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Factsheet

SWD/2021/613 final

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

Supporting model(s)

PRIMES, PRIMES-TREMOVE, GEM-E3, E3ME, DIONE

Document based on Ares(2021)4354657

Impact assessment
SWD/2021/613 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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Document ID
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2021

Led by
CLIMA

Model(s) used
PRIMES, PRIMES-TREMOVE, GEM-E3, E3ME, DIONE

Additional information on model use for this Impact assessment

The most recent EU reference scenario [1] forms the baseline for this impact assessment. The policy scenarios are developed from the basis of the Climate Target Plan policy scenarios (SWD/2020/176 final).

[1] European Commission, EU Reference Scenario 2020: Energy, Transport ad GHG Emissions: Trends to 2050, Publications Office, Luxembourg, 2021, https://doi.org/10.2833/35750.

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

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.

PRIMES - TREMOVE

Full title

PRIMES-TREMOVE Transport Model (PRIMES-TREMOVE)

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 is used to assess the projected evolution of the transport system, resulting from changes in the CO2 emission standards for vehicles.

GEM-E3

Full title

General Equilibrium Model - Economy, Energy, Environment

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

GEM-E3 is used for macroeconomic assessment of different CO2 emission standards for vehicles levels.

E3ME

Full title

Energy - Environment - Economy Model for Europe (E3ME)

Run for this impact assessment by

Cambridge Econometrics

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

E3ME is used for macroeconomic assessment of different CO2 emission standards for vehicles levels.

DIONE

Full title

Road Transport Fleet Impact Model (DIONE)

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

DIONE is used to assess economic impacts of different CO2 emission standards for vehicles levels.

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

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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

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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

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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
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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

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*

- *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*

GEM-E3

General Equilibrium Model - Economy, Energy, Environment

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

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Overview

Acronym GEM-E3
Full title General Equilibrium Model - Economy, Energy, Environment

Main purpose
A macro-economic model used to assess energy, climate and air quality policies.

Summary
The GEM-E3 model is a global multi-sectoral general equilibrium model. GEM-E3 covers the interactions between the economy, the energy system and the environment. The model is used to calculate macro-economic impacts such as GDP, welfare, consumption, trade, employment, sectoral output, and carbon price.

It covers all EU Member States and the rest of the world, which is divided into 19 major economies. Countries are linked through endogenous bilateral trade. The calibration of the model is based on the GTAP database and uses techno-economic inputs from sectoral models such as POTEnCIA, PRIMES, POLES, GAINS, and GLOBIOM. The model simultaneously computes the equilibrium prices of goods, services, labour, capital and tradable emission rights such that all markets are in equilibrium. It integrates micro-economic behaviour into a macro-economic framework and allows assessing the medium to long-term implications of policies. The model evaluates the emissions of carbon dioxide (CO2) and other GHG (e.g. CH4). There are three mechanisms of emission reduction: (i) substitution between fuels, and between energetic and non-energetic inputs, (ii) emission reduction due to less production and consumption, and (iii) purchasing abatement equipment.

The model can be used for policy anticipation, formulation and implementation to assess macro-economic impacts of energy, climate and air quality policies. The model has been used, among others, for the Impact Assessments of the 2030 Framework of Energy and Climate Policies, its implementation in the context of the Energy Union, the Paris Agreement, and the Clean Air Package.

Keywords
Energy , Environment , Climate , General equilibrium , Climate policy , Air Pollution

Model category (thematic)
Economy

Model home page
https://ec.europa.eu/jrc/gem-e3

Ownership & license

Ownership
Joint copyright

Ownership details
The ownership is shared with the institutions that developed the model and the JRC, European Commission: a) Institute of Communication and Computer Systems - National Technical University of Athens (ICCS/NTUA); b) CES, Centre for Economic Studies, Katholieke Universiteit Leuven c) DG JRC, European Commission (C6) which has developed various modules for GEM-E3, as well as extended and updated the supporting databases (incl. GTAP).

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

GEM-E3 structure and approach
GEM-E3 can be used for policy anticipation, formulation and implementation.

In terms of anticipation and formulation, as applied general equilibrium model covering the interactions between the Economy, the Energy system and the Environment with high level of details, the GEM-E3 Model is well suited to assess the impact of climate, energy, and transport regulations, as well as fiscal, air quality, and labour market policies. It can simulate the welfare effects of alternative regulation regimes as well as the consequences of emission targets.

The Clean Air Programme for Europe envisages a regular update of the impact assessment analysis, to track progress towards the objectives of the Directive and to serve as input into the regular Clean Air Forum. In 2018 GEM-E3 was used to update the Impact Assessment during the implementation phase. For more information see http://ec.europa.eu/environment/air/clean_air/outlook.htm. Results featured in the First Clean Air Outlook.

One of the applications of the model includes an economic and employment impact assessment of different EU decarbonisation scenarios for 2050. This is included in the in-depth analysis accompanying the European Commission's *Clean Planet for All* communication of 2018. See https://ec.europa.eu/clima/policies/strategies/2050_en#tab-0-1

See https://ec.europa.eu/jrc/en/gem-e3 for latest updates.

Input and parametrization

- Input/Output tables and SAM (GTAP, Eurostat)
- Energy balances (International Energy Agency, IEA)
- Elasticity of Substitution and Armington elasticity (economic literature)
- Costs of Abatement Technology (Research Projects)
- Emission coefficients (Research Projects)
- Techno-economic inputs from sectoral models such as POTEnCIA, PRIMES, POLES, GAINS, and GLOBIOM

Main output
GEM-E3 analyzes the economic and distributional effects of environmental and economic policies for sectors, agents and regions. The output of GEM-E3 includes projections of

- input-output tables
- employment

- trade
- capital flows
- government revenues
- household consumption
- energy use
- atmospheric emissions.

The model allows the evaluation of the welfare and distributional effects of various environmental policy scenarios, including different burden sharing scenarios, environmental instruments (i.e. taxes, pollution permits or command-and-control policy) and revenue recycling scenarios.

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	Global coverage; EU 27 Member States + UK and 18 World Regions
(Spatial) resolution	Country level for each of the 27 EU Member States and for 8 non-EU countries; regional resolution for the rest of the world
Temporal extent	Currently, typical runs go up to 2050 (but can be extended beyond if there is a need to)
Temporal resolution	The model is solved in 5-year 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	Policy uncertainty is covered by running several scenarios in a what-if fashion
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Sensitivity of output results is done on ad-hoc basis
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	The output published in academic papers and presented on academic conferences have been reviewed by peers. In addition, separate versions of the model are run independently by JRC and NTUA / E3M-Lab in Athens, enabling comparison of findings and investigation of differences.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	As the model does not aim to predict the future, we mainly validate the model through results with our peer group. In addition, elasticity parameters are based on historical data to validate partial model responses, such as reactions to changes in energy prices

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

- Vandyck T; Keramidas K; Saveyn B; Kitous A; Vrontisi Z. A global stocktake of the Paris pledges: Implications for energy systems and economy. GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS 41; 2016. p. 46-63. JRC101134
- Vandyck, T., Keramidas, K., Kitous, A., Spadaro, J., Van Dingenen, R., Holland, M. and Saveyn, B., Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges, NATURE COMMUNICATIONS, ISSN 2041-1723 (online), 9, 2018, p. 4939, JRC111245.

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	The core data, GTAP, are publicly available (if purchased) Other major inputs like IEA energy balances etc. are as well. The input-output tables for future years are published and freely available for the GECO report (from 2018 onwards).
Can model outputs be made publicly available?	yes	Output usually is published in Report and academic papers. Most of them can be downloaded from https://ec.europa.eu/jrc/en/gem-e3/publications

		More detailed output can be published upon request
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	See model documentation. JRC C.6 published a complete manual as an open-access Technical Report in 2013 with a detailed description of the model. Documentation of the NTUA/E3M-Lab version is also available online under http://www.e3mlab.eu/e3mlab/index.php?option=com_content&view=article&id=56%3Amanual-of-gem-e3-model&catid=36%3Agem-e3&Itemid=71&lang=en
Is the model source code publicly accessible or open for inspection?	no	The GAMS model code is not published as such, but can be replicated from the published set of equations.

References related to documentation:

- Capros P, Van Regemorter D, Paroussos L, Karkatsoulis P, Fragkiadakis C, Tsani S, Charalampidis I, Revesz T, authors Perry M, Abrell J, Ciscar Martinez J, Pycroft J, Saveyn B, editors. GEM-E3 Model Documentation. EUR 26034. Luxembourg (Luxembourg): Publications Office of the European Union; 2013. JRC83177

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
- Taxation
- Employment and social affairs
- Energy
- Environment
- Transport

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

- Anticipation
- Formulation
- Implementation

The model's potential

GEM-E3 can be used for policy anticipation, formulation and implementation.

In terms of anticipation and formulation, as applied general equilibrium model covering the interactions between the Economy, the Energy system and the Environment with high level of details, the GEM-E3 Model is well suited to assess the impact of climate, energy, and transport regulations, as well as fiscal, air quality, and labour market policies. It can simulate the welfare effects of alternative regulation regimes as well as the consequences of emission targets.

The Clean Air Programme for Europe envisages a regular update of the impact assessment analysis, to track progress towards the objectives of the Directive and to serve as input into the regular Clean Air Forum. In 2018 GEM-E3 is used to update the Impact Assessment during the implementation phase. For more information see http://ec.europa.eu/environment/air/clean_air/outlook.htm. Results featured in the First Clean Air Outlook.

One of the applications of the model includes an economic and employment impact assessment of the European Commission's strategic long-term vision for greenhouse gas reductions, a document that sets the stage for the debate on the long-term climate policy in the EU.

Concerning contributions to Impact Assessments see www.gem-e3.net for latest updates.

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	GEM-E3 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 document Proposal for a Council Directive: restructuring the Union framework for the taxation of energy products and electricity (recast) SWD/2021/641 final	TAXUD	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Equal treatment of products and businesses - Affects on individual Member States - 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 - Goods traded with developing countries - Economic growth and employment - Investments and functioning of markets - Macro-economic stabilisation - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Indirect effects on employment levels - Wages, labour costs or wage setting mechanisms - Employment, social protection and poverty impacts in non-Member States (including developing countries) - Emission of greenhouse gases

					- Economic incentives set up by market based mechanisms - Emissions of acidifying, eutrophying, photochemical or harmful air pollutants - 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 - Demand for transport - Vehicle emissions - Energy and fuel consumption
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 - Macro-economic stabilisation - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Indirect effects on employment levels - Households income and at risk of poverty rates - Inequalities and the distribution of incomes and wealth - Access to and quality of social protection benefits
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: - EU Exports & imports - Cost of doing business - Economic growth and employment - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Wages, labour costs or wage setting mechanisms
2021	Impact assessment accompanying the document Proposal for a regulation of the European Parliament and of the Council: establishing a carbon border	TAXUD	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Equal treatment of products and businesses - Affects on individual Member

	adjustment mechanism SWD/2021/643 final				States - EU Exports & imports - Investment flows & trade in services - Non-trade barriers - 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 - Adjustment costs in developing countries - Goods traded with developing countries - Economic growth and employment - Investments and functioning of markets - Macro-economic stabilisation - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Indirect effects on employment levels - Wages, labour costs or wage setting mechanisms - Employment, social protection and poverty impacts in non-Member States (including developing countries) - Emission of greenhouse gases - Economic incentives set up by market based mechanisms - Sustainable production and consumption - Relative prices of environmental friendly and unfriendly products - Polution by businesses - Environment in third countries - Energy and fuel consumption
2021	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council:	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory,*	GEM-E3 is used for macroeconomic assessment of different CO2 emission standards for vehicles levels.

	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			*National Technical University of Athens*	
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 only	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	GEM-E3 is used for sectoral economic assumptions used as inputs for the PRIMES energy system model.
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	*European Commission*	GEM-E3 is used for the assessment of the impacts of policy options on key economic variables, including GDP, sectoral output and aggregate and sectoral employment.
2017	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast) SWD/2017/0650 final	CLIMA	Baseline and assessment of policy options	*European Commission*	GEM-E3 was used to assess macroeconomic impacts of target setting based on GDP per capita.
2017	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast) SWD/2017/0650 final	CLIMA	Baseline and assessment of policy options	*Energy - Economy - Environment Modelling Laboratory, National Technical University of Athens*	The model has been used by E3MLab/ICCS to provide the macro assumptions for the Reference scenario and for the policy scenarios.

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E3ME

Energy - Environment - Economy Model for Europe

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

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Overview

Acronym E3ME
Full title Energy - Environment - Economy Model for Europe

Main purpose
A macro-econometric model used to simulate and assess the medium to long-term effects of environmental and economic policies for Europe.

Summary
The E3ME model is used to simulate and assess the medium to long-term effects of environmental and economic policies, and covering explicitly Europe at Member State level (incl. Croatia), three EU candidate countries, Norway Switzerland and UK, 11 other major economies while the rest of the world is grouped into political regions. The model can be solved until 2050. The first version was built by an international European team under a succession of contracts in the 1980s and 1990s under EEC/EU research programmes (such as JOULE/THERMIE). The current version of the model was developed by Cambridge Econometrics.

E3ME is a macro-econometric model which comprises the accounting framework of the economy, based on the ESA95 system of national accounts, coupled with balances for energy and material demands and environmental emission flows, detailed historical data sets, with time series covering the period since 1970 and sectoral disaggregation using the NACE classification of economic activities at 2-digit level. E3ME has an econometric specification of behavioural relationships in which short-term deviations move towards long-term trends.

E3ME can be used for impact assessments, and has been used for several recent high-profile assessments, including an assessment of the impacts of high oil prices on the global economy for the 2009, input to the EU's Impact Assessment of the revised Energy Taxation Directive or input to the EU's Impact Assessment of the Energy Efficiency Directive.

Keywords
energy system model , environmental policies , econometric input-output model , resource consumption

Model category (thematic)
Economy

Model home page
http://www.camecon.com/how/e3me-model/

Ownership & license

Ownership
Sole ownership [3rd party]

Ownership details
Cambridge Econometrics

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

E3ME structure and approach

The structure of E3ME is based on the system of national accounts, as defined by the ESA 95 system [1], with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, with estimated sets of equations for labour demand, supply, wages and working hours. In total there are 29 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, international trade), prices, energy demand and materials demands. Each equation set is disaggregated by country and by sector. E3ME's historical database covers the period 1970-2010 and the model projects forward annually to 2050. The main data sources are Eurostat, DG ECFIN AMECO database and the IEA, supplemented by the OECD's STAN database and other sources where appropriate. Gaps in the data are estimated using customised software algorithms.

The model covers 69 economic sectors, 43 categories of household expenditure, 22 different users of 12 different fuel types,16 different material users of 8 different mineral material types plus water, 14 types of air-borne emissions (where data are available) including the six greenhouse gases monitored under the Kyoto protocol, 13 types of household, including income quintiles and socio-economic groups such as the unemployed, inactive and retired, plus an urban/rural split.

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:European_system_of_national_and_regional_accounts_(ESA95)

Input and parametrization

There are three categories of inputs to the model: (time series) data, assumptions on basic economic parameters and values, and scenario variables describing the policy option that is to be examined. Data include

- output (constant and current price bases)
- Gross Value Added (GVA) at market prices and factor cost
- investment
- R&D spending
- household expenditure (by product)
- government final consumption (by category)
- exports
- imports
- employment

- labour costs (current prices)
- average working hours.

In addition, there are time series for population and labour force.

Assumptions include:

- market exchange rate, local currency per dollar, current prices
- long-run interest rate
- short-run interest rate (only used for comparative purposes)
- change in government final consumption, year on year
- % of government consumption spent on defence, education and health
- standard VAT rate
- aggregate rate of direct taxes
- average indirect tax rates
- ratio of benefits to wages (giving implicit rate)
- employees' social security rate
- employers' social security rate

Policy options can be described using the following parameters:

- annual CO2 tax rate, € per tonne of carbon
- annual EU ETS allowance prices, € per tonne of carbon (if level of ETS caps are unknown)
- annual ETS emissions caps, thousand tonnes of carbon
- switches to include different energy users in the policies
- switches to include different fuel types in the policies
- switch to set EU ETS policy to use caps (endogenous price) or exogenous ETS
- prices
- annual energy tax rate, € per toe
- switches to include different users in policies

- switch to include different fuel types in policies
- switch to differentiate tax rates for different groups, e.g. industries or households
- annual material tax rates for seven types of materials, in percentage cost increase
- switches to include different material users in policies

In addition, the model includes options to recycle automatically the revenues generated from carbon taxes, energy taxes, ETS (with auctioned allowances) and materials taxes. There are two options in the model for how the revenues are recycled:

- To lower employers' social security contributions;
- To lower income tax;
- To increase levels of R&D spending.

Main output

Outputs produced by the model include:

- GDP and its aggregate components (household expenditure, investment, government expenditure and international trade)
- sectoral output and Gross Value Added (GVA), prices, trade and competitiveness effects
- international trade by sector, origin and destination
- consumer prices and expenditures
- sectoral employment, unemployment, sectoral wage rates and labour supply
- energy demand, by sector and by fuel, energy prices
- CO2 emissions by sector and by fuel
- other air-borne emissions
- material demands

E3ME is capable of producing a broad range of economic, energy and environment indicators. The following list provides a summary of the most common outputs: GDP and its aggregate components (household expenditure, investment, government expenditure and international trade) sectoral output and GVA, prices, trade and competitiveness effects on consumer prices and expenditures, and implied household distributional effects sectoral employment, unemployment, sectoral wage rates and labour supply energy demand, by sector and by fuel, energy prices, CO2 emissions by sector and by fuel other airborne emissions material demands. Each of these is available at national and EU levels, and most are

also defined by economic sector. This list is by no means exhaustive and the delivered outputs often depend on the requirements of the specific analysis. In addition to the sectoral dimension mentioned in the list, all indicators are produced at the Member State level and annually over the period up to 2050. The measures of endogenous technical change that are included in E3ME are allowed to influence key economic relationships, as well as energy and material demands.

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	EU27, Norway, Switzerland, UK, Iceland, Turkey and Macedonia
(Spatial) resolution	At national level
Temporal extent	E3ME's historical database covers the period 1970-2010 and the model projects forward annually to 2050.
Temporal resolution	annually

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 can be run multiple times (automatically) to test sensitivity to assess uncertainty or test model properties.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?		Information not provided
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	Several peer-reviewed publications have been made by the developers of the model. References on www.camecon.com . For a recent model version published in peer reviewed journal see Mercure et al (2018).
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?		Information not provided

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

- Mercure, J.-F., Pollitt, H., Edwards, N. R., Holden, P. B., Chewpreecha, U., Salas, P., … Vinuales, J. E. (2018). Environmental impact assessment for climate change policy with the simulation-based integrated assessment model E3ME-FTT-GENIE. Energy Strategy Reviews, 20, 195–208. doi:10.1016/j.esr.2018.03.003

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	Data are from publicly available sources such as OECD, Eurostat and AMECO.
Can model outputs be made publicly available?	yes	Depending on contract.
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 available at https://www.e3me.com (https://www.e3me.com/what/e3me/). This fact sheet is based on version 6.1 of the technical manual. Version 7.0 will be published at the same location at some point in 2020.
Is the model source code publicly accessible or open for inspection?	no	The model code is not publicly accessible.

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
- Institutional affairs
- Economy, finance and the euro
- Energy
- Environment

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

- Formulation
- Evaluation

The model's potential

Although E3ME can be used for forecasting, the model is more commonly used for evaluating the impacts of an input shock through a scenario-based analysis. The shock may be either a change in policy, a change in economic assumptions or another change to a model variable. The analysis can be either forward looking (ex-ante) or evaluating previous developments in an ex-post manner. Scenarios can be used either to assess policy, or to assess sensitivities to key inputs, such as international energy prices.

The model provides support for the resource efficiency flagship initiative and sustainability assessment.

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	E3ME 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 document Proposal for a Directive of the European Parliament and of the Council: amending Directive 2003/87/EC as regards aviation's contribution to the Union's economy-wide emission reduction target and appropriately implementing a global market-based measure SWD/2021/603 final	CLIMA	Baseline and assessment of policy options	*Cambridge Econometrics*	The E3ME model used the outputs from the AIM model (per capita aviation spending, fuel demand, and EU ETS revenues) to estimate social and economic impacts outside the aviation sector of changes in demand for air transport and air transport fuels and use of auctioning revenues from aviation EU ETS, including on GVA and employment.
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	*Cambridge Econometrics*	E3ME is used for macroeconomic assessment of different CO2 emission standards for vehicles levels.
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	*Cambridge Econometrics*	E3ME is used for macroeconomic assessment.
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	CLIMA	Baseline and assessment of policy options	*Cambridge Econometrics*	E3ME used together with GEM-E3 to assess macroeconomic and sectoral economic impacts. In particular, these models are used to quantify the impacts of the different CO2 targets for light-duty vehicles on the wider economy, i.e. GDP, sectoral output and employment.

CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast)

SWD/2017/0650 final

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DIONE

Road Transport Fleet Impact Model

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

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Overview

Acronym DIONE
Full title Road Transport Fleet Impact Model

Main purpose
DIONE can support road transport related policies by assessing the implications of future road vehicle fleet composition and drive patterns on energy consumption, emissions and total costs of ownership.

Summary
The **DIONE Fleet Impact Model** is used to assess the impacts of changes in the European and MS road transport fleet characteristics up to the year 2050. It is a flexible tool which can be employed to analyse scenarios on road vehicle stock development and composition, vehicle activity and driving patterns, and vehicle technology and fuel use trends. The model contains a calibrated baseline which is consistent with the country-specific stock and activity data collected in the project TRACCS, and is taken forward following the trends of a PRIMES baseline scenario. Fuel consumption and emission calculation for combustion engine vehicles is based on COPERT methodology. For alternative fuel vehicles, an energy and emission calculation methodology has been developed which takes account of vehicle characteristics, trip lengths and speed distributions. For both energy consumption and greenhouse gas (GHG) emissions, DIONE can provide real world Tank-to-Wheel (TtW) up to the year 2050 as well as Well-to-Wheel (WtW) results up to 2030.

The **DIONE cost curve model** is employed for developing cost curves which describe the costs associated with reaching a given CO2 standard, for a given vehicle segment and powertrain. Cost curves are constructed by identifying cost-optimal bundles of technologies for CO2 reduction and then fitting a continuous cost curve.

The **DIONE Cross-optimization module** identifies cost-optimal strategies to reach given emission targets, building on the cost curves. Cross-optimization outcomes can be used to assess the impact of different policy options on manufacturing costs for different manufacturers and the market as a whole.

The **DIONE Total Cost of Ownership Module** computes total costs of ownership for different vehicle types and powertrains, summarizing the results from the previous steps and adding fuel/energy costs and maintenance costs. This allows assessing the societal costs associated with a policy option, as well as costs for consumers (new vehicle buyers and second-hand vehicle buyers).

DIONE can be used for ex-ante policy support. All DIONE modules are employed to provide policy support in the context of decarbonisation and electrification of road transport, as well as for assessing possible transitions towards alternative fuels for road transport.

Keywords
transport model , road transport , scenario analysis , electromobility , CO2 emissions , alternative fuels , energy consumption , air pollutant emissions , Cost Curve , Total Costs of Ownership

Model category (thematic)

Transport

Model home page

No information provided

Ownership & license

Ownership
Multiple ownership [Original code owned by 3rd party]

Ownership details
Code based on 3rd party

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

DIONE structure and approach

The DIONE model uses a modular structure which allows to add new functionalities as more data becomes available and as policy needs arise. Model development originally started with the DIONE fleet impact model, which is used to calculate road transport fuel and energy consumption and emissions for future fleet development scenarios. The model presently consists of the following modules, which can be used either standalone or in combinations, and cover a broad range of road vehicles (cars, vans, trucks):

- DIONE Fleet Impact Model
- DIONE COPERT module (under development)
- DIONE Cost Curve Module
- DIONE Cross-Optimization Module
- DIONE Fuel and Energy Cost Module
- DIONE TCO and Payback Module

Input and parametrization

Parametrisation: The DIONE fleet impact model contains a calibrated stock baseline which is consistent with the country-specific stock and activity data collected in the project TRACCS, and is taken forward following the trends of PRIMES 2012 baseline scenario with adopted measures.

Fuel consumption and emission calculation for combustion engine vehicles is based on COPERT 4 v.11 road transport emission inventory software. For alternative fuel vehicles, an energy and emission calculation methodology has been developed which takes account of vehicle characteristics, trip lengths and speed distributions.

Inputs:

Main variables that can be defined by the user include:

- vehicle stock,
- new registrations,
- survival rates,
- activity,
- efficiency improvement,

- fuel use of flex-fuel vehicles,
- fuel pathways for well-to-wheel energy consumption and emissions,
- biofuel admixture shares for conventional fuels,
- driving patterns.

Users can define custom scenarios either by adapting baseline values in the DIONE input tables or graphical user interface graphs, or by uploading input files. The user can decide to create a scenario for any predefined entity, i.e., any single EU member state (plus some extra neighbour countries), pre-defined groupings such as EU28, EU15 and EU12, but can also decide to define a custom scenario for any region, city, country or other entity of interest.

The DIONE Cost Curve Module uses data on vehicle efficiency improvement technologies (their efficiencies, costs and compatibilities) as additional inputs, whereas the DIONE Fuel and Energy Cost Module needs to be fed with energy price estimates. For Cross-Optimization and TCO/Payback Calculations, Fleet Composition scenarios can be aligned with DIONE fleet impact model runs or provided from other sources.

Main output

The output of the DIONE fleet impact model contains fleet development and activity, energy demand, CO2 emissions, other GHGs and all air pollutants included in the COPERT methodology.

For both energy consumption and greenhouse gas (GHG) emissions, DIONE can provide real world tank-to-wheel (TtW) figures up to the year 2050 as well as well-to-wheel (WtW) results up to 2030. For CO2 emissions, NEDC type approval values can be calculated, as well. DIONE also includes a cost module which determines additional costs for achieving given efficiency targets for conventional passenger cars.

DIONE can be used for policy-relevant scenario analysis, including analysis of the following options:

- Fuel efficiency targets
- Technology replacement, Stock composition or new registration technology share targets
- Biofuel Admixture
- Fuel GHG intensities
- Scrappage Schemes
- Vehicle Activity

The further modules provide additional outputs such as

- Cost-optimal segment and powertrain-specific CO2 reductions and related costs

- Fuel and energy costs of vehicle types and fleets
- Total costs of ownership for vehicles within a given scenario,
- Payback times for efficiency technology

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	EU Member states 27, UK, Iceland, Norway, Switzerland, Former Yugoslav Republic of Macedonia, Turkey
(Spatial) resolution	Several possible aggregation levels: National, EU Member states 27, EU Member states 15, EU Member states 12, Non-EU
Temporal extent	2010-2050
Temporal resolution	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?	no	Most of the DIONE modules are deterministic, such that uncertainties relate mainly to the quality of input data, which is hard to quantify and quality checks of which remain with data providers. The DIONE Cost Curve Model uses random and probabilistic elements in the exploration process for determining optimal technology packages, which according to internal test have very little impact on the final cost curves.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Sensitivities of model results have been explored before making use of the model, and by verifying the response of model outcomes to the variation of input parameters during intensive scenario calculation.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	no	The model code is under development and cannot presently be shared outside the Commission.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	no	Model projections regard future years and cannot yet be confronted with observed data.

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	Most modules rely extensively on publicly available data. Input data used for the Cost Curves and total costs of ownership calculations is referenced in the respective JRC reports.
Can model outputs be made publicly available?	yes	Some fleet model outputs are summarized in papers; all final JRC cost curves as well as exemplary total cost of ownership (TCO) results are specified in the respective JRC reports; central TCO results have been included in the impact assessments for CO2 standards for LDV and HDV.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	The cost curve model, cross-optimization module and TCO module documentation have been published in two JRC reports (for LDV and HDV respectively). For the fleet impact model, an updated model version is under development, publication of the model documentation outstanding.
Is the model source code publicly accessible or open for inspection?	no	The model code is under development and cannot presently be shared outside the Commission.

References related to documentation:

- Krause, J. and Donati, A., Heavy duty vehicle CO2 emission reduction cost curves and cost assessment – enhancement of the DIONE model, EUR 29284 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-88812-0, doi:10.2760/555936, JRC112013.
- Krause, J., Donati, A. and Thiel, C., Light Duty Vehicle CO2 Emission Reduction Cost Curves and Cost Assessment - the DIONE Model, EUR 28821 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74136-4 (online),978-92-79-74137-1 (print), doi:10.2760/87837 (online),10.2760/462088 (print), JRC108725.

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
- Environment
- Transport

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

- Anticipation
- Formulation

The model's potential

The model is employed to provide policy support in the context of decarbonisation and electrification of road transport, as well as for assessing possible transitions towards alternative fuels for road transport in general.

It has been used in support of the **Impact Assessment for post-2020 emissions standards for cars and vans (2017)** supporting DG CLIMA, for the **Assessment of National Framework Plans under the Alternative Fuels Infrastructure Directive (2017)** supporting DG MOVE, and for the support of the **Impact Assessment on fuel efficiency standards for heavy-duty vehicles (2018)** supporting DG CLIMA. Previously, it has been employed to prepare scenarios as an input for the EC **Communication on decarbonising the transport sector**. Furthermore, it was recently used to calculate road transport energy consumptions for a 2050 scenario study within the ERTRAC CO2 working group. Further work is under way to soft-link DIONE emission calculation and cost curves with JRC's POTEnCIA model and employ it for scenario analysis on behalf of DG MOVE.

It can also be used to assess scenarios on the electrification of transport in line with the **Energy Union** strategy, to analyse possible transport sector measures for implementing a new **effort sharing decision**, as well as for reaching the **Transport White Paper** carbon emission reduction and conventional vehicle phase-out goals.

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	DIONE 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 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	*European Commission*	DIONE is used to assess economic impacts of different CO2 emission standards for vehicles levels.
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	*European Commission*	Refer to Study: Heavy duty vehicle CO2 emission reduction cost curves and cost assessment – enhancement of the DIONE model Documented in: - DOI 10.2760/555936
2017	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast) SWD/2017/0650 final	CLIMA	Baseline and assessment of policy options	*European Commission*	Refer to Study: Light duty vehicle CO2 emission reduction cost curves and cost assessment Documented in: - DOI 10.2760/87837

Bibliographic references

- *Krause, J. and Donati, A., Heavy duty vehicle CO2 emission reduction cost curves and cost assessment – enhancement of the DIONE model, EUR 29284 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-88812-0, doi:10.2760/555936, JRC112013.*

- *Krause, J., Donati, A. and Thiel, C., Light Duty Vehicle CO2 Emission Reduction Cost Curves and Cost Assessment - the DIONE Model, EUR 28821 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74136-4 (online),978-92-79-74137-1 (print), doi:10.2760/87837 (online),10.2760/462088 (print), JRC108725.*

- *Harrison, G., Krause, J., & Thiel, C. (2016). Transitions and Impacts of Passenger Car Powertrain Technologies in European Member States. Transportation Research Procedia, 14, 2620–2629. doi:10.1016/j.trpro.2016.05.418*

- *Thiel, C., Drossinos, Y., Krause, J., Harrison, G., Gkatzoflias, D., & Donati, A. V. (2016). Modelling Electro-mobility: An Integrated Modelling Platform for Assessing European Policies. Transportation Research Procedia, 14, 2544–2553. doi:10.1016/j.trpro.2016.05.341*