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.

Find out more at https://knowledge4policy.ec.europa.eu/modelling/about_en
Contact: EU-MIDAS@ec.europa.eu

Factsheet

SWD/2021/603 final

IMPACT ASSESSMENT REPORT 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

Supporting model(s)

AIM, E3ME

Document based on Ares(2021)4263157

Impact assessment
SWD/2021/603 final

Fact sheet on model contributions

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

Date of Report Generation: 02/09/2021

Dissemination: Public

Table of Contents

Overview

Title
IMPACT ASSESSMENT REPORT 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

Document ID
SWD/2021/603 final

Year of publication
2021

Led by
CLIMA

Model(s) used
AIM, E3ME

Additional information

The modelling results are available in the report *'Assessment of ICAO's global market-based measure (CORSIA) pursuant to Article 28b and for studying cost pass-through pursuant to Article 3d of the EU ETS* Directive' [for details, see the impact assessment report] as well as in the document presenting an update of the modelling results, taking account of the impact of the COVID-19 outbreak [full reference to be inserted after publication of the document].

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).

The Reference Scenario from PRIMES-TREMOVE modelling was used to provide inputs to AIM modelling, including base scenario carbon price, share of biofuels in total energy consumption, fuel prices, population and GDP, aviation and energy demand.

[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.

AIM

Full title
Aviation Integrated Model

Run for this impact assessment by
University College London, Air Transportation Analytics

Contributed to
Baseline and assessment of policy options

Helped to assess the following impacts

The AIM model was used to assess the impacts of options on the aviation sector, including direct and net aviation CO2 emissions, the percentage of global aviation CO2 emissions covered, carbon costs as a proportion of airline fuel and operating costs, impacts on demand for passenger and freight transport, demand for EU allowances and CORSIA offsets, auctioning revenues, ticket prices, and other externalities including from congestion and local air pollutants.

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

Helped to assess the following impacts

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.

AIM

Aviation Integrated Model

Fact sheet

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

Date of Report Generation: 02/09/2021

Dissemination: Public

Overview

Acronym AIM
Full title Aviation Integrated Model

Main purpose
The Aviation Integrated Model (AIM) is a global aviation systems model which simulates interactions between passengers, airlines, airports and other system actors into the future, with the goal of providing insight into how policy levers and other projected system changes will affect aviation's externalities and economic impacts.

Summary
The Aviation Integrated Model (AIM) is a systems model of global aviation. It simulates the behaviour of passengers, airlines, airports and other system actors going forward to 2050 and beyond, with the goal of providing insight into how policy levers and other projected system changes will affect aviation's externalities and economic impacts. The model was originally developed in 2006-2009 with UK research council funding (e.g. Reynolds et al., 2007; Dray et al. 2014), and was updated as part of the ACCLAIM project (2015-2018) between University College London, Imperial College and Southampton University (e.g. Dray et al., 2019; Schäfer et al., 2018), with additional input from MIT. The model is open-source, with code, documentation and a simplified version of model databases which omit confidential data available from the UCL Air Transportation Systems Group website [1].

AIM uses a modular, integrated approach to simulate the global aviation system and its response to policy. AIM consists of seven interconnected modules. The Demand and Fare Module projects true origin-ultimate destination demand between a set of cities representing approximately 95% of global scheduled RPK, using a gravity-type demand model (Dray et al. 2014). Within each city-city passenger flow, itinerary, airport and routing choice (including hub airport for multi-segment journeys) are handled using a multinomial logit model (Dray & Doyme 2019), and itinerary fares are simulated using a fare model (see Dray et al,. 2019 and references therein) based on segment airline costs and other factors. These models are complemented by simpler models for freight flow and non-scheduled passengers. The Airport Activity Module simulates the flight schedule that would be required to transport passengers and freight, the aircraft that would be used per flight segment, and airport-level operations and delays, and the Aircraft Movement Module simulates en-route fuel use and inefficiency factors. The Aircraft Technology and Cost Module calculates fleet composition, airline costs, and airline choices on technology adoption, and feeds airline costs back into the fare model. Once the model has converged, climate impacts, local air quality and noise, and regional economic impacts are calculated by the three output modules. These models are estimated primarily on detailed disaggregate global passenger routing, fare and schedule data.

AIM has been used for multiple studies on the impact of aircraft technology and policy interventions, both in the academic literature and for policymakers. This includes studies for DG CLIMA on the EU

Emissions Trading Scheme for aviation, the UK Department for Transport on carbon leakage, and the International Energy Agency on long-term aviation emissions projections.

[1] http://www.atslab.org; note that the website-available version is not always the most recent version of the model.

Keywords
aviation

Model category (thematic)
Transport

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

Ownership & license

Ownership
Sole ownership [3rd party]

Ownership details
The model is owned by University College London (UCL)

Licence type
Free software licence. The license grants freedom to run the programme for any purpose; freedom to run the program for any purpose; freedom to study (by accessing the source code) how the program works, and change it so it does enable computing; freedom to redistribute copies; and freedom to distribute copies of modified versions to others.

Details

AIM structure and approach

AIM uses a modular, integrated approach to simulate the global aviation system and its response to new policies and technologies. AIM consists of seven interconnected modules. The Demand and Fare Module projects true origin-ultimate destination demand between a set of cities representing approximately 95% of global scheduled RPK, using a gravity-type demand model (Dray et al. 2014) where demand is a function of origin and destination population and income, and city-pair trip characteristics such as fare and journey time. Within each city-city passenger flow, itinerary, airport and routing choice (including hub airport for multi-segment journeys) are handled using a multinomial logit model (Dray & Doyme 2019) which assesses choices as a function of itinerary fare, time, frequency and other factors, and itinerary fares are simulated using a fare model (see Dray et al,. 2019 and references therein) based on segment airline costs and other factors. These models are complemented by simpler models for freight flows and non-scheduled passengers.

The Airline and Airport Activity Module, given segment-level demand, assesses which aircraft will be used to fly these routes and at what frequency, using a multinomial logit model estimated from historical scheduling data (Sabre, 2017) and dividing the fleet into nine size categories. Given these aircraft movements per airport, a queuing model then estimates what the resulting airport-level delays would be (see Dray et al,. 2019 and references therein). Given the lack of long-term airport capacity forecasts, in most cases this delay model is used to estimate the amount of (city-level) capacity that would be required to keep delays at current levels.

The aircraft movement module assesses the corresponding airborne routes and the consequent location of emissions. In particular, routing inefficiencies which increase ground track distance flown beyond great circle distance, and fuel use above optimal for the given flight distance, are modelled using distance-based regional inefficiency factors based on an analysis of radar track data.

Given typical aircraft utilization, the aircraft technology and cost module assesses the size, composition, age and technology use of the aircraft fleet, and the resulting costs for airlines and emissions implications. First, aircraft movements by size class including routing inefficiency from the Aircraft Movement Module are input to a performance model (estimated from outputs of the PIANO-X (Lissys, 2017) model with reference aircraft types and missions for CO2 and NOx, the FOX methodology (Stettler et al. 2013) for PM2.5, and Wood et al. (2008) for NO2). Second, the costs of operating this fleet for the given schedule are estimated based on historical cost data by category and aircraft type (see Dray et al,. 2019 and references therein). Third, emissions and costs are adjusted to account for the current age distribution and technology utilization of the fleet, including typical retirement and freighter conversion behavior (e.g. Dray, 2013). Finally, any shortfall in aircraft required to perform the given schedule is assumed made up by new purchases, and the uptake of technology and emissions mitigation measures by both new aircraft and existing ones is assessed on a net present value basis, as described in Dray et al. (2018), and the impact of this on costs and emissions is assessed.

These four modules are run iteratively until a stable solution is reached. Data is then output which can be used in the global climate, air quality and noise, and regional economics modules. The global climate module is a rapid, reduced-form climate model which calculates the resulting climate metrics (e.g. CO2e in terms of global temperature potential (GTP) and global warming potential (GWP) at different time horizons; see Krammer et al., 2013). The air quality and noise module are similarly rapid, reduced-form models which provide metrics by airport for the noise and local/regional air quality impacts of the projected aviation system. In the case of air quality, dispersion modelling for primary pollutants uses a version of the RDC code (e.g. Yim et al., 2015). The type of noise modelling carried out depends on whether data on standard flight routes per airport is available, but for all airports noise modelling based on total noise energy is carried out (Torija et al. 2017). The regional economics module looks in more detail at the economic impacts, including benefits such as increased employment as well as costing of noise and air quality impacts.

The output data from the first four AIM modules can also be used more generally as input to external impacts models: for example, the model includes the option to produce detailed emissions inventories which can be input into climate models. Further information on the individual sub-models, on model validation, and on typical model inputs and outputs can be found in the papers cited above and in the model documentation (Dray, 2020. AIM2015: Documentation. http://www.atslab.org/wp-content/uploads/2020/01/AIM-2015-Documentation-v9-270120.pdf).

Input and parametrization

- Population, GDP and urbanisation projections at regional or country level, by year, across the model time horizon
- Energy price projections (oil, electricity, gas), by year and country/region where relevant, across the model time horizon
- Carbon price projections by year and applicable scheme (e.g. EU ETS, CORSIA) across the model time horizon
- Carbon intensity of electricity generation by year and country/region across the model time horizon
- Technology characteristics (e.g. entry into service date of next aircraft generation, biofuel feedstock costs, etc; dependent on what is being evaluated, default assumptions are included in the model)
- Other policy characteristics as required (dependent on what is being evaluated; e.g. contrail or NOx pricing)

Main output

- Passenger and freight aviation demand projections (passengers, flights, RPK, FTK) – at global, regional, country or flight segment level_
- Airport passenger flows, local emissions (NOx, PM) and revenues

- Average fares and airline operating costs, global/regional or individual itinerary/flight segment level
- Aviation CO_2 and other emissions (NO_x, PM, H_2O, fuel lifecycle CH_4, N_2O) – on a direct, fuel lifecycle or net basis, global/regional/country/flight segment/aircraft type level
- Uptake of new technologies, on a regional basis, number of aircraft

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	Global model, includes all countries with significant aviation activity.
(Spatial) resolution	Outputs can be spatially disaggregated down to world region, country, airport, or flight segment level.
Temporal extent	Base year is 2015. The latest year the model can be run to is 2100 (with considerable uncertainty).
Temporal resolution	A year timestep is used.

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 are accounted for via scenario or Monte Carlo analysis for socioeconomic/policy variables and lens/monte carlo modelling for uncertain technology/fuel parameters.
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 was carried out as part of the initial AIM2015 validation process (Dray et al. 2019). Further sensitivity analysis, concentrating on fuel and carbon costs and socioeconomic scenario, was carried out as part of the process of making an AIM metamodel for the HORIZON2020 NAVIGATE project.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	A comprehensive list of peer reviewed review publications are indicated in the 'Reference' section. The ACCLAIM project, during which the model was comprehensively updated, involved periodic review by a project advisory board.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Validation is via peer review in the scientific literature and through comparing backcasting outcomes with actual developments (in particular see Dray et al., 2019). During this process, the model is run with a 2005 base year and outcomes between 2005 and the present day are assessed against observed outcomes.

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	Available at www.atslab.org/data-tools (note that some model data is confidential and so a simplified version is provided in the public database)
Can model outputs be made publicly available?	yes	There is no limitation on making model outputs public
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	Full documentation is available with the model code and databases at www.atslab.org/data-tools (Dray, 2020. AIM2015: Documentation. http://www.atslab.org/wp-content/uploads/2020/01/AIM-2015-Documentation-v9-270120.pdf)
Is the model source code publicly accessible or open for inspection?	yes	Available at www.atslab.org/data-tools

References related to documentation:

- Dray, L. M., Krammer, P., Doyme, K., Wang, B., Al Zayat, K., O'Sullivan, A., & Schäfer, A. W. (2019). AIM2015: Validation and initial results from an open-source aviation systems model. Transport Policy, 79, 93–102. doi:10.1016/j.tranpol.2019.04.013

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

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

- Anticipation
- Formulation

The model’s potential

AIM is intended to be used to assess policy or technology levels applied to all or part of the global aviation system. This could include changes in costs to airlines or passengers, or changes in the cost or availability of alternative technology. It has been used to assess carbon trading and offsetting policy (e.g., as part of the assessment for DG CLIMA on how the EU ETS and CORSIA should interact). In the academic literature it has been used to assess the environmental and economic impacts of a range of interventions, including the availability of battery electric aircraft (Schafer et al. 2018) and early aircraft retirement (Dray et al. 2014).

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	AIM 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	*University College London, Air Transportation Analytics*	The AIM model was used to assess the impacts of options on the aviation sector, including direct and net aviation CO2 emissions, the percentage of global aviation CO2 emissions covered, carbon costs as a proportion of airline fuel and operating costs, impacts on demand for passenger and freight transport, demand for EU allowances and CORSIA offsets, auctioning revenues, ticket prices, and other externalities including from congestion and local air pollutants.

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- *Dray, L. M., Krammer, P., Doyme, K., Wang, B., Al Zayat, K., O'Sullivan, A., & Schäfer, A. W. (2019). AIM2015: Validation and initial results from an open-source aviation systems model. Transport Policy, 79, 93–102. doi:10.1016/j.tranpol.2019.04.013*
- *Dray, L., & Doyme, K. (2019). Carbon leakage in aviation policy. Climate Policy, 19(10), 1284–1296. doi:10.1080/14693062.2019.1668745*
- *Dray, L. M., Schäfer, A. W., & Al Zayat, K. (2018). The Global Potential for CO2 Emissions Reduction from Jet Engine Passenger Aircraft. Transportation Research Record: Journal of the Transportation Research Board, 2672(23), 40–51. doi:10.1177/0361198118787361*
- *Schäfer, A. W., Barrett, S. R. H., Doyme, K., Dray, L. M., Gnadt, A. R., Self, R., … Torija, A. J. (2018). Technological, economic and environmental prospects of all-electric aircraft. Nature Energy, 4(2), 160–166. doi:10.1038/s41560-018-0294-x*
- *Torija, A. J., Self, R. H., & Flindell, I. H. (2017). A model for the rapid assessment of the impact of aviation noise near airports. The Journal of the Acoustical Society of America, 141(2), 981–995. doi:10.1121/1.4976053*
- *Yim, S. H. L., Lee, G. L., Lee, I. H., Allroggen, F., Ashok, A., Caiazzo, F., … Barrett, S. R. H. (2015). Global, regional and local health impacts of civil aviation emissions. Environmental Research Letters, 10(3), 034001. doi:10.1088/1748-9326/10/3/034001*
- *Dray, L., Evans, A., Reynolds, T., Schäfer, A. W., Vera-Morales, M., & Bosbach, W. (2014). Airline fleet replacement funded by a carbon tax: An integrated assessment. Transport Policy, 34, 75–84. doi:10.1016/j.tranpol.2014.02.021*
- *Dray, L. (2013). An analysis of the impact of aircraft lifecycles on aviation emissions mitigation policies. Journal of Air Transport Management, 28, 62–69. doi:10.1016/j.jairtraman.2012.12.012*
- *Krammer, P., Dray, L., & Köhler, M. O. (2013). Climate-neutrality versus carbon-neutrality for aviation biofuel policy. Transportation Research Part D: Transport and Environment, 23, 64–72. doi:10.1016/j.trd.2013.03.013*
- *Stettler, M. E. J., Boies, A. M., Petzold, A., & Barrett, S. R. H. (2013). Global Civil Aviation Black Carbon Emissions. Environmental Science & Technology, 130823150610008. doi:10.1021/es401356v*
- *Wood, E. C., Herndon, S. C., Timko, M. T., Yelvington, P. E., & Miake-Lye, R. C. (2008). Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust near Airports. Environmental Science & Technology, 42(6), 1884–1891. doi:10.1021/es072050a*

- *Reynolds, T., Barrett, S., Dray, L., Evans, A., Köhler, M., Vera-Morales, M., … Hunsley, R. (2007). Modelling Environmental and Economic Impacts of Aviation: Introducing the Aviation Integrated Modelling Project. 7th AIAA ATIO Conf, 2nd CEIAT Int'l Conf on Innov and Integr in Aero Sciences,17th LTA Systems Tech Conf; Followed by 2nd TEOS Forum. doi:10.2514/6.2007-7751*

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

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,

CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast) SWD/2017/0650 final	sectoral output and employment.

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