ALTER-MOTIVE

Final Report

A report compiled within the European research project

Deriving effective least-cost policy strategies for alternative automotive concepts and alternative fuels-ALTER-MOTIVE

Intelligent Energy – Europe (IEE), STEER
Contract no. IEE/07/807/SI2.499569

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(work package 1 – deliverable D23)

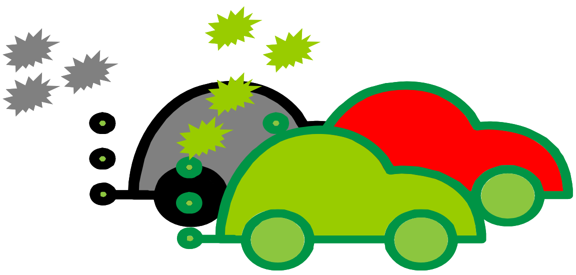

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Table of Contents

1. Introduction

This report documents the major work conducted within the EU-funded project "Deriving effective least-cost policy strategies for alternative automotive concepts and alternative fuels – ALTER-MOTIVE" and summarizes its major outcomes. It serves as the final topical report of this project[1].

The core objective of this project is to derive effective least-cost policy strategies to achieve a significant increase in innovative alternative fuels (AF) and corresponding alternative more efficient automotive technologies (AAMT) to head towards a sustainable transport system.

The work in ALTER-MOTIVE has been broken down in eight work packages (WP), see Figure 1.

WP1 covered the project management. In WP2 country reviews of the most important historical developments in road transport in different European countries regarding energy consumption, vehicle and fuel use, CO_2 emissions and other features were conducted. Moreover, in this WP also the relevant policies and measures in individual passenger transport implemented so far were identified for EU countries. The objective of WP3 was to conduct a sound and comprehensive assessment of all relevant AF & AAMT, encompassing ecological, economical and technical aspects. Furthermore, the limits of the production potentials for alternative fuels were identified.

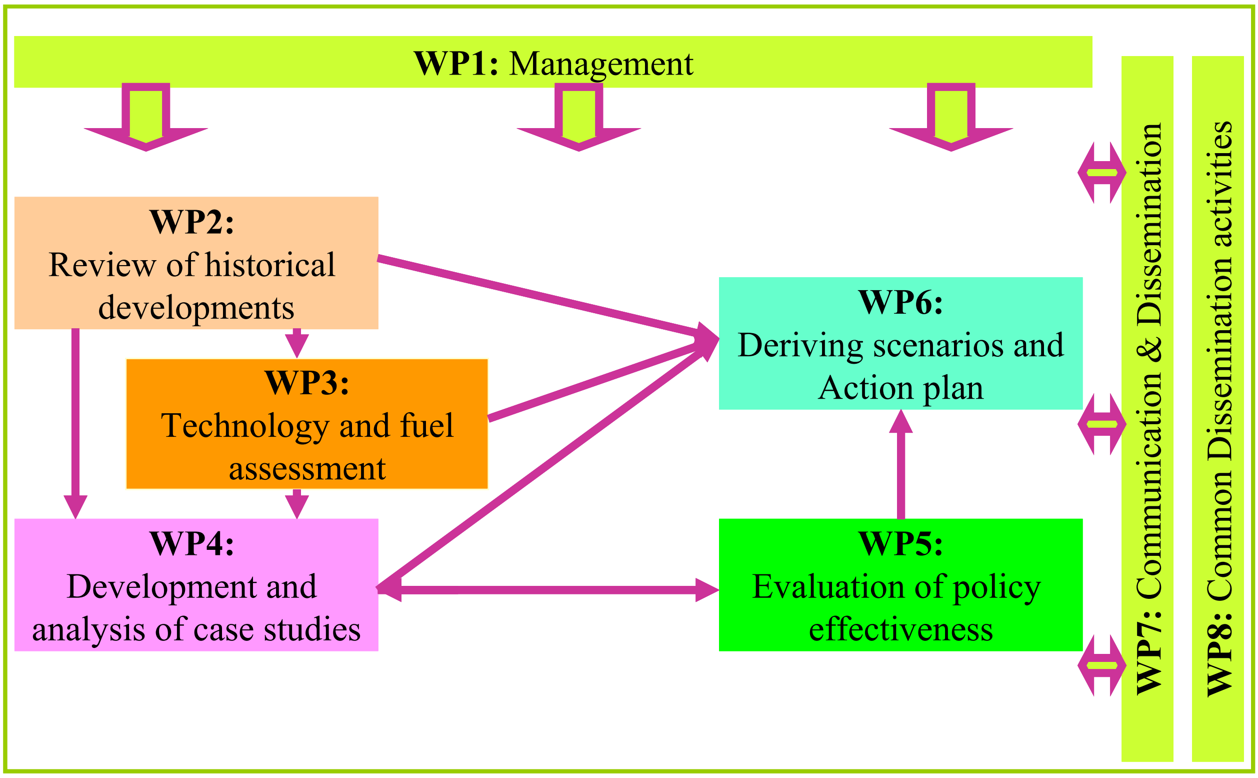


Figure 1. Overview of ALTER-MOTIVE project work packages

[1] Note that in some parts of this report the information documented has already been published in other ALTER-MOTIVE reports.

In WP4 more than 130 recently implemented pilot projects for disseminating AF & AAMT with focus on European countries were collected and documented on the web page. About 80 of these case studies were evaluated in detail based on the work conducted in WP3. The effects of policies on local, national and EU-level were analysed in WP5 based on the perceptions from the pilot projects and the documentation of national policies in WP2.

In WP6 the results of the above described WPs were put together. Scenarios were derived for selected EU countries showing which developments are possible up to 2020 if the proper policies identified in WP5 are implemented. In addition, an action plan for policy makers on EU-level and in specific regions and countries was developed. This action plan provides guide-lines for implementing effective least-cost policy strategies in Europe to achieve a significant increase of alternative fuels (AF) and corresponding alternative more efficient automotive technologies (AAMT) to head towards a sustainable individual and public European transport system.

Beyond the "Common Dissemination Activities" as foreseen by the **eaci** and done in WP8, in WP7 comprehensive and targeted dissemination activities took place. To discuss the project ideas and perceptions as well as specific national issues and to receive detailed feedback, nine stakeholders' workshops were organised in different EU countries (Austria, France, Germany, Greece, Italy, Poland, Portugal, The Netherlands, Sweden). Finally, an international final conference in Brussels took place with the major focus of presenting and discussing the Action Plan, especially with representatives of DG Transport and the European Parliament. Moreover, within the ALTER-MOTIVE website (www.alter-motive.org) an online discussion forum was created to collect feedback on our ideas and results.

1.1 Motivation and European policy targets

In 2008, the EU agreed to a 'climate and energy package' and the so called 20-20-20-targets. This package supports the EU's strategic objective of limiting global warming to no more than 2° C above pre-industrial temperature, as set out in the 2007 Bali Climate Declaration and included in the 2009 Copenhagen Accord (EC, 2007a; Allan et al, 2007; UNFCCC, 2009).

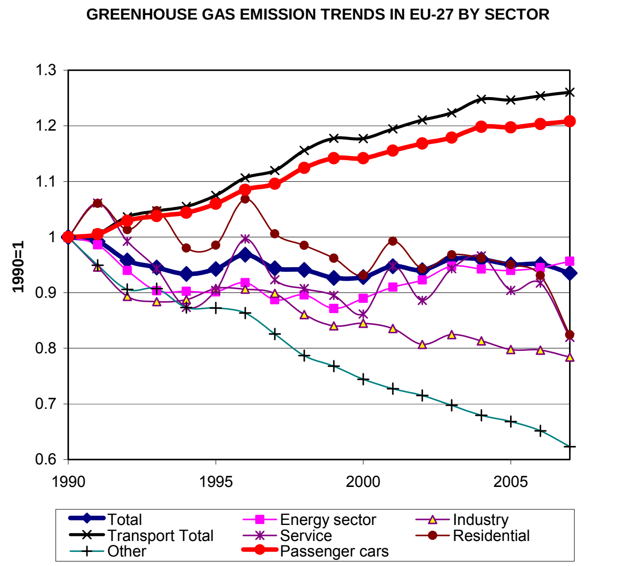
The ambition of the EU policy is threefold: to combat climate change, reduce dependence on (imported) fossil fuels and to promote rural development, growth and jobs.

The 20-20-20 targets provide concrete goals which state that

- at least 20% renewable fuels should be used in the energy sector;
- at least 20% CO_2 emission[2] reduction (compared to the 1990 level);
- at least 20% energy efficiency improvements by 2020;
- at least 10% renewable fuels for transport (attached to the 20-20-20-target (EC, 2008; EC, 2009b)).

[2] Note that throughout this report the term "CO_2" corresponds to "CO_2-equivalents" of greenhouse gas emissions

Since transport accounts for about a quarter of EU greenhouse gas (GHG) emissions – the only sector with increasing trend, see Figure 2a – a large part of these targets must be directed to this sector. It is especially important to focus on road transport as it contributes with about 23% to the EU's total emissions of GHG, see Figure 2b. Passenger cars alone contribute to 70% of road transport GHG emissions in the EU (EU, 2011).



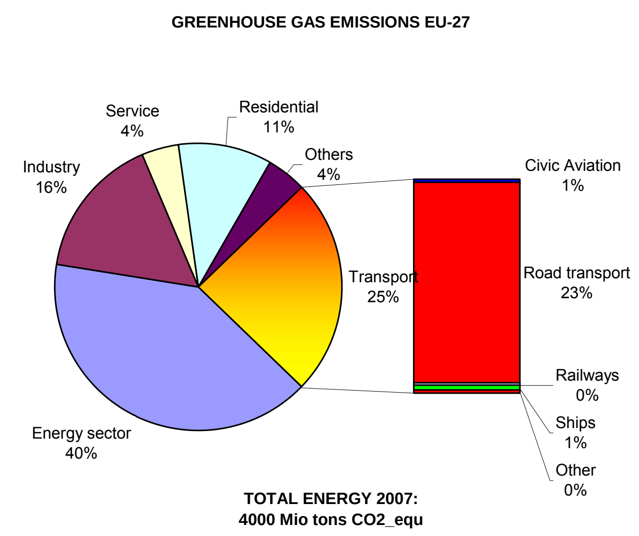


Figure 2a. Greenhouse gas emission trends in EU-27 by sector (EU, 2010)	Figure 2b. Share of Greenhouse gas emissions in EU-27 by sector in 2007 (only domestic transport considered) (EU, 2010)

So the major challenges for EU climate and energy policy are to implement effective policies and measures to mitigate global warming, to improve air quality and to reduce energy consumption, see Figure 3. A wide range of EU policies to lower emissions from passenger car transport is already in place, such as emissions targets for new cars; targets to reduce the greenhouse gas intensity of fuels; labelling requirements etc.

For sustainable development in passenger car transport an integrated approach based on cooperation between policy makers, car industry and car users is necessary. This should ensure reduction of GHG emission at lowest costs for all involved sides.

Hence, it is obvious that urgent action is required to meet these EU-targets. The motivation for conducting the project ALTER-MOTIVE is to provide a sound base which actions are most effective for CO_2 reduction with lowest burden for the European society.

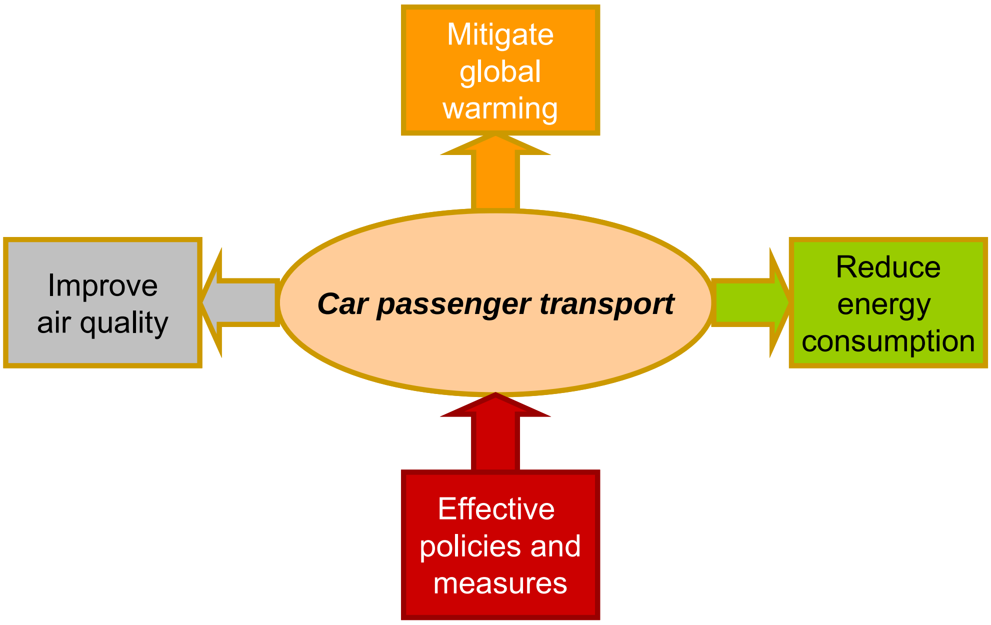


Figure 3. The challenges for EU climate and energy policies

1.2 Currently implemented EU policies[3]

Transport is one of the key challenges for the sustainable development in EU. Sustainable development requires an integrated approach based on environmental, social and economic constraints.

The Community strategy proposed by the Commission in 1995[4] and subsequently supported by the Council and European Parliament has been based on three pillars (EC, 2007), see Figure 4.

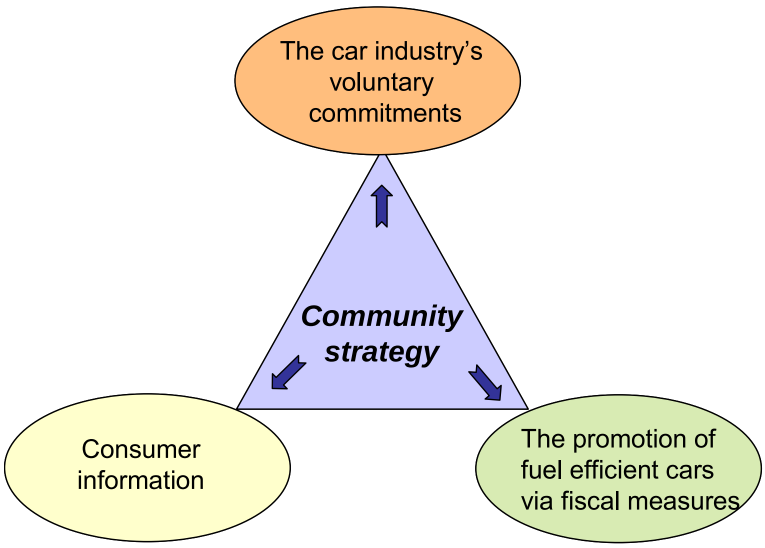


Figure 4. The three pillars of the Community strategy

[3] Close to the deadline of this document, the "White paper" of the EC has been published, see EC: WHITE PAPER – Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels, 28.3.2011, COM(2011) 144 final. Its content is not yet referred in this work.
[4] COM(95) 689, Council conclusions of 25.6.1996, European Parliament resolution of 22.9.1997.

First pillar: car industry voluntary commitments

In 2007 the EC adopted a target for reduction of average CO_2 emissions from new cars to 120 gCO_2/km by 2012 - a reduction of around 25% from 2006 levels. However, already in 2010 it could be noticed, that this goal of reducing emissions of new cars was not likely to be achieved (EC, 2010), see Figure 5. This figure shows the development of CO_2 emissions from new passenger cars by association as well as the voluntary commitments undertaken by the car manufacturer associations related to average new car emission targets of 140 gCO_2/km by 2008/2009.

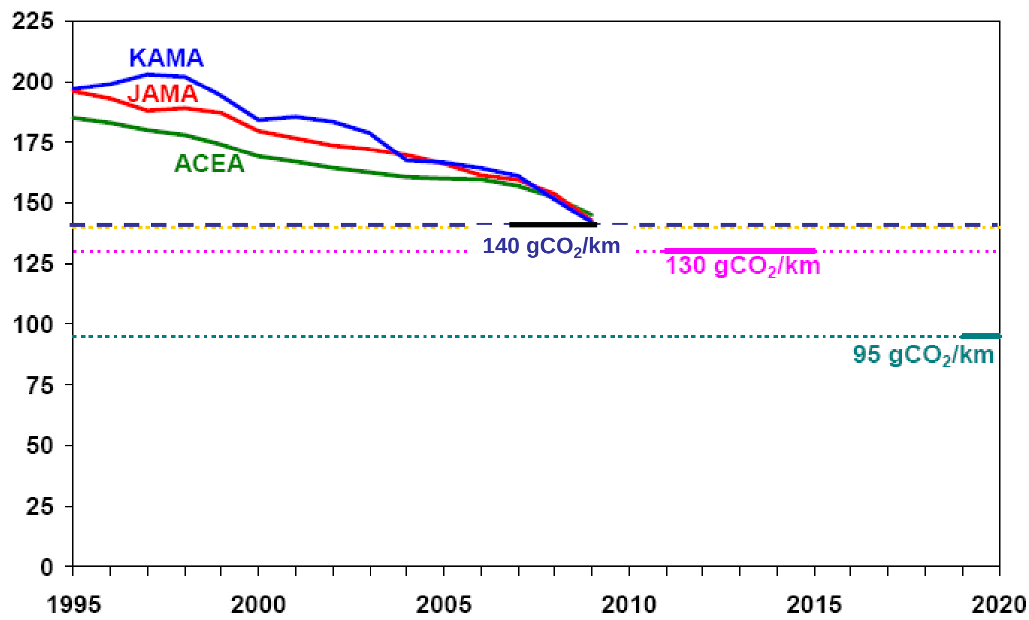


Figure 5. Evolution of CO_2 emissions from new passenger cars by the European (ACEA), Japanese (JAMA) and Korean (KAMA) car manufacturer associations (adjusted for changes in the test cycle procedure) (EC, 2010)

Yet, despite a low probability of achieving the 2012 target, the strategy, and the measures it includes, still plays an important role in reducing CO_2 emissions from light-duty vehicles. So since the achievement of the EU objective of 120 gCO_2/km in 2012 is not likely, a new objective implemented by Regulation (EC) No443/2009 is to achieve 130 gCO_2/km in the period 2012-2015. A target of 95 gCO_2/km announced in the Strategy as a target for further consideration is included for 2020. This reduction of average CO_2 emissions from new cars can be achieved by means of improvements in vehicle motor technology as well as with the increased use of biofuels and by a reduction of the size of vehicles

Second pillar: consumer information

Behaviour oriented measures, such as fuel economy labels, a guide on fuel economy and CO_2 emissions, home location and choice of vehicle and type of transport, etc., are important to increase public awareness regarding the environmental problems caused by car passenger transport. A number of Member States already promote eco-driving, which could have an energy saving potential up to 15% (EC, 2010).

Third pillar: the promotion of fuel efficient cars via fiscal measures

Taxation has a track record as policy instrument. Efficient taxation policies can promote the purchase of fuel efficient cars and could significantly contribute to the reduction of CO_2 emissions in transport sector (EC, 2007). Mostly used fiscal policy measures are registration taxes, annual circulation taxes and excise duties.

The specific actions of the EC linked to the scope of the "Strategy" in the timeline 2010-2020 include review of modalities of reaching the 2020 target of 95 gCO_2/km set out in the cars legislation, and possibly modalities of the long-term target as proposed in the draft regulation on CO_2 from light commercial vehicles. In addition, the EC is committed to propose a new test-cycle to reflect more accurately the real world driving conditions as well as the specific CO_2 emissions and fuel consumption related to it (EC, 2010).

1.3 Organisation of the report

In the next chapter we summarize the outcomes of WP2 documenting the major developments in car passenger transport in recent years in the EU. We document the current situation with respect to CO_2 emissions and energy consumption for EU-15 countries and show the major historical developments and trends.

Chapter 3 describes the major results of the analyses conducted within WP3 of this project. It provides the major results of our comprehensive technical, economic and ecological assessment of AAMTs and AFs.

A summary of the major outcomes of WP 4 – mainly a documentation of more than 130 recently implemented pilot projects for disseminating AF & AAMT – is provided in Chapter 4. In Chapter 5 we describe the effects of policies on local, national and EU-level which were analysed in WP5.

A major dissemination effort – the organisation and evaluation of country-specific workshops – was conducted within WP7 and is described in Chapter 6 of this report.

In the remaining chapters we describe perceptions of our econometric analyses in Chapter 7 and we show how we put together the results of the WPs 2 to 5 in a scenario analysis (Chapter 8) and in the derivation of an Action Plan (Chapter 9).

Conclusions complete this report, followed by the major references and some appendices. Within these we want to draw special attention on country boxes in Appendix C which has been put together by national project partners and which document in a clear and concise way the major problems and focuses in the countries participating in this project.

2. Survey on historical developments

In this section a summary on the major developments in car passenger transport in recent years in the EU countries is provided. It builds on the work in WP2, especially on the report Ajanovic ed. (2009).

2.1 Energy consumption of passenger car transport

Overall energy consumption of passenger car transport in the EU-15[5] in 2007 amounted to about 7 EJ. This is an increase of 28% in comparison to the year 1990. As Figure 6a depicts gasoline contributed by 55% in 2007 (compared to 81% in 1990), diesel with 41% (17% in 1990), and alternative fuels with 4% (2% in 1990).

A major feature of car passenger transport in EU countries is the continuous increase of the market share of diesel, which in 2007 almost reached 2100 PJ.

The share of alternative fuels in passenger transport in EU has increased continuously since 2000 especially in Germany and contributes currently with about 4% to total energy consumption, Figure 6b.

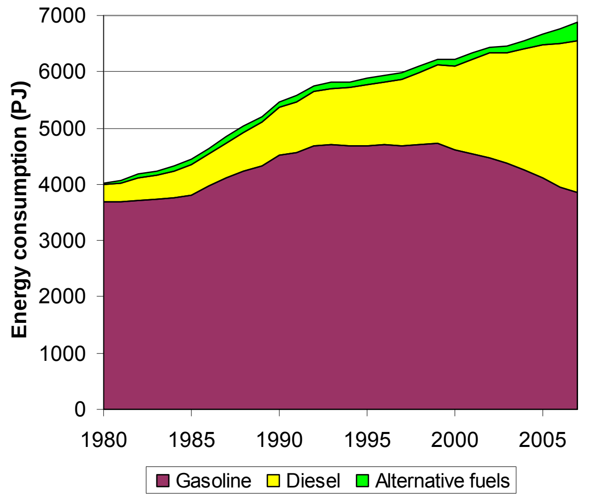


Figure 6a. Energy consumption in car passenger transport in EU-15 by fuel, 1980 – 2007

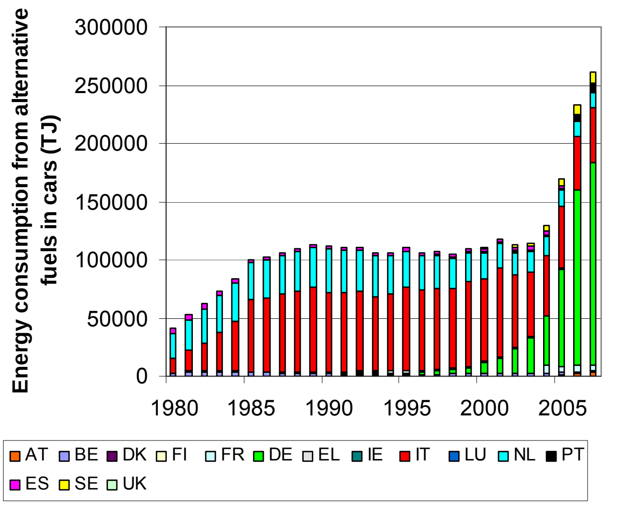


Figure 6b. Energy consumption from alternative fuels in car transport in EU-15 by country, 1980 – 2007

Figure 7 depict the corresponding CO_2 emissions. It can be seen that the profile is very similar to over-all energy consumption.

[5] For EU-27 no reliable time series back to 1980 are available.

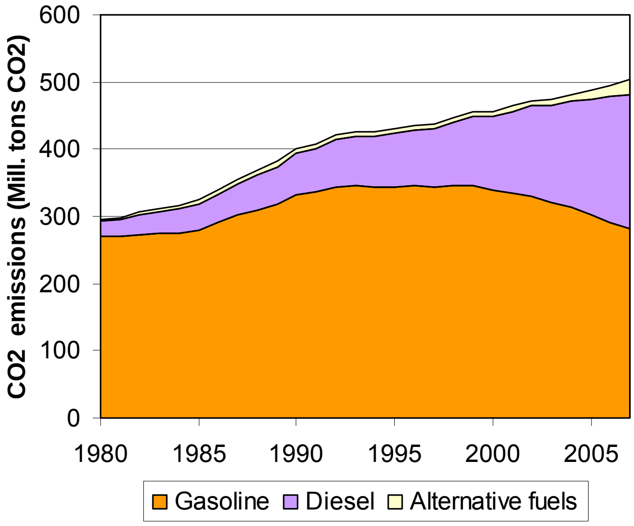


Figure 7. Development of CO_2 emissions of car passenger transport in EU-15 by fuel, 1980 – 2007

2.2 Biofuels consumption and production

Currently, the most interesting alternative fuels are biodiesel and bioethanol. In this chapter the most recent developments in biofuels production in European Member States compared to a global perspective are shown.

2.2.1 Europe in the world

Global production of biofuels amounted to 46 Mtoe in 2008. Brazil and the United States together account for almost three-quarters of global biofuels supply. Currently, the share of biofuels is relatively small in almost all countries with the exceptions of USA and Brazil. The share of biofuels in total transport fuels demand in 2007 was about 20% in Brazil, 3% in the USA and less than 2% in the EU, see Figure 8. Many countries have set the goal to replace a significant part of fossil fuels by biofuels.

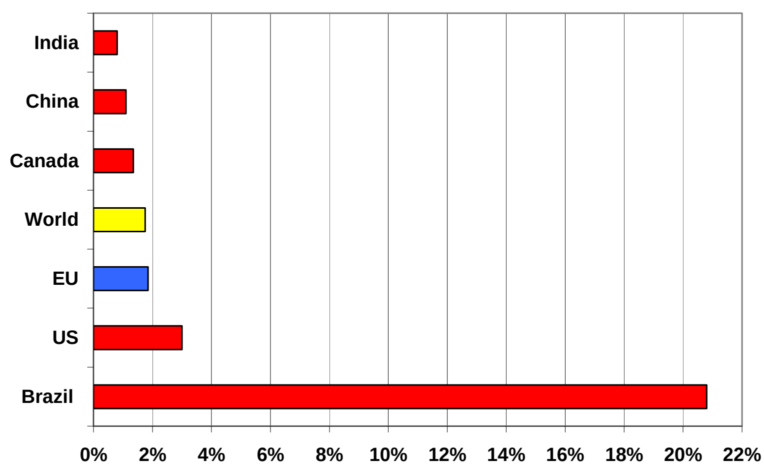


Figure 8. Share of biofuels in total road-fuel consumption in energy terms, 2007 (IEA, F.O.Licht)

Ethanol production is rising rapidly in many parts of the world mainly due to higher oil prices, which are making ethanol more competitive, especially in combination with government incentives. Recent trends in ethanol production are shown in Figure 9. As shown, in 2008 global bioethanol production was 65 billion litres. This is an almost 4 times higher amount than in 2000.

In total bioethanol production, Europe accounted for about 2% in 2003 and for about 3.6 % in 2008.

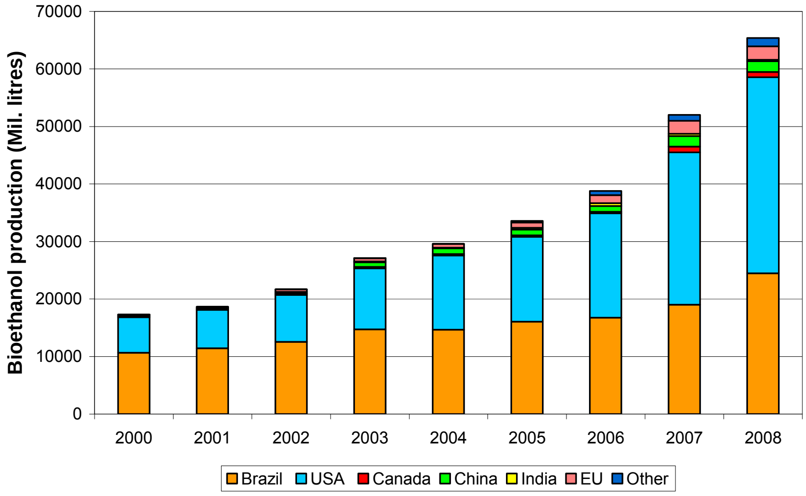


Figure 9. Recent trends in world-wide bioethanol production by region/country (Data source: F.O.Licht, IEA, EBTP)

Total production of biodiesel worldwide was about 12.75 Mtoe in 2008. This is very small compared with that of ethanol production. The largest part of biodiesel, 55% in 2008, was produced in the European Union, 16% in USA, and the rest in other countries. Recent trends in biodiesel production are shown in Figure 10.

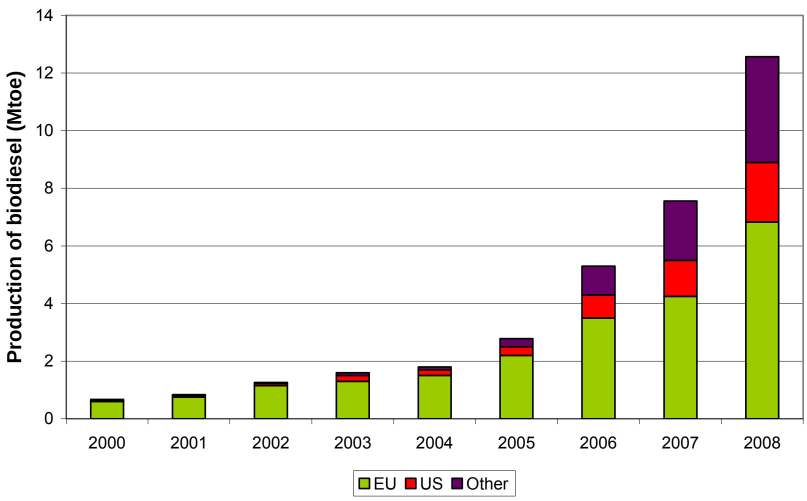


Figure 10. Recent trends in worldwide biodiesel production by region/country (Data source: F.O.Licht,IEA, EBTP)

2.2.2 Development in EU-27

The production of liquid biofuels in EU-27 increased from 62 PJ in 2003 to about 345 PJ in 2008, see Table 1.

Table 1. Total production and total consumption of biofuels in EU-27 in 2003 and 2008 (PJ)

	Biofuel production		Biofuel consumption	
	2003	2008	2003	2008
Biodiesel	53	285	48	331
Bioethanol	9	60	11	67
Total	**62**	**345**	**59**	**399**

The EU is today the third largest producer of bioethanol in the world behind the United States and Brazil, but its production is much lower than in the first two. In 2008 the production of bioethanol in EU-27 amounted to 2.816 million litres. After a rather moderate growth in 2007 (+11% with respect to 2006), European bioethanol production increased considerably in 2008 (+56% with respect to 2007).

The total number of bioethanol producing Member States in 2008 was 17. Currently, France is the biggest bioethanol producer in EU. On the second place is Germany, followed by Spain, see Figure 11. All other countries together contributed only one third.

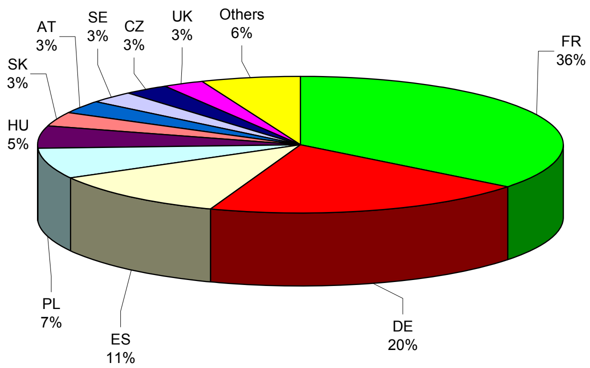


Figure 11. Shares of bioethanol production 2008 in EU-27 countries

The year 2008 was also a record year in terms of imports. Total imports are estimated to have reached almost 1.9 billion litres in 2008, i.e. an increase of 400 million compared to 2007. About 75% of the imported ethanol came from Brazil only [EBTP].

Figure 12 shows the evolution of bioethanol production over the past 7 years in the 10 major producing countries in the EU. The bioethanol production in EU is increasing, especially in the last few years, mostly in response to higher oil prices, which are making ethanol more competitive, especially in combination with government incentives.

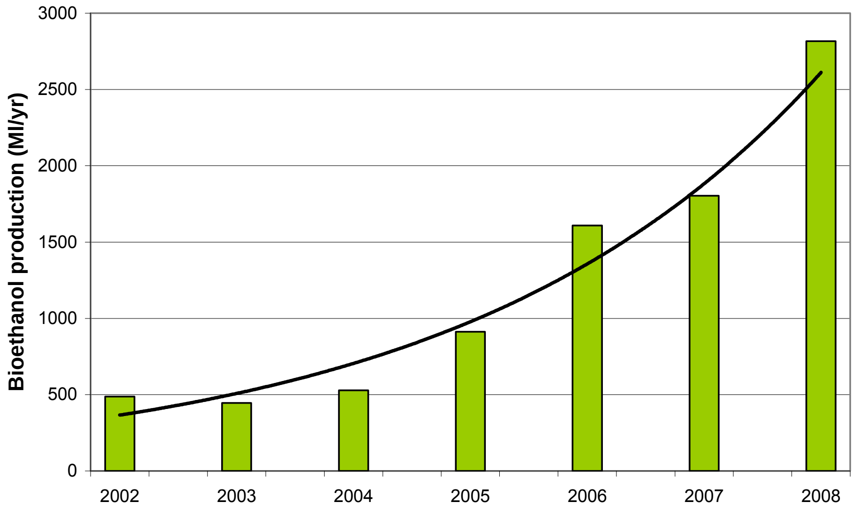


Figure 12. Recent trends in ethanol production in EU-27 (Data source: EBTP)

Almost all European countries have started biodiesel production. Currently the largest biodiesel producer in 2008 was Germany, followed by France and Italy, see Figure 13. These three countries alone contribute to about two-third of total production.

Total production of biodiesel in EU was 7.75 million tonnes in 2008. This is relative large production compared with the total biodiesel production in the world.

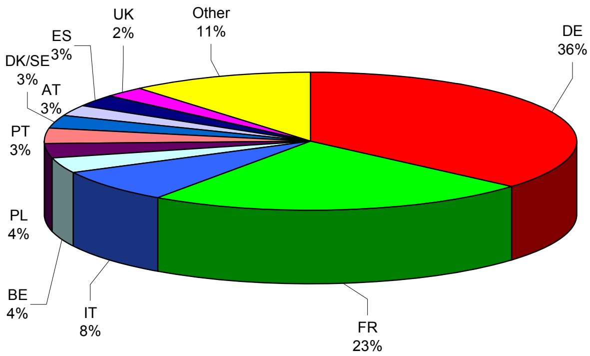


Figure 13. Shares of biodiesel production 2008 in EU-27 countries

Recent trends in biodiesel production in EU are shown in Figure 14.

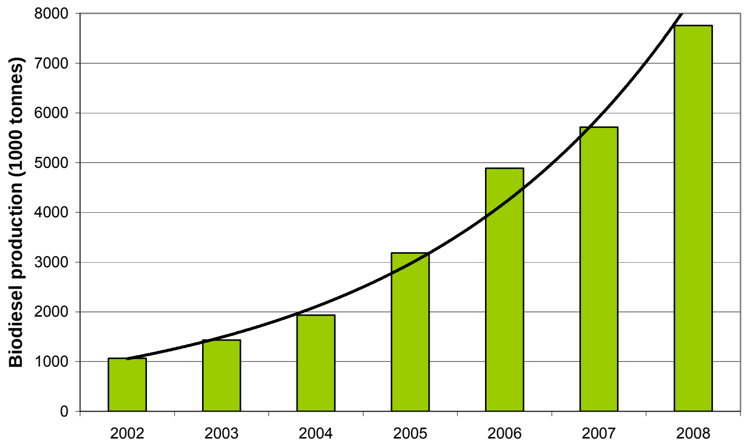


Figure 14. Recent trends in biodiesel production in EU (Data source: EBTP)

With respect to feedstocks in EU-27 wheat was most important for bioethanol production. In 2008 70% of total European bioethanol production was based on wheat. On the second place is barley, followed by corn and rye, see Figure 15a. In the future, according to many studies, ethanol production from lingo-cellulosic sources should play a significant role because of lower feedstock costs.

Biodiesel production in EU-27 is mainly based on rapeseed oil. Only 3% of biodiesel in EU is produced from sunflower oil and 18% from soybean oil, see Figure 15b.

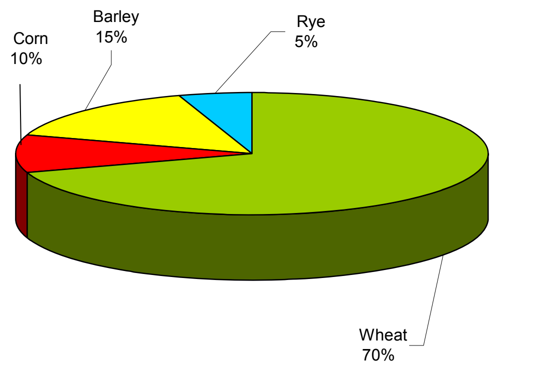


Figure 15a. EU-27: Feedstock use in ethanol production in 2008 [Data source: FAPRI]

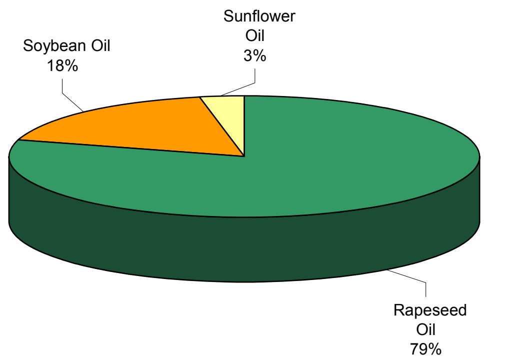


Figure 15b. EU-27: Feedstock use in biodiesel production in 2008 [Data source: FAPRI]

2.2.3 EU-27: country-specific issues

The rapid growth of biofuels in recent years is supported by the fact that many countries have set the goal to replace a part of fossil fuels by biofuels. By 2020 10% of energy used in transport should be from renewable energy source, biofuels in practical terms.

A comparison of biofuel production in 2009 by country is shown in Figure 16.

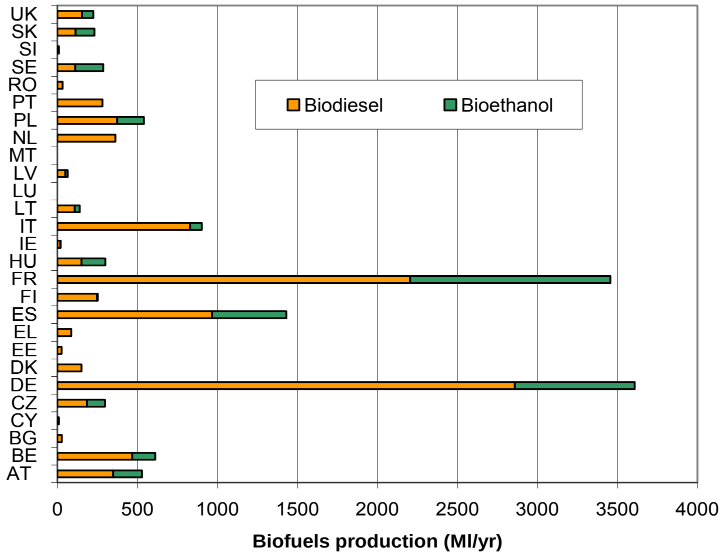


Figure 16. Comparison of biofuel production in 2009 in EU-27 countries (Data source: EBTP, 2011)

The share of LPG, electricity or other alternative fuels, apart from biodiesel and bioethanol, is currently low in almost all analysed countries.

2.3 Development of fuel prices

Fuel prices have a significant impact on travel demand and fuel intensity. They were rather volatile during the last three decades. The development of fossil fuel prices – a weighted average of gasoline and diesel - in selected EU countries for the period 1980 to 2007 is shown in Figure 17. The general characteristics were high price levels in the early 1980s, remarkable drops after 1985, stagnation up to 1999 and finally in recent years since 2003 rather continuous increases. In 2009 prices dropped in all countries – due to the economic crisis – but recovered fast in 2010.

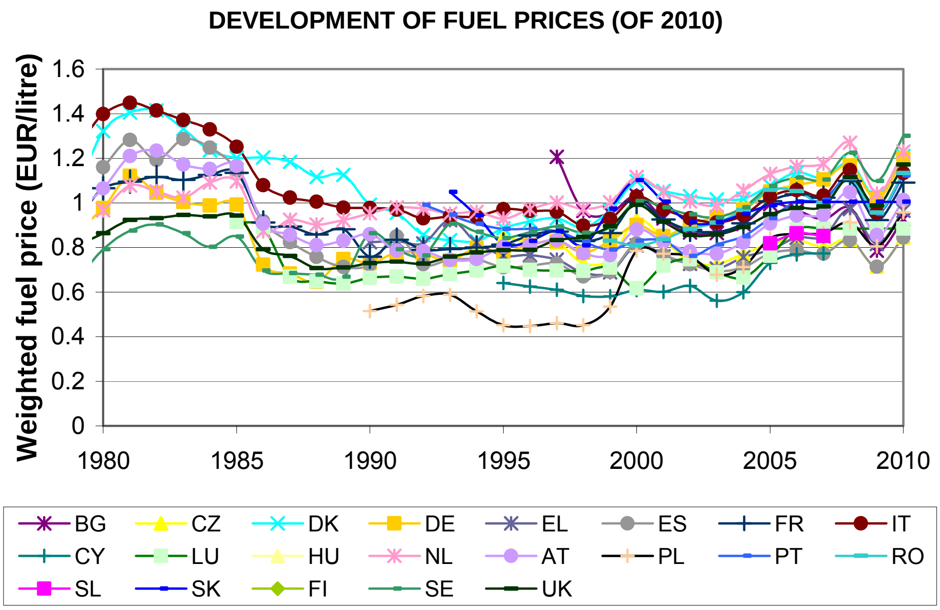


Figure 17. Weighted fuel prices (including all taxes) for EU countries 1980 – 2010 (in prices of 2010, numbers for 2010 preliminary) (Source: EEP; IEA, 2010)

The range of fuel prices vary wide across the analyzed countries mostly due to the different taxes. The share of total tax (VAT and excise taxes) on gasoline is very different across the EU-countries ranging from 40% to 60% of the total gasoline price, see Figure 18. Actually, the largest part of fuel price in most of the countries is tax. Currently, the highest tax on gasoline is in the Netherlands, Germany and Sweden. In eighteen EU countries the share of tax in total fuel price is more than 50%. The lowest tax on gasoline is in Cyprus.

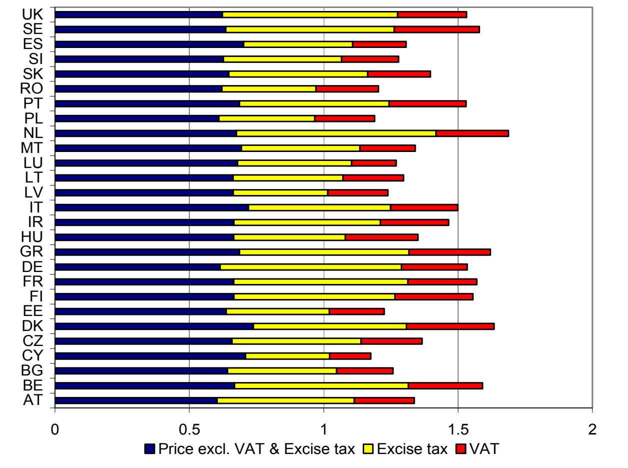


Figure 18. Price structure of gasoline in EU-27 (data source: EEP, 2011 - effective March 2, 2011)

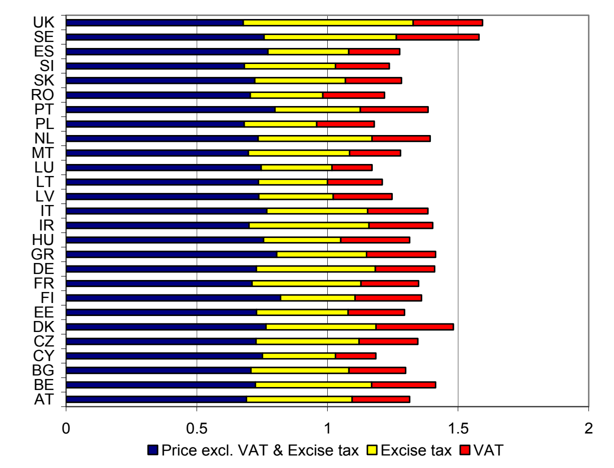


Figure 19. Diesel prices in 2011 for EU-27 (data source:EEP, 2011 - effective March 2, 2011)

The share of tax in total diesel price in 2011 is shown in Figure 19. Currently, the highest tax on diesel fuel is in United Kingdom, 0.92 EUR per litre of diesel. The share of tax in total diesel price is a little bit lower comparing to tax on gasoline. In EU the share of tax on diesel is in range from 36% to 57% of the total diesel price, see Figure 19.

2.4 Development of car stock

The following figures depict major features regarding the development of car stock and new registered vehicles in (selected) EU Member States.

Car stock in EU-15 has grown from about 100 million cars in 1980 to more than 190 million cars in 2007, see Figure 20. Diesel cars increased their market share continuously. In 1980 the share of diesel cars in the total vehicle stock in EU 15 was 3.3% and 32% in 2007.

The share of alternative automotive technologies, such as electric vehicles, fuel cell vehicles, various types of hybrid systems, ethanol cars and systems based on natural gas or biogas, is still very low in EU countries. In 2007 in EU-15 share of alternative automotive technologies was about 1%.

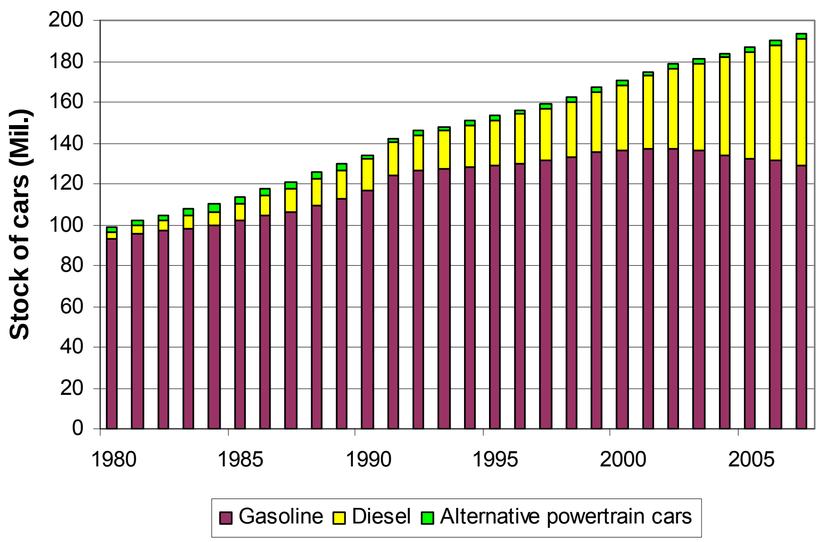


Figure 20. Development of car stock in passenger transport in EU-15, 1980 – 2007

One of the main reasons for the increasing energy consumption in car passenger transport is the continuous increase in car ownership in all EU countries, see Figure 21. In 1970 it was ranging between 2 (Romania) and 280 (Sweden) cars per 1000 capita, in 2009 between 200 (Romania) and 685 (Luxemburg) cars per 1000 capita.

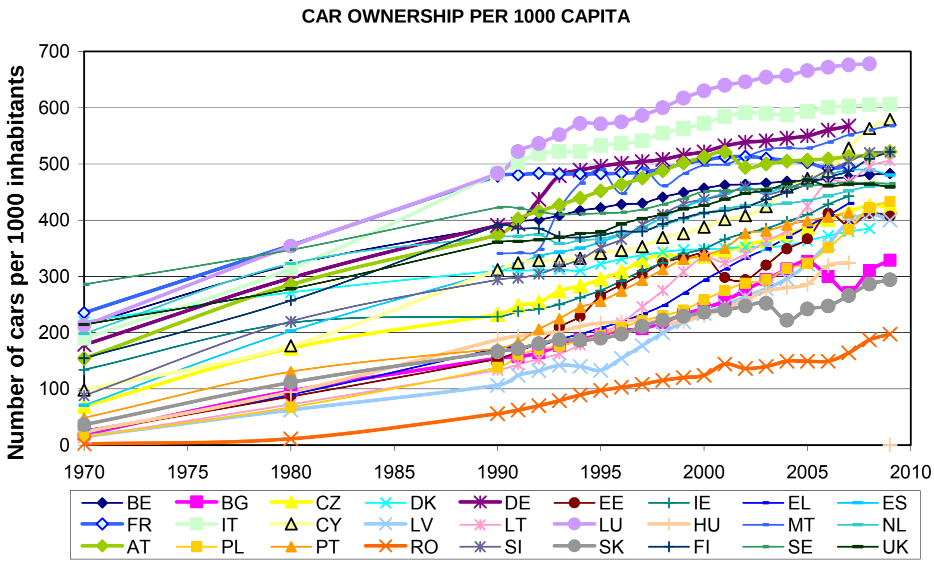


Figure 21. Car ownership per 1000 capita in EU-27 countries 1970 – 2009 (Source: EUROSTAT; ALTER-MOTIVE database)

There is a strong correlation between number of vehicles per capita and GDP per capita and income - these two parameters are strongly linked and both increasing over time, see also Ajanovic ed. 2009. However, some specific developments in some EU countries could be noticed. E.g. Denmark has a relatively high GDP per capita and low car ownership level; Italy has almost the highest car ownership level in EU and relatively low GPD comparing with

Denmark, Sweden etc. These differences between countries could be explained with different vehicle and fuel taxes.

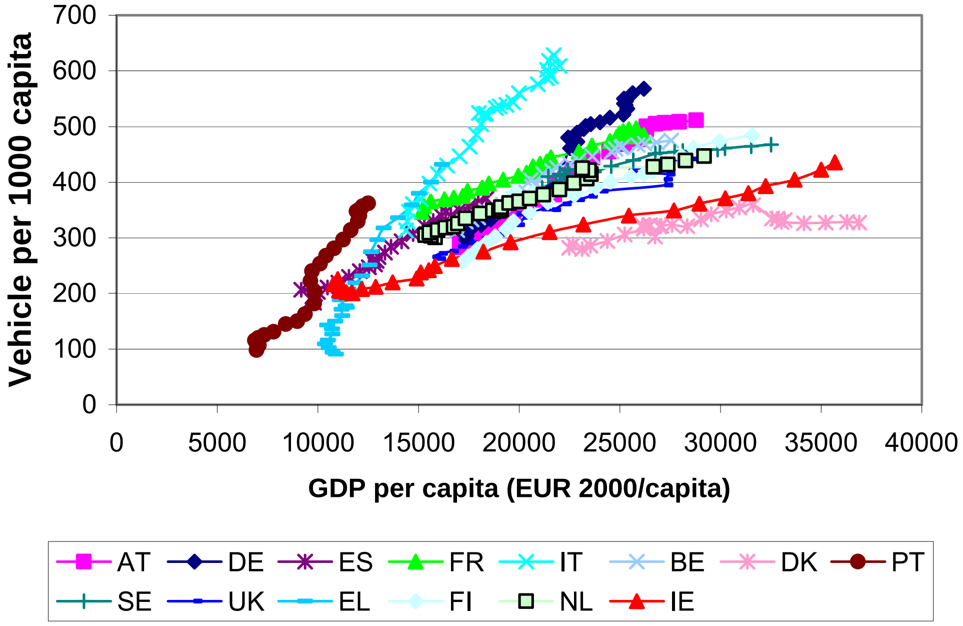


Figure 22. Car ownership versus GDP per capita 1980-2007

The relation between number of vehicles per capita and GDP per capita is shown in Figure 22. It can be notice that these two parameters are strongly linked and both increasing over time.

Denmark has a relatively high GDP per capita and low car ownership level. This can be explained with the high vehicle taxes in Denmark. Denmark has tried to influence the drivers to buy cars which are energy efficient –with low CO_2 emission through the registration tax and the car owners' tax. From 2000 the registration tax was reduced for the most fuel efficient cars.

From the analysed countries, the highest car ownership level is in Italy and it is rapidly increasing with GDP increase.

Aside from the increasing car ownership also an increasing share of diesel cars can be noticed. One of the biggest advantages of choosing a diesel car is fuel economy. A diesel's extra 20 to 30 percent of fuel efficiency makes a difference. Out of town, some emit even less CO_2 than hybrids. This is one reason why diesels are becoming a more and more popular choice (ACEA, 2011).

As shown in Figure 23, in 1998 in most of European countries the share of diesel cars was relatively low. However, already in 2008 in some EU countries the diesel share was remarkably higher than gasoline share, e.g. in Austria, Belgium, France.

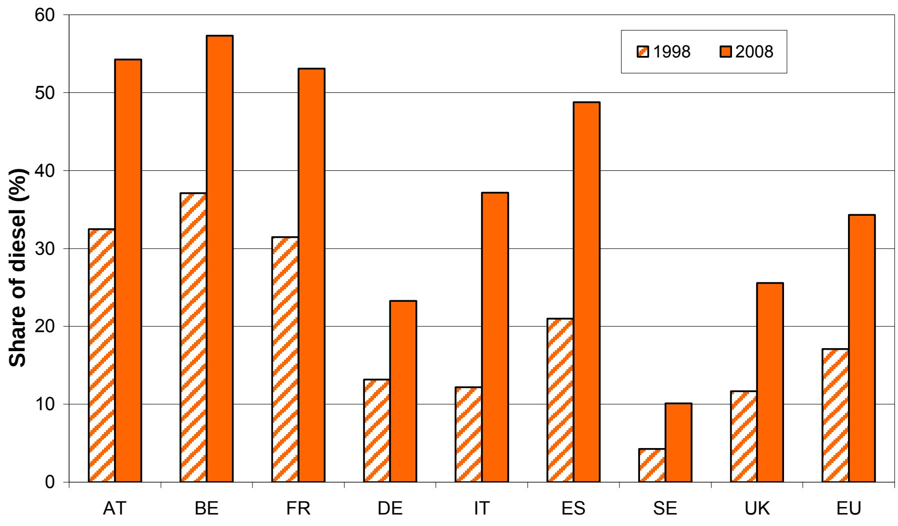


Figure 23. Share of the stock of diesel cars in total fossil fuel consumption, selected EU countries 1998 vs 2008 (data source: ODYSSEE database; ALTER-MOTIVE database)

2.5 Performance of new registered cars

The major features of new registered cars in EU-27 countries regarding fuel intensity, CO_2 emissions and power are depicted in the following figures. Figure 24 documents the wide range of CO_2 emissions of new cars in EU-countries in 2009. There is a very broad range: while countries like France, Italy, Malta, Denmark and Portugal purchased on average cars with less than 140 gCO_2 /km the other extreme are Sweden, Bulgaria and the Baltic countries with more than 160 average gCO_2 /km per new car.

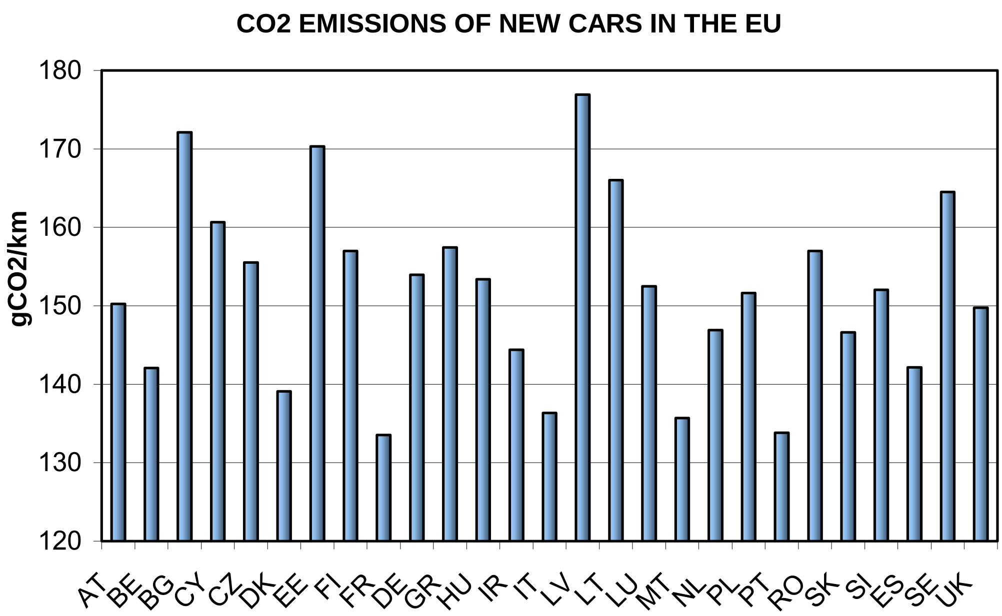


Figure 24. CO_2 emissions of new cars in EU-countries in 2009 (data source: DB,2009)

The development of average CO_2 emissions from new passenger cars by fuel in EU-27 countries from 2000 to 2009 is shown in Figure 25. Most interesting in this figure is that – due to the switch to larger cars – diesel cars had almost the some emissions than gasoline cars.

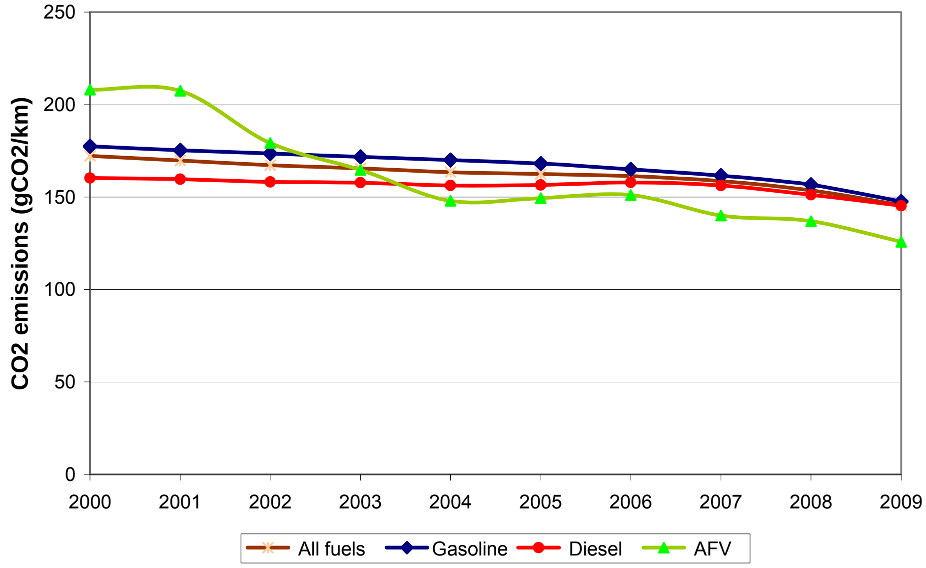


Figure 25. Development of average CO_2 emissions from new passenger cars by fuel in EU-27 countries from 2000 to 2009 (data source: EC, 2010)

Figure 26 shows the development of fuel intensity (FI), power-specific fuel intensity (FIP) and power (kW) of new vehicles in EU-15 from 1990 to 2009. Note, that fuel intensity FI in Figure 26 and Figure 27 does not reflect the real efficiency improvement because it is distorted by the switch to larger cars. To correct this we define a power-specific fuel intensity:

$$FIP = \frac{FI}{kW} \qquad (l/(100km\ kW)) \qquad (1)$$

It can clearly be seen from Figure 26 and Figure 27 that the decrease in FIP from 1990 to 2009 was virtually twice as high as the decrease of FI. So actual efficiency was improved twice as much as actual FI developments have performed.

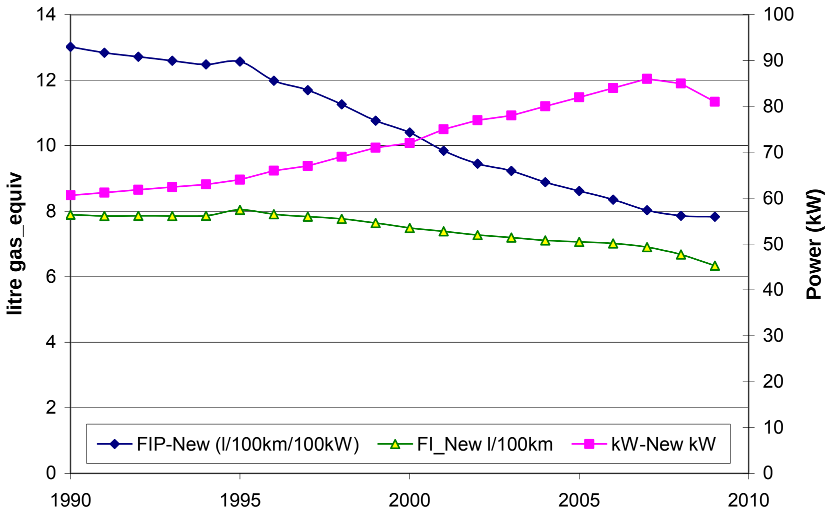


Figure 26. Development of fuel intensity, power-specific fuel intensity and power (kW) of new vehicles in EU-15 from 1990 to 2009

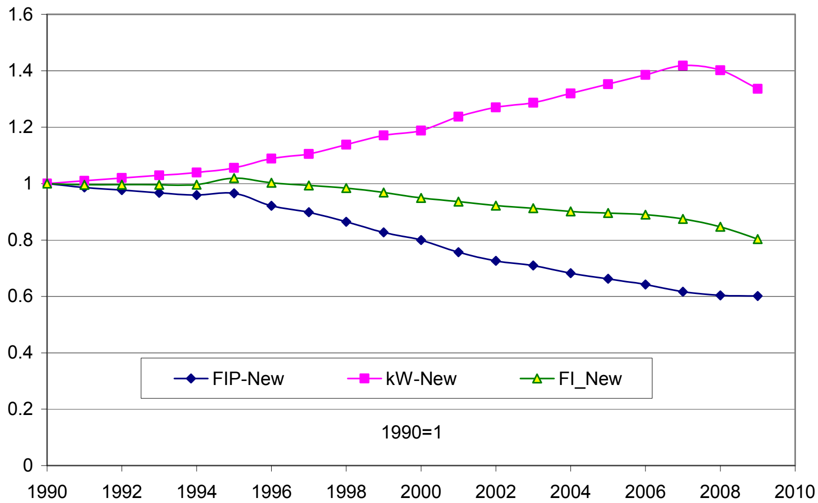


Figure 27. Normalised development (1990=1) of fuel intensity, power-specific fuel intensity and power (kW) of new vehicles in EU-15 from 1990 to 2009

2.6 Development of vehicle - km driven

With the increasing car ownership, also overall travel activity is continuously increasing in all countries and the range of vehicle kilometers per capita is between 3 200 and 8 600 vehicle kilometers per capita, see Figure 28. From analyzed countries the highest travel activity is in Finland, Italy, Slovenian and Ireland, and the lowest in Slovakia, Czech Republic and Spain. The low travel activity per capita reflects low car ownership and utilization rates.

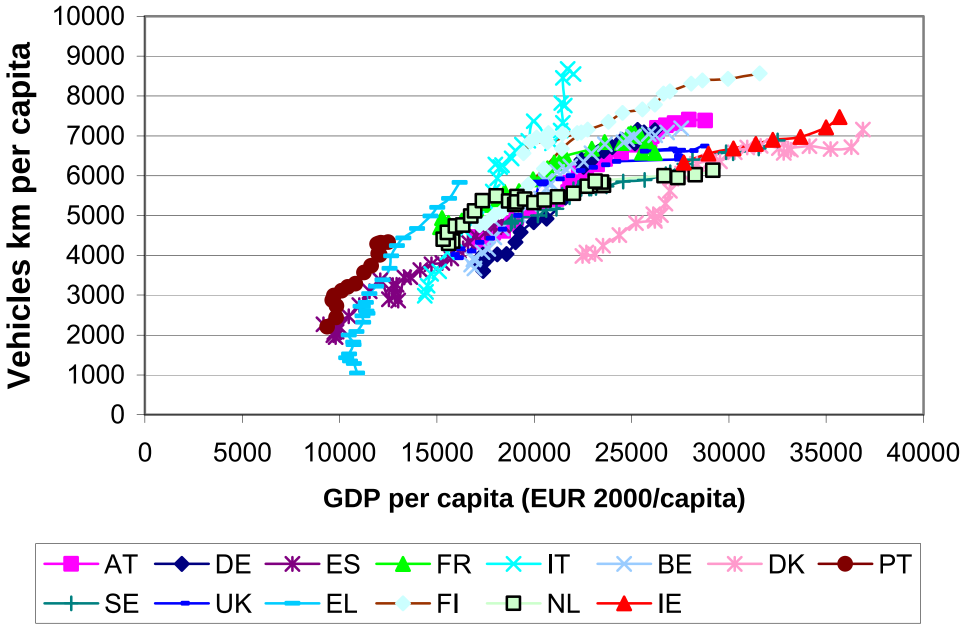


Figure 28. Development of vehicle kilometer per capita in selected EU countries 1980-2007

As shown in Figure 28, it is clear that GDP is an important driver of travel activity. In all analysed countries strong correlation between these two parameters can be noticed.

2.7 Fuel Intensities

In 2007 the fleets in the European countries have had on-road fuel intensity in the range of 6.5- 8.2 liter per 100 kilometer, see Figure 29.

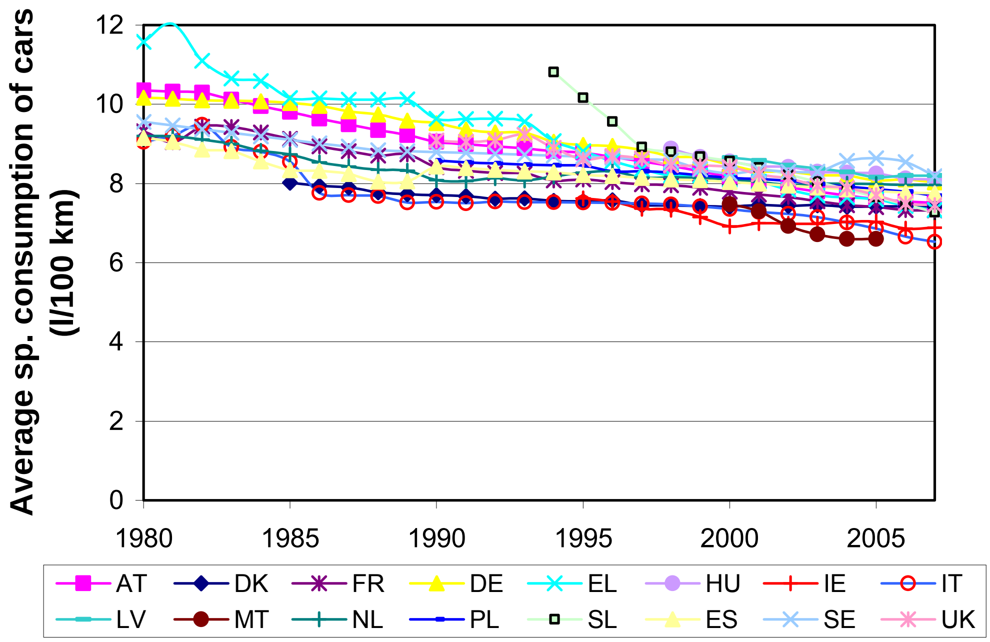


Figure 29. Average on road fuel intensity of stock of cars, gasoline equivalent (Diesel and LPG are converted to liters of gasoline at their energy content. 1 litre diesel = 1.12 litre gasoline)

The fuel economy improvement in new cars in Europe between 1980 and 2006 according to tests, was in range of 18% - 30%. These improvements were mainly due to the voluntary agreements to improve fuel economy, but currently agreements in Japan and Europe are expected to be both tighter and mandatory (Schipper, 2008). The EU proposes to strengthen their "Voluntary Agreement" to become a mandatory target with goal of 120 g/km CO_2 emissions from tests of new cars, which corresponds to roughly 5.5 l/100 km (Major, 2008).

Summing up, the major fact is that important technical improvements have been made to engine and other cars components, but these have been mostly outweighed by heavier, larger and more powerful cars.

2.8 Major policies

According to the European Commission, at present there is little Community legislation, or harmonisation of national fiscal provisions, applied by the Member States in the area of passenger car taxation. Therefore, it is for each Member State to lay down national provisions for the taxation of these cars.

The mostly used policy measures in transport in the twenty-seven Member States of the European Union are:

- Motor vehicle and fuel taxation
    - Taxes on acquisition/registration - A tax on acquisition is tax paid once, by each vehicle owner, for each vehicle purchased and entered into service (sales tax, registration tax).
    - Taxes on ownership - Taxes on ownership are paid annually, regardless of how often the vehicle is used.
    - Taxes on fuel - Excise duites on fuels.

An overview of these taxes as well as CO_2 based motor vehicle taxes in the EU is provided in the Appendix A.

3. Energetic, economic and ecological assessment of alternative fuels and alternative more efficient powertrains

This chapter summarizes the major results of the analyses conducted within work package 3 (WP3) of this project, see especially Toro et al, 2010. It provides a comprehensive technical, economic and ecological assessment of AAMTs and AFs. To meet this objective it is necessary to have clear understanding of the current state-of-the-art and improvement potentials for these various AFs & AAMTs for passenger transport. This documentation is the basis for further analyses in the scope of the ALTER-MOTIVE project.

To meet the above-stated target of the project ALTER-MOTIVE it is necessary to use a proper dynamic modelling framework. This framework must be based on a sound database for the various considered AFs & AAMTs for passenger transport. This work focuses on providing a fundamental database for biofuels, natural gas, electricity and hydrogen and AAMTs including technical, ecological and economic characterisations of each relevant technology.

The database is organised in excel-files that contain relevant technical, environmental and economic data delivering specific costs, carbon emissions and where possible also NOx emissions for all relevant electricity, hydrogen and biofuel technologies in the sub-systems production, distribution, conditioning, storage, refuelling and conversion.

3.1 Perspectives for current and future biofuels

Biofuels are expected in many policy directives and scientific papers to have the potential to contribute significantly to replacing fossil fuel consumption and corresponding CO_2 emissions. Indeed, in recent years biofuels first generation (BF-1) – biodiesel (BD-1), bioethanol (BE-1), – have entered the market in significant amounts. Of further interest are bio-methane (BM), bioethanol from lignocellulose (BE-1) and BTL-Fischer-Tropsch-Diesel (BD-2).

Yet, biofuels are still under discussion mainly because of their currently poor ecological and energetic performance. In this context it is very important to consider the whole fuel chain by means of a so-called Well-to-Wheel (WTW) assessment for the ecological assessment. The WTW-balance adds Well-to-Tank (WTT) and Tank-to-Wheel (TTW) see Figure 30. The calculation of WTT-net CO_2 emission balances used in Figure 30 is described in detail in Figure 31 based on the following equation:

$$WTT_{net} = WTT_{minus} + WTT_{plus} \quad (2)$$

where
WTT_{plus} ….. CO_2 Fixation due to biomass planting
WTT_{minus}… CO_2 emissions during fuel production

Note that in this calculation no land-use changes are considered.

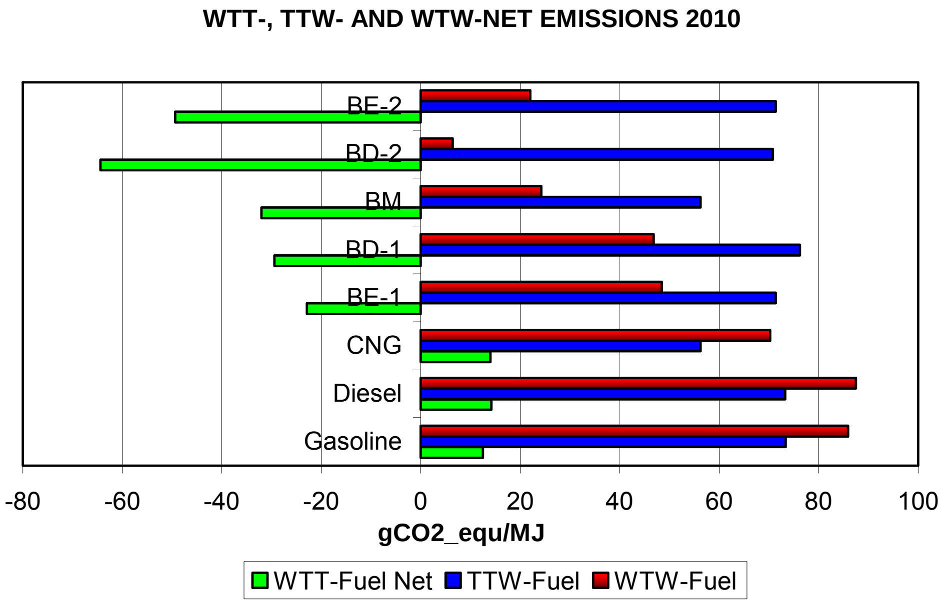


Figure 30. WTT-, TTW- and WTW net CO_2 emissions of fossil fuels vs biofuels in 2010 for the average of EU-countries on a WTW basis (Source: CONCAWE, 2008a, Toro at al 2010)

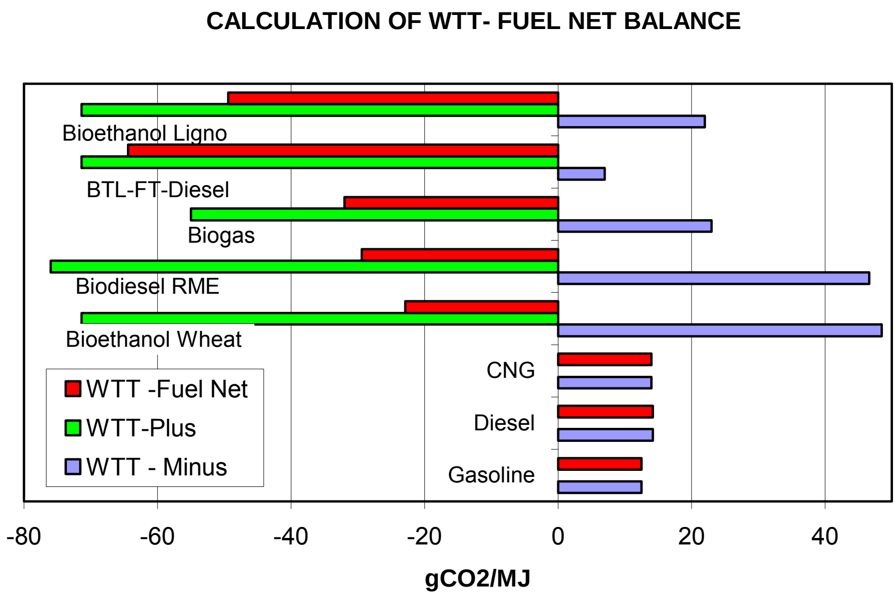


Figure 31. Calculation of WTT-net CO_2 emission balances (Source: CONCAWE, 2008a, Toro at al 2010)

In 2010 BD-1 and BE-1 had overall only about 45% lower CO_2 emissions (on a WTW basis) than the corresponding fossil fuels. Figure 32 depicts the expected development of CO_2 emissions of fossil fuels and biofuels in 2010 and 2020 for the average of EU countries on a WTW basis[6]. For the ecological and economic analysis it is important to note that for all fuels by-products were considered in all cases as they result to have a positive influence on costs and emissions performance. However, the use of by-products and the way they are characterized in analysing

[6] In Appendix E a table on the main properties of fuels is provided.

biofuels production from WTT is not always comparable with other studies, as assumptions regarding their use and value differ considerably.

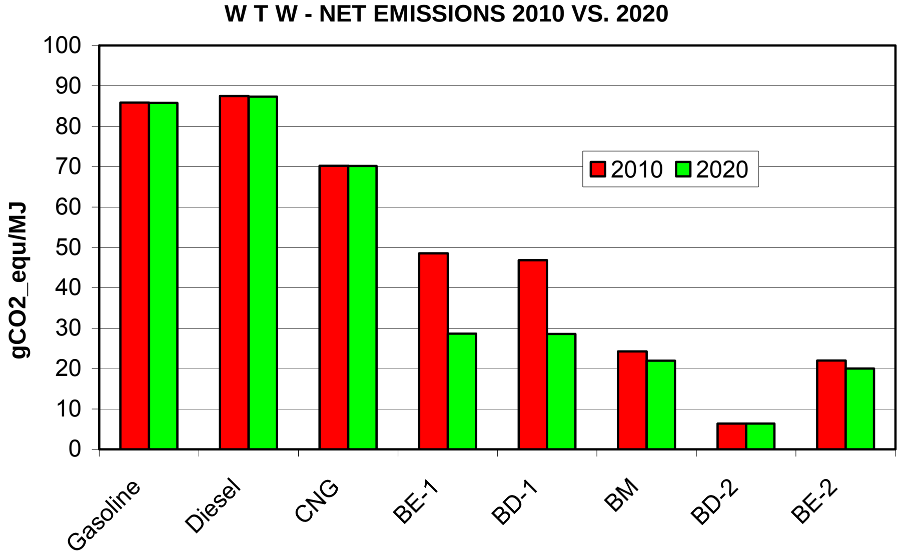


Figure 32. CO_2 emissions of fossil fuels versus biofuels in 2010 and 2020 for the average of EU countries on a WTW basis (Source: CONCAWE, 2008a; own assumptions based on EC, 2009c)

The major reason for the recent market share increases is that biofuels were so far exempted from excise taxes. In this context it is important to identify the shares of cost categories.

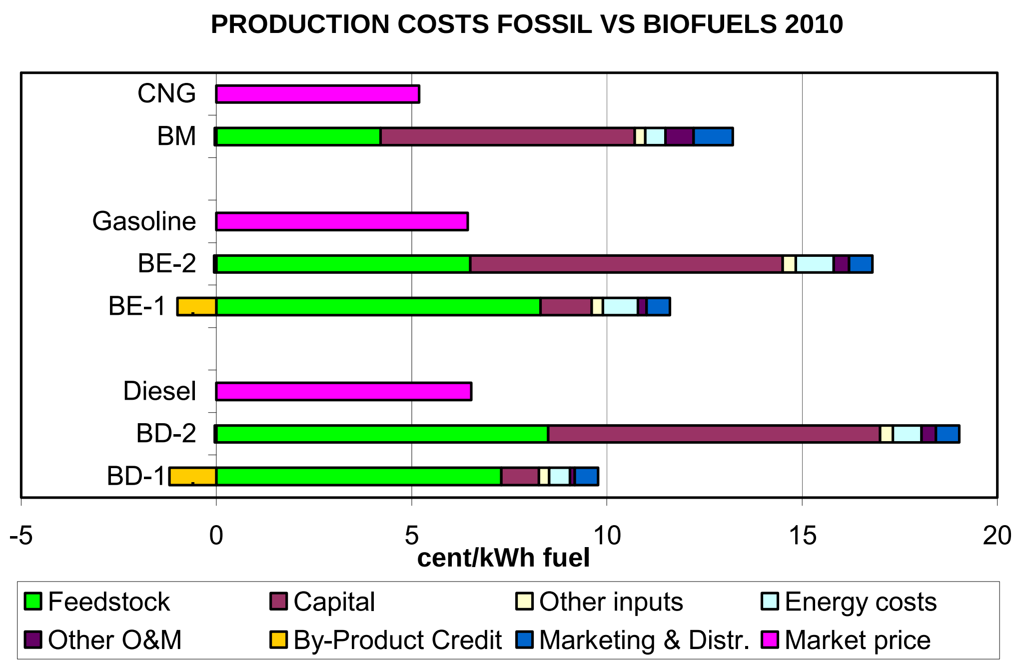


Figure 33. Production costs of fossil fuels versus biofuels excl. taxes in 2010 for the average of EU countries (Source: Toro et al, 2010)

Figure 33 provides a snapshot of the production costs of fossil fuels and biofuels excluding taxes in 2010 for the average of EU countries compared to fossil fuels. The costs documented also reflect the current size categories installed. Especially for BM, BD-2 and BE-2 the currently small sizes contributes to rather high specific capital costs. Scaling could bring the costs down. As can be seen clearly from Figure 33 the by far largest cost share of BD-1 and BE-1 are feedstock costs. Feedstock costs for BE-2 are rather low mainly because of straw is used. We can see that biofuels are still considerably more expensive than fossil fuels. So it is clear that their economic performance has to be improved.

Figure 34 depicts the costs of fossil fuels and biofuels inclusive and exclusive taxes in 2010 versus 2020 for the average of EU countries. We can see that when the excise tax is replaced by a CO_2 based tax – given the assumptions in Figure 32 for 2020 – the economic attractiveness of all biofuel fractions – except BE-1 – increases. Note that for biogas the costs are a mix of biogas from grass, green maize and manure.

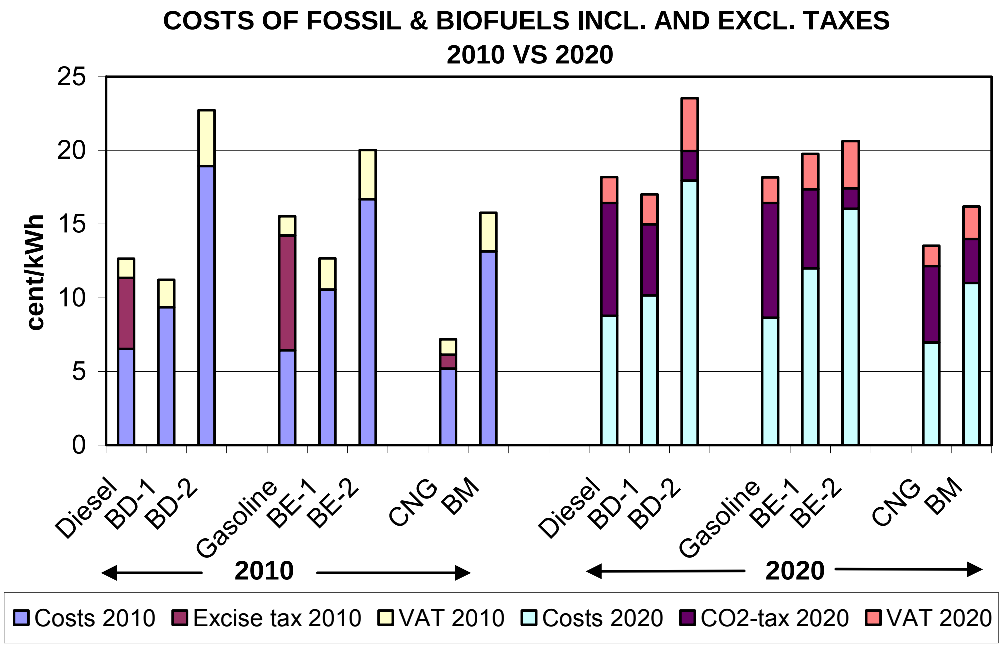


Figure 34. Cost of fossil fuels vs biofuels incl. and excl. taxes in 2010 vs 2020 for the average of EU-countries (based on assumptions in Section 8.1)

Figure 35 shows an aggregated picture of the development of fossil fuels versus biofuels production costs and WTW CO_2 emissions [g CO_{2eq}/MJ] from 2010 to 2020. We can see that only the costs of BF-2 can be expected to decrease moderate, while BF-1 will become slightly more expensive. Yet, the potential for ecological improvements is highest for BF-1, see Figure 35.

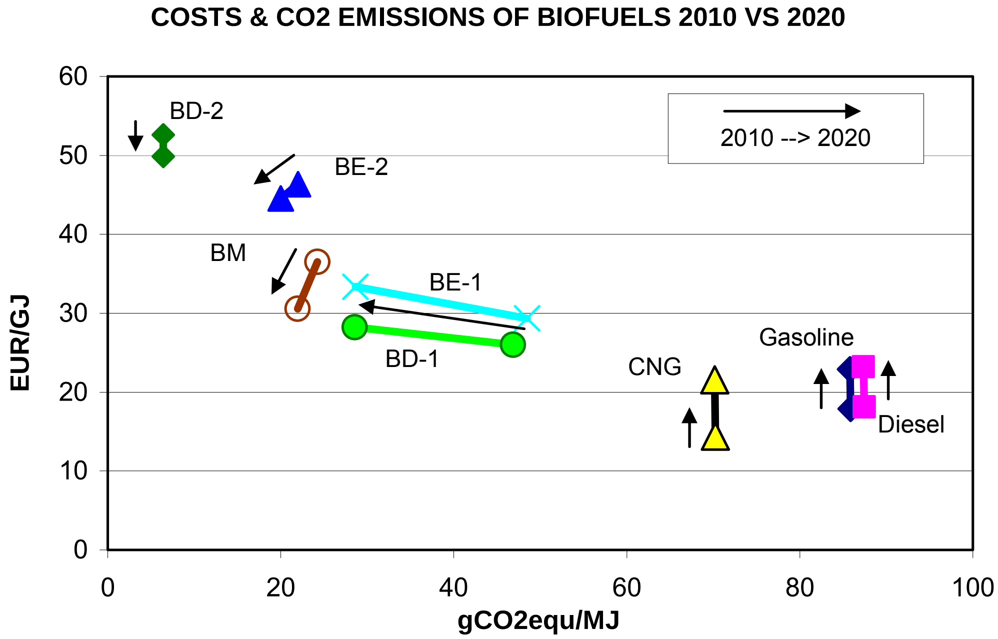


Figure 35. Fossil vs. biofuels production costs (exclusive taxes) and WTW CO_2 emissions [g CO_{2equ}/MJ] 2010 and 2020 (Source: Toro et al, 2010; own calculations based on assumptions in Section 8.1)

The results are: With respect to the ecological performance of BF-1 the best option corresponds to biogas with lowest specific emissions. BD-2 performs better than BE-2 in terms of CO_2 emissions per Megajoule (MJ). The values provided here for 2^{nd} generation biofuels are still disputable as they are based on R&D or demonstration figures, but still no scalable experience has been obtained. BTL has the prospect to offer lower emissions in this case due to the co-generation assumption covering high energy inputs; however, the capital requirements observed are very high. Along the whole chain biodiesel from rapeseed and bioethanol from wheat are exhibiting the higher CO_{2eq} emissions per delivered MJ of fuel due mostly by cultivation and fertilizers use as well as the use of fossil based inputs.

3.2 The relevance of alternative and more efficient powertrains for reducing CO_2 emissions

Battery electric vehicles (BEV), fuel cell cars and more efficient internal combustion engines (ICE) may to some extent contribute to a relief of the overall CO_2 emissions. The former ones may especially in cities contribute to the improvement of the air quality.

Yet, currently high costs – mainly of batteries and fuel cells – and other limitations (e.g. driving range) state a major barrier for a broader market penetration of BEV and FCV.

In addition, it is important to recognize that the overall ecological performance of BEV strongly depends on how electricity is generated, how the battery performs ecologically and whether actually conventional passenger cars are substituted or additional transport is triggered.

Figures 36 and 37 show the specific CO_2 emissions of BEV for three different ways of generating electricity: It can clearly be seen, that in the case where electricity is generated with the current mix in the UCTE (Union for the Co-ordination of Transmission of Electricity) or from natural gas power plants no clear advantage compared to conventional or hybrid vehicles can be revealed. So we can clearly see that the environmental benignness of BEV and FCV depends solely on which source electricity or hydrogen is produced. Only if the electricity for BEV and FCV is produced from renewable energy sources (RES) an undoubtedly ecological advantage can be expected.

So it is very important to consider that "green" electricity for E-mobility is not available self-evident now and not indefinite available in the future and not for free. Hence, in lockstep with the market introduction of BEV the corresponding deployment of new RES-E capacities must be ensured and proven by certificates without forgetting the problems of time of charging, linked to other storages and smart grids.

We can clearly see that the environment benignness of BEV and FCV depends solely from which source electricity or hydrogen is produced. Only if renewables are the primary source a significant reduction of CO_2 emissions can be expected.

Figure 36 provides a comparison of specific CO_2 emissions of conventional and hybrid gasoline and diesel vehicles with pure BEV based on different electricity generation mixes and FCV with hydrogen from natural gas versus renewables.

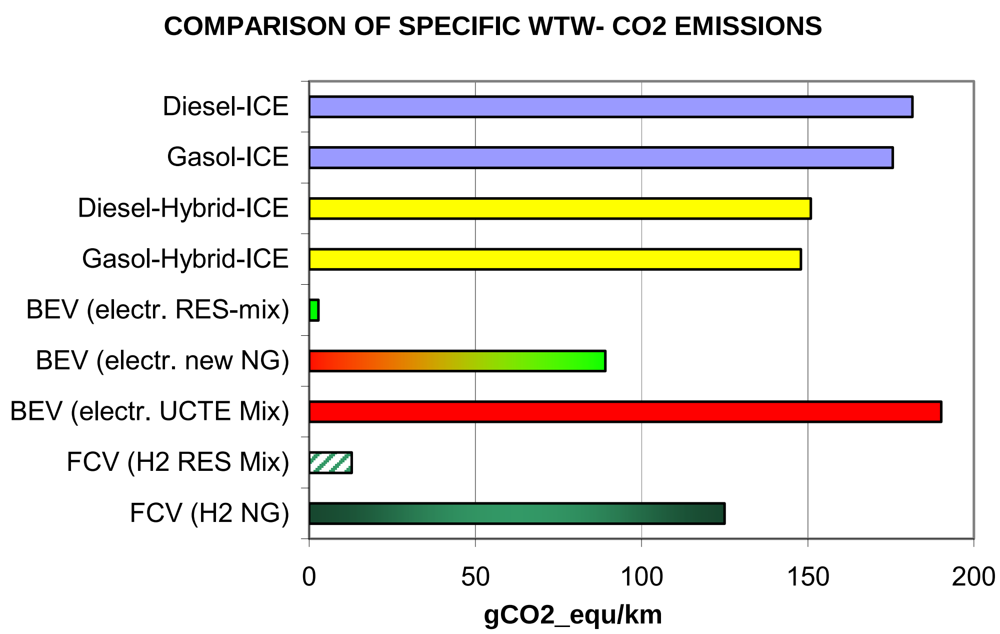


Figure 36. Comparison of specific CO_2 emissions of conventional and hybrid gasoline and diesel vehicles with pure BEV based on different electricity generation mixes and FCV with hydrogen from NG vs RES

Figure 37 depicts the CO_2 emissions of fossil versus hydrogen and electricity in 2010 and 2020 for the average of EU countries on a WTW basis.

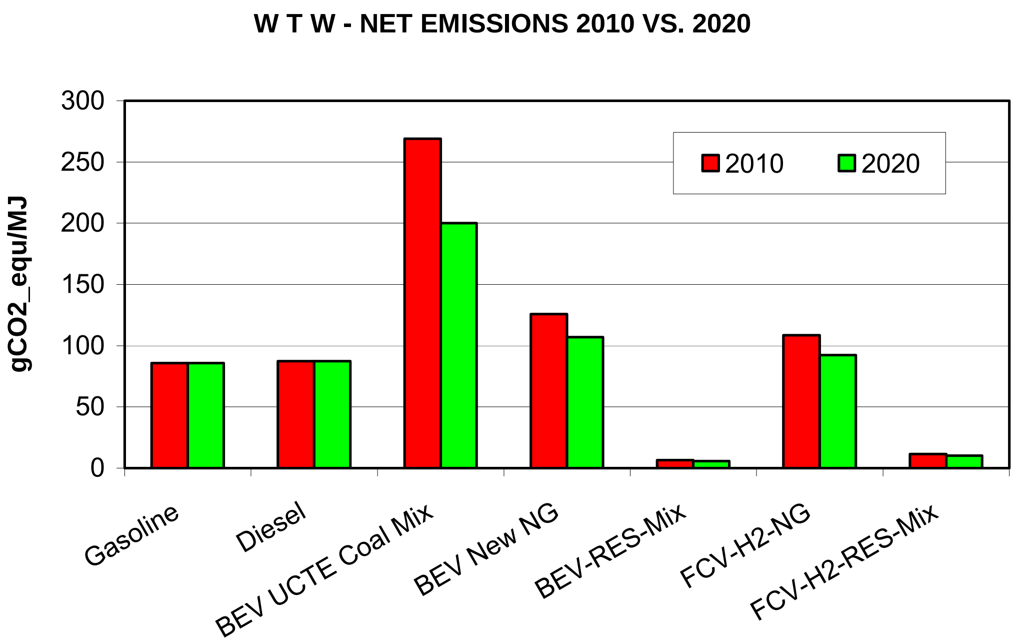


Figure 37. WTW-emissions [gCO_{2eq}/MJ] of electricity and hydrogen compared to fossil fuels of 2010 and 2020 (Source: Toro et al, 2010; CONCAWE, 2008)

With respect to a state of the art assessment of AAMT, the modification of the existing internal combustion engine to run on alternative fuels, able to be blended with fossil diesel and gasoline or natural gas performs differently in terms of emission reductions stating better for biodiesel and biomass-to-liquids than for gasoline or flex-fuel vehicles running on ethanol mixtures.

Hybrid vehicles may serve as a bridging technology. They do not have most of the disadvantages of pure BEV: They are economically almost competitive, use less fuel than conventional gasoline and diesel vehicles and can compete with BEVs also on WTW CO_2 emissions, except for BEVs running on electricity based on pure renewable energy sources, see Figure 36 and 38.

Moreover, AAMTs including parallel hybrids, battery electric vehicles (BEVs) and hydrogen technologies combined with ICEs have been assessed on their economic performance and on their environmental performance, see Figures 36, 38 and 39.

The specific capital costs are the highest component of the driving costs for all technologies. Hybrids, battery electric vehicles and plug-in hybrids take into account the actual costs for batteries as well as for fuel cells. However, these costs can be reduced until 2020 based on technical improvement potentials. The objective for batteries reaches the 500 €/kWh for Li-Ion batteries while fuel cells for transportation until 2020 exhibit higher figures.

The costs per km driven C_{km} in Figure 38 are calculated as:

$$C_{km} = \frac{IC \cdot C.R.F.}{skm} + P_F \cdot FI + C_{O\&M} \qquad [€/km] \qquad (3)$$

where:

IC……….Investment costs [€/car]
C.R.F.……Capital recovery factor
skm…… ...specific km driven per car per year [km/(car.yr)]
P_F………...fuel price [€/litre]
$C_{O\&M}$……..operating and maintenance costs [€/km]
FI…………fuel intensity [litre/100 km]

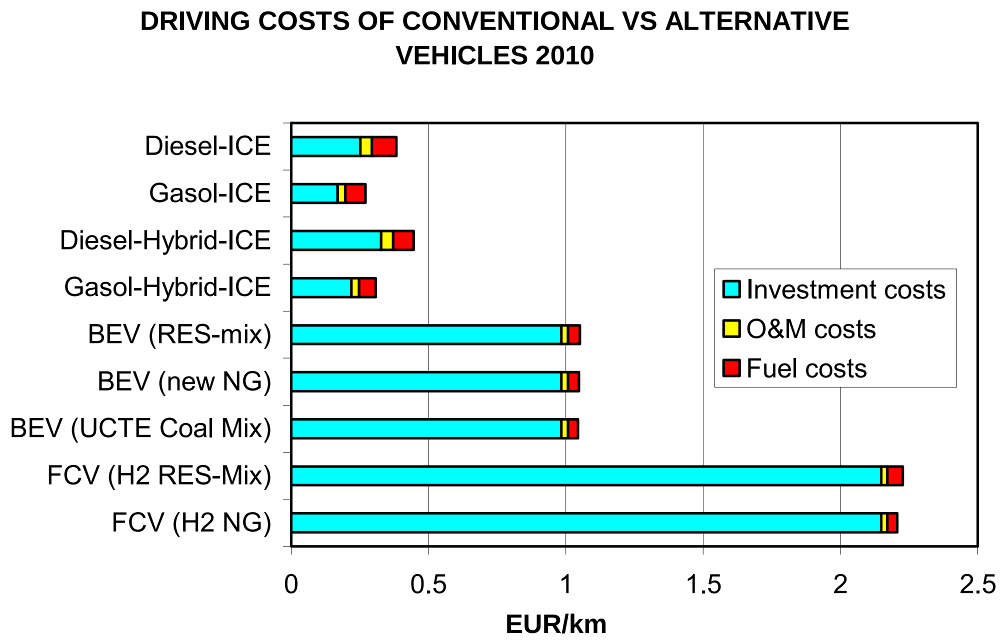


Figure 38. Hydrogen and Electric vehicles – State of the Art of economic assessment of driving costs 2010 (Size of vehicle: 80 kW)
(*H2: Hydrogen, ICE: Internal Combustion Engine, FCV: Fuel Cell vehicle, BEV: Battery Electric Vehicle, NG: Natural gas*)

Figure 39 provides a comparison of specific CO_2 emissions and costs of conventional and hybrid gasoline and diesel vehicles with pure BEV based on different electricity generation mixes and FCV with H_2 from RES or natural gas.

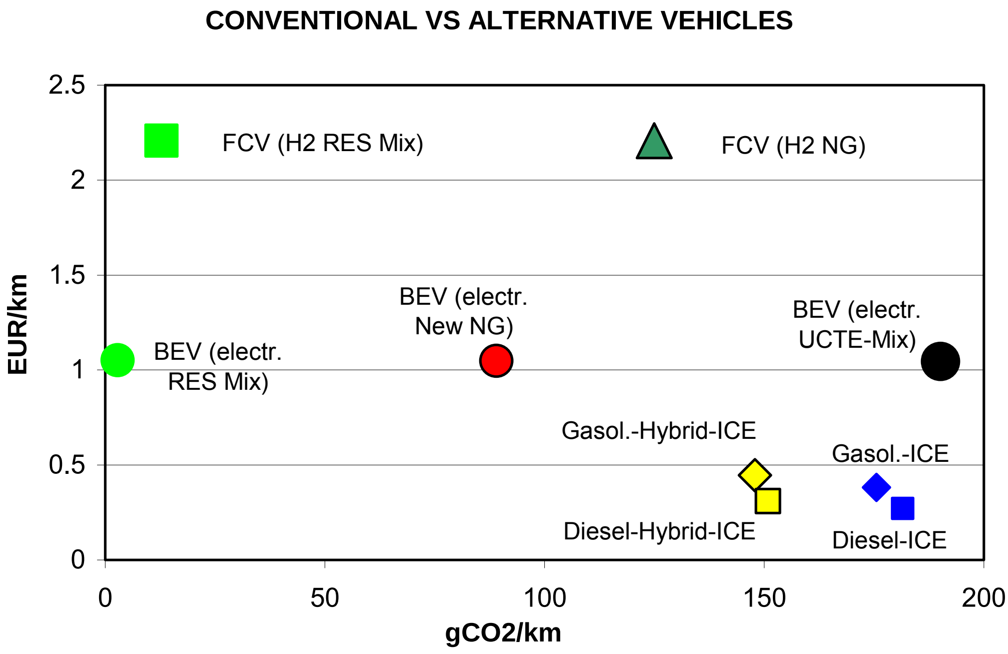


Figure 39. Comparison of specific CO_2 emissions and costs of conventional and hybrid gasoline and diesel vehicles with pure BEV based on different electricity generation mixes and FCV with hydrogen from NG vs RES (Source: Toro et al, 2010)

The major perceptions of Figure 39 are: (i) Hybrid ICEs are an alternative with slightly higher costs but clearly better performance than conventional vehicles; (ii) BEV as well as FCV are only preferable to conventional cars if they are fully based on RES.

Yet, it is important to note that there are considerable technical improvement potentials for AAMTs – see Toro et al (2010) for further details – which include:

- BEVs are still an immature technology. Major R&D and demonstration activities relate to further development of battery technologies and technology improvements indicate a wide range of weight and costs reduction potentials until 2020 probably explained by the different scaling factors for battery and cell sizes;
- Technical improvements for fuel cells include power density and platinum loading which are necessary to go on commercial scale. The cost evaluation of fuel cells for automotive power trains suggests, that in future significantly lower costs of fuel cell systems can be expected due to scale production and technology learning;
- Until 2020, the contribution from hydrogen as a transport fuel remains limited and several technical improvements remain at research, development and demonstration with promising potentials after 2020. Major challenges include reduction of energy and resource losses in over-all conversion chains, to make the production process cheaper as well as to enhance the reliability and life-time of fuel cells and to bring the learning curve of costs.

3.3 Technical improvement potential of ICE modifications

Aside from switching to completely new technologies like BEV or FCV continuous improvements of conventional cars will play an important role in future CO_2 reductions. There are still technical improvement potential of ICEs. Manifold solutions for future technological developments and modifications are discussed. With rapid pace of development and innovation, it is not probable to say which technology will prove to be the most viable solution. However, two broad categories of technologies can be improved to reduce the fuel usage and GHG emissions in vehicles, i.e. engine technologies and transmission technologies, described in more detail below (www.fueleconomy.gov).

Engine Technologies

Variable Valve Timing & Lift (VVT&L)[7] – improves the engine efficiency by optimizing the flow of fuel & air into the engine for various engine speeds. Valves control the flow of air and fuel, into the cylinders and exhaust out of them. When and how long the valves are open (timing) and how much the valves move (lift) both affect engine efficiency. Optimum timing and lift settings are different for high and low engine speeds. Traditional designs, however, use fixed timing and lift settings, which are a compromise between the optimum for high and low speeds. VVT&L systems automatically alter timing and lift to the optimum settings for the engine speed. VVT&Ls can improve the ICE's fuel economy by 1-9%, see Table 2.

Cylinder Deactivation - saves fuel by deactivating cylinders when they are not needed. Also called multiple displacement, displacement on demand (DOD), and variable cylinder management. This technology simply deactivates some of the engine's cylinders when they are not needed. This temporarily turns 8- or 6-cylinder engine into a 4- or 3-cylinder engine. This technology is not used on 4-cylinder engines since it would cause a noticeable decrease in engine smoothness.

Example : GM's Displacement on Demand, it automatically turns off half of the cylinders during lightload operating conditions, enabling the working cylinders to achieve higher fuel efficiency through better thermal, pumping and mechanical efficiency. Under light loads, the control module automatically closes both intake and exhaust valves for half of the cylinders.

Turbochargers & Superchargers - increase engine power, by downsizing of engines (the use of a smaller capacity engine operating at higher specific engine loads) without sacrificing performance or to increase performance without lowering fuel economy. Turbochargers and superchargers are fans that force compressed air into an engine's cylinders. A turbocharger fan is powered by exhaust from the engine, while a supercharger fan is powered by the engine itself. Both technologies allow more compressed air and fuel to be injected into the cylinders, generating extra power from each explosion. A turbocharged or supercharged engine produces more power than the same engine without the charging, hence it makes possible to use smaller

[7] VVT&L is also called variable valve actuation, variable-cam timing, and variable valve timing and lift electronic control.

engines without sacrificing performance. With this technology efficiency between 2 to 7.5% can be increased.

Integrated Starter/Generator (ISG) Systems - These systems automatically turn the engine off when the vehicle comes to a stop and restart it instantaneously when the accelerator is pressed so that fuel isn't wasted for idling. In addition, regenerative braking is often used to convert mechanical energy lost in braking into electricity, which is stored in a battery and used to power the automatic starter. With this technology efficiency between 0.5 to 8% can be increased.

Direct Fuel Injection (w/turbocharging or supercharging) – it delivers higher performance with lower fuel consumption. Also called fuel stratified injection or direct injection stratified charge. In conventional multi-port fuel injection systems, fuel is injected into the port and mixed with air before the air-fuel mixture is pumped into the cylinder. In direct injection systems, fuel is injected directly into the cylinder so that the timing and shape of the fuel mist can be precisely controlled. This allows higher compression ratios and more efficient fuel intake, which deliver higher performance with lower fuel consumption.

Transmission Technologies

Continuously Variable Transmissions (CVTs) have an infinite number of "gears", providing seamless acceleration and improved fuel economy. Most conventional transmission systems control the ratio between engine speed and wheel speed using a fixed number of metal gears. Rather than using gears, the CVTs in currently available vehicles utilize a pair of variable-diameter pulleys connected by a belt or chain that can produce an infinite number of engine/wheel speed ratios.

This system has several advantages over conventional transmission designs:

- Seamless acceleration without the jerk or jolt from changing gears
- No frequent downshifting or "gear hunting" on hills
- Better fuel efficiency

Automated Manual Transmission (AMT) - Automated manual transmissions combine the best features of manual and automatic transmissions. Manual transmissions are lighter than conventional automatic transmissions and suffer fewer energy losses. AMT operates similarly to a manual transmission except that it does not require clutch actuation or shifting by the driver. Automatic shifting is controlled electronically (shift-by-wire) and performed by a hydraulic system or electric motor. In addition, technologies can be employed to make the shifting process smoother than conventional manual transmissions.

Table 2: Examples of Advanced Technologies in the global market and expected increase in efficiency

Technology	Sample Manufacturers (Models)	Increase in fuel efficiency (%)
Variable Valve Lift & Timing	Honda (Honda DOHC i-VTEC® System), Toyota (Toyota VVT-i,), BMW (BMW VALVETRONIC), Ford F-150	1-9
Gas Direct Injection (S)	Audi (A3, A4, A6), Isuzu (Rodeo), Mazda (Speed 6)	3-15
Cylinder Deactivation	Chevrolet (Trailblazer, Impala SS), DaimlerChrysler, Honda (Odyssey, Pilot, Hybrid Accord), Honda Accord (V6)	7-7.5
AMTs	Ford (Fusion), BMW, Jaguar, Audi (A3, TT), VW (Beetle, Jetta)	7-9
CVTs	Honda (Civic), Ford (Five Hundred, Freestyle) Nissan (Murano), Audi MultiTronic CVT	3-8

(Source –EPA, 2005; Kobayashi, Plotkin & Ribeiro, (2008))

Assuming the technological improvements in various ICEs, Figure 40 shows a picture on fuel consumption improvements by 2030. The sources for this are documented in Toro et al. 2010. Figure 40 summarizes how fuel consumption (l/100 km) can be reduced through 2030 following current developments. For example, ICE ethanol shows substantial improvements by 2030 as compared to 2002.

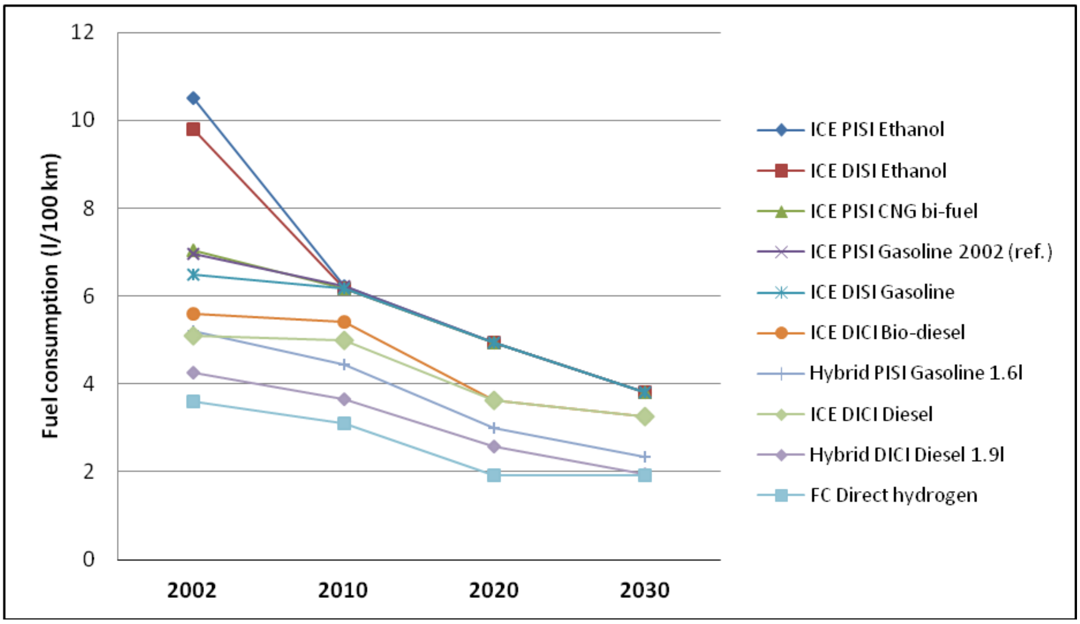


Figure 40. AAMTs fuel consumption improvements until 2030 (PISI: Port Injection Spark Ignition, DISI: Direct Injection Spark Ignition, DICI: Direct Injection Compression Ignition FC: Fuel Cell) *Source- Own calculations and elaboration*

Major improvements to be considered are:

- The internal combustion engines exhibit important technical improvements with the potential to increase efficiency and reduce emissions with moderate extra costs. Several of these technologies are highlighted and among others include the application of engine test bed, optimised fuel injection and electronic systems, modern valve controlling and innovative gear drives (e.g. duplex clutch, continuous automatic gearbox, hydraulic impulse store);
- Further improvements include chassis suspension and brake technology, reduction of rolling resistance of tyres (e. g. innovative materials or optimised tyre profiles), improved

aerodynamics, light weight constructions (e.g. substitution of steel by plastics and carbon fibres, substitution of conventional headlights by light-emitting diodes), material from renewable raw materials and optimisation of the power train;

- Integration and use of advanced accessories such as tire pressure monitoring system (TPMS), gear shift indicators (GSI), navigation systems, radio based traffic monitoring and update systems are few other measures that will add to vehicle / system efficiency;
- Additional modification on ICE include the adaptation of motors to run on low or high blend biodiesel or bioethanol which offer a potential to reduce emissions while making few changes in the technology.

Major measures considered and their costs as well as their CO_2 reduction potential in 2010 are documented in Table 3.

Table 3. Major gradual efficiency improvements of conventional cars and corresponding costs and CO_2 reduction

Efficiency improvement	Invest. Costs	ΔFI-reduction	CO_2 reduction	
	ΔEUR/car	litre/100km	kg CO_2/car/year	g CO_2/km
ETA-1: Start-Stop automatics	500	0.35	98	8
ETA-2: Power assistant (Mild hybrid)	1500	0.64	179	15
ETA-3: Power split (Full hybrid)	1700	0.9	252	21
ETA-4: Improvement of conventional gasoline powertrain	700	0.64	179	15
ETA-5: Improvement of conventional diesel powertrain	400	0.38	120	10

4. Lessons learned from case studies

This chapter summarizes the major outcomes of WP 4 on “Evaluation of international case studies”. In this WP more than 130 recently implemented pilot projects for disseminating AF & AAMT with focus on European countries were collected and documented on the web page. About 80 of these case studies were evaluated in detail based on the work conducted in WP3. This evaluation was reported in Cebrat G., Ajanovic A., 2010.

4.1 Set-up of the action

The case studies were collected since the beginning of the project in 2008 and immediately after that documented on the ALTER-MOTIVE webpage. The focus was on completely new cases which has not yet been documented anywhere as well as on case studies already described within other projects like ELTIS. By the end of the project more than 130 show cases were presented on www.alter-motive.org. In the following we present some key results of this work.

Of interest is of course how these cases were distributed by technology, fuel and region and what was their success. If we look at titles within the cases collected, some terms occur more often than others, see Figure 41.

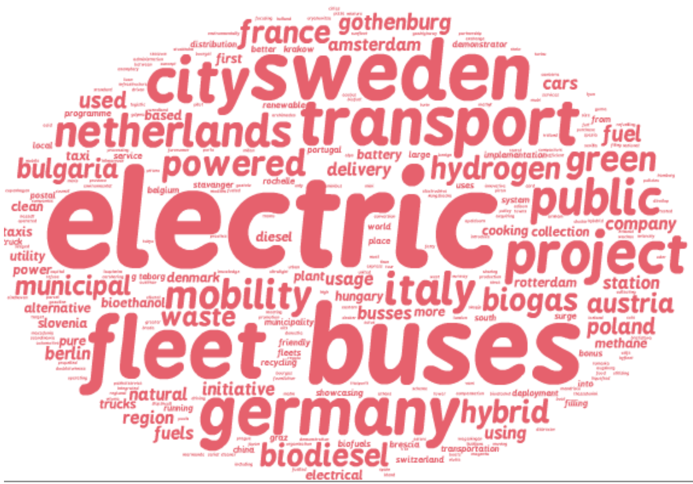


Figure 41. Word cloud of the case titles

Regarding geographical locations most prominent are cases in Sweden, Germany, The Netherlands and Italy. There are more cases in cities, e.g. fleets run by public entities, municipalities as Gothenburg, Amsterdam, Berlin, Rotterdam catch one's eye stepping out from the word cloud.

The term mentioned most often is “electric” having had a steep start in 2010 with a lot of new cases flowing in. But electric is also part of more integrative policies and included in hybrid-electric, so in the database CNG-cases precedes E-mobility 2:1. After electric, buses are mentioned second often. Biogas is catching up, being mentioned as often as hydrogen which has still some prominence as well as hybrid increasing in terms of cases, biodiesel is mentioned as well but in decline with regards to recent cases coming in.

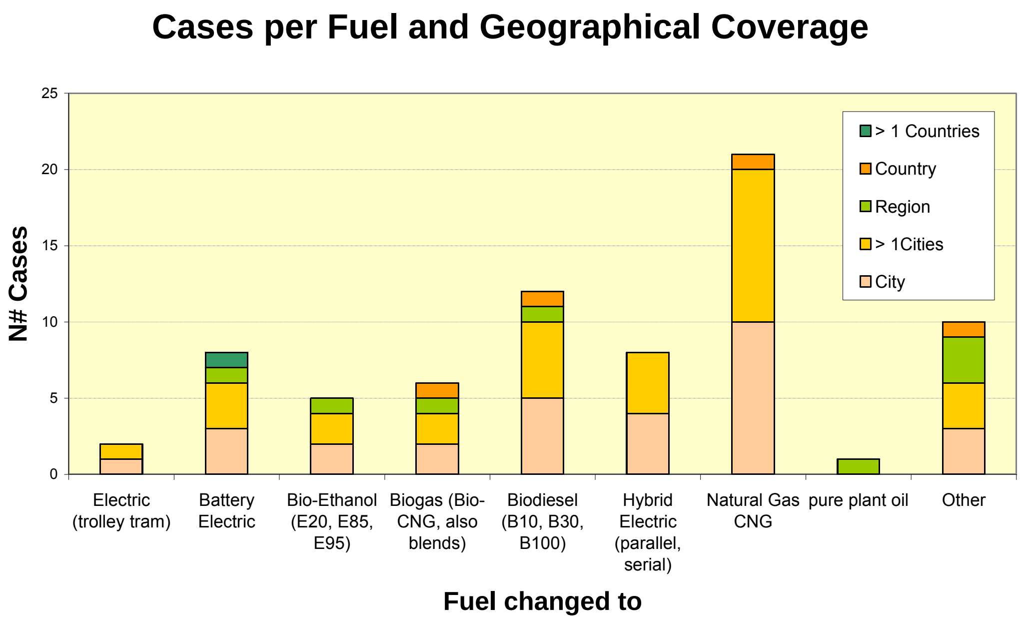


Figure 42. Distribution of collected cases per fuel and geographical area

Figure 42 documents a distribution of collected cases per fuel and geographical area. From the data collected it is clear that CNG is a very suitable and popular solution in urban areas.

The show cases presented in the database do not represent a valid statistic of fuel usage or vehicle conversions. There was active management in case production in order to avoid blind patches. Geographical coverage is not only depending on facts but also endeavour, and self esteem (is it worth showing my countries case?). This especially is true for electric trolley buses which are a perfect solution when going electric but are shut down in the old member states and seldom refurbished in new member states. So there only exist a few cases in the database showing new introduction of trolley buses.

We employed three tasks to acquire valid data:

- Case database
  - holding more than 130 cases (new and old revamped case descriptions) by the end of February 2011
- Stakeholder interviews delivering
  - 34 fleet case questionnaires
  - 8 policy case questionnaires
- Additional Internet survey
  - to validate forward looking conclusions some hypothesis' were put to the test including measures and their sequence.

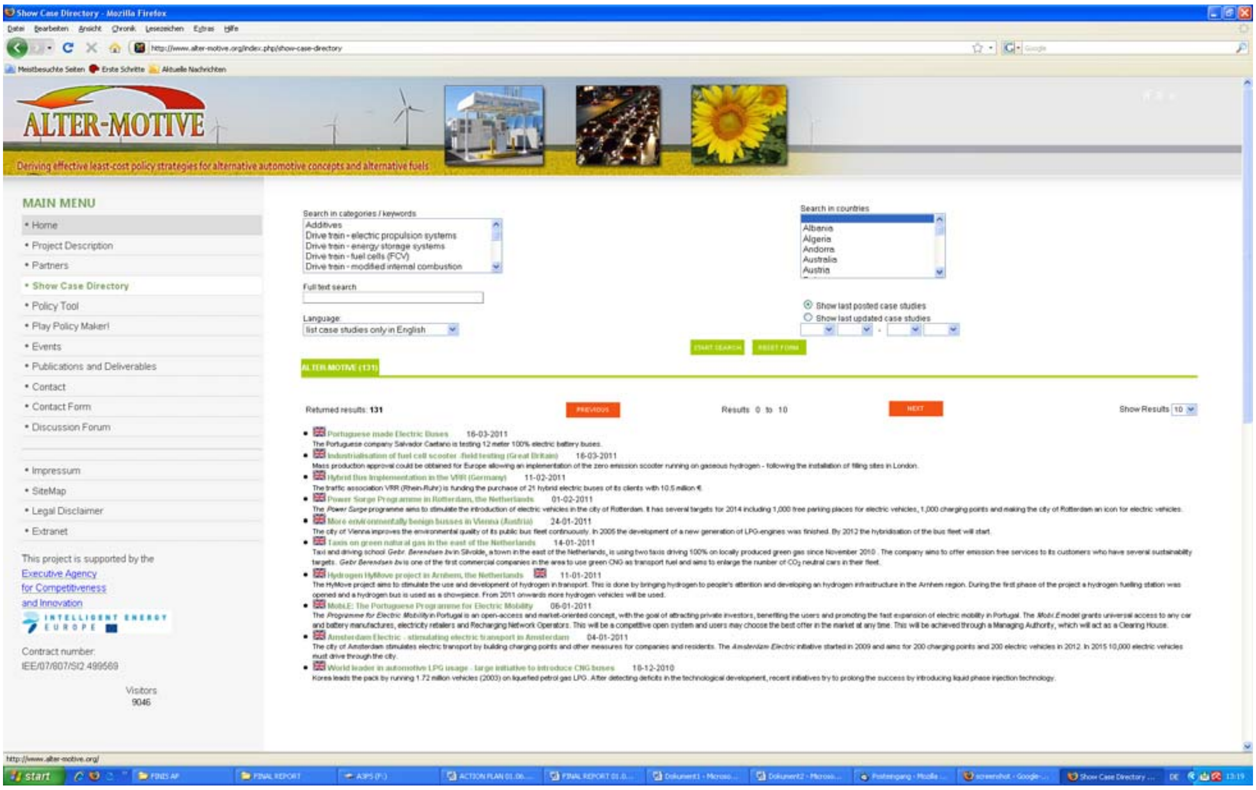


Figure 43. Screenshot of the case database at www.alter-motive.org

What may be learned when collecting cases is that the willingness to talk about a case is biggest after the start of the project. Some countries publish sparsely in English but partner could translate, anyhow Europe is lacking market-wide platforms generating alternative fuel visibility featuring demonstrators. Fuel specific platforms are just meeting the current hypes therefore are not suitable to cover all alternative fuels. Getting valuable information needs a skilled investigator who also may challenge the published results and add an external evaluation. Especially with the use of pure plant oil and also biodiesel it is sometimes delicate to praise the cases knowing that from a technical standpoint the risk is big and answered Emails from contacts of completed projects sometimes also revealed this that they had come to an halt. A mandatory evaluation scheme for demonstrators of all EU funded projects could contribute to a more transparent situation answering how many alternative fuel vehicles are at current part of the ordinary fleet. An independent ex-post evaluation of innovative projects may give valuable technology foresight info for European policy makers. It would also make sense to focus especially on member states policies since fiscal measures are in their hands, but it might be a delicate job to judge them.

4.2 Some cases worth mentioning

In the following we present some selected cases with some special features.

Biogas use in public transport buses in Lille (France)

The biogas station in Lille, France is serving 150 buses, replacing 4 million litre diesel. It shows an integrated approach including waste processing and following unknown terrain for regulating authorities.

Figure 44. Biogas filling station in Lille (France)

Electric vehicles in the Municipality of Reggio Emilia, Italy

There are many cases on E-Mobility in Italy, one are electric vehicles in the Municipality of Reggio Emilia. Apart from this case we see cost efficient lead acid batteries in buses in Rome, new serial hybrid bus concepts for buses in Brescia (micro-turbine), PEDELEC support in Modena and other like battery electric ships and mobile advertising in Como.

Figure 45. Examples Electric Mobility in Italy

It is of interest how Reggio Emilia (RE) solved the chicken and egg problem for electric mobility. The problem is that buyers demand for recharging stations and vice versa, ending in a deadlock. RE now had set up a regional initiative with the help of practitioners supported by a long tradition of BEV manufacturing by a SME (Microvett) converting conventional cargo vans to electric propulsion and offering them businesses. 250 rental vehicles are used by social services, firms, utilities and recently also private users.

Figure 46. Serial hybrid buss for a public transport in Brescia (Italy)

4.3 As special example: the Swedish policy case for E85

Looking at the findings of top-down measures namely policy initiatives we see a huge difference in alternative fuel penetration and try to explain this presenting the successful show case of FFV in Sweden. By planning a sound policy about 200.000 of approx. 4.4 million vehicles are able to run on E85. The general setting in Sweden, contributing to a bundle of alternative fuel projects, is depicted in the following figure.

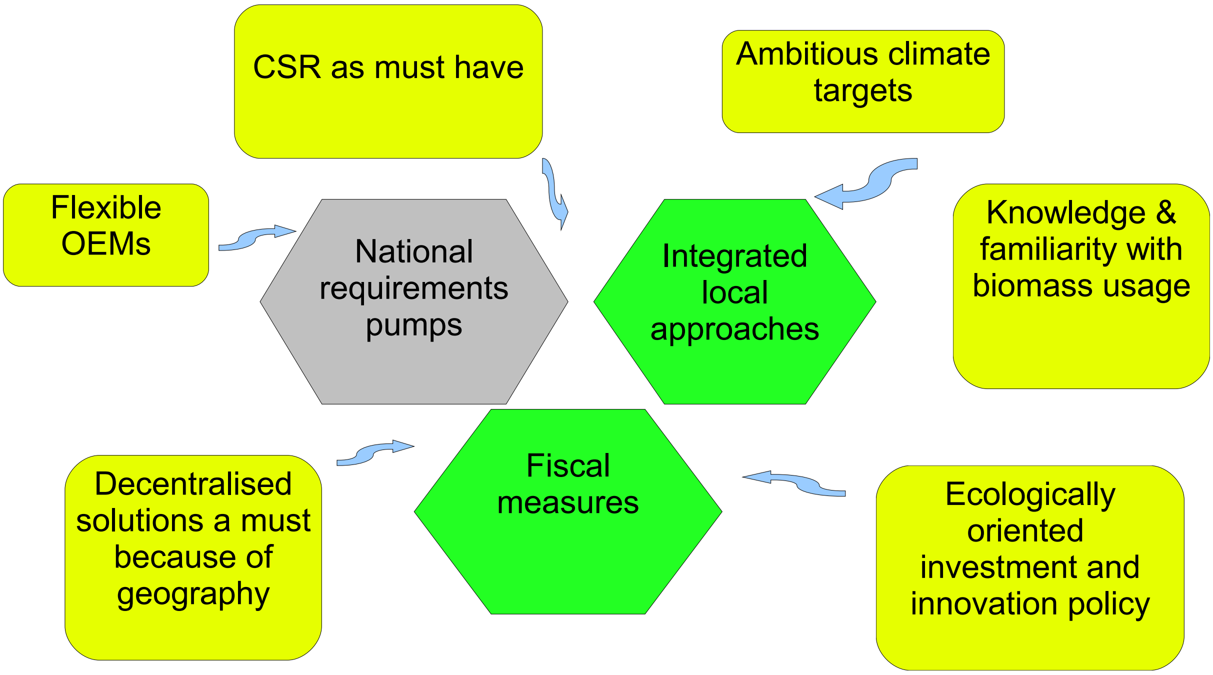


Figure 47. Successful integrated approach in Sweden

The measures causing the success include:

- Reduction of vehicle taxes for alternative fuels
- Exemption from congestion charging
- Reduced taxation company car usage

From the Swedish Model we may derive hints as

- Combine financial and other regulative sectoral approaches
- Unite all stakeholders.
- Adapt to obvious facts – cars are sponsored by employers

4.4 Findings

The major results of the analysis of questionnaires are: Fleet operators were asked about their motivation to start their projects (n=35). Bottom Up initiatives mostly mention local air quality, climate change but the measures were often imposed by city government, and public fleets had to follow. This sometimes explains why their own acceptance was lower than the acceptance of their users.

Acceptance is high for biogas, BEV, CNG and lower for PPO/SVO only. Looking at the choice of liquid biofuels offering a bigger range compared to gaseous fuels we compare: biodiesel and bioethanol. Besides, low blending - without being shown in the cases - proved to be successful for both fuels and now targets B7, E15. The use of pure biodiesel posed several problems like lack of suited engines, exhaust after-treatment, price binding to diesel, sustainability concerns. Ethanol is mostly present in Swedish case studies profiting from a bus and engine producer having a fully mature E95 solution. A FFV in the form of a range extended Volt/Ampera is in work and we will see if this will be a competitor for the hybrid electric Toyota Prius we see in taxis fleets and of course also in the case database. Hybrid solutions tend to avoid costly solutions with monovalent concepts. Asking for renewed effort in initiatives such featuring catenary electric bio-ethanol, biogas and hybrid electric claimed to have follow ups more often than others.

From the cases we also learn that focus on hybrids (like pedal electric vehicles) is definitely less risky but requires change of mobility patterns/behaviour if cars are traded for two wheelers. Focusing on PEDELECs allows for reaching a diffusion of up to ~8% (The Netherlands), The Modena Show Case features a successful city approach towards pedal electric bicycles.

Technology may follow society and shift from FFV into Bio-CNG because of sustainability issues. Waste as feedstock is better off and present also in some biogas and biodiesel show cases but supply is limited.

One point missed in the cases is the use of B30 as example for medium blends since compliant vehicles do exist. There is room for users acting on their own risk – Blend your own may be seen as forerunner in the USA.

2nd generation biofuel experience was not possible to show in the cases, electric mobility seems top offer more flexibility with regards to feedstock. Innovation in engines like direct injection methane and bio-diesel compatible exhaust after-treatment technology was also not explicitly mentioned, but we have some LNG cases and also hydrogen and methane blending.

The Internet survey after the interviews had been closed, delivers further hints for a practical policy approach. The following measures proved to be effective?

- Tax reductions – excise duties alternative fuels 64%
- Vehicle taxation 54%
- Access control 53%

Given a policy of empty pockets then we have

- Tax increase fossil fuels excise duties 58%
- Parking priority 42%
- Access control 42%

The best sequence of measures was determined as:

- Ensure technological maturity of propulsion technology
- Reduce propulsion demand
- Reduce mobility demand (lifestyle)
- 2nd generation biofuels

This introduces a new degree of freedom because reducing the energy demand as such reduces dependence on oil and the ability to substitute a higher share with biofuels at the same time.

From the results of WP4 we may derive fuel specific policy recommendations. The Internet Survey (n= 25) shows gaps/hurdles and tips on what to concentrate for each of the fuels:

- Biodiesel & Ethanol – sustainability
- Pure Plant Oil – maturity of propulsion technology
- (Bio) CNG – refilling facilities
- Battery Electric – charging infrastructure, (sustainability)
- Range Extended Battery Electric – technological maturity
- Catenary Electric - infrastructure
- Hydrogen – refuelling facilities & cost

In the end interviewees opted for a multi-fueled transport, even though 30% of the internet users answering would concentrate on electric mobility, but also 55% vote for a blend of fuels & propulsion systems. Lack of feedstock dictates inclusion of all alternative means in order to reach the share of renewable fuels. 53% say that a focused approach is best on a local level.

5. Lessons learned from analyses of past and current policies to facilitate the introduction of alternative fuels

A specific focus of the ALTER-MOTIVE project was the analyses of past and currently implemented government policies. These investigations were conducted in work package 5 “Evaluation of policy effectiveness” and are summarized in this chapter. It analyzes the potential and effectiveness of different policy measures to facilitate the introduction of sustainable fuels in the EU up to 2020 and beyond. Due to the variety of fuels, technical solutions as well as technical and market maturity, particular attention needs to be paid to their stimulation towards market introduction by means of policy support.

The aim of the study is to provide recommendations to policy makers about the potential policy solutions. The methodological approach takes into account the technological development status of each fuel/technology by applying the S-curve approach that defines the current technological development status and measured market penetration, see Figure 48. Our research is based on literature research and expert interviews and supplemented by insights from 40 alternative transport case studies during the course of the project. Policy effectiveness can also be influenced by other external factors such as specific location characteristics that have contributed to the success of the project. We have therefore also performed a thorough analysis of impact factors that have played a role in the projects, see ALTER-MOTIVE report: ‘Copy-Paste Policies. Analysis of transferability of successful policies related to alternative fuels and alternative automotive concepts in transport’ (Feenstra, 2010).

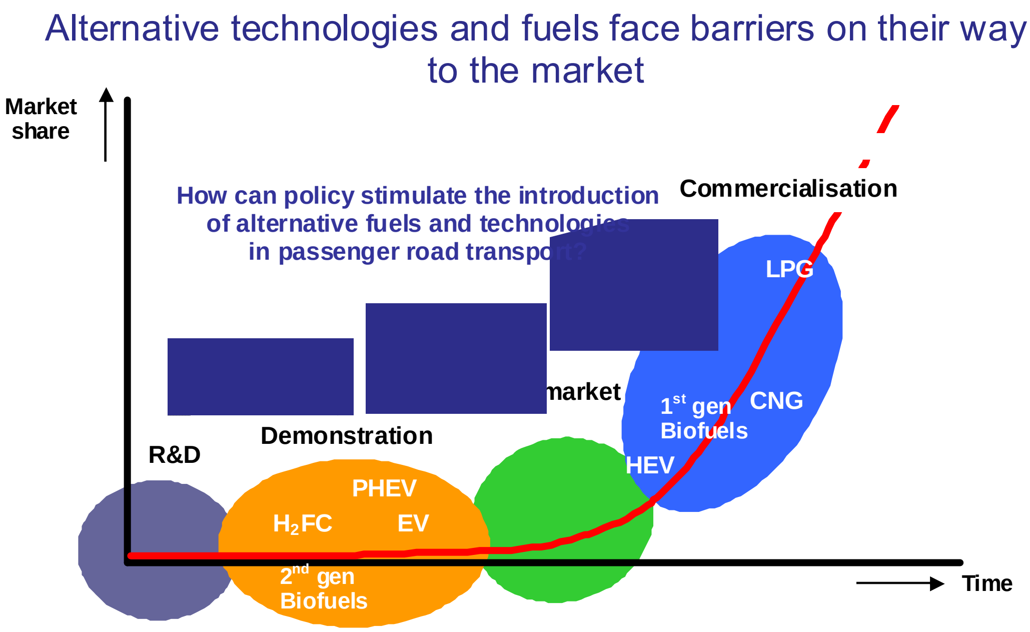


Figure 48. Market phases of various alternative fuels and alternative automotive powertrains (Source: Bunzeck at al, 2010)

5.1 General results

Through the analysis of the current technological status of the respective technology, specific barriers for each technology could be identified. Barriers (such as market readiness, cost or fuel supply) can be tackled and overcome through different policy measures. Basically, policies to facilitate the introduction of alternative fuels e.g. to overcome barriers can be divided into four categories named after their objective: Protection, Competition, Regulation and Obligation (see Figure 49). In each of the technological development phases, different policy measures exist that can help the specific technology overcome barriers that prevent their increased market penetration or to regulate the market towards a more environmental friendly technology. In reality, the policy measures cannot sharply be divided and will have an overlap between the phases. It is therefore of high importance to closely monitor developments and design policies in a way that they can respond to a new situation. Also, technical mature technologies are more prone to be stimulated by means of top-down (mostly generic) approaches such as vehicle taxation, while technologies in an early development stage can benefit from bottom-up (on national level) approaches such as local applications.

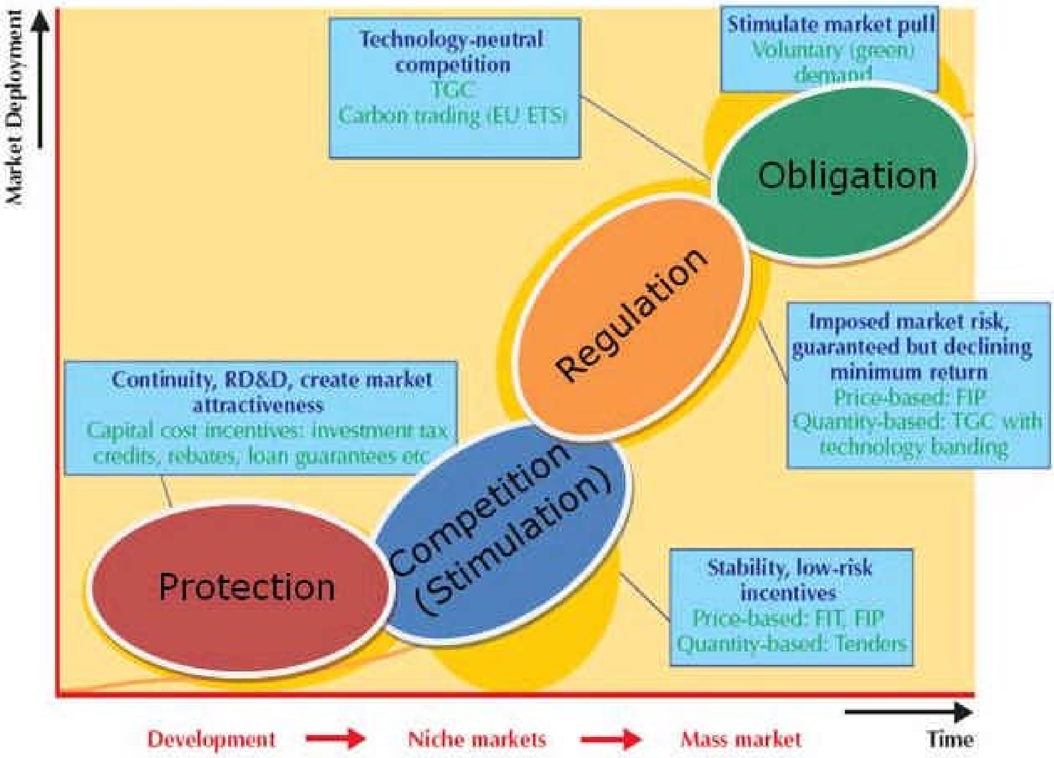


Figure 49. Policy objectives and measures along the technological development curve (IEA 2008a, adapted by ECN)

Measures that in their design are not specific towards any type of alternative fuel ('generic policy') can help to overcome barriers (e.g. high costs) that prevent alternative fuels to enter the market by themselves. In that sense, this type of policy provides a backdrop for measures that do target specific alternative fuels ('specific policy'). The aim of specific policy is to provide extra incentives that render these fuels so attractive that they can overcome their barriers and enter the market.

Specific/General policy

Specific policy can be successful in stimulating the uptake of alternative fuels. Biofuels, liquefied petroleum gas (LPG), compressed natural gas (CNG), and hybrid-electric vehicles HEVs have all been successfully stimulated by specific policy measures. Generally, the success of these measures is to a large extent dependent on whether the incentive they provide is sufficiently large enough to become economically competitive[8]. However, promoting alternative fuels is only worthwhile if there is sufficient perspective that the barriers that these policies tackle are solved permanently in the longer run. The costs and other implications of specific policy measures are typically acceptable in the short run and with relatively low market shares, but become infeasible to sustain in the longer run and/or with larger market shares. There are two situations in which the application of specific policy measures is justified: to 'kick-start' a market and to trigger learning-by-doing.

In the previous case, a combination of barriers exists that makes private actors hesitant to start commercial activities with respect to an alternative fuel. The chicken-and-egg dilemma is an excellent example for this. Specific policy measures may provide incentives for a first batch of consumers to switch to an alternative fuel and convince stakeholders that a viable market exists. After this first introduction, the policy measures should be gradually phased out. Note that this requires that the alternative fuel is in principle competitive with conventional fuels, e.g. have intrinsically lower cost or comparable to that conventional fuels (excluding taxation)[9].

In the latter case, cost reductions, technological improvements and information required to enter the early market phase (e.g. consumer behaviour) should be collected through learning-by-doing. Support for demonstration projects, but in some cases (e.g. HEVs) also support to create an early market, are warranted, since these measures offer the perspective that the cost and other aspects (e.g. move to sustainable fuel production) of the alternative fuel can become competitive with conventional fuels.

At any rate, policies need to adapt over time to changing conditions. Once measures aimed at creating an early market (primarily tax exemptions and subsidies) become successful, they will become very budget-intense and should be phased out. In case the alternative fuel has now reached competitiveness, the measures have to be adjusted to avoid overcompensation. In case the alternative fuel is not (yet) competitive, measures such as an obligation to supply (a certain

8 Note that economic competitiveness may differ between countries/regions and between technologies/fuels.

9 It is unclear to which extent this is the case for the alternative fuels that have been studied in this report. In general, even fuels that are not more expensive than conventional fuels (e.g. CNG, LPG) proved not competitive with conventional fuels after support measures were reduced.

percentage of sales) the alternative fuel could be introduced instead[10]. Following this procedure is in line with the approach that the S-curve framework suggests.

The S-curve approach also suggests that proceeding through the various innovation stages is a linear process. In practice, this is not always the case. EVs are a case in this respect. A major barrier for EVs is their limited driving range in combination with long charging times (compared with conventional refuelling). This can be solved in various ways, e.g. the development of batteries with higher specific capacities (through R&D), the development of battery exchange programmes (R&D/demonstration), the development of fast charging solutions (R&D/demonstration) or the willingness on the part of consumers to only use EVs for relatively short trips (demonstration/early market). Hence, even though a barrier may seem to require correction in a particular phase, it may be overcome by new solutions of developments in the next phase. Therefore, it makes sense in some cases to support an innovation moving into a next phase even before all barriers have been solved, provided there is a perspective that the barrier can be solved in the next phase. In the case of EVs, it makes sense to support R&D programmes, initiate demonstration projects and stimulate early (niche) markets, all at the same time. Another approach is to support business developments that can later more easily make use of market dynamics to tackle further barriers.

Next to being balanced over time, policy packages should be comprehensive in the sense that all major barriers relating to a particular technology need to be addressed. Not all of these barriers are equally important, however. LPG can be taken as example. In some countries, only an incentive that keeps the cost of LPG fuel low (e.g. a very low excise duty in the Netherlands) was in place. Nonetheless, this incentive has provided sufficient market perspective for entrepreneurs. Consequently, the development of infrastructure was triggered in the absence of dedicated policy support by market forces. It is therefore wise to only address the major barriers in each technology and leave solving the remaining barriers to the market.

However, it is not guaranteed that a policy measure that brings down the cost of LPG to the consumer will trigger a market for LPG. In many cases, the entrepreneurs have to undertake (risk) investments that enable the provision of the alternative fuel to consumers. The willingness of private parties to undertake these investments can be enhanced by the appropriate policy measures. The role of the government is to bring the relevant stakeholders[11] together and to develop a common vision on what is required to make the introduction of the alternative fuel a success. This includes common identification of major barriers and actions to be undertaken by all stakeholders involved to overcome these barriers. The result of this approach can be that only

[10] In the latter case, the costs of subsidizing the alternative fuel are shifted from the government budget to the consumers of the fuel (via the fuel providers).

[11] Typically, these will include stakeholders with an interest in the vehicle (car manufacturers, car dealers, car lease companies, maintenance companies) and stakeholders with an interest in the fuel (fuel producers, fuel distributors, fuel providers).

a subset of barriers is to be addressed by specific government policy measures[12]. Finally, some measures are clearly the most effective when applied at a certain policy level.

Table 4 provides an overview the role various levels of government could play in selected specific policy measures.

Table 4. Appropriate levels for implementation of specific policy measures[13]

European level	
Standardisation	Codes, regulation and technical standardisation should be designed for an application as broad as possible to ensure interoperability across borders. Preferably, these should be set at global level. If that is not feasible, they should be set at European level.
R&D	Supporting R&D at a European level allows for programmes that are large enough to tackle major barriers. Another role for the EU is to coordinate the various national R&D programmes.
Large-scale demonstration & rollout	Some technologies (such as fuel cell vehicles) require a (costly) rollout on a large scale. The EU level is therefore the most appropriate to coordinate the rollout of these technologies.
National level	
Fiscal measures	Although the discussion for more fiscal harmonisation is ongoing, fiscal systems are currently still defined at national level. Hence this is the most appropriate level for this type of policy measure.
Local/regional level	
Demonstration projects (execution)	The practical implementation of demonstration projects takes place at the local level. Demonstration projects are often introduced with accompanying measures as support.
Accompanying measures	Measures such as reduced parking tariffs and exemption of congestion charge are related to local circumstances. These measures may even help solve local issues such as air quality problems.

More than 40 case studies from alternative transport case studies have been analyzed with respect to their policy measures and successes. Most of the case studies took place on a city or regional level, only a few cases looked into the country wide deployment of new transport fuel or technology (mostly delivery companies that operate in a wider environment or maintenance companies). The technological focus of the cases is more into mature technologies such as CNG/LPG and biofuels, which have the highest number of case studies. The reason to focus on

[12] The approach suggested here is comparable to the approach called ‘network management’ (Kleindienst Muntwyler et al, 2010).

[13] The overview of policy measures in this table is not exhaustive, but only includes those policy measures that are more effective when applied at the level that is indicated in the table.

mature technologies is low upfront investment costs for the operators. In most cases, the alternative fuel was applied in the public bus fleet or other, municipality related fleet such as cleaning or waste collection.

Less mature technologies with currently low market penetration and little or no available infrastructure such as hydrogen fuel cells and electric vehicles are introduced via projects financed by the European Commission, due to their high upfront investments. One of the examples is the HyFleetCute project that deployed 47 hydrogen buses in 10 European cities to demonstrate their everyday feasibility. However, after the end of the project the technology could not be continued due to non-availability of vehicles.

5.2 Fiscal instruments related to conventional fuels

A large-scale introduction of alternative fuels and technologies requires an increase in their competitiveness. In the innovation process different kinds of activities (R&D, demonstration projects, mass production to enter early market phase) help to improve competitiveness. As pointed out in Chapter 5.1 these different activities require different forms of policy support. It is therefore important that policies are applied at the right moment in time.

In the early market phase, alternative fuels will enter direct competition with conventional fuels. In this phase, policy on alternative fuels aims to change the competitive playing field in the advantage of alternative fuels. The playing field is to a large extent defined by fiscal policy.

Fiscal policies, such as vehicle and fuel taxation are widely applied with today's conventional fuels, with the objective of increasing overall energy efficiency of the transport sector. Those policies can be either levied on the vehicle or the fuel. A recent case study on Scandinavian countries showed that one-time measures such as a vehicle purchase tax do have an influence on the car sales and the choice of the model. Further on, the calculation basis of annual vehicle taxes changed from being previously based on weight or cylinder volume of the engine towards a model that is based on the vehicle's CO_2 emissions. This method is seen as a more direct way to influence consumer car purchase decisions based on its emissions performance, but that depends on the cap put in place, i.e. whether it provides a benefit or imposes an additional penalty for the consumer.

All road transport fuels are taxed to a certain degree varying by the respective EU member country. Main objective of fuel taxation is for fiscal reasons, although some taxation schemes also entail environmental components. Most commonly used is a tax differentiation between gasoline and diesel that originally dates back from the time when diesel was widely used only by commercial vehicles. As the number of diesel vehicles grew, some countries have reversed the trend and set a higher fuel tax for diesel than for gasoline, see chapter 2. The level of fuel taxation can be differentiated to encourage the use of more sustainable alternatives to gasoline and diesel, e.g. biofuels.

Fuel prices vary greatly, especially between most European countries and the US, Australia and Canada, were they have been historically always lower than in Europe. Over the last decade however, fuel price levels have increased across the board but in total levels still Europe is leading in terms of overall price levels for fuels

A study commissioned by the Nordic Council of Ministers found out that higher fuel taxation, resulting in high fuel prices is a successful policy instrument that influences overall mileage driven and also partly the choice for a particular car model. [Nordic Council of Ministers 2008, Sprei 2009]. Car drivers remain price sensitive as high fuel prices have an immediate effect on the expenses.

Nevertheless, large improvement potential remains in the commercial vehicle sector with regard to taxation schemes that favour low CO_2 fuels. The higher energy yield of diesel comes together with higher non-CO_2 pollution such as particulate matter, thus external cost are higher per litre diesel than gasoline which should be reflected in the taxation levels.

A stricter limit compared to today's targets (EU: 130g/km CO_2 in 2015), e.g. <100g CO_2/km could trigger the shift to more energy efficient and environmentally friendly cars more rapidly. The case study also concludes that taxation on transport fuels influences the overall mileage driven per car and also the choice of the car itself during the car purchase process. Another type of fiscal measures can be applied to the use of the road infrastructure, e.g. by means of congestion charge. Currently, such charges are levied in London, Stockholm and Oslo. This instrument can be particularly effective in decreasing local pollution, but needs to be introduced in tandem with public transport improvements.

Levels of implementation for policy measures

Policies to reduce GHG emissions from road transport by means of alternative fuels and technologies can be implemented on several political levels, generally locally or regionally, through the national government, or through the European Union and their respective institutions. Regulations at EU-level, such as the emission limits of passenger cars, are gaining importance. Nevertheless, the member state level is still a prominent level in the introduction of alternative fuels with regard to policy support measures, as the EU is not supporting technologies beyond their innovation stage, further explained in the following. Also, interests and motives for the implementation of legislation and measures by institutions on the different levels differ quite substantially.

Local/regional level

The local transport policy maker will balance between environmental objectives (e.g. improving air quality, reduction of congestion) and regional industry objectives to facilitate innovation and create jobs. That's why usually demonstration projects are perfectly suited for local policy makers because they can already contribute to air quality improvements in confined spaces, while on the national level there is generally no significant impact yet. Also, it helps local industry to overcome initial barriers for deployment of the new technology and can support creation of new jobs. Yet, for technologies that are still in a very early phase it requires high upfront investments (e.g. in infrastructure or expensive vehicles) which usually cannot be afforded by local governments. Also, local policy makers need to be aware how a technology can grow further (beyond the local level) once it is tested and demonstrated on local level. It is important to have strategic plans ready early on, otherwise there is a high risk of stranded investments.

National level

National governments are concerned about CO_2 and other emissions (e.g. particulates) as well as solving security of supply, congestion and safety issues in the most cost-efficient way and preferably on short notice. As most cabinets try to achieve results within their elected period, this means that politicians will often favour the 'low-hanging' fruit, meaning the cheapest, but not necessarily best technological option in the long-run. Other options might promise a much higher abatement potential but face the obstacle that results will only become visible in later stages. Only cabinets that manage to achieve a consensus across the political spectrum can achieve long-lasting support for certain technologies. One example is the German feed-in-tariff for photovoltaic energy which has been often debated to be abolished, but it remains virtually untouchable even with cabinet changes. This stable horizon has provided a lot of investment security for industry and resulted in high growth rates.

High cost effectiveness can only be achieved with options that fit well into the current energy system as no substantial no upfront investments in retrofitting of vehicles and/or infrastructure investments are necessary, thereby favouring incremental innovation over disruptive ones.

European level

EU R&D policy for new technologies only covers the initial phases until the technology is ready to enter the early market, as mass-market support is not an objective of the EU. EU research policy focuses on the early stages of technological development and on medium to long-term benefits. Therefore, measures that aim to improve cost competitiveness and make a new technology attractive to the consumer are still widely a field of the national member states.

Once the technology is more mature and widely available, the EU can intervene through e.g. EU wide standards, such as the Fuel Quality Directive (FQD)[14] or the emission limits for passenger cars.

Key recommendations for policy support to introduce alternative fuels:

- Policy measures to support the introduction of an alternative fuel or technology need to be well-timed according to their current technological status. Therefore, the technology status should be carefully analysed before the introduction of measures. As sometimes the

[14] Directive 2009/30/EC.

technological development and learning curve move ahead fast, close technology monitoring and flexible policies are suited best. The biggest pitfall from a policy maker perspective can be tax exemptions without budget restrictions which become (very) expensive when the market share of the technology or fuel in case grows more rapidly as expected.

- Each of the fuels under consideration in ALTER-MOTIVE requires a tailor-made approach, but also different framework conditions in the EU member states need to be considered in the choice of the policy instruments. For example, due to the specific economic importance of car manufactures in Germany the development of more efficient cars such electric and fuel cell vehicles plays an important role in designing polices. On the other hand, due to a high share of agriculture in the Polish economy, biofuel developments are much more important.
- The key stakeholders involved in introducing a particular alternative fuel should develop a common vision. Policy measures should result from this common vision and offer enough perspective to the other stakeholders for a viable future market.
- Generic policies like CO_2 based fuel taxes are effective to achieve overarching goal of emission reductions, however the market will decide upon the cheapest technological option. This option does not necessarily entail the biggest carbon abatement potential in the long-term.
- Fiscal policies currently applied for conventional vehicles need to be distinguished between one time measures such as vehicle purchase tax (also called registration tax) and annually levied road taxes. Vehicle purchase taxes have proven to be influential on the magnitude of car sales and the choice by the consumer for a certain model. Annual taxation schemes based on vehicle's CO_2 emissions (and the car footprint, not weight) are seen as a more direct way of influencing consumer decisions. In this case, a limit needs to be defined for maximum allowed emissions level together with penalties that are imposed if the limit is exceeded. Favourable company car depreciation schemes do currently weaken the impact of purchase taxation schemes, therefore more personalized schemes targeting the behaviour of the individual motorist (e.g. incentivising reduction of kilometres driven per car through fuel taxation) are seen as a next step.
- Biofuels 1st gen.: Main barrier for the first generation of biofuels is cost and debate on environmental impact. The scope for cost reductions in the first-generation of biofuels is limited, so policy measures to increase the market share of biofuels are likely to be expensive. The basic choice is which stakeholder is going to bear these costs. When tax exemptions are applied, the costs are borne by the national government and eventually all tax payers. When an obligation is applied, the costs are born by the fuel providers and eventually all fuel consumers.
- Biofuels 2nd gen.: Their costs are currently too high to allow the development of an early market. Policy should for now focus on support for R&D and demonstration projects.

- LPG requires a significant fuel price discount over conventional fuels to be successful, but is only triggered when market players see a market perspective and act on that. Markets for LPG have been developed in the past without other support measures in place.
- CNG requires a significant fuel price discount over conventional fuels and a shared vision by the relevant market actors that a viable market for CNG can be developed. Since CNG is currently more popular in new vehicles than in conversions and because CNG infrastructure is relatively expensive (compared to LPG), measures aimed at direct support for vehicles and infrastructure development may be considered to accelerate early market development.
- Hybrid electric vehicles (HEV): Main barrier are high vehicle costs in comparison to conventional vehicles. Support measures that bring the costs of vehicles down are successful, especially measures that make the private use of company cars (lease) more attractive.
- Hydrogen: Main barriers are the initial cost of fuel cell vehicles (consumers) and high upfront investments in infrastructure (industry). The costs of vehicles can be brought down by (i) R&D and learning-by-doing in demonstration projects and (ii) reaping scale advantages of mass production. This requires support for R&D and demonstration projects on the one hand and direct support to bring down the costs of the first batches of vehicles on the other hand. Infrastructure investments can be triggered by implementing measures that offer a viable long-term perspective to fuel providers, but also by more direct measures such as investment subsidies and accelerated depreciation. Locally initiated hydrogen implementation projects (bottom-up) can provide first experiences with technology and grow out into corridors (links) to other hydrogen application centres. With limited availability of hydrogen passenger cars, public transport buses or niche applications such as materials handling can be a starting point.
- BEV: Main barriers are high initial vehicle cost (in particular for batteries) and limited driving ranges. Support should aim to lower cost through battery R&D and demonstration projects (learning by doing and volume effects). More experiences are needed regarding what coverage of charging infrastructure is really required (and will be utilized) by end-users. Consumer incentives are suitable to provide a financial relief to reduce initial high vehicle cost, either in form of tax incentives or a direct subsidy.
- Although providing incentives and other amenities for particular fuels & technologies is often regarded as ‘picking winners’ from which policy makers should refrain, the risks from choosing certain innovations are outweighed by the risk of not attaining climate policy targets at all.
- In order to achieve the GHG emission reduction target of -80% in 2050, the transport sector will need to contribute its share. Most emission reduction potential is expected to come from the de-carbonization of transport fuels (through electric vehicles and hydrogen fuel cells powered by energy from sustainable sources) which represents a big challenge for policy makers in the next decade. Therefore, framework conditions need to be shaped now in order

to prepare for a successful market introduction of those innovative transport technologies with high carbon abatement potential.

5.3 Analysis of policy transferability – introduction

Copying and pasting successful policies to other situations to promote alternative fuels and alternative fuel technologies in Europe can be advantageous. Policies based on the experience of others are in general more efficient and effective because time can be saved and the wheel does not need to be re-invented. At first sight it also looks simple to accomplish. However, when looking more in depth into the transferability of policies, we can conclude that transferring policies successfully is much more difficult than it seems.

Both literature and the data-analysis show that many factors influence the success of policies. This makes each policy unique. In order to transfer a successful policy to another situation in which it has the same effect requires that these factors are similar to the original situation. The 'uniqueness' of the situation must thus in some way be similar.

The factors influencing the success of policies are diverse. They include the type of fuels or fuel technologies that are targeted by the policy, the policy instruments the policy consists of and external factors (economic and financial, social and environmental, technical and cultural and demographic factors) which form the context. Investigating the transferability of a policy therefore includes the analysis of these different factors. We did so in the analysis of the data we collected via a questionnaire about existing successful policies to promote alternative fuel and alternative fuel technologies in Europe. These questionnaires were filled in by local and national policy makers, researchers and representatives of transport organizations and thus represent the opinions of these respondents. The outcomes of the questionnaires are summarized in Table 5. The conclusions based on these are further described below.

Table 5. Summary analysis of questionnaires

	All policies	Policies related to fuel distribution and sales	Policies related to vehicles	Policies related to users
Fuels (technologies) targeted by policies				
Most	Electric fuel technology	Bioethanol and biodiesel	Electric and hybrid fuel technologies	Electric vehicles and CNG
Least	Synthetic fuel and fuel cell	Fuel cells and hydrogen	Synthetic fuel and LNG	Hydrogen, synthetic fuels and fuel cells
Policy instruments used				
Most	Fiscal measures	Fiscal measures	Fiscal measures	Information dissemination and awareness raising
Least	Other assisting or voluntary measures	Other or voluntary measures	Other or voluntary measures	Legislative and regulatory
Influence of categories of external factors				
Most	Technical factors	Technical factors	Economic and financial factors	Social and environmental factors
Least	Cultural and demographic factors	Social and environmental factors	Cultural and demographical factors	Cultural and demographic factors
Influence of individual external factors				
Most	Emission reduction targets	Emission reduction targets	High price conventional fuels and emission reduction targets	Parking problems inner cities
Least	Good cooperation between investors	Parking problems inner cities and specific demographic conditions	Good cooperation between investors and debate between biofuels and food	Debate about safety of specific fuel
Potential for (complete or partial) policy transfer				
Total	80%	88%	66%	79%
Elements of policy transfer				
Complete policy	51%	63%	52%	33%
Most	Policy goals	Policy goals and policy instruments	Policy goals	Institutions involved
Least	Negative lessons	Administrative techniques	Negative lessons	Administrative techniques and negative lessons

5.4 Summary and conclusions of the overall analysis

113 successful policies spread over Europe and different policy levels (local, regional and national) named by the respondents are analysed. The most important outcomes are:

- Related to the fuel or fuel technology targeted by the policies

  - Most of successful policies target more than one alternative fuel or fuel technology.

  - Most successful policies target electric and/or hybrid vehicles and/or biodiesel as a fuel.

  - Policies targeting only one fuel or fuel technology are most successful when targeting electric vehicles or biodiesel as a fuel. No successful policies targeting only synthetic fuels, hydrogen or LPG are mentioned by the respondents.

- Related to policy instruments

- Both policies based on a single policy instrument as policies based on a combination of different policy instrument can be successful.

- Most successful policies include fiscal measures, followed by legislative and regulatory measures and measures to stimulate research and technology development.

- Related to the external factors

  - External factors can be categorised in economic and financial factors; social and environmental factors; technical factors and cultural and demographic factors.

  - The four categories of factors influence the success of the policies relatively equally.

  - Large differences exist in the impact of individual factors.

  - Influencing the success of more than 50% of the policies are *existing emission reduction targets* and *high prices of conventional fuels*.

- Related to transferability

  - Most of the policies can be transferred to another situation (geographic location, other policy level or other fuel (technology).

  - In half of the cases the whole policy measure can be transferred.

  - When only parts of the policy can be transferred, these are mainly the policy goals and the institutions involved.

From this overall analysis we can conclude that successful policies to promote alternative fuels and fuel technology mostly target different fuels or fuel technologies and consist of one or more different policy instruments. There are many different external factors playing a role in the different policies. To transfer these policies successfully to another situation, the external factors influencing the policy should be similar to the initial situation. Apart from existing emission reduction targets and high prices of conventional fuels, no other factor is influencing more than 50% of the policies. This shows the uniqueness of the set of factors influencing policies and the need for thorough investigation of the external factors influencing each individual policy before starting the transfer of it.

Additionally the data show that although the majority of the policies might be transferred, often not the complete policy but only elements of it can be transferred. When investigating the possibilities of transfer of a specific policy, attention must thus also be given on what elements of the policy can be transferred.

Recommendations for policy makers – policy transfer

Many successful policies to promote alternative fuels and fuel technologies exist in the EU on different policy levels. These are an important resource in the development of new policies. On first sight, the easiest way to make use of existing policies is to copy and apply them in another situation. This transfer of policies is an efficient way to create new policies because experiences from others can be incorporated, shortcomings can be improved and time for reinventing the wheel is saved.

Many factors influence the success of policies. In order to transfer a successful policy to another situation (another geographical location or other fuel (technology)) in which it has the same effect requires that these factors are similar to the original situation. The factors influencing the success of policies are diverse. They include the type of fuels or fuel technologies that are targeted by the policy, the policy instruments the policy consists of and external factors (economic and financial, social and environmental, technical and cultural and demographic factors) which form the context.

Investigating the transferability of a policy therefore includes the analysis of these different factors. This can be done via the following four step approach developed in this study to support policy makers in the development of new or improved policies that are based on existing policies.

1. A first step is to define the aim of the new policy, the impact that it should have, e.g. have citizens buy more electric cars, or sell more biofuels.
2. A second step is to investigate what policies currently exist in other situations (other countries, or other technologies) that are / have been successful in reaching similar aims. This can be done by investigating the 'successfulness' of policies in terms of effectiveness and efficiency of reaching the objectives. Only policies that fulfill these two requirements sufficiently are eligible for transfer.
3. Once one or more policies eligible for transfer are found, a third step is to investigate in detail the elements that influence the success of these existing policies. A combination of elements influences the success of each policy. This combination of elements is unique in every case and consists of:
    - The *external factors* that cannot be influenced (easily) by the policy maker. These include financial and economic factors, social and environmental factors, technical factors and cultural and demographic factors.
    - The *characteristics of the policy* that can be influenced and changed by policy makers. These include the objectives, the fuels or fuel technologies targeted and the policy instruments it consists of.

    The external factors should be investigated first. Only when these are similar to those in your own situation, the chances for successful policy transfer increase. When these are not similar, little chances for successful transfer exist and we recommend to look for other policies with more similar external factors.

When the external factors are similar to your own situation you can continue with investigating the characteristics of the existing policy. These characteristics are the base for your new policy.

4. In the fourth step you can design your new policy based on the characteristics of the existing policy which is eligible for successful transfer based on the previous steps. This design should be based on a detailed investigation of what elements of the existing policy can be transferred (whole policy or only the policy goals, structure and content, instrument, administrative techniques, institutions involved, ideas, attitudes and concepts, etc). The parts that cannot be transferred should be replaced by others.

6. Feedback from stakeholders

The following text presents a summary of the results from nine national workshops organised in the framework of the ALTER-MOTIVE project in nine countries which were represented in the project Consortium: Austria, France, Germany, Greece, Italy, Poland, Portugal, Sweden and The Netherlands.

On the basis of the discussions during the workshops and feedback provided by the participants in the questionnaires distributed among the participating stakeholders, an attempt is made to address the following questions:

- What are the major recommendations that can be formulated on the basis of the national workshops?
- What can be recommended or concluded with respect to country specific aspects learned from the workshops?
- What can be recommended or concluded with respect to acceptance of biofuels?
- What can be recommended for potential initiators or investors in the field of biofuels?

First, a short introduction to the action undertaken in the scope of WP7 is given (Section 6.1). It is followed by short summaries of the particular workshops (Section 6.2), which is done with the aim to provide a background for giving answers to the above questions, which is done in Sections 6.3 – 6.6. It should be noted, however, that the presented summaries of the answers to the above questions are based on the whole detailed reports that can be found on the ALTER-MOTIVE webpage, rather than on the short summaries presented below. Finally, the results of the survey of stakeholders' opinions performed by means of a questionnaire distributed among the workshops' participants are presented in Section 6.7. This is followed by a short overall summary.

6.1 The action

The topics of the National Workshops were adjusted to the focal interest regarding the subject of the ALTER-MOTIVE project in the particular countries. In Poland, and also largely in Greece, those were concentrated on the perspectives and concerns of the agricultural sector - providers of the plant material for biofuels. On the other side, in Germany and Austria the focus was on the technological and financial issues, while in Sweden and The Netherlands on policy-making.

The topics overlapped to a large extent in all workshops, so that a common set of conclusions and recommendations could be outlined. Deriving a common denominator for the summary conclusions was helpfully supported by the answers to the questions asked in the questionnaires given by the interviewed participants of the workshops.

One should note, however, that the composition of the stakeholder groups differed from country-to-country as explained below. This stakeholder bias has been reflected in the responses given, but finally it turned out to be an advantage as it helped to cover a wide spectrum of opinions.

The titles of the workshops are listed below:

- Deriving effective least-cost policy strategies for alternative automotive concepts and alternative fuels - Electro-Mobility or Biofuels? (AUSTRIA)
- Deriving effective least-cost policy strategies for alternative automotive concepts and alternative fuels (FRANCE)
- CO_2 reduction potentials of alternative fuels and passenger car technologies until 2020-2030 - The role of transport, energy and R&D policies (GERMANY)
- Alternative fuels for green transportation (GREECE)
- Alternative fuels and vehicles: different aspects on current and future policy instruments (ITALY)
- What should be done to boost the biofuel market in Poland? (POLAND)
- Deriving effective least-cost policy strategies for alternative automotive concepts and fuels (PORTUGAL)
- Alternative fuels and vehicles: different aspects on current and future policy instruments (SWEDEN)
- Deriving effective least-cost policy strategies for alternative automotive concepts and fuels (The NETHERLANDS)

Table 6 gives some technical information about the workshops, including the date, venue, the number of participants and the organizing institution.

Table 6. National Workshops

Country	Location	Number of participants	Organising institution
Austria	Vienna	52	EEG
France	Bron	50	RAEE
Germany	Berlin	33	IREES
Greece	Anthousa	71	CRES
Italy	Milano	42	ECU
Poland	Poswietne	82	KISE
Portugal	Lisbon	63	CEEETA-ECO
Sweden	Uddevalla	25	CHALMERS
The Netherlands	Den Haag	28	ECN

In the next section a short description of each workshop is presented together with a short summary of the discussions. The full reports can be found on the ALTER-MOTIVE web page www.alter-motive.org.

6.2 Short presentation of the national workshops

In this section short summaries of the particular workshops are presented. The aim is to provide an insight in the main recommendations and conclusions that are finally integrated to answer the questions listed above. This is done in Sections (6.2-6.6) below.

Austria

The spectrum of stakeholders included policy makers, municipal officers, consultants, researchers and academics, representatives of energy companies, financial institutions, vehicle technology providers and other interest associations.

The workshop was largely focused on E-mobility and biofuels. The issues addressed included a critical review of the state of art, recent and planned policy developments, action plan for an EU strategy towards a sustainable transport, coordination/harmonization of the support systems, specific national requirements and policy integration.

In summary:

- There was an intensive discussion between advocates of E-mobility and those of biofuels. Each group was pointing out the disadvantages of the other technology. In this discussion the final agreement was reached that fuels should be taxed due to their WTW-emissions;
- Another major conclusion was that there is actually no need for public support to investment in the infrastructure. It is preferable to extend the idea of model regions for E-Mobility as well as for biogas and hydrogen-fuelled vehicles. Moreover, there should rather be an agreement of the industry and the (local) policy makers to provide a minimum reliable infrastructure at park&ride, airports and other crucial locations.

In wake of the discussion during the workshop several recommendations for policy makers were formulated:

- Regarding infrastructure for E-mobility: no financial public support is justified.
- Lessons for eco-driving should be mandatory
- The requests to the automobile industry should be stronger
- R&D as well as financial promotion should be technology neutral; e.g. there should not be excise tax exemptions for low carbon fuels but the tax should be CO_2 based considering the whole WTW chain
- Regarding biofuels the ecological performance should be proved by certification
- Regarding emission-free zones: zones for low-emission-vehicles with a specific maximum emissions should rather be introduced
- Biofuels use for other transport segments than passenger cars should be recommended

France

The participants included mostly representatives of municipalities (public organisations), researchers and consultants.

The issues addressed included:

A critical review of the state of the art, recent and planned policy developments, specific national requirements, policy integration and common projects between scientists and fleet owners.

The main overall conclusion was that scientists and fleet owners both need to work together to develop new solutions.

Germany

The spectrum of stakeholders was very vast: the participants included national level policy makers, applied research institutes in the area of biomass and biofuels, transport economics and policy, energy economics and policy, alternative fuel technologies, original equipment manufacturers (OEM) including R&D divisions, the biofuel and car manufacturers associations as well as energy agencies from the *Länder* and at national level umbrella organizations such as the National organization for hydrogen including the E-mobility model-regions programme.

A number of important messages were highlighted, in particular:

- Different production approaches to biofuels are in an R&D stage, but nobody can assure today which is the most convenient approach to reduce CO_2 emissions.
- The biomass potential in Europe is limited. Therefore, the various uses of biomass in competition should be considered.
- Biofuels should play a determined role for passenger cars. However, in the medium and long run the uses will be extended to other types of transport modes (trucks, buses, LDV, airplanes)
- Sustainability should be included in the criteria catalogue of biofuels at all costs. For calculating the CO_2 balance the complete production process must be considered.
- Based on high investments of new plants the production technology will be inserted in production technologies of existing plants.
- Partial battle between the chemical industry and biofuel industry for alcohols because they can be used in production of both branches. The input of resources is quote-driven. This argument is, however, difficult to be measured in real markets.
- E.g. KIT conducts the so-called pyrolysis pilot plant (bioliq) since 2008. In 2015 Bioliq will be brought into the market. Other approaches experiment with H_2 production by algae or with

carbon algae recycling systems. No synthetic biofuel will be brought onto market before 2020. Biodiesel production in Germany will double within the next ten years.

- The abatement costs of biofuels are comparatively high.
- The build-up of a necessary infrastructure is most important for the market success of alternative fuels.

The major conclusions, which were not disputed, were:

- Various solutions are required, because it is difficult to assess today what is the most convenient approach for Germany;
- Of highest priority are improvements of technical efficiency: for gasoline and diesel cars,
- ICE and hybrid as well as for fuel cell cars (FCC), battery electric vehicles (BEV). Here special focus must be put on batteries, however, in combination with H_2 and FC efforts as it is happening in Germany. These technologies are complementary to each other and not substituting;
- Incentives provided should not be technology-specific but should rather be based on CO_2 emission reduction;
- Valid rules and standards must be defined;
- For BEV and FCC specific model regions to learn also which business cases are feasible are of high relevance;
- With respect to BEV there was rather broad scepticism that infrastructure should be pre-financed by the public;
- As general principles for future technologies it was agreed to think what has to be put on the way before 2020 so that it works by 2030;
- With respect to biofuels 1st generation the potentials up to 2020 are limited to about twice the amount of today;
- Moreover, it should be proven carefully whether the use of biofuels in other transport sectors than passenger cars could make more sense;
- Regarding recommendations for policies in the EU: It should be considered that not all technologies and fuel types are relevant to the same extent in all countries;
- An integrated treatment of alternative fuels is necessary. There must be an interaction of biofuel itself, necessary infrastructure, user groups, stakeholders and technology (common coordination of stakeholders and research programmes). Thereby, the costs of technology should be considered;

- European and national research programmes should be harmonised. This will also lead to a diversity in policy priorities. In some countries, like Poland biofuels might be of high priority, in other countries like for example Germany the focus is also put on fuel cell cars and hydrogen as well as electric vehicles and batteries due to the nature of the industries.

The panel discussion has led to formulation of a list of important recommendations to Action Plan:

- The Action Plan should recommend actions in the next decade that will have influence for the decade from 2020 until 2030.
- This involves further on Hydrogen and Fuel Cells

Also recommendations that are not technology dependent, but more general:

- The lack of stronger know how about Hydrogen and FCs is observed and should be brought in the action plan
- Some of the measures are irrelevant such as Eco-Driving or Car-Sharing. Further studies are needed to determine their contribution to CO_2 emissions reduction.
- Infrastructure issues should be brought in stronger such as for Hydrogen and Electricity and the issue of subsidies for it.
- Integrated approach taking into account society, technology and policy
- The portfolio from AF and AAMTs could be extended also to buses.
- Stronger network between EU and National Project in order to avoid repetition of research studies.

<u>Greece</u>

The spectrum of stakeholders was very wide. It included energy companies, fuel producers and fuel distributors, academia, research and development people, policy makers, interested associations and interested individuals, as well as representatives of fleet operators and non-governmental organizations.

The discussions were focused on how biomass and biofuels will be dealt in the new Energy Policy and Planning of the country, in order to rejuvenate the poorly structured Agricultural sector and help towards regional development, now that the country is facing a financial recession. Big interest was shown for the best suited biofuels and biofuel technologies to be used in marine transportation (small or bigger fishing vessels, yachts, ferries, etc.) and relevant people to address (fishermen, cooperatives of fishermen, transporting companies, etc) in Greece that marine transportation, especially in the high tourist period but also year around is quite crucial for the islands.

The change towards diesel consumption was argued by the participants because diesel engines have advanced emission standards, higher performance efficiency, lower consumption and lower CO_2 emissions; but it was pointed out that diesel quality has to be improved. The higher diesel consumption would then facilitate the higher consumption of biodiesel that is produced since 2006 in the country by small to medium size biodiesel plants. It was vividly discussed here that the higher biofuels production/consumption would give motives to farmers to shift towards the cultivation of energy crops in substitution of the crops that will be released from agriculture in the frame of the reformed CAP. It was agreed by the audience that that would rejuvenate the Greek agriculture in these difficult recession period.

Italy

A wide range of stakeholders within the area of alternative fuels and car makers took part in the participants of the workshop were representing energy companies, academia, fuel producers/distributors, interest associations within fuels and fleets stakeholders, local and regional policy makers, municipality representatives, as well as other research and development partners.

The following findings and observations should be highlighted:

- One of the main obstacles to the diffusion of alternative vehicles diffusion and use is that the administrative levels of decision-making are sometimes in conflict. City, province, regional, national and European levels all are in charge of sustainable transport issues. For example EU set the environmental standards for fuels and car performance, national governments decide about the fiscal policy, the regional and province levels promote local policies but, the city authorities have the right to promote and fix some policies that are not necessarily consistent with the higher levels.
- A general consensus has been found over the need to develop second generation biofuels that will overcome the dispute on the food versus fuels prices impact.
- Italy has a significant biofuels production but the diffusion of alternative vehicles has been historically driven towards gas fuelled vehicles. In fact, the gas vehicles fleet is one of the biggest in the world. This is not consistent with a technology policy that should invest more on biofuels technology. The major problem raised was the lack of consistency between technology improvements, fiscal policies, sustainable transport actions. It seems that the decentralised administrative powers do not fit the dimension of the problem that overcomes even the national dimension and needs translational decisions.
- A major consensus was found about the need to have clear long term policies. For a long time Italy has experienced inconsistent short term policies that were driving nowhere.

- The debate around the need to rise fuel taxes did not find a wide consensus. In Italy the majority of transports are on road. This means that rising taxes on fuels will have inflationary effects on a depressed economy. Being one of the countries with the highest tax rate on final fuel prices, Italy has not registered any reduction in car usage. On the contrary, in periods when fuel prices decreased, a further increase in car use was observed.
- Car scrappage system was revealing some distortions in the car markets, not even suitable for car companies. The argument concerning new cars, that they are less fuel consuming, is disputable because although new cars pollute less they are driven longer distances per year. It was suggested that the only environmental driven car scrappage policy adopted should be that bonuses are paid to people who do not buy new cars after scrapping the old ones.
- Local, time to time policy measures risk to be dispersive.

As a result of the debate the following recommendations for policy makers were formulated:

- Resources and efforts should be concentrated on some technologies that proved to have positive perspectives.
- Ministry of Environment should monitor and coach local initiatives (building up a national database) to avoid dispersion of resources, and support in consistent way the overall efforts.
- Administrative framework and specific rules must facilitate the new alternative fuels and vehicles. They must be clear, viable and sustainable for all actors involved. This has to be true at all administrative levels: local, regional, national according to the EU directives.
- Rising taxes on fuels is not seen as a sustainable fiscal policy: the whole energy fiscal policy should comply with environmental constrains instead to be the easiest and fastest option to collect resources to cover the budget deficit.
- Italy has one of the highest numbers of fuel stations per squared kilometre. This leads to higher costs, if we add also the fact that most of such stations have not exclusive self-service infrastructures. To modernize such distribution infrastructures, pushing people to shift to self servicing could be the occasion to propose multi-fuel stations to make alternative fuels a more acceptable option.

Poland

The profile of participants was rather homogenous as they represented the main stakeholder group in Poland, which are farmers and the consulting companies and advisory institutions (national or regional) offering ago-technical and market assistance to farmers. The farmers and those institutions are interested in the development of Polish biofuel market, from the point of view of the potential source of the additional income for farmers, by broadening their product spectrum. The remaining group of participants were researchers, consultants and the interested NGOs. Notably high ranking national politicians also took part in the workshop.

From the presentations and interventions of the politicians and the discussion that followed, it became apparent, that there is still an ample room for changes towards the final shape of the policies concerning the promotion of biofuels in Poland. The general observation was that the promotion of biofuels is not sufficient and more stable policies would be needed. It was emphasized that for Poland where electricity is produce in over 90% from coal the electric vehicles will not lead to the expected CO_2 emission reduction. Therefore, to achieve that goal in the transport sector Poland must rely on biofuels. However, it was also noted that measures reducing the demand for private car mobility and measures in support of public transport and modal change towards rail transport are very important.

Considering the rather high temperature of the debate it was difficult to adopt common recommendations, especially that the expectations of the farmers' lobby diverged in some points with the realistic possibilities of the national government. However, there was no opposition on part of the farmers and their representatives to the main ideas and plans outlined by a government representative, notably:

- The new amendments should be designed in such a way that they would promote and support the domestic origin of bio-components.
- The public support to bio-components imported to Poland, which has been given a support in the country of origin (where it was produced) seriously decreases the competitive position for the domestic actors. This issue should be properly addressed.
- The changes should promote the development of the domestic market of the bio-components. This statement was received by the participants with great satisfaction, because it would mean that Polish farmers may benefit from the changes.

The proposed regulations concerning the support for environmental actions should include:

- Rules to allow for a flat-rate support for the purchase of new vehicles adapted to use biofuels (such as E-85 and B-100) on the condition of scrapping the old vehicle using fossil fuel
- Provisions empowering the owners of vehicles adapted to use biofuels (such as E-85 and B-100) free parking in the so-called "ecological zones" and proper labelling of those vehicles.

Portugal

The participants were mainly representing municipalities, fleet companies and universities. However, many other sectors were also represented at the workshop: fleet operators, fuel distributors and fuel producers, local energy agencies, media, NGOs, policy makers, vehicle dealers and vehicle (technology) providers.

Presentations from municipality representatives and local transport companies showed that local policy makers are moving towards a more sustainable transport policy implementing several measures to reduce individual motorized transport and promote alternative mobility. However, these measures are not always integrated through a coherent plan which would reduce their effectiveness.

Some recommendations were made for EU and national policy makers.

At the EU level:

- Coordination is needed of national EV plans in order to implement EU wide technological solutions instead of the national ones.
- More careful management is required of environmental standards which could lead to the abolition of current implementations regarding AF&AAMT.

At the national level:

- Coordination of national plans with local plans is needed.
- More careful implementation of the new EV programmes is desired to avoid the abolition of previous energy efficiency measures.

At the local level:

More coordination regarding mobility measures is needed. Otherwise some of them could be implemented only partly or be in conflict with other. Fleet owners (including municipal fleets) are very cautious with AF&AAMT. This is due on one hand, to the high capital cost and, in some cases, O&M costs they have to bear and, on the other hand, to the lack of reliability they had to face sometimes. Consequently, they are not ready to embark on new experiments with different technologies or fuels.

Regarding the recommendations and future developments, the wide range of stakeholders represented at the workshop did not allow for the emergence of a consensual statement, since the particular stakeholder groups had diverging opinions on some issues.

<u>Sweden</u>

The participants covered a wide spectrum of stakeholders: R&D, policy makers, fuel producers and distributor, fleet operators, energy companies, vehicle producers.

The following points were taken from the Swedish regarding future policy instruments. All participants agreed on that future policy instruments should

- be as technology neutral as possible.
- be stable over long-term time horizons (difficult to get investors if rules are changing).
- steer towards energy efficiency no matter fuel and technology (e.g., continue to strengthen the EU emission policy on maximum gram CO_2 per km).

The recommendations were divided into two tracks where one was focusing on that we cannot wait for the very best solution but need to make radical changes now. That the society should have the courage to take a decision and stand by it even if it later turns out to be a second best solution. Future policy instruments should then

- be very clear with the goal.
- stimulate a quick phase out of old cars (e.g., introduce a scrapping premium, take away current policy that cars older than 20 years are exempted from annual circulation tax).
- create niche markets (e.g., purchasing requirements for authorities).
- stimulate radical different innovations. Technologies that have the potential of replacing the entire use of gasoline and diesel.

The other track was more focusing on doing the changes as thoughtful as possible. Future policy instruments should then

- be transparent and progressive (easy to adjust).
- be as compatible as possible with other EU member states.
- be carefully tested in models before implemented (to avoid unwanted side effects).
- less focusing on specific new technologies. We have no idea what has not yet been invented.
- focusing on what we don't want in society (e.g., introduce a much higher cost on fossil fuels) and use the revenues to stimulate a broad range of innovations.
- encouraging a change towards lower transport demand or less amount of vehicles (e.g., allow longer vehicles in road freight sector, steer towards more compact cities, improved public transport systems, car pools etc.).
- avoid dictating an increased use of biofuels.

<u>The Netherlands</u>

The participants were representing mainly the research institution and policy makers. Other represented stakeholders groups were a fuel producer, a fuel distributor and a municipal officer, consultant.

The workshop focused on effective policy instruments for the introduction of alternative fuels and automotive technologies. The aim was to discuss the findings from the policy analysis and the recommendations of the Action Plan with the national stakeholders.

The issues addressed covered:

- Recent and planned policy developments
- Action plan for an EU strategy towards a sustainable transport

- Coordination/harmonisation of the support systems
- Specific national requirements
- Policy integration
- Consumer behaviour

The participants concluded that targets for emission reduction and accelerated introduction of alternative fuels until 2020 are important, but the much bigger challenge will be towards the 2050 targets for emissions reduction. Many measures need to be implemented now in order to be effective in the long-term. Additionally, it can be noted that on the regional level, demonstration activities are going on that can be seen as bottom-up initiatives and could be helpful in the introduction of new transport technologies. In the future, more regulations will be probably be implemented on EU level such as the Directive on passenger car emissions. The participants mentioned that the participation of the EU commission in the workshop would have been welcomed.

Recommendations for policy makers.

The following recommendations have been taken during the panel debate on the Action Plan:

- The overall number of measures should be decreased;
- It should be determined which measures are particularly important for 2050;
- Measures that influence purely cost – politically not acceptable;
- Introduce WTW based vehicle taxation, noting the (practical) difficulties that such a system entails (e.g. accounting for the different production pathways of various alternative fuels);
- Introduction of Zero emission vehicles (ZEV) mandate;
- Regulation needs to be EU wide.

6.3 What are the major recommendations that can be formulated on the basis of the national workshops

Considering the fact that - by their nature - the National Workshops were to a large extent influenced by the country-specific concerns and situations, it is difficult to formulate a set of overall general conclusions that would apply to all of the partner countries. The situation is even more complex, because within the participants of the workshops different interest groups were represented, whose opinions and postulates sometimes diverged or were in conflict. This notwithstanding, some important conclusions can be drawn. Those are summarised below. (References to the exemplary national workshops are given as abbreviations, e.g. AT, DE etc.).

It was generally agreed that biofuels or – more generally – alternative fuels and alternative automotive technologies themselves do not provide the ultimate solution for the sustainable transportation system and/or to achieving the CO_2 emission reduction targets.

Several major concerns have been raised in this connection:

- the rebound effect: new more efficient cars produce less emissions per kilometre driven, but this is compensated (e.g. IT) – or even over-compensated – by the average yearly mileage of those cars. Indeed, what counts for a typical consumer is primarily the cost of using the car which is mainly the product of fuel price times the litres of fuel burnt which is determined by the specific fuel consumption and kilometres driven. Thus more kilometres driven are not more costly because the product of the two factors may remain constant.
- the congestion problem: even with a wide use of bio- or hydrogen-fuelled cars or electric vehicles, the congestions will not decrease unless some other measures are undertaken. In an ideal situation, when all vehicles in use are zero emission, ones this would indeed lead to CO_2 emission reduction. However, in a realistic perspective fossil fuel cars will still emit excessive amounts CO_2, while running idle their engines in traffic jams.
- conflict between food and biofuels: this issue has ranked as an existing problem. However, the gravity of the potential conflict has been assessed in different countries differently, as far as the degree of its importance is concerned (see the discussion below, where results of the questionnaire survey are presented). This has led to the proposal to put more emphasis on the second generation of biofuels (e.g. IT)
- limited potential of biomass in EU. Another related important remark was made in the German and in Polish workshops. It was pointed out that the biomass potential in Europe is limited. Therefore, the various energy uses of biomass are in competition with each other that should be adequately considered. This issue is attracting an increasing attention among the biomass experts. Most of Europe are regions with high density of population, where other energy uses of biomass are important. For instance in counties like Poland and its neighbours, the heating needs are significant and could be largely satisfied by a local use of biomass for this purpose. It may turn out that crops for heating would provide higher CO_2 emission reductions, than using the available agricultural land for biodiesel or bioethanol production.

As a consequence, in several national workshops, as well as during the Final Conference in Brussels on March 1st 2011, the importance of other approaches aimed at achieving a sustainable transportation system has been highlighted. This has also been reflected in the opinions of the stakeholders in the questionnaires, which is discussed in Section 6.7. E.g. at the Dutch national workshop the following hierarchy of measures was proposed:

- reducing the demand for mobility such as e.g. changes in the trends of urban planning; (SE: more compact cities, or preventing the urban sprawl)
- a wider use of other mobility modes (public transportation, modal shift to rail, bicycles…)

- more efficient cars (in terms of energy use per kilometre)
- shift to CO_2 emission free fuels (biofuels, hydrogen, electricity)

However, it was noted that in the latter case there are still CO_2 emissions embedded in the process of fuel production (and distribution), or – in case of electricity – in power generation, which is particularly important in countries like Poland, where coal is the basic fuel.

- In connection with the latter problem, consensus has been reached that the support schemes should be based on Well to Wheel (WTW) evaluation (e.g. AT)
- This entails the need that the ecological performance should be proved by certification (DE,AT). Valid rules and standards must be defined. Sustainability should be included in the criteria catalogue of biofuels at all costs. For calculating the CO_2 balance the complete production process must be considered.

This in turn has led to another undisputed conclusion that further R&D effort is needed. However, this need was also addressed to researchers and developers of new technologies and new biofuels and researchers analysing the impact of economic and policy instruments. It was emphasised (e.g. DE) that different production approaches to biofuels are in an R&D stage, but nobody can assure today which is the most effective approach to reduce CO_2 emissions. In this connection it has been stated (SE) that the financial support to R&D should be less focusing on specific new technologies but rather on the CO_2 emission reduction. We have no idea about what has not yet been invented and one should avoid dictating an increased use of biofuels.

Regarding the financial instruments the opinions varied between the partner countries. In general, the experts agreed that taxation measures – if it were to be applied – should be based on the net CO_2 emissions (reduction or release). However, it has been emphasized (NE) that measures that influence purely cost (increases) are politically not acceptable. To minimize the negative perception of such cost-oriented measures (higher cost on fossil fuels) one should use the revenues to stimulate a broad range of innovations (SE).

In the Italian workshop this problem was given a special attention. In Italy the majority of transport is on road. This means that rising taxes on fuels will have inflationary effects and would depress the economy. In this connection an important remark was made: being one of the countries with the highest taxation rate on the final fuel prices, Italy did not register any reduction in use of cars. On the contrary, in periods when fuel prices increased, a further increase in car use was observed. This finding should be examined closer in different counties and taken into account in shaping the national policies accordingly.

In two countries (AT, DE) it was concluded that the public support to EV infrastructure is not needed.

It was generally agreed that the use of biofuels should be extended/promoted also in other transport sector: busses, aviation (DE, AT), or marine transport (GR).

Another important issue raised (PT, IT) was the problem of co-ordinating policy making (i) at different decision-making levels and (ii) among the EU member countries. It was agreed that regulations need to be possibly EU wide or at least harmonized. However, those should take into account the specific conditions of the particular member states. For example the use of electric vehicles in Poland, may bring a limited or no CO_2 emission abatement, because the CO_2 emission factor of the Polish power sector is high due to the heavy reliance on coal.

The deficiency of the present decision-making system has been pointed out especially by the participants of the Italian and Portuguese workshops. One of the main obstacles to the diffusion of alternative vehicles diffusion and use is that the administrative levels of decision-making are sometimes in conflict (IT). City, province, regional, national and European levels all are in charge of sustainable transport issues. For example EU sets the environmental standards for fuels and car performance, national governments decide about the fiscal policy, the regional and province levels promote local policies but, the city authorities have the right to promote and fix some policies that are not necessarily consistent with the higher levels.

Finally, it should be noted that as far as some detailed measures are concerned there was disagreement between conclusions of different workshops, which only means that further research and testing are required. The same concerns the scrappage system: while, on one hand, its fast and radical introduction was claimed (SE), on the other hand, doubts about its impact in the present form were voiced (IT) on grounds that the rebound effect annihilates the expected emission reduction effect.

6.4 What can be recommended or concluded with respect to country specific aspects learned from the workshops

Potential country specific recommendations differ as much as the country specific conditions differ from each other. In general, despite claims of a need for the EU wide harmonisation of legislation and policy instruments, it was stressed that this should not be done disregarding the country-specific constraints and conditions (SE: “avoid dictating an increased use of biofuels”).

However, some recommendations seem to be rather universal such as:

- First make attempts to approach the problem at source, i.e. undertake measures that will reduce the demand for road vehicle mobility (passenger cars primarily).
- Another recommendation, applicable to all countries is that their legislative frameworks should be as stable as possible and have a longer perspective (2030 or even 2050). This is primarily needed for investors planning to engage their money in AF or AAMT.
- Yet one more, recommendation, applicable to all countries should be mentioned: that all countries should support the R&D efforts, on one hand, in the technological solutions (both AF and AAMT), and, on the other hand, in the evaluation of impacts of the various policy instruments in support of the sustainable transport system. This should be done including the

life cycle analyses and WtW balances with the external costs taken into account (to the extent possible). According to the findings of the conclusions of the French workshop it is particularly important that the R&D and fleet people work in close cooperation.

The recommendation to support technological R&D applies especially to the countries advanced on the way to the sustainable transport system: Germany, Austria, Sweden and The Netherlands. In particular, in those countries where electricity is generated largely from the renewable energy sources, further research and promotion of Electric Vehicles (including Fuel Cells) should be advocated. On the contrary, in countries like Poland where emissions from the power sector are high a wide use of electric vehicles would very likely bring limited or no effect – if not a negative one.

Consequently, in Poland and other countries with strong agricultural sector (e.g. Greece) a wide use of biofuels may bring, apart from positive emission reduction results, also broadly understood benefits for the agricultural sectors and the national economies as a whole. Of course, one should remember that, still, biomass is a limited resource and has a number of possible energy uses: motor fuels, electricity generation, heating, or converting it into a gaseous form, each with a variety of potential final applications. In each country the policy decisions should be preceded by an optimisation exercise, where the goal function should be (primarily) the amount of reduction of CO_2 emissions. Considering the arguments raised by the Italian experts and also supported in the conclusions of the Dutch and Swedish workshops, one should preferably apply the “carrot” rather than the “stick” approach, of course within the financial possibilities that the particular countries have. Selective and effective EU support would be greatly helpful in some countries that can find it unaffordable.

Considering the problem of the vertical co-ordination of policies raised in Italy and Portugal (which may well be relevant also for other countries) the problems should be solved individually based on the ”subsidiarity” principle, and the experiences should be shared with other EU Member States.

6.5 What can be recommended or concluded with respect to acceptance of biofuels

In some countries, especially in Poland and Greece, the increased demand for biofuels gives a chance of development of the agricultural sectors, and rural areas and thus biofuels are strongly supported by the agricultural stakeholders. Generally, no opposition to the use of biofuels was identified, although a very important warning has been included in the conclusions of the German workshop, when the reference to the limited biomass resource in Europe was made.

Still, the apparent (looming) conflict between food and fodder production and biomass use for energy purposes raises some concerns among the general public. Consequently, the recommendation to pay more attention to second generation biofuels (IT,PL) seems to be very up-to-date.

Another issue is the fear (or reservation) of car (both passenger and commercial) users concerning the effects of the use of biofuels or fuels with bio-components on performance and life-time of their cars' engines. The recommendation here is getting reliable results of independent tests that should be widely communicated to the car users community.

6.6 What can be recommended for potential initiators or investors in the field of biofuels

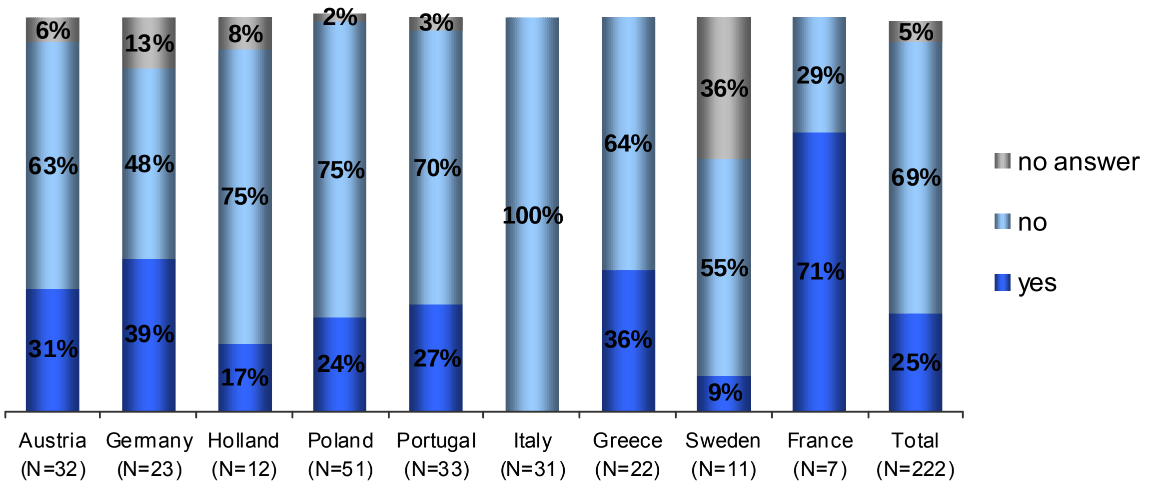
As stated in the German workshop "different production approaches to biofuels are in an R&D stage, but nobody can assure today which is the most convenient approach to reduce CO_2 emissions. Incentives provided should not be technology-specific but should rather be based on CO_2 emission reduction". It is very likely that political decisions will be based on the environmental performance of the new solutions, so that there is a degree of inherent uncertainty for the potential invertors. Another remark is based also on the conclusion from the German workshop (biomass in the EU is a limited resource): having in mind different possible energy uses of biomass resulting-in competition within the energy applications of biomass alone (apart from the competition with food/fodder/industry) it may turn out that the investors may find it difficult to acquire the needed amounts of substrate from sources close enough to keep the embedded transportation emissions within the required ceiling. This effect is already seen. The investors should precede their decisions with proper analyses taking those limitations into account together with the other environment criteria which are already in place in some countries. If the EU policies are to be taken seriously from the environmental point of view, those will be likely tightened and extended to other Member States, possibly in a not very distant future.

6.7 The questionnaire survey

In this section results of the questionnaire survey concerning the general issues related to the project, which had been distributed among the stakeholders are summarised. A short discussion of the answers to the particular questions is given following each graph showing the fractions of the different answers.

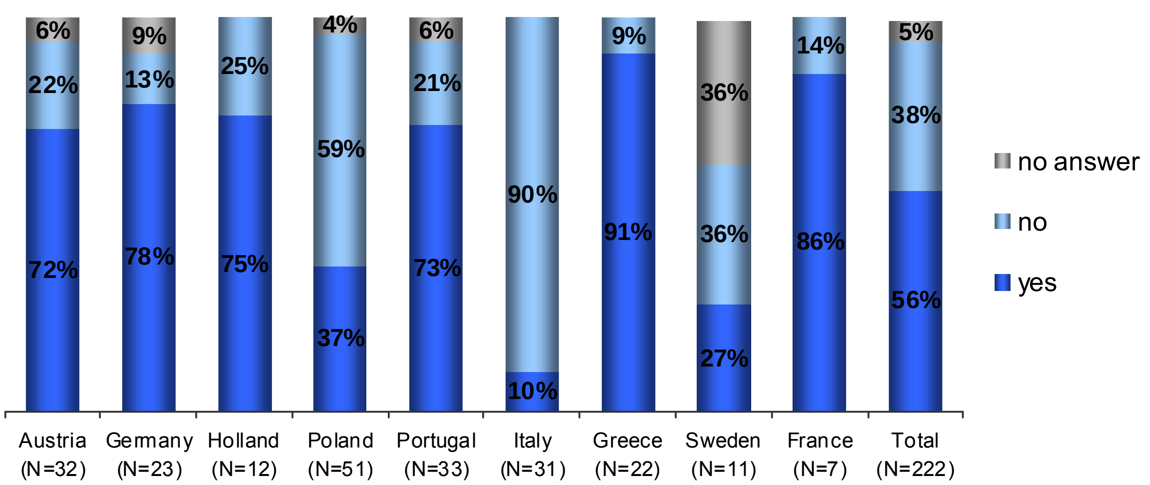
Those questions are listed below, followed by graphical presentations of the numbers of the corresponding answers as shown on the right-hand-side of the respective figures. A total of 222 responses were received. The numbers corresponding to the particular countries are shown below each column

Question 1. Do you think that in your country there is a serious conflict between a wide use of biofuels and nutrition needs?



As it is seen a particular concern about possible conflict between wide use of biofuels and nutrition needs exists in France followed by Germany. The least concerned seemed the Dutch, which is rather surprising taking into consideration the high population density of this country. On the other hand, Holland has one of the most efficient agricultural sectors and this justifies their trust in the food sufficiency of their country. The large share of "no answers" from Sweden might be a result of misinterpretation the question[15].

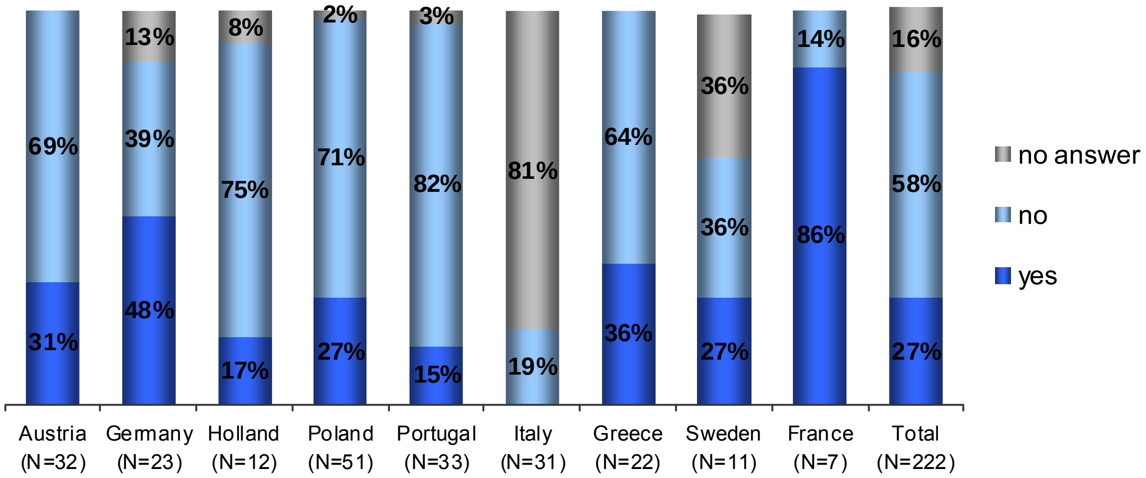
Question 2. Do you think that there is a serious conflict between wide use of biofuels and nutrition needs on the global scale?



[15] "nutrition needs" was discussed at the workshop as soil nutrition and how to improve carbon content and nutritions to forests, to avoid impoverishment and leaching, after having removed stumps and branches for biofuel production.

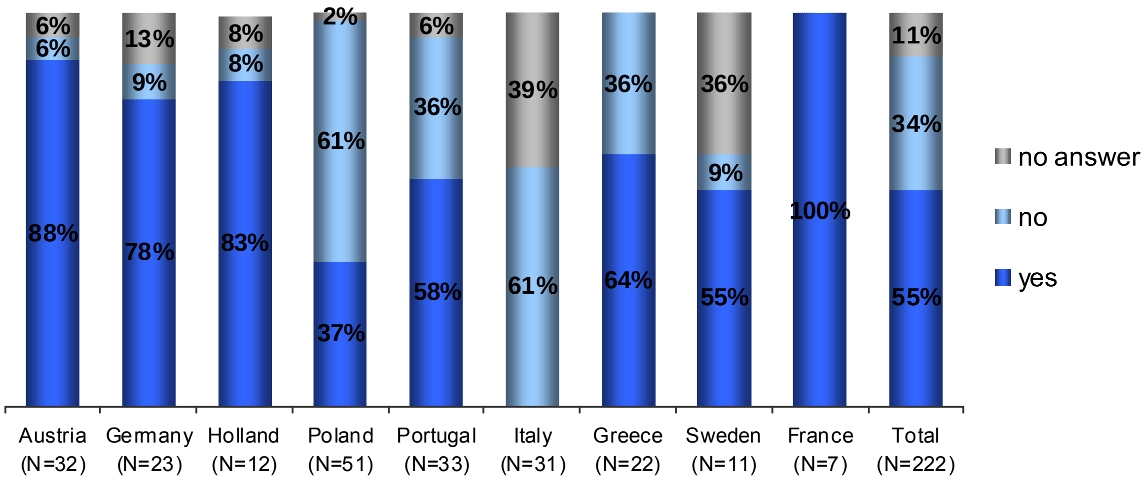
As it is seen the picture is quite different when it comes to the conflict on the global scale. Now the Dutch are among the most concerned with France, Greece, Austria and Germany. Apparently in those countries there is strong awareness that the rich North may drain the land resources needed in poor South for feeding their people.

Question 3. Do you think that in your country there is a serious conflict between wide use of biofuels and environment/biodiversity protection?



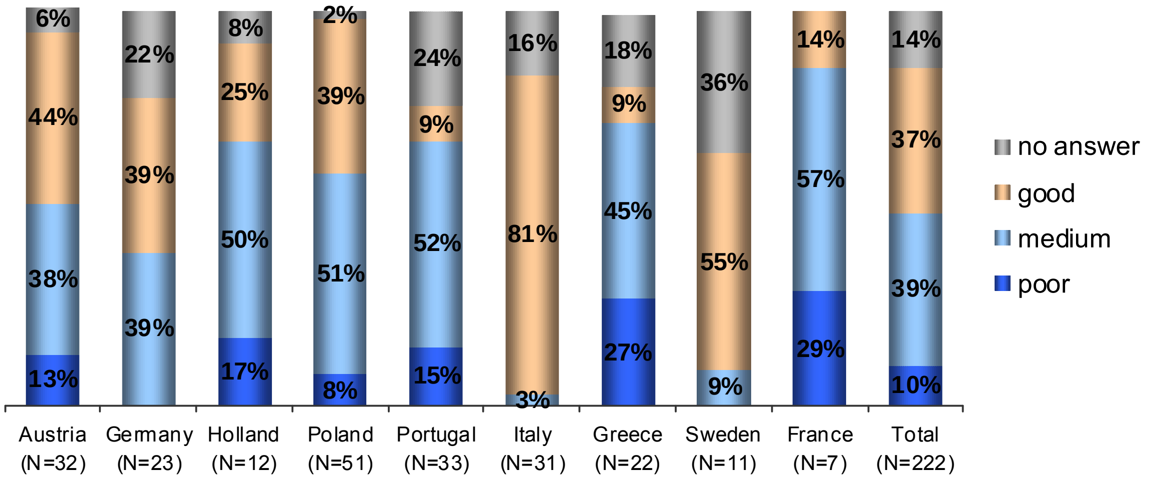
As it is seen, most of the total participants do not see a conflict between biodiversity (environment) protection and a wide use of biofuels in their own country. Notably, France is leading among the concerned nations.

Question 4. Do you think that there is a serious conflict between wide use of biofuels and wilderness protection on the global scale?



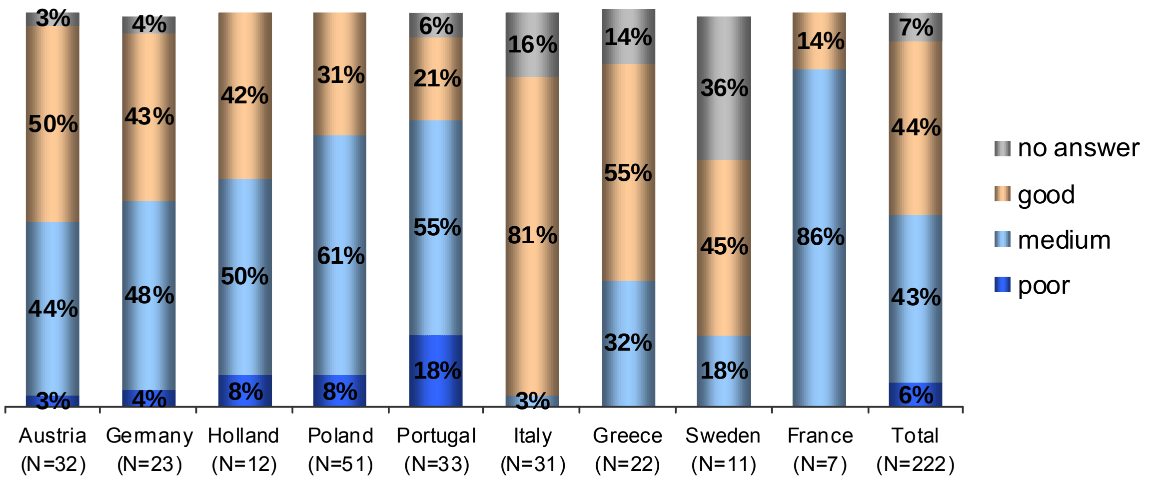
As it is seen, the situation is reversed when it comes to the global scale. Majority of participants see a potential conflict between biodiversity (environment) protection and a wide use of biofuels. Again, the most concerned are French.

Question 5. Do you think that the environmental standards related to production of biofuels are good in your country?



As is it seen, in the total the answers are about 50/50. However, the average is driven mainly by Italy, so that in most of cases the respondents are rather concerned regarding the environmental standards of biofuels production in their countries. Sweden and Italy assess their own standards most positively, while France, Portugal and Greece are on opposite side.

Question 6. Do you think that biofuels, fuel cell cars, electric cars etc. provide a sufficient (good) solution for environmental friendly automotive mobility in the next (15 – 20 years)?



As it is seen, the skeptics (6%) and semi-skeptics (43%) together with those who have no opinion (7%) slightly prevail over the optimists. structure of the answers to this questions is similar to the previous one. This result is heavily driven by the Italian stakeholders. Optimists prevail also in Italy, Greece and Sweden. Notably, France, Portugal and Poland are rather skeptical. A closer look at the discussion during the Workshops it can be interpreted that the respondents see a need to apply other measures, such as traffic restrictions, urban planning, public transport etc.

6.8 Overall concluding remarks

The topics of the particular national workshops covered a wide spectrum of problems addressed in the ALTER-MOTIVE project, which only partly overlapped with each other. On the other hand, the questionnaires distributed among the stakeholders during the workshops asked the same questions to stakeholders in all countries, so that they covered the same issues. However, the composition of the interviewed stakeholders groups differed from country to country, depending on the country specific focus of the debate, which to some extent influenced the outcomes of the survey in the particular countries. The inhomogeneous sample of interviewed stakeholders helped us to see the differences of the priorities and opinions of the particular segments of the stakeholders groups.

As mentioned above, the focal points of the particular National Workshops differed from each other. In Poland and largely also in Greece this was the interest of the farmers who saw the cultivation or harvesting of the biomass material as an additional source of income. On the other side, the interest of Germany and Austria is rather in the technological aspects, with emphasis on electric vehicles and hydrogen fuel. In The Netherlands and also in Germany and Austria and Sweden great emphasis was put on policy solutions.

The conclusions and recommendations for policy makers included a wide range proposals. Those have mostly reached a consensus of the participants or did not face clear-cut opposition or was not at the workshop. In two countries Poland and Portugal it was difficult to come up with a common set of recommendations, because the claims or opinions of different stakeholder groups represented at the workshops diverged.

This notwithstanding the workshops have provided an abundant source of information which should be further analyzed with the aim of providing a basis for a harmonized EU policy framework for promotion of a more environment friendly and sustainable transportation system in Europe.

It is remarkable that the importance of research and development was never disputed and it was highlighted as important in most of the workshops, particularly in Germany, France, Austria, Portugal, Sweden and Italy.

The specific conclusions and recommendations for policy makers have been presented in more detail in the previous Sections, so that they are not summarised here again.

On the basis of the reports from the national workshops and of the questionnaires it should be concluded that collected information and suggestions should be further analysed from the point of view of shaping the biomass strategies in different countries and in the EU as a whole.

7. Perceptions from econometric analyses

In this chapter we present the results of the econometric analysis concluded within the scope of WP6 to identify the impact of taxes and fuel intensity standards on overall energy demand for car passenger transport in EU-15 and we show how a tax versus standard works. We pay special attention to the interactions between price and efficiency changes and investigate the crucial role of service price elasticity.

How does a tax work in comparison to a standard?

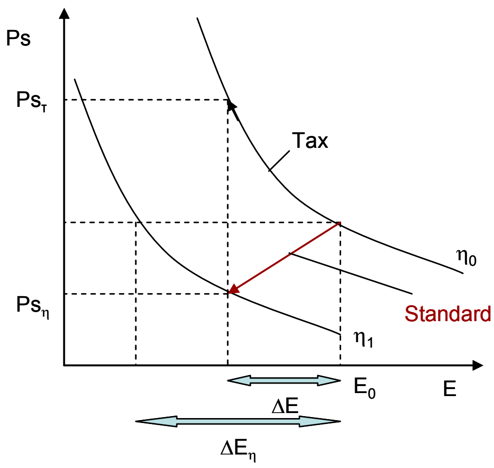


Figure 50. How a tax vs a standard works

Figure 50 depicts the principle of changes in efficiency, energy consumption and service price. For a tax the reduction in energy consumption ΔE results from higher service price $Ps\tau$ remaining on the same curve η_0. When a standard is implemented we switch from η_0 to η_1 leading to a reduction ΔE of energy consumption. Yet, due to a lower service price $Ps\eta$ this saving effect is lower than the theoretical effect which is $\Delta E\eta$.

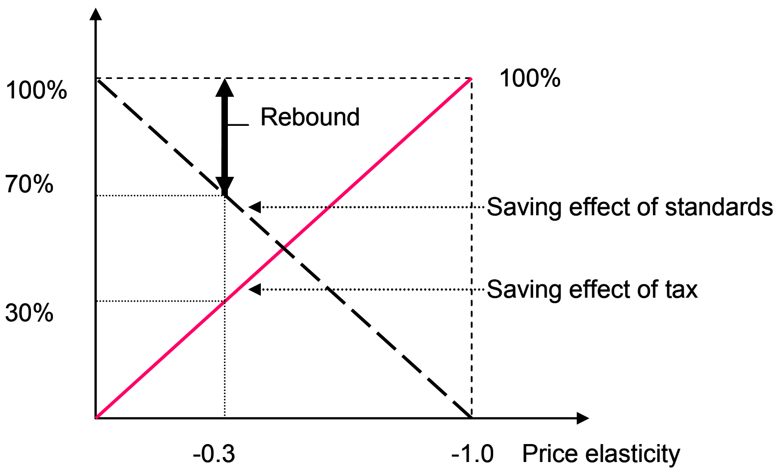


Figure 51. Effect of a tax vs standard depending on service price elasticity

Figure 51 depicts the effect of a tax vs standard depending on service price elasticity. As shown, if a tax in the magnitude of 1% is introduced and the price elasticity is e.g. (-0.3) then the energy saving effect is 0.3%. If standard in the magnitude of 1% is introduced and the price elasticity is e.g. (-0.3) then the energy saving effect is 0.7% and the rebound effect due to more km driven is 0.3%.

When is it now undoubtedly possible to identify one favourable strategy? This is only the case if price elasticity is very low (or insignificant) – then a standard is clearly favourable – or very high (close to 1) – then a tax is clear more effective. In a range between about -0.3 and -0.7 a combination of both is recommendable.

7.1 Modeling energy consumption and service demand: Results of econometric analyses

The method of approach applied in this work is based on the fundamental relationship:

$$E = S \cdot FI \quad (4)$$

In addition energy consumption E and service demand S (vehicle km driven) are analyzed by means of econometric approaches.

To analyze the impact of fuel intensity and prices on energy consumption, we start with a simple estimation of total energy consumption. We apply the conventional approach where energy consumption depends on price and income assuming symmetric price elasticities:

$$\ln E_t = C + \alpha \ln P_t + \beta \ln Y_t \text{ - model 1} \quad (5)$$

$$\ln E_t = C + \alpha \ln P_t + \beta \ln Y_t + \gamma \ln FI \text{ - model 2} \quad (6)$$

where:

C…………Intercept
Et……….. Energy demand in year t
Pt…..……. Real energy price (calculated by means of weighted fuel prices)
Yt…………Real private final consumption expenditures as a proxy for income

Additionally to estimating energy consumption we conduct an econometric estimate of service S (vkm driven).

The level of service demand S[16] of e.g. a household with respect to km driven depends on available income Y and the price of energy service Ps:

$$S = f(P_S, Y) \quad (7)$$

[16] It is important to note, that "energy service“ for cars is not just distance driven. Rather it is kg-km define or even kW-km, and efficiency is energy use/kg-km or energy use/kW-km. By these measures, efficiency increased enormously fed mostly by increasing weight and power and not simply by reducing fuel consumption. Thus, a large part of the increase in energy efficiency is not translated into a decrease of FI.

Table 7A. Estimates for long-term over-all energy consumption (with and without fuel intensity) and service demand for period 1980-2007 (t-statistics in parentheses)

	Model 1	Model 2		Model 3
C (intercept long-term)	2.95 (11.75)	0.89 (0.43)	C (intercept long-term)	6.71 (13.3)
α (long-term price elasticity)	-0.44 (-11.89)	-0.43 (-15.7)	α (long-term service price elast.)	-0.42 (-8.41)
β (long-term income elasticity)	0.63 (22.7)	0.78 (5.31)	β (long-term income elasticity)	0.97 (21.1)
γ (long-term fuel intensity elasticity)	-	0.33 (0.95)		-

Table 7B. Estimates of ECM for over-all energy consumption energy consumption (with and without fuel intensity) and service demand for period 1980-2007 (t-statistics in parentheses)

	Model 1	Model 2		Model 3
ARDL* order	(1,0,0)	(1,0,0,1)	ARDL order	(1,0,0)
C (intercept short-term)	0.96 (11.45)	3.33 (0.44)	C (intercept short-term)	2.59 (8.61)
A (short-term price elasticity)	-0.15 (-9.91)	-0.16 (-12.0)	A (short-term service price elast.)	-0.16 (-7.92)
B (short-term income elasticity)	0.21 (6.27)	0.29 (4.12)	B (short-term income elasticity)	0.37 (5.08)
Γ (short-term fuel intensity elasticity)	-	0.48 (3.38)		-
ECM*(-1)	-0.32 (-7.99)	-0.37 (-9.83)	ECM(-1)	-0.38 (-6.26)
$\bar{R}^2$	0.85	0.90	$\bar{R}^2$	0.75
RESS	0.000801	0.000506	RESS	0.00187
F-Stat	50.0	57.1	F-Stat	27.65
AIC*	98.4	102.6	AIC	86.9
SBC*	95.8	108.6	SBC	84.3
DW*	1.93	1.80	DW	1.96

*ARDL (AutoRegressive Distributed Lag); AIC (Akaike Information Criteria); ECM (Error-Correction-Model); DW (Durbin-Watson statistic)

We estimate the impacts on vkm driven by using a cointegration approach:

$$\ln S_t = C + \alpha \ln P_{S_t} + \beta \ln Y_t \quad \text{- model 3} \qquad (8)$$

where:

C………..Intercept
S_t……….. .Demand for service, vehicle km driven in year t in a country
P_{St}……… Weighted average price of service vkm driven (calculated by means of weighted fuel prices)

The most interesting numbers of this analysis are the service price elasticities because they contain information for both - price and efficiency impact.

The results of cointegration are shown in Tables 7A and 7B.

The most important finding of this analysis is that long-term as well as short term price elasticities are virtually the same for energy and service demand. Moreover, the coefficient γ for the impact of fuel intensity in Model 2 is not significant. These results indicate that there is no long-term – no irreversible – impact of changes in efficiency and virtually all theoretically calculated energy saving due to efficiency improvements are eaten up by a rebound e.g. due to the larger cars and more km driven.

7.2 Interaction of taxes and standards

In this section we analyze the impacts of changes in fuel intensity – due to standards vs changes in fuel prices – due to taxes on energy consumption. This is important to derive conclusions with respect to the effect of the implementation of standards for fuel intensity vs the effect of the introduction of fuel taxes increasing fuel prices.

One of the most critically discussed issues with respect to the implementation of standards for fuel intensity or corresponding CO_2 emissions is the rebound effect.

In the following, we conduct an estimation of the following effects: (i) the effect of changes in fuel intensity due to standards including a saving effect and a rebound effect because of increases in vehicle km driven and (ii) the price effect.

The definition of service demand S in equ. (7) can be extended to:

$$S = f(P \cdot FI, Y) = C(P \cdot FI)^{\alpha} Y^{\beta} \tag{9}$$

Using derivations the change in service demand (dS) can be split up into the price, the efficiency and the income effects:

$$dS = \frac{\partial f}{\partial P} dP + \frac{\partial f}{\partial FI} dFI + \frac{\partial f}{\partial Y} dY \tag{10}$$

In this paper we are further on interested in the change of service demand due to a change in the fuel price and the fuel intensity. We do not look at the income effect.

We proceed further using equ. (4)[17] and we obtain for the change in energy consumption:

[17] See also the detailed derivation in Ajanovic/Haas (2011)

$$dE = SdFI + FIdS \tag{11}$$

The change with respect to price is:

$$\frac{dE}{dP} = \frac{SdFI}{dP} + \frac{FIdS}{dP} \tag{12}$$

The change in energy demand (if dFI/dP=0)[18] due to the direct price effect is:

$$\frac{dE}{dP} = \frac{FIdS}{dP} \tag{13}$$

The change in service demand vehicle km driven caused by the price effect and using equ. (9) is:

$$\frac{dS}{dP} = \frac{\partial f}{\partial P} = \alpha (P\,FI)^{\alpha-1} FI \frac{P}{P} = \alpha \frac{S}{P} \tag{14}$$

where α is the elasticity of vehicle kilometres driven with respect to service price Ps.

Straightforward, the change in energy demand due to a change in the fuel price is:

$$\frac{dE}{dP} = FI \frac{dS}{dP} = FI\alpha \frac{S}{P} \tag{15}$$

and the total energy change from a price change with dP=f(τ) (τ…tax) is:

$$dE(dP) = FI\alpha\ S \frac{dP}{P} \tag{16}$$

Next we analyse the effect of an exogenous fuel intensity change with dFI=f(η) (η…standard):

$$\frac{dE}{dFI} = FI \frac{dS}{dFI} + S \frac{dFI}{dFI} = \alpha FI (P\,FI)^{\alpha-1} P + S = S(\alpha + 1) \tag{17}$$

and the total energy change from a change in FI is:

$$dE(dFI) = S(1+\alpha)dFI = SdFI + \alpha SdFI \tag{18}$$

Introducing the fuel intensity savings factor γ we can rewrite equ. (18) as:

$$dE(dFI) = \gamma SdFI \tag{19}$$

and we obtain for the relationship between the impact of fuel intensity and price (see also Walker/Wirl (1993) and Greene (1997)):

[18] In the long run, lasting price changes will have an impact see e.g. Walker/Wirl (1993).

$$\gamma = 1 + \alpha \tag{20}$$

This relationship can be illustrated by the following simple example. If the short-term price elasticity is (-0.3) resulting elasticity for fuel intensity γ is (1+(-0.3))=0.7. That is to say, if fuel intensity is decreased by e.g.10% due to a standard, the energy savings are only 7% because of a rebound in service demand due to the price elasticity of -0.3.

Figure 51 shows the two effects due to changes in fuel intensity from equ. (18). The first effect is change in demand from driving more fuel efficient vehicles the same number of miles (SdFI). It can be noticed that the total change in FI led to total energy savings dE(dFI) of about 500 PJ in EU-15. The second effect is the energy change from driving more kilometers, (α S dFI) called the rebound effect. The rebound effect led to an additional energy consumption of about 350 PJ.

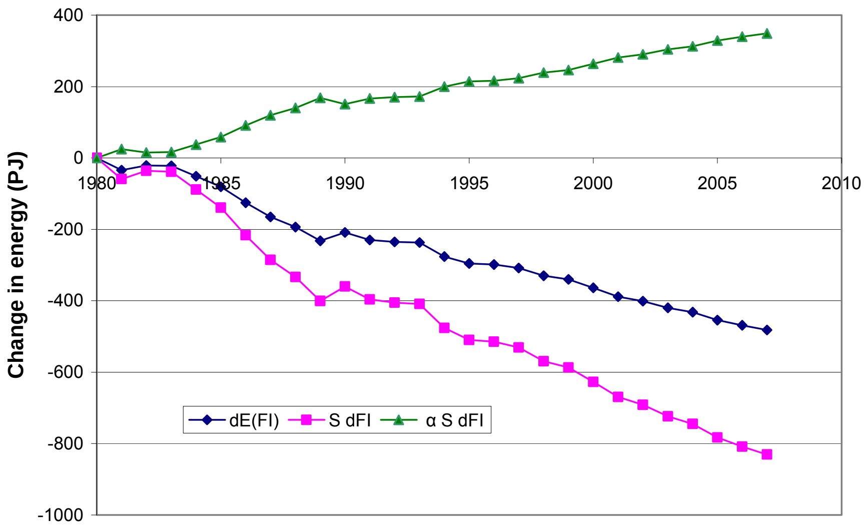


Figure 52. The change of energy consumption in passenger car transport due to changes in fuel intensity for EU-15, base 1980

Figure 53 compares the overall effect due to a change in fuel intensity (dE(FI)) and the price effect (dE(dP)). As shown in Figure 53, due to the volatility of the fuel price, the price effect can lead to higher or lower energy consumption. With respect to the fuel intensity effect savings compared to the base year can be observed starting from 1980.

The saving effect of prices can be noticed between 1980 and 1985. After 1985 the price drop led to an increase in energy consumption. In total the price and the fuel intensity effect brought about energy savings dE of about 500 PJ.

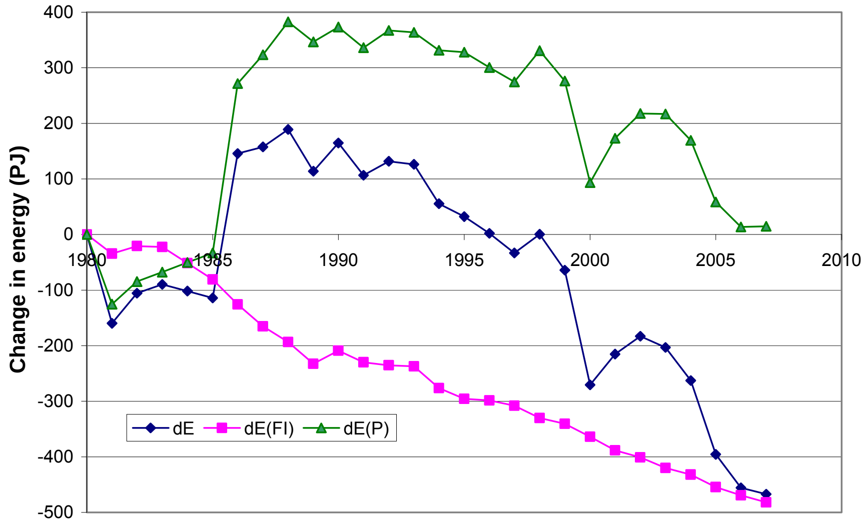


Figure 53. The change of energy consumption in passenger car transport due to changes in fuel intensity and fuel price for EU-15, base 1980

Figure 54 depicts the development of total energy consumption in comparison to the impact of fuel intensity and fuel prices. In 2007 was the impact of price effect was almost zero and the fuel efficiency effect reduced energy consumption by about 8%.

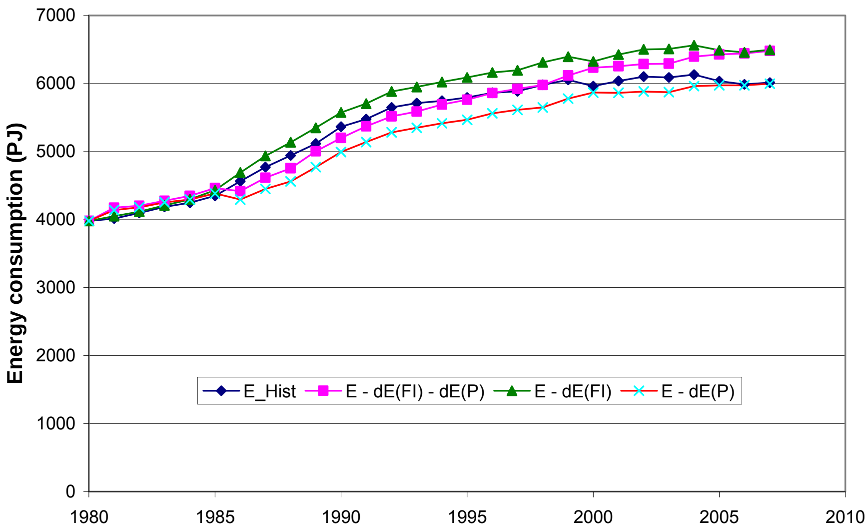


Figure 54. Historic development of total energy consumption in passenger car transport in comparison to the impact of fuel intensity and the fuel price for EU-15, base 1980

8. Results from scenario analysis

A major objective of the project ALTER-MOTIVE was to develop so-called internet-based scenarios. This tool provides an on-line possibility for stakeholders to design own policy scenarios and to get an indication for the effect of various types of policies[19]. These policies are described in detail in Section 8.1.

For extracting the impact of these policy types we use a dynamic model which is based mainly on econometric estimates of service demand (number of new vehicles by category, vehicle km driven by country and category) from time series compiled in WP2 (see Ajanovic (2009)).

The basic approach is:

$$S_t = S_{t-1}\left(\frac{P_{S_t} - P_{S_{t-1}}}{P_{S_t}}\right)^{\alpha}\left(\frac{Y_t - Y_{t-1}}{Y_t}\right)^{\beta}\left(\frac{IC_t - IC_{t-1}}{IC_t}\right)^{\gamma}\prod_{i=1}^{n}\left(\frac{X_{i_t} - X_{i_{t-1}}}{X_{i_t}}\right)^{\delta_x} \qquad (21)$$

With:

X_i … various additional variables covering cross-price and cross-investment costs effects

From these service figures the resulting energy consumption (E) and CO_2 emissions are calculated by using the fuel intensities (FI) and the fuel-specific CO_2 emissions (f_{CO2}):

$$E = vkm \cdot FI \qquad (22)$$

$$CO_2 = f_{CO_2} FI\ vkm \qquad (23)$$

Figure 55 depicts the relationships between the variables. The starting point are the assumptions for income, price, investment costs and fuel intensity developments, see also Section 8.1. Next we define policies for fuel taxes, registration taxes, CO_2 emission standards, and biofuel targets. CO_2 emission standards lead to the assumptions for FI from new vehicles.

[19] These internet-based scenarios are available on www.alter-motive.org under "Play policy maker". Currently, for eleven countries – Austria, Bulgaria, Czech Republic, Denmark, France, Germany, Italy, The Netherlands, Poland, Portugal, Sweden and the EU-15 as a whole. It is possible to test the policies described above online.

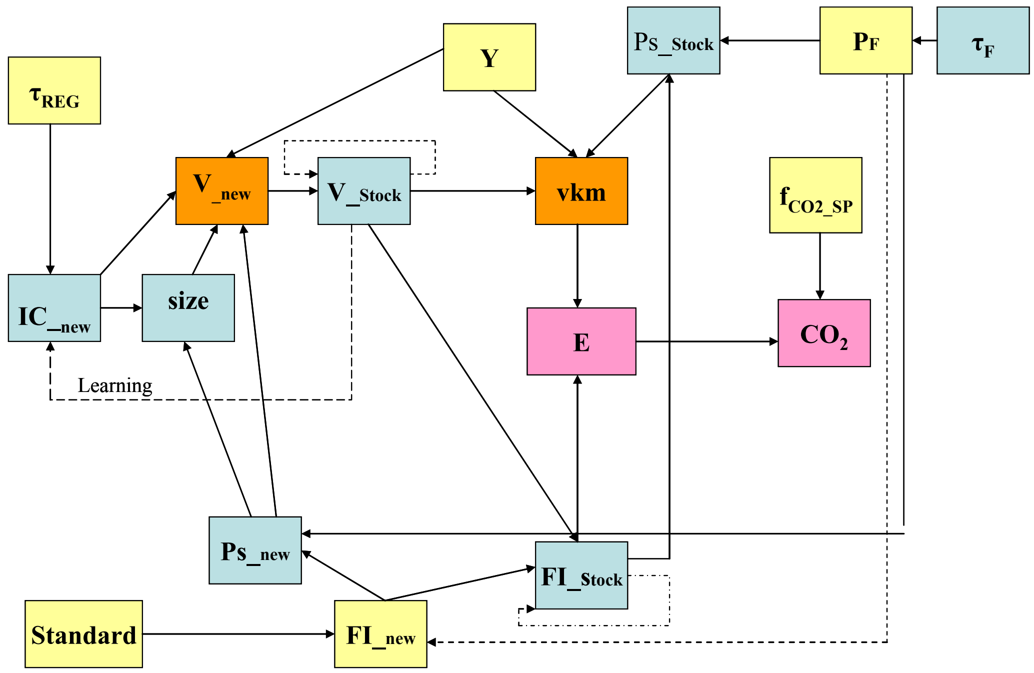


Figure 55. Relationships between variables for modelling energy consumption and CO_2 emissions

Based on these and the other assumptions made we calculate further-on:

- The number of new vehicles per year $V_{New\_ij\_t}$ by size and car category per year using equ. (21) and
- the stock of vehicles $V_{ST\_ij\_t}$

$$V_{ST\_ij} = \varphi_i \cdot V_{ST\_ij_{t-1}} + V_{new\_ij_t} \qquad (24)$$

where

i….car size

j…..car category

φ…stock remaining factor

From remaining stock ($\varphi\ V_{ST\_ij\_t\text{-}1}$) and $V_{New\_ij\_t}$ we can now calculate the fuel intensity of new stock:

$$FI_{ST\_ij\,t} = FI_{ST\_ij_{t-1}} \cdot V_{ST\_ij_{t-1}} \cdot \varphi_i + FI_{new-ij_t} Vnew\_ij_t \qquad (25)$$

and finally we calculate vehicle km driven vkm using equ. (18):

$$vkm\_ij_t = vkm\_ij_{t-1} \left(\frac{P_{S_t} - P_{S_{t-1}}}{P_{S_t}}\right)^{\alpha} \left(\frac{Y_t - Y_{t-1}}{Y_t}\right)^{\beta} \left(\frac{IC_t - IC_{t-1}}{IC_t}\right)^{\gamma} \qquad (23)$$

and using equ.(22) and (23) we obtain straightforward energy consumption and CO_2 emissions.

Based on this formal framework and the assumptions documented in the following chapter finally the scenarios will be derived.

8.1 Major assumptions for price, income, cost and technological developments

In this chapter we summarize the major assumptions regarding price, income, cost and technological developments up to 2020.

Note that in the scenario analyses the major focus is on EU-15. The major reason for this is that reliable data for time series on energy consumption of passenger cars are only available for this subset of countries and not for the all EU-27 countries[19].

The starting points for the analyses are the years 2007-2010 depending on the data available by country and parameter type. As far as possible we used the latest available data from 2009/2010 (e.g. for personal consumption expenditures (PCE), prices, new registrations and CO_2 emissions of new registered cars). From our analyses by the end of 2010 about 200 million cars were on roads in EU-15 countries. Of these there were about 60000 BEV and about 140 fuel cell cars. About 13.5 million new cars were registered in 2010.

Major specific assumptions in the BAU-scenario

Based on these figures a Business as usual (BAU) scenario is developed. In this context the following assumptions are of specific interest:

- Conversion of excise tax to CO_2 tax;
- For km-specific CO_2 emissions (and implicitly fuel intensities) the EU aims to set a target of 95 g CO_2/km for 2020. However, the EU has not reached recent targets in this sector (120 gCO_2/km by 2010, see above) and not in other sectors e.g. targets of the RES-E-directive. So we define a so-called “target fulfilment factor” (TFFF) and use a value of 65% for the difference between starting value 2010 (130 g CO_2/km) and the announced target of 95 g CO_2/km. This result in a BAU-scenario value of 107 g CO_2/km which we expect to be met by 2020, see Table B-1. Because in the BAU-scenario no other policies are implemented this figure must be brought about by pure technical efficiency improvements (and voluntary size reductions). As can be seen from Figure 70 it leads to about 3 million tons CO_2 reduction up to 2020.

Figure 56 depicts the historical fuel price developments and the assumptions for price development in the scenarios up to 2020. Figure 57 describes the historical developments of passenger cars’ fuel intensities and assumptions for development in the scenarios up to 2020 (for average car size of 80 kW). Figure 58 shows the developments of car investment costs in the scenarios up to 2020 (for average car size of 80 kW).

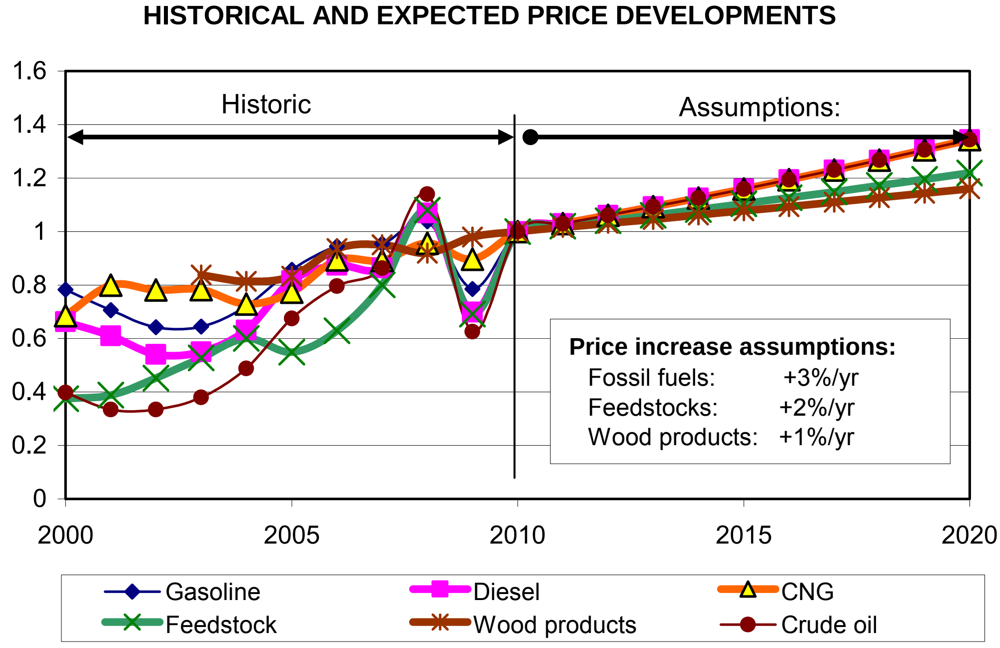


Figure 56. Historical price developments and assumptions for price development in the scenarios up to 2020 (own calculation)

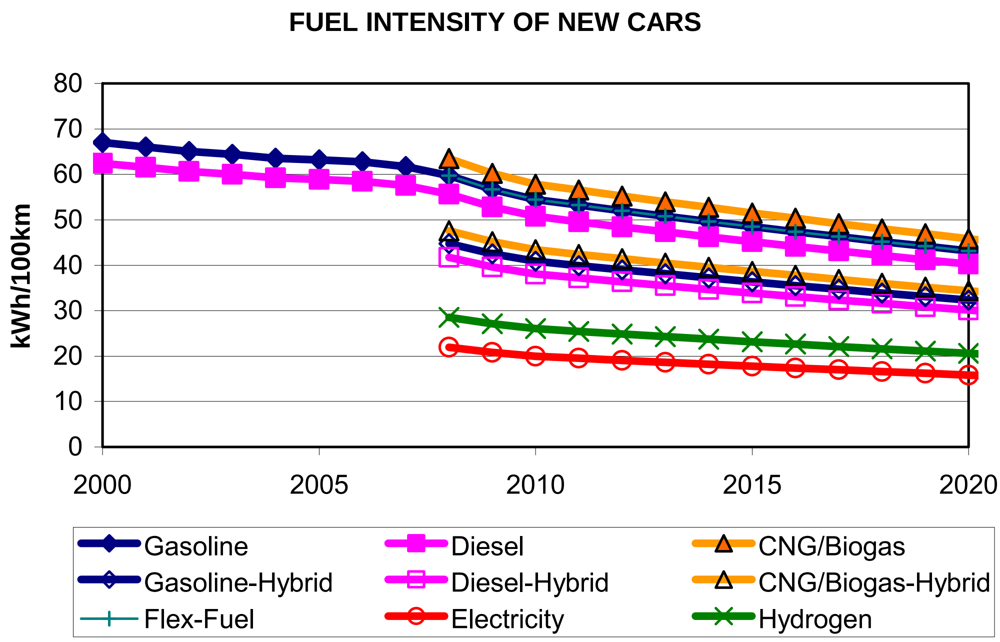


Figure 57. Historical developments of passenger cars' fuel intensities and assumptions for development in the BAU scenarios up to 2020 (for average car size of 80 kW) (Source: EC,2010; Toro et al, 2010; CONCAWE, 2008; DB, 2009)

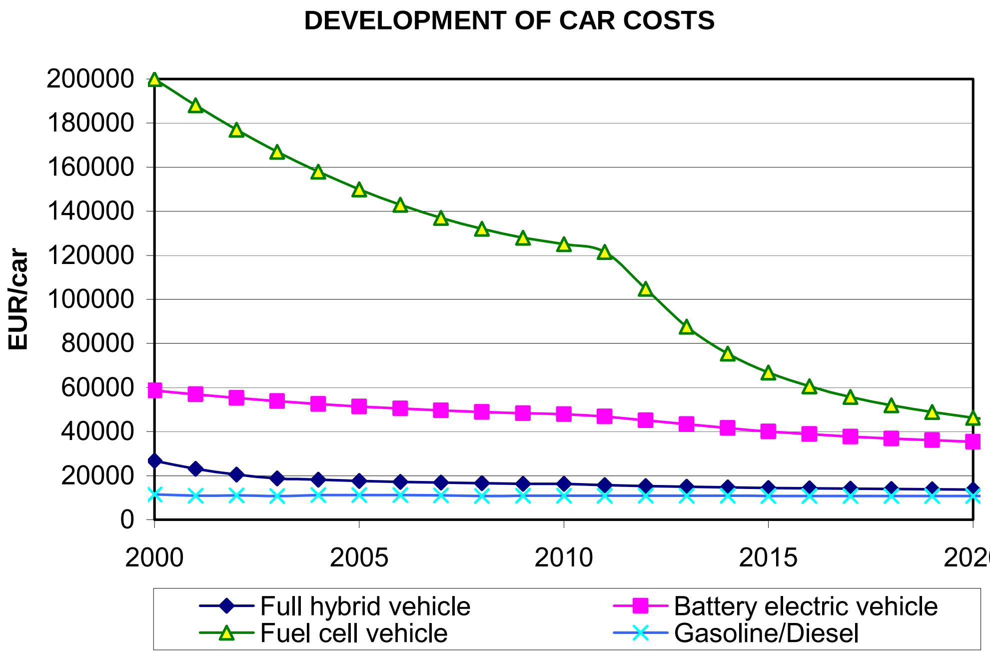


Figure 58. Developments of car investment costs in the BAU scenarios up to 2020 (for average car size of 80 kW) (own calculation)

Major assumptions in the policy scenarios

To extract the effects of different policies we proceed as follows:

First, we calculated separate scenarios for the following categories of policies (note that all policies in all scenarios become effective from 2011 on):

- **Fiscal policy scenario:**

➢ <u>fuel tax:</u> we introduce a CO_2 based fuel tax and a car size-dependent registration tax. The fuel tax increases – based on the initial excise tax of gasoline, which is equivalent to 0.29 EUR/kg CO_2 (0.68 EUR/litre gasoline) – by 3 cent/kg CO_2 / year (this is an increase of 7 cent/litre gasoline). For the other fuels the tax is calculated and increases relative to their CO_2 emissions compared to gasoline, see Figure 59. Note that all calculations of specific emissions are based on gasoline.

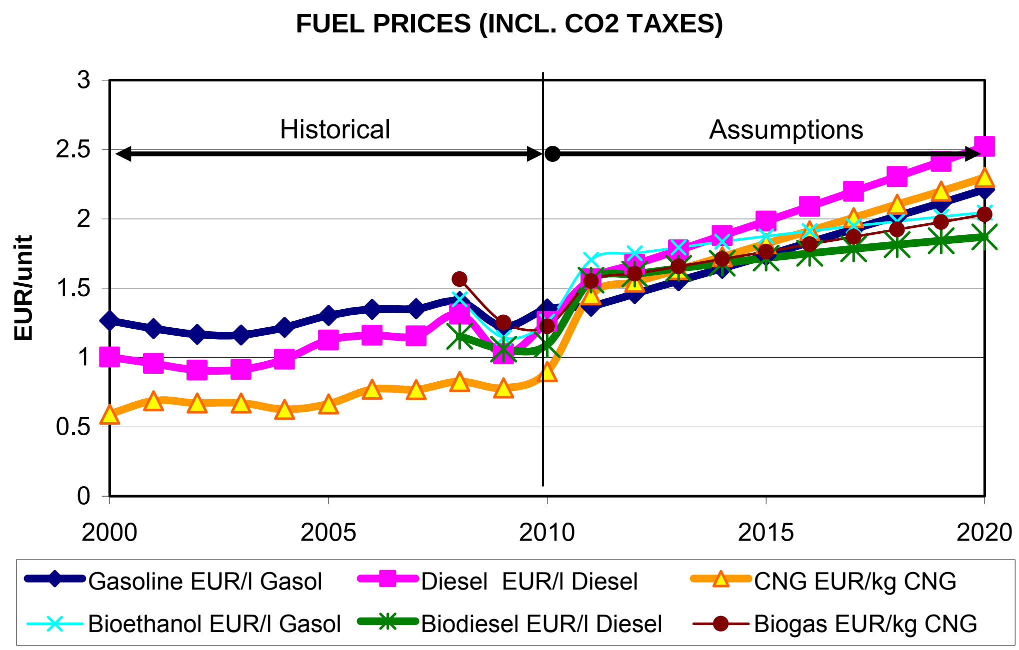


Figure 59. Historical developments of prices incl. and excl. taxes and development in the fiscal policy scenarios up to 2020 (Source: Own calculation, ALTER-MOTIVE database)

- registration taxes: furthermore we introduce a differentiated scheme of registration taxes depending on the size of cars: for small cars (up to 60kW) tax increases by 2%/year as in BAU-scenario. For medium-size cars (60-100kW) the increase is 4% per year and for cars with larger power than 100 kW the increase is 8% per year.

- **Technical standards scenario:**

- we introduce a 5%/year improvement of technical efficiency up to 2020 starting in 2011. This lead finally to CO_2 emission standards to 87 gCO_2/km by 2020.

- **Fuel switching scenario:**

- procurement of biofuels: we increase the amount of biofuels in a quota-based stile by 8%/year compared to 4% in the BAU-scenario; for biogas we use a different path resulting in a biogas use of 5 PJ in 2020. Moreover the specific CO_2 emissions of biofuels decrease by 5%/year compared to a decrease of 0.5% in the BAU-scenario. This leads by 2020 to 70% lower CO_2 emissions than fossil fuels.

- procurement of BEV and FCV: for BEV we start with a procurement of 5000 BEV in 2011 and reduce this amount by 1000 over the following years (compared to 2000 in the BAU-scenario and a reduction of 500 per year); for FCV we start with a procurement of 500 FCV in 2011 and reduce this amount by 50 over the following years (compared to 200 in the BAU-scenario and a reduction of 20 per year).

- **Ambitious policy (AP) scenario**

- all policies described above are implemented simultaneously.

The results of these single different policies are depicted in Figure 70.

8.2 Major results of the scenarios

The results of the BAU-scenario compared to the ambitious policy (AP) scenario up to 2020 for the EU-15 are shown in the figures 60 to 69.

The major perceptions are:

- In the BAU-scenario energy consumption as well as CO_2 emissions remain fairly stabile while in the AP-scenario both decrease to an about 20% lower level in 2020;
- Within the alternative fuels mainly due to increases in BD-1 and BE-1 in the AP-scenario by 2020 100PJ more AF are used; However, it must be noted that with about 700 PJ the potential for BF-1 with a limitation of BD-1 and BE-1 to 30% of arable land is almost exhausted.
- The vehicle stock as well as new registered cars increase very moderate in BAU while they decrease slightly in AP-scenario;
- Regarding alternative powertrain vehicles in total they grow less than in BAU-scenario (following the over-all trend for new vehicles) but due to procurement policies BEV and FCV increase in absolute numbers.

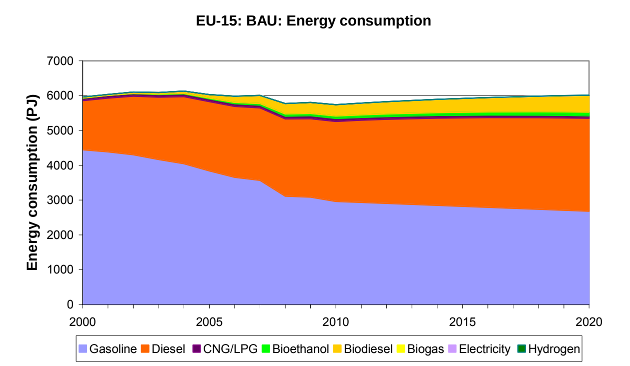


Figure 60a. Energy consumption in the BAU-scenario

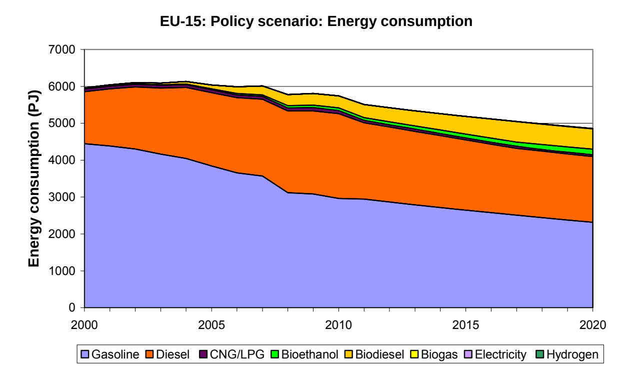


Figure 60b. Energy consumption in the AP-scenario

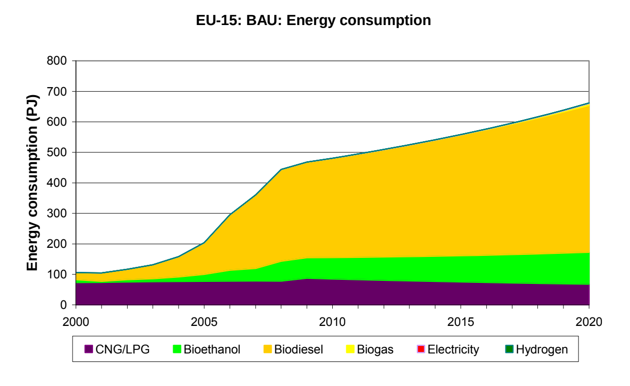


Figure 61a. Alternative energy consumption in the BAU-scenario

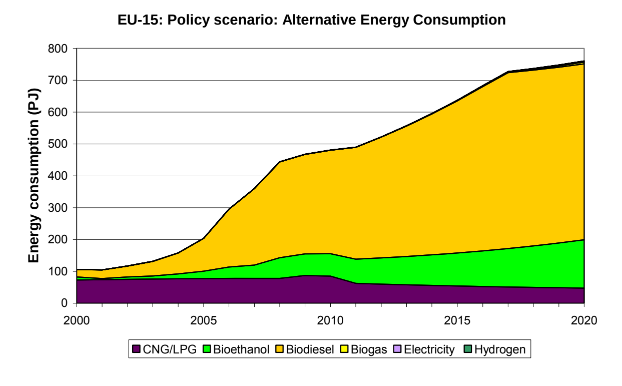


Figure 61b. Alternative energy consumption in the AP-scenario

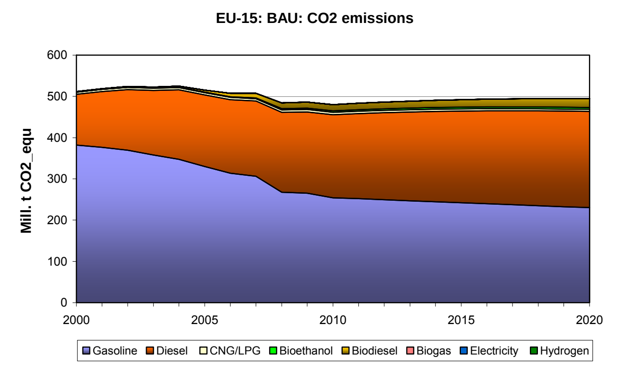


Figure 62a. CO_2 emissions in the BAU-scenario

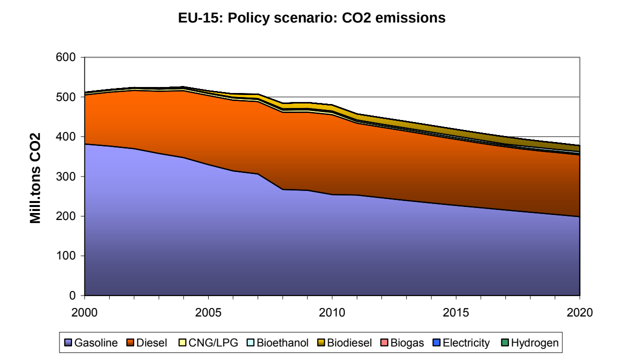


Figure 62b. CO_2 emissions in the AP-scenario

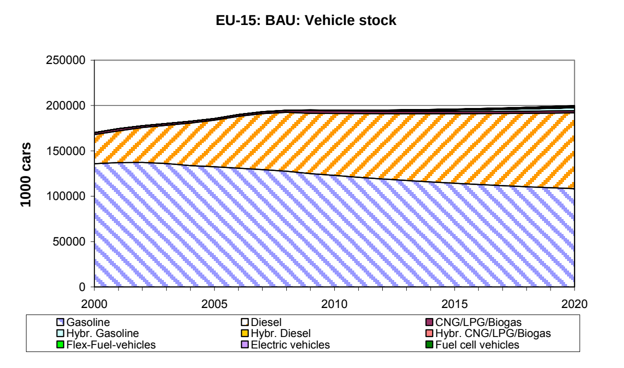


Figure 63a. Development of vehicle stock in the BAU-scenario

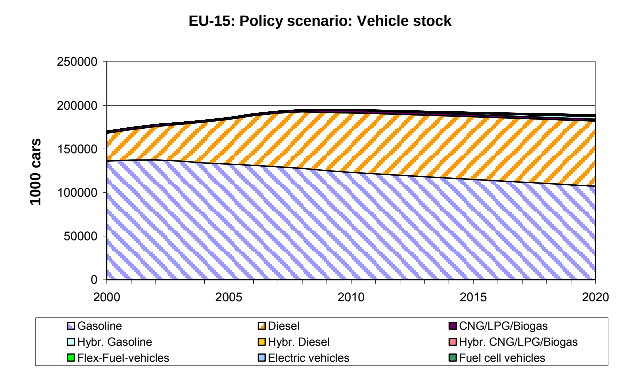


Figure 63b. Development of vehicle stock in the AP-scenario

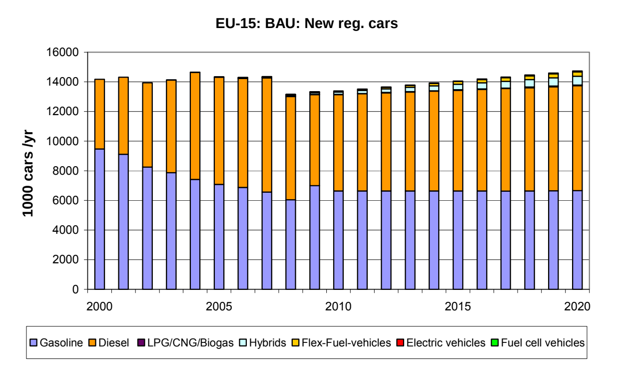


Figure 64a. Development of new registered cars in the BAU-scenario

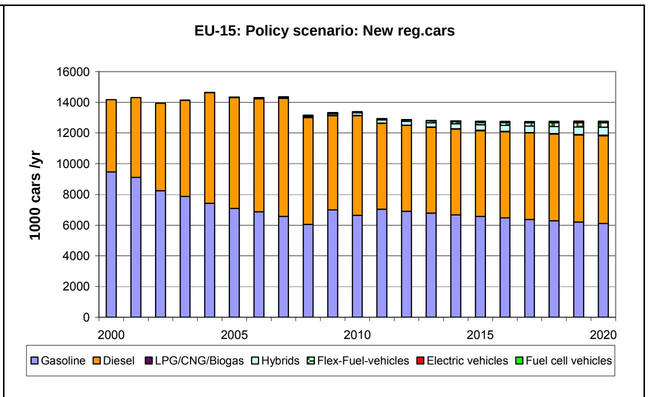


Figure 64b. Development of new registered cars in the AP-scenario

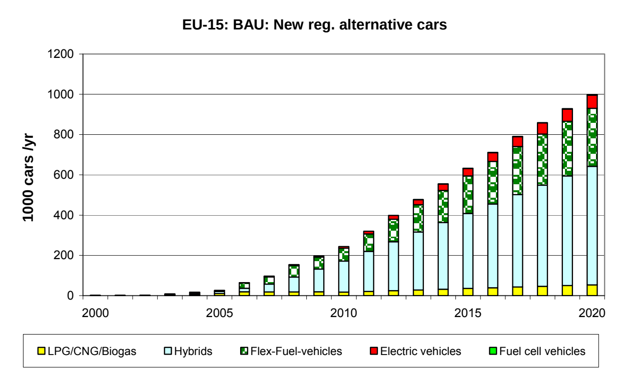


Figure 65a. Development of new registered alternative cars in the BAU-scenario

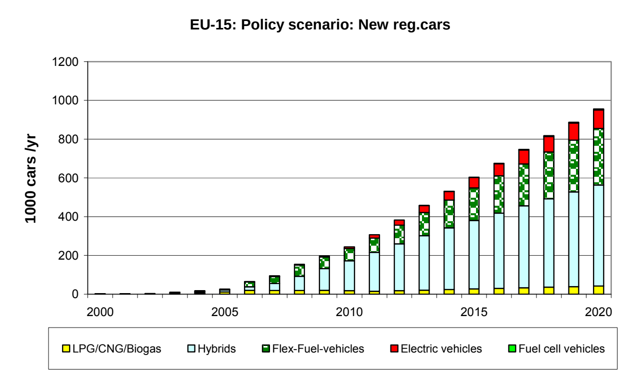


Figure 65b. Development of new registered alternative cars in the AP-scenario

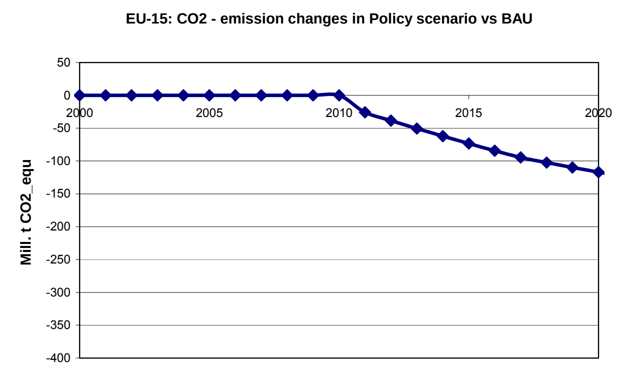


Figure 66. Comparison of CO_2 emission changes in the BAU-scenario and in the AP-scenario

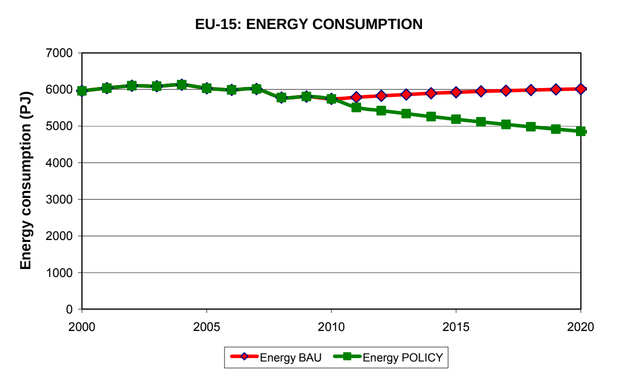


Figure 67. Comparison of energy consumption in the BAU-scenario and in the AP-scenario

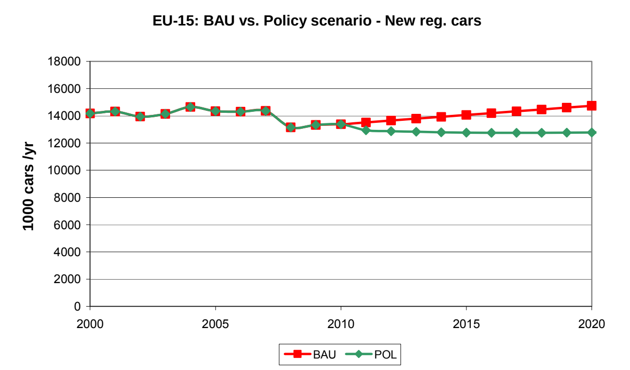


Figure 68. Development of new registered cars in the BAU-scenario and in the AP-scenario

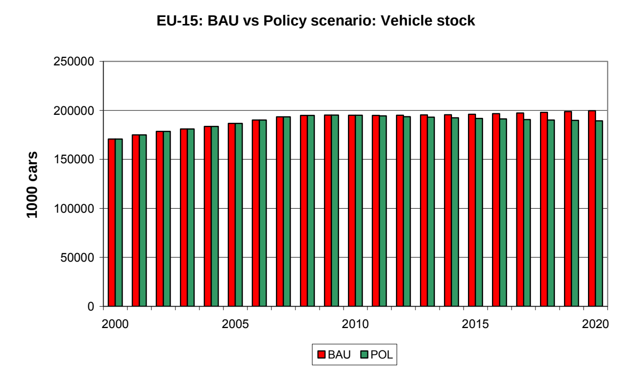


Figure 69. Comparison of vehicle stock development in the BAU- and the AP-scenario

Note that in Appendix D the corresponding results for selected single countries are documented.

8.3 Which measures contribute to CO_2 reduction ....

A comparison of the measures, which contribute to CO_2 reduction in BAU-scenario and in the ambitious policy (AP) scenario, is shown in Figure 70[20]. We can see that fiscal measures, standards and switch to biofuels contribute about the same amount.

[20] Note that all comparisons regarding CO_2 savings are calculated compared to 2008 because this was the last year for which we think that we can rely on sound data.

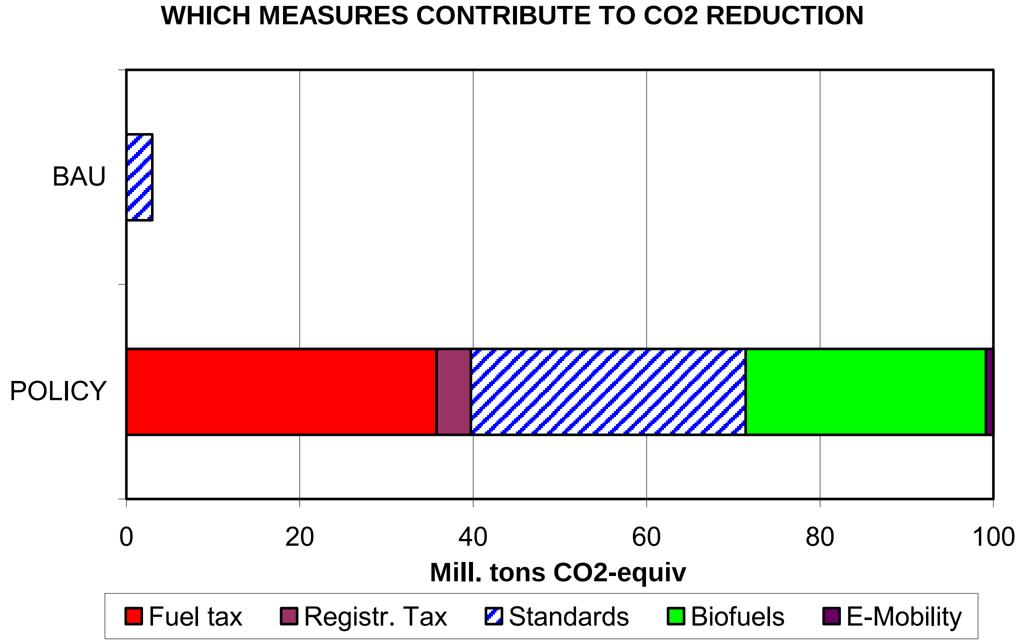


Figure 70. Comparison of which measures contribute to CO_2 reduction in BAU-scenario and in the Policy scenario

Figure 71 provides a comparison of the measure which contributes to CO_2 reduction in different scenarios. In the single scenarios we have the highest reduction in the Fiscal policy scenario followed by the Technical standard scenario and the Fuel switching scenario. The detailed results for the different scenarios are documented in the Appendix B.

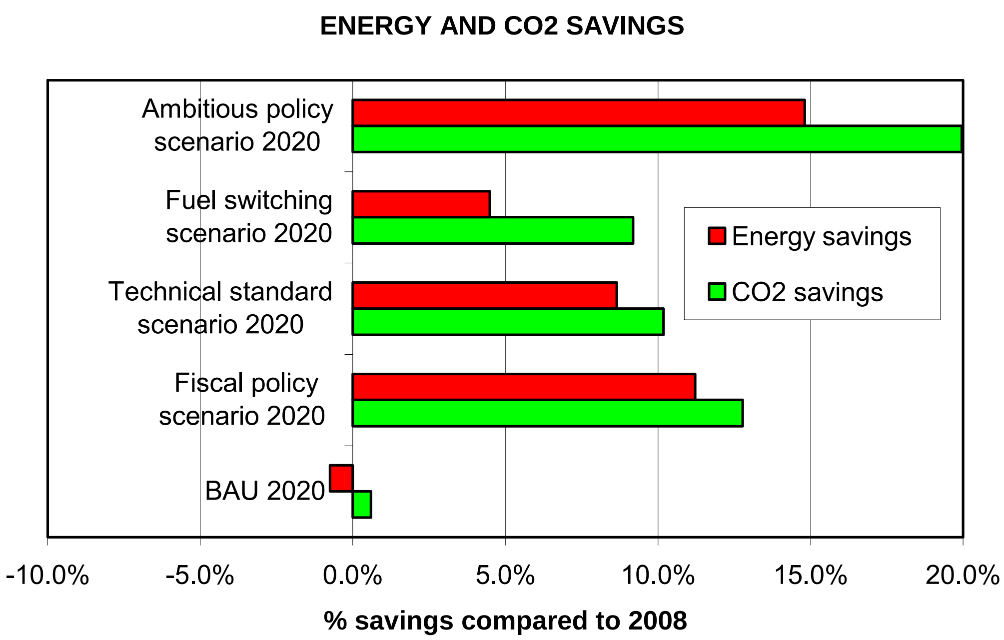


Figure 71. Comparison of which measures contribute to CO_2 reduction in different scenarios

8.4 … and at which costs?

Finally the crucial question is of course "How much do European citizens have to pay for achieving these goals?"

In this chapter we give a survey on the costs of various measures to head towards a least-cost approach. Figure 72 shows the basic principle of a least-cost approach. The different measures are put in a least-cost order including the possible saving potentials up to 2020 for achieving finally 100 million tons CO_2 reduction which corresponds to about 20% CO_2 reduction compared to 2008.

The method of approach of identifying these costs is based on calculation of total costs for society and resulting CO_2 reductions:

- For taxes these costs are the over-all welfare losses for society due to a tax divided by CO_2 savings;
- For the technologies we consider the additional investment costs of the technology and the energy cost reduction for the customers (purchasers of cars) respectively the increased producer surplus if the technology is produced in the region;
- For alternative fuels we have to consider the additional production costs minus the increased producer surplus if the technology is produced in the region.

For the last two categories it is furthermore important to consider the technological learning effect. Moreover, we have assumed that 75% of the value chain of new technologies is produced within the EU countries and hence these additional costs are converted into producer surplus.

The CO_2 reduction effects and the corresponding costs of the measures considered in the above categories for the aggregate of EU-15 countries are depicted in Figure 72.

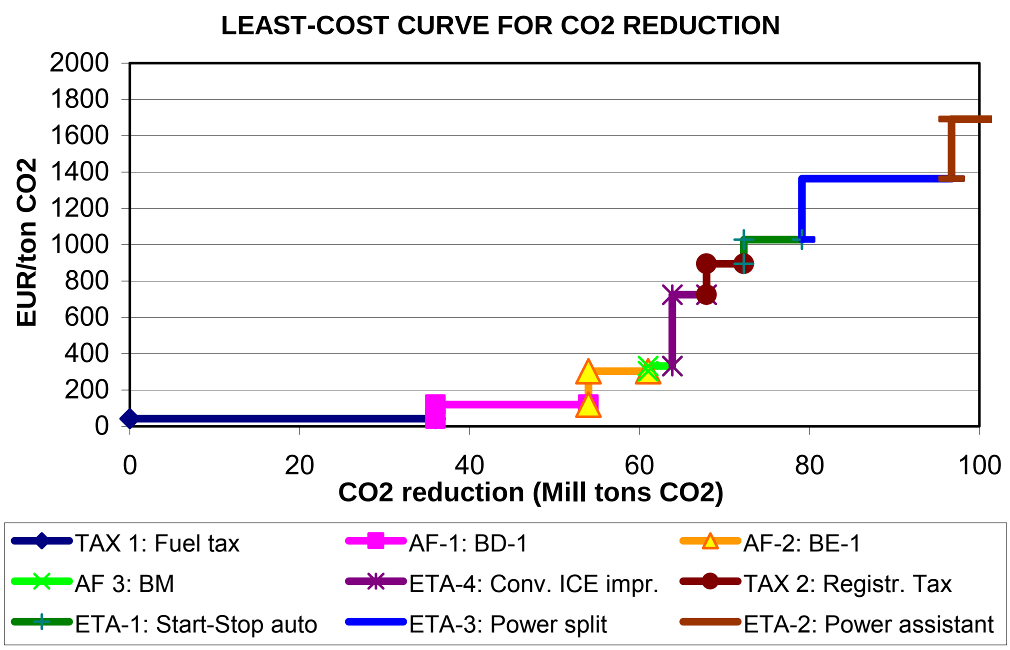


Figure 72. Least-cost curve for CO_2 reduction in passenger car transport in the EU-15 in 2010

The major result of this analysis is that the costs of taxes up to 36 million tons CO_2 reduction at a price of about 40 EUR/ton CO_2 are cheapest for society. So reducing especially the vkm driven and valuing the corresponding welfare loss has the first priority. Next cheapest is switch to biofuels first generation – biodiesel, bioethanol and biogas. This implies that by 2020 biofuels save at least 70% CO_2 compared to fossil fuels. Based on this pre-condition these biofuels in our scenario save 28 million tons CO_2 at costs between 180 and 350 EUR/ton CO_2. Measures of technical efficiency improvements – starting with start/stop automatics, over electric power assistants (mild hybrids) to power splits (full hybrids) and efficiency improvements of the classical gasoline and diesel engine – are in the range of about 1000 to 1500 EUR/ton CO_2. The most expensive measures are to promote fuel cell cars and battery electric vehicles with saving costs above 2000 EUR/ton CO_2. This is the reason why neither BEV nor FCV show up in this figure for least-cost reduction of 100 million tons CO_2. Also BF 2nd generation are not among the least-cost solutions up to 2020 and do, hence, not show up in Figure 72.

Yet, most of these technological solutions are still in the early phase of market introduction. Given that a continuous adaptation of these technologies takes place up to 2020 a remarkable cost reduction of these technologies is possible. However, even if this takes place up to 2020 fuel tax will remain the cheapest solution for CO_2 reductions.

The principle of the cost calculations can be visualized by means of the following example. We analyze the costs of hybrid electric vehicles. They save about 0.9 litre gasoline per 100 km. With a driving distance of 12000 km this is 108 litre/car and year or 252 kg CO_{2_equ}. The corresponding investment costs are 1700 EUR/car or 340 EUR/car/year with a C.R.F: of 0.2. Assuming that 75% of this investment contributes to producer surplus of the European companies, the costs are 85 EUR/0.25 ton CO_{2_equ}, this is about 340 EUR/ton CO_{2_equ}.

A result of Figure 72 is that the quantities of the measures fit very good with the shares of our ambitious scenario analysis. However, neither BEV nor FCV show up in this figure for least-cost reduction of 100 million tons CO_2.

An important aspect is that a specific least-cost measure could be the voluntary change to smaller cars. However, this measure must be brought about by changes in awareness and not only by financial incentives.

The costs of fuel taxes C_{CO2_FT} for society are calculated as:

$$C_{CO_{2\_FT}} = \frac{\Delta C_{FT}}{\Delta CO_{2\_FT}} = \frac{\tau \cdot \Delta E}{2 \cdot \Delta E \cdot f_{CO_2}} = \frac{\tau}{2 \cdot f_{CO_2}} \qquad (27)$$

with:

ΔC_{FT}.........Costs of a fuel tax (EUR);
ΔCO_{2_FT}...CO_2 reduction of a fuel tax (tons CO_{2_equ})
τ........... Fuel tax

The costs of a new car technology or an efficiency improvement of cars is calculated as:

$$C_{CO_{2\_ETA}} = \frac{\Delta C_{ETA}}{\Delta CO_{2\_ETA}} = \frac{\Delta IC_{ETA} \cdot C.R.F. + (FI_i vkm_i P_i)(FI_j vkm_j P_j) - \Delta PS}{(E_j f_{CO_{2\_j}} - E_i f_{CO_{2\_i}})} \quad (28)$$

with:

ΔIC_{ETA}.....Investment costs of a new technology (EUR);

ΔPS……...Producer surplus

Note that in ALTER-MOTIVE policies for new technologies are mainly focusing on procurement policies. That is to say, the cars are purchased by companies like electric utilities, car-sharing firms and not primarily by individuals.

The costs of alternative fuels for society are:

$$C_{CO_{2\_AF}} = \frac{\Delta C_{AF}}{\Delta CO_{2\_AF}} = \frac{(C_{BF} - C_{FF})\Delta E_{BF}}{\Delta E_{BF}(f_{CO_{2\_FF}} - f_{CO_{2\_BF}})} \quad (29)$$

9. Action Plan

The derivation of an Action Plan was the final target of this project. The objective of the Action Plan is to provide key findings and targeted recommendations for policy makers and stakeholders (e.g. car manufactures civil servants and officers in transport ministries) regarding the activities that could improve the environmental performance of the transport system and bring EU countries closer to the EU targets for 2020.

To meeting this objective we proceeded as depicted in Figure 73. To provide recommendations for policy makers and stakeholders regarding the activities that could improve the environmental performance of the transport system we have in the scope of the ALTER-MOTIVE project done comprehensive top-down and bottom-up analysis related to AF and AAMT. Within the bottom-up analyses we have collected and documented about 130 individual case studies – see www.alter-motive.org – and investigated around 80 of these case studies in detail from economic, ecological and energetic point-of-view, see Cebrat, Ajanovic (2010).

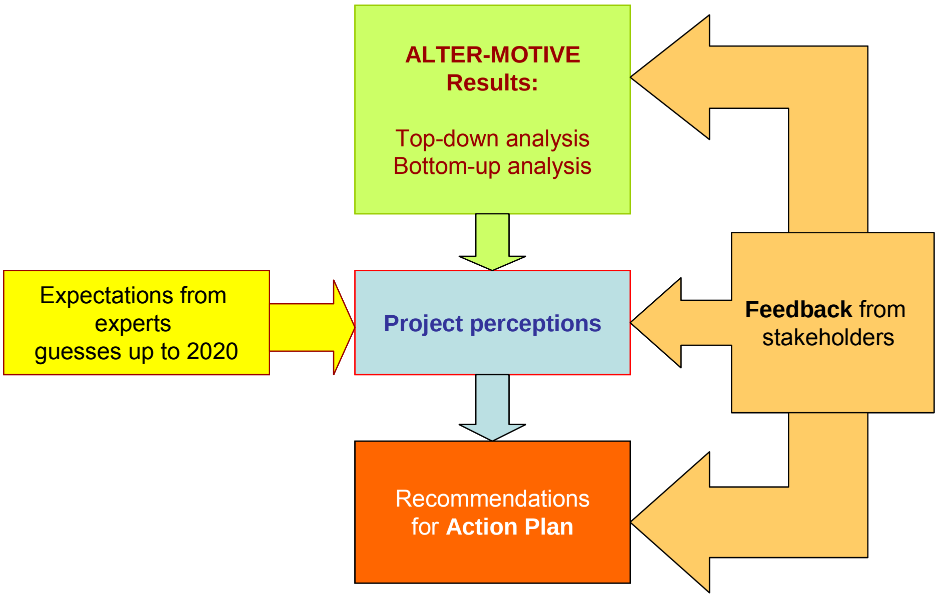


Figure 73. Action plan – method of approach

However, beside our analyses we have also considered stakeholders', policy makers' and experts' opinions. To discuss the proposals of the Action Plan and project results and to receive national feedback, nine national workshops were organised in different EU countries (Austria, France, Germany, Greece, Italy, Portugal, Poland, The Netherlands, Sweden).

Also within the ALTER-MOTIVE website (www.alter-motive.org) we have created a discussion forum trying to collect feedback on some of our ideas and results.

Finally, to show the impact of different policy actions on the future development in passenger car transport as well as on the reduction of CO_2 emissions we have derived scenarios.

These scenarios should help policy makers to visualize short and mid-term effect of implemented policy measures. The scenarios are described in Chapter 8.

Derived from the perceptions described above our suggestions for action – based on further scenario analysis in ALTER-MOTIVE – lead to the following recommendations:

First, actions that should be implemented immediately are:

- *Introduce a green bonus scheme for CO_2 reduction in passenger transport*

Aside from the technology analyses conducted in ALTER-MOTIVE one major perception emerged regarding direct monetary incentives for individuals to change their personal short-term and long-term behaviour.

It is to introduce a green bonus/malus system for every citizen that provides monetary incentives for car sharing, turning-in or not owning a car (incl. scrapping scheme), using low-emission highly efficient vehicles and including (plus and minus) links to an ownership tax and to the use of public transport.

This system will work like an annual tax declaration and can be seen as a forerunner for a personal carbon allowances system.

- *Convert fuel taxes to CO_2 based tax and adapt at a 5% higher level per year*

Fuel taxes in Europe have been a reason why fuel consumption as well as CO_2 emissions of passenger cars compared to e.g. USA has been lower.

We suggest that all excise taxes are converted to a CO_2 emissions based tax system. This tax should be on a 5% higher level per year and take into account the WTW CO_2 emissions of the corresponding fuels.

Moreover, these additional tax revenues should be used to:

* reduce taxes on wages and ensure balanced burden for different social groups;

* provide incentives for using zero-emission transport modes (walking, biking …);

* improve performance of public transport.

- *New vehicles: tighten requirements to the car manufacturing industry*

Standards for the aggregate of all segments of sold vehicles in every country should be enforced by 6% per year. This is linked to an emission target of 87 g CO_2/km by 2020 based on the test cycle monitoring approach.

Yet the major effect could mainly come about from a switch to smaller cars. In this context it is important that car producers are further committed to market a higher share of smart cars with less kW and lower CO_2 emissions.

- *Implement a size-dependent registration fee for cars and limit depreciation of company cars by size*

A size-dependent registration fee for cars would provide a monetary incentive for customers to purchase smaller cars. Moreover, for company cars there should be a clear size-dependent limitation for depreciation to medium-size car costs and taxes.

- *Continue to procure case studies*

Our analysis of more than 130 case studies practically implemented on local level shows that virtually all of these initiatives received very positive feed-back and contribute to further acceptance and learning about AF and AAMT. This is many cases especially a sign that the public is a fore-runner regarding these new technologies. We encourage local authorities and initiatives from NGOs strongly to pursue such projects further. The collection of examples on the A-M homepage is a very good starting point for this, providing ideas for what can be done and documenting lessons learned regarding empirical performance.

Second, actions that should be implemented up to 2020 are:

- *Develop infrastructure for "emission free" vehicles*

Battery electric vehicles and fuel cell vehicles may to some extent contribute to a relief of over-all CO_2 emissions and may especially in cities contribute to improve air quality.

Yet, the potentials for market penetration and CO_2 reduction up to 2020 are very limited for all three major technologies (BEV, FCV and FFV). In an optimistic scenario the number of BEV in EU-15 will grow to a stock of about 528.000 cars in 2020 leading to less than 1% CO-reduction (because the overall stock of cars remains at about 200 millions).

In addition, the overall ecological performance of BEV strongly depends on how electricity is generated, how the battery performs ecologically and whether actually conventional passenger cars are substituted or additional transport is triggered. Moreover, in parallel to the market introduction of BEV the corresponding deployment of new renewable electricity capacities must be ensured and proven by certificates.

Regarding infrastructure for E-mobility: In most cities an infrastructure sufficient for the needs of the next years already exist. No further financial public support is needed. There should rather be an agreement between the electricity supply of the industry and (local) policy makers to provide a minimum reliable infrastructure at connection points to public transport, park & ride, airports and other crucial locations. Hence, it is recommended that the electricity supply industry and municipalities design joint roadmaps for an efficient development of infrastructure.

Regarding infrastructure for hydrogen vehicles: Experts - especially from Germany - expect that up to 2020 the market introduction of H_2 based vehicles will have started at least in some parts of Europe. We suggest that based on the model region concept for specific areas road-maps considering infrastructure and market introduction of cars will be developed.

- *Biofuels first generation: tighten standards – ensure better ecological performance*

Biofuels are expected in many policy directives and scientific papers to have the potential to contribute significantly to reducing fossil fuel consumption and corresponding CO_2 emissions. Yet, they are still under discussion mainly because of their currently poor ecological and economic performance. To cope with this problem, measures must be implemented that ensure that the ecological performance of these BF-1 improves and net specific CO_2 emissions are reduced significant up to 2020.

One strategy to cope with these problems is to pursue a strict path towards an improvement of BF-1 to "Renewable fuels" (see EC, 2009) leading to 70% less CO_2 emissions of BF-1 by 2020 compared to about 45% today. This is strongly recommended along with certification and monitoring schemes.

In addition passenger cars might not be the priority target for biofuels. We recommend to revisit very carefully, whether the use of biofuels in other sectors where less alternatives exist, e.g. freight transport could make more sense.

Third, actions that focus on the long run, after 2020 are:

- *Emphasize efficient R&D for second generation biofuels and hydrogen*

The time horizon of this project is 2020. Within the remaining period, it is very unlikely that either 2nd generation biofuels or hydrogen enter the market in a significant quantity. Yet, to harvest the benefits of these fuels in the time after 2020 it is important to undertake the necessary steps in the next years.

For hydrogen it is important that the preparation of the ideal infrastructure is planned and forced continuously. Moreover, it is very important that R&D is intensified focussing especially on a more efficient conversion of feedstock and primary energy carriers into these alternative fuels. This should finally also lead to more cost-effective production paths and market competitiveness beyond 2020.

THE CORE RULES OF ALTER-MOTIVE:

- Introduce a green bonus scheme for CO_2 reduction in passenger transport
- Convert fuel taxes to CO_2 based tax and adapt at an 5% /year higher level
- New vehicles: tighten requirements to the car manufacturing industry
- Implement a size-dependent registration fee for cars and limit depreciation of company cars by size
- Extend the procurement of case studies
- Develop infrastructure for "emission free" vehicles
- Tighten standards and ensure better performance of biofuels first generation
- Emphasize efficient R&D for second generation biofuels and hydrogen

10. Conclusions and recommendations

The major conclusions of this project as also outlined in the „Key messages“ of the Action Plan are:

The EU aims to reduce CO_2 emissions by 20% in 2020. Car passenger transport is one of the few sectors with continuously increasing CO_2 emissions and, hence, must deliver a remarkable contribution to meeting this goal. Yet, given this recent trend and the slow response of the car park in responding to technical solutions it is clear that this is a very tough challenge.

The core objective of this project was to contribute to meeting this target. In this context we state that since the start of this project in 2008 many conditions changed and actions which are proposed in this report and which are the outcomes of our investigations has in similar ways in the meantime been proposed by others, e.g. also by the EC.

Our key message for European policy is: Be rigorous and set clear priorities for the following two targets that have to be pursued now: **improve energy efficiency** and **reduce energy consumption**. This statement is important for the following reasons: To meet the 2020 target a major policy of the EU is to implement lower CO_2 emission standards. Indeed, we consider this enforcement of standards as a very important policy measure to reduce fuel consumed and CO_2 emitted per km driven.

But improving energy efficiency alone does not necessarily lead to an equivalent energy and CO_2 saving effect. We have seen this problem in recent years in passenger car transport from two major features:

- Europeans purchased larger cars which reduced savings that were expected due to efficiency improvements by about half;
- car owners increased vehicle km driven – to some extent due to lower service prices due to lower fuel intensity (but also due to increase in income);

As a consequence, these CO_2 emission standards will also lead to cheaper costs per km driven and hence, as one response, to more driving activities and larger cars. So a very important aspect is that accompanying to standards there is an additional focus on energy conservation by introducing fuel taxes.

The measures described are also important because of the following sobering conclusions with respect to the future contributions of AF and AAMT. These are:

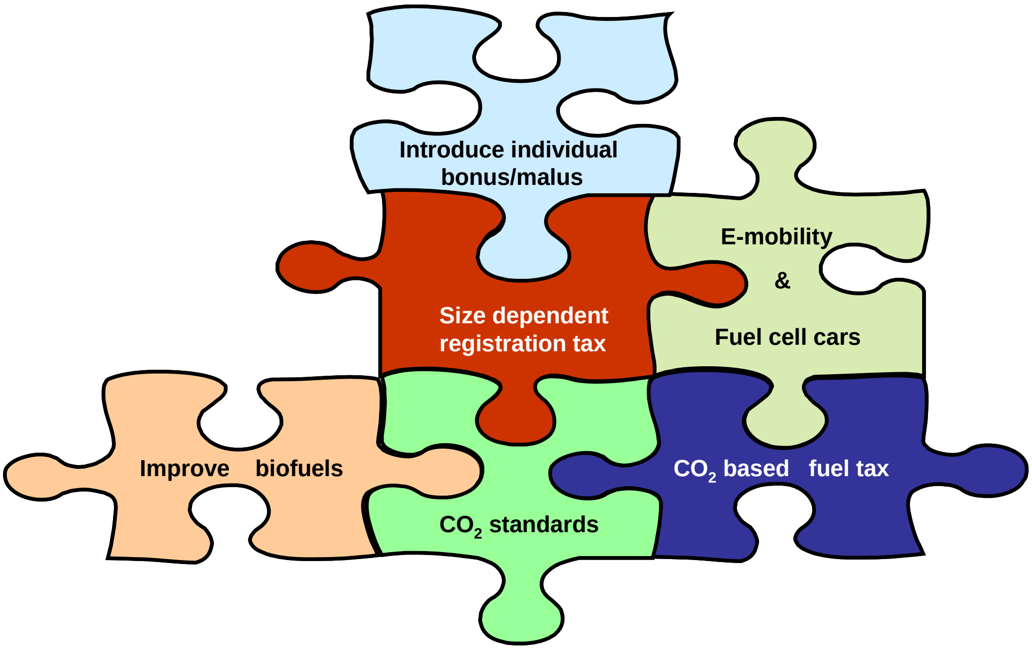
Regarding biofuels the potentials of BF-1 are to a large extent already exhausted, especially for BD-1 and BE-1. Moreover, they have to prove a better ecological performance up to 2020 to be considered seriously as CO_2 mitigating fuels. The market prospects of BF-2 today are very uncertain. The major problems are the currently still very high capital costs and the lack of continuous deployment of large production plants. Yet up to 2020 there are no signs that they will enter the market in considerable amounts.

With respect to AAMT the potentials for market penetration and CO_2 reduction of BEV and FCV up to 2020 are very limited. If they may reach in a very optimistic scenario 1% market share by 2020 they will straightforward only contribute at the maximum in the same range to CO_2 reduction. This will not provide a significant contribution to the 2020 CO_2 reduction target.

Yet it is also important to state that the situation is not the same in all countries. To illustrate this we have compiled specific country boxes which are documented in Appendix C. These boxes has been put together by national project partners and document in a clear and concise way the major problems and focuses in the countries participating in this project regarding mainly the perspectives of AF and AAMT in the corresponding countries .

So two final statements are important:

- Firstly, of course, in the long-term only a very broad portfolio of policy instruments (taxes, standards, quotas, emissions free-zones…) and new technologies (BEV, FCV …) can reduce energy consumption and straightforward CO_2 emissions significantly. Yet, there will not be any measure or technology that has the capability to solve all problems alone;



- Secondly, it is currently of **urgent importance** that there is a clear **focus** on implementing the two instruments with highest short-term effects: **standards and taxes**. And a simple but very important key message is that the intended targets and policies are pursued more strictly and more tight and continuous pressure is put on the involved stakeholders: European and national policy makers, car manufacturing companies and also European citizens regarding their driving and car purchase behaviour.

Only if we manage to implement very soon the above described **urgent** measures and if we pave the way towards the **long-term goals** the vision of a sustainable transport system will come closer to reality – even before 2020.

REFERENCES

ACEA. European Automobile Manufacturer's Association. Tax Guide 2011. www.acea.be

ACEA, 2011: Why diesel?. www.acea.be

Ajanovic A. ed., 2009: Country review report, ALTER-MOTIVE, Deliverable D3

Ajanovic A., R. Haas, 2011: On the effectiveness of standards vs taxes for reducing CO_2 emissions in passenger car transport Europe. Risø International Energy Conference 2011.

ALTER-MOTIVE database: www.alter-motive.org

Allan R et al. (2007). 2007 Bali climate declaration by scientists. Climate Change Research Centre, University of New South Wales (UNSW), Sydney, Australia. Available at http://www.ccrc.unsw.edu.au/news/2007/Bali.html

Bunzeck I., Bree B., Uyterlinde M., 2010: Strategies for the introduction of alternative fuels and automotive technologies: Analysis of effective policy instruments, ALTER-MOTIVE, D14

Cebrat G., Ajanovic A.,2010: Case studies evaluation report: Summary report on case studies of pilot projects including documentation and comprehensive assessment: ALTER-MOTIVE, D12

CONCAWE, 2008: Well-to-Wheels analysis of future automotive fuels and powertrains in the European context, TANK-to-WHEELS Report
Version 3, October 2008

CONCAWE: Well-to-Wheels analysis of future automotive fuels and powertrains in the European context, WELL-TO-TANK Report APPENDIX 2, Description and detailed energy and GHG balance of individual pathways, November 2008a

DB, 2009: Database CO_2 emissions monitoring: Decision No 1753/2000/EC of the European Parliament and of the Council of 22 June 2000. Database to monitor the average specific emissions of CO_2 from new passenger cars, 2009

EBTP, European biofuels technology platform, www.biofuelstp.eu

EC, 2007a: An energy policy for Europe, SEC(2007)12. Communication from the Commission to the European Council and the European Parliament, Commission of the European Communities, Brussels, 10.1.2007.

EC, 2007: COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT; Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles; (COM(2007) 19 final)

EC, 2008. DIRECTIVE 2009/0016/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources, COM(2008) 19 final, 23.1.2008,

EC, 2009a: DIRECTIVE 2009/18/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council

EC, 2009b: DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

EC, 2009c. DIRECTIVE 2009/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009, amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC

EC, 2010: Progress report on implementation of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles, 2010, (COM 2010, 656)

EEA, 2006: How much Bioenergy can Europe produce without harming the environment? Report 07/206, European Environment Agency, Copenhagen, Denmark

EEP, 2011: Europe's Energy Portal, http://www.energy.eu/ (effective March 2, 2011)

EU, 2010: EU Energy in Figures, 2010: Green House Gas Emissions (GHG) from Transport by Mode

EU, 2011: Reducing CO2 emissions from passenger; European Commission, Climate Action: http://ec.europa.eu/clima/policies/transport/vehicles/cars_en.htm

EUROSTAT database: http://epp.eurostat.ec.europa.eu

EPA, 2005: Interim Report: New Powertrain Technologies and Their Projected Costs. U.S. Environmental Protection Agency, Office of Transportation and Air Quality.

FAPRI (Food and Agricultural Policy Research Institute) - http://www.fapri.iastate.edu/tools/outlook.aspx

Feenstra, C.F.J.Y., 2010: Copy-Paste Policies. Analysis of transferability of successful policies related to alternative fuels and alternative automotive concepts in transport, ALTER-MOTIVE, D9

F.O. Lichts. World Ethanol Markets, The Outlook to 2015. An F.O. Licht Special Study, 2006

Greene, D. L., 1997. Theory and empirical estimates of the Rebound Effect for the U.S. transportation sector. ORNL.

IEA, 2008: International Energy Agency,World Energy Outlook 2008.

IEA, 2008a: Energy Technology Perspectives 2008. Paris: International Energy Agency.

IEA, 2010: International Energy Agency, IEA Statistics, Energy Prices & Taxes, 2010

JAMA, 2008: Reducing CO_2 emissions in the global road transport sector. Japan automobile manufacturers association. Inc., August 2008

Kleindienst Muntwyler, S., M. Van Walwijk, A. Mattucci, S. Rieder, T. Månsson, M., 2010: Deployment strategies with hybrid, electric, and alternative fuel vehicles. A report of the IEA project "Deployment strategies for hybrid, electric and alternative fuel vehicles", 2010.

Kobayashi, S., Plotkin, S., & Ribeiro, S. K. (2008). Energy efficiency technologies for road vehicles. Energy Efficiency .

ODYSSEE database : http://www.odyssee-indicators.org/database/database.php

Panoutsou C., Eleftheriadis J., Nikolaou A.,, 2009: Biomass supply in EU27 from 2010 to 2030, Energy Policy 37, 5675–5686

Regulation (EC) No 443/2009: Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles

Schipper L., 2008.: Automobile Fuel: Economy and CO2 Emissions in Industrialized Countries: Troubling Trends through 2005/6, Submitted to "Transport Policy", 2008

Sterner, T., 2007. Fuel taxes – an important instrument for climate policy, Energy Policy, 35, 3194-3202.

Toro F., Jain S., Reitze F., Ajanovic A., Haas R., Furlan S., Wilde H., 2010: State of the art for alternative fuels and alternative automotive technologies, ALTER-MOTIVE, D8

UNFCCC (2009). Copenhagen Accord, (FCCC/CP/2009/L.7). The website of United Nations Framework Convention on Climate Change http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf

Walker, I. O., F. Wirl, 1993. Irreversible Price-Induced Efficiency Improvements: Theory and Empirical Application to Road Transportation. The Energy Journal 14(4), 183-205

APPENDIX A: Car taxation – EU summary

A.1 Taxes on acquisition / registration

A tax on acquisition is tax paid once, by each vehicle owner, for each vehicle purchased and entered into service (sales tax, registration tax).

As shown in Table A-1., the criterions for registration taxes are different across Member States of the European Union. The most of criterions are based on fuel consumption, on cylinder capacity, CO_2 emissions and price.

The range of Value Added Tax (VAT) in EU-27 is between 15% and 25%, see Table A.1.

Table A-1. Taxes on Acquisition (Source: ACEA, 2011, information from project partners)

Country	VAT	Registration Tax
Austria	20%	Based on fuel consumption Maximum 16% + bonus/malus
Belgium	21%	Based on cc + age CO2 emissions (Wallonia)
Bulgaria	20%	The "product tax" is defined according to the age of the cars and is paid once, upon first acquisition or registration of the vehicle. The taxes for 2010 are defined, as follows: for new cars - 133 BGL (68 €) cars up to 5 years - 182 BGL (93 €) cars between 6-10 years - 230 BGL (118 €) cars, older than 10 years - 242 BGL (124 €)
Cyprus	15%	Based on cc + CO2
Czech Republic	20%	None
Germany	19%	None
Denmark	25%	105% up to DKK 79,000 180% on the remainder
Estonia	20%	None
Spain	18%	Based on CO2 emissions From 4.75% (121-159g/km) to 14.75% (200g/km or more)
Finland	23%	Based on price + CO2 emissions Tax % = 4.88 + (0.122 x CO2) Min. 12.2%, max. 48.8 %
France	19.6%	Based on CO2 emissions From € 200 (151 to 155g/km) to € 2,600 (above 240g/km)
Greece	23%	Based on cc + emissions 5% - 50% Luxury tax 0 - 40%
Hungary	25%	Based on cc+ emissions
Ireland	21%	Based on CO2 emissions 14 to 36%
Italy	20%	Based on kilowatt /weight/seats
Lithuania	21%	LTL 50
Luxembourg	15%	None
Latvia	21%	Based on CO2 emissions
Malta	18%	Based on price, CO2 emissions, vehicle length
The Netherlands	19%	Based on price + CO2 emissions
Poland	23%	Based on cc 3.1% - 18.6%
Portugal	23%	Based on cc + CO2 emissions
Romania	24%	Based on cc + emissions + CO2
Sweden	25%	None
Slovenia	20%	Based on price + CO2 emissions
Slovakia	19%	None
United Kingdom	20%	None

A.2 Taxes on ownership

Taxes on ownership are paid annually, regardless of how often the vehicle is used.

For passenger cars taxes on ownership are mostly based on kilowatt, cylinder capacity, CO_2 emissions, fuel consumption and weight, see Table A-2.

For commercial vehicles taxes on ownership is mostly based on weight.

Table A-2. Taxes on ownership (Source: ACEA, 2011)

Country	Passenger Cars	Commercial Vehicles
Austria	Kilowatt	weight
Belgium	Cylinder capacity	weight, axles
Bulgaria	Kilowatt	Weight, axles
Cyprus	Cylinder capacity, CO2 emissions	NA
Czech Republic	None	Weight, axles
Germany	CO2 emissions	Weight, exhaust emissions, noise
Denmark	Fuel consumption, weight	Fuel consumption, weight
Estonia	None	Weight, axles suspension
Spain	Horsepower	Payload
Finland	CO2 emissions/ Weight x days	Weight x days
France	None	Weight, axles, suspension
Greece	CO2 emissions	Weight
Hungary	Kilowatt	Weight
Ireland	CO2 emissions/ cylinder capacity	Weight
Italy	Kilowatt, exhaust emissions	Weight, axles, suspension
Lithuania	None	Weight, axles, suspension
Luxembourg	CO2 emissions	Weight, axles
Latvia	Weight	Weight
Malta	Cylinder capacity	NA
The Netherlands	Weight, province	Weight
Poland	None	Weight, axles
Portugal	Cylinder capacity, CO2 emissions	Weight, axles, suspension
Romania	Cylinder capacity	Weight, axles
Sweden	CO2 emissions/ weight	Weight, axles, exhaust emissions
Slovenia	None	NA
Slovakia	None	Weight, axles
United Kingdom	CO2 emissions/ cylinder capacity	Weight, axles, exhaust emissions

NA-not available

A.3 Taxes on fuel

Taxes on motoring are taxes on fuels. Excise duties on fuels in EU countries are shown in Table A-3.

Table A-3. Excise duties on fuels in €/1,000 litres
(Status: 1 January 2011, Source: European Commission)

Country	Unleaded Petrol	Diesel
Austria	442	347
Belgium	614	335
Bulgaria	350	307
Cyprus	359	330
Czech Republic	505	431
Germany	655	470
Denmark	571	386
Estonia	423	393
Spain	425	331
Finland	627	364
France	607	428
Greece	610	382
Hungary	444	360
Ireland	543	449
Italy	564	423
Lithuania	434	330
Luxembourg	462	302
Latvia	380	274
Malta	459	352
The Netherlands	714	421
Poland	390	302
Portugal	583	364
Romania	348	293
Sweden	542	425
Slovenia	514	425
Slovakia	514	368
United Kingdom	617	617
EU minimum rates	359	330

A.4 Overview of CO_2 based motor vehicle taxes in the EU

Since the motor vehicle taxes in most of the EU Member States are totally or partially based on CO_2 emissions and/or fuel consumption, Table A-4 provides an overview of these taxes.

Table A-4. Overview of CO_2 based motor vehicle taxes in the EU (Source: ACEA, 2011)

Country	CO_2/Fuel consumption taxes
AT	A fuel consumption tax (Normverbrauchsabsage or NoVA) is levied upon the first registration of a passenger car. It is calculated as follows: - Petrol cars: 2% of the purchase price x (fuel consumption in litres – 3 litres) - Diesel cars: 2% of the purchase price x (fuel consumption in litres – 2 litres) Under a bonus-malus system, cars emitting less than 120g/km receive a maximum bonus of € 300. Cars emitting more than 160g/km pay a penalty of € 25 for each gram emitted in excess of 160g/km. Since 1 March 2011, there is an additional penalty of € 25 for each gram emitted in excess of 180 g/km and another penalty of € 25 for each gram emitted in excess of 220 g/km. These penalties are cumulative. Alternative fuel vehicles attract a bonus of maximum € 500. In addition, diesel cars emitting more than 5 mg of particulate matter per km pay a penalty of maximum € 300. Conversely, diesel cars emitting less than 5 mg of particulate matter per km and less than 80 g of NOx per km attract a bonus of maximum € 200. The same applies to petrol cars emitting less than 60 g of NOx per km.
BE	1. Tax incentives are granted to private persons purchasing a car that emits less than 115g CO2/km. The incentives consist of a reduction of the invoice price with the following amount: - Cars emitting less than 105g/km: 15% of the purchase price, with a maximum of € 4,640 - Cars emitting between 105 and 115 g/km: 3% of the purchase price, with a maximum of € 870 2. The company car tax is based on CO2 emissions. 3. The deductibility under corporate tax of expenses related to the use company cars (50 to 120%) is linked to CO 2 emissions. 4. The Walloon Region operates a bonus-malus system whereby new cars emitting less than 99 g/km obtain a bonus of € 600 and cars emitting more than 155 g/km pay a penalty (maximum € 1,500 for cars emitting more than 245 g/km).
CY	1. The rates of the registration tax (based on engine capacity) are adjusted in accordance with the vehicle's CO2 emissions. This adjustment ranges from a 30% reduction for cars emitting less than 120 g/km to a 20% increase for cars emitting more than 250 g/km. 2. The rates of the annual circulation tax (based on engine capacity) are reduced by 15% for cars emitting less than 150 g/km.
DK	1. The annual circulation tax is based on fuel consumption. - Petrol cars: rates vary from 520 Danish Kroner (DKK) for cars driving at least 20 km per litre of fuel to DKK 18,460 for cars driving less than 4.5 km per litre of fuel. - Diesel cars: rates vary from DKK 160 for cars driving at least 32.1 km per litre of fuel to DKK 25,060 for cars driving less than 5.1 km per litre of fuel. 2. Registration tax (based on price): An allowance of DKK 4,000 is granted for cars for every kilometre in excess of 16 km (petrol) respectively 18 km (diesel) they can run on one litre of fuel. A supplement of DKK 1,000 is payable for cars for every kilometre less than 16 km (petrol) respectively 18 km (diesel) they can run on one litre of fuel.
FI	1. The registration tax is based on CO2 emissions. Rates vary from 12.2% for cars emitting 60g/km or less to 48.8% for cars emitting 360g/km or more. The system is fully linear and technologically neutral. 2. The annual circulation tax is based on CO2 emissions for cars registered since 1 January 2001 (total mass up to 2,500 kg) or 1 January 2002 (total mass above 2,500 kg) respectively and for vans registered since 1 January 2008. Rates for cars vary from € 20 to € 600.
FR	1. Under a bonus-malus system, a premium is granted for the purchase of a new car when its CO2 emissions are 110 g/km or less. The maximum premium is € 5,000 (below 60 g/km). An additional bonus of € 300 is granted when a car of at least 15 years old is scrapped and the new car purchased emits maximum 110 g/km. A malus is payable for the purchase of a car when its CO2 emissions exceed 150 g/km. The maximum tax amounts to € 2,600 (above 240 g/km). In addition to this one-off malus, cars emitting more than 245 g/km pay a yearly tax of € 160. 2. The regional tax on registration certificates ("carte grise") is based on fiscal horsepower, which includes a CO 2 emissions factor. Tax rates vary between € 27 and € 46 per horsepower according to the region. 3. The company car tax is based on CO2 emissions. Tax rates vary from € 2 for each gram emitted for cars emitting 100g/km or less to € 19 for each gram emitted for cars emitting more than 250g/km.

Country	CO_2/Fuel consumption taxes
DE	The annual circulation tax for cars registered as from 1 July 2009 is based on CO2 emissions. It consists of a base tax and a CO2 tax. The rates of the base tax are € 2 per 100 cc (petrol) and € 9.50 per 100 cc (diesel) respectively. The CO2 tax is linear at € 2 per g/km. Cars with CO2 emissions below 120 g/km are exempt (110 g/km in 2012-13, 95 g/km subsequently).
GR	The annual circulation tax for cars registered since 1 January 2011 is based on CO2 emissions. Rates vary from € 0.80 per gram of CO2 emitted (101 – 120 g/km) to € 3.00 per gram (above 250 g/km).
IE	1. The registration tax is based on CO2 emissions. Rates vary from 14% for cars with CO 2 emissions of up to 120 g/km to 36% for cars with CO 2 emissions above 225 g/km. 2. The annual circulation tax for cars registered since 1 July 2008 is based on CO2 emissions. Rates vary from € 104 (up to 120 g/km) to € 2,100 (above 225 g/km).
IT	Purchasers of new cars emitting maximum 130 g/km (diesel) and 140 g/km (other fuels) respectively receive an incentive of € 1,500 if they have a car that is 9 years old or more scrapped simultaneously. Higher incentives apply for alternative fuel vehicles (CNG, LPG, electricity, hydrogen).
LV	The registration tax is based on CO2 emissions. Rates vary from LVL 0.3 per g/km for cars emitting 120 g/km or less to LVL 5.0 per g/km for cars emitting more than 350 g/km.
LU	1. The annual circulation tax for cars registered since 1 January 2001 is based on CO2 emissions. Tax rates are calculated by multiplying the CO2 emissions in g/km with 0.9 for diesel cars and 0.6 for cars using other fuels respectively and with an exponential factor (0.5 below 90 g/km and increased by 0.1 for each additional 10 g of CO2 /km). 2. Purchasers of new cars emitting maximum 110 g/km (100 g/km as from 1 August 2011) receive an incentive of € 750. The incentive is doubled to € 1,500 for cars emitting maximum 100 g/km (90 g/km as from 1 August). It amounts to € 3,000 for cars emitting maximum 60 g/km.
MT	1. The registration tax is calculated through a formula that takes into account CO2 emissions, the registration value and the length of the vehicle. 2. The annual circulation tax is based on CO2 emissions and the age of the vehicle. During the first five years, the tax only depends on CO2 emissions and varies from € 100 for a car emitting up to 100 g/km to € 180 for a car emitting between 150 and 180 g/km.
NL	1. The registration tax is based on price and CO2 emissions. Cars emitting maximum 95 g/km (diesel) and 110 g/km (other fuels) respectively are exempt from this registration tax. 2. Cars emitting maximum 95 g/km (diesel) and 110 g/km (other fuels) respectively are also exempt from the annual circulation tax.
PT	1. The registration tax is based on engine capacity and CO2 emissions. The CO2 component is calculated as follows: - Petrol cars emitting up to 115 g pay [(€ 3.57 x g/km) – 335.58]. Diesel cars emitting up to 95 g pay [(€ 17.18 x g/km) – 1,364.61] - The highest rates are for petrol cars emitting more than 195g (€ 127.03 x g/km) – 20,661.74] and for diesel cars emitting more than 160g [(€ 166.53 x g/km) – 20,761.61]. 2. The annual circulation tax for cars registered since 1 July 2007 is based on cylinder capacity, CO2 emissions and age.
RO	The special pollution tax (registration tax) is based on CO 2 emissions, cylinder capacity and compliance with Euro emission standards.
ES	The registration tax is based on CO2 emissions. Rates vary from 4.75% (121 - 159g/km) to 14.75% (200 g/km and more).
SI	The registration tax is based on price and CO2 emissions. Rates vary from 0.5% (petrol) and 1 % (diesel) respectively for cars emitting up to 110 g/km to 28% (petrol) and 31% (diesel) respectively for cars emitting more than 250 g/km.
SE	1. The annual circulation tax for cars meeting at least Euro 4 exhaust emission standards is based on CO2 emissions. The tax consists of a basic rate (360 Swedish Kroner) plus SEK 20 for each gram of CO2 emitted above 120 g/km. This sum is multiplied by 2.55 for diesel cars. Diesel cars registered for the first time in 2008 or later pay an additional SEK 250 and those registered earlier an additional SEK 500. For alternative fuel vehicles, the tax is SEK 10 for every gram emitted above 120 g/km. 2. A five-year exemption from annual circulation tax applies for “environmentally-friendly cars”: - Petrol/diesel/hybrid cars with CO2 emissions up to 120 g/km - Alternative fuel/flexible fuel cars with a maximum consumption of 9.2 l (petrol)/8.4 l (diesel)/9.7cm/100 km (CNG, biogas) - Electric cars with a maximum consumption of 37 kwh/100 km
UK	1. The annual circulation tax is based on CO2 emissions. Rates range from £ 20 (101 - 110 g/km)/ £ 10 (alternative fuels) to £ 435 (petrol, diesel)/ £425 (alternative fuels) for cars emitting more than 255 g/km. A special first year rate of registration applies since 1 April 2010. Rates vary from £ 110 (131 – 140 g/km) to £ 950 (more than 255 g/km). 2. The private use of a company is taxed as a benefit in kind under personal income tax. Tax rates range from 5% of the car price for cars emitting up to 75 g/km to 35% for cars emitting 235 g/km or more. Diesel cars pay a 3% surcharge, up to the 35% top rate. Electric cars are exempt.

APPENDIX B: Assumptions and results of different scenarios

Table B-1. Assumptions of different scenarios

	BAU	Fiscal policy scenario	Technical Standard scenario	Fuel switching (Biofuels, E-mobility, H2)-scen.	Ambitious policy scenario
Assumptions:					
Income	+2.5%/yr	+2.5%/yr	+2.5%/yr	+2.5%/yr	+2.5%/yr
Gas price	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr
Dies price	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr
CNG price	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr
Ele. price	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr	+3.0%/yr
Fuel tax increase	0	3.5 cent/l/yr (=1.5 cent/kg CO_2/yr)	0 cent/ litre/yr	0 cent/ litre/yr	3.5 cent/l/yr (=1.5 cent/kg CO_2/yr)
Registration tax increase	All: 2%/year	Small: 2%/yr Med: 4%/yr Large: 8%/yr	All: 2%/year	All: 2%/year	Small: 2%/yr Med: 4%/yr Large: 8%/yr
Specific CO_2 emissions of Biofuels	-0.5%/yr	-0.5%/yr	-0.5%/yr	-5.0%/yr	-5.0%/yr
Increase of biofuels / year	4 % /yr	4 % /yr	4 % /yr	8 % /yr	8 % /yr
Specific emissions (gCO_2/km) of new cars 2020	107 g CO_2/km	107 g CO_2/km	87 g CO_2/km	87 g CO_2/km	87 g CO_2/km
Reduction in spec. CO_2 emissions of new cars up to 2020	-2.3 %/yr	-2.3 %/yr	-5.0%/yr	-5.0%/yr	-5.0%/yr
Procurement of BEV in 2011	2000	2000	2000	5000	5000
Procurement. of BEV in 2012-2020	1800, 1600, 1400, …	1800, 1600, 1400, …	1800, 1600, 1400, …	4500, 4000, 3500, …	4500, 4000, 3500, …
Procurement of FCV in 2011	50	50	50	100	100
Procurement of FCV in 2012-2020	100, 150, 200 …	100, 150, 200 …	100, 150, 200 …	200, 300, 400 …	200, 300, 400 …

Table B-2. Results of different scenarios

	BAU	Fiscal policy scenario	Technical Standard scenario	Fuel switching scenario (Biofuels, E-mobility, H2)	Ambitious policy scenario
Results:					
Stock of BEV 2020	382 000	380 000	401 000	512 000	528 000
Biofuels by 2020	586 PJ	586 PJ	586 PJ	710 PJ	710 PJ
CO_2 2008	501 Mill. tons CO_2	501 Mill. tons CO_2	501 Mill. tons CO_2	501 Mill. tons CO_2	501 Mill. tons CO_2
CO_2 2020	498 Mill. tons CO_2	437 Mill. tons CO_2	450 Mill. tons CO_2	455 Mill. tons CO_2	401 Mill. tons CO_2
Effect CO_2 (%): Compar. 2020-2008	-0.6%	-12.8%	-10.2%	-9.2%	-20.0%
Effect CO_2 (%) Compar. policy scenario with BAU	0.0%	-12.2%	-9.6%	-8.6%	-19.5%
Energy 2008	5970 PJ	5970 PJ	5970 PJ	5970 PJ	5970 PJ
Energy 2020	6015 PJ	5340 PJ	5495 PJ	5745 PJ	5124 PJ
Effect Energy (%): Compar. 2020-2008	0.8%	-10.6%	-8%	-3.8%	-14.2%
Effect Energy (%): Comparison policy scenario with BAU	0.0%	-11.2%	-8.7%	-4.5%	-14.8%

APPENDIX C: Country boxes

AUSTRIA: BIOFUELS AND E-MOBILITY IN LOCKSTEP

In Austria the specific focus of national policies in recent years was put on:

- Promoting biofuels and
- Forcing the introduction of E-Mobility

This position – promoting biofuels and E-Mobility simultaneously – was also endorsed by representatives from ministries at the national workshop.

Regarding biofuels

It has to be stated that there is a strong lobby that forces the production of biofuels and this pressure group also sees clear economic advantage in an increase of biofuels production. Moreover, also in R&D biofuels are a major cornerstone of Austrian energy policy. There was a continuous increase in biofuel production from about 1 PJ in 2005 up to about 15 PJ in 2009.

Promising pilot projects have been launched for feeding biogas into the grid and also for building up local infrastructures for use of pure biogas for passenger cars.

Austria also forced the introduction of a quota, supported by the corresponding EU-Directive and met the EU-target of 5.75% already in 2008.

Regarding E-Mobility

The strong interest in E-mobility virtually erupted in 2008. It has further-on been accompanied on a rather broad scale by

- model region projects launched by KLIEN (national research foundation for climate and energy),
- the start of build-up of an infrastructure by the electricity supply industry,
- subsidies by cities and provinces and
- leasing activities of banks.

The concept of model regions emerged to become very popular and two of these are case studies in ALTER-MOTIVE (VLOTTE in Vorarlberg, E-DRIVE in Salzburg)

Pro's and Cons:

As a con with respect to biofuels it can be seen that the ecological quality improve of BF-1 were not pursued in the same intensity as the quantities produced.
Regarding E-Mobility there might be some economic inefficiency considering that money is spent for almost every type of E-mobility (bikes, scooters…) which do not necessarily prove to save fossil energy but rather add electricity consumption to the overall energy balance.

Major results of workshop discussions and conclusions:

Summing up in Austria there is a broad acceptance of stakeholders for a technology-neutral CO_2 based promotion for AF and AAMT. If CO_2 based tax is introduced it should build on Well-to-Wheel assessment of fuels and vehicles.
Finally, it can be stated that the expectations are that biofuels and E-Mobility will play a significant role.

BULGARIA: SLOW MOVES

The Bulgarian policies and activities concerning the reduction of GHG and transport sustainability in the recent years have been focused on the harmonisation of the national legislation with the EU legislation.

Regarding biofuels

The RES Act, which is expected to be adopted soon, stipulates for the blending of petrol fuels (petrol and diesel) with biofuels starting with biodiesel content of 5% since 1 March 2011 and 2% bioethanol in 2014. As of March 2011, discussions are ongoing and it is more likely that these targets will be postponed, due to the intensive pressure from the side of the society against higher fuel prices.

In the last years, the use of CNG as a fuel for cars - private, state-owned, taxis, has become very common. Methane usage for the needs of the public bus transport has become part of the transport policies of the bigger Bulgarian cities; a net of methane refuelling stations has been developed on the whole territory of the country.

Electrical mobility

The new Energy Strategy proposes to put efforts in the development of electrical vehicles (EV) market, through specific support for the introduction and development of EVs and financial support for strengthening the R&D activities and easing the investors' access to the scientific studies.

The new RES Act stipulates the encouragement of the production and utilisation of EVs through:

- development and introduction of electrical vehicles in public and individual transport;
- construction of charging stations for BEV during the building or reconstruction of existing parking lots in the urban areas;
- construction of infrastructure for charging of BEVs outside urban areas.

Since the beginning of 2011, the political interest in electric vehicles has sharply increased.
The Ministry of Economy, Energy & Tourism intends to create an integrated policy set to support the EVs industry. Electrical vehicles manufacturing is expected to start in 2011 in Lovech and Stara Zagora. Possible measures for promotion of the use of EVs are currently being discussed. Due to the very high prices for BEVs, however, their share in individual transport would not be noticeable in the coming years.

Change of behaviour

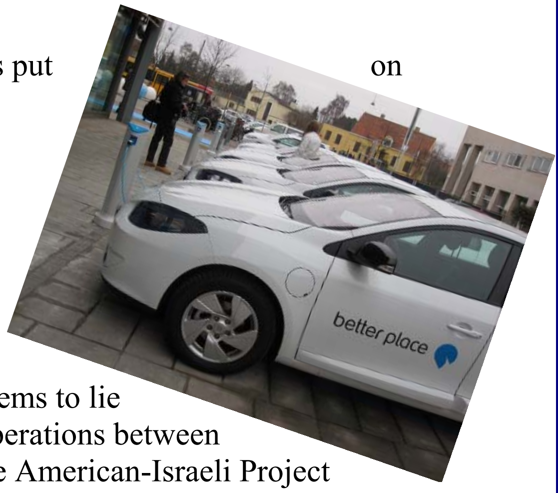
There are sparks of change of attitudes and behaviours of parts of the society towards sustainability and environmental protection. This includes higher requirements towards the vehicles, use of bicycles, car pooling, preference to public transportation means, on the contrary to the other (greater) parts who still suffer from striving to compensate the lack of opportunities in the past.

Major conclusions

Bulgarian transport sector still has a long way towards reaching sustainability and contributing to the reduction of energy consumption and GHG emissions. As a result of the inrush of second-hand passenger cars, poor state of the railway transport and the insufficient organisation and control of the public transportation, the energy consumption in the sector has taken the first place in the energy balance of the country and continues to constantly increase. A strategy for the optimal coordination of the development of all types of transport, including transport structure, organisation, parking, registration, control, etc. is necessary to be implemented.

DENMARK: ELECTRIC MOBILITY – A HUGE POTENTIAL – BUT STANDARDS ARE NEEDED

In Denmark the specific focus of national policies was put on



- Exception of taxes on electric vehicles
- Hybrid cars

Electric cars, hybrids and plug-in- hybrids in Denmark in the future
Denmark is a pioneer country for the future development of electric cars and plug-in-hybrids. The greatest potential for electric cars in the near future seems to lie with the Project Better Place – contract between co-operations between DongEnergy (the largest Danish energy company), the American-Israeli Project Better Place financial investors – apart from this a number of hybrid passenger cars also appear to have a potential.The Better Place Project, however, is a very ambitious project that provides a strong infrastructure. If this will not succeed, plug-in hybrids might turn out to be the alternative. In March 2011 Better Place launched the prizes of cars/Renault and the prizes of subscription.

From 2011 Better Place Denmark plan to introduce an infrastructure for charging and battery changing and car companies will sell electric cars on the Danish market. Better Place has just introduced their prizes. However, according to the plans, the Better Place services should include personal and public charge spots and battery switch stations. It is also planned to have battery switch stations for unlimited range – and some charging spots have already been installed. The customer should, ideally, be able to replace a depleted battery with a fully-charged one during trips more than 100 kilometres. As a consequence of an energy political agreement between the Danish government and the opposition in the Danish Parliament, electric cars and hydrogen cars are - until 2012 - free of duty in Denmark. 2The plans are to increase the number of electric vehicles from the current 200 to 100,000 within two years. The Danishenergy Corporation DONG and the American company Better Place are planning to invest 100 million Euros to build up infrastructure for electric cars in the country. The idea is to make it just as fast to charge up a battery as it is to fill up a tank of gasoline. But this has not been technically developed yet, and it is not clear where the shift of batteries must take place (no shifting stations have been established. Project Better Place and DONG wants it to take place at gasoline stations, but the association of owners of gasoline stations has not yet agreed to this. This can be a crucial point, which might delay the process. The battery shift must be done automatically by a robot, and The Danish Oil Association claims that such robots can only work inside, and it will be very expensive to establish buildings for this at the gasoline stations. A plug-in for the car/battery should also be available which can be installed at home and at work places. The idea is that charging should normally take place at night. This will be very beneficial for the energy system, especially in Denmark, because we have a relatively high share of wind power in the electricity production. The wind power production is as high at night-time as in day-time, but the consumption is much lower. As it is not possible to store electricity, except in batteries, an increase of night consumption through charging of car batteries will be very beneficial allowing a higher share of wind power in the future. This provides introduction of intelligent electricity meters, which can allow a differentiation of the tariffs in order to make sure that people will charge at night-time. It must also be possible to make quick-charging of batteries during daytime. However, it will still endure longer than changing the battery. The infrastructure is planned ready for 2011 and the first electric cars should be launched in 2010 – to be spread more widely in 2011. However, the wider success of the project will depend on whether a European standardisation of the components will succeed. Such a standard is under negotiation and is expected to be adopted in about two years.

Hybrid cars - Toyota Prius, Honda and Colt
The hybrid car Prius is already on the Danish market. This car combines a diesel and an electric motor - the consumption of fuel is 4,2 L/100 kilometre or 23,2 km pr. litre with combined/mixed driving. A new model of the Prius will be introduced to the Danish market in Sept. 2009. This model will be a family car, with fuel consumption just below 26 km per litre. In 2009, Honda launched the new Honda Insight model on the Danish market. Honda Insight introduces the new technology „Integrated Motor Assist"and it holds a fuel Energy agreement between the Danish government and members of the Danish Parliament: Together with the Toyota Prius, the Honda, hence defines a new era of hybrid cars at the Danish market, which gradually becomes more energy efficient. Clear Tec, a hybrid car from General Motors, holds a range of app. 20km/L.

Plug-in hybrids - BYD etc.
The greatest competitor to Better Place, is expected to be the Chinese plug-in hybrid BYD which was first planned to hit the Danish market in spring 2009 – however, it has now been delayed several times. BYD based on a different technology than Better place. In this concept the car obtains its original battery – a battery which is, however, loaded in only few minutes where after the electric motor holds a range of app. 100 kilometres. The plug-in hybrid BY obtains its original battery.

Major results of discussions with partners
Pro's and con's
As a pro – the environmental potential of focusing on electric vehicles in Denmark is huge – because of our electric system. On the pro-side the Danish customers are not as committed because the future prospect (in terms of standardization) is quite unsure. The customers are generally afraid to invest in one or the other technology. Standardization appears to be needed.

FRANCE:
BIOFUELS AND ELECTRIC VEHICLES IN FRANCE

In France the specific focus of national policies in recent years was put on :
- promoting biofuels and
- enhancing development of electric vehicles

Regarding biofuels
In France, until 2008, an important lobbying existed for the development of biofuels. The consumption was increasing with about 49 TJ of biodiesel and 11 TJ of bioethanol in 2009 (i.e. about + 10% compared to 2008).
In France, currently 363 refuelling stations are distributing E85. France met with its commitments and exceeded the European objectives with 7% (in energetic share) of biofuels in 2010 and an objective of 10% for 2015, by anticipation with the European objectives of 2020.

Regarding electric vehicles
In 2009 the French Government launched a National Plan for the promotion of electric vehicles that aims at supporting both the equipment with electric (plug in) refuelling terminals (70 M€), the production of ion lithium batteries (625 M€), the purchase of 100 000 electric vehicles within 2015, a financial support to the purchase (5 000 € per vehicle).

Pro's and Cons
The advantage of the current actions are a diversification of fuels and motorisations types. The major disadvantage is a public perception of politics' weakness that regularly changed these last years (in France we remember the support to LPG and the efforts done for the development of CNG).

Majors results of workshops discussions and conclusions
These additional workshops have gathered around 50 participants in France on electric vehicles, PPO and NGV. During these workshops the participants answered to questions on the main reasons which explain the alternative fuels state in France. Most of them are waiting for development of infrastructures and refuelling stations. They said that they are ready to buy some experimental vehicles as soon as this question of refuelling is solved. Concerning electric vehicles the main barrier is the cost and the low diversity of cars.

GERMANY: LOW EMISSION VEHICLES AND BIOFUELS

In **Germany** the specific focus of national policies in recent years has been put on:

- R&D and promotion of Fuel Cells and Hydrogen
- Increase the use of Biofuels (E10) & other alternatives
- Demonstration in Model-Regions for EVs

Regarding low (zero) emission vehicles

Germany has been doing extensive R&D and promotion of *fuel cells and hydrogen* implemented by the National Innovation Program (NIP) and the Clean Energy Partnership with large scale demonstration and lighthouse projects. A total of 1.4 Billion € funding has been approved until 2016 and it has been almost completely allocated in several projects covering transport and infrastructure of H_2 and stationary energy supply and special markets. In addition, 8 E-Mobility Regions, with a budget of 115 Million until 2011, should bring the E-mobility topic in the public sphere. Additional 500 Mio. € are foreseen until 2020 with the vision that Germany becomes the leading E-Mobility market worldwide. The program has set a target for introduction of 1 million electric vehicles by 2020. Various actors are involved including science, industry and local authorities with the aim to integrate EVs in everyday operations. Further research is also taking place in infrastructure and Information Technology issues. New Mobility concepts are also as part of the demonstration within the eight regions complemented by the development of new business models taking into account the consumer's acceptance. Several ALTER-MOTIVE Case Studies refer to the German Hydrogen, Fuel Cells and EVs.

Regarding renewable fuels

The big "biofuel boom" came in Germany between 2005 and 2006 following tax exemptions that have increased the biofuels shares in the market. Economic studies observed overcompensation that lead to a modification of the tax exemption to a quota based system (Quota Act) that modified the promotion rules for biofuels leading to a dramatic turndown for the biodiesel industry. Recent developments with respect to the increasing quotas for biodiesel and bioethanol have led to the introduction of E10 in the market from 2011; however, the initial experiences conclude that the public have not been correctly informed about the consequences on the use of increased bioethanol blends leading to a decrease in sales of blended gasoline and increasing the prices of non-blend sorts. Information campaigns and price measures have been re-launched to revitalize the market. The import of biofuels follows stricter sustainability criteria and certification schemes are requested.

Pro's and Cons:

The current fuels strategy is being revaluated, however, the promotion of several technologies until now indicate a balanced approach for supporting different levels of technology diffusions into the markets (research, demo, early commercial). Demand side activities will be stronger within the 8 model regions and mobility concepts but emphasis should be put on infrastructure too. The disadvantage is that these several options, with an important CO_2 reduction potential, will take time to enter widely the market, therefore the short term seems to be constrained to few alternatives.

Major results of workshop discussions and conclusions:

The policy recommendations today should prepare the ground for the post 2020 time as most of the other measures are part of existing regulations, directives and standards (95 g/CO_2 per km) especially with respect to Fuel Cells, Hydrogen and Batteries. Further uses of biofuels (e.g. heavy trucks) should be enhanced. Further attention should be given to the "integrated approach" as well as the design of alternative "mobility" concepts combining several options with the objective to facilitate an improved mobility instead of improving individual modes.

GREECE: BIOFUELS AND ALTERNATIVE VEHICLES

In Greece the specific focus of national policies in recent years was put on:

- Promoting biofuels
- Promoting green transportation

Regarding biofuels

Although diesel consumption is lower than gasoline, biodiesel is the only biofuel that is used in Greece. The biodiesel market has fast developed in the last 5 years, and a robust industry is developed with almost 16 companies and a total capacity exceeding 800,000 tons, that is around 4 times higher than the 2010 target for the substitution of diesel by biodiesel (140,000 tons). However, the overall target for 2010 is not met because of the lack of bioethanol in the biofuels mix. Moreover, there is strong motivation for using locally produced vegetable oils thus biodiesel is produced mostly by sunflower oils that amounts almost 50% of the total oils used.

Regarding mobility

The constantly increased price of gasoline and the limited use of diesel for transportation – diesel is forbidden in the metropolitan areas of Athens and Salonica – put a strong pressure for electric, hybrid and hydrogen cars. The motives are tax excemption/reduction measures. However, from November 2010 all new registered cars will be subjected to circulation taxes according to their CO2 emissions.

On the other there is strong governmental pressure towards the use of public transportation means. The Transport Master Plan for Athens for 2010-2013 includes among others expansion of transport networks of metro, tram and suburban, increasing the costs for holding a private car, increasing the share of urban public transport, etc. To this direction, the bus fleet of Athens (ETHEL) is procuring 204 new urban buses, the 200 of which will run on natural gas with engine technology EEV, increasing thus the total number of buses run by natural gas to 614.

Pro's and Cons:

Regarding biofuels, the main disadvantage is the unstable policy framework, which however is going to improve with the harmonization of the 2009/28 and 2009/30 EC directives. Regarding mobility, an overall strategy of green transportation is missing.

Major results of workshop discussions and conclusions:

In Greece there is a broad acceptance of stakeholders for biofuels and alternative vehicles and a strong belief that only integrated approaches will help reducing emissions. Stakeholders expect that biomass and biofuels have to be dealt in the new Energy Policy and Planning of the country, in order to rejuvenate the poorly structured Agricultural sector and help towards regional development.

ITALY: BIOFUELS AND SUSTAINABLE MOBILITY - THE PECULIARITY OF THE ITALIAN CASE

In Italy, national policies are in fact mainly the (puzzled) outcome of regional/local policies focusing on more sustainable transports :

- Biofuels are a rare example of a major recent effort on alternative fuels diffusion at national level.
- Gas (methane/GPL) and electric vehicles (EV) are historically the technologies local authorities have widely experienced in urban projects in the last 20 years.

The national workshop as many other symposium in recent time have confirmed the absence of a consistent long run national policy on sustainable/alternative transports. From the other side has been underlined that local specific transport problems need local specific solutions.

Regarding biofuels

Biofuels production has significantly increased as a result of a peculiar national effort of agricultural associations and fuel producers. But it must be noted that in Italy, 2010 biodiesel production — which relies predominantly on import palm oil and canola for feedstocks—fell in the face of competition from cheap imports, a trend that is expected to continue in 2011. In 2010, biodiesel production was at 410,000 tons through September compared to 795,118 tons during all of 2009. Imports jumped by 73,000 tons to 540,000 tons in through September. This aspect is important when in the overall accounting for production costs comparison among alternatives.

Important efforts have been made on the R&D of new generation biofuels (i.e. algae) to avoid the biofuels-food use competition.

Regarding E-Mobility

E-mobility local projects have a long experience. The major problem is that rarely they passed from experimental stage. Many local projects started but rarely they have seen a broad diffusion of the technology.
The (only) policy that has been and still is widely applied to a great majority of Italian cities is the significant "no access zones for polluting vehicles" in the inner city centres. This means that only ecological lower emission vehicles (EV, methane/LPG, Hybrid) are allowed to circulate in the city centres.
Further, in periods of heavy pollution measured levels, most of the cities restrict the city centres access to ecological vehicles and those respecting the Euro 4 (diesel with APF) standards. Although this policy shown some deficiencies due to a wide number of exemptions and their temporary application.
Best experiences are those registered in small-medium size cities. Biggest cities like Rome, Milan, Naples did not registered significant improvements regarding E-mobility diffusion.
The only considerable recent experience of "entry toll"(Milano eco-pass) to the city centre of Milan that conventional vehicles have to pay to enter the inner city centre. Such project is revealing an encouraging impact with a reduction of 14% of vehicles entering the restricted area. That means almost -19% of PM10 emitted (year 2009).

Pro's and Cons:

Regarding E-Mobility, the major problem is the energy mix of the electricity production. Italian electricity production is mainly due to fossil fuels and hydro. If the electricity consumption (in the transport sector) should significantly increase this could lead to an overall energy/ecological balance. Although many experts made evidence of the fact that is easier to deal with fixed source emissions (from electric power plants: i.e. new generation filters) than to cope with diffuse mobile pollution sources as that from conventional powered vehicles.
As a matter of fact the share of alternative vehicles (methane/LPG, gas-electric hybrid) in Italy did not increase from the 2009. It remains at 4% of total vehicle fleet. To confirm the big differences among the Italian Regions performances, Emilia Romagna has the highest share of alternative vehicles with more than 7% of the overall vehicle fleet meanwhile Southern Regions register insignificant percentages.
Cost of vehicles, reduced subsidies and insignificant infrastructure network are the major obstacles.

Major results of workshop discussions and conclusions:

As a matter of fact, the decentralised political/administrative country structure is not helping the definition and the implementation of a national long run policy on sustainable transports able to meet with the European goals.
Public acceptance of alternative/reduced impact technologies has significantly improved in the last decades as the increase of hybrid (gas/petrol and Electric/petrol), LPG vehicle fleets (both public and private) confirms. Although this positive trend has been counteracted by opposite choice of a significant diffusion of SUV vehicles (even in tiny historical city centres). This paradox is confirming the inconsistency of some trends in public choices.

Biofuels are just added to conventional fuels and not offered as a clear alternative, and this is not helping the promotion of such option. Further, the fact not clear choice of alternatives fuels support has been made until now is making the biofuels future quite uncertain.
Italy is on the move towards a decentralised fiscal system (where local taxes will have a growing role) that will not help to build up a national clear choice on a consistent fiscal policy in the transport sector.

POLAND: PROMOTION OF BIOFUELS

In Poland the main focus of the national policies in recent years was put on promoting biofuels. The interest of the policy makers in promotion of biofuels is threefold:

- Poland is still largely an agricultural country and as such it is considered to have a relatively large domestic supply base for production of biofuels
- Farmers perceive the production of input plant material for biofuels as an additional source of income, which creates a strong pressure on decision-makers to develop the domestic biofuel sector
- Poland is prone to potential disruptions of the fossil motor fuels.

Regarding biofuels

Farmers constitute a strong lobby that sees clear economic advantage in the increase of the demand for biofuels based on the **domestic** supplies. However, the ambitious "Programme of Promotion of Biofuels for the Years 2008-14", accepted by the Council of Ministers in 2007, has not brought the expected results. True, production of bioethanol has increased from 289 thousand m^3 in 2008 to 463 000 in 2010. Similarly, production of esters increased from 356 to 648 thousand m^3 in the same period. However, the existing domestic production capacity is used only in ca. 20% and 60% respectively. In April 2010 the Minister of Agriculture prepared proposals to update the programme of 2007 to make it more effective. One of the main questions addressed is the unfair competition on the Polish market, where the Polish biofuels cannot compete with the imported ones, which have already been granted support in another EU country. The proposal also includes introduction at the national level of solutions that would increase the demand for biofuels (e.g. preferential parking rules). Such measures have been so far applied at the local level only.
In the present budgetary crisis the excise tax reliefs for bio-components are to be withdrawn, which will seriously decrease the competitiveness of biofuels. Therefore, it is proposed to redirect 80% of the money saved for the budget to support biofuel producers and farmers cultivating plants for biocomponents.

E-Mobility and Eco-driving

Considering the power generation structure in Poland (above 90% of electricity is derived from coal), a wide use of electric vehicles is unlikely to bring reduction of CO_2 emissions.
The interest in promotion of EVs is therefore limited to big cities, where it is seen as a measure to improve local air quality. No national level initiatives have been undertaken yet.
Since the development of road infrastructure is lagging behind the increase of traffic (car ownership and use) the cities consider rather structural measures (promotion of public transport, park & ride solutions etc.).
Eco-driving is neither supported or promoted.

Pro's and Cons:

A strong Pro with respect to biofuels is the chance for the development of rural areas (more jobs, increased income of farmers). The Con against the EVs is that their wide use is likely to have a negative overall environmental impact.

Major results of workshop discussions and conclusions:

Summing up: in Poland there is a broad acceptance of farmers for biofuels with a rather ambivalent attitude of the general public and most of other stakeholders. Consequently, the price of biofuels must play a decisive role, if biofuels are to be more widely used.

PORTUGAL:
MAIN DRIVERS: BIOFUELS AND E-MOBILITY

In **Portugal** the specific focus of national policies in recent years was put on:

- promoting biofuels (biodiesel) and, more recently,
- developping the E-Mobility.

This position – promoting biofuels and E-Mobility simultaneously – was also endorsed by representatives from Transport Ministry at the national workshop.

Regarding biofuels

The main reasons for promoting biofuels in Portugal were environmental (measure introduced in the first National Climate Change Programme) and legal with the application of the corresponding EU-Directive which aim was to reach the EU-target of 5.75% in 2010.
This target has been revised (10% in 2010) in the second National Climate Change Programme but not fully achieved.
For 2010, only biodiesel with a share of 7% was enforced. The biofuel target for 2020 remains 10%.

Regarding E-Mobility

Transport is responsible for over one third of final energy consumption in Portugal. To promote renewable energy in this area and reduce fossil fuel imports, the Mobi.E Programme was launched early in 2008.
This programme for Electric Mobility in Portugal is an open-access and market-oriented concept, with the goal of attracting private investors, benefiting the users and promoting the fast expansion of electric mobility in Portugal. The Mobi.E model grants universal access to any car and battery manufacturers, electricity retailers and recharging network operators. This will be an open system and users may choose the best offer in the market at any time. This will be achieved through a Managing Authority, which will act as a Clearing House.
Electric mobility also represents an opportunity to consolidate renewable energies policies in Portugal and to create new business for Portuguese companies and is a pull factor for direct foreign investment.

Pro's and Cons:

As a con with respect to biofuels it can be seen that the environmental balance has to be improve as well as their potential impacts on food prices.
Regarding E-Mobility there might be some negative effects considering that this programme promotes car mobility which do not solve city problems like congestion and accidents.

Major results of workshop discussions and conclusions:

As Portuguese national workshop shows, there is not a clear confidence in AF and AAMT as a solution for environmental friendly automotive mobility in the near future. Recent difficulties in promoting biofuels and general scepticism regarding electric mobility programme explain why Portuguese expectations on biofuels and electric mobility as an alternative solution to fossil fuels in transport are not very high.

SWEDEN: INFRASTRUCTURE FOR BIOFUELS AND E-MOBILITY

In **Sweden** the specific focus of national policies in recent years has been on promoting vehicles that can run on renewable fuels and on developing a widespread infrastructure for renewable fuels. The pros and cons of these policies were also discussed at the national workshop.

Regarding biofuels

About 88 TWh fuel was used for road based transport in Sweden, 2008, whereof 4.9% was biofuels. The main use of biofuels was as low blend of ethanol in gasoline (1.34 TWh). Other biofuel use were ethanol as E85 (1,01 TWh), ethanol for busses E100 (0,14 TWh), RME for lowblend in diesel (1,47 TWh), pure biodiesel (0,04 TWh) and biogas (0,33 TWh).

Swedish research and development, on biofuels, has focused on second generation wood-based fuels where for example demonstration plants have been built for gasification of black liquor for DME production, for developing cellulose-based ethanol, and for the gasification of solid wood for e.g. biomethane production.

Swedish policy makers have also focused on developing a national widespread infrastructure for biofuels e.g. by implementing a "the pump law", where all fuel stations were compelled to offer at least one pump with alternative fuel. In August 2010 the number of filling stations supplying renewable fuels, in Sweden, was: 1562 ethanol, 107 biogas and 18 biodiesel.

Regarding E-Mobility

During the last five years a wide range of research and development within the electromobility area has arisen in Sweden, e.g. improvements of hybrids, plug-in hybrids and battery electric vehicles, as well as research in road electrification with the purpose of supplying electricity while driving for heavy trucks, buses and passenger vehicles. Commercial available options are, e.g. passenger vehicles from Volvo and Saab, heavy truck applications such as Renova's garbage truck hybrid as well as EV charging poles.

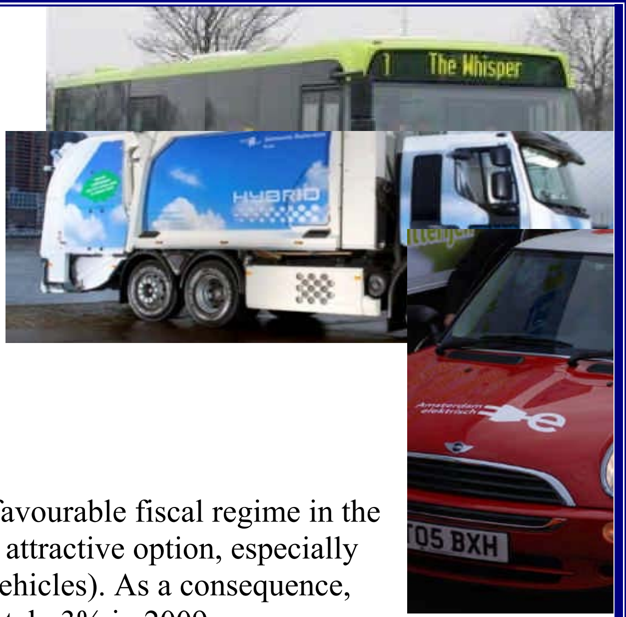
Pro's and Cons:

The benefits from reducing CO_2 emissions, improving local air quality, and lower the traffic noise are high. A major challenge for biofuel production is the increasing demand for wood based biomass supply. In Sweden the demand on biomethane and bioethanol from the petrochemical industry, as well as solid biomass of heat and power compete with the supply for biofuel production. Other challenges for Swedish biofuel production are connected to the debate around the quality of by-products, e.g. protein pellets for animal feed and digestion rests, from biogas production, as fertilizer. So far the quality has varied and the market hesitates.

Major results of workshop discussions and conclusions:

The purpose of the Swedish workshop was to discuss current and future policy instruments affecting alternative fuels and vehicles. Swedish stakeholders' message to other EU member states is that policy makers should take a dialogue with the industry regarding costs, competition, and technology neutrality before implementing new policies such as a pump law. Stakeholders' disappointment, facing capital destruction (when pumps are built with limited access to fuels and few customers) as well as an unfair governmental financial support, might spread to the general public and lead to a drawback for the entire alternative fuel acceptance.

THE NETHERLANDS: ELECTRIC VEHICLES AND ECODRIVING



In the **Netherlands** the specific focus of national policies for sustainable transport in recent years was put on:

- Stimulating hybrid-electric vehicles
- Preparing the way for electric vehicles
- Ecodriving

Regarding hybrid-electric vehicles
Hybrid-electric vehicles (HEVs) have enjoyed a favourable fiscal regime in the period 2006-2010. As a results, HEVs became an attractive option, especially for the growing market for company cars (lease vehicles). As a consequence, the market share of HEVs increased to approximately 3% in 2009.

Regarding electric vehicles
The national government has started a programme of demonstration projects for EVs (*'proeftuinen'*). €10m has been allocated to 9 projects that will work with a variety of EVs, ranging from urban distribution vehicles to passenger cars to garbage trucks. On top of this, €55m has been allocated for R&D, on infrastructure and a launching customer role for the national government. Infrastructure is also addressed by the electricity grid operators, who have started a project to install 10,000 charging points in the Netherlands. In the ALTERMOTIVE case studies, the Power Surge programme (Rotterdam), Amsterdam Electric, and the Whisper Bus (Apeldoorn) are other projects related to electric transportation. Finally, EVs are stimulated by a full exemption from registration and road tax.

Regarding ecodriving
Since 1999, the Dutch government has promoted ecodriving in its programme '*Het Nieuwe Rijden*'. This programme stimulates an energy efficient driving style and represents the bridge between low-carbon technology and behaviour. In 2006, ecodriving has become a mandatory part of driving courses. Interestingly, since 2010 the ecodriving campaign is executed by the associations of car importers, garage owners, and fuel station owners.

Pro's and Cons:
The advantage of the current approach is that it provides specific policy for a number of technologies with different levels of market readiness. With the ecodriving programme also demand-side measures are included. The disadvantage is that the short-term impact – besides an effective mandate for biofuels – is limited. The planned introduction of a road pricing scheme *('kilometerheffing')* was abandoned due to political resistance.

Major results of workshop discussions and conclusions:
With regard to policy measures up to 2020, the low-hanging fruit has been exploited, especially at a European level (e.g. Directive on passenger car emissions 120g/CO_2 per km in 2015, 95 g/CO_2 by 2020). Member states can complement by introducing WTW-based, CO_2 taxes or tougher regulation on the demand side. Another promising approach is to address the broader concept of mobility instead of individual modes & technologies.

Appendix D: Results of scenarios for selected countries

In this appendix we document the results of the BAU- and the ambitious policy scenario up to 2020 for some selected EU-countries.

D-1 Austria

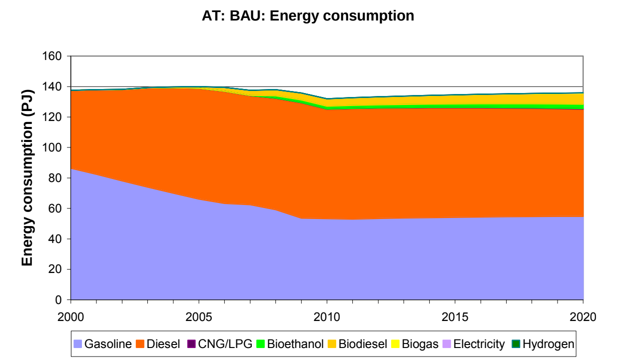


Figure D-1.1a. Energy consumption in the BAU-scenario

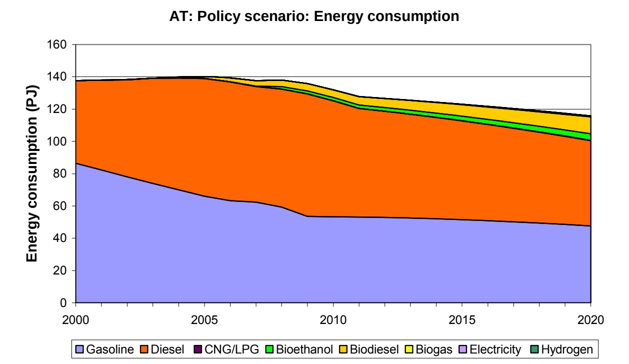


Figure D-1.1b. Energy consumption in the AP-scenario

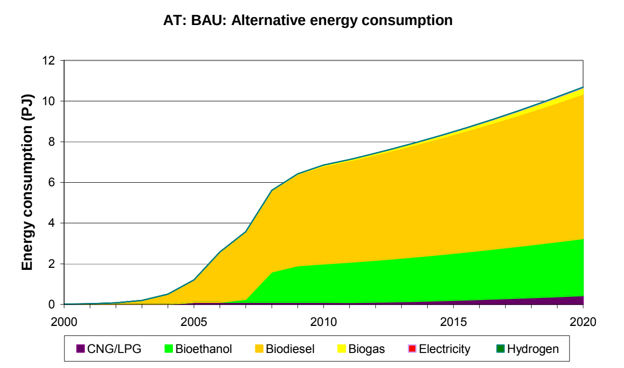


Figure D-1.2a. Alternative energy consumption in the BAU-scenario

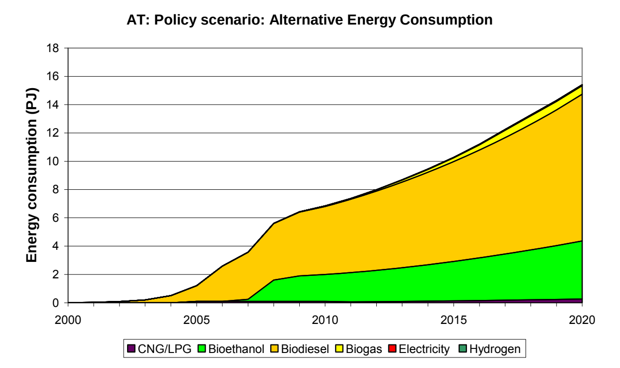


Figure D-1.2b. Alternative energy consumption in the AP-scenario

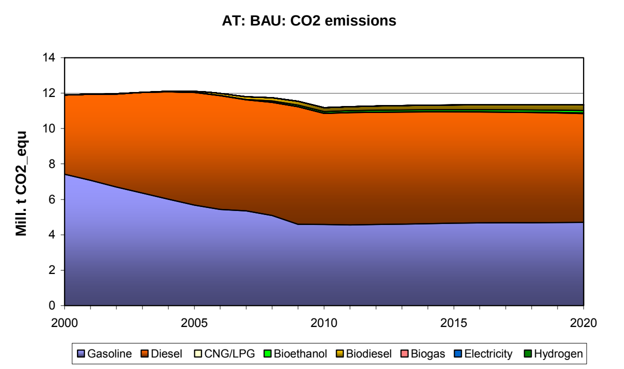


Figure D-1.3a. CO2 emissions in the BAU-scenario

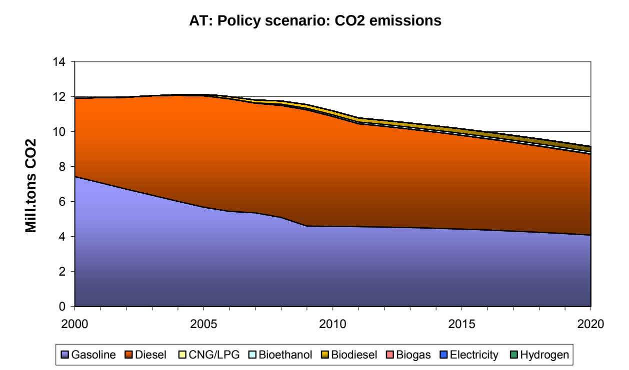


Figure D-1.3b. CO2 emissions in the AP-scenario

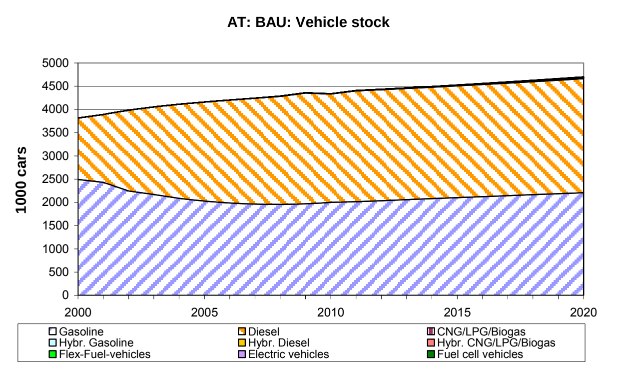


Figure D-1.4a. Development of vehicle stock in the BAU-scenario

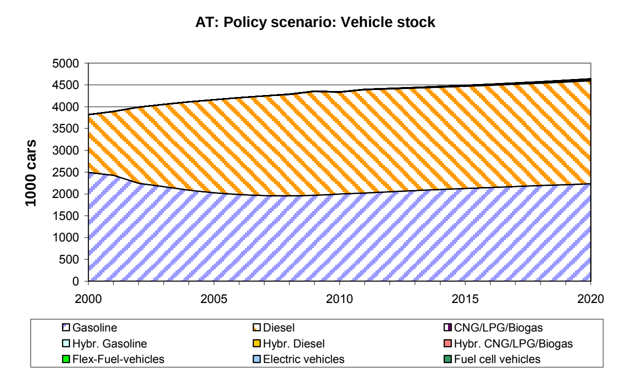


Figure D-1.4b. Development of vehicle stock in the AP-scenario

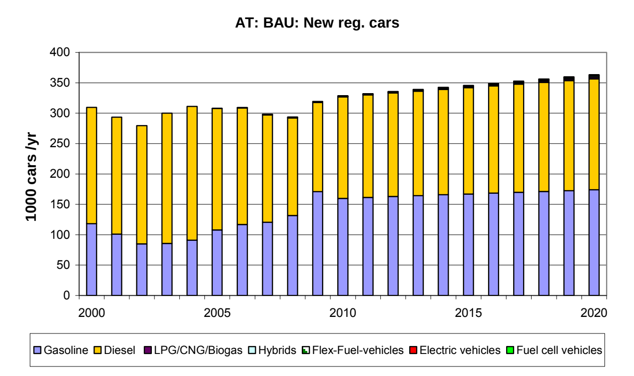


Figure D-1.5a. Development of new registered cars in the BAU-scenario

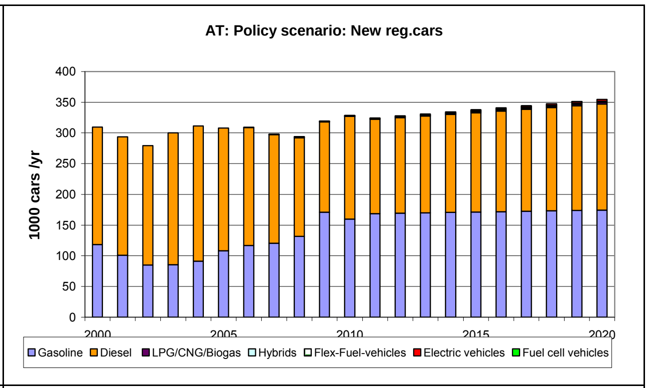


Figure D-1.5b. Development of new registered cars in the AP-scenario

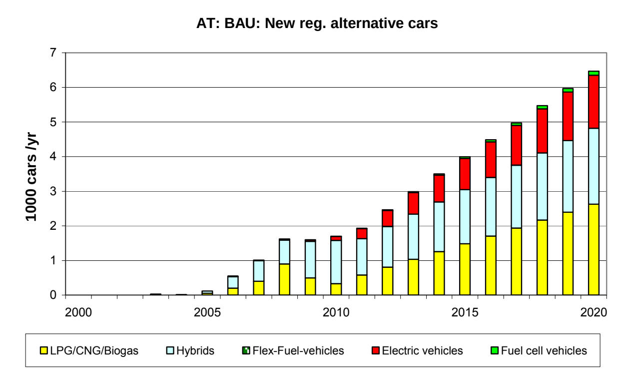


Figure D-1.6a. Development of new registered alternative cars in the BAU-scenario

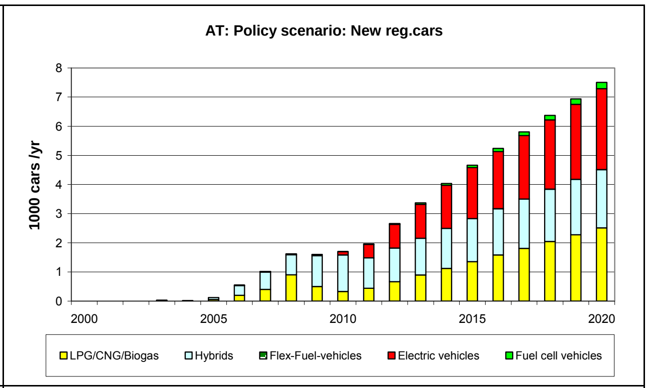


Figure D-1.6b. Development of new registered alternative cars in the AP-scenario

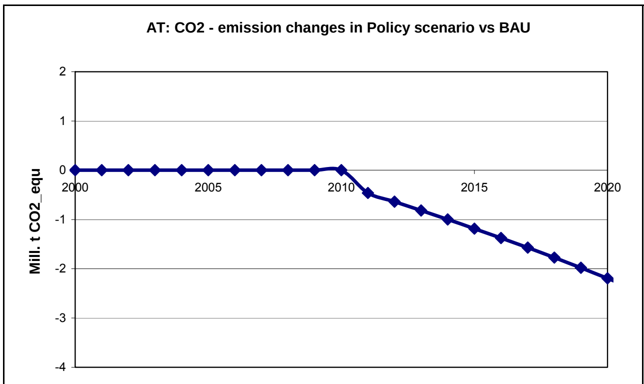


Figure D-1.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

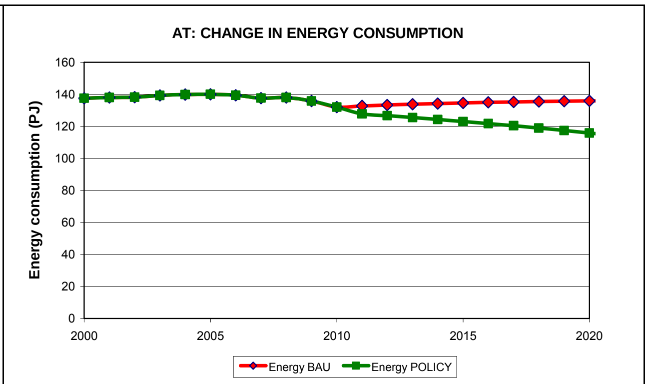


Figure D-1.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

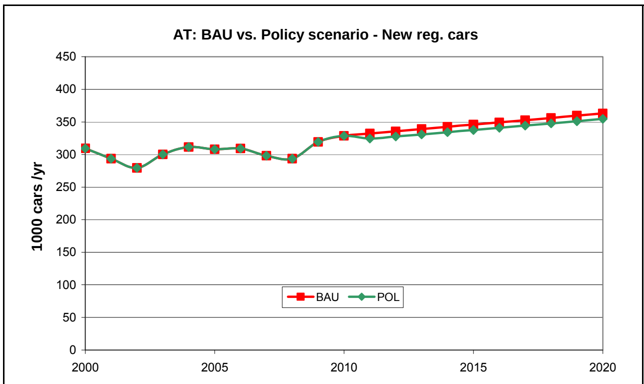
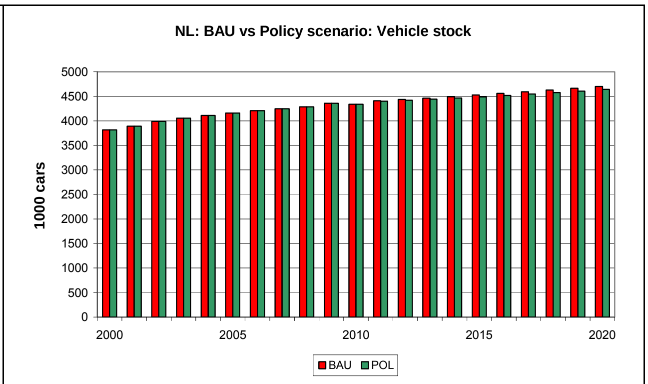


Figure D-1.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-1.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-2 Bulgaria

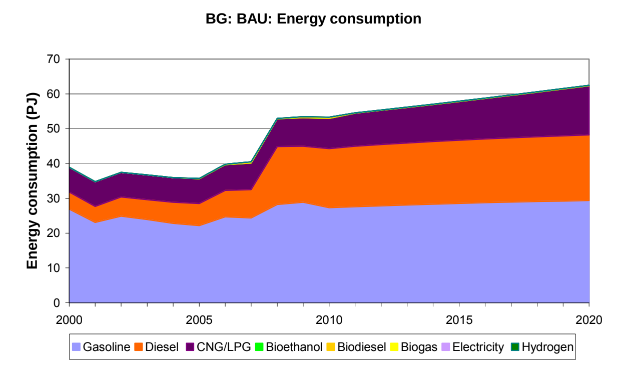


Figure D-2.1a. Energy consumption in the BAU-scenario

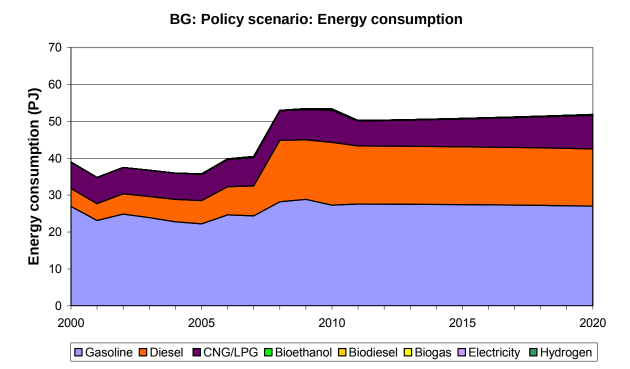


Figure D-2.1b. Energy consumption in the AP-scenario

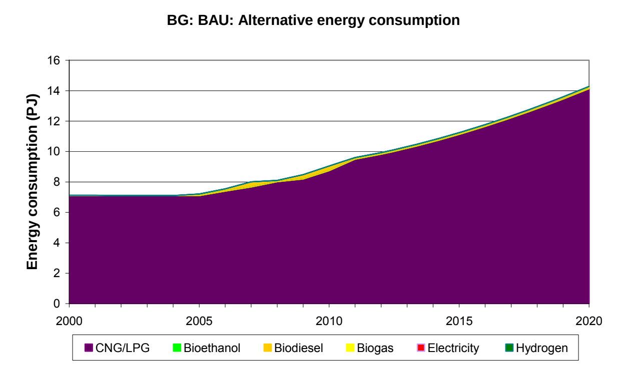


Figure D-2.2a. Alternative energy consumption in the BAU-scenario

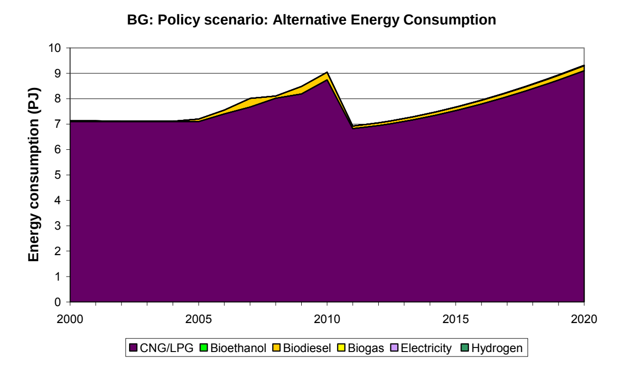


Figure D-2.2b. Alternative energy consumption in the AP-scenario

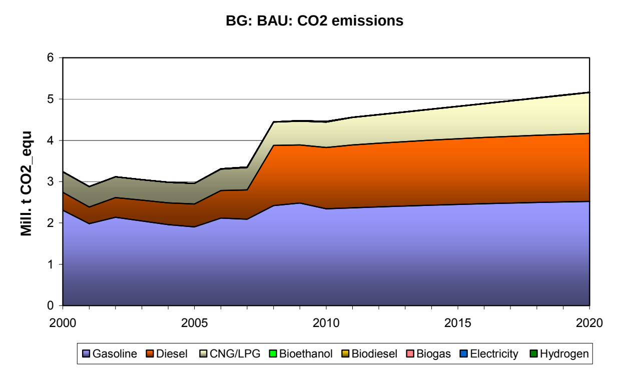


Figure D-2.3a. CO2 emissions in the BAU-scenario

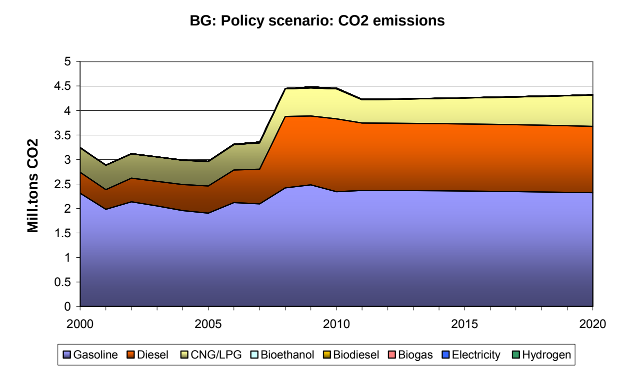


Figure D-2.3b. CO2 emissions in the AP-scenario

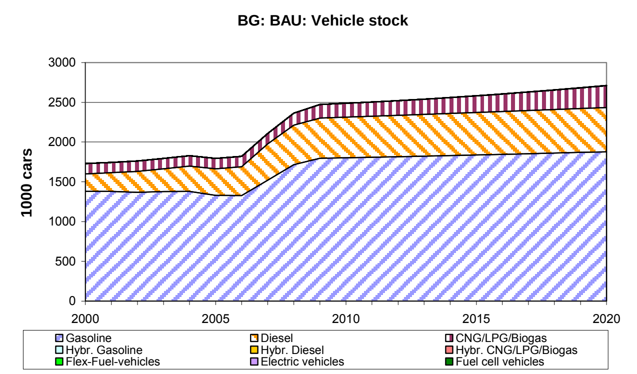


Figure D-2.4a. Development of vehicle stock in the BAU-scenario

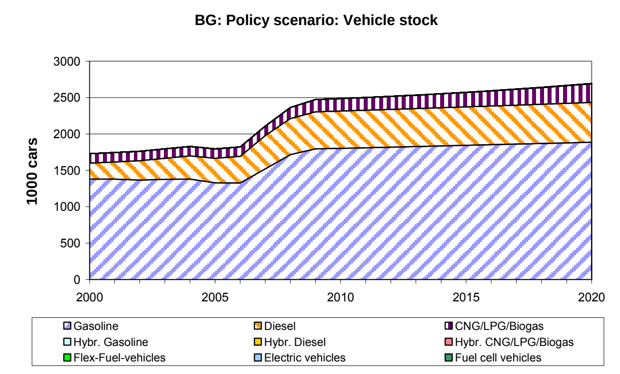


Figure D-2.4b. Development of vehicle stock in the AP-scenario

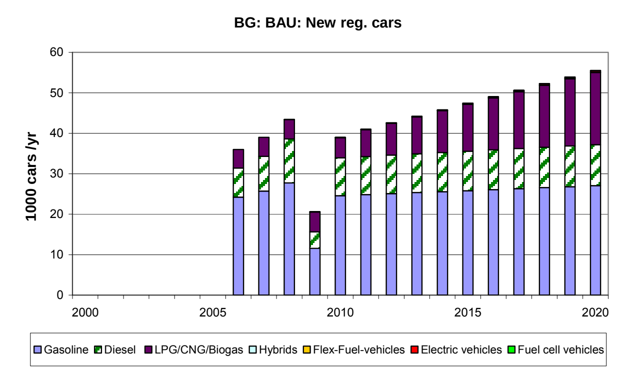


Figure D-2.5a. Development of new registered cars in the BAU-scenario

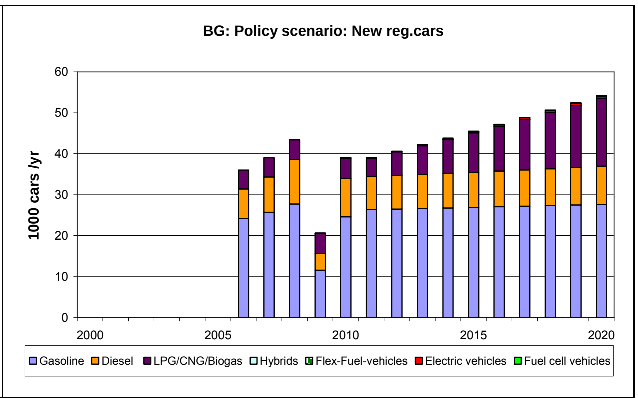


Figure D-2.5b. Development of new registered cars in the AP-scenario

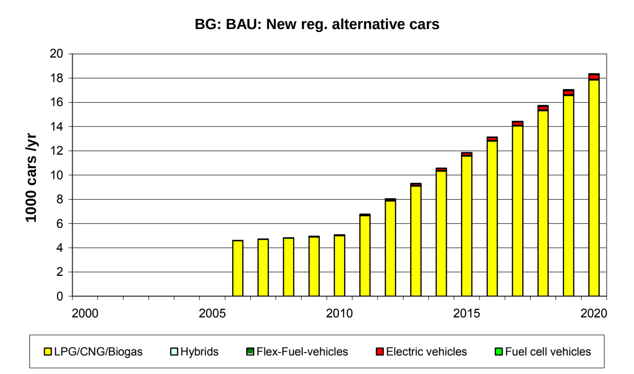


Figure D-2.6a. Development of new registered alternative cars in the BAU-scenario

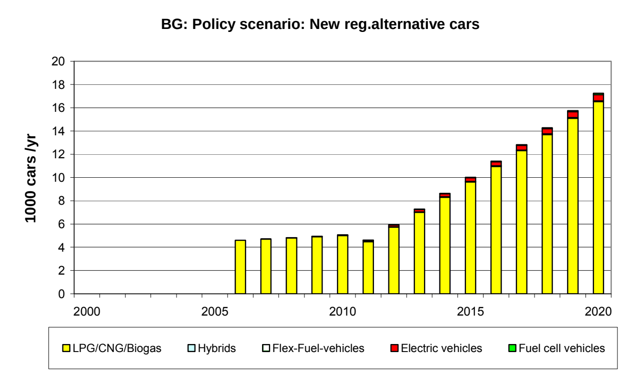


Figure D-2.6b. Development of new registered alternative cars in the AP-scenario

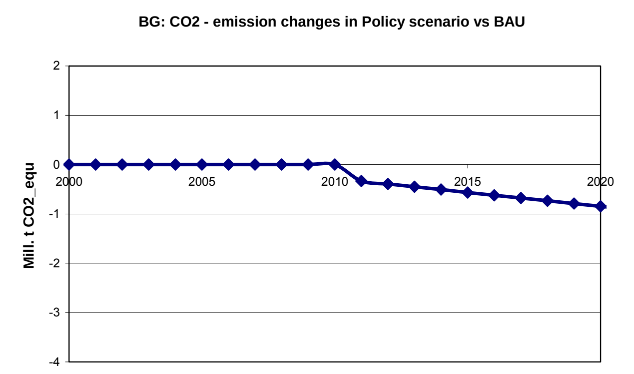


Figure D-2.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

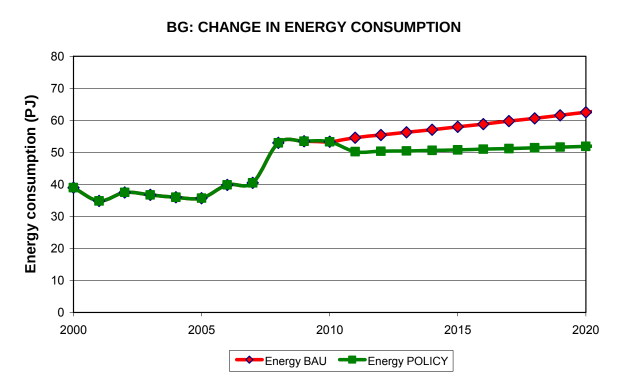


Figure D-2.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

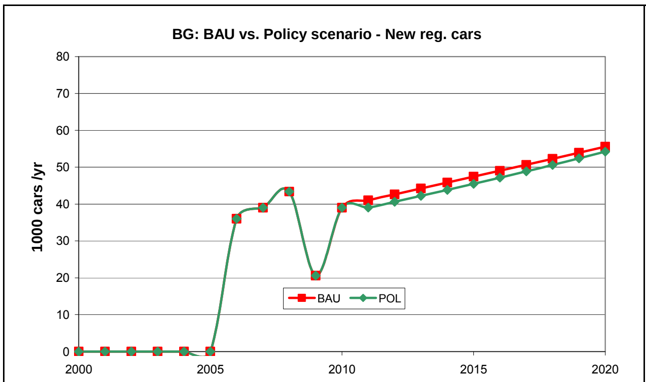
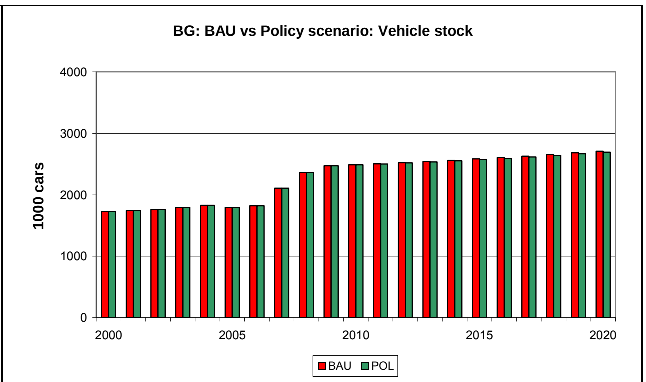


Figure D-2.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-2.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-3 Germany

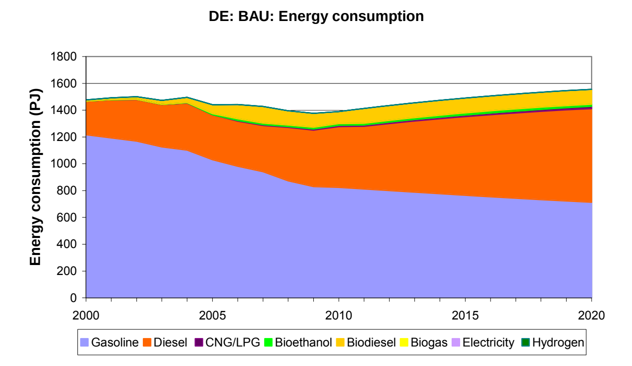


Figure D-3.1a. Energy consumption in the BAU-scenario

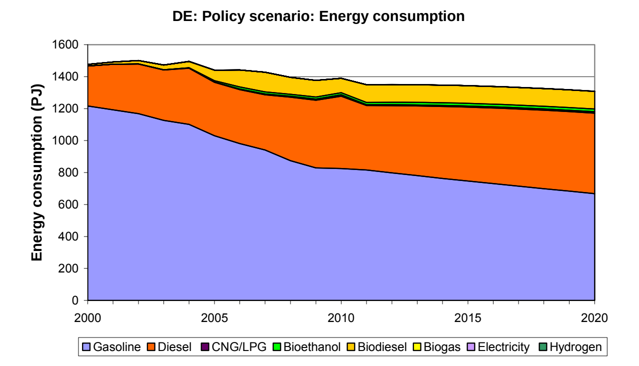


Figure D-3.1b. Energy consumption in the AP-scenario

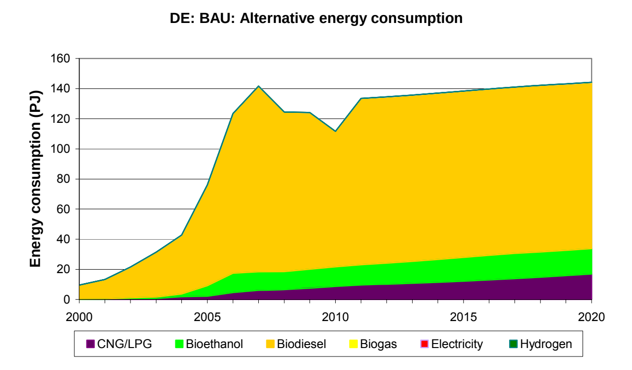


Figure A-3.2a. Alternative energy consumption in the BAU-scenario

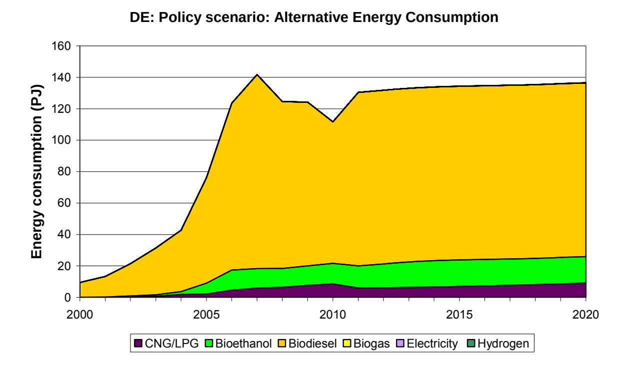


Figure A-3.2b. Alternative energy consumption in the AP-scenario

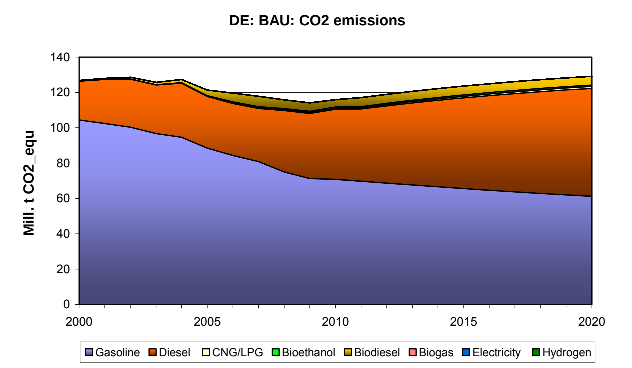


Figure D-3.3a. CO_2 emissions in the BAU-scenario

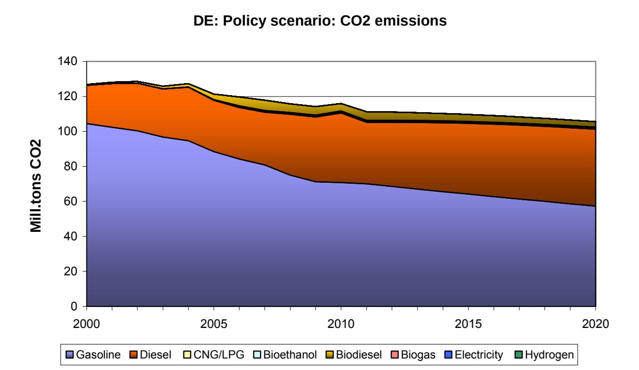


Figure D-3.3b. CO_2 emissions in the AP-scenario

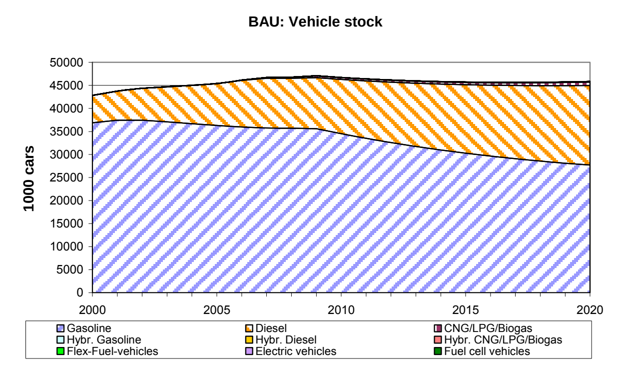


Figure D-3.4a. Development of vehicle stock in the BAU-scenario

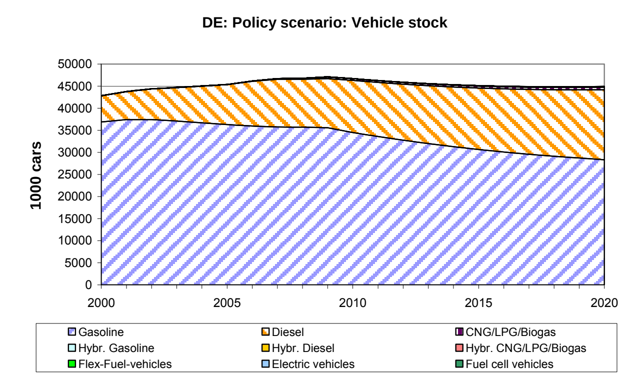


Figure D-3.4b. Development of vehicle stock in the AP-scenario

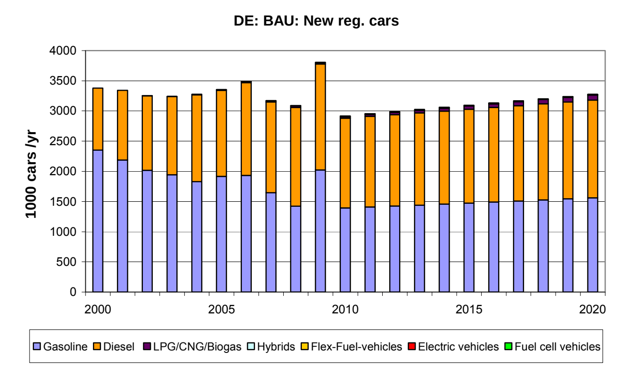


Figure D-3.5a. Development of new registered cars in the BAU-scenario

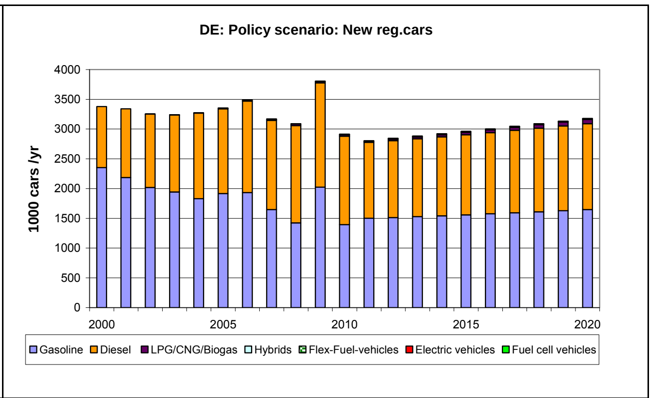


Figure D-3.5b. Development of new registered cars in the AP-scenario

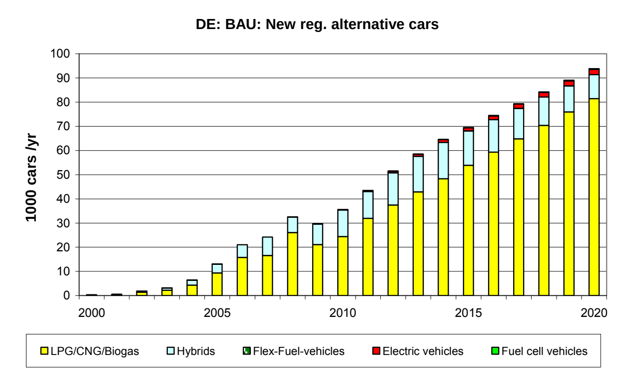


Figure D-3.6a. Development of new registered alternative cars in the BAU-scenario

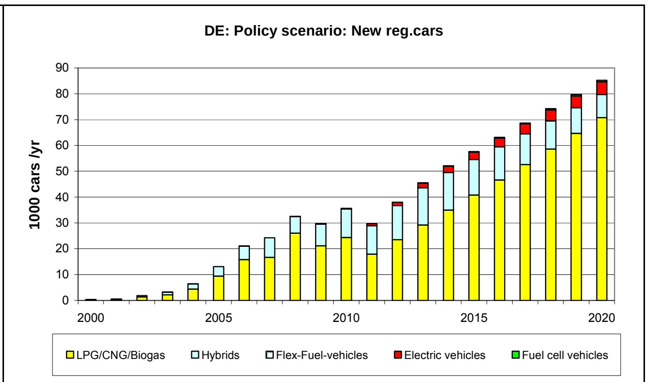


Figure D-3.6b. Development of new registered alternative cars in the AP-scenario

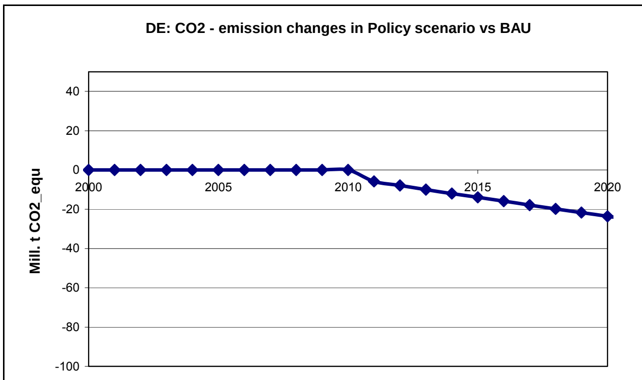


Figure D-3.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

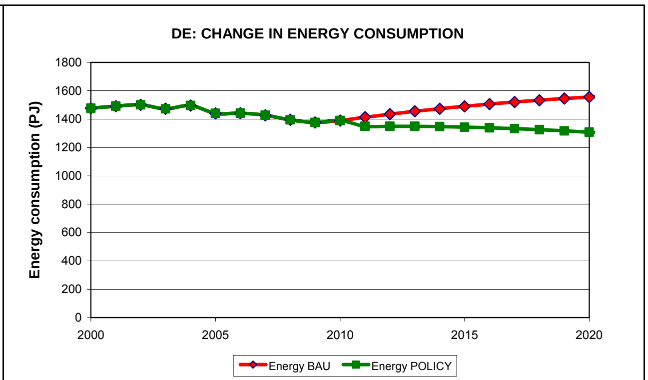


Figure D-3.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

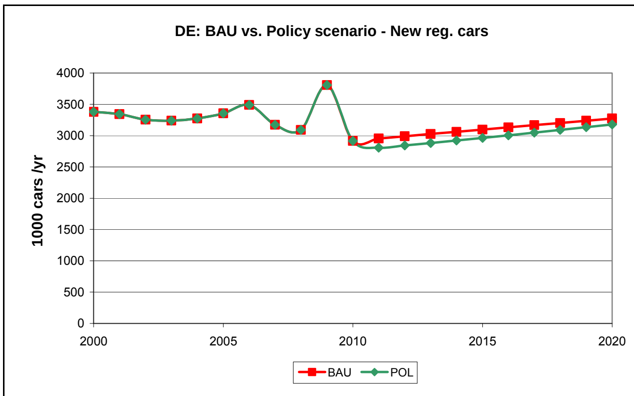
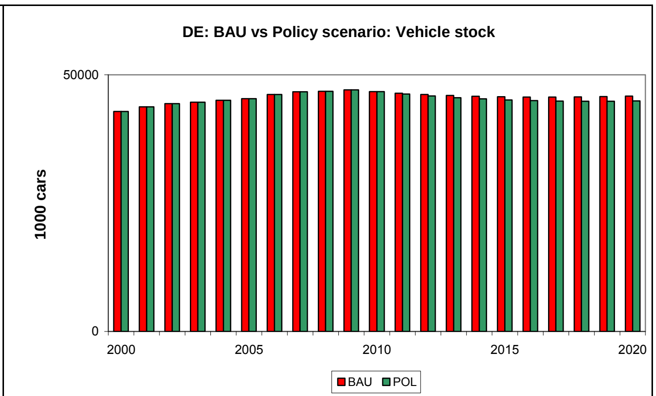


Figure D-3.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-3.8a. Comparison of vehicle stock development in the BAU- and the AP scenario

D-4 Denmark

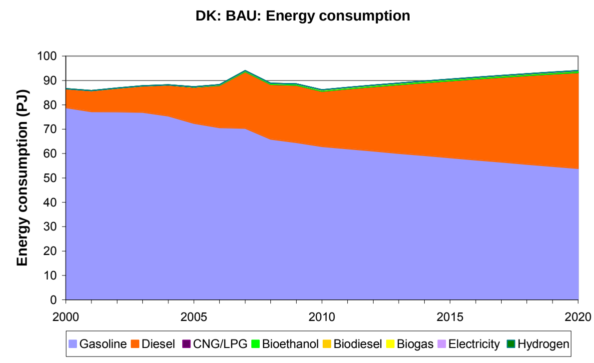


Figure D-4.1a. Energy consumption in the BAU-scenario

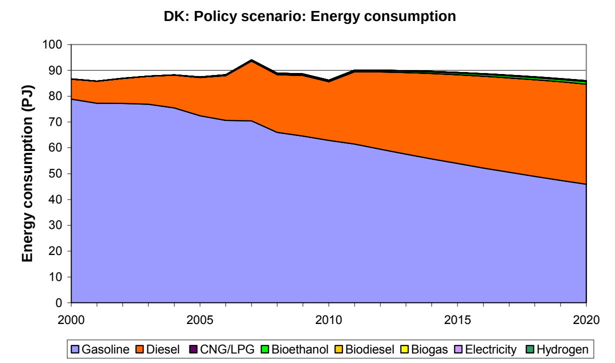


Figure D-4.1b. Energy consumption in the AP-scenario

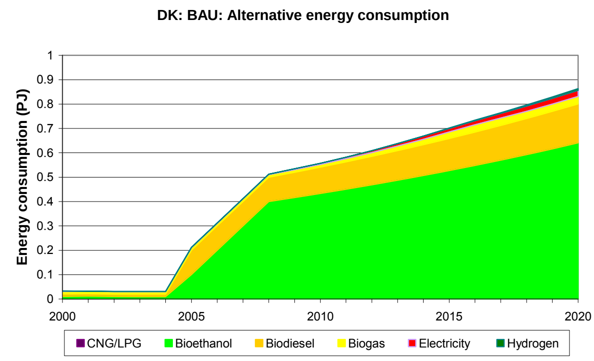


Figure D-4.2a. Alternative energy consumption in the BAU-scenario

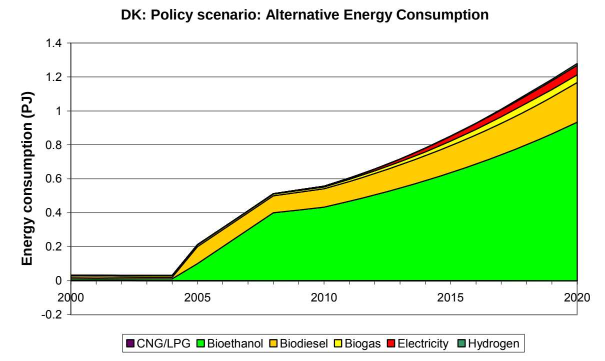


Figure D-4.2b. Alternative energy consumption in the AP-scenario

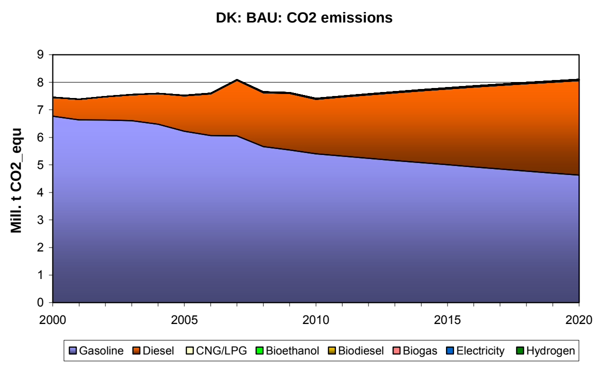


Figure D-4.3a. CO2 emissions in the BAU-scenario

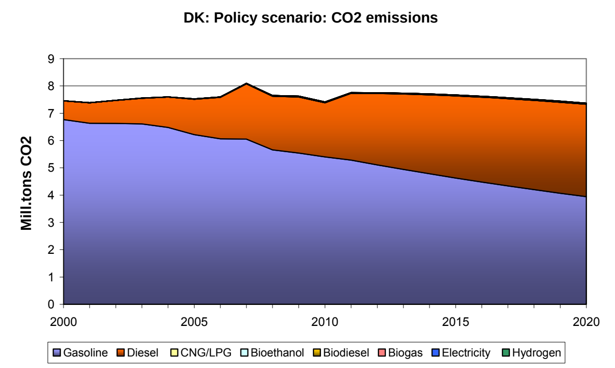


Figure D-4.3b. CO2 emissions in the AP-scenario

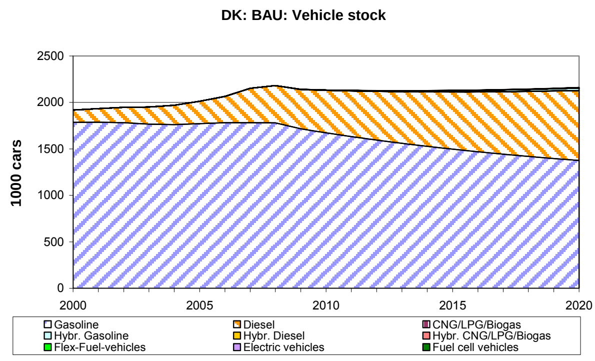


Figure D-4.4a. Development of vehicle stock in the BAU-scenario

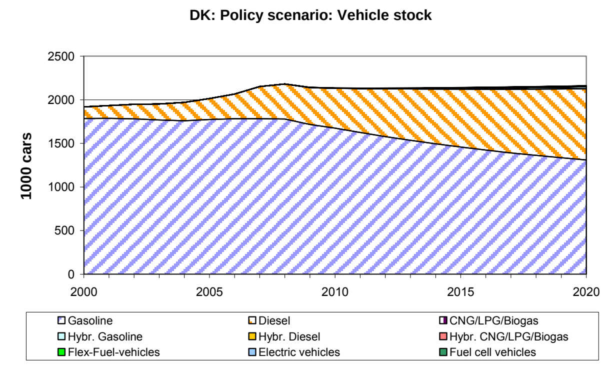


Figure D-4.4b. Development of vehicle stock in the AP-scenario

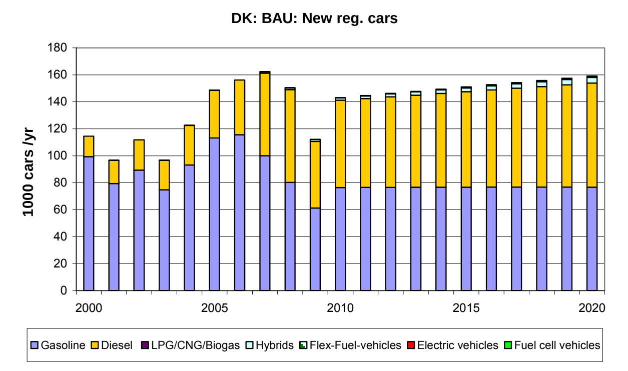


Figure D-4.5a. Development of new registered cars in the BAU-scenario

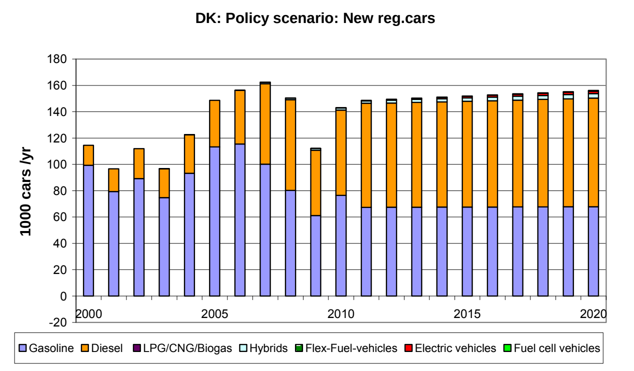


Figure D-4.5b. Development of new registered cars in the AP-scenario

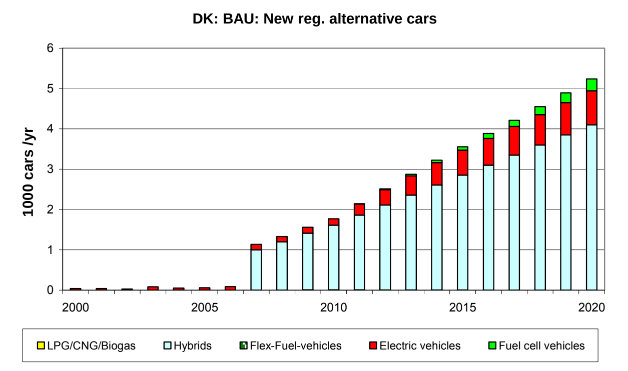


Figure D-4.6a. Development of new registered alternative cars in the BAU-scenario

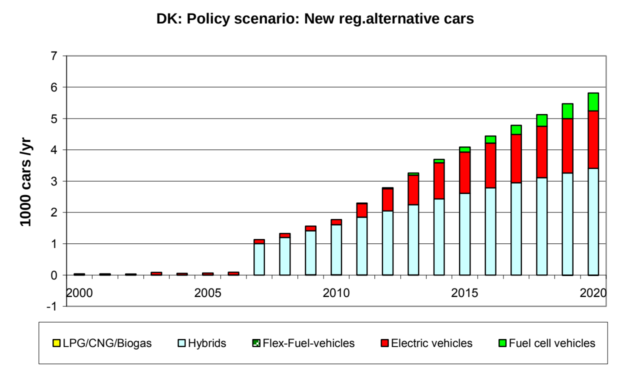


Figure D-4.6b. Development of new registered alternative cars in the AP-scenario

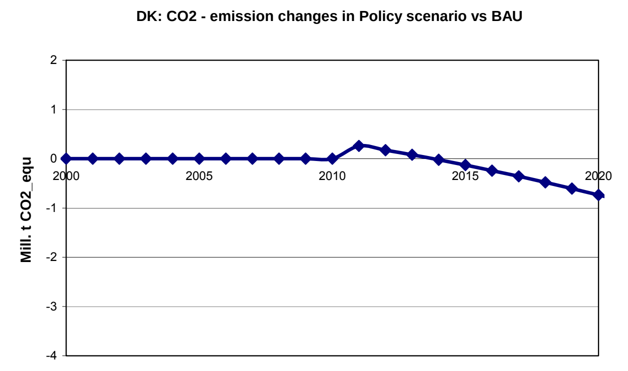


Figure D-4.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

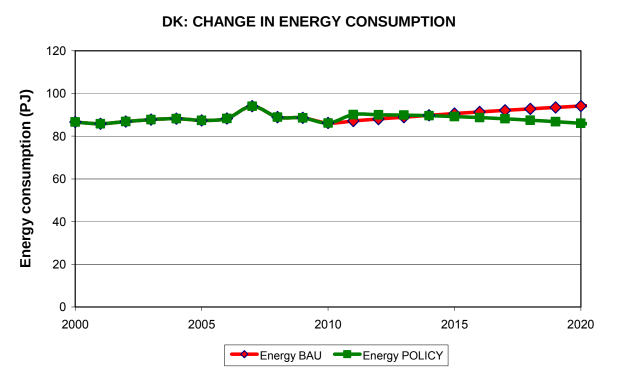


Figure D-4.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

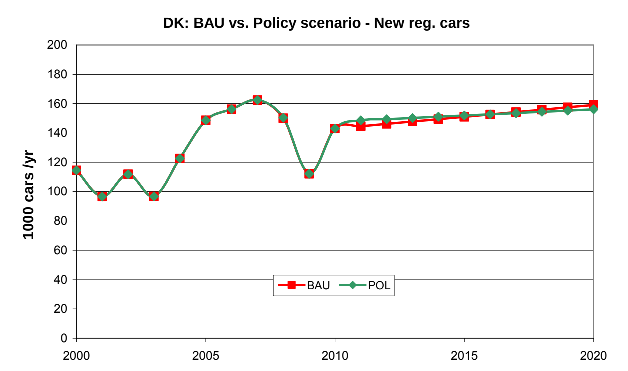
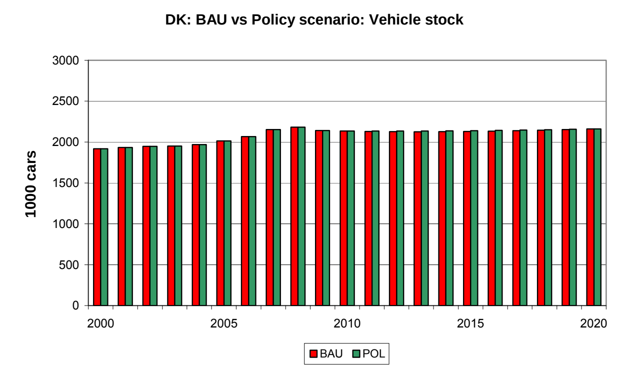


Figure D-4.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-4.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-5 France

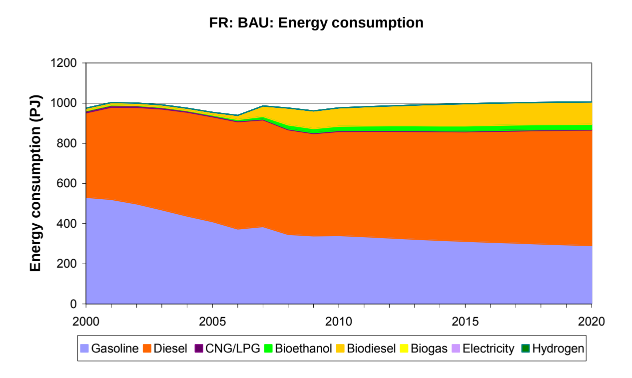


Figure D-5.1a. Energy consumption in the BAU-scenario

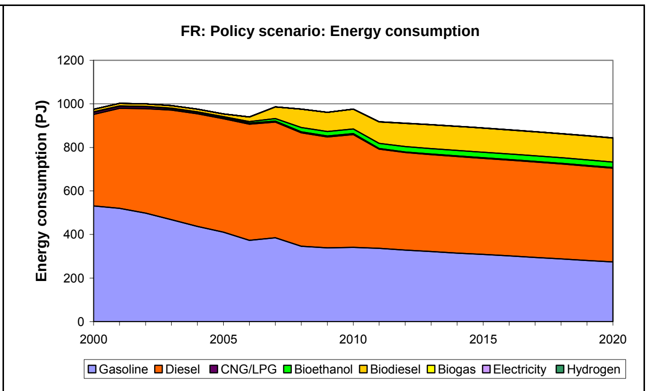


Figure D-5.1b. Energy consumption in the AP-scenario

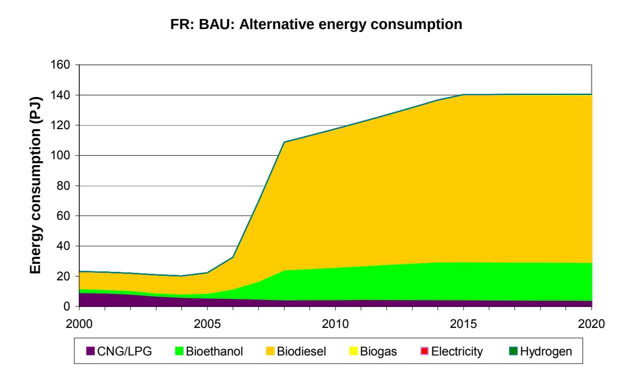


Figure D-5.2a. Alternative energy consumption in the BAU-scenario

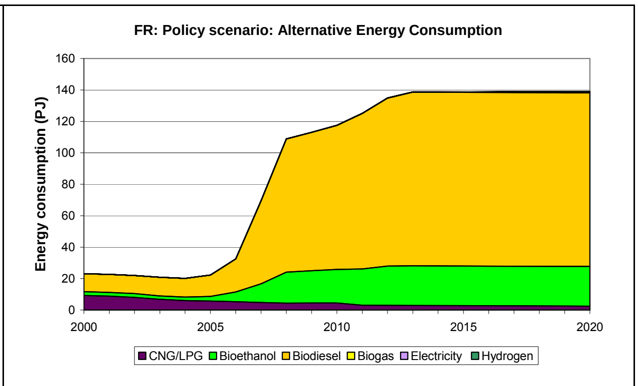


Figure D-5.2b. Alternative energy consumption in the AP-scenario

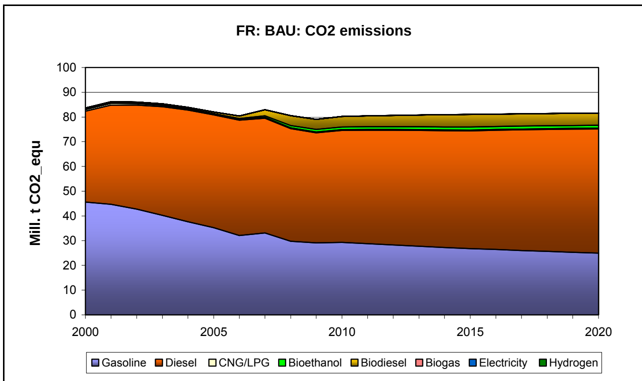


Figure D-5.3a. CO2 emissions in the BAU-scenario

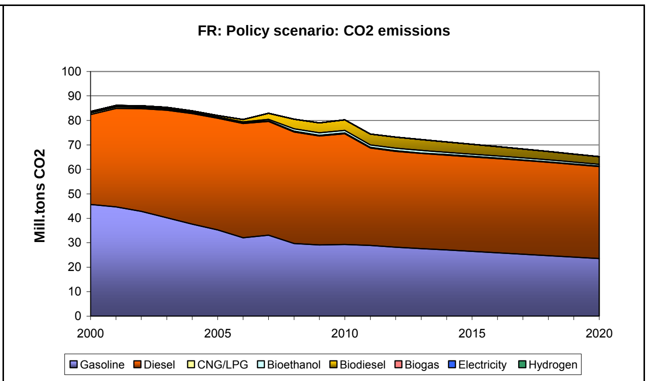


Figure D-5.3b. CO2 emissions in the AP-scenario

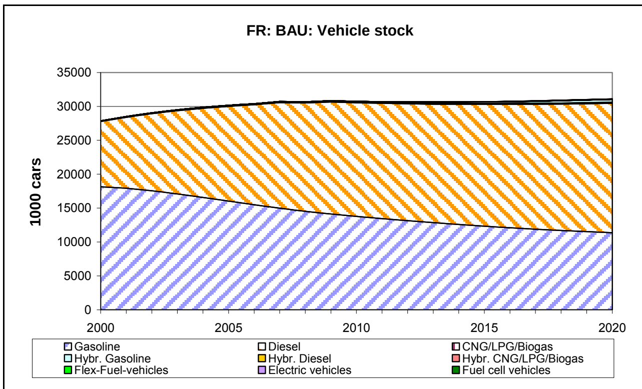


Figure D-5.4a. Development of vehicle stock in the BAU-scenario

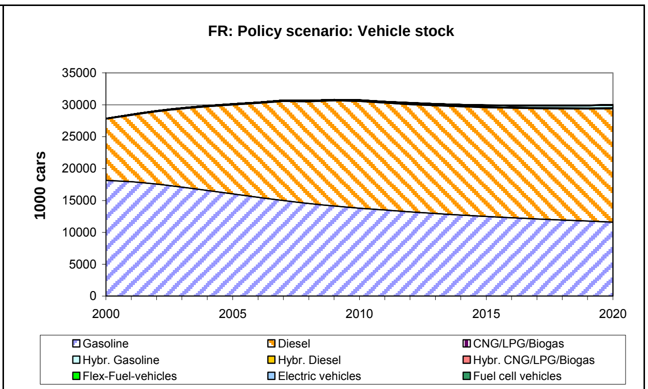


Figure D-5.4b. Development of vehicle stock in the AP-scenario

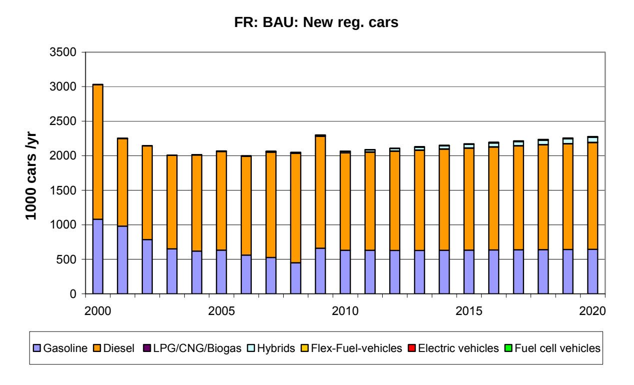


Figure D-5.5a. Development of new registered cars in the BAU-scenario

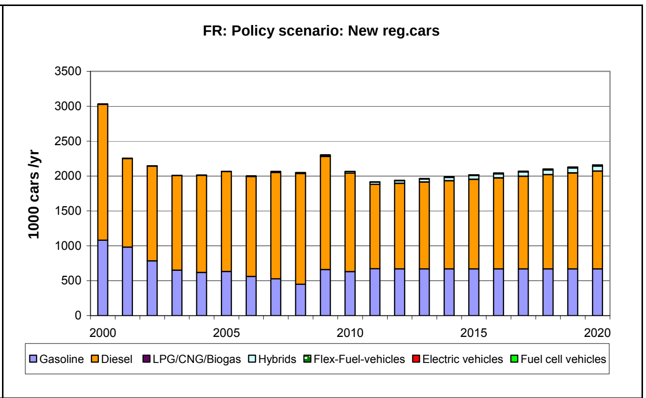


Figure D-5.5b. Development of new registered cars in the AP-scenario

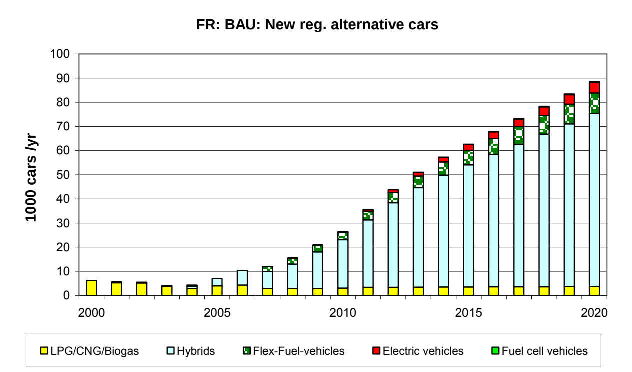


Figure D-5.6a. Development of new registered alternative cars in the BAU-scenario

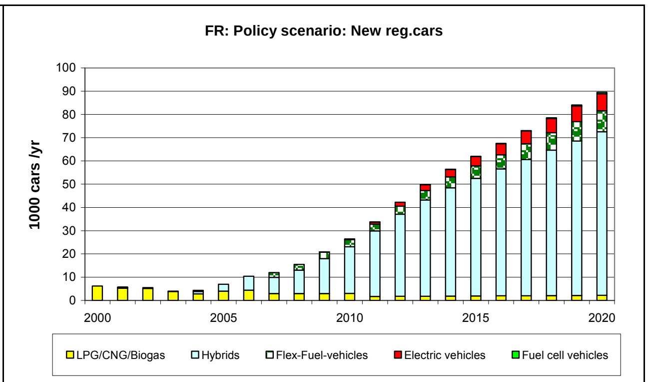


Figure D-5.6b. Development of new registerd alternative cars in the AP-scenario

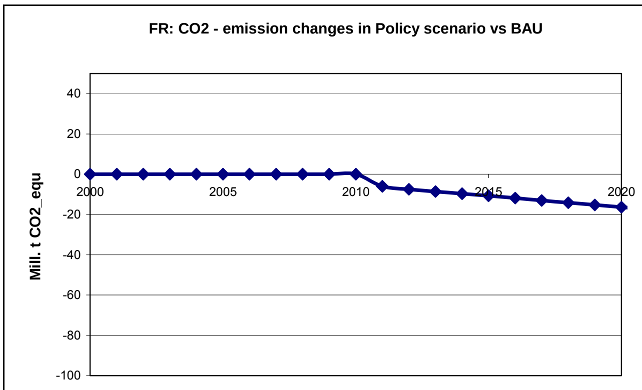


Figure D-5.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

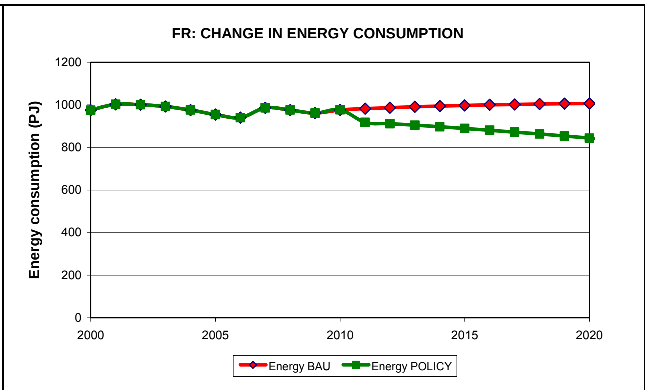


Figure D-5.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

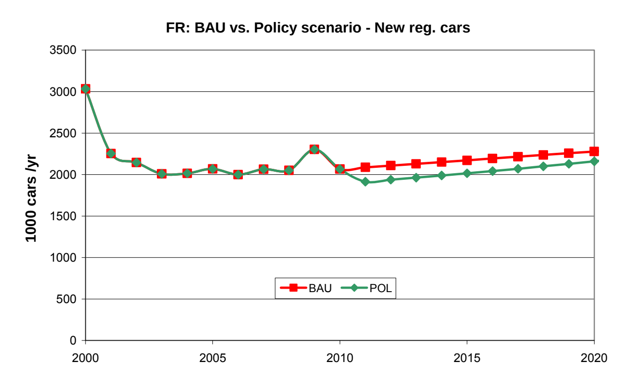
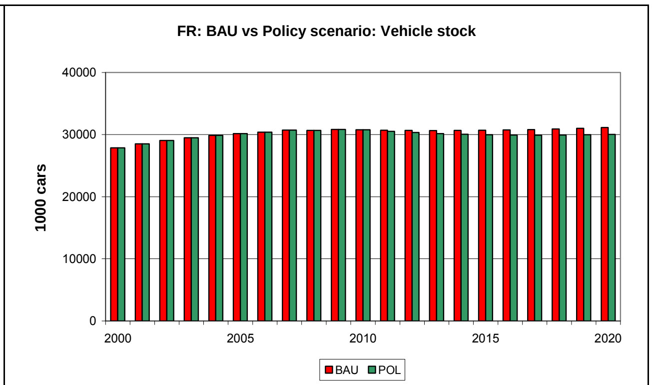


Figure D-5.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-5.8a. Comparison of vehicle stock development in the BAU- and the AP scenario

D-6 Italy

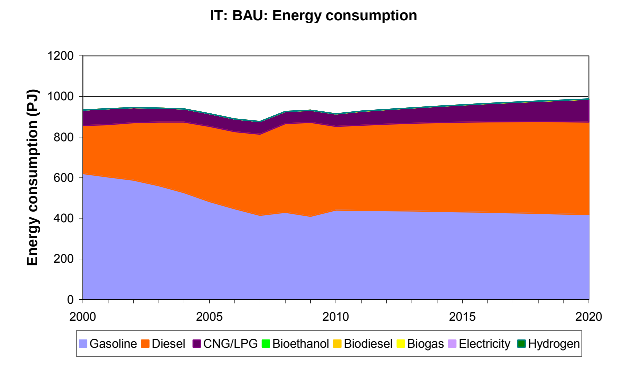


Figure D-6.1a. Energy consumption in the BAU-scenario

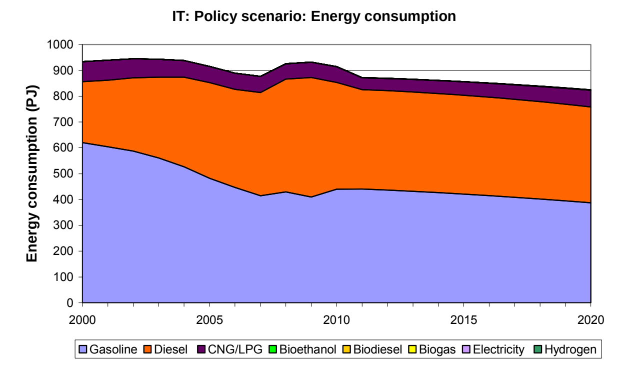


Figure D-6.1b. Energy consumption in the AP-scenario

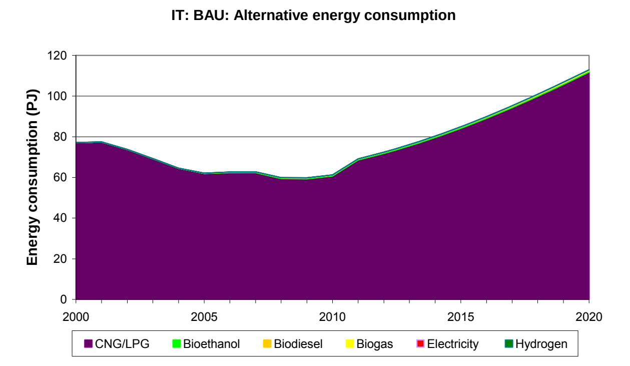


Figure D-6.2a. Alternative energy consumption in the BAU-scenario

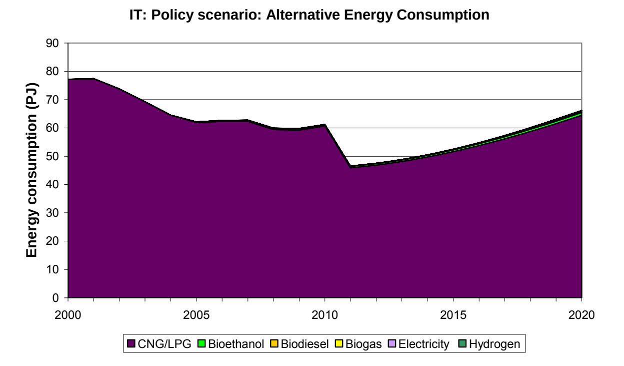


Figure D-6.2b. Alternative energy consumption in the AP-scenario

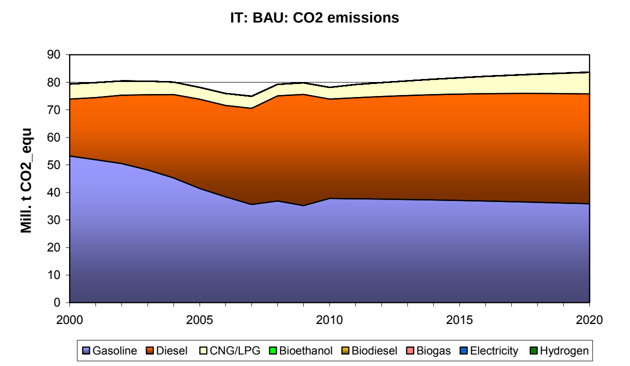


Figure D-6.3a. CO2 emissions in the BAU-scenario

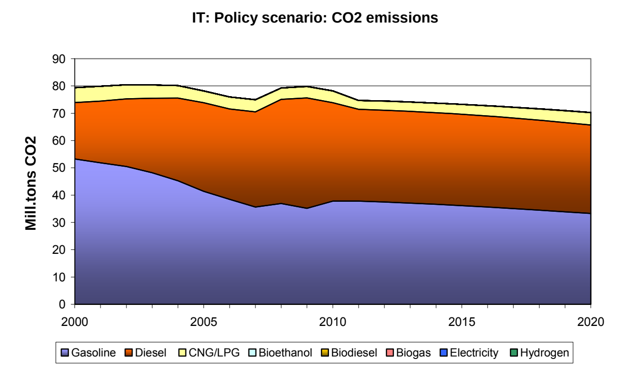


Figure D-6.3b. CO2 emissions in the AP-scenario

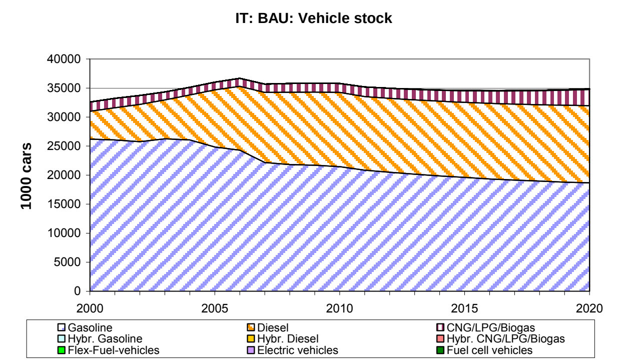


Figure D-6.4a. Development of vehicle stock in the BAU-scenario

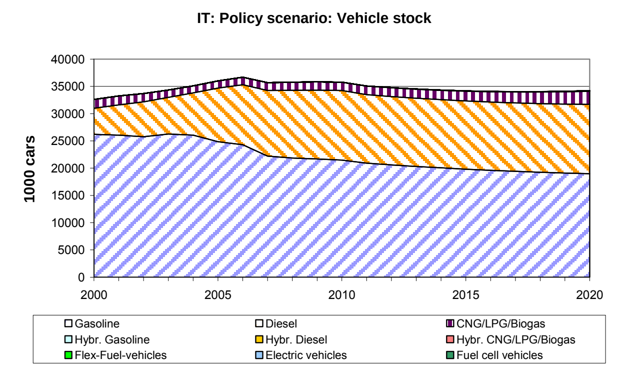


Figure D-6.4b. Development of vehicle stock in the AP-scenario

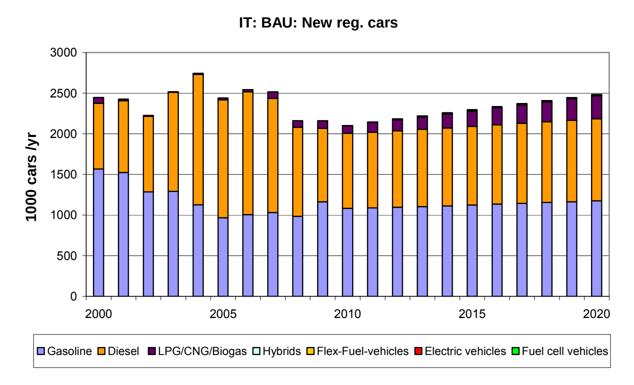


Figure D-6.5a. Development of new registered cars in the BAU-scenario

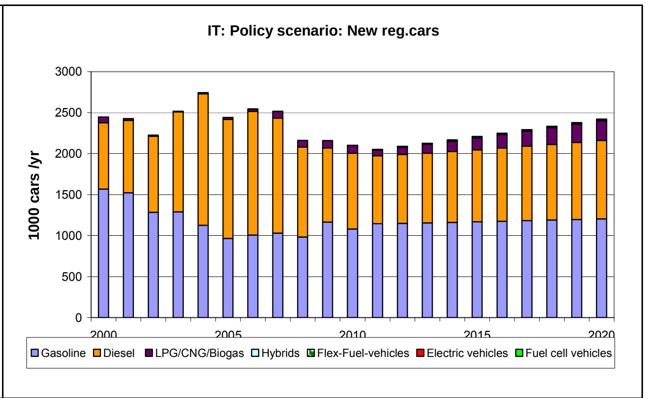


Figure D-6.5b. Development of new registered cars in the AP-scenario

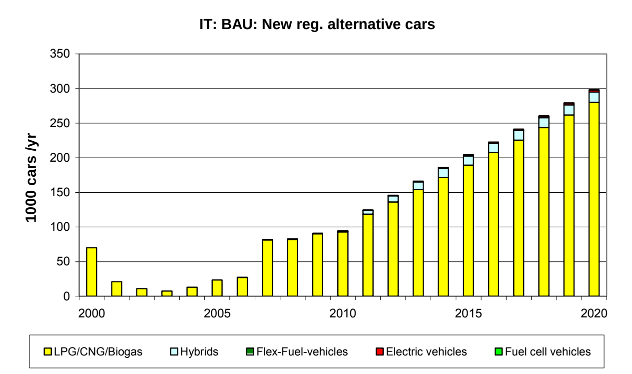


Figure D-6.6a. Development of new registered alternative cars in the BAU-scenario

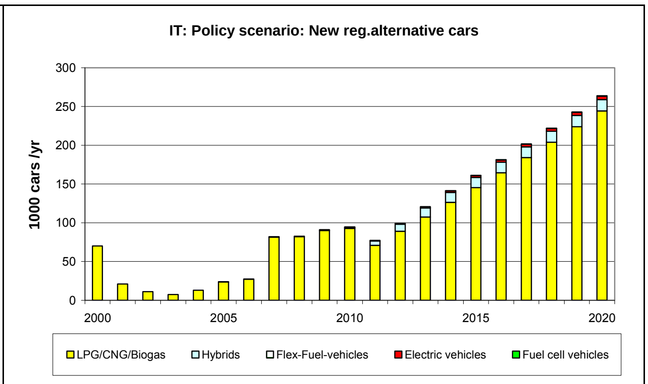


Figure D-6.6b. Development of new registered alternative cars in the AP-scenario

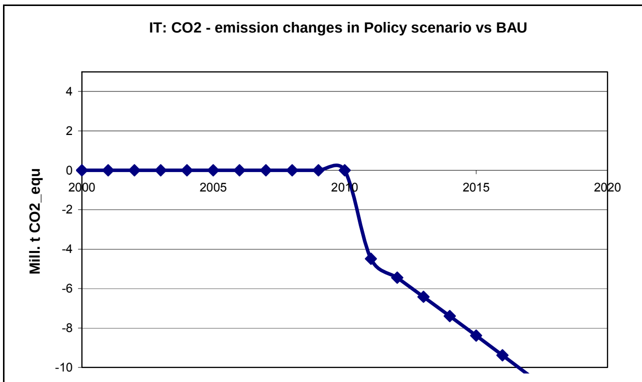


Figure D-6.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

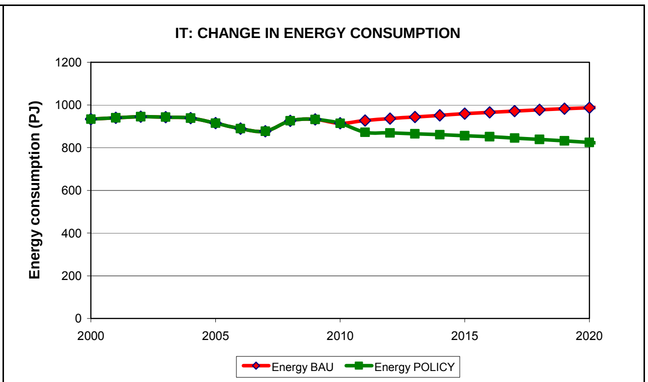


Figure D-6.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

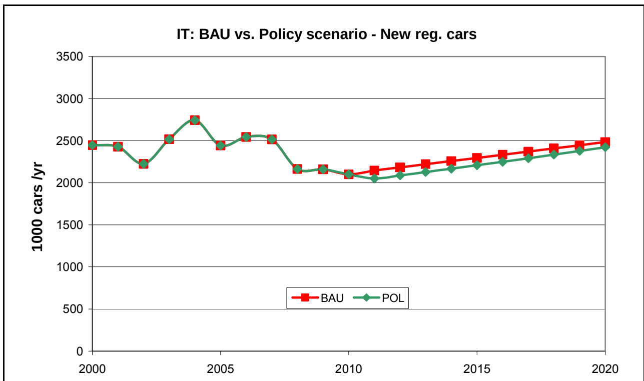
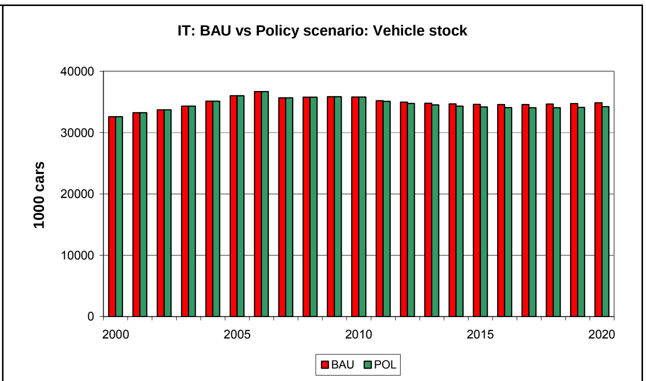


Figure D-6.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-6.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-7 The Netherlands

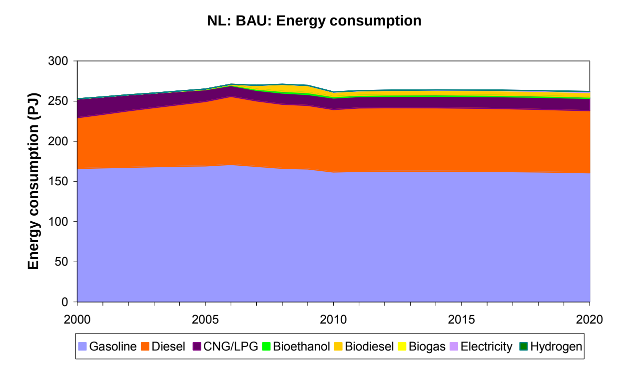


Figure D-7.1a. Energy consumption in the BAU-scenario

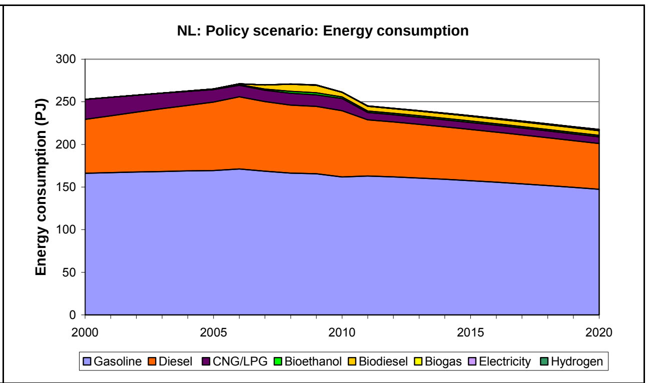


Figure D-7.1b. Energy consumption in the AP-scenario

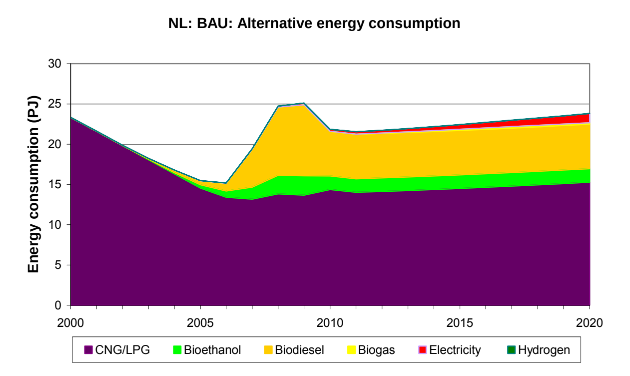


Figure D-7.2a. Alternative energy consumption in the BAU-scenario

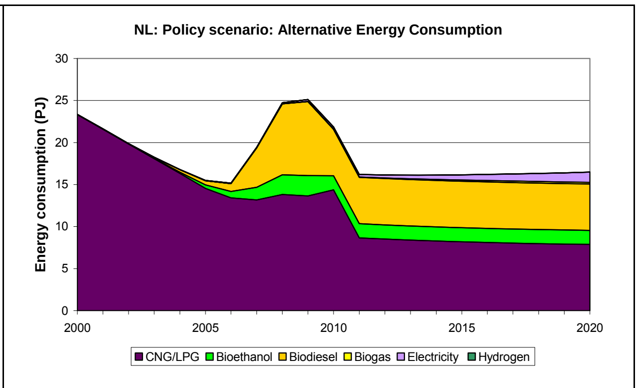


Figure D-7.2b. Alternative energy consumption in the AP-scenario

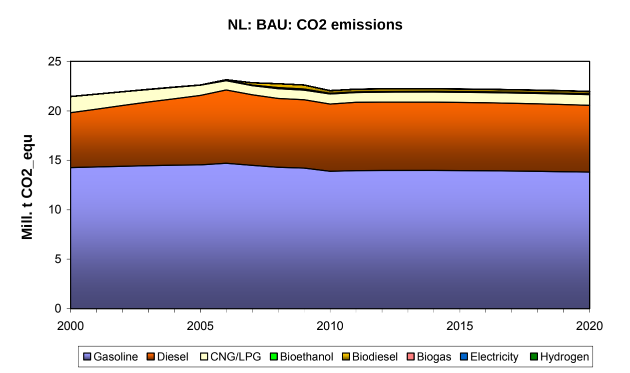


Figure D-7.3a. CO2 emissions in the BAU-scenario

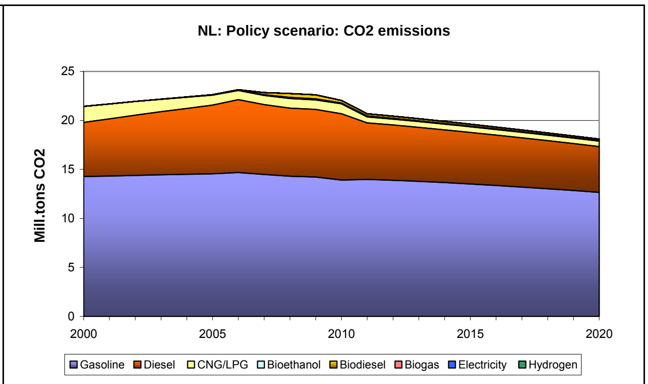


Figure D-7.3b. CO2 emissions in the AP-scenario

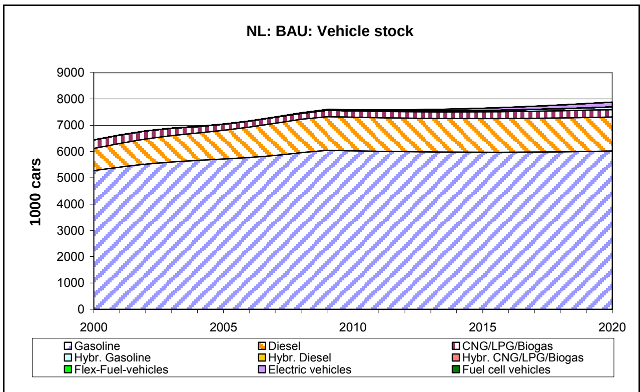


Figure D-7.4a. Development of vehicle stock in the BAU-scenario

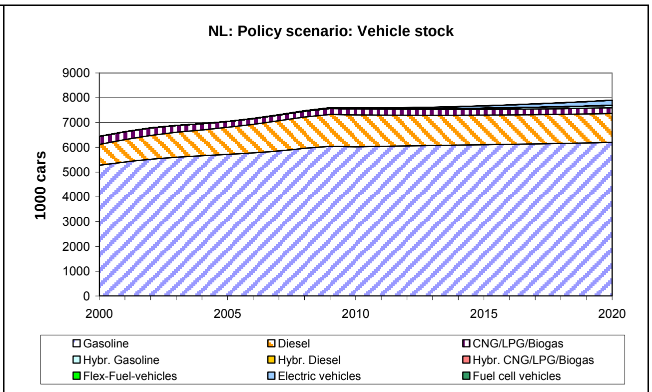


Figure D-7.4b. Development of vehicle stock in the AP-scenario

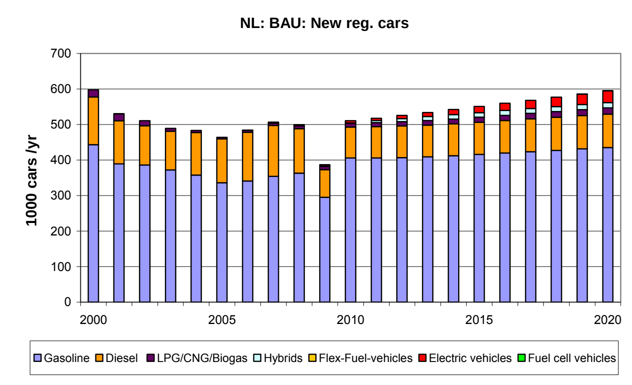


Figure D-7.5a. Development of new registered cars in the BAU-scenario

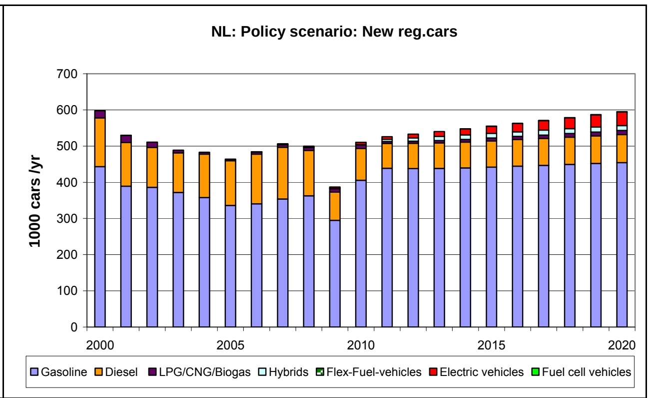


Figure D-7.5b. Development of new registerd cars in the AP-scenario

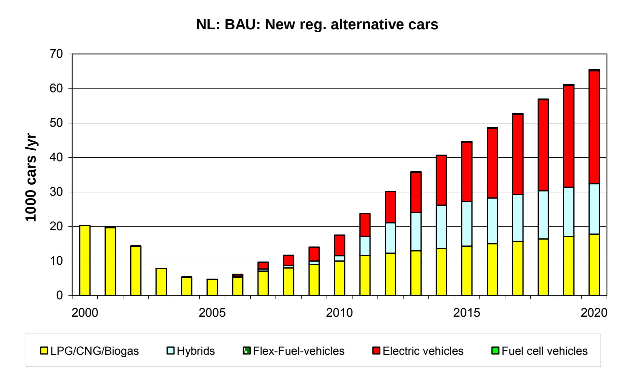


Figure D-7.6a. Development of new registered alternative cars in the BAU-scenario

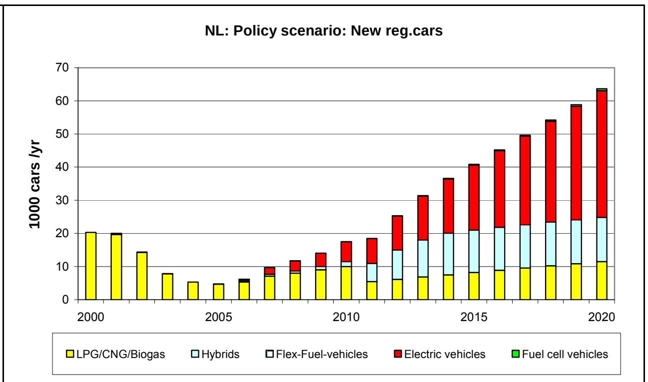


Figure D-7.6b. Development of new registerd alternative cars in the AP-scenario

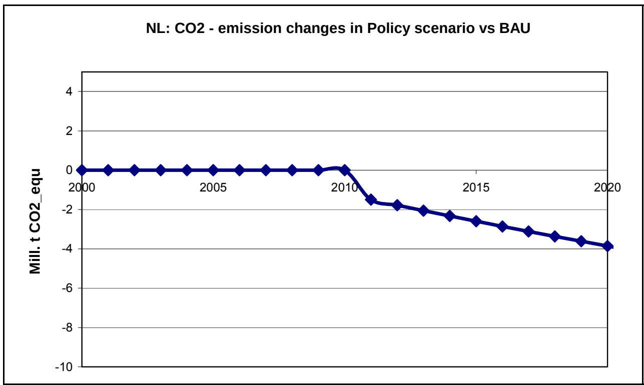


Figure D-7.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

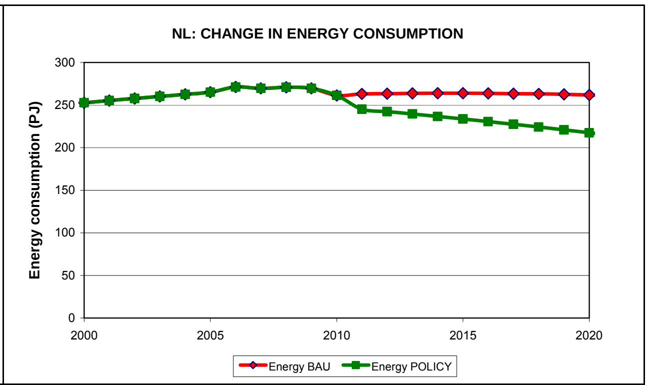


Figure D-7.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

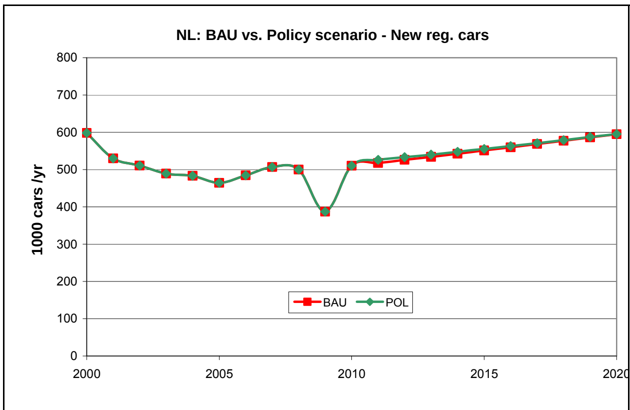
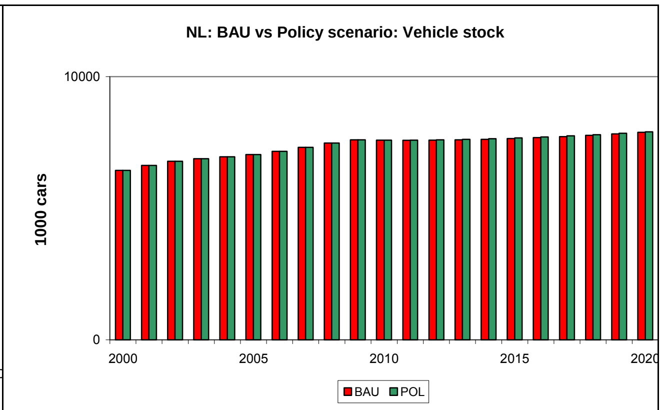


Figure D-7.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-7.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-8 Poland

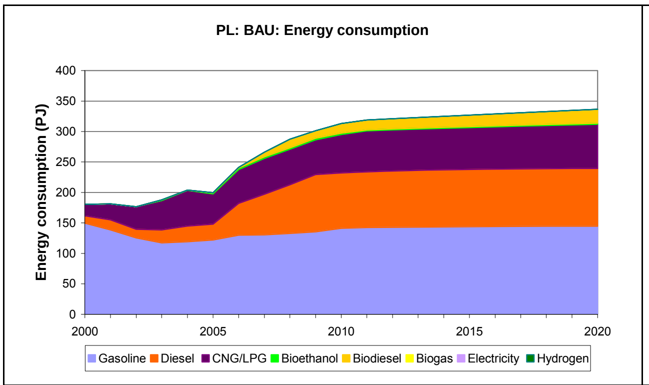
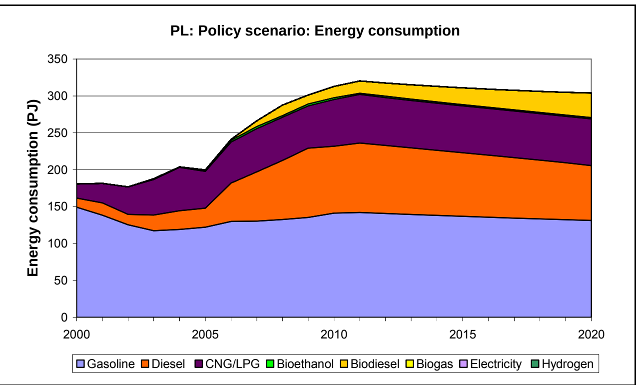


Figure D-8.1a. Energy consumption in the BAU-scenario



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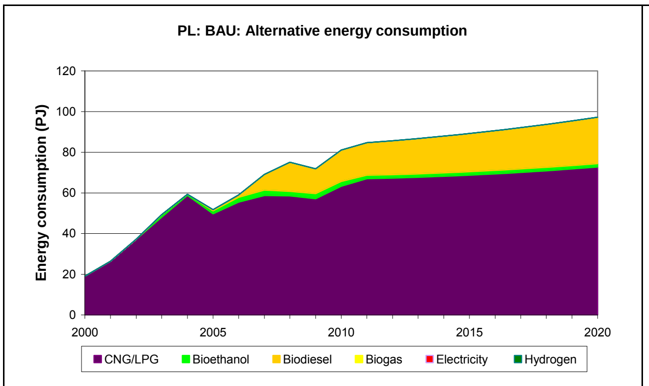

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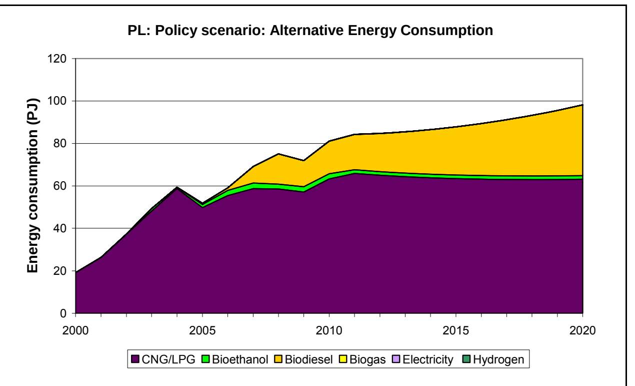


Figure D-8.2b. Alternative energy consumption in the AP-scenario

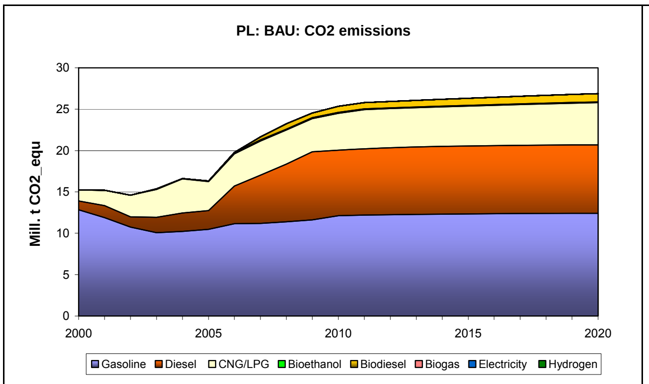


Figure D-8.3a. CO2 emissions in the BAU-scenario

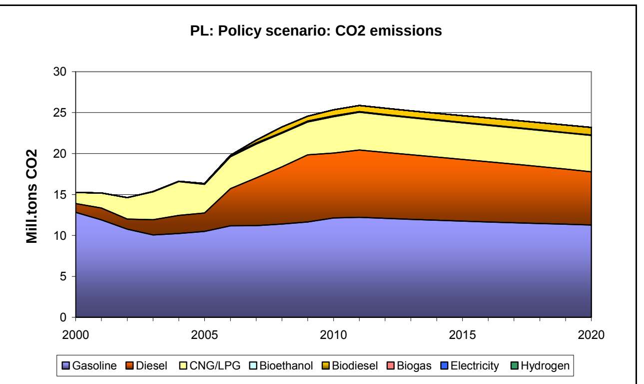


Figure D-8.3b. CO2 emissions in the AP-scenario

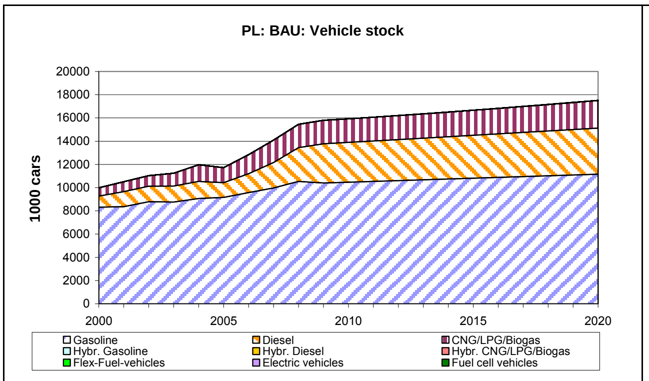
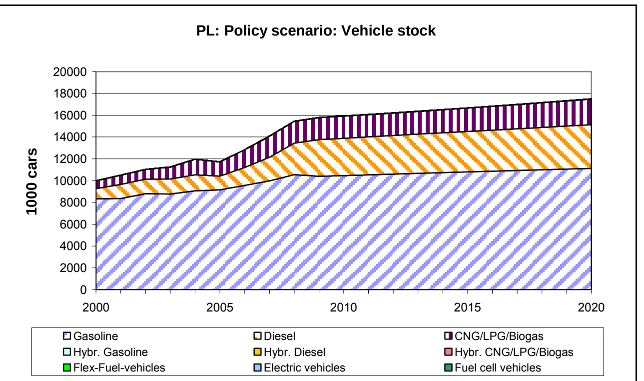


Figure D-8.4a. Development of vehicle stock in the BAU-scenario



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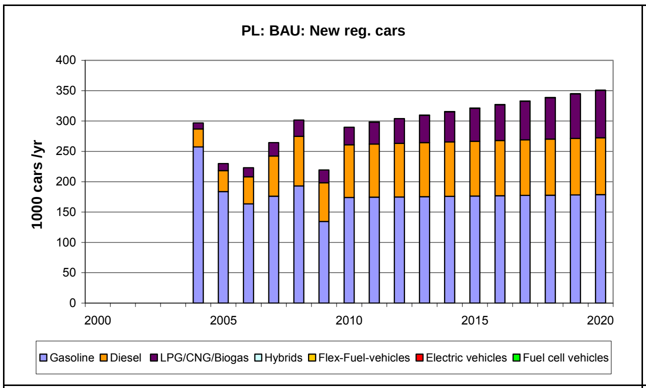
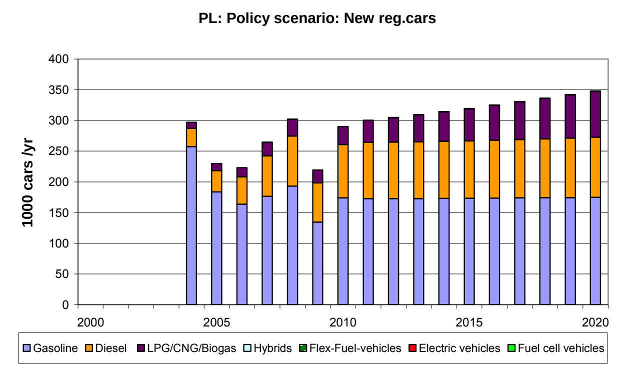


Figure D-8.5a. Development of new registered cars in the BAU-scenario



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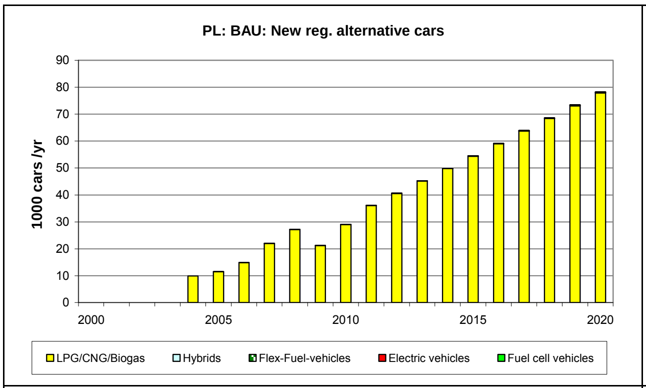

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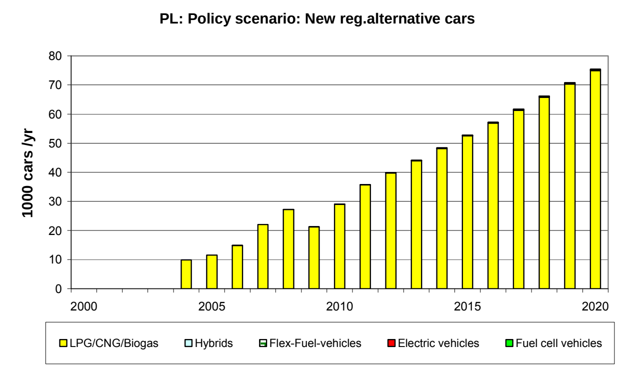

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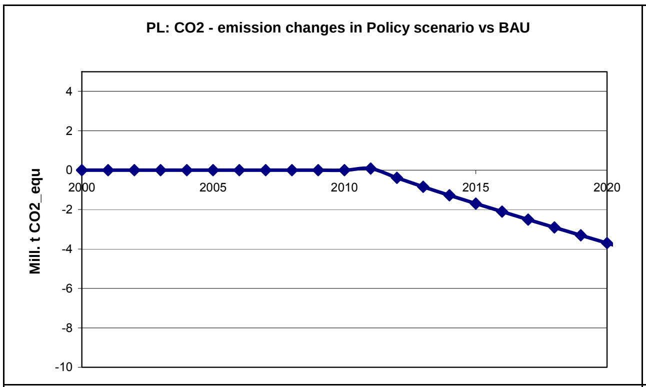
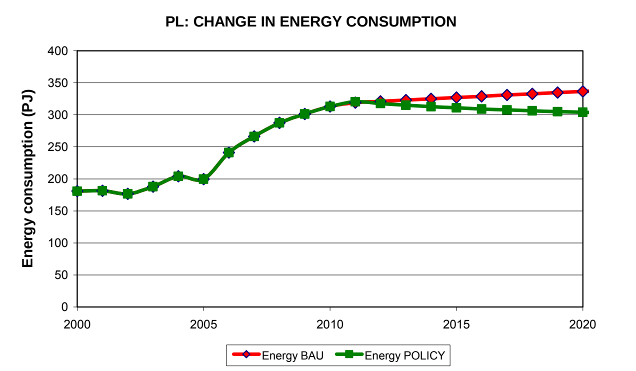


Figure D-8.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario



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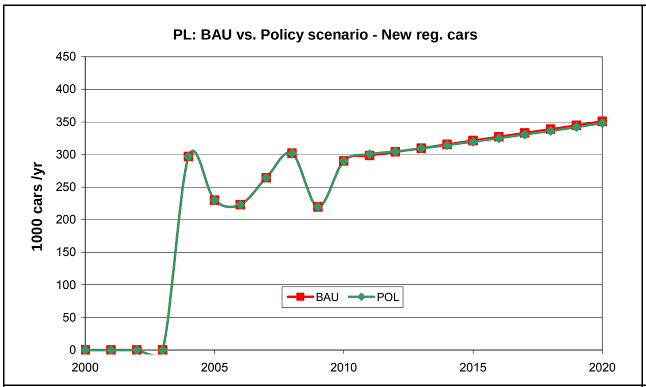

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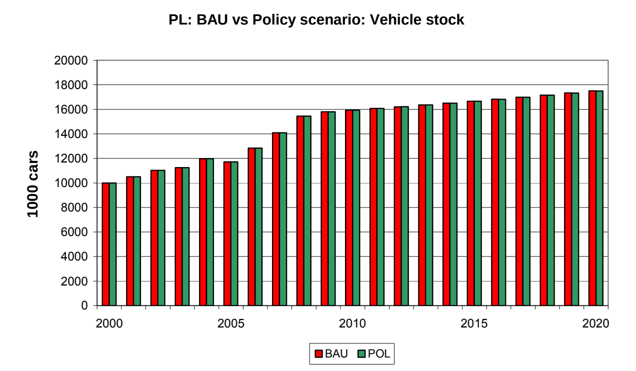
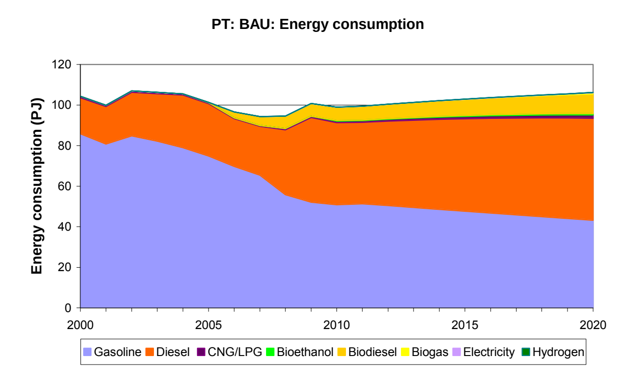


D-8.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-9 Portugal



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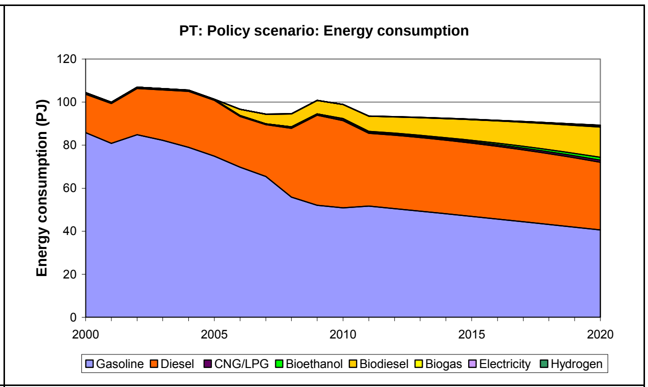

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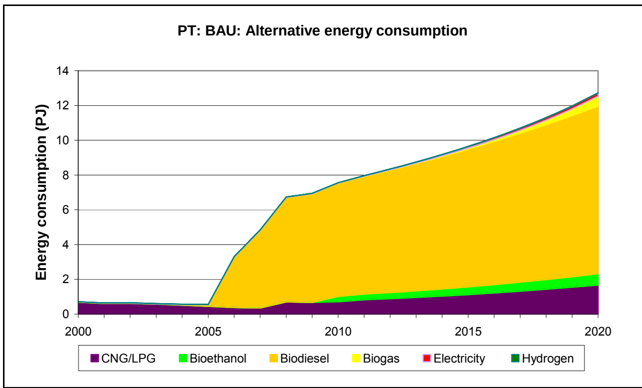


Figure D-9.2a. Alternative energy consumption in the BAU-scenario

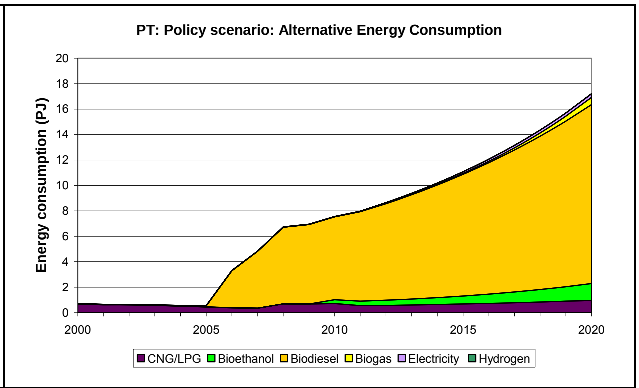


Figure D-9.2b. Alternative energy consumption in the AP-scenario

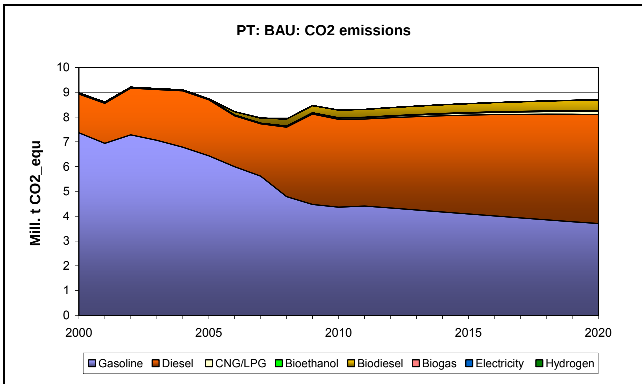


Figure D-9.3a. CO2 emissions in the BAU-scenario

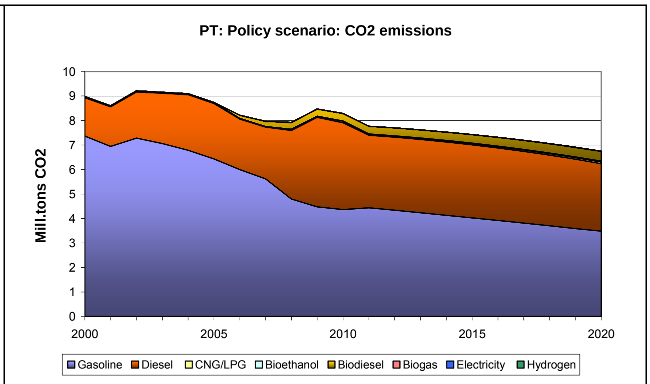


Figure D-9.3b. CO2 emissions in the AP-scenario

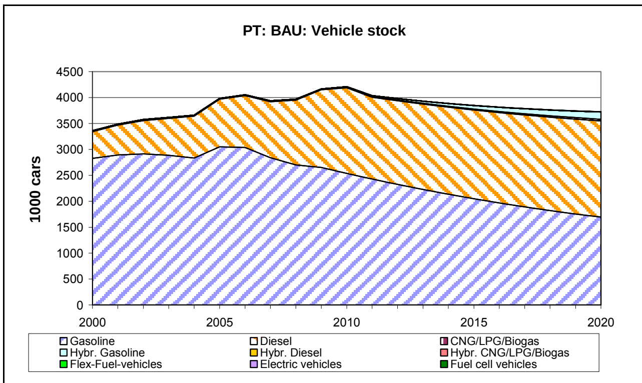


Figure D-9.4a. Development of vehicle stock in the BAU-scenario

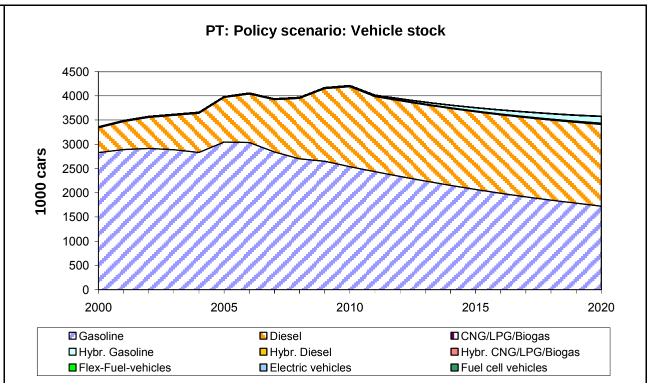


Figure D-9.4b. Development of vehicle stock in the AP-scenario

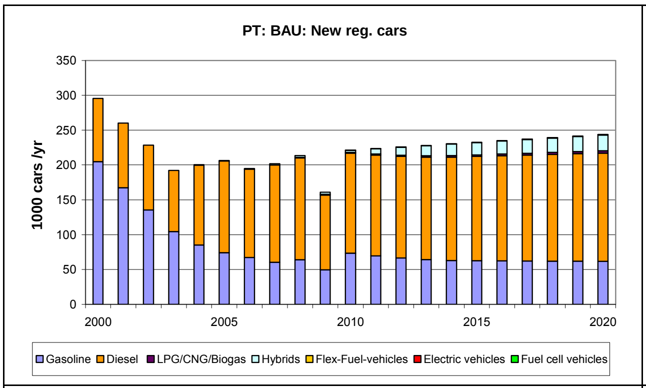
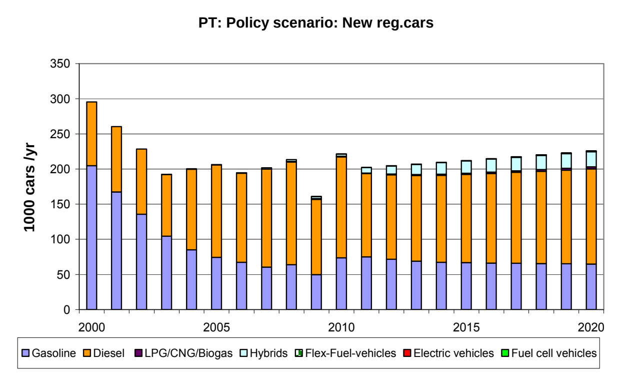


Figure D-9.5a. Development of new registered cars in the BAU-scenario



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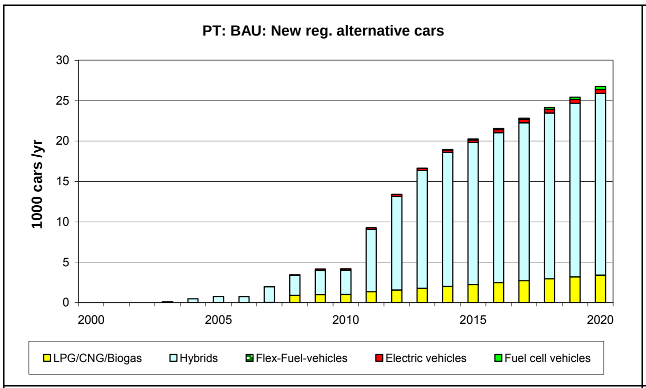
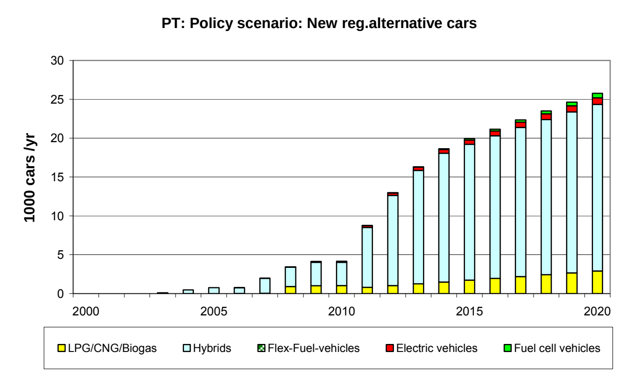


Figure D-9.6a. Development of new registered alternative cars in the BAU-scenario



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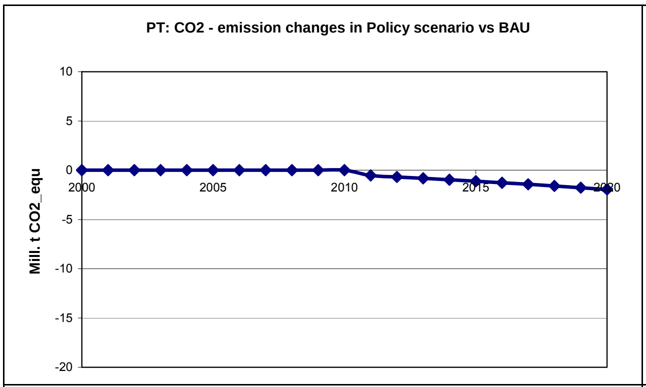


Figure D-9.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

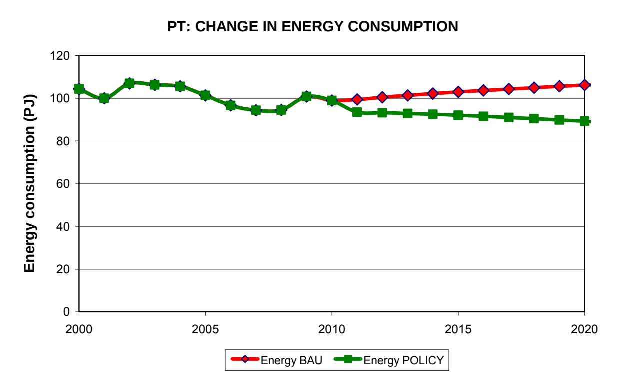


Figure D-9.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

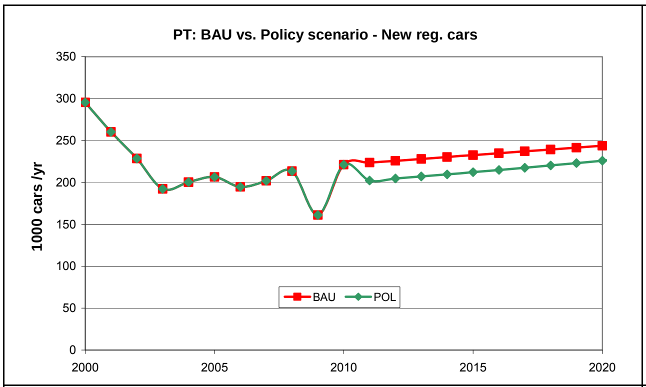
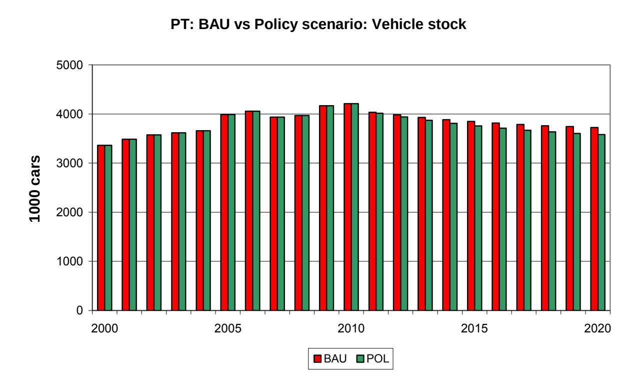
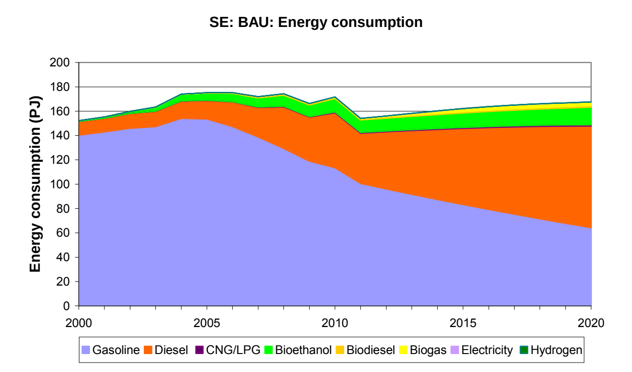


Figure D-9.8a. Development of new registered cars in the BAU-scenario and in the AP scenario



D-9.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

D-10 Sweden



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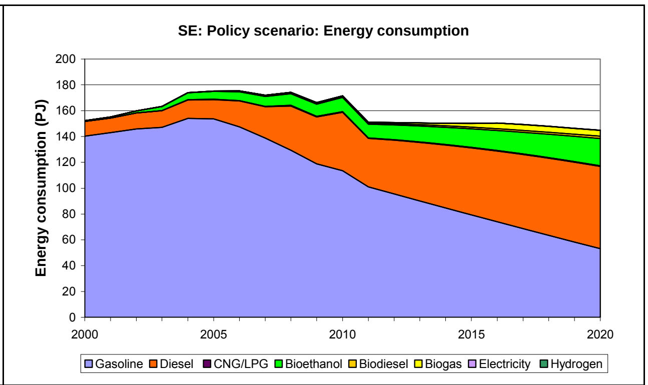


Figure D-10.1b. Energy consumption in the AP-scenario

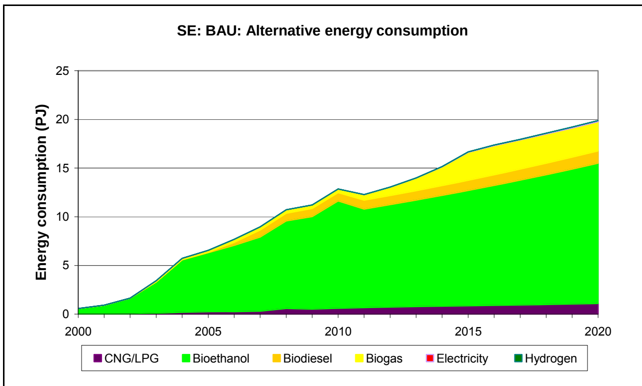


Figure D-10.2a. Alternative energy consumption in the BAU-scenario

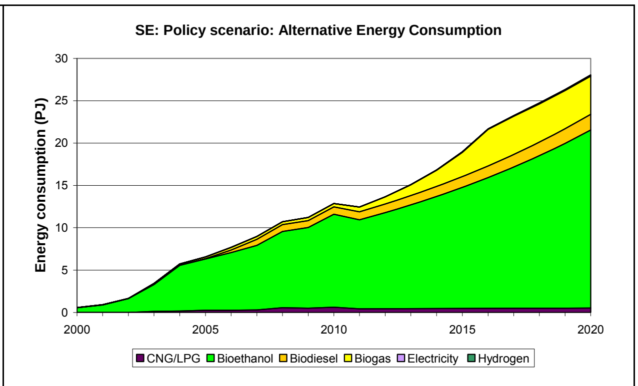


Figure D-10.2b. Alternative energy consumption in the AP-scenario

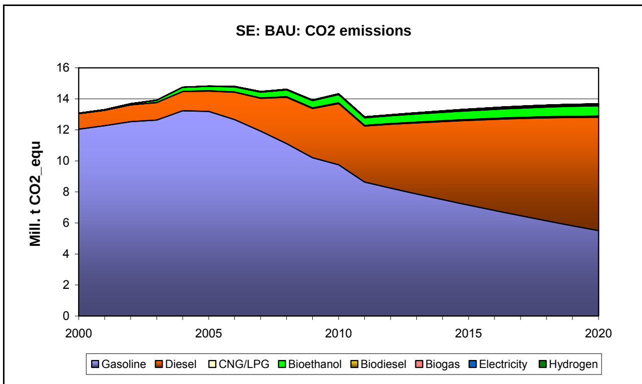


Figure D-10.3a. CO2 emissions in the BAU-scenario

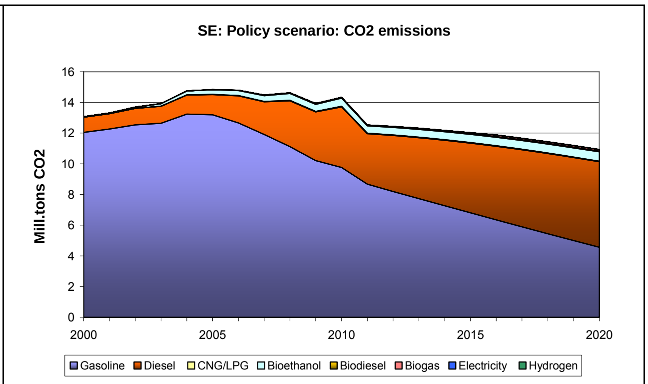


Figure D-10.3b. CO2 emissions in the AP-scenario

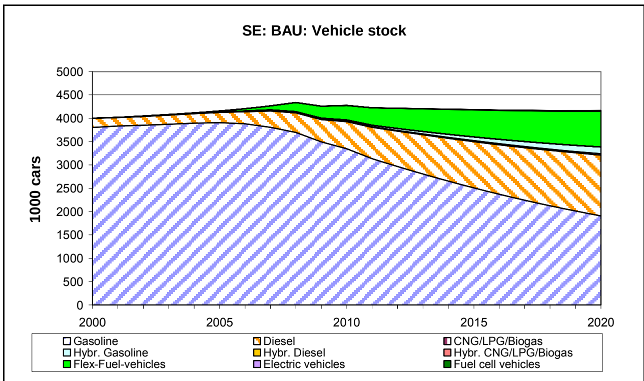


Figure D-10.4a. Development of vehicle stock in the BAU-scenario

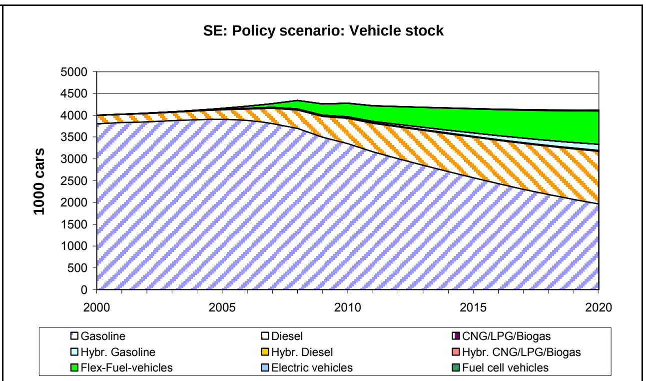


Figure D-10.4b. Development of vehicle stock in the AP-scenario

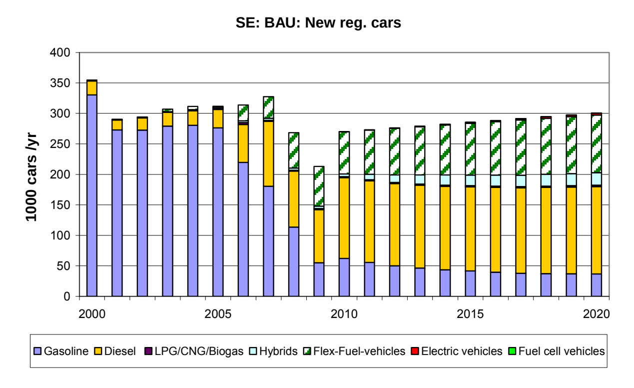
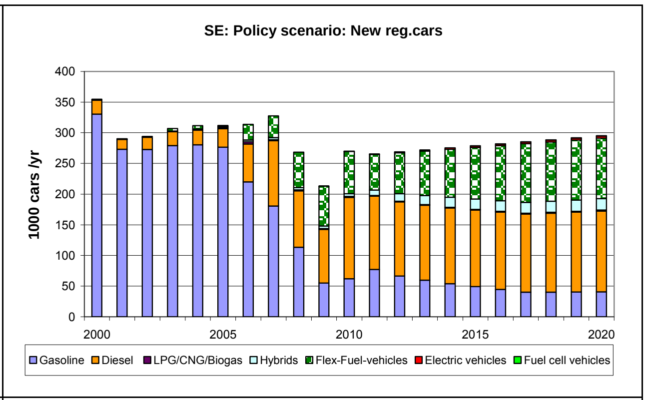


Figure D-10.5a. Development of new registered cars in the BAU-scenario



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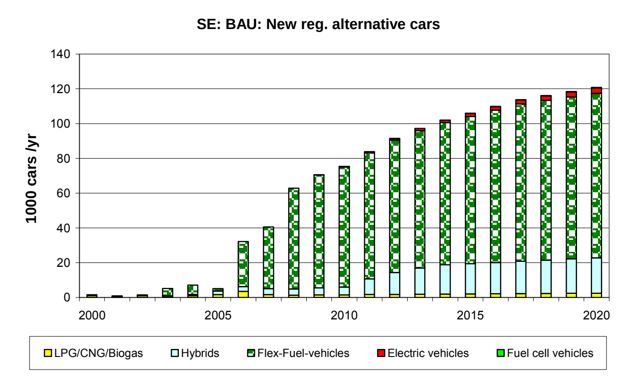
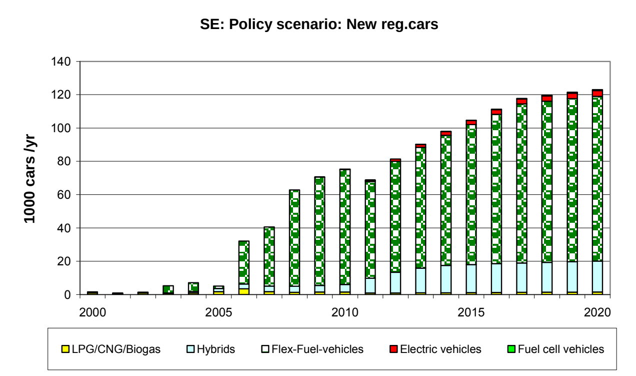


Figure D-10.6a. Development of new registered alternative cars in the BAU-scenario



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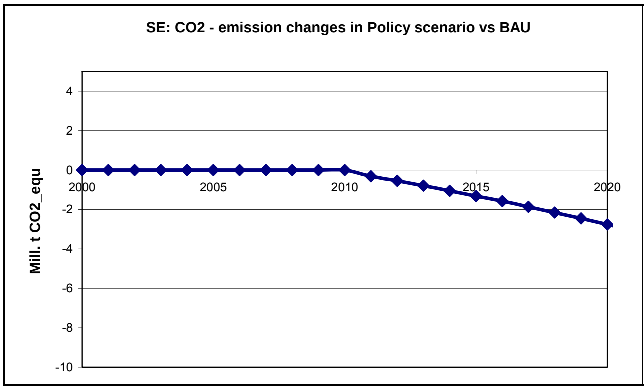


Figure D-10.7a. Comparison of CO2 emission changes in the BAU-scenario and in the AP scenario

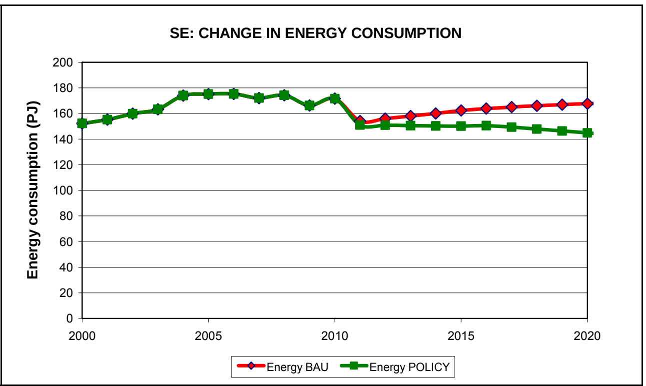


Figure D-10.7b. Comparison of energy consumption in the BAU-scenario and in the AP scenario

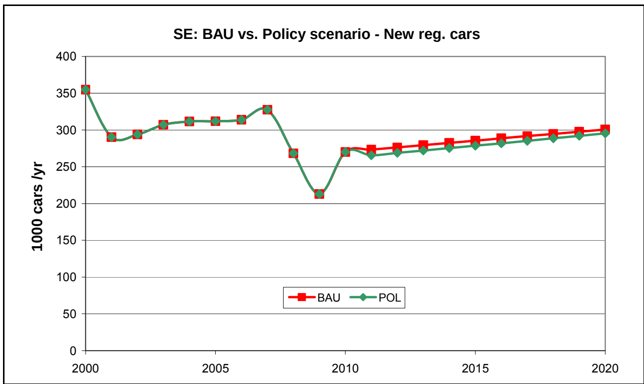
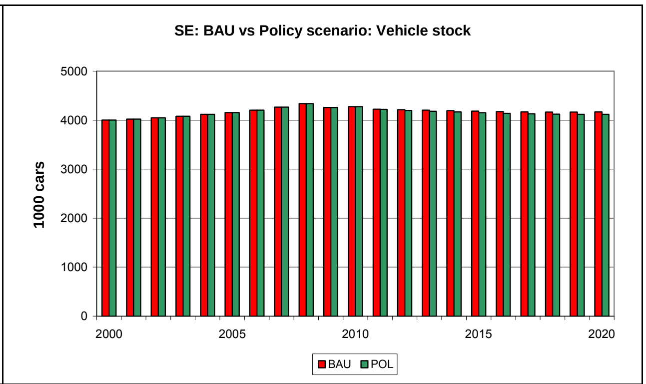


Figure D-10.8a. Development of new registered cars in the BAU-scenario and in the AP scenario

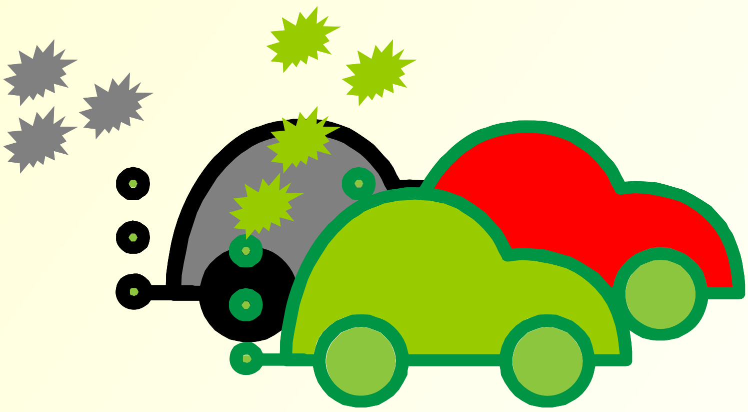


D-10.8b. Comparison of vehicle stock development in the BAU- and the AP scenario

APPENDIX E: Main properties of fuels by 2010

	Density	Lower heat value	Energy content	CO2-content		CO2-WTW
Fuel:	kg/m3	MJ/kg	kWh/litre	kg/kg	gCO2/MJ	gCO2/MJ
Gasoline	745	43.2	8.70	3.17	73.38	85.9
Diesel	835	43.1	10.00	3.16	73.32	87.5
CNG	1.008	45.1	0.01	2.54	56.32	70.2
LPG	550	46.0	7.03	3.02	65.65	73.7
Bioethanol Wheat	794	28.0	6.18	1.91	68.21	48.5
Biodiesel Rapeseed	890	36.8	9.10	2.81	76.36	46.8
Biogas	1.003	30.0	0.01	2.54	84.67	24.2
Bioethanol Ligno	794	28.0	6.18	1.91	68.21	22.0
Biodiesel BTL-FT	890	36.8	9.10	2.81	76.36	6.4
Hydrogen RES	0.09	120.1	0.003	0.00	0.00	14.0
Hydrogen Natural gas	0.09	120.1	0.003	0.00	0.00	112.0
Electricity RES					0.00	7.0
Electricity New Natural gas					0.00	126
Electricity UCTE Coal Mix					0.00	269

Sources: CONCAWE, TTW-Report 2008, own calculations



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