4. Toolkit: Data to support policy making and evaluation

Till BUNSEN

Paris, May 15, 2018

IEA #energyefficientworld

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Presentation Outline

Finalize this slide

se) approach

and analysis

4. Policy evaluation

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What data do you need?

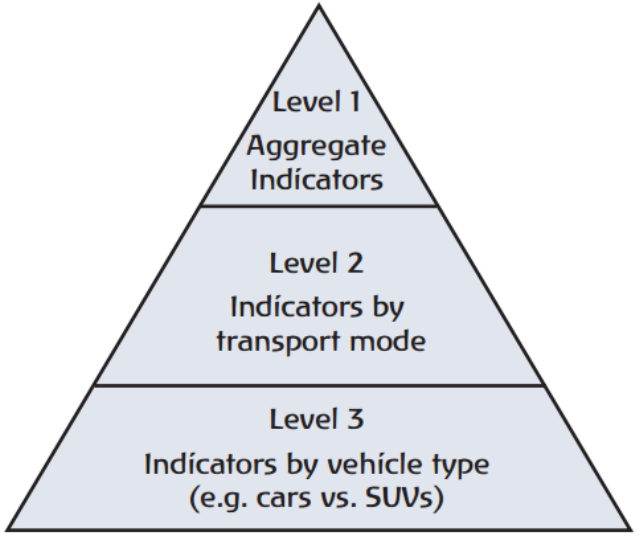
ASIF approach to estimate energy consumption from road vehicles

Transport energy efficiency indicators to support policy making and evaluation

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Using energy efficiency indicators for policy making

Figure 6.5 • Detailed indicators pyramid for passenger transport



How much does the transport sector contribute to a country's energy demand?

Is freight transport more energy efficient by ship or by rail?

What are the implications from the trend to larger passenger cars for transport energy demand?

Using energy efficiency indicators faces a trade off between usefulness of information and data collection requirements

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The ASIF approach of IEA's Mobility Model (MoMo)








Distance travelled × **Vehicle stock** × **Energy intensity** = **Energy consumption**

- Vehicle ***A****ctivity*
- the ***S****tructure* of the organization of vehicle across services, modes, vehicle classes and powertrain groups
- the *energy* ***I****ntensity* of each of the vehicles in this structure

… allow to calculate ***F****uel consumption*

The ASIF approach of IEA's Mobility Model (MoMo) makes possible to estimate transport fuel consumption by vehicle type and fuel

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Linking activity and fuel use – ASIF approach



Distance travelled × Vehicle stock × Energy intensity = **Energy consumption**



Energy consumption × **Emission factor** = **Transport GHG emissions**

The ASIF approach makes possible to estimate transport fuel consumption at sector level

Apply emission factors to quantify climate impacts of fuel consumption

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ASIF Approach: Linking Activity and Fuel Use

The calculation is based on Laspeyres identities

$$F = \sum_i F_i = A \sum_i \left(\frac{A_i}{A}\right)\left(\frac{F_i}{A_i}\right) = \boxed{A \sum_i S_i I_i = F}$$

F	total ***F***uel use
A	vehicle ***A***ctivity (expressed in *vkm*)
F_i	fuel used by vehicles with a given set of characteristics (***i***) (e.g. segments by service, mode, vehicle and powertrain)
$A_i/A = S_i$	sectorial ***S***tructure (same disaggregation level)
$F_i/A_i = I_i$	energy ***I***ntensity, i.e. the average fuel consumption per *vkm* (same disaggregation level)

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ASIF Approach: Linking Activity and Fuel Use (Extended)

The same methodological approach used for the calculation of fuel consumption (ASIF) can be extended to evaluate CO_2 emissions.

This extension is suitable to the case of where several energy carriers need to be considered:

$$E = \sum_i E_i = A \sum_i \frac{A_i}{A} \times \frac{F_i}{A} \times \frac{F_{ij}}{F_i} \times \frac{E_{ij}}{F_i} = A \sum_i S_i I_i E F_{ij} = E$$

A	activity (in vkm)
E	emissions
E_i	emissions due to vehicle *i*
F_{ij}	fuel (energy carrier) *j* used in vehicle *i*
EF_{ij}	emission factor for the fuel (energy carrier) *j* used in vehicle *i*

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ASIF Approach: Well-to-wheel versus tank-to-wheel

Well-to-wheel: tank-to-wheel emissions + well-to-tank emissions

Using the example of biofuels…

Well-to-wheel

well-to-tank emissions

Production → Logistics → Processing → Distribution → End Use







tank-to-wheel emissions



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Aggregate indictors provide limited insight for policy making








Distance travelled ✖ **Vehicle stock** ✖ **Energy intensity** = **Energy consumption**

- Vehicle ***A****ctivity*
- the ***S****tructure* of the organization of vehicle across services, modes, vehicle classes and powertrain groups
- the *energy* ***I****ntensity* of each of the vehicles in this structure

… allow to calculate ***F****uel consumption*

Aggregate indicators provide no information on specific energy efficiency of transport modes and are of limited use for policy making

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Fundamentals of transport activity parameters: vehicle-km (vkm)

Number of vehicles × kilometres per vehicle

(Stock) (Mileage)

Vehicle kilometres (vkm)





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Fundamentals of transport activity parameters: passenger-km (pkm)

Vehicle kilometres x passengers per vehicle

(vkm) (Occupancy rate)

Passenger kilometres (pkm)



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Fundamentals of transport activity parameters: ton-km (tkm)

Vehicle kilometres x tonnes per vehicle

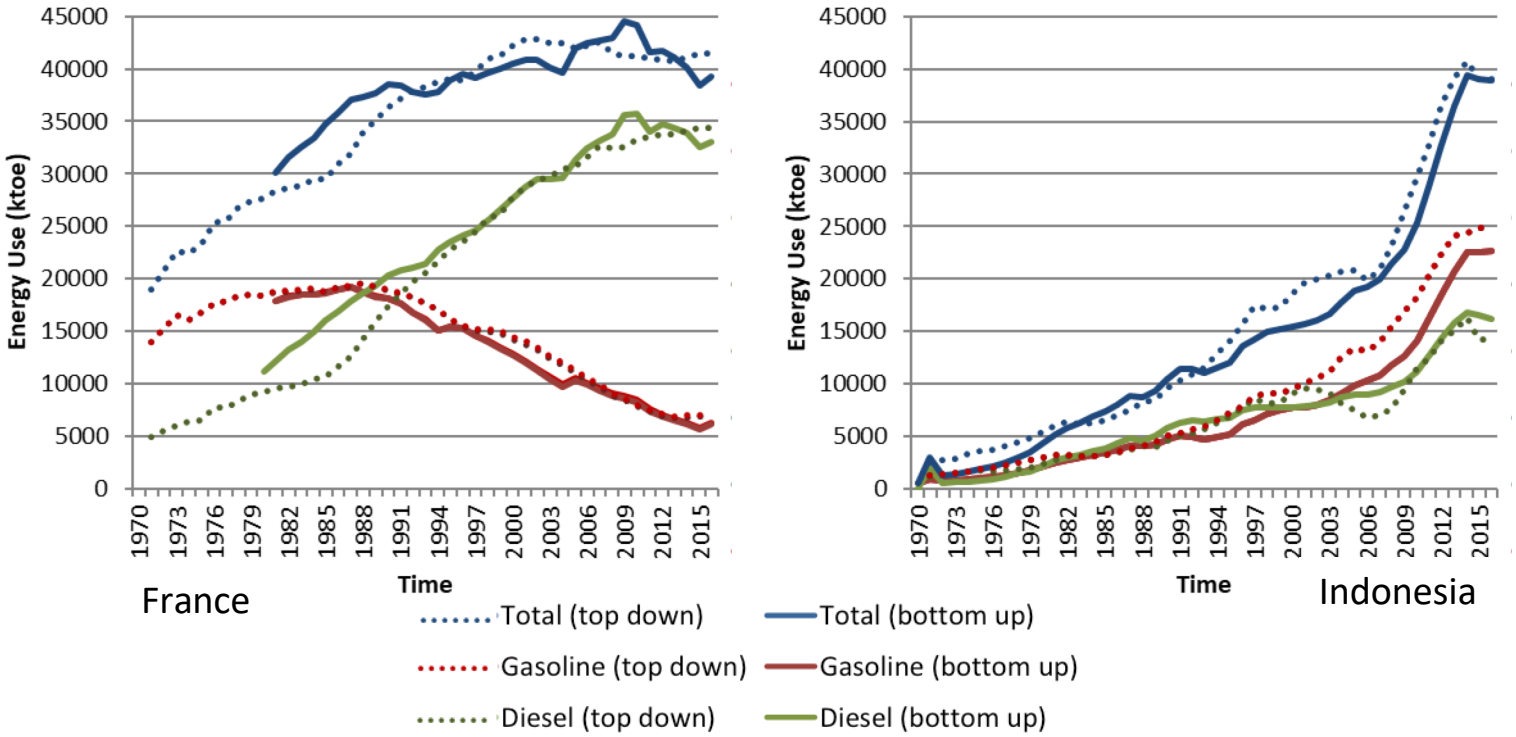
(vkm) (Load factor)

Tonne kilometres (tkm)



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Energy consumption: Aggregate results bring limited insight

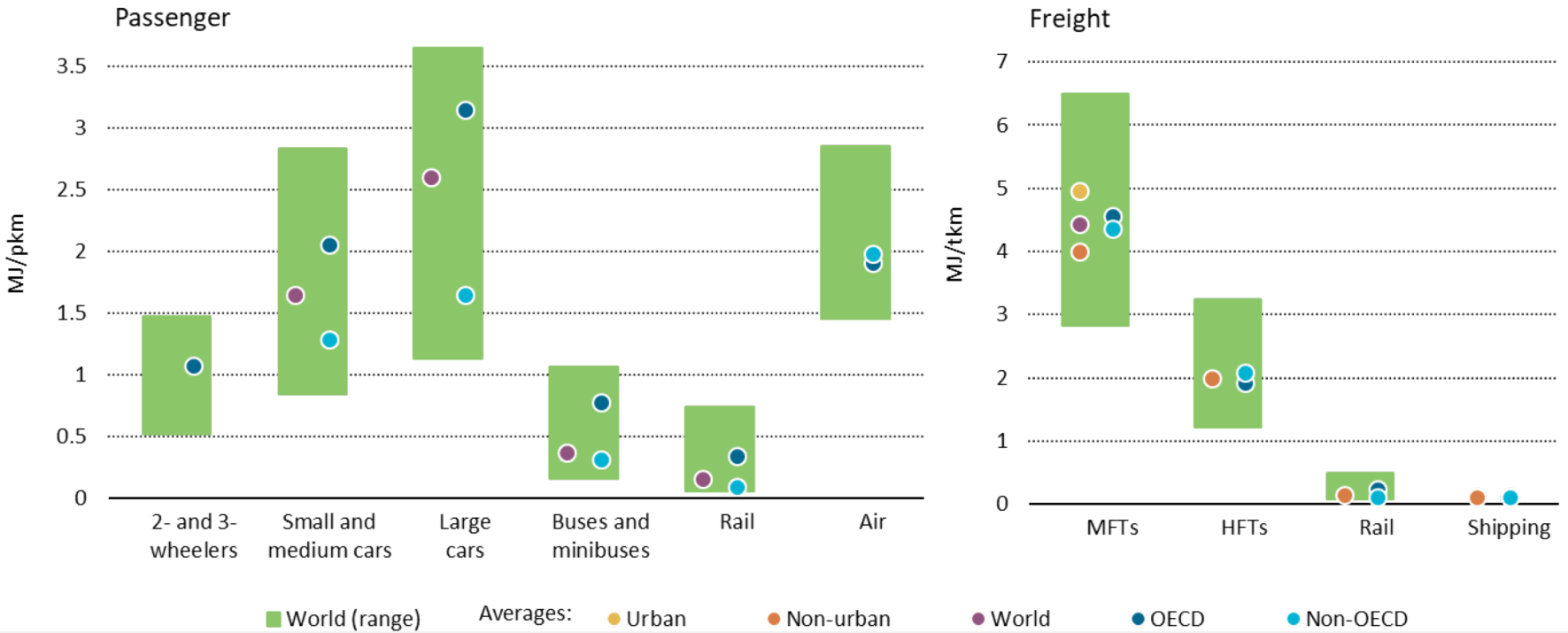


Absolute results for energy consumption do not allow to evaluate specific energy efficiency across modes

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Specific energy efficiency of transport: Modal Choice matters

Energy intensity of different modes of transport, 2015



Air and light road passenger modes are more energy intensive than public ('mass') transport. Light road freight is the most energy intensive freight transport mode.

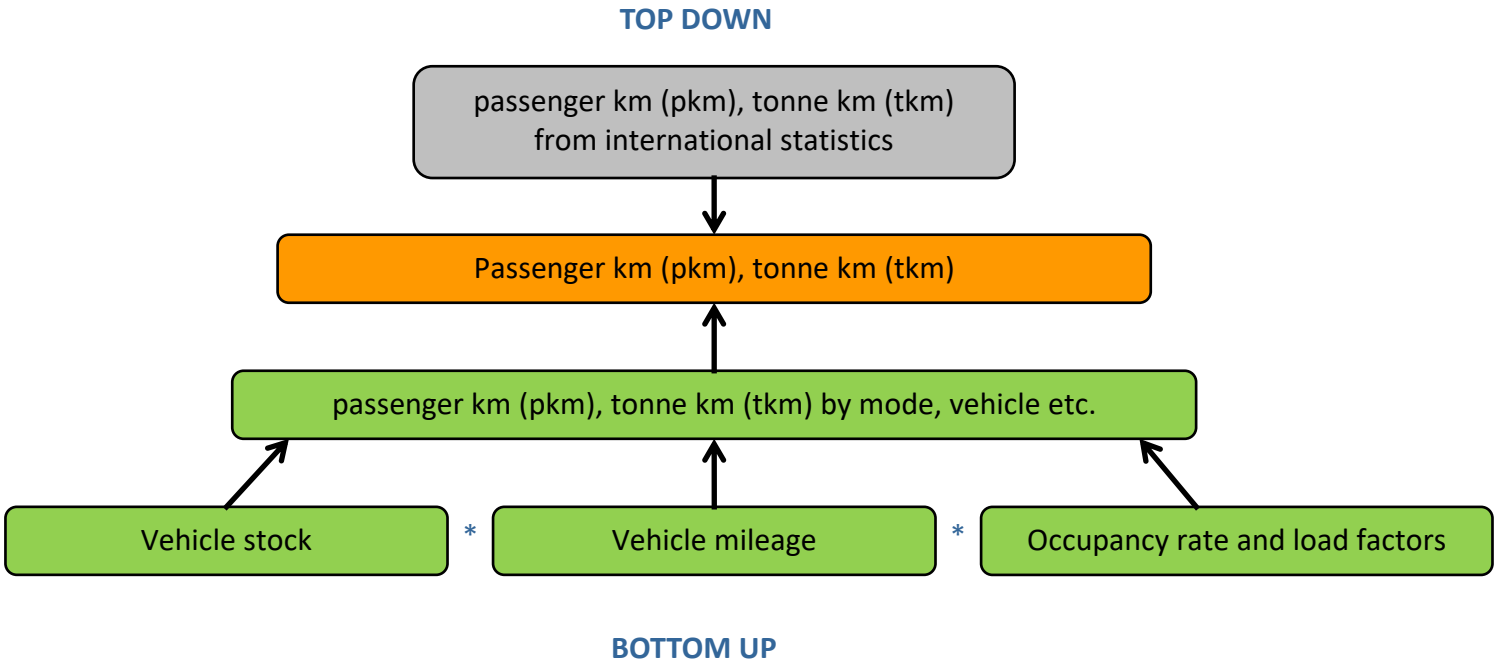
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Where to find data?

Data: requirements, collection, uncertainties, and analysis

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Transport Data: Activity and energy consumption



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Vehicle stock

- Generally available from administrative sources
  - e.g. from ministries, statistical offices
  - Available stock data may not be corrected for scrappage
- Stock can be calculated from scrappage and new registrations
  - Industry associations provide sales data
  - Make assumptions on vehicle life time
- Vehicle classification is not the same everywhere
  - Two wheelers
  - Passenger light duty vehicles (PLDV): passenger car and SUV
  - Mass transport: minibus, bus, bus rapid transit (BRT)
  - Commercial vehicles: Light commercial vehicle, medium freight truck, heavy freight truck

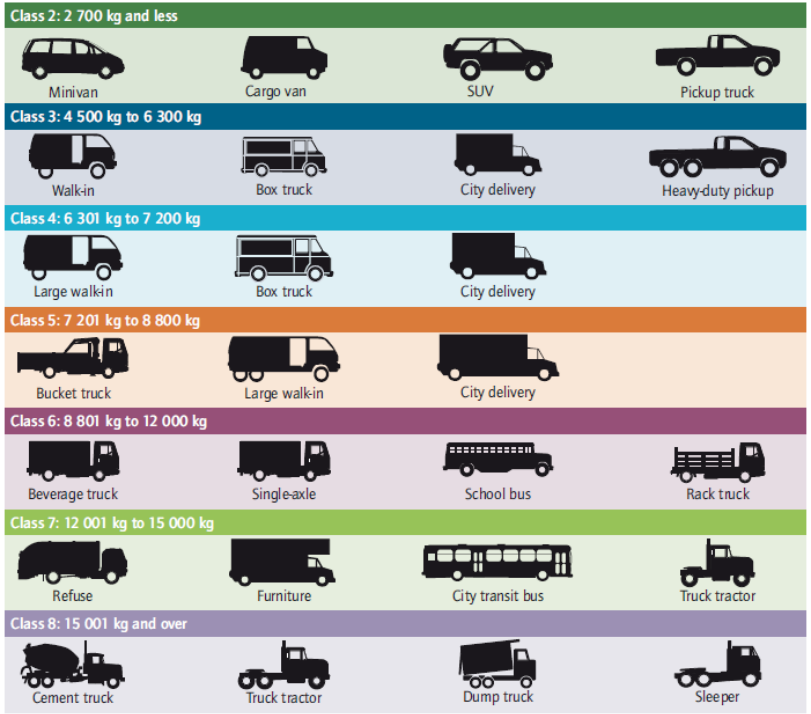
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Vehicle stock: Classification of commercial vehicles

UN Regulations

Passenger transport (buses)	
M2	> 8 seats + driver, maximum mass < 5 t
M3	> 8 seats + driver, maximum mass > 5 t
Class I	with areas for standing passengers
Class II	principally seated passengers, standing possible
Class III	seated passengers only
Goods transport (trucks and trailers)	
N	Trucks
N1	maximum mass < 3.5 t
N2	maximum mass > 3.5 t and < 12 t
N3	maximum mass > 12 t
O	Trailers
O1	maximum mass < 0.75 t
O2	maximum mass > 0.75 t and < 3.5 t
O3	maximum mass > 3.5 t and < 10 t
O4	maximum mass > 10 t

United States



Classification systems for commercial vehicles are inconsistent
An appropriate balance of detail vs. data availability needs to be found

Source: Consolidated resolution on the construction of vehicles (n.a.), US DoE (2011)

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Mileage

- Household surveys, travel diaries, odometer readings, public transit operators
- Information less frequently available than data on vehicle stock
- Mileage of vehicles depends on user profile and differs across users
- Geographical coverage limited to regions where the surveys are performed
- Estimations may use analogies with similar modes in geographical areas with similar fuel taxation and population densities

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Occupancy rate and load factors

Public passenger transport

- Peak versus off-peak (evenings, weekends)
- Route types (feeder line, main line)
- Surveys and legal obligations of public transit operators

Goods transport

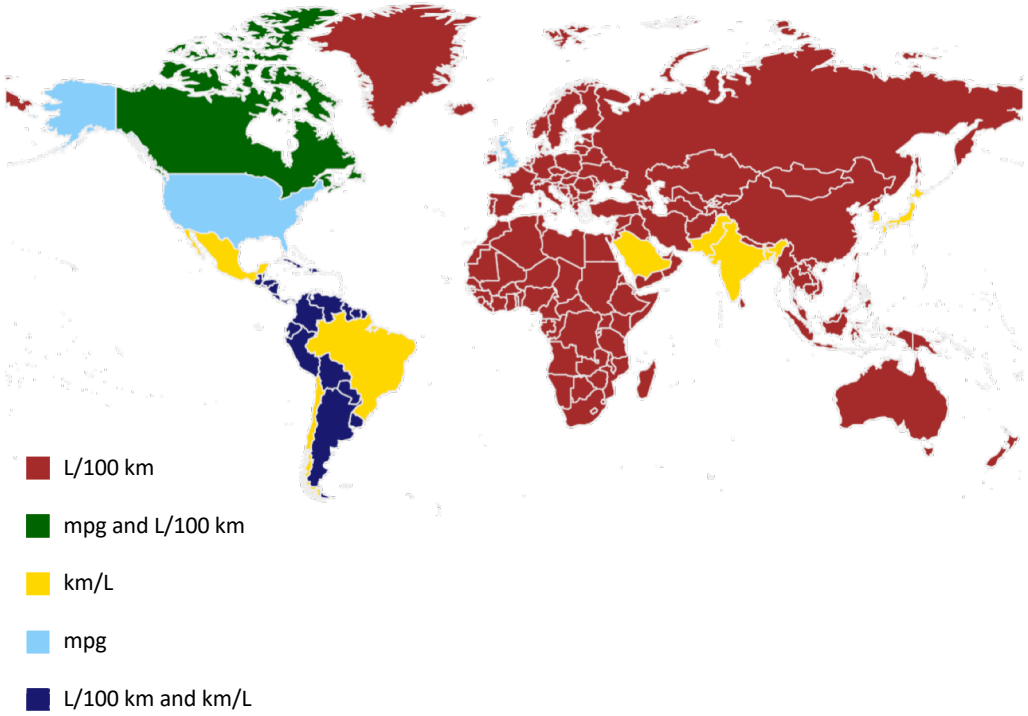
- Average load factors calculated as:
    a) Average load on laden trips
    b) Share of empty running
- Load of laden trips varies both among journeys and during a single journey
- Average loads dependent on mission profile, value of goods
- Surveys and legal obligations of shipping companies

Passenger cars

- Estimate occupancy rate based on analogies within geographical areas with similar socio-economic and taxation characteristics

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Energy Intensity

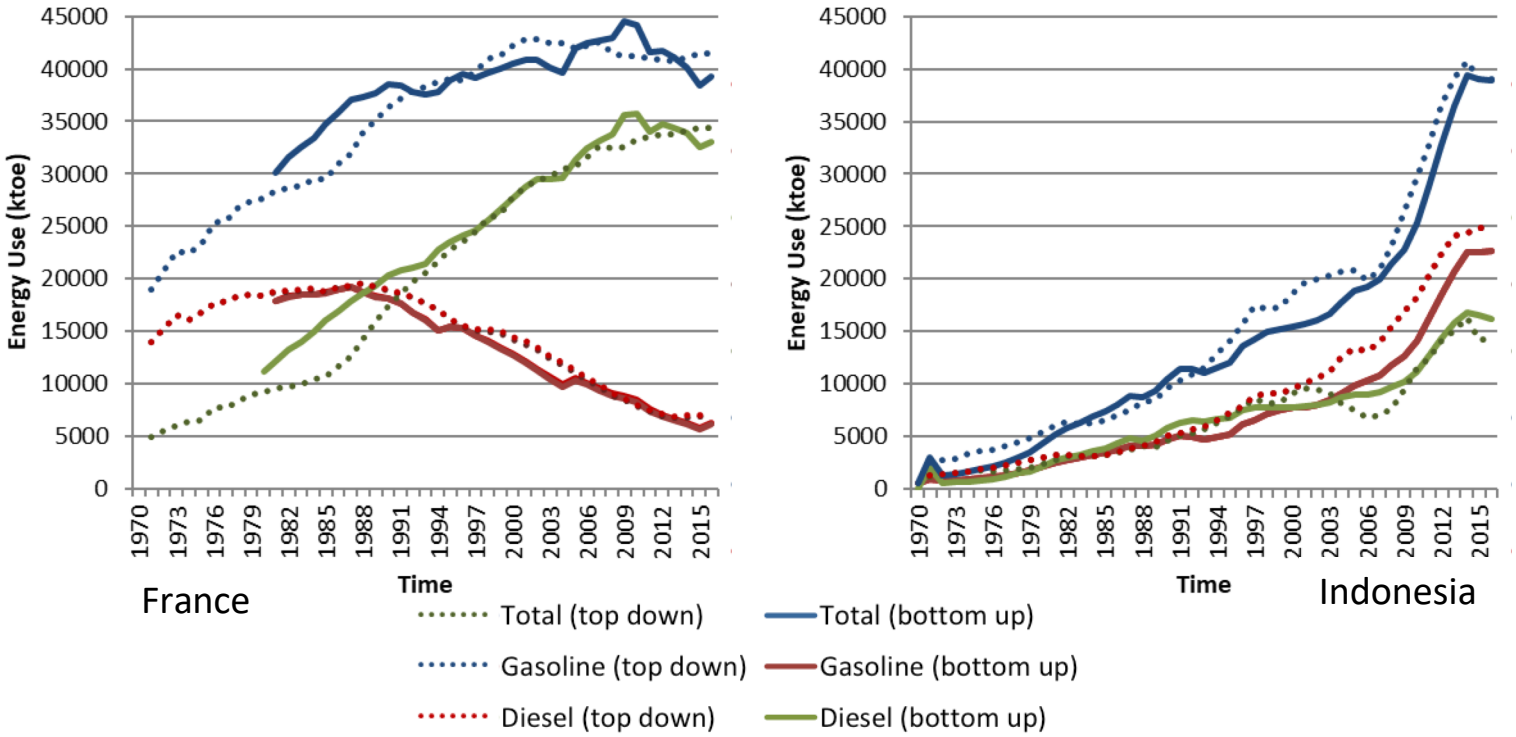


- Energy intensity describes **fuel use per vkm**
- This is measured in different units around the world
  - "fuel economy"(travel/consumption, e.g. MPG)
  - "fuel consumption" (consumption/travel, e.g. L/100 km)

This map is without prejudice to the status of or sovereignty over any territory, to the delineation of international frontiers and boundaries, and to the name of any territory, city or area.

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Energy use: Comparing bottom-up and top-down approaches



Dual results of the two complementary transport analysis approaches provides high degree of certainty

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Transport data collection methods

Four methods are typically used to collect and process data on transport activity and energy use:

- **Data collection methods:**
  - Administrative sources
  - Surveys
  - Metering
  - Estimations

➢ What are some examples, in general and in your country, of the data collection sources and methods listed above?

➢ What are some of the pros (benefits) and cons (drawbacks) of collecting data from each source or method?

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Transport data collection: Administrative sources

- Annual fuel use from national energy balances
  (collected via questionnaires sent to ministries and national statistical offices)
- Activity statistics from transport operators and government agencies
  (e.g. railway operators)
- Vehicle registration data, with detailed characteristics from respective government bodies and the private sector (e.g. associations of vehicle manufacturers)
- Vehicle import/export data, with detailed characteristics (e.g. from trade offices/border control services/private sector vehicle trade associations)
- Vehicle characteristics (by size/fuel) from government organizations (e.g. US EPA or EU EEA) and comparative studies issued by NGOs
- Studies on: mode share, travel, trips, fuel content, fuel consumption, travel patterns, etc.

Great way to get comprehensive, often official data, however:

- Collection methodology (and data quality) sometimes unclear
- Comparisons between providers may be difficult

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Transport data collection: Surveys

Pros:

- Data collection via direct observation or questionnaires on travel activities, energy use, etc.
- Can provide very rich information, useful for understanding variation, correlations, and other aspects of the sample
- The people

Cons:

- Can be labor intensive, require large sample sizes, etc.
- Estimates, not hard data

Examples:

- National travel survey
- Household surveys, focus groups
- Survey of fleets, trucking companies
- Observational (e.g. roadside) surveys

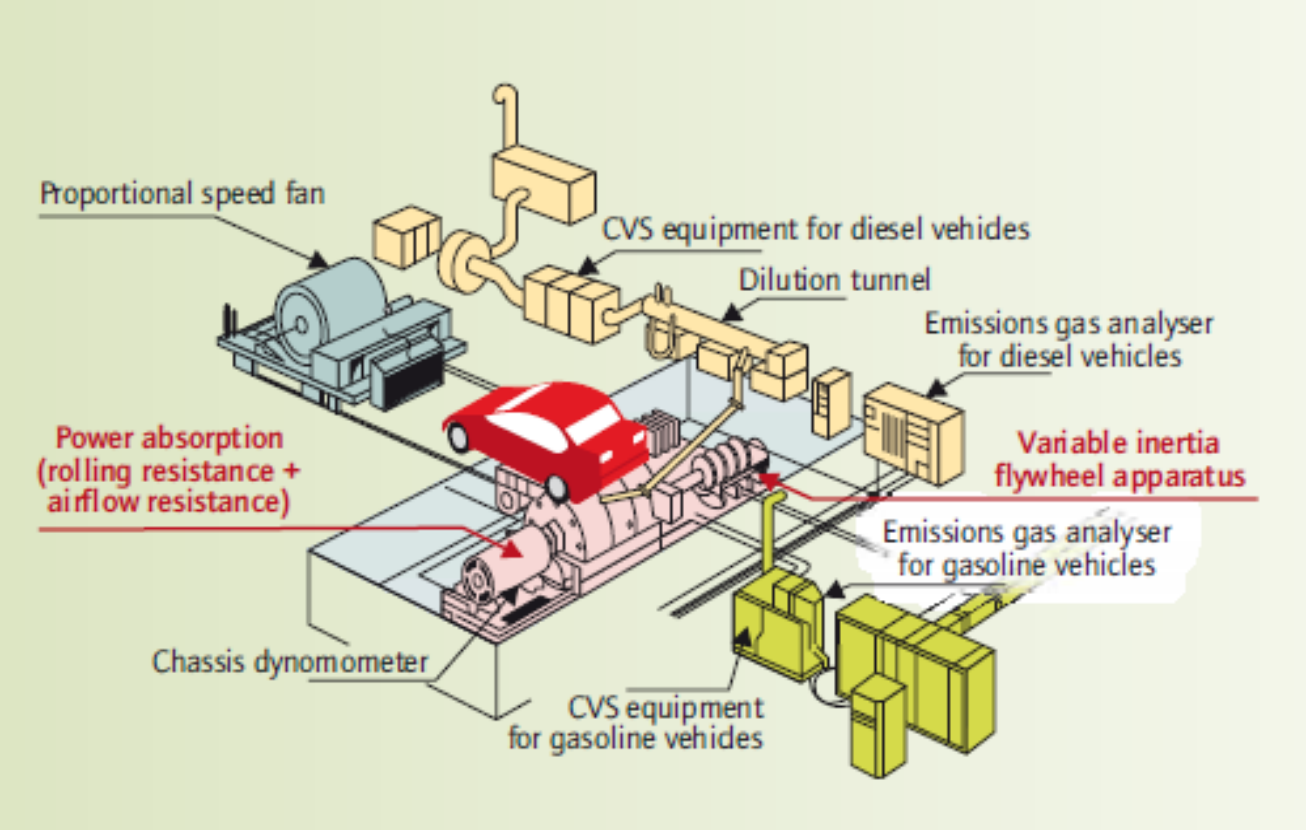
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Transport data collection: Measuring and metering

- Pros: Direct observation, usually of a physical phenomenon
  - Can use existing metering systems or involve creating new ones
  - Roadside car counters
  - Vehicle fuel economy testing
  - GPS data and vehicle location monitoring
  - Vehicle fuel economy computers (in use performance)
  - Portable Emissions Monitoring (PEMS)
  - Speed detection systems
  - Atmospheric concentration monitoring
- Cons: Typically reliable but often expensive
  - Based on scientific and replicable tests
  - Sample size and data processing requirements affect costs

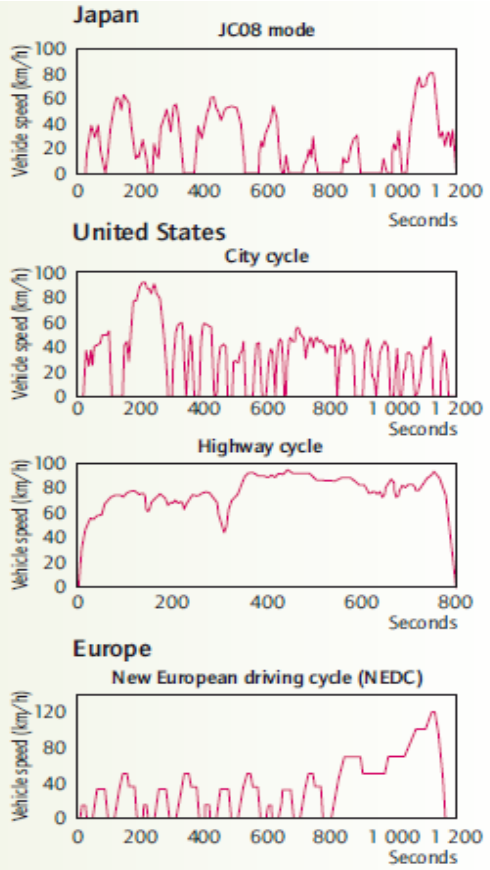
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Transport data collection: Measuring fuel consumption and emissions



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Transport data collection: Measuring fuel consumption and emissions



- Different test cycles in US, Japan & Europe exist
- Use conversion formulas to make tested data comparable
- On-road fuel economy often higher than tested fuel economy (approx. 15% - 30%) due to:
  - Climate conditions
  - Use of auxiliary aggregates
  - Road conditions
  - Nature of driving cycles (e.g. not realistic)
  - Vehicle preconditioning

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Transport data collection: Estimations

What if data shows gaps?

- Statistical methods: interpolation, curve fitting etc.
- Use of correlations/elasticities
- Elimination of degrees of freedom and reality check, e.g. the least certain parameter is adjusted to match certain data



What if reality is too complex and diverse?

- Modelling/simulation (e.g. heavy duty vehicle fuel economy)

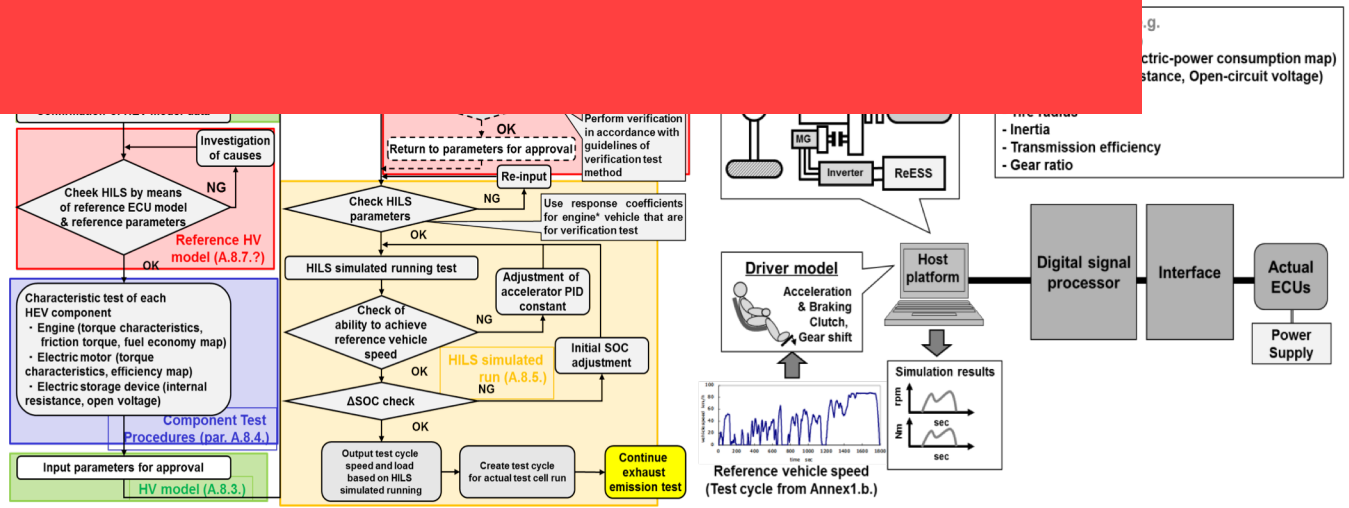
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Transport Data: Focus on Data Collection

Maybe I rather do not present this since I did bot read the paper, focus on evaluation case study instead instead

the heavy

ated run



Source: UNECE, World Forum for the Harmonization of Vehicle Regulations, Working Party on Pollution and Energy, informal working group on Heavy Duty Hybrids (HDH)

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Transport data collection: MoMo historical database as example for estimations

The IEA Mobility Model comprises an historical database:

- Stock data
- Travel data (pkm)
- Mileage data (km/y)
- Fuel consumption data (L/100 km)

→ Primarily based on the collection and comparison of published information

→ Bottom-up results on the energy consumption are checked against historic fuel consumption by sector and fuel type (from import/export/production balances: remember the examples of France and Indonesia?)

→ Fitted adjusting the least reliable data (mileage)

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Conlusions

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Conclusions

- Substantial data requirements
- Vehicle stock, fuel economy, and energy use are key parameters
- Reality checking is possible
- Bottom-up estimates can be done with limited investment
- Need to compromise between detail and available resources
- The better the historical data set, the more reliable are models
- A good model is an important basis for the definition of effective policy instruments!

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Exercise I: Filling the Gaps

Include the exercise after the presentation, will be a similar concept but better

			2012
			630000
			185000
			?
			9950
			?
New car fuel economy (L/100km)	8.5	8.2	8
Stock avg fuel economy L/100km)	8.8	?	?
fuel consumption (bil L)	?	?	?
CO2 emissions factor (kg/L)	3.6	3.5	3.4
CO2 emissions (million tonnes)	?	?	?

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Exercise I: Filling the Gaps

CO2 emissions are rising!

Include the exercise after the presentation, will be a similar concept but better

			2012
			630000
			185000
			5480000
			9950
Total travel, all vehicles (bil km)	**45.0**	**49.7**	**54.5**
New car fuel economy (L/100km)	8.5	8.2	8
Stock avg fuel economy L/100km)	8.8	**8.7**	**8.6**
fuel consumption (bil L)	**4.0**	**4.3**	**4.7**
CO2 emissions factor (kg/L)	3.6	3.5	3.4
CO2 emissions (million tonnes)	**14.3**	**15.2**	**16.0**

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Key parameters: vehicle-kilometres (vkm)

Number of vehicles × kilometres per vehicle

(Stock) (Mileage)

Vehicle kilometres (vkm)





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Key parameters: passenger-kilometres (pkm)

Vehicle kilometres x passengers per vehicle

(vkm) (Occupancy rate)

Passenger kilometres (pkm)



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Key parameters: tonne-kilometres (tkm)

Vehicle kilometres x tonnes per vehicle

(vkm) (Load factor)

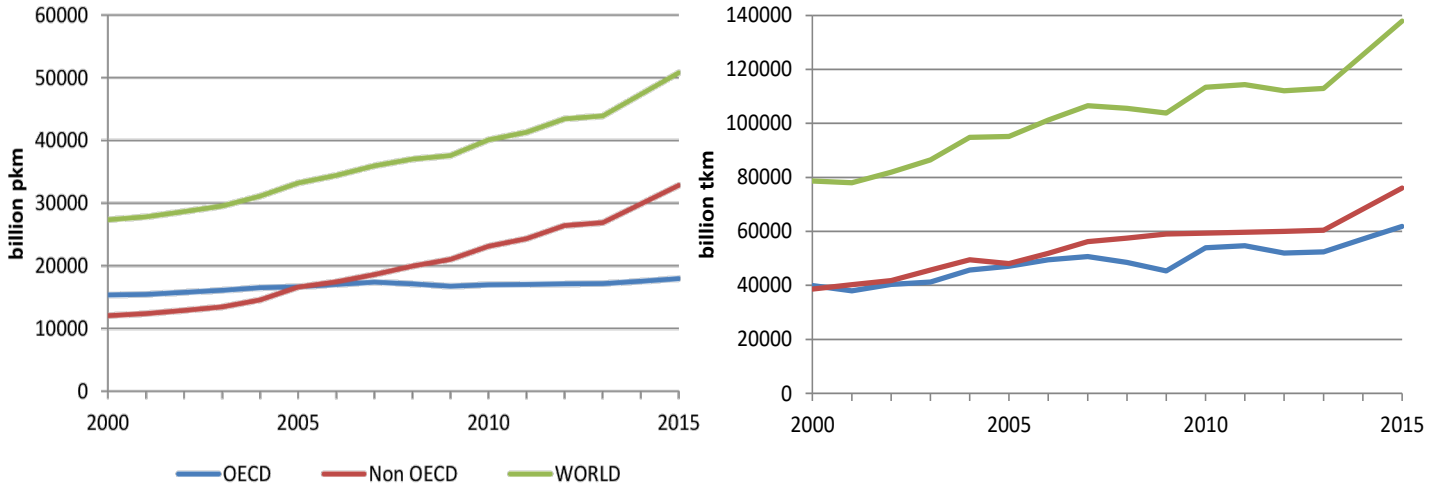
Tonne kilometres (tkm)



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Transport Activity: Travel Growth

Passenger and freight transport by region, 2000-2015



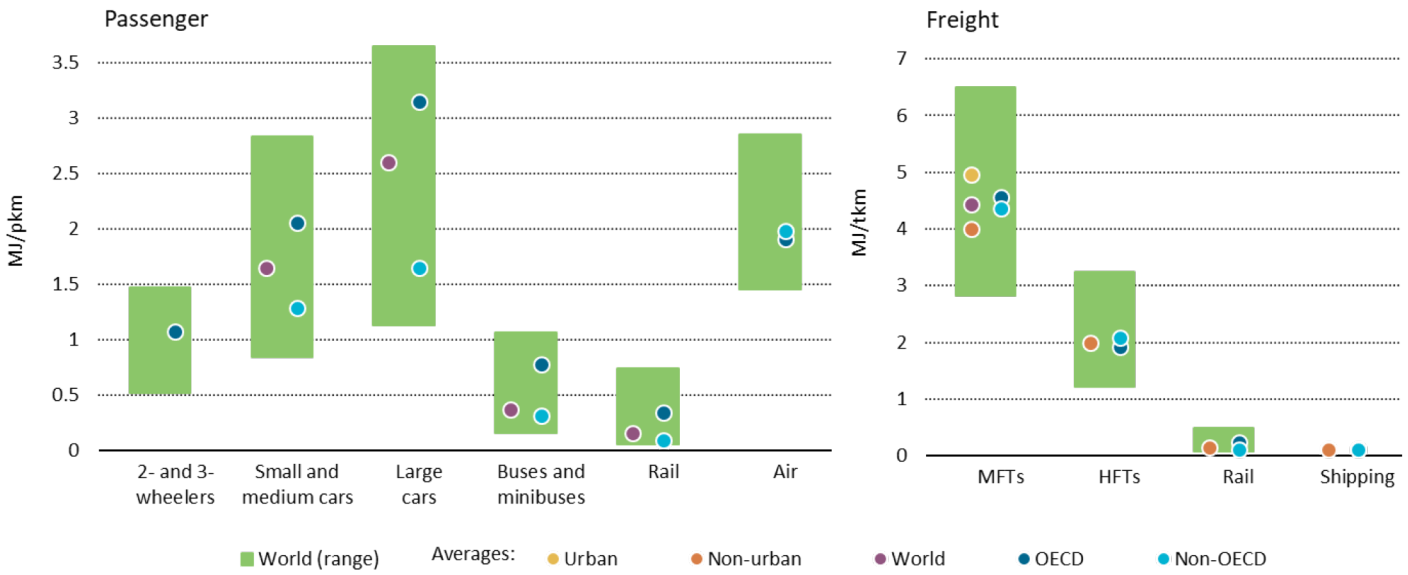
Transport activity grew by 86% (pkm) and 75% (tkm) between 2000 and 2015.
Growth in non-OECD countries is faster than in the OECD.

Source: ETP 2017

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Transport Activity: Modal Choice

Energy intensity of different modes of transport, 2015



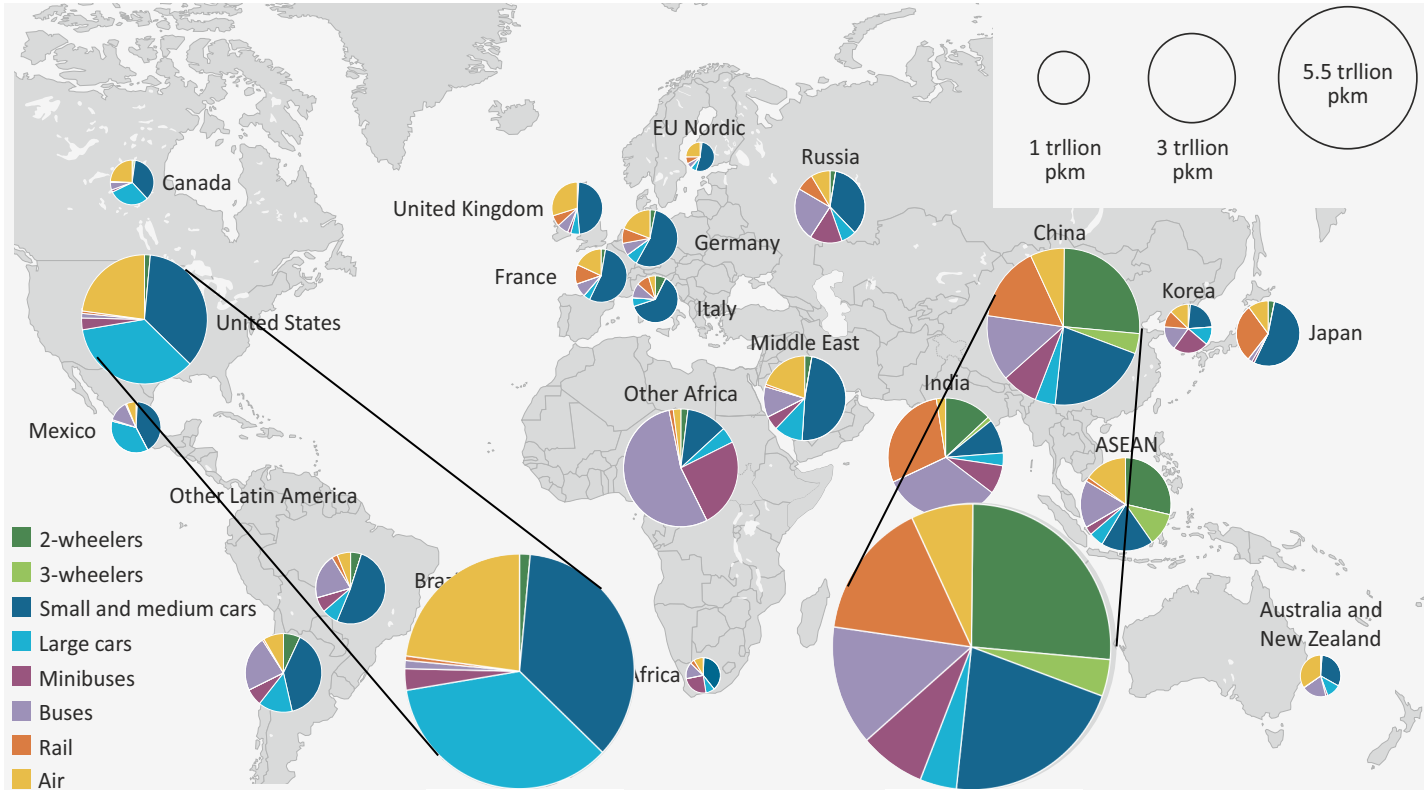
Air and light road passenger modes are more energy intensive than public ('mass') transport.
Air and light road freight are more energy intensive than large road vehicles, rail and shipping.

Source: ETP 2017

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Transport Activity: Modal Choice

National passenger activity (pkm) by mode, 2015



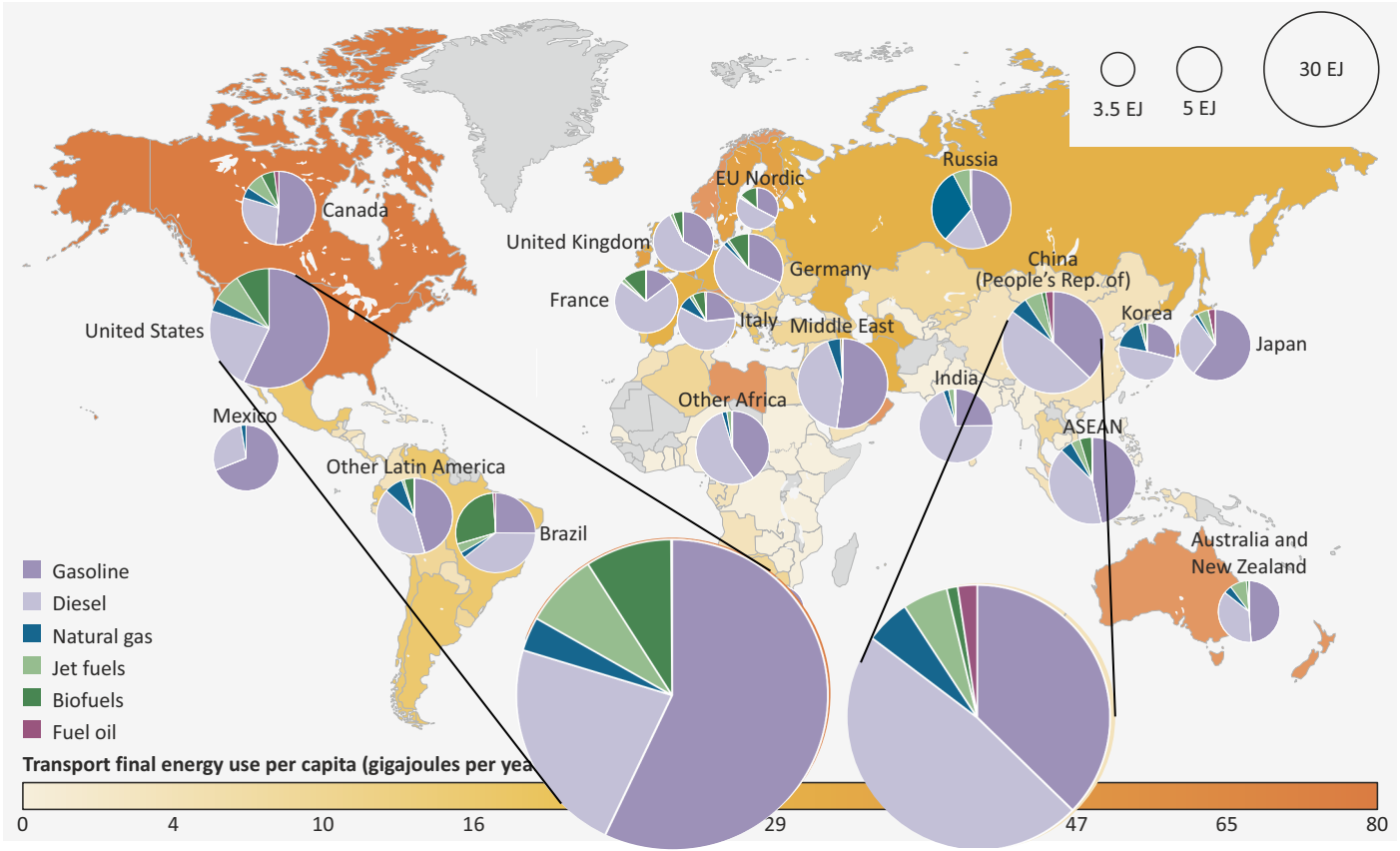
This map is without prejudice to the status of or sove to the delineation of international fr to the name of any territory, city or area.

Source: ETP 2016

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Transport Activity: Modal Choice

Transport energy use by country, 2013



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Source: ETP 2016

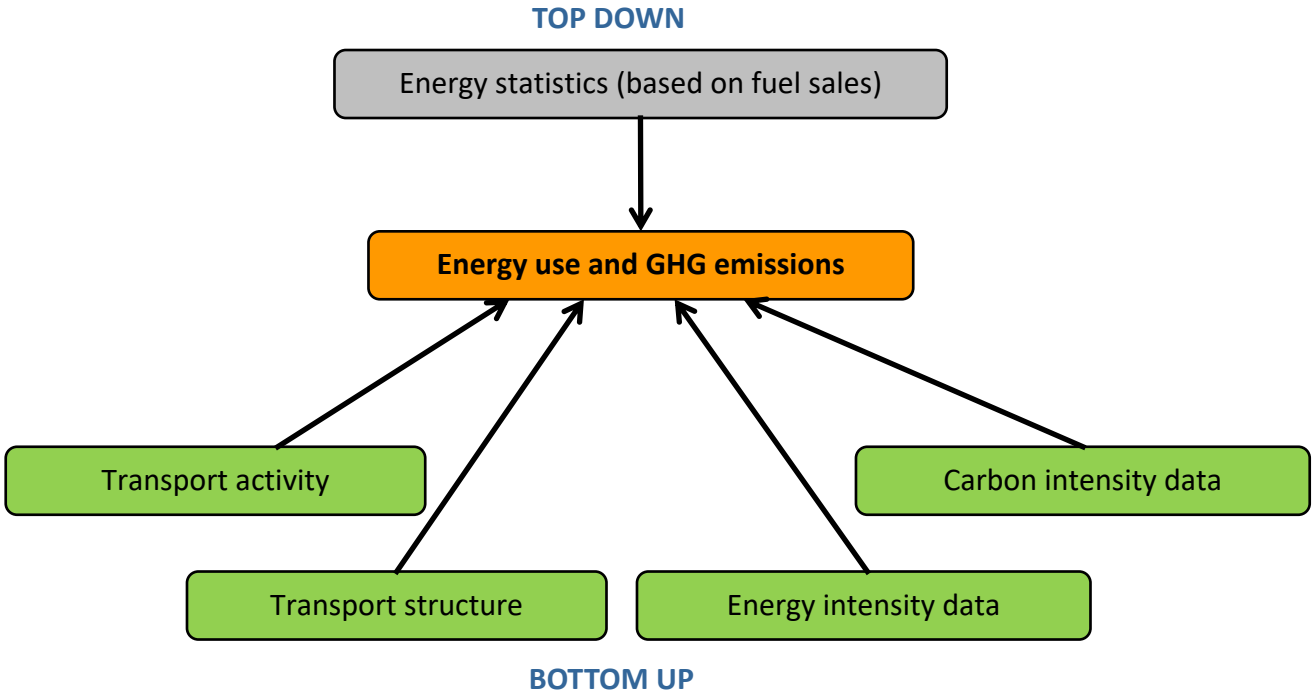
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Overview of historical trends and main transport energy parameters

1. Energy consumption in transport
2. Transport activity (*pkm*, *tkm*, *vkm*)
3. **ASIF (Activity, Structure, Intensity → Fuel use) approach**
4. Data: requirements, collection, uncertainties, and analysis

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ASIF Approach: Linking Activity and Fuel Use



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ASIF Approach: Linking Activity and Fuel Use

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$F_i/A_i = I_i$	energy ***I***ntensity, i.e. the average fuel consumption per *vkm* (same disaggregation level)

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This extension is suitable to the case of where several energy carriers need to be considered:

$$E = \sum_i E_i = A \sum_i \frac{A_i}{A} \times \frac{F_i}{A} \times \frac{F_{ij}}{F_i} \times \frac{E_{ij}}{F_i} = A \sum_i S_i I_i E F_{ij} = E$$

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ASIF Approach: Well-to-wheel versus tank-to-wheel

Well-to-wheel: tank-to-wheel emissions + well-to-tank emissions

Using the example of biofuels…

Well-to-wheel

well-to-tank emissions

Production → Logistics → Processing → Distribution → End Use







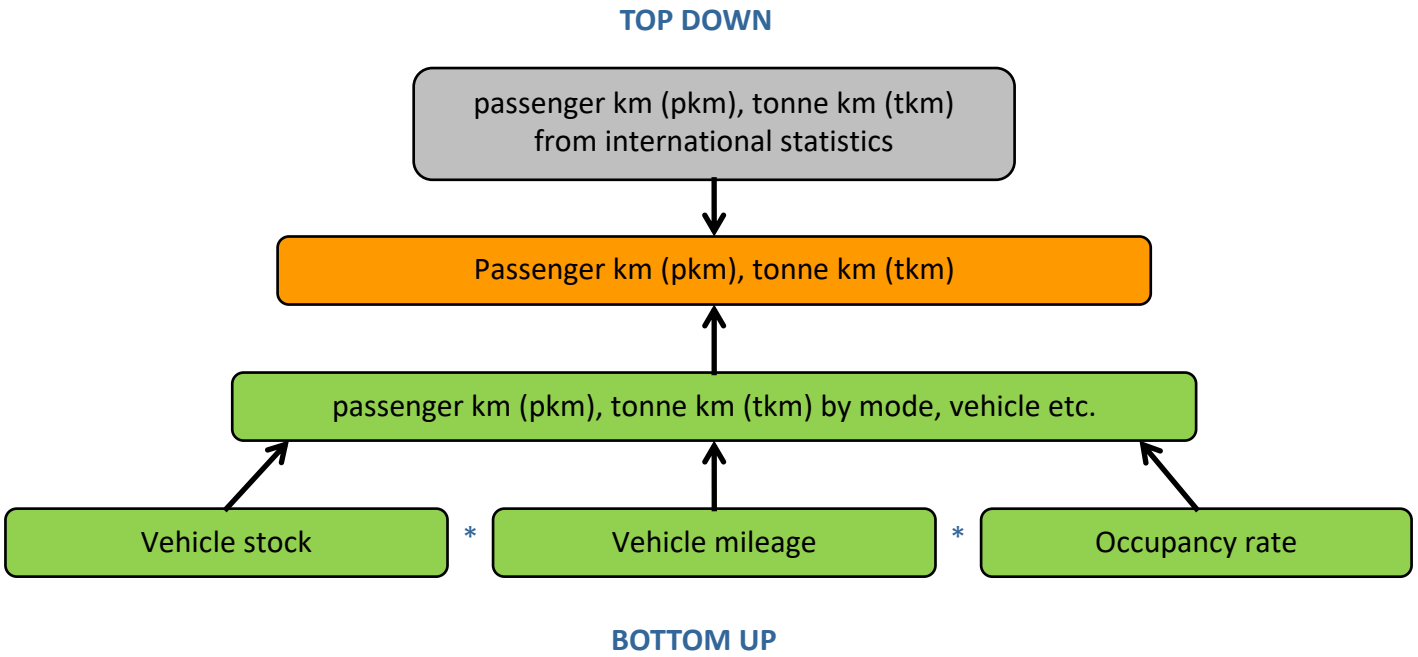

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Overview of historical trends and main transport energy parameters

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2. Transport activity (*pkm*, *tkm*, *vkm*)
3. ASIF (Activity, Structure, Intensity → Fuel use) approach
4. **Data: requirements, collection, uncertainties, and analysis**

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Transport Data: Activity



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Transport Data: Activity

Vehicle stock

- Generally available (e.g. from ministries, statistical offices)
- Can be calculated from new registrations & scrappage
- Available data may not be corrected for scrappage (e.g. Brazil, Algeria)
- Vehicle classification is not the same everywhere

Mileage and occupancy rates

- Household surveys, travel diaries, odometer readings, public transit operators
- Information less frequently available than data on vehicle stock
- ***Geographical coverage*** limited to regions where the surveys are performed
- ***Mileage***: estimated using analogies with similar modes in geographical areas with similar fuel taxation and population densities
- ***Occupancy rate*** of personal vehicles: estimated by analogies / assumptions within geographical areas with similar socio-economic and taxation characteristics

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Transport Data: Activity

Disaggregating modes: example of Commercial Vehicles (CVs)

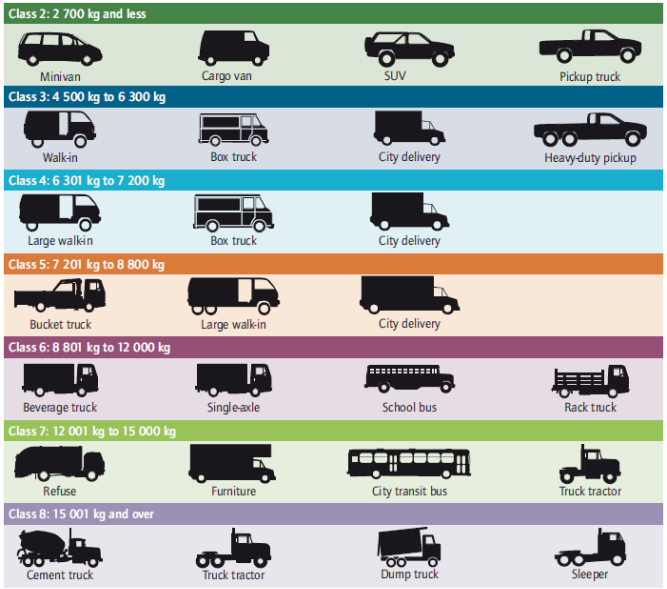
- The CV subsector is very diverse: vehicle classification is not uniform across countries

UN Regulations

Passenger transport (buses)	
M2	> 8 seats + driver, maximum mass < 5 t
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O	Trailers
O1	maximum mass < 0.75 t
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O3	maximum mass > 3.5 t and < 10 t
O4	maximum mass > 10 t

Source: Consolidated Resolution on the Construction of Vehicles

United States



Source: US DoE, 2011.

- Fuel use of CVs depends on ***mission profile*** and ***load***
- An appropriate balance of ***detail*** vs. ***data availability*** needs to be found

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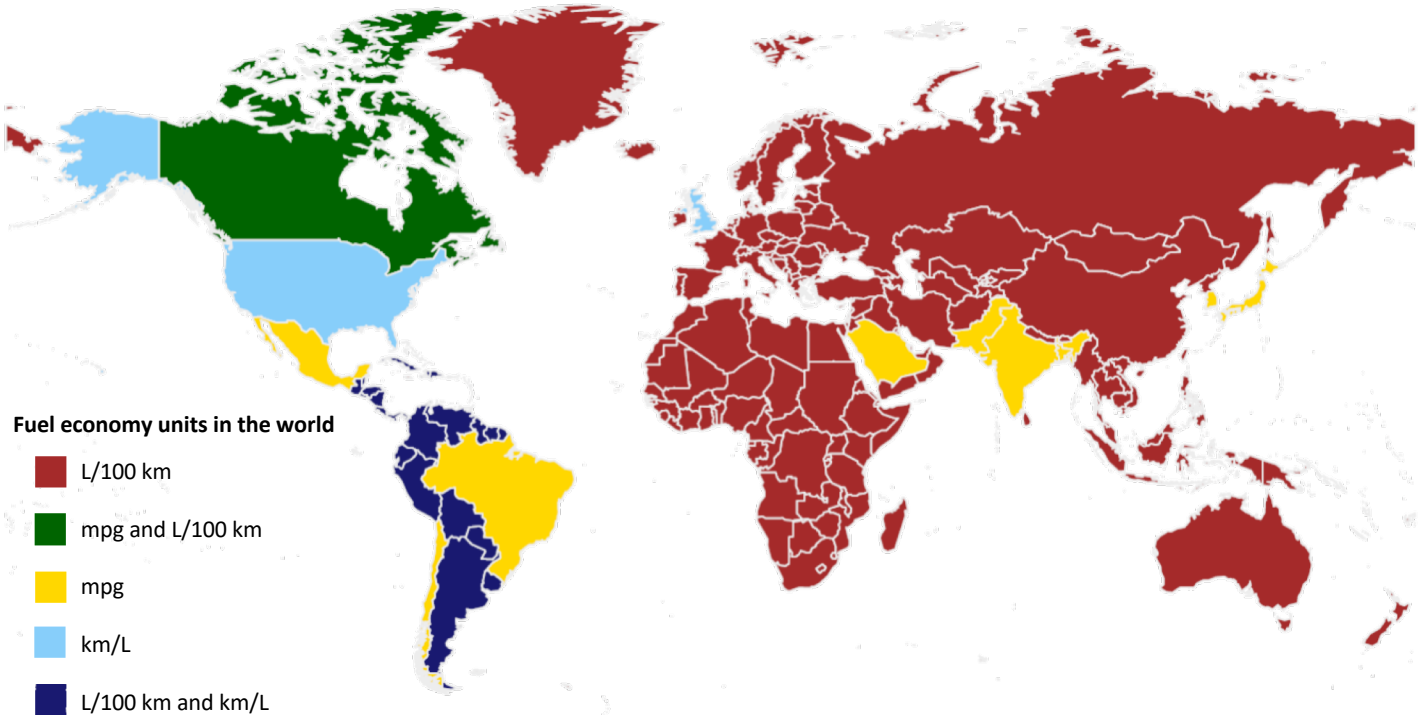
Occupancy rates and load factors

Difficult to measure

- Public passenger transport
  - Peak versus off-peak (evenings, weekends)
  - Route types
  - Surveys and legal obligations of public transit operators
- Goods transport
  - Average load factors calculated as:
    a) Average load on laden trips
    b) Share of empty running
  - Load of laden trips varies both among journeys and during a single journey
  - Average loads dependent on mission profile, value of goods
  - Surveys and legal obligations of public transit operators

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Transport Data: Energy Intensity



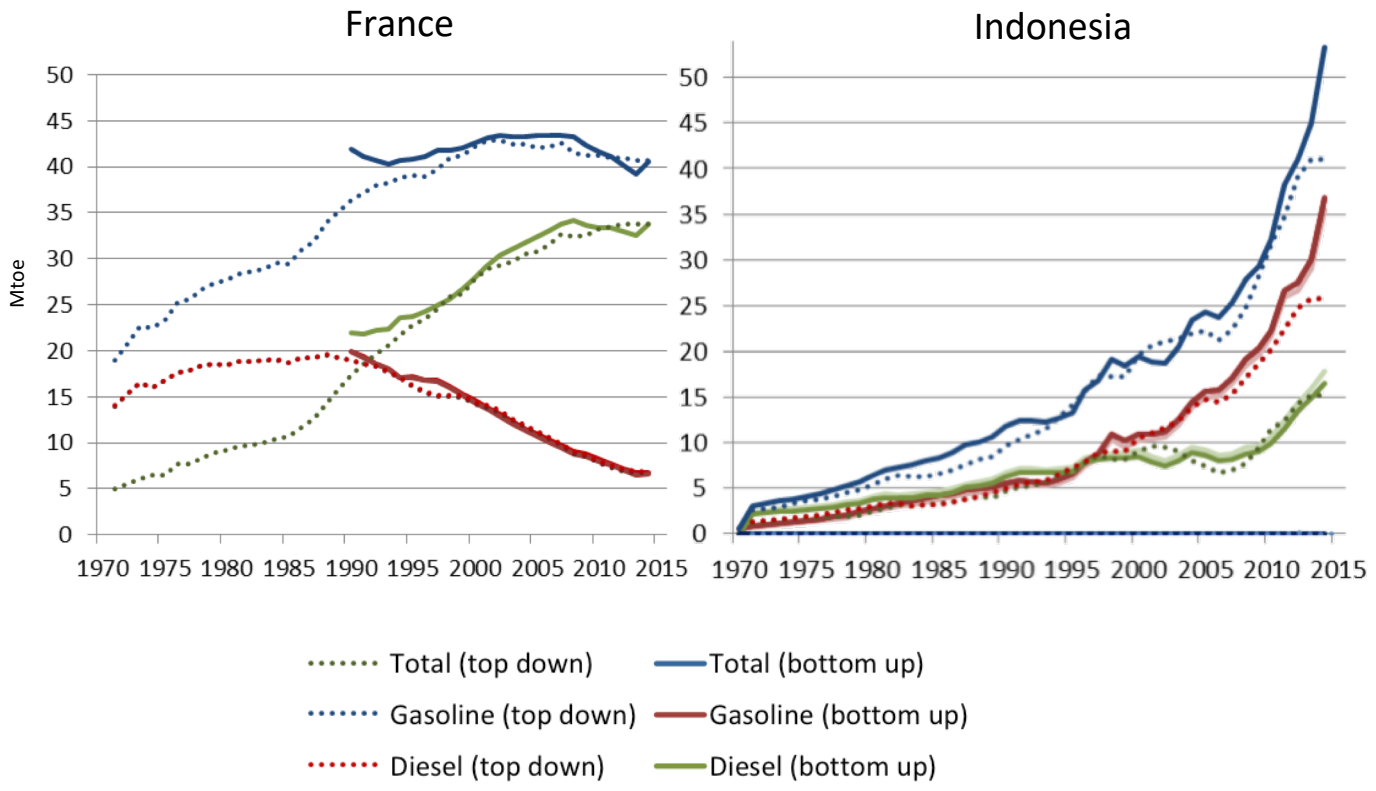
This map is without prejudice to the status of or sovereignty over any territory, to the delineation of international frontiers and boundaries, and to the name of any territory, city or area.

- Energy intensity = fuel use per vkm
- This is measured in different units around the world
  - “fuel economy”(travel/consumption, e.g. MPG)
  - “fuel consumption” (consumption/travel, e.g. L/100 km)

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Transport Data: Energy Use

Comparing bottom-up and top-down approaches



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Exercise I: Filling the Gaps

Are CO_2 emissions rising or falling over time?

	2010	2011	2012
New car sales	570000	600000	630000
Retirements	150000	165000	185000
Total car stock	4600000	?	?
Average travel per vehicle (km/year)	9780	9875	9950
Total travel, all vehicles (bil km)	?	?	?
New car fuel economy (L/100km)	8.5	8.2	8
Stock avg fuel economy L/100km)	8.8	?	?
fuel consumption (bil L)	?	?	?
CO2 emissions factor (kg/L)	3.6	3.5	3.4
CO2 emissions (million tonnes)	?	?	?

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Exercise I: Filling the Gaps

CO_2 emissions are rising!

	2010	2011	2012
New car sales	570000	600000	630000
Retirements	150000	165000	185000
Total car stock	4600000	**5035000**	**5480000**
Average travel per vehicle (km/year)	9780	9875	9950
Total travel, all vehicles (bil km)	**45.0**	**49.7**	**54.5**
New car fuel economy (L/100km)	8.5	8.2	8
Stock avg fuel economy L/100km)	8.8	**8.7**	**8.6**
fuel consumption (bil L)	**4.0**	**4.3**	**4.7**
CO2 emissions factor (kg/L)	3.6	3.5	3.4
CO2 emissions (million tonnes)	**14.3**	**15.2**	**16.0**

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Transport Data: Focus on Data Collection

Four methods are typically used to collect and process data on transport activity and energy use:

- **Data collection methods:**
  - Administrative sources
  - Surveys
  - Metering
  - Estimations

➢ What are some examples, in general and in your country, of the data collection sources and methods listed above?

➢ What are some of the pros (benefits) and cons (drawbacks) of collecting data from each source or method?

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Transport Data: Focus on Data Collection

Administrative sources:

- Annual fuel use from national energy balances
  (collected via questionnaires sent to ministries and national statistical offices)
- Activity statistics from transport operators and government agencies
  (e.g. railway operators)
- Vehicle registration data, with detailed characteristics from respective government bodies and the private sector (e.g. associations of vehicle manufacturers)
- Vehicle import/export data, with detailed characteristics (e.g. from trade offices/border control services/private sector vehicle trade associations)
- Vehicle characteristics (by size/fuel) from government organisations (e.g. US EPA or EU EEA) and comparative studies issued by NGOs
- Studies on: mode share, travel, trips, fuel content, fuel consumption, travel patterns, etc.

Great way to get comprehensive, often official data, however:

- Collection methodology (and data quality) sometimes unclear
- Comparisons between providers may be difficult

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Transport Data: Focus on Data Collection

Surveys:

Pros:

- Data collection via direct observation or questionnaires on travel activities, energy use, etc.
- Can provide very rich information, useful for understanding variation, correlations, and other aspects of the sample
- The people

Cons:

- Can be labour intensive, require large sample sizes, etc.
- Estimates, not hard data

Examples:

- National travel survey
- Household surveys, focus groups
- Survey of fleets, trucking companies
- Observational (e.g. roadside) surveys

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Transport Data: Focus on Data Collection

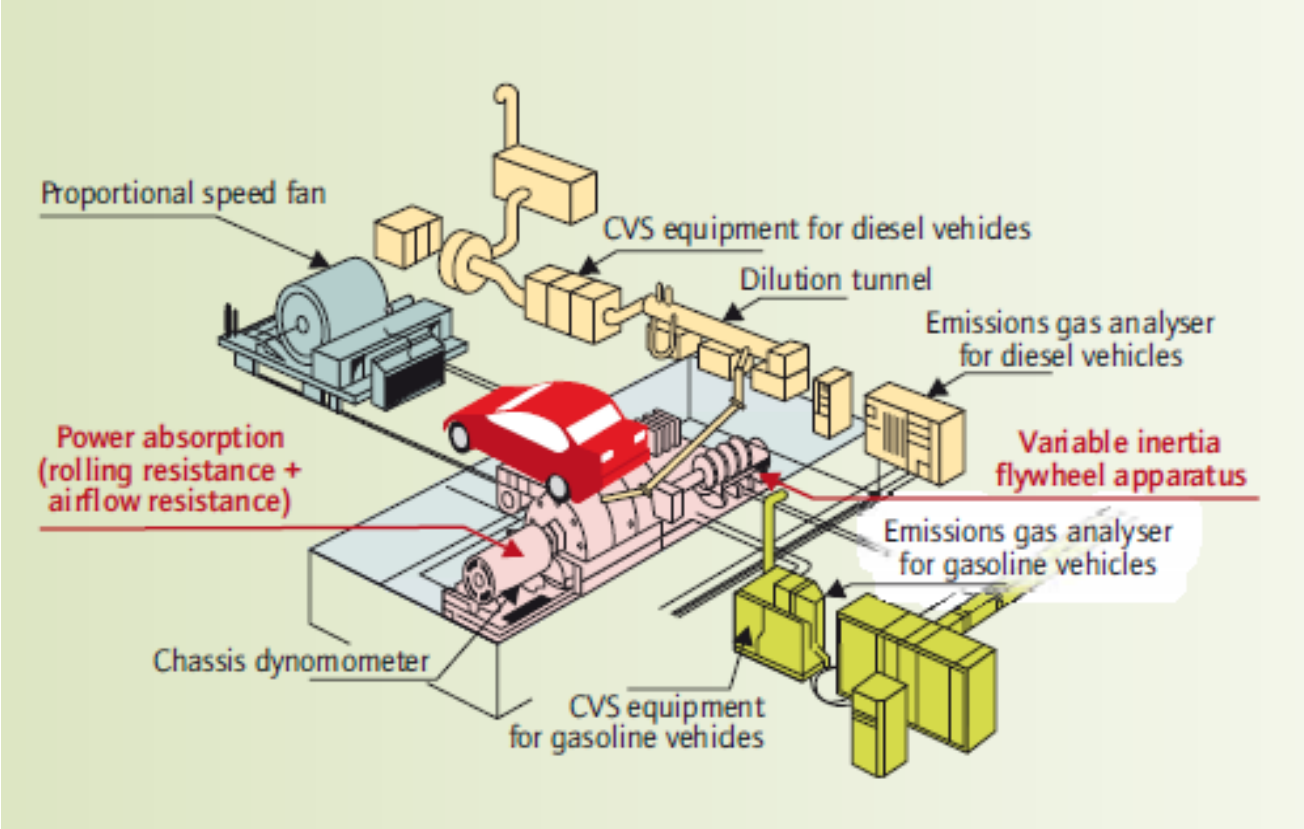
Measuring and metering:

- Direct observation, usually of a physical phenomenon
- Can use existing metering systems or involve creating new ones
  - Roadside car counters
  - Vehicle fuel economy testing
  - GPS data and vehicle location monitoring
  - Vehicle fuel economy computers (in use performance)
  - Portable Emissions Monitoring (PEMS)
  - Speed detection systems
  - Atmospheric concentration monitoring
- Typically reliable but often expensive
  - Based on scientific and replicable tests
  - Sample size and data processing requirements affect costs

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Transport Data: Focus on Data Collection

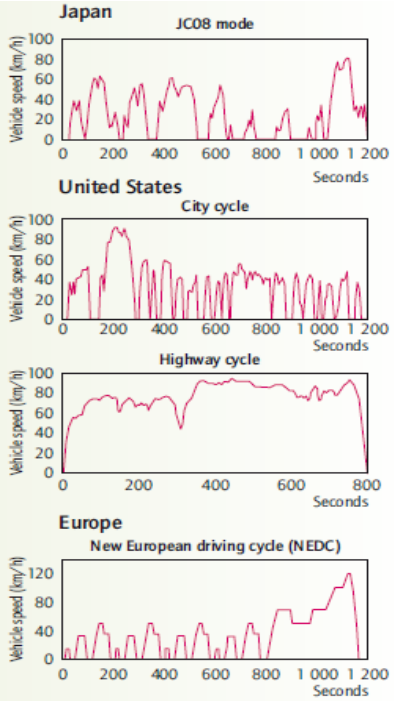
Measuring: example of fuel consumption and pollutant emissions testing



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Transport Data: Focus on Data Collection

Measuring: example of fuel consumption and pollutant emissions testing



Different test cycles in US, Japan & Europe exist

Conversion formulas to make tested data comparable

On-road fuel economy often higher than tested fuel economy (approx. 15% - 30%) due to:

- Climate conditions
- Use of auxiliary aggregates
- Road conditions
- Nature of driving cycles (e.g. not realistic)
- Vehicle preconditioning

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Transport Data: Focus on Data Collection

Estimations (with data uncertainties)

What if data shows gaps?

- Statistical methods: interpolation, curve fitting etc.
- Use of correlations/elasticities
- Elimination of degrees of freedom and reality check, e.g. the least certain parameter is adjusted to match certain data

Energy use = Vehicle stock * Fuel consumption * Mileage

What if reality is too complex and diverse?

- Modelling/simulation (e.g. heavy duty vehicle fuel economy)

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Transport Data: Focus on Data Collection

Estimations: example of MoMo historical database

The IEA Mobility Model comprises an historical database:

- Stock data
- Travel data (pkm)
- Mileage data (km/y)
- Fuel consumption data (L/100 km)

→ Primarily based on the collection and comparison of published information

→ Bottom-up results on the energy consumption are checked against historic fuel consumption by sector and fuel type (from import/export/production balances: remember the examples of France and Indonesia?)

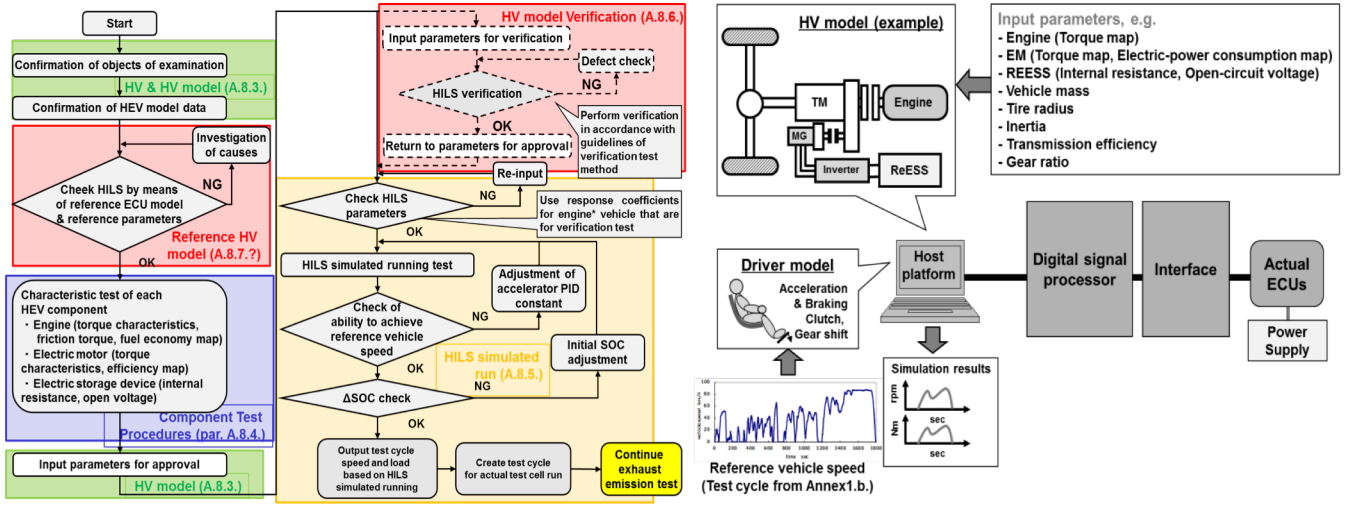
→ Fitted adjusting the least reliable data (mileage)

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Estimations: simulation of HDV fuel economy

Hardware In the Loop System (HILS)

- Running the internal combustion engine on the test bench using the heavy duty engine test cycle
- Calculate the engine operating conditions by performing a simulated run



Source: UNECE, World Forum for the Harmonization of Vehicle Regulations, Working Party on Pollution and Energy, informal working group on Heavy Duty Hybrids (HDH)

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Conclusions

- Substantial data requirements
- Vehicle stock, fuel economy, and energy use are key parameters
- Reality checking is possible
- Bottom-up estimates can be done with limited investment
- Need to compromise between detail and available resources
- The better the historical data set, the more reliable are models
- A good model is an important basis for the definition of effective policy instruments!

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Feedback and Discussion

The goal of this session was to introduce key concepts that will be explored in greater detail in the coming days.

- How new or familiar was the material we covered?
- How was the level of detail?
- What important issues have we not addressed?
- What other examples from your countries are relevant?

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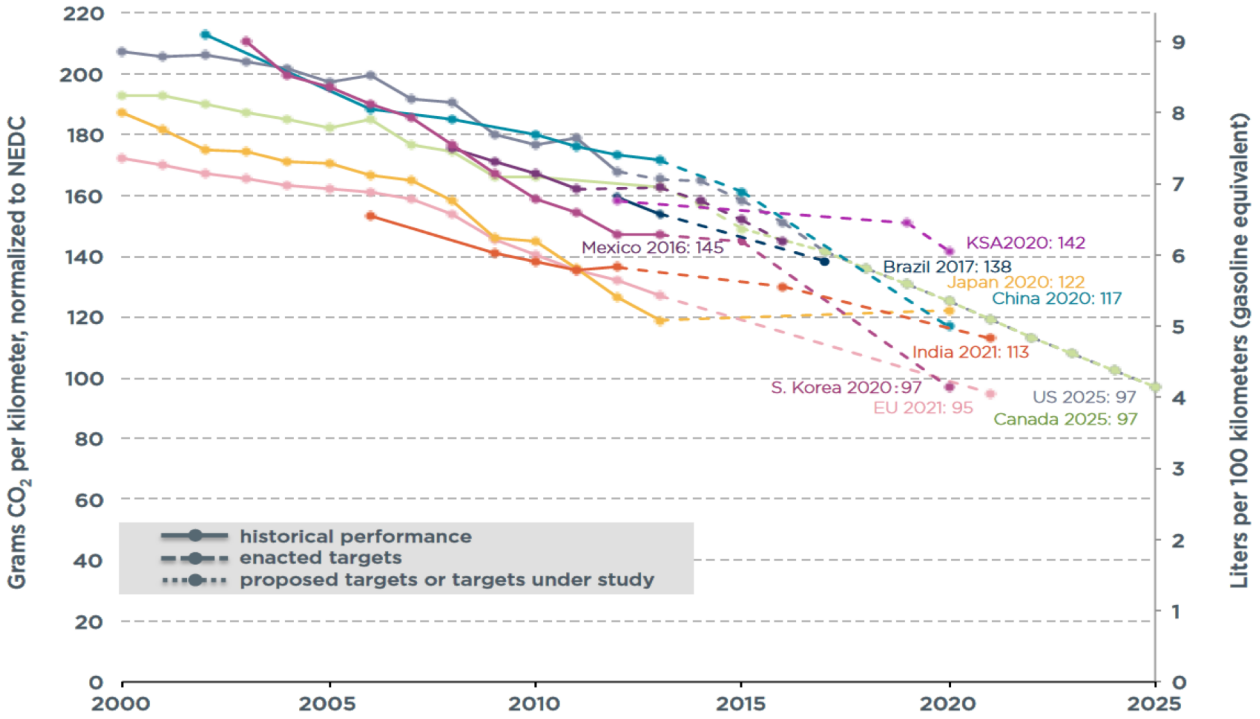
Supplemental slides

Source: ETP 2017

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Fuel economy policies

Specific fuel consumption of light passenger vehicles, 2005-2010



Light passenger vehicles experienced some improvement in recent years.

Source: ETP 2017

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Exercise

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What data do you need?

Transport energy efficiency indicators to support policy making and evaluation

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Aggregate indictors provide limited insight for policy making








Distance travelled ✖ **Vehicle stock** ✖ **Energy intensity** = **Energy consumption**

- Vehicle ***A****ctivity*
- the ***S****tructure* of the organization of vehicle across services, modes, vehicle classes and powertrain groups
- the *energy* ***I****ntensity* of each of the vehicles in this structure

… allow to calculate ***F****uel consumption*

Aggregate indicators provide no information on specific energy efficiency of transport modes and are of limited use for policy making

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Fundamentals of transport activity parameters: vehicle-km (vkm)

Number of vehicles × kilometres per vehicle

(Stock) (Mileage)

Vehicle kilometres (vkm)





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Fundamentals of transport activity parameters: passenger-km (pkm)

Vehicle kilometres x passengers per vehicle

(vkm) (Occupancy rate)

Passenger kilometres (pkm)



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Fundamentals of transport activity parameters: ton-km (tkm)

Vehicle kilometres x tonnes per vehicle

(vkm) (Load factor)

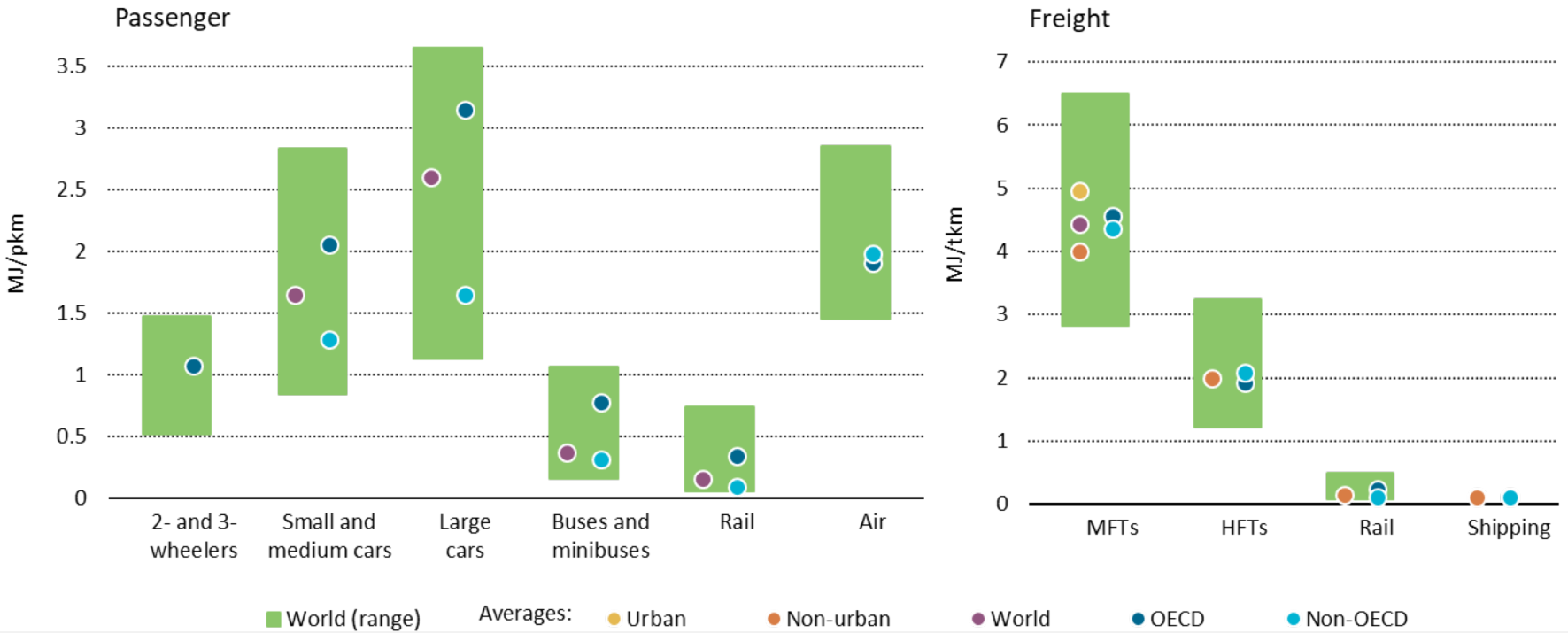
Tonne kilometres (tkm)



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Specific energy efficiency of transport: Modal Choice matters

Energy intensity of different modes of transport, 2015



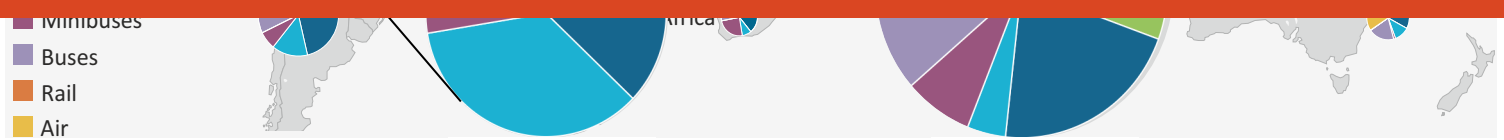
Air and light road passenger modes are more energy intensive than public ('mass') transport.
Air and light road freight are more energy intensive than large road vehicles, rail and shipping.

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Transport Activity: Modal Choice

National passenger activity (pkm) by mode, 2015

delete



6.3 trillion

9.3 trillion

This map is without prejudice to the status of or sovere ıe delineation of international frontier name of any territory, city or area.

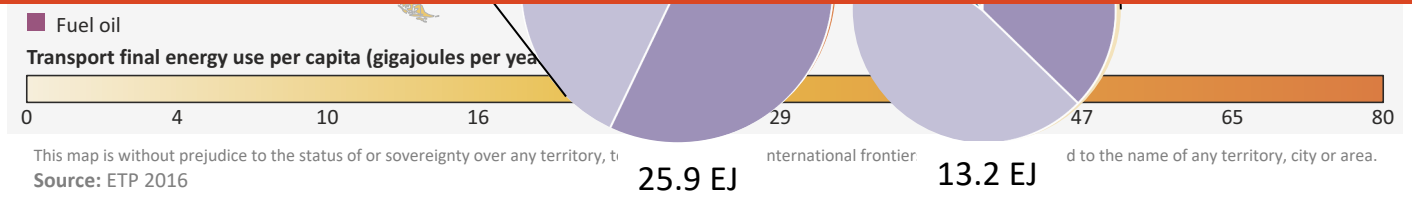
Source: ETP 2016

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Transport Activity: Modal Choice

Transport energy use by country, 2013

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Source: ETP 2016

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