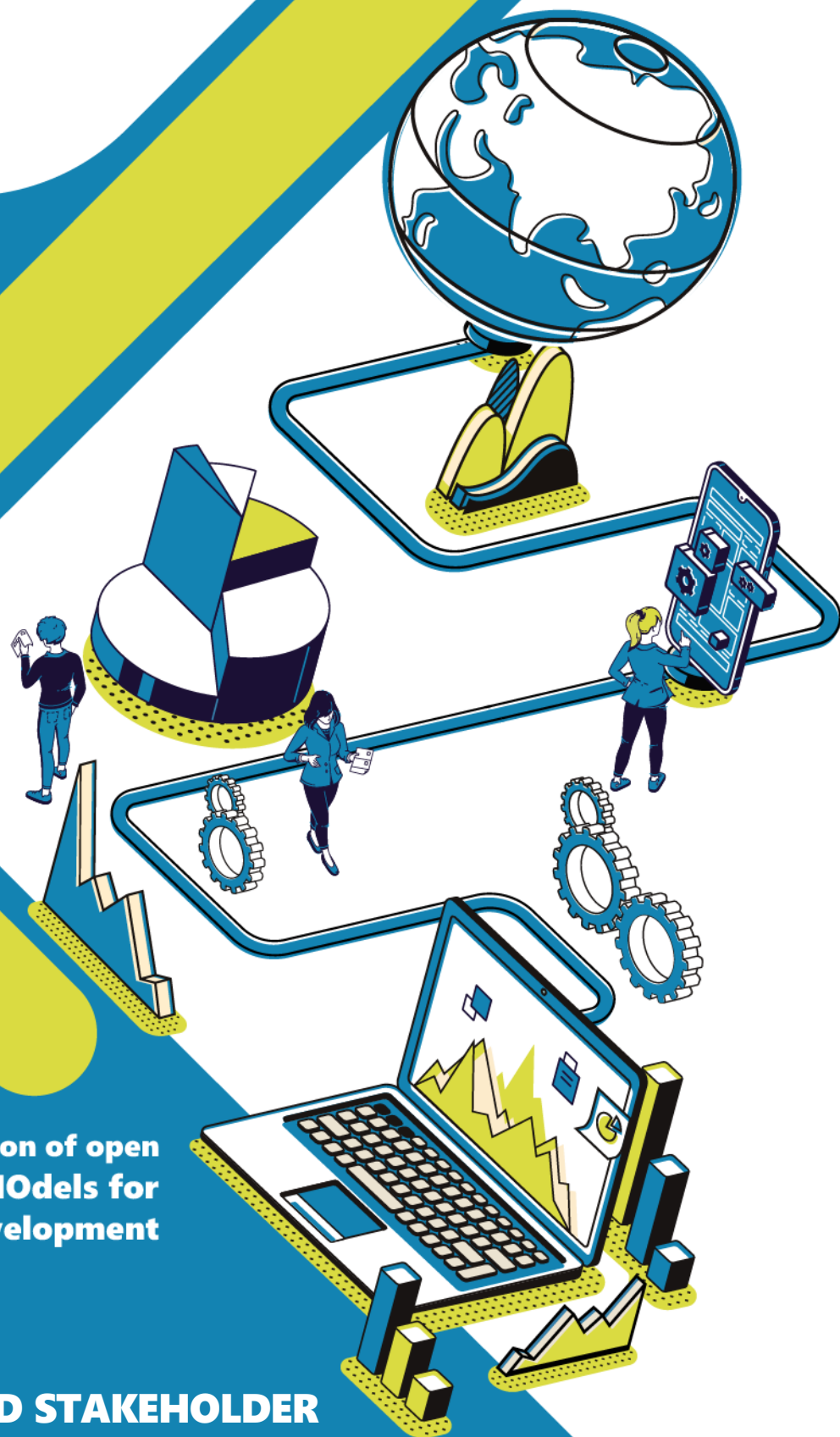




**Delivering the next generation of open
Integrated Assessment MOdels for
Net-zero, sustainable Development**

D2.3 – MULTI-LAYERED STAKEHOLDER ENGAGEMENT STRATEGY – UPDATE 2

WP2 – Codesign

30/04/2025



Funded by
the European Union

Disclaimer

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them. This work has also received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Copyright Message

This report, if not confidential, is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0); a copy is available here: <https://creativecommons.org/licenses/by/4.0/>. You are free to share (copy and redistribute the material in any medium or format) and adapt (remix, transform, and build upon the material for any purpose, even commercially) under the following terms: (i) attribution (you must give appropriate credit, provide a link to the license, and indicate if changes were made; you may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use); (ii) no additional restrictions (you may not apply legal terms or technological measures that legally restrict others from doing anything the license permits).

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	D2.3 – Multi-layered stakeholder engagement strategy – Update 2			
Work Package	WP2 – Codesign			
Date of Delivery	Contractual	30/04/2025	Actual	30/04/2025
Nature	Report	Dissemination	Public	
Lead Beneficiary	ISINNOVA			
Responsible Author	Daniel R. Cassola	E-mail address	dcassola@isinnova.org	
	ISINNOVA	Telephone No.	-	
Contributors	Stefano Faberi, Carlo Sessa [ISINNOVA]; Stephanie Briers, Bianca Vienni Baptista [ETH]; Glen Peters [CICERO]; Maurizio Gargiulo [E4SMA]; Lukas Engel [UNIBAS]			
Reviewer(s)	Lukas Engel [UNIBAS]; Anastasios Karamaneas, Konstantinos Koasidis [ICCS]; Dimitra Spatharidou [HOLISTIC]			
Keywords	Co-design; engagement plan; stakeholders; citizens; cross-disciplinary integration; participatory process			

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

Along with the first version of the stakeholder engagement strategy (D2.1) and its subsequent update (D2.2), this deliverable will serve as a reference document among consortium partners to describe the engagement strategy of the co-design phase of the project, including the methodology and approaches used for cross-disciplinary integration. The deliverable also documents the stakeholder engagement plan, including the events already organised and their outcomes, as well as the foreseen events. This is a dynamic plan designed to identify and engage all relevant stakeholder groups. It can also be used by policymakers and other stakeholders as a documentation of cross-disciplinary participatory processes and citizens' involvement.

3. Short summary of results (<250 words)

The DIAMOND multi-layered stakeholder engagement strategy accompanies and enriches the research process by enabling the exploration of the multiplicity of perspectives on how models can address concerns from the target groups, attending carefully to differences, complexities, and range of variation in the data.

It provides a description of the heuristic cross-disciplinary integration methodology adopted in the project; illustrates the co-design process involving researchers (e.g., modellers, SSH researchers), policymakers, business, social and environmental stakeholders, and citizens; and gives details on the stakeholder engagement plan.

We highlight how the integrated approach facilitates seamless interaction with other WPs, optimising co-creation and application of models, scenario building, and policy roadmap development. The strategy also takes stock of the work done in Phases 1-2 of the co-design process, while outlining the plan for outstanding activities in all three phases. It describes the dynamically updated stakeholder database, which incorporates over 50 stakeholders pledging to actively participate in all DIAMOND stakeholder-related activities. These play a key role in the co-design process, and those initially allowing us to contact were invited to strategic foresight workshops alongside other experts, and other project activities.

In this final update, we present the outcomes and assessment of the first two strategic foresight workshops with stakeholders, we describe the methodology and approach for the third one and the planned climate-friendly practice workshop engaging citizens, and we outline the process for the upcoming engagement phases.

The report also provides examples of the dialogue loops between researchers and practitioners aiming to co-create and assess climate change neutralisation actions, and the database structure for stakeholder engagement.

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



bc³ BASQUE CENTRE FOR CLIMATE CHANGE
Klima Aldaketa Ikergai



°CICERO



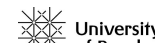
E4SMA



ISINNOVA
research innovation sustainability



ETH zürich



Imperial College London



Executive Summary

This report constitutes the final update of the multi-layered stakeholder engagement strategy of the DIAMOND project — as described in the preceding deliverables D2.1 and D2.2 — for model co-development, scenario building and policy roadmaps' co-creation exercises. This report takes stock of progress during 'Phase 1 - Toward mutual understanding' and provides details on activities and foreseen events belonging to Phase 1 and 'Phase 2 – Towards knowledge co-production', notably the strategic foresight workshops with stakeholders and the values and practice driven foresight workshops with citizens, while at the same time providing outlines for work in Phase 3.

Applying a heuristic cross-disciplinary integration methodology, the project aspires to both equip participating models with advanced decision rules and acceptance insights on different aspects of the transition, and improve the communication, usability, uptake, and relevance of modelling results to the wider society. The integrated assessment literature has long pinpointed the benefits and challenges of opening up participation of non-expert stakeholders in modelling activities and scenario development. Wide stakeholder participation and co-production can improve the legitimacy and robustness of the modelling outputs as well as help build consensus and a sense of ownership among stakeholders over specific solutions, reinforcing the success and speed of their implementation. In order to meet this challenge and achieve understanding between diverse actors with different scientific backgrounds and traditions of thought, it is necessary to create a common frame of reference.

DIAMOND develops continuous dialogue loops between researchers and practitioners aiming to co-create and assess climate change neutralisation actions and two boundary objects – a Three Horizons participatory foresight framework and the suite of IAMs – which will support the DIAMOND cross-disciplinary dialogue loops. Each loop iteration starts by exploring together future scenarios – *A: EXPLORE SCENARIOS* –, then goes down to test possible solutions in the modelling simulation environment – *B: SIMULATE SOLUTIONS* – to go back to assess how these solutions actually fit into present reality – *C: VALIDATE OUTCOMES* – to end with the formulation of recommended further research and policy actions – *D: FORMULATE RESEARCH & POLICY AGENDAS*. Thematic streams with researchers and stakeholders take place within the co-design process (e.g., circular economy and climate change mitigation; land use and nature-based solutions; household heterogeneity and distributional impacts; refining climate mitigation strategies assessment; integrating finance, labour dynamics and novel operationalisation of well-being; and improving the electricity system assessment). One additional ethical foresight dialogue will be organised with a representative group of citizens, focusing on behavioural change and ethical issues of climate change neutralisation.

In this report, the co-design process is developed through a path identified by three closely connected and sequential phases: it starts with the definition of a common knowledge base and the common understanding of the content, goals, and limitations of the IAMs in the DIAMOND project, and continues with the co-development of tools and knowledge, and ends with the joint validation and quality assessment of modelling improvements. The concluded stages of Phase 1 of the co-design process have been conducted with a special focus on reaching mutual understanding within DIAMOND partners. The results of these activities have been integrated into the updated stakeholder strategy. Phase 2 is currently involving different groups of stakeholders in co-developing the IAM upgrades and in co-producing alternative, feasible, and desirable policy scenarios through strategic foresight workshops, and groups of citizens through climate-friendly practice workshops to optimise both model development's relevance to society and applicability in the real world. Phase 3 will commence in Month 31, integrating and applying the co-produced knowledge into societal and scientific practices.

In order to meet the project expectations in terms of model co-development and policy scenarios and roadmaps

co-creation, the stakeholder engagement in DIAMOND is structured through the involvement of three groups of stakeholders, namely the wider community of IAM developers and researchers, climate stakeholders and decision makers concerned with climate policymaking and/or climate change impacts, and citizens and civil society representatives. Ethical foresight is used to explain why the socio-political dimension needs to involve ordinary citizens to lay down the foundations for mature information societies. The aim is to ensure a good balance of stakeholders across groups (and gender) and maintain stakeholder contacts throughout the project's life. The stakeholder database is a vessel in all activities related to co-creation and engagement in WP2.

This report also provides updates on the interactions of the stakeholder engagement strategy with other work packages within the project framework, the approach to identify and include all relevant stakeholders in the co-design process of DIAMOND, and highlights insights from the organization of the strategic foresight workshops with stakeholders and the values and practice driven foresight with citizens.

Notably, this report describes the outcomes of the first two workshops: the Requirements Workshop and the 1st Foresight Workshop. The Requirements Workshop successfully identified key stakeholder needs and expectations, providing valuable insights into the project's objectives and guiding future actions. The 1st Foresight Workshop focused on envisioning future climate scenarios, fostering discussions around potential challenges and opportunities.

This updated version of the stakeholder engagement strategy also includes a description of the methodology that will be employed in the Climate-Friendly Practice Workshop, which will engage citizens through Citizen Assemblies on Climate to further inform model development and increase societal relevance, as well as elaborations on outstanding work to be performed under all the engagement Phases.

Contents

1	Introduction	1
2	Cross-disciplinary integration methodology	3
2.1	Knowledge integration: the heuristic approach to cross-disciplinary integration in DIAMOND	3
2.2	Three Horizons foresight framework	6
2.3	DIAMOND integrated assessment modelling framework	11
3	The Co-design process	13
3.1	The DIAMOND approach and objectives	13
3.2	Which types of stakeholders to be involved	13
3.3	The Co-design pathway	15
3.3.1	Multi-stakeholder co-design process	15
3.3.2	Interactions of the stakeholder engagement strategy with other project work packages	18
3.3.3	Citizens' involvement	21
4	Stakeholder engagement plan	24
4.1	Organisation of stakeholders mapping and database	24
4.2	The introductory survey: register in the DIAMOND stakeholder pool	25
4.3	Planning of the stakeholder engagement events	29
4.3.1	Phase 1 – Towards mutual understanding and framing of project goals and requirements	29
4.3.2	Phase 2 – Towards knowledge co-production	29
4.3.3	Phase 3 – Towards model co-ownership	36
5	Reports from the completed stakeholder workshops	37
5.1	DIAMOND Requirements Workshop Online 13 September 2024	37
	1st Session: Enhancing analytical capacities for more effective climate policy support	38
	2nd Session. Defining requirements aligned with stakeholders' pertinent questions	38
	Mural board from the 1st session	xl
	Mural board from the 2nd session	xli
5.1.1	Contributions of the Requirements Workshop to the modelling teams expectations	42
5.1.2	Assessment of the Requirements Workshop	42
5.2	DIAMOND 1st Foresight Workshop Online 12 November 2024	43
	1st Session: – Pathway H1, Business as Usual	45
	2nd Session. H3 – Viable Future	45
	Additional characterisation	46
	Mural board from the 1st room	47
	Mural board from the 2nd room	48
5.2.1	Main insights from the 1st Foresight Workshop	49
5.2.2	Assessment of the 1st Foresight Workshop	49
	Bibliography	51

Table of Figures

Figure 1. DIAMOND common cross-disciplinary goal. <i>Source: Own elaboration</i>	5
Figure 2. Three Horizons foresight framework. <i>Source: Sharpe et al. (2016)</i>	6
Figure 3. 3H methodology applied to envision conservative vs transformative climate change neutralization scenarios (Participatory Foresight Framework). <i>Source: Adapted from J. Fullerton (2015), Regenerative Capitalism, Capital Institute, p. 43</i>	8
Figure 4. The Diamond participatory foresight space. <i>Source: Own elaboration</i>	10
Figure 5. Types of stakeholders in DIAMOND. <i>Source: Own elaboration</i>	14
Figure 6. The co-design pathway in DIAMOND. <i>Source: Own elaboration</i>	18
Figure 7. Professional capacity of the stakeholders that agreed to participate in collaborative activities	26
Figure 8. Familiarity with IAMs of stakeholders agreeing to participate in collaborative activities.....	26
Figure 9. Familiarity with the project IAMs of stakeholders agreeing to participate in collaborative activities	27
Figure 10. Three Horizons structure of the foresight process in DIAMOND. <i>Source: Adapted from Schaal-Lagodzinski et al., 2023</i>	45

Table of Tables

Table 1. Models used in DIAMOND	11
Table 2. Disciplines and Areas of Expertise of the stakeholders	27
Table 3. Updated structure and timeline for the organisation of stakeholders' workshops	32
Table 4. Requirements workshop agenda	37
Table 5. First foresight workshop agenda.....	44

1 Introduction

The main purpose of the DIAMOND project is to update, upgrade, and fully open six Integrated Assessment Models (IAMs) that are emblematic in scientific and policy processes so that they provide a comprehensive and integrated framework of analysis to inform and support the design of climate policies based on:

- theories from a plurality of scientific disciplines that address causal factors and phenomena in the personal sphere (e.g. behavioural economics and psychology), in the socio-economic sphere (e.g. economics, social sciences), and in the ecological sphere (e.g., natural and life sciences);
- insights from societal actors themselves;
- empirical data from cross-national surveys of EU citizens to examine their mobility and energy use behaviours and willingness to change consumption behaviour.

Developing and implementing a comprehensive stakeholder engagement strategy is the primary objective of the stakeholder engagement activities conducted within WP2 of the DIAMOND project. This strategy aims to facilitate meaningful interactions and collaborations with stakeholders throughout the project lifecycle, particularly focusing on the integration and utilisation of updated IAMs within climate policy and decision-making processes.

Applying transdisciplinary methods, the project aspires to co-create the research questions, legitimise the implementation process and model development, and improve the communication, usability, uptake, and relevance of modelling results to the wider society.

To this end, the entire work structure of DIAMOND is operationalised with the help of a heuristic cross-disciplinary integration methodology for model co-development, application to scenario building and policy roadmaps' co-creation exercises. Recognising that knowledge flows through various communities with diverse disciplinary perspectives and stakeholders, this mechanism ensures a balanced flow of information that is both relevant to policy needs and better based in real-life perspectives, providing comprehensive yet easily understandable information for all researchers, policymakers, and stakeholders involved.

In connection with the transdisciplinary approach that DIAMOND adopts, establishing meaningful linkages between science, policy, and society presents significant challenges. Specifically, engaging stakeholders in a meaningful way involves identifying the appropriate stakeholders and building trust. Delivering impactful outcomes for decision-makers is similarly challenging and is intertwined with technical model challenges. Political factors, such as competing agendas and a lack of transformative commitment from stakeholders, also influence the interplay between science outcomes and policy making processes.

To provide substance to these objectives and continue their implementation, started during the previous project period, we illustrate:

- the heuristic cross-disciplinary integration methodology adopted in the project (Section 2);
- the co-design process, involving researchers (modellers); policy makers; business, social and environmental stakeholders; and groups of citizens (Section 3);
- the detailed stakeholder engagement plan (Section 4).

In order to complement the theoretical framework of the multi-layered stakeholder engagement strategy described in the preceding deliverables D2.1 and D2.2 based on the progress made since their publication, here we provide updates on:

- the interactions of the stakeholder engagement strategy with other work packages within the project

framework (Section 3.3.2);

- the facilitation of mapping stakeholders into our database (Section 4.1);
- the planning and methodology of upcoming stakeholder engagement events: 2nd Foresight Workshop and Climate-Friendly Practice Workshop (Section 4.3);
- the reports from the completed stakeholder workshops (Section 5).

This stakeholder engagement strategy is continuously updated and refined throughout the duration of the project, incorporating feedback, evolving based on stakeholder and project partner needs, and emerging new insights to ensure its effectiveness and relevance.

2 Cross-disciplinary integration methodology

2.1 Knowledge integration: the heuristic approach to cross-disciplinary integration in DIAMOND

The integrated assessment literature has long pinpointed the benefits and challenges of opening up participation of non-expert stakeholders in modelling activities and scenario development (Van Vuuren et al., 2012; Salter et al., 2010). Wide stakeholder participation and co-production can improve the legitimacy and robustness of the modelling outputs as well as help build consensus and a sense of ownership among stakeholders over specific solutions, reinforcing the success and speed of their implementation (McGookin et al., 2021). While engagement activities with decision-makers and societal actors have been used in the past as a reality check on IAM assumptions and for assessing the feasibility of their outputs, they have been rarely used to feed or further develop IAMs with a plurality of perspectives on the low-carbon transition (Braunreiter et al., 2021). Apart from challenges related to stakeholder availability, the sheer complexity of integrated assessments and the stakeholder heterogeneity in terms of expertise, beliefs, and values can often hinder meaningful engagement in modelling, scenario development, and impact (Elsawah et al., 2020).

To go beyond the current state-of-the-art, DIAMOND builds on the path opened by previous modelling exercises that recently started employing information from stakeholders.¹ That requires the constructive combination – or *integration* – of multiple forms of expertise and perspectives, or what we shall refer to as cross-disciplinary integration. We use ‘cross-disciplinary’ as a cover term for both interdisciplinary and transdisciplinary activity. When the context requires more specificity, the term ‘interdisciplinary’ is used to mean the integrative combination of disciplinary perspectives and ‘transdisciplinary’ to mean the integrative combination of disciplinary and stakeholder perspectives.² Turning to the multitude of theoretical accounts,³ there is a large consensus that the integrative process consists of activities structured with the help of various techniques, yielding outcomes that advance cross-disciplinary research. These accounts also agree in taking integration to be *contextual*, i.e., dependent for its specific form on the context in which it is pursued, and *purposive*, i.e., a process intentionally implemented by researchers from several disciplines plus stakeholders working together in pursuit of objectives.

In the DIAMOND project, cross-disciplinarity is understood as a ‘heuristic integrative research approach’ that adds cooperation between academic researchers and non-academic practitioners to the inner-scientific cooperation between various disciplines, facilitating the combination of inputs into an integrated output. This knowledge integration is more than just adding up disciplinary findings but rather means the combination of heterogeneous knowledge assets with the aim of creating an identifiable synthesis product and new insights that go beyond the juxtaposition of different insights. To meet this challenge and achieve understanding between diverse actors with

¹ See for example:

- PARIS REINFORCE
<https://www.sciencedirect.com/science/article/pii/S0048969721036214?via%3Dihub>
<https://www.sciencedirect.com/journal/renewable-and-sustainable-energy-transition/special-issue/10ZRPC0C1P4>
- ENGAGE
[https://www.frontiersin.org/articles/10.3389/frsus.2022.1063719/full?&utm_source=Email_to_authors&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers in Sustainability&id=1063719](https://www.frontiersin.org/articles/10.3389/frsus.2022.1063719/full?&utm_source=Email_to_authors&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers%20in%20Sustainability&id=1063719)

² For discussion of these modes of research, see Klein (2010).

³ See for instance O’Rourke et al. (2015)

different scientific backgrounds and traditions of thought, it is necessary to have a common reference frame. In the DIAMOND project, a common frame is provided by:

- the project objectives, with a special emphasis on objective 6 (O6);⁴
- using the whole range of available IAMs, WP3 upgrades and WP4 integration modules;
- using a Three Horizons participatory foresight framework to structure participants' (researchers and stakeholders) climate change neutralisation scenarios building activities;
- adopting a standard dialogue loop process for seven different but coordinated foresight thematic streams focused on:
 1. *Circular economy and climate change mitigation* (jointly with Task 4.1: An integrated framework for circular economy & mitigation).
 2. *Land use and nature-based solutions* (jointly with Task 4.2: Improving the representation of land use, nature-based solutions).
 3. *Household heterogeneity and distributional impacts* (jointly with Task 4.3: Distributional impacts: refining household heterogeneity).
 4. *Refining climate mitigation strategies assessment* (jointly with Task 4.4: Linking IAMs to climate/physical impact models).
 5. *Integrating finance, labour dynamics and novel operationalization of well-being* (jointly with Task 4.5: Integrating finance, labour dynamics, and well-being in IAMs).
 6. *Improving the electricity system assessment* (jointly with Task 4.7: A finer detail of electricity in IAMs for interconnectivity in EU).
 7. In addition, one ethical foresight dialogue will be organised with a representative group of citizens, participants in citizen's assemblies on climate, focusing on *behavioural change and ethical issues of climate change neutralisation*, also taking stock of Task 4.6: Representation of behavioural aspects & preferences for action results and of Task 4.3: analysis of household heterogeneity.

Figure 1 shows the DIAMOND dialogue loops between researchers and practitioners aiming to co-create and assess climate change neutralisation actions, with the support of two 'boundary objects': a Three Horizons participatory foresight framework and the suite of IAMs, WP3 upgrades and WP4 integration modules. As stated in the PARIS REINFORCE Policy Briefs⁶, models cannot be expected to produce fundamentally *true* policy insights,

⁴ To develop a transdisciplinary scientific approach to co-create the research questions, legitimise the implementation process and model development, and optimise the communication of project results, in collaboration with representatives from policy, business, and civil society. This approach aims to translate the motives, concerns, and actions of decision-makers and citizens regarding climate action into measurable and quantifiable terms, and to demonstrate how these can influence and contribute to broader climate policy and sustainable development goals.

⁵ Broadly speaking, in the field of cross-disciplinary research such diverse objects as scenarios (e.g., scenarios for the deployment of renewable energy), models (e.g., climate models), and interdisciplinary frameworks and concepts (e.g., ecosystem services framework or biodiversity), spatial foci (e.g., case studies in a specific city or region) are considered and applied as boundary objects. A boundary object works well if it establishes a shared language so that the different cooperating actors can represent their knowledge, enabling them to learn about their differences and dependencies (e.g., on undisclosed stereotypes) and facilitating a common process of knowledge transformation and integration.

⁶ PARIS REINFORCE Policy Briefs: <https://paris-reinforce.eu/publications/policy-briefs>.

but to feed **constructive dialogues** regarding inputs into the model, as well as the interpretation of results.

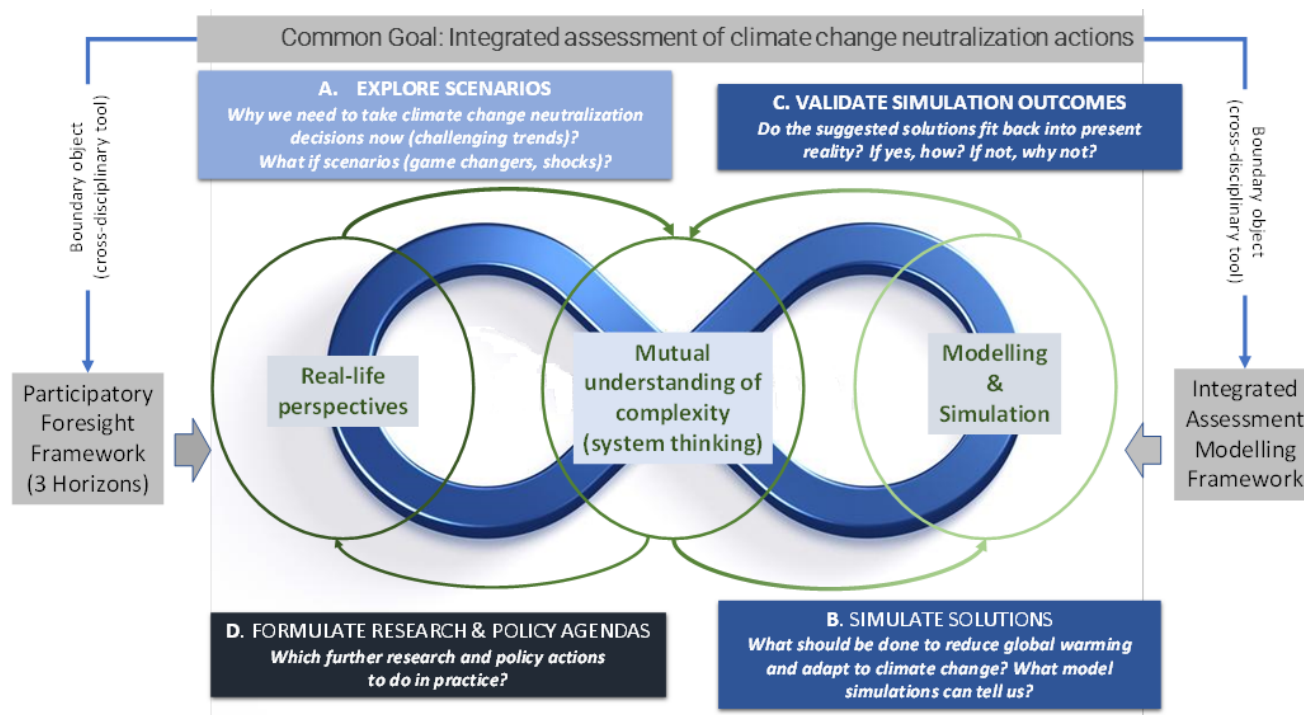


Figure 1. DIAMOND common cross-disciplinary goal. *Source: Own elaboration.*

The DIAMOND project is currently engaged in developing such structured dialogues to co-create and assess low carbon, net-zero or beyond net-zero target policies and actions. These dialogues, which began in the project's co-design phase (WP2), will extend beyond the project's duration as an ongoing task within the DIAMOND open community (WP6). This is represented in Figure 1 by a loop connecting stakeholders/practitioners' real-life perspectives and the scientific evidence perspective embedded in the modelling structure and reality simulation functions, to co-produce a mutual understanding of the complex climate change challenge and devise possible responses. Each loop iteration starts by exploring together future scenarios – A: *EXPLORE SCENARIOS* –, then goes down to test possible solutions in the modelling simulation environment – B: *SIMULATE SOLUTIONS* – to go back to assess how these solutions actually fit into present reality – C: *VALIDATE OUTCOMES* – to end with the formulation of recommended further research and policy actions – D: *FORMULATE RESEARCH & POLICY AGENDAS*.

It is important to note that:

- After a first policy co-creation iteration that will be tested within the DIAMOND lifetime, the same heuristic approach of knowledge integration should be used to replicate integrated assessment exercises, continuing to involve both researchers and stakeholders, as a form of project exploitation activity.
- The whole DIAMOND project scope is too wide to develop a meaningful dialogue covering all the climate change neutralisation related issues simultaneously in one process. Therefore, after having identified and classified a wide range of stakeholders by their thematic expertise and interest, the project engaged them in an initial IAM user requirements-modellers capabilities matching workshop including specific thematic clusters sessions. This initial step allowed stakeholders and modellers to reach common ground on what *should* and *can* be done and by which model, triggering potential adaptations to the model development strategy in WP3, and then produce stakeholder-driven research questions that will be addressed in WP4 and WP5 module and scenario development activities. This is expected to be achieved by developing

structured dialogues — using the same A-B-C-D loop logic — for specific extensions planned under 'WP4 – Integrate & Expand' and user-driven scenario exploration tasks in 'WP5 – Apply & Explore' planned in the project.

In practice, modellers and stakeholders worked together in the first workshop to mutually understand which issues are useful and feasible to analyse with the available IAM capabilities and/or planned improvements, and co-design the specific dialogues settings (e.g., defining the modellers-stakeholders discussion groups) and research questions, to be addressed later in the project and in future exploitation activities. However, it is important to recognise that such processes could be shaped by existing power dynamics — for instance, the perspectives of citizens and NGOs may not carry the same weight in shaping decision-making outcomes as those of technical experts or institutional stakeholders.

2.2 Three Horizons foresight framework

Through the lens of a multi-layer stakeholder analysis, the DIAMOND project is currently engaging invited representatives of four main target layers of actors – policymakers, business and social stakeholders, actors focused on environmental protection and sustainability, and citizens – together with researchers (DIAMOND modelling teams) in a cross-disciplinary process of user-driven climate change neutralisation scenarios exploration, interpretation, and impact assessment. This activity applies the Three Horizons participatory foresight framework which is a tool that helps structure the thinking about the future of a multi-disciplinary & multi-stakeholder group in ways that spark innovation. It describes three patterns or ways of proceeding and how their relative prevalence and interactions evolve over time. The evolution from the established pattern of the first horizon to the emergence of fundamentally new patterns in the third occurs via the transition activity of the second horizon. The framework not only makes us think in terms of interactive patterns, but more importantly, draws attention to the three horizons always existing in the present moment. By observing how people — including ourselves — are currently behaving, we can detect early signs or signals of change that hint at which future may already be emerging. As told by the main author, "The essence of Three Horizons practice is to develop both an individual and a shared awareness of all three horizons, seeing them as perspectives that must all come into the discussion, and to work flexibly with the contributions that each one makes to the continuing process of renewal on which we all depend. We step out of our individual mindset into a shared space of creative possibility" (Sharpe, 2013).

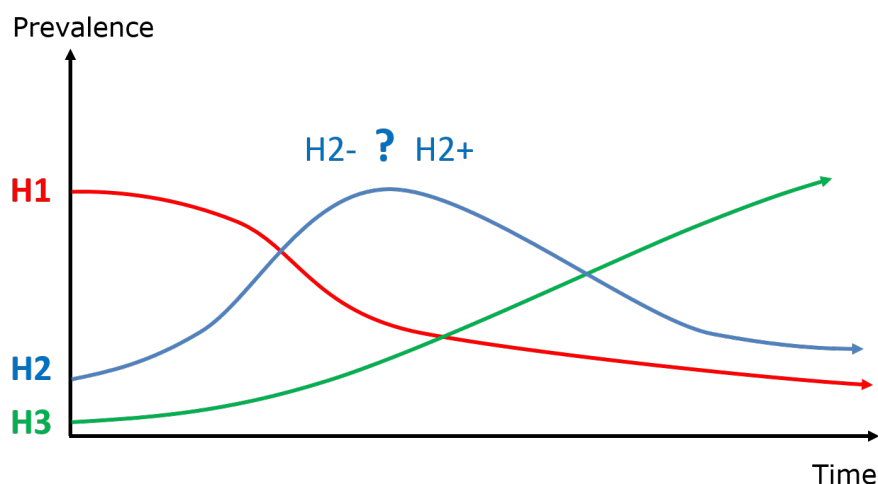
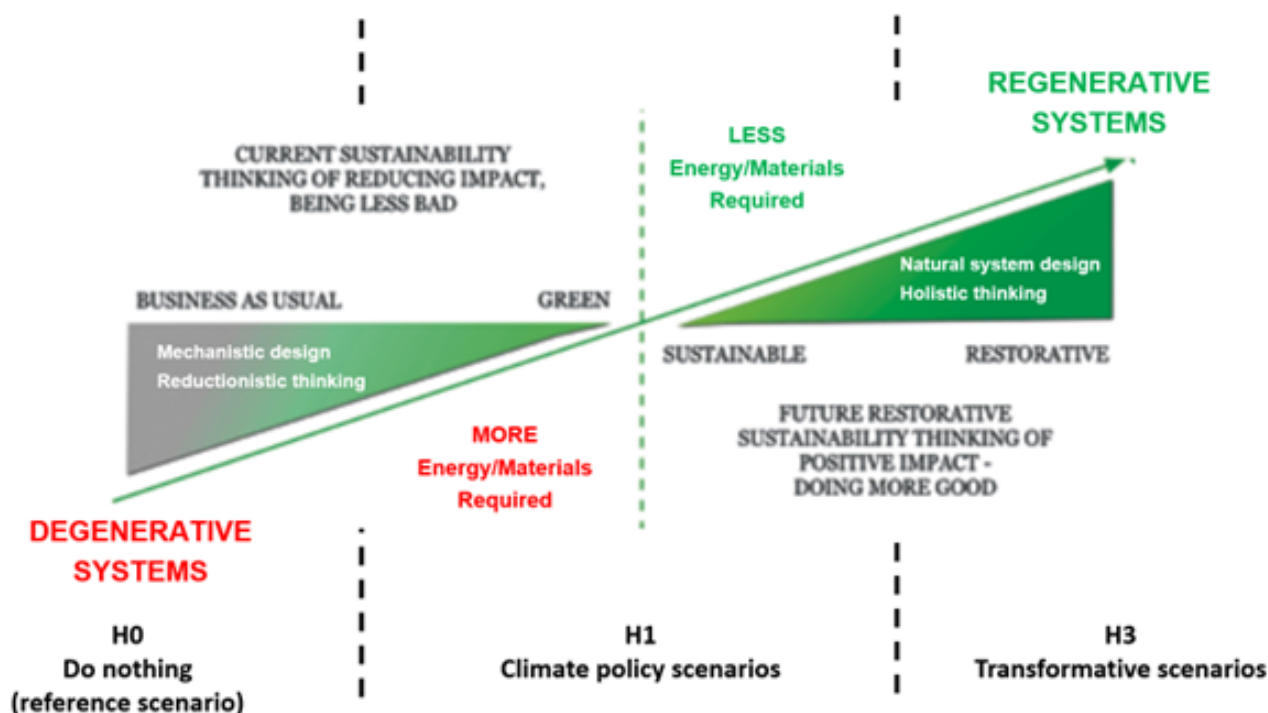


Figure 2. Three Horizons foresight framework. *Source: Sharpe et al. (2016)*

Horizon 1 is 'business as usual', or 'the world in crisis' (H1). It is characterised by 'sustaining innovation' that keeps 'business as usual' going. Horizon 3 is how we envision a 'viable world' (H3). We may not be able to define this future in large detail – as the future is always uncertain – yet we can intuit what fundamental transformations lie ahead, and we can pay attention to social, ecological, economic, cultural, and technological experiments around us that may be pockets of this future in the present. Horizon 2 represents 'world in transition' (H2) – the entrepreneurial and culturally creative space of already technologically, economically, and culturally feasible innovations that can disrupt and transform H1 to varying degrees and can have either regenerative, neutral or degenerative socio-ecological effects.

At the point where the H2 innovations become more effective than the existing practices, they begin to replace aspects of 'business as usual'. Yet some forms of disruptive innovation ultimately get absorbed by H1 without leading to fundamental and transformative change, while other forms of disruptive innovation can be thought of as a possible bridge from H1 to H3. Therefore, it is useful to classify H2 innovations into two categories. The first category is called H2- (Horizon 2 minus). H2- innovations change the technology employed and therefore disrupt 'business as usual' temporarily but without leading to a profound systemic transformation. The second category is H2+ (Horizon 2 plus). H2+ innovations offer a bridge to H3, leading to a structural change and transformation of the system itself. For example, providing power to the national grid via large-scale wind farms is on the H2+ as it is a strategy of moving towards a 100% renewable energy-based system, and on H2- innovation locked into an H1 mindset as it is still structurally supporting a centralised energy system. An example of a genuine H2+ innovation in this area could be a blend of diverse and decentralised renewable energy technologies that combine stand-alone and grid-connected options to increase the flexibility, efficiency, and resilience of the energy system overall.

Beyond sustainability: We no longer have the luxury of just being less bad



H1 Conservative scenarios, where the system will stand in 2100 if current drivers and trends will continue unchanged

H3 Transformative scenarios, how the system will look in 2100 if new emerging paradigms will become dominant

H2 Window of opportunity, what can be done until 2050 to facilitate the best future outcome

Who is it for?

Stakeholders and public engagement to envision 'the future we want'

Figure 3. 3H methodology applied to envision conservative vs transformative climate change neutralization scenarios (Participatory Foresight Framework). Source: Adapted from J. Fullerton (2015), *Regenerative Capitalism*, Capital Institute, p. 43

The Three Horizons framework (Figure 3) is used in the DIAMOND dialogue loops to discuss two typologies of scenarios: more conservative (H1) climate policy scenarios, mostly envisaging the deployment of the currently dominant technological trends and climate mitigation and adaptation policies; and more transformative (H3) scenarios, which consider not only the impact of new technological and economic measures, but also possible behavioural, social and cultural changes switching towards a regenerative economy paradigm. Both categories of

scenarios will diverge from the reference scenario (named H0), which represents a 'no-policy' action, where the business-as-usual trends are perpetuated, but with a different intensity and sustainability outcome (see box *Switching to a regenerative economy* below).

Switching to a regenerative economy

The rationale of switching to a regenerative economy paradigm worldwide is increasingly evident. We are in a situation where a rapid change to a healthy relationship with the planet is in order. In this respect, the concept of 'regeneration' and 'regenerative growth' moves our frame of discourse from 'doing things to nature' to 'participating as partners with and as nature'. At the core of the regeneration paradigm, the economic system is conceived as a living system, working with the same universal pattern of self-organisation, interdependence between and diversity of the various parts connected in a whole organic system. By taking this regenerative worldview, we radically change the concept of sustainability. Rather than a 'goal' measured by targets that can be achieved and then maintained forever after, sustainability is interpreted as a dynamic 'process' of nature and human techno-sphere co-evolution, and a community-based process of continuous conversation and learning how to participate appropriately in the constantly transforming life-sustaining processes that we are part of and that our future depends upon. What a regenerative economy would sustain is the underlying pattern of planetary and human health, resilience and adaptability that maintain this planet in a condition where life satisfaction and human well-being can flourish.

The best-known example of a regenerative economy is in the agriculture sector, where it is now technologically possible and economically competitive to produce food while simultaneously leaving the plot of land better off. But regeneration can work across all development sectors – not just agriculture – going beyond sustainability. The question in sustainable development was "*How can the economy work in such a way that we sustain or do not hurt the underlying (ecological and social) support systems?*". Now, the question in regenerative development becomes "*How can the economy work in such a way that we improve the capacity of the underlying support systems?*". It is no longer enough to do no harm, sustainability and zero-waste and zero-emissions policies are noble goals, but we can and must do better than zero, we need to do good – this is the key message of regenerative economy.

Given the 'diversity' of scientific disciplines and stakeholders' knowledge involved in the cross-disciplinary process, the DIAMOND dialogue loops aim to match the scientific knowledge embodied in the IAM models with the values, mindsets and perspectives of users/stakeholders. This 'matching' is achieved by immersing the holders of different kinds of knowledge – scientific and experiential – in the dialogue setting represented in Figure 4 as a synergic sense-making space. This conceptual representation of the DIAMOND dialogue setting considers:

- Three definitions of the term 'sense' to identify a 3D field of synergic sense-making from three angles: 1) sense as meaning (the scientific knowledge perspective), 2) sense as sensation/feeling (the practitioners' knowledge perspective), and 3) sense as a way to/direction (the forward-looking systemic perspective shared by both scientists and practitioners).
- Four fields of simultaneously co-existing systemic relations between agents – represented in the figure as superimposed layers, but tightly interwoven in reality: the ecological, economy & technology, society & culture, and political layers.
- A purpose-driven participatory process with structured dialogues spanning across the different layers, generated by using the Three Horizon scenarios framework.
- The synergic sense-making game players, i.e., the participants involved in the dialogue loops from the different

practical perspectives - policymakers, environmental stakeholders, business and social stakeholders, and citizens – and from nested holistic evidence-based perspectives. The latter are ‘holistic’ insofar as they combine multiple disciplines to explain human behaviour (‘ego-logy’), the economy and innovation dynamics (‘eco-nomy’), the ecosystem dynamics (‘eco-logy’) and finally the influence of historical, societal, and cultural value contexts (‘context-ology’, the focus of social science, art and humanities).⁷

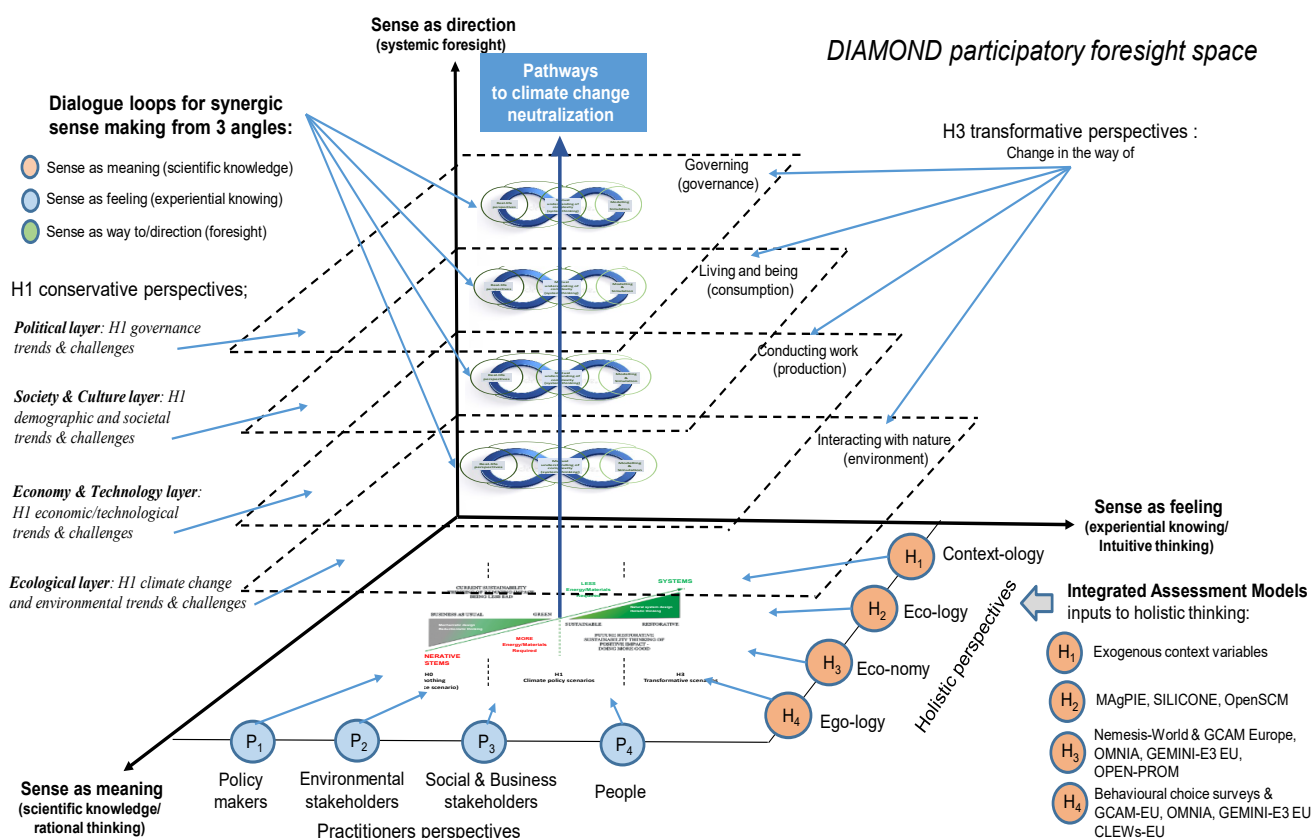


Figure 4. The Diamond participatory foresight space. Source: Own elaboration

In this space — an immaterial boundary object — researchers (modellers) and different groups of stakeholders meet and confront themselves from different perspectives. The scientific evidence-informed modelling of individual/household behaviour, economy, natural processes, and policy regulations must be married with the value-driven mindsets and experiential knowing of lay citizens, business and social stakeholders, environmental stakeholders, and policymakers, to discuss relevant topics in the different macro-layers: ecological, economy and technology, society and culture, and political. Crucially, the process recognises that different social groups imagine the future differently, shaped by their cultural, economic, and political positioning, which affects how they interpret

⁷ It is useful to note that ‘ego-logy’, ‘eco-nomy’ and ‘eco-ecology’ are nested holistic perspectives, i.e. holons, while ‘context-ology’ is key to contextualise any intervention – policy, decision, investment, etc. – in the real-life setting. A holon (Greek: ὅλον, from ὅλος, holos, ‘whole’ and -ov, -on, ‘part’) is something that is simultaneously a whole in and of itself, as well as a part of a larger whole. In other words, holons can be understood as the constituent part-wholes of a hierarchy. ‘Ego-logy’, looking to individuals, ‘Eco-nomy’ looking to economic systems, and ‘Eco-logy’ looking to ecological systems are in an holonic hierarchy. In other terms, holistic thinking considers the individual immersed in nested systems of relations internally with himself (body and mind organisms and functions), and externally in economic (market and non-market) and ecological relations. These systems of relations exist and evolves in concrete geographical, historical, anthropological, and cultural contexts - what human sciences study most (‘context-ology’) - which eventually influence most of the policy makers decisions.

challenges, prioritise needs, and envision desirable transformations.

In this process, conversations *across the boundaries* help participants to disclose the ingrained disciplinary or mental frames — deeply held ways of interpreting reality that influence, for instance, what drives the adoption of certain innovations. Modellers can discover hidden motivations and drivers, that could be feasible to include in a model to build more realistic representations, while stakeholders can overcome mental barriers against innovation by better understanding potential benefits or how to handle trade-offs. This whole process of collective intelligence is being catalysed by sharing the third dimension shown in the cross-disciplinary space graphic, i.e., the imagination of future scenario pathways for climate change mitigation and/or adaptation.

2.3 DIAMOND integrated assessment modelling framework

The first boundary object is purely abstract thinking – the Three Horizons scheme applied to frame transition scenarios. The second boundary object is still immaterial, but more concrete, being a collection of IAMs codified with software procedures and databases. While the first object has the highest interpretive flexibility – it is a shared language for collaborative future thinking that can be adapted to the purpose and context of specific foresight exercises to deliver scenario narratives and policy roadmaps – the second object is unavoidably more rigid.

This dichotomy occurs because models are a code environment that provides a structured testing ground to simulate the effects of hypothetical assumptions, and they can be modified to a certain extent, but never without several limitations that modellers face (e.g., model limitations, data limitations, time limitations). Moreover, models are a broad approximation to reality: they are only as good as the assumptions that go into them, but there will be always relevant aspects that escape quantification and can only be considered in a qualitative fashion in the scenario narratives. Often these qualitative aspects are equally important as simulated outcomes, and they can be fundamental to interpreting some quantitative results. This is also the reason why in DIAMOND we combine the two boundary objects — the participatory foresight framework and the IAMs — to feed forward-looking dialogue loops.

Table 1 summarises the list of models used in DIAMOND. For more information on the models, see project deliverable 'D3.1 Model development strategy' and the I²AM PARIS platform.⁸

Table 1. Models used in DIAMOND

CLEWs
CLEWs is a nexus modelling framework for integrated assessment of resource systems and of interlinkages among energy, water, and agricultural systems as well as their impacts on — and vulnerability to — climate change.
GCAM
GCAM is a dynamic-recursive model with technology-rich representations of the economy, energy sector, land use and water linked to a climate model that can be used to explore climate change mitigation policies.
GEMINI-E3
GEMINI-E3 is a multi-country, multi-sector, recursive computable general equilibrium (CGE) model. It simulates all relevant markets, domestic and international.
NEMESIS

⁸ <https://www.i2am-paris.eu/>

NEMESIS is a sectoral detailed macro-econometric model for the EU used to assess a wide spectrum of policies, including fiscal, budgetary, labour market, research and innovation, energy, climate, and environment.

OMNIA

TIAM is a leading partial-equilibrium, inter-temporal optimisation IAM, based on the TIMES model generator, along with which it has been used to support national and international climate policy. DIAMOND will produce OMNIA, featuring fully open access.

PROMETHEUS

PROMETHEUS is a global energy system model covering in detail the complex interactions between energy demand, supply and energy prices at the regional and global level.

3 The Co-design process

The co-design process elaborates on the stakeholder engagement, which is structured through the involvement of researchers (modellers and experts), policymakers, businesses (i.e., industry and private sector), social and environmental organisations, and civil society representatives, to achieve model co-development and co-creation of policy scenarios and roadmaps.

3.1 The DIAMOND approach and objectives

DIAMOND conducts an open and cross-disciplinary research process based on adjusting and integrating knowledge from the wider IAM community and relevant experts from other scientific disciplines (e.g., psychology, behavioural economics, labour economics), as well as from policy, industry, and civil society stakeholders. This process accompanies and enriches all other methodological modules of the project: it refines the requirements for model improvements (UPDATE & UPGRADE), pinpoints critical aspects for climate action that are currently missing from (or underrepresented in) IAMs (INTEGRATE & EXPAND), jointly co-creates currently unexplored mitigation scenarios to simulate using the improved models (APPLY & EXPLORE), and codesigns communication tools and applications of IAM results that are useful and user-friendly (OPEN). Most co-productive activities take stock of experience/knowledge systematised in the td-net toolbox⁹ of transdisciplinary methods, allowing us to create a community of experts and societal actors that inform project activities based on a distributed model of knowledge instead of a hierarchical one. This cross-disciplinary process helps us explore the multiplicity of perspectives on IAMs, understand how new models and scenarios address concerns from diverse stakeholders as well as map actionable knowledge and ensure usability via participatory development and validation.

Based on this general and conceptual framework, at the end of its implementation path, the DIAMOND co-design process will provide the following key outcomes:

- Co-produce the guiding questions to ensure a transformational impact of our modelling framework in practice.
- Implement an interactive cross-disciplinary approach to inform modelling improvements and ensuing scenarios.
- Validate all project outputs to ensure policy relevance, usefulness in industry, and societal robustness.

3.2 Which types of stakeholders to be involved

As already outlined in the previous chapter, to implement in the most effective manner the DIAMOND cross-disciplinary co-design process, the project involves three groups of stakeholders as shown in Figure 5:

⁹ The [td-net toolbox](#) is an online resource platform containing different methods for systematically co-producing knowledge in heterogeneous groups across science and society.



Figure 5. Types of stakeholders in DIAMOND. *Source: Own elaboration*

In the first group, we engage with the wider community of IAM developers and researchers to involve them in the development of the new, enhanced, open-source IAMs as well as relevant datasets and applications. Key experts to invite include the coordinators of other European or national research IAM-oriented projects in support of climate, energy, and environmental/sustainability policies (e.g., WorldTrans¹⁰, PRISMA¹¹, LOCOMOTION¹², NAVIGATE¹³). To guarantee a robust interdisciplinary integration process, representatives from Social Sciences and Humanities (SSH) disciplines actively participate in the analysis of societal impacts related to climate policies.

In the second group, we invite climate stakeholders and decision-makers concerned with climate policymaking and/or climate change impacts to understand their perspectives, expectations, and requirements. This broad group encompasses several categories, including but not limited to European Commission and national policymakers (including negotiators in UNFCCC processes), local governments, industry stakeholders, business associations, NGOs, unions, and other institutions.

In the third group, we invite citizens and civil society representatives concerned with future impacts of climate change and climate-related actions on everyday life and the ethical acceptability of policy measures to further

¹⁰ <https://worldtrans-horizon.eu/>

¹¹ <https://www.net0prisma.eu/>

¹² <https://www.locomotion-h2020.eu/>

¹³ <https://www.navigate-h2020.eu/>

inform model development and increase societal relevance.

The actor constellation¹⁴ method is used to identify the stakeholders that could contribute to and benefit from the project, acknowledging the increasing complexity of global, multi-level environmental governance (Jänicke, 2008; Feldhoff et al., 2019).

3.3 The Co-design pathway

3.3.1 Multi-stakeholder co-design process

The co-design process (see Figure 6) develops through a path identified by three, closely connected and sequential, phases: it starts with the definition of a common knowledge base and the common understanding of the contents, objectives and limits of the DIAMOND project IAMs, it then follows with co-developing tools and knowledge and ends by jointly validating and assessing the quality of modelling improvements.

Phase 1 – Towards mutual understanding and framing of project goals and requirements (June 2023 – May 2025)

In the first phase of the co-design process, the focus is placed on exploring how IAMs are being perceived by different stakeholders and identifying relevant understandings of current IAM gaps and needs. The ‘but why’ technique¹⁵ (Virapongse et al., 2020) is used to extensively discuss the existing situation and reach to the root causes of problems with current IAMs as well as define research questions from the perspective of different fields of knowledge (project partners) and practice (stakeholders). Moreover, multi-stakeholder discussion groups (Fry, 2021) are employed to ensure that our project asks relevant research questions from the point of view of societal priorities and stakeholder interests and will complement this qualitative approach with representative studies to examine how IAM outputs are understood and interpreted by the public. Based on this multimethodological assessment, WP2 identifies the respective demand for knowledge that the improved IAMs will need to provide. In this context, we also identify citizen-sensitive research topics — i.e., related to behavioural change and societal transformation practices at a small scale, but with the potential to deliver effective impacts if upscaled (Nikas et al., 2020). The main aim of this initial phase is to reach a mutual understanding of models’ interpretations and needs. The output will take the form of research questions from the perspectives of both researchers and stakeholders and of shared co-created research questions that will be used in the next Phase 2 of knowledge co-production to trigger the DIAMOND dialogue loops illustrated in Section 2.2.

During the first period of the project (between deliverable D2.1 submitted on April 2023 and deliverable D2.2 submitted on April 2024), under T2.2, the first two stages of Phase 1 were concluded by ETH in January 2024, with a focus on reaching mutual understanding between DIAMOND partners. Stage 1 focused on familiarising with DIAMOND’s ‘problem space’ and outlined project member perceptions around the DIAMOND mission and opportunities; gaps and limitations of IAMs; and stakeholder engagement barriers and opportunities. Stage 2 focused on reaching mutual understanding within the consortium and exploring how project members envision

¹⁴ According to the Swiss Academy of Sciences (SCNAT), an actor constellation is a role-play, in which all scientific and societal actors involved in a project are represented and positioned around the central research question. The distance from an actor to the research question, and to other actors, expresses how relevant they are in the project.

¹⁵ The ‘but why’ technique is a problem-solving method that involves repeatedly asking the question ‘Why?’ to explore the root causes of issues. By iterating this question, participants can break down complex problems into simpler, more fundamental factors, helping to uncover the underlying issues that contribute to the problem.

different codesign activities, and clarified DIAMOND partner understandings and expectations of stakeholder engagement. The findings of these activities have been integrated into the updated stakeholder strategy (see deliverable 'D2.4 Stakeholder-informed research questions', for more details).

Through these two initial stages of mutual understanding, a set of codesign activities have been produced guided by three core objectives: i) strengthening the external and internal community of practice will allow DIAMOND to learn from other experiences and transfer knowledge on such co-productive processes in IAMs; ii) achieving more effective stakeholder engagement will focus on developing a richer understanding of stakeholders, when to engage them, how to improve communication with them, and how to achieve a heterogeneous representation of stakeholders; and iii) an elaboration on where to focus co-design and co-productive activities in model development. With these three criteria well framed, a rich set of information has been created to be used in Stage 3. Stage 3 commenced in March 2024 and is currently being finalised (expected end May 2025) and it is focused on co-creating a set of research questions with DIAMOND partners and stakeholders that drive model and scenario development.

The codesign activities are designed as multi-stakeholder discussion groups, a flexible, tailor-made format that caters to the different needs depending on the codesign activity. ETH ran these multi-stakeholder discussion groups in parallel with the foresight workshops described in Phase 2 and the results of the two formats aim to feed into one another.

More details on the description of Phase 1, stage 1 and 2, are provided in deliverable "D2.4 Stakeholder-informed research questions" and the forthcoming (May 2025) deliverable 'D2.5 Stakeholder-informed research questions – update' provides details on stage 3 and concludes Phase 1. These research questions will be carried forward into the upcoming foresight workshops.

Phase 2 – Towards knowledge co-production (June 2024 – November 2025)

This is ISINNOVA's main phase of the stakeholder engagement process, involving the different groups of stakeholders either in co-developing the IAM upgrades or in co-producing scenarios making use of the expanded tools. Along with members from the broader IAM community (in collaboration with H2020 ECEMF¹⁶ and the IAMC¹⁷, openmod¹⁸, OpTIMUS¹⁹, CCG²⁰, IEA-ETSAP²¹, IEW²², EMP-E²³, and CLEWs²⁴ communities/networks), we will organise capacity building activities to co-develop new modelling capabilities and harmonise modelling assumptions/inputs in order to address across-the-board gaps and needs of the community. The use of these improvements will not be restricted to the DIAMOND IAMs but will be made available to duplicate in/export to other IAMs accompanied by adequate support and training material. In parallel, we are engaging with the group of stakeholders and decision-makers in scenario planning workshops to envision and assess alternative, feasible, and desirable policy scenarios. We are reflecting on validity problems associated with existing reference/baseline scenarios to which modelling research anchors and subsequently improve these scenarios by accounting for

¹⁶ <https://www.ecemf.eu/>

¹⁷ <https://www.iamconsortium.org/>

¹⁸ <https://openmod-initiative.org/>

¹⁹ <http://www.optimus.community/>

²⁰ <https://climatecompatiblegrowth.com/>

²¹ <https://www.iea-etsap.org/>

²² <https://www.internationalenergyworkshop.org/>

²³ <http://www.energymodellingplatform.org/>

²⁴ <https://www.sparkblue.org/dashboard/CLEWs>

current policies, restrictions, and *game-changing issues*²⁵. Thus, we first understand what ‘we are currently looking at’ before grasping ‘what we need to do against that’. For this, we are employing the ‘strategic foresight’ methodology (Iden et al., 2017), a systematic approach for stakeholders to look beyond current expectations, account for a variety of plausible future developments, and identify implications for policies. More in detail, we apply here the heuristic approach to cross-disciplinary integration described in Section 2.2 to frame six dialogue loops focused on the DIAMOND WP4 planned extensions. In addition, an ‘ethical foresight’ approach (Floridi and Strait, 2020) will be used to engage with our citizen group, looking into the ethical implications of technology development and policies, focusing on what is actually feasible in everyday practice, and prioritising — within this — what is environmentally sustainable, socially acceptable, and preferred by the citizens (see section 3.3.3.1 below). This will be complemented by representative surveys allowing us to make assumptions about the support of various policies and scenarios in the public as well as associated risk perceptions. Through this approach, we will define reference scenarios and model improvements for IAMs that respond to the most relevant citizens’ concerns, perceptions, needs, and desires. As described in section 3.3.3.2 below, climate-friendly practice workshops with citizens will be organised to develop scenarios for a sustainable transition based on local practices and behavioural shifts that could be transformed into powerful, bottom-up actions for climate mitigation and adaptation, drawing from recent experience of consortium partners in H2020 projects (e.g., Nikas et al., 2021).

Finally, the outputs of the strategic and ethical foresight exercises will be synthesised in Task 2.3.3 using a Situation Analysis (Task 2.3.3). This qualitative interpretative method will explore the multiplicity of perspectives as they emerge in the dialogue loops structured with the heuristic cross-disciplinary integration approach described in Section 2.2.

Phase 3 – Towards model co-ownership (June 2025 – October 2026)

In the last phase, all stakeholder groups will be brought together to jointly validate and assess the quality of the modelling improvements and resulting scenarios with respect to scientific robustness and contribution to the IAM community (researchers), practical relevance (decision-makers, industries, and NGOs), and societal robustness²⁶ (civil society). WP2 different tools from the Td-net toolbox, such as emancipatory boundary critique (Pohl, 2020) to uncover the priorities and assumptions of the different stakeholders within project outputs — for instance, system boundaries that were set when creating the new IAMs and aspects that were stressed or neglected in defining scenarios. To evaluate the impact of implemented model improvements and scenarios and discuss them considering stakeholders’ interests, methods such as the ‘most significant change’ method (Wülser, 2020) will be used. Finally, we will identify potential impacts that the project can achieve in the mid- and longer term.

²⁵ Game-changing issues refer to disruptive or transformative developments that can significantly alter existing socio-economic or environmental pathways — for instance, geopolitical instability, pandemics, breakthrough technologies (such as AI or carbon capture), major shifts in public policy (e.g., Green New Deals), or social tipping points (e.g., widespread civil mobilisation around climate action).

²⁶ Societal robustness refers to the perceived legitimacy, relevance, and acceptability of the models and scenarios across a diverse social spectrum, considering whether outputs resonate with citizens’ values, priorities, and lived experiences.

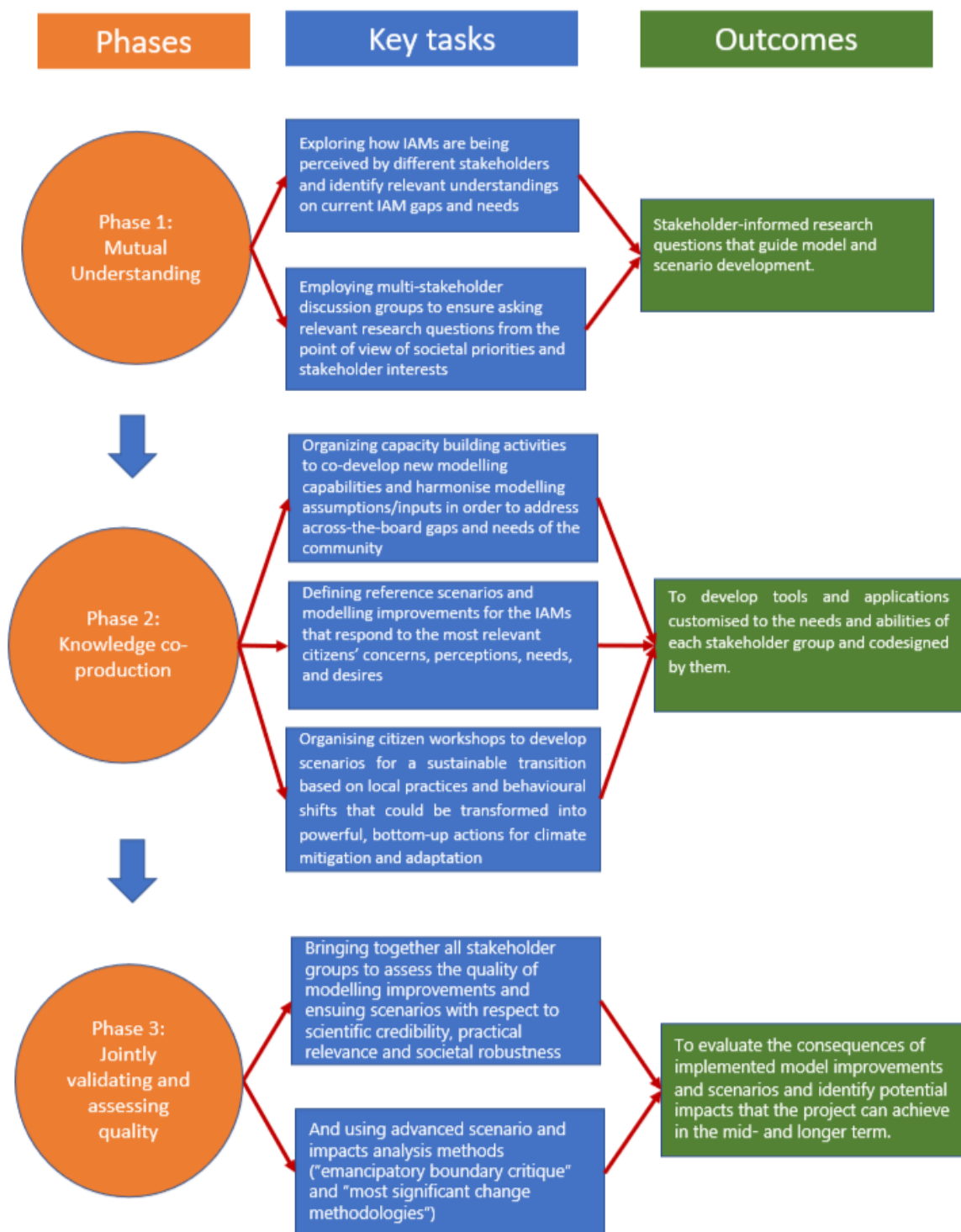


Figure 6. The co-design pathway in DIAMOND. Source: Own elaboration

3.3.2 Interactions of the stakeholder engagement strategy with other project work packages

The DIAMOND project aims to collaboratively formulate research questions, validate the implementation process and model development, and enhance the communication, usability, adoption, and societal relevance of modelling outcomes. In pursuit of these objectives, the entire framework of the DIAMOND project is

operationalised using a heuristic cross-disciplinary integration methodology for co-developing models and scenarios, applying them to scenario design, and engaging in policy roadmap creation exercises. Recognising that knowledge flows across communities with diverse disciplinary and stakeholder perspectives, this approach ensures a policy-oriented (demand-driven) yet objective (rigorous and scientifically credible) dissemination of comprehensive (analytical and detailed) yet understandable information to all researchers and policymakers/stakeholders involved.

Additionally, this integrated approach facilitates seamless interaction with other work packages within the project. By leveraging cross-disciplinary insights and collaborative efforts, the project aims to optimise the co-creation and application of models, scenario building, and policy roadmap development across different phases and components. This interactive engagement fosters synergies, enhances the relevance and impact of project outcomes, and promotes effective knowledge dissemination within and beyond the DIAMOND project framework.

A robust stakeholder engagement strategy is essential for ensuring the success and impact of the project's objectives across various work packages. A key aspect of this strategy is the interaction of the stakeholder engagement strategy with other work packages within the project framework. There exists interconnections and synergies between stakeholder engagement activities and various project components. Stakeholder inputs and feedback should contribute to the advancement and refinement of project objectives across different WPs, as illustrated in the following sub-sections.

3.3.2.1 WP3 – Update & Upgrade

One of the main objectives of DIAMOND is to update and expand existing IAMs, incorporating stakeholder information and the potential interconnection with bottom-up sectoral models, in order to overcome existing limitations and make sure that the outcomes produced will be robust, trustful, and socially relevant. While these models have largely contributed to global and regional policymaking and climate change mitigation strategies (Weyant, 2017), scientific literature has pointed out some weaknesses or areas of improvement that should be considered for the robustness of future IAM applications. For example, IAMs have frequently been considered as black boxes, with opaque input assumptions that do not allow a full understanding of the uncertainties embedded in the produced outputs (Pfeninger et al., 2018). Other critiques note the limited representation of socioeconomic and political barriers that different policymakers face in the implementation of alternative policies (Peng et al., 2021).

Model development in WP3 will ensure open access, transparency, and the ability to address the most relevant research questions from different stakeholders and policymakers at different scales. The main features of each model, e.g., regional, sectoral and technological coverage, as well as scenario/policy-specific information such as implementable policies and mitigation measures have been collected through an internal survey. This information is crucial to collect and incorporate stakeholder inputs on how model development can meet their needs, which will be an important input for the final model development plans.

In order to incorporate stakeholder insights into each model in an effective and efficient way, the modelling teams need to identify the research questions that stakeholders want to address and use stakeholder information to identify the most crucial aspects to be improved (i.e., geographical and temporal scales, sectoral coverage, input information and assumptions, misrepresented dynamics and uncertainties, and interconnection with additional sectoral models). As an initial step, modellers established 'clear asks' directed towards the relevant stakeholder. This information was then utilised, for example, during the Requirements Workshop to ensure that stakeholder input was effectively integrated into the modelling process. Following this, WP2 is closely collaborating with WP3 to engage pertinent stakeholders in contributing technical insights to inform the modelling process. More details

on the model development strategies can be found on deliverable 'D3.1 Model development strategy'.

3.3.2.2 WP4 – Integrate & Expand

In WP4, DIAMOND expands IAM capabilities by integrating models, theories, and insights from a diversity of disciplines, including behavioural economics, psychology, finance research, labour economics, and climate science. A key output from this will be a series of fully-fledged integrated assessment frameworks with capabilities that transcend the scope and capacity of individual IAMs operating separately.

Comprehensive cross-sectoral insights and methodologies from social sciences are reflected in DIAMOND to assess lifestyle changes and desirability, alternative growth and welfare, as well as labour diversity/shifts. Considering the WP4 planned extensions, researchers from diverse communities are guided to build common understandings of their shared questions, early integrating findings from the following fields of practice considered in the project:

- Circular economy and climate change mitigation;
- Land use and nature-based solutions;
- Household heterogeneity and distributional impacts;
- Refining climate mitigation strategies assessment;
- Integrating finance, labour dynamics and novel operationalisation of well-being;
- Improving the electricity system assessment;
- Behavioural change and ethical issues of climate change neutralisation.

Effective collection of research questions requires careful consideration of the project's scope, objectives, and desired outcomes. It involves input from diverse stakeholders, including subject matter experts, collaborators, and end-users, to ensure that the questions reflect the broader context and address relevant issues. By systematically gathering and refining research questions, DIAMOND will establish a strong framework to pursue the integration and expansion of IAMs.

3.3.2.3 WP5 – Apply & Explore

The engagement of different stakeholders for scenario development and policy analysis has become essential for the trustfulness and social acceptance of IAM results (Miller & Wyborn, 2020). While IAM modellers use stakeholder inputs to better represent certain model parameters or dynamics, stakeholders have only recently started to be part of the scenario design (Nikas et al., 2023). The co-creation and co-production of alternative scenarios, taking onboard collective stakeholder insights, is an active research line for the IAM community to produce results that are more meaningful and socially relevant. In addition, stakeholder information is key to identifying model weaknesses and potential improvements.

Either formulating new or improving existing scenarios requires planning to ensure adequate stakeholder engagement. Work package 5 (WP5) focusing on scenario development began its tasks in collaboration with WP2 during January 2024, and multi-stakeholder discussion groups are organised as part of Task 2.2 (Phase 1; see above) that feed into and run in parallel with the foresight workshops. Stakeholders are going to be engaged early on for 'Task 5.1 Unpacking scenario pipeline uncertainties', with other Tasks progressively starting to scope the new scenario definition space and prioritisation in 2024. The model developments (WP3) and extensions (WP4) link to the applications in WP5 (Tasks 5.2-5.5) and there are various steps of harmonisation to ensure consistency across stakeholder engagements in the different WPs. Engaging stakeholders early on aids in identifying synergies

with other tasks in WP3 and WP4, which acts as one of the criteria for prioritising the development and expansion of the models.

3.3.2.4 WP6 – Open

DIAMOND establishes and sustains an active network of IAM developers and users, including the wider development teams of the project models (GCAM, IEA-ETSAP, OSeMOSYS/CLEWs), the modelling landscape (via IAMC, EMF, ECEMF, EFECT), and open modelling consortia (openmod, OpTIMUS, etc.). Using the strong ties of DIAMOND partners to these communities/projects, the project invited members of this network to participate in our codesign activities, developing and evaluating all project's outputs. Moreover, the importance of interacting with other modellers within a community of practice (CoP) is widely acknowledged. In the interest-influence matrix activity in the Stage 2 workshops held by ETH Zurich, WP6 was mentioned in relation to a CoP where people imagined collaborative and consulting interactions in the CoP. As an initial step to building a CoP, WP2 supported a series of outward facing webinars led by WP6 that introduced the DIAMOND project to modellers who might be interested in being part of a CoP. Priority was given to DIAMOND's sister projects. We also recommend that DIAMOND invites projects of interest to present their work, with specific focus on codesign in IAM development. More details on these activities will be described on deliverable 'D2.5 Stakeholder-informed research questions – Update'.

3.3.3 Citizens' involvement

3.3.3.1 Why do we need to involve citizens?

In the process of building a mature information and sustainable society, the real challenge is not only building technological innovation but also governance of social and ethical impacts. Ethical foresight is crucial to explain why the socio-political dimension needs to involve ordinary citizens to lay down the foundations for our mature information and sustainable societies.

When policymakers, both in political and business contexts, wonder why we should engage in moral evaluation when legal compliance is already available, the answer should be clear: compliance is necessary but insufficient to steer society in the right direction. Ethical problems matter and we must engage with stakeholders dealing with such ethical problems. Regulations indicate what the legal and illegal moves in the game are, but they say nothing about what the good and best moves could be to have a better society (EDPS Ethics Advisory Group, 2018). So, the task of ethical foresight is not simply to forecast the most plausible future developments, but also to determine which ones should grow and which ones should not. In other words, we need to anticipate and steer the ethical development of technological innovation. We can do this by looking at what is actually feasible, privileging firstly what is environmentally sustainable, secondly, what is socially acceptable and finally, ideally, choosing what is socially preferable (Floridi, 2018).

3.3.3.2 Climate-friendly practice workshops

Public engagement plays a vital role in fostering understanding, collaboration, and informed decision-making within communities, ultimately shaping policies and initiatives that reflect diverse perspectives and address shared concerns (Pidgeon, 2021). Citizens and civil society representatives concerned with future impacts of climate change and climate-related actions on everyday life and the ethical acceptability of policy measures will be involved within DIAMOND through climate-friendly practice workshops, taking inspiration from the transition

practice workshops held in the ENABLE.EU Horizon 2020 project²⁷. The DIAMOND Climate-friendly Practice Workshop will aim to elicit the opinions of 40 citizens to further inform model development and increase societal relevance. The results of the workshop will also feed the exploitation plan with possible replication opportunities of the DIAMOND approach into other projects. The workshops are tentatively scheduled for September 2025.

Ethical foresight workshops with citizens will attempt to better understand people's values, beliefs and habits that influence everyday consumption practices, including transport use and households' investment in durable goods and services, and to reflect on how these, at the aggregated level, contribute to global warming and climate change, with the help of IAM-based analyses.

Within the DIAMOND project, climate-friendly practice workshops will be designed to produce ethical foresight and public validation, supplementing WP4's behavioural approach. These workshops will ask citizens' opinions to further inform model development and increase societal relevance. They are also expected to feed the exploitation plan with possible replication opportunities of the DIAMOND approach into other projects.

Climate-friendly practice workshops will aim to engage a heterogeneous and diverse set of participants, as those which have been identified in current climate citizens' assemblies at the local level, specifically in Italian cities like Milan, Florence, Bologna and Trento, to examine changes in behaviour towards climate-neutrality and willingness to adopt sustainable consumption practices. These assemblies typically include individuals already concerned or engaged with climate issues; therefore, we acknowledge the limitations of this selection in fully capturing the views of disengaged, doubtful, or marginalised citizens, including underrepresented groups such as youth and low-income communities. To address this, efforts will be made to enhance the diversity of perspectives, particularly by ensuring gender balance among participants, so that a broad range of gender-related views and lived experiences are reflected in the discussions. Participants will be representative of the broad spectrum of backgrounds and perspectives in these existing participatory processes. The workshop agenda will be adjusted in a manner such that the emphasis on participation will be in alignment with the survey findings to be able to cater to the diverse interests and needs of the participants. The citizens will be invited to: i) identify socially acceptable and desirable practices to simulate in the IAMs; ii) provide opinions on whether reference scenarios are consistent with their perceptions, needs and aspirations; and iii) envision actionable practices and behavioural change to more sustainable scenarios.

The workshops will establish an interactive discussion on concrete choices and the implications of these on sustainability, engaging participants in constructive dialogue to explore actionable practices and behavioural shifts that contribute to more sustainable scenarios. Through the discussion, participants may exchange valuable experience and know-how and add value to the qualitative understanding of climate-friendly practices.

A key part of the workshops is building people-oriented questions based on citizens' everyday experiences and concerns: energy at home, mobility, food, and waste. The questions are meant to form the foundation of discussion of what practices are regarded as preferable and socially acceptable to simulate in IAMs in a manner that embeds modelling efforts in real-world perceptions and aspirations.

DIAMOND partners have expressed a need to increase engagement with a diverse range of civil societies and NGOs. These actors can guide research questions and include elements that may not have been considered before in scenario development. Partners think that involving citizens from all spheres is important. The private sector is an important and largely missing stakeholder group which can inform modellers on technology developments as

²⁷ <http://www.enable-eu.com/>

well as policy adaptability and feasibility. Government and institutions are also important because they play important roles in decision-making, but here partners pointed out that government at different levels needs to be included, even local.

The following Section presents details on the stakeholder engagement plan, including timelines of the abovementioned outlined activities.

4 Stakeholder engagement plan

4.1 Organisation of stakeholders mapping and database

The DIAMOND project emphasises heterogeneous and inclusive stakeholder engagement as a critical aspect of its approach to addressing climate change mitigation. It recognises the importance of ensuring a balanced representation of actors who are influenced by or influence climate change dynamics. This approach aims to foster collaboration and consensus-building among diverse stakeholders to enhance the relevance and impact of the project's outcomes.

To achieve this goal, DIAMOND has implemented a comprehensive and continuously updated strategy for identifying, engaging, and maintaining the involvement of relevant stakeholders throughout the co-design process. This strategy involves several key components:

- **Stakeholder identification and inclusion:** The project takes a rigorous and ongoing approach to identifying and including all relevant stakeholders in the co-design process. This process is designed to be inclusive and transparent, ensuring that stakeholders from various sectors, disciplines, and geographic regions are represented. Stakeholder identification is not a one-time event but a continuous process, particularly before each participatory activity, to ensure that the stakeholder landscape remains dynamic and reflects the evolving needs, priorities, and perspectives of all involved.
- **Continuous engagement:** The project is committed to keeping stakeholders engaged over the duration of the project. This includes regular communication, updates, and opportunities for collaboration and feedback to ensure ongoing participation and commitment.
- **Examining stakeholder types and contributions:** The project examines the different types of stakeholders involved and their expected contributions to the project. This analysis considers the specific interests, expertise, and capabilities that stakeholders bring to the table, ensuring that their involvement is meaningful and productive.

A critical aspect of the stakeholder engagement strategy involves mapping stakeholders across different layers, tailored to the specific needs of different project tasks. This tailored approach ensures that stakeholders are appropriately engaged based on their relevance to specific aspects of the project. Understanding which stakeholders would be most useful involves a nuanced assessment of their expertise, perspectives, and potential contributions.

To implement the DIAMOND cross-disciplinary co-design process in the most effective manner, the project involves three groups of stakeholders, as described in the preceding deliverables D2.1 and D2.2:

- a) the wider community of IAM developers and researchers, to involve them in the development of the new, enhanced, open-source IAMs as well as relevant datasets and applications,
- b) climate stakeholders and decision-makers concerned with climate policymaking and/or climate change impacts, to understand their perspectives, expectations, and requirements,
- c) citizens and civil society representatives concerned with future impacts of climate change and climate-related actions on everyday life and the ethical acceptability of policy measures, to further inform model development and use in order to increase societal relevance.

ISINNOVA organises the process of managing the database of stakeholders to be involved in DIAMOND. The database contains the following fields:

- Name
- Surname
- Email
- Partner Reference
- Organisation
- Individuals' position within the organisation
- Main fields of activity/interest: *Agriculture, Citizen Association, Climate, Construction, Economy, Energy, Engineering, Food, Health, Labour, Model development, Natural Environment, Policy government, Social sciences and humanities (SSH), Technology, Transport/mobility.*
- Country
- City
- Category: *Academia, Cities Network, Consultant, EU policymaker, International Agency, Local Energy Agency, Local Government, National Agency, National Government, NGO, Private sector/Industry, Regional Government, Research Center, Trade Union.*
- Level of Activity: *Global, National, Regional, Local.*
- Date of registration

During the initial development of the database, more than 300 relevant stakeholder contacts from all project partners were gathered, with the aim of ensuring a good balance of stakeholders across groups (and gender).

In order to have heterogeneous stakeholders involved in DIAMOND, partners reviewed the breakdown of the stakeholder database and noted key stakeholder groups/backgrounds missing and how to fill those gaps. By doing this, partners were involved in ensuring that the database is heterogeneous through their active participation in searching for and adding stakeholders of interest. The database is continuously refined and enlarged after each activity, driven by a snowball effect where both partners and stakeholders contribute to expanding its diversity. Ensuring a heterogeneous representation of stakeholders is very important to the success of effectively co-producing model developments that represent society more accurately. It is crucial, during initial engagements with stakeholders, to effectively communicate DIAMOND's expectations and in turn receive feedback and perceptions of those expectations from stakeholders, as well as incorporate stakeholder perceptions and expectations into the codesign focus.

4.2 The introductory survey: register in the DIAMOND stakeholder pool

Based on this initial stakeholder mapping, stakeholders have been contacted starting December 2023 via a survey to express their interest in joining the project activities, on the merits of their previous contact with each project partner. As core members of the co-design process, they have been told that they may be invited to participate in a series of events and/or activities, including but not limited to foresight workshops, bilateral meetings/interviews, discussion groups with other stakeholders, and surveys, always in consideration of their valuable time. For example, in the first phase of this process, they will be invited to participate with other experts in three strategic foresight workshops described in the next section.

The survey asks for permission to contact the stakeholders again in the context of this project and allows us to understand their interest in and level of knowledge of IAMs. A total of 73 experts completed the survey, 53 of

whom expressed interest in participating in DIAMOND collaborative activities such as workshops. The rest agreed to participate in project-related online surveys rolled out by the consortium and/or to be kept informed of the project activities and results (e.g., by around 6 newsletters per year). Following GDPR guidelines, only stakeholders who provided their permission to be contacted again will be kept as part of the DIAMOND stakeholder database. In the survey, we made sure to include all necessary disclaimers for stakeholders to be able to exercise their rights based on GDPR guidelines. Stakeholders that did not respond will not be part of the database. It therefore falls to the partners' jurisdiction whether they can be invited through personal communications (depending on their previous contacts and familiarity — always in respect of GDPR rules).

The summary of the survey results is shown in Figures 7-9 below.

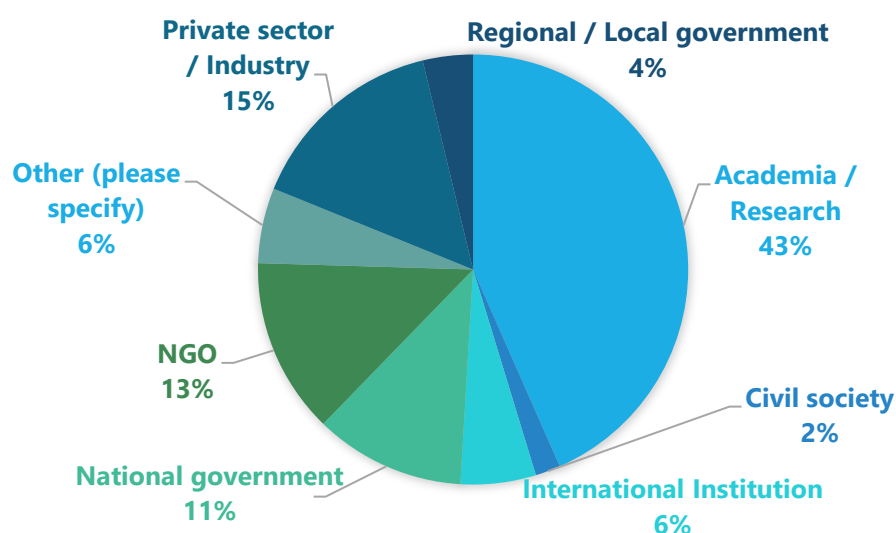


Figure 7. Professional capacity of the stakeholders that agreed to participate in collaborative activities

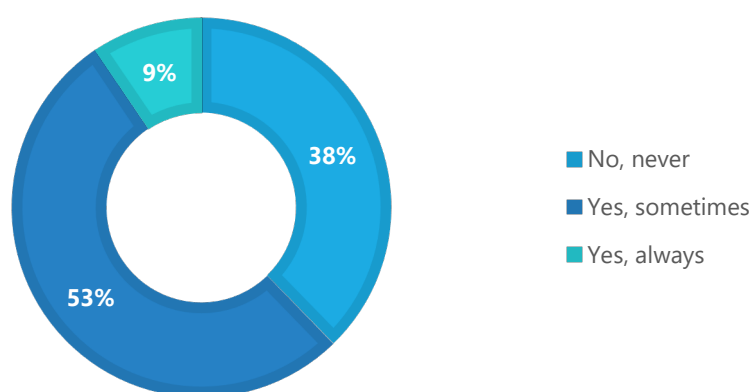


Figure 8. Familiarity with IAMs of stakeholders agreeing to participate in collaborative activities

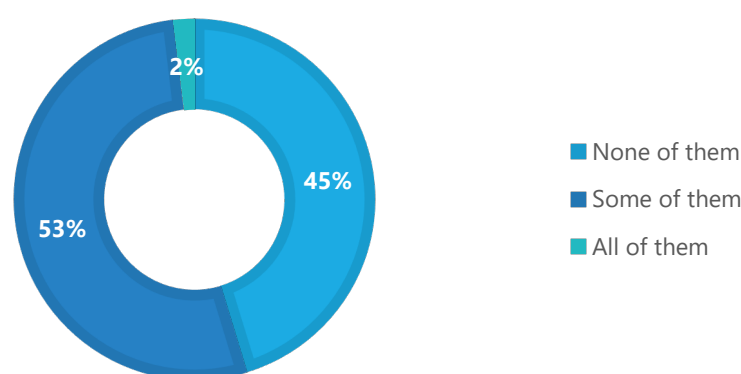


Figure 9. Familiarity with the project IAMs of stakeholders agreeing to participate in collaborative activities

The respondents' fields of expertise cover a wide range of disciplines²⁸, such as sustainability, energy, climate change, economics, and policy. Table 2 provides a categorised summary of the areas of expertise based on the provided open-ended response.

Table 2. Disciplines and Areas of Expertise of the stakeholders

Discipline	Areas of Expertise	Num. Stakeholders
Energy and Climate Modelling	- Long-term energy planning - Energy decarbonization scenarios - Renewable energy power system integration - Energy system modelling (Vensim, CGE, TIMES) - Carbon pricing policy and market modelling - Energy scenario interface and user interaction - Energy system analysis and modelling - Capacity development in energy systems	21
Economics and Policy	- Ecological economics - Macroeconomics - Climate economics - Economic modelling and integration with energy systems	16

²⁸ Some stakeholders may possess expertise spanning multiple disciplines. Therefore, their contributions and perspectives may reflect diverse knowledge areas within the project's scope.

	• <i>Climate change policy and mitigation scenarios</i> • <i>International macroeconomics and finance</i> • <i>Legal regulation in renewable energy</i>	
Sustainability and Sustainable Development	• <i>Sustainability sciences</i> • <i>Social and ecological sustainability</i> • <i>Integrated assessment of urban resource systems</i> • <i>Sustainable development policy and analysis</i>	6
Systems Analysis and Modelling	• <i>Integrated land use modelling (bottom-up IAMs)</i> • <i>Macroeconomic implications of climate policies</i> • <i>Energy system capacity expansion modelling</i> • <i>Life cycle assessment (LCA) and sustainability analysis</i> • <i>Linear programming for energy systems</i> • <i>Social lifecycle assessment</i>	7
Technology and Engineering	• <i>Energy system engineering and planning</i> • <i>Energy access and open-source software engineering</i> • <i>Mobility and urban transportation planning</i> • <i>Engineering for energy transition</i> • <i>Assessment of energy and transport technologies</i>	9
Stakeholder Engagement and Participation	• <i>Participative research methods and stakeholder engagement</i> • <i>Barriers and enablers of collective forms of energy-citizenship</i> • <i>Stakeholder engagement in energy communities</i>	4
Other Expertise Areas	• <i>Risk modelling and reliability analysis</i> • <i>Project management and strategy development</i> • <i>Applied ethics, research ethics, and epistemology</i> • <i>Conservation, agriculture, agroforestry and biotechnology</i> • <i>Comparative politics and international cooperation</i>	9

These diverse areas of expertise reflect a comprehensive approach to addressing complex challenges related to climate change, energy transition, sustainability, and policy formulation. The respondents' collective knowledge and skills encompass various dimensions of sustainable development, offering valuable insights and contributions

to the DIAMOND project's objectives and activities. The stakeholder database will be a vessel in all activities related to co-creation and engagement in WP2.

4.3 Planning of the stakeholder engagement events

4.3.1 Phase 1 – Towards mutual understanding and framing of project goals and requirements

Phase 1 is methodologically based on the concept of 'joint-problem framing' indicated by the transdisciplinary scientific literature as the initial step within a fruitful stakeholder engagement plan. The aim and output of this phase is a set of stakeholder-informed research questions, which are co-created in three stages. Stage 1 is a familiarisation stage, aiming to find common ground among DIAMOND partners and their work. Stage 2 focuses on reaching a mutual understanding of the goals and aims of the transdisciplinary approach to be implemented by DIAMOND partners. These two stages conclude in actions falling under three themes. These themes include: (a) strengthening internal and external communities of practice, (b) focusing codesign activities, and (c) improving the effectiveness of stakeholder engagement. Outstanding activities and a detailed description of this phase are provided in deliverable "D2.4 Stakeholder-informed research questions".

Stages 1 and 2 were conducted by ETH between March and November 2023. Methods used in these two stages include seven in-person focus groups, two online workshops, and two surveys. The data was analysed using a situational and thematic analysis approach. Stage 1 produced takeaway questions that were further explored in Stage 2. The outcomes of the first two stages are picked up in Stage 3, which commenced in January 2024 and will conclude Phase 1 of DIAMOND's codesign process in May 2025, with the output of a final set of stakeholder-informed research questions, to be presented in deliverable D2.5 (update of deliverable D2.4).

The methodological approach of Stage 3 includes 10 co-design modules divided into three groups that will be developed based on the scenario themes outlined in WP5 to inform a novel scenario space. The groups and their modules are: Land use and forestry (1 & 2) and Climate Change Impact (Group 1: Climate Change Scenarios) ; Sustainable Development Goals (SDGs), Disruptive events, and Circular Economy (Group 2: Climate Action Scenarios) Labour, Finance, and Household heterogeneity and behaviour (Group 3: User-driven scenarios). Within each module, research questions are co-designed with stakeholders through multi-stakeholder discussion groups, which meet multiple times in a facilitated and equal footing exchange process. Participants represent diverse stakeholder groups from science and practice, including civil society, private and public sectors, and academia.

The results, including the research questions will be published in May 2025 in 'D2.5 Stakeholder-informed research questions – update'. In June 2025, ETH will conduct one additional workshop with DIAMOND partners to integrate the co-designed questions into the work plan and upcoming tasks.

4.3.2 Phase 2 – Towards knowledge co-production

This phase aims to involve the different groups of stakeholders either in co-developing the IAM upgrades or in co-producing alternative, feasible, and desirable policy scenarios that respond to the most relevant stakeholders' and citizens' concerns.

4.3.2.1 Strategic foresight workshops with stakeholders (Task 2.3.1)

A core element of stakeholder engagement within the DIAMOND project is organising participatory foresight workshops informed by cross-disciplinary integration methodologies and leveraging the Three Horizons foresight framework, introduced in Section 2.2, to drive collaborative policy scenario building and long-term impact

assessment exercises.

Key research questions are being developed to guide model co-development, scenario building, and the co-creation of policy roadmaps, emphasising a participatory approach that incorporates insights from societal actors. This collaborative process ensures that scenario-building efforts are inclusive, relevant, and aligned with stakeholder needs and expectations.

One of the key objectives of the strategic foresight workshops is to integrate IAM developers into the discussion process. This integration allows for the exploration of broad and overarching questions related to climate action. The workshops enable modellers to interact with stakeholders from various sectors and disciplines, translating technical insights into accessible and actionable strategies. By engaging with modellers, stakeholders can contribute their expertise and perspectives to shape the development of scenarios and policy roadmaps. This integration ensures that modelling efforts align with real-world needs and priorities, promoting the relevance and applicability of project outcomes.

Three main workshops are organised via online conference platforms with interactive tools, such as *inter alia* a MURAL²⁹ board, supporting the interaction and lasting approximately 3 hours. The first two workshops have already taken place, and the third one is scheduled to occur soon (June 2025).

- **Requirements Workshop:** co-define the requirements of IAM improvements to best respond to relevant stakeholders' concerns.
- **Reference Scenarios Workshop:** validate realistic reference scenarios describing where we are heading based on current policies.
- **Alternative Scenarios Workshop:** envision and assess alternative/desirable policy scenarios.

For each event, ISINNOVA:

- ensures a transparent and inclusive participation process and timely invitation,
- prepares and sends background documents to the participants before each workshop (a brief is shared containing information regarding the project, aims and progress as well as the agenda and the objectives of the related workshop),
- applies the facilitation techniques most suitable for the workshop aims and participants, and
- drafts workshop reports to be then analysed to gather insights for the next stages.

The workflow is articulated in three consecutive steps as follows: the preparatory step phase, the on-stage step (online delivery) and the reporting step:

I. **Preparatory step:**

- Workshop organisation: selecting dates, streamlining the invitation process, and defining workshop roles. Efforts are made to send an invitation to workshop participants a month before the workshop.
- Workshop operational design: selection of facilitation techniques and supporting tools, preparation of agenda, workshop guide and report template. A draft is shared with the project partners no later than two weeks before the workshop.
- Workshop brief: prioritising comprehensible items to be presented to the workshop participants thus

²⁹ <https://www.mural.co/>

allowing swift and effective interaction during the workshop sessions. A brief is sent to the workshop participants no later than one week before the workshop.

Following, the mutual understanding principles set forth in Phase 1, continuous interactions between project partners take place to ensure that the workshops' scope and structure are useful for the activities of DIAMOND.

II. **On-stage step:** The three specialised workshops follow a similar structure:

- In the first session, the team briefly recaps the workshop objectives and methods.
- In the second session, interactive breakout rooms are moderated by a member of the team to gather inputs from the participants. Though it is challenging to ensure that each participant has a chance to express their views, this constraint can be satisfactorily addressed by making use of boards and polls, which allow participants to contribute. Nonetheless, efforts are made to ensure that all voices are heard within the workshops.
- In the third session, a plenary discussion is held to compare and summarise the group's discussion findings (qualitative and/or quantitative).

For each workshop, the following roles are distributed among the DIAMOND team members:

a. *Moderator and rapporteur:*

- Remind participants of the task and encourage the initiation of the discussion;
- Monitor and announce the remaining time for each breakout room;
- Try to keep the discussion on topic by bringing it back if it starts to drift. Prompts are provided for each activity;
- Ensure all participants have a chance to contribute to the discussion: encourage non-contributing participants to engage;
- Double-check that the breakout rooms operate as intended;
- Capture the key points of the discussion;
- Synthesise all different perspectives;
- Share the highlights of the discussion during the plenary session in roughly 5 minutes.

b. *Discussant:*

- Have the technical role of co-host to share slides;
- Present the project and the relevant model(s) to the discussion in roughly 15 minutes;
- Try to be as receptive as possible to participants' ideas and sensitivities;
- Intervene in the discussion when explicitly requested by participants and/or moderator;
- Monitor the chat to capture questions, comments, or relevant input from participants.

c. *Note taker:*

- Have the technical role of co-host to facilitate the operation of breakout rooms;
- Capture the discussion by taking as many notes as possible (depending on the rules of the workshop; e.g., whether the Chatham House Rule applies or not);
- Responsible for troubleshooting and flagging quotes or insights for follow-up or reporting.

III. **Reporting step:** To summarise workshop results and feed them to the next stages of the project in order to influence model development and drive applications that are customised to the needs and abilities of each stakeholder group.

Table 3. Updated structure and timeline for the organisation of stakeholders' workshops

WHAT	HOW			WHEN	WHO
	Mode	Methodology	Frame		
Requirements	Online	3H	- Breakout rooms - MURAL support	September 2024	- Team facilitators - Stakeholders
1 st Foresight WS	Online	3H	- Breakout rooms - MURAL support	November 2024	- Team facilitators - Stakeholders
2 nd Foresight WS	Online	3H	- Breakout rooms - MURAL support	June 2025 (tbc)	- Team facilitators - Stakeholders

4.3.2.2 Requirements Workshop (September 2024)

The first workshop with stakeholders in the DIAMOND project was the Requirements Workshop, which served as a foundational step in aligning stakeholder needs and expectations with modelling objectives. The Requirements Workshop aimed to kickstart collaborative efforts between modellers and stakeholders. Its primary objective was to confront and reconcile the expectations of both parties, ensuring a shared understanding of useful and feasible stakeholders-driven research and IAM application. In this workshop, we intended to co-define the requirements of IAM improvements to best respond to relevant stakeholders' concerns. This workshop was particularly relevant for WP3 and WP4.

The workshop aimed to engage stakeholders who represent the research modelling community and use IAMs within specific sectors. By involving these stakeholders, who have domain knowledge for model building and sectoral use, the workshop ensured interdisciplinary collaboration and knowledge exchange. Such engagement ensures that IAMs are not only technically robust but also useful and meaningful in terms of being applicable to real challenges of different sectors.

The expected outcome of the Requirements Workshop was a set of stakeholders-driven priorities that IAM researchers will use to guide model improvement and scenario design, such that IAM research aligns with stakeholder interests and priorities. The full report of the Requirements Workshop is found in section 5.1.

4.3.2.3 1st Foresight Workshop (November 2024)

The 1st Foresight Workshop was the project's first workshop that employed the foresight methodology, centred on scenario development. This workshop was renamed from Reference Scenarios Workshop in the previous version on the stakeholder engagement strategy due to the dynamic nature of our approach. We aim to be adaptable, adjusting our plans along the way as we learn new insights and receive stakeholder feedback. This rebranding was intended to clearly communicate to all participants that the foresight aspect of the scenario development process is of utter importance.

The workshop focused on the validation of realistic reference scenarios representing the trajectory based on current policies and practices. The overall objective of the 1st Foresight Workshop was to validate and refine reference scenarios describing the projected future trajectory based on current policies and trends.

During the workshop, participants analysed and discussed research questions on scenario development, i.e., those investigated under WP5. These acted as beacons for scenario design and guided us to identify key areas of research and analysis in the future. Research questions and task queries from WP5 were shared with the

stakeholders to receive reactions and inputs, allowing for the alignment and enhancement of scenario parameters based on diverse perspectives and expertise.

DIAMOND partners felt that stakeholders tend to misinterpret that IAMs project (scenarios) and not predict (forecasts), and that internally the distinction between these two approaches had to be made apparent.

Concrete scenarios developed during the workshop were based on stakeholders' feedback and participation. With the inclusion of stakeholders' feedback and insights, the scenarios were envisioned to become more robust, relevant, and mirror real-world dynamics. The full report of the 1st Foresight Workshop is available in section 5.2.

4.3.2.4 2nd Foresight Workshop (June 2025)

The 2nd Foresight Workshop, Alternative Scenarios Workshop in the previous version on the stakeholder engagement strategy, is the last activity of the DIAMOND project's strategic foresight process, wherein the objective is to imagine and assess alternative and improved policy scenarios. The workshop is a place where stakeholders and modellers can browse new and innovative pathways out of current trajectories. By exploring alternative scenarios, participants can assess — based on their expertise and perspectives — the potential impacts of different policy measures, technologies, and societal changes on climate action. Through scenario-building exercises and group discussions, the workshop will encourage creativity and critical thinking to enable stakeholders to co-create potential and desirable futures for sustainable development. Through this exercise, the stakeholders offer valuable visions and insights that inform future and integrated policy advice and strategies. Finally, the 2nd Foresight Workshop aims to encourage stakeholders to explore new directions and envision potential lines of action towards a more sustainable and resilient future.

The 2nd foresight workshop is to follow up and complement discussions conducted in previous sessions and specifically extend the scenario space and consideration of alternative pathways for climate action. It complements the multi-stakeholder discourse forums organized in WP2 by ETH to allow for a rich diversity tapestry of input to be channelled into the development process. In addition, the workshop will offer a connection to the novel scenario-building activities in WP5 with particular reference to climate action, climate change, and user-driven scenarios.

One of the key objectives is to find new alternative scenarios that disrupt existing patterns and enable transformative change with particular emphasis on currently underdeveloped options for achieving the 1.5°C target. These activities involve upholding land rights, safeguarding ecosystem integrity, and ensuring food security, in addition to an evaluation of the entire portfolio of Carbon Dioxide Removal (CDR) solutions. Furthermore, the workshop will take a broader range of policy stakeholders on board, encouraging them to find future priorities and assist in defining concrete, inclusive, and efficient climate action plans.

This workshop is rescheduled for June 2025, subsequent to the closure of the multi-stakeholder discussion groups and when the project team feels it more suitable for WP5 to address stakeholder-led alternative scenario priorities.

4.3.2.5 Values and practice driven foresight with citizens (September 2025)

A key element of the DIAMOND project is the delivery of climate-friendly practice and policy formulation with the inputs of citizens to optimise both model development's relevance to society and applicability in the real world. Toward this end, a climate-friendly practice workshop with citizens, discussed in section 3.3.3.2, is described in this update of the stakeholder engagement strategy.

The climate-friendly practice workshop with citizens will be organised to gather citizen opinion, not just refining the models but also mapping opportunities to replicate the DIAMOND strategy in other projects. One of the

biggest challenges is making effective connections between DIAMOND's themes and topics at various stakeholder levels so that actual interaction between experts, policymakers, and citizens occurs. In response to this, the project will establish solid connections with active climate citizens' assemblies at the local level, and in particular will exploit opportunities within Italian cities such as Milan, Florence, Bologna and Trento. Through connection with these already existing participatory processes, DIAMOND will be able to incorporate a wide range of perspectives, strengthen scenario-building, and enable results to be communicated to other cities in Europe, ensuring a wider impact.

This activity will also take into consideration the results of Tasks 4.3 and 4.6, which will respectively describe to what extent and how heterogeneity of household behaviour and behaviour change for the desirability of climate action is represented in IAMs, as these are designed to provide a range of answers these models can provide to questions regarding the matter.

In this context, citizens who are already members of deliberative assemblies, such as the *Assemblea Permanente dei Cittadini sul Clima*³⁰ in Milan, are invited to make comments and proposals. With a series of online focus groups conducted under the umbrella of DIAMOND, these citizens will have the opportunity to participate in interactive discussions to look back on the influence of previous climate consultation exercises and examine how these experiences can be integrated more effectively into the development of climate policy models.

The focus groups will be centred around key themes such as mobility, domestic energy use, well-being, and consumption patterns. These sessions provide an exchange platform where participants share their experiences from climate governance, gain knowledge about weaknesses and strengths, and offer their expertise on how the wishes and values of citizens can best be integrated into climate modelling platforms. Moreover, the debates will examine how the day-to-day actions of citizens and local communities contribute to bigger ecological transition systems, helping to create frameworks for maximising the dialogue between research, institutions, and society at large.

With a collaborative approach, DIAMOND aims to ensure that climate policy becomes more inclusive, equitable, and efficient. Active participation by citizens, in conjunction with that of other civil society activities and networks such as the Knowledge Network on Climate Assemblies (KNOCA)³¹, will assist in consolidating the European-wide network of climate civic engagement into decision-making frameworks. This approach not only enhances the scientific integrity of climate models but also makes them more reflective of society's diverse values and needs, leading to more acceptable and sustainable climate solutions.

Lastly, values and ethical practice-based foresight with citizens ensure that the voice of local communities is heard and their concerns are incorporated in shaping future climate scenarios towards more inclusive and holistic climate action.

A shared approach that we seek to follow will be conducted following three thematic focus groups — i) Mobility, ii) Energy, iii) Well-being and Consumption — aimed at securing input from citizens of different social and cultural backgrounds, to derive valuable insights that will inform the design of simulation models (IAMs) and enhance their social acceptability.

³⁰ <https://partecipazione.comune.milano.it/processes/assemblea-permanente-dei-cittadini-sul-clima>

³¹ <https://www.knoca.eu/>

Objectives

The focus groups are designed to engage citizens in qualitative discussions about the behavioural changes needed to adopt sustainable and climate-neutral practices. The main objectives are:

- To define socially acceptable and preferable practices to simulate in IAMs.
- To assess whether the proposed baseline scenarios align with the perceptions, needs, and desires of participants.
- To consider feasible practices and behavioural changes necessary for a more sustainable future.

Focus Group 1: Mobility

Purpose: To explore citizens' behaviours related to mobility and how behavioural influences can affect future IAM-based scenarios.

Focus Group 2: Energy

Purpose: To examine citizens' habits regarding domestic energy consumption and their views on improving energy efficiency, promoting the adoption of renewable technologies, and responsible energy behaviours, and how these can affect future IAM-based scenarios.

Focus Group 3: Well-being and Consumption

Purpose: To investigate how consumption habits and well-being-related behaviours (diet, health, clothing, etc.) affect citizens' ecological footprint and how changing lifestyles can affect future IAM-based scenarios.

Workshop structure

Each focus group will follow a structured format with the following phases, and will last 1 hour and 30 minutes:

- Introduction:** Presentation of the DIAMOND project and the specific objectives of the focus group.
- Group Discussion:** Participants will explore the proposed themes. The approach will focus on open-ended questions to stimulate debate and gather opinions and suggestions.
- Summary of Discussions:** After the group work, a plenary session will collect the summaries to share them and integrate them into a comprehensive framework.
- Conclusions:** Final reflections on how the results of the focus groups can inform the development of the IAM model and contribute to the exploitation plan of the project.

Participation methodology

The focus groups will be held under Chatham House rules, ensuring that everyone can express themselves freely without their information being directly attributed to them. Interactive tools (such as bulletin boards, and surveys) will be used to collect ideas and ensure that every voice is heard.

Expected outcome

Each of the focus groups will provide a list of priorities and suggestions that will help the DIAMOND partners tailor the simulation models (IAMs) to citizens' needs and perceptions, inform future policy and measures towards a transition to more sustainable climate scenarios, and enable replicability of the project in other contexts and exchange of findings with other actors in civil society and politics.

4.3.3 Phase 3 – Towards model co-ownership

Phase 3 commences in June 2025, integrating and applying the coproduced knowledge into societal and scientific practices. This phase is a follow up on the co-produced research questions and subsequent scenario and model development of Phase 1 and Phase 2. Phase 3 presents the results of model runs and scenario assessments to relevant stakeholders who were part of the co-productive process, inviting their feedback on how to make the results most useful in policy and practice. The detailed description of this phase will be provided in deliverable 'D2.7 Stakeholder-informed research questions – Update'.

5 Reports from the completed stakeholder workshops

5.1 DIAMOND Requirements Workshop | Online | 13 September 2024

This workshop allowed the project team to learn from stakeholders' experience and expertise. It was the first step in contributing to the process of addressing climate change mitigation and adaptation. It was a forum for sharing different understandings and learning from the experiences of diverse perspectives, with valuable insights from scientists (including modellers), policymakers, industry representatives, and other societal stakeholders. This allowed us to explore broad and overarching questions related to climate action while enabling science-societal interactions and matching technical requirements with stakeholder-driven research questions.

To align stakeholder needs and expectations with modelling objectives, the first objective for this workshop was to co-define the requirements for IAM improvements to best respond to the most pertinent concerns. In practice, modellers and stakeholders worked together to mutually understand which issues are useful and feasible to analyse with the available IAM capabilities and/or planned improvements and co-design the questions to be addressed later in our research.

On the workshop day, 51 participants — including 22 stakeholders and 29 modellers — were able to actively contribute to group discussions, strictly conducted by the ISINNOVA team under Chatham House rules, designed to explore broad and overarching questions related to climate action. The workshop featured interactive breakout rooms aiming to elicit views and ideas, inter alia by means of boards and polls and efforts to ensure that all voices are heard. At the end of the workshop, a plenary discussion was held to compare and summarise each group's discussions, ensuring that key takeaways were collectively presented and integrated into a comprehensive overview.

The outcome of the workshop was, as expected, a clear set of stakeholders-driven priorities to be used by DIAMOND to guide model upgrades and scenario design, ensuring that research efforts are aligned with stakeholder interests and priorities. This collaborative process ensured that our research efforts were inclusive, relevant, and aligned with stakeholder needs and expectations.

Table 4. Requirements workshop agenda

Duration	Topic
15'	Introduction to the project and the workshop's themes <i>Daniel Cassolà, Carlo Sessa (ISINNOVA)</i>
5'	Introductory/practical notes on the breakout rooms
45'	<u>Enhancing analytical capacities for more effective climate policy support</u> <i>Parallel interactive sessions:</i> a. High-level and cross-sectoral b. Residential & transport c. Power (including upstream) d. Industry e. Water, land, and other sectors
10'	Outcomes of the first group discussion <i>One speaker per group (project team)</i>

10'	Short break
45'	<u>Defining requirements aligned with stakeholders' pertinent questions</u> <i>Parallel interactive sessions focusing on DIAMOND model development fields:</i> <i>Climate change impacts and disruptive events</i> <i>Finance and labour</i> <i>Human behaviour and household choices</i> <i>Circular economy</i> <i>Land use change, forestry, and broader sustainability dimensions</i>
10'	Outcomes of the second group discussion <i>One speaker per group (project team)</i>
10'	Concluding remarks

1st Session: Enhancing analytical capacities for more effective climate policy support

During the first session, the participants were guided through a facilitated process to reflect and comment on proposed research themes. The session was held with the support of a Mural board, where the participants could leave comments. Thematic discussions took place in 5 breakout rooms: i) High-level and cross-sectoral; ii) Residential & transport; iii) Power (including upstream); iv) Industry; and v) Water, land, and other sectors. To begin with, the participants were asked to read through the proposed themes and comment on how they were relevant to their policy needs. They were asked to score the themes for relevance and mark where they needed improvement. The moderator then initiated a round discussion in which people explained their comments, with group feedback and further reflection. This was intended to assess how the modelling competencies align with stakeholder expectations. People were also invited to suggest other research themes of importance that they felt were necessary, and they put these up on MURAL for debate. The session concluded with an opportunity for participants to put forward their suggested themes and receive comments, with the option of further developing these ideas in the second session. The rationale behind these exercises was to stimulate individual reflection followed by group discussions, to make the suggested research themes address real policy problems in the real world and to identify gaps or new themes worth exploring.

2nd Session. Defining requirements aligned with stakeholders' pertinent questions

The second session of the workshop was structured to foster collaboration between stakeholders and modellers in three breakout rooms. The session began with an introductory part, where the participants were asked to post their contributions. Each participant was asked to post up to three sticky notes on the Mural board, identifying the research themes they considered most pertinent in relation to five DIAMOND model development fields: i) climate change impacts and disruptive events; ii) land use change, forestry, sustainability; iii) finance and labour; iv) human behaviour and households' choices; and v) circular economy. This initial action allowed stakeholders to provide input on the key themes they believed should be addressed in future modelling efforts. The modellers, at this stage, were primarily in a listening role, preparing to provide feedback on how treatable these themes might be within the scope of the IAMs and how these themes could potentially be included in future applications.

When the stakeholders provided their comments, a round discussion took over. The moderators invited each stakeholder to summarise the rationale behind the comments they had left. During this discussion, the modellers were invited to respond to the ideas suggested by the stakeholders by providing remarks on the feasibility and applicability of the proposed themes to IAMs. The modellers aided by posting comments directly on the MURAL board as a discussion ensued.

This approach ensured a focused conversation around how relevant the proposed research themes were to future climate policy scenarios. It also allowed the participants to assess whether these themes could be realistically integrated and treated within the IAM framework, ensuring that the enhanced models would align with stakeholders' needs and policy objectives.

[illegible]



Mural board from the 2nd session

DIAMOND

Requirements Workshop - Session 2

13 September 2024

Group 1

Designing IAM requirements aligned with stakeholders' pertinent needs: mapping of prioritised themes from Session 1 to broader thematic areas (e.g., finance, sustainability) to further expand our IAM development strategy with the introduction of dedicated thematic modules, and assessment of the feasibility to model such dimensions from the IAM researchers' perspective (can the themes be translated into modelling features?)

Facilitator

Carlo Sessa 45 minutes Open discussion

From your perspective, which research themes are more pertinent to consider for designing our development strategy? Please identify up to 3 most pertinent questions.

Climate change impacts & disruptive events

Land use change, forestry, sustainability

Finance and labour

Human behaviour and household choice

Circular economy

Other issues

Group 2

Designing IAM requirements aligned with stakeholders' pertinent needs: mapping of prioritised themes from Session 1 to broader thematic areas (e.g., finance, sustainability) to further expand our IAM development strategy with the introduction of dedicated thematic modules, and assessment of the feasibility to model such dimensions from the IAM researchers' perspective (can the themes be translated into modelling features?)

Facilitator

Stefano Fabiani 45 minutes Open discussion

From your perspective, which research themes are more pertinent to consider for designing our development strategy? Please identify up to 3 most pertinent questions.

Climate change impacts & disruptive events

Land use change, forestry, sustainability

Finance and labour

Human behaviour and household choice

Circular economy

Other issues

Group 3

Designing IAM requirements aligned with stakeholders' pertinent needs: mapping of prioritised themes from Session 1 to broader thematic areas (e.g., finance, sustainability) to further expand our IAM development strategy with the introduction of dedicated thematic modules, and assessment of the feasibility to model such dimensions from the IAM researchers' perspective (can the themes be translated into modelling features?)

Facilitator

Daniel Cassab 45 minutes Open discussion

From your perspective, which research themes are more pertinent to consider for designing our development strategy? Please identify up to 3 most pertinent questions.

Climate change impacts & disruptive events

Land use change, forestry, sustainability

Finance and labour

Human behaviour and household choice

Circular economy

Other issues

Examples of research themes proposed by the DIAMOND team

High-level and cross sectoral

H1. Enhanced technological representation

H2. Introduction/Expansion of climate damages and shocks

H3. Updated technology adoption curves

H4. Better regional disaggregation of our IAMs

Residential and transport

R1. Expanded demand-side mitigation strategies

R2. Enhanced residential energy efficiency options

R3. Improved representation of transport demand

R4. Introduction of modal shift options

Power (including upstream)

P1. Improved representation of the electricity generation sector (dispatch, time-slices, technologies)

P2. Introduction of energy storage technologies in IAMs

P3. Updated infrastructure representation (e.g., grids)

P4. Implications of spatial disaggregation to electricity trade

P5. Implications of spatial disaggregation to fuel trade

Industry

I1. Better representation of circular economy measures

I2. Better representation of material efficiency policies

I3. Updated representation of industrial CCS

I4. Primary production of steel

I5. Carbon Border Adjusting Mechanisms (CBAM)

Water, land and other sectors

W1. Enhances energy-water-land links

W2. Better land use planning practices

W3. Advanced irrigation technologies

W4. Nuanced AFOLU sector

Page 41

5.1.1 Contributions of the Requirements Workshop to the modelling teams expectations

DIAMOND deliverable 'D3.1 Model development strategy' highlights what kind of requirements the DIAMOND modelling teams expect to receive from the stakeholders participating in the co-creation workshops, to better adapt their model improvement to the needs of end users. As illustrated by the summary of the requirements workshop presented in the previous sections, the participants recommended considering a wide range of research themes, aimed at providing more effective and reliable simulations of the energy and climate policies for both the supply and demand energy sectors and the conservation of natural ecosystems. Stakeholders' suggestions were summarised focusing on four supply and demand sectors: residential and transport sectors, energy sector, industry, as well as water, land, and agriculture sectors. Stakeholders' recommendations on how the models can be applied for supporting policymakers in the design and assessment of different policy packages were included as well were also clustered to consider some landscape factors, from climate change impacts and natural resources to economics and technologies, which models should consider when designing the impacts of energy and climate transition policies.

In almost all discussion rooms the participants stressed the need to increase the granularity of the models both in spatial and temporal directions as well as to increase the sectoral coverage (see, i.e. the hydrogen economics) and to better detail the sectors description (see the transport debate). In addition, they highlighted the importance of integrating emerging technologies and managing uncertainty in climate models pointing out the need to move from deterministic to probabilistic models and to include both climate and transition risks. Nonetheless, minor or even no emphasis was given to the other points highlighted by the modelling teams in D3.1, especially for what concerns the input information and the interconnection with other sectoral models.

Discussion contents and takeaways of the workshop were detailed in an internal report that was subsequently shared with the modelling teams to inform their work.

5.1.2 Assessment of the Requirements Workshop

This section summarises the feedback obtained through the post-event survey, with 19 responses, and discusses strengths and weaknesses.

58% of the participants indicated that workshop goals were clearly defined, while 37% indicated that they were somewhat clear. Few (5%) indicated that they were unclear, implying room for improvement in communicating the objectives.

53% found the workshop clear and organised, while 42% indicated somewhat clear. Only 5% said very clear, which indicates that although the overall structure was good, there was room for improvement regarding clarity. Asked whether the workshop met expectations, 63% said yes, and 26% said that it only partially met their expectations. A small minority of 11% said that it did not meet their expectations, emphasising that future sessions should be more sensitive to what the participants require.

Technical delivery and interactivity received mixed marks. 52% were satisfied and 21% very satisfied, whereas 16% were not satisfied and 11% neutral. This suggests that whereas the interactive elements were well enjoyed, further work can be done to improve levels of engagement and technical delivery to maximise the experience.

The aspects most appreciated by the respondents were the opportunity to discuss relevant IAM design areas to and exchange visions about climate action. They all valued being involved as stakeholders in an early development stage and also gaining from an open space where they could provide feedback. Working together with other modelling teams, along with the project team members and stakeholder experience, was also viewed as a strength. The Mural board and interactive tools were both said to be simple to use and highly effective at drawing out

participation. Additionally, the structured format of the meeting and the ease of use of the platform contributed to a positive experience.

Some ideas were offered by the respondents for how subsequent workshops could be enhanced. One of the major recommendations was making the goal of each session explicit and targeted explanations so the stakeholders know very clearly what is expected of them and the purpose of the discussions. A number of respondents explained that there were a few inefficiencies in breakout rooms, and they proposed fewer breakout rooms or in-group sessions for the stakeholders in order to maximise their participation. In addition, providing open early notification of workshop material, discussion topics, and tools to be employed (e.g., Mural) was deemed as crucial. Some elementary organisational improvements were proposed, including improved timing management, avoiding Friday sessions, and considering one large session in place of multiple smaller sessions. Other participants also proposed alternative interactive elements like Mentimeter, with online voting, and allocation of post-workshop time for stakeholder contribution refinement. Increased involvement of other external stakeholders in the industry, water, and land use sector was also proposed, with the additional suggestion that all consortium partners sign up to involve two stakeholders in order to enhance participation further.

Respondents listed a number of expectations for future foresight workshops. Many emphasised the necessity of a clear and sharp proposal to act as the starting point for dialogue, such that stakeholders could provide well-informed contributions. There was specific interest in testing realistic reference scenarios at the following workshop and alignment with IAMs. A number of the respondents stressed the importance of explanations and targeted questions and requested stakeholders to be provided beforehand with relevant material to better prepare for their contributions. Some of them stressed having a set of participants as diverse as possible, with more non-consortium stakeholders and fewer consortium partners. Others suggested giving more time to the stakeholders by structuring discussions around specific themes and leading participants with more specific questions. Interest was also shown in using case study simulations to stimulate discussion, particularly for the electricity sector, and conducting sensitivity analyses to explore possible possibilities. Major thematic topics of concern addressed included industrial clusters, hydrogen production and trade, funding difficulties for fair transition, geopolitics and security, and energy communities in the EU. Some of the attendees offered the observation that having an overt introduction to each session would likely allow the stakeholders to become involved more eagerly in discourse and offer more meaningful input.

To improve future workshops, the following steps can be taken: making objectives communications clearer, refining session construction, adding more interactive content, more optimised scheduling, improving technical execution, and tailoring content to fit better stakeholders' needs.

5.2 DIAMOND 1st Foresight Workshop | Online | 12 November 2024

This workshop helped the project team in the process of shaping the development of instrumental capacities, scenarios, and policy roadmaps, thereby ensuring that modelling efforts align with real-world needs and priorities, promoting the relevance and applicability of project outcomes.

In this workshop, as will be the case in the following one, the objective was to co-create scenarios of incremental versus transformative change and transition pathways to be represented in enhanced IAM applications by applying the Three Horizons participatory foresight framework, a tool for structuring future thinking. In this first workshop applying the foresight methodology, modellers and stakeholders worked together to respond to pertinent questions regarding signs of crises in our current trajectory as well elements to retain in the current system to ensure competitiveness and the seeds of change that should be pursued urgently to lead to desirable and sustainable futures. A follow-up workshop will be organised in June 2025, to identify elements in the pathways

that disrupt existing patterns and create an opportunity for a different future.

Before the workshop, stakeholders were kindly asked to fill out a very short survey, to register and indicate the sector(s) that they are most interested in discussing. After their common interest, the ISINNOVA team tailored the breakout rooms to ensure that all workshop participants had an opportunity to contribute productively and share their opinions.

On workshop day (see agenda in Table 5), 41 participants — including 17 stakeholders and 24 modellers — actively contributed to group discussions and embarked on exploring open-ended and overarching questions relating to climate action. The workshop featured interactive breakout rooms aiming to elicit views and ideas, inter alia by means of boards and polls and efforts to ensure that all voices were heard. At the end of the workshop, a plenary discussion was held to compare and summarise each group's discussions, ensuring that key takeaways were collectively presented and integrated into a comprehensive overview.

The outcome of the workshop, as expected, was a set of alternative incremental versus transformative change qualitative trajectories of future change and decarbonisation pathways to achieve climate neutrality.

Table 5. First foresight workshop agenda

Duration	Topic
10'	Introduction to the project and the workshop's scope <i>Carlo Sessa (ISINNOVA), Alexandros Nikas (ICCS)</i>
10'	Presentations of the 3 Horizons Framework and practical notes on the breakout rooms <i>Carlo Sessa, Daniel Cassolà (ISINNOVA)</i>
30'	Horizon 1 — Business as Usual - What are the signs that the current system is not viable/sustainable? - What is essential to keep about the current system? <i>Parallel interactive sessions.</i>
10'	Plenary: Outcomes of the first group discussions
10'	Short break
30'	Horizon 3 — Viable Future - What are the characteristics of the future system that we want? - Where/what are the seeds of the future we want that exist now? <i>Parallel interactive sessions.</i>
10'	Plenary: Outcomes of the second group discussions
10'	Concluding remarks <i>Carlo Sessa (ISINNOVA)</i>

In this workshop, the participants were guided through a structured process to think about their desired futures without imposing any previous assumptions on them, e. g. in terms of what type of economic and political development is realistically feasible (e.g., based on researchers' beliefs and values, or worldviews about political or economic systems). By using the Three Horizons methodology, briefly illustrated in Figure 10 below, the transformation scenarios are set up by following three conceptual pathways: H3, concerning the identification of a desirable vision of the future (a system we want to transform to), H1, focused on the undesirable features of the

current system, (a system we want to transform from) and H2 regarding the necessary changes to shift from the current undesirable features to the desirable vision. The focus of this workshop was on pathways H1 and H3, while pathway H2 will be discussed in the next workshop.

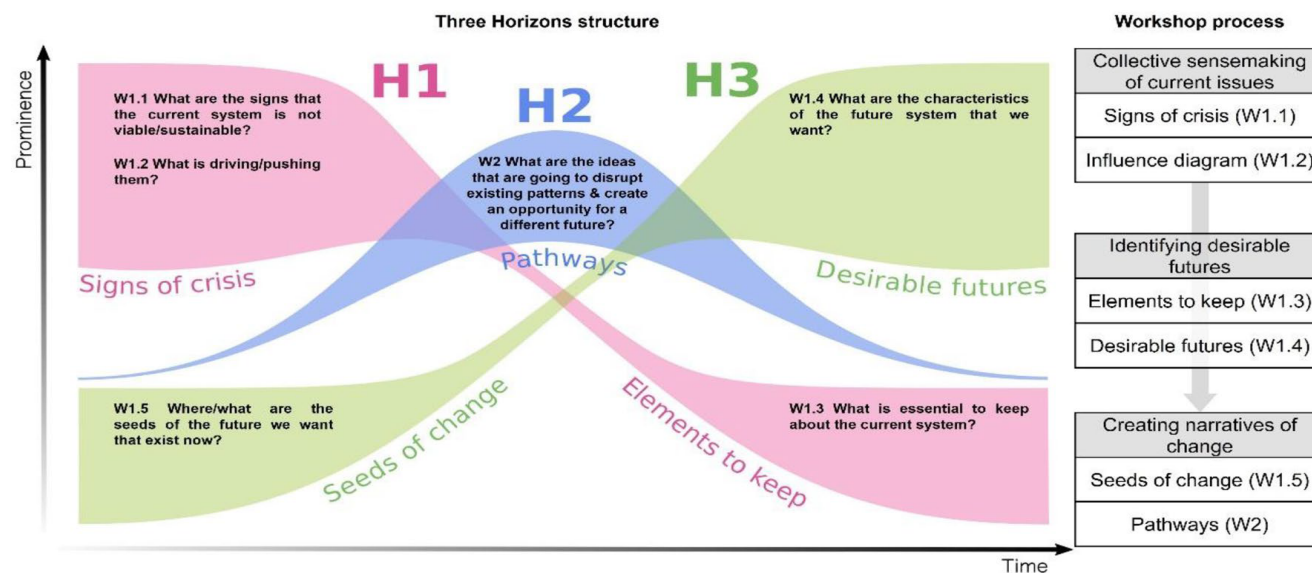


Figure 10. Three Horizons structure of the foresight process in DIAMOND. Source: Adapted from Schaal-Lagodzinski et al., 2023

The sessions of this workshop were facilitated in breakout rooms using a Mural board, where the participants could post their comments and contribute to the discussion. The topics discussed in these breakout rooms were:

- Power and upstream (room 1)
- Water, Land Use, Biodiversity, and Food (room1)
- Residential and Transport Systems (room 2)
- Industry and Circular Economy (room 2)
- Human Behaviour and Household Choices (room 2)

1st Session: – Pathway H1, Business as Usual

In this session, the participants contributed to the description of pathway H1, which is the current, declining, pattern. The conversation began by bringing the issue of concern into view and describing the ways in which the current way of doing things is seen to be losing its fit with emerging conditions. As a first step, the participants were asked to examine present issues by answering the question “What are the signs that the current system is not viable/sustainable and what is driving/pushing them?”. Then the participants were asked about the essential features to maintain from the current paradigm. This step drew attention to those aspects of the old system that will persist into the future within the context of the new dominant system. These are often deemed as the key or desirable elements that need to be retained.

2nd Session. H3 – Viable Future

The second session of the workshop was structured to foster collaboration between stakeholders and modellers in the previous two breakout rooms using the same Mural board, where the participants could post in this occasion

their comments and contribute to the description of pathway H3, which represents an emerging future pattern. The conversation began by exploring future aspirations. This involved examining the third horizon, where visions, aspirations, and possibilities for the reality that will emerge over time were explored as a replacement for H1. The participants were asked to answer the question *"What are the characteristics of the future system that we want?"*. Then the participants explored inspirational practice in the present. This step led to the identification of 'seeds of change', which are concrete examples of where new ways of doing things are visible at the margins of the mainstream H1 systems. To do this, the participants addressed the question *"Where/what are the seeds of the future we want that exist now?"*.

Additional characterisation

The workshop concluded with an opportunity for participants to further refine the elements that are part of future visions by responding to two additional questions with the help of Slido:

- *H3: Tell us up to three key characteristics you think should be included in the transformative scenario pattern (divergence elements)*
- *H1: Tell us up to three characteristics you think are essential to keep off the business-as-usual scenario pattern (convergence elements)*

The contributions from the participants have been integrated into the two horizons' descriptions.

Mural board from the 1st room

DIAMOND

Scenarios Workshop

First room

Power and upstream
Water, land use, biodiversity and food

Facilitator

Carto Sessa

30 minutes H1 + 30 minutes H3

Open discussion

Horizon 1 - Business as Usual (current declining pattern)

A. What are the signs that the current system is not viable/sustainable? What is driving/pushing them?

Many power plants are aging, requiring investments for water for cooling, impacting local water resources.

Energy production is still largely based on fossil fuels, with associated greenhouse gas emissions and air pollution.

Renewable energy production is still a small fraction of total energy production, and its growth is slow.

H2 production is a vector for decarbonization, but it also requires a lot of water.

Water scarcity, soil degradation, and deforestation are major threats to food security and ecosystem services.

At the end of the century, water storage will be a key factor for water security.

Non-sustainable land use practices, such as overgrazing and deforestation, are leading to soil degradation and loss of biodiversity.

Over-exploitation of groundwater is leading to saltwater intrusion and land subsidence.

Over-fishing and over-exploitation of marine resources are leading to the collapse of fish stocks.

Over-exploitation of forests is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the oceans is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the atmosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the hydrosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the lithosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the biosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the geosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the atmosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the hydrosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the lithosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the biosphere is leading to the loss of biodiversity and ecosystem services.

Over-exploitation of the geosphere is leading to the loss of biodiversity and ecosystem services.

Horizon 3 - Viable Future (new emerging pattern)

C. Where/what are the seeds of the future we want that exist now?

Energy communities

Cooperation

Integration of smart grids, renewable energy, and digital technologies

Renewable energy production

Green jobs and new companies are emerging in the area

Non-fossil and nuclear power production

The Three Horizons Framework

H1 is a current, declining, pattern. H3 represents an emerging future pattern. H2 is the turbulent domain of transitional activities and innovations which people are trying out in response to the changing landscape between H1 and H3.

Scenarios co-creation

Stakeholders and researchers co-create scenarios of incremental vs transformative change and transition pathways to be represented/handled in enhanced IAMs applications.

Page 47

Mural board from the 2nd room

DIAMOND

Scenarios Workshop

Second room

Residential and transport
Industry and circular economy
Human behaviour and household choices

Facilitator

Daniel Cassels 30 minutes H1 - 30 minutes H3 Open discussion

Horizon 1 - Business as Usual (current declining pattern)

A. What are the signs that the current system is not viable/sustainable? What is driving/pushing them?

Negative environmental and social spillovers

Energy transition: technological and economic challenges in decarbonising the energy sector

Costs for households and companies: energy bills are expected to increase, affecting public and private companies

Political Uncertainty

Trade issues

Security issues, lack of resources

Drivers for increased use of resources/transitioning due to the energy transition: pressure for sustainable technologies (solar panels, batteries) and electrification of transport, grid expansion and upgrade, energy storage, decentralised energy production (small-scale renewable), public/private resources for electronics, reserves and data storage

Uncertainty in demand patterns

Lack of evidence of infrastructure to increase frequency of virtual systems and based on sustainability modelling, future data requirements, sustainability and resilience the transition process

Possible Current Drivers for energy security issues below (provisional): resource (climate-driven) conflicts, Middle East tensions, dependence on fossil fuels in energy countries, critical mineral supply, cyber security threats due to increased digitisation of energy systems, climate change impacts (damage on energy infrastructure and capacity, fluctuating energy prices and volatility, fluctuating energy prices and volatility, policy and regulatory uncertainties)

Horizon 3 - Viable Future (new emerging pattern)

C. Where/what are the seeds of the future we want that exist now?

Technologies

Localism

Circularity

Sufficiency

Actually from the past: Community-managed grids

Democracy

Citizen-led initiatives

Experimental pilot projects

Awareness

Degrowth

Rethinking of energy as a basic human right

Non-consumption based growth

Innovation

The Three Horizons Framework

H1 is a current, declining, pattern. H3 represents an emerging future pattern. H2 is the turbulent domain of transitional activities and innovations which people are trying out in response to the changing landscape between H1 and H3.

Horizon 3 - Viable Future (new emerging pattern)

D. What are the characteristics of the future system that we want?

Accessible for all

Fair and just

Not-for-profit based energy system

Affordability

Energy efficiency

Horizon 1 - Business as Usual (current declining pattern)

B. What is essential to keep about the current system?

Interconnectedness

Seeds of change

Elements to keep

Signs of crisis

Pathways

Desirable futures

Cheer renewable Energy

Low/affordable investment costs for renewables (such as solar PV)

Resilient to new disruption, new business models, maintaining and enhancing the production and distribution of energy

Social Market economy

Democracy, free choice, free press

Page 48

5.2.1 Main insights from the 1st Foresight Workshop

Detailed summaries, for each of the topics covered in the workshop, were added to an internal report by the ISINNOVA team to share the main insights of the workshop with the modelling teams. The information provided in the breakout rooms was structured by comparing the description of the present with the vision of the future. This comparison, which clearly shows the different and conflicting visions, present and future, of the various ecosystems and sectors of activity analysed, will be taken up and deepened when in the second foresight workshop the policy scenarios allowing to move from the present reality to the one we hope for in the future will be discussed. We believe that the set of scenario proposals arising from these two workshops, and starting from this one, can provide the project's modellers with sufficient analysis material to refine and update their IAMs.

5.2.2 Assessment of the 1st Foresight Workshop

This section assesses participant responses obtained from 14 survey respondents. The majority, 10 out of the 14 respondents, said the workshop objectives were clearly defined, and 4 said they were only somewhat clear. This implies that even though most of the participants knew the workshop objectives, a percentage needed more clarity. Also, the organisation and structure of the session were seen as clear by 8, while the remaining 6 saw them as somewhat clear, indicating room for improvement in how content is being delivered.

With regard to meeting expectations, 10 respondents reported that the workshop met their expectations, while 4 reported that it partly met their expectations. No participant claimed that the workshop was below their expectation or above their expectation.

The interactive features and technological platform were highly acclaimed, with 11 being overall satisfied and 3 making reference to great satisfaction. This implies a high appreciation of the mechanisms and tools used to facilitate interaction, with no participants expressing dissatisfaction.

One of the strongest aspects of the workshop was its ability to provide an increased understanding of different perspectives, particularly of methods of power. Participants enjoyed the opportunity to interact with more than one point of view, providing richness to the discussion and leading to a better-informed discussion of major issues. Furthermore, the general framework established in the workshop was noted to be especially useful, giving a good platform for creating future scenarios. The structured approach allowed participants to place intricate problems into context and think about a broader set of possibilities in scenario development.

Useful suggestions for improving future workshops were made by participants, and the majority of these had a strong emphasis on increased stakeholder involvement and more interactive discussion. While the tools employed during the session were valued, there was a general agreement to spend more time on debate and interaction. One of the ideas that was put forward was to ensure that half of the workshop is dedicated to discussing things rather than working purely on the filling in of the Mural board. This would ensure greater contact and richer interaction between participants and ultimately, a more satisfying experience overall and to ensure differing opinions are actively introduced into the discussion.

The interest in the follow-up foresight workshop was vast, as respondents were eager to critically evaluate upcoming situations for the energy industry, particularly against the backdrop of existing political events. There has been a necessity to transcend the idea of futuristic perspectives and rather hark back more towards current realities as a means of making the discourse relevant and grounded. One of the key expectations is to explain how DIAMOND can make an input in present knowledge on energy mixes by providing a more advanced analysis of co-existence among different technologies, along with non-renewable sources. This would help the participants realise the complexities of the energy transition, as well as drivers for its growth.

Overall quality-wise, the workshop received an average score of 3.5/5. Based on the feedback given, it is indicated that while the workshop is able to stimulate discussion and interaction among participants, there are areas for improvement. Making objectives clearer, incorporating more interactive sessions, and soliciting more specific participant feedback before conducting future sessions would maximise the experience. For the 2nd Foresight Workshop, efforts will be made to describe how each session contributes to the broader objectives of the foresight process by outlining the workshop's goals and the intended outcomes. To increase interactivity, we aim to include real-time voting on scenario options and collaborative scenario mapping added to the facilitated small group discussions. Additionally, to ensure that the discussions reflect the concerns and expertise of participants, a pre-workshop survey can be conducted to tailor the workshop sessions to their needs. With these changes, future workshops can remain highly interactive while maximising clarity and participant satisfaction.

Bibliography

- Bammer, G. (2013). Disciplining interdisciplinarity: Integration and implementation sciences for researching complex real-world problems. Canberra: ANU E-Press.
- Bergmann, M., Jahn, T., Knobloch, T., Krohn, W., Pohl, C., & Schramm, E. (2012). Methods for transdisciplinary research. Frankfurt/New York: Campus Verlag.
- Berker, T.; Kvellheim, A.K. (2018) Boundary Objects as Facilitators in Sustainable Building Research. *Sci. Public Policy* 2018, 45, 202–210.
- Braunreiter, L., van Beek, L., Hajer, M., & van Vuuren, D. (2021). Transformative pathways—Using integrated assessment models more effectively to open up plausible and desirable low-carbon futures. *Energy Research & Social Science*, 80, 102220.
- Brooks, S., Leach, M., Lucas, H., & Millstone, E. (2009). Silver bullets, grand challenges and the new philanthropy (STEPS Working Paper 24). <http://www.ids.ac.uk/files/dmfile/STEPSWorkingPaper24.pdf>
- Capros, P., Paroussos, L., Fragkos, P., Tsani, S., Boitier, B., Wagner, F., ... & Bollen, J. (2014). Description of models and scenarios used to assess European decarbonisation pathways. *Energy Strategy Reviews*, 2(3-4), 220-230.
- Elsawah, S., Hamilton, S. H., Jakeman, A. J., Rothman, D., Schweizer, V., Trutnevyte, E., ... & van Delden, H. (2020). Scenario processes for socio-environmental systems analysis of futures: a review of recent efforts and a salient research agenda for supporting decision making. *Science of the Total Environment*, 729, 138393.
- ENABLE.EU Horizon 2020 project. <http://www.enable-eu.com/> (accessed on 31 March 2023)
- European Data Protection Supervisor EDPS (2018). Ethics Advisory Group Report 2018. https://edps.europa.eu/data-protection/our-work/publications/ethical-framework/ethics-advisory-group-report-2018_en (accessed on 31 March 2023)
- Feldhoff, B., Stockmann, N., Fanderl, N., Gahle, A.-K., Graf, A., Leger, M., & Sonnberger, M. (2019). Bridging Theories and Practices: Boundary Objects and Constellation Analysis as Vehicles for Interdisciplinary Knowledge Integration. *Sustainability*, 11(19), 5357.
- Floridi, L. (2018). Soft ethics and the governance of the digital. *Philosophy & Technology*, 31, 1-8.
- Floridi, L., & Strait, A. (2021). Ethical foresight analysis: what it is and why it is needed?. *The 2020 Yearbook of the Digital Ethics Lab*, 173-194.
- Fry (2021). Multi-stakeholder discussion group. (Number 15). Zenodo. <https://doi.org/10.5281/zenodo.4627091>
- Fullerton J. (2015). Regenerative Capitalism. How Universal Principles and Patterns Will Shape Our New Economy. Capital Institute. <https://capitalinstitute.org/wp-content/uploads/2015/04/2015-Regenerative-Capitalism-4-20-15-final.pdf>
- Iden, J., Methlie, L. B., & Christensen, G. E. (2017). The nature of strategic foresight research: A systematic literature review. *Technological Forecasting and Social Change*, 116, 87-97.
- Jänicke, M. (2008). Ecological modernisation: new perspectives. *Journal of cleaner production*, 16(5), 557-565.
- Klein, J. T. (2010). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 15e30). Oxford: Oxford University Press.



- Klein, J. T. (2012). Research integration: A comparative knowledge base. In A. F. Repko, W. H. Newell, & R. Szostak (Eds.), *Case studies in interdisciplinary research* (pp. 283-298). Thousand Oaks, CA: Sage Publications.
- Loulou, R., & Labriet, M. (2008). ETSAP-TIAM: the TIMES integrated assessment model Part I: Model structure. *Computational Management Science*, 5.
- McGookin, C., Gallachóir, B. Ó., & Byrne, E. (2021). Participatory methods in energy system modelling and planning—a review. *Renewable and Sustainable Energy Reviews*, 151, 111504.
- Miller, C. A., & Wyborn, C. (2020). Co-production in global sustainability: Histories and theories. *Environmental Science & Policy*, 113, 88–95.
- Nikas, A., Lieu, J., Sorman, A., Gambhir, A., Turhan, E., Baptista, B. V., & Doukas, H. (2020). The desirability of transitions in demand: Incorporating behavioural and societal transformations into energy modelling. *Energy Research & Social Science*, 70, 101780.
- Nikas, A., Elia, A., Boitier, B., Koasidis, K., Doukas, H., Cassetti, G., ... & Chiodi, A. (2021). Where is the EU headed given its current climate policy? A stakeholder-driven model inter-comparison. *Science of the Total Environment*, 793, 148549.
- O'Rourke, M., Crowley, S., & Gonnerman, C. (2016). On the nature of Cross-disciplinary integration: a philosophical framework. *Studies in history and philosophy of science part C: studies in history and philosophy of biological and biomedical sciences*, 56, 62-70.
- PARIS REINFORCE Policy Briefs. <https://paris-reinforce.eu/publications/policy-briefs> (accessed on 31 March 2023)
- Peng, W., Iyer, G., Bosetti, V., Chaturvedi, V., Edmonds, J., Fawcett, A. A., Hallegatte, S., Victor, D. G., van Vuuren, D., & Weyant, J. (2021). Climate policy models need to get real about people—Here's how.
- Pfenniger, S., et al. (2018). *Energy Strategy Reviews*, 19, 63-71. <https://doi.org/10.1016/j.esr.2017.12.002>
- Pidgeon, N. (2021). Engaging publics about environmental and technology risks: Frames, values and deliberation. *Journal of Risk Research*, 24(1), 28–46. <https://doi.org/10.1080/13669877.2020.1749118>
- Pohl (2020). Emancipatory boundary critique. (Vol. 15, Number 1). Zenodo. <https://doi.org/10.5281/zenodo.3717029>
- Repko, A. F. (2007). Integrating interdisciplinarity: How the theories of common ground and cognitive interdisciplinarity are informing the debate on interdisciplinary integration. *Issues in Integrative Studies*, 25, 1e31.
- Salter, J., Robinson, J., & Wiek, A. (2010). Participatory methods of integrated assessment—a review. *Wiley Interdisciplinary Reviews: Climate Change*, 1(5), 697-717.
- Schaal-Lagodzinski, Tamara & Mitchell, Michael & Scheele, Ben & Ryan, Paul & Hanspach, Jan. (2023). Using the three horizons approach to explore pathways towards positive futures for agricultural landscapes with rich biodiversity. *Sustainability Science*. 18. 1-19. 10.1007/s11625-022-01275-z.
- Sharpe, B. 2013. *Three horizons: patterning of hope*. Triarchy Press, Axminster, Devon, UK.
- Sharpe, B., Hodgson, A., Leicester, G., Lyon, A., & Fazey, I. (2016). Three horizons: a pathways practice for transformation. *Ecology and Society*, 21(2).
- Van Vuuren, D. P., Riahi, K., Moss, R., Edmonds, J., Thomson, A., Nakicenovic, N., ... & Arnell, N. (2012). A proposal for a new scenario framework to support research and assessment in different climate research communities. *Global Environmental Change*, 22(1), 21-35.

- Virapongse, A., Pearlman, F., Pearlman, J., Murambadoro, M. D., Kuwayama, Y., & Glasscoe, M. T. (2020). Ten rules to increase the societal value of earth observations. *Earth Science Informatics*, 13, 233-247.
- Wahl, D.C. (2016). *Designing Regenerative Cultures*, Triarchy Press, UK, May 2016
- Weyant, J. (2017). Some contributions of integrated assessment models of global climate change. *Review of Environmental Economics and Policy*.
- Wülser (2020). Most significant change technique. td-net toolbox profile (4). Zenodo. doi.org/10.5281/zenodo.3717069

