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Rail modelling at EU level: context and challenges

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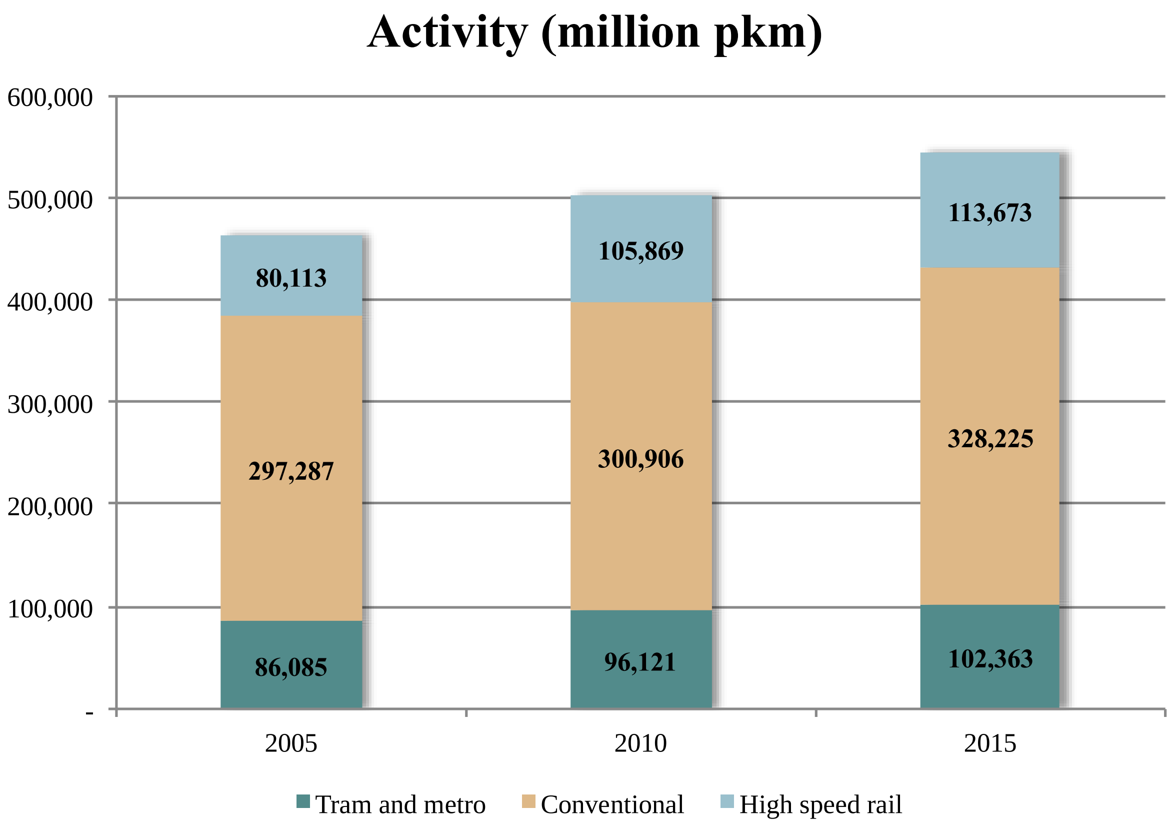
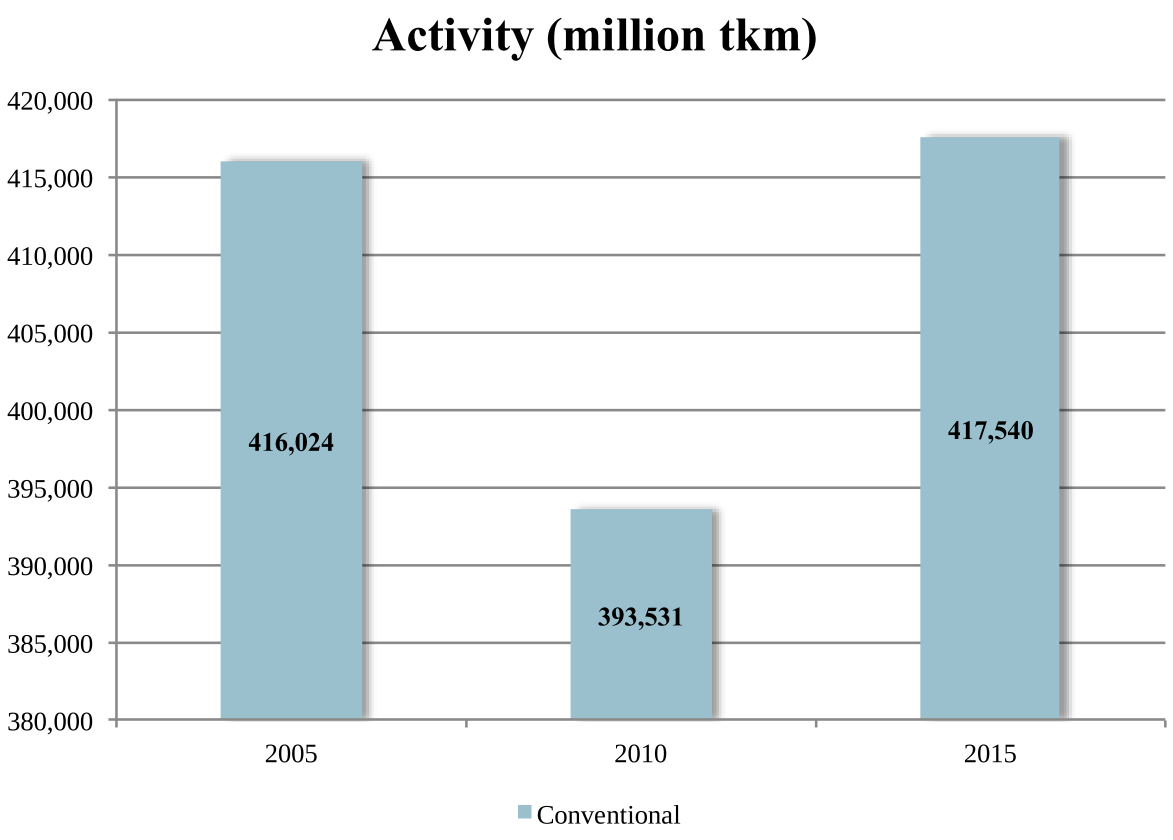
Rail transport and the EU context: some figures

- Rail passenger activity has shown strong growth in the last decade, particulary compared to road passenger growth over the same period.
- Tram and metro activity in pkm grew over a 18%, conventional train increased 10% more and HST witnessed a growth of more than 40% in pkm compared to 2005…



Rail transport and the EU context: some figures

- … however, rail freight transport has yet to recover pre-crisis activity levels (activity in tkm peaked in 2007 at 452 billion tkm)



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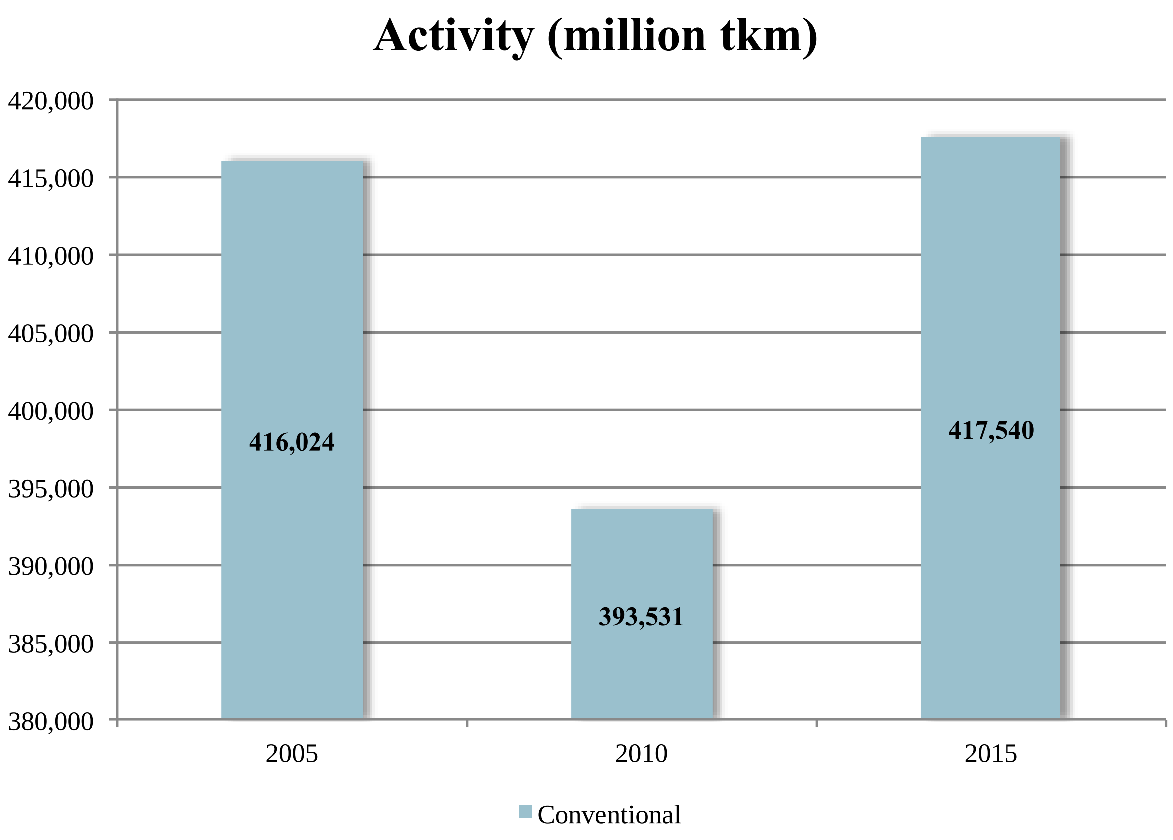
Rail transport and the EU context: some figures

- … however, rail freight transport has yet to recover pre-crisis activity levels (activity in tkm peaked in 2007 at 452 billion tkm)
- YET these figures alone do not provide enough insight to understand relevant dynamics:

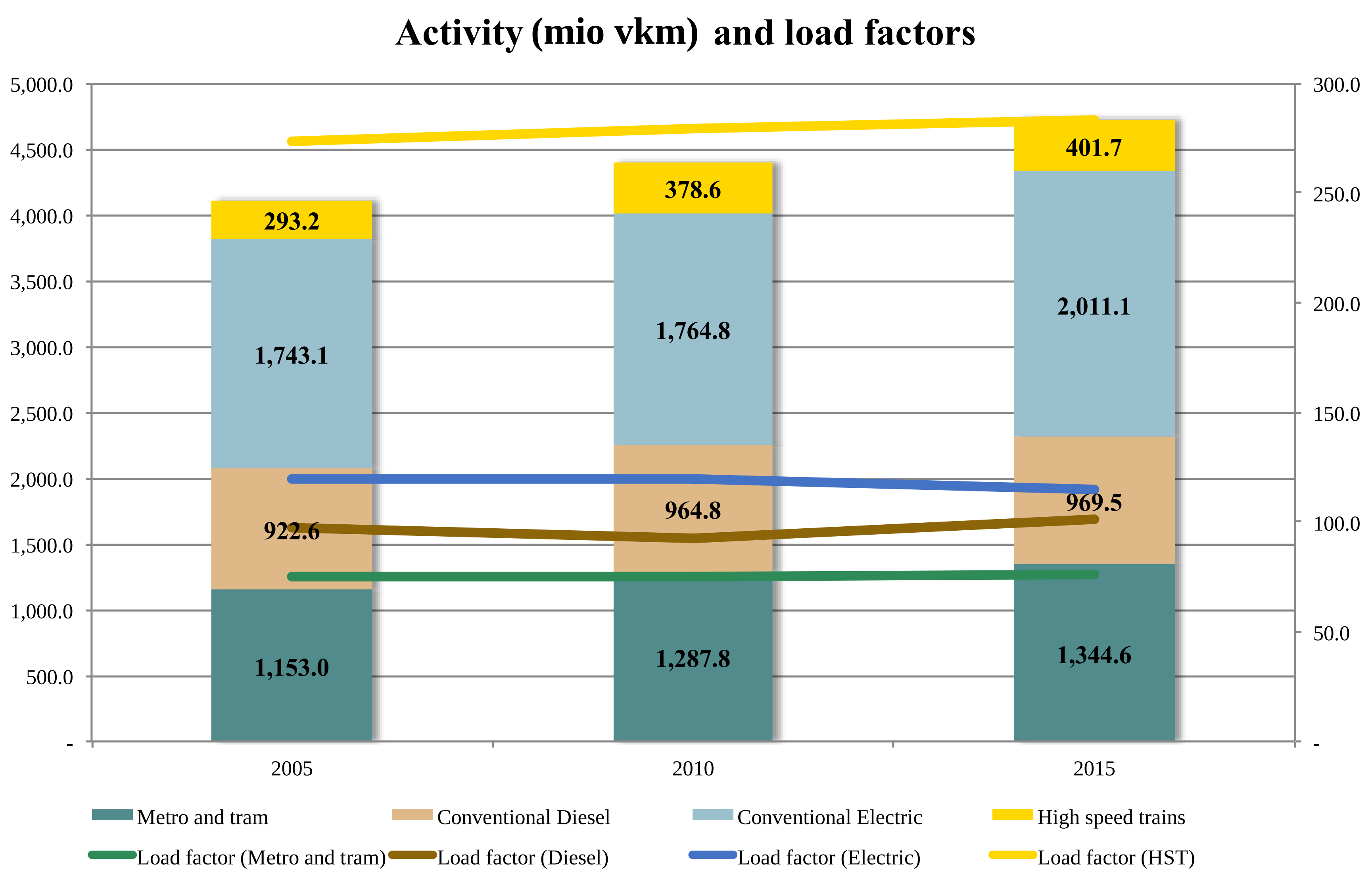
  Fleet evolution and operation?
  Load factors?
  Capacity issues?



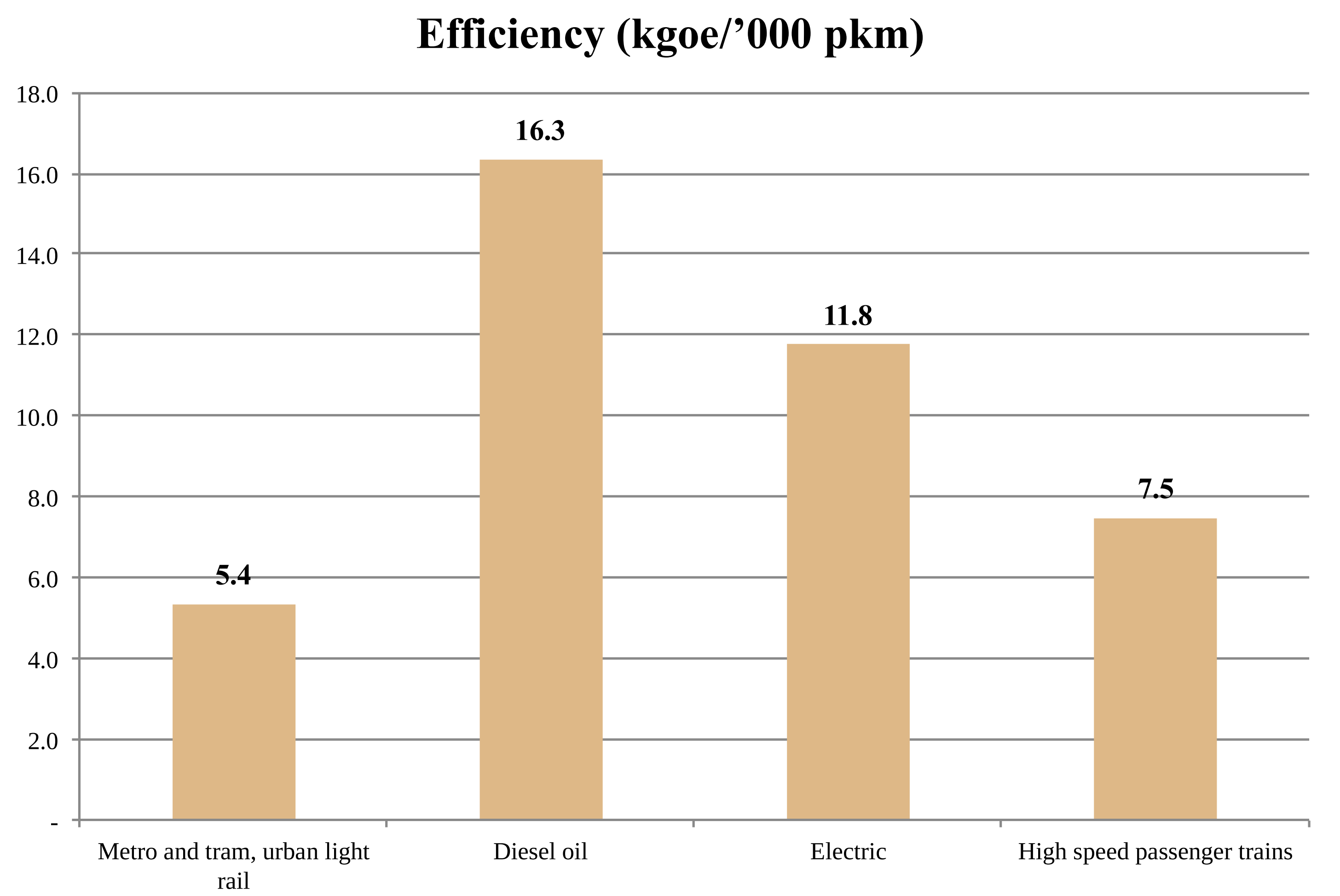
Modelling initiatives: JRC-IDEES

- Energy modelling: Joint Research Centre's Integrated Database of the European Energy Sector (JRC-IDEES) offers a consistent set of disaggregated energy-economy-environment data, covering all energy demand sectors and power generation and is compliant with the EUROSTAT energy balances.
- JRC-IDEES provides, for transport, the following indicators:
  - Annual mileage
  - Load factors
  - Stock
  - Energy consumption - by passenger/freight train and fuel type (diesel/electrical)
  - Fuel efficiency

Modelling initiatives: JRC-IDEES

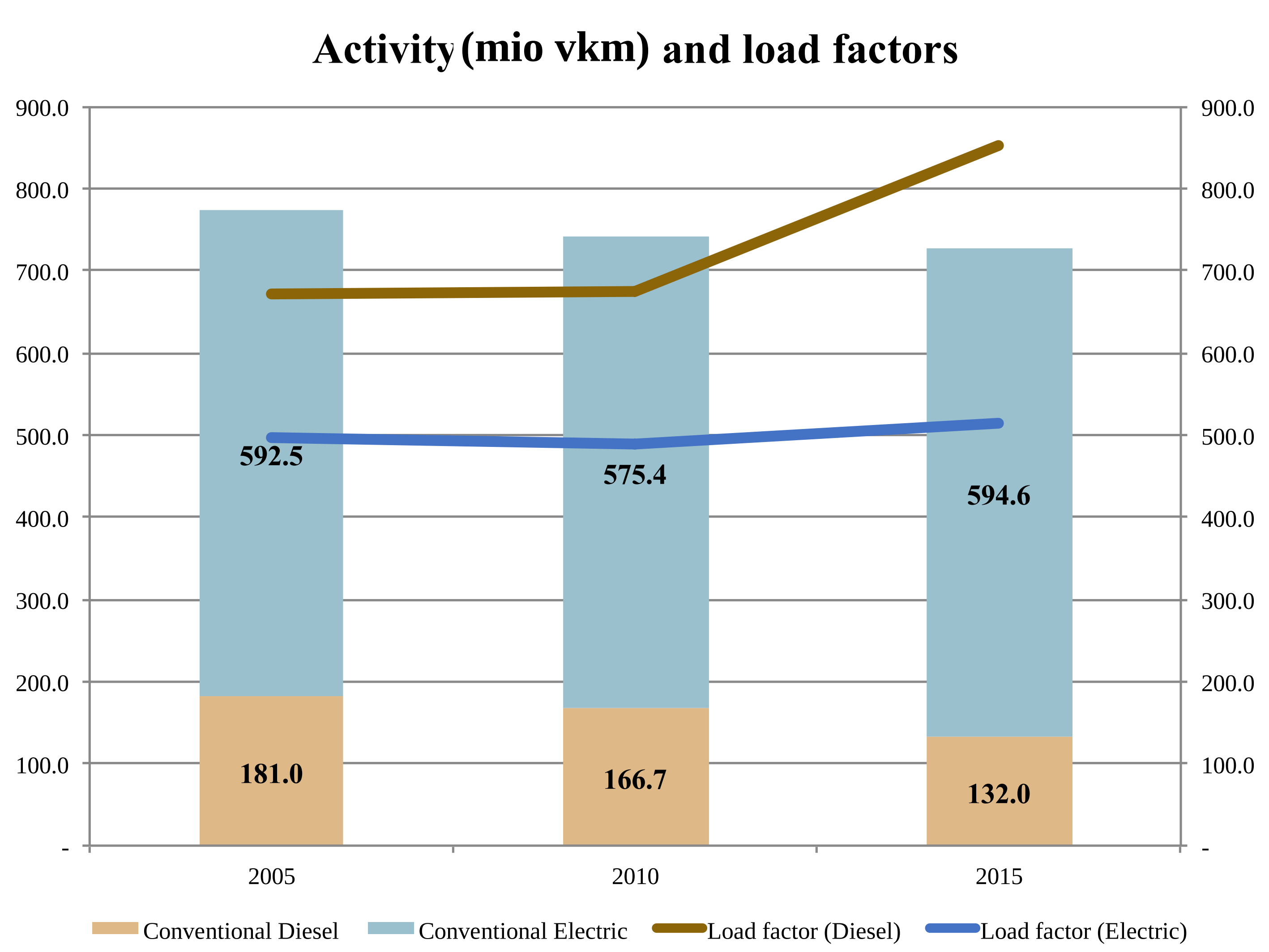


Modelling initiatives: JRC-IDEES

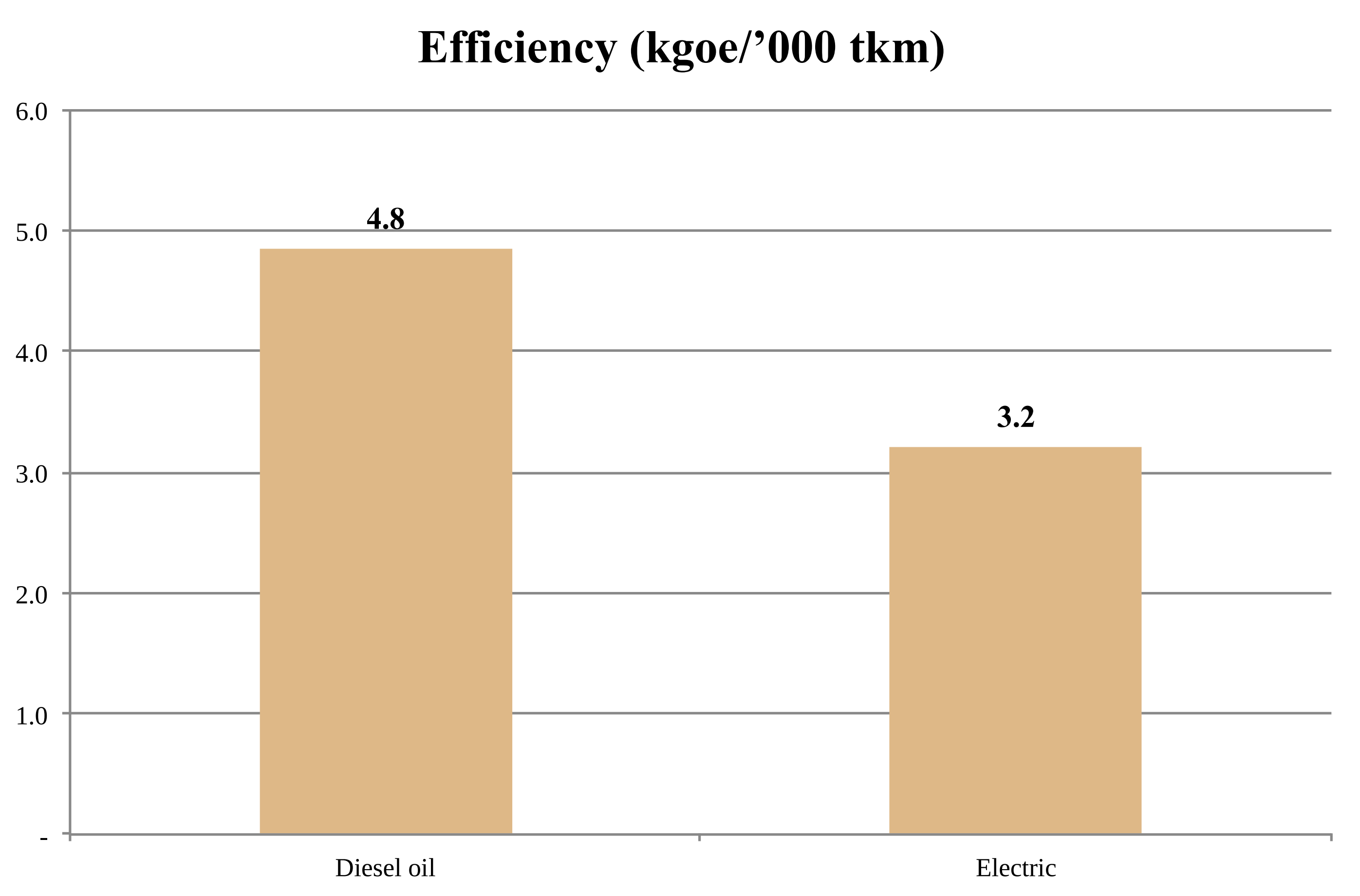


2015

Modelling initiatives: JRC-IDEES



Modelling initiatives: JRC-IDEES



2015

Modelling initiatives: JRC-IDEES

- JRC-IDEES is not a statistical database, although it incorporates various statistical sources in a consistent manner.
- Estimations and modelling work supports efficiency estimations in a way that reflects technological and behavioural factors (vehicle efficiency, load factors)

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Passenger Aviation and High Speed Rail: A Comparison of Emissions Profiles on Selected European Routes

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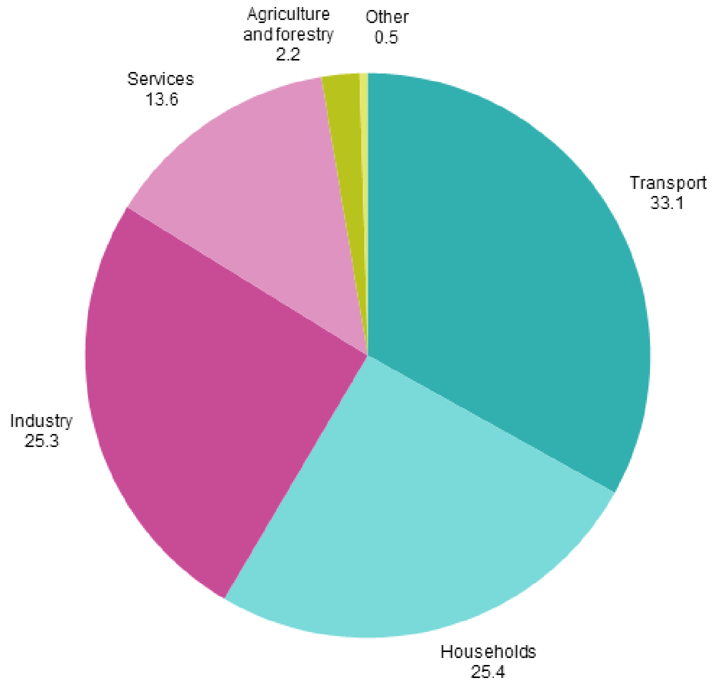
Aim of the study

- The **EU-28** entire **transport sector** in 2015 has been 358.6Mtoe, accounting for the **33% of the total EU-28 primary energy consumption.**

- **Road transport** is the most relevant segment (**82.0%**), followed by the **international aviation** (**12.8%**), whereas the **domestic aviation** (**1.54%**) and **rail** (**1.73%**)



Note: figures do not sum to 100.0 % due to rounding.
Source: Eurostat (online data code: nrg_100a)

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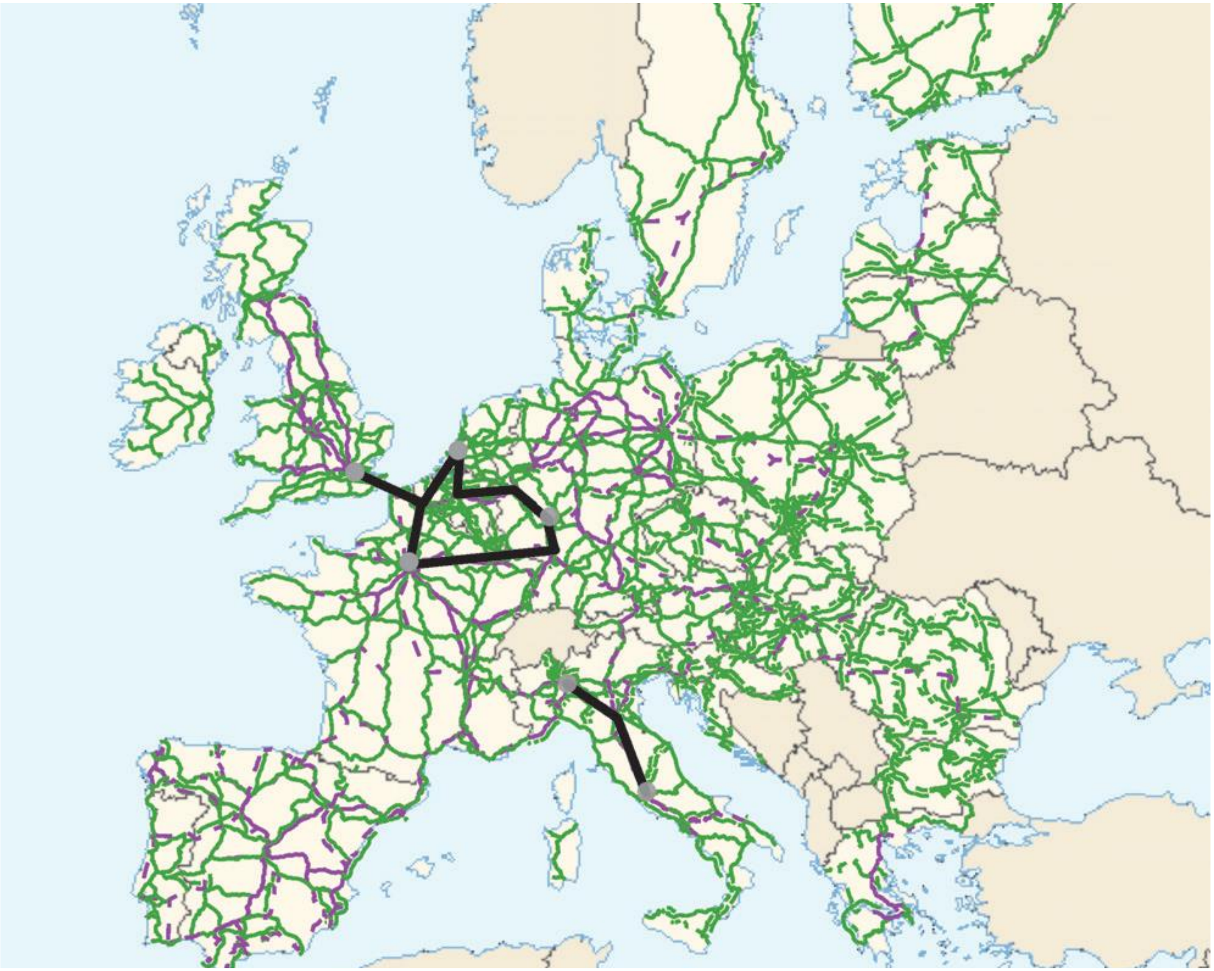
Expected benefit of modal shift

- The availability of **High Speed Train (HST)** lines opens the possibility of **partial substitution with short-haul and medium-haul intra-EU flights**.
- Main aims for **increasing the rail potential** is the expected **better environmental performance** of this mode of transport: several studies defined the **potential per-seat saving in emissions**, achievable by substituting short-haul flights with HSTs.



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Potential for substitution

- **Rail** transport can be a **real alternative** to **aviation** providing **specific conditions**, among others:
  - the **cost** of the travel,
  - the **safety** standards,
  - the **comfort** level,
  - the **frequency** of the service and the
  - **accessibility** of the **terminals**,
  - the service **reliability**,
  - the **time-efficiency**.

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Present study

- Present work investigates **GHG potential reduction by substituting shares of intra EU-28 flights** with **HSR** services, in the **time period** between **2017-2025**.
- The **analysis** is carried out for a **specific set of city pairs**, representing a significant share of the passenger transported.
- In the paper the **type of aircraft**, the **distance bands** and the **occupancy rate** are **varied** to study potential **scenarios**.

Present study

- **Two ranges** of **distance bands** are defined to compare aviation and rail services: **six medium-haul intra EU-28**, **plus a national route**.
  - (i) **LHE**: London Heathrow the busiest airport in the EU with a total of 75.0 million passengers carried in 2015,
  - (ii) **CDG**: Paris-Charles de Gaulle (France),
  - (iii) **FRA**: Frankfurt Main (Germany),
  - (iv) **AMS**: Amsterdam Schiphol (The Netherlands).
  - Italian **Rome Fiumicino-Milan Linate (IT)**

The **expected flight duration** on this route is **1:10h**, over a **distance** of about **510 km**.
The **time required for reaching the airports from** the **city centres** is expected to be 50 min in MI plus 45 min in Rome the **air journey** is **therefore 2:45 h**, without considering internal transfers.

The **HSR** service takes **3:00 h**, covering the **distance of 620 km**.

Time and distances comparison

TABLE 2: Relative distances for railways (∗) and air flights (∗∗).

Distance: Rail/Flight [km]	London Heathrow (LHR)	Paris-Charles de Gaulle (CDG)	Frankfurt/Main (FRA)	Amsterdam/Schiphol (AMS)	Rome Fiumicino (FCO)	Milano Linate (LIN)
London Heathrow (LHR)		480*	800*	565*	-*	-*
Paris-Charles de Gaulle (CDG)	348**		570*	485*	-*	-*
Frankfurt/Main (FRA)	655**	450**		450*	-*	-*
Amsterdam/Schiphol (AMS)	372**	400**	365**		-*	470*
Rome Fiumicino (FCO)	-**	-**	-**	-**		
Milano Linate (LIN)	-**	-**	-**	-**	562**	

Time and distances comparison

TABLE 3: Relative journey duration for railways (*) and air flights (**).

Duration: HST/Flights [h:mm]	London Heathrow (LHR)	Paris-Charles de Gaulle (CDG)	Frankfurt/Main (FRA)	Amsterdam/Schiphol (AMS)	Rome Fiumicino (FCO)	Milano Linate (LIN)
London Heathrow (LHR)		3:05*	6:30*	5:30*	-*	-*
Paris-Charles de Gaulle (CDG)	1:15**		5:00*	3:15*	-*	-*
Frankfurt/Main (FRA)	1:30**	1:15**		4:30*	-*	-*
Amsterdam/Schiphol (AMS)	1:20**	1:20**	1:15**		-*	-*
Rome Fiumicino (FCO)	-**	-**	-**	-**		1:10*
Milano Linate (LIN)	-**	-**	-**	-**	3:00**	

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Aircraft Type, Consumption, and CO2 Emissions

To calculate the emission for flights:

- aircraft type has to be taken into account.

(i) Small regional jets (SJ): up to 100 seats-single aisle

(ii) Narrow bodies (NB): > 100 seats-single aisle

(iii) Small wide bodies: up to 300-twin aisle

(iv) Medium wide bodies: between 300 and 400 seats-twin aisle

(v) Large wide bodies: > 400 seats-twin aisle

- Corinair database the **fuel consumption** has been evaluated.

Table 7: Fuel consumption and CO_2 emission per route.

Route	Distance	Avg. fuel consumption	Avg. CO_2 emissions	
-	km	ton	ton	g/PKM
CDG-LHE	348	1.75	5.51	143
AMS-FRA	365	1.50	4.72	116
AMS-LHE	372	1.63	5.14	124
CDG-AMS	400	1.88	5.91	133
FRA-CDG	450	1.76	5.56	111
FRA-LHE	655	2.79	8.79	102
FCO - LIN	510	2.73	8.61	128

Rail Emissions

To calculate the emission for rails:

- In HSR **only electricity** is **used** and consequently the **emissions** are a **direct function of the primary energy country mix**.

TABLE 4: Carbon intensity of *medium-voltage electricity* [19].

Country	CI of electricity consumed at MV (with Upstream) gCO_2/kWh
BE	262
DE	602
FR	101
IT	417
NL	558
UK	599

- **Specific energy consumption of HST results in 0.057 kWh/PKM**

TABLE 8: Specific carbon intensity of each route.

Route	gCO_2/kWh avg	gCO_2/PKM
CDG-LHE	315.8	18.0
AMS-FRA	589.6	33.6
AMS-LHE	436.9	24.9
CDG-AMS	263.5	15.0
FRA-CDG	351.3	20.0
FRA-LHE	448.2	25.6
FCO - LIN	417.0	23.8

- *Indirect effects of rail infrastructure construction has been considered by adding 5 gCO_2/PKM as proposed by Union of Railways*
- *All the routes crossing France have the best performance, due to the low carbon intensity of electricity in France.*

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Scenario definition

All **scenarios** aim to represent the expected **trend** in the next coming **years for aviation growth**, assuming the used average growth as representative of the period 2017–2025.

(i) Business as Usual (BAU) scenario, baseline: none of the expected aviation passenger growth (on the analysed routes) is shifted to HSR service.

(ii) High-rail scenario: 25% of the expected aviation passenger growth (on the analysed routes) is shifted to HSR service.

(iii) Low-rail scenario: only 5% of the expected aviation passenger growth (on the analysed routes) is shifted to HSR service.

Results for the high rail scneario

TABLE 11: High rail scenario with 3.5% annual growth and 25% shifting between the modes.

Total Passenger		Total CO_2	Annual passengers increase	Annual CO_2 increase	Passenger to Rail	CO_2 Rail	CO_2 saved respect to aviation	CO_2 Balance	
2016		ton	-	ton		ton	ton	ton	%
FRA - CDG	906,005	45,343	31,710	1,587	7,928	90.5	396.8	-306.3	-19.3%
FRA - LHE	1,486,291	98,932	52,020	3,463	13,005	265.8	865.7	-599.8	-17.3%
CDG - LHE	1,209,158	59,986	42,321	2,100	10,580	91.4	524.9	-433.5	-20.6%
AMS-FRA	817,514	34,751	28,613	1,216	7,153	108.2	304.1	-195.9	-16.1%
AMS-CDG	1,187,339	63,193	41,557	2,212	10,389	75.7	552.9	-477.3	-21.6%
AMS-LHE	1,617,170	74,817	56,601	2,619	14,150	199.1	654.6	-455.5	-17.4%
FCO - LIN	1,188,538	77,483	41,599	2,712	10,400	153.3	678.0	-524.72	-19.3%

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Conclusions

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Key messages

- The results here presented **confirm a remarkable advantage of high speed trains compared to aircraft**, with regard to direct **CO_{2eq}** emissions **per PKM**.

- **Apart** from **energy efficiency** considerations, a **relevant medium term advantage of HSR** deals with **transport resilience** to **adverse weather conditions**. *There is in fact general agreement that climate change will affect the functioning of the European transport system, specifically for aviation.*

Publication

"Passenger aviation and high speed rail: a comparison of emission profiles in selected European routes"

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Please download the **open access** publication at:

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Research Article

Passenger Aviation and High Speed Rail: A Comparison of Emissions Profiles on Selected European Routes

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Air transport has been constantly growing and forecasts seem to confirm the trend; the resulting environmental impact is relevant, both at local and at global scale. In this paper, data from various datasets have been integrated to assess the environmental impact of modal substitution with high speed rail. Six intra-EU28 routes and a domestic route have been defined for comparison. The airports have been chosen considering the share of the total number of passengers on flights to/from other EU Member States. Three scenarios have been proposed in the time period 2017–2025; aircraft types, distance bands, and occupancy rate are investigated on each scenario. The comparison with HSR service has been carried out only on passenger service and not for freight. The energy consumption and the consequent emissions for the aircraft have been estimated on the base of the available data for the mix of aircraft types, performing the routes. The results indicate the advantage of the high speed trains, in terms of direct CO_{2eq} emissions per passenger km. Compared to a neutral scenario, with an annual passenger increment of 3.5%, the HSR substitution of the 5% and the 25% of this increment allow a GHG saving of 4% and 20%, respectively. Some of the analysed routes (e.g., Frankfurt Main–Paris CDG) have interesting GHG savings but the duration of the trip today is limiting for a real substitution. Moreover, there is general agreement that the extreme weather events induced by climate change will affect the functioning of the European transport system. In this sense, transportation by the rail mode is expected to play a significant role in strengthening the EU transport system, its resilience, and its reliability, as it is less immediately subject to the impacts of severe weather conditions.

1. Introduction

Transport impacts EU citizens' daily life, directly affecting life quality in many ways. The energy consumption of the EU-28 entire transport sector in 2015 has been 358.6 Mtoe, accounting for the 33% of the total EU-28 primary energy consumption: 1084 Mtoe [1]. Road transport is the most relevant segment (82.0%) with a consumption of about 293.9 Mtoe today followed by the international aviation segment (12.8%) 45.7 Mtoe, whereas the domestic aviation (1.54%) and rail (1.73%) account for 5.54 Mtoe and 6.22 Mtoe, respectively.

The total number of passengers travelling by air in the European Union in 2016 has been estimated in 973 million, with an increment of about 5.9% compared to 2015; 47% of total passengers moved to/from Intra-EU-28 airports, with an increment of 10.2% with respect to 2015 (Table 1).

In the last 25 years (1990–2015), inland waterways and rail recorded the largest decreases in energy consumption: 1.9 and 2.0 Mtoe reduction, respectively in EU-28 [1]. With the decline of rail transport becoming more evident, a stronger effort from various actors (EC, decision-makers, authorities, etc.) have been put in place to find solutions to increase sector competitiveness. In 2001, the EC released its "first Railway Package" and through the White Paper on Transport claimed its willingness to support rail revitalization [2]. Between 2002 and 2016 the second, third, and fourth Railway Packages have followed. Six legislative texts constitute the so called "fourth Railway Package," aiming to complete the single market for rail services (Single European Railway Area) [3] and also establishing the European Union Agency for Railways [4]. An interesting initiative is the Shift2Rail Joint Undertaking [5, 6]: it focuses on R&I and market-driven solutions for promoting the competitiveness of the European rail industry.

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