



# RAILWAY HANDBOOK 2012



## ENERGY CONSUMPTION AND CO<sub>2</sub> EMISSIONS



International  
Energy Agency



INTERNATIONAL UNION  
OF RAILWAYS

**Railway Handbook 2012**  
**Energy Consumption**  
**and CO<sub>2</sub> 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.

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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.



■ UIC Members

[WWW.UIC.ORG](http://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<sub>2</sub> emissions of world railway sector”.

Tracking progress of energy use and CO<sub>2</sub> 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 questionnaires.

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

Energy and CO<sub>2</sub> data provide the key to understand environmental issues and decarbonize the transport sector and we need them as a foundation on which to build the greening of our future choices.

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

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Energy Agency

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## Acknowledgments

This publication has been possible thanks to UIC railway members (that fed constantly the UIC Railway Energy and CO<sub>2</sub> Database since 2005 with commitment and patience) and to IEA Statistics Department, that collected and managed energy balances and CO<sub>2</sub> emissions data from fuel combustion.

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

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

**Railway Handbook 2012**



**Energy Consumption  
and CO<sub>2</sub> Emissions**



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## Introduction

### IEA Transport statistics and UIC energy database

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The transport sector is responsible of nearly 30% of energy-based CO<sub>2</sub> emissions in OECD countries, mainly due to road traffic. Transport CO<sub>2</sub> total emissions have constantly increased since 1990 in most OECD countries and all transport modes – except railways – have increased their emissions from fuel combustion (IEA, 2011a).

The International Energy Agency, 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 energy statistics for OECD countries and CO<sub>2</sub> emissions from fuel combustion, which include transport-related data.

The International Union of Railways represents more than 200 railway companies and associations in the world. The railway companies operating in OECD countries produce less than 2% of total CO<sub>2</sub> emissions (IEA, 2011a and UIC, 2011b).

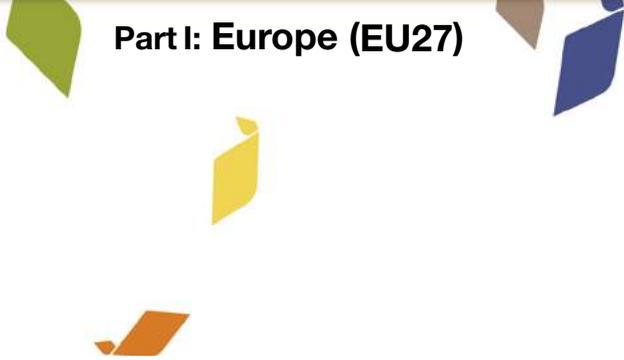
Because of their low-carbon performance, railways are considered an important milestone to reach sustainable mobility. Trains, especially in Europe, rely mostly on electricity, and the electricity markets are already subjected to mechanisms to lower the carbon content of electricity through the EU ETS (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, UIC started to collect energy and CO<sub>2</sub> 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<sub>2</sub> emission trends from 1990

In this book you will find the result of the effort of harmonizing the UIC energy/CO<sub>2</sub> railway database with IEA world energy balances (IEA, 2011a), and CO<sub>2</sub> from fuel combustion (IEA 2012b) databases.

The publication is divided into a European part and a Non-European part. 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<sub>2</sub> data from railway operators. The UIC and the IEA are calling for a harmonized and global approach to reach such a standard across all regions. This publication is aiming to be updated yearly. Hopefully, the next edition of the data handbook will embrace a wider set of countries representing more accurately the energy and CO<sub>2</sub> performance of the global railway sector.



## Part I: Europe (EU27)

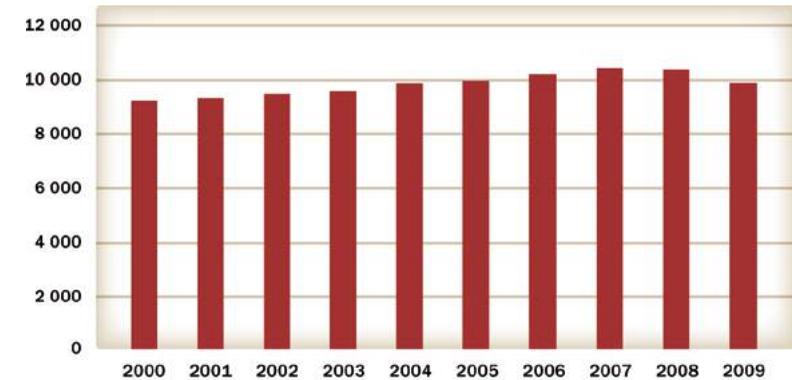


## Transport Trends and Modal Split

### Key facts

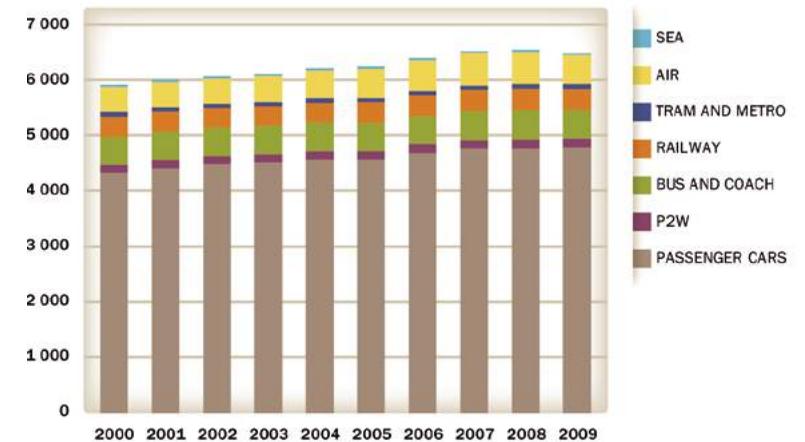
- ◆ Total transport demand in Europe has grown by 7% from 2000 to 2009.
- ◆ The financial and economic crisis has substantially decreased transport demand between 2008 and 2009, in particular for the freight sector (-12% from 2008 to 2009).
- ◆ In 10 years (2000-2009), no significant change in modal 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)



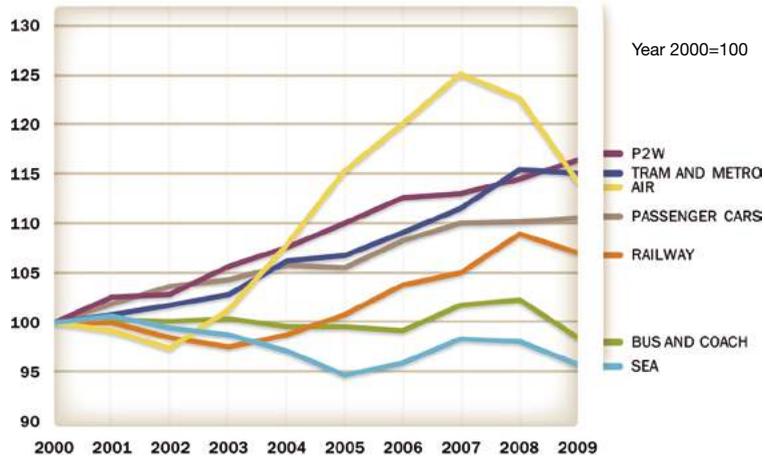
Source: Elaboration based on EC (2011) and UIC (2011a)

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



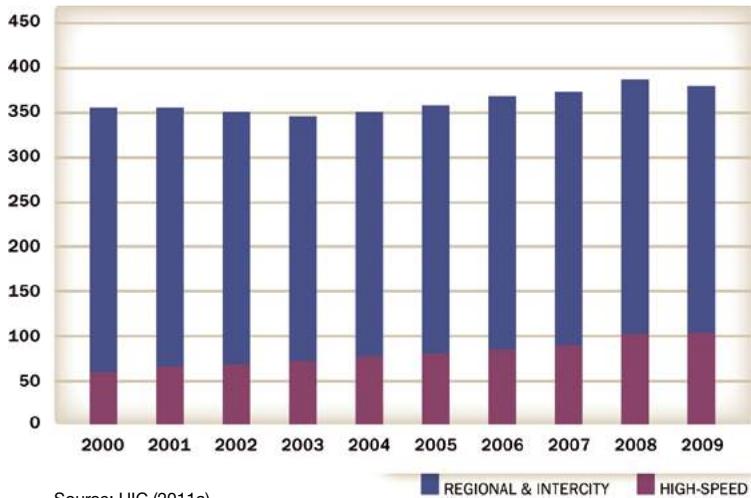
Source: EC (2011) and UIC (2011a)

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



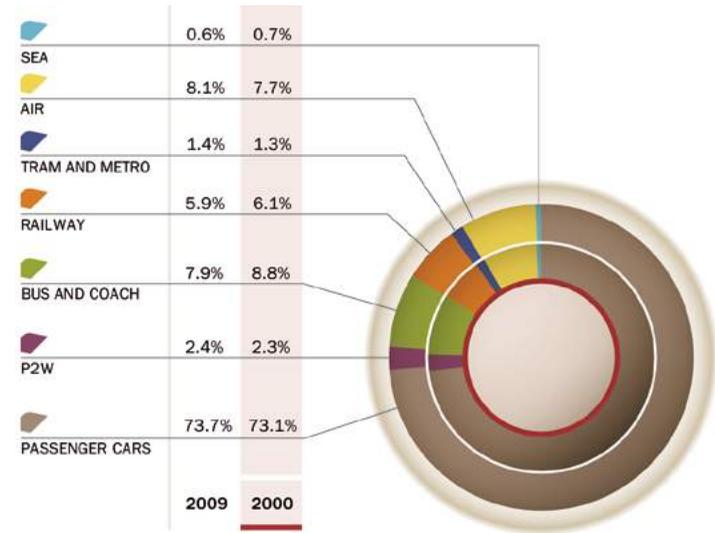
Source: EC (2011) and UIC (2011a)

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



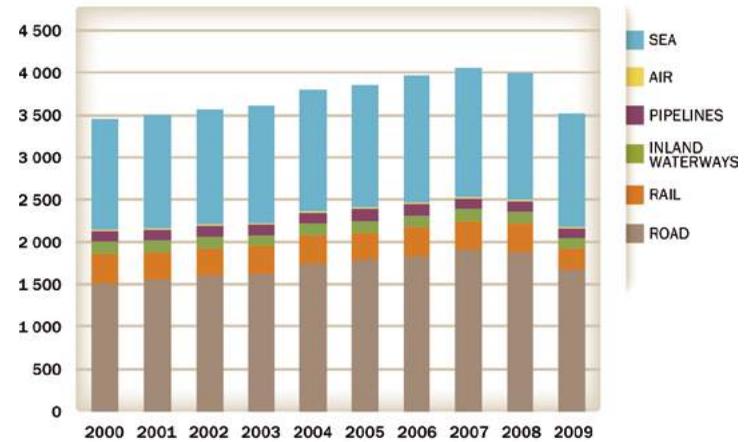
Source: UIC (2011a)

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



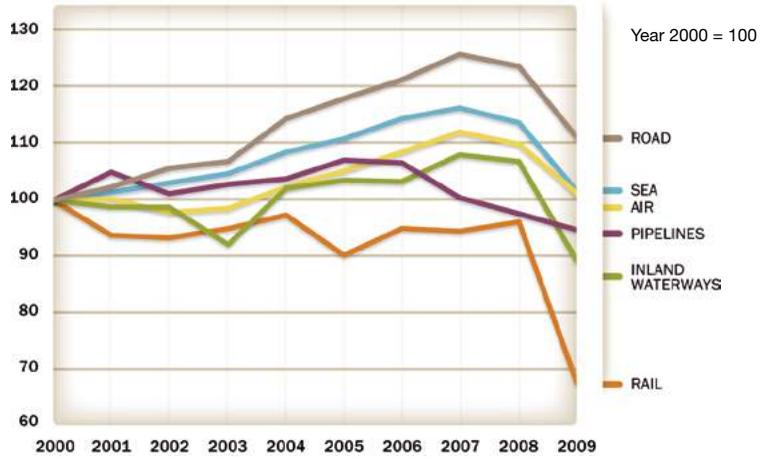
Source: EC (2011) and UIC (2011a)

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



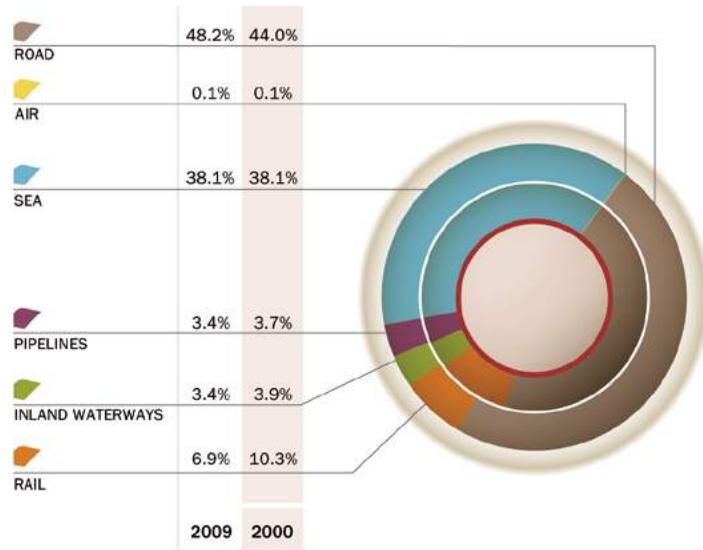
Source: EC (2011) and UIC (2011a)

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



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

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



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

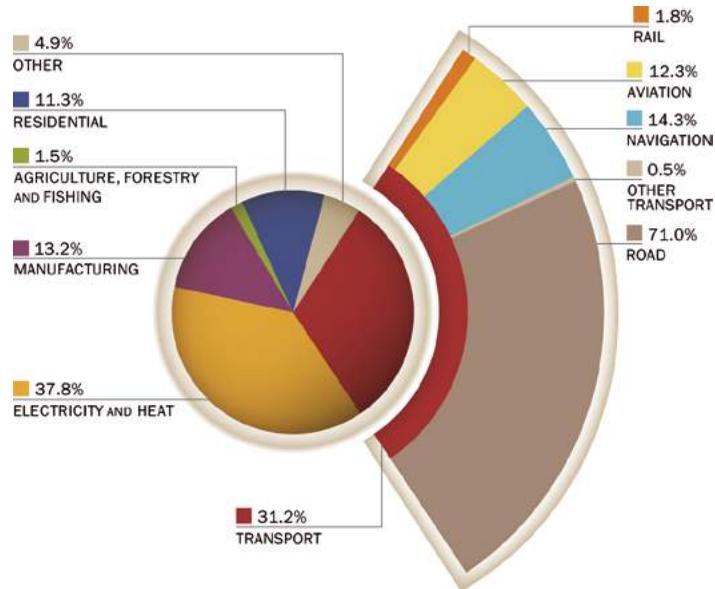


## Energy Consumption and CO<sub>2</sub> Emissions of Transport Sector

### Key facts

- ◆ The transport sector in 2009 was responsible for about 31% of total CO<sub>2</sub> emission from fuel combustion in Europe.
- ◆ In 2009, road was responsible for 71% of total CO<sub>2</sub> emission from transport sector. Navigation was responsible for 14.3% and aviation for 12.3%. Railways produced 18% of total CO<sub>2</sub> emission from transport sector, corresponding to 0.6% of total CO<sub>2</sub> emission in EU27.
- ◆ Transport CO<sub>2</sub> 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<sub>2</sub> Emissions from fuel combustion by sector, 2009

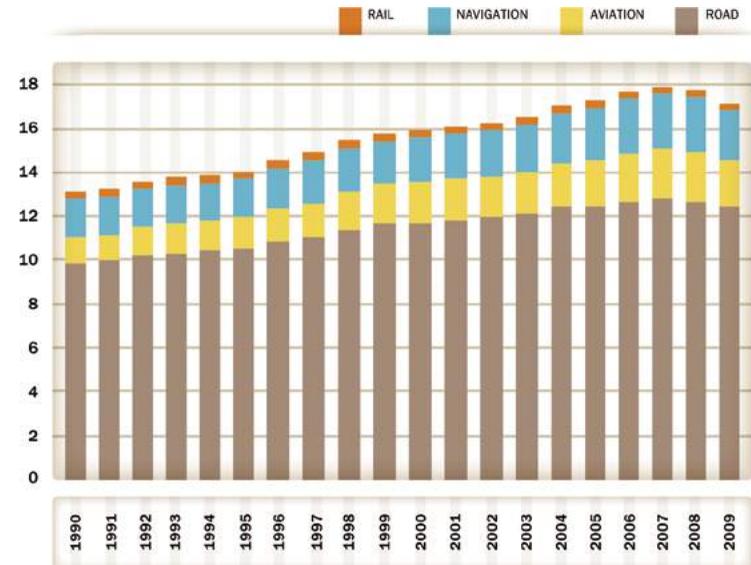


Transport modal share, 2009 (transport units)



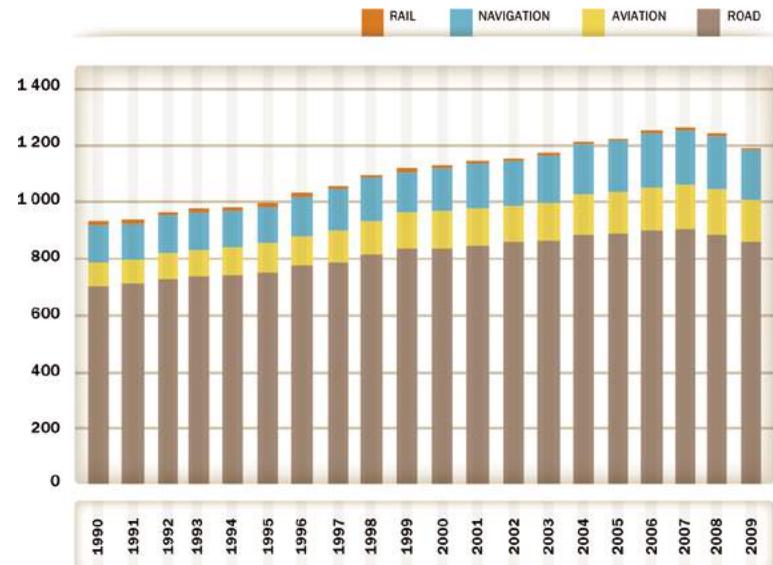
Source: IEA (2011a) and UIC (2011b)

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



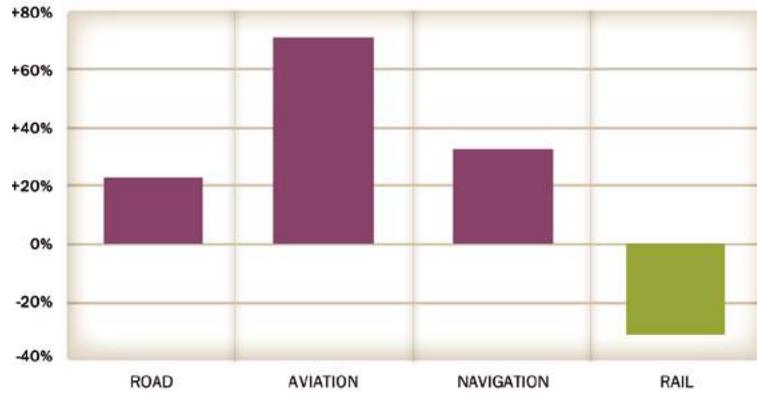
Source: IEA (2011b)

Fig.11: Transport sector CO<sub>2</sub> emissions by mode, 1990-2009 (million tCO<sub>2</sub>)



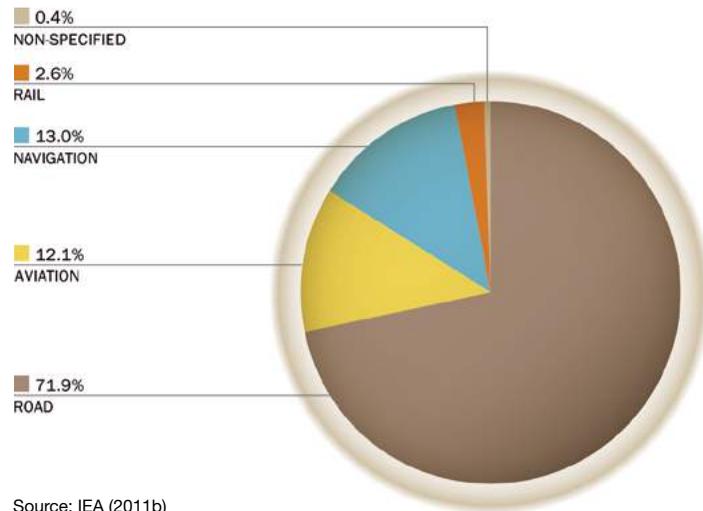
Source: IEA (2011a)

Fig.12: Change in CO<sub>2</sub> emissions from fuel combustion by mode, 1990-2009



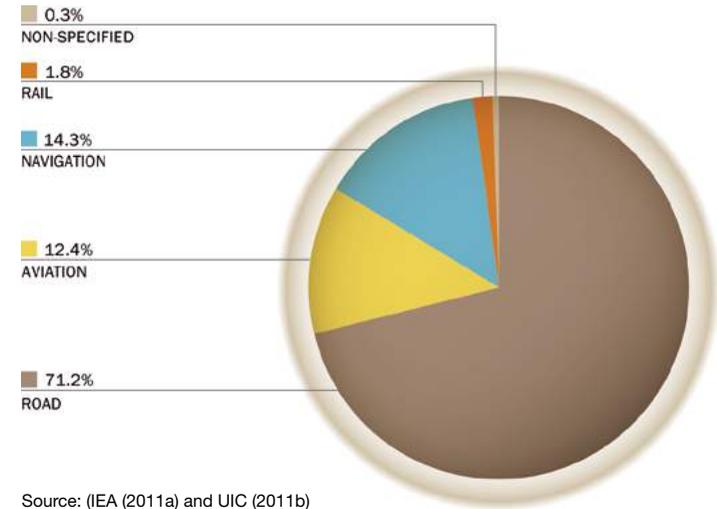
Source: elaboration based on IEA (2011a)

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



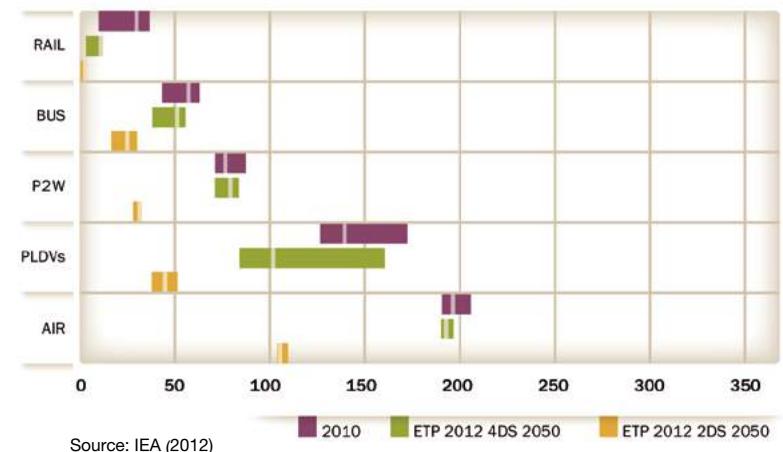
Source: IEA (2011b)

Fig.14: Transport sector CO<sub>2</sub> emissions by mode, 2009



Source: (IEA (2011a) and UIC (2011b)  
Note: See Methodology notes pag.101

Fig.15: EU27 evolution of the GHG intensity of motorised passenger transport modes, 2010-2050 (WTW gCO<sub>2</sub>/pkm)



Source: IEA (2012)

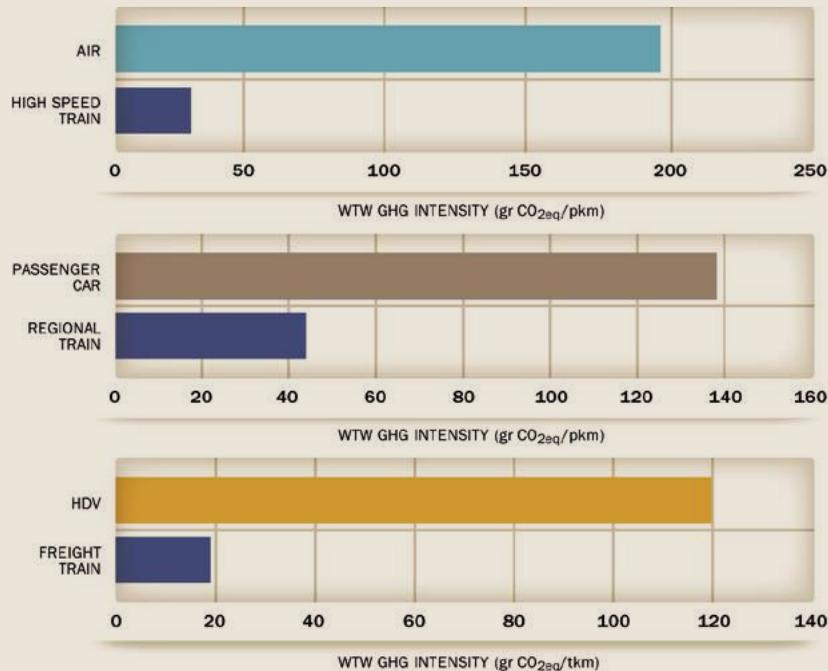


## CROSS INDICATORS: plane vs highspeed, car vs regional, freight train vs HDVs

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 its needs. Taking greenhouse gases into account is important, and interactive tools such as EcoPassenger and EcoTransit 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<sub>2</sub>/pkm, not drastically changing the picture shown below.

Fig.16: plane vs highspeed, car vs regional, freight train vs HDVs



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



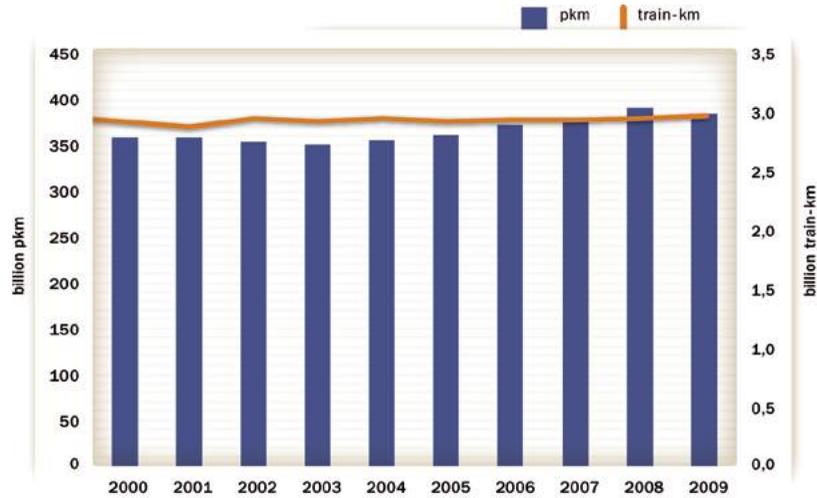
## The Railway Sector

### Key facts

- ◆ The total length of railway lines in Europe is stable from 1990 (around 210 000 km).
- ◆ In 1990, only 30% of railway lines were electrified. In 2009, this percentage reached 53%. Around 80% of the traffic is performed nowadays with electrified trains.
- ◆ Railways have definitely 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.
- ◆ In general, the carbon intensity of electricity used by railways is constantly decreasing.
- ◆ 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.
- ◆ Railways have committed to reduce in 2020 their specific emissions by 30%, calculated from 1990.
- ◆ From 1990 to 2009, railways have reduced total CO<sub>2</sub> 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.

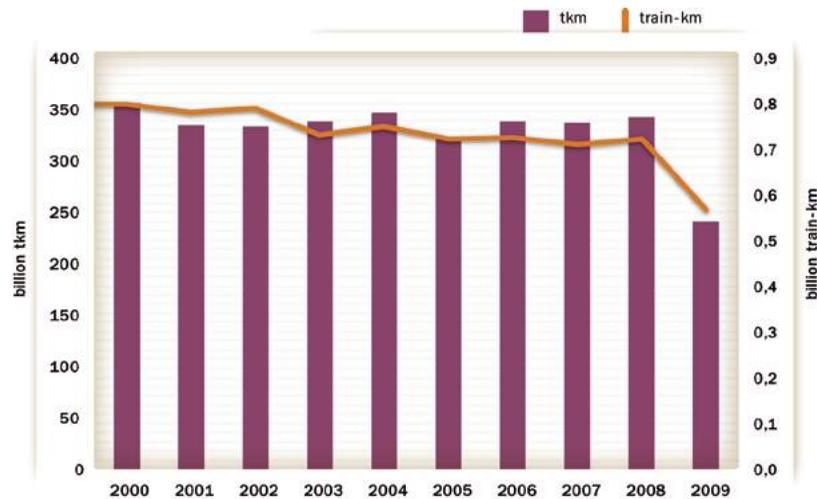
## Total activity passenger and freight

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



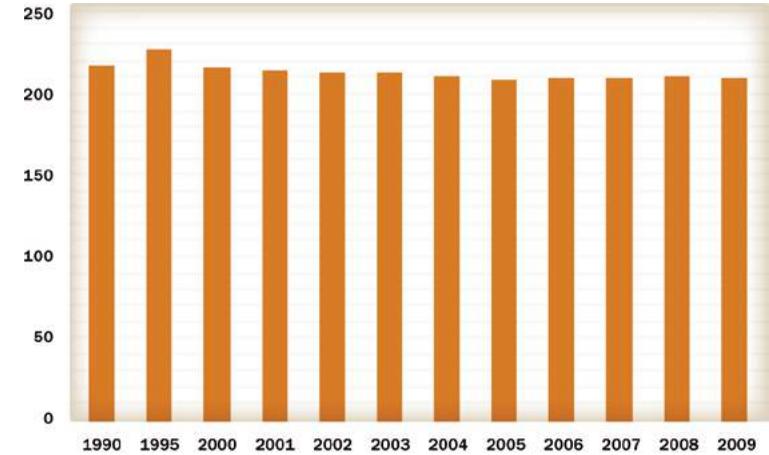
Source: UIC (2011a)

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



Source: UIC (2011a)

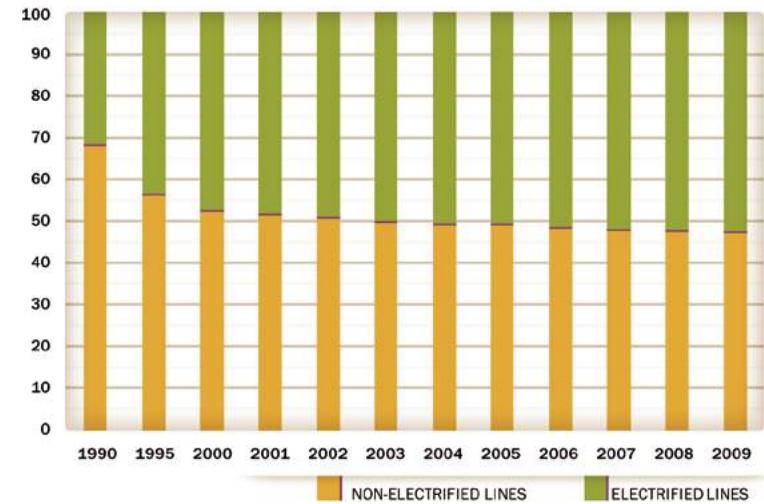
Fig.19: Length of railway line in operation, 1990-2009 (thousands km)



Source: UIC (2011a)

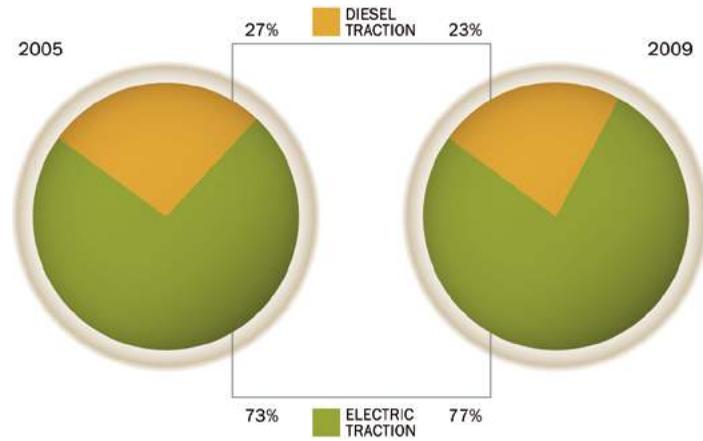
## Electric and diesel

Fig.20: Share of electrified versus non-electrified railway lines, 1990-2009



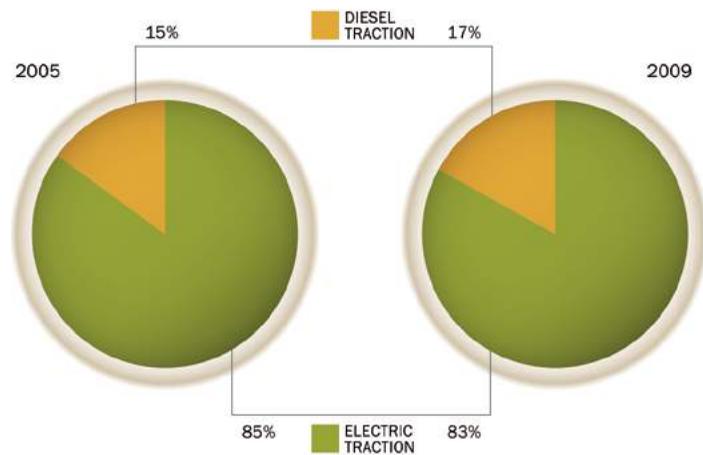
Source: elaboration based on UIC (2011a)

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



Source: elaboration based on UIC (2011b)

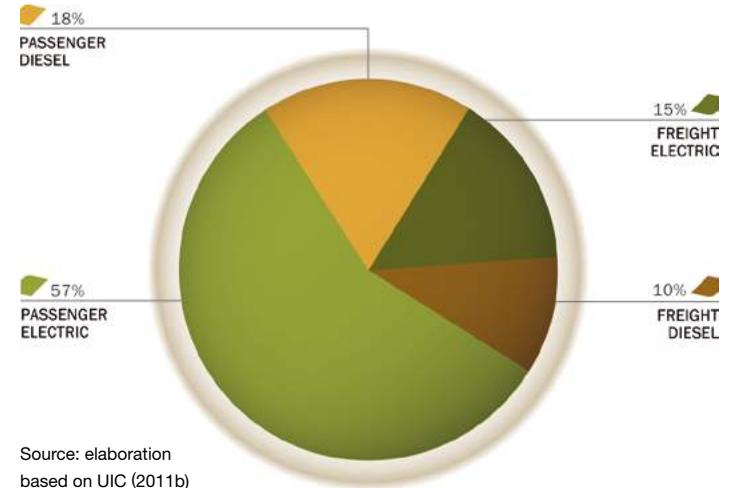
Fig.22: Freight activity split by traction type, 2005 and 2009 (train-km)



Source: elaboration based on UIC (2011b)

## Energy consumption

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



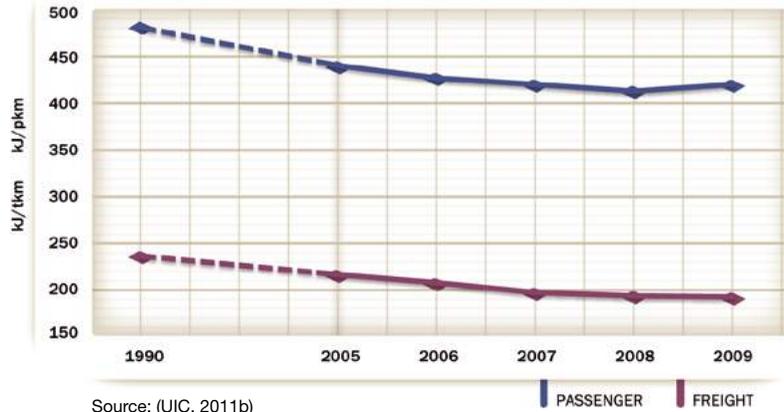
Source: elaboration based on UIC (2011b)

Table 1: Railway energy consumption by train type and traction type, 2005-2009 (PJ)

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

Source: elaboration based on UIC (2011b)

Fig.24: Specific energy consumption, Passenger and freight, 1990-2009 (kJ/pkm, kJ/tkm)



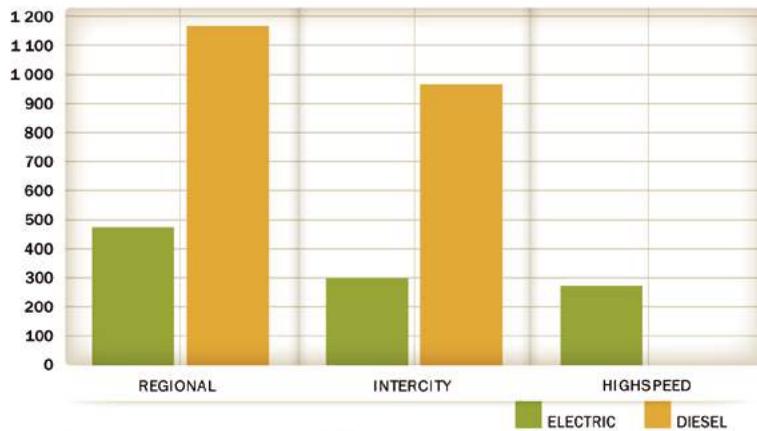
Source: (UIC, 2011b)

Table 2: 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%

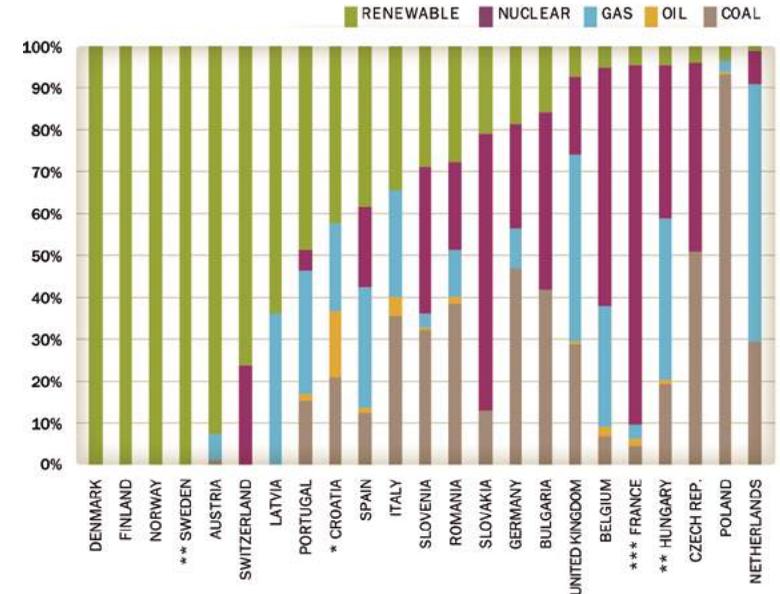
Fig.25: Passenger specific consumption by service type and traction type, 2005 (kJ/pkm)



Source: elaboration based on UIC (2011b)

## Electricity mix

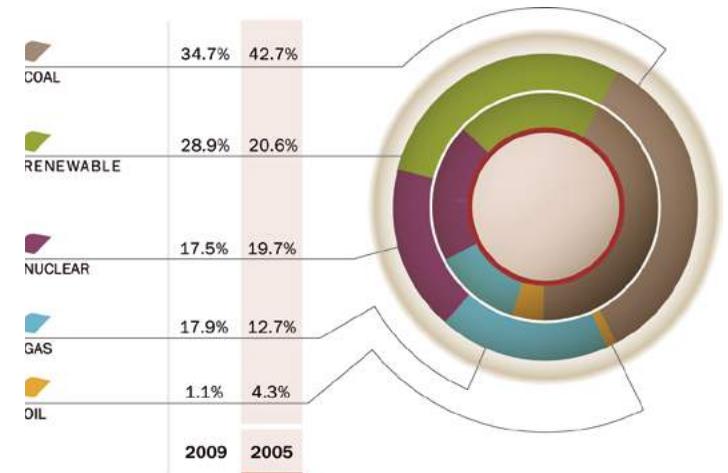
Fig.26: Railways electricity mix by country, 2009



Source: UIC (2011b)

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

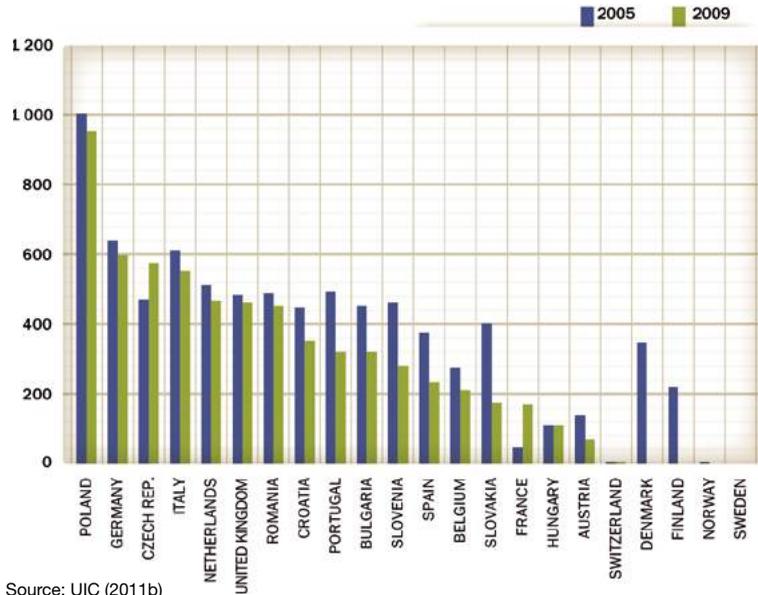
Fig.27: Railways electricity mix, 2005 inside - 2009 outside,



Source: elaboration based on UIC (2011b)

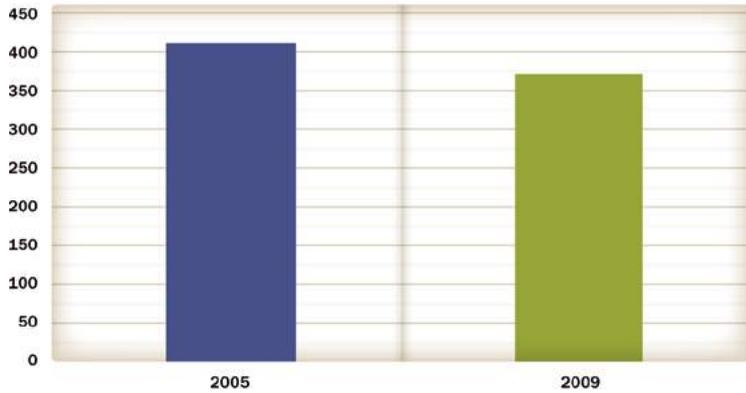
### CO<sub>2</sub> emission factors

Fig.28: Carbon intensity of railway electricity by country, 2005 and 2009 (gCO<sub>2</sub>/kWh)



Source: UIC (2011b)

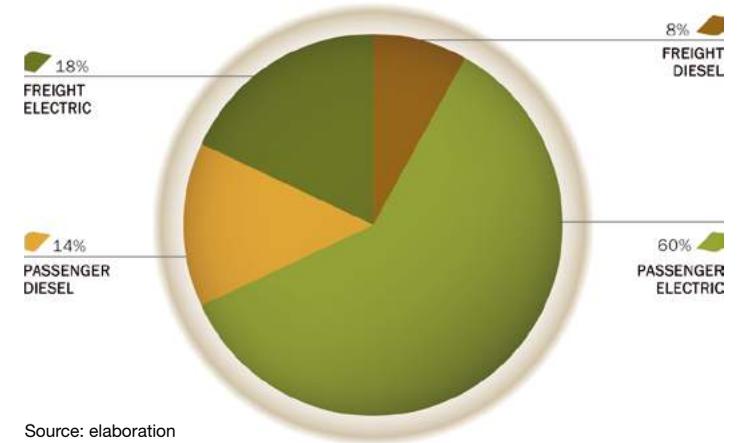
Fig.29: European average carbon intensity of railway electricity, 2005 and 2009 (gCO<sub>2</sub>/kWh)



Source: elaboration based on UIC (2011b)

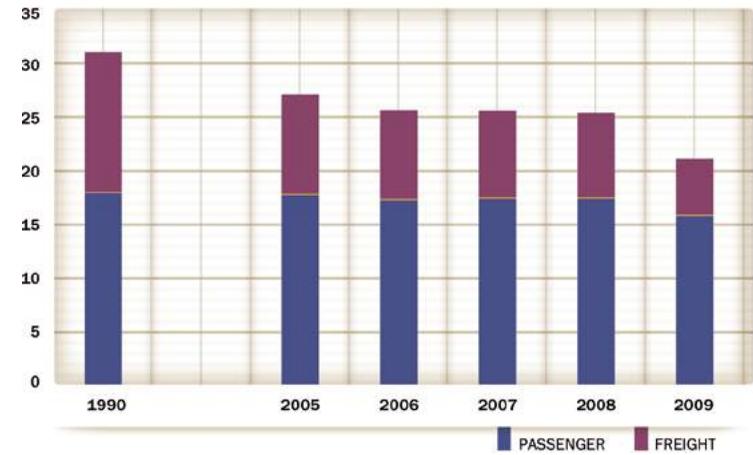
### CO<sub>2</sub> emissions

Fig.30: Railway sector CO<sub>2</sub> emissions by train type and traction type, 2009



Source: elaboration based on UIC (2011b)

Fig.31: Railway sector CO<sub>2</sub> emissions by train type, 1990-2009 (million tonnes)



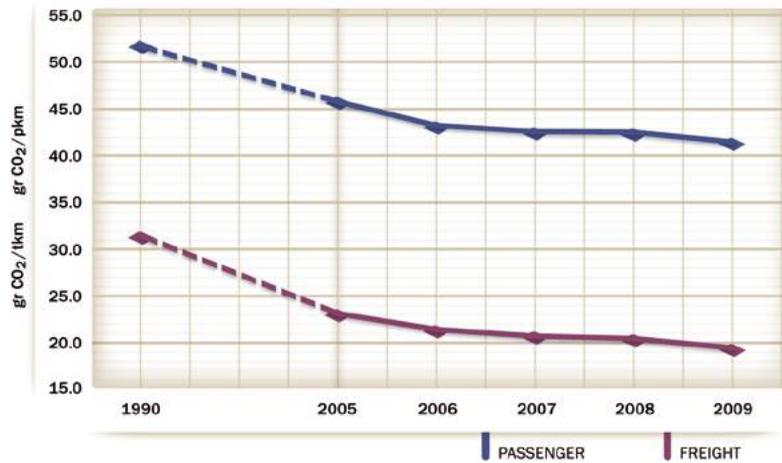
Source: elaboration based on UIC (2011b)

Table 3: Railway CO<sub>2</sub> emissions by train type and traction type, 2005-2009 (ktCO<sub>2</sub>)

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

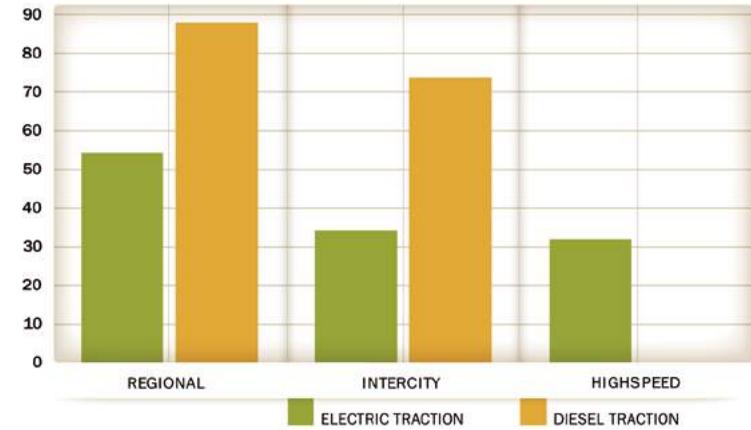
Source: elaboration based on UIC (2011b)

Fig.32: Specific CO<sub>2</sub> emissions by train type, 1990-2009 (gCO<sub>2</sub>/pkm, gCO<sub>2</sub>/tkm)



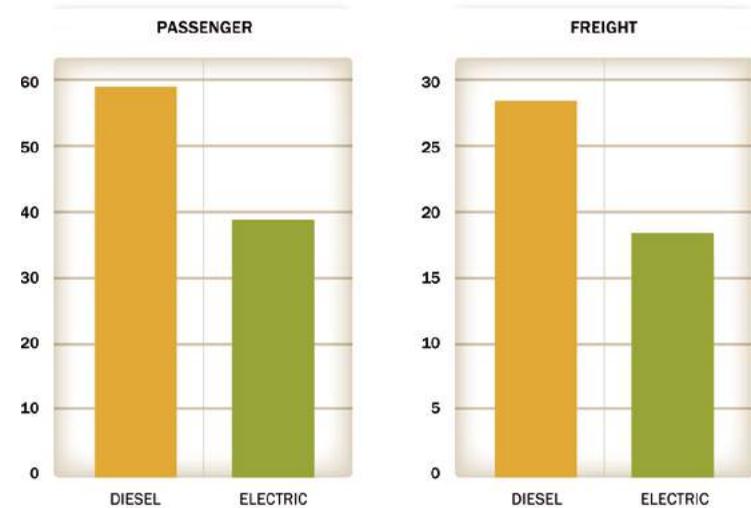
Source: UIC (2011b)

Fig.33: Passenger specific CO<sub>2</sub> emissions by service type and traction type, 2005 (gCO<sub>2</sub>/pkm)



Source: elaboration based on UIC (2011b)

Fig.34: Specific CO<sub>2</sub> emission by train type and traction type, 2009 (gCO<sub>2</sub>/pkm, gCO<sub>2</sub>/tkm)



Source: elaboration based on UIC (2011b)





## UIC 's Vision 2050

In order for the railway sector to maintain and expand its leading sustainability performance and to keep representing a solution for transport sector environmental problems, a Vision 2050 has also been set. The Vision 2050 of Railway Sector expresses its commitment for contributing to the construction of a possible zero-emissions and low energy consumer society.

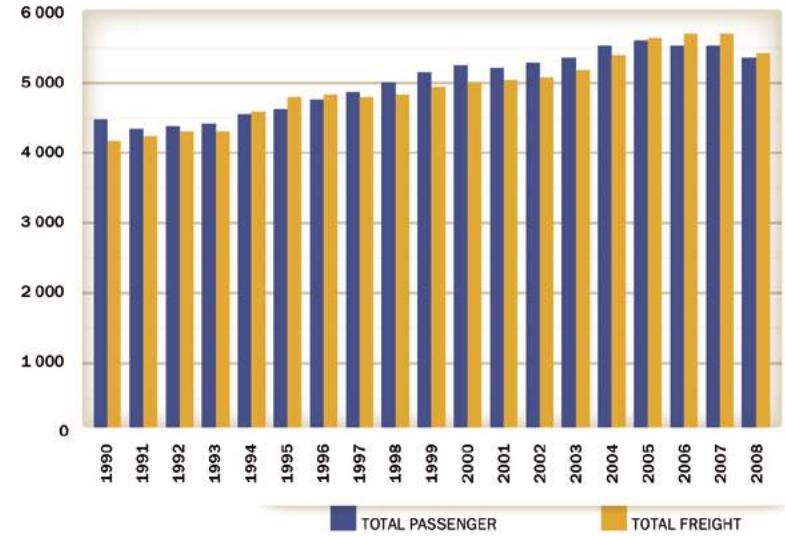
The goals are the following:

- 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 G20 Countries

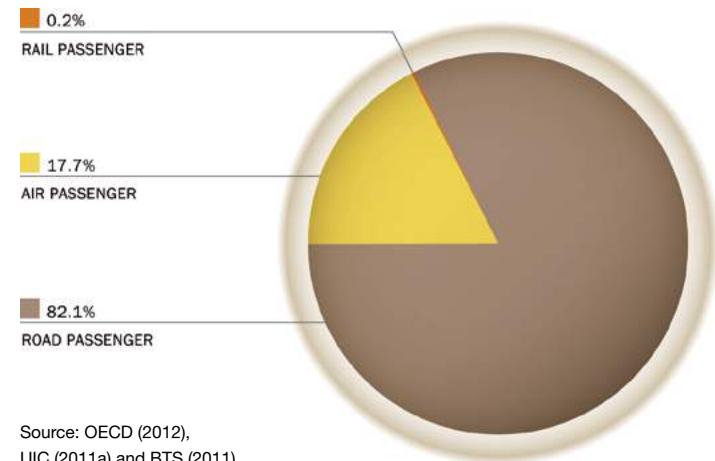


Fig. 37: Passenger and freight transport activity, 1990-2008 (billion pkm and tkm)



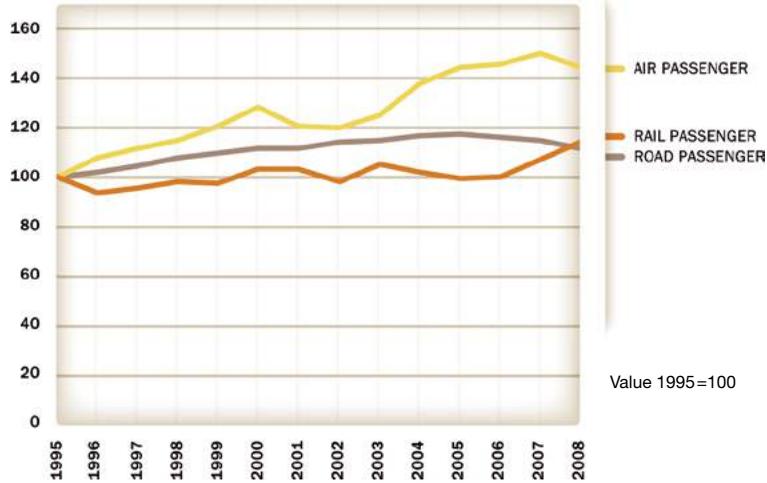
Source: OECD (2012), UIC (2011a) and BTS (2011)

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



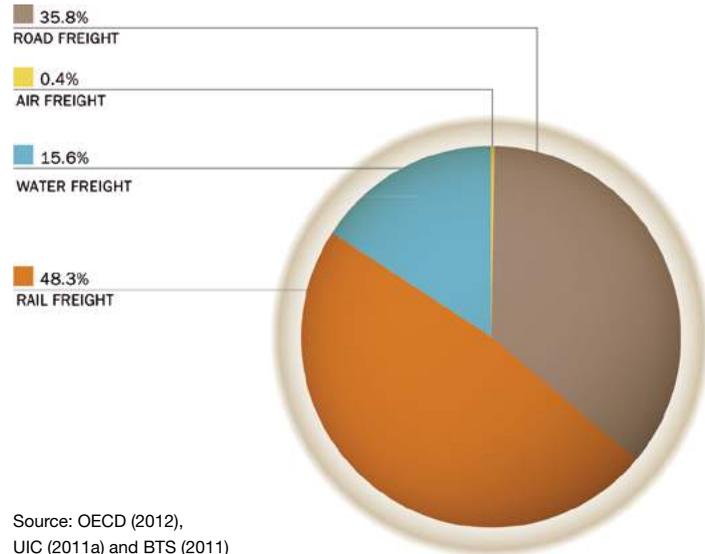
Source: OECD (2012), UIC (2011a) and BTS (2011)

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



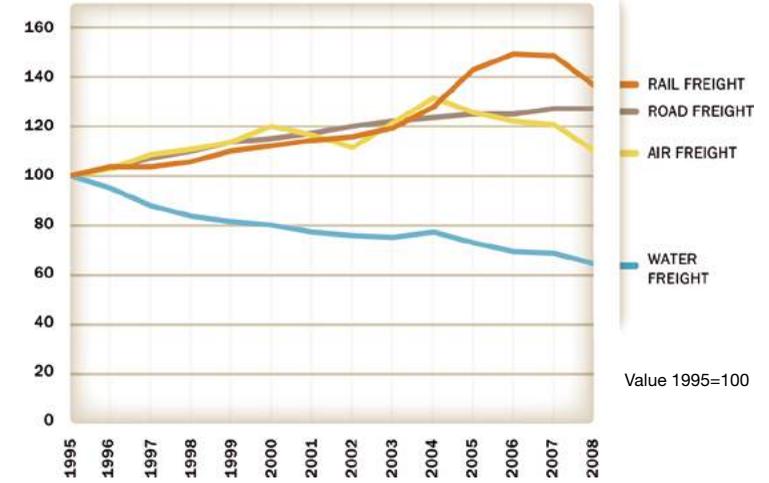
Source: OECD (2012), UIC (2011a) and BTS (2011)

Figure 40: Modal split in freight transport, 2008 (tkm)



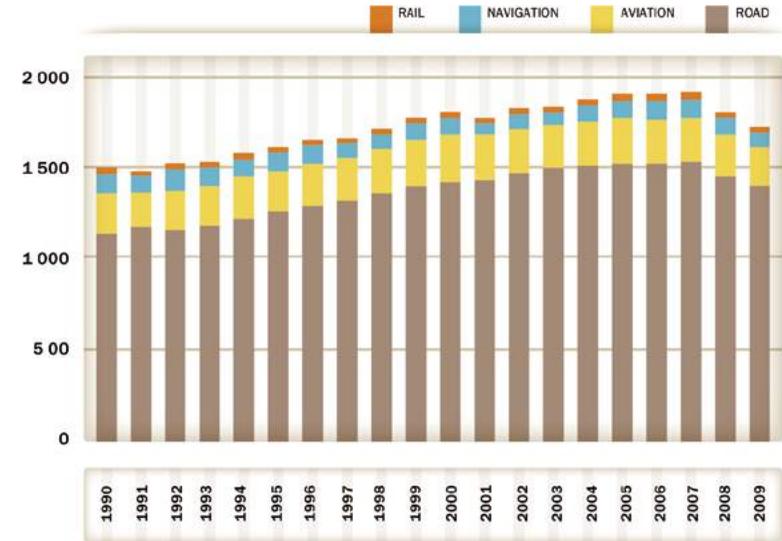
Source: OECD (2012), UIC (2011a) and BTS (2011)

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



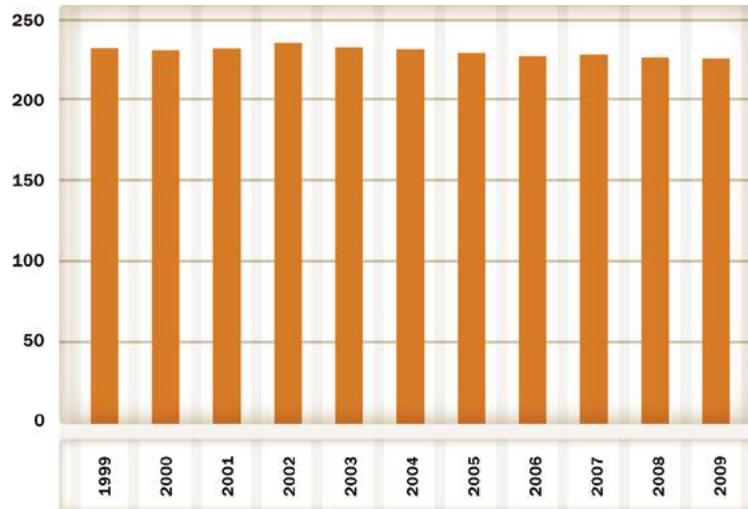
Source: OECD (2012), UIC (2011a) and BTS (2011)

Fig. 42: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



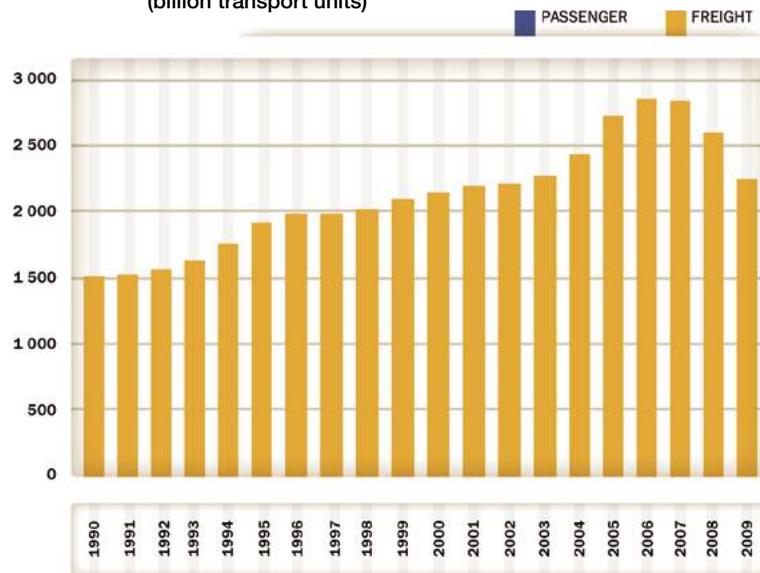
Source: IEA (2011a)

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



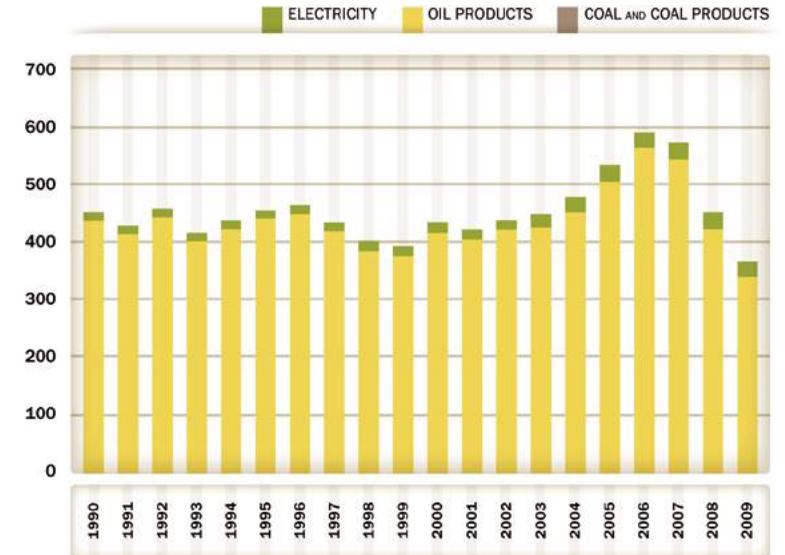
Source: UIC (2011a)

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)

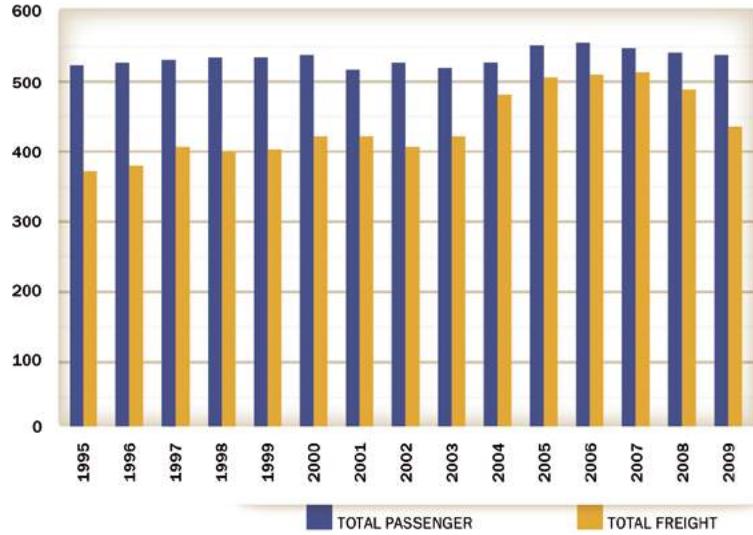
Fig. 46: Railway specific energy consumption, 1990-2009 (kJ/transport unit)



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

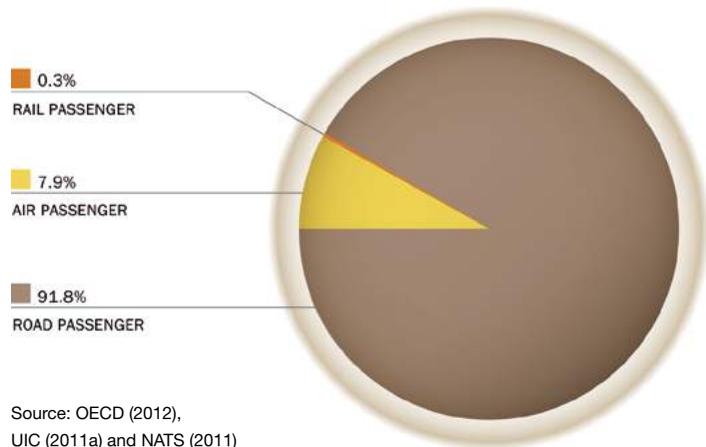
Canada

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



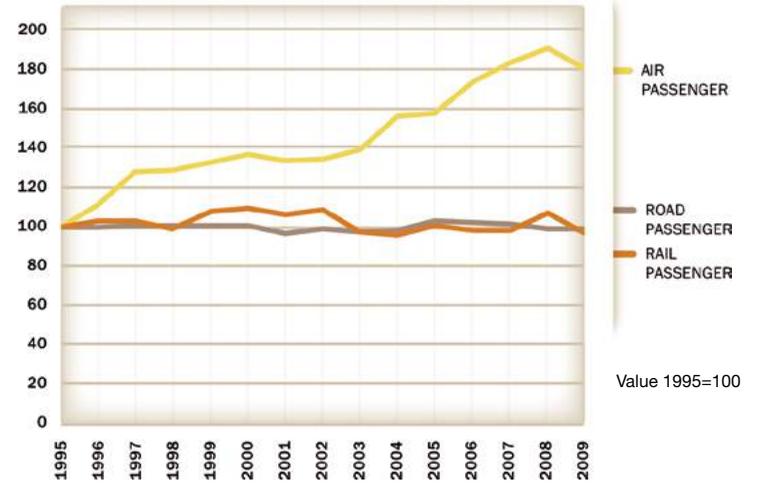
Source: OECD (2012), UIC (2011a) and NATS (2011)

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



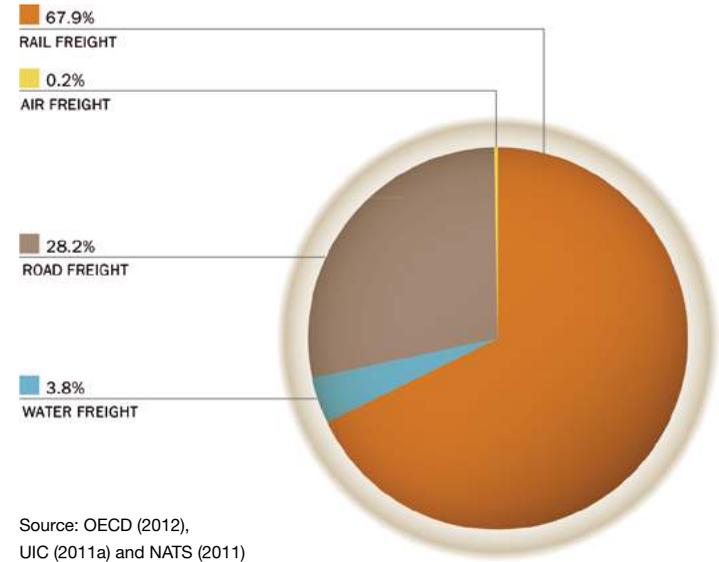
Source: OECD (2012), UIC (2011a) and NATS (2011)

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



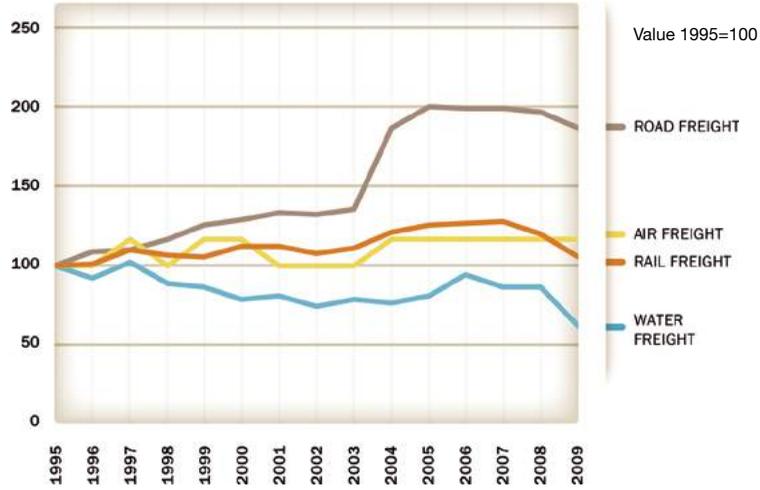
Source: OECD (2012), UIC (2011a) and NATS (2011)

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



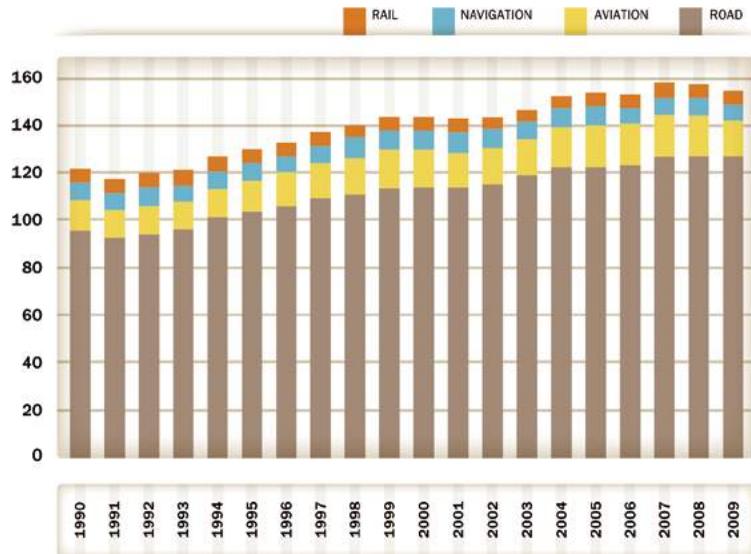
Source: OECD (2012), UIC (2011a) and NATS (2011)

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



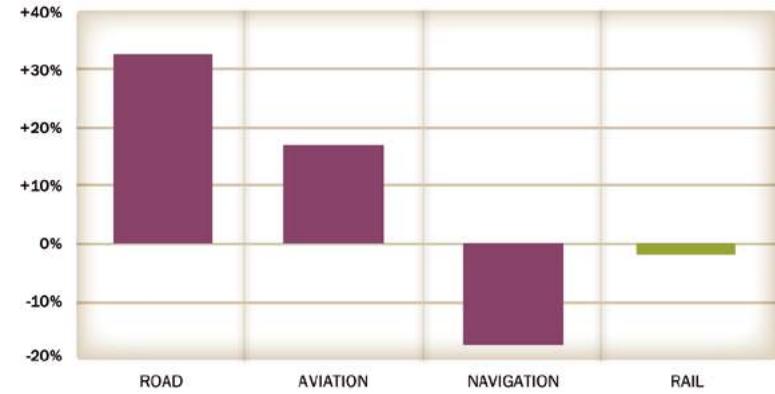
Source: OECD (2012), UIC (2011a) and NATS (2011)

Fig. 52: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



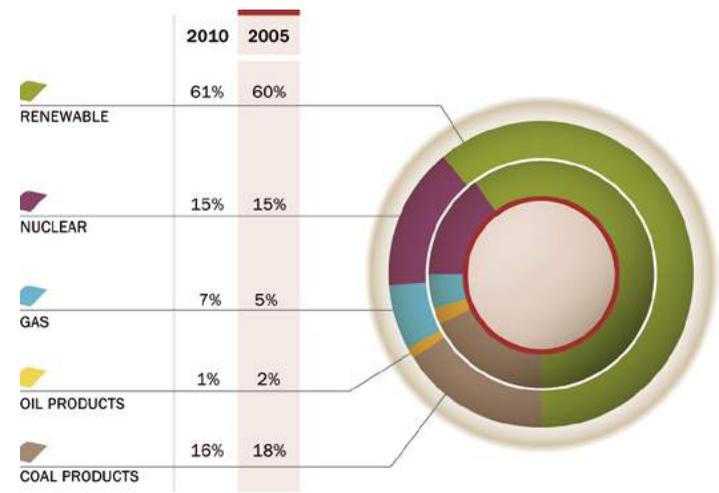
Source: IEA (2011a)

Fig. 53: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



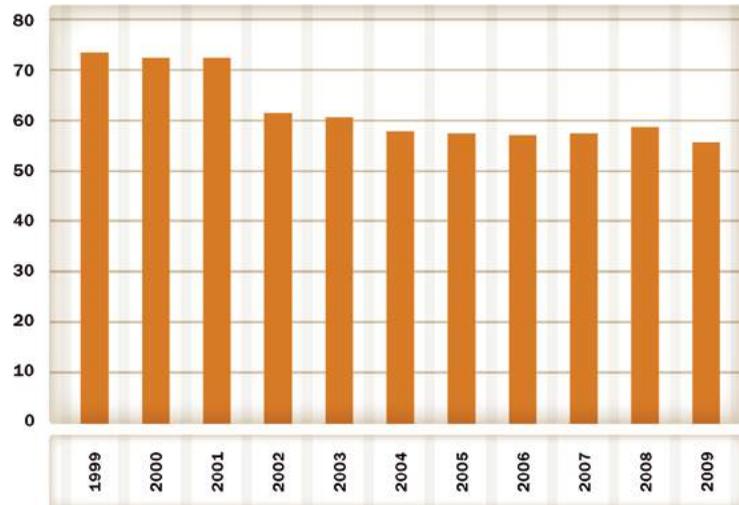
Source: IEA (2011a)

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



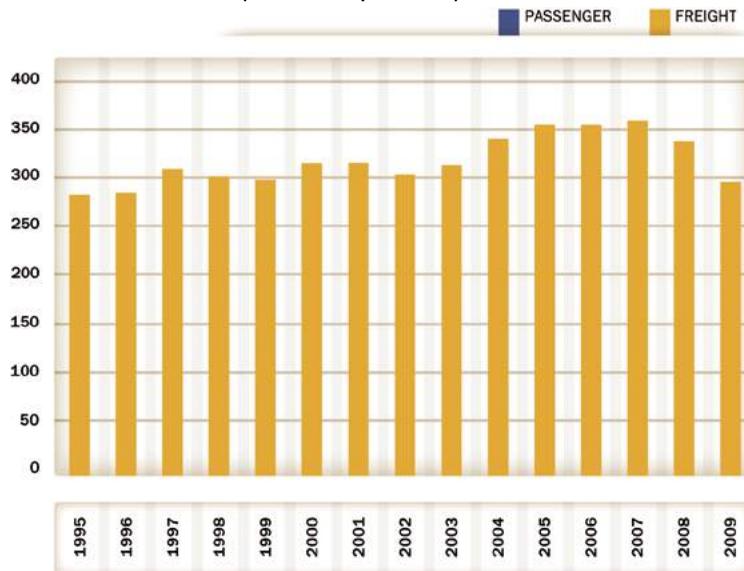
Source: IEA (2011b)

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



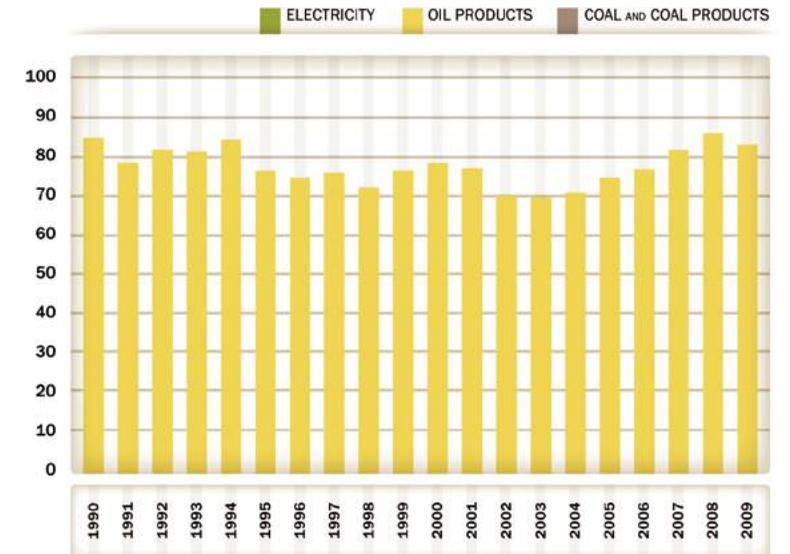
Source: UIC (2011a)

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



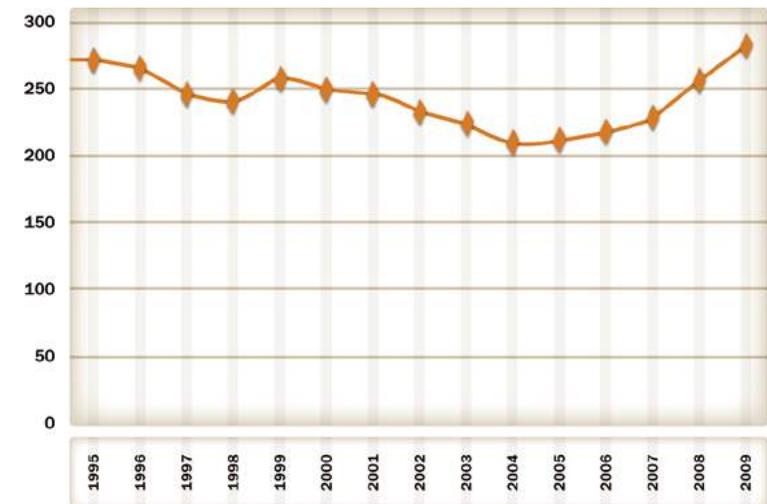
Source: UIC (2011a)

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



Source: UIC (2011a)

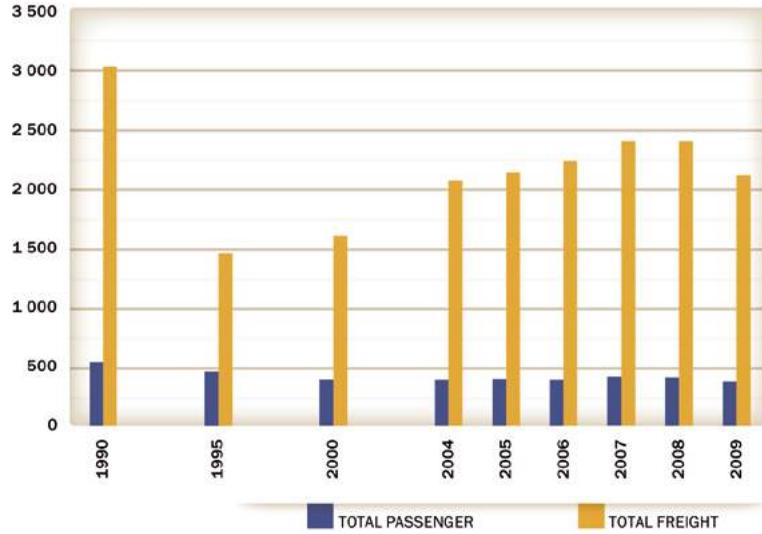
Fig. 58: Railway specific energy consumption, 1995-2009 (kJ/transport unit)



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

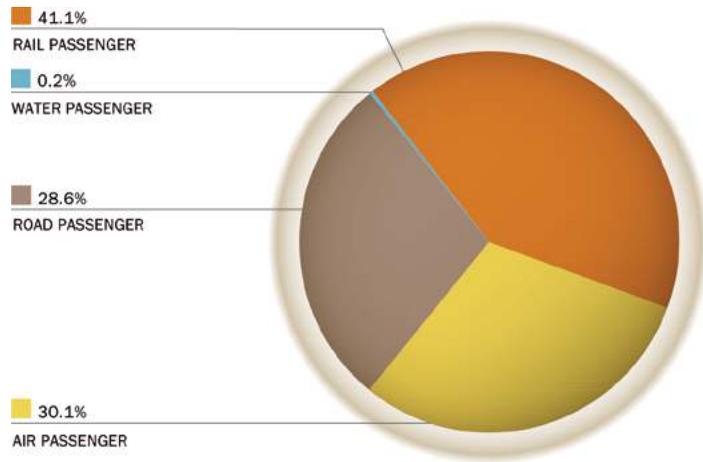
# Russia

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



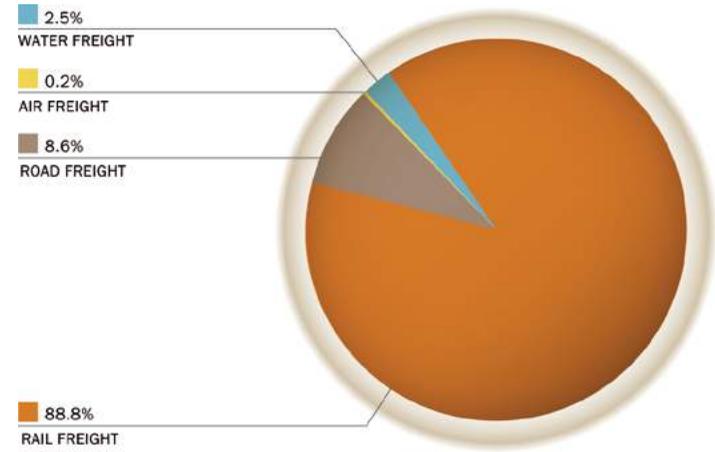
Source: OECD (2012), UIC (2011a) and Rosstat (2010)

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



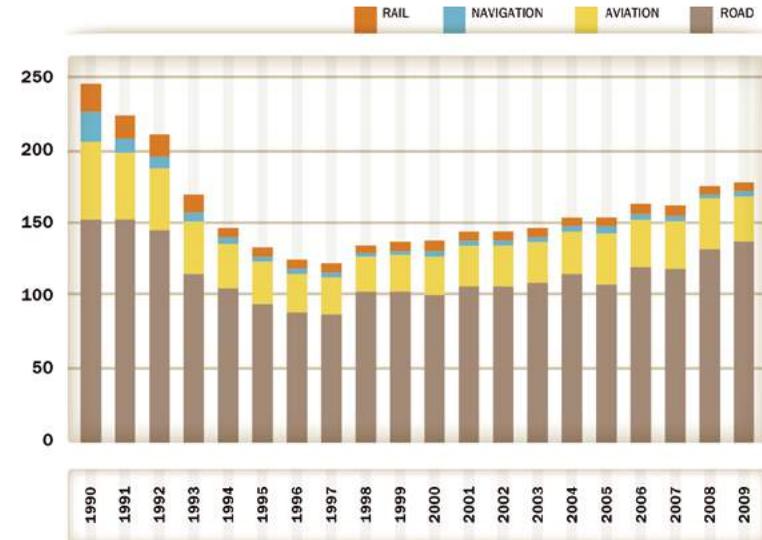
Source: OECD (2012), UIC (2011a) and Rosstat (2010)

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



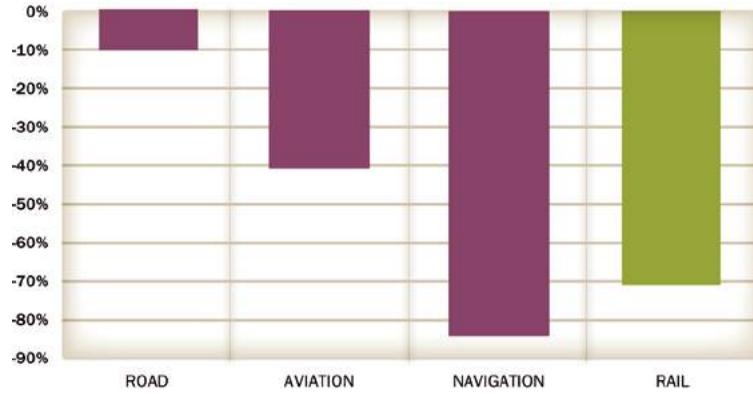
Source: OECD (2012), UIC (2011a) and Rosstat (2010)

Fig. 62: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



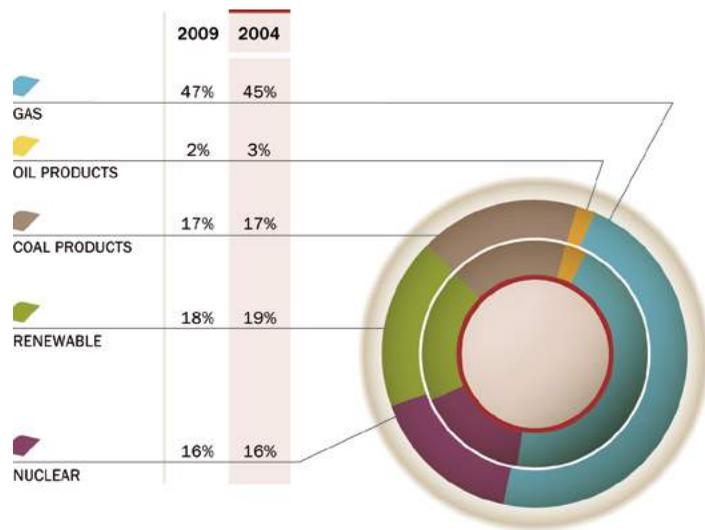
Source: IEA (2011a)

Fig. 63: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



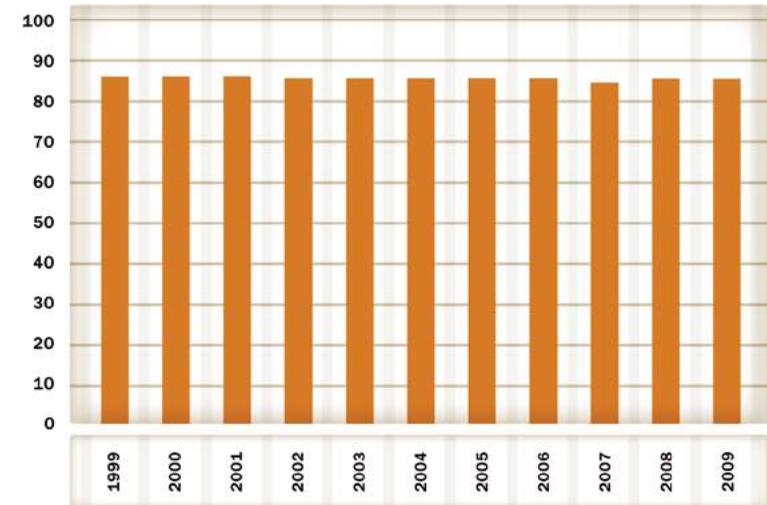
Source: IEA (2011a)

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



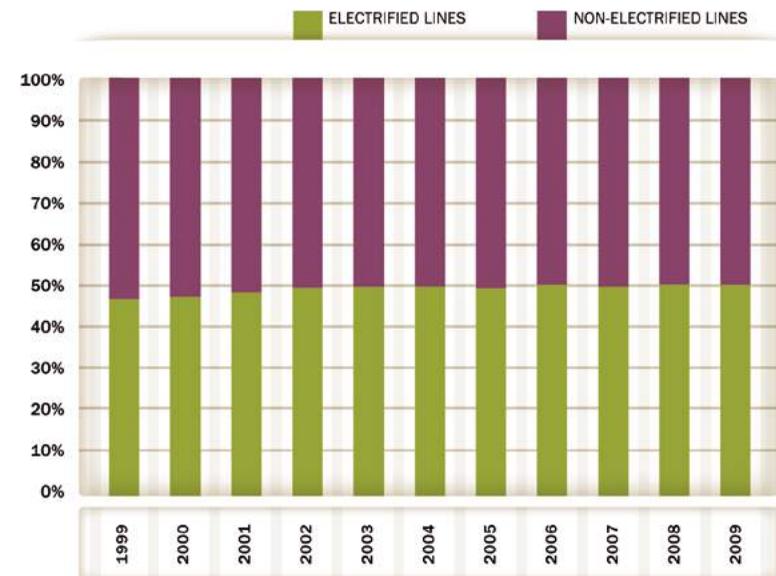
Source: IEA (2011b)

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



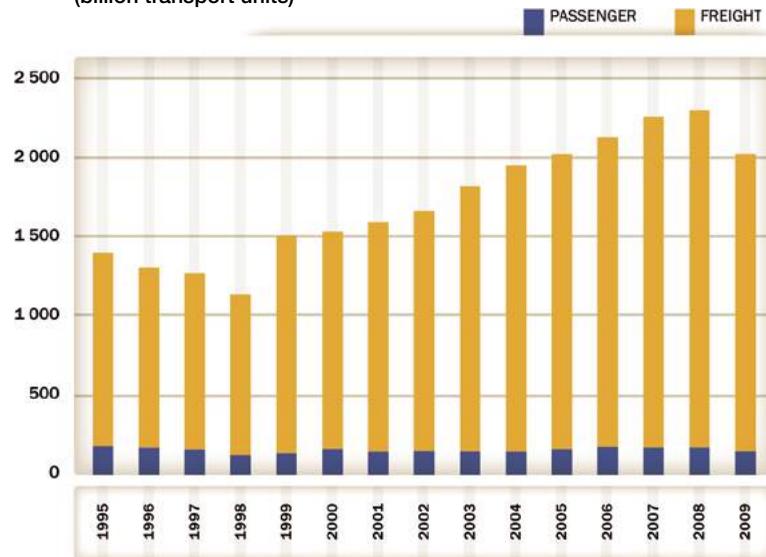
Source: UIC (2011a)

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



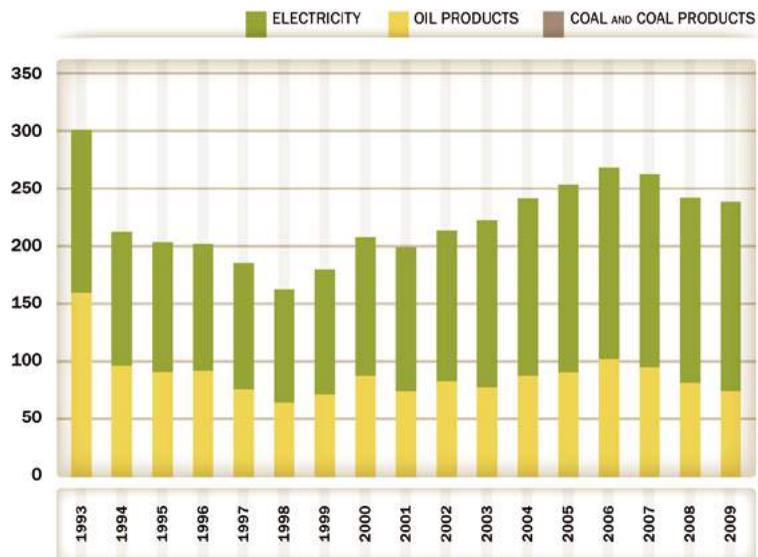
Source: UIC (2011a)

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



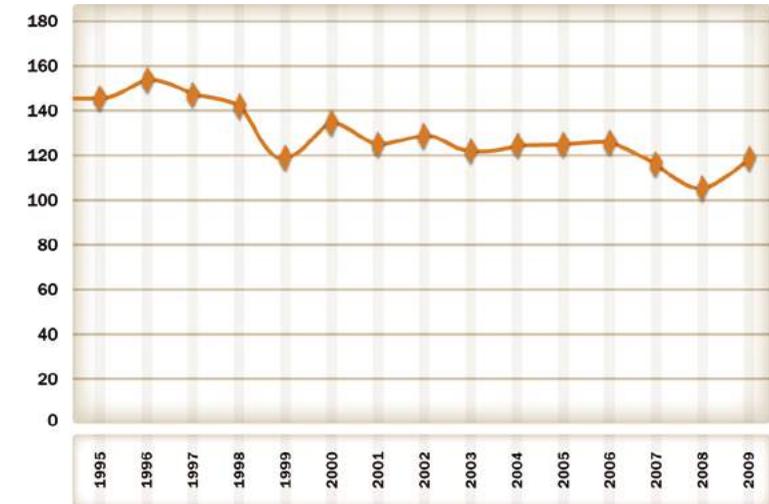
Source: UIC (2011a)

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



Source: IEA (2011b)

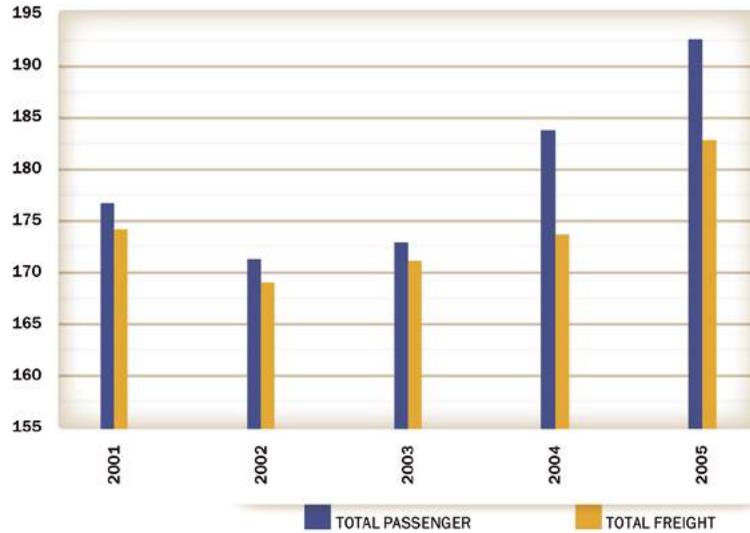
Fig. 69: Railway specific energy consumption, 1995-2009 (kJ/transport unit)



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

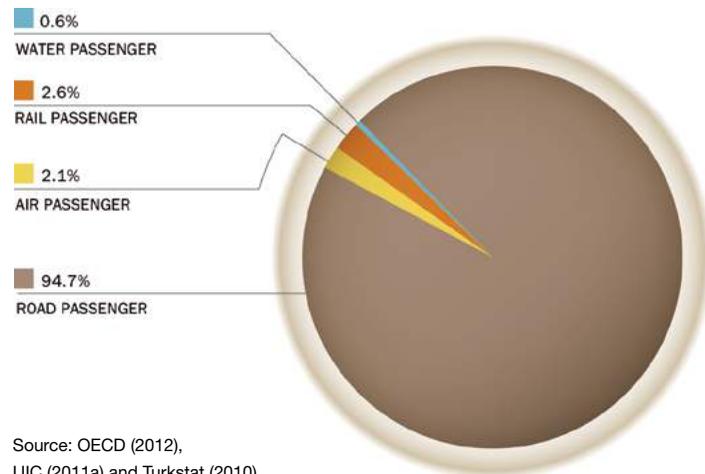
# Turkey

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



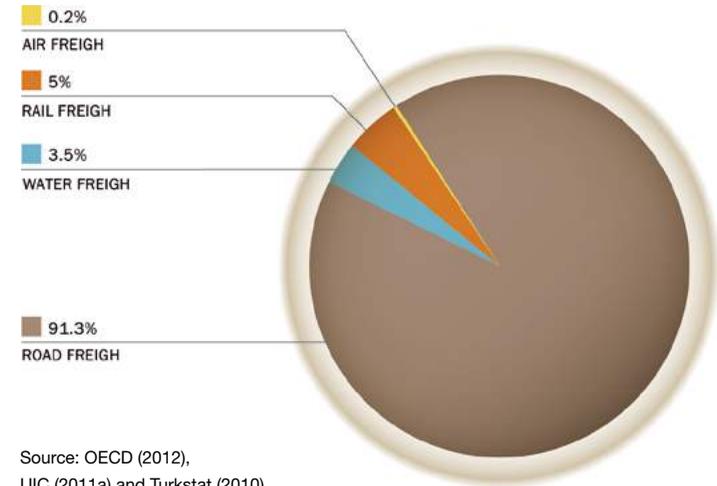
Source: OECD (2012), UIC (2011a) and Turkstat (2010)

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



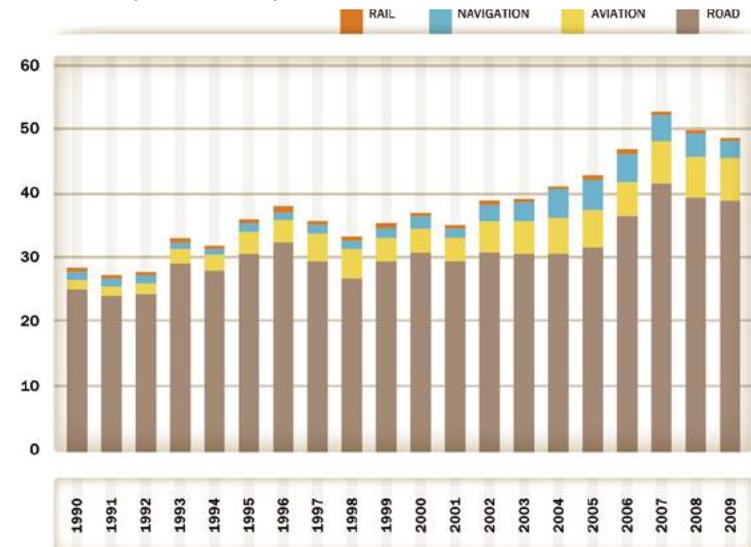
Source: OECD (2012), UIC (2011a) and Turkstat (2010)

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



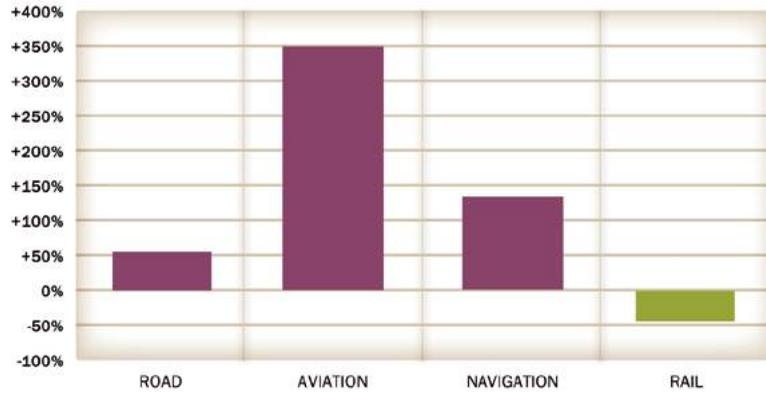
Source: OECD (2012), UIC (2011a) and Turkstat (2010)

Fig. 73: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



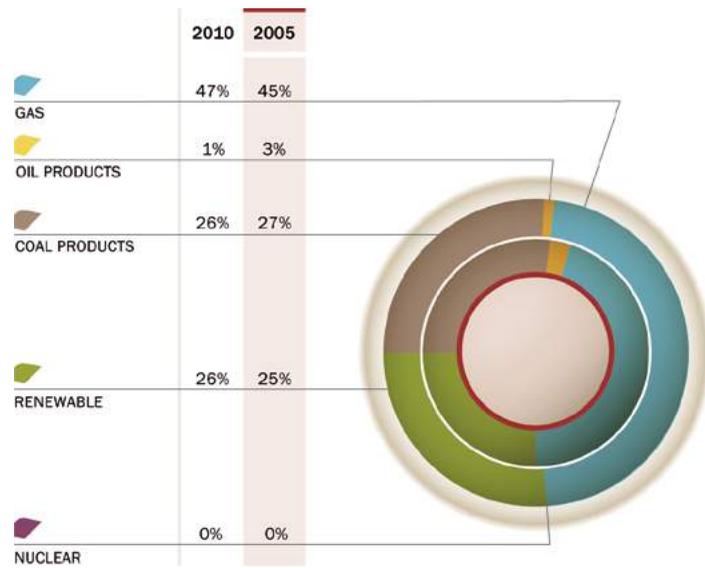
Source: IEA (2011a)

Fig. 74: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



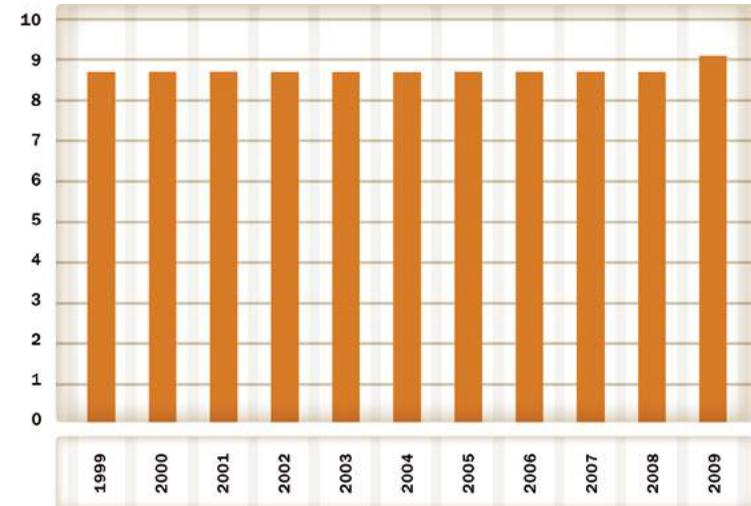
Source: IEA (2011a)

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



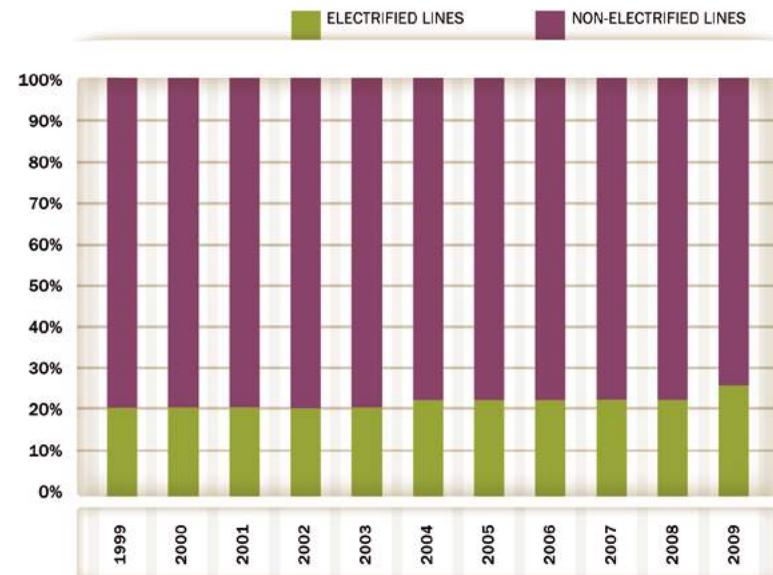
Source: IEA (2011b)

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



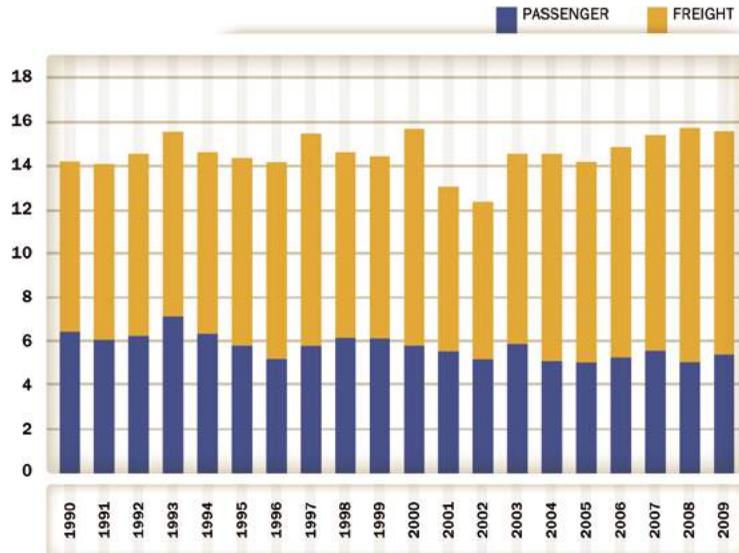
Source: UIC (2011a)

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



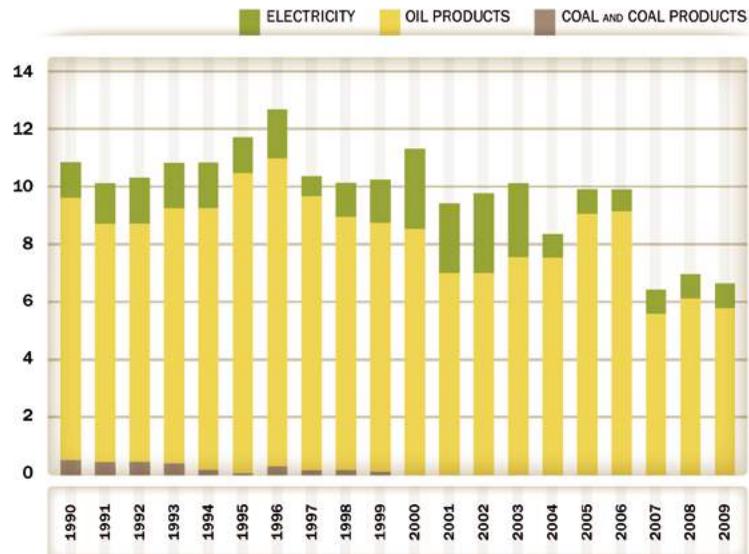
Source: UIC (2011a)

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)

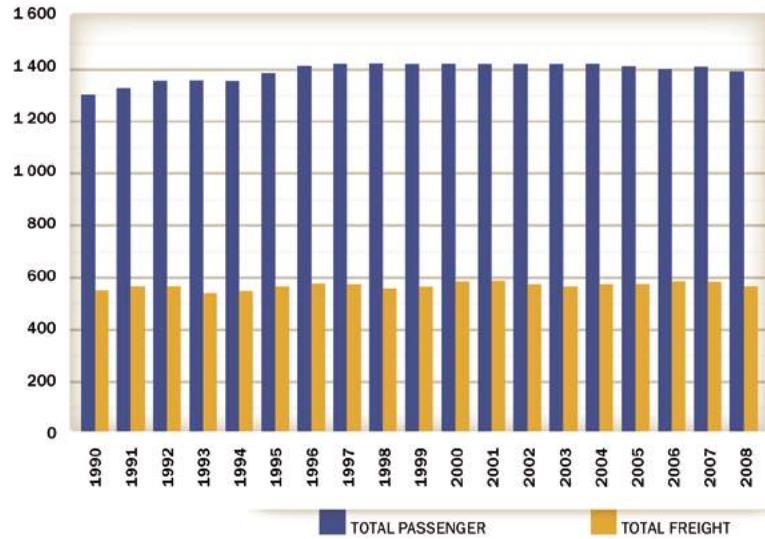
Fig. 80: Railway specific energy consumption, 1990-2009 (kJ/transport unit)



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

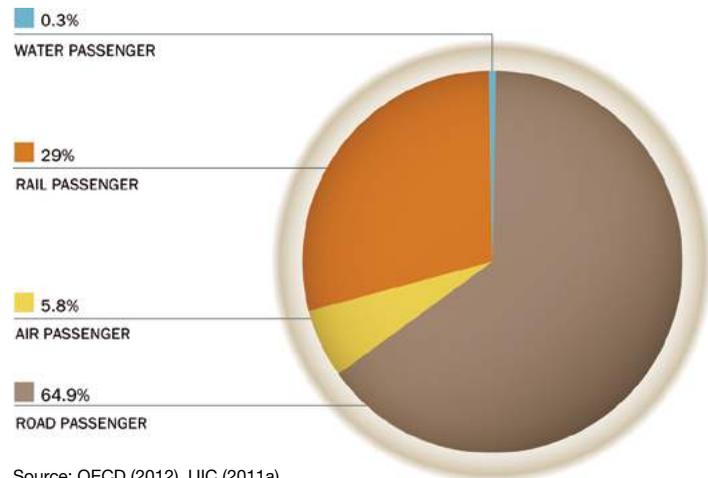
# Japan

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



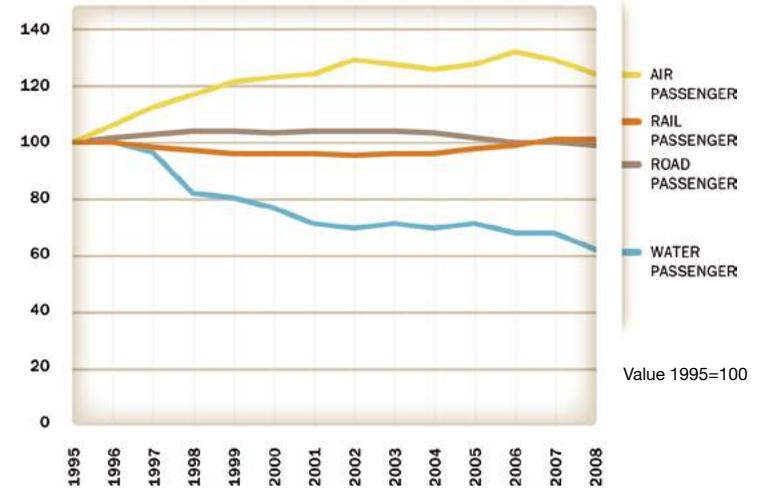
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

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



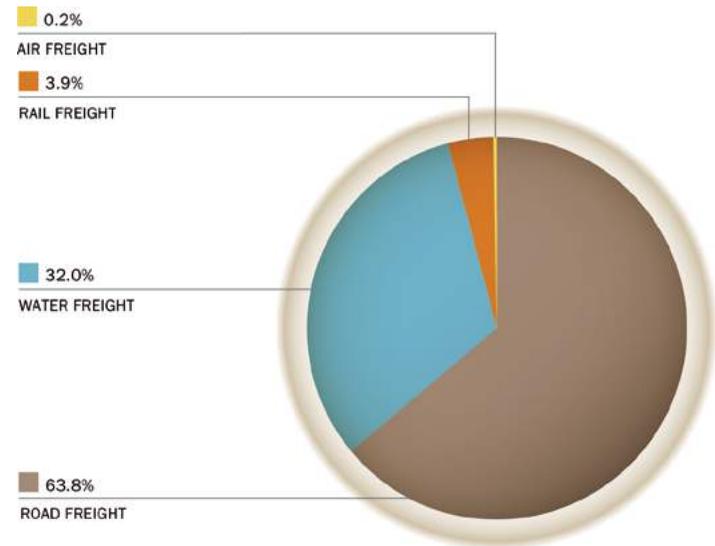
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

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



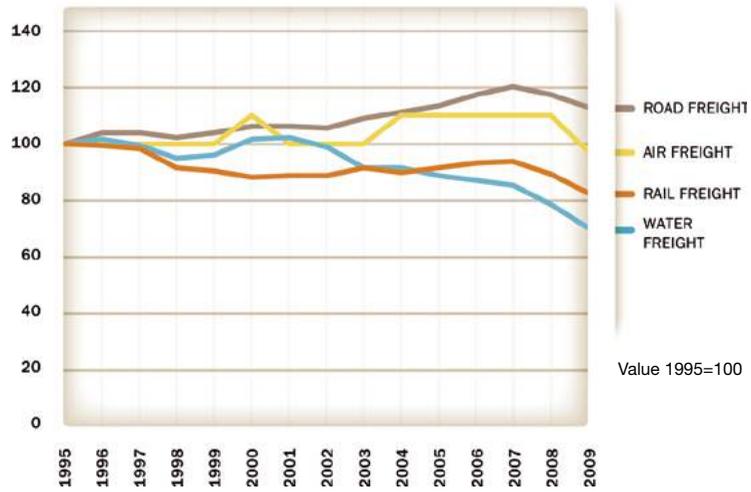
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

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



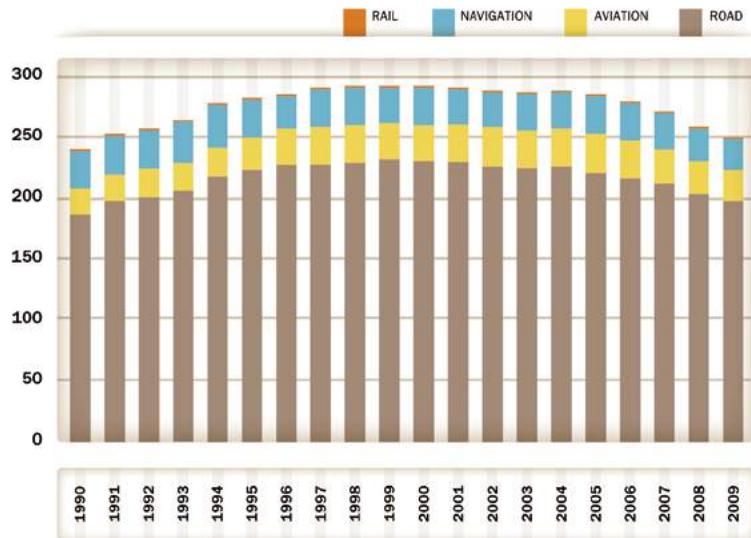
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

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



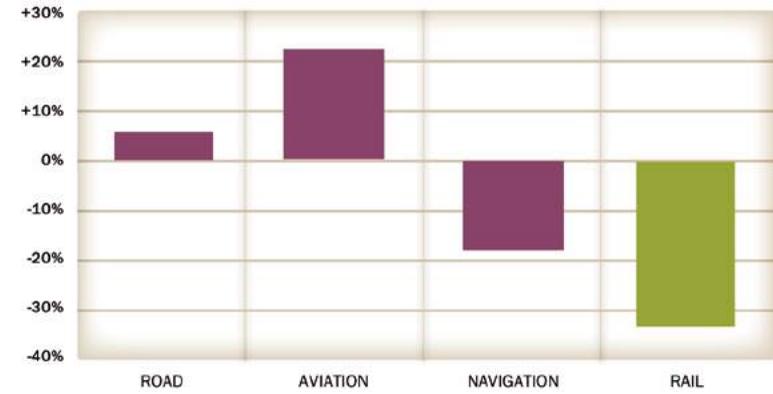
Source: OECD (2012), UIC (2011a), JSB (2011) and JMLIT (2011)

Fig. 86: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



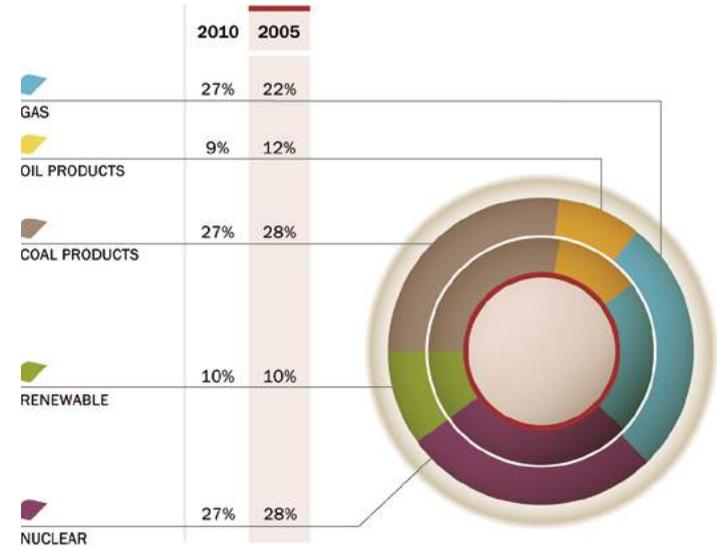
Source: IEA (2011a)

Fig. 87: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



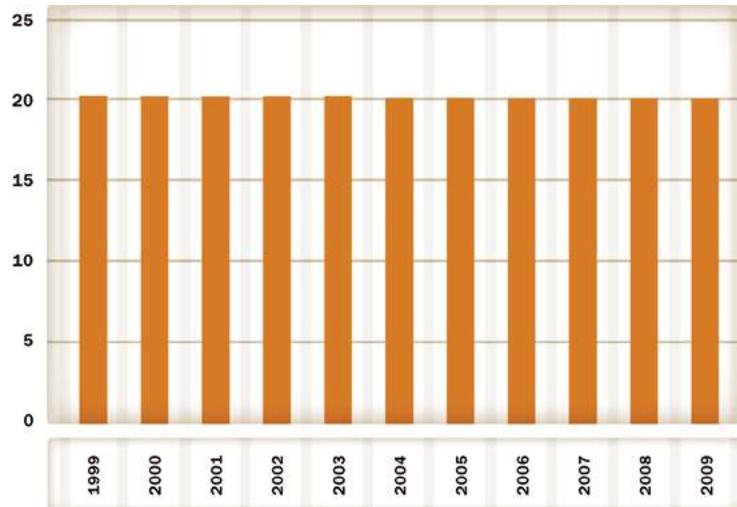
Source: IEA (2011a)

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



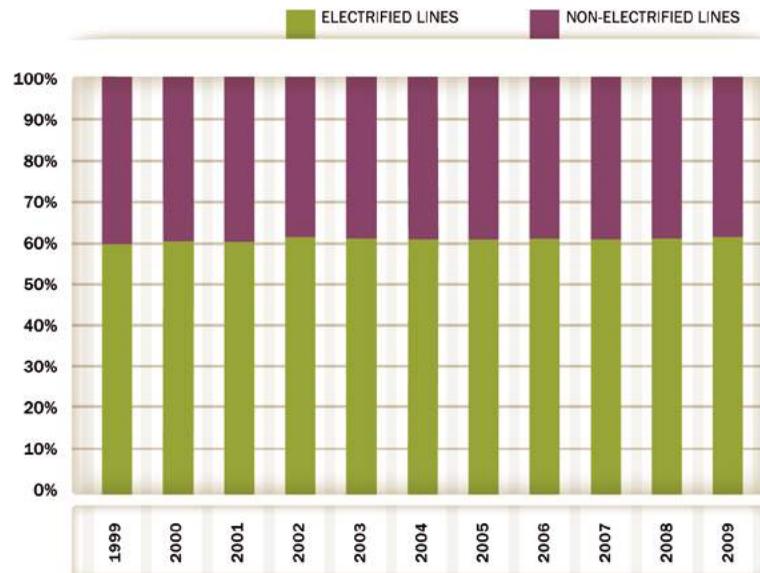
Source: IEA (2011b)

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)



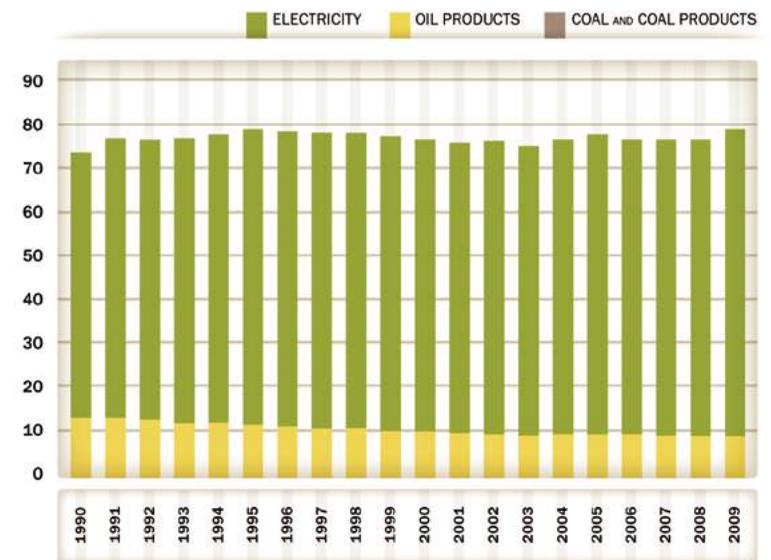
Source: UIC (2011a)

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



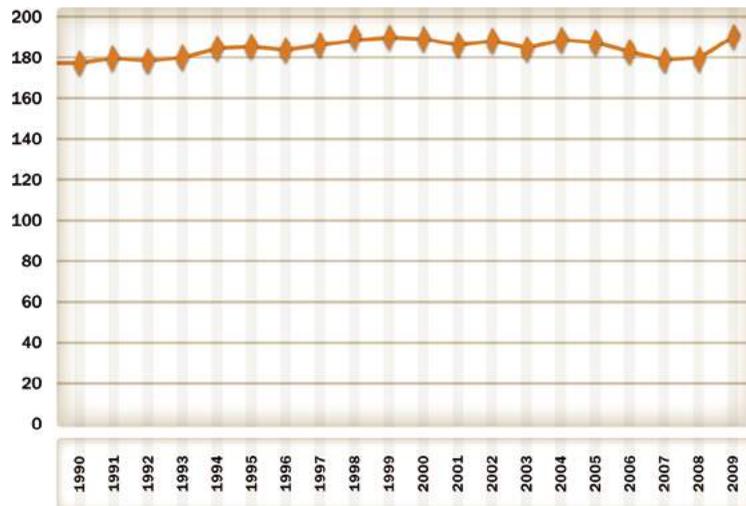
Source: UIC (2011a)

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



Source: IEA (2011b)

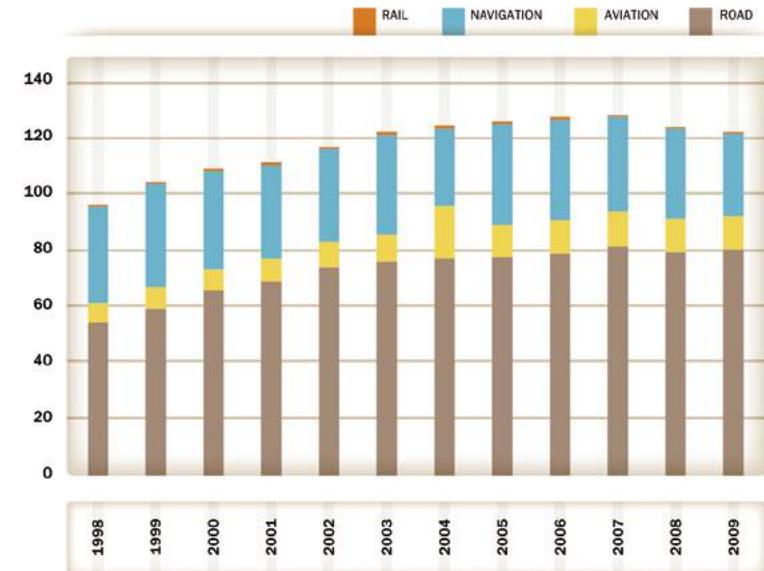
Fig. 93: Railway specific energy consumption, 1990-2009 (kJ/transport unit)



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

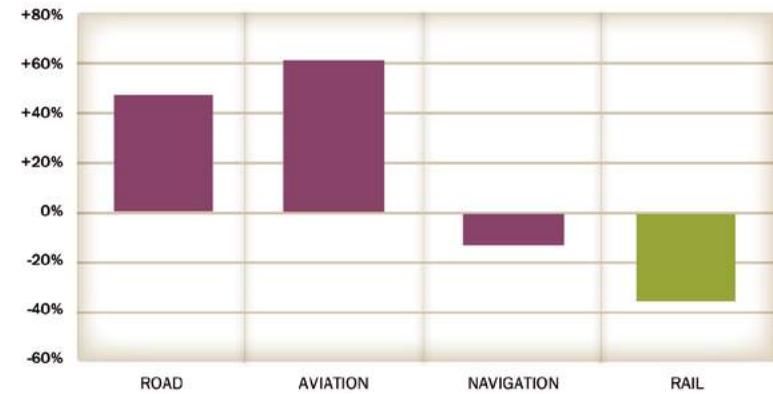
## Korea

Fig. 94: Transport CO<sub>2</sub> emissions by mode, 1998-2009 (million tonnes)



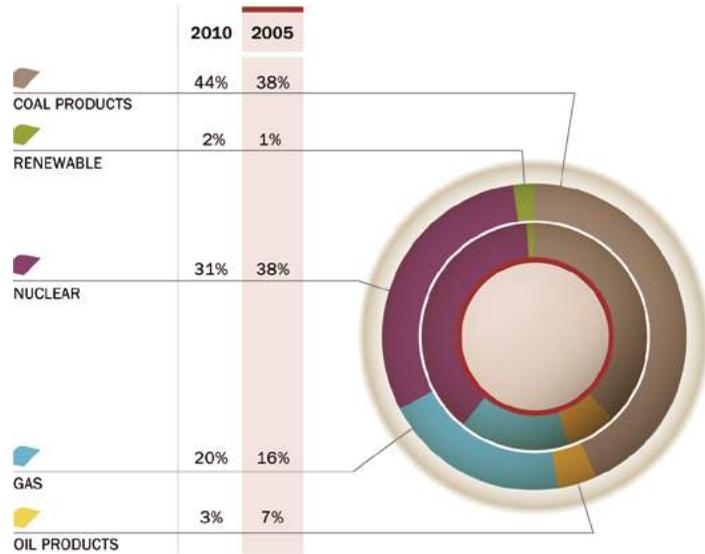
Source: IEA (2011a)

Fig. 95: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1998 and 2009



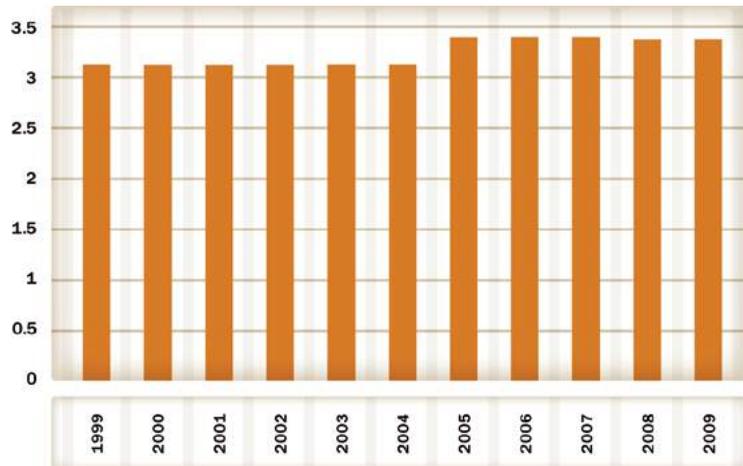
Source: IEA (2011a)

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



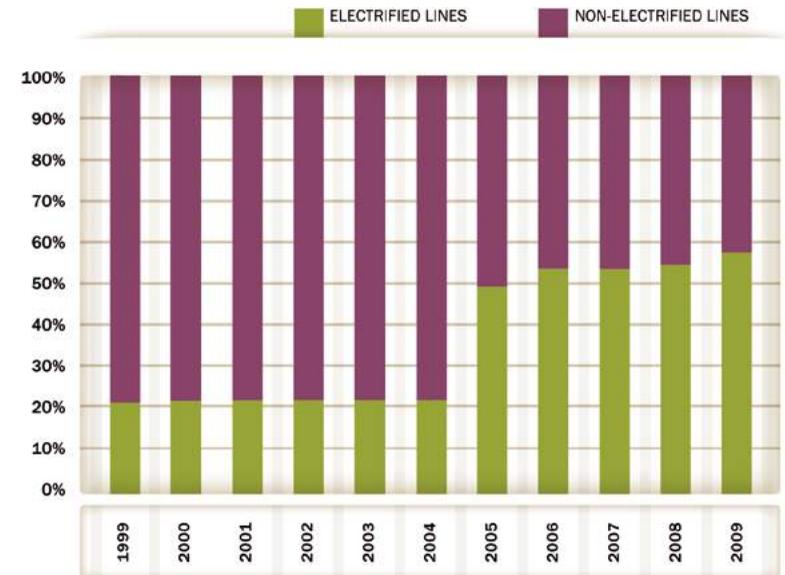
Source: IEA (2011b)

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



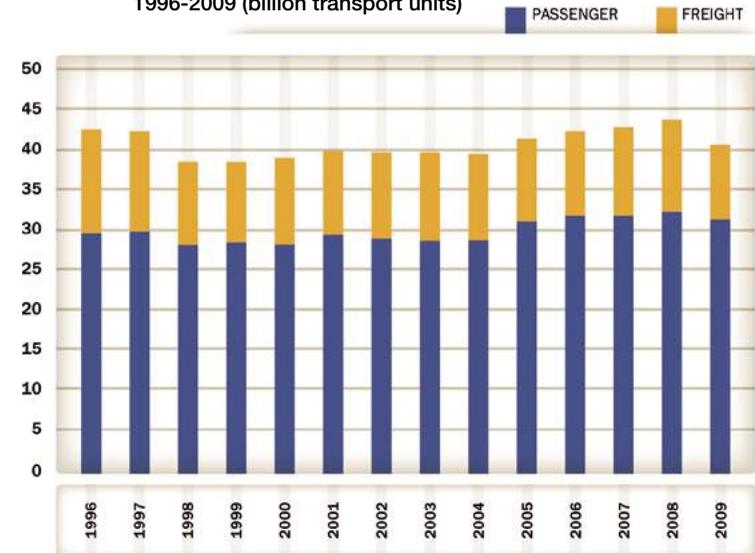
Source: UIC (2011a)

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



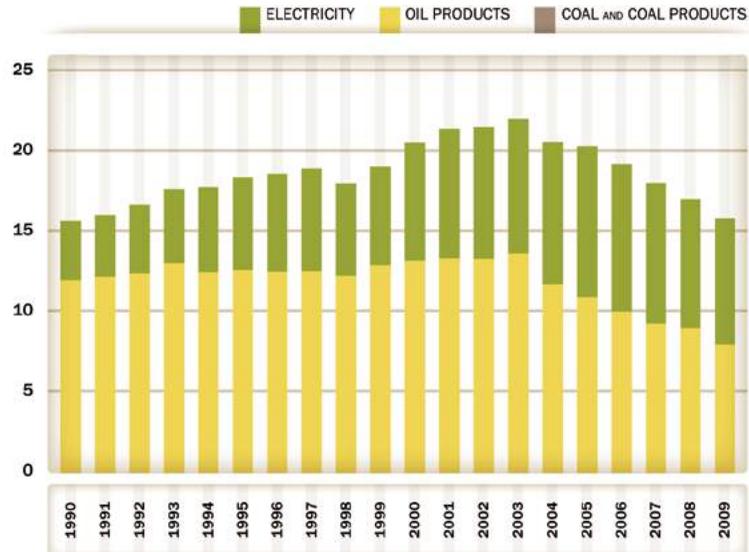
Source: UIC (2011a)

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



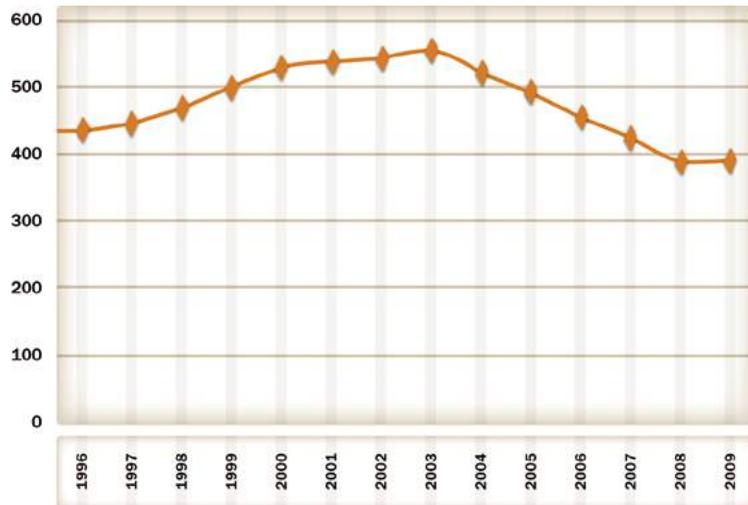
Source: UIC (2011a)

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



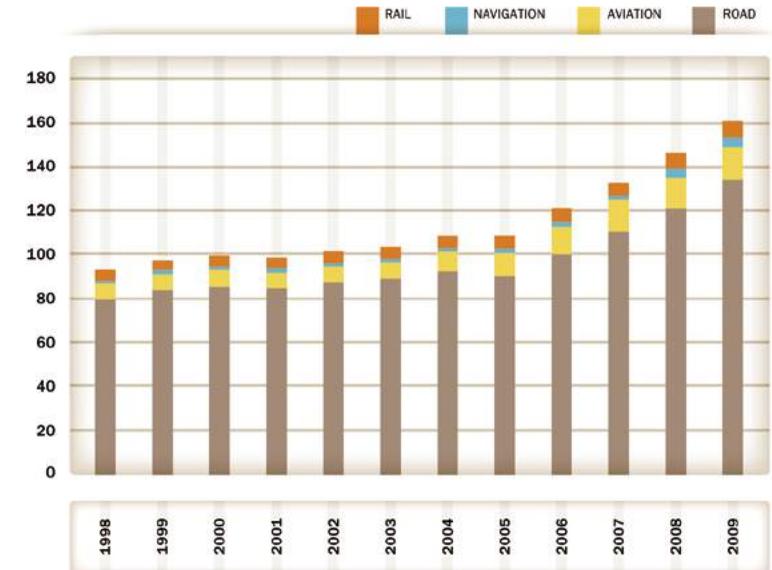
Source: IEA (2011b)

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



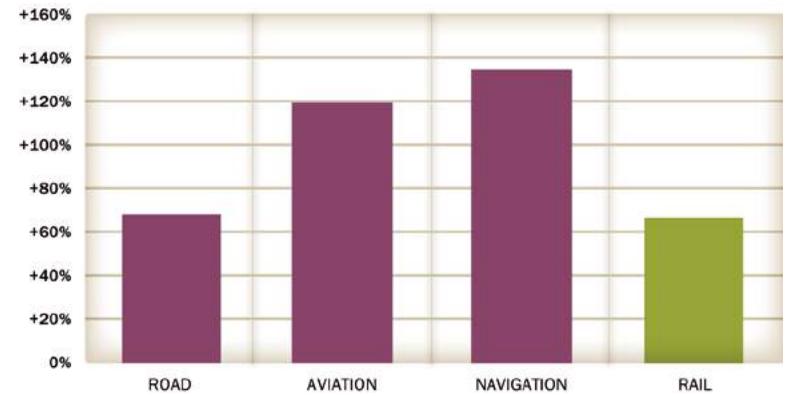
Source: IEA (2011b) and UIC (2011a)

Fig. 102: Transport CO<sub>2</sub> emissions by mode, 1998-2009 (million tonnes)



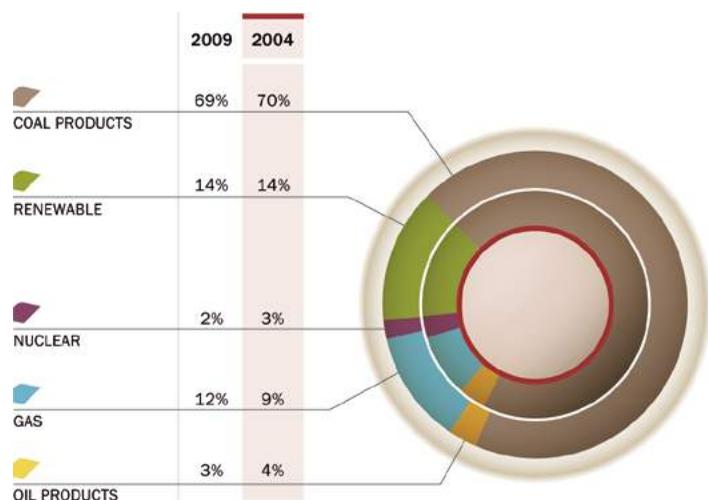
Source: IEA (2011a)

Fig. 103: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1998 and 2009



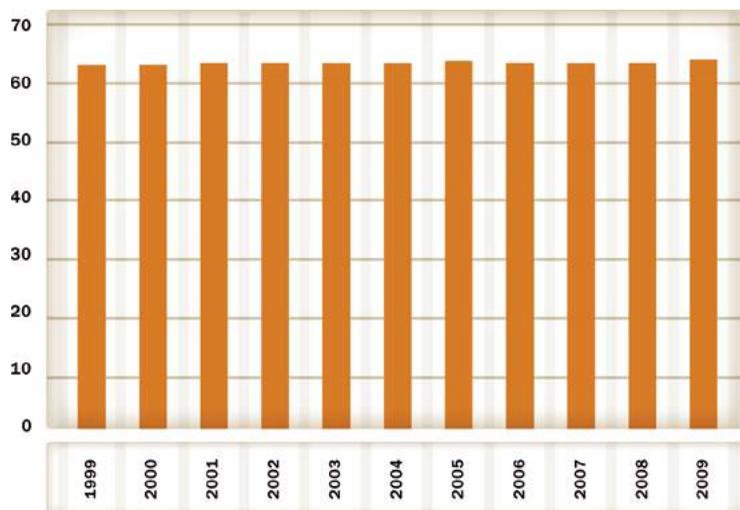
Source: IEA (2011a)

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



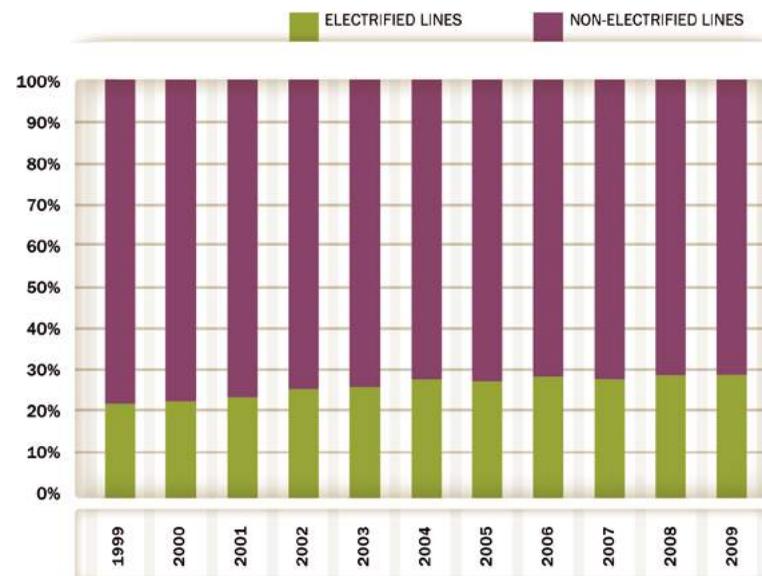
Source: IEA (2011b)

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



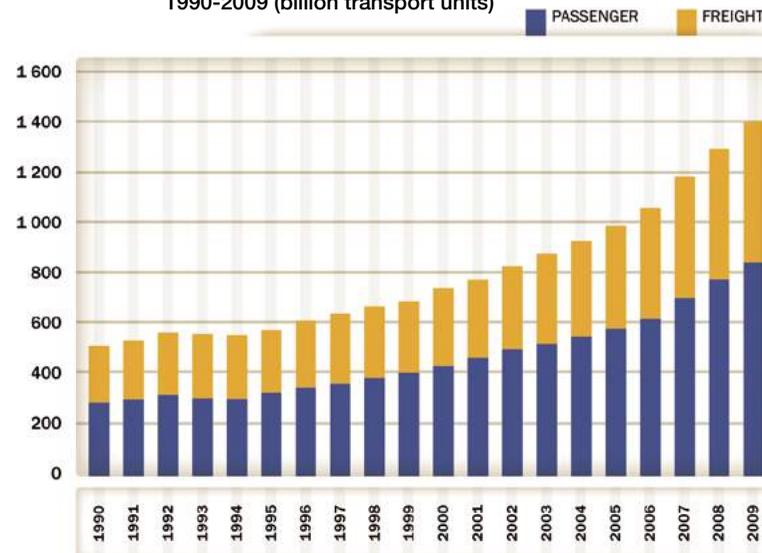
Source: UIC (2011a)

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



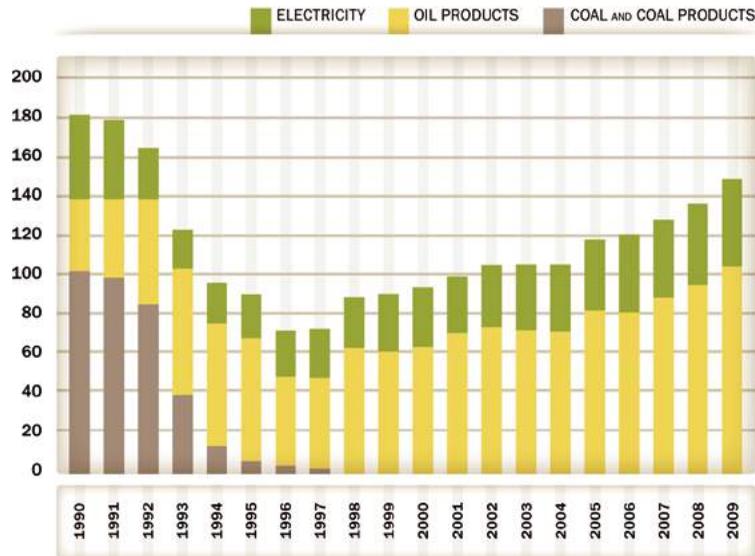
Source: UIC (2011a)

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)



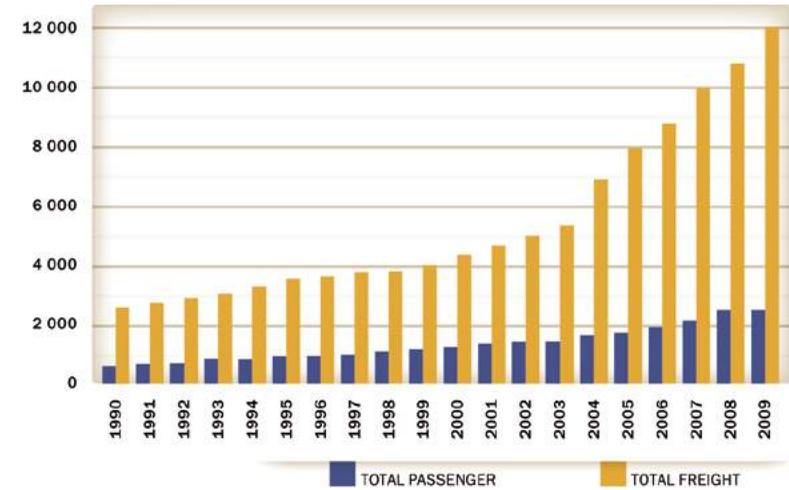
Source: IEA (2011b)

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



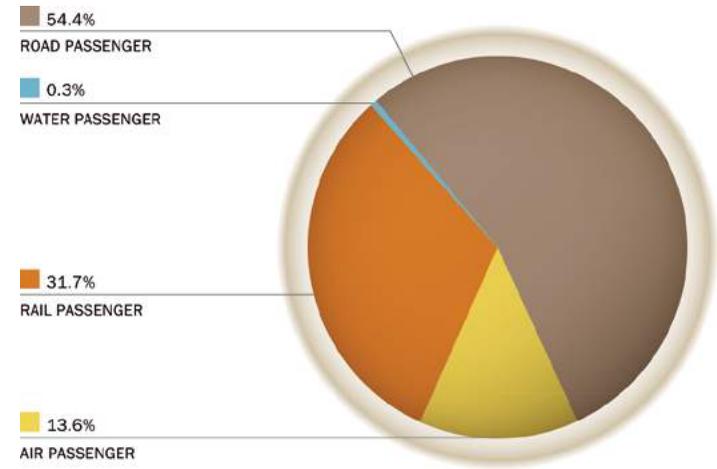
Source: IEA (2011b) and UIC (2011a)

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



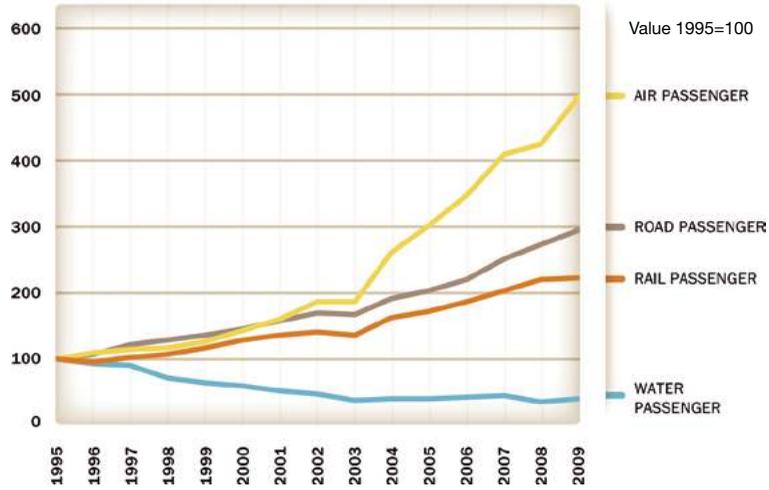
Source: UIC (2011a) and CNBS (2011)

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



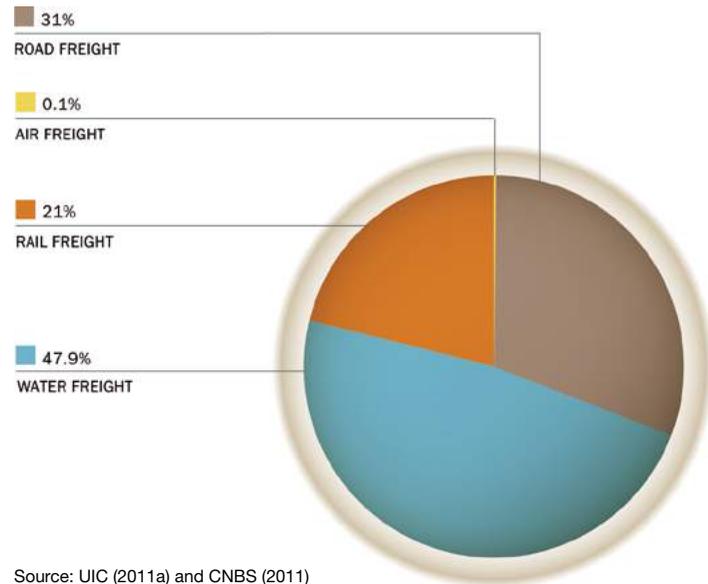
Source: UIC (2011a) and CNBS (2011)

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



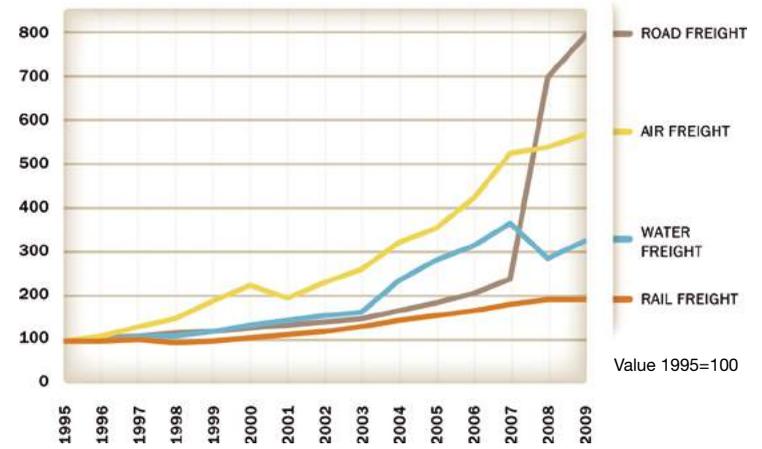
Source: UIC (2011a) and CNBS (2011)

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



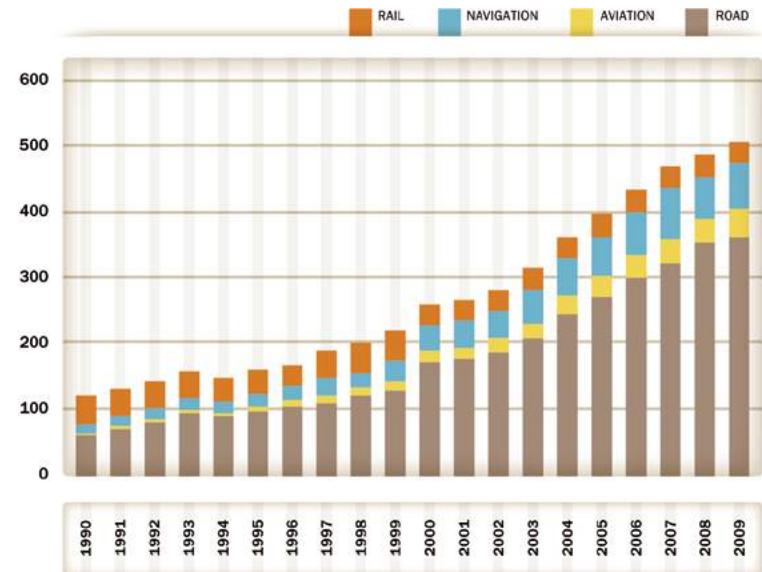
Source: UIC (2011a) and CNBS (2011)

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



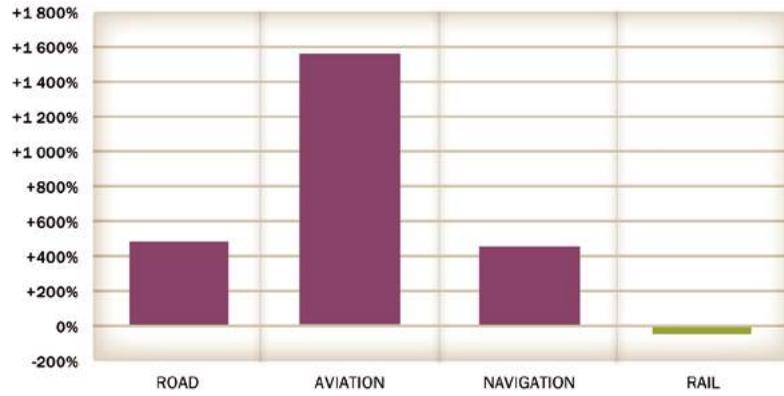
Source: UIC (2011a) and CNBS (2011)

Fig. 115: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



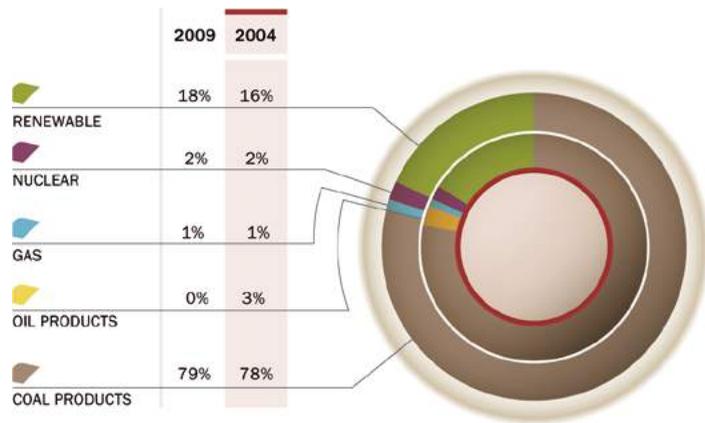
Source: IEA (2011a)

Fig. 116: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



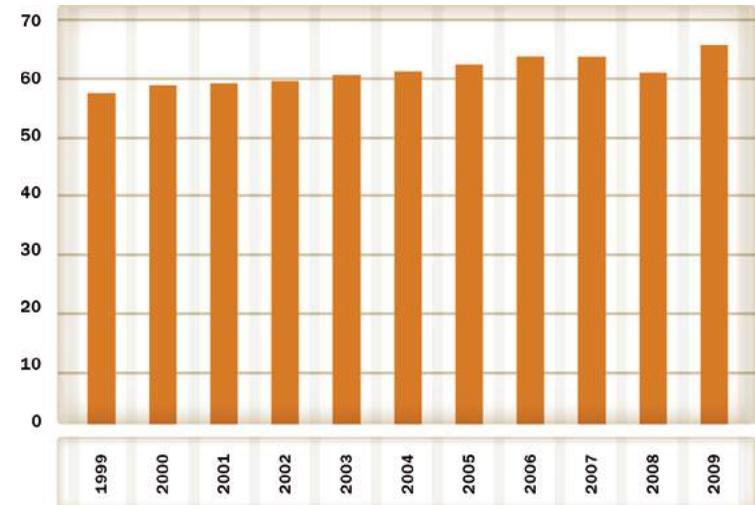
Source: IEA (2011a)

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



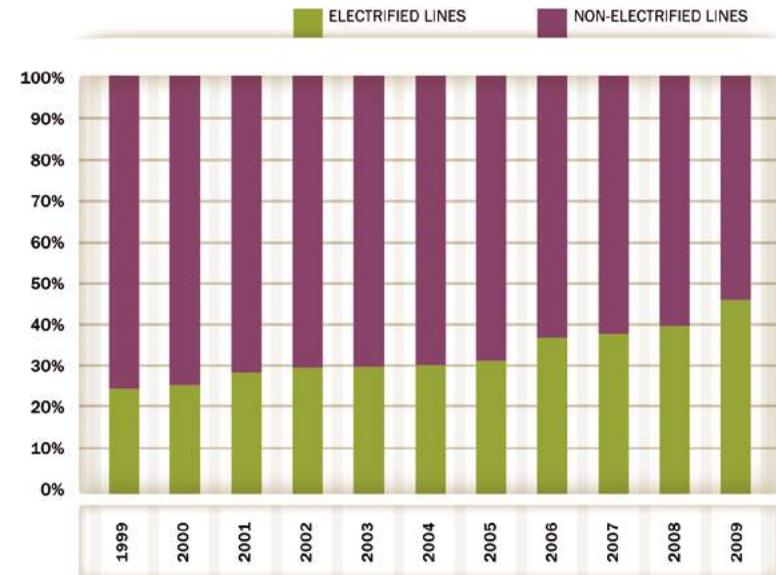
Source: IEA (2011b)

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



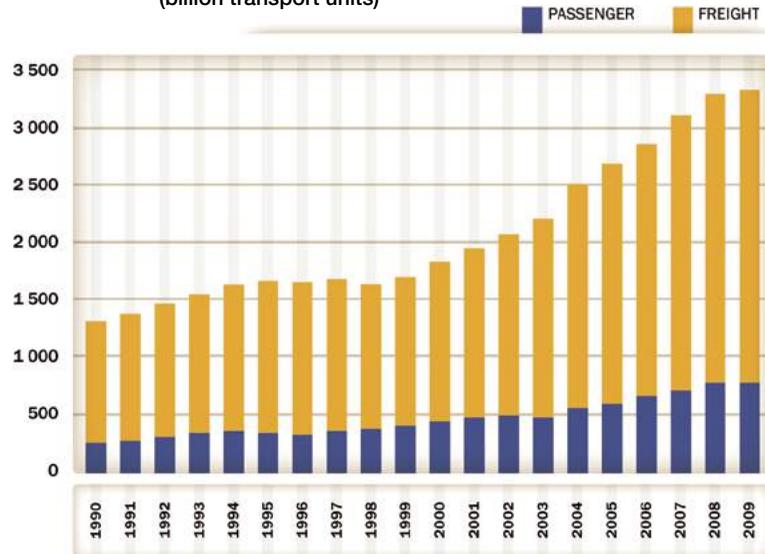
Source: UIC (2011a)

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



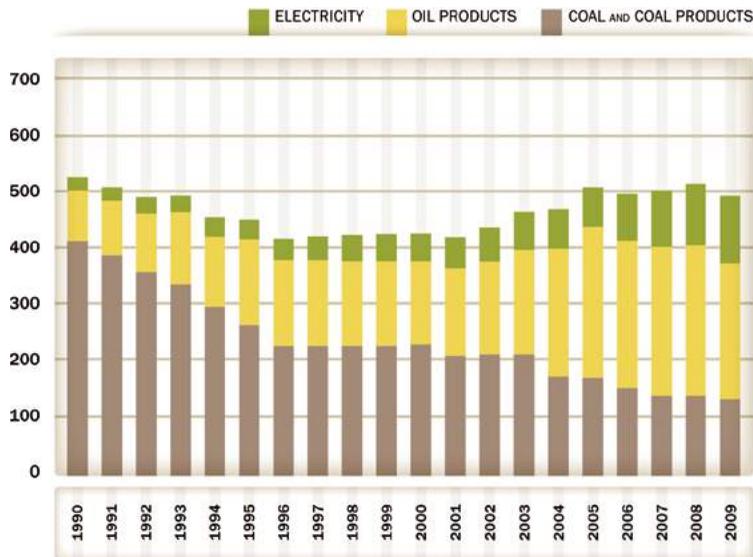
Source: UIC (2011a)

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



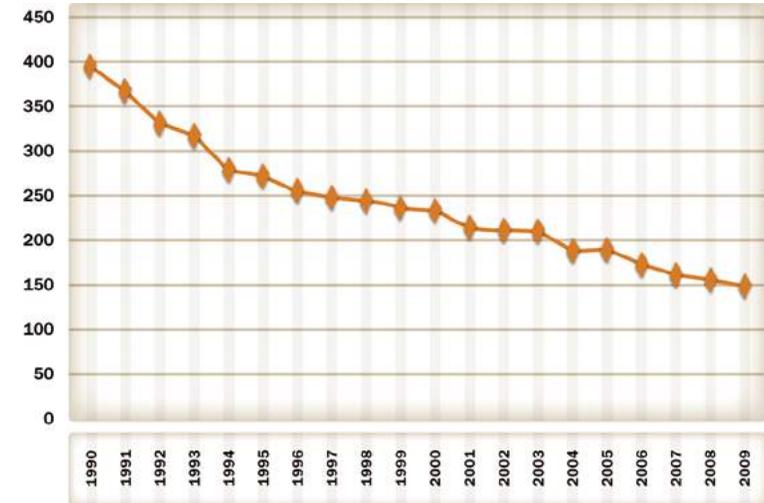
Source: UIC (2011a)

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



Source: (EA (2011b)

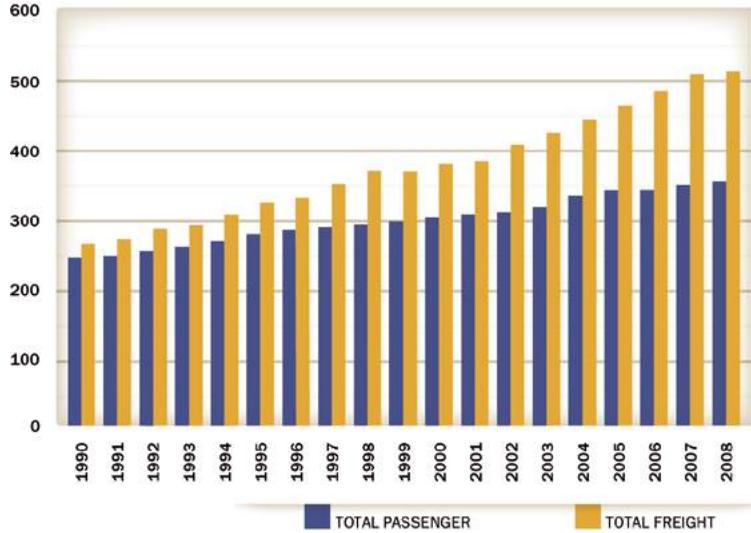
Fig. 122: Railway specific energy consumption, 1990-2009 (kJ/transport unit)



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

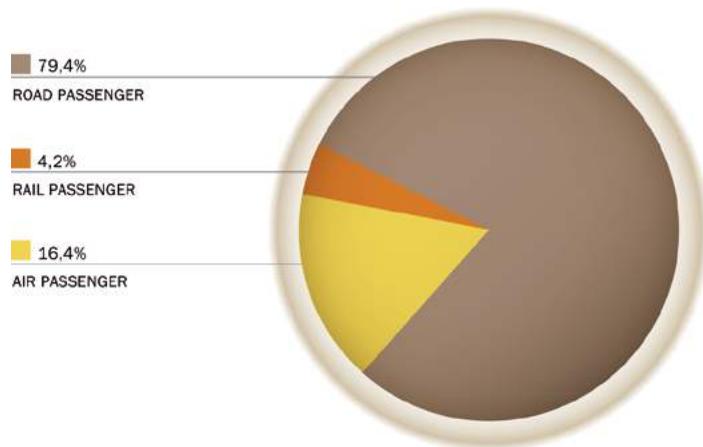
# Australia

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



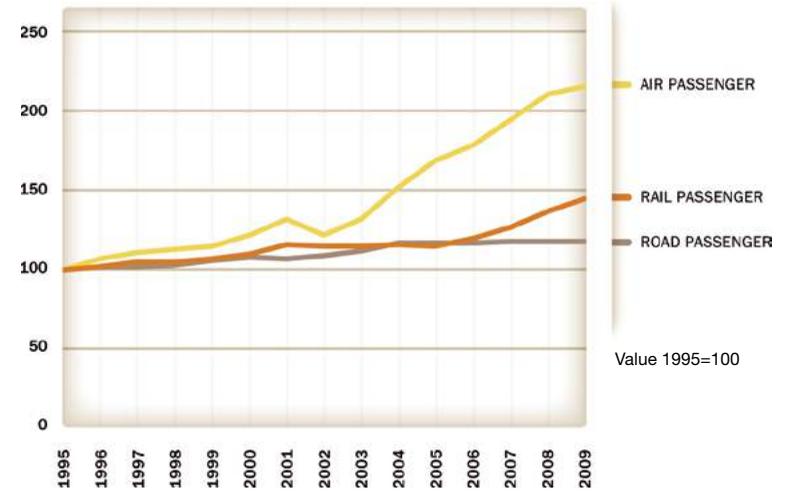
Source: OECD (2012) and BITRE (2011)

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



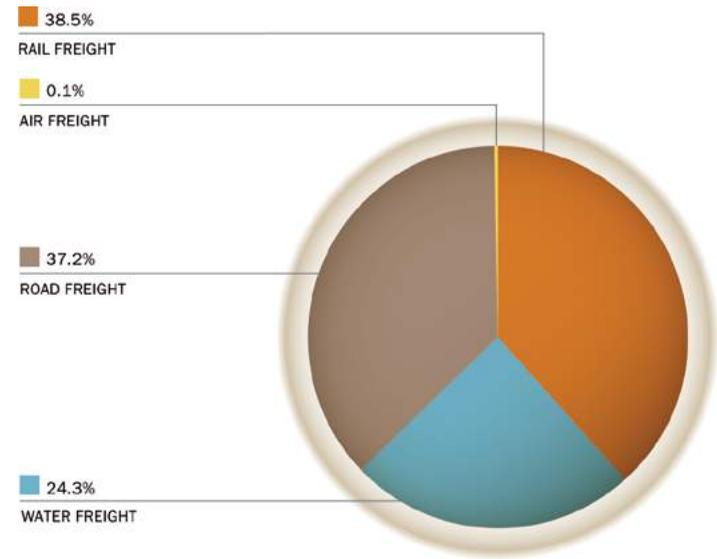
Source: OECD (2012) and BITRE (2011)

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



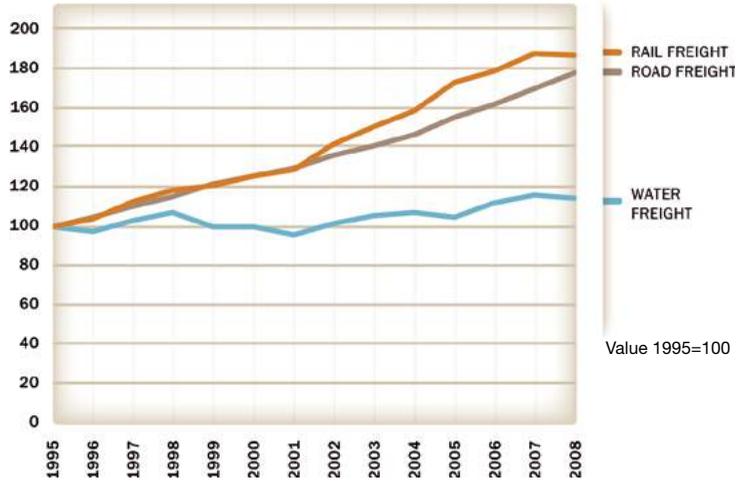
Source: OECD (2012) and BITRE (2011)

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



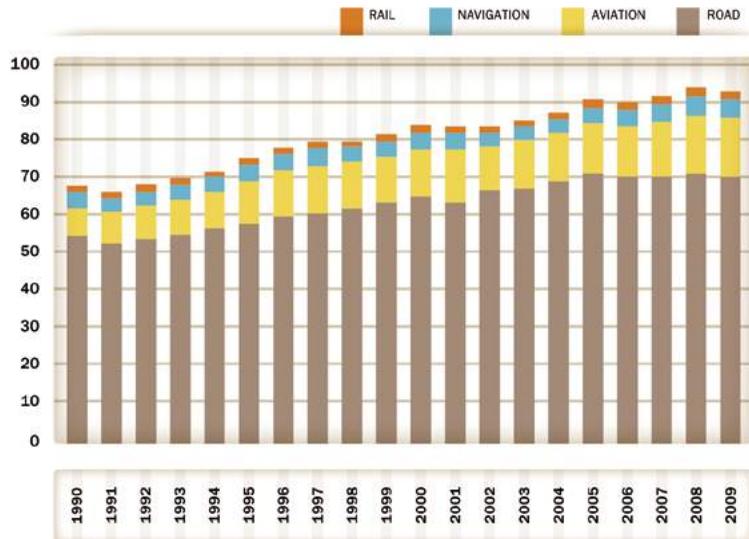
Source: OECD (2012) and BITRE (2011)

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



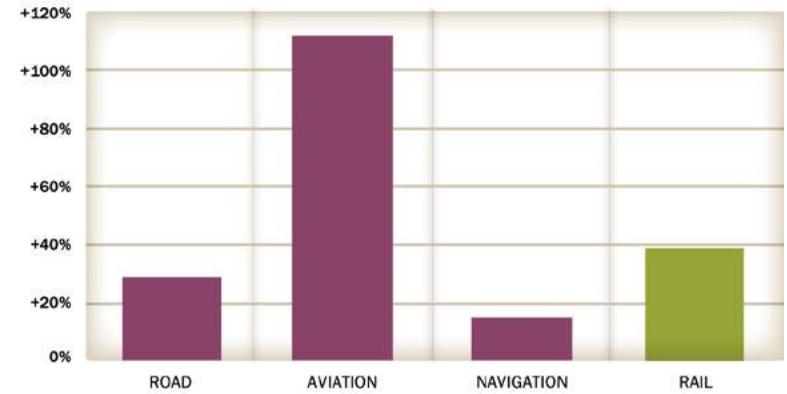
Source: OECD (2012) and BITRE (2011)

Fig. 128: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



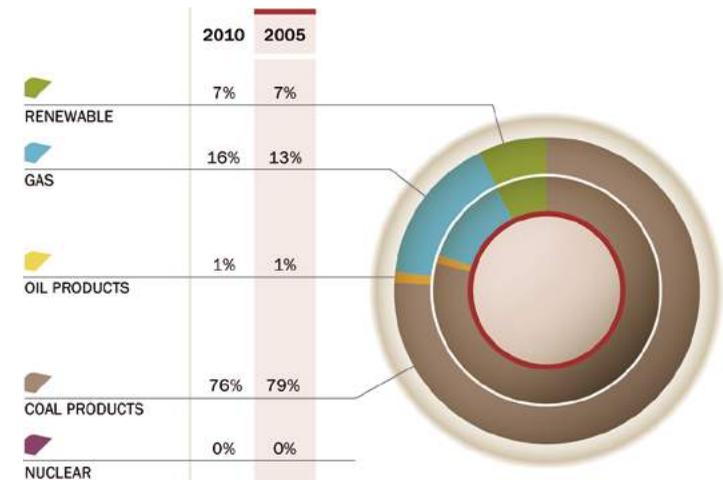
Source: IEA (2011a)

Fig. 129: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



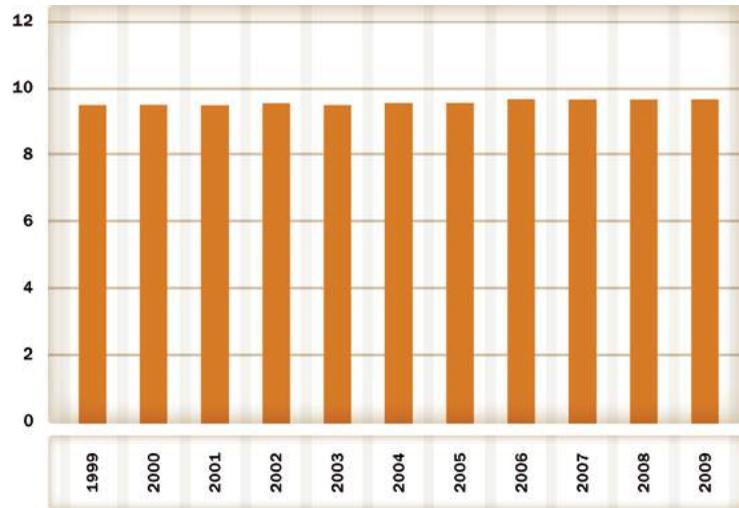
Source: IEA (2011a)

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



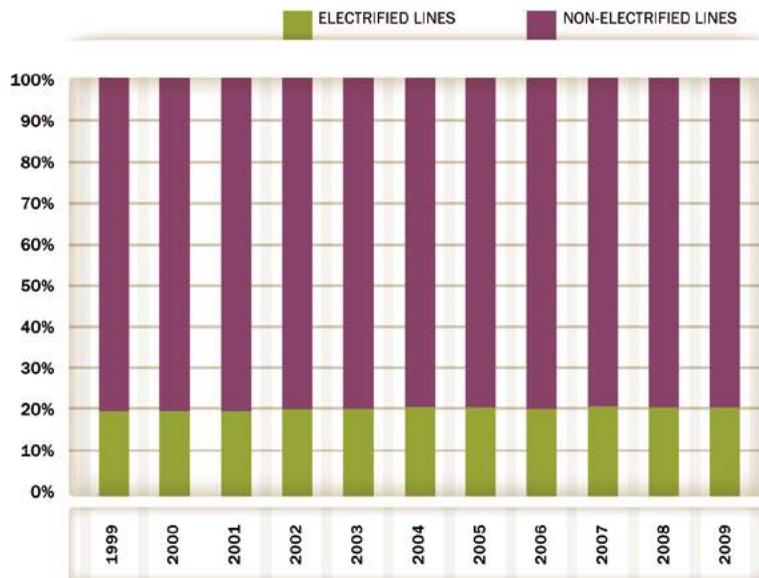
Source: IEA (2011b)

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



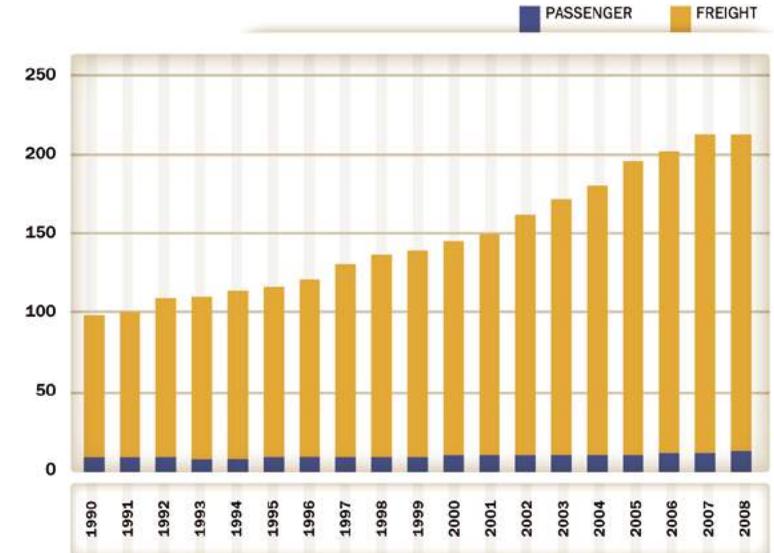
Source: UIC (2011a)

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



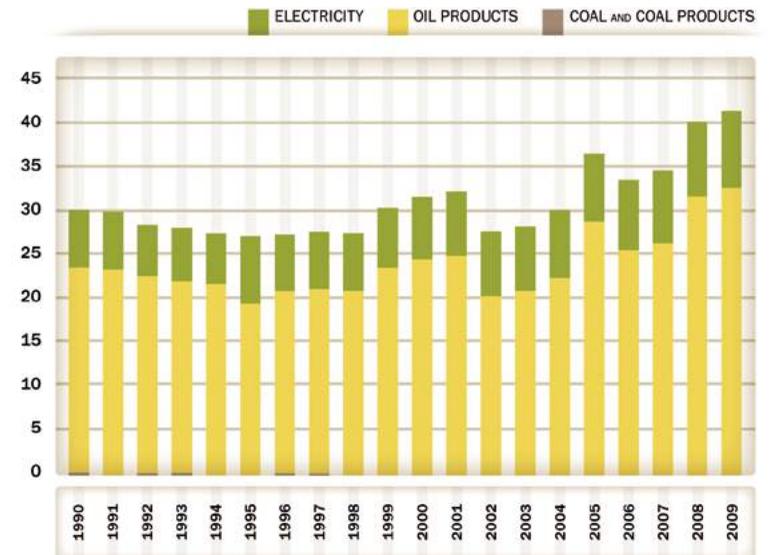
Source: UIC (2011a)

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



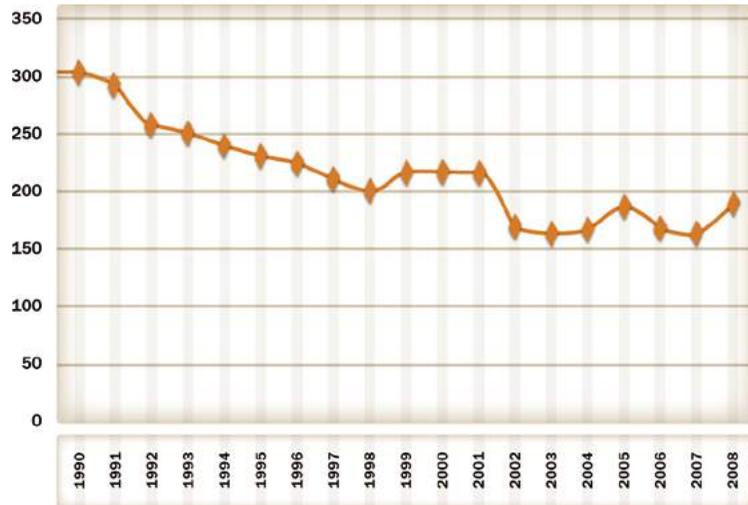
Source: UIC (2011a)

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



Source: UIC (2011b)

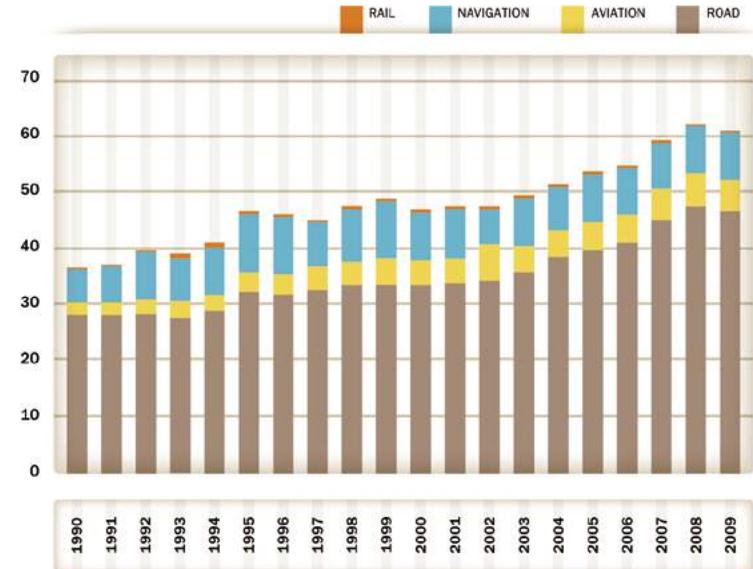
Fig. 135: Railway specific energy consumption, 1990-2009 (kJ/transport unit)



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

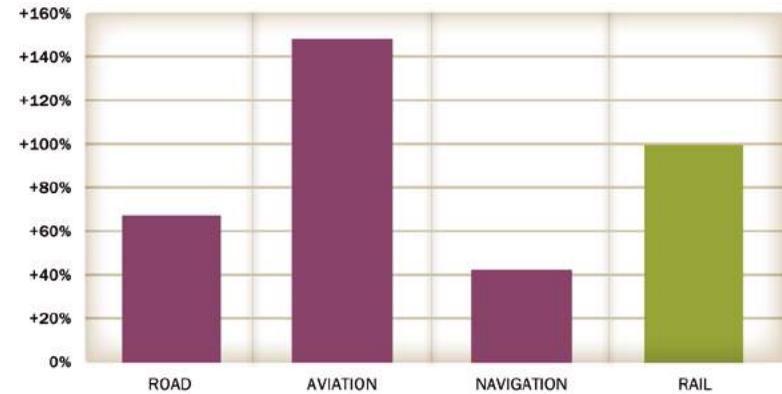
## South Africa

Fig. 136: Transport CO<sub>2</sub> emissions by mode, 1990-2009 (million tonnes)



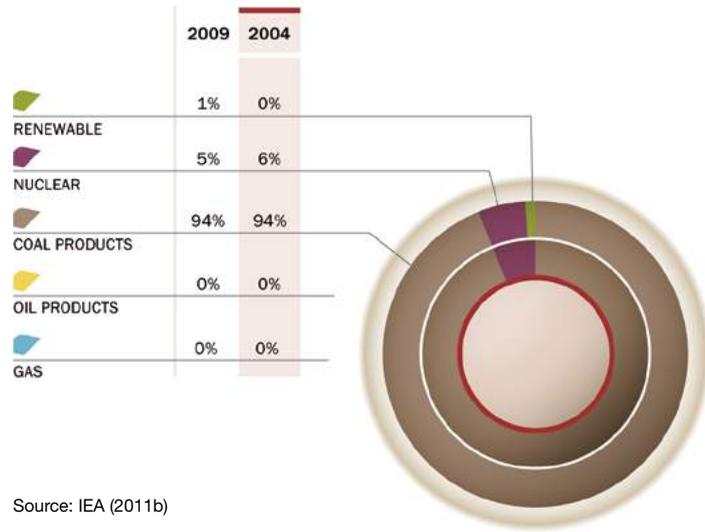
Source: IEA (2011a)

Fig. 137: Change in CO<sub>2</sub> emissions from fuel combustion by mode between 1990 and 2009



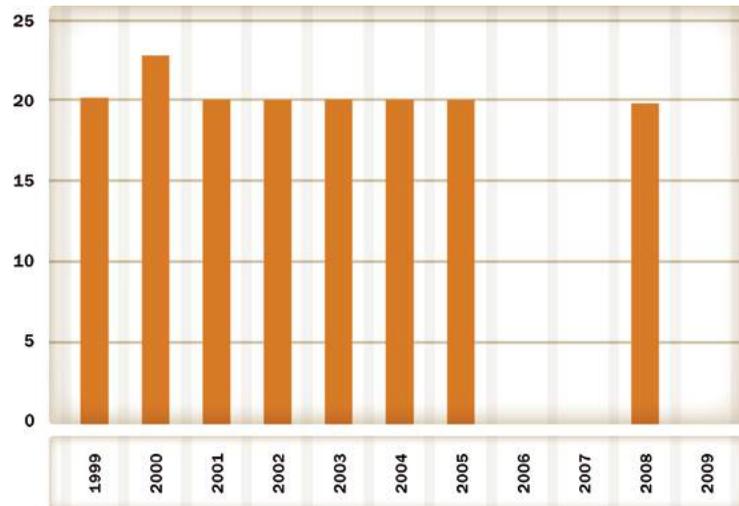
Source: IEA (2011a)

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



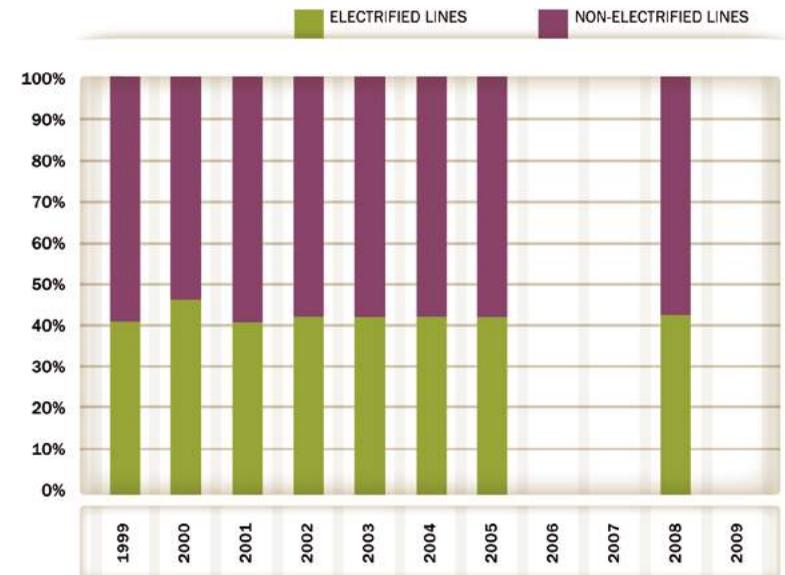
Source: IEA (2011b)

Fig. 138: Length of railway line, 1999-2009 (thousand km)



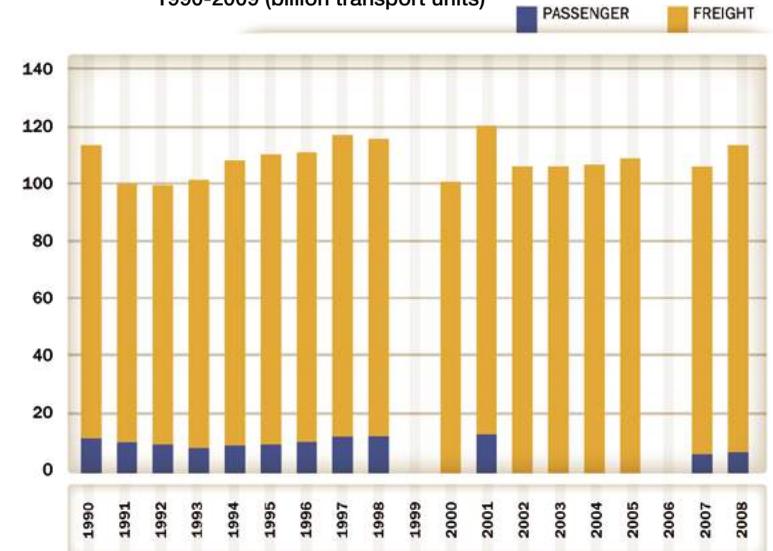
Source: UIC (2011a)

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



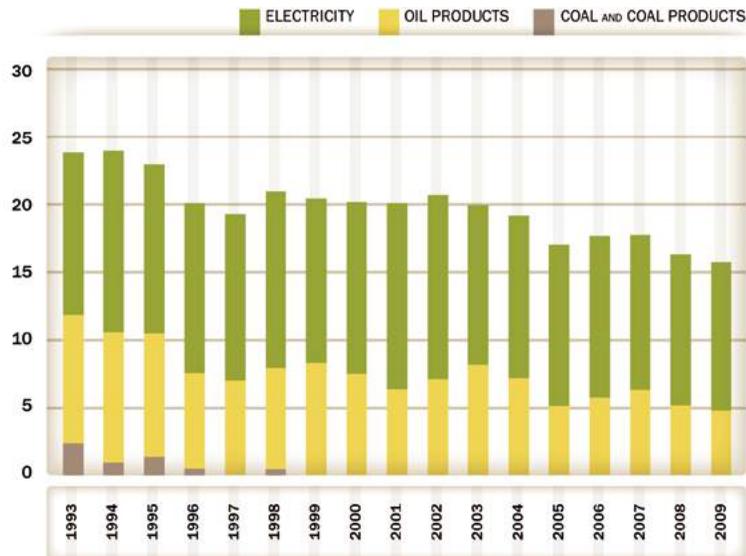
Source: UIC (2011a)

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



Source: UIC (2011a)

Fig. 142: Railway energy consumption by fuel, 1990-2008 (PJ)



Source: IEA (2011b)



## 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 does not include urban rail metro and train.

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<sub>2</sub> 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<sub>2</sub> from fuel combustion* database does not attribute any CO<sub>2</sub> emissions from the use of electricity in the transport sector. The CO<sub>2</sub> 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<sub>2</sub> emission reduction, such as the EU ETS in the EU.

Railway CO<sub>2</sub> emissions in Fig.9 are an exception to the previous rule, as that figure takes 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 tonnekilometre

**TTW:** Tank to wheel

**WTT:** Well to tank

**WTW:** Well to Wheel

Source: (Eurostat, 2010)

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