INTERNATIONAL ELECTROTECHNICAL COMMISSION

CENELEC

Energy Efficiency and standardisation in Railway State of the Art and Future Perspectives

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Presented by Pietro Marmo to:

EMRailS 2019

Electrical Measurements for Energy Management in Railway Systems

WORKSHOP

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Museo Nazionale Ferroviario di Pietrarsa

Energy System management

Production

- **Fossil fuels**
  - Oil
  - Natural gas
  - Coal
- **Nuclear fuels**
- **Hydrogen**
- **Renewables**
  - Wind
  - Sunlight
  - Tides
  - Geothermal heat

Delivery

- **Electrical grids**
- **Smart grids**
- **Storage**
- **CCS (Carbon Capture and Storage)**

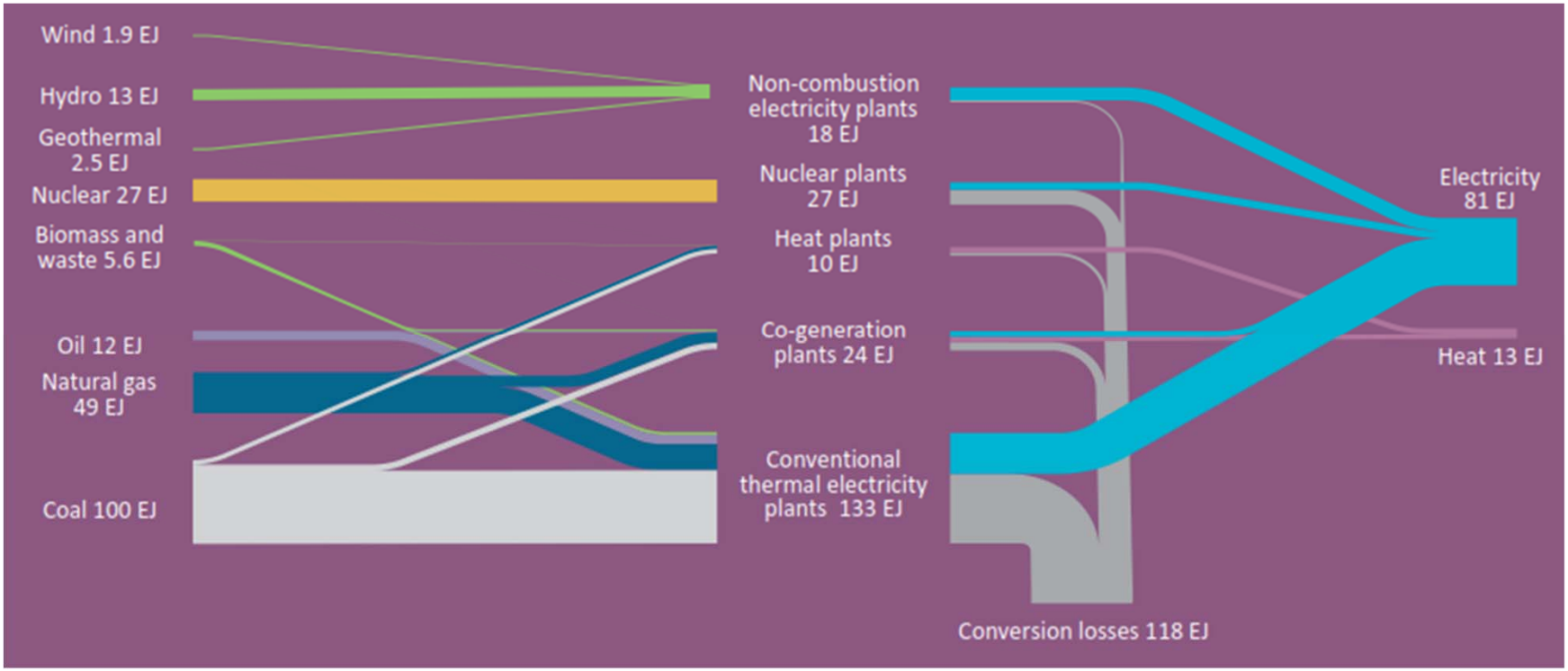
Consumption

- **Industries**
  - Cement
  - Steal
  - Manufacturing
- **Heating**
  - Residential
  - Industrial
- **Public lighting**
- **Residential use**
- **Transportion**

Energy flowing and wasting

It is to be noted that:

- The percentage of energy produced by coal is still high;
- The efficiency of energy production is really poor

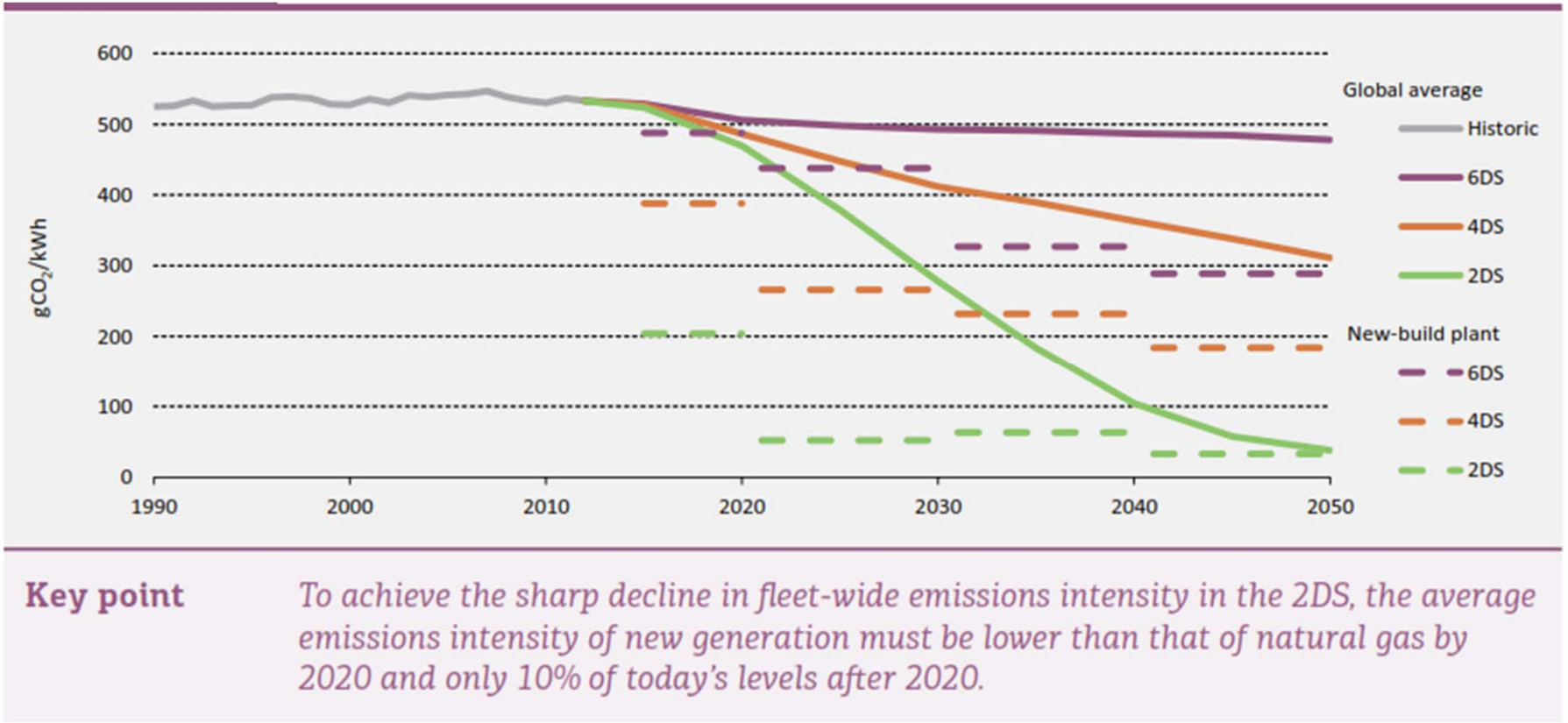


Consumed energy 94 EJ energy losses: 118 EJ – EJ is Exa Joule i.e. 10^{18} Joules

Source: Tracking Clean Energy Progress – IEA 2015

Specific CO_2 Emissions Scenario

Starting from the historic value (in grey), the picture shows the scenario from now to 2050 in three conditions: 2 degrees shift (violet line), 4 degrees shift (orange line) and 2degress shift (green line).



Key point *To achieve the sharp decline in fleet-wide emissions intensity in the 2DS, the average emissions intensity of new generation must be lower than that of natural gas by 2020 and only 10% of today's levels after 2020.*

Source: Tracking Clean Energy Progress – IEA 2015

World and EU28 transport modal share in 2015

The comparison between the different transport mode is done calculating:

- the value PKM (*Passenger * Kilometre)* for passenger transport
- the value TKM (*Tons * Kilometre)* for freight transport

	Passenger PKM	Freight TKM	Total TU
ROAD	82.2%	50.8%	71.5%
AVIATION	9.9%	0.1%	6.6%
NAVIGATION	0.3%	37.2%	12.9%
RAIL	7.6%	11.9%	9.0%

Source: Elaboration by Susdef based on EC (2017) and UIC (2016a)

EU28 transport modal share, 2015

	Passenger PKM	Freight TKM	Total TU
ROAD	79.6%	20.2%	35.1%
AVIATION	13.7%	0.7%	4.0%
NAVIGATION	-	72.2%	54.0%
RAIL	6.7%	6.9%	6.9%

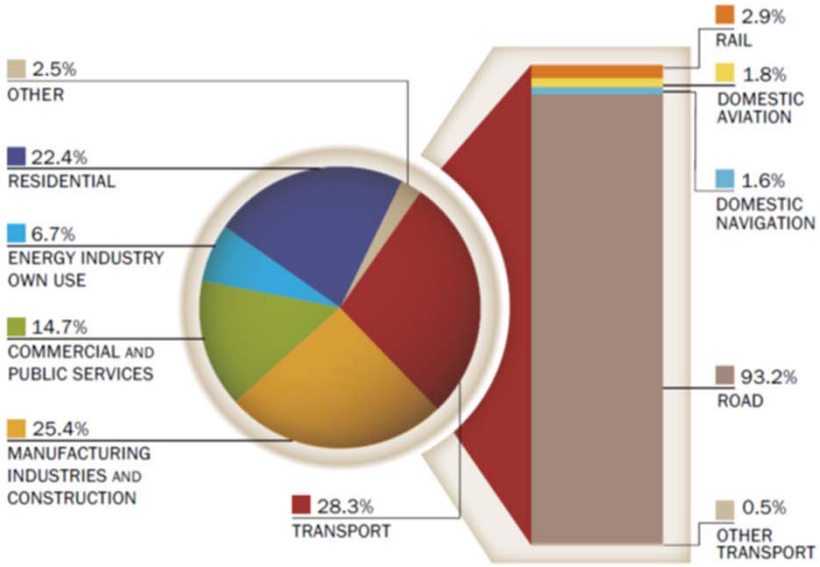
Note: Navigation is allocated to freight transport only.

Source: Elaboration by IEA based on IEA (2017b), UIC (2016a) and UNCTAD (2016)

World transport modal share, 2015

Share of CO2 emissions worldwide and EU 28 from fuel combustion by sector in 2015

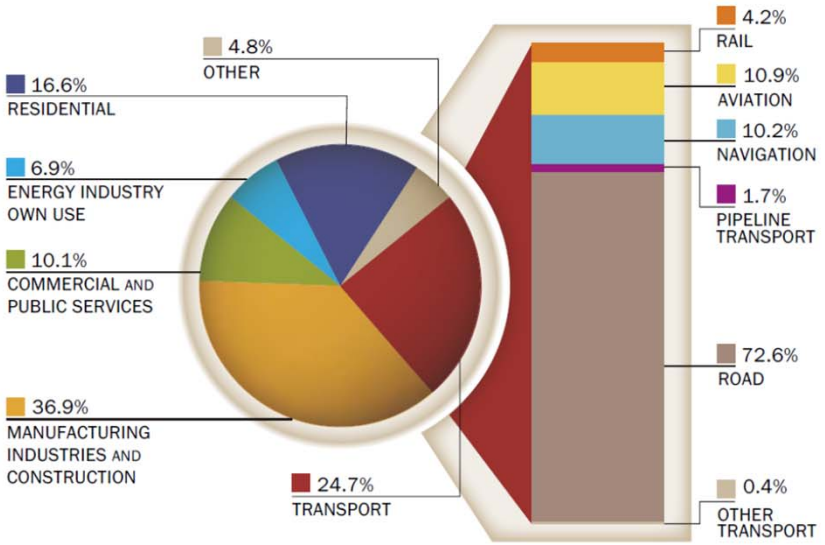
EU28 transport CO_2 emission share, 2015



Note: Electricity and heat production related emissions are reallocated to the end-use sectors. In transport, all the emissions from electricity and heat production are reallocated to rail. "Other transport" includes emissions from Pipeline transport.

Source: Elaboration by Susdef based on IEA (2017a)

Worl transport CO_2 emission share, 2015



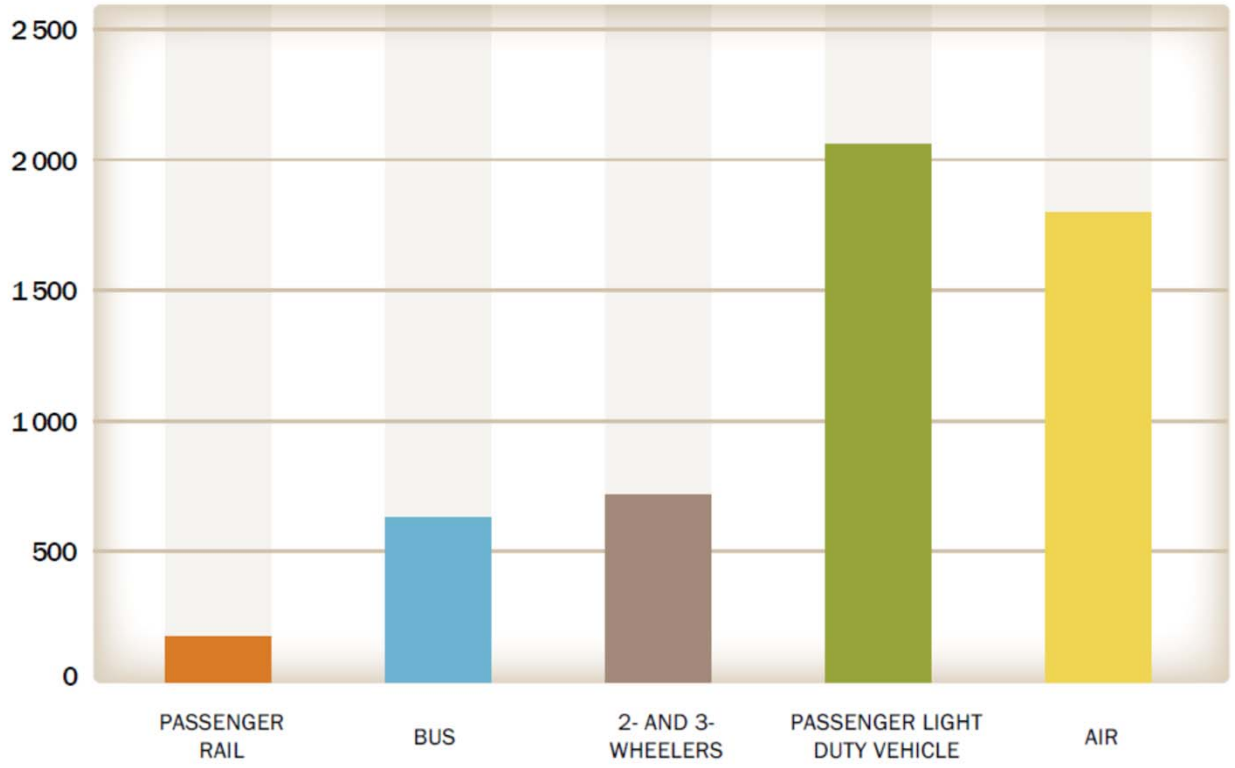
Note: Electricity and heat production related emissions are reallocated to the end-use sectors. In transport, all the emissions from electricity and heat production are reallocated to rail.

Source: Elaboration by Susdef based on IEA (2017a)

Energy intensity of passenger transport modes, 2015 (kJ/pkm)

The comparison between the different transport mode is done calculating:

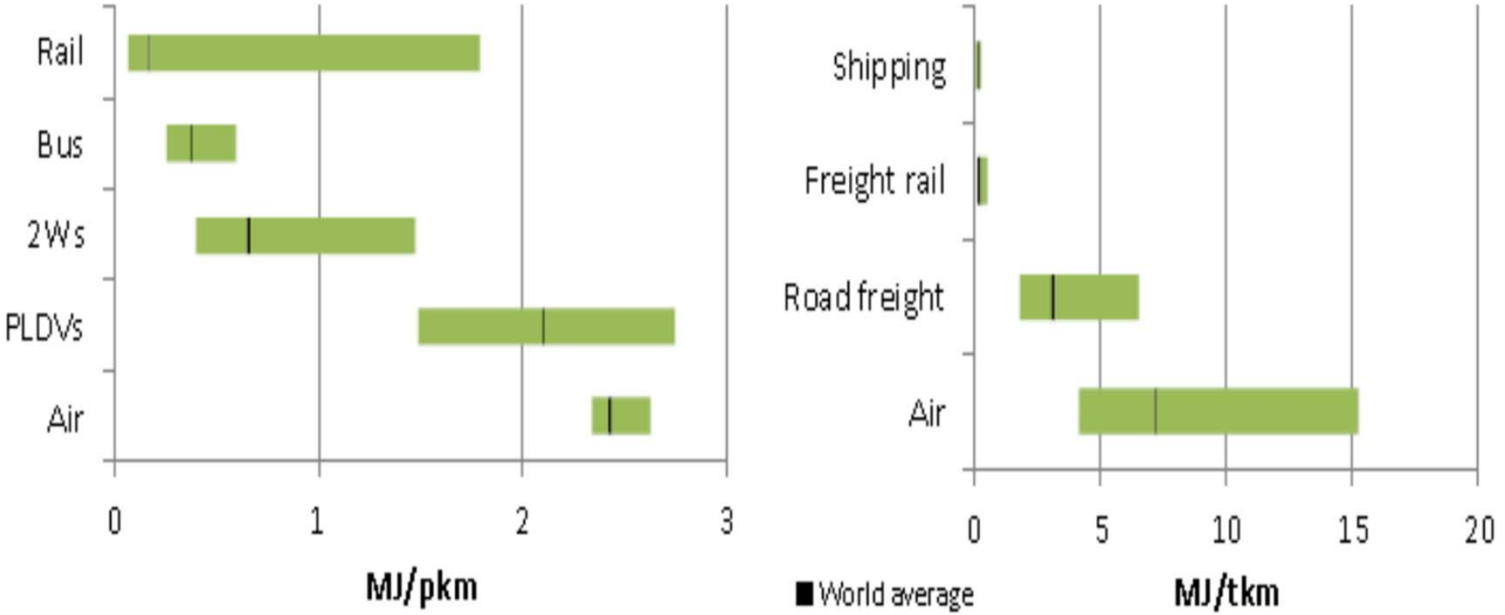
- the value kJ/pkm (*Kilojoule/ passenger* Kilometre)*



Source: IEA estimates based on IEA (2017b), ITDP (2014), UITP (2002) and UITP (2015b)

Energy intensity of transport modes, freight and passenger, in 2015

The horizontal green bar is mainly due to discrepancy, in the different regions of the world, due to differences in the energy efficiency and fuel type usage). Values are given in MJ/pkm (*Megajoule/ passenger* Kilometre)* and MJ/tkm (*Megajoule/ ton* Kilometre)*



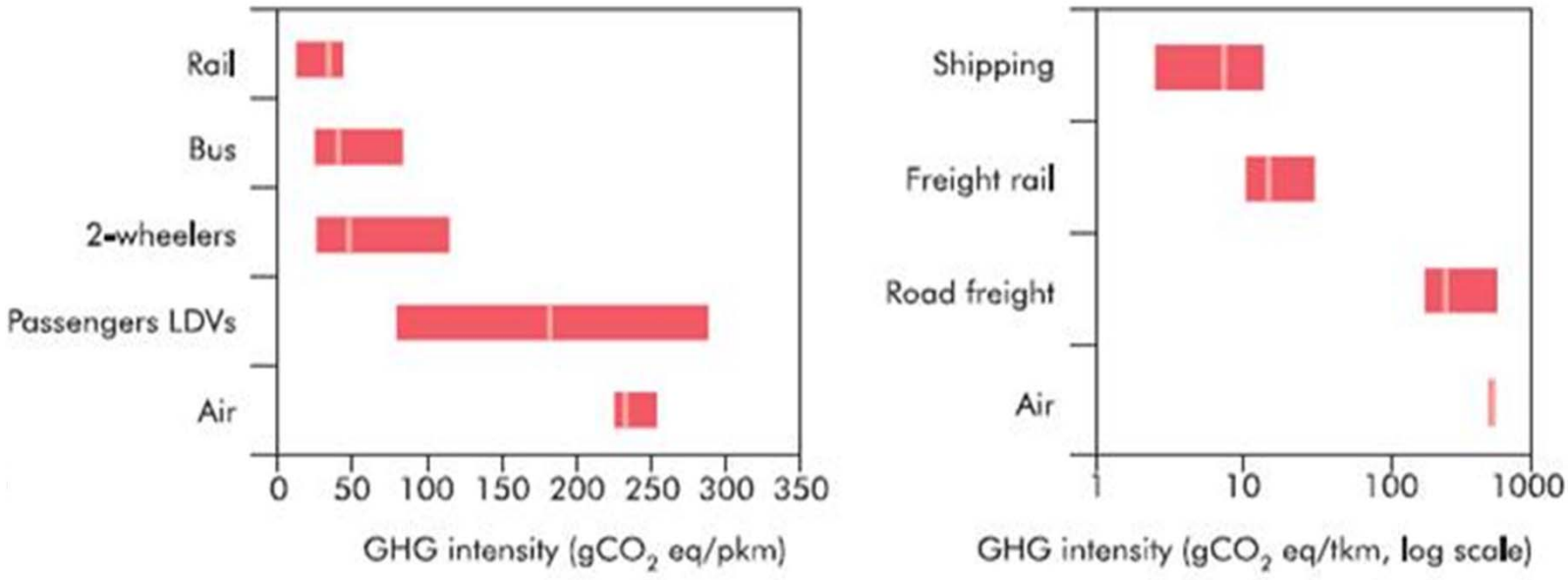
Note 1: PLDV = Passenger Light Duty Vehicle
Note 2: the vertical black line indicates the world average value, the green bar represents the Mobility Model regions discrepancy

Source: IEA Mobility Model

GHG intensity of transport modes, freight and passenger, in 2015

The horizontal red bar is mainly due to discrepancy, in the different regions of the world, due to differences in the energy efficiency and fuel type usage). Values are given in gCO2 eq/pkm (*grams of* CO2 equivalent*/ passenger* Kilometre)* and gCO2 eq/tkm (*grams of* CO2 equivalent*/ ton* Kilometre)*

Note: Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO2 that would have the same global warming potential (GWP)



Note 1: LDV = Light Duty Vehicle
Note 2: the vertical white line indicates the world average value, the red bar represents the Mobility Model regions discrepancy

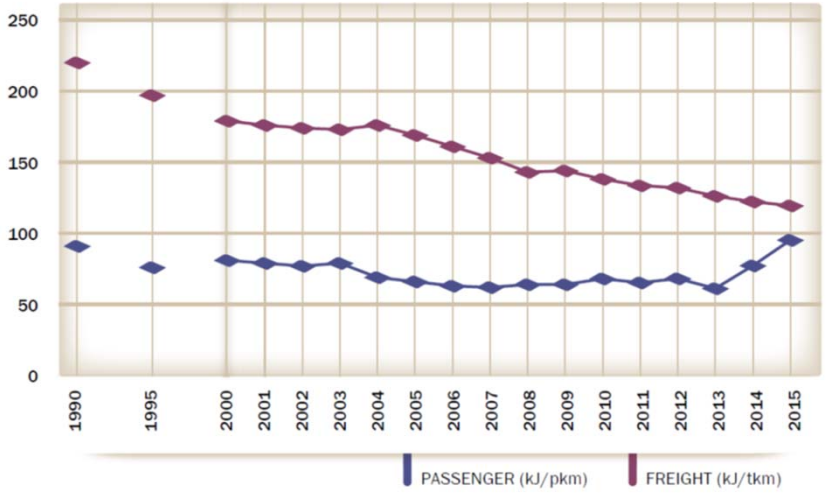
Source: IEA Mobility Model

Why Railway sector needs energy efficiency management?

Railway sector actual trends

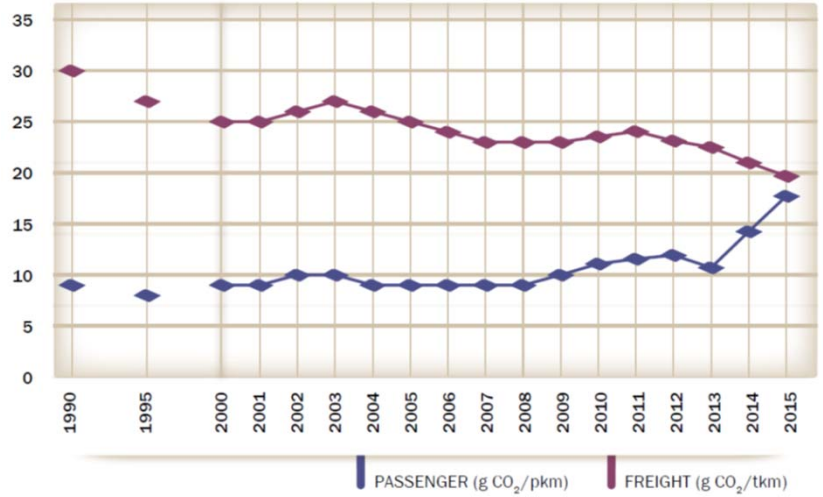
Railway specific energy consumption 1990-2015

Source: Elaboration by IEA and Susdef based on IEA (2017b) and UIC (2016a)

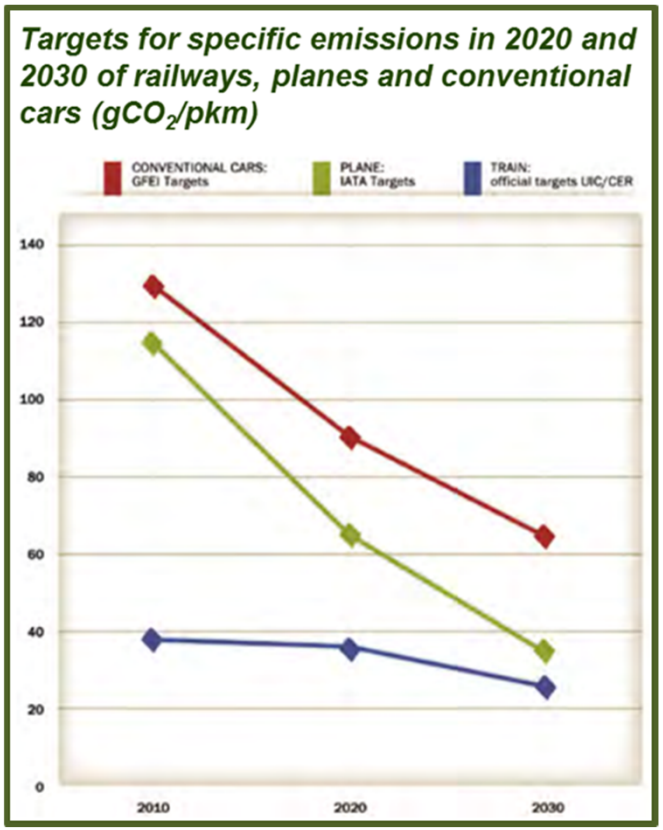


Railway specific CO2 emissions 1990-2015

Source: Elaboration by IEA and Susdef based on IEA (2017b) and UIC (2016a)



Transport modes targets



European Commission Targets according to the White Paper 2011 (1)

- **2020**
  - ✓ Passenger rail share shall be increased from 6% to 10%;
  - ✓ Freight rail share shall be increased from 8% to 15%
- **2030**
  - ✓ the use of 'conventionally-fuelled' cars in urban transport shall be halved;
  - ✓ essentially CO2-free city logistics in major urban centres shall be achieved;
  - ✓ 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport;
  - ✓ the length of the existing high-speed rail network should be tripled.

Note: targets referred to year 1990

European Commission Targets according to the White Paper 2011 (2)

- **2050**
  - ✓ phase out in cities the use of 'conventionally-fuelled' cars;
  - ✓ 50% of road freight over 300 km should shift to other modes such as rail or waterborne transport;
  - ✓ Completion of a European high-speed rail network.
  - ✓ the majority of medium-distance passenger transport should go by rail;
  - ✓ Move towards full application of "user pays" and "polluter pays" principles.

Note: targets referred to year 1990

CEN/CENELEC addressing Energy Management (1)

On 2002 the CEN/CENELEC Technical Board considered the relevance of energy management for future standardisation activities. As a consequence CEN and CENELEC decided to set up a CEN/CENELEC BT joint working group called “Energy Management”.

From 2002 until 2006, the joint working group analysed the matter in all the application fields including transportation of goods and passengers. 21 standardisation priorities were analysed and listed such as:

- energy management systems;
- benchmarking;
- energy efficiency and saving calculations,
- ESCOs, Energy Service COmpanies;
- white certificates;
- CO2 capture and storage;
- Transportation.

CEN/CENELEC addressing Energy Management (2)

As a final result, the joint working group recommended to set up a new permanent horizontal strategic body on energy management.

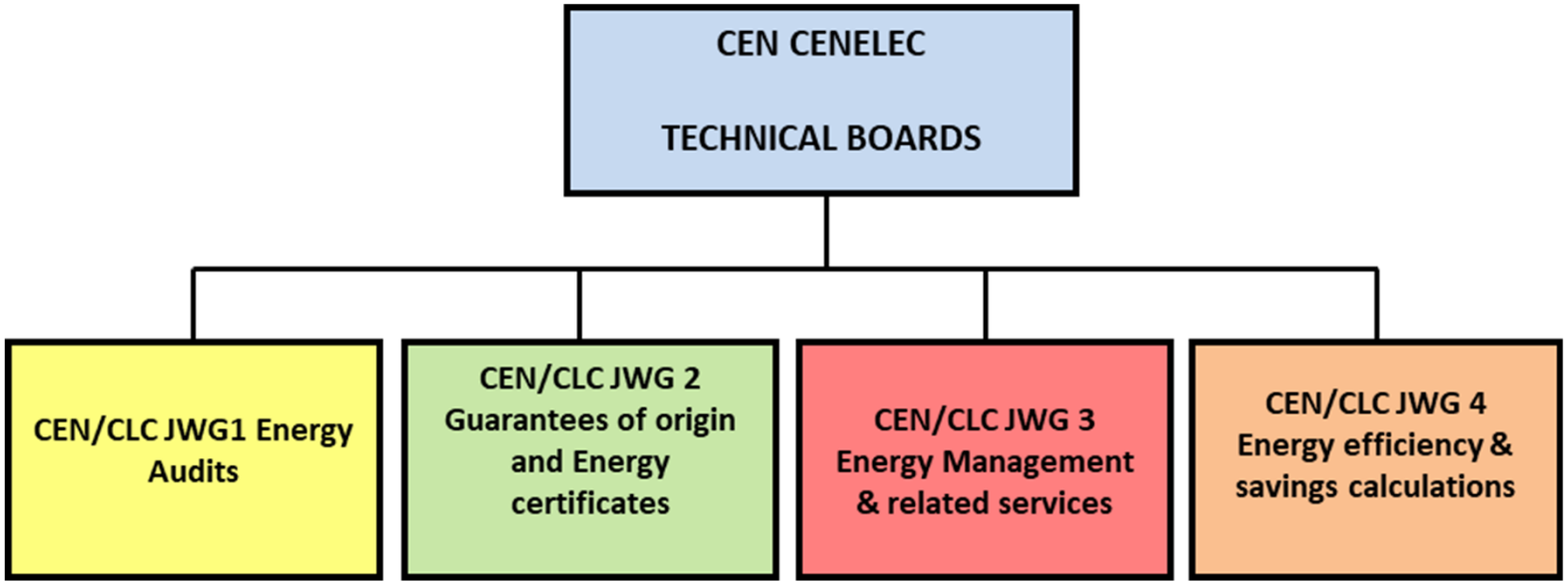
Following the recommendation, the CEN/CENELEC Sector Forum for Energy Management (SFEM) was created.

SFEM is a horizontal strategic body on energy management which promotes:

- energy management;
- energy efficiency and Renewables;
- information exchange between experts;
- identification of standardisation needs,
- coordination of CEN/CENELEC JWG and TCs active in the area of energy management.

CEN/CENELEC addressing Energy Management (3)

The following picture shows the CEN/CENELEC Energy Management structure which includes 4 Technical Boards interacting with SFEM in terms of requests and recommendation aimed to coordination.



CEN/CENELEC published standards

CEN-CENELEC following the SFEMadvices, published the following standards:

EN 16001:2009 - Energy Management Systems
Now replaced by
EN ISO 50001:2018
Energy management systems - Requirements with guidance for use

EN 15900:2010 - Energy efficiency services - Definitions and requirements
This European Standard specifies the definitions and minimum requirements for an energy efficiency service.

CEN published standard (1)

CEN published the standard:
The EN 16258:2012 - Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers).

This standard defines accurate, credible and verifiable declarations, regarding energy consumption and GHG emissions related to any transport service relevant to:

- operators (carriers)
- organizers (freight forwarders, travel agencies)
- users (shippers and passengers)

introducing the following concepts:

CEN published standard (2)

Processes:

- ✓ Energy operational processes (“well-to-tank”);
- ✓ Vehicle operational processes (“tank-to-wheel”);

Principles of calculation

- ✓ All vehicles used, all fuel consumption used, all loaded and empty trips are taken into account in the calculation;

Production of four results:

- ✓ well-to-wheels energy consumption (Ew)
- ✓ well-to-wheels GHG emissions (Gw)
- ✓ tank-to-wheels energy consumption (Et)
- ✓ tank-to-wheels GHG emissions (Gt)

CENELEC published standards

Published CENELEC TC9X standards:

EN 50463:2018 - Railway applications - Energy measurement on board trains - Part 1, 2,3,4,5.

This series of standards is offered to IEC TC9 and will be published as IEC 62888 series.

TS 50591:2013 - Specification and verification of energy consumption for railway rolling stock.

This document is commonly used in Europe when offering and then selling/purchasing traction units.

It establishes a criterion for calculation, simulation and verification of the energy consumption of rolling stock to calculate the total net energy consumed, either at pantograph or from the fuel tank, over a predefined service profile. Energy consumed and regenerated by the rolling stock is taken into account.

This document will be very soon an European Norm.

Coordination between CLC TC9X and IEC TC9 on Total Energy Management (TEM)

Two years ago, CENELEC TC9X set up the Survey Group SG 23 with the task to investigate the matter of total energy management in railways.

According to the Frankfurt agreement, the IEC TC9 Chair informed the CLC TC9X SG 23 convenor on the decision to set up an Ad Hoc Group in IEC dealing with the same matter.

During the last plenary meeting in Kista on June 2017 and following the presentation of the SG 23 Convenor, TC9X decided to ask IEC/TC9 "*to tackle the subject of "Total Energy Management" within the IEC/TC9 standardisation activities and to offer the findings of SG23"*.

IEC TC9, during the Plenary meeting in Vladivostok on October 2017, decided to accept the offer from CLC TC9X.

IEC TC9 AHG 19 activities in TEM

During the plenary meeting in Vladivostok, TC 9 decides to accept the offer of CLC/TC 9X on Energy Efficiency and Total Energy Management and asks AHG 19 to study the findings of CLC/TC 9X/SG 23 together with the ACEE guides 118 and 119 in view of potential impact on the work of TC 9.

AHG 19 has started the work and has planned the following actions:

- ✓ Studying the ACEE guide and the findings of CLC TC9 SG 23;
- ✓ Assessing if a sector standard on *Energy Management and Energy Efficiency* for railway application is necessary and, if the case, to prepare a NWIP.
- ✓ revising of existing standards in order to include EE aspects as indicated by the ACEE guides and, if the case, to report to IEC TC9 a list of such existing standards with the rationale for the revision.
- ✓ Assessing if and which new standards are requested to address the *Energy Management and Energy Efficiency* on board of trains and in fixed installations.

IEC TC9 participation in ACEE (1)

ACEE is the “Advisory Committee on Energy Efficiency”, set up by IEC in 2013 and has the following main tasks:

- ✓ To coordinate activities related to energy efficiency.
- ✓ To be responsible for the assignment of horizontal energy efficiency aspects and requirements.
- ✓ To deal with energy efficiency matters which are not specific to one single technical committee of the IEC.
- ✓ To provide guidance for implementation in a general perspective and for specific sectors.
- ✓ To encourage a systems perspective for the development of standards for energy efficiency and provides support for system considerations.

IEC TC9 participation in ACEE (2)

ACEE has already published the following documents:

IEC GUIDE 118:2017 Edition 1.0 - Inclusion of energy efficiency aspects in electro-technical publications. The guide was published on the 28th March 2017.

IEC GUIDE 119:2017 Edition 1.0 - Preparation of energy efficiency publications and the use of basic energy efficiency publications and group energy efficiency publications. The guide was published on the 28th March 2017.

Furthermore ACEE published:

IEC ACEE 01: ed. 2018 - Introduction to ACEE work

It is an overview of energy efficiency concepts and an introduction to the use of the ACEE guides.

IEC ACEE 02: ed. 2018 - Case study: electric motors

This case study is provided to illustrate a practical example (in practice) on how IEC Guide 118 concepts can be applied/found in electric motors standards

IEC TC9 Standards relevant to EE (1)

IEC 62864-1:2016 Ed1 - Railway applications - Rolling stock - Power supply with onboard energy storage system - Part 1: Series hybrid system

The part 1 specifies the general requirement for a railway traction system using a series hybrid system propulsion with energy recovery and storage capability. It is foreseen to prepare a future part 2 on parallel hybrid system.

IEC 62924:2017 ED1 - Railway applications - Fixed installations - Stationary energy storage system for DC traction systems

IEC 62924:2017 specifies the requirements and test methods for a stationary energy storage system to be introduced as a trackside installation and used in a power supply network of a DC electrified railway.

IEC TC9 Standards relevant to EE (2)

IEC 61881-3:2012 ED1 - Railway applications - Rolling stock equipment - Capacitors for power electronics - Part 3: Electric double-layer capacitors

IEC 61881-3:2012 specifies the requirements and test methods for double layer capacitors (commonly known as super caps).

IEC 62888 part 1 to 5: Railway applications - Energy measurement on board trains

This is the transposition of the European Norm series EN 50463 into an International series of standards.

IEC 62888 part 6: Railway applications - Energy measurement on board trains - Part 6: Requirements for purposes other than billing

This is an additional part of the series which does not exist in the European series. The scope is to specify requirements for energy measurement relevant to investigation, benchmarking and energy efficiency evaluation of electric rolling stocks.

IEC TC9 Standards relevant to EE (3)

IEC 62973 series: Railway applications - Batteries for auxiliary power supply systems

The part 1 specifies the general requirement and the part 2 specifies the NiCd batteries. Other parts are foreseen (e.g. NiMH).

IEC 62928 Ed1 - Railway applications - Rolling stock equipment - Onboard lithium-ion traction batteries

The standards specifies the requirements of lithium-ion batteries and their application for traction on railway vehicle.

It is a standard linked to IEC 62864-1:2016 ED1 - Railway applications - Rolling stock - Power supply with onboard energy storage system - Part 1: Series hybrid system

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THANK YOU for YOUR KIND ATTENTION

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