PACT
Pilot Actions For Combined Transport

Combined Transport

CO_2 Reduction

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PACT PROGRAMME

Assessment of the Contribution of European Combined Transport to Environmental Policy Goals: Reduction of the Transport related Carbon Dioxide Emissions to hamper the overall Temperature Increase (Greenhouse Effect)

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I. Assessment of existing research results

A European Survey
(English, German, French, Italian and other studies)

Introduction

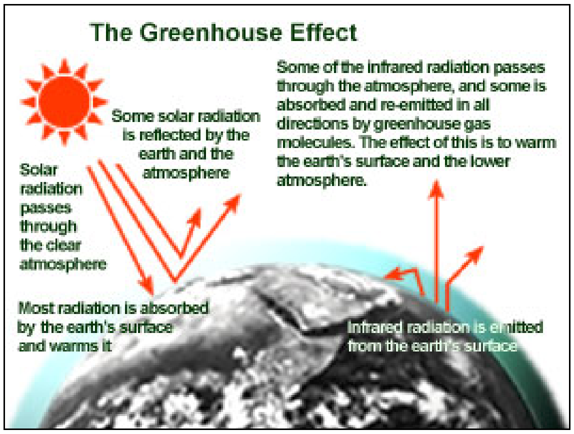
Background: The Kyoto protocol

Nowadays the following conclusion is general awareness: the climatic changes with a global warming over the past 100 years constitute a real threat for the planet. Even if it is punctually difficult to attribute the responsibility to such or such event, everyone recognizes the disastrous consequences of these climatic changes. While the expectations count on an average increase of the temperatures of 1,5 to 6°C, the temperatures have globally increased by 0,6% during the last century, not only for natural reasons, but also due to men. There was even acceleration in the rate of warming over the last 25 years. Some parts of the planet have warmed more: the Antarctic Peninsula, where average temperatures have risen by 2,5°C over the last 25 years.

How can changes in the world climate be explained? Through the reflection and absorption of long-wave warming rays from earth, atmosphere heats itself and beams energy back to earth. This leads to a warming, so the average temperature increases ("greenhouse effect"). Greenhouse effect results from steam: the greenhouse gas is then emitted into the troposphere where they trap heat. In fact, the earth reheats itself because the part of the greenhouse gas in the atmosphere has increased as most of the experts have pointed out.[1] Especially the emissions of greenhouse gas caused by man influence very noticeably the warming (and therefore environmental climate change) by the mechanism of the greenhouse effect.

[1] These are the main physical mechanisms leading to greenhouse effect, but it has also to be mentioned that there do exist some other mechanisms more difficult to explain: other connections (also some feedback-loops) between the eco-systems of atmosphere, ocean, continent and biosphere. These are not sufficiently known or sufficiently considered in the calculation models, for instance because of the variety of links, the uncertain data or the non-linear behaviour of the (mathematical) chaotic system "atmosphere", so that a detailed prognosis is very difficult to create. There is a lack of *proof* for climatic change, but the strengthening of the natural greenhouse effect by man is indisputable, so a further global warming and climate change can be predicted. What still has to be investigated are the variety, the total volume and the geographical distribution of the effect (development of local temperatures and vegetation, implications for weather etc.).

Mechanism of the greenhouse gas



Why should man be blamed for the effect? Various natural greenhouse gases exist: the carbon dioxide (CO_2), the methane (CH_4), the nitrogen (N_2O) and the ozone (O_3). A natural balance of these gases exists, for instance CO_2 is part of the natural clean air (share 0,028 %). But over the last years, a lot of experts have noticed an increase of the average carbon dioxide rate in the atmosphere (today's share: 0,036 %), and since 1850 this increase goes parallel with the carbon dioxide emissions caused by human action.[2] The CO_2 emission counts nowadays for 6 billion tonnes per year. A strong connection between the growing carbon dioxide emissions caused by man and the carbon dioxide emissions in total seems evident. Since the beginning of industrialization, man disturbs the natural balance of greenhouse gas by emitting the types of gas mentioned above in higher volumes, especially for CO_2. This results from the combustion of fossil energies like refined petroleum (main reason), exaggerated forestry and different forms of agriculture (see table with data for Germany). Example: fossil energies consist mainly of hydrocarbon (HC). Through the combustion of fossil energies, water and CO_2 are produced. Emissions of CO_2 from the burning of fossil fuels increased by a factor of seven during the 20th century; with a corresponding increase of about a third in the atmospheric CO_2 levels. As the following table shows, the CO_2 is the single gas with the strongest warming effect. As a consequence, the nitrogen effect will not be described in the study because it has no major effect on climate changes.

Warming effect of greenhouse gases

Source	CO_2	FCKW	Methane	Ozone	Nitrogen	Total
Combustion of fossil energies	35 %	-	4 %	6 %	4 %	49 %
Exaggerated forestry	10 %	-	4 %	-	-	14 %
Agriculture	3	-	8 %	2 %	-	13 %
Industry	2 %	20 %	-	-	2 %	24 %
Warming effect of the single gas	50 %	20 %	16 %	8 %	6 %	100 %

Source: German national environment authority (Umweltbundesamt)

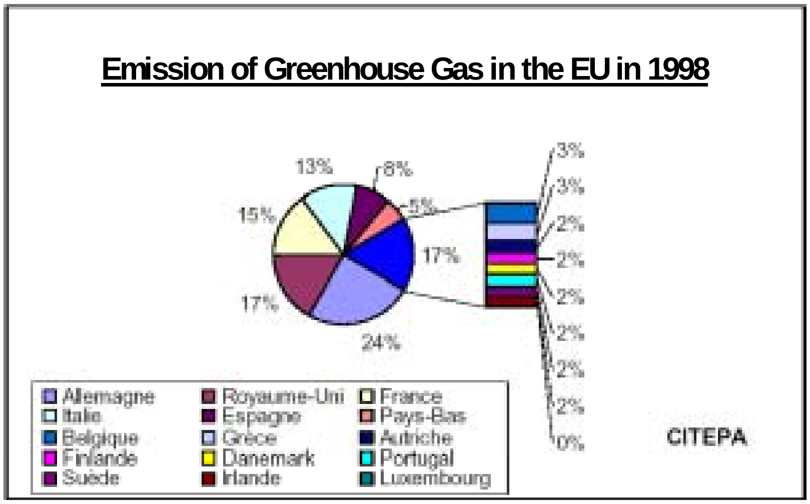
The international community, through the Convention Framework of the United Nations on the climatic changes and the Kyoto Protocol of 1997, act henceforth in reducing the CO_2 emissions in the atmosphere, even if the promises taken in Kyoto are today undermined by the United States. The Kyoto Protocol established in November 1997 aims at a decrease of the

[2] Another source of higher "natural" CO_2 emissions are eruptions of volcano.

greenhouse gas. Altogether, the industrialized countries shall reduce their greenhouse gas emissions by 5 per cent compared to the year 1990, among them the European Union has to achieve a reduction by 8 per cent.[3]

Until 2002, the EU was able to keep the CO_2 emissions with the level of 1990, but a reduction by 8 per cent has not yet been achieved. The EU therefore is looking for effective measures to meet the objective of 8%, for instance the dealing with emission certificates.

The distribution of the greenhouse gas emissions in the European Union among the member countries in 1998 shows the following diagram:



France has emitted in 1990 for the six gases withheld by the Kyoto protocol 144 million tonnes equivalent carbon. Without measures, this figure could attain 175 million in 2010. In 2000, the emissions were +1,5 per cent higher than in 1990. IEA reports that the energy-related CO_2 emissions in France in 1999 were about 360 Mio. tonnes.[4]

Germany, wants to achieve two goals concerning greenhouse gas emissions:

- Klimaschutzprogramm of 1990: the reduction of CO_2 emissions by 25% up to 2005 (basis: 1990), voluntary, today valid;
- Kyoto-protocol of 1997: reduction of the greenhouse gas by 21% (EU: 8%) within 2008-2010 (basis: 1990, for HFC, PFC and SF_6 also 1995), mandatory, not yet valid.

The second objective is the reduction of annual emissions by 21 per cent compared to 1990. In 2000, a reduction of 18,7 % has been achieved. IEA reports that the energy-related emissions in Germany in 1999 were about 820 Mio. tonnes.[5]

Besides Kyoto, the **OECD** organization set up the following target to prevent climate change:[6] carbon dioxide emissions shall be reduced at or below the level of 1990. In order to stabilise atmospheric CO_2 concentrations at near current levels, worldwide CO_2 emissions

[3] See also Verband der Automobilindustrie (VDA): Auto-Jahresbericht 2002, Frankfurt/Main.
[4] Source: dpa-Grafik out of IHK Wirtschaftsforum No. 11/02.
[5] Source: dpa-Grafik out of IHK Wirtschaftsforum No. 11/02.
[6] Source: est! **e**nvironmentally **s**ustainable **t**ransport, Guidelines developed by OECD

would need to be reduced by 50 % to 70 % with further reductions thereafter.[7] In order to allow increases in emissions in the developing countries, the OECD countries should reduce their emissions by 80 % or more so that a global reduction of 50 % may be attained.[8]

[7] Source: IPCC: Second Assessment Report of the Intergovernmental Panel on Climate Change, 1996
[8] Source: OECD Environment Directorate (Ref. 29): Environmental Criteria for Sustainable Transport, Paris 1996

Greenhouse Gas and Transportation

In the transport sector, the CO_2 emissions are generally proportional to fuel consumption. Out of one litre Diesel combusted, 2,64 kg of CO_2 is produced. As one of the big emitters, the transport sector shows principally a potential to provide savings in CO_2 emissions. As shares of these emissions are decreasing in other sectors, transports' share of climate-impacting emissions continues to grow. Transport directly contributes to about 20 per cent of *anthropogenic* CO_2 emissions worldwide. Under the assumption that no drastic interventions will occur, global CO_2 emissions from motor vehicles are projected to increase by more than 300 per cent by 2030 compared to 1990 levels (even if interventions occur, worldwide carbon dioxide emissions from the transport sector will double by 2030). This increase is expected in all parts of the world and primarily due to growth in road traffic, especially freight transport.

It should be mentioned that several other greenhouse gases are emitted as a result of transport activity: methane is released during petroleum extraction, and nitrous oxide (N_2O) is present in vehicle exhaust gases. But (aviation even excluded) more than 90 per cent of the transports contribution to climate change come from CO_2 produced during fossil-fuel combustion.

<u>OECD:</u>

In the OECD countries, the overall increase will be "only" 56 per cent by 2030. In those countries, the transport sector is today responsible for 27% of the total CO_2 emissions (close to 30 per cent of the *anthropogenic* emissions), and road transportation generally represents between 55 and 99% of the greenhouse gas emissions emitted by the transport sector, about two third being attributable to the private car[9]. According to OECDs targets to prevent climate changes, the total CO_2 emissions should not exceed 20 to 50% of the emissions of 1990 depending on specific national conditions. For example, a reduction target of 50 % might be more appropriate for certain areas like the Central and Eastern European region where changes in favour of a more environmentally friendly energy production coincide with structural economic changes.

<u>EU:</u>

In the **European Union**, about 28 per cent of the CO_2 emissions presently come from the transport area, with 84 per cent from road transport. Between 1985 and 2010, without further acting, the CO_2 emissions of the transport sector in the European Union will rise by around 60 per cent.[10] In 2001, the European Union started its ECCP program to protect world climate. According to this program, the transport sector shall save 107-127 Million tonnes of CO_2 emissions with a cost under 20 € per ton, and further 45-50 Million tonnes with a cost above 20 € per ton. Some starting-points are

- reduction of CO_2 emissions through a contract with the automotive industry,
- technical improvements in vehicle technology and fuel,
- a toll system charging road traffic and internalising external costs,
- fiscal policy,
- global awareness and behavioural changes,
- promotion of combined transport and intermodality.

[9] OECD, *Reduction Strategies of the greenhouse gases emanating from road transportation: method of analysis*, 2002.
[10] Source: EEA, Ref. 8

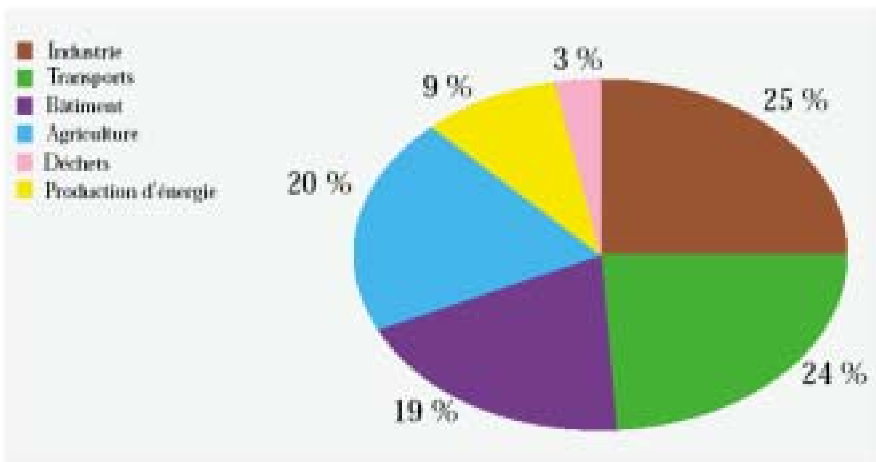
This has to be seen in the context of the EU White Paper on common transport policy published in 2001.

To better understand the influences of the transport sector in the European Union, the CO_2 emissions in France and Germany, as main examples, will be analysed deeper.

France

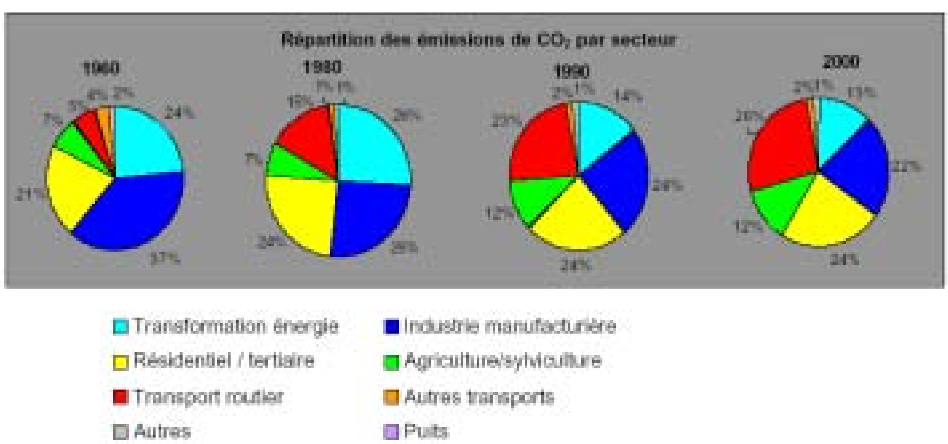
In 1996 the relative part of the greenhouse gas emissions for the transport sector was 25%. But more appalling is the evolution of the $C0_2$ emissions of the road sector between 1960 and 2000, passing from 5% to 26% in 40 years:

Relative part of the different sectors in the French emissions of the greenhouse gas in 1996



Source : PNLCC

CO_2 Emissions in France



Source : CITEPA

In France, we can ascribe to the freight transport 46.820 tonnes of carbon dioxide emissions per year, of which more than 99% have their origin in the road transport. These emissions can be divided in geographic zones: 19% for the cities, 25% for the regions and 56% for the inter-regional transport.

In 1997, the traffic volume of vehicles heavier than 3 tonnes registered in France was estimated to 20 billion vehicle kilometres, of which a quarter runs empty. The road trains add up 7,5 billion vkm while the articulated vehicles add up 12,5 billion vkm.

The total traffic of freight was estimated to 241,5 billion ton-kilometres. The corresponding tonnage is 2.008 million of tonnes, the average shipping distance is 120 km. Two-third of the traffic is assured by road and 22% by rail.

The consumption of railway energy traction represents in 1997 about 1,9 Mtoe (million tonnes oil equivalent), be 3,8% of the total consumption of the transportation sector in France, against 1,6 Mtoe in 1985 (4,4% of the transport's consumption). The part of electricity in the traction consumption was about 87% in 1997.

The evolution of the consumption at global level is summarised in the following table:

Energy consumption of Trains					
	TKBR	TRAFFIC	ELECTRICITY	DIESEL	TOTAL
(Mtrain-km)	(billion)	(Guk)	(GWh)	(thousand of m^3)	(ktoe)
499,32	263,58	114,25	7315	292	1872

(The energetic data expressed in tonnes equivalent oils are calculated with the following coefficients of equivalence: 1MWh=0,222 toe for electricity (equivalent to the production) and $1m^3$=0,85 toe for the diesel).

GWh= gigawatthour

The energy consumption of freight trains has increased by 4% in 1997. Considering the gaps between the growth of the energy consumption and traffics, the energy efficiency has improved for all the categories of freight, with in average -2,5% per tkbr (tonne-kilometre brute hauled - gross ton-kilometre hauled) and –4% by tkm.

Unitary energy consumption of the freight trains in 1997:

		In kgep/train-km	In gep/tkbr	In gep/tk
	Total freight	4,2	4,6	12,1
Of which:	Block Trains	4,7	4,1	9,0
	Combined Transport	4,8	5,9	12,1

The block trains have the best performance (9 gep/tk in 1997), because of a notably better load rate (average tonnage transported by train about 522 tonnes for a total average freight of 344 tonnes). The combined transport is situated in the average of the freight (12 gep/tk).

Average Tonnage of the freight trains in 1997

Ratio traffic (tk)	**Tot. freight**	**Block Trains**	**Combined Transport**
In tonnes/train	344	522	395

Between 1985 and 1997, the energy consumption dropped by 8% (-0,5% for electricity and -36% for diesel), in conjunction with a decrease of the traverses (-13%), tkbr (-10%) and traffic (-11%). This explains the weak increase of freight's unitary energy consumption during this period (+5% for train per km, +2% for the tkbr and +3% for the ton km).

Germany

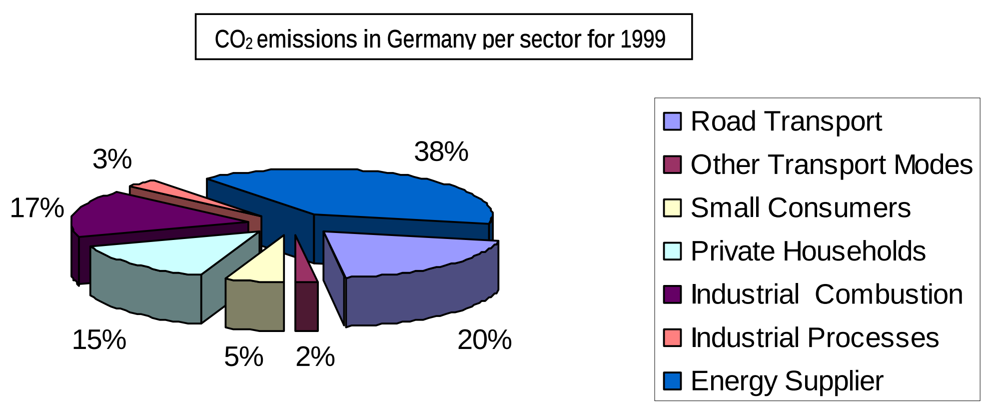
As far as **Germany** is concerned, the annual carbon dioxide emissions in Mt (Mega tonnes) for different sectors can be compared in the following table:

Annual CO_2 Emissions in Megatonnes per Sector (Germany)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Road Transport	150	154	160	164	161	165	165	166	169	174
Other Transport Modes	22	20	18	18	19	18	17	17	18	17
Small Consumers	76	74	65	62	56	59	67	54	52	46
Private Households	128	131	123	134	128	129	146	141	136	125
Industrial Combustion	213	184	168	158	159	158	153	154	149	144
Industrial Processes	28	25	25	25	27	27	25	25	26	26
Energy Supplier	397	389	368	356	354	349	351	336	339	326
Total	1.014	976	928	918	904	904	925	894	888	859

Source : German national environment authority (Umweltbundesamt)

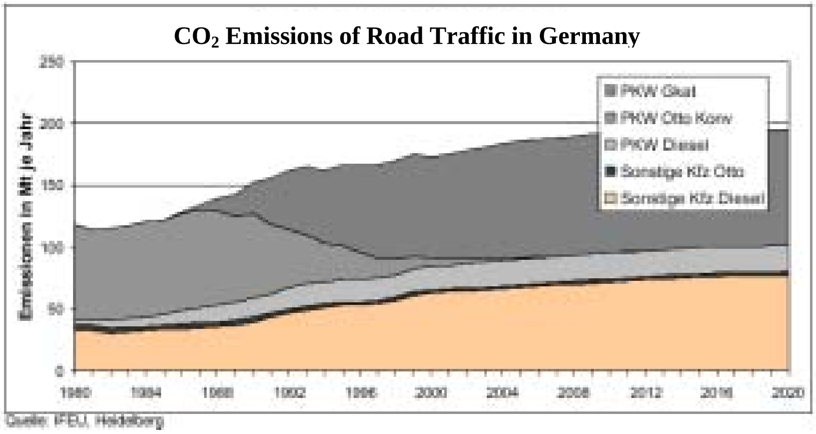
In 1999 road traffic caused 174 Mt of carbon dioxide emissions. That is 20 per cent (France: 25 %) of the total volume of CO_2 emissions in Germany or 91 per cent (France: 99 %) of the emissions of the whole transport sector. The following diagram presents the different shares of the energy sector (Kraft- und Fernheizwerke):



A projection of the CO_2 emissions of all transport modes in Germany for a "business-as-usual" scenario forecasts an increase of about 40 per cent between 1990 and 2030[11] But the development in Germany since 1999 includes no further increase of CO_2 emissions of the main emitter road traffic: in 2000, compared to 1999, the emissions have been reduced by 1,9 per cent.[12]

[11] Source: OECD: est! **e**nvironmentally **s**ustainable **t**ransport, Wien 2000
[12] Source: Süddeutscher Verkehrskurier Nr. 8/9-2002

Freight transport has an important share of the whole volume of road transport carbon dioxide emissions. The evolution of the CO_2 emissions caused by road transport in Germany is shown in the following chart, which presents even a prognosis:



CO_2 Emissions of Road Traffic in Germany

As a conclusion for Germany, the CO_2 emissions of non-passenger Diesel vehicles (=lowest category in the figure: trucks, buses, tractors) will further increase by the year 2020. The other main emitters will still be the private cars used for passenger transport.

In Germany, road transport caused in 1997 0,145 tonnes of direct CO_2 emissions per 1.000 ton-kilometres.[13] According to experts, this value will be reduced by 21,4 per cent to about 0,114 tonnes per 1.000 tonne-kilometres until 2015.

[13] Source: BVU/ifo/ITP/Planco/Verkehrsprognose 2015

Greenhouse Gas and Modal Shift

According to the OECD, reductions in carbon dioxide emissions can be achieved even if freight transport activities will further grow. The contributions can be separated in:

- transport avoidance (19 %),
- technological improvements to vehicles, fuels and infrastructure (40 %),
- improved load factors (11 %), which means higher occupancy,
- and **modal shifts** (24 %).

In 2001, the European Union created working groups, which were tackling the problem of CO_2 reduction in the context of the Kyoto protocol. The EU was looking for ways to reduce the CO_2 emissions. Those groups asked the industry to define their projects to contribute to the reduction of the greenhouse gases. Also, the European Commission, DG TREN, considered intermodal transport and especially combined transport as an important tool to reduce CO_2 emissions in transport sector.

In the final report of the European Climate Change Programme (ECCP),[14] a modal shift from road to rail and waterway can result in a reduction in fuel consumption and therefore play an important role in this matter. This has to be seen in the context of the latest White Paper and the new Marco Polo programme promoting modal shift. The focus lies not only on waterway transport, but explicitly also on combined transport road/rail.

For this reason, the DG TREN of the European Commission and also participants in the field of combined transport (operators, customers…) were interested in a research project aiming at evaluating the amount of CO_2 reduction in Europe generated by the shift from road to rail in combined transport. In this research project (PACT "Combined Transport - CO_2 emissions"), on basis of the results obtained, some recommendations and strategies will be presented on how to maximise the environmental effects of combined transport. Current prognosis data will be used for evaluations of the further development of combined transport volume in the next 10 years. Finally some considerations will be made on the anticipated development in the field of the specific CO_2 emissions of road and combined transport in order to give a prognosis of the overall CO_2 reduction that can be generated by combined transport if the anticipated volume increase can be realized.

[14] Published in Brussels, February 2002

The European Survey

Introduction

Different German and English research results about the energy consumptions and CO_2 emissions in the road and rail transport sectors have been examined. 39 studies have been found, analysed and compared covering the period from 1988 until now. The first conclusions are described below:

- Among a large variety of studies dealing with environmental effects of transport, 39 of them considering CO_2 emissions of rail / road transport were assessed.
- All of the 39 assessed studies dealing with the topic were published during the last fifteen years or are to be published, with the majority (34) of them later than 1998. This is a sign for a shift of emphasis within the environmental discussion towards CO_2 emissions.
- Twelve of the studies analyse certain transport relations, while 27 of the examinations deal with a "global" (country-specific, EU-wide etc.) analysis.
- Different methods lead to results that are difficult to compare. Nevertheless, in all of the assessed studies giving results in form of CO_2 emissions, the ratio of the emissions for combined road/rail transport or pure rail transport to road transport rates between 1:1 and 1:7 (weighted average: about 1:3-1:4, median: 1:3).

The French and Italian studies have also been analysed. They can be split into three categories:

- the technical studies (e.g. truck and locomotive emissions),
- the policy measure studies (e.g. truck utilisation in the urban area, comparison of trucks being used only for Combined Transport to trucks used for pure road transport),
- the aggregate studies (production of reference figures by national and environmental accounts,…).

While the German and English studies contain a lot of quantifying corridor analysis (micro-perspective), the French and Italian studies are more extensive: They show an underlying macro-perspective by focalising on national or more global effects, even going into monetary evaluation of the caused damage. They are not limited to combined transport, but deal with the implications of CO_2 emissions resulting from road and/or rail transport. While the micro-analysis studies provide useful input and feedback for the case studies, the macro-analysis gives important input and feedback for the global prognosis.

Studies considered

During the assessment and analysis of existing research results concerning a comparison of CO_2 emissions of (combined) rail transport and road transport, the following summary board shows the studies examined in the European survey:

Research Institute / Author	**Title of Project**
SGKV (1988)	Volkswirtschaftliche Bedingungen des Kombinierten Verkehrs Schiene/Straße
Fonger (1993)	Gesamtwirtschaftlicher Effizienzvergleich alternativer Transportketten
Danielis (1994)	Transport and Energy in Italy: changes in the period 1975-1991
DIW/IFEU/IVU/HACON (1994)	Verminderung der Luft- und Lärmbelastungen im Güterfernverkehr 2010
Intraplan (1996)	Gesamtwirtschaftliche Bewertung der Rollenden Landstraße Dresden-Lobositz
EPCEM (1998)	Shifting Freight from Road to Rail: the potential of intermodal transport in Europe
Benz (1999)	Umweltverträglichkeit von Transportketten
CNT Rapport Bonnafous (1999)	Les transports et l´environnement: vers un nouvel équilibre
DZLR (1999)	Die Umweltbilanz des Verkehrs
IFEU (1999)	Mobilitäts-Bilanz für Personen und Güter
FH Pforzheim/IFEU (1999)	Anleitung zur betrieblichen Erfassung verkehrsbedingter Umwelteinwirkungen
Orfeuil (1999)	Transport et effet de serre
ADEME/MIES (2000)	Changement climatique: un défi majeur
AEE/EAA (2000)	Are we moving in the right direction? Indicators on transport and environment in the EU
Beauvais Consultants (2000)	Transport de marchandises et environnement : Données et références
CGEA/Connex (2000)	Estimation de la réduction des émissions de CO_2 entre le transport routier et le transport combiné rail-route
DAEI/SES/INSEE (2000)	38ème Rapport de la commission de compte de la nation. Thème du chapitre 11 des nuisances générées par les transports
ISIS, ZEW et al. (2000)	Real Cost Reduction of Door-to-Door Intermodal Transport (ReCoRDIT)
MIES/MATE (2000)	Programme National de lutte contre le changement climatique
OCDE (2000)	Stratégies de réduction des gaz à effet de serre émanants du transport routier: méthode d´analyse
TRAFICO (2000)	Verkehrs- und Umweltpolitische Bedeutung der ROLA für Österreich
Die Bahn (2001)	Umweltbericht 2000
Bahn-Umweltzentrum (2001)	Railways and Environment – Contribution to Sustainable Mobility

CGP- Boiteux (2001)	Transport : choix des investissements et coûts des nuisances - Rapport Boiteux
Externproject series (2001)	External costs of energy conversion
Girault (2001)	Le volet transport du programme national de lutte contre le changement climatique
IEA (2001a)	Saving Oil and Reducing CO_2 Emissions in Transport
IEA (2001b)	CO_2 Emissions from Fuel Combustion 1971-1999 (2001 Edition)
Jeger (2001)	Transports et environnements dans les pays européens
CITEPA (2002)	Emissions dans l´air en France (Métropole-Comparaison des données d´émissions de la France et d´autres pays)
CITEPA (2002)	Emissions dans l´air en France (Métropole-substances impliquées dans le phénomène d´accroissement de l´effet de serre)
FS/Amici della terra (2002)	The environmental and social costs of mobility in Italy
IFEU/SGKV (2002)	Comparative Analysis of Energy Consumption and CO_2 Emissions of Road Transport and Combined Transport Road/Rail
JacobsGibb (2002)	Environmental benefits of the WCML modernisation programme on air quality and climate change
CGP-Giraud (2002)	Effet de serre: Modélisation économique et décision politique
SBB/BLS Cargo (2002)	Schienengüterverkehr in der Schweiz: Ein innovatives Vorreitermodell zur Eindämmung des Klimawandels
SPE (2002)	Thema Europa: Verkehr und Umwelt – Strategien für ein nachhaltiges Verkehrssystem in Europa
DSC/ITD/ITS (current)	Transport, Economy and CO_2 (TRANS ECO2)
FIAT/Grimaldi (current)	Door to Door developments within short sea shipping

While some of the studies compare conventional rail transport to road transport (instead of comparing combined road/rail transport to pure road transport), they provide valuable information about reference emission values for main course transport by rail and about methods for the analysis of combined transport.

Conclusion 1: Among a large variety of studies dealing with environmental effects of freight transport, 39 of them considering CO_2 emissions of rail and/or road transport were assessed.

The Shift within the Environmental Discussion

While there are numerous other studies about environmental impacts (e.g. energy consumption) and emissions of especially road (but also rail) transport, most of them deal with toxic emissions, but not with carbon dioxide emissions. During the 1980s in Europe, the debate concentrated on emissions like NO_x, CO, HC, SO_2, Diesel particles etc., but their environmental impact diminishes as catalyst vehicles and diesel vehicles with few emissions replace older vehicles.[15] As stated in an often-cited study[16] made by the German "IFEU Institut für Energie- und Umweltforschung", Heidelberg, the road transport in Germany will emit in 2015 64 up to 88 per cent less NO_x, CO, HC and Diesel particles compared to 1990 although a further high increase of the total transport volume is assumed.

Since the same pollutant in many cases is relevant for several environmental problems, reducing the emissions for one pollutant will also create benefit for other ones. For example, reductions of CO_2 emissions to address climate change will also reduce SO_2, NO_x and CO emissions and hence improve acidification, tropospheric ozone and urban air quality (as stated by the European Environment Agency under http://reports.eea.eu.int/92-9167-059-6-sum/en/page001.html). Most of the studies have concluded that if the CO_2 targets were met, the other emission targets would also be met. Thus, CO_2 reduction should be the core point in the political discussions about environmental issues.

Road transport emissions in the field of SO_2/SO_3, NO_x and CO have decreased, so that environmental discussions have concentrated on CO_2 and the "greenhouse effect" discussion came up in the 1990s, so since that time, the researches on the emissions in transport lies on CO_2. This is the reason why nearly all of the studies listed above derive from the 1990s.

While a projection of CO_2 emissions in the Alpine Region (Austria, France, Italy, Switzerland) of all transport modes for a "business-as-usual" scenario forecasts an increase of about 40 per cent between 1990 and 2030,[17] another recent important case to be mentioned is the problem of NO_x immissions in the Austrian Inn valley, which means the effect on neighbouring property of NO_x emissions. There do exist several studies examining the implications of the NO_x emissions on NO_x immissions, and they claim heavy road transport as emitter (in connection with complex meteorological (wind) and topographic (small valley) circumstances) to be the main reason for high immissions in winter and at night.[18]

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[15] This is especially true for CO and NMHC. Source: Süddeutscher Verkehrskurier No. 8/9-2002

[16] „Entwicklung der Fahrleistungen und Emissionen des Straßengüterverkehrs 1990 bis 2015", published in 1999 by Verband der Automobilindustrie e.V. (VDA). For this study, the area of interest is Germany. See also the paper "SPE (2002)" listed in part IV.

[17] Source: OECD: est! **e**nvironnemental **s**ustainable **t**ransport, Wien 2000

[18] These at least six studies were for instance made by the Oekosience AG (Zürich), the European Environment Agency, and others. One result is: at night, a vehicle driving along the Inn valley motorway causes, in spite of equal and comparable emissions, six times higher immissions than during the day. In winter, this negative external effect is even 3,5 times higher. For these reasons, and because of current national and European legal regulations, Tyrolean Government has justified a night ban for heavy truck traffic in the lower Inn valley during the winter. Source: Verkehrs-Rundschau Nr. 42/2002, http://www.tirol.gv.at/regierung/

Nevertheless, there are still some very actual studies dealing with toxic emissions of different transport modes (road transport, combined transport), such as the new study of the Hungarian ministry of transport and waterways (2001).[19]

Conclusion 2: All of the 39 assessed studies dealing with the topic CO_2 emissions were published during the last fifteen years or are to be published, with the majority (34) of them later than 1998. This is a sign for a shift of emphasis within the environmental discussion towards CO_2 emissions.

Towards a European Perspective

Among these 39 assessed studies, 14 were published in German, 13 in English, 16 in French, one in Danish and one in Italian (double counts exist because of the multilingual publishing of at least six of the studies). The analysis mainly focused on national geographic units, as the table below shows:

Research Institute / Author	**Geographical Area of Interest**	**Client**
SGKV (1988)	Germany	*German* Research Consortium Combined Transport
Fonger (1993)	Germany / (Austria)	-- *[20]
Danielis (1994)	Italy	-- **[21]
DIW/IFEU/IVU/HACON(1994)	Germany	Umweltbundesamt (*German* environmental agency)
Intraplan (1996)	Germany (Czech Republic)	Government of Saxonia (Land in *Germany*)
EPCEM (1998)	Germany/Netherlands (international)	--***[22]
Benz (1999)	Germany	--****[23]
CNT-Bonnafous (1999)	Global Analysis	Public, *French* National Council of Transportations
DZLR (1999)	Germany	Deutsches Verkehrsforum (*Germany*)
IFEU (1999)	Germany	*German* Railways, WWF
FH Pforzheim/IFEU (1999)	Germany	Umweltbundesamt (*German* environmental agency)
Orfeuil (1999)	especially France	***** [24]
ADEME/MIES (2000)	mainly Global Analysis	Interdepartmental Mission of two *French* Agencies

[19] „Die Perspektive des Kombinierten Verkehrs im Spiegel der aufrechterhaltbaren Entwicklung der bürgerlichen Gesellschaft und seine Wirkung auf die Umwelt“, published in December 2001 in Budapest in German and Hungarian language (Author: János Verbóczky) and taken into consideration by the UN/ECE.
* Theoretical approach of a research institute at the University of Münster (Germany)
** Paper of a research institute at the University of Trieste (Italy)
*** European Postgraduate scientific work
**** Dissertation in Germany
***** Book of professor at the University of Paris

AEE/EEA (2000)	Europe	EU (project TERM)
Beauvais Consultants (2000)	France	?
CGEA/Connex (2000)	France/Italy	?
DAEI/SES/INSEE (2000)	France	Public, national (*France*)
ISIS, ZEW et al. (2000)	Europe	Supported by EU, DG TREN
MIES/MATE (2000)	France	Interdepartmental Mission two *French* Authorities
OCDE (2000)	OECD countries	International Program research regarding transportations road and intermodal liaisons (RTR)
TRAFICO (2000)	Austria	*Austrian* operator ÖKOMBI
Die Bahn (2001)	Germany	*German* Railways
Bahn-Umweltzentrum (2001)	Germany	UIC, CER, German Railways
CGP-Boiteux (2001)	France	Public, national (*France*)
ExternE project series(2001)	Europe	Supported by EU, DG Research
Girault (2001)	France	*French* Ministry of the equipment, Transportations, Lodging (SES)
IEA (2001a)	26 countries in different continents	International Energy Agency
IEA (2001b)	140 countries and regions in different continents	International Energy Agency, in preparation for a Convention of the United Nations (UN)
Jeger (2001)	Europe	*French* Ministry of the equipment, Transportations, Lodging (SES)
CITEPA (2002a)	EU, France	?
CITEPA (2002b)	France	?
FS/Amici della Terra (2002)	Italy	?
IFEU/SGKV (2002)	Central and Western Europe, Alps	IRU/BGL
JacobsGibb (2002)	Great Britain	Rail Freight Group / Railtrack (from *Britain*)
CGP-Giraud (2002)	esp. France	Public, national (*France*)
SBB/BLS Cargo (2002)	Switzerland	--****[25]
SPE (2002)	EU	--*****[26]
DSC/ITD/ITS (current)	Denmark, Intra-European traffic	DSC, ITS, ITD (all from *Denmark*)
FIAT/Grimaldi (current)	International Traffic in Western Europe/ Mediterranean Region, originating in Italy	FIAT/Grimaldi

**** Own initiative
***** Contribution to political discussion.

Conclusion 3: Most of the examined studies are published in French, German and English. The lack of European perspective within the analysis is diminishing as more and more international organisations (e.g. OECD, the European Union) are involved in the research process about CO_2 emissions of different transport modes.

Micro versus Macro Perspective

Some of the above mentioned studies focus on certain relations/corridors/transport chains, while other found their area of observation in countries as a whole. As a consequence, the studies can be divided into studies with an underlying "room" perspective with the output "global/regional/country-specific CO_2 emissions", and studies with an underlying "corridor" perspective with the output "CO_2 emissions per main course/pre-carriage/on-carriage/transport chain". The following table illustrates the underlying, basic perspective/view of the examined research studies, which has strong implementations for the methods and results provided by the studies:

Research Institute / Author	Country of Interest	Unit of interest
SGKV (1988)	Germany	All combined transport road/rail
Fonger (1993)	Germany / (Austria)	Five long-distance transport chains
Danielis (1994)	Italy	Italy
DIW/IFEU/IVU/HACON (1994)	Germany	Germany
Intraplan (1996)	Germany (Czech Republic)	Corridor between Dresden and Lovosice
EPCEM (1998)	Germany/Netherlands (international)	Long-distance freight transport
Benz (1999)	Germany	Relations Düsseldorf-Stuttgart, Hamburg-München
CNT-Bonnafous (1999)	Global Analysis	Common Approach
DZLR (1999)	Germany	Germany
IFEU (1999)	Germany	Germany
FH Pforzheim/IFEU (1999)	Germany	Germany
Orfeuil (1999)	especially France	France
ADEME/MIES (2000)	mainly Global analysis	World
AEE/EAA (2000)	Europe	EU
Beauvais Consultants (2000)	France	France
CGEA/Connex (2000)	France/Italy	Two relations: Bonneuil-Milan and Bonneuil-Tarascon
DAEI/SES/INSEE (2000)	France	France

ISIS, ZEW et al. (2000)	Europe	EU (WP1), Corridors Genova-Manchester, Patras-Gothenburg, Barcelona-Warsaw (WP2)
MIES/MATE (2000)	France	France
OCDE (2000)	OECD countries	OECD member countries
TRAFICO (2000)	Austria	Austrian Rolling Road operations
Die Bahn (2001)	Germany	Germany
Bahn-Umweltzentrum (2001)	Germany	Relation München-Hamburg-Billwerder
CGP-Boiteux (2001)	France	Common Approach
ExternE project series (2001)	Europe	Europe
Girault (2001)	France	France
IEA (2001a)	26 countries in different continents	26 industrialized IEA member countries
IEA (2001b)	140 countries and regions in different continents	140 countries and regions
Jeger (2001)	Europe	EU
CITEPA (2002a)	EU, France	EU, France
CITEPA (2002b)	France	France
FS/Amici della Terra (2002)	Italy	Italy
IFEU/SGKV (2002)	Central and Western Europe, Alps	Twelve typical currently served European transport corridors plus one fictive and one short-distance operation
JacobsGibb (2002)	Great Britain	West Coast Main Line
CGP-Giraud (2002)	esp. France	France
SBB/BLS Cargo (2002)	Switzerland	All transalpine traffic of *Swiss* operators Hupac and RALpin via the corridors “Gotthard” and “Lötschberg”
SPE (2002)	EU / Western Europe	EU member states
DSC/ITD/ITS (current)	Denmark, Intra-European traffic	Relation Billund (DK)-Baar (CH)
FIAT/Grimaldi (current)	International Traffic in Western Europe/Mediterranean Region, originating in Italy	Destinations between Italian and other European locations

Conclusion 4: Twelve studies have analysed certain transport relations, while the other 27 examinations deal with a more or less “global” (country-specific, EU-wide etc.) analysis. Most of the “micro” studies come from Germany, while most of the French studies are “macro” studies.

The principal Methods

The methods used for accounting the carbon dioxide emissions can be different according to the parameters used in the studies. For instance, most of the studies derive the CO_2 emissions from the energy consumption, but some do not. If energy consumption is regarded, the transfer of primary energy into secondary energy can be taken into account in a way that the whole energy chain is analysed, or not. Another aspect for clustering the research is what the unit of the results looks like. Some calculations took the pre- and on-carriage by truck needed for combined transport into consideration and some did not. Quite important aspects of the results are the data input: the question is whether they are assumed, averaged, typical, historical or real-time. As far as the survey of **German and English studies** is concerned, the table below shows the principal methods of calculation:

Research Institute / Author	Calculation out of energy consumption	Primary energy consumption considered	Unit of calculation result	Feeding/Delivery explicitly considered	Principal Method
SGKV (1988)	yes	road transport = no, rail transport = yes	"Intoxication units"	no	With-or-without-Analysis between road transport and combined transport
Fonger (1993)	(Data derived from other studies)	(Data derived from other studies)	g/tkm, tonnes	yes	(Data derived from other studies)
DIW/IFEU/IVU/HACON (1994)	yes	?	tonnes	yes	Scenario analysis (horizon: 2010), sensitivity analysis, (TREMOD-model)
Intraplan (1996)	yes	?	monetary value (costs per ton)	no	With-or-without-Analysis, calculation out of given consumption functions
EPCEM (1998)	?	?	g/tkm, tonnes	no	Scenario analysis (horizon: 1990, 2015)
Benz (1999)	yes	yes	percentage of saving	yes	Sensitivity analysis, calculation out of modelled consumption functions, break-even analysis
DZLR (1999)	yes	yes	g/tkm, tonnes	yes	Sum-up of the results of other work, including technical improvements in future, TREMOD-model
IFEU (1999)	yes	yes	kg/ton moved	yes	TREMOD-model (by IFEU) with actual data
FH Pforzheim/IFEU (1999)	yes	yes	g/tkm	yes	TREMOD
ISIS, ZEW et al. (2000)	yes	yes	tonnes, monetary shadow value in €/t of emission	(Data derived from other studies)	Avoidance cost approach, data underlying the Kyoto protocol used, most data derived from other studies,

					emissions for manufacturing of the vehicles included
TRAFICO (2000)	(Data derived from other studies)	(Data derived from other studies)	saved external costs per ton-kilometre, tonnes	(Data derived from other studies)	real data and scenario data "2010", GLOBEMI-model, rail calculation data taken from other studies
Die Bahn (2001)	yes	yes	g/tkm	no	TREMOD-model
Bahn-Umweltzentrum (2001)	yes	yes	g/tkm, tonnes, kg/ton moved	no	see "IFEU (1999)", TREMOD, some actual real data, one-way-analysis
ExternE project series (2001)	?	?	marginal external costs throughout Europe	?	„Impact Pathway"-approach, avoidance cost approach,. Cost-benefit-analysis, technical progress considered
IEA (2001a)			costs/benefits per option		Technical approaches to reduce emissions are shown.
IEA (2001b)					IEA databases and emission factors of IPCC guidelines used
IFEU/SGKV (2002)	yes	yes	kg/truck unit	yes	TREMOD, sensitivity analysis, break-even analysis
JacobsGibb (2002)		yes	tonnes, monetary values (£) per tkm	no	With-or-without-Analysis between road transport and rail transport
SBB/BLS Cargo (2002)	yes	yes	tonnes		Average value of calculation results given through two former methods
SPE (2002)	(Data derived from other studies)	(Data derived from other studies)	tonnes, g/tkm, monetary values (€, €/tkm)	(Data derived from other studies)	Sum-up of the results of other work (e.g. TREMOD by IFEU).
DSC/ITD/ITS (current)	yes	?	percentage of saving potential, costs	yes	NN
FIAT/Grimaldi (current)	?	?	g/tkm, tonnes	yes	NN

Out of the table, it is obvious that most of the research institutes calculate the carbon dioxide emissions as a result of energy consumption. In nearly all of these 13 studies, the aspect primary energy input (the energy mix of the power plants) is respected. The implication is that, for a meaningful analysis, the whole energy chain has to be regarded.

While nine studies consider the pre- and on-carriage by road, six do not. But one has to keep in mind, that the research work provided by IEA and ExternE has focused on the technical development in transport.

In eight of the studies, data of the TREMOD-model, developed by IFEU, is used as input for the calculation. This might be because IFEU has been involved in the topic very often and has a good reputation as an expert.

Some of the research leads to a further scenario analysis. In some work, sensivity analysis or break-even analysis took place.

The unit of the calculation is strongly related with the unit of interest: a potential reduction for a whole country is expressed in emitted tonnes of CO_2, while a certain transport causes a certain amount of CO_2 measured in kg or g per ton moved or per ton-kilometre. IFEU/SGKV (2002) and SPE (2002) provide information about the emitted amount of CO_2 expressed in kg/truckload moved on road or rail.

As far as the **French studies** are concerned, some are providing technical information on e.g. truck and locomotive emissions, policy measure studies (e.g. about truck utilisation in the urban area, comparison of trucks being used only for Combined Transport to trucks used for pure road transport), and aggregate studies (production of reference figures by national and environmental accounts,…).

Some of the (German, French and Italian) studies contain a monetary evaluation of the CO_2 emissions, like Intraplan (1996), Trafico (2000), ISIS/ZEW et al. (2000), CGP-Boiteux (2001), ExternE (2001), IEA (2001), Jacobs Gibb (2002), SPE (2002), FS/Amici della Terra (2002) and DSC et al. give monetary values. Besides, SGKV (1988) measures the result in form of “intoxication units”.

Conclusion 5: To calculate the CO_2 emissions, it is common to compute them out of the energy consumption including the consumption of primary energy (many studies provide valuable information on the technical details needed). To compare road and combined road/rail transport as an alternative transport system; feeding/delivery by truck has to be included into the energy consumption figures. To get the results, usually functions are modelled. Then, real or assumed data are put into the functions, and various kind of analysis can be carried out. It is common to measure CO_2 saving potential in tonnes per year or in gram per ton-kilometre. To get to monetary values, the emission functions have to be supplemented by more or less subjective cost functions. For future scenarios, some studies provide the impact of technical innovations in transport technology. A differentiation has to be made between preliminary studies on technical features, concrete calculation models and studies dealing with an analysis of more or less global effects.

The main results

It is important to mention that the methods and assumptions of the studies deviate, so the results cannot be easily compared. In most cases, rail transport or combined road/rail transport helps clearly to reduce carbon dioxide emissions.

Research Institute / Author	Result
SGKV (1988)	combined transport produces only 13 % of toxic emissions of road transport
Fonger (1993)	emission ratio between combined and road transport *for certain relations* is about 1:3
Danielis (1994)	(In Italy, rail transport uses less energy per ton-km, only about 13 % than road transport)
DIW/IFEU/IVU/HACON (1994)	emission ratio between combined and road transport *for whole Germany*: 1:3 (1988), 1:7 (2010 « Trend »), 1:4 (2010 « Reduction »)
Intraplan (1996)	--*
EPCEM (1998)	emission ratio between combined (only main course) and road transport *in g/tkm*: 1:4 both for the year 1990 and the year 2015
Benz (1999)	Increase of emissions with shift to combined transport because of electricity mix of German Railways
CNT-Bonnafous (1999)	-
DZLR (1999)	emission ratio between rail and road transport *in g/tkm*: 1:5,5 for the year 1980, 1:6 for 1990, 1:5 for 1996.
IFEU (1999)	emission ratio between combined and road transport *for certain relations* is about 1:3.
FH Pforzheim/IFEU (1999)	emission ratio between rail and road transport (average truck) *in g/tkm*: 1:4,5. For articulated trucks >32 t vehicle gross weight, the ratio is only 1:3,5.
Orfeuil (1999)	(In France, rail transport uses less energy per ton-km, but only direct trains, no single wagon traffic)
ADEME/MIES (2000)	-
AEE/EAA (2000)	France is in favour of rail transport because it is more economic in energy per ton kilometre transported.
Beauvais consultants (2000)	In France, road transport causes 0,015 kg of CO_2 emissions, rail transport 0 kg per tkm (nuclear power!).
CGEA/Connex (2000)	emission ratio between combined road/rail transport and road transport for two relations: about 1:2
DAEI/SES/INSEE (2000)	In France, in 1999 road transport in total caused 126 Mio. t of CO_2 emissions, while rail transport caused only 0,7 Mio. t.
ISIS, ZEW et al. (2000)	37 € per ton of CO_2 emission as shadow value for reducing the CO_2 emissions in Europe to reach the guidelines of the Kyoto protocol (5,2 % reduction).

* It is not recognizable whether the environmental Benefit of the RoLa results from lower CO_2 emissions or the induced reduction of other emissions.

MIES/MATE (2000)	To reduce CO_2 emissions of transport in France by 4 Mio. t to grow to 40 Mio t in 2010, five actions of combined transport lead to 0,2 Mio. t less CO_2.
OCDE (2000)	In France, road transport causes 94 %, in Italy 98 %, in Germany 97 % and in Britain 87 % of all CO_2 emissions deriving from the transport sector.
TRAFICO (2000)	Austrian Rolling Roads helped to save 113.500 t in 1999 and help to save between 106.000 and 148.300 t in 2010
Die Bahn (2001)	emission ratio between rail and road transport *in g/tkm*: 1:7
Bahn-Umweltzentrum (2001)	emission ratio between rail and road transport *in g/tkm*: 1:6; emission ratio between combined and road transport *for a certain relation* is about 1:1,7. Combined transport in Switzerland helped to save 91.000 t of CO_2 emissions in 2001, for 2007, 230.000 t could be reached.
CGP-Boiteux (2001)	The reference value per ton of carbon dioxide for its negative impact in the public infrastructure choices is estimated to be 100 €.
ExternE project series (2001)	--
Girault (2001)	In France, between 1990 and 2010 CO_2 emissions of road transport will grow by 29 % from 30.3 to 39.11 Mio. t, while rail transport will remain at about 0.3 Mio. t.
IEA (2001a)	--
IEA (2001b)	NN
Jeger (2001)	-
CITEPA (2002a)	-
CITEPA (2002b)	-
FS/Amici della Terra (2002)	-
IFEU/SGKV (2002)	Of 19 considered transport relations, in six cases the CO_2 emissions of combined transport are between 15 % lower and 3 % higher than road transport (ratio nearly 1:1), in other seven cases between 50 and 80 % of road transport emissions (ratio between 1:1,25 and1:2), in six cases less than 50 % of road transport emissions (ratio between 1:2 and 1:6).
JacobsGibb (2002)	emission ratio in relative cost per tkm for rail freight transport and for road freight transport 1:3,5
CGP (2002)	In France, between 1990 and 2010 CO_2 emissions of road transport will grow by 29 % from 30.3 to 39.11 Mio. t, while rail transport will remain at about 0.3 Mio. t.
SBB/BLS Cargo (2002)	For the transalpine traffic between 1994 and 2000, *on average* one unaccompanied consignment carried by Hupac on the Gotthard or Lötschberg axis saved between 4 and 4.5 t of CO_2 emission, and one accompanied consignment carried by Hupac (on the Gotthard axis) *on average* helped to save between 4 and 5 t of CO_2 emission.
SPE (2002)	emission ratio between rail and road transport throughout Europe expressed in costs per ton-km: 1:2,5 / expressed in g/tkm 1:3,5
DSC/ITD/ITS (current)	for a certain relation, combined transport reduced up to 50 % of the CO_2 emissions
FIAT/Grimaldi (current)	emission ratio between combined and road transport *for certain relations* is about 1:2,5

Conclusion 6: Different methods lead to results that are difficult to compare. Nevertheless, in all of the assessed studies, *the results in form of CO_2 emissions*, the ratio of the emissions for combined road/rail transport or pure rail transport to road transport rates between 1:1 and 1:7 (weighted average: about 1:3-1:4, median: 1:3). The large variety of results from the specific assumptions, basic data and methods underlying the analysis, so the results are in a way determined before the analysis. Rail transport is always favourable when only the main course is regarded and pre- and on-carriages neglected. This is also true for energy consumption of the transport modes.

About the monetary evaluation of CO_2 emissions

The environmental question, and particularly the greenhouse gas emissions (CO_2) are treated in every transport infrastructure project. The conclusion of the study of such investments must include an assessment of environmental impacts (in monetary units if possible). For the external costs of the carbon dioxide ton, it is necessary to note in the following comparative table a certain disparity, which notably refers to the difference of the reference year and also the geographical unit of observation.

Evaluation of the external costs per Ton CO_2

Study	IWW-INFRAS	Amici della Terra	Rapport Boiteux
Year of reference	1995	1999	2000
Cost per ton CO_2	37-135€	77€	100€
			(150 € proposed by the sensitivity analysis)

The idea of the entitled report « Transportation: choices of the investments and costs of the nuisances » presided by Mr. Boiteux (a well known "economist" for public analysis in the world) for the French General Commissionership to the Plan in 2001, is to take the environmental external effects of transport (effect on noise, air pollution, greenhouse gas emissions…) into account, and give them monetary estimation. In the Boiteux Report, the reference value for negative environmental impacts per carbon dioxide ton is estimated to 100 € and the supposed emissions of the transport sector equal to 0,71 kg of carbon dioxide per litre consumed.

The French national programme against the climatic change 2000-2010 has fixed a tax on the carbon dioxide that will be progressively put to 500 F/ton of carbon. (= 76 EUR/ton). This value was obtained with following references: a barrel price of 24 dollars in 2010 and a franc-dollar parity of 0,75 EUR for a dollar). However, in the Boiteux Report, it is estimated that, considering the use of infrastructure beyond 2012 (after Kyoto), it is necessary to take "a value a little higher". It gives a cost of the "carbon dioxide ton" equal to 100 euros for the period that goes from 2000 to 2010.

The approach is a cost-effective one that has to define an implicit "external price of carbon". In the Boiteux Report, it has been considered that this will be influenced by the evolution of the oil and gas prices. Thus, the definition of a temporal evolution of the "carbon price" becomes a technical and a political exercise.

So it is proposed to apply in the economic calculations concerning the public choices of transportation infrastructures a price of 100 euros by ton of carbon for the period 2000-2010. The report proposes to apply a moderate growth rate of the carbon price equal to 3% per year after that the objectives of the Kyoto Protocol will be fully realised.

Why this conclusion? The estimation of the Boiteux Report is based on a three-step analysis:

1. The theory of non-renewable resources cannot be applied for CO_2 emissions. The question is more related to a problem of CO_2 accumulation than to a problem of global limited amount of petroleum and risk of exhaustive of such an energy source.
2. The modelling approach of a general equilibrium of the economy under constraints (which are in this case the Kyoto constraints: reduction of CO_2 emission at the horizon of 2012) is relevant; according to different computations, this will give a price range between 70 and 150 Euros per ton of carbon saved, (with a barrel price from 7 to 24 dollars per ton).
3. However the dynamic aspect must also be taken into account on a medium and long term horizon, this means:
    - Possibility of alternative primary energy source, which will appear more credible when the price of a barrel will be above 30 dollars per ton.
    - The political risk due to political instability in producing countries.

Based on these three elements, there is a will to attribute a "tutelary value" to the ton of carbon dioxide saved (so that it is included in CBA analysis - otherwise it will never be – and so that the estimation is the same for all projects).

It is also important to mention that the "Groupe Boiteux" proposed to set a group to pursue research on the method, to follow up the results of the models and eventually propose an update of this estimation. In any case, this value will become a reference value in France and CBA methodology. The "Groupe Boiteux" might also influence other CBA directives.

II. Case studies on different corridors based on current traffic volumes

Methodology

As the budget for the PACT project does not allow a complete own scientific research, the main data of CO_2 reduction through combined transport have to be obtained by exploiting existing studies. The PACT study will adopt the same methodological approach as the IFEU/SGKV study with a deduction of CO_2 emissions via the energy consumption. The latter study implies a comparison of a one-way transport of one single consignment from A to B by road and by combined road/rail transport taking into account the following parameters: the energy consumption and the CO_2 emissions (disaggregated micro-perspective). Furthermore, it seems that the IFEU/SGKV study, as one of the latest studies in this field and going very much in detail for the area of combined transport, is already seen as a reference for the scientific approach in forthcoming studies.

The main features of the IFEU/SGKV study are

- considering a *typical* transport (no extreme values),
- taking pre- and on carriage into consideration,
- using real data as far as routes, weights of loading units, typical loading mixes, terminal haulage and train capacity usage are concerned,
- focalising on block trains (no single wagon traffic),
- analysing all sorts of intermodal loading units (swap bodies, containers, semi-trailers, articulated vehicles and road trains),
- deducting the CO_2 emissions out of the energy consumption, because CO_2 emissions depend on the specific energy consumption,
- taking into account the country-specific energy input mix (power supply system) of railway electricity and the use of Diesel traction.

Empty runs of intermodal loading units on their way back are neglected, because (at least as far as swap bodies and trailers are concerned) hauliers are able to allocate their intermodal equipment efficiently, so equivalent conditions for the way back can be assumed.

Empty runs of railway wagons are neglected, too. In this study, the focus is on well-performing segments of combined transport market with high traffic volume. These well-performing market segments show nearly always the production type “shuttle train” or “block train”, so the re-positioning of empty railway wagons represents for this kind of railway business only a small problem. The operators try to avoid the production type of “single wagon traffic”. There are more and more shuttles, so the re-positioning problem becomes nearly redundant.

CO_2 emissions depend on primary energy input. In Switzerland and Austria (Water), the share of renewable energies is high, and the train electricity generation implies few CO_2. The same is true for France, with a major share of nuclear energy production. On the other hand, the energy efficiency of some power plants is only about 45 %, with electric locomotives loosing some additional energy. The German company IFEU has developed the energy model of the IFEU/SGKV study. Seven other studies have based their calculation on this model, (see “German and English Survey”).

As one result of the study, it became clear that shunting and intermodal transfers are not as energy intensive as thought before. The same could be pointed out about the influence of grade along the routes on energy consumption, because in most of the cases (except the corridor Germany-Czech Republic), road and rail show comparable grades and therefore parallel modifications in energy consumption.

Of a much higher importance is the train capacity usage. Even 5 % more or less of train capacity usage oscillation is quite relevant to the result. Commercially viable trains imply environmental benefits and vice versa. As one may say that 80 % of capacity usage is necessary for a commercially viable shuttle train, most of the trains operating under market conditions show environmental benefits. Another important influence factor is the deadweight of intermodal loading units and route deviations resulting from political restraints.

The IFEU/SGKV study has ended with a description of cases with different practical relevance. The PACT study wants to aggregate such a case-by-case-comparison by multiplying the single-trip values with the real traffic volume (practical relevance). The cases will be weighted by their real importance (unlike the method of IFEU/SGKV study) and updated where more precise data are available for the same period (year 2001).

The focus on the analysis remains on certain European corridors, not on the whole European traffic volume. On the other hand, the most important corridors are involved in the analysis anyway.

In conclusion, the methodology of this study proceeds in the following steps:

1. Evaluation of the energy use
   a) per case road versus CT-chain
   b) per kilometre road versus rail
2. Deduction of CO_2 emissions out of the energy consumptions,
   a) per case road versus CT-chain
   b) per kilometre road versus rail
3. Annual CO2 savings of real traffic volume
4. Projection for doubling of Combined Transport

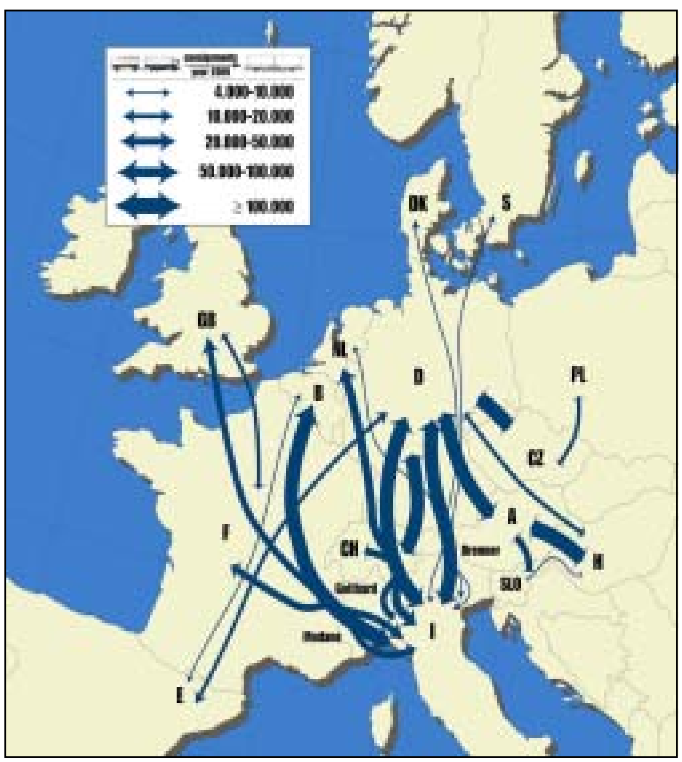
Analysed corridors

This study will analyse in a deeper way mainly the corridors in which the twenty UIRR member companies are active. The reason for this is that UIRR members have a market share of approximately 65% of European combined transport and provide consistent European wide harmonised statistics. In addition data from Intercontainer-Interfrigo is used, so that the intermodal rail–road market is widely covered. Special attention has been paid to the following major European corridors: UK/Belgium-Italy, Scandinavia/Germany-Spain, Germany-Austria/Italy and Germany-Hungary. On these corridors, the CT operators have commercialised different relations. Each corridor consists of at least one relation.

For this study, 20 relevant cases have been chosen. The table on the following page illustrates these 20 relations representing the main traffic of the UIRR member companies. A majority of cases is compatible with the study made by IFEU/SGKV[27] in order to be able to compare the results of both studies easily. Cases without practical relevance were dropped, whereas some additional cases were added in order to cover the most important combined transport axes.[28]

The study focuses on the most current CT techniques: the unaccompanied combined transport of swap bodies, containers and trailers. But, as results for Rolling motorways were recently published and with obvious shortcomings, the partners decided to investigate and update the Rolling motorway cases treated in the IFEU/SGKV study.

UIRR Traffic flows 2000/2001



[27] See description of IRU/BGL study in chapter 1 " Assessment of existing research results: A European Survey".

[28] More attention had to be paid to the Germany-Spain axis, which should show a promising development.

The analysed relations in detail

The following table shows the analysed relations with volumes of the year 2001.

Case			Relevant Units *	Consignments 2001 **			Data
No	Relation	Corridor		From	To	Sum	Source ***
UNACCOMPANIED TRAFFIC (with swap bodies, containers and trailers)							
1	Wien-Neuss	A-D	ISO Container	12.504	8.486	20.990	KV, ÖK
2	Genk - Novara	B-I	Swap Body Class A	11.604	9.332	20.936	TRW
3	Antwerpen - Busto Arsizio	B-I	40' Container	11.073	9.274	20.347	UIRR
4	Köln - Granollers	D-E	ISO Container	3.280	2.001	5.281	KV
5	Ludwigshafen - Tarragona	D-E	30' Container	2.009	1.626	3.635	KV
6	Hamburg - Budapest	D-H	ISO Container	6.059	9.680	15.739	HK
7	Köln - Busto Arsizio	D-I	2 Swap Bodies Class C	33.532	29.117	62.649	KV
8	München - Verona	D-I	ISO Container	16.092	15.792	31.884	KV, CE
9	Nürnberg - Verona	D-I	Semi-Trailer	15.026	13.770	28.796	KV, CE
10	Paris-Vercelli	F-I	Swap Body Class A	11.159	10.998	22.157	NT
11	London - Novara	GB–I	Swap Body Class A	3.001	3.664	6.665	CTL, NT
12	Novara - Rotterdam	I-NL	Swap Body Class A	21.818	22.632	44.450	CE
13a	Stockholm - Lübeck - Basel	D-CH	Semi-Trailer	2.218	1.555	3.773	UIRR
13b	Hamburg - Basel	D-CH	2 Swap Bodies Class C	6.750	4.310	11.060	KV
14	Stuttgart - Bremen	D	2 Swap Bodies Class C	6.472	6.290	12.762	KV
15	Paris -Avignon	F	Swap Body Class A	12.427	14.521	26.948	NT
16	Lille - Avignon	F	Swap Body Class A	3.770	3.128	6.898	UIRR
17	Milano - Bari	I	Swap Body Class A	6.681	6.673	13.354	CE
UNACCOMPANIED TRAFFIC				**185.475**	**172.849**	**358.324**	
ACCOMPANIED TRAFFIC (with articulated vehicles and road trains)							
18	Manching -Brennersee	D-I	Articulated Vehicle or Road Train	70.633	63.782	134.415	KV, ÖK
19	Szeged – Wels	H-A	Articulated Vehicle or Road Train	27.262	27.276	54.538	HK, ÖK
ACCOMPANIED TRAFFIC				**97.895**	**91.058**	**188.953**	
20	*Dresden - Lovosice special temporary case*	*D-CZ*	*Articulated Vehicle or Road Train*	*41.163*	*42.851*	*84.014*	*UIRR*

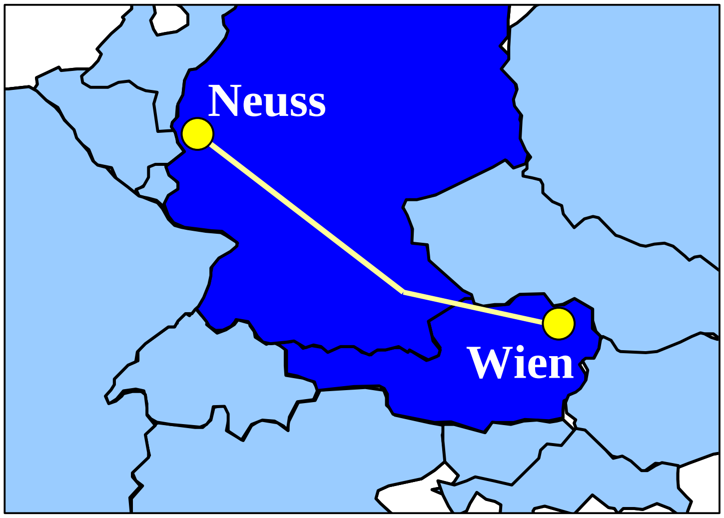
* Relevant units: Swap Body Class A (13…m or similar length), Swap Body Class C (7,15m, 7,45m, 7,82m)

** A UIRR consignment corresponds to the transport capacity of one lorry on the road (equivalent to 2,3 EVP/TEU), meaning: one semi-trailer, two swap bodies less than 8,30 m and less than 16t, one swap body more than 8,30 m or more than 16t or one vehicle on the Rolling Road.

*** KV=Kombiverkehr (Germany), ÖK=Ökombi (Austria), CE=CEMAT (Italy), HK=Hungarokombi (Hungary), TRW=Transport Route Wagon (Belgium), NT=Novatrans (France), CTL=Combined Transport Limited (UK), UIRR=International Union of combined Road-Rail transport companies

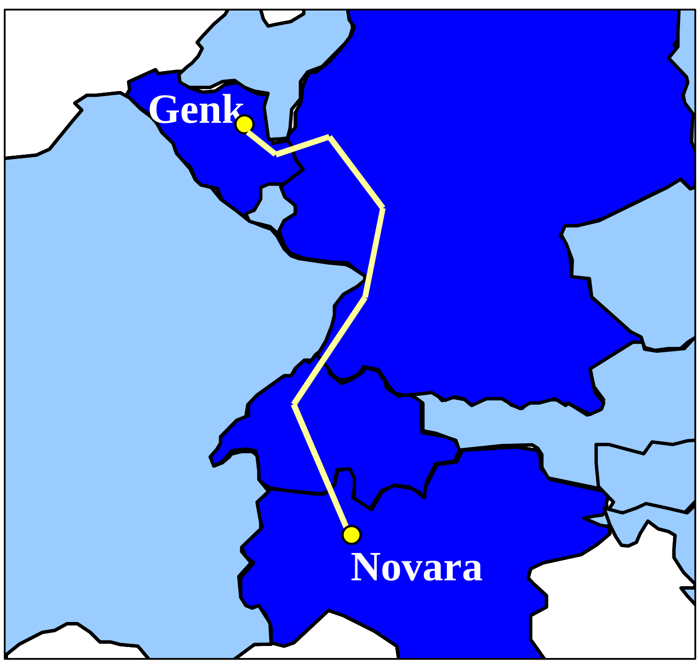
1) Wien-Neuss (Kombiverkehr, Ökombi)

This unaccompanied traffic carries lots of ISO containers, so the transport of an ISO container is observed. The corresponding road transport comes from Schwechat near Wien and goes to the Krefeld chemical industrial district near Neuss. The relation belongs to the corridor Germany-Austria.



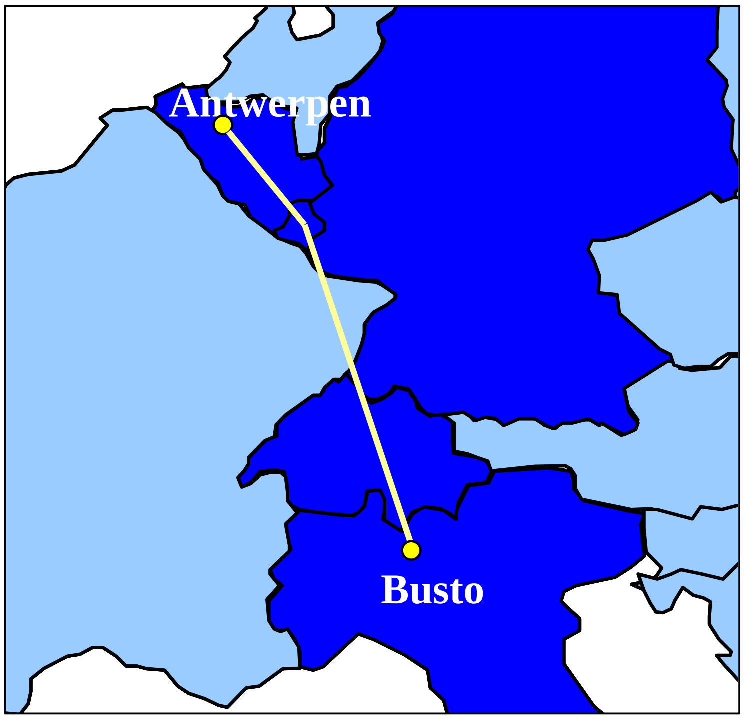
2) Genk-Novara (TRW, Cemat)

A transport from an automotive factory near Genk to the Novara/Milano industrial region is assumed. A transport of a swap body class A is typical for this relation. The corresponding road transport goes via Luxembourg and Dijon, and uses the Mt. Cenis tunnel. The relation belongs to the corridor Belgium-Italy.



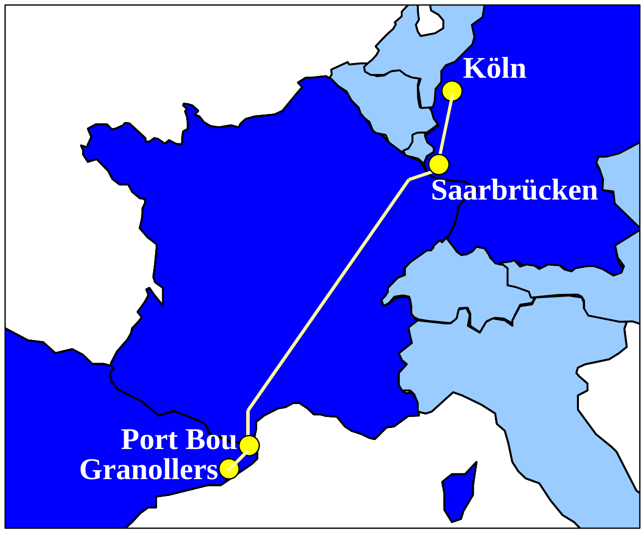
3) Antwerpen-Busto Arsizio (Hupac)

This shuttle train links the huge container port Antwerp and its industrial districts along the North Sea with the northern Italian industrial districts. 15 % of the transported units leave the terminal in Busto Arsizio by combined gateway traffic to Roma or Bari. The trains carry mainly ISO containers and swap bodies, but the transport of a 40' container is typical on this relation. The equivalent road transport follows mostly via Lyon-Mt. Cenis-Torino. The relation belongs to the corridor Belgium-Italy.



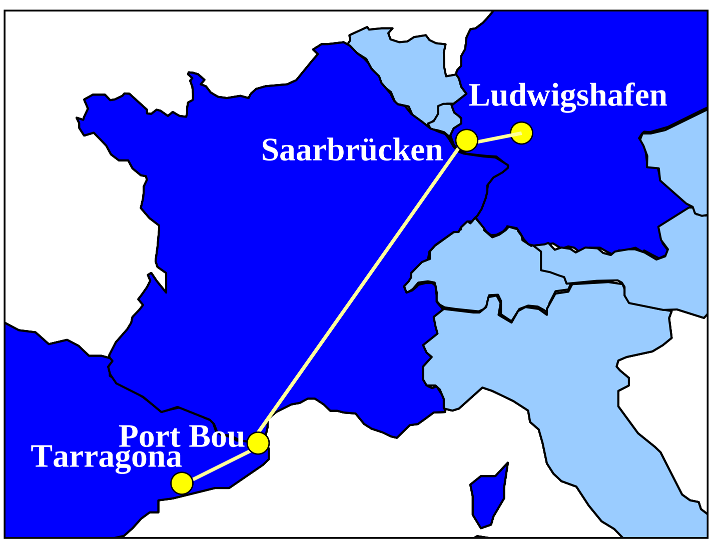
4) Köln-Granollers (Kombiverkehr, Combiberia)

Two shorter trains are coming from Mannheim and Köln to Saarbrücken with final destinations in Spain (Irun or Port Bou). In Saarbrücken, both of them are merged into one longer train. Saarbrücken has here the function of a small hub. Arriving in Port Bou, the train is again split in two smaller trains: one going to Granollers and one to Tarragona. The road transport is assumed to go via Karlsruhe-Freiburg-Lyon because of the toll fees of the French motorways. The point of departure of the transport is the industrial zone of Leverkusen and the final destination is Sabadell. The relation belongs to the corridor from the Rhine-Ruhr region/BeNeLux via France to Spain. This train moves a lot of tank containers for the chemical industry.



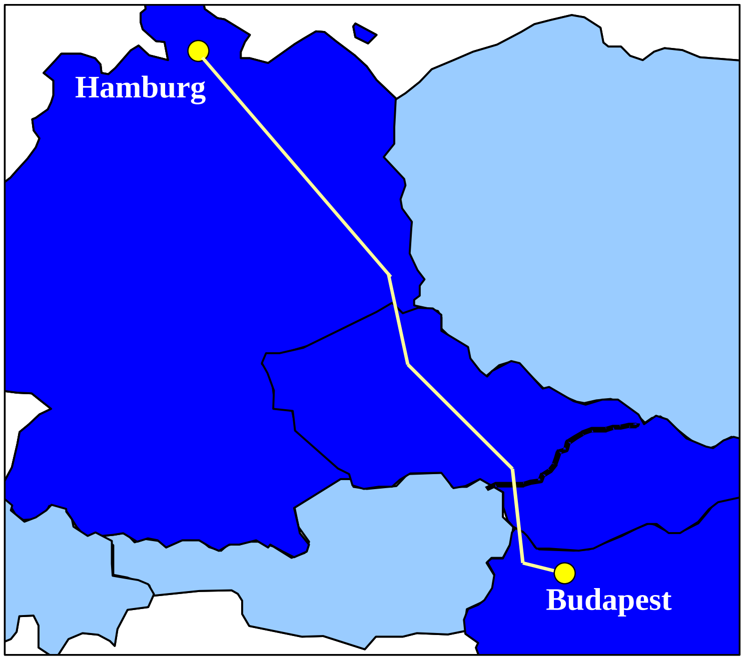
5) Ludwigshafen-Tarragona (Kombiverkehr, Combiberia)

The observed part of the Köln/Ludwigshafen-Granollers/Tarragona train coming from Ludwigshafen and going to Tarragona features just one part of the whole train, which consistsof about 10 wagons leaving for Granollers. At the French-Spanish border, the loading units are vertically craned onto other wagons having different track widths. In Granollers, about 50 % of wagons and loading units leave the train. Nearly all of the loading units are tank containers of different lengths and swap bodies coming from the chemical industry district in Ludwigshafen. The main destination is the Tarragona industrial district. The corresponding road transport is carried out by tank road trains and articulated tank vehicles driving from Ludwigshafen via Freiburg, Mulhouse, Besancon, Bourg-en-Bresse, Lyon-Sud, Avignon, Montpellier, Perpignan, Gerona and Barcelona to Tarragona. The transport of a 30' tank container is calculated. The relation belongs to the corridor Germany - Spain.



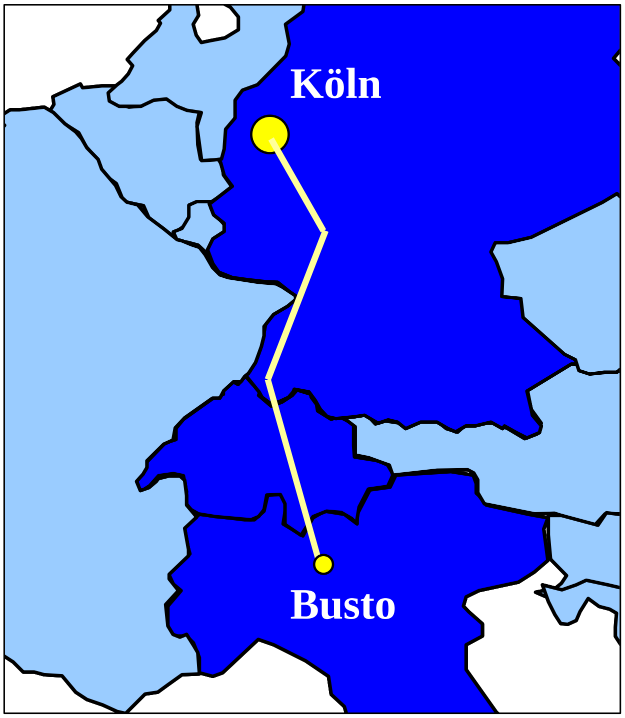
6) Hamburg-Budapest (Kombiverkehr, Hungarokombi)

This unaccompanied transport line carries only ISO containers, with greater percentage of laden containers in direction East. The containers are coming from the ports of Hamburg and Bremerhaven and are delivered by truck in the Budapest area over short distances. After transhipment on a lorry in Budapest, the container is carried for about 20 kilometres to its final destination on city and rural roads. Road transport goes via Würzburg-Passau-Wien, assumed that eco-points are available. The relation belongs to the corridor Germany-Hungary.



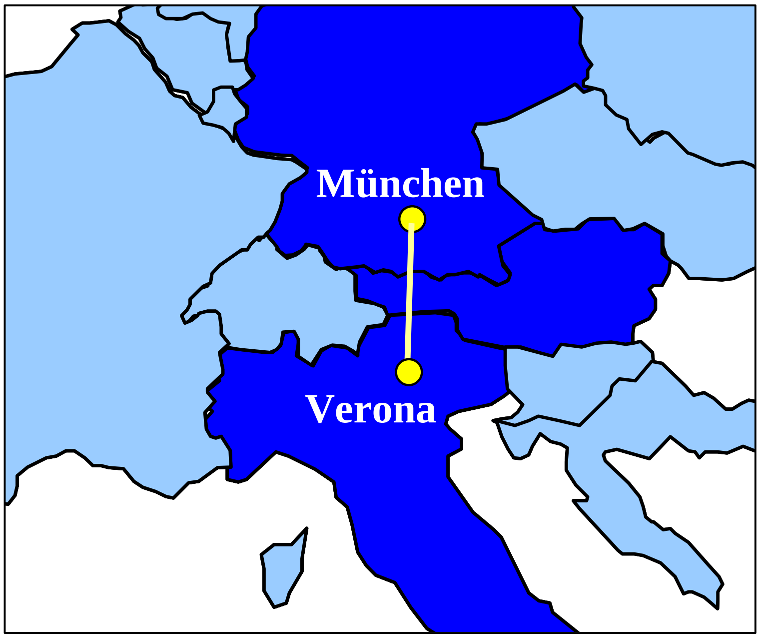
7) Köln-Busto Arsizio (Kombiverkehr, Hupac)

This relation is an unaccompanied transit through the Alps. The trains carry a lot of short swap bodies, so the trip is calculated for two class C swap bodies. Many load units are coming from the Rhine-Ruhr region, others are arriving in intermodal transport trains from the Baltic sea ports or from Hamburg and others coming by truck from Belgium, Holland or Great Britain. In Busto Arsizio, they are in the heart of the Lombardia industrial district and are mainly distributed within 20 or 50 kilometres (a certain percentage using the gateway possibilities to go further to the South). The relation belongs principally to the corridor Germany-Italy.



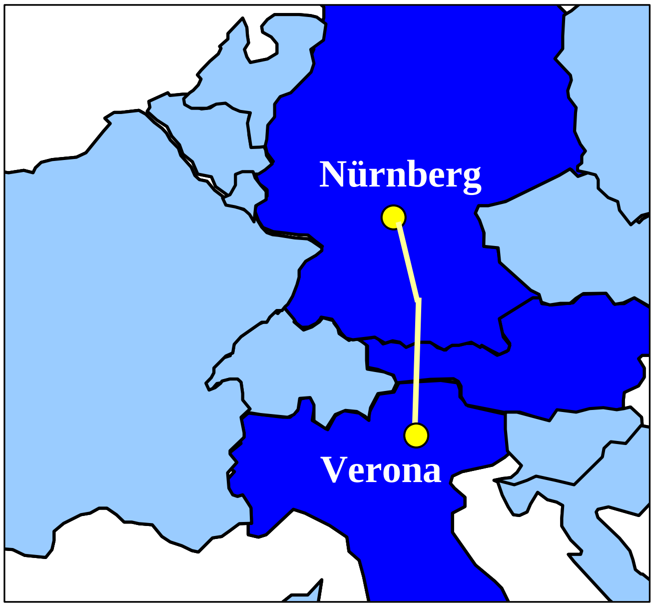
8) München-Verona (Kombiverkehr, Cemat)

The loading unit is going from the industrial area in the north of München to the Verona/Brescia region. The relation belongs to the corridor Germany-Italy. The relevant freight consists of ISO containers.



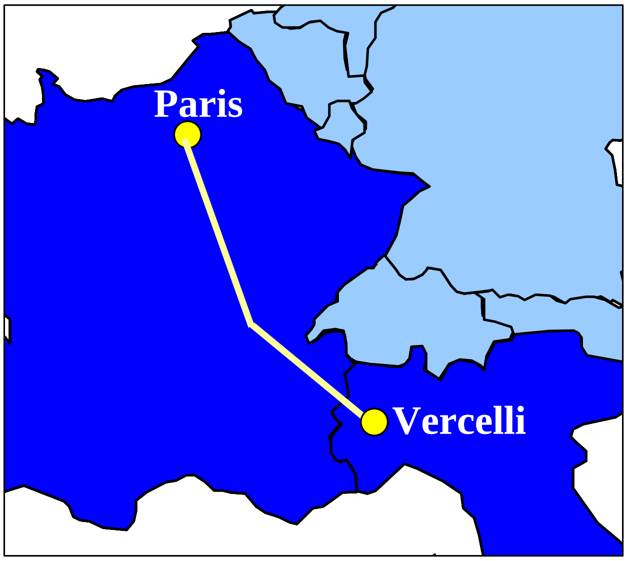
9) Nürnberg-Verona (Kombiverkehr, Cemat)

The loading units are coming from the Nürnberg region; their final destination is mostly the Verona/Brescia area, while about 20 % of the units are determined for gateway traffic to central or southern Italy. The train is carrying swap bodies, ISO containers and semi-trailers. For the calculation, the transport of a semi-trailer is assumed. The relation belongs to the corridor Germany-Italy.



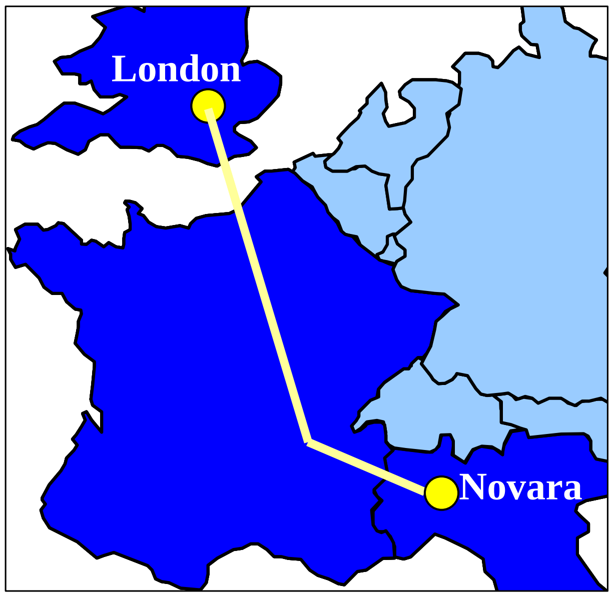
10) Paris-Vercelli (Novatrans)

The Paris-Vercelli relation goes from the Ile-de-France region to Vercelli in Piemont (north-east of Italy). This combined transport relation represents a typical European land transport relation. For the comparative calculation, a swap body class A is considered. But some semi-trailers are carried, too. The feeding and delivery distances are between 20 and 50 km. As the relation belongs to the corridor from Belgium via France to Italy (transalpine traffic), some loading units might have a longer pre-carriage.



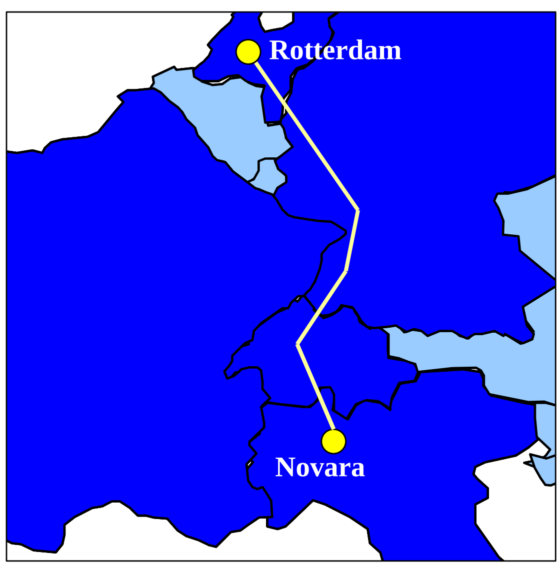
11) London-Novara (Novatrans, CTL)

This line uses the Channel Tunnel. The equivalent road transport goes either through the Channel Tunnel or the sea ferry Dover-Calais and then follows nearly the same route as the rail track. For the calculation, the relevant transport unit is a swap body class C. The loading units, namely ISO containers and swap bodies, are coming from the London area. Their destination is mostly the Lombardian industrial district. As for the Antwerpen - Busto Arsizio relation, there is also about 15 % delivery to Roma or Bari in gateway relations. The relation belongs to the corridor UK-Italy.



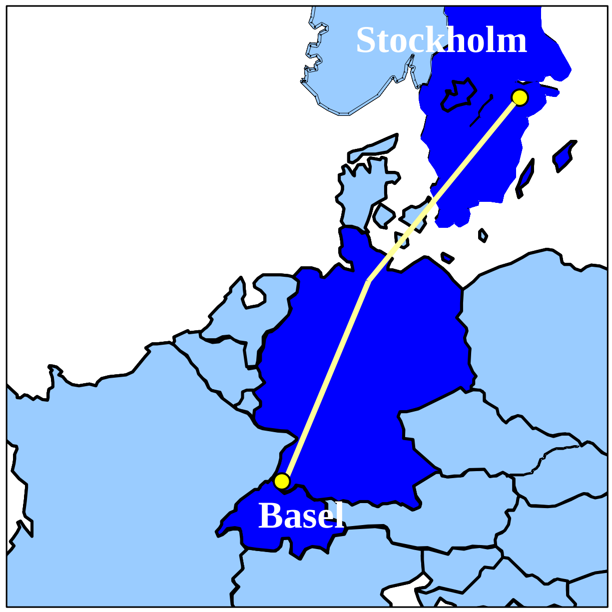
12) Novara-Rotterdam (Cemat, Trailstar)

A transport of a swap body class A is assumed. It is going from the Milano industrial region to Vlaardingen in the North-West of Rotterdam. The relation Novara-Rotterdam is the dominant combined transport relation for the traffic between the Netherlands and Italy.



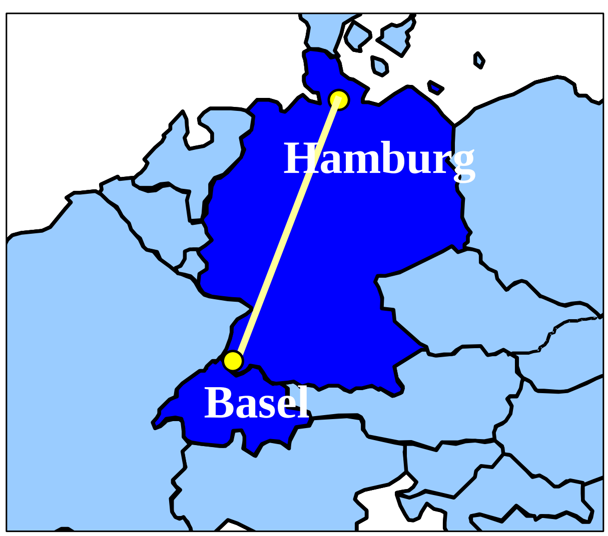
13a) Stockholm-Lübeck-Basel (Kombiverkehr)

This is a special case, which has to be treated specifically due to its different type of traffic and pre-carriage. This line contains a combination of road transport (in Sweden to the port, for instance departing from Stockholm), ferry boat carriage (crossing the Baltic Sea), and delivery by intermodal transport trains, versus a longer road voyage over Sweden, Denmark over the Danish bridges and through Germany. Some of the units end in the industrial region of Basel, but many go by long-distance delivery to Central France and via the Mt. Cenis rail tunnel to Italy. The largest part of the loading units consists of semi-trailers, but swap bodies and a low percentage of 20'-containers are also carried. The relation belongs to the corridor to Italy, because some of the trailers go on to Italy by road.



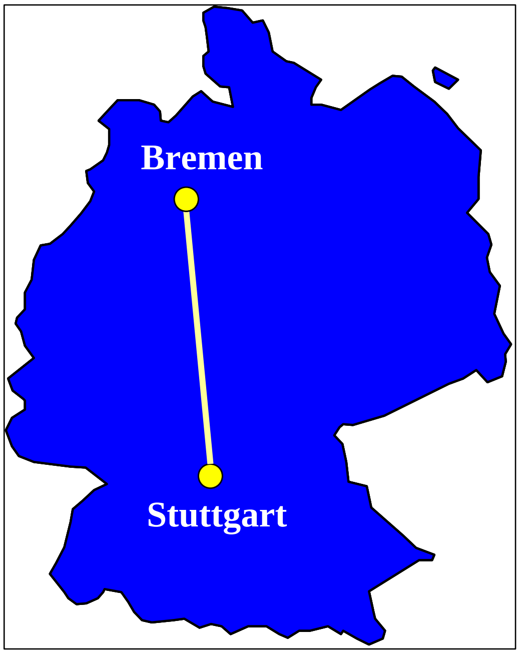
13b) Hamburg-Basel (Kombiverkehr)

The loading unit is coming from Hamburg-Harburg and is going to the Birsfelden/Pratteln/Muttenz industrial district in the east of Basel. The relation belongs to the corridor Germany-Switzerland(-Italy). The transport of two swap bodies class C is analysed.



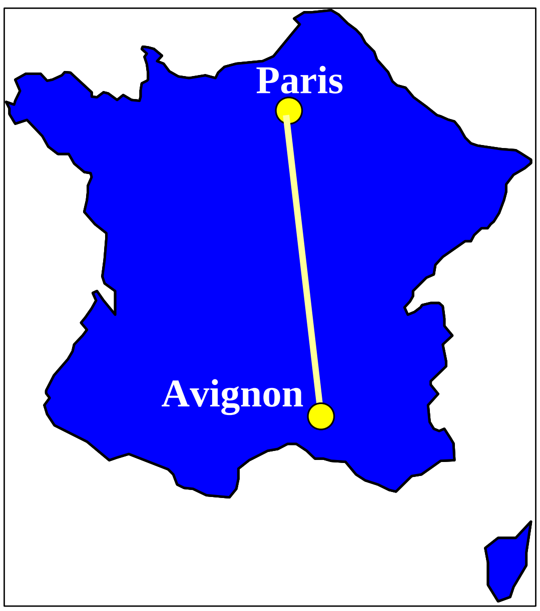
14) Stuttgart-Bremen (Kombiverkehr)

The train is used by the automotive industry. A real pre- or on-carriage does not exist, because the terminals are located close to the manufacturing facilities. The relation belongs to the national German North-South corridor. The transport of two swap bodies class C is compared.



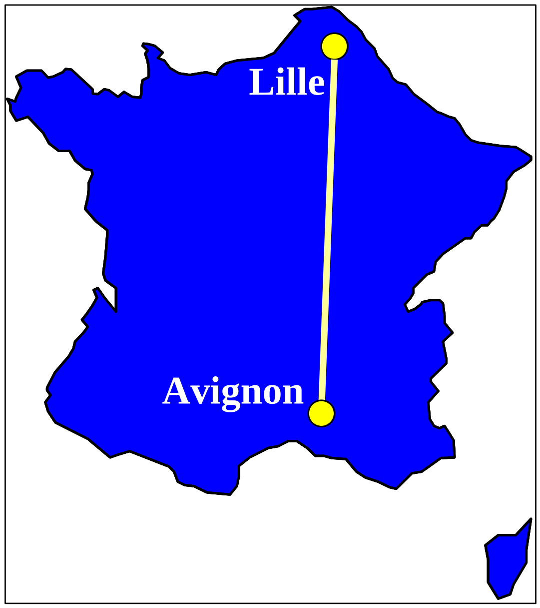
15) Paris-Avignon (Novatrans)

Long swap bodies and semi-trailers use this French national relation. A certain percentage of 30' containers are also carried. A transport of a swap body class A is considered. The typical pre- and on-carriage distances are rather short.



16) Lille-Avignon (Novatrans)

The feeding routes of this national unaccompanied traffic vary considerably. Some trucks have their origin in the area and others drive more than 100 kilometres from Germany, Holland or Belgium. Around 70 % of the destinations of the loading units are the Nimes/Arles/Avignon area, for the rest the Marseille industrial district. The train carries mostly semi-trailers and a few swap bodies. A part of the loading units consists of tank trailers. The calculation assumes a semi-trailer.

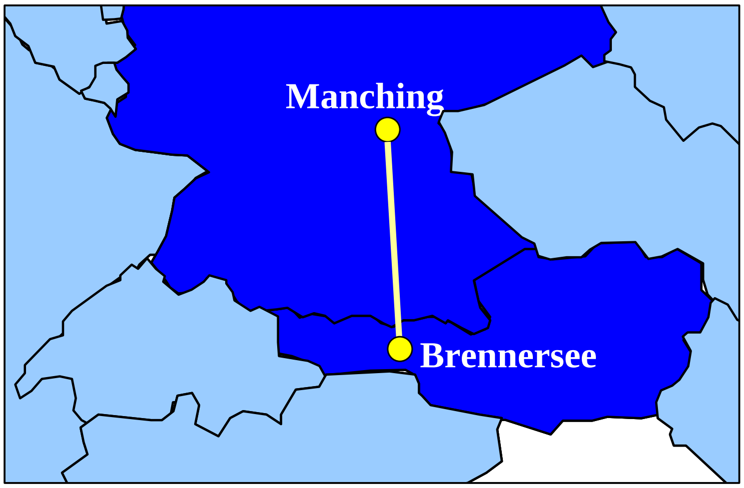


17) Milano-Bari (Cemat)

The relation belongs to the Italian North-South corridor and is also used for gateway traffic in case of transport coming from northern Europe. The typical origin is assumed to be in the Milan region, and the destination is the port of Bari. The relevant freight is a swap body class A.

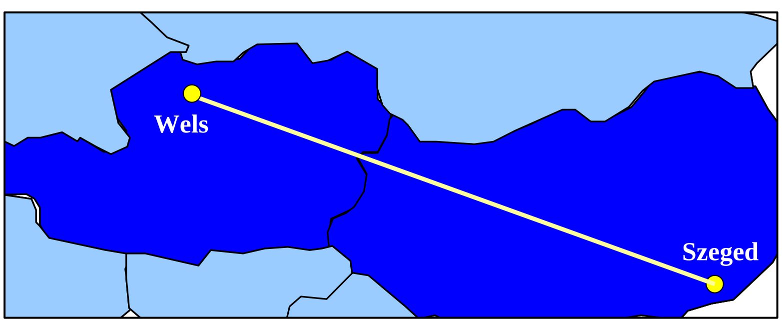
18) Manching-Brennersee (Kombiverkehr, Ökombi):

The transport goes from a station near Ingolstadt to the Austrian-Italian border. The feeding is mainly from the North, e.g. the Nürnberg area; the delivery goes to the Verona region, but even to Turkey. The pure road transport goes directly from Nürnberg via Kufstein and Brenner to Verona. The relation belongs to the corridor Germany-Austria(-Italy).



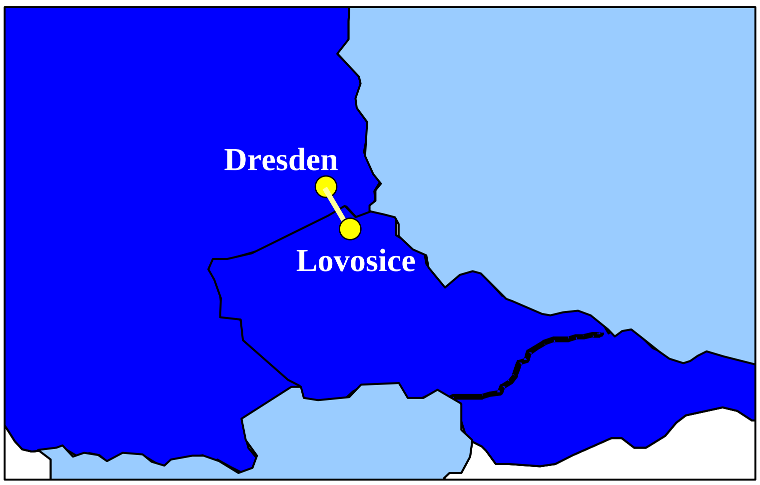
19) Szeged-Wels (Hungarokombi, Ökombi)

This Rolling Road starts at the Hungarian/Serbian/Romanian borderline and ends in Western Austria. It carries mainly trucks from Turkey, Romania and Bulgaria with final destination Germany, in most cases München. The feeding goes by road and ranges up to 800 km, the delivery is normally more than 200 km. The origin is Istanbul and destination is München. We assume an articulate combination that either uses the rolling road from Szeged to Wels and then carries on to München or alternatively runs from Nadlac/Romanian Border via Budapest-Bratislava-Praha to München. The relation belongs to the corridor Austria-Hungary.



20) Dresden-Lovosice (Kombiverkehr, Bohemiakombi)

The Rolling motorway from Dresden to Lovosice has to be regarded separately and treated apart, because it represents a non-typical temporary case. Czech and Slovak road carriers mainly frequent this accompanied combined transport service. It goes – other than the other Rolling Road corridors – over a very short distance. The feeding and delivery might be – compared to this – very long. For the calculation a transport from Praha to Berlin is assumed, which either boards the rolling road in Lovosice to Dresden-Friedrichstadt or otherwise carries on rural roads to Dresden and on highway to Berlin. The service has been established to protect the people living in the River Elbe valley and the Erzgebirge region from noise and pollution of the transit traffic on rural roads. It is certain that the Rolling Road service is going to be discontinued when the new motorway between Dresden and Praha will be completed. The relation belongs to the corridor Germany-Czech Republic.



Evaluation of the energy usage of road and rail

Truck Fleet Benchmark

In the following chapter an average fuel consumption of 34 l/100 km for a today's commercial vehicle with average load (reference year: 2001) was assumed. Then, the load factor and different road categories had been taken into account.

The influence of the **load factor** was modelled according to the differentiation in the TREMOD model of IFEU. Accordingly, the fuel consumption of an empty vehicle can be 1/3 below the fuel consumption of a fully loaded vehicle. This influence can be even stronger depending on the driver characteristics and the grade. The average data of 34 l/100 km refers to the average German load factor of 47 % (2000, heavy truck trains and articulated trucks, including empty trips).[29] Taking 34 l/100 km as reference, a fully loaded vehicle consumes 39 l/100 km, an empty vehicle 29 l/100 km. For all relations, fully loaded vehicles with a corresponding fuel consumption of 39 l/100 km minimum were assumed.

The **influence of the road category** was assessed according to the data presented in the table below. On highways, the reference consumption of 34 l/100 km (corresponds to 39,2 l/100 km with full load, which is the assumed load factor) was taken, as long distance transport in Germany occurs almost exclusively on highways. For rural main roads, we assumed 36 l/100 km due to the higher driving dynamics. For other extra-urban and urban roads, 48 l/100 km were assumed. However, these roads have an almost negligible share of the total distance travelled.

The **influence of the grade** can only roughly be estimated as long as the individual topography of a relation is not entirely known. In addition, an average normal gradient for Germany is already considered in the average fuel consumption data used here. Therefore, an influence of grade should only be considered when extraordinary uphill trips are investigated, such as transalpine transfers, mountain passes, etc.

According to the available data (see table) and the detailed TREMOD data, the following grade factors were estimated:

- Upgrade: 2,7 x average consumption
- Downgrade: 0,3 x average consumption
- Average grade: 1,5 x average consumption.

But: keep in mind that the influence of the grade is not significant for the investigated relations. Hence, an exact, more detailed analysis is not required.

[29] Source: KBA 2001

Energy consumption for truck trains and articulated trucks:

	Highway	Rural main roads	Urban roads/other
Average load (47%)	34,0 l/100 km	36,0 l/100 km	47,7 l/100 km
Empty (0% load weight)	29,3 l/100 km	30,4 l/100 km	37,1 l/100 km
Full (100% load weight)*	**39,2 l/100 km**	**42,4 l/100 km**	**59,6 l/100 km**
Additional grade factors			
Upgrade	2,7		
Downgrade	0,3		
Average grade	1,5		

* For the comparison full load is assumed
Source: BGL, VDA, IFEU assumptions by IFEU Heidelberg 2001

Lugmair Benchmarking

For this study, the energy consumption and CO_2 emissions of road transport were verified with data from the Austrian transport company Lugmair Handels- und Transport GmbH, Roitham. Combined transport customer Lugmair set up these data concerning its truck fleet (quantity, split road/combined transport, life cycle etc.). The data reflecting the time span of the first quarter of 2002 could only be taken as a reference in the study for the relations in which Lugmair is very active, but they provided a benchmark for the other relations too. The figures allowed to compare in a much better way the “theoretical” values found in the different former studies.

Lugmair is engaged in road transport, and, for more than ten years now, in combined road/rail transport as well. About 60 % of the total number of transports use combined transport offers. The main destinations are in Austria, Germany, France, and the Netherlands. The combined transport is especially used within Austria and in the corridors Germany-Austria, France-Austria and Netherlands-Austria. The transported goods are exclusively liquid bulks, carried in tank containers and 40 % of the carried goods represent dangerous goods.

Lugmair presented figures about:

- (a) the truck distances in the pre- and post-haulage,
- (b) the average load factor of trucks used for terminal haulage,
- (c) the repartition of the transported tonnes (total/combined transport/road only),
- (d) the energy consumption per truck type (EURO-classification) and per traffic category (short- and long-distance traffic),
- (e) the energy consumption in case of empty or full runs,
- (f) the theoretical energy consumptions per truck manufacturer in case of empty and full runs.

Results:

(a) As Lugmair´s tank containers are mainly used in the one-way traffic and are mainly dedicated to the same transports (same product, same loading and unloading station), the distances in the pre-haulage as well as in the post-haulage consequently have to be equal. The **average truck distance** of Lugmair fleet in pre- and post-haulage is 66,5 km. Some terminal traction in Wien is quite short (7,4 km, 10 km assumed for the study), as it is for the majority of other terminals shorter than 50 km. The longer terminal traction distances provided by Lugmair trucks can be found in countries outside Austria (up to 250 km for feeding/delivery into the Netherlands and Hungary), but they represent the minority.

(b) Furthermore, Lugmair has also presented the **loading factor** for trucks used for the terminal traction. Following Lugmair, due to main operations in one-way-traffic as well as the fact that the tank containers are mainly used for the same transports, the loading factor of their trucks used in the combined transport pre- and on-carriage can be stated with only 50 %. Lugmair mainly carries swap tanks and tank containers. For the calculations, in case of transport of swap bodies and of short-distance hauling (<50 km), it was assumed that every second trip is empty, so the load factor is 50 %. This fits in with the Lugmair data. On long distances (>50 km), every fifth trip is assumed to be empty (load factor of 80 %). The estimations lead also to the conclusion that for container feeding/delivery by truck, every second trip is empty (load factor 50 %), which also corresponds with the Lugmair data. For the Rolling motorway, naturally no empty runs (vehicle without loading unit) occur because the loading unit is represented by the whole truck/trailer combination. Pre-/on-carriage of semi-trailers usually causes no empty runs of trucks.

(c) Concerning the allocation of the transported tonnes, the **average tonnage** of the trucks used for the combined transport pre- and on-carriage ranges between 26,5 and 33,5 t, the average tonnage of road transport between 15 and 22,5 t. So the load weight is, generally speaking, higher for trucks used for combined transport. This reflects the advantage of combined transport regarding the legal maximum vehicle gross weight (in many EC member countries 44 t vs. 40 t). Another implication of this result: the energy consumption per transported ton is definitely lower for the CT pre-/on-carriage than for pure road transport (about 10 % per ton-km if the same type of truck is used).

(d) The older trucks (EURONORM I and II) are more used for the short-distance traffic and the newer ones (EURONORM II or III) for the long-distance traffic. This implicates that, compared to pure road transport, combined transport has a certain disadvantage concerning the energy consumption and CO_2 emissions on the pre- and on-carriage. The trucks used for the terminal traction showed an average consumption of 38,4 l/100 km[30], while those used for long-distance transport had only 35,9 l/100 km, or 7 % less.[31] Otherwise, one should not forget (I) that long-distance traffic consumes less fuel because of the uncomfortable road characteristics in short-distance terminal trucking (many rural and urban roads), the frequent cold starts of the engine (per 100 km) and (II) the lower maximum gross weight of the trucks used for long-distance road transport, see above under (c).

(e) The **energy consumption** of Lugmair´s truck fleet used for terminal traction (average load factor of 50 %) is 38,4 litres per 100 km in average. In case of empty runs, it amounts to 30,0 l/100 km and in case of full runs to 46,8 l/100 km. The assumptions of this study, differentiated by road category, can be seen in the table above. As Lugmair´s trucks in pre- and on-carriage often have to take urban or rural roads, the average consumption of 38,4 l/100 km is within the range of the values of the study (36 l/100 km for rural main roads

[30] The trucks used for pre- and on-carriage trucking in the Vienna area have an average fuel consumption of 45 l/100 km. This might be because of the urban traffic and city road specific characteristics.
[31] The values are not weighted according to their real significance regarding transport volume.

flat to 47,7 l/100 km for urban roads flat).[32] Lugmair´s consumption of empty vehicles (30 l/ 100 km) is quite close to the assumptions of the study (29 l/100 km), as at least Lugmair trucks´ fuel consumption of full vehicles is within the range of the assumption for full vehicles using rural main roads or urban roads (42,4 l/100 km-59,6 l/100 km).

(f) Concerning the **theoretical energy consumptions** of long-distance road traffic per truck manufacturer: ÖAF & Steyr has reported for MAN-trucks EURO 3 or the older EURO 2 a Diesel consumption of 33-37 l/100 km (full) and a consumption of 29-32 l/100 km (empty). They have pointed out the strong influence of the driving behaviour of the truck drivers, the road characteristics and weather circumstances. Renault referred to the driving test results of its EURO 3-trucks: the Diesel consumption was between 29,3 and 33,4 l/100 km (full). For Scani, it lied between 31 and 32,6 l/100 km under full load conditions and about 22-23 l/100 km for empty trucks (EURO 3). And Volvo indicated for a EURO 3-truck a Diesel consumption of 29-32 l/100 km (full) or 18-20 l/100 km (empty). Most of these values show a better performance than the values presented in this study (39 l/100 km full, 29 l/100 km empty). But the values represent the most actual offer for long distance trucks. On the other hand, many of the trucks used on the road today are not that new, so in the average, a worse performance with respect to Diesel consumption is quite normal. The values provided by the manufacturers and sellers can instead give a really good indication for truck fuel consumption in the near future.

[32] Important note: as in most of the cases the truck used for feeding/delivery shows one empty trip per terminal haulage (load factor 50 %), the uphill- or downhill effects in terminal haulage might be neglected because the trucks often use the same routes to or from the terminal, so the grade effects in terminal traction compensate each other.

Schenker Benchmarking

European haulier Schenker-BTL had developed an emission calculation tool to determine the total environmental influences caused by transport and logistic systems in its European land transport network. The calculation provides information about transport-related emissions, including carbon dioxide (CO_2), and expressed in kilos. Information about the total energy consumption in kWh is also included. In 2000, they said it to be the “most advanced and comprehensive tool currently available on the market”.

The application is linked to an internal database that continuously provides real-time information about transports of Schenker´s European network. Individual consignment data constitute the lowest common denominator.

It seems interesting to know whether the calculation results of the IFEU/SGKV study fit the corresponding calculation results provided by Schenker´s tool.[33] To analyse common findings and differences, on the one hand, the calculation results have to be normalised over the distances, which lie behind the calculations, and on the other hand, the units of the results have to be made comparable: 1 kWh corresponds to 3.600.000 J or 3,6 MJ.

Results:

1. Differences between the calculation results (in primary energy consumption and CO_2 emissions) mainly result from different distances and therefore the chosen routes.
2. Except for one case (London-Novara), there are no significant differences in the results. The results - normalised over the underlying distances - range from nearly 0 to +/- 12,5 %

Below are some exemplary calculation results of the comparison :

Example München-Verona:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Art. Truck 40 t	437 km	7.949 MJ = 2.208 kWh	553 kg
Schenker-BTL	Truck 40 t Euro 2	395 km	1.800 kWh	470 kg

Example Nürnberg-Verona:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Art. Truck 40 t	ca. 600 km	ca. 10.500MJ = 2.916,7 kWh	ca. 740 kg
Schenker-BTL	Truck 40 t Euro 2	566 km	2.600 kWh	680 kg

Example Praha-Berlin:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Art. Truck 40 t	342 km	5.717 MJ = 1.588kWh	398 kg
Schenker-BTL	Truck 40 t Euro 1	339 km	1.600 kWh	410 kg

[33] The tool can be found on the internet under the following link : http://www.schenker.nu/schenker_btl/about/environment/calculation/english/calculator.html

Example Hamburg-Budapest:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Art. Truck 40 t with 40' Container	1.220 km	20.000 MJ (=5.555,6 kWh)	1.400 kg
Schenker-BTL	Truck 40 t Euro 1	1.137 km	5.100 kWh	1.300 kg

Example Stockholm-Basel, using ferry:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Truck with Semitrailer 40 t	ca. 1.700 km	ca. 33.000 MJ (=9.166,7 kWh)	ca. 2.300 kg
Schenker-BTL	Truck 40 t Euro 2	1.728 km	9.300 kWh	2.400 kg

Example Köln-Milano:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Art. Truck 40 t with two Swap Bodies	ca. 810 km	ca. 14.000 MJ (=3.888,9 kWh)	ca. 970 kg
Schenker-BTL	Truck 40 t Euro 2	771 km	3.600 kWh	930 kg

Example Nürnberg-Verona:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Truck+Semitrailer 40 t	606 km	ca. 10.706 MJ (=2.973,9 kWh)	745 kg
Schenker-BTL	Truck 40 t Euro 2	566 km	2.600 kWh	680 kg

Example London-Novara:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Truck+Swap Body 13,60 m, 40 t	1.271 road + 40 km rail = 1.311 km (via France)	21.356 MJ (=5.932,2 kWh)	1.453 kg
Schenker-BTL	Truck 40 t Euro 2	1.130 km Road (Milano), + 20 km using rail + 20 km ferry = 1.170 km	4.200 kWh	1.100 kg

Example Ludwigshafen-Tarragona:

	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Truck + 30' Container	1.385 km	21.911 MJ (=6.086,4 kWh)	1.524 kg
Schenker-BTL	Truck 40 t Euro 2	1.185 km (Barcelona)	4.700 kWh	1.200 kg

Example Lille-Avignon:

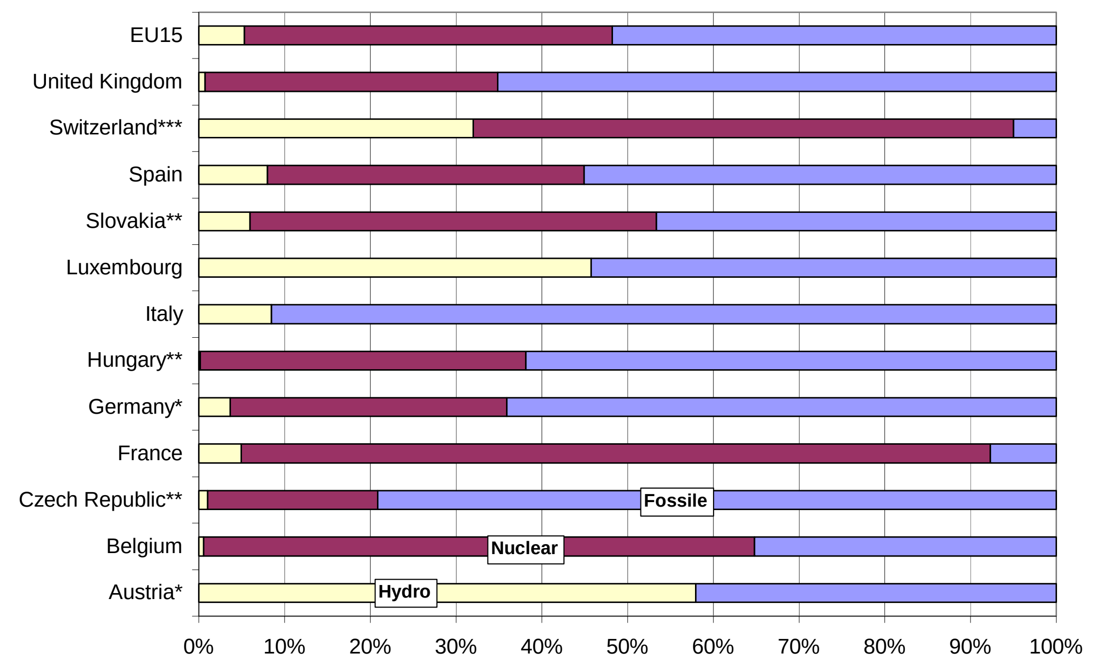
	Vehicle Type	Distance	Energy Consumption	CO_2 Emission
SGKV/IFEU	Rep. Truck + Semitrailer 40 t	915 km	14.476 MJ (=4.021,1 kWh)	1.007 kg
Schenker-BTL	Truck 40 t Euro 2; 10 loading meters	970 km (Marseille)	4.100 kWh	1.100 kg

Rail and road energy consumption

Whether for road or rail transport, CO_2 emissions depend on the energy input used. For the electric traction of railways, electricity consumption and therefore the energy input mix of the power plants are important. Diesel traction has lower energy efficiency than electric traction, but shows less losses of energy in the power supply network.

For the country-specific primary energy input mix, data come from the European Commission (DG TREN, DG XVII) and the International Energy Agency (IEA), because these sources might be the most reliable and respected ones.

Energy input mix for electricity production in different European countries



Remarks: all data from 1997 except **(1996), ***(1999, by IEA); data of public electricity except *(electricity mix for railway). For the Czech Republic and the Hungarian energy mix, more actual data are used.
Source: European Commission, DG XVII, IEA, IFEU estimations IFEU Heidelberg 2001

Railway transport energy consumption:

The main influencing factors for rail transport regarding energy consumption are:

- traction type (diesel vs. electric)
- train length and total weight
- ratio load/empty weight of wagons and transport vessel
- route characteristic (gradient)
- driving behaviour (speed, acceleration) and air resistance.

The main indicator for calculating energy consumption and emissions of rail transport is the energy consumption of the total train depending on the total weight of the train. Different average energy consumption data including the influence of these parameters are available:

Train Type	Situation	Value	Source
Average DB 1998	Average	21,4 (Wh/gross-tkm)	TREMOD /IFEU 1999b/
Long distance trains	Average	19,7-25,7 (Wh/gross-tkm)	/DB 1993/
DB Freight Trains	Average	1994: 0,168 (kWh/tkm) 2001: 0,150 (kWh/tkm)	Cargo aktuell No.4/August 2002
German Freight Trains	Average	1988: 230,9 (Wh/tkm)	VDI-Nachrichten Nr. 16/1988, own calculation
Austrian Freight Train	Brenner ramp (Innsbruck-Brenner)	60-70 Wh/train-m	Expert Interview
International Container Train	Full Empty	30 kWh/train-km 20 kWh/train-km	Expert Interview
DSB , Train 1000 Bt	Average	17 (Wh/gross-tkm)	/TEMA 2000/
SBB 1000-1500t (1988)	Flat	25 (Wh/gross-tkm)	SBB
	Gotthard (Erstfeld-Chiasso-Erstfeld)	35 (Wh/gross-tkm)	
Values in this Study			
Train, 600 gross tonnes	Average	26,7 (Wh/gross-tkm)	IFEU-estimation from different sources
Train, 1000 gross tonnes		21,0 (Wh/gross-tkm)	
Train, 1500 gross tonnes		17,6(Wh/gross-tkm)	
Remarks: gross tonnes: Vehicle gross weight of wagons Source: DB, DSB, SBB IFEU Heidelberg 2001, SGKV 2002			

There is no empirical representative model for “real” energy consumption in railway transport. Hence, the following approach will be adopted: the typical average consumption is determined and additionally, important parameters for the energy consumption of freight trains are considered. An important parameter is the total train weight. The higher the weight of the train is, the lower the specific energy consumption per gross ton km will be.

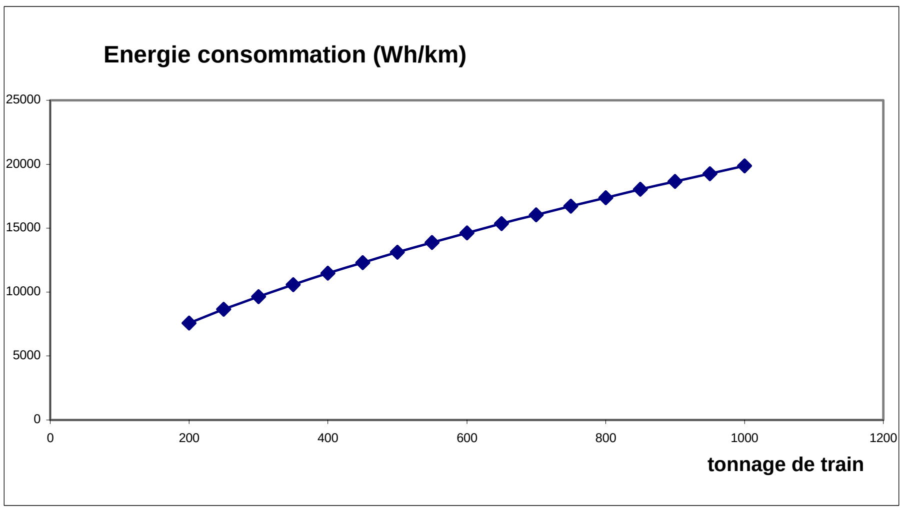
The reported average consumption data for DB is in good accordance with the results determined by modelling specific train types. Average data for DSB are lower than DB-data. This might be due to different analysis methods, a different train technology and the almost grade-free rails in Denmark. The available SBB consumption data is higher, but not quite up-to-date. Therefore, the DB data is the most recent and transparent one. They will be used as reference for all the European countries.

From the average consumption of a DB long-distance train (1000 t gross ton weight and 21 Wh/gross tkm), the energy consumption as a function of the weight can be estimated as follows:

$$\mathbf{EC_{Train}[in\ Wh/km] = 315 * M_{Train}[t]^{0,6}}$$

EC_{Train}: specific energy consumption per train-km
M_{Train}: total weight of train (vehicle gross weight of all locomotives and wagons) in t

The resulting consumptions for trains weighing 600 gross tonnes and 1500 gross tonnes (vehicle gross weight of the wagons) are presented in the table above. The whole formula can be presented in a graph where the energy consumption is shown as a function of the total weight of the train:



Source: NESTEAR calculation

Using recent yearly averages, the country specific conditions and other influences on the energy consumption of combined trains, such as increased air resistance, are neglected. This is consistent with the method applied for road transport.

The average weight specific energy consumption data used in this study already considers an average gradient. Again, as for road transport, *only significant gradients* have to be explicitly included in the calculation.

For uphill transport legs, an additional locomotive is often added to the train. This increases the weight of the train. In total, the energy demand can increase compared to flat distances. On the other hand, electric traction does not consume any energy on downhill gradients. Possibly, brake energy can be recovered and fed into the electricity grid (for instance 10 % for the Austrian locomotive "Taurus").[34]

An exact consideration of gradients for chosen relations is not feasible in this study because the exact topographic condition cannot be quantified. Therefore, average factors were defined to include the gradients. A sensitivity analysis has been carried out and showed that the gradient does not change the final results.

[34] Source: Verkehr Nr. 26A/2002

Road transport energy consumption:

As far as road transport is concerned, it is fair to assume that an average fuel consumption of 34 l/100 km can be applied for a current commercial vehicle (reference year 2001). This consumption will be used for all countries and relations. Potential differences due to varying vehicle age, maintenance standards or driving behaviours will therefore be neglected because such impacts are case specific and cannot be derived generally.

Starting from this average consumption, the real consumption for a specific relation or transport process must be determined based on:
- different load factors
- different road categories and
- roads with grades.

In chapter IV, two benchmarks on road transport fuel and energy consumption have been made using the assumed data and current data provided by the company Lugmair.

Other assumptions for the calculations:

- typical, mostly real input data is used,
- no single wagon traffic is considered,
- no additional empty runs of railway wagons and intermodal loading units are caused by combined transport.

For each relation, a relevant freight was chosen, which represents the most typical intermodal loading unit. This does not mean that the other loading units are not reflected in the results, but the *compared* loading unit is called the “relevant freight” because it is the typical loading unit shifted from road to combined transport on the specific relation.

In chapter 2, energy consumption and CO_2 emissions of pure road transport and combined road/rail transport (per relation and per corridor) are observed. Therefore, data on the real annual traffic volume (in both directions) were gathered and examined. Also, the frequency of operations (number of trains per year) was provided. After all, this means that the annual weighted average data for all combined transport traffic are used.

Influence of the train capacity usage

Former research on railway transport energy usage and CO_2 emissions showed that one of the main parameters influencing the calculation results is the ratio between payload (weight of freight) and the total weight (payload plus empty weight of loading units plus empty weight of wagons). To supplement the description of the relations analysed and to prepare the interpretation of the calculation results, it therefore seems useful to show these ratios in a summarising table:

No	Relation	Corridor	Relevant Units	Number of platforms	Distance Road	Distance Combined Transport Chain				Ratio payload/total weight
						Rail	Road	Water	Sum	
				units	km	km				%
UNACCOMPANIED TRAFFIC (with swap bodies, containers and trailers)										
1	Wien-Neuss	A-D	ISO Container	22	1.048	1.011	25		1.036	53%
2	Genk - Novara	B-I	Swap Body Class A	24	1.058	1.010	40		1.050	65%
3	Antwerpen - Busto Arsizio	B-I	40' Container	36	1.302	963	66		1.029	58%
4	Köln - Granollers	D-E	ISO Container	25	1.506	1.370	50		1.420	48%
5	Ludwigshafen - Tarragona	D-E	30' Container	23	1.385	1.318	24		1.342	54%
6	Hamburg - Budapest	D-H	ISO Container	32	1.365	1.243	20		1.263	55%
7	Köln - Busto Arsizio	D-I	2 Swap Bodies Class C	25	1.204	852	46		898	44%
8	München - Verona	D-I	ISO Container	28	472	436	50		486	54%
9	Nürnberg - Verona	D-I	Semi-Trailer	24	606	642	60		702	47%
10	Paris-Vercelli	F-I	Swap Body Class A	17	845	845	70		915	46%
11	London - Novara	GB–I	Swap Body Class A	26	1.311	1.343	80		1.423	51%
12	Novara - Rotterdam	I-NL	Swap Body Class A	27	1.208	1.167	40		1.207	45%
13a	Stockholm - Lübeck - Basel	D-CH	Semi-Trailer	28	1.937	914	680	200	1.794	45%
13b	Hamburg - Basel	D-CH	2 Swap Bodies Class C	21	817	847	35		882	38%
14	Stuttgart - Bremen	D	2 Swap Bodies Class C	22	647	630	0		630	28%
15	Paris -Avignon	F	Swap Body Class A	25	650	596	40		636	38%
16	Lille - Avignon	F	Semi-Trailer	30	915	815	60		875	36%
17	Milano - Bari	I	Swap Body Class A	24	909	859	20		879	40%
			UNACCOMPANIED TRAFFIC							**48%**
ACCOMPANIED TRAFFIC (with articulated vehicles and road trains)										
18	Manching -Brennersee	D-I	Articulated Vehicle or Road Train	18	606	294	311		605	41%
19	Szeged – Wels	H-A	Articulated Vehicle or Road Train	18	2.352	648	1.471		2.119	35%
			ACCOMPANIED TRAFFIC							**38%**
20	*Dresden - Lovosice special temporary case*	*D-CZ*	Articulated Vehicle or Road Train	*25*	*342*	*117*	*257*		*374*	41%

It is obvious that the heavier the tare of the single loading units is, the worse becomes the ratio presented in the table. For instance, if one looks at the single loading units carried, for Rolling motorways the whole truck+trailer deadweight (about 13 or 14 tonnes) has to be carried, while for a pure container train there is a much smaller deadweight of the single loading units, as two 20'ISO-containers perform with 2 x 2,2 tonnes (= 4.4 tonnes). The same argumentation is valid for the comparison of a semi-trailer (tare of about eight tonnes each) and a 13,60 m swap body (tare of about 3,5 tonnes). Of course the type of wagon (train composition) plays a (less important) role, too, as well as the type of goods carried in the loading units (liquid bulk vs. voluminous), and certainly the load factor of the trains.

A short analysis of the calculation results proves this consideration: the Rolling motorways show low values (35-41 %). This is true for the trailer service Lille-Avignon as well. In addition, some trailers on Lille-Avignon are empty or contain lightweight goods, so the ratio regarded is smaller than for other relations where heavy goods are carried in trailers. The best performing trains with regard to the criterion "payload/deadweight" are trains carrying loading units with rather heavy goods (e.g. Köln-Busto with many tanks full of liquids), pure container trains with lightweight loading units (e.g. Hamburg-Budapest), and, generally speaking, trains showing a good loading factor (e.g. Novara-Rotterdam).

The main parameters influencing the energy consumption and the deduced CO_2 emissions are described above. The following pages show the detailed results for the different cases, obtained by using the model of the IFEU/SGKV study.

Results: Comparison of the energy usage

Energy consumption of Road versus CT-chain per MJ/Lorry unit

Case			Road Transport	Combined Transport Chain				Comparison (road=100%)	Main reasons for energy savings CT-chain to Road
No	Relation	Corridor	Road	Rail	Road	Water	Sum	CT-chain to road	
			MJ/lorry unit					%	
UNACCOMPANIED TRAFFIC									
1	Wien-Neuss	A-D	16.580	12.684	544	0	13.228	80%	+ High Payload
2	Genk - Novara	B-I	16.115	10.701	901	0	11.602	72%	+ High Payload/Load Factor
3	Antwerpen - Busto Arsizio	B-I	21.287	8.834	2.450	0	11.284	53%	+ High Payload/Heavy train
4	Köln - Granollers	D-E	23.825	19.671	1.087	0	20.758	87%	+ High Load Factor + Long Rail distance
5	Ludwigshafen - Tarragona	D-E	21.911	15.300	800	0	16.100	73%	+High Payload/Heavy train/Loading Factor
6	Hamburg - Budapest	D-H	22.567	13.712	435	0	14.147	63%	+ High Payload/Load Factor/Heavy train
7	Köln - Busto Arsizio	D-I	20.208	8.820	2.176	0	10.996	54%	+ High Load Factor/Heavy train
8	München - Verona	D-I	7.490	4.703	1.097	0	5.800	77%	+ High Payload + Long Train - Short Rail distance
9	Nürnberg - Verona	D-I	10.706	8.898	238	0	9.136	85%	- Lower Load Factor
10	Paris-Vercelli	F-I	14.653	13.945	1.690	0	15.635	107%	+ High Load Factor but - Short and light train
11	London - Novara	GB–I	21.356	17.713	349	0	18.062	85%	+ High Load Factor + Long Rail distance
12	Novara - Rotterdam	I-NL	18.703	11.440	869	0	12.309	66%	+ High Load Factor + Long Rail Distance
13a	Stockholm - Lübeck - Basel	D-CH	31.625	12.196	10.000	7.500	29.696	94%	+ Heavy Train - Long road distance - Maritime Transport
13b	Hamburg - Basel	D-CH	12.925	11.604	760	0	12.364	96%	- Light Train - Short rail distance - High Payload
14	Stuttgart - Bremen	D	10.367	7.692	0	0	7.692	74%	+ No pre/post road raulage + Long Train - High Deadweight
15	Paris -Avignon	F	10.695	7.841	983	0	8.824	83%	+ High Load Factor - Short Rail distance
16	Lille - Avignon	F	14.476	10.880	167	0	11.047	76%	+ High Load Factor - Higher Deadweight
17	Milano - Bari	I	14.514	9.831	440	0	10.271	71%	+ High Load Factor
UNACCOMPANIED TRAFFIC								71%	
ACCOMPANIED TRAFFIC									
18	Manching -Brennersee	D-I	10.248	4.309	5.331	0	9.640	94%	+ High Loading Factor - High Deadweight
19	Szeged – Wels	H-A	38.823	10.059	23.544	0	33.603	87%	+ High Loading Factor + High Road Distance - High Deadweight
ACCOMPANIED TRAFFIC								90%	
20	*Dresden - Lovosice special temporary case*	*D-CZ*	*5.743*	*1.777*	*4.066*	*0*	*5.843*	*102%*	*-High Deadweight - Short Rail Distance + Long Train*

This table shows the energy use of pure road transport compared to the whole combined transport chain between the same origin and destination.

Depending on the really employed routes, the distances between road and the combined transport chain are different, (see summarising table page 55). There are cases where road has to use deviations for political reasons, for example transit restrictions. On the other hand, there are cases where the motorway connections on road are shorter than the connection on the existing rail infrastructure or where certain deviations are necessary to reach CT-terminals. The combined transport chain contains also a road part, the usually short road traction to and from the terminals and in one case (13a) a maritime short sea transport.

Especially for the rolling motorway the road traction, which is included in the CT-chain might be even longer than the rail part, so in this table the energy consumption of road has a major influence on the results of the CT-chain.

Results: Comparison of the energy use

Energy consumption of Road versus Rail per kilometre

Case			Road Transport		Pure Rail Transport		Transport system		Comparison (road=100%)
No	Relation	Corridor	Energy	Distance	Energy	Distance	Energy Pure Road	Energy Pure Rail	Pure rail to pure road
			MJ/lorry unit	km	MJ/lorry unit	km	MJ/lorry unit/km	MJ/lorry unit/km	%
UNACCOMPANIED TRAFFIC									
1	Wien-Neuss	A-D	16.262	1.028	12.684	1.011	15,8	12,5	79%
2	Genk - Novara	B-I	16.214	955	10.701	1.010	17,0	10,6	62%
3	Antwerpen - Busto Arsizio	B-I	20.544	1.258	8.834	963	16,3	9,2	56%
4	Köln - Granollers	D-E	22.577	1.464	19.671	1.370	15,4	14,4	93%
5	Ludwigshafen - Tarragona	D-E	20.959	1.360	15.300	1.318	15,4	11,6	75%
6	Hamburg - Budapest	D-H	22.116	1.348	13.712	1.243	16,4	11,0	67%
7	Köln - Busto Arsizio	D-I	19.600	1.160	8.820	852	16,9	10,4	61%
8	München - Verona	D-I	6.916	434	4.703	436	15,9	10,8	68%
9	Nürnberg - Verona	D-I	10.593	598	8.898	642	17,7	13,9	78%
10	Paris-Vercelli	F-I	13.672	785	13.945	845	17,4	16,5	95%
11	London - Novara	GB–I	20.597	1.266	17.713	1.343	16,3	13,2	81%
12	Novara - Rotterdam	I-NL	18.754	1.130	11.440	1.167	16,6	9,8	59%
13a	Stockholm - Lübeck - Basel	D-CH	14.018	890	12.196	914	15,8	13,3	85%
13b	Hamburg - Basel	D-CH	12.893	813	11.604	847	15,9	13,7	86%
14	Stuttgart - Bremen	D	10.395	647	7.692	630	16,1	12,2	76%
15	Paris -Avignon	F	10.053	615	7.841	596	16,3	13,2	80%
16	Lille - Avignon	F	14.316	904	10.880	815	15,8	13,3	84%
17	Milano - Bari	I	14.248	892	9.831	859	16,0	11,4	72%
					UNACCOMPANIED TRAFFIC				**71%**
ACCOMPANIED TRAFFIC									
18	Manching -Brennersee	D-I	4.489	263	4.309	294	17,1	14,7	86%
19	Szeged – Wels	H-A	9.490	592	10.059	648	16,0	15,5	97%
					ACCOMPANIED TRAFFIC				**89%**
20	*Dresden - Lovosice special temporary case*	*D-CZ*	2.019	108	1.777	*117*	*18,7*	*15,2*	*81%*

The objective of this table is to show the system characteristics of the road transport mode versus those of the CT-rail mode. The energy consumption per kilometre of road or rail excludes all influences mentioned in the table before. This table shows the real system advantages of CT-rail compared to the benchmark road (100%).
The differences for unaccompanied transport with only short road legs are minimal, except the case 13a, where the long road and short sea shipping parts have worsened the results.
For the case 18, RoMo Manching-Brennersee, the higher performance in this table is due to the fact, that the low Italian railway gauge allows only a short rail part between Manching and the Austrian-Italian border. The differences show that the system advantage of rail could be better used if Italy would provide a higher gauge, enabling a longer rail part.

Results: Comparison of CO_2 emissions

CO_2 emission: road versus CT-chain

No	Relation	Corridor	Relevant Units	CO_2 emissions road	CO_2 emissions CT-chain	CT-chain in percent of road	Main reasons for CO_2 savings
				per lorry unit in kg		%	
UNACCOMPANIED TRAFFIC (with swap bodies, containers and trailers)							
1	Schwechat-Wien-Neuss-Krefeld	A-D	ISO Container	1.154	711	62%	+ High Payload + Electricity Production Austria
2	Genk - Novara	B-I	Swap Body Class A	1.121	563	50%	+ High Payload/Load Factor + Electricity Production
3	Antwerpen - Busto Arsizio-Milano	B-I	40' Container	1.481	298	20%	+ High Payload/Heavy train + Electricity Production France
4	Leverkusen-Köln - Granollers-Labadell	D-E	ISO Container	1.658	491	30%	+ High Load Factor + Long Rail distance + Electricity Production France
5	Ludwigshafen - Tarragona	D-E	30' Container	1.524	374	25%	+High Payload/Heavy train/Loading Factor + Electricity Production France
6	Hamburg - Budapest	D-H	ISO Container	1.570	916	58%	+ High Payload/Load Factor/Heavy train
7	Köln - Busto Arsizio - Milano	D-I	2 Swap Bodies Class C	1.406	459	33%	+ High Load Factor/Heavy train + Electricity Production CH
8	München - Verona (Brescia)	D-I	ISO Container	521	357	69%	+ High Payload + Long Train - Short Rail distance + Electricity Production A
9	Nürnberg - Verona	D-I	Semi-Trailer	745	530	71%	- Lower Load Factor + Electricity Production Austria
10	Paris-Vercelli	F-I	Swap Body Class A	1.020	379	37%	+ High Load Factor but - Short and light train + Electricity Production France
11	London - Novara	GB–I	Swap Body Class A	1.453	457	31%	+ High Load Factor + Long Rail distance + Electricity Production France
12	Novara - Rotterdam	I-NL	Swap Body Class A	1.301	652	50%	+ High Load Factor + Long Rail Distance + Electricity Production CH
13a	Stockholm - Basel	D-CH	Semi-Trailer	2.200	1.912	87%	+ Heavy Train - Long road distance - Maritime Transport
13b	Hamburg - Basel - Pratteln	D-CH	2 Swap Bodies Class C	899	684	76%	- Light Train - Short rail distance - High Payload
14	Stuttgart - Bremen	D	2 Swap Bodies Class C	721	421	58%	+ No pre/post road raulage + Long Train - High Deadweight
15	Paris -Avignon	F	Swap Body Class A	744	132	18%	+ High Load Factor - Short Rail distance + Electricity Prodcution France
16	Lille - Avignon	F	Semi-Trailer	1.007	166	16%	+ High Load Factor - Higher Deadweight + Electricity Production France
17	Milano - Bari	I	Swap Body Class A	1.010	678	67%	+ High Load Factor + Electricity Production Italy
UNACCOMPANIED TRAFFIC						**45%**	
ACCOMPANIED TRAFFIC (with articulated units and road trains)							
18	Nürnberg-Manching -Brennersee-Verona	D-I	Articulated Vehicle or Road Train	713	599	84%	+ High Loading Factor - High Deadweight + Electricity Production Austria
19	Istanbul-Szeged – Wels-München	H-A	Articulated Vehicle or Road Train	2.701	2.176	81%	+ High Loading Factor + High Road Distance - High Deadweight + Electricity Production Austria
ACCOMPANIED TRAFFIC						**82%**	
20	*Berlin-Dresden - Lovosice -Praha special temporary case*	*D-CZ*	*Articulated Vehicle or Road Train*	*400*	*411*	*103 %*	*-High Deadweight - Short Rail Distance + Long Train - Electricity Production Czech Republic*

This table shows the CO_2 emissions of pure road transport compared to the whole combined transport chain between the same origin and destination.

Depending on the really employed routes the distances between road and the combined transport chain are different. The latter includes road terminal traction and even short sea in case 13a, (see remarks for the energy table). Road is taken as benchmark (100%). So the last column shows the percentage of the CT-chain emissions compared to road. The corresponding savings are 100% minus the mentioned figures.

Results: Comparison of CO_2 emissions

CO_2 emission: road versus rail per kilometre

No	Relation	Corridor	Relevant Units	CO_2 emissions road	CO_2 emission on rail	Pure rail in percent of road	Main reasons for CO_2 savings
				per lorry unit in kg *		%	
UNACCOMPANIED TRAFFIC (with swap bodies, containers and trailers)							
1	Wien-Neuss	A-D	ISO Container	1.132	673	59%	+ High Payload + Electricity Production Austria
2	Genk - Novara **	B-I	Swap Body Class A	1.126	500	44%	+ High Payload/Load Factor + Electricity Production
3	Antwerpen - Busto Arsizio	B-I	40' Container	1.420	171	12%	+ High Payload/Heavy train + Electricity Production France
4	Köln - Granollers	D-E	ISO Container	1.611	438	27%	+ High Load Factor + Long Rail distance + Electricity Production France
5	Ludwigshafen - Tarragona	D-E	30' Container	1.505	341	23%	+High Payload/Heavy train/Loading Factor + Electricity Production France
6	Hamburg - Budapest	D-H	ISO Container	1.551	886	57%	+ High Payload/Load Factor/Heavy train
7	Köln - Busto Arsizio	D-I	2 Swap Bodies Class C	1.354	405	30%	+ High Load Factor/Heavy train + Electricity Production CH
8	München - Verona	D-I	ISO Container	478	281	59%	+ High Payload + Long Train - Short Rail distance + Electricity Production A
9	Nürnberg - Verona	D-I	Semi-Trailer	737	510	69%	- Lower Load Factor + Electricity Production Austria
10	Paris-Vercelli	F-I	Swap Body Class A	953	261	27%	+ High Load Factor but - Short and light train + Electricity Production France
11	London - Novara	GB–I	Swap Body Class A	1.432	343	24%	+ High Load Factor + Long Rail distance + Electricity Production France
12	Novara - Rotterdam	I-NL	Swap Body Class A	1.310	591	45%	+ High Load Factor + Long Rail Distance + Electricity Production CH
13a	Stockholm - Lübeck - Basel	D-CH	Semi-Trailer	980	683	70%	+ Heavy Train - Long road distance - Maritime Transport
13b	Hamburg - Basel	D-CH	2 Swap Bodies Class C	895	632	71%	- Light Train - Short rail distance - High Payload
14	Stuttgart - Bremen	D	2 Swap Bodies Class C	721	421	58%	+ No pre/post road raulage + Long Train - High Deadweight
15	Paris -Avignon	F	Swap Body Class A	700	64	9%	+ High Load Factor - Short Rail distance + Electricity Prodcution France
16	Lille - Avignon	F	Semi-Trailer	1.000	89	9%	+ High Load Factor - Higher Deadweight + Electricity Production France
17	Milano - Bari	I	Swap Body Class A	987	648	66%	+ High Load Factor + Electricity Production Italy
	UNACCOMPANIED TRAFFIC					**40%**	
ACCOMPANIED TRAFFIC (with articulated units and road trains)							
18	Manching -Brennersee	D-I	Articulated Vehicle or Road Train	311	228	73%	+ High Loading Factor - High Deadweight + Electricity Production Austria
19	Szeged – Wels	H-A	Articulated Vehicle or Road Train	660	537	81%	+ High Loading Factor + High Road Distance - High Deadweight + Electricity Production Austria
	ACCOMPANIED TRAFFIC					**77%**	
20	*Dresden - Lovosice special temporary case*	*D-CZ*	*Articulated Vehicle or Road Train*	*141*	*128*	*91%*	*-High Deadweight - Short Rail Distance + Long Train - Electricity Production Czech Republic*

* For the road calculation, only the main course terminal-terminal (pure distance on rail) was observed, which implies that the corresponding road transport starts and ends at the terminals, so road distances have changed compared to former analysis. Generally speaking, for shorter distances, the use of combined transport road/rail does not induce deviations, while for longer distances it might do so. These results, therefore, are subject to abstraction from deviations probably induced through the use of combined transport road/rail.

** Genk - Novara: even if the road distance is shorter, the CO_2 emission is higher due to variation in the ratio normal road/highway.

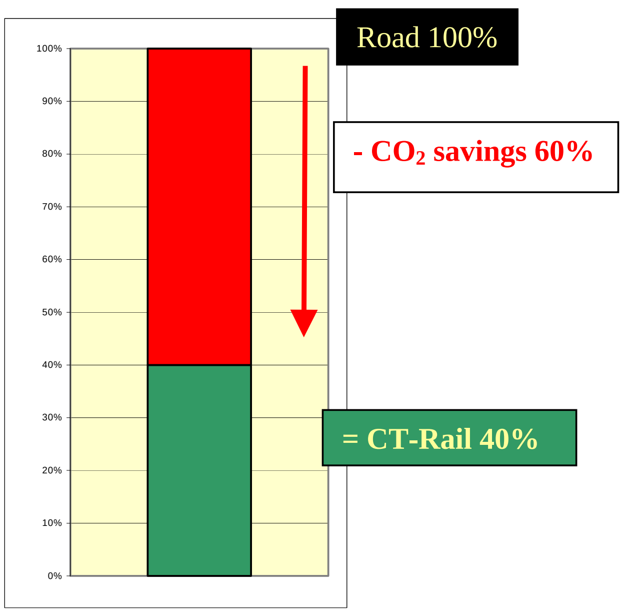
This is the table containing the main results of the study. In this table, the road emissions are compared with CT-rail. All other influences resulting from the specific cases like deviations or the use of other modes than rail in the combined transport chain are excluded. The message of the results is quite clear. If we take road as a benchmark (100%), a transfer to unaccompanied combined rail traffic will reduce the emissions to only 40%. This means a reduction of 60%! Even the rolling motorways with their higher deadweight allow a CO_2 reduction to 77%, in other words a significant saving of 23%.

<u>Results: Comparison of CO_2 emissions</u>

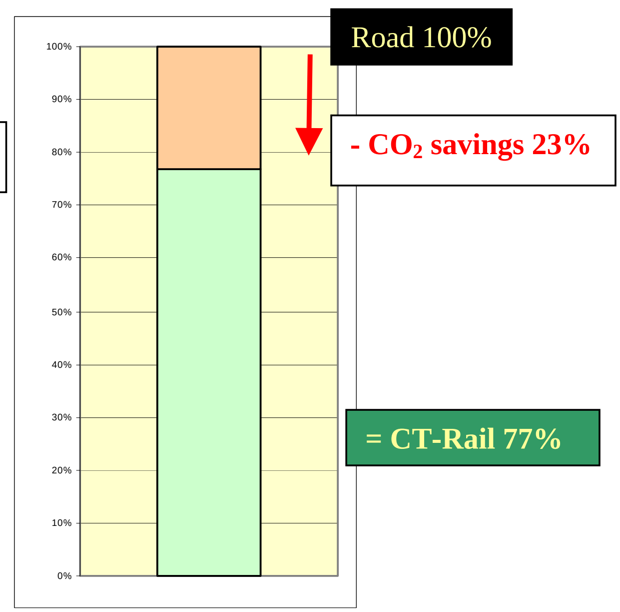
CO_2 emission: road versus rail per kilometre

The following graphics demonstrate the system advantage of combined transport, of CT-rail compared to the benchmark road (100%)

Unaccompanied CT



Rolling Motorway



If we take road as a benchmark (100%), a transfer to unaccompanied combined rail traffic will reduce the emissions to 40%. This means a saving of 60%! Even the rolling motorways with their higher deadweight allow a CO_2 reduction to 77%, in other words a significant saving of 23%.

Results: Comparison of CO_2 emissions

Annual CO_2 savings of Combined Transport

Out of the results in the table 'CO_2 emissions: CT-chain to road', the actual real CO_2 savings can easily be obtained taking into account the real traffic volume for each relation (in consignments[35])

No	Relation	Corridor	Relevant Units	Number of consign-ments 2001	Annual CO_2 emission per relation road	Annual CO_2 emissionper relation CT-chain	Annual saved CO_2 emissionby CT-chain	Annual saved CO_2 emission CT-chain to road
				units	tons			%
UNACCOMPANIED TRAFFIC (with swap bodies, containers and trailers)								
1	Schwechat-Wien-Neuss-Krefeld-Ürdingen	A-D	ISO Container	20.990	24.222	14.924	9.299	38%
2	Genk - Novara	B-I	Swap Body Class A	20.936	23.469	11.787	11.682	50%
3	Antwerpen - Busto Arsizio-Milano	B-I	40' Container	20.347	30.134	6.063	24.071	80%
4	Leverkusen-Köln - Granollers-Labadell	D-E	ISO Container	5.281	8.756	2.593	6.163	70%
5	Ludwigshafen - Tarragona	D-E	30' Container	3.635	5.540	1.359	4.180	75%
6	Hamburg - Budapest	D-H	ISO Container	15.739	24.710	14.417	10.293	42%
7	Köln - Busto Arsizio - Milano	D-I	2 Swap Bodies Class C	62.649	88.084	28.756	59.329	67%
8	München - Verona (Brescia)	D-I	ISO Container	31.884	16.612	11.383	5.229	31%
9	Nürnberg - Verona	D-I	Semi-Trailer	28.796	21.453	15.262	6.191	29%
10	Paris-Vercelli	F-I	Swap Body Class A	22.157	22.600	8.398	14.203	63%
11	London - Novara	GB–I	Swap Body Class A	6.665	9.684	3.046	6.638	69%
12	Novara - Rotterdam	I-NL	Swap Body Class A	44.450	57.829	28.981	28.848	50%
13a	Stockholm - Basel	D-CH	Semi-Trailer	3.773	8.301	7.214	1.087	13%
13b	Hamburg - Basel - Pratteln	D-CH	2 Swap Bodies Class C	11.060	9.943	7.565	2.378	24%
14	Stuttgart - Bremen	D	2 Swap Bodies Class C	12.762	9.201	5.373	3.829	42%
15	Paris -Avignon	F	Swap Body Class A	26.948	20.049	3.557	16.492	82%
16	Lille - Avignon	F	Semi-Trailer	6.898	6.946	1.145	5.801	84%
17	Milano - Bari	I	Swap Body Class A	13.354	13.488	9.054	4.434	33%
SUM UNACCOMPANIED TRAFFIC				**358.324**	**401.021**	**180.877**	**220.146**	**55%**
ACCOMPANIED TRAFFIC (with articulated units and road trains)								
18	Nürnberg-Manching -Brennersee-Verona	D-I	Articulated Vehicle or Road Train	134.415	95.838	80.515	15.323	16%
19	Istanbul-Szeged – Wels-München	H-A	Articulated Vehicle or Road Train	54.538	147.307	118.675	28.632	19%
SUM ACCOMPANIED TRAFFIC				**188.953**	**243.145**	**199.190**	**43.955**	**18%**
20	*Berlin-Dresden - Lovosice -Praha special temporary case*	*D-CZ*	*Articulated Vehicle or Road Train*	*84.014*	*33.606*	*34.530*	*-924*	*-3%*

The annual figures are calculated on the basis of the tables, which compare road to the whole actual combined transport chain. Based on the situation of the year 2001 the observed unaccompanied traffic has helped to save 220.146 tonnes of CO_2 emissions in transporting those units in the combined transport chain rather than on road. The number of transferred truck-units (=consignments) was 358.324. In other words, for each truckload transferred to combined transport, 614 Kg less CO_2 was emitted.

[35] A UIRR consignment corresponds to the transport capacity of one lorry on the road (equivalent to 2,3 EVP/TEU), meaning: one semi-trailer, two swap bodies shorter than 8,30 m and less than 16t, one swap body longer than 8,30 m or more than 16t or one vehicle on the Rolling Road.

For the whole unaccompanied traffic of UIRR with 1,75 million consignments this means savings of 1,1 Mio. tonnes carbon dioxide and about 90.000 tonnes for the 465.553 trucks transported on the rolling motorway, in total about 1,2 million tonnes carbon dioxide saved by the transfer of 2,2 million trucks or their loading units to rail. According to the evaluations mentioned earlier, which assign 100 EUR for the environmental damage of a ton CO_2 this would mean savings of 120 million EUR. Taking into account that UIRR companies represent 65 % of the market, the whole combined transport saves yearly about 1,8 million tonnes of CO_2 with environmental savings of 180 million EUR.

If in the future all emitters have to pay for the damage caused to the environment, the combined transport would have a real additional commercial advantage. In a transitional time until the EU policy of inclusion of all external costs is realised, these and other environmental savings justify measures in favour of combined transport.

Corridor related observations

CO_2 Savings of international unaccompanied traffic

Out of the table in the section above, the annual savings for the international unaccompanied traffic can be calculated and grouped in relation to European corridors.

No	Relation	Corridor	Relevant Units	Number of consign-ments 2001	Annual CO_2 emission per relation road	Annual CO_2 emission per relation CT-chain	Annual saved CO_2 emission by CT-chain	Annual saved CO_2 emission CT-chain to road
				units	tonnes			%
UNACCOMPANIED INTERNATIONAL TRAFFIC (with swap bodies, containers and trailers)								
GERMANY - AUSTRIA								
1	Schwechat-Wien-Neuss-Krefeld-Ürdingen	A-D	ISO Container	**20.990**	**24.222**	**14.924**	**9.299**	**38%**
GERMANY/BENELUX - ITALY								
2	Genk - Novara	B-I	Swap Body Class A	20.936	23.469	11.787	11.682	50%
3	Antwerpen - Busto Arsizio-Milano	B-I	40' Container	20.347	30.134	6.063	24.071	80%
7	Köln - Busto Arsizio - Milano	D-I	2 Swap Bodies Class C	62.649	88.084	28.756	59.329	67%
8	München - Verona (Brescia)	D-I	ISO Container	31.884	16.612	11.383	5.229	31%
9	Nürnberg - Verona	D-I	Semi-Trailer	28.796	21.453	15.262	6.191	29%
12	Novara - Rotterdam	I-NL	Swap Body Class A	44.450	57.829	28.981	28.848	50%
13a	Stockholm - Basel	D-CH	Semi-Trailer	3.773	8.301	7.214	1.087	13%
13b	Hamburg - Basel - Pratteln	D-CH	2 Swap Bodies Class C	11.060	9.943	7.565	2.378	24%
TOTAL CORRIDOR				**223.895**	**255.825**	**117.011**	**138.814**	**54%**
GERMANY - SPAIN								
4	Leverkusen-Köln - Granollers-Labadell	D-E	ISO Container	5.281	8.756	2.593	6.163	70%
5	Ludwigshafen - Tarragona	D-E	30' Container	3.635	5.540	1.359	4.180	75%
TOTAL CORRIDOR				**8.916**	**14.296**	**3.952**	**10.343**	**72%**
GERMANY - HUNGARY								
6	Hamburg - Budapest	D-H	ISO Container	**15.739**	**24.710**	**14.417**	**10.293**	**42%**
UK/FRANCE - ITALY								
10	Paris-Vercelli	F-I	Swap Body Class A	22.157	22.600	8.398	14.203	63%
11	London - Novara	GB–I	Swap Body Class A	6.665	9.684	3.046	6.638	69%
TOTAL CORRIDOR				**28.822**	**32.284**	**11.443**	**20.841**	**65%**
TOTAL ALL CORRIDORS				**298.362**	**351.338**	**161.748**	**189.590**	**54%**

On the observed *international* relations, the use of unaccompanied combined road/rail transport helped to reduce the CO_2 emissions by about 54 per cent. Otherwise, by moving on the road, the amount of carbon dioxide emissions of these 298.362 consignments would have risen from 162.836 to 351.338 tonnes (in 2001). Each relation has contributed to this result. The saved emissions by frequent combined transport trains range between 13 and 80 per cent compared to pure road transport, depending on the specific relation.

In absolute figures, the transalpine corridors to Italy show the highest savings in CO_2 emissions in international unaccompanied combined transport. This is especially true for the relations with large main railway parts on rail through France and Switzerland. (e.g. Antwerpen - Busto Arsizio, Paris-Vercelli). The reason is the favourable energy mix for the railway electricity production. Another aspect of the high savings in transalpine corridor is the high traffic volume, which is the result of efficient bundling of traffic flows through the Alps, where only a few opportunities to cross exist (Gotthard, Lötschberg-Simplon, Brenner, Mt. Cenis). As far as the relations Köln-Busto and Antwerpen-Busto are concerned, a high capacity usage combined with a high payload in the North-South direction is responsible for the very good results.

A case to be treated separately is the relation Sweden-Lübeck-Basel: first, the relevant loading unit is a semi-trailer, with a smaller payload than swap bodies or containers. Second, the ferry carriage is used between Sweden and Lübeck (trimodal traffic) and ferry generally produces more CO_2 than rail. Third, the traction between Lübeck and Hamburg is Diesel and this leads to higher CO_2 emissions per ton-kilometre. And last but not least, pre- and on-carriage on the road are quite long (Stockholm-Trelleborg, possibly Basel-Italy). But even under these considerations, this relation has saved 13 per cent of carbon dioxide emissions.[36]

Wien-Neuss is an environmentally successful relation on the corridor Austria and Germany. About 38 per cent of the CO_2 emissions were saved compared to a scenario where all the traffic would have been shifted to road. For the corridor Germany to Hungary, the “Hinterland”-container train from Hamburg to Budapest shows environmentally even more favourable performance in spite of some shunting on the way and the high share of Brown Coal in Czech Republic and Slovakian electricity production for railway electricity. This is due to the high payload (pure container train) and the production scheme (block train).

On the corridor Germany to Spain, the combined trains benefit from the French electricity production leading to nearly zero carbon dioxide emissions (nuclear power plants). The emissions saved through combined transport are clearly over 50 per cent. The part train from Köln shows a longer crossing through Germany with a higher share of fossil energy input, so the other part train from Ludwigshafen performs better. Another important fact for the whole train system is the high payload and the good capacity use of tank containers moved for chemical industry between these countries. Additional shuntings and intermodal transfers do not play a part in CO_2 emission. Up to 75 % less carbon dioxide emissions than road transport means a very good environmental performance on the corridor Germany-Spain.
The same remarks apply to the corridor UK/France to Italy, the combined trains benefit from the French electricity production leading to nearly zero carbon dioxide emissions (nuclear power plants). The emissions saved through combined transport on the whole are clearly over 50 %.

CO_2 savings of national unaccompanied traffic

Four unaccompanied CT national relations were also investigated in this study (one German, two French and one Italian). They can be seen as a part of international corridors crossing the countries (e.g. Lille-Avignon as part of a Belgium-Spain corridor, Milano-Bari as part of Germany-Italy corridor). The results for these relations can be represented as follows:

[36] Important notice: The road calculation was based on a pure road transport over the Danish land bridges. But, there are other ferry relations for trucks between Sweden and Germany.

No	Relation	Corridor	Relevant Units	Number of consign-ments 2001	Annual CO_2 emission per relation road	Annual CO_2 emission per relation CT-chain	Annual saved CO_2 emission by CT-chain	Annual saved CO_2 emission CT-chain to road
				units	tonnes			%
UNACCOMPANIED NATIONAL TRAFFIC (with swap bodies, containers and trailers)								
14	Stuttgart - Bremen	D	2 Swap Bodies Class C	12.762	9.201	5.373	3.829	42%
15	Paris -Avignon	F	Swap Body Class A	26.948	20.049	3.557	16.492	82%
16	Lille - Avignon	F	Semi-Trailer	6.898	6.946	1.145	5.801	84%
17	Milano - Bari	I	Swap Body Class A	13.354	13.488	9.054	4.434	33%
TOTAL				**59.962**	**49.685**	**19.129**	**30.556**	**61%**

These four national services have all reduced the CO_2 emissions in 2001. If the consignments were transported by truck, the annual emissions of these activities would have been 49.684 tonnes instead of 19.129 tonnes. The total saving of 30.556 tonnes meant about 61 per cent less CO_2 emissions. This could imply an even better performance than the international unaccompanied transport. But the international relations saved more carbon dioxide emission per relation served (about 13.000 tonnes per relation) than the national ones (about 8.000 tonnes per relation)!

Again, relations passing the French railway network provide rather high potential to tackle greenhouse gas emissions. Especially for the relation Paris-Avignon with its high number of consignments, combined transport reduced the CO_2 emissions by 82 per cent or 16.492 tonnes less emissions. Without the typical pre- or on-carriage, the reduction must come near to 100 per cent. Regarding the German national relation Stuttgart-Hafen to Bremen, there is nearly no pre- and on-carriage. The contribution of this service was a reduction of carbon dioxide emissions by 42 per cent (for the year 2001). The Italian relation Milano-Bari is a kind of gateway service continuing transalpine international traffic and reducing emissions by one third or 4.434 tonnes compared to a corresponding pure road transport of the consignments on the Adriatic coastal motorway.

CO_2 savings of the rolling motorway traffic

As rolling motorways record high traffic volume and political notice in these days, they have also been taken into consideration. The results for the two analysed relations are as follows:

No	Relation	Corridor	Relevant Units	Number of consign-ments 2001	Annual CO_2 emission per relation road	Annual CO_2 emission per relation CT-chain	Annual saved CO_2 emission by CT-chain	Annual saved CO_2 emission CT-chain to road
				units	tonnes			%
INTERNATIONAL ACCOMPANIED TRAFFIC (with articulated units and road trains)								
GERMANY - ITALY								
18	Nürnberg-Manching -Brennersee-Verona	D-I	Articulated Vehicle or Road Train	134.415	95.838	80.515	15.323	16%
AUSTRIA - HUNGARY								
19	Istanbul-Szeged – Wels-München	H-A	Articulated Vehicle or Road Train	54.538	147.307	118.675	28.632	19%
SUM ACCOMPANIED TRAFFIC				188.953	243.145	199.190	43.955	18%

These rolling motorways show advantages concerning CO_2 emissions compared to pure road transport, but it seems evident that the environmental effects of these services differ: The Manching-Brennersee Rolling motorway (being part of the corridor Germany (or Belgium)-Italy) in 2001 saved 15.323 tonnes of carbon dioxide emissions. This is largely due to the high number of consignments (134.415 vehicles). The reduction is in fact smaller than for each of the observed unaccompanied relations (except the Stockholm-Basel one, that is part of a trimodal traffic, see above), namely 16 per cent, which is still very favourable concerning greenhouse gas emission.[37]

Along the corridor Germany-Hungary exists the rolling motorway via Austria (Szeged/Kiskundorozsma-Wels). The rolling motorway from Szeged to Wels is embedded in a transport chain linking Turkey with Germany (via Hungary). A high load factor and especially the railway electricity mix of Austria lead to savings in carbon dioxide emissions. Through the shift to rail, 28.632 tonnes of CO_2 emissions were saved: that it is nearly 20 per cent less than the pure road transport.

Special case: Dresden-Lovosice

The rolling motorway service between Dresden in Germany and Lovosice in the Czech Republic is the only one, which does not contribute to reduce the CO_2 emissions. The Czech energy production for railway electricity has a large share of brown coal with reduced energy efficiency and therefore higher carbon dioxide emissions along the whole energy chain. In addition, the pre- and on-carriage are quite long compared to unique and very short rail main course of only 114 kilometres, so emissions behave like a typical road transport. As mentioned before, the establishment of this temporary rolling motorway solution dealt with

[37] It has to be stressed again that average typical data for 2001 is underlying the calculation. The values change over time, as certain parameters change.

other external effects (road congestions, noise, air pollution in villages). So the setting up of this service was completely justifiable.[38]

The results for this relation are:

No	Relation	Corridor	Relevant Units	Number of consign-ments 2001	Annual CO_2 emission per relation road	Annual CO_2 emission per relation CT-chain	Annual saved CO_2 emission by CT-chain	Annual saved CO_2 emission CT-chain to road
				units	tonnes			%
20	*Berlin-Dresden - Lovosice -Praha special temporary case*	*D-CZ*	*Articulated Vehicle or Road Train*	*84.014*	*33.606*	*34.530*	*-924*	*-3%*

It seems evident that it depends on the specific circumstances whether a rolling motorway is able to contribute to savings in CO_2 emissions or not.

[38] In any way, the theoretical calculated plus of 924 tonnes of CO_2 emissions through the service in the year 2001 is in the tolerance of the measurement

III: Scenarios and projections for CO_2 and intermodal transport

Introduction

Intermodal transport is a priority of the EU White paper and becomes essential for certain European corridors, especially for the transalpine corridors where the road capacity is saturated.

The purpose of this chapter is not to come back to the reasons of such choices, which have been frequently commented, but to make an estimation of their consequences as far as CO_2 emissions are concerned.

For the transport sector, the projection of the White Paper should be a traffic growth of 38 % from 1998 to 2010 with a higher road transport growth of around 3,5 % per year, which corresponds to a doubling over 20 years. In this trend, the railway share will decrease but the importance of combined transport within the railway market is not really precise. This work package will focus on different combined transport scenarios and more precisely on international corridors where the long-distance shipments, within an enlarged Europe, should bring new opportunities for combined transport.

When looking at the past CT-trends, the unaccompanied international traffic of UIRR increased with an average yearly rate of 16 % between 1987 and 1996. During the last decade, it doubled to reach almost 20 Mio. tonnes in 2001 with around 900 000 consignments, excluding the Rolling motorway technique, which means an annual growth of around 7 %. During the same period, the ICF traffic was more stable: between 1990 and 1998 the number of TEU was around 1,3 Mio. and since 1998 ICF has recorded some negative figures. For 2001, 835.000 TEU were transported by ICF. But new entrants are developing very quickly new maritime container services from the major ports. This part of the intermodal market has probably also increased but it is difficult to really measure it.

However, this study focuses more on the percentage of CO_2 emission saving than on traffic volumes scenarios for combined transport. The estimation of an exact growth rate is less important than the future evolution in the transport flows. The investigations will concentrate on a better understanding of the types of transport markets and of the intermodal techniques, which might be concerned by this evolution. The former corridor studies have shown that, according to the type of corridor and techniques, the expected reduction of CO_2 emissions per shipment is different.

In this work package, three different scenarios have been elaborated based on a doubling of the CT traffic:

- The first projection at the horizon 2010 is a uniform doubling of the combined transport traffic for the different international traffic flows.
- The second scenario is focusing on a very critical situation across the Alps and the Pyrenees. The doubling of the traffic is only due to the growth of intermodal transport across these sensitive areas where road capacity is limited without changing the present level of traffic on other corridors.

- The third scenario concentrates on Europe's enlargement, which means a doubling of the East-West traffic as well as a doubling of the port traffic without changing the traffic level for the Alps and Pyrenees.

Such contrasted scenarios will point out the importance of the traffic flows' structure on CO_2 saving, being aware that the future situation will be certainly some mixture of these different scenarios.

To estimate the CO_2 saving for each scenario, the UIRR traffic flow patterns will be privileged, and when available complementary statistics, mainly form ICF or from some ports statistics, will also be presented. For each relation, and according to the techniques used, the basic saving ratios will be deduced from the detailed results of chapter 2.

The analysis will be presented as follows:

- The first chapter analyses the transport projections, which give an overview of the global transport market and justify the general hypothesis of traffic growth chosen for combined transport.
- The second part presents the three scenarios and the estimation of the CO_2 savings for each scenario.

Traffic growth and intermodal flows pattern

Although the objective of this study is not to analyse the intermodal traffic growth, the CO_2 savings have to be evaluated in accordance with the overall transport development. The main reason is that the European trade pattern will change in terms of market type and flow concentration so that the appropriate answer for intermodal transport and its energy "efficiency" will also depend on such structural changes. The objective of this chapter concerns more structural changes than global growth of intermodal transport, which includes combined transport techniques.

Several projects of the fourth and fifth framework programmes developed models for traffic projection in the future. Out of these studies, it can be stated that a doubling of the transport volume roughly corresponds to the expected increase of long-distance traffic in Europe over the next twenty years. For intermodal transport, such a hypothesis means that this traffic will also double without any impact on the road's market share. Even if the intermodal traffic will twofold in 2010, its market share will still remain at a moderate level, certainly between 5% and 7%. But on major corridors, and in particular on the congested ones, the changes will be much more significant with an intermodal share reaching 30 % or even more. This is especially true when crossing the Alps and the Pyrenees. This stresses again the importance of structural analysis, from a market and geographical point of view.

General evolution of the intermodal market

Many studies produced projections for the European transport sector. National master plans also gave some references for future traffic growth concerning several European countries, and in particular France and Germany. It is therefore important to keep these references in mind in order to build a common basis of understanding for the final recommendations of this study. However, it is also important to stress that except for the global figures produced in the White Paper no common European reference has been accepted by the experts.
In the White paper of the Commission, traffic references are given for rail, road, inland waterway and sea transport as a whole; but no explicit projections for intermodal transport have been realised (in particular with evolution of the relative transport costs for the different modes). In 2003, the Commission will normally publish new transport forecasts with detailed figures for the major European corridors.

Major projects for EU traffic projections are:

- the SCENES project from the fifth framework programme which was a second phase of SCENARIOS and STREAMS projects; projections are made on a region-to-region basis and have also been used in the SEA project (pilot study for Strategic Environmental Assessment of TEN network)

- the 2020 European traffic projections produced with the NEAC model for DG TREN

- the EUFRANET project from the fourth framework programme which focused on road, rail and inland waterway forecasts and made specific assumptions on rail operating system ("dedicated European rail freight network").

These studies and researches refer to a European economic growth of about 2,5 %. This means that the external socio-economic variables are compatible and the results were confronted in the THINK-UP thematic network, where the European forecasts were also compared to the national previsions.

The SCENES results

The project results are the basic figures, which were used in the last White Paper for transport projections. In 2003 and 2004, the Commission will probably produce new results for the major European corridors in order to better prepare the revision of the TEN criteria.

The results of this project (as well as other studies) point out an important difference between the international/national traffic growths.

The international traffic is split into three categories:

- long-distance intercontinental traffic which includes bulk and container traffics
- exchanges between EU and CEEC countries
- traffic between EU countries.

Out of the project the following results have been calculated:

Total freight tonnages by movement, 1995 & 2020 (‘000 / annum)

	TREX ‘observed’	**2020 Modelled**	***1995-2020 Pa growth***
Intra-EU15 international	764.633	1.488.318	*2,59*
EU15 national	10.653.388	13.116.210	*0,84*
Intra-EU15 total	11.418.021	14.604.528	*0,99*
CEEC – EU15	98.227	245.022	*3,51*
EU15 – CEEC	25.588	60.270	*3,40*
Rest Europe - EU15	191.426	453.161	*3,52*
EU15 – rest Europe	79.891	163.471	*3,18*
Rest World – EU15	544.016	1.171.908	*3,13*
EU15 – rest World	179.210	427.821	*3,46*

In this table, it appears that the intra EU international traffic will grow faster than the GDP growth (2,6 % per year), and much more rapidly than the EU national traffic (0,84 % per year). In tonne-kilometres, the growth rate will be probably higher for both international and national transports, because the distances for a shipment are increasing. Therefore, the total traffic growth in tonne-kilometres is a little bit higher than 2 % (instead of 1 % for tonnes) with probably less differences between national and international traffic growth: the ratio in tonne-kilometres between international and national EU traffic is about 2 to 1.

If the traffic with CEEC countries and traffic with the rest of the world are considered, a higher increase is obtained (up to 3,5 %). These are the consequences of the EU-enlargement and the globalisation of the world economy. For the EU transport sector, it means new exchange markets with the East and a continuous steady growth of the maritime containers traffic.

EUFRANET

EUFRANET concentrates on EU traffics and analyses more in detail the railway potential. EUFRANET’s model is the only one, which has explicitly introduced the combined transport in the modal split, in parallel with the conventional rail and bulk transport. The general socio-economic growth hypothesis of EUFRANET is compatible with the hypothesis of SCENES.

From a transport point of view, EUFRANET differentiates different levels of service quality, which influence the modal split. The survey on the railway services as well as intermodal services estimated that the offered services are lower in quality than road transport. However, there are differences in the assessments according to the corridor considered.

In the reference project of EUFRANET, the market share of rail is decreasing from 14 % to 9 % between 2000 and 2020 and combined transport is not increasing very much, at a rate lower than road. Improvements in quality - the priority for railway - would indeed double the CT-traffic at the horizon 2020: a “dedicated freight network” including the major European corridors is the solution proposed in the White Paper. This is an essential measure for promoting Combined Transport.

The EUFRANET results can be very useful: they give a framework of the possible structural changes in the European traffic flows. Another interesting aspect of EUFRANET is the introduction of the different performances in the combined transport's operations: shuttle trains and block trains are much better performing than the single wagon production scheme.

As the UIRR members are commercialising mainly shuttle and block trains, an average between low quality of railway services and high quality of service can be taken as reference to estimate different growth rates on different European corridors.

Deep-sea traffic evolution

The deep-sea traffic evolution is usually split into bulk, general cargo and maritime container.

Inland transport of maritime containers on the European continent is part of the intermodal transport when rail is used, which is often the case on long-distance with the port hinterlands. Inland waterways can also bring a contribution to intermodal transport but this combination is not dealt with in this study. The intermodal market of maritime container is growing fast with the globalisation of the world economy.

However, this market is difficult to trace in the European land network, except through specific services, which are proposed from the major ports to the inland terminals (and inversely). Some of the UIRR corridors are now integrating maritime containers in their market offers. Thus, there is less and less differentiation between continental and maritime markets. Again lack of statistics make the analysis more difficult although it is clear that major changes have occurred in the land transport of maritime containers over the past twenty years.

This maritime container market is included in the SCENES model but with no specific outputs concerning the assignment on the continental networks. As mentioned above, it is not considered in EUFRANET.

The maritime container market is originally a privileged one for ICF. Now, independent and combined transport operators are also offering inland services for maritime containers. An initial sharing of the intermodal market gives a more global competition with the transport liberalisation and does not facilitate a statistical appraisal of this evolution.

For the present study, although the focus will not be on maritime container but more on combined transport market, it is nevertheless interesting to track in parallel the evolution of the container movements in ports, being aware that only part of these containers are transported in the port hinterlands. The majority of the maritime containers are transhipped in ports or loaded and unloaded in areas closed to the ports.

Container Throughputs	1990	1999	99/90
France - North	791	1 583	2,0
Belgium	1 485	4 424	3,0
Netherlands	2 792	6 265	2,2
Germany -West	2 234	5 869	2,6
	7 302	18 141	2,5

In France, the intermodal services are supplied to serve French cities but also Switzerland, Italy, Hungary and Austria once or twice a week. The modal share in the port hinterland is estimated at 14 %, the rest being transported by road or inland waterways.

From the Belgian ports, different operators and services are proposed: the ICF services to Germany, Hungary, Italy and Scandinavia as well as UIRR services (TRW and Kombiverkehr) to Germany and Hungary, with, in addition the IFB services on shorter distances. In the “Northern ports”, a quite complex logistic organisation on short distances is in place in order to consolidate and distribute freight between ports which are very close to each other and which compete. Railway plays a role in this short-distance organisation which objective is also to prepare longer railway trips along major European corridors.

The port of Rotterdam has many inland connections with Western and Eastern countries offered by ICF but also by many specialised companies. However, railway represents only about 10 % of the total container throughput, compared to 40 % for road and 27 % for inland waterways (the rest is transhipment).

Railway services in Hamburg also supply the major German cities as well as southern and central European countries: ICF; Kombiverkehr and specialised companies provide these services. The railway share is estimated at 30% of the hinterland traffic, but this represents more than 2/3 of the long-distance hinterland traffic.

The container traffic in the Mediterranean ports (France, Spain and Italy) is much lower, about 20 % of the Northern range, but increases very quickly. However, the port hinterlands are in general national hinterlands (although Barcelona has recently implemented a platform in France).

An important factor in the organisational changes of the inland maritime container transport is the traffic concentration in the major ports using bigger vessels - the “mother vessels” -, which can handle up to 7.000 TEU. Thus, the hinterland of these ports, served by either Short Sea Shipping (the so-called feeding) or inland transport services, will be enlarged. New “entrants” have developed on this market and the group ERS has now more than 200 shuttle trains per week for the port services.

For the major ports, there is a clear opportunity for rail along the main European corridors and the handling performances in the maritime terminals reduce the terminal costs of such railway intermodal chains. It is difficult to organise quick transhipment directly on trucks in maritime terminals for several hundreds, and sometimes, several thousands of boxes.

The projections by 2010 are related to the general economic growth with an elasticity which was often in the past close to 3, but which has decreased due to the maturity of the container market. With a hypothesis of a 2,5 % GDP growth, an average for Europe should be closed to 5,5 % for this market (elasticity of 2,5).

For railway, the expected market growth (doubling over 10 years) seems to be reasonable, although this would require for some ports additional railway investments (including access investments). From an operating point of view, it is then important to stress that services to ports are a privileged market for the entrance of new operators, which will boost the railway supply in order to adapt the offer to the increasing demand, as long as slots can be allocated to these new services.

The analysis of trends and structural changes

Two approaches will be developed in this chapter: first, an indirect approach through the so-called "intermodal potential" and then a detailed analysis of the UIRR statistics, completed by ICF data.

The "intermodal potential"

The concept of "intermodal potential" is based on the idea that certain types of goods (high value-added goods or low value products) are privileged markets for an efficient intermodal transport under some circumstances: certain trip distances (a minimum trip distance is required so that the terminal costs can be compensated by a long-distance railway trip), and a minimum of O/D volumes (railway is better performing for concentrated flows whereas road is more adapted for diffusing flows) These criteria have been used to define the "intermodal potential" described in the IQ (Intermodal Quality) project.

More precisely, the IQ study made a difference between the "intermodal potential" usually defined with a certain transported volume of goods (unitised product) between regions and the "accessible potential" for which more stringent conditions are set: distances of 500 km or even more) and general conditions on traffic volumes (a minimum of 100 000 t to 200 000 t a year to start an intermodal service).

Two types of results from SCENES and IQ studies can then be mentioned in order to estimate intermodal trends, which are above the average trend of transport. In SCENES, the concept of "intermodal potential" only refers to the transported type of product with the definitions of goods, which are usually transported in a loading unit (trailer, box…).

The following table of SCENES shows that intercontinental transport of Unitised Goods (UG) will be comparable to the international intra-European transport of unitised goods. National transport of unitised goods is certainly more than four times higher in tonnes, but concerns much lower transport distances (excluding intra regional traffic). The transport of unitised goods gives a higher growth rate ranging from 3,1 % for national transport to 3,5 % and 4 % for international transport.

Transport of unitised goods in Europe

Unitised goods	Extra EU		Intra EU		Net	
Mill. tonnes	2020	1995	2020	1995	2020	1995
Consumer food	373	150	203	114	1.560	626
Conditioned food	210	84	157	99	762	522
Cement and manufact. Build. mat	262	91	131	77	992	264
Small machinery	64	23	79	22	110	65
Miscell. manufact. Articles	734	271	845	302	2.445	1.264
Total unitised goods	1.643	619	1.445	614	5.869	2.741
% price	4%		3,5%		3,1%	

As regards the IQ project, the "intermodal potential" for the hinterland of the Northern range amounts to 25 Mio. tonnes of goods in 1994 and a projection of 57 Mio. tonnes for 2010. This means for 2000 an estimation of 35 Mio. tonnes with a yearly progression close to 5 %, slightly lower than the container progression in the ports: this means an elasticity of 2 versus an elasticity of 2,5 quoted before.

If considering the global container volume transhipped in ports, which is in fact the only global statistics available, it appears that between a third (1/3) and a quarter (1/4) of the total container throughput are actually direct inland transport. ICF statistics, adding the statistics of new entrants statistics, probably represent less than 50 % of this estimated “accessible intermodal potential”.

The northwestern European ports generate most of the long-distance shipments of containers within the European continental traffic, although it represents around 1/3 of the total European container throughput including the northeastern ports (Baltic), and the western Mediterranean ones (the Atlantic generates much lower container volumes).

With a filter on distance (distance longer than 500 km) and a minimum O/D volume (more than 100 000 t a year), the intra EU market was estimated to 79 Mio. tonnes in 1994, growing at a rate of 4,4% a year: this estimation gives an accessible potential of around 100 Mio. tonnes for combined transport in 2000. The present combined transport shown in the UIRR statistics represents about 1/3 of the accessible potential market.

If intermodal market becomes competitive on the lower distances (distances between 400 and 500 km), this potential will considerably increase and almost double by 2010. Tests of growing regional penetration have also been made considering lower minima for volume, which increase the intermodal intra-EU potential and give a 6,2 % growth per year (113 Mio. tonnes in 2000).

All these results from European research projects define the framework of the UIRR market. They show how to achieve an intermodal market growth: with an increase in trade and in the share taken within an “accessible market” when the competitive conditions for all transport modes will be really fix.

Development of accessible potential demand in intercontinental flows via French, Belgian, Dutch and German seaports.

	1994	2010	Increase
Hazardous goods	1.695	3.810	+125%
Perishables	2.568	5.725	+123%
High-value goods	13.570	31.703	+134%
Low-value goods	7.598	15.559	+105%
Total	25.431	56.796	+123%

(criteria: minimum volume > 50.000 tonnes,
only if related to other than the seaport region itself)

Development of accessible intermodal potential on the European continent

	1994	2010	Increase
Hazardous goods	3.440	6.874	+100%
Perishables	8.273	14.566	+76%
High-value goods	56.158	113.591	+102%
Low-value goods	11.193	22.834	+104%
Total	79.063	157.865	+100%

(criteria: minimum volume > 100.000 tonnes,
distance > 500 km as the crow flies)

Development of accessible intermodal potential
after decreasing the break-even distance

	1994	2010	Increase
Hazardous	3.440	11.006	+222%
Perishables	8.273	21.810	+164%
High-value	56.158	191.277	+241%
Low-value	11.193	39.126	+250%
Total	79.063	263.219	+246%

(criteria: minimum volume > 100.000 tonnes,
distance in 1994 > 500 km as the crow flies, distance in 2010 > 400 km as the crow flies)

Development of accessible intermodal potential after
decreasing the break-even volume and after increasing regional penetration.

	1994	2010	Increase
Hazardous goods	3.440	9.605	+179%
Perishables	8.273	18.960	+129%
High-value goods	56.158	146.624	+161%
Low-value goods	11.193	30.850	+176%
Total	79.063	206.038	+161%

(criteria: minimum volume in 1994 > 100,000 tonnes, minimum volume in 2010 > 50,000 tonnes, distance > 500 km as the crow flies)

	1994	2010	Increase
Hazardous goods	3.440	14.452	+320%
Perishables	8.273	26.902	+225%
High-value goods	56.158	232.527	+314%
Low-value goods	11.193	49.191	+339%
Total	79.063	323.072	+309%

(criteria: minimum volume in 1994 > 100.000 tonnes, minimum volume in 2010 > 50,000 tonnes, distance in 1994 > 500 km as the crow flies, distance in 2010 > 400 km as the crow flies)

Analysis of the UIRR statistics: a quick growth and important structural changes

The UIRR statistics are available in a country-to-country basis with following data: number of consignments, consignments x km, tonnes, ton-kilometres, details on the different intermodal techniques (%semi-trailer, % swap-bodies/containers, and % Rolling motorway).

Originally, the UIRR market was concentrated on the intra EU combined transport market (rail-road techniques), but for several years, the UIRR companies have also transported maritime containers.

Over the past ten years, the total number of tonnes has increased by 80 %, which means a yearly growth above 6 %. This growth is certainly lower than the one observed before 1990 but it reflects the maturity of a fast growing market. However, this growth is the result of two parameters: an almost stagnating “national” market (1,5 % growth per year, in average) and a very fast growing international market (8,7 % growth per year). In 2001, the international market is 2,5 times the national market (expressed in tonnes).

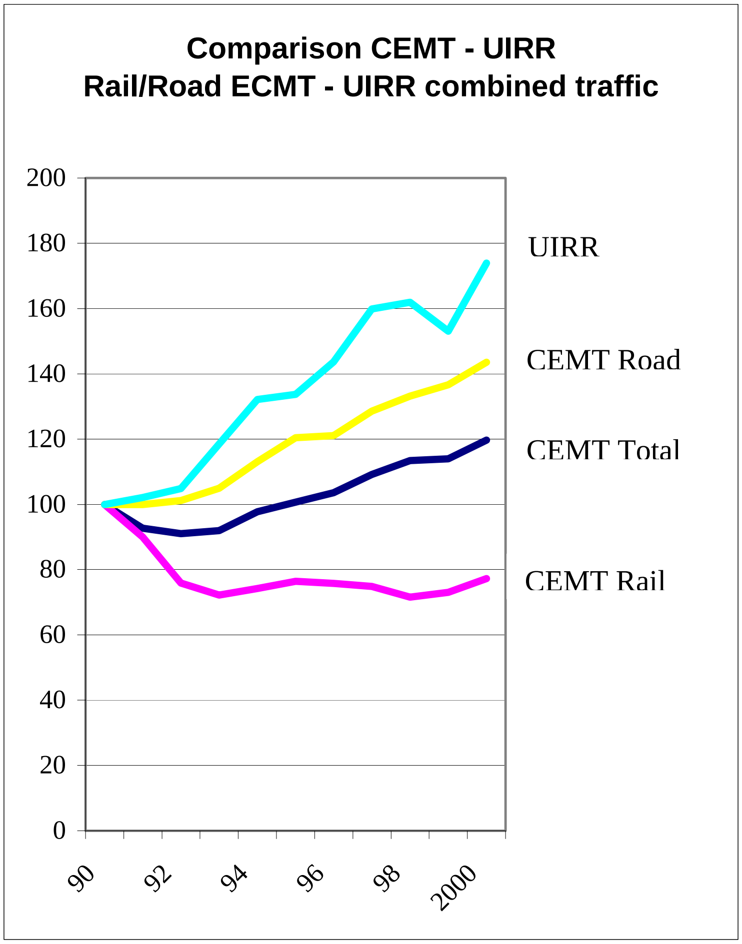
The results in tonne-kilometres are quite equal to the results in tonnes: 1,6 % growth for the national market, 7,6 % for the international market and 5,7 % for the total over the period 1990-2000. The average distance is slightly decreasing and this will partly be explained by the geographic analysis.

When comparing these figures with the global ECMT transport figures, the UIRR market expressed in tonnes-kilometres is apparently growing much faster than the transport market in the ECMT countries (2,4 % versus 5,7%) at a rate, which is slightly higher than the ECMT road growth over the period 1990-2000.

When considering only the international transport, the UIRR traffic is growing faster than the international road transport trend estimated in the project SCENES (4,8 % per year in tonnes versus 8,6 % per year in tonnes for UIRR).

When considering the techniques, the share of semi-trailer is clearly decreasing over the period, but the Rolling motorway technique remains at a fairly stable share of 30 % of the international combined traffic.

But this evolution of UIRR activity reflects in fact deep structural changes, which occurred during the period.



A market very sensitive to geopolitical changes

The nature of these changes appears quickly when considering the classification of O/D according to their importance in the UIRR market:

When comparing 2000 with 1990 classification we observed that:

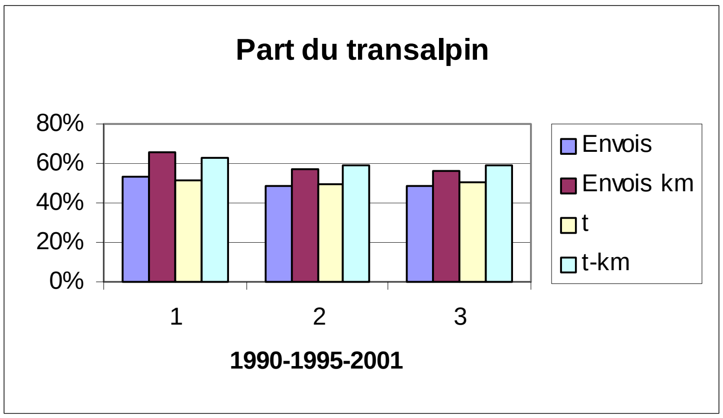
- 10 relations have more than 1 Mio. tonnes
- 25 have between 1 Mio. tonnes and 100 000 t
- 10 relations have between 100 000 tonnes and 500 000 tonnes
- the rest is below 50 000 tonnes.

This means first a strong traffic concentration on the major corridors, which can be explained by the existence of more efficient intermodal railway services. But what is more interesting to notice is that among the ten first relations and "a fortiori" among the following forty relations, the order has significantly changed.

The importance of transalpine traffic is certainly the main characteristic of the UIRR members' activity. Transalpine traffic represents around 2/3 of this market and its relative importance is not declining. This is partly due to Swiss restrictions on road traffic and affects in particular relations from Germany to Italy. Today, Switzerland is removing the 28t limit for trucks but the road capacity in the tunnels have been in the same time limited for safety reasons after the fire (accidents) outbreaks.

The following table shows that the share of transalpine traffic is close to 60 % and stable over the last 10 years, whether measured in tonnes, tkm, or shipments (consignments or shipments-km, with a slightly higher percentage when distance is taken into account). This means in particular that the analysis can be carried out in tonnes or shipments without affecting the results over this period.

UIRR part of transalpine traffic



The perspective for the 10 years to come is that the road traffic increase will remain very limited in the Alps at a time when exchanges with Italy are expected to grow for several reasons:

- increase of the maritime container traffic across the Alps

This is not only due to the extension of the hinterland of the northern ports but also to the new vocation of the Mediterranean ports to become a gateway for Euro-Asian as well as Mediterranean traffic

- the development of Spanish-Italian trade which has been particularly dynamic over the last 10 years and resulted in a very high increase of truck traffic between these two countries at a rate above 6 % per year.

- and finally the increase of trade with the central European countries: this traffic develops quickly through Austria, Slovenia in direction to Poland, Czech Republic and Hungary as well as towards south-east of Europe; the enlargement process will certainly stimulate the transalpine traffic as it was already the case during the past five years.

With such perspectives, an over-proportional growth of transalpine traffic is still possible and will just reflect the implementation of more voluntary policy measures for the crossing of “sensitive” areas.

But if the distribution of the UIRR O/D relations remains very concentrated over the period 1990-2000 across the Alps, it is also worth noting that the proposed number of relations has increased a lot, in particular with the East. New relations to UK and Scandinavian countries reflect former enlargement stages of the European Union. Relations with the major ports have been developed. In conclusion, the UIRR market has been very reactive to geopolitical changes of Europe as well as to internationalisation of economy.

This means that scenarios for "over proportional growth" are interesting to study, focusing on the EU-enlargement, although these relations represent a more modest share in the total UIRR traffic. The impact of the Alpine traffic on the CO_2 saving will not be eliminated but just reduced.

Over the last 10 years, the table of the international relations shows:

- The first two relations with the highest volume are linking Germany and Italy, with a higher North-South traffic in 2000, unlike 1990. This German-Italian traffic represents nearly 20 % of the UIRR total traffic and has doubled over the period

- The next two relations are between Germany and Austria with also a very high volume: more than 2 millions tonnes in each direction but with a limited increase. For these two relations, the RoMo technique represents an important share, which was not the case for the relation between Germany and Italy. The RoMo services between the two countries have also deeply changed with more importance given to short distance services.

- Then in importance order are a series of East-West and transalpine relations. Many of the East-West relations are new ones with in particular the development of the RoMo technique. The unaccompanied transalpine relations of northern Italy are also in a fairly good position and show a high increase over the period.

- A very significant increase in the German-Spanish relations is also worth noting, with a spectacular increase in the direction North to South (a quadrupling of the transported volume) but much more limited in the other direction (30 % increase).

- Some relations have recorded traffic falls: links between Denmark and Italy, Swiss and Belgium, Belgium and Austria as well as France and Germany, which would probably require some more in-depth analysis upon the reasons of such evolution.

In conclusion, the UIRR traffic evolution reflects both a traffic increase on the major economic European relations and on the corridors with the East. This structural evolution explains that the overall UIRR international activity has developed quicker than the general international traffic trends over the period. From these elements, different scenarios to explore the contribution of combined transport in CO_2 reduction can be chosen.

Reduction of CO_2 emissions: modelling and scenarios

In chapter 2, a detailed comparison of CO_2 emission for road and combined transport has been conducted: 20 cases have been analysed, covering different types of situation. In this chapter, the results of these analyses will be used for the different scenarios. The projections are based on the remarks of chapter I describing the major structural changes in the UIRR market.

From the results of these 20 specific cases, two steps have been defined:

- First, the definition of a methodology, which allows deducing a scientific model for the CO_2 reduction from these specific observations,
- Second, the definition of scenarios, which will explore different possible futures of intermodal markets and assess the expected reduction of CO_2 in ten years.

From case studies to market analysis: definition of a methodology

The 20 case studies represent a very large range of situations, making it difficult to envisage a structural analysis according to all the different types of variables. The dispersion of the results, regarding the impact on CO_2 savings, reflects this diversity of situations and it is hard to generalise the results.

The approach of modelling

The method used is first aimed at analysing each case study performances (CO_2 sources) and then at taking different representative variables, which privileged in the first place the distance, the technique used and the relation's performances.

In the results of chapter 2, all the O/D relations have been summarised. Distances as well as performance criteria regarding deadweight ratios have been reported in the columns. Since the CO_2 emission per tkm is lower by rail than by road, it can be expected that the longer the transport is, the higher the CO_2 savings are.

But for the modelling, the criteria of distances are not sufficient: the ratio between net weight and total weight has also to be taken into account. For rail, this ratio varies according to the density of the product, the technique used, the loading unit, the percentage of empty wagons… These factors have a direct influence on energy consumption and on CO_2 emissions. For road, several elements also influence fuel consumption per transported tonnes. In the comparison between road and rail, the technique used for combined transport is very important. Unaccompanied trains with swap-bodies and containers allow reducing the CO_2 emissions by two third. The Rolling motorway, which transports more deadweight, allows nevertheless an important reduction of CO_2 emissions by about one fifth.

Another very important factor is the route chosen for rail and for road. For rail, the route across a country where the primary energy source is not fossil energy (Austria, Switzerland and France), the CO_2 emission will be limited to the terminal transport by trucks. For road, the route distance along a corridor can deviate (political reasons, etc.) and most of the time, the road distances are longer (not always true because the gradient is also considered).

Therefore the modelling attempt is made to check the influence of generic factors such as distance and an indicator for the performance of the chosen technique (net weight compared to global weight). The performance indicator takes into account most of the elements characterising the logistic chain but not completely those related to the chosen route or to the primary energy source. Thus, it gives the possibility to find a model generalising the results as well as an indication for improving the results (through the indicator of performance for example). It also proves the consistency of the observations made but it does not really provide an instrument to estimate the CO_2 savings: an analytical procedure is necessary to create a global model.

Some data corrections have been made regarding the differences of the route distances between pure road and combined transport. The cases where the primary energy source is mainly produced without fossil energy is treated separately: the basic relation distances with performances can be verified. Unaccompanied traffic with containers, swap-bodies and semi-trailer allows a higher reduction of CO_2 emission than Rolling motorway. Not much difference however appears between the different loading units used in combined transport: (swap bodies (13,6 m or 7 m long), maritime containers or even semi-trailers). The trains' length and weight are probably a discrimination factor when comparing CO_2 emissions with road, but in the selected cases, the differences in the train length and weight were too small to clearly point out the impact of these parameters. However, these differences are implicit in the estimation process itself since a formula linking train weight and energy consumption has been used in chapter 2.

The plotting of performances related to the distances does not show a convincing correlation mainly because of RoMo relations as well as relations with the total or partial use of the French railway network. Another "disturbing" factor for such correlation comes from the comparison with road. When the road distance is very different from the railway distance, railway should take advantage of it but it is not a factor that can easily be generalised to other situations. Correction of such factors to obtain a comparable situation in terms of length of routes for rail and road increase the correlation between performances of distance.

In the case of transalpine traffic, the question of relative distance between modes is certainly a permanent factor to be taken into account in favour of rail, in particular when basic tunnels will be built.

When such "connections" are made according to distance comparison, techniques used or transit through France, then a much clearer relation between distance and performance will appear.

The analytic approach

The analytic approach is based on a number of very simple principles:

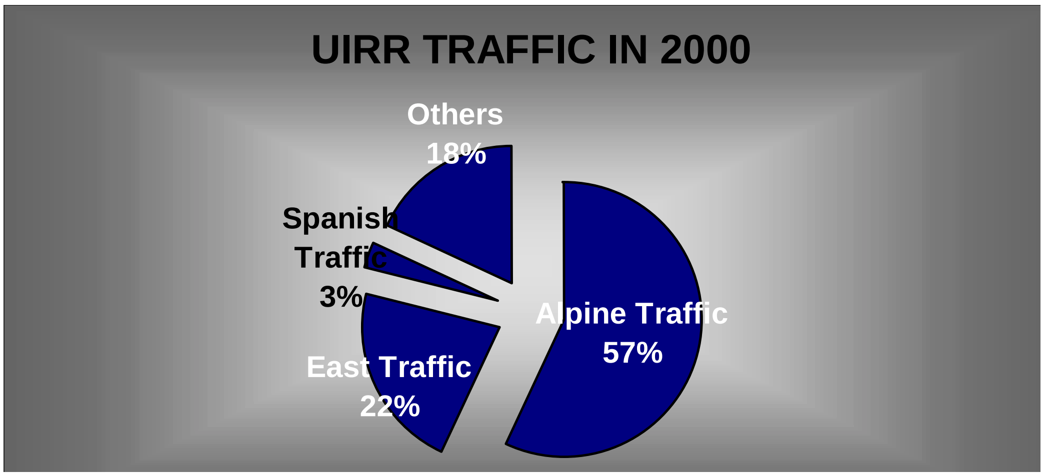
a. Each operation made for a shipment (consignment) is considered as representative of a terminal-to-terminal traffic flow.
b. Each terminal-to-terminal traffic flow is considered as representative of a part or the total traffic flows between two countries. It is representative of a part of a country-to-country traffic if several observations have been made for the same country-to-country relation: in that case each observation is weighted according to its relative importance.
c. Where no observation has been made, the general ratio of all cases is used.

However, the RoMo services will be treated separately and cannot be considered in any case as representing the total traffic country-to-country unless no other CT services are available in the UIRR statistics (which is not the case).

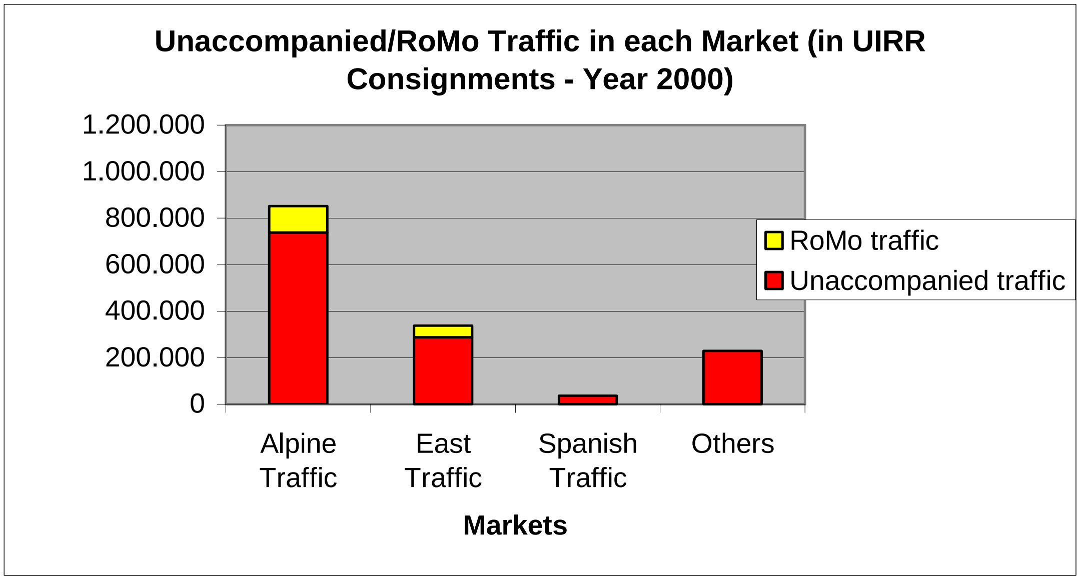
Once these principles were settled, the O/D relations country-to-country were classified according to the following segmentation

(a) the transalpine traffic
(b) the port traffic (which is the two cases observed are also transalpine traffic)
(c) the East-West relations
(d) the relations with the Iberian Peninsula
(e) the other relations.

This differentiation is set up in order to define the various scenarios, which will be based on such geographic criteria.



	UIRR TRAFFIC IN 2000	RoMo Part in each market
Transalpine Traffic	57%	12,5%
East-West Traffic	22%	18%
Spanish Traffic	3%	0%
Others	18%	0%



The remaining influencing factor will then be the loading factors, or the ratio net weight/total weight.

Scenarios and evaluation of the CO_2 savings

The choice of scenario results from the following structural analyses: trends in the intermodal transport and the evolution of the UIRR traffics.

In this perspective, a doubling of the international intermodal transport in 2010 might appear as very reasonable. This will be the common basis for all the scenarios, which will focus on structural market changes.

From this point on, it is always possible to establish even more ambitious strategies: the tripling of the intermodal traffic, which can still be considered as a realistic projection in a context of strong voluntary policy action or of strategies of improving the CO_2 savings per unit with longer trains or heavier trains.

The scenario analysis will be made in two steps.

1. First, the definition of a reference scenario with a uniform doubling of the O/D traffic by 2010 and the estimation of the resulting CO_2 saving
2. Second, the definition of two alternative scenarios focusing on the structural changes:
   - In the first one, the doubling is due only to an increase of the transalpine traffic, the Alps and the Pyrenees (tripling for Pyrenees) with no increase on other markets. This is the “sensitive area” scenario.
   - In the second one, the doubling is due to a traffic increase in the East-West relations as well as an increase of the port traffic.

For each scenario, the CO_2 savings are estimated in relation with the UIRR data. From these results, a global saving expressed in tonnes will be calculated for the whole European intermodal market, by adding a fix percentage of the other companies and in particular the ICF contribution.

The reference scenario

For this scenario, the traffic of all O/D relations is doubled.

· Doubling the transalpine market

This has been achieved over the past ten years by the UIRR operators as mentioned in the Alp Info statistics: 9,2 Mio. tonnes in 1990 for unaccompanied transport and 16,7 Mio. tonnes in 2000. Including the RoMo traffic, the figures will change as follows: 10,1 Mio. tonnes in 1990 and 20,4 Mio. tonnes in 2000. The modal share of intermodal transport has increased by more than 5 points to reach 16,7 % without Rolling motorway and 20,4 % with Rolling motorway.

For the future, this can be considered as a moderate objective to reach when the situation of the Alpine transit is considered:

- Fairly fast growing international market on the major North-South corridors which still represent the majority of the traffic across the Alps with in parallel fast growing relations with CEEC countries, a growth of potential market of around 40 % over 10 years.

- The clear objective of Switzerland is to limit their road traffic, which represents at the moment more than 1,3 Mio. trucks: this figure should be reduced by half in the future. But to transfer this traffic to other routes (via France for example) will be difficult as new safety regulations in the alpine tunnels have been implemented.

· Doubling the maritime container market from/to major ports
This is also in line with the evolution of the maritime container traffic but will probably require adaptations in the railway infrastructures near the ports and in the creation of new slots.

· Doubling the East-West traffic
More than doubling the East-West traffic is already expected: most of the East-West expansion scenarios have confirmed these trends and the confirmed enlargement of the EU will speed up the commercial relations with East and West.

· Doubling the traffic with Spain
It has been stressed that this market is currently at a fairly low level. For this reason, it is rather normal to envisage a doubling or tripling of this intermodal relation. However, such a perspective will depend on the improvements of the railway networks: on the French side, the railway bottlenecks must be solved and on the Spanish side, the investments should be dedicated to the transhipment border points.

The results of doubling uniformly the traffic are shown in the next table:

Market	Relation	Type of traffic	Part in UIRR	% CO2 savings
ALPINE				
	D-I	Unaccompanied	26,4%	56%
		RoMo	1,7%	18%
	A-D	Unaccompanied	4,4%	38%
		RoMo	10,4%	16%
	F-I	Unaccompanied	3,5%	63%
	CH-I	Unaccompanied	2,3%	55%
	GB-I	Unaccompanied	1,7%	69%
	Others	Unaccompanied	2,2%	55%
		RoMo	0,4%	18%
TOTAL ALPINE			**53%**	**48%**
ALPINE PORTS				
	B-I	Unaccompanied	9,8%	67%
	I-NL	Unaccompanied	5,5%	50%
	D-CH	Unaccompanied	4,1%	24%
		RoMo	0,3%	18%
TOTAL ALPINE PORTS			**20%**	**54%**
SPAIN				
	D-E	Unaccompanied	1,6%	72%
	Others	Unaccompanied	0,5%	55%
TOTAL SPAIN			**2%**	**69%**
EASTERN COUNTRIES				
	A-H	Unaccompanied	0,3%	55%
		RoMo	8,1%	19%
	CZ-D	Unaccompanied	0,1%	55%
		RoMo	6,5%	-3%
	A-SLO	Unaccompanied	0,2%	55%
		RoMo	1,8%	18%
	D-H	Unaccompanied	1,2%	42%
	SLO-H	Unaccompanied	0,3%	55%
		RoMo	0,4%	18%
	Others	Unaccompanied	1,6%	55%
TOTAL EASTERN COUNTRIES			**21%**	**22%**
OTHERS		Unaccompanied	**4%**	**55%**
TOTAL			**100%**	**43%**

The percentage of savings in this scenario is 43% for the UIRR market. This result is certainly much influenced by the Alpine results, which dominate in this scenario with 52 % of the total volume. Then the relations from the north of Europe to Switzerland and Austria are included in the Alpine traffic, which do not completely cross the Alps; then the performance in percentage of CO_2 saving decreases, as the lengths of trip are shorter. For the traffic across the Alps in relation with Italy the average percentage of saving will be more than 50 %, probably around 55 % or more. However, the port traffic has been treated separately: this traffic concerns the maritime containers and refers to different market types and organisations. The port traffic represents almost 20 % of the total UIRR market. Adding the transports of ICF and of the new entrants, the share of the maritime containers in the total intermodal transalpine traffic will significantly increase. New entrants, in particular, have strongly increased their service supply from the northern ports to the Alps. The CO_2 savings for the port traffic across the Alps are 54%, higher than the average for non-port traffics, due to the transport distances from the northern ports to Italy or Switzerland.

The traffic with Spain is a third segment with good CO_2 performances as already mentioned, due to different factors and in particular the trip distance across France. The rate of CO_2 saving is 69%. The volume is presently fairly low and limited to 2% of UIRR market, due partially to technical reasons (different gauge). The CO_2 savings in absolute value are fairly low and do not really influence the global results of CO_2 savings.

Finally, the fourth segment is the traffic with Eastern countries. As already noticed, it has reached a quite significant level during the past years and represents 21% of the UIRR traffic. However, the CO_2 performance is beyond the average: 22%. This is partly due to the inclusion of the RoMo services with lower performances. But this is also due to the fact that the estimations had to be made with only one representative relation from Germany to Hungary. It should be certainly interesting to consider more relations, but no drastic changes of the coefficient must be expected, because most of the East-West relations are in the centre of Europe (between Germany and CEEC countries with some relations with Italy and Netherlands) Therefore, the average distances are not obviously very long, as it is the case in Spain or between the Benelux countries and Italy. For a prospective approach, this pattern might change. If the commercial relations will continue to increase between the Eastern countries (thanks to the enlargement of the European Union), all EU member countries will probably participate to this process. There are certainly interesting perspectives for very long intermodal corridors: the distances will be much more longer and these new solutions will be saving much more CO_2 tonnes.

The sensitive area scenario

In this scenario focus is put on traffic crossing sensitive areas: the mountains. For the Pyrenees, a hypothesis of tripling the traffic is taken. For the Alps, the tripling of the Alps' intermodal traffic will imply more than doubling the total intermodal traffic in Europe or reduce existing traffic on other relations and in particular the East-West relations, which is not realistic. In order to keep a total of a doubling UIRR market by 2010, the traffic for the Alps has been multiplied only by 2,8. This represents a traffic growth close to 11 % per year. In this scenario the results are as follows

Market segment	**% of UIRR traffic**	**% CO_2 savings**
Alpine	77%	48%
Alpine Ports	10%	54%
Spain	1%	69%
Eastern Countries	10%	22%
Others	2%	55%
Total	**100%**	**45%**

The traffic growth across the Pyrenees is not sufficient to compensate the traffic growth of the Alps, which represents 3/4 of the total traffic: the CO_2 savings are closed to reference scenario.

Globalisation scenario

Tripling the port traffic (maritime containers) means a continuous growth of exchanges between the continents; it will probably be superior to the expected growth of the world trade in a context where the containerisation technique is reaching its “maturity”. But it has been stressed that the elasticity of the container traffic related to world trade is still at a very high level and will progressively decrease to 2,5 by 2010, and reach 2 at the horizon 2020. In other words, such projections for container traffic are compatible with past trends.

Furthermore, many governments are planning important investments to better connect their ports with their hinterlands. The rail transport of containers in the continent is a solution that many operators will favour in the future because the major areas of the main ports will be completely congested in a near future.

Finally, this market is a very dynamic one with new entrants providing new kind of services: it will further develop the offers along the North-South corridors but also in the direction of the CEEC countries. For the forthcoming years, new services from the southern ports will also be created.

Therefore tripling the port traffic is a very plausible trend. The UIRR figures are reflecting only a part of this traffic, certainly less than one third of the total traffic realised by ICF and the new entrants. The port traffic is really a privileged one for combined transport and the chosen cases which give good CO_2 performances are representing for the moment a minor part of the whole container traffic.
The enlargement to the East is already decided with high expectation for the international trade; tripling that market by 2010 is completely in line with what can be expected. Concerning the performance rate in CO_2 saving, it has already been stressed that more relations should be taken as reference. New unaccompanied solutions will be developed and progressively replace the Rolling motorway solutions: the rate of the CO_2 performances will increase.

Based on these elements, a more moderate growth rate will be assigned to the other segments (intra EU Alpine and Pyrenean markets) in order to obtain a global doubling of the UIRR figures: this growth rate will be 38 % by 2010, a rate almost equivalent to the global freight growth stated in the White Paper.

These results of the scenario are as follows:

Market segment	**% of UIRR traffic**	**% CO_2 savings**
Alpine	35%	48%
Alpine Ports	30%	54%
Spain	1%	69%
Eastern Countries	31%	22%
Others	3%	55%
Total	**100%**	**40%**

Conclusions

After this prospective analysis of the combined transport market, following conclusions can be made concerning the CO_2 savings by this market:

(a) From a methodological point of view

- First, the analysis of a limited number of CT relations has been conducted in a very detailed way and provides a wide variety of situation.
- Secondly, the results obtained in the projections give stable results. Some factors like the primary energy source have a positive incidence on the savings for traffic passing countries with important nuclear energy source. But even without this positive incidence, the global CT rate for CO_2 savings is close to 45 %.
- Finally, this study is a factual contribution based on real transport figures. It could be of course enlarged to become a very good basis for a more scientific contribution.

(b) From an economical point of view

- The combined transport market will be a very dynamic market, a plausible strong growth can be made for all segments; the analysed projections are furthermore in line with past trends.
- The CO_2 performances of the combined transport system were certainly influenced by the distances (the European enlargement also means for international trade, longer distances) but also by the logistic organisation (only shuttle trains or block trains were considered).
- Finally, if the market develops and if performances exist then the future of the contribution of CO_2 saving will highly depend upon the possibility for the supply to follow up the rhythm of growth, without degradation of the quality of services and possibly with improvement in order to keep the potential economical gains.

c) From an environmental point of view

- First, a direct relation exists between the logistic performances (and consequently the economic performances) and the CO_2 savings.
- Secondly, the enlargement of the European Union will increase traffic inside these new EU member states but also with all the Western countries. This is really an opportunity for the combined transport sector to propose new services, which as assessed in this study will save much more CO_2 than the road sector (even if RoMo services are run).
- Finally, the outputs in absolute values must also be considered. The saving per consignment, according to the relation, varies from 0,4 ton (excluding RoMo service) to more than 10,5 tonnes. This means that a substantial amount of CO_2 emission measured in tonnes can be saved: between 1,3 to 1,5 million tonnes per year for the UIRR market, and probably 2 or 2,5 millions including the overall intermodal market.

If the value of savings of one ton of CO_2 is about 100 EUR, as it is proposed for reference in some countries, then the global amount will double in 2020 to about 240 Mio. EUR a year for UIRR and 360 Mio. EUR for the whole combined transport market!

IV. Conclusions and Recommendations

Conclusions

The PACT study on CO_2 savings was based on a detailed comparison between an intermodal solution and pure road transport. A sample of twenty relations was chosen, giving an overview of today's Combined Rail-Road Transport. The focus was on the unaccompanied transport of swap-bodies, containers and trailers with two market segments: international transport and national traffic relations in the larger European countries Germany, France and Italy. These segments are representing each about 40 % of the total UIRR traffic. As the Rolling motorway (trains transporting whole lorries on special low platform wagons) plays an important role in some markets and represent 20% of total UIRR traffic, some relations were analysed as well.

Today, road transport has by far the largest market share of all continental transport modes. The objective of Combined Transport is to shift traffic from road to rail. So, pure road transport was taken as the reference and the objective of this project was to find out if CO_2 savings could be achieved by transferring traffic to rail and to quantify the effects.

The first step consisted in evaluating the energy consumption of both alternative modes. The second step was the deduction of the CO_2 emissions.

The analysis was based on the current state of science and research. A lot of recently published data could be used to calculate energy consumption and CO_2 emissions for road and rail.

The UIRR and its member companies delivered all specific Combined Transport related data taking into account some data from other CT-operators. The existing data for road were verified in collaboration with an intermodal operator who was part of the consortium and could provide detailed truck fleet consumption for both direct lorry service and intermodal services.

The results were calculated in detail for each of the 20 chosen cases. To achieve overall results, a weighted average was calculated, taking into account the real importance, measured by actual volumes transported on those corridors.

The overall results for the traffic of the year 2001 are, with road (100%) as benchmark:

1. The Combined Transport chain is reducing energy consumption to 72 %. This is of course partly due to the road terminal transport legs.
2. The rail part is reducing the consumption to only 66% (rail km compared to road km in CT).
3. The Combined Transport chain is reducing CO_2 consumption to 45 %. This is of course due to the road terminal transport legs.
4. The rail part is reducing the consumption to 40% (rail km compared to road km in CT). (= CO_2 savings are 60%)

For the Rolling motorway, transporting not only the loading units but the whole lorry, the savings are still remarkable, but of course lower: energy consumption about 10% less for road, while CO_2 level of the whole transport chain with pre- and post road transport is reduced to 82% and the rail part only to 77 %.

The study has shown that CO_2 savings of unaccompanied Combined Transport (today representing 80 % of CT) are considerable: The rail level of emissions is at about 40 % of

road transport, in other words savings of 60% may be obtained by shifting traffic from road to rail.
The savings already achieved by the UIRR companies in CT transport are 1,2 Mio tonnes CO_2. A doubling of combined traffic by 2010 will more than double these figures. This is because most of UIRR traffic is today realised in complete trains, the most energy and CO_2 saving forms of CT. A small percentage is still done in trains with wagon group exchange or even in single wagon mode. A certain number of these second level activities are necessary to introduce new traffic relations or to enlarge existing traffic. The absolute part of these types will probably remain constant even if traffic doubles so that their relative part will shrink further.
There are evaluations about value of one ton CO_2 saved. If we consider the French evaluation of about 100 EUR per ton, the CT saves environmental damages of 120 Mio EUR in 2001 and will help to save two times 240 Mio EUR yearly after doubling in 2010.
In case the European Union decides to charge for CO_2 emissions, Combined Transport has a chance to realise these “system advantages” on the market. For a transition period Combined Transport may claim public support until market distortion to other modes is resolved by a pricing system taking into account the environmental damages caused by the different modes.

General recommendations

Basically, all savings in CO_2 emissions realised by intermodal transport can be traced back to three sources:

- Intermodal transport consolidates smaller loads into large volumes which can be moved with less specific energy consumption, i. e. with less energy input needed per unit carried;
- Intermodal transport shifts transport operations from road to rail. The rolling friction of the system steel wheel on rails is three to six times less than those of lorry rubber tyres on road.
- Rail transport, at least in long distance traffic on the main axes, uses mainly electric traction in Europe. This electric energy is partly generated from other sources than conventional fuel burning. When electric energy is generated by waterpower or nuclear power, the energy for rail traction is provided without creation of CO_2.

The latter case develops completely independently from the question, whether intermodal transport is used or not, and which volumes are transported in intermodal transport. It is mainly decided by infrastructure and rail administration how they generate their electrical energy for rail traction. The decision making process occurs in another field of political action. Insofar, this study notes the effect but does not evaluate it into political recommendation.
In other words: in this chapter, we shall concentrate on the energy saving effect of intermodal transport and its origins and sources. Of course, the amount of energy savings depends in the first place on the amount of cargo shifted from road transport to intermodal road/rail transport, and from the amount of energy saved per consignment or per block train.
Looking such a case-by-case comparison, we find as a basic rule:

- The better the ratio from payload to gross weight of the intermodal transport train is, the higher is the energy saving per trainload.

These parameters may be influenced in a positive way by four main parameters

1. Transporting heavier payload
2. Reducing tare of loading units

3. Reducing tare of wagons (lighter construction, higher axle load)
4. Longer trains

point 1 The advantages of rail compared to road are more significant in the sector of heavy transports than of those with high volume.

point 2 The use of containers and swap bodies as intermodal loading units creates the best ratio of payload/gross weight; the more intermodal transport uses such units the more energy-efficient it can be moved.

The use of semi-trailers as intermodal loading units creates the second best ratio of payload/gross weight; when intermodal transport uses such units, the shift from road to intermodal transport creates more energy-efficiency but not that much as if containers and swap bodies would have been used.

The use of full road vehicles (road trains and articulated vehicles including the truck) as intermodal loading units together with transport of drivers in a separate railcar creates the third best ratio of payload/gross weight. When intermodal transport uses such a technique, the shift from road to intermodal transport creates in most cases additional energy-efficiency but not that much as if containers, swap bodies or semi-trailers would have been used.

points 3 and 4 These parameters give a high potential for optimising environmental savings by organisational changes and technical progress.

This leads to a first set of recommendations:

- Encourage and promote all technical, operational and commercial solutions that increase the average capacity use per intermodal transport train.
- Encourage and promote all technical, operational and commercial solutions that increase the concentration of cargo flows to certain corridors, which will allow for the operation of longer and heavier trains.
- As far as the political and commercial environment allows for a selection of intermodal transport techniques and loading units, energy saving recommends the operation of containers and swap bodies as the most efficient way and the operation of semi-trailers as the second efficient way. The operation of complete road vehicles creates energy savings but not as much as the other techniques.

Another consideration in this field leads to the routing of road transport and the alternative routing of intermodal transport / rail transport. In almost all cases of European corridors, the routes for rail transport and for road transport run rather in parallel so that a shift from one mode to the other will not create additional or less mileage. This might change once the Swiss new Trans-Alpine rail tunnels come into service. That might offer underground direct mountain crossing while parallel road transport will have to use the conventional ways through the valleys that often meander through the corridors (incidentally, a similar effect can be observed in some cases of inland waterway transport: Using a barge on a European river might incur up to double the mileage for the same itinerary than using the more direct rail line. Thus, the barge must at least offer the double productivity than a block train just to break even.)

While normally choosing between road and rail does not make a great difference in mileage, we observe that certain itineraries with considerable additional mileage are used because of traffic restrictions. This leads of course almost automatically to additional emissions of CO_2. When intermodal transport can, by its specific features, circumvent such restrictions, it can generate additional savings.

On the other hand, intermodal road/rail transport incurs the need for the operator first to go over the road to the next available terminal (which might not necessarily be situated in the route of the desired transport corridor), then go over the main distance per rail, and make the final run per road again. Basically, the saving of energy is achieved only during the rail carriage. So, all values show that the relation of road distance for pick up and delivery run to rail carriage during the main corridor movement decide on the percentage of CO_2 saving during the entire operation. Further deterioration can occur when the specific local choice of terminals used in intermodal transport force the operator to include additional mileage in the total door-to-door operation.

But these considerations do not necessarily lead to specific recommendations: All possible deviations incurring additional mileage create a commercial penalty to the operator that is well known and avoided. In other words: the operator will only shift to intermodal transport if eventual needs for driving additional mileage are minimal. Otherwise, he would drop the possibility and take the direct way over the road.

Similar in ratio pick up + delivery to main run: The saving is created during the main run using rail transport. This saving relates to the length of the rail trip, the train configuration and the type of loading unit used. Pre-carriage and on-carriage over the road do not influence these figures.

4. In some cases in Europe, intermodal transport allows to organise door-to-door carriage over shorter distances than road transport. This will add further to energy saving and should be promoted especially.

Recommendation for transport policy

Intermodal international transport is positioned on a fast growing market and adapts quickly to trade evolution and in particular to world trade evolution and enlargement of Europe. For crossing sensitive zone, such as Alps and Pyrenees, to serve major ports in the dense metropolitan areas of Europe intermodal transport might be the only solution to face increase of traffic, in parallel with rolling road for Alpine crossing.

The solution provided with shuttle and block trains appear to be competitive along major long distance corridors and this should be also the case in the future when road will face more capacity or congestion problems on this specific axis.

East-West and North-South markets, in particular when considered as specific corridors do offer interesting perspectives for intermodal transport so that doubling the traffic by 2010 or even more should not be a problem from this point of view; from 20 to 30 % of its "potential"[39] to major corridors (for example in Alpine corridor, up to 50 % already for long distance transport with Scandinavian) intermodal transport could reach up to 50 %.

Therefore, the major uncertainties come from the availability of slots on such corridors for freight trains. If the European trade has to develop along such corridors as the result of integration and enlargement and of an opening of the economies then an important decision would be to grant more priority for freight and to reserve slots for intermodal transport on such specific routes. In the definition of "dedicated freight network" stressed in the White Paper (or "priority freight network”), main corridors for intermodal transport, major terminals should be considered. In the revision of the TEN in 2004, contribution to improvement of intermodal services, including terminal, which are a new part of TEN should be integrated in the criteria. Another organisation of the White Paper to support intermodal transport is to transfer road to alternative modes, mainly rail and SSS.

Such an increase is estimated to 50 billions tkm per year. Assuming that half of this increase is due to international transport[40] and half of that half of this one should be transferred to sea, this gives an objective of 12,5 billions tkm for a shift in favour of rail (or inland waterways). Such an amount of traffic represents around 25 % of the actual intermodal traffic; with the available data and the projection made by existing studies it is hard to make a more precise estimation.

The study, considered only a doubling of intermodal traffic over ten years, taking as reference a trend lower than the past one. This would mean tripling intermodal transport. Therefore, if all the burden of land transfer should be carried by intermodal transport, considering conventional rail as a fairly stable market more than tripling should be envisaged over 10 years.

[39] Potential defined for certain type of goods, minimum distance and minimum volume of traffic between region

[40] It is difficult to estimate the share of international transport in TK. In EUFRANET, domestic interregional road transport as estimated close to the international road transport. Intraregional transport is the segment where estimations are the most different but intraregional transport should increase at a much lower rate; this is why such a hypothesis of splitting road growth can appear fairly rough but is not without some fundament and cannot in any case be estimated very precisely, at the time being.

In any case doubling the traffic can be taken as reference for assessing the benefit of promotion of intermodal transport as far as CO_2 emission and policy orientation are concerned.

The different scenarios of doubling the traffic predict for the UIRR international market CO_2 savings between 46 and 48 %, in other words close to 50 %. If we take aside Ro-Mo traffic, then the percentage of savings will certainly be above 50 %.

For the UIRR market the total saving in tonnes of CO_2 was about 1,4 Mill. of tonnes.

If we now consider the total intermodal market, including ICF and shuttle trains to ports, the percentage of saving can also be assumed to be close to 50 %, in a first approximation, since:

- ICF transport is more diffuse and therefore might be less efficient when the use of direct trains is not possible but the average distance for rail is fairly long.
- The port service on new entrants has only "one" road terminal leg and not two, what can compensate a shorter rail distance, although port concentration of traffic increases the hinterland distances.

Considering all these elements, the total amount of CO_2 saved can be estimated to reach 2,5 or 3 Mill. tonnes.

From this general analysis different specific actions could be taken within for example the Marco Polo programme.

When performances in saving are above average, let's say more than 60 to 70 %, the "label" of "CO_2 saving train" could be promoted: existing and potential traffic transferred from road would, in this case, more than compensate the increase of traffic due to integration and supplement of CO_2 emission of rail transport.

From a global socio-economic and financial point of view several studies have estimated the benefit for the society of the equivalence of one ton of CO_2 emission saving.

In the "Boiteux" report, in France the figure of 100 EUR/tonne saved CO_2 is proposed. This figure is consistent with other estimations in particular in Italy (70 EUR/t). It can be considered as well founded although the economists are well aware of the difficulty of such an estimation, which nevertheless is more and more necessary to orientate decision relative to global warming and climate changes.

If we apply such estimation to CO_2 saving of intermodal transport, then we have a yearly benefit of around 180 Mill. Euros in 2001 and an expected benefit of 360 Mio. Euros in 2010 which amounts to almost 2,6 billions EUR accumulated benefits over the period.

This is a quite significant amount even as regards investment costs for terminals in infrastructure which return is estimated over a much longer period, 20 to 30 years: over a period of 30 years intermodal traffic will be multiplied by 8 if a 7 % increase rate per year is maintained, and at that time the saving would be 4 billions per year. Modal share could be re-equilibrated.

Therefore from a socio-economic point of view the saving of CO_2 could be a major advantage of intermodal transport when good conditions of transport logistics are met and this can be a very realistic perspective along major European corridors.

Then the recommendations would be to consider not only taxes for CO_2 emission but also a policy of pricing for CO_2 savings in order to stimulate transport solutions (and not only transport modes), which bring more CO_2 savings. This would be short and medium term recommendation.

In the longer term, when efficient ecologic and economic solutions are promoted, a parallel recommendation would be to integrate CO_2 saving in investment operations over a period from 20 to 30 years, when they concern directly intermodal transport on major corridors, for links or terminals so that perspectives of capacity are secured.

Annex I: Short Description of Existing Research Studies

The Micro-Studies

1) Fonger:

Research Institute:	Institut für Verkehrswissenschaft an der Universität Münster
Title of project:	Gesamtwirtschaftlicher Effizienzvergleich alternativer Transportketten
Date of Publishing:	July 1993
Language:	German
Area of interest:	Five long distance transport chains within Germany (one of them international including Austria)
Content:	The goal of this theoretical approach is to investigate with certain transport chains, whether and under which circumstances multimodal freight traffic under a macroeconomic perspective makes sense. Therefore, also CO_2 emissions are taken into consideration.
Method:	Pre- and on-Carriage are taken into account. Most of the data is derived from other studies.
Result:	Along with the study, in 1988, road transport caused 28,4 Mil. t of CO_2 in total and 188,1 g/tkm; rail transport caused 2,3 Mio. t of CO_2 or 37,5 g/tkm. The emissions of long distance road traffic per tkm are lower (140 g/tkm) than for short distance road traffic (255 g/tkm). For the relation Krefeld-Stuttgart, the CO_2 emissions of one transport (main course) are 0,263 t, for the relation Hamburg-Stuttgart 0,491 t. The ratio of carbon dioxide emissions between multimodal (combined) and unimodal transport (road) is about 1:3.

2) Intraplan:

Research Institute:	Intraplan Consult GmbH
Title of project:	Gesamtwirtschaftliche Bewertung der Rollenden Landstraße Dresden-Lobositz, Final Report
Date of publishing:	April 1996
Language:	German
Area of interest:	The corridor Dresden (Germany) – Lovosice (Czech Republic), especially the German part thereof
Content:	The government of Saxonia (Germany) wanted Intraplan to examine and compare the costs and benefits resulting from the establishment of the Rolling Road from Dresden to Lovosice. A with-or-without analysis included the decline of the environmental pollution induced by the new Rolling Road.
Method:	The method of measurement of CO, No_x, SO_2 and CO_2 was chosen according to the German "Bundesverkehrswegeplan": After the average speed of trucks using road was measured, the fuel consumption of the trucks was derived. Afterwards, the fuel consumption was transformed into emissions. As far as the Rolling Road is concerned, the energy consumption of the trains was expressed as a function of the transport distance and the gross weight of the wagon units (including loads). Using "emission rates", the energy consumption again was transformed into emissions.
Result:	The Rolling Road helped to diminish the *total* emissions expressed in monetary value. But it has to be mentioned that, in this study, CO_2 had a lower monetary value in costs/ton than the other emission components, so (regarding the final report) it is not recognizable whether the environmental benefit of the RoLa results from lower CO_2 emissions or the induced reduction of other emissions.

3) EPCEM:

Research Institute:	European Postgraduate Course in Environmental Management, Centre of Environmental Science, Leiden University
Title of project:	Shifting Freight from Road to Rail: the potential of intermodal transport in Europe
Date of publishing:	April 1998
Language:	English
Area of interest:	International combined long distance freight transport, relying data taken from Germany and the Netherlands.
Content:	In a postgraduate and interdisciplinary context, road transport and combined transport road/rail are analysed with respect to their environmental and economic impact. Within the study, the relative CO_2 emission of each transport mode (per ton kilometre) and the absolute CO_2 emission impact in 1990 and 2015 (two scenarios) are compared.
Method:	Only the main course of combined transport is taken into consideration. In the study, up to 2015, improvements of transport technology of each mode take place. The implications of the Kyoto protocol are involved in the calculations and estimations.
Result:	The difference in emission per ton-km of road transport and intermodal transport road/rail in 1990 is shown as follows: In 1990, trucks emit 198 g/ton-km CO_2, trains 50 g/ton-km (difference is 148 g/ton-km). In 2015, trucks will emit 156 g/ton-km, trains 40 g/ton-km (difference 116 g/ton-km). The difference will become smaller in 2015.

4) Benz:

Research Institute:	Dissertation TU Berlin
Title of project:	Umweltverträglichkeit von Transportketten – Eine vergleichende Betrachtung des Energieverbrauchs und der Schadstoffemissionen von ausgewählten Gütertransportketten unter Berücksichtigung der Veränderungspotentiale durch Verkehrsverlagerungen und Logistik-Konzepte
Date of publishing:	November 1999
Language:	German
Area of interest:	National German transport relations (Dusseldorf-Stuttgart and Hamburg-Munich)
Content:	Chosen freight transport chains are compared with respect to their specific energy consumption and their specific emissions. The energy and emission saving potential of modal shift and of (multimodal) logistical concepts are shown.
Method:	Sensitivity analysis. Transport chains and their functions of energy consumption and emissions with transport distance and tonnage as determinants are modelled. The common approach follows a chain-specific calculation and an ecological break-even analysis.
Result:	Theoretically, 9 % of CO_2 emission of a combined transport (500 km, >500 t, pre- and on carriage 25 km each) can be referred to pre- and on-carriage. If, on the relation Stuttgart-Dusseldorf, traffic is shifted from road to rail, inland vessel and combined transport, the CO_2 emissions will increase. This is due to the energy input mix of the German railway. According to the study, the same effect takes place on the transport relation Hamburg-Munich. The logistical concept “combined transport road/rail” rises the CO_2 emissions.

5) TRAFICO:

Research Institute:	TRAFICO Verkehrsplanung
Title of project:	Verkehrs- und umweltpolitische Bedeutung der ROLA für Österreich, Endbericht
Date of publishing:	2000
Language:	German
Area of interest:	All Rolling Road relations inside and through Austria being operated in the second half of 1999
Content:	Austrian operator ÖKOMBI Österreichische Gesellschaft für den kombinierten Verkehr Ges.m.b.H. &Co. KG was interested in a cost-benefit-analysis showing whether a further investment program in the Rolling Road concept pays its rent up to the year 2010. Therefore, the benefits for road traffic and environment resulting from the Rolling Road investment were taken into account. These are expressed in saved external costs, for instance costs created by road accidents, noise pollution, and negative effects on climate.
Method:	Starting with generating basis data "1999" and developing scenario data "2010" for road transport and Rolling Road transport on four main corridors through Austria (Brenner, Tauern, Phyrn, Donau), the positive influence of the Rolling Road system for the environment in terms of CO_2 emission costs is estimated. For road traffic, after calculating the carbon dioxide emissions for each truck class via a computer simulation model (GLOBEMI) developed at the Technical University Graz, the specific emission per ton kilometre is computed, summed over the whole road traffic on the corridors and multiplied with the specific climate costs per ton kilometre. For the calculation of external climate costs of the Rolling Road, the quotient (average vehicle gross weight/average weight of vehicle load) is multiplied with the CO_2 costs per ton kilometre carried by rail (derived from former investigations) and the Rolling Road transport volume. The intermediate values can show the effect-per-ton-kilometre on the environment. As the compared vehicle collective deviates, further corrections in favour of the road are made.
Result:	According to this study, the Austrian Rolling Roads should have helped to save 113.500 tonnes of carbon dioxide emission in 1999 and could help to save between 106.000 and 148.300 tonnes of CO_2 emission in 2010 (depending on the underlying scenario).

6) CGEA CONNEX:

Research institute: CGEA CONNEX in partnership with Transport Auto Brunier
Title: « Estimation of the reduction of the CO2 transmissions by the set up of a combined transportation rail/road system » - Project T3M
Date of publishing: November 2000
Language: French
Subject: Combined Transportation rail/road and carbon dioxide emissions.
Summarized: The project studies the results of a combined transport operation on two axes: the first one between Bonneuil in Parisian suburbs and Lungavilla near of Milan and the second between Bonneuil and Beaucaire, close to Tarascon. The project is interested by exclusively to the calculation of carbon dioxide emissions by the road transportations on these corridors, particularly previously, for the trip of the Parisian suburbs to Italy.
Result: According to the different calculation hypotheses, the obtained results are the following ones:

Carbon dioxide emissions in tonnes for the two solutions:

	Road	Combined
On the basis of the real emissions	32,5	16,4
On the basis of moderated data	38,8	17,8

For a same transported tonnage between two points, the combined transport appears as being two less transmitting times of carbon dioxide that the road transportation.

7) Bahn-Umweltzentrum:

Research Institute:	Bahn-Umweltzentrum (Berlin)
Title of project:	published by UIC and CER as “Railways and Environment – Contribution to Sustainable Mobility: Examples of Good Practice”
Date of publishing:	September 2001
Language:	French/English/German
Area of interest:	Relation Munich - Hamburg-Billwerder
Content:	Quantified drops in CO_2 and other greenhouse gas emissions by shifts from road to rail. In a brochure, UIC and CER (GEB) draw a whole series of examples to demonstrate how successes and initiatives taken by railway companies are contributing in a tangible way to preserve the environment. In detail, the Bahn-Umweltzentrum calculated the energy consumption and the emissions of the German combined train system “Parcel InterCity” (PIC) on a certain relation. On this train, swap bodies with valuable goods (parcels) inside are carried (14 containers and 63 t of loading net weight). Capacity use of the train is usually higher than 80 %.
Method:	The calculation of 25 different examples was built upon the “Mobilitäts-Bilanz” scheme provided by IFEU (1999). Like in the Mobilitäts-Bilanz, some data come out o the TREMOD-Model, but real data of German Railways (DB Cargo) underlie combined transport calculation. In the specific “PIC”-case, the train has a high velocity of 160 km/h, and rail traction is electric. Concrete compared data: 2 Container transport with 40 tonnes; road distance: 779 km; rail distance: 800 km; 3 times shunting, no pre- and on-carriage is involved. It is a one-way analysis. Real energy consumption simulations are considered.
Result:	Approximately 25 % of worldwide CO_2 emissions are produced in transport sector (EUROSTAT), with 80-90 % of that percentage generated by private cars and road hauliers alone. Rail transport sector is, according to the brochure, “naturally“ blessed with very modest environmental “external costs” (less than 2 % across Europe opposed to 93 % for the roads) and a very low level of toxic emissions. Road transport causes 190 g/tkm of CO_2, rail transport 30 g/tkm. The PIC contributes to environmental goals. The computed CO_2 emissions show that, on this relation, the PIC saves 11.500 tonnes of CO_2 emissions per year. In detail, on this relation the carbon dioxide emissions in kg/transported ton are 59,68 for combined transport road/rail and 105,37 for pure road transport. Another example of UIC/CER deals with the combined traffic of the operators Hupac and RAlpin in Switzerland: 91.000 tonnes of CO_2 should have been saved by the accompanied and unaccompanied combined transport in 2001; up to 2007, an annual saving of 230.000 t will be achieved.

8) IFEU/SGKV:

Research Institute:	IFEU Institut für Energie- und Umweltforschung Heidelberg GmbH, Studiengesellschaft für den kombinierten Verkehr e.V.
Title of project:	Comparative Analysis of Energy Consumption and CO_2 Emissions of Road Transport and Combined Transport Road/Rail, Final Report
Date of publishing:	Spring 2002
Language:	English, German, French
Area of interest:	Twelve typical currently served and commercially viable European corridors plus one fictive and one short distance relation
Content:	The task of the project submitted by the International Road Trandport Union (IRU) and the Bundesverband Güterkraftverkehr Logistik und Entsorgung (BGL) e.V. was to compare primary energy consumption and CO_2 emissions of a single road transport (one 40 ton truckload) and a corresponding combined transport road/rail with different technologies for defined European relations *including* vehicle operation in feeding/delivery and energy production. The results should allow to identify the relevant parameters for more or less energy consumption and CO_2 emissions of a transport and to estimate energy consumption and carbon dioxide emissions of combined transport road/rail and road transport for a given relation.
Method:	First, the production of railway specific electricity in terms of fossil energies, nuclear energy and Hydropower/other renewable energies was determined for each country. Then, typical (not average) transport European relations were chosen. Using data as transport route, train capacity usage, feeding/delivery distances, typically used transport unit etc. the energy consumption of a transport in each mode was quantified as primary energy consumption. Then, the total CO_2 emissions of operation and energy supply were calculated out of the energy input of each transport.
Result:	The route-specific grade as well as shunting and terminal operations are not as energy intensive as thought before. One main influence factor for the calculation results is the train capacity usage, so that commercially successful combined transport operations contribute to give some blessings to the environment, too. Other main influence factors are the weight of the intermodal unit, the distance of feeding/delivery and the country-specific energy mix. In six cases (especially for the Rolling Roads), the emissions are from 15 per cent less or up to 3 per cent higher than road transport and thus nearly equal. The combined transport causes in further seven cases between 50 and 80 per cent of the carbon dioxide emissions of road transport and in six cases less than 50 per cent.

9) JacobsGibb:

Research Institute:	Jacobs Gibb, a British engineering and environmental consultancy part of the US-based Jacobs Engineering Group
Title of project:	Evaluation of the Environmental Benefits of the West Coast Main Line Modernisation Programme (WCRM) on air quality and climate change
Date of publishing:	2002
Language:	English
Area of interest:	West Coast Main Line, Britain´s principal rail freight corridor
Content:	The study evaluates the environmental benefits of the WCRM and quantifies the results in monetary terms.
Method:	Road and rail freight emissions are modelled over a 25-year-period and take into account the indirect impact of power station emissions on electric rail traction. The model assumes that the loco fleet is made up of 25 per cent class 66 diesel and 75 per cent electric. The electric freight locos are assumed to have the same electricity consumption as electric locos for passenger services. The road fleet is assumed to be made up 50 per cent with articulated trailers and 50 per cent with rigid trucks (7-9 m). Average train payload is assumed to be 400 t, while the true figure for net tonnes is probably near 800 t than the 400 t assumed. Projected rail freight kms are derived purely from modal shift from road to rail. It is assumed that the modernised line has an 11 per cent market share of this vital freight corridor, which equates to an additional 300 billion net tkms of rail freight over the next 25 years. Predicted reduction in annual road freight kms is taken as 50 time rail freight kms.
Result:	Transferring freight from road to rail is much more important in terms of CO_2 emissions than transferring passengers to rail from cars, buses and coaches. By 2026, up to 302 tonnes/day of CO_2 entering the atmosphere could be avoided as a result of the shift from road freight transport to rail. That means 110.000 t for the whole year 2026. The annual net change in freight emissions of CO_2 in 2006 is a reduction of 54.000 t. For the whole period from 2001-2026, the net emissions saving of CO_2 deriving from a modal shift in freight transport is about 1.982.000 t (average: 80.000 t/year). The relative cost per tkm of road freight transport deriving from CO_2 emissions is 250 £, the corresponding cost for rail freight transport is about 70-75 £ (ratio: 1:3,5). The relative cost deriving from CO_2 emissions per train-km are 0,6 £ for a Diesel Class 66 loco, and about 0,2 £ for an Electric loco, so electric traction is much cleaner than Diesel.

10) SBB/BLS Cargo (2002):

Research Institute: SBB AG, BLS Cargo AG

Title of project: Schienengüterverkehr in der Schweiz: Ein innovatives Vorreitermodell zur Eindämmung des Klimawandels

Date of publishing: February 2002

Language: German

Area of interest: Combined transport of the operators Hupac AG and Ralpin AG through the Swiss Alps

Content: The national Swiss railway company SBB and the two Swiss operators wanted to show the environmental advantage of combined transport operations through the Swiss Alps, as far as the greenhouse effect is concerned.

Method: Two methods were chosen: The first one is based on the emission factors (g/truck-km for 28 tonnes and 40 tonnes maximum vehicle gross weight) provided by the federal Swiss authority for environment, forests and landscape. The second is part of the work of a SBB-trainee, which considers the real loading capacity usage measured in tonnes as well as the CO_2 emissions resulting from fuel burning measured in g/tkm ("Umweltvergleich des schweren Gütertransports in der Schweiz", Piero Mazzoletti, 01.09.2000-31.12.2000). Then, an average value of the results of the two methods was computed. Swiss railway electricity is considered to be 100 per cent emission-free, and the Swiss railway network is 100 per cent electrified. The opening of the Lötschberg basis tunnel in 2006 is taken into account as well as an improvement in operations of Hupac and RAlpin or an improvement at the Italian gateways.

Result: Hupac operations:

Year	Unaccompanied combined transport of Hupac through the Alps	Avoided CO_2 emissions (tonnes)	Accompanied combined transport of Hupac via Gotthard	Avoided CO_2 emissions
1994	163.386	40.675	42.952	8.467
1995	180.982	43.495	39.664	7.819
1996	180.533	43.174	38.484	7.586
1997	214.053	51.063	44.985	8.868
1998	223.092	53.512	48.091	9.480
1999	233.372	56.202	51.733	10.198
2000	277.551	64.610	53.571	10.453
2005 (prognosis, goal)	455.000	112.830	50.900	12.622

RAlpin operations of accompanied combined transport:

Time span	Number of RoLa trains via Lötschberg axis	Number of platforms per train	Number of platforms in total	Avoided CO_2 emissions (tonnes)
11.06.2001-31.12.2001	676 1.168	17 19	34.000	8.431
01.01.2002-31.12.2002 (prognosis, goal)	1.750 2.300	19 25	90.000	22.318
from 2003 on (prognosis, goal)	4.200	25	105.000	26.038
from 2004 on	6.600	25	165.000	40.916

(prognosis, goal)				
from 2005 on (prognosis, goal)	8.400	25	210.000	52.075
from 2007 on (prognosis, goal)	14.000	25	350.000	86.792

Altogether, for the year 2001 combined transport through the Swiss Alps provided by Hupac and RAlpin helped to save 91.031 t of CO_2 emissions. Up to the year 2007, according to the prognosis (business plans), the amount of saved CO_2 emissions will be tripled and will reach 229.414 t/year. In 1999, the whole amount of emitted CO_2 in Switzerland was 40.610.000 tonnes. 38 per cent of these (15.320.000 t) were induced by transport. It is important to mention that other competitors in combined transport may help to reduce the emissions by another factor, too.

11) DSC/ITD/Danish Companies/Danish Ministry of Transport:

Research Institute: Danish Shipper´s Council (DSC, Erhvervenes Transportudvalg), Institution for Transport Studies (ITS, Institut for Transportstudier), Danish Trade Association of International Transport (ITD, International Transport Danmark)

Title of project: Transport, Economy and CO_2 (TRANS ECO2)

Date of publishing: The project was scheduled to be due at the end of 1999.

Language: Danish, English

Area of interest: Denmark, international European traffic

Content: Present Best Industry Practices are developed in which hauliers and transport buyers will jointly implement methods to reduce the CO_2 emission of transport. Experiences from 8 demonstrations performed by 14 participating companies (mainly cooperation between shipper and operator) focussed on different topics, amongst the effects of combined road/rail alternatives: Four transport alternatives between LEGO's central stores in Billund and Baar in Switzerland were analysed.

Under the next steps of TRANS ECO2, an operational basis for generating environmental data from international transport chains covering all modes is developed on a European scale under the OMIT project and in a CEN working group (TC 320). Furthermore, a benchmarking system for freight transport including data for environmental performance is expected to be developed.

Method: A method of management information was established providing LEGO with an overview of the correlation between energy consumption, CO_2 emission, costs and flexibility for different transport alternatives (clean lorry vs. combined road/rail).

Result: The project indicated very individual potentials for savings in CO_2 and cost savings. LEGO and operator Hangartner have proved that the actual choice of combined transport between Billund and Baar in 1998 was connected with 34% less energy consumption and less emissions (up to 50 % using Taulov terminal) than it would have been the case with clean lorry transports. And that with the same flexibility and at lower costs.

12) FIAT/Grimaldi case study:

Research Institute:	FIAT/Grimaldi
Title of project:	The development of the Door to Door in short sea shipping
Date of publishing:	
Language:	
Area of interest:	The origin of the traffic is Italy. The destinations are in various Western European and Mediterranean countries.
Content:	A case study on multimodal car transports from car factories to dealers with respect to a partnership between sea carrier and the car industry. The best technical and econmically optimal solution is used, taking advantage of the most efficient combination of different modes of transport (sea, road, rail). In most of the cases, short sea shipping is the main transport mode. The example refers to the door-to-door intermodal car distribution service by Grimaldi (Naples) to Fiat.
Method:	Several parameters were used to evaluate CO_2 emissions: Consumption of fuel both in navigation, while manoeuvring and in the port and 2 types of vessels.
Result:	A car carrier transport vehicle (gross weight of 16-32 t) produced 724 g/tkm of CO_2; a full train load of 15 wagons produces about 8.311 g/tkm of CO_2. Road transport CO_2 emissions: 59.853 t; rail transport CO_2 emissions: 30.719 t; intermodal transport CO_2 emissions: 23.369 t.

The Macro-Studies

1) SGKV:

Research Institute:	Studiengesellschaft für den kombinierten Verkehr e.V.
Title of project:	Verkehrspolitische Bedeutung des kombinierten Verkehrs Straße/Schiene, Part 2: Volkswirtschaftliche Wirkungen des Kombinierten Verkehrs Straße/Schiene
Date of publishing:	1988
Language:	German
Area of interest:	All combined transport road/rail in Germany
Content:	The German Research Consortium Combined Transport “FKV” wanted the SGKV to investigate the macroeconomic costs and benefits of combined transport and whether combined transport justifies special political treatment (subsidies, promotion etc.). Besides other factors, emissions are considered. But, unlike CO, CH_x, No_x, NO_2, SO_2 and soot, carbon dioxide is not considered. The reason is certainly that, in 1988, the environmental discussion had not focussed on CO_2 emissions yet.
Method:	For road transport, only the secondary energy input is considered. For rail transport, the change of primary into secondary energy is taken into account, too. About the energy consumption of energy transport, data were not available yet. Only the main course of combined transport was taken into account. Then, a with-or-without analysis took place: The existing emission values of road transport were multiplied with the transport service provided by combined transport; the result was the amount of emissions saved by combined transport. Then, the additional emissions caused by combined rail transport were calculated: The specific energy consumption and volume of combined transport led to the total combined transport energy input. The primary energy mix of German railway electricity could be transformed into emissions of the used power plants. After considering the total power production for the German Railways, the single emissions per energy input were calculated and after multiplying with the energy input consumed by combined transport, the whole emissions for the main course (on rail) could be computed and compared to the corresponding values for road transport. For a total comparison, the single results were transformed into weighted intoxication units.
Result:	Combined transport road/rail leads to only 13 % of the amount of emissions (measured in intoxication units) as road transport, given the same transport service provided.

2) DIW/IFEU/IVU/HACON:

Research Institute:	Deutsches Institut für Wirtschaftsforschung, Institut für Energie- und Umweltforschung, Gesellschaft für Informatik, Verkehrs- und Umweltplanung/Hannoversche Consulting für Verkehrswesen, Transporttechnik und Elektronische Datenverarbeitung
Title of project:	Verminderung der Luft- und Lärmbelastungen im Güterfernverkehr 2010
Date of Publishing:	March 1994
Language:	German
Area of interest:	Germany
Content:	The German authority "Umweltbundesamt" wanted the project partners to investigate the technical and political options to diminish the emissions caused by long distance road transport. For the year 2010, two scenarios were developed.
Method:	The total emission values were computed via the energy consumption of the transport modes and the amount of transport service provided. For rail transport it is assumed that for three out of four transports a pre- and on-carriage is needed. There are two small sensitivity analysis for the year 2010, "Technique" and "Emission Factors".
Result:	The CO_2 emission in Germany for long distance road transport is 12 Mil. t for 1988, 23 Mil. t for the scenario "Trend 2010" and 15 Mil. t for the scenario "Reduction 2010". Rail transport caused CO_2 emissions of 1,86 Mil. t in 1988, and 0,892 Mil. t for the scenario "Trend 2010" as well as 1,55 Mil. t for the scenario "Reduction 2010". For the year 1988, pre- and on-carriages and intermodal transfers together cause 2,2 Mil. t of CO_2 emissions in total and climb up to 2,3 Mil. t for the scenario "Trend 2010" and up to 2,5 Mil. t for the scenario "Reduction".

3) Danielis, Presentation at the time of the 22nd PTRC, University of Warwick (UK)

Research institute: Trieste University of Study (Italy), Department of Economic Science and Statistics, Romeo DANIELIS

Title: Transportation and energy in Italy: change in the period 1975-1991

Date of publishing: September 1994

Language: English

Subject:

Summarized: The paper analyses the change in energy use and energy intensity in passenger and freight transport in Italy over the period 1975-91. The analysis is carried out at a modal level and allows to make inter-modal comparisons. The mathematical framework used in the analysis is taken from Schipper et al. The paper disaggregates energy use between passenger and freight transport with an ad hoc methodology and presents a global view on energy use and efficiency for all modes in both passenger and freight transport. It is found that the dynamics that have taken place in passenger and freight transport are quite similar. The enormous increase in energy use is due mainly to the increase in transport volumes and to the shift towards more energy intensive modes (i.e. road transport, and some air transport for passenger transport). Both tendencies have been stronger for freight than for passenger transport. Nevertheless, aggregate and modal energy intensity has decreased, i.e. the transport system has become more energy efficient. The decrease is more relevant for freight transport. At the modal level, the main gains in efficiency took place in the most energy intensive modes in passenger transport (there is an inverse relationship between energy consumption and fuel economy gains) so that a convergence in energy intensities took place. This does not hold true for freight transport.

The report is composed of seven parts. The first part is about volumes of traffic and energy consumption for the three modes of transport being considered; in fact, a knowledge of these figures is indispensable to making any physical quantification of the principal instances of impact. A second part is about external costs of greenhouse gases and particularly of carbon dioxide. The third part is about external costs of air pollution: the evaluation of them due to the various modes of transport is based on a wide-ranging review of studies available in the international and Italian literature.

Result : In Italy, the consumption of primary energy went from 120,1 million tonnes of petroleum equivalent (tep) in 1970 to 167,4 million tep in 1992. In this period, energy use in freight transport increased by 90,94% at an annual rate of 4,04%.Transport volumes increased by 116,84% at an annual rate of 4,83%. The decomposition can do as follows:

	Energy use (thousand tep)		Tonnes-km (million tkm)	
	1975	1991	1975	1991
Rail	167,1	168,3	15814	22352
Road	4466	10281,4	62795	182746

4) Orfeuil, UNIVERSITY OF PARIS XII

Research institute: UNIVERSITY OF PARIS XII – MR. professor Jean-Pierre ORFEUIL
Title: The transportations and greenhouse effect
Date of publishing: January 1999
Language: French
Subject: Transportation and greenhouse effect
Summarized: After a presentation of the greenhouse effect phenomenon and of climatic change, the author details us the different greenhouse gases, their origins, the certainties that about it result as well as the international recent summits. In a second time, it is a question of the concepts, informers and basic vocabulary in matter energy. The third part manages the transportations and energy consumptions. On bases statistics, the position in the world and in France, the differences energetic efficiencies of the transportation methods in France and the evolution of the usages of these methods are turn to explored turns here. The study finishes itself by the exploration of the factors devolvement of the request of energy transportation and regulation instruments, then by an example devaluation long-term of the energy consumptions of the transportations: the exercise energy 2020 of the General Commissionership to the Plan.
Result: We find the energetic report of the transportations in France to various years. The automobile occupies 47% of the report, the road transportation of merchandises 31%, and the others modes a very minority part.

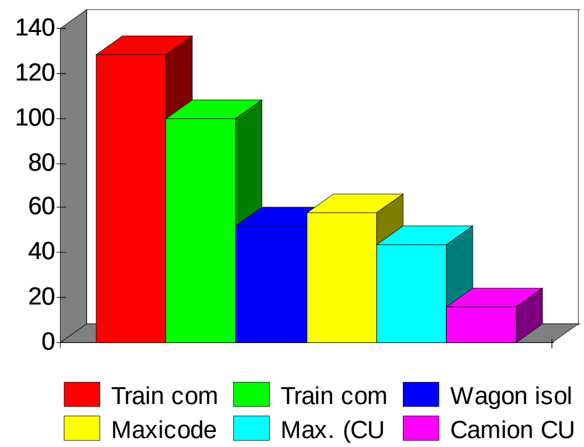
Evolution of the energetic report Transportation in France

	1975	1985	1990	1997	1997/1975
Road transport of merchandises	8,2	10	13,6	15,1	+84%
SNCF	1,7	1,6	1,7	1,9	+11%
Air	1,9	2,7	4	5,3	+179%
Waterway	0,2	0,2	0,2	0,2	+0%

For goods, the most efficient situation is the one that corresponds to the arrangement of maximum flow, the direct train. The HGV are more efficient than single wagon units. There is an enormous difference between long distance, relatively efficient because it is realised in mass, and distribution transport.

Energy efficiency 1992 – Transport of merchandises
(in ton-km/kilo equivalent petrol)

Direct train	128,2
Train comp. Comb.Tr.	100
Single Wagon	52,1
HGV (CU 25t.)	57,6
Max. (CU 15t.) Comb. Tr.	43,3
Truck CU>3t.	16,1



5) CNT:

Research institute: National Counsel of the Transportations
Title: The transportations and the environment: towards a new balance. Report of the work group presided by Alain BONNAFOUS
Date of the publishing: 1999
Language: French
Subject: Transportation and environment
Summarized: The environmental questions to planetary dimensions to which ones the transportations are located and will be located more and more confronted concern all at once their supplying in energy and their greenhouse gases rejections. From one point of view, the sector take globally appears very depending of the oil market on which one requests it should grow very strongly with the apparition again big country consumers. Of the other side, the take into account growing to an international level of the warming risks of the planet, on one hand leaves, and the strong growth of the traffics and of their greenhouse gas emissions, on the other hand leaves doubtless will bring the sector of the transportations to adapt.

6) DZLR:

Research Institute: Deutsches Zentrum für Luft- und Raumfahrt

Title of project: Die Umweltbilanz des Verkehrs – Bisherige Entwicklung und künftige technische Reduktionspotentiale

Date of publishing: June 1999

Language: German

Area of interest: Germany (national)

Content: The "Deutsches Verkehrsforum" wants to know more about the state of the art of the environmental impact (energy consumption, emissions) caused by traffic and about further technical potentials to reduce pollution.

Method: The study summarizes the results of other studies concerning the topic, such as Prognos (1995), Fichtner (1994), and IFEU (1992, 1999).

Result: Concerning goods transport by rail, the study refers to Prognos (1995) and the energy mix of railway electricity. According to that, primary energy consumption of railway is triple as high as end energy consumption because of the low energy efficiency at some power plants. The induced emissions of a transport depend on the specific amount of electricity consumption and on the energy mix of the power plants. In 1992, 45 % of the power plants used for railway electricity were emission-free (nuclear, water). As far as road transport is considered, IFEU (1992) shows that road transport (goods) is responsible for 19 % of the CO_2 emissions caused by traffic (which is responsible for 20 % of the whole total carbon dioxide emissions). Fichtner (1994) points out that long distance road transport causes 140 g/tkm of CO_2. Furthermore, IFEU (1999) shows the specific CO_2 emission in g/tkm:

Transport mode	1980	1990	1996
Road transport with trucks > 3,5 t	193	167	145
Rail transport (goods)	35,4	27,4	29,7

A potential reduction of the CO_2 emissions of road transport is closely linked with a reduction in the pure amount of fuel consumption (weight, motor efficiency, aerodynamics of vehicles, driving behaviour). Other potentials are given through alternative fuels like liquid gas (-5 %) or rape oil (-35 up to -60 %). In rail transport, the most important factors for a lower energy consumption are capacity usage, driving behaviour, regenerative breaking, and tare of wagon units.

7) IFEU:

Research Institute:	IFEU Institut für Energie- und Umweltforschung Heidelberg GmbH
Title of project:	Mobilitäts-Bilanz für Personen und Güter
Date of publishing:	September 1999
Language:	German
Area of interest:	Germany
Content:	In this common initiative of German Railways and WWF (World Wide fund for Nature), different passenger and goods transport modes are compared. The different aspects of mobility examined include environmental aspects. A comparison of CO_2 emission caused by road/rail transport on two intra-German relations is published.
Method:	On the basis of actual data of the German Federal Environmental Authority (Umweltbundesamt), the TREMOD-model was used. TREMOD data consist of average values. TREMOD is a computer model developed by IFEU in cooperation with the DB AG, the VDA and the Mineralölwirtschaftsverband for the Umweltbundesamt. It is regularly updated and was first released in the early 1990s. The whole transport and energy chain was observed. Real capacity usage was taken into consideration. The emissions were derived from energy consumption.
Result:	In the automotive sector, on the relation Kassel – Emden (408 km distance by rail, 356 km distance by road), rail transport causes 11,8 kg/transported ton of CO_2 and road transport 40,9 kg/transported ton. In the refrigerated fruit sector, the relation Bremerhaven - Munich (Road: 796 km, Rail: 814 km) shows 20,3 kg/transported ton of CO_2 emissions for rail transport and 51,9 kg/transported ton for road transport.

8) FH Pforzheim/IFEU:

Research Institute: FH Pforzheim, IFEU Institut für Energie- und Umweltforschung

Title of project: Anleitung zur betrieblichen Erfassung verkehrsbedingter Umwelteinwirkungen: Ein Leitfaden erstellt im Auftrag des Umweltbundesamtes Berlin

Date of publishing: September 1999

Language: German

Area of interest: Germany

Content: A guideline to support enterprises in integrating the negative environmental impacts of traffic into their environmental business plan (micro perspective). The guideline show relevant data, how to collect the data and methods to derive actions to be taken. Underlying basic data (like emissions factors) are given. The main focus is not on theory, but on practice.

Method: Some of the values are referred to the computer model TREMOD (1999) and Borken (member of IFEU, 1999). Primary energy consumption is considered (incl. fuel and energy provided). The observed trucks are the average German truck fleet operated in 2000; the observed train is a typical train employed in combined transport road/rail (KLV).

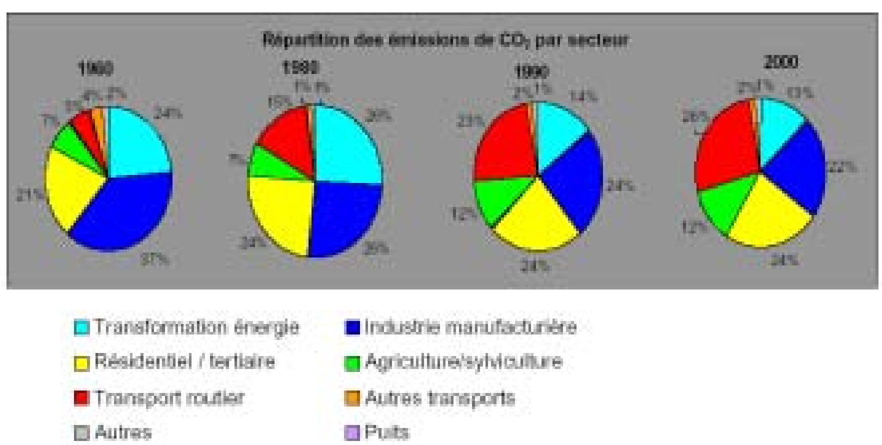
Result: Truck 147,3 g/tkm; Rail 32,2 g/tkm. For different kinds of trucks, the CO_2 emissions are:

Vehicle Gross Weight	**CO_2 emissions in g/tkm**
Truck <7,5 t	452
Truck 7,5 t-14 t	294
Truck 14-20 t	294
Truck >20 t	218
Road Train <20 t	161
Road Train 20-28 t	133
Road Train 28-32 t	128
Road Train >32 t	128
Articulated Truck <32 t	114
Articulated Truck >32 t	111
Average	**147**

9) MIES – MATE:

Research institute:	Interdepartmental Mission of Greenhouse Effect – Ministry of Development of the Territory and of Environment
Title:	National Program of Fight against the Climatic Change
Date of publishing:	January 2000
Language:	French
Subject:	Greenhouse Effect
Summarized:	This program identifies about one hundred measures so that France honours its Kyoto engagements and brings back in 2010 its greenhouse gas emissions at the level of 1990. It the result many reports coming from different work group that called together ministerial representatives, experts and economical and associative actors. The sector of the transportations is studied in 3 parties: the emissions of the sector of the transportations, the measures existing and the new measures.
Result:	The greenhouse gases emissions of the transportations sector essentially are had to the combustion of the fuel for the road and aerial transportations (respectively 84,3% and 10,8%, essentially in CO_2). The part of transportations sector in the greenhouse gases emissions is very important in all of the industrialized countries. That appears more again in France on account of the fact that the electric sector there east comparatively more transmitting. This sector characterizes itself also by a strong tendency to the very growth with the measures already existing. It takes a more and more important place in the carbon dioxide emissions. The part of the transportations in the carbon dioxide emissions is passed of 23% in 1990 to 26% in 2000; the reference scenario gives a projection of 34% in 2010.

Carbon dioxide emissions in air in France:



To reduce CO_2 emissions of transport by 4MtC to grow to 40 MtC in 2010, there is a tablet of measures concerning transport in MteC:

	Gains in CO_2
Alternative in climatisation	0,05
Alternative vehicles	0,11
Railway Energy	0,11
Reglementation/control	0,2
Air Emissions	0,05
Congestion of important interurbain axes	0,01
Traffic light regulation	0,1
Priority for collective transport	0,02
Regulation of fast urbain tracks	0,05
Lower railway tariffs	
Respect to working rules	0,15
Taxation	0,3
Taxation of kerosene	0,1
Taxe of carbon	1
Control of urban evolution	0,4
Supply of urbain infrastructure	1
Combined transport (5 actions)	**0,2**
Total	4

10) AEE – EEA:

Research institute: European Environment Agency

Title: Are we moving in the right direction? Indicators on transportation and environment integration in UE – TERM 2000

Date of publishing: January 2000

Language: English

Subject: Transportation and environment

Summarized: This is the first indicator-based report developed under the Transport and Environment Reporting Mechanism for the EU (TERM). Several questions are addressed which policy-makers in the EU regards as key to understanding whether current policy measures and instruments are influencing transport/environment interactions in a sustainable direction. To answer these questions, a selection of 31 indicators was made, dealing with the various aspects of the transport and environment system.

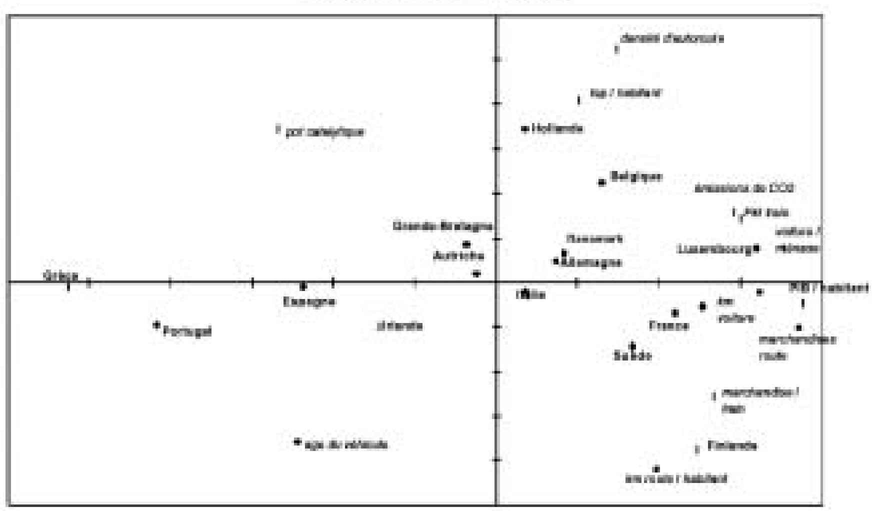
Result: Among the 31 indicators selected in the project TERM, a group of fifteen are kept to effectuate a typology of the countries. These indicators focus :

-on the transportation demand (travellers- kilometres and tonnes-kilometres by inhabitant) ventilated by modals,

-on the characteristics of the infrastructures (density of motorway, mileage of roads by inhabitant) and motor park (average age, equipment in catalytic converter),

-on the greenhouse gases emissions (carbon dioxide).

Transport, Europe et Environnement



-On the right are situated the countries the more riches ,where the number of kilometres by inhabitant is more raised and that emit the more carbon dioxide,

-On the left, figure the countries of European Union
of which the economy is less developed,

-In the bottom, the countries to weak density that dispose a long network of roads (by inhabitant), resorting to more to the rail transport,
-In top, the countries to strong population density disposing a network of motorways very dense, strongly motorized.

Then the analysis led to the conclusion that France characterizes itself by a weak population density, therefore a very long network of roads (kilometres/inhabitant). This geographic configuration is in favour of the rail transport of merchandises, more economic in energy to the ton kilometre transported. France is therefore less transmitting of carbon dioxide that Italy of which the environmental performances are near of the average.

<u>11) Beauvais:</u>

Research institute: BEAUVAIS CONSULTANTS
Title: Transportation of merchandises and environment: Given and References
Date of publishing: 28th January 2000
Language: French
Subject: Transportation of merchandises and environment
Summarized: The first part is a synthesis statistics in the form of a pictures on the transportation businesses of merchandises, transportation equipment of merchandises, the circulation of the trucks, on the traffic of merchandises and on the impact of environment. The second part is devoted to a bibliographical analysis on the transportation of merchandises and environment.
Result : In France, we can ascribe to the transportation of merchandises 46 820 tonnes of carbon dioxide emissions per year, of which more than 99% in origin of the road transportation. These emissions divide up themselves by geographic zones to reason of 19% for the city, 25% for the regional one and 56% for the inter-regional.

CO_2 in kt		Zone géographique		
		Urbain	Regional	Inter-regional
	road transport	8880,668	11840,21	17248,42
	rail transport		0,016	0,478
	waterway		0,042	0,209

The costs linked to greenhouse effect are presented in the following picture:

Mode	carbone (CO_2)	coût
	kilogramme par t.km utile	centimes par t.km utile
Road transport with more than 3 t	0,053	2,4
of which maxicode	0,015	0,7
electric train complete	0	0
Inland barge	0,009	0,4

12) CITEPA:

Research institute:	Centres Technical Interprofessional of Studies on Atmospheric Pollution
Title :	Emissions in air in France – Metropolis –
Date of publishing:	June 2000
Language:	French
Subject:	Comparisons of data emissions of France and others countries.
Summarized:	The distribution of the emissions in European Union is presented for five parameters: SO2, NOX, COVNM, CO, PRG, calculated on 3 gas (CO_2, CH4 and N2O). She can be compared to the distribution of the populations The absolute emissions do not constitute intrinsically an informer of pertinent performance but situate the location of the principal flows.

13) ISIS/ZEW et al.:

Research Institute:	ZEW / IER / ISIS / Gruppo CLAS / Tetraplan / Cranfield / TNO – Inro / LATTS-ENPC
Title of project:	Real Cost Reduction of Door-to-Door Intermodal Transport (ReCoRDIT)
Date of publishing:	June 2000 (WP1), December 2001 (Draft WP 2)
Language:	English
Area of interest:	EU-wide in WP 1, three European corridors Genova-Manchester, Patras-Gothenburg, Barcelona-Warsaw in WP 2
Content:	This research project performed by an European team is supported by the Commission of the European Communities – DG TREN within the European Commission 5th RTD Framework Programme – Sustainable Mobility and Intermodality. " It aims at an “analysis of the cost structure of door-to-door intermodal freight transport services and the conditions to optimise it". The ultimate objective of RECORDIT is to improve the competitiveness of intermodal transport in Europe through the reduction of cost and price barriers which currently hinder its development, while respecting the principle of sustainable mobility. The objective of WP 1 is to define and specify the accounting framework for the analysis of the real costs (including different kinds of external costs) of door-to-door intermodal freight transport services. Furthermore, the goal is to compare real costs to charges and taxes currently paid; to assess current imbalances and market distortions, to recommend policy and business actions allowing to drastically reduce intermodal costs, and to increase the attractiveness of intermodal transport options. The objective of WP 2 is to present a methodology for the analysis of the mechanisms of cost and price formation at corridor level and to describe the results of a preliminary analysis of cost formation for the three international corridors selected for RECORDIT. The climate change issue, which is the main impediment on the way to a sustainable transport system, is integrated into the analysis.
Method:	The methodology for external cost calculation and data collection is given from former research. The valuation of global warming due to CO_2 emissions is based on sustainability criteria for setting specific reduction targets. The target applied is a 5.2% reduction target which is equal to the OECD average agreed at the Kyoto process and is regarded as an EU-wide reduction target. The appropriate value for the effects resulting from anthropogenic emissions of greenhouse gases was then found by applying cost-effectiveness analysis on the target, which are based on the avoidance cost approach.
Result:	The resulting shadow value for reducing the CO_2 emissions is 37 € per tonne of CO_2 as general value for Europe. Underlying, there is a figure of 3.150 g CO_2 per kg Diesel burned (the same as used for road transport) and yields for both, gasoline and diesel (see e.g. Handbuch Emissionsfaktoren des Strassenverkehrs, V1.1, Grundlagenbericht, Umweltbundesamt Berlin). Emissions due to manufacture and fuel production of heavy duty vehicles (based on 600,000 lifetime km and

9.52 MJ/km energy consumption; Source: ExternE internal information) are considered: 198.94 t CO_2 for truck manufacturing, and the fuel production of Diesel leads to 64,74 CO_2. According to RECORDIT, a follow up of the well known top-down study of IWW/Infras (1995) on behalf of the UIC, has presented new avoidance cost and damage cost results for climate change. According to IWW/Infras update 2000 review of former research ("Externe Kosten des Verkehrs – Unfall-, Umwelt- und Staukosten in Westeuropa"), the calculated ranges are: avoidance costs: 37–135 €/t CO_2 for 5.2%-50% reduction of CO_2; damage costs: 0,05–200 €/t CO_2. The 5.2% reduction target corresponds to an 8% reduction for Western Europe (EU). For a reduction of 25 % from 1990 to 2005, (the Federal German goal), a range is estimated from 30 to 70 €/t CO_2. Another study of IWW calculates shadow values for several targets according to a sustainable transport system. For the CO_2–sustainability criteria of –30%, a shadow value of about 200 €/t CO_2 is estimated by using a rather distinguished approach (Schade et al 2000).

14) ADEME – MIES:

Research institute:	Agency of Environment and Mastery of Energy – Interdepartmental Mission of Greenhouse Effect
Titles:	Climatic Change: a major challenge
Date of publishing:	December 2000
Language:	French
Subject:	Greenhouse Effect
Summarized:	After a presentation of the current climatic position and consequences of the warming of atmosphere, stretched study an explanation of the mechanisms of greenhouse effect. The accent next is concerned the international engagements, Convention framework on the climatic change of the United Nations, adopted to the summit of Rio of Janeiro in 1992 and that marks the conscience hold of the international Community, to the Kyoto Protocol of 1997. At last, the report do up to propose solutions by sectors, notably in transportation.

15) Die Bahn:

Research Institute:	Bahn-Umweltzentrum
Title of project:	Umweltbericht 2000
Date of publishing:	2001
Language:	German
Area of interest:	Germany
Content:	The environmental report for the year 2000 published by the German Railways concerning different environmental aspects of rail traffic, amongst carbon dioxide emissions.
Method:	The German Railways calculate the emissions via the TREMOD-model developed by IFEU (Institut für Energie- und Umweltforschung, Germany). Combined transport is not analysed separately.
Result:	The report shows a ratio of 1:7 for the CO_2 emissions of rail freight transport (32 g/tkm) compared to corresponding road transport (204 g/tkm). The CO_2-emissions in German rail freight traffic turned down from 47,82 g/tkm in 1990 to 31,96 g/tkm in 2000. In the meantime, from 1994 till 1999, they rose from 34,31 g/tkm in 1994 via 35,77 g/tkm in 1998 to 36,72 g/tkm in 1999.

16) ExternE project series:

Research Institute:	University of Stuttgart/Prof. Friedrich (Ed.)
Title of project:	External costs of energy conversion – improvement of the ExternE methodology and assessment of energy-related transport externalities
Date of publishing:	2001
Language:	English
Area of interest:	Europe
Content:	This research project on the estimation of external costs is part of the ExternE project series and has been supported by the European Comission (EC) DG Research. The external costs stemming from the emissions of atmospheric pollutants of transport include damage caused by greenhouse gases (i.e. carbon dioxide). The methodology of the ExternE-project series is applied to calculate the external costs of different transport modes (road, rail, ship, air) caused by air pollution. The analysis deals with a large number of current and future transport techniques operating in different locations throughout Europe.
Method:	Updated "Impact Pathway"-approach, including the currently used and recommended exposure-response-relationships and monetary values to estimate marginal and aggregated external costs of energy conversion. For CO_2 impact/effects, the avoidance cost approach is chosen.
Result:	A large number of marginal external costs throughout Europe is given. In addition, aggregated values and case studies that demonstrate the use of these figures within cost-benefit analyses are presented. The results can be used as a basis for assessing transport techniques, discussing transport axes and charges and implementing ecopolitical instruments.

17) Girault, for Ministry of the equipment, Transportations, Lodging –SES-:

Research institute: Economic and Statistics Service – Michel GIRAULT
Title: Transport part of the national program of fight against the climatic change
Date of publishing: January/February 2001

Language: French

Subject: Greenhouse effect

Summarized: The Kyoto protocol, established in 1997, keeps a global objective of greenhouse gases of the developed nations between 1990 and 2010. France must stabilize its transmissions to 144 million tonnes equivalent carbon (MteC).
For the transportations, withheld objective is to limit the greenhouse gases transmissions to 40 MteC in 2010 as in 2020, against 32,6 MteC in 1990.

Result : A national program of fight against the climatic change (PNLCC) was elaborated in order to lower the carbon dioxide emissions, notably in the transportations.
In a reference position, that takes into account the extension of their clean tendencies and already adopted measures, the carbon dioxide emissions would continue to progress in the transportation.

Reference projection: evolution 1990-2010 and MteC in 2010:

	Emissions of CO_2	MteC in 2010
Industry (hors énergie)	-6%	31
Transports	**29%**	**44**
Buildings and tertiaire	8%	28
Agriculture	6%	29
Energy	27%	21
All sectors	19%	160

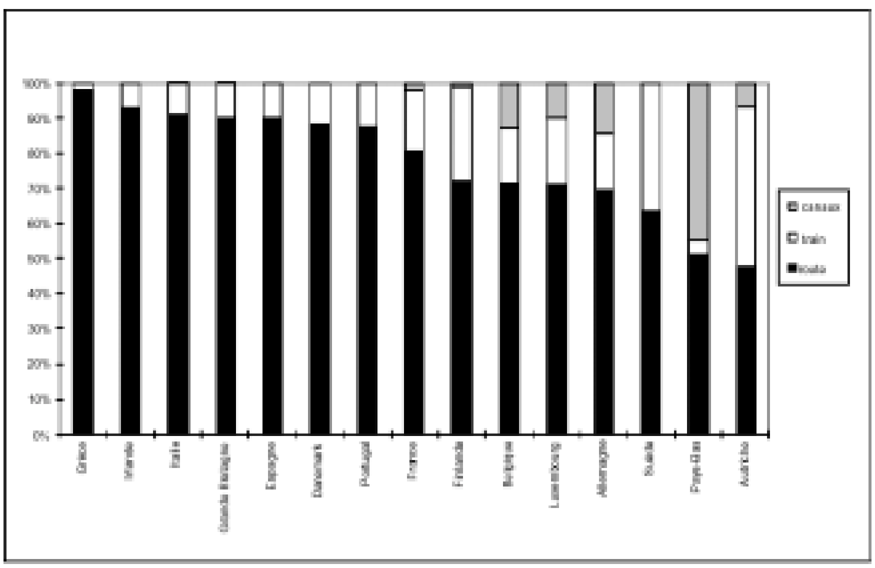
Carbon dioxide evolution of the transportations in reference position:

	1990	2010	Evolution between 1990 and 2010
road transport	30,3	39,11	29%
air transport	1,3	1,8	38%
rail transport	0,3	0,3	0%

18) Jeger, for Ministry of the equipment, Transportations, Lodging –SES-:

Research institute: Economic and Statistics Service – François JEGER
Title: Transportation and environment in the European countries.
Date of publishing: March/April 2001
Language: French
Subject: Transportation and environment
Summarized: The comparison of the composing transportation request by method between the fifteen countries of European Union to appear some determining of this request.
It's principally the wealth of the country, measured by the PIB by inhabitant, that explains the differences of the level of the transportation request of travellers and of merchandises by inhabitant. The geographic characteristics –density, area, maritime facade- explain more divides it modal, notably for the merchandises. Beyond these structural differences of the transmissions of polluting by the transportations, there remains a tonality more concerned of environment in the countries of Europe.
Result: The carbon dioxide emissions depend especially car traffic. Save the northern countries, it's in France and in Germany that the transportations by earthly way are the most important ones: 6.000 tonnes kilometres by inhabitant, be four times more than Greece and Portugal. The road realizes 77% of the tonnes kilometres by earthly modes. France is situated in an intermediary position with a modal part of 80% for the road. The modal part of the rail transportation (17%) is situated in France in the European average.

Modal division of the earthly transportations of merchandises:



19) Ministry of the equipment, Transportations, Lodging:

Research institute: DAEI/ITS/INSEE

Title: The Transportations in 2000. 38th Report of the Commission of the Accounts of the Transportations of the Nation.

Date of publishing: June 2001

Language: French

Subject: The chapter 11 is devoted to the «nuisances generated by the transportations»

Summarized: Under effect of the modernization of the park of vehicles and modifications of the composition of the fuels, the emissions of a number of noxious gas (dioxide of suffers, oxidizes nitrogen, oxidizes carbon) contributed to reduce itself in 1999. The increase of the circulation and the power of the vehicles nevertheless contributed to do to progress the emissions of carbon dioxide, principal gas has greenhouse effect but the amelioration of the energy yield of the motors and the pursuit of dieselisation of the park of vehicles moderate its importance.

Result: In 1999, the road vehicles were to implicate in 65% to 99% of atmospheric pollution due to the transportations. The trucks represented an important part of the emissions of carbon dioxide (26,5%). By fuel type, we note that the gas oil dominates for the carbon dioxide (63,5%).

Emissions of the road traffic in France in 1999:

Trucks	CO_2	
	M.t.	0%
Essence	0	0%
Diesel	33,5	100%

Carbon dioxide emissions in France in million tonnes:

	1985	1986	1987	1988	1989	1990	1991
Transport	97	102	105	111	115	116	119
Road	90	95	98	104	107	109	111
Rail	1,2	1,2	1,1	1,1	1,1	1,1	1
Waterway	1,8	1,8	1,7	1,7	1,7	1,6	1,4
Maritime	1,4	1,3	1,4	1,4	1,4	1,5	1,6
Air	2,6	2,7	2,9	3,3	3,5	3,6	3,5
Road part in transportation	93%	93%	93%	93%	93%	93%	94%

	1992	1993	1994	1995	1996	1997	1998	1999p
Transport	123	123	124	126	127	130	132	135
Road	116	116	117	118	119	121	124	126
Rail	1	0,9	0,8	0,8	0,8	0,8	0,7	0,7
Waterway	1,4	1,6	1,7	1,8	1,6	1,6	1,6	1,8
Maritime	1,5	1,7	1,6	1,5	1,4	1,5	1,5	1,5
Air	3,5	3,4	3,5	3,9	4,3	4,3	4,5	4,5
Road part in transportation	94%	94%	94%	94%	94%	94%	94%	94%

20) CGP:

Research institute:	General Commissionership of the Plan
Title:	Transportations: choices of the investments and costs of the nuisances – President Marcel BOITEUX
Date of publishing:	June 2001
Language:	French
Subject:	Transportations
Summarized:	Several points were examined in this report: - the utilisation of the rule of Hotelling to promote the irreversible effects affecting resources cannot renewable (modification of the climate by the greenhouse gas and exhaustion of the oil reserves); - the evaluation, in urban zone, of the effects of the congestion on the other transportation methods that the car, the evaluation of the cuts and the one of the occupied surfaces; - the development of the noise, especially in urban zone; - the value of the time; - the evaluation of the effect of classical pollution; - the development of human life.
Result:	The value of the carbon dioxide tonne in the public infrastructure choices is estimated to 100 €. The report propose by the continuation to keep after 2010 a moderate growth rate of the carbon price carbon equal to 3% per year.

	2000-2005	2000-2010	2010-2020	après 2020	Remarques
Valeur de la tonne de carbone					
Prix du pétrole **HT** ($/baril)	-	24 € + 1,4 %/an		+ 2 %/an	Test de sensibilité pour un taux de croissance de 5 %/an après 2020
Prix de la tonne de carbone (€/tC)	100 €/tC	100 €/tC	+ 3 %/an	+ 3 %/an	Révision périodique de ces valeurs

21) IEA I:

Research Institute: International Energy Agency (IEA)
Title of project: Saving Oil and Reducing CO_2 Emissions in Transport: Options and Strategies
Date of publishing: October 2001
Language: English
Area of interest: 26 industrialized IEA member countries
Content: This report examines the many policy approaches being taken by IEA member countries to reduce transport-related carbon emissions. These include improving fuel economy in and trucks, as well as reducing fuel consumption by vehicles already on the road. Alternative fuel sources are also covered as are ways to cut the growth in travel, by improving transit systems and using new technologies to reduce congestion. Energy-saving options in freight transport are also explored, such as making trucks and trucking systems more efficient and moving more goods by rail and water-borne transport.
Method: More than twenty different approaches are developed, including some which have been neglected by most IEA countries, e.g. improvements in motor efficiency, driving behaviour, vehicle maintenance, and telematics, speed limits, abolishment of older vehicles, road pricing, alternative fuel, intermodal transport. The study discusses the benefits and costs of each option, as well as the obstacles it faces, and quantifies the effect of each option in reducing oil use and CO_2 emissions. Success stories from IEA countries are presented, as well as some stories of failure.
Result: NN

22) IEA II:

Research Institute: International Energy Agency (IEA)
Title of project: CO_2 Emissions from Fuel Combustion 1971-1999 (2001 Edition)
Date of publishing: October 2002 (meanwhile, 2002 edition is released)
Language: English, French
Area of interest: 140 countries and regions
Content: Recent years have witnessed a fundamental change in the way governments approach energy-related environmental issues. In recognition of this change and in preparation for the Seventh Conference of the Parties (COP-7) meeting under the U.N. Climate Convention in Marrakech, Morocco from 29 October to 9 November 2001, the IEA has prepared this publication on CO_2 emissions from fuel combustion. The data in this book are designed to assist in understanding the evolution of these emissions from 1971 to 1999 by sector and by fuel.
Method: Emissions were calculated using IEA energy databases and the default methods and emission factors from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.
Result: NN

23) SPE:

Research Institute:	Fraktion der Sozialdemokratischen Partei Europas
Title of project:	Thema Europa: Verkehr und Umwelt – Strategien für ein nachhaltiges Verkehrssystem in Europa
Date of publishing:	January/February 2002
Language:	German
Area of interest:	EU
Content:	The party of European social-democrats develops strategies for a sustainable transport system. The paper shall the enrich political discussion.
Method:	The contribution refers to many other sources, and embeds them in a common context.
Result:	Transport is one of the most dangerous CO_2-emitters throughout Europe: About 28 % of all current CO_2 emissions derive from transport sector. According to the European Commission, between 1990 and 1998, in the EU 15 transport sector, they climbed up by 15 %, between 1990 and 1999 even by nearly 20 %. For the time span 1990-1999, the transport sector was the sector with the highest growth rate of CO_2 emissions. Of the 28 % of all CO_2 emissions deriving from the transport sectors and listed above, 84 % can be referred to road transport. The fact that during the last 30 years, the modal split developed in favour of road transport makes the problem more difficult: the share of road freight transport climbed up from 31 to 44 %, the share of rail freight transport fell from 21 % to 8,5 %. Compared to the year 1990, the carbon dioxide emissions in 2010 (in the case of no additional action concerning modal split taken = laissez-faire) would increase by 50 % up to 1,113 Bill. t (1990: 739 Mill. t). To this, the freight transport contributes with a 38 % growth rate and the passenger transport with a 24 % growth. According to INFRAS/IWW, the climate change effect evoked by CO_2 leads in Western Europe to costs of 121,8 Bill. €. These are 23 % of all external costs in Western Europe (besides external costs deriving from road congestion). Freight transport by road causes 88 €/1.000 tkm of external costs and thereof about 12,5 €/1.000 tkm deriving from climate change. Rail transport causes only 19 €/1.000 tkm of external costs, thereof about 5 €/1.000 tkm deriving from climate change. This results in an estimated ratio of climate change costs of 1:2,5 between rail freight and road freight transport. The European Commission reports that one (average) single road transport trip on motorways without congestion, which is 500 kms long, causes external “climate change” costs between 0,2 € and 1,54 €. Besides, the European Commission reports CO_2 emissions of 98,301 g/tkm for road and 28,338 g/tkm for rail transport (ratio: 3,5 : 1). IFEU´s TREMOD-model calculated 55 Mill. t of CO_2 emissions coming from commercial vehicles (Diesel engine) for the year 2000, and predict 60 Mill. t for the year 2010 and about 70 Mill. t for 2020.

24) FERROVIE DELLO STATO/AMICI DELLA TERRA:

Research institute:	Amici della Terra in collaboration with Ferrovie dello stato. Work group directed by Pier Luigi LOMBARD
Title:	The environmental and social costs of mobility in Italy
Date of publication:	28 February 2002
Language:	English
Subject:	
Summarized:	This report presents a summary of the results of the last research effort regarding the environmental and social costs of mobility in Italy. The year referred to is 1999; the modes of transport taken into consideration, both passenger and freight, are: roadway, railway and air. The report is composed of seven parts. The first part is about volumes of traffic and energy consumption for the three modes of transport being considered; in fact, a knowledge of these figures is indispensable to making any physical quantification of the principal instances of impact. A second part is about external costs of greenhouse gases and particularly of carbon dioxide. The third part is about external costs of air pollution: the evaluation of them due to the various modes of transport is based on a wide-ranging review of studies available in the international and Italian literature.

25) CGP:

Research institute: General Commissionership of the Plan
Title: Greenhouse Effect: economical modelling and political decision – President Pierre- Noël GIRAUD
Date of publishing: March 2002
Language: French
Subject: Greenhouse effect and political
Summarized: As all the engaged countries in the fight against the climatic change, France must anticipate its greenhouse gas emissions and to value at priori its preventive actions. The models currently in usage allow it, but incompletely: the impact of the measures against the climatic change is imperfectly known, and therefore subject to controversies. The available economical tools authorize today to do better. The technical group presided by Pierre- Noël GIRAUD proposes to use them widely, and in a manner coordinated, for more better to know the transmissions, evaluate more exactly the effect of the political national one and improve the dialog on the division of the efforts at the European Union.
Result: Two scenarios are compared: the scenario « B » of the Ministry of Equipment, Transportations and Lodging (METL) and the pre-Kyoto tendency scenario elaborated (DGEMP) for the ministry of Industry for the forecast of the energy sector to the 2nd semester of 1999. The carbon dioxide emissions of the transportations increase of 2% per year in the scenario DGEMP and of 1,3% per year in the scenario METL, the one of the road vehicles of 0,7% a year.

CO_2 emissions of transport – Mt :

	1997	2010	2020	1997-2020
Scén. DEGEMP	151	195	237	2%
Scén.METL (road vehicles)	128	145,3	150,1	0,7%

The evolution of the carbon emissions in the reference scenario of the METL between 1990 and 2010 can be detailed following way:

Emissions in MtC	1990	2010
Road transport	30,3	39,11
Air	1,3	1,8
Rail	0,3	0,3
Others	0,71	1,3
Total	32,61	42,51

Without new measures, the emissions of the sectors of the transportations would attain thus 42,5 million tonnes carbon (MtC) in 2010, for the only carbon dioxide while the objective of the National Plan of Fight against the Climatic Change is to bring back them to 38,5 MtC.

26) CITEPA:

Research institute:	Centres Technical Interprofessional of Studies on Atmospheric Pollution
Title:	Emissions in air in France – Metropolis –
Date of publishing:	April 2002
Language:	French
Subject:	Implied substances in the phenomenon of greenhouse increase effect
Summarized:	The substances and informers followed in matter of effect greenhouse are the CO_2, CH_4, N_2O, HFC, PFC, SF_6. The emissions are presented in the form of a graph for every substance and the principal categories of emitters by not any 5 years until 1990 then for each year that follows. The years relating to the maximum and to the observed minima are equally mentioned. The year 2001 is a preliminary result.

27) OCDE/OECD:

Research institute: Programs research regarding transportations road and intermodals liaisons (RTR)

Title: Reduction Strategies of the greenhouse gases emanating road transportation: method of analysis

Date of publishing: 2002

Language: French

Subject: Environment, planning of the roads and transportations

Summarized: The sector of the transportations is at the origin of about 27% of the emissions of carbon dioxide of the OECD countries of which 80% originate road transportations. The research Program regarding transportations road and intermodals liaisons of OECD constituted a work Group having for mission to realize a deepened study on the carbon dioxide transmissions of the road transportations and to produce a pertinent framework devaluation of the reduction strategies of these emissions.

Some measures can favour a reduction from the road transportations in the greenhouse gas emissions. The approaches more effective regarding reduction greenhouse gases transmissions attributable to the special cars and to the road transportations should call upon a combination of measures such as: voluntary engagement of the car manufacturers with the authorities to produce vehicles thriftiest in fuel, tax on the vehicles, tax on the fuels and tax modulated of excise modulated according to carbon dioxide emissions, information of consumers and promotion of a better energy effectiveness in the various sectors interested.

Result: According to the data of the work Group of OECD, the part that represents the road transportations in the carbon dioxide emissions varies of 13 to 40% according to the countries. There exist the uncertainties on the way of which the various countries classify the transport vehicles of merchandises; so it's difficult, owing to heterogeneousness of the data, to compare the emissions due to the transport of merchandises in the various countries.

The total emissions of carbon dioxide of all origins increase in all the countries of OECD. The relative part of the transportation in the carbon dioxide emissions increased in a global way on the period 1990-1995. The data of the countries of OECD are not comparable, but it appears that the part of the transportation of merchandises in the carbon dioxide emissions grows in comparison with the one of the passengers transportation ones.

	Evolution of the carbon dioxide emissions of transport between 1990 and 1999	Evolution of the carbon dioxide emissions of the road transport between 1990 and 1999	Part of road transport in the carbon dioxide due to the transport
France	**+17,60%**	**+16,90%**	**94%**
Italy	**+17,50%**	**+19,10%**	**98%**
Germany	+11,50%	+14,90%	97%
United Kingdom	+7,50%	+5,40%	87%

The Organisms Applied in CO_2 Research in France as a result of political action

The environmental question is one of the mains the preoccupations of the French governments that, latter years, attached themselves to favour the research on these questions, particularly on the questions of the environment and of transportation. The problem of the warming of the planet and emissions of the greenhouse gas was the object of much research it is easy to find a lot technical studies relating to the carbon dioxide emissions and to the combined transportation rail/road.

In this respect, France privileged the works that drove to keep a number of parameters for the evaluation of projects and of political ones. She endowed herself, to be able to reply to the interrogations put by its questions, of specialized structure in transportation and environment calling together the experts more qualified.

1-The National Counsel of the Transportations (C.N.T.)

It was instituted by the LOTI [law n° 82-1153 of December 30 of 1982 of orientation of the internal transportations (item 16) in substitution to the superior Counsel of the transportations with explicit will of the legislator to develop the global approaches and intermodal systems of the transportation, and to return the composition of the Counsel more representative. Consultation organism, it is associated at the elaboration and to the implement politics of the transportations. It is consulted on the questions relating to the organization and to the functioning of the transportation systems of persons and of merchandises more earthly, more aerial and more maritime. To this title, it executes the missions of studies and of suggestions that are entrusted for him. It has, of more, the possibility to seize itself himself of questions that appear for him necessary to treat.

The statute of the C. N. T. and his composition allow him to be a confrontation place and consultation between the different professional partners of the transportations, all confused modes. If it research well heard the maximum of consensus, it has equally for principle to put in light the strategies of each of the partners.

The orientations which he proposes to the authorities or to the professional organizations, well that specific to every modes, put systematically the accent on these intermodal questions.

The transportation questions and environment questions have, between other, summer treated in the report of the vice-president of the C. N. T. Alain BONNAFOUS[41].

[41] C.N.T., *the transportations and the environment: towards a new balance,* Report of the work group presided by Alain BONAFOUS

2-The general Commissionership of the Plan

From the standpoint economical calculation, The general Commissionership of the Plan, created in 1946 by the general of Gaulle, redraws 50 years of the French planning. The essential function of this service of the Prime Minister is today to light up the public choices. She leans on four principal missions:

-The strategy:
The Plan contributes to the elaboration of the strategy of the State. Recently assured by the vote of the Plan laws, she rests today on the definition of objectives based on the analysis of the big challenges to which ones the French corporation is confronted, and the preparation of the necessary reformations. She assures the coherence of the action of the State and uses framework to the contracts signed with the regions and the businesses participating in the management of a public service.

-The forecast:
The Plan takes and gives rise to long-term analyses on all the subject general interest for the future of the Nation and the framing of politics of the State. With this aim, it effectuates also international comparisons and analyses the foreign experiences.

-The evaluation:
The Plan assures the evaluation of the political public one and contracts between the State and the regions, to the request of the government. It's to put back the national choices in perspective and to do appear the productivity of the public expenditure.

-The consultation:
The Plan is a dialog and consultation place. Commissions and work groups gather some elects, economical and social partners, representing administrations, experts and qualified personalities.

The general Commissionership of the Plan today composed of six services:

- Service of Economy and International Financial;
- Service of the evaluation and Modernization of the state;
- Service of the Social Matters;
- Service Energy, Environment, Farming, service Industry;
- Service of the Technological and Industrial Development;
- Service of the Studies and Research.

The constitution of work groups allows the general Commissionership of the Plan to confront the different ones approach the problems. The publications and the symposia or seminaries contribute to the organization of the public debate and to the exchanges on interest subjects general.

The general Commissionership of the Plan therefore brought to treat questions of transportations and environment for which ones it notably ordered a report to the president Marcel BOITEUX. The external effects of the transportation (CO_2, noise, human life, atmospheric pollution) are explored from the standpoint of their cost and their origins. It springs equally of this report that the foreseeable emissions of all the gas of the road transportation in Europe to the horizon 2020 are in reduction. Only the carbon dioxide rejections should stabilize themselves to their current level.

As for concrete application of these economical evaluations, she is allowed thanks to reference tool that constitutes the circular « Idrac » of 1995. She sets up the value of the time, the pollution parameters (CO_2, atmosphere, noise), the exploitation costs, the security.

Valorisation des effets externes dans les évaluations socio-économiques

(valeurs de la tonne de carbone, du bruit, de la vie humaine, de la pollution atmosphérique)

	2000-2005	2000-2010	2010-2020	après 2020	Remarques
Valeur de la tonne de carbone					
Prix du pétrole HT ($/baril)	-	24 € + 1,4 %/an		+ 2 %/an	Test de sensibilité pour un taux de croissance de 5 %/an après 2020
Prix de la tonne de carbone (€/tC)	100 €/tC	100 €/tC	+ 3 %/an	+ 3 %/an	Révision périodique de ces valeurs
Valeur du bruit					
Valorisation du bruit	Le coût unitaire du bruit est défini par la dépréciation des prix moyens de location par m² de surface occupée et exposée à des niveaux de bruit dépassant un seuil. Loyer mensuel au m² du secteur locatif publié par l'INSEE à l'échelle nationale				
Calcul de base	36 F m² (1996)	Évolution du prix indexé sur le taux de croissance du PIB			55-60 / 60-65 / 65-70 / 70-75 / + de 75 % dépréciation/décibel: 0,4 % / 0,8 % / 0,9 % / 1 % / 1,1 %
Effet nuit	+ 5 dB(A)				Cela ne s'applique pas au transport aérien, l'effet nuit étant déjà intégré dans le calcul de l'indice propre au transport aérien.
Effet sur la santé	+ 30 % au dessus de 70 dB(A) jour et de 65 dB(A) nuit				À titre conservatoire, en attendant le résultat d'études ultérieures.
Espace non habité (bâtiments publics et zones d'activités)					On utilisera les mêmes valeurs que celles utilisées pour les habitations en appliquant un coefficient supérieur à 1 pour les établissements publics réputés sensibles et un coefficient inférieur à 1 dans les autres cas. Ces coefficients, fixés *a priori*, restent à préciser.
Zones non bâties destinées à le devenir					Les dommages causés par le bruit seront négligés, sauf pour les zones destinées à l'habitation dans un avenir prévisible.
Zones de détente					Pas de monétarisation de l'évaluation, qui restera qualitative.
Tracé insuffisamment défini					L'évaluation concerne l'ensemble du réseau dans lequel un nouveau projet est envisagé (identification des différentes zones, utilisation de modèle simplifié de propagation du bruit). L'évaluation quantitative est accompagnée de commentaires spécifiques.
Valeur de la vie humaine					
Tué					
Transports routiers	66 % (1,5 M€)	Ces valeurs devront croître au même rythme que les consommations des ménages par tête			Il est admis que la valeur unique de la vie humaine à retenir dans les calculs puissent être modulés entre les transports individuels et les transports collectifs sur la base de plusieurs arguments (relation au risque ; contexte, particularité des accidents collectifs, etc.).
Transports collectifs	100 % (1,5 M€)				
Blessé grave					
Transports routiers	150 m€				
Transports collectifs	225 m€				
Blessé léger					
Transports routiers	22 m€				
Transports collectifs	33 m€				
Valeur de la pollution atmosphérique (euro par unités de trafic) €/100.veh.km ; €/100.train.km					
Valeur urbain dense		- Réduction de 6,5 % par an pour les PL et 9,4 % par an pour les VP et VUL - Augmentation annuelle sur la base de l'évolution des dépenses de consommation des ménages			- Correction envisageable pour les zones présentant des caractéristiques très particulières (vallées de montagne, par exemple) ; - Tests de sensibilité à plus ou moins 70 % ; - Révision de ces valeurs en fonction des travaux menés sur l'impact sanitaire de la pollution atmosphérique et des progrès constatés dans le secteur des transports en matière d'émission de polluants.
VP	2,9				
PL	28.2				
Train diesel (fret)	458				
Train diesel (voy.)	164				
Bus	24.9				
Valeur urbain diffus					
VP	1				
PL	9.9				
Train diesel (fret)	160				
Train diesel (voy.)	57				
Bus	8.7				
Valeur rase campagne					
VP	0.1				
PL	0,6				
Train diesel (fret)	11				
Train diesel (voy.)	4				
Bus	0,6				

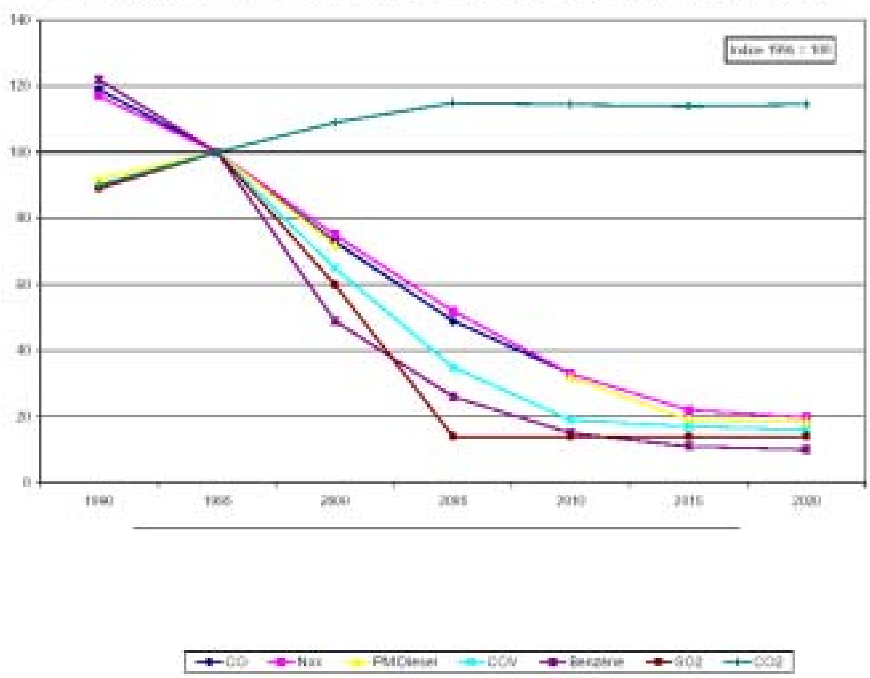
Origine des pollutions atmosphériques en France

(émissions nationales de l'année 1996)

	Dioxyde de soufre	Oxydes d'azote	Composés organiques volatils non méthaniques	Dioxyde de carbone (gaz à effet de serre)
Combustion dans l'industrie, procédés industriels, raffinage, prod. d'énergie	71 %	18 %	8 %	33 %
Transports	14 %	75 %	42 %	36 %
Résidentiels et tertiaire	13 %	6 %	9 %	31 %
Solvants et utilisation d'autres produits			23 %	
Autres	2 %	1 %	18 %	

Source : Centre interprofessionnel technique d'études de la pollution atmosphérique (CITEPA), 1999

Évolution prévisible des émissions du transport routier en Europe



Source : communication de la Commission, « Bilan du programme Auto-Oil II », COM(2000)626 final, 5 octobre 2000

3-The concerned Ministries and their services

France is more structured in matter of environment and of transportations and has others services and affected organisms to these spots.

The investment of the Ministry in charge of the questions of transportations as well as the one in charge of the environmental questions goes in the direction of research of solutions to the problems of greenhouse effect and carbon dioxide rejection by the transportations.

The Ministry of Equipment, Transportations and lodging, tourism and sea takes into account the environmental aspects in his help process to the decision.

The economical Service and statistics (S.E.S.), that belongs to the direction of the economical and international Matters (D.A.E.I.) has for essential mission to produce, analyse and broadcast results statistics and economical studies in the domains of the transportations, construction and lodging. For that, the service exploits administrative information or realizes investigations with businesses.

The Ministry of ecology and sustainable development, very implied in the fight against the emissions of the greenhouse gas, has access to numerous tools. It has under his supervision the **Agency of the Environment and Mastery of the Energy (A.D.E.M.E.)**, that a public establishment of which moon of the missions is to preserve the quality of the air while developing the supervision and the prevention of the transmissions polluting. Very established locally, A.D.E.M.E . publishes many reports on the state of the environment, particularly in the transportations.

At last, the theme of greenhouse effect being a major preoccupation of French State, an **Interdepartmental Mission of Greenhouse Effect (M.I.E.S.)** was created in 1992. Reformed in June 1998 by modification of the decree governing it, she was related to the Prime Minister all while being placed at the disposal of the minister of the ecology and sustainable development that drives the French delegations in the European and international negotiations on the subject. Its actions carry essentially on the preparation of the positions that France must defend at the international level with the concerned instances, on the presentation of its positions in the meetings of governmental experts, on the identification of the clean measures to allow our country to attain its objectives and on follow-up on them put in application.

4-Conclusion: The P.R.E.D.I.T., a common program of research

All these organisms are a proof of the will of the French government to follow actively fights against the greenhouse effect to the levels national, European and international. The creation of these structures allows many experts of look into the questions of transportations and environment in a general way, and particularly questions relating to the carbon dioxide rejection by the different transportations (road, maritime, rail, aerial, river). The incurred risk of the dispersion of the energies and knowledge because of the important number organism loaded to treat the question is obliterated in front of the creation of the **P.R.E.D.I.T. (national Program of research and of innovation in the earthly transportations)**, creates to the initiative of the loaded ministries of the research, transportations, environment and industry, of A.D.E.M.E. and of A.N.V.A.R.(Agency National of the development of the research).

The P.R.E.D.I.T. covers the field of the earthly mobility according to the methods: road, river or rail, motorized or not, at once for the travellers and the merchandises, as well as the problems of interfaces with the transportation aerial and maritime modes. The program articulates itself with the others program or research networks and of technological innovation.

It understands 11 work groups of which it group Impacts of energy and environment that has some loads the production of the necessary knowledge to the public action on environmental impacts of the earthly transportations, there understand their translation in term of costs, on the pollution of the air, the greenhouse gas production, the sonorous nuisances, the attained to the ecosystems and to the landscapes.

Interesting Links & Related Websites

International Energy Agency:

http://www.iea.org/

European Environment Agency :

http://reports.eea.eu.int/92-9167-059-6-sum/en/page001.html
http://reports.eea.eu.int/ENVISSUENo12/en/page007.html

Eurostat:

http://europa.eu.int/comm/eurostat/Public/datashop/print-catalogue/FR?catalogue=Eurostat&collection=13-Pocketbooks&product=KS-AE-01-001-__-C-FR
http://europa.eu.int/comm/eurostat/Public/datashop/print-catalogue/FR?catalogue=Eurostat&collection=13-Pocketbooks&product=KS-41-01-074-__-C-FR
http://europa.eu.int/comm/eurostat/Public/datashop/print-product/FR?catalogue=Eurostat&product=KS-37-01-558-__-N-FR&type=toc

European Commission:

http://europa.eu.int/comm/environment/pubs/studies.htm

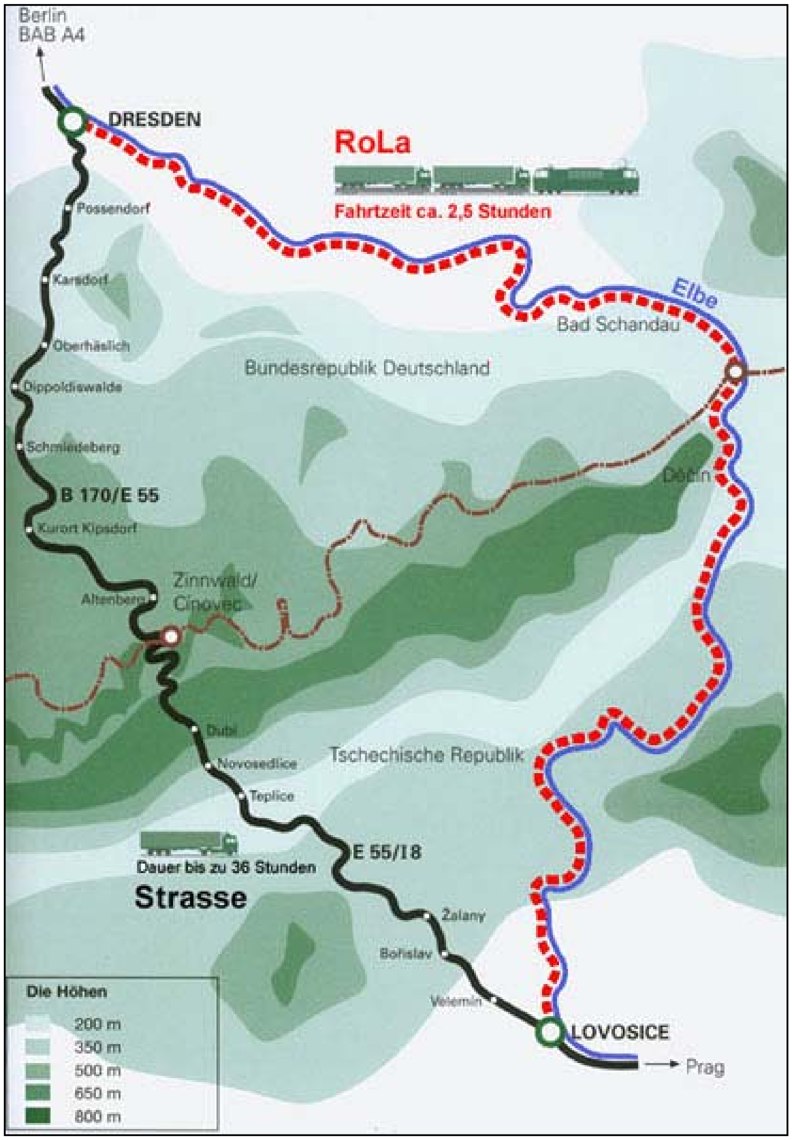
Allgemeiner Deutscher Automobil Club (ADAC):

http://www.verkehr.adac.de

Annex II: Special Case Rolling Motorway Dresden Lovosice

As for the Rolling motorway relation Dresden-Lovosice, the topography of the road and railway routes seemed to have a strong influence on the comparison results of energy consumption (and therefore CO_2 emission), project partners SGKV and Lugmair made a relation-specific benchmark analysis. As the picture below clearly shows, the railway route all the way follows the river Elbe valley, while the road (E 55) crosses the Erzgebirge mountains along the Czech Republic/German border line. The mountains are more than 800 m high, while Lovosice and Dresden (the starting and ending points of the Rolling Road) are less than 200 m above the Sea. In addition, there are some hills to climb up and down between Lovosice and Teplice. On this relation, the motorway between Dresden and Praha, which will go through some tunnels, is not completed yet.

Topography Profile of Dresden-Lovosice Rolling Motorway



Source: Transport Ministry of Saxony

The route can be divided into 40 % upgrade, 40 % downgrade and 20 % average grade. Taking into account the additional grade factors from above for moving along these rural main roads (as the E 55/B 170 is a rural main road), this would mean

(40 %)x(42,4 l/100 km)x(2,7)+(40 %)x(42,4 l/100 km)x0,3+(20 %)x(42,4 l/100 km)x1,5
= 63,6 l/100 km.

So SGKV supposed an average fuel consumption of 60 litres per 100 km for a truck with 100 % load weight (40 tonnes, Euro 3) driving from Dresden to Lovosice.

Lugmair, on the other hand, compared the specific route characteristics (first part: upgrade, second part: downgrade, third part: nearly flat) with similar routes they already operate on for a longer time. In August 2002, Lugmair company interviewed some of their experienced truck drivers and came to the conclusion that an average fuel consumption of 60 l/100 km is too high and that they would prefer 50 l/100 km for the specific route. It seems valuable for the other cases that this consumption value is nearly the value that was used in former IRU/BGL study.

On the other hand (besides the 2002 floods in Germany and their influence on German and Czech transport system), the load factor of the Rolling motorway from Dresden to Lovosice had become worse, but meanwhile has improved again.[42] For the calculation, also the specific different profile of the rail and road routes (river Elbe valley vs. road climbing up the Erzgebirge mountains) had to be taken into account.

In addition, in the Czech Republic the energy mix of railway electricity had changed in the late 90s, as the tablets below demonstrate:[43]

<u>Basic table of IRU/BGL study (2002):</u>

Nuclear	Hydro	Other renewable	Hard Coal	Brown Coal	Oil	Gas	Other
19,8 %	1,0 %	0 %	0 %	73,7 %	2,4 %	2,9 %	0 %

Source: European Commission, DG 17, IEA, IFEU estimations; data of public electricity, data from 1996

<u>EU DG TREN (2002):</u>

Nuclear	“Renewables” (Hydro and other)	Solid Fuels (Hard & Brown Coal)	Oil	Gas	Other
20,4 %	3,9 %	71,6 %	0,9 %	3,2 %	0 %

Source: Eurostat, OECD; data from 1998

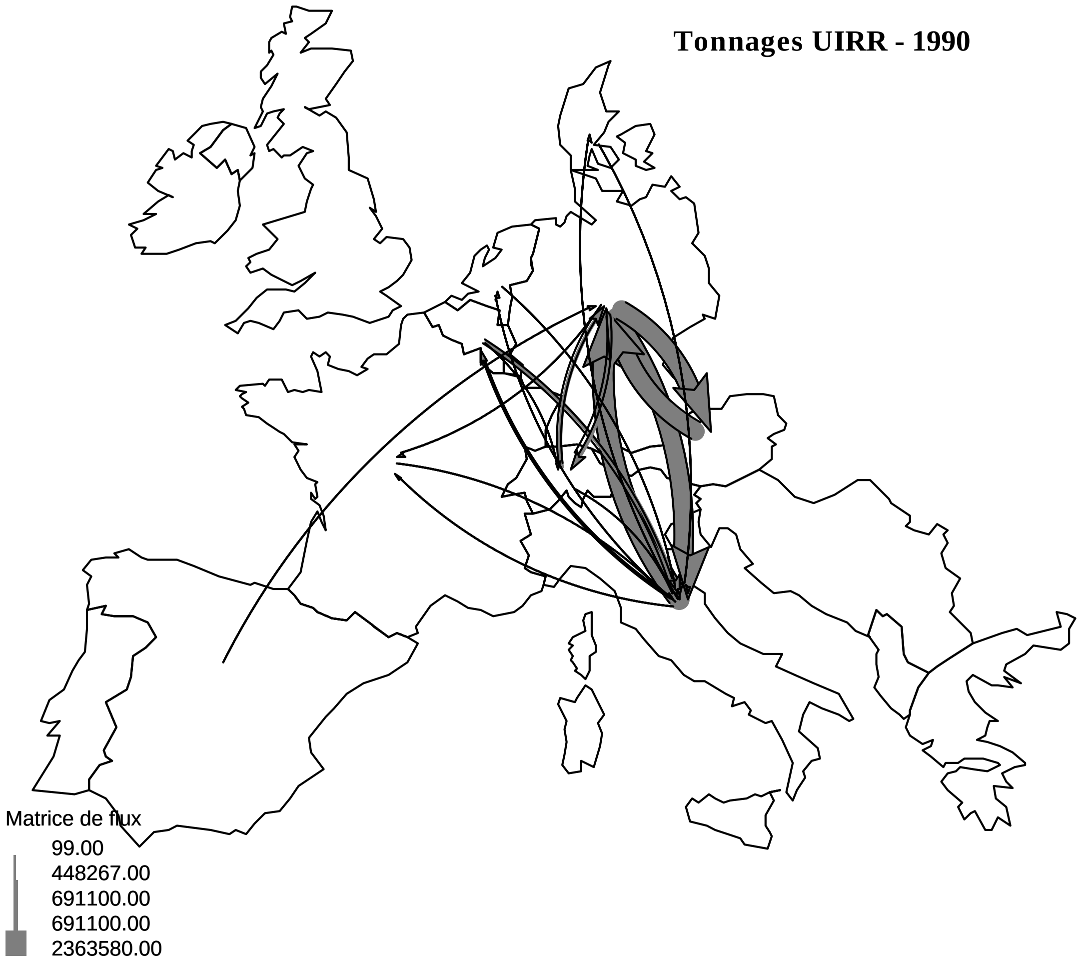
[42] The reasons were: (a) The border crossing of the rural road B 170 Altenberg/Cinovec had been fully developed, so that the border crossing time for trucks was reduced; (b) the works on the Dresden downtown train network lead to delays of the Rolling motorway and fewer departures as well; (c) the winter 2000/2001 was quite mild. Sources: dpa; DVZ Nr. 104 of august 30th, 2001; http://www.autobahn17.de/presse6/011226.htm , Verkehr Nr. 37/2002

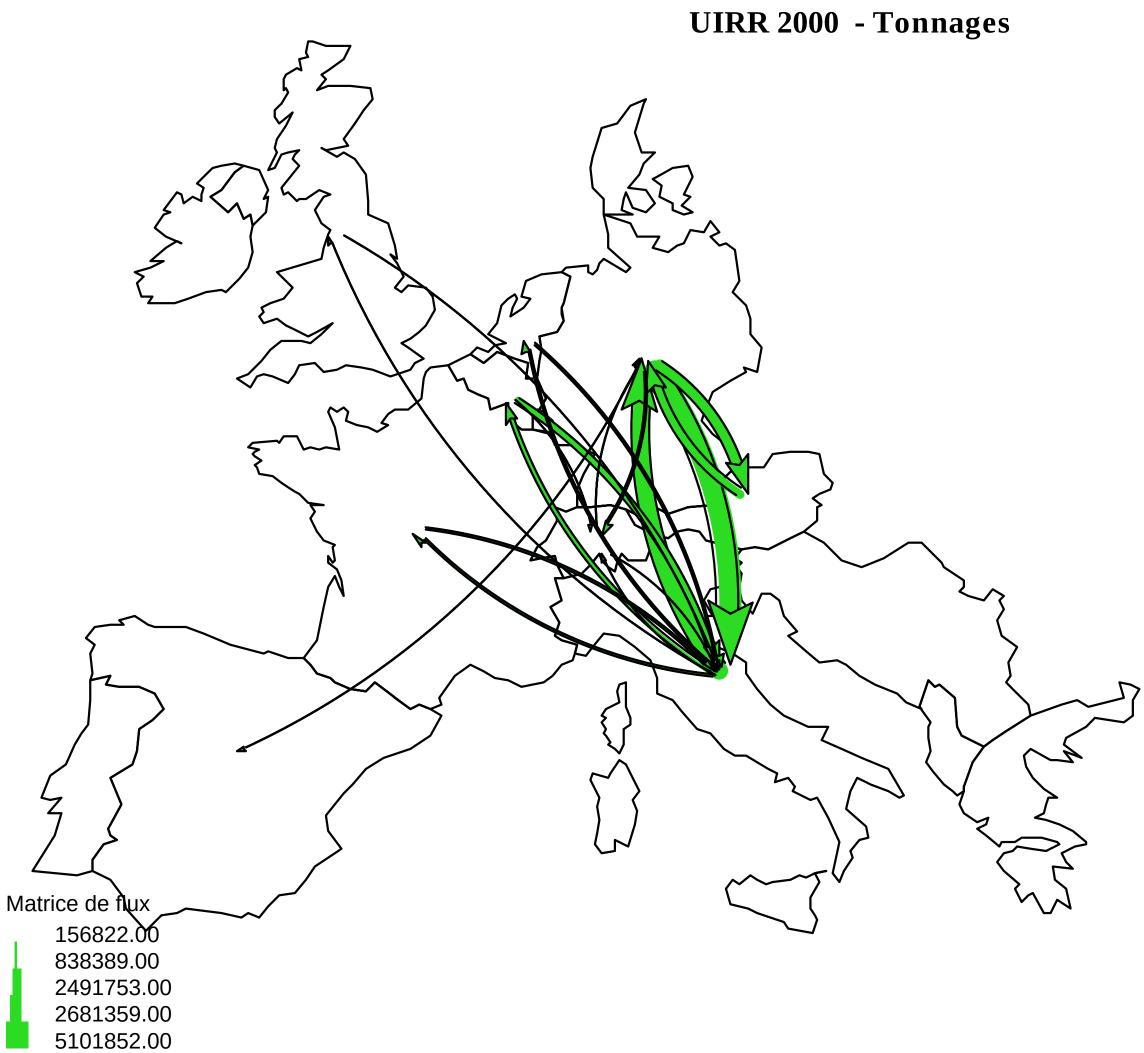
[43] Sources: Energy Policies of IEA Countries - Czech Republic 2001 Review, http://www.iea.org/public/reviews , 2002-07-23; IEA Press Release (01) 24, 22 November 2001

Coal is the leading fuel for power generation in the Czech Republic, it still dominates the Czech Fuel mix and generates 70 % of total electricity. But its role is declining. The development in the Czech energy mix is clearly shown: Nuclear, Gas and other “Renewables” substitute Coal and Oil. According to Czech operator Bohemiakombi, there is a national program to clean all the Czech power stations up.

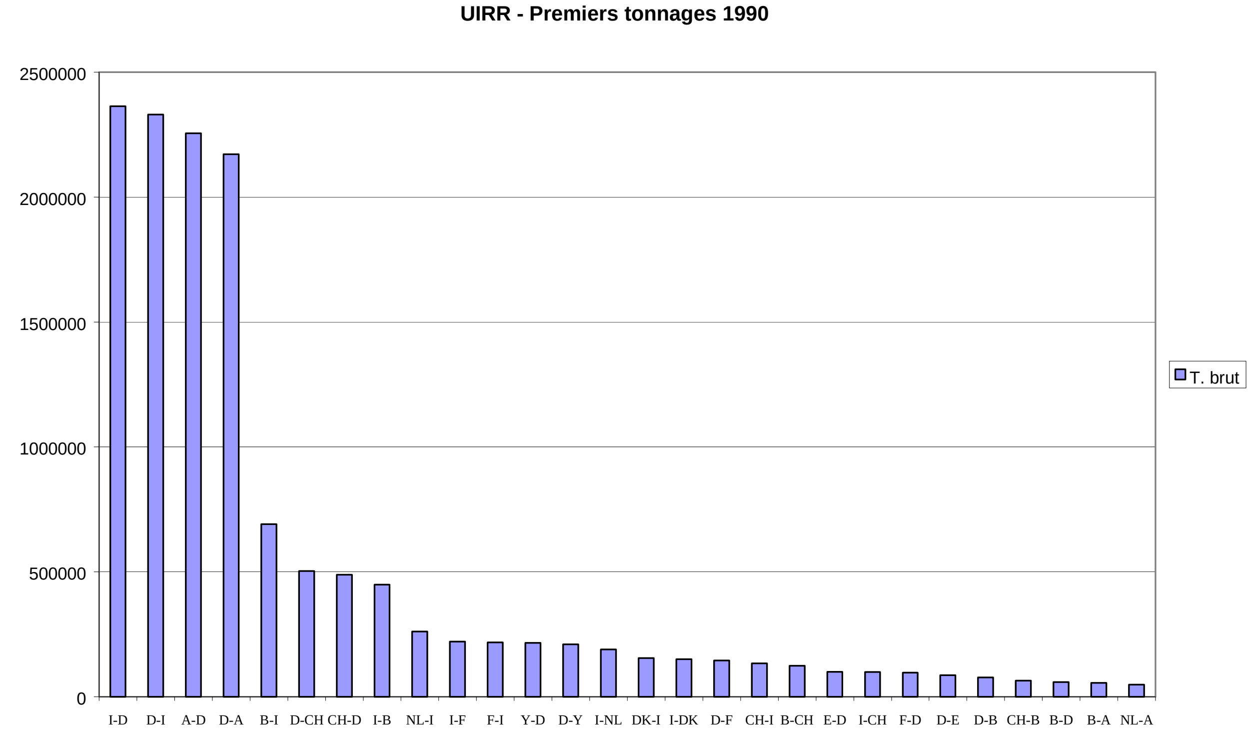
Annex III: Detailed structural analysis of UIRR traffic

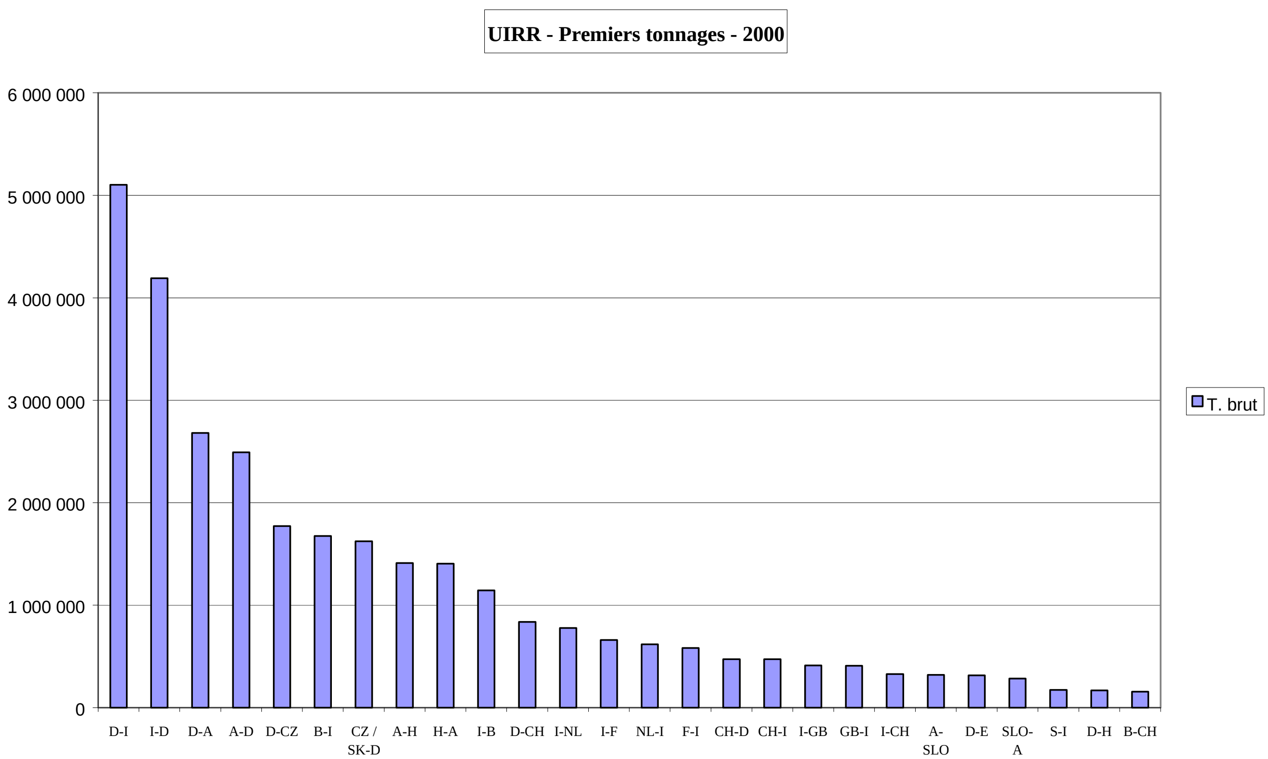
Geographic concentration

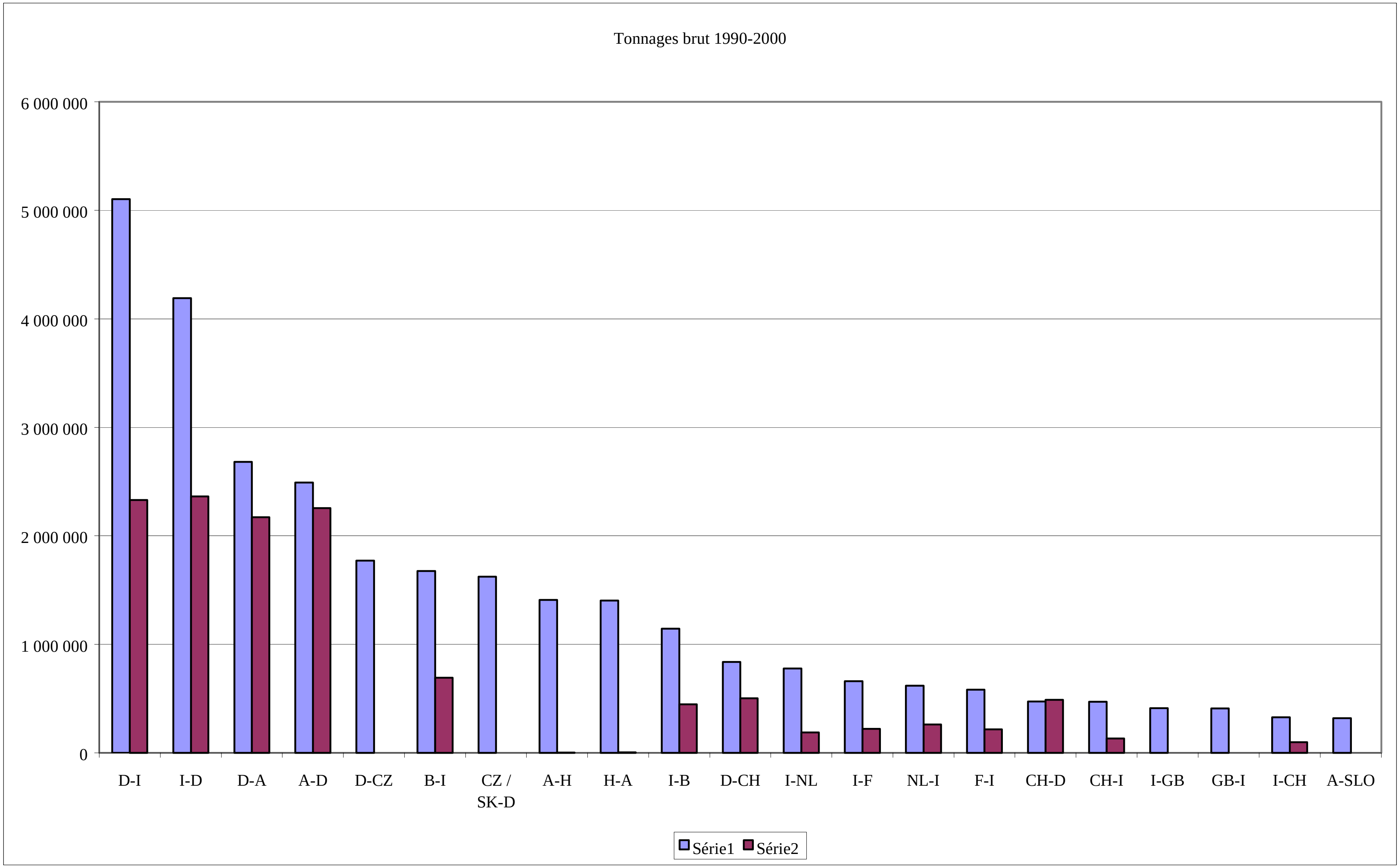



UIRR 2000 - Tonnages
Matrice de flux
156822.00
838389.00
2491753.00
2681359.00
5101852.00

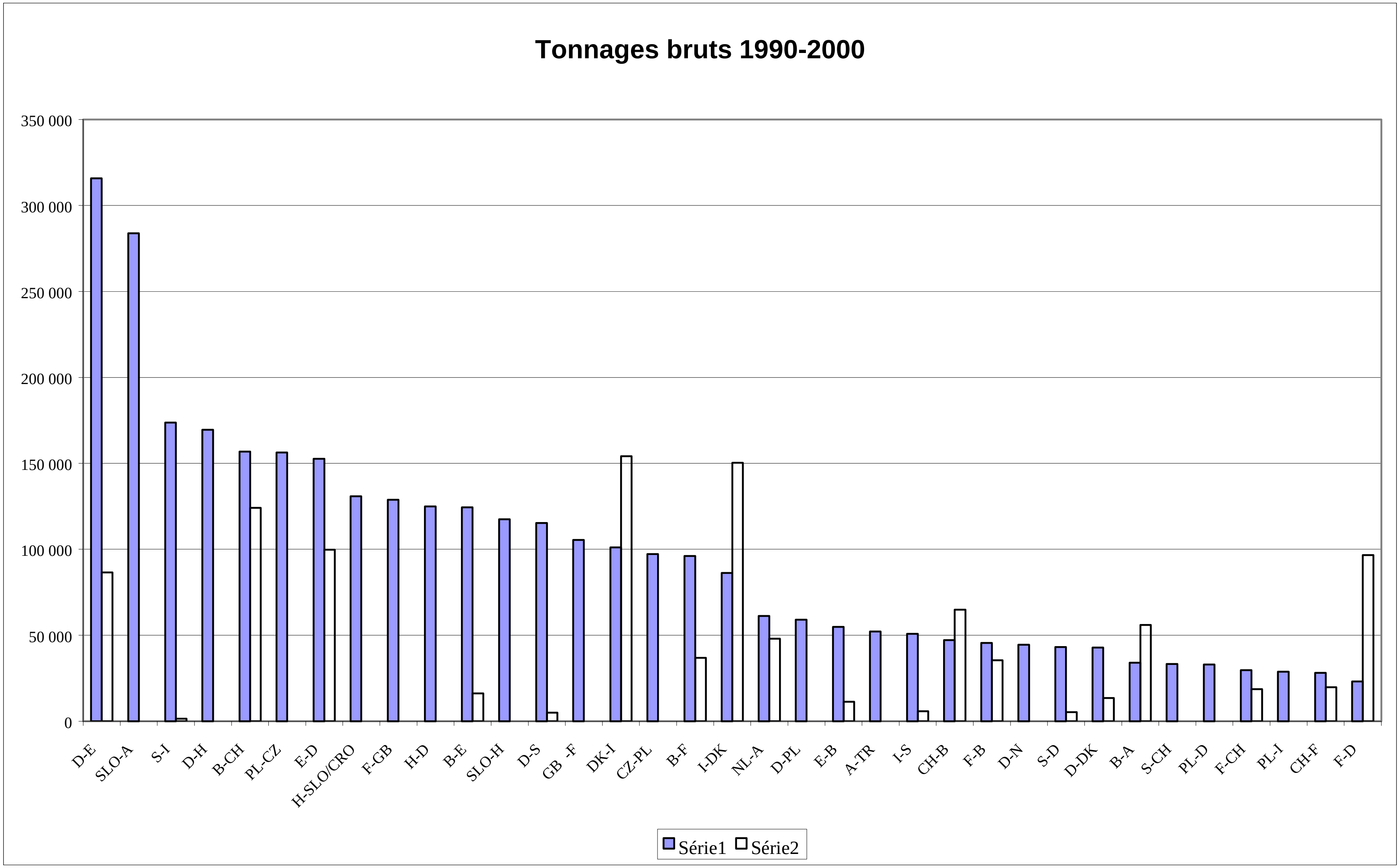
Relations spectrum per O/D and direction between 1990 and 2000







Tonnages brut 1990-2000
6 000 000
5 000 000
4 000 000
3 000 000
2 000 000
1 000 000
0
D-I
I-D
D-A
A-D
D-CZ
B-I
CZ / SK-D
A-H
H-A
I-B
D-CH
I-NL
I-F
NL-I
F-I
CH-D
CH-I
I-GB
GB-I
I-CH
A-SLO
Série1
Série2


Tonnages bruts 1990-2000
350 000
300 000
250 000
200 000
150 000
100 000
50 000
0
D-E
SLO-A
S-I
D-H
B-CH
PL-CZ
E-D
H-SLO/CRO
F-GB
H-D
B-E
SLO-H
D-S
GB -F
DK-I
CZ-PL
B-F
I-DK
NL-A
D-PL
E-B
A-TR
I-S
CH-B
F-B
D-N
S-D
D-DK
B-A
S-CH
PL-D
F-CH
PL-I
CH-F
F-D
Série1
Série2

Year	90	91	92	93	94	95	96	97	98	99	00	01	
Intercontainer-Interfrigo	1 147	1 200	1 193	1 148	1 322	1 319	1 331	1 286	1 249	1 075	962	835	
Union Internat. Rail Route	1 250	1 351	1 494	1 550	1 959	2 228	2 410	2 621	2 850	2 807	3 114	3 090	wi
Sum	2 397	2 552	2 686	2 699	3 281	3 547	3 741	3 908	4 099	3 882	4 075	3 925	
Part in %													
Intercontainer-Interfrigo	48%	47%	44%	43%	40%	37%	36%	33%	30%	28%	24%	21%	
Union Internat. Rail Route	52%	53%	56%	57%	60%	63%	64%	67%	70%	72%	76%	79%	wi
Growth in %													
Intercontainer-Interfrigo		4,6%	-0,6%	-3,7%	15,1%	-0,3%	0,9%	-3,4%	-2,9%	-13,9%	-10,5%	-13,2%	
Union Internat. Rail Route		8,1%	10,5%	3,8%	26,3%	13,8%	8,1%	8,8%	8,7%	-1,5%	10,9%	-0,7%	

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Intercontainer - Interfrigo	1 146 919	1 200 213	1 192 656	1 148 262	1 322 213	1 318 678	1 331 005	1 286 286	1 249 024	1 075 046	961 675	834 894	
Union Internat. Rail Route	1 250 303	1 351 335	1 493 721	1 550 492	1 958 763	2 228 493	2 410 092	2 621 231	2 850 386	2 807 020	3 113 539	3 090 383	wi
Sum	2 397 222	2 551 548	2 686 377	2 698 754	3 280 976	3 547 171	3 741 097	3 907 517	4 099 410	3 882 066	4 075 214	3 925 277	
UIRR in Consignments	543 610	587 537	649 444	674 127	851 636	968 910	1 047 866	1 139 666	1 167 345	1 158 735	1 289 981	1 286 673	
					Conversion rate								
						2,3							

Annex IV: Traffic in major European corridors and projections

EU corridors

Table 5,1: Total trade flows, all commodities, 2000 (*1000 tons); Reference scenario

	F	BLEU	NL	D	I	GB	IRL	DK	GR	P	ESP	N	S	FIN	CH	A	WORLD	**Total**
F	1498453	25545	11570	34495	22247	12383	769	822	1365	3132	13036	749	959	570	8562	708	43120	**1678485**
BLEU	37118	313790	34401	27934	6177	7214	715	885	552	805	2339	789	1328	899	2074	643	30078	**467742**
N L	18392	76245	435413	83827	8968	14372	1428	1867	987	1263	2829	1931	2057	1171	2768	945	39170	**693632**
D	25916	26048	61867	685512	19573	13023	891	5568	1143	1150	5361	2755	5564	2376	12954	12390	67740	**949831**
1	12392	2396	1848	14992	1190486	4381	203	556	2495	1794	4411	311	636	426	5086	2840	49680	**1294931**
GB	18836	9776	16829	25258	9450	1863867	11818	2642	732	1781	8174	3508	4737	4203	1340	278	31529	**2014757**
IRL	846	364	916	1105	296	7506	126579	90	31	38	211	420	124	58	71	9	800	**139465**
D K	1178	499	1323	9678	1483	2935	114	254506	183	156	475	2235	5656	1050	154	103	7820	**289548**
GR	1206	269	617	1475	4311	1190	37	159	232662	16	1031	84	153	25	26	66	13604	**256930**
P	1353	570	714	1515	657	1950	45	135	71	312729	4032	176	163	103	146	56	4989	**329403**
ESP	9423	2002	3083	5675	4531	5593	363	737	595	5982	1293384	1343	596	338	447	195	34070	**1368358**
N	21286	11011	26283	44405	2460	44662	537	6726	66	938	2100		12740	4538	236	56	33579	**211623**
S	3655	3752	2782	13650	2501	7588	407	6414	276	166	957	1974	375715	5689	440	381	16999	**443349**
FIN	2077	1255	2283	5422	1173	4370	230	1540	268	255	1177	736	5670	453596	352	144	15181	**495728**
C H	8750	248	342	3854	2259	297	7	93	26	30	125	45	73	30	45853	508	2014	**64554**
A	1047	390	594	10539	6250	582	21	197	172	48	226	111	256	128	2107	186777	8486	**217931**
WORLD	145252	74604	154092	24713ï	219ï15	98239	3017	24752	21814	29030	118716	11111	47160	30319	9128	36335	12543	**1282964**
Total	**1807180**	**548764**	**754956**	**1216474**	**1502537**	**2090152**	**147182**	**307688**	**263438**	**359311**	**1458584**	**28277**	**463590**	**505518**	**91744**	**242436**	**411401**	**12199231**

Source: NEA: projection for DG TREN at horizon 2010 and 2020

Table 6.1: Total trade flows, all commodities, 2010 (* 1000 tons); Sustainable policy scenario

	F	BLEU	NL	D	I	GB	IRL	DK	GR	P	ESP	N	S	FIN	CH	A	WORLD	Total
F	1697743	30545	14233	41161	25616	15205	943	1132	1763	3690	16511	896	1222	730	10270	942	57760	1920363
BLEU	45484	367762	46183	33937	7645	9150	850	1238	771	1017	3044	974	1727	1169	2588	850	42191	566580
NL	22942	89704	529122	99586	10675	17434	1779	2574	1336	1567	3492	2369	2681	1522	3339	1228	55367	846714
D	30898	30596	76684	767033	22144	15437	1035	7017	1433	1387	6707	3206	6695	2815	15184	14847	95364	1098482
I	15494	3025	2391	18189	1340540	5388	256	745	3259	2189	5766	403	824	550	6059	3550	69655	1478283
GB	21659	11821	20519	28124	10958	2114546	14547	3291	974	2133	9650	4131	5636	4588	1554	366	43257	2297753
IRL	995	432	1145	1329	339	8880	156550	115	40	45	267	466	164	65	97	12	1127	172068
D K	1505	656	1723	12469	1795	3513	148	369748	267	202	593	2786	7012	1306	210	146	12004	416083
GR	1468	333	805	1858	5331	1475	43	245	362191	20	1441	101	213	31	33	84	20178	395850
P	1731	718	934	1881	799	2435	63	188	105	356489	5178	218	217	123	188	78	6270	377615
ESP	11619	2544	3788	6688	5561	6605	431	1018	811	7407	1577468	1652	746	421	515	242	47250	1674768
N	23429	11846	28339	48749	3031	46470	551	7841	95	1001	2475.		14255	4891	263	76	36209	229520
S	4697	4353	3723	16579	3215	9771	541	8767	374	234	1316	2375	455370	6935	590	534	24253	543627
FIN	2736	1694	3035	6965	1544	5906	310	2200	383	340	1673	926	7340	586155	459	196	21517	643379
C H	9608	324	436	4686	2546	384	9	129	36	39	171	57	95	38	54315	653	2749	76276
A	1383	528	790	13444	7150	806	31	286	245	65	332	151	336	179	2614	210909	13281	252528
WORLD	176092	90019	183679	323902	268758	123704	3762	32330	26702	33031	138316	14841	63656	37658	11201	45404	21312	1594366
Total	**2069485**	**646901**	**917528**	**1426580**	**1717647**	**2387108**	**181849**	**438863**	**400787**	**410856**	**1774400**	**35551**	**568189**	**649174**	**109478**	**280115**	**569744**	**14584255**

Source: NEA

Table 5.7: Total trade flows, all countries, all modes, per commodity, 2000 (*1000 tons); Reference scenario

ALL MODES	EU Trade with community countries			EU Trade with non-communit countries				EU trade	Non-EU trade		Total
	EU domestic intra-regional	EU domestic Inter-regional	International trade within EU	Total	Eastern Europe		Rest world	total	Norway & Switzerland	Transit	
					A	I. Non-appl.					
Agricultural products	413847	367354	92461	107121	13235	21567	72319	**980783**	7045	1524	**989352**
Foodstuffs	536069	495735	94268	147623	9462	8192	129969	**1273695**	6095	2338	**1282128**
Solid mineral fuels	116483	120824	12833	150306	26103	5424	118778	**400445**	1290	18	**401754**
Crude oil	5830	105294	62349	459142	239	53847	405056	**632615**	30771	569	**663956**
Ores metal waste	113916	68050	34616	199516	3028	5397	191091	**416099**	3629	296	**420024**
Metal products	191467	203011	82782	76781	10604	14224	51954	**554041**	5486	1784	**561311**
Building minerals & material	2575559	1036039	162856	122615	25256	8850	88509	**3897069**	14684	294	**3912046**
Fertilisers	65237	51133	21147	36445	4449	7639	24357	**173963**	606	67	**174635**
Chemicals	124275	200851	123397	104230	9796	7844	86589	**552753**	10632	2152	**565537**
Machiner & other manufact.	1072026	869439	144051	171244	16329	9004	145911	**2256761**	13414	2799	**2272974**
Petroleum products	280475	210553	168949	286521	6996	59693	219833	**946498**	8313	702	**955513**
Total	**5495185**	**3728284**	**999709**	**1861544**	**125496**	**201682**	**1534366**	**12084722**	**101966**	**12543**	**12199231**

Table 5.10: Index total trade flows, all countries, all modes, per commodity, 2010 (index 1995 = 100); Reference scenario

ALL MODES	EU Trade with community countries			EU Trade with non-community countries					Non-EU trade		Total
	EU domestic intra-regional	EU domestic inter-re ional	International trade within EU	Total	Eastern Europe		Rest world	**EU trade total**	Norway & Switzerland	Transit	**Total**
					Appl.	Non-appl.					
Agricultural products	110,2	132,2	129,8	162,7	278,7	128,0	154,5	**125,4**	129,1	227,1	**125,5**
Foodstuffs	109,0	129,6	138,0	178,3	494,7	140,4	163,5	**126,3**	147,0	179,1	**126,4**
Solid mineral fuels	102,2	103,2	101,9	104,5	107,6	100,3	104,1	**103,4**	107,8	113,3	**103,4**
Crude oil	100,0	100,0	100,0	100,0	100,0	100,0	100,0	**100,0**	100,0	100,0	**100,0**
Ores metal waste	112,2	115,9	110,4	114,5	153,9	170,7	112,4	**113,7**	118,1	237,5	**113,8**
Metal roducts	128,4	153,4	145,0	207,9	393,2	218,5	174,0	**150,3**	142,3	271,2	**150,6**
Buildin minerals & material	122,3	154,2	136,7	148,9	169,0	134,6	145,0	**131,7**	118,9	211,8	**131,7**
Fertilisers	105,0	125,4	106,1	152,6	521,5	146,5	110,7	**120,6**	123,9	120,9	**120,7**
Chemicals	134,6	176,9	158,0	176,9	208,8	206,5	170,5	**162,5**	173,1	226,0	**163,0**
Machiner & other manufact.	125,9	157,0	174,5	191,0	144,1	188,1	197,0	**144,9**	155,0	202,5	**145,1**
Petroleum products	135,1	163,2	131,7	1514	160,1	215,6	133	**145,4**	150,7	175,3	**145,5**
Total	**120,9**	**146,0**	**138,8**	**138,6**	**207,3**	**160,2**	**130,6**	**132,6**	**128,4**	**207,7**	**132,6**

Source: NEAC

Annex V: Detailed UIRR statistics analysis per segments

TRAFIC	Relations		Envois	Envois-km	Dist. moy.	Poids moy.	Poids brut	tkm	Techniques, quote-part des envois			
EST UIRR									SR	C/CT 7	C/CT 9-13	RR
2000	A	CRO	6	2 948	491	27	151	81	0%	100%	0%	0,0%
	CRO	A	28	12 684	453	3	84	38		100%		
	A	CZ	22	14 376	653	3	63	42	0%	95%	5%	0,0%
	CZ	A	53	29 150	550	13	684	376		89%	11%	
	A	H	48 569	21 257 658	438	29	1 410 026	616 472	0%	2%		98%
	H	A	49 572	19 088 720	385	28	1 403 884	540 594	0%	1%	2%	97%
	A	PL	1	189	189	8	4	1	0%	100%	0%	0,0%
	PL	A	7	4 900	700	12	84	59	0%	100%	0%	0,0%
	A	SK	6	1 336	223	5	26	6	0%	100%	0%	0,0%
	A	SLO	10 469	3 178 066	304	31	319 449	96 931	0%	7%	3%	90%
	SLO	A	11 351	3 632 320	320	25	283 775	90 808		20%		80%
	A	TR	2 586	4 652 214	1 799	20	52 187	93 975	0%	100%	0%	0,0%
	B	CZ	33	51 103	1 572	22	716	1 125	0%	35%	65%	
	CZ	B	24	30 792	1 283	12	281	360		98%	2%	
	B	H	155	230 840	1 494	26	4 060	6 065	0%	4%	96%	
	H	B	65	107 250	1 650	25	1 625	2 681	0%	40%	60%	0,0%
	B	SLO	635	790 575	1 246	29	18 614	23 193	0%	0%	100%	
	SLO	B	626	751 200	1 200	5	3 130	3 756		100%		0,0%
	BiH	SLO	315	220 500	700	2	630	441		100%		
	SLO	BiH	314	219 800	700	19	5 966	4 176		100%		0,0%
	CRO	H	337	197 819	587	3	1 011	593		100%		
	SLO	H	4 893	3 669 750	750	24	117 432	88 074		27%		73%
	H	SLO/CRO	4 896	3 777 580	772	27	130 928	101 019	0%	28%	0%	72%
	CRO	SLO	1 624	568 400	350	11	17 864	6 252		100%		
	SLO	CRO	748	261 800	350	15	11 220	3 927		100%		0,0%
	CZ	NL	182	185 640	1 020	19	3 513	3 583		100%		

CZ / SK	D	50 709	6 744 297	133	32	1 622 688	215 818		1%	1%	98%
D	CZ	55 512	8 023 109	145	32	1 771 114	255 980	0%	2%	1%	97%
D	SK	93	126	1 363	19	2	2	0%	59%	41%	
CZ / SK	H	5	2 795	559	31	155	87		100%		
H	CZ	64	40 320	630	4	256	161	0%	50%	50%	0,0%
H	SK	27	4 968	184	4	108	20	0%	50%	50%	0,0%
CZ	PL	7 596	2 977 632	392	13	97 229	38 114		99%	1%	
PL	CZ	8 683	4 775 650	550	18	156 294	85 962	0%	96%	4%	0,0%
CZ	RO	111	111 666	1 006	19	2 153	2 166		100%		
CZ / SK	SLO	60	47 400	790	23	1 368	1 081		83%	17%	
SLO	CZ	23	18 400	800	5	115	92		100%		0,0%
SLO	SK	67	46 900	700	11	737	516		100%		0,0%
D	H	10 352	12 919 234	1 248	16	169 534	211 588	0%	38%	62%	
H	D	6 573	8 084 790	1 230	19	124 925	153 658	0%	50%	50%	0,0%
D	CRO	51	61 765	1 223	26	1 304	1 595	0%	64%	36%	
D	PL	2 459	2 440 409	992	24	59 102	58 655	9%	70%	21%	
PL	D	2 541	2 548 623	1 003	13	33 033	33 132	10%	66%	24%	0,0%
D	SLO	769	757 507	985	25	19 040	18 756	0%	100%	0%	
SLO	D	1 271	1 271 000	1 000	12	15 252	15 252		100%		0%
H	NL	44	61 600	1 400	25	1 100	1 540	0%	50%	50%	0,0%
NL	H	60	93 000	1 550	26	1 535	2 379	0%	47%	53%	
H	PL	7	4 746	678	4	28	19	0%	50%	50%	0,0%
PL	H	861	439 110	510	26	22 386	11 417	90%	0%	10%	
H	RO	95	87 875	925	17	1 615	1 494	0%	50%	50%	0,0%
RO	H	76	75 544	994	9	646	642		70%	30%	
I	RO	149	46 176	310	30	4 470	1 385	0%	3%	97%	
RO	I	128	231 424	1 808	31	3 904	7 058		80%	20%	
I	SLO	16	5 225	327	6	101	33	0%	13%	88%	
SLO	I	194	67 900	350	4	776	272		48%	52%	0,0%
NL	PL	115	138 690	1 206	28	3 231	3 897	0%	20%	80%	
PL	NL	205	246 000	1 200	18	3 690	4 428	1%	5%	94%	0,0%

	RO	SLO	111	104 229	939	19	2 109	1 980		100%		
	S	H	19	41 230	2 170	28	532	1 154		100%		
	S	N	260	139 880	538	26	6 760	3 637	86%	11%	3%	
	SLO	PL	3	3 600	1 200	10	30	36		100%		0,0%
	SLO	YU	9	5 400	600	16	144	86		100%		0,0%
	YU	SLO	6	3 600	600	4	24	14		100%		0,0%
TOTAL			286 838	115 609 428			7 914 896	2 818 737				
%TOTAL UIRR			**22**									**18%**

TRAFIC	Relations		Envois	Envois-km	Dist. moy.	Poids moy.	Poids brut	tkm	Techniques, quote-part des envois			
ALPIN UIRR									SR	C/CT 7	C/CT 9-13	RR
2000	A	CH	726	381 304	525	14	9 767	5 148	0%	100%	0%	0,0%
	CH	A	275	174 506	635	20	5 519	3 502	0%	100%	0%	0,0%
	A	D	82 613	37 185 004	450	30	2 491 753	1 122 987	1%	21%	6%	72%
	D	A	88 716	45 634 379	514	30	2 681 359	1 379 265	1%	17%	16%	66%
	A	F	17	27 319	1 607	11	180	298	0%	39%	61%	0,0%
	F	A	12	19 267	1 606	29	344	552	0%	8%	92%	0,0%
	CH	F	1 074	871 014	811	26	28 088	22 779	0%	83%	17%	0,0%
	F	CH	1 272	1 040 087	818	23	29 729	24 319	0%	55%	45%	0,0%
	CH	D	27 897	18 181 248	652	17	472 613	308 020	16%	63%	13%	8%
	D	CH	32 739	21 849 009	667	26	838 389	559 524	13%	67%	9%	11%
	CH	NL	352	262 240	745	14	4 887	3 641	0%	23%	77%	0,0%
	NL	CH	281	210 375	750	21	5 755	4 316	0%	17%	83%	
	A	I	774	467 732	604	20	15 272	9 214	0%	35%	65%	0,0%
	I	A	1 123	630 565	562	19	21 694	12 187	0%	27%	73%	
	CH	I	17 386	5 686 441	327	27	471 704	154 280	2%	85%	13%	0,0%
	I	CH	16 024	5 839 947	364	21	328 489	119 722	2%	75%	23%	
	CZ / SK	I	277	228 802	826	16	4 515	3 729		50%	50%	
	I	CZ	74	31 976	435	9	692	301	0%	17%	83%	
	I	SK	60	14 029	236	24	1 402	331	0%	4%	96%	
	D	I	181 090	145 314 860	802	28	5 101 852	4 093 969	23%	46%	22%	10%
	I	D	184 836	137 426 290	744	23	4 190 710	3 115 818	25%	35%	30%	10%
	DK	I	3 325	5 070 497	1 525	30	101 103	154 178		100%		
	I	DK	3 744	5 595 662	1 495	23	86 185	128 809		85%	15%	
	E	I	1	647	1 293	8	4	5		100%		

	F	I	21 712	20 506 328	944	27	581 868	549 569	19%	3%	78%	0,0%
	I	F	27 540	24 484 595	889	24	659 902	586 701	15%	9%	76%	0,0%
	GB	I	17 030	27 038 456	1 588	24	408 505	648 576		20%	80%	
	I	GB	16 535	24 518 450	1 483	25	411 668	610 430		1%	99%	
	I	PL	882	1 071 113	1 215	23	20 261	24 620	0%	1%	99%	
	PL	I	1 107	1 240 947	1 121	26	28 782	32 265	0%	0%	100%	0,0%
	I	S	2 210	2 690 934	1 218	23	50 816	61 874	14%	78%	8%	0,0%
	S	I	6 120	9 527 537	1 557	28	173 726	270 455	10%	68%	22%	
TOTAL			737 817	543 221 557			19 227 533	14 011 384				
% TOTAL UIRR			**57**									**12,50%**

TRAFIC	Relations		Envois	Envois-km	Dist. moy.	Poids moy.	Poids brut	tkm	Techniques, quote-part des envois			
Espagne									SR	C/CT 7	C/CT 9-13	RR
UIRR	B	E	4 575	6 508 070	1 423	27	124 434	177 030	0%	2%	98%	
2000	E	B	3 401	6 752 043	1 986	16	54 895	109 000	0%	43%	57%	
	D	E	12 578	17 351 261	1 380	25	315 800	435 661	15%	59%	26%	
	E	D	9 741	13 372 908	1 373	16	152 562	209 444	19%	48%	33%	
	F	E	40	34 320	858	26	1 027	881	0%	2%	98%	0,0%
TOTAL			36 443	48 211 223			777 506	1 020 404				
%TOTAL UIRR			**3**									**0%**