Commission modelling inventory and knowledge management system (MIDAS)
Report generation date 04/11/2020

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

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Factsheet

SWD/2020/176 final

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

Supporting model(s)

E3ME, GAINS, GEM-E3, GLOBIOM, PRIMES, QUEST

Impact assessment
SWD/2020/176 final

Fact sheet on model contributions

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

Date of Report Generation: 04/11/2020

Overview

Title
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

Document ID
SWD/2020/176 final

Year of publication
2020

Led by
CLIMA

Model(s) used
E3ME, GAINS, GEM-E3, GLOBIOM, PRIMES, QUEST

E3ME

Full title

Energy - Environment - Economy Model for Europe

Run for this impact assessment by

Cambridge Econometrics

Contributed to

Baseline and assessment of policy options

Details of the contribution

E3ME is used for macroeconomic assessment.

GAINS

Full title

Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model

Run for this impact assessment by

International Institute for Applied Systems Analysis

Contributed to

Baseline and assessment of policy options

Details of the contribution

GAINS models non-CO2 greenhouse gases for diverse sectors such as agriculture, waste, energy and industry and their associated cost for reducing emissions of non-CO2 greenhouse gases (CH4, N2O, F-gases).

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 only

Details of the contribution

GEM-E3 is used for sectoral economic assumptions used as inputs for the PRIMES energy system model.

GEM-E3

Full title

General Equilibrium Model - Economy, Energy, Environment

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Details of the contribution

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.

GLOBIOM

Full title

Global Biosphere Management Model

Run for this impact assessment by

International Institute for Applied Systems Analysis

Contributed to

Baseline and assessment of policy options

Details of the contribution

GLOBIOM is used to model land use, land use change, and forestry.

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

Details of the contribution

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.

QUEST

Full title

Macroeconomic model QUEST

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Details of the contribution

QUEST is used for macroeconomic assessment.

E3ME - Energy - Environment - Economy Model for Europe

Fact sheet

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

Date of Report Generation: 04/11/2020

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 copyright [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
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 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	*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.

Bibliographic references

- *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*
- *Rosenbaum E, Vasta A, Ciuffo B. Model-based Development of Scenarios for a Sustainable Europe - Methodologies, assumptions and first results. EUR 27727. Luxembourg (Luxembourg): Publications Office of the European Union; 2015. JRC96495*

Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model

Fact sheet

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

Date of Report Generation: 04/11/2020

Overview

Acronym GAINS
Full title Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model

Main purpose
GAINS is an analytical framework for assessing future potentials and costs for reducing air pollution impacts on human health and the environment while simultaneously mitigating climate change through reduced greenhouse gas emissions. It explores synergies and trade-offs in cost-effective emission control strategies so as to maximize benefits across multiple scales.

Summary
The **G**reenhouse gas - **A**ir pollution **In**teractions and **S**ynergies (GAINS) model (http://gains.iiasa.ac.at/) developed by the International Institute for Applied Systems Analysis (IIASA), describes the pathways of atmospheric pollution from its anthropogenic origin to the most relevant environmental impacts (Amann et al. 2011). It brings together information on future economic, energy and agricultural development, emission control potentials and costs, atmospheric dispersion and environmental sensitivities towards air pollution. The model addresses threats to human health posed by fine particulates and ground-level ozone, risk of ecosystems damage from acidification, excess nitrogen deposition (eutrophication) and exposure to elevated levels of ozone, as well as various global and regional climate metrics to calculate warming potential or temperature change. The assessed impacts are considered in a multi-pollutant context, quantifying the contributions of sulphur dioxide (SO2), nitrogen oxides (NOx), ammonia (NH3), non-methane volatile organic compounds (VOCs), primary emissions of particulate matter (PM2.5, PM10), carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), fluorinated gases (HFCs, PFCs and SF6), and black and organic carbon (BC, OC).

The GAINS model can explore cost-effective strategies to reduce emissions of air pollutants and greenhouse gases in order to meet specified environmental targets. It also assesses how specific control measures simultaneously influence different pollutants, permitting a combined analysis of air pollution and climate change mitigation strategies, which can reveal important synergies and trade-offs between these policy areas. The optimization mode of the GAINS model balances emission control measures across countries, pollutants and economic sectors such that user-defined target levels on various environmental impacts are met at least costs.

The GAINS model framework has global coverage with a geographic representation of 180 countries/regions and spanning the period 1990 to 2050 in five-year intervals with extension to 2070 for the European region. The estimation of emissions is combining activity data with emission factors describing alternative sets of pollutant reduction technologies. The emphasis lies on a rich representation of more than a thousand emission source sectors with associated alternative sets of abatement technologies. This allows for identification and quantification of emission sources, exposure levels, and mitigation potentials at a policy relevant level, e.g., by region (EU, country, sub-

national, city level), by sector (industry, residential, transport, agriculture), by farm size, by urban/rural contribution. Atmospheric dispersion processes are modeled using a source-receptor methodology that linearly approximates results of full chemical transport models. Critical load information (characterizing ecosystem sensitivities) are often compiled exogenously and incorporated into the GAINS model framework.

The model can be operated in the 'scenario analysis' mode, i.e., following the pathways of the emissions from their sources to their impacts. In this case the model provides estimates of regional costs and environmental benefits of alternative emission control strategies. The Model can also operate in the 'optimization mode', which identifies cost-optimal allocations of emission reductions in order to achieve specified deposition levels, concentration targets, or GHG emissions ceilings. The current version of the model can be used for viewing activity levels and emission control strategies, as well as calculating emissions and control costs for those strategies.

GAINS is frequently used to provide model input for air pollution and climate policy formulation. For example, GAINS has been used for policy analyses by the European Commission for the EU Reference Scenario (Energy, transport and GHG emissions: trends to 2070) and for the EU Thematic Strategy on Air Pollution and the air policy review (e.g., Amann et al., 2016, 2018; EC, 2019).

Keywords
Air Pollution , climate change , emissions , air pollutant emissions

Model category (thematic)
Climate

Model home page
https://iiasa.ac.at/web/home/research/researchPrograms/air/GAINS.html

Ownership & license

Ownership
Sole copyright [3rd party]

Ownership details
International Institute for Applied Systems Analysis (IIASA)

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

GAINS structure and approach
No information provided

Input and parametrization
GAINS uses externally produced activity scenarios for the macroeconomic, energy sector and agricultural sector developments. These are imported through links to partial equilibrium models, e.g., PRIMES for energy sector developments in Europe, CAPRI for developments in agricultural activity (livestock numbers and fertilizer use) in Europe, and the IEA-WEO and FAO for global energy and agricultural sector scenarios, respectively. In consistency with respective macroeconomic developments, GAINS generates internally projections for waste generation, relevant industry production, and consumption of F-gases. Technology-specific emission factors and cost parameters are developed internally in GAINS through information from literature and from direct dialogues and iterative consultations with stakeholders.

Main output
GAINS estimates emissions, mitigation potentials and costs for the major air pollutants (SO2, NOx, PM, NH3, VOC, BC/OC) and for the six greenhouse gases included in the Kyoto Protocol.

Outputs include emissions, impacts and costs of alternative policy configurations, prescribed or identified as cost-effective.

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

Parameter	Description
Spatial Extent / Country Coverage	GAINS has global coverage, distinguishing 180 regions including 48 European countries and 46 provinces/states in China and India.
(Spatial) resolution	Depends on the indicator. Grid resolution for calculating ambient PM2.5 in Europe: 0.125^{o} (longitude) x 0.0625^{o} (latitude), approx. 7x7km. Different resolution in the global domain outside Europe.
Temporal extent	1990 to 2050 with extension to 2070 for the European region
Temporal resolution	Five years intervals

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	Uncertainty is in GAINS handled through: - The use of alternative activity data scenarios reflecting a range of macroeconomic, energy and agricultural sector developments - Extension of sector/technology model resolution to reflect policy relevant implications of e.g., scale, urban/rural differences, etc. on emission factors and costs - Consideration of a wealth of country-specific factors and circumstances in the derivation of emission factors, cost parameters, and emission control strategies.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Sensitivity analyses are frequently performed on GAINS model results on a case-by-case basis, e.g., by the use of alternative activity data scenarios or by using ranges for emission factors and costs in simulations.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	GAINS model results have been presented in numerous peer-reviewed publications and has been evaluated by an external expert panel on a few occasions as part of regular IIASA program reviews.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Modelled ambient PM concentrations at (urban or rural) background level have been validated against observations, see Kiesewetter et al (2015a,b) and Amann, M., Kiesewetter, G., Schoepp, W., Klimont, Z., Winiwarter, W. et al., 2020. Reducing global air pollution: The scope for further policy interventions. Phil. Trns. R. Soc. A. (In press). GAINS bottom-up emission inventory for global methane emissions evaluated against top-down atmospheric measurements of CH4 concentration, see Höglund-Isaksson et al. (2020); Saunois et al. (2020).

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

- Höglund-Isaksson, L., Gómez-Sanabria, A., Klimont, Z., Rafaj, P., & Schöpp, W. (2020). Technical potentials and costs for reducing global anthropogenic methane emissions in the 2050 timeframe –results from the GAINS model. Environmental Research Communications, 2(2), 025004. doi:10.1088/2515-7620/ab7457
- Kiesewetter, G., Borken-Kleefeld, J., Schöpp, W., Heyes, C., Thunis, P., Bessagnet, B., … Amann, M. (2015). Modelling street level PM₁₀ concentrations across Europe: source apportionment and possible futures. Atmospheric Chemistry and Physics, 15(3), 1539–1553. doi:10.5194/acp-15-1539-2015
- Kiesewetter, G., Schoepp, W., Heyes, C., & Amann, M. (2015). Modelling PM2.5 impact indicators in Europe: Health effects and legal compliance. Environmental Modelling & Software, 74, 201–211. doi:10.1016/j.envsoft.2015.02.022

- Saunois, M., Stavert, A. R., Poulter, B., Bousquet, P., Canadell, J. G., Jackson, R. B., … Patra, P. K. (2020). The Global Methane Budget 2000–2017. Earth System Science Data, 12(3), 1561–1623. doi:10.5194/essd-12-1561-2020

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	The GAINS database is publicly available and can be accessed through the GAINS website http://gains.iiasa.ac.at/models/index.html. The information supplied on the GAINS website or parts thereof may be freely used for non-commercial and educational purposes. Data from this site is for informational purposes only, and may only be used as input to other models with explicit permission of IIASA. Information from this site may be reproduced with proper acknowledgment to IIASA, Laxenburg, Austria.
Can model outputs be made publicly available?	yes	Simulation mode results can be produced within the public model framework. Optimization mode results have been made available through peer-reviewed publications.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	Amann et al. (2011): general model approach for Europe; Höglund-Isaksson et al. (2018): documentation of methodology for non-CO2 policy scenarios for EU-28, see https://ec.europa.eu/clima/sites/clima/files/strategies/analysis/models/docs/non_co2_methodology_report_en.pdf; Klimont et al (2017): documentation of methodology for PM emission calculation; Klimont and Winiwarter (2015): documentation of NH3 emission and cost calculation.
Is the model source code publicly accessible or open for inspection?	yes	Can be made available upon request

References related to documentation:

- Nguyen, T. B., Wagner, F., & Schoepp, W. (2011). GAINS – An Interactive Tool for Assessing International GHG Mitigation Regimes. Information and Communication on Technology for the Fight Against Global Warming, 124–135. doi:10.1007/978-3-642-23447-7_12
- Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., … Winiwarter, W. (2011). Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. Environmental Modelling & Software, 26(12), 1489–1501. doi:10.1016/j.envsoft.2011.07.012
- Klimont, Z., Kupiainen, K., Heyes, C., Purohit, P., Cofala, J., Rafaj, P., … Schöpp, W. (2017). Global anthropogenic emissions of particulate matter including black carbon. Atmospheric Chemistry and Physics, 17(14), 8681–8723. doi:10.5194/acp-17-8681-2017
- Klimont, Z., & Winiwarter, W. (2015). Estimating Costs and Potential for Reduction of Ammonia Emissions from Agriculture in the GAINS Model. Costs of Ammonia Abatement and the Climate Co-Benefits, 233–261. doi:10.1007/978-94-017-9722-1_9

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
- Public health

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

- Formulation

The model's potential

The model is designed to contribute to the following policy areas:

- Climate action through mitigation potentials for non-CO2 GHGs and Black Carbon
- Climate action through harnessing health co-benefits
- Public health through air pollution exposure levels
- Ecosystem protection through critical loads

GAINS is used for policy analyses under the Convention on Long-range Transboundary Air Pollution (CLRTAP), e.g., for the revision of the Gothenburg Protocol, and by the European Commission for the EU Thematic Strategy on Air Pollution and the air policy review, and it was among the models used to inform the EC proposal "A Clean Planet for All" (COM (2018) 773). GAINS is used to assess domestic mitigation potential of non-CO2 GHGs for EU climate policy analyses. Scientists and government agencies in many nations (e.g., in Europe, China, India, Vietnam) use GAINS as a tool to assess emission reduction potentials in their regions.

In "scenario analysis" mode, it follows emission pathways from sources to impacts, providing estimates of regional costs and the environmental benefits of alternative emission control strategies.

In "optimization" mode, GAINS identifies cost-optimal portfolios of emission control measures for achieving specified targets, such as absolute emission limits, or health impacts.

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	GAINS contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
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	*International Institute for Applied Systems Analysis*	GAINS models non-CO2 greenhouse gases for diverse sectors such as agriculture, waste, energy and industry and their associated cost for reducing emissions of non-CO2 greenhouse gases (CH4, N2O, F-gases).

Bibliographic references

- *Höglund-Isaksson, L., Gómez-Sanabria, A., Klimont, Z., Rafaj, P., & Schöpp, W. (2020). Technical potentials and costs for reducing global anthropogenic methane emissions in the 2050 timeframe –results from the GAINS model. Environmental Research Communications, 2(2), 025004. doi:10.1088/2515-7620/ab7457*

- *Saunois, M., Stavert, A. R., Poulter, B., Bousquet, P., Canadell, J. G., Jackson, R. B., … Patra, P. K. (2020). The Global Methane Budget 2000–2017. Earth System Science Data, 12(3), 1561–1623. doi:10.5194/essd-12-1561-2020*

- *Rafaj, P., Kiesewetter, G., Gül, T., Schöpp, W., Cofala, J., Klimont, Z., … Cozzi, L. (2018). Outlook for clean air in the context of sustainable development goals. Global Environmental Change, 53, 1–11. doi:10.1016/j.gloenvcha.2018.08.008*

- *Winiwarter, W., Höglund-Isaksson, L., Klimont, Z., Schöpp, W., & Amann, M. (2018). Technical opportunities to reduce global anthropogenic emissions of nitrous oxide. Environmental Research Letters, 13(1), 014011. doi:10.1088/1748-9326/aa9ec9*

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GEM-E3 - General Equilibrium Model - Economy, Energy, Environment

Fact sheet

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

Date of Report Generation: 04/11/2020

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
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.
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 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 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.
2017	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast)	CLIMA	Baseline and assessment of policy options	*European Commission*	GEM-E3 was used to assess macroeconomic impacts of target setting based on GDP per capita.

SWD/2017/0650 final

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- *Ciscar Martinez J, Feyen L, Iglesias A, Szabo L, Van Regemorter D, Amelung B, Nicholls R, Watkiss P, Christensen O, Dankers R, Garrote L, M. Goodess C, Hunt A, Moreno A, Richards J, Soria Ramirez A. Physical and economic consequences of climate change in Europe. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 108 (7); 2011. p. 2678-2683. JRC63970*

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- *Russ H, Ciscar Martinez J, Szabo` L. Analysis of Post-2012 Climate Policy Scenarios with Limited Participation. EUR 21758 EN. 2005. JRC30404*

GLOBIOM - Global Biosphere Management Model

Fact sheet

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

Date of Report Generation: 04/11/2020

Overview

Acronym GLOBIOM
Full title Global Biosphere Management Model

Main purpose
GLOBIOM is a global economic land use model covering the sectors of agriculture, forestry and bioenergy. The model has spatially explicit supply side representation covering different management systems and land use activities. It simulates economic market equilibrium for the analysis of economic as well as environmental consequences of future land use drivers and polices.

Summary
GLOBIOM is a global model capturing the multiple relationships between the different systems involved in provision of agricultural, forestry and bioenergy products, for example, population dynamics, ecosystems, technology, and climate.

GLOBIOM integrates the agricultural, bioenergy, and forestry sectors and draws on comprehensive socioeconomic and geospatial data. It accounts for the 18 most globally important crops, a range of livestock production activities, forestry commodities, first- and second-generation bioenergy, and water. The supply side of the model is represented at the spatially explicit level of simulation units and takes into account biophysical land and soil, management, and weather characteristics. Land and other resources are allocated to the different production and processing activities to maximize a social welfare function which consists of the sum of producer and consumer surplus subject to resource, technological and policy constraints. Using the year 2000 as the baseline, GLOBIOM simulates demand and supply quantities, bilateral trade flows, and prices for commodities and natural resources at 10-year-step intervals up to 2100. The model allows for a full account of all agriculture and forestry GHG sources based on advanced IPCC methods.

GLOBIOM can be used for policy anticipation and formulation. The GLOBIOM approach is strongly grounded in the idea that the production of food, forest fibre, and bioenergy, must be analysed and planned in an integrated way across agriculture, forestry, and bioenergy sectors. GLOBIOM can be used to explore the various trade-offs and synergies around land use and ecosystem services, and helps policy makers understand and minimize land use and resource competition through more holistic thinking.

Keywords
agriculture , land use , forestry , bioenergy

Model category (thematic)
Agriculture, Environment

Model home page
http://www.globiom.org/

Ownership & license

Ownership
Sole copyright [3rd party]

Ownership details
GLOBIOM was developed and is maintained and updated at the International Institute for Applied Systems Analysis (IIASA).

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

GLOBIOM structure and approach

GLOBIOM is a global, recursive dynamic, linear programming, partial equilibrium model covering the sectors of agriculture, forestry and bioenergy including economic as well as bio-physical aspects. The market equilibrium is solved by maximizing the sum of producer and consumer surplus subject to resource, technological, and political constraints. The modelling approach represents bilateral trade based on cost competitiveness.

Input and parametrization

Economic data is based on the market balances of Eurostat and FAOSTAT. Land cover maps rely on CORINE/PELCOM and GLC 2000. The source of bio-physical crop parameters is the crop model Environmental Policy Integrated Climate Model (EPIC). The price demand elasticities of the USDA are used to model changes in demand. Nearly all greenhouse gas emissions from land using sectors and land use change are included and based on Intergovernmental Panel on Climate Change (IPCC) accounting guidelines. Other data were compiled from various sources (Ecofys, IIASA and E4tech, 2013).

Main output

GLOBIOM provides output for land use change in hectares, carbon emission in tonnes CO2, water use through irrigation in km3 and commodity prices in US$. Furthermore supply and demand is projected in tonnes.

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	Global
(Spatial) resolution	GLOBIOM has a spatial resolution of 0.5° x 0.5° grid which can be aggregated to countries or regions. It distinguishes a flexible amount of 30 world regions (default is 30) currently represented in the global version. Regional versions of the model, have been designed with national and regional institutes. These versions provide more detailed spatial representation of land use changes to assess the impact of specific regional policies.
Temporal extent	Projections over time up to 2100 are possible
Temporal resolution	10 years

Quality & transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	yes	Depending on the concrete analysis, often different types of sensitivity analyses of the most important parameters can be provided.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Depending on the concrete analysis, different types of sensitivity analyses of the most important parameters can be provided.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	Model analyses are frequently published in high ranking scientific journals.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	The first 20 years of a scenario are usually used for validation purpose (baseyear is 2000).

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	Main databases are: Eurostat and FAOSTAT
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	Model documentation can be found under https://ec.europa.eu/clima/sites/clima/files/strategies/analysis/models/docs/lulucf_methodology_report_may2016_en.pdf, http://www.globiom-iluc.eu/globiom-model/model-documentation/ and https://iiasa.github.io/GLOBIOM/ .
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

- Agriculture and rural development
- Climate action
- Energy
- Environment

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

- Anticipation
- Formulation

The model's potential

The GLOBIOM approach is strongly grounded in the idea that the production of food, forest fibre, and bioenergy, must be analysed and planned in an integrated way across agriculture, forestry, and bioenergy sectors. GLOBIOM can be used to explore the various trade-offs and synergies around land use and ecosystem services, and helps scientists and policy makers understand and minimize land use and resource competition through more holistic thinking.

GLOBIOM can advise on a number of policy questions, for example:

- Capability of the agricultural system to supply future food demand and other societal services;
- Future agricultural land requirements and other pressures of the agricultural system on the environment (water needs, nitrogen);
- Trends in future deforestation and the impact of measures to reduce deforestation and forest degradation;
- Future greenhouse gas emissions from the agricultural sector and from land use change;
- The potential contribution of bioenergy to climate change mitigation;
- Assess the current and future demand and supply of water for irrigation;
- The relative costs and benefits of importing or exporting food and raw materials;
- The profitability, incentives, and impacts of changing agricultural management practices; and
- Adaptation of agriculture to future climate change.

The model was initially developed mostly for integrated assessment of climate change mitigation policies in land based sectors, including biofuels, and is increasingly being implemented also for agricultural and timber markets foresight, and economic impacts analysis of climate change and adaptation.

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	GLOBIOM contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
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	*International Institute for Applied Systems Analysis*	GLOBIOM is used to model land use, land use change, and forestry.

Bibliographic references

- *No references provided in MIDAS*

PRIMES Energy System Model

Fact sheet

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

Date of Report Generation: 04/11/2020

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 copyright [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 table 'Previous use of the model in ex-ante impact assessments of the European Commission' specifically reports 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
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.

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*

Macroeconomic model QUEST

Fact sheet

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

Date of Report Generation: 04/11/2020

Overview

Acronym QUEST
Full title Macroeconomic model QUEST

Main purpose
A macro-economic model used to analyse and understand the state of the EU economy.

Summary
QUEST is a macro-economic model (Dynamic Stochastic General Equilibrium) used to analyse and understand the state of the EU economy. It is developed by DG ECFIN, and estimated model variants have been developed jointly with support from the JRC. The first version of QUEST was applied in 2007, and many extensions have been developed since.

QUEST belongs to the class of New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) models that are now widely used by international institutions and central banks. These models have rigorous microeconomic foundations derived from utility and profit optimisation and include frictions in goods, labour and financial markets. With empirically plausible estimation and calibration they are able to fit the main features of the macroeconomic time series. The QUEST model has been estimated on euro area and US data using Bayesian estimation methods. Calibrated model versions are used in wider applications.

QUEST supports questions related to policy formulation, implementation and evaluation. Many of the main applications deal with fiscal and monetary policy interactions. In order to deal with the wide range of policy issues in DG ECFIN, different model versions of the QUEST model have been constructed, each with a specific focus and regional and sectoral disaggregation.

Keywords
macroeconomic model , DSGE model

Model category (thematic)
Economy

Model home page
https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/economic-research/macroeconomic-models_en

Ownership & license

Ownership
Sole copyright [European Union]

Ownership details
The model is owned by DG ECFIN.DDG2.B.3

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

QUEST structure and approach

QUEST III belongs to the class of New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) models that are now widely used by international institutions and central banks. These models have rigorous microeconomic foundations derived from utility and profit optimisation and include frictions in goods, labour and financial markets. With empirically plausible estimation and calibration they are able to fit the main features of the macroeconomic time series. Calibrated model versions are used for most policy applications, but the QUEST III model has also been estimated on Euro Area, US and specific Euro Area countries (ES, DE) data using Bayesian estimation methods.

In order to deal with the wide range of policy issues in DG ECFIN, different model versions of the QUEST III model have been constructed, each with a specific focus and regional and sectoral disaggregation. Many of the main applications deal with fiscal and monetary policy interactions and either use a one-sector model or models that explicitly distinguish tradable and nontradable sectors, and include trade in intermediates. Other model variants also include housing and collateral constraints.

QUEST III has also been used for the analysis of structural reforms and another version has been employed for the analysis of energy and climate change policies. All these models are employed using different country disaggregations, focusing on the euro area or EU as a whole, and other global regions, or on individual member states.

The models are developed by the modelling unit in DG ECFIN. The Joint Research Centre of the European Commission supports QUEST development providing econometric, computational and methodological expertise in estimation and calibration, maintaining dedicated IT resources.

An update of some new developments of the QUEST III models was described in ECFIN Research Letter Vol.3.Issue 1/2009 (pp 10-13). For further references on the QUEST model, see the model homepage.

Input and parametrization

Key inputs for the estimated model versions are coming from national accounts and other macroeconomic data source. The main ones are:

- National account data (GDP and its components, current and constant prices)
- Labour market data (wages, employment)
- Financial variables (interest rates)
- Trade data
- Monetary data (interest rates)

Main output

Key outputs produced by the model:

- Model parameter estimates to be used for simulation (time evolution of all macro-variables of interest in response to a shock in the economy or changes in policy) and model-based policy analysis;
- Among the macroeconomic variables of interest, the model allows to study dynamics and economic drivers of:
    - GDP and its components
    - Price deflators
    - Fiscal variables
    - Employment, wages
    - Interest rates
    - Trade

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	Global, incl. individual EU countries, various EU aggregates (EU, Euro area, OMS, NMS, etc).
(Spatial) resolution	Up to country aggregation
Temporal extent	Estimation data range: 1985-2013 for Euro area aggregate; 1995-2013 for individual countries. Simulation horizon: the model is simulated for several periods ahead to allow convergence.
Temporal resolution	Quarterly

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	Possible
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Very often model versions are subject to sensitivity analysis.
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 many publications in peer-reviewed journals.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	k-periods ahead behavior of the model variables is compared with historical observations.

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

- Ratto M, Roeger W, Int Veld J. QUEST III: An Estimated Open-Economy DSGE Model of the Euro Area with Fiscal and Monetary Policy. ECONOMIC MODELLING 26; 2009. p. 222-233. JRC46465

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	Taken from public sources.
Can model outputs be made publicly available?	yes	In publications.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	Model structure is typically documented in scientific publications (e.g. Ratto et.al 2009). Technical algorithms and codes are available upon request.
Is the model source code publicly accessible or open for inspection?	no	Technical algorithms and codes of estimated model versions published in academic journals are made available upon request.

References related to documentation:

- Fiscal stimulus and exit strategies in the EU : a model-based analysis. - 10.2765/44208

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

The model is designed to contribute to the following policy areas

- Economy, finance and the euro
- Taxation
- Employment and social affairs
- Trade

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

- Anticipation
- Formulation
- Implementation
- Evaluation

The model's potential

QUEST III is a tool suitable for policy preparation and implementation. It is designed to analyze economic issues like the occurrence boom-bust cycles, the study of structural reforms (Lisbon process), fiscal policy, country debt stabilization and sustainability. Main policy areas requiring QUEST based analysis concern MIP (Macroeconomic Imbalance Procedure) assessments, EDP (Excess Deficit) procedures and debt sustainability analysis.

DG ECFIN uses QUEST III for macroeconomic policy analysis and research. Results of the studies feed into ECFIN policy repots. JRC supports DG ECFIN for the development of QUEST III, focusing on the estimation. JRC provides estimated versions of QUEST models for individual member states, used to support policy studies for macro-economic surveillance by DG ECFIN

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	QUEST contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
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*	QUEST is used for macroeconomic assessment.
2018	Impact assessment accompanying the document Proposals for a Regulation of the European Parliament and of the Council on: the European Regional Development Fund and on the Cohesion Fund and; Proposal for a Regulation of the European Parliament and the Council on: a mechanism to resolve legal and administrative obstacles in a cross-border context and; Proposal for a Regulation of the European Parliament and the Council on: specific provisions for the European territorial cooperation goal (Interreg) supported by the European Regional Development Fund and external financing instruments SWD/2018/282 final	REGIO	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Economic growth and employment - Investment cycle - Affects on individual Member States - Stimulation of research and development - Innovation for productivity/resource efficiency
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council on: the establishment of a European Investment Stabilisation Function SWD/2018/297 final	ECFIN	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Budgetary consequences for public authorities - Economic growth and employment - Macro-economic stabilisation
2018	Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and the Council on: establishing Horizon Europe - the	RTD	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Investment cycle - Affects on individual Member States

	Framework Programme for Research and Innovation, laying down its rules for participation and dissemination and; Proposal for a Decision of the European Parliament and the Council on: establishing the specific programme implementing Horizon Europe - the Framework Programme for Research and Innovation and; Proposal for a Regulation of the European Parliament and the Council on: establishing the Research and Training Programme of the European Atomic Energy Community for the period 2021-2025 complementing Horizon Europe - the Framework Programme for Research and Innovation SWD/2018/307 final	- Stimulation of research and development - Innovation for productivity/resource efficiency - Economic growth and employment

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