D8.9 EUCalc "European Pathways Explorer": Achievements, Benefits and Model Simplifications

Cross-Sectoral Policy brief

D8.9

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Short Description
This document is a detailed policy brief, outlining i) where the EU Calc model fits and which policy questions can be addressed with the model and its various modules ii) a brief description of key modelling features, and the key achievements of the project, and iii) the simplifications required and their mitigation. It is related to Task 8.8.

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This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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List of abbreviations

CCS	Carbon Capture and Storage
CCU	Carbon Capture and Usage
EU	European Union
EU28	European Union 28 Member States
EUCalc	European Calculator project
GHG	Greenhouse Gases
GTAP model	Global Trade Analysis Project model
TPE	Transition Pathway Explorer
WP	Working Package

Summary for policy makers

The European Calculator (EUCalc model) is a model of energy, land, materials, product and food systems at European and member-state (plus Switzerland) levels for representing GHG emissions dynamics up to 2050. The EUCalc model has these 2 concepts at its core: 1) it defines computation sequences based on an extensive range of drivers, with the ability to sequentially trace, from products and food to material and land demand down to energy supply and then to emissions, the main leverage points for reducing GHG emissions across sectors in a country or at an aggregated EU level; and then 2) it sets a range of ambition levels for the most important drivers for which the user can define the projected level of ambition. These drivers are called *levers* and they are at the center of the scenario creation logic.

Users of EUCalc can develop their own sustainable transformation pathways that test possible technological and behavioural emissions reductions options at both the European and member state levels simultaneously. EUCalc enables the user to explore the option space for decarbonization that would otherwise be narrowed down to the constraint of optimum economic feasibility, which is often the norm in low carbon analysis. Given the substantial uncertainties arising from taking a long-term horizon such as 2050 or 2100, optimizing on certain factors like costs is extremely challenging. Accordingly, optimization models should be complemented with other approaches to identifying possible low carbon trajectories, particularly as the potential for breakthroughs or non-linear changes must be included. Addressing these system dynamics with a driver- and lever-based simulation model provides a very powerful and complementary alternative.

The cost implications of each pathway cover the annual capital expenditures (e.g., for new infrastructures or assets), operational costs (e.g., maintenance) and fuel costs. Although the EUCalc model assesses these cost implications, it is a simulation model as opposed to optimisation models. This implies that the EUCalc model does not optimise based on costs or consumer utility and therefore does not identify the least costly way of reaching specific 2050 targets. The aim, instead, is to look at what might be practically and physically achievable in each sector over the next 30 years (until 2050) under different assumptions.

The EUCalc model also provides outputs on non-monetary outputs such as air quality, impact on resources such as water and land, climate change damages, and biodiversity. These externalities are nevertheless not accounted in the cost estimates.

No model brings all the answers, and all have their advantages and disadvantages. In terms of key advantages, EU Calc brings immediacy of response; whole system-level coverage as well as whole system interactions which allow the user to rapidly explore a very wide range of options linked with potential tradeoffs and synergies, and it covers a large range of impacts (negative and positive); it also has a medium to long term perspective. In terms of disadvantages: it has coarser resolution than very detailed technical models, the economic assessment is not fully integrated, and some of the feedbacks or loops are not modelled.

This document describes the added value of the approach and its key characteristics, as well as the simplifications that were required to build it, particularly around the limitation on the amount and the complexity of the feedback loops allowed, in order to ensure a decent real-time running time. Detailed information on the model set-up and the rationale of the different sector modules is available at http://www.european-calculator.eu/.

Our strong belief is that policy makers should have access to a wider range of expertise and informed opinion including through leveraging different types of models, general or partial equilibrium ones as well as extensive simulation tools such as EUCalc, as they each shed a different light on the options available for the low carbon and energy transition.

The EU Calculator fills a critical gap in the decision support and modelling landscape

EUCalc is a bridge between complex models and simple tools

EUCalc is a new model for the assessment of climate protection solutions for Europe as a whole and for European Member states plus Switzerland. The model relates emission reduction with human lifestyles, energy demand and production, land use and agriculture, the exploitation and / or conservation of natural resources like water and biodiversity, and also connects to investments and job creation, etc. in one highly integrative approach.

Given the complexity of the interrelations between energy demanding/supplying sectors it is currently difficult for stakeholders to have a sound overview of potential transition pathways. This model is complementary to pure dynamic energy system models and integrated impact assessment tools as it introduces an intermediate level of complexity and a multi-sector approach assessing multiple impacts. It is also based on co-design with scientific and societal actors. Stakeholders often need to rely on the outputs of energy models that might not always be flexible enough to represent the stakeholder's view of the evolution for a particular sector she/he is interested or knowledgeable on. Consequently, the EUCalc project developed a new approach which comprises all GHG emitting sectors, but simplified some of the interrelationships between sectors. As constructed, the EUCalc model allows the user to near-freely explore the full option space for decarbonization without the latter being narrowed to the constraints of optimum economic feasibility or political inaction. The advantage of doing so is that it frees users to detect combinations of levers that break long established trade-offs in other modelling exercises. The option space for decarbonization is determined by the so-called levels of ambition whose range has been established during an intensive co-creation process with sectoral experts and wider societal institutions and actors. As test for the robustness and adequacy of the model approach chosen, the EUCalc model is able to reproduce the main activities, energy and emission outputs of previous modelling exercises/scenarios (E.g., the EU-Reference scenario as in Capros et al, 2016[1]).

Overall, the tool is built to enable decision makers to get near real-time policy support underpinned by comprehensive trade-off analyses. Policy makers -- but also any expert working on the energy and climate transition -- can have access to the model and test the assumptions for the future developments of the European energy and land nexus, for Europe and for each member country.

Policy makers can get a finer understanding of typical issues of the low carbon transition, but also explore new dimensions like the impact on water and other natural resources, or material flows

The EUCalc model computes different types of *impacts*: the energy consumption and GHG emissions at a country level, resource depletion (water, fossil fuel, lands) and other environmental impacts such as biodiversity, and socio-economic impacts such as employment and air pollution impacts. A summary of the main outputs modelled in the EUCalc is provided in Table 1.

[1] Capros P, De Vita A, Tasios N, Siskos P, Kannavou M, Petropoulos A, Evangelopoulou S, Zampara M, et al. (2016).

Category	Main outputs
Energy	Total energy consumption in EU Energy consumption by energy vector and consumption sector
GHG emissions	Total GHG emissions in the EU and by country
	GHG emissions imported/exported outside of the EU (linked to import/export of products/resources)
Pollution	Air pollution: Fine particulate matter
	Fertilizer input
Resources use & availability	Water availability, consumption
	Minerals & rare earths availability
	Fossil fuels use
	Land and forest use
	Food waste
	Renewable resources: wood
Socio-economic	Competitiveness & employment
	Food import
	Material import
	Impact of air quality
Environmental impacts	Biodiversity : impact of land use allocation, species habitat
	World temperature change

Table 1. Modelized impacts in the EUCalc model

For more details about the scope of those impacts' calculation and about the methodology, please refer to the related module documentation documents which can be found on the project website www.european-calculator.eu/.

EUCalc is a simulation lever-based model, highly complementary to other system simulation models

The EUCalc model is a simulation model, driven by simulating the impacts of human *activities* in a given *context.* It reflects the impact of using technologies to perform the activities on *energy*, *emissions*, *socio-economic impacts* and *environment & resources*. It also assesses links to the economy, to policies and to transboundary flows.

To start a simulation users define the inputs to the calculator by making choices, using a number of levers. These levers typically make a change in either the supply or demand of energy (or other resources) in a particular sector, for example building wind turbines, or reducing the share of distance people travel by car over the next three decades to 2050. The users can choose a lever ambition level based on four main choices that are available in the interface of the Transition Pathways Explorer.

The 4 levels are defined as follows:

Level 1	Level 2	Level 3	Level 4

Projections of **historical trends**	**Intermediate scenario**, more ambitious than a projection of historical trends but not reaching the full potential of available solutions	**Very ambitious but realistic** scenario, given the current technology evolutions and the best practices observed in some geographical areas	**Transformational and requires some additional breakthrough** or efforts such as important costs reduction for some technologies, very fast and extended deployment of infrastructures, major technological advances, strong societal changes, etc.

A combination of all the lever choices across all sectors creates a comprehensive scenario which enables the user to understand the impact of certain ambition levels across the whole economy. The model outputs for a given input scenario are named pathways, because the focus is on the final impact and overall evolution trend. For each pathway, the calculator displays the implications over time (for example in terms of energy, emissions, resource use, job creation and land-use). See a snapshot of the tool in figure 1 with levers on the left and graphical outputs on the right.

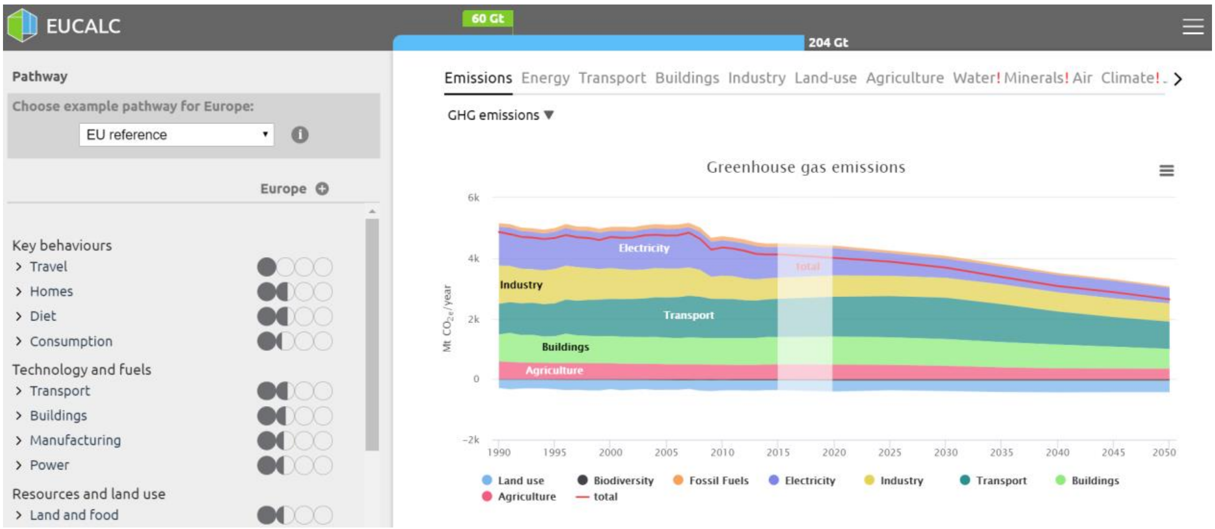

Figure 1. Illustration of EU Calc webtool interface.

Simulation tools like EU Calc with its user interface – the Transition Pathways Explorer – are typically used as eye-openers, especially in the first phase of the analysis to get a 'sense of scale' grasp of the impact of changes to the drivers / technological or behavioural options (levers) being explored. It is typically complemented by:

- optimization models such as TIMES/PRIMES/GTAP which are used to answer questions such as: "what is the cheapest way of", "in which order should I perform this". However, determining the energy transition only based on economic optimality would be dangerous as the cost projections in such timeframes are highly uncertain, and choices made may end up being arbitrary.
- sector specific models on each of the issues addressed to better operationalize the pathway recommendations in the sector; for example, in "buildings", or "air quality".

The scope of EUCalc is much broader than previous calculators

The development of 2050 calculators has started about 10 years ago with the UK version, and was quickly followed by a series of other national calculators and complemented with a global version. These calculators are all mostly based on the same modelling structure and efforts are still ongoing for further developments of additional features, as well as to expand the international coverage. More information can be found at https://www.gov.uk/guidance/international-outreach-work-of-the-2050-calculator

We have added more sectors, more interlinkages, more impacts and a more in-depth modelling of each specific issue. Figure 2 gives a global overview of the EUCalc model architecture.

The general model logic is as follows:

The model starts by assessing the energy demand based on three **context** modules (*lifestyle*, *technology* and *climate*). They each provide contextual data to the activity and impact modules.

Then five **demand** modules cover consumption sectors (*agriculture*, *transport*, *building*, *manufacturing* and *CCU*). These modules use technologies which compute emissions, based on an assessment of the production and consumption of energy, products, materials & resources.

Then three **supply** modules cover energy sectors (*electricity production*, *electricity storage*, *biomass production*, *refinery of oil and gas, and GHG removal technologies*).

These modules use technologies which compute emissions, based on an assessment of the production and consumption of energy, products, materials & resources.

Then, seven **impact** modules which include social impacts (such as employment, health and safety, energy security, education and working conditions), resource impacts (such as land-use, water, biodiversity, minerals and climate) and water-energy nexus module, then compute various types of impacts based on data from input modules and on results from activity modules.

Finally, the **external module** makes the link between the output of our model with another model called GTAP which allow us to position our results compare to a well known model.

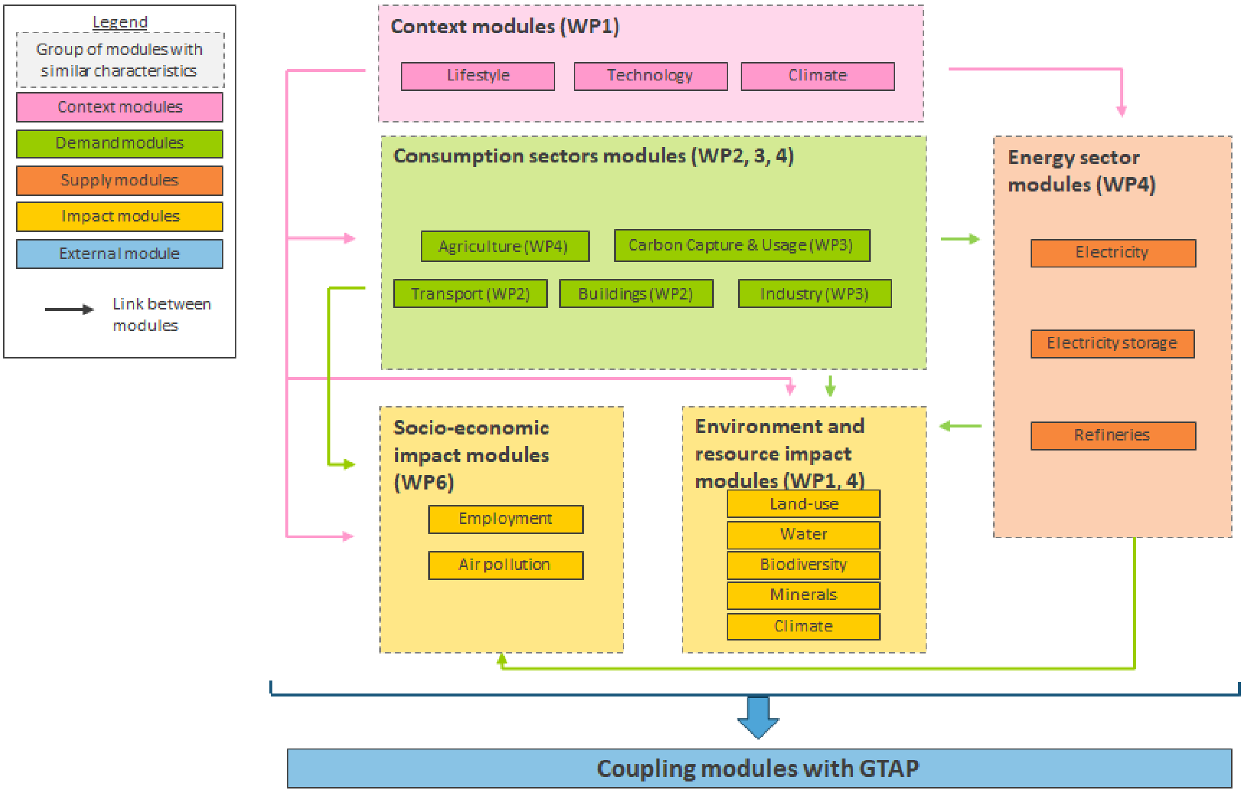

Figure 2. Overview of model architecture.

For further details on each specific module, please refer to the module specific documentation available at the project website www.european-calculator.eu/.

Achievements of the EUCalc model

Several key characteristics are brought together to make it unique

The model relates emission reduction with human lifestyles, the exploitation and/or conservation of natural resources, job creation, energy production, agriculture, costs, etc. in one highly integrative approach and tool which enables decision makers to get real-time guidance on possible policy choices underpinned by comprehensive trade-off analyses.

The model strived to achieve the following key characteristics :

Answers questions in near-real time	The Pathways Explorer is being programmed to present as a real-time experience to the user, while the model may run in several hours or days to pre-compile data. At the time of writing this policy brief we have reached a running time of roughly a minute and are still exploring how to reduce this further closer to real-time.
Covers a wider and more relevant array of issues for better decision making	The EU-Calc model computes a wide range of *impacts*: the energy consumption and GHG emissions at a country level, resource depletion (water, fossil fuel, lands), socio-economic impacts such as air pollution and employment and other environmental impacts such as biodiversity.
Has the geographic granularity to provide relevant answers	The model enables the user to set the levers for Europe plus Switzerland as a block and for each of the 28 countries separately. The model also assesses interactions between Member States and Switzerland and with the Rest of the World (RoW).
Goes deep enough to provide added value	The model enables a user to answer key questions regarding energy transition pathway and to explore trade offs and synergies. This model has several new added value elements in relation to LULUCF, water, air quality, employment and trans- boundary effects. The model has sufficient analytical depth to be considered credible by stakeholders - especially given that was developed through a co-design process involving many of them -within the technical constraints of running as close as possible to real time.
Is collaboratively built	The model is built in parallel by the 10 organisations of the consortium with the inputs of significant numbers of expert stakeholders.
Is transparent enough to enhance stakeholder validation and buy in	The model is developed through a participative process involving expert stakeholders in each of the sectors addressed. Stakeholders consulted have a good technical understanding of the main assumptions underpinning modelling choices performed in their area of expertise. The model is as transparent as possible to enable stakeholder and end-user buy-in. Transparency can be observed in: · The input data used in the model; · The rationale of the calculation applied on the input data; · The ease of use by the end user of the tools used; · The open-source access of the tools

Table 2. Key characteristics of the model

Model actively open to expert validation

One of the unique benefits of the European Calculator co-creation process has been how it has helped, in previous iterations, to engage more effectively with stakeholders; not just so that they understand the project but also so they provide expert, real world perspectives on the data/assumptions and scenario setting. Managed sensitively the Calculator can be used as a useful consensus building tool and getting stakeholders involved at an early stage is vital to this.

Before creating scenarios it is crucial to take a sectoral view to understand what types and levels of change are technically possible in each sector. For each defined lever a range of ambition levels was derived on the basis of expert/stakeholder elicitation (more than 1000 experts[2] from academics, businesses, and NGOs, etc.) and thorough literature studies describing a range of potential futures for the respective sectors. Our work has built on comments from these experts to better identify and understand the key implications for Europe of a move to a low carbon society. This concept is described below and each sector documentation goes at length on the reasoning behind the ambition levels defined. These *levers* and their possible *ambition levels* are the building blocks of the EUCalc model. They allow the user to construct possible pathways to 2050 and beyond. The approach looks not only at 2050 as an end point, but also at the sequence of changes that would need to occur over the next 40 years, i.e. for the implementation of a successful climate protection policy.

It is for this reason that EUCalc embedded a co-creation process with stakeholders who are leading experts in their field, organized through a series of workshops, one for each main module. Early engagement with expert stakeholders also adds value by building a network of supporters for actions within the project related to communication, dissemination, and the future exploitation of the tool.

The key numbers from the co-creation participation process are:

- Number of Expert Stakeholder Workshops: 10
- Number of experts informed & mapped: › 1000
- Number of expert workshop participants: 171
- Breakdown by target group of workshop participants: 29% academia, 22% private sector, 27% science CSOs and professional associations, 22% European Institutions and others
- Gender balance: 2/3 Male and 1/3 Female

All expert stakeholder interactions taking place within the EUCalc project have been documented published in the format of sector related expert workshop deliverables.

Transboundary effects and interaction with other models (GTAP - EUCalc)

The EUCalc model allows the user to select and simulate decarbonization pathways for EU28 + Switzerland. As the envisioned decarbonization pathways impose changes in both demand and supply, levels and structures of production and consumption at sectoral and country levels would also be altered. This, in turn, would change the economic dependencies concerning the EU28 MS + Switzerland at sectoral levels and lead to altered trade patterns. Furthermore, as transboundary flows of goods and services also embody energy consumption and GHG emissions, projecting international trade impacts is also an important consideration in evaluating the options and tradeoffs of EU decarbonization pathways and their "emission effectiveness" in a global context.

[2] The contributions of experts are gratefully acknowledged. However, the responsibility of the analyses lies with the partners of EUCalc, and the experts and stakeholders consulted do not necessarily endorse the analyses or the conclusions of our work.

Within the broader scope of the calculator, the transboundary effects are quantified, including intra- and extra-EU trade flows. To do so, a modified version of the GTAP-E model[3] (nicknamed "GTAP-EUCalc") is developed, simulating perturbations to a projected baseline of the world economy in 2050. Results are shown specifying imports and exports along the commodity dimensions, expressed in both monetary and CO2e terms. Additionally, the EUCalc model aims at addressing trade linkages with the rest of the world at a greater granularity than one "average" region. In fact, transboundary results for major trade partners (e.g. USA and China) are computed. The GTAP-EUCalc general equilibrium approach differs from the EUCalc modularized approach, in which the lever setting reflects a range of ambition levels expressed by the end-user. The combination of the two adds value to the EUCalc with respect to the current existing calculators.

The EUCalc model then provides users with a set of levers on both the demand and supply side to create their own decarbonization pathways. The lever settings on the demand side (i.e. lifestyle choices) are essentially considered changes to the demand curves relative to the baseline in the GTAP-EUCalc model, whereas changes on the supply side imposed in the individual EUCalc model are modeled in the GTAP-EUCalc as changes in the supply function either through changes in the cost structure of producers and/or through total or biased productivity progresses. Consistent with the overall set up of WP7 and the generally accepted economic theory, the simultaneous shifts of the demand and supply functions arising from implementing the EUCalc pathways then endogenously determine the excess demand (i.e. imports) or excess supply (exports) of each and every product for each and every country/region included in the model. In addition, the specific modeling structure allows for generating bilateral trade flows between any pair of trading countries.

More details on this connection between EU Calc and GTAP-E can be found in deliverable 7.4.

Summing up the key achievements of this project

The consortium has been able to manage the complexity of creating a completely new model from scratch while at the same time ensuring the scientific credibility of the approach and the open-source nature of the tool.

- The consortium has successfully managed to build this new model with the required level of granularity and robustness to be relevant for policy making and complement the existing models
- The consortium has received the input of hundreds of experts in the process, particularly on the sectoral dimensions, increasing its credibility and the range of scenarios it can meaningfully represent
- The consortium has worked based on fully open source data and also provides the underlying code with full transparency to all interested experts
- The project has produced an online tool which captures the essence of the model and simplifies its outputs in order to allow policy makers to quickly and efficiently create scenarios, test them and view their outputs at EU and Member states granularity.

[3] MCDOUGALL, R. & GOLUB, A. 2007. GTAP-E: A Revised Energy-Environmental Version of the GTAP Model. Department of Agricultural Economics, Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

The model has simplifications, but these are mitigated

Overview of key simplifications

Any model is a simplification of reality. In the case of the European calculator the granularity of **the technical representation is strong** (e.g., the full range of vehicle types is represented) and the **connection between the key sectors** is also very strong as beyond the typical link between energy demand and supply, it captures the **link across value chains** from demand for products to the need for the underlying materials and how they are produced in the industry. The **connection between food consumption and diets to land and to bioenergy** production is also strongly modelled.

In real life, the interactions between the sectors are even more tightly intertwined and lead to **feedback loops** when sector A has an impact on sector B which in turn has an impact on sector A (e.g., industry requires power, but the construction of power plants requires materials produced in the industry sectors like steel). These interactions between sectors are required but generate complexity. This complexity brings an increase of the calculation time and thus must be limited to allow the model to run faster. We detail the feedback loops avoided below.

The model is focused on the impact of a large range of levers from behavioral or societal changes to technological levers, but it does not cover directly the link to policies. The impact of specific policy instruments, such as taxes or setting a price on externalities like carbon or biodiversity, is not included in the model. Other examples of policies which are not captured directly in the model but can be reflected through the technical levers include the “emissions standards” for cars. Users can use instead the levers covering the efficiency of the vehicles and the shift to electric vehicles. Another example is that the user cannot test the impact of increasing the cap of the Emission Trading System for large emitters in the power sector and the industry but can test how to reach reductions in these sectors with the many levers available.

Importantly, the model leaves aside market dynamics and leaves the choice of the evolution of the various sectors and of the economy overall in the hands of the user who must define the trajectories and the ambition levels of the main model drivers. The model therefore avoids any type of optimisation be it on the total costs of the transition or on the utility for the consumers. The model does however **interact with the GTAP model** which is a General equilibrium model which can therefore provide a set of results on other key issues to the user. This is described below.

Another simplification is the choice of regional granularity. The model works at Member states level, which means all values are national averages, disregarding differences across regions or population groups (e.g., with different income levels). The values for the future ambition levels for each of the member states are based on the **convergence and compression principle** described below.

Another feature of the model is **how data is being interpolated and projected**, both for historical values when these may be missing for certain years, and for the future trajectories which by definition are uncertain in nature and need to be projected based on a logic that best reflects the nature of the sector or the lever being used (e.g., linear change for the penetration of behavioral measures and mature market technologies, and s-curves for the uptake of new technologies).

Additionally, the uncertainty of the transition is captured through the creation of multiple scenarios and not through stochastic elements. Finally, policies are not explicitly modelled but are underlying the concrete levers that can be tested to reduce emissions.

Feedback loops

In real life, sectors are tightly intertwined and their interactions lead to feedback loops. These interactions must be modelled but generate complexity which brings an increase in calculation time and thus must be reduced to allow real time computation. There are 2 ways to remove a loop:

1. the first option is to create a lever dedicated to it, allowing the user to decide the ambition for a specific branch of the loop;
2. the second is to reduce the number of interactions, cutting the 'weakest' link between the sectors, which is the one that has the least material impact on the rest of the sectors.

We illustrate below the effects of an increase steel demand and how the feedback loop can be cut to limit modelling complexity by reducing the number of interactions between sectors or by adding new levers.

1. *More steel demand leads to more freight demand;*
2. *More freight demand leads to more demand for ships (and ships building materials);*
3. *Building & using more ships requires more electricity;*
4. *Supplying more electricity requires the deployment of new power plants;*
5. *Building power plants requires steel;*

In the example above, several links do not make a material difference because they do not explain a significant portion of the influenced variable. At a global level, ships represent only 2% of steel and power plants represent only a minor contribution to steel demand, which means the necessity of keeping links 3 & 5 should be challenged.

Furthermore, we can also assess modelling freight demand through a lever, which breaks the link 1.

Box 2. Example of increasing steel demand

The example above is a feedback loop between 2 sectors, but we must also consider the feedback loops that may occur between a larger number of sectors. The Climate loop is one of the major feedback loops running all over the module as temperature changes influence multiple sectors that are emitting GHG emissions which in turn influence the climate and the temperature increase. To avoid this loop, the climate was converted into a lever: the user chooses the target temperature he wants to achieve with his simulation and the web application show him the carbon budget allowed to stay under this target.

The consortium has identified the main feedback loops and took decisions on how to deal with them. This is described in detail in deliverable 8.2.

Warning the user when levers are incompatible

One way to solve feedback loops is to convert them to lever as described above. This can lead to lever incompatibilities when the choice of levers is not completely mutually exclusive and collectively exhaustive (MECE). This means that different levers quantities are linked in the real life, but not in the model. This can lead to some incompatibilities between two levers positions.

We identify different types of lever incompatibilities:

- If [Lever 1] is moved to a higher ambition, then [Lever 2] should be moved to a higher ambition;
- If [Lever 1] moved to a higher ambition, then [Lever 2] should be moved to a lower ambition;
- Some positions of [Lever 1] and [Lever 2] are completely incompatible.

Those lever incompatibilities are generating warnings in the Transition Pathways Explorer to let the user know that the levers position is out of the solution space.

A concrete example is the use of synthetic fuels in some of the sectors like transport. These fuels can be helpful to reach full decarbonization, but seen the large inefficiencies in their production where they require much more energy than they ultimately provide to vehicles, they cannot become a widespread solution. If the user uses only that lever to decarbonize transport fully it will have a warning on the large increase in power required to produce them.

Quality management and modelling of key trends

In addition to input data quality and results calibration, the modelization choices were also subject to quality management. The goal was to integrate the most important trends and future decarbonization solutions to the model and avoid missing major evolutions.

In order to reach those objectives, we proceeded in several steps:

- **Analysis of the current situation**: the first step is to analyse the current situation in each sector. This analysis allows to identify the sub-sectors that are the most important in terms of energy consumption and GHG emissions, and the global trends of those subsectors (are their activity increasing or decreasing? Is there a subsector which is growing faster than the others?). This information is very useful to decide which trends should be modelized in priority (we will first concentrate on the trends concerning major sub-sectors).
- **Identification of major trends for the future**: to identify the major trends and expected evolutions in a sector, we base our analysis on an extensive literature review, on other sectoral models' comparison, and on exchanges with experts (through the workshops and through bilateral discussions).
- **Prioritization of trends to be included in the model**: to decide which trends should include in the model in priority, we asked ourselves 3 questions:
    - <u>Which sub-sectors will this trend impact?</u> If the impacted sub-sectors are important in terms of energy and emissions, it will be of higher priority than if the trend only impacts small sub-sectors.
    - <u>What is the development potential of this trend?</u> If the trend is expected to stay very marginal and does not have a large development potential, its will be considered as a lower priority.
    - <u>Does this trend have a clear impact on activity, energy consumption and GHG emissions of the sector?</u> If the identified trend does not have a clear impact on the activity level, energy consumption or GHG emissions, it is not included in the model. A good example of such a case is the car automation case: it can either drastically reduce passenger activity or largely increase it, depending on the context in which it will develop.
- **Modelization of those trends**: once we have identified the trends that will be included in the model, we still need to ensure that they are modelled correctly. Just as for the identification of major trends, we base our analysis on an extensive literature review, on other sectoral models' comparison, and on exchanges with experts. A good way to assess if our modelization is coherent, for example, is to reproduce a scenario from another study in our model, and to compare the results and analyse the differences.

References

Pashaei Kamali F., Thurm B., Rankovic A., Vielle M., Posada J. and Osseweijer P., 2018. Deliverable 6.3: Identification of the parameters relevant to assess socio-economic impacts and consultation workshop – Public deliverable of the EUCalc project

Stettler, M., Ma, L., Mehlig, D., Anciaux, A., Holland, M., and Osseweijer P. (2019). D6.7: EUCalc scenario impacts on air pollution and human health– Public deliverable of the EUCalc project

Thurm, B. and Vielle M. (2019a). Deliverable 6.6: Library of input for the employment module and analysis of the impact on employment and GDP for EU and per MS – Public deliverable of the EUCalc project

Thurm, B. and Vielle M. (2019b). Deliverable 6.8: New EUCalc module on socio-economic impacts – Public deliverable of the EUCalc project

Yu, W. and Clora, F. (2018). Deliverable 7.1: Formulation of baseline projections and documentation on modeling approach review – Public deliverable of the EUCalc project

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Further information on the EU Calculator:

The EUCalc project aims at providing a highly accessible, user-friendly, dynamic modelling solution to quantify the sectoral energy demand, greenhouse gas (GHG) trajectories and social implications of lifestyle and energy technology choices in Europe.

The novel and pragmatic modelling approach is rooted between pure complex society-energy systems and integrated impact assessment tools. The EUCalc model with its user interface - the Transition Pathways Explorer – has been designed to be both accurate but also accessible to decision-makers and practitioners. It covers all sectors and can be used by one or many people. The model is also open source so that experts can refine the model itself. The tool will have an e-learning version, the "My Europe 2050" tool as well as a Massive open online course (MOOC). See more on the EUCalc project, its scientific reports and all other outputs and access the Transition Pathways Explorer at:

www.european-calculator.eu

EUCalc partners: