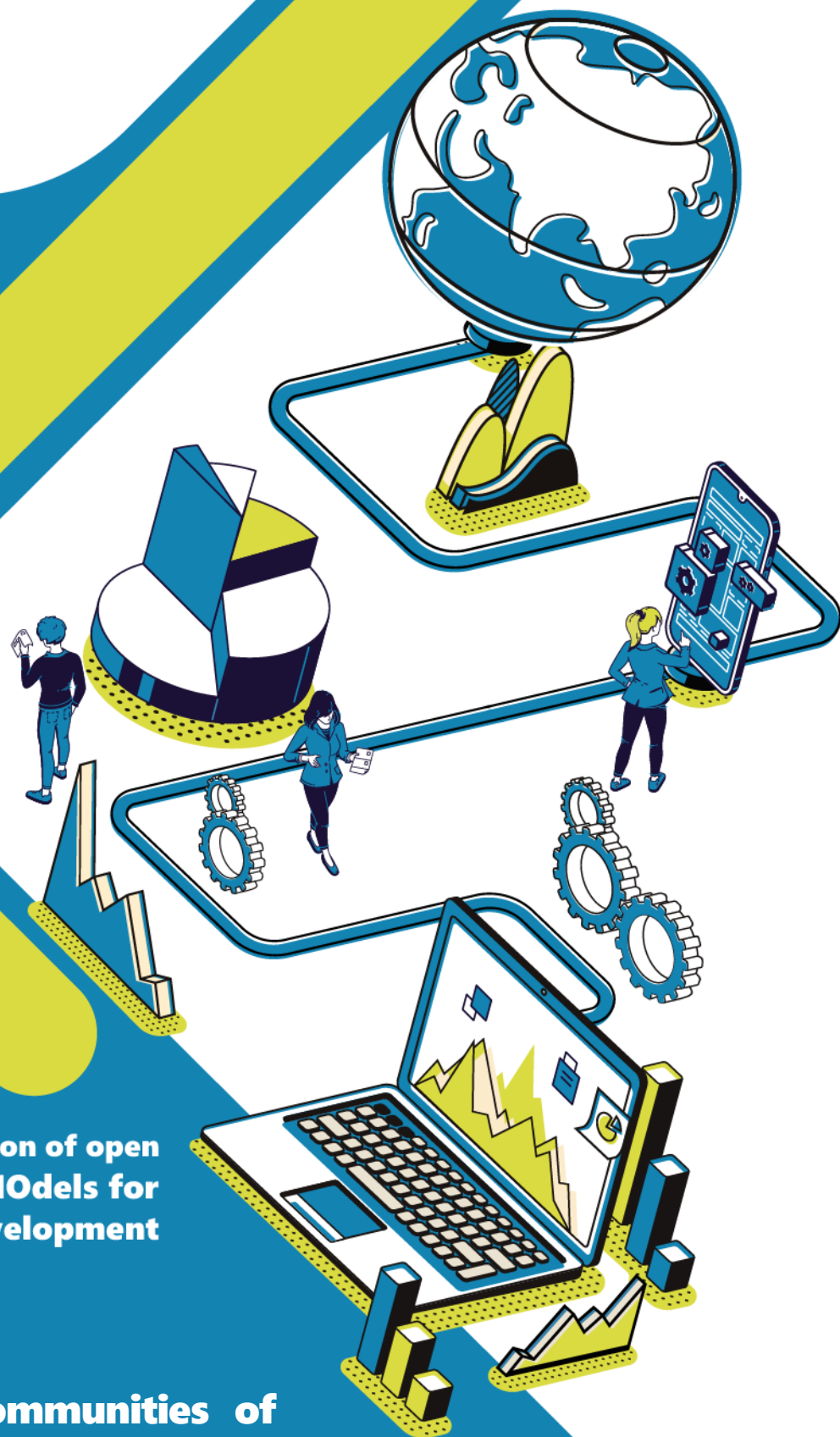




**Delivering the next generation of open
Integrated Assessment MOdels for
Net-zero, sustainable Development**

D6.4 - Report on communities of practice

WP6 – Open

28/12/2024



Funded by
the European Union

Disclaimer

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Grant Agreement Number	101081179		Acronym	DIAMOND
Full Title	Delivering the next generation of open Integrated Assessment MOdels for Net-zero, sustainable Development			
Topic	HORIZON-CL5-2022-D1-02			
Funding scheme	HORIZON EUROPE, RIA – Research and Innovation Action			
Start Date	December 2022	Duration	48 Months	
Project URL	http://www.climate-diamond.eu/			
EU Project Advisor	Silvia Vaghi			
Project Coordinator	Institute of Communications and Computer Systems – ICCS			
Deliverable	D6.4 – Report on communities of practice			
Work Package	WP6 – Open			
Date of Delivery	Contractual	31/12/2024	Actual	28/12/2024
Nature	Report	Dissemination	Public	
Lead Beneficiary	Institute of Communications and Computer Systems (ICCS)			
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Keywords	Communities of practice, capacity development, modelling consortia			

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

This deliverable will serve as a reference document among consortium partners to support the communities of practice and capacity development activities of the project. It can also be used by members of the broader scientific and policy community to identify potential networks to collaborate.

3. Short summary of results (<250 words)

DIAMOND's key objective is to produce iteratively updated, upgraded, open-source versions of six leading integrated assessment models (IAMs). Two major challenges arise in this endeavour. First, the models should be associated with a community of users that will actively employ these models both during and beyond the duration of the project. Second, IAMs are usually associated with a steep learning curve, making it difficult for any new users to overcome the barriers to entry, familiarise with, and actively use the models. In this report, we attempt to tackle these two challenges, by reporting on the activities of the project to establish an active and engaged network of IAM developers and users, as well as organise capacity development activities. Focus is placed on pre-existing dedicated communities of each model, broader modelling communities, forums, and conferences, as well as communities in the broader sustainability landscape. The report also presents courses developed to train the young generation of scientists and modellers, as well as the plans for organising capacity development webinars. The report will continue to be updated as more communities and capacity development activities are organised in the duration of the project.

4. Evidence of accomplishment

This report.

Preface

DIAMOND will update, upgrade, and fully open six Integrated Assessment Models (IAMs) that are emblematic in scientific and policy processes, improving their sectoral and technological detail, spatiotemporal resolution, and geographic granularity. It will further enhance modelling capacity to assess the feasibility and desirability of Paris-compliant mitigation pathways, their interplay with adaptation, circular economy, and other SDGs, their distributional and equity effects, and their resilience to extremes, as well as robust risk management and investment strategies. This will be done via integration of tools and insights from psychology, finance research, behavioural and labour economics, operational research, and physical science. The project will develop a transdisciplinary scientific approach to legitimise the implementation process and co-create research questions that stretch the frontiers of climate science, as well as establish vibrant communities of practice to transparently open model enhancements and to develop capacities, thereby lowering the entrance barriers to the established IAM community.

ICCS	INSTITUTE OF COMMUNICATIONS AND COMPUTER SYSTEMS	EL	
BC3	ASOCIACION BC3 BASQUE CENTRE FOR CLIMATE CHANGE - KLIMA ALDAKETA IKERGAI	ES	
CESAR	KRATENA KURT	AT	
CICERO	CICERO SENTER FOR KLIMAFORSKNING	NO	
CYI	THE CYPRUS INSTITUTE	CY	
E4SMA	ENERGY ENGINEERING ECONOMIC ENVIRONMENT SYSTEMS MODELING AND ANALYSIS SRL	IT	
HOLISTIC	HOLISTIC IKE	EL	
COMILLAS	UNIVERSIDAD PONTIFICIA COMILLAS	ES	
ISINNOVA	ISTITUTO DI STUDI PER L'INTEGRAZIONE DEI SISTEMI (I.S.I.S) - SOCIETA' COOPERATIVA	IT	
SEURECO	SEURECO SOCIETE EUROPEENNE D'ECONOMIE SARL	FR	
UM	UNIVERSITEIT MAASTRICHT	NL	
ESMIA	ESMIA CONSULTANTS INC.	CA	
USMF	THE UNIVERSITY OF MARYLAND FOUNDATION INC	US	
UMD	UNIVERSITY OF MARYLAND	US	
EPFL	ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE	CH	
ETH	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH	CH	
UNIBAS	UNIVERSITAT BASEL	CH	
Imperial	IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE	UK	
Oxford	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD	UK	
UCL	UNIVERSITY COLLEGE LONDON	UK	

Executive Summary

The DIAMOND project's key objective is to produce iteratively updated, upgraded, open-source versions of six leading integrated assessment models (IAMs). Two major challenges arise in this endeavour. First, the models should be associated with a community of users that will actively employ these models both during and beyond the duration of the project. Second, IAMs are usually associated with a steep learning curve, making it difficult for any new users to overcome the barriers to entry, familiarise with, and actively use the models. In this report, we attempt to tackle these two challenges, by reporting on the activities of the project to establish an active and engaged network of IAM developers and users, as well as organise capacity development activities.

First, focus is placed on pre-existing dedicated communities of each model, such as the GCAM Annual Meetings, the OptIMUS community, the IEA-ETSAP initiative, and the GTAP network, which are useful for GCAM-Europe, CLEWs, OMNIA, and GEMINI-E3-EU, respectively, to ensure adequate integration of the project's expanded versions with the core versions of the respective communities. To this end, we list activities already performed for capacity development, including a training seminar on GCAM, and uploads of descriptive material for CLEWs-EU and OPEN-PROM on GitHub. We further enhance the integration with the broader communities of the models, by developing or selecting/tailoring a set of supporting tools to ensure interoperability. We also discuss existing and upcoming research projects solidly planning to leverage models produced in DIAMOND in their work programme.

Second, emphasis is placed on communities, forums, and conferences within the modelling landscape, notably including the IAMC, ECEMP, and EGU meetings. We discuss the project's participation in these meetings, not only from the standpoint of scientific contributions, but also from the perspective of engaging with the primary communities of practice for our models and research outputs. We highlight contributions, such as those related to the introduction/presentation of the OMNIA model to the IEA-ETSAP and broader modelling community, which encapsulates our strategy to participate in these events to foster such communities.

Third, the activities to foster communities of practice in academia and the broader sustainability research community is also discussed. We present two university courses developed to incorporate material produced through DIAMOND: (i) a transdisciplinary integration course at ETH Zurich (ETH); and (ii) a climate change mitigation modelling course at the National Technical University of Athens (NTUA, ICCS). We also present three communities operating within the borders of the modelling field, namely a newly established participatory modelling community, the SSH Energy Network, and the MORSE Conference. We highlight the DIAMOND project's intention to bridge the gaps with such communities in the broader sustainability landscape, which could be useful towards exchanging tools and methodologies.

Finally, we present the current planning/timeline for organising three webinars on stakeholder engagement, the novel scenario space intended to contribute to the IPCC AR7 cycle, and open science, as preparatory steps for our core capacity development webinars and training materials featuring the models produced in DIAMOND.

This report constitutes a first version to address the issue of communities of practice and capacity development, with one update expected to be presented towards the end of the project.

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1 Introduction

The DIAMOND project is dedicated to advancing integrated assessment models (IAMs) by creating a robust, inclusive, and sustainable network of developers and users. Efforts focus on reducing barriers to entry for new/potential users, fostering collaboration between core modelling institutions, and building long-term capacity to ensure the models' relevance beyond the project's duration. A key focus of the project's goals involves leveraging already established—as well as creating new—communities of practice, providing accessible training resources, and facilitating open collaboration to encourage broad adoption and continuous improvement of IAMs. These activities are envisaged to contribute towards strengthening the European Research Area on climate change, by not only delivering the next generation of IAMs, but also the relevant networks and supporting materials, ensuring inclusivity, active collaboration, and access to state-of-the-art research.

First, DIAMOND seeks to establish an active and engaged network of IAM developers and users, with a particular focus on the existing wider development teams/communities of the project models. On top of these, the project is actively participating in modelling consortia and initiatives, including inter alia the IAMC, ECEMP, and EGU activities. Personal invitations have also been issued to members and experts within these networks to encourage participation in our co-design activities (in WP2). These collaborations are central to aligning the diverse expertise of the community with the project's goals, ensuring that the models developed are both scientifically rigorous and practically relevant, and are well integrated within the communities that are envisaged to use them. This emerging network is envisioned as a dynamic platform where stakeholders can share insights, contribute to model enhancements, and collectively address challenges. Early engagement efforts have highlighted the importance of fostering a sense of ownership and inclusivity among participants, which will be essential for sustaining these communities beyond the project timeline.

Second, acknowledging the typically steep learning curve associated with IAM engagement from the perspective of new users, DIAMOND is prioritising the development of comprehensible and accessible training materials and other capacity-development initiatives. A core part of this effort will focus on the organisation of webinars and the development of learning resources (e.g., videos, user guides) tailored to different levels of expertise. These webinars will exploit the diverse capabilities of the different models (e.g., the aggregated CLEWs-EU model already developed as an entry point for non-modellers owing to its low computational complexity) but will also go beyond IAMs themselves and instead focus on the wider spectrum of transdisciplinary activities within DIAMOND. Additional resources, such as training materials, will aim to provide participants with the knowledge and skills needed to effectively use and potentially contribute to further development activities. Through these processes DIAMOND seeks to contribute to the democratisation of the modelling landscape, by providing access to the developed tools, while ensuring that they can be used by a broader audience, including policymakers, researchers, and practitioners.

Third, and considering that transparency and openness are at the heart of DIAMOND, the project has begun releasing open-source iterations of its models accompanied by preliminary resources to ensure ease of use. On top of core modelling advancement, these releases include supporting software, such as diagnostics tools, made available through platforms like the project's dedicated GitHub—and soon to be migrated into the updated I²AM PARIS platform. By sharing these resources through accessible channels and providing easy navigation to the project's outputs, the project aims to further lower barriers to entry and create opportunities for external teams to engage and contribute to the development process. Early adopters are encouraged to adopt improvements into their own models, fostering a culture of continuous learning and innovation.

This report aims to document currently implemented and planned activities to leverage existing, and create new,

communities of modelling practice, including current efforts towards capacity development. As these activities are in tandem with the model development process and as progress will be made towards the development of more of our models, this report serves to guide our engagement with stakeholders through these communities, refine the needs for tailored training materials, and design the initial scope of capacity-development activities, including plans to deliver on conducting the first set of webinars, gathering insights from participants, and using these insights to improve subsequent model-based sessions.

Following this introductory section (Section 1), this report documents efforts within the communities of practice for the six DIAMOND IAMs (Section 2), exchanges with the IAM modelling landscape (Section 3) and the broader sustainability research (Section 4), and next steps including current planning for the organisation of webinars (Section 5).

2 Communities of practice for the DIAMOND models

In this section, key activities that underpin the implementation and enhancement of each model are outlined. These activities focus on annual meetings that modelling teams have participated, the development of training material, the use or creation of supporting tools to ensure interoperability, and the participation of the new modelling capacities in new research efforts. Such activities are pursued to ensure the development of the models remains dynamic, effective, and responsive to emerging challenges and research opportunities of the dedicated model communities. It also serves as a means of fostering collaboration and facilitating knowledge transfer, not only to support the ongoing use of each model within DIAMOND but also to drive continuous improvement even beyond the scope of the project.

2.1 Model-dedicated communities of practice and annual meetings

Considering that most models envisaged to be updated and expanded in DIAMOND have a longstanding presence in supporting climate change mitigation policies, core communities of practice have been established within the networks developing each model. Such forums provide opportunities for modelling teams to exchange best practices, address common research challenges, and foster collaboration and open dialogue. As such, these meetings strengthen the networks underpinning each model but also contribute to their continuous update and in response to emerging needs. DIAMOND partners actively seek to engage and contribute to these communities, as well as to integrate research outputs (including tools developed) within relevant activities, ensuring exploitation of the research produced. Although not all models currently feature such a community, Table 1 provides an overview of existing networks that DIAMOND leverages.

Table 1. Existing model-dedicated communities of practice

Community/Annual Meetings	Leading Institution	Core activities	DIAMOND model	DIAMOND participation
GCAM Annual Meetings ¹	Joint Global Change Research Institute (JGCRI)	Networking, capacity development, knowledge sharing	GCAM-Europe	BC3, UMD, ICCS
OpTIMUS ²	United Nations Development Programme (UNDP), United Nations Department of Economic and Social Affairs (UNDESA)	Networking, capacity development, open model development	CLEWs-EU	Cyl, Imperial, ICCS
Energy Technology Systems Analysis Program (IEA-ETSAP) ³	International Energy Agency (IEA)	Networking, capacity development, knowledge sharing	OMNIA	E4SMA, UCL, Imperial, ESMIA

¹ <https://www.pnnl.gov/projects/jgcric/annual-meeting-resources>

² <http://www.optimus.community/>

³ <https://iea-etsap.org/index.php>

Global Trade Analysis Project (GTAP)⁴	Center for Global Trade Analysis	Database maintenance and update, capacity development	GEMINI-E3-EU	EPFL
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2.1.1 GCAM Annual Meetings

The GCAM Community Modelling Meeting, organised by the Joint Global Change Research Institute, provides a knowledge sharing forum for the broader GCAM community to communicate about the latest developments and current uses of GCAM in the form of annual meetings. For new GCAM users, the meetings feature workshops and other training activities, serving as an in-depth opportunity to learn and gain a better understanding of the model.

DIAMOND partners from BC3, UMD, and ICCS actively participate in the activities organised within the annual meetings, paving the way for the introduction of GCAM-Europe, which was notably referenced as a promising next step, to the community in the 2023 annual meeting. DIAMOND also participated in the 2023 meeting with respective GCAM-related advancements in the poster session with the following studies:

- gcamreport: An R tool to Process and Standardise GCAM Outputs
- Residential Energy Demand, Emissions, and Expenditures at Regional and Income-decile Level for Alternative Futures
- Implementation of Current Policies in GCAM.

2.1.2 OpTIMUS.community

The OpTIMUS community aims to promote quantitative analysis to inform sustainable development policy, by coordinating networks to advance open-source software, knowledge development and capacity development. The community focuses on fostering a network of individuals from academia, research, and the development community engaged in the practice of supporting, directly or indirectly, sustainable development policies with evidence derived from modelling. Relevant to DIAMOND, these hitherto include CLEWs and OSeMOSYS. The forum has established a process for producing open tools and including them within the community, following the steps below:

- Development: Experts develop and disseminate open-source modelling tools.
- Review: Academics and specialists in the relevant domains provide reviews of the developed modelling tools and develop teaching curricula to facilitate their use.
- Capacity Development: Members of their community, and their institutions, collaborate in organising capacity development activities to train the next generation of analysts.

The DIAMOND team aims to follow this process towards integrating the developments of CLEWs-EU within the community.

Additionally, OpTIMUS is organised in three practices: i) modelling and capacity development for policy support; ii) expert review and quality control; and iii) software development.

OpTIMUS meets annually during an international high-level, teaching and experience transfer event, the Energy

⁴ <https://www.gtap.agecon.purdue.edu/about/project.asp>

Modelling Platform - Joint Global Training School. Within this meeting, the Joint Summer School on Modelling Tools for Sustainable Development was organised in 2023 and hosted by the International Centre for Theoretical Physics (ICTP), providing free training, access to discussion forums, and activating for coaching skills in energy planning models and tools. Two of our models were taught in the school: OSeMOSYS and CLEWs. DIAMOND partner Imperial was part of the organisation team and responsible for training sessions, while colleagues from ICCS registered and participated in the Summer School as well.

2.1.3 Energy Technology Systems Analysis Program (IEA-ETSAP)

The Energy Technology Systems Analysis Program (ETSAP) is a core initiative within the Technology Collaboration Programme of the International Energy Agency (IEA). Notably, the IEA-ETSAP community focuses on a major effort for open-source solutions for energy scenario modelling needs. It constitutes a consortium of member country teams and invited teams that cooperate towards establishing, maintaining, and expanding consistent multi-country energy-economy modelling capabilities, mainly based on the MARKAL/TIMES family of models, permitting the compilation of long-term energy scenarios and in-depth national, multi-country, and global energy and environmental analyses.

IEA-ETSAP organises a bi-annual meeting to share knowledge, discuss contemporary research topics and design common working activities. This meeting is oftenly organised back-to-back with the International Energy Workshop (IEW), a leading conference for the global energy modelling community, that provides a venue for scholars and researchers to compare modelling tools, discuss modelling advances for emerging energy sector issues, and observe new trends in the global energy sector.

E4SMA, UCL, Imperial, and ESMIA are active members of this community, participating in the meetings and contributing to the relevant workshops organised. Notably, DIAMOND is actively involved in the development of the open model TIMES-GEO a multi-region, global version of TIMES, that acts as the basis for the OMNIA model (see D3.2). Both advancements were presented in the broader IAM community in the IAMC2024 (see Section 3).

2.1.4 Global Trade Analysis Project

GTAP (Global Trade Analysis Project) is a global network of researchers and policy makers conducting quantitative analysis of international policy issues, notably focusing on the interplay between trade and the climate-economy nexus. GTAP's goal is to improve the quality of quantitative analysis of global economic issues within an economy-wide framework.

The core activity of the network lies in developing and maintaining the GTAP database, a global multi-region input output database describing bilateral trade patterns, production, consumption and intermediate use of commodities and services. On top of that, the network organises training seminars on the use of the database and the models associated with it.

Although updating the GTAP database is not part of the DIAMOND activities, GEMINI-E3-EU—as a general equilibrium model—relies on the database as a core foundation of the model. As such, EPFL is an active part of this network, participating in relevant activities, and monitoring the updates of the database, to integrate them in GEMINI, as well as communicate with the community any advancements made in DIAMOND.

2.2 Capacity development activities

Efficient capacity development activities are necessary to ensure that the communities established overcome challenges associated with learning and effectively using the models. Considering that these models are extremely

complex and often viewed as black-boxes, significant barriers to entry exist for new users and aspiring modellers. Therefore, it is essential to provide comprehensive material and resources that enable potential modellers to use the tools by facilitating understanding and skill-building. Towards this, efforts are made to develop training materials, organise training webinars, and offer other tools designed to empower both new and existing users. These initiatives, along with the open access principles guiding DIAMOND play a crucial role towards ensuring broader accessibility and the long-term impact of the models developed within the project.

Although, developing training material and performing extensive capacity development requires significant progress in model development, activities have already implemented, paving the way towards more elaborate initiatives.

One of the first activities organised, was a GCAM training seminar hosted by BC3 on the 28th- 30th of May 2023. The purpose of this meeting was to bring all DIAMOND teams working on the development of GCAM-Europe up to speed with the latest updates of the model and facilitate harmonisation of model development through hands-on exercises. A core part of this workshop was to engage with non-GCAM teams both from the DIAMOND institutions and beyond to scope potential synergies and innovative uses for the newly developed model. Table 2 presents the agenda of the meeting.

Table 2. Agenda of the DIAMOND 2023 GCAM training seminar

Day I: GCAM basics

Tuesday, March 28, 2023		
09:30 – 11:00	GCAM Overview - General presentation - GCAM-Ecosystem - Q&A and Discussion: How can the model be linked/connected with other tools at BC3	Dirk-Jan van de Ven (BC3), Konstantinos Koasidis (ICCS)
11:00- 11:30	Coffee break	
11:30 – 13:00	Running the GCAM reference scenario - Structure and logic - Explore configuration file - Check the loaded files (xml) Running a carbon tax scenario	Russel Horowitz (BC3), Claudia Rhodes (BC3) Jon Sampedro (BC3), Dirk-Jan van de Ven (BC3)
13:00- 14:00	Lunch	
14:00 – 15:30	Visualizing GCAM results - Model Interface - Queries and extracting data - Integration of GCAM results in the I²AM PARIS platform (online)	Jon Sampedro (BC3), George Xexakis (HOLISTIC), Natasha Frilingou (ICCS)

Day II: Alternative scenario building: GCAM data system

Wednesday, March 29, 2023		
09:30 – 11:00	Exploring alternative policy options - Electricity Generation Mix - Building Envelope Efficiency - Transport Mode Shift GCAM Data System - Introduction	Dirk-Jan van de Ven (BC3), Konstantinos Koasidis (ICCS), Jon Sampedro (BC3)
11:00- 11:30	Coffee break	
11:30 – 13:00	GCAM Data System (cont)	Russel Horowitz (BC3), Claudia

	- Changing inputs through the GCAM DS - Generating multiple xml	Rhodes (BC3)
13:00- 14:00	Lunch	
14:00 – 15:30	Exploring GCAM outputs - gcamextractor - rchart/rmap - Additional GCAM-Ecosystem tools	Jon Sampedro (BC3), Claudia Rhodes (BC3)

Day III: Hands-on modelling marathon session

Thursday, March 30, 2023		
10:00 – 14:00	Hands-on modelling marathon session (hybrid)	Jon Sampedro (BC3), Dirk-Jan van de Ven (BC3), Russel Horowitz (BC3), Claudia Rhodes (BC3) Konstantinos Koasidis (ICCS), Natasha Frilingou (ICCS), George Xexakis (HOLISTIC), Alexandros Nikas (ICCS)

Drawing from the lessons learned during the organization of this seminar, hands-on seminars and webinar for the other models of the project.

Apart from seminar and webinars, additional training material is envisaged to be developed in the form of detailed documentations and 'user guides', including for example presentations, videos, use cases, as well as training exercises, to facilitate an asynchronous learning experience. Although significant advancements will be made once the first versions of the models are ready, currently, DIAMOND's GitHub page features extensive elaborations and information on the CLEWs-EU model, and in particular the aggregated CLEWs-EU version. These include both details on how to install and run the model (Figure 1), as well as details on the methodological premises of the tool (both high-level and detailed on each block (Figure 2), written however in a way that is comprehensible to non-CLEWs experts. Similarly, the GitHub page of the OPEN-PROM model that follows an open model-development strategy (meaning that the basis of the model is already open and updates are directly parsed in this version; see D3.2) features tutorials to enable easy use and learning.

How to run the Aggregated EU-CLEWs model

Please choose the relevant model file from either one of the following three folders. This selection is important if you want to run the individual modules or the integrated Energy, Land and water module.

- Energy
- Land and Water
- Integrated_CLEWs

The data is constructed in a excel file with multiple worksheets. Each worksheet corresponds to a particular SET or Parameter in the OSeMOSYS model. A python package, [Otoole](#), is used handle all the data manipulations required for running the EU CLEWs model. Please make sure you have the latest version of Otoole installed in your computer along with the latest stable version of [Python](#). To use Otoole, a configuration file (YAML) is required. A YAML file has been specifically developed for this project and it can be found in the [model_files](#) folder. Additionally, an optimisation solver is required to run the model. Please refer to any one of the following and install the latest version of anyone of the solvers. Some solvers are proprietary and some are free and open source. Please select one based on your needs.

- [CBC](#)
- [GLPSOL](#)
 - This is mandatory as GLPSOL is part of GLPK and it is mandatory for creating the matrix)
- [CPLEX](#)
- [GUROBI](#)

Steps

1. First we convert the OSeMOSYS model file from Excel data format to a text file
2. Use GLPK to create the LP file version of our model
3. Optimise the LP file using anyone of the solvers. Write the solution file
4. Use Otoole to write the results from the optimised solution file to result-CSVs
5. The users can open the CSVs to view the results. At a later stage, visualization scripts will be developed to automatically view results in an interactive format.

Please refer to the [examples](#) page of the [Otoole documentation](#) for the syntax used to carry out the previous steps.

Figure 1. Information on how to run the aggregated CLEWs-EU model in DIAMOND's GitHub page

```

Readme_UsefulEnergyDemand_Methodology.txt
1 -----
2 USEFUL ENERGY DEMAND: BUILDINGS SECTOR
3 -----
4 by Irene Gkiouleka (The Cyprus Institute), 2023
5
6 -----
7
8 Structure of this folder
9 -----
10 This folder includes subfolders corresponding to all EU Member States. Each
11 includes a Buildings_Services_FinalEnergyConsumption.xlsx" file as well as the
12 relevant JRC IDEES energy balances. All JRC IDEES datasets are to be found in
13 the "!!JRC-IDEES Datasets" for reference. The final energy consumption for each
14 Member State is also to be found in each subfolder
15 ("Buildings_Total_FinalEnergyConsumption.xlsx").
16
17 The folder "EU27", in teal colour, is also included in this folder, providing
18 calculations for the whole EU as a single node. It contains the file
19 "EU27_Buildings_Total_FinalEnergyConsumption.xlsx" which lists both services and
20 households disaggregated energy demand for the whole European Union (EU27). The
21 efficiency factor for heat pumps used for EU27 was that of Middle North.
22
23 Finally, the file "nrg_bal_c_Tertiary_Eurostat_fuel_aggr.xlsx" includes the
24 "Complete energy balances" [nrg_bal_c] for the EU and each Member State.
25
26 -----
27 CALCULATION OF TOTAL FINAL ENERGY CONSUMPTION
28 -----
29 The total final energy consumption values for the period 2018 to 2021 (base
30 years), were calculated on the basis of the Eurostat values for the households
31 sector as well as the Eurostat-derived values for the services sector as
32 explained below.
33
34 The efficiency factors (to be found in the Sheet "Efficiencies") were retrieved
35 from EU Reference Scenario 2020 technology assumptions, with the exception of
36 solid fuel boiler/furnaces, which are taken from IEA ETSAP (IEA ETSAP Technology
37 Brief R02 – Space Heating and Cooling). Some information is the same both for
38 households and services, as the EU Ref Scenario only provided information for
39 the former.
40
41 The final values are the sum of the households and the services sectors, with
42 efficiency factors applied to them.

```

Figure 2. ReadMe file with detailed information on the energy demand of the building sector in the CLEWS-EU model

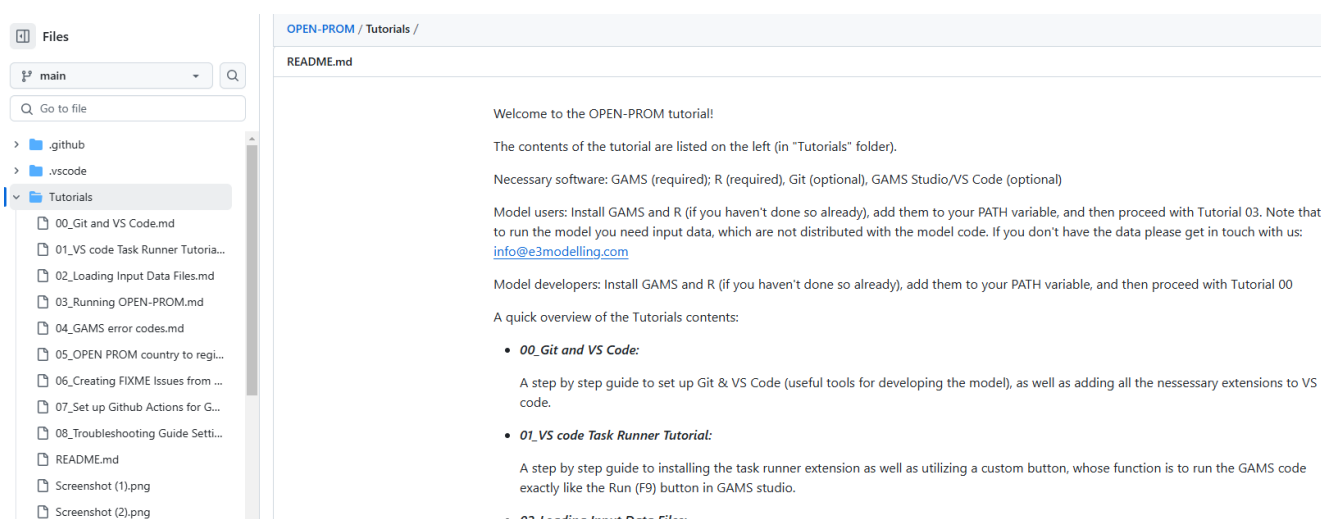


Figure 3. Tutorials for OPEN-PROM included in the models GitHub page

Both the synchronous (e.g., recordings of webinars) and the asynchronous training material will be provided as open access and uploaded onto Zenodo on a case-by-case basis, while dedicated spaces in the I²AM PARIS platform will be created to host the material in easy access formats, ensuring that the users can easily navigate the complexities of the extensive and potentially overwhelming material.

2.3 Interoperability

IAMs usually rely on a suite of supporting tools for inter alia data management, scenario development, and post-analysis of results. Ensuring seamless integration both internally between these components as well as with different versions of the core models (e.g., GCAM-Europe with GCAM-core) is therefore essential to maximise the uptake of the models by the community. As such, efforts to enhance interoperability focus on creating and refining tools that are compatible with the models and are usually employed by the community of each model, enabling streamlined workflows and promoting application-wide consistency, thus ensuring accessibility and usability for a diverse range of stakeholders and potential model users.

Towards this, DIAMOND selected and/or developed—either exclusively as part of DIAMOND or through synergies with other relevant projects and initiatives—a set of initial versions of supporting tools to accompany modelling frameworks, including:

- gcamreport: an R tool to support data handling for GGAM; the tool was presented in the GCAM Annual Meeting 2023.
- mrprom: an R package to handle data for the OPEN-PROM model.
- Selection and adaptation of the open python-based pyiode package to solve the NEMESIS model.
- MEDUSA: an R package to perform distributional analyses
- Otoole: a python package which provides commonly used pre- and post-processing steps when working with OSeMOSYS-based models, that is extensively used in the OpTIMUS community.
- a vetting tool: a tool hosted within the I²AM PARIS platform that currently performs check for common errors (basic sums, variable check etc.), and vetting based on the IPCC's AR6 process, but to be further expanded to perform vetting at the regional level.
- a visualisation tool: a tool hosted within the I²AM PARIS platform that performs quick visualisations based on IAM outputs following the IAMC template, which was chosen as a standardised format to deliver model results within the project.

2.4 Exploitation in current and new research activities

Towards fostering synergies (see also MS4) and also reaching out to wider communities of practice, existing and new research activities within the HORIZON EUROPE framework are envisaged to be among the first practitioners of the DIAMOND models.

2.4.1 IAM COMPACT

The [IAM COMPACT](#) project is an EU-funded research project under the Horizon Europe framework programme, aimed at effectively supporting the assessment of global climate goals, progress, and feasibility space, as well as the design of the next round of NDCs and policy planning beyond 2030 for major emitters and non-high-income countries. The project aims to:

- support the assessment of global climate progress, needs, and feasibility, and the preparation of national policies for the post-2030 period, toward mid-century climate neutrality.
- place climate action in a holistic sustainable development framework, working across the broad spectrum of sustainability.
- enhance the robustness of scientific outputs via an interdisciplinary toolbox benchmarking and validating

IAM results with sectoral models and coupling modelling with uncertainty analysis tools.

- co-create policy-relevant modelling via an international policy response mechanism.
- establish an integration process that co-produces science and policy prescriptions.
- open the ‘black box’ of scientific inputs, processes and outputs in line with the principles of open science, ensuring the data used/produced are FAIR.
- engage in the deep/extreme uncertainty space.
- boost international cooperation, partnership, and capacity.

Key aspects of the IAM COMPACT project that could prove vital with DIAMOND from a communities of practice include: (a) the use of two IAMs and one modelling framework that are used in both projects (GCAM, PROMETHEUS, and CLEWs). Such activities are already taking place, with DIAMOND exchanging for the purposes of providing the tools required to underpinned extensive and contemporary stakeholder-driven policy analyses.

2.4.2 ACCLIMATE

ACCLIMATE is a new Horizon Europe research project, expected to start early in 2025. The objective of the project is to develop enhanced national and international strategies for climate-resilient, low-emission development. In particular, ACCLIMATE aims to identify needs for improvements of current policies, NDCs and long-term strategies, towards ensuring adequacy, fairness and feasibility across a range of global, national, and sectoral pathways. ACCLIMATE further aims to establish frameworks that improving the transparency, consistency, and clarity of emission reduction and climate change mitigations commitments.

Considering the focus of ACCLIMATE on different regional scales of climate policy and the mutual participation of DIAMOND partners in this project as well, GCAM-Europe, OPEN-PROM, and CLEWs-EU are envisaged to be used in the project’s research activities.

2.4.3 ENTICE

ENTICE is also an upcoming research project which aims to develop novel modelling capacity on the positive and negative impacts of trade and trade policy on climate and the environment. ENTICE aims to define a novel theoretical conceptualisation of trade, climate, environment, and industry interactions, perform significant improvements to sectoral detail, improve the granularity in the GTAP database, and integrate the new data into well-renowned CGE, macroeconometric, integrated assessment, and sectoral models, to analyse the interactions between trade (policy), climate (policy), the environment, and broader economic and sustainability objectives in the EU and beyond.

DIAMOND models, notably GEMINI-EU-EU and NEMESIS-World, will play a significant role in the ENTICE project’s research activities.

2.4.4 THESEUS

THESEUS is another new Horizon Europe project (kicked off in December 2024), although this one is focusing on circularity performance at the city level.

Two DIAMOND models, CLEWs-EU and GCAM-Europe, are envisaged to be employed towards upscaling circularity improvements at the EU level.

3 Exchanges with the broader modelling landscape

The IAMC Annual Meeting, the ECEMP Conference, and the EGU General Assembly constitute major events related to the development and use of IAMs. DIAMOND's detailed participation in these meetings is documented in D7.5 reporting inter alia the project's academic outreach. Here, we revisit DIAMOND's participation in these meetings, not only from a strictly scientific perspective (i.e., as in participating in a scientific conference to present research outputs), but also from the viewpoint of engaging with the core modelling community of practice and capacity development within our field. These meetings provide critical platforms for engaging with experts in IAMs and other closely related fields, sharing insights and advancements that can be found useful by other colleagues, and contributing to collective knowledge on IAM modelling, energy transition scenarios, and geoscientific research. Active participation in such events is a must for DIAMOND, to ensure that cutting-edge model developments are clearly positioned within the field that's the most likely go-to place to shape future research and policy discussions.

3.1 Integrated Assessment Modeling Consortium (IAMC)

In particular, the IAMC Annual Meeting constitutes a cornerstone of the IAM community, offering significant opportunities for setting active communities of practice. DIAMOND's involvement focuses on presenting research outputs, and notably new models and methodologies developed, exchanging best practices, as well as exploring opportunities for using the project's models in new scientific endeavours. This fosters a stronger network of practitioners equipped with the knowledge and access to the latest tools to conduct energy and climate policy analyses.

Notably, two posters were presented in the 2024 IAMC featuring advancements made and work related to OMNIA and the TIMES-GEO model (acting as a basis for OMNIA). In the case of OMNIA, the key features enhanced developed within DIAMOND were stressed, including its capability to support comprehensive climate policy analysis. Features highlighted included mainly the granular representation of key energy and industrial sectors, the expansion of the upstream energy sector to include fossil fuel extraction and hydrogen, the enhanced industry sector to include an explicit representation of iron and steel, cement and aluminium sector and the enhanced temporal profile for residential sector (for more details on the OMNIA model and the detailed material presented see D3.2).

Another DIAMOND presentation focused on the methodological advancements made to establish an integrated framework that allocates mitigation effort aligned with carbon budgets into different economic sectors, to reach different end-of-century temperature outcomes, with our framework endogenising performance in selected SDG indicators within a model's solution, shedding light onto different characterisations of trade-offs and model dynamics.

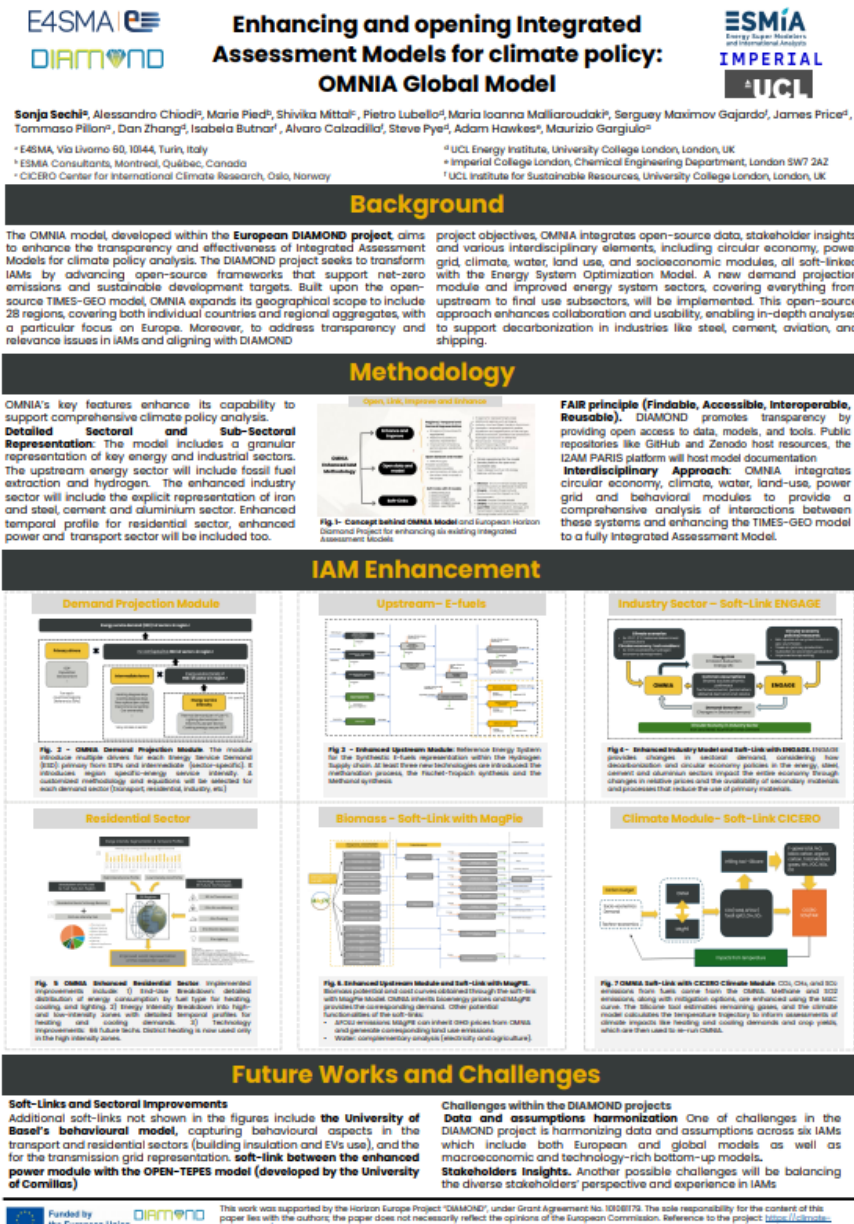
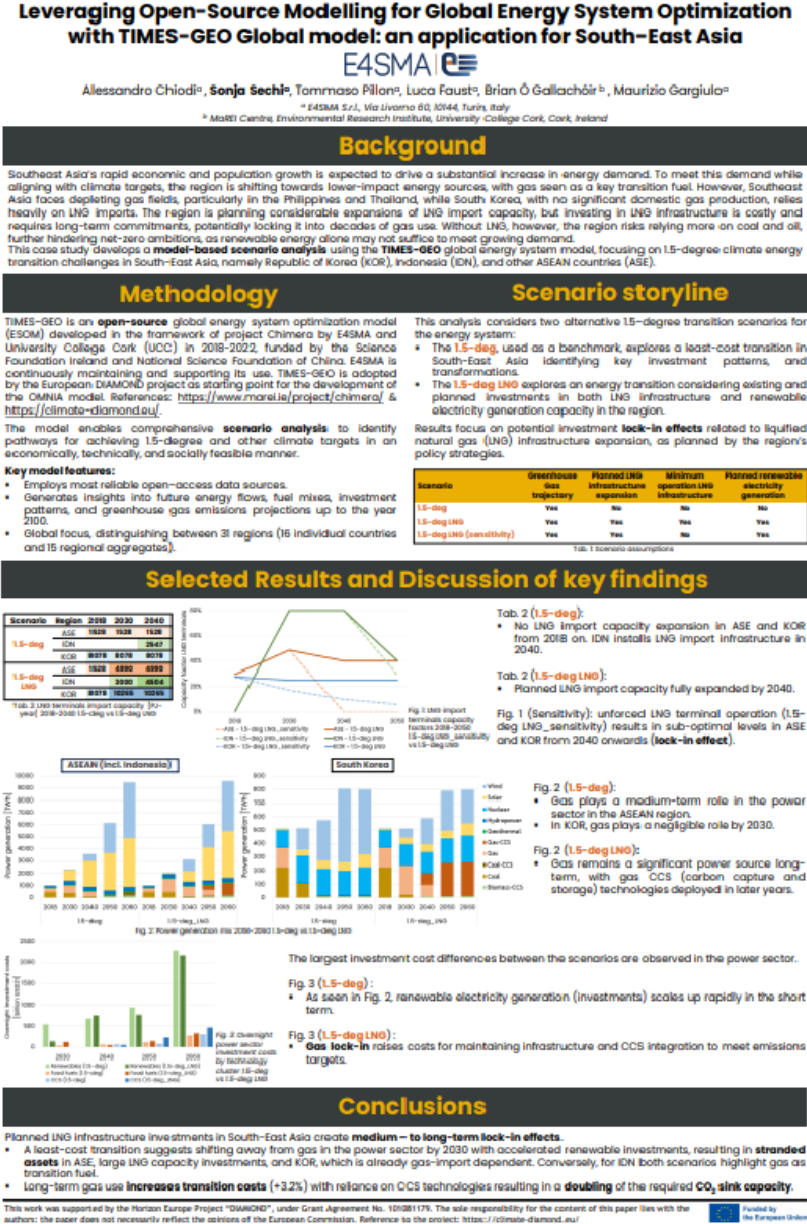


Figure 4. The OMNIA and TIMES-GEO posters presented in IAMC2024



3.2 European Climate and Energy Modelling Platform (ECEMP)

Similarly, the ECEMP Conference provides a dedicated European forum with a similar scope to the IAMC, with an aim to discuss Europe's transition to climate neutrality. Similarly, DIAMOND's participation in this context focused on presenting tangible research related to how DIAMOND's model can be used to develop actionable scenarios and policies through collaborative engagement. Notably, in 2023, a key theme of the conference focused on the energy crisis, with DIAMOND chairing a session on energy security and presenting research relevant to the theme, notably on the EU's path to net zero, strategies to eliminate Russian gas imports, and on industrial regions at risk. A key dimension on DIAMOND's participation related to the presentation of results with high regional granularity (within the EU), using improved versions of the models under development and providing them to other projects towards building synergies, and operationalising the communities of practice developed. In 2024, DIAMOND presented similar work on the carbon border adjustment mechanism and climate damages, both aspects highlighted as priorities in our stakeholder development activities.

3.3 European Geosciences Union (EGU)

The EGU General Assembly is a prominent event that brings together geoscientists to discuss topics related to the Earth, planetary, and space sciences, as well as the interplay with the economy, which is of particular relevance to IAMs. In this context, DIAMOND's participation focused on presenting tools, results and insights that can be found useful by the multidisciplinary community the meeting attracts. Notably, in the 2024 meeting, the project chaired a session on incorporating equity, gender, health and other co-benefits into nexus and IAM research, including presentations on equity considerations and tools to perform such analyses, and on inclusivity. Generally, DIAMOND's approach focused on tools and themes that two different, albeit intertwined modelling—the climate and the climate-economy—fields can leverage advancements to address mutual real-world challenges.

4 Fostering communities of practice in academia and the broader sustainability research community

The communities of practice, fora, and meetings discussed in the previous sections primarily focused on initiatives involving members who possessed some prior experience and knowledge in climate-economy modelling processes. However, DIAMOND's aim to develop a transdisciplinary scientific approach to legitimise the implementation process and co-create research questions implies the establishment of communities of practice to transparently open model enhancements and to develop capacities that have hitherto remained strictly within the borders of the IAM field, thereby lowering the entrance barriers for a larger pool of researchers. In this section, efforts to develop university courses based on lessons learned within DIAMOND to train the next generation of scientists that will engage with or use models and their results, as well as efforts to engage with communities within the broader sustainability—but not necessarily IAM-based—research are presented.

4.1 University courses

Creating university courses integrating IAM research within the curricula serves as an excellent community of practice by equipping the next generation of researchers and practitioners with the skills necessary to address complex sustainability challenges through a climate-economy lens. Integrating education with practical modelling experience can foster a culture of innovation and knowledge-sharing within university courses, ensuring that communities of practice continue to grow with young talents, who can also provide the modelling community with fresh perspectives. So far, DIAMOND has contributed in and is featured in two university courses.

4.1.1 NTUA's climate change mitigation modelling course⁵

In 2023, following efforts from the ICCS project team and drawing inter alia on the content and scope of the DIAMOND project, the School of Electrical and Computer Engineering at the National Technical University of Athens (ECE-NTUA) established a climate change mitigation modelling course, aiming to introduce students to the core scientific processes underpinning major assessments and climate policies. This notably includes the role of different types of climate-economy models, such as IAMs, energy system models, and simulation models, with the aim to acquaint students with the methodological foundations of the different types of economic equilibrium, optimisation for energy, economy, and climate research. The didactic approach followed emphasises the whole range of relevant decision support tools, including those used to analyse the role and value of stakeholders in the decarbonisation of all economic sectors, socio-technical analyses of low-carbon innovation systems, and methods related to climate governance and management at international national and regional levels.

Lessons learnt from DIAMOND play a prominent role in the course, with students familiarising themselves with models such as CLEWs and GCAM, through a combination of lectures and interactive lab exercises, in which the students are guided towards downloading the models developed in the project and performing simple analyses of their own. The course also provides the opportunity to interested students to advance their familiarity with such models, by continuing their research in their diploma theses.

Moreover, a set of guest lectures on the integrated assessment models of DIAMOND is also part of the post-

⁵ <https://www.ece.ntua.gr/gr/undergraduate/courses/3407> (in Greek)

graduate course “Least Cost Energy Planning”⁶ of ECE-NTUA.

4.1.2 ETH’s Inter- and Transdisciplinary Course⁷

The Department of Environmental Systems Science at ETH Zürich offers the course “Integration in Science, Policy and Practice: Inter- and Transdisciplinary Concepts, Methods, Tools” as part of its “Environmental Sciences Master” program. The course offers students the opportunity to explore both the theoretical concepts and hands-on methods and tools of interdisciplinary and transdisciplinary integration, towards co-producing and synthesising different perspectives—especially those arising when collaborating across scientific disciplines—to handle problems and provide potential solutions.

In particular, the course aims to assist students in understanding and applying concepts, dimensions, and principles of integration, as well as indicators to assess different integration processes. Then, through applying different methods and tools of integration to complex socio-environmental problems, an empirical approach is pursued, based on allowing students to engage with practical case studies from active research programs and initiatives; in this process, DIAMOND brings on board the transdisciplinary integration framework pursued towards co-developing IAMs as well as co-designing research questions to be addressed within the project. Finally, the course offers reflections on the role of researchers within this scientific process, when operating at the interface between science, policy, and practice, including challenges and opportunities in designing and applying integration processes.

As part of the activities of the Cultural Studies of Science and Technology at the ETH Zürich, a guest lecture on “Pathways to Transdisciplinary Research for the Arts, Humanities and Social Sciences” has also been integrated in the SUPSI (Scuola Universitaria Professionale della Svizzera Italiana) event on “Transdisciplinary Research: Its Nature and Value for Society”⁸.

4.2 Communities of practice in the broader sustainability domain

4.2.1 Engagement with the participatory modelling community

While the IAM and energy systems modelling literature frequently stresses the lack of—and calls for emphasis on—stakeholder perspectives in model and scenario development, the active participation of stakeholders in such processes remains rather scarce. In this context, members of the DIAMOND project participated in a community of academics and practitioners working on ways to enhance the inclusion of stakeholders in modelling processes. This community was initiated by colleagues from University College Cork—in fact, coordinated by a member of the DIAMOND SAB, and included several participants from universities and research centres around Europe (including modellers and non-modellers alike). The community organised a number of structured workshops within 2023 to define a conceptual framework on participatory modelling, suggest good practices, create a list of relevant case studies, and reflect on next steps for improving the impact of this emerging field. While the workshops focused on energy systems modelling, the insights collected are very relevant for the IAM community,

⁶ <https://www.ece.ntua.gr/en/doctoral/courses/109>

⁷ <https://www.vorlesungen.ethz.ch/Vorlesungsverzeichnis/lerneinheit.view?semkez=2024S&ansicht=ALLE&lerneinheitId=176540&lang=en>

⁸ <https://www.supsi.ch/en/transdisciplinary-research-its-nature-and-value-for-society>

since the steps of the modelling process are similar. The results of these workshops, in which DIAMOND partners (ICCS and HOLISTIC) actively participated, were presented in a research article which has been published in the Energy Strategy Reviews journal⁹, acknowledging the project.

The framework was developed based on a transdisciplinary approach and contains six main phases in the modelling process, along with relevant opportunities for co-creation with stakeholders and for collaboration across disciplines (Figure 5). These opportunities include the co-definition of relevant research questions, the identification of model input assumptions and parameters, the development of storylines and narratives, and the co-creation of materials and web platforms to communicate modelling results. These insights can be especially useful for modelling teams to plan adequate stakeholder engagement activities in their work. For the DIAMOND consortium, they can strengthen the co-creation process in future WP2 activities, e.g., provide ideas for activities with stakeholders in upcoming workshops or identify information that is needed from them.

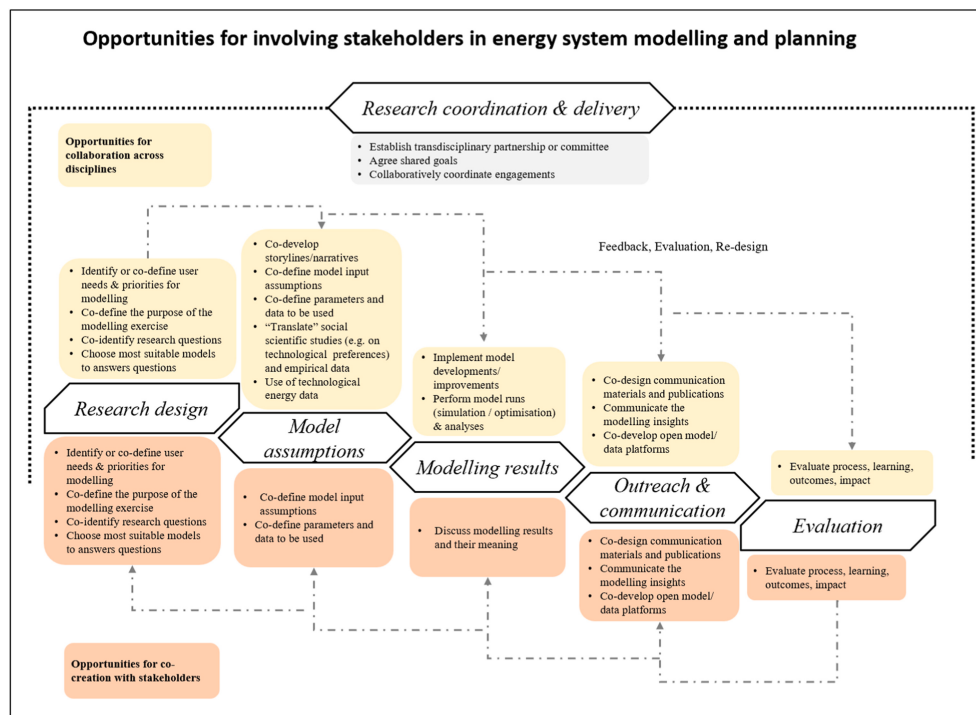


Figure 5. Framework for participatory modelling developed through community engagement. Source: McGookin et al., 2024⁹

Similarly, several good practice principles have been identified that can be also used in DIAMOND as well as in other projects and modelling exercises. These principles include the need for a good planning of who should be engaged in a modelling exercise and for what reason as well as the use of an adaptable approach that can respond to different stakeholder needs. Further principles include the clear acknowledgement of model limitations to stakeholders, the respect for divergent views during engagement, and a critical assessment of the stakeholder inclusion process and potential biases. All these recommendations were based on the experience of the community participants and were inspired by case studies assembled by the participants and provided as supplementary material in the publication¹⁰. Essentially, this process facilitates a community of practice with mutual benefits. On the one hand, DIAMOND has contributed towards the development of a set of participatory

⁹ McGookin et al., 2024; <https://doi.org/10.1016/j.esr.2024.101319>

¹⁰ <https://ars.els-cdn.com/content/image/1-s2.0-S2211467X24000269-mmc2.pdf>

principles that can influence the projects scientific discourse and, on the other hand, models and scientific insights produced by the project following said principles have an immediate space to be disseminated and used within this community.

Efforts to continue the engagement with this community are expected to continue through relevant thematic webinars in 2025 (see Section 5).

4.2.2 Social Sciences and Humanities Energy workshop

The DIAMOND partner Cultural Studies of Science and Technology at the ETH Zürich co-organises an annual SSH (Social Sciences and Humanities) Energy workshop as part of the activities of the "Co-Evolution and Coordinated Simulation of the Swiss Energy System and Swiss Society" (SWEE-CoSi) community.

CoSi¹¹ constitutes a platform for exchange towards creating a common understanding and achieving a co-creation process with stakeholders, in order to link all involved disciplines in the broader energy research community. It is also envisaged to operate as a test-lab for new approaches to energy modelling, with a focus to enhance the usability of models, scenario structures, and simulation insights, and finally provide a window into the future.

The workshop provides an opportunity for diverse stakeholders including researchers, practitioners, and policymakers to share perspectives and insights on the societal implications, discourses, and transformation processes required to transition to a more sustainable energy system and seeks to provide a learning space for SSH energy initiatives to share insights on inter- and trans-disciplinary approaches into energy transitions.

Although the network and the corresponding initiatives have a primarily Swiss focus, the lessons learnt, experiences, and the community itself can be very useful for DIAMOND to share project insights, as well as be influenced by advancements presented, the project closely monitors developments and actively participates in the organisation of the activities through ETH Zürich.

4.2.3 MORSE Conference

DIAMOND partner University of Maastricht organises the annual "Science for a resilient, responsible and sustainable future (MORSE)" Conference¹² which brings together scholars from different disciplines around Europe working towards a responsible, resilient, and sustainable future to discuss their research and its practical application and societal impact. A mix of academic and applied work over a broad range of topics from sustainable employability to finance for resilience gives all the opportunity to exchange ideas and forge new collaborations. In the plenary sessions, keynote speakers reflect on how responsible business can contribute to the urgent transition to resilience and sustainability, while practitioner sessions make this discussion very tangible and concrete.

On top of the University of Maastricht organising the event, DIAMOND actively participates in this initiative, aiming to bridge the gap between IAMs and mitigation research with the broader economic and financial domain, by organising dedicated sessions within the conference on the project's contribution to labour, finance, and behavioural economics.

¹¹ <https://www.sweet-cosi.ch/cosi-at-a-glance/>

¹² <https://www.maastrichtuniversity.nl/events/morse-conference>

5 Planning for the next capacity development activities

A key vessel for DIAMOND to achieve its objective to transparently open all modelling enhancements to the wider scientific and policy community will be the organisation of capacity development activities. The webinar structure will be leveraged considering the effectiveness of this approach towards reaching a wider audience from different backgrounds. Although the key aspiration is to organise webinars to present the models produced within DIAMOND, until these models reach stable versions, the team is planning to leverage existing work produced to organise webinars that pave the way towards the core model-related capacity development activities. So far, three such webinars are under preparation within the first half of 2025.

First, in collaboration with the participatory modelling community (see Section 4.2.1), a webinar tentatively titled “Demystifying stakeholder engagement in IAM development and scenarios” will feature presentations from members of the community and other relevant scholars, ideally leading to further exchanges of good practices and shedding light on the different terms used to describe stakeholder engagement. Within this context, DIAMOND will present ongoing and future WP2 activities, inviting webinar participants to assess our progress in stakeholder inclusion and suggest improvements, as well as share ideas for collaborations.

The second workshop will aim to provide lessons learnt from the shifts observed from IPCC AR5 to AR6 with the aim of informing on the role of the new models developed in DIAMOND within AR7. Central to this process will be the novel scenario definition space produced as part of our activities in WP5.

Finally, a third workshop is planned to focus on open science, including challenges related to fully opening models, selecting open licenses, as well as providing a set of open supporting tools to facilitate flawless model operations.

The three webinars are under preparation, and currently at the stage of inviting potential speakers and fixing final dates; the first one is scheduled for Q1 2025, while the latter two towards Q2 2025.

Ideally, these webinars should pave the way for starting the model-based webinars during the second half of 2025, once the first stable versions of the models are delivered. Priority will be given to the CLEWs-EU model considering the low complexity and computational demands, making it ideal for engaging with non-modellers.