IAM COMPACT

Expanding Integrated Assessment Modelling: Comprehensive and Comprehensible Science for Sustainable, Co-Created Climate Action

D3.8 – I²AM PARIS v2.0

WP3 – Exchanging: Open & FAIR science, mutual learning

30/01/2024

The IAM COMPACT project has received funding from the European Union's HORIZON EUROPE Research and Innovation Programme under grant agreement No 101056306.

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EC Summary Requirements

1. Changes with respect to the DoA

No changes with respect to the work described in the DoA.

2. Dissemination and uptake

The report documents the latest developments deployed in the I²AM PARIS platform, as part of the work carried out in the context of the IAM COMPACT project; it is intended to benefit developers and users of models employed in support of climate action as well as all other users of the platform, both within and beyond the consortium, by keeping track of all changes and functionalities of the platform.

3. Short summary of results (<250 words)

I²AM PARIS is an open data exchange platform for climate and energy policy modelling, developed by the Horizon 2020 PARIS REINFORCE project. This report provides a summary of implemented and planned platform improvements in the context of the IAM COMPACT project, following up on the strategy documented in the I²AM PARIS Upgrade Plan (D3.1), delivered in the beginning of the project. Notably, efforts have been placed on adding validity checks for modelling data that is uploaded to the platform and providing an indication of whether modelling results are plausible by comparing them with relevant benchmarks such as the vetting criteria from IPCC AR6 WGIII. Existing components of the platform have also been improved in terms of functionalities. New model documentation has been added, while the existing documentation has been updated, emphasising interpretability by non-experts. In this direction, we have also created a component with videos and additional training material for new modellers. In terms of future improvements, we also plan to develop user-friendly interfaces for data input, allowing modellers from other projects to easily interact with, and add new modelling and scenario information to, the platform. Finally, the representation of sectoral models is planned to be enhanced, while new result workspaces to be created to showcase the outcomes of the project's modelling exercises.

4. Evidence of accomplishment

This report, the I²AM PARIS platform (https://i2am-paris.eu/), as well as the platform's GitHub, which keeps track of and provides access to all platform code (https://github.com/i2amparis/i2amparis_platform).

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Preface

IAM COMPACT supports the assessment of global climate goals, progress, and feasibility space, and the design of the next round of Nationally Determined Contributions (NDCs) and policy planning beyond 2030 for major emitters and non-high-income countries. It uses a diverse ensemble of models, tools, and insights from social and political sciences and operations research, integrating bodies of knowledge to co-create the research process and enhance transparency, robustness, and policy relevance. It explores the role of structural changes in major emitting sectors and of political, behaviour, and social aspects in mitigation, quantifies factors promoting or hindering climate neutrality, and accounts for extreme scenarios, to deliver a range of global and national pathways that are environmentally effective, viable, feasible, and desirable. In doing so, it fully accounts for COVID-19 impacts and recovery strategies and aligns climate action with broader sustainability goals, while developing technical capacity and promoting ownership in non-high-income countries.

NTUA – National Technical University of Athens	EL	
Aalto – Aalto Korkeakoulusaatio SR	FI	
AAU – Aalborg Universitet	DK	
BC3 – Asociacion BC3 Basque Centre for Climate Change – Klima Aldaketa Ikergai	ES	
Bruegel – Bruegel AISBL	BE	
CARTIF – Fundacion CARTIF	ES	
CICERO – Cicero Senter for Klimaforskning Stiftelse	NO	
E3M – E3-Modelling AE	EL	
KTH – Kungliga Tekniska Hoegskolan	SE	
POLIMI – Politecnico di Milano	IT	
UPRC – University of Piraeus Research Center	EL	
UVa – Universidad De Valladolid	ES	
WI – Wuppertal Institut fur Klima, Umwelt, Energie GGMBH	DE	
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UNIGE – Université de Genève	CH	
Imperial – Imperial College of Science, Technology and Medicine	UK	

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Executive Summary

I²AM PARIS is an open data exchange platform for climate and energy policy modelling that was originally developed in the context of the Horizon 2020 PARIS REINFORCE project. This report provides a summary of the improvements of the platform that have been implemented within IAM COMPACT, following up on the I²AM PARIS Upgrade Plan that was developed in the beginning of the project (Deliverable D3.1).

To provide tangible support to EU and international climate policy, a major requirement for modelling exercises is to ensure the validity of modelling inputs and the credibility of their results. In the context of IAM COMPACT, we have added automatic validity checks in the platform to promote data quality and consistency with major formats of modelling information and results regarding climate change mitigation— for the time being, this mainly refers to the IPCC AR6 cycle format, but we will remain flexible to adapt to any changes emerging during the AR7 cycle. This way, the platform offers a valuable indication of whether modelling results are plausible by comparing them with various scenario benchmarks such as the ones used in the vetting process of the IPCC AR6 WGIII. Both types of checks can be performed whenever new modelling inputs and outputs are uploaded to the platform—to be combined with the development of user-friendly interfaces for data input that will be developed throughout 2024. These interfaces will also allow modelling teams from other projects to automatically add new modelling information to the platform, without needing to send it first to the I²AM PARIS development team, thus ensuring the usability and long-term sustainability of the platform and facilitate its usage.

Apart from new features, existing components of the platform have been improved in terms of functionalities. New model documentation has been added, while the existing documentation and methods for visualising model details will be updated based on the feedback of IAM COMPACT stakeholders, emphasising interpretability by non-experts. The capacity development activities of the project are also featured extensively in the platform, by creating a component with videos and training materials for new modellers and for further supporting the understanding of modelling documentation.

The representation of sectoral models will be also enhanced in existing components, complementing the work of the NDC ASPECTS project. Finally, new result workspaces are being created to showcase the outcomes of the project's modelling exercises. All (new) modelling documentation and workspaces are (will be) publicly available, allowing for easy dissemination and adhering to the FAIR principles for data management.

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Contents

Table of Figures

The IAM COMPACT project has received funding from the European Union's HORIZON EUROPE Research and Innovation Programme under grant agreement No 101056306.

Table of Tables

The IAM COMPACT project has received funding from the European Union's HORIZON EUROPE Research and Innovation Programme under grant agreement No 101056306.

1 Introduction

I²AM PARIS[1] is an open-source data exchange platform for modelling information in support of climate action. It was created in 2019 by the Horizon 2020 PARIS REINFORCE project to facilitate understanding of the diverse Integrated Assessment Models (IAMs), energy system models, and sectoral models that were used in that project, as well as to provide interactive interfaces for exploring results of model intercomparisons. Nevertheless, the intention from the very beginning was for the platform to evolve into a vessel for knowledge exchange for the wider modelling community and an authoritative source of modelling information for stakeholders.

Towards this goal and to ensure the sustainability of the platform, the development of the platform is continued by the IAM COMPACT project as well as by four other EU-funded projects, the Horizon 2020 projects NDC ASPECTS[2] and ENCLUDE[3], the Horizon Europe project DIAMOND[4], and the Horizon Europe project TRANSIENCE[5]. While most new platform development will take place simultaneously among the five projects, each of them has a different scope: NDC ASPECTS focuses on improving the documentation of sectoral models and producing more interfaces to dive into national and sectoral results; ENCLUDE emphasises results on citizen-led climate action; DIAMOND will develop applications of modelling results for different audiences; and TRANSIENCE will use I²AM PARIS as a dissemination channel for climate-economy modelling related to the industrial sector, with interfaces for stakeholders to explore data/insights. In the case of IAM COMPACT, I²AM PARIS will be enhanced in terms of content and features to support model intercomparison exercises and capacity development activities of the project. This report provides an outlook of the realised and envisaged platform improvements within IAM COMPACT.

In comparison to similar IAM community platforms, such as the Scenario Explorer developed and hosted by IIASA, I²AM PARIS prioritises open-source availability[6], and coherent interlinkages among workspaces, and will eventually offer external users the possibility to create their own model profile/documentation and exercise workspaces.

The next section (2) provides an overview of existing functionalities of the platform, realised through the PARIS REINFORCE project, while IAM COMPACT-related improvements are described in more detail in Sections 3-6. The final section (section 7) includes a plan for the roll-out of future improvements in response to other planned activities of the project as well as a short outlook for further work. It is noted that, apart from these planned functionalities, more enhancements can be potentially applied in the platform, based on the needs of the project partners and stakeholders and in coordination with the development work of the other projects.

[1] https://www.i2am-paris.eu/
[2] https://www.ndc-aspects.eu/
[3] https://www.encludeproject.eu/
[4] https://www.climate-diamond.eu
[5] TRANSIENCE
[6] https://github.com/i2amparis/i2amparis_platform

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2 Pre-existing functionalities of I²AM PARIS

The platform had originally two main functionalities: First, it provided extensive documentation for more than 40 global, national, and sectoral models that are used to support climate policy. Model details were provided through four diverse interfaces that provide relevant information for different use cases and different audiences, such as detailed model descriptions intended for modelling experts and infographic-like visualisations for policymakers and other non-expert stakeholders. The emphasis on user-specific information was an important requirement for the platform and it was co-designed along a variety of stakeholders, including other modelling experts as well as users of modelling information such as EU and national policymakers. Second, I²AM PARIS showcased the outputs of the main modelling exercises of the PARIS REINFORCE project through six workspace components, most of them including links to related publications and modelling data and featuring interactive visualisations of the results, customised for different audiences. These two main functionalities can still be accessed directly through the sections 'Documentation' and 'Results' in the homepage of the platform (see Figure 1).

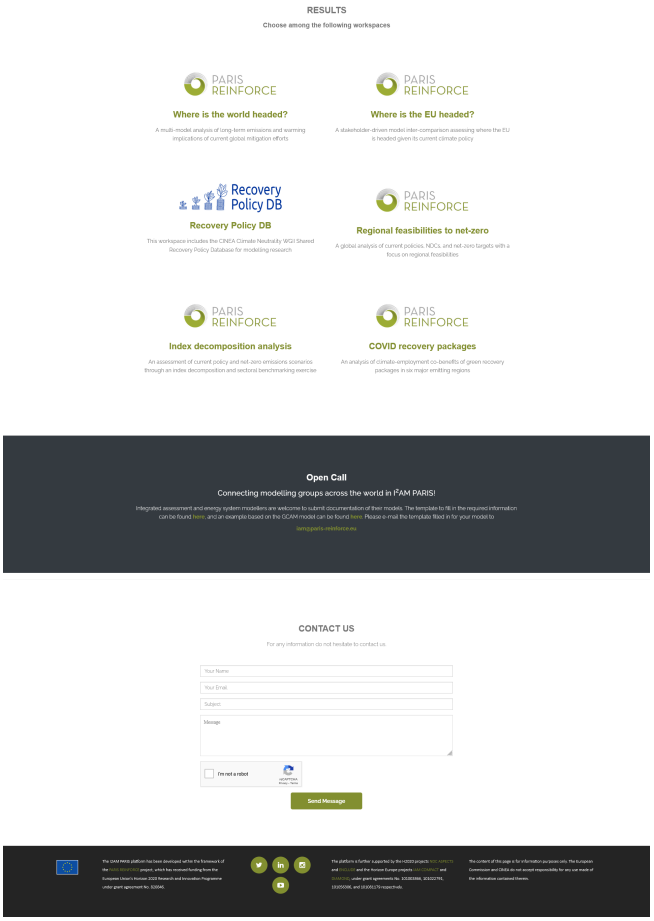

Figure 1. I²AM PARIS homepage (https://i2am-paris.eu); left: banner, slider and model documentation; right: modelling results, open call to submit documentation, contact details, and footer.

For a detailed explanation of the 'Documentation' & 'Results' sections as well as the six workspaces developed for PARIS REINFORCE, see Deliverable '**D3.1 – I²AM PARIS Upgrade Plan**'[7].

These functionalities are kept up to date for the IAM COMPACT project, as documentation of modelling

[7] https://iam-compact.eu/publications/deliverables

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characteristics enables scientists from different disciplines and viewpoints to share a common language as well as other stakeholders to know what modelling tools can be exploited to address different policy questions. Figure 2 shows the 25 models which are part of the IAM COMPACT modelling suite: **17** pre-existing models have been updated to reflect their latest functionalities (e.g., GCAM, TIAM, etc), while **8** models (shown with '**+**' in Figure 2) have been added to the platform exclusively for the IAM COMPACT project.

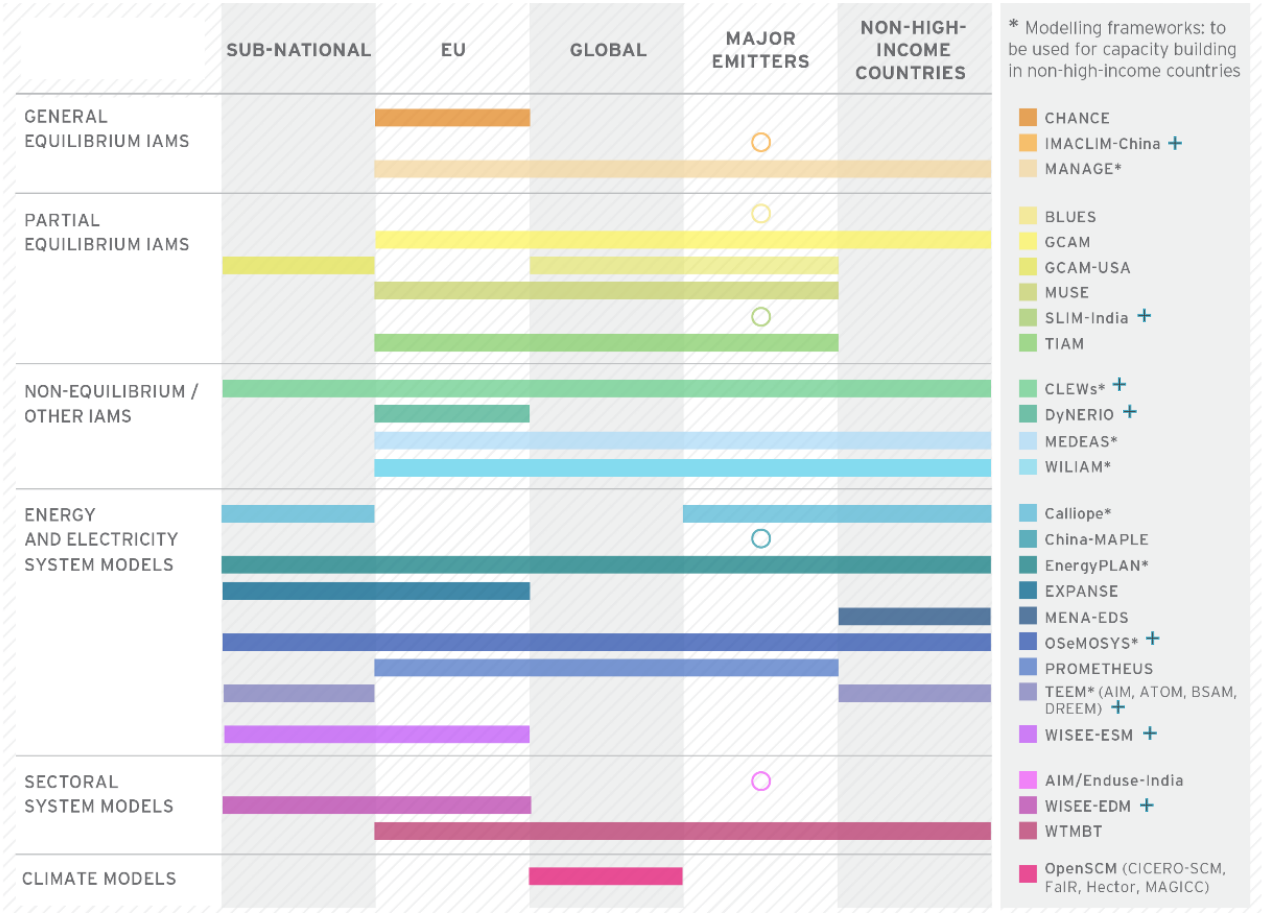

Figure 2. IAM COMPACT modelling suite (https://iam-compact.eu/exchanging/models). New models added to the platform are indicated with '**+**'.

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3 Validity checks

The validity and reliability of modelling methods, inputs, and outputs are essential for providing stakeholders of climate action with the confidence to use modelling information in strategic decision-making, investment planning and policy design (Gardumi et al., 2022). Data quality is even more significant in large modelling exercises, where the volume of modelling and scenario data increases to a level that it becomes difficult to visually keep track, requiring automatic algorithmic checks. While a wide range of validation methods and protocols have been developed in the last decade, the growing modelling community and the wide production of studies require user-friendly and transparent methods for helping modellers to ensure data quality in their results (Süsser et al., 2022).

During PARIS REINFORCE, an initial level of quality check was achieved by means of a common template for formatting modelling results from the Integrated Assessment Modelling Consortium (IAMC)[8]. The template is prevalent and extensively exploited by the climate change mitigation modelling community for standardising modelling results and has been notably used for data collection in the scenario database of the Sixth Assessment Report (AR6) of the Intergovernmental Panel for Climate Change (IPCC). The template has five initial columns for reporting models, scenarios, regions, variables, and units, and then shows annual data values for multiple years following a timeseries format (see Table 1). As the time step between reported years varies among the different models, it is not standardised in the template, but it is usually a 5-year or a 10-year time step. While the template helped to standardise the format of scenario results of the PARIS REINFORCE project, parsing errors were observed due to discrepancies in variable names or model names as well as due to duplicate data.

Table 1. Example of the IAMC template[9] for modelling results of climate change mitigation

Model	Scenario	Region	Variable	Unit	2005	2010	…
GCAM 5.3	R_MAC_30_n0	World	Emissions|CO2	Mt CO2/yr	31425.8416	36026.1588	…

Based on a meeting with modelling partners within IAM COMPACT in December 2022 as well as drawing from the experience of PARIS REINORCE and other modelling projects, the following validation checks were suggested:

- **Model name consistency**: Model names in results should be kept consistent with the ones used in the documentation components. In this way, the different platform sections can cross-reference one another, allowing visitors to directly access details of models that were used to create specific results and vice versa. Model names in the results will include the exact model version used for a specific modelling run, providing a link to version-specific documentation in the platform or in other locations such as code repositories (for instance, the repository of the GCAM model in GitHub[10]).
- **Variable name consistency**: Variable entries will be checked against the typical list of variables used in the IPCC reports. In case that a new variable is added, it will be flagged so that the user can confirm whether it is truly a new variable or a misspelt version of an existing one. This check can facilitate additional disaggregation capabilities among the numerous models.
- **Region name consistency**: Like variables, regions will be checked against the typical list of regions used in the IPCC as well as in other major modelling projects, such as the ECEMF or NAVIGATE projects.
- **Unit consistency**: Typical units will be coupled with specific variables to avoid the case that models use different units for the same variable, allowing for easier comparison. Deviations will be reported, and users will be recommended to use the standard unit type. For many standard unit conversions, such as between joule, watt hour, and tonne oil equivalent, a unit converter routine will be developed and

[8] https://www.iamconsortium.org/scientific-working-groups/data-protocols-and-management/iamc-time-series-data-template/
[9] https://pyam-iamc.readthedocs.io/en/stable/
[10] https://github.com/JGCRI/gcam-core

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automatically apply when new modelling results are added to the platform (subject to confirmation from the user that uploads these results).

- **Duplication checks:** An automatic process will search for entries with the same indices and flag potential duplicates.
- **Value format**: Entries under the value columns will be checked as to whether they contain numerical data. Empty entries will be assumed to indicate a N/A value. This will be communicated to all consortium modellers, as some models may indicate zero values as an empty entry. In that case, these cells will need to be changed to a zero numeral before adding data to the platform.
- **Basic sums across variables**: When variables are provided both in a disaggregated and an aggregated form (for instance, total emissions and emissions per sector), the sum of the disaggregated variables will be checked against the aggregated one and flagged when the deviation is larger than ±1-2%. Since the IAMC template does not specify any specific deviation nor any other test for disaggregated variables, this check would be optional. Nevertheless, in case of a failed check, users will be prompted to re-examine their modelling results before uploading them to any data repository.

Apart from validation checks, data consistency and feasibility checks have been also implemented, based on different benchmarks. Among other metrics, we evaluate our modelling results against the 'vetting' criteria used at the IPCC AR6 scenario database. This vetting process required key indicators of modelled scenarios of the first modelling cycle of IAM COMPACT to be within reasonable ranges for a historical year (commonly 2019 or 2015); other vetting criteria can assess the feasibility of future scenario projections, indicating, for instance, whether models assumed very high or unrealistic ramp-up rates for specific technologies. The IPCC AR6 vetting criteria mostly relate to emissions and energy sector characteristics and can be seen in Table 2 below.

Table 2. Summary of vetting criteria from the IPCC AR6 scenario database (Annex 3[11], Section 3.1)

Indicators	Reference value	Vetting range for all global scenarios	Vetting range for illustrative pathways
Historical emissions (sources EDGAR v6 IPCC and CEDS, 2019 values)			
CO_2 total emissions (EIP + AFOLU)	44,251 $MtCO_2/yr$	±40%	±20%
CO_2 EIP emissions	37,646 $MtCO_2/yr$	±20%	±10%
CH_4 emissions	379 $MtCH_4/yr$	±20%	±20%
CO_2 emissions EIP 2010-2020 - % change	-	0 to +50%	0 to +50%
CCS from Energy 2020	-	0-250 $MtCO_2/yr$	0-100 $MtCO_2/yr$
Historical energy production (sources IEA 2019; IRENA; BP; EMBERS; trends extrapolated to 2020)			
Primary Energy (2020, IEA)	578 EJ	±20%	±10%
Electricity Nuclear (2020, IEA)	9.77 EJ	±30%	±20%
Electricity Solar & Wind (2020, IEA, IRENA, BP, EMBERS)	8.51 EJ	±50%	±25%
Future criteria (not used for exclusion, only flagged as potentially problematic)			
No net negative CO_2 emissions before 2030	CO_2 total in 2030 > 0	-	-
CCS from Energy in 2030	< 2000 $MtCO_2/yr$	-	-
Electricity from Nuclear in 2030	< 20 EJ/yr	-	-
CH_4 emissions in 2040	100-1000 $MtCH_4/yr$	-	-

Note: EIP stands for energy and industrial process emissions; AFOLU stands for Agriculture, Forestry and Other Land Use.

[11] https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_Annex-III.pdf

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All data checks are scripted using the Python programming language. The script takes scenario results from a modelling exercise as an input, using an Excel or CSV format based on the IAMC template (see Figure 3).

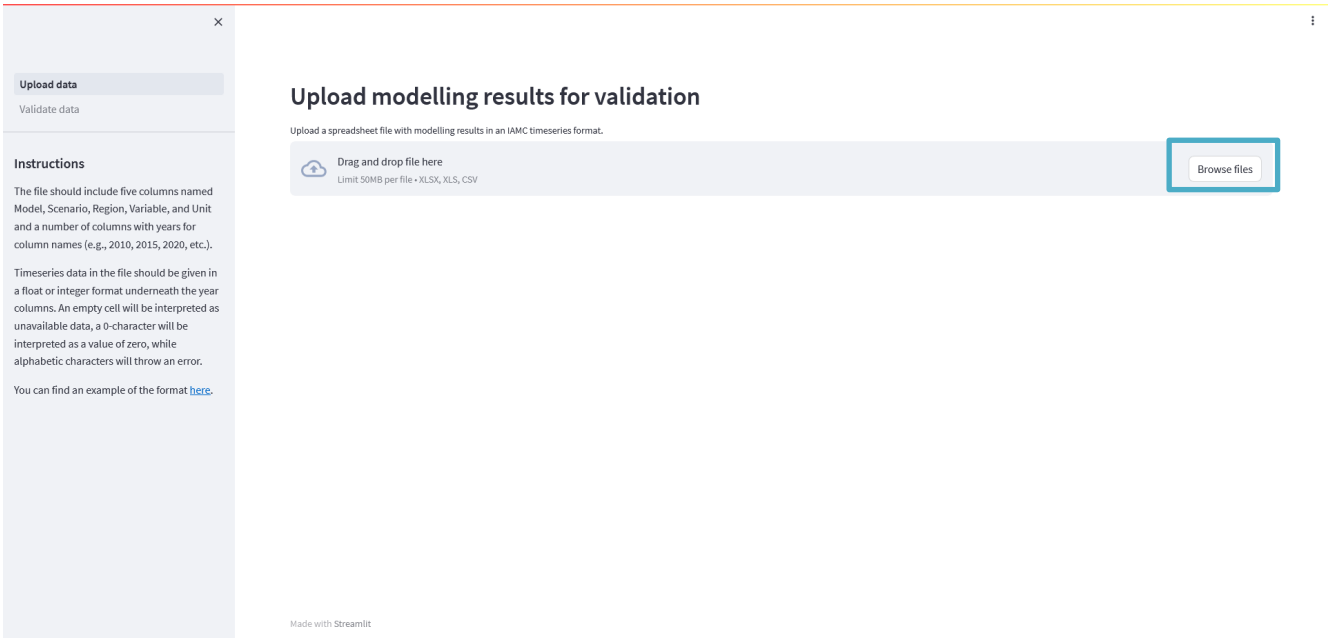

Figure 3. Validation checks tool homepage (https://validation.i2am-paris.eu/)

After uploading the data, the tool informs the user whether the file has the correct format. If the format is correct, the user can validate their data (see Figure 4).

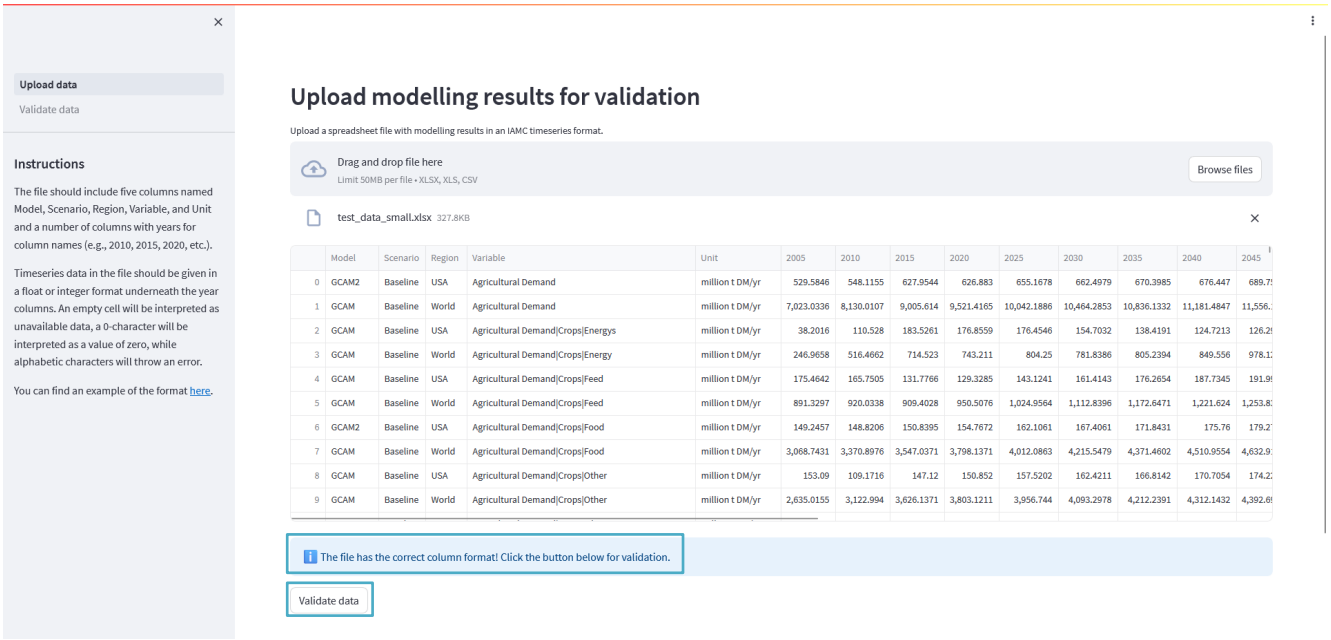

Figure 4. Uploading data for results validation (https://validation.i2am-paris.eu/)

Upon clicking on "Validate data" the user is prompted to choose which validation check(s) they want to perform (see Figure 5) before staring the validation process. These are the possible options:

- Consistency of model, variable, and region names
- Vetting checks, and/or
- Consistency between disaggregated and aggregated variables

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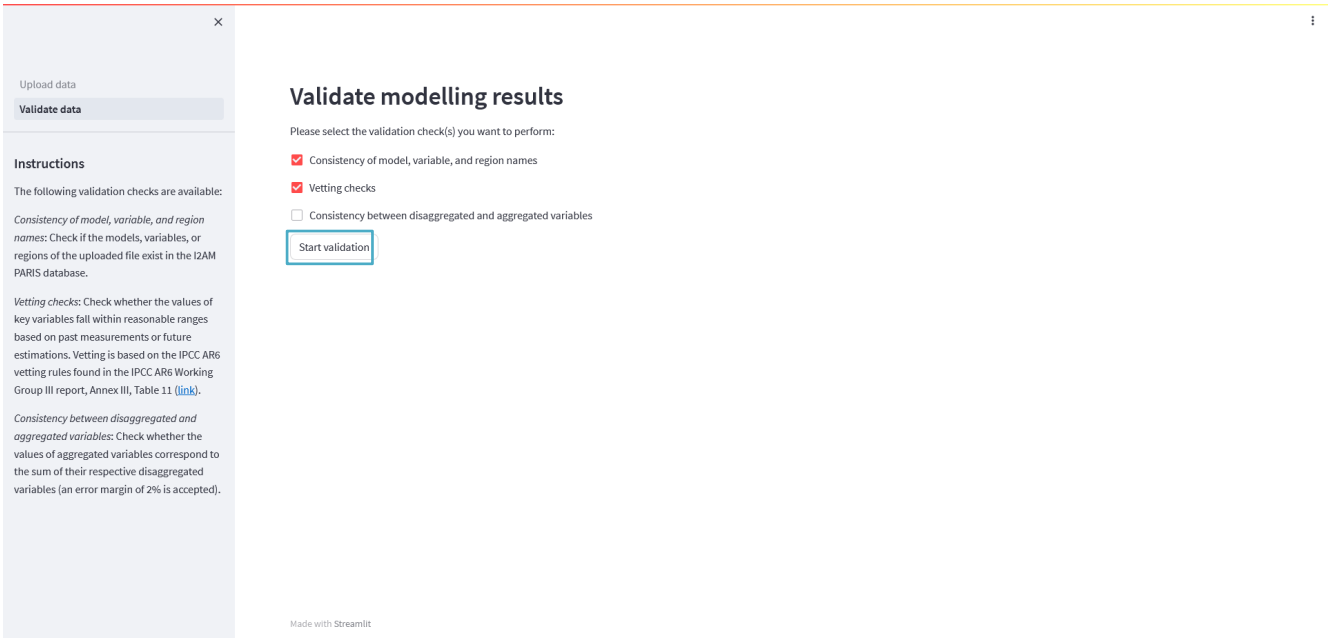

Figure 5. Choosing validation check(s) (https://validation.i2am-paris.eu/)

As an output, the script flags the scenarios that do not pass the data consistency and validation process and explicitly show the indicators that fail (see Figure 6). Users can scroll the data frame to see all errors and warnings in detail. They can also download validation results in an Excel file, fix potential errors, and re-upload them.

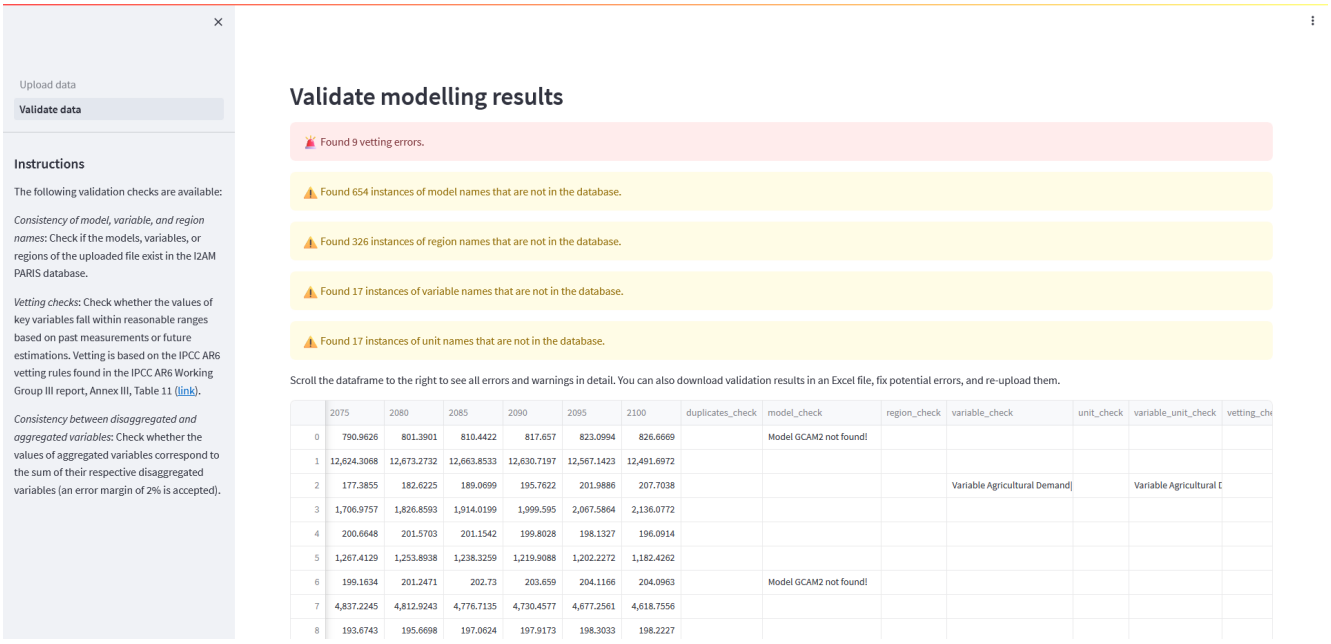

Figure 6: Validation checks outputs (https://validation.i2am-paris.eu/)

The script has been integrated in the platform and modellers within the consortium have been encouraged to test it to ensure its usability. The script's code is open source and provided in GitHub[12], allowing every interested user to modify the validity checks, e.g., changing vetting checks or decreasing and increasing the allowed deviation

[12] https://github.com/i2amparis/validation

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between aggregated variables and sums of disaggregated variables. Within 2024, the script will be integrated within an automated data input interface, where data will be directly uploaded in the platform database after it has passed a successful validation check.

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4 Enhancement of documentation components

The documentation section of I²AM PARIS has been enhanced to match the requirements and needs of IAM COMPACT. While many of the project models have already been documented (as part of PARIS REINFORCE work or in response to the platform's previous open calls to the modelling community), many of them needed to be updated while new models had to be included. Because IAM COMPACT features many sectoral models, the platform faces the pressing need to better showcase the characteristics and level of sectoral detail that is missing from the platform's current documentation templates. Additionally, the capacity development activities of the project have resulted in the development of training material hosted in the platform in a way that complements and increases the comprehensibility of the existing model documentation.

Towards this goal, a library of learning resources has been created in the documentation section of the platform, comprising videos, tutorials, and slide packs. The library component currently contains training materials created by the IAM COMPACT project and will eventually also link to materials from other projects and modelling forums, such as the SENTINEL project and the IAMC consortium[13]. The intention is to create a focal point of learning resources about modelling for climate action (considering IAMs but also other modelling frameworks as well without focusing only on IAMs) to provide modelling teams the information they need to understand and operate models in terms of their features, capabilities, and usage. In this way, we can also support the exploitation of materials created from other projects, contributing to the sustainability and usefulness of their outputs. An interface will be made to allow researchers outside the consortium to add training materials for their own models, while IAM COMPACT consortium partners will help curate all new content and ensure its quality. Training materials will be then cross-linked to other documentation components, helping visitors to find specific resources corresponding to each model.

In this direction, IAM COMPACT held a series of modelling seminars throughout November and December 2022 with detailed presentation of the various global, national, and sectoral models included in IAM COMPACT. All presentations were recorded and the slide packs along with the records have been uploaded and provided as documentation/information material for each IAM COMPACT model in the platform's Documentation components (see Figure 7).

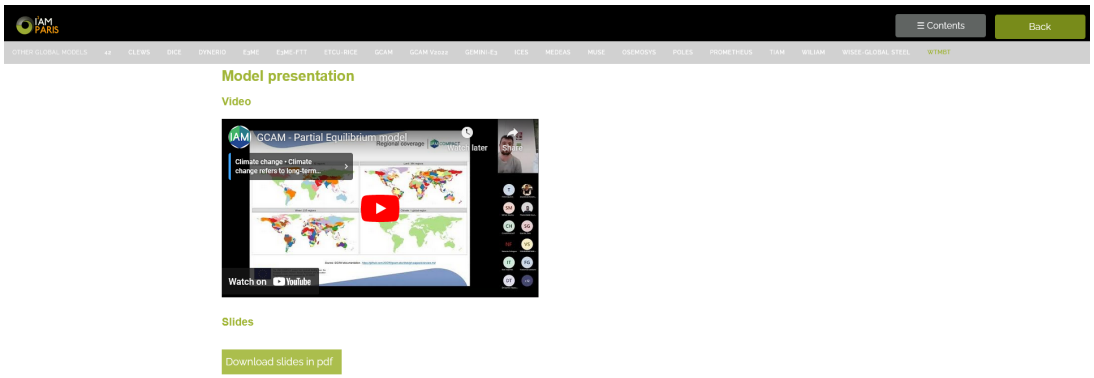

Figure 7. Model presentation and slide pack for the GCAM model in "Detailed model documentation" (https://www.i2am-paris.eu/detailed_model_doc/gcamv2022)

The existing documentation components will also be updated to better showcase the characteristics of sectoral models such as transportation, specific industries (e.g., steel or cement), buildings, water, as well as agriculture forestry, and other land use (AFOLU). A first project meeting among NTUA and sectoral modelling teams on this topic took place in December 2022, helping the platform development team understand what is needed to best represent sectoral models while also allowing associated improvements to align with the current structure, without

[13] https://www.iamconsortium.org/resources/tools-visualization/

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splitting the documentation section depending on model focus.

While few sectoral models were already present in the platform, it was acknowledged that it was not readily apparent in all documentation components that these are specialised sectoral models. For instance, the infographic-like Model Dynamic Documentation[14] component, featuring an overview of the characteristics of each modelling tool, is currently indicating that the ALADIN sectoral model is simulating only one sector, without showing any other specialised features of the model such as its high technological granularity for that specific sector. This component will thus be enhanced to show the highlights of sectoral models, such as a more granular representation of sub-sectors and specific technologies that are covered by the models along with other special modelling details such as hourly resolution, subnational granularity, specific impacts examined. These highlights will be shown through icons that will be flexibly created for each model. Sectoral models will be further distinguished by other models by visualising them through different colours and by allowing users to filter them, for instance, in order to find sectoral models for specific sectors, e.g., transport or buildings.

The need to show sectoral model highlights will potentially require harmonising/updating the template for model documentation that is currently used by the platform, as sectoral models frequently include more variables than global or national models due to their different granularity. The same can be said for the scenario template, which corresponds to IPCC AR6 template for global and national models. A similar adaptation will be made to specific vetting requirements for sectoral models, adding the respective checks to the data validation component described in Chapter 3. Additionally, it will be examined whether there is a need to modify the Variable Harmonisation Heatmap[15] component for showing the harmonisation details between sectoral and global/national models, as it was already done for the models of the PARIS REINFORCE project.

Apart from modifications for sectoral models, existing documentation components will be further updated to match new requirements and ongoing feedback from the modelling community. As part of *Task 5.6: Truly sustainable decarbonisation pathways, including biodiversity, materials, biophysical limits*, modelling teams have been asked to evaluate the capacity to assess Sustainable Development Goals (SDGs) in the IAM COMPACT models. The results of the evaluation will be used to populate and/or update the 'SDG' section of the Dynamic Documentation. As part of *Task 5.1: Making a green step forward into the post-COVID era* qualitatively identified, gathered, and classified announces recovery packages, and will pass this information to the I²AM PARIS platform with the aim to update its Recovery Policy DB[16].

Additionally, a content management system (CMS) will be made to allow the users to interact directly with the platform without the need of contacting the platform developers (apart from the validation of major data entries). In the Detailed Model Documentation[17], the interface will include a field for adding documents such as detailed documentation, links to scientific publications, and presentation slides. In addition, new sub-sections will be introduced—e.g., one showing an overview of the models' key features. In the Model Dynamic Documentation[12] component, a feature will be developed allowing visitors to hide icons that are not relevant for a model, facilitating the understanding of its characteristics. The map of the same component will be also modified to show regional or sub-national detail for specific models by zooming in. The Overview and Comparative Assessment will be also updated with comparisons among the specific models of IAM COMPACT. Finally, we will reach out to the ECEMF[18] project and the EFECT[19] forum as well as other modelling projects and/or networks to discuss potential synergies related to the platform, while encouraging modelling teams beyond the consortium to add their models to the platform.

The CMS system is currently under development and is expected to finish within the first half of 2024. While the

[14] https://www.i2am-paris.eu/dynamic_doc/
[15] https://www.i2am-paris.eu/harmonisation_map_tool/harmonisation_manual
[16] https://www.i2am-paris.eu/rrf_policy_intro
[17] https://www.i2am-paris.eu/detailed_model_doc
[18] https://www.ecemf.eu
[19] https://www.efect.eu/

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user management system, the interface for parsing data, and the interface for new documentation have been mostly finished, they have not been yet released publicly. The new interface is planned to be released when the interface for workspace creation will be also completed, around August-September 2024 (see Section 7). The reason for this is that the technical implementations and code of all the functionalities of the CMS need to be harmonised to ensure usability and efficiency.

However, a screenshot of beta version of the CMS can be seen in Figure 8, offering an example of its functionalities. As indicated in the screenshot, the modeling documentation related to the Gemini-E3 model can be changed through the new interface while, on the right sidebar, the user can see a revision of all changes, comment on them, and share the interface with another user. The final version of the interface will be formatted accordingly to match the visual identity of I²AM PARIS.

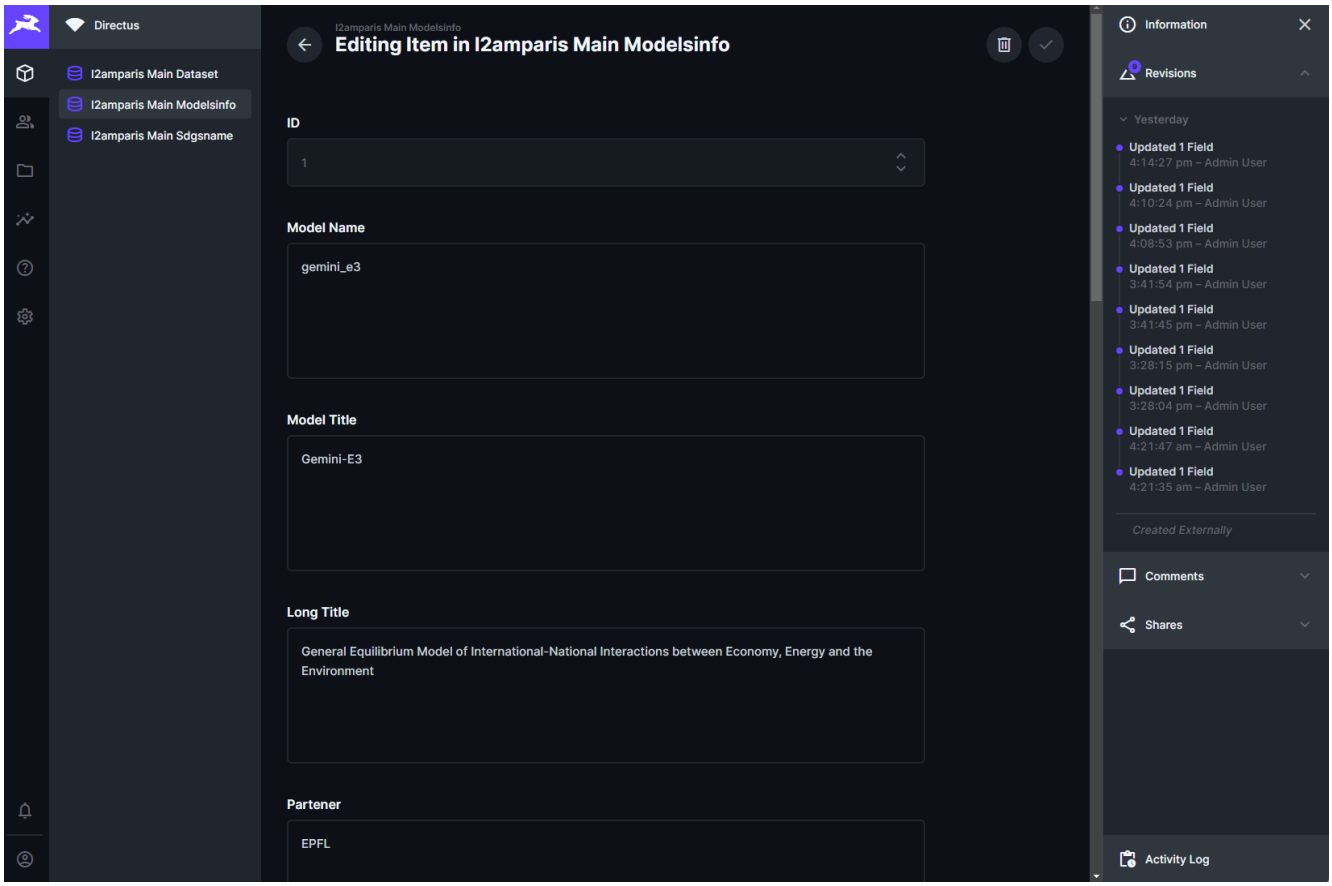

Figure 8. Early version of the Content Management System in the I²AM PARIS platform

Finally, it is noted that the documentation component of I²AM PARIS is not aiming to substitute the official documentation websites and repositories of the models included (at least for the models that have them), but, instead, focusses on comparing documentation and features among different models. While this is also possible in other modelling documentation efforts, e.g., the wiki of the IAMC community[20], I²AM PARIS strives to be user friendly to non-expert users (e.g., through the interactive infographic of the Dynamic Documentation[21]) and allow for the comparison of different modelling versions.

[20] https://www.iamcdocumentation.eu/index.php/IAMC_wiki
[21] https://www.i2am-paris.eu/dynamic_doc/

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5 Enhancement of result components

Similar to the documentation component, a key motivation for the result components includes creating an interface for platform users to add modelling results automatically. Currently, the development team of the platform needs to manually initiate the parsing of new modelling results in the database and create the respective workspaces and interactive visualisations to visualise these results. This requires many development hours and iterations between the providers of the modelling data and the development team and can be potentially subject to errors.

In the context of IAM COMPACT, the process of data parsing will be automated and integrated with the validation checks described in Chapter 3. Thus, platform users will be able to directly initiate data parsing and checks from a dedicated user-friendly interface and iteratively fix potential problems in the data without the time-consuming intervention by the development team. Similarly, an interface will be made to create a results workspace connected to a specific data stream by choosing specific visualisations and by adding explanations, analysis, and relevant research questions. While such functionalities can be partly found in tools such as the Scenario Explorer from IIASA[22] (Figure 9), the added value of I²AM PARIS is that workspaces (and all other functionalities of the platform) are open source and can be further improved or modified by any interested individual. Additionally, the I²AM PARIS workspaces can provide tailor-made interfaces for policymakers and other users, helping them to better understand and potentially use modelling results. I²AM PARIS workspaces can be also linked to all available data in the platform (both for modelling documentation and results), e.g., allowing users to compare the features of models participating in a modelling exercise.

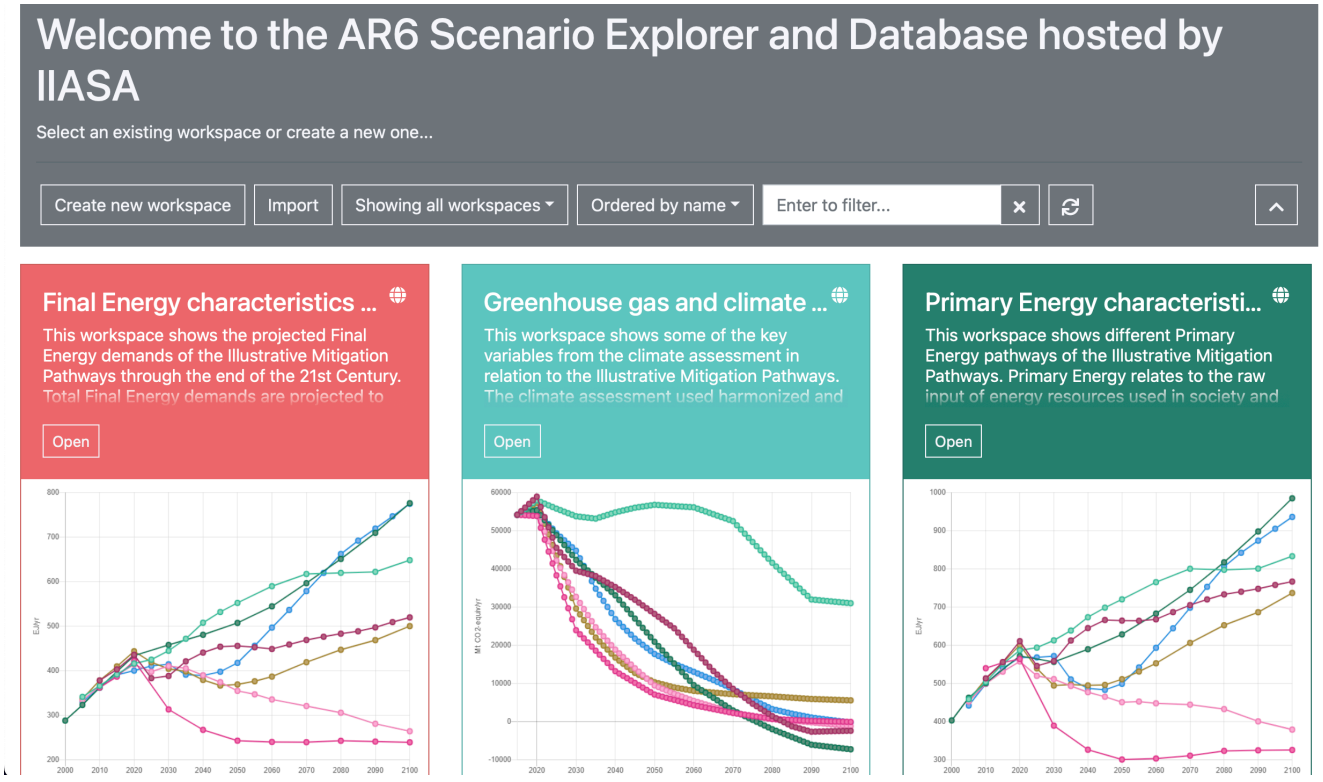

Figure 9. Example of user interfaces to visualise modelling results from the IIASA Scenario Explorer

To ensure data quality and avoid cyber-attacks through code injection, visitors that want to add data will need to provide proof that are related to a specific modelling team or organisation, for instance, by registering with their professional email account. Registered users will be able to add new data and modify data that was added by

[22] https://data.ece.iiasa.ac.at/ar6/#/workspaces

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them. In case of a major data entry or change, a platform admin will be able to check and confirm the change. Registered users will be also able to change the visibility settings of their workspaces, for instance, by keeping the workspace private during its implementation and then releasing it for all users in the platform.

Last but not least, new workspaces related to the modelling work of IAM COMPACT will be developed. Two new workspaces have been already developed and detailed in Section 6 while more workspaces will be developed throughout the duration of the project. Initially, project partners will need to send their modelling results to the development team to create the workspaces, but gradually the automatic user interfaces will come online, allowing partners to directly upload their modelling results onto the platform. To further support the comprehensibility of results and the rationale between modelling studies, the relevant research questions of each study will be added in the Advanced Scientific Module of new workspaces, similar to policy questions in the Public Interface. Further improvements to the result modules may be also elaborated per request of consortium partners and platform users.

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6 New workspaces

The 'Results'[23] section of I²AM PARIS platform contains workspaces that showcase the outcomes of flagship modelling exercises from different participating projects as well as other relevant research activities. Each workspace features meaningful, user-friendly, and interactive visualisations that show the input and output data from these activities, including related policy questions as well as links to scientific publications. For a more detailed description of workspaces, see also Deliverable D3.1 – I²AM PARIS Upgrade Plan.

By January 2024, two result workspaces have been developed in the context of IAM COMPACT project. Since the majority of the research studies of the project have not been yet completed, most new workspaces are expected towards the end of the project. For now, the new workspaces have followed the format and functionalities of workspaces that were developed during PARIS REINFORCE. The workspaces will be updated in the future when the new platform features become available. Additionally, the workspaces will be further enriched with more content, e.g., answers to more policy questions.

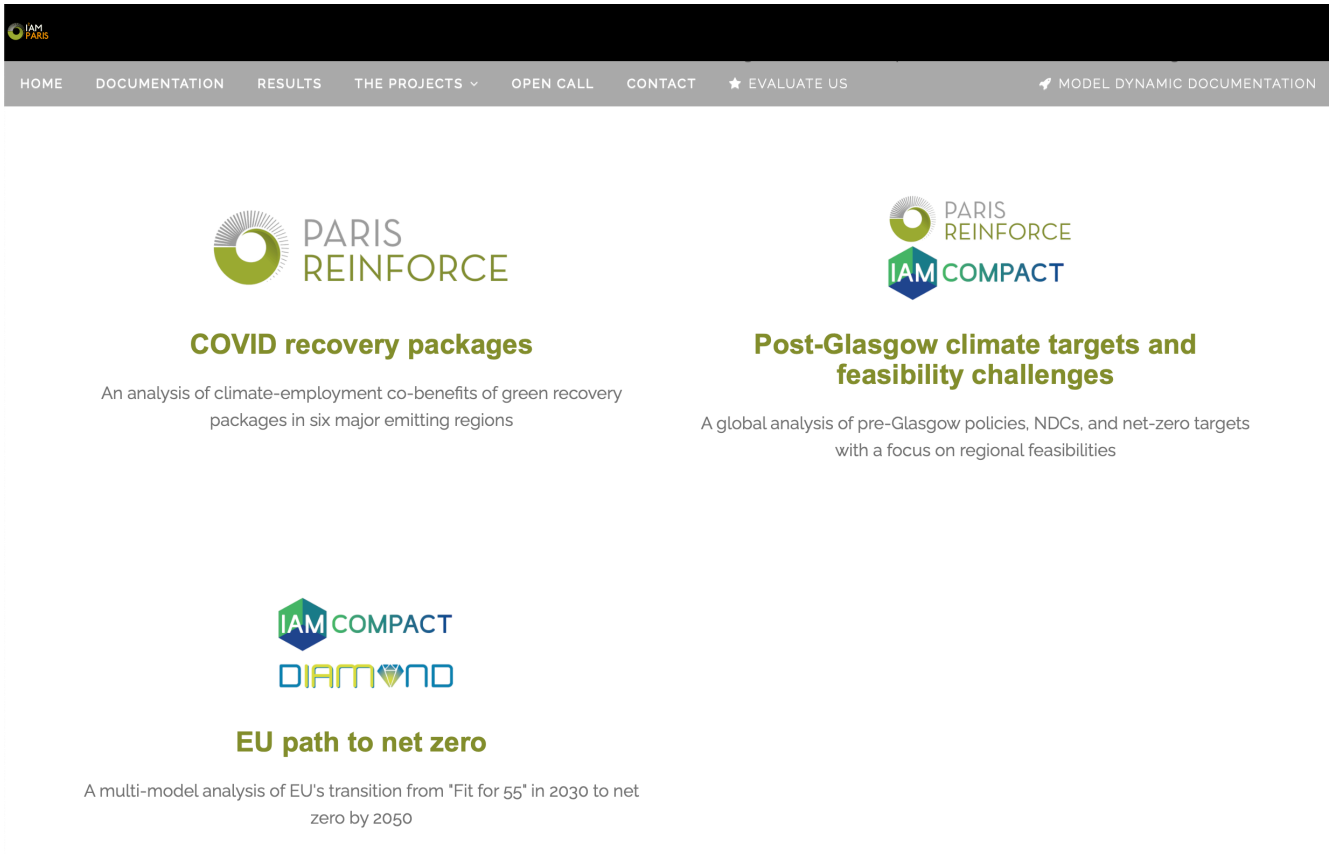

Figure 10. New workspaces for IAM COMPACT

6.1 Post-Glasgow climate targets and feasibility challenges

The "Post-Glasgow climate targets and feasibility challenges" workspace[24] presents the results of a large model intercomparison on global scenarios of current (post-Glasgow) climate policies, mostly based on the publication

[23] https://www.i2am-paris.eu/#section-services
[24] https://www.i2am-paris.eu/feasibility/landing

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of van de Ven et al. in Nature Climate Change (van de Ven et al., 2023). The intercomparison mostly focused on CO_2 emissions pathways and their resulting temperature increase, as well as on feasibility challenges of these pathways in terms of socioeconomics, technology scale up, and physical/sustainability limits. The workspace has been an updated from a pre-existing workspace that was developed in PARIS REINFORCE called "Regional Feasibilities to Net Zero". The data of this workspace has been updated and new policy interfaces have been developed.

Since the main focus of the study was on CO_2 emissions and temperature increase, the scientific data explorer provided interfaces for these variables as well as an interface for getting line or bar charts for all variables of the study (Figure 11).

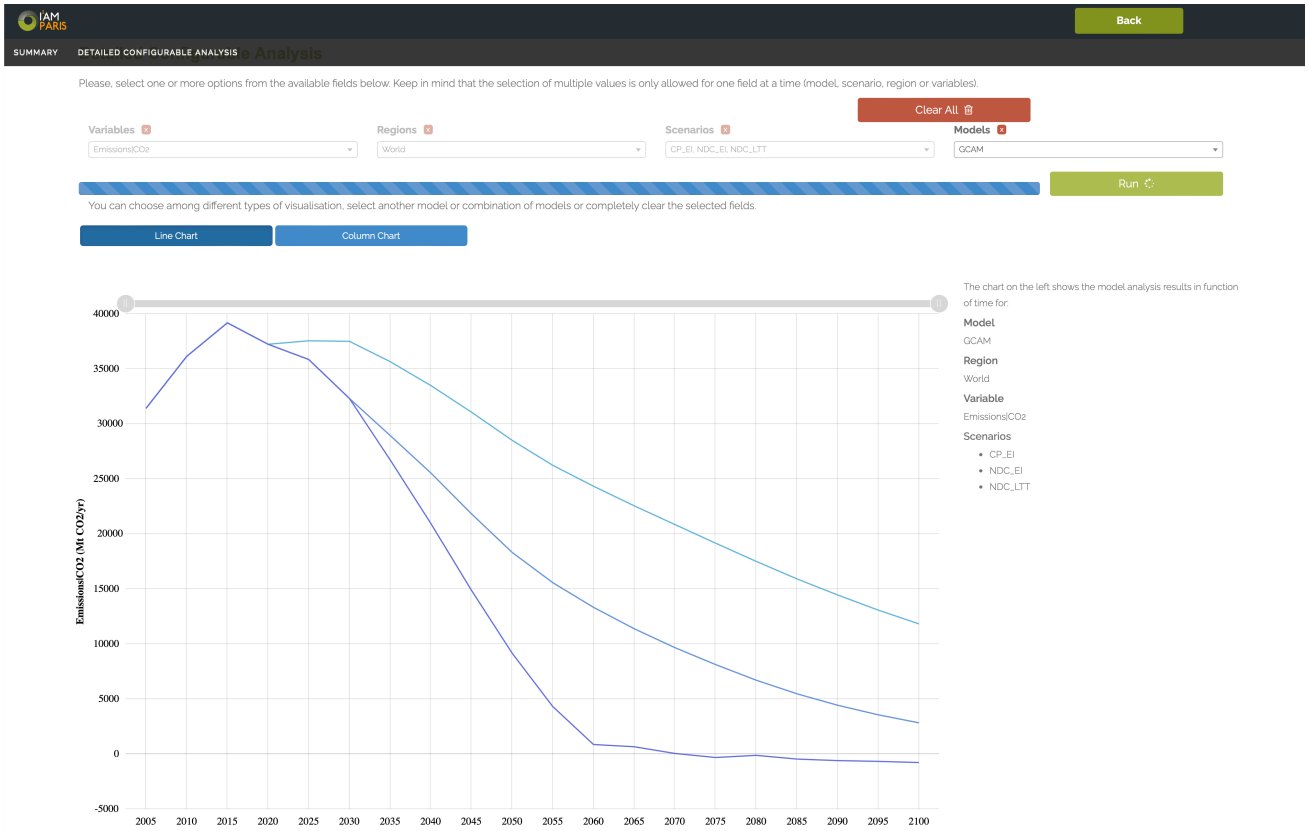

Figure 11. Detailed configurable analysis interface for the "post-Glasgow climate targets and feasibility challenges" workspace

The policy interface follows a similar focus, providing first an introduction to the study and its methodology (Figure 12) and then proceeding to provide answers to the following three policy questions:

- What is the trajectory of global fossil CO2 emissions based on pre-Glasgow current policies, NDCs, and pledges announced in Glasgow?
- How does global warming until 2100 changes?
- What are the feasibility concerns of the resulting pathways?

The answers are supported by a series of interactive interfaces that emphasise the outcomes of the study. An example of this is provided in Figure 13.

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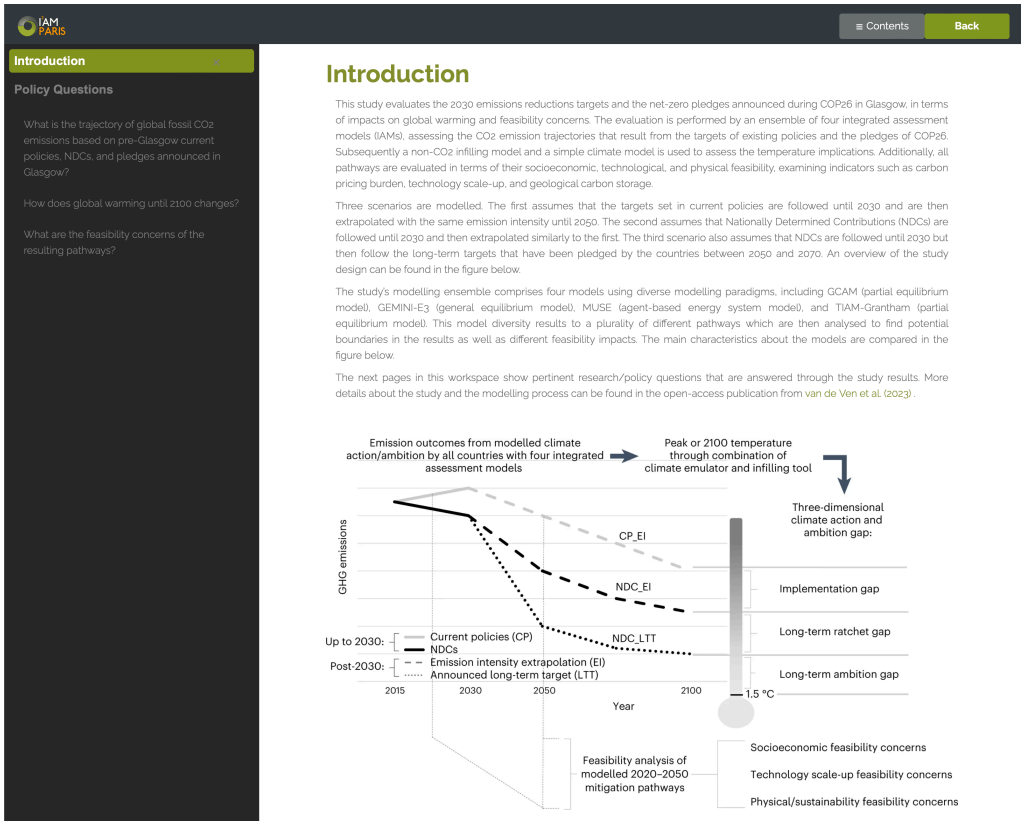

Figure 12. The introduction to the policy interface of the "Post-Glasgow climate targets and feasibility challenges" workspace

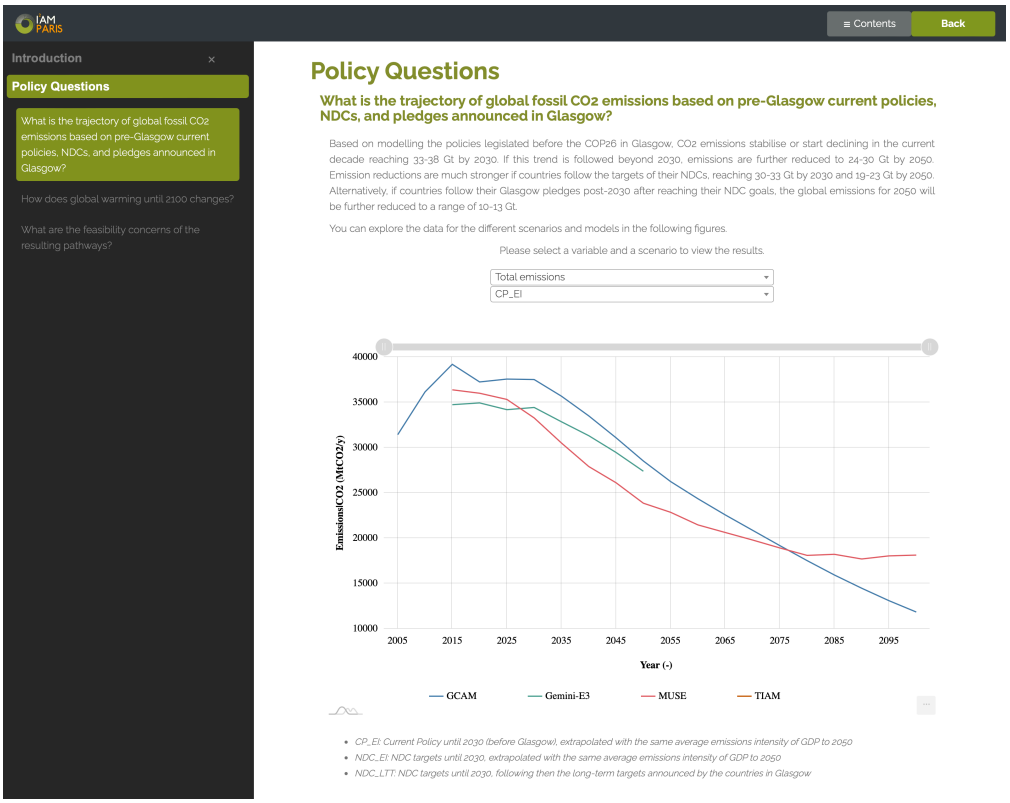

Figure 13. An example of a policy question answered in the "Post-Glasgow climate targets and feasibility challenges" workspace

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Finally, a virtual library is created for the workspaces including all relevant publications and datasets.

Figure 14. Virtual library of the "Post-Glasgow climate targets and feasibility challenges" workspace

6.2 EU path to net zero

"The EU path to net zero" workspace[25] presents the results of a multi-model analysis on the impacts of current (Fit-for-55) mitigation efforts in Europe. The analysis has been mainly presented in the publication from Boitier et al. (2023) in the Joule journal (Boitier et al., 2023). Here the emphasis is given on the transition of different sectors as, along with the five climate-economy models used for the study, two sectoral models have been also used, provided detailed insights to the transport, buildings, and industry sector. The results from this diverse modelling ensemble suggests that there are many alternative ways to reach the Fit-for-55 policy targets and the 2050 net-zero goal of the bloc. Nevertheless, most climate-economy models agree that the power sector needs to be decarbonised by 2040.

As in the previous workspace, a scientific interface is developed with access to all results of the study (Figure 15). Additionally, a policy interface is developed including the following research questions:

- What is the CO2 emissions reduction required for achieving Net-Zero Emissions (NZE) in the EU in 2050?
- What is the level of Carbon Capture and Storage that is assumed by different NZE scenarios?
- How do primary energy consumption and power generation in the EU change across different models and scenarios?

A screenshot of the introduction of the policy interface is given in Figure 16, while an example of the interface for the first question is given in Figure 17. Finally, a virtual library is also created, as seen in Figure 18.

[25] https://www.i2am-paris.eu/fitfor55/landing

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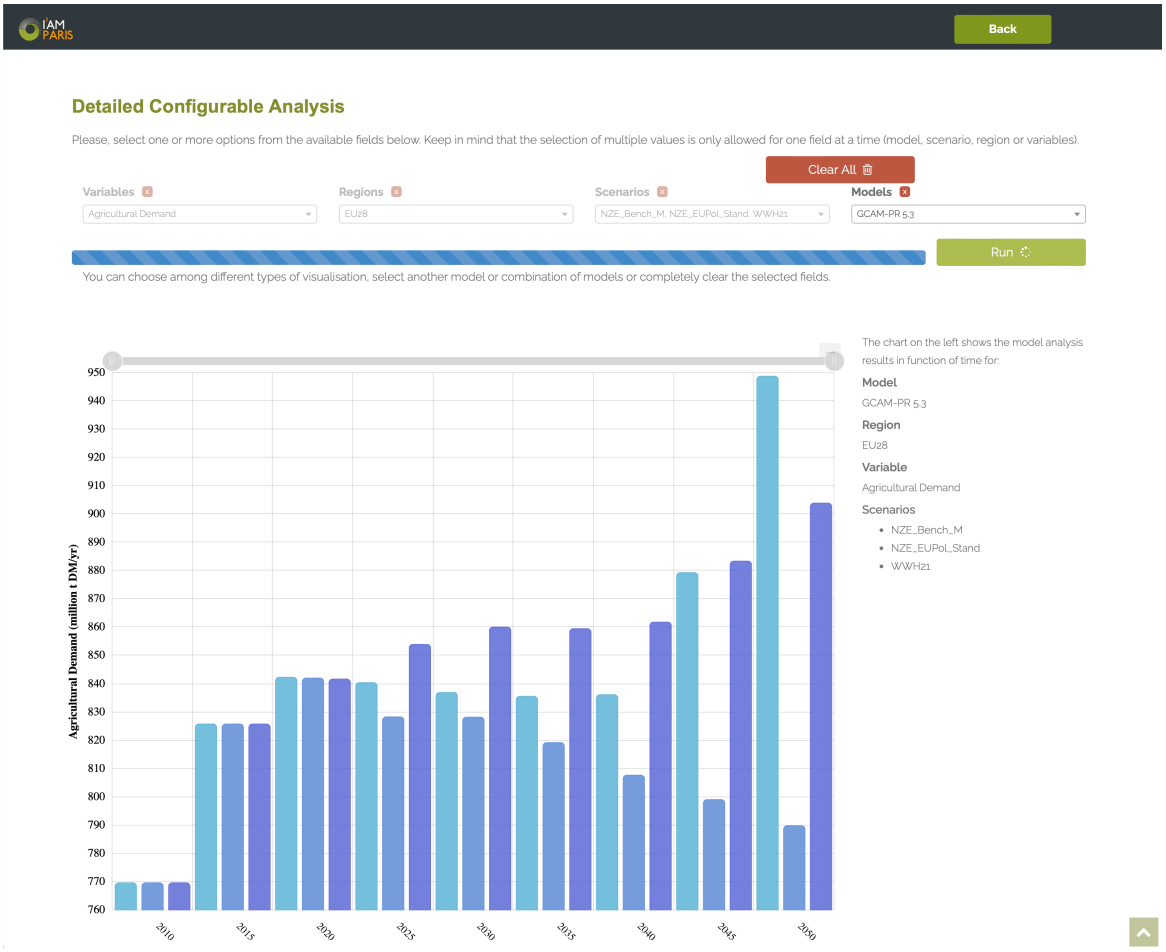

Figure 15. Detailed configurable analysis interface for the "EU path to net zero" workspace

Figure 16. The introduction to the policy interface of the "EU path to net zero" workspace

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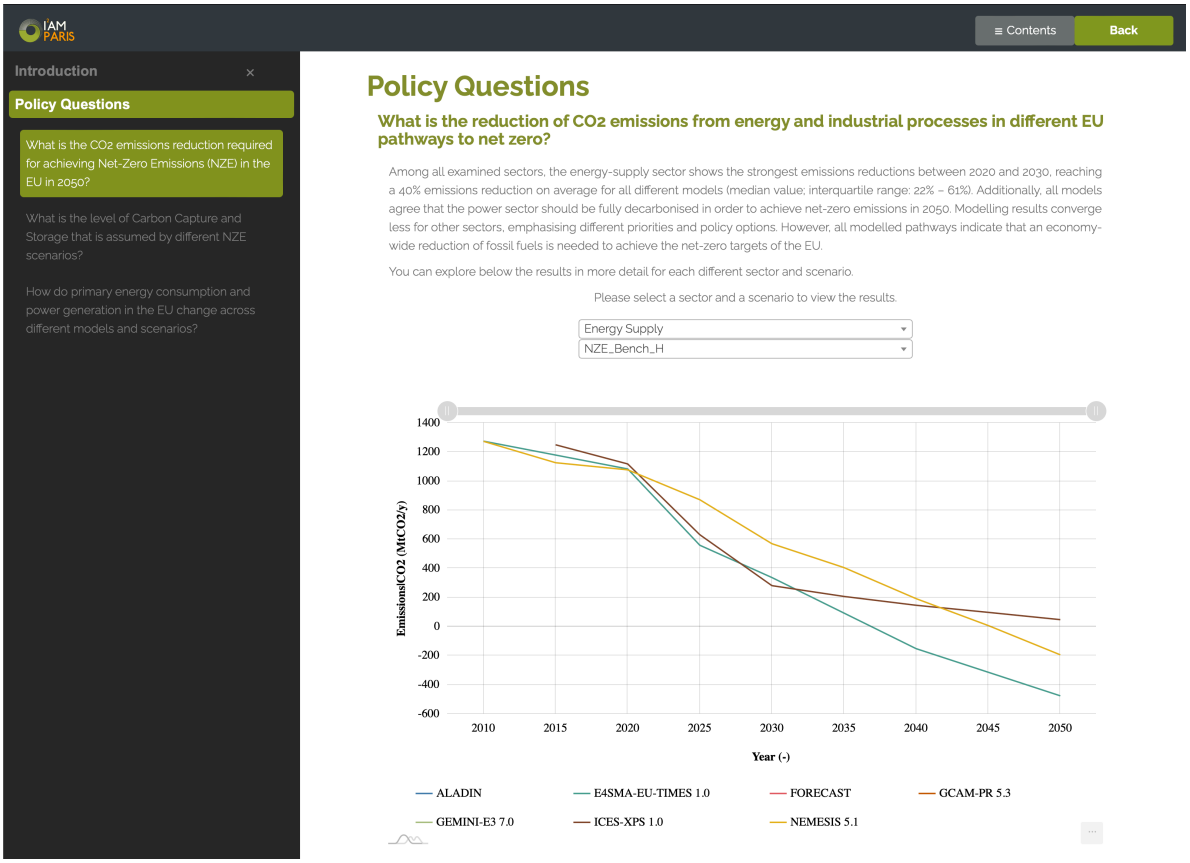

Figure 17. An example of a policy question answered in the "EU path to net zero" workspace

Figure 18. Virtual library for the "EU path to net zero" workspace

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7 Planning of upgrades and current progress

The platform upgrades that were described in the previous chapters have been and will be implemented gradually over the entire duration of the project. A list of implemented and planned elements is shown in Figure 19. During the beginning of the project, two meetings with project partners have taken place to understand the requirements for the validation and vetting checks. Based on these meetings, the validation script has been successfully implemented (see Section 3). Additionally, all new models have been added in the platform including training materials such as videos and presentations (see Section 4). Finally, new workspaces from the first modelling round of the project have been recently added.

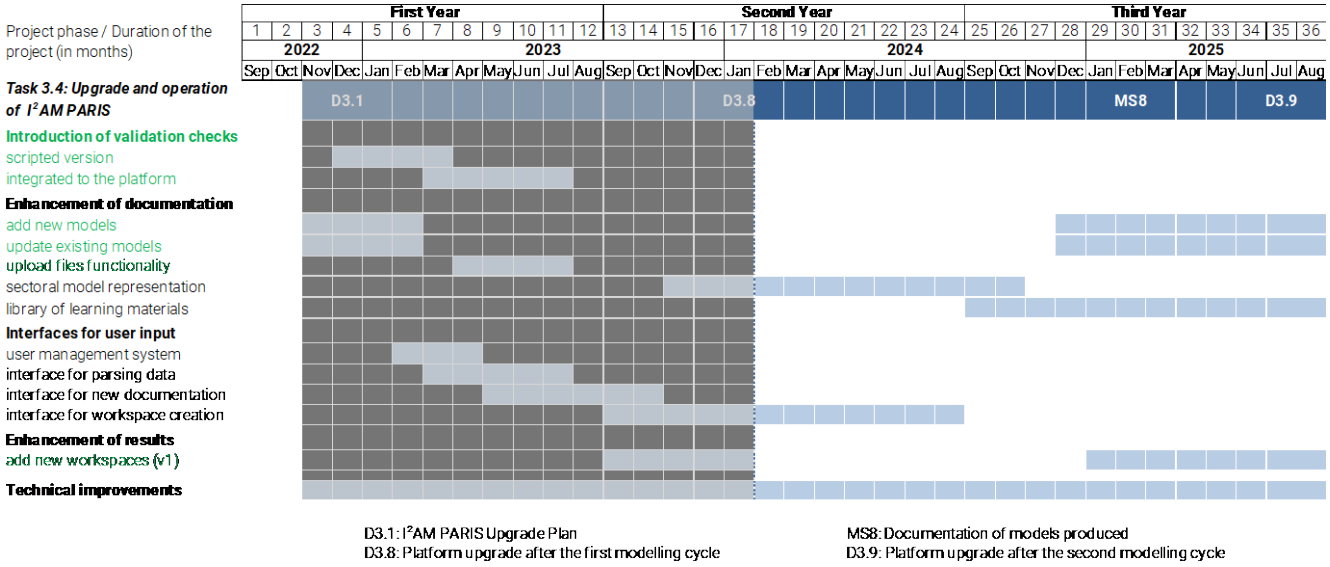

Figure 19. Planning of I²AM PARIS upgrades. Tasks in green have been already completed.

In terms of future tasks, model documentation will be again updated during the last year of the project based on the new features and functionalities developed in WP5. Additionally, the Content Management System will be completed, including an interface for workspace creation and an interface for adding and editing modelling documentation. Subsequently, we will focus on the improvement of sectoral model representation (by around mid-2024), followed by the creation of the library of learning materials. During 2025, we expect to update modelling documentation and add the new workspaces from the second modelling round. Additionally, in collaboration with the DIAMOND project[26], we will further improve the validation tool based on user feedback and assess opportunities to connect, extend, or collaborate with other similar platforms and initiatives such as IIASA's Scenario Explorer, pyam package[27] or nomenclature package[28].

Throughout the project duration, technical improvements will be implemented in the platform. The most important changes required will be to update the existing technical framework of the platform to allow for user interfaces and to facilitate the creation of the workspaces, according to TRUST[29] principles for digital repositories. We will follow an API-first and language-agnostic approach to develop components, for instance by keeping the existing technical components for visualisation in Python and creating user interfaces in Node.js. Moreover, we intend to modernise the appearance of the platform and provide it with its own visual identity, independent of the project or organisation that is currently managing or will manage the platform in the future. Nevertheless, we will allow the possibility for future projects to provide their workspaces in their own custom visual identity. Finally, adhering

[26] https://climate-diamond.eu
[27] https://github.com/IAMconsortium/pyam
[28] https://github.com/IAMconsortium/nomenclature
[29] Transparency, Responsibility, User focus, Sustainability and Technology

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to the FAIR principles (Wilkinson et al., 2016) for data management and digital repositories, all materials in the platform will remain available at least for five years after the end of IAM COMPACT and the other supporting projects, while efforts will be made within with the wider modelling community to establish the long-term sustainability of the platform.

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8 References

Boitier, B., Nikas, A., Gambhir, A., Koasidis, K., Elia, A., Al-Dabbas, K., Alibaş, Ş., Campagnolo, L., Chiodi, A., Delpiazzo, E., Doukas, H., Fougeyrollas, A., Gargiulo, M., Mouël, P. Le, Neuner, F., Perdana, S., Ven, D.-J. van de, Vielle, M., Zagamé, P., & Mittal, S. (2023). A multi-model analysis of the EU's path to net zero. *Joule*, *7*(0). https://doi.org/10.1016/J.JOULE.2023.11.002

Gardumi, F., Keppo, I., Howells, M., Pye, S., Avgerinopoulos, G., Lekavičius, V., Galinis, A., Martišauskas, L., Fahl, U., Korkmaz, P., Schmid, D., Montenegro, R. C., Syri, S., Hast, A., Mörtberg, U., Balyk, O., Karlsson, K., Pang, X., Mozgeris, G., … Mikulić, M. (2022). Carrying out a multi-model integrated assessment of European energy transition pathways: Challenges and benefits. *Energy*, *258*, 124329. https://doi.org/10.1016/J.ENERGY.2022.124329

Süsser, D., Gaschnig, H., Ceglarz, A., Stavrakas, V., Flamos, A., & Lilliestam, J. (2022). Better suited or just more complex? On the fit between user needs and modeller-driven improvements of energy system models. *Energy*, *239*, 121909. https://doi.org/10.1016/J.ENERGY.2021.121909

van de Ven, D. J., Mittal, S., Gambhir, A., Lamboll, R. D., Doukas, H., Giarola, S., Hawkes, A., Koasidis, K., Köberle, A. C., McJeon, H., Perdana, S., Peters, G. P., Rogelj, J., Sognnaes, I., Vielle, M., & Nikas, A. (2023). A multimodel analysis of post-Glasgow climate targets and feasibility challenges. *Nature Climate Change 2023 13:6*, *13*(6), 570–578. https://doi.org/10.1038/s41558-023-01661-0

Wilkinson, M. D., Dumontier, M., Aalbersberg, Ij. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J. W., da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., … Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data 2016 3:1*, *3*(1), 1–9. https://doi.org/10.1038/sdata.2016.18

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