EUCALC

Explore sustainable European futures

Identification of levers and levels of ambition for passenger & freight transport in Europe

D2.2

04/2018

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Short Description
This report summarises the key findings and insights of the transport sector within the EU Calc project. The various drivers have been identified and defined. The calculation method is described for passenger transport and freight transport. The various choices and assumptions are explained and detailed. Then the respective ambition levels for each of the driver are developed, from a 'business as usual' ambition (level one) to a 'disruptive/game changing' ambition (level four). The work has been thoroughly discussed with the stakeholders at a meeting in April 2018. The feedback from the consultations and some complementary analyses will be integrated in a later version of the report (foreseen in June 18). References are provided at the end of the report.

Quality check	
Name of reviewer	**Date**
Luís Costa, PIK	11.04.2018.
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Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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List of abbreviations

BAU – Business as Usual

BEV – Battery Electric Vehicle

CE – Catenary Electric

DSS – Deep Sea Shipping

EU – European Union

FCEV – Fuel Cell Electric Vehicle

HDV – Heavy Duty Vehicle

ICE – Internal Combustion Engine

IWW – Inland WaterWays

LDV – Light Duty Vehicle

Mtoe – Mega ton oil equivalent

PHEV – Plug-in Hybrid Electric Vehicle

pkm – Passenger-kilometer

$PtCH_4$ – Power to CH_4

PtG – Power to Gas

PtL – Power to Liquid

SSS – Short Sea Shipping

tkm – Ton-kilometer

veh - Vehicle

vkm – Vehicle-kilometer

1G – First generation (for biofuels)

2G – Second generation (for biofuels)

2W – 2-Wheels

1 Executive Summary

This report focuses on Transport in the broader context of the EU Calculator project.

The EU Calc uses a range of drivers/levers[1] that represent changes we could make to mitigate climate change from now until 2050 and onwards, in the various countries, across sectors.

The transport module of the EU Calc enables to assess direct emissions, energy consumption, size of vehicle fleet, needs for infrastructures and costs for the EU28 + Switzerland transport sector, at a country level.

The various drivers/levers for Transport are identified and defined in the report. Factors of influence for each lever are identified and ambition levels for EU 28 + Switzerland are proposed based on historic trends and most up to date research, including the work done in other reports on transport scenarios.

The key drivers in transport for energy consumption and GHG emissions can be grouped into three categories *[GIZ, 2015]*:

- Avoid/reduce: those drivers consist in reducing vehicle activity and vehicle needs by changing behaviours, improving logistics, urban planning, etc.
- Shift: those drivers consist in shifting to more efficient/environmentally friendly modes such as public transport by improving public infrastructures, changing behaviours, making public transport more attractive, etc.
- Improve: those drivers consist in making vehicles more energy efficient and less carbon-intensive (eg. EV instead of thermic).

The main levers of transport GHG emissions are:

- Transport demand (per capita for passenger transport and per unit of GDP for freight);
- Occupancy (for passenger) or load factor (for freight), utilization rate and lifetime of vehicles;
- Modal share;
- Vehicle efficiency;
- Low emission technology development;
- Fuel mix.

Calculation trees detail how each main lever acts on the calculation logic.
This report first describes the global logic of the transport module: drivers for energy consumption and GHG emissions, methodology to define ambition levels at EU level and at country level and calculation logic of the module. The chosen ambition levels for each lever are detailed.
The calculation scope also covers infrastructure needs such as charging stations and e-highways and costs of the system, including fuel prices, CAPEX and OPEX for vehicles and infrastructures (this will be elaborated in the next version of the report).

[1] Drivers and levers are used intercheangbly in the report. They are defined as the factors influencing transport GHG emission.

2 Introduction

The objective of this report is to provide a structured and transparent identification and explanation of the transport levers and their possible evolution through time.

Within the overall EU Calc project timing, this deliverable provides a framework on which the other Work packages will align. Stakeholder feedbacks from the expert consultation end April will be provided in the next version.

This report intends to link up the various analysis performed in the transport low carbon transition.

This report focuses on identifying and detailing comprehensively for passenger and freight transport respectively the various levers that influence GHG emissions. For each lever, extensive documentation is provided to describe the various ambition levels ranging from a low ambition level to a disruptive ambition level.

Then, the calculation method is thoroughly explained, by detailing the calculation scope, the choice of the levers, the influence of a multitude of external factors and the calculation method.

Some of the content sections will be further detailed by end of June 2018:

- the treatment of emissions beyond 2050;
- the impacts of transport evolution on the infrastructure needs;
- the costs estimations for the transport system;
- the review of best practices for each lever, supporting the evaluation of the level 3 ambitions;
- possibly complementary insights on convergence and compression factors through further analysis.

3 Drivers of transport energy consumption & GHG emissions

In their 2012 global transportation roadmap, the ICCT proposes a bottom-up approach to calculate energy consumption and emissions from transport (see Figure 1).

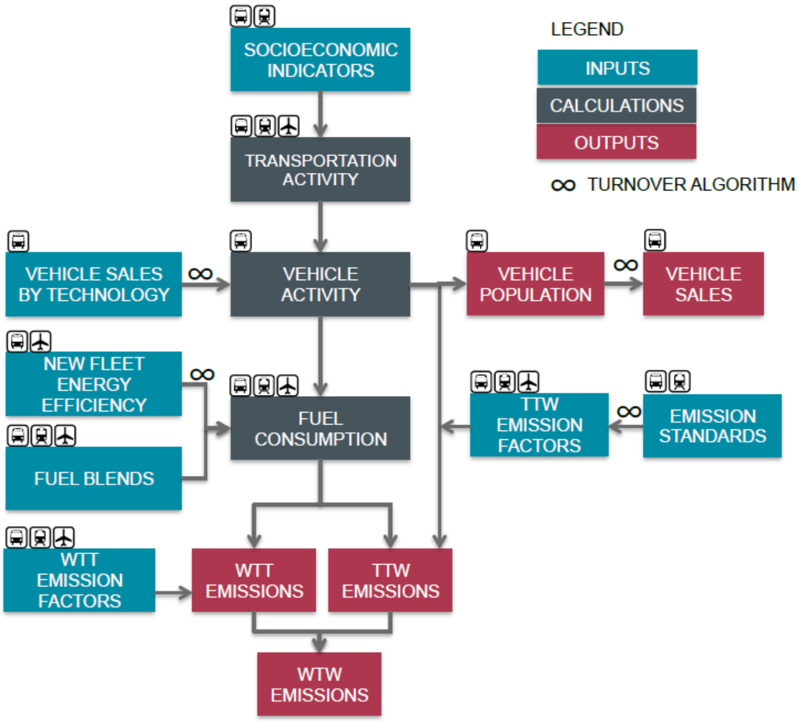


Figure 1 – Simplified Emission calculation method (ICCT, 2012)

The avoid/reduce-shift-improve approach gives us a first insight into the main factor of influence to reduce transport energy demand and GHG emissions (see Figure 2):

- **Avoid** vehicle activity by:
  - reducing transport demand
  - increasing vehicle occupancy/load factor
- Further **reduce** the number of vehicles needed by:
  - increasing the utilization rate of vehicles
  - increasing the mileage lifetime of vehicles
- **Shift** to more efficient/environmentally friendly modes (e.g. active modes or public transport)
- **Improve** efficiency of transport by:
  - making more efficient new vehicles
  - shifting to more efficient fuels and technologies

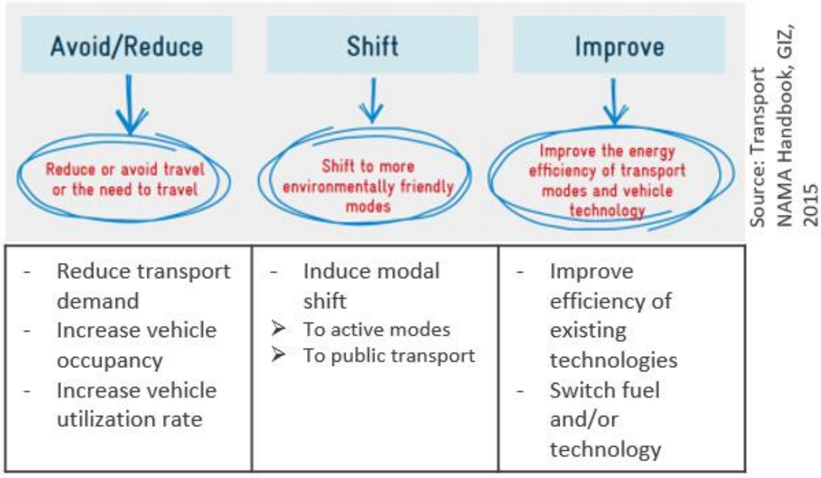


Figure 2 – Avoid – Shift – Improve applied to the transport sector

Each factor of influence mentioned here above is influenced by a multitude of external factors. Table 1 gives some examples of external drivers.

Table 1 – Categories of factors influencing the transport energy consumption and emissions

		Factor of influence	**Examples of external drivers** (non exhaustive)
Avoid	1.	Transport demand	• *Social drivers*: demography (population, age structure of population, etc.), societal trends (e.g. generalisation of teleworking), behaviour & awareness, etc. • *Technological drivers*: development of faster, more comfortable transports, autonomous vehicles, etc. • *Economical drivers*: fuel prices, GDP/capita, degree of globalization of the economy/industry (for freight), etc. • *Political drivers*: urban planning, etc.
	2.	Occupancy/load factor and utilization rates	• *Social drivers*: societal trends (e.g. carpooling, car-sharing), behaviour changes, etc. • *Economical drivers*: fuel prices (could increase operational optimization of fret hauls for example), GDP/capita, etc. • *Political drivers*: subsidies and other accompanying measures stimulating freight logistics efficiency
	3.	Lifetime of vehicles	• *Technological drivers*: availability of long-lasting vehicles • *Economical drivers*: Investment in R&D, material & vehicle prices, etc. • *Political drivers*: subsidies and other accompanying measures encouraging sustainable vehicles
Shift	4.	Modal shift	• *Social drivers*: demography (age structure of population, etc.), behaviour & awareness, etc. • *Economical drivers*: fuel prices, public transport prices, etc. • *Political drivers*: Public infrastructures availability, efficiency of public transport, etc.
Improve	5.	Evolution of vehicle efficiency	• *Technological drivers*: availability of efficient vehicles on the market, etc. • *Economical drivers*: Investment in R&D, • *Political drivers*: subsidies and other accompanying measures stimulating energy efficient vehicles

	6.	Changes in technology and energy vectors	• *Technological drivers*: Maturity of new technologies, availability of alternative fuels, • *Economical drivers*: Costs of new technologies, etc. • *Political drivers*: Availability of adapted infrastructures, etc.

4 Definition of ambition levels

For each chosen lever, four levels of ambition are proposed. This is done in two steps:

1. Definition of four EU-wide levels of ambition
2. Disaggregation of the levels of ambition by country

4.1 Ambition levels, EU-wide definition

The lever ambitions are consistent across all the EU Calc model sectors. This means that a level one ambition represents the same effort in the transport sector as f.i. in the buildings sector.

They range from 1 to 4 with the following definitions:

- Level 1: it is a BAU scenario, aligned and coherent with either the historical trends or with the EU Reference scenario 2016 (when the results are available).
- Level 2: it is an intermediate scenario, more ambitious than BAU but not reaching the full potential of available solutions.
- Level 3: it is considered as very ambitious but realistic scenario, given the current technology evolutions and the best practices observed in some geographical areas
- Level 4: it is considered as transformational and requires some additional breakthrough or efforts to reach (disruptive/game changing).

We base the four EU28 (+Switzerland) levels of ambition on a literature review, analysis and expert discussions.

The definition of the four levels is given in Table 2, and will be further described for each lever in the next sections.

Table 2 – Levels of ambition for Transport Module

Level 1	**Level 2**
This level is considered as a BAU scenario. The projections are aligned and coherent with either the historical trends or with the EU Reference scenario 2016 (when the results are available).	This level is an intermediate scenario, more ambitious than BAU but not reaching the full potential of available solutions.
Level 3	**Level 4**
This level is considered as very ambitious but realistic scenario, given	This level is considered as transformational and requires some

the current technology evolutions and the best practices observed in some geographical areas.	additional breakthrough or efforts such as important costs reduction for some technologies, very fast and extended deployment of infrastructures, major technological advances, strong societal changes, etc.

It is worth noting that transport might change drastically from now until 2050, even faster than we can expect today, e.g. with the further development of transport as service, deployment of new technologies, full electrification, etc. As a consequence, what appears today as being disruptive might end up as a more reasonable ambition within a short time frame.

4.2 Ambition levels, per country disaggregation

Based on the EU-wide levels of ambition, we use the Science-based target concepts [Science Based Target, 2015] to disaggregate ambition levels at the country level.

The Science-based target uses two concepts to describe the targets evolution: the convergence and the compression concepts (see Figure 3 and Figure 4).

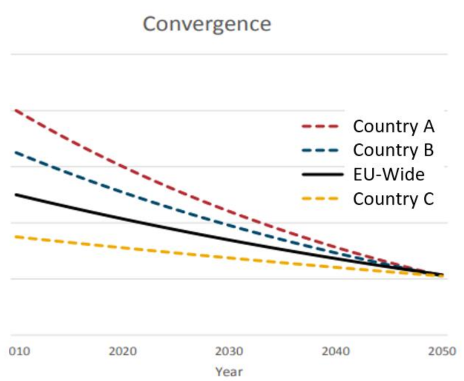


Figure 3 – Convergence concept [Science Based Target, 2015]

Convergence:

- The *absolute* 2050 ambition is the same for all countries (e.g. x kwh electricity/km for small electric vehicles) in 2050.
- This results in some countries having to do greater efforts than others, depending on their 2015 situation.

The convergence is better suited when country-specific parameters have little to no influence on the long-term evolution of the lever value. This is usually accepted for technological levers such as energy efficiency of a given technology for example.

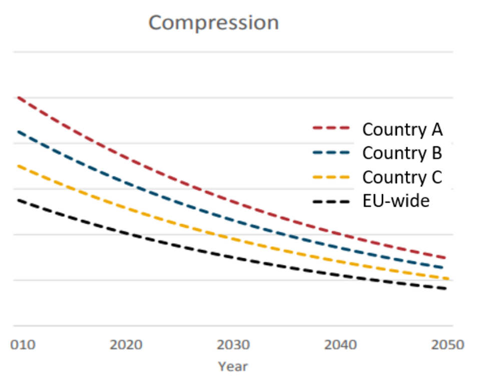


Figure 4 – Compression concept [Science Based Target, 2015]

Compression:

- The *relative* 2050 ambition is the same for all countries (e.g. -30% passenger.km/year by 2050 vs 2015 in each country)
- This results in all countries having to do the same relative efforts based on their 2015 situation

The compression is better suited when local or country-specific parameters have an important influence on the long-term evolution of the lever value. This could be the case for transport demand, for example, for which urbanization rate, population density or local topography can have an influence.

A hybrid calculation which sets goals per country based on a weighted average of convergence and compression results is also used. The weights of the hybrid calculation that are used are specified for each lever in the following sections and are based on literature review when available and on expert judgment. Expressing the influence of each and every factor is not possible based only on available literature: when there is no other specific external reason, the team has opted for a further convergence. This assumption could further evolve during the project.

5 Calculation logic of the transport module

The transport module is based on a bottom-up approach to compute energy consumption and emissions from the transport sector. This calculation is based on historical data (sources for historical data are described in D2.1), and on projections until 2050 (the different projection levels are described in Section 6).

The main outputs of the transport module are:

- The direct GHG emissions from transport;
- The energy demand from transport;
- The number of vehicles required and new vehicles sales;
- The need for infrastructures;
- The total costs of the transport system.

It is important to stress that transport indirect emissions are addressed by other WPs (e.g. Power assesses the emissions related to the electricity production and the upstream emissions of fossil fuels, and manufacturing assesses the emissions related to the manufacturing of the vehicles and infrastructures)[2].

The bottom-up approach adopted here consists in six steps to successively estimate (see Figure 5):

1. the transport activity for each mode (in vkm, pkm or tkm);
2. the technology share for each mode (in %);
3. the energy consumption of each technology in each mode (in MJ/vkm, MJ/pkm or MJ/tkm);
4. the emission intensity of each type of fuel used in the various technologies (gCO_2e/MJ);
5. the needs for infrastructures depending on the activity level for each mode and technology (e.g: km of rail/vkm of trains);
6. the costs for the purchase, O&M and fuel consumption of vehicles and of infrastructures (e.g: EUR/vehicle).

The different modes, types & technologies of vehicles and types of fuels are further described in the Passenger Transport Section and in the Freight Section.

[2] WP5: Electricity and Fossil Fuels, WP3:Production and Manufacturing http://www.european-calculator.eu/research-approach-wps/

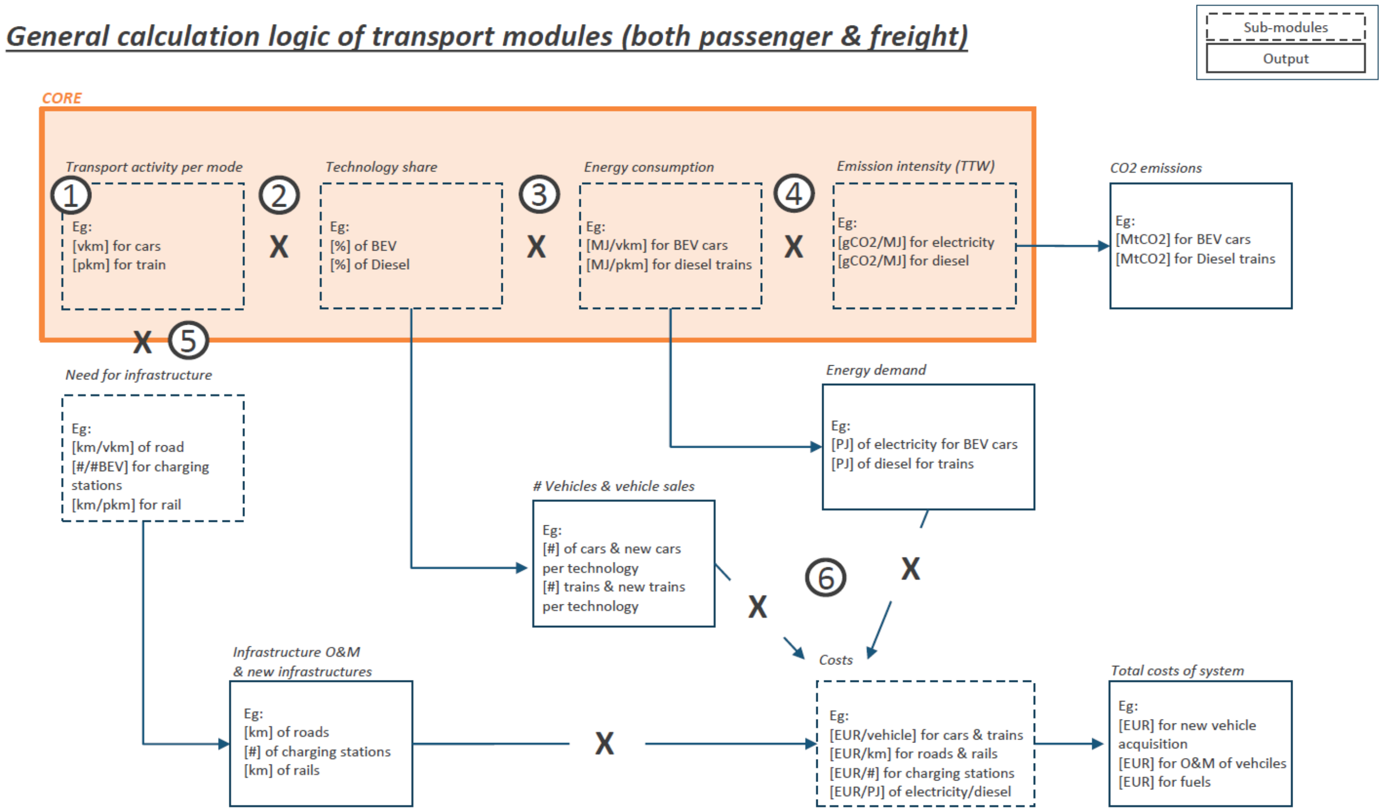


Figure 5 - General calculation logic of transport module both for passenger & freight transport.

The following section will dive deeper into the passenger and the freight sub-modules, the levers we chose for each one, and the levels of ambition we have defined.

5.1 Passenger transport

5.1.1 Scope definition

Figure 6 defines the scope of the passenger transport modules in terms of:

- The different modes & types of vehicles considered;
- The technologies included in the model;
- The types of fuels and vectors of energy taken into account.

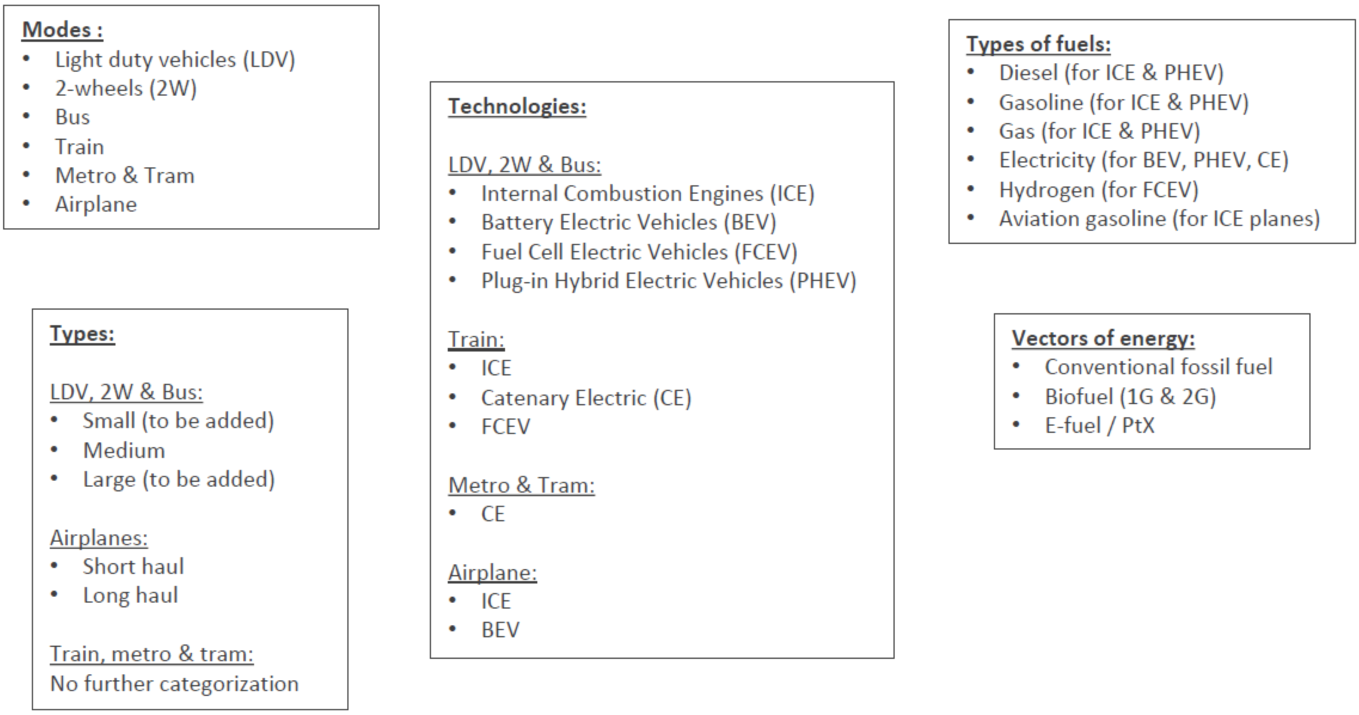


Figure 6 – Scope definition of the passenger transport module: modes, types of vehicles, technologies, types of fuels and vectors of energy (for Diesel, Gasoline & Gas)

5.1.2 Lever choice

In Section 6, we have identified a series of drivers and influencing factors for the transport energy consumption and GHG emissions. The passenger transport levers are based on these factors.

To reflect the varying stakeholder's visions, the team also assessed which lever combination best reflects the possible action points for each stakeholder group. Assessed stakeholders include Civil Society, the Business and Financial Sector, Technology Innovators, Policy Makers and Planners (for example public planners often have an emphasis on territorial structuration).

To reduce the end user complexity, the team identified a combination of levers which can be aggregated in the three groups (avoid, shift and improve).

As a result, the Table 3 summarizes the proposed levers.

Table 3 – List of levers for passenger transport module

	Lever	**Brief description**
1.	Transport demand [pkm/capita]	The transport demand is expressed as passenger km/capita per year and is broken down into land passenger demand and aviation demand. The ambition levels are linked to the lifestyle lever position.
2.	Occupancy [passenger/vehicle]	Occupancy is expressed as number of passenger per vehicle, and only has an impact on road vehicles. The ambition levels are linked to the lifestyle[3] lever position.

[3] WP1: Climate, Lifestyle and technological Transitions

3.	Utilization rates [km/vehicle/year]	The utilization rate is the number of kilometres travelled by a vehicle yearly. The ambition level for utilization rate is linked to the lifestyle lever position.
4.	Lifetime of vehicles [total km/vehicle]	The lifetime of vehicles is expressed in total kilometres that can be travelled by a vehicle before being discarded. It will be translated in years depending on the utilization rate. The choice of ambition level for lifetime is linked to the industry lever position.
5.	Modal share [%/mode]	The modal share lever describes how passenger are travelling: by car, bus, train, etc. The ambition level for modal shift is estimated to be strongly linked to the lifestyle lever position, this will be further analysed: the ambition level for modal shift disaggregates the values from the transport demand lever.
6.	Vehicle efficiency [MJ/km] or [MJ/pkm]	The vehicle efficiency is expressed in MJ/km for road vehicles and in MJ/pkm for rail and aviation. The ambition level for efficiency is linked to the technology lever position.
7.	Low Emission Technology development [% of new vehicles/technology]	This lever described the level of adoption of low emission technologies. Its ambition level is linked to the technology lever position.
8.	Fuel mix [%/fuel type]	This lever described the fuel mix, taking into account biofuels and e-fuels (electricity is linked to the technology lever).

5.1.3 Calculation trees

The calculation trees presented hereafter represent the steps 1 to 4 of Figure 5 for the passenger module.

5.1.3.1 Passenger transport activity per mode

The goal of this step illustrated in Figure 7 is to compute the passenger transport activity per mode (car, 2-wheel, bus, rail or plane). Aviation demand is handled separately of land transport for different reasons:

- It is important to make the distinction between domestic, intra-EU and international aviation for various reasons: the technical solutions available depend on the flying range, and the legal framework makes it easier to take action for the decarbonisation of domestic and intra-EU aviation than for international aviation.
- Modal shift from aviation to another mode is not as direct as modal shift between land transports, especially for long haul flights.

The outputs of this calculation step are of two types:

- Road passenger transport demand expressed in vkm: the main driver for road vehicle emissions are the vehicle-kilometres, which are determined

http://www.european-calculator.eu/research-approach-wps/

as the km driven by road vehicles and can be reduced if the vehicle occupancy increases.
- Rail and aviation transport demand expressed in pkm: for rail and aviation, it makes more sense to base our calculation on the passenger-kilometers for different reasons. First, the vehicle size is much more variable and can be adapted based on the number of passenger that will travel in it. Second, public transport only works if the service offer and flexibility is sufficient. Diminishing the number of vehicles to have higher occupancy is therefore not always a solution.

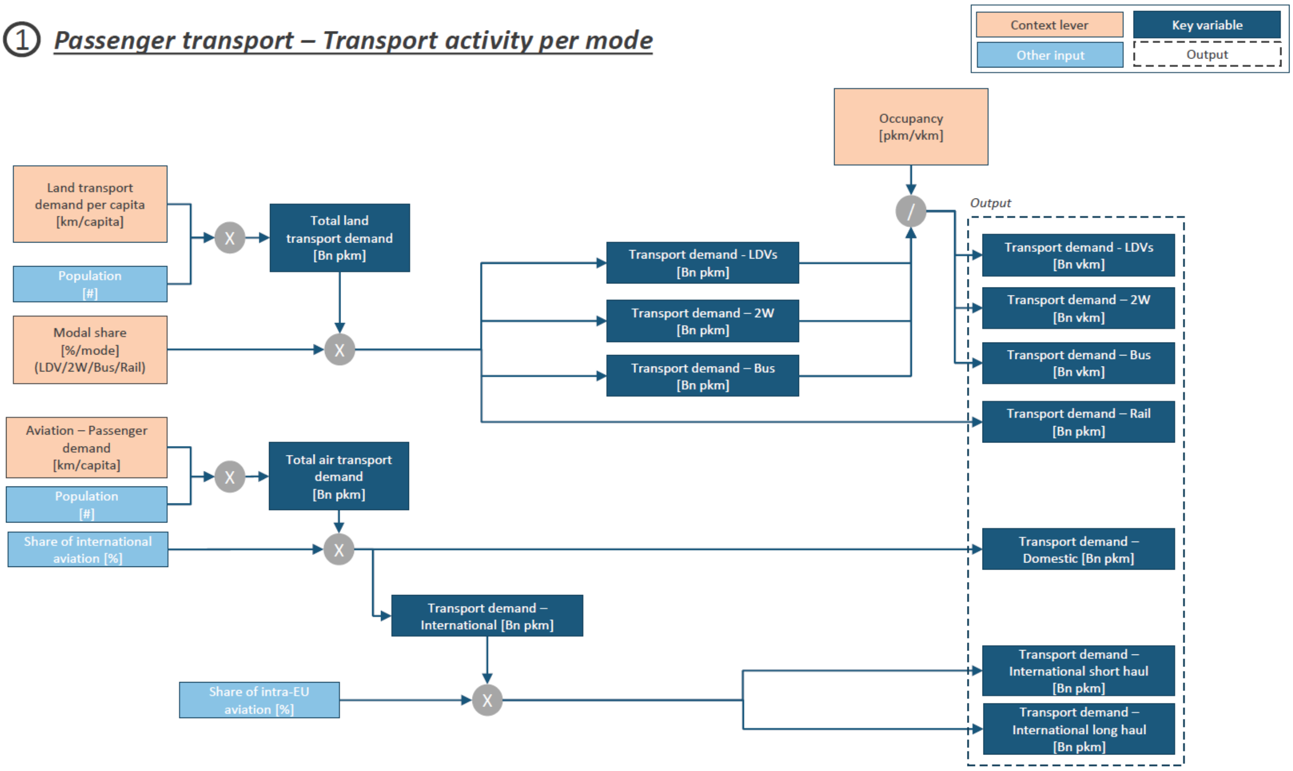


Figure 7 – Calculation tree to determine the passenger transport activity per mode

Different inputs are required to compute passenger transport demand by mode:

- The population: this input is provided by the lifestyle work package;
- The land and aviation transport demand per capita;
- The modal share (in land transport);
- The occupancy of road vehicles;
- The share of international aviation, and of intra-EU aviation: this is considered as a fix input, it is kept constant at the 2015 level. Those fixed inputs could be subject to a sensitivity analysis, to better reflect future evolutions[4].

The transport demand, modal share and occupancy levels are further discussed in Section 6.

5.1.3.2 Characterization of new fleet of vehicles

The goal of this calculation step is to determine the technology share in new vehicle sales. This step first estimates the number of new vehicles needed each year, based on the renewal rate of existing vehicles, and on the new needs of

[4] Eurostat data

vehicles depending on transport demand. Then, the amount of new vehicles needed is multiplied by the technology share in new vehicle sales, to obtain the yearly number of new vehicles for each technology.

The output of this calculation step is the total amount of new vehicles per technology (see Figure 8).

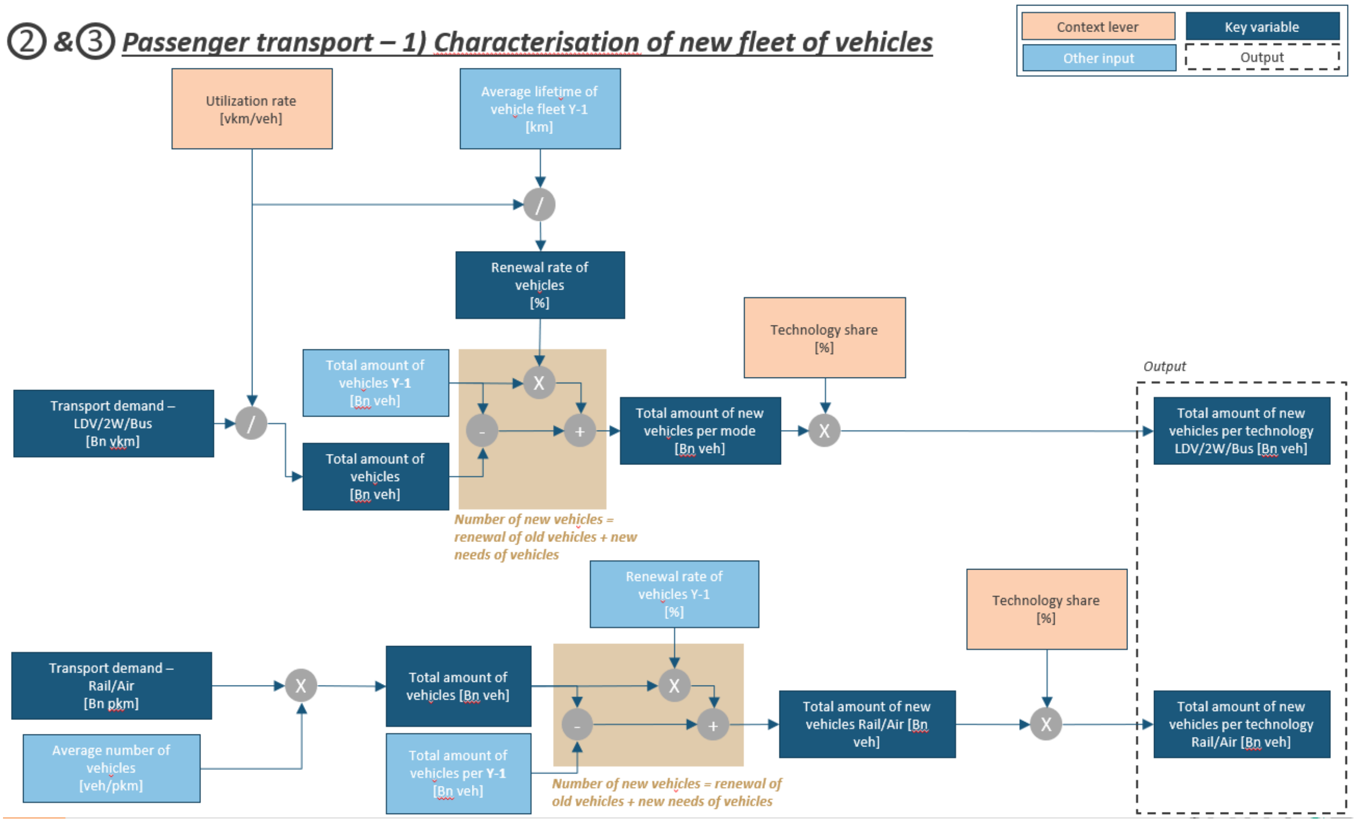


Figure 8 – Calculation tree to determine the characteristics of new vehicle sales fleet for passenger transport

Different inputs are required:

- The utilization rate of road vehicles;
- The technology shares in new vehicle sales;
- The average lifetime and number of vehicles in the existing fleet.

The utilization rate and technology share are further discussed in Section 6.

5.1.3.3 Characterization of total fleet of vehicles

The goal of this calculation step is to update the characteristics of the existing vehicle fleet, taking into account the characteristics of the new vehicle sales. The average lifetime, average energy consumption of vehicles and the share of each technology in the vehicle fleet will be impacted by the new sales. Then, based on the total fleet characteristics, we compute the energy consumption by type of vehicle (see Figure 9).

The outputs are of two types:

- The characteristics of the total vehicle fleet (average lifetime, average energy consumption & share per technology);
- The total energy consumption per type of vehicle and per type of fuel.

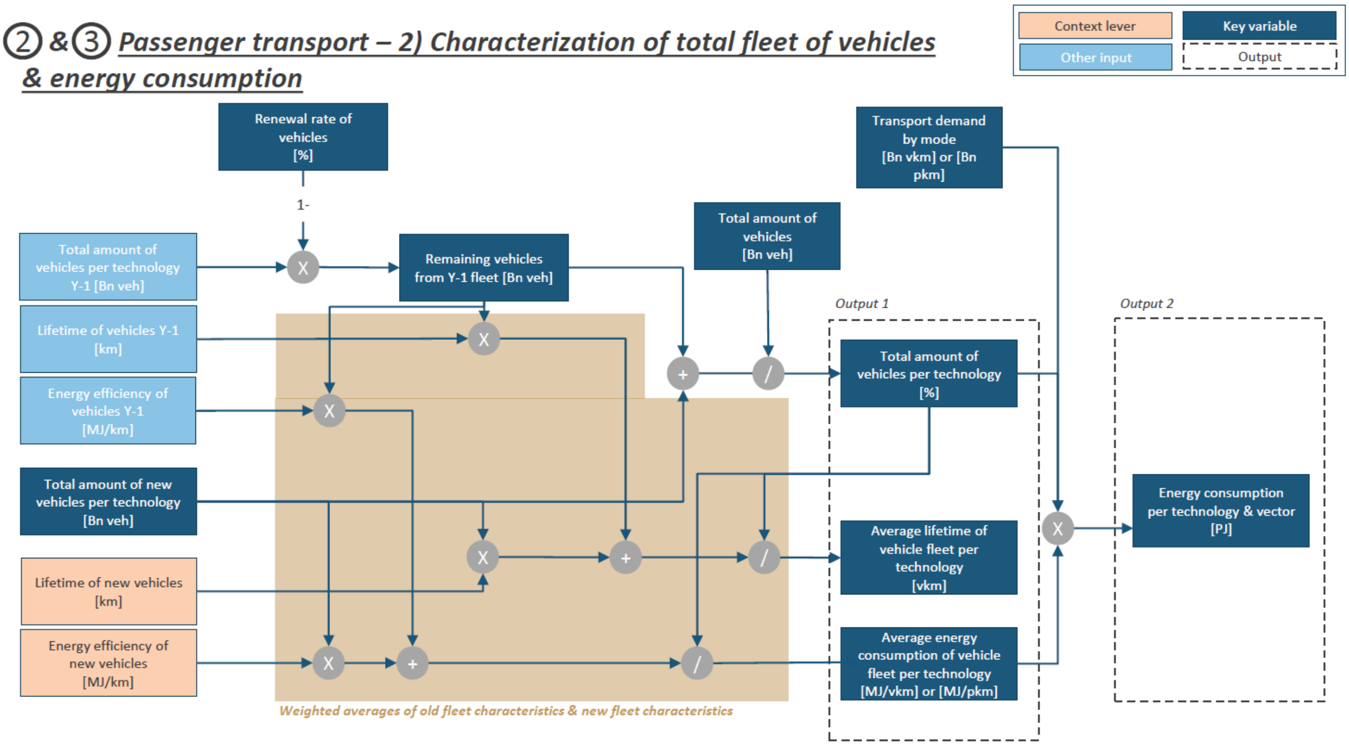


Figure 9 – Calculation tree to determine the characteristics of total new vehicle fleet (existing fleet + new sales) for passenger transport

Different types of inputs are necessary to make those calculations:

- Characteristics of the existing vehicle fleet: this is based on the previous year calculation results.
- Characteristics of the new sales vehicles: lifetime and energy efficiency. This will be further discussed in Section 6.

5.2 Freight

5.2.1 Scope definition

Figure 10 defines the scope of the freight transport modules in terms of:

- The different modes & types of vehicles considered;
- The technologies included in the model;
- The types of fuels and vectors of energy taken into account.

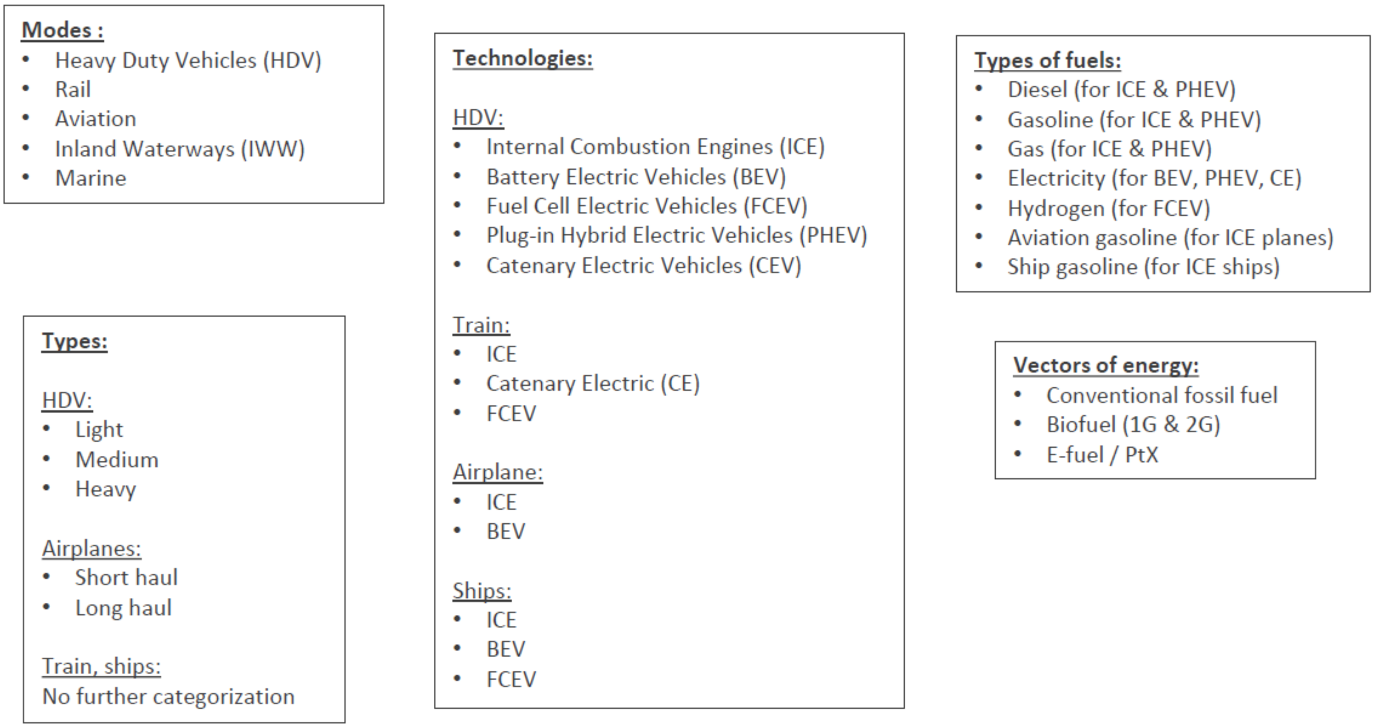


Figure 10 – Scope definition of the freight transport module: modes, types of vehicles, technologies, types of fuels and vectors of energy (for Diesel, Gasoline & Gas)

5.2.2 Lever choice

We have identified a series of drivers and influencing factors for the transport energy consumption and GHG emissions. The freight transport levers are based on these factors.

As for passenger transport, various lever combination have been assessed to reflect possible sensitivities of different stakeholder groups. Assessed stakeholders include Civil Society, the Business and Financial Sector, Technology Innovators, Policy Makers and Planners (for example public planners are often focused on territorial structuration).

To reduce the end user complexity, the team identified a combination of levers which can be aggregated in three groups already mentioned above (avoid, shift and improve)

As a result, the Table 4 summarizes the proposed levers.

Table 4 – List of levers for freight module

	Lever	**Brief description**
1.	Transport demand [tkm]	The transport demand is expressed as tkm. In this module, aviation, land transport and shipping are considered together. The ambition levels for those is linked to the lifestyle lever position: the evolution to digital consumption has as consequence that more (small) packages are delivered daily.
2.	Load factor [ton/vehicle]	Load factor is expressed as tons per vehicle, and only has an impact on road vehicles. The ambition level is linked to the lifestyle lever position.

3.	Utilization rates [km/vehicle/year]	The utilization rate is the number of kilometres travelled by a vehicle yearly. The ambition level for utilization rate is linked to the lifestyle lever position.
4.	Lifetime of vehicles [total km/vehicle]	The lifetime of vehicles is expressed in total kilometres that can be travelled by a vehicle before being discarded. It will be traduced in years depending on the utilization rate. The choice of ambition level for lifetime of vehicles is linked to the industry lever position.
5.	Modal share [%/mode]	The modal share lever describes how goods are transported: by truck, train, boat or aircraft. The ambition level for modal shift is linked to the lifestyle lever position.
6.	Vehicle efficiency [MJ/km] or [MJ/pkm]	The vehicle efficiency is expressed in MJ/km for road vehicles and in MJ/tkm for rail, boat and aviation. The ambition level for efficiency is linked to the technology lever position.
7.	Low Emission Technology development [% of new vehicles/technology]	This lever described the level of adoption of low emission technologies. Its ambition level is linked to the technology lever position.
8.	Fuel mix [%/fuel type]	This lever described the fuel mix, taking into account biofuels and e-fuels (electricity is linked to the technology lever). Its ambition level is linked to the technology lever position.

5.2.3 Calculation trees

The calculation trees presented in Figure 11 hereafter represent the steps 1 to 4 for the freight module.

5.2.3.1 Transport activity per mode

The goal of this step is to compute the freight transport activity per mode (HDV, train, ship, aircrafts).

The outputs of this calculation step are of two types:

- Road transport demand expressed in vkm: the main driver for road vehicle emissions are the vehicle-kilometres, which will be reduced if the load factor increases.
- Maritime, IWW, rail and aviation transport demand expressed in tkm: for those modes, we have chosen to base our calculation on the ton-kilometres as the vehicle size is much more variable and can be adapted based on the number of tons that will be transported.

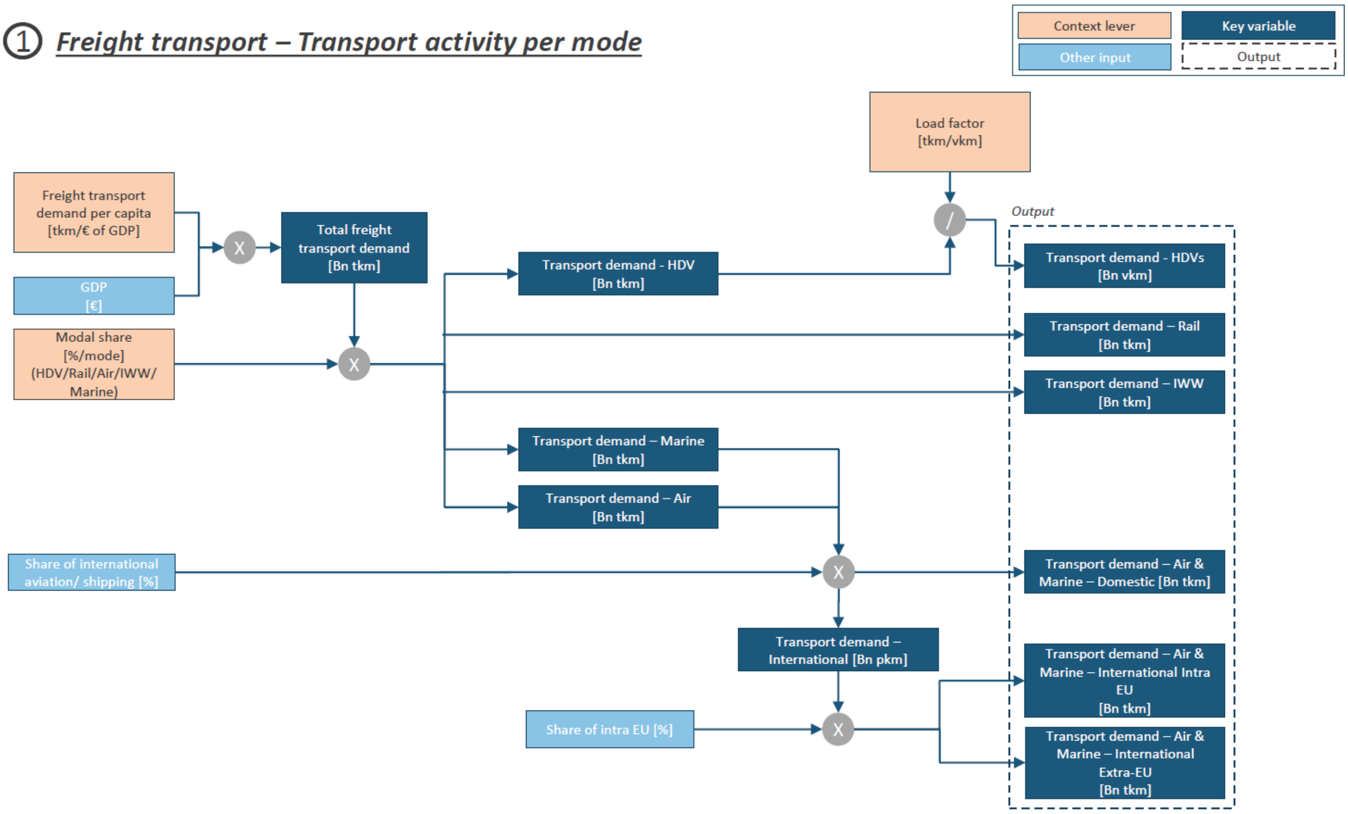


Figure 11 – Calculation tree to determine the freight transport activity per mode

Different inputs are required to compute freight transport demand by mode:

- The GDP: this input is provided by the lifestyle work package;
- The freight transport demand per capita;
- The modal share;
- The load factor of road vehicles;
- The share of international aviation and maritime, and of intra-EU aviation and maritime: this is considered as a fix input, it is kept constant at the 2015 level.

5.2.3.2 Characterization of new fleet of vehicles

The goal of this calculation step is to determine the technology share in new vehicle sales. This step first estimates the number of new vehicles needed each year, based on the renewal rate of existing vehicles, and on the new needs of vehicles depending on transport demand. Then, the amount of new vehicle needed is multiplied by the technology share in new vehicle sales, to obtain the yearly number of new vehicles for each technology.

The output of this calculation step is the total number of new vehicles per technology (see Figure 12).

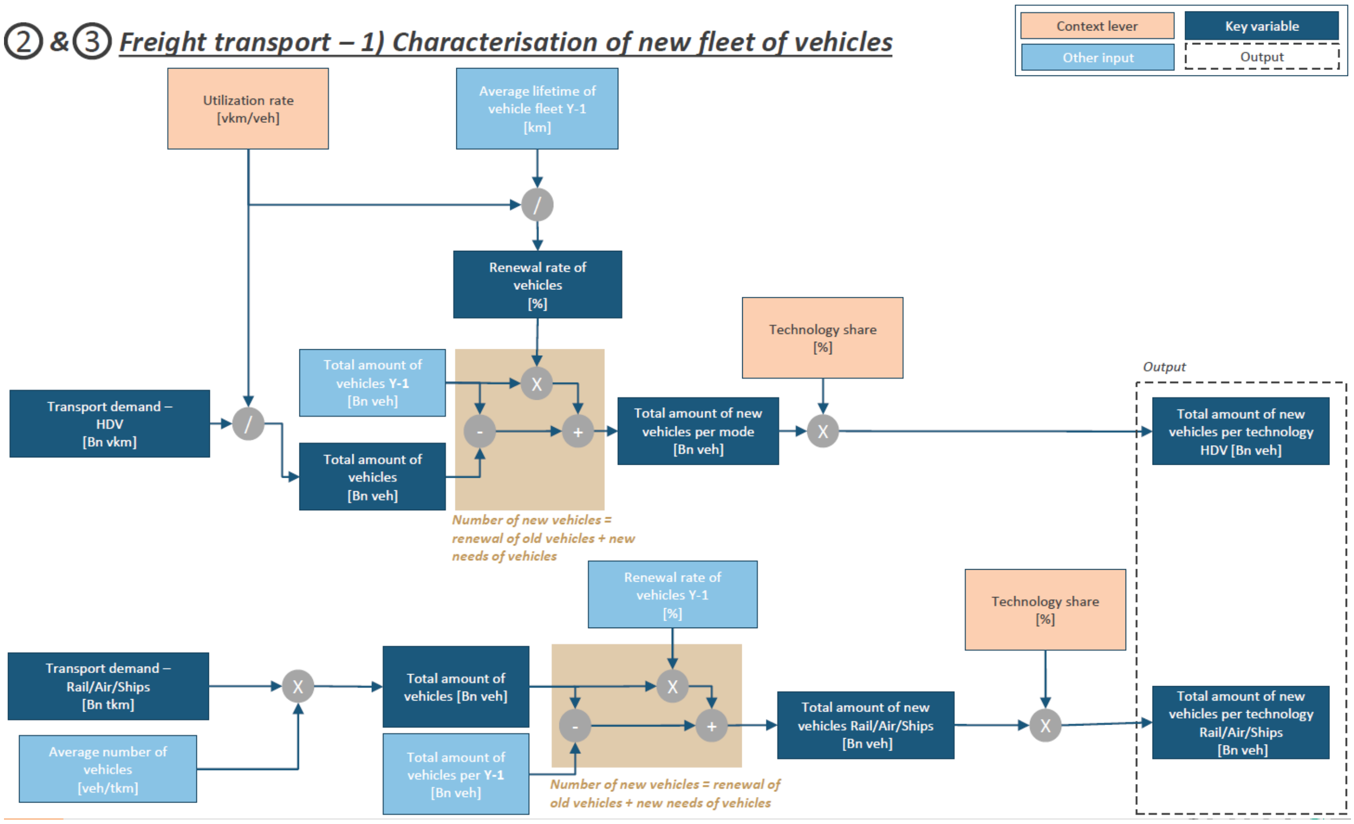


Figure 12 – Calculation tree to determine the characteristics of new vehicle sales fleet for freight transport

Different inputs are required those outputs:

- The utilization rate of road vehicles;
- The technology share in new vehicle sales;
- The average lifetime and number of vehicles in the existing fleet: this data comes from the previous year calculation.

5.2.3.3 Characterization of total fleet of vehicles

The goal of this calculation step is to update the characteristics of the existing vehicle fleet, taking into account the characteristic of the new vehicle sales. The average lifetime, average energy consumption of vehicles and the share of each technology in the vehicle fleet will be impacted by the new sales. Then, based on the total fleet characteristics, we compute the energy consumption by type of vehicle (see Figure 13).

The outputs are of two types:

- The characteristics of the total vehicle fleet (average lifetime, average energy consumption & share per technology);
- The total energy consumption per type of vehicle and per type of fuel.

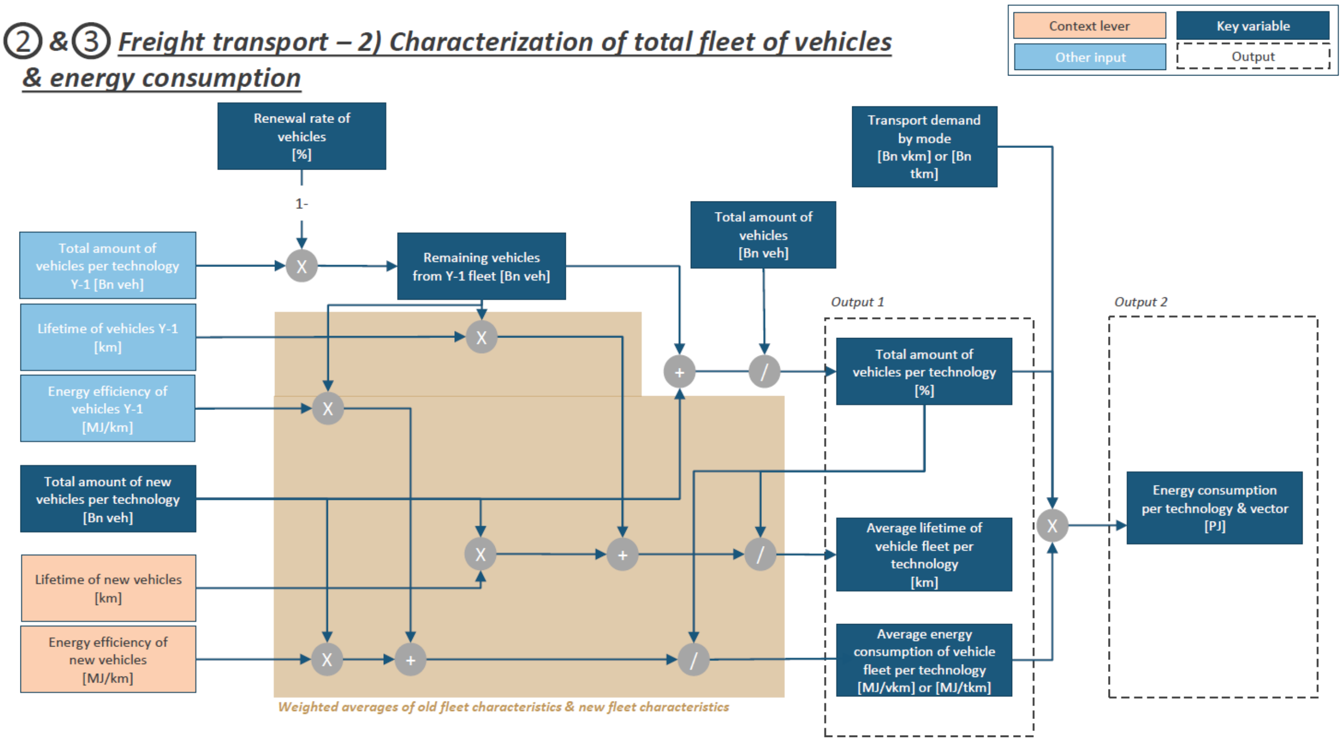


Figure 13 – Calculation tree to determine the characteristics of total new vehicle fleet (existing fleet + new sales) for freight transport

Different types of inputs are necessary to make those calculations:

- Characteristics of the existing vehicle fleet: this is based on the previous year calculation results;
- Characteristics of the new sales vehicles.

5.2.3.4 Emission intensity

Finally, based on the energy consumption by type of fuel, on the "vector mix" (biofuel, conventional & e-fuel shares in diesel, gasoline, etc.) for each type of fuel and on the emission intensity per vector.

The main output here is the total GHG emissions per technology and per vector (see Figure 14).

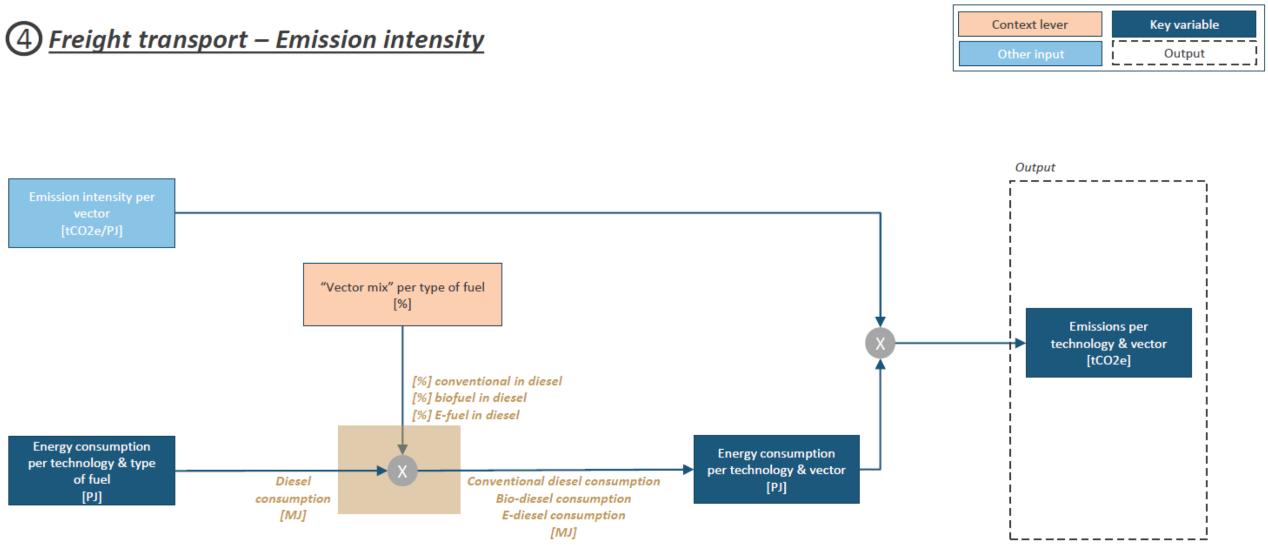


Figure 14 – Calculation tree to determine the total emissions of freight transport

Different types of inputs are necessary to make those calculations: emission factors and fuel mix.

5.3 Infrastructures & costs

The scope definition and calculation trees will be added for infrastructure and for cost in the next version of this report.

6 Levers and levels of ambition

6.1 Passenger transport

As discussed earlier in this report, we have identified eight main levers for the Passenger transport module. The levels of ambition are discussed in more details in this section.

6.1.1 Transport demand

As described in a 2010 report [*Skinner et al., 2010*], transport demand is driven by a wide range of external factors, including: GDP, personal incomes, globalisation, tourism, urbanisation, population, employment rate, real cost of transport, speed of transport, etc.

In this module, transport demand is divided into land transport demand and aviation transport demand, for reasons already explained in Chapter 5.

6.1.1.1 Land transport demand

The passenger land transport demand is furnished and computed by the lifestyle module. This lever will therefore not be further detailed in this report. The methodology for determining the four scenarios is described in deliverable D1.3 "Lifestyle in Europe: Perspectives and scenarios".

The results of this analysis are presented in Figure 15.

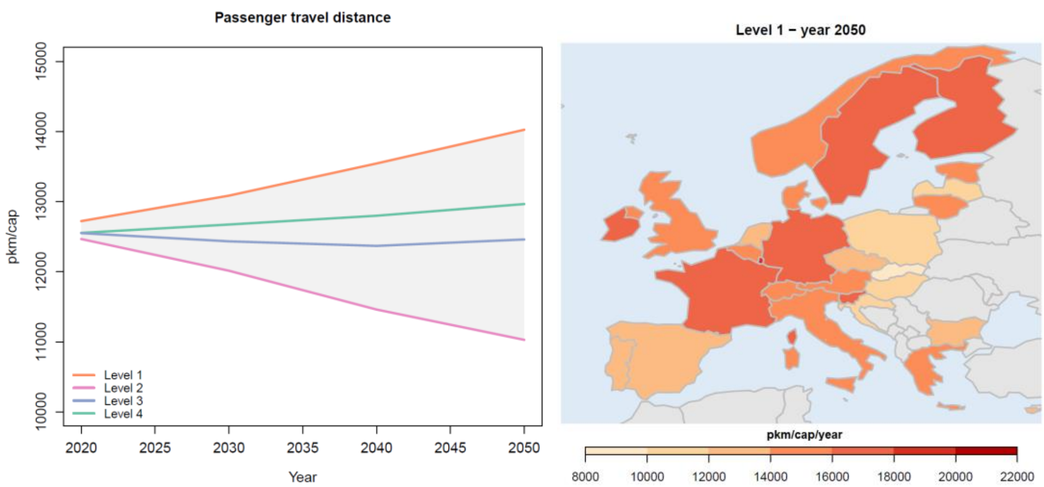


Figure 15 – Development of EU28+Swizerland passenger land transport demand implied in the definition of Level 1 (left). Spatial distribution of Level 1 for the year 2050 (right) – for more details, see Deliverable 1.3.

Table 5 - Suggested definition of levels for the passenger land transport demand lever – for more details see Deliverable 1.3.

Level 1	**Level 2**
By 2050, average passenger travel distance in EU28 members + Switzerland reaches 14000 pkm per person, a 25% increase from	By 2050, average passenger travel distance in EU28 members + Switzerland reaches 13000 pkm per person, a 15% increase from 2015

2015 levels following the past trend. Increases are driven primarily by the growth in travel time dedicated to leisure/social activities. Travel to work/study decreases with aging population and travel time for shopping is kept constant. Daily travel speeds are kept constant at 2015 levels for countries with high GDP in 2015 and increases for the ones below according to past rates.	levels. Moderate changes in lifestyles make the need of daily travel time to work/study fall by 20% in countries with highest GDP and 10% in others, while advances in automation cut the need for travelling for shopping by 5% in all countries. Travel time dedicated to leisure/social activities increases as in level 1. Daily travel speeds are kept constant at 2015 levels for countries with high GDP in 2015 and increases for the ones below according to past rates.
Level 3	**Level 4**
By 2050, average passenger travel distance in EU28 members + Switzerland reaches 12400 pkm per person, a 10% increase from 2015 levels. Moderate lifestyle changes that make the need of daily travel time to work/study fall by 20% in all countries and advances in automation cut the need for travelling time for shopping by 10%. Travel time dedicated to leisure/social activities increases as in levels 1 and 2. Daily travel speeds are kept constant at 2015 levels for countries with high GDP in 2015 and increases for the ones below according to past rates.	By 2050, average passenger travel distance in EU28 members + Switzerland stays at 11000 pkm per person, roughly the same level of 2015. Substantial changes in lifestyles make the need of daily travel time to work/study fall by 50% in all countries and advances in automation cut the need for travelling time for shopping by 25%. Travel time dedicated to leisure/social activities increases as in levels 1, 2 and 3. Daily travel speeds are kept constant at 2015 levels for countries with high GDP in 2015 and increases for the ones below according to past rates.

6.1.1.2 Aviation transport demand

<u>Context</u>

In 2015, the EU28 + Switzerland area had an average aviation transport demand of 1417 pkm/capita. This average hides very different realities in the individual countries (sources: historical database, see D2.1):

- Cyprus and Malta are the two countries that have the highest aviation demand per capita in the area in 2015 with, respectively, 6300 pkm/capita and 7570 pkm/capita;
- On the other hand, Slovakia and Slovenia have the lowest aviation demand in the EU28 + Switzerland area in 2015 with, respectively, 265 pkm/capita and 445 pkm/capita.

As explained in [Mott Macdonald, 2017], drivers of aviation demand can be grouped into 3 categories:

- Economic activity: for passenger demand, the main drivers in this category include per capita income, tourism, costs of air travels, etc.;

- Ease of travel: existence of direct routes for given destinations, speed of travel, cost of travel etc.;
- Local market factors: it includes local congestion of air routes that can constrain air travel growth, etc.

Globally, aviation demand is expected to grow by 2050 in Europe, even faster than land transport demand, [Skinner et al., 2010].

Best practices review

A review of best practices will be performed in the next version of this deliverable. This review will support the level 3 ambition definition.

Definition of the four EU-wide levels of ambition

The four levels of ambition on EU28 + Switzerland scale are defined as follow (see Table 6 and Figure 16).

As stated by [Skinner et al., 2010], demand reduction policies tend to be expected to curb growth rather than to reduce overall demand.

Table 6 – 4 levels of ambition for passenger aviation demand at EU28 + Switzerland leve l

Level 1 (BAU)	**Level 2 (Intermediate)**
This level follows the EU Ref 2016 scenario based on the PRIMES model [E3M-Lab, 2016]. It considers an EU-wide annual rate of change of +1.91% until 2050, resulting in an aviation demand of about 2750 pkm/capita in 2050.	Levels 2 and 3 are scenarios of curbed growth compared to Level 1. This scenario considers a EU-wide annual rate of change of +1% until 2050, reaching an aviation demand around 2000 pkm/capita in 2050.
Level 3 (Ambitious)	**Level 4 (Transformational)**
This scenario considers a EU-wide annual rate of change of +0% until 2050, reaching an aviation demand around 1417 pkm/capita in 2050.	Even if aviation demand is expected to grow in usual scenarios, [Oeko-Institut, 2015] clearly states that aviation demand reduction is one of the only solutions to cut emissions by 2050 (along with technological breakthrough or emission offsetting). [Bows-Larkin, 2015] argues that a technological overhaul of the aviation fleet would most probably be much slower than behaviour changes. Various policies can drive this behaviour change, such as: a personal carbon quota scheme that includes international flights, the promotion of virtual communication, the development of low-carbon rail travel for example. This scenario therefore considers a

	EU-wide annual rate of change of -1% until 2050, reaching an aviation demand around 1000 pkm/capita in 2050.

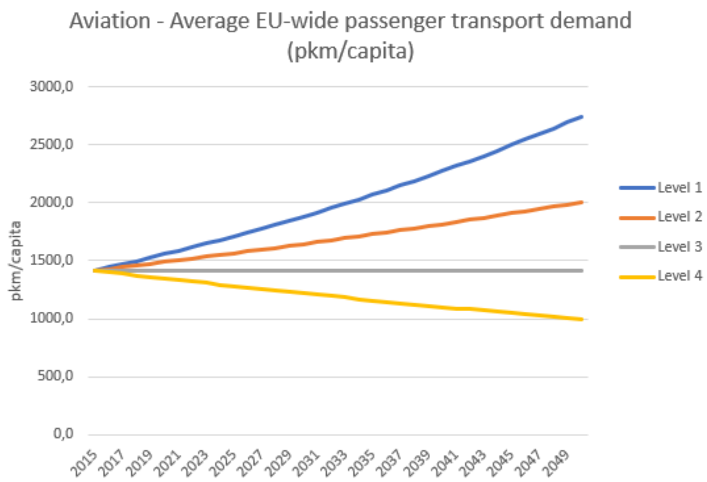


Figure 16 – EU-wide levels of ambition for aviation demand

<u>Disaggregation by country</u>

As described above [Mott Macdonald, 2017], aviation demand depends on various factors grouped into three categories: Economic activity, Ease of travel, and Local market factors.

Most of those factors are local or country-specific. On the other hand, economic activity and ease of travel could converge between countries by 2050. This convergence could even be an objective by 2050. That is why we have considered a strong convergence of aviation demand between European countries. Eurostat historic data shows a clear increase in aviation emissions coupled to GDP improvements in Europe.

However, Cyprus and Malta are considered as exceptions, as they depend more on aviation due to their islanded position and their small size. For these countries we have considered a lower convergence.

Table 7 – Convergence and Compression weights

Scope	**Convergence**	**Compression**
All expect Cyprus & Malta	90%	10%
Cyprus & Malta	60%	40%

The weights between convergence and compression mechanisms and the levels by country for 2050 are given in more details in Annex 1, based on internal analytical work that could be complemented with further expert contributions.

6.1.2 Modal share

<u>Context</u>

The Table 8 hereafter gives the modal share for land transport at EU28 + Switzerland level, for 2015 (sources: historical database, see D2.1).

Table 8 – Land transport modal share at EU28 + Switzerland level in 2015

Mode	**Modal share**
Car	78.3%
2W	3.6%
Bus	8.9%
Metro & Tram	1.7%
Train	7.5%

As explained in *[G.Santos&T.vonBrunn, 2011] and in [J.Flode, et al., 2010]*, a large variety of factors have an influence on modal share, such as:

- Cost of the different modes of transport
- Car ownership
- Transport time
- Parking space limitations & parking charges
- Public transport availability, reliability, frequency, etc.
- Integrated ticketing.

As a consequence of the today different realities in the different countries, experts expect further convergence in the future.

<u>Definition of the four EU-wide levels of ambition</u>

Table 9 – 4 levels of ambition for modal share for passenger transport at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
For this level, we consider a modal share of: - 75.1% for cars - 4.3% for 2W - 8.5% for buses - 2.2% for Metro & tram - 9.9% for trains This modal share is aligned with 2016 EU reference scenario *[E3M-Lab, 2016].*	This scenario is built to reach 1/3 of level 4 ambition level compared to level 1: - 68.2% for cars - 3.6% for 2W - 11.4% for buses - 4.0% for Metro & tram - 12.8% for trains
Level 3 (Ambitious)	**Level 4 (Transformational)**
This scenario is built to reach 2/3 of level 4 ambition level compared to level 1: - 61.3% for cars	This scenario is based on the proximobility scenario of *[V.Kaufmann&E.Ravalet, 2016]* for France:

- 3.0% for 2W - 14.4% for buses - 5.7% for Metro & tram - 15.6% for trains	- 54.4% for cars - 2.3% for 2W - 17.3% for buses - 7.5% for Metro & tram - 18.5% for trains

Disaggregation by country

For the disaggregation by country, we have assumed that car shares and 2W shares would strongly converge between countries, but that a small difference could remain by 2050 to take into account local specificities such as low population density of some regions.

For the remaining transport demand, we have assumed the same breakdown between bus, metro/tram and train than in 2015. This means that for countries that do not have metro or train infrastructures (e.g. Malta and Cyprus), all the remaining transport demand is provided by buses.

6.1.3 Occupancy

Context

In 2015, average occupancy levels of transport the EU28 + Switzerland were as follows: 1.6 person/vehicle for cars, an 1,1 person/vehicle for 2W and an average bus occupancy of 18.8 person/vehicle. This average hides very different realities in the individual countries (sources: historical database, see D2.1)

- Car occupancy level varies from 1,03 person/car in Czech Republic to 2.1 person/car in Poland (Figure 17);
- 2W occupancy level varies from 1 person/vehicle in Finland to 1.4 person/vehicle in Lithuania (Figure 18);
- Bus occupancy level varies from 6.8 person/vehicle in Poland to 35,1 person/vehicle in Belgium, Luxemburg, Netherlands and Malta (Figure 19).

A large panel of factors can influence vehicle occupancy. For cars, we can cite the following examples [N.Levine & M.Wachs, 1996]:

- Time of day and day of week
- Geographic area
- Traffic density in the area
- Trip purpose (work related, education, social/recreational, etc.)
- Trip distance

Definition of the four EU-wide levels of ambition

Table 10 – 4 levels of ambition for occupancy of passenger road vehicles at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
For this level, we consider a status quo compared to the 2015 occupancy levels for cars, 2Ws and buses, most probably in line with [E3M-Lab, 2016].	This scenario considers a EU-wide total change of +20% in occupancy levels for cars, reaching an average occupancy of 2 person/vehicle by

The 2050 occupancy levels therefore reach 1,6 person/vehicle for cars, 1,1 person/vehicle for 2W and 18,8 person/vehicle.	2050 which is aligned with [V.Duscha & L.Donat, 2017] scenario and is close to Poland current performance. It also considers +5% for 2Ws and +15% for buses by 2050, respectively reaching 1,2 person/vehicle and 21,6 person/vehicle.
Level 3 (Ambitious) This scenario considers a EU-wide total change of +40% in occupancy levels for cars, which is consistent with the 3R scenario of [L.Fulton et al., 2017], reaching 2,3 person/vehicle by 2050. 6.1.4 It also considers +10% for 2Ws and +30% for buses by 2050, respectively reaching 1,25 person/vehicle and 24,4 person/vehicle.	**Level 4 (Transformational)** This scenario considers a EU-wide total change of +60% in occupancy levels for cars, reaching 2,6 person/vehicle by 2050, which is aligned with the most optimistic scenario of [TRANSvisions, 2009] for urban transport. It also considers +15% for 2Ws and +45% for buses by 2050, reaching respectively, 1,3 person/vehicle and 27,2 person/vehicle.

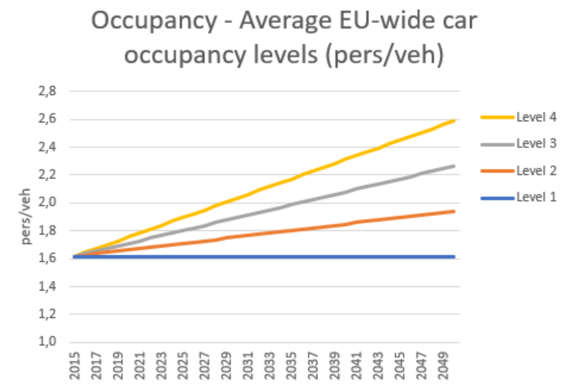


Figure 17 - Occupancy Cars

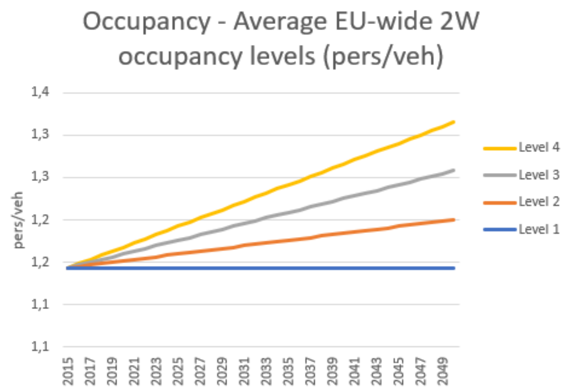


Figure 18 - Occupancy 2 W

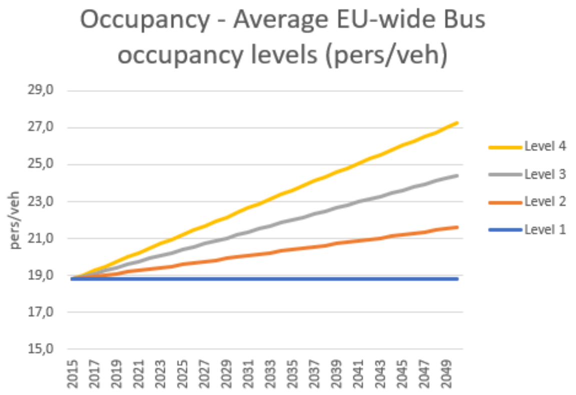


Figure 19 - Occupancy Bus

Disaggregation by country

Car occupancy level is mainly cultural and behavioural and can change significantly with the development of new transport trends as "transport as a service", carpooling, autonomous vehicles and incentive systems. This is particularly true for urban trips.

For the disaggregation by country, we have assumed that car occupancy levels would strongly converge between countries, but that a small difference could remain by 2050. We have therefore applied a weighted average of 90% convergence and 10% compression. We have taken the same hypothesis for 2W occupancy.

The large variations between countries in the 2015 bus occupancy data probably reveals that the difference is not only cultural but also strongly depends on other factors, such the population density of a region, territory development, urbanization, bus sizes, etc. We have therefore assumed of a light convergence between countries (40% convergence and 60% compression).

2050 targets for each country and ambition level are given in Annex 1.

6.1.5 Utilization rate

Context

In 2015, the EU28 + Switzerland area had an average car utilization rate of 12 600 vkm/vehicle/year, an average 2W utilization of 4300 vkm/vehicle/year and an average bus utilization of 5300 vkm/vehicle/year. This average hides very different realities in the individual countries (sources: historical database, see D2.1):

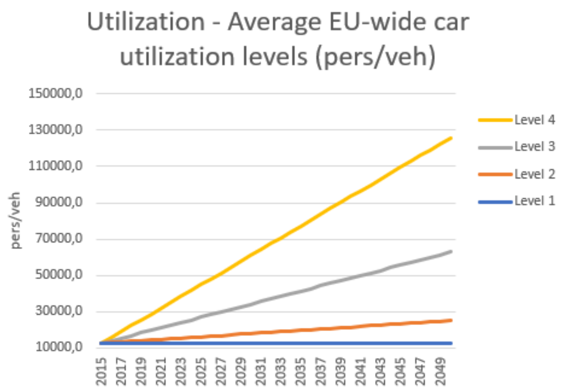
- Car utilization rate varies from 4122 vkm/veh in Lithuania to 59000 vkm/veh in Luxemburg.
- 2W utilization rate varies from 1029 vkm/veh in Romania to 16500 vkm/veh in Ireland.
- Bus utilization rate varies from 10000 vkm/veh in Malta to 170000 vkm/veh in Luxemburg.

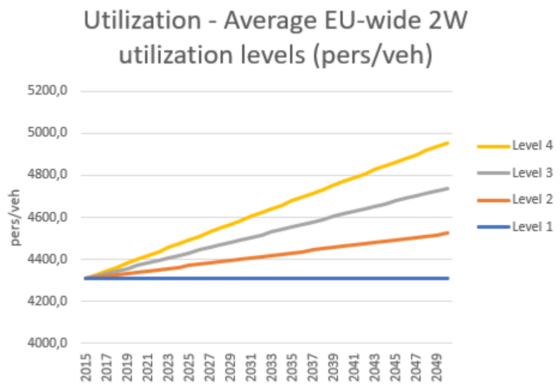
For cars, we assume that the most important driver of utilization rate are the development of new trends such as car sharing, "transport as a service", etc.

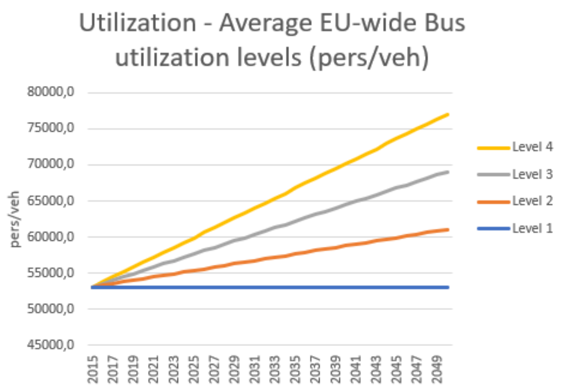
Definition of the 4 EU-wide levels of ambition

Table 11 – 4 levels of ambition for utilization rate of passenger vehicles at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
For this level, we consider a status quo compared to the 2015 utilization rates for cars, 2Ws and buses. The 2050 utilization rates therefore reach 12600 vkm/vehicle for cars, 4300 vkm/vehicle for 2Ws and 5300 vkm/vehicle for buses.	This scenario considers a EU-wide total change of +100% in utilization rate for cars, reaching an average of 25000 pkm/vehicle by 2050. It also considers +5% for 2Ws and +15% for buses by 2050.
Level 3 (Ambitious)	**Level 4 (Transformational)**
This scenario considers a EU-wide total change of +400% in utilization rate for cars, which is a bit lower than expected increase of utilization for shared cars in [Element Energy Ltd, 2016]. It also considers +10% for 2Ws and +30% for buses by 2050.	This scenario considers a strong EU-wide change of car utilization rate of +900% aligned with [RethinkX, 2017] disruption scenario, reaching 125 700 vkm/vehicle in average by 2050. It also considers +15% for 2Ws and +45% for buses by 2050.







Disaggregation by country

As said earlier, we assume that the most important driver of utilization rate for cars are the development of new trends such as car sharing, "transport as a service", etc. However, local factors such as urbanization rate and population density are key for the deployment of such services.

We therefore assume a lower convergence rate (70% convergence and 30% compression) for cars and 2Ws. For buses, we make the assumption that the convergence is a bit higher (80% convergence, 20% compression).

2050 targets for each country and ambition level are given in Annex 1.

6.1.6 Energy efficiency

Context

Energy efficiency of the different modes and technology are the same for all countries. The data collected for 2015 is given in the Table here under (sources: historical database, see D2.1).

Table 12 – Energy efficiency by type of passenger vehicle at EU28 + Switzerland level

Type of vehicle	**kWh/vkm**	**MJ/vkm**	**kWh/pkm**	**MJ/pkm**
Car – Gasoline	0,83	2,99		
Car – Diesel	0,74	2,68		
Car – Electric	0,23	0,81		
Car – Gas	0,74	2,65		

Car - HEV diesel	0,56	2,01		
Car - HEV gasoline	0,62	2,24		
Car - PHEV diesel	0,37	1,35		
Car - PHEV gasoline	0,41	1,48		
Bus – Diesel	4,68	16,84		
Bus – HEV	3,28	11,81		
Bus – BEV	1,88	6,76		
Bus - Hydrogen	2,91	10,48		
Aviation			0,53	1,91
Train			0,08	0,30
2W	0,19	0,70		

Definition of the 4 EU-wide levels of ambition

The ambition levels for this lever are considered the same for all countries.

Table 13 – 4 levels of ambition for energy efficiency of passenger vehicles at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
This level considers an energy efficiency improvement aligned with *[Climact& VITO, 2013] level 1 for Belgium:* • 20% for cars • 15% for buses • 10% for rails • 5% for aviation	This level considers reaching energy efficiency improvements of: • 27% for cars • 20% for buses • 25% for rails • 11% for aviation
Level 3 (Ambitious)	**Level 4 (Transformational)**
This level considers an energy efficiency improvement of: • 35% for cars based on the scenarios proposed in *[A.Hoeltl et al., 2017]* • 25% for buses based on estimations from *[T&E, 2017]* • 40% for rails based on *[UIC & CER, 2015] estimations (saving potential of 5-15% for eco-driving, 10-20% for efficient traffic management measures and 4-8% for parked train management)* • 22% for aviation based on *[Sustainable aviation, 2016]*	This level considers an energy efficiency improvement aligned with *[Climact& VITO, 2013] level 2 for Belgium:* • 50% for cars • 30% for buses • 45% for rails • 30% for aviation

6.1.7 Technology share

<u>Context</u>

The Table 14 hereafter gives the share of existing fleet and of new car and buses sales by technology for the EU28 + Switzerland area, for 2015. It also shows the share of existing fleet by technology for cars, buses, trains and aircrafts (sources: historical database, see D2.1).

Table 14 - Technology shares

Type of vehicle	% of total fleet	% of new sales
Car - Gasoline	55.7%	45%
Car - Diesel	41.2%	51.2%
Car - BEV	0.1%	0.4%
Car - Gas	2.2%	1.1%
Car - HEV	0.4%	0.6%
Car - PHEV	0.4%	1.7%
Car - FCEV	0%	0%

Type of vehicle	% of total fleet	% of new sales
Bus - Gasoline	1.1%	2.8%
Bus - Diesel	95.5%	92.3%
Bus - BEV	0.3%	1.1%
Bus - Gas	0.5%	1.6%
Bus - HEV	0.04%	2.2%
Bus - Others	2.6%	0%

Type of vehicle	% of total fleet
Train – Diesel	50%
Train- Electric	50%

Type of vehicle	% of total fleet
Aircraft - Kerosene	100%
Aircraft - Others	0%

<u>Definition of the 4 EU-wide levels of ambition</u>

For this lever, we define 2 sub-levers:

- The share of Zero Emission Vehicles (ZEV) in new sales: this includes fully electric vehicles and fuel cells vehicles.
- The share of Low Emission Vehicles (LEV) in new sales: this includes hybrid electric vehicles and gas-powered vehicles.

Table 15 – 4 levels of ambition for technology share in new sales of passenger vehicles at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
For this level, we consider: • 2% of ZEV and 6% of LEV in new car sales by 2050. This is aligned with the 8% electric vehicles considered in *[E3M-Lab, 2016]* • 10% of ZEV + LEV in new bus sales • 0% of ZEV or LEV in new plane sales by 2050	For this level, we consider: • 20% of ZEV and 50% of LEV in new car sales by 2050 • 25% of ZEV + LEV in new bus sales • 0% of ZEV or LEV in new plane sales by 2050

Level 3 (Ambitious)	Level 4 (Transformational)
For this level, we consider: • 73% of ZEV and 27% of LEV in new car sales by 2050 *[A.Hoeltl et al., 2017]* • 65% of ZEV + LEV in new bus sales • 0% of ZEV or LEV in new plane sales by 2050	For this level, we consider: • 100% of ZEV in new car sales by 2050, which is aligned with the TECH OEM scenario of *[ECF, 2018]* • 100% of ZEV in new bus sales by 2050 • 10% of ZEV in new plane sales by 2050

Disaggregation by country

For this lever, we assume 100% convergence by 2050 between countries.

6.1.8 Fuel mix

The fuel mix lever is a transversal lever that has an influence on both passenger and freight modules.

Context

The table hereafter gives the fuel mix for different types of energy vectors for the EU28 + Switzerland area, for 2015 (sources: historical database, see D2.1).

Table 16 – fuel mix in EU28 + Switzerland area for Diesel, gasoline, gas and kerosene

	% conventional	**% biofuel**	**% efuel** (fuels produced by electricity, power to gaz, power to liquid, hydrogen, amnonia)
Diesel	94%	6%	0%
Gasoline	97%	3%	0%
Gas	93%	7%	0%
Kerosene	100%	0%	0%

In terms of energy demand, EU28 used 2,7Mtoe of bio gasoline in 2015, 11,2 Mtoe of biodiesel and 0,2 Mtoe of biogas.

Definition of the 4 EU-wide levels of ambition

[Ecorys, 2017] estimates that advanced biofuels could be able to meet around 50% of EU transport sector energy demand by 2050, which represents between 134 Mtoe and 147 Mtoe of advanced biofuel demand in their scenarios.

[LBST & Dena, 2017] estimates that the concentrated CO2 potential from biogenic sources and industrial processes in EU28 could reach around 165 million tons/year. This could lead to a PtL potential of 597 TWh/year (51 Mtoe) and a PtCH4 potential of around 832 TWh/year (71 Mtoe).

As HDV, aviation and maritime transport are the most difficult to decarbonize by 2050, priority is put on those modes for biofuel and e-fuel usage.

Table 17 – 4 levels of ambition for fuel mix at EU28 + Switzerland level

Level 1 (BAU)	Level 2 (Intermediate)
In this level, we consider that biofuels reach 7% of liquid fuel demand in transport (including kerosene and boat fuel). This is aligned with EU objectives and with 2016 EU Reference Scenario *[E3M-Lab, 2016]*. This represents around 21 Mtoe for a BAU demand scenario. E-fuels are supposed to be marginal by 2050 in this level. We assume a 3% penetration of e-fuels for aviation and maritime, which represent around 3Mtoe.	For this level, we consider that 25% of biofuel and e-fuel potential is available which represents around 37 Mtoe of biofuels and 31 Mtoe of e-fuels. This quantity is allocated following this priority order: 1. Aviation 2. Maritime 3. HDV 4. LDV
Level 3 (Ambitious)	**Level 4 (Transformational)**
For this level, we consider that 50% of biofuel and e-fuel potential is available which represents around 75 Mtoe of biofuels and 61 Mtoe of e-fuels. This quantity is allocated following the same priority order than level 2.	In this level, we consider that biofuels and e-fuels reach their full potential. This means that 147 Mtoe of biofuels *[Ecorys, 2017]* and 122 Mtoe of e-fuels *[LBST & Dena, 2017]* are available for transport. This quantity is allocated following the same priority order than level 2.

Disaggregation by country

For this lever, we assume 100% convergence by 2050 between countries. The biofuel and e-fuel potential for each country in 2050 is given in pro-rata of the population of the country compared to total population of EU28 + Switzerland.

6.1.9 Lifetime

<u>Context</u>

The Table hereafter gives the lifetime of the different vehicle types for the EU28 + Switzerland area, for 2015 (sources: historical database, see D2.1).

Table 18 – Lifetime of vehicles (EU28 + Switzerland, 2015)

Vehicle type	lifetime
LDV	180 000 km
Bus	400 000 km
Train	30 years
Aircraft	30 years

For train and planes, the lifetime is expressed in years of functioning instead than kilometres, to reflect the market functioning. One should keep in mind that vehicles have a second life and that are still responsible of GHG emissions outside Europe.

Definition of the 4 EU-wide levels of ambition

Table 19 – 4 levels of ambition for average lifetime of passenger vehicles for EU28 + Switzerland

Level 1 (BAU)	**Level 2 (Intermediate)**
For this level, we consider that the lifetime of all type of vehicles stay the same as currently.	Lifetime of cars is supposed to reach 0.3 million km. Lifetime of other types of vehicles is considered to increase by 10%.
Level 3 (Ambitious)	**Level 4 (Transformational)**
Lifetime of cars is supposed to reach 0.8 million km. Lifetime of other types of vehicles is considered to increase by 20%.	Lifetime of cars is supposed to reach 1,6 million km as stated in *[RethinkX, 2017] due to the strong development of "transport as a service".* Lifetime of other types of vehicles is considered to increase by 30%.

Disaggregation by country

For this lever, we assume 100% convergence by 2050 between countries.

6.2 Freight

As discussed earlier in this report, we have identified eight main levers for the Freight module. The levels of ambition will be discussed in more details in this section.

6.2.1 Transport demand

Context

In 2015, the total intra-EU freight transport demand in EU28 + Switzerland reached 3480 billion tkm. The freight transport intensity of EU28 + Switzerland economy (tkm/GDP) is around 0,25tkm/$€_{GDP}$ and is globally rather decreasing since 2008 (0,27 tkm/$€_{GDP}$).

Definition of the 4 EU-wide levels of ambition[5]

Table 20 – 4 levels of ambition for freight transport demand at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
For this level, we assume a diminution of 11% by 2050 of the freight	For this level, we assume a diminution of 15% by 2050 of the freight

[5] See also F. Creutzig, Energy and Environment "Transport: A roadblock to climate change mitigation?", November 2015

intensity of EU economy, in alignment with the 2016 EU Reference Scenario *[E3M-Lab, 2016]*. It means that the intensity decreases to 0,22tkm/€$_{GDP}$ by 2050.	intensity of EU economy, reaching the 2015 Swedish freight intensity of GDP. It means that the intensity decreases to 0,21tkm/€$_{GDP}$ by 2050 at the EU level.
Level 3 (Ambitious) For this level, we assume a diminution of 20% by 2050 of the freight intensity of EU economy, reaching the 2015 Austrian freight intensity of GDP. It means that the intensity decreases to 0,2tkm/€$_{GDP}$ by 2050 at the EU level.	**Level 4 (Transformational)** For this level, we assume a diminution of 25% by 2050 of the freight intensity of EU economy, reaching an intensity of 0,19tkm/€$_{GDP}$ by 2050.

<u>Disaggregation by country</u>

The freight intensity of an economy strongly depends on the local economy structure and characteristics. Therefore, we assume 100% compression, meaning that each country will have to do the same level of effort compared to 2015 situation.

6.2.2 Modal shift

<u>Context</u>

The Table 20 hereafter gives the modal share for intra-EU freight transport at EU28 + Switzerland level, for 2015 (sources: historical database, see D2.1).

Table 21 – Freight modal share at EU28 + Switzerland level in 2015

Mode	**Modal share**
Road	51,3%
Rail	12,1%
IWW	4,3%
Sea	32,2%
Air	0,1%

This does not include international extra-EU freight.

<u>Definition of the four EU-wide levels of ambition</u>

In its transport white paper *[EC, 2011]* the European commission sets the goal to shift 30% of road freight of over 300km to other types of transport such as train and IWW by 2030 and more than 50% by 2050.

Based on our analysis of Eurostat data, trips of over 300km represent between 40% and 45% of total European ton-kilometers. Therefore, we estimate that the Commission goal translate into a road share that deceases to around 40-42% of freight modal share, replaced by rail and, in a lesser degree, by IWW.

Air share is considered constant, as it already plays a minor role in intra-EU freight.

On the other hand, the potential of modal shift to SSS is very difficult to assess and is therefore not included in this analysis. This point should be examined in the next version of this report.

Table 22 – 4 levels of ambition for modal share on EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
This level is aligned with the 2016 EU reference scenario *[E3M-Lab, 2016]*: • Road share:48.9% • Rail share: 13.2% • IWW share:3.7% • Sea share: 34.1% • Air share:0.1%	This level considers a modal share of: • Road share:45.1% • Rail share: 16.7% • IWW share:4.0% • Sea share: 34.1% • Air share:0.1%
Level 3 (Ambitious)	**Level 4 (Transformational)**
This level is aligned with the European commission goals *[EC, 2011]:* • Road share:41% • Rail share: 20.4% • IWW share:4.4% • Sea share: 34.1% • Air share:0.1%	This level is inspired by the Négawatt scenario proposed for France [NégaWatt, 2017]: • Road share:35.5% • Rail share: 23.7% • IWW share:6.6% • Sea share: 34.1% • Air share:0.1%

<u>Disaggregation by country</u>

For the disaggregation by country, we have assumed that road share would strongly converge between countries, but that some difference could remain by 2050 to take into account local specificities such as the current absence of alternative infrastructure.

For the remaining transport demand, we have assumed the same breakdown between rail, IWW and sea than in 2015.

This means that for countries that do not have rail or IWW infrastructures (e.g. Malta and Cyprus), road stays the only solution.

6.2.3 Load factor

<u>Context</u>

The load factor for road freight transport at EU28 + Switzerland level, for 2015 is around 10,8tkm/vkm (sources: historical database, see D2.1).

Definition of the four EU-wide levels of ambition

In [T&E, 2017], Transport and Environment states that empty rides could be reduced by one quarter if road freight was more expensive. This corresponds to a 5% increase of load factors.

Table 23 – 4 levels of ambition for modal share on EU28 + Switzerland level

Level 1 (BAU) For this level, we consider a status quo compared to the 2015 load factor.	**Level 2 (Intermediate)** *For this level, we consider a 5% increase of load factor compared to 2015 [T&E, 2017]*
Level 3 (Ambitious) *For this level, we consider a 10% increase of load factor compared to 2015*	**Level 4 (Transformational)** *For this level, we consider a 15% increase of load factor compared to 2015 [IEA, 2017]*

Disaggregation by country

For this lever, we consider a strong convergence (90%) between countries.

6.2.4 Utilization rate

Context

The utilization rate for road freight transport at EU28 + Switzerland level, for 2015 is around 68500 vkm/year (sources: historical database, see D2.1).

Definition of the 4 EU-wide levels of ambition

Table 24 – 4 levels of ambition for modal share on EU28 + Switzerland level

Level 1 (BAU) For this level, we consider a status quo compared to the 2015 utilization rate.	**Level 2 (Intermediate)** For this level, we consider a 3% increase compared to the 2015 utilization rate.
Level 3 (Ambitious) For this level, we consider a 7% increase compared to the 2015 utilization rate.	**Level 4 (Transformational)** For this level, we consider a 10% increase compared to the 2015 utilization rate [Climact, 2018].

Disaggregation by country

For this lever, we consider a strong convergence (90%) between countries.

6.2.5 Energy efficiency

Context

Energy efficiency of the different modes and technology are considered the same for all countries. The data collected for 2015 is given in the Table hereunder (sources: historical database, see D2.1).

Table 25 – Energy efficiency by type of freight vehicle

Type of vehicle	kWh/km	MJ/km	kWh/tkm	MJ/tkm
Medium Truck - Gasoline	1,57	5,66		
Medium Truck - Diesel	1,41	5,07		
Medium Truck - Electric	0,43	1,53		
Medium Truck - Gas	1,39	5,02		
Medium Truck - HEV diesel	1,06	3,80		
Medium Truck - HEV gasoline	1,18	4,25		
Medium Truck - PHEV diesel	0,71	2,55		
Medium Truck - PHEV gasoline	0,78	2,79		
Heavy Truck - Gasoline	3,36	12,08		
Heavy Truck - Diesel	3,01	10,83		
Heavy Truck - Electric	0,43	1,53		
Heavy Truck – Gas	1,39	5,02		
Heavy Truck - HEV diesel	1,06	3,80		
Heavy Truck - HEV gasoline	1,18	4,25		
Heavy Truck - PHEV diesel	0,71	2,55		
Heavy Truck - PHEV gasoline	0,78	2,79		
Aviation			5,31	19,10
Train			0,04	0,15
Sea boat			0,04	0,16
IWW boat			0,12	0,43

Definition of the four EU-wide levels of ambition

Table 26 – 4 levels of ambition for modal share at EU28 + Switzerland level

Level 1 (BAU)	**Level 2 (Intermediate)**
This level considers an energy efficiency improvement aligned with *[Climact& VITO, 2013] level 1 for Belgium:* • 10% for trucks • 10% for rails • 5% for aviation • 5% for shipping	This level considers an energy efficiency improvement of 1/3 of level 4: • 17% for trucks • 13% for rails • 7% for aviation • 13% for shipping
Level 3 (Ambitious)	**Level 4 (Transformational)**

This level considers an energy efficiency improvement of: • 33% for trucks • 27% for rails • 15% for aviation • 30% for shipping, which corresponds to IMO 2030 target *[T&E, 2018]*	This level considers an energy efficiency improvement of: • 50% for trucks based on the analysis of *[T&E, 2017] and [IEA, 2017]* • 40% for rails based on *[UIC & CER, 2015] estimations (saving potential of 5-15% for eco-driving, 10-20% for efficient traffic management measures and 4-8% for parked train management)* • 22% for aviation based on *[Sustainable aviation, 2016]* • 40% for shipping *[DNV-GL, 2017]*

6.2.6 Technology share

Context

The share of the different technologies is considered the same for all countries. The data collected for 2015 is given in the Table hereunder (sources: historical database, see D2.1).

Table 27 – Technology share for freight vehicles in 2015 at EU28 + Switzerland level

Type of vehicle	% conventional	% hybrid	% full electric
Truck	99.66%	0.04	0.3%
Aviation	50%	/	50%
Train	100%	0%	0%
Boats	100%	0%	0%

Definition of the four EU-wide levels of ambition

For this lever, we define 2 sub-levers:

- The share of Zero Emission Vehicles (ZEV) in new sales: this includes fully electric vehicles and fuel cells vehicles.
- The share of Low Emission Vehicles (LEV) in new sales: this includes hybrid electric vehicles and gas-powered vehicles.

[DNV-GL, 2017] states that the most promising solution for shipping is gas. In their scenarios, they assume a LNG/LPG share of 40% to 70% for ships, but gas only allows small GHG reduction (around 20%). Biofuels and battery electric vehicles are also possible option starting from 2030.

Table 28 – 4 levels of ambition for technology share of new freight vehicle sales at EU28 + Switzerland level

Level 1 (BAU)	Level 2 (Intermediate)
For this level, we consider: • 10% of ZEV or LEV for trucks • 15% of ZEV or LEV for boats • 55% of electric trains	For this level, we consider: • 40% of ZEV or LEV for trucks • 40% of ZEV or LEV for boats • 70% of electric trains

• 0% of ZEV in new plane sales by 2050	• 0% of ZEV in new plane sales by 2050
Level 3 (Ambitious) For this level, we consider: • 70% of ZEV or LEV for trucks • 70% of ZEV or LEV for boats • 85% of electric trains • 0% of ZEV in new plane sales by 2050	**Level 4 (Transformational)** For this level, we consider: • 100% of ZEV or LEV for trucks [T&E, 2017 (b)] • 100% of ZEV or LEV for boats • 100% of electric trains • 10% of ZEV in new plane sales by 2050

Disaggregation by country

For this lever, we assume 100% convergence by 2050 between countries.

6.2.7 Fuel mix

The fuel mix lever is a transversal lever that has an influence on both passenger and freight modules. The context and definition of the 4 levels are explained in Section 6.1.8.

6.2.8 Lifetime

Context

The Table hereafter gives the lifetime of the different vehicle types for the EU28 + Switzerland area, for 2015 (sources: historical database, see D2.1).

Table 29 – Lifetime of vehicles (EU28 + Switzerland, 2015)

Vehicle type	lifetime
Truck	400 000 km
Train	30 years
Aircraft	30 years
Boat	30 years

Definition of the four EU-wide levels of ambition

Table 30 – 4 levels of ambition for average lifetime of freight vehicles for EU28 + Switzerland

Level 1 (BAU)	Level 2 (Intermediate)
For this level, we consider that the lifetime of all type of vehicles stay the same as currently.	Lifetime of all types of vehicles is considered to increase by 10%.
Level 3 (Ambitious)	**Level 4 (Transformational)**

Lifetime of all types of vehicles is considered to increase by 20%.	Lifetime of all types of vehicles is considered to increase by 30% [Climact, 2018].

Disaggregation by country

For this lever, we assume 100% convergence by 2050 between countries.

6.3 Infrastructures and costs

The ambition levels will be added for infrastructure and for cost in the next version of this report.

7 Conclusion

This report focuses on transport GHG emissions for both passenger transport and freight transport in the context of the EU Calc project.

The report develops the logic in building the transport model and the calculation tool by identifying and detailing the relevant drivers that influence transport GHG emissions in Europe. For each driver, the report explains the proposed ambition levels, based on extensive literature review, analysis and a first stakeholder consultation in April 2018.

Based on complementary analyses and further stakeholder consultation, some other improvements/adaptations will be performed. Some possible improvements are listed below:

- refine some model assumptions:
    - the curve shapes of the ambition levels: for now, all ambition curves are linear up to 2050, but some curves could be S-shaped or take other forms;
    - the passenger short-haul aviation could be subjected to modal share to very-high-speed trains, which is not taken into consideration for now;
    - The modal shift from road to SSS for freight has not be explored and could be included.
- include additional elements to the scope of the analysis:
    - Inclusion of international extra-EU freight (mainly shipping and aviation);
    - boat fuel could be considered separately, as for aviation kerosene;
    - other types of emissions could be computed (e.g. fine particles).

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Annexe 1 – Levels of ambition by country for 2050

8.1 Aviation demand

Country	% of convergence mechanism	2015[pkm/capita]	2050			
			Level 1[pkm/capita]	Level 2[pkm/capita]	Level 3[pkm/capita]	Level 4[pkm/capita]
BE	90%	2477,1	2952,4	2157,0	1522,6	1071,1
BG	90%	889,8	2644,7	1932,1	1363,9	959,4
CZ	90%	979,0	2661,9	1944,7	1372,8	965,7
DK	90%	3140,1	3081,0	2250,9	1588,9	1117,7
DE	90%	960,3	2658,3	1942,1	1370,9	964,4
EE	90%	671,1	2602,3	1901,1	1342,0	944,0
IE	90%	2825,5	3020,0	2206,3	1557,5	1095,6
EL	90%	2228,8	2904,3	2121,8	1497,8	1053,6
ES	90%	1196,5	2704,1	1975,5	1394,6	981,0
FR	90%	1582,6	2779,0	2030,2	1433,2	1008,2
HR	90%	848,1	2636,6	1926,2	1359,7	956,5
IT	90%	1152,0	2695,5	1969,2	1390,1	977,9
CY	60%	6300,8	6535,1	4774,3	3370,3	2370,8
LV	90%	3875,4	3223,6	2355,0	1662,5	1169,5
LT	90%	960,0	2658,3	1942,0	1370,9	964,4
LU	90%	1829,1	2826,8	2065,2	1457,8	1025,5
HU	90%	562,1	2581,1	1885,7	1331,1	936,4
MT	60%	7570,0	7519,5	5493,5	3878,0	2727,9
NL	90%	3192,1	3091,1	2258,2	1594,1	1121,4
AT	90%	2102,0	2879,7	2103,8	1485,1	1044,7
PL	90%	476,1	2564,4	1873,5	1322,5	930,3
PT	90%	1848,7	2830,6	2067,9	1459,8	1026,9
RO	90%	865,0	2639,9	1928,6	1361,4	957,7
SI	90%	444,6	2558,3	1869,0	1319,4	928,1
SK	90%	264,8	2523,5	1843,6	1301,4	915,5
FI	90%	4150,1	3276,9	2394,0	1689,9	1188,8
SE	90%	2556,7	2967,9	2168,2	1530,6	1076,7
UK	90%	1217,2	2708,1	1978,5	1396,6	982,5
NO	90%	2716,5	2998,9	2190,9	1546,6	1087,9

8.2 Occupancy

8.2.1 Car occupancy

Country	% of convergence mechanism	2015 [pkm/vkm]	2050			
			Level 1[pkm/vkm]	Level 2[pkm/vkm]	Level 3[pkm/vkm]	Level 4[pkm/vkm]

BE	90%	1,5	1,6	1,9	2,2	2,6
BG	90%	1,7	1,6	2,0	2,3	2,6
CZ	90%	1,0	1,6	1,9	2,2	2,5
DK	90%	1,7	1,6	2,0	2,3	2,6
DE	90%	1,5	1,6	1,9	2,2	2,6
EE	90%	1,3	1,6	1,9	2,2	2,5
IE	90%	1,5	1,6	1,9	2,2	2,6
EL	90%	1,5	1,6	1,9	2,2	2,6
ES	90%	1,7	1,6	2,0	2,3	2,6
FR	90%	1,8	1,6	2,0	2,3	2,6
HR	90%	1,4	1,6	1,9	2,2	2,6
IT	90%	1,7	1,6	2,0	2,3	2,6
CY	90%	1,5	1,6	1,9	2,2	2,6
LV	90%	1,4	1,6	1,9	2,2	2,5
LT	90%	1,9	1,6	2,0	2,3	2,6
LU	90%	1,5	1,6	1,9	2,2	2,6
HU	90%	1,8	1,6	2,0	2,3	2,6
MT	90%	1,5	1,6	1,9	2,2	2,6
NL	90%	1,3	1,6	1,9	2,2	2,5
AT	90%	1,2	1,6	1,9	2,2	2,5
PL	90%	2,1	1,7	2,0	2,3	2,7
PT	90%	1,5	1,6	1,9	2,2	2,6
RO	90%	1,9	1,7	2,0	2,3	2,6
SI	90%	1,6	1,6	1,9	2,3	2,6
SK	90%	2,0	1,7	2,0	2,3	2,6
FI	90%	1,4	1,6	1,9	2,2	2,6
SE	90%	1,3	1,6	1,9	2,2	2,5
UK	90%	1,5	1,6	1,9	2,3	2,6
NO	90%	1,7	1,6	1,9	2,3	2,6

8.2.2 2W occupancy

Country	**% of convergence mechanism**	**2015** [pkm/vkm]	**2050**			
			Level 1[pkm/vkm]	**Level 2**[pkm/vkm]	**Level 1**[pkm/vkm]	**Level 4**[pkm/vkm]
BE	90%	1,1	1,1	1,2	1,2	1,3
BG	90%	1,1	1,1	1,2	1,3	1,3
CZ	90%	1,1	1,1	1,2	1,3	1,3
DK	90%	1,1	1,1	1,2	1,3	1,3
DE	90%	1,1	1,1	1,2	1,3	1,3
EE	90%	1,1	1,1	1,2	1,3	1,3
IE	90%	1,1	1,1	1,2	1,3	1,3
EL	90%	1,1	1,1	1,2	1,3	1,3
ES	90%	1,3	1,2	1,2	1,3	1,3
FR	90%	1,1	1,1	1,2	1,3	1,3

HR	90%	1,1	1,1	1,2	1,3	1,3
IT	90%	1,1	1,1	1,2	1,3	1,3
CY	90%	1,1	1,1	1,2	1,3	1,3
LV	90%	1,1	1,1	1,2	1,3	1,3
LT	90%	1,4	1,2	1,2	1,3	1,3
LU	90%	1,1	1,1	1,2	1,3	1,3
HU	90%	1,1	1,1	1,2	1,3	1,3
MT	90%	1,1	1,1	1,2	1,3	1,3
NL	90%	1,1	1,1	1,2	1,3	1,3
AT	90%	1,1	1,1	1,2	1,3	1,3
PL	90%	1,1	1,1	1,2	1,3	1,3
PT	90%	1,1	1,1	1,2	1,3	1,3
RO	90%	1,1	1,1	1,2	1,3	1,3
SI	90%	1,1	1,1	1,2	1,3	1,3
SK	90%	1,1	1,1	1,2	1,3	1,3
FI	90%	1,0	1,1	1,2	1,2	1,3
SE	90%	1,1	1,1	1,2	1,3	1,3
UK	90%	1,1	1,1	1,2	1,3	1,3
NO	90%	1,1	1,1	1,2	1,2	1,3

8.2.3 Bus occupancy

Country	**% of convergence mechanism**	**2015** [pkm/vkm]	**2050**			
			Level 1[pkm/vkm]	**Level 2**[pkm/vkm]	**Level 1**[pkm/vkm]	**Level 4**[pkm/vkm]
BE	40%	35,1	28,6	32,9	37,2	41,4
BG	40%	15,8	17,0	19,5	22,1	24,6
CZ	40%	24,4	22,2	25,5	28,8	32,1
DK	40%	12,0	14,7	16,9	19,1	21,3
DE	40%	20,4	19,7	22,7	25,6	28,6
EE	40%	9,2	13,0	15,0	16,9	18,9
IE	40%	26,7	23,5	27,1	30,6	34,1
EL	40%	26,7	23,5	27,1	30,6	34,1
ES	40%	24,0	21,9	25,2	28,5	31,8
FR	40%	17,8	18,2	20,9	23,7	26,4
HR	40%	7,7	12,2	14,0	15,8	17,6
IT	40%	20,0	19,5	22,4	25,3	28,3
CY	40%	9,6	13,3	15,3	17,3	19,3
LV	40%	10,5	13,8	15,9	17,9	20,0
LT	40%	29,9	25,5	29,3	33,1	36,9
LU	40%	35,1	28,6	32,9	37,2	41,4
HU	40%	29,9	25,5	29,3	33,1	36,9
MT	40%	35,1	28,6	32,9	37,2	41,4
NL	40%	35,1	28,6	32,9	37,2	41,4
AT	40%	18,9	18,8	21,7	24,5	27,3

PL	40%	6,8	11,6	13,4	15,1	16,8
PT	40%	27,8	24,2	27,8	31,5	35,1
RO	40%	15,8	17,0	19,5	22,1	24,6
SI	40%	21,9	20,6	23,7	26,8	29,9
SK	40%	10,7	13,9	16,0	18,1	20,2
FI	40%	13,0	15,3	17,6	19,9	22,2
SE	40%	9,4	13,1	15,1	17,1	19,0
UK	40%	16,1	17,1	19,7	22,3	24,9
NO	40%	13,4	15,5	17,9	20,2	22,5

8.3 Utilization rate

8.3.1 Car utilization rate

Country	**% of convergence mechanism**	**2015**[vkm/veh]	**2050**			
			Level 1[vkm/veh]	**Level 2**[vkm/veh]	**Level 3**[vkm/veh]	**Level 4**[vkm/veh]
BE	70%	18179,0	14251,8	28503,6	71259,0	142518,0
BG	70%	11572,7	12269,9	24539,9	61349,6	122699,3
CZ	70%	10944,2	12081,4	24162,7	60406,8	120813,6
DK	70%	18407,2	14320,3	28640,5	71601,4	143202,7
DE	70%	15500,1	13448,1	26896,3	67240,7	134481,4
EE	70%	15871,2	13559,5	27118,9	67797,3	135594,6
IE	70%	16171,1	13649,4	27298,9	68247,2	136494,4
EL	70%	6554,0	10764,3	21528,6	53821,6	107643,2
ES	70%	10912,0	12071,7	24143,4	60358,5	120716,9
FR	70%	14724,0	13215,3	26430,6	66076,6	132153,1
HR	70%	14579,9	13172,1	26344,1	65860,3	131720,7
IT	70%	9731,0	11717,4	23434,8	58587,1	117174,2
CY	70%	13391,5	12815,6	25631,1	64077,8	128155,6
LV	70%	14529,7	13157,0	26314,0	65785,1	131570,2
LT	70%	4122,4	10034,8	20069,6	50174,1	100348,2
LU	70%	59000,1	26498,2	52996,3	132490,8	264981,5
HU	70%	12857,0	12655,2	25310,4	63276,0	126552,0
MT	70%	6379,5	10712,0	21423,9	53559,9	107119,7
NL	70%	14456,2	13135,0	26269,9	65674,8	131349,7
AT	70%	18926,1	14475,9	28951,8	72379,6	144759,2
PL	70%	8726,6	11416,1	22832,2	57080,4	114160,8
PT	70%	13089,6	12725,0	25449,9	63624,9	127249,7
RO	70%	5020,1	10304,1	20608,3	51520,7	103041,5
SI	70%	16926,0	13875,9	27751,8	69379,6	138759,1
SK	70%	7426,6	11026,1	22052,2	55130,4	110260,8
FI	70%	11722,3	12314,8	24629,6	61574,0	123148,0
SE	70%	16142,4	13640,8	27281,7	68204,2	136408,3
UK	70%	13860,2	12956,2	25912,4	64780,9	129561,8
NO	70%	14312,2	13091,8	26183,5	65458,8	130917,6

8.3.2 2W utilization rate

Country	% of convergence mechanism	2015[vkm/veh]	2050			
			Level 1[vkm/veh]	Level 2[vkm/veh]	Level 3[vkm/veh]	Level 4[vkm/veh]
BE	70%	2152,8	3661,8	3844,9	4028,0	4211,1
BG	70%	3325,8	4013,8	4214,4	4415,1	4615,8
CZ	70%	2511,8	3769,5	3958,0	4146,5	4335,0
DK	70%	2533,6	3776,1	3964,9	4153,7	4342,5
DE	70%	2761,2	3844,4	4036,6	4228,8	4421,0
EE	70%	5993,6	4814,1	5054,8	5295,5	5536,2
IE	70%	16499,0	7965,7	8364,0	8762,3	9160,6
EL	70%	7052,1	5131,6	5388,2	5644,8	5901,4
ES	70%	5966,5	4805,9	5046,2	5286,5	5526,8
FR	70%	5233,9	4586,2	4815,5	5044,8	5274,1
HR	70%	13801,6	7156,5	7514,3	7872,1	8229,9
IT	70%	5153,7	4562,1	4790,2	5018,3	5246,4
CY	70%	7148,9	5160,7	5418,7	5676,7	5934,8
LV	70%	3133,4	3956,0	4153,8	4351,6	4549,4
LT	70%	1631,1	3505,3	3680,6	3855,9	4031,1
LU	70%	8798,2	5655,5	5938,2	6221,0	6503,8
HU	70%	2273,1	3697,9	3882,8	4067,7	4252,6
MT	70%	3685,7	4121,7	4327,8	4533,9	4740,0
NL	70%	1579,9	3490,0	3664,5	3839,0	4013,5
AT	70%	2581,4	3790,4	3979,9	4169,5	4359,0
PL	70%	2569,9	3787,0	3976,3	4165,7	4355,0
PT	70%	3242,6	3988,8	4188,2	4387,7	4587,1
RO	70%	1028,9	3324,7	3490,9	3657,1	3823,4
SI	70%	3930,1	4195,0	4404,8	4614,5	4824,3
SK	70%	1758,6	3543,6	3720,8	3897,9	4075,1
FI	70%	1310,7	3409,2	3579,7	3750,1	3920,6
SE	70%	2283,8	3701,1	3886,2	4071,3	4256,3
UK	70%	5452,5	4651,8	4884,4	5116,9	5349,5
NO	70%	2975,0	3908,5	4103,9	4299,4	4494,8

8.3.3 Bus utilization rate

Country	% of convergence mechanism	2015[vkm/veh]	2050			
			Level 1[vkm/veh]	Level 2[vkm/veh]	Level 3[vkm/veh]	Level 4[vkm/veh]
BE	80%	74853,9	57456,8	66075,3	74693,8	83312,4
BG	80%	21924,3	46870,9	53901,5	60932,1	67962,8
CZ	80%	41435,9	50773,2	58389,2	66005,2	73621,1
DK	80%	60159,2	54517,9	62695,5	70873,2	79050,9
DE	80%	55482,2	53582,5	61619,8	69657,2	77694,6
EE	80%	36997,7	49885,6	57368,4	64851,2	72334,1
IE	80%	39017,9	50289,6	57833,0	65376,5	72919,9
EL	80%	119041,9	66294,4	76238,6	86182,7	96126,9

ES	80%	69037,6	56293,5	64737,6	73181,6	81625,6
FR	80%	52060,3	52898,1	60832,8	68767,5	76702,2
HR	80%	119246,6	66335,3	76285,6	86235,9	96186,2
IT	80%	38953,8	50276,8	57818,3	65359,8	72901,3
CY	80%	34273,7	49340,8	56741,9	64143,0	71544,1
LV	80%	156467,2	73779,5	84846,4	95913,3	106980,2
LT	80%	44646,5	51415,3	59127,6	66839,9	74552,2
LU	80%	169011,3	76288,3	87731,5	99174,8	110618,0
HU	80%	61157,1	54717,4	62925,0	71132,7	79340,3
MT	80%	10058,0	44497,6	51172,2	57846,9	64521,5
NL	80%	63267,7	55139,5	63410,5	71681,4	79952,3
AT	80%	112671,1	65020,2	74773,3	84526,3	94279,3
PL	80%	29194,2	48324,9	55573,6	62822,3	70071,0
PT	80%	37030,4	49892,1	57375,9	64859,7	72343,5
RO	80%	28999,8	48286,0	55528,9	62771,8	70014,7
SI	80%	65000,4	55486,1	63809,0	72131,9	80454,8
SK	80%	71171,5	56720,3	65228,4	73736,4	82244,5
FI	80%	47708,1	52027,6	59831,8	67635,9	75440,1
SE	80%	84358,6	59357,7	68261,4	77165,1	86068,7
UK	80%	62329,9	54952,0	63194,8	71437,6	79680,4
NO	80%	63265,2	55139,1	63409,9	71680,8	79951,6