IAM COMPACT

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

D4.1 - From policy needs to scenario frameworks

WP4 – Modelling – Quantitative
evidence in support of post-2030
Paris-compliant climate action

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EC Summary Requirements

1. Changes with respect to the DoA

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

2. Dissemination and uptake

This deliverable will be used as a reference document for the translation of the policy needs into scenario frameworks in the context of the IAM COMPACT project and model ensemble and can provide guidance to modelling teams and other researchers—within and beyond the consortium—on how policies can be addressed from a modelling perspective.

3. Short summary of results (<250 words)

The IAM COMPACT project aims to evaluate global and national climate goals, progress, and feasibility, and formulate policy planning beyond 2030 for key emitters and non-high-income nations. This report outlines the first flow of activities carried out under Work Package 4, Task 4.1, to produce guidelines to translate policy needs into scenario frameworks, by understanding the different types of climate and sustainability policies, and how they can be represented in the modelling of mitigation scenarios within the consortium. This involves categorising and linking policy questions to the IAM COMPACT modelling ensemble.

The report begins by reviewing the relevant literature and establishing a set of policy types and categories. The consortium's models are then analysed to assess how policy needs can be best represented from a modelling perspective. Next, the preliminary policy questions provided by stakeholders in the context of the IAM COMPACT Policy Response Mechanism (PRM) within WP2 are explained, classified, and clustered as a first step to represent them into models and translate them into scenarios. Finally, the report concludes with a proposal of a process to follow for matching policy needs with modelling frameworks as a guideline for forthcoming work, which will include the formulation of a policy catalogue (MS9), the grouping of interrelated policy questions into common scenario logics, examining policy-model matching, and addressing synergies and trade-offs.

4. Evidence of accomplishment

This report.

Preface

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

NTUA – National Technical University of Athens	EL	
Aalto – Aalto Korkeakoulusaatio SR	FI	
AAU – Aalborg Universitet	DK	
BC3 – Asociacion BC3 Basque Centre for Climate Change – Klima Aldaketa Ikergai	ES	
Bruegel – Bruegel AISBL	BE	
CARTIF – Fundacion CARTIF	ES	
CICERO – Cicero Senter for Klimaforskning Stiftelse	NO	
E3M – E3-Modelling AE	EL	
KTH – Kungliga Tekniska Hoegskolan	SE	
POLIMI – Politecnico di Milano	IT	
UPRC – University of Piraeus Research Center	EL	
UVa – Universidad De Valladolid	ES	
WI – Wuppertal Institut fur Klima, Umwelt, Energie GGMBH	DE	
IIMA – Indian Institute of Management	IN	
THU – Tsinghua University	CN	
USMF – University System of Maryland	US	
AAiT – Addis Ababa University	ET	
KEI – International Civic Organisation Kyiv Economics Institute	UA	
RUSL – Raja Rata University of Sri Lanka	LK	
TUM – Technical University of Mombasa	KE	
UNIGE – Université de Genève	CH	
Imperial – Imperial College of Science, Technology and Medicine	UK	

Executive Summary

The objectives of the IAM COMPACT project are to assist in the evaluation of global and national climate goals, progress, and feasibility space, as well as in the formulation of the next round of Nationally Determined Contributions (NDCs) and policy planning beyond 2030 for key emitters and non-high-income nations. The main objectives of this deliverable, part of Task 4.1, is to identify the most relevant climate and sustainability policies, formulate their categorisation into policy types, and produce guidelines to translate policy needs into scenario frameworks. Policy needs are received from WP2 ("Listening – Ensuring policy relevance and ownership") and transformed into modelling requirements for IAM COMPACT models to explore.

For the categorisation and identification of policies, a literature review of scientific articles, policy briefs, databases, and relevant European H2020 projects is carried out (Section 2). This review allows for the establishment of a set of policy types and categories which can be filtered (e.g., sector of application, policy instruments, jurisdiction, etc.) to allow for further classification of policies and provides the groundwork for the establishment of a comprehensive policy catalogue. Next, we proceed to analyse the features and policy types that can potentially be represented in the consortium's models (Section 3), before delving into the formulation of guidelines that will support the matching of policy needs with the most suitable models (Section 4). In Section 5, the initial policy questions provided by stakeholders through Deliverable 2.2 ("Scoping Policy Relevant Research Questions") are briefly introduced, analysed, and clustered. This process, essential for translating questions into scenarios, is preliminary and iterative, as the policy questions arisen from the engagement with stakeholders will be updated and expanded. As a result, a two-step process for matching policies and models is proposed and will be deployed in future activities within this task.

The deliverable provides a set of general guidelines that can support the translation of policy needs into modelling scenarios and feeds into the Task 3.2 on cross-cutting dialogues and model comparability and Task 4.2 on the development of the broad scenario logic. Furthermore, the policy analysis of Task 6.4 will contribute to the understanding of mitigation synergies and trade-offs, drivers, and barriers and support grouping of interrelated policy needs and identification of those which can be simulated jointly in scenario protocols (D4.2).

Finally, future work will expand the range of climate and sustainability policy options and the policy types proposed here, considering the final list of policy questions from the two IAM COMPACT modelling cycles, and result in the creation of a final policy catalogue (MS9).

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Abbreviations

Acronyms	Meaning
AFOLU	Agriculture, Forestry and Other Land Use
B3W	Build Back Better World
CAF	Cancun Adaptation Framework
CAP	Common agricultural policy
CEAP	Circular Economy Action Plan
CCLW	Climate Change Laws of the World
CEDI	Clean Energy Demand Initiative
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPD	Climate Policy Database
EAP	Circular Economy Action Plan
EC	European Commission
EEA	European Environment Agency
EU	European Union
FMC	First Movers Coalition
IAMs	Integrated Assessment Models
I^2 AM PARIS	Integrating Integrated Assessment Modelling in Support of the Paris Agreement
ICAO	International Aviation Organisation
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LT-LEDS	Long-term low emissions development strategies
LULUCF	Land Use, Land-Use Change and Forestry
NAPs	National Action Plans
NCCAS	National Climate Change Adaptation Strategy
NCDs	Nationally Determined Contributions
NECPs	National Energy and Climate Plan
OECD	The Organization for Economic Cooperation and Development
REDD	Reducing Emissions from Deforestation and Forest Degradation
R&D	Research & Development
SDGs	Sustainable Development Goals
UNFCCC	The United Nations Framework Convention on Climate Change
UN-REDD Programme	The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
WCS	World Conservation Strategy

1   Introduction

The deliverable D4.1 "From policy needs to scenario frameworks" is part of Work Package WP4 "Modelling – Quantitative evidence in support of post-2030 Paris-complaint climate action", which involves the main modelling work of the IAM COMPACT project and aims to simulate post-2030 policy implications, considering different transition risks, technology development patterns, investment requirements or mitigation implications of the main sectors (energy industry, land use, etc.). WP4 starts with Task 4.1 "Understanding policies, policy needs, and their representation in modelling tools", of which the main goal is to provide an improved understanding of the climate and sustainability policies, policy needs and their representation in models, and assess socio-environmental sustainability alongside climate policy needs.

Sustainable Development Goals (SDGs) are often treated as synergies/trade-offs of mitigation in modelling, yet they are rarely explored in a holistic framework of sustainable development pathways. In addition, the optimal assessment of the nexus between climate and sustainability remains a challenge for IAMs to achieve (Nikas, Elia, Doukas, Bui, Delpiazzo, & Giarola, 2021). In this regard, cross-sectoral modelling (from IAMs to sectoral models) is fundamental to effectively evaluate not only climate but also sustainability and provide insights to policymakers on how this nexus interacts and what policy packages can maximise the synergies between emissions reductions and SDGs (Sustainable Development Goals). In addition, the importance of considering behavioural, distributional and societal aspects in modelling scenarios is often overlooked, despite that, first, meeting the Paris Agreement objectives will not be feasible without the necessary behavioural and societal transformations (Nikas, Lieu, Sorman, & Gambhir, 2020), and, second, climate policies can have adverse distributional and societal impacts, increase energy poverty, affect consumption patterns, and reduce the social and political acceptance of the transition. To this end, IAM COMPACT uses a diverse ensemble of Integrated Assessment Models (IAMs), energy system models, and other sectoral models, covering different scales, and incorporating insights from social and political sciences, which facilitates the combined analysis of climate and sustainable objectives within a broader "whole systems" framework (Pye, Broad, & Bataille, 2021).

IAM COMPACT envisions the quantification of sustainable futures, the assessment of feasibility and desirability, in terms of when, where and for whom, and the exploration of impacts on environmental, energy and climate justice. To achieve these goals, the recognition of already existing policies and the scoping of stakeholders' needs is required. The consideration of stakeholders, including decision makers, is also key in a policy evaluation process supported by models, since they are the ones who design and apply policies (OECD, 2021). Due to this, IAM COMPACT uses participatory modelling to ensure relevance and enhance acceptance.

This task supports IAM COMPACT objectives by creating guidelines for the translation of policy needs into scenario frameworks and assists the development of a broad scenario logic (Task 4.2) during the two modelling cycles. For each co-creative cycle, this analysis will facilitate the selection of models (or a combination of them) that can better explore the relevant research questions stemming from stakeholders. In addition, it will result in a policy catalogue, where the policies will be classified according to different specifications and modelling requirements (e.g., scale, sectors involved, countries covered, etc.), thus supporting the process of linking policies to fit-for-purpose modelling sets.

Thus, this deliverable produces an initial framework for the understanding of climate and sustainable development policy needs and their representation in models during the first policy and modelling cycles.

Figure 1 shows a schematic representation of how these activities interact with the entire project.
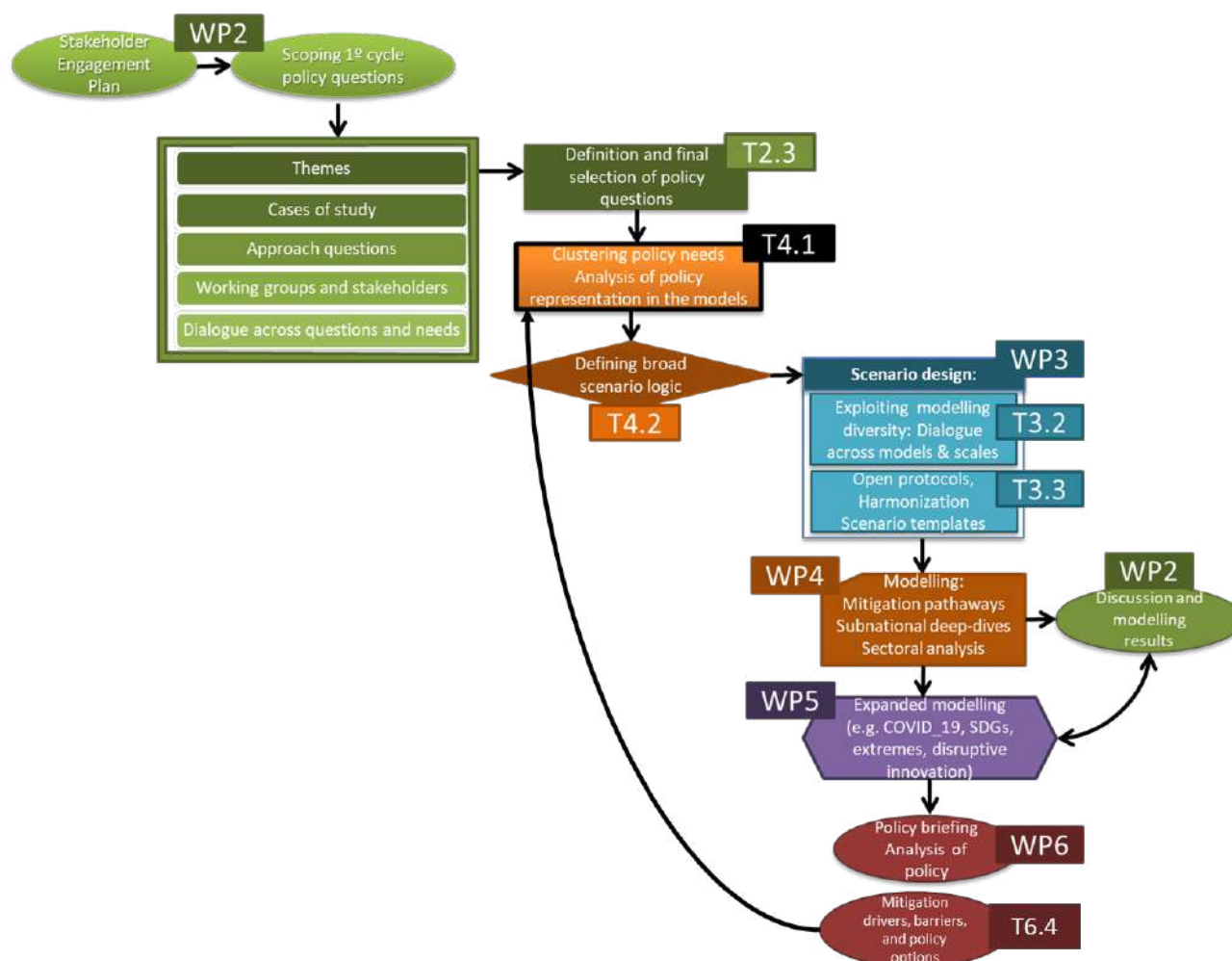
Figure 1. Graphical representation of IAM COMPACT activities (for each policy cycle) and their interactions with Task 4.1

1.1 Purpose and structure of the document

The purpose of this deliverable is to document the process carried out under the Task 4.1 "Understanding policies, policy needs, and their representation in modelling tools" in the framework of the activities developed under WP4.

The main goals of Task 4.1 guide the activities throughout this deliverable, which consist of the following:

- Identifying main policy types and categories:
  - o By analysing the most relevant climate and sustainability plans and policies (policy types) with different geographical scope, from global agreements to European and national policies. Particular focus has been given on policies in the case study counties (Ukraine, Sri-Lanka, Ethiopia and Kenya).
  - o By reviewing relevant H2020 and other European projects in which partners are involved as well as additional literature to create an adequate and up-to-date policy clustering catalogue for climate and sustainability policies, which will support the subsequent matching of models and policies.

- Analysis of which policies can be represented in the models: establish a framework for analysing the models involved in the project to understand their characteristics and how they model the different types of policies. This framework will support the identification of models that can better explore stakeholders' policy questions of the first co-creation cycle and the enhancement of evidence-based policymaking. (Süsser, Ceglarz, Gaschnig, & Stavrakas, 2021)

- Identifying and clustering the preliminary policy questions/needs coming from D2.2 based on the categories established according to the literature review on policy types. This categorisation will consider the requirements policies impose on model selection (e.g., sector-specific questions), thus supporting their future matching with the appropriate models.

The specific procedure followed through the deliverable can be observed in Figure 2 as an initial approach, to categorise the different policies and link them with the models that best shape them:
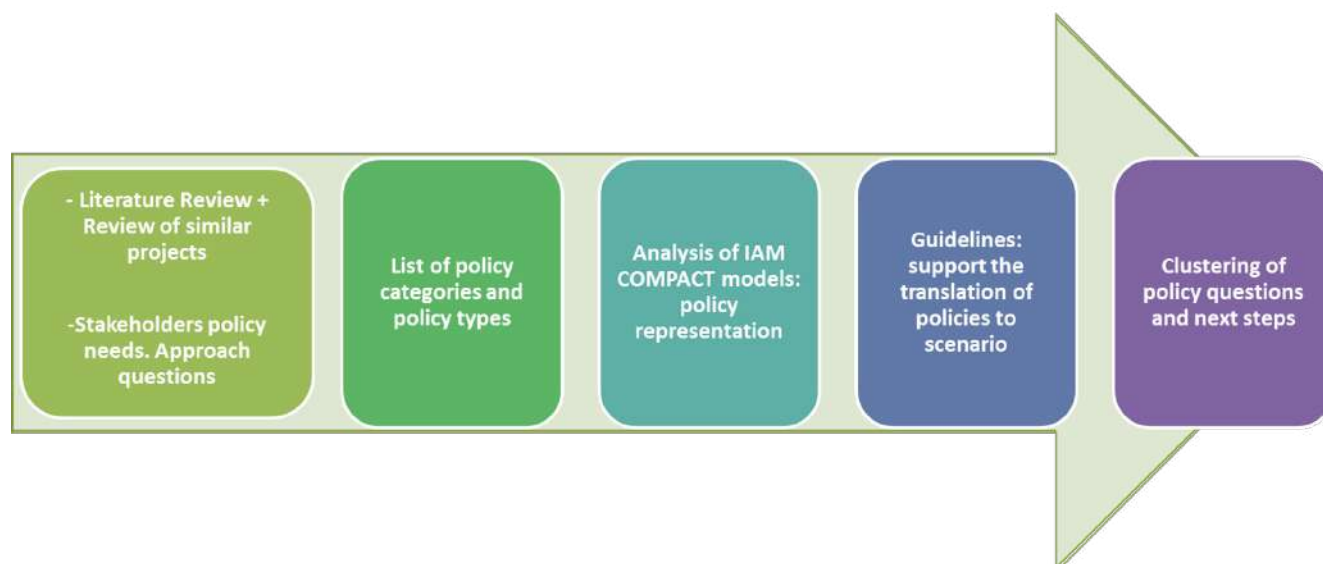
Figure 2. Schematic representation of the procedure followed in the Deliverable 4.1**.**

Considering the previous list of activities, this deliverable has the following structure:

- o Section 1 (present section) provides an outline for this Deliverable and how it fits into WP4 and overall project structure.

- o Section 2 gives an overview of current policy plans, strategies and agreements related to sustainability and climate science. It also reviews documentation and papers of policy types and policy clusters, proposing a new categorisation of policy questions. Key terms are included in this section too.

- o Section 3 gives an analysis of the features of the IAM COMPACT modelling ensemble to determine the most appropriate tools to answer the policy questions.

- o Section 4 outlines the guidelines that result from this deliverable, which will support the translation of policies to scenario frameworks based on previous sections' analysis.

- o Section 5 applies the guidelines developed in Section 4, including the clustering of the preliminary policy questions and formulates the future procedure to be followed for matching the final policy questions with the most suitable models, in line with the research of Section 3.

- o Section 6 presents the conclusions and future work to be developed in the update of this Deliverable (D.4.2) and determines the feedbacks and synergies with co-related tasks of the project.

2   Identification of policy types and categories

The aim of this section is to identify main climate, sustainability and energy policy types, and to provide a policy clustering methodology capable of classifying a large spectrum of climate and sustainability policies that are to be represented in the models throughout this project. First, this section defines a set of key terms that are highly repeated and discussed through the document and thus their accurate description will support a common understanding.

Then, an introduction to climate and sustainability policies is carried out, including the analysis of key global or international agreements, European strategies, and national plans. Policies from the case study countries have also been reviewed to allow for country-level specific analyses. The focus of this section is to conduct literature review of primary and secondary sources (scientific or policy papers, relevant EU projects, etc.) and understand how climate and sustainability policies are usually classified, in order to obtain an overall framework of different policy types and provide a method for clustering stakeholders' policy questions. The classification and explanation of each reference specifies which studies and databases have been included and serves to justify that the final categorisation (Section 4.2.1) fulfils its purpose.

The last subsection provides a review synthesis, determining which categories are agreed as suitable for this deliverable and incorporating sub-categories to make the clustering as comprehensive as possible. When choosing the final categories, a distinction is made between those categories that converge in multiple references and those that, because they are novel or inclusive, bring greater diversity to the final set of categories and policy types.

2.1 Key Terms

Through this section, a set of key terms are defined in order to establish an appropriate and standardised nomenclature for this deliverable, as each reviewed reference may use different terms to refer to the same concept. Key terms are explained below:

Policy → According to the Oxford English Dictionary, a policy is a plan of action agreed or chosen by a political party, a business, etc.

Agreement → Arrangement made between two or more countries. Once the agreement enters into force, parties to the agreement become legally bound by it.

Deal → Initiative to achieve diverse goals between two countries or more. It is not a law, but it has to inspire a legislative change.

Plan → A detailed scheme, method, arrangement, pattern or program for attaining a definitive purpose over a period of time. In nature, it is very concrete, without potential deviation, and explains how the strategy will be executed. (Sabatier, 2007)

Strategy → According to Oxford Dictionary a Strategy, it is a blueprint, idea or layout implemented to accomplish a certain goal that is open for change and adaptation. It identifies the needs to meet the purpose. (Sabatier, 2007)

Policy questions → Specific issues or problems that policymakers seek to address through the development of policy measures. Policy questions can be framed in various ways, such as identifying the root causes of a problem, exploring potential solutions, assessing the feasibility of policy options, or evaluating the outcomes of existing policies. (Sabatier, 2007)

Policy needs → Gaps or challenges that require the development of policy solutions to address them. These may arise due to changes in the social, economic, or political environment, emerging issues, or persistent problems that require attention. Policy needs can be identified through various methods such as research, stakeholder consultations, or monitoring and evaluation of existing policies. (Buse, Mays, & Walt, 2012)

Policy Sector → Also mentioned as "Policy implementation category", it refers to the areas in which the policies will be directly implemented (i.e. transport or industry), as opposed to "Policy objectives" (term explained below) where the impact may be indirect. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

Policy measures → Interventions to generate a change in the technology used, behaviour shown, infrastructure constructed, etc. with relation to current trends, promoted by institutions (usually a public one like the government). To implement a policy measure it is necessary to define the policy instrument, which is going to be applied, the sector of implementation, the objective and target of the policy and the co-benefit associated.

o *Policy instrument*: Tools used by the government to achieve the desired policy target. Those could include regulatory instruments to soft and economic tools, as well as research & development instruments, among others. To implement a policy measure, single instruments or combinations of different instruments may be used. The major instruments are defined below. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

▪ Regulatory instrument: Government intervention setting rules and trends, banning inefficient or unsustainable practices or technologies, or limiting production or consumption of certain goods and services for target groups (i.e., obligation schemes, codes, or regulatory standards). (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

▪ Economic instrument: Provision of financial incentives, taxes, tax reliefs and other tools by governments or international institutions to encourage certain actions, investments or behaviours. They can be classified as direct investment (i.e. procurements), fiscal incentives (i.e. taxes or subsidies) and market-based instruments (i.e. emissions trading). (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

▪ Soft instrument: Instruments that rely on voluntarism, learning processes and procedural change, rather than direct regulatory or economic control (i.e. voluntary agreements). (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

▪ Research & Development instrument: Public funding for research and development projects. As opposed to the economic instruments, funding for research and development projects does not directly lead to the reduction of GHG emissions. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

o *Policy objective*: It indicates the generally formulated expected outcome of the implementation of a policy or the area of impact of it. The main difference with the category of "Sector" is that "Policy objective" refers to the area in which the measure will enfold its expected impact, which can also be indirect (e.g., transition to hybrid/electric cars is a policy measure implemented in the sector of transport, but it also affects industry and mitigation, which are considered "objectives" in this deliverable). It is a synonym of "Policy outcomes". (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

o *Policy target*: The quantifiable intended effect of a given policy measure. Examples of policy targets are 32% of renewable energy in total energy by 2030 or increasing public transport passengers by 20%. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

Co-benefit → The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare'. Climate co-benefits are the benefits in addition to avoided climate change costs. (Mayrhofer & Gupta, 2016) (Intergovernmental Panel on Climate Change (IPCC), 2014)

Trade-offs → In climate science terms, the negative side effects or unintended consequences caused by climate policies with a positive primary goal in an area other than that of implementation (Liu, et al., 2019)

Synergies → In climate terms, mean combining two or more different climate measures to achieve a larger effect than the sum of their effects when implemented in isolation. Synergies ensure fewer trade-offs and more

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co-benefits. (Dugumaa, Wambugua, Minanga, & Noordwijk, 2014)

2.2 Introduction

In line with WP4 objectives, the major policy topics addressed in this deliverable are climate and sustainability. As explained before, it is important to consider them together as they are often complementary. Aiming to clarify the difference between both terms, they are described below:

- Climate policies → Set of policies to mitigate climate change (reducing greenhouse gas emissions and removing greenhouse gases from the atmosphere, so that the climate does not change as much or as quickly); and to adapt to climate change (helping communities and businesses to build resilience and avoid the worst effects of warmer temperatures, extreme weather, and other impacts) (UNFCCC).

- Sustainability policies → "Measures and strategies put in place by governments to promote sustainable development, and minimise climate change impacts and reduce GHG emissions. They are aimed at ensuring that economic, social, and environmental activities are balanced, i.e., present needs are met without compromising the natural resources on which they depend on (Nathaniel, Yalçiner, & Bekun, Assessing the environmental sustainability corridor, 2021). These are related to all the goals and targets of the UN 2030 Agenda (A/RES/70/1).

Integrated assessment models (IAMs) use information from several scientific domains to provide a comprehensive understanding of complex, dynamic systems characterised by large uncertainties (Wilson, et al., 2021), especially climate change and the study of interactions between humans and the Earth systems. They are key tools designed to inform climate-policy making (Van Beek, Hajer, Pelzer, Van Vuuren, & Cassen, 2020) and provide insights into sustainable development issues. IAMs incorporate knowledge from physical, biological, economic, earth, and social sciences, and study the interactions among them into a single framework that allows evaluation of the status and consequences of climate change, as well as the policy responses to it (Intergovernmental Panel on Climate Change (IPCC), 2014). As such, IAMs can potentially support stakeholders' inclusion in the scenario design and help align research questions with their preferences. (Xexakis, Hansmann, Volken, & Trutnevyte, 2020)

Due to their nature, IAMs are able to integrate and track progress of different SDGs (Intergovernmental Panel on Climate Change (IPCC), 2018), which cover a wide range of areas that need to be explored alongside climate policies to ensure they are aligned with sustainable development. However, it must be mentioned that these models usually do not cover the full range of SDGs or analyse the impact of mitigation action on specific SDG indicators, so further enhancement of these capacities is needed (future Task 5.6.1 Capacity to assess SDGs in the IAM COMPACT models).

In addition, the design of policies to respond to climate change requires cooperation and institutional arrangements at different scales, i.e., poses the need to adopt a multiscale perspective (multi-governance). In this respect, policies generally follow the hierarchy principle (a lower-ranking rule cannot contradict or violate what a higher-ranking rule establishes) (Ziller, 2014). This means that policies at national and regional level must follow the objectives, ideas and standards of European and global policies, and if they fail to do so, they will be sanctioned. On the other hand, the international and EU policies need to be adapted to the local conditions (bottom-up approach), considering potential national or subnational restrictions or particularities. In IAM COMPACT, the models cover different scales allowing us to deploy a multi-scale coherent policy analysis, which can also be applied to the pilot countries of the project.

SUSTAINABILITY AND CLIMATE POLICIES AT DIFFERENT SCALES

In the following paragraphs, examples of relevant sustainability and climate policies are presented to create a general framework which will serve as a basis and complement to the posterior literature review that identifies general policy types and how to cluster them. The policies are organised from the general, in this case global and European scale, to the specific national strategies and plans, with an emphasis on the cases of greatest interest to the project (case study countries and major emitters: Ukraine, Ethiopia, Kenya, Sri Lanka, India, China and the United States).

Global-scale policies refer mainly to agreements between almost all countries and they set the baseline for smaller-scale policies. As a European project, IAM COMPACT addresses also continental strategies that regulate climate and sustainability policies for the 27 countries of the European Union. Finally, examples at the national level include the individual plans of European countries, as well as the policies of our pilot counties and major emitters.

Global climate and sustainability policies

Globally, commitments and targets developed during international meetings (mainly during Conference of the Parties (COPs)) and ratified by almost all countries, serve as guidelines, or form the basis for the creation of policies at other levels. A similar process occurs with respect to policies developed by European organisations and agencies. For a directive to take effect at national level, Member States adopt laws to transpose it; the national law must achieve the objectives set by the directive through specified measures communicated to the European Commission. However, at the global scale, targets are set and communicated without any legally binding or enforceable commitments.

The principal global climate change agreement which is the basis for other climate policies is the Paris Agreement, intended to limit global temperatures to well below 2ºC and strength the ability of countries to deal with the impacts of climate change. It was adopted in the 21st Conference of the Parties (COP21), held in Paris in 2015.

Specifically, regarding adaptation to climate change, the Cancun Adaptation Framework (CAF) (United Nations, a) presents a set of balanced international decisions under the United Nations Framework Convention on Climate Change (UNFCCC) set in the 16th COP in Cancun in 2010. This framework aims to enhance action on adaptation in developing countries through international cooperation, financial and technical support, and regional networks. Ultimately enhanced action on adaptation seeks to reduce vulnerability and build resilience in developing country Parties, taking into account the urgent and immediate needs of those developing countries that are particularly vulnerable.

Although focused only on the shipping and aviation sector, the International Aviation Organisation (ICAO), and the measure market-based called Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) are also considered, as the related policies/measures are legally binding international targets that influence the transition. The ICAO creates regulations for aviation safety, security, efficiency and regularity and environmental protection. CORSIA represents a cooperative approach that moves away from a "patchwork" of national or regional regulatory initiatives. (ICAO)

In terms of energy-climate policies, the International Energy Agency (IEA) provides policy advice to its 31 member states and 11 associated counties, supports the understanding of the interconnectedness between energy systems and climate change, and the need to transition to a socially and environmentally sustainable future. The policy recommendations and solutions IEA provides prioritise the reduction of emissions, the promotion of energy efficiency and sustainable energy access, and the international cooperation. (IEA)

Regarding sustainable development, The United Nations High Level Political Forum on Sustainable Development (HLPF) (United Nations, b), which was established by UN General Assembly is the main forum for sustainable development issues to follow up and review the 2030 Agenda and the SDGs.

In addition, there are global frameworks that cover specific SDGs, such as environment/protection of natural resources and biodiversity e.g., the United Nations Summit on Sustainable Development launched in 2015 where more than 150 world leaders gathered at United Nations Headquarters in New York to formally approve an ambitious new agenda for sustainable development, or The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (The UN-REDD Programme), launched in 2008 and related to on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations, the United Nations Development Programme and UN Environment.

Also, the Organization for Economic Cooperation and Development (OECD) creates frameworks and policies through targets to achieve SDGs, like the Target 18 of the Post-2020 Global Biodiversity Framework aiming to inform and strengthen incentives for a just transition towards a more sustainable economy and ensure that they are either neutral or positive for biodiversity.

European climate and sustainability policies

In Europe there are many different targets related to climate and sustainability. The European Green Deal (European Commission, a) includes the European Climate Law, the European Climate Pact, the 2030 Climate Target Plan, and the EU Strategy on Climate Adaptation and aims to transform Europe in the world's first climate-neutral continent. In particular, the European Green Deal is a general approach which relates sustainability, climate and environment among other themes (WECOOP, Central Asia Water, Environment and Climate Change Cooperation, 2022). It consists of a plan, promoted by the European Commission in 2019 and to which all 27 EU Member States have committed, to turn the economy and society of the EU Member States into a more sustainable one and to "transform EU into the first climate-neutral continent by 2050". This set of measures boosts resource efficiency and economic-growth while protecting biodiversity, reducing emissions and improving quality of life. The key areas influenced by the Green Deal go beyond purely climate objectives, and are:

(i)   Climate action → reducing the gas emissions by, at least, 55% by 2030 compared to 1990 levels and reaching net-zero emissions by 2050. Carbon pricing: EU Emissions Trading System, ETS (including its expansion to buildings and transport), energy-efficient buildings and renewable energy are the main tools to achieve it.

(ii)   Circular economy → reducing waste generation and promoting a more sustainable use of resources. The circular economy model seeks better waste management and sustainable products.

(iii) Biodiversity → protecting and restoring the biodiversity in the EU is an essential part of the Green Deal and measures such as establishing a larger EU-wide network of protected areas on land and at sea are set out.

(iv)   Sustainable mobility → promoting low-emissions transport, especially focused on the development of the electric and other renewable energies vehicles, and expanding the use of public transport.

(v)   Farm to fork → this strategy aims to create a sustainable food system in the EU, ensuring food security, nutritional quality, etc.

(vi)   Green Deal Industrial plan→ to drive the transformation of the industry towards net-zero while protecting competitiveness and ensuring innovation and high-quality jobs

The European Green Deal includes several policies, strategies and plans. Some examples of the policies that this plan includes are listed below:

- Common agricultural policy (CAP) → is a partnership between society and agriculture that ensures a stable supply of food, safeguards farmers' income, protects the environment and keeps rural areas vibrant. (European Commission, b)

- 2030 climate & energy framework → this implies a reduction emissions target that has been raised in 2020, to a target of at least 55% cuts in greenhouse gas emissions (from 1990 levels). Also, it includes the following targets: at least 32% share for renewable energy and at least 32.5% improvement in energy efficiency. Precisely the renewable energy target has been recently updated to a 40% share for renewable energy, and even the Commission is proposing to increase it to 45% in the REPowerEU Plan (explained below). (European Commission, c)

- Zero Pollution Action Plan → it is for air, water and soil pollution to be reduced to levels no longer considered harmful to health and natural ecosystems that respect the boundaries with which our planet can cope, thereby creating a toxic-free environment. It aims to improving the quality of air, water and soil, and also reducing pollution or waste. (European Commission, d)

- Biodiversity strategy for 2030 → long-term plan included in the EU Green Deal to protect nature and reverse the degradation of ecosystems. This strategy is precisely the EU´s contribution to the international negotiation on the "global post-2020 biodiversity framework" already explained before. (European Commission, e)

In addition, a brief guide of European environmental policies till 2030 is developed by the 8th Environment Action Programme (EAP) (European Commission, f) or General Union Environment Action Programme to 2030. This programme will guide the European environmental policy until 2030. Also, it supports the environment and climate action objectives of the European Green Deal. It provides an opportunity for the EU as a whole to reiterate our commitment to the 7th EAP's 2050 vision

Also, in Europe there are specific strategies such as:

- European Climate Adaptation Strategy (Climate-ADAPT) → outlines a long-term vision for the EU to become a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050. (EEA, a)

- EU Sustainable Development Strategy→ The overall aim of the EU Sustainable Development Strategy is to identify and develop actions to enable the EU to achieve a continuous long-term improvement of quality of life through the creation of sustainable communities able to manage and use resources efficiently, able to tap the ecological and social innovation potential of the economy and ultimately able to ensure prosperity, environmental protection and social cohesion. (EUR-Lex)

- Net-Zero Industry Act Proposal → it reinforces industrial manufacturing of key technologies in the EU and provides a simplified regulatory framework for production capacities of net-zero products across value chains. (European Commission, g)

- REPowerEU Plan → its response to the hardships and global energy market disruption caused by Russia's invasion of Ukraine, which also accelerates the transition. There is a double urgency to transform Europe's energy system: ending the EU's dependence on Russian fossil fuels, which are used as an economic and political weapon and cost European taxpayers nearly €100 billion per year, and tackling the climate crisis. The measures in the REPowerEU Plan can respond to this ambition, through energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy to replace fossil fuels in homes, industry and power generation. (European Commission, h)

Finally in the European context, the European Environment Agency catalogue of European environment and climate policy evaluations can serve as a key source of obtaining a big picture of the most relevant environmental policy types. It gives access to each policy and provides basic information about it (policy areas and economic sectors that are covered; information on the geographic and timely scope, etc.). (EEA, b)

Another important catalogue of policies is the one available through the European Commission, which also targets a broad list of policies, strategies and measures along different themes. It covers climate, energy and food safety as shown in Figure 3.

Policies and initiatives

Agriculture and rural development	Banking and financial services	Borders and security
Budget	Business and industry	Climate action
Competition	Consumers	Culture and media
Customs	Digital economy and society	Economy, finance and the euro
Education and training	Employment and social affairs	Energy
Environment	EU enlargement	European neighbourhood policy
Food safety	Foreign affairs and security policy	Fraud prevention
Home affairs	Humanitarian aid and civil protection	Institutional affairs
International partnerships	Justice and fundamental rights	Maritime affairs and fisheries
Migration and asylum	Public health	Regional policy
Research and innovation	Single market	Sport
Statistics	Taxation	Trade
Transport	Youth	

Figure 3. Themes of policies and initiatives of European Commission. Source: **(European Commission, i)**.

Other regulations (European Commission, j) preceding the European Green Deal, are (i) the 2020 climate & energy package (GHG emissions were reduced by 24% between 1900 and 2019) or; (ii) the Kyoto Protocol with 2 commitment periods (2008-2012 and 2013-2020, keeping emissions at an average of 20% below base-year levels over the entire second period).

National climate and sustainability policies

European Commission supports compliance assurance at the national level (e.g. implementation of EU environmental laws through infringements procedures). At state level, there are different types of strategies and plans related to climate and sustainability:

- Nationally Determined Contributions (NDCs) → Climate actions to achieve the goals of the Paris Agreement. Embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. NDCs are submitted every five years to the UNFCCC secretariat. In order to enhance the ambition over time the Paris Agreement provides that successive NDCs will represent a progression compared to the previous NDC and reflect its highest possible ambition. (United Nations, c)

- National Climate Change Adaptation Strategies (NCCAS) → provide a common vision of climate change adaptation and climate resilience for the country, drawing from the National Development Plan, the National Strategy for Sustainable Development, the adaptation commitments included in its Nationally Determined Contributions, sector adaptation plans, provincial adaptation plans and municipality adaptation plans. (United Nations, c)

- National energy and climate plans (NECPs) - European Union (to be updated in June 2023) → part of the Clean Energy for all Europeans package, they were introduced and mandated by the EU Regulation on the Governance of the Energy Union and Climate Action. The NECPs outline how EU counties will achieve their climate and energy targets, policies, and measures in the areas of renewable energy, GHG emissions, research and innovation, energy efficiency, and interconnections. They characterise the specific targets and methods of each country to cover the next 10 years, from 2021 to 2030. They have periodic revision and strengthening like the NDCs (but legally binding). (European Commission, k) (European Comission, l)

- National Adaptation Plans (NAPs) → established under the Cancun Adaptation Framework (CAF), they are country-driven processes where national governments analyse current and future climate risks and deliberate with stakeholders how the risks can be addressed. They identify medium- and long-term adaptation needs

and develop strategies and programmes to address those needs. (United Nations, d)

- <u>Long-term low emissions development strategies (LT-LEDS)/ Net-Zero Strategies</u> → are a crucial policy tool that can help to place short-term actions in the context of the long-term structural changes required to transition to a low-carbon, resilient economy by 2050. (IDDRI)

Regions outside EU in IAM COMPACT

This section is focused on the regions of interest outside the EU in IAM COMPACT defined in Deliverable 2.2 (Heussaff & Zachmann, 2023). These regions were selected collaboratively by non-EU partners and their analysis is focused on local energy and climate policies.

In **Ukraine,** most adopted energy and climate policies have faced implementation challenges due to the COVID-19 pandemic and the large-scale military invasion of the country (Government of Ukraine, a). Most of them are related to the reduction of GHG Emissions. Some examples are the following:

- Law of Ukraine No. 376-IX of 12 December 2019 → "On regulation of activities using ozone-depleting substances and fluorinated greenhouse gases" (Government of Ukraine, a).

- Law of Ukraine No. 337-IX of 12 December 2019 → "On Principles of Monitoring, Reporting and Verification of Greenhouse Gas Emissions". (Government of Ukraine, a)

- EU4Climate→ adaptation of Paris Agreement to the six EU Eastern Partner countries (Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine) to take action against climate change and towards a low-emissions and climate-resilient economy. (EU4Climate)

- NDC application in Ukraine → The revision of the NDC was supported by the European Union (EU) through awareness-raising events organized under the EU4Climate initiative. NDC raises its emissions reduction target to 65% by 2030 compared to 1990 levels. Also, it provides limited information on adaptation, but the country aims to establish a baseline for adaptation and resilience measures by 2030. (UNDP)

- Strategy of Low Carbon Development (LEDS) of Ukraine for the period up to 2050 → its main goal is to determine strategic directions for Ukraine's economy sustainable development based on national priorities accordant transition to low emission growth trajectory. (UNFCCC, 2017)

- Action Plan for the implementation of the Concept of Public Policy in Climate Change → enhancing institutional capacity to develop and ensure the implementation of state climate change policy; preventing climate change by reducing anthropogenic emissions and increasing the absorption of GHGs; ensuring a gradual transition to low carbon development of the state and adapting to climate change, strengthening resilience and reducing risks related to climate change. (Government of Ukraine, b)

- National Waste Management Strategy of Ukraine to 2030 → it defines the vision, priorities and targets of the reform to solve the problem of production and consumption waste accumulation as one of the leading threats to environmental safety. (Government of Ukraine, c)

In the **African** countries the main climate policies are related to the reduction of Greenhouse Gases (GHGs) Emissions, climate change adaptation, and deforestation. With respect to the priorities for sustainable development in the African countries, the main ones are focused on food security (agricultural programmes and plans), industrial development plans, water security, and the efficient use of energy resources. In particular, in **Kenya** is important migration, energy accessibility, health and clean water (United Nations, e). Meanwhile in **Ethiopia** agriculture, gender gap, green energy, low emissions or industrial and service sector growth are the goals or milestones to get (United Nations, f). Some examples of climate policies are the following:

- UN-REDD Programme, REDDD+ in Africa→ incentivizes forest conservation that stands for "reducing emissions from deforestation and degradation of forests, plus sustainable land use" (African Development Bank Group, 2016).

- Adaptation of Climate Change Act (2016) to Kenya → which provides a framework for the promotion of climate-resilient low-carbon economic development (Goverment of Kenya, 2020; Kenya, The Climate Change Act, 2016)

- Least Cost Power Development Plan (LCPDP) (Kenya)→ major planning process in the electricity supply sector in Kenya and deals with capacity planning, demand projections and transmission investment requirements summarised in a 20-year rolling plan on a biennial basis (Republic of Kenya, 2018)

- Sustainable Waste Management Act (Kenya)→ since 2021, the bill would establish take back schemes, extended producer responsibility, and materials recovery facilities. It would also close open dumpsites and introduce sorting receptacles for organic, plastic, and general waste so that it can be eventually composted or recycled (Ministry of Environment and Forestry, 2021)

- Implementation of the Agenda 2030 for Sustainable Development (Kenya)→ it is to spearhead the implementation of the SDGs in the country and in their respective sectors; ensure that the SDGs are mainstreamed in the development planning documents and; track and report on progress on SDGs. (MINISTRY OF DEVOLUTION AND PLANNING, 2017)

- NDC of Kenya → Low carbon, climate resilient development pathways promoting mitigation activities like increasing of renewable in electricity generation mix of the national grid, low carbon and efficient transportation systems or make efforts towards achieving land degradation neutrality. (NCD Partnership, a)

- Ethiopian Water Resources Management Policy (Ethiopia)→ to enhance the well-being and productivity of the Ethiopian people through provision of adequate, reliable and clean water supply and sanitation services and to foster its tangible contribution to the economy by providing water supply services that meet the livestock, industry and other water users' demands. (MINISTRY OF WATER RESOURCES, 1999)

- Resilient Green Economy Strategy (Ethiopia) → to improve the living conditions of Ethiopian people by reaching a middle-income status by 2025 based on carbon-neutral growth, and also, to effectively transforming Ethiopia into an early adopter of a low-carbon growth path. (United Nations, g)

- Ten Year Development Plan: A Pathway to Prosperity (2021-2030) (Ethiopia)→ aims to bring economic growth, expecting 10.2% annual growth, while also supporting a climate-resilient green economy (Ethiopian Monitor, 2020)

- NDC of Ethiopia → commit to reduce emissions by 68.8% compared to BAU projections by 2030, including 14% reductions unconditionally committed and 54.8% contingent on international support. It includes 40 prioritized adaptation actions that derive from the NAP and align with the 10 year national development plan. (NDC Partnership, b)

Due to the war between the Tigray People's Liberation Front and the federal government of Prime Minister Abiy Ahmed, it is difficult to assess the implementation of policies in Ethiopia related to climate change and sustainability. (NDC Partnership, b)

In relation to **Sri Lanka and India**, their emitting status is highly differentiated, but they have close economic and cultural ties, and some policies treat them under a common umbrella. Sri Lanka focuses on how to achieve better water and waste management, use of land, energy accessibility and climate action (United Nations, h). India focuses on clean energy accessibility, agriculture, and waste management.

Some examples of important policies and plans are:

- UN World Food Programme applied in both countries (Sri Lanka and India)→ the main goal is to strengthen the adaptive capacity and food security of vulnerable communities in Sri Lanka's dry zone and India's eastern coastal states, utilizing a regional, integrated approach. (United Nations, i) (United Nations, j)

- Climate Prosperity Plan (CPP) (Sri Lanka)→ it sets a target of increasing Sri Lanka's renewable energy generation from 35% to 70% by 2030, and provides a pathway to become a carbon negative economy before mid-century. (Group, 2022)

- National Adaptation Plan for Climate Change Impacts In Sri Lanka →The main goals pf this plans are to enhancing the resilience of different sectors, communities and ecosystems to cope with climate change impacts and reduce vulnerability to climate risks (Climate Change Secretariat,Ministry Ministry of Mahaweli Development and Environment, 2016)

- Sri Lanka Sustainable Development Act, No. 19 of 2017 → Aims to ensure an ecologically efficient use of natural, social, and economic resources. Promotes the integration and maintenance of balance among environmental, economic, and social factors in the government decision-making (Parliament of Democratic Socialist Republic of Sri Lanka, 2017)

- Energy Conservation Amendment Bill (India) → it aims to mandate the use of non-fossil fuel sources including green hydrogen, green ammonia, biomass and ethanol for energy and feedstock in industries. (PRS)

- Long-Term Low-Carbon Development Strategy (India) (2022) → strategy that wants to identify and explore opportunities to shift to low-carbon development pathways, while ensuring adequate access to household energy, energy security, and energy for the development of all sectors of the economy. (United Nations, k)

- National Agricultural Development Plan (India) →it operates to encourage the formulation of state and district level plans and to induce the states to increase own spending on a highly diverse set of activities. (Krishi IQ)

- National Mission for Sustainable Agriculture (NMSA) (India)→ it aims to make agriculture more productive, sustainable, remunerative, and climate resilient. Also aims to mitigate the effects of drought and increase the area under irrigation. (Government of India)

- National Clean Air Programme→ time-bound national level strategy for pan-India implementation to tackle the increasing air pollution problem across the country through prevention, control, and abatement; other features include increasing the air quality monitoring network across the country and technology support. (Ministry of Finance of India, 2019)

- National Policy on Resource Efficiency (RE) → seeks to create a facilitative and regulatory environment to mainstream resource efficiency across all sectors by fostering cross-sectoral collaborations, development of policy instruments, action plans and efficient implementation and monitoring frameworks. Its main goals are the reduction in primary resource consumption to 'sustainable' levels, creation of higher value with less material through resource efficient and circular approaches, waste minimisation, material security and creation of employment. (Ministry of Finance of India, 2019)

China accounts for the greatest share of global GHGs so most of its policies are related to reducing emissions and energy source transformation:

- Enhanced Actions on Climate Change: China's Nationally Determined Contributions: aims at peaking CO_2 emissions before 2030 and achieve carbon neutrality before 2060; to increase the share of non-fossil fuels in primary energy consumption. (FAO)

- The Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035 → issued in 2021, it sets the goal to achieve reduction of energy consumption per unit of GDP by 13.5% and CO_2 emissions per unit of GDP by 18% compared to 2015. (CSET)

- The Energy Supply and Consumption Revolution Strategy (2016– 2030) → released in 2016, it sets out the goal of "Four Reforms and One Cooperation" for the energy sector to actively build a clean, low-carbon, safe and efficient energy system (Sandalow, Meidan, & Andrews-Speed, 2022).

- China is formulating and issuing relevant policy documents, including the Opinions on Full, Accurate and Comprehensive Implementation of New Development Philosophy to Well Execute Tasks for CO_2 Emission Peak

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and Carbon Neutrality and the Action Plan for Carbon Dioxide Peaking before 2030. (UNFCCC, 2016)

United States accounts for the second greatest share of global GHGs relates most of its policies to reducing emissions and energy source transformation. The main policies (Government of the US) that stand out are:

- NDC → is setting an economy-wide target of reducing its net greenhouse gas emissions by 50-52% below 2005 levels in 2030. (UNFCCC, 2021)

- U.S. Methane emissions reduction action plan → to reduce overall methane emissions by 30% below 2020 levels by 2030. (The White House Office of Domestic Climate Policy, 2021)

- Plan to Conserve Global Forests: Critical Carbon Sinks → it launches the effort to conserve forests and other terrestrial and coastal ecosystems that serve as critical carbon sinks. The main set goal is to conserve 30% of lands and waters by 2030. (Hyman, 2022)

- USAID's Biodiversity Policy→ the goals are to conserve biodiversity in priority places and integrate biodiversity as an essential component of human development. (Hyman, 2022)

- Inflation Reduction Act (IRA) → marks the single largest investment in climate and energy in USA. It directs $500 billion in new spending and tax breaks that aim to boost clean energy, reduce healthcare costs, and increase tax revenues. (Energy.gov)

2.3 Review of policy types from literature and other projects

Task 4.1 involves identifying the most relevant climate and sustainability policy needs via literature review and clustering them. To achieve this goal, it is necessary to identify how climate policies are typically categorised in the published literature and in major online databases. A comprehensive review of the available references has been carried out, considering the different categories and subcategories presented by the authors, and their justification.

Information on policy categorisation from other European projects has also been reviewed to make use of the prior work of project partners. Thus, references and tools analysed include those provided by projects such as LOCOMOTION (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020), PARIS REINFORCE, ENGAGE, INNOPATHS (Siskos, 2021), (Verdolini & Fragkos, 2021), (Peñasco, Díaz, & Verdolini, 2021), NDC ASPECTS (Fragkos & Zisarou, Energy System Transition in the Context of NDC and Mitigation Strategies in Tunisia, 2022), (Fragkos, Decarbonizing the International Shipping and Aviation Sectors, 2022), SENTINEL, REEEM, ENCLUDE and NAVIGATE (Fragkos, Fragkiadakis, & Paroussos, Reducing the Decarbonisation Cost Burden for EU Energy-Intensive Industries, 2021), (Fragkos, Assessing the Role of Carbon Capture and Storage in Mitigation Pathways of Developing Economies, 2021).

LOCOMOTION, PARIS REINFORCE, INNOPATHS and ENGAGE introduce a widespread policy categorisation and provide a set of useful online tools and deliverables which are analysed for this task. On the other hand, projects like SENTINEL, REEEM and ENCLUDE do not have a special focus on policy analysis, but instead are mainly oriented towards modelling activities related to the energy transition. In these projects, policy instruments, objectives and sectors are either not explicitly discussed or specified. Instead, they only refer to objectives related to emissions as well as the electrification of some sectors such as buildings, transport, and industry.

The main references analysed are listed and described below:

a) **Climate Policy Database (CPD)**: This database was originally created by a previous project called CD-LINKS and, then, improved in the framework of the European Union H2020 project ENGAGE to identify different types of climate policies and their coverage gaps, categorising and analysing mitigation and adaptation policies to support global environmental ambitions and national low-carbon development transformational plans. (Climate Policy Database)

Through this website, a comprehensive classification of policies can be made, clustering them according to their impact, status, decision date, country of application, jurisdiction, policy objective, sector, and policy instrument (with several subcategories). In CPD, some subcategories of regulatory, soft, and economic instruments are included, as well as several examples of policy types (specific instruments).

Impact is related to the potential of a policy to reduce GHG emissions; jurisdiction sets out the extent of the policy in geographical terms; status refers to the situation of the measure at the time of categorisation, whether it is just a draft, planned, under review, etc. This project was, in the previous phase, funded as part of the project CD-Links.

b) **Integrating Integrated Assessment Modelling in Support of the Paris Agreement (I^2 AM PARIS):** With the goal of becoming the flagship of the international energy- and climate-economy modelling community, I^{2}AM PARIS is an open-access, data exchange platform hosting detailed documentation, inputs, and outputs of modelling tools and exercises for all audiences. It has been developed in the framework of the project PARIS REINFORCE.

Sectoral categories modelled throughout the project are industry, buildings, AFOLU, energy sources, energy transformation, energy storage and transportation. It also includes a classification of policy instruments according to the topic addressed: emissions mitigation, trade, energy and land. Paris Reinforce implements almost the same subcategories as LOCOMOTION. (I^2 AM PARIS)

c) **Deliverable 8.1 from LOCOMOTION:** *Review of policy options to drive societies towards sustainability: Deliverable 8.1. LOW-CARBON SOCIETY: AN ENHANCED MODELLING TOOL FOR THE TRANSITION TO SUSTAINABILITY (LOCOMOTION), (2016)*: This deliverable reviews a collection of measurements aiming to build a database of different climate policies and to determine which should be included in the LOCOMOTION integrated assessment model. This study makes it possible to compare the similarities and distinctions among national policies and modes of implementation. For most of the key terms previously introduced, this deliverable has been considered as a basis. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

d) **INNOPATHS, Decarbonisation Policy Evaluation Tool (DPET):** It is an online interface developed under the EU H2020 funded project INNOPATHS mainly focused on policy instruments used to accelerate low-carbon energy transition on a set of several indicators (cost, competitiveness, etc.). (INNOPATHS)

Remaining European projects (NDC ASPECTS and NAVIGATE) have been reviewed and analysed, concluding that they present a less extensive but considerable policy categorisation which has been considered for this deliverable. Both the projects focused on policy clustering (LOCOMOTION, PARIS REINFORCE, INNOPATHS and ENGAGE) and those that addressed it in less depth are listed in Annex I of this deliverable, with their policy categories summarised in Tables 22 to 35.

To broaden the references of this task and to widen the range of categorisations and policy examples, an additional **literature review** has been carried out, consulting multiple websites and reports from scientific and grey databases (Scopus, Science Direct, etc.). A brief description of each reference is provided below:

Online databases

a) **IEA Database of Policies (IEA Database):** The IEA (International Energy Agency) was formed in 1974 to participate in the coordination of a collective response to major oil supply disruptions. Notwithstanding, its scope has been considerably expanded since, providing authoritative analysis, data, policy recommendations to help countries provide secure and sustainable energy.

According to this database, policies can be classified depending on their region of application, status,

jurisdiction, topic, technology, sector, and policy instrument. As this agency is entirely energy-related, all topics deal with energy, not including other themes such as land use, economy, or society.

In this database, as energy is the main theme, the "topic" category may be understood as specific energy policy objectives (i.e. energy efficiency, energy poverty, electrification, etc.) while the "technology" category as specific sub-sectors (i.e. wind, solar, cooling or heating technologies). (IEA)

b) **Climate Change Laws of the World (CCLW):** It is a database created to search and browse climate laws, policies, and litigation cases internationally by the Grantham Research Institute at LSE and the Sabin Center at Columbia Law School. The website covers climate and climate-related laws and policies promoting low carbon transitions, which reflects the importance of climate policy in areas including energy, transport, land use, and climate resilience.

In order to narrow down the search of policies, the database presents several filters such as regions, sectors, frameworks, or policy instruments. Although there is no agreed definition of a "climate framework law", this term is used in this database to refer to a discrete class of laws that contain national long- or medium-term targets, are multi-sectoral and set out the strategic path for national climate change policy. (LSE)

c) **European Environment Agency (EEA**): This institution aims to help both the general public and private partners develop, adopt, implement and evaluate environmental policy. EEA gathers data and produces assessments on a wide range of topics related to the environment for the 32 member countries.

The main economic sectors presented by the agency are agriculture, buildings, waste, fisheries, energy, industry, and transport. Alongside them, EEA also establishes a database with a set of policy measures collecting a wide range of categories (policy instruments, objectives, status, etc.). (EEA, b)

Scientific reports:

a) *"Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments", Cristina Peñasco et al. (2021):* It aims to create a framework for reviewing and synthesising the impact of various climate policy instruments which impacts on a variety of technical and socioeconomic outputs. This article shows how several regulatory and economic instruments, which are usually associated with positive environmental and technological performance, can also generate negative distributional and competitiveness outcomes and discusses how to reduce or transform these trade-offs. (Peñasco, Díaz, & Verdolini, 2021)

The authors present three types of policy instruments: regulatory, economic, and soft instruments. The first two categories can be divided into direct investment, fiscal incentives, and market-based instruments (economic) and codes and obligation schemes (regulatory). At the same time, policies are also categorised according to their jurisdiction, sector of application and outcomes or objectives. This article is funded from the European Union's Horizon 2020 research and innovation via the **INNOPATHS** project.

b) "*Challenges in the harmonisation of global integrated assessment models: A comprehensive methodology to reduce model response heterogeneity", Sara Giarola et al. (2021):* This paper intends to **formalise a framework for a harmonisation methodology** so as to facilitate the **inter-comparison of integrated assessment models** (IAMs). This achievement would play an important role in climate economic policy-making. (Giarola, et al., 2021)

To carry out appropriate modelling exercise, policy implementation is essential. For this purpose, the authors provide a policy clustering where policies are mainly classified **according to the sector** in which they are applied. They are further categorised **depending on their types,** which can be thought of as specific policy objectives.

c) *"Global roll-out of comprehensive policy measures may aid in bridging emissions gap", Heleen L. Van Soest et al. (2021):* According to the authors of this literature, developing a set of comprehensive policy measures could be key to reduce the emissions gap between NDCs and the emission levels needed to achieve the climate targets of the Paris Agreement. It provides a bridge scenario based on national policies developed by experts in each country (van Soest, et al., 2021).

These policy measures vary depending on the application sector and the economic development of the country where they are adopted. The latter category includes high-, medium- and low-income countries while the first category covers broader sectors such as buildings, transport, industry etc. This study has been funded via the **COMMIT project.**

d) *"Where is the EU headed given its current climate policy? A stakeholder-driven model inter-comparison", Alexandros Nikas et al. (2021):* In this article, its authors define a model inter-comparison with stakeholders while exploring the EU's energy present and future. The result of this work is a hypothetical framework that explores where the region is headed and not how to achieve its goals, extrapolating its current policy efforts into the future. (Nikas, et al., 2021)

The themes selected by the stakeholders for the research of the project are: "Where is the world headed?"; "Potential failure of key technology"; "Game-changing innovations"; "Behavioural and lifestyle changes"; "The role of electrification and storage"; "Hydrogen's future in industry, transport, & energy"; "Required investments and their implications"; "Implications for employment". This work is part of the **PARIS REINFORCE project** and has served as reference to understand the relationship between stakeholders and modelling teams**.**

e) *"Interests, institutions, and climate policy: Explaining the choice of policy instruments for the energy sector", Llewelyn Hughes et al. (2015):* This paper aims to demonstrate an energy-related climate policy theory in which the positive distributional effects on both the population sentiment and the climate-economic outcomes of regulatory instruments over fiscal incentives are enhanced. The authors draw on the International Energy Agency, which distinguish between regulatory instruments (standards, mandates…), soft instruments (education, advertisements…) and fiscal instruments (taxes, credits…). (Hughes & Urpelainen, 2015)

Moreover, the report adds two distributional attributes to the policies: industrial (a policy which provides a benefit to some specific industries like a particular subsidy for a certain technology) and environmental (a policy which imposes costs on segments of population such as carbon permits). (Hughes & Urpelainen, 2015)

f) *"Climate policy co-benefits: a review", Mikael Karlsson et al. (2020):* The significant role of <u>co-benefits</u> in climate policy-making is the main theme of *"Climate policy co-benefits: a review".* The authors structure, describe, analyse, and classifies the available literature regarding co-benefits, of climate policies and focus less on mitigation costs, with the aim to support policymakers and identify research gaps. (Karlsson, Alfredsson, & Westling, 2020)

The most well-known co-benefit is air quality but throughout this paper more topics are discussed such as energy security, biodiversity protection, and economic performance. The authors address the following definition of co-benefits, based on the IPCC (Intergovernmental Panel on Climate Change (IPCC), 2018): "the positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare'.

g) *"The science and politics of co-benefits in climate policy", Jan P. Mayrhofer et al. (2016):* Co-benefits are the main tool used to avoid trade-offs between developmental and environmental issues. The evolution,

weakness, limits and strengths of climate co-benefits are reviewed in this report. (Mayrhofer & Gupta, 2016)

However, this report does not limit its scope of study to the different kinds of co-benefits, but categorises policies according to their scale (local, regional, country or international) and the economic development of the application country (developed, emerging or developing).

h) *Public health co-benefits of greenhouse gas emissions reduction: A systematic review, Jinghong Gao et al. (2018):* This article analyses the relationships among GHG mitigation measures through five economic sectors and how the related public health co-benefits emerge from them, making these policies more attractive. For this purpose, the authors have carried out a review of studies published in English. The five studied domains are: transport, energy, food and agriculture, households and industry and economy. (Gao, Kovats, Vardoulakis, Wilkinson, Woodward, & Li, 2018)

i) *Global patterns of national climate policies: Analysing 171 country portfolios on climate policy integration, Nicole M. Schmidt et al. (2018):* In this study, climate policies of 171 countries over the last 27 years have been looked through in order to assess their development. Authors draw on the Climate Change Laws of the World database for national climate legislation across eight policy categories: adaptation, carbon pricing, energy demand, energy supply, administrative arrangements, REDD & LULUCF, transportation and R&D. (Schmidt & Fleig, 2018)

All the policies are categorised depending on the area affected by the measurement (policy objective, such as agriculture or changes in society); the area of implementation (sectors like buildings, industry…); the policy instrument (regulatory, economic…) and the region and economic development of the country where they are implemented. The clustering includes several subsectors, specifying, for example, the fuel technology (coal, solar, wind…) or the type of industry (cement, textiles…).

To conclude and ensure a sound clustering mechanism of climate policies, the different methodologies analysed from literature and other projects have been compared, selecting the most frequent categories and finding those that combined from different sources so that we obtained a more expanded categorization capable of covering the large range of potential policy needs that will emerge from WP2.

CLASSIFICATION OF REFERENCES

As mentioned above, in order to develop this project, three types of references have been reviewed: online databases, published articles related to climate policies and tools and deliverables from European projects related to climate policies. With the goal of establishing a comprehensive policy clustering, along this literature review, references related to several topics and targets have been consulted, so as not to focus only on one kind of policy (i.e. emissions or energy) and to include categories ranging from traditional sectors and instruments to current policy trends. The references consulted can be grouped according to the objectives and topics listed below:

Classification according to the objective of the study (articles and projects)

- Reviewing topic-related bibliography
  - *Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments"* (Peñasco, Díaz, & Verdolini, 2021);
  - *"Climate policy co-benefits: a review"* (Karlsson, Alfredsson, & Westling, 2020);
  - *"The science and politics of co-benefits in climate policy"* (Mayrhofer & Gupta, 2016).

- Establishing a framework to inter-comparison of models

- *"Where is the EU headed given its current climate policy? A stakeholder-driven model inter-comparison"* (Nikas, et al., 2021);
- "*Challenges in the harmonisation of global integrated assessment models: A comprehensive methodology to reduce model response heterogeneity*" (Giarola, et al., 2021);

- Providing scenarios to analyse the impact of climate measures and allowing the transition to a low-carbon energy economy, enhancing positive effects and favouring policy-making
    - *"Global roll-out of comprehensive policy measures may aid in bridging emissions gap"* (van Soest, et al., 2021);
    - *"Interests, institutions, and climate policy: Explaining the choice of policy instruments for the energy sector"* (Hughes & Urpelainen, 2015);
    - *"Public health co-benefits of greenhouse gas emissions reduction: A systematic review"* (Gao, Kovats, Vardoulakis, Wilkinson, Woodward, & Li, 2018) ;
    - Projects such as NDC ASPECTS (Fragkos, Fragkiadakis, & Paroussos, Reducing the Decarbonisation Cost Burden for EU Energy-Intensive Industries, 2021) or INNOPATHS (Siskos, 2021).

- Collecting, identifying and categorising climate policies to analyse countries' climate action in order to, for example, determine which of these policies could be modelled.
    - LOCOMOTION (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020) and
    - *Global patterns of national climate policies: Analysing 171 country portfolios on climate policy integration* (Schmidt & Fleig, 2018)

Classification according to the topics (all references)

- General climate policies: These references deal with climate policies in general, without focusing on the analysis of specific impacts on a particular sector, i.e. LOCOMOTION*,* NDC ASPECTS, NAVIGATE, CPD, I^2 AM PARIS, CCLW Database, EEA database, (van Soest, et al., 2021), (Karlsson, Alfredsson, & Westling, 2020)*,* (Nikas, et al., 2021) and (Schmidt & Fleig, 2018)*.*

- Energy-related policies: They focus mainly on policies related to energy, fuels and technologies in different sectors and instruments, i.e. IEA Database and (Hughes & Urpelainen, 2015).

- Technical-, social- or economic-related topics: They analyse the impacts of climate laws from a social, technical or/and economic point of view, i.e. INNOPATHS, (Peñasco, Díaz, & Verdolini, 2021), (Mayrhofer & Gupta, 2016)*,* (Gao, Kovats, Vardoulakis, Wilkinson, Woodward, & Li, 2018) and (Giarola, et al., 2021)*.*

STANDARDISATION OF REFERENCES

Due to the lack of a general rule or standard guidelines, policy clustering is not well defined and varies depending on the author or literature. Thus, each reference presents its particular categories and subcategories, resulting in a set of classifications that may match or be completely different from each other. At the same time, some clusters coincide but with a different nomenclature and, on the contrary, some subcategories play a significant role or not depending on the article.

To solve this problem, a consistent nomenclature has been introduced in the previous section of key terms. Those terms not included in most of the literature are not taken into account for the ultimate catalogue. Reviewing the bibliography, some categories just appear in a few or only one reference, i.e. "Impact" in CPD or "Status" in CPD and IEA Database.

COMPARING DIFFERENT REFERENCES

In this section, the most discussed categories in the bibliography are defined and explained, specifying the reference in which the category appears, comparing the same or similar categories among articles and developing, if appropriate, subcategories and sub-subcategories. As previously mentioned, the clustering presented by the projects is included in Annex I and therefore, in this section, only the categories from the extended literature review appear.

Categorisation according to jurisdiction and economic development

This category does not vary much from one reference to another and can be done not only from a geographical perspective but also from an economic perspective. It is presented in IEAD, EEA and (Peñasco, Díaz, & Verdolini, 2021) as "Jurisdiction", focused on geographic terms. (Hughes & Urpelainen, 2015) cluster the policies according to the "Economic Development" of the country (high to low income). (Mayrhofer & Gupta, 2016) Incorporate both "Economic Development" and "Jurisdiction".

Both jurisdiction and economic development could be used to describe the policy scope. The subcategories presented in each reference for both major clusters are very similar (except for the EEA, which includes several different groups of EU members), as presented in Table 1.

Table 1. Categories of jurisdiction and economic development. Source: own elaboration based on literature review.

Jurisdiction				Economic development	
IEA Database	Cristina Peñasco et al.	EEA	Jan P. Mayrhofer et al.	Llewelyn Hughes et al.	Jan P. Mayrhofer et al.
City/Municipal	Local	-	Local	High-income country	Developed country
State/Provincial	State/Regional	Regional	Regional (i.e. state)	Middle-income country	Emerging country
National	National	National	Country	Low-income country	Developing country
Regional International	International	Global	International		
Other	-	EU28	Multiple		
Unknown	-	EU27	-		
-	-	EU25	-		

Categorisation according to sector

Mainly five or six sectors are referenced by most of the authors. This set of sectors matches with the IPCC economic sector division and it involves: "Buildings", "Industry", "Economy", "Energy", "AFOLU" (Agriculture, Forestry and other Land Uses) and "Transport" (van Soest, et al., 2021), (Giarola, et al., 2021), (Peñasco, Díaz, & Verdolini, 2021). Each reference may include subcategories of major sectors (i.e. "Power generation", "Power Utilities" and "Energy Materials" as parts of "Energy") (Giarola, et al., 2021) (Gao, Kovats, Vardoulakis, Wilkinson, Woodward, & Li, 2018) so policies can be clustered with greater detail. Moreover, references like CCLWD incorporate more sectors (materials, health, governance education, etc.) which could be interesting as they refer to not just economic sectors, but also include social aspects that may be crucial for future policies. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

According to this description, the most convenient option may be to choose the major sectors alongside some less discussed categories in order to cover the whole climate policy spectrum. In Table 2, a summary of sectors presented by each reference is shown. Moreover, in Table 3 the subcategories included by the references for some sectors are shown. The additional sectors introduced by the European projects can be seen in Annex I.

Table 2. Categories of sectors according to references. Source: own elaboration based on literature review

Sectors						
IEA Database	Cristina Peñasco et al.	EEA	Jinghong Gao et al.	Sara Giarola et al.	Heleen L. Van Soest et al.	CCLWD
-	-	AFOLU	AFOLU	Land	AFOLU	AFOLU
Buildings	Buildings	Buildings	Households	Buildings	Buildings	Buildings
Energy	Power	Energy	Energy	Energy	Energy	Energy
Economy-wide (Multi-sector)	Cross-sector	-	Economy	-	Economy-wide (Multi-sector)	Economy-wide (Multi-sector)
Industry	Industry	Industry	Industry	Industry	Industry	Industry
Transport	Transport	Transport	Transport	Transport	Transport	Transport
-	-	Waste	-	-	Waste	Waste
Services	-	Fisheries	-	-	Non-CO_2 emissions	Environment
-	-	-	-	-	-	Social development
-	-	-	-	-	-	Water
-	-	-	-	-	-	Tourism

Table 3. Subcategories of sectors according to references. Source: own elaboration based on literature review

	Subcategories of sectors					
	IEA Database	EEA	Jinghong Gao et al.	Sara Giarola et al.	Heleen L. Van Soest et al.	CCLWD
AFOLU	-	-	Agriculture	-	-	Agriculture
	-	-	Food	-	-	LULUCF
Buildings	Buildings	-	Buildings	-	-	-
	Residential	-	Households	-	-	-
Energy	Energy generation[1]	Renewable energy	Energy generation	Power generation	Energy supply	-
	Electricity & Heat generation[2]	-	-	-	-	-

Economy	-	-	-	-	-	Business
						Finances
Social development	-	-	-	-	-	Health
	-	-	-	-	-	Public sector
Transport	-	Electric vehicles	-	-	-	-
	-	Heavy-duty vehicles	-	-	-	-

[1] process of generating electrical power from a source of energy (fossil fuels or renewable)

[2] simultaneous generation of electricity and heat from a single energy source, such as a combined heat and power (CHP) plant

Categorisation according to policy instruments

Policy-makers can implement different techniques to achieve the intended policy objective, depending on the type of intervention they make to promote a given issue (Karlsson, Alfredsson, & Westling, 2020). This intervention can be done through economic tools such as taxes and incentives, but there are other instruments based on raising social awareness and educating society. Alongside these two policy techniques, regulatory instruments have an important role in policy-making as they set rules, prohibit certain practices and constrain social trends. These instruments can be applied in combination or individually. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

All references consulted on policy instruments include and highlight "Economic" and "Regulatory Instruments" as the most widely used (Peñasco, Díaz, & Verdolini, 2021) (Karlsson, Alfredsson, & Westling, 2020) and (Hughes & Urpelainen, 2015). Several of them also include "Soft Instruments" as a major category. Moreover, CPD add more specific categories as "Research & Development" or "Policy support", among others.

The major policy instruments are clustered in Table 4, according to the corresponding literature. In Table 5, a sub-classification has been carried out, dividing major clusters into more specific policy instruments.

Table 4. Categories of policy instruments according to references. Source: own elaboration based on literature review

Policy Instruments			
IEA Database	Cristina Peñasco et al.	Llewelyn Hughes et al.	CCLW
Economic	Economic	Economic	Economic
Information & Education	Soft instruments	Soft instruments	Education & Training Information
Regulatory	Regulatory	Regulatory	Regulation
-	-	-	Research & Development
-	-	-	Governance

Table 5. Subcategories of policy instruments according to references. Source: own elaboration based on literature review

	Subcategories of policy instruments			
	IEA Database	Cristina Peñasco et al.	Llewelyn Hughes et al.	CCLW
Economic	-	Direct investment	-	Direct Investment
	Fiscal incentives	Fiscal incentives	Fiscal incentives	Fiscal incentives
	Performance-based policies	Market-based instruments	-	Market-based instruments
Regulatory	Codes & Standards	Codes & Standards	Standards & Mandates	Standards & Norms
	Targets, Plans & Obligations	Obligation Schemes/Quotas	-	Disclosure obligations
	Regulation	-	-	Moratoria & Bans
Soft	Information & Education	-	-	Information & Education
	-	-	-	Voluntary approaches

According to the literature review, "Fiscal Incentives" is the most mentioned economic subcategory and it consists, mainly, of taxes and subsidies tools. "Direct investment" and "Market Based Instruments" are referenced as well but not as exhaustively. In regulatory terms, "Standards" and "Obligation Schemes" seem to be the most prominent ones.

Throughout Section 3, the policy types of the above-mentioned instruments are explained and examples of each are discussed.

Categorisation according to policy objectives

Throughout this section, various perspectives for the same concept are presented and discussed in order to determine the most appropriate nomenclature and categories. Each reference refers to this type of clustering in a different way: EEA uses "Policy Objective" while (Peñasco, Díaz, & Verdolini, 2021) present "Outcomes" categorisation and (Giarola, et al., 2021) introduce "Policy Type". All terminology refers to the same, the expected area to be affected by the application of the measure in question.

This is the clustering category discussed with the highest variability among categories. Some of them present broad categories (social, economic, land use…) while others are more specific (air pollution, clean energy targets, resource and materials…) as it is shown in Table 6.

Table 6. Categories of policy objectives according to references. Source: own elaboration based on literature review

Policy objectives			
Nicole M. Schmidt et al.	Cristina Peñasco et al.	Sara Giarola et al.	EEA
Mitigation	Environmental Effectiveness	Cap on emissions	Air pollution and quality
			Mitigation
Adaptation			Adaptation
-	Social-related	-	Health and well-being
-	Competitiveness	Economic	-
	Cost-related		
	Distributional		

REDD+LULUCF	-	Land use	AFOLU
Transportation	-	Cap on fossil fuel use	Transport
Energy demand	-	Quality of the energy access	Renewable energy
Energy supply	-	Clean energy targets	Energy efficiency
R&D	Innovation	Efficiency standards	Water and marine environment
Administrative arrangements	Technological Effectiveness	-	Resource efficiency and waste
-		-	Industry
-	-	-	Local development
-	-	-	Biodiversity
-	-	-	Soil
-	-	-	Sustainability transitions
-	-	-	International cooperation

As in the case of the sectors, Annex I shows the categorisation of the policy objectives of European projects. Both LOCOMOTION and PARIS REINFORCE are the most comprehensive projects on this topic. Therefore, a very extensive list of categories is included in (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020) so that the catalogue, if necessary, could be highly detailed.

Co-benefits

A related concept to the objectives is that of "co-benefits", defined as additional outcomes coming from climate policies which are not the initial goals but generate benefits to society (economic, environmental, social...) and encourage policy-makers to favour some laws over others. (Intergovernmental Panel on Climate Change (IPCC), 2014)

Co-benefit categories are shown in Table 7 according to (Mayrhofer & Gupta, 2016) and (Karlsson, Alfredsson, & Westling, 2020). Furthermore, (Mayrhofer & Gupta, 2016) expand the major categories with some particular co-benefits, as shown in Table 8:

Table 7. Categories of co-benefits according to references. Source: own elaboration based on literature review

Co-benefits	
Mikael Karlsson et al.	Jan P. Mayrhofer et al.
Air quality	Climate-related
Soil & Water quality Biodiversity	Environmental
Diet & Physical activity	Social
Economic performance	Economic

	Energy security
	Political & Institutional

Table 8. Subcategories of co-benefits according to **(Mayrhofer & Gupta, 2016)**. Source: own elaboration based on literature review

Subcategories of co-benefits	
Climate-related	Reduce GHG emissions
	Enhance resilience to CC
Economic	Enhance energy security
	Trigger private investment
	Improve economic performance and industrial competitiveness
	Generate employment
	Stimulate technological change
	Contribute to fiscal sustainability
Environmental	Protect environmental resources
	Protect biodiversity
	Support ecosystem services
	Improve soil quality
	Reduce air pollution
Social	Enhance energy access
	Reduce poverty incidence and inequality
	Contribute to food and water security
	Improve health
	Reduce stressors
Political & Institutional	Contribute to political stability
	Improve democratic quality of governance
	Contribute to interregional collaboration

Two closely related terms to co-benefits are trade-offs and synergies, which have already been defined in the previous Section 2.1. Both trade-offs and synergies as well as co-benefits are often narrowly related to SDGs as

can be observed in (Karlsson, Alfredsson, & Westling, 2020)'s co-benefit categorisation. These terms are highly relevant for the future work as synergies and trade-offs of the policy questions will be discussed in the Task 6.4.

2.4 Synthesis of the review

The selected catalogue of policies defined in this deliverable has to include both general categories which are usually mentioned in most references and projects as useful, and also specific categories that represent new political and behavioural trends which, each day, cover wider areas.

Thus, sectors such as transport, energy or industry and instruments such as taxes or regulations appear in the catalogue as a representation of the policies with the greatest weight at present. However, in order to broaden and update the clustering of policies, sectors such as materials and social development, and instruments such as research and innovation or the country's economic development have also been considered, establishing a cross-cutting, multi-sectoral and up-to-date classification of policies.

To sum up, policies can be classified along six different dimensions: jurisdiction, economic development, policy objective, sector, policy instrument and co-benefit. Additionally, the measure could be categorised into subcategories of sectors, instruments or objectives if necessary. Certain policies may not correspond to any of the co-benefits or match with various instruments or sectors. The policy clustering determined in this task is shown in Tables 9, 10, 11 and 12.

Table 9. Policy categorisation summary. Source: own elaboration based on literature review

Policy categorisation					
Jurisdiction	**Economic Development**	**Policy objective**	**Policy sector**	**Policy instrument**	**Co-benefit***
Local	Developed country	Mitigation & Adaptation	AFOLU	Economic & financial instruments	Air quality
National	Emerging country	Social related	Buildings	Soft instruments	Soil & Water quality
Subnational region	Developing country	Economic development	Energy	Regulatory instruments	Biodiversity
Supranational region		AFOLU	Economy-Wide	Research & Development & Deployment	Diet & Physical activity
		Transport	Industry	Policy support	Economic performance
		Energy generation, storage & transmission	Transport	Barrier removal	Energy security
		Energy efficiency & security	Waste	Climate strategy	Political & Institutional
		Resources & Materials	Tourism		
		Innovation	Public sector		

		Industry	Water		
		Behavioural changes	Materials		
			Social development		

*Related to SDGs

Table 10. Subcategories of policy objectives summary. Source: own elaboration based on literature review

Subcategories of policy objectives				
Social related	**AFOLU**	**Transport**	**Energy G,S & T**	**Resources & Materials**
Health	Agriculture	Modal shifts	Cooling	Water
Well-being	Land Use	Road	Electricity generation	Soil
	Forestry & REDD	Aviation	Heat generation	Resource efficiency
		Shipping		Waste
		Rail		

Table 11. Subcategories of policy sectors summary. Source: own elaboration based on literature review

Subcategories of policy sectors							
AFOLU	**Buildings**	**Energy**	**Economy-wide**	**Industry**	**Transport**	**Materials**	**Social development**
Agriculture	Commercial	Sources	Business	Iron & Steel	Passenger	Non-energy materials	Consumption
Forestry	Households	Renewables	Economy & Trade	Aluminium	Freight	Energy materials	Education & Culture
Food		Power generation		Cements & Concrete			Governance
Land Use		Electricity & Heat generation		Chemicals			Health
		Transformation					Labour
		Storage					Population
							Public sector

Table 12. Subcategories of policy instruments summary. Source: own elaboration based on literature review

Subcategories of policy instruments		
Economic	**Soft**	**Regulatory**
Direct investment	Information and education	Codes & Standards
Fiscal incentives	Voluntary approaches	Targets, Quotas and Obligations
Market-based instruments	Training	Auditing
		Monitoring
		Mandatories

The proposed categories make it possible to address the full spectrum of policy questions that could be raised by stakeholders, from more traditional policies to policies that are more aligned with the new global trends of social awareness and greater respect for the environment.

The clustering not only allows policies to be grouped into broad categories, but they can be classified into subcategories of instruments, sectors and objectives to make the catalogue more specific. In addition, this classification facilitates the assessment of which of the models can best explore the policy needs (which sectors need to be modelled, if the specific policy instrument type is included, etc.).

3 Policies that can be addressed by IAM COMPACT models

Models are powerful tools for informing policymakers about the effects, consequences, and costs of different policies. Models support policymakers, particularly when it comes to impact assessments, target setting, and exploration of alternative policy pathways. On the one hand, models can aid in the development of strategies for an uncertain future by providing evidence-based policy making. On the other hand, stakeholders also influence modelling and scenario design, and modelling results can be used as "convenient arguments" based on "science" to defend and justify pre-decided political choices (Süsser, Ceglarz, Gaschnig, & Stavrakas, 2021). However, not all policies can be directly represented in models, and modelling frameworks often deploy restrictions and debatable judgement calls imposed by modelling capabilities rather than knowledge. (Doukas & Nikos, 2020) (Stanton, Ackerman, & Kartha, 2009)

The process of modelling can be seen as a cycle. According to (Refsgaard, Van der Sluijs, Hojberg, & Vanrolleghem, 2007) it is composed of five major steps: model study plan, design and data, model setup, calibration and validation and simulation and evaluation. The characterisation of the problem and the needs and goals for the modelling are all part of step one. In the second one, modellers prepare the input data and conceptualise how the system should be simulated in sufficient detail to satisfy the model study plan's requirements. The model is then created, calibrated, or validated. The final stage involves running simulations to ensure that the model study's goals and specifications are met. The outcomes can then be analysed and discussed with decision-makers, and the results be used to inform decisions. (Süsser, Ceglarz, Gaschnig, & Stavrakas, 2021)

The engagement of stakeholders in the modelling process can be manifested through participatory modelling, group model building or participatory simulation. Stakeholders can be included in any step, from data collection to validation and interpretation of model results, a process with can increase legitimacy and drive better decisions with less conflict (Voinov & Bousquet, 2010). In Figure 4, a schematic representation of the policy-modelling cycle is shown, including the feedback between models and policy steps.
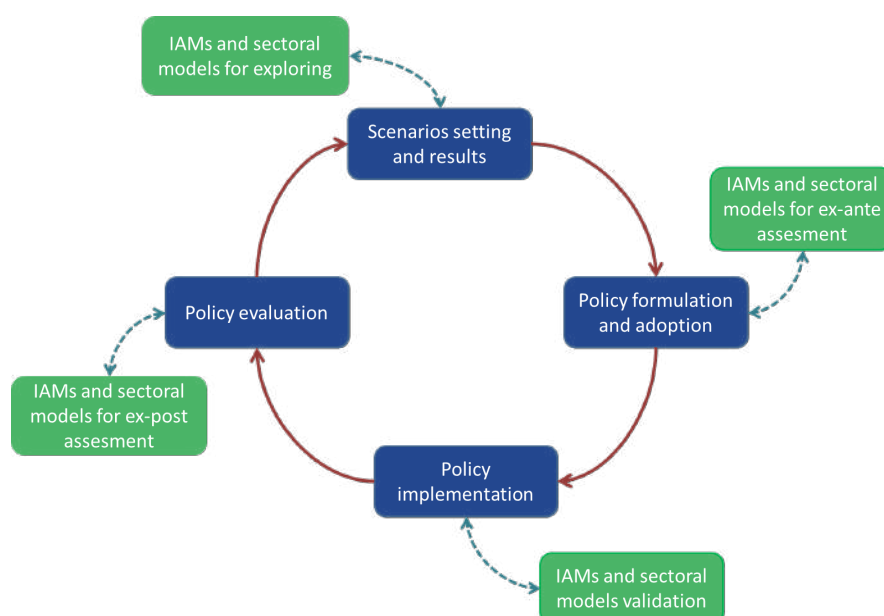
Figure 4. Cycle of the policy-modelling process.
Source: figure elaborated based on (Süsser, Ceglarz, Gaschnig, & Stavrakas, 2021)

In this regard, integrated assessment and sectoral models are powerful tools for estimating and evaluating the potential consequences of implementing a policy-decision. However, as already mentioned, not all models can represent all policies, since this process requires some specific features and characteristic model have to fulfil, e.g. ability to model a specific sector (e.g. land use, or transport). For this reason, each model is able to evaluate just those instruments or objectives which are included/represented in it. Therefore, the main goal of this section

is to define the submodules or features incorporated by each model of the IAM COMPACT project to facilitate a policy question-model match.

Although models play a crucial role for climate economic policies, there is no standardised methodology that all IAMs or sectoral models follow to model the same policy instrument or objective (Diemer, Gladkykh, Spittler, & Collste, 2019). Therefore, there is a lack of transparency of the modelling assumptions as well as some variability among the outputs, which makes it difficult to determine which policy can be modelled and how it is implemented in the model. (Giarola, et al., 2021)

In addition, the types of policies that can be represented in models are many and vary according to the dimensions they represent: their geographical coverage, the range of technologies and measures they include, the detail with which each economic sector sectors are represented, the time scales they cover, and the temporal resolution (e.g. seasonal, annual, multi-annual).

It is also necessary also to take into account that, typically, IAMs tend to model policy targets and objectives (i.e., decreasing the road traffic by 25% in 10 years) but they often do not model policy instruments or, at least, explicitly (see Section 2.1 Key Terms). IAMs typically model "traditional" policies (regulatory, economic, and soft), which are related to the economic literature. However, the current sustainability and social trends are not covered by these references. Sectoral models, due to their additional granularity, can model a different range of policy instruments, but only for the specific sector they represent.

Additionally, models usually do not list either the policies they represent or the instruments/sectors/targets they include, but rather the possible policy options implicitly depend on the structure and characteristics of a model (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020). Modelling policies could often be done following two different pathways: modelling policy effects through endogenous features of the model or modelling policy effects through exogenous assumptions. These assumptions must be assessed by the modellers to ensure that they are consistent with the scenario.

Assessing which models can best explore the policy needs is one of the main objectives of this project, yet there are various barriers related to the different technology and granularity of the models. In order to align and analyse how different IAMs and sectoral models in IAM COMPACT can represent the different policy questions coming from stakeholders, a set of policy types from various sectors, measures, targets and policy instruments has been proposed as templates to be filled by modellers, based on the literature review of policy categories (Section 2)

Therefore, two templates have been created: one for specific types of policy instruments and the other for policy sectors and "broader" policy measures types (policy objectives). LOCOMOTION and PARIS REINFORCE documentation has been the main source of the list of sector-related policy measures, extended by literature review; while the policy types in the instruments sheet have been adapted from the comprehensive literature review. In each of the templates, each modelling team has defined whether their model has the specified features and, if so, whether any modifications are needed to implement them (exogenous inputs, proxies, or other types of modifications). Each instrument type and measure is categorised according to the category and subcategory to which it belongs (see Tables 9-12). For example, "energy taxes" are part of "fiscal incentives" which, in turn, are "economic instruments" (policy instruments) and "gas replacing oil" is a policy measure, and more specifically, a policy objective, that can be framed within the "industry" sector and the "heating" subcategory.

The selection of the **policy types** included in the templates has been carried out following the literature review in the previous Section 2.3 with a special focus on the policy measures presented by LOCOMOTION, INNOPATHS and I^2 AM PARIS. It will serve also as basis for analysing the way that models and stakeholders (i.e., their policy needs/policy questions) are matched. However, it must be commented that it is not possible to reach a complete level of understanding on how models and policy questions fit together, and a wide range of policies that cannot be adequately modelled remains. This task will support the initial process of matching of policy-questions with models, but inevitably it needs to dive deeper into a specific one-to-one discussion when the final policy-questions coming from WP2 are defined.

The two templates to be filled in by modelling teams are shown below. The methodology to complete them consists of specifying whether the model can or cannot represent a policy instrument/measure, annotating a "Yes" or leaving the box blank, respectively. In case the policy measure is not directly represented in the model, the box is filled in with a "M" (for the measure sheet, meaning "yes, but with modification") or a "P" (for the instrument sheet, meaning "yes, but partially"), meaning that the model can represent it with some modifications (a proxy, a code modification, using an exogenous input, etc.…). An additional document template was provided to partners to explain in detail the modelling modifications needed to represent those policies along with any further justification. This process has been aligned also with to facilitate the objectives of Task 3.4 Upgrade and operation of the I^2 AM PARIS data exchange platform and Task 3.2 Dialogue across scales and disciplines: Model comparability and interdisciplinary integration.

It should be noted that the Simple Climate Models provided by CICERO have not been included in this analysis because of their nature and objective, which is not to evaluate sectoral policies, but convert emission pathways into climate variables (like CO_2 concentration, temperature, etc.). (Hartin, Patel, & Schwarber, 2015)

The results obtained after analysing the data provided by the modellers (see Tables 15 and 16) confirm that the policy sectors (sectors where related policies are applied and modelled) most widely represented in IAM COMPACT models are **buildings, transport and industry**, while, as could be expected, policy sectors not commonly found in the literature such as social/behavioural change or sustainability ones (agricultural, land, and water) are also not widely examined by our models. In particular the "water" sector is the sector less represented. Regarding policy instruments, the models include the most discussed categories in the literature (regulatory and economic), while the rest still represent fields that need further development.

The structure of the two templates is included below, in Tables 13 and 14. For the analysis applied to each specific IAM COMPACT model, see Annex II.

Table 13. Structure of the measures & sectors template. Source: own elaboration based on literature review

POLICY SECTOR	SUBCATEGORY	POLICY MEASURES TYPE	Model 1	Model 2	…
BUILDINGS	Heating	Gas replacing oil / coal			
		Biofuels			
		Electricity			
		Hydrogen			
		Solar thermal			
		Building shell efficiency			
	Cooling	Electricity			
		Building shell efficiency			
	Lighting	Efficient lighting			
	Appliances	Efficient appliances			
INDUSTRY	Process heat	Gas replacing oil / coal			
		Biomass			
		Hydrogen			
		Electricity			
	Machine drives	Gas replacing oil / coal			
		Electricity			
	Steam	Gas replacing oil / coal			
		Electricity			
	CHP	Gas replacing oil / coal			

POLICY SECTOR	SUBCATEGORY	POLICY MEASURES TYPE	LIST OF MODELS		
			Model 1	Model 2	...
	Overall Industry	Biomass			
		CCS			
		CDR/NETs			
AGRICULTURE & LULUCF (Land Use, Land Use Change and Forestry)	Agric: Energy use	Gas replacing oil / coal			
		Biomass			
		Electricity			
	Agric: Land practices	Land yield maximisation			
		Organic fertilizer use			
		No tillage			
		Agroforestry			
	Agric: Animal husbandry practices	Improved feeding practices			
		Manure management			
		Feed additives			
	LULUCF	Afforestation			
		Land protection			
		Biomaterials			
		Area set aside for nature (from agriculture or forestry) (Biodiversity)			
ENERGY	Synthetic fuel production	Coal to gas with CCS			
		Coal to liquids with CCS			
		Gas to liquids with CCS			
		Biomass to liquids			
		Biomass to liquids with CCS			
		Hydrogen to gas with CCU			
	Hydrogen production	Electrolysis			
		Coal to hydrogen with CCS			
		Gas to hydrogen with CCS			
		Biomass to hydrogen with CCS			
	Electricity generation	Coal with CCS			
		Gas with CCS			
		Nuclear fission			
		Nuclear fusion			
		Hydro			
		Biomass			
		Biomass with CCS			
		Geothermal			
		Solar PV			
		Solar CSP			
		Onshore Wind			
		Offshore Wind			
	Heat generation	Coal with CCS			
		Gas with CCS			
		Oil with CCS			
		Geothermal			
		Biomass			
		Biomass with CCS			

POLICY SECTOR	SUBCATEGORY	POLICY MEASURES TYPE	LIST OF MODELS		
			Model 1	Model 2	...
TRANSPORT	Road	Gas (LNG / CNG) vehicles			
		Hybrid electric vehicles			
		Fully electric vehicles			
		Hydrogen fuel cell vehicles			
		Biofuels in fuel mix			
		Efficiency			
	Rail	Electric rail			
		Hydrogen fuel cell rail			
		Efficiency			
	Aviation	Biofuels in fuel mix			
		Hydrogen planes			
		Electric planes			
		Efficiency			
	Shipping	Gas (LNG / CNG)			
		Hydrogen			
		Biofuels in fuel mix			
		Electric			
		Efficiency			
WATER	Water	Water management (efficient and saving)			
		Managing of floods/floods risk			
SOCIAL/BEHAVIOURAL	Behavioural/Consumption	Travelling less			
		Change mode of transport			
		Less energy service demand			
		Lower material consumption			
		Less product demand			
		Change of diet			
		Less food waste			
		Change of values			
	Education	Climate education in schools			
		Renewal of the contents and methodologies			
	Health	Diet and Physical Activity			
		Health investment			
	Labour	Minimum-wage policy			
		Rural unemployment			
		Urban unemployment			
	Governance	Regulatory management system			
		Quality of new regulations			
OTHER					

Table 14. Structure of the policy instruments template. Source: own elaboration based on literature review

POLICY INSTRUMENT	SUBCATEGORY OF POLICY INSTRUMENT	POLICY INSTRUMENT TYPE	LIST OF MODELS		
			Model 1	Model 2	...
Economic and financial instruments	Direct investment	Procurement rules			
		RD&D funding			
		Infrastructure investments			
		Funds to sub-national governments			
		Climate finance tools			
	Fiscal incentives	FITs/FIPs			
		Energy taxes & Tax exemptions			
		Energy auctions			
		Grants and subsidies			
		Loans and soft loans			
		User charges			
	Market-based instruments	GHG emissions allowance trading schemes			
		Green certificates			
		White certificates			
		Carbon pricing			
Regulatory instruments	Codes and Standards	Building codes			
		Industrial air pollution standards			
		Product standards			
		Sectorial standards			
		Vehicle air pollution standards			
		Vehicle fuel-economy and emissions standards			
	Targets, Quotas and Obligations	Renewable energy obligations			
Soft instruments	Information and Education	Information provision			
		Performance Label (comparison or endorsement)			
		Professional training and qualification			
		Advice or aid in implementation			
	Voluntary Approaches	Negotiated agreements (public-private sector)			
		Public voluntary schemes			
		Unilateral commitments (private sector)			
Barrier removal	-	Grid access and priority for renewables			
		Net metering			
		Removal of fossil fuel subsidies			
		Removal of split incentives			
Policy support	-	Processes, plans and strategies			

POLICY INSTRUMENT	SUBCATEGORY OF POLICY INSTRUMENT	POLICY INSTRUMENT TYPE	Model 1	Model 2	...
		Subnational and citizen participation			
		Subnational and citizen participation			
		MRV			
		Institutional mandates			
		International cooperation			
		Institutional creation			
Research & Development & Deployment	-	Demonstration project			
		Research programme			
OTHER					

An analysis and summary of the results, including the number of potential policy types that the models can represent (both directly and "with modifications") in absolute value and in percentage relative to the number of policies covered from those listed in the template (in brackets), can be found in Tables 15 and 16.

Table 15. Summary of results: Policy measure types represented by each model (in brackets, the percentage of types represented as proposed for each sector).

LIST OF MODELS	BUILDINGS	INDUSTRY	AGRICULTURE & LULUCF	TRANSPORT	WATER	BEHAVIOUR
CHANCE	2 (20%)	3 (25%)	1 (7%)	4 (22%)	0 (0%)	7 (39%)
IMACLIM-China	0 (0%)	1 (8%)	0 (0%)	0 (0%)	0 (0%)	2 (11%)
GCAM	7 (41%)	11 (92%)	9 (64%)	13 (72%)	1 (50%)	6 (33%)
GCAM-USA	10 (50%)	9 (75%)	10 (71%)	11 (61%)	0 (0%)	0 (0%)
MUSE	10 (50%)	12 (100%)	7 (50%)	15 (83%)	0 (0%)	8 (44%)
SLIM-India	4 (29%)	6 (50%)	3 (21%)	18 (100%)	0 (0%)	5 (28%)
TIAM	10 (50%)	12 (100%)	4 (29%)	15 (83%)	0 (0%)	5 (28%)
CLEWs	9 (47%)	11 (92%)	11 (79%)	18 (100%)	2 (100%)	6 (33%)
DyNERIO	4 (29%)	6 (50%)	3 (21%)	8 (44%)	0 (0%)	0 (0%)
MEDEAS	0 (0%)	10 (83%)	3 (21%)	13 (72%)	0 (0%)	3 (17%)
WILIAM	10 (50%)	10 (83%)	11 (79%)	18 (100%)	1 (50%)	10 (56%)
Calliope	10 (50%)	11 (92%)	3 (21%)	0 (0%)	0 (0%)	0 (0%)
China-MAPLE	8 (44%)	12 (100%)	3 (21%)	16 (89%)	0 (0%)	3 (17%)
EnergyPLAN	10 (50%)	7 (58%)	3 (21%)	18 (100%)	0 (0%)	0 (0%)
EXPANSE	2 (17%)	3 (25%)	0 (0%)	2 (11%)	0 (0%)	0 (0%)
MENA-EDS	9 (47%)	11 (92%)	3 (21%)	17 (94%)	0 (0%)	5 (28%)
OSeMOSYS	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
PROMETHEUS	9 (47%)	11 (92%)	3 (21%)	13 (72%)	0 (0%)	5 (28%)
DREEM (TEEM)	10 (50%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	9 (50%)
ATOM (TEEM)	1 (9%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (11%)
WISEE-EDM Industry EU	0 (0%)	11 (92%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

| WISEE-EDM | 0 (0%) | 6 (50%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| WTMBT | 7 (41%) | 5 (42%) | 0 (0%) | 8 (44%) | 0 (0%) | 5 (28%) |

Table 16. Summary of results: Policy instruments represented by each model (in brackets, the percentage of types represented as proposed for each category).

POLICY INSTRUMENTS						
LIST OF MODELS	ECONOMIC INST.	REGULATORY INST.	SOFT INST.	BARRIER REMOVAL	POLICY SUPPORT	RESEARCH & DEVELOPMENT
CHANCE	6 (38%)	3 (43%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
IMACLIM-China	4 (25%)	0 (0%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
GCAM	11 (69%)	5 (71%)	0 (0%)	2 (50%)	0 (0%)	0 (0%)
GCAM-USA	12 (75%)	5 (71%)	0 (0%)	2 (50%)	0 (0%)	0 (0%)
MUSE	8 (50%)	5 (71%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
SLIM-India	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
TIAM	7 (44%)	3 (43%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
CLEWs	5 (31%)	4 (57%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
DyNERIO	5 (31%)	4 (57%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
MEDEAS	1 (6%)	2 (29%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
WILIAM	5 (31%)	2 (29%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
Calliope	2 (13%)	0 (0%)	0 (0%)	3 (75%)	0 (0%)	0 (0%)
China-MAPLE	4 (25%)	3 (43%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
EnergyPLAN	3 (19%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
EXPANSE	5 (31%)	1 (14%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
MENA-EDS	7 (44%)	4 (57%)	1 (14%)	2 (50%)	0 (0%)	0 (0%)
OSeMOSYS	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
PROMETHEUS	8 (50%)	4 (57%)	1 (14%)	2 (50%)	0 (0%)	1 (50%)
DREEM (TEEM)	12 (75%)	2 (29%)	4 (57%)	4 (100%)	2 (33%)	2 (100%)
ATOM (TEEM)	10 (63%)	2 (29%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)
WISEE-EDM Industry EU	7 (44%)	0 (0%)	0 (0%)	1 (25%)	0 (0%)	1 (50%)
WISEE-EDM	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
WTMBT	7 (44%)	4 (57%)	0 (0%)	1 (25%)	0 (0%)	0 (0%)

4   Guidelines for translating policy needs into scenarios

The objective of this section is to provide guidelines to translate policy needs into scenario frameworks based on the information analysed in previous sections (the policy clustering and the IAM COMPACT modelling ensembles analysis). These guidelines are based on the following sub-activities or steps:

- Analysing and clustering the different types and categories of policy needs (or policy questions) as a preliminary step for translating them into scenarios, based on the classification made in Section 2.

- Identification of policy types and categories (from current and "potential future" climate and sustainability policies implemented at different levels), but also differentiating the different type of policy questions (e.g., target related, exploratory questions which further extends the scope, etc.). (Section 4.1.1)

- Creating guidelines supporting the matching of policy needs with the most suitable models, supported by the information collected in Section 3 Policies that can be addressed by IAM COMPACT models, and also considering the policies' modelling requirements (i.e. model characteristics needed to represent that policies in the models) (Section 4.1.2)

4.1 Needs for translating policy questions into scenario frameworks in IAM COMPACT

Scenario frameworks are tools which help to thinking about the future in a structured way, favouring policy discussions more specific and based on reliable sources. They involve creating a set of hypothetical scenarios or stories that describe how different variables involved could play out over time, and how they might interact with each other, identifying uncertainties and potential risks that stakeholders should face.

When it comes to policy analysis and decision-making, it can be useful analysing complex policies and clustering them r. By doing this, it is possible to identify common themes, objectives, and underlying principles that drive these policies as well as potential areas of overlap or conflict between policies (trade-offs) and synergies. Once categorised, these groups of categories can act as a starting point for translating them into scenarios so that it becomes easier to visualize how different policies might interact with one another in various contexts, and how they might be affected by changes in external factors such as economic conditions, technological developments, or behavioural shifts.

Therefore, before translating the policy question into scenarios, it is necessary to consider the different type of policy approaches/questions that can be suggested by stakeholders (discussed topic along the sub-section 4.1.1), and also understand what the requirements and specifications of a policy need are (measure, policy instrument, etc.) to be modelled (sub-section 4.1.2). Both analyses will support the above-mentioned match of policy questions and models needed in this project.

4.1.1 For addressing the policy needs

Policy design and their analysis is part of a cycle (shown in the Figure 5). The core of the interactions in this process is based on the objectives or preferences from policymakers and stakeholders as they are the ones who define the policies. However, the results or effects of applying a policy that has well-defined objectives or goals are not easy to know in advance (e.g. unintended consequences). For supporting this, models are very useful tools for policy decision-making, as they allow to analyse and compare the effects of different policies before they are implemented. However, it is necessary to take into account that it is not possible to predict and quantify with total certainty since there are some external factors potentially uncontrollable.
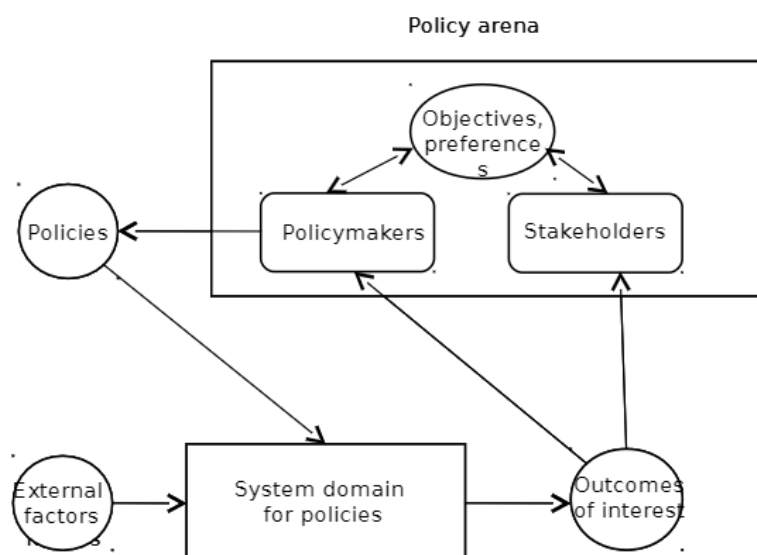
Figure 5. A framework for the rational style of policy analysis. (Walker & Daalen, 2013)

Apart from the broader current climate and sustainability policy types and categories, which were defined in the Section 2 based on the literature review), the specific policy questions can cover a wide range of typologies and objectives: analysis of specific impacts, effects, achievement of an objective, exploration of different scenarios, etc... The type of question that should be addressed is highly relevant for the suitability of models to answer. Some examples of different policy question types which are typically answered by different types of models are the following:

- "Optimal" policy design ("what would be a cost-optimal carbon price to reach goal xy")

- Target-related questions ("what are plausible pathways for reaching a specific target with different pros and cons")

- Explorative questions ("what happens if the prices for electricity rise to XY Euro/MWh" or "what happens if we set an energy tax to XX EUR/MWh")

- Stakeholder / actor related questions ("what measures are needed to provide a level-playing field for the already struggling European steel industry?")

Table 17 shows a list of different categories of policy questions or needs identified by stakeholders (Osman & Cosstick, 2022):

Table 17. Categorisation of policy questions. Source: (Osman & Cosstick, 2022)

Category	What type of question is included
Verification	Did X occur?
Disjunctive	Is X or Y the case?
Concept completion	Who? What? What is the referent of a noun argument slot?
Feature specification	What attributes does X have?
Quantification	How many are there of X?
Definition	What does X mean?
Example	What is an example of X?

Comparison	How is X similar to Y?
Interpretation	What concept can be inferred from X?
Causal Antecedent	What event caused X?
Causal consequence	What are the consequences of X?
Goal orientation	What are the motives behind X's actions?
Instrumental procedural	What plan can allow for X to be achieved?
Enablement	What resource allows X to perform their action?
Expectational	Why did X event not occur?
Value judgement	What value does responder place on X?
Assertion	The inquirer makes a statement indicating lack of knowledge
Request/directive	The inquirer wants the responder to perform an action

Deliverable D2.2 of the IAM COMPACT project (Heussaff & Zachmann, 2023) identifies stakeholders' interests and policy needs through questions organised by themes and regions (see Figure 6). The views of stakeholders—including, among others, policy makers, industry representatives and civil society organisations—is particularly important in this project.
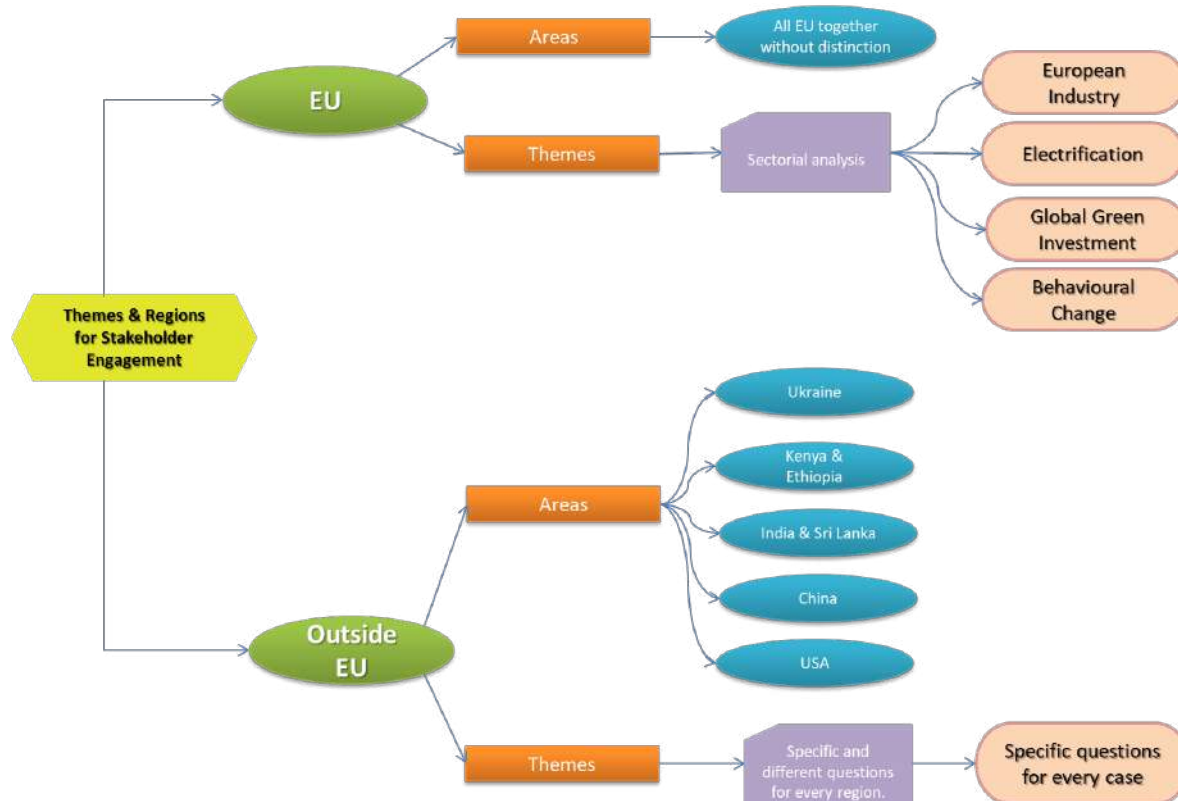
Figure 6. Themes and regions selected to be in IAM COMPACT.

Themes and regions defined will determine the kinds of policy questions proposed by stakeholders. It is necessary to remark that at the time of developing this deliverable the policy questions are still preliminary, therefore full list of questions is not yet available, but they would be finalised by end of March and reported in the update of the Deliverable 2.2.

It is anticipated that, in most cases, it will be clear which models are unsuitable for investigating particular policy questions. Matching models to stakeholder groups and policy questions, as well as identifying appropriate models for model linking, will be a collaborative process and input will be required from across the consortium. Priority will be given to using multiple types of models in parallel, to provide a more robust view.

4.1.2 For supporting the representation of policies in models

Apart from classifying the policy questions into categories considering the different needs coming from stakeholders and the most relevant climate and social-environmental sustainability current policy types and categories at different levels (as explained in the previous section), it is necessary to account for the specific requirements needed to be represented in models: e.g. the spatial range of application, the sector in which it is implemented and which ones it may affect, or which instrument will be used to carry it out.

As it has been previously commented on Section 3, policies can be modelled by endogenous parameters, external inputs (proxies, exogenous data) or combining both endogenous features and assumptions which are based on historical data, expert knowledge, forecasts and theoretical hypotheses (Intergovernmental Panel on Climate Change (IPCC), 2014).

The process of policy modelling depends on the policy objective and the context of application of the policy, but the most usual approaches are (Calvin, Wise, Kyle, Patel, Clarke, & Edmonds, 2019):

- Reference scenarios: These hypothetical situations outline how the political and economic system might develop in the absence of new policies i.e., they intuit what the future trajectory of certain variables would be like, if trends to date were to continue. These scenario outcomes serve as a benchmark for comparing the effects of various strategies.

- Sensitivity analysis: this method entails analysing how IAM outcomes vary when one or more underlying hypotheses or key policy-relevant variables are altered.

- Alternative scenarios: These scenarios show how the political and economic system is anticipated to change under various suppositions and policy parameters, enabling comparison of model-based scenarios.

Matching policy questions and models involves a process of ensuring that the model is designed to answer the policy question or address the policy issue at hand. In order to ensure a perfect match, a **sequence of guidelines** should be followed (Weimer, The Universal and the Particular in Policy Analysis and Training, 2012) (Weimer & Vining, Policy Analysis: Concepts and Practice, 2017):

1. **Clear definition of the policy question:** This is necessary to ensure that the chosen model is able to answer the specific question. The process of defining a policy question involves identifying a specific issue that requires attention, and developing a question that can guide policy analysis and decision-making.

2. **Identification of the policy objective:** Identifying the relevant goals of the policy question is essential to align both model and policy overall targets.

3. **Categorisation of the relevant policy requirements:** Along with the policy objective, policy questions have a specific framework which defines them. Each question can be categorised according to various parameters such as the sector of implementation, the geographical jurisdiction, the SDG's affected (impact) or the kind of policy type (instrument/measure), previously defined in Section 2. Additionally, some other requirements have been included in order to increase the accuracy of the policy question definition (presented below).

4. **Selection of an appropriate model type:** This choice should be based on the nature of the policy

question and the available data and features of the model.

5. **Validation of the model and communication of the results**: Using testing techniques like sensitivity analysis or running a set of diagnostic scenarios (Harmsen, Kriegler, van Vuuren, & van der Wijst, 2021)the model can be validated before modelling the policy question. The outputs have to be presented in a clear and concise way to stakeholders and policy-makers.

Considering the above, there are some useful categories of policy questions that can guide the process of supporting the match policy needs to models, specifically the categorisation of the requirements of the policy.

As such, categories obtained in Section 2 can support the third step of the guidelines, allowing to describe and cluster the policy questions according to the need for their adequate representation in models. This can be linked to the analysis of each model carried through Section 3, and jointly support the fourth step, of the guidelines listed above: *Selection of an appropriate model type.*

In addition, apart from the categories defined in Section 2, there are other requirements that a policy may impose a model. These additional specifications are briefly defined in the following list:

- Granularity → It refers to the level of detail or specificity of the data or analysis. A high level of granularity means that the data or analysis is very detailed and specific, while a low level of granularity means that it is more general or abstract (Degbelo & Kuhn, 2018). It is possible to classify data granularity in terms of temporality and spatiality:

    - Temporal resolution → Specific time frame or time horizon over which a policy is being considered or evaluated. It is the degree of granularity with which the policy issue is being examined in terms of time (Luderer, Bertram, Kriegler, & Meinshausen, 2019). It may be determined by various factors, such as the nature of the policy issue, the availability of data, the political and economic context, and the policy objectives. Policy questions can be framed in different time frames, such as short-term (days to weeks), medium-term (months to years), or long-term (decades or more).

    - Spatial resolution → Specific level of spatial detail at which a policy is being considered or evaluated. For example, high spatial resolution data might represent a city block or a specific building, while low spatial resolution data might represent an entire neighbourhood or region. Similarly, a policy that is effective for one population or location may not be effective for another population or location. (Baker, 2019)

- Sectors where the policy is applied → Specific areas or domains of social and economic activity where the policy is implemented. It is the scope or breadth of the policy intervention in terms of the sectors of the economy, society, or environment that are affected. (Leipold & Prakash, 2018). This is the "Policy sector" category explained in Section 2.

- Model variables-inputs-assumptions → These components form the analytical framework used to evaluate the potential impacts of a particular policy. Their transparency and accuracy are responsible for the consistency of the model outputs.

- Which outputs are needed to answer the policy questions? → This category includes both the SDGs affected and the areas in which the policy has an impact (not the area of implementation). The SDGs affected are closely related to co-benefits.

In parallel to these policy requirements, it is necessary to make a prior analysis of the possible scenarios to be generated in order to know whether the model is able to run with them or not. Scenarios have to be coherent and self-consistent future visions or events that are constructed to help policymakers and analysts explore the potential impacts of different policy decisions or external factors. There can be different scenarios depending on the type of policy question considered. These are also related to the definition of the scenario logic to be developed in the Task 4.2 "Development of the broad scenario logic for modelling".

Although they have already been introduced, this deliverable does not take into account those policy requirements

that are not yet known such as the possible scenarios generated, how the inputs/assumptions of the model relate to the policies and the granularity of the policy (levels and sub-levels of the question). However, for the matching of policy questions to models , they will be taken into account as soon as the final policy needs from the first modelling cycle are defined and reflected in the update of Deliverable 2.2 (update of (Heussaff & Zachmann, 2023))

Due to the lack of information about some factors related to both the policy questions and the models, the clustering of policies performed in this task entails a preliminary approach and results in the categories presented in Section 2. This analysis could be extended in the update of this Deliverable (D4.2), as explained in the Conclusions and future work Section. The clustering of the policy questions could be complemented by the clustering presented in the Table 9 of Section 2.3 which divides them according to their overall goal or orientation.

4.2 Method proposed for policy categorisation

4.2.1 Final policy categorisation based on the needs of IAM COMPACT

In order to ensure the correct use of models for policy analysis, the policy questions have to be categorised and matched with appropriate model features. Since these questions are diverse and complex, it is necessary to establish a categorisation method which can help to identify commonalities and differences among them. The basis of this categorisation is the synthesis of literature review presented in the Table 9. (Section 2), and the analysis made in the Section 4.

The final policy categories based on 1) the different type of policy questions coming from stakeholders, and the different type of climate and socio-environmental sustainability policies (currently in force or presented in the literature) and 2) the requirements /specifications for representing a policy in a model collected and defined in the previous section 4.1.2 which are listed in the following table. These categories will support the process of matching policy questions to modelling frameworks.

Table 18. Policy questions categorisation. Source: own elaboration.

Policy questions categorisation	
Policy question	What is the impact of…
Theme	European industry, electrification…
Subtheme	Social impact, hydrogen…
Type of policy question	Explorative, optimal…
Policy type	Instrument, measure…
Sector where the policy is applied	Energy, transport…
Policy objective type (if applicable)	Hydrogen, afforestation…
Policy instrument type (if applicable)	Economic, regulatory…
Geographical Scale (Jurisdiction)	National, global…
Spatial resolution	Specific city, country…
Temporal resolution	2030, 2050…

Scenarios	
Main sectors involved	Industry, climate…
Granularity	High, low
Main SDGs affected/involved	SDG 7, SDG 9…

5   First modelling cycle: clustering of policy needs and process for matching them with the models

Throughout this task several activities have been conducted, culminating with clustering the policy questions (provided by the stakeholders) into categories based on common parameters such as theme, sector, impact, resolution, etc.

As the project progresses, a closer inspection of policy needs and model capabilities will be needed. This will involve going beyond just classifying them and defining which policy categories each of the models can represent; a detailed feedback from the modellers will be needed, explaining how the model could address the question specifically and which data inputs would be required.

5.1 Clustering of policy questions identified for the 1st cycle

In this section the preliminary policy questions are classified based on broad and key policy categories defined in previous sections.

5.1.1 Policy needs from Deliverable 2.2.

As already discussed, the questions coming from the D.2.2 are just preliminary. These preliminary questions cover different themes: European Industry (potential scenarios including hydrogen), as well as electrification (including the impact on domestic economy, or on biodiversity/land-use, dependency of innovation, etc.), and, a behavioural change, covering questions regarding the role of behaviour in the energy transition and its potential representation in modelling

A summary of the policy needs identified by stakeholders can be found in the following Table 19 and Table 20:

Table 19. Themes and regions of policy questions. Source: Own elaboration based on Deliverable 2.2

Themes	Regions
European Industry	Ukraine
Electrification	Kenia & Ethiopia
Global Green Investment	India & Sri Lanka
Behavioural Change	China
	USA

Table 20. Summary of the need identified by stakeholders

Themes needs abstract		
European Industry	**Electrification**	**Behavioural change**
Economic effects of different potential scenarios of European industrial organisation	The affordability dimension of increasing electrification as the main question.	Effects of heterogeneous consumer preferences and its changes in the model suite

Comparison of supply, cost savings and emissions impacts of reshoring and importing essential green technologies.	Balance between grid investment and demand response, smart grids and flexibility (including its needs)	Related to this theme, it is considered important which policies can drive behavioural change, in addition to the cost-saving and emission reductions of those changes
Potential European hydrogen (production, cost, demand)	Holistic vision of the energy system, types of energy, electricity…	

5.1.2 Categorisation of policy needs

The categories presented in Section 2 and 3 formulate the groundwork of policy clustering and will be further expanded as interactions with stakeholders advance and recorded in the updated Deliverable D4.2, as explained in the Conclusions and future work Section.

The categorisation of the list of initial questions is included in Annex III.

Table 21. Template used for classifying the preliminary list of policy questions coming from Deliverable 2.2.

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
Policy question 1: XXX											
Policy question 2: XXX											

5.2 Matching of policies with models from the consortium

In this deliverable, the linkage between policies and models is formalised, but as the policy needs for the first policy cycle are only preliminary, its application will be carried out in Deliverable 4.2, when the final ones are established.

Preliminary, some examples of this mapping of policies and models are the following:

- Policy questions about electricity system balancing require high spatial and temporal granularity, and therefore it is possible to note that this type of policies could suit models like Expanse.

- Policy questions on specific sectors like industry would suit models like TIAM (as this model includes a good technological representation of industry). Also, an industry sector-specific model like WISEE could be included in the analysis.

- Policy questions about the sustainability aspects of specific policies would match with IAMs. For example, the policy question about the impacts on land-use and on biodiversity of increasing renewable electricity capacity, could apply to those IAMs able not only to model the "energy" sector, but also those that include a "land-use" module (e.g. WILIAM or GCAM models), and are able to measure (or to represent with modifications) biodiversity related indicators.

Given that models may be able to address several policy questions, specific process is necessary to decide / balance out which model should be used in each theme / policy question. Even with a pre-defined process, the

direct link of a policy question to a model still has inherent limitations and uncertainties, as explained in Section 3.

Considering this, the future process for matching of policies and models, after policy needs being analysed and classified, should include two necessary steps:

1) Brief cross-check of policy needs and model capabilities based on categories developed in this Deliverable and on the template filled by modelling teams which includes the categories and the policy types that can be represented in each model (See Annex II). This would allow a fast filtering to detect potentially fit-for-purpose models that are suitable to model the policy types: this list of models will be included in the second step. In addition, this would allow to discard those models that are not suitable.

2) Closer inspection of policy needs and model capabilities that goes beyond "checkboxes": First, a detailed analysis, which will allow an initial screening of potentially suitable models /models combinations to be used. Second, modelling teams will need to know how the model could address the question specifically and which kind of results can be expected.

   The modelling teams will be able to specify whether their models can implement different types of policies and, if not, the possibility of linking several models and improving capabilities. This potential combination of models will be supported by the activities and methods to be defined in Task 3.2, related to comparability and integration of models.

6   Conclusions and future work

One of the main outcomes of this deliverable is the establishment of policy types and categories aimed at clustering climate and sustainability policy needs. The categories, based on a review of European projects, online databases, and scientific and grey literature, consist of six major dimensions: jurisdiction, economic development, policy objective, sector, policy instrument and co-benefit. The sector, instrument and objective categories also include subcategories to provide a more detailed categorisation. Consequently, the broad climate and sustainability policy spectrum is comprehensively covered, offering a range of classification alternatives that account not only for technical, economic or energy aspects but also for environmental, social, and behavioural factors.

The template of modelling features (provided in Annex II) highlights the modelling diversity of IAM COMPACT and shows that even for the same policy type there are different assumptions or approaches adopted for modelling purposes. The initial clustering of policy questions presented in this task represents an initial draft, incorporating the preliminary policy questions provided by D2.2. Nonetheless, this first categorisation has served as validation of the categories and the method proposed, setting some guidelines and steps to be followed in the future activities of this Task. As explained, the first filter of models supported by our templates can provide a preliminary list of models suitable to explore different policy questions. However, this process needs to be followed by a deeper analysis of needs and model capabilities supported also by modellers, through Tasks 3.4 and 4.2.

Future work (Deliverable 4.2: Update of the guidelines)

Once the policy questions are defined, the categories listed in this deliverable will be improved and refined by expanding the policy types and categories as well as the requirements for their matching with models. Furthermore, the template filled in by the modellers can be augmented and customised to suit different policy questions. Finally, the matching between policies and models will be more comprehensive, as the deep dive into drivers, barriers and policy options of Task 6.4 and the updated policy questions originating from Deliverable 2.2 become available, leading to the formulation of a wide-ranging policy catalogue (MS9) as the final output of this task.

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Annex I

Policy categorisation in European projects

1. LOCOMOTION

Table 22. Policy categorisation according to LOCOMOTION (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

LOCOMOTION policy categorisation		
Sector	**Policy objective**	**Policy instrument**
Industry	Climate Action	Economic instruments
Building	Changes in Society	Regulatory instruments
AFOLU	Changes in Economy	Soft instruments
Transport	Agriculture & Land use	RD&D
Energy	Transport	Roadmaps and plans
Economy	Energy generation, storage & transmission	Other
Waste	Energy efficiency	
Environment & climate	Resources & Materials	
Research & Innovation		
Social development		
Non-energy materials		
Water		

Table 23. Subcategories of sectors according to LOCOMOTION. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

Subcategories of LOCOMOTION (sectors)				
AFOLU	Buildings	Economy	Energy	Social Development
Agriculture	Buildings	Economy & Trade	Energy materials	Consumption
Land use	Households	Business		Education and Culture
Food				Governance
				Health
				Labour
				Population

				Public sector

Table 24. Subcategories of policy objectives according to LOCOMOTION. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

	Subcategories of LOCOMOTION (objectives)		
AFOLU	Animal health	Forest Protection	Increase of multistrata agroforestry
	Improved LULUCF capacity	Improve soil health	Increase of silvopasture
	Afforestation	Increase conversation agriculture	Increase organic agriculture
	Protection of peatlands	Regenerative Agriculture	Restoration of tropical forests
	Protection of wetlands	Restoration of temperate forests	Soil protection/fertility
Climate action	Climate change adaptation	Carbon sequestration	GHG emissions: Fugitive emissions
	Climate change mitigation	GHG emissions: F-gases	Improved carbon pricing
	GHG emissions: Agriculture	GHG emissions: Food	GHG emissions: Industry
	GHG emissions: Livestock	Reduced GHG emissions	Reduced environmental impact of human activities
Economy & Society	Alternative indicators for progress	Consumer protection	Demand response
	Alternative structure of economy	Consumption habits	Enable research, innovation and competitiveness
	Circular economy	Degrowth	Energy poverty
	Equitable and resource efficient governance	Green growth	Improve education
	Family Planning	Improved health	Improve education for girls
	Increase economic stability	Minimize the rebound effect	Reduced poverty and inequality
	Increased investment in green economy	Reduce overall debt	Regionalization of production
	Increased public property ownership	Reduced investment in brown economy	Social equity
	Stabilize population growth	Transition from materialistic society	Work-Life Balance
	Strategies to boost technological progress	Unemployment reduction	-
Energy Efficiency	Electrification	Behaviour building users	Energy Management Systems

	Agriculture	Buildings	Farmland irrigation
	Appliances and machinery	End-use	Increased quality of wastewater treatment
	Increased quality of water supply network	Monitoring	Public lighting
	Industry	Nearly Zero Energy Buildings	Transport
	Information and training	Public buildings	Transport - airplanes
	Transport - Eco-driving	Transport - ships	Water saving
	Transport - Passenger cars	Transport - trains	-
	Transport - Public transport	Transport - trucks	-
Energy generation, storage & transmission	Energy storage: consumer level	Fuel shift: Green H2 production & use	Heat generation: Geothermal
	Energy storage: utility level	Fuel shift: Industry	Heat generation: Heat pumps
	Energy system flexibility	Fuel shift: Power-to-Fuel production & use	Heat generation: RES
	Energy system security	Heat generation: Biogas	Heat generation: Solar
	Energy transmission infrastructure	Heat generation: Biomass	RES: Education and information
	Fossil fuel phase-out	Heat generation: district heating	RES: promotion
	Fossil fuel to RES	Heat generation: Fuel cells	-
Resources & Materials	Increase of plant-rich diet	Increased use of biomass	Material Use
	Increased use of alternative cement	Increased use of bioplastic	New materials and technologies
	Increased use of biochar	Increased use of organic waste for composting	Recycling - households
	Increased use of biogas	Land management	Recycling - industry
	Reduced use of fertilizers	Reduction of waste	Waste management
	Reduction of extractive activities	Substitution of HFCs for cooling	Water management
	Reduction of food waste	Treatment of landfill gas	-
Transport	Alternative fuels	Infrastructure	Reduced transport volume - people
	Electric mobility	Reduced transport volume - flights	-

	Hybrid cars	Reduced transport volume - freight	-

Table 25. Subcategories of policy instruments according to LOCOMOTION. (Böck, Eggler, Rohrer, Papagianni, Christodoulaki, & Taxeri, 2020)

	Subcategories of LOCOMOTION (policy instruments)
Economic	Public Procurement
Economic	Financial incentives & Taxes
Regulatory	Obligation Schemes
Soft	Education & Training
Soft	Behavioural

2. PARIS REINFORCE

Table 26. Policy categorisation according to PARIS REINFORE (I^{2}AM PARIS).

PARIS REINFORCE policy categorisation (I^2 AM PARIS)	
Sector	**Policy objective**
Industry	Adaptation
Building	Behavioural changes
AFOLU	AFOLU
Transport	Transport
Energy	Energy
	Fuel production
	Industry
	Buildings

Table 27. Subcategories of sectors and policy objectives according to PARIS REINFORE (I^{2}AM PARIS).

	Subcategories of PARIS REINFORCE (sectors and objectives)	
	Sectors	Objectives
AFOLU	-	Agriculture

Buildings		LULUCF
	Commercial	Heating
		Cooling
	Residential	Lightning
		Appliances
Energy	Sources	Electricity generation
	Transformation	
	Storage	Electricity generation
Industry	-	Process heat
		Machine drives
		Steam
		CHP
		Overall industry
Transport	Passenger	Modal shifts
		Road
		Aviation
	Freight	Shipping
		Rail
Fuel production		Hydrogen production
		Synthetic fuel production

3. INNOPATHS

Table 28. Policy categorisation according to INNOPATHS. (Siskos, 2021)

INNOPATHS policy categorisation		
Sector	**Policy objective**	**Policy instrument**
Agriculture	Energy efficiency	Economic
Buildings	Transport	Soft instruments

Business	Climate action	Regulatory
Consumption	Changes in Economy and Society	
Economy & Trade		
Education and Culture		
Households		
Industry		
Power		
Transport		

Table 29. Subcategories of policy instruments according to INNOPATHS.

Subcategories of INNOPATHS (policy instruments)		
Economic	Direct investment	Government procurement
		R&D funding
	Fiscal incentives	Auctions
		Loan/soft loans
		User charges
		FITs/FIPs
		Grants, subsidies & other tax allowances
		Taxes & exemptions
	Market-based instruments	GHG emissions allowance trading scheme
		Green certificates
		White certificates
Soft	-	-
Regulatory	Codes & Standards	Building codes and standards
		Product standards
		Vehicle fuel-economy and emission standards
	Obligation Schemes/Quotas	RE obligation schemes

4. ENGAGE (Climate Policy Database)

Table 30. Policy categorisation according to ENGAGE (CPD).

ENGAGE policy categorisation (CPD)			
Jurisdiction	**Sector**	**Policy objective**	**Policy instrument**
City	Industry	Climate Action	Barrier removal
Country	Building	Economic development	Climate strategy
Subnational Region	AFOLU	Land use	Economic instruments
Supranational Region	Transport	Energy access	Regulatory instruments
	Energy (Electricity & Heat)	Energy security	Soft instruments
	General & Economy	Water	RD&D
		Food security	Policy support

Table 31. Subcategories of policy objectives according to ENGAGE (CPD)

	Subcategories of ENGAGE (objectives)
Climate action	Air pollution
	Mitigation
	Adaptation
Energy (mitigation area)	Energy efficiency
	Energy service demand reduction and resource efficiency
	Non-energy use
	Other low-carbon technologies and fuel switch
	Renewables

Table 32. Subcategories of policy instruments according to ENGAGE (CPD)

	Subcategories of ENGAGE (policy instruments)
Economic	Direct investment
	Fiscal incentives
	Market-based instruments
Regulatory	Codes/Standards
	Obligation Schemes
	Auditing
	Monitoring
Soft	Information and education
	Voluntary approaches

5. NDC ASPECTS

Table 33. Policy categorisation according to NDC ASPECTS.

NDC ASPECTS policy categorisation			
Jurisdiction	**Sector**	**Policy objective**	**Policy instrument**
National	Industry	Mitigation	Soft instruments
	Building	Energy efficiency	Regulatory instruments
	AFOLU	Transport re-structuring	Economic and financial instruments
	Transport	Fuel production	Policy support
	Energy		Barriers removal
			Climate strategy

Table 34. Subcategories of sectors and policy objectives according to NDC ASPECTS. **(Fragkos & Zisarou, Energy System Transition in the Context of NDC and Mitigation Strategies in Tunisia, 2022)**

Subcategories of NDC ASPECTS (sectors and objectives)			
	Sectors		Objectives
Energy efficiency			Energy supply
			Energy demand
Industry	Iron & Steel		

	Aluminium	
	Cements & Concrete	
	Chemicals	
Transport	-	Passenger cars
		Aviation
		Shipping
		Freight
Fuel production		Synthetic green fuels
		Biofuels
		Green electricity

6. NAVIGATE

Table 35. Policy categorisation according to NAVIGATE.

NAVIGATE policy categorisation	
Sector	**Policy objective**
Consumption	Energy efficiency
Energy	Changes in Economy and Society
Environment & Climate	Mitigation
Households	Climate Change
Industry	Agriculture & Land use
Labour	

Annex II

Template of features of models

Table 36. Template of features of models: Sectors & Measure Types

POLICY MEASURES TYPE	CHANCE	IMACLIM-China	GCAM	GCAM-USA	MUSE	SLIM-India	TIAM	CLEWs
Gas replacing oil / coal	Yes		Yes	Yes	Yes		Yes	Yes
Biofuels			Yes	Yes	Yes		Yes	Yes
Electricity			Yes	Yes	Yes		Yes	Yes
Hydrogen			Yes	Yes	Yes		Yes	Yes
Solar thermal				Yes	Yes		Yes	Yes
Building shell efficiency			Yes	Yes	M		M	
Electricity			Yes	Yes	Yes	Yes	Yes	Yes
Building shell efficiency			Yes	Yes	M	M	M	M
Efficient lighting	Yes			Yes	Yes	Yes	Yes	Yes
Efficient appliances				Yes	Yes	Yes	Yes	Yes
Gas replacing oil / coal	Yes		Yes	Yes	M	Yes	Yes	Yes
Biomass			Yes	Yes	M	Yes	Yes	Yes
Hydrogen			Yes	Yes	M	M	Yes	Yes
Electricity			Yes	Yes	M	Yes	Yes	Yes
Gas replacing oil / coal	Yes		Yes		M		Yes	Yes
Electricity			Yes		M		Yes	Yes
Gas replacing oil / coal	Yes		Yes		M		Yes	Yes
Electricity			Yes	M	M		Yes	Yes
Gas replacing oil / coal			Yes	M	M		Yes	Yes
Biomass			Yes	M	M		Yes	Yes
CCS		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CDR/NETs				Yes	Yes	Yes	Yes	
Gas replacing oil / coal	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Biomass			Yes	Yes	Yes	Yes	Yes	Yes
Electricity			Yes		Yes	Yes	Yes	Yes
Land yield maximisation			Yes	Yes	Yes			Yes
Organic fertilizer use								Yes
No tillage				Yes				Yes
Agroforestry				Yes				Yes
Improved feeding practices			Yes		Yes			M
Manure management					Yes			
Feed additives				Yes				
Afforestation			Yes	Yes	Yes		Yes	Yes
Land protection			Yes	Yes				Yes
Biomaterials			Yes	Yes				
Area set aside for nature			Yes	Yes				Yes
Coal to gas with CCS				Yes	Yes		Yes	Yes

POLICY MEASURES TYPE	CHANCE	IMACLIM-China	GCAM	GCAM-USA	MUSE	SLIM-India	TIAM	CLEWs
Coal to liquids with CCS			Yes	Yes	Yes		Yes	Yes
Gas to liquids with CCS					Yes		Yes	Yes
Biomass to liquids			Yes	Yes	Yes		Yes	Yes
Biomass to liquids with CCS			Yes	Yes	Yes		Yes	Yes
Hydrogen to gas with CCU				Yes				Yes
Hydrogen to liquid with CCU				Yes				Yes
Electrolysis			Yes	Yes	Yes		Yes	Yes
Coal to hydrogen with CCS			Yes	Yes	Yes		Yes	Yes
Gas to hydrogen with CCS			Yes	Yes	Yes		Yes	Yes
Biomass to hydrogen with CCS			Yes	Yes	Yes		Yes	Yes
Coal with CCS		Yes	Yes		Yes	Yes	Yes	Yes
Gas with CCS		Yes	Yes		Yes	Yes	Yes	Yes
Nuclear fission	M		Yes		Yes	Yes	Yes	Yes
Nuclear fusion					Yes	Yes	Yes	Yes
Hydro	M	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Biomass	M	Yes	Yes		Yes	Yes	Yes	Yes
Biomass with CCS		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geothermal	M		Yes	Yes	Yes	Yes	Yes	Yes
Solar PV	M		Yes	Yes	Yes	Yes	Yes	Yes
Solar CSP	M		Yes	Yes	Yes	Yes	Yes	Yes
Onshore Wind	M		Yes	Yes	Yes	Yes	Yes	Yes
Offshore Wind	M		Yes	Yes	Yes	Yes	Yes	Yes
Coal with CCS		Yes		Yes			Yes	Yes
Gas with CCS		Yes		Yes			Yes	Yes
Oil with CCS		Yes		M			Yes	Yes
Geothermal				Yes			Yes	Yes
Biomass		Yes	Yes	Yes	Yes		Yes	Yes
Biomass with CCS		Yes		Yes			Yes	Yes
Gas (LNG / CNG) vehicles			Yes	M	Yes	Yes	Yes	Yes
Hybrid electric vehicles			Yes		Yes	Yes	Yes	Yes
Fully electric vehicles			Yes	Yes	Yes	Yes	Yes	Yes
Hydrogen fuel cell vehicles			Yes	Yes	Yes	Yes	Yes	Yes
Biofuels in fuel mix			Yes	Yes	Yes	Yes	Yes	Yes
Efficiency	Yes				Yes	Yes	Yes	Yes
Electric rail			Yes	Yes	Yes	Yes	Yes	M
Hydrogen fuel cell rail			Yes		Yes	Yes		M
Efficiency	Yes			Yes	Yes	Yes	Yes	M
Biofuels in fuel mix			Yes	Yes	Yes	Yes	Yes	M
Hydrogen planes			Yes	Yes	Yes	Yes	Yes	M
Electric planes			Yes		Yes	Yes	Yes	M

POLICY MEASURES TYPE	CHANCE	IMACLIM-China	GCAM	GCAM-USA	MUSE	SLIM-India	TIAM	CLEWs
Efficiency	Yes			Yes		Yes		M
Gas (LNG / CNG)				Yes	Yes	Yes	Yes	M
Hydrogen			Yes	Yes	Yes	Yes	Yes	M
Biofuels in fuel mix			Yes		Yes	Yes	Yes	M
Electric			Yes			Yes	Yes	M
Efficiency	Yes					Yes		M
Water management (efficient and saving)			Yes					Yes
Managing of floods/floods risk								M
Travelling less	Yes		Yes		M	M	M	M
Change mode of transport /occupancy	Yes		Yes		M	M	M	Yes
Less energy service demand	Yes	Yes	Yes		M	M	M	M
Lower material consumption					M	M	M	M
Less product demand	Yes	Yes	Yes		M	M	M	M
Change of diet	M		Yes		M			M
Less food waste			Yes		M			
Change of values					M			
Climate education in schools								
Renewal of the contents and methodologies								
Disaster risk reduction								
Diet and Physical Activity								
Health investment								
Minimum-wage policy								
Rural unemployment	M							
Urban unemployment	M							
Regulatory management system								
Quality of new regulations								
OTHERS								

POLICY MEASURES	DyNERIO	MEDEAS	WILIAM	Calliope	China-MAPLE	EnergyPLAN	EXPANSE	MENA-EDS
Gas replacing oil / coal	Yes		Yes	Yes	Yes	Yes		Yes
Biofuels	Yes		Yes	Yes	Yes	Yes		Yes
Electricity	Yes		Yes	Yes	Yes	Yes	M	Yes
Hydrogen			Yes	Yes	Yes	Yes		Yes
Solar thermal			Yes	Yes	Yes	Yes		
Building shell efficiency			Yes	M		M		Yes
Electricity	Yes		Yes	Yes	Yes	Yes	M	Yes

POLICY MEASURES	DyNERIO	MEDEAS	WILIAM	Calliope	China-MAPLE	EnergyPLAN	EXPANSE	MENA-EDS
Building shell efficiency			Yes	M		M		Yes
Efficient lighting			Yes	Yes	Yes	M		Yes
Efficient appliances			Yes	Yes	Yes	M		Yes
Gas replacing oil / coal	Yes	M	Yes	Yes	Yes	Yes		Yes
Biomass	Yes	M	Yes	Yes	Yes	Yes		Yes
Hydrogen		M	Yes	Yes	Yes	Yes		Yes
Electricity	Yes	M	Yes	Yes	Yes	Yes	M	Yes
Gas replacing oil / coal	Yes	M	Yes	Yes	Yes			Yes
Electricity	Yes	M	Yes	Yes	Yes		M	Yes
Gas replacing oil / coal		M	Yes	Yes	Yes			Yes
Electricity		M	Yes	Yes	Yes		M	Yes
Gas replacing oil / coal		M	Yes	Yes	Yes	M		Yes
Biomass		M	Yes	Yes	Yes	M		Yes
CCS	Yes			Yes	Yes	Yes		Yes
CDR/NETs					Yes			
Gas replacing oil / coal	Yes	M	M	Yes	Yes	Yes		Yes
Biomass	Yes	M	M	Yes	Yes	Yes		Yes
Electricity	Yes	M	M	Yes	Yes	Yes		Yes
Land yield maximisation			Yes					
Organic fertilizer use			M					
No tillage			M					
Agroforestry			Yes					
Improved feeding practices								
Manure management			M					
Feed additives								
Afforestation			Yes					
Land protection			Yes					
Biomaterials								
Area set aside for nature			M					
Coal to gas with CCS	M		M	Yes	Yes			Yes
Coal to liquids with CCS	M		M	Yes	Yes			Yes
Gas to liquids with CCS	M		M	Yes	Yes	Yes		Yes
Biomass to liquids	M		M	Yes	Yes	Yes		Yes
Biomass to liquids with CCS	M		M	Yes	Yes	Yes		Yes
Hydrogen to gas with CCU						Yes		
Hydrogen to liquid with CCU						Yes		
Electrolysis			Yes	Yes	Yes	Yes	M	Yes
Coal to hydrogen with CCS				Yes	Yes			Yes
Gas to hydrogen with CCS			Yes	Yes	Yes			Yes
Biomass to hydrogen with CCS				Yes	Yes	Yes		Yes

POLICY MEASURES	DyNERIO	MEDEAS	WILIAM	Calliope	China-MAPLE	EnergyPLAN	EXPANSE	MENA-EDS
Coal with CCS	Yes		M	Yes	Yes	Yes	Yes	Yes
Gas with CCS	Yes		M	Yes	Yes	Yes	Yes	Yes
Nuclear fission	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nuclear fusion				Yes	Yes			
Hydro	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Biomass	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Biomass with CCS	Yes		Yes	Yes	Yes	Yes		Yes
Geothermal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Solar PV	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Solar CSP	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Onshore Wind	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Offshore Wind	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Coal with CCS			Yes	Yes	Yes	Yes		Yes
Gas with CCS			Yes	Yes	Yes	Yes		Yes
Oil with CCS			Yes	Yes	Yes	Yes		
Geothermal		Yes	Yes	Yes	Yes	Yes		
Biomass		Yes	Yes	Yes	Yes	Yes		Yes
Biomass with CCS			Yes	Yes	Yes	Yes		Yes
Gas (LNG / CNG) vehicles	M	Yes	Yes		Yes	M		
Hybrid electric vehicles	M	Yes	Yes		Yes	M		Yes
Fully electric vehicles	M	Yes	Yes		Yes	M	M	Yes
Hydrogen fuel cell vehicles	M		Yes		Yes	M		Yes
Biofuels in fuel mix	M	Yes	M		Yes	M		Yes
Efficiency	Yes	Yes	Yes		Yes	M		Yes
Electric rail	Yes	Yes	Yes		Yes	M	M	Yes
Hydrogen fuel cell rail			Yes			M		Yes
Efficiency	Yes	M	Yes		Yes	M		Yes
Biofuels in fuel mix		Yes	M		Yes	M		Yes
Hydrogen planes			Yes		Yes	M		Yes
Electric planes			Yes			M		Yes
Efficiency		M	Yes		Yes	M		Yes
Gas (LNG / CNG)		Yes	Yes		Yes	M		Yes
Hydrogen			Yes		Yes	M		Yes
Biofuels in fuel mix		Yes	M		Yes	M		Yes
Electric		Yes	Yes		Yes	M		Yes
Efficiency		M	Yes		Yes	M		Yes
Water management (efficient and saving)			Yes					
Managing of floods/floods risk								
Travelling less		M	Yes					Yes

POLICY MEASURES	DyNERIO	MEDEAS	WILIAM	Calliope	China-MAPLE	EnergyPLAN	EXPANSE	MENA-EDS
Change mode of transport /occupancy			Yes		Yes			Yes
Less energy service demand		M	M		Yes			Yes
Lower material consumption		M	M					Yes
Less product demand			M		Yes			Yes
Change of diet			Yes					
Less food waste			Yes					
Change of values								
Climate education in schools								
Renewal of the contents and methodologies								
Disaster risk reduction								
Diet and Physical Activity			Yes					
Health investment			M					
Minimum-wage policy			Yes					
Rural unemployment								
Urban unemployment								
Regulatory management system								
Quality of new regulations								
OTHERS	Domestic critical consumption							

POLICY MEASURES TYPE	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Gas replacing oil / coal	Yes	Yes	Yes				Yes
Biofuels	Yes	Yes	Yes				Yes
Electricity	Yes	Yes	Yes	Yes			Yes
Hydrogen	Yes	Yes	Yes				
Solar thermal	Yes		Yes				
Building shell efficiency		Yes	Yes				
Electricity	Yes	Yes	Yes				Yes
Building shell efficiency	M	Yes	Yes				Yes
Efficient lighting	Yes	Yes	Yes				Yes
Efficient appliances	Yes	Yes	Yes				Yes
Gas replacing oil / coal	Yes	Yes			Yes	Yes (for steel only)	Yes
Biomass	Yes	Yes			Yes	Yes (for steel only)	Yes
Hydrogen	Yes	Yes			Yes	Yes (for steel only)	
Electricity	Yes	Yes			Yes	Yes (for steel only)	Yes
Gas replacing oil / coal	Yes	Yes					Yes
Electricity	Yes	Yes			Yes		Yes

POLICY MEASURES TYPE	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Gas replacing oil / coal	Yes	Yes			Yes		
Electricity	Yes	Yes			Yes		
Gas replacing oil / coal	Yes	Yes			Yes		
Biomass	Yes	Yes			Yes		
CCS	Yes	Yes			Yes	Yes (for steel only)	
CDR/NETs					M	M	
Gas replacing oil / coal	Yes	Yes					
Biomass	Yes	Yes					
Electricity	Yes	Yes					
Land yield maximisation	Yes						
Organic fertilizer use	Yes						
No tillage	Yes						
Agroforestry	Yes						
Improved feeding practices	M						
Manure management							
Feed additives							
Afforestation	Yes						
Land protection	Yes						
Biomaterials							
Area set aside for nature	Yes						
Coal to gas with CCS	Yes	Yes					M
Coal to liquids with CCS	Yes	Yes					M
Gas to liquids with CCS	Yes	Yes					M
Biomass to liquids	Yes	Yes					M
Biomass to liquids with CCS	Yes	Yes					M
Hydrogen to gas with CCU	Yes						
Hydrogen to liquid with CCU	Yes						
Electrolysis	Yes	Yes					
Coal to hydrogen with CCS	Yes	Yes					
Gas to hydrogen with CCS	Yes	Yes					
Biomass to hydrogen with CCS	Yes	Yes					
Coal with CCS	Yes	Yes					Yes
Gas with CCS	Yes	Yes					Yes
Nuclear fission	Yes	Yes					Yes
Nuclear fusion	Yes						
Hydro	Yes	Yes					Yes
Biomass	Yes	Yes					Yes
Biomass with CCS	Yes	Yes					Yes
Geothermal	Yes						Yes

POLICY MEASURES TYPE	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Solar PV	Yes	Yes		Yes			Yes
Solar CSP	Yes	Yes					Yes
Onshore Wind	Yes	Yes					Yes
Offshore Wind	Yes	Yes					Yes
Coal with CCS	Yes	Yes					
Gas with CCS	Yes	Yes					
Oil with CCS	Yes						
Geothermal	Yes						
Biomass	Yes	Yes					
Biomass with CCS	Yes	Yes					
Gas (LNG / CNG) vehicles	Yes						M
Hybrid electric vehicles	Yes	Yes					M
Fully electric vehicles	Yes	Yes					M
Hydrogen fuel cell vehicles	Yes	Yes					M
Biofuels in fuel mix	Yes	Yes					M
Efficiency	Yes	Yes					Yes
Electric rail	M	Yes					Yes
Hydrogen fuel cell rail	M						
Efficiency	M						Yes
Biofuels in fuel mix	M	Yes					
Hydrogen planes	M	Yes					
Electric planes	M						
Efficiency	M	Yes					
Gas (LNG / CNG)	M	Yes					
Hydrogen	M	Yes					
Biofuels in fuel mix	M	Yes					
Electric	M						
Efficiency	M	Yes					
Water management (efficient and saving)	Yes						
Managing of floods/floods risk	M						
Travelling less	M	Yes					M
Change mode of transport /occupancy	Yes	Yes					M
Less energy service demand	M	Yes	Yes				M
Lower material consumption	M	Yes	M				
Less product demand	M	Yes	M				
Change of diet	M		M				
Less food waste			M				M
Change of values			M	Yes			

POLICY MEASURES TYPE	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Climate education in schools			M	M			
Renewal of the contents and methodologies							
Disaster risk reduction							
Diet and Physical Activity			M				
Health investment			M				
Minimum-wage policy							Yes
Rural unemployment							
Urban unemployment							
Regulatory management system							
Quality of new regulations							
OTHERS			Demand response measures, Additional cooling of buildings (Adaptation category)	Technology adoption & Diffusion model			Yes

Table 37. Template of features of models: Policy instruments

POLICY INSTRUMENTS	CHANCE	IMACLIM-China	GCAM	GCAM-USA	MUSE	SLIM-India	TIAM	CLEWs
Procurement rules								
RD&D funding								
Infrastructure investments	P		P	P				Yes
Funds to sub-national governments				P				
Climate finance tools			P	P				
FITs/FIPs	Yes		Yes	Yes	P		P	
Energy taxes & Tax exemptions	Yes	Yes	Yes	Yes	P		P	P
Energy auctions								
Grants and subsidies	Yes	Yes	Yes	Yes	Yes		Yes	P
Loans and soft loans			P	P				
User charges			P	P	P		P	
GHG emissions allowance trading schemes	Yes	Yes	Yes	Yes	P		Yes	Yes
Green certificates			P	P	P		Yes	
White certificates			P	P	P			
Carbon pricing	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Building codes			P	P				
Industrial air pollution standards	Yes		Yes	Yes	P			Yes
Product standards					P		P	
Sectoral standards	Yes							

POLICY INSTRUMENTS	CHANCE	IMACLIM-China	GCAM	GCAM-USA	MUSE	SLIM-India	TIAM	CLEWs
Vehicle air pollution standards			Yes	Yes	P			Yes
Vehicle fuel-economy and emissions standards			Yes	Yes	Yes		Yes	Yes
Renewable energy obligations	Yes		Yes	Yes	P		P	Yes
Information provision								
Performance Label (comparison or endorsement)								
Professional training and qualification								
Advice or aid in implementation								
Negotiated agreements (public-private sector)								
Public voluntary schemes								
Unilateral commitments (private sector)								
Grid access and priority for renewable								
Net metering			P	P				
Removal of fossil fuel subsidies	Yes	Yes	P	P			Yes	Yes
Removal of split incentives (landlord tenant problem)								
Processes, plans and strategies								
Sub-national and citizen participation								
MRV								
Institutional mandates								
International cooperation								
Institutional creation								
Demonstration project								
Research programme								
OTHERS								

POLICY INSTRUMENTS	DyNERIO	MEDEAS	WILIAM	Calliope	China-MAPLE	EnergyPLAN	EXPANSE	MENA-EDS
Procurement rules								
RD&D funding								
Infrastructure investments	Yes	P	Yes			P		P
Funds to sub-national governments								
Climate finance tools	P							P
FITs/FIPs							Yes	Yes
Energy taxes & Tax exemptions	Yes		Yes		Yes	P	Yes	Yes
Energy auctions								
Grants and subsidies	Yes		Yes	Yes	Yes		Yes	Yes
Loans and soft loans			Yes					
User charges								

POLICY INSTRUMENTS	DyNERIO	MEDEAS	WILIAM	Calliope	China-MAPLE	EnergyPLAN	EXPANSE	MENA-EDS
GHG emissions allowance trading schemes					Yes		Yes	P
Green certificates								
White certificates								
Carbon pricing	P		Yes	Yes	Yes	P	Yes	Yes
Building codes								P
Industrial air pollution standards	Yes							
Product standards	Yes				Yes			
Sectorial standards	Yes				Yes			
Vehicle air pollution standards								P
Vehicle fuel-economy and emissions standards		Yes	Yes		Yes			P
Renewable energy obligations	Yes	Yes	Yes				Yes	Yes
Information provision								
Performance Label (comparison or endorsement)								
Professional training and qualification								
Advice or aid in implementation								
Negotiated agreements (public-private sector)								
Public voluntary schemes								
Unilateral commitments (private sector)								P
Grid access and priority for renewables		Yes	Yes	Yes				P
Net metering				P				
Removal of fossil fuel subsidies	Yes			Yes	Yes		Yes	Yes
Removal of split incentives (landlord tenant problem)								
Processes, plans and strategies								
Subnational and citizen participation								
MRV								
Institutional mandates								
International cooperation								
Institutional creation								
Demonstration project								
Research programme								
OTHERS								

POLICY INSTRUMENTS	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Procurement rules					P		
RD&D funding		Yes	P		P		
Infrastructure investments	Yes	P	Yes		P		Yes

POLICY INSTRUMENTS	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Funds to sub-national governments			Yes				
Climate finance tools		P					P
FITs/FIPs		Yes	Yes	Yes			
Energy taxes & Tax exemptions	P	Yes	Yes	Yes	P		Yes
Energy auctions				Yes			P
Grants and subsidies	P	Yes	Yes	Yes	P		Yes
Loans and soft loans			Yes	Yes			
User charges			Yes	Yes			
GHG emissions allowance trading schemes	Yes	Yes	Yes	P	P		Yes
Green certificates			P	P			
White certificates			P	P			
Carbon pricing	Yes	Yes	Yes	P	Yes		Yes
Building codes		P	Yes	P			
Industrial air pollution standards	Yes						Yes
Product standards							Yes
Sectorial standards							Yes
Vehicle air pollution standards	Yes	P					
Vehicle fuel-economy and emissions standards	Yes	P					
Renewable energy obligations	Yes	Yes	Yes	Yes			Yes
Information provision			P				
Performance Label (comparison or endorsement)			P				
Professional training and qualification			P				
Advice or aid in implementation							
Negotiated agreements (public-private sector)							
Public voluntary schemes		P					
Unilateral commitments (private sector)		P	P				
Grid access and priority for renewables			Yes	Yes			
Net metering		Yes	Yes		P		Yes
Removal of fossil fuel subsidies	Yes		P				
Removal of split incentives (landlord tenant problem)			P				
Processes, plans and strategies							
Subnational and citizen participation			P				
MRV			Yes				
Institutional mandates							
International cooperation							
Institutional creation							

POLICY INSTRUMENTS	OSeMOSYS	PROMETHEUS	DREEM (TEEM)	ATOM (TEEM)	WISEE-EDM Industry EU	WISEE-EDM global steel	WTMBT
Demonstration project			P		Yes		
Research programme		P	P				
OTHERS			Efficiency target (Y), Emissions target (Y)				

Annex III

Table 37. Clustering of policy questions

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
What are the potential levels of hydrogen demand, available volumes, costs, and optimal usage in 2030 and 2040?											
European Industry	Hydrogen	Policy measure + Other (market question)	Industry	Overall industry	Hydrogen				European, National,	Industry, Energy, Buildings, Transport	SDG 9
How can a potential European hydrogen market compete with other hydrogen production regions, such as the Gulf of Mexico?											
European Industry	Hydrogen	Other (market question)	Industry	Hydrogen production	Hydrogen				European, National	Industry, Energy, Buildings, Transport Energy supply	SDG 9
What are the overall costs and emissions saving potentials for circular economy and energy efficiency measures in European industry?											
European Industry	Economy (circular) and energy efficiency	Policy measure + Policy instrument + Other (market question)	Industry	Overall industry	Efficiency	Regulatory instruments	Codes and Standards	Sectorial standards	European, National,	Industry	SDG 9
Is it more economically sensible to produce energy-intensive industrial inputs (such as ammonia) in other regions (in Europe or globally) and import them to industrial clusters?											
European Industry	Economy (circular) and energy efficiency	Policy instrument + Other (market question)	Industry	Overall industry		Policy support		International cooperation	European, National,	Industry	SDG 9
What are the energy, climate, and labour implications of reshoring critical industries?											
European Industry	Implications and effects	Policy measure + Other (market question)	Industry	Overall industry					Global, European, National, Various (regional clusters)	Industry, Energy, Social/Behavioural, Climate, Transport	
How different future (2030 and 2040) scenarios of European industry (e.g., in terms of production, location, energy-intensiveness, and input costs) are in terms of cost, resilience, and social (labour market) perspectives?											

European Industry	Implications and effects	Policy measure + Other (broad system/societal question)	Industry	Overall industry					European, National, Subnational, Various (regional clusters)	Industry, Energy, Social/Behavioural, Climate, Transport	

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
To what extent are we reliant on innovation to reduce carbon emissions in the power sector?											
Electrification	Innovation/Feasibility	Policy instrument	Energy	Electricity generation	Electricity	Research & Development	Direct investment	RD&D funding	European/Global	Electricity	SDG 7
How will increasing electrification impact customers' bills?											
Electrification	Social impacts /Costs/Costumers	Policy measure	Energy	Electricity generation	Electricity				European/Global	Household buildings, Personal transport	SDG 7
Are real-world consumer prices higher than the resource costs produced by models?											
Electrification	Social impacts /Costs/Costumers	Other (market question)	Energy	Electricity generation	Electricity	Economic and financial instruments	Market-based instruments		European/Global	Households / business	SDG 7
Which technologies are best placed to provide flexibility in a low-carbon system?											
Electrification	Technologies /Flexibility	Policy measure	Energy	Electricity generation	Electricity				European/Global	Electricity	SDG 7
Are there certain future system configurations that are more susceptible to disruption from geopolitical events?											
Electrification	Disruptive events/resilience	Other (system question)	Energy						European/Global	Whole system	SDG 7
What are the land-use implications of increasing renewable electricity capacity and, specifically, what are the biodiversity impacts?											
Electrification	Land-use/Biodiversity	Policy measure	Energy	Electricity generation	Renewables				European/Global	AGRICULTURE & LULUCF (Land Use, Land Use Change and Forestry) Biodiversity	SDG 15; SDG 7

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
What are the flexibility needs for the future electricity system?											
Electrification	Flexibility of the system	Policy Instrument	Energy	Electricity generation	Regulatory management system	Regulatory instruments	Targets, Quotas and Obligations		Global, National	Electricity generation, transmission and distribution networks, energy storage	SDG 7
What technologies can replace the flexibility provided gas in the power system?											
Electrification	Flexibility of the system	Policy Instrument	Energy	Electricity generation	Regulatory management system	Barrier removal	Targets, Quotas and Obligations	Removal of fossil fuel subsidies	EU - wide	Electricity generation technologies	SDG 7
Are certain technologies better for balancing and others for congestion management?											
Electrification	Flexibility of the system	Policy Instrument	Energy	Electricity generation	Electricity	Policy support	Targets, Quotas and Obligations		EU - wide	Electricity generation, transmission and distribution network technologies	SDG 7
Will there be different requirements during the transition and once the system is decarbonised?											
Electrification	Flexibility of the system	Policy Instrument	Energy	Electricity generation	Quality of new regulations	R&D&D		Research programme	Global, National	All sectors	SDG 7
What are the infrastructure needs for the future electricity system?											
Electrification	Infrastructure	Policy measure + Other (market question)	Energy	Electricity generation	Electricity				European, National, Subnational	Energy, Industry	SDG 7
To what extent are grids and storage complementary?											
Electrification	Infrastructure	Policy measure + Other (market question)	Energy	Electricity generation	Electricity				European, National, Subnational	Energy, Industry, Transport, Buildings	SDG 7

IAM COMPACT

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
What will the demand for hydrogen be in the future electricity system?											
Electrification	Infrastructure	Policy measure + Other (market question)	Energy	Hydrogen production					European, National, Subnational	Energy; Electricity	SDG 7
What benefits can interconnection provide for system balancing?											
Electrification	Infrastructure	Policy measure + Other (market question)	Energy		Electricity				European, National	Energy	SDG 7
How much can increasing levels of interconnection reduce renewables curtailment?											
Electrification	Infrastructure	Other (market question)	Energy	Electricity generation	Renewables				European, National	Energy	SDG 7
What are the costs and benefits of increasing levels of interconnection capacity?											
Electrification	Infrastructure	Other (market question)	Energy		Electricity				European, National	Energy	SDG 7
How can local, distribution-level flexibility reduce the need for grid expansion?											
Electrification	Infrastructure	Policy instrument + Other (market question)	Energy		Electricity	Economic and financial instruments	Market-based instruments		Subnational	Energy, Industry, Transport, Buildings	
What energy carriers are most likely to dominate in future (2040 and beyond) power systems and what are the implications for markets?											
Electrification	Energy carriers/Markets-Trade	Policy instrument + Other (market question)	Energy	Electricity generation					European, National, Subnational, Various (electricity trading areas)	Energy (all subsectors)	SDG 7
Could traders be indifferent to energy carriers as many options will have comparable costs?											

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
Electrification	Energy carriers/Markets-Trade	Policy instrument + Other (market question)	Energy	Electricity generation		Economic and financial instruments			European, National, Subnational, Various (electricity trading areas)	Electricity generation	SDG 7
What are the implications for system cost of subsidising clean technologies to a certain level?											
Electrification	Energy carriers/Markets-Trade	Policy instrument + Other (market question)	Energy	Electricity generation		Economic and financial instruments	Market-based instruments	Grants and subsidies	European, National, Subnational, Various (electricity trading areas)	Electricity generation, transmission and distribution networks, energy storage	SDG 7
What will the peak demand be in 2040 and 2050 and how can a responsive demand side reduce system costs (e.g., by mitigating the need for capacity investment)?											
Electrification	Demand changes	Policy measure + Other (market question)	Energy	Electricity generation + Consumption	Electricity + Less energy service demand				Global, National	Electricity generation + Consumption	SDG 7; SDG 12
What are the distributional impacts of climate and energy policies on different consumer categories, such as male and female, young and old, as well as income categories? In particular, how do mitigation measures impact those living in energy poverty?											
Behavioural Change	Social impacts	Policy measure	Social/Behavioural	Labour	Unemployment (but also other distributional impacts related to household budgets)				various, from global to local	Consumers	SDG 1; SDG 7; SDG 8; SDG 10
How do the same behavioural interventions compare in the context of a price shock and in the context of no price shock?											
Behavioural Change	Behaviour/Prices	Policy measure	Social/Behavioural	Behavioural/Consumption	All listed in the table under this subcategory				National/EU	Consumers	

Themes	Subthemes	Type	Policy sector	Subcategory of policy sector (if applicable)	Policy objective/measure type (if applicable)	Policy instrument category (if applicable)	Policy instrument subcategory (if applicable)	Policy instrument type (if applicable)	Jurisdiction	Sectors of impact	SDGs related
What are the effects of habit formation on low-carbon consumer choices?											
Behavioural Change	Behaviour /Information	Policy measure	Social/Behavioural	Behavioural/Consumption	All listed in the table under this subcategory				various, from global to local	Consumers	SDG 7; SDG 13; SDG 12
How does intrinsic motivation impact on consumer mitigation strategies given various capabilities to act (e.g., motivation to drive an EV but insufficient infrastructure for charging EVs)?											
Behavioural Change	Capabilities	Policy measure	Social/Behavioural	Behavioural/Consumption	All listed in the table under this subcategory				various, from global to local	Consumers	SDG 122
How do heterogeneous discount rates across consumer categories affect the adoption rates of clean technologies?											
Behavioural Change	Discount rates	Policy measure	Social/Behavioural	Behavioural/Consumption	Change of values				various, from global to local	Energy	SDG 7; SDG 12
How can certain digital innovations (such as remote working) reduce energy consumption?											
Behavioural Change	Digital innovation	Policy measure	Social/Behavioural	Labour	Less energy service demand; Travel less				¿National/Local?	Energy Transport	SDG 8; SDG 12
How can consumer preferences, represented in IAMs, be validated without sufficient empirical data?											
Behavioural Change	Validation	Other (system question)	Social/Behavioural	Behavioural/Consumption	Change of values				Global	Consumers	-
Do certain policymakers have a greater impact on changing behaviour than others?											
Behavioural Change	Policy makers	Policy measure	All	Behavioural/Consumption	Change of values				Global	Consumers	SDG; SDG 12
How can the market impacts (rather than the cost of policy implementation) of a behavioural change be modelled?											
Behavioural Change	Market/Risk Aversion	Policy measure	All	Behavioural/Consumption	Change of values				Global	Consumers	SDG 7; SDG 12
How does heterogeneous risk aversion amongst consumers impact on total system cost											
Behavioural Change	Market/Risk Aversion	Policy measure	All	Behavioural/Consumption	Change of values				Global	Consumers	SDG 7; SDG 12
How would segmenting consumer risk preferences across their consumption (e.g., high risk aversion for essential energy services but low risk aversion for less essential segments) reduce system cost?											
Behavioural Change	Segmenting Consumer Risk	Policy measure	All	Behavioural/Consumption	Change of values				Global	Consumers	SDG 7; SDG 12