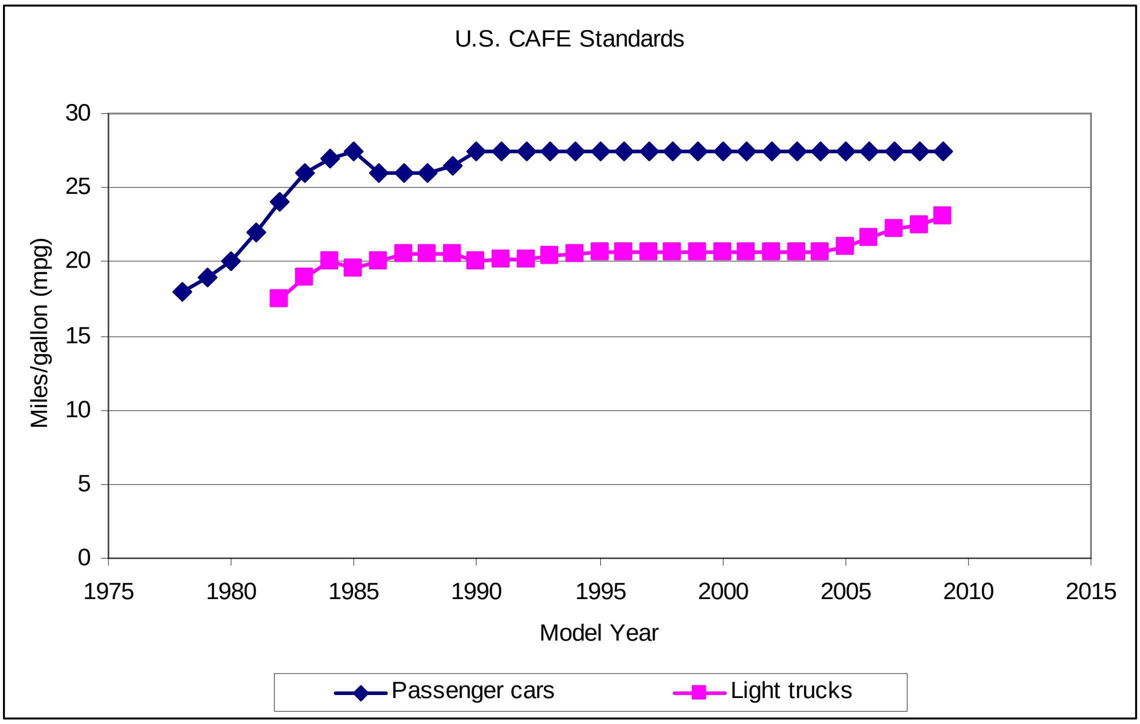


Fig. 3.1.2.3-1: Historical CAFE Levels in the United States

In 2008, NHTSA proposed CAFE standards for model years (MY) 2011 through 2015. However, responding to a Presidential Memorandum of January 26, 2009, NHTSA issued CAFE standards limited to MY 2011 [47], and has been comprehensively reviewing how it sets CAFE standards in the context of preparing to propose CAFE standards for MY 2012 and later model years.

The U.S. EPA is responsible for a standard that focuses on GHG emissions, and NHTSA is responsible for a standard that focuses on fuel economy. In addition, in 2005 California adopted GHG emissions standards for new light-duty vehicles. Thirteen states and the District of Columbia to date, comprising approximately 40 percent of the light-duty vehicle market, have adopted California's GHG emission standards

On 19 May 2009, President Obama announced a new national policy aimed at both reducing greenhouse gas pollution and increasing fuel economy for all new cars and trucks sold in the

---

[1] The projected industry-wide level of average fuel economy for passenger cars and light trucks in 2011 is 31.2 miles/gallon for passenger cars and 25.0 miles/gallon for light trucks.
[2] Note that any comparisons of fuel economy and emission limits should be done with care since the test procedure for measuring fuel economy and fuel consumption may differ from country to country.

United States. The intended proposed program would establish a consistent, harmonized, and streamlined approach to delivering environmental and energy benefits, cost savings, and administrative efficiencies. The new standards will cover model years 2012-2016 and are targetting an average carbon dioxide limit of 250 grams/mile (155 grams/km) with appropriate related CAFE standards in 2016. This groundbreaking policy is a commitment to enact more stringent greenhouse gas and fuel economy standards and represents an unprecedented collaboration between the Environmental Protection Agency (EPA), the Department of Transportation (DOT), the world's largest auto manufacturers, the United Auto Workers, leaders in the environmental community, the State of California, and other state governments. The new standards will ultimately be put into place via a joint rulemaking by EPA and DOT and further details about the joint effort can be found in a recent *Federal Register* notice [48]. The new standards will represent a cohesive and comprehensive National program for reducing GHGs and increasing fuel economy.

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

China - Environmental Regulations				
	Regulation China nationwide	**Regulation China special areas**	**Reference**	**Comment**
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 Require-ments	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 Consump-tion 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 People's Republic of China	Regulation Name: Limits and measurement methods for noise emitted by accelerating motor vehicles Regulation Number: GB 1495-2002

China - Environmental Regulations				
	Regulation China nationwide	**Regulation China special areas**	**Reference**	**Comment**
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.

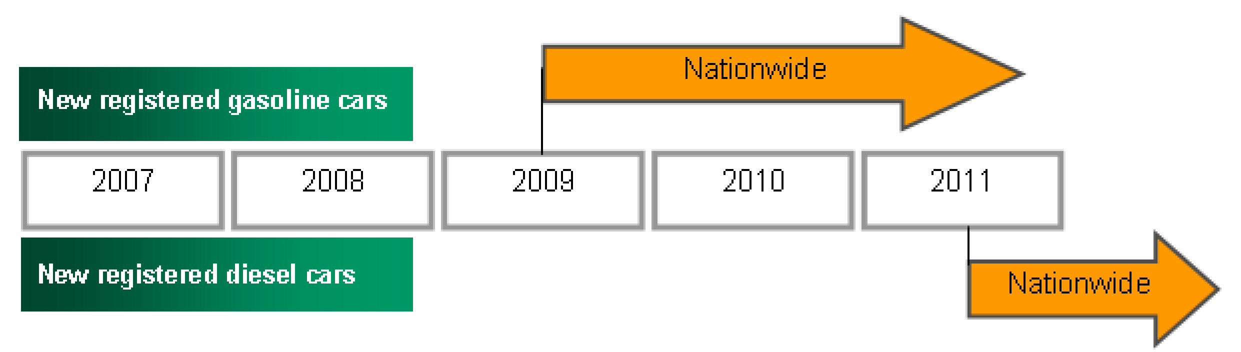


Fig. 3.1.3.2-3: OBD implementation plan China-wide.

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:

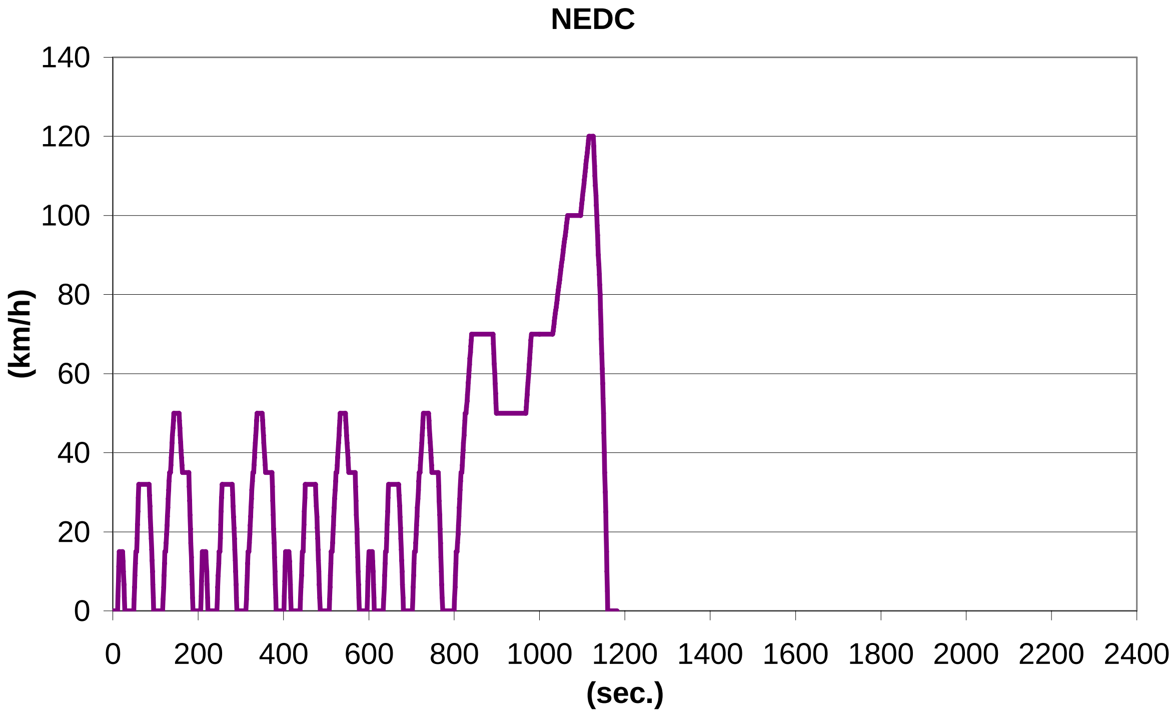


Fig. 3.1.3.2-4: NEDC 2000.

Tab. 3.1.3.2-1: Driving cycle summary.

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:

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.

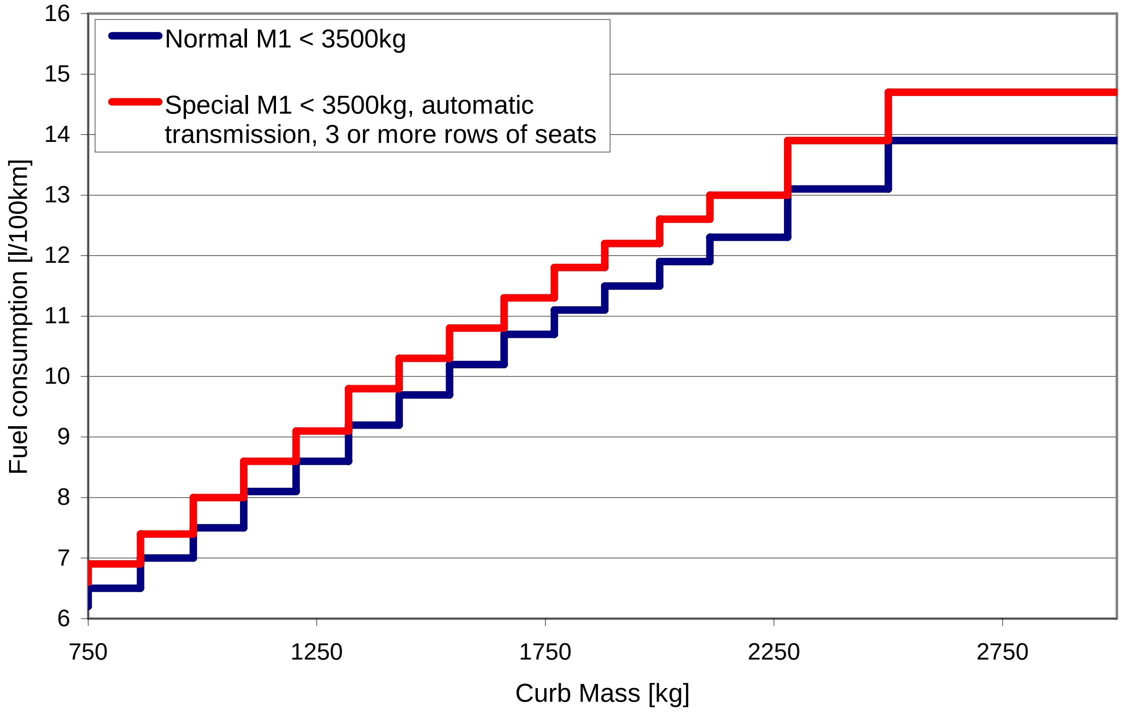


Fig. 3.1.3.3-1: Standard – Fuel consumption Phase-2 limits.

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).

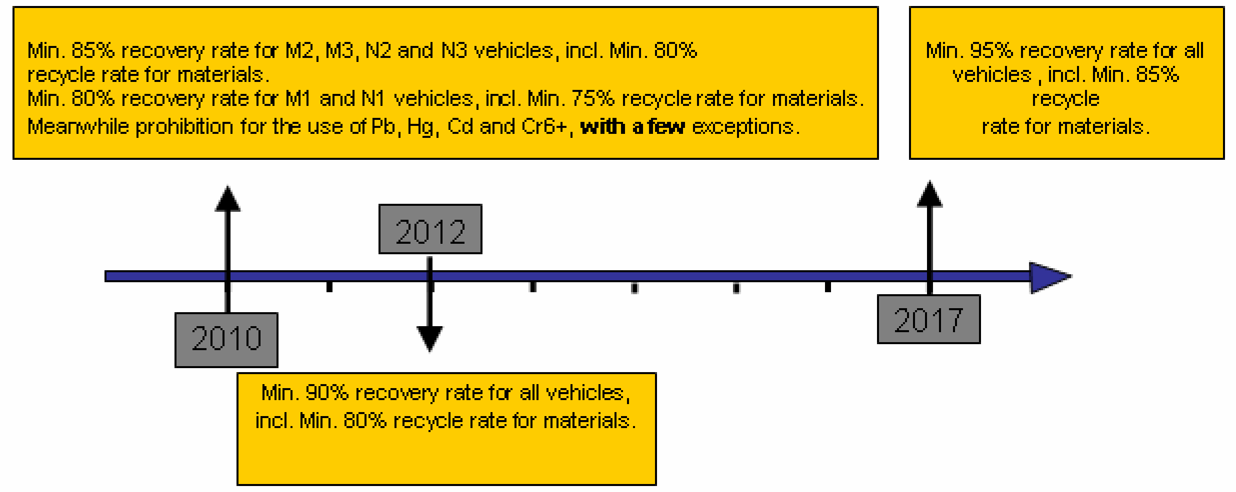


Fig. 3.1.3.4-1: 3-phase research projects.

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; 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
			Airquality: 2008/50/EC on ambient air quality and cleaner air for Europe	Regulations of ambient air quality in relation to sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate Matter (PM_{10}, $PM_{2,5}$), lead, benzene, carbon monoxide and ozone
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		
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

	UN-ECE Environmental Regulations		European Regulations	
Regulation	Reference	Comment	Reference	Comment
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		project agreed, legislation adopted	Scope M1 decided N1 announced for 2nd step
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_1	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_1	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:

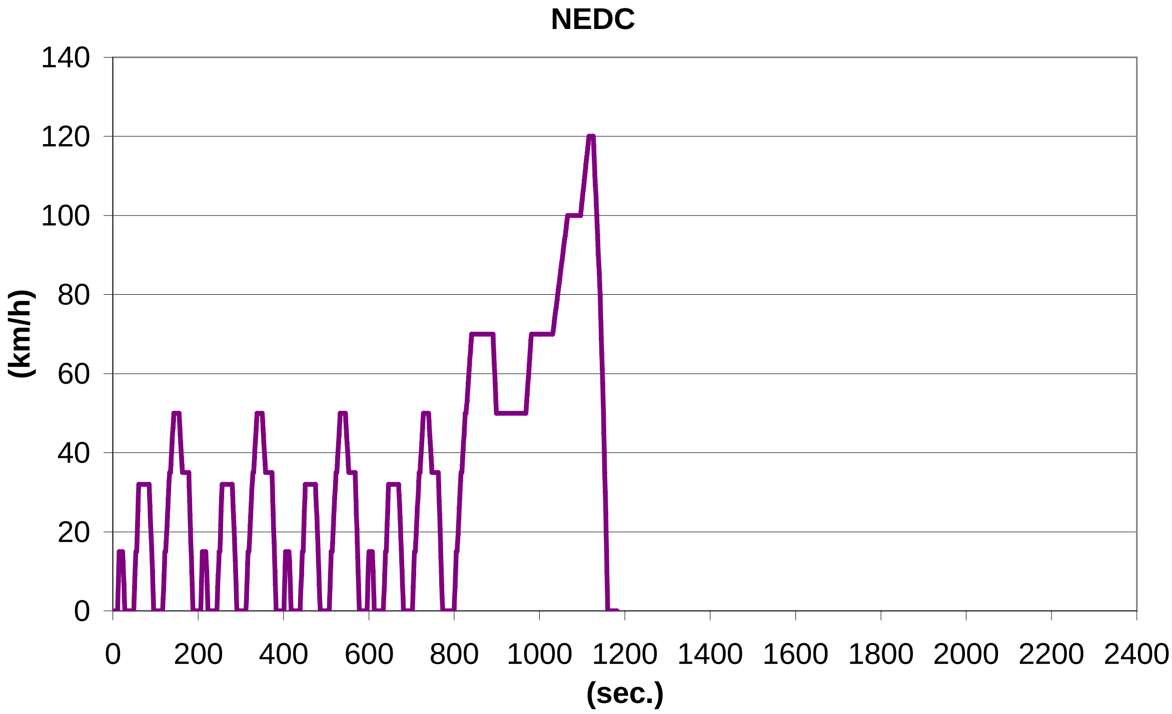


Fig. 3.1.4.2-1: Driving cycle for European Union (NEDC 2000).

Tab. 3.1.4.2-4: Driving cycle summary.

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 - EUROPEAN REGULATION

The objective of the regulation is to reach 120 g/km in 2015, as an average for the whole passenger car fleet (new vehicles), starting in 2012 (phase-in). This goal is split in 130 g/km based on type approval of M1 vehicles (by means of improvements in vehicle motor technology) and 10 g/km related to the complementary measures (GSI; TPMS; LRRT; MAC system efficiency; biofuels).

Each car manufacturer has to comply with an objective according to the CO_2 function defined as follows: CO_2 = 130 + ax (M - M0), compared to the actual average emissions from new cars sold in the EU-27. (NB : M = mass in running order; a = 0,0457; M0 = 1372kg). In the case of non conformity penalties have to be paid.

The phase-in is defined as follows: 65% in 2012; 75% in 2013; 80 % in 2014; 100% in 2015, using proportions of new passenger cars registered in each year.

New passenger cars with specific CO_2 emissions of less than 50 g/km count as 3,5 cars in 2012 and 2013, as 2,5 cars in 2014, as 1,5 cars in 2015 and 1 car from 2016 onwards. The regulation includes also special rules for cars using E 85.

Eco-innovation technology will be taken into account in the limitation of 7g/km by car manufacturer, provided the contribution to the CO_2 reduction is not taken into account by the type approval procedure.

The 2020 target is 95 g/km, depending on an impact assessment, planned for 2013, e.g. to reconsider the key parameter (footprint versus mass ?).

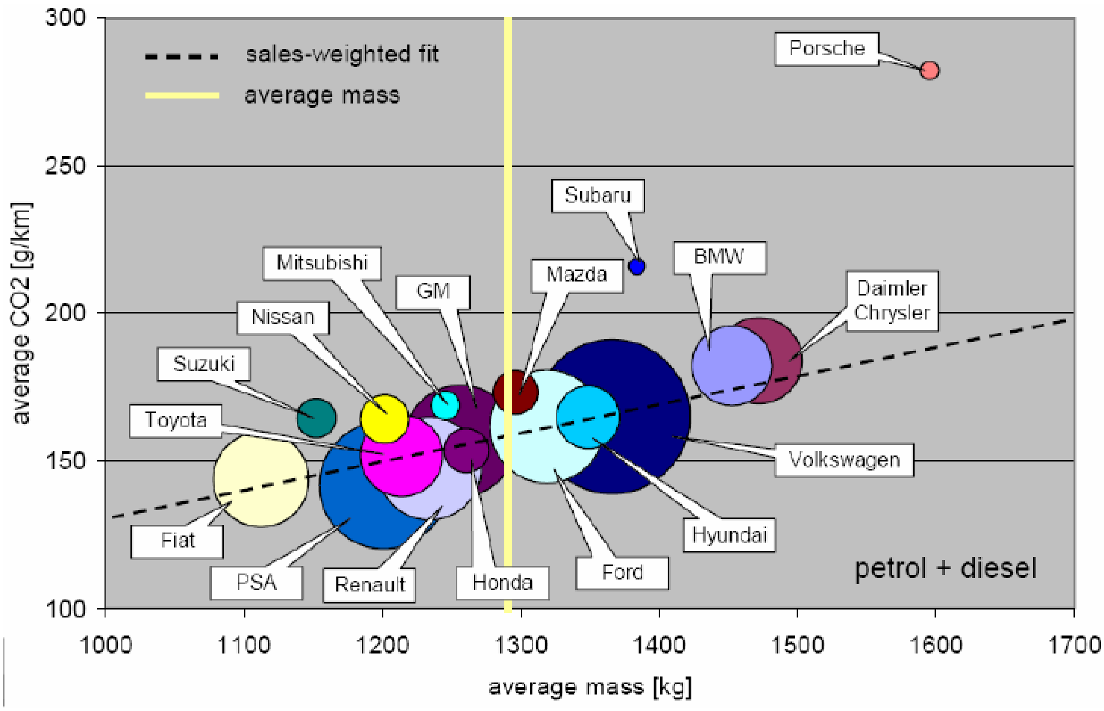


Fig. 3.1.4.3-1: CO_2 emissions versus average vehicle mass in 2006 [44]

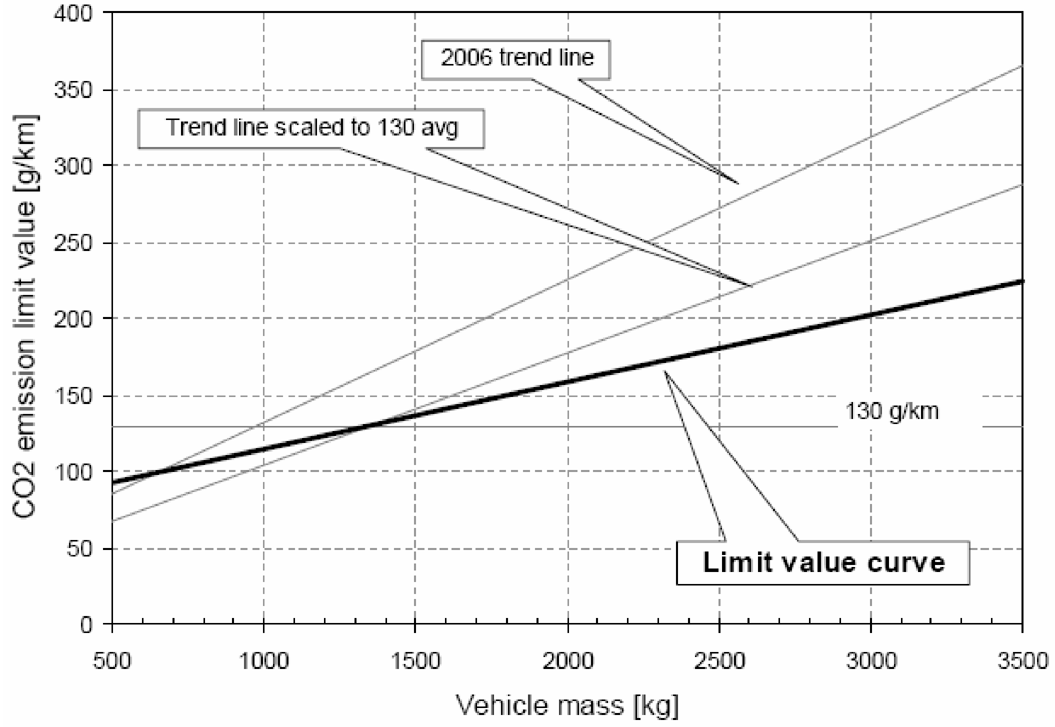


Fig. 3.1.4.3-2: Target curve for the manufacturers – phase in 2012 - 2015 [44]

3.1.4.4. CO_2 - LABELLING DIRECTIVE

In January 2000 the directive 1999/94/EC [41] (amended by directive 2003/73/EC) of the European Parliament and of the council of 13 December 1999 relating to the availability of consumer information on fuel economy and CO_2 emissions in respect of the marketing of new passenger cars was published in the Official Journal of the European Communities.

The purpose of this directive is to ensure that information relating to the fuel economy and CO_2 emissions of new passenger cars offered for sale or lease in the Community is made available to consumers in order to enable consumers to make an informed choice.

The labelling directive requires the display of a label on fuel consumption and CO_2 emissions on all new cars, the publication of national guides on the fuel efficiency of new cars, the display of posters at the dealerships and the inclusion of fuel efficiency information in printed promotional literature. The directive is considered a useful tool in raising awareness but its impact has not been visible, with labels of strongly varying quality in different Member States.

With the implementation of directive 1999/94/EC into national law some Member States introduced a ranking scheme, based on the European Energy Labelling System (A (green) … G (red)).

Currently an European Regulation concerning the labelling on tyres (rolling resistance, noise, wet grip) is in the decision making process.

3.1.4.5. FUEL REGULATIONS

The fuel quality directive establishes minimum specifications for petrol and diesel fuels for use in road and non-road mobile applications for health and environmental reasons, including the well-functioning of engines and after-treatment systems. Fuels for use in road vehicles are sulphur free as from 2008.

One new aspect introduced in the amended fuel quality directive, adopted in December 2008, the obligation for motor fuel suppliers to reduce fuel life cycle greenhouse gas emissions by 6% in 2020, compared to 2010. Subject to a review in 2012 this reduction could be increased to 8% or 10%. This can be considered a well-to-wheel approach for fuels. The introduction of biofuels, electric vehicles, other alternative fuels, but also reduction of CO_2 emission related to flaring are among the measures that would qualify as means to fulfil the target.

The simultaneous adopted Renewable Energy Directive sets a target that by 2020 10% (on energy) of diesel and petrol should be replaced by alternatives like biofuels (fulfilling sustainability criteria), CNG, LPG and electric vehicles.

3.1.4.6. NOISE

Preliminary: there are several noise sources which contribute to noise pollution. One of those comes from the vehicles explaining regulation on vehicle external noise.

References:
- European Regulation: 70/157 * 2007/34/EC
- UN-ECE regulation as an equivalence: ECE R51-02

Summary of the requirements:
According to both stationary and rolling test procedures, the level of the external noise of vehicles is checked.
For the purpose of M1 and N1 vehicle categories, the mandatory limit values are currently:
- Category M1: 74 dB(A)
  (derogation for compression ignition engines and direct injection engines: 75 dB(A))
- Category N1: 76 dB(A) if the MTALW≤ 2t and 77 dB(A) in other cases.
  (MTALW = Maximum Technically Admissible Laden Weight)

Next step:
A new test procedure have been defined in order to better evaluate the noise behaviour in urban conditions. So, based on this procedure and in parallel with the current one, a monitoring phasis is ongoing in order to allow decision makers to define new limits.

3.1.4.7. RECYCLING

References :
- European Regulation: End of Life Vehicles (ELVs) Directive 2000/53/EC
  Recyclability, Recovery and Reuse (RRR) 2005/64/EC
- UN-ECE regulation: no equivalence

Summary of the requirements:

* 2000/53/EC:

The main purpose is to constrain the European Member States to improve the recycling and the recovery of their ELVs, starting with an objective of a minimum threshold to achieve for both:

- recycling: 80 % in 2006 and 85 % in 2015
- recovery: 85 % in 2006 and 95 % in 2015

First results have been published in 2008 as follow:

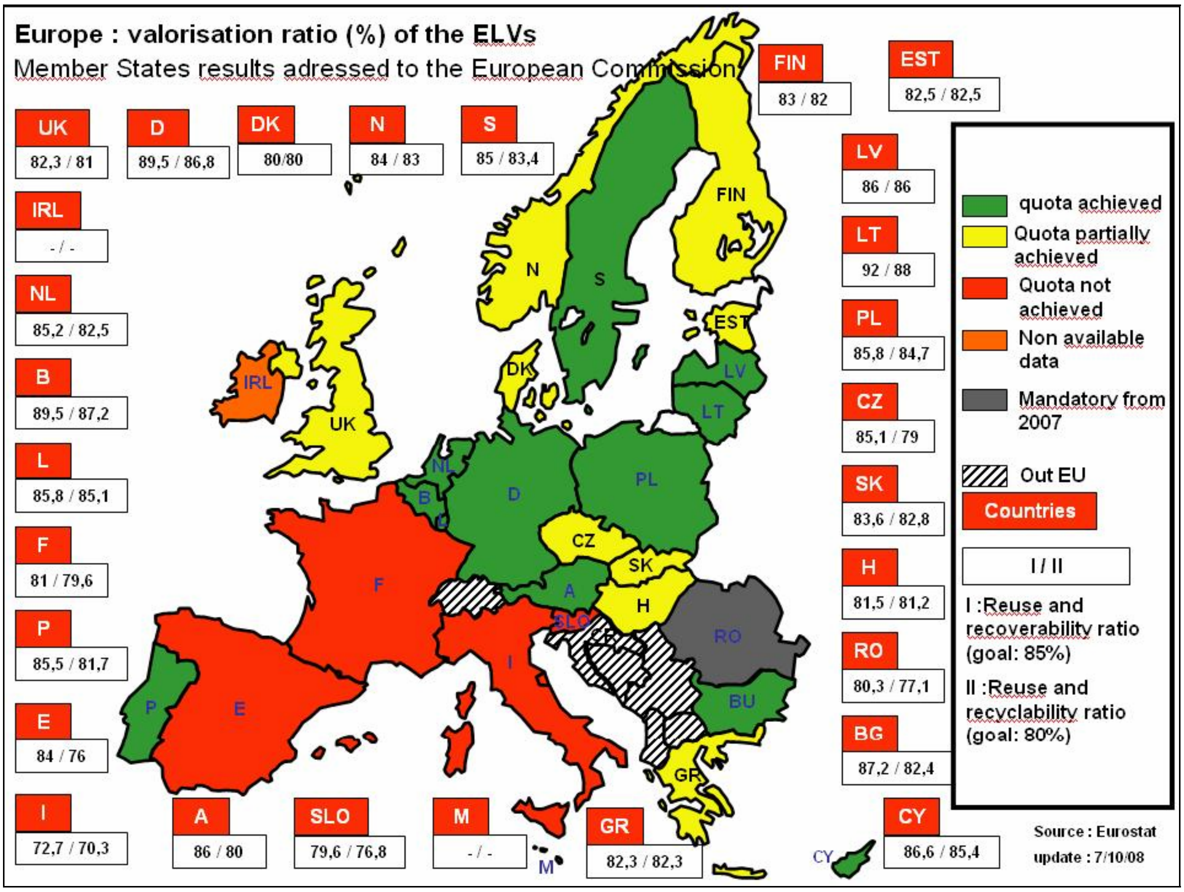


Fig. 3.1.4.7-1: Valorisation Ration of the ELVs.

* 2005/64/EC

To contribute to the above targets, the main purpose of the RRR Directive is to constrain the Cars manufacturers to improve the recyclability and the recoverability of their vehicles, starting with an objective at the type approval of a minimum threshold to achieve for both:

- recyclability: 85 %
- recoverability: 95 %

from 15/12/2008 for New Types and from 15/07/2010 for all types.

The process established by the car manufacturer in terms of:

- Recommended strategy for recycling and recovery,
- Collection and traceability of the relevant data (weights of the components, chemical nature of the materials),
- Calculation of the ratio according to ISO 22628.
- Compliance with the heavy metals ban (Lead, Mercury, Cadmium, ChromiumVI) , except for certain applications under derogation

is evaluated by the type approval authorities each two years.

3.1.4.8. ‘GREEN PUBLIC PROCUREMENT’ DIRECTIVE

Public procurement can be a powerful market mover for the introduction of new technologies.

The new Directive 2009/33/EC of 23 April 2009 on the Promotion of Clean and Energy Efficient Road Transport Vehicles aims at a broad market introduction of environmentally-friendly vehicles [45].

It requires that energy and environmental impacts linked to the operation of vehicles over their whole lifetime are taken into account in all purchases of road transport vehicles, as covered by the public procurement directives (Directives 2004/17/EC and 2004/18/EC) and the public service regulation (Regulation EC Nº 1370/2007).

These lifetime impacts of vehicles shall include at least energy consumption, CO_2 emissions and emissions of the regulated pollutants of NOx, NMHC and PM. Purchasers may also consider other environmental impacts.

Two options are offered to meet the requirements:

1. setting technical specifications for energy and environmental performance in the documentation for the purchase of road transport vehicles on each of the impacts considered (e.g. a certain minimum emission standard)
2. or by including energy and environmental impacts in the purchasing decision, whereby:
   a. in cases where a procurement procedure is applied, this shall be done by using these impacts as award criteria (e.g. maximum CO_2 emissions)
   b. in cases where these impacts are monetised for inclusion in the purchasing decision, a proposed calculation methodology shall be applied (internalisation of external costs).

In case of 2b, the lifetime cost for the operation of a vehicle shall be calculated by:

- determining operational lifetime fuel consumption, and converting it into ‚energy consumption’, based on values proposed in the legislation
- determining operational lifetime CO_2 emissions and emissions of NO_x, NMHC, and PM
- determining emissions based on standardised EU test procedures for the vehicles for which such test procedures are defined in EU type approval legislation. For vehicles not covered by standardised EU test procedures, comparability between different offers shall be ensured by using widely recognised test procedures, or the results of tests for the authority, or information supplied by the manufacturer.
- Converting operational lifetime energy consumption, CO_2 emissions and emissions of NO_x, NMHC and PM, into ‚costs’ based data provided by the legislation (table 3.1.4.8-1)
- using lifetime mileages defined in the legislation, if not otherwise specified

This internalisation of external costs into new vehicle procurements will improve the contribution of the transport sector to the environment, climate and energy policies of the Community by reducing energy consumption, CO_2 emissions and pollutant emissions.

This Directive is expected to result, in the longer term, in a wider deployment of clean and energy efficient vehicles. Increased sales will help reduce costs through economies of scale, resulting in progressive improvement in the energy and environmental performance of the whole vehicle fleet.

Member States must transpose it into national laws by 18 months after the date of publication, when it will enter into force.

Tab. 3.1.4.8-1: Cost for emissions in road transport (in 2007 prices).

CO_2	**NO_x**	**NMHC**	**Particulate Matter**
3-4 €cents/kg	0.44 €cents/g	0.1 €cents/g	8.7 €cents/g

3.1.4.9. ENVIRONMENTALLY ENHANCED VEHICLE (EEV) TARGET STANDARD (HEAVY DUTY VEHICLES)

The scope of this background document is limited to passenger cars (vehicles of category 1-1). But to explain the approach of "target standards", the EFV concept of directive 88/77/EEC [42] for Heavy Duty Vehicles is shown here as example.

The Environmentally Enhanced Vehicle (EEV) was a concept advocated by the European Natural Gas Vehicle Association (ENGVA) in 1995. The EEV provided a non-mandatory, target emissions standard well below the Euro IV, designed initially to enable national and local government policy makers to identify clean fuel vehicles, and create incentives and laws favoring their use. It also was intended to be used by vehicle manufacturers of heavy duty natural gas engines/vehicles to differentiate their products from the typical state-of-the-art diesel engines, and to provide an additional opportunity to promote their natural gas technology.

The limit values were, compared to the existing Euro 4 regulations:

Tab. 3.1.4.9-1: Heavy Duty Vehicle Standards for Diesel and Gas Engines and EEV** Target Values (g/kWh) (ETC test cycle)

	CO	NMHC	CH4	NOx	PM*
Euro IV Diesel	4.0	0.55	1.1	3.5	0.03
EEV Diesel & Natural Gas	3.0	0.40	0.65	2.0	0.02

* not applicable for natural gas vehicles
** Environmentally enhanced vehicle

ETC =European transient cycle; NMHC = Non Methane Hydrocarbons; $CH_{4=}$ methane ;

Importantly, the EEV was the first time in Europe that a standard was developed to include a non-methane hydrocarbon limit value. This was especially important for natural gas vehicles, which normally produced total hydrocarbons in excess of the Euro IV limit, but whose total hydrocarbon carbon emissions consisted of approximately 85% methane, which does not contribute to smog formation, one of the key concerns of the hydrocarbon emissions regulation.

The EEV proved popular among engine manufacturers shortly after adoption in 1999. The EEV standard still (as of 2009) is used by manufacturers as a benchmark clean fuel vehicle, but The European Commission has chosen not to include an EEV approach in the Euro VI regulation.

3.1.5. INDIA

3.1.5.1. INDIA ENVIRONMENTAL REGULATIONS

	Regulation	Reference	Comment
CO_2	Discussion ongoing. Proposals based on mass CO_2 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
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 manufacture.	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
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	UN-ECE Regulation 24	Regulation Number: ECE-24 amended to ECE-24.03 Supp. 2. Regulation Name: DIESEL SMOKE EMISSIONS

	Regulation	Reference	Comment
	acceleration test result increased by 0.5-1 and marked close to vehicle VIN plate.		
[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

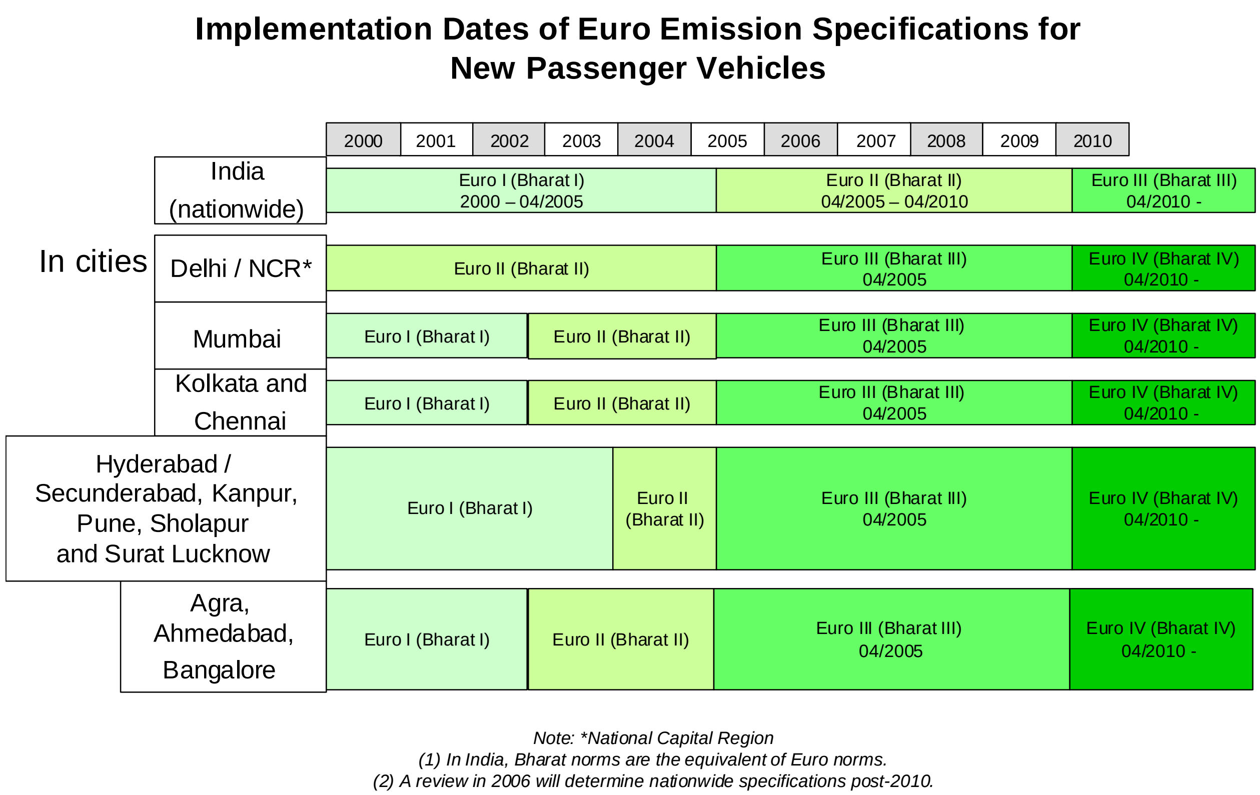


Fig. 3.1.5.2-1: Implementation Dates of Euro Emission Specifications for New Passenger Vehicles.

Driving Cycles:

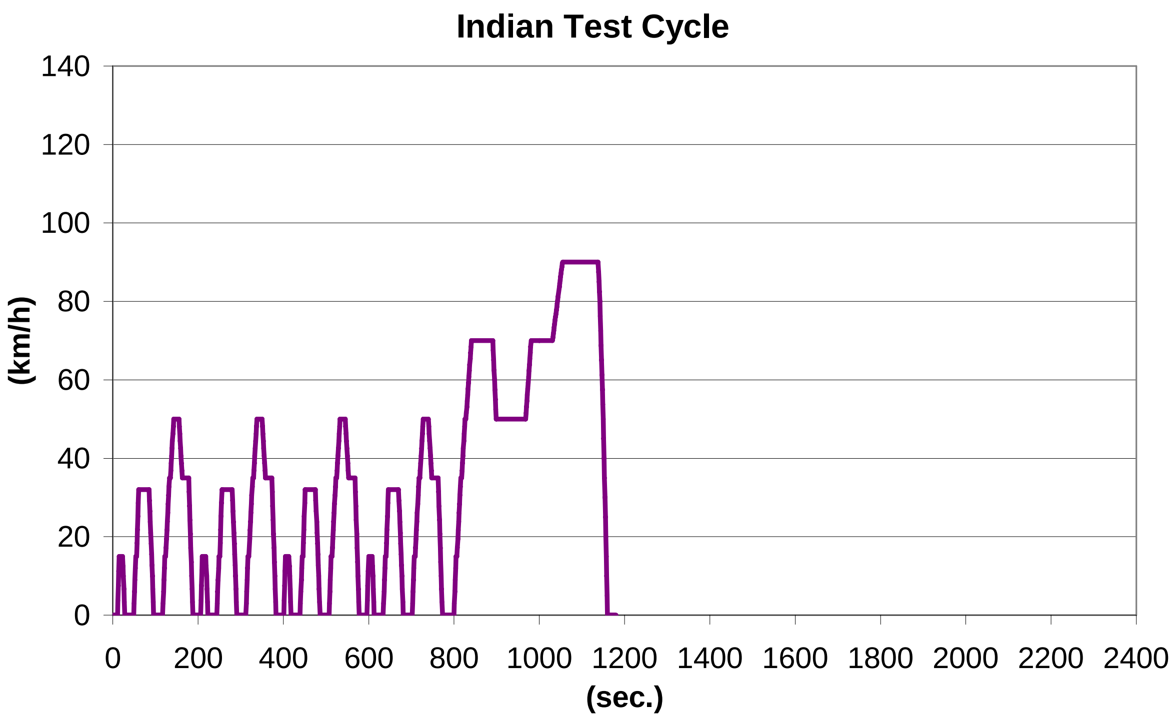


Fig. 3.1.5.2-2: Indian Test Cycle.

Tab. 3.1.5.2-1: Driving cycle summary.

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

Automotive Industry (SIAM) is going to issue fuel efficiency labels at the point of sale as well as fuel economy brochures. The Indian Standing committee of Sub committee on Emission under MoSRTH has proposed CO_2 limits. The limits are based on the kerb weight.

3.1.5.4. NOISE

Indian noise regulation is basically similar to ECE R-51.02 with the exception that the tyres need to have 90% of the residual tread pattern depth detailed in the ECE R-51.02.

3.1.6. RUSSIA

Note: Some of the following information is preliminary, because the final adoption of some requirements is outstanding.

3.1.6.1. EXHAUST GAS EMISSION

Tab. 3.1.6.1-1: Exhaust, Governmental regulation No. 609, October 12, 2005

Environmental class, Date of application	Scope	Reference	Comment
2 April 2006- 31 Dec. 2007	M_1, M_2 with a maximum mass not exceeding 3.5 t, N_1 with spark-ignition (petrol and gas) engines and diesels	ECE R 83-04	Emission levels B, C, D
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_1, N_2, N_3 with gas engines and diesels	ECE R 49-02	Emission level B
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_2, N_3 with petrol engines	CO – 55 g/kWh HC – 2.4 g/kWh NO_x – 10 g/kWh ECE R 49-04	ESC test cycle only
3 Jan 1, 2008- Dec.31, 2009	M_1, M_2 with a maximum mass not exceeding 3.5 t, N_1 with spark-ignition (petrol and gas) engines and diesels	ECE R 83-05	Emission level A
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_1, N_2, N_3 with gas engines and diesels	ECE R 49-04	Emission level A
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_1, N_2, N_3 off-road vehicles with diesels	ECE R 96-01	
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_2, N_3 with petrol engines	CO – 20 g/kWh HC – 1.1 g/kWh NO_x – 7 g/kWh ECE R 49-04	ESC test cycle only
4 Jan 1, 2010- Dec.31, 2013	M_1, M_2 with a maximum mass not exceeding 3.5 t, N_1 with spark-ignition (petrol and gas) engines and diesels	ECE R 83-05	Emission level B
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_1, N_2, N_3 with gas engines and diesels	ECE R 49-04	Emission level B1
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_2, N_3 with petrol engines	CO – 4 g/kWh HC – 0.55 g/kWh NO_x – 2 g/kWh ECE R 49-04	ETC test cycle only

Environmental class, Date of application	Scope	Reference	Comment
	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_1, N_2, N_3 off-road vehicles with diesels	ECE R 96-02	
5 Jan 1, 2014	M_1 with maximum mass exceeding 3.5 t, M_2, M_3, N_1, N_2, N_3 with gas engines and diesels	ECE R 49-05	Emission level B2, C

3.1.6.2. NOISE

Tab. 3.1.6.2-1: External Noise, Governmental regulation No. 3453, December 10, 2007

Scope	Reference	Comment
M, N	Reg. № 51-02 (incorporating Supplements 1-4,6).	1. The test results according to the EEC Directive 70/157 (1999/101) can also be recognized; 2. For vehicle categories N_2G, N_3G, M_2G, M3G the Reg. № 51-01 (EEC Directive 70/157 (84/424)) is applicable; 3. As of 01.01.2010 the Supplement 5 of Reg. № 51-02 (EEC Directive 2007/34) is valid
L	For vehicles categories L_2, L_4, L_5, L_6, L_7 - Reg. № 9-06 (incorporating Supplement 1) are applied For vehicles category L_3 - Reg. № 41-03 (incorporating Supplement 1) is applied For vehicles category L_1- Reg. № 63-01 (incorporating Supplement 1) is applied.	The test results according to the Directive EC 97/24/9, can also be recognized
M, N, O	Reg. № 117-00.	1. The results of tests according to the Directive EC 92/23 (2001/43) can also be recognized; 2. Date of entry into force: 01.01.2010 for vehicles categories M1, N1, O1, O2; 3. Date of entry into force: 01.01.2012 for vehicles categories M2, M3, N2, N3, O3

3.1.6.3. INTERIOR NOISE

Tab.: 3.1.6.3-1: Internal Noise, Russian requirements, GOST R 51616
(The testing techniques basically correspond to standard ISO 5128 and Appendix 8 of the Summary resolution on a design of the vehicles).

Vehicle Category	Permissible levels, dB (A)
Passenger vehicles:	
Category M_1	78
Category M_1 (wagon or semi bonnet body)	80
Category M_2, M_3	
- with the engine located at the vehicle's front or in the driver's seat area (in the driver's or passenger compartment)	80
- with the other engine location:	
a) in the driver's compartment,	78
b) in the passenger compartment (except city bus)	80
c) in the passenger compartment of a city bus	82
Trucks:	
Category N_1 with fully loaded mass up to 2 tons	80
Category N_1 with fully loaded mass from 2 to 3.5 tons	82
Category N_2, N_3	
- intended for the international and long-distance transportations	80
- other vehicles	82
Passenger trailers and semi trailers:	
Categories O_2, O_3, O_4	80
Trolleybuses:	
a) in the driver's compartment	78
b) in the passenger compartment	82
Note: For off-road vehicles of Category M_1 the permissible noise levels are 2 dB(A) higher than the abovementioned	

3.1.6.4. FUEL CONSUMPTION

ECE R 84, ECE R 101 (voluntary).

3.1.6.5. CONCENTRATION OF HARMFUL SUBSTANCES IN THE PASSENGER COMPARTMENT

Tab. 3.1.6.5-1: Pollutants level inside the vehicle (Russian requirements, GOST R 51206)
Current situation:

Pollutant	Limit, mg/m^3
CO	5,0
NO_2	0,085
NO	0,400
CH_4 1)	50,0
Saturated Hydrocarbons C_2–C10 2)	50,0
CH_2O 3)	0,035

Plan (coming into force as of Jan.1, 2010)

Pollutant	Limit, mg/m^3
CO	5,00
NO_2	0,200
NO	0,400
CH_4 1)	50,0
Saturated Hydrocarbons C_2–C_7 2)	50,0
CH_2O 3)	0,035

Notes:
1) For vehicles equipped with NG engines only;
2) For vehicles equipped with P.I.(petrol and LPG) engines only;
3) For vehicles equipped with C.I. engines only;

3.1.7. BRAZIL

3.1.7.1. EXHAUST GAS EMISSION

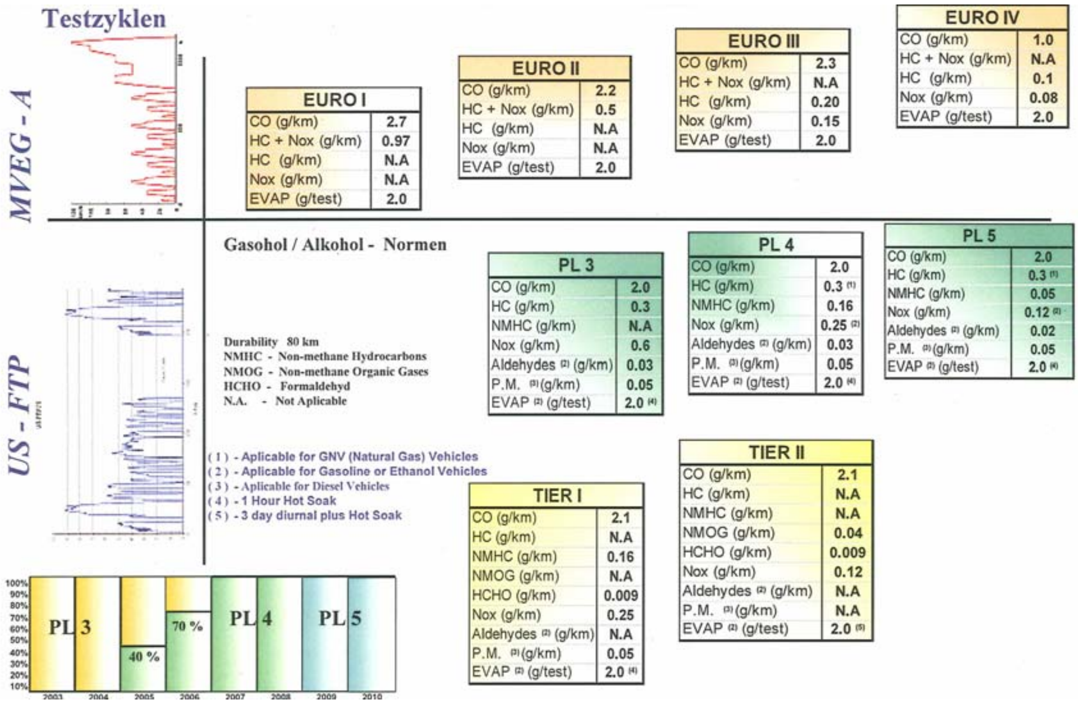


Fig. 3.1.7.1-1: Exhaust gas emission legislation.

- CONAMA Resolution No. 315/2002 PROCONVE L -5

Article 4 As of January 1st, 2009, the following maximum exhaust emission limits for light duty passenger vehicles (PROCONVE L -5) shall apply:

a) carbon monoxide (CO): 2.0 g/km;
b) total hydrocarbons (THC), only for natural gas vehicles: 0.30 g/km;
c) non-methane hydrocarbons (NMHC): 0.05 g/km;
d) nitrogen oxides (NO_x) for gasoline engines: 0.12 g/km;
e) nitrogen oxides (NO_x) for Diesel engines: 0.25 g/km;
f) aldehydes (CHO*), only for gasoline engines (except natural gas): 0.02 g/km;
g) particulate matter (PM), only for Diesel engines: 0.05 g /km;
h) content of carbon monoxide at idling speed, only for gasoline engines: 0.50% vol.

Driving Cycle: FTP75.

3.1.7.2. NOISE

Targets CONAMA Resolution No. 272/2000 in line with 70/157/EWG

Tab. 3.1.7.2-1: Maximum noise emission limits for motor vehicles.

	CATEGORY		NOISE LEVEL – dB(A)		
	DESCRIPTION		OTTO	DIESEL Injection	
				Direct	Indirect
a	Passenger vehicle up to nine seats		74	75	74
b	Passenger vehicle with more than nine seats	PBT up to 2,000 kg	76	77	76
	Cargo or traction vehicle and multi-purpose vehicle	PBT between 2,000 kg and 3,500 kg	77	78	77
c	Passenger vehicle or multi-purpose vehicle with PBT exceeding 3,500 kg	Maximum power lower than 150 kW (204 HP)	78	78	78
		Maximum power equal to or exceeding 150 kW (204 HP)	80	80	80
d	Cargo or traction vehicle with PBT exceeding 3,500 kg	Maximum power lower than 75 kW (102 HP)	77	77	77
		Maximum power be-tween 75 kW (102 HP) and 150 kW (204 HP)	78	78	78
		Maximum power equal to or exceeding 150 kW (204 HP)	80	80	80

3.1.8. AUSTRALIA

3.1.8.1. EXHAUST GAS EMISSION

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

Alternative Standards:
ECE R- 83, Revision 3, incorporating the 05 series of amendments and all amendments up to and including Supplement 1 to the 05 series of amendments.

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

3.1.8.2. NOISE

ADR 83/00 – External Noise.

Alternative Standards:
For M and N category vehicles, the technical requirements of United Nations Economic Commission for Europe Regulation No. 51 Uniform Provisions Concerning the Approval of Motor Vehicles Having at Least Four Wheels with Regard to Their Noise Emissions, incorporating the 02 series of Amendments, up to and including corrigendum 1 to supplement 3 to the 02 series, are deemed to be equivalent to the technical requirements of this vehicle standard.

3.1.8.3. FUEL CONSUMPTION

ADR 81/02 –Fuel Consumption Labelling for Light Vehicles.

Alternative Standards:
The fuel consumption values and carbon dioxide emissions values declared for the vehicle by the manufacturer in accordance with the requirements ECE R-101, Revision 2 – Amendment 1, including all amendments up to and including Supplement 7, are deemed to be equivalent to the fuel consumption values and carbon dioxide emissions values specified for that vehicle in clause 4.3 of this vehicle standard.

3.1.9. KOREAN EMISSION LEGISLATION

Tab. 3.1.9-1: Gasoline

F. From 2009.1.1

Class			CO	NOx	HC			HCHO	Test Method
					Tailpipe	Blow-by	Evap.		
Light-wt. V, Small-sized PC & T, Mid-sized PC & T	Std 1	A	=<2.11 g/km	=<0.031 g/km	=<0.047 g/km	0g/1 run	=<2g/test	=<0.009 g/km	CVS-75 mode
		B	=<2.61 g/km	=<0.044 g/km	=<0.056 g/km	0g/1 run	=<2g/test	=<0.011 g/km	
	Std 2	A	=<1.06 g/km	=<0.031 g/km	=<0.025 g/km	0g/1 run	=<2g/test	=<0.005 g/km	
		B	=<1.31 g/km	=<0.044 g/km	=<0.034 g/km	0g/1 run	=<2g/test	=<0.007 g/km	
	Std 3		=<0.625 g/km	=<0.0125 g/km	=<0.00625 g/km	0g/1 run	=<2g/test	=<0.0025 g/km	
	Std 4		0g/km	0g/km	0g/km	0g/1 run	0g/test	0g/km	
Large-sized PC & T, XL PC & T			=<4.0 g/kwH	=<2.0 g/kwH	=<0.55 g/kwH	0g/1 run	-	-	ETC mode

Tab. 3.1.9-2: Diesel

F. From 2009.9.1

Class	Criteria	CO	NOx	HC + NOx	PM	Smoke	Test method
Light-wt V., Small-sized PC		=<0.50 g/km	=<0.18 g/km	=<0.23 g/km	=< 0.005 g/km	-	ECE-15 & EUDC mode
Small-sized T, Mid-sized PC & T	RW=< 1,305kg	=<0.50 g/km	=<0.18 g/km	=<0.23 g/km	=<0.005 g/km	-	
	1,305kg <RW=< 1,760kg	=<0.63 g/km	=<0.235 g/km	=<0.295 g/km	=<0.005 g/km	-	
	RW> 1,760kg	=<0.74 g/km	=<0.28 g/km	=<0.35 g/km	=<0.005 g/km	-	
Large-sized PC & T, XL PC & T		1.50 g/kWH	2.0 g/kWH	0.46 g/kWH	0.02 g/kWH	$K=0.5m^{-1}$	ND-13 mode
		4.0 g/kWH	2.0 g/kWH	0.55 g/kWH	0.03 g/kWH		ETC mode

3.1.10. STANDARDS

There are different International Standards that relate to the subject of environmental friendly products. Most of them are part of the 14xxx series covering environmental aspects. In this series only the product related standards are of interest:

- ISO 14020/21
- ISO 14040/44
- ISO 14062

In addition ISO 22628 is of interest as referenced in various worldwide regulations covering recyclability.

3.1.10.1. ISO 14020 SERIES

The ISO 14020 series is of relevance in the discussion around Environmental Friendly Vehicles (EFV) as an EFV can be seen as an environmental label, declaration or claim. For this type of statements the ISO 14020 series is to be followed.

The frame is covered in ISO 14020 about "Environmental label and declarations – General principles." It is defined that environmental labels or declarations are any claims that indicate the environmental aspects of a product or service – either in form of a statement, symbol etc in product literature, technical bulletins, advertising or in publicity, amongst other things. The key principle laid down is that these types of claims should communicate only verifiable and accurate information that is not misleading. The underlying aim of all these claims is to stimulate the potential demand and supply of those products and services. The second important principle is that all this should never create unnecessary obstacles to international trade. Other principles include the required scientific approach, the consideration of all relevant aspects of a product's life cycle, transparency and availability of data etc.

The following ISO rules specify different types of environmental labels and declarations:

- ISO 14021 about Self-declared environmental claims (Type II environmental labelling). The most interesting section in the context of EFVs is the clarification of the consequences out of the first general principle of ISO 14020 (verifiable, not misleading etc.). Looking at the complexity of environmental impacts (climate change, acidification, resource depletion, etc.) any vague or non-specific claim as "environmentally friendly", "green", "earth friendly" etc. shall not be used.
- ISO 14024 about Environmental labelling Type I. This type is based on a voluntary, multiple-criteria based third party programme that awards a license allowing the use of an environmental label on products based on life cycle considerations. This standard repeats the general rules of the above standards but adds rules for the environmental label body and makes clear that a pre-requisite for awarding any label is compliance with environmental and other relevant legislation. This later requirement should be also of relevance for an EFV definition.
- ISO 14025 about Type III environmental declarations (EPD). This type is based on a specific rules for one or more product categories, i.e. in so-called Product Category Rules (PCR) the requirements for life cycle based environmental declarations are laid down that are certified by a third party. Again, the rules of ISO 14020/21 are in place but also specific rules as avoiding comparative assertions as such an EPD is a collection of life cycle related environmental information about a product or service.

3.1.10.2. ISO 14040 SERIES

The ISO 14040 series is about Life Cycle Assessment (see vehicle related applications in chapter 3.2.2.). While ISO 14040 is about the "Principle and Framework" the more detailed rules are covered in ISO 14044 called "Requirements and guidelines". ISO 14044 is summarizing the previous standards ISO 14041, 14042 and 14043 that had been established between 1998 and 2000.

An LCA is an environmental management techniques for supporting decisions by providing information about the environmental impacts of inputs and outputs related to a product system throughout its life cycle. The product life cycle covers all processes of a product system from raw material acquisition or generation of natural resources to final disposal. This so-called "life cycle" approach is the base principle of all LCAs. LCA typically does not address the economic or social aspects of a product, but the life cycle approach and methodologies can be applied also on these other aspects (leading to a Life Cycle Costing or a Social LCA). Figure 3.1.10.2-1 is showing the different parts of an LCA:

- Goal and Scope Definition – basically defining the functional unit (reference flow) and system boundaries
- Inventory Analysis – is basically the input / output compilation of all materials or energies entering or leaving the product system as defined above. Here so-called "elementary flows" are reported, i.e. those flows without previous / subsequent human transformation. (Figure 3.1.10.2-2)
- Impact Assessment – is translating and aggregating these input / output elementary flows in different environmental impact categories (e.g. climate change, acidification, resource depletion)
- Interpretation – is evaluating the data (completeness, sensitivity and other checks), identifying significant issues and draws conclusions, recommendations etc. by underlining limitations of the study.

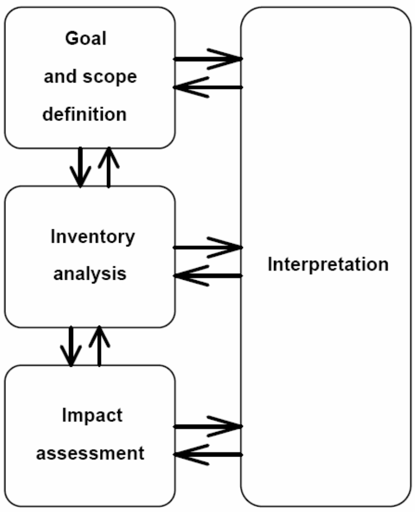


Fig. 3.1.10.2-1:
Life Cycle Assessment Framework: Phases of an LCA (ISO 14040)

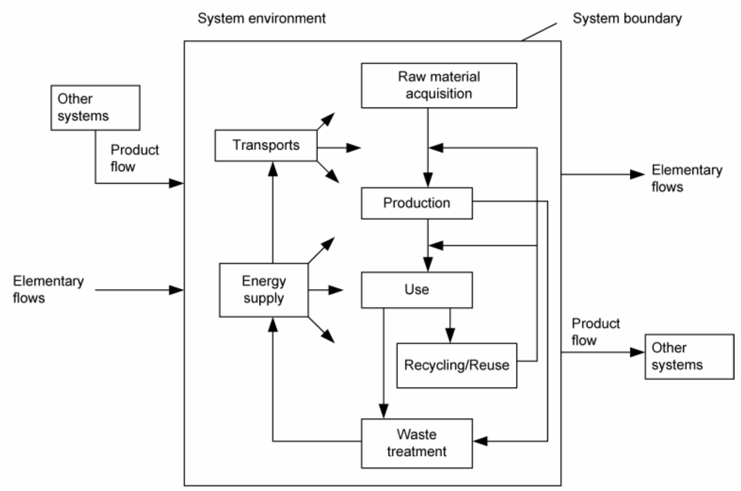


Fig. 3.1.10.2-2:
Example of a product system for LCA (ISO 14040)

3.1.10.3. ISO TR 14062

The ISO TR 14062 series is a technical report about "Integrating environmental aspects into product development". ISO explicitly notes that it is not applicable as a specification for certification and registration purposes but it describes concepts and current practices relating to the integration of environmental aspects into product design and development. Strategic and business thinking is necessary for its application:

- First of all, integration has to be performed on the existing company specific framework of management and product development.
- Secondly, ISO TR 14062 covers, in particular, the addition of environmental aspects and tools for the framework. However, many other influences, like social acceptance or competition, have also to be taken into consideration.
- Thirdly, product systems are often very complex and interlinked. Tools for the description of such complex systems exist, but for a design and development engineer, there is a missing link to the level of his needs for detailing his product.

While all this may make this ISO/TR less relevant for an EFV definition it explains that the integration of environmental aspects in vehicle development is already covered.

3.1.10.4. ISO 22628

The ISO 22628 "Road Vehicles – Recyclability and Recoverability – Calculation method" is describing in detail how the vehicle recyclability and recoverability rate is calculated on a vehicle level. The recyclability rate is the percentage by mass of the new vehicle potentially able to be recycled, reused or both. The recoverability rate is the percentage by mass of the new vehicle potentially able to be recovered, reused or both. Recovery includes recycling, i.e. is a reprocessing of the materials for any purposes as recycling but including also the purpose of generating energy.

3.2. TOOLS FOR A HOLISTIC APPROACH

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

3.2.1. WELL TO WHEEL APPROACHES

3.2.1.1. EU STUDY "WELL-TO-WHEEL ANALYSIS FOR FUTURE AUTOMOTIVE FUELS AND POWERTRAINS IN THE EUROPEAN CONTEXT" BY EUCAR/CONCAVE/JRC [2]

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 power-train options relevant to Europe in 2010 and beyond [2].

Aside from the above mentioned main study (integrated documents) additionally two separate dedicated reports were published: one concerning the well-to-tank concerns and the other dedicated to 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.

- <u>WTT-Report</u>

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 (i.e. subsidies and taxes are not included). Two scenarios are calculated: One in which the alternative fuel was introduced or expanded in 2010-2020 and one "business as usual" reference scenario which assumed that demand was met by the forecast mix of conventional fossil fuels in the considered period.

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. 3.2.1.1-1: 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	↕			
	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

- <u>TTW-Report</u>

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 power-train options were compared. The study was not carried out using real vehicles but rather done on a virtual basis. For this purpose a model vehicle representing a typical European compact 5-seater sedan (similar to a VW Golf model) was considered to be the common passenger vehicle platform for comparison in combination with a number of power-train options (see Tab. 3.2.1.1-2). The required data were calculated by means of computer simulation on the basis of the NEDC. Key to the methodology and in order to obtain a valid comparison between the various power-train/fuel combinations the model vehicle also had to meet a minimum set of performance criteria (e.g. maximum speed, range or acceleration) relevant to European customers, while retaining similar characteristics of comfort, driveability and interior space. Also the appropriate technologies (engine, power-train 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).

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

Tab. 3.2.1.1-2: Automotive fuel and power-train 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

Note: An update of this study is in progress.

- Results of EUCAR/CONCAWE/JCR Study

General observations and general remarks:
- Both fuel production pathway and power-train 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.

- 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/power-train 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.
- The study only addresses the energy use and greenhouse gas emissions, other environmental aspects are not considered. Regulated pollutants have only been considered in so far as all plants and vehicles are deemed to meet all current and already agreed future regulations.

3.2.1.2. EU-PROJECT: CLEANER DRIVE

The ″Cleaner Drive″-project [12] 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".

Note: The EU-Project "Cleaner drive" could also be considered as an assessment concept and ranking from public authorities (chapter 3.3.1.).

3.2.1.3. BELGIAN ECOSCORE

In 2004 the "Cleaner Drive" rating concept was compared with another similar rating method called "Ecoscore" [13, 43]. 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. The weighting factors are now suited for a mix of urban and extra urban environment, where the first version of Ecoscore was targeted more towards an exclusively urban environment (e.g. the damage to buildings was excluded in the update). Some pollutants were removed (e.g. aromatic compounds), and the update uses external costs (ExternE) to express the impact on air quality.

An overview of the current Ecoscore methodology is shown below.

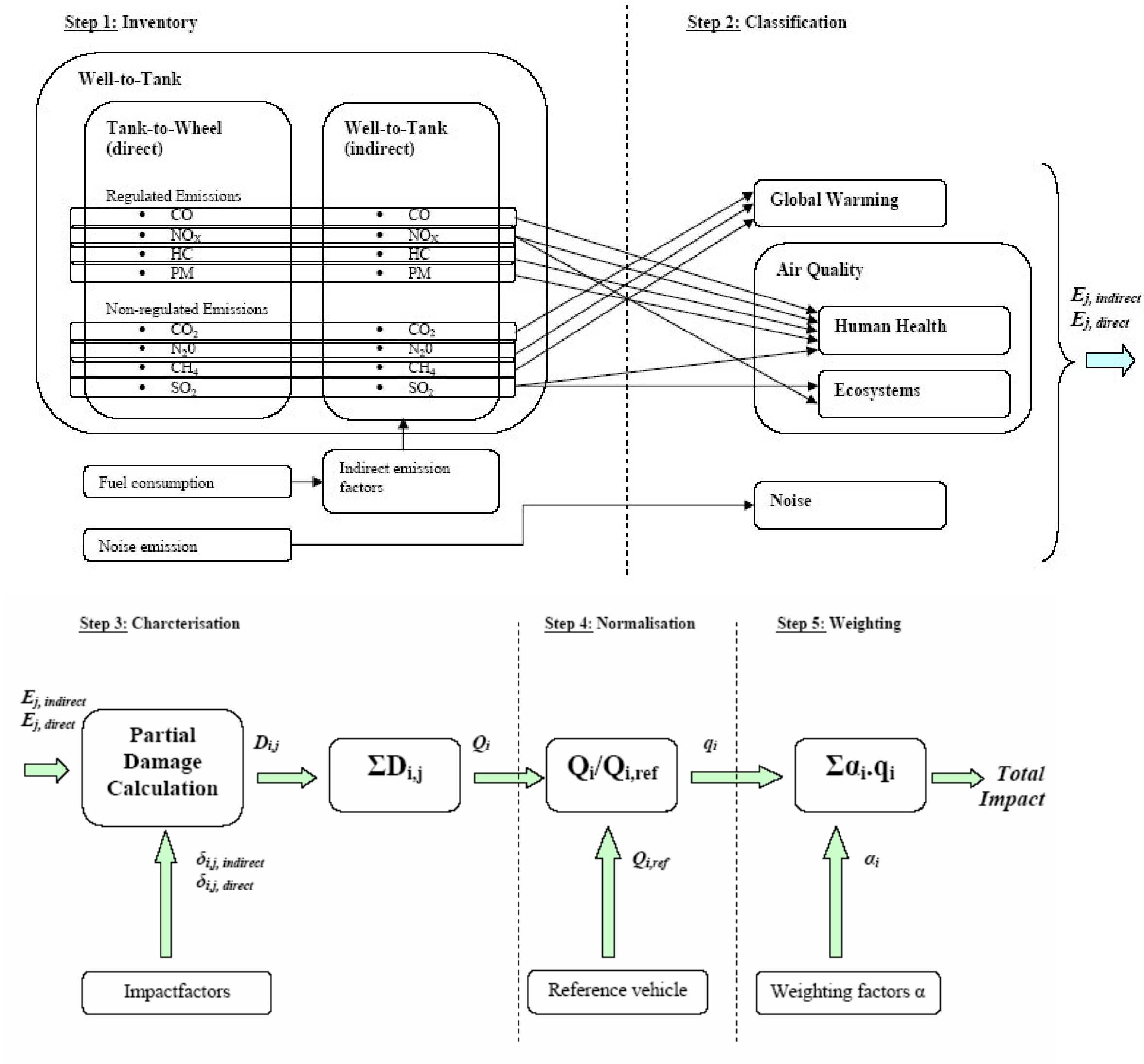


Fig. 3.2.1.3-1: Ecoscore Methodology Overview [13].

For communication purposes towards a broad public, it is important to use a score that is easy to understand. That's why the total impact (TI) is transformed into a score ranging from 0 to 100, 0 representing an infinitely polluting vehicle and 100 indicating an emission free and silent (40dB(A)) vehicle. The reference vehicle corresponds to an Ecoscore of 70. The transformation is based on an exponential function (see figure 3.2.1.3-1), so it can not deliver negative scores.

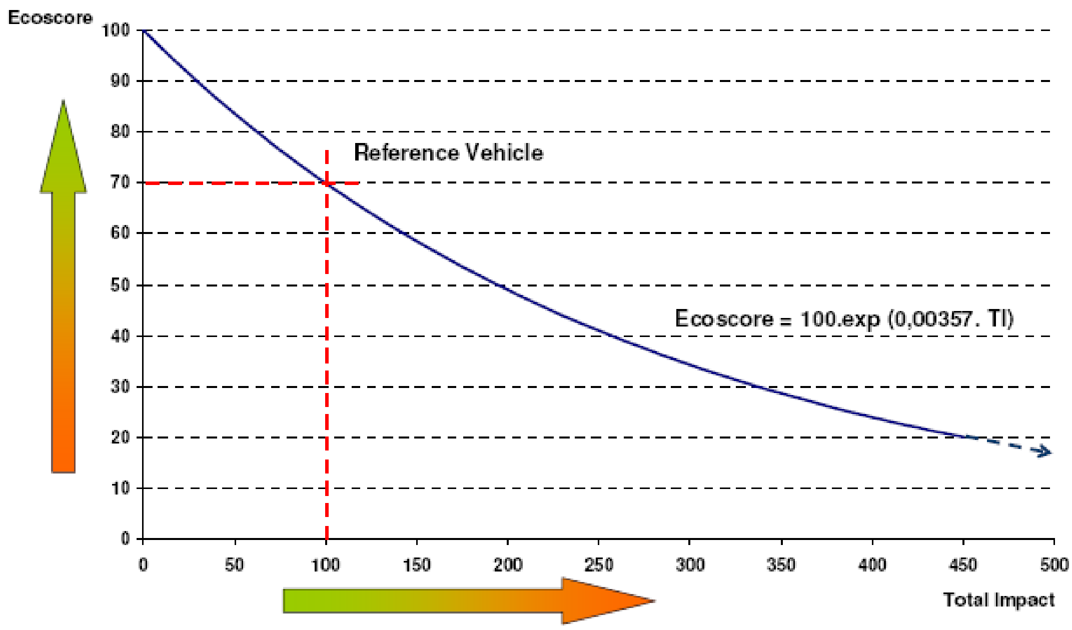


Fig. 3.2.1.3-2: Transformation of the Total Impact to Ecoscore [13].

Ecoscore is used in the three Belgian regions (Walloon Region, Flemish region and Brussels Capital region). For information purposes a bilingual website (Dutch/French) is developed: www.ecoscore.be. This website gives rankings, the ecoscore of all passenger cars and allows you to calculate the ecoscore of your car based on the emissions from the coc (certificate of conformity) of your car. Ecoscore is also used in the Flemish Region for purchasing reasons, as well as cars purchased by the Flemish region as cars purchased by municipalities. Also the federal government and the Brussels region plan to used ecoscore as purchasing tool. The Flemish region is also planning to reform registration tax and annual vehicle tax based on the ecoscore of the car.

Note: The Belgian Ecoscore could also be considered as an assessment concept and ranking from public authorities (chapter 3.3.1.).

3.2.1.4. CONCEPT FOR AN ENVIRONMENTALLY FRIENDLY VEHICLE (EFV) FROM TNO [BASED ON EFV-02-05] [14]

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. The TNO concept proposes a separation into a part related to the fuel side and a part related to the vehicle side. For the fuel side, the fuel production or fuel type are considered by means of CO_2 emissions or carbon content from well to wheel, per unit of energy at the tank. For the vehicle side, the main attribute is the energy efficiency of the vehicle.

In order to evaluate EFVs, the two key aspects energy efficiency (EE) and CO_2 emissions need to be combined. However, it would help to clear responsibilities (and therefore facilitate implementation) if it would be possible to separate fuel characteristics form vehicle characteristics. This concept is visualised in the following graph:

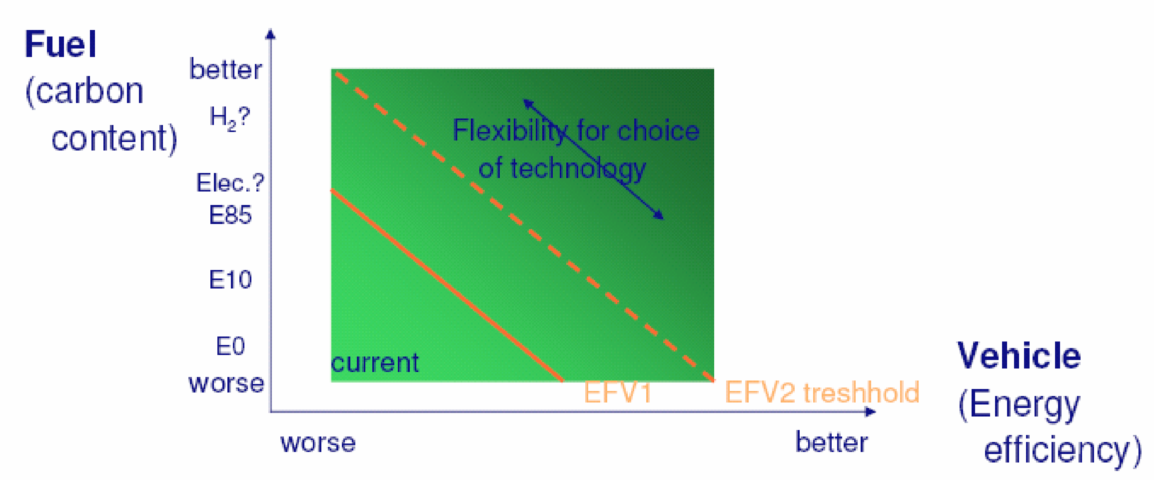


Fig.: 3.2.1.4-1: Visualisation of an EFV concept with separation of vehicle and fuel characteristics.

For the concept of the EFV, the following choices are proposed:

- focus on passenger cars first
- pollutant emissions need a minimum standard (e.g. euro 6, but could depend on region)
- Focus on well-to-wheel CO_2 emissions and energy efficiency
- A EFV criteria should be technology neutral

How to evaluate vehicles as EFV, needs to be considered in more detail; possible ways include:

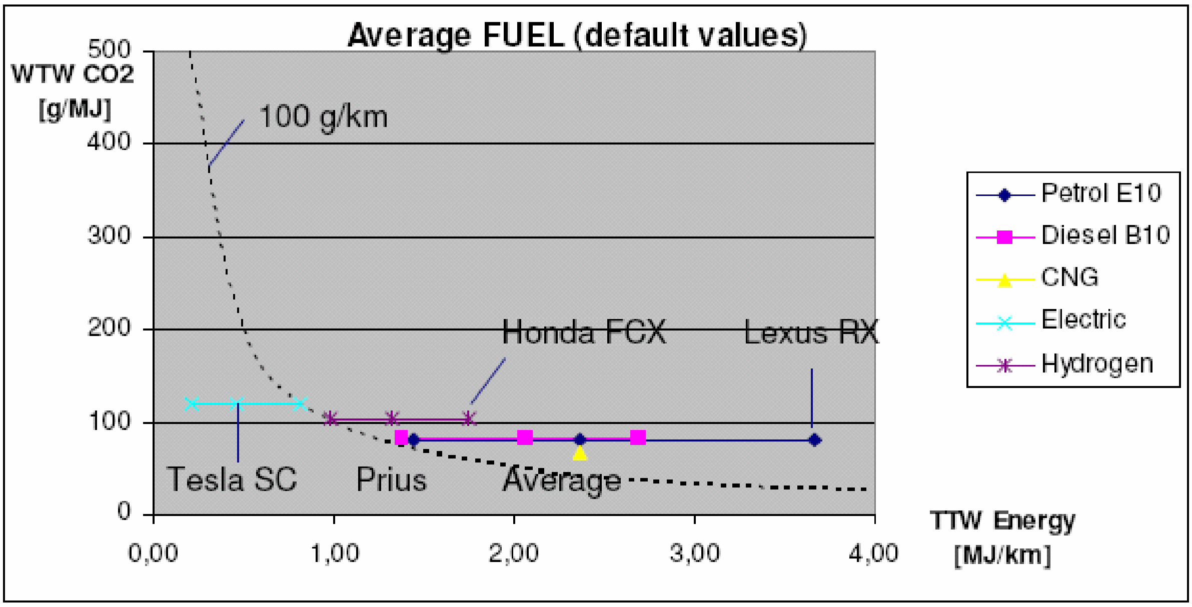


Fig.: 3.2.1.4-2: WTW CO_2 emissions versus TTW energy efficiency, but it has the disadvantage that WTT energy efficiency is not included.

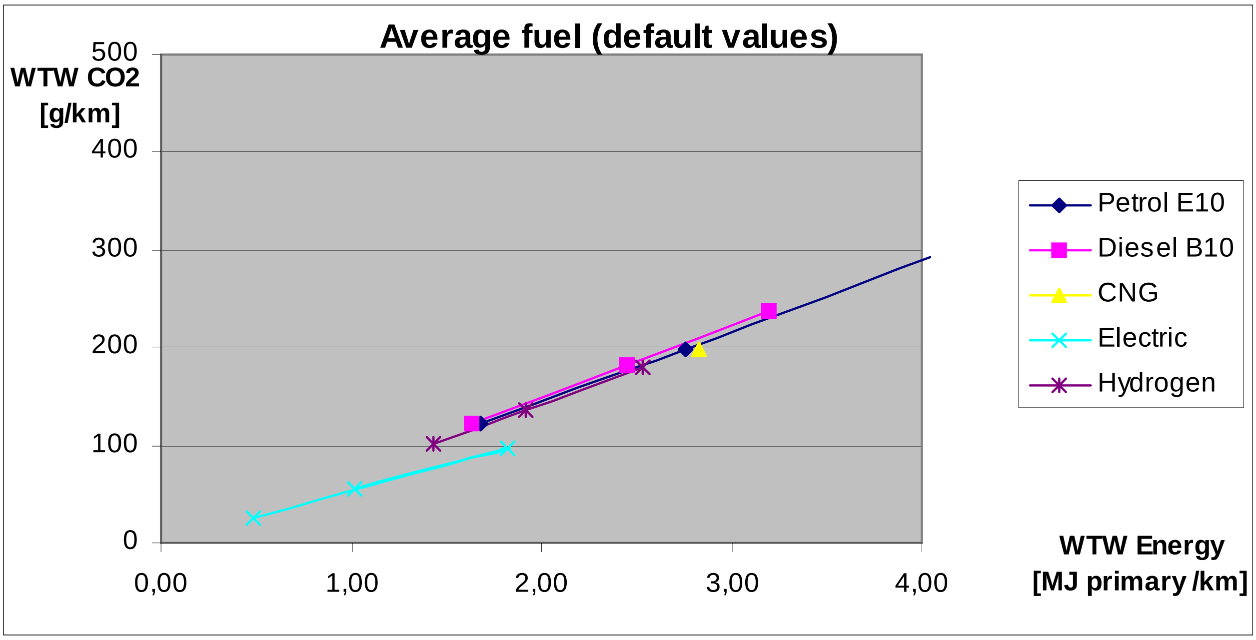


Fig.: 3.2.1.4-3: WTW CO_2 emissions versus WTW energy efficiency, but the disadvantage is horizontal axis is not independent (of the fuel characteristics).

3.2.1.5. IEA STUDIES ON IMPROVING VEHICLE FUEL EFFICIENCY

Well to Wheel approaches could play a very important role in defining EFVs. At the same time, Tank to Wheel analysis could be considered as a key element of the Well to Wheel approached when reduction of fuel consumption is concerned. Therefore, Tank to Wheel analysis should also attract attentions. The International Energy Agency (IEA) has conducted several studies on improving Tank to Wheel fuel efficiency to increase energy security. Following sub-chapters describe two IEA studies on policies: the one for vehicle fuel efficiency and the one for efficiency of non-engine components.

3.2.1.5.1. IEA STUDY ON REVIEW OF INTERNATIONAL POLICIES FOR VEHICLE FUEL EFFICIENCY [39]

This study has examined fuel efficient vehicles from the points of view of fuel saving potentials, current and past policies and measures, and their effectiveness of realizing these potentials. Existing technologies have huge opportunity to improve fuel efficiency. However, these technologies are not always applied in a way that takes advantage of their energy efficiency capabilities.

Various policies and measures to improve vehicle fuel efficiency have been used in most major countries. Some existing policies and measures were more effective than others because of their binding power, standard design, standard stringency and standard related policies. A review of the history and current status of those policies and measures leads to a number of conclusions regarding effective strategies for increasing the fuel efficiency of motor vehicles.

Voluntary vs. Regulatory Measures

While both voluntary and regulatory measures have been widely introduced to improve vehicle fuel efficiency, the results have been mixed. On the one hand, voluntary programs have generally fallen short of their targets. On the other hand, mandatory programs produced decent results, although their effectiveness seems to depend on the ways in which the policies were designed. In most cases, mandatory targets achieved their goals, although in one case, overall fleet average fuel efficiency deteriorated partly because of perverse effects in the standard design.

As a result of the general ineffectiveness of voluntary programs to constrain vehicle energy efficiency, there is a general trend away from them. Japan switched from a voluntary program to a regulatory one in 1999 as did Korea in 2005. In December 2008, the European Union adopted the regulation for reduction of CO_2 emission from light-duty vehicles which is mandatory scheme and will entry into force as from 2012. Canada is also considering such a change.

Regulatory measures could have played a role in deterring the ever-increasing trend of fleet average vehicle weight that can be seen worldwide. In some cases, a regulatory measure prompted manufacturers to apply innovative technologies to vehicles to make them more efficient rather than bigger and more powerful, and thus heavier.

Attributes of an Effective Standard

The saying, "The devil hides in the details", applies to designing an effective standard. Several key attributes of effective standards are outlined below.

Scope

Both the range of vehicles to which a standard applies in a vehicle category, such as the passenger car category, and the coverage of vehicle categories are closely related to the effectiveness of the standard. In general, standards with a broader scope (e.g. covering a greater range of vehicle types) tend to lead to greater fuel savings. However, broadening the scope of a standard may increase the administrative cost of testing vehicles. Some manufacturers – especially those of light duty vehicles – can reduce such costs by producing large amounts of the same type of vehicles. Others (e.g. some small-volume truck manufacturers) need to find ways to decrease the costs of the testing, by utilizing new methods, such as computer simulation, for example.

With the exception of Japan, standards for heavy duty vehicles have not yet been introduced. Based on the Japanese experience, it appears that such standards could result in fuel savings world wide although some further in-depth analysis is needed to confirm this.

Testing procedures

What makes a good testing procedure? Consumers expect the tested fuel efficiency values to be similar to the fuel efficiency values they experience on road. In order to move in that direction, test procedures should reflect as many factors affecting the value of the fuel efficiency as possible. These requirements must be balanced against the increased cost of testing.

Fuel efficiency values are generally tested with the same or similar test procedures used to test local pollutant emissions of vehicles. This is done in part because it is an effective way to reduce the cost of testing and because some technologies for improving fuel efficiency can adversely affect the amount of local pollutant emissions.

There have also been some efforts to harmonize at least some aspects of testing procedures. This would be another effective way of reducing costs although it would be very difficult to achieve, especially in the short term. Eventually there could be large benefits from an internationally harmonized test procedure, allowing countries around the world to use similar libelling systems and adopt similar regulatory systems (or at least systems based on similar measurements).

Technology neutrality

Fuel efficiency standards are usually set to require the same level of efficiency regardless of the technologies that vehicles adopt. There are, however, cases where requirements are established on the basis of the technology used. In general, setting requirements that favour one kind of energy efficiency technology over another will distort technology development.

Regulatory flexibility

Regulatory policies can suffer from being inflexible. Existing regulatory measures generally try to use a range of mechanisms such as manufacturer fleet averaging, attribute based targets, weighted average criteria and credit trading systems to increase policy flexibility. In general, high degrees of regulatory flexibility allow more stringent targets to be met at lower cost (compared to less flexible approaches). Lead time would also be an important factor for lowering the cost.

Attribute based standards can offer the possibility that standards can get much closer to economic efficiency and may be more likely to ensure greater fairness among all automakers. Although they would not necessarily ensure the achievement of an overall improvement for vehicle fuel efficiency (as such standards are subject to weight or size shifts), a standard design in which relatively stringent requirements are imposed on heavier and bigger vehicles could solve at least part of this concern.

Flexible measures can bring some regulatory costs. In order to properly implement a credit trading system, for example, credits must be tracked and all related data such as registration data should be available within a short period of time.

Standard Stringency

The effectiveness of a vehicle fuel efficiency standard also varies depending on the stringency of the standard.

There are several approaches to setting the level of stringency of a policy. The approach that guides part of the European Commission and NHTSA's policy is to set the level of ambition at the point where the increased retail cost of the vehicle is offset by savings from reduced fuel consumption. This cost effectiveness analysis depends largely on expectations of existing and emerging technologies (cost and effectiveness), and financial considerations such as discount rates and payback period. An alternative approach is the Japanese Top-Runner programme, in which stringency is based on the performance of the best in each weight class on the market. Under this program, the value of the mass produced vehicle with the highest fuel efficiency is used as a base value and factors such as fuel saving potential of future technologies are taken into consideration afterward.

Given that vehicle manufacturers are global entities and fuel efficiency technologies spread around the globe rapidly, governments could also look to the situation in other countries and regions for additional guidance. Although detailed country-by-country analysis is crucial and direct comparison of standard stringency would be a considerable challenge in light of different test procedures and other factors, governments could nonetheless refer to fuel efficiency improvement rates achieved and targeted in other countries or regions as a starting point.

Standard-related policies

Finally, the outcome of vehicle fuel efficiency standards may also vary depending on the existence of standard-related policies aimed at stimulating demand for fuel efficient vehicles. Such policies would push manufacturers to produce vehicles that meet standards well before they are required and could act as a disincentive to manufacturers to produce less fuel efficient vehicles than standards.

Labelling

Governments have been asking manufacturers to introduce labelling schemes with the hope that they will lead to fuel savings and various labelling schemes have been introduced, though in isolation these appear unlikely to lead to significant fuel efficiency improvements. However, fuel efficiency labels do help consumers compare vehicle choices, and might particularly influence choices between otherwise similar vehicles that have different fuel efficiency ratings.

Financial incentives

Differentiated financial incentives based on tested fuel efficiency or CO_2 emissions would be effective tools to stimulate demand for fuel efficient vehicles, particularly when coupled with good labelling programs. It can provide additional stimulus to producers and consumers to go beyond simply the attainment of designated targets. Such incentives could take the form of a tax deduction based on the fuel efficient performance, a fee for less fuel efficient cards or a "feebate" which is a combination of rebates for fuel efficient cars and the fees. Given the fact that some technologies for improving fuel efficiency have a negative impact on local pollutant emissions, performance in reducing local pollutant emissions could also be taken into consideration when certifying vehicles for financial incentives.

3.2.1.5.2. IEA STUDY ON FUEL EFFICIENT ROAD VEHICLE NON-ENGINE COMPONENTS [40]

There are significant energy savings potentials in the transport sector. Achieving such savings requires urgent policy attention. Implementation of appropriate mandatory fuel efficiency standards for cars and small trucks (light-duty vehicles) in all countries is a necessary condition for achieving the significant energy savings in this sector. However, additional measures are also needed to realize the savings.

Roughly 20 percent of a motor vehicle's fuel is used to overcome rolling resistance of tyres. Additionally nearly 10 percent fuel is consumed for the other accessories including those for cooling and lighting addressed in this paper. The automobile components, therefore, have high potential for reduction of fuel consumption and CO_2 emissions. There is now consensus that aggressive policies for promoting the deployment of fuel efficient tyres and proper tyre maintenance, while maintaining safety and so forth, can achieve as much as a 5% reduction in overall vehicle fuel consumption. Fuel efficiency policies for cooling cars and vehicle lighting combined could be as effective as the policies for tyres. The following chart sums up the potentials calculated in the earlier chapter of this study for each type of components.

Tab. 3.2.1.5.2-1: Potential energy savings and CO_2 emission reductions of non-engine components

	Tyres	Cooling	Lighting
Vehicles addressed	All road vehicles	Passenger cars only	All road vehicles
Consumption in 2004 (Mtoe)	300	50	48
Potential energy savings by 2030 (Mtoe)	70-120	38	45
Potential CO_2 emissions reductions by 2030 ($MtCO_2$)	190-320	100	120

Total possible energy savings for the three addressed components reach 153 to 203 Mtoe, which corresponds to a reduction of CO_2 emissions of 410 to 540 MtCO2. That is about 6 to 8% of the road vehicle energy use and greenhouse gases emissions in 2030. The issue of raising energy efficiency of these components, however, often tends to receive low priority in consumer information programmes. This is partly because government responsibility for the components is often widely dispersed among ministries of transportation, industry, and environment.

The IEA thought specific, high-level actions were justified and recommended an action on fuel efficient tyres to G8 leaders in 2006. This recommendation was based on international best practice and consisted of two elements: maximum allowable levels of rolling resistance for major categories of tyres; and measures to promote proper inflation levels of tyres. The St Petersburg G8 communiqué reiterated that the issue should be investigated further.

Automobile industry and automobile component industry are global industries. Therefore, experts have reached a consensus that international perspectives including international test procedures are necessary, at least for effective deployment of fuel efficient tyres and cooling systems. Following this, many activities on international test procedures such as those for maximum level of tyre rolling resistance, and international regulations such as those for compulsory fitting of tyre pressure monitoring devices can be expected at international fora including the International Standard Organization and UNECE/WP29.

Given the above mentioned facts, the IEA recommends that governments should consider adopting new international test procedures for measuring the rolling resistance of tyres to set maximum rolling resistance limits and for road-vehicle tyre labelling. In addition, all governments, in cooperation with international organisations including UNECE/WP29, should consider making the fitting of tyre-pressure monitoring systems on new road vehicles mandatory.

3.2.2. LIFE CYCLE ASSESSMENT (LCA)

3.2.2.1. GREET MODEL (DOE USA) [15]

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.

For purposes of complying with the California Low Carbon Fuel Standard regulation, a regulated party must choose one of the methods (Method 1 or Method 2) for determining its fuel’s carbon intensity value. Method 1 uses the California-modified GREET model (version 1.8b).

3.2.2.2. ACEEE’s GREEN BOOK (US) [16]

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 [17] and [18] are worth mentioning.

3.2.2.3. LIRECAR PROJECT [1]

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) [19]. 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).

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. 3.2.2.3-1), 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).

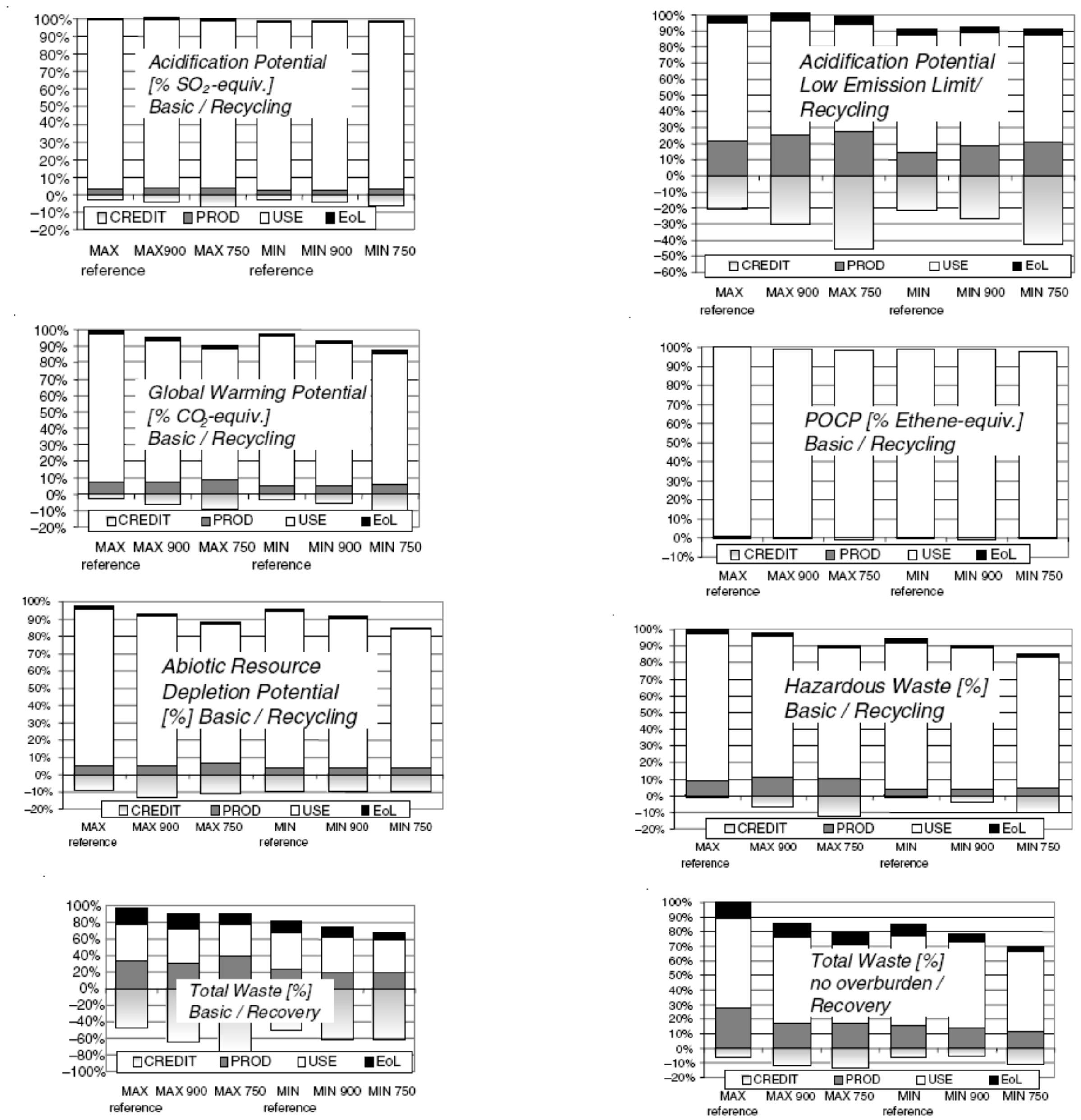


Fig. 3.2.2.3-1: Shares of different life cycle stages looking at different scenarios (8 examples for scenarios detailed in (Schmidt et al 2004)– other sensitivity results may show different results; minimum or maximum values for different LCIA parameters are not necessarily referring to the same vehicle 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. 3.2.2.3-1 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. 3.2.2.3-1: Significant differences between the scenarios applying the criterion 'No overlap'

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. 3.2.2.3-2: Significant differences between the scenarios applying the criterion 'No overlap and difference larger than the material range'

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

3.2.2.4. EXAMPLES OF LCA CONCEPTS FROM VEHICLE MANUFACTURERS

The methodological details in applying the life cycle concept are not fully aligned between the vehicle manufacturer reflecting different vehicle segments, approaches, target groups etc. Comparability is only given within one study. LCA's for passenger vehicles require several simplifications and data estimates. The complex information may lead to confusion and misleading conclusions by customers and regulators. Aggregation of LCA results to a single-score is not allowed according to ISO14040 (no scientific basis for single-score/biased weighting).

➢ **Mercedes** [20]

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:

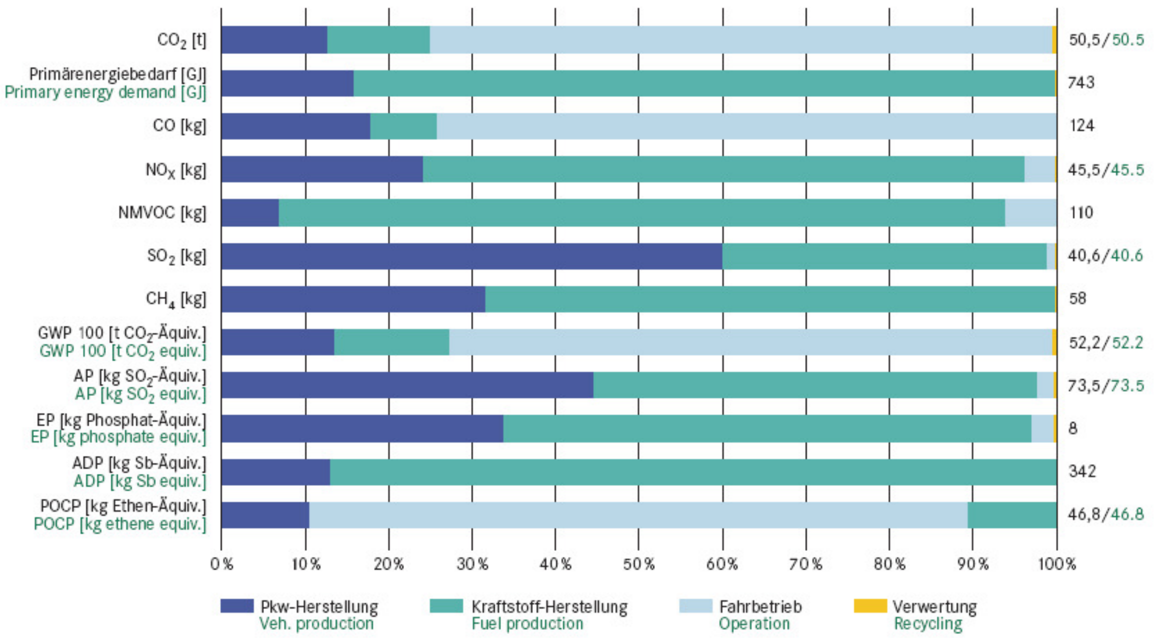


Fig. 3.2.2.4-1: Selected parameters from Mercedes LCA.

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** [21]

VW also uses life cycle assessments in accordance with ISO 14040/44 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.

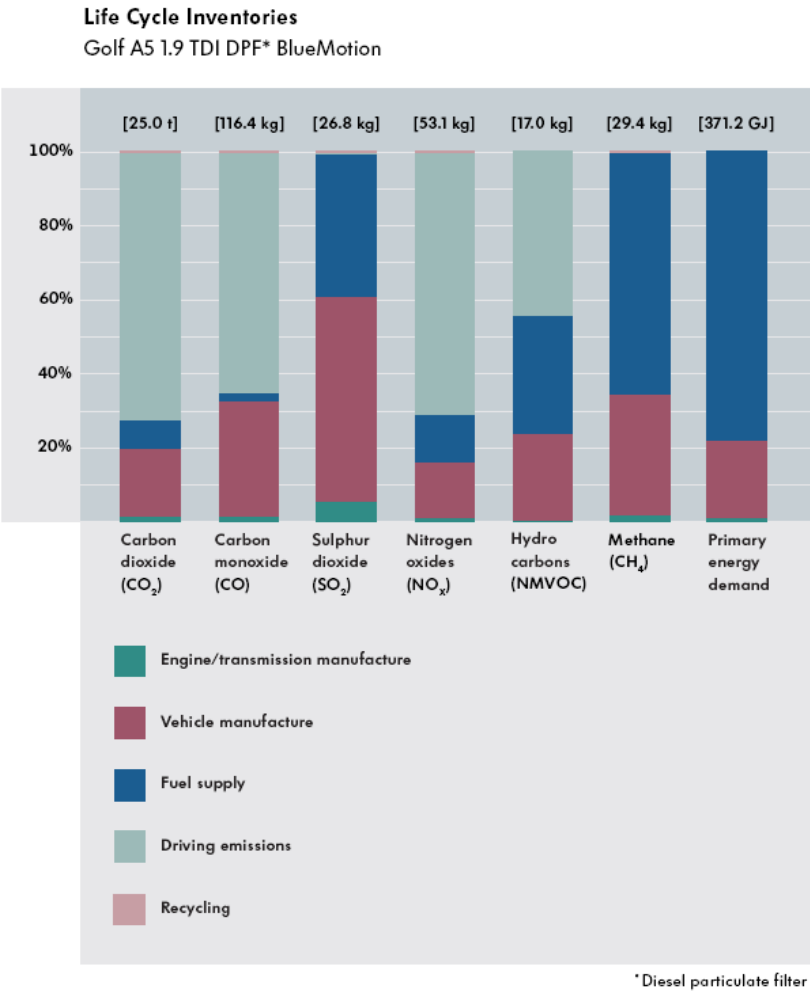


Fig. 3.2.2.4-2: Life Cycle Inventories VW.

Furthermore a Life 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).

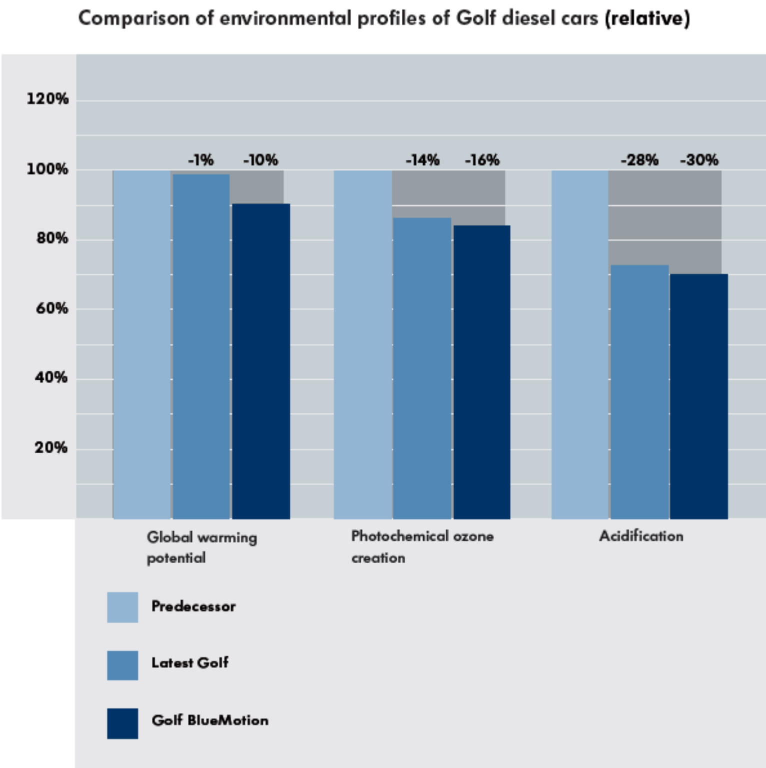


Fig. 3.2.2.4-3: Comparison of environmental profiles of golf diesel cars (relative).

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** [22]

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:

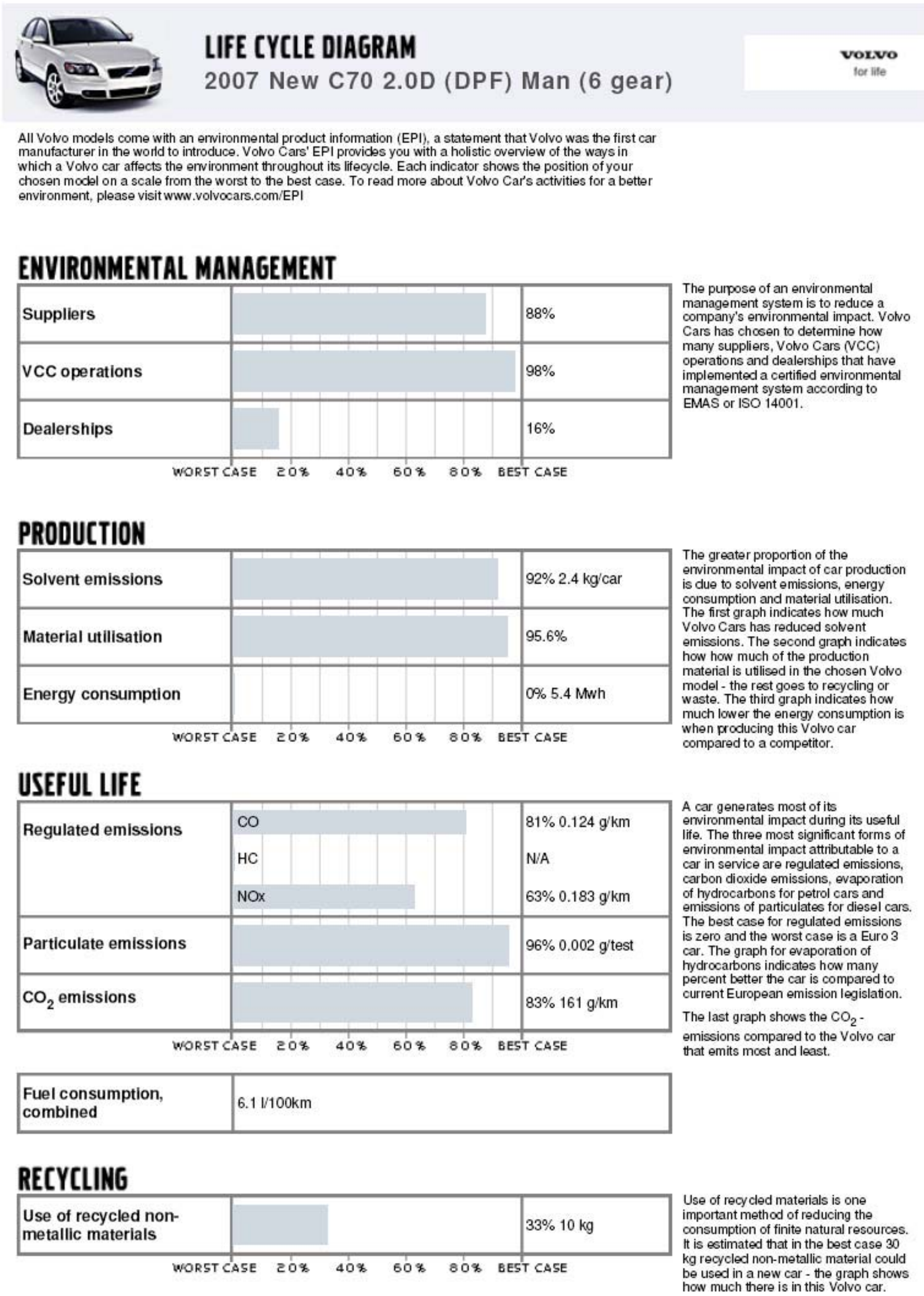


Fig. 3.2.2.4-4: Life Cycle Diagram Volvo.

➢ **Ford of Europe's Product Sustainability Index** [23]

Ford uses Life Cycle Assessment (LCA) certified against ISO 14040 series to compare a vehicle with its predecessor respectively the industry performance along the vehicle and fuel life cycle.

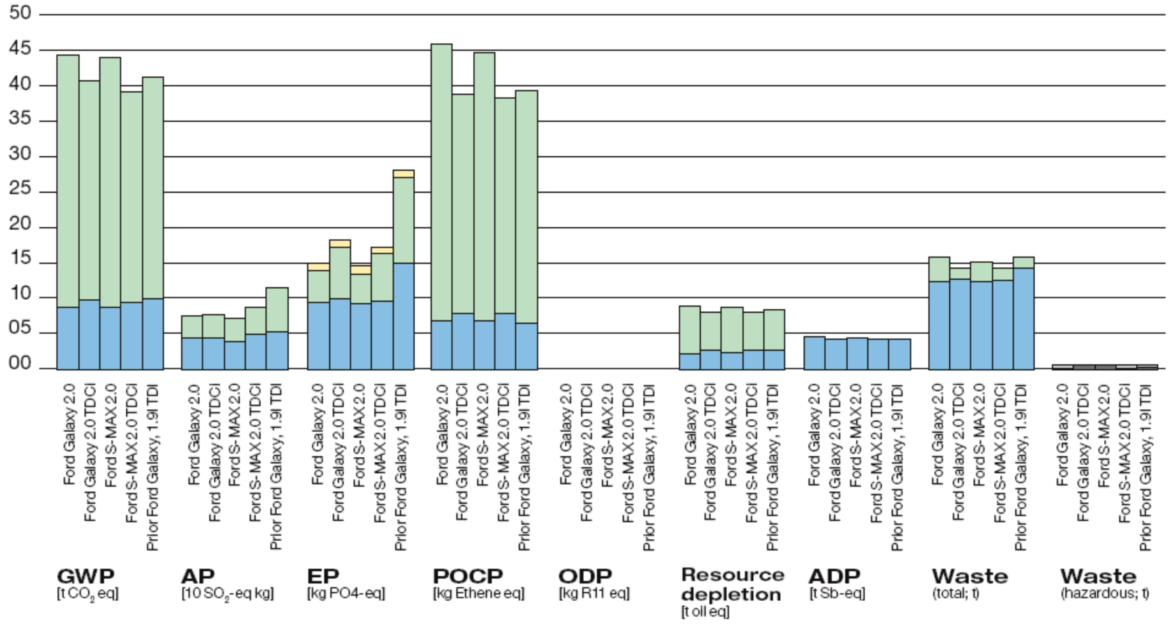


Fig. 3.2.2.4-5: Comparison of environmental profiles of Ford Galaxy (current vs predecessor), and Ford S-MAX.

In spite of its complexity LCA is not comprehensive enough. Therefore, Ford broadens the LCA assessment to a "Product Sustainability Index" by adding other environmental aspects and putting them into perspective looking also at societal and life cycle cost items (Fig. 3.2.2.4-6). The methodology might be further developed and is completed by indicators for other company areas (e.g. manufacturing etc.).

	Indicator	Metric / Method	Driver for Inclusion
Environ-mental and health	Life Cycle Global Warming	Greenhouse emissions along the life cycle (CO_2 and equivalent emissions from raw material extraction through production, use to recovery) – part of an LCA according to ISO 14040	Carbon intensity is the main strategic issue in automotive industry
	Life Cycle Air Quality	Emissions related to Summer Smog along the life cycle (Ethene and equivalent emissions) – part of an LCA according to ISO 14040	Potential trade-offs between CO_2 and non-CO_2 emissions
	Sustainable Materials	Recycled and natural materials related to all polymers[1]	Resource Scarcity
	Substance Management	Vehicle Interior Air Quality (VIAQ) / allergy-tested interior, management of substances along the supply chain	Substance risk management is key
	Drive-by-Noise	Drive-by-Exterior Noise = dB(A)	Main societal concern
Societal[2]	Safety	Including EuroNCAP stars (including occupant and pedestrian protection)	Main direct impact
	Mobility Capability	Mobility capacity (seats, luggage) to vehicle size	Crowded cities (future issues include: diversity – disabled drivers, etc.)
Economics	Life Cycle Cost	Sum of vehicle price and 3 years service (fuel cost, maintenance cost, taxation) minus residual value (note: for simplification reasons cost have been tracked for one selected market; Life Cycle Costing approach using discounting)	Customer focus, competitiveness

[1] Note: There are, of course, no materials that are inherently sustainable. All materials are linked to environmental, social and economic impacts. However, recycled materials and renewably grown, natural fibers represent an example of how limited resources can be used in a more sustainable way. The overriding factor is whether or not these materials have, in their specific application, a lower environmental impact through the product life cycle than potential alternative materials (see life cycle related PSI indicators and previous paper [24]).
[2] Note: The social aspects are being refined and developed for the future. Please note that aspects related to labor, rights etc. are part of other Ford of Europe sustainability management tools such as the MSI.

Fig. 3.2.2.4-6: Indicators of the Ford Product Sustainability Index.

➢ Hyundai-Motor

Hyundai Motors Company evaluates environmental aspects to compare brand new vehicles with previous model by using Life Cycle Assessment. These are based on ISO 14040 series and are covering the following areas. The Hyundai Motors Company LCA process has been certified by TÜV Nord.

- Vehicle Production
- Fuel Production
- Driving (12 years/150,000km)
- Maintenance
- End of Life Vehicle

This is the LCA result of Hyundai i20 model. It includes life cycle inventories and impact assessments.

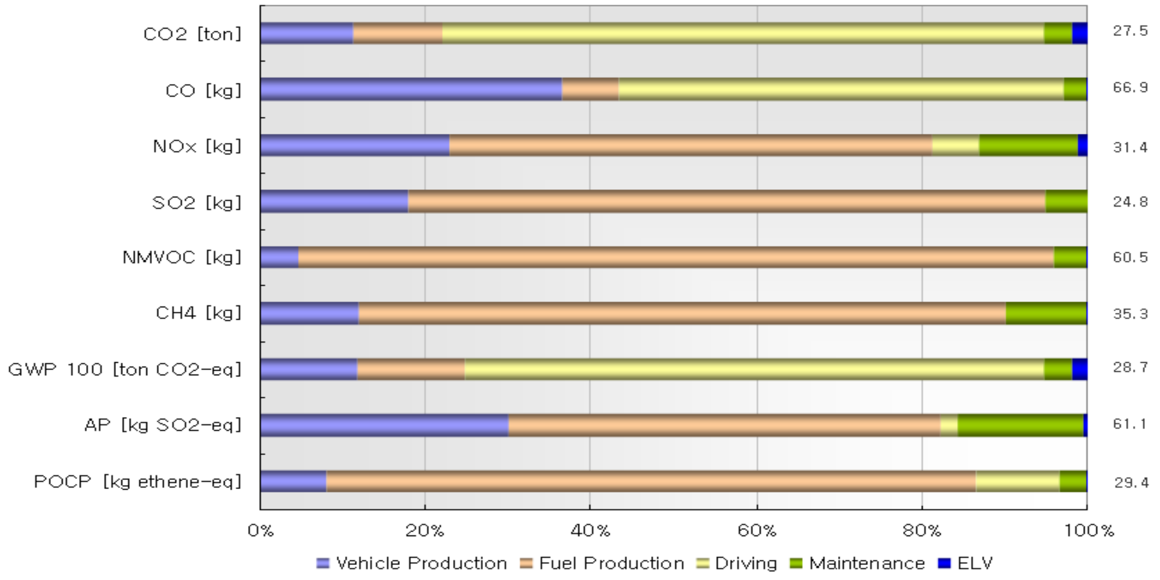


Fig. 3.2.2.4-7: LCA Result of i20

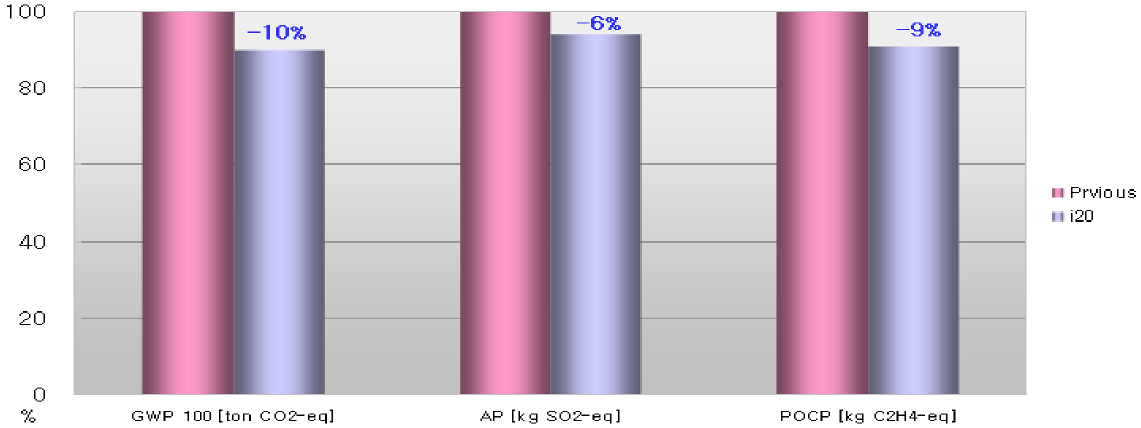


Fig. 3.2.2.4-8: Comparison of LCA results

3.3. ASSESSMENT CONCEPTS

It has to be taken into consideration that the findings within the literature review carried out 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 these findings.

3.3.1. CONCEPTS AND RANKINGS FROM PUBLIC AUTHORITIES

This chapter includes some examples. Further concepts and programs based on governmental initiatives in order to provide the users with relevant information benefits. This was not examined within a greater extent within this study until now.

3.3.1.1. ENVIRONMENTAL PERFORMANCE LABEL FROM CARB

In California all new cars beginning with the 2009 model year are required to display an ″Environmental Performance″ label (EP label) [24], 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.

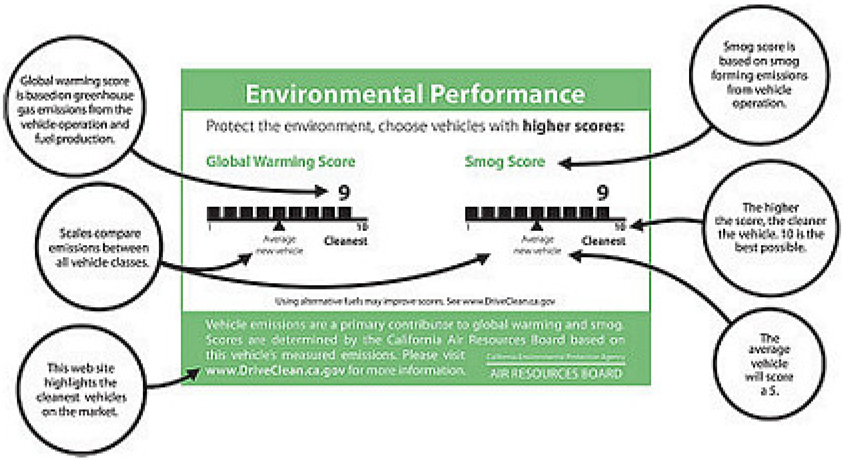


Fig. 3.3.1.1-1: Environmental Performance.

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. 3.3.1.1-1: Global warming score and 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

Tab. 3.3.1.1-2: 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.

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 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.

3.3.1.2. GREEN VEHICLE GUIDE FROM THE AUSTRALIAN GOVERNMENT

The Green Vehicle Guide [25] 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 CO_2 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. 3.3.1.2-1: 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. 3.3.1.2-2: 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 (0–10 Best)	Electric	All	All	-	-	-	-	-
8.5 (0–10 Best)	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 (0–10 Best)	Petrol, LPG, NG	Passenger Goods carrying (RM ≤ 1305)	ADR79/02	*Euro 4* certification	*Euro 4*	0.10	0.08	-
6 (0–10 Best)	Petrol, LPG, NG	Goods carrying (1305 < RM ≤ 1760)	ADR79/02	*Euro 4* certification	*Euro 4*	0.13	0.10	-
5.5 (0–10 Best)	Petrol, LPG, NG	Goods carrying (RM > 1760)	ADR79/02	*Euro 4* certification	*Euro 4*	0.16	0.11	-
5 (0–10 Best)	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 (0–10 Best)	Petrol	Goods carrying (1305 < RM ≤ 1760)	ADR79/01	-	*Euro 3*	0.25	0.18	-
4 (0–10 Best)	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 (0–10 Best)	Diesel	Goods carrying (RM > 1760)	ADR79/01	-	*Euro 4*	HC + NOx ≤ 0.46	0.39	0.06
2.5 (0–10 Best)	Diesel	Passenger Goods carrying (RM ≤ 1305)	ADR79/00	*Euro 3* certification	*Euro 3*	HC + NOx ≤ 0.56	0.50	0.05
2 (0–10 Best)	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 (0–10 Best)	Diesel	Goods carrying (RM > 1760)	ADR79/00	*Euro 3* certification	*Euro 3*	HC + NOx ≤ 0.86	0.78	0.10
1 (0–10 Best)	Diesel	Goods carrying (1250 < RM ≤ 1700)	ADR79/00	-	*Euro 2*	HC + NOx ≤ 1.00		0.12
0.5 (0–10 Best)	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. 3.3.1.2-1: Overall star rating.

3.3.1.3. GREEN VEHICLE GUIDE FROM US EPA

The Environmental Protection Agency (EPA) also publishes a "Green Vehicle Guide" [26, 27]: 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. 3.3.1.3-1: 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.

<u>City</u>:	Represents urban driving, in which a vehicle is started with the engine cold and driven in stop-and-go rush hour traffic.
<u>Highway</u>:	Represents a mixture of rural and interstate highway driving with a warmed-up engine, typical of longer trips in free-flowing traffic.
<u>High Speed</u>:	Represents city and highway driving at higher speeds with more aggressive acceleration and braking.
<u>Air Conditioning</u>:	Account for air conditioning use under hot outside conditions (95°F sun load).
<u>Cold Temperature</u>:	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. 3.3.1.3-2) 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 3.2.2.1. 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. 3.3.1.3-2: 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.

3.3.1.4. ″ECO-CAR″ CONCEPTS FROM SWEDEN

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 [28] is an example for such a scheme building the basis for incentives.

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[3]/100 km
  - 9,7 m3 CNG/100 km
  - 37 kWh electric energy/100 km
- 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.

3.3.1.5. JAPANESE ECO-RANKING SYSTEMS

Promoting the Widespread Use of Fuel-Efficient Vehicles
Auto manufactures in Japan made all-out efforts to achieve early compliance with 2010 fuel efficiency targets in response to consumer demand. Also, the central government introduced tax incentives for the purchase of low-emission and fuel-efficient vehicles, which are designated as such by means of an environmental performance certification system.

Japan´s Green Tax Scheme:

- Reductions on the Automobile Tax (introduced in 2001)
  Reduction on the Automobile Tax are applied to low-emission and fuel-efficient vehicles. (Note: 10 % surcharges on the tax are mandated for diesel vehicles on the road 11 years or longer, and for gasoline vehicles on the road 13 years or longer, since first registration)

- Reductions on the Acquisition Tax (introduced in 1999)
  Financial incentives are applied to the Acquisition Tax for purchasers of low-emission and fuel-efficient vehicles.

[3] 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.

Tab. 3.3.1.5-1: CO_2 Reduction in Global Road Transport [29 (Status August 2008)]

	Emissions Performance	Fuel efficiency	Incentives	
			Automobil Tax	Acquisition Tax
Passenger Cars	Emission down by 75 % from 2005 standards	Compliant + 25 % compared to 2010 standards	50 % reduction	Amount deducted: ¥ 300,000
Passenger Cars	Emission down by 75 % from 2005 standards	Compliant + 15 % compared to 2010 standards	25 % reduction	Amount deducted: ¥ 150,000
Heavy-Duty Vehicles	Compliance with 2009 Standard	Compliant with 2015 standards	–	2 % reduction
Heavy-Duty Vehicles			–	

Promoting Vehicles with Greater Fuel Efficiency and Lower Emissions [29]:

Vehicles with greater fuel efficiency help counter global warming through their reduced emission of CO_2, while vehicles with reduced tailpipe emissions help improve air quality. The Japanese government has established one certification system for gasoline and diesel vehicles as well as heavy-duty trucks and buses with advanced fuel efficiency; another certification system for gasoline and diesel (including heavy-duty) vehicles whose emissions performance is superior to current regulatory levels for carbon monoxide (CO), nitrogen oxides (NO_x), and particulate matter (PM); and a third certification system for trucks and buses that comply either with 2005 emission (including NO_x and PM) standards or with the "long-term" or "new short-term" regulatory standards. To promote widespread public awareness of vehicles with advanced fuel efficiency and/or low emissions, such vehicles are identified with appropriately coded stickers.

For Gasoline and LPG Vehicles

Rating/Performance Level		Vehicle Sticker
Compliant +25% compared to standards	Performing 25% better or more compared to 2010 target fuel efficiency standards	
Compliant +20% compared to standards	Performing 20% better or more compared to 2010 target fuel efficiency standards	
Compliant +15% compared to standards	Performing 15% better or more compared to 2010 target fuel efficiency standards	

For Diesel Vehicles

Rating/Performance Level		Vehicle Sticker
Compliant +25% compared to standards	Performing 25% better or more compared to 2005 fuel efficiency standards	
Compliant +20% compared to standards	Performing 20% better or more compared to 2005 fuel efficiency standards	
Compliant +15% compared to standards	Performing 15% better or more compared to 2005 fuel efficiency standards	

For Trucks and Buses with GVW>3.5 tons

Rating/Performance Level		Vehicle Sticker
Compliant with standards	Meeting 2015 target fuel efficiency standards or better	

Fig. 3.3.1.5-1: Advanced fuel efficiency certification.

Rating/Performance Level		Vehicle Sticker
★★★★	Emissions down by 75% from 2005 standards	
★★★	Emissions down by 50% from 2005 standards	
★	Heavy-duty diesel vehicles with NOx and PM emissions down by 10% from 2005 standards	
☆	Heavy-duty diesel vehicles with NOx emissions down by 10% from 2005 standards	
☆	Heavy-duty diesel vehicles with PM emissions down by 10% from 2005 standards	

Fig. 3.3.1.5-2: Environmental performance certification for vehicles with low emissions.

Rating/Performance Level	Vehicle Sticker
Compliant with 2005 emission standards	
Compliant with other regulatory standards (see above)	

Fig. 3.3.1.5-3: Low NO_x & PM emissions certification for trucks and buses.

3.3.1.6. ENVIRONMENTAL LABEL SWITZERLAND

Development of an environmental rating label for cars [11]

In 2007, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) decided to continue development of the energy rating label for cars, which assesses the energy efficiency of cars according to categories on a scale from A to G. An environmental label is to be developed from the current rating label, which, apart from the classification of cars into efficiency categories, also makes possible differentiation according to ecological and especially air quality criteria. It is planned to introduce the new environmental label on 1 January 2010.

The content of the existing energy label should be transferred to the future environmental label virtually without change, though complemented by additional information on the environmental impact of the vehicle. Included in the environmental rating are two assessments that are independent of one another. The energy efficiency is appraised according to the previous seven categories from A to G. The same number of vehicle models is now to be classified in each category. The energy section will be supplemented by an environmental section in the form of environmental impact points. These environmental impact points will appear on the environmental label in the form of figures and graphically, similar to what is currently the case on the energy label for CO_2 emissions. The environmental impact points derive from the criteria compiled by the Federal Office for the Environment (FOEN) for energy efficient and low-emission vehicles (Kriterien für energieeffiziente und emissionsarme Fahrzeuge (KeeF)). The calculation of environmental impact points includes emissions of NO_X, HC, PM_{10}, CO, CO_2, noise and fuel production.

Along with more comprehensive consumer and fuel consumption information, the future environmental label should also make it possible to take into consideration further environmental aspects in the ecological differentiation of Cantonal motor vehicle taxes and Federal car tax. The Commission for the Environment, Town and Country Planning and Communications of the Council of States UREK-S provided information on the main features of a bonus system in October 2008. With effect from today, car tax should be increased from 4 to 8%. The increased income should be used for the financial promotion of energy-efficient and environmentally-friendly vehicles. With this scheme, vehicles in energy efficiency category A should receive the energy efficiency bonus in full, whereas those in category B should receive 50%. It is also planned that vehicles below a certain number of environmental impact points will receive an environmental bonus. The relevant amendment to the Car Tax Act will be put out to consultation from November 2008.

The environmental label with its additional consumer information and the differences in car tax it supports should result in cars on Swiss roads which in future are more modern and resource-efficient, with less impact on the environment.

3.3.2. ECO RANKING BY CONSUMER ASSOCIATIONS

Most of the screened articles reflect to the purpose consumer information especially those with regard to eco-ratings.

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 suitable 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.

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).

3.3.2.1. ECO-TEST ADAC / FIA

On behalf of FIA the so-called "Eco-Test" [30, 31] 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.

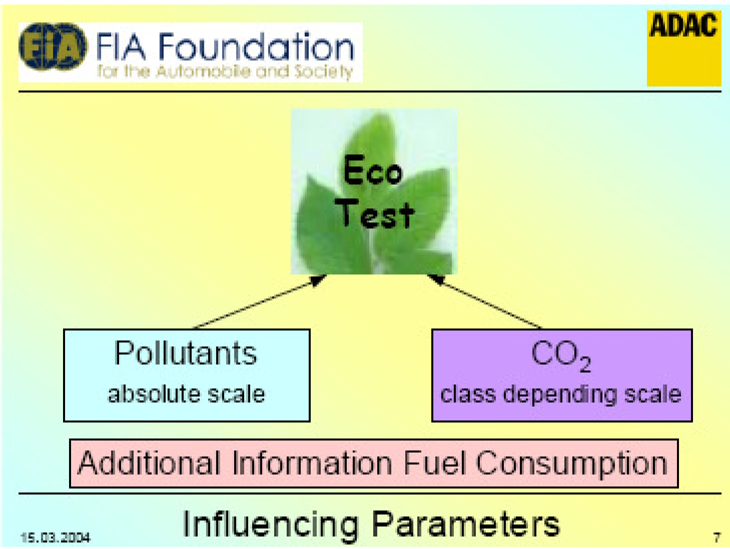


Fig. 3.3.2.1-1: Scheme of "Eco-Test" from the German Automobile Club ADAC.

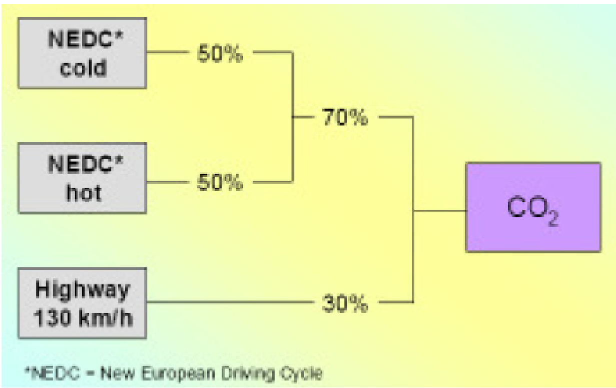
Both categories (limited pollutants on the one side and CO_2-emissions on the other side) contribute with a share of 50 per cent to the overall rating. The Eco-Test awards up to 5 stars, derived from the scores achieved for CO_2 and limited pollutants.

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.

Tab. 3.3.2.1-1: Ranking list ADAC.

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

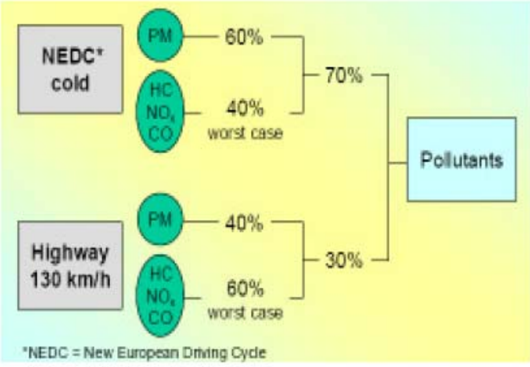
The rating of CO_2 is due to the contribution of the NEDC Cold, NEDC Hot and ADAC Highway results with different weighting factors for the involved cycles and based on seven vehicle classes each with different thresholds.



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. 3.3.2.1-2: 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. 3.3.2.1-3: 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.

3.3.2.2. VCD

Based on an expert's report of IFEU, VCD [32, 33] 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.

Tab. 3.3.2.2-1: German VCD approach.

	Euro 4		Euro 5		Euro 6 *
	Gasoline	Diesel	Gasoline	Diesel	Diesel
Health – NO_x	6,8	0,0	7,6	2,8	6,8
Health – NO_2	9,7	0,0	9,8	2,8	6,8
Health – Particulates	10,0	10,0	10,0	10,0	10,0
total value for Health	9,13	5,0	9,35	6,4	8,4
Environment – NO_x	6,8	0,0	7,6	2,8	6,8
to convert in total points	1,7	0,8	1,8	1,1	1,6

* In limit value stage Euro 6 the values for gasoline passenger cars remain on the level of Euro 5.

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 of vehicle manufacturers.

3.3.2.3. ÖKO-TREND INSTITUTE

Öko-TREND institute [34] 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. 3.3.2.3-1: German Auto-Umwelt-Zertifikat, Öko-Trend approach.

3.3.2.4. J.D. POWER

The J.D. Power Green Efficiency Rating (a 5-star-rating) [35][4] is based on an ″Automotive Environmental Index (AEI)″, which combines information from the Environmental Protection 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.

3.3.2.5. ENVIRONMENTAL TRANSPORT ASSOCIATION (UK)

The Environmental Transport Association (ETA) [36][4] 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.

[4] The sources [35] and [36] 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 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.

3.4. GREEN MANUFACTURING

'Green Manufacturing' in this context can be best described as 'sustainable manufacturing'
Can be viewed as:

1. manufacturing a 'green' = sustainable product – this is than linked to eco-innovation
2. the manufacturing itself should be 'green' = a sustainable plant

In our view, green manufacturing is both: producing a green product in a green plant.

Several stakeholders indicate that the business case for green manufacturing should first be established, the economic framework, base on a number of possible policy instruments, such as:

- norms & standards,
- taxes & charges
- subsidies & incentives
- trading certificates
- education & training
- public & private partnerships (subsidizing capital expenditures)
- voluntary agreements
- technology transfers
- information, advisory services
- eco-labelling, consumer advise
- green public procurement
- corporate reporting
- environmental management system

These instruments could be reflected in a number of indicators.

Indicators for sustainable manufacturing:

- The concept of "sustainable manufacturing" seemed not commonly used by European manufacturers. Some participants considered it to cover only factory/facility-level processes. It was shared that clear mapping of the scope applied for particular measurement is needed when developing sustainable manufacturing indicators.
- The measurement used at factory/facility level can be useful to compare between factories/facilities within the same company but is difficult to apply for external benchmarking due to many factors that influence performance. There was a suggestion that the OECD could provide an indicator set for internal manufacturing process improvement together with a collecting of best practice examples.
- On the other hand, product-based or per-unit (not absolute-level) measurement can be applied for comparison of performance between companies and encourage further improvement and innovation as far as the common benchmark methodology is established (e.g. EU energy level).
- It was shared that LCA is useful for comparing between old and new products within the same company but has to be used correctly for external comparison since its calculation depends on scope and many other factors (e.g. manufacturing processes and use materials). However, participants recognised that more needs and pressures for some performance benchmarking are expected in the near future.
- It was also shared that the measurement should not focus only on CO_2 but also take into account other environmental aspects, such as other emissions, chemical use, waste and energy, with balance.

Eco-innovation for green product manufacturing is also linked to eco-efficiency.
Eco-efficiency of the manufacturing process (material production + assembly).
Energy, GHG emissions, resource efficiency all contribute to eco-efficiency.

There is a need for a broader view on green manufacturing of a green product in a green plant.
One must look at greening the whole value chain.
This is the only way to move to a low carbon society (a vision the UK government wishes to follow).

In a recent EC/OECD industry focus group on sustainable manufacturing and eco-innovation the following comments where made on the role of government and international institutions.

The role of government and the OECD:

- There was a shared concern over the capability of suppliers for delivering sustainable components as the supply chain of automotive manufactures is very complex. The automotive industry is working to fill this gap, for example, by developing a guideline for understanding the EU´s REACH directive. The government should help educate suppliers and improve their capability from the viewpoint of competitiveness. A good example of this kind is the Green Suppliers Network established by the US Environmental Protection Agency.
- Some participants expressed that certain environmental regulations may create unintended consequences or do not encourage investment in new technologies – e.g. the EU´s Emission Trading Scheme (ETS) sets the targets of CO_2 reduction at the absolute level and does not consider different capabilities of companies to make further reduction, while excluding certain industries from the regulation. In other case, there are several regulations that aim the same objective. They argued that there is a need to streamline the existing regulations and to keep the regulations simpler and flexible ("outcome-based") based on consistent long-term visions/targets if the government would like to promote eco-innovation. The OECD could take a role in this area.
- There was a call for harmonising environmental regulations, certifications schemes, planning regimes and their implementation/enforcement between regions and countries as it will reduce the costs for environmental investment for companies operating in different countries. The definitions of same basic terminology should also be harmonised – e.g. "waste" can be used as new input in another company/country and the current definition does not encourage reuse and remanufacturing.
- It was suggested that eco-innovation can spontaneously if it makes economic sense. The government should help companies build up business cases for investing in innovation with a longer payback and capital allowance differentiation for green technologies.
- It was also pointed out that commitment of top management is very critical and there is a need to change their mindsets as they tend to focus too much on risk avoidance. The OECD could set a stage for shifting the course of the global debate – e.g. from CO_2 to resource efficiency.
- The government should show examples by themselves first, for example, by implementing green public procurement more thoroughly. The OECD could start from a mapping of the current policy instruments for promoting eco-innovation and benchmark governmental policies and performance.
- The importance of improving consumer awareness, especially about intangible environmental impact of products and their usage, was also emphasised in terms of facilitating sustainable manufacturing and eco-innovations.
- It was shared that there is a need to investigate the processes by which eco-innovation happens and is successfully marketed more depth so that right levers could be identified.

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

4.1. EXPLANATORY INTRODUCTION

Chapter 3. showed a lot of options to define and evaluate vehicles. However it needs to be assessed whether these approaches can be used for the development of a holistic evaluation concept. This assessment needs to understand the political context concerning the motivation of the potential foreseen target groups and their purpose(s) in evaluating whether a vehicle concept can be called something close to "environmentally-friendly" – Considering also the words of caution provided by ISO 14021 actually prohibiting this terminology in claims it is indispensable to check whether all relevant environmental aspects are considered – or not (see chapter 4.2.1.). Figure 4.1-1 shows the principle course of the creation of a basis for the assessment of the feasibility. This should not be misunderstood as a pure one way serial process, but more as a closed loop.

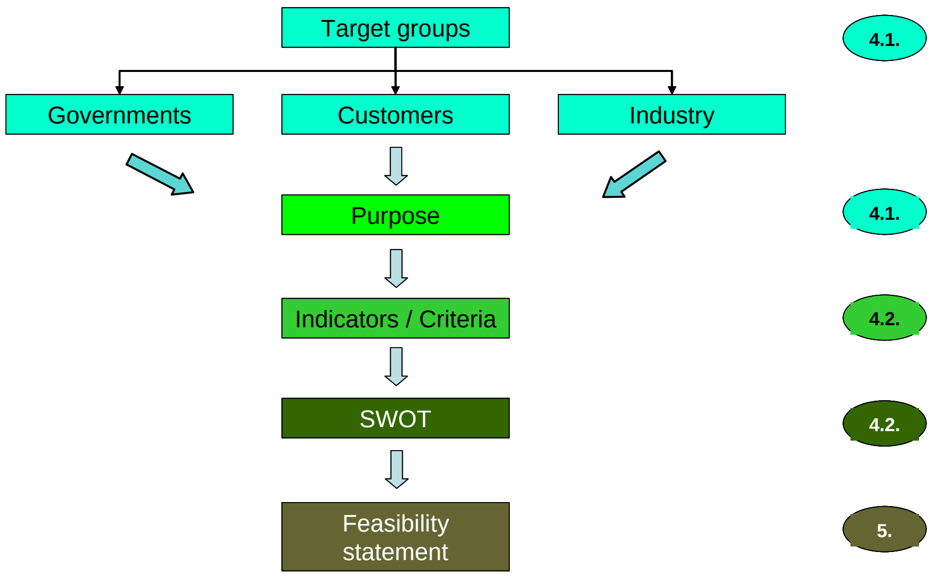


Fig. 4.1-1: Steps of the assessment of the feasibility to introduce an EFV concept.

The target groups are important to assess whether a method is suitable from their perspective. Therefore, chapter 4.4 tries to identify **s**trengths, **w**eaknesses, **o**pportunities and **t**hreats (SWOT) looking from their perspective. These target groups are also defining the purposes why vehicle should be differentiated between "environmentally friendly" ones and those being not "environmentally friendly". The following potential target groups could be identified together with their purposes:

- Local, regional, national or supra-national governmental bodies
  Purpose: - Regulation, fiscal systems
  - Information systems for e.g. public and private procurement
  - green zones, access restriction
  - guidance on strategies
- Customers
  Purpose: - Information systems for purchasing decision
- Automotive industry
  Purpose: - Design specifications

4.2. CRITERIA

- In a first step it will be analysed what environmental aspects (4.2.1.) are covered by the different regulations, concepts and tools provided in chapter 3.
- Additionally the tool evaluation criteria (4.2.2.) will help to describe the dimensions and applicability of regulations, concepts and tools.
- In a second step the SWOT analysis (4.3.) is used for every regulations, concepts and tools to develop a basis for the feasibility assessment.

4.2.1. POSSIBLE ENVIRONMENTAL ASPECTS COVERED

- Air emissions: CO_2
- Air emissions: regulated pollutants
- Air emissions: other GHG
- Other pollutants: water (yes/no)
- Other pollutants (e.g. waste streams): land (yes/no)
- Use of:
  - materials/resources (recycled, renewable, non-renewable)
  - energy resources (e.g. fossil fuels)
  - water
  - land
- Recyclability
- Toxics (health effects)
- Noise
- EMC
- Effects on biodiversity and sustainability

4.2.2. TOOL EVALUATION CRITERIA

- Data (regional / worldwide):
  - Availability of data
  - Quality of data
  - Data is available to whom? Can data be ensured reliable of good quality at world/regional level?
  - Frequency of data updating
  - Comparability worldwide
- System boundaries (to the point, solely):
  - Tailpipe
  - Usage of vehicle; (incl. evap emissions etc.)
    means all inputs (e.g. fuel consumption) and emissions which are caused during the usage of the vehicle (excluding production and disposal). The production of energy for moving the vehicle in service (e.g. fuel production) is normally also included.
  - Production (vehicle, spare parts, fuel, other materials)
    means all processes from the extraction of raw materials or energy resources respectively the growth of renewable materials to the material, part production and final vehicle assembly including all good transport processes between these processes.

- End-of-Vehicle-Life
  means all processes from the pre-treatment of the End-of-Life Vehicle (ELV) to the shredding and post-shredder treatment. It includes all processes for recycling, (energy) recovery and disposal of the various fractions.
- Holistic (lifecycle & integrated approach)

- Time horizon:
  - current vehicle technology
  - future vehicle technology
- Application:
  - For specific vehicles
    (Specific vehicle is a variant of a vehicle model where the engine, body style, option package is defined)
  - Vehicle model (e.g. Opel Astra, VW Golf, Ford Fiesta, Peugeot 308...)
  - Vehicle categories
  - other parts/systems (e.g. MAC's, tyres, GSI, TPMS, ...)
  - interface: surface, infrastructure
- Evaluation context:
  - global environmentally impacts
  - local environmentally impacts
  - short term impacts
  - mid term impacts
  - long term impacts
  - absolute versus segment-based evaluation
    (Method provides an evaluation based on an absolute or segment-based (relative) scale. An absolute scale would result for example in '49392 MJ energy use' while a segment-based result would refer that to the vehicle segment in stating e.g. '3 % lower energy use than average mid-sized cars in India'.)
- Effort for application/Accuracy:
  - Time/cost
  - Self declaration, independent 3rd party review
  - User expertise for applying the concept and need for education and experience
  - Communication

4.2.3. APPLICATION OF TOOL EVALUATION CRITERIA

In this table the „regulations and standards, concepts and tools“ are compared to different criteria, which are evaluated by using a colour scheme. The criteria were grouped to certain topics („Environmental aspects covered“, „Data“, „System boundaries“, „Application“, “Evaluation context“ und „Effort for application“).

Some of the „regulations and standards, concepts and tools“ are combined concepts (e.g. “Green vehicles” and “vehicle rankings”) which consist of several concepts.

To evaluate the „regulations and standards, concepts and tools“ there are different colours available.

The colour green, respectively “**yes**” means, that the „regulations and standards, concepts and tools“ fulfil the conditions which are listed under the groups „Environmental aspects covered“, „System boundaries“ and “Evaluation context“. Red respectively “**no**” means, that the criteria were not fulfilled.

To assign the colour yellow, respectively “**partly**” there are two options.

Example 1: One can use yellow if not all of the criteria have been achieved. This case one see at „Recycling and substance restrictions“ and „Use of materials“, because there are only a few materials considered but e.g. not renewable materials.

Example 2: One can use yellow to differentiate the combined concepts (e.g. „Green vehicles“ and „vehicle rankings“). If there’s a criteria that is considered only by one concept (China Green vehicles for example uniquely considers the criteria “Noise”) so the field has to set on yellow.

The criteria group “data” is divided into “**low/regional**” and “**high/worldwide**” instead of yes and no. Low means in this case, that the „regulations and standards, concepts and tools“ insufficiently fulfil the conditions of the criteria group “data” or if this does not apply on a global scale. An example is the lack of LCA data for each region in the world that would be important looking at the global supply chains in the automotive sector. High means, that the criteria are fulfilled sufficiently. An example is the data availability for recyclability based on the International Material Data System (IMDS). There is also the possibility to choose “**partly**” if for example the quality of data for LCAs or WtW is for some processes good and for others less adequate.

The group "Application" was divided into “**applied**” and “**not applied**”, in which the "regulations and standards, concepts and tools" are either applicable or not applicable to the single criteria. For example, vehicle rating systems are normally not applied to future vehicle technologies while recycling and substance restrictions cover also future technologies.

In the last group „Effort for application“ one can choose between 5 different colours (**very high**, **high**, **neutral**, **low**, **very low**), to evaluate the „regulations and standards, concepts and tools“ on the basis of the single criteria. The differentiation in more ratings than for the other groups is necessary to better understand the substantial difference in effort decreasing e.g. from LCAs (highest effort) to WtW (considerably high effort), recyclability calculations to easier vehicle ranking approaches.

Based on the definition given in chapter 2.7. and 4.2. regulations and standards are analyzed:

Criteria from chapter 4.2.1.	regulations and standards, concepts and tools														
	CO_2 regualtions, fuel economy (MAC, CAFE)	fuel directives (renewable & quality in EU)	Top runner	regulated pollutants	Green Public Procurement	Green vehicles (EPA, Australien, China, Sweden)	noise	recyclability ISO 22628	Recycling and substance restrictions	interior air quality	LCA / ISO 14040/44	WTW	vehicle rankings e.g. VCD, Ökotrend	green manufacturing	life cycle cost - externalties (GPP)
Environmental aspects covered: no - partly - yes															
Air emissions: CO_2	yes	yes	yes	no	yes	yes	no	no	no	no	yes	yes	yes	partly	yes
Air emissions: regulated pollutants	no	yes	no	yes	yes	yes	no	no	no	no	yes	no	yes	partly	yes
Air emissions: other GHG	partly	yes	partly	partly	no	no	no	no	no	no	yes	no	no	partly	no
other pollutants: water (yes/no)	no	partly	no	no	no	no	no	no	yes	no	yes	no	no	partly	no
other pollutants (e.g. waste streams): land (yes/no)	no	no	no	no	no	no	no	no	yes	no	yes	no	no	partly	no
Use of materials/resources (recycled, renewable, non-renewable)	no	partly	no	no	no	no	no	no	partly	no	partly	no	partly	partly	no
Use of energy resources (e.g. fossil fuels)	no	partly	no	no	partly	no	no	no	no	no	yes	partly	no	partly	partly
Use of water	no	partly	no	no	no	no	no	no	no	no	yes	no	no	partly	no
Use of land	no	partly	no	no	no	no	no	no	no	no	partly *	no	no	partly	no
Recyclability	no	no	no	no	no	partly	no	yes	partly	no	no	no	no	partly	no
Toxics (health effects)	no	partly	no	no	no	no	no	no	yes	yes	partly *	no	no	partly	no
Noise	no	no	no	no	no	partly	yes	no	no	no	partly *	no	yes	partly	partly
EMC	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Effects on biodiversity and sustainability	no	yes	no	no	no	no	no	no	no	no	partly *	no	no	partly	no

* method currently not suitable

Criteria from chapter 4.2.2.	regulations and standards, concepts and tools														
	CO_2 regualtions, fuel economy (MAC, CAFE)	fuel directives (renewable & quality in EU)	Top runner	regulated pollutants	Green Public Procurement	Green vehicles (EPA, Australien, China, Sweden)	noise	recyclability ISO 22628	Recycling and substance restrictions	interior air quality	LCA / ISO 14040/44	WTW	vehicle rankings e.g. VCD, Ökotrend	green manufacturing	life cycle cost - externalities (GPP)
Data: low/regional - partly - high/worldwide															
Availability of data regional	green	green	green	green	green	green	green	green	green	yellow	yellow	green	green	green	green
Quality of data regional	green	green	green	green	green	green	green	green	green	yellow	yellow	yellow	green	green	yellow
Flexibility/Frequency of data updating regional	green	green	green	green	yellow	green	green	green	green	yellow	yellow	green	green	green	red
Availability of data worldwide/applicability	green	yellow	yellow	?	yellow	yellow	red	green	yellow	yellow	red	yellow	red	green	red
Quality of data worldwide/applicability	green	yellow	yellow	?	green	green	red	green	yellow	yellow	yellow	red	yellow	green	red
Frequency of data updating worldwide/applicability	green	yellow	yellow	?	yellow	green	red	green	yellow	yellow	red	red	green	green	red
Comparability worldwide	red	red	red	red	red	red	red	red	red	red	red	red	red	red	red
System boundaries: no - partly - yes															
Tailpipe	green	yellow	green	green	green	green	green	red	red	red	green	green	green	red	green
Usage of vehicle (incl. evap emission etc.)	red	yellow	red	green	red	yellow	green	red	red	green	green	green	red	red	red
Production (vehicle, spare parts, fuel, other materials)	red	yellow	red	red	red	red	green	red	yellow	red	green	red	green	green	yellow
Recycling	red	red	red	red	red	yellow	red	green	green	red	green	red	red	yellow	red
Holistic (lifecycle & integrated approach)	red	?	red	red	red	red	yellow	red	red	red	red	red	red	yellow	red
Time horizon: not applied - partly - applied															
current vehicle technology	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
future vehicle technology	yellow	green	yellow	yellow	green	red	green	red	green	red	green	green	red	red	yellow
Application: not applied - partly - applied															
For specific vehicles	green	green	green	green	green	green	red	green	red	green	green	green	green	red	green
Vehicle model	green	green	green	green	green	red	green	red	green	green	red	red	red	green	green
Vehicle categories	red	green	red	red	red	red	green	green	red	red	green	green	red	red	green
other parts/systems (e.g. MAC´s, tyres, GSI, TPMS, ...)	yellow	red	yellow	red	red	red	green	red	green	red	green	yellow	red	red	red
interface: surface, infrastructure	red	red	red	red	red	red	green	red	red	red	yellow	red	red	green	red
Evaluation context: no - partly - yes															
global environmentally impacts	green	green	green	red	yellow	yellow	red	red	red	red	green	green	green	red	green
local environmentally impacts	red	yellow	red	green	yellow	yellow	green	red	green	yellow	green	green	green	green	yellow
short term environmenrtal impacts	red	yellow	red	yellow	red	green	green	red	red	yellow	*	red	green	green	yellow
mid term impacts	yellow	green	yellow	yellow	yellow	green	yellow	red	green	yellow	yellow	yellow	yellow	green	yellow
long term environmenrtal impacts	yellow	green	yellow	yellow	yellow	green	red	red	red	yellow	green	green	yellow	red	green
Segment-based	green	red	green	yellow	yellow	yellow	red	red	red	red	yellow	yellow	yellow	green	yellow
Effort for application/Accuracy: very high - high - neutral - low - very low															
Time/cost	light green	yellow	light green	light green	yellow	light green	orange	yellow	red	orange	red	orange	yellow	green	orange
Self declaration, independend 3rd party review	yellow	light green	yellow	yellow	yellow	orange	orange	red	red	red	red	red	yellow	green	red
User expertise	yellow	yellow	yellow	yellow	yellow	yellow	orange	red	red	orange	red	red	green	green	red
Communication	yellow	yellow	yellow	yellow	yellow	light green	green	red	red	light green	red	red	green	yellow	orange

4.3. SWOT ANALYSIS

OICA [37] submitted a paper how to analyse the different approaches concerning the assessment of EFV. The conceptual idea of OICA rests upon the so-called SWOT analysis. The idea of this conception depends on the four issues: **S**trength, **W**eakness, **O**pportunity and **T**hreat which should be taken into consideration when various approaches with regard to the assessment of the environmental friendliness of vehicles are analysed.

Different evaluation methods from the table above are investigated and analysed by means of the SWOT methodology.

It is necessary to clarify the target group of an EFV concept when defining whether something is a strength or a weakness. For example, a very data-intensive method resulting in complex figures might be appropriate and thus a strength for experts while consumers would prefer an EFV concept that is intuitively understandable. At the moment the fundamental discussion about the target groups (governments, industry, consumers) of the evaluation concept and the allocated purposes isn't finalized. But the conclusions of that discussion is needed as basis to perform the SWOT analysis. Based on the decision of GRPE in January 2009 it is assumed that either governments and/or consumers could be the target group of an EFV concept looking for an information system.

1) CO_2-regulations:

Strength	In line with current regulations. Addresses one of the most important environmental indicators (climate protection).
Weakness	No EFV definition in itself. Focus of only one environmental aspect (climate protection). Other item e.g. local air quality are not addressed.
Opportunity	Third party certification possible. Can be easily added to other methods.
Threat	Discussion about environmental protection could be reduced to one aspect (climate protection) and other important aspects such as local air quality will be not addressed properly.

2) Fuel regulations:

Strength	In Europe regulation of fuel quality is an accepted approach to define certain fuel parameters that are health and environmentally related. Regulations in many, but not all, world areas follow the example of EU regulations. International standards are also defined in different world regions for traditional hydrocarbon fuels and also for biofuels for the quality of the final blend and also the quality of the blending bio-components. In standards, the fuel characteristics are defined as performance parameters. In the EU, the issue of lifecycle GHG emissions and sustainability will be included in the new (2009) fuel quality directive and the directive on the promotion of renewable energy use. Default values for lifecycle GHG emissions and WTW data is laid down in EU legislation and will be revised in the future as better data is made available.
Weakness	While the EU defines certain fuel parameters according to their health and environmental impact, not all world regions follow that method. Many countries or regions set parameters just as performance specifications (i.e. limits that may be practical to achieve by ‘nationalised’ oil refining industry). Market fuel quality data and the monitoring of market fuel quality are good in developed markets but not so good in developing markets.

Fuel quality regulations do not provide an EFV definition in itself -fuel quality regulation provides data that can be used to support the application of an EFV concept.

Opportunity Support world-wide recommendations (or regulations) for market fuel quality matched to the application of emission standards.

3) Top-runner approach:

Strength

- Accepted approach in Japan. Similar concepts have been adopted world widely especially in purpose to assess technological feasibility of future targets in the relevant regulations.
- Setting the most ambitious and realistic target values because of detailed analysis of available technology for improvement (e.g. engine improvement or introduction of fuel efficiency vehicles).
- Equal stringency for all weight categories
- Concrete achievement
- Flexibility by Credit system/Averaged evaluation of performance for each weight category
- More effective in cooperation with other measures (e.g. labelling, tax incentives)

Weakness

- Not world-wide harmonized
- Not top-down approach, but bottom-up approach, even having quantitative information on energy saving achievements. Actual energy use as such as well as the aggregated energy saving effects are not addressed solely. Therefore, to have a detailed and quantitative impact analysis, we need additional information on the impact of supplemental measures, such as fiscal incentives, labelling, and so on.
- Name and shame sanctions only effective in Japan

Opportunity 7-8 years Lead time enough to allow manufactures to research and develop new technologies for the future.

Threat Continuous definition update depending on local circumstances will lead to fragmentation.

4) Regulated Pollutants:

Strength Based on existing regional standards and test methods a third party verification can be done → easy to communicate.

Weakness Currently not worldwide harmonized.
Substantial regional differences in e.g. fuel quality, market specifics, test procedures, in-use issues, effective time to be taken into account.
Future vehicles cannot be assessed as real testing is needed.
Covering only limited pollutant issue – thus not a stand-alone suitable to define an EFV.

Opportunity Support world-wide harmonization of test cycles and procedures based on common fuel quality.
Synergetic effects with type approval.

Threat Complex interactions with other emission sources and atmospheric chemistry with respect to cause-effect studies. Different regional focus of legislation.

Environmental and other NGO's may favour only certain standards with massive technology implications.

5) Green Public Procurement:

Strength	Already in use in European green public procurement. Not technology based. Based on regulated, verified emission data. Easy to calculate. Easy to compare by consumer: single score in Euro.
Weakness	Include a data, which can vary for a one single car: selling cost. Cost for pollutant emission - internalization - is not scientifically agreed. Mixing of impact of emissions both of local and global relevance has no scientific acceptance. Emission measurement standards drive test are different between EU, JP, US, and are not available for all vehicle types. Disconnected from real environmental stakes: single score in Euro. All depending on criteria selection, limit values. Adoption to regional conditions → further market fragmentation. Development efforts on issues out of customer focus (ELV RRR rates).
Opportunity	potential for easier market introduction of cleaner products.
Threat	Other environmental aspect could be added (noise, toxic substances). Regulated data will be public and could be misinterpreted by e.g. consumers, or journalists... Market fragmentation: emission type criteria may vary from one country to another, and in time. Single euro score does not help to educate the consumer on a responsible purchase.

6) Green vehicle certification (EPA, Australia, China, Sweden):

Strength	Transparent, understandable and easy to establish. Mainly criteria that are anyhow in the development focus, legal base. Relating to existing regulations i.e. harmonized with and supporting legislation.
Weakness	All depending on criteria selection, limit values. Adoption to regional conditions → further market fragmentation. Development efforts on issues out of customer focus (ELV RRR rates).
Opportunity	If EFV definition can be globally agreed on the basis of legislation this could foster a global harmonization of legislation.
Threat	Different schemes create market fragmentation.

7) Noise regulation related to vehicles:

Strength	Outdoor noise recognized as a source of pollution of a vehicle, everywhere in the world. Nor global nor long term environmental impacts of Noise on earth sustainability.
Weakness	To improve the global noise performance, noise regulation on vehicles is not sufficient. It should also involve other stakeholders such as: tyres manufacturers, roads and pavements builders, roads and pavements decision makers, infrastructure and city managers, ..).

	High effort for execution related to data update. Data only available on a regional level.
Opportunity	To reveal some cars with a low level of external noise (?), but in contradiction with the recent request from the blind associations asking for minimum noise level of cars for the pedestrians safety….
Threat	High workload and costs for car manufacturers for low benefits on the global environmental impact.

8) Recyclability/Recoverability:

Strength	Calculation is based on world wide harmonized ISO standard (ISO 22628). The evaluation of the recyclability/recoverability quotas is part of the vehicle type approval in Europe (2005/64/EG), other regions follow with similar concepts (China, Korea). It takes design and material properties of new vehicles into consideration and is based on proven recycling technologies. Easy to communicate.
Weakness	No EFV definition in itself / delivers only data that can be used for EFV definitions. It can not reflect the physical processes that will actually be applied to the road vehicles reaching the end of their life. High effort for execution/update but no significant differences in the environmental performance of different recycling/recovery technology variations.
Opportunity	Can be easily added to other methods → suitable for an information system for both target groups (customer and governments).
Threat	Design for Recycling options might be contradictory to other environmental strategies (lightweight design, etc.).

9) ELV Recycling and substance restrictions:

Strength	ELV directive in Europe (2000/53/EC) as an accepted approach to improve recycling and dismantling standards, to prevent waste from vehicles and to limit the use of hazardous substances in vehicles. Regulations in many, but not all, world areas follow the example of EU regulations.
Weakness	No competitive feature for an EFV definition because all vehicles have to comply with legal requirements (e.g. heavy metal ban). Restricted substances within ELV regulation intended to avoid the disposal of hazardous waste, however on a world-wide and full life cycle scale additional national and international regulations for substances need to be considered (chemical law, REACH, etc.).
Opportunity	Increase quantity of recycled material in vehicles and other products, in order to develop the markets for recycled materials, as one possible aspect for an information system.
Threat	Complexity of approaches for different industry products with different exemptions (E/E, vehicle, etc.) will confuse customer.

10) Vehicle Interior Air Quality:

Strength Based on existing standards and test methods a third party verification can be done resulting in labels used also in other sectors (e.g. textiles, TUeV TOXPROOF). → easy to communicate.
Addressing a consumer health issue.

Weakness Currently not worldwide harmonized.
Complex, time consuming and costly testing required and data are only partly readily available.
Covering only consumer health issue – thus not as a stand-alone suitable to define an EFV.
Future vehicles cannot be really assessed as real testing is needed.

Opportunity Can be easily added to other methods.

Threat Toxicity is an evolving topic with steadily increasing knowledge about the impact of substances. In addition, the real consumer health impact is highly dependent on ventilation, vehicle age and other factors not constant during vehicle life.

11) Life Cycle Assessment:

Strength Already world-wide harmonized standard (ISO14040/44).
Comprehensive method covering many important environmental aspects along the whole life cycle (more than WtW).

Weakness No EFV definition in itself / delivers only data that can be used for EFV definitions.
Very high effort for execution / update.
Interpretation of LCAs only possible by LCA experts judging details of used approach, data quality and results → no EFV concept for consumers. Questionable whether suitable for general governmental bodies (only where experts available).
Often not including infrastructure and integrated approach items.
Data only available on a regional level and for generic vehicle applications.
Complex database needed that is not globally available.
Certain environmental aspects are not covered in an appropriate way (e.g. toxicity, noise, …).
Results for the identical vehicle will be different depending on regional assumptions (e.g. for electric vehicles with different electricity grids in India compared to Europe or US).

Opportunity Third party review to ensure credibility

Threat Complexity of method will confuse customer who in consequence would ignore the results.
Common fuel quality enhances application of a world-wide (or regional) EFV concept.
Strengthen vehicle requirements for fully compatible biofuels and future fuel quality, i.e. second generation biofuel production pathways.
Streamlined WTW approach including the fuel production and distribution chain.
Monitoring of market fuel quality and third-party certification of fuel quality.
National fuel refiners have a big say in political decisions and consequential refinery investment for cleaner fuels.

Environmental and other NGOs may favour only certain biomass pathways. Other national and regional policies, e.g. trade and agriculture, will have a high political impact on fuel regulations.

12) Well to wheel approach:

Strength In Europe accepted approach.

Weakness No EFV definition in itself / delivers only data that can be used for EFV definitions.
High effort for execution / update.
Environmental discussion is reduced to one single parameter (Energy/GHG).
Well-to-wheel analysis deal with different fuel options instead of EFVs.
Data only available on a regional level and for generic vehicle applications.
Data based on scenarios relevant to Europe in 2010 and beyond.

Opportunity Other environmental aspects such as emissions can be integrated.
Streamlined Life-cycle Approach (only fuel chain is additionally considered).
Third party certification possible.

Threat High additional expenditure for the inclusion of other environmental aspects.

13) ECO Ranking by Consumer associations (e.g. Öko-Trend, VCD):

Strength Easy to establish and third party verification.
Top Ten results / Labelling.
Methods with more than CO_2 and emission standards.

Weakness Multi Criteria / impact category approach with questionable "scientific" approved weighting.
Criteria with less benefit for environment are included, but no WTW / lifecycle-data.

Opportunity WTW and other items can be included.

Threat Due to non-suitable and non-scientific method changing criteria and weightings over time → confuse customer, moving development targets.

14) Green Manufacturing:

Strength Environmental impact categories exist.
Legislative requirements for environmental aspects.
Accepted approach to improve performance.
Positive impact of product life cycle.
Positive impact on emission cap & trade.

Weakness Not clearly defined, scope can be different.
Difficult to compare performances with other plants in same sector.
No direct link (yet) to the type of vehicle being produced/assembled on the site.
Additional green investments have longer ROI.

Opportunity To further reduce environmental impact.
Linked to potential operational cost reductions = cost-efficiency.
Image of company can be approved through communication.
Support zero-carbon strategy.
Decouple green investments from normal capital expenditures – look at net present value.
Comparison on process basis.

Threat 'Green-washing'.
Does the consumer care? If not, why invest, in case of cost-disadvantage?

4.4. EXPLANATORY NOTE

The discussion in the EFV informal group regarding chapter 4. showed, that a certain level of understanding and agreement could be reached. But maybe people outside of the informal group may come to other conclusions about the criteria, the decisions about the colours of each box in the table and the SWOT analysis of each approach. Therefore the current content of chapter 4. should be taken as an interim result or as an example. But the conclusion can be drawn, that the current status of chapter 4. can be taken as general basis for further consideration, and that the procedural approach is reasonable.

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

5.1. PROCEDURAL FEASIBILITY OF DEVELOPING AN EFV CONCEPT

Chapter 3. gave an overview about existing legislation, tools for holistic approaches and assessment concepts. All these regulations, standards, assessment concepts and ranking systems are based on different principles, structures, conditions and timelines. In general the following main aspects are included in these approaches, characterising them:

- system boundaries (end of pipe / tank to wheel, well to tank, life cycle)
- mandatory by legislation or disengaged recommendation
- environmental performance criteria, either single or in combination (two or more criteria)
- performance levels defined as absolute values, or related to reference values (average of fleet or new registered vehicles) or related to a technical reference parameter (vehicle mass, footprint)
- ranking based on a function or defined classes.

Chapter 4. showed in example that with an analysis of environmental aspects and tool evaluation criteria plus a following SWOT analysis an assessment of the existing tools and approaches is possible and reasonable.

Therefore, from a procedural point of view the development of a harmonised EFV concept is feasible by this approach, with the following principle options:

- selection of the most suitable concepts from all existing approaches or tools
- combination of two or more of the existing approaches or tools
- definition of a new EFV concept, not comparable to the existing approaches or tools.

The weaknesses and constraints of potential EFV concepts are considered in detail in chapter 5.3.

5.2. POTENTIAL TARGET GROUPS AND PURPOSES OF AN EFV CONCEPT

For an assessment of the feasibility to develop an EFV concept it is necessary to understand the political context concerning the motivation of the potential target groups (governments, customers, industry) as well as the purposes and fields of application. The following table gives an overview of the interrelation of target groups and purposes with a first estimation of feasibility.

Potential target groups	Purpose	Comment	Level of feasibility
Local, regional, national or supra-national governmental bodies	Regulations, fiscal systems, road charging	Regulations already in place, specific for certain aspects (emissions, waste), might form the basis for EFV definition but not the other way around.	very low
	Information systems for e.g. public and private procurement	Requires comprehensive information to assess future and current vehicle models. Specific vehicle variant is less important.	high
	Green zones, access restrictions	Too dependent on local conditions; better directly referring to existing regulations. No harmonisation of local aspects possible. Mainly focused on pollutant emissions.	low
	Guidance on strategies for future mobility concepts (research, demonstration projects, creation of framework).	Requires a long term, globally harmonised EFV concept, assessing technologies based on presumptions and future prospects.	low
Customers	Voluntary information systems for purchasing decisions and raising interest in EFV	Requires easily understandable information for a currently offered specific vehicle variant.	high / very high
Automotive industry	Design specifications	Already available (see chapter 3.2.2.4. – very specific for each model). Each manufacturer needs to look for a competitive advantage resulting in different strategies and approaches → harmonisation of designs not reasonable	very low

It is not the aim of the EFV activities under the framework of WP.29 to develop an additional legally binding regulation on EFV. Nevertheless, it could be feasible with certain constraints to develop an EFV concept as a recommendation, a harmonised method, commonly applied. It seems reasonable to develop and adopt such a document as a Special Resolution or Consolidated Recommendation under the umbrella of the 98 or 58 agreement.

However, the EFV informal group concluded that a clear positive feasibility statement is not possible from a political point of view for the time being. More guidance from WP.29 and the EFV Conference is needed, with respect to the needs of the target groups and possible applications of an EFV concept.

5.3. GENERAL COMMENTS AND CONCLUSIONS CONCERNING AN EFV CONCEPT

Theoretically, the environmental profile of a vehicle could be based on a wide range of indicators mentioned in chapter 4. (all types of emissions to air, use of materials/water/resources/substances etc.). But from a feasibility perspective the different indicators are quite diverse and difficult to capture in a one-size fits all approach.

The background study clearly emphasizes these results. The study has analysed different concepts and methodologies (by the SWOT analysis) for the environmental performance of vehicles. None of the investigated concepts is able to assess and evaluate sufficiently the environmental performance on a global harmonised level due to the following reasons:

- An aggregation of different environmental aspects to a single score is based on subjective weightings that would lead to arbitrary and confusing changes in definitions.
- The environmental profile of a product has always to be interpreted against the background of different regional and temporal environmental circumstances.
- Data for all environmental aspects are not available and / or are measured in different ways depending on the region or regulations/legislation.

For example, whereas greenhouse gas emissions or material use are addressing the global effect of climate change and resource depletion, the other indicators are addressing regional or even specific local effects. Even more, there are fundamental temporal differences within even one indicator. For example, looking at the electric power generation for an electric vehicle even the well-to-wheel CO_2 emissions differ between regions (e.g. captured or not in an Emission Trade Scheme avoiding an increase in CO_2 emissions, change in E-Mix over time). This means that the same vehicle driving around a region over a certain time will have a continuously changing environmental profile. This makes a robust definition of an EFV impossible. The environmental performance of a vehicle would need to be evaluated differently depending on the local and temporal environmental conditions. E.g. the emission standard of a vehicle in a mega-city has another relevance than in areas with a very low load of air pollutants.

Looking at the SWOT analysis (chapter 4.3.) all different approaches have remarkable weaknesses. Either the approaches are too simple and/or not comprehensive enough to define an EFV or they are too complicated for the targeted groups and the application to them. From a technical / scientific point of view the aggregation of different environmental aspects to a single score is not at all recommended due to the fact that environmental indicators have to be interpreted based on the local or temporal situation and there is no scientific / technical justification for setting of weighting factors. Also a flexible approach allowing regional modification within a range of globally harmonised weighting factors is not reasonable as this could mean local adjustment factors almost continuously changing over time, different from a town or area to another, leading to a lot of confusion and missing stability for any applications.

In consequence, single scores for defining EFVs shall not be used for comparative assertions according to ISO14040 [9, 38] as well as the term ″environmentally friendly″ shall be avoided according to ISO 14021. The reason for this ISO rule is that 'environmentally friendly' is a very comprehensive and bold statement that is not likely to be justifiable looking at all the indicators mentioned in chapter 4. It might be the case that e.g. a vehicle has lower NO_x emissions than another vehicle during its life-time, regarding local air quality. However, 'environment' is much more than NO_x emissions and needs to take into consideration also other relevant items as for example CO_2 emissions, other Greenhouse gas emissions, recycling and end-of-life treatment, noise emissions, hazardous substances etc. In consequence, a vehicle having lower CO_2 emissions might be identified as a low-CO_2-emission-vehicle but not necessarily "environmentally friendly". The application of the ISO norm requires a specific definition/wording, not a misleading terminology.

Therefore, any approach for an EFV concept has to assume the following guidelines :

- consider the target group(s) and purpose(s)
- address clearly the approach on a voluntary base
- ensure a technology- and segment-neutral instead of a technology- and segment-prescriptive approach
- concentrate on already existing legislation or tools, and focus on the crucial aspects in order to avoid misleading and information overloading
- take into account national or regional differentiation in order to reflect local/regional legislation and requirements
- take into account the time horizon
- avoid simplification of complex indicators or impacts in a single score
- define a realistic and affordable EFV threshold concept from a customer perspective (a broad share of existing vehicles in all segments)

Additional work may include the evaluation of the interface between an EFV and an "environmentally friendly infrastructure" (e.g. clean fuels and electricity).

The conclusion is, that from a technical and scientific point of view it is not feasible to develop an entire holistic EFV concept, because there are differences and certain specifications concerning environmental aspects, subjective weightings, regional or temporal circumstances and data availability.

A possible way out is to avoid the misleading term EFV concept, but to create specific names fitting to the concept (e.g. LNV-Low Noise Vehicle, LCEV-Low Carbon dioxide Emission Vehicle). In this sense in future "EFV" should be written in quotation marks.

5.4. FIRST OUTLINE OF AN "EFV CONCEPT"

In the previous sub-chapter some principles of an "EFV concept" are considered. Mainly the disadvantages of a single score "EFV" definition are described in chapter 5.3., presuming that such a single score is calculated by mixing up different (environmental) values with incomparable units, applied for different cases (regions, environmental needs etc.). This might lead to the conclusion that an "one size fits all" solution was created.

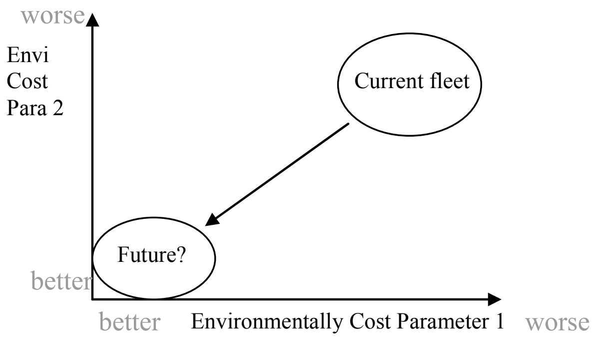
However, this does not exclude the non-aggregated combination of several environmental criteria or evaluation tools for the development of an "EFV concept". In addition the application of an "EFV concept" may require a simplified structure and ranking parameter, e.g. to be implementable and understandable. As an example one can take the emission levels Euro 1…6, in Europe established as an information system and tool, combining different environmental criteria (pollutant emissions), staged on time and performance, simple and understandable. However, several environmental aspects need to be considered and should not be aggregated to one parameter.

As a starting point, the EFV informal group considered in general the aspects and principles of possible "EFV concepts" with 2 non-defined environmental performance parameters of vehicles.

A) The Ultimate "EFV concept"

This concept defines where we want to be in a fully sustainable future regardless of the current state of technology.

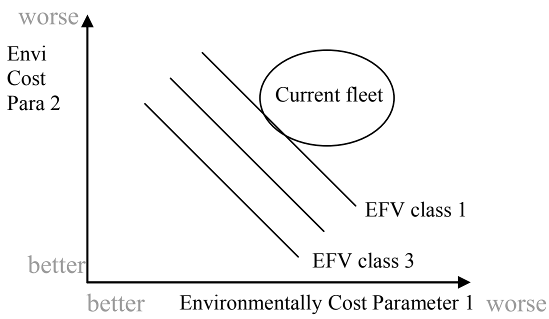
There is no example of such a concept in chapter 4. (this is more a theoretical concept).



B) The Threshold "EFV concept"

This concept defines a future sustainable vehicle not existing yet, but imaginable with the current technological ideas (threshold should exclude e.g. most of current models).

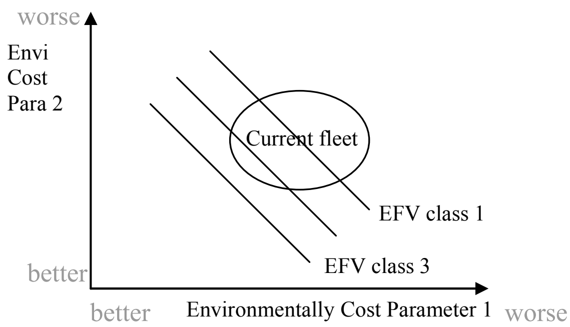
The Threshold "EFV concept" includes concepts such as top runner principle (3.1.1.1.) from chapter 3.



C) **The "EFV label concept"**

This concept defines the most sustainable vehicle based on current technology.

The "EFV label concept" includes concepts such as vehicle rankings (3.3.1. and 3.3.2.) from chapter 3.



D) Discussion of the concepts

The ultimate “EFV concept” has a high feasibility, with low effort involved, but low added value (see also document EFV-04-06 “ACEA comments to NL EFV guidance paper): not suitable for differentiation of current vehicles and no incentive for improvements as the distance to the future target is too large. Therefore this seems a concept that should not have priority to further investigate at this stage.

The Threshold concept and “EFV label concept” both have advantage and disadvantage (see EFV-04-04 & EFV-04-06). The consequence of using the Label concept for multiple target groups and purposes (resulting in high added-value) would require a considerable effort and manpower. This manpower and effort could be reduced by accepting (limited) regional differences, and/or limitations to information-only, thus increasing feasibility. However, the resulting added-value will consequently be lowered.

The feasibility of the Threshold concept is higher as it requires less effort to work out in detail and regional differences can be overcome (e.g. by equivalence tables). However, the added value is less as it could not serve as tool for incentives and consumer information from the start. Special attention should be paid to ensure this concept is technology neutral.

In further activities a new approach has to be identified for an “EFV Concept” which is not only feasible, but also adds value for the potential target groups and purposes.

6. REFERENCES

The EFV Informal Group met four times until April 2009. The documentation is available on the UN-ECE-Website (http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/efv04.html). The reference to an EFV document in the text of this document is as follows: GRPE-EFV-“no. of meeting”-“no. of document”.

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

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

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

[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] The Motor Industry of Japan 2008. Japan Automobile Manufacturers Association, Inc. http://www.jama.org/library/pdf/brochures2008MIJReport.pdf

[11] Medieninformation des Bundesamtes für Umwelt zur Umweltetikette: http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=de&msg-id=16974
Informationen zur energieEtikette für Personenwagen des Bundesamtes für Energie: http://www.bfe.admin.ch/energieetikette/00886/index.html?lang=de

[12] “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=8

[13] Timmermans et al, Environmental rating of vehicles with different fuels and drive trains: a univocal and applicable methodology, European Journal of Transport and Infrastructure Research, 6, no. 4 (2006), pp. 313-334

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

[15] “The GREET Model”, Argonne
http://www.transportation.anl.gov/modeling_simulation/GREET/

[16] “guide to green”, ACEEE
http://greenercars.org/guide.htm

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

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

[19] 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.
[20] "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
[21] "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
[22] "Environmental Product Information", VOLVO http://www.volvocars.com/intl/corporation/FactsandFig.s/EnvironmentalProductInformationEurope/Pages/default.aspx
[23] Product Sustainability Index, Ford 2006 http://media.ford.com/newsroom/release_display.cfm?release=26596
„Studie CO_2-freie Mobilität durch Biokraftstoffe", Forschungsvereinigung Verbrennungskraftmaschinen
http://www.fvv-net.eu/download/plonearticle.2006-11-01.2016161066
[24] "DRIVECLEAN, a guide to clean and efficient vehicle technologies", California Air Resources Board
http://driveclean.ca.gov/
[25] "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
[26] "Green Vehicle Guide", EPA
http://www.epa.gov/greenvehicle/
[27] "Fuel Economy", EPA
http://www.fueleconomy.gov/
[28] "Eco cars", Vägverket
http://vv.se/templates/page3____21943.aspx
[29] Reducing CO_2 Emissions in the Global Road Transport Sector. Japan Automobile Manufacturers Association, Inc.
http://www.jama-english.jp/publications/2008_CO2_RoadTransport.pdf
[30] „5 Jahre EcoTest: Europa sucht den Umweltstar", ADAC
http://www.adac.de/Tests/Autotest/Ecotest/default.asp?ComponentID=185779&SourcePageID=8447
[31] „EcoTest", FIA Foundation
http://ecotest.eu/Pages/Home.aspx
[32] Lottsiepen, G.: „VCD Auto-Umweltliste 2008/2009", fairkehr, Nr. 4/2008
[33] „Auto-Umweltliste 2008", VCS
http://www.verkehrsclub.ch/de/politik-kampagnen/ratgeber/auto-umweltliste.html
[34] „Auto-Umwelt-Zertifikat", ÖKOTREND-Institut
http://www.oeko-trend.de/start/index.php?page=2&lang=de
[35] "Green Efficiency Ratings", JDPower
http://www.jdpower.com/autos/ratings/green-efficiency-ratings
[36] "Car Buyers' Guide", ETA
http://www.eta.co.uk/car_buyers_guide
[37] "Informal working group on EFV, working papers", UNECE
http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/efv01.html

[38] W.P. Schmidt, J. Sullivan; Weighting in Life Cycle Assessments in a Global Context; IJLCA, Int J LCA 7 (1) 5 – 10 (2002)
[39] "Review of International Policies for Vehicle Fuel Efficiency", IEA 2008 http://www.iea.org/Textbase/Publications/free_new_Desc.asp?PUBS_ID=2049
[40] "Fuel Efficient Road Vehicle Non-Engine Components", IEA 2007 http://www.iea.org/Textbase/Publications/free_new_Desc.asp?PUBS_ID=1977
[41] Directive 1999/94/EC:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:012:0016:0023:EN:PDF
Directive 2003/73/EC:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:186:0034:0035:EN:PDF
[42] Directive 88/77/EEC:
http://ec.europa.eu/enterprise/automotive/directives/vehicles/dir88_77_cee.html
[43] "Ecoscore", VITO
http://www.ecoscore.be/ecoscore/EcoScoreDownloads.asp?Language=NL&vcat=M1&ExtendedSearch=Y
[44] Presentation TCMV meeting
http://ec.europa.eu/enterprise/automotive/tcmv_meetings/docs/7d_presentation.pdf
[45] Directive 2009/33/EC of 23 April 2009, O.J. L 120, 15.05.2009, p. 5-12:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:120:0005:0012:EN:PDF
[46] 74 Fed. Reg. 18886; April 24, 2009
[47] 74 Fed. Reg. 14196; March 30, 2009
[48] 74 FR 24007, May 22, 2009

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/

- - - - -