# Insights on energy consumption and $CO_2$ emissions of railways emerging from the Railway Handbook 2015

**Marine Gorner**
International Energy Agency

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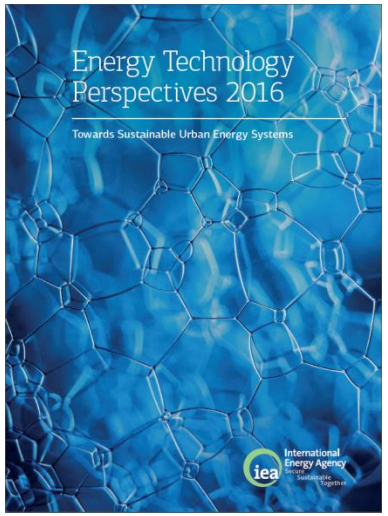
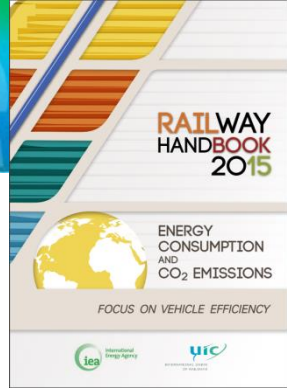
# IEA and the Mobility Model




- "The IEA is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 29 member countries and beyond"

- In transport, development of the **Mobility Model**
  - Analytical tool used to elaborate the projections of transport activity, energy demand and $CO_2$ emissions in ETP since 2006
  - The foundation of transport-related analysis in the Sustainable Policy and Technology Directorate
  - An essential tool for transport-related activities on…
    - energy efficiency: Global Fuel Economy Initiative (GFEI)
    - energy technology: Electric Vehicle Initiative (EVI)
    - **cooperative efforts: Railway Handbook on Energy Consumption and $CO_2$ emissions with UIC**
  - 2015: extension of MoMo analytical capabilities to urban/non-urban energy use
    - implication for rail services energy use
  - Funded by "MoMo partners" – private sector, academia and NGOs

# Railway Handbook – Energy consumption and $CO_2$ emissions, 2015 and 2016 editions




- 2016: 5th year of collaboration between UIC and IEA

in releasing a statistical pocketbook on rail network, activity, energy consumption and $CO_2$ emissions

  - **2016 Handbook to be released in September 2016 – focus on progress toward energy efficiency targets**

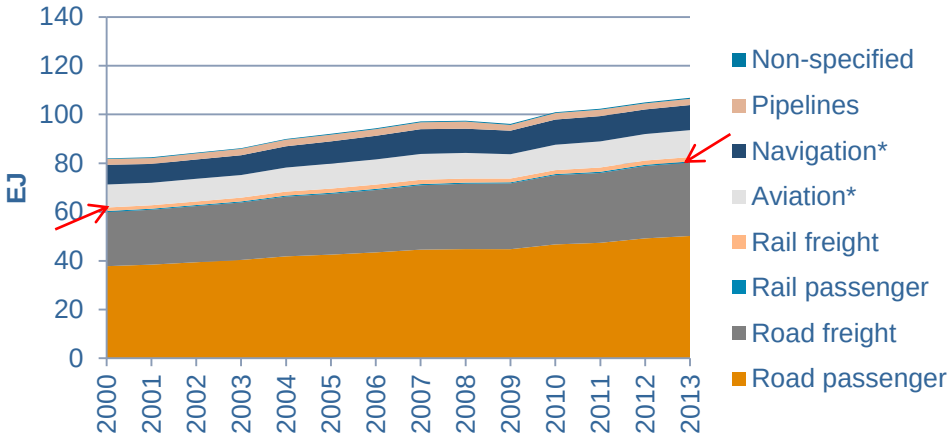
- Ongoing improvement of methodology and data consistency
- **Focus in 2015: energy efficiency in the rail sector**
  - Includes a review of the latest developments in technologies and operational tools for improving the energy efficiency of rail
  - Data presented today are from the 2015 edition

# Rail in context - Global picture

## Rail accounts for just a fraction of total transport energy use

**Global transport energy demand**

*Rail (2015): 2 EJ*
*Total: 107 EJ*

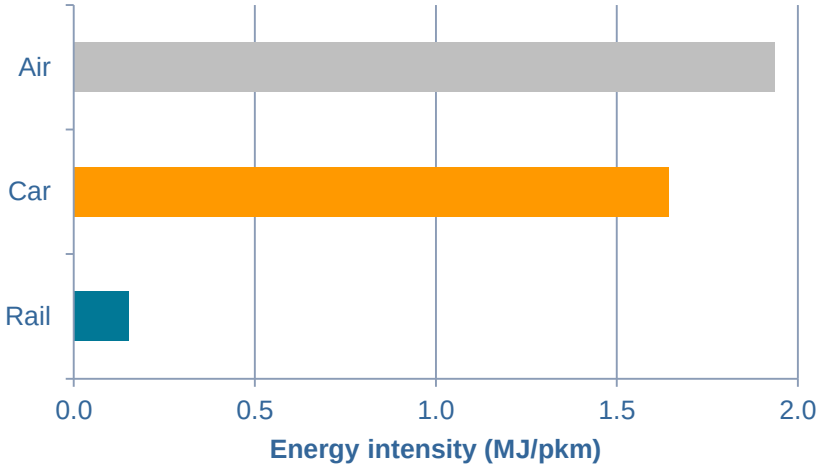



Source: IEA energy balances and IEA Mobility Model

* Includes international bunkers

## Rail is one of the most energy efficient transport modes

**Energy intensity of passenger transport modes in 2015, global averages**



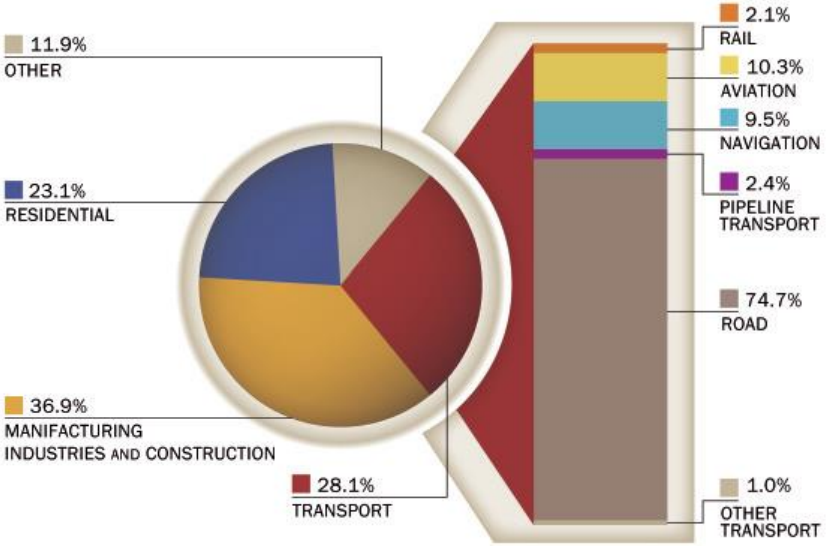

Source: IEA Mobility Model – outputs for ETP 2016

# Key findings

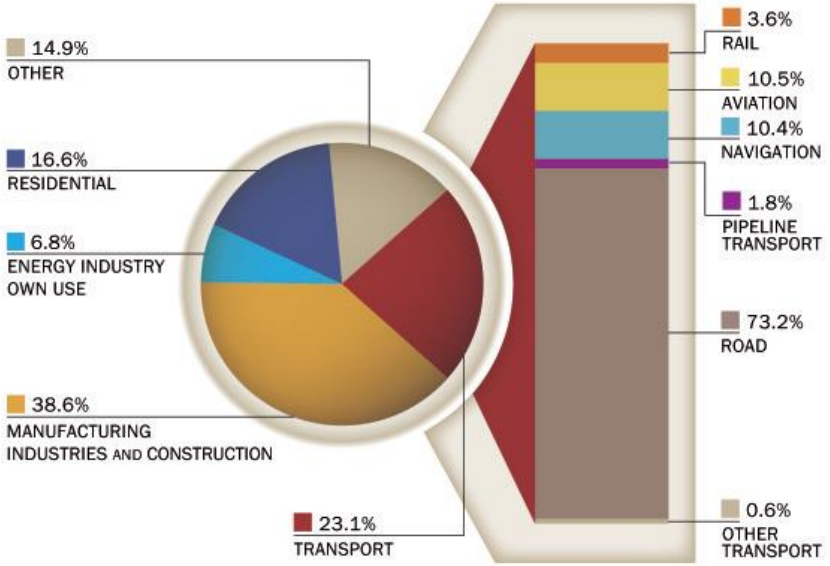
- Rail is already amongst the most energy efficient transport modes
- Energy intensity of passenger and freight trains is improving, but some indicators show a weakening trend in recent years
- Electric trains are the most efficient: electrification should be prioritized in high frequency portions of networks
- Diesel use is still relevant: continuous technological innovation of diesel trains is necessary
- High-speed rail is more efficient than intercity rail, despite higher speed, and than other alternatives (car, aviation): opportunity for more sustainable mobility

# World, 2012

## Energy




## GHG emissions




Source: Elaboration by SusDef based on IEA Statistics "$CO_2$ emissions from fuel combustion"

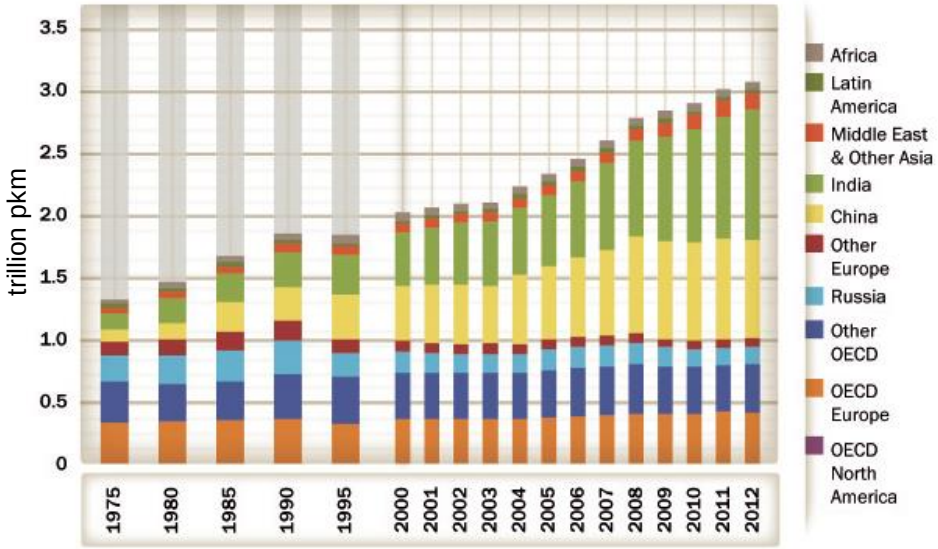
Electricity and heat emissions are reallocated to the end-use sectors. In transport, all the emissions from electricity/heat production are reallocated to rail.

Rail accounts for

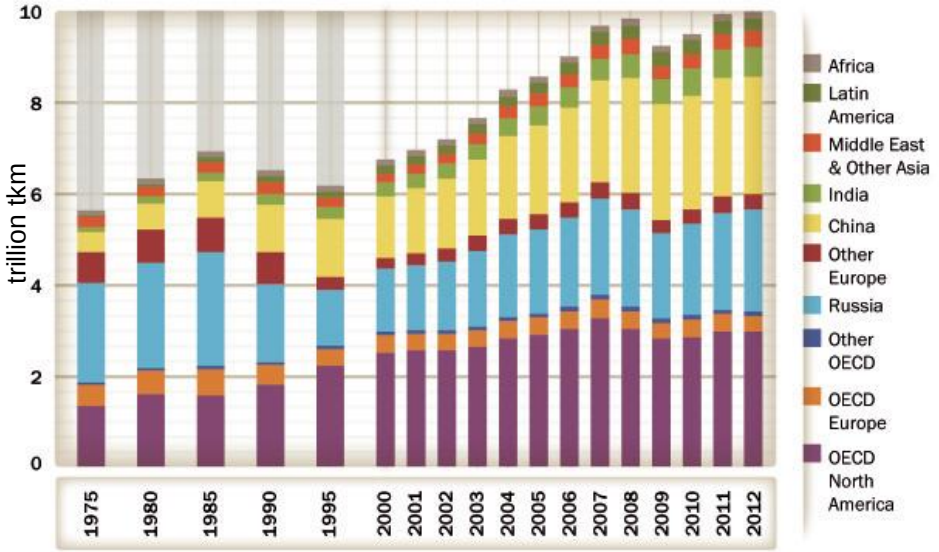
- 3.6% of transport GHG emissions and 2% of the energy use
- 0.8% of total GHG emissions and 0.6% of energy use

# Global rail activity

Passenger (excluding urban)




Freight

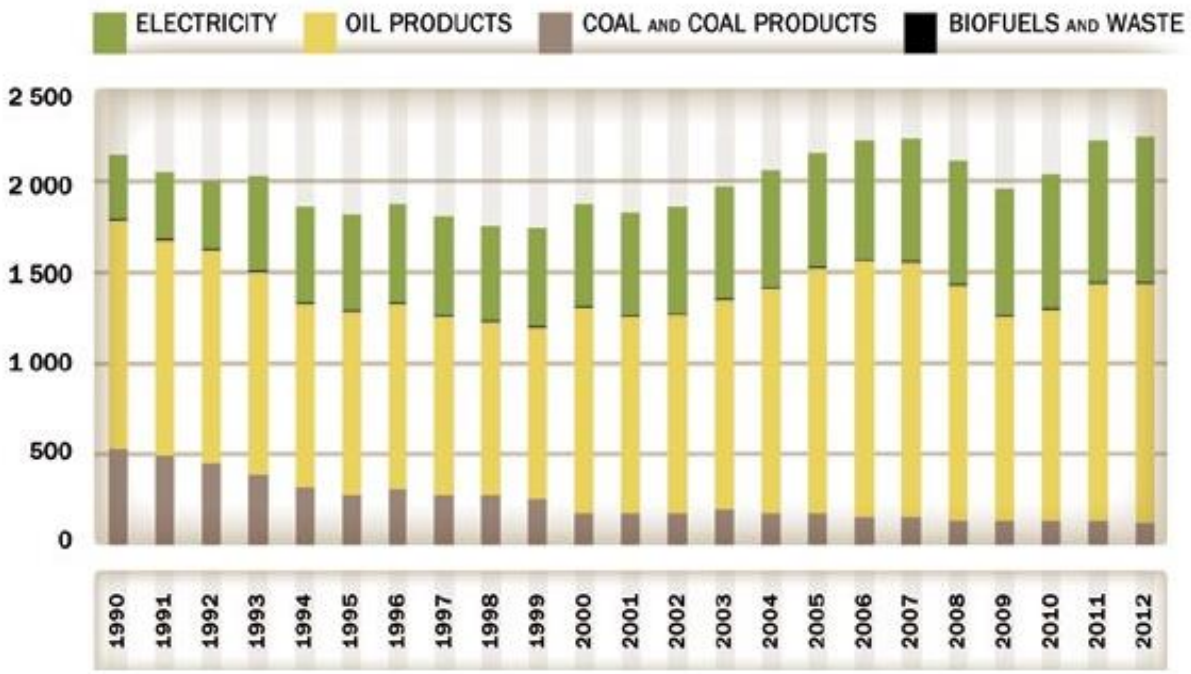



Source: Elaboration by IEA based on UIC "International Railway Statistics" .

- Passenger rail travel increased 131% between 1975 and 2012
  - China and India: seven-fold increase 1975-2012
  - OECD: rail passenger activity stable since decades
- Freight rail up 78% since 1975, most relevant in North America, Russia and China
- India: 1000 billion pkm - 650 billion tkm (2012)

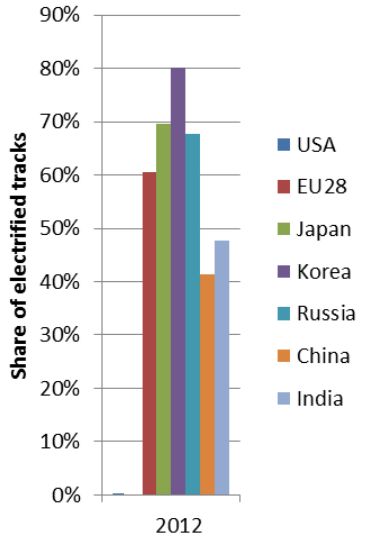
# Evolution of global rail energy consumption and fuel mix

**Railway final energy consumption by fuel, World, 1990-2012 (PJ)**




Source: Elaboration by SusDef based on IEA Statistics "World energy balances"

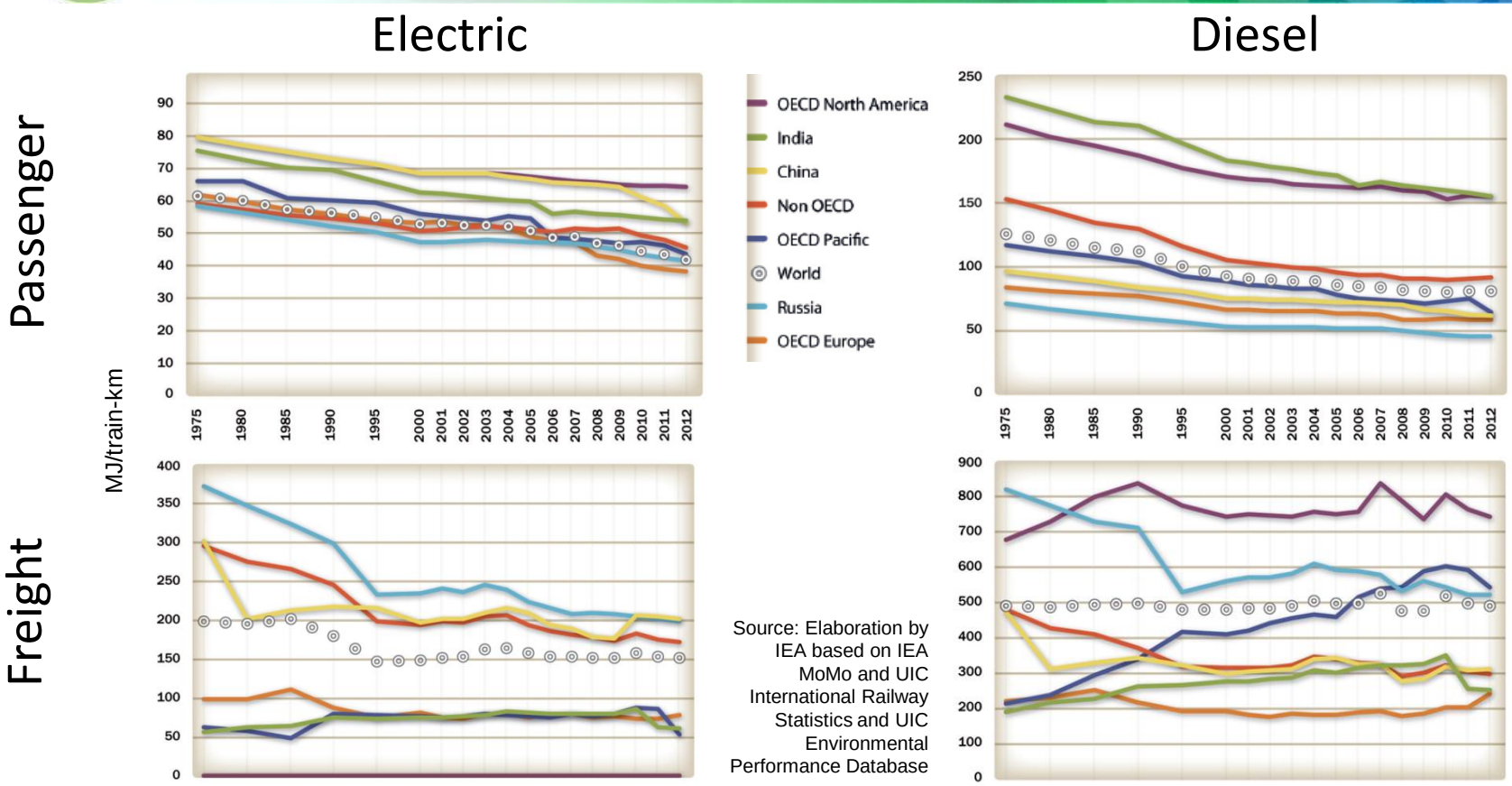
**Track electrification share by country, 2012**




Source: Elaboration by IEA based on UIC "International Railway Statistics"

- In spite of a continuously growing trend in activity over 2 decades, the total energy consumption of rail services worlwide was comparable in 2012 to 1990 levels
- This is partly due to the progressive phasing out of inefficient coal powered locomotives to the benefit of electrification

# Energy intensity per vehicle-km

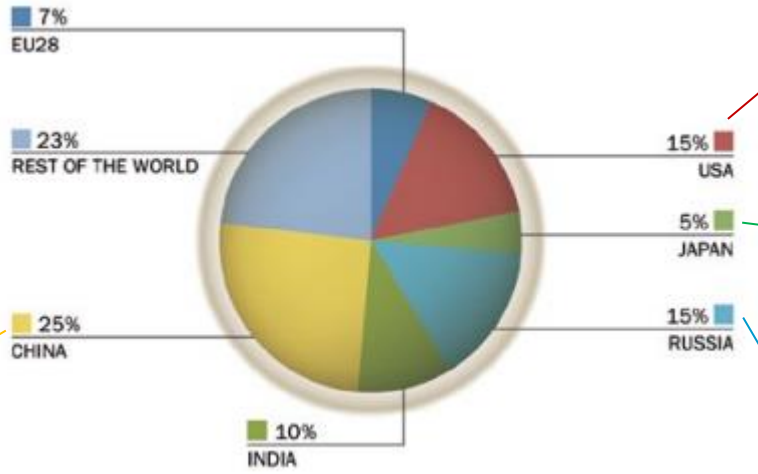



- Energy intensities are way higher for diesel trains (global average about double), improvements in passenger diesel and freight have been stabilizing in recent years
- Methodology: matching information from IEA energy balances and UIC activity data
- *Besides vehicle performance, country-specific characteristics play a part (vehicle composition, weight due to load)*

# Country contributions to global railways $CO_2$ emissions

**Share of railway $CO_2$ emissions by geographic area, 2012**

**(Total: 210 million tCO2)**




- Electrification rate: 70%
- Ren. & Nuclear in electricity mix: 40%

- Dieselisation rate: 95%
- Mostly freight traffic

- High use of rail : 22% of pkm
- Electrification rate: 90%

- Main rail user in the world: 800 billion pkm, 2500 billion tkm

- Rail is the main transport mode in the country: 30% of pkm, 90% of tkm

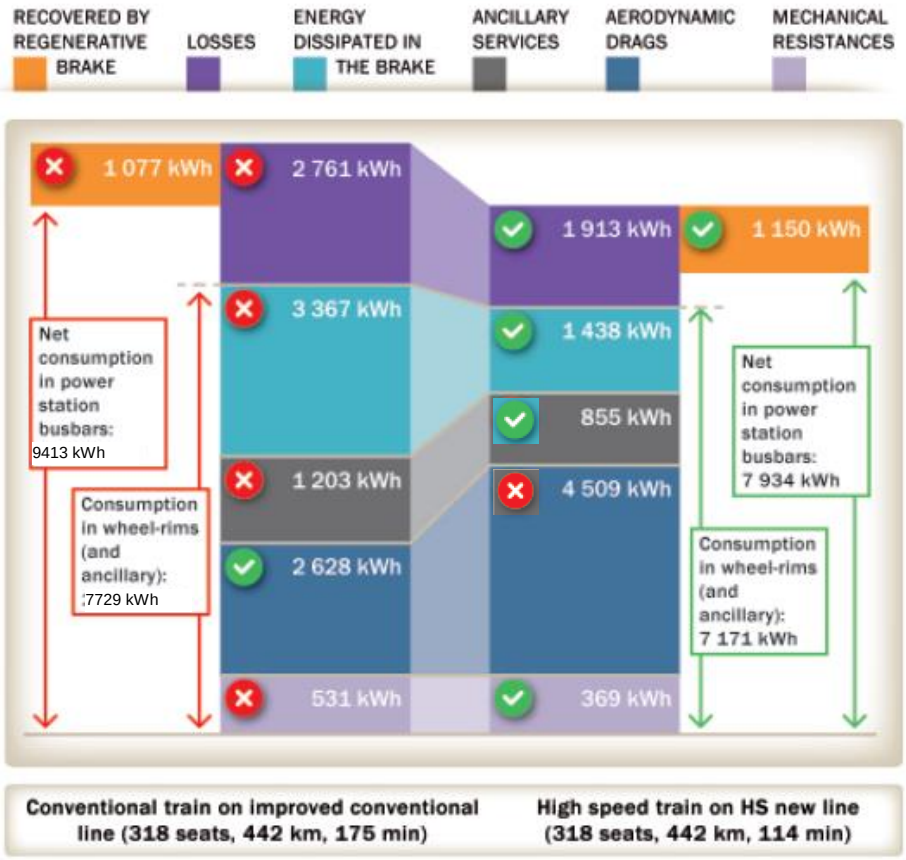
- Highest passenger activity: 1 trillion pkm
- Lower rail energy consumption than in 1990 while increasing activity

Source: Elaboration by SusDef based on IEA Statistics "CO2 emissions from fuel combustion"

# Conventional and high-speed rail energy efficiency

**Comparison of energy consumption between a conventional train and a high-speed train**

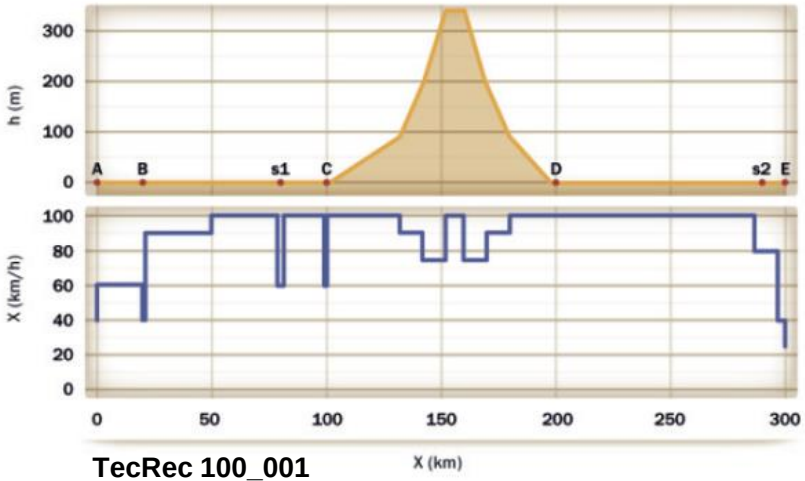
Source: Fundación de los ferrocarriles españoles (FFE) 2010, High speed, energy consumption and emissions, Study and research group for railway energy and emissions. Commissioned by UIC. Paris, 2010



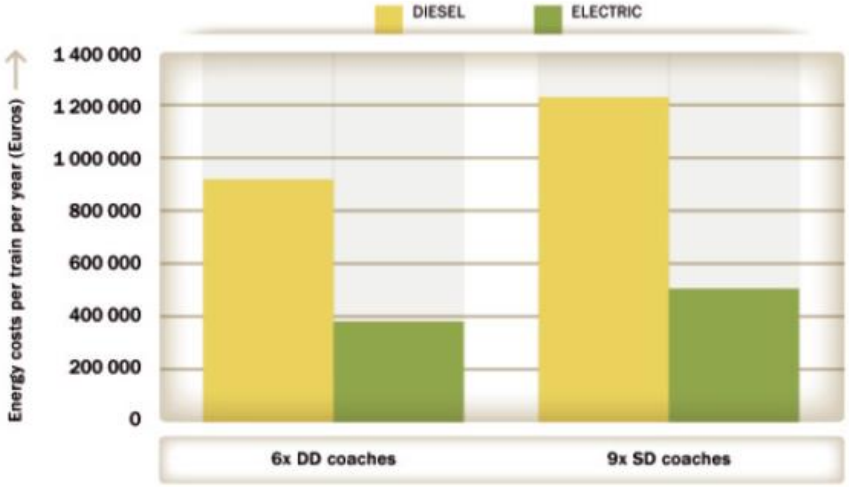

- High-speed rail seems to be more efficient than intercity rail, despite higher speed (higher aerodynamic drag is offset by other savings)
- High-Speed rail is also more efficient per pkm than other alternatives such as car or aviation: opportunity for more sustainable mobility
- Main issue remains cost: need to make sure that HSR networks are highly used

# Case studies showing paths for improved energy efficiency described in the Railway Handbook

| Vehicles and fuels | Technical operations | Benchmarking tools |
|---|---|---|
| Aerodynamics, engines, vehicle weight | Energy recovery from braking<br>JR inter-vehicle energy exchange system | *UIC/UNIFE standard:*<br>"Specification and verification of energy consumption for railway rolling stock" |
| Fuels<br>*Electric vs diesel cost assessment by Bombardier* | Infrastructure management<br>*RZD "Elbrus" system* | Retrofitting energy meters on electric trains<br>*plans for European operators: 25,000 energy meters by 2020* |
| Hotel loads<br>*IR PV panels initiative* | Eco-driving and driver advisory systems | |




**TecRec 100_001**
Source: UNIFE/UIC



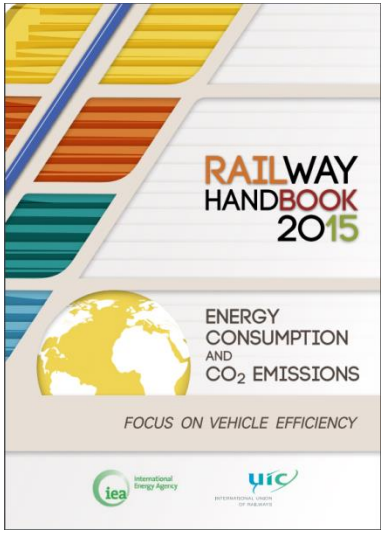

**Energy costs assessment**
Source: Bombardier


**JR recovered energy storage system**
Source: Japan Railway Group

# Summary and prospects for the rail sector

- Rail is one of the most energy efficient transport modes
- Electrification (ideally coupled with a low-carbon electricity mix) and better energy management (e.g. hotel loads, driving behaviour) can help making rail more sustainable
- High-speed rail can substitute to part of air and road travel, as a more sustainable alternative

- **Interest in understanding better energy consumption in urban vs. non-urban rail, and in high-speed services**

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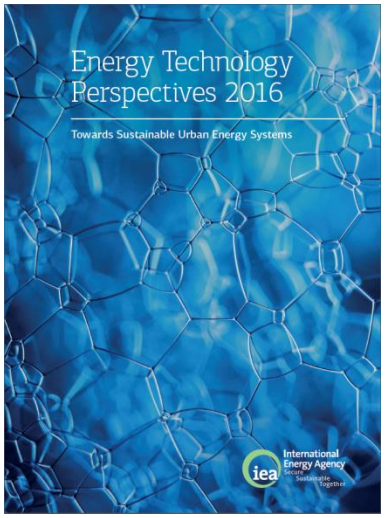


# Thank you for your attention

Marine Gorner

marine.gorner@iea.org