Centre for Climate and Energy Analyses

LIFE VIIEW 2050

Vision on Impact & Improvement of the EU ETS Working by 2050

INFORMATION ABOUT THE MODELS MODIFICATIONS

LIFE VIIEW 2050

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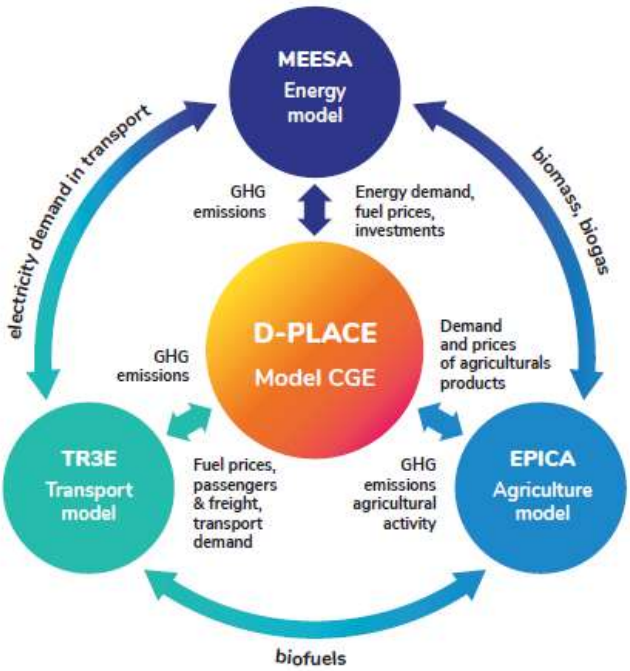
1. INTRODUCTION

The comprehensive revision of the toolkit documentation, showcasing the proper alignment of models with project objectives, has been completed and is now available on the project website in the versions for each model called: 2.0. However, it is essential to consistently prepare and present information about the updated documentation as new reports are generated.

2. MODELS OVERVIEW

The toolkit consists of four mathematical models: **d-PLACE (general equilibrium model of the global economy), MEESA (energy sector), TR3E (transport sector) and EPICA (agriculture sector)**.



d-Place is a recursive dynamic, multi-sector Computable General Equilibrium (CGE) model with global coverage, based on GTAP data base. Model distinguishes in its current version 29 industries/commodities, 11 regions including 9 EU regions + UK and 2 non-EU. The model operates in 5-years steps, with time horizon of 2050. Methodologically d-Place follows standard CGE formulations, with nested Leontief-CES production functions, marginal cost pricing and trade based on Armington assumption. The model implements EU ETS system along with emission reduction targets, as well as technical options for emission reduction and energy efficiency improvement, which makes it perfect tool for analysing different climate policy strategies.

MEESA is linear optimisation energy model which currently covers EU countries (plus UK, Norway and Switzerland). Model includes approximately 50 energy technologies with conventional units, RES, BECCS, CCS, green hydrogen production units, energy storages (batteries, hydrogen, hydro-pumped storage) etc. The model uses annual demand disaggregation for characteristic days for different seasons with 2-hours daily resolution. Model also takes into account electricity demand for BEV and its influence on energy system.

TR3E is partial equilibrium model, based on the bottom-up approach. The immanent characteristic of bottom-up models is the fragmented view of representative model agent. In other words, each agent understands only a small part of the whole economy. Transport model covers 4 main transport modes (road, rail, aviation and water transport) for passenger and freight transport, up to 37 means of transport, as well as the characteristics on engine types and technology options per mean. TR3E covers all 28 countries (EU + UK), it is solved with a time horizon up to 2050 with an annual resolution.

EPICA is an Positive Mathematical Programming optimization model. It is covers 27 EU countries and UK. The structure of the agricultural sector in each of the countries is optimized separately. The solutions are iteratively exchanged with the d-Place model to provide market equilibrium in the agricultural sector at EU level. In order to comprehensively assess responses of agricultural sector to policy measures the optimization module, at its basic level, is divided into interlinked crop and animal production (19 activities), each represented by both extensive and intensive production intensities. The model include labour, nutrients (N,P,K) and animal feed balances. The outcome of the model is the projected supply and the prices for agricultural products, and GHG emission from the sector, in all considered countries at assumed climate policy scenarios.

These models can be used as separate tools but can also operate in an iterative mode - the results of the CGE model (mainly the demand for energy and other goods and prices of emission allowances) are transferred to sectoral models, which in turn, thanks to a more detailed mapping of the specificity of sectors, enable a precise analysis of the effects on sectors, returning a number of data to the d-Place model. In case of the energy model it is the costs of electricity and heat generation, costs of producing green hydrogen, emissions (including information on absorbed emissions) and investment. The transport model returns information about the fleet in particular categories of vehicles, fuel and energy consumption, investment outlays. The agricultural model comprehensively assesses responses of the agricultural sector to policy measures at its basic level, divided into interlinked crop and animal production (total 19 activities), each represented by extensive and intensive production intensities. The final output of the agricultural model is projected supply based on the new farm activities' structure and corresponding GHG emissions from the agricultural sector. The iterative process of exchanging information between models is carried out until convergence in results is achieved - this usually requires about 15-20 iterations but may vary depending on the scenario.

3. MODELS MODIFICATIONS

Details regarding the latest modifications and extensions to the four models for upcoming analyses are provided below.

a. d-PLACE

- **Efficiency enhancement in numerical solving:**
  Solution procedure of the CGE model has been significantly restructured and simplified, reducing solution times by around half and improving code clarity. This modification is

relevant for manageability of the models suite, given the ongoing enlargement of the agricultural model and further sectoral disaggregation of the d-PLACE model.

- **Effective corrections for alignment with sectoral models:**
  The exchange of results between sectoral models, mediated by d-PLACE, has been optimized, resulting in improved convergence of simulation results in iterative solutions of the interlinked models. In particular, it relates to the results concerning biomass supplies and prices.
- **Disaggregation of agricultural and food products:**
  Agriculture in the d-PLACE model has been disaggregated into seven activities, and food processing into three activities. This enhancement serves the linking with the new agriculture model. It required disaggregation of the model's database and formulation of a preliminary version of consumers' food demand function.
- **Integration with new agricultural model for all EU countries:**
  The d-PLACE model has been connected with a new agricultural model covering all the European Member States. Harmonization of results, including volumes and prices of agricultural production, as well as agricultural emissions has been achieved.
- **Adaptation of the GTAP 11 data to d-PLACE requirements:**
  The newly introduced GTAP 11 has been integrated into the data processing workflow, with a view to including it in the d-PLACE model. It aims to increase the precision of analyses and enhance forecasting quality. The GTAP 11 database provides a consistent representation of the global economy for the year 2017, compared with 2014 in the previous database. Additionally, the new database is enriched with enhanced information on greenhouse gas emissions.

b. MEESA

- Various possibilities of implementing e-fuels production technology in the MEESA model were analyzed – in the future development of CAKE Team tools the selected option will be implemented in combination with the TR3E model.
- The code responsible for the exchange data on agricultural biomass between the MEESA and EPICA models was change, to take into account influence of the demand generated by the energy sector on price of biomass established by EPICA model.
- The way of modeling negative emissions in the MEESA model has been modified allowing different prices in EU ETS system and for the negative emissions system. New approach also allows negative emissions to be reported as a separate result (previously the emission balance was reported).
- The reporting system for MESSA model results and related external tools was rebuilt to facilitate the analysis of results.

c. TR3E

- Update of basic input parameters related to the size of the zero-emission fleet of transport and passenger vehicles.
- Verification of key structural parameters such as elasticities of substitution and analyzing their role in the output of simulation by means of sensitivity analysis.
- Verification of new emission standards for heavy duty vehicles and modifications in the TR3E model in order to account for these new emission standards.
- Conceptual work on the use of synthetic fuels (e-fuels) in road and air transport.
- Work on the integration on TR3E model with d-PLACE through the mutual exchange of data on the size of investment in the transport sector.

d. EPICA

- Expansion of the model of Polish agriculture onto EU level.
- Defining and calibrating models for each EU member country and each region along with the D-Place delimitation.
- Developing the database of agricultural activities parameters for each of EU countries including intensity level, costs of production, yields and prices.
- Elaborating costs of GHG mitigation measures for EU countries like: afforestation and peatland rewetting.
- Supplementation of data on the areas of organic soils within cropland and grassland land types
- Supplementation of data on forest losses due to fires.
- Supplementing of data on afforestation of cropland and peatland flooding for each EU Member States.
- Verification of applied coefficients regarding chosen emission sink methods (afforestation of agricultural land, peatland flooding, biogas production).
- Detecting data inconsistencies and verification of the results of individual model iterations.
- Testing the alignment of the extended agricultural EPICA model with the d-PLACE model, improving compatibility and convergence between the models.

4. PERSPECTIVE MODEL DEVELOPMENTS

Ensuring that the project tools and know-how is utilized in future, we are currently envisaged a few potential directions:

- including other countries, candidates and bordering the EU, into the EU ETS,
- extension the calculation horizon beyond 2050,

- migration from GTAP 10 to GTAP 11 database in d-PLACE model,
- introduction of the Carbon Border Adjustment Mechanism (CBAM) mechanism to d-PLACE,
- disaggregation of the Rest-of-World region in d-PLACE model,
- refinement of the representation of emission abatement options in the energy, transport and agriculture sectors in d-PLACE model for the Rest-of-World region, in order to compensate the lack of specialized sectoral models for those regions,
- distinguishing between short- and long-run responses to policy shocks,
- elaborating and developing additional GHG mitigation measures to be used within agricultural sector model: selected carbon farming technologies e.g. tillage cessation, intercrops, cover crops, and technologies lowering GHG emissions in dairy cattle production (e.g. feed additives, vaccination),
- improvement of peatland rewetting measures to include methane and carbon dioxide emissions (part of the LULUCF sector),
- enhancing the model with GHG mitigation measures to capture changes of the GHG emissions resulting from conversion of croplands into other land types (part of the LULUCF sector).

5. CONCLUSIONS

In conclusion, the project operates under the fundamental assumption that the analytical toolkit and the proficient expert team in modelling and analyses will maintain sustainable operations. The ongoing modification and extension of models align with the evolving needs of the project. The future development of these models will be intricately tied to the subjects addressed in upcoming analyses utilizing the versatile modelling toolbox. This strategic approach ensures adaptability and responsiveness to the dynamic requirements of the project's objectives.

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