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/2021/633 final

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

Supporting model(s)

PRIMES, PRIMES-TREMOVE

Document based on Ares(2021)4032934

Impact assessment
SWD/2021/633 final

Fact sheet on model contributions

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

Date of Report Generation: 02/09/2021

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Overview

Title
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

Document ID
SWD/2021/633 final

Year of publication
2021

Led by
MOVE

Model(s) used
PRIMES, PRIMES - TREMOVE

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).

Relevant supporting study related to the modelling exercise:

Ricardo at al., Study supporting the impact assessment of the ReFuelEU Aviation initiative (for details, see the impact assessment report)

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 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 (for details, see the impact assessment report).

PRIMES-TREMOVE

Full title

PRIMES-TREMOVE Transport 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

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 the air pollution emissions, as well as the associated costs.

Supporting study: Ricardo et al., Study supporting the impact assessment of the ReFuelEU Aviation initiative (for details, see the impact assessment report).

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*

PRIMES-TREMOVE

PRIMES-TREMOVE Transport Model

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

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 2050) 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

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

Ownership & license

Ownership
Sole ownership [3rd party]

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.

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	EU27, EU27+UK and by Member State
(Spatial) resolution	Country
Temporal extent	2005 to 2050 time horizon
Temporal resolution	5-year time steps

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.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	As module of the PRIMES energy system model, PRIMES-TREMOVE has been successfully peer reviewed in 2011. The model results have been communicated to the scientific audience (see list of relevant publications below). Model results have also been reviewed as part of deliverables in H2020 research projects.
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

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	Key databases upon which the model is built are publically available (e.g. EUROSTAT data on transport activity and energy balances).
Can model outputs be made publicly available?	yes	In publically available technical reports, scientific papers and research projects final reports.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	These are documented in selected publications in scientific journals and in the model documentation which is publically available.
Is the model source code publicly accessible or open for inspection?	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

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 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 and new heavy goods 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.

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
- Fuel quality through:
    - Changing fuel cost by fuel type
- 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 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-TREMOVE 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 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*	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 the air pollution emissions, as well as the associated costs. 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*	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	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.

	(EC) No 715/2007 (recast) 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.

Bibliographic references

- *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*

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- *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*