Railway Handbook 2012

Energy Consumption and CO_2 Emissions

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea (Republic of)
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

International Energy Agency

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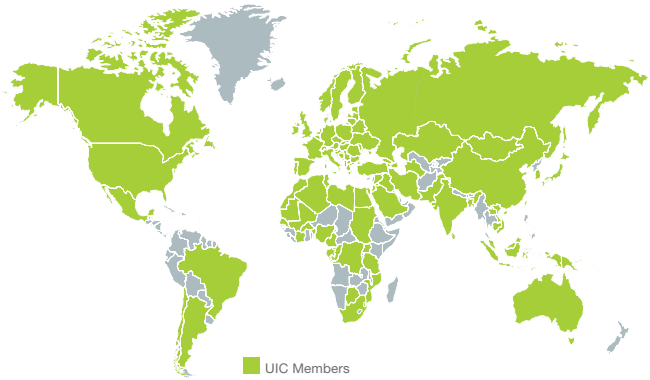
INTERNATIONAL UNION
OF RAILWAYS

UIC: the international professional association representing the railway sector

UIC, the international railway association which celebrates its 90th anniversary in 2012, counts 200 members across 5 continents (railway companies, infrastructure managers, rail-related transport operators, etc.). UIC's members represent 1 million kilometres of lines, 2,800 billion passenger-km, 9,500 billion tonne-km, and a workforce of 6.7 million people.

ACCORDING TO THE STATUTES, UIC 'S MISSION FOCUSES MAINLY ON:

- Promoting rail transport around the world with the aim to meet current and future challenges of mobility and sustainable development.
- Promoting interoperability, creating new world standards for railways, including common standards with other transport modes.
- Developing and facilitating all forms of international cooperation among members, facilitating the sharing of best practices (benchmarking).
- Supporting members in their efforts to develop new business and new areas of activity.
- Proposing new ways to improve technical and environmental performance of rail transport, boosting competitiveness and reducing costs.



WWW.UIC.ORG

Foreword

The International Energy Agency and the International Union of Railways are pleased to introduce the first data handbook on "Energy Consumption and CO_2 Emissions of world railway sector".

Tracking the progress of energy use and CO_2 emissions is at the core of both institutions and synergies have emerged in order to improve data quality and collection for the rail sector. The IEA and UIC now work together in consolidating the data gathered from their respective data requests.

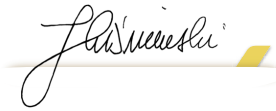
The idea of producing a joint publication between our two agencies did not come about just because of the proximity of our respective headquarters in Paris, but from the intention of supporting the overall framework constructed by the International Energy Agency on energy-related transport trends. This publication complements, the IEA data with official railway data, collected and quality-checked yearly by UIC since 2008.

Energy and CO_2 data provide the key to understanding environmental issues and decarbonising the transport sector. We need robust data as the foundation on which to build the greening of our future transport choices.

We sincerely hope that this will be only the first step of a longer co-operation on the path to sustainable mobility.

Bo Diczfalusy

Director of the Sustainable Energy Policy and Technology directorate of the International Energy Agency



Jerzy Wisniewski

Director of the Fundamental Values Department of the International Union of Railways

Acknowledgments

This publication has been made possible thanks to UIC railway members, who have constantly contributed to the UIC Railway Energy and CO_2 Database since 2005 with commitment and patience and to the IEA Statistics Department, who has collected and managed energy balances and CO_2 emissions data from fuel combustion.

A special mention goes to the cooperation of UIC and IEA staff, and in particular to: François Cuenot, Lew Fulton, Henning Schwarz, Alexander Veitch and Veronica Aneris.

A special thanks to the Sustainable Development Foundation for its technical support.

Railway Handbook 2012

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Introduction
IEA Transport statistics and UIC energy database

The transport sector is responsible for nearly 23% of energy-based CO_2 emissions worldwide, mainly due to road traffic. Transport CO_2 total emissions have constantly increased since 1990 and all transport modes – except railways – have increased their GHG emissions from fuel combustion (IEA, 2011a).

The International Energy Agency (IEA), established in November 1974, has over the years gained recognition as one of the world's most authoritative sources for energy statistics. Every year the Agency publishes global energy statistics and CO_2 emissions from fuel combustion, which include transport-related data.

The International Union of Railways (UIC) represents more than 200 railway companies and associations over the world. The railway companies operating worldwide produce less than 1% of total CO_2 emissions (IEA, 2011a and UIC, 2011b).

Due to their low-carbon performance, railways are an important means to reach sustainable mobility. Trains, especially in Europe, rely mostly on electricity, and the electricity markets are already subjected to mechanisms to lower the carbon content of electricity through the EU ETS (European Union Emission Trading Scheme). With electro-mobility being a key objective for many European countries, one of the most cost-effective actions should be to promote railway mobility.

In 2005, the UIC started to collect energy and CO_2 data from its members within a dedicated database (UIC, 2011b) which produces figures on:

- Railway activity (passenger-km and tonne-km of freight)
- Energy consumption (total, per pkm, tkm and service type)
- Electricity mix and atmospheric pollution conversion factors
- Use of diesel and biofuel
- CO_2 emission trends from 1990

In this book you will find the result of the harmonization of the UIC energy/CO_2 railway database with the IEA world energy balances (IEA, 2011a) and CO_2 from fuel combustion (IEA, 2011b) databases.

The publication is composed of a European part, followed by a selection from Non-European countries where partial data were available. The data quality and availability is not homogenously represented for all regions: the EU UIC members have set an accurate framework to collect energy use and CO_2 data from railway operators. The UIC and the IEA are calling for a harmonized and global approach to reach such a standard worldwide. This publication is aiming to be updated regularly. Hopefully, the next edition of the data handbook will embrace a wider set of countries representing more accurately the energy and CO_2 performance of the global railway sector.

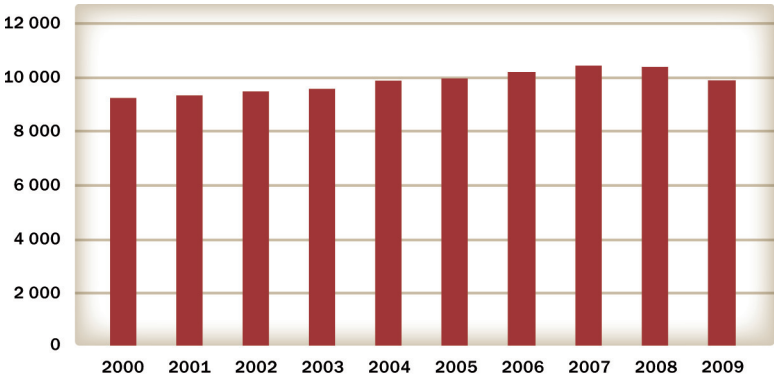
Part I: Europe (EU27)

Transport Trends and Modal Split

Key facts

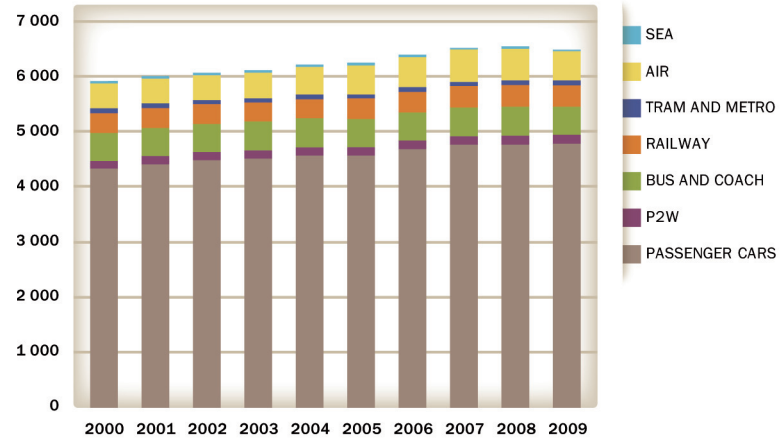
- Total transport demand in Europe has grown by 7% from 2000 to 2009.
- The financial and economic crisis has substantially decreased transport demand between 2008 and 2009, in particular for the freight sector (-12% from 2008 to 2009).
- In 10 years (2000-2009), no significant change in modal split for the passenger sector has been recorded. For the freight sector there have been small changes towards road freight.
- Railways modal share in 2009 was 6% for passenger and 7% for freight transport activities.

Fig.1: **Passenger and freight transport activity, 2000-2009 (billion transport units)**



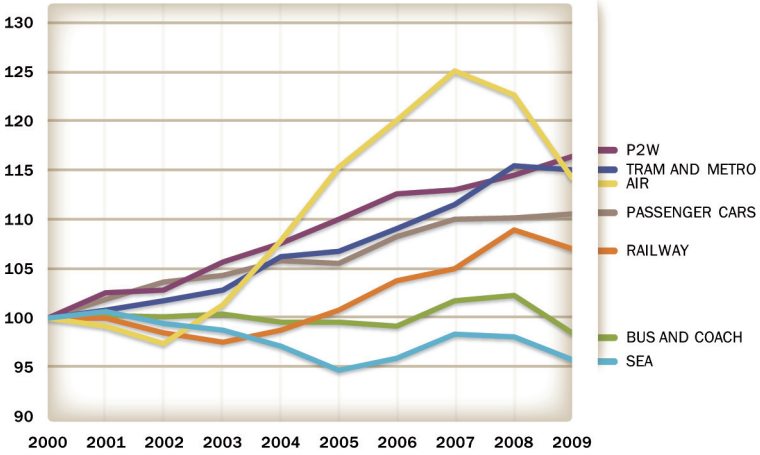
Source: Elaboration based on EC (2011) and UIC (2011a)

Fig.2: **Passenger transport activity by mode, 2000-2009 (billion pkm)**



Source: EC (2011) and UIC (2011a)

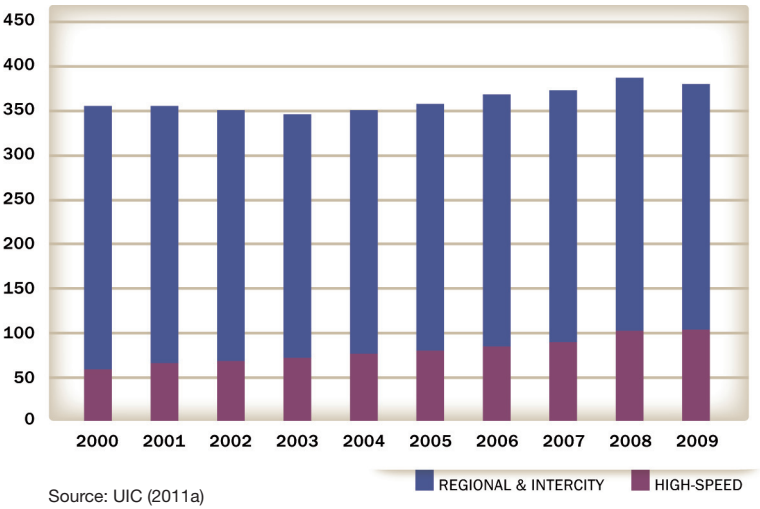
Fig.3: **Modal evolution of passenger traffic activity, 2000-2009 (pkm)**



Year 2000=100

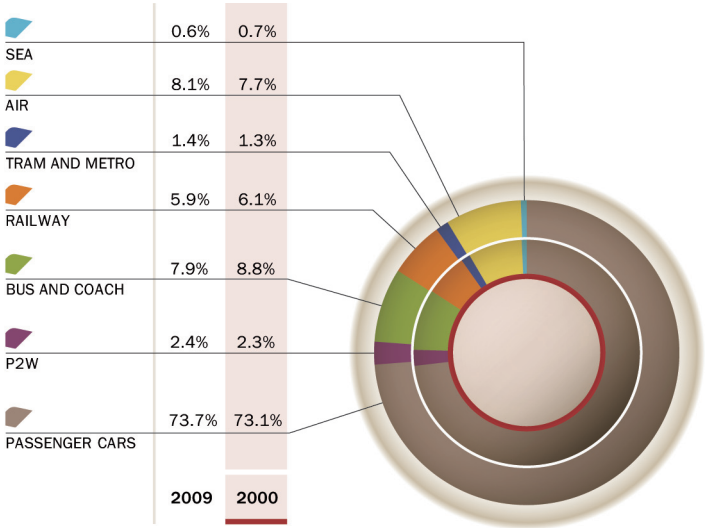
Source: EC (2011) and UIC (2011a)

Fig.4: **Railway passenger activity by service type, 2000-2009 (billion pkm)**



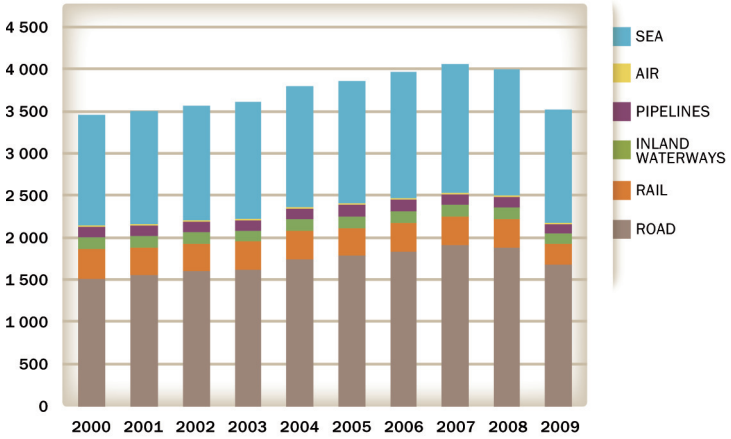
Source: UIC (2011a)

Fig.5: **Passenger motorised transport modal split, 2000 inside - 2009 outside (% pkm)**



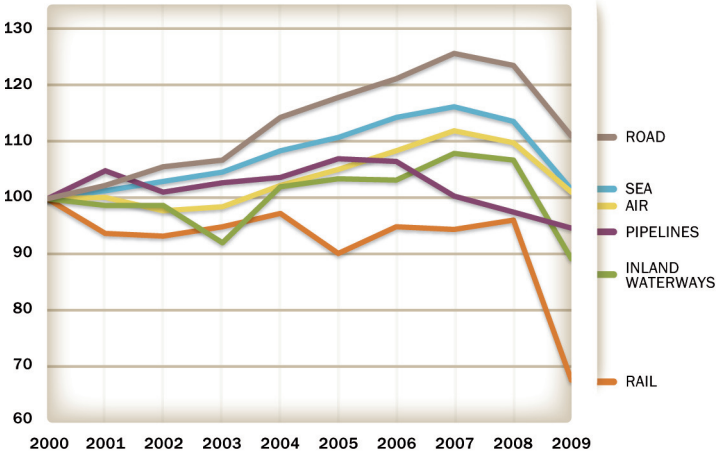
Source: EC (2011) and UIC (2011a)

Fig.6: **Freight transport activity by mode, 2000-2009 (billion tkm)**



Source: EC (2011) and UIC (2011a)

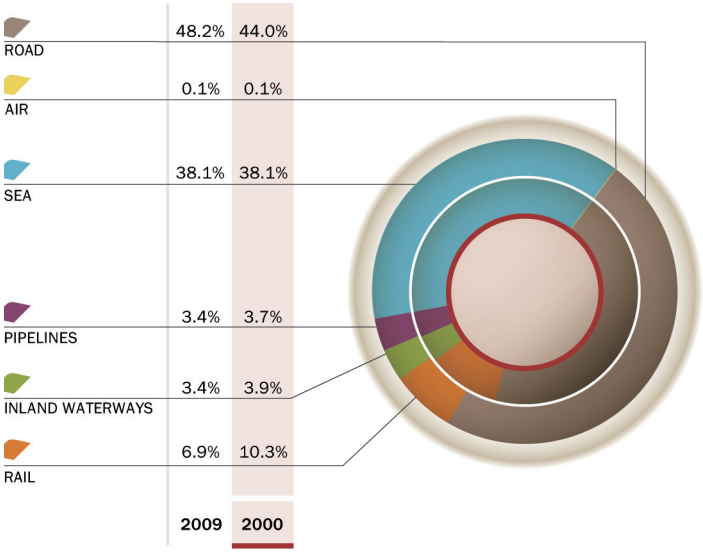
Fig.7: **Modal evolution of freight traffic activity, 2000-2009 (tkm)**



Year 2000 = 100

Source: EC (2011) and UIC (2011a)

Fig.8: **Freight transport modal split, 2000 inside - 2009 outside (% tkm)**



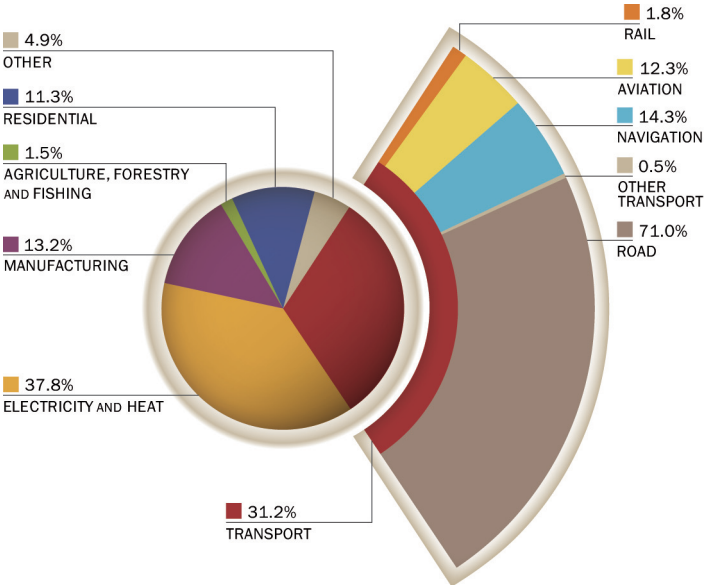
Source: EC (2011) and UIC (2011a)

Energy Consumption and CO_2 Emissions of Transport Sector

Key facts

- In 2009, road was responsible for 71% of total CO_2 emission from transport sector. Navigation was responsible for 14.3% and aviation for 12.3%. Railways produced 1.8% of total CO_2 emission from transport sector, corresponding to 0.6% of total CO_2 emission in EU27.
- The transport sector in 2009 was responsible for about 31% of total CO_2 emission from fuel combustion in Europe.
- Transport CO_2 total emissions grew by nearly 28% from 1990 to 2009 and by 5% from 2000 to 2009: all transport modes - except railways - have increased their total emissions.

Fig.9: **CO_2 Emissions from fuel combustion by sector, 2009**



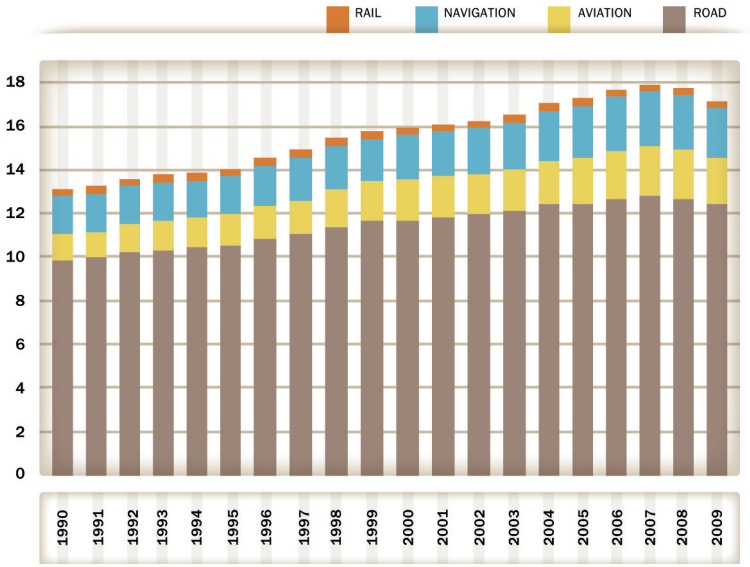
Note: Emissions from rail electric traction are included into the transport sector, see Methodology Notes, p. 107.

Table 1: **Transport modal share, 2009 (transport units)**

ROAD	71.4%
NAVIGATION	15.0%
RAIL	7.1%
AVIATION	5.2%
OTHER	1.2%

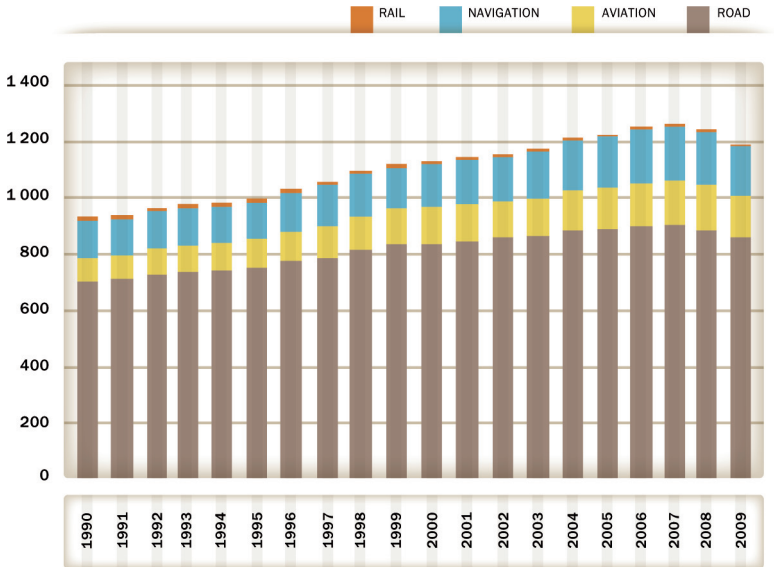
Source: IEA (2011a) and UIC (2011b)

Fig.10: **Transport sector energy consumption by mode, 1990-2009 (EJ)**



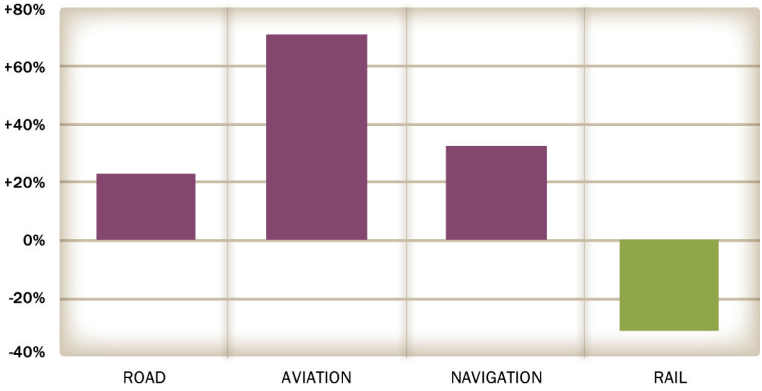
Source: IEA (2011b)

Fig.11: **Transport sector CO_2 emissions by mode, 1990-2009 (million tCO_2)**



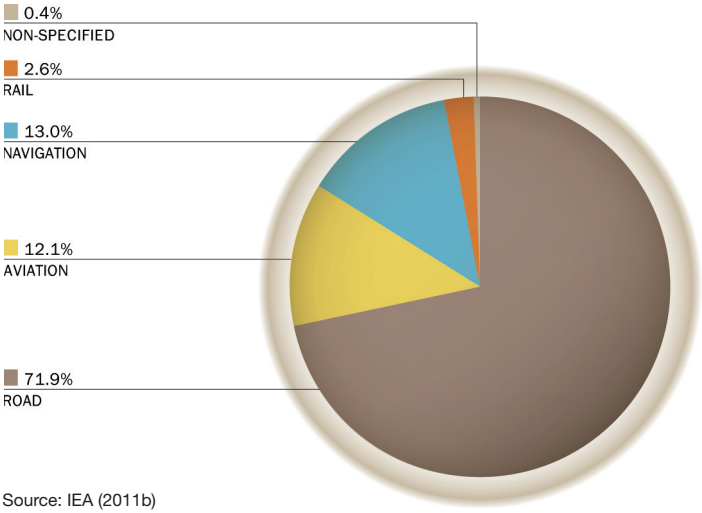
Source: IEA (2011a)

Fig.12: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



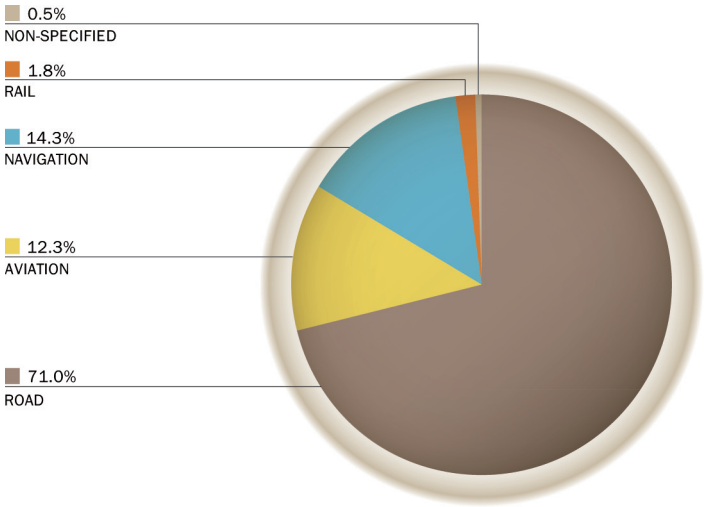
Source: elaboration based on IEA (2011a)

Fig.13: **Transport sector energy consumption by mode, 2009**



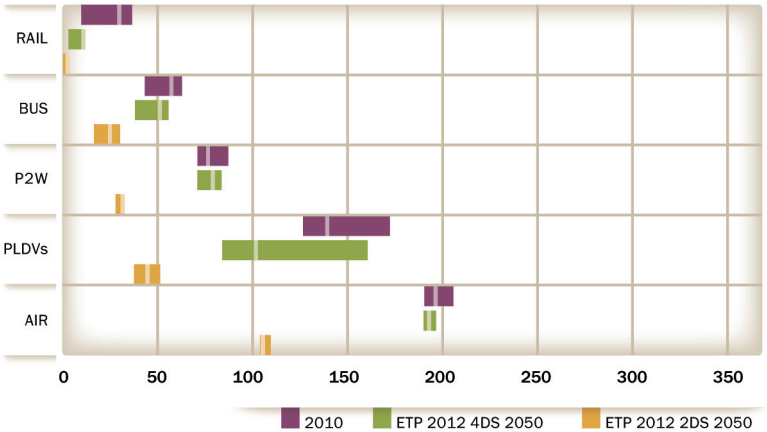
Source: IEA (2011b)

Fig.14: **Transport sector CO_2 emissions by mode, 2009**



Source: IEA (2011a) and UIC (2011b)
Note: See Methodology notes p.107

Fig.15: **EU27 evolution of the GHG intensity of motorised passenger transport modes, 2010-2050 (WTW gCO_2/pkm)**



Source: IEA (2012)

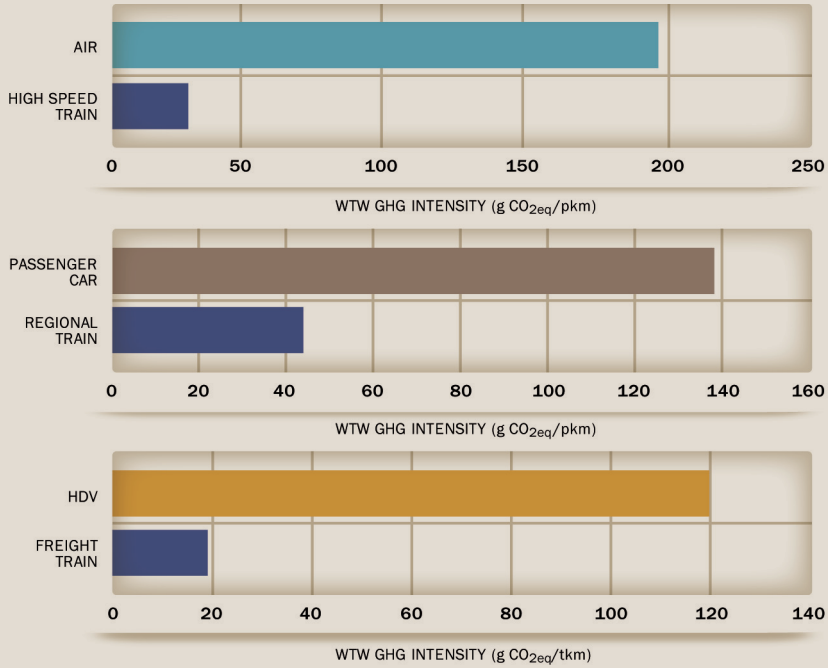
CROSS INDICATORS: plane vs highspeed, car vs regional, freight train vs HDVs

For certain trip purposes, some modes are in competition with respect to travel comfort, speed and cost. The traveler or the freight operator can then choose which mode suits better their needs. Taking greenhouse gases into account is important, and interactive tools such as EcoPassenger and EcoTransit (www.ecopassenger.org and www.ecotransit.org) are offering a platform to compare each mode's emissions.

On average, when taking the Well to Wheel (WTW) emissions from the energy needed to propel the vehicle, rail appears to be the most efficient. Below a few key comparisons are shown using today's average Greenhouse Gas (GHG) emissions from WTW.

Vehicle and infrastructure manufacture and operation and maintenance carbon emissions would ideally also have to be taken into account in order to fully be able to compare modes among each other. Baron (2011) showed that including infrastructure embedded carbon into the HSR carbon intensity would add an extra 5 gCO_2/pkm, not drastically changing the picture shown below.

Fig.16: **GHG benefits of railway versus other mode, EU average**



Source: IEA (2012), UIC (2011a)

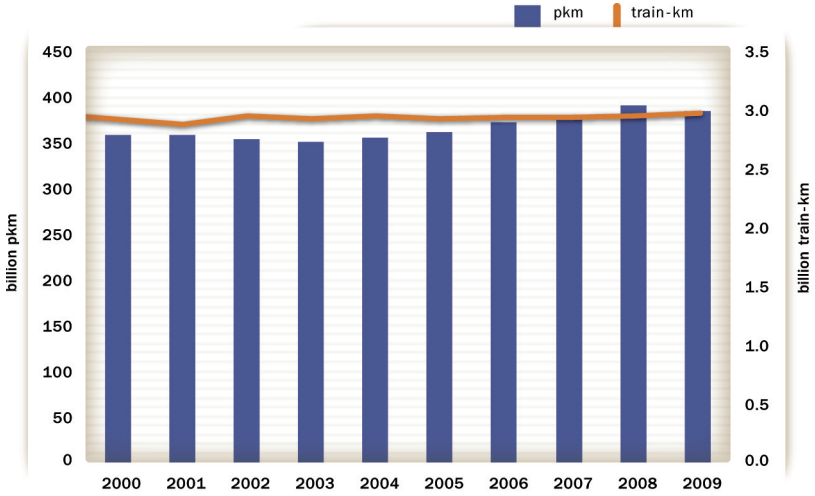
The Railway Sector

Key facts

- The total length of railway lines in Europe has remained stable since 1990 (around 210 000 km).
- In 1990, only 30% of railway lines were electrified. In 2009, this percentage reached 53%. Around 80% of rail traffic is performed nowadays with electrified trains.
- Railways have improved their energy efficiency from 1990 to 2009: 13% less energy is needed now to move a passenger km and 19% less energy to move a tonne km.
- Electricity used by railways in Europe is produced with an average of 30% from renewable sources. This percentage has highly increased in the last 4 years.
- High-speed and intercity trains - as expected - consume more energy per train km, but due to the higher load factor they consume less energy per passenger km.
- European railways have committed to reduce in 2020 their specific emissions by 30%, calculated from 1990.
- From 1990 to 2009 European railways have reduced total CO_2 emissions by 32%, passenger specific emissions (per passenger km) by 20% and freight specific emissions (per tonne km) by 38%. Freight sector has already reached its 2020 target for specific emissions.

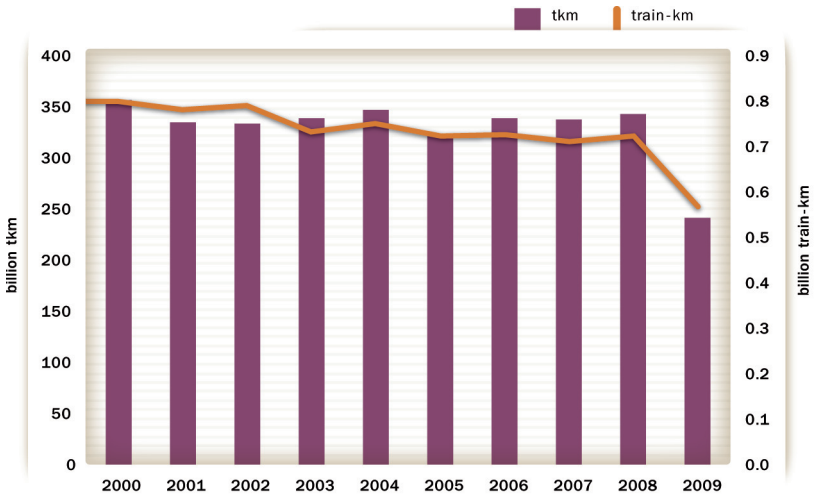
Total activity passenger and freight

Fig.17: **Railway passenger transport activity, 2000-2009 (pkm and train-km)**



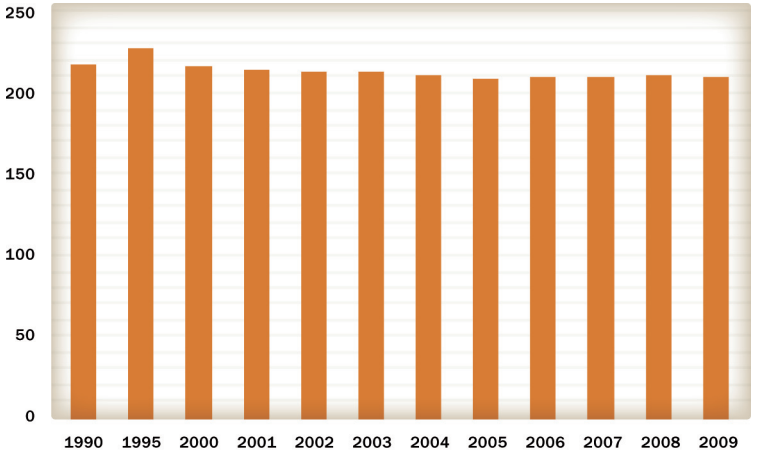
Source: UIC (2011a)

Fig.18: **Railway freight transport activity, 2000-2009 (tkm and train-km)**



Source: UIC (2011a)

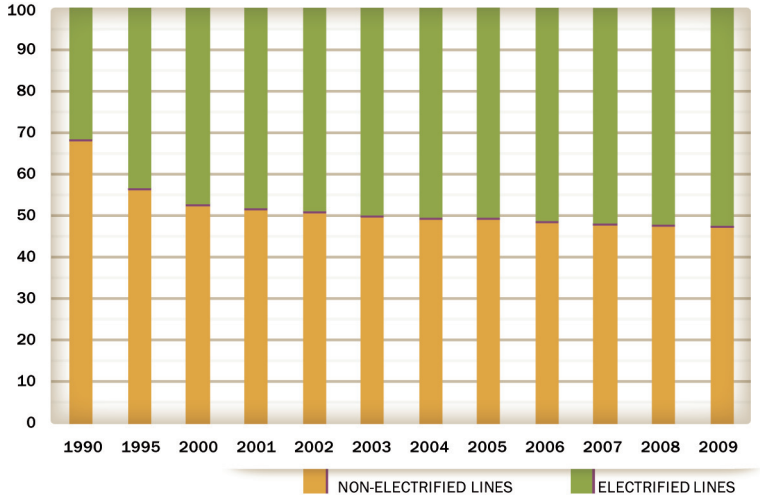
Fig.19: **Length of railway line in operation, 1990-2009 (thousand km)**



Source: UIC (2011a)

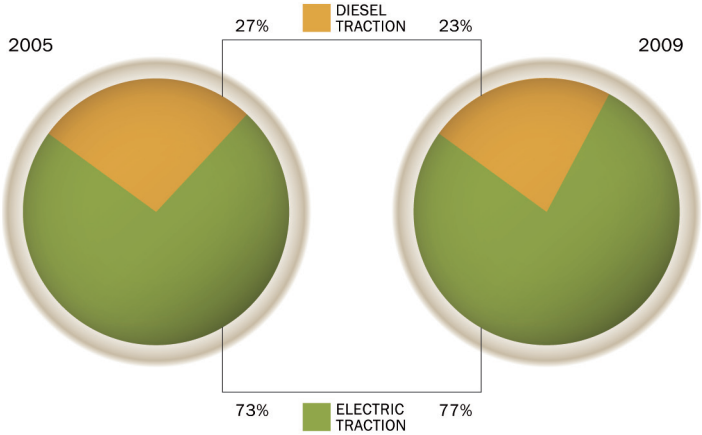
Electric and diesel

Fig.20: **Share of electrified versus non-electrified railway lines, 1990-2009 (% of track-km)**



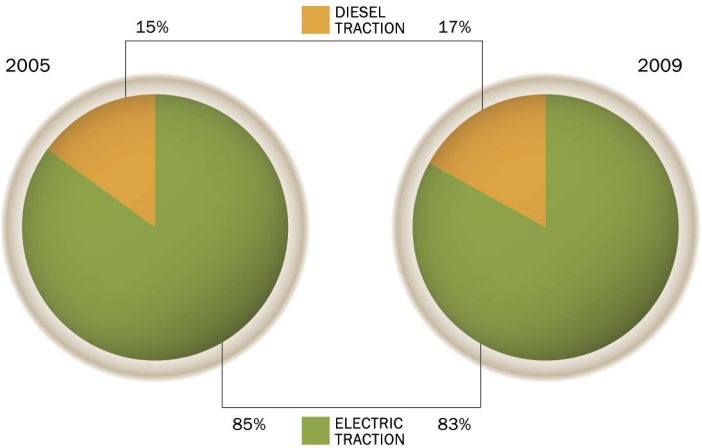
Source: elaboration based on UIC (2011a)

Fig.21: **Passenger activity split by traction type, 2005 and 2009 (train-km)**



Source: elaboration based on UIC (2011b)

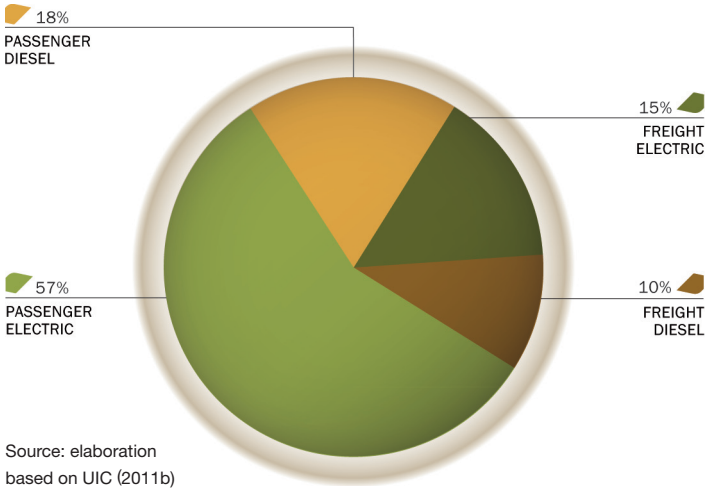
Fig.22: **Freight activity split by traction type, 2005 and 2009 (train-km)**



Source: elaboration based on UIC (2011b)

Energy consumption

Fig.23: **Railway energy consumption, by traction and train type, 2009**



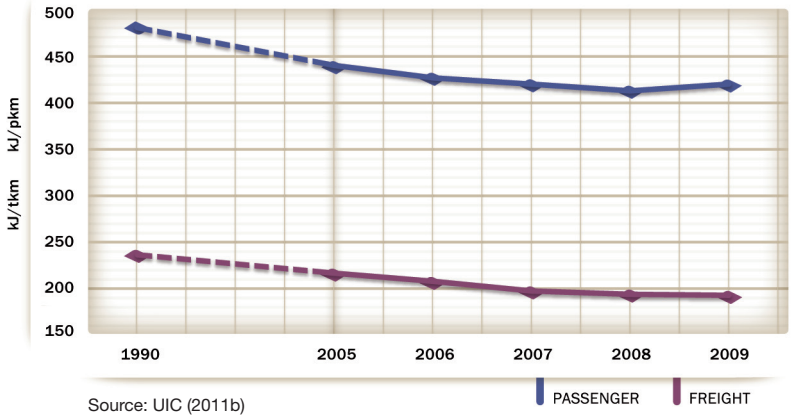
Source: elaboration based on UIC (2011b)

Table 2: **Railway energy consumption by train type and traction type, 2005-2009 (PJ)**

	2005	2006	2007	2008	2009
PASSENGER					
ELECTRIC TRACTION	119.80	125.42	126.62	121.96	127.89
DIESEL TRACTION	49.87	42.88	41.91	41.06	40.81
TOTAL PASSENGER	169.66	168.30	168.53	163.02	168.70
ELECTRIC TRACTION	45.85	47.11	44.40	42.93	33.09
DIESEL TRACTION	26.78	26.01	22.61	30.61	22.80
TOTAL FREIGHT	72.63	73.12	67.01	73.55	55.89
FREIGHT					
TOTAL	242.29	241.42	235.54	236.57	224.60

Source: elaboration based on UIC (2011b)

Fig.24: **Specific energy consumption by train type, 1990-2009 (kJ/pkm, kJ/tkm)**



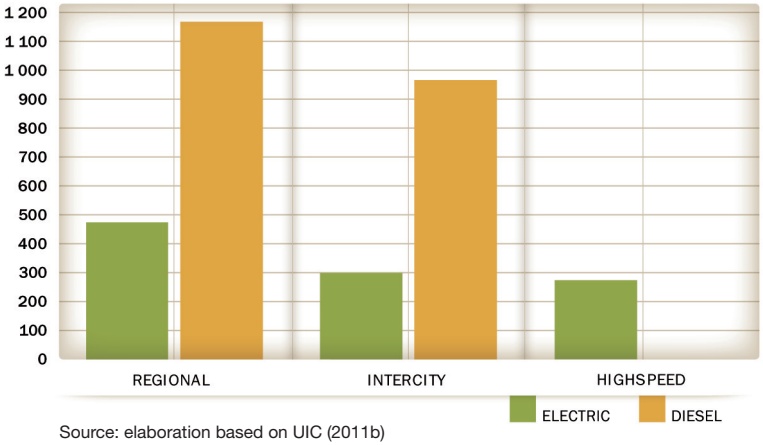
Source: UIC (2011b)

Table 3: **Specific energy consumption by train type, 1990-2009 (kJ/pkm, kJ/tkm)**

Source: UIC (2011b)

	1990	2005	2006	2007	2008	2009	Δ 1990 2009
PASSENGER (KJ/PKM)	478.8	437.8	425.6	418.7	411.0	418.7	-13%
FREIGHT (KJ/TKM)	234.0	214.8	205.3	195.4	192.1	190.5	-19%

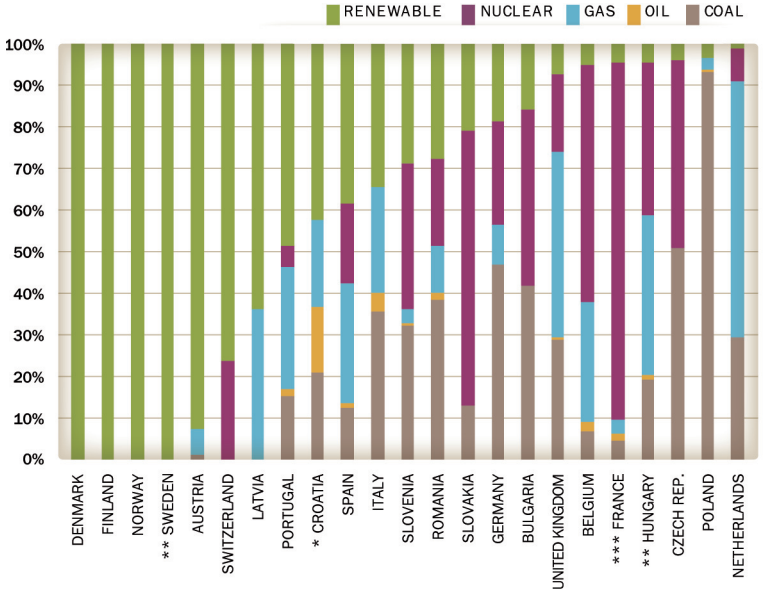
Fig.25: **Passenger specific consumption by service type and traction type, 2005 (kJ/pkm)**



Source: elaboration based on UIC (2011b)

Electricity mix

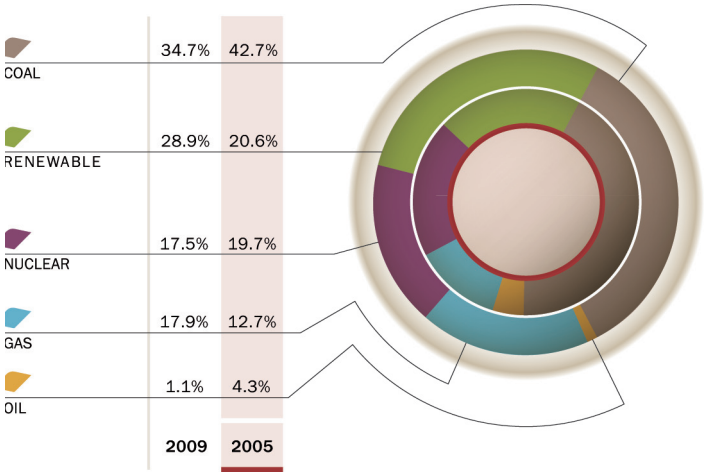
Fig.26: **Railways electricity mix by country, 2009**



Source: UIC (2011b)

* Value 2008 - ** Value 2007 - *** Value 2005

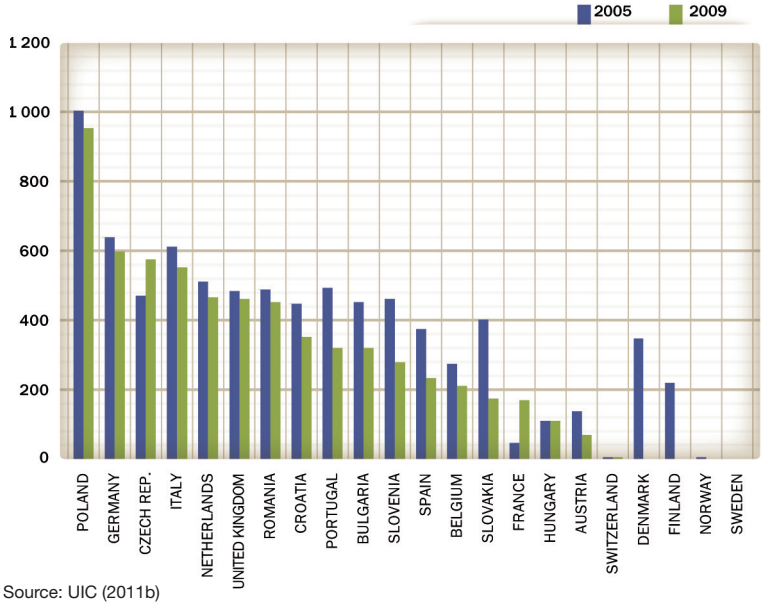
Fig.27: **Railways electricity mix, 2005 inside - 2009 outside**



Source: elaboration based on UIC (2011b)

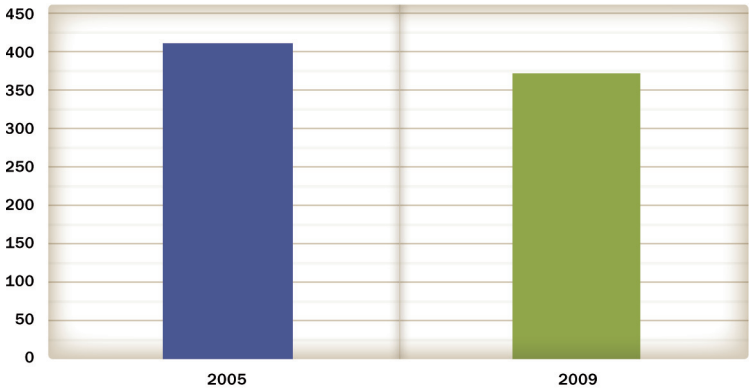
CO_2 emission factors

Fig.28: Carbon intensity of railway electricity by country, 2005 and 2009 (gCO_2/kWh)



Source: UIC (2011b)

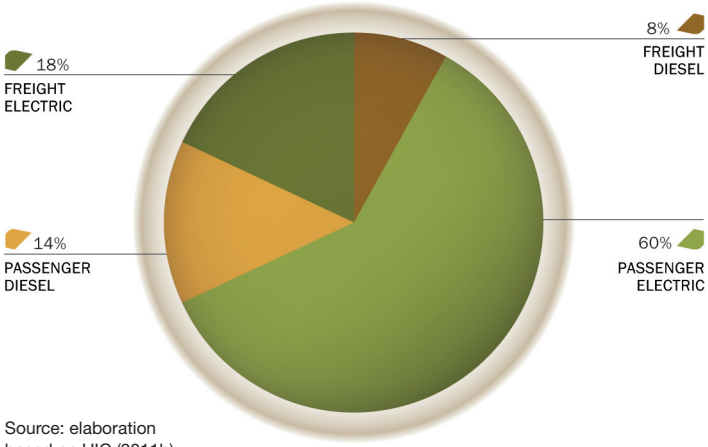
Fig.29: European average carbon intensity of railway electricity, 2005 and 2009 (gCO_2/kWh)



Source: elaboration based on UIC (2011b)

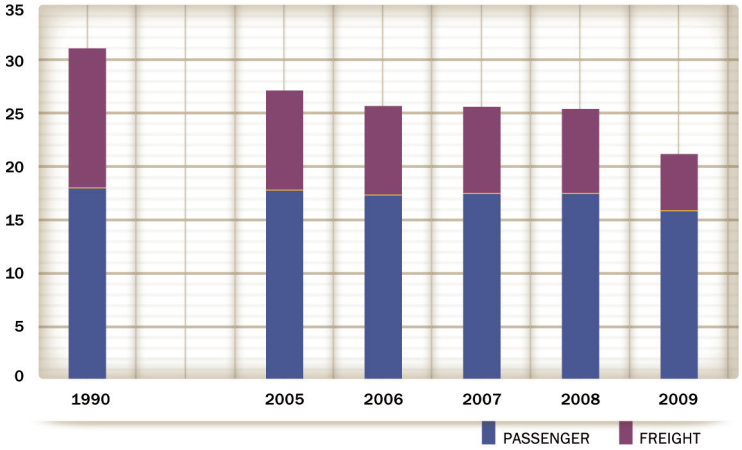
CO_2 emissions

Fig.30: Railway sector CO_2 emissions by train type and traction type, 2009



Source: elaboration based on UIC (2011b)

Fig.31: Railway sector CO_2 emissions by train type, 1990-2009 (million tonnes)



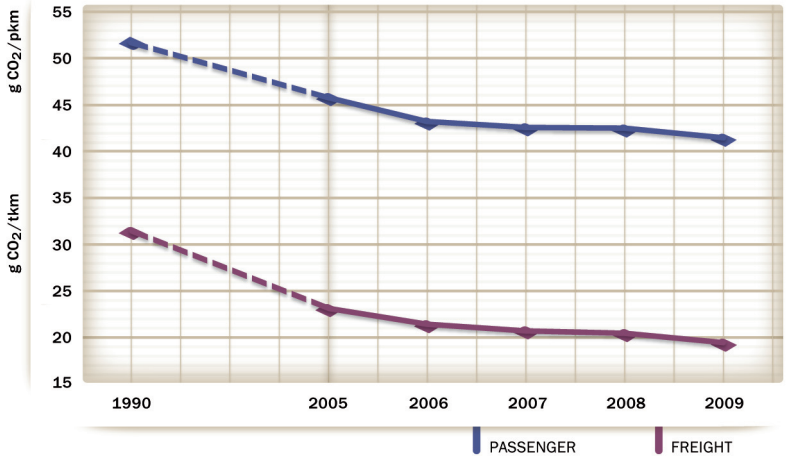
Source: elaboration based on UIC (2011b)

Table 4: **Railway CO_2 emissions by train type and traction type, 2005-2009 ($ktCO_2$)**

	2005	2006	2007	2008	2009
PASSENGER					
ELECTRIC TRACTION	13 395	12 897	13 111	13 264	12 949
DIESEL TRACTION	4 597	4 528	4 424	4 361	3 042
TOTAL PASSENGER	17 992	17 425	17 535	17 624	15 991
ELECTRIC TRACTION	7 012	6 289	6 265	5 632	3 889
DIESEL TRACTION	2 518	2 384	2 170	2 492	1 720
TOTAL FREIGHT	9 530	8 672	8 434	8 124	5 609
FREIGHT					
TOTAL	27 522	26 097	25 969	25 749	21 600

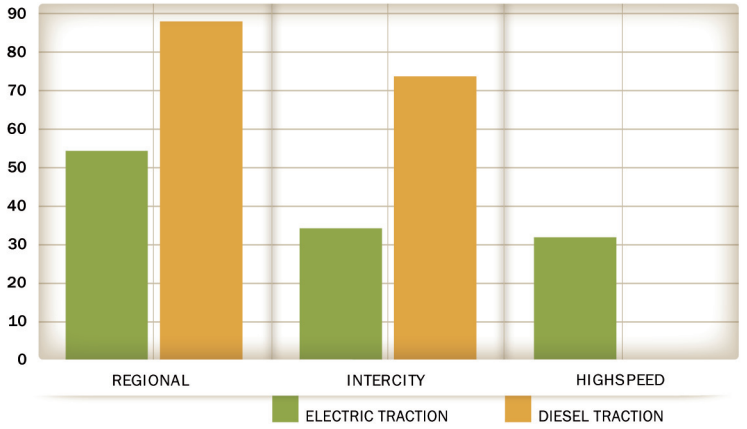
Source: elaboration based on UIC (2011b)

Fig.32: **Specific CO_2 emissions by train type, 1990-2009 (gCO_2/pkm, gCO_2/tkm)**



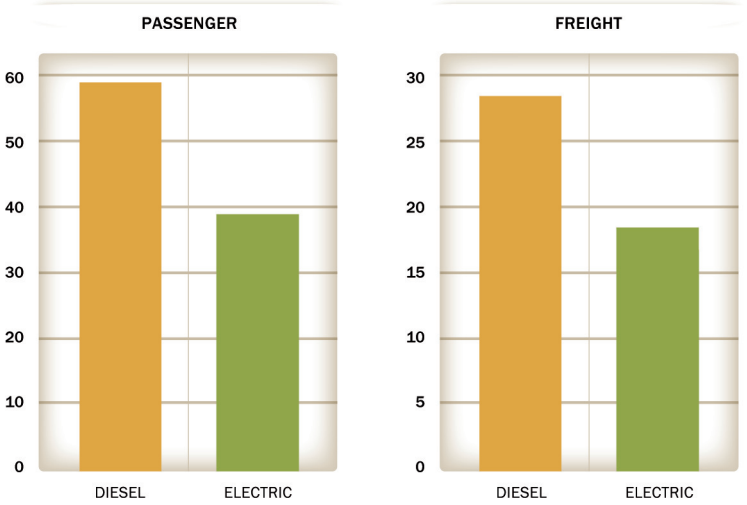
Source: UIC (2011b)

Fig.33: **Passenger specific CO_2 emissions by service type and traction type, 2005 (gCO_2/pkm)**



Source: elaboration based on UIC (2011b)

Fig.34: **Specific CO_2 emissions by train type and traction type, 2009 (gCO_2/pkm, gCO_2/tkm)**



Source: elaboration based on UIC (2011b)

Commitment of European railway sector

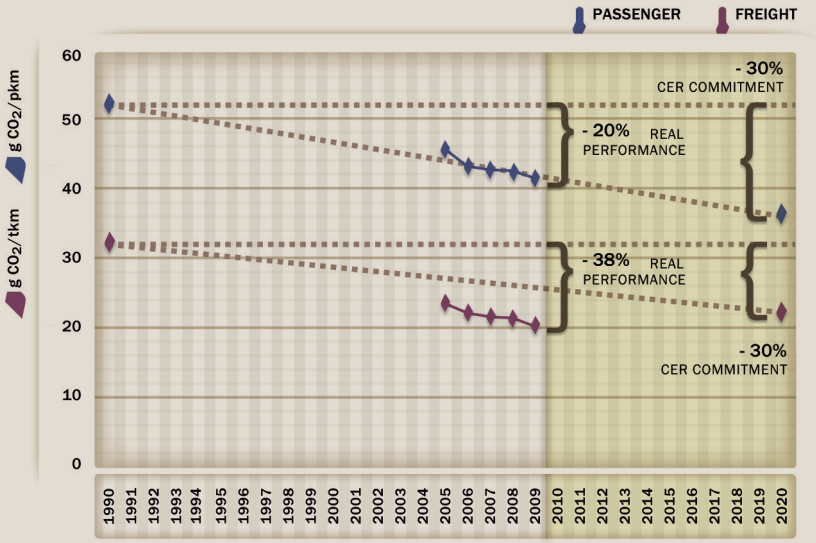
In 2008 the members of the Community of European Railways and European Infrastructure Managers (CER and EIM) set a CO_2 emission reduction target, as part of their commitment to ensure that the rail sector maintains its strong environmental performance.

The commitment entails a reduction of the levels of emissions per passenger km and per tonne km by 30% from 1990 to 2020.

The progress towards the target is monitored and reported yearly by UIC, based on data from the UIC "Energy and CO_2 Database". The database has collected energy and CO_2 emissions values from UIC members on a yearly basis since 2005 and is part of UIC Official Statistics.

According to the last monitoring report the sector is clearly on target to meet the 30% reduction both in freight and in the passenger sector. In particular, CO_2 emissions per passenger km have been reduced by 20% in 2009 from 1990 levels and CO_2 emissions per tonne km have been reduced by 38%, surpassing already the 2020 target.

Fig.35: **Specific CO_2 emissions, progress towards 2020 targets**



Source: UIC (2011c)

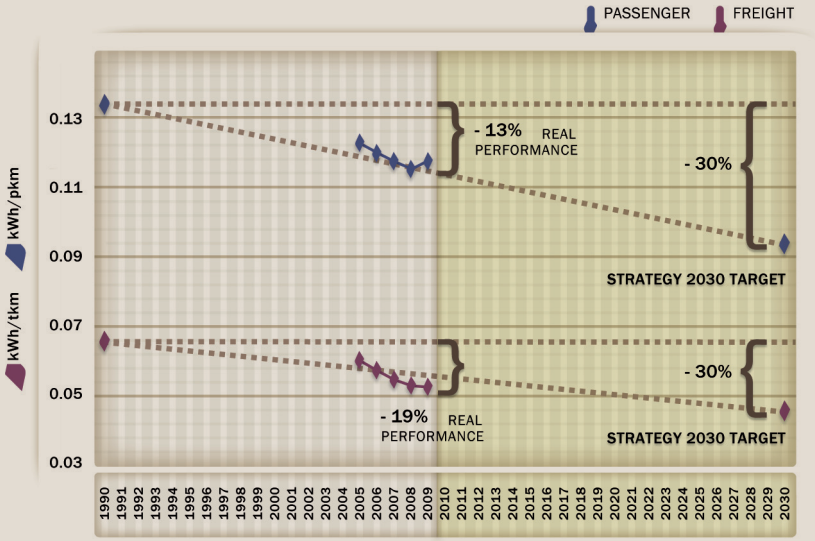
European railways' strategy towards 2030

In order to keep the railway sector at the forefront as the most environment friendly mass transport mode, UIC and CER have already agreed on a new target for 2030.
This time the commitment concerns not only CO_2 emissions but also energy efficiency levels.
In particular the commitment involves the following goals:

- Reduce specific final energy consumption from train operation by 30% with respect to 1990 levels (pkm and gross tkm);
- Reduce specific average CO_2 emissions from train operation by 50% with respect to 1990 levels (pkm and gross tkm);
- By 2030, not exceed the total CO_2 emission level from train operation in absolute terms even with projected traffic growth compared to base year 1990.

The feasibility of 2030 targets has been studied and documented by UIC in the technical report "Moving towards Sustainable Mobility: European Rail Sector Strategy 2030 and beyond". The targets have been approved in December 2010 by UIC and CER. Since 2011, the progress towards 2030 targets is monitored and reported yearly by UIC (technical document "Monitoring report to 2020-2030 UIC/CER strategy targets").

Fig.36: **Specific energy consumption, progress towards 2030 targets**



Source: UIC (2011d)

UIC's Vision 2050

In order for the railway sector to maintain its leading sustainability performance a Vision 2050 has also been set.

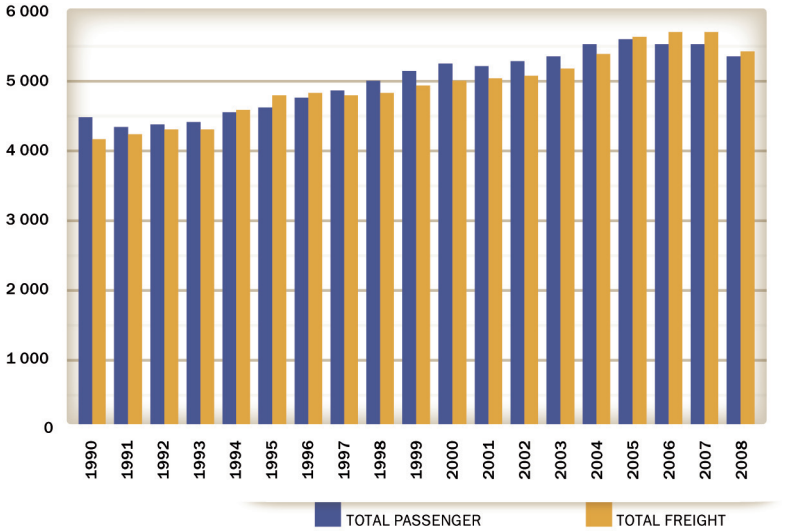
The goals are the following:

- The European railways will strive towards **carbon-free train operation** by 2050 and provide society with a climate neutral transport alternative.
- The European railways will strive towards **halving their specific final energy consumption** from train operation by 2050 compared to the base year 1990; measured per passenger-km (passenger service) and gross tonne-km (freight service).

Part II: Selection from Non-European Countries

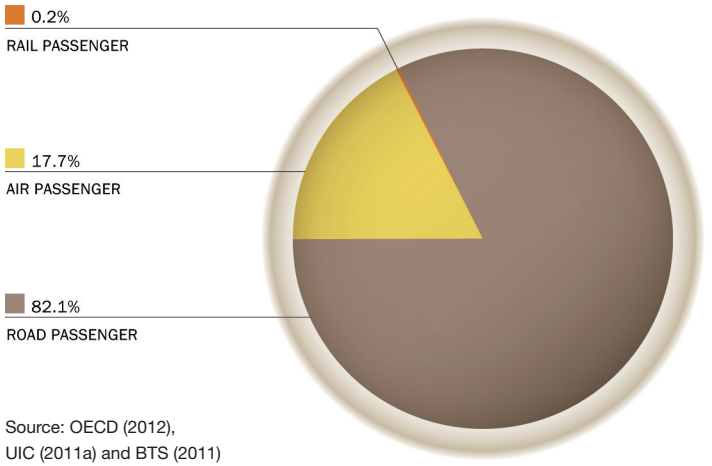
USA

Fig. 37: **Passenger and freight transport activity, 1990-2008 (billion pkm and tkm)**



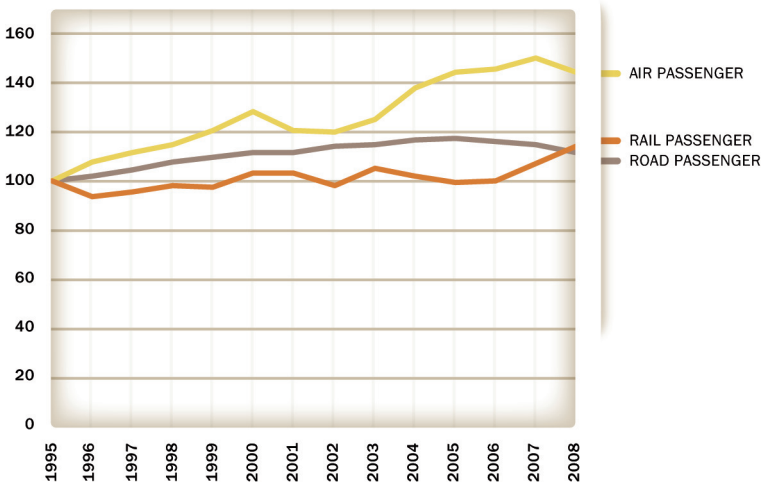
Source: OECD (2012), UIC (2011a) and BTS (2011)

Fig. 38: **Passenger transport modal split, 2008 (% pkm)**



Source: OECD (2012),
UIC (2011a) and BTS (2011)

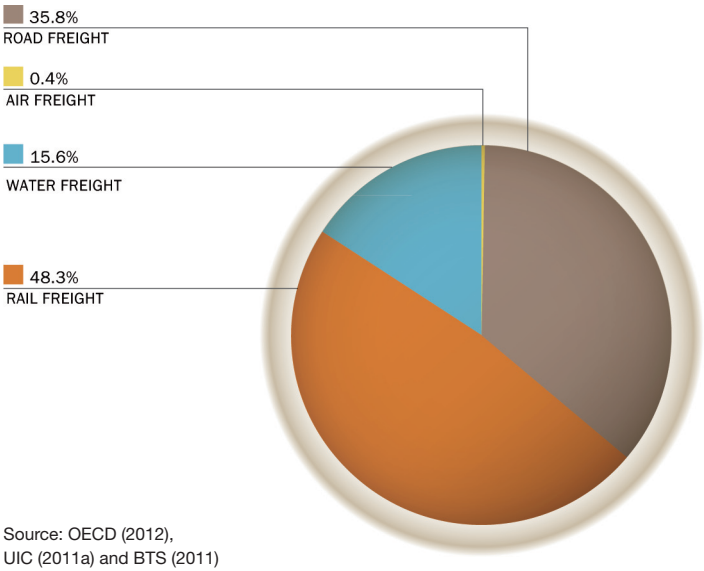
Fig. 39: **Passenger traffic activity by mode, 1995-2008 (pkm)**



Value 1995=100

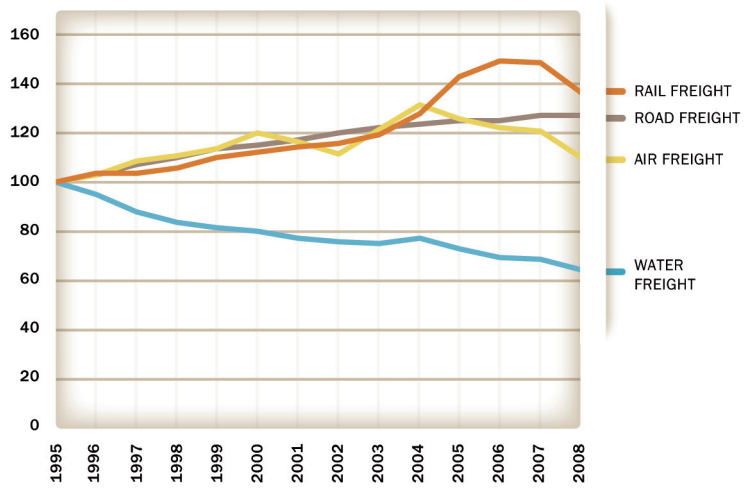
Source: OECD (2012), UIC (2011a) and BTS (2011)

Figure 40: **Freight transport in modal split, 2008 (tkm)**



Source: OECD (2012),
UIC (2011a) and BTS (2011)

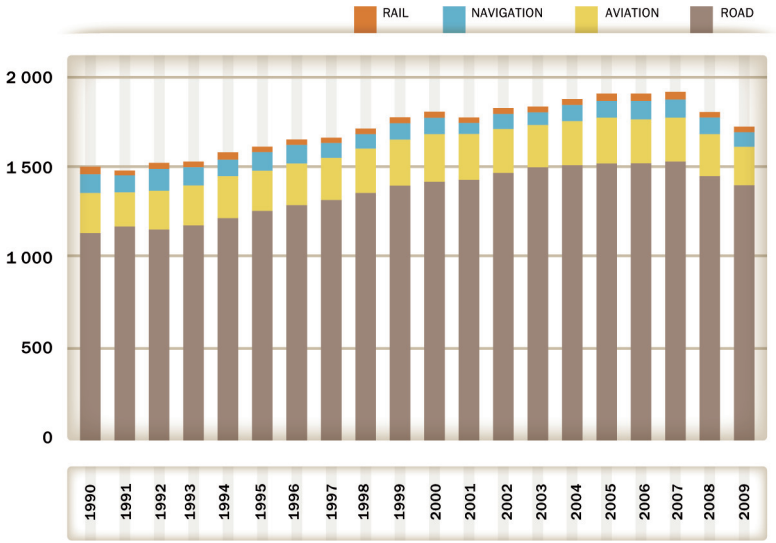
Fig. 41: **Freight traffic activity by mode, 1995-2008 (tkm)**



Value 1995=100

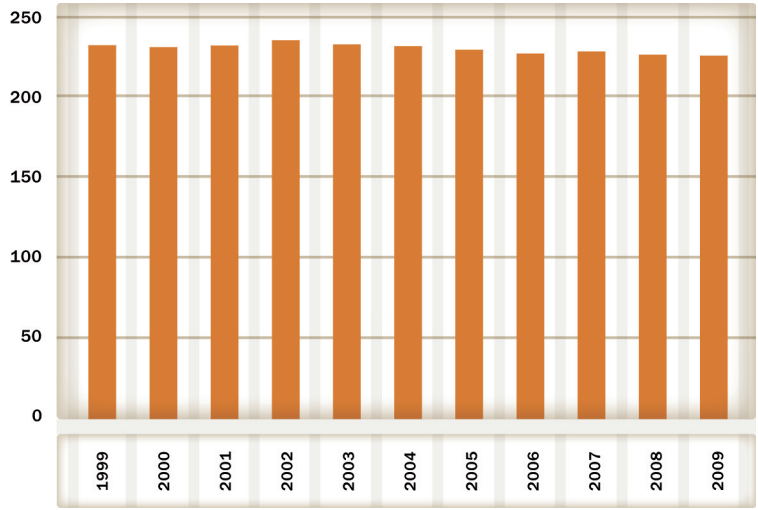
Source: OECD (2012), UIC (2011a) and BTS (2011)

Fig. 42: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



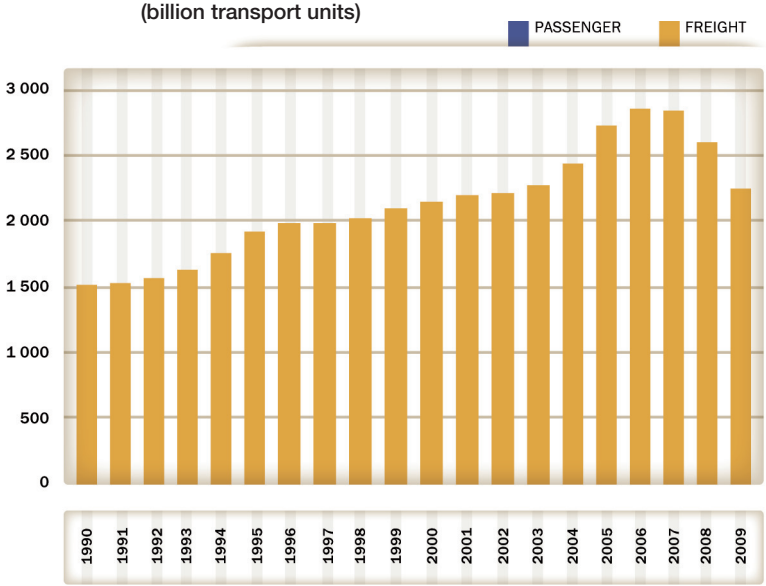
Source: IEA (2011a)

Fig. 43: **Length of railway line, 1999-2009 (thousand km)**



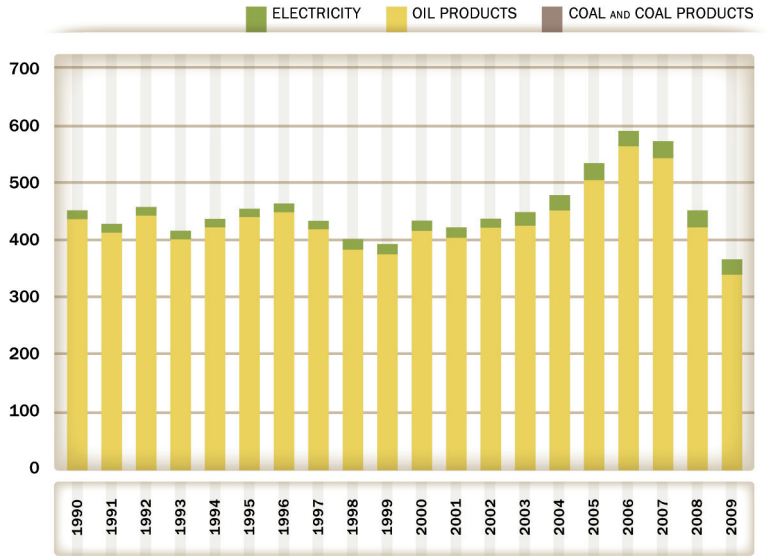
Source: UIC (2011a)

Fig. 44: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



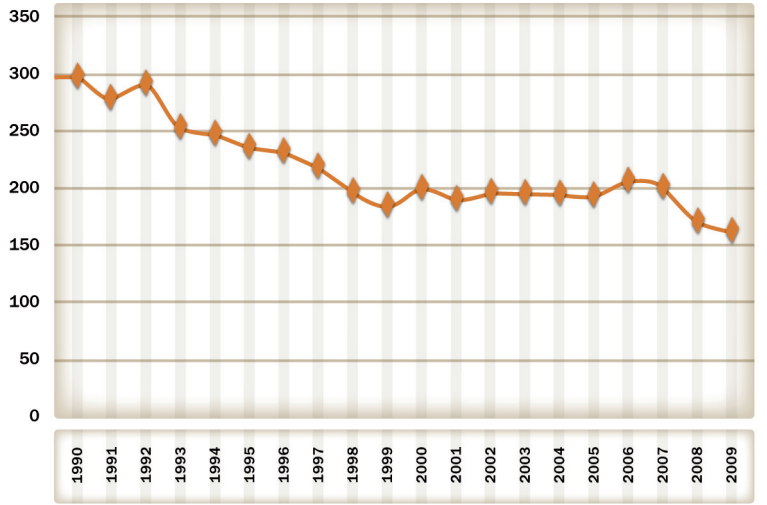
Source: UIC (2011a)

Fig. 45: **Railway energy consumption by fuel, 1990-2009 (PJ)**



Source: IEA (2011b)

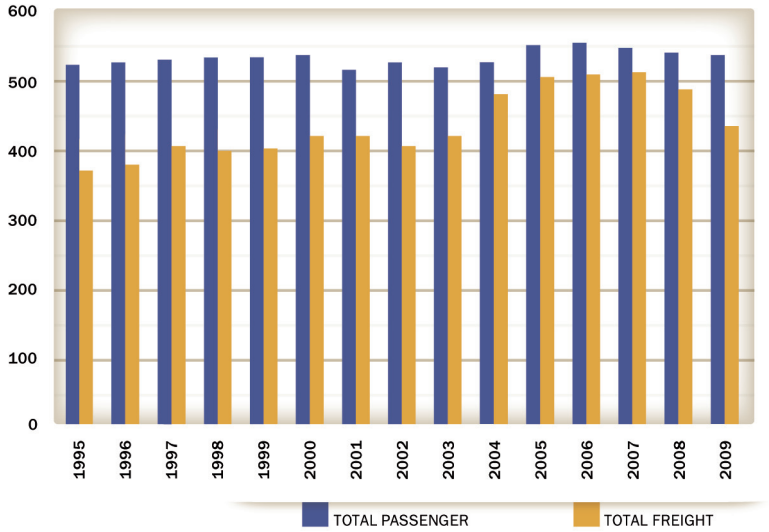
Fig. 46: **Railway specific energy consumption, 1990-2009 (kJ/transport unit)**



Source: (EA (2011b) and UIC (2011a)

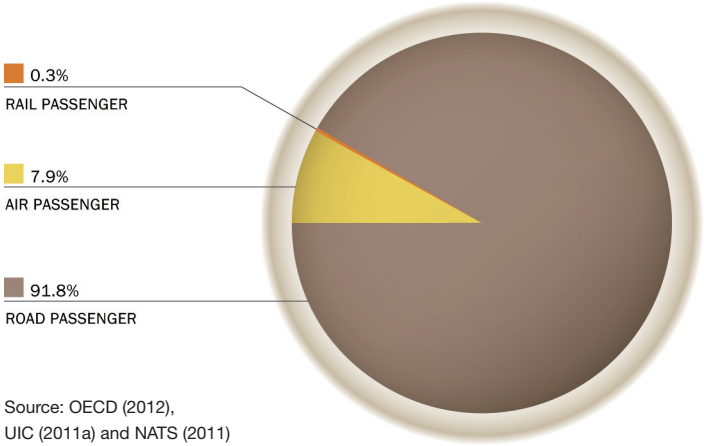
Canada

Fig. 47: **Passenger and freight transport activity, 1995-2009 (billion pkm and tkm)**



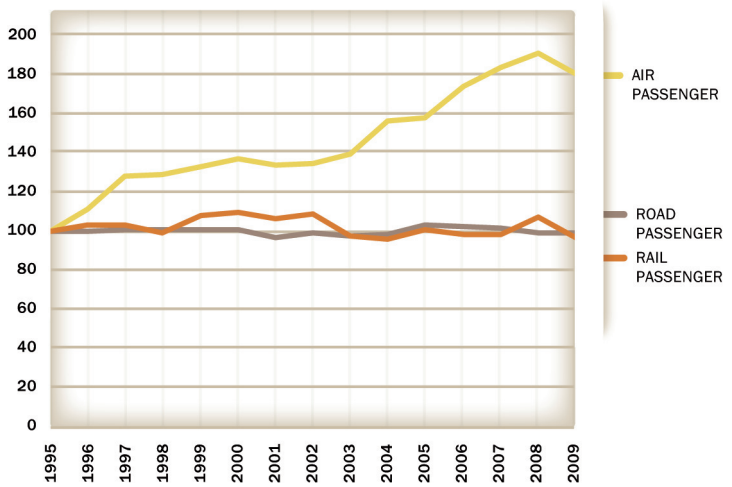
Source: OECD (2012), UIC (2011a) and NATS (2011)

Fig. 48: **Passenger transport modal split, 2009 (% pkm)**



Source: OECD (2012),
UIC (2011a) and NATS (2011)

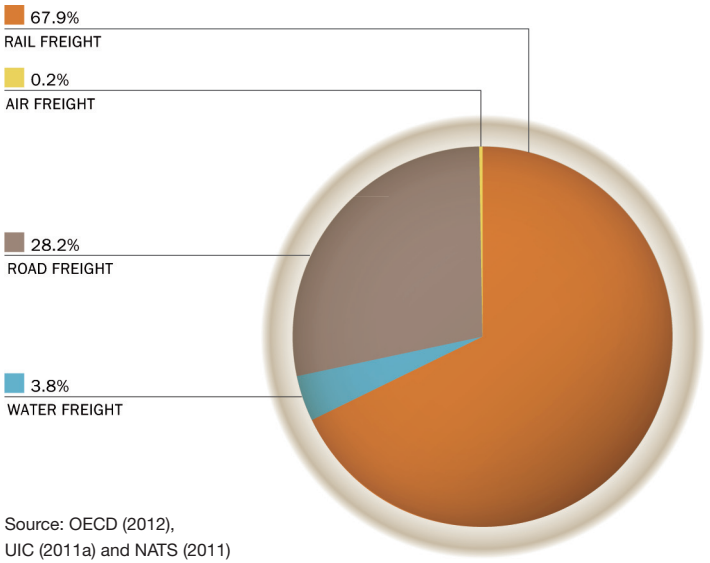
Fig. 49: **Passenger traffic activity by mode, 1995-2009 (pkm)**



Value 1995=100

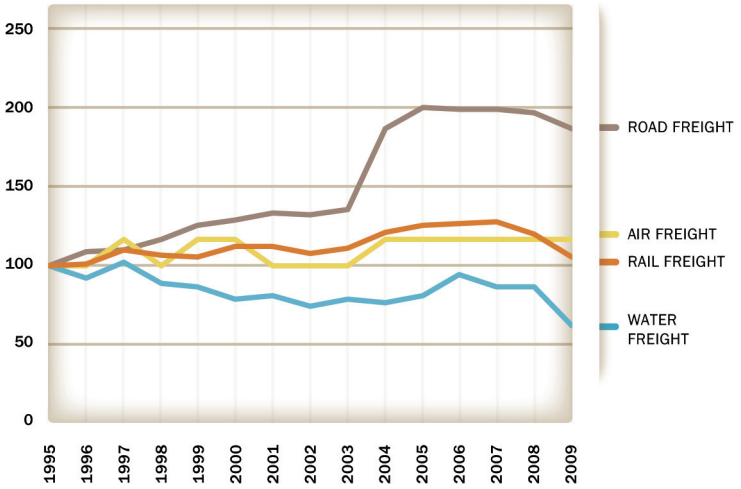
Source: OECD (2012), UIC (2011a) and NATS (2011)

Fig. 50: **Freight transport modal split, 2009 (% tkm)**



Source: OECD (2012),
UIC (2011a) and NATS (2011)

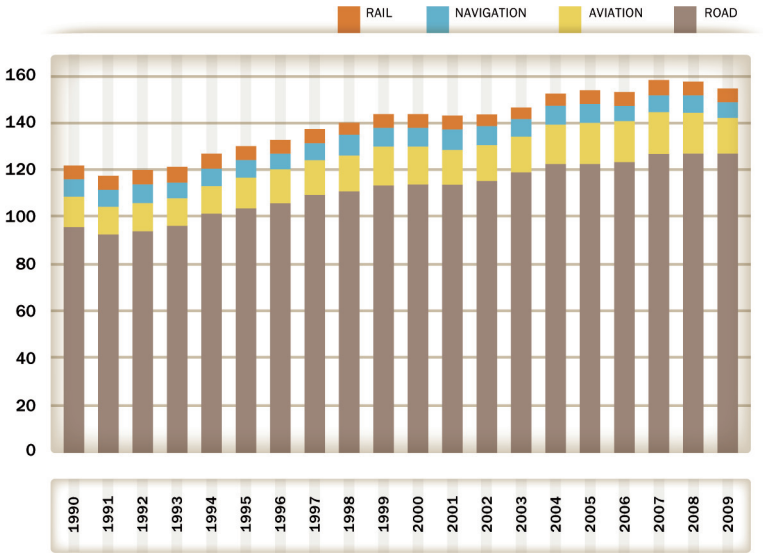
Fig. 51: **Freight traffic activity by mode, 1995-2009 (tkm)**



Value 1995=100

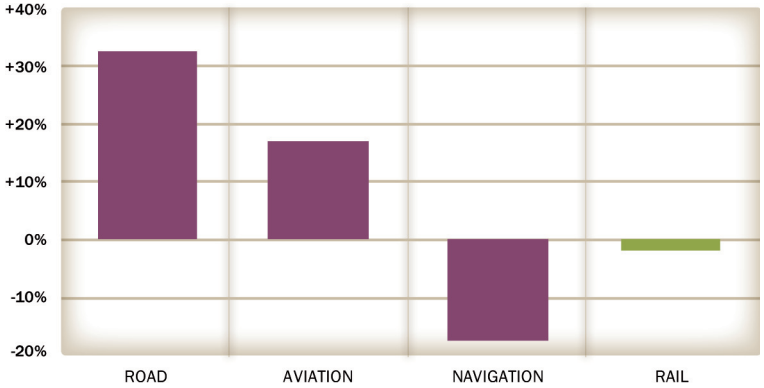
Source: OECD (2012), UIC (2011a) and NATS (2011)

Fig. 52: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



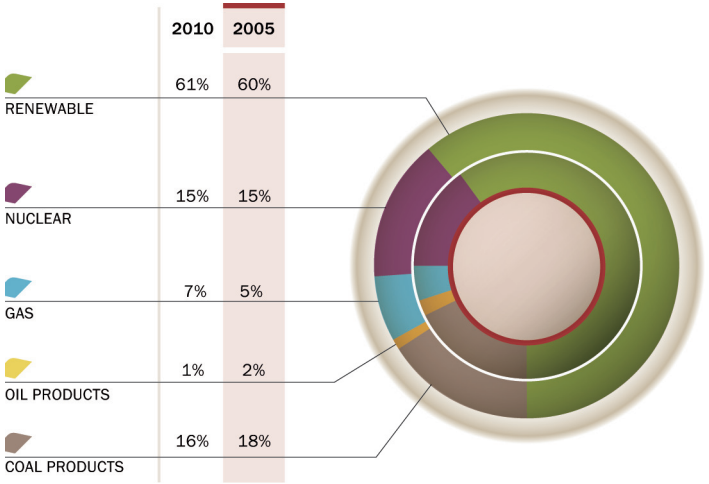
Source: IEA (2011a)

Fig. 53: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



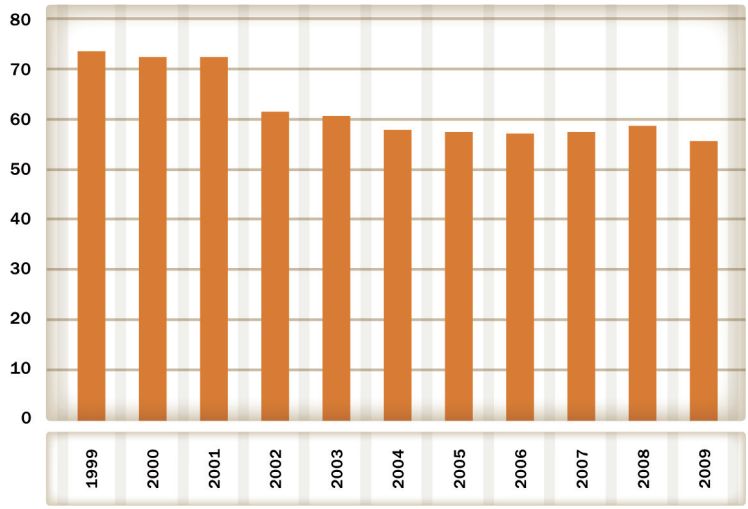
Source: IEA (2011a)

Fig. 54: **National electricity mix evolution, 2010 outside - 2005 inside**



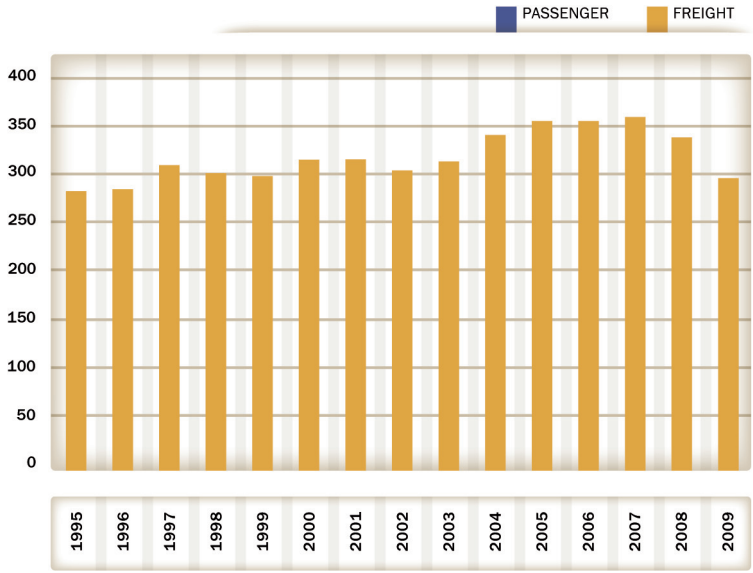
Source: IEA (2011b)

Fig. 55: **Length of railway line, 1999-2009 (thousand km)**



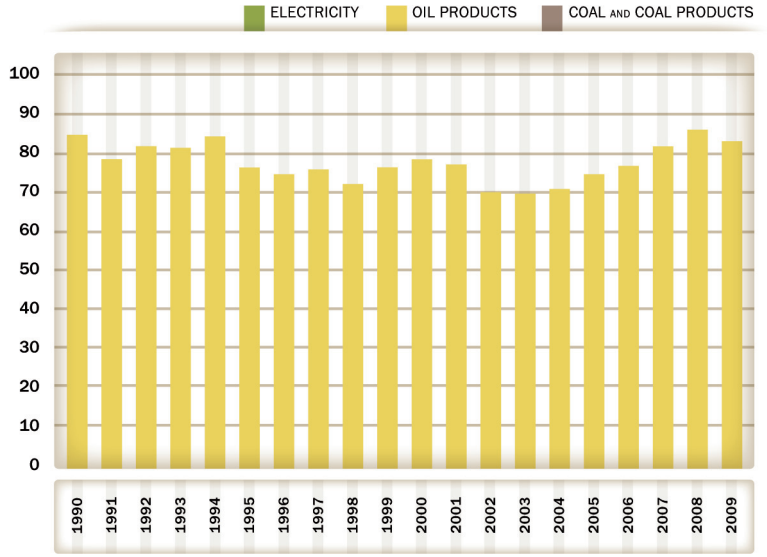
Source: UIC (2011a)

Fig. 56: **Railway transport activity for passenger and freight, 1995-2009 (billion transport units)**



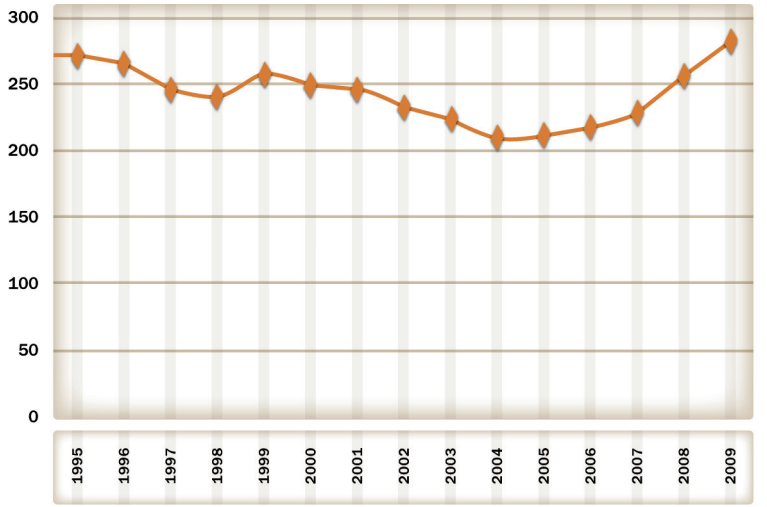
Source: UIC (2011a)

Fig. 57: **Railway energy consumption by fuel, 1990-2009 (PJ)**



Source: IEA (2011b)

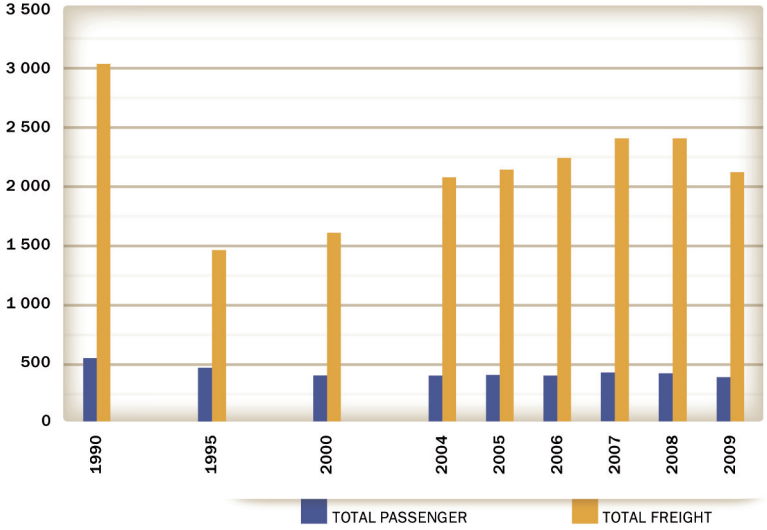
Fig. 58: **Railway specific energy consumption, 1995-2009 (kJ/transport unit)**



Source: IEA (2011b) and UIC (2011a)

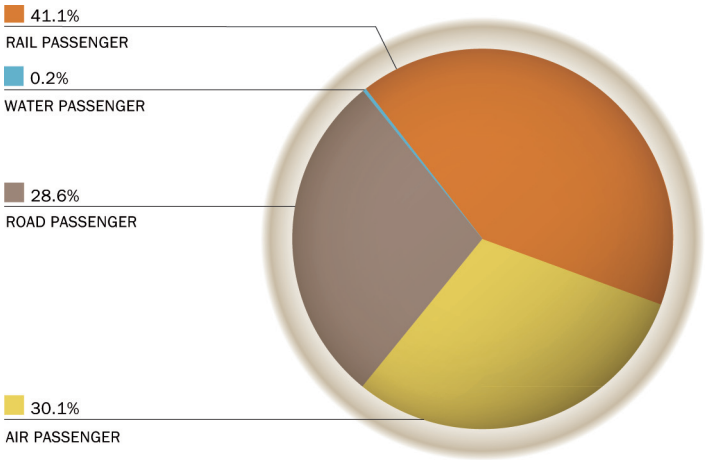
Russian Federation

Fig. 59: **Passenger and freight transport activity, 1990-2009 (billion pkm and tkm)**



Source: OECD (2012), UIC (2011a) and Rosstat (2010)

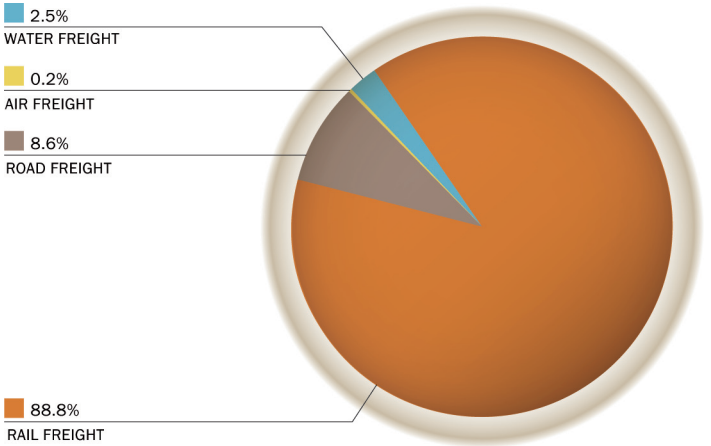
Fig. 60: **Passenger transport modal split, 2009 (% pkm)**



Source: OECD (2012), UIC (2011a) and Rosstat (2010)

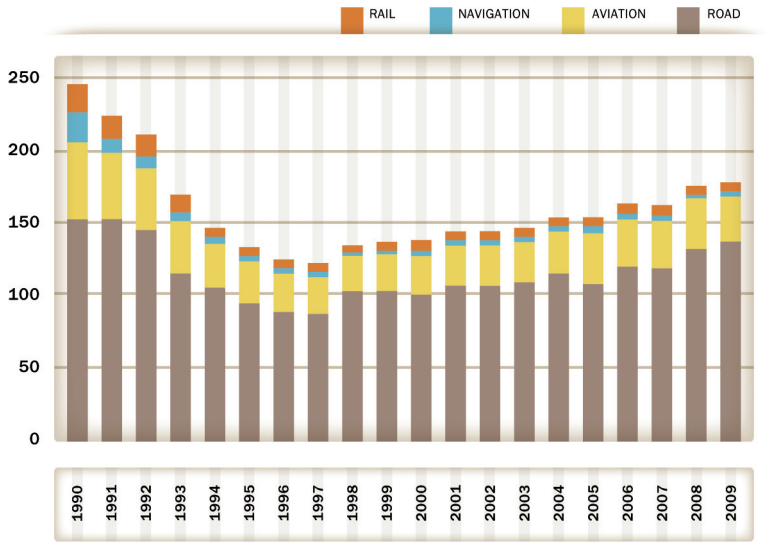
Note: ROSSTAT provides only passenger activity by public transport, so private passenger cars are not taken into account

Fig. 61: **Freight transport modal split, 2009 (% tkm)**



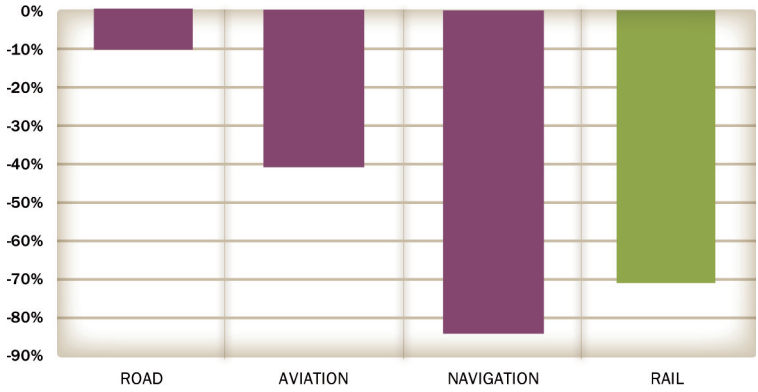
Source: OECD (2012),
UIC (2011a) and Rosstat (2010)

Fig. 62: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



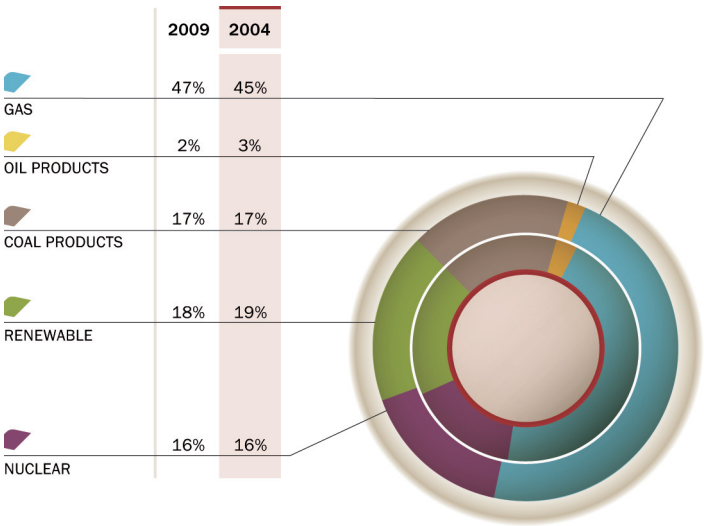
Source: IEA (2011a)

Fig. 63: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



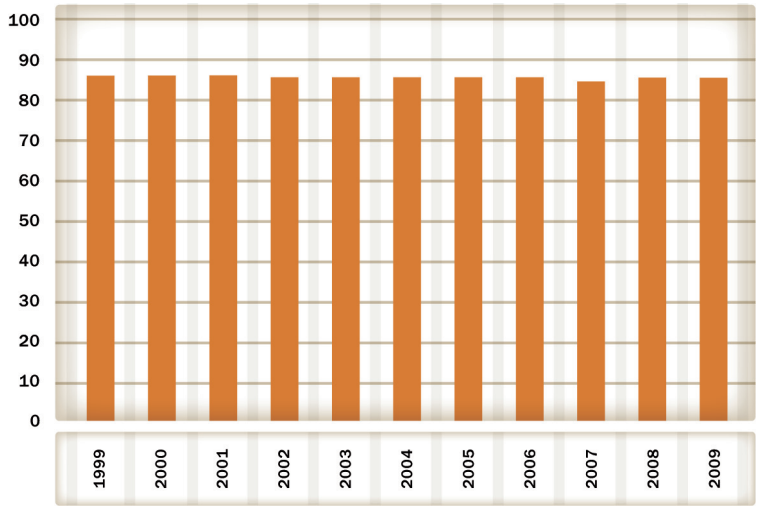
Source: IEA (2011a)

Fig. 64: **National electricity mix evolution, 2009 outside - 2004 inside**



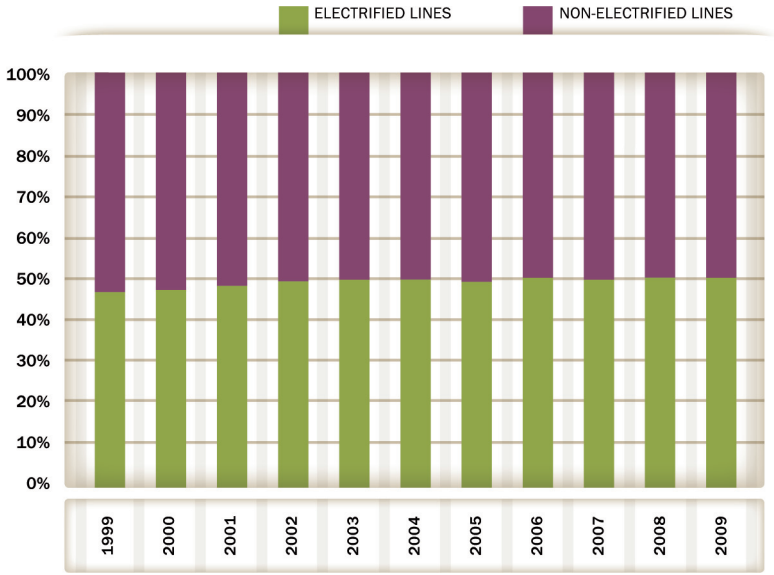
Source: IEA (2011b)

Fig. 65: **Length of railway line, 1999-2009 (thousand km)**



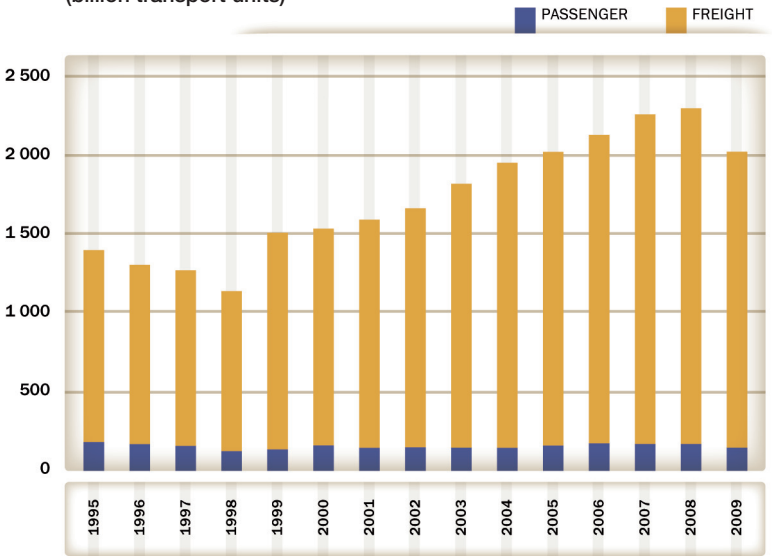
Source: UIC (2011a)

Fig. 66: **Line electrification share,1999-2009 (% over total length of line)**



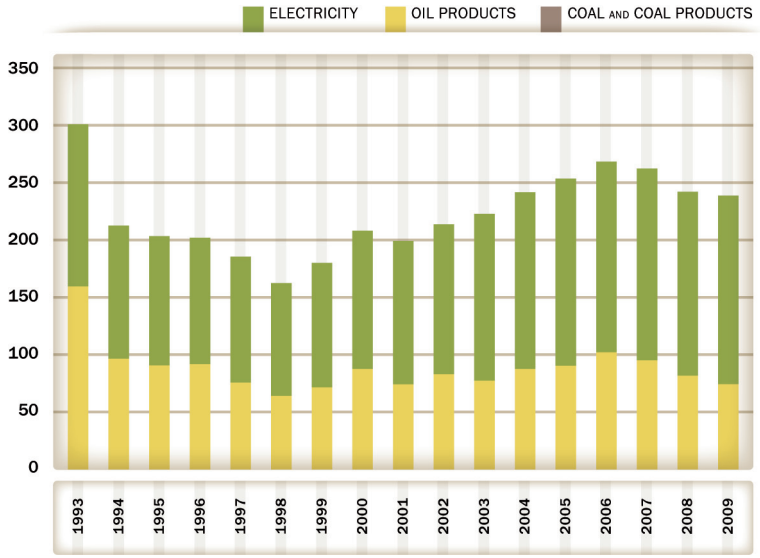
Source: UIC (2011a)

Fig. 67: **Railway transport activity for passenger and freight, 1995-2009 (billion transport units)**



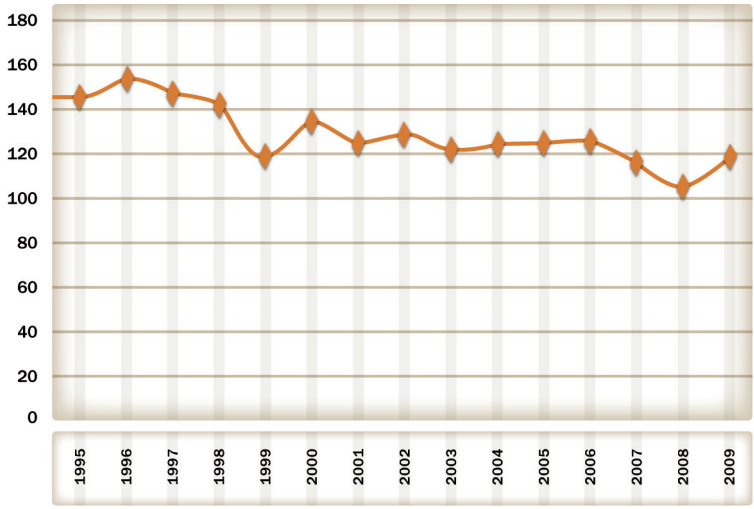
Source: UIC (2011a)

Fig. 68: **Railway energy consumption by fuel, 1993-2009 (PJ)**



Source: IEA (2011b)

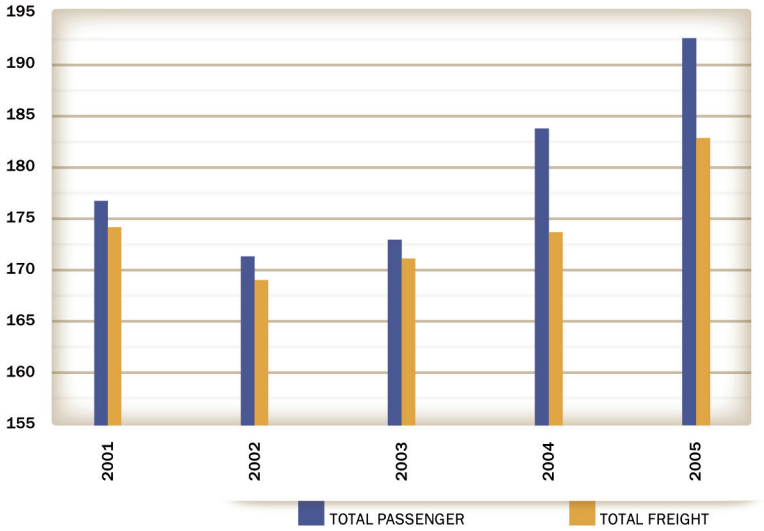
Fig. 69: **Railway specific energy consumption, 1995-2009 (kJ/transport unit)**



Source: IEA (2011b) and UIC (2011a)

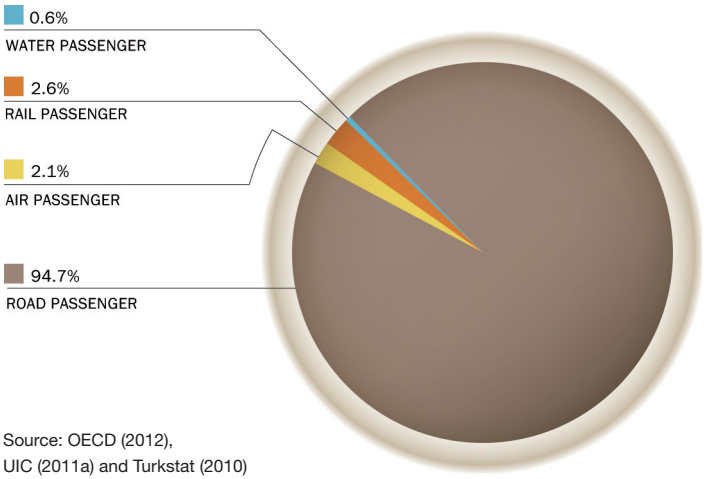
Turkey

Fig. 70: **Passenger and freight transport activity, 2001-2005 (billion pkm and tkm)**



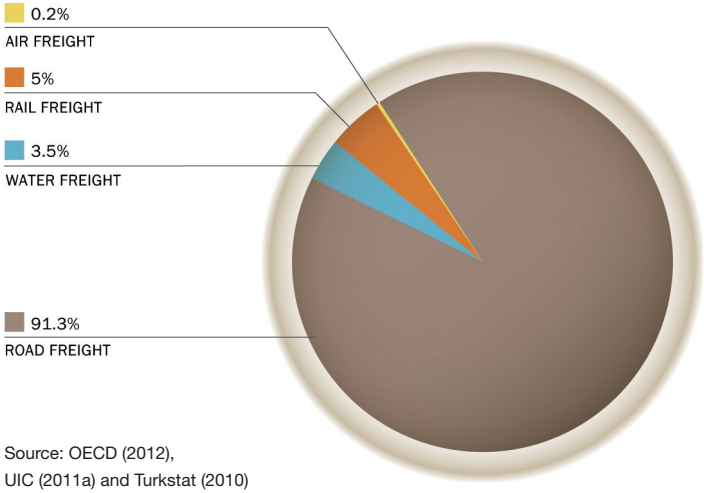
Source: OECD (2012), UIC (2011a) and Turkstat (2010)

Fig. 71: **Passenger transport modal split, 2005 (% pkm)**



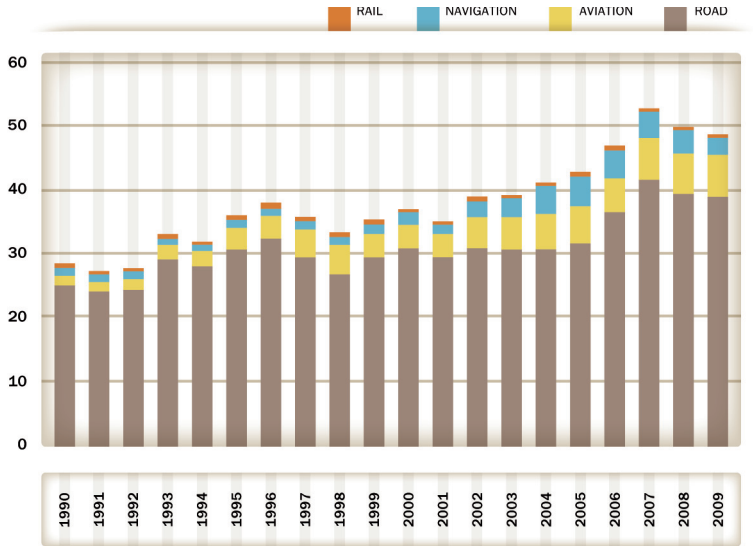
Source: OECD (2012),
UIC (2011a) and Turkstat (2010)

Fig. 72: **Freight transport modal split, 2005 (% tkm)**



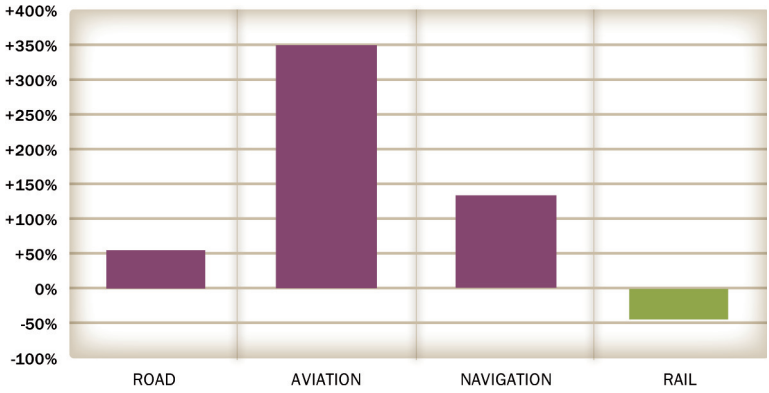
Source: OECD (2012),
UIC (2011a) and Turkstat (2010)

Fig. 73: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



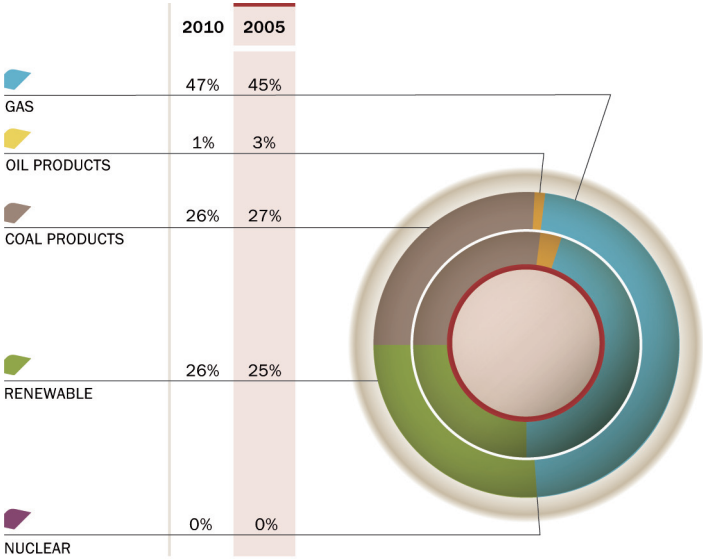
Source: IEA (2011a)

Fig. 74: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



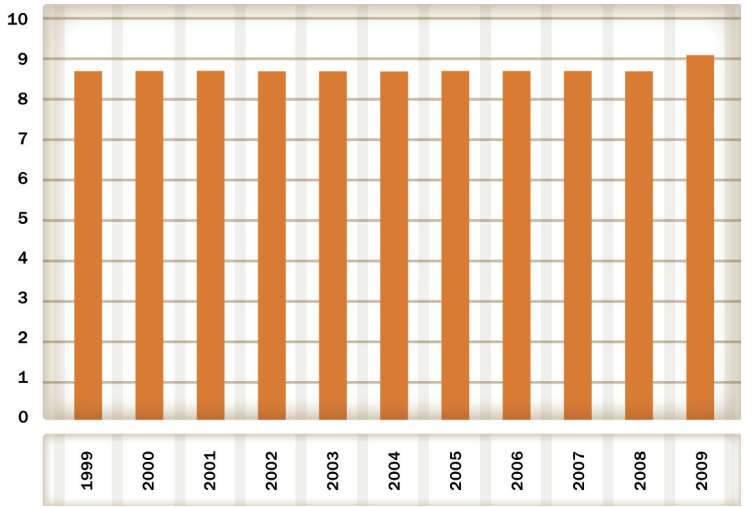
Source: IEA (2011a)

Fig. 75: **National electricity mix evolution, 2010 outside - 2005 inside**



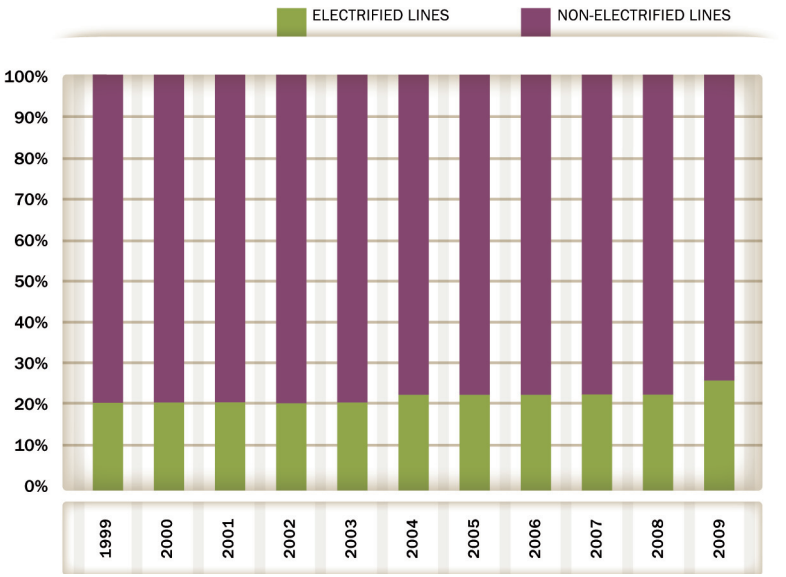
Source: IEA (2011b)

Fig. 76: **Length of railway line, 1999-2009 (thousand km)**



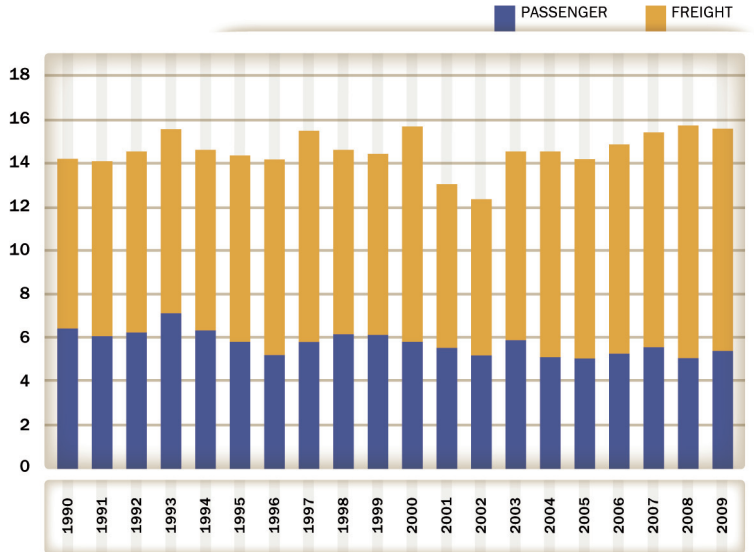
Source: UIC (2011a)

Fig. 77: **Line electrification share, 1999-2009 (% over total length of line)**



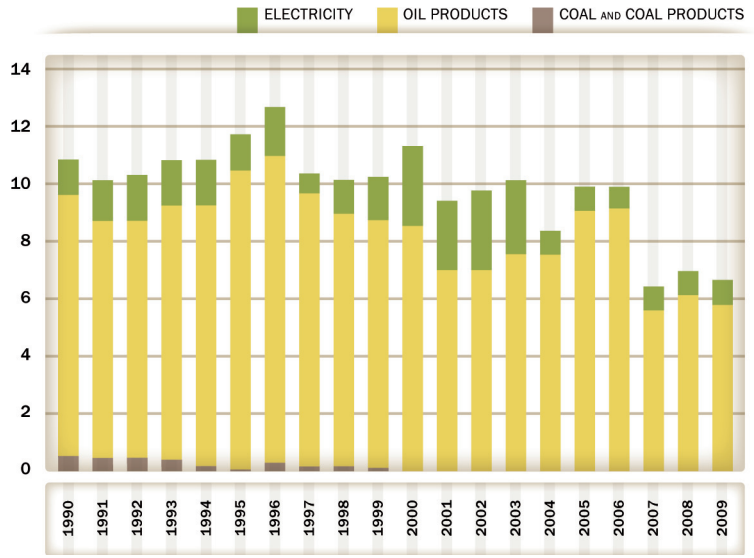
Source: UIC (2011a)

Fig. 78: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



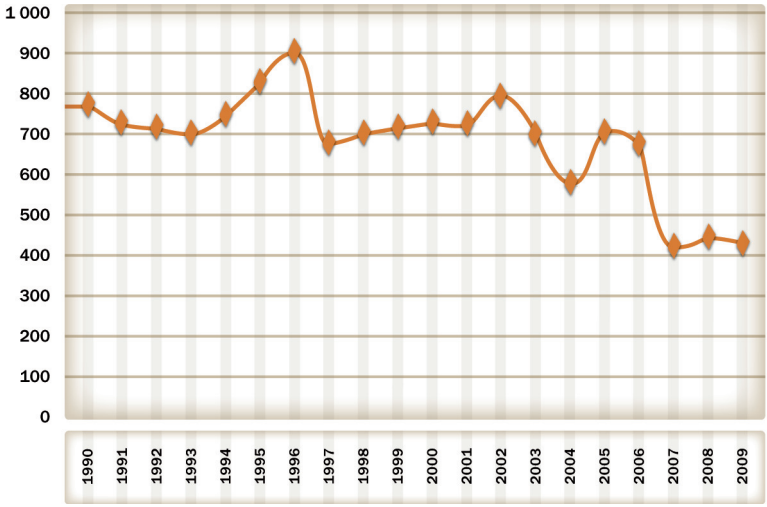
Source: UIC (2011a)

Fig. 79: **Railway energy consumption by fuel, 1990-2009 (PJ)**



Source: IEA (2011b)

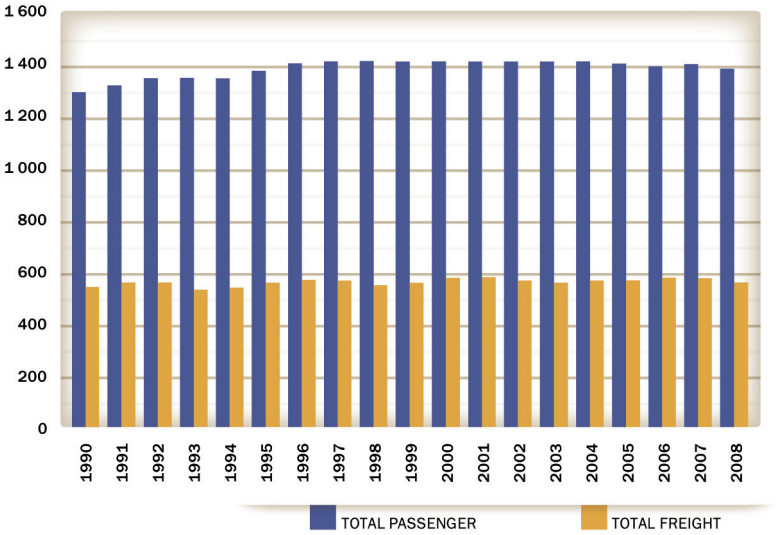
Fig. 80: **Railway specific energy consumption, 1990-2009 (kJ/transport unit)**



Source: IEA (2011b) and UIC (2011a)

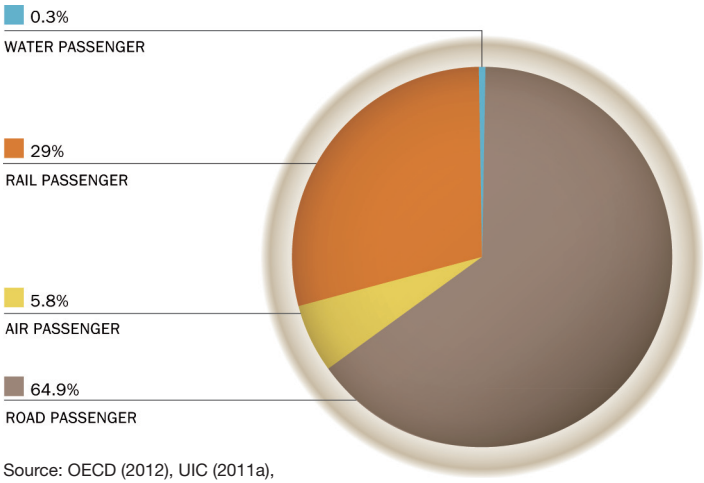
Japan

Fig. 81: **Passenger and freight transport activity, 1990-2008 (billion pkm and tkm)**



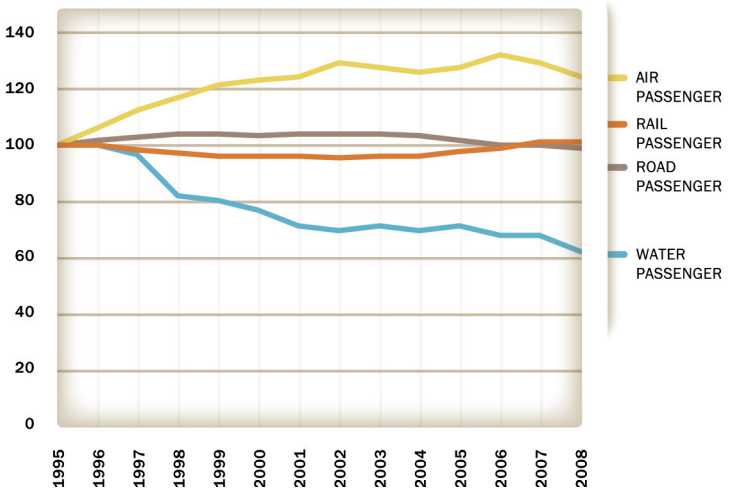
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

Fig. 82: **Passenger transport modal split, 2008 (% pkm)**



Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

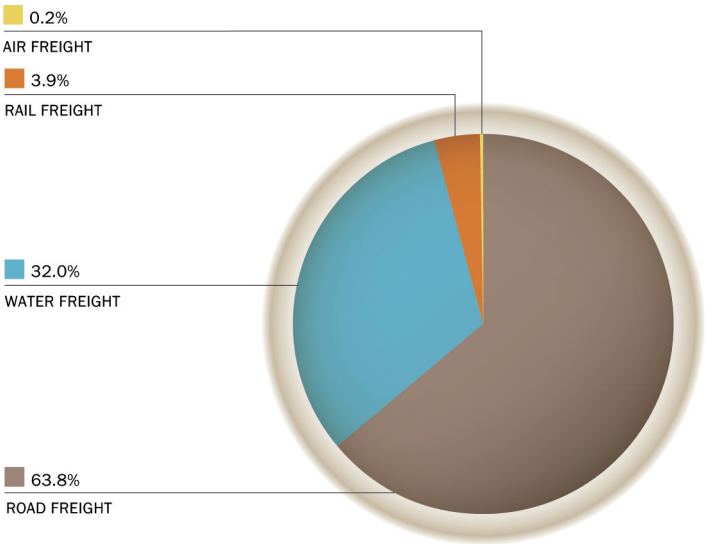
Fig. 83: **Passenger traffic activity by mode, 1995-2008 (pkm)**



Value 1995=100

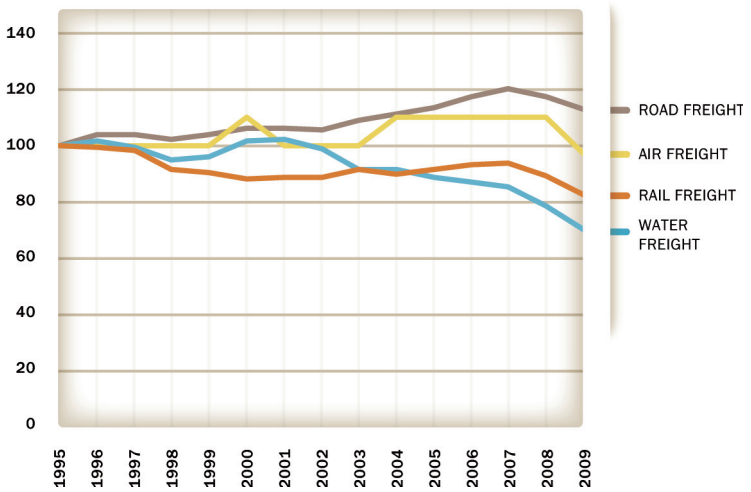
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

Fig. 84: **Freight transport modal split, 2009 (% tkm)**



Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

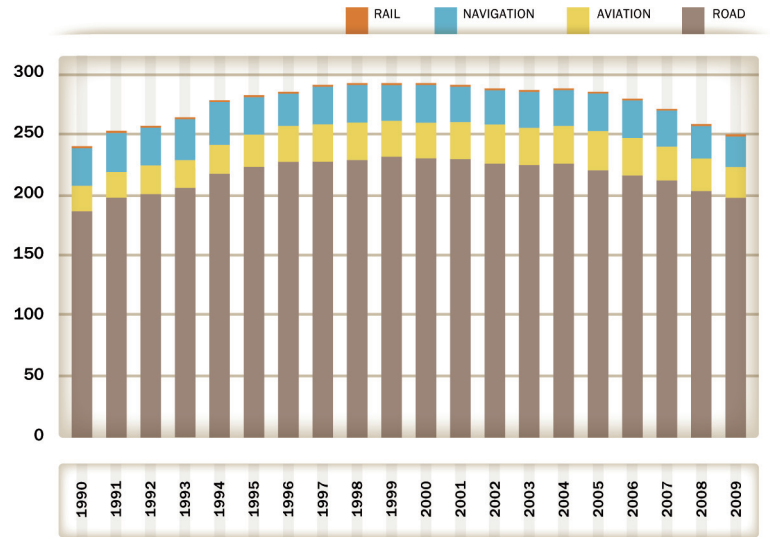
Fig. 85: **Freight traffic activity by mode, 1995-2009 (tkm)**



Value 1995=100

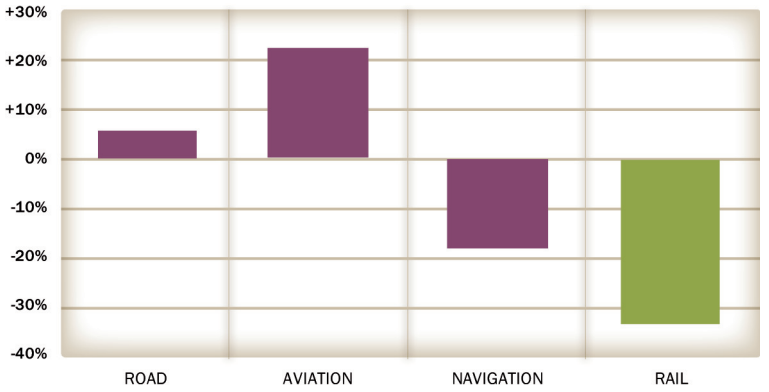
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

Fig. 86: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



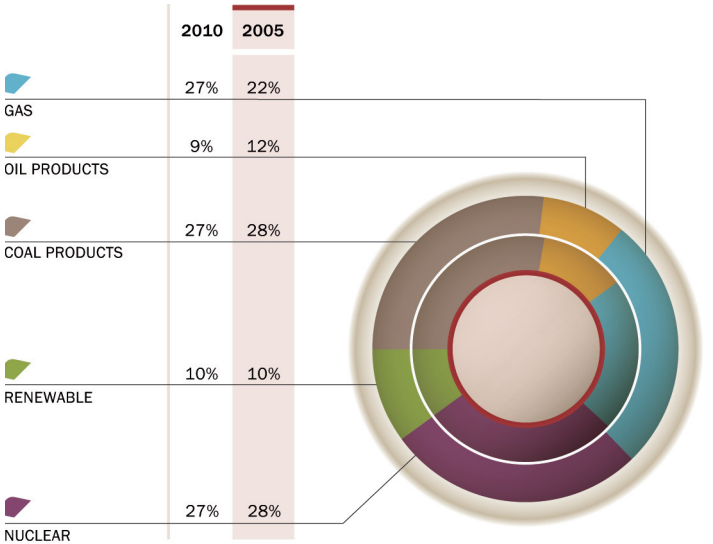
Source: IEA (2011a)

Fig. 87: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



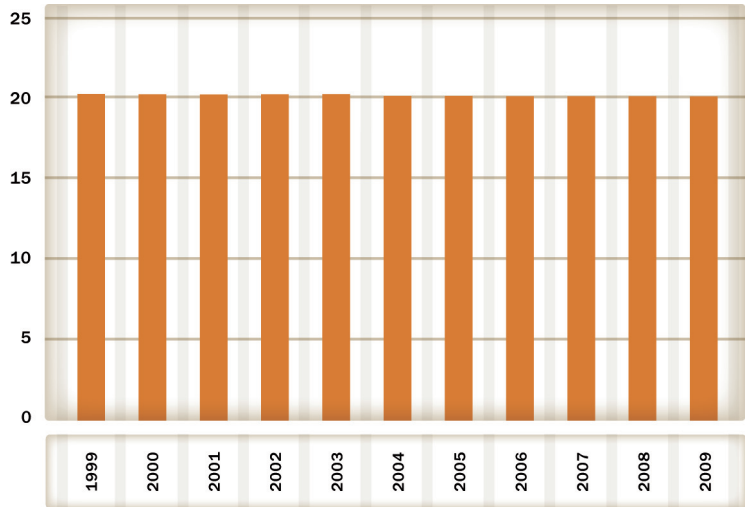
Source: IEA (2011a)

Fig. 88: **National electricity mix evolution, 2010 outside - 2005 inside**



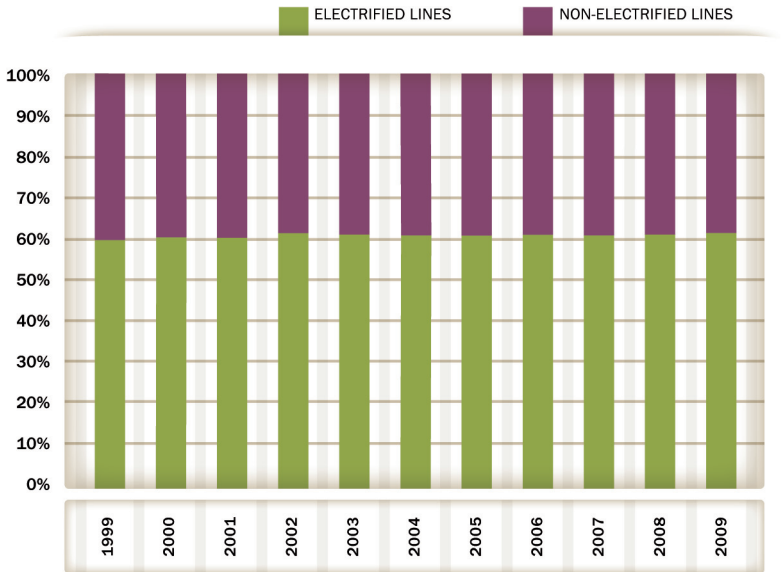
Source: IEA (2011b)

Fig. 89: **Length of railway line, 1999-2009 (thousand km)**



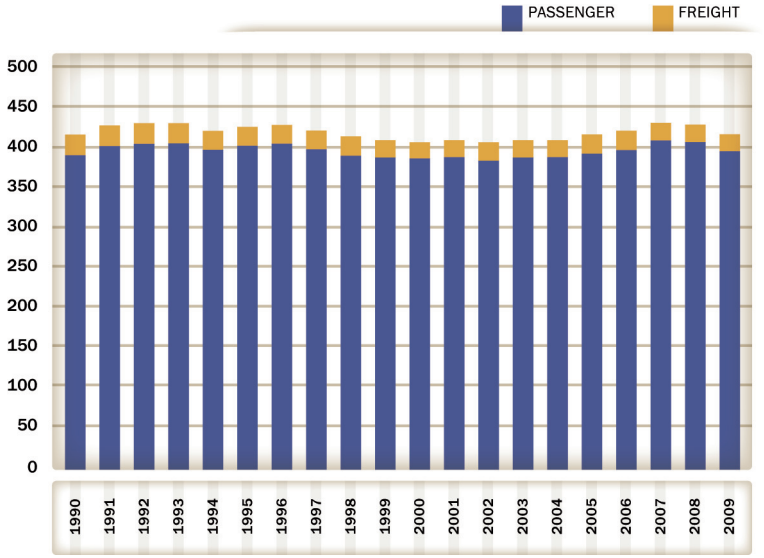
Source: UIC (2011a)

Fig. 90: **Line electrification share, 1999-2009 (% over total length of line)**



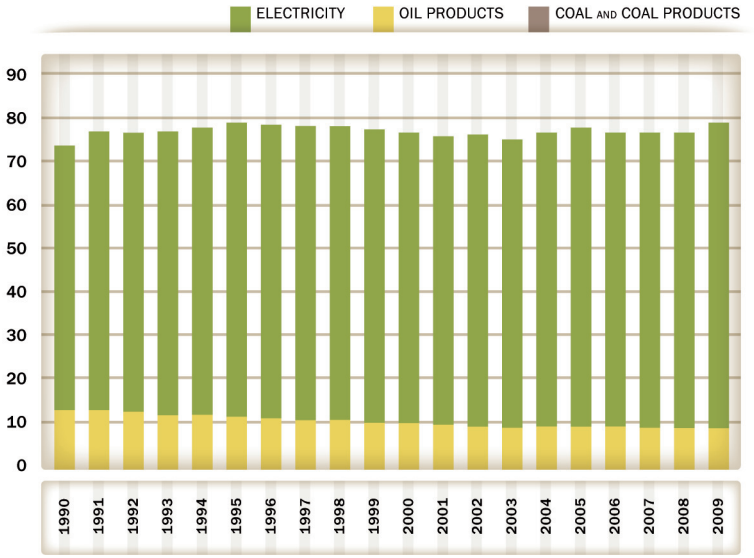
Source: UIC (2011a)

Fig. 91: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



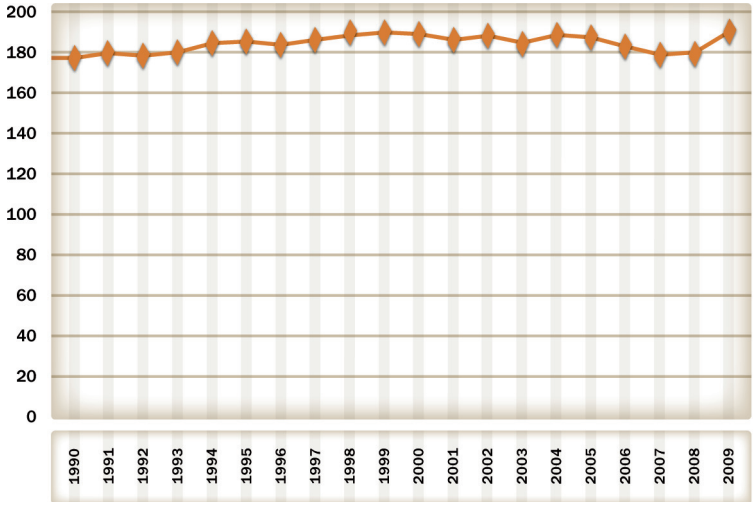
Source: UIC (2011a)

Fig. 92: **Railway energy consumption by fuel, 1990-2009 (PJ)**



Source: IEA (2011b)

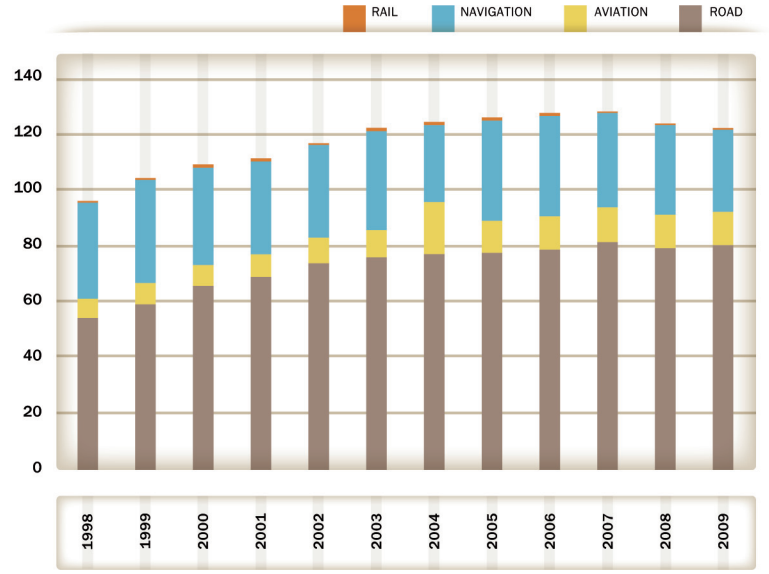
Fig. 93: **Railway specific energy consumption, 1990-2009 (kJ/transport unit)**



Source: IEA (2011b) and UIC (2011a)

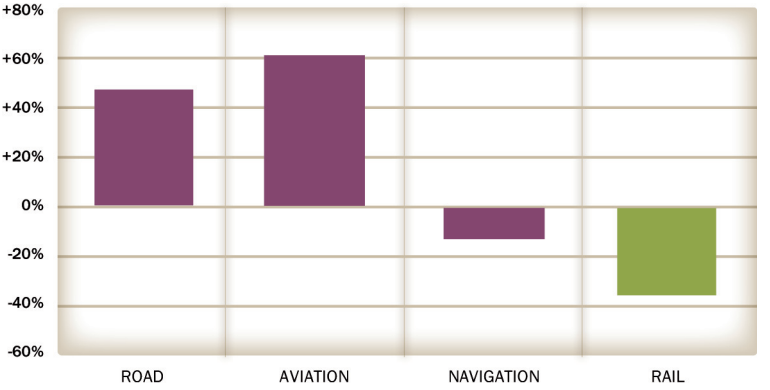
Republic of Korea

Fig. 94: **Transport CO_2 emissions by mode, 1998-2009 (million tonnes)**



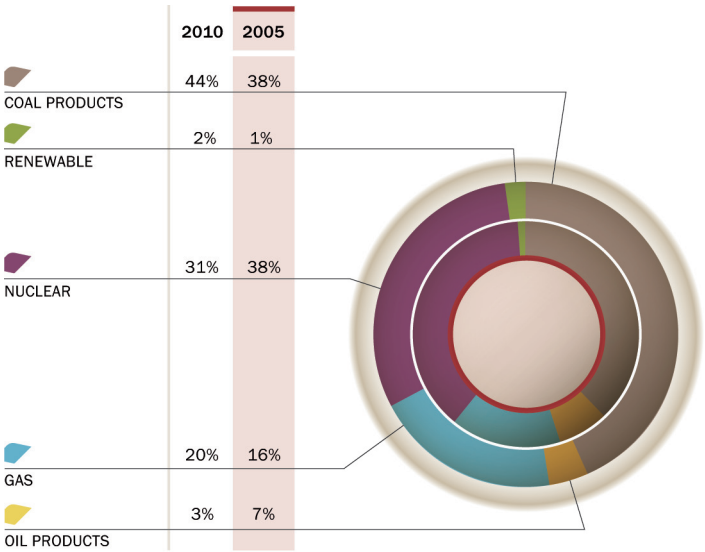
Source: IEA (2011a)

Fig. 95: **Change in CO_2 emissions from fuel combustion by mode between 1998 and 2009**



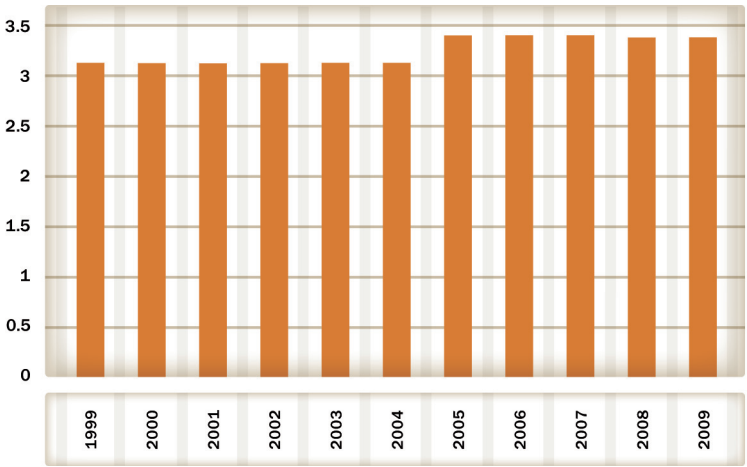
Source: IEA (2011a)

Fig. 96: **National electricity mix evolution, 2010 outside - 2005 inside**



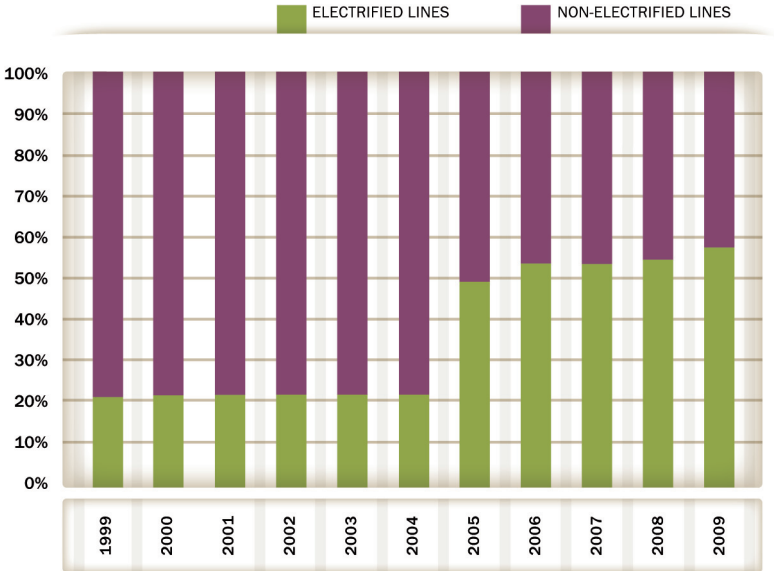
Source: IEA (2011b)

Fig. 97: **Length of railway line, 1999-2009 (thousand km)**



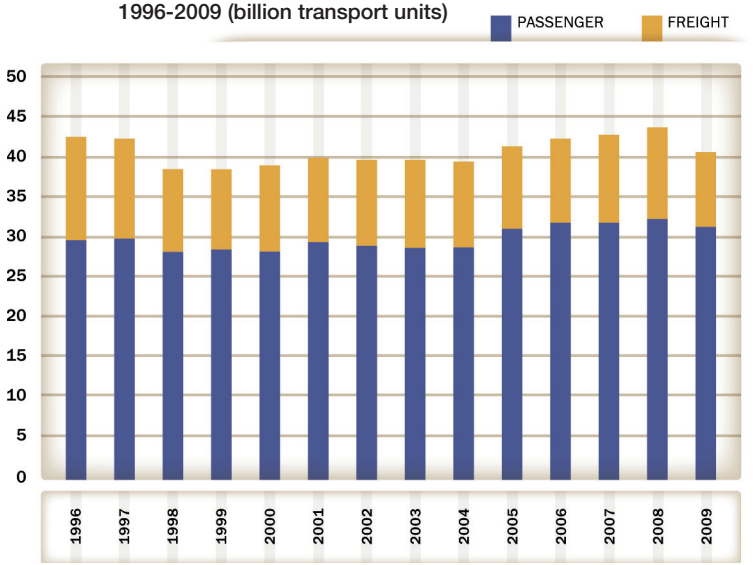
Source: UIC (2011a)

Fig. 98: **Line electrification share, 1999-2009 (% over total length of line)**



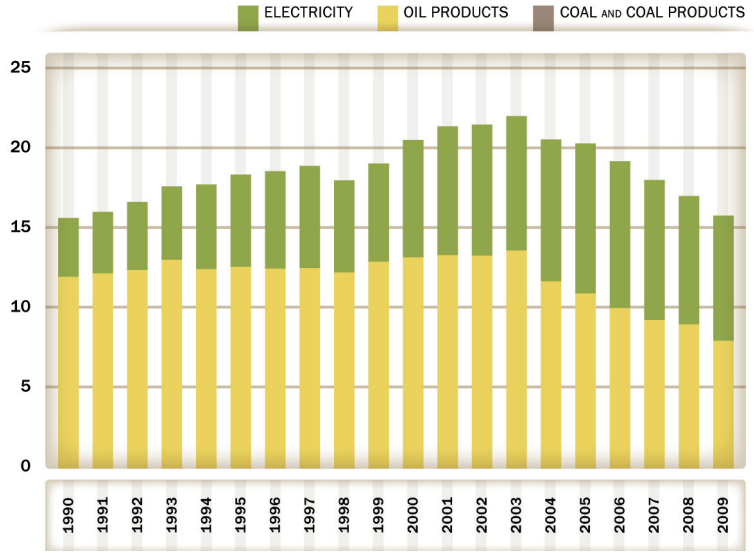
Source: UIC (2011a)

Fig. 99: **Railway transport activity for passenger and freight, 1996-2009 (billion transport units)**



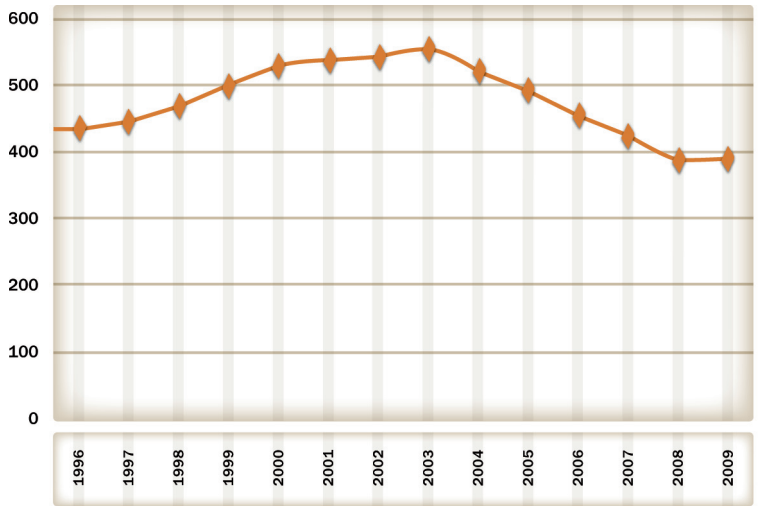
Source: UIC (2011a)

Fig. 100: **Railway energy consumption by fuel, 1990-2009 (PJ)**



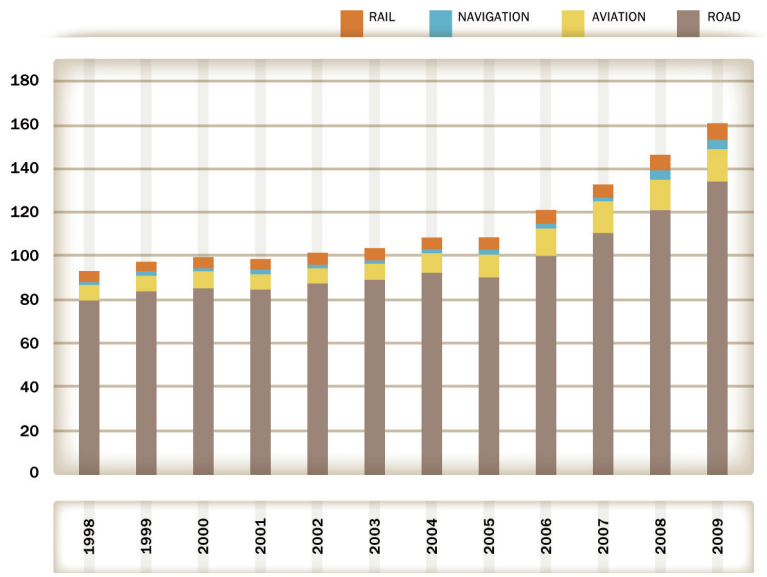
Source: IEA (2011b)

Fig. 101: **Railway specific energy consumption, 1996-2009 (kJ/transport unit)**



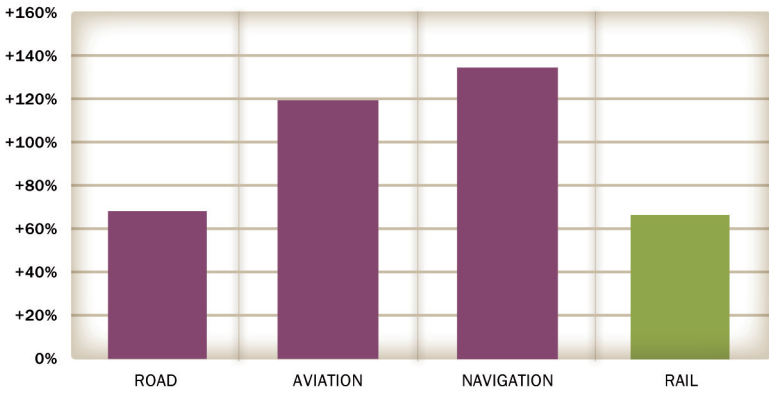
Source: IEA (2011b) and UIC (2011a)

Fig. 102: **Transport CO_2 emissions by mode, 1998-2009 (million tonnes)**



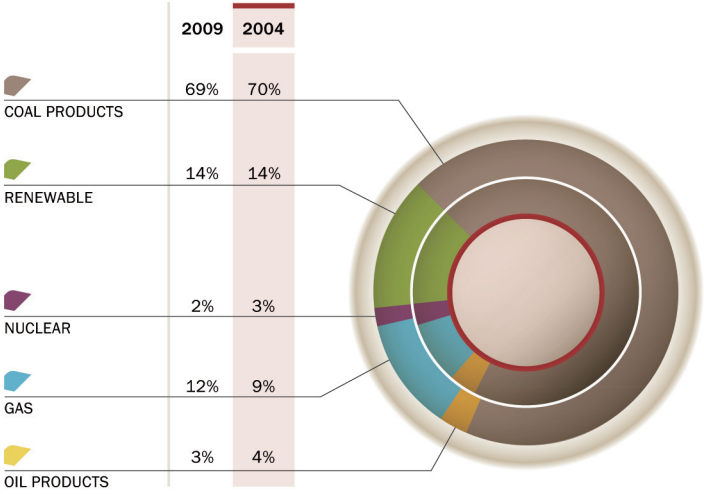
Source: IEA (2011a)

Fig. 103: **Change in CO_2 emissions from fuel combustion by mode between 1998 and 2009**



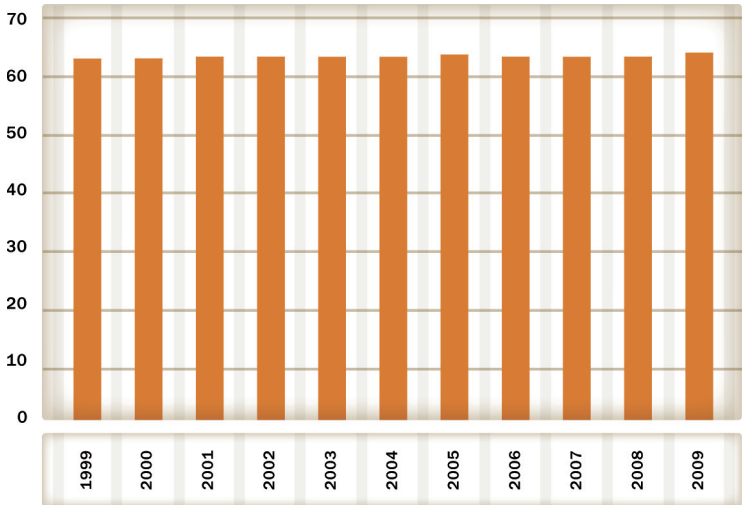
Source: IEA (2011a)

Fig. 104: **National electricity mix evolution, 2009 outside - 2004 inside**



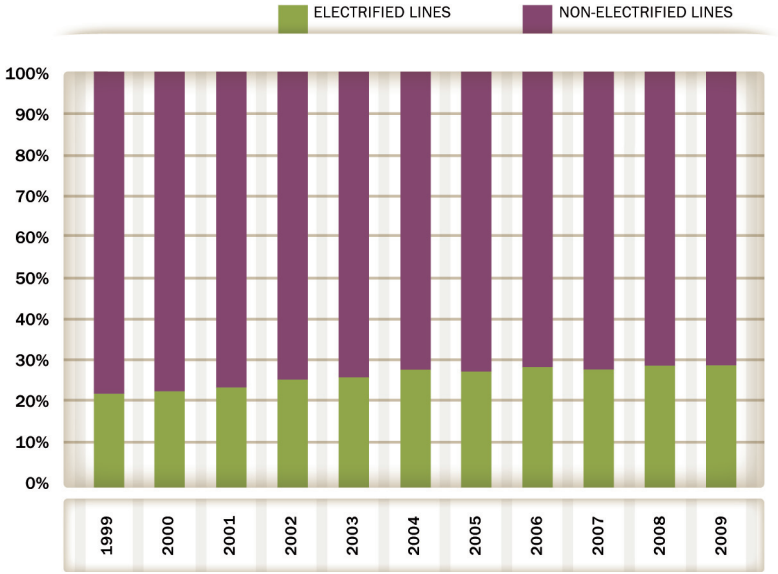
Source: IEA (2011b)

Fig. 105: **Length of railway line, 1999-2009 (thousand km)**



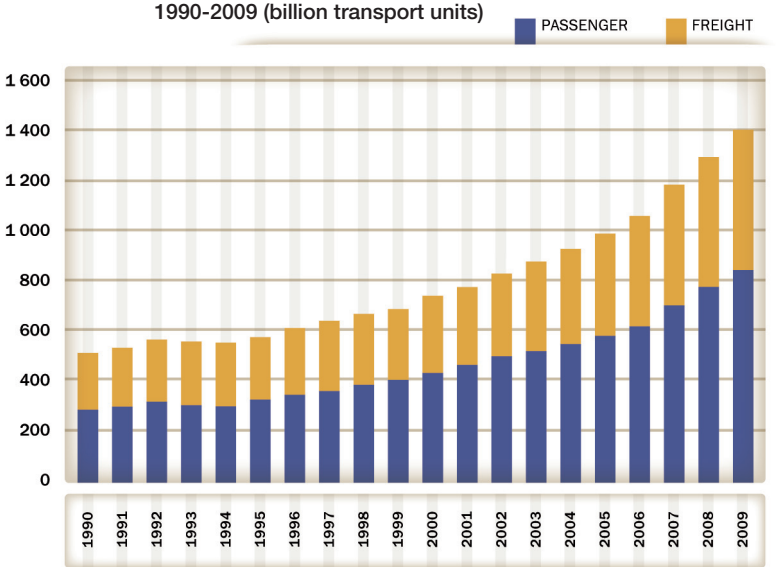
Source: UIC (2011a)

Fig. 106: **Line electrification share, 1999-2009 (% over total length of line)**



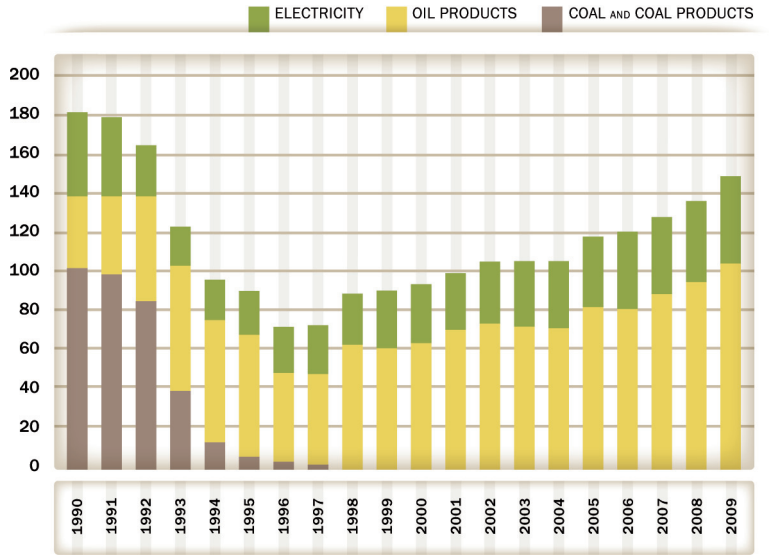
Source: UIC (2011a)

Fig. 107: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



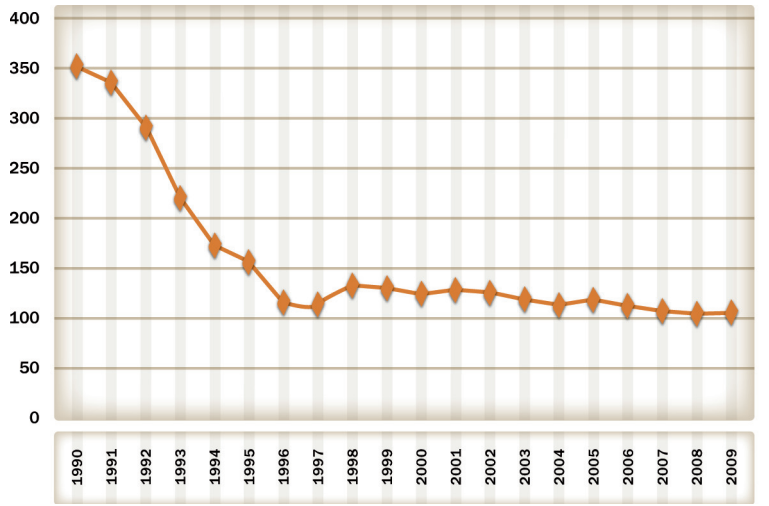
Source: UIC (2011a)

Fig. 108: **Railway energy consumption by fuel, 1990-2009 (PJ)**



Source: IEA (2011b)

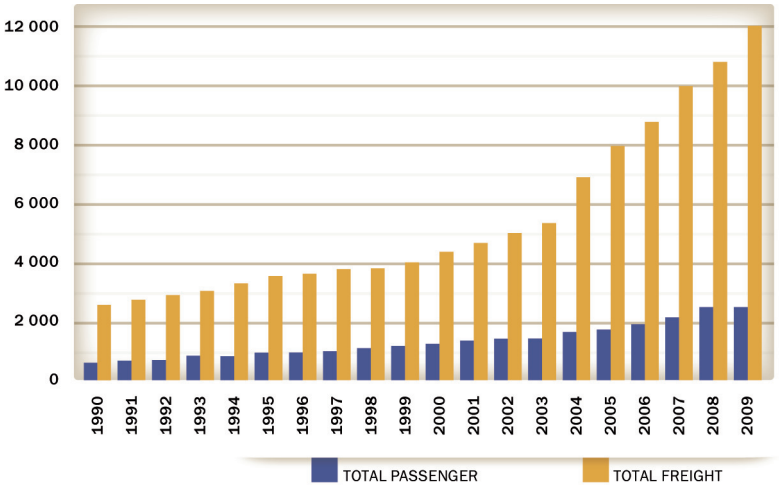
Fig. 109: **Railway specific energy consumption, 1990-2009 (kJ/transport unit)**



Source: IEA (2011b) and UIC (2011a)

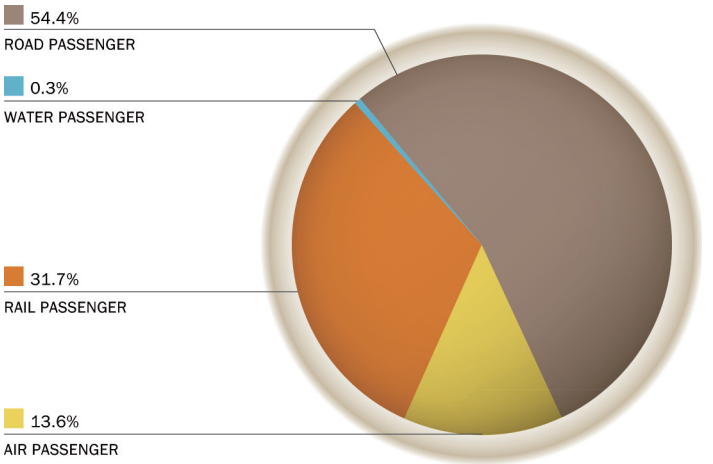
People's Republic of China

Fig. 110: **Passenger and freight transport activity, 1990-2009 (billion pkm and tkm)**



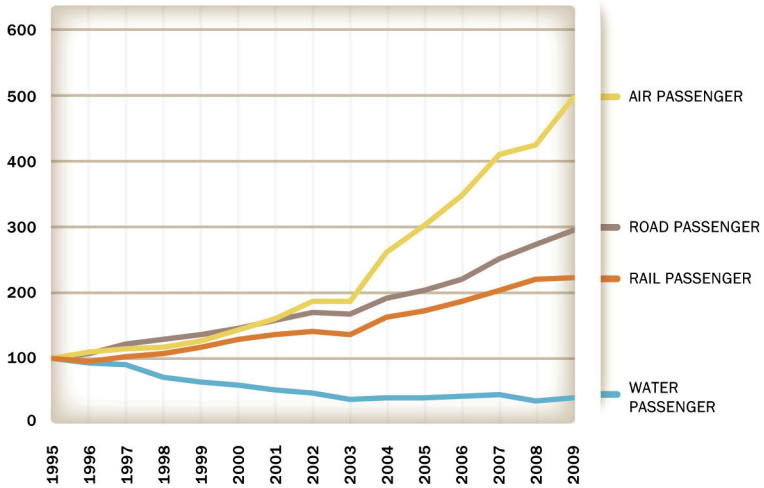
Source: UIC (2011a) and CNBS (2011)

Fig. 111: **Passenger transport modal split, 2009 (% pkm)**



Source: UIC (2011a) and CNBS (2011)

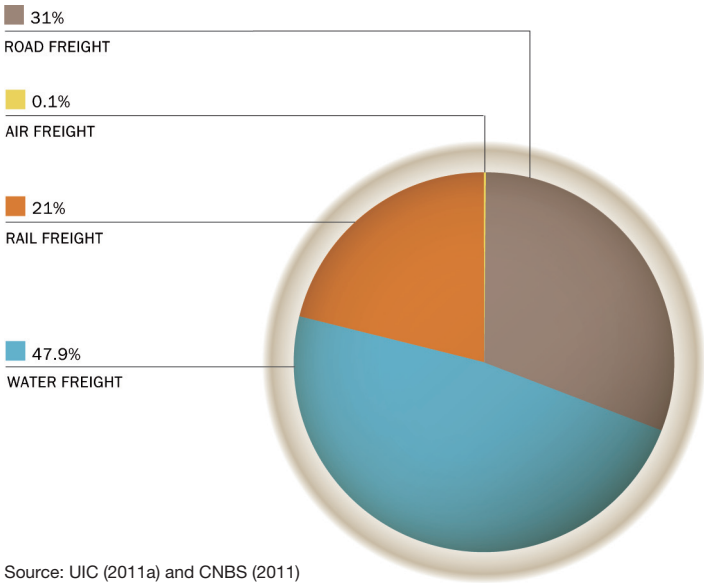
Fig. 112: **Passenger traffic activity by mode, 1995-2009 (pkm)**



Value 1995=100

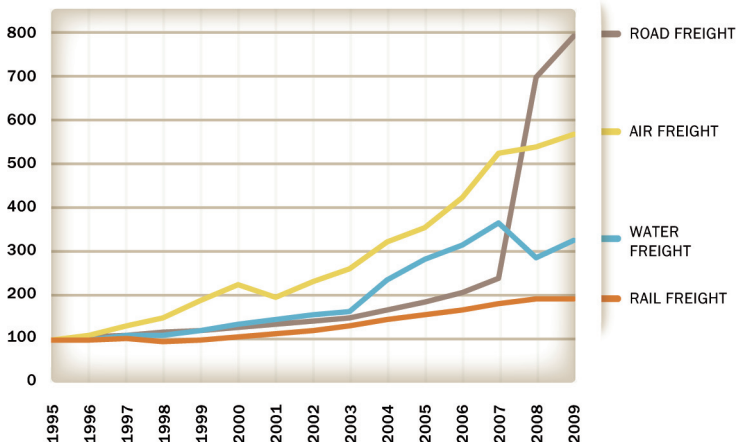
Source: UIC (2011a) and CNBS (2011)

Fig. 113: **Freight transport modal split, 2009 (% tkm)**



Source: UIC (2011a) and CNBS (2011)

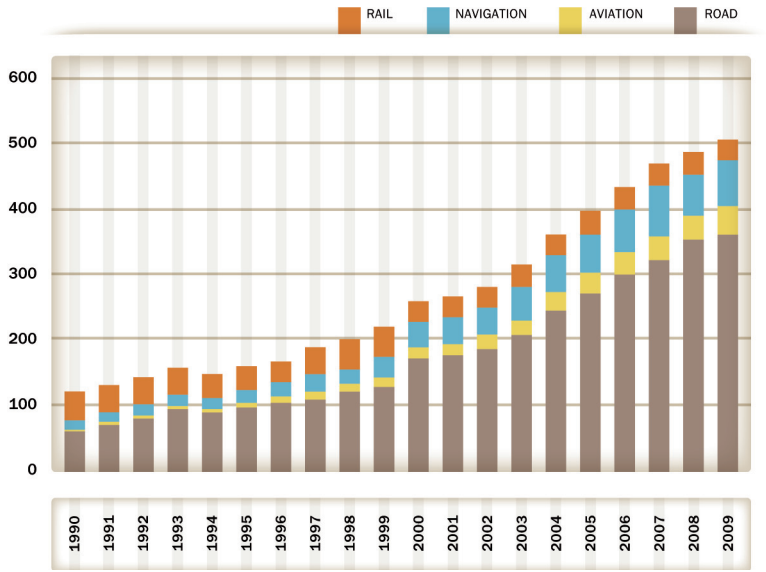
Fig. 114: **Freight traffic activity by mode, 1995-2009 (tkm)**



Value 1995=100

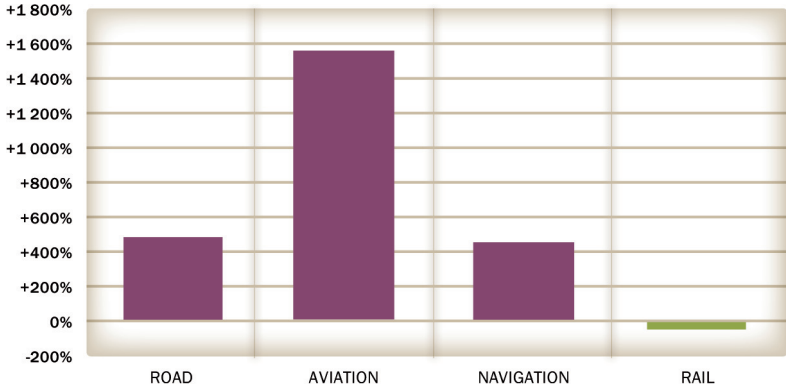
Source: UIC (2011a) and CNBS (2011)

Fig. 115: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



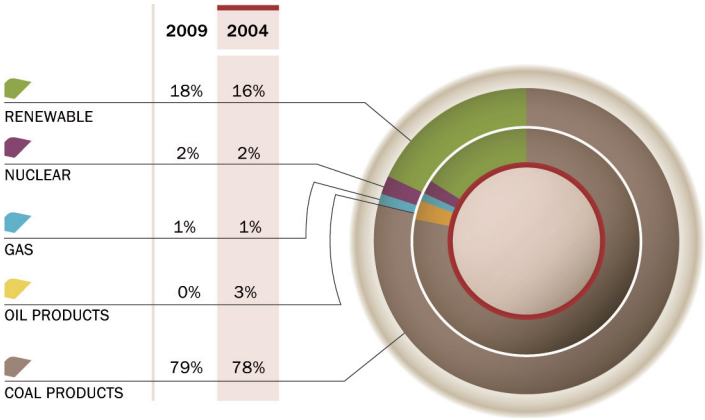
Source: IEA (2011a)

Fig. 116: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



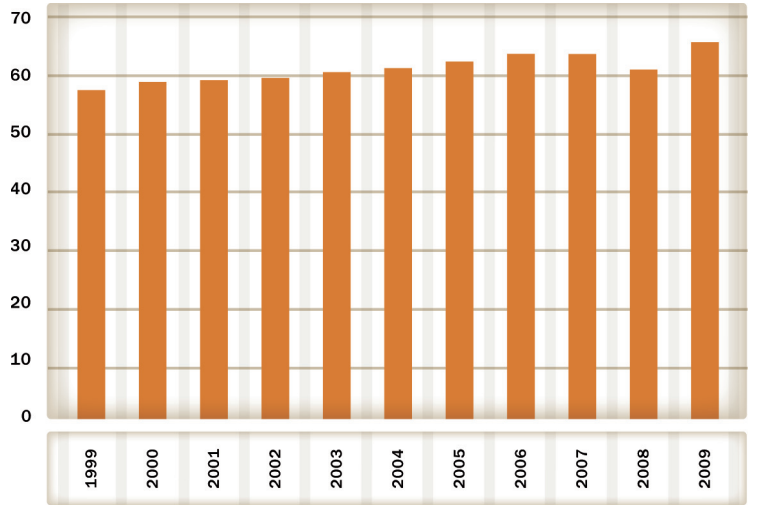
Source: IEA (2011a)

Fig. 117: **National electricity mix evolution, 2009 outside -2004 inside**



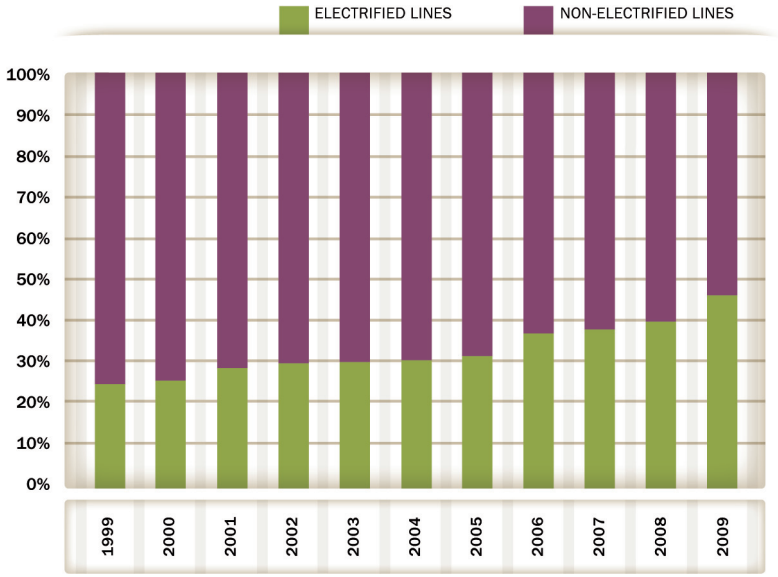
Source: IEA (2011b)

Fig. 118: **Length of railway line, 1999-2009 (thousand km)**



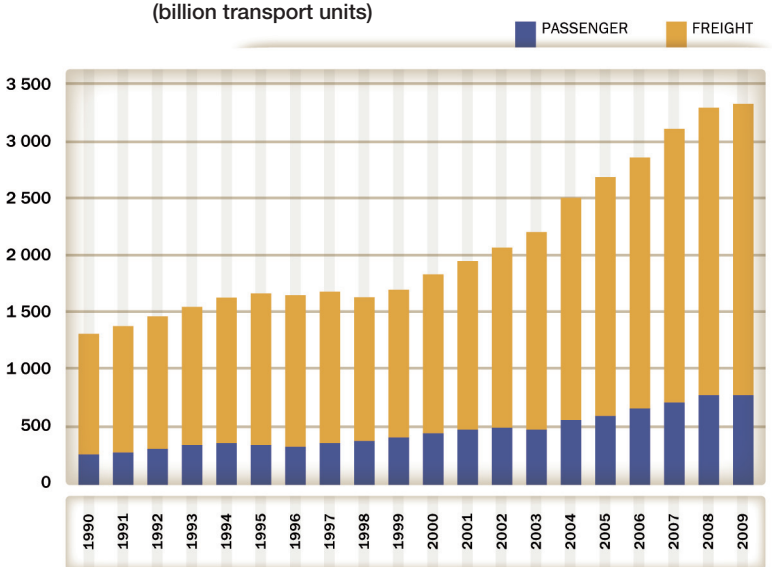
Source: UIC (2011a)

Fig. 119: **Line electrification share, 1999-2009 (% over total length of line)**



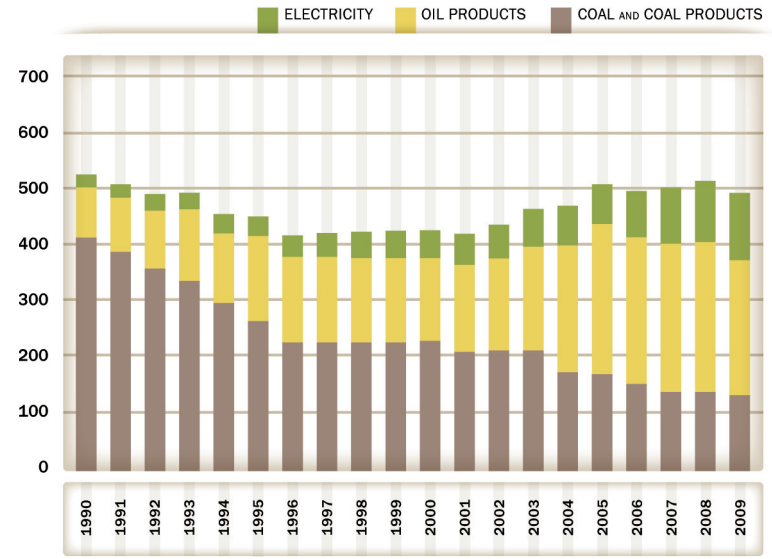
Source: UIC (2011a)

Fig. 120: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



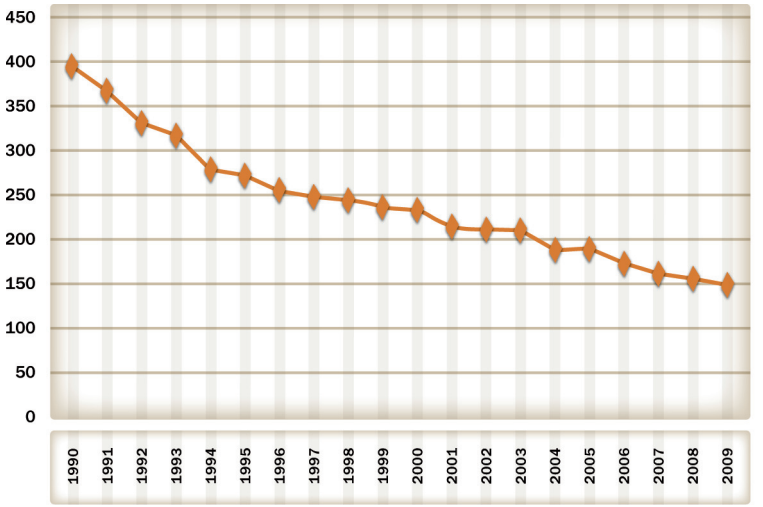
Source: UIC (2011a)

Fig. 121: **Railway energy consumption by fuel, 1990-2009 (PJ)**



Source: Elaboration from IEA (2011b)

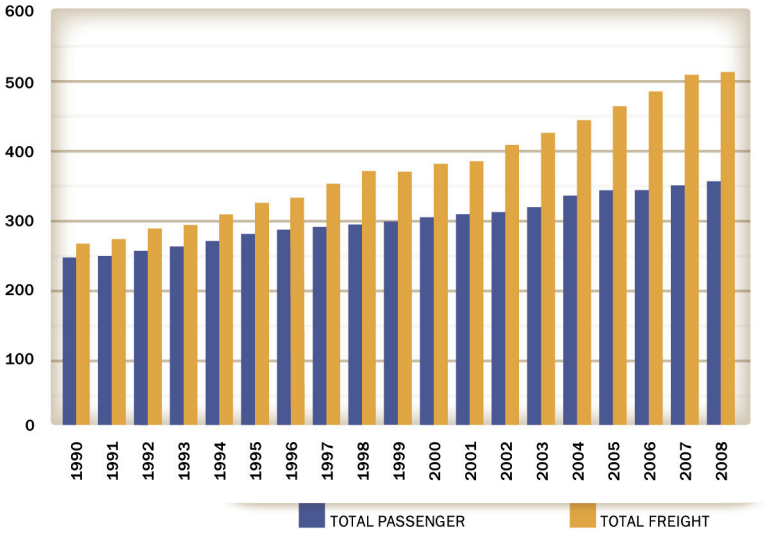
Fig. 122: **Railway specific energy consumption, 1990-2009 (kJ/transport unit)**



Source: Elaboration from IEA (2011b) and UIC (2011a)

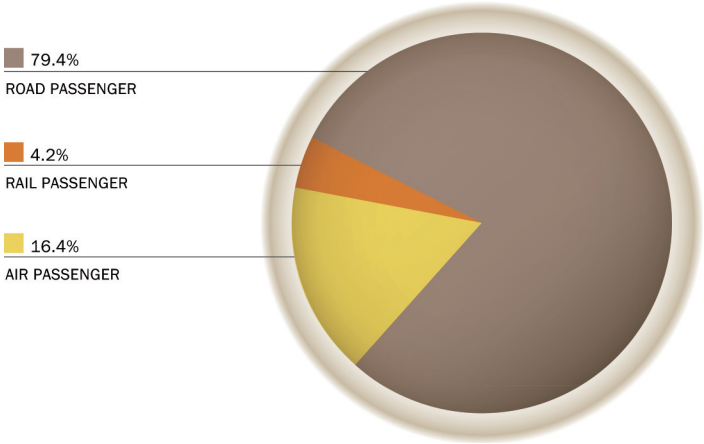
Australia

Fig. 123: **Passenger and freight transport activity, 1990-2008 (billion pkm and tkm)**



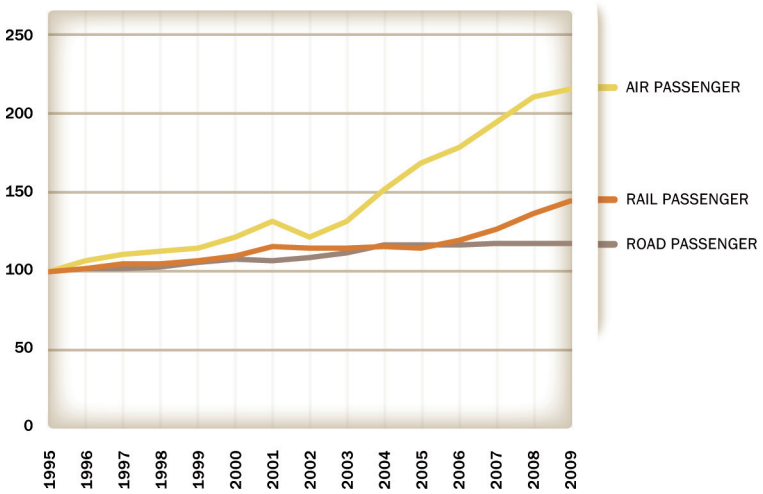
Source: OECD (2012) and BITRE (2011)

Fig. 124: **Passenger transport modal split, 2009 (% pkm)**



Source: OECD (2012) and BITRE (2011)

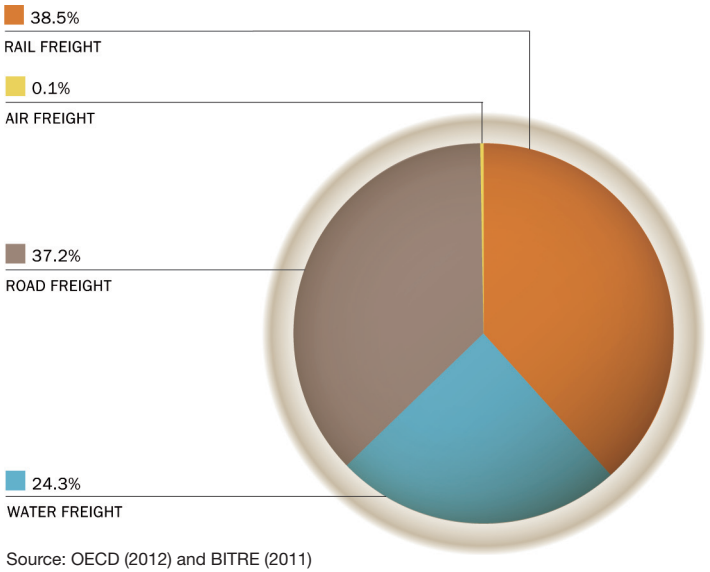
Fig. 125: **Passenger traffic activity by mode, 1995-2009 (pkm)**



Value 1995=100

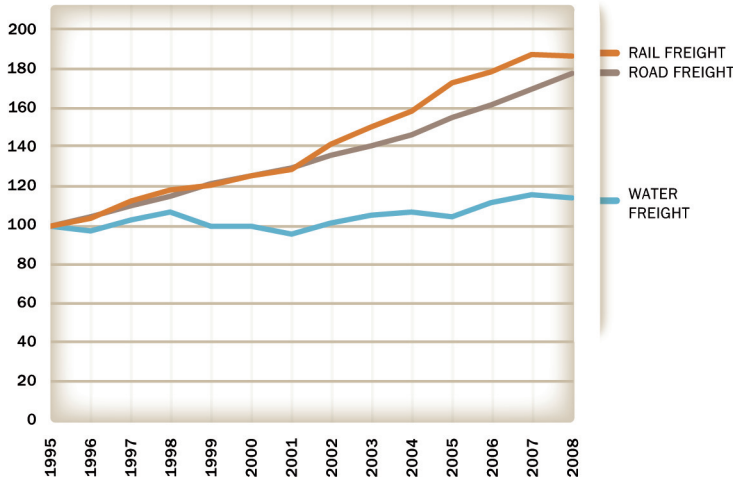
Source: OECD (2012) and BITRE (2011)

Fig. 126: **Freight transport modal split, 2008 (% tkm)**



Source: OECD (2012) and BITRE (2011)

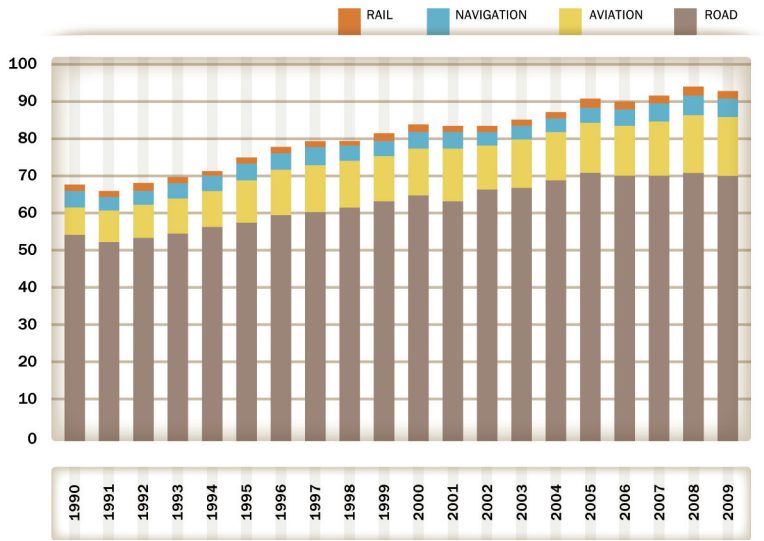
Fig. 127: **Freight traffic activity by mode, 1995-2008 (tkm)**



Value 1995=100

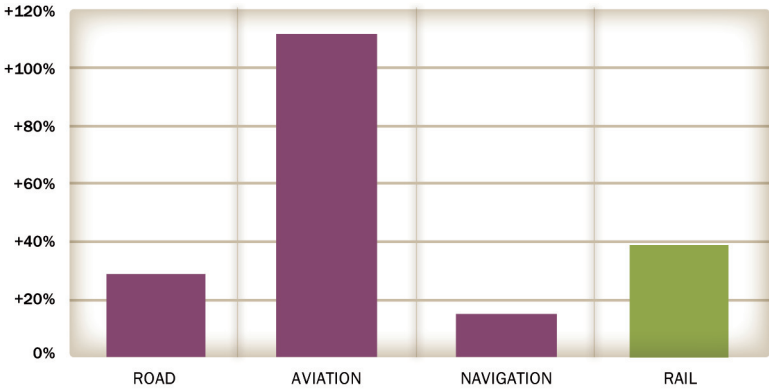
Source: OECD (2012) and BITRE (2011)

Fig. 128: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



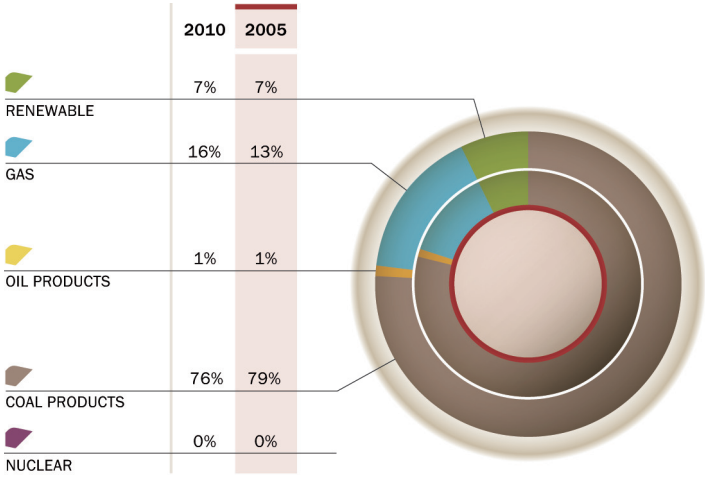
Source: IEA (2011a)

Fig. 129: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



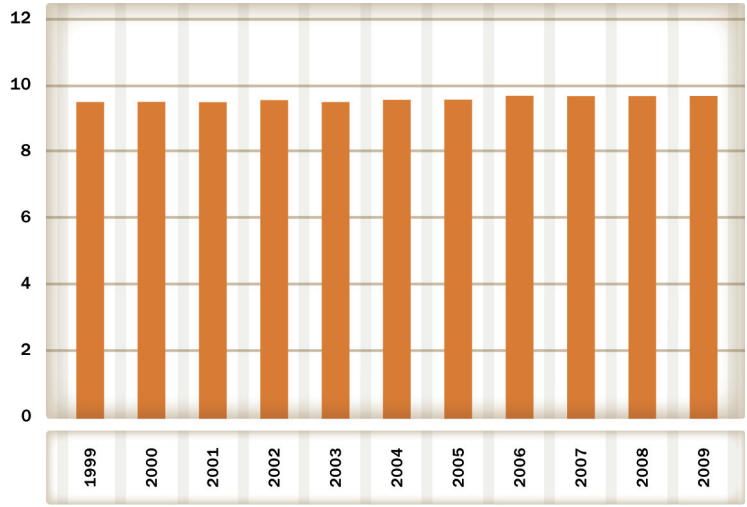
Source: IEA (2011a)

Fig. 130: **National electricity mix evolution, 2010 outside - 2005 inside**



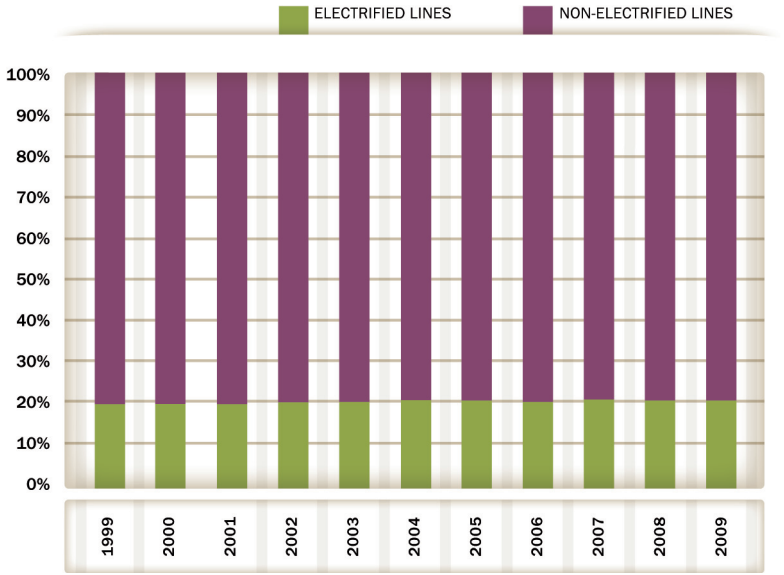
Source: IEA (2011b)

Fig. 131: **Length of railway line, 1999-2009 (thousand km)**



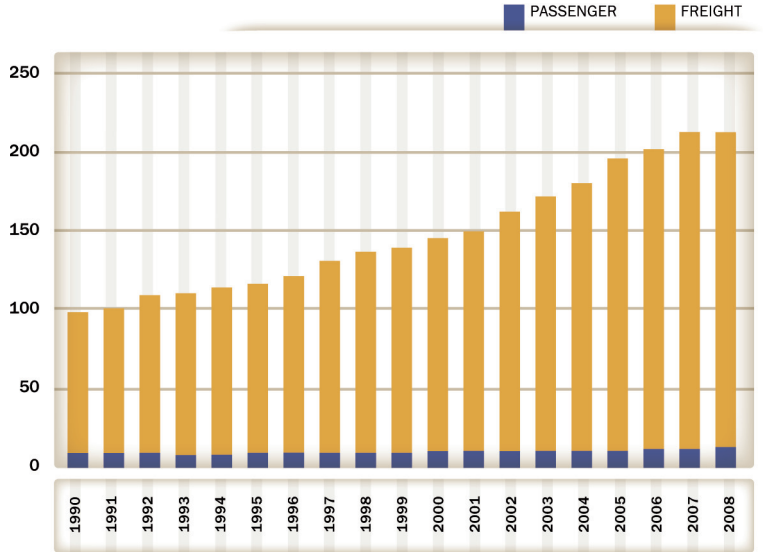
Source: UIC (2011a)

Fig. 132: **Line electrification share, 1999-2009 (% over total length of line)**



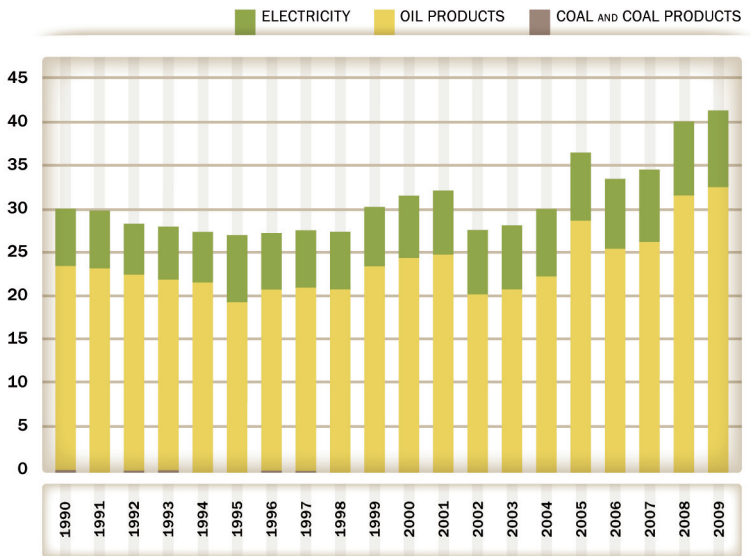
Source: UIC (2011a)

Fig. 133: **Railway transport activity for passenger and freight, 1990-2008 (billion transport units)**



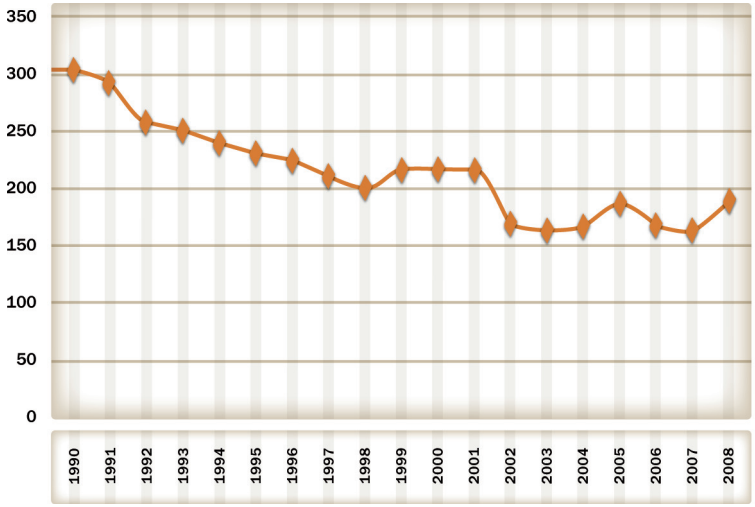
Source: UIC (2011a)

Fig. 134: **Railway energy consumption by fuel, 1990-2009** (PJ)



Source: IEA (2011b)

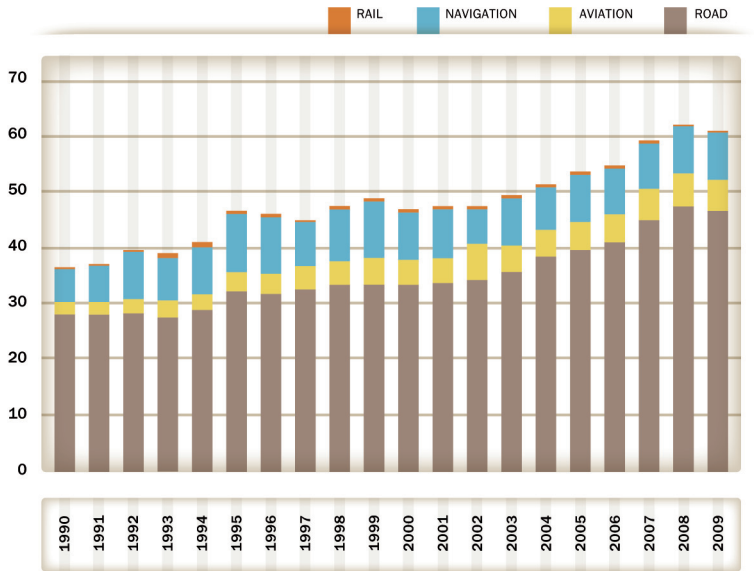
Fig. 135: **Railway specific energy consumption, 1990-2008 (kJ/transport unit)**



Source: IEA (2011b) and UIC (2011a)

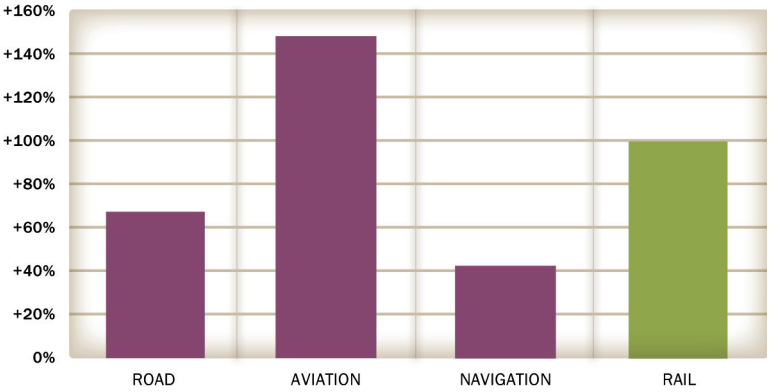
South Africa

Fig. 136: **Transport CO_2 emissions by mode, 1990-2009 (million tonnes)**



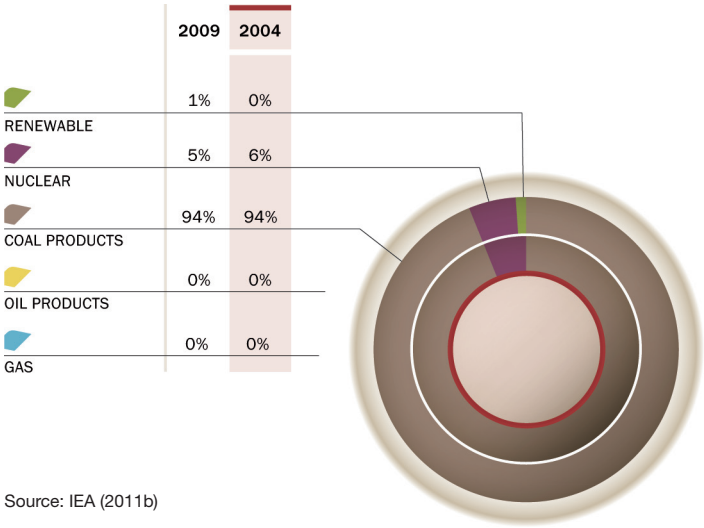
Source: IEA (2011a)

Fig. 137: **Change in CO_2 emissions from fuel combustion by mode between 1990 and 2009**



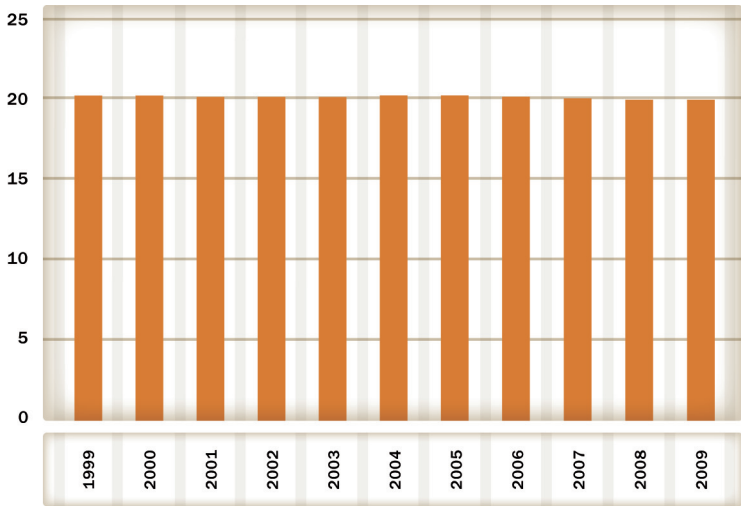
Source: IEA (2011a)

Fig. 138: **National electricity mix evolution, 2009 outside - 2004 inside**



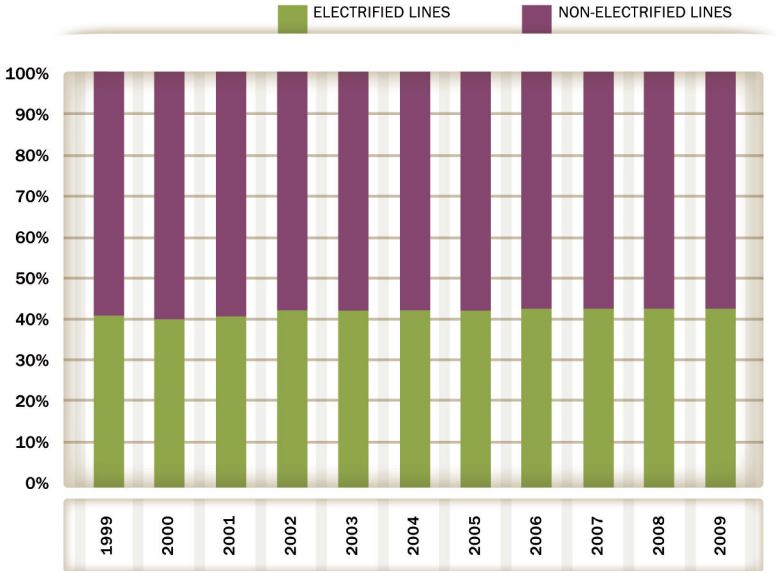
Source: IEA (2011b)

Fig. 139: **Length of railway line, 1999-2009 (thousand km)**



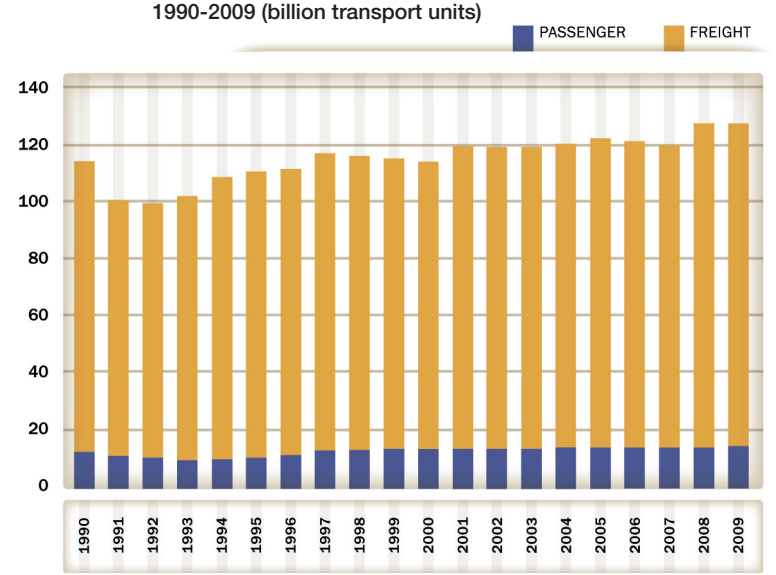
Source: Elaboration from UIC (2011a)

Fig. 140: **Line electrification share, 1999-2009 (% over total length of line)**



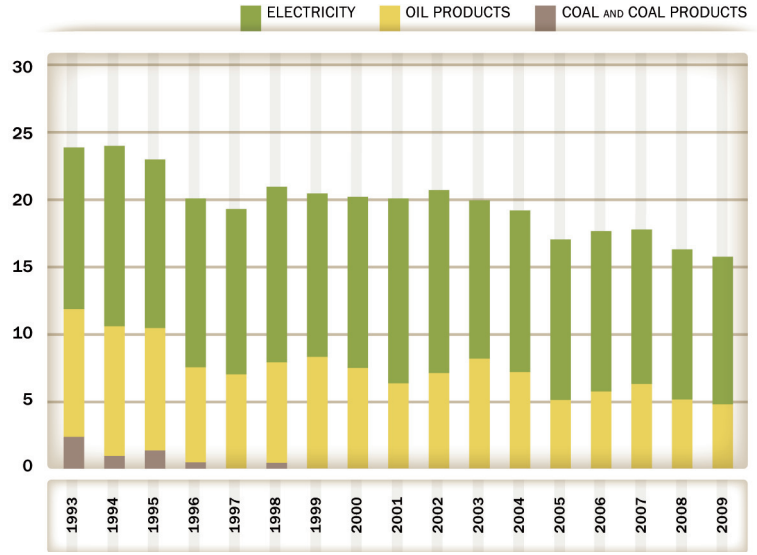
Source: Elaboration from UIC (2011a)

Fig. 141: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



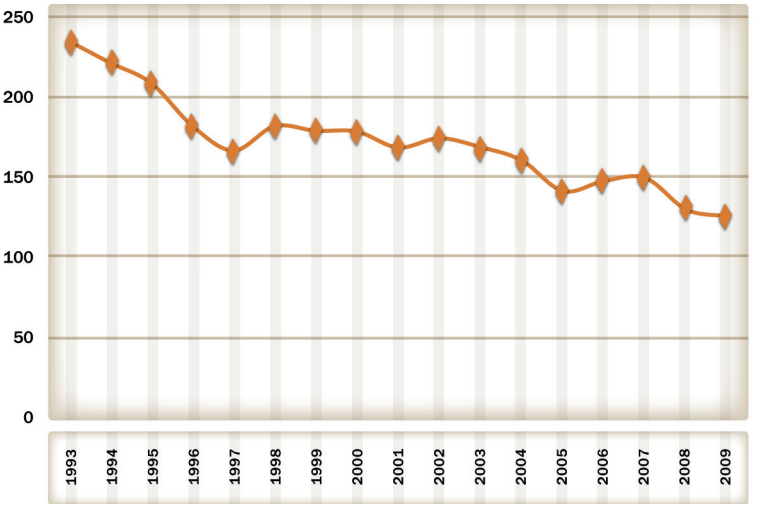
Source: Elaboration from UIC (2011a)

Fig. 142: **Railway energy consumption by fuel, 1993-2009 (PJ)**



Source: IEA (2011b)

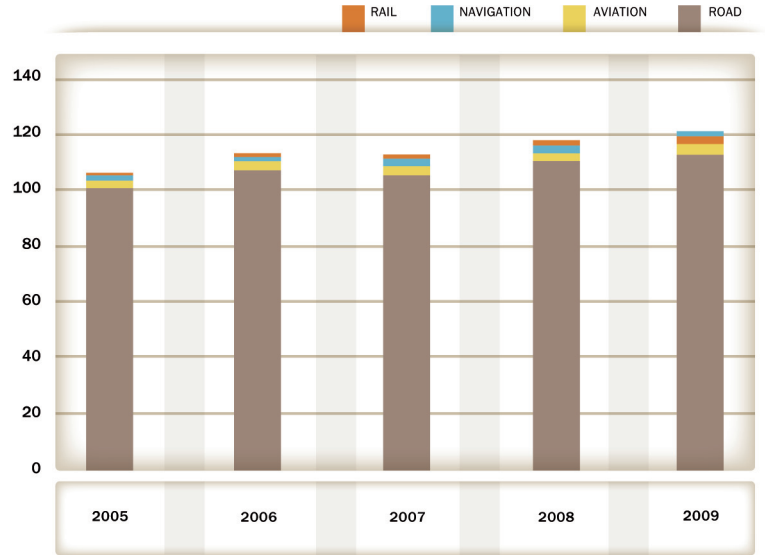
Fig. 143: **Railway specific energy consumption, 1993-2009 (kJ/transport unit)**



Source: Elaboration from IEA (2011b) and UIC (2011a)

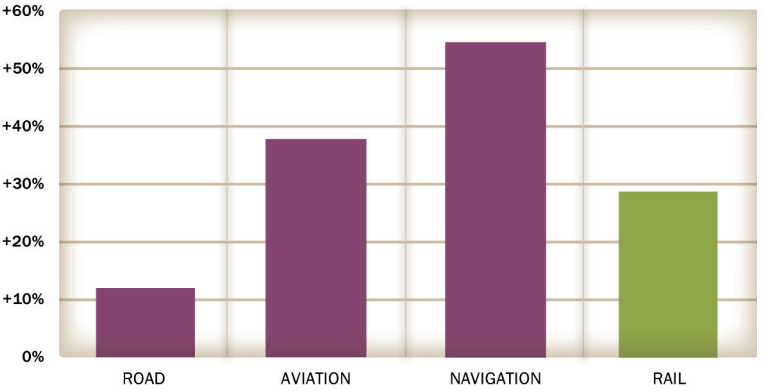
Islamic Republic of Iran

Fig. 144: **Transport CO_2 emissions by mode, 2005-2009 (million tonnes)**



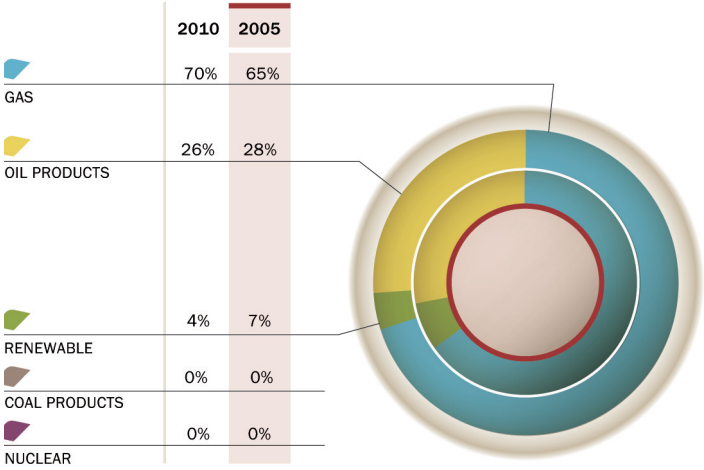
Source: Elaboration from IEA (2011a), UIC (2011a) and RAI (2012)

Fig. 145: **Change in CO_2 emissions from fuel combustion by mode between 2005 and 2009**



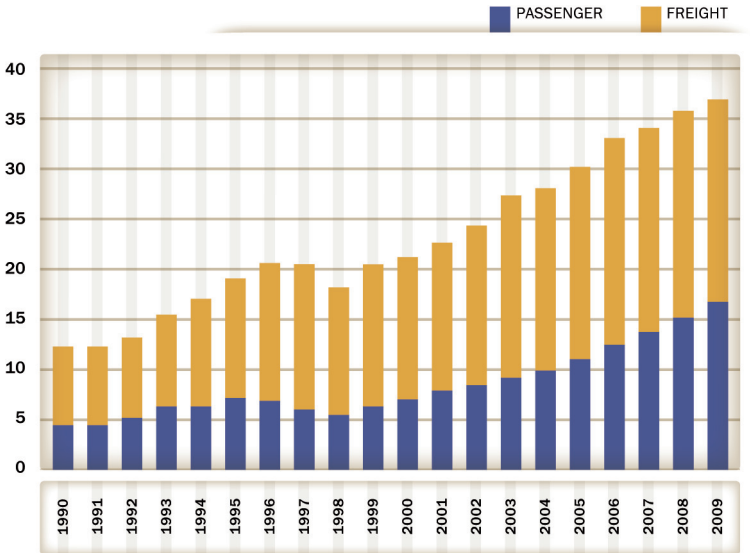
Source: Elaboration from IEA (2011a), UIC (2011a) and RAI (2012)

Fig. 146: **National electricity mix evolution, 2010 outside - 2005 inside**



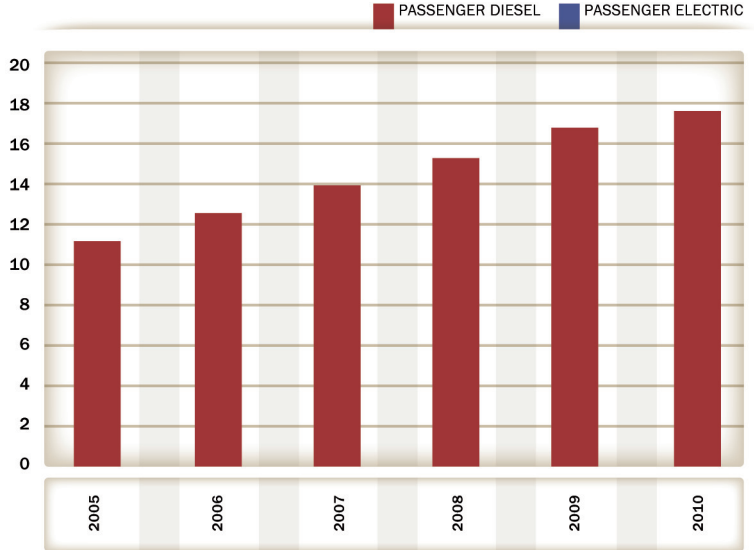
Source: IEA (2011b)

Fig. 147: **Railway transport activity for passenger and freight, 1990-2009 (billion transport units)**



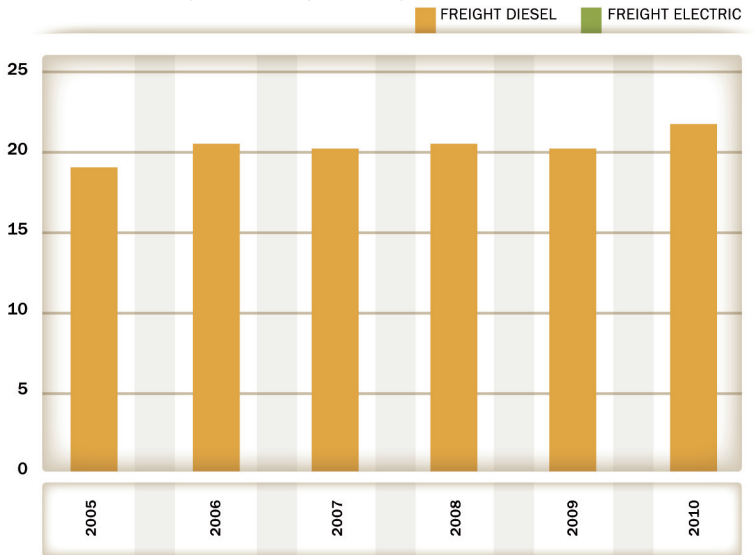
Source: UIC (2011a)

Fig. 148: **Railway passenger transport activity for electric and diesel traction, 2005-2010 (billion transport units)**



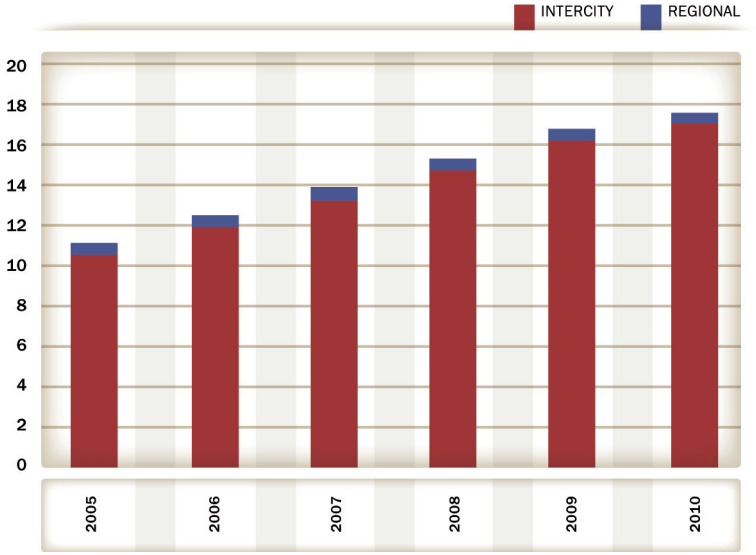
Source: RAI (2012)

Fig. 149: **Railway freight transport activity for electric and diesel traction, 2005-2010 (billion transport units)**



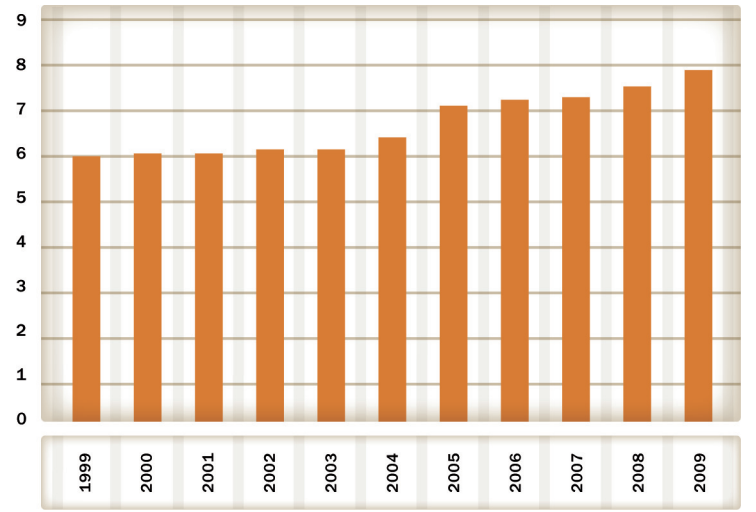
Source: RAI (2012)

Fig. 150: **Railway passenger transport activity by service type, 2005-2010 (billion transport units)**



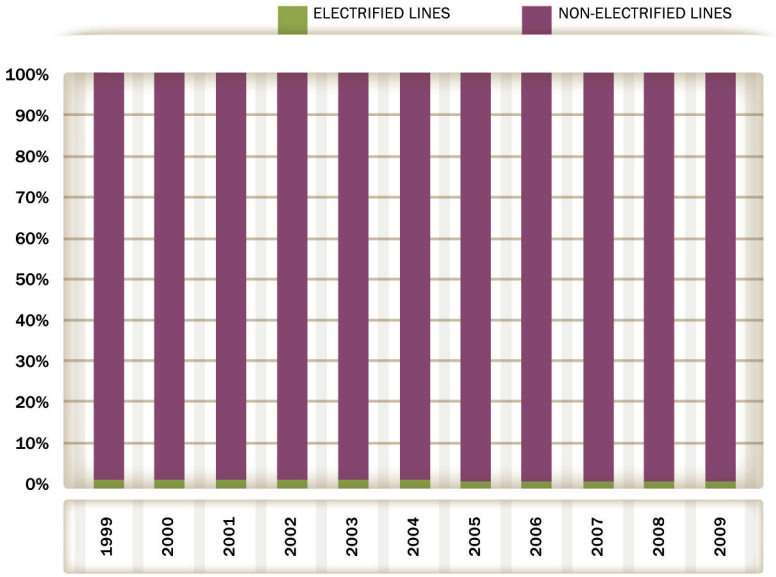
Source: RAI (2012)

Fig. 151: **Length of railway line, 1999-2009 (thousand km)**



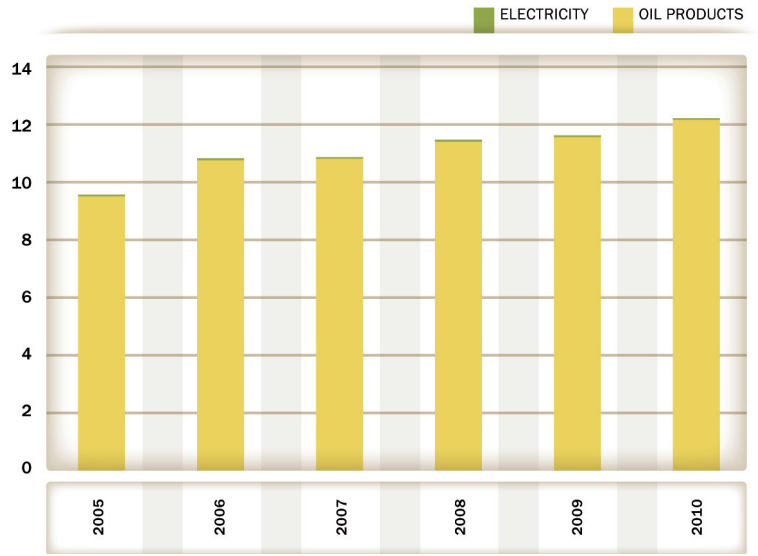
Source: UIC (2011a)

Fig. 152: **Line electrification share, 1999-2009 (% over total length of line)**



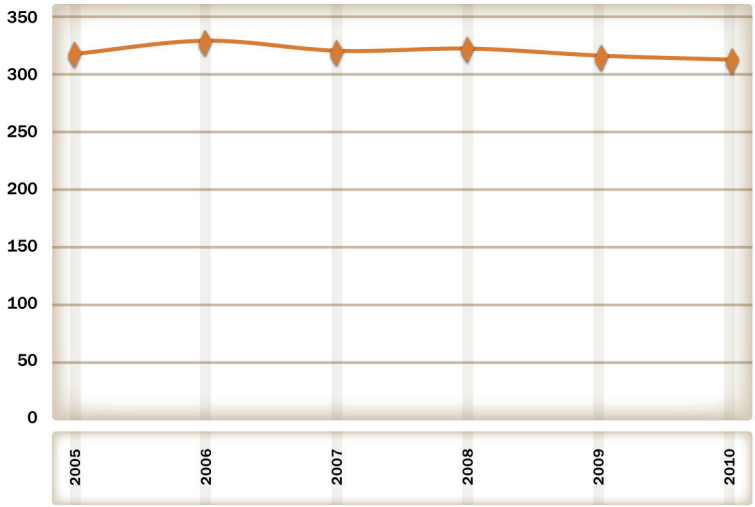
Source: UIC (2011a)

Fig. 153: **Railway energy consumption by fuel, 2005-2010 (PJ)**



Source: Elaboration from RAI (2012)

Fig. 154: **Railway specific energy consumption, 2005-2010 (kj/transport unit)**



Source: Elaboration from RAI (2012)

Methodology Notes

The data used in this publication has mainly been extracted from three sources: the International Energy Agency (IEA), the International Union of Railways (UIC) and the European Commission (see References). UIC data do not include urban rail metro and train services.

It has to be noted that European Commission activity data for air and sea transport in EU27 (for both passenger and freight) only includes domestic and intra-EU27 transport, while IEA data for CO_2 emissions also includes the EU share of international transport.

Another important consideration to be taken into account when reading this data handbook is that the IEA *CO_2 from fuel combustion* database does not attribute any CO_2 emissions from the use of electricity in the transport sector. The CO_2 emissions from electricity generation are attributed to the power sector. The power sector, even though not being a final user of energy, is subjected to its own objective in terms of CO_2 emission reduction, such as the EU ETS in the EU.

Railway CO_2 emissions in Fig.9 and Fig. 14are an exception to the previous rule, as those figures take into account emissions for the whole railway sector, including electric traction. Accordingly, in Fig.9 the emissions for electric traction have not been counted in the power sector.
Trends for passenger transportation until 2050 (Fig.15) have been generated with the IEA Mobility Model (MoMo).

IEA Mobility Model (MoMo)

Over the past 10 years the IEA has developed the Mobility Model, a global transport spreadsheet model that allows projections and policy analysis to 2050, with considerable regional and technology detail. It includes all transport modes and most vehicle and technology types. MoMo is linked to the ETP optimisation model that is used to produce the ETP publication series (IEA, 2012).

MoMo covers 29 countries and regions. It contains assumptions on technology availability and cost at different points in the future, how costs could drop if technologies are deployed at a commercial scale, and other features. It therefore allows fairly detailed bottom-up "what-if" modelling. Energy use is estimated using a bottom-up approach. MoMo is used to produce projections of vehicle sales, stocks and travel, energy use, GHG emissions (on a vehicle and well-to-wheel basis). It allows a comparison of marginal costs of technologies and aggregates to total cost across all modes and regions for a given scenario.

More information on MoMo is provided in IEA (2009).

Glossary

Electrified track
Track provided with an overhead catenary or a conductor rail to permit electric traction.

Electrified line
Line with one or more electrified running tracks.

Energy consumption by rail transport
Final energy consumed by tractive vehicles for traction, train services and facilities (heating, air conditioning,lighting etc.).

Gross tonne-kilometre hauled
Unit of measurement representing the movement over a distance of one kilometre of one tonne of hauled vehicles (and railcars) and contents.

HDV
Heavy Duty Vehicle (gross vehicle weight >3.5 tonnes)

Passenger-kilometre (pkm)
Unit of measurement representing the transport of one passenger over a distance of one kilometre.

P2W
Powered 2 wheelers

PLDV
Passenger light duty vehicle

Tonne-kilometre (tkm)
Unit of measurement of goods transport which represents the transport of one tonne of goods over a distance of one kilometre.

Tonne of oil equivalent (toe)
Unit of measurement of energy consumption: 1 toe = 41.868GJ

Train-kilometre
Unit of measurement representing the movement of a train over one kilometre.

Transport Unit (tu)
The sum of passenger kilometre and tonne-kilometre

TTW: Tank to wheel

WTT: Well to tank

WTW: Well to Wheel

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