MIDAS includes the descriptions of models in use by the Commission in support to the policy cycle. MIDAS is developed and managed by the **Competence Centre on Modelling** of the European Commission.

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Contact: EU-MIDAS@ec.europa.eu

Factsheet

SWD/2021/474

IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a Directive of the European Parliament and of the Council amending Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport

Supporting model(s)

ASTRA, TRUST, PRIMES-TREMOVE

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 20/12/2021

Contents

Overview of model contributions to the impact assessment SWD/2021/474

Title
IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a Directive of the European Parliament and of the Council amending Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport

Document ID
SWD/2021/474

Year of publication
2021

Led by
MOVE

Model(s) used
ASTRA, TRUST, PRIMES-TREMOVE

Additional information on model use for this Impact assessment
Information about studies underpinning the IA

Ricardo et al. (forthcoming), Impact Assessment Support Study for the revision of the Intelligent Transport System Directive (2010/40/EU); study contract no. MOVE/B4/SER/2020-230

ASTRA

Full title
ASsessment of TRAnsport Strategies

Run for this impact assessment by
Trasporti e Territorio Srl

Contributed to
Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	Impact category	Impact subcategory
Economic impacts	Operating costs and conduct of business	Cost/availability of essential inputs (raw materials, machinery, labour, energy, ..)
Economic impacts	Competitiveness (sectoral) of business	Cost of doing business
Economic impacts	Consumers and households	Prices, quality, availability or choice of consumer goods and services
Economic impacts	Consumers and households	Safety or sustainability of consumer goods and services
Economic impacts	Macroeconomic environment	Economic growth and employment
Social	Public health and safety and health systems	Health and safety of individuals/populations
Social	Public health and safety and health systems	Health due to changes in the amount of noise, air, water or soil quality
Environmental	Climate	Emission of greenhouse gases
Environmental	Air quality	Emissions of acidifying, eutrophying, photochemical or harmful air pollutants
Environmental	Transport and the use of energy	Demand for transport
Environmental	Transport and the use of energy	Vehicle emissions
Environmental	Transport and the use of energy	Energy and fuel consumption

TRUST

Full title
TRansport eUropean Simulation Tool

Run for this impact assessment by
Trasporti e Territorio Srl

Contributed to
Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	Impact category	Impact subcategory
Economic impacts	Operating costs and conduct of business	Cost/availability of essential inputs (raw materials, machinery, labour, energy, ..)
Economic impacts	Competitiveness (sectoral) of business	Cost of doing business
Economic impacts	Consumers and households	Prices, quality, availability or choice of consumer goods and services
Economic impacts	Consumers and households	Safety or sustainability of consumer goods and services

PRIMES-TREMOVE

Full title
PRIMES-TREMOVE Transport Model

Run for this impact assessment by
Environment Modelling Laboratory, National Technical University of Athens

Contributed to
Baseline only

Helped to assess the following impacts

Impact area	Impact category	Impact subcategory
Economic impacts	Operating costs and conduct of business	Cost/availability of essential inputs (raw materials, machinery, labour, energy, ..)
Economic impacts	Competitiveness (sectoral) of business	Cost of doing business
Economic impacts	Consumers and households	Prices, quality, availability or choice of consumer goods and services
Economic impacts	Consumers and households	Safety or sustainability of consumer goods and services
Social	Public health and safety and health systems	Health and safety of individuals/populations
Environmental	Climate	Emission of greenhouse gases
Environmental	Air quality	Emissions of acidifying, eutrophying, photochemical or harmful air pollutants
Environmental	Transport and the use of energy	Demand for transport
Environmental	Transport and the use of energy	Vehicle emissions
Environmental	Transport and the use of energy	Energy and fuel consumption

Overview of models

ASTRA

Overview

Acronym ASTRA
Full title ASsessment of TRAnsport Strategies

Main purpose
ASTRA (ASsessment of TRAnsport Strategies) is an integrated assessment model designed for strategic policy assessment of transport policies and investments up to the year 2050. Policy assessment capabilities in ASTRA cover a wide range of measures with flexible timing and levels of implementation. Potential policies include vehicle technologies, infrastructure development, pricing, taxation, speed limits, trade policies etc. A strong feature of the model is the ability to simulate integrated policy packages and to provide indicators for the indirect effects of transport policies and investments on the economy and the environment. Over time the application of the model has been extended from transport also towards economic impact assessment of climate policy and of renewable energy policy. For such analyses the ASTRA model has often been coupled to bottom-up techno-economic models.

Summary
ASTRA is a strategic model based on the Systems Dynamics Modelling approach simulating the transport system development in combination with the economy and the environment until the year 2050. The ASTRA model is grounded on empirical data of its calibration period (which today is from 2000 until 2015). The model is made of different modules that interact among each other with direct and feed-back effects.

Strategic assessment capabilities in ASTRA cover a wide range of transport measures and investments with flexible timing and levels of implementation. Also when coupled with bottom-up models economic impact assessment of climate policy has been provided. Since many years the ASTRA model has been successfully used for the following applications:

- Transport policy assessment: pricing, taxation (on fuel or vehicle), emissions and efficiency standards, infrastructure investments
- Technology and scenario analysis: alternative vehicle technology (e.g. electric and fuel cell vehicles), integrated energy and transport policy (e.g. vehicle efficiency improvement)

- Renewable policy assessment: subsidies, feed-in tariffs, investment strategies
- Climate policy assessment and energy price trends

Geographically, ASTRA covers all EU 27 Member States plus United Kingdom, Norway and Switzerland. The model is built in Vensim software and is developed and maintained by TRT, M-Five and ISI Fraunhofer.

Keywords
Transport , Energy , Environment , economy

Model category (thematic)
Transport

Model home page
http://www.astra-model.eu/

Ownership & license

Ownership

Third-party ownership (commercial companies, Member States, other organisations, …)

Ownership details

ASTRA is a private model, developed and maintained by TRT, M-FIVE and Fraunhofer-ISI [1]. The 2020 version of ASTRA, so called ASTRA 2.0, is currently used at the Energy and Transport Unit of Economics of climate change at EC JRC Seville. The 2021 version of ASTRA, aligned with projections of EU Reference 2020, has been used for EU studies supporting IA. [1] Source: http://www.astra-model.eu/index.htm.

Licence type

Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

ASTRA structure and approach

ASTRA consists of different modules, each related to one specific aspect such as the economy, transport demand or the vehicle fleet. The main modules cover the following aspects:

- Population and social structure (age cohorts and income groups)
- Economy (e.g. GDP, input-output tables, employment, consumption and investment both at aggregate and at sectoral level)
- Foreign trade (inside EU and to partners from outside EU)
- Transport (including demand estimation, modal split, transport cost and infrastructure networks)
- Vehicle fleet (passenger and freight road vehicles by segment and drivetrain)
- Environment (including pollutant emissions, CO2 emissions, energy consumption).

The economy module simulates the fundamental economic variables. Some of these variables (e.g. GDP) are transferred to the transport generation module, which uses the input to generate a distributed transport demand. In the transport module, demand is split by mode of transport. The traffic performance by mode is associated with the composition of the fleet (computed in the vehicle fleet module) and the emissions factors (defined in the environmental module), in order to estimate total emissions.

Several feedback effects take place in the ASTRA model. For instance, the economy module provides the level of income to the fleet module, in order to estimate vehicle purchase. The economy module then receives information on the total number of purchased vehicles from the fleet module to account for this item of transport consumption and investment. Furthermore, changes in the economic system immediately feed into changes of the transport behaviour and alter origins, destinations and volumes of European transport flows.

The indicators that ASTRA can produce cover a wide range of impacts; in particular transport system operation, economic, environmental and social indicators. The environment module uses input from the transport module (in terms of vehicle-kilometres-travelled per mode and geographical context) and from the vehicle fleet module (in terms of the technical composition of vehicle fleets), in order to compute fuel consumption, greenhouse gas emissions and air pollutant emissions from transport. ASTRA also estimates the upstream emissions (well-to-tank) due to fuel production and vehicles production. Therefore, well-to-wheel emissions can be provided as well.

ASTRA is calibrated to reproduce major indicators such as transport performance, fuel consumption, CO2 emissions and GDP according to the main European reference sources such as Eurostat and the EU Reference Scenario (European Commission, 2016) for future trends.

By simulating different policy bundles and framework conditions, ASTRA enables the comparison of different scenarios concerning, e.g., the diffusion of technologies, emission reductions, energy demand by energy carrier, required investments, etc.

Input and parametrization

The model includes four main components: economy, transport, technology and environment.

The *economy component* consists of five elements: supply side, demand side (including an investment module), an input-output model based on 25 economic sectors, employment module and government module. In addition, two trade models are implemented (i.e. intra-EU trade and EU to rest-of-the-world trade) [3].

The *transport component* is represented by means of two classical 4-stage transport models, one for passenger and one for freight transport, including endogenous feedback on all stages. Even if a full origin-destination matrix is not modelled, demand is segmented according to trip purpose and in different distance bands to better consider the competition between alternative modes. The transport network is not explicitly represented but information on network capacity is considered in a simplified way for the different transport modes drawing on a network based transport model such as TRUST.

The *technology component* covers the differentiation of road vehicle fleets into drivetrain technologies, age classes and different emission standard categories[1],[2]. The technologies considered are listed below and cover gasoline, diesel, compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), fuel cell electric vehicles (FCEV) and trolleys for urban buses and long-distance trucks.

- Car: gasoline, diesel, CNG, LPG, BEV, PHEV, FCEV
- LDV: gasoline, diesel, CNG, LPG, BEV, PHEV, FCEV
- HDV: diesel, CNG, LNG, BEV, PHEV, FCEV, trolley
- Urban Buses: diesel, CNG, BEV, PHEV, FCEV
- Coaches: diesel, LNG, FCEV

Investments and learning curves are included in the simulation of the fleet development process. Road freight transport demand is segmented by different vehicle types: light commercial vehicles (below 3.5 tonnes), medium heavy goods vehicles (from 3.5 to 12 tonnes) and large heavy goods vehicles (from 12 to 26 tonnes, from 26 to 32 tonnes and above 36 tonnes) - according to different spatial domains (i.e. local, short, national, international). Assumptions on the composition of vehicle fleet used in each spatial domain are made to reflect the use of each vehicle type. The demand for new heavy goods

vehicles as well as the replaced vehicles is associated with emission standards depending on the year of registration, covering conventional diesel technologies as well as other technologies mentioned above. Efficiency improvements are also included for non-road modes.

The *environment component* calculates the air pollutant emissions and energy consumption from transport based on traffic flows, the information on the composition of the vehicle fleets and on emission / energy consumption factors. ASTRA quantifies the impacts on energy consumption by fuel, CO2 emissions and air pollutants (NOx, PM, CO and VOC), as well as transport accidents and the related externality value.

References

[1] See Deliverable D4.3 of REFLEX project (Analysis of the European energy system under the aspects of flexibility and technological progress), Call: H2020-LCE-21-2015, Grant Agreement Number: 691685

[2] See Annex A of Ricardo et al. (2017) Support Study for the Impact Assessment Accompanying the Revision of Directive 1999/62/EC.

[3] See Schade et al. (2018) The impact of TEN-T completion on growth, jobs and the environment - METHODOLOGY AND RESULTS. Final Report. On behalf of the European Commission.

Main output

ASTRA assessment capabilities cover a wide range of policies with flexible timing and variable levels of the policy implementation. Potential policies include standards setting, infrastructure pricing, fuel taxation, speed limits, carbon taxes, investment in energy and transport infrastructure, trade policies etc. A strong feature of ASTRA is the ability to simulate and test integrated policy packages and to provide indicators for the indirect effects of transport on the economic system (e.g. sectoral value-added, sectoral employment, GDP, trade flows, income by income groups). ASTRA has also been applied to analyse future challenges, in particular the impact of high oil prices on the EU economy and the impact of ambitious European climate policy until 2050.

ASTRA model has been successfully used for the following applications:

- Transport policy assessment: pricing, taxation, TEN infrastructure, CO2-standards, Cost-benefit-analysis of transport projects;
- Technology and scenario analysis: technology and employment policy, hydrogen technology strategy, integrated energy and transport scenarios, energy and transport policy, impacts of connected and automated driving;
- Renewable policy assessment: subsidies, feed-in tariffs, investment strategies;
- Climate policy assessment: transport policy, EU-ETS, energy scenarios, decarbonisation strategies, investment strategies, cost implications.

The indicators that ASTRA can produce cover a wide range of impacts; in particular transport system operation, economy, environmental and social indicators.

More in detail, transport system operation indicators are estimated at aggregated level (namely at Country level); nevertheless, the additional value of using system dynamics for transport modelling enriches the analysis with respect to a traditional transport model, thanks to the linkage with the modules related to economic and technological aspects. The economic module of the ASTRA model addresses the linkages between transport and economy, mainly in terms of the effects of transport policy measures on regional GDP, consumption or sectoral employment; the fleet module reflects impacts on the technology side; the environmental module deals with health impacts of air-pollution. Furthermore, these additional impacts can interact with each other. As an example, let's take the impact of road charging. If a charge is introduced or increased for cars in the transport module, this measure has a depressing effect on car purchasing. In turn, less cars mean that some less population has a private vehicle available and, since car availability promotes personal mobility, less trips will be generated. In another step forward, the impact of road charging on the vehicle fleet propagates itself until the economic model, where less consumption and investment are modelled and therefore lower GDP, less employment and less production. The reduction of economic activity is fed back into the demand estimation, because freight transport demand depends on production and because employed people travel more than unemployed people. However, since endogenous productivity impacts are considered in the ASTRA economy model, the economic impulses of a policy may generate different impacts than in general equilibrium models primarily considering price effects.

In general, the variety of indicators estimated with the ASTRA model and the fact that these indicators are provided as time series offer the opportunity to apply a large variety of different assessment schemes to support the development of European energy, transport and climate policies. As an example, the following indicators can be provided by the ASTRA model:

- Passenger trips by mode
- Freight tonnes transported by mode
- Passenger-km travelled by mode
- Tonne-km travelled by mode
- Air pollutant emissions
- Energy consumption of transport sector
- GHG emissions of transport sector
- Transport Accidents
- Externalities of transport sector

- Transport expenditure
- Road vehicle fleet composition by technology
- GDP
- Employment total and sectoral
- Consumption total and sectoral
- Investment total and sectoral
- Sectoral gross value-added
- Sectoral trade flows.

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	EU Member states 27 and UK; Norway; Switzerland
(Spatial) resolution	National; Sub-national (NUTS1); Sub-national (NUTS2)
Temporal extent	Medium-term (5 to 15 years); Long-term (more than 15 years)
Temporal resolution	Years

Quality & transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	yes	ASTRA is a model based on the System Dynamics approach which is a methodology perfectly suited for dealing with uncertainty as it offers the possibility to combine quantitative and qualitative inputs in the modelling. Furthermore, the running time of ASTRA model simulations up to the year 2050 takes only a few minutes and this makes it possible to analyse effectively different scenarios and respective variants.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Sensitivity analysis tests are usually performed during the ASTRA model calibration phase. In many studies sensitivity tests have been done as well during the analysis of policy options in order to assess the soundness of model results.
Have model results been published in peer-reviewed articles?	yes	Model results have been published in different peer reviewed journals as well as in PhD thesis. Since many years the model is also regularly used by the Energy and Transport Unit of Economics of climate change at EC JRC Seville.
Has the model formally undergone scientific review by a panel of external experts? (Please note that this does not refer to the cases when model results were validated by stakeholders)	no	A peer review of the model itself by a panel of experts has not been performed.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	no	

References related to external peer-review and publication in scientific journals:

- No references provided in MIDAS

Transparency

Question	Answer	Details
To what extent do input data come from publicly available sources? (Note: this may include sources accessible upon subscription and/or payment)	Based on both publicly available and restricted-access sources	The ASTRA database is a combination of publicly available data from official sources (such as Eurostat) and specific data that have been elaborated by the modelers team drawing from scientific literature, statistics, sector studies, etc.
Is the full model database as such available to external users? (The answer 'yes' comprises the cases when access to the database implies a specific procedure or a fee)	no	
Have model results been presented in publicly available reports (in addition to IA reports and journal articles)?	Yes	According to the needs of the clients of the studies, model outputs have been made public. Over the years ASTRA model results have been presented in many publicly available reports.
Have output datasets been made	no	

publicly available? (Note: this could also imply a specific procedure or a fee)		
Is there any user-friendly interface presenting model results – such as dashboards or interactive interfaces – that is accessible to the public?	no	The development of a dashboard to present results would be an interesting objective that would be supported by the developers. So far, projects did not fund such an endeavour.
Has the model been documented in a publicly available report or a manual?	Yes	The detailed description of ASTRA-EC version of the model is available at [1] http://www.astra-model.eu/index.htm, [2] Fermi F., Fiorello D., Krail M., Schade W. (2014): Description of the ASTRA-EC model and of the user interface. Deliverable D4.2 of ASSIST (Assessing the social and economic impacts of past and future sustainable transport policy in Europe). Project co-funded by European Commission 7th RTD Programme. Fraunhofer-ISI, Karlsruhe, Germany, and [3] Schade W. (2005): Strategic Sustainability Analysis: Concept and application for the assessment of European Transport Policy". NOMOS-Verlag, ISBN 3-8329-1248-7, Baden-Baden.
Is there a dedicated public website where information about the model is provided?	yes	
Is the model code open source?	no	
Can the code be accessed upon request?	no	

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Climate action
- Economy, finance and the euro
- Energy
- Environment
- Transport
- Research and innovation

The model is designed to contribute to the following phases of the policy cycle

- Formulation
- Evaluation

The model's potential

Policy assessment capabilities in ASTRA cover a wide range of policies with flexible timing and levels of the policy implementation. Potential policies include standard setting, infrastructure pricing, fuel taxation, speed limits, carbon taxes, trade policies etc. A strong feature of ASTRA is the ability to simulate and test integrated policy packages and to provide indicators for the indirect effects of transport on the economic system. More info can be found at: http://www.astra-model.eu/index.htm

Impact types that can be assessed with the models include:

Transport

- Transport modes
    - Transport volumes
    - Modal split
    - Transport expenditure

Can be assessed through: Modelling of specific scenarios, also in combination with TRUST

Economy

- Economy sectors
    - GDP

- Employment
- Trade

Can be assessed through: Modelling of specific scenarios; Combined modelling with bottom-up models

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Environment and Climate Policy

- Emissions
  - GHG emissions
  - Air Pollutant emissions
  - Accidents

Can be assessed through: Modelling of specific scenarios

Energy

- Energy consumption from the transport sector
  - Energy consumption by mode of transport

Can be assessed through: Modelling of specific scenarios

Innovation and Technology Policy

- Economy
  - GDP,
  - Investment,
  - Productivity

Can be assessed through: Modelling of specific scenarios; Combined modelling with bottom-up models

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	ASTRA contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2021	Revision of the Intelligent Transport Systems Directive	MOVE	Baseline and assessment of policy options	*Trasporti e Territorio Srl*	The model helped to assess the following impacts: - Cost/availability of essential inputs (raw materials, machinery, labour, energy, ..) - Cost of doing business - Prices, quality, availability or choice of consumer goods and services - Safety or sustainability of consumer goods and services - Economic growth and employment - Health and safety of individuals/populations - Health due to changes in the amount of noise, air, water or soil quality - Emission of greenhouse gases - Emissions of acidifying, eutrophying, photochemical or harmful air pollutants - Demand for transport - Vehicle emissions - Energy and fuel consumption
2019	Impact assessment accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to: the deployment and operational use of cooperative intelligent transport systems SWD/2019/0096 final	MOVE	Baseline and assessment of policy options	*Trasporti e Territorio Srl*	The baseline and a set of policy options and deployment scenarios were assessed with the European scale modelling tools ASTRA and TRUST for the analysis and comparison of the impacts in terms of economic, environmental and social indicators. Documented in: - DOI 10.2832/067308

Bibliographic references

- *No references provided in MIDAS*

TRUST

Overview

Acronym TRUST
Full title TRansport eUropean Simulation Tool

Main purpose
TRUST is a European scale transport network model simulating road, rail and maritime transport activity.

Summary
TRUST is a European scale transport network model developed and maintained by TRT and simulating road, rail, inland waterways and maritime transport activity.

TRUST covers the whole Europe and its neighbouring countries and it allows for the assignment of passenger and freight origin-destination matrices at NUTS3 level of detail (about 1600 zones) on the multimodal transport network. Based on Eurostat data, national statistics and ETISPLUS database (CORDIS RCN : 92896), TRUST is calibrated to reproduce tonnes-km and passengers-km by country consistent to the statistics reported in the DG MOVE Transport in Figures pocketbook.

TRUST can be used in the context of impact assessments and for supporting policy formulation and evaluation. It is particularly suitable for modelling road charging schemes for cars and heavy goods vehicles as well as policies in the field of infrastructure (e.g. completion of the core and comprehensive Trans-European Transport (TEN-T) network). The model is currently used in the DG MOVE Framework Contract regarding the elaboration of long-term policy scenarios and variants for the transport system of all 27 Member States of the European Union with the time horizon of 2050.

Further information on TRUST is available on http://www.trt.it/en/tools/trust/

Keywords
transport network

Model category (thematic)
Transport

Model home page
http://www.trt.it/en/tools/trust/

Ownership & license

Ownership

Third-party ownership (commercial companies, Member States, other organisations, …)

Ownership details

TRT

Licence type

Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

TRUST structure and approach

TRUST is a transport network model for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight demand on the multimodal transport network of Europe. Road rail, inland waterways and maritime transport modes are covered in separate modules, each with its own matrices, that are then assigned simultaneously on the multimodal transport network. The current version of the TRUST model does not deal with modal split and its main output is the load on road network links in terms of vehicles per day and on non-road links in terms of either passengers or tonnes per day.

TRUST is built in PTV-VISUM software environment. The assignment algorithm used is Equilibrium Assignment which distributes demand for each origin/destination pair among available alternative routes, according to Wardrop first principle. This principle assumes that each traveller is identical, non-cooperative and rational in selecting the shortest route, and knows the exact travel time he/she will encounter. If all travellers select routes according to this principle the road network will be at equilibrium, such that no one can reduce their travel times by unilaterally choosing another route of the same OD pair. This principle has been extended to consider generalised travel cost instead of travel time, where generalised travel cost can include the monetary cost of in-vehicle travel time, tolls, parking charges and fuel consumption costs. The impedance function is defined in terms of generalised time from an origin O to a destination D. Travel costs are defined separately by link types using combinations of fixed, time-dependent and distance-dependent parameters. Travel time is estimated endogenously by the model as result of the assignment. Speed-flow functions are used to model the impact of traffic on free-flow speeds, given links capacity. The model iterates until a pre-defined convergence criterion for equilibrium is reached.

TRUST road transport module

The TRUST road module deals with the assignment of road transport O-D matrices for both passenger (cars) and freight (trucks>3.5t). The road network includes all relevant links between the NUTS3 regions, i.e. motorways, primary roads as well as roads of regional and sub-regional interest. Also ferry connections (Ro-Ro services) between European regions and between European regions and North Africa are explicitly modelled with their travel time and fare.

Road transport demand is modelled in TRUST by means of origin/destination matrices between NUTS3 zones. Intra-NUTS3 demand is not part of the matrices as it is not assigned to the network, but implicitly considered as pre-load on network links. For some non EU countries (e.g. Russia or Ukraine) domestic demand is not part of the matrices.

The passenger matrix includes car trips (coach trips are not modelled) and is segmented into three groups:

- Short distance (< 100 km) commuting

- Short distance (< 100 km) non-commuting
- Long distance (> 100 km)

The freight matrix includes vehicles above 3.5 tonnes between NUTS3 zones and is segmented into the following demand groups:

- Domestic Short distance (<=50 km)
- Domestic average distance (50 –150 km)
- Domestic Long distance (>= 150 km)
- International.

This segmentation allows us to apply dedicated parameters (e.g. considering that short distance domestic transport usually is made of lighter trucks than long distance international transport) and to measure the contribution of the typical vehicles of each segment to link loads. In addition, each demand group is further divided by considering the origin country (the are 242 flows in total) as this allows for the differentiation of fuel costs for the vehicles. Base year (2017) matrices are derived from those estimated in the ETISplus project with further revisions to match Eurostat statistics on road traffic. For forecasting purposes, future matrices are estimated exogenously by applying demand growth rates taken from available sources (e.g. EU Energy and transport trend, ASTRA model, etc.).

Speed-flow functions in TRUST are used to simulate congestion on road links. Since the model assigns daily matrices the speed-flow curves implemented as attributes of the road links are adjusted to take into account that congestion is more hardly recognisable if demand and supply are compared on a 24 hour basis. Speed-flow functions depends on link type, speed and flow/capacity ratio.

Fuel consumption and emissions factors for road modes build on COPERT IV functions but with a relevant modification. Basically, the convex form of the COPERT function has been modified to consider that in real traffic conditions average speeds (the assignment model provides average speeds) are most likely the result of repeated stop-and-go. An average speed of e.g. 70 km/h on motorways means that there is more traffic than when average speed is 110 km/h so one should expect more fuel consumption rather than less fuel consumption as implied by original COPERT functions.

Since COPERT functions are different by vehicle type, an average fleet composition is considered to derive the parameters used in TRUST. When the model is run for forecasting purposes for future years, the emission factors are updated considering projections regarding the evolution of fleet in the selected year.

TRUST rail transport module

TRUST rail module does not consider capacity restrictions and follows an AON (All or Nothing) assignment of origin/destination matrices on the minimum path available on the network. This means

that the transport volume on the rail links are computed irrespective of the availability of rail services and of transport chains.

The rail network includes different link types according to technical elements (number of tracks, electrification, maximum speed allowed, etc.) as drawn from the ETISplus database. Links dedicated to some type of traffic (e.g. high-speed service or freight trains) are distinguished as well as links where some types of train are not allowed. The rail network is linked to the road network as intermodal transport is modelled. Rail supply includes intermodal terminals where loads are transferred between road and rail. There are 917 intermodal terminals across the EU countries. In case of passenger transport the interchange links between local/intercity services and high-speed services and transfer between car feeder and local/intercity services are modelled as well.

Rail demand is segmented according to types of traffic which correspond to different train types in terms of occupancy of rail capacity. For passenger demand, three segments based on train type are used:

- Regional Trains
- Intercity Trains
- High Speed Trains (or similar, like the German ICE trains)

Two different types of freight trains are considered:

- intermodal trains,
- conventional trains (conventional block trains or single wagon load trains), which is further split into three groups:
    - conventional trains 700 tonnes
    - conventional train 1200 tonnes
    - conventional train 2900 tonnes.

TRUST maritime transport module

The maritime network includes several ports throughout Europe. Fictitious maritime links provide sea routes to link ports and allows the model to compute travel distances of maritime connections.

Maritime ports are classified into three categories: bulk ports, container ports and general cargo ports. Most of the ports belong to more than one category but some ports have only one or two specialisations; ports can host only demand for those freight segments (e.g. if one port is classified as a bulk port only, maritime routes for general cargo and container demand cannot go through that port). For zones without ports there is no direct access to ship mode, which in turn can be accessed through feeder modes (truck, rail or inland waterway according to existing infrastructures). As a consequence,

rail, road and inland waterway networks are also used in the TRUST maritime model because trains, trucks and barges are used as feeder modes to connect inland zones with ports and allow a full path between the origin and the final destination of freight shipment.

Maritime demand consists of origin/destination matrices segmented according to the three categories of bulk, container and general cargo. Matrices are in terms of tonnes per year and each segment of demand has its matrix that is assigned independently to the network.

TRUST inland waterway transport module

TRUST inland waterways (IWW) network includes all the relevant canals among all the NUTS3 regions covered by the spatial area of the model. The network includes 70 main inland ports across Europe selected on the basis of the quantities of goods handled or on their strategic role along the international routes. Each IWW network link has specific features in term of free-flow speed. Specific flags are used to identify links belonging to the Core TEN-T Network, to each TEN-T Corridor and to the comprehensive network. Therefore, results can be provided for these subsets of the network. Demand Origin-Destination matrices are segmented according to two main freight categories: container and non-container. Matrices are based on ETISplus project and further refined on Eurostat statistics.

Further information on TRUST is available on http://www.trt.it/en/tools/trust/

Input and parametrization

TRUST road transport module input

- OD Matrices at NUTS3 level in terms of vehicles
- Speed-flow functions
- Transport costs by mode
- Travel time value
- Average fuel consumption
- Average emission factors

TRUST rail transport module input

- OD Matrices at NUTS3 level in terms of trips or tonnes in an average day (24 hours)
- Transport costs
- Occupancy / Load factors
- Rail link attributes

TRUST maritime transport module input

- OD Matrices at NUTS3 level in terms of tonnes (bulk, container and general cargo)
- Transport costs
- Occupancy / Load factors
- Maritime link attributes

TRUST inland waterways transport module input

- OD Matrices at NUTS3 level in terms of tonnes (container, non-container)
- Transport costs
- Occupancy / Load factors
- Iww link attributes

Main output

TRUST road module outputs

- Average daily loads on road links split by demand segment and by country of origin
- Road traffic activity (passenger-km, tonnes-km, vehicle-km) per year by country (based on territoriality principle).
- Road traffic activity (passenger-km, tonnes-km, vehicle-km) per year on TEN-T core network and on TEN-T corridors.
- Origin-destination journey time.
- Origin-destination journey (perceived) cost.
- Road accessibility measures by NUTS-III region.
- Origin-Destination Paths.
- Energy consumption by link. This can be aggregated to get results by country (territorial principle), on TEN-T core network and on TEN-T corridors.
- Emissions by link for NOx, PM, VOC, CO and CO2.This can be aggregated to get results by country (territorial principle), on TEN-T core network and on TEN-T corridors.

TRUST rail module outputs

- Average daily loads on rail links split by demand segment.

- Rail traffic activity (passenger-km, tonnes-km) per year by country (based on territoriality principle).
- Rail accessibility measures by NUTS-III region.

TRUST maritime module outputs

- Seaport throughput (tonnes) per year by port and cargo type (container, bulk, other)
- Share of feeder modes transporting freight to/from seaports
- Maritime accessibility measures by NUTS-III region

TRUST inland waterways module outputs

- Average daily loads on iww links split by demand segment
- Iww traffic activity (tonnes-km) per year by country (based on territoriality principle).

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	EU Member States 27; Andorra; Serbia; Macedonia; Albania; Bosnia and Herzegovina; Kosovo; Lichtenstein; Montenegro; Turkey; United Kingdom; Norway; Switzerland; Belarus; Ukraine; Moldova; Russia.
(Spatial) resolution	National; Sub-national (NUTS1); Sub-national (NUTS2); Sub-national (NUTS3)
Temporal extent	Medium-term (5 to 15 years); Long-term (more than 15 years)
Temporal resolution	Multiple years

Quality & Transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	Yes	TRUST assigns O/D matrices at NUTS3 level. Intra-zonal traffic is not assigned on the network, although it is taken into account as pre-load on road links. The lack of intra-zonal demand modelling might be particularly relevant for passenger demand as the most part of it is short to medium distance. TRUST rail assignment does not consider capacity restrictions. This means that transport volumes on the rail links are computed irrespective of the availability of rail services and of transport chains. Given the strategic European scale of the model, detailed analysis at local level or at project level are outside its scope.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	Yes	Sensitivity analysis on key model's parameters are regularly performed during the calibration of the model and its applications.
Have model results been published in peer-reviewed articles?	No	
Has the model formally undergone scientific review by a panel of external experts? (Please note that this does not refer to the cases when model results were validated by stakeholders)	No	
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	No	

References related to external peer-review and publication in scientific journals:

- No references provided in MIDAS

Transparency

Question	Answer	Details
To what extent do input data come from publicly available sources? (Note: this may include sources accessible upon subscription and/or payment)	Based on both publicly available and restricted-access sources	TRUST model databases are the results of TRT work of harmonization and integration of different sources, including public ones.
Is the full model database as such available to external users? (The answer 'yes' comprises the cases when	No	

access to the database implies a specific procedure or a fee)		
Have model results been presented in publicly available reports (in addition to IA reports and journal articles)?	Yes	Results of model applications are provided to the Client. The Client has the right to make outputs publicly available or not.
Have output datasets been made publicly available? (Note: this could also imply a specific procedure or a fee)	No	
Is there any user-friendly interface presenting model results – such as dashboards or interactive interfaces – that is accessible to the public?	No	
Has the model been documented in a publicly available report or a manual?	Yes	http://www.trt.it/wp/wp-content/uploads/2016/09/TRUST-model-detailed-description-1.pdf
Is there a dedicated public website where information about the model is provided?	Yes	http://www.trt.it/en/tools/trust/
Is the model code open source?	No	The model source code is property of TRT.
Can the code be accessed upon request?	No	

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Transport

The model is designed to contribute to the following phases of the policy cycle

- Formulation
- Evaluation

The model's potential

TRUST is particularly suitable for modelling road charging schemes for cars and heavy goods vehicles, and policies in the field of infrastructure (e.g. completion of the core and comprehensive Trans-European Transport (TEN-T) network).

More specifically the policy measures that can be simulated with TRUST are:

Road sector

- Road charging (e.g. Eurovignette): Charges can be coded directly if they are based on demand segments of the model, otherwise average charges based on e.g. fleet composition should be estimated exogenously
- Energy taxation: average change of operating cost can be coded according to fleet composition by country
- Road infrastructure changes: Changes can consist of new links and improved links. Given the scale of the model, simulation is meaningful for major modifications (e.g. one corridor) rather than for single links.
- Speed limits
- Technology – transport information system, management & service: As far as technology is supposed to modify elements like travel speed or link capacity. The entity of the modification should be estimated exogenously
- Truck driver regulations: Indirect simulation based on exogenous assumption on expected impact of regulation on driving cost.

Rail sector

- Infrastructure charging: Charges can be coded directly if they are based on demand segments of the model otherwise average charges should be estimated exogenously

- Rail infrastructure changes: Changes can consist of new links and improved links. Given the scale of the model, simulation is meaningful for major modifications (e.g. one corridor) rather than for single links.
- Technology – transport information system, management & service: As far as technology is supposed to modify elements like travel speed or operational costs. The entity of the modification should be estimated exogenously

Maritime sector

- Infrastructure charging: As far as ports can be charged
- Technology – transport information system, management & service: As far as technology is supposed to modify costs or times at ports. Modification should be estimated exogenously
- Port regulations: As far as regulation is supposed to modify costs or times at ports. Modification should be estimated exogenously

Inland waterways sector

- IWW infrastructure changes: Changes can consist of new links and improved links. Given the scale of the model, simulation is meaningful for major modifications.
- Port regulations : As far as regulation is supposed to modify costs or times at IWW ports. Modification should be estimated exogenously
- Technology – transport information system, management & service: As far as technology is supposed to modify elements like travel speed or reduce operation costs. The entity of the modification should be estimated exogenously.

Impact types that can be assessed with the models include:

Transport

- Transport impact, Environmental impact, Economic impact
    - Transport volumes
    - Modal split
    - Network impacts
    - Emissions
    - Noise
    - Transport costs

Can be assessed through: Modelling of specific scenarios in combination with ASTRA

Previous use of the model in ex-ante impact assessments of the European Commission

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	TRUST contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2021	Revision of the Intelligent Transport Systems Directive	MOVE	Baseline and assessment of policy options	*Trasporti e Territorio Srl*	The model helped to assess the following impacts: - Cost/availability of essential inputs (raw materials, machinery, labour, energy, ..) - Cost of doing business - Prices, quality, availability or choice of consumer goods and services - Safety or sustainability of consumer goods and services
2021	Impact assessment accompanying the Proposal for a Regulation of the European Parliament and of the Council: on the use of renewable and low-carbon fuels in maritime transport SWD/2021/635 final	MOVE	Baseline and assessment of policy options	*Trasporti e Territorio Srl*	TRUST model helped assessing the impacts on carbon leakage
2019	Impact assessment accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to: the deployment and operational use of cooperative intelligent transport systems SWD/2019/0096 final	MOVE	Baseline and assessment of policy options	*Trasporti e Territorio Srl*	The baseline and a set of policy options and deployment scenarios were assessed with the European scale modelling tools ASTRA and TRUST for the analysis and comparison of the impacts in terms of economic, environmental and social indicators. Documented in: - DOI 10.2832/067308
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: establishing a European Maritime Single Window environment and repealing directive 2010/65/EU SWD/2018/181 final	MOVE	Baseline and assessment of policy options	*Trasporti e Territorio Srl*	PRIMES-TREMOVE together with TRUST have been also used to assess the impacts of policy options on modal shift and CO2 emissions.

Bibliographic references

- *Support study for the evaluation of Regulation (EU) N° 1315/2013 on Union guidelines for the development of the trans-European transport network : final report. - 10.2832/106561*
- *The impact of Ten-T completion on growth, jobs and the environment : methodology and results : final report. - 10.2832/374574*

PRIMES-TREMOVE

Overview

Acronym PRIMES-TREMOVE
Full title PRIMES-TREMOVE Transport Model

Main purpose
PRIMES-TREMOVE simulates the transport modelling system and projects the evolution of the demand for passenger and freight transport by mode, energy consumption by fuel and emissions. The model is rich in the representation of policy measures and is used to assess policy impacts.

Summary
PRIMES-TREMOVE is a transport modelling system of multi-agent choices. The model has been developed by the E3MLab and is part of the PRIMES suite of models. Part of the model (i.e. the transport demand module), has been based on features of the open source TREMOVE model developed by Transport & Mobility Leuven. The model is suited for long term (up to 2070) projections in 5-year steps and covers all EU Member States and selected EFTA and candidate countries.

PRIMES-TREMOVE solves partial market equilibrium between the demand and the supply of transport services. Choices among alternative transport options and investment are represented by various agents' types, which differ in terms of their transport demand. Solving for equilibrium also involves the computation of energy consumption, emissions of pollutants and externality impacts related to the use of transportation means.

The model is used for policy formulation. Model projections include the transport demand by transport mode, technologies and fuels, including conventional and alternative types, and their penetration in various transport market segments. Model projections also include information about greenhouse gas and air pollution emissions, as well as impacts on external costs of congestion, noise and accidents. PRIMES-TREMOVE has been used for the 2011 Transport White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" (COM(2011) 144 final); for the "A European Strategy for low-emission mobility" (COM(2016) 501), for the 2050 Long-term Strategy (A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy; COM (2018) 773) and for many other policy documents and Impact Assessments.

Keywords
Transport , Energy , Environment , Climate , Climate policy , Air Pollution , transport demand , GHG emissions , technology innovation , market outlook

Model category (thematic)
Transport

Commission modelling inventory and knowledge management system (MIDAS)
Report generation date 20/12/2021

Model home page
https://e3modelling.com/modelling-tools/primes-tremove

Ownership & license

Ownership

Third-party ownership (commercial companies, Member States, other organisations, …)

Ownership details

The PRIMES-TREMOVE is a private model that has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens and E3-Modelling SA.

Licence type

Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

PRIMES-TREMOVE structure and approach

The model consists of two main modules: the *transport demand allocation module* and the *technology choice and equipment operation module*. The two modules interact with each other and are solved simultaneously.

The *transport demand allocation module* simulates mobility decisions driven by macroeconomic drivers which distribute the transport activity over different transport modes and trip types, so as to calculate transport services by mode for both individuals and firms. The decision process is simulated as a utility maximisation problem under budget and other constraints for individual private passengers and as a cost minimisation problem for firms.

The *technology choice and equipment operation module* determines the mix of vehicle technologies (generally the transportation means), the operation of transport means by the trip type and fuel mix such as to meet the modal transport demand at the least cost. In the case of supply by transportation companies, the module calculates transportation tariffs (ticket prices). Consumer or firm choices at various levels of the supply module use total costs, inclusive of capital costs, or only variable costs, as appropriate. For example purchasing a new car involves total cost comparisons among alternative solutions, but the choice of the fuel type for an existing car, if that is possible, or determining the rate of use of an existing car naturally involves only variable costs. The choice of technology is generally the result of a discrete choice problem which considers relative costs which optionally include factors indicating impacts on externalities and the impacts of intangible costs (e.g. market acceptance, range anxiety).

Part of the supply of transport services is carried out by the same agent who is consuming such services; in other words, supply is split between self-supply of transport services and the purchasing of transport services from transportation companies. To self-supply the service, the consumer (individual or firm) faces both capital and variable costs, where capital costs correspond to the purchase of transportation means, whereas when purchasing transport services from transport suppliers the consumer faces only variable costs (corresponding to ticket prices). Transportation companies also face capital and variable costs. They sell their services at transport tariffs (ticket prices, etc.). Further, there is no capital rent for the self-supply of transport services and the consumer chooses between alternative self-supply solutions by comparing total costs, assuming the average cost pricing of alternative solutions.

Both the *transport demand allocation* and *technology choice and equipment operation* modules are dynamic over time, simulate capital turnover with possibility of premature replacement of equipment and keep track of equipment technology vintages.

Prices – as set by transportation companies – are based on marginal costs, which may allow for capital rents (e.g. aviation). Other transportation companies – owned by the state and subject to a strong price regulation – apply average (instead of marginal) cost pricing rules to determine transportation tariffs. To include external costs, such as congestion, the model includes additional components in the equilibrium

prices which is termed the “generalised price of transportation” and is calculated both for the self-production and for the business supply of transport services.

Computationally, the model is solved as a non-linear mixed complementarity problem. Optionally, policy targets related to externalities (or the overall efficiency or overall emissions) may be included as binding constraints; through the mixed complementarity formulation of the model, such overall constraints influence all choices in the demand and supply transport modules.

Formally, the model solves an equilibrium problem with equilibrium constraints (EPEC) simultaneously for multiple transport services and for multiple agents, some of which are individual consumers and firms, which consume or produce transport services. The EPEC formulation also includes overall constraints which represent policy targets, e.g. emissions, energy, etc., which influence both demand and supply. Solving for equilibrium also involves the computation of energy consumption, emissions of pollutants and externality impacts related to the use of transportation means.

Input and parametrization

The PRIMES-TREMOVE transport model is calibrated to 2005, 2010 and 2015 historical data.

The main data (such as activity and energy consumption) comes from EUROSTAT database and from the Statistical Pocketbook "EU transport in figures" (DG MOVE). Excise taxes are derived from DG TAXUD excise duty tables (https://ec.europa.eu/taxation_customs/tedb/splSearchForm.html;jsessionid=gDc40clH3ufxfoKOdXcM1t26oFiV84od01egfLest4uUPKZdXGiM!530641174). Other data comes from different sources such as research projects (e.g. TRACCS project) and reports. Technology cost assumptions for the transport modes have been validated by a large group of stakeholders in the process of the development of the Reference scenario 2020.

Main output

The PRIMES-TREMOVE model produces projections of transport activity, stock turnover of transport means, technology choice, energy consumption by fuel, greenhouse gas and air pollution emissions, and costs (including impacts on external costs of air pollution, congestion, noise and accidents). The projection includes details for a large number of transport means, technologies and fuels, including conventional and alternative types, and their penetration in various transport market segments.

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	EU Member states 27 and UK; Norway; Switzerland; Iceland; Albania; Republic of North Macedonia; Bosnia and Herzegovina; Serbia; Montenegro; Moldova (the Republic of); Turkey; Ukraine
(Spatial) resolution	National
Temporal extent	Long-term (more than 15 years)
Temporal resolution	Multiple years

Quality & transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	Yes	The model accounts for the various uncertainties in specific input data assumptions by carrying out scenario analysis and modifying the values on selected or a set of input data. Such are the cases related to technology cost assumptions, GDP and fuel prices evolution and a combination of those. Scenarios analysis is also carried out on policy parameters like charges, taxation, vehicle standards, etc.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	Yes	The model has been frequently used for carrying out sensitivity analysis around specific uncertain inputs. The sensitivity analysis used in the model only considers changes in one input parameter such as fuel prices or GDP evolution.
Have model results been published in peer-reviewed articles?	Yes	The model results have been communicated to the scientific audience. Model results have also been reviewed as part of deliverables in H2020 research projects.
Has the model formally undergone scientific review by a panel of external experts? (Please note that this does not refer to the cases when model results were validated by stakeholders)	Yes	As module of the PRIMES energy system model, PRIMES-TREMOVE has been successfully peer reviewed in 2011. See Commission staff working paper: SEC(2011)1569.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	Yes	Validation consists in comparing to officially published policy indicators and on checking continuity of time series from past to future. The model includes calibration routines, which ensure that when the model runs retrospectively it replicates statistical data. With respect to future projections, validation is more complex because it relies on economic theory and practice. Academic validation is also practiced through publications subject to external peer review and comparisons to other studies and independent publications.

References related to external peer-review and publication in scientific journals:

- Capros, P., Zazias, G., Evangelopoulou, S., Kannavou, M., Fotiou, T., Siskos, P., … Sakellaris, K. (2019). Energy-system modelling of the EU strategy towards climate-neutrality. Energy Policy, 134, 110960. doi:10.1016/j.enpol.2019.110960
- Statharas, S., Moysoglou, Y., Siskos, P., Zazias, G., & Capros, P. (2019). Factors Influencing Electric Vehicle Penetration in the EU by 2030: A Model-Based Policy Assessment. Energies, 12(14), 2739. doi:10.3390/en12142739

- Siskos, P., & Moysoglou, Y. (2019). Assessing the impacts of setting CO2 emission targets on truck manufacturers: A model implementation and application for the EU. Transportation Research Part A: Policy and Practice, 125, 123–138. doi:10.1016/j.tra.2019.05.010
- Siskos, P., Zazias, G., Petropoulos, A., Evangelopoulou, S., & Capros, P. (2018). Implications of delaying transport decarbonisation in the EU: A systems analysis using the PRIMES model. Energy Policy, 121, 48–60. doi:10.1016/j.enpol.2018.06.016
- Capros, P., Kannavou, M., Evangelopoulou, S., Petropoulos, A., Siskos, P., Tasios, N., … DeVita, A. (2018). Outlook of the EU energy system up to 2050: The case of scenarios prepared for European Commission's "clean energy for all Europeans" package using the PRIMES model. Energy Strategy Reviews, 22, 255–263. doi:10.1016/j.esr.2018.06.009
- Siskos, P., Capros, P., & De Vita, A. (2015). CO 2 and energy efficiency car standards in the EU in the context of a decarbonisation strategy: A model-based policy assessment. Energy Policy, 84, 22–34. doi:10.1016/j.enpol.2015.04.024
- Capros, P., De Vita, A., Fragkos, P., Kouvaritakis, N., Paroussos, L., Fragkiadakis, K., … Siskos, P. (2015). The impact of hydrocarbon resources and GDP growth assumptions for the evolution of the EU energy system for the medium and long term. Energy Strategy Reviews, 6, 64–79. doi:10.1016/j.esr.2015.03.003
- Rodrigues, R., Pietzcker, R., Fragkos, P., Price, J., McDowall, W., Siskos, P., … Capros, P. (2022). Narrative-driven alternative roads to achieve mid-century CO2 net neutrality in Europe. Energy, 239, 121908. doi:10.1016/j.energy.2021.121908
- Gómez Vilchez, J. J., Julea, A., Peduzzi, E., Pisoni, E., Krause, J., Siskos, P., & Thiel, C. (2019). Modelling the impacts of EU countries' electric car deployment plans on atmospheric emissions and concentrations. European Transport Research Review, 11(1). doi:10.1186/s12544-019-0377-1
- Statharas, S., Moysoglou, Y., Siskos, P., & Capros, P. (2021). Simulating the Evolution of Business Models for Electricity Recharging Infrastructure Development by 2030: A Case Study for Greece. Energies, 14(9), 2345. doi:10.3390/en14092345

Transparency

Question	Answer	Details
To what extent do input data come from publicly available sources? (Note: this may include sources accessible upon subscription and/or payment)	Based on both publicly available and restricted-access sources	Key databases upon which the model is built are publically available (e.g. EUROSTAT data on transport activity and energy balances). The technology input data, as well as other elements are fully publicly available.
Is the full model database as such available to external users? (The answer 'yes' comprises the cases when access to the database implies a specific procedure or a fee)	No	
Have model results been presented in	Yes	Outputs are reported in publically available technical

publicly available reports (in addition to IA reports and journal articles)?		reports, scientific papers and research projects final reports.
Have output datasets been made publicly available? (Note: this could also imply a specific procedure or a fee)	Yes	Selected model outputs are made publicly available. Published outputs are defined by the Commission and are project-specific.
Is there any user-friendly interface presenting model results – such as dashboards or interactive interfaces – that is accessible to the public?	Yes	
Has the model been documented in a publicly available report or a manual?	Yes	These are documented in several publications in scientific journals and in the model documentation which is publically available.
Is there a dedicated public website where information about the model is provided?	Yes	
Is the model code open source?	No	The code is not open. However, the mathematical formulations of the model are published in the manual as well as in peer reviewed articles
Can the code be accessed upon request?	No	

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Climate action
- Energy
- Transport

The model is designed to contribute to the following phases of the policy cycle

- Formulation
- Evaluation

The model's potential

The model can be used for policy formulation. Model projections include the transport demand by the transport mean, technologies and fuels, including conventional and alternative types, and their penetration in various transport market segments. It also includes details about greenhouse gases and air pollution emissions, as well as impacts on external costs of congestion, noise and accidents.

In the transport field, PRIMES-TREMOVE is suitable for modelling *soft measures* (e.g. eco-driving, deployment of Intelligent Transport Systems, labelling) *economic measures* (e.g. subsidies and taxes on fuels, vehicles, emissions; ETS for transport (road transport, aviation and maritime) when linked with PRIMES; pricing of congestion and other externalities such as air pollution, accidents and noise; measures supporting R&D), *regulatory measures* (e.g. CO2 emission performance standards for new passenger cars, new light commercial vehicles, heavy duty vehicles); EURO standards on road transport vehicles; technology standards for non-road transport technologies), *infrastructure policies for alternative fuels* (e.g. deployment of refuelling/recharging infrastructure for electricity, hydrogen, LNG, CNG). Used as a module which contributes to a broader PRIMES scenario, PRIMES-TREMOVE can show how policies and trends in the field of transport contribute to economy wide trends in energy use and emissions. Using data disaggregated per Member State, it can show differentiated trends across Member States.

The PRIMES-TREMOVE model has been used for the Impact Assessments accompanying the 2011 Transport White Paper , "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" (COM(2011) 144 final); for the "A European Strategy for low-emission mobility" (COM(2016) 501), for the 2050 Long-term Strategy (A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy; COM (2018) 773) and for many other policy documents and Impact Assessments. In 2020 and 2021, the model also provided quantitative input in various IA of the Fit for 55 policy package and in evaluation studies of existing directives (e.g. AFID) and initiatives (e.g. White Paper in transport).

PRIMES-TREMOVE can help to assess:

Pricing

- Infrastructure charging (e.g. Eurovignette) through:
    - Changing travel cost associated to specific infrastructures
- External costs charges (for all modes) through:
    - Changing travel costs of transport modes
- Public funding of transport (subsidies) through:
    - Changing travel cost of bus and rail

Taxation

- Energy taxation (identify energy and CO2 component) through: Changing fuel tax values by fuel type
- Vehicle taxation Changing through: cost of new vehicles

Regulation

- Standard - Transport safety through:
    - Reduction of accident factors
- Regulation on CO2 from road vehicles through:
    - Assumptions on CO2 emissions limits of new cars, light commercial vehicles and heavy goods vehicles are implemented
- Regulation on polluting emission from road vehicles (EURO standards) through:
    - Assumptions on polluting emissions limits of new cars and heavy goods vehicles are implemented
- Emissions standards for non-road modes (e.g. ICAO chapter 3 on aircraft emissions, Energy Efficiency Design Index for maritime, sulphur limits of marine fuels, etc.) through:
    - Assumptions on emissions limits of new trains/aircrafts, etc. are implemented; reduction of emissions factors for vessels
- Emissions Trading Scheme through:
    - Inclusion of aviation in EU ETS starting with 2012 – Changing transport costs of air transport; similar examples for road and maritime transport
- Fuel quality through:

  - Changing fuel cost by fuel type, fuel blends, maximum blending percentages, air pollutant emission factors

- Renewable energy directive through:
  - Mandatory fuels blending

- Clean Power for Transport andAvailability of refuelling/recharging Infrastructure through:
  - Changing parameters interpreting availability of refuelling/recharging infrastructures leading to faster penetration of alternative technologies

Note: the model contributions indicated in this section focus on the assessment for policy options. *In addition, this model is extensively used for the construction of the baseline in the EU Reference Scenario. This is indicated under the 'additional information' section for the related impact assessments. To learn more please see the following publications:*

EU reference scenario 2016. Energy, transport and GHG emissions: trends to 2050, Luxembourg: Publications Office of the European Union, 2016, https://doi.org/10.2833/9127

EU Reference Scenario 2020. Energy, Transport and GHG Emissions: Trends to 2050, Publications Office, Luxembourg, 2021, https://doi.org/10.2833/35750

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	PRIMES-TREMOVE contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2021	Revision of the Intelligent Transport Systems Directive	MOVE	Baseline only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The model helped to assess the following impacts: - Cost/availability of essential inputs (raw materials, machinery, labour, energy, ..) - Cost of doing business - Prices, quality, availability or choice of consumer goods and services - Safety or sustainability of consumer goods and services - Health and safety of individuals/populations - Emission of greenhouse gases - Emissions of acidifying, eutrophying, photochemical or harmful air pollutants - Demand for transport - Vehicle emissions - Energy and fuel consumption
2021	Impact assessment accompanying the Proposal for a Regulation of the European Parliament and of the Council: on ensuring a level playing field for sustainable air transport SWD/2021/633 final	MOVE	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	Documented in: - DOI 10.2832/219963
2021	Impact assessment accompanying the Proposal for a Regulation of the European Parliament and of the Council: on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council SWD/2021/631 final	MOVE	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES-TREMOVE model provided the developments in the vehicle fleet and the associated recharging and refuelling infrastructure, as well as the developments in CO2 emissions and air pollution emissions. Supporting study: Ricardo et al. (2021), Impact assessment support study on the revision of the Directive on the Deployment of Alternative Fuels Infrastructure (2014/94/EC) (for details, see the impact assessment report).
2021	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: amending Regulation (EU) 2019/631 as regards strengthening the CO2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES-TREMOVE model is used to assess the projected evolution of the transport system, resulting from changes in the CO2 emission standards for vehicles.

	SWD/2021/613 final				
2018	Impact assessment accompanying the document Proposal for a Directive of the European Parliament and of the Council: amending Directive 2008/96/EC on road infrastructure safety management SWD/2018/175 final	MOVE	Baseline only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	PRIMES-TREMOVE model has been used for the baseline scenario.
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: setting CO2 emission performance standards for new heavy duty vehicles SWD/2018/185 final	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	Projections include details for a large number of transport means, technologies and fuels, and their penetration in various transport market segments. Include details about GHG and air pollution emissions, final energy demand.
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council on: streamlining measures for advancing the realisation of the trans-European transport network SWD/2018/178 final	MOVE	Baseline only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES-TREMOVE model was used to build the baseline scenario.
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council on: electronic freight transport information SWD/2018/183 final	MOVE	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	PRIMES-TREMOVE has been used to assess the impacts of policy options on user costs, modal shift, energy use, CO2 and air pollutant emissions.
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: establishing a European Maritime Single Window environment and repealing directive 2010/65/EU SWD/2018/181 final	MOVE	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	PRIMES-TREMOVE together with TRUST have been also used to assess the impacts of policy options on modal shift and CO2 emissions.
2017	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast)	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES-TREMOVE model is used to project the evolution of the road transport sector.

	SWD/2017/0650 final				
2017	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: amending Regulation (EC) No 1073/2009 on common rules for access to the international market for coach and bus services SWD/2017/0358 final	MOVE	Baseline only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The baseline scenario has been developed with the PRIMES-TREMOVE model.
2017	Impact assessment accompanying the document Proposal for a Directive of the European Parliament and of the Council: amending Directive 92/106/EEC on the establishment of common rules for certain types of combined transport of goods between Member States SWD/2017/0362 final	MOVE	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	PRIMES-TREMOVE was used for the baseline and for the assessment of the environmental impacts.
2017	Impact assessment accompanying the document Proposal for a Regulation from the European Parliament and the Council on: rail passengers' rights and obligations (recast) SWD/2017/0318 final/2	MOVE	Baseline only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	Refer to Study: EU reference scenario 2016 Energy, transport and GHG emissions : trends to 2050. Documented in: - DOI 10.2833/001137
2017	Impact assessment accompanying the document Proposal for a Directive of the European Parliament and of the Council: amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles SWD/2017/0366 final	MOVE	Baseline only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The updated baseline was developed using the PRIMES-TREMOVE model.

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