PRISM

Net0Pathways through impRoved IAMs across Sectors, diMensions, and scAles

Deliverable 1.1: Non-technical brief: What can our models deliver?

Informing Europe's 2040 Climate Targets - Developing Integrated Assessment Models to support Climate and Energy Policymaking

Deliverable

09/11/2023

"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them."
This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

Deliverable Title	Non-technical brief: What can our models deliver?
Deliverable number	D1.1
Brief Description	Policy brief based on outcomes of a policy-maker event on the EU 2040 emission targets held in Brussels in September 2023
WP number	WP1
Lead Beneficiary	Bruegel
Author(s)	Conall Heussaff
Deliverable Due Date	30/06/2023
Actual Delivery Date	09/11/2023
Nature of the Deliverable	R — Document, report
Dissemination Level	PU - Public
KeyWords	Policy Brief, Models, Stakeholder input

"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them."
This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

Background

The Policy brief, attached below, summarises the insights gathered from the project's stakeholder launch event which was organised by Bruegel in Brussels on 13th September 2023.

The event focused on the EU's 2040 emission targets which will be announced in Q1 2024 and which will play an important role in shaping the integrated assessment modelling scenarios which will be developed over the course of the PRISMA project.

The policy brief explores the main challenges involved in setting the 2040 targets, gives examples of how results from ongoing Horizon projects closely related to PRISMA can inform this process, and details the main needs and concerns raised by policy-makers during the meeting.

It also sets out how the improvements to integrated assessment models which are ongoing and planned as part of the PRISMA project will help in addressing the priorities highlighted by stakeholders during the meeting.

The policy brief is publicly available on the PRISMA project website (https://www.net0prisma.eu/outputs/) and will be promoted through project partners' social media channels.

Attached:

- Agenda for the stakeholder event in Brussels
- Policy brief

"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them."
This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

Climate Targets 2040: Bridging Modelling and Policy

Wednesday 13 September 2023

Location: Bruegel (Rue de la Charité 33, 4th floor, 1210 Brussels)

The EU must declare its 2040 climate targets by the beginning of 2024, as required in the European Climate Law. To inform, justify and communicate the targets, policymakers will rely on energy, climate and economic modelling of the impacts of various emission mitigation pathways. The main type of models used to assess the trade-offs related to different pathways are detailed-process Integrated Assessment Models (IAMs), contributing to IPCC and other scientific reviews.

At this event, the panellists, which include European policymakers and modellers involved in leading research projects on modelling climate mitigation will discuss the considerations for the 2040 targets and how modelling can support policymaking in this space. Emerging challenges in the climate policy space will be discussed as well as the potential model development to respond to the changing needs of policymaking.

The event will also serve to launch a first policy brief that will address the challenges and opportunities associated with delivering the EU's 2040 climate targets and more broadly informing international climate negotiations towards the global stocktake process.

This event is co-organised by the Net-Zero Pathway Research Through Integrated Assessment Model Advancements (PRISMA) and the European Climate and Energy Modelling Forum (ECEMF) projects funded by the EU Horizon Europe and Horizon 2020 programmes, respectively.

Agenda

12:00–12:30 Closed Door Session *Participants tbc*	Closed-door discussion between lead modellers (5) and high-level European Commission policymakers to discuss how modelling can support policymaking in the EU and internationally.
12:30–13:00 Lunch served at the Bruegel event space.	
13:00–14:30 *Public session* ***Framing the 2040 climate target discussions*** *Georg Zachmann, Senior Fellow at Bruegel – Framing the 2040 climate target discussions (13:00-13:10)* ***Europe's 2040 targets through the lens of Integrated Assessment Models*** *Bas van Ruijven, Group Leader, Sustainable Service Systems Research Group, IIASA (13:25-13:40)* ***How does the 2040 target look across models for climate neutrality pathways?*** *Findings from the ECEMF model intercomparison project* *Robert Pietzcker, Senior Scientist, Potsdam Institute for Climate Impact Research (PIK-Potsdam) - ECEMF (13:10-13:25)* ***Comments by representatives from the European Commission's Directorate-General for Climate and Directorate-General for Energy*** *Miguel Gil Terte, Chief Economist, DG ENER* *TBC: Vicky Pollard/Alban Kitous, Head of Unit/Deputy Head of Unit, Foresight, Economic Analysis & Modelling, DG CLIMA* *(13:40-13:50)* ***Panel discussion / Q&A*** *(13:50-14:30)*	

PRISM

Net0Pathways through impRoved IAMs across Sectors, diMensions, and scAles

Policy brief

Informing Europe's 2040 Climate Targets

Developing Integrated Assessment Models to support Climate and Energy Policymaking

1 PRISMA and the 2040 Targets

PRISMA (Net0**P**athways through imp**R**oved **I**AMs across **S**ectors, di**M**ensions and sc**A**les) is a Horizon Europe funded project bringing together a consortium of thirteen European partners. The project aims to make improvements to integrated assessment models (IAMs), such that the modelling community can continue to contribute insights and analyses to the climate and energy policy debate as the European Union moves forwards with decarbonisation. The next major milestone for climate policy in Europe is the 2040 emissions reduction target, which will be set out by the European Commission in the first quarter of 2024.

Legal Basis

The legal basis for a 2040 emissions reduction target resides in the European Climate Law (European Union, 2021). The Climate Law entered into force in 2021, establishing a number of legally binding obligations. The EU must have net zero emissions in 2050 and must achieve 55% emissions reduction (compared to 1990 levels) by 2030. The Climate Law also requires a 2040 target to be determined. Governance mechanisms such as the National Energy and Climate Plans (introduced in a 2018 regulation (European Union, 2018)) that must be submitted to the European Commission for review, are intended to incentivise Member States to take sufficient action to achieve the Union's collective goals.

The timeline for establishing a 2040 target is directly aligned with the Paris Agreement process. According to the European Climate Law, the 2040 target must be announced within six months of the first global stocktake, which will be concluded at COP28 in December 2023. Therefore, a target is expected in the first half of 2024.

The global stocktakes will take place every five years. Under this workstream, all parties to the Paris Agreement take stock of their progress towards cutting emissions, in terms of stated policies, technological development, and social inclusion, amongst many climate action aspects. The technical dialogue of the first global stocktake, bringing together parties, experts and stakeholders, has emphasised that the world is far short of meeting its emissions reduction goals (UNFCCC, 2023). The report called for increased ambition when it comes to emissions reduction targets and ramped up mitigation across all sectors.

The EU, as a single block under the Paris Agreement, will need to update its Nationally Determined Contributions (NDCs) in 2025. This round of NDCs will include actions for the post-2030 period and will reflect the soon-to-be established 2040 target. Based on the post-2030 NDCs, the EU will need to refine its internal climate governance process to ensure that each Member State enacts sufficient policies for the Union to meet its collective emissions reduction goals. This will require a post-2030 or 2040 climate and energy policy framework, analogous to the Fit-for-55 package that aims to put the policies in place to meet Europe's 2030 targets.

Setting the targets and their purpose

The 2030 target and the associated Fit-for-55 policy framework involved internal modelling carried out by the Commission, making use of the PRIMES-GAINS-GLOBIOM and GEM-E3 models developed by E3Modelling, one of the PRISMA project partners. An associated impact assessment used these integrated assessment modelling tools to explore the environmental and economic impact of a 55% emissions reduction target on the energy system, land use, health, and many other areas (European Commission, 2021). The process for setting the 2040 target has been more structured in

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

terms of seeking input from stakeholders involved in European climate and energy policy, including the integrated assessment modelling community (Fig 01).

A public consultation was carried out, in which stakeholders could share views and analyses, with submissions intended to form part of the evidence base for the 2040 target itself. Input from the integrated assessment modelling community was also directly requested. Most notably, a report on the 2040 target by the European Scientific Advisory Board on Climate Change (ESABCC) was delivered. The ESABCC was established under the European Climate Law and, as part of its legal mandate, provides independent scientific advice on EU climate measures, targets and budgets. The ESABCC report concluded that 90-95% emissions reductions by 2040 compared to 1990 levels would be both feasible and fair (ESABCC, 2023).

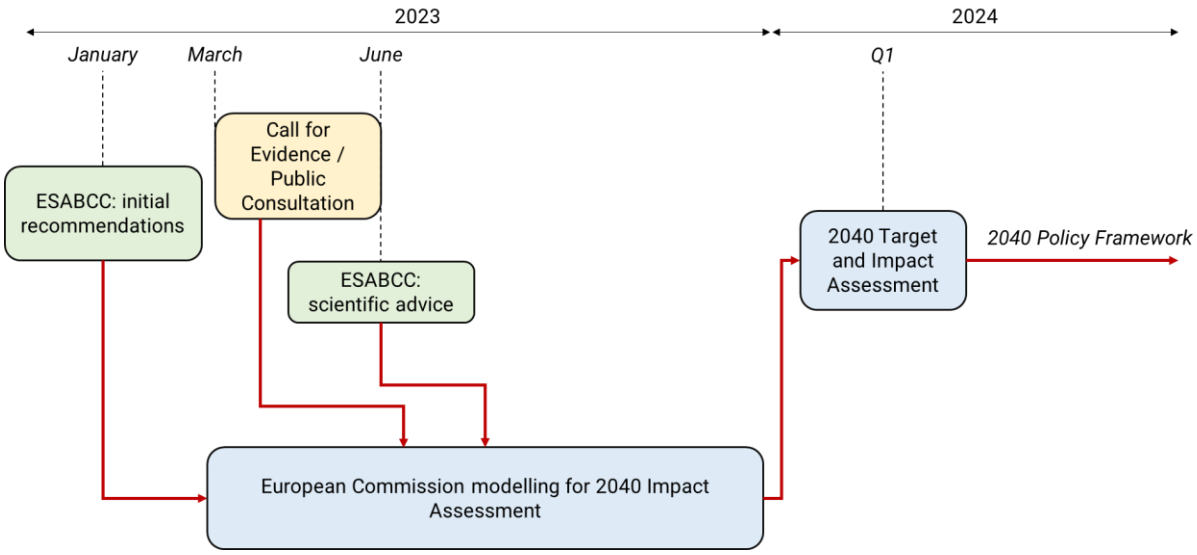

Fig 01 *– The 2040 target setting process. Calls for evidence included integrated assessment modelling studies carried out by the academic community.*

The 2040 targets serve complementary purposes. Firstly, an emissions reduction target is a signalling mechanism for the EU's Member States regarding the level of action required to achieve carbon neutrality in 2050. Secondly, the target can provide a cornerstone for the post-2030 climate and energy policy framework. An ambitious target at the European level communicates to national governments that the EU institutions are serious about climate action and will implement policies to deliver on those ambitions. These policies will involve revisions to the existing Emissions Trading system (ETS) and forthcoming ETS 2, as well as a ramping up of clean energy sources in the electricity sector and an emphasis on rapid electrification of heat and transport. Many energy efficiency measures are intended to take place before 2030, including buildings renovations, but robust standards for new constructions will likely be required.

Certainty regarding the post-2030 policy framework and the underpinning 2040 target are essential for the current investment cycle, as large capital projects built in the current decade will last into the 2040s and beyond. The policy framework will indicate whether there is a business case for 'transition technologies', such as combined cycle gas turbine power plants or gas space heaters, or if investments should focus on entirely emissions free technologies from the second half of the 2020s onwards. It will be especially important to send the appropriate signals for investment in the network infrastructures

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

required for the transition and the ensuing green economy, such as the electricity grid, electric vehicle charging points, and possibly hydrogen pipelines.

Finally, the 2040 targets also signal to the EU's international partners that the bloc is committed to decarbonisation. Such commitments will be critical as Europe increasingly focuses on driving emissions reductions in other parts of the world, either through diplomacy, financial support or policy instruments like the carbon border adjustment mechanism. Without ambitious targets, Europe cannot legitimately argue that other regions, especially those in the Global South, should follow similarly ambitious decarbonisation pathways. Meeting the targets will be even more important in this regard.

Challenges and constraints with target setting

While emissions reduction targets can signal commitment to decarbonisation and provide the foundation for the associated policy framework, there are a number of challenges and constraints involved. Perhaps the most significant challenge is the balance between ambition and political or economic realism. An unrealistic target will undermine the signalling function, weaken political support, and possibly delegitimise the governance framework. At the same time, if the target is set too weak, Europe will not decarbonise rapidly enough, thereby failing to do its part in global emissions mitigation and setting a poor example on the international stage.

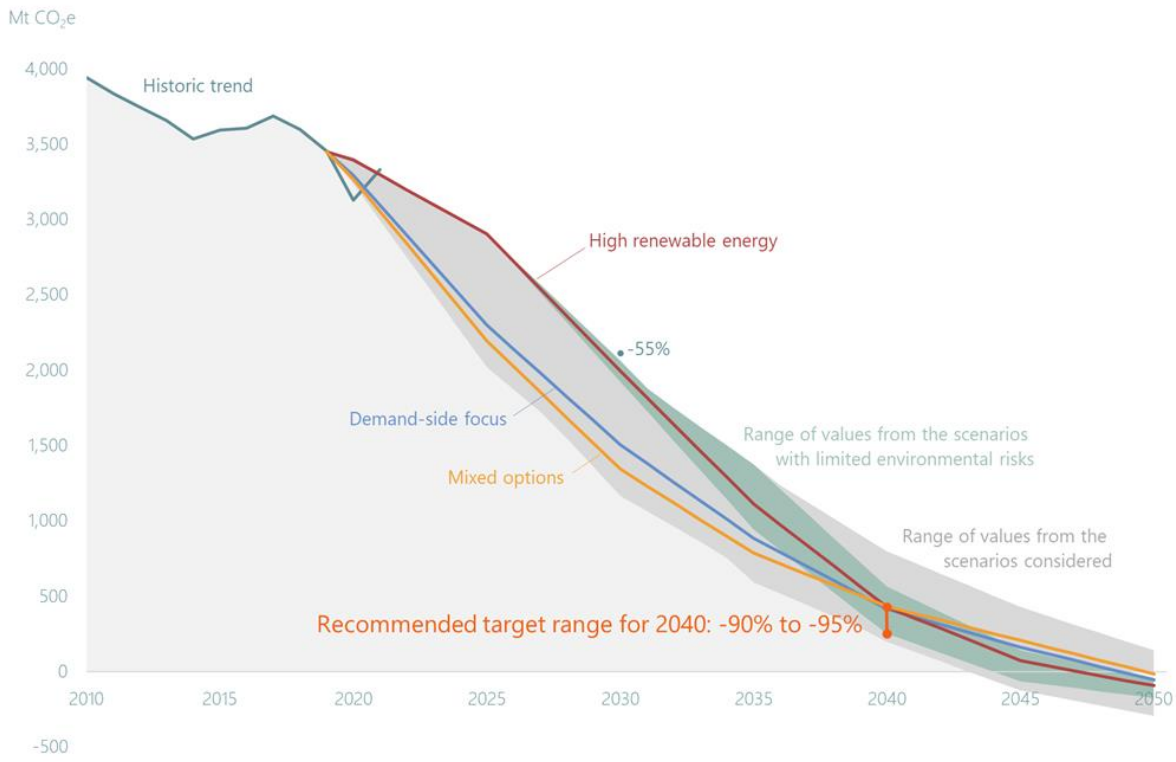

Fig 02 *– Recommended range of 2040 greenhouse gas emission reductions and iconic pathways (ESABCC, 2023). Each pathway describes a different emissions trajectory with emphasis on different policy options.*

The start and end points of the decarbonisation pathway between 2030 and 2050 are already fixed. The 2040 target will represent the midpoint of this pathway, and there are several considerations that constrain its potential value. Global fairness, which assesses what Europe's share of the remaining

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

global carbon budget should be, can be evaluated in different ways, leading to different outcomes (see section 2). Agreeing a framework for determining Europe's carbon budget prescribes the 'area under the curve' of the decarbonisation pathway (Fig 02 shows decarbonisation scenarios from the ESABCC report). Once the budget is determined, what remains to be decided is whether more decarbonisation takes place in the 2030s or the 2040s.

Emissions decline in the 2030s is expected to be steep, mainly driven by clean electricity powering more affordable electrified heat and transport. In contrast, 'hard-to-abate' sectors like shipping and aviation likely will not see emissions reduction until technological improvements are achieved, as clean alternatives are currently too expensive. Such cost-efficiency considerations constrain the shape of the decarbonisation pathway, and therefore the possible 2040 target values. However, flexibility emerges from options such as carbon capture and storage, or an international emissions trading scheme. Rapid technological progress in carbon removal might significantly change the target-setting calculus. Similarly, a robust international framework for efficient emissions and resource reallocation around the globe might imply that quickly and aggressively driving down European emissions suddenly appears to be a less efficient option. Ultimately, these possibilities are speculative, but highlight the uncertainty faced when trying to set a specific target value for European emissions in 2040.

More nebulous considerations for setting the 2040 target and the associated policy framework are intra-EU fairness and the international decarbonisation context. Some regions in Europe may find it easier to quickly decarbonise than others, due to more abundant renewable energy resources, for example. Certain sectors may be more affected than others, leading to uneven distributional economic impacts of an ambitious target. All of these internal complications are bracketed by the uncertainty of international mitigation developments. The pathways for the USA, China and rapidly developing countries such as India remain unclear. Slower progress from other regions may mean that the EU will need to invest more political and economic capital in encouraging decarbonisation elsewhere in the world.

A final challenge regarding the 2040 targets lies within the political realm. The messaging around the target – its process, its aims and its consequences – must be accurate and clear so as to generate a wide consensus for continued decarbonisation. The green transition in Europe will require sustained support from citizens and stakeholders across countries and sectors. The European elections will take place soon after the target is set, meaning that the political environment will be especially sensitive. In this tense arena, politicians and policymakers focused on climate issues must find the right balance between aggressive ambition and savvy realism.

2 Modellers and Policymakers in Discussion

The PRISMA project organized a public event on 13 September 2023 to discuss the interplay between modelling and policymaking in the context of the EU's 2040 targets[1]. The event was moderated by Bruegel and brought together a panel of modellers from the project (representing the International Institute for Applied Systems Analysis (IIASA) and the Potsdam Institute for Climate Impact Research (PIK)) and senior policymakers from Directorate-General for Energy (DG ENER) and Directorate-General for Climate Actions (DG CLIMA). Modellers from the Euro-Mediterranean Center on Climate Change (CMCC) and the University of Oxford were also present. The event was

[1] The recording of the event can be found here: https://www.bruegel.org/event/climate-targets-2040-bridging-modelling-and-policy-0

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

hosted at the Bruegel premises in Brussels and was attended by 62 people in person and viewed live by 282 people. The aim of the event was to bring the modelling community and policymakers together and discuss the evolving role of integrated assessment modelling in the context of the 2040 target process and forward-looking EU climate policy more broadly.

Modelling Perspectives

Two presentations were made by the PRISMA representatives. The first focused on the recommendations from the ESABCC report on the 2040 targets (ESABCC, 2023). As mentioned, the report called for a 2040 emissions reduction target of 90-95% relative to 1990. The dual criteria for the recommendation — **feasibility** and **fairness** — were discussed in detail.

The feasibility criteria refers to the plausibility of the transformation required to deliver a certain decarbonisation pathway over a particular temporal and geographical range. It was noted that a number of different feasibility dimensions could be considered, such as: geophysical, economic, technological, and socio-cultural. Over 1000 modelling scenarios were gathered by the ESABCC from a call for evidence, which were then filtered down to 5-7 scenarios based on feasibility considerations. These scenarios were then used as the evidence base for the ESABCC advice.

The fairness criteria refers to the EU's share of the global carbon budget, which can be quantified depending on the fairness principle applied. Four fairness principles were discussed:

- **Equality:** all regions are allocated the same remaining carbon budget per capita.
- **Polluter pays:** remaining carbon budget is allocated in inverse proportion to historical emissions.
- **Ability to pay:** remaining carbon budget is allocated in inverse proportion to the ability to pay mitigation costs.
- **Beneficiary pays** remaining carbon budget is allocated in inverse proportion to benefit received from past emissions.

The fairness principles can be translated into specific remaining carbon budgets for different regions, leading to different budgets depending on the stringency of the principle applied. Combining the feasibility and fairness criteria and applying them to the broad sample of modelling scenarios, the ESABCC advised its target of **90-95% emissions reduction by 2040** (relative to 1990). Also noted in the advice was that the EU should complement its internal mitigation with support for decarbonisation elsewhere in the world as part of an effort to do its fair share of global climate action.

Results from a modelling comparison exercise from the ECEMF Horizon project were also presented (Pietzcker et al, 2023). The study arrived at an 86% reduction in emissions in 2040, similar although slightly less than the ESABCC numbers (Fig 03). The main reason for the difference was that the ESABCC fairness criteria increased the level of ambition in Europe. However, there were also some technical differences between the methodologies, such as the inclusion of the United Kingdom in the ECEMF studies and the treatment of aviation and maritime emissions. Such sectoral delimitations will become more important as other sectors approach zero emissions and the 'hard-to-abate' sectors become relatively more important in the remaining budget.

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

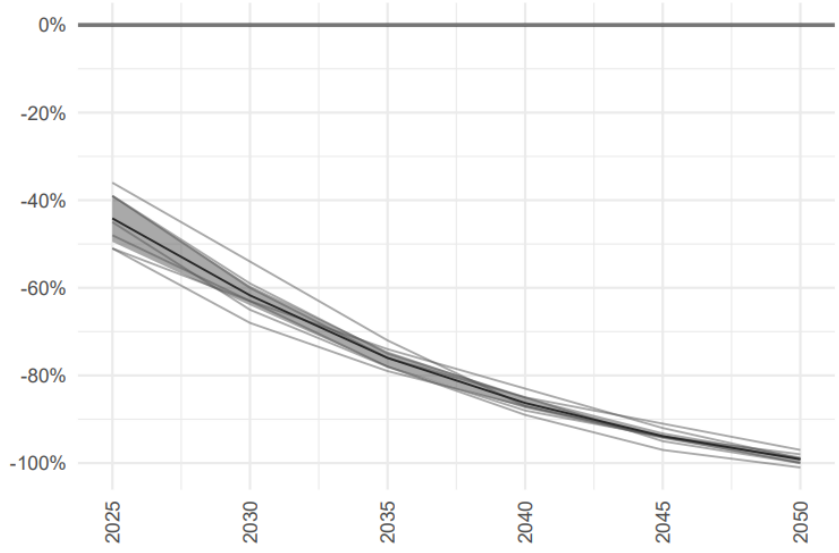

Fig 03 *– EU GHG emission reductions compared to 1990 for the years 2025-2050 based on modelled scenarios in the ECEMF project. The thick line represents the average value (at 86% in 2040), shaded areas the interquartile range, and the thin lines show individual model results (Pietzcker et al, 2023).*

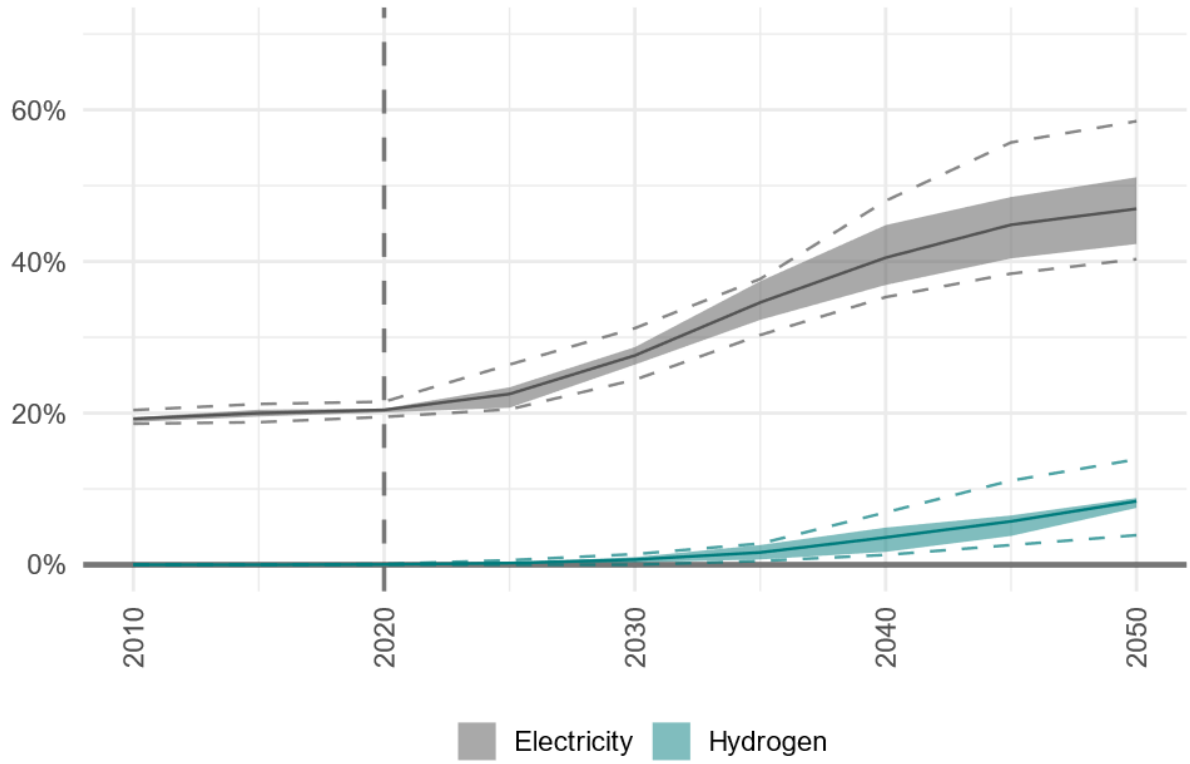

Fig 04 *– Share of electricity (grey) and hydrogen (turquoise) in final energy demand for EU 27 & UK (including bunker fuels), according to the ECEMF multi-model study. Continuous lines represent average values, shaded areas the interquartile range, and dashed lines the highest/lowest values (Pietzcker et al, 2023).*

Modelling results from the ECEMF study that help to contextualise the required sectoral transformations were further presented. The modelling comparison study found that hydrogen could

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

be at only at 3% of final energy use in 2040 compared to 41% for electricity (Fig 04). The need for substantial CCS and sequestration to meet the 2040 targets was also highlighted.

Policy Priorities

The policymakers from DG ENER and DG CLIMA put forward some key concerns and questions for the post-2030 policy framework and the 2040 target setting:

i. The global decarbonization context, in terms of emissions reductions achieved by other regions.
ii. The impact of innovations, in terms of unexpected cost reductions or failing technologies.
iii. Distributional and economic impacts of European decarbonisation.
iv. Emphasis on the need for better data.
v. Better representation of climate impacts in macroeconomic models.
vi. Better representation of macroeconomic effects of climate action in IAMs.

The PRISMA project will seek to develop and improve models such that the integrated assessment modelling community is better placed to contribute on several of the above issues. Specifically, there are specific tasks in the PRISMA project that relate to improved representation of climate impacts in macroeconomic models and to develop the representation of finance and innovation in existing IAMs. Better data was agreed by both policymakers and modellers as a public good that is necessary for informed decision making, with PRISMA aiming to do empirical work as part of its broader aims.

Generally, the engagement between modellers and stakeholders highlighted the changing needs of policy as we move towards the 2040 policy framework domain, especially in terms of understanding distributional effects across regions, income groups and sectors, as well as insights on the macroeconomic impacts of decarbonization.

3 PRISMA's Integrated Assessment Modelling Improvements

The goals of the PRISMA project are well aligned with the concerns raised by policymakers. Specifically, PRISMA aims to:

1. Advance IAMs to more societally relevant process representation and evaluation.
2. Strengthen empirical basis of modelling.
3. Make models more policy relevant.

PRISMA will seek to achieve these aims through its own work and also in collaboration with other Horizon projects, aiming to harvest the value of synergies across the IAM and climate and energy policy communities. In particular, PRISMA expects to leverage its connections to the ECEMF, SPARCCLE, CAPABLE and CircEUlar project, amongst others.

Model Development

The first goal of advancing IAMs and increasing their explanatory power will be achieved through four specific areas of model development: **distributional justice, low carbon finance and innovation, lifestyle changes and circular economy strategies, and climate impacts and sustainable development**. Cross cutting developments of increasing spatial and temporal granularity and improving the representation of structural change are also planned and will apply to each of the four specific areas of improvement.

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

Regarding *distributional justice*, research under the PRISMA project will aim to improve the representation of socio-economic trends in in IAMs by capturing heterogeneous preferences amongst households. Understanding the distributional effects of climate policy was highlighted by policymakers as an increasingly important aspect of analysis, and PRISMA will achieve this by increasing the sectoral detail in models. Another step will be to move away from the paradigm of representative agents towards the inclusion of distinct households with specific preferences, classed by income and other characteristics. The variegated repercussions of climate actions between sectors and households can then be better understood through modelling.

Financial dynamics and innovation will be included in IAMs through the addition of specific modules and empirical work to identify the various costs of capital for clean energy technologies in different regions. In terms of forecasting technological costs over time, probabilistic methods will be employed in models, along with endogenisation of learning curves and R&D. Such model developments will allow IAMs to contribute to the estimation of financing needs for decarbonisation and the identification of robust de-risking methods for climate finance.

The digital transition will lead to significant *lifestyle changes* that will need to be represented in IAMs, as well as the material consequences of *circular economy* strategies that are central to the green transition. Lifestyle choices will be endogenised in IAMs as a task in PRISMA. Recycling, reuse and other circular economy strategies will also be added to the model frameworks, facilitating the development of scenarios that can explore lifestyle changes in a realistic and accurate manner. The combination of better representation of distributional aspects and lifestyles may open up new avenues of research that will become key as the green transition disrupts daily life in more noticeable ways. In particular, understanding the impact of climate policy on higher or lower carbon lifestyle groups could provide new and relevant insights.

The final specific area of improvement is the representation of *climate impacts*, which are expected to increase in severity as the planet continues to warm. The PRISMA project will devote significant resources to linking a representation of biodiversity to IAMs such that the biophysical impacts of policy scenarios can be explored. A set of adaptation options will also be explored. On the economic side, the consequences of climate change for labour productivity and inequality will be explored and incorporated into IAMs.

<u>Empirical Foundations</u>

PRISMA's second objective, to improve the availability of data such that integrated assessment modelling is carried out on firm empirical ground, involves data collection and refinement on a number of topics. The PRISMA consortium brings together both modelling and empirical expertise to ensure that databases are well aligned with IAM needs. Specifically, PRISMA will release new datasets on:

- Structural economic change,
- Inequality of income and other socio demographic factors,
- Regionally weighted average cost of capital,
- Cost projections of different technologies,
- Low carbon lifestyle heterogeneity,
- Biodiversity indicators, and
- Climate change biophysical and economic risks.

Furthermore, model inputs and outputs will be harmonized with official data source structures to ensure that model scenario results can be easily compared to official statistics (for example from Eurostat or the IEA). Novel approaches to processing model outputs will also be leveraged with a focus on machine learning. Hundreds of variables across thousands of modelling scenarios are now publicly available.

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

Machine learning techniques will be applied to multi-model scenarios to explore uncertainties in these results.

4 Conclusions

Discussions with policymakers from the European Commission and the input from stakeholders in attendance at the public event highlighted a number of key issues for climate and energy policymaking over the duration of the PRISMA project.

The 2040 emissions reduction target for Europe, set to be presented in Q1 2024, will frame much of the debate that follows it. The challenge is to balance fairness and feasibility, ensuring that the target is sufficiently ambitious to meet Europe's and the world's climate goals, but pragmatic enough to generate a broad consensus for action.

The post-2030 policy framework that follows the presentation of the 2040 target will need to manage the emerging distributional impacts of climate policy in Europe, from both a sectoral and geographical perspective. Decarbonisation will become more disruptive to daily lives, eliminating some business models but creating new opportunities elsewhere, and just transition considerations will become more central to the policy discussion. Also important from a distributional perspective are climate impacts, with adaptation becoming more relevant as climate change intensifies.

The discussion at PRISMA's event highlighted a number of areas that are seen by policymakers as critically important to understand, including but not limited to the distributional effects of climate policy, the role of innovation in decarbonisation, and the economic consequences of increasing climate impacts. PRISMA will focus on model developments to lay the groundwork for research about these exact questions, ensuring that the integrated assessment modelling community will be well-placed to continue to provide essential insights for climate and energy policymaking.

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.

References

ESABCC, 2023, *Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050,* European Scientific Advisory Board on Climate Change. Available at: https://climate-advisory-board.europa.eu/reports-and-publications/scientific-advice-for-the-determination-of-an-eu-wide-2040/scientific-advice-for-the-determination-of-an-eu-wide-2040-climate-target-and-a-greenhouse-gas-budget-for-2030-2050.pdf/@@display-file/file

European Commission, 2021, *COMMISSION STAFF WORKING DOCUMENT 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 Investing in a climate-neutral future for the benefit of our people*. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:749e04bb-f8c5-11ea-991b-01aa75ed71a1.0001.02/DOC_1&format=PDF

European Union, 2018, *Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0001.01.ENG

European Union, 2021, *REGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119

Pietzcker, R., V. Daioglou, F.D. Longa, H.S. de Boer, M. Dekker, J. Emmerling, A. Fattahi, E. Fejzic, T. Fotiou, P.Fragkos, O. Fricko, H. Henke, M. Kannavou, F. Lombardi, G.Luderer, S. Pfenninger, R. Rodrigues, J. Sitarz, I. Tatarewicz, M. Tavoni, W.Usher, B. van der Zwaan, B. Zakeri, E. Zisarou, 2023, *ECEMF Policy Brief: Insights on EU2040 targets based on a model intercomparison exercise of EU Climate Neutrality Pathways*, European Climate+Energy Modelling Forum (ECEMF). Available at: https://www.ecemf.eu/wp-content/uploads/2023/09/Pietzcker2023_ECEMF_Insights_on_EU2040_targets.pdf

UNFCCC, 2023, *Technical dialogue of the first global stocktake Synthesis report by the co-facilitators on the technical dialogue,* United Nations Framework Convention on Climate Change. Available at: https://unfccc.int/sites/default/files/resource/sb2023_09_adv.pdf

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101081604.