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EUCALC

Explore sustainable European futures

Expert consultation on transport

D2.3

April/2018

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Short Description

This report summarizes the presentations, discussions and lessons learned during the EU calculator Expert Stakeholder Workshop on the low carbon transition for Transport in Europe. Transport is one of the key GHG emitting sectors representing 23% of emissions in 2015 and needs to be fully decarbonized in the next decades. Hence the need to understand its dynamics and the impact of recent and future trends on possible future emissions trajectories is critical.

The Expert Stakeholder Workshop opened with a presentation on logic of the project and the concept of the EUCalc model. This was followed by a presentation on Schiphol Airport – one of the busiest in Europe - as a leader in its field in terms of tackling GHG emissions across all sectors. Actual initiatives being taken on the ground to electrify and decarbonize transport links to Schiphol were presented and discussed. Our sister project INNOPATH provided input on the complexity of transitioning to Electric Vehicles (EVs) based on research done for Scandinavia, followed by a presentation of the actual state of EUCalc research, assumptions, levers, and possible ambition levels.

The core of the Stakeholder feedback was a facilitated workshop, in which Expert Stakeholders were broken into small problem solving groups, two groups dealing with Passenger Transport and two groups dealing with Freight Transport. The questions they were all asked to reflect on and later discuss in plenum included,

whether any Levers were missing, whether Levers were correctly described and whether the Ambition levels were right? This document first describes the logic of the model and the suggested levers. It captures suggestions from stakeholders. In the following months the EUCalc team will critically evaluate these comments and take them into account.

Quality check	
Name of reviewer	**Date**
J. P. Kropp, PIK	**29.4.2018**
Garret Patric Kelly	**30.4.2018**

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This deliverable contains original unpublished work except where clearly indicated otherwise.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.

EUCalc policy of personal data protection in regard to the workshop

EUCalc defined the procedures in order to reply to ethical requirements in Deliverable 12.1 (Ethics requirements – procedures and criteria to identify research participants in EUCalc – H – Requirements No. 1). All procedures in relation to the co-design process, in particular the stakeholder mapping, the implementation of the workshops and the follow-up of the workshops, follow these procedures. The informed consent procedure in relation to the workshops is based on D9.2 "Stakeholder mapping" and D9.4 "Method for implementation of EUCalc co-design process". The originals of the signed consent forms are stored at the coordinators' premises without possibility of access of externals. Scans of the informed consent forms are stored on the internal EUCalc file storing system.

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Glossary

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

The goal of this project is to test and to propose low-carbon transformation pathways on the European and member state level. Pathways are to be based on detailed research and modelling in all energy producing and consuming sectors. As the EUCalc model is intended for use by a wide range of stakeholders - and in particular policy makers - then collaboration, discussion, participation and policy creation are central. The final output of the work should therefore, besides being scientifically rigorous and based on expert knowledge, should also include expectations, inputs and information from experts and stakeholders related to any given field of study.

The main outcome of this specific task was therefore the organization of a stakeholder workshop to discuss the options available to decarbonize the transport sectors (both passenger and freight) looking at both technology and behavioural options. The discussion focused on possible lever settings and ambition levels, derived from a literature review of previous research on all likely decarbonisation levers being currently used or discussed, so that experts were able to react to these assumptions.

The half-day workshop started with a series of presentations. First, Julien Pestiaux from Climact made a presentation on logic of the project and the concept of the EUCalc model. Subsequently, Denise Pronk presented the concrete challenges and concrete actions at Schiphol Airport particularly highlighting concrete initiatives being taken on the ground to electrify and decarbonize transport. Then the INNOPATH sister project gave input on the complexity of transitioning to Electric Vehicles based on research for the Scandinavian region. Emily Taylor from Climact concluded by presenting the status of our research to the experts.

For the remaining segment of the morning experts responded to suggested levers and levels of ambition. A series of interesting suggestions were made. For example, it was proposed to split both the passenger and the freight modules into urban and rural transport so as to be much more refined in terms of the potential for modal shift or even reducing transport demand. It was also suggested to better reflect non-motorized transport, particularly in terms of the urban context where bikes have the potential to both reduce GHG emissions but also to increase the quality of life in urban centres. Questions were also raised about whether disruptive technology, or technologies in general should have their own Lever(s).

This workshop on transport was an important milestone in our research. We have been able to consolidate a significant body of research, present our assumptions and get the reactions of a sizeable set of experts from the field covering wide ranges of expertise, from non-motorized transport like the EU Cycle Federation, to smarter freight, and also innovative solutions like the hyperloop[1]. The reactions were varied and have shown again how much the EU Calc should prove useful in the future if it well calibrated and covers the appropriate options.

The various inputs will be critically assessed and will make it feasible to improve the EUCalc approach further. The project will continue to interact with the experts, both from the ones who attended the workshop and others who were contacted and expressed interest to be involved.

[1] Two sectors conspicuously absent were the automotive industry and the airline, plane industries and this issue will need to be addressed before Levers and Ambition levels are finalized.

2 Introduction

The goal of this project is to test low-carbon transformation pathways on the European and member state scale. Pathways are based on detailed research and modelling in all energy producing and consuming sectors. The project will develop a user friendly, transparent, open source model giving real time results, combined with a Transition Pathways Explorer and a learning tools designed at a level of complexity that is adequate for European and national policy makers, businesses, NGOs and other actors of society.

With EUCalc, politicians, innovators and investors will be able to co-create their own pathways online and in real-time and directly visualize how compliant these are with the European mitigation targets under certain decisions taken in other sectors, like buildings, transport, water, industry, energy, or food production.

For more information, please see http://www.european-calculator.eu/

As the EUCalc model is intended for use by a wide range of stakeholders - and in particular policy makers - then collaboration, discussion, participation and policy creation are central. The final output of the work should therefore, besides being scientifically rigorous and based on expert knowledge, should also include expectations, inputs and information from experts and stakeholders related to any given field of study.

The main outcome of this specific task was the organization of an Expert Stakeholder Workshop to discuss the options available to decarbonize the transport sectors (both passenger and freight) looking at both technological and behavioural options.

The workshop took place on the last day of the TRA 2018 (Transport Research Arena) conference in Vienna so that participants could join both events. Emily Taylor (Climact) joined the third day of TRA 2018, which was focused on the decarbonization of transport. See the section on p3 called "EUCalc policy of personal data protection in regard to the workshop" concerning our use of personal data.

Climact identified, defined and evaluated beforehand potential decarbonization levers being currently used or discussed. To specify technical needs and constraints for these levers background information was provided to the participants. This comprised of relevant data, levers suggestions and underlying assumptions and the derivation of possible ambition levels.

The half-day workshop started with a presentation provided by Julien Pestiaux from Climact presenting the logic of the project and the EUCalc model. This was followed by Denise Pronk presenting the concrete challenges and actions at Schiphol Airport highlighting concrete initiatives being taken on the ground to electrify and decarbonize transport. The INNOPATH sister project gave input on the complexity of transitioning to Electric Vehicles, while Emily Taylor from Climact presented the status of our research to the experts. The remaining part of the morning was used by experts to respond to suggested levers and levels of ambition.

A list of participants can be found in Annex 7.1.

2.1 Objectives of the expert consultation

The objective of the stakeholder consultations is to present current achievements of the modelling work in EUCalc, to validate and to critically discuss the underlying methodology, the ambition levels and levers for the transport sector.

Pre-reading materials provided to the experts included a detailed description of the EUCalc model and levers as well as a series of concrete questions we had for the group of experts to be discussed during workshop (see paragraph 2.2.).

In his presentation Julien Pestiaux (Climact) introduced the EUCalc project, its modelling work, underlying hypotheses and the actual model structure to the audience (the presentation called “180419 - EU Calc - Intro Vienna Workshop” will be uploaded to the EU Calc website).

During the Q&A session the following issues were discussed:

- Should soft modes (non-motorized transport) be part of modal share options or considered as a reduction of motorized transport demand?

  → while it is currently modelled as a reduction of motorized demand, we agreed with experts to reflect soft modes as a separate mode.

- For which option is the model designed for: developing one overarching roadmap or creating different scenarios for fact-based discussion?

  → the focus is on the creation of a variety of contrasting scenarios

- Whether disruptive technologies are properly reflected in the model as the Levers are currently described

→ We will continue to strive doing so, for example looking at how to best reflect the hyperloop concept

- How are the interconnections between model sectors done?

  →The full EUCalc model was described as in the slide below where the links between lifestyle, manufacturing, energy supply, biomass and the social and economic impacts are clarified. More details can be found in deliverable 8.1 on the model developments.

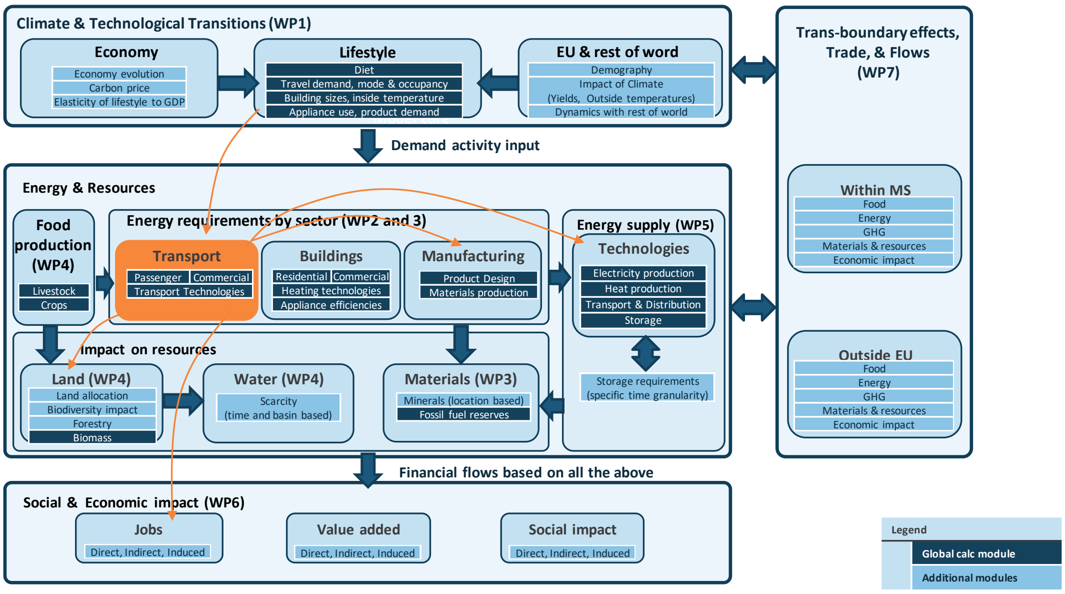

Figure 1 – Structure of the EU-Calc model, with highlights of the links of transport to other modules

2.2 Questions asked to the experts

The following list of questions was sent to the experts before the workshop together with a description of the EUCalc model and of defined levers.

2.2.1 Calculation logic and scope of analysis:

- *Do you think our scope of analysis is complete? Or should we add some transport modes, vehicle technologies, or types of fuels?*
- *Do you think our choice of lever is coherent and comprehensive? Do you have other suggestions?*
- *What do you think about our "per country disaggregation" methodology?*
- *What should we include in the infrastructure sub-module? What are the most ambitious infrastructure needs in the future?*
- *What types of costs should be included? (What are the main costs in infrastructures for example?)*

2.2.2 Ambition levels and future scenarios:

- *What are the future trends in the transport sector? Does the model logic allow enough flexibility to take them into account?*
- *How much can lifestyle and behaviour change influence future transport demand?*
- *Where could we expect some major disruptions in the transport sector?*
- *How fast will be the up take of new technologies? (Electric vehicles, fuel cells, electric ships and aircrafts, etc.)*
- *What do you think about our ambition levels for 2050? And about the disaggregation method and the curve shapes we propose?*

3 Setting the scene

3.1 Contributions from invited speakers

3.1.1 Ms Denise Pronk - Programme Manager for Corporate Responsibility & Sustainability at Schiphol Airport

Denise's presentation called "EU CALC_Sustainability Schiphol Group 20180419" will be uploaded to the EU Calc website.

Key elements of the presentation:

- Schiphol airport is managed based on 5 high level corporate goals. "Create sustainable & safe performance" is one of them, and therefore key for the Management Board
- It has a revised sustainability strategy which includes changes in EU and global climate objectives and includes emerging technical innovation (hyperloop, e-vehicles).
- It has a sustainable energy strategy comprising energy reduction (reduction in use of fossil energy and fuel; use of e-cars), the use of renewable energy (Dutch energy from wind), a reduction of emissions (example: electricity is used in the landed airplane instead of kerosene for air-conditioning), for example;
- It is following the logic of the circular economy (for example: the new parking area is built ready for disassembling in the future and to be used for other purposes if it becomes obsolete with the reduction in car ownership)

Transport focus:

- All taxis are electric vehicles based on their latest tender;
- 42% passengers use public transport to come to the airport;
- All airport busses are electric;
- 5% of employees travel to work by bicycle;
- Heavy duty vehicles are mostly electric as are all machines;
- Self-driving cars are managing transport parking to shuttle
- Next step: biofuels in aircraft, hybrid and e-planes, hydrogen, short haul shifts to train/hyperloop
- And very importantly, all investment decisions are taken with a 100EUR as an internal CO2 price.

Q&A - Joint discussion on the subject between the participants of the workshop:

- A participant – an expert of biofuel manufacture - questioned whether biofuels are an economically efficient way to decarbonize aviation. His opinion is that Europe does not have a clear view of this topic and should clarify the full life-cycle implications of importing Brazilian bioethanol or Indonesian palm oil.
- On the issue of reducing air transport demand, for example by replacing short-haul flights with train rides, a participant questioned whose role it was to motivate citizens to make the shift. Denise answered that in her view it is not the role of airport operators, but other stakeholders such as public administrations.

- There were some discussions on the limitations of reducing GHG emissions[2] based on airport operations as this excludes from the scope the flights themselves, effectively highlighting the limitations of an airport's sustainability strategy. However, they do have an important impact, not only with limiting GHG emissions from their operations (e.g., through electrification), but particularly through making short-haul connections available via alternatives such as the train, and the feasibility to support the deployment of innovative transport alternatives such as the hyperloop.
- Finally, there were also discussions on the limitations of their investments due to considerations of return on investments as private operator. Denise highlighted the importance of their internal carbon price of 100 euros in this context to make sure a wider range of business cases were considered profitable.

3.1.2 Johannes Kester – Department of Business Development and Technology, Aarhus University, DK on behalf of INNOPATH[3]

Key discussion points

- Johannes identified 3 major technology changes, i.e.: electrification, hydrogen fuelled cars, and autonomous vehicles (which may lead to a concern regarding the potential increase in the use of cars);
- In terms of the integration of other modes of transport his expectation is that consumers will start buying e-vehicles in significant numbers when their investment price would reaches parity with traditional diesel/gasoline alternatives;
- The electricity grid will experience massive transformations and cars are just a small part of it. For example the Norwegian car use is mainly long distance driving and leads to increased difficulties for grid operators, but their are developing the grid over time as the electric vehicle expansion is taking place;
- Vehicle to grids are expected to be part of an aggregated system, not expected for single users;

Comments and Q&A:

- There is very significant resistance from traditional internal combustion engine (ICE) car producers
- Battery development is seen as the key issue to make this widespread, affordable and overcome range anxiety (didn't he say this?)
- There has to be a wider look at subsidies and commercial prices of different technologies
- A discussion is also needed on how human interaction and social needs are changing with the evolution of the transport sector (working in your car while travelling could become much more widespread with autonomous vehicles).

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[2] The Airport complex itself only represents 8% of GHG emissions, the rest comes from flights

[3] http://www.innopaths.eu

3.2 Description of the transport module of the EU-calculator

Participants received an extensive pre-read document, and at the workshop a presentation entitled "180419_EU-Calc_Transport_Module" by Emily Taylor of Climact. It will be uploaded to the EU Calc website.

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 and on projections scenarios until 2050.

The main outputs of the transport module are:

- The direct CO_2 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 system.

Indirect emissions from the transport sector are addressed by the other WPs (WP5 covers power and fossil fuels production and assesses the emissions related to the electricity production and the upstream emissions of fossil fuels, WP3 covers manufacturing and assesses the emissions related to the manufacturing of the vehicles and the infrastructures, WP4 covers land use and biomass and the emissions related to biofuels production).

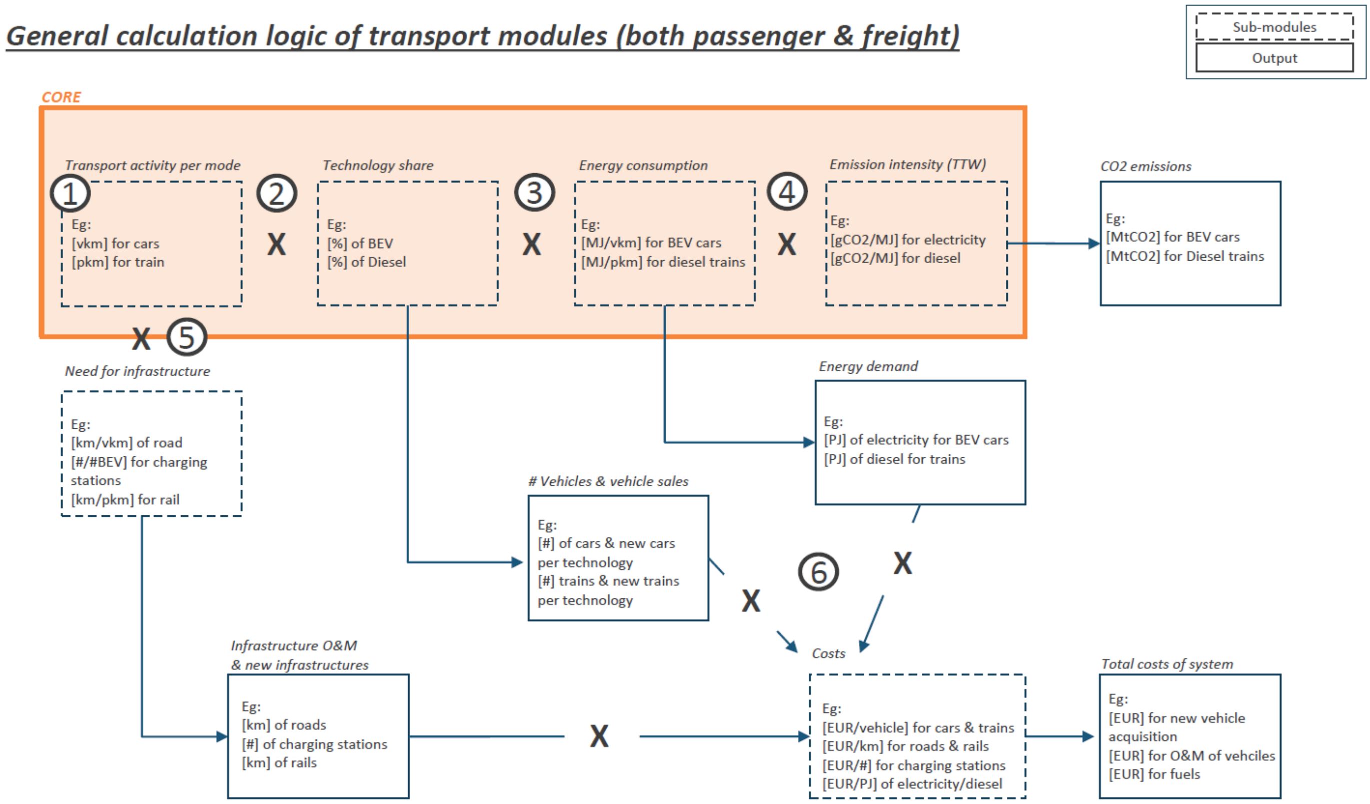


Figure 2 - General calculation logic of transport module (passenger & freight)

The bottom-up approach adopted here consists in 6 steps to successively estimate (see Figure 2). (All terms are clarified in the Glossary)

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 detailed calculation trees are given in Annex 1.

3.2.1 Scope of the analysis

The modes, types of vehicles, technologies and types of fuels that are taken into account in the transport module are listed here below (Figure 3).

Modes for passenger transport:
- Light duty vehicles (LDV)
- 2-wheels (2W)
- Bus
- Train
- Metro & Tram
- Airplane

Modes for freight:
- Heavy Duty Vehicles (HDV)
- Rail
- Aviation
- Inland Waterways (IWW)
- Marine

Types of vehicles/trip:

LDV:
- Small (to be added)
- Medium
- Large (to be added)

Airplanes:
- Short haul
- Long haul

HDV:
- Light
- Medium
- Heavy

Ships:
- IWW
- SSS
- DSS

2W, bus, train, metro & tram :
No further categorization

Technologies:

LDV, 2W & Bus:
- Internal Combustion Engines (ICE)
- Battery Electric Vehicles (BEV)
- Fuel Cell Electric Vehicles (FCEV)
- Plug-in Hybrid Electric Vehicles (PHEV)

Train:
- ICE
- Catenary Electric (CE)
- FCEV

Metro & Tram:
- CE

Airplane:
- ICE
- BEV

HDV:
- Internal Combustion Engines (ICE)
- Battery Electric Vehicles (BEV)
- Fuel Cell Electric Vehicles (FCEV)
- Plug-in Hybrid Electric Vehicles (PHEV)
- Catenary Electric Vehicles (CEV)

Ships:
- ICE
- BEV
- FCEV

Types of fuels:
- Diesel (for ICE & PHEV)
- Gasoline (for ICE & PHEV)
- Gas (for ICE & PHEV)
- Electricity (for BEV, PHEV, CE)
- Hydrogen (for FCEV)
- Aviation gasoline (for ICE planes)

Source of fuels:
- Conventional fossil fuel
- Biofuel (1G & 2G)
- E-fuel / PtX

Figure 3 – Scope of the core transport module

As shown in Figure 2, our analysis also covers infrastructures and costs.

3.2.2 Choice of levers

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:

- **Avoid** vehicle activity by:
  - reducing the demand for transport with improved urban planning (working closer from home), and pricing transport externalities so that citizens take these into account when deciding to travel (e.g., week-end city-trips flying across Europe)
  - avoid vehicle use by increasing vehicle occupancy and load factors
- Further **reduce** the number of vehicles needed by:
  - increasing the utilization rate of vehicles

  - increasing the mileage lifetime of vehicles by making them more robust and limiting their wear and tear (e.g., autonomous vehicles could potentially drive more smoothly, and with lower speed limits, with also less risk of accidents). Electric vehicles have fewer parts and can be maintained longer at reasonable cost.
- **Shift** to more efficient/environmentally friendly modes (e.g. active modes or public transport, increased use of a fleet of autonomous vehicles which would cover user needs better)
- **Improve** efficiency of transport by:
  - producing more efficient new vehicles
  - shifting to more efficient fuels and technologies

Based on this, we have chosen to have 8 types of levers (see Table 1);

Table 1 – Levers for the transport module

	Lever	**Brief description**
1.	Transport demand [pkm/capita] or [tkm/€$_{GDP}$]	The transport demand is expressed as pkm/capita for passenger transport and as tkm/€$_{GDP}$.
2.	Occupancy/load factor [passenger/vehicle] or [ton/vehicle]	Occupancy is expressed as number of passenger per vehicle, and only has an impact on road vehicles.
3.	Utilization rates [km/vehicle/year]	The utilization rate is the number of kilometres travelled by a vehicle yearly.
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.
5.	Modal share [%/mode]	The modal share lever describes how passenger are travelling: by car, bus, train, etc; or how goods are being transported.
6.	Vehicle efficiency [MJ/km] or [MJ/pkm] or [MJ/tkm]	The vehicle efficiency is expressed in MJ/km for road vehicles and in MJ/pkm for rail, aviation and shipping.
7.	Low Emission Technology development [% of new vehicles/technology]	This lever described the level of adoption of low emission technologies.
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).

3.2.3 Levels of ambition

For each chosen lever, we propose four levels of ambition for 2050. This is done in three steps:

1. Definition of four EU-wide levels of ambition by 2050
2. Disaggregation of the levels of ambition by country up to 2050
3. Choice of change curves between 2015 and 2050

3.2.3.1 Ambition levels, EU-wide definition

We based the first suggestion for the 4 levels of ambition for the EU28 (+Switzerland) on a literature review. The references used for this exercise can be found in Appendix 6. Deliverable 2.1 and 2.2 for WP2 on the transport sector also provide further information.

The definition of the 4 levels for each lever 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 Reference or Business-as-usual scenario. The projections are aligned and coherent with either the historical trends or with the EU Reference scenario 2016 (when the results are available). See https://ec.europa.eu/energy/en/data-analysis/energy-modelling	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 the current technology evolutions and the best practices observed in some geographical areas.	This level is considered as transformational and requires some additional breakthrough or efforts such as important costs reduction for some technologies (e.g. batteries and hydrogen vehicles), very fast and extended deployment of infrastructures, major technological advances (e.g., electric planes), strong societal changes (extensive use of autonomous vehicles, strong reduction in transport demand), etc.

3.2.3.2 Ambition levels, per country disaggregation

Based on the EU-wide levels of ambition, we use the Science-based target[4] concepts to disaggregate ambition levels at the country level.

The Science-based target uses two concepts to describe the targets evolution: the convergence or the compression (see Figure 4 and Figure 5).

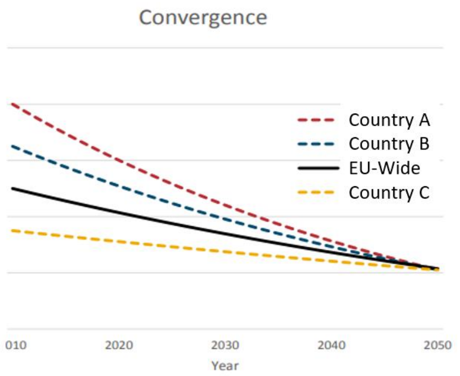


Figure 4 – Convergence concept [Science Based Target, 2015]

Convergence:

- The *absolute* 2050 ambition is the same for all countries (e.g. x kwh electricity/km for small electric vehicles in 2050 in all countries)
- 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 typically used by experts following the science-based target approach for technological levers such as energy efficiency of a given technology for example.

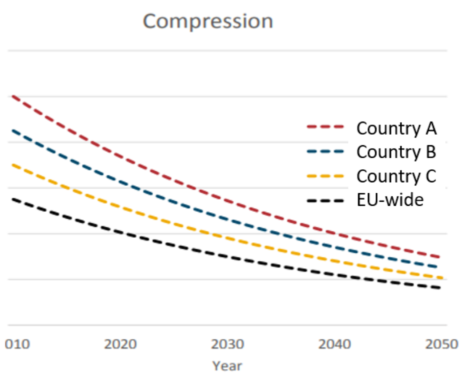


Figure 5 – Compression concept [Science Based Target, 2015]

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

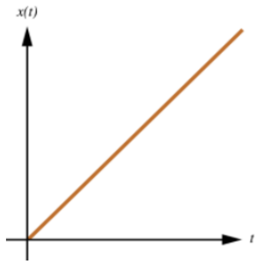
The compression is better suited when local or country-specific parameters have an important influence on the long-term evolution of the lever value. This could be the case for transport demand, for example, for which urbanization rate, population density or local topography can have an influence.

[4] [Science Based Target, 2015] CDP, UN Global Compact, WRI, WWF (2015). Science Based Target – How businesses are aligning their goals with climate science.

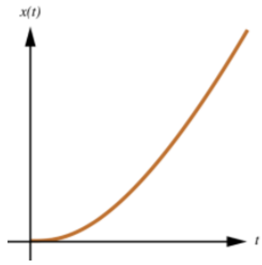
We also use a hybrid calculation which sets goals per country based on a weighted average of convergence and compression results. The weights of the hybrid calculation that are used are specified for each lever in the following sections.

3.2.3.3 Choice of curve shape

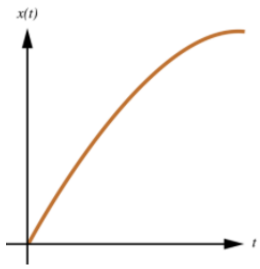
For the interpolation between 2015 situation and 2050 level, the modelling team is choosing based on different types of curves which can be used in the model: linear, S-shaped, exponential or saturation curve.



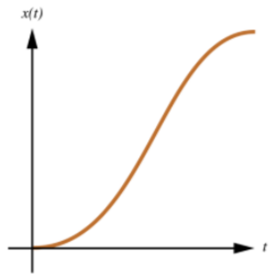
L-curve



E-curve



G-curve



S-curve

3.2.3.4 Levels of ambition for specific levers

The following table describe the situation 2015, EU-wide levels of ambition for 2050, disaggregation method and growth curves for each chosen lever.

We refer the reader looking for more details to Deliverable 2.2. (Identification of levers and levels of ambition for passenger & freight transport in Europe) which describes each of these levers along with key sources used for the 4 levels of ambition.

Table 3 – Levels of ambition for specific levers – Passenger transport

Lever	Curve shape	2015 situation for EU28+CH	2050 ambition for EU28+CH			Disaggregation by country
			Level 1	Level 3	Level 4	
Passenger – transport demand	L	11941 pkm/capita for land transport 1417 pkm/capita for aviation	+25% for land transport +94% for aviation	+10% for land transport +0% for aviation	+0% for land transport -30% for aviation	Land demand is computed based on GDP and population evolutions 90% convergence for aviation demand
Passenger – Modal share	L	Car: 78% 2W: 4% Bus: 9% Rail: 9%	Car: 75% 2W: 4% Bus: 9% Rail: 12%	Car: 61% 2W: 3% Bus: 15% Rail: 21%	Car: 55% 2W: 2% Bus: 17% Rail: 26%	90% convergence for car and 2W shares Same breakdown as historically for Bus/rail

Passenger - Occupancy	L	Car: 1,6 p/v 2W: 1,1 p/v Bus: 18,8 p/v	Status quo compared to 2015	Car: 2,3 p/v 2W: 1,2 p/v Bus: 24,4 p/v	Car: 2,6 p/v 2W: 1,3 p/v Bus: 27,3 p/v	90% convergence for car and 2W shares 40% convergence for Bus
Passenger – Utilization rate	L	Car: 12600 vkm/v 2W: 4300 vkm/v Bus: 53000 vkm/v	Status quo compared to 2015	Car: +400% 2W: +10% Bus: +30%	Car: +900% 2W: +15% Bus: +45%	70% convergence for cars & 2W 80% convergence for buses
Passenger – Energy efficiency	L	Car: 3 MJ/vkm Bus: 17 MJ/vkm Rail: 0,3 MJ/pkm Air: 2 MJ/pkm	Car: -20% Bus: -15% Rail: -10% Aviation: -5%	Car: -35% Bus: -25% Rail: -40% Aviation: -22%	Car: -50% Bus: -30% Rail: -45% Aviation: -30%	100% convergence
Passenger – Technology share	S	Car: 3% LEV, 0,1% ZEV Bus: 0,5% LEV, 0,3% ZEV Train: 50% ZEV Air: 0% LEV + ZEV	Car: 6% LEV, 2% ZEV Bus: 10% LEV + ZEV Air: 0% LEV + ZEV	Car: 27% LEV, 73% ZEV Bus: 65% LEV + ZEV Air: 0% LEV + ZEV	Car: 100% ZEV Bus: 100% ZEV Air: 10% ZEV	100% convergence
Passenger – Lifetime of vehicles	L	Car: 180000 km Bus: 400000 km Train: 30 years Air: 30 years	Status quo compared to 2015	Car: +350% Bus: +20% Train: +20% Air: +20%	Car: +700% Bus: +30% Train: +30% Air: +30%	100% convergence
Passenger & Freight – Fuel mix	L	Biofuels: 14 Mtoe E-fuels: 0 Mtoe	Biofuels: 21 Mtoe E-fuels: 3 Mtoe	Biofuels: 75 Mtoe E-fuels: 61 Mtoe	Biofuels: 147 Mtoe E-fuels: 122 Mtoe	The biofuel and e-fuel potential for each country in 2050 is given in pro-rata of the population of the country.

Table 4 – Levels of ambition for specific levers – Freight

Lever	Curve shape	2015 situation for EU28+CH	2050 ambition for EU28+CH			Disaggregation by country
			Level 1	Level 3	Level 4	
Freight – transport demand	L	0,25 tkm/€GDP	-11%	-20%	-25%	0% convergence (100% compression)
Freight – Modal share	L	Road: 51,3% Rail: 12,1% IWW: 4,3% Sea: 32,2% Air: 0,1%	Road: 48,9% Rail: 13,2% IWW: 3,7% Sea: 34,1% Air: 0,1%	Road: 41% Rail: 20,4% IWW: 4,4% Sea: 34,1% Air: 0,1%	Road: 35,5% Rail: 23,7% IWW: 6,6% Sea: 34,1% Air: 0,1%	90% convergence for road share Same breakdown as historically Rail/IWW
Freight – Load factor	L	Road: 10,8 tkm/vkm	Status quo compared to 2015	Road: +10%	Road: +15%	90% convergence
Freight – Utilization rate	L	Road: 68500 vkm/year	Status quo compared to 2015	Road: +7%	Road: +10%	90% convergence
Freight – Energy efficiency	L	Medium truck: 6 MJ/vkm Heavy truck: 12 MJ/vkm Boat: 0,3 MJ/tkm Rail: 0,15 MJ/tkm Air: 20 MJ/tkm	Truck: -10% Boat: -5% Rail: -10% Air: -5%	Truck: -33% Boat: -30% Rail: -27% Air: -15%	Truck: -50% Boat: -40% Rail: -40% Air: -22%	100% convergence
Freight – Technology share	S	Truck: 0,04% LEV, 0,3% ZEV Boat: 0% LEV + ZEV Air: 0% LEV + ZEV	Truck: 10% LEV+ZEV Boat: 15% LEV+ZEV Air: 0% LEV+ZEV	Truck: 70% LEV+ZEV Boat: 70% LEV+ZEV Air: 0% LEV+ZEV	Truck: 100% LEV+ZEV Boat: 100% LEV+ZEV Air: 10% LEV+ZEV	100% convergence
Freight – Lifetime of vehicles	L	Truck: 400000km Boat, train, aircraft: 30 years	Status quo compared to 2015	All vehicles: +20%	All vehicles: +30%	100% convergence

3.2.4 Q&A after the presentation of the model and levers

- Zero-emissions-vehicles should be spoken of and defined as they are, that is "transferred emissions" to other sectors.
  → This is very clear and is recognized as the strength of such an integrated model which can test cross-sectoral issues (e.g. the impact of electric vehicles on GHG emissions if the power sector is not fully decarbonized).
- Disruptive technologies for air transport are still in their infancy, and therefore limited ambition is currently assumed (e.g., will electric planes effectively work before mid-century);
- Whether and to what extent Hyperloop or similar might substitute for planes for short haul journeys
- Maritime transport is not included as a specific mode on the passenger side, but only for freight, since it is considered it has too small influence on passenger transport;
- You should strive to consider carbon abatement cost in the cost discussions, as this is key to decide which solutions to implement;
- What are the assumptions for electrification of rail? This depends on the scenario, in scenario 4 it is assumed to be 100%.

4 Discussion & recommendations

The rest of the morning was focused on extracting input from experts by splitting the group in 4 sub-groups who discussed the relevance of levers and their ambition levels. Two groups focused on passenger transport while two other analysed and discussed freight.

The paragraphs below capture the input which will be reviewed critically by the EU Calc team over the next few months to assess the impacts they may have on the transport module.

It is structured looking first at improvements on existing levers, then reactions to ambition levels on existing ones, and finally suggested new levers or logic.

4.1 Suggested improvements on existing levers

4.1.1 Passenger transport

Participants have made the following suggestions:

- In the description of the lever "passenger travel demand" it is suggested to add to the description the fact that demographic change and economic determinants were used in the calculation of the levels. The link to the lifestyle module is key.
- Clarify in the communication that the levers the user may manipulate are input variables to the model, not a result from the model.
- It is still to be seen how the shift to more autonomous vehicles will influence turnover and lifetime. It could lead to higher transport demand, higher vehicle and

quicker vehicle turnover, so lifetime could decrease but the total vehicle mileage could increase during this shorter lifetime.

- Levers can help both clarify the required ambition to decarbonize as well as to test trade-offs between various technology options. The link to specific policies will be weaker in the tool (e.g., no carbon price will be modelled).
- You should clarify the links between passenger and freight (for example, is the model able to leverage cargo space in passenger planes)
- Occupancy rate: can you clarify the assumptions on vehicle size? Can it be stated in percentage?
- Can you clarify where e-bikes are captured?
- The projected 30% decrease in air travel is an assumption going in the right direction, but does it assume those trips will not happen or that they will be electric planes or hyperloops? This lever implies that they will not happen; we assume modal shift and electrification separately.

4.1.2 Freight transport

Participants have made the following suggestions:

- The load factor lever seems missing for shipping/air travel: is it feasible to add for non-road transport?
- There are 3 options to deal with air freight
    - Increase the efficiency of cargo planes and decarbonize them (including by using biofuels as alternatives to fossil fuels)
    - Leverage alternatives and modal shift (covered in the tool)
    - But you can also leverage belly cargo in passenger flights: leverage the space available in passenger flights

  The last one is not yet reflected in the model, the question is whether the model will do so in the future.

- Recyclability of vehicles should be increased, we should be able to dismantle them and reuse the materials. Can the model account for this link? Yes, it does.
- Are we considering efficiency retrofits, particularly for ships? – This could improve the efficiency of vehicles before the vehicle is replaced (which is potentially only after 30-35 years).
- Be careful with the increase in utilization: if the utilization rate increases, the lifetime of the vehicle should decrease.
- You may consider the build-up of an electricity-powered platform for freight road transport (sometimes also called e-trolleys) – yes, this is considered.
- You may consider separating trucks into sub-groups light light-medium-heavy duty. This is also necessary to better capture the difference between urban and non-urban freight.

- Consider non-motorized sources of energy. Bicycles could take up a large share of the last mile.

4.2 Feedback on the levels of ambition

4.2.1 Passenger transport

Different points and questions have been raised about the levels of ambition for the passenger transport:

- the logic behind the definition of the passenger occupancy lever is not clear and should be further explained and detailed;
- the ambition level for the buses modal share is not high enough: the view of some participants was that it could go up to ~60%, in particular for high-density urban areas;
- the level of ambition for biofuels is too high, it should not be higher than 25%;
- some levels of ambitions are overly ambitious (100% is generally too ambitious);
- the definition of buses is not clear.

Those questions will be treated, and the relevant points could be included in the next version of the transport module.

4.2.2 Freight transport

Different points and questions have been raised about the levels of ambition for the freight transport:

- Freight demand
    - It is very likely to increase, at least urban (e.g., online shopping with goods being sent front and back) – based on the growth of online markets
    - It should not depend on GDP but on GDP per capita in order to take into account population growth also
- Load factors
    - There is overcapacity in the market, so load factors of ships are lower than they should be today in a well-functioning market, so there is first potential to increase the use of existing capacity – and then the optimized capacity potential could be higher
    - Load factor much higher (to consider larger trucks)
- Modal share
    - Rail:
        - it's important to keep in mind that with major efforts in the past the share of rail in freight has only been maintained stable at historical levels.
        - Rail ambition level in terms of modal share looks too high (at least for level 4, but maybe even in level 3) but could be partly compensated by increasing the share of shipping

- Bikes: The following modal shift potential was mentioned: 50% of freight in urban area could be shifted to bikes and e-bikes (last mile) - for logistic purposes. Think for example of the potential for Pharmacies, with small/very frequent loads. Source to be asked to ECF (EU Cyclist Federation).
- Overall modal share potential on freight:
    - Review the documents from the Marco Polo program EU,
    - and its follow-up program Motorways of the sea
    - TEN-T: Trans-EU transport network
- Energy Efficiency
    - The International Maritime Organisation came out with higher efficiency potential for sea shipping : the level can be increased to -70% (IMO UN) →We could not directly find that figure back, but the following report is interesting: Efficency in Shipping
- Technology share: potentially check the reports from
    - ITF: International Transport Workers Federation
    - IRU: International Road Organisation : for example on the coverage of external costs by infrastructure
- You may find additional information from the following organizations
    - European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe): see their report on a "Roadmap Towards Zero Emissions Logistics in 2050"

      There are suggestions on
        - Some sort of physical network for better logistics in EU
        - More flexible inter-modal transport with modular container cargo
        - Suggestions on how freight can be organized differently
    - Waterborne technical platform: their 2030 report on innovation potential
- More input can potentially be asked from other associations:
    - ESCA: European community of ship owners: see for example the following publication on CO2
    - ESPO: European Sea Ports Organisation : see for example the following publication on their sustainability
    - FEPORT: Federation of EU Private Port Companies and Terminals

4.3 Potential adaptations to levers or modelling logic

4.3.1 Passenger transport

During the workshop, the stakeholders identified some potential additions in the passenger transport module that could be included in the model:

- The EU sectoral goals could be reflected in the tool, for transport, but also for other sectors.

- A lever for active transport (e.g., walking, cycling, e-bikes) may be added to fit the "transformational" description of the level 4.
- Shift to other transport modes – you should consider including short haul flights
- A lever for peak capacity (travel demand) compared to transport during day could be added. This would have ramifications on the need of less infrastructure and better use of capacities. Literature from Northern countries could be helpful on that subject.
- Levers and levels could be selected based on objective evidence (such as costs)
- Fuel cells and e-fuels could have less ambitious levels
- The measures needed to reach a level need to be linked or stated somewhere (e.g. taxes)
- The air travel could be included in the total transport demand and not separated.
- You may consider adding levers specifically addressing disruptive technologies, for example the hyperloop could emerge to support a shift from air to land transport

4.3.2 Freight transport

During the workshop, the stakeholders have identified some potential additions to the freight transport module that could be included in the model:

- There could be a link with the economy module. The levels of ambition could consider the impact on the economy and could include the necessity of economic growth (this is actually planned)
- There could be a differentiation between urban, inter-urban and international transport. This would allow more granularity and precision in the model.
- Freight module could include the possibility of bike-freight. Aviation- containers and EUR-Pallets on bikes have already been tested. 50% of last mile deliveries, in terms of number of trips, could be shifted to bicycle delivery.
- The shift from motor vehicles to human powered transport (bikes, walking etc.) could be considered in the modal shift lever or via the energy efficiency lever. Shift to bikes would have different consequences:
    - This would free some space in urban areas that were dedicated to heavy transport as bikes need less space.
    - This would avoid the need for robust, expensive and resource intensive infrastructures and decrease costs for maintenance.
- Disruptive technologies such as the use of drones for delivery could be included in the model

5 Lessons and conclusions

This workshop on transport was an important milestone in our research. We have been able to consolidate a significant body of research, present our assumptions and get the reactions of a sizeable set of experts from the field covering wide ranges of expertise, from non-motorized transport like the EU Cycle Federation, to smarter freight, and also innovative solutions like the hyperloop[5]. The reactions were varied and have shown again how much the EU Calc should prove useful in the future if it well calibrated and covers the appropriate options.

It is not the objective of this document to define how each of the suggestions will be taken into account in the work, but we can mention at least two issues that were raised and seem appropriate to raise the quality of the modelling:

- The suggestion to split both the passenger and the freight modules into urban and rural transport seems to be useful. It would refine the potentials for modal shift changes or even would reduce transport demand.
- It was also suggested to better reflect non-motorized transport, particularly in the urban context where bikes have the potential to both reduce GHG emissions but also to increase the quality of life in urban centres.

Altogether we are very thankful for the time spent by the experts. We will continue assessing their input and refining the work. We also suggest continuing expert interactions as this meeting provided very fruitful and inspiring insights.

[5] Two sectors conspicuously absent were the automotive industry and the airline, plane industries and this issue will need to be addressed before Levers and Ambition levels are finalized.

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7 Annexes

7.1 Participants list

See the section on p3 called “EUCalc policy of personal data protection in regard to the workshop” concerning our use of personal data.

Participants – Stakeholders:

Externals		Organization
Alan	Lewis	Smart freight center
Denise	Pronk	Schiphol
Paul	Hugues	International Energy Agency (Remote)
Floridea	Di Ciommo	CambiaMO
Hakan	Johansson	Trafikverket
Laura	Fariello	Austrian rails
Eric	Sievers	Ethanol Europe Renewable
Alan	Mckinnon	KLU university
Imre	Kesurü	VUB University
Johannes	Kester	Aarhus University (INNOPATH)
Mars	Geuze	Hardt (hyperloop)
Benoit	Loicq	Sea Europe
Laura	Lonza	European Commission’s Joint Research Centre, Institute for Energy and Transport
Randy	Rzewnicki	European Cyclist Federation
Baris	Ünsal	Vienna University
Onur Baran	Tezgel	CEVA Logistics
Utku	Arslan	Vienna University
Bruno	Goncalves	GMV
Orest	Gavrylyak	Axon partners
Efe	Usanmaz	UITP

Participants – European Calculator:

EU Calc members	

Garret	Patric Kelly	See Change Net
Ivana	Rogulj	See Change Net
Emily	Taylor	Climact
Julien	Pestiaux	Climact
Hannes	Warmuth	Oegut
Luis	Costa	PIK

Facilitators:

Adrian Taylor from 4sing

Jonathan Buhl from 4sing

7.2 Workshop agenda

Program:

8:30-9:00	Welcome & coffee
9:00-9:15	Introduction to the EU-Calc project and objectives of the workshop
9:15-09:50	Presentation of Denise Pronk (Sustainability Manager of Schiphol airport)
09:50-10:15	Q&A Session with INNOPATH
10:15-10:30	Coffee break
10:30-11:00	Presentation of the transport module: - Global logic and scope of analysis - Levels of ambition
11:00-12:30	Interactive sessions: Discussions about the global logic and scope of analysis, and about the ambition levels
12:30–13:00	Lunch