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Recent progress in developing renewable energy sources and technical evaluation of the use of biofuels and other renewable fuels in transport in accordance with Article 3 of Directive 2001/77/EC and Article 4(2) of Directive 2003/30/EC

Accompanying document to the

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Renewable Energy: Progressing towards the 2020 target

{COM(2011) 31 final}

1. INTRODUCTION

This staff working document accompanies the renewable energy progress report and covers the legal obligation of the Commission to report on the progress in renewable energy use in the Member States in accordance with Article 3 of Directive 2001/77/EC and Article 4 of Directive 2003/30/EC. It also provides further background material and detailed analysis of the economic aspects and environmental impacts of biofuels in transport, as required by Art. 4(2) of Directive 2003/20/EC[1].

The purpose of this staff working document is to assess Member State's progress towards 2010 targets for renewable electricity and renewable fuel use. It also briefly looks into developments in the heating and cooling sector. As the most recent available statistical data from Eurostat only cover the period up to 2008, it is not yet possible to determine whether Member States have met their 2010 targets based on Eurostat data. For this reason the Commission refers, where appropriate, to the National Renewable Energy Action Plans (NREAP) submitted by Member States in accordance with the Renewable Energy Directive 2009/28/EC.

2. PROGRESS TO DATE

Since the last progress report[2], the renewable energy sector experienced continued growth in the period 2006-2008, with the overall renewable energy share in the EU reaching 10.3% in 2008 (8.8% in 2006) and progress in all three final sectors (to shares of 16.6% in electricity, 11.9% in heating and cooling and 3.5% in transport)[3]. In the absence of Eurostat data for 2009 and 2010, it is not yet possible to determine whether the EU will reach its 2010 targets for renewable electricity and transport. Preliminary analysis of Member State's intentions stated in their NREAPs indicate that overall EU share for renewable energy use in electricity in 2010 could reach 19,4%, for transport – 5% and for heating and cooling – 12,5%.

2.1. Electricity from renewable energy sources

Since the last progress report[4], the share of green electricity in the EU has grown continuously reaching 15.8% in 2007 and 16.6% in 2008, compared to 15.1% in 2006. In spite of this solid growth it remains likely that the EU will fail to reach its 2010 target of 21%.

In 2008 Hungary and Germany were the only Member States that had already met or exceeded their national target for 2010. In its NREAP Germany confirms its intention to reach a higher 17.4% share of RES in electricity in 2010 (compared to its original 12.5% target).

An additional 5 to 10 Member States are well placed to meet their 2010 national targets, but only Denmark, Ireland, Lithuania and Portugal confirm their intention to exceed their 2010 targets in their NREAPs. For the remaining Member States the distance to the target remains significant and indeed, most Member States acknowledge that they expect to fail to reach the

[1] Directive 2002/20/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport, OJ L 123, 17.5.2003, p. 42-46

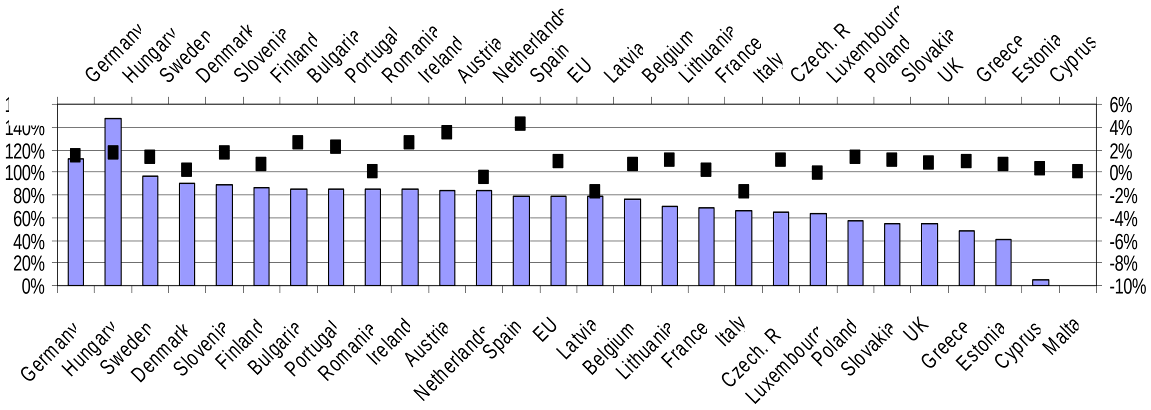
[2] COM (2009) 192 The Renewable Energy progress Report, covering 2004-2006/7.

[3] All statistical data presented in this report, unless otherwise specified, are sourced from EUROSTAT.

[4] COM (2009) 192 The Renewable Energy progress Report

2010 targets in their NREAPs. Progress achieved in each Member State is set out in Figure 1 below.

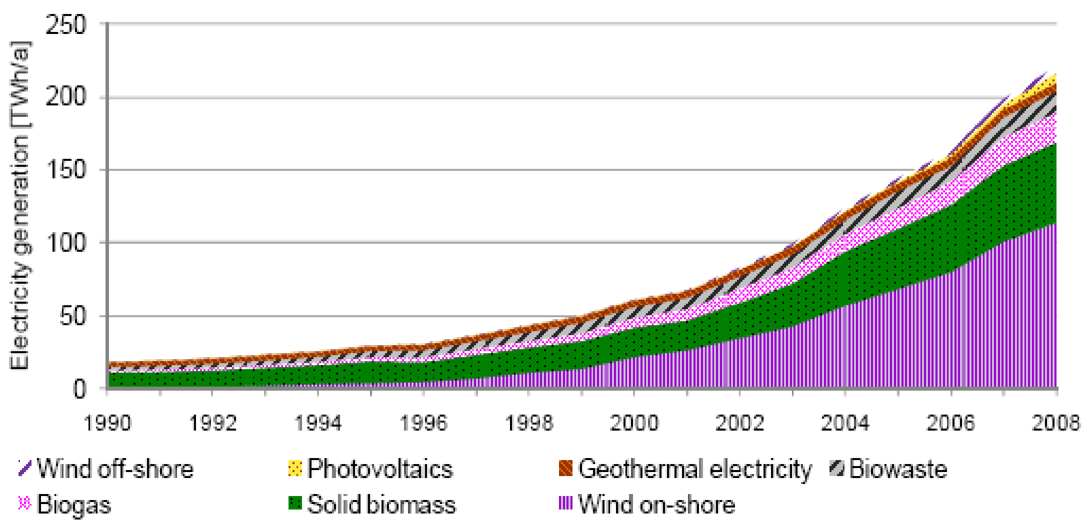
Figure 1: Progress made towards national 2010 targets (columns and left hand axis, where 100% is the reference value for national target) **and the 2006-2008 change in Member State's renewable electricity shares** (points, right hand axis)



Source: based on Eurostat 2008 data and 2010 targets

Hydropower still represents the dominant source in renewable electricity generation, but has become less important during recent years. This technology accounted for 94% of green electricity generation by 1990 while by 2008 its share had decreased to below 60%. This is caused by strong development of emerging renewable energy technologies, such as wind and biomass.

Figure 2: Market development of new renewable energy technologies in electricity sector



Source: RE-Shaping: Shaping an effective and efficient European renewable energy market, D5&D6 Report, Fraunhofer ISI, Ecofys, 2010

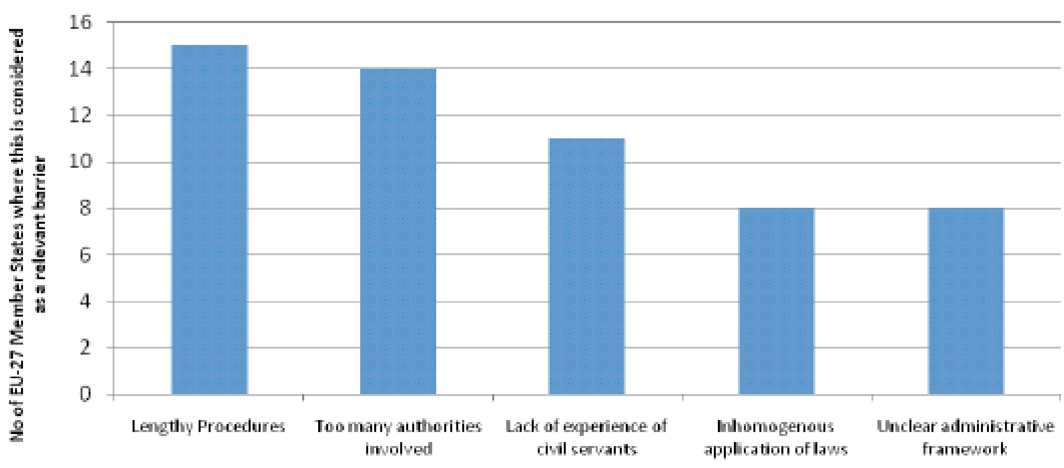
The contribution from these technologies increased tenfold from 19 TWh in 1990 to 223 TWh in 2008 (less than 170 TWh in 2006) as a consequence of policy efforts undertaken at European and at national level.

As the Commission noted in its earlier reports[5], in the absence of a legally binding EU framework, growth in the EU renewable electricity sector was mainly driven by a limited number of pioneering Member States and by a few technologies (onshore wind in Spain, Germany and Denmark, solid biomass in Finland, Sweden, Austria and Belgium, PV in Germany, Austria and Spain). Whilst in 2007 and 2008 some new members joined this group (e.g. Portugal and Ireland are major wind energy producers now), and despite the targets adopted by all Member States, this pattern does not appear to be changing rapidly.

Cumbersome authorisation and planning procedures continue to be important barriers to the growth of the renewable electricity sector in the EU. Commission analysis suggests that administrative hurdles such as planning delays and restrictions, lack of coordination between different authorities, long lead times in obtaining authorizations and high costs of obtaining permissions are still regarded as major barriers by renewable energy promoters and developers, and little progress has been made in this area.[6]

The chart in Figure 3 considers different possible sources of administrative barriers. For each of them, the chart shows in how many Member States this source has been identified by renewable energy planners and developers as a relevant barrier to the development of renewables.

Figure 3: Sources of administrative barriers (various RES technologies)



Source: Assessment of non-cost barriers to renewable energy growth in EU Member States, Final Report, ECORYS et al, 2010

The duration of the procedures and the number of authorities involved in the authorisation process are considered the most intense problems and they have been listed by stakeholders as problems in the majority of Member States. On average over nine different authorities needed to be contacted for building renewable electricity plants. Lack of specific experience in

5 COM (2006) 849 and COM (2009) 192

6 Assessment of non-cost barriers to renewable energy growth in EU Member States, Study by ECORYS Nederland BV in consortium with Eclareon, EREC and Golder Associates (DG TREN No.TREN/D1/48-2008), final report, 2010. http://ec.europa.eu/energy/renewables/studies/renewables_en.htm

renewables of the civil servants, the non-homogeneous application of laws in different regions, or even in different individual cases, the lack of clarity of the administrative framework, including problems such as legal uncertainty, contradictory or unclear legal provisions, opaque procedures, excessive margins of discretion of the administration and sheer extortion and corruption are also listed.[7]

The new EU legal framework (Directive 2009/28/EC) requires Member States to take appropriate steps to address these weaknesses. The Commission will monitor the performance of Member States in this respect, including by evaluating the National Renewable Energy Action plans and Member States' national renewable energy progress reports.

The expected expansion of supply of electricity from renewable sources makes the reform of the electricity grid even more important. The third internal energy market package[8] introduced the coordination of European energy regulators (ACER) and European transmission system operators (ENTSO-E), and requires the preparation of ten year network development plans (TYNDP). The pilot TYNDP prepared by ENTSO-E in 2010 has not met the expectations about renewable energy integration, as its assumption of a 25% renewable electricity share in 2020 is well below any other estimate of the expected proportion of renewables in electricity in that year, and can be compared with the value of 37% that can be derived from the 23 NREAPs so far received. The slow pace of infrastructure development indicates that urgent action is necessary: electricity systems have to become more interconnected, and flexible, new infrastructure development and reinforcements are necessary (whilst respecting the precautionary principle and mitigating environmental impacts), including the deployment of smart grid technologies.

One of the greatest challenges regarding the grid infrastructure is to connect the offshore wind potential foreseen in the Northern Seas of Europe by developing the electricity network both off- and onshore.

Whilst the Renewable Energy Directive requires Member States to develop their grids to be able to absorb more renewable energy, the specific tasks related to infrastructure adaptation are addressed in the Commission's 2010 Communication on energy infrastructure priorities.[9]

With the adoption of the Renewable Energy Directive the overall legal framework is now stronger, but the financial and fiscal situation in Member States has had a negative impact on investment in the renewable energy sector. The Commission must therefore remain vigilant in ensuring that Member States properly implement the measures necessary to encourage renewable energy growth.

2.2. Renewable energy in the transport sector

In 2008 the EU share of renewable energy in transport was 3.5%, up from 2.6% in 2007. Preliminary data for 2009 indicate further growth in the sector, with the biofuels share reaching 4% of the total fuel consumption in transport.[10]

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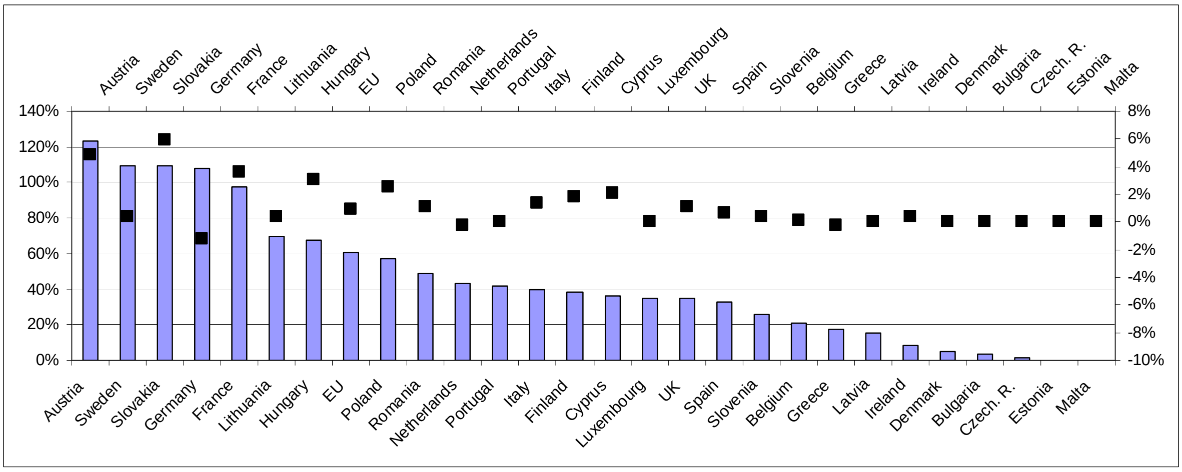
7 Assessment of non-cost barriers to renewable energy growth in EU Member States, Study by ECORYS Nederland BV in consortium with Eclareon, EREC and Golder Associates (DG TREN No.TREN/D1/48-2008), final report, 2010. http://ec.europa.eu/energy/renewables/studies/renewables_en.htm

8 Directive 2009/72/EC concerning common rules for the internal market in electricity.

9 COM (2010) 677 Energy infrastructure priorities for 2020 and beyond – A Blueprint for an integrated European energy network .g

Four countries – Austria, Germany, Slovakia and Sweden – had already met their 2010 transport targets in 2008, with France being almost certain to join this group of countries in 2009. With the exception of Slovakia, all of these countries, as well as Finland and Portugal state in their NREAPs their intention to exceed the 5.75% target for renewable energy use in transport in 2010. Figure 4 below depicts the progress achieved in each Member State.

Figure 4: The progress made towards national 2010 targets (columns and left hand axis, where 100% is the reference value for national target) **and the 2007-2008 change in Member State's renewable transport fuel shares** (points, right hand axis)



Source: based on Eurostat 2008 data and 2010 targets

In 2008 biodiesel remained the most frequently used biofuel in the EU accounting for 81% (8.2 Mtoe) of the total biofuels consumed, and while bioethanol makes 18% (1.8 Mtoe) and the remaining 1% includes other biofuels such as biogas used in a limited number of Member States[11].

In 2007, around 15% of the biofuels consumed in the EU were imported; in 2008 it was 25%. At the same time, export shares rose from 7% (2007) to 10% (2008), so that the net import in 2008 was about 15%. Growth in imports was largely due to increased biodiesel imports from the USA, which decreased significantly again in 2009 when the EU imposed anti-dumping duties and countervailing duties.[12] Biodiesel imports seem to have levelled off in 2009, with Argentina as the main source. For imported ethanol Brazil remains the main country of origin.

The EU exported ethanol (all end-use purposes, excluding ETBE) to a range of countries including Switzerland, the United States, Norway, Turkey, Israel, Cameroon, Algeria, Guinea, the United Arab Emirates, and others. Around three quarters of the EU exports of biodiesel (i.e. FAMAE – fatty-acid mono-alkyl ester) however were solely destined for Norway; the

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10 *Biofuels Barometer, Eurobserv'er, July 2010.* It must be noted however, that the 4% share does not include other renewable energy use in transport and is based on producer data. The 2009 share for renewable energy use in transport is subject changes once the official *Eurostat* statistics for 2009 become available,

11 Due to unclear specification in the statistical data, it is assumed that the pure vegetable oil consumed in some Member States is included in the biodiesel category.

12 In August 2010 the European Commission started - after an official complaint from the European biodiesel industry - a formal investigation of possible circumvention of these imposed anti-dumping duties and countervailing duties.

remaining share being split between Belarus, the United States, Switzerland, Pakistan, Canada, Turkey, China, and Israel.

The share of biofuels produced from waste, residues and lignocellulose biomass, often referred to as second generation biofuels, is still limited, however, the quantity is gradually increasing, due to stronger interest in such fuels and increased deployment of advanced biofuels technologies. With 810 ktoe of biodiesel produced from waste oils and around 114 ktoe of biofuels from non-food cellulosic and ligno-cellulosic material, the total production volume in 2009 of biofuels that would count double towards the "transport" target in the Renewable Energy Directive was estimated to be around 9% of the total biofuel production in the EU.[13]

The use of electricity sources (renewable or otherwise) and hydrogen in road transport was still negligible in 2008.

Tax reductions and biofuel obligations remained the two most common instruments used by Member States to promote biofuels in 2008 and 2009.

In 2008, obligations were in force in 16 Member States[14] – 14 of which also provide tax exemptions (Finland and the Netherlands are the exceptions). Many Member States, while maintaining tax exemptions, have reduced their value.

The Commission's analysis indicates that the highest biofuel market shares are usually achieved by those Member States that have obligations in place, combined with tax incentives (Germany, Slovakia, France). If no obligations are in place, substantial tax incentives are required to reach substantial biofuel market shares. Sweden and Hungary are the only Member States that achieved a biofuel market share above 3% without any obligations and they are the two countries with the highest tax reductions.

The table in Annex I summarises Member States' progress towards 2010 targets in renewable electricity and transport, the two sectors covered by Directives 2001/77/EC and 2003/30/EC.

Further analysis evaluating the use of biofuels and other renewable fuels in transport, including a review of the economic and environmental impacts of biofuels in accordance with Article 4(2) of Directive 2003/30/EC, is included in Annex II..

2.3. Renewable energy in heating and cooling[15]

Despite being the dominant sector in renewable energy's contribution to final energy (where heating and cooling represent 54%), the growth in renewables based heating and cooling has been less rapid than in the other two sectors.

In 2008 the share of renewable heating and cooling was 11.9%, compared to 11.5% in 2007 and 10.3% in 2006.

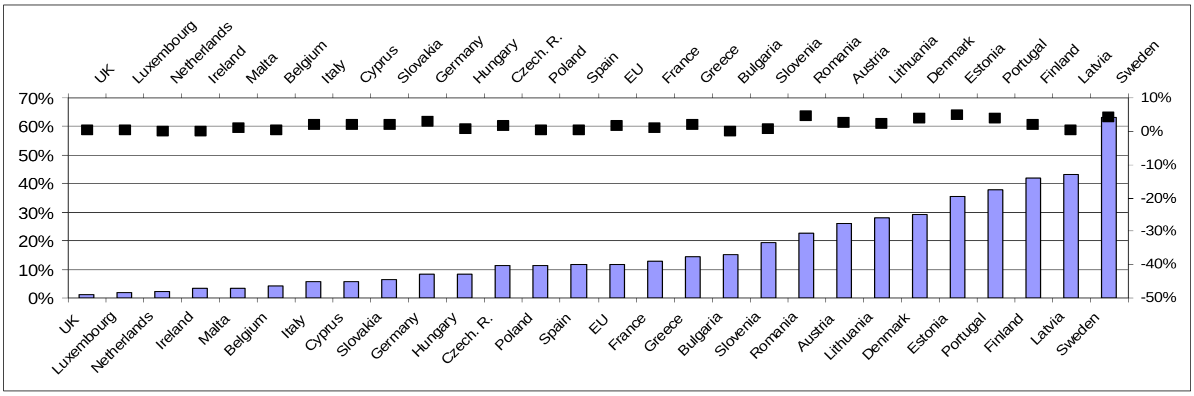
[13] Biofuels from non-food cellulosic and ligno-cellulosic material are biofuels produced from wood, grasses, or the non-edible parts of plants.

[14] Spain, Portugal and Latvia enacted obligations after 2008, so currently, 19 MS have obligations in place.

[15] The use of renewable energy in heating and cooling is not covered by the Directive 2001/77/EC and 2003/30/EC and is thus not part of the reporting requirements under these two directives. This sector has only been included in the report for information purposes.

Figure 5 below shows the considerable share of renewable heating and cooling in some 10 Member States. Within the last two years, the share of renewable heating and cooling increased considerably only in a few Member States (Estonia, Romania and Sweden).

Figure 5: The share of renewable energy in the heating sector in 2008 (columns and left hand axis) **and the change in Member State's renewable heating and cooling shares** (points, right hand axis)



Source: Eurostat

The EU renewables based heating market is dominated by domestic decentralised heating appliances using biomass. The use of biomass in centralised heating plants or CHP-plants also plays an important role in Nordic countries, Germany and Italy. Solar thermal heating technologies account for a low share of the total amount of heat generated from renewable energy. Similarly, ground source heat pumps and geothermal heating technologies represent a relatively limited share of renewables based heat production but are expected to experience some growth in the future.

The modest market development of renewables based heat production can be explained by the lack of an adequate support framework in most Member States. However this should change in the next years following the inclusion of the renewables based heating and cooling sector in the new EU renewable energy framework.

3. CONCLUSION

Despite continued growth in the last two years with the overall renewable energy share in the EU reaching 10.3% in 2008 (8.8% in 2006) and growth in all three final sectors (to shares of 16.6% in electricity, 3.5% in transport and 11.9% in heating and cooling) this staff working document highlights that there is still limited convergence in Member States' performance in developing renewable energy sources. Indeed, most Member States have recognised in their NREAPs their expectation of failure to reach their 2010 renewable electricity targets. For renewable energy use in transport the trend is somewhat better, as many Member States note in their NREAPs their expectation to exceed the 2010 targets. This is however not the case for all Member States.

It has been acknowledged that the previous European regulatory framework for renewable energy was too weak, and the new framework is much stronger, indeed one of the strongest in the world. Member States have presented the Commission with their NREAPs outlining their national strategies and measures to reach the 2020 renewable energy targets, and these plans confirm the ambition to reach the EU target of 20%for renewable energy use by 2020. Turning this ambition into reality, however, will require the complete and correct implementation of the new Renewable Energy Directive.

Annex I

Summary of Member States' progress in developing renewable energy

	Electricity					Biofuels				
	2008 share (%)	**2010 target (%)**	**2010 NREAP (%)**	**recent growth**	**progress made**	**2008 share (%)**	**2010 target (%)**	**2010 NREAP (%)**	**recent growth**	**progress made**
Austria	65.1	78.1	69.3	☺	☹	7.1	5.75	6.8	☺	☺
Belgium	4.6	6	4,8	😐	☺	1.2	5.75	3,8	😐	☹
Bulgaria	9.4	11	10.6	☺	😐	0.2	5.75	1.7	☹	☹
Cyprus	0.3	6	4.3	😐	☹	2.1	2.5	2.2	☺	😐
Czech Rep.	5.2	8	7.4	☺	😐	0.2	5.75	4.1	☹	☹
Denmark	26.1	29	34.3	😐	☺	0.3	5.75	1.0	☹	☹
Estonia	2.1	5.1	1,7	😐	☹	0.0	5.0	0.0	☹	☹
Finland	27.2	31.5	26.8	😐	☹	2.2	4.0	5.7	☺	😐
France	14.4	21	15.4	😐	☹	5.6	7.0	6.4	☺	☺
Germany	14.0	12.5	17.4	☺	☺	6.2	5.75	7.3	☹	☺
Greece	9.7	20.1	13.3	😐	☹	1.0	5.75	1.7	☹	☹
Hungary	5.3	3.6	9	☺	☺	3.9	5.75	3.7	☺	☺
Ireland	11.2	13.2	20.4	☺	☺	1.2	4.0	3	😐	☹
Italy	16.6	22.5	19	☹	☹	2.3	5.75	3.5	☺	😐
Latvia	38.7	49.3	44.7	☹	☹	0.9	5.75	4	😐	☹
Lithuania	4.9	7	8	☺	😐	4.0	5.75	4	😐	☺
Luxemburg	3.6	5.7	4	☹	☹	2.0	5.75	2.1	😐	😐
Malta	0.0	5	0.6	☹	☹	0.0	1.25	2.8	☹	☹
Netherlands	7.5	9	8.6	☹	☺	2.5	4.0	4.1	☹	😐
Poland	4.3	7.5	7.5	☺	😐	3.3	5.75	5.8	☺	☺
Portugal	33.3	39	41.4	☺	😐	2.4	10.0	5	😐	😐
Romania	28.1	33	27.5	😐	☹	2.8	4.0	5.8	☺	😐
Slovakia	17.1	31	19.1	☺	☹	6.3	5.75	4.1	☺	☺
Slovenia	30.0	33.6	32.4	☺	☹	1.5	3.0	2.6	😐	☹
Spain	23.3	29.4	28.8	☺	😐	1.9	5.83	6	😐	☹
Sweden	53.6	60.0	55	☺	☺	6.3	5.75	7.4	😐	☺
UK	5.4	10	8.6	😐	☹	2.0	3.5	2.6	☺	😐

Source: Eurostat 2008 and Member States NREAPs

Key to "smiley" grades

progress made towards target	*0-33%*	*34-66%*	*67-100%;*
2006/2007-2008 growth	*≤ 0 percentage point change*	*> 0 – 1 percentage point change*	*> 1 percentage point change*

Annex II.

Evaluation of the use of biofuels and other renewable fuels in transport and review of the economic and environmental impacts of biofuels in accordance with Article 4(2) of Directive 2003/30/EC.

1. PROGRESS IN THE CONSUMPTION OF BIOFUELS AND OTHER RENEWABLE FUELS

In 2008, 10.1 Mtoe of biofuels were consumed in road transport, representing 3.5% of all petroleum products consumed in road transport (293 Mtoe). About 81% of these biofuels concerned biodiesel, 18% concerned bioethanol and about 1% other biofuels (mostly biogas)[16].

Germany and France are the main consumers of biodiesel, followed by the UK, Italy and Spain. The general trend is an increase in consumption of biodiesel per Member State, however consumption of biodiesel in Germany shows a reduction from 2006 onwards (partly due to the phasing out of tax exemptions). For bioethanol, France, Germany and Sweden are the main consumers in Europe.

Total biofuels consumption in transport 2008.

	2008
Total Biofuel consumption in road transport	10.1 Mtoe
Total Biodiesel	8.2 Mtoe
Total Bioethanol	1.8 Mtoe
Other liquid biofuels	0.1 Mtoe
Total fuels consumed in transport	293 Mtoe
Share of biofuels in transport	3.5%

Source: Eurostat

The following table gives a detailed overview of the biofuels market in 2007 and 2008 in the 27 EU Member States. Germany remains the largest consumer of biofuels, even though the consumption level decreased in 2008, while Finland's biofuels market had the strongest growth. Six of the 27 Member States (Germany, France, UK, Italy, Spain and Poland) account for three quarters of the EU27 market.

16 Although biogas is produced in all Member States and several Member States have installed some support for the use of biogas in transport, only Sweden has a significant use of biogas in road transport.

EU biofuels consumption in road transport in ktoe in 2007-2009; growth of this consumption in 2007 -2009 (ranked according to market size)**.**

Country	2007	2008	Growth 2007-2008 (%)	2009	Growth 2008-2009 (%)
Germany	3827	3083	-19%	2894	-6%
France	1455	2291	57%	2511	10%
United Kingdom	346	790	128%	982	24%
Italy	141	723	413%	1167	61%
Spain	386	610	58%	1046	71%
Poland	94	441	369%	705	60%
Austria	339	419	24%	502	20%
Sweden	285	352	24%	394	12%
Netherlands	311	287	-8%	367	28%
Hungary	29	165	469%	184	12%
Portugal	133	128	-4%	231	80%
Slovakia	89	126	42%	61	-52%
Czech Republic	33	111	236%	171	54%
Romania	40	107	168%	185	73%
Belgium	90	101	12%	259	156%
Finland	1	75	7400%	146	95%
Greece	85	69	-19%	57	-17%
Lithuania	52	61	17%	52	-15%
Ireland	25	53	112%	74	40%
Luxembourg	36	37	3%	41	11%
Slovenia	13	22	69%	30	36%
Cyprus	1	14	1300%	15	7%
Denmark	6	5	-17%	4	-20%

Bulgaria	4	4	0%	6	50%
Latvia	2	2	0%	5	150%
Malta	1	2	117%	1	-50%
Estonia	1	1	-19%	n.a.	n.a.
Total EU	7824	10078		12092	

Source: Eurostat (2007-2008) and Eurobserv'er (2009)

The share of biofuels consumption per country in 2008 and 2007 can vary significantly due to various factors: the volatility of agricultural feedstock costs, global market trends, legislation changes (in Germany’s case, biofuels consumption dropped), fuel consumption level adjustments on small markets (a relatively small change in consumption led to a high change in biofuels share in Cyprus and Bulgaria), attractive support measures (France’s attractive tax exemption and increasing openness of the market led to a production increase of more than 800 ktoe in 2008).

Most biodiesel and bioethanol consumed within the EU is used in low proportions as blends in diesel and gasoline respectively. High blends of biodiesel, varying from 20% to 100%, are mainly consumed in Germany where pure biodiesel sales in 2008 accounted for 980 ktoe, compared to 1.4 Mtoe of blended biodiesel (mostly B5).

Germany also has a high consumption of pure vegetable oil in road transport. In 2008, 353 ktoe of vegetable oil fuel were used, but the share is rapidly decreasing (737 ktoe used in 2007) as the excise exemption system is gradually phased out.

For bioethanol, E85 (consisting of 85% ethanol with 15% petrol by volume) is sold for use in flex-fuel vehicles. The table below shows that Sweden has by far the most selling points for E85. The total sales of E85 in Europe are estimated to be about 100 ktoe in 2008, on the basis of extrapolation of the known sales in Germany (where the 100 filling stations selling E85 – 5% of the European total of such filling stations – sold about 5.5 ktoe of the fuel).

Number of filling stations selling E85 in 2008.

	Number of filling stations
Sweden	1300
France	320
Germany	100
UK	18
Ireland	16
Hungary	15

Norway	10
Spain	8
Netherlands	3
Total	1790

Source: BEST, Procura, Member State reports

Some Member State (Sweden, France, Ireland and Cyprus) offer support in order to increase the use of flex-fuel vehicles. Most notably in Sweden, incentives include reduced registration charges and road taxes, free parking in some cities and waived congestion charges[17].

2. PRODUCTION OF BIOFUELS

The table below presents an overview of EU biofuel production in 2007 and 2008.

It can be seen that the production in France increased by more than 800 ktoe (mainly biodiesel), the largest increase in 2007 and 2008 in the EU27. Italy also reported a large increase of around 490 ktoe (mainly in biodiesel production, but also in ethanol). Germany experienced a strong contraction in biofuels production from 2007 to 2008, which was completely determined by the decrease in biodiesel production; ethanol production in Germany increased during this period.

Germany, France, Italy, Sweden and Spain accounted for over 75% percent of EU biofuel production in 2008.

[17] Biofuels and food security, International Institute for Applied Systems Analysis (IIASA), Laxemburg, Austria, 2009.

EU Biofuel production (in ktoe) in 2007 and 2008; growth of this production from 2007 to 2008 (ranked according to the 2008 market size)**.**

Country	2007	2008	Growth 2007-2008 (%)
Germany	5,092	4,455	-13%
France	1,142	1,952	71%
Italy	180	671	273%
Sweden	430	463	8%
Spain	382	369	-3%
Poland	102	296	190%
Belgium	165	289	75%
United Kingdom	384	283	-26%
Austria	261	279	7%
Romania	19	163	758%
Hungary	17	162	853%
Portugal	163	149	-9%
Slovakia	59	139	136%
Netherlands	120	122	2%
Czech Republic	90	105	17%
Denmark	63	89	41%
Lithuania	32	68	113%
Greece	83	63	-24%
Latvia	16	33	106%
Ireland	15	21	40%
Bulgaria	4	11	175%
Finland	0	10	
Slovenia	4	7	75%
Cyprus	0	6	
Luxembourg	1	0	-100%
Total EU	**8,824**	**10,205**	**16%**

Source: Ecofys, based on Eurostat.

Biofuel production plants are not evenly distributed across Europe. Conversion capacity around the North Sea area is increasing, mostly due to easy access for overseas feedstock (palm and soy oil), capacity in France is concentrated in the north of the country, along the major waterways. There is still limited production capacity and significant development potential in Poland and South-Eastern Europe.

The current installed production capacity in Europe is not fully utilised. The table below shows the ratio between the capacity and actual production with the calculation of the capacity factor. Only 40% of the bioethanol conversion capacity has actually been used between 2005 and 2008. Also the biodiesel production capacity has grown faster then the actual production.

Production of biofuels within the EU compared to the production capacity (Mtoe)

	Capacity	**Actual production**	**Capacity factor**
Bioethanol			
2005	1.3	0.55	42%
2006	2.0	0.84	41%
2007	2.8	1.12	40%
2008	3.9	1.51	39%
2009	4.1		
Biodiesel			
2005	3.76	2.79	74%
2006	5.40	4.77	88%
2007	9.16	6.15	67%
2008	14.2	7.12	50%
2009	18.6		

Source: Eurostat, eBio, EBB, FO licht.

This could have several underlying reasons. The market may have seemed very attractive when decisions for construction were taken and construction started, but several developments could influence the market situation once the plants were commissioned. The biodiesel subsidy programme in the USA, in some cases, made imports of biodiesel into the EU more attractive than local production. This factor, however, could be of temporary importance as the imports from the US reduced noticeably in 2009 when the EU applied anti-dumping and countervailing duties to biodiesel. The gap between market price and production costs could have been another reason, making the full use of the existing capacity economically unviable in some cases.

It must be noted, however, that despite these temporary negative developments biofuels have been one of the fastest growing renewable energy sectors in absolute terms, and the growth is even more considerable relative to the low starting point.

2.1. Feedstocks of biofuels

With its share ranging between 57-70% EU-produced rapeseed oil is by far the most important feedstock for biodiesel production in the EU. Imported soybean oil and palm oil are following at a distance with their respective shares being in the ranges of 14%-24% and 5-

11%. The biodiesel fraction produced from waste streams can be estimated to be around 5-10%.[18]

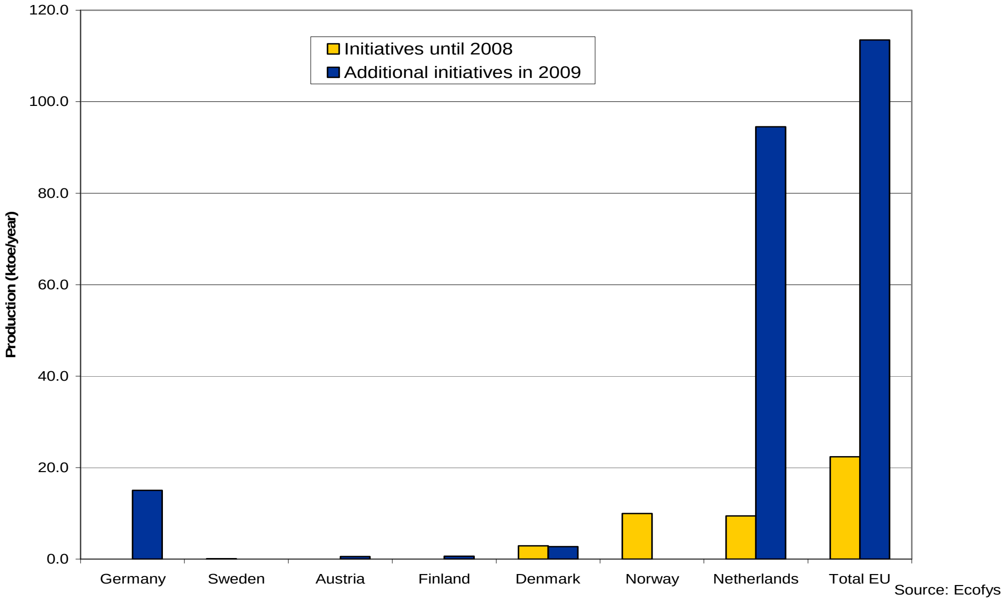
Bioethanol is produced mainly from EU cereals (wheat, maize, barley) and EU sugarbeet, with the remaining share being sourced mainly from imported sugarcane.

The share of biofuels produced from waste, residues and lignocellulose biomass is still limited, however, the quantity is gradually increasing, due to stronger interest for such fuels and increased deployment of advanced biofuels technologies. With 810 ktoe of biodiesel produced from waste oils and around 114 ktoe of other initiatives that produce "double counting"[19] fuels, the total production volume of "double counting" biofuels in 2009 could be estimated to be around 9% of the total biofuel production in the EU.

The production of bioethanol from waste streams is limited to a small amount of whey ethanol (produced in Ireland).

In 2008, the European cellulose-based biofuel facilities were present in seven countries (Finland, Netherlands, Norway, Denmark, Austria, Sweden and Germany) led by Netherlands, Norway and Denmark in terms of production capacity.

Production volumes of biofuels from [non-food cellulose and] lignocellulose in Europe in 2008 and 2009



Source: Ecofys

18 Various studies give different shares for biofuels feedstocks. *The Market analysis Oils and Fats for Fuel, productshap MVO, December 2009* put rapeseed oil at 70% as the most important biodiesel feedstock in the EU in 2008/2009. *Renewable Energy in Transport* study by Ecofys et al, 2010 prepared for the European Commission (DG ENER contract TREN/D1/458/2009) estimated the rapeseed share to be around 57%. Similar differences can be observed for other feedstocks.

19 For the purposes of demonstrating compliance with national renewable energy obligations and the target for the use of renewable energy in transport art. 19.2. of the RES directive allows Member States to consider the contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and lignocellulosic material to be twice that made by other biofuels.

By the end of 2009 Europe's largest advanced biofuel producer Dutch **BioMCN** finalized the construction of the first large-scale production unit with a capacity of 200,000 tons per year. Capacity is expected to increase over the next few years up to a maximum of 800,000 tons. BioMCN applies an innovative large-scale industrial process that converts crude glycerin via synthesis gas into bio-methanol. This means that the plant could in the future also run on gasified biomass.

2.2. Consumption of other sources of renewable energy in transport

The consumption of other sources of renewable energy in road transport remains limited.

Electric vehicles are used in several Member States, with the largest number of them being used in France, Italy, Germany, Sweden, Austria, Denmark, UK, Belgium and Netherlands) however they are estimated to represent less than 0,01 % of the total EU personal vehicle fleet[20]. They can be considered to run on the average electricity mix, of which only a relatively small percentage is renewable, therefore the contribution of renewable electricity consumed in transport remained minimal.

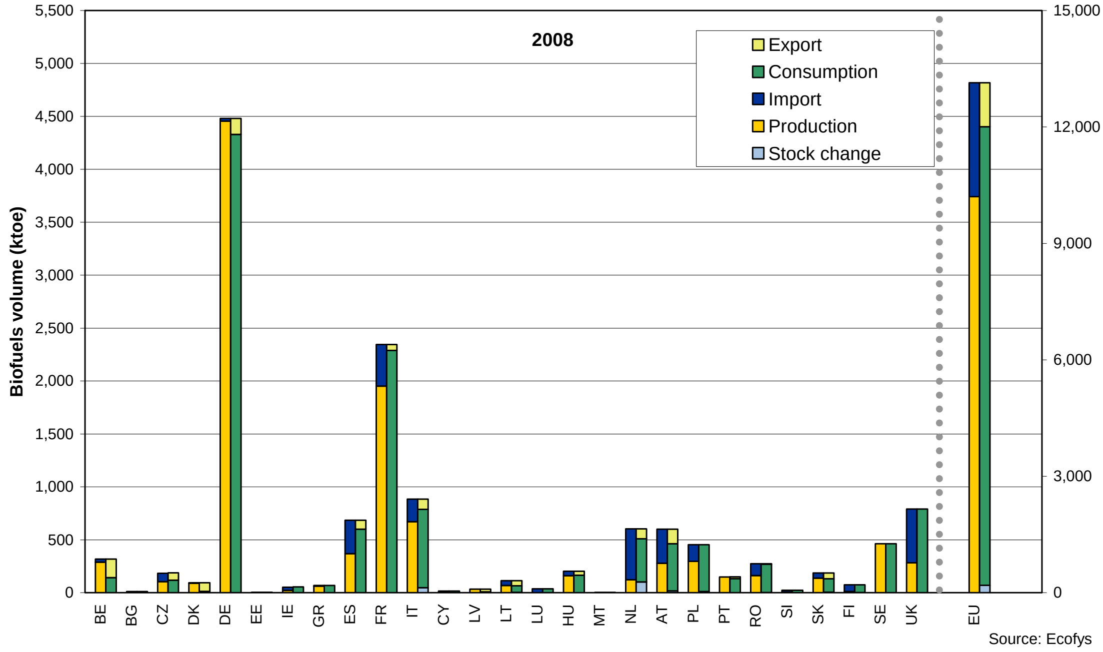
Electricity is also used in rail transport; this constitutes about 1.7% of all energy use in European transport, so that the contribution of renewable energy in rail to transport is about 0.23%. This does not count towards the 2003 Biofuels directive, but it does count towards the 2009 Renewable Energy Directive.

3. TRADE IN BIOFUELS

The trade balance of biofuels for the year 2008 reveals a diverse picture. While some Member States depend heavily on imports (e.g. Netherlands, UK, Austria) others (e.g. Germany and Sweden) seem to provide most of their consumption from their own production.

[20] For many EU Member States no recent statistics are available. Two different studies (IA-HEV Annual report 2008, IA-HEV, February 2009, European Motor vehicle park 2008, ACEA 2008) and AVERE (European Association for Battery, Hybrid and Fuell Cell Vehicles) statistics for 2005 give quite different estimates ranging between apprx. 4500 and 25 000 vehicles.

Biofuels trade balances in 2008 for the overall EU and individual Member States[21].



Source: Ecofys calculations based on Eurostat data

In 2007, around 15% of the biofuels consumed were imports; in 2008 it was 25%. At the same time, export shares rose from 7% (2007) to 10% (2008)[22]. Thus the overall net imports of biofuels to the European market increased from 8% in 2007 to 15% in 2008. Between 2005 and 2008, total EU biofuels imports increased from 399 ktoe to 2,932 ktoe while total EU biofuel exports rose from 335 to 1,131 ktoe[23].

Biofuel imports

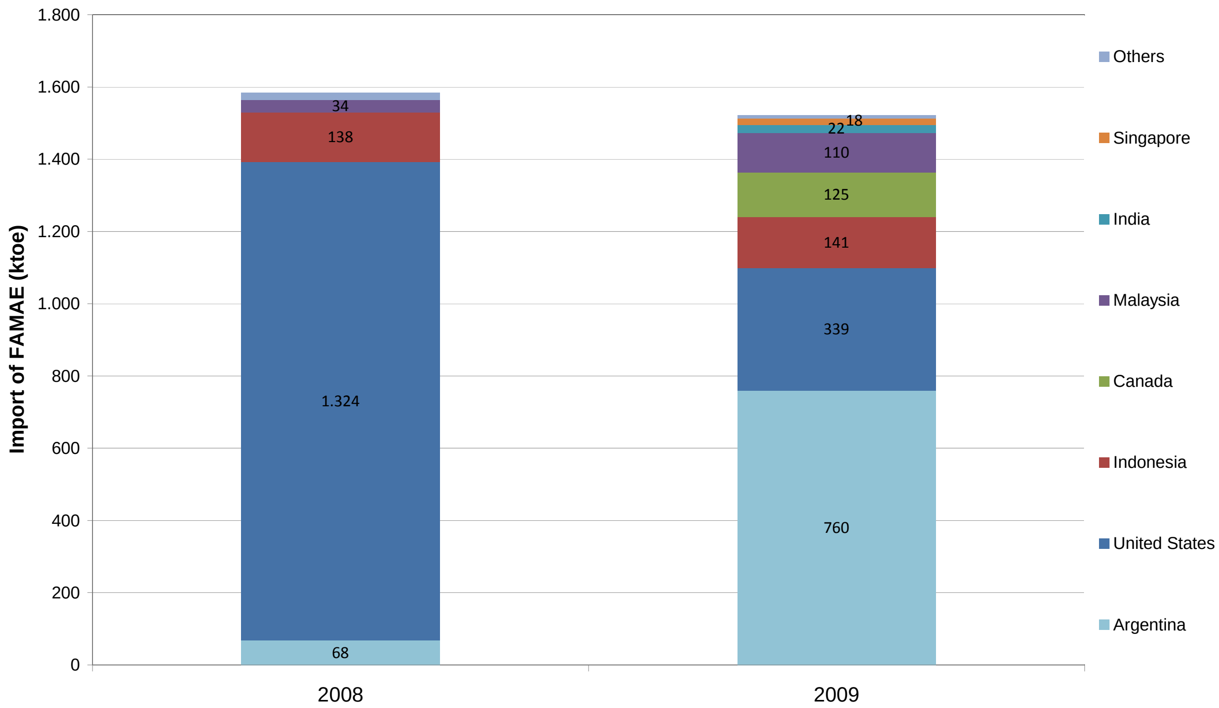
Imported biofuels in the EU come from a range of countries, and the last two years have seen considerable changes in the list of countries from which the EU imported biofuels, thus reflecting the impact that EU tariff preferences can have on such imports. This is demonstrated in the figure and table below, depicting changes in EU biodiesel imports in 2008 and 2009.

21 For Estonia and Malta no data were available; for several Members States data on either imports or exports, or both, were not available. The data for consumption in this table refer to all biofuels consumed, not only those used in road transport.

22 These percentages are based directly on Eurostat nrg_1073a relating imports to gross inland biofuel consumption or production. Numbers of imports as presented in former progress report are not similar, but were not based on Eurostat, which could be a reason for the difference.

23 Eurostat.

Imports of FAMAE[24] into the EU in 2008 and 2009 (ktoe)



Source: Eurostat[25].

24 FAMAE refers to fatty-acid mono-alkyl ester.

25 In the EU biodiesel trade regimes are governed through Regulation 1549/06 which defines the import duties since 01.01.2007. It is important to note that tariffs apply to biodiesel concentrations of B20 and higher. As a result, B19 and lower biodiesel concentrations do not fall under the EU biodiesel tariffs. Apart from the effect this might have on trade, it also implies that trade of B19 (and lower concentrations) is not recorded by Eurostat trade statistics yet (which rely on the codification).

	2008		2009	
United States	1,324	83.6%	339	22.3%
Argentina	68	4.3%	760	49.9%
Canada	1.5	0.1%	125	8.2%
Indonesia	133	8.7%	141	9.2%
Malaysia	33	2.1%	110	7.2%
India	7	0.4%	22	1.4%
Singapore	0.2	0.0%	18	1.2%
Others	11	0.7%	9	0.6%
Total	**1,584**	**100%**	**1,523**	**100%**

Source: Eurostat.

Looking at the trade volumes of FAMAE, the impact of the tariff preferences becomes apparent: The imports from the US reduced noticeably after the EU applied anti-dumping and countervailing duties for biodiesel (i.e. B20 and above).

Imports of subsidised biodiesel from the US

The introduction of anti-dumping and countervailing duties on US biodiesel (i.e. B20 and above) imports aimed at counteracting the so-called "splash-and-dash" practice or "B99" effect. This effect was based on a federal US tax credit for biodiesel of 1US$ per gallon of biodiesel blended with fossil fuel, equivalent to about 210 EUR/t, established in 2004 by the US Congress. The definition of "blending" made it possible to receive the credit by adding only 0.1% of mineral oil. The resulting B99.9 biodiesel could be exported to the EU where the biodiesel would receive a second financial incentive in many Member States' support schemes. In addition, it was even possible to import biodiesel from a third country to the US (also from the EU), claim the tax credit and then export the product, including back to the EU. This practice was commonly known as "splash-and-dash". It led to an increase in biodiesel imports from the US to the EU from 6.3 ktoe in 2005 to 871 ktoe in 2007 and to 1,505 ktoe over the first eight months of 2008[26].

In October 2008, the US Emergency Economic Stabilization Act extended the credit until end of 2009. However, it also partially eliminated the splash-and-dash practice by limiting the credit to biodiesel with a connection to the US. Biodiesel imported and sold for export was not eligible for the credit effective retroactively as of 15 May 2008[27]. Nevertheless, US produced biodiesel could still receive the credit, be exported to the EU and be eligible for tax exemptions. Therefore the Commission imposed anti-dumping and countervailing duties on US imports – effective as of 11 July 2009 under the Regulations 598/09 and 599/09.

The EU duties reduced US imports significantly as can be seen in the figure above. US FAMAE imports were mainly replaced by exports from Argentina, but also from Malaysia, India, and Singapore. Prior to 2009, US imports consisted to a large extent of Argentinean biodiesel which was imported to the EU through the US[28]. In 2008 alone, Argentinean biodiesel imports into the US were 486.5 ktoe[29]. With the introduction of the anti-dumping and countervailing measures in 2008, Argentinean biodiesel was directly imported into the EU. As the trade balance of 2009 for FAMAE already indicates, Argentina has taken a leading role in exporting competitively priced biodiesel to the EU.

Unexpectedly, a large share of the FAMAE imports in 2009 came from Canada which increased its exports from a mere 1.5 ktoe in 2008 up to 125 ktoe in 2009. Part of this Canadian biodiesel is claimed[30] to be of US origin i.e. having received tax credits in the US and in Canada, a practice termed "double-splash-and-go".

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[26] Oosterveer P. & Mol A.P.J. Biofuels, trade and sustainability: a review of perspectives for developing countries. *Biofuels, Bioproducts & Biorefining 4* (October 2, 2009): 66-76

[27] US Department of Energy: http://www.energy.gov/media/HR_1424.pdf [24.06.2010]

[28] USDA 2009.

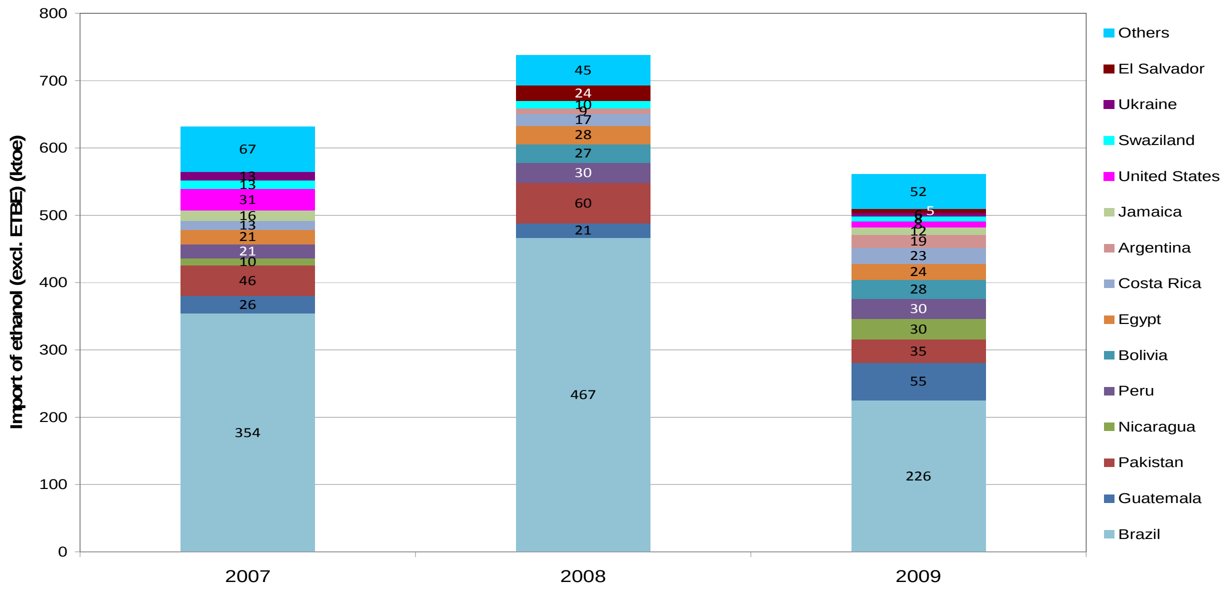
[29] Idem.

[30] Al-Riffai P., Dimaranan B. and Laborde D. *Global trade and environmental impact study of the EU Biofuels Mandate.* Washington, D.C., USA: International Food Policy Research Institute (IFPRI), 2010.

Ethanol

Brazil dominates the EU ethanol imports. More than 56% of the total imports were of Brazilian origin in 2007 and more than 63% in 2008. With the decrease in ethanol imports in 2009, the share of Brazilian ethanol also dropped to 40%. At the same time the shares and total trade volumes of other South American countries including Guatemala, Nicaragua, Peru, Bolivia, Costa Rica, and Argentina rose. Imports from the US declined to almost zero in 2008 and only slowly recovered in 2009.

Imports of ethanol[31] (both denatured and undenatured, excluding ETBE) **in the EU in 2008 and 2009** (ktoe)**.**



Source: Eurostat

31 Fuel-grade ethanol is still imported under the classification of denatured and non-denatured ethanol. According to Kutas et al. [2007], custom experts claim that due to the various end-uses (industrial, pharmaceutical, and beverage) it would be too difficult to verify the purpose of the imported ethanol. Thus no further itemization is made.

	2007		2008		2009	
Brazil (denatured)	29	4.6%	69	10.9%	88	13.9%
Brazil (undenatured)	326	51.5%	331	52.3%	166	26.3%
Guatemala	23	4.1%	16	2.9%	55	9.9%
Pakistan	41	7.3%	46	8.2%	35	6.3%
Nicaragua	9	1.6%	0	0%	30	5.4%
Peru	19	3.4%	22	4.0%	30	5.4%
Bolivia	2	0.4%	21	3.7%	28	5.0%
Egypt	19	3.3%	21	3.8%	24	4.3%
Costa Rica	12	2.1%	13	2.3%	23	4.2%
Argentina	3	0.5%	7	1.2%	19	3.4%
Jamaica	14	2.5%	0	0%	12	2.1%
United States	28	5.0%	2	0.3%	8	1.5%
Swaziland	11	2.0%	8	1.4%	8	1.4%
Ukraine	11	2.0%	4	0.8%	6	1.0%
El Salvador	0	0%	18	3.2%	5	0.9%
Others	54	9.7%	28	5.0%	52	9.2%
Total	**632**	100%	**738**	100%	**561**	100%

Source: Eurostat

Most Member States only permit blending with undenatured ethanol if the blended petrol is to count towards national quotas.[32] As a result, more than 80% of EU ethanol imports are undenatured and face a higher import tariff. This shields local production against cheap imports (mainly from Brazil).The UK and Netherlands also allow biofuel blending with denatured ethanol[33], exposing their local industry to more price competition.

Biofuel exports

Ethanol exports (all end-use purposes, excluding ETBE) were destined to a range of countries including Switzerland, the United States, Norway, Turkey, Israel, Cameroon, Algeria, Guinea,

32 USDA 2009, see e.g. Germany as defined in §37b Bundesemmissionsschutzgesetz (BImSchG) i.e. “Federal Emmission Protection Law”

33 USDA 2009.

the United Arab Emirates, and others. Around three quarters of EU exports of biodiesel (i.e. fatty-acid mono-alkyl ester: FAMAE) are destined for Norway, the remaining share being split between exports to Belarus, the United States, Switzerland, Pakistan, Canada, Turkey, China, and Israel.

4. ECONOMIC IMPACTS

This chapter covers the following economic aspects: commodity price impacts and employment impacts.

4.1. Impact on commodity prices

In the wake of food price increases in 2008, the discussion about the use of food crops for biofuels heated up worldwide. In 2008 many studies analysed the price developments. Some concluded that the production of biofuels was an important cause for the price rise, others took the opposite view.

IFPRI (2008)[34] simulated market developments between 2000 and 2007 and concluded that biofuel growth accounted for 30 percent of the food price increases seen in that period, with the contribution varying from 39 percent for maize to 21 percent for rice. The latter though is not a feedstock for biofuels.

LEI (2008)[35] also suggested that the impact of biofuels on corn prices is relatively high due to the fact that most US ethanol production is corn based. However, for other cereals such as wheat and rice, the latter not being a feedstock for biofuels, biofuels would only indirectly impact the price, via land use or cereal substitution in the market. For those commodities, LEI stated that the 30% – as indicated in the IFPRI estimates – were rather high. LEI also signalled that increasing food and feedstock prices made biofuels less profitable and food more profitable.

The Commission's analysis of food prices, published in two separate reports in May and December 2008[36], found that the surge in agricultural commodity prices resulted from a combination of structural and temporary factors. The biofuels market was only one of these factors, and its recent development had impacts on the oilseed market, although this impact is smaller than the increased demand for human and animal consumption. The cereal markets on the other hand have not been greatly influenced by EU biofuels policies.

In a recent study, the World Bank (2010) came to the conclusion that the effect of biofuels on food prices was not as large as originally thought, as worldwide biofuels accounted for only about 1.5 percent of the area under grains/oilseeds[37]. This raises serious doubts about claims that biofuels accounted for a big shift in global demand. It also noted that corn prices hardly moved during the first period of increase in US ethanol production, and oilseed prices

34 Biofuels and Grain Prices: Impacts and Policy Responses, International Food Policy Research Institute, Washington, 2008 .

35 Why are current world food prices so high? Report 2008-040, Wageningen, 2008.

36 Commission's Communication *Tackling the challenge of rising food prices,* adopted on 20 May 2008, COM(2008) 321 final and The Commission Staff Working Document "Monitoring prices developments" (SEC(2008)2970) accompanying Communication on *Food prices in Europe,* adopted on 9 December 2008, COM(2008) 821

37 Though LEI stated a higher fraction of 5% of global oilseed production being processed to biodiesel or used directly for transportation and 4.5% of global cereal production being used for ethanol production.

dropped when the EU increased impressively its use of biodiesel. On the other hand, prices spiked while ethanol use was slowing down in the US and biodiesel use was stabilizing in the EU.

Also DEFRA (2010)[38] concluded that higher global energy prices, currency fluctuations, poorer harvests in key production regions and export restrictions applied by some countries, as well as speculation on the commodity markets were the main reasons behind the 2008 food price spikes, by far overtaking the increased demand for biofuels in terms of their importance.

4.2. Employment

The production of biofuels involves employment all along the supply chain; in agriculture, logistics and at biofuels production facilities, but also in sectors that supply to or support biofuels supply chains.

Since the use of biofuels avoids the use of fossil fuels it can lead to loss of employment in that sector, as less production capacity (in exploration, oil drilling and refining) is required compared to a scenario without biofuels. On the other hand, it should be understood that even in oil refineries some changes have been necessary to adapt to the inclusion of biofuels and those changes could also yield jobs (e.g. the adaptation of petrol to make it suitable for blending ethanol). The overall employment balance remains positive, since the supply of biofuels creates more jobs in agriculture and processing industry than will be lost in the fossil fuel sector, because both the agricultural sector and the biofuel industry are more labour intensive than the fossil fuel industry. UNEP (2008)[39] stated that, on average, biofuels require about 100 times more workers per joule of energy content produced than the fossil fuel industry.

The EmployRES study (EC 2009)[40] calculated that the deployment of biofuels in Europe in 2005 induced in total (directly and indirectly) about 105,000 jobs in Europe. About 55% of this employment is linked to the production of biofuels, while about 45% of it is linked to the consumption of biofuels. EmployRES study also found that more employment was created per value added in the new EU Member States, due to significantly lower labour productivity. Assuming that the employment per volume of biofuel produced and consumed in the European Union has roughly remained the same in the years 2005-2008, it can be estimated that the total net employment resulting from biofuels in 2008 involved around 300,000 jobs. Worldwide, the latest REN21 study (2010)[41] estimated that in 2009 there were more than 1.5 million jobs resulting directly and indirectly from the biofuels industry.

5. ENVIRONMENTAL IMPACTS

In this chapter the greenhouse gas (GHG) emissions, other life-cycle related environmental impacts and the sustainability of crops will be discussed.

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[38] The 2007/2008 Agricultural Price Spikes: Causes and Policy Implications, HM Government Cross-Whitehall Global Food Markets Group, DEFRA, London, 2010.

[39] Green Jobs: Towards decent work in a sustainable, low-carbon world, United Nations Environment Programme (UNEP), 2008.

[40] Employ RES: The impact of renewable energy policy on economic growth and employment in the European Union, *Fraunhofer ISI et al., 2009*

[41] *REN 21: Renewables 2010 Global Status report, Paris 2010.*

5.1. Greenhouse gas life-cycle perspective biofuels and land use

The analysis presented here assesses the estimated greenhouse gas savings due to EU biofuel consumption.

Estimated greenhouse gas savings from biofuel use in the EU in 2008 have been calculated using the data on the total EU biofuel consumption (including imported and EU produced biofuels) and the 'typical' values for various feedstock types and production pathways from the RES directive.

From the data about biofuels consumed in the EU in 2008 and their respective feedstocks, as described earlier in this report, it follows that majority (81%) of the biofuel supplied to the EU market in 2008 was biodiesel, with rapeseed oil being the most important feedstock for biofiesel followed by imported soybean oil and palm oil.. EU produced wheat and sugarbeet were the dominant feedstocks for bioethanol, followed by imported sugarcane ethanol.. Typical greenhouse gas values from the RES directive were applied to these feedstocks to determine the amount of greenhouse gas savings for each type of feedstock and the overall amount for the EU. Reflecting the future requirements of the RES directive, the analysis was done in duplicate, using both the energy allocation method and the substitution method to account for co-products.At an aggregated level, the EU had a biofuel share of 3,5% in 2008 and an overall weighted greenhouse gas saving of 49% relative to fossil fuels replaced (energy allocation method) or 43% (substitution method).

Focusing on the physical savings in terms of CO2 eq, 10,1 Mtoe of biofuels consumed in 2008 can be translated into greenhouse gas emissions savings. The life cycle greenhouse gas emissions associated to traditional fuels is 83,8 gCo2/MJ (energy allocation method). Applying the above mentioned coefficients, in 2008 35.4-36.6 Mt CO2eq which would have been emitted in the atmosphere from fossil fuels, have been avoided. Deducing the emissions from the production of biofuels from this gross saving, the net saving achieved in the EU from biofuels placed on the market and consumed in 2008 are estimated to be 17,4 Mt Co2-eq. (energy allocation) or 15.0 Mt CO2-eq (substitution).

Emissions resulting from indirect land use change are not included in this report Following its report on indirect land use change related to biofuels of 22 December 2010, the Commission is currently finalising its impact assessment related to the potential impacts from indirect land use change on the GHG performance of biofuels.[42]

In order to comply with the requirements of the RES directive and in view of its higher GHG thresholds from 2017[43], biofuel producers will need to work towards increasing the GHG savings. There are two important EU policies that are likely to lead to an increase in GHG savings for biofuels by 2020:

– 20% GHG emission reduction across the EU imposed by the EU’s climate and energy package; e.g. inclusion of the fertiliser industry in the EU Emissions Trading Scheme (ETS) and CO2 emission limits for vehicles;

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42 COM (2010) 811 Report from the Commission on indirect land-use change related to biofuels and bioliquids.

43 The RES directive requires that from 1 January 2017 the greenhouse gas emission saving from the use of biofuels shall be at least 50%. From 1 January 2018 the GHG savings shall be at least 60% for biofuels and bioliquids produced in plants in which production started after 2017.

– 20% energy efficiency ambition of the European Commission, as the biofuels processing industry will also have to comply with the CO2 emission and energy efficiency improvement policies.

Biofuel producers can also take other measures leading to improved GHG performance of the biofuel, such as using a CHP based electricity and heat from natural gas or biomass or use of biomethanol instead of fossil methanol in the production process.

5.2. Other lifecycle environmental aspects

Lifecycle analysis assessments (LCA) of biofuels often consider the environmental impact of GHGs only. There are, however, several other environmental effects that can also be considered through the use of a full LCA if a complete assessment of the performance of a biofuel compared to its fossil fuel alternative is to be made.

This section will give a brief overview of some effects of biofuel chains related to air quality, eutrophication, acidification and human toxicity. This analysis is limited. Acidification and eutrophication focus mainly on impacts that relate to the agricultural nature of biofuels (and thus to all crops produced). Some of the important environmental impacts and risks of fossil fuel supply chains such as oil spills or flaring are not included in this section. Rather it addresses a number of issues which can have an environmental effect in biofuel and fossil supply chains and which through policies or better practices can be limited in future practices reducing the impact of crop production (including for biofuels) on the environment.

Air quality emissions

Air pollution effects from bioenergy supply chains were recently analysed in the 'BOLK II' study[44] for the Netherlands government, completed in 2009. Both current and future biofuels, and their fossil fuel alternatives, were included in this study, and the specific biofuel feedstocks covered were rapeseed, palm, wood and biogas for biodiesel and sugar cane, sugar beet, wood and straw for bioethanol. The analysis focused on the following emissions of NO_x, SO_x, particle matter (PM2.5 and PM10) or non methane volatile organic compounds.

44 Air polluting emissions from biofuels and biomass supply chains, Final report from the Dutch research program on air and climate (BOLK), ECOFYS BOLK II, Utrecht, 2009.

The results of the study are summarised in the following tables:

2020 emissions for diesel replacers and their fossil reference

Emission	Units	Biodiesel from rapeseed	Biodiesel from palm oil	FT diesel from wood	Biogas as a transport fuel	Diesel reference
NO_X	g/GJ	42.88	46.08	17.18	21.14	42.80
SO_X	g/GJ	21.60	30.86	10.16	13.26	96.29
NH_3	g/GJ	51.10	23.14	0.07	0.23	0.14
PM10	g/GJ	14.81	5.82	0.95	1.14	2.24
PM2.5	g/GJ	3.89	2.18	1.38	0.46	4.36
NMVOC	g/GJ	13.74	7.45	13.32	9.71	27.09

2020 emissions for gasoline replacers and their fossil reference

Emission	Units	Ethanol from sugar cane	Ethanol from sugar beet	Ethanol from straw	Ethanol from wood	Gasoline
NO_X	g/GJ	130.60	56.11	10.61	-8.15	50.53
SO_X	g/GJ	40.79	49.63	66.00	53.82	133.07
NH_3	g/GJ	3.77	6.79	25.17	-0.58	0.16
PM10	g/GJ	9.08	8.97	6.24	0.45	2.67
PM2.5	g/GJ	1.62	2.88	1.56	0.98	5.29
NMVOC	g/GJ	39.95	41.94	13.57	13.83	27.75

Source: BOLK II study, Ecofys, 2009

From the above analysis, it can be said that **biodiesel** from rape and palm oil in general have lower emissions than the fossil reference for SOx, NMVOC and PM2.5. Meanwhile, biodiesel chains performed considerably worse than fossil diesel on NH_3 emissions, particularly for rapeseed, reflecting the use of fertilisers. Fischer-Tropsch diesel and biogas performed better on all emissions than conventional diesel.

For **bioethanol** the following conclusions can be drawn: ethanol from sugar cane and sugar beet in general have higher emissions than the fossil reference except for SOx and PM2.5. The NH_3 emissions for sugar cane and sugar beet were considerably lower than those for biodiesel from rapeseed and palm, but still higher than gasoline. NO_x emissions for ethanol to sugar cane are significantly higher compared to gasoline. Ethanol from wood chips performed better than conventional gasoline for all emissions. In particular, the calculated emissions for NO_x and NH_3 were negative, caused by excess electricity generated in the ethanol conversion process replacing electricity from the grid. Meanwhile, NH_3 emissions for ethanol from straw were found to be significantly higher than for sugar cane and sugar beet.

The advanced biofuel supply chains as modelled within this study (BOLK II) generally have lower emissions affecting air quality than current biofuel or fossil chains. For biofuels chains, the agricultural part of the supply chain is reflected in the ammonia emissions, which are considerably higher than the fossil chain emissions. However on SO_x PM2.5 biofuel chains tend to perform better than fossil chains.

Acidification

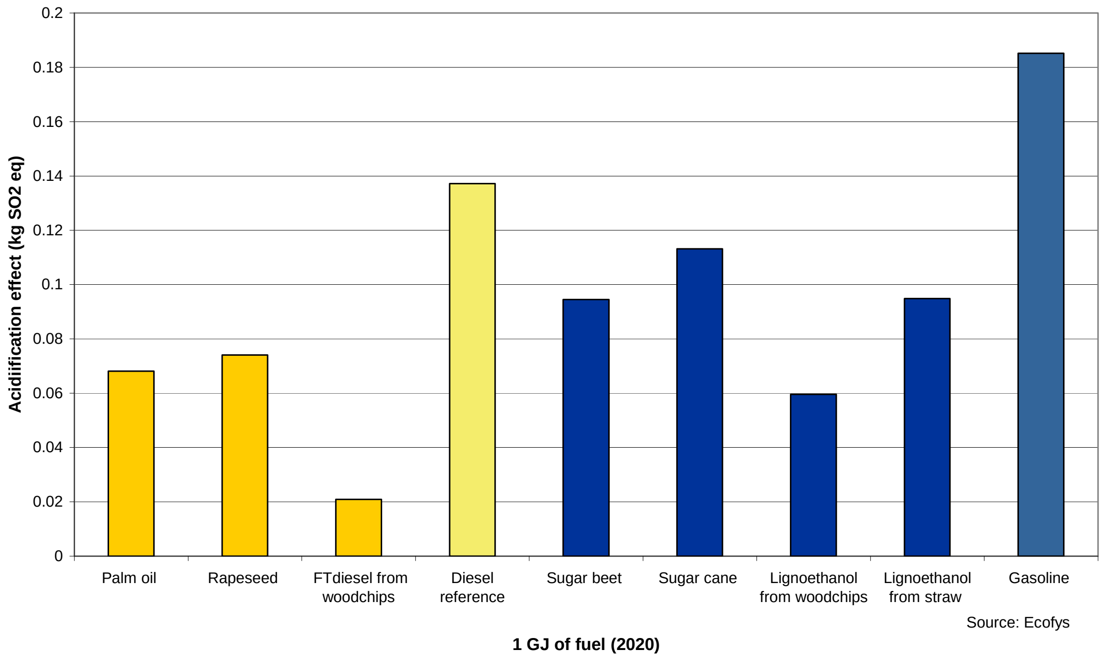
Acidification is a term used to describe the loss of nutrient bases (calcium, magnesium and potassium) through the process of leaching and their replacement by acidic elements (hydrogen and aluminium). However, acidification is commonly associated with atmospheric pollution arising from anthropogenically derived sulphur (S) and nitrogen (N) (in the form of NO_x and SO_x. Acidification can influence soil and water resources.

The main sources of acidifying substances are agriculture, vehicle traffic, industry and power generation. In agriculture, this is primarily related to the production and use of synthetic nitrogen fertiliser and spreading of manure. This leads to the volatilisation of ammonia from fields and the release of nitrous oxide by denitrification. In vehicle traffic, this is primarily caused by the release of oxides of nitrogen gases resulting from the combustion process.

Using the BOLK II biofuel chains a further assessment has been conducted to assess the overall acidification effect[45]. The figure below provides an overview of the results, expressed in terms of kg SO_2 eq.

[45] SIMAPro was used in this assessment using both the CML 2 baseline 2000 V2.1 / World, 1990 and Eco-indicator 99 (E) V2.1 / Europe EI 99 E/E. The results from the more recent CML data set have been used, although the Eco-indicator 99 data set also provides similar trends.

Acidification effect of current and future biofuels referenced against their fossil fuel alternative.



Source: Ecofys

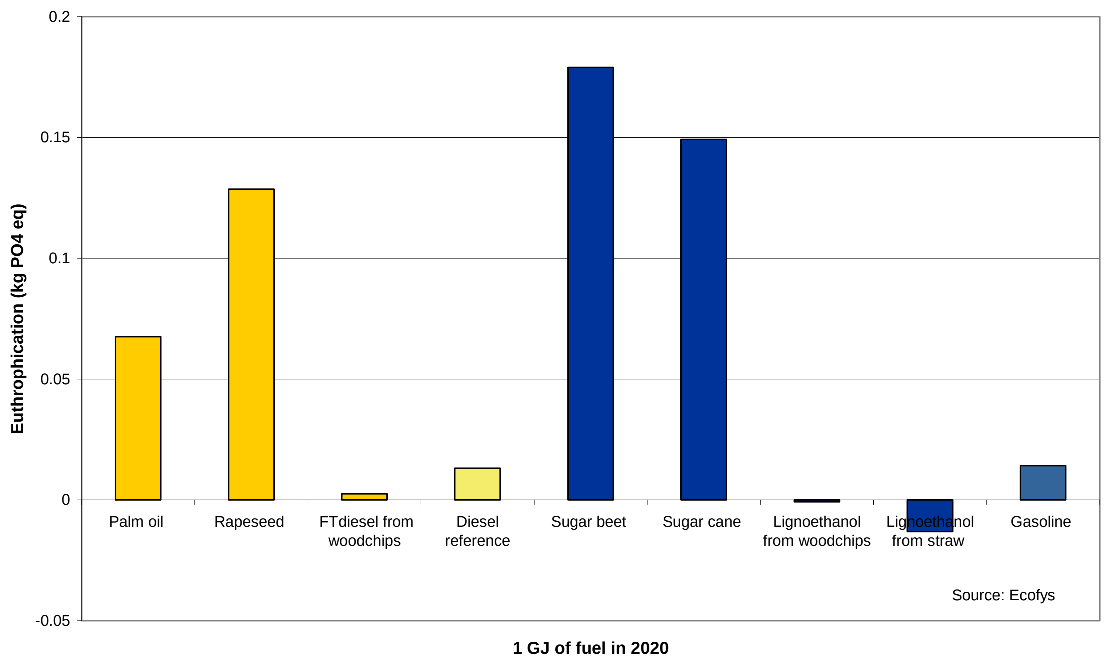
A remarkable aspect it shows is that fossil chains (at least in their current supply chain) have quite high SO_x emissions, resulting in a relatively high acidification effect compared to the biofuel chains[46].

Eutrophication

Eutrophication is a process whereby water bodies receive excess nutrients, namely nitrates and phosphates, from erosion and runoff of surrounding lands. This stimulates excessive plant growth in the water, leading to algal blooms and the growth of nuisance plants. In aquatic environments, this disrupts the normal functioning of the ecosystem, causing a variety of problems such as reducing the dissolved oxygen content in the water, creating 'dead zones' and causing marine life to die.

Agriculture is a very large contributor to eutrophication effects, the primary cause being the use of synthetic fertilisers. As current (i.e. 'first generation') biofuel production is predominantly based on agricultural crops, which require fertiliser input, it would be expected that their performance related to eutrophication effects would be worse when compared to fossil fuel alternatives.

Eutrophication effect of current and future biofuels referenced against their fossil fuel alternative.



Source: Ecofys

Biofuels produced from future feedstocks, based on residues or lignocellulosic materials such as wood and straw perform better than their fossil fuel alternatives. This is due to the minimal fertiliser requirement in the case of wood and the fact that only a portion of the total

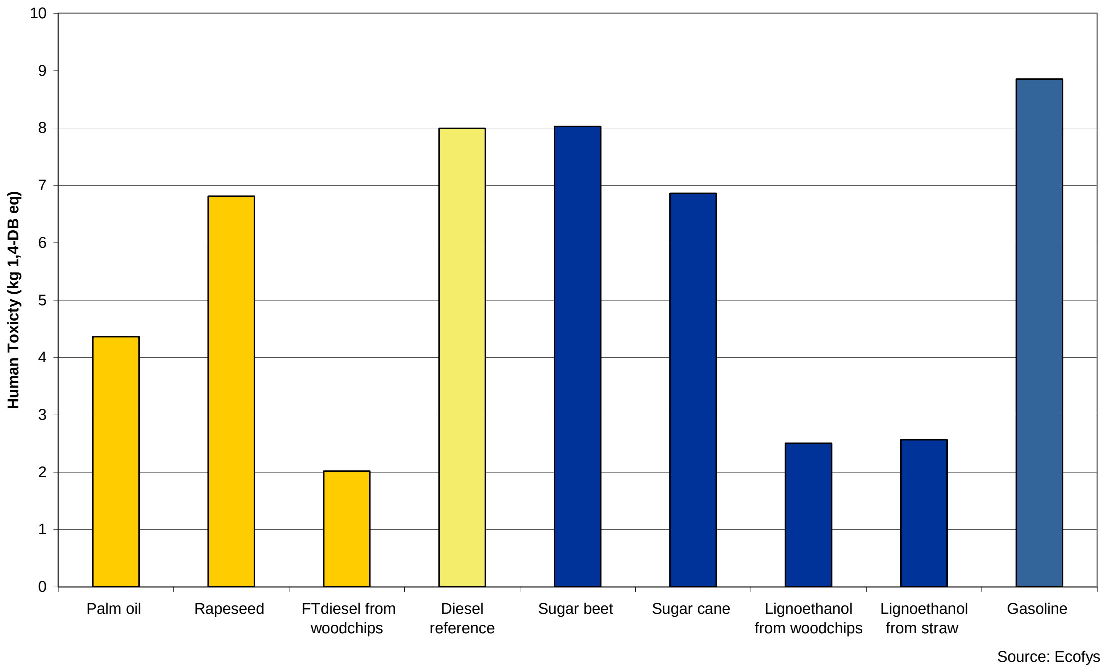
46 Air polluting emissions from biofuels and biomass supply chains, Final report from the Dutch research program on air and climate (BOLK), ECOFYS BOLK II, Utrecht, 2009.

eutrophication effects are allocated to these feedstocks[47]. The negative emissions for ethanol from wood chips and straw are a result of allocation of excess generation of electricity in the ethanol production process.

Human toxicity

The emission of some substances (such as heavy metals) can have impacts on human health. Assessments of toxicity are based on tolerable concentrations in air, water, air quality guidelines, tolerable daily intake and acceptable daily intake for human toxicity. Human toxicity is represented in Human Toxicity Potentials (HTP), which is expressed in 1,4-dichlorobenzene equivalents. The following figure gives an illustrative overview of effects on human toxicity.

Human toxicity effect of current and future biofuels referenced against their fossil fuel alternative.



Source: Ecofys

The graph shows that in general fossil supply chains have a larger effect on human toxicity. This is mainly due to crude oil extraction and metal production of steel and iron. Biofuel chains and especially the advanced biofuel chains tend to have lower emissions related to human toxicity.

5.3. Sustainability of crops

As noted in previous sections, most of the crops used for biofuel production in the EU are produced in the EU. The other countries of origin for crops used to produce biofuels for the EU market are the USA, Indonesia, Malaysia, Argentina and Brazil. Thus it is assumed that most of the impacts discussed in this part would occur in these regions, though these impacts

47 Note that the allocation method used in the modeling was allocation by 'economic value'. The GHG methodology of the RES directive uses allocation by 'energy content'.

would result from any kind of agricultural activity, irrespective of the final use of the feedstock.

Crop rotation

It is important to take into account that for many crops, it may be beneficial or even necessary to practice rotation with other crops – one of the most fundamental agricultural practices to maintain soil quality and support sustainable use of land [Castellazzi et al, 2007][48]. A typical reason is to avoid the build-up of pests or pathogens, but also to increase overall yield. Smith et al [2008][49] showed linearly increasing corn yield with the number of crop species in rotation, an experiment also using cover crops, and without fertilizer or pesticides. In the case of sugar beet, which was calculated above to be the most land use efficient crop, it is in some cases not possible to grow it more than one year out of three due to risk of parasites [Hamelinck, 2004 and Power et al, 2008][50], which of course alters land use efficiency in practice.

A specific crop rotation scheme can be optimized for different outcomes, e.g. maximizing profits (financial), minimising pesticide use (environmental), maximizing the output of a specific mix of crops (agricultural) [Castellazzi et al, 2007], or in the case of biofuels, energy ratio or output. The choice of which factor to optimize ultimately decides the scheme, as seen in a study by Power et al [2008] on bioethanol production in Ireland. Here, optimizing crop rotation of sugar beet for land use efficiency gave a different result than for optimizing for economy. The most cost efficient rotation scenario was wheat only, but the most land efficient rotation was wheat, wheat and sugar beet.

The introduction of rape seed into cereal-only rotations (to meet EU biodiesel demand) can have a positive effect on yields, as demonstrated by Christen [2001].[51] The grain rotation experiment during the years 1988 to 2000 showed that between the most and the least favourable combination within the crop rotation the differences in grain yield increased to 18% in rapeseed, 11% in barley and 13% in wheat. Wheat grown after wheat showed a smaller yield stability compared with wheat after rapeseed.

All-in-all, the effects of crop rotation is an important factor to take into account when calculating land use efficiency, but it can be complicated by the fact that it is dependent on many choices concerning land management.

Biodiversity

An assessment of the impact of EU's consumption of biofuels on biodiversity requires a detailed analysis of each of the countries supplying the biofuels and/or the feedstock. Such an assessment requires chain-of-custody data, specific geographic information, cropping/fertilizer/pesticide management review, threatened species and habitat analyses and the like; it is an exercise that is beyond the scope of this report. Many of the threats to

[48] Castelazzi M.S. et al. A systematic representation of crop rotations, Agricultural Systems, 97:1-2, pp. 26-33, 2007

[49] Smith R.G., Effects of Crop Diversity on Agroecosystem Function: Crop Yield Response, Ecosystems, 11, pp. 355-366, 2008.

[50] SEI, Hamelinck C.N. et al, 2004, Liquid Biofuels Strategy Study for Ireland, Sustainable Energy Ireland, Dublin Ireland.

[51] Christen O. *Ertrag, Ertragsstruktur und Etragsstabiltaet von Weizen, Gerste und Raps in untershiedlichen Fruchtfolgen (Yield, yield formation and yield stability of wheat, barley and rapeseed in different crop rotations),* Pflanzenbauwissenshaften, 5(1), p.33-39, 2001, Stuttgart.

biodiversity are related to agricultural practices in general. As it follows from the previous sections, most of the EU consumed biofuels are produced from EU feedstocks. Imported feedstocks originate in USA, Argentina, Brazil, Indonesia and Malaysia. Each of these countries, like the EU Member States, is also an active party to global conventions and treaties that recognize the importance of biodiversity, critical wetland resources, and the necessity of limiting trade in critical and endangered species. They also each adhere to the comprehensive planning and reporting protocols required by the global treaties. Environmental awareness and NGO activity is relatively high and usually focused on critical resources (e.g., Brazil - the Amazon rainforest and the Cerrado; Indonesia - the rainforests of Sumatra and Central Borneo and coastal resources).

Despite this awareness, threats to species, habitats, and ecosystems occur in these countries. Many are attributable to poor agricultural practices and unregulated agricultural land use changes [Sheil et. al., 2009][52], which can occur for multiple purposes (grazing, expansion of agricultural land etc). Policies and laws do exist in most countries that stipulate environmental impact assessments for land use changes, but there is often no transparent enforcement, or there are opposing policies and incentives that negate the penalties that are enforced for land use violations.

Several observations can be made on reduction of risks to biodiversity:

– In the EU and USA direct risks to biodiversity are more likely to be low due to strict regulations on agricultural practices followed by producers and enforced when they are not. Brazil has also adopted regulations on agricultural practices for sugar cane, aimed at reducing the risks to biodiversity;

– Agro-zoning and delineation of conservation areas contribute to a better planning of biofuel production, but depend on the national regulation of each country;

– Outside the EU, threats to biodiversity can be more severe and are mostly related to all agricultural practices and not just those pertaining to biofuel production for export and consumption in the EU;

– Possible solutions to reducing these threats can be found in certification practices, policies and regulations covering agricultural activities in general as well as the enforcement of the regulations;

– Macro-monitoring, with an extension to food crops or country-wide systems could provide possible alternatives and solutions.

6. MEASURES TO PROMOTE ADVANCED BIOFUELS

A number of Member States have adopted policy measures or financial incentives to promote certain types of biofuels based on their environmental performance.

[52] Sheil D. et al. The impacts and opportunities of palm oil in Southeast Asia. CIFOR Occasional paper No.51, July 2010.

6.1. Investment support

Member States are allowed, and the RES directive encourages such support, to promote the better performing biofuels that are more expensive by giving them better treatment in the national support systems (and by double counting them towards the renewable energy in transport target).

Denmark has supported 6 advanced biofuels projects through a 200 million DKK (€25 million) fund managed by the Energy Technology Development and Demonstration Programme (EUDP), most notably the successful demonstration of cellulose ethanol production at Inbicon.

In **Finland**, the technology and innovation development centre Tekes operates the BioRefine programme. The specific aim of this programme is to promote the development of second-generation production technologies for biofuels for transport. In 2009, € 37 million was granted to business development and 19 M€ to research in this area. The main biofuel products developed under this programme are synthetic biodiesel from wood/forest residues, gasification; synthetic biodiesel from new raw materials, algae, microorganism; biofuel oil from wood/forest residues, integrated pyrolysis and lignocellulosic ethanol, straw, refuse, waste. Additionally, and in cooperation with this programme, the Ministry of Employment and the Economy manages a programme for pilot and demonstration projects for these new technologies (€9 million in 2007 and €5 million/yr for 2008-2010).

In **Germany** synthetic biofuels produced via gasification (BTL fuels), most notably through the Choren initiative have been developed over the past decade. Over the past five years, the focus of government support has been mainly on the provision and pre-treatment of feedstock for such BTL processes.

At the end of 2006, the **Dutch** government dedicated a €60 million fund to the development of innovative biofuels that yield significant reductions in CO_2 emissions. The programme supports both investments and operating costs for applications or uses that reduce CO_2 emissions in transport. So far, a total of €19.4 million was granted to four projects.

The **Swedish** Energy Agency is investing in research and development of cellulose based fuels, with focus on three areas: ethanol produced from cellulose, gasification of biomass and gasification of black liquor.

6.2. Other support policies

Since 2005 Denmark and Sweden apply a CO_2 tax on conventional diesel and petrol, and biofuels are exempted from this tax. The exemption does not depend on the amount of CO_2 emission reduction achieved and, therefore it does not discriminate between different biofuels according to their environmental performance.

Combining CO_2 taxation with actually achieved CO_2 performance according to the methodology in the RES directive could eventually serve as an extra incentive for better performing biofuels.

In France a government level working group was created with the aim to develop in particular the second-generation biofuels. Ireland assessed the energy potential from marine algae in the 2020 perspective.

7. ENERGY EFFICIENCY MEASURES IN TRANSPORT

Transport accounts for nearly one-quarter of global energy-related CO_2 emissions[53]. The majority of the CO_2 emissions from transport originate from road transport.

The EU strategy[54] put forward by the European Commission in 2007 provided a target for CO_2 emissions from new passenger cars of 120g/km on average in 2012. Various means of improvements in vehicle technology were envisaged such as setting the minimum efficiency requirements for air-conditioning systems, compulsory fitting of accurate tyre pressure monitoring systems and setting the maximum tyre rolling resistance limits; introducing further fuel efficiency requirements in the light commercial vehicles with the objective of reaching 175 g/km CO_2 by 2012 and 160g/km CO_2 by 2015 and increased use of biofuels maximizing environmental performance.

Energy efficiency options for transport can be grouped in three main focus areas: vehicles, power trains and fuels. These various options are reviewed in the following tables summarising findings from various studies (TNO (2006), IEA (2008), Sharpe (2009), Ricardo (2009))[55].

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53 Transport, Energy and CO2: Moving toward Sustainability – How the world can achieve deep CO2 reductions in transport by 2050, IEA, 2009.

54 COM (2007) 19 Communication from the European Commission on Results of the review of the Community Strategy to reduce CO2 emissions from passenger cars and light-commercial vehicles.

55 TNO Science and Industry (2006) - Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars. For the European Commission; Smokers, R.; Vermeulen, R.; Van Mieghem, R; Gense, R. et al.; IEA, International Energy Agency (2008) - Energy technology perspectives 2008 – Scenarios & Strategies to 2050. OECD / IEA.Sharpe, R.B.A. (2009) - Technical options for fossil fuel based road transport Paper produced as part of contract ENV.C.3/SER/2008/0053 between European Commission Directorate-General Environment and AEA Technology plc; see website www.eutransportghg2050.eu;Ricardo (2009) - Review of Low Carbon Technologies for Heavy Goods Vehicles. For UK Department of Transport. Baker, H.; Cornwell, R.; Koehler, E.; Patterson, J.

Energy efficiency measures for passenger cars and light commercial vehicles

Passenger cars / LCV		Measure	Source	Time horizon for implementation	Fossil fuel savings (in 2020) [%]	Maxiumum theoretical fossil fuel savings (beyond 2020) [%]
Vehicle	Driver behaviour	Eco Driving training / gear shift indicator	TNO, 2006	Immediatelly / well established	3 % or 4,5 % (when combined with gear shift indicator)	3 % or 4,5 % (when combined with gear shift indicator)
Vehicle	Rolling resistance	Low rolling resistance tyres	TNO, 2006 Sharpe, 2009 IEA, 2008 (for	2002 - 2012 / 2030 Sharpe: not defined	2% Sharpe: 3 %	0,5 - 4 %
Vehicle	Rolling resistance	TPMS and low rolling resistance tyres	TNO, 2006	Now	4 - 6 %	
Vehicle	Aerodynamics	Aerodynamics	TNO, 2006 Sharpe, 2009 IEA, 2008 (for 2050)	2002 - 2012 / 2030 Sharpe: not defined	1,5% Sharpe: 2 - 4 % (cars)	0,5 - 4 %
Vehicle	Other	Weight reduction of vehicle	TNO, 2006 Sharpe, 2009 IEA, 2008 (for 2050)	2002 - 2012 / 2030 Sharpe: not defined	up to 5 - 6 % (for strong reductions of 30 % Body- in White or 9 % vehicle weight) Sharpe: 6.5 % (10 % reduction of vehicle weight, if engine power adjusted)	10 - 11 % (25 % lower weight)
Vehicle	Other	Electrically assisted steering (EPS, EPHS)	TNO, 2006		large vehicle: 2 % small vehicle: 3 %	
Powertrain	Engine effiency	Downsizing with turbocharging (petrol)	TNO, 2006		< 12 %	
Powertrain	Engine effiency	DI / stratified charge (petrol)	TNO, 2006		< 10 %	
Powertrain	Engine effiency	Variable valve control (petrol)	TNO, 2006 Sharpe, 2009 IEA, 2008	TNO: 2002 - 2012 Sharpe: not specified IEA: 2050	< 7 % (TNO / Sharpe)	6 - 8 %
Powertrain	Engine effiency	Downsizing (diesel)	TNO, 2006		< 5 - 10 %	
Powertrain	Engine effiency	Advanced cooling circuit and electric water pump (diesel)	TNO, 2006		3%	
Powertrain	Engine effiency	Reduction of engine friction losses (diesel)	TNO, 2006 Sharpe, 2009	Sharpe: < 2020	3 - 5 % (depending on car size) 3 % (Sharpe)	
Powertrain	Engine effiency	Downsizing	Sharpe, 2009	2020 - 2030		10 - 20 %
Powertrain	Engine effiency	Variable compression ratio	Sharpe, 2009	not specified	10%	
Powertrain	Engine effiency	Direct injection	Sharpe, 2009	not specified	3 - 10 %	
Powertrain	Waste heat recovery	Heat2Power	Sharpe, 2009	not specified	15 - 35 %	
Powertrain	Waste heat recovery	Rankine	Sharpe, 2009	not specified	3,8 % - 31,7 % (tests / simulations)	
Powertrain	Waste heat recovery	Thermoelectric conversion	Sharpe, 2009	not specified	1 - 5 %	
Powertrain	Alternative powertrains	Start stop function (with regenerative braking)	TNO, 2006		6 % (diesel) 7 % (petrol)	
Powertrain	Alternative powertrains	Hybrid vehicles	Sharpe, 2009	not specified	10 - 25 %	
Powertrain	Alternative powertrains	Fuel cell vehicles	IEA, 2008	2050		< 70%
Powertrain	Alternative powertrains	Electric vehicle	IEA, 2008	2050		< 70%
Powertrain	Transmission	Piloted gear box / optimized gearboxes	TNO, 2006 Sharpe, 2009	2002 - 2012 Sharpe: not defined	4% 2 % (Sharpe)	
Powertrain	Transmission	Dual- clutch	TNO, 2006 Sharpe, 2009	2002 - 2012 Sharpe: not defined	4 - 5 % 5 - 15 % (automatic transmission) (Sharpe)	

Energy efficiency measures for heavy goods vehicles

Heavy Goods Vehicles		Measure	Source	Time horizon for implementation	Fossil fuel savings (in 2020) [%]	Maxiumum theoretical fossil fuel savings (beyond 2020) [%]
Vehicle	Driver behaviour	Eco Driving training	Ricardo, 2009 Sharpe, 2009	Immediatelly / well established	10 % on Day of training, Sharpe: average: 5 %	
		Predicticve cruise controll	Ricardo, 2009	first entry into the market	2 - 5 %	
		Vehicle platooning	Ricardo, 2009	university research	motorways: 20 % urban conditions: 7 %	
	Rolling resistance	Low rolling resistance tyres	Ricardo, 2009	well established in the market	5%	
		Single wide Tyres	Ricardo, 2009 Sharpe, 2009	well established in the market	6 % (average) - 10 % (fully loaded vehicles) Sharpe: 6 %	
		Automatic tyre pressure adjustment	Ricardo, 2009		7%	
	Aerodynamics	Aerodynamic trailers / Active Flow control (AFC)	Ricardo, 2009 Sharpe, 2009	first entry into the market <2020; 2020 - 2030	10% Sharpe: 6 %	Sharpe: 7 - 10 %
		Aerodynamic fairings	Ricardo, 2009 Sharpe, 2009	technology is mature	0,1 % to 6.5 % per device and vehicle Sharpe: 3 - 8 %	
		Trailer spray suppressers	Ricardo, 2009		up to 3.5 % (test under constant speed)	
	Other	Leightweight construction	Sharpe, 2009	not defined	7%	
Powertrain	Engine effiency	Engine efficiency total	Sharpe, 2009	not defined	5%	
		Optimization of the combustion system	Ricardo, 2009	fleet trials / first entry into the market	increase in fuel consumption up to 3 % savings	
		Engine accessories	Ricardo, 2009	Prototypes / first entry into the market	3 % each	
		Air hybrid system / pneumatic booster system (PBS)	Ricardo, 2009	frist prototypes	1 - 2 %	
		Gas exchange	Ricardo, 2009	available technology, but has not yet been applied to HDV's	1 - 2 %	
	Waste heat recovery	Heat recycling technologies	Sharpe, 2009	next five years	5%	
		Waste heat for steam generation	Sharpe, 2009	Test stage	40%	
		Turbocompound (electrical / mechanical)	Ricardo, 2009	electrcial: first prototypes mechanical: available on the market	3%	
		Heat exchanger	Ricardo, 2009	research	3 - 6 %	
		Thermoelectric generators	Ricardo, 2009	research	2%	
	Alternative powertrains	fuel cell vehicles (*see respective chapter for further explanations)	Ricardo, 2009	early stage of development	not quantified*	
		fully electric vehicles (*see respective chapter for further explanations)	Ricardo, 2009	first entry into the market	not quantified*	
		hybrid vehicles	Ricardo, 2009 Sharpe, 2009	hybrids: fleet trials (HDV), but available for medium duty applications	14 - 39 %	
		Start stop hybrids (with regenerative braking)	Ricardo, 2009		4 - 21 %, average 6 %	
	Transmission	Automated manual transmission (AMT)	Ricardo, 2009		7 % compared with manual (depends on driver, benefit for trained drivers is lower)	

It follows from the tables that passenger cars and light commercial vehicles offer a higher average potential for efficiency improvements in the medium term of 50% compared with heavy goods vehicles with 20%.

The main points for improvements are the reduction of aerodynamic drag and weight for passenger cars, light commercial vehicles and heavy goods vehicles (reductions in fuel consumption by around 3 % - 8 % (aerodynamics) to 7 -10 % (weight reduction)).

For heavy goods vehicles additionally innovative measures which require a change in driving behaviour such as e.g. vehicle platooning[56] can reach significant fuel reductions of 7 – 20%. The highest saving potentials in the powertrain area are waste heat recovery and alternative power trains (with savings up to 40 %). Alternative power trains can lead to fuel reductions of 4 – 39 % in the medium term and up to 70 % for passenger cars and light commercial vehicles in the long-term.

[56] The aim of vehicle platooning is to enable vehicles to drive in close proximity to each other to "create a train" and to reduce aerodynamic drag and fuel consumption.