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/2021/635 final

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

Supporting model(s)

PRIMES, TRUST

Document based on Ares(2021)4032920

Impact assessment
SWD/2021/635 final

Fact sheet on model contributions

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

Date of Report Generation: 02/09/2021

Table of Contents

Overview

Title
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

Document ID
SWD/2021/635 final

Year of publication
2021

Led by
MOVE

Model(s) used
PRIMES, TRUST

Additional information on model use for this Impact assessment

The baseline scenario builds on the baseline scenario underpinning the impact assessment accompanying the 2030 Climate Target Plan (SWD/2020/176 final) and the staff working document accompanying the Sustainable and Smart Mobility Strategy (SWD/2020/331 final), but it additionally considers the impacts of the COVID-19 pandemic and the National Energy and Climate Plans. The policy scenarios are developed on the basis of the Climate Target Plan policy scenarios (SWD/2020/176 final).

PRIMES

Full title

PRIMES Energy System Model

Run for this impact assessment by

Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

PRIMES is one of the core models of the modelling framework for energy, transport and greenhouse gas emissions projections. PRIMES-Maritime, a module of PRIMES and PRIMES-TREMOVE transport model, provided the developments in the maritime transport activity, energy use in the maritime sector, the greenhouse gas emissions and air pollution emissions, as well as the associated costs. The PRIMES model also provided an assessment of the biomass feedstock and the electricity consumption for producing synthetic fuels, while ensuring the links with the rest of the energy system.

TRUST

Full title

TRUST (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

TRUST model helped assessing the impacts on carbon leakage.

PRIMES

PRIMES Energy System Model

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

Overview

Acronym PRIMES
Full title PRIMES Energy System Model

Main purpose
Energy system model designed to project the energy demand, supply, prices, trade and emissions for European countries and assess policy impacts.

Summary
The PRIMES (Price-induced market equilibrium system) model is being developed by E3Modelling, a spin-off of the E3MLab at National Technical University of Athens (NTUA). The model is suited for medium-term and long-term (up to 2070) projections in 5-year steps and covers all EU Member States, and EFTA (except Lichtenstein) and candidate countries.

PRIMES combines micro-economic foundations of the behavioural modelling with the engineering and energy-system approach, covering all energy sectors and markets at a disaggregated level. The model determines energy prices, energy supply, energy demand, trade, emissions, costs and investment. Furthermore, the model captures the technology learning and economies of scale.

PRIMES can be used for policy analysis and impact assessment. It provides energy sectors, markets and system projections including energy system restructuring, both in the demand and supply sides. The model can support the impact assessment of specific energy, transport and environment policies and measures applied either at the Member State or EU level, including taxation, subsidies, emissions trading system, technology promoting policies, renewable energy sources policies, efficiency promoting policies, environmental policies and technology standards.

PRIMES can be linked to other models such as GAINS and GLOBIOM for a full coverage of sectors when assessing climate or environmental policies.

Keywords
emissions , energy demand , energy supply

Model category (thematic)
Energy

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

Ownership & license

Ownership
Sole ownership [3rd party]

Ownership details
E3Modelling and E3Mlab at NTUA

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 structure and approach

The PRIMES model (Price-Induced Market Equilibrium System) is a large scale applied energy system model that provides detailed projections of energy demand, supply, prices and investment into the future, covering the entire energy system including emissions. The distinctive feature of PRIMES is the combination of behavioural modelling (following a micro-economic foundation of optimisation by agent or sector) with engineering aspects, covering all energy sectors, and with market equilibrium. The model includes a detailed representation of instruments for policy impact assessment related to energy markets, technology adoption and climate mitigation, including market drivers, standards, and targets by sector or overall. It simulates the EU Emissions Trading System in its current form (changes can be simulated). It handles multiple policy objectives, such as GHG emissions reductions, energy efficiency, and renewable energy targets, and provides pan-European simulation of internal markets for electricity and gas.

PRIMES offer the possibility of handling market distortions, barriers to rational decisions, behaviours and market coordination issues and it performs a full accounting of costs (CAPEX and OPEX) and investment in equipment, energy savings and infrastructure. The model covers the horizon up to 2070 in 5-year interval periods and includes all Member States of the EU individually, as well as neighbouring and candidate countries in Europe. PRIMES is designed to analyse complex interactions within the energy system in a multiple agent – multiple markets framework.

Decisions by agents are formulated based on microeconomic foundation (utility maximization, cost minimization influenced by market equilibrium) embedding engineering constraints and explicit representation of technologies and capital vintages; optionally perfect or imperfect foresight for the modelling of investment applies in all sectors. The model allows simulating long-term transformations/transitions and includes non-linear formulation of potentials by type (resources, sites, acceptability etc.) and technology learning.

The PRIMES model is modular and consists of several sub-models (modules), each one representing the behaviour of a specific agent, a demander or supplier of energy. Sub-models link with each other through a model integration algorithm, which determines equilibrium prices in multiple markets and equilibrium volumes, including cap and trade systems (e.g. ETS), which satisfy balancing and policy, e.g. emissions, constraints and policy targets.

Demand modules formulate a representative agent who maximises benefits (profit, utility, etc.) from the energy demand and non-energy inputs (commodities, production factors) subject to prices, budget and other constraints. Constraints relate to activity, comfort, equipment, technology, environment or the fuel availability. In the demand sub-models, the agents may be simultaneously self-producers of energy services (e.g. using a private car, heating using a residential boiler, etc.) and purchasers of marketed energy commodities. The pricing of self-supplied energy services is endogenous and reflects average total costs. The mix of self- supply and the purchasing from external suppliers (e.g. private cars

versus public transportation, residential boiler versus district heating) derives from agent's optimisation, which depends on market conditions where the agents are price-takers.

Supply modules formulate stylised companies aiming at minimising costs (or maximising profits in model variants focusing on market competition) to meet demand subject to constraints related to capacities, fuel availability, environment, system reliability, etc. Supply-side modules determine commodity and infrastructure prices by end-use sector (tariffs) by applying various methodologies by sector as appropriate for recovering costs depending on market conditions and regulations.

Both demand and supply modules are subject to system-wide constraints, mirroring overall targets for example on emissions, renewables, efficiency, import dependency, etc. When binding, constraints convey non-zero shadow prices (dual values) to the demand and supply modules. Hence, the PRIMES model has overall a mixed-complementarity mathematical structure.

Agents are price-takers when being energy demanders and price-makers when being energy suppliers. Optionally, the model can handle non-perfect market competition regimes. The electricity and gas market modules can optionally include explicit companies and apply the Nash-Cournot competition with conjectural variations. Pricing and costing includes taxes, subsidies, levies and charges, congestion fees, tariffs for use of infrastructure etc. Usually, these instruments are exogenous to the model and reflect policy assumptions.

PRIMES follows a descriptive approach concerning factors which influence decisions by private entities, where perceived costs and uncertainty factors play a significant role. Policy measures can reduce uncertainty and decrease perceived costs: such mechanism in the model is often used to simulate policy inducing higher uptake of advanced technology or investment enabling accelerated energy efficiency progress.

The capital formation derives from an economically driven investment and follows a dynamic accounting of equipment technology vintages: equipment invested on a specific date inherits the technical-economic characteristics of the technology vintage corresponding to that date. Capital turnover is dynamic and the model keeps track of capital vintages and their specific technical characteristics. The agent's investment behaviour consists in building or purchasing new energy equipment to cover new needs, or retrofitting existing equipment or even for replacing prematurely old equipment for economic reasons.

The PRIMES model is fully dynamic and has options regarding future anticipation by agents in decision-making. Usually, PRIMES assumes a perfect foresight over a short time horizon for demand sectors and an imperfect foresight over long time horizon for supply sectors. All economic decisions of agents are dynamic and concern both operation of existing equipment and investment in new equipment, both when equipment is using energy and when it is producing energy.

The PRIMES model also includes a detailed numerical model on biomass supply, namely PRIMES-Biomass, which simulates the economics of supply of biomass and waste for energy purposes through a network of current and future processes. The PRIMES-Biomass model is a key link of communication

between the energy system projections obtained by the PRIMES energy system model and the projections on agriculture, forestry and non-CO2 emissions provided by other modelling specialist tools (CAPRI, GLOBIOM/G4M, GAINS).

Computationally, PRIMES solves an EPEC problem (equilibrium problem with equilibrium constraints), which allows prices to be explicitly determined. The overall convergence algorithm simultaneously determines multi-market equilibrium while meeting system-wide constraints.

Input and parametrization

A summary of database sources, in the current version of PRIMES, is provided below:

- Eurostat and EEA: Energy Balance sheets, Energy prices (complemented by other sources, such IEA), macroeconomic and sectoral activity data (PRIMES sectors correspond to NACE 3-digit classification), population data and projections, physical activity data (complemented by other sources), CHP surveys, CO2 emission factors (sectoral and reference approaches) and EU ETS registry for allocating emissions between ETS and non ETS, Process CO2 emisssions
- Technology databases: ODYSSEE-MURE, ICARUS, Eco-design, VGB (power technology costs), TECHPOL – supply sector technologies, NEMS model database, IPPC BAT Technologies
- Power Plant Inventory: ESAP SA and PLATTS
- RES capacities, potential and availability: JRC ENSPRESO, JRC EMHIRES, RES ninja, ECN, DLR and Observer, IRENA
- Network infrastructure: ENTSOE, GIE, other operators
- Other databases: District heating surveys (e.g. from COGEN), buildings and houses statistics and surveys (various sources, including ENTRANZE project, INSPIRE archive, BPIE), JRC-IDEES, update to the EU Building stock Observatory

The model is fully calibrated to match the historical energy balance of the last PRIMES historical year (5-year step modelling: historical points years are 2000, 2005, 2010, 2015, ..) and to capture the more recent evolution since that year.

Main output

The PRIMES model provides, per country represented and for the EU as a whole detailed and comprehensive energy balances of the energy system, related CO2 emissions and detailed economic information associated to the energy system (investments, costs, prices, taxes, ..).

In association with the GAINS model and the GLOBIOM model, it provides comprehensive GHG balances per country represented and for the EU as a whole.

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	EU Member States plus United Kingdom, Norway, Switzerland, Iceland, Albania, Serbia, Montenegro, Kosovo, Bosnia-Herzegovina, FYROM and Turkey.
(Spatial) resolution	Country level
Temporal extent	Until 2070
Temporal resolution	5 yearly

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	Uncertainties on assumptions can be addressed by producing variants with the model.
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 can be produced with the model.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	The model has undergone a peer review. See Commission staff working paper: SEC(2011)1569. Results have been published in peer-reviewed journals. The model has been used in multiple peer reviewed publications, that can be found here: https://e3modelling.com/publications/
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	not_applicable	The model is calibrated on historical data. The model does not do predictions but comparative scenario analysis based on assumptions.

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

- No references provided in MIDAS

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	The input data to the model is not published, but it builds on multiple sources, a large number of which being publicly accessible.
Can model outputs be made publicly available?	yes	Selected model outputs are made publicly available. Published outputs are defined by the Commission and are project-specific.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	The model documentation is publicly available. The model documentation includes the architecture and logic of the model and its different modules as well as the mathematical formulation.
Is the model source code publicly accessible or open for inspection?	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.

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

The model's potential

The PRIMES model is designed to provide long-term energy system projections and system restructuring up to 2070, both in demand and supply sides. The model (including its transport module PRIMES-TREMOVE) can support impact assessment of specific energy, climate, transport and environment policies and measures, applied at Member State or EU level, including price signals, such as taxation, subsidies, ETS, as well as technology promoting policies, RES supporting policies, efficiency promoting policies, environmental policies and technology standards. The PRIMES model is sufficiently detailed to represent concrete policy measures in various sectors, including market design options for the EU internal electricity and gas markets. Policy analysis is based on comparative analysis of policy scenarios against a "baseline" projection.

NOTE *The field 'use of the model in ex-ante impact assessments of the European Commission' focuses on the contributions of the model to the assessment of policy options.*

In addition, please note that the model has also been extensively used in impact assessments to contribute to the construction of the baseline as part of the modelling framework of the EU reference scenario 2016 Energy, transport and GHG emissions : trends to 2050, Luxembourg: Publications Office of the European Union, 2016, doi:10.2833/9127.

The use of the Reference Scenario is reported under 'Additional information' in the entries of the related impact assessments.

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 contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
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	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	PRIMES is one of the core models of the modelling framework for energy, transport and greenhouse gas emissions projections. PRIMES-Maritime, a module of PRIMES and PRIMES-TREMOVE transport model, provided the developments in the maritime transport activity, energy use in the maritime sector, the greenhouse gas emissions and air pollution emissions, as well as the associated costs. The PRIMES model also provided an assessment of the biomass feedstock and the electricity consumption for producing synthetic fuels, while ensuring the links with the rest of the energy system.
2021	Impact assessment accompanying the Proposal for a Directive of the European Parliament and the Council: amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 SWD/2021/621 final	ENER	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The model helped to assess the following impacts: - Significant effects on sectors - Economic growth and employment - Investments and functioning of markets - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Households income and at risk of poverty rates - Emission of greenhouse gases - Economic incentives set up by market based mechanisms - Emission of ozone-depleting substances - Ability to adapt to climate change - Energy intensity of the economy - Fuel mix used in energy production

					- Demand for transport - Vehicle emissions - Energy and fuel consumption - Change in land use
2021	Impact assessment accompanying the Proposal for a Directive of the European Parliament and of the Council: on energy efficiency (recast) SWD/2021/623 final	ENER	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The model helped to assess the following impacts: - Investment cycle - Markets for Innovation - Innovation for productivity/resource efficiency - Investments and functioning of markets - Emission of greenhouse gases - Energy intensity of the economy - Fuel mix used in energy production - 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*	PRIMES is one of the core models of the modelling framework for energy, transport and greenhouse gas emission projections. The PRIMES-TREMOVE model, a module of PRIMES, provided the developments in the air transport activity, the energy use in the aviation sector, the greenhouse gas emissions and air pollution emissions, as well as the associated costs. The PRIMES model also provided an assessment of the biomass feedstock and the electricity consumption for producing synthetic fuels, while ensuring the links with the rest of the energy system. Supporting study: Ricardo et al. , Study supporting the impact assessment of the ReFuelEU Aviation initiative
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*	PRIMES is one of the core models of the modelling framework for energy, transport and greenhouse gas emission projections. The PRIMES-TREMOVE model, a module of PRIMES, 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. The PRIMES model ensured the links with the rest of the energy system in developing the baseline and the policy scenarios. 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: establishing a carbon border adjustment mechanism SWD/2021/643 final	TAXUD	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The model helped to assess the following impacts: - EU Exports & imports - Investment flows & trade in services - Cost of doing business - Business' capacity to innovate - Market share & advantages in international context - Free movement of goods, services, capital and workers - Competition - Innovation for productivity/resource efficiency - Budgetary consequences for public authorities - Consumer's ability to benefit from the internal market or to access goods and services from outside the EU - Prices, quality, availability or choice of consumer goods and services - Significant effects on sectors - Disproportionately affected region or sector - Impacts on third countries - Goods traded with developing countries - Investments and functioning of markets - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Wages, labour costs or wage setting mechanisms - Emission of greenhouse gases - Sustainable production and consumption - Relative prices of environmental friendly and unfriendly products

					- Polution by businesses - Environment in third countries - Energy intensity of the economy - Fuel mix used in energy production - Energy and fuel consumption
2021	Impact assessment accompanying the document Proposal for a regulation of the European Parliament and of the Council: amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement SWD/2021/611 final	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES model and its variants are used to model all aspects of the energy system, including buildings, transport and industry. Regarding greenhouse gas emissions it reports all CO2 emissions from these sectors.
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 SWD/2021/613 final	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES model is used to assess the projected evolution of the transport system, as part of the wider energy system, resulting from different policies, including CO2 emission standards for vehicles.
2021	Impact assessment accompanying the document Directive of the European Parliament and of the Council: amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757 SWD/2021/601 final	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	(1) General modelling of ETS strengthening and possible extension to buildings and transport/ all fossil fuel combustion. (2) Extension of emissions trading to maritime transport and alternatives. The PRIMES-Maritime module has been used to assess the impact of the various maritime policy options. PRIMES-Maritime is a specific sub-module of the PRIMES-TREMOVE transport and the overall PRIMES energy systems model aiming to enhance the representation of the maritime sector within the energy- economy-environment modelling nexus.

2020	Impact Assessment accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Stepping up Europe's 2030 climate ambition SWD/2020/176 final	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The PRIMES model and its variants are used to model all aspects of the energy system, including buildings, transport and industry. Regarding greenhouse gas emissions it reports all CO2 emissions from these sectors.
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council on: the establishment of a framework to facilitate sustainable investment and; Proposal for a Regulation of the European Parliament and of the Council on: disclosures relating to sustainable investments and sustainability risks and amending Directive (EU) 2016/2341 and; Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 2016/1011 on: low carbon benchmarks and positive carbon impact benchmarks SWD/2018/264 final	FISMA	Problem definition	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The yearly average investment gap for the period 2021 to 2030 was based on PRIMES projections

Bibliographic references

- *EU reference scenario 2016 : energy, transport and GHG emissions : trends to 2050. - MJ-01-15-793-EN-N*
- *EU energy, transport and GHG emissions, trends to 2050 : reference scenario 2013. - 10.2833/17897*

TRUST

TRansport eUropean Simulation Tool

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

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
Sole ownership [3rd party]

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	The 27 EU Member States; 8 Candidate and potential candidate countries: Western Balkans (Serbia, FYROM, Albania, Bosnia and Herzegovina, Kosovo, Montenegro), Turkey, Iceland; 7 Other EU bordering countries: United Kingdom, Norway, Switzerland, Belarus, Ukraine, Moldova, Russia.
(Spatial) resolution	The spatial segmentation is at NUST3 zones level for EU27, Accession and Neighbouring countries. A less detailed zoning system is used for other European countries (e.g. European Russia, Ukraine). The NUTS3 classification is the most updated version of ETISplus zoning referring to year 2006. In total 1559 zones are used in the model. Additional external zones are defined in order to consider overseas connections for air and maritime transport.
Temporal extent	2020 - 2050
Temporal resolution	2020, 2025, 2030, 2040, 2050

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.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	no	Not provided
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	no	Not provided

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

- No references provided in MIDAS

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	no	TRUST model databases are the results of TRT work of harmonization and integration of different sources. They are property of TRT.
Can model outputs be made publicly available?	yes	Results of model applications are provided to the Client. The Client has the right to make outputs publicly available or not.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	A detailed description of the model is available at: http://www.trt.it/en/tools/trust/
Is the model source code publicly accessible or open for inspection?	no	The model source code is property of TRT.

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

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	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

- *No references provided in MIDAS*