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Environmentally Friendly Vehicles

Experiences and Definitions

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Nordic co-operation

Nordic cooperation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and three autonomous areas: the Faroe Islands, Greenland, and Åland.

Nordic cooperation has firm traditions in politics, the economy, and culture. It plays an important role in European and international collaboration, and aims at creating a strong Nordic community in a strong Europe.

Nordic cooperation seeks to safeguard Nordic and regional interests and principles in the global community. Common Nordic values help the region solidify its position as one of the world's most innovative and competitive.

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Preface

Different criteria are used to define environmentally-friendly vehicles, and different schemes are used to promote them. Is it possible to provide a more sound background for policymaking? In this study we have dealt with these and related questions.

The study was contracted by the Nordic Council of Ministries, Theme Group for Sustainable Mobility, and performed by Rolf Hagman, Institute of Transport Economics (TØI), and Eivind Selvig, Civitas Consultants'.

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Eivind Selvig
Rolf Hagman

Forord

Studien som er utført på oppdrag fra Nordisk Ministerråds arbeidsgruppe for bærekraftig transport. Rolf Hagman, Transportøkonomisk Institutt (TØI), og Eivind Selvig, Civitas AS Rågivergruppen, har utført arbeidet.

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Eivind Selvig
Rolf Hagman

Summary

Vehicles will remain important transport means for decades to come. Improving the environmental performance of vehicles is therefore an important issue. However, we need to be able to give a clear answer to what an environmentally-friendly vehicle is. Should we promote these vehicles? What are the experiences from such vehicles? Is it possible to provide a sound background for policymaking? These are the questions that are dealt with in this study for the Nordic Council of Ministries, Theme Group for Sustainable Mobility.

Experience of Environmentally-Friendly Vehicles and incentives

Different criteria are used to define environmentally-friendly vehicles in the EU, the USA and the Nordic countries. These criteria often mix performance and emission limits with technology and fuels. Certain technologies are pre-qualified as being environmentally-friendly. Alternative technologies and renewable fuels are tempting – but are no guarantee for great environmental effects. It is the real-life emissions with a specific fuel that indicate whether a vehicle is environmentally-friendly or not.

Authorities usually state that their own criteria are a success. The Californian Air Resource Board underlines the impact of the Zero Emission Vehicle programme and the pressure this has put on the vehicle industry. The Swedish programme, 'Miljöfordon', in Stockholm and Gothenburg is described as a success story. Since 2000, Denmark has used energy labelling for new vehicles. The Danish labelling system, together with high fees and taxation, is thought to have succeeded in making the vehicle fleet in Denmark highly energy-efficient. A common feature of programmes aimed at environmentally-friendly vehicles is that they are often poorly evaluated. Thorough analyses and evaluations should be part of all programmes and should stimulate improvements.

Labelling of environmentally-friendly vehicles

Environmental Product Information Schemes have been used on a wide range of products and services. The Euro NCAP's labelling, for example, has been an effective way of classifying and improving vehicle safety. The experiences from vehicle labelling in California, Sweden and Den-

mark, together with eco-labelling of other products, show that simple, well-evaluated labelling of environmentally-friendly vehicles can be an effective way to stimulate the market and influence the vehicle industry.

Our recommendations are to rely on existing label schemes, to develop easily- understandable, technology-independent criteria and to introduce economic incentives. Incentives such as tax reduction, access to sensitive areas, use of public transport lanes and free parking are means to stimulate the market to choose environmentally-friendly vehicles.

Technology independent criteria for light vehicles

In this report we will to use the acronym LZV, Low or Zero emission Vehicle to define a sufficient environmentally-friendly light vehicle. To qualify for LZV classification a vehicle must – in accordance with our considerations – comply with specified environmental criteria. These criteria must reflect strict high environmental values and must be supported by society.

The primary environmental concerns about vehicles are exhaust emissions that affect human health, global warming and high energy consumption. Zero and technology neutral exhaust emission limits can meet society's concern to reduce these environmental problems. In our opinion, technology-neutral criteria will stimulate the vehicle industry to develop the best and most economical solutions.

We recommend two main criteria to define a LZV. The two criteria are based on the knowledge we have today, are simple to understand and can be checked:

- Strict limits for the local pollutants NO_x, VOC and Particulate Matter
- Strict limits for CO_2 emissions, which also imply reduced fossil fuel consumption

As limits for local pollutants we suggest using the 'Californian Super Ultra Low Emission Vehicle limits for personal cars', since they are currently regarded as the most demanding criteria in the world. For the second criterion, we suggest 120 g CO_2/km. The emission values from mixed driving and the European Driving Cycle are well- known and mandatory for the homologation of all new car models in Europe.

In addition to the LZV rating, environmental vehicle criteria for the future may include:

- Strict cold start emission limitations at Nordic low ambient temperatures
- Life-cycle perspectives on CO_2 emissions including production, use and recycling
- Strict vehicle noise emission restrictions

LZV labelling – vehicle and fuel technology

Electric vehicles and fuel cell vehicles will easily comply with the suggested LZV criteria. A few hybrid passenger car models, lightweight petrol and diesel cars qualify or have the potential to qualify as LZVs, if they are equipped with efficient emission reduction systems. Methane/-biogas, LPG and hydrogen fuelled vehicles have CO_2-emission advantages, which help them to comply with LZV criteria.

Vehicles using renewable fuels contribute to reduced emissions of fossil CO_2. However energy efficiency and emissions of local pollutants may also be considered as important environmental criteria. In our opinion, alternative fuel vehicles should not be considered as LZV unless they comply with the two criteria for local pollutants and CO_2 emissions. Bio fuels can be used both in low mixtures with fossil fuels and in flexi fuel vehicles. Exemption from high Nordic rates of taxation on fossil fuels (60–70%) should, within a reasonable time frame, enable alternative fuels to be competitive. Incentives to increase the use of bio fuels should thus preferably be directed towards the fuel rather than the vehicle. Since Sweden strongly supports renewable ethanol, dedicated bio fuel vehicles may be classified in a sub-group of environmentally-friendly vehicles in addition to LZVs in some countries.

Heavy Duty Vehicles

In order to safeguard human heath, Heavy Duty Vehicles used in sensitive urban areas should only emit acceptable amounts of NO_x, VOC, and PM. Emissions from Heavy Duty Vehicles is a difficult topic since it is the engines that are regulated by EURO I–V emission limits and not the vehicles. Heavy Duty Vehicles equipped with engines that pass the strictest Euro limit may be classified as environmentally-friendly. The application of greenhouse gas emission limits to this category of vehicles is difficult, since vehicle weight, size, applications and emissions may differ considerably for the same engine.

1. Background, task and approach

1.1 Background

The project has been initiated and funded by the Nordic Council of Ministers, Theme Group for Sustainable Mobility.

Road vehicles will remain important transport means for decades to come. Improving the environmental performance of vehicles is therefore an important issue.

In Nordic literature and reports, environmentally-friendly Vehicles are largely specified according to their technology and the possibility of using alternative fuels. There have been initiatives involving tax reductions or other incentives as part of strategies to introduce new technologies, alternative fuels and low emission vehicles in the Nordic countries. Electric vehicles may be exempt from road taxes. Specified environmentally-friendly vehicles may also be permitted to use public transport lanes and free parking. In Sweden 25% of the public administration car pools are required to be environmentally-friendly vehicles.

Definitions of environmentally-friendly vehicles in the Nordic countries seem to focus on transmission technologies and fuel alternatives ("Avrapportering av regeringsoppdrag att ta fram en definition av miljöbilar" (Vägverket, 2004)).

Definitions of environmentally-friendly vehicles differ between regions and from country to country. This makes it confusing and difficult for consumers and for international action. Different definitions and confusion about criteria also makes it complicated for the vehicle industry to plan the types of fuels and propulsion technologies to be developed next and what the future generation of vehicles should be.

However neither technology nor alternative fuels are clean in themselves. For example hydrogen is no guarantee for avoiding harmful emissions since hydrogen used in combustion engines produces NO_x. Some natural-gas buses have shown to be high NO_x polluters when driving in real traffic, and bio-ethanol has the potential to emit harmful aldehydes when used in combustion engines. Hybrid vehicles which combine engines with electric motors may or may not have low emission levels.

The Auto Oil programme and the emission schemes for homologation of all new vehicles provide Europe and the European Union (EU) with efficient tools for reducing local polluting vehicle emissions. The Euro 1 emission limits from 1992 up to the Euro 5 limits in 2008–2010 are gradually reducing vehicle local pollutant emissions all over Europe. In addition there is a voluntary agreement between the European Union and the vehicle industry to reduce CO_2 emissions from new light vehicles.

The USA has generally been conservative with regard to automobile technology, but the State of California has long been at the forefront with mobile emission source control efforts through the Zero Emission Vehicle (ZEV) programme. However the original ZEV programme has been modified in light of litigation and new trends in ZEV technology and marketing. The focus in California is now increasingly directed towards acceptable low emission vehicles rather than on zero emissions.

The main environmental objectives in Europe, California and the Nordic countries are to improve the local air quality and to reduce the emissions of greenhouse gases. This can be done through use of zero and near-zero (low) emission technologies, alternative fuels, reformulated fuels and other pollution prevention methods. The objective is not to specify technologies or alternative fuels. The focus, in our opinion, should be on reducing the health and environmental problems by the use of electric vehicles, fuel cell technology and hydrogen or by extremely clean combustion engines and renewable fuels.

1.2 Tasks

The task we have been asked to deal with is to evaluate experiences in the Nordic countries, EU and USA, using different environmentally-friendly vehicles definitions and economic and administrative instruments to promote those vehicles. We will also analyse problems and advantages connected with emission limits as criteria for environmentally-friendly vehicles compared with a combination of technology and fuel restrictions. It is important to provide a sound scientific basis for representatives from the Nordic countries to be able to:

- Contribute and promote the work within and directed at the EU on schemes to promote Nordic interests concerning environmentally-friendly vehicles
- Suggest guidelines and criteria for Nordic customers to enable them to realise why and what they should be looking for when purchasing environmentally-friendly vehicles
- Suggest criteria for developing steering tools to promote environmentally-friendly vehicles
- Evaluate and discuss different labelling systems for vehicles

1.3 Approach

The work has been structured in three sections:

- Evaluation of experiences in the Nordic countries/cities and the EU and international use of environmentally-friendly vehicle definitions and steering tools to improve the integration of such vehicles
- Analysis, discussion and evaluation of environmentally-friendly vehicle criteria.
- Description and evaluation of different international attempts to label environmentally-friendly vehicles and other product categories

As a part of the evaluation we have interviewed several key persons in government and public administration. In addition we have sent a questionnaire to organisations and to the private sector.

Criteria for the definition of environmentally-friendly vehicles are discussed and summarised in chapter 3.

Definitions of environmentally-friendly vehicles and environmental product information are discussed in chapter 6 and 7. Conclusions and recommendations related to the tasks of this study are given in chapter 8.

2. Why environmentally-friendly vehicles?

2.1 Driving Forces

Transport is energy intensive. In the long run, the technology and energy used to provide this service should be sustainable. Strictly defined, this implies that the energy should be derived from renewable sources, and the entire energy chain, well to wheel, should not emit harmful emissions to the environment. In the present situation, almost all energy (over 95%) used in the transport sector is derived from fossil resources. Combustion of fossil fuels involves the emission of air pollutants with serious health consequences at both local and regional levels. Emissions of greenhouse gases, primarily CO_2, are scientifically regarded as having severe consequences for climate change and contribute to global warming.

The EU emission limits for local pollutants and new vehicles have not been tight enough to solve the local air quality problems in all urban areas. The CO_2 emissions from road transport are increasing. Thus, there are strong forces in society to take actions for clean technologies, lower energy consumption and sustainable fuels in the transport sector.

There are many other problems connected with the growing, worldwide transport sector, such as noise pollution, congestion and traffic accidents. These problems can also be solved to some extent by the introduction of new technology. Noise pollution, congestion and traffic accidents, together with vehicle emissions, can be reduced by reductions in transport volume and shifts in transport modes. Societal changes and changes in the structure of urban areas are often a consequence of traffic problems. Accomplishing changes at a socio-economic level includes actions to motivate a move towards using public transportation.

2.1.1 Air Quality and Health Effects

Harmful emissions from the transport sector include SO_2 (sulphur dioxide), NO_x (nitrogen oxides), CO (carbon monoxide), HC (hydrocarbons), and PM (particulate matter). Of these pollutants SO_2 is no longer considered to be a problem from road transport as a result of improvements in fuel quality within EU. However SO_2 is still a problem in the maritime sector. NO_x and PM are the major local pollutants from the road, ship and air transport sectors.

Air pollution can affect the lungs and heart, and may even cause cancer. The respiratory system is most commonly affected and evidence suggests that air pollution may play a significant role in exacerbating and perhaps even causing lung problems (SFT, 2006). Approximately one of ten adults now suffers from chronic respiratory diseases, which severely restrict the activities of these people. As air pollution can worsen their symptoms, it may seriously affect their quality of life (SFT, 2006).

A number of chemicals present in petrol and diesel fuels, exhaust fumes, engine lubricating oils and other accessories are known to be carcinogenic (cancer causing). Benzene and particulates are classified as ‘carcinogenic’, diesel exhaust as ‘probably carcinogenic’ and petrol exhaust as ‘possibly carcinogenic’. Some organic emissions, like benzene, are toxic and carcinogenic.

In 1990 the Swedish Environmental Protection Agency estimated that of Sweden’s 8.4 million inhabitants, between 300 and 2000 people would develop cancer each year because of general ambient air pollution. The main contributors to the cancer risk were particulates and polycyclic aromatic hydrocarbons both originating primarily from vehicles (exhaust and evaporative emissions). The report concluded that emissions of cancer-causing pollution had to be reduced by 90% in urban areas to protect public health (OECD, 1995).

In recent years, WHO expert groups have verified these and other findings. The WHO Air Quality Guidelines have therefore been revised several times and WHO has suggested a sharpening of the legislation. Both in EU/ECE and in US the Ambient Air Quality Limit Values have been lowered during the last 10–15 years. The risk of health effects due to air quality has been the main driving force in reducing the emissions from the transport sector, and has forced authorities to introduce regulations, both for urban air quality and for emissions from vehicles.

The concentration of particles in the air is measured in microgram/m^3, and particles with a diameter below 2.5 micrometer ($PM_{2.5}$) are regarded as a more severe problem than larger particles (PM_{10}). The concentrations of nano-sized (<0.1 micrometers, $PM_{0.1}$) particles in diesel exhaust are in the range of 10^8/cm^3. Nano-sized particles are attracting increased medical attention and are discussed as a potential health hazard since they penetrate deep into the lungs and may even penetrate into the blood vessels of the lungs.

EURO I–V emission standards for vehicles are important measures for improving air quality in urban areas.

2.1.2 Regional pollution – Acidification, Eutrophication and Ozone

NO_x and NMVOC (non-methane volatile organic compounds, the most important part of the HC emissions) result in the formation of ground level ozone or tropospheric ozone (O_3), a harmful substance causing damage to materials, crops and health, and contributing to smog formation.

NO_x and NH_3 (ammonia) contribute to eutrophication and acidification, and SO_2 causes acidification. In recent years, the effects of long-range trans-boundary air pollution have lead to increased international cooperation through Protocols under the UN/ECE Convention on Long-range Transboundary Air Pollution. Strategies to reduce acidification, eutrophication and tropospheric ozone formation have been drawn up under the UN/ECE and the Protocol to Abate Acidification, Eutrophication and Tropospheric Ozone, so-called “Gothenburg Protocol”, and the European Union, Directive on National Emission Ceilings.

The Gothenburg Protocol came into force on 17 May 2005. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_x, VOC and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties where emissions have a severe environmental or health impact, and who are capable of applying inexpensive measures, will have to make the biggest emission reductions. Once the Protocol is fully implemented, Europe’s sulphur emissions should be cut by at least 63%, NOx emissions by 41%, VOC emissions by 40% and ammonia emissions by 17% compared to 1990.

The Protocol sets tight limit values for specific emission sources (e.g. combustion plants, electricity production, dry cleaning, cars and Heavy Duty vehicles) and requires best available techniques to be used to keep emissions down. The requirement to use vehicles and engines certified according to EURO I–V is one answer to the Gothenburg Protocol. EURO I–V limits are considered to be the best available technique with specified time frames and setting tight limits for exhaust emissions.

2.1.3 Greenhouse gases

The transport sector is a major contributor to the emission of greenhouse gases in all industrialised countries. The greenhouse gas CO_2 from vehicles is most important since it contributes 20–30% of the total CO_2 emissions from the Nordic countries.

In the Kyoto Protocol of 1997, industrialised countries agreed to reduce their emissions of greenhouse gases to the atmosphere. The reduction obligations, of an average of 5% of the 1990 level until 2012, differ from country to country. USA and Australia have withdrawn their commitment, but the protocol has been ratified, accepted, sanctioned or approved by 151 other countries including the EU countries and Norway (Kyoto Protocol, Status of Ratification, 12. July 2005 (UNFCCC). Among these countries there are 30 Annex I Parties (industrialized countries). The industrialised counties will face extra pressure to find measures to reduce greenhouse gases.

The European Community has declared as part of the ratification that: “The European Community and its Member States will fulfil their respective commitments of the Protocol jointly in accordance with the provisions”.

With hydrocarbon fuels, CO_2 emissions are directly linked to the amount of fuel consumed in the transport sector, i.e. the fuel efficiency of the vehicles. Improvement in fuel economy is therefore an immediate technological solution, but there is obviously a limit to the reductions obtainable in this manner. For further reductions, it will be necessary to turn to CO_2 neutral fuels or energy carriers with less carbon content per unit of energy, and ultimately to zero carbon fuels like electricity and hydrogen.

The Association of European Car Manufacturers (ACEA) and Japanese and Korean exporters have agreed with the EU Commission to achieve average emissions of 140 g CO_2/km by 2008 and 120 g CO_2/km by 2012. However after experiences from CO_2 emissions developments and the market demand the European Car Industry addressed the question if these targets are too ambitious.

In February 2007 the European Commission responded and published that it will pursue an integrated approach with a view to reaching the EU objective of 120 g/km CO_2 by 2012. This can be achieved through a combination of EU and Member States action. The Commission will propose a legislative framework, if possible in 2007 and at latest by mid 2008, to achieve the EU objective of 120 g/km CO_2, focusing on mandatory reductions of the emissions of CO_2 to reach the objective of 130 g/km for the average new car fleet by means of improvements in vehicle motor technology, and a further reduction of 10 g/km of CO_2, or equivalent if technically necessary, by other technological improvements and by an increased use of bio-fuels.

If the new EU targets are achieved by the car manufacturers and accepted by the market, this could be an important measure and a step towards a fulfilment of the EU commitment under the Kyoto Protocol.

3. Defining environmentally-friendly vehicles

This chapter discusses the following questions:

- Is it possible to work towards a universal and technology-neutral definition for environmentally-friendly vehicles?
- Will such a definition gain broad acceptance by stakeholders and car producers?
- What should the emission characteristics for environmentally-friendly vehicles be?
- How should renewable fuels be treated in light of a technology-neutral definition?

Emission characteristics are an alternative to the use of a specific vehicle technology and specification of fuel alternatives. Characteristics such as zero emissions or extremely low levels of emissions do not bind the vehicle suppliers to specific technologies or fuels. Open opportunities to approach problems related to pollution from vehicles, engines and road traffic are probably the best and preferred way to stimulate a dynamic and competitive vehicle industry. Encouragement to find solutions and to comply with specified targets will lead to the development of economical and efficient technical solutions. Efficient and attractive technical designs and solutions are essential for market penetration of environmentally-friendly vehicles.

Alternative fuels are expected to gain in demand with the future anticipated shortage of fossil oil, future shortages of natural gas and increased concern about global warming. Emissions from vehicles are dependent on a combination of choice of fuel, the conversion process of chemical energy to motion and clean-up systems. We find technology-neutral and fuel-neutral vehicle criteria to be appropriate, preferable and simple to understand.

We will conclude that technology and fuel-neutral vehicle criteria can be made elegantly simple and will stimulate the vehicle industry to develop the best and most economical solutions to both global and local environmental problems.

However, objections to technology neutral-criteria can be expected from different stakeholders. Stakeholders may have political or economical interests that in the short run are best served by technologically-specified criteria for vehicles or defined fuels.

3.1 Technologically-neutral criteria for a Low or Zero emitting Vehicle, LZV

There is a great interest among politicians, environmentalists and the general public in promoting environmentally-friendly vehicles. To further increase the interest and to give incentives that stimulate the industry, it is necessary to define specific criteria for characterising vehicles as environmentally- friendly. A commitment to respected and accepted criteria for Low or Zero emitting Vehicles, LZVs will support local incentives, and international cooperation. The abbreviation LZV has been chosen in accordance with similar abbreviations from California and the Californian Air Resources Board, CARB. In our opinion, a LZV shall be a vehicle that complies with the most stringent local emission limits as well as with global emission standards for greenhouse gases.

The main environmental objectives in most countries are to improve local air quality and reduce the greenhouse gas emissions. This can be done through combinations of zero, near-zero and low emission technologies, renewable fuels and other pollution- prevention methods.

There are several reasons for choosing technology neutral criteria to define environmentally-friendly vehicles (LZVs). Technology-neutral criteria are robust, can be elegantly simple, easily understood, internationally verified and will give the automobile industry opportunities to find the best solutions to the challenges.

When defining criteria for environmentally-friendly vehicles we have to bear in mind that the objective is not to specify technologies or alternative fuels but to reduce environmental stress. It should not make any difference whether the problem is solved by fuel cell technology or by extremely clean combustion engines.

In contrast to technology-specific regulations, characteristics such as zero emissions or extremely low levels of emissions do not bind vehicle suppliers to specific technologies or fuels. Well-defined emission limits will ideally stimulate the vehicle industry to develop the best and most economical solutions to environmental problems.

On this basis we recommend defining highly environmentally-friendly vehicles as Low or Zero Emission Vehicles, LZVs, if they comply with the most demanding local emission limits. The most demanding emissions requirements for vehicles in 2007 are regarded to be the Californian Super Ultra Low Emission Vehicle, SULEV limits. Specific emission limits for new European passenger cars and SULEV limits are shown in table 1.

Table 1: European emission limits for light vehicles, and Californian emission limits for Super Ultra Low Emission Vehicle, SULEV light vehicles

Light vehicles	PM(g/km)	NO_x(g/km)	HC(g/km)	CO(g/km)
EURO IV[1] – from 2005 petrol		0.08	0.100	1.00
EURO V[1] – from 2009 petrol	0,005	0.06	0.100	1.00
California SULEV[2]	0,007	0,015	0,007	0,70
EURO IV[1] – from 2005 diesel	0.025	0.25		0.50
EURO V[1] – from 2009 diesel	0,005	0,18		0,50
		NO_x + HC (g/km)		
EURO IV[1] – from 2005 diesel		0,300		
EURO V[1] – from 2009 diesel		0,230		

[1] EDC Test Cycle; [2] California emission limits transformed to g/km from g/mile

These criteria, relating to local air pollution, need to be combined with strict limits on the emission of greenhouse gases. Based on the voluntary agreement between the EU, the Association of European Automobile industries, ACEA and others, we suggest using 120 g CO_2/km in mixed driving European Driving cycle, EDC, as an appropriate limit.

3.1.1 Discussion of selected LZV criteria

For the future it is necessary to search look for a global and technology-neutral LZV definition, based on future accepted emission test regimes and test cycles. Strategies and the future of sustainable transport involve political decisions. Internationally and politically acceptable criteria for environmental vehicles are essential. However, in addition to basic LZV emission criteria there should be room for national interests and the promotion of vehicles with different fuel alternatives that are of local or national interest.

The main environmental objectives in most countries are to improve local air quality and reduce greenhouse gas emissions. This can be done through increased use of LZV emission technologies, alternative fuels and other pollution-prevention methods. However, it needs to be born in mind that the objective is not to specify technologies or alternative fuels. Whether emission problems are solved by fuel cell technology or by extremely clean combustion engines should make no difference.

Society is primarily concerned about exhaust emissions that directly affect human health, the natural environment, global warming and energy consumption. Zero and low exhaust emission limits are technology-neutral criteria that will meet society's concerns and the need to reduce these problems. Well-defined, predictable emission limits will very likely stimulate the vehicle industry and make it possible to develop the best and most economical solutions to environmental problems.

Technology alone may not always define if a vehicle is environmentally- friendly. Renewable bio fuels and carbon-lean or carbon-free fuels are preferable from a global warming point of view since they contribute to reduced emissions of fossil CO_2. In addition, they reduce our dependence on fossil oil. Zero emission is possible with pure electric drive and vehicles with energy stored in batteries or hydrogen. Basically, we want vehicles that satisfy our needs, but we do not want them to affect our health, disturb us or be a dangerous threat to the future of mankind.

Several flexi fuel vehicles can use both fossil fuels and bio-based fuels. However, in our opinion, technology- independent criteria should not look at the source of the fuels, and only relate to the emitted quantities of CO_2. Low energy consumption and low CO_2 emissions have values of their own. Incentives intended to favour special fuels such as ethanol, bio-diesel or the next generation of bio fuels can be supplementary to incentives that support the marketing of LZVs.

In the Nordic countries and several other European countries, fossil petrol and diesel fuels are taxed so highly that the international market price only represents about 30–40% of the retail price. This creates an opportunity for the authorities to provide incentives for the market and to stimulate distribution of alternative fuels at a competitive price. The international market price for ethanol and bio-diesel may consequently carry twice the duty and tax-free price of fossil fuels and still be competitive. Authorities can thus subsidise alternative fuels for a long introductory phase simply by allowing them to be free of duties and taxes. An economic advantage of 60–70% for renewable alternative fuels is, in our opinion, a substantial benefit. However, there is a limit to how much society ought to subsidise promising new fuel alternatives. Our thoughts are that additional subsidises for flexi fuel vehicles or classifying them as LZVs even though they do not qualify in terms of measured emissions is a step too far.

Knowledge about environmental threats and the opportunities to reduce environmental problems increases as a result of technical developments and scientific research. At the same time, the environmental agenda and political priorities may change. Environmental standards, including the environmentally-friendly vehicles definitions above, should therefore be reviewed and redefined on a regular basis.

It may be that vehicles with diesel engine, exhaust cleaning and hybrid power trains are the ideal and most cost-effective solutions to city transport. We do not know this for certain, but with an effective cleaning system they could comply with close to zero particle emission and even comply with extremely low NO_x emissions levels as well as acceptable CO_2 emissions.

Noise and vehicle safety are not included in our criteria for LZV classification. Low noise and high vehicle safety according to Euro NCAP's labelling are related to attractive and environmentally-friendly vehicles. However, here we have chosen to focus specifically on local air pollution and global warming emissions.

We are convinced that LZVs will represent an efficient contribution to reducing environmental problems. LZVs are not likely to be an impediment for efforts to achieve sustainable transport with pure electric drive or fuel cell vehicles. Hydrogen and other renewable fuels together with sufficient LZVs have to be competitive from a holistic point of view. Efficient LZVs with low emissions of local pollutants and CO_2 also comply with reduced energy consumption.

Whether the defined low CO_2 emissions originate from bio- or fossil fuels is relevant for global warming but not for energy consumption. Vehicles with low carbon fuels such as hydrogen and methane are favoured to some extent by the simple CO_2 limits, without low energy consumption demands. Vehicles that can use bio fuels are not favoured, since they emit approximately the same amounts of CO_2 whether the fuel is based on fossil energy or bio-energy.

3.1.2 Summary of requirements for environmental Low or Zero emission Vehicles, LZVs

Low or Zero Emission Vehicle criteria could in our opinion be:

- The strictest available legislation limits for the local pollutants NO_x, VOC and PM (Particulate Matter) – in 2007 the strongest US CARB limits are regarded as meeting this specification
- Strict limits for CO_2 emissions – mean 120 g CO_2/km in mixed driving

3.1.3 Indicators for local air quality and transboundary air pollutants – health impacts, acidification and ground level ozone

In Europe, local pollutants are regulated via the EURO I–V emission limits for all new vehicles. America, Japan and other resource-rich regions have corresponding regimes. This allows for use of the quantifiable emission indicators PM_{10}, NO_x, CO, HC/NMVOC/VOC (different specifications of non- burned fuel hydrocarbon compounds). The emissions of these pollutants are measured as a gravimetric amount per km (g/km) for light vehicles and as a gravimetric amount per energy unit, kWh (g/kWh) for engines in heavy duty vehicles. When dispersed in air and affecting air quality, pollution is measured as a gravimetric amount per cubic meter (g/m^3).

Sulphur dioxide, SO_2 is an air pollutant from road traffic but is entirely dependent on the original amount of sulphur in the fuel. A combustion engine simply transforms all (almost) sulphur to SO_2 and a vehicle cannot be environmentally- friendly without acceptable low concentrations of sulphur in the fuel. The fuel directives within the European Auto oil programme consequently prescribe limits for sulphur content, and SO_2 emission is not a characteristic for the vehicle.

Emission data from legislation emission tests of new car models are reliable and available. Legislation emission data from new car models are therefore well suited to serve as criteria for environmentally-friendly vehicles and ZLV classification.

3.1.4 Indicators for global impact – climate change and energy resources

There are two indicators for emissions of greenhouse gases and the impact on global energy resources. Emission of CO_2 per km (g/km) or even better, emission of CO_2-equivalents/km. Emission of CO_2-equivalents/km is the sum of the greenhouse gases CO_2, CH_4 and N_2O. The other indicator is the consumption of energy and is best described as energy efficiency. Energy efficiency for vehicles is measured as the consumption of energy per km (kWh/km or MJ/km).

Emission of CO_2 is a result of combustion of carbon rich fuels. Bio-fuels are produced from bio organic mass and consist of carbon compounds. However bio-fuels are classified as climate neutral, since the combustion and emission of CO_2 is part of a short-term carbon cycle. In contrast to fossil carbon compounds, the combustion of bio-fuels does not emit additional CO_2 to the atmosphere.

3.1.5 Cold start emissions at low ambient temperatures

In the Nordic countries air pollution is a much more difficult problem in wintertime than in summer. Humans suffering from respiratory problems have an increasing sensitivity to polluted air at low ambient temperatures and in Nordic climates (NAAF).

Insufficient air quality in winter is caused by weather conditions, topography and as a result of vehicle cold start emissions at low ambient temperatures. Inversion on clear cold winter days, where warm air forms a lid, which prevents the polluted cold air at ground level from circulating, is a problem. Air quality problems in wintertime are typical for mountain areas with deep valleys and fjords and the above meteorological conditions.

Nordic countries took the initiative for mandatory cold start emission tests at low ambient temperature (-7ºC) for light vehicles from 2002. The intention was to prevent vehicles, which pass the European Driving Cycle, EDC (cold start at 20–25ºC), from being heavy polluters at low ambient temperatures. The demand for stricter cold start emissions levels at low ambient temperatures can improve air quality in cold climate areas. Evaluating more stringent low ambient emission limits may be a suitable research task for the Nordic countries.

3.1.6 Indicators for local noise – health impacts

Noise from vehicles is measured in dB(A) and limits for noise are required for homologation of new vehicle models. The dominant source of noise is tyres, particularly in connection with high speed. Even though vehicle noise may be a health problem, we do not see much benefit in defining tighter criteria for noise from LZVs than for ordinary new vehicles.

Generally, vehicles with electric or hybrid drive have lower noise emissions from the transmission than vehicles with a conventional combustion engine.

3.1.7 Indicators for accident safety and health impacts

All new car models have to pass homologation crash tests to show that they satisfy safety limits. However it is not mandatory to state how well the cars pass the tests.

The NCAP "stars" classify how well a vehicle model perform in crash tests and most manufactures voluntarily use the NCAP-test to show the safety standard of their new models. As with noise, we regard crash safety to be important but have decided not to include it in the LZV requirements.

3.2 Objections to technology neutral criteria

Manufacturers who make their profits from producing large vehicles like SUVs are obviously likely to object to incentives for lightweight and low energy consuming cars. Companies and importers of vehicles may not be ready to adapt or adjust to new and stricter environmental demands. Some countries may have invested in industrial solutions and transport policies for economic growth that are in conflict with low emitting vehicles.

National and industrial interests are different in different countries. Settlement patterns, social structures, resources and different industrial strategies will influence attitudes to the introduction of new technologies, environmentally-friendly vehicles and alternative energy carriers.

Denmark has developed wind power plants as a profitable industry. Sweden has put great efforts into becoming a leading nation in technology for renewable fuels and reducing its dependence on oil. Swedish car producers have invested in flexi fuel cars. Norway has oil and gas resources and an oil industry that contribute considerably to the national wealth. Finland has invested in nuclear power. Iceland has extensive natural resources in hydropower and geothermal energy which make future hydrogen production feasible. Regionally, there may be political interest in redeploying agricultural capacity in the direction of renewable fuel production.

Some Non Governmental Environmental Organisations, (NGOs) and environmentalists are likely to argue in favour of Zero Emission Vehicles (ZEVs) as the only acceptable solution. Zero Emission Vehicles is a good, technology-neutral definition with the implication that only zero emission of all environmental pollutants and greenhouse gases is good enough. The implication is that LZVs with any measurable emissions are unacceptable.

The market and customers are interested in attractive, comfortable, safe and affordable vehicles. Parts of the market regard powerful and heavy vehicles with high energy consumption as attractive and are not motivated to change their means of transport. The production costs of environmentally- friendly technology systems and components such as electric drive, hybrid drive and batteries are higher than for conventional combustion engines. High costs and to some extent the preferences of the customers are a hurdle for the switch to clean technology. The market itself is has its objections and needs to be motivated and stimulated to choose environmental vehicles.

Alternative fuels have the potential to reduce fossil CO_2 emissions. Evaluating alternative fuels in a Well to Wheel perspective and not only Tank to Wheel, is however necessary in order to obtain the whole, correct picture. The EU has recently published a study “Well-to-wheel energy use and greenhouse gas emissions” for a wide range of potential future fuel and power train options (EUCAR, CONCAWE and JRC (the Joint Research Centre of the EU Commission, IES Ispra)). This study was updated in March 2007 and is among other well to wheel assessments a background for our discussion on how to handle alternative fuels. The fuel by itself is neither environmental friendly nor polluting but combusted in an engine or together with vehicle technologies it has an environmental effect.

A challenge is that fluid hydrocarbon fuels are very convenient to use in road vehicles and when combusted these fuels emit CO_2. Petrol or diesel fuels may originate from fossil energy as fossil oil or natural gas but they may also be produced from biomass. The origin of fuels and whether the fuels are CO_2 neutral or not, makes defining environmentally-friendly vehicles somewhat complicated. It can be argued whether the possibility of using CO_2 neutral bio fuels should qualify a car for a LZV label or not.

4. Propulsion technologies

In this chapter we present known propulsion technologies, which, with sufficient fuel alternatives, are used in or have the potential to create clean vehicles, LZVs. Basically, a vehicle can be powered by a combustion engine or an electric motor. We briefly discuss the commercial status, the possibilities and we try to estimate a time frame for possible commercial introduction of more futuristic technological systems.

The internal combustion engine, fuelled by petrol or diesel, is currently the totally dominant technology for vehicle propulsion. New light vehicles with combustion engines have efficiency from tank to wheel in the order of 15–20%. Today’s compression ignition diesel engine is about 20–25% more efficient than the spark ignition petrol engine. Direct fuel injection has been practised for heavy-duty diesel engines since the 1950s. The introduction and development of injection systems for small diesel engines for light vehicles since 1990 has led to great improvements in performance and efficiency.

In Europe light diesel vehicles have captured an increasing share of the market for new cars compared with light petrol vehicles. The focus on efficiency and a robust power source favours diesel engines.

Electric power and electric motors are superior to combustion propulsion in every way. Electric drive has the advantage of zero emissions and efficiency from power source to the wheels of about 85%. The energy for electric drive can be stored in batteries, or stored as hydrogen for conversion to electric power in fuel cells. The superior efficiency in converting electric energy to useful power on the wheels is a strong argument for electric drive. However, challenges with storage of electric energy and the technology gap for fuel cells are major barriers to their commercialisation.

4.1 LZV possibilities with combustion engine vehicles

Combustion engines have been produced and continuously developed for more than 100 years. Even though combustion engines are complicated with a lot of moving parts, they are very competitive and have the potential for further development. Acceptable low limits for emission of local pollutants appear to be within reach in the next 10 years (Oberg, 2001).

Weight and size are important for energy consumption and low CO_2 emission with carbon-rich fuels. With a vehicle weight of 1000 kg, an extra weight of 100 kg potentially increases the fuel consumption by about 7% (Kågeson 2005).

Small cars with small diesel engines such as the Volkswagen LUPO have achieved a fuel economy of 3,0 l/100 km. Volkswagen, a pioneer in the development of advanced diesel engines, has a theory that petrol and diesel engines may merge to a universal all purpose combustion engine using clean synthetic fuels (Oberg, 2001). The exhaust cleaning systems in diesel vehicle have to some extent solved technical challenges of high emissions of PM and NO_x. Stricter legal emission limits for new cars, are from our point of view, expected to force the vehicle industry to equip new light diesel engine vehicles with both efficient particle traps and appropriate NO_x reduction technology within 2009.

Small petrol vehicles have few problems in complying with the LZV limits for local emissions. The greenhouse gas limit of 120 g CO_2/km is more or less a question of vehicle weight and engine displacement. New and advanced engine technology for petrol combustion may also be a future pathway to achieve the CO_2 limit. To satisfy customer demands for somewhat larger petrol passenger cars it is possible to lower fuel consumption by combining combustion engines with electric drive in petrol hybrid cars and in that way reduce CO_2 emissions.

Dedicated methane, LPG, DME combustion engine vehicles have the competitive advantage of low or carbon content per unit of energy for methane, LPG and DME and thus low CO_2-emissions. Hydrogen fuelled vehicles always has zero CO_2-emissions. Since these fuels also have the potential advantage of very clean combustion, vehicles dedicated to alternative, clean fuels are strong candidates for qualifying for our proposed LZV criteria.

Advanced exhaust clean-up is a necessity with most fuels. However dedicated engines for clean fuels such as synthetic fuel, methane (from bio- or natural gas), hydrogen and DiMethyl Ether, DME, will have the advantage of simpler, low-cost emission reduction systems. A drawback is that vehicles that could use these alternative fuels often have their engines adjusted relatively simply for the alternative fuel and may not burn the fuel as efficiently and cleanly as they could potentially.

Vehicles with combustion engines using hydrogen as fuel will qualify for LZV status if the NO_x emissions meet with the prescribed limits. Since hydrogen is burnt without CO_2-emissions, hydrogen vehicles will never exceed CO_2-emission limits. However, energy efficiency, Tank to Wheel, will be low for hydrogen vehicles with combustion engines which might make classifying them as LZVs somewhat open to dispute.

Flexi-fuel vehicles, which can combust ethanol or bio-diesel, must comply with both local emission limits and CO_2-emissions to qualify for LZV status. As discussed earlier they will not be allowed to emit over 120 g/km of CO_2, even if the combustion of bio fuels is regarded as CO_2 neutral.

Vehicles with combustion engine and increased use of alternative bio-based fuels are expected to have the potential to play an important role for road traffic the next 25 years (Bio fuels in the European Union). With bio fuels that can be mixed with fossil fuels in different proportions, there is a limited need to develop specialised engines and additional infrastructure. Our conclusion is that a vehicle with combustion engine, to qualify as environmentally- friendly and a LZV, must fulfil understandable simple terms of CO_2 and local emission, independent of fuel origin or fuel mixes.

4.1.1 Hybrid Electric Vehicles

One approach to improve efficiency and reduce emissions for combustion engine vehicles is to use hybrid technology with combined electric propulsion. The hybrid concept, where the transmission includes a combustion engine and an electric motor plus batteries for energy storage, is commercially available from at least two international vehicle producers. Others major producers are preparing to introduce hybrid technology in their new models. Mild hybrid vehicles produced in large numbers with low production costs are with increased oil prices expected to become a profitable choice for ordinary customers.

There are different ways for configuring the hybrid functions. Basically, the combustion engine powers a generator, which provides electric power for a motor to drive the wheels. The hybrid passenger car model, Toyota Prius, has complex energy management systems that make it possible to combine the best features from combustion engines and electric drive. The Honda Civic hybrid with integrated motor assist, IMS has an efficient mild hybrid system. With mild hybrid systems the electric power contribution is relatively small compared with the combustion engine, and may be produced from a combined flywheel-starter-generator and a battery. Battery electric vehicles may in principle move towards hybrid propulsion with a small combustion engine or small fuel cells as range extenders and to charge the batteries.

Hybrid Electric Vehicles offer several advantages. The combustion engine may run at optimum speed and load to yield maximum efficiency. Locally harmful exhaust emissions can be significantly reduced during harsh transient driving and be totally eliminated during short periods of electric urban driving. Brake energy can be recovered and stored in the battery. The engine can stop and restart according to the need for power. Idling is unnecessary and extra power for acceleration and climbing can be drawn from the battery. Well-to-Wheel studies indicate that hybrid light vehicles equipped with compression ignition engines will be comparable with fuel cell vehicles, with respect to energy efficiency and CO_2 emissions in a life cycle perspective (Wriss, M. et al, 2000).

The hybrid passenger cars the Toyota Prius and the Honda Civic hybrid already satisfy the LZV criteria and other hybrid passenger cars will have the potential to satisfy both air pollution exhaust emission and emission of greenhouse gas LZV limits within a few years.

4.1.2 Exhaust Clean-up

Local air pollution problems were recognised 30–40 years ago, and it was a significant leap forward when the three-way catalyst for petrol vehicles was introduced 25–30 years ago.

The three-way catalyst emission reduction capacity has improved over time and is by now to a large extent capable of eliminating CO, HC and NO_x from hot engine exhaust. The remaining harmful local emissions for new petrol vehicles are related to congestion with harsh transient stop-start driving. Harsh transient driving must comply with the ability of the closed loop system to regulate the air/fuel mixture. Only accurate regulation makes it possible for the catalyst to clean up the exhaust.

In addition to transient driving, cold start emissions still remain a challenge for petrol vehicles and the three-way catalyst. Modern petrol vehicles emit extremely low amounts of local pollutants when the three-way catalyst is working properly. The challenge is a cold start with rich air/fuel mixture to ensure ignition and light-off temperature for the catalyst. At Nordic low ambient temperatures, even modern petrol cars with certified low emission levels contribute to local pollution since the time taken by the catalyst to reach light-off temperature is longer in wintertime.

Diesel exhaust still poses problems, especially with regard to PM, particles and NO_x. Modern direct injection and lean-burn petrol engines also have such problems, which cannot be satisfactorily solved with the three-way catalyst technology. Therefore, great efforts are being made to develop exhaust cleanup systems that can adequately handle these problems. The automotive industry appears confident that these problems can be solved. Efficient particle filters are available but convenient NO_x reduction systems still lag behind. There is a DCAT NO_x catalytic converter available that appears to reduce the NO_x on one car model by about 50%, when the car is new. Chemical reduction of NO_x with urea is another alternative as an exhaust after-treatment system. The timeframe for a general introduction of real effective and commercially-available diesel exhaust cleaning systems on new vehicles is estimated to be 5–10 years.

4.2 LZV and electric drive

Electric motors as the source of power in vehicles are superior to combustion propulsion in all ways. Electric drive with energy stored in batteries, or stored as hydrogen for conversion to electric power in fuel ells has the advantage of zero emissions. Electric propulsion provides efficiency from electric source to wheels of about 85%. However challenges with the storage of electric energy and a technology gap in fuel cells are major barriers to commercialisation. The superior efficiency from electric energy is a strong argument for research to try to find means to store electric energy in a vehicle in an economically acceptable way. With a future invention of lightweight, high energy density, long life and low cost batteries the ideal environmentally- friendly vehicle could be in sight.

All electric vehicles will qualify for LZV classification unless an extension range engine or a combustion warming system contributes to substantial high emissions. True zero emission vehicles are thus vehicles with electric drive and energy stored in batteries, or as hydrogen for conversion to electric power in fuel cells.

4.2.1 Electric Vehicles

The only real zero emission vehicles that are or have been commercially available on the market are electric vehicles. With energy stored in batteries and with no exhaust, there are no exhaust emissions. The electricity required for charging them may of course produce emissions when electricity is generated. However electricity production is not a vehicle characteristic and should not be a part of vehicle environmental characterisations. The international car industry has produced prototypes, a range of battery models has been demonstrated and small series have even been produced for the market.

PSA – the Citroën/Peugeot group in France – produced and again produce small series of small electrical vehicles. GM offered their advanced “EV1” for lease and retail sale in the USA. In Norway, Th!nk produced nearly 1000 electrical vehicles, and when purchased by Ford they worked on a new model. However Ford’s motivation to produce and market electrical vehicles vanished when the American Motor industry won a legal trial against the State of California and the plan to force the vehicle industry to sell set numbers of zero emission vehicles from 2003.

Electrical vehicles are the most energy efficient vehicles in a ‘Tank (or electric source) to Wheel’ perspective but they also have severe limitations. Only small amounts of energy have been possible to store in the batteries, which limits the range of the vehicles before recharging is required. Charging the batteries is generally time-consuming, and batteries are traditionally heavy and expensive. Progress is being made in battery technology development, and Lithium Ion batteries are regarded as a promising future solution for electric vehicles. Great breakthrough has been expected before but so far costs and reliability have not proved to be competitive. At present, it seems as though the use of electric vehicles will be restricted to certain niche markets, such as light fleet vehicles for special distribution purposes. They also have a potential as commuter vehicles, as the second car in a household, and for urban driving.

The number of electric vehicles may well increase up to 2015. Small lightweight battery vehicles might very well become competitive for short distance commuting, if the automotive industry invests in this market segment.

4.2.2 Fuel Cell Vehicles

Almost all the major vehicle producers have developed and tested prototype fuel cell vehicles. Small series of prototypes and demonstration vehicles are planned. As with the fuel cell buses in the European CUTE project, these vehicles are not yet mature or ready for production and commercial marketing.

Fuel cell vehicles have the capability to achieve zero emissions without compromising performance and comfort. The fuel cell is an electrochemical converter that can be fuelled from on-board fuel storage, thus providing a much longer range before refuelling than electric vehicles with all energy stored in batteries. There are several different types of fuel cells. The type being seriously considered for propulsion of vehicles is the Proton Exchange Membrane, (PEM) fuel cell. In PEM cells, hydrogen fuel reacts with oxygen from air, generating electricity, heat and pure water. Electricity then powers the motor and drives the wheels. The heat that is generated in the fuel cell may be utilised for vehicle compartment heating in cold weather. Fuel cell vehicles will ideally be equipped with some battery capacity to allow downsizing of costly fuel cell stacks. As in combustion engine hybrid electric vehicles, regeneration of braking energy is to some extent possible with fuel cell vehicles, when batteries are included in the propulsion system.

Hydrogen-powered fuel cell vehicles have the potential to become a sustainable technology alternative for the transport sector. The fuel, hydrogen, may be produced and distributed without harmful effects in relation to the environment. With hydrogen produced from partial oxidation of natural gas, the sustainable fossil free CO_2 ‘well to wheel’ perspective is violated.

Fuel cell vehicles are not likely to be commercially available, at least not the next ten years. Reliable information about fuel cell vehicle development and when they will be commercially available is difficult to obtain. Japanese and European automotive companies have stated that Fuel Cell Vehicles will not be commercially available until 2015 or 2020. However Honda states that they will begin limited marketing in Japan of a totally new fuel-cell vehicle model in 2008. In the U.S.A, Larry Burn of GM states that GM will deliver fuel cell vehicles in 2010. It will be interesting to see what GM and Honda really will deliver and market.

The serious challenges for Fuel Cell Vehicles production are compatibility with cold ambient temperature conditions, durability and high production costs. Storage of hydrogen in vehicles is accomplished with high-pressure tanks (up to 700 bars). More efficient on board storage may in the future be provided using solid carbon structures and other promising material compounds solutions with high hydrogen density storage capacity.

It is generally agreed that one possible way of introducing hydrogen-powered fuel cell vehicles is to start with buses. Bus systems can deal with the on-board storage and infrastructure challenges in a convenient way. With local fleet vehicles it is possible to test new fuels, new technologies and increase the vehicle production in small and controlled steps.

Even if or when the technical and economical problems with fuel cell vehicles are solved, the challenges to produce and distribute hydrogen in a commercially- acceptable and competitive way remain. For success the Well to Wheel chain must be competitive with bio fuels and synthetic fuels in future combustion hybrid vehicles.

The infrastructure for hydrogen refuelling is not available today except at a few demonstration sites. Making hydrogen generally available will be expensive. Efficient sustainable production of hydrogen and filling facilities are seen as barriers to the speedy introduction of fuel cell vehicles if or when they are commercially available.

Electric vehicles with energy stored in batteries or as hydrogen, represent true Zero Emission Vehicles. As such, they will pass the strictest limits and qualify as LZVs.

4.3 Environmentally- friendly Heavy Duty Vehicles

Buses and delivery trucks are necessary in large cities to fulfil the needs for public transport and the delivery of commercial products. The diesel engine is the preferred source of power for heavy-duty vehicles. Diesel engines are reliable, efficient, economical and powerful. However a challenge is that heavy duty vehicles with diesel engines in normal urban traffic conditions emit considerable amounts of particles and NO_x.

An engine concept called Homogeneous Charge Compression Ignition mixes the petrol and diesel engine concepts. Homogeneous Charge Compression Ignition prototype engines have been laboratory tested with several fuel alternatives, and are promising concepts for future clean and efficient combustion propulsion. According to Swedish heavy duty vehicle manufacturers, this engine concept has the potential to become the source of power for their vehicles in 15 years. Possible advantages are that high efficiency, combined with clean emissions, is within reach without complicated and costly cleaning systems.

In recent years, clean low sulphur fuel in Europe and improved combustion in new diesel engines have lead to significant improvements regarding diesel exhaust emissions. Most harmful compounds in the exhaust, except for PM and NO_x, are reduced to near zero levels with new technology. The challenge to reduce PM and NO_x emissions is a primary objective for heavy-duty vehicle manufacturers. Efficient, continuously self-cleaning filters seem to be a solution to the particle emission problem and practical solutions to the NO_x-reduction challenges seem to be within reach.

An alternative to diesel engines in heavy duty vehicles is natural gas vehicles. Natural gas (CNG), bio gas or methane buses are popular in environmentally-sensitive centres of large cities, since they do not generally emit particles from combustion. Ethanol buses have become popular in Stockholm, Sweden since they are cleaner than ordinary diesel buses and since their emissions of CO_2 are regarded as neutral to global worming.

A simple and convenient way to achieve more environmentally-friendly bus services and reduce fossil CO_2 emissions is to mix the fossil diesel with bio diesel or CO_{2}- neutral synthetic diesel fuels from biomass.

For heavy duty vehicles, it is difficult to impose limits on fuel consumption and CO_2 emissions. Different buses and trucks are not directly comparable since they come in a variety of sizes and with very different load capacity. One large heavy duty vehicle with high CO_2 emissions and large load capacity might be a better environmental choice than two smaller vehicles with equivalent load capacity. For large-scale transporters, fuel price motivates the choice of the most fuel efficient option.

Environmentally-friendly heavy duty vehicles in sensitive city centres should have restrictions on the emission of local pollutants. Limits for emissions of NO_x, VOC, and Particles from engines for heavy-duty vehicles are well defined by the EURO IV and V limits.

The emission approval scheme for heavy duty transport is not related to vehicles but to engines. The European Transient Test Cycle for engines for heavy-duty vehicles has been developed to make sure that engines with advanced clean-up systems perform well in real traffic situations with transient engine loads.

The EURO IV, and from 2008 the EuroV limits for tests with the transient engine test cycle are technology-neutral simple criteria and may to some extent be suitable for classifying heavy duty vehicles. Emission factors based on real life driving emissions from heavy duty vehicles are even better. The bus emission data bank that is under continuous development by the VTT Emission laboratory in Helsinki, Finland, is thus an important source of knowledge.

EURO IV and V certified engines and real life emission factors for buses are probably the criteria that are practically available and can be used to allow or restrict admission to environmental zones in cities that have or are planning to establish such zones. In addition to technology neutral criteria we find it appropriate to use renewable and CO_2 neutral fuels for heavy duty vehicles.

5. Clean Fuels and Fuel Alternatives

We have tried to separate the definitions of environmental friendly vehicles from fuel alternatives and have suggested technology and fuel neutral criteria for environmentally friendly vehicles, LZV classification. In this chapter we present today's most relevant fuel alternatives and discuss their possibilities, advantages and drawbacks. In addition we shortly address the life cycle perspectives that are highly essential when different systems for transportation are evaluated. Fuels derived from biomass are a possible replacement for fossil fuels and represent technical and business opportunities (Biofuels in the European Union, 2006). On the other hand production of bio-fuels may represent an ethic dilemma if it leads to competition with production of food or if the harvesting of biomass leads to reduced areas of CO_2 capturing forests.

5.1 Fossil fuels

5.1.1 Petroleum based fuels

Petroleum-based fuels completely dominate the transport sector, and consumption of such fuels is expected to grow, especially in developing countries (Goodwin, 2001). In order to reduce air pollution problems, efforts are being made to reformulate these fuels. In practice this largely involves reducing the contents of aromatics and sulphur. The sulphur limitations in particular have been strongly emphasised. In Europe a limit of 50 ppm was set for 2005, but in practice, most fuels in the Nordic countries comply with less than 10 ppm sulphur as a consequence of national incentives. Reducing the sulphur content to 10 ppm allows for more efficient engine and more efficient exhaust-cleaning technology to be applied.

Diesel and petrol fuels fulfil in Europe the quality demands of the European standards EN590 for diesel fuel and EN228 for gasoline. There are further possibilities to improve fuel quality to reduce emissions of local pollutants from the petroleum oil-derived fuels. However new vehicles and engines are developed to fulfil emission regulations with the standardised fuels, and improved engine and emission reduction technology seems to be the most cost effective way to further reduce emissions. Simple and equally formed hydrocarbon molecules as in synthetic fuels generally provide the best opportunities for clean combustion of carbon based fuels. To reduce emissions of greenhouse gases the carbon content per unit of energy is crucial. In all practical application with oil-derived fuels, the CO_2 emission is a result of the combustion efficiency and not of the fuel itself. Fossil based petrol may with possible future new inventions in engine combustion technology close the gap to fossil diesel as a CO_2 efficient fuel.

Incentives to promote petrol instead of diesel fuel or the opposite may bewilder the producers and the market. Technology and fuel neutral specifications are in our opinion actions that most likely a better way to stimulate creativity to meet environmental challenges.

5.1.2 Liquefied Petroleum Gas, LPG

Liquefied Petroleum Gas, LPG, which is a mixture of propane and butane, is a common alternative fuel in some markets such as The Netherlands and Italy. LPG is a gas at ambient conditions, but can be handled as a liquid under moderate overpressure of 7 bars. It is shown to be feasible to obtain emission reductions of local pollutants with LPG in comparison with petrol when dedicated vehicles are developed and delivered by the original equipment vehicle manufacturers. However, the emission reductions are marginal since the sophisticated exhaust clean-up systems determine the levels of the emissions. The experiences of emission reductions from retrofitted LPG equipment are mixed, and high NO_x levels are often detected in real-life driving.

LPG vehicles potentially produce 10% less emission of greenhouse gases than diesel and petrol vehicles, since propane emits 10% less CO_2 per energy unit.

LPG has gained in popularity due to its availability and competitive pricing, but it should be kept in mind that LPG is a limited commodity and there is a competitive demand from industrial users. Thus, LPG should only be regarded as an alternative fuel for limited improvements in air quality.

5.1.3 Compressed Natural Gas, CNG, Methane

Natural gas is widely used as a vehicle fuel. It is most commonly stored in the vehicle as compressed gas, CNG, but to some extent also in liquid form, LNG. The essential compound in natural gas is methane, which can also be derived from biogas through fermentation of organic materials, including waste.

According to the International Association of Natural Gas Vehicles there are more than five million vehicles around the world running on natural gas and biogas (IANGV 2006). Over 100 vehicle models for methane or dual fuel are available, but there is also an active retrofit market. In fact most of the natural gas vehicles on the roads are retrofit and dual-fuel vehicles (Nylund 2002). Emission-wise, natural gas vehicles represent an improvement compared with diesel vehicles. Well designed and well-tuned CNG buses emit practically no particulate material and have the potential of emitting only insignificant amounts of NO_x, which make them clean alternatives in city traffic.

With improved but costly diesel exhaust-cleaning technology demanded by the EURO V limits, the differences in local emission between natural gas and diesel fuels is expected to be reduced. Natural gas vehicles potentially produce 25% less emission of greenhouse gases than diesel and petrol vehicles, since methane emits 25% less CO_2 per energy unit. However gas engine technology is not developed to the same level of efficiency as diesel engines and in addition unwanted leakage of methane may contribute to global warming. Methane is 20 times more powerful as a greenhouse gas than CO_2.

An important argument for natural gas, biogas/methane as a fuel is a reduction in dependency on oil. Natural gas is available from other, more geographically widespread sources than oil is, and the reserves are considerably larger. There seems to be quite a strong drive worldwide to shift to natural gas as a fuel, particularly for buses. Handling of gaseous fuels is obviously less convenient and involves additional costs compared with liquid fuels.

The problems related to infrastructure and the on-board storage of gaseous fuels has led to the development and testing of liquid natural gas/methane derivatives. Such fuels are methanol, dimethyl ether, DME and Gas-to-Liquid (GTL) fuels.

5.1.4 Methanol

Methanol has been extensively tested in California, mainly as an 85% mixture with petrol, M85. It has also been tested in Sweden, Finland and other countries, and performs well as a fuel in combustion engines. Methanol has the drawback of being highly toxic, corrosive to certain materials and water-soluble.

The use of methanol as a fuel is declining, but up until 2003 Daimler Chrysler considered it as a possible energy carrier for fuel cell vehicles with on-board reformers for hydrogen production. Methanol is currently produced from natural gas, but may also be produced from biomass or by synthesis from hydrogen and CO_2, and may in such cases be considered as CO_2 neutral.

5.1.5 Dimethyl Ether, DME

Dimethyl Ether, DME, when used in a compression combustion engine, is an extremely efficient and clean fuel. As with methane, DME emits practically no particles and has the potential to emit only small amounts of NO_x.

Volvo Industries, the producer of heavy duty Vehicles, regard DME as a strong candidate as a future substitute for diesel. Like LPG, it is a gas at ambient conditions, but can be handled as a liquid at a moderate overpressure. It will, however, require engine and infrastructure modifications. DME is being promoted by the Danish company Haldor Topsøe, and has been tested in prototype vehicles in Sweden and Denmark. DME can be produced from natural gas or biogas. When produced from biogas, DME can be considered as a CO_2 neutral energy carrier. The possibilities and timeframe for introduction of DME as a commercial fuel are regarded as uncertain. A possible introduction could be as fuel for fleets of city-buses.

5.1.6 Gas to Liquid, GTL fuels

Gas to Liquid, GTL fuels are derived from natural gas via synthesis gas and the industrial so-called Fischer Tropsch synthesis, yielding hydrocarbon products similar to gas oil and naphtha. These products are very clean, and with ultra low sulphur contents they can successfully replace or be mixed with fossil diesel and petrol fuels.

The technology for GTL production is well known and refining the processes is under development among companies with large natural gas resources, like Shell and Statoil. South Africa used GTL technology to produce their fuel during the embargos. With high prices for petroleum oil, GTL plants are being planned and built around the world. To make GTL compete economically with diesel and petrol prices, natural gas prices must be low compared with fossil oil. GTL is an interesting option at locations where cheap natural gas is available but where it is not economically possible to transport it to markets (stranded gas).

5.2 Renewable fuels

Renewable fuels and bio fuels are produced from renewable energy sources. CO_2 released by the combustion of bio fuel and biomass is regarded as CO_{2}- neutral, since in the short term it will not increase the CO_2 concentration in the atmosphere. Carbon in biological compounds will be released as CO_2 and methane emissions in the short term perspective anyway, as a result of natural fermentation and decomposition.

Two politically popular liquid bio fuels that often (without taxes) can be sold to competitive prices are rapeseed oil methyl ester, (RME) and ethanol. They are often called first generation bio fuels and can be distributed as additives (2–5% blend with fossil fuels) and in some markets they are available as pure bio diesel or high blend ethanol.

Other fuels to replace fossil petrol and diesel can be produced from either renewable energy or from fossil energy sources. It may be somewhat confusing with renewable hydrogen, methane or DME, which are regarded to be CO_2-neutral in comparison with the same fuels, derived from fossil energy sources with or without CO_2 sequestration.

In countries with high taxation of fossil fuels, as in the Nordic countries, about 70% of the retail price is tax. This makes it possible to support alternative fuels in more direct ways than with incentives for dedicated or flexi fuel cars.

Vehicles designed to run on ethanol should in our opinion meet the same challenges as petrol passenger cars to qualify for LZV status. The Swedish target to make 40% of all civil service cars environmentally-friendly by 2008, may however require a less stringent environmental criterion than our proposed LZV limits. The Swedish target for the use of bio fuels and ethanol in particular, may make it relevant to encourage the use of vehicles with high energy consumption and CO_2 emissions exceeding 120g/km. Incentives and support for vehicles that may use pure biofuels in combination with less stringent emissions levels than our LZV criteria are without doubt efficient ways to increase the number of flexi-fuel vehicles.

Alternative fuels will gain increased popularity with the future expected shortage of petroleum oil and increased concern about global warming. Emissions from vehicles, ‘Tank to Wheel’ are a result of the choice of fuel, the conversion process of chemical energy to motion and the clean-up process.

We conclude that technology and fuel neutral vehicle criteria can well be combined with ambitions to increase use of renewable fuel in countries with high taxes on fossil fuels. Exemption from taxation should be a sufficient advantage in the short run perspective but in the long run renewable fuels also have to meet ‘Well to Wheel’ competition.

5.2.1 Biodiesel – Fatty Methyl Esthers, FAME

Fatty Methyl Esters, FAME are produced by mixing different biological oils with methanol. FAME products are commonly called first generation bio diesel since they are compression ignition fuels. Rapeseed Methyl Ester, RME is the most widely spread FAME product in Europe. FAME or bio diesel is a replacement for fossil diesel and can be used alone or mixed with fossil diesel in any proportions. Challenges for FAME products are high production costs, limited production capacity, somewhat higher NO_x emissions and cold temperature performance.

Diesel engine manufacturers develop their engines for standardised diesel fuels defined by the EN590 standard, and FAME products don’t comply with EN590. Engine manufacturers are not expected to optimise their engines for first generation bio diesel products, since the production potential of biological oils in Europe is limited to less than 5% of the diesel oil demand (EUCAR, CONCAVE). Next generations of diesel fuels with biomass origin like hydrogenated fatty acids (hydrocarbons) like Neste's NexBTL and synthetic diesel fuels are preferred in the long run.

5.2.2 Ethanol

Ethanol can be produced from various biomasses and can be mixed with petrol. It has been extensively used in Brazil, where it is produced from sugar cane. It is also being used at various levels in the USA, Sweden and other countries. The increased introduction of bio fuels in Europe recommended by the EU Commission (Communication from EU, 2001) might be achieved by the mandatory blending of certain proportions of ethanol with fossil petrol. In Sweden, ethanol has gained increasing popularity with financial incentives directed towards dedicated bi-fuel ethanol passenger vehicles in addition to financial support for the fuel itself.

Ethanol is basically a fuel with petrol-like properties, such as high octane ratings and is used together with petrol vehicles with spark ignition engines. One Swedish bus producer however also provides modified diesel buses fuelled with ethanol and a requisite additive. Ethanol can only be used as a fuel in diesel engines with an effective compression ignition additive. The use of ethanol as a diesel fuel has in the Swedish buses the advantage of improved energy efficiency and also improved local pollutant emissions.

E 85 is a mixture of 85% ethanol and 15% petrol. In 2005, there were between 200 and 300 filling stations for E 85 in Sweden. Although some countries in Europe could grow crops for bio fuels, the agricultural area available will always limit the amount of production. Large-scale production of ethanol will in the long run require large amounts of available biomass such as wood and organic refuse.

Sweden is a country where efficient ethanol production methods are under development. Efficient ethanol production is regarded as an industrial opportunity for Swedish forestry, and will reduce the Swedish dependence of imported fossil oil.

5.2.3 Biogas

Biogas is a methane-rich gas produced by fermentation of organic material. Dealing with the biogas produced in landfills has the effect of reducing emissions of methane and is a way of using a free source of energy. Biogas contains some CO_2 and other impurities and must be purified to about 95% prior to use as a fuel. As such, it performs similarly to natural gas. The gasification process of waste and biomass may be accelerated by adding energy to the gasification. It is also possible to produce synthesis gas, which can be further processed to yield hydrogen, DME or other synthetic fuels.

5.2.4 Synthetic fuels and BTL

Synthetic fuel is a concept that was introduced by Volkswagen (Oberg, 2001) and refers to a fuel, produced from natural gas in the short term and from biomass or other renewable bio energy sources in the longer term. Synthetic fuels or GTL from natural gas, as mentioned in 5.1.6, are pure hydrocarbon compounds, in liquid form, and are universally applicable.

When Gas to Liquid GTL fuels are produced from biomass or biogas they are classified as CO_{2-} neutral energy carriers and for purposes of distinction they are then referred to as Biomass to Liquids, BTL fuels.

5.2.5 Hydrogen

Hydrogen is a serious candidate for the fuel of the future. However, hydrogen is only an energy carrier and needs to be produced by a primary energy source. Hydrogen produced from water, through water electrolysis using renewable power, represents sustainability without harmful emissions. This option may be practicable in hydropower- rich countries such as Iceland and Norway, but generally, costs of global hydrogen production with renewable electric energy today appear to be too high to be commercially competitive.

Hydrogen production today is mainly based on steam-reforming of fossil natural gas and thus involves CO_2 emissions. CO_2 emissions can be avoided or at least substantially reduced by CO_2 sequestration. Sequestration is not yet practised in large-scale projects and there are different opinions about cost, benefits and risks. Centralised electricity or hydrogen production with CO_2 sequestration and utilization of generated heat for warming is being discussed and planned in Norway.

Renewable hydrogen can already be produced at a small scale from wind power, electricity generation and electrolyses in a sustainable way. Future inventions may make other new sustainable power or direct hydrogen-generating systems available. There is an increasing interest in several countries for nuclear power that can be used to generate hydrogen without CO_2 emissions.

Hydrogen can in principle be produced anywhere from a variety of energy sources. Thus, for improved energy security and energy source flexibility it is an attractive choice. The challenges are infrastructure and distribution, together with safety and public acceptance. It is generally assumed that competitive hydrogen vehicles are a more demanding challenge than pilot hydrogen production for these vehicles. Small- scale hydrogen delivery and local production for fuel supply can be arranged from current industrial production and local electrolysers.

5.3 The Life Cycle Perspective – Well to Wheel

A life cycle perspective is essential when different systems for transportation are evaluated. Local and global emissions as well as the energy consumption must be evaluated in a 'Well to Wheel' perspective in order to assess the possibilities for vehicle and fuel technologies. 'Well to Wheel' chains for road transport can for practical reasons here be divided into two factors: 'Well to Tank' and 'Well to Wheel'. The product of these two factors, in terms of energy consumption and CO_2 emissions, is crucial for a fuel and vehicle technology Life Cycle Chain to be competitive in the long run.

Several environmental questions are addressed in the vehicle and fuel production phase, in the driving phase (in use) and in the disposal of cars. Challenges and different criteria that are important when judging products and systems are:

- Global impact – climate change, global environmentally-threatening toxic substances, energy resources and raw materials
- Local impacts – health effects of exposure to particulate matter, nitrogen oxides, sulphur oxides, volatile organic compounds
- Local noise impacts – health effects, learning difficulties
- Constrains on the use of land areas
- Accidental impacts and barriers – health effects, material damage, economy

The Life Cycle perspective as shown in figure 1 is a crucial perspective if we prioritise the global environmental questions as climate change, emissions of the greenhouse gases CO_2, N_2O and CH_4, and accumulations of toxic substances.

All car models should preferably be given a life cycle-documentation. This is not the case today and there is no accepted standardized methodology on how to perform a life cycle-documentation and Life Cycle Analysis (LCA) for vehicles.

When choosing ways to evaluate vehicles it becomes almost necessary to pick criteria from "on the road" performance, and give priority to local air quality, global warming and noise. In this perspective the life cycle-view is less important. Looking at local air quality, on-the-road emissions, geographical location and the total traffic volumes are crucial. The most severe threats to health are particles, NO_x and Benzene. There have since long been regulations and limits for "on-the-road" emissions, noise and accident security. To get a car approved for sale, the manufacturers have to document local emissions at specified performance levels. This documentation is available for all new models certified and sold in Europe.

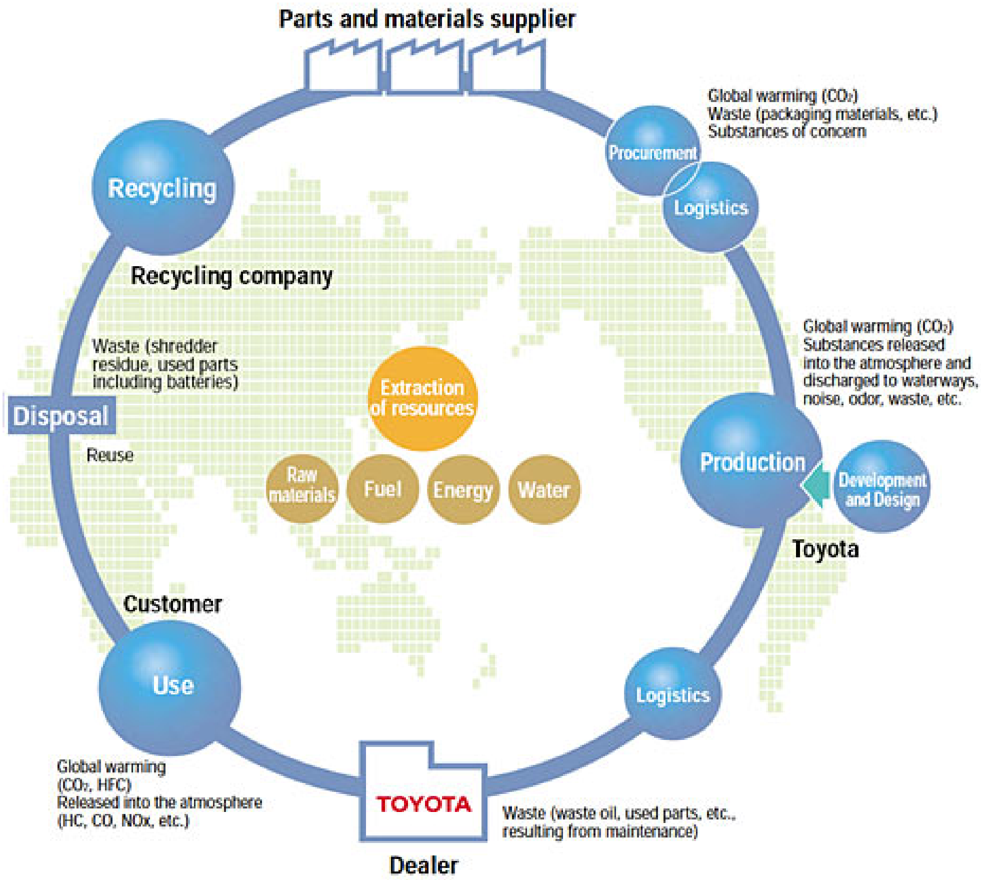

Figure 1: "A car's life" and the environmental impact – the Life Cycle perspective. Source: Toyota

6. Vehicles and Environmental Product Information Schemes

6.1 EPIS, Eco labelling and environmental policy

Eco-labelling is a part of the systems that aim to inform consumers about the environmental impact of products and services. These systems are called Environmental Product Information Schemes, EPIS, and are important tools in environmental policy. They range from mandatory, for example product declarations, to voluntary approaches such as national eco-labels, and cover third party labelling as well as 'green' claims by companies. Eco-labelling is the 'communicating-to-the-consumer' part of these systems.

EPIS and eco-labelling fit well into the multi-stakeholder policy framework and Integrated Product Policy, IPP. There are several questions with regard to eco-labelling in general and to eco-labelling of vehicles in particular, such as:

- Are EPIS and eco-labelling an effective tool to achieve the development, production, sale and use of environmentally-friendly vehicles?
- Is eco-labelling an effective tool to provide consumers with useful information about the environmental impacts of products and services?
- Should eco-labelling be voluntary or mandatory?
- Does eco-labelling focus only on the most obvious and most serious environmental problems?
- Should eco-labels be harmonised? Are there any difficulties with different national labels?
- Is there really a need for a harmonised system for labelling vehicles, for example as Low or Zero Emission Vehicles, LZVs in the EU and the Nordic countries?

Some of these questions are answered in The future of Eco-labelling (Rubik and Frankl, 2005), and in several global reviews of the situations of eco-labelling, for example US EPA (1998), Fickle et al (1999) and Dröge (2001). The mandate in our project is limited and in this report we will give only a short summary of findings and recommendations about eco-labelling from these studies. We will focus on the ongoing discussions in the EU Commission and on some aspects about the possible future of eco-labelling of vehicles in the Nordic countries and the EU.

6.2 EPIS in different countries and for different products

For a wide range of products there are systems and regimes, which inform about and promote the most environmentally-friendly vehicles in each category and services. Some of them are mandatory and some are voluntary. Possible criteria in an eco-labelling system for vehicles are discussed later in this chapter. In this study we have looked into the following questions about a possible labelling system for vehicles:

- Is there a need for a simple and understandable system for labelling Zero or Low emission Vehicles (LZVs) in the Nordic countries and in Europe?
- What can be learned from the vehicle labelling systems in California?
- What can be learned from the experiences of A-F labelling of refrigerators, other household electrical appliances or eco-labelling of food?
- What can be learned from the preparatory work on a labelling system for energy performance of buildings?

The main objective for the mandatory EPIS is not to inform the public about the general environmental issues, but to provide information on health and safety to ensure human protection. The voluntary EPIS have focused on broader environmental information and ecological impacts of products and services, and in several cases includes ranking systems.

6.2.1 EPIS with relevance for vehicle labelling

Examples of EPIS with relevance for vehicle labelling are:

- The Nordic “Svanemerke” is one possible way
- US Energy Star Logo
- US Fuel Economy Information Programme
- EU Energy labels for household appliances
- European system for labelling refrigerators and freezers, framework directive 94/75/EEC, and daughter directives for specific product groups
- EU labelling of office equipment (in corporation with the US Energy Star programme, agreement between the Government of the USA and the EU)
- EU labelling of fuel consumption and CO_2–emissions from light vehicles (Directive 1999/94/EC)
- FIA foundation – stars – ranking due to CO_2-emissions and other pollutants

There are national mandatory labelling systems for product groups not relevant to the energy issue, emissions or vehicles such as:

- The Belgian ‘packaging logo’
- The Netherlands labelling of product waste in specific product groups (KCA), for example, batteries containing mercury, oil filters and so on
- The International Organization for Standardization, ISO, has identified three broad types of voluntary environmental performance labelling:
    - Type I: a voluntary, multiple-criteria based, third party programme that awards a license that authorises the use of environmental labels on products indicating the overall environmental preferability of a product within a particular product category based on life-cycle considerations
    - Type II: informative environmental self-declaration claims
    - Type III: voluntary programmes that provide quantified environmental data of a product, under pre-set categories of parameters set by a qualified third party and based on life cycle assessment, and verified by that party or another qualified third party

These labels share a common goal, which is:

> “...through communication of verifiable and accurate information, that is not misleading, on environmental aspects of products and services, to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement.” (ISO, 14001)

The EPIS reflect a changing perspective in environmental policy, from the 1970s to the 1990s, towards a more extensive use of second-generation policy tools. The main objective is to guide consumers to choose products with less environmental impact and in this case to encourage manufactures to develop and supply environmentally-friendly vehicles. In this way, EPIS are used as a market-oriented instrument and not only as product information to ensure human protection.

Examples of voluntary EPIS are:

- Nordic ‘Swan’ (http://www.svanen.nu/Eng/default.asp?nav=sokkriterie)
- ‘EU flower’ (http://europa.eu.int/comm/environment/ecolabel/index_en.htm)
- German ‘Blue Angel’ (http://www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm)
- Czech Programme ‘Environmentally Friendly Product’ (http://www.ekoznacka.cz/ENG/about.asp)

The majority of EU member states have introduced voluntary EPIS Type I–III. The schemes are similar in terms of included elements, but show institutional differences. They differ mainly in the role of government and other stakeholders. A Swedish scheme ‘Bra Miljöval’ has been set up by independent environmental NGOs, the German ‘Blue Angel’ and the Czech ‘Environmentally Friendly Product’ are based on a multi-stakeholders governmental approach.

The schemes include a set of criteria and administrative awards, which are institutionalised. The main aims of these institutional elements are to increase the efficiency of the decision-making processes and to have an independent third party as a guarantee of quality.

Several products and services provide information about their environmental performance or impact, and more will come. This has led to a discussion about harmonisation of eco-labelling and more formalised mandatory labelling schemes. Energy use is another area for eco-labelling and an example is a rating from A to F where A-products have the lowest energy consumption.

6.2.2 Eco-label

An eco-label is a label which identifies the overall environmental preference of a product or service within a specific product/service category based on life-cycle considerations. Eco-labelling comes under the ISO Type I designation. An eco-label is awarded by an impartial third-party in relation to certain products or services that are independently determined to meet environmental leadership criteria. This is in contrast to a wide range of other “green” symbols or claim statements developed by manufacturers and service providers.

The roots of eco-labelling can be found in the growing global concern for serious environmental protection. Businesses have recognized that environmental concerns may be translated into a market advantage for certain products and services. Various environmental declarations/claims/labels such as “natural, recyclable, eco-friendly, low energy, and recycled content” have appeared on products and services in the marketplace. These declarations have attracted consumers who are looking for ways to reduce adverse environmental impact through their purchasing choices. However, they have also led to confusion and scepticism from sometimes bewildered consumers.

Without guiding standards and investigations by an independent third party, consumers cannot be certain that a company’s assertions guarantee that each labelled product or service is an environmentally-preferable alternative. Concern about credibility and impartiality has led to the formation of both public and private organizations providing third party labelling. In many instances, such labelling has taken the form of eco-labels awarded to products approved by an eco-labelling programme operated at a national, regional or multinational level (GEN, 2005).

In the vehicle domain there are several systems regarding different aspects of the vehicles and their performance. For instance there is a voluntary classification system for vehicle crash safety, the Euro-NCAP tests.

For emissions of local pollutants Europe has the EURO I–V regime for new light vehicles and for new engines to heavy vehicles. The regime demands documentation that the local pollutant emissions from new vehicles and new engines are lower than a specified level. It is also mandatory in the EU to inform about the energy use and CO_2–emissions per km from new light vehicles. However several countries have not developed any standardized labelling systems for this purpose.

EU does not have environmental ranking of vehicles within a Euro class (for example EURO IV) and there is no information and few incentives to lower the emissions further than the standard regulations. Therefore there is almost no public promotion of the vehicles with extreme or best environmental performance.

In the USA, vehicle emissions characterisations are similar to Europe. However, to make it simple, the California Air Resources Board classifies environmentally-friendly vehicles as Bronze, Silver or Gold.

6.3 European Vehicles Environmental Product Information

There are several systems – Environmental Product Information Schemes – EPIS – related to different aspects of the vehicles and their performance:

- A mandatory ‘vehicle emission standard’ in Europe; the EURO I–V regime for new light vehicles and new engines for heavy vehicles. (Several emission directives are linked with directives on fuel quality)
- A mandatory labelling of vehicles, ‘fuel efficiency and CO_2-emissions per km’ (1999/94/EC)
- A voluntary classification system for vehicle crash safety, the Euro-NCAP tests

Legislation approval of all new vehicles models according to EURO I–V guarantees low local emissions related to the year of production. The EURO I–V regime demands documentation that the emissions are lower than specified limit values. The EURO I–V classification tells an insider about levels of emissions for a specified test cycle and the year of production. However it is difficult for the general customer to differ between the emission levels and they are also complicated to understand. The EURO

I–V regime does not inform the customer about differences between different vehicle models of the same production year.

It is mandatory for the manufactures of vehicles to run the specified test cycle (EDC) and label vehicles in order to inform consumers of fuel efficiency and CO_2 – emissions. However there is no ranking system, no easy understandable labels or standardized labelling system. This makes it difficult for the consumers to understand what a certain level of CO_2-emissions from one car means relative to other cars. A positive aspect is that in Europe a consumer when buying a new light vehicle always is guaranteed low emissions of local pollutants.

There are no harmonised EU incentives to reduce emissions of locally harmful pollutants to below the standard EURO I–V regulation. The consequence is almost no public promotion of vehicles with the best environmental performance. Introducing an easy to understand labelling system that makes it possible for consumers to make comparisons, is discussed, but there is no EU-wide agreement today. This means that there are no requirements for information about the total environmental impact in a life- cycle perspective. There are no incentives for environmental ranking of vehicles of the same size and/or model year or to lower the emissions further than the minimum regulation

During the last 10–20 years, car crash safety has improved significantly, and the NCAP 1–5 stars are likely to have played an important role in the process with increasing customer awareness, demand and pressure on the vehicle industry.

6.3.1 EU Directives and Mandatory Vehicle Emission Standards

International agreements are important driving forces for establishing stricter legislation in the EU. The Nordic countries have in many ways been the driving force in this work due to the severe acidification damage to ecosystems in Norway, Sweden and Finland. Norway is not a part of the European Union but has an agreement on economic cooperation, the EEC agreement. This agreement includes implementation of the EU's environmental legislation and is important for communities and the Norwegian industry.

The bio fuel directive gives guidelines to the member states on introducing and using at least 5.75% bio fuels from 2009 (Commission EC, On Alternative Fuels for Transportation, Brussels, 28.06.01).

EU negotiations/work and agreements with the Association of European Car Manufacturers (ACEA), Japanese and Korean importers have been important in improving the technology and harmonising legislation for a huge and important market.

Several important EU directives regulate the emissions from vehicles and engines.

The Auto-Oil programme and the regulation of fuel quality is a condition for the EURO I–V emission levels. Specific emission limits for new European passenger cars, the EURO I–V emission levels, Californian SULEV limits and heavy duty engines, are shown in table 2.

Table 2: European emission limits for light vehicles, California limits for Super Ultra Low Emission Vehicle, SULEV and European heavy duty engines

Light vehicles	PM (g/km)	NO_x (g/km)	HC (g/km)	CO (g/km)	HC+NO_x (g/km)	CH_4 (g/km)
EURO II – 1996 petrol				2.20	0.50	
EURO III[1] – 2000 petrol		0.15	0.20	2.30		
EURO IV[1] – 2005 petrol		0.08	0.10	1.00		
EURO V[1] – from 2009 petrol	0,005	0.06	0.10	1.00		
EURO II – 1996 diesel	0.080			1.06	0.50	
EURO III[1] – 2000 diesel	0.050	0.50		0.64	0.71	
EURO IV[1] – 2005 diesel	0.025	0.25		0.50	0.56	
EURO V[1] – 2009 diesel	0,005	0,18		0,50	0,23	
		NO_x + HC (g/km)				
EURO IV[1] – from 2005 diesel		0,300				
EURO V[1] – from 2009 diesel		0,230				
California SULEV[2]	0,007	0,015	0,007	0,70		
Engines for heavy-duty vehicles (diesel)	**(g/kWh)**	**(g/kWh)**	**(g/kWh)**	**(g/kWh)**	**(g/kWh)**	**(g/kWh)**
EURO II – 1996	0.15	7.0	1.1	4.0		
EURO III – 2000	0.10	5.0	0.66	2.1		
EURO IV[3] – 2005	0.02	3.5	0.46	1.5		
EURO IV[4] – 2005	0.03	3.5	0.55	4.0		1.10
EURO V[3] – 2008	0.02	2.0	0.46	1.5		
EURO V[4] – 2008	0.03	2.0	0.55	4.0		1.10

[1]) EDC Test Cycle; [2]) California emission limits converted to g/km from g/mile; [3]) ESC Test Cycle; [4]) ETC Test Cycle

The EURO IV rules came into force in January 2005. The new rules, EURO V, will be enforced in 2009 and are the latest in a series of regulations designed to reduce car emissions that pollute the air and damage human health.

A very important change in the proposal is the regulation of SUVs. The EURO V rules stipulate that passenger cars that weigh more than 2500 kg may not use ‘less ambitious’ standards than light commercial vehicles.

The new standards are applicable to all cars produced and imported into the EU. That means the top producers from the United States and Asia must join European auto giants from countries like Germany and Italy in cleaning up new car emissions.

6.3.2 EU Directive and Mandatory Fuel Efficiency and CO_2 - emission Information Scheme

The Commission has introduced a directive on fuel economy information (Directive 1999/94/EC). It is now mandatory to have this information in the advertising of new vehicles. The information about fuel economy is one part of the EU's strategy to reduce CO_2 emissions from passenger cars.

An easy to understand that a label can be one aspect of this information, but there is no EU-wide mandatory system for such a label. The consequence of "no agreement" on an EU-wide labelling system is that competing systems in different countries are confusing for producers and consumers.

The Austrian Energy Agency, E.V.A. carried out a study together with five other European institutions and came up with advice about how to develop an easy understandable labelling system for vehicles (E.V.A., 1999). E.V.A. summarized the status of implementation or plans for implementation of labelling of vehicles in the EU15-countries as seen in table 3. In 2002/03 the FIA Foundation and ADAC (German motorists association) developed an additional system to those shown in table 3.

Table 3: EU15- status of labelling energy performance and emissions of vehicles, Source: EVA, 1999

Country	Absolute fuel consumption figures	Fuel consumption in comparison to other cars	Planned or existing	Mandatory or voluntary	Temporary/ permanent	Accompanying measures (booklet, brochures, ...)
EU Directive	yes	not obligatory	planned	mandatory	temporary	yes
Sweden	yes	indirect*	existing	mandatory	temporary	yes
UK	yes	no	existing	mandatory	temporary	yes
Canada	yes	no	existing	voluntary	temporary	yes
USA	yes	indirect****	existing	mandatory	temporary	Yes
Netherlands	yes	yes	planned	mandatory	temporary	yes***
Denmark	yes	yes	planned	mandatory	temporary	yes
Switzerland	yes	indirect**	planned	mandatory	permanent	yes
Austria	yes	no	not realistic	voluntary	temporary	yes

*indirect in form of environmental categories from 1 to 3 due to exhaust fumes
**indirect in form of awarded and not awarded cars in different classes due to fuel consumption
***The campaign 'Buy Eco-wise, Drive Eco-nice
****indirect in form of the best and worst fuel economy in the class given on the label

The E.V.A study gave some recommendations for labelling systems for passenger cars, and the type of labelling system that appears best suited to influence consumers to purchase and manufacturers to produce more energy-efficient cars. Estimates of impact of an energy performance label on the entire car fleet's fuel consumption and CO_2 emissions indicate 4–5% EU-wide reductions by 2010. The study does not discuss local emissions. Figure 2 illustrates the recommended label.

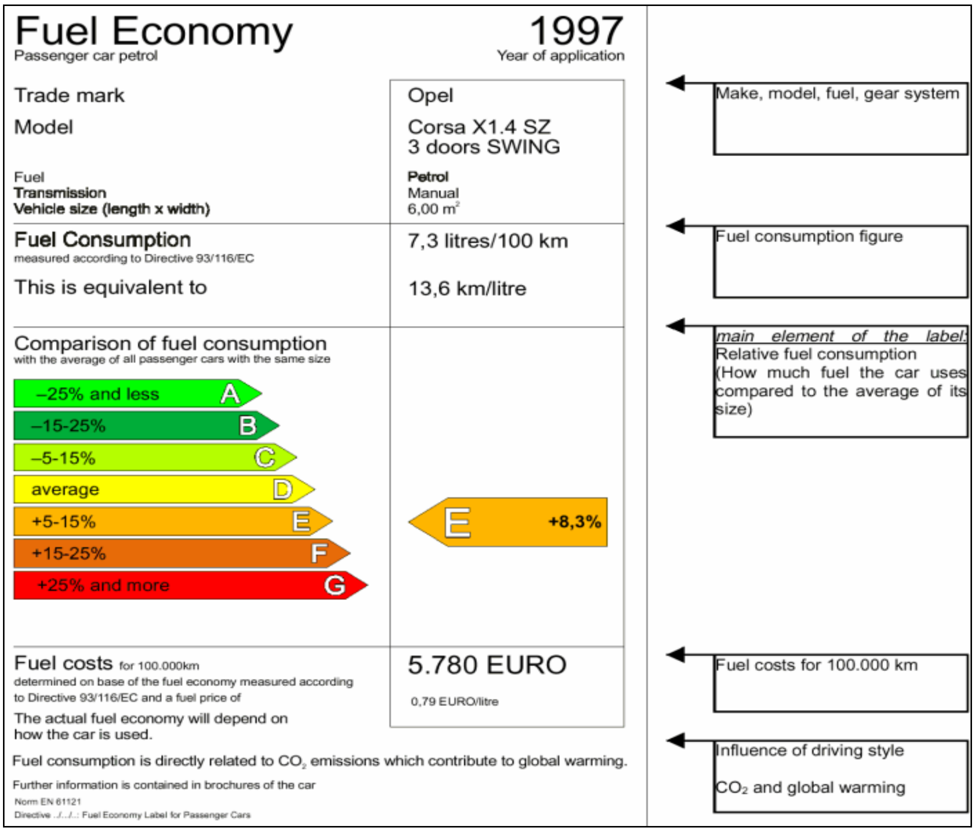

Figure 2: Recommended energy performance labelling system of passenger cars, Source: E.V.A., 1999.

E.V.A.'s consumer tests and market research showed that a comparison of a specific car's fuel consumption compared to other cars on a label is essential to get the consumers interested. The label is a real added value for the consumer, although standardized fuel consumption figures are already displayed in sales brochures.

Since car buyers have a certain idea of the car they want to purchase, they definitely prefer a comparison of similar cars with respect to size or segment. This "relative" comparison is clearly preferred compared with an "absolute" comparison in relation to all the others in all sizes. Vehicle size is the standardisation parameter best suited for comparison, because it is easily available, indisputable and easy for consumers to understand.

A label is a consumer-oriented measure, based on consumer tests and market research. The main requirement for the label seems to be a good communication effect. The relevant information has to be communicated within a few seconds, and therefore simplicity of design and contents are important. A well-communicated label results in a market push from the consumer side, urging manufacturers to provide cars with higher fuel efficiency.

An EU-wide standardised design derived from EU household appliance labels will enhance the recognition effect. Similar labels for other products strengthen this effect and marketing carried out for one label can also be used for others.

Most car manufacturers tend to reject the idea of a comparative label. Therefore dialogue with the car industry is needed to make the label proposal known and to prevent misunderstandings. Regarding “relative” and “absolute” comparisons, manufacturers clearly prefer the former.

Fuel consumption as a parameter for comparison is much better known among consumers than CO_2 and is therefore recommended. Nevertheless, CO_2 emissions in g/km could be mentioned on the label and should be given in the accompanying fuel economy guide. A fuel economy label is just one part of a consumer information strategy and accompanying measures. Fuel economy guides, posters and fuel consumption data in promotional literature will increases the impact on buying behaviour and fuel efficiency. A fuel economy label is one way to influence consumer behaviour, as well as to induce a market push by encouraging car manufacturers to produce vehicles that are more efficient.

Raising awareness and communication work on consumer information regarding fuel economy should be based on economic motives, particularly on the argument that car drivers save money by purchasing fuel-efficient cars. Fuel economy has been shown to be ranked higher than ecological aspects or environmental friendliness when customers purchase a car (E.V.A., 1999).

Denmark and UK are two of a handful of member states which have introduced a labelling scheme in accordance with the EU energy labelling of household appliances and a system more or less similar to the E.V.A. recommendations. The Danish system and experiences are discussed in chapter 7. The FIA-foundation has developed the EcoTest that include both local pollutants and CO_2. The FIA EcoTest is discussed later in this chapter.

6.3.3 UK incentives – environmental label vehicles

In the UK, a number of steps have been taken to promote the purchase and use of more efficient vehicles. In March 2001 low rate vehicle excise duty, (road tax in the UK) was introduced for cars in the Private and Light Goods taxation class with engine displacement of 1,549 litres or less. A graduated vehicle excise duty based primarily on their level of CO_2 emissions was also introduced for new cars. In April 2002 a Company Car Tax based on the CO_2 emissions of vehicles provided to employees for private use was introduced. In July 2005 an environment label system for vehicles came in force.

The environmental label shown in figure 3 is a result of a voluntary agreement by car manufacturers as a result of discussions between environment groups and road transport stakeholders under the auspices of the Low Carbon Vehicle Partnership, LowCVP. The LowCVP is a partnership of organisations, automotive and fuel industries, government, academia and environmental Non Governmental Organisations who are working together to bring about the change to low CO_2 emitting vehicles (VCA, 2005).

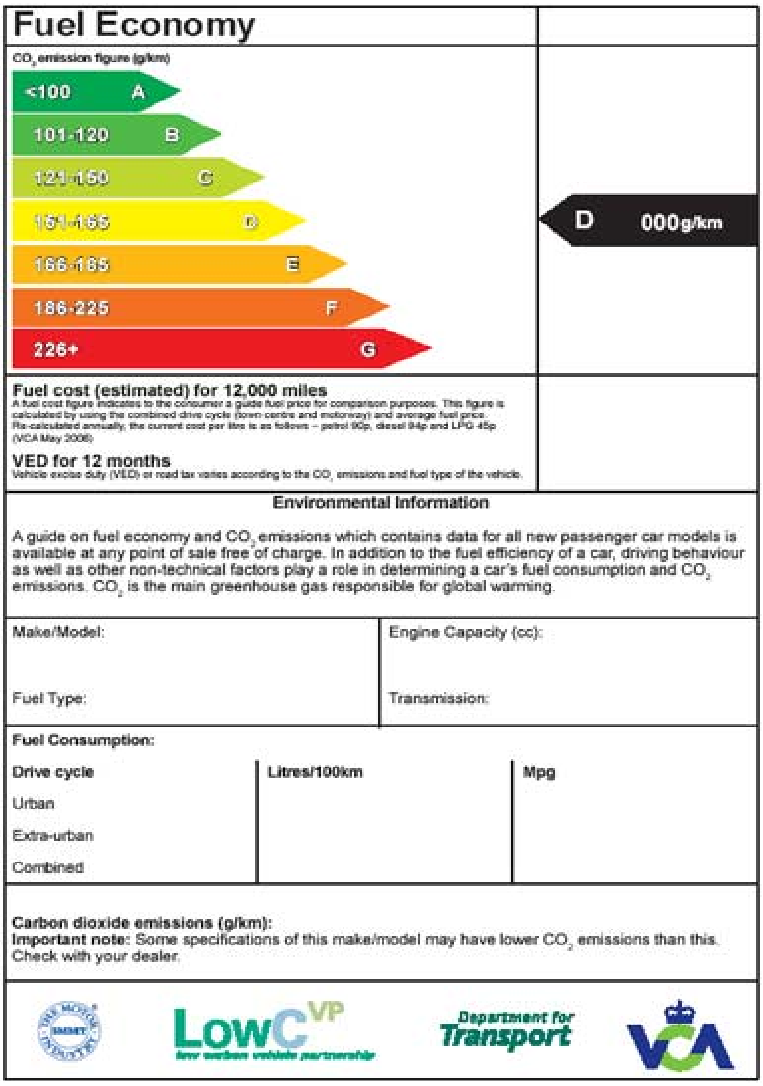

Figure 3: UK-Label showing CO_2-emissions and fuel costs for vehicles.

The label is intended to be familiar to consumers, as it shows important aspects of the design and colour coding of the energy efficiency labels that appear on other goods. The ranking on the label is consistent with the CO_2 bandings used for vehicle excise duty to ensure that the environmental message is backed up by a clear fiscal signal: lower carbon emissions = lower road tax. The label also provides clear cost information showing that lower carbon-emitting, climate-friendly vehicles are economical to run.

Vehicle manufacturers have made arrangements for their dealers to produce the label. The label will help car buyers to assess the climate change impacts of different cars and emphasise that – increasingly – better environmental performance means lower road tax and lower running costs.

This label only provides information about CO_2 and fuel consumption and no information about other pollutants. However in the VCA database there is also information on NO_x, PM_{10} and CO emissions.

6.3.4 Voluntary EcoTest system for vehicles, the FIA-foundation

The FIA Foundation, established in the United Kingdom, is a non-profit federation of motoring organisations that together with ADAC conduct environment and mobility research. An EcoTest was developed by ADAC in 2003 with the purpose of monitoring the environmental behaviour of passenger cars. The aim is to provide consumer information about the environmental performance of car models in Europe.

The EcoTest database includes more than 270 models and different classes of vehicles. The comparisons are made for emissions of local air pollutants and CO_2. The exhaust emissions are measured according to the European Driving Cycle, EDC (directive 98/69/EC). The measured data are compared with the manufacturer's specifications.

The calculations and ratings are based on measured values for emissions. Both local pollutants and CO_2 emission are rated from zero to 60 points. The vehicle CO_2 emissions are rated in different model size classes. This enables a clear differentiation within the size classes. The local pollutant rating includes PM, NO_x, HC. Unlike the European emission legislation that tolerates higher emissions for diesel-powered vehicles, the EcoTest assessments of vehicles and ratings are independent of fuel and technology.

The total EcoTest rating relates to 50% from the sum of the rating of local pollutants and to 50% from the CO_2-rating. Further information about the calculations is given in FIA, 2003, 2004 and 2005. Figure 4 shows the rating chart with one and up to five green stars. Petrol vehicles generally have good local pollution ratings while diesel vehicles in general have much better carbon dioxide ratings. According to figure 4, petrol vehicles generally have a somewhat higher total rating than diesel vehicles. The figure indicates that the emission reduction technology of the petrol vehicles is at a higher level, but that diesel vehicles with particulate filter are closing the gap. The two natural gas vehicles get 4 stars on the total rating

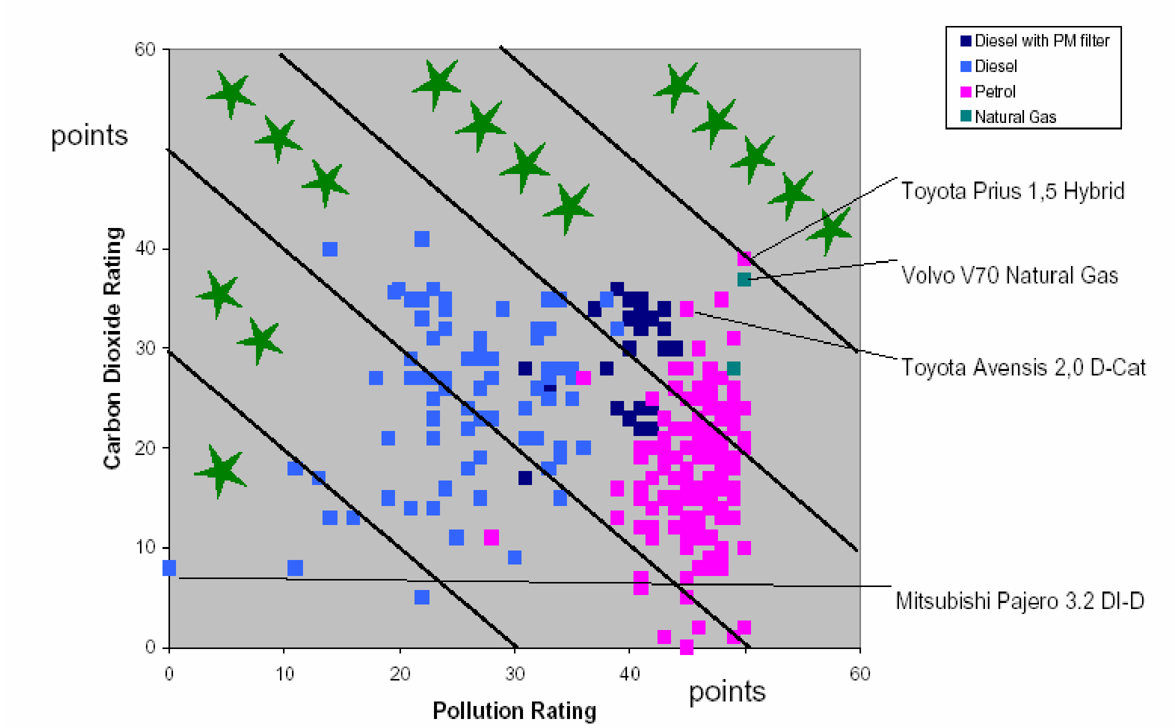

Figure 4: Comparison using local pollution and carbon dioxide ratings for all ADAC/FIA Foundation tested Diesel and Petrol vehicles. 276 vehicles are in the database. Source: ADAC/FIA Foundation – EcoTest Phase 3, 2005.

The latest results from the EcoTest show that new vehicles with the latest engine technologies such as petrol direct injection and FSI, hybrids, natural gas vehicles, diesel with PM traps and DeNOx catalysts have improved environmental quality in comparison with older vehicles. Diesel and petrol cars with new technologies are closer than before. Hybrid technology is clearly ahead of others propulsion technologies with regard to environmental impact and natural gas vehicles are close to hybrid vehicles. The resulting points for local pollutant emissions and CO_2 emission are rated and presented with labelling stars in tables. The vehicles are rated in different classes according to size. An extract from a rating table is shown in figure 5.

Model	Engine Technologie	displacement [cm³]/ Power	Emission Levels	Fuel Consumption	Points Pollution	Points CO2		EcoTest Rating
City								
Fiat Panda 1.2 8V Emotion		1242/44	Euro4	6,1	48	31	79	★★★★
Daihatsu Cuore 1.0 Top		989/43	Euro4	5,8	43	35	78	★★★★
Citroen C2 1.4 VTR SensoDrive		1360/54	Euro3, D4	7,1	45	24	69	★★★
Daewoo Matiz 1.0 SE		995/47	Euro3	7,0	41	26	67	★★★
Daihatsu Copen		659/50	Euro3	7,1	28	29	57	★★★
Supermini								
VW Polo 1.4 FSI Highline	DI	1390/63	Euro4	6,2	50	29	79	★★★★
Renault Clio 1.2 16V Confort Authentique		1149/55	Euro3, D4	6,3	48	29	77	★★★★
Audi A2 1,6 FSI	DI	1598/81	Euro4	6,6	49	26	75	★★★★
Nissan Micra 1,2 visia		1240/48	Euro4	6,5	47	28	75	★★★★
Hyundai Getz 1,1 GL		1086/46	Euro4	6,5	46	28	74	★★★★
Fiat Punto 1.3 JTD Dynamic		**1248/51**	**Euro3, D4**	**4,8**	**35**	**36**	**71**	★★★★
VW Polo Limousine 1.4 Comfortline		1390/55	Euro4	6,9	46	25	71	★★★★
Seat Ibiza Signo 1.2 12V		1198/47	Euro4	6,9	45	26	71	★★★★
Peugeot 206 1,1 Filou 60		1124/44	Euro3, D4	6,3	41	29	70	★★★★
Lancia Ypsilon 1.3 Multijet Platino		**1248/51**	**Euro4**	**4,8**	**34**	**36**	**70**	★★★★
Toyota Yaris 1.0 linea sol MMT		998/48	Euro4	6,8	41	28	69	★★★
Suzuki Ignis 1.5 Comfort		1490/73	Euro4	7,2	46	22	68	★★★
Mini One 1,6		1598/66	Euro4	7,5	48	20	68	★★★
VW Polo 1.2 Basis		1198/47	Euro4	7,1	41	25	66	★★★

Figure 5:Example of EcoTest results from ADAC/FIA Foundation tested vehicles according to absolute scale and ordered by vehicle classes and test result.

The response and demand for further tests and measurements indicate that the FIA- ADAC EcoTest is informative and has contributed to raising awareness of the environmental choices available. The results have also been communicated to politicians via the workshop "Car Emissions and EURO V" in Brussels organized by the ADAC on behalf of the FIA (FIA, 2005). The results and stars have been an important force in the EU-process towards a Europe-wide labelling and information system.

6.3.5 Voluntary classification system for vehicle crash safety, the Euro-NCAP

Euro NCAP provides consumers with a realistic and independent assessment of the crash safety performance of the most popular cars sold in Europe. NCAP was established in 1997. Today Euro NCAP is backed by five European governments, the European Commission and consumer organisations in every EU country. The Euro NCAP has rapidly become a catalyst for encouraging significant safety improvements to new car design. The Internet pages www.EuroNCAP.com provide guidance for purchasers of new cars.

The Euro NCAP stars for safety rating are so successful that it is possible to imagine that Euro NCAP also could provide stars for environmental rating. However Anders Lie, the Swedish delegate in Euro NCAP informed us that this organisation has no plans to address the environmental issue. Anders Lie, on the other hand, stresses that the customer, in his opinion, should be informed about environmental and not only safety properties when evaluating a new vehicle.

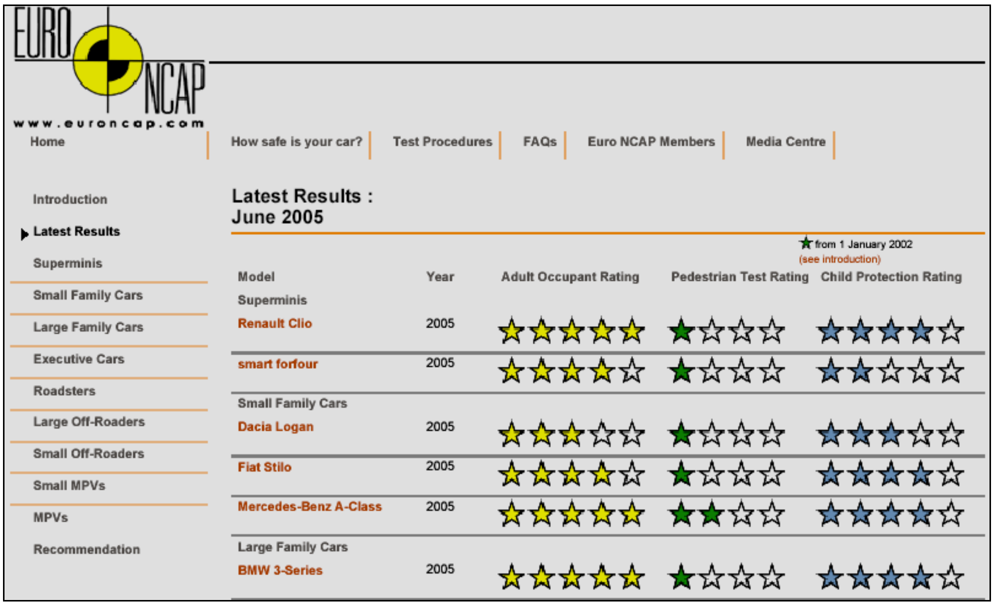

Figure 6:Euro NCAP ranting with up to 5 stars provides consumers with realistic and independent assessment of vehicle crash safety performance. *(http://www.euroncap.com/content/safety_ratings/ratings.php?id1=6)*

6.4 USA Vehicles Environmental Product Information Schemes – EPIS

The USA is the land of road vehicles. American society is totally dependent on automobiles. It was also in the US that air pollution from vehicles was first recognised as a serious problem and petrol exhaust cleaning using catalytic converters was introduced. The State of California has long been in the forefront with mobile emission source control efforts. The schemes in USA try to combine product information, legislation and freedom of choice for the customer.

6.4.1 US EPA federal regulations, standards and information schemes

In USA characteristics of vehicle emissions are similar to Europe. The US EPA Federal Light-Duty Vehicle standards are summarized in table 4. The Tier 2 Vehicle and Petrol Sulphur Programme is a landmark programme that affects every new passenger vehicle and every gallon of petrol sold in the USA (EPA, 2005). For the first time SUVs, pickups, vans, and the largest personal passenger vehicles are subject to the same national emission standards as ordinary passenger cars.

Vehicles and the fuels they use are treated as a system, so potentially clean vehicles will have the low-sulphur petrol they need to perform at their best. New emission standards apply to all light vehicles, regardless of whether they run on petrol, diesel fuel, or alternative fuels.

A new proposal was put forward in June 2005, which introduces even tighter limits for existing light and heavy vehicles as well as for working machineries. This will require retrofitting exhaust emission cleaning equipment on existing vehicles. The first phase will be in 2007 (US EPA, 2005 and 2007; http://epa.gov).

The vehicle categories, Bin 1–11 in table 4 are a set of emission standards within the Tier 2 Programme. Manufacturers must certify that each vehicle will not exceed the pollution limits for the selected bin. Manufacturers may choose from the range of bins, as long as all vehicles of each model year they sell fall below a certain average emission limit.

Table 4: Summery of US EPA Federal Light-Duty Vehicle (passenger cars and light trucks) Emissions Standards for Air Pollutants, Included is also the 'Air Pollution Score' which is used in the 'Green Vehicle Guide, an Internet based information system. Source: US EPA 10.01.2005

US EPA Federal Light-Duty Vehicle Emissions Standards for Air Pollutants

Tier 2 Program

Standard	Model Year	Vehicles	Emission Limits at Full Useful Life (100,000-120,000 miles) Maximum Allowed Grams per Mile					Air Pollution Score	
			NOx	NMOG	CO	PM	HCHO	Original	Updated
Bin 1	2004+	LDV, LLDT, HLDT, MDPV	0.00	0.000	0.0	0.0	0.0	10	10
Bin 2	2004+	LDV, LLDT, HLDT, MDPV	0.02	0.010	2.1	0.01	0.004	10	9
Bin 3	2004+	LDV, LLDT, HLDT, MDPV	0.03	0.055	2.1	0.01	0.011	9	8
Bin 4	2004+	LDV, LLDT, HLDT, MDPV	0.04	0.070	2.1	0.01	0.011	9	7
Bin 5	2004+	LDV, LLDT, HLDT, MDPV	0.07	0.090	4.2	0.01	0.018	8	6
Bin 6	2004+	LDV, LLDT, HLDT, MDPV	0.10	0.090	4.2	0.01	0.018	8	5
Bin 7	2004+	LDV, LLDT, HLDT, MDPV	0.15	0.090	4.2	0.02	0.018	7	4
Bin 8a	2004+	LDV, LLDT, HLDT, MDPV	0.20	0.125	4.2	0.02	0.018	7	3
Bin 8b	2004-2008	HLDT, MDPV	0.20	0.156	4.2	0.02	0.018	7	3
Bin 9a	2004-2006	LDV, LLDT	0.30	0.090	4.2	0.06	0.018	6	2
Bin 9b	2004-2006	LDT2	0.30	0.130	4.2	0.06	0.018	5	2
Bin 9c	2004-2008	HLDT, MDPV	0.30	0.180	4.2	0.06	0.018	5	2
Bin 10a	2004-2006	LDV, LLDT	0.60	0.156	4.2	0.08	0.018	4	1
Bin 10b	2004-2008	HLDT, MDPV	0.60	0.230	6.4	0.08	0.027	3	1
Bin 10c	2004-2008	LDT4, MDPV	0.60	0.280	6.4	0.08	0.027	3	1
Bin 11	2004-2008	MDPV	0.90	0.280	7.3	0.12	0.032	2	0

Tier 1 Program

LDV	1994-2003	LDV	0.6	0.31	4.2	0.10	--	3	1
LDT1	1994-2003	LDT1	0.6	0.31	4.2	0.10	0.8	3	1
LDV diesel	1994-2003	LDV	1.25	0.31	4.2	0.10	--	1	0
LDT1 diesel	1994-2003	LDT1	1.25	0.31	4.2	0.10	0.8	1	0
LDT2	1994-2003	LDT2	0.97	0.40	5.5	0.10	0.8	1	0
LDT3	1994-2003	LDT3	0.98	0.46	6.4	0.10	0.8	1	0
LDT4	1994-2003	LDT4	1.53	0.56	7.3	0.12	0.8	0	0

To promote low-emission vehicles and to make it simple for customers to choose, the US-EPA has an online system with a layout shown in figure 7, (http://www.epa.gov/autoemissions/) where all vehicles sold are compared. The vehicles, cars and trucks are given a CO_2 -emission score and an air pollution score that relates to local emissions and information on the fuel consumption (miles per gallon).

The federal regulations allow for the different states to introduce more stringent regulations and higher environmental ambitions, and so far New York and California have done so. For many years, California has been one of the major driving forces in demand and evolution of environmentally-friendly vehicles. Different states have also different incentives coupled to this rating (US EPA, 2005; US DOE, 2005).

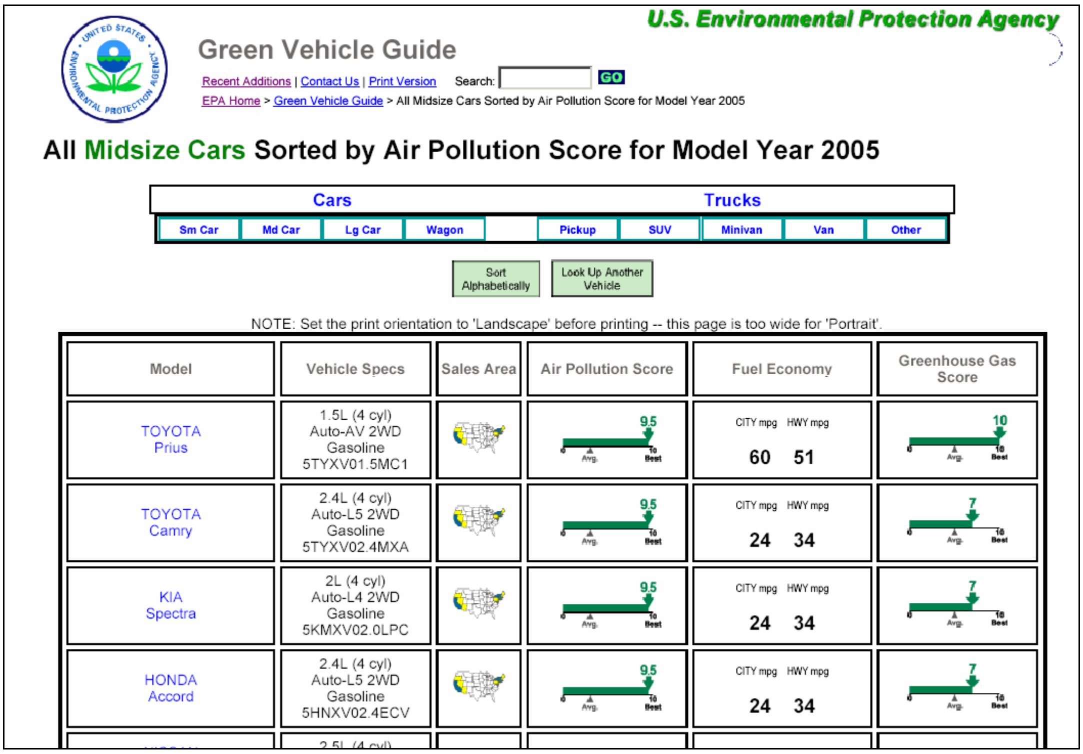

Figure 7: US EPA Green Vehicle Guide. (http://www.epa.gov/autoemissions/)

6.4.2 New York – EPIS and economic incentives

New York's Alternative Fuel Vehicle Tax Incentive Programme offers tax credits for the purchase of new Hybrid Electric Vehicles, HEV, Electric Vehicles, EV, Alternative Fuel Vehicles, AFV, and the installation of alternative fuel vehicle refuelling facilities. New York gives purchasers of qualified Hybrid Electric Vehicles eligible for a tax credit of $2,000. To qualify, a vehicle must obtain its propulsion energy from an internal combustion engine, have an energy storage device; and employ a regenerative braking system that recovers waste energy to charge that device. Models from the year 2004 and later must meet or exceed the California LEV II emission standard.

Purchasers of EVs are eligible for a tax credit of 50% of the incremental cost, up to $5,000 per vehicle.

Purchasers of AFVs are eligible for a tax credit worth 60% of the incremental cost of the vehicle. The maximum value of the incentive is $5,000 for vehicles with less than 14,000 pounds gross vehicle weight rating, and up to $10,000 for vehicles over 14,000 pounds gross vehicle weight rating (GVWR, US Department of Energy, 2005).

6.4.3 Californian efforts to stimulate clean vehicles

The California Air Resources Board, CARB classifies vehicles from an environmental point of view as Bronze, Silver or Gold vehicles, and offers tax refunds. California's innovative new vehicle standards introduce increasingly cleaner emission levels for new cars and trucks. These different levels of emissions standards give manufacturers the flexibility to rapidly introduce cleaner vehicles to California by allowing them to choose when to upgrade models.

In the early 1990s, the California Air Resource Board started the Zero Emission Vehicle, ZEV programme. This programme planned the number of ZEV vehicles the producers should produce and sell in the coming years. The programme is an integral part of the mobile source control efforts. However a vehicle programme specialist from the California Air Resources Board states that the ZEV programme had to be modified (Shulock, 2003). The modifications were needed in light of ongoing litigation and recent trends in ZEV technology and marketing. The result is that the California Air Resources Board now to a larger extent includes and promotes advanced clean conventional vehicles. Those vehicles are known as “Partial Zero-Emission Vehicles, PZEV” and “Advanced Technology Partial Zero-Emission Vehicles, ATPZEV”. They shall not only meet the basic PZEV criteria, but also have other ZEV-like characteristics such as electric drive.

In 1990 the California Air Resource Board’s ambitions was to reduce vehicle emissions to zero through the introduction of the Zero Emission Vehicles. At that time, the Air Resources Board implementation required that by 1998, 2% of the vehicles sold in California had to be ZEVs. This share should increase to 5% in 2001 and in 2003 10% of all sold vehicles should be ZEVs.

The ZEV mandate/regulation was adjusted several times. In 1996 changes were made to eliminate problems with the start-up years, but the 10% ZEV requirement for 2003 remained in place for some time. It was adjusted in 1998 to allow Partial ZEVs (PZEVs) and credits for extremely clean vehicles that were not pure zero emitters. The underlying goal, however, never changed. California remained committed to increase the numbers of ZEVs in the vehicle fleet.

In January 2001 the California Air Resource Board once again considered the status of the ZEV programme leading to more modifications. The challenge at that time was to maintain progress towards commercialisation of ZEVs, while recognizing constraints due to cost, lead-time, and technical challenges. The 2001 modifications allowed large manufacturers to meet their ZEV requirement with a mix of vehicles, which also included near-zero emission technology as shown in table 5.

Table 5: The 2001 California ARB required mix of vehicles.

Requirement	Category	Description
2% Gold	Pure ZEVs	Battery Evs or hydrogen fuel cells; zero exhaust emissions
2% Silver	Advanced technology PZEVs (AT PZEVs)	These vehicles shall have extremely low (PZEV) emission levels and also employ ZEV-enabling technologies such as electric drive
6% Bronze	Partial Zero Emission Vehicles (PZEVs)	These vehicles shall meet the most stringent exhaust emission standards and come with a 15 year / 150,000 mile warranty

In June 2002, due to a lawsuit filed against the California Air Resource Board, a federal district judge issued a preliminary injunction that prohibited the enforcement of the 2001 ZEV amendments with respect to the sale of new motor vehicles for model years 2003 or 2004. Since adopting the 2003 amendments to the ZEV regulation, the parties have agreed to end the litigation.

In 2003 there was a new modification. In order to address the preliminary injunction and to better align the programme requirements with the status of technology development, staff proposed additional modifications to the ZEV regulation in March 2003. After hearing extensive testimony and public comment, the Board adopted changes to the ZEV programme on April 24, 2003. The significant features of the April 2003 changes to the ZEV regulation were:

- The ZEV percentage requirements will restart in the 2005 model year, while allowing manufacturers to earn and bank credits for vehicles produced prior to the 2005 model year
- The way that credits from ZEVs are calculated is revised to remove the efficiency multiplier and specify the number of credits earned each model year by each five “types” of pure ZEV’s ranging from Low speed “Neighbourhood Electric Vehicles” to Fuel cell vehicles
- The ATPZEV calculation methods are amended to remove all references to fuel economy or efficiency
- The criteria for determining if a hybrid electric vehicle earns advanced ZEV component allowances were changed so that a hybrid-electric PZEV would have to exhibit traction drive boost, regenerative braking and idle start/stop in order to qualify at one of three levels

Table 6: Hybrid electric vehicles and AT PZEV advanced ZEV credits – modification of the ZEV-programme

Level	Description	AT PZEV Credits
Level 1: Low voltage, Low power	Less than 60 volts and at least four kilowatt (kW) motor power	0.2 credits through model-year 2008
Level 2: High voltage	60 volts or more and minimum 10 kW motor power	0.4 credits, reduced in stages in the 2012 and 2015 model years to 0.25
Level 3: High voltage, high power	60 volts or more and minimum 50 kW motor power	0.5 credits, reduced in stages in the 2012 and 2015 model years to 0.35

Large volume manufacturers will be allowed to comply with either a "base compliance path" using percentage ZEV requirements structured like those in the 2001 ZEV amendments, or with an "alternative compliance path." The "alternative compliance path" allows ATPZEVs to be used to meet pure ZEV obligations, provided that the manufacturer meets the yearly requirements:

- 250 fuel cell vehicles in 2001–2008
- 2,500 fuel cell vehicles in 2009–2011
- 25,000 fuel cell vehicles in 2012–2014
- 50,000 fuel cell vehicles in 2015–2017

An independent expert review panel will be established to advise the Board on technological advances made in pure ZEV and ATPZEV technologies, in order for the Board to consider changes to the requirements for the 2009 and subsequent model years.

In 1998, the California Air Resources Board extended the passenger car emission standards to heavier sport utility vehicles, SUVs and pickup trucks with gross vehicle weight up to 8,500 pounds, which formerly had been regulated under less stringent emission standards, LEV I. The new regulations LEV II provide a transition period between 2004 and 2007 for manufacturers to meet the new standards for trucks, vans and SUVs. Consequently, a portion of the large vehicle fleet will meet the less stringent emission standards LEV I until 2008.

For the consumer this means that until 2008, larger vehicles can have a SULEV emissions rating according to the old standards and will create up to ten times more pollution than a passenger vehicle with that same rating. This can be confusing and is not an optimal solution, but it is seen as necessary for the transition period.

6.4.4 The label

The different California Air Resources Board classifications of vehicles are summarised in table 7 and the information scheme includes visualization of the performance as shown in figure 8. The guide helps the purchaser to make the cleanest vehicle choice of this model type available in California.

The system is not technology-neutral and there is no guarantee that an ATPZEV-vehicle is more environmentally-friendly than an ordinary super ultra low emitting vehicle, SULEV.

The most environmentally- friendly vehicle types in certain "classes" related to size are ranked against each other, but small vehicles are not compared in relation to larger models. This is illustrated in figure 8.

Table 7: Classification of light vehicles which have lower emissions than an average 1999-model

LEV	Low Emission Vehicles are the least stringent emission standard for all new cars sold in California in 2004 and beyond.
ULEV	Ultra Low Emission Vehicles are 50% cleaner than the average new 2003 model year vehicle.
SULEV	Super Ultra Low Emission Vehicles are 90% cleaner than the average new 2003 model year vehicle.
PZEV	Partial Zero Emission Vehicles meet SULEV exhaust emission standards, have a 15 year / 150,000 mile warranty and have zero evaporative emissions.
ATPZEV	Advanced Technology PZEVs meet SULEV exhaust emission standards, have a 15-year / 150,000-mile warranty, have zero evaporative emissions and include advanced technology components. For example, a plug-in hybrid or a compressed natural gas vehicle would qualify in this category.
ZEV	Zero Emission Vehicles have zero exhaust emissions and are 98% cleaner than the average new 2003 model year vehicle.

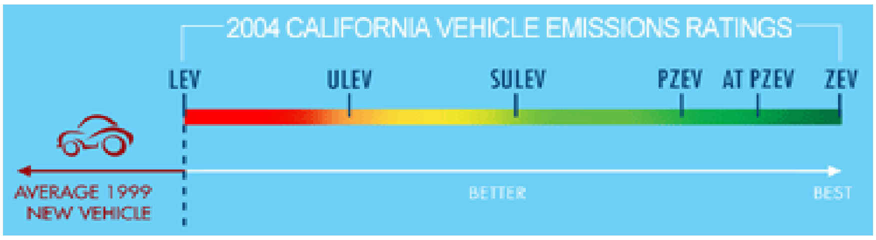

Figure 8: Visualisation of the California Zero Emission Vehicle Programme (http://www.driveclean.ca.gov/en/gv/vsearch/cleansearch.asp).

Several categories shown in figure 8 have the same rating according to the 2004 Californian scheme but there can be huge differences in emissions. SULEV passenger cars and light trucks have 90% lower emissions compared with the average 2004 vehicle. A SULEV Duty 2 truck and a SULEV Van on the other hand produce 15% more emissions than the average 2004 vehicle. This can be confusing for the purchasers since the labelling in both cases is SULEV.

HOW VEHICLE EMISSIONS COMPARE

VEHICLE TYPE	% DIFFERENCE FROM AVERAGE 2004 VEHICLE	REFERENCE
ZEVs ALL	100 % LESS	
SULEV PASSENGER CARS & LIGHT TRUCKS	90% LESS	
LEV II ULEV PASSENGER CAR & LIGHT TRUCKS	66% LESS	
LEV II LEV PASSENGER CAR & LIGHT TRUCKS	55% LESS	
SULEV MED DUTY 1 TRUCK, VAN, OR SUV	28% LESS	
ULEV PASSENGER CAR	13% LESS	
LEV PASSENGER CAR	AVERAGE EMISSIONS	
SULEV MED DUTY 2 TRUCK, VAN, OR SUV	15% GREATER	
LEV II ULEV MED DUTY 1 TRUCK, VAN, OR SUV	25% GREATER	
LEV II LEV MED DUTY 1 TRUCK, VAN, OR SUV	43% GREATER	
LEV II ULEV MED DUTY 2 TRUCK, VAN, OR SUV	130% GREATER	
LEV II LEV MED DUTY 2 TRUCK, VAN, OR SUV	190% GREATER	
ULEV MED DUTY 5 TRUCK, VAN, OR SUV	330% GREATER	

Figure 8: Emissions from vehicles with California Air Resources Board rating in relation to the average 2004 vehicle, Source: CARB, reviewed 5/20/05

6.4.5 Introduction of vehicles in California

Although some may question the benefits or success of the ZEV regulation – according to the Californian Air Resource Board it has been a success for California's air quality. Other statements from CARB are that:

California's innovative vehicle standards provide increasingly cleaner emission levels for new cars and trucks. The different levels of emissions standards give manufacturers the flexibility to rapidly introduce cleaner vehicles to California by allowing them to choose when to upgrade particular models.

During the ZEV-programme the major car manufactures placed over 4 000 battery-powered ZEVs in California between 1998 and 2003. Consumers quickly bought these highly functional vehicles and called for more.

The regulations spurred advances for natural gas vehicles, other alternative fuelled vehicles and super clean petrol vehicles. The sale of fuel-efficient hybrid vehicles that are powered by a combination of electric motors and internal combustion engines is a true success in California. Fuel cell vehicles powered by electricity created from hydrogen are demonstrated as well-qualified candidates for future transportation as experimental vehicles and prototypes tested in California.

There are today large numbers of PZEVs on the road and there are high expectations that many more PZEVs and ATPZEVs will be around in the years to come. With the high demands for air quality, an innovative and wealthy population California will step forward as a leading force for new environmentally-friendly vehicles.

6.5 EPIS and eco-labelling of other products and services

Environmental Product Information Schemes have been used on a wide range of products and services. The experience is that eco-labelling of other products show that labelling can be an effective way to stimulate the market and influence the industry.

Existing labelling information schemes are known to the customers and are preferable since the customer is used to understanding how the information is presented. The information and the label must catch the interest of the customer, be simple and easy to understand. Technology-independent well-defined criteria for the products are efficient and may allow for evaluations and comparisons between different product types and applications. Colours from green to red appear to be easy to relate to in addition to specific figures. The information itself seems to be a strong incentive for the market to choose environmentally-friendly vehicles.

6.5.1 Electric household appliances

A European system for labelling refrigerators and freezers and other household appliances in accordance to energy consumption has been in operation for the last 10 years. Label with classifications from A to G shows the energy consumption of the product, and an A-product has the lowest energy consumption. The European system was introduced in 1992 with directive 92/75/EEC and implemented in Norway in 1996 as part of the law on labelling consumers products.

Several daughter directives are directed at specific product groups, for example 94/2/EC for refrigerators and freezers, 95/12/EC for washing machines, 95/13/EC for tumble dryers, 96/60/EC for combined washer-dryers, 97/17/EC for dishwashers, 98/11/EC for lamps and light bulbs, 2002/31/EC for air-conditioning) and 2002/40/EC for electric ovens.

Energy consumption in relation to the volume of the refrigerator, with at least seven steps ranging from A to G, was introduced with directive 92/75/EEC. Every product has to be supplied with documentation of energy consumption and functional parameters.

Energy labelling of household appliances has with no doubt been a success story. Because of consumer awareness, manufacturers have been forced to improve their products. After some 10 years of labelling there are now almost only A, A+ and A++ products on the market. The original comparative scale has been exposed to inflation. The energy efficiency is now much better than was predicted 10 years ago when the threshold values for the scale A to G was established. The top ranging A is just not high enough any more and hence one or two + had to be added. An update has been discussed but there have been no new agreements, and the A++ will still appear over the next few years.

Since 2001, energy labels for office products have been a harmonisation between the EU with Regulation 2422/2001 and the USA's Energy Star Programme.

6.5.2 Labelling Energy performance of buildings

There is an EU-directive on environmental performance of buildings, Directive 2002/91/EC. In this system the energy use per m^2 must be measured, calculated and the source of energy documented in an energy label or energy pass for the building. This information must be attached or made known to buyers, when buildings are sold or hired out. There is yet no agreement on what an energy pass will look like or how the information should be presented. Ranking of buildings however seems unlikely to appear in the near future. A label for performance of buildings is shown in figure 9 (CEN/TC 89/WG4 N251, 2004).

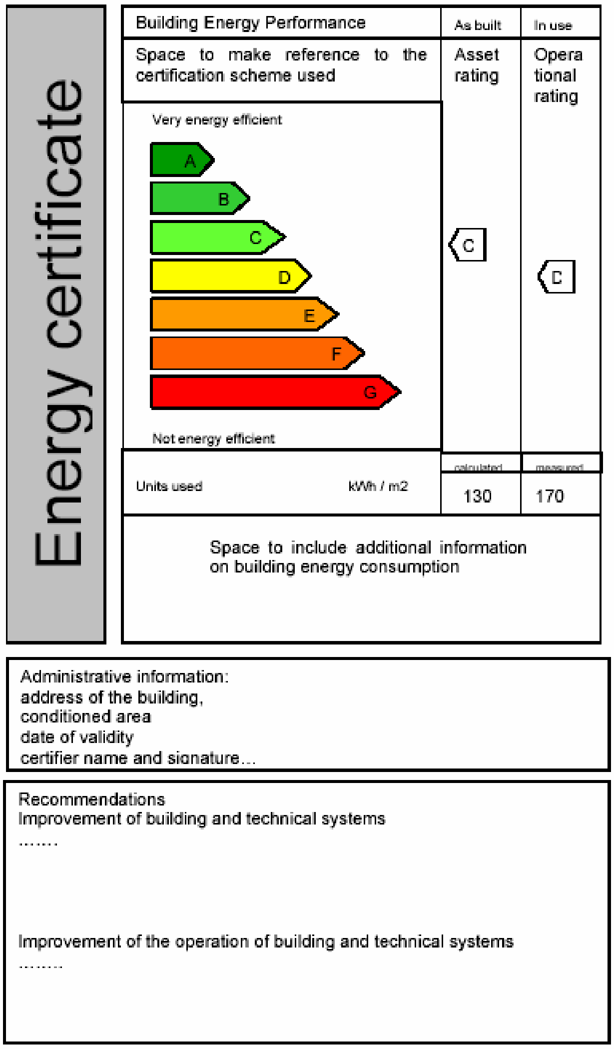

Figure 9: Label showing the environmental performance of buildings. The system requires that energy use and supply to be measured, calculated and documented (also source of energy/fuel), per m^2.

7 Environmentally-friendly vehicles in the Nordic countries

The information from the Nordic countries is based on white papers and other relevant literature, supplemented with interviews with key persons in several Ministries, research institutions and NGOs in the Nordic countries.

7.1 Denmark

The description of Danish efforts to promote EFVs is based on literature/the internet and short interviews with Niels-Anders Nielsen, Road Safety and Transport Agency, and Finn Terp, Copenhagen City Administration.

In the Danish legislation there is no definition of an environmentally-friendly vehicle, but there is an energy labelling system, which includes information about CO_2-emission, NCAP-stars and PM traps for diesel vehicles. There are also tax incentives connected to energy consumption and fossil CO_2 emissions. In 2003 The Ministry of the Environment introduced a fund for retrofitting of PM traps on heavy-duty vehicles and for funding demonstration projects with alternative fuels.

In 1997 the Danish Energy Agency, DEA proposed a plan for the Danish Government to introduce an energy labelling system for new cars. The goal was to promote smaller and more energy-efficient passenger cars and through this reduce the CO_2 emissions from the transport sector. The labelling system was originally intended to be a voluntary agreement with car dealers and agencies.

However, the new energy labelling system was fully and compulsorily implemented in March 2000, with starting point of 1 January 2001. The energy labelling regulation was followed by a change in the annual tax on new vehicles from a weight-basis to an energy consumption basis, and it was called the “Green owner tax”.

Each year Denmark’s Road Safety and Transport Agency publishes a brochure containing information about new vehicles’ energy consumption and green taxes. This is an environmental guide to help the purchaser to choose the most environmentally- friendly vehicle. This now forms the Danish implementation of the EU directive on labelling of fuel consumption and CO_2 emissions from light vehicles from 1999.

The Scheme uses the same design as the household appliance labels. The reason for this choice was the ‘recognition effect’ for consumers.

The need for brand-building was reduced to more or less zero. The scheme shown in figure 10 and 11 includes printed information and an Internet guide, where it is possible to search for car models.

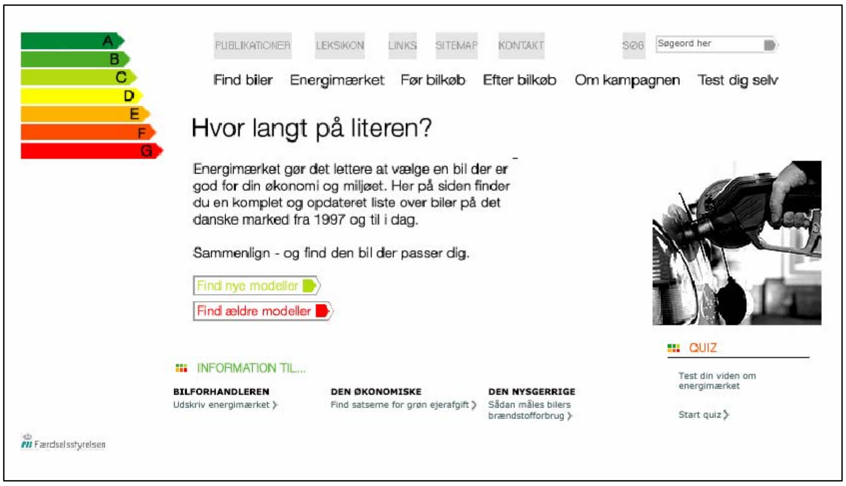

Figure 10: Danish Internet site with vehicle energy labelling (Danish only).
http://www.hvorlangtpaaliteren.dk/sw445.asp

The information scheme contains data about all models sold in Denmark:

- Model/size, horsepower/engine and total vehicle weight
- Energy efficiency rated as km/litre fuel.
- CO_2 emissions per vehicle km.
- Diesel models are marked with a flower symbol if it has a PM trap.
- Crash safety stars from Euro NCAP
- Economic fuel savings/fuel cost at 20,000 km/year
- Owners' annual tax and dependency of CO_2 emissions

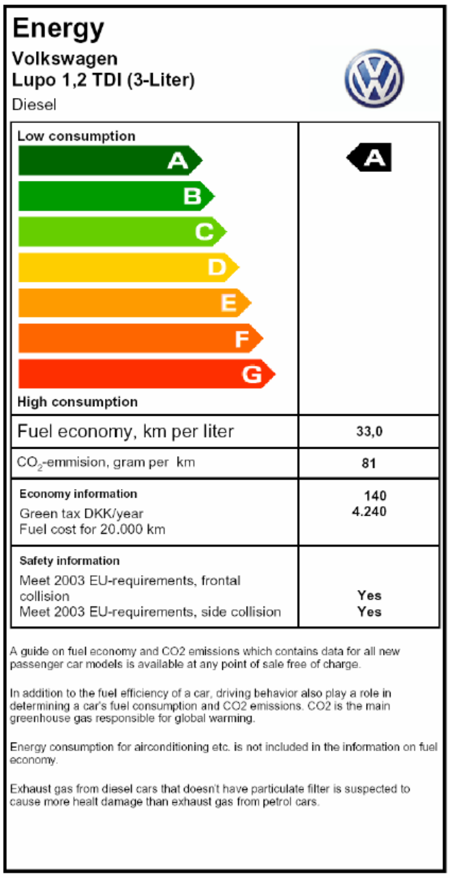

Figure 11: The Danish system for energy and emission labelling of vehicles. The safety information now uses NCAP-stars instead of EU-2003-requirements. There is also a clover mark, a plant with three-lobed leaves to show if the model has a particulate PM- trap

The data is not sorted by class or size of cars. Petrol and diesel cars are classified separately, but easy to compare due to figures for emission of CO_2/km.

The fuel consumption is given as a rating from A to F and as distance in km per litre. The absolute figures for how far a vehicle will drive on one litre fuel are important since it is believed, that this makes it easier for consumers to compare with their own driving experience. Hence the heading is “How far per litre”. According to Færdselsstyrelsen in Denmark, it might also be interesting for customers to compare their own real-life driving with the published distance per litre

The intervals in the score, A to G, are based on petrol cars, average fuel use and a Gaussian distribution of models sold in Denmark. The diesel scale is adjusted to the petrol scale.

Information about local emissions of NO_x, PM, HC, CO since 2005 has been given as written comments and with the clover mark for PM traps. Alternative fuel vehicles are not included in the scheme, because they have a very low market share, and because there are no official emission limits or approval of alternative vehicles and fuels.

The label compares the fuel economy of a specific model with all other new passenger cars. The main argument for not using different categories such as small, medium and large cars is that it would reduce the incentive for car buyers to choose smaller cars. Even though many car buyers in practice choose between vehicles within the same size category of vehicles, it is assumed to be confusing with comparisons divided in different categories. If a large car in one category is rated with "A - low consumption", and a small car in another category is rated with "C" this is confusing, since in absolute terms the small car is more energy- efficient than the large car. The confusion and somewhat misleading A and C rating is thought to give the label low credibility.

Another reason for not using model categories is the difficulty in making them consistent. For example it would be unfair and difficult to classify cars near the upper and lower categories limits according to weight or size. In the Californian ZEV-programme this is a problem, and is confusing for the purchasers.

Denmark's Road Safety and Transport Agency believes that it is important for the success of energy labelling system that the information is supported by economic incentives. In accordance with this, the annual taxes in Denmark are related to CO_2 emissions. The tax level may thus differ by up to DKK 25 000 per year with different CO_2 emissions.

In 2003 and 2004 there was a campaign to improve knowledge about the tax incentives and the available information for new vehicles. The campaign spent DKK 3.5 million DKK a year on influencing Danish car customer behaviour and brand-building of energy and emission labelling.

The scheme was very much developed by Denmark's Road Safety and Transport Agency alone, with some minor cooperation with the car dealers' organisation. There are no plans for further development of the labelling system related to the ongoing discussions in the EU Commission.

7.1.1 Alternative fuels and other initiatives and programmes

In Denmark alternative fuels or vehicle technology are not highly prioritised issues in transport policy. On the other hand, there are some economic incentives and traffic advantages related to alternative fuels and environmentally- friendly technologies. Denmark's Road Safety and Transport Agency does not promote these technologies. The government does not want to use economic incentives for these vehicles, and the argument is that they have to be able to compete to increase the market share.

On the other hand, green purchasing guidance is given to all governmental offices about prioritising the purchase or lease of low emission and especially low CO_2 emitting vehicles. Electric vehicles are free of taxes, have free parking and can use the dedicated lanes for public transport.

The Ministry of Environment provides financial support for the retrofitting of PM traps. The maximum support is DKK 15 000 which is related to the total cost of retrofitting an approved PM-filter of DKK 30 000 to 100 000. Few vehicle owners currently use this support programme but the number is increasing.

Denmark's Road Safety and Transport is responsible for approving the PM-filters. Their experiences show that retrofitting of after-treatment equipment works well on all heavy-duty vehicles (>3.5 tonne) with EURO I, II and III engines. There have been some difficulties with the EURO IV engines, probably due to the electronic fuel-ignition system. Retrofitting does not work well on light vehicles. The reasons are not known, but further investigations and test programmes will be performed as part of the Odense project, http://www.fstyr.dk/sw24330.asp.

7.1.2 Local initiatives – municipalities and NGOs

There are several local initiatives to promote alternative fuels and technology electric vehicles, bio fuels, LPG and so on. The cities and communities of Copenhagen, Aalborg, Odense and Svendborg have introduced rules and guidance about vehicles in the city centres and use of transport services.

There are almost 500 LPG-busses in Copenhagen. This is a part of Green Municipality Policy. The Copenhagen administration demands that all vehicles used in their services must comply with a set of strict emission standards.

In 2003 Copenhagen took the initiative to establish an environmental zone in the city centre. The idea was that only busses and heavy-duty vehicles that comply with a set of strict emission limits (EURO V for the engine) would be allowed to enter the environmental zone. The Government did not give the municipality permission to do so. The argument was that the costs to truck owners and society would be too high compared to the benefit to society.

There have been other campaigns as the 'Miljøbilistkampagne i hovedstadsområdet' (1998 – Environmental Drivers Campaign in the Capital Area). The main purpose of this campaign was to underline the opportunities for choosing an environmentally-friendly car when you are going to bye a new one, and to put focus on how to drive to minimise energy use and emissions.

7.2 Finland

7.2.1 National initiatives and programmes

In Finland alternative fuels or vehicle technology do not appear to have been highly- prioritised issues in the transport policy. However, there are political discussions about the possibilities of introducing new vehicle taxation regimes that may result in incentives for environmental issues.

A short interview with Juhani Laurikko at VTT Energy reveals that there in Finland are no economical or traffic incentives to stimulate the introduction and use of environmentally-friendly vehicles. The taxation of electrical vehicles even appears to punish such vehicles, since as diesel engine vehicles, they are taxed by weight. Taxation in relation to weight is clearly a problem for marketing of electrical vehicles with heavy batteries for energy storage. According to Laurikko, CNG and biogas vehicles meet bureaucratic challenges in the process of getting approval for ordinary use.

In Finland there are strong national programmes directed towards the development and introduction of new technology and clean fuels in the transport sector. TEKES, the Finnish council for technological research and development supervise, and together with Ministries and industry, jointly finance national research programmes. VTT is also well- represented in international environmental research and EU programmes. Finnish research and knowledge about vehicle particle emissions and characterisation is internationally highly respected.

In the Airnet Project, Finland and the Netherlands are planning collaborative research into environmentally-friendly vehicles.

Advanced Motor Fuels, AMF is an ongoing programme at VTT in co-operation with the International Energy Agency, IEA. The purpose of this programme is to develop new options and evaluate the possible introduction of both new fuels and new vehicle technologies. The goal is to increase the use of alternative fuels and corresponding clean technology. AMF provides an international platform for co-operation to promote cleaner and more energy-efficient fuels and vehicle technologies. VTT's advanced vehicle emission laboratory is working on and is publishing important contributions to the knowledge about real-life driving bus exhaust emissions. These VTT publications are unique and of great value for evaluating the environmental impact of different new bus technologies.

7.2.2 Local initiatives – municipalities and NGOs

In Finland there are several demonstration projects for use of alternative fuels. Some 75 CNG buses are operating in Helsinki, and the city has ambitions to expand this number to 300. However, due to the risk of gas explosion, CNG buses are banned from using an advanced city centre underground bus terminal.

Elcat was an electric vehicle manufacturer based in Järvenpää. The first commercial product was released in 1990 but production ceased in 2002. Elcat did not have enough resources to design new models. Elcat produced about 160 vehicles and the main user was "Post of Finland, Posti".

No cities in Finland have yet introduced environmental zones for the use of environmentally-friendly vehicles.

7.3 Iceland

The description of Icelandic efforts to introduce EFVs is based on an interview with Hersir Oddson who represented Iceland at the meeting of Group 54 of “Nordiska Vägtekniska Förbundet” in Helsinki in September 2005.

The Government of Iceland has announced that it is aiming to transform Iceland into a hydrogen society in the near future and thus, many hydrogen-related studies are being carried out, using Iceland as a case study. Iceland has similar standards and a similar transportation system as most other developed countries, and very useful experiences with hydrogen as fuel and vehicles running on hydrogen can be adapted to other industrialised societies.

Iceland is an island with huge geothermic and hydro-power resources. Energy for producing hydrogen from water electrolysis using renewable power is available, so introducing fuel cell vehicles is a matter of competitive and reliable vehicle fuel cell technology. In Iceland, the infrastructure for hydrogen, the initiation costs for hydrogen production and the production costs are supposed to be more favourable than for most other locations. In addition a future Icelandic hydrogen society would be spared the costly import of fossil fuels.

Iceland is an attractive and demanding pilot playground for hydrogen vehicle and hydrogen ship demonstration projects. Three hydrogen fuel cell buses have in operation in Reykjavík as a part of the Ecological City Transport System ECTOS. The project period is over but hydrogen demonstration projects are planned to continue.

Iceland has a number of vehicles fuelled by biogas – methane from a waste deposit near Reykjavik. In 2005 two waste collection trucks and about 30 small cars were running on this biogas. The intention is to produce enough methane from waste to fulfil the needs of 3000 vehicles.

Reduced import fees and taxes are incentives to increase the import of biogas vehicles. Biogas fuel has no taxes and in Iceland it is a more economical fuel for customers than fossil fuels such as petrol and diesel.

7.4 Norway

7.4.1 National initiatives

The description is based on official documents and short interviews with administration personnel in the Ministries and research institutions.

There is no official definition, in legislation or guidelines, of environmentally-friendly vehicles in Norway. Since 1990 there has been a CO_2 tax on fuels, but this has not been coupled with vehicle environmental performance and information about differences in vehicle fuel consumption and CO_2-emissions.

EPIS or labelling systems for environmentally-friendly vehicles are not aviliable in Norway. The Nordic Swan is an EPIS, but vehicles or transport services are not included or labelled in their scheme. The main conclusion from a study (Nordic Swan, 2006) was not to develop labelling schemes for vehicles at that stage. The group reported that the state administrations in the Nordic countries were not against Swan labelling of vehicles, but Finland and Denmark felt that it would not provide any benefits. In Sweden there was some resistance from a competing system organized by Gröna Bilister.

From 1 January 2007 the registration fee for new cars is related to CO_2-emissions instead of correlation to the engine displacement. The new system for registration fee calculation has so far had the effect that energy efficient vehicles have gained in popularity. New diesel engine powered cars has after 1 January 2007 increased their share of the new light vehicles sale to 70–80%.

Environmentally-friendly vehicles and alternative fuels are on the political agenda and different demonstration projects have been carried out. Bus projects using waste gas, buses running on natural gas, ferries running on natural gas, buses using bio diesel and vehicles driven on electricity, hydrogen and natural gas are examples of demonstration projects supported by the Government.

Norway has implemented the EU directive on fuel economy information and CO_2-emissions. All PR-campaigns and advertisements offering new cars include this information. The Norwegian Road Administration has developed an Internet site (www.vegvesen.no/sikkerbil/miljo.stm), which, amongst other information, compares different models and classes. Up to 2004 the Administration had its own reports/database but since 2005 the information has been retrieved from different European sites in Sweden, UK and Denmark

The Ministry of Transport is legislatively preparing the introduction of low emission city zones or environmental zones. These zones will only be accessible to vehicles which comply with EURO V or other low emission criteria. The local authorities are given the opportunity to establish such zones as one of several measures to achieve the PM_{10} and NO_2 targets in the EU directive for local air quality.

The Norwegian Road Administration has proposed rating of environmentally-friendly vehicles in a report for the Ministry of Transport (Norwegian Road Administration, “Kriterier for miljøklassifisering av lette kjøretøy, 19.07.2006”). This report recommends rating environmentally-friendly vehicles in four technology-neutral classes. It is recommended that vehicles be rated according to their CO_2 emissions and with demand for stringent local polluting demands in relation to EU legislation limits. The four environmentally-friendly vehicles classes range from zero emission vehicles up to vehicles with CO_2 emissions less than 140 g/km.

In 2007 there are about 1 600 electrical vehicles on Norwegian roads. All electric vehicles are free of all taxes and fees. Hybrid vehicles are free from Norwegian vehicle taxes, related to the electric power. Electrical vehicles and hydrogen vehicles have the advantage of free use of public transport lanes, free public parking and exemption from payment on toll roads and toll bridges in all Norwegian cities.

The development and production of an electric vehicle called Think (previously called Pivco) has been of great interest in Norway through the 1990's and up to the present day. Ford took over the business and developed a new model but sold the enterprise in 2003. After the Ford period there have been several owners but yet no real production of vehicles. Official plans however tell that the model, basically developed under the Ford period, will be ready for production and sale during the autumn 2007. Kewet Buddy is a small inexpensive Norwegian electric vehicle produced by Elbil Norge AS.

Gaseous fuels (CNG, LNG, LPG) in Norway have always been duty-free, and from time to time this has created incentives for petrol car owners to retrofit passenger with LPG and CNG kits. Bio diesel is free from all taxes and the same is suggested for ethanol when used as fuel. The Government has decided to implement the EU directive on bio fuels and the goal is to achieve an amount of 2% in 2007 and 4% in 2010 of all fuels sold.

Since 2000 substantial national research funds have been allocated to demonstration and research projects with hydrogen as a fuel for the transport sector. Bio fuels in the transport sector are receiving attention and increasing support. The Norwegian Research Board and the Research Programme RENERGI administrates the support to alternative vehicles and fuels.

7.4.2 Local initiatives – municipalities and NGOs

"Miljøbil Grenland" is a local initiative established in 1997, and is supported by Norsk Hydro ASA. It is located in the industrial area of Grenland, and the business plan is to promote the use of alternative power, by encouraging as many professionals as possible to drive electric cars. The companies who join the project take advantage of the fleet offers and electric cars are available through a leasing system.

Some 59 CNG buses are operating in Bergen, and in 2006 the bus company of Bergen will operate a further 16 CNG buses in Haugesund (www.gaia-trafikk.no)

In Oslo there have been several demonstration projects with buses using natural gas, LPG and bio diesel. None of them has yet had any success, because of high costs compared to benefits. The City Administration has decided to use fuel consumption and CO_2-emissions as criteria when leasing or contracting vehicles for use. This is a part of the sustainable city strategy, and the implementation of measures to reduce greenhouse gases and improve local air quality. There are similar initiatives in other cities and among private companies, but there are no co-ordinated or joint efforts on this issue.

HyNor is a concept which aims to establish a "Hydrogen link' from Stavanger to Oslo and further to Sweden, Gothenburg and Malmø. Norsk Hydro ASA was the initial driving force in this project, but there are now several other partners. The city administrations in Stavanger, Kristiansand, Drammen and Oslo are supporters. HyNoR is funded by the Norwegian Research Boards Research Programme RENERGI.

7.5 Sweden

7.5.1 National initiatives

Sweden is one of the world's leading manufacturers of heavy duty vehicles for an international market. In addition, 500 000–600 000 light vehicles of the brands Volvo and SAAB are produced each year. Development of these products in a world with increasing focus on environmental concerns and pollution from road vehicles implies that Swedish activities in favour of environmentally-friendly vehicles are substantial. Swedish research on environmental vehicles is supported by the Swedish research funding agency Vinnova.

In Sweden there are different EPIS and labelling systems for several product groups. However there is no national official scheme or overall definition for environmentally-friendly vehicles. In Sweden, there seems to be somewhat different opinions about how to define and classify environmentally-friendly vehicles. The first is according to the ability to use specified alternative fuels as ethanol, biogas and biodiesel and vehicle technology. The second is according to technology neutral criteria, with emphasis on energy efficiency, CO_2-emissions and other emission limits energy use.

Discussions and initiatives have led to several definitions. The government has adopted a definition where vehicles with specific technologies and fuels are subject to reduced tax and are permitted to drive in the environmental zone of Stockholm. This definition is also the guideline for purchasing cars for use in public administration. The selected vehicles have to meet the EURO IV emission limits. The governmental tax incentives to promote alternative fuels are quite strong and all alternative fuels are priced lower than conventional fossil fuels. The government has also given a thorough documentation of the effects (environmental impacts and social costs) of introducing strong tax incentives for bio fuels and other alternative fuels.

Gothenburg and Malmö use more or less the same definition as the government. However Gothenburg also includes fossil fuel powered cars when they are extremely energy-efficient, with CO_2 emissions less than 120 g/km and also they added some CO_2-emission limits for vehicles with alternative fuels (www.miljofordon.se).

Each year, the non-governmental association, Green Motorists, Gröna bilister, publishes a survey of new car models and make a list of what they define as environmentally-friendly vehicles. The work of Green Motorists is supported by the Swedish road administration, but their criteria are different from the governmental basis for tax refunds and from what vehicles the cities allow in their environmental zones.

There is an ongoing effort in the government to develop an environmental policy for vehicles used in public administration. The government's objective is that 25% of the vehicles used in public administration shall be classified as environmentally- friendly.

The Swedish Road Administration (SRA) in collaboration with the Swedish Environmental Protection Agency and the police (Rikspolisstyrelsen) aims to elaborate and suggest definitions for environmentally-friendly vehicles. The Swedish Road Administration has elaborated preliminary definitions and incentives in a report "Avrapportering av regeringsuppdrag att ta fram definition av miljöbilar", 2004. According to this report the recommended definitions of environmentally- friendly are categorised in three classes according to size. The three classes are Small cars, Large cars and Minibuses (more than 6–8 but less than 16 passengers) and are specified to comply with the following criteria:

Small car (< 5 passengers):

- <120 g/fossil CO_2
- Energy use < 68 kWh/100 km or < 7,5 l petrol/100 km
- Meet the EURO IV and for diesel vehicles also emit less than 0,0025g PM/km
- At least 4 Euro NCAP stars

Large car (5 passengers or more, including SUVs):

- <140 g/fossil CO_2
- Energy use < 84 kWh/100 km or < 9,2 l petrol/100 km
- Meet the EURO IV and for diesel vehicles also emit less than 0,0025g PM/km
- At least 4 Euro NCAP stars

Minibus (more than 6–8 but less than 16 passengers):

- <160 g/fossil CO_2
- Energy use < 84 kWh/100 km or < 9,5 l petrol/100 km
- Meet the EURO IV and for diesel vehicles also emit less than 0,0025g PM/km
- At least 4 Euro NCAP stars

If the vehicles are close to the upper limit for energy use, they will not meet the fossil CO_2 emission limit unless they are using bio-blended petrol or diesel or 100% bio diesel, electricity or hybrids. The Swedish Environmental Protection Agency does not support the idea of categorisation into three classes, due to insufficient objective criteria for the categorisation.

The Swedish Road Administration (SRA) in collaboration with Swedish Environmental Protection Agency and 'Rikspolisstyrelsen' has revised some of the criteria. The limit for PM is increased from 25 mg/km to 50 mg/km.

7.5.2 Local initiatives – municipalities and NGOs

The big cities of Stockholm, Malmö, Lund and Gothenburg have collaborated over several years on improving air quality in the city centre. However, they have different definitions of environmental vehicles and use different incentives to promote the use of these vehicles

The activities used to focus on and promote environmental vehicles are:

- A continuously updated website www.miljofordon.se with information about clean and environmentally- friendly transport and promotion of the use of clean vehicles.
- Dissemination of information to city administrations and their suppliers, companies, taxi and courier companies, car sales staff, fuel suppliers, environmental consultants and the government.
- Activities such as mail shots, telephone marketing, newsletters, seminars, personal visits and press activities, mobility management and so on.
- Activities targeted at heavy vehicles

The local incentives in Gothenburg and Malmö are free entrance for the environmentally-rated vehicles to the city centre and free parking at the special parking places. The allowance is given for three years and it is necessary to re-apply after the three years period is up. There is no guarantee of getting another three-year period because of revisions of the EFV definition. In Stockholm the incentives are parking subsidies and lower congestion charges.

The local Swedish criteria for vehicle ratings as environmentally-friendly are extensive, demanding and to some extent complicated. The existing criteria are available at www.miljofordon.se with links to Gothenburg and Malmö who use the same environmental vehicles definitions. These definitions include light vehicles less than 3 years old, electric-hybrid, electrical vehicles and vehicles that could use specified alternative fuels. Vehicles using fossil petrol and diesel but with extremely low emissions of CO_2 are also included. The vehicles must also comply with the defined EU IV standard for emission regulations. There is a car safety criterion for small vehicles demanding a minimum of three NCAP-stars. Enhanced Environmental Vehicle, EEV, according to the EU standards is a local criterion for heavy duty vehicles in Gothenburg and Malmö.

In Stockholm the environmentally- friendly definition includes light vehicles. The vehicle types that qualify for environmentally- friendly rating are electric vehicles, vehicles with bi or flexi fuel possibilities but with the restriction that the main part of the driven distance should be driven with renewable fuel. Vehicles that meet the EURO IV limits are also included as environmentally- friendly. Stockholm has no limits for energy efficiency or CO_2–emissions.

The Swedish Association of Green Motorists (Gröna bilister) collaborates with government and private companies and participates in international, national and local activities. In their annual report on the environmental performance of new car models they label the best as “a good environmental choice". They also lobby to make state agencies, regional authorities and local communities include stricter environmental demands and safety requirements for the public procurement of vehicles, fuels and transport services.

To rate the best vehicle as “a good environmental choice” they use a set of criteria:

- Low emissions of regulated substances, Swedish environmental class 2005, and a guarantee that these requirements are met also after at least 100,000 km driving distance
- Each year the association defines a CO_2 -limit where usage of the vehicle, fuel production and fuel distribution are considered.
- Rating according to crash safety tests and NCAP stars

The Green Motorists has made an evaluation of the municipalities’ incentives to promote environmentally-friendly vehicles. A municipality gets a score of 1 to 10. Some conclusions from Green Motorists’ evaluation are:

- The municipalities need help from experts/state administration to establish common definitions of environmentally-friendly vehicles
- A minority, of the municipalities promote environmental vehicles

- Few manufactures, agencies and dealers advertise environmental vehicles
- Distribution of alternative fuels has to be improved

8. Conclusions and Recommendations

Transport and particularly road traffic is one of the largest sources of emissions of CO_2 and local pollutants worldwide. The international society is concerned about the consequences. Emissions of CO_2 and other greenhouse gases affect the global climate, and thereby ecosystems and human health (IPCC, 2005). Emissions of particles and nitrogen oxides affect local air quality and human health (WHO, 2005).

Vehicles will remain important means of transport for decades to come. Improving the environmental performance and the energy efficiency of vehicles is an important issue from an environmental point of view. If we want to convince people to buy environmentally-friendly vehicles, we must make sure that they have good knowledge about what these vehicles are. People must know the differences between propulsion technology alternatives and the true advantages of buying clean, efficient vehicles. They must be convinced that an environmentally-friendly vehicle is a better choice.

Although strict air quality standards are exceeded in urban areas, the air quality is slowly getting better. The smell of vehicle exhaust is a vanishing problem for most people, even if we sometimes observe black smoke, and in wintertime we recognise the scent of fossil petrol and diesel. People hear from the media that poor air quality cause health problems, and that mortality is increasing due to pollution.

Visibly good, but insufficient air quality and high CO_2 concentrations seem to be relatively weak driving forces to motivate people to buy environmentally-friendly vehicles. Global warming and possible future shortages of fuels are more dramatic arguments, but those problems do not influence the customer here and now. The implication is that designing efficient Environmental Product Information Schemes (EPIS) is a demanding task.

The criteria to define environmentally-friendly vehicles must be as simple as possible, and they must be trustworthy. When information is complicated and confusing it is far from convincing. We must try to give an undisputable, clear picture of what environmentally-friendly vehicles are. A labelling system can be an effective way to communicate with potential customers. Different types of incentives, ranging from small benefits to real substantial economic support, will increase the number of environmentally-friendly vehicles.

The study describes experiences of existing programmes and incentives, which promote environmentally-friendly vehicles. Our examples from the Nordic countries, the EU-community, the UK, the USA and the international automotive organisation FIA foundation show that environmentally-friendly vehicles are classified in many different ways. Different Environmental Product Information Systems and labelling schemes, with strengths and weaknesses are in use but have only been independently evaluated to a small extent.

Interest and environmental aims are high in the Nordic countries. Key persons have been interviewed and, together with thorough literature studies, it is clear that there are very different schemes and somewhat divergent strategies both within and between the countries.

8.1 Technology-independent criteria

We have used the acronym LZV, Low or Zero emission Vehicle to define a sufficiently environmentally- friendly light vehicle. According to our considerations a vehicle qualifies for a LZV classification when it complies with specified high environmental criteria. These criteria shall reflect high environmental concern and must be supported by society.

In 2005 the primary environmental concern about vehicles was exhaust emissions that affect human health, global warming and high energy consumption. Zero and technology neutral exhaust emission limits will meet society's concern to reduce environmental problems. Technology neutral criteria will in our opinion stimulate the vehicle industry to develop the best and most economical solutions.

We recommend two main criteria for defining a LZV. The two criteria are based on the knowledge we have today and are simple to understand and possible to check:

- Strict limits for the local pollutants NO_x, VOC and particulate matter
- Strict limits for CO_2 emissions, which imply reduced fossil fuel consumption

As limits for local pollutants we suggest using the strictest available requirements. The'Californian Super Ultra Low Emission Vehicle limits' for private cars, are currently regarded to be the most demanding criteria in the world. For the second criterion, we suggest 120 g CO_2/km as the limit since the value of CO_2 emissions is well-known from mixed driving (EDC) from homologation of all new car models in Europe.

The contemporary LZV classifications, environmental vehicle criteria must generally in the future be updated with stricter limits and new test regimes. In addition they could also include:

- Strict cold start emission limitations at Nordic low ambient temperatures, since this would improve air quality in vulnerable Nordic cold climate areas
- Life Cycle Perspective on CO_2 emissions including production, use and recycling
- Strict vehicle noise emission restrictions

8.2 LZV rating – impacts on technology and size

Electric vehicles and fuel cell vehicles will easily comply with the suggested LZV criteria. A few hybrid passenger car models, lightweight petrol and diesel cars qualify or have the potential to qualify as LZVs, if they are equipped with efficient emission reduction systems. Methane/biogas, LPG and hydrogen fuelled vehicles have CO_2-emission advantages, which will help them to comply with LZV criteria.

Vehicles with renewable fuels contribute to reduction of emissions of fossil fuel CO_2. However energy efficiency and emissions of local pollutants may be considered as equally import parameters. With a financially-subsidised flexi-fuel vehicle, a driver can choose to drive using an alternative fuel or fossil fuels. In the case of a flexi-fuel vehicle driven on fossil fuel, governmental support goes to the distribution of cars and not to supporting CO_2 neutral fuels. In our opinion, alternative fuel vehicles should not be considered as LZVs unless they comply with the two criteria for local pollutants and CO_2 emissions. We argue that the CO_2 emissions are true measures of efficiency for combustion of carbon rich fuels, and that all vehicles also ought to be energy efficient a when they run on bio fuels.

Bio fuels can be used both in mixtures with fossil fuels and in duel fuel vehicles. Exemption from high Nordic taxation of fossil fuels, about 60–70%, in a manageable timeframe, should make it possible for alternative fuels to be competitive. Incentives aimed at increasing the use of bio fuels should thus ideally be directed at fuels rather than vehicles. Since Sweden strongly supports renewable ethanol, dedicated bio fuel or flexi fuel vehicles may be classified as a sub-group of environmentally-friendly vehicles in some countries

Objections to technology-neutral LZV criteria are that large four-wheel traction vehicles like SUVs are the only possible means of transport for some applications such as steep terrain locations. Production costs of environmentally- friendly technology systems and components such as electric drive, hybrid drive and batteries are higher than for conventional combustion engines. Without support for certain technologies and certain fuels they may never be able to enter the market or their market penetration might take a very long time.

8.3 Heavy Duty Vehicles

Heavy Duty Vehicles are difficult to categorise with simple and understandable environmental criteria. These vehicles are used in sensitive urban areas and there is an essential need to be able to distinguish out vehicles with acceptable emissions from heavy polluters.

For heavy duty vehicles it is the emission from engines and not the actual vehicles that are regulated by EURO I–V limits. Rating vehicles according to their engine type is not totally wrong but may be unfair to some extent, since the engines will emit differently in different vehicles. CO_2 emissions from engines are thus not suitable criteria for the choice of Heavy Duty Vehicles.

There is a requirement to reduce emissions of the harmful pollutants NO_x, VOC, and PM by heavy duty vehicles in urban areas. The best we can do is to request engines certified with the best EURO IV or V limits, with efficient exhaust-cleaning systems. In practice, the choice of heavy duty vehicles for urban transport is a fleet purchase, which makes fuel and technologies specifications a possible option.

A simple and convenient way to achieve more environmentally-friendly buses, bus services and to reduce fossil CO_2 emissions is to mix the fossil diesel fuel with bio diesel or other CO_2 -neutral synthetic diesel fuels from biomass. Knowledge about emissions based on real- life driving emissions is the best basis for choosing environmentally- friendly heavy duty vehicles. The bus emission data bank that is under continuous development by VTT Emission laboratory in Helsinki, Finland, is an important source of knowledge. In the Nordic countries, independent tests of real life emissions from heavy duty vehicles be tested by AVL-MTC outside Stockholm, as well as by VTT.

8.4 Experiences with environmental product information

Different criteria are used to define environmentally-friendly vehicles in the EU-countries, the USA and the Nordic countries.

The EU introduced a mandatory directive on information of vehicle energy efficiency and CO_2-emissions, but did not develop any labelling system. Denmark implemented this directive and since 2000 has had an energy labelling system for all new light vehicles. The scheme looks very much like the scheme for household appliances. The Danish labelling system, together with the high taxation on fuel consumption, has according to the Danish Road Administration made Denmark's vehicle fleet more energy-efficient. In 2005, the UK through the Vehicle Certification Agency introduced a very similar scheme. In addition to energy use and CO_2-emission there are also rankings where other pollutants are taken in to account.

Due to lack of a national or international definition, several local authorities have developed their own environmentally-friendly vehicle criteria. The local authorities usually state that they are very pleased with their own systems. For example the Californian Air Resource Board underlines the success of the Zero Emission Vehicle programme and the pressure it has put on vehicle industry. The Swedish programme, 'Miljöfordon', developed in Stockholm, Gothenburg, Malmö and Lund is described as a success story. Local criteria are often related to technology and specified fuels, which means that certain technologies are pre-qualified as environmentally- friendly. Alternative technology can be favourable, but is no guarantee for environmental effects.

A common feature of the local programmes is that the environmental effects are often poorly analysed. In our opinion, thorough analyses and evaluations should be part of all programmes. Only then will it be possible to improve the schemes and incentives.

Environmental Product Information Schemes have been used on a wide range of products and services. The Euro NCAP's labelling has clearly been an effective way of classifying and improving vehicle safety. The European system of labelling energy efficiency on household appliances has also been a success. Almost every refrigerator sold today has the top score, which is an A++.

The FIA Foundation argues that their EcoTest and a corresponding labelling system are simple and correct. The EcoTest takes into account both CO_2 and other pollutants. The label is very similar to the EuroNCAP label for crash safety and to the US-Green Vehicle Guide system for classification and weighting of CO_2 and other pollutants.

Ranking of vehicles according to the FIA EcoTest stars system has been expressed as an overall absolute rating and alternatively as a class-dependent rating. There are good arguments for both systems. An overall ranking tells us that several of the small cars are good and only very few of the big ones, which seems logical. The difference between cars in the same class will however be smaller with an overall rating. Using a class dependent rating makes the difference between similar-sized car models both bigger and more obvious.

From an environmental point of view the absolute scale is the most revealing. The important message is that small cars are usually more environmentally- friendly than bigger ones.

The US Green Vehicle Guide has the same weakness with class-dependent ranking. In our view it can be confusing when two vehicles with different emission levels are given the same environmental score. There are no independent evaluations of different labelling systems for vehicles and therefore no documentation of any reduction in fuel consumption/CO_2 or other emissions due to the labelling schemes. The Austrian Energy Agency has made a calculation based on experiences from labelling of household appliances and indicates a reduction of 4–5% CO_2-emissions 10 years after its implementation.

The study ‘The Future of Eco-labelling – Making Environmental Product Information Systems Effective’ (2005) is one of a few studies, which look at Environmental Product Information Schemes from a consumer’s point of view. Vehicles are not one of the case studies but the experiences are transferable to other products.

In the Nordic countries, there have been both national and local initiatives to promote environmentally-friendly vehicles. The definitions have been and are different from country to country and between different local initiatives. The Swedish systems are technology dependent and focus on alternative fuels, especially biofuels and waste gas.

Despite many years of information and promotion, there are only limited numbers of environmentally-friendly vehicles on the roads. To meet the challenge of climate change and the national goals for the reduction of greenhouse gases, the Swedish government has developed a national strategy. The strategy includes an action plan to increase purchases of environmental cars for use in public administration and state-owned companies. The mandatory limit is at least 25% environmentally-friendly vehicles in all public administration and companies.

The experiences from vehicle labelling in California, Sweden and Denmark together with eco-labelling of other products shows us that future labelling of environmentally-friendly vehicles can be an effective way to stimulate the market and put pressure on the vehicle industry to develop more attractive green cars for the future.

Our advice is to rely on existing label schemes such as energy labelling or NCAP stars. The introduction of easy to understand technology-independent criteria, the introduction of economic incentives or other advantages together with labelling will increase the popularity of environmentally-friendly vehicles in an introductory phase. The criteria should be revised regularly after extensive reviews and evaluations.

Experiences from Environmental Product Information Schemes concerning other product groups, tells the same story. If the schemes are coupled with ‘effective technology and money to save’, the consumer’s choice shifts to the most environmentally-friendly vehicles. “Money to save” can be direct incentives or significantly lower taxes.

Together with the experiences from the design and use of vehicle information schemes, which are limited, we conclude that a successful labelling has to:

- Be simple and easy to understand
- Be compatible with environmental labels concerning other products
- Be compatible with existing emission tests and regulations for vehicles
- Show significant differences between the best and worst vehicles

- Be based on international agreement between governments and vehicle manufacturers
- Be possible to supplement and link with national tax incentives or local incentives such as admission to environmental zones and free parking

Sammendrag

Kjøretøy vil i mange tiår forbli et sentralt transportmiddel, og forbedring av kjøretøyenes miljøegenskaper er derfor svært viktig i lys av klimaendringer og lokal luftforurensning. Skal dette lykkes å redusere miljøbelastningen fra kjøretøyparken er det nødvendig å kunne gi et klart svar på hva som kjennetegner et miljøvennlig kjøretøy.

Spørsmålet er om det er mulig å legge fram et entydig vitenskapelig underlag som grunnlag for politikkutformingen på området? Er det noen erfaringer fra bruken av miljøkriterier? Er det så et grunnlag for aktivt å arbeide for å fremme bruken av miljøvennlige kjøretøy? Dette er blant spørsmålene som vi tar opp i denne studien som er utført på oppdrag fra Nordisk Ministerråds arbeidsgruppe for bærekraftig transport.

Erfaringer med bruk av kriterier for å definere miljøvennlige kjøretøy og incentiver for å fremme bruken kjøretøyene

Ulike kriterier er brukt som grunnlag for å definere miljøvennlige kjøretøy i EU-landene, USA og i Norden. Disse kriteriene er ofte en blanding av utslippsgrenser, teknologikrav og egenskaper ved drivstoff. Noen teknologier har i enkelte systemer blitt pre kvalifisert som miljøvennlige. Det er fristende å gripe til nye alternative teknologier og fornybare drivstoff, men dette er ingen garanti for redusert negativ miljøpåvirkning. Det er de reelle utslippene ved bruk og under kjøring i et normalt trafikkbilde, som avgjør om kjøretøyet og drivstoffet samlet sett er en miljøvennlig kombinasjon eller ikke.

Myndigheter understreker vanligvis at deres egne kriterier er de beste og at ordninger ved bruk av disse kriteriene har vært vellykket. Luftforurensningsmyndighetene i California (California Air Resource Board) trekker fram sitt eget program for "null-utslipps-kjøretøy" som en suksess, blant annet fordi det har presset bilindustrien til å produsere og tilby for salg en viss andel null-utslipps-kjøretøy. Det svenske programmet, "Miljöfordon", blant annet gjennomført i Stockholm og Göteborg er også beskrevet som en suksesshistorie. I Danmark har man brukt energimerking av nye kjøretøy, og som sammen med en avgiftsdifferensiering etter energibruk, har ført til en mer energieffektiv dansk kjøretøypark.

Det er dessverre et fellestrekk at svært få av ordningene for å fremme miljøvennlige kjøretøy, er skikkelig evaluert. Grunnlaget for å trekke generelle konklusjoner av de reelle utslippseffektene er derfor bare delvis tilstede. I fremtiden er det vesentlig at alle slike program og incentivordninger, følges av grundige evalueringer som gir kunnskap og underlag til videre forbedringer av ordningene.

Merking av miljøvennlige kjøretøy

Opplegg og system for miljøinformasjon (EPIS – Environmental Product Information Schemes) brukes for en rekke varer og tjenester. Den europeiske NCAP-merking har for eksempel vært en effektiv måte å klassifisere og forbedre sikkerheten til kjøretøyene. Erfaringene fra merkeordning for kjøretøy i California, Sverige og Danmark, og øko-merking av andre produkter, indikerer at enkle godt dokumenterte merkeordninger kan være en effektiv måte å stimulere markedet til å etterspørre miljøvennlige kjøretøy, og dermed påvirke bilindustrien til å utvikle og forbedre slike biler.

Vi anbefaler å benytte eksisterende etablerte merkesystemer hentet fra andre produktområder, basere klassifiseringen på teknologiuavhengige kriterier, og introdusere økonomiske incentivordninger som bygger opp under klassifiserings- og merkeordningen. Slike incentiver kan være reduserte avgifter, tilgang til forurensningsfølsomme områder (miljøsoner), tillatelse til å bruke kollektivfelt og gratis parkering. Alle disse vil være med på å stimulere markedet til å velge miljøvennlige biler.

Teknologi uavhengige kriterier for lette kjøretøy – personbiler og små varebiler

I denne rapporten bruker vi forkortelsen LZV, Low or Zero emission Vehicle, dvs. lav eller nullutslippskjøretøy, som betegnelse på et miljøvennlig kjøretøy. For å oppnå LZV klassifikasjonen må gitte miljøkriterier oppfylles. Kriteriene må reflektere strenge miljøkrav basert på et vitenskapelig underlag, men som også er innenfor samfunnets prioriteringer og politisk akseptert.

De viktigste miljøvirkningene ved bruk av et kjøretøy er utslipp av gasser og partikler som påvirker menneskers helse, klimagassutslipp og energiforbruk. Teknologinøytrale utslippsgrenser kan tilfredsstille ønskene om å redusere de negative miljøvirkningene av transportaktiviteter, og det er vår oppfatning at slike kriterier vil stimulerer bilindustrien til å utvikle de beste og mest kostnadseffektive løsningene.

Vi anbefaler to hovedkriterier for klassifisering av kjøretøy. Disse er basert på dagens kunnskap og er enkel å forstå, kommunisere og evaluere/kontrollere:

- Strenge grenseverdier for utslipp av NO_x, VOC og PM (partikler)
- Strenge grenseverdier for utslipp av klimagasser, CO_2-ekv. Dette kriteriet fanger opp både energieffektivitet og deretter bruk av fossilt drivstoff.

Med hensyn på lokal luftkvalitet foreslår vi å bruke Californias “Super Ultra Low Emission Vehicle Limits” for personbiler. Disse er de strengeste kriteriene i verden i dag.

For utslipp av klimagasser og energieffektivitet foreslår vi å bruke en grense på 120 g CO_2/km. Utslippene anbefales målt ved blandet kjøring og etter den europeiske testkjøresyklusen (EDC). Denne er velkjent og lovfestet som del av godkjenningsordningen for nye bilmodeller til det europeiske markedet.

I tillegg til LZV klassifiseringen for drift av kjøretøyet etter EDC-testsyklusen, bør det i fremtiden inkludere også andre kriterier, faser i kjøresyklusen og i kjøretøyets livssyklus. Følgende kriterier bør inkluderes:

- Strenge utslippsgrenser for kaldstart ved lave nordiske temperaturer. Det vil bedre luftkvaliteten i følsomme områder, boligområder, om vinteren.
- Livssyklus perspektivet for CO_2-ekv. utslipp, inklusive produksjon, bruk og resirkulering/avhending.
- Strenge støykrav

LZV merking, kjøretøy og drivstoff som potensielt kan tilfredstille kravene

Elektriske kjøretøy og brenselceller vil enkelt tilfredsstille våre foreslåtte LZV-kriterier. Noen få hybrid personbiler, noen få lette bensin og lette dieselbiler, har også potensialet til å tilfredsstille LZV-kriteriene. Disse er avhengig av effektiv utslippsrensing. Kjøretøy som kan bruke metan/biogass-, LPG- (flytende petroleumsbasert gass, f.eks. propan/butan) og hydrogen har lave CO_2-utslipp og oppfyller dette LZV-kriteriet. Imidlertid må også kravene til energieffektivitet og utslipp av lokal forurensninger oppnås. Kjøretøy som bruker fornybare drivstoff kan derfor ikke automatisk klassifiseres som LZV-kjøretøy. Imidlertid kan rene biodrivstoff kjøretøy klassifiseres som en undergruppe av miljøvennlige kjøretøy i tillegg til “ekte” LZV-kjøretøy. I Sverige er det en sterk støtte til kjøretøy som kun går på biodrivstoff.

Biodrivstoff kan være både innblandet i fossile drivstoff og som et 100% rent biodrivstoff. Enkelte fleksi-drivstoff- kjøretøy kan bruke begge deler. Hvis disse uansett drivstoff tilfredstiller kriteriene for energieffektivitet og lokal forurensningskomponenter, så kan disse klassifiseres som LZV'er. For å sikre at disse kjøretøyene anvender biodrivstoff bør man sørge for at dette drivstoffet og andre fornybare drivstoff blir konkurransedyktige, ved at de unntas fra de høye nordiske drivstoffavgiftene (60 til 70% av prisen). Incentiver for å ta i bruk biodrivstoff bør primært rettes mot drivstoffene og ikke mot kjøretøyteknologiene.

Tyngre kjøretøy – lastebiler

Utslipp fra tyngre kjøretøy er i de fleste land og byer en stor bidragsyter til lokale forurensningsproblemer. For å kunne sikre god luftkvalitet og redusere risiko for helseeffekter, bør tyngre kjøretøy oppfylle strenge utslippskrav for NO_x, VOC og PM. Spesielt er dette nødvendig hvis de brukes i sentrumsområder og boligområder.

Det er ikke helt enkelt å sette slike krav fordi utslippene fra tyngre kjøretøy reguleres gjennom typegodkjenning av motoren (Euro I–V), og ikke bilen i seg selv. De tyngre kjøretøyene som har motorer som tilfredsstiller de strengeste kravene, Euro V, kan potensielt klassifiseres som miljøvennlige. Det er imidlertid vanskeligere å lage et krav for klimagasser for disse kjøretøyene. På grunn av den store variasjon i høyde, lengde og tilleggsutstyr (for eksempel kjølevogn, kran, mv.), vil drivstofforbruk og utslipp variere svært mye fra en og samme motor. Det må derfor arbeides videre med entydige test og godkjenningsordninger for denne kjøretøygruppen.

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