Workshop ETTAR

Transport and the Environment:

Barriers to the take up of environmental technologies in the transport sector

Background Paper

Gothenburg

25 – 26 October 2007

1 Introduction

This introduction will describe the objectives of the ETTAR **(Environmental Technologies, Training and Awareness-Raising)** Project and will explain the function and structure of the background paper.

1.1 The ETTAR Project

Transportation is a service that has a significant impact on the environment. The volume of transport, transport modes and the technology used by the transport vehicles determine the level of emissions into air (CO_2, SO_2, NO_x, noise, etc.) and consumption of resources (energy, raw materials, land), and thus have a major impact on the environment. Since the 1950s, transport volumes (world wide and within the EU) have continually grown faster than GDP. Between 1990 and 2005, world trade volumes increased by 5.8% annually, while total economic output grew by 2.5% per year. Against this background, the need for employment of advanced environmental technologies for passenger and freight transport in all transport modes (road, air, inland waterways and the maritime sector) is apparent.

At the same time, stakeholder consultations have shown that environmental technologies are not sufficiently used in this sector, partially due to a lack of knowledge and clear information. There is also a lack of capacity, as well as of accurate and easily accessible information to provide a holistic picture of the potential benefits and costs of utilising environmental technologies. This prevents users (for freight transport: logistics companies) from making informed decisions on investing in these technologies. Business actors have pointed out that transparency should be improved with regard to the environmental technologies available and/or under development.

Additionally, there is the perception of insufficient co-operation between the different actors involved in the development and use of environmental technologies. There is a lack of co-operation between the research and business sectors, as they sometimes find it difficult to communicate their specific needs, but also within companies, as procurement and financial departments on the one hand and environmental departments on the other often have different perceptions of the benefits of environmental technologies.

Against the background of insufficient deployment of environmental technologies in the transport sector, the **ETTAR (Environmental Technologies, Training and Awareness-Raising)** project has been set up to identify and assess training needs, methods and activities for the wider use of environmental technologies in the transportation sector with a particular focus on **freight transport in the EU**.

ETTAR focuses on activities that could assist the transport sector in contributing to reductions not just of greenhouse gases, but also of other emissions that have significant environmental consequences (for example fine particles, NO_x, SO_x, noise, etc.).

The project intends to raise awareness and build capacities to address the environmental impacts occurring along the supply chain, so that businesses can become more aware of the impact linked to transport. Another major focus of the project is the identification and assessment of training needed to promote the practical adoption or up-take and application of environmental technologies in the transport sector.

The **first ETTAR-workshop in Gothenburg on 25-26 October 2007** will focus on

- best available and environmentally sound **vehicle and fuel technology** for freight transport of all transport modes (road, rail, air and inland waterways);
- **the barriers to an extended implementation**; and
- **best-practice examples** outlining how these technologies can be employed at a large scale and without economic setbacks.[1]

The second workshop to be held in the beginning of 2008 will focus on logistics processes, whilst the third workshop to be held in spring 2008 will take a broader look at how technology can be used, in the wider context of transport and planning, in order to achieve environmental improvements. A final conference will discuss the findings of the project as a whole.

The findings of the workshops and the project will also be documented in two Policy Briefs designed to raise awareness of the potential and take-up of environmental transport technology.

1.2 Function and Contents of this Background Paper

The **function** of this paper is to provide relevant background information to the participants of the first workshop and to outline key questions to be discussed at the event. The paper is meant to be used as a common starting point for further discussions and will further serve as a basis for the Policy Brief[2] to be developed after the workshop. This paper thus serves as a stimulus for debate and does not constitute a research or policy paper, nor does it formulate its own policy recommendations. Instead, it is intended to give an overview of the subject of environmental technologies, illuminating it from different angles (political, technological and economic). Most importantly, it identifies key issues of the workshop by revealing existing knowledge gaps that should be filled or narrowed by the contributions of speakers and the discussions of all participants at the workshop.

The paper is **structured** along the following lines.

- Chapter 1 – provides and introduction and background of the project,

[1] The second workshop, scheduled for January 2008, will concentrate on logistics planning processes.

[2] The focus of the Policy Briefs will be set on policy recommendations for the European level as well as the national level to develop a future common approach. The Policy Brief will be based on the discussions in the workshop.

- Chapter 2 will give insight into the current **political actions** at the EU level to foster adoption of sustainable environmental vehicle and fuel technologies in the freight sector;
- Chapter 3 will present an overview but not a complete enumeration of **currently available environmental technologies (i.e. vehicle and fuel technologies) for freight vehicles** (road, rail, air, inland water ways).
- Chapter 4 will deal with basic **parameters** constituting **main pressure points** that influence and all too often impede the use of environmental transport technologies, such as supply chains, consumer demand, cost-benefit considerations, and co-operation within companies and between companies.
- Chapter 5 will provide a summary, and will contain the quintessential findings of the paper and derive from these the **key questions** to be addressed at the workshop.

The **main pressure points** discussed in Chapter 4 will form the **centre of the discussions** at the workshop.

Given that the issues of the main pressure points, such as concrete customer demands, supply chains, and costs/benefits in connection with environmental technologies, are complex and their analysis requires much company-specific insider knowledge, Chapter 4 will often present assumptions rather than final conclusions. These assumptions will be put to debate at the workshop and might be invalidated in the discussions.

2 EU Policy context

2.1 Introduction

This chapter will provide a brief overview of current EU policy actions in the freight transport field focussing on vehicle and fuel technology. Other political aspects such as promoting shifts from road-based freight transport to rail transport or improvement in logistics planning technologies aiming at better exploiting capacities and reducing kilometres driven, are outside the scope of this workshop and background paper, but will be dealt with extensively in subsequent workshops.

A concise overview of political actions will be included in this Chapter, but this discussion will not encompass all aspects of promoting environmental technologies in the transport sector, e.g. not all research activities can be covered. Rather, the chapter will focus on command-and-control measures.

The intent of this chapter is to inform the reader about which adaptations of transport technology to new environmental technology standards are dictated by law and thus will need to be undertaken as opposed to adaptations based on voluntary decisions and environmental considerations of the transport industry.

2.2 White Paper 2001

The 2001 White Paper "European Transport Policy for 2010: Time to Decide"[3] placed much of its focus on the shift occurring in freight transport, from railway to road-based transport, and proposed ways to organise a shift of freight transport from road transport to other more environmentally friendly transport modes.[4]

With regard to environmental technologies, the White Paper in its chapter “Rationalising Urban Transport” acknowledged that conventional engines and vehicles, whose energy efficiency is far from optimal, are one of the main sources of urban pollution and greenhouse gases and contribute to the European Union’s excessive energy dependency. According to the White Paper, important progress has been made thanks to anti-pollution standards for motor vehicles and fuel quality laid out in the European Fuel Quality Directive.[5]

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[3] COM(2001)370; http://ec.europa.eu/transport/white_paper/index_en.htm

[4] These aspects are not subject to the first workshop and will, therefore, not be discussed in this background paper.

[5] Directive 98/69/EC of the European Parliament and of the Council of 13 October 1998 relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directive 70/220/EEC; http://eur-

The White Paper specifically relies on the agreement with the automotive industry, whose implementation should result in a 25% reduction in average emissions of carbon dioxide from new cars produced or distributed in Europe by 2008. As part of this agreement, new emission reduction objectives ought to be set for the time after 2008 and these should be extended to utility[6] vehicles.[7] Additional measures should be taken at the Community level to introduce alternative fuels, especially biofuels, and to stimulate demand by experimentation.[8]

The White Paper considers the most promising forms of alternative fuels to be biofuels in the short and medium term, natural gas in the medium and long term, and hydrogen in the long term. To promote biofuels, the Commission pledged to fix percentage targets of biofuel use in a Biofuels Directive, and to pass new community rules on tax reductions for biofuels. These directives were issued in the year 2003.[9, 10]

2.3 Commission Communication "Keep Europe moving - Sustainable mobility for our continent": Actions envisaged in the field of transport technology and energy efficiency

The Communication from the Commission "Keep Europe Moving"[11] served as a mid-term review of the White Paper 2001, adding the climate change perspective to these issues. The Communication takes into account the European Union of 25 Member States, whereas the White Paper had been modelled on the Europe of 15 Member States. The main objectives laid down in 2001 still remain valid. A number of concrete actions have been envisaged, ranging from optimisation of existing transport modes to citizen mobility and better transport solutions through new technologies.

The next sections will describe the actions envisaged in the Communication with regards to **transport technology and energy efficiency**.

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lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!CELEXnumdoc&lg=EN&numdoc=32001L0100

[6] There is no specification of the term "utility" vehicles in the White Paper.

[7] Meanwhile, it has become clear that the voluntary agreement will not achieve the results envisioned for passenger cars (see 2.3.2).

[8] http://ec.europa.eu/transport/white_paper/documents/doc/lb_com_2001_0370_en.pdf (7 October 2007), p. 86.

[9] Directive 2003/30/EC of the European Parliament and the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport;

[10] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity

[11] Communication from the Commission to the Council and the European Parliament "Keep Europe Moving – Sustainable Mobility for our Continent", SEC(2006) 768; http://ec.europa.eu/transport/transport_policy_review/index_en.htm (7 October 2007).

The Communication acknowledges that transport as such (freight transport and passenger transport) accounts for some 71% of all oil consumption in the EU. Road transport, most importantly, uses 60% of all oil; air transport accounts for some 9% of overall oil consumption. Thus, the transport sector (freight and public transport) is also the cause of a high share of the oil demand.

The high costs of fossil fuels and the need to reduce the EU's strategic dependency are important reasons behind the drive towards optimisation of the potential of each mode of transport. A European energy policy which aims at ensuring competitiveness and environmental protection has to focus on transport policies which reduce energy consumption by improving fuel efficiency on the vehicle-side, and gradually replacing oil by other fuels, be it biofuels, natural gas, hydrogen, electricity, or others.[12]

Subsequent to the research and demonstration stages, the EU Commission pledges to stimulate environmentally friendly innovation, by creating the conditions to bring mature new technologies to the market through standard-setting and regulation.

In this context the following political measures have been announced:

- Successive EURO norms (emissions standards) for road vehicles;
- voluntary agreement with the automotive industry to lower CO_2 emissions to 140 g/km by 2008 and to 120 g/km by 2012 in line with the EU strategy on CO_2 emissions or international greenhouse gas emissions reduction targets;
- discussion of norms for improved tyres;
- promotion of agreed targets (e.g. the attainment of the 5,75% biofuel target for 2010).

The promotion of clean vehicles on the basis of public procurement (e.g. of buses) and fiscal regulations also belongs to these measures.

In the following sections, the current EU actions, which have only vaguely been envisaged in the White Paper and the Communication, are described:

2.3.1 Emission Standards

Currently, emissions of nitrogen oxides (NOx), hydrocarbon (HC), carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicle types, including cars, lorries, trains, tractors and similar machinery, and barges, but excluding seagoing ships and airplanes. Different standards apply for each vehicle type.

The pollutant emissions from road vehicles are regulated separately for light-duty vehicles (cars and light vans) and for heavy-duty vehicles (trucks and buses). The stages are typically referred to as Euro 1, Euro 2, Euro 3, Euro 4 and Euro 5 for light-duty vehicle standards. The corresponding series of standards for heavy-duty vehicles use Roman numerals (Euro I,

[12] Ibidem, p. 15.

Euro II, etc.). The legal framework consists in a series of directives, each of them an amendment to the basic Directive 70/220/EEC. [13]

Light-duty vehicles

European Union emission regulations for new light duty vehicles (cars and light commercial vehicles) are specified in Directive 70/220/EEC[14], amended a number of times. For light-duty vehicles, the emission standard currently in force is Euro 4, as defined by Directive 98/70/EC[15]. Since the Euro 2 stage, EU regulations have introduced different emission limits for diesel and gasoline vehicles. Diesels have more stringent CO standards but are allowed higher NOx emissions. Gasoline vehicles have so far been exempted from PM standards.

Euro 5 will enter into force in September 2009. The "political" part of the legislation establishing Euro 5 and 6, which in turn will come into effect in 2014, is Regulation 715/2007 of 20 June 2007. The implementing part of the regulation (which will cover test procedures, deterioration factors and, if agreed by Member States, revised PM requirements) is to be finalised by 2 July 2008.

The main effects of Euro 5 are:

- to reduce the emission of particulate matter of diesel cars/light vans from the current 25 mg/km to 5 mg/km, making the introduction of particle filters for diesel cars obligatory, since practically the only way to comply with the norm will be through the use of particle filters,[16]
- to reduce the HC-NOx emissions considerably according to the type of van, and
- to limit emissions for NOx emissions for diesel and gasoline driven vans;
- Euro 5 introduces PM mass emission standards, numerically equal to those for diesels, for gasoline cars with DI engines.

The emission limits for CO remains at the limit of Euro 4.

Euro 6 lays a focus on a further reduction of the emissions of Nox.

The following table gives a broad overview of the different categories of light vans.

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[13] http://ec.europa.eu/enterprise/automotive/directives/vehicles/dir70_220_cee.html

[14] Council Directive 70/220/EEC of 20 March 1970 on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles

[15] Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC.

[16]

http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/1800&format=HTML&aged=0&language=EN&guiLanguage=en;

Table 1: Euro norm 4-6

Category	Tier	Date	CO	HC	HC+NOx	NOx	PM
Diesel							
$\mathbf{N_1}$, Class I ≤1305 kg	Euro 4	2005	0.50	-	0.30	0.25	0.025
	Euro 5	2009[b]	0.50	-	0.23	0.18	0.005[e]
	Euro 6	2014	0.50	-	0.17	0.08	0.005[e]
$\mathbf{N_1}$, Class II 1305-1760 kg	Euro 4	2006	0.63	-	0.39	0.33	0.04
	Euro 5	2010[c]	0.63	-	0.295	0.235	0.005[e]
	Euro 6	2015	0.63	-	0.195	0.105	0.005[e]
$\mathbf{N_1}$, Class III >1760 kg	Euro 4	2006	0.74	-	0.46	0.39	0.06
	Euro 5	2010[c]	0.74	-	0.350	0.280	0.005[e]
	Euro 6	2015	0.74	-	0.215	0.125	0.005[e]
Petrol (Gasoline)							
$\mathbf{N_1}$, Class I ≤1305 kg	Euro 4	2005	1.0	0.1	-	0.08	-
	Euro 5	2009[b]	1.0	0.10[f]	-	0.06	0.005[d,e]
	Euro 6	2014	1.0	0.10[f]	-	0.06	0.005[d,e]
$\mathbf{N_1}$, Class II 1305-1760 kg	Euro 4	2006	1.81	0.13	-	0.10	-
	Euro 5	2010[c]	1.81	0.13[g]	-	0.075	0.005[d,e]
	Euro 6	2015	1.81	0.13[g]	-	0.075	0.005[d,e]
$\mathbf{N_1}$, Class III >1760 kg	Euro 4	2006	2.27	0.16	-	0.11	-
	Euro 5	2010[c]	2.27	0.16[h]	-	0.082	0.005[d,e]
	Euro 6	2015	2.27	0.16[h]	-	0.082	0.005[d,e]

† For Euro 1/2 the Category N_1 reference mass classes were Class I ≤ 1250 kg, Class II 1250-1700 kg, Class III > 1700 kg.
a - until 1999.09.30 (after that date DI engines must meet the IDI limits)
b - 2011.01 for all models
c - 2012.01 for all models
d - applicable only to vehicles using DI engines
e - proposed to be changed to 0.003 g/km using the PMP measurement procedure
f - and NMHC = 0.068 g/km
g - and NMHC = 0.090 g/km
h - and NMHC = 0.108 g/km

See http://www.dieselnet.com/standards/eu/ld.html.

Heavy-duty vehicles

The European Union emission regulations for **heavy-duty vehicles** are also specified in Directive 70/220/EEC. In 2005, the regulations were re-cast and consolidated by Directive 2005/55/EC (agreed in co-decision) and Directive 2005/78/EC (implementing provisions).

The emission standards apply to all motor vehicles over 3,500 kg equipped with compression-ignition, positive-ignition natural gas or LPG engines. The current emission standard is Euro IV; the next stage, Euro V, will enter into force in October 2008 and will reduce the emission limits for NO_x from 3,5 to 2,0 g/kWh. Directive 2005/55/EC also laid down further technical requirements for the On-Board Diagnostics (OBD) system constantly monitoring emission limits and the proper functioning of the different car subsystems having an influence on emission limits.[17] The table below contains a summary of the emission standards and their implementation dates for diesel and heavy-duty gas engines that are tested on the Emission Test Cycle (ETC).[18]

Table 2: Euro norms IV-V

Emission Standards for Diesel and Gas Engines, ETC Test, g/kWh							
Tier	**Date**	**Test**	**CO**	**NMHC**	**CH_4[a]**	**NOx**	**PM[b]**
Euro IV	Since October 2005		4.0	0.55	1.1	3.5	0.03
Euro V	From October 2008		4.0	0.55	1.1	2.0	0.03

a - for natural gas engines only
b - not applicable for gas-fuelled engines at the year 2000 and 2005 stages

Source: http://www.dieselnet.com/standards/eu/hd.php

Reducing harmful emissions from trucks and buses is the objective of a draft package, which the European Commission intends to bring forward by the end of 2007. Before finalising this so-called “Euro VI” proposal, the Commission is now inviting stakeholders to comment on the future limit values, for emissions such as particulate matters or nitrogen oxides (NOx). The Commission proposal is intended to significantly contribute to a further improvement of air quality in Europe.[19] During this consultation process, the European Commission is asking for input about the different possible scenarios regarding fuel consumption and CO2 emissions.

2.3.2 Voluntary agreements with the automotive industry to lower CO_2 emissions from passenger cars

To control the emission of CO_2 from cars, the European Commission signed voluntary agreements with car associations representing about 90% of the total EU-produced or imported vehicle sales to reduce the emissions of carbon dioxide (CO_2). The agreements define fleet-average CO_2 emission targets from new cars. In its Communication “Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles”[20], the European Commission recognised that the voluntary

[17] see for further information: http://ec.europa.eu/enterprise/automotive/speeches_presentations/toulouse12092006_2.pdf (6 October 2007).

[18] http://www.dieselnet.com/standards/eu/ld.html, *op. cit.*

[19] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1100&format=HTML&aged=0&language=EN&guiLanguage=en (7 October 2007).

[20] COM(2007)19.

agreement did not succeed with regards to the attainment of its objectives. Thus the Commission proposed **mandatory targets** for CO_2 emissions from cars and light duty vehicles[21], after it became evident that it was not likely that the targets agreed to under the 10 year voluntary agreement on CO_2 emissions in 1998 would be met.[22]

While the White Paper 2001 envisaged the **extension of the voluntary agreement to utility vehicles**, these plans have not been taken up. In contrast to passenger cars, there are as for now no concrete legislative plans for CO_2 emissions from heavy duty commercial vehicles.

2.3.3 Discussions on Euro Norms for improved tyres

The Green Paper on Energy Efficiency[23] states that friction between tyres and ground surface can account for up to 20% of a vehicle's consumption. The Commission's Communication on "Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles" envisages setting maximum tyre rolling resistance limits in the EU for tyres fitted on passenger cars and light commercial vehicles.[24]

Properly performing tyres can reduce the rolling resistance by up to 5%, and sales of such tyres should be encouraged not only for new cars but also for replacements. Better pressure checks also lead to lower consumption. Estimates suggest that between 45 and 70% of vehicles are driven with at least one tyre below the prescribed pressure, which causes 4% over-consumption, not to mention the increased risk of accidents.

Neither the Transport White Paper 2001 nor the Midterm Review lay out exactly which norms of tyres they envisage.[25] The Green Paper on Energy Efficiency considered developing systems to encourage service stations to better inform and assist drivers with regards to tyre pressure checks. Another option would be to consider a voluntary agreement with industry to install tyre pressure sensors on the dashboard of cars. [26]

2.3.4 Biofuel Target

The European Union Biofuels Directive was adopted in May 2003. It aims to promote the use in transport of fuels made from biomass and other renewable fuels, and to reduce conventional emissions of CO_2, CO, NO_x, and VOC.

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[21] See also http://www.ec.europa.eu/environment/co2/co2_home.htm (7 October 2007).

[22] For further information please refer to: http://www.euractiv.com/de/verkehr/autos-co2/article-162421 (7 October 2007).

[23] Document COM(2005) 265 final of 22 June 2005.

[24] see COM(2007)19, http://www.ec.europa.eu/environment/co2/pdf/com_2007_19_en.pdf, p. 9.

[25] Document COM(2005) 265 final of 22 June 2005

[26] ibidem, p. 32.

The Biofuels Directive sets reference values of a 2% market share for biofuels to be attained by 31 December 2005, and a 5.75% share by 31 December 2010.[27] Many Member States are relying on fuel tax exemptions for the implementation of the Directive, which are facilitated by the Energy Taxation Directive. With the actual share in 2005 being 1.4%, the 2005 target share of 2% was not achieved by the Member States.

In order to promote the attainment of the targets laid out in the Biofuel Directive and to foster biofuels in general, the EU Commission issued in 2006 a Communication “A Strategy for Biofuels” (COM(2006)34) with three main aims:

- to further promote biofuels in the EU and developing countries, ensure that their production and use is globally positive for the environment, and ensure that they contribute to the objectives of the Lisbon Strategy taking into account competitiveness considerations,
- to prepare for the large-scale use of biofuels by improving their cost-competitiveness through the optimised cultivation of dedicated feedstocks, research into "second generation" biofuels, and support for market penetration by scaling up demonstration projects and removing non-technical barriers,
- to explore the opportunities for developing countries - including those affected by the reform of the EU sugar regime - for the production of biofuel feedstocks and biofuels, and to set out the role the EU could play in supporting the development of sustainable biofuel production.[28]

In March 2007 the EU heads of state adopted a target to raise the share of biofuels in transport fuels to 10% by 2020, subject to sustainability criteria and the availability of second-generation biofuels (EED 09/03/07).[29] The European Commission is currently drafting sustainability criteria to accompany the new biofuel proposal, scheduled for adoption in December (EED 24/04/07).[30]

A discussion of biofuel technologies follows in Chapter 3 where also the environmental advantages and drawbacks (“environmental impacts”) of these technologies are briefly discussed.

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[27] Market share to be calculated on the basis of energy content,of all petrol and diesel for transport purposes placed on their markets by 31 December 2005/2010.

[28] A good summary on the Biofuel Directive can be found under http://www.biomatnet.org/secure/Ec/S2031.htm

[29] See http://www.endseuropedaily.com/22792

[30] See http://www.endseuropedaily.com/23071

2.4 Other initiatives: Revision of the Directive 98/70/EC

The European Commission has recently proposed the revision of Directive 98/70/EC on Fuel Quality (COM(2007)18).

The revised Directive is intended to introduce an obligation for fuel suppliers to reduce the greenhouse gas emissions their fuels cause over their life-cycle, i.e. when they are refined, transported and used. From 2011 onwards, suppliers will have to reduce emissions per unit of energy by 1% a year (based on 2010 levels). This should result in a 10% cut by 2020. This obligation is intended to promote the further development of low-carbon fuels and other measures to reduce emissions from the fuel production chain, and will help ensure that the fuel sector contributes to achieving the EU's greenhouse gas reduction goals.

2.5 Policy Action concerning the different transport modes

The political actions outlined in the White Paper and the Midterm Review that target vehicle and fuel technology aim at road-based transports or – as with the biofuel target – at all transport modes employing diesel or petrol.

In the following chapters, current EU actions regarding vehicle and fuel technologies of inland water shipping, rail transport and air traffic will be explained.

Inland water shipping

As for **inland water shipping**, the Communication from the Commission on the Promotion of Inland Waterway Transport "NAIADES"[31] states "Standards for emissions *(from inland water shipping)* to air have to be refined in an ongoing process. These standards will significantly improve environmental performance of the inland navigation sector. First steps have been taken with the introduction of emission standards by the Central Commission for the Navigation on the Rhine (CCNR) and the European Union. Additional regulation by the Community may be required in order to reduce the sulphur content of gas oil[32]."

The emission standards covering diesel-fuelled inland waterway vessels ("Standard III A" emissions) are laid down currently in Directive 97/68/EC amended by 2004/26/EC.

A review of the standards is planned at the end of 2007, to consider some issues that have been highlighted, as further stages for reducing the emissions of inland waterway vessels. These issues include flexibilities, in-use-compliance, durability testing, preventing cycle beating, cycle by-pass at testing, and further exemptions.

The standard III A emission limits which are currently used for inland waterway vessels are outlined in the table below. Engines are divided into categories based on the displacement (swept volume) per cylinder and net power output. The engine categories and the standards are harmonized with the US standards for marine engines.

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[31] see Annex to this Communication, COM(2006)6, Nr. SEC(2006) 34/3 .

[32] The Proposal for the revision of Directive 98/70/EC, see 2.4, proposes that the maximum sulphur content in non-road gas-oil will be reduced from 1000ppm 300ppm for inland waterways.

Table 3: Stage III A Standards for Inland Waterway Vessels

Cat.	Displacement (D),	Date of coming into effect	CO	NOx+HC	PM
	unit: dm^3 per cylinder		g/kWh		
V1:1	D ≤ 0.9, P > 37 kW	Jan. 2007	5.0	7.5	0.40
V1:2	0.9 < D ≤ 1.2		5.0	7.2	0.30
V1:3	1.2 < D ≤ 2.5		5.0	7.2	0.20
V1:4	2.5 < D ≤ 5	Jan. 2009	5.0	7.2	0.20
V2:1	5 < D ≤ 15		5.0	7.8	0.27
V2:2	15 < D ≤ 20, P ≤ 3300 kW		5.0	8.7	0.50
V2:3	15 < D ≤ 20, P > 3300 kW		5.0	9.8	0.50
V2:4	20 < D ≤ 25		5.0	9.8	0.50
V2:5	25 < D ≤ 30		5.0	11.0	0.50

Source: Dieselnet, http://www.dieselnet.com/standards/eu/offroad.html

As a further action, the Communication on the Promotion of Inland Waterway Transport says that the Funding for R&D and demonstration projects regarding eco-efficient engines, hull design, propeller design etc. should be provided. Funds should also be made available for the introduction of catalytic converters, SJAC (Steamjet aerosol collector) and other filtering techniques. Bilge water and waste collection services as offered along the river Rhine should be made available throughout Europe. In order to create a level playing field, further harmonisation needs to be considered. [33]

Rail-based transport

European policy activities in the rail sector are at present mainly focused on promoting a shift from road-based transport to rail-based transport.

As for vehicle and fuel issues, Directive 97/68/EC, amended by Directive 2004/26/EC regulates emissions from railroad locomotive engines. It fixes emission limits, according to a timetable of implementation in two stages (Stage IIIA and IIIB).

Emission Standards of the Stage III A and III B standards have been adopted for engines above 130 kW used for the propulsion of railroad locomotives (categories R, RL, RH) and Rail Cars (RC).:

[33] See Annex to this Communication, COM(2006)6, Nr. SEC(2006) 34/3, p. 16.

Table 4: Stage III A Emissions Standards for Rail Trachtion Engines

Cat.	Net Power (P)	Date	CO	HC	HC+NOx	NOx	PM
	kW		g/kWh				
RC A	130 < P	Jan. 2006	3.5	-	4.0	-	0.2
RL A	130 ≤ P ≤ 560	Jan. 2007.	3.5	-	4.0	-	0.2
RH A	P > 560	Jan. 2009	3.5	0.5*	-	6.0*	0.2

HC = 0.4 g/kWh and NOx = 7.4 g/kWh for engines of P > 2000 kW and D > 5 liters/cylinder

Tabelle 5: Stage III B Emissions Standards for Rail Trachtion Engines

Cat.	Net Power	Date	CO	HC	HC+NOx	NOx	PM
	kW		g/kWh				
RC B	130 < P	Jan. 2012	3.5	0.19	-	2.0	0.025
R B	130 < P	Jan. 2012	3.5	-	4.0	-	0.025

Source: http://www.dieselnet.com/standards/eu/offroad.html

Furthermore, in addition to these emissions standards, in the fall of 2007 the European Commission, plans to adopt a Communication **on rail noise abatement measures** from railroads addressing the existing fleets.

Aviation

While the EU's total greenhouse gas emissions fell by 3 % from 1990 to 2002, emissions from international aviation increased by almost 70 %. The Commission estimates that even though there has been significant improvement in aircraft technology and operational efficiency this has not been enough to neutralise the effect of increased traffic, and the growth in emissions is likely to continue in the decades to come.[34]

As an emission abatement measure, the Commission presented plans to include aviation in the EU's cap-and-trade system for CO2 emissions.[35] The proposal provides for aviation to be brought into the EU Emission Trading System (ETS) in two steps. From the start of 2011, emissions from all domestic and international flights between EU airports would be covered. One year later, at the start of 2012, the scope would be expanded to cover emissions from all international flights – to or from anywhere in the world - that arrive at or depart from an EU airport. The intention is for the EU ETS to serve as a model for other countries considering

[34] http://ec.europa.eu/environment/climat/aviation_en.htm (7. October 2007).

[35] http://ec.europa.eu/transport/rail/environment/noise_en.htm (7 October 2007).

similar national or regional schemes, and to link these to the EU scheme over time. Therefore, the EU ETS can form the basis for wider, global action.[36]

2.6 Conclusions

The following conclusions can be drawn from this chapter:

- While there exists extensive legislative material as well as a number of strategy papers targeted at vehicle and fuel technology for nearly all transport modes, a number of these do not distinguish between freight and passenger transport;
- Voluntary agreements as the only measure for emission abatement from transport have been diagnosed by the EU Commission to be insufficient in the case of passenger cars and might thus not be adopted for freight vehicles;
- Command and control measures (such as the Euro Norms) push the transport industry to adapt their transport technology to new environmental standards, thereby employing environmental technologies. Even so, European legislation might not motivate companies to use the best available transport technology, which is why other measures than command-and-control need to be included in a policy package promoting the take-up of environmental transport technologies;
- The Command and control measures leave in most cases considerable transition periods to the transport companies to adapt their technology to the new standards, which gives the latter the time to ponder the optimal use of environmental technologies;
- The European Commission evaluates its policies on a regular basis and, based on this evaluation, updates their political agenda.

[36] http://ec.europa.eu/environment/climat/aviation_en.htm /7 October 2007).

3 Currently Available Environmental Technologies

3.1 Introduction

Environmental Technologies are concisely but broadly described in the Environmental Technologies Action Plan[37] as "all technologies whose use is less environmentally harmful than relevant alternatives", in turn drawing upon the description in Chapter 34 of Agenda 21.

Transport is inherently a linking activity, requiring an infrastructure i.e. harbours, airports, roads, railways, hence the ensuing technologies can range from simple to very complex, involving a combination of technologies and actors. At the simplest level, driver training can achieve "eco-driving". Avoiding empty running for freight or public transport vehicles on return journeys improves vehicle utilisation. Both can be achieved without the support of technology, but information technology can assist these measures. "End of pipe" devices may be used to treat air emissions or noise, without fundamentally altering their creation. More complex technologies may require the development of efficient hydrogen fuel cells, the installation of a hydrogen distribution network and hydrogen manufacturing industry. Intermodal shifts or reconfiguring production and distribution systems are even more radical options, requiring modification to the basic system or business structure. Sustainability requires the satisfaction of economic, social and environmental needs – a difficult balance with a long-term perspective.

This chapter outlines applicable technologies, broadly divided into three categories: vehicles, alternative fuels, and logistics, though overlaps occur. Vehicles and alternative fuels are the primary focus since logistics will be the focus of a later workshop. Noise is an environmental issue, but more attention has been paid to concerns about fuel consumption and the associated emissions. There is greater emphasis on road transport, to reflect existing patterns of freight distribution in Europe, with consideration also given to rail, sea and air movement.

3.2 Vehicles

A vehicle typically converts chemical energy into mechanical energy via an "engine", and then converts this energy into motion to overcome resistance. Petrol (gasoline) – fuelled spark ignition engines are common for small vehicles, e.g. passenger cars. Diesel (kerosene) – fuelled compression ignition engines are also used for small vehicles and are standard for larger vehicles.

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[37] EC, 2004, Stimulating Technologies for Sustainable Development: An Environmental Technologies Action Plan for the European Union, COM(2004) 38 final.

3.2.1 Vehicles – road

Road freight vehicles may be categorised by weight: light, medium and heavy weight vehicles, or by usage: urban, rural or highway traffic. Compression ignition diesel engines are favoured for all but the smallest freight vehicles. Long-haul vehicles have the advantages of being operated at a constant speed, with limited stopping and braking, for sustained periods, allowing the use of optimised systems. The desire for reliability, cost-effective fuel efficiency and conformity with emission regulations has led to significant improvements based on environmental technologies. “Eco-driving” (driver training to avoid excessive fuel consumption) is a low-technology environmental protection measure that may be easily applied, but most technologies in use or under consideration require greater investment.

Table 1 Technologies for diesel road vehicles

Engine management systems	Better fuel injection (common rail), improved ignition, reduced idling time, lean burn, variable valve timing, etc.[38]
Homogeneous Charge Compression Ignition (HCCI)	This is a developing hybrid between conventional compression ignition diesel engines and spark ignition Otto gasoline engines. The fuel-air mixture is premixed and then compressed to auto-ignition. Control of this process in road operating conditions is a key requirement.
Improved transmission systems	Multiple gears, adjusted to different driving conditions
Reduced resistance	Aerodynamic styling can reduce drag, improving fuel efficiency[39]. Tyre specifications can be matched with driving conditions to provide low rolling resistance. These technologies may be applied to both new and existing vehicles.
NOx reduction at source	Exhaust Gas Recirculation (EGR) returns some of the exhaust to the engine to reduce the combustion temperature and thereby reduce the production of NOx.
Emission after-treatment	Selective catalytic reduction (SCR) employs the addition of urea and water into the exhaust to form ammonia, reducing the NOx to nitrogen and water via a catalyst. Particulate filters capture the small emission particles emitted by a diesel

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[38] Joint Research Centre - Institute for Prospective Technological Studies, 2003, Trends in vehicle and fuel

technologies - Overview of current research activities, IPTS Technical Report Series, EUR 20747, May 2003, Joint Research Centre.

[39] Aerodynamics for Efficient Road Freight Operations, 2007, Freight Best Practice, UK Dept for Transport, downloaded from http://www.freightbestpractice.org.uk/default.aspx?appid=1960&cid=38 on 6 Sept 07.

	engine and may be regenerated. These technologies may be applied to both new and existing vehicles.

Engines fuelled by natural gas or biogas are cleaner and quieter than current diesel engines and may be preferred in urban environments. However, electric motors are the primary category of alternative drivetrain currently under development. While battery powered vehicles were historically very common, their current use is confined to golf buggies, and areas where either exhaust emissions or noise are not tolerated. Modern batteries, i.e. NiMH and Li-ion, have much higher energy densities than older lead or NiCd ones. This reduces the weight required to be carried. Nevertheless, battery powered systems are currently most suited to smaller vehicles, particularly in urban settings.

Hybrid vehicles combine both a combustion engine and one or more electric motors. Hybrid vehicles are suitable where driving conditions have a significant proportion of stop-go operation, short distance runs or routes prone to congested traffic, and are suited to local delivery vans, urban buses, etc. They are reported to lead to 20 – 30% reduction in energy consumption and associated emissions[40]. The electricity may be generated elsewhere and stored in a battery ("plug-in"), generated by recovering ("regenerating") energy from the braking system or obtained from a chemical source in an on-board fuel cell.

Table 2 Combustion engine / electric motor hybrids

"Regenerative charging"	Energy losses from braking can amount to 46% of tractive losses and regenerative systems use some of this for battery charging[41].
"Plug-in"	"Plug-in" hybrid electric vehicles (PHEVs) that are charged from the grid are claimed to have significant environmental benefits[42]. These may be operated on battery only until the battery becomes depleted, possibly 50 – 100km, with a following switch-over to conventional combustion engine.

The addition of a fuel cell is seen as part of the innovation pathway to a hydrogen-based economy[43] though there are contrasting views.[44] The auxiliary electrical power requirements

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[40] Van Mierlo, J., et al, 2006, Which energy source for road transport in the future? A comparison of battery, hybrid and fuel cell vehicles, Energy Conversion and Management 47, 2748–2760.

[41] Joint Research Centre - Institute for Prospective Technological Studies, 2005, Hybrids for road transport

Status and prospects of hybrid technology and the regeneration of energy in road vehicles, IPTS Technical Report Series, EUR 21743, 2005, Joint Research Centre.

[42] Bradley, T.H., & Frank, A.A., 2007, Design, demonstrations and sustainability impact assessments for plug-in hybrid electric vehicles. Renew Sustain Energy Rev, doi:10.1016/j.rser.2007.05.003 article in press

[43] Suppes, G.J., 2006, Roles of plug-in hybrid electric vehicles in the transition to the hydrogen economy, International Journal of Hydrogen Energy 31, 353 – 360.

on vehicles, e.g. climate control, cooling fans, may be provided or supplemented by fuel cells or capacitor/battery charging by regenerative braking systems. Manufacturers (such as Volvo[45], Iveco[46], MercedesBenz[47], DAF[48] and Scania[49] are implementing many of these improvements. However, considerable challenges remain in developing batteries and fuel-cells that will satisfy commercial requirements.[50]

3.2.2 Vehicles – rail

A high proportion of European railways are electrified, with the majority of the remainder operating diesel-electric locomotives. In these latter vehicles, diesel engines operate at constant optimum speeds, generating electricity which in turn operates motors that drive the train. The operation of the diesel engine is analogous to long-distance road vehicles, with the benefit of potentially longer hauls and more consistent operating conditions. On average, diesel traction accounts for 20% of European railway operations. In the Baltic States, Ireland and Greece, there is almost no electrified track, and diesel traction is the backbone of rail traffic. This is in contrast to countries such as Germany and France where diesel traction is typically used for feeder traffic on sparsely used lines. In a fully electrified country like Switzerland or Sweden, diesel traction is only rarely used for some maintenance and shunting operations.

Improved energy efficiency can be achieved by measures applied to train motion and traction efficiency[51]:

- Mass reduction (lightweight composite materials);
- Reducing air resistance and friction (aerodynamic styling);
- Reducing conversion losses (increasing traction efficiency);
- Regenerative braking and energy storage (fly wheels);
- Energy efficient driving (eco-driving).

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[44] Romm, J., 2006, The car and fuel of the future, Energy Policy 34, 2609–2614.

[45] VOLVO, Powerful ways to the future, 2006.

[46] Iveco, Respect for the environment is the road ahead, 2004.

[47] Mercedesbenz, More miles, less fuel: how to boost fuel economy, 2006.

[48] DAF, DAF and the environment.

[49] Scania, Technological breakthrough for Scania: Euro 5 without after-treatment or fuel penalty, P07901EN, 2007

[50] Chalk, S.G., & Miller, J.F., 2006, Key challenges and recent progress in batteries, fuel cells,

and hydrogen storage for clean energy systems, Journal of Power Sources 159, 73–80.

[51] H. Schwarz et al., 2003, Environmental Guide for the Procurement of new Rolling Stock, UIC PROSPER Project.

NO_x and PM10 emissions from some individual diesel locomotives can be high, and as yet, exhaust after-treatment equipment is not commonly applied to railway vehicles. Only a limited number of technical options can be applied to older locomotives to reduce emissions. Open channel Diesel Particulate Filters (DPFs) or engine replacement (assuming that suitable engines are available) were found to be the best options. Other available **exhaust after-treatment technologies** are Selective Catalytic Reduction (SCR) technology and combined SCR + DPF technology. Currently, there is very little experience of using exhaust after-treatment options on rail vehicles. It is not clear whether such equipment can, in practice, be widely used on traction units. Potential limitations include a lack of available space on existing rail vehicles to fit emissions abatement equipment, and the possibility that such equipment may lead to maximum axle loads being exceeded. Furthermore, some DPF equipment may cause excessive exhaust back-pressure when fitted to rail traction units, and it is not always possible to retrofit older traction units with new engines due to the need to significantly modify off-engine support systems.[52]

3.2.3 Vehicles – sea

Shipping is a highly carbon-efficient transport mode, i.e. carbon dioxide emissions are low, relative to the weight of cargo transported. However, air emissions, in particular sulphur dioxide (SO_2) and nitrogen oxides (NO_x), from ships has been unregulated until recently. As a result, fuel oils with high sulphur content are widely used and emission control technologies are not required. Ships currently produce about half as much sulphur dioxide as land-based sources and about a third as much nitrogen oxides[53].

The major marine engine manufacturers have acknowledged that the technology exists to achieve significant emission reductions from marine vessels, but there needs to be some form of motivation to create more of an interest from the maritime shipping industry in implementing these technologies on their vessels[54].

Technologies similar to those applicable to land-based diesel engines are available for a reduction of NO_X and SO_X in the exhaust gases. These methods aim to either optimise combustion, improve air charge characteristics or alter the fuel injection system[55]. However, in addition to the positive cleaning potential of these technologies they may suffer disadvantages e.g. an increase in fuel consumption or high costs of implementation.

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[52] S. Kollamthodi, 2006, Rail Diesel Study, AEA for UIC.

[53] J. Wahlström, N. Karvosenoja and P. Porvari, 2006. Ship emissions and technical emission reduction potential in the Northern Baltic Sea, Reports of Finnish Environment Institute, 8/2006.

[54] Fournier, A., 2006. Controlling Air Emissions from Marine Vessels: Problems and Opportunities, Donald Bren School of Environmental Science and Management, University of California Santa Barbara

[55] Entec UK Limited, A. Ritchie, E. de Jonge, C. Hugi and D. Cooper, 2005. Service Contract on Ship Emissions Assignment, Abatement and Market-based Instruments: European Commission Directorate General Environment.

NO_X reduction technologies include:

- selective catalytic reduction (SCR);
- water-based technologies, e.g. humid air motors (fumigation), direct water injection, water-oil emulsion;
- exhaust gas recirculation (EGR);
- minor engine modifications, e.g. slide valves, and
- internal engine modifications (IEM), e.g. higher compression ratio, common rail injection, injection rate shaping, time of injection etc.

SO_2 reduction requires either:

- switching fuels to those with a lower sulphur content;
- using scrubber technology (washing exhausts with e.g. sea water – which may transfer the emissions to water).

Liquefied natural gas (LNG) is transported globally, and the boil-off from the storage may be used as fuel. The Finnish company Wärtsilä has developed dual-fuel engines with electric propulsion for LNG carriers[56]. The engines may run in liquid-fuelled diesel mode or in gas mode with supplementary diesel. In the latter case, the engine runs as a lean-burn Otto engine with gas as the primary fuel but with diesel as a pilot fuel. The main focus in improving the vessels' propulsion efficiency is through the use of speed-adapted propellers, high efficiency nozzles and a new hub for controllable pitch propellers.

3.2.4 Vehicles - air

Conventional turbofan aircraft are believed to offer limited potential for improvement, but high speed propeller aircraft could achieve a 56% cut in carbon-dioxide emissions per passenger kilometre, with a 25% reduction in cruise speed.[57] Boeing suggest that improved aerodynamic shape, increased use of composite materials and new engine designs still have potential for improvement.[58] The addition of small fins ("winglets") to the end of aircraft wings reduces drag and has the additional benefit of reducing turbulence for following aircraft, which may allow closer take-off and landings.[59] The specific fuel consumption can be improved by increasing the engine by-pass and overall pressure ratios and major

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[56] Wärtsilä, 2002, The DF electric LNG carrier concept, Wärtsilä, downloaded from www.wartsila.com on 5 Oct 07.

[57] Ackerman, J., 2005. Sustainable air transport – on track in 2050. Transportation Research Part D – Transport and Environment 10, 111–126.

[58] Yu, J., 2007, Presentation to 32nd Annual FAA Forecast Conference, Washington, March 15-16, 2007, downloaded from http://www.faa.gov/news/conferences_events/aviation_forecast_2007/breakouts/ on 11 Sep. 07.

[59] ETAP Newsletter, 2007, A new device to make planes more efficient, May 2007.

improvements are theoretically feasible using intercooled / regenerative engine cycles, but in all cases, limits may be imposed by materials and weight and drag increases.[60]

3.3 Alternative Fuels

The primary transport fuels in use today are petrol (gasoline) and diesel (kerosene), both of which are fossil based and finite. Though many alternatives exist, there are also many barriers to their adoption[61],[62]. Alternatives range from existing available fuels: liquefied petroleum gas (LPG) and compressed natural gas (CNG); liquid or gas fuels derived from other fossil sources e.g. shale oils, tar sands, coal, methane hydrates [63]; fuels derived from biomass deliberately grown (agricultural / renewable) or recovered as waste, e.g. bio-methanol, bio-ethanol, bio-diesel, dimethylether (DME), bio-gas and hydrogen; and blends of the forementioned.

3.3.1 "1st generation" biofuels.

Most current biofuel processes rely on just the sugar, starch, or oilseed parts of a few types of crops and rely on fossil energy to convert these to biofuels. As a result, these processes provide "well-to-wheels" greenhouse gas reductions on the order of 20% to 50% compared with petroleum fuels. These processes are well developed, but may rely on fiscal support measures to become competitive with fossil fuel alternatives. Compared to petroleum, the use of biofuels for transport is still quite low in nearly every country[64] and, as has been commented in an earlier chapter, is an EU target for increased usage.

Table 3 Production of 1st generation biofuels

Biofuel	Comment
Biodiesel	Oils and fats may be chemically reacted (via transesterification) into fatty-acid methyl ester (FAME), commonly known as **biodiesel.** Most commercial production of biodiesel is based on vegetable oils such as those obtained from

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[60] Tilston, J., et al, CYPRESS Future Engine Cycle Prediction and Emissions Study, Contract G4RD-CT-2000-00383, EU Competitive and Sustainable Growth Programme (1998-2002).

[61] Steenberghen, T., & Lopez, E., 2007, Overcoming barriers to the implementation of alternative fuels for road transport in Europe, Journal of Cleaner Production, in press, oi:10.1016/j.jclepro.2006.12.001

[62] Joint Research Centre - Institute for Prospective Technological Studies, 2004, The introduction of alternative fuels in the European transport sector: Techno-economic barriers and perspectives , IPTS Technical Report Series, EUR 21173, May 2004, Joint Research Centre.

[63] Joint Research Centre - Institute for Prospective Technological Studies, 2005, Prospective Analysis of the Potential Non Conventional World Oil Supply: Tar Sands, Oil Shales and Non Conventional Liquid Fuels from Coal and Gas, IPTS Technical Report Series, EUR 21178, Dec 2005, Joint Research Centre.

[64] International Energy Agency (IE), 2004, Biofuels for transport, IEA-OECD.

	oil palm, rapeseed, sunflower seed, and soybean, but some is made from waste material: tallow, used frying oil and even fish oil. Finding commercial outlets for the process by-products is important to achieve cost efficiency.
Bioethanol (sugar crops)	Ethyl alcohol, or **ethanol**, can be produced (via traditional fermentation) from any feedstock that contains relatively dense quantities of sugar or starchy crops. The most common feedstocks are sugarcane, sugar beet, maize (corn), wheat and other starchy cereals such as barley, sorghum and rye. Fermentation produces relatively low concentration ethanol and improved and cost-effective routes to bioethanol are the subject of considerable research [65], [66].

3.3.2 "2nd generation biofuels"

New processes under development can convert much more of the plant – including much of the "green", cellulosic parts – to biofuels with very low, possibly zero, net greenhouse gas emissions[58]. Large scale demonstrations have been achieved but further research and development is required to achieve commercialisation.

Table 4 Production of 2nd generation biofuels

Biofuel	Comment
Lignocellulosic feedstock via hydrolysis and fermentation to ethanol	Forestry products and the entire plant mass is converted via a series of (bio)chemical processes to ethanol. Improved process efficiency is still sought.
Biomass feedstock via gasification and the Fischer-Tropsch (F-T) process to "synthetic diesel"	Gasification converts biomass into a mixture of carbon monoxide and hydrogen, called synthesis gas, which in turn is used to produce liquid fuels.
Biomass feedstock via gasification followed by chemical reaction to methanol or dimethylether (DME)	The initial gasification step again produces synthesis gas, which is then chemically reacted to methanol, which may, in turn, be chemically dehydrated to dimethylether.

Biofuels bring potential benefits, but also costs[58]:

[65] Cardona, C.A., & Sanchez, O.J., 2007, Fuel ethanol production: Process design trends and integration opportunities, Bioresource Technology 98, 2415–2457

[66] Hahn-Hagerdal, B., et al, 2006, Bio-ethanol – the fuel of tomorrow from the residues of today, TRENDS in Biotechnology Vol.24 No.12

Table 5 Potential benefits and costs of biofuels

Potential benefits	Potential costs
• Energy security • Balance of trade • Lower GHG emissions • Reduced air pollution emissions • Vehicle performance • Agricultural sector income, jobs and community development • Waste reduction	• Higher fuel costs • Increases in some air emissions • Higher crop (and crop product) prices • Other environmental impacts, such as land use change and loss of habitat

A wide, sustainability oriented, perspective must be taken. Biofuels are claimed to reduce emissions and provide a new income stream for farmers, but at the same time critics assert "*that biofuels will increase energy-price volatility, food prices and even life-cycle emissions of greenhouse gases*" and cause damage to biodiversity. When negative impacts are taken into account, "*the overall environmental impacts of ethanol and biodiesel can very easily exceed those of petrol and mineral diesel*"[67]. However, there is a contrary viewpoint in assessing the impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets which holds that "*the additional land use requirements would not overly draw on the land resources of the EU-27*"[68]. A recent study suggests that afforestation rather than growing and using bio-fuels would bring greater climate change benefits[69]. Clearly the topic is still open to debate.

3.3.3 Alternative fossil-fuels

In contrast to the use of liquid fuels, **natural gas** (methane) is used in Europe as vehicle fuel to a limited extent. The European Commission has set a target that natural gas will have 10% of the energy consumption in the transport sector in 2020. To reach that goal a large number (approx. 27-28 million) of vehicles need to be in use, requiring a development of a large natural gas vehicle market. The technical standards for vehicles and fuel infrastructure are rather developed, but an extensive refuelling network is needed. The use of LNG

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[67] Doornbosch, R., & Steenblik, R., 2007, Biofuels: is the cure worse than the disease? Round Table on Sustainable Development, SG/SD/RT(2007)3, OECD.

[68] EU Commission, 2007, Impact assessment of the Renewable Energy Roadmap - March 2007, The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets, File note AGRI G-2/WM D(2007)

69 Righelato, R., & Spracklen, D., 2007, Carbon Mitigation by Biofuels or by Saving and Restoring Forests? Science, 317, 902, 17 August 2007.

(Liquefied Natural Gas) seems to be more competitive in terms of cost than CNG (Compressed Natural Gas) transported via pipelines over long distances.

3.3.4 Hydrogen

Hydrogen gas seems to be the energy carrier for the future, creating the so-called "Hydrogen-Economy". The use of hydrogen can significantly reduce greenhouse gas emissions and the use of fossil fuels. But there are technical barriers, e.g. sustainable hydrogen production, distribution, storage and utilisation (via fuel cells). Political factors as well as technical development will have an important role if the Hydrogen-economy is to be realised. There have been successful tests with hydrogen vehicles in Iceland for example (www.ectos.is). Research has shown that focusing on climate change policy, renewable energy sources, nuclear energy and coal/natural gas pathways to hydrogen production with carbon-dioxide sequestration have the lowest carbon-dioxide emissions over the entire fuel chain. However, there are several ways of producing hydrogen and driven by the interest of governments and public foundations, electrolysis is the most publicly researched hydrogen production technology (which is also one of the most cost effective methods). Overall, it has been argued that "the potential benefit of hydrogen for transport applications is high, but the necessary investment in order to be able to reap those benefits is also considerable"[70] and there are also cautionary viewpoints. [71],[72],[73].

3.3.5 "Well to wheels" approach

In principle any type of biomass could be used as feedstock for the gasification – Fischer-Tropsch process including fossil feedstocks such as coal or natural gas. These are currently more cost effective, but the disadvantage is, of course, the fossil fuel production base. "Alternative fuels" are not, by definition, more environmentally friendly than traditional ones. The main difference is that bio-based alternative fuels reduce the emissions of green house gases. Producing alternative fuels from non-biological sources without carbon capture and storage may nearly double the carbon dioxide burden. Avoiding scarcity is not the same as addressing climate change. Therefore in assessing the relative merits of alternative fuels, it is important to take a "life-cycle" or "well to wheels" or "energy balance" approach, one that

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[70] Altman, M., et al, 2004, Potential for Hydrogen as a Fuel for Transport in the Long Term (2020-2030), Institute for Prospective Technological Studies, IPTS, EUR 21089 EN, Joint Research Centre.

[71] Hammerschlag, R., & Mazza, P., 2005, Questioning hydrogen, Energy Policy 33, 2039–2043.

[72] Ramesohl, S., & Merton, F., 2006, Energy system aspects of hydrogen as an alternative fuel in transport, Energy Policy 34, 1251–1259.

[73] Svennson, A-M., et al, 2007, Well-to-wheel study of passenger vehicles in the Norwegian energy system, Energy 32, 437–445

is not confined to efficiency or emissions at the point of use, but considers also the extraction or manufacture and distribution phases and the other environmental impacts [74],[75].

3.3.6 Application of alternative fuels to road and rail transport

Ethanol can be used in pure form as motor fuel or as a blending component in gasoline (as ethanol or after being converted to ethyl-tertiary-butyl-ether, ETBE).

Biodiesel may be used at varying concentrations in compression ignition engines. There have been concerns about materials compatibility, reduced power and increased fuel consumption, associated with variations in fuel quality and required engine adjustments, but these have been largely addressed. Biodiesel use has also been suggested for rail vehicles as a mechanism to improve “green” credentials and promote modal shift. The use of 2nd generation biofuels is suggested to bring improved specification and possibly better performance than fossil fuels[76]. The main environmental benefits from synthetic diesel are that there is little or no sulphur content, and low NOx, hydrocarbon and particulate emissions but the production costs are much higher, depending on the product and the production route.

Biofuels have the potential to leapfrog traditional barriers to entry because they are liquid fuels compatible with current vehicles and blendable with current fuels. They share the long-established distribution infrastructure with little modification of equipment. In fact, low-percentage ethanol blends, such as E10 (10% ethanol by volume), are already dispensed in many service stations worldwide, with almost no incompatibility with materials and equipment. Biodiesel is currently blended with conventional diesel fuel in many OECD countries, ranging from 5% in France to 20% in the US, and is used as a neat fuel (100% biodiesel) in some trucks in Germany (IEA, Biofuels for Transport, 2004).

Several notable innovations are being piloted in the rail sector:

- Japan Rail East has introduced a hybrid diesel electric train. The electric motor is powered by a lithium – ion battery, which is charged either by intermittent running of the diesel or by regenerative braking. A hydrogen powered fuel cell has also been piloted;
- General Electric in the US has manufactured hybrid diesel – electric locomotives using regenerative braking;

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[74] Joint Research Centre, 2007, Well-to-Wheels analysis of future automotive fuels and powertrains in the European context, WELL-to-WHEELS Report Version 2c, March 2007, Joint Research Centre, CONCAWE, EUCAR.

[75] Holden, E, & Hoyer, K.G., 2005, The ecological footprinting of fuels, Transportation Research Part D 10, 395–403

[76] Skinner, S. Kollamthodi, N. Hill and J. Mayhew, 2007, Railways and Biofuels, ATOC in Association with AEA.

- The EU project, HyRAIL, is examining the state of the art of hydrogen fuel cells applied to rail, and “The Hydrogen Train” is a European consortium aiming to launch Europe’s first hydrogen train by 2010;
- Natural gas powered trains have been used in Germany for shunting operations and also in Russia.

3.3.7 Application of alternative fuels to air and sea transport

Marine and air transport of freight present different challenges compared to land-based operations. Sea transport may present an efficient mode in terms of greenhouse gas emissions, but it should be recognised that it is the only mode that uses residual fuel, a by-product or lower grade fuel from the distillation of crude oil. Changing from this fuel (which is generally much cheaper) to another fuel will result in greater changes in the emission profile than would be the case with land-based operations.[77] Emissions of NOx and SOx from sea transport are either deposited in the oceans, or transported by wind to land where they are deposited. Therefore any increase in shipping, whether due to inter-modal shift or increase in trade, will bring an increase of these latter emissions in the future, unless preventive measures are taken. Consequently, emission after-treatment and improved engine combustion management are important unless there is a shift to cleaner fuels.

The alternative fuels mostly discussed in the air sector are **synthetic diesel, biodiesel (“biojet”) and hydrogen**. There is significant work underway involving both civil (Commercial Aviation Alternative Fuels Initiative CAAFI, International Civil Aviation Organization - Committee On Aviation Environmental Protection ICAO-CAEP, Partnership for AiR Transportation Noise and Emissions Reduction PARTNER, Environmental Compatible Air Transport System ECATS) and military[78] aviation to investigate alternative fuels. The most probable scenario is that aircraft will be driven using synthetic kerosene, manufactured via a Fischer-Tropsch process, possibly mixed at high concentration (50/50) with fossil fuel kerosene, or a low concentration mix of biodiesel and kerosene. Successful trials have been achieved with the synthetic – fossil kerosene blend. The mixture is clean burning with lower particulate emissions, high thermal stability and good low-temperature properties, but with reduced lubrication properties, lower volumetric heat content and issues with rubber seal compatibility.[79]

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[77] Winebrake, J. J., et al 2007, Energy Use and Emissions from Marine Vessels: A Total Fuel

Life Cycle Approach, J. Air & Waste Manage. Assoc. 57:102–110.

[78] Phillips, D., 2007, Military looks at synthetic fuel for bombers and fighters, International Herald Tribune, 17 June 2007.

[79] Daggett, D.L., 2007, Alternate fuels for use in commercial aircraft, Boeing, 2007, downloaded from www.boeing.com/commercial/environment/ on 10 Sept 2007.

Bio diesel is seen to be one of the possible substitutes to jet fuels but must be used as a low percentage mix. One big problem is that conventional biodiesel becomes jelly-like in the low temperatures experienced at high altitudes. These problems have solutions, but these physical attributes make many doubt the adoption of bio diesel in the air sector.

Hydrogen has also been suggested as a jet fuel, but while it has a good energy mass intensity, it has a poor energy volumetric intensity, leading to a need for large, cryogenic, fuel tanks. These tanks could not be accommodated inside conventional wing structures. Weight and drag would be increased. In addition to concerns about producing the hydrogen in an environmentally friendly way, the water vapour produced by combustion of hydrogen is a strong contributor to the greenhouse effect when released at high altitude, though this is somewhat offset by the avoidance of carbon dioxide emissions from kerosene[80]. NOx produced by aircraft in the upper troposphere and lower stratosphere are more significant contributors to climate change than those emitted at ground level[81] and the science of aviation emissions is an area of considerable study.

3.4 Logistics: routing & vehicles

The focus of this workshop is environmental technologies applicable to vehicles and fuels, with logistics being considered in the second workshop. However, vehicles and fuels do not operate in a vacuum, rather they operate in the context of their purpose: the transport of freight as part of a logistics system. Therefore some discussion is provided to introduce the issues of logistics and vehicles.

Information technology can be used to match loads, routes and vehicles to schedule deliveries prior to dispatch. Real time positioning of vehicles via telematics can take account of congestion, revisions to required delivery routes and match partially empty vehicles with new demands en route[82],[83]. “Backloading” involves a vehicle being used to carry goods on

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[80] CRYOPLANE, 2003, Liquid Hydrogen Fuelled Aircraft – System Analysis, Contract G4RD-CT-2000-00192, EU Competitive and Sustainable Growth Programme (1998-2002), downloaded from http://www.aero-net.org/ on 12 Sept 2007.

[81] Wuebbles, D. (Ed), 2006, Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and

Recommendations, June 7-9, 2006, Cambridge, MA, REPORT N0. PARTNER-COE-2006-004, Partnership for AiR Transportation Noise and Emissions Reduction

[82] Telematics benefiting from technology, Energy Saving Trust, UK Dept for Transport, downloaded from
http://www.energysavingtrust.org.uk/fleet/organisations/efficientdriving/getthebestfromyourvehicle/telematics/ 31 August 2007

[83] Computerised Computerised Vehicle Routing and Scheduling (CVRS) for Efficient Logistics, Freight Best Practice, UK Dept for Transport, downloaded from http://www.freightbestpractice.org.uk/default.aspx?appid=1960&cid=38, 31 Aug. 07

its return journey. Along with the sharing of vehicles by suppliers, this load matching can improve vehicle utilisation. Changes in the management practices of deliveries, e.g. nominated day deliveries, evening or night-time deliveries and alterations to city logistics, e.g. consolidation of shipments to the periphery of cities with fewer delivery runs to the centre, can also bring environmental and economic benefits, though to the possible detriment of social conditions[84]. A further complication is that minimising distance travelled may not equate with minimising fuel consumption, due to more demanding gradients or road congestion[85]. Finally, taking Germany as an example, a survey[86] found that advanced IT initiatives were self-financing with a rate of return of 40 – 75%, yet were poorly implemented. This was attributed to “poor public information regarding such things as cost - revenue ratios” and “limited recognition of energy and performance inefficiency inside the logistics companies themselves”.

An analogy for air traffic to this approach is an improvement to air traffic control to reduce holding and to optimise flight paths[87], and freight may be carried in spare passenger flight capacity. Continuous descent arrival (CDA) at airports, a new operating practice, also reduces noise, emissions and fuel consumption. The recent development of small long-haul aircraft suggest that hub-bypass (point to point) travel may be more environmentally efficient than the common hub-to-hub model[88].

Increasing the permitted weight loading on vehicles with six axles and appropriate suspension has consolidated loads with economic and environmental benefits[89]. In addition to loading limits imposed by weight, loading may be restricted by area or volume of the cargo carrying area. Space efficiency may be improved by the use of raised roofs or lowered floors to achieve a “double-decking”, or modification of transit packaging, e.g. use of “slip-trays” rather than pallets or several standard packages rather than a single package. Modified handling equipment may be necessary to achieve this. Compartmented cargo space may also improve load efficiency[78].

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[84] McKinnon, A., 2003, Logistics and the Environment, in Hensher, D.A. & Button, K.J., (Eds.), Handbook of Transport and the Environment, Elsevier.

[85] McKinnon, A., 1999, A logistical perspective on the fuel efficiency of road freight transport, Report presented to the workshop on “Improving fuel efficiency in road freight: the role of information technologies” organised by the International Energy Agency and European Conference of Ministers of Transport , Paris, 24th February 1999.

[86] Léonardi, J., & Baumgartnert, M., 2004, CO_2 efficiency in road freight transportation: Status quo, measures and potential, Transportation Research Part D 9, 451–464.

[87] Somerville, H., 2003, Transport Energy and Emissions: Aviation, in Hensher, D.A. & Button, K.J., (Eds.), Handbook of Transport and the Environment, Elsevier.

[88] Morrell, P., & Lu, C., 2007, The environmental cost implication of hub–hub versus hub by-pass flight networks, Transportation Research Part D 12 , 143–157

[89] McKinnon, A., 2005, The economic and environmental benefits of increasing maximum truck weight: the British experience, Transportation Research Part D 10, 77–95.

3.5 Conclusions

It is necessary to assess all aspects of sustainability: environmental, economic and social and to adopt a life-cycle approach, “well to wheels”, to consider the many impacts of any change. A narrow focus may lead to a sub-optimal conclusion and neglect changes that might be more radical, but have greater lasting benefit. The roadmap to the future of the transport sector is unclear and contentious. The projected growth in the sector demands substantial change, potentially radical and awaiting the adoption of a “disruptive” technology.

3.6 Key-points

- The technology mix applicable to long haul road transport is different to urban operations:
    - Hybrid electric vehicles have more potential in an urban setting,
    - fuel cells or energy recuperative systems are beneficial in supplying the auxiliary equipment of long-haul vehicles.
- Engine technology improvements have been driven by regulation and desired fuel economy:
    - Road vehicle technology improvements have been achieved by a combination of actors: vehicle, engine and fuel injection designers,
    - Regulation has focused on road transport because of its “visibility” – so regulation of sea and air transport has lagged behind.
- A total energy balance or “well to wheels” assessment is needed to determine the advantages or disadvantages of an alternative fuel:
    - The air emission profile may be altered by the use of alternative fuels, with some emissions better, some worse,
    - “drop-in” fuels are preferred, i.e. using the existing fuel distribution infrastructure and requiring little or no engine modification,
    - flexi-fuel vehicles are preferred to allow for inadequacies in a fuel distribution infrastructure,
    - the merits of first-generation biofuels are still debated, but biofuels derived from waste are beneficial,
    - second-generation biofuels will be more carbon efficient.
- A hydrogen fuelled transport system will require massive investment in infrastructure.
- Sustainability i.e. social and economic as well as environmental, criteria must be applied to any examination of alternative fuels.

4 The supply chain – the system in which technologies and fuels are used

4.1 Introduction

Having said the above about the need for different kinds of technologies and alternative fuels in the transport sector to reduce environmental impact (emissions to air above all), this chapter deals with a simplified and by no means complete description of typical supply chains as the systems in which the implementation of technologies and use of fuels take place. Looking at the freight transport industry and the possibilities to reduce environmental impact, the investigation of a supply chain reveals a more holistic approach and addresses more pressure points and key questions than an independent investigation of different transport modes.

A **supply chain** is a coordinated system of organizations, people, activities, information and resources involved in moving a product or service in physical or virtual manner from supplier to customer. Supply chain activities transform raw materials and components into a finished product that is delivered to the end customer. Supply chains link value chains.

The supply chain usually begins with the extraction of raw materials and includes several production links, for instance; component construction, assembly and merging before moving onto several layers of storage facilities, and finally reaching the consumer.

Many of the exchanges encountered in the supply chain will be between different companies who will all generally seek to maximize company revenue within their sphere of interest but will have little or no knowledge of or interest in the remaining players in the supply chain except those to which they are directly linked.

Thus, the supply chain is the backbone of freight transport. Major changes in supply chains concerning transport modes and technology used may have direct repercussions on business relations and costs and benefits of logistics firms and producers.

4.2 Supply chain according to the type of good in question

The set-up of a supply chain depends to a large extent on the good in question. Three rather typical types of goods have been chosen below to illustrate different pressure points. However, as mentioned above, there are also common characteristics of supply chains in general. Only occasionally will companies seek to have detailed supply chain information and thus the potential to control their complete supply chains. These are often small or medium-sized companies, which have a central procurement department. The larger and more global a company becomes, the more difficult it usually becomes to keep all information of all supply chain partners together and exert a certain influence over all of them. This is an important point to consider when discussing the reconciliation of supply chains with environmental considerations.

4.2.1 Consumer goods

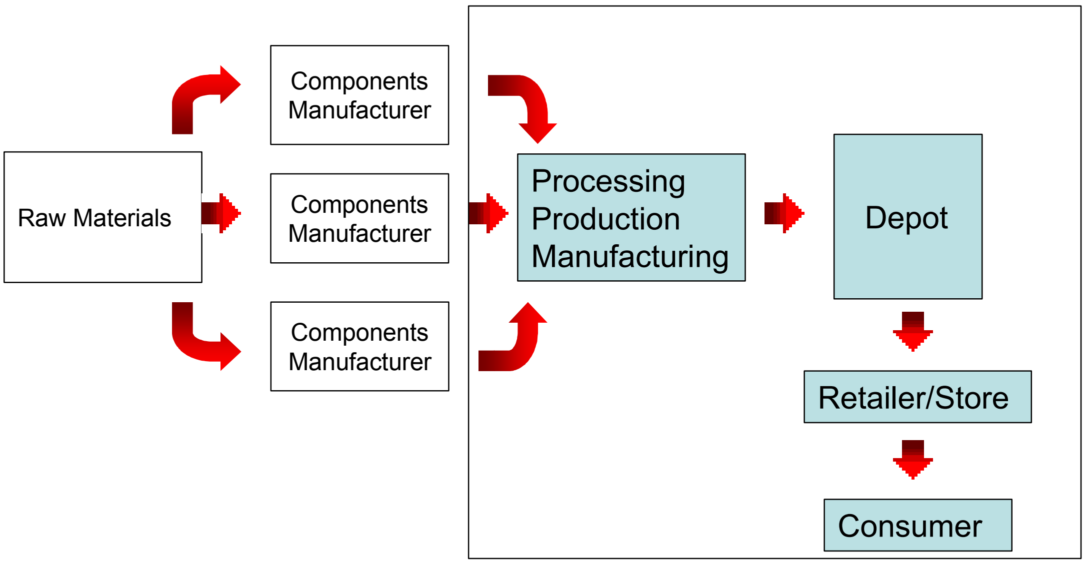
Pressure points in supply chains related to the production of consumer goods are that the goods reach their destination without damage and on time (e.g. clothes collections, mobiles phones, computers etc.). New product models are constantly being developed and these new models must reach their market (through the supply chain) in a timely and efficient manner in order to generate the expected revenue.

The choice of transport and environmental considerations vary at different locations in the supply chain. Producers may become the target of activist groups if they violate social/labour and environmental laws. As producers usually lay a very high value on the reputation of their brand name, they are quite sensitive to image threats. However, producers may not have the ability to exercise the same control instruments guaranteeing compliance with social/environmental standards abroad as they do in their country of origins.

Consumers can be informed of a company's breaches of social, environmental laws and voluntary agreements and, if the media reacts accordingly, can be influenced to refrain from buying certain products. This can result in substantial financial losses by the producers. However, transport companies act behind well-known brand names in the market and are not as anchored in consumers' awareness, as they are mostly in the business-to-business arena. Logistics providers have just begun to notice political and societal pressure whereas producers have long ago learned to deal with this pressure and therefore manage it in a professional way.

Producers of consumer goods currently focus their environmental and social efforts on their core business. However, more and more analysts rating companies' performance also include the supply chain perspective, and some producers have started to widen their perspective. This will surely be reflected by additional criteria in transport procurement calls and tenders in the future.

The **flow diagram** of consumer goods can be illustrated as follows:



4.2.2 Food

The increasing transport of food (“food miles”) has also become a matter of policy and societal concern and can influence customer demand.[90]

Informed consumers, who take their environmental and social responsibility seriously, might not buy fresh food from far-away foreign countries but stick to domestic products instead precisely because of the transport issue. Even if they do buy exotic fruits or apples from far-away countries, this group of consumers often wants the food to be produced in an environmentally sound way, no matter where it comes from.[91] Certain producers of food have already integrated environmental and social aspects into their supply chains (South America, Africa etc.) and expect farmers around the globe to follow their social and environmental guidelines. Control of compliance with these guidelines is tightly exercised to satisfy increasingly critical consumers in Europe or elsewhere.

Some food producers have examined their transport chains and attempted to make them as environmentally friendly as possible. From a broader perspective, however, it can be stated that this is the exception and not the rule. For many producers, the main priority is still to create a high quality product for a low price. This is especially true for large discounters who exercise considerable market power and press for as low prices as possible, which does not leave much room for other considerations. This pattern can be found in other industries as well and contradicts the concepts of sustainability. Transportation as a source of environmental impact is then of very little importance.

The **flow diagram** of (fresh) food can be illustrated as follows:

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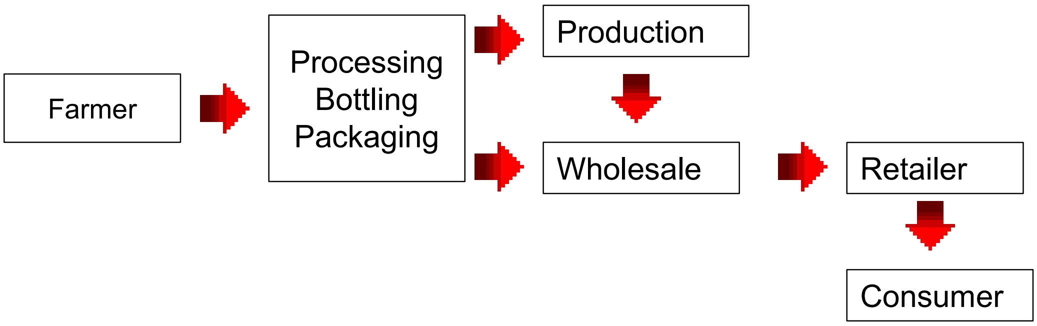
[90] see for example DEFRA report: The Validity of Food Miles as an Indicator of Sustainable Development, 2005, see summary http://statistics.defra.gov.uk/esg/reports/foodmiles/execsumm.pdf (7 October 2007).

[91] In its report “The Validity of Food Miles as an Indicator of Sustainable Development” (see footnote above), DEFRA found that the relationship of food transport to overall sustainability is complex. They established that the transport of food, especially the mode of transport and the efficiency of the transport, has significant direct environmental, economic and social impacts. Therefore, in like for like systems, where food supply chains are identical except for transport distance, reducing food transport will improve sustainability. However, differences between food supply systems often involve trade-offs between various environmental, social and economic effects. These must be taken into account when designing an indicator to measure the impacts of food transport, and when formulating associated policies. The impact of food transport can beoffset to some extent if food imported to an area has been produced more sustainably than the food available locally.



Transport to retailers and perhaps directly to consumers may mean transport to and within (inner) cities. In this context, certain environmental considerations may play a role, such as deciding about the use of more environmentally friendly trucks. Apart from this, freight transport in cities is often subject to municipal restrictions forcing transport companies to use rather environmentally friendly transport vehicles. For example, access of larger trucks (above 6 or 12 tons) to certain city quarters is often limited or even prohibited. Noise plays an important role as well, but will not be considered further due to the main focus of this workshop being on vehicle technologies and alternative fuels.

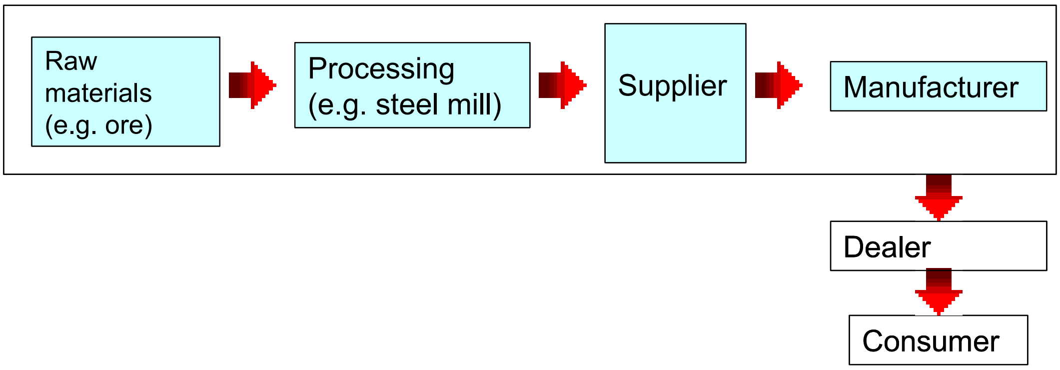
4.2.3 Raw materials

Raw materials include iron ore, coal, liquid fuels, bulk chemicals etc. These materials require a transportation mode with a large capacity. Raw materials are usually transported from and to a limited number of places (from mines to harbours or factories). Often factories (e.g. steel mills, refineries) are located at places where the logistics are in place for the direct delivery of the raw materials (e.g. sea harbours). The masses of goods to be transported as well as their timing to these sites is comparably predictable and can be planned over a longer term. As a result, transport modes could be chosen which have less of a negative impact on the environment, e. g. ocean vessels, trains and barges. However, as raw materials are usually one of the first elements in the supply chain, they escape the immediate control area of product producers and even though they are necessary to create the final product, their production is not considered as belonging to the core business of producers of products.

As far as raw materials are concerned, customers might, if anything, rather ask whether the concerned product has been fabricated on the basis of renewable versus primary materials or whether the product design has saved resources in any considerable way. The question of the mode of raw material transport will, on the other hand, probably be raised only by specialists.

Therefore, the transportation of raw materials to production sites has until now been considered mainly under the price and times aspect by producers, with few exceptions.

The **flow diagram** of raw materials can be illustrated as follows:



4.2.4 Conclusions

From what is said above, it follows that transport services are the invisible links in supply chains that the end-customer is often unaware of. Therefore transport services are not subject to direct consumer pressure, except in the case of urban deliveries and arguably in the case of food miles. Transport services may also be subject to pressure from brand owners or producers as a result of concerns related to environmental impacts along their supply chain. Thus, it appears that especially producers of products occupy an important position in the supply chain. They can influence the environmental qualities of the supply chain quite considerably. Every linked element in supply chains refers to a producer and would not exist without producers' demands. Having said this, it could be debated whether producers should and could take a higher level of responsibility for social conditions and environmental protection in the supply chain that evolves around them, including transportation. This does not exempt raw material and part suppliers from their responsibility. Sustainability can only be reached if all elements of the entire supply chain, work together.

As transport prices and transport costs play an important role in different supply chains, and thus exert a significant influence on the decision to employ environmental technologies or not, the next paragraphs will deal with the decisive issue of costs and prices in supply chain relations.

4.3 Relations between the actors along the supply chain regarding price formation

<u>In addressing the costs/prices and the financial benefits issues in the following four sections, it has to be emphasised that most of the points and conclusions given below reflect observations, often based on information from the industry, impressions and assumptions, which will all be discussed during the workshop. Thus the following chapters are intended to fuel discussions, the results of which could create quite a different picture from the one painted below.</u>

As far as the logistics providers are concerned[92], it seems that there is sometimes a lack of transparency with regard to how transport costs and prices are formed.

The basic elements based on which transport costs are formed are: leasing rate, vehicle insurance, vehicle tax, goods' insurance, wages of the vehicle driver, legal social costs, fuel costs, lubricant surcharge, repair and maintenance, tyres and toll charges (information from industry).

Competition in the logistics sector is fierce. This contributes to the fact that the transport industry is an industry with small margins. This has an important influence on price formation as the transport price is often the winning factor in a tender process.

Thus, transport prices given out from logistics providers might not always reflect economic necessities but can sometimes be set up in a strategic way – to keep important customers and to attract new customers. Secondly, international logistics providers have key accounts, which are of high strategic importance for the companies. Sometimes the logistics provider might therefore accept prices, which again do not cover all costs in one of its operating countries, but counts on making up for that in another operating country. To re-distribute earnings fairly to all subsidiaries, which have been involved in a customer business, is equally difficult and lacks transparency.

These factors might all contribute to an identified yet acceptable grey zone, within large transport organisations as well as within large transport buyer organisations. If procurement or sales are not centralised and controlled tightly from one single point in the organisation, it is very difficult to get a good overview on prices and costs as well as on results with specific customers.

It is therefore difficult to establish the exact transport cost distribution along the supply chain and it is also difficult to fully understand the transport price structure. The concrete price formation depends on many different factors such as:

- Service level (including questions like: e. g. are there unusual demands on the transport time, does the customer demand handling of special documents, is a complicated custom clearance necessary etc.)?
- Special demands or standard procedures?
- Balance of goods – export / import or regional imbalances in the goods' flows?
- Empty returns?
- Type of vehicle – normal trailers vs. megatrailers etc.?
- Type of goods – dry/frozen/cooled goods; full loads, part loads or piece goods?
- Handling of goods – is a forklift necessary or a crane or any special machinery?
- Do the customer and his goods fit into the transport provider's profile?
- Possibility to co-load with another customer?

[92] This insight came up in discussions with people working in the industry.

- Possibility to find a combined solution?
- Duration of contract?
- Situation in the market – competition?

Thus, the price formation depends on many different factors. The following section will deal with the important issues of costs/benefits and the employment of environmental technologies.

4.4 Costs/benefits in transportation vs. environmental technologies

From the point of view of the logistics industry and transport buyers, most strategic decisions including the choice of transport modes and technologies, are motivated by profit interests or by legal obligations.

As far as the use of environmental technologies is concerned, enterprises will be forced to adopt them in order to meet legal obligations. Any engagement beyond that, will be considered only especially if a financial benefit can be achieved.[93]

While a series of scientific studies exist that indicate primarily a long-term financial benefit from the employment of some environmental transport technologies, especially when it comes to energy-efficient technology, it seems that the cost-effectiveness of these environmental technologies is not well known in the sector.

This may be due to the fact that the technologies themselves are not well known to companies and the profitability is difficult to assess as costs are uncertain. Michael Porter, a Harvard professor specialising in management and economics, is known for saying "There are $50 dollar bills lying on the ground" to state that there are many opportunities for cost savings available if companies only bothered to identify them. Often the savings were very obvious, but the companies were blinded by the "normality" of their actions. Another reason for logistic companies' lacking interest in environmental technologies might be that the procurement departments do not confide too much in scientific studies promising financial benefits and the practicability of these studies' results. Finally, given the background of fierce competition and uncertain long-term revenues in the logistics sector, many companies do not pursue a long-term strategy and are interested first and foremost in quick profits and quick amortisation of their investments.

If a financial gain from the employment of environmental technologies were certain and commonly assumed by a company's strategists, this would make investments more arguable.

Secondly, in order to be able to measure the financial benefit of a technology, certain instruments and expertise need to be in place. Both are currently scarce among transport providers, as such measurement methods have never been demanded.

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[93] As stated in the sections above, very few transport buyers have included transport in their environmental and social guidelines.

Another important question in this context is the question of responsibility. Before environmental technologies can be implemented or their benefits can be measured, there must be a decision to use them. As long as there is no agreement between transport buyers and transport sellers on who is responsible for this decision and on who will accordingly cover which costs, they are unlikely to be adopted. Given the “subordinate” relationship of transport sellers to transport buyers and the fierce competition in the logistics sector, there is currently little incentive to engage in cost or profit sharing initiatives.

Another aspect is that, if the efficiency of the transport system is increased, customers usually expect to get a lower price in return because the costs for transport of the goods have been lowered. It can thus be asked where the incentives for such increases in efficiency are if nothing or only very small sums can be gained by it. Here it might even turn out that the marginal costs outweigh the benefits realised. This can for example be the case if a transport firms buys new, highly modern trucks to boost sustainability for their transports but cannot fully finance these investments by raising the transport price accordingly. The investment will be all the more risky if at the end of the day the logistics company cannot utilise the trucks in a way that emissions are really reduced to a large extent because of a lack of customer demand for the environmentally more friendly but more expensive type of transport.

It could be argued as a result that many enterprises see any investment in environmental technologies that surpass legal obligations as a way to reduce mainly external costs. Thus, the (immediate) economic benefit is questioned all the more by the respective enterprise for external costs are currently by definition, borne by society, implying that the logistics provider or the transport buyer does not pay them. From this perspective, reducing these costs does not bring any direct financial benefits.

4.5 Image / USP in connection to costs/prices

Based on the considerations of the preceding chapter, the inclusion of environmental technologies into the service/product portfolio of transport providers is, for the time being, often not rewarded either by an image improvement or a unique selling point (enhanced attractiveness for environmentally minded customers and a distinctive feature) worth the effort. Such adapted transport services might be remarked by a small niche group of customers, and even among those it is not clear if they would be welcomed if the up take of environmental transport technology is accompanied by a rise in price

This means that the implementation of new technologies (that includes vehicle technology and/or alternative fuels) will in general not necessarily help a transport provider to successfully distinguish himself from competition.

As a consequence, any initiative on the part of a transport firm that goes beyond the basic legal environmental requirement is often inhibited by the - short-term - cost argument, which in many cases thwarts environmental ambitions. Eventually, environmental performance of a transport mode is generally not a selling factor, either to end consumers (because of their lacking awareness) or to transport buyers (because of disinterest).

4.6 Strategic value of environmental technologies leading to a cost/price advantage in the future

Still today, many transport buyers and transport providers have not analysed in depth how the development towards more environmental protection and sustainability may impact their transports and their supply chain set-ups. A considerable number of industrial producers, i.e. transport buyers, especially small and medium-sized companies, are little aware of the share of transport emissions caused by them out of their total emissions, or in other words, the environmental impact of their transport in comparison to the total environmental impact. Transport buyers who know the share of transport costs out of their total costs, and may have connected this information to the environmental relevance of transports within their business are not standard transport customers yet.

Transport providers, in turn, have seemingly not yet undertaken many efforts to systematically measure the environmental impact of their transports even though it is their core business. If this holds true, it may cause a large discrepancy in experience and knowledge between transport buyers and transport providers regarding the environmental impact of the respective core businesses. Transport buyers expect that their providers shall know about these facts, as they know the (environmental) facts of their own core businesses.

Last but not least, the time horizon of logistics planning is rarely long-term, so consideration for sustainability (environmental, social and economic) appears to be limited. Additionally, financial evaluation horizons are too short to allow transport providers and their customers to compare the short-term costs of change with the longer-term costs of failing to change.

As a thorough analysis seems to be lacking among the majority of transport sellers, future cost/price advantages due to early implementation of environmental technologies cannot be realised. Neither do deciders seem to realise that by waiting longer and longer before they act, avoidance/reduction costs might rise (along with prices) higher and higher. The decision to not act may sometimes also prevail because the incurred cost benefits will probably appear well after management's retirement.

4.7 Conclusions

From the three supply chains discussed, one can see that the most important issue in customer demands for goods transport are costs, followed closely by delivery time and quality. Customers usually look for the optimal mix at the optimal price.

The basic question is now: *how can environmental considerations be integrated into this scheme?* Looking at the supply chain one can identify a number of areas where environmental considerations play an important role, as for example in the production process (energy use / emissions) and agriculture. Consumer preferences often take into account these environmental aspects, but very little consideration is given to the question of whether the transport of raw materials/goods is sustainable.

From the supply chains discussed above, it becomes clear that the choice of a specific transport mode is often (but not always) dictated by the type of product. Consumer products usually have to be transported in a fixed time span to a certain market; otherwise they become much less valuable. For chemicals, machine parts etc., customers might accept slower transport modes (ocean freight) as long as the delivery schedule does not impact production.

Logistics enterprises in turn often do not see any added value in terms of profit increase in employing environmental technologies as they often associate them with rising costs and higher prices which are not necessarily well received by the mass market. Awareness of possible financial benefits linked with environmental technologies or an improved image with end-consumers resulting from environmentally improved transports seems to be still rather rare in the transport sector including both transport sellers and buyers.

4.8 Key questions

The key questions to be answered in the workshop are:

- What are the main barriers/reasons preventing companies buying and selling transport from using the most environmentally friendly technologies available (vehicle/engine technologies or fuel technologies)?
  - Is it mainly the fear of rising costs/prices?
  - Lacking awareness of the existence of environmental technologies practicable for the enterprise?
  - Lacking awareness of a potential long-term benefit of specific environmental technologies?
- How could these barriers be overcome?
- Which type of business relationships (industry-freight companies-retail firms) would be needed to foster the use of environmental vehicle or fuel technologies?
- How could EU policy help in promoting a massive uptake of such technologies and alternative fuels?
- What could companies do (alone and in co-operations) to support EU policy makers?
- How can awareness-raising help?

5 Summary and Conclusions: Barriers to adopting current environmental technologies

5.1 Summary

Transport in Europe including freight and public transport is a growing business that has a strong impact on the environment and on energy demands in general. Thus, the employment of environmental transport technology aimed at the reduction of emissions and noise and the improvement of energy efficiency has a huge potential to reduce environmental impacts.

European legislation helps to realise this potential. European environmental law has tightened the requirements for emission standards and energy use and will also set new standards for fuel quality. Other political initiatives have been envisioned, including standards for tyres. Long-term legislation with specified transition periods has the effect that the tightening of standards is foreseeable by all users and gives them time to adapt to the new requirements. Legislative activity in the field of transport and environmental technologies has intensified over the last years and will contribute to a transformation of the technological standards of transport vehicles and fuel use.

European legislation does not foresee the use of specific technology but is objective-based. Therefore, it remains up to the users to decide which technology to use to meet these objectives and independently of current environmental minimum standards improve the environmental impact of transport undertaken by them. Research and Development has led to the development of various approaches to ease the environmental impacts of transports with regards to emissions, fuel use, noise, etc. for all transport modes addressed in this workshop (road, rail, sea, and air) as well as for long-haul transport versus urban transport.

Environmental technologies encompass new vehicle and engine technologies focusing on emission abatement and energy efficiency as well as alternative fuels (such as biofuels, hydrogen; fuel cell) even though there is still controversy around the real environmental benefits of alternative fuels. Generally, when it comes to the assessment of the environmental benefits of any technology, only a life-cycle approach can yield a holistic picture of its environmental effects. These life-cycle analyses are very complex and not every firm has the knowledge and the resources to use them. There is an ISO standard for LCA and work is being done under the Integrated Product Policy theme on selected product groups. Thus, policy makers are required to provide transport companies and transport buyers with all the information they have to enable users/buyers to judge which environmental technology to use.

There is a large variety of options for logistics firms and transport buyers to employ or command environmental technologies. Notwithstanding the advancing European legislation in this area, there remain strong economic or psychological barriers to the adoption (or up take) of new environment technologies in the transport sector which exceed the legal requirements. While most of the environmental technologies described in this paper have not been used to a large extent, in most cases there is no strictly technical reason why these technologies are underused.

The chances to increase the share of cleaner transport technologies are to a large extent determined by the willingness of freight transport firms to invest in cleaner transport technologies. The reasons for the reluctance of businesses basically lie in;

Costs:

- high investment costs for the adaptation of the existing transport fleet to more advanced standards and acquisition of new environmental technologies (e.g. new truck fleet).
- Lack of opportunities to increase prices on the basis of increased costs due to the employment of environmental transport technologies
- Unawareness of any potential long-term financial benefit from using environmental technologies

Infrastructure:

- missing infrastructure for the provision of alternative fuels;
- lacking flexibility of new technologies;

Missing incentives:

- missing incentives to employ environmental technologies and lacking demand of end-customers for goods transported in a sustainable way;

An important barrier for any quick spread of environmental technologies in the transport sector is the lacking business case for both the logistics companies and – in most cases – customers to employ or demand the use of environmental technologies in the freight transport. The fact that the freight transport sector is subject to fierce price competition leads to companies minimising costs and inhibits them from investing in environmental technologies. It is hard for them to establish an even long-term financial advantage from employing environmental technologies given that environmental damages represent to a large extent external costs.

End-consumers of goods demand more and more environmentally sound goods but seldom pay attention to *how* the goods have been transported. Those who are very informed and aware of environmental and sustainable matters will integrate them into their consumer decisions, and prefer buying regional products to buying imported goods anyway.

Therefore, the identification of motivating factors to foster the adoption or up take of environmental technologies in the freight transport sector is a prime question of this workshop. The range of key question is therefore outlined in the following section:

5.2 Key questions

The key questions to be answered in the workshop are:

- What are the main barriers/reasons preventing companies buying and selling transport from using the most environmentally friendly technologies available (vehicle/engine technologies or fuel technologies)?
    - Is it mainly the fear of rising costs/prices?
    - Lacking awareness of the existence of environmental technologies practicable for the enterprise?
    - Lacking awareness of a potential long-term benefit of specific environmental technologies?
- How could these barriers be overcome?
    - What would be the economic pre-conditions for a quicker and more extensive use of environmental technologies in the freight sector? (E.g. Consumer demands, environmental publicity, long-term cost reduction, etc.)
    - Would fiscal instruments help to surmount the identified obstacles?
    - What implications would a more extensive use of environmental technologies have for the fuel sector and remaining technology suppliers?
- How could EU policy help in promoting theses pre-conditions?
- Which type of business relationships (industry-freight companies-retail firms) would be needed to foster the use of environmental vehicle or fuel technologies?
    - How should logistics providers and their customers work together in the future to support the uptake of environmental technologies and alternative fuels in transportation?
    - Does their relationship need to change in order to enable sustainable transport systems?
    - What could be the role of professional organizations/ business chambers/ joint working groups in this process?
- How could EU policy help in promoting a massive uptake of such technologies and alternative fuels?
- What could companies do (alone and in co-operations) to support EU policy makers and what could the role of professional organisations / business chambers / joint working groups in this process?
- How can awareness-raising help? What kind of dissemination of the results of the ETTAR project would be most effective?