Horizon 2020 Societal challenge 5
Climate action, environment, resource
Efficiency and raw materials

D4.4: SEMANTIC REPOSITORY

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PROJECT	Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe (SIM4NEXUS)
PROJECT NUMBER	EC/689150 SIM4NEXUS/2016
TYPE OF FUNDING	RIA (Research Innovation Action)
DELIVERABLE	D.4.4 Semantic repository containing all use cases information, stored in a standardised and interoperable way
WP NAME/WP NUMBER	Serious Game development and testing (WP 4)
TASK	T4.3 Setting-up the project database and metadata ontology (Semantic Repository)
VERSION	Deliverable 4.4 v4.0.docx
DISSEMINATION LEVEL	Public
DATE	25/11/2020 (Date of this version)
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DOCUMENT HISTORY

VERSION	INITIALS/NAME	DATE	COMMENTS-DESCRIPTION OF ACTIONS
1.0	AITOR CORCHERO (EURECAT)	06/08/2019	1^{ST} VERSION
1.1	LLUIS ECHEVERRIA (EURECAT)	14/08/2019	ADDED KEE INFORMATION

2.0	XAVIER DOMINGO (EURECAT)	23/08/2019	ADDED ANNEX WITH CASE STUDIES TEMPLATES GENERAL REVIEW
2.1	XAVIER DOMINGO (EURECAT)	27/08/2019	MINOR REVIEW
2.2	FLOOR BROUWER	28/08/2019	INTERNAL REVIEW
3.0	AITOR CORCHERO (EURECAT	29/08/2019	FINAL VERSION SOLVING COMMENTS
4.0	LLUIS ECHEVERRIA (EURECAT)	23/11/2020	FINAL VERSION SOLVING COMMENTS

Addressing revision comments	
Comment	Response
The link to Semantic Repository backend does not work (summary p.11) and should be corrected: https://seriousgame.sim4nexus.eu/semanticRepositoryBE	The Semantic Repository backend is a REST API, which cannot be accessed via common web browsers requests, but meant for system to system integration
Please harmonize the “tonne” unit (tn, tonne, ton, t)	Done

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Glossary / Acronyms

TERM	EXPLANATION / MEANING
API	Application Programming Interface
CQ	Competency Question
CRUD	Create, Read, Update, Delete
CS	Case Study
CSS3	Cascading Style Sheets version 3
DSD	Data Structure Definition
DSS	Decision Support System
EDI	Electronic Data Interchange
ESCB	European System of Central Banks
EU	European Union
GDP	Gross Domestic Product
HTML	Hypertext Mark-up Language
ISO	International Organization for Standardization
JSON-LD	JavaScript Object Notation for Linked Data
KEE	Knowledge Elicitation Engine
MER	Maximizing Economic Recovery
OGC	Open Geospatial Consortium
OWL	Ontology Web Language
RDF	Resource Description Framework
REST	Representational State Transfer
RIA	Research and Innovation Action
SDM	System Dynamics Modelling
SDMX	Statistical data and metadata exchange
SG	Serious Game
SPARQL	SPARQL Protocol and RDF Query Language
SPIN	SPARQL Inferencing Notation
SR	Semantic Repository
SSN	Semantic Sensor Network
SWRL	Semantic Web Rule Language
UI	User Interface
WMO	World Meteorological Organization
W3C	World Wide Web Consortium

Executive Summary

This document presents the SIM4NEXUS Semantic Repository (SR) to improve the Nexus understanding, including open access to the policies information and objectives. The semantic repository tool has been developed following a REST-API[1] and a visual front-end[2] to facilitate the data navigation and exploration using semantic-enriched information and facets.

The development of the semantic repository has also involved the elaboration of an ontology for linking policies with the Nexus variables and models. This common vocabulary[3] offers the community the possibility to interrelate cross-domain variables and models to improve the Nexus modelling, aspect that becomes a novelty in the field.

Complementary, a naming convention tool[4] has been elaborated in order to convey in the naming of the Nexus variables and provide a common understanding and categorization of the variables across different case-studies.

For SIM4NEXUS, the elaboration of these three tools has been beneficial to:

- Have a common vision about the Nexus variables involved in policy making process.
- Provide metadata and context-based information to the KEE and the GameUI.
- Generate open liked data about the Nexus and subsequent policies.
- Harmonise the information exchange between SIM4NEXUS modules.

Changes with respect to the DoA

N/A.

Dissemination and uptake

The deliverable is publicly available, based on the participation of SIM4NEXUS to the Pilot on Open Research Data in Horizon 2020[5]. Special attention will be paid to how personal data will be properly catered together with other important data and/or scientific information, following General Data Protection Regulation (GDPR) (EU) 2016/679.

[1] Semantic Repository backend: https://seriousgame.sim4nexus.eu/semanticRepositoryB/s4n
[2] Semantic Repository front-end: https://seriousgame.sim4nexus.eu/semanticRepository
[3] SIM4NEXUS ontology: https://seriousgame.sim4nexus.eu/ontology
[4] Naming Convention Tool: https://seriousgame.sim4nexus.eu/namingConvention
[5] According to article 43.2 of Regulation (EU) No 1290/2013 of the European Parliament and of the Council, of 11 December 2013, laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006.

Short Summary of results (<250 words)

The present deliverable describes the semantic repository tool as a data exploration and navigation tool for the nexus variables and policy information. Moreover, the present deliverable also shows the elaboration of a SIM4NEXUS ontology that has the novelty of interrelating cross-domain variables and models to improve the Nexus understanding. Last but not least, a naming convention tool has also served to establish a methodology to harmonise variables representation across case-studies. All these three tools have been elaborated using open source software and are publicly available for the community and the society.

Evidence of accomplishment

The deliverable itself, the SIM4NEXUS ontology, the online version of the naming convention and the online version of the semantic repository released within this period. On the one hand, the SIM4NEXUS webpage published version of the deliverable as well as the links to the tools can act as an evidence of accomplishment.

1. Introduction

1.1. Scope

This document describes the SIM4NEXUS Semantic Repository (SR), corresponding to the title of the deliverable. For the construction of the SR, we developed the SIM4NEXUS ontology in order to represent the variables and policy context to support Nexus knowledge and data representation in the game. Moreover, we also elaborated a naming convention tool as a system to agree on the name of the variables for both, the thematic models and the case-study models. Therefore, the present deliverable:

- Provides a description of the requirements collected to build the SIM4NEXUS ontology, the semantic repository and the naming convention tool
- Describes the current version of the ontology aimed at representing and interrelating Nexus variables
- Describes the development of the naming convention tool used as data catalogue to agree on the name of the Nexus variables
- Describes the SIM4NEXUS semantic repository with twofold objectives: (i) data exploration tool for the variables as an open data catalogue of policies and nexus information; (ii) Open API for the integration in the Knowledge Elicitation Engine

The presented document corresponds with the work elaborated under the Task 4.3 that indeed considers information from the Task 4.1, Task 4.2 and from WP1, WP2, WP3, WP5, and WP6, to accomplish requirements and necessities for SIM4NEXUS project.

Despite the work presented, it is considered a continuous work and it will continue to be in progress during SIM4NEXUS project span, there is no envisioned an update of this document in future deliverables. However, any updates of the work in this deliverable will be included in D4.5 (Serious Game tool final version).

1.2. Document Structure

The following chapters are organized as follows:

- Section 2 presents the semantic repository requirements
- Section 3 describes the SIM4NEXUS ontology
- Section 4 deals with the development of the naming convention tool
- Section 5 describes the semantic repository technical implementation
- Section 6 depicts the third-party connection and data exchange API
- Section 7 provides conclusions and future work

2.Semantic Repository Requirements

This section is mainly devoted to the description of the main requirements to drive the ontology and the semantic repository development. The ontology development will follow the NeON methodology to convert informational requirements into entities and relationships (ontology). These aspects will be covered within Section 2.1. The ontology will be the core for the semantic repository, which also feeds from requirements from case-studies and the Knowledge Elicitation Engine (KEE) in order to elaborate a complete informational tool to exchange Nexus data and variables under a common vocabulary. In this regard, Section 2.2 will cover KEE requirements and the Section 2.3 will cover the requirements coming from the variables identified in each case-study.

2.1. Ontology Requirements

The main objective of this section is to describe the main requirements and the identified vocabulary for the development of the SIM4NEXUS ontology (Section 3). This ontology is aimed at supporting the generation of policies based on the information fusion from water, energy, food, and land use, under climate change scenario.

The role of the SIM4NEXUS ontology is to support the data and variables harmonization for the different models to be implemented at case-study level (thematic models and system dynamic models) as well as policy and game data. Indeed, the SIM4NEXUS ontology will permit the "Knowledge Elicitation Engine" (KEE) to analyse the information and to perform the policies recommendations to the game.

In detail, the SIM4NEXUS ontology has to consider the integration and extension of the following ontologies types:

- **Reference Ontology Model** as a core component to share and harmonize information-based information coming from systems and the different models
- **Domain Ontologies** capable of describing the link between water, energy, food, and land use, under climate change, and their Nexus to support the generation of relevant events and policies
- **Mappings between ontologies** to link/extend the reference ontology models with the domain-specific ontologies

The SIM4NEXUS Ontology will be constructed following the NeON Methodology (Baonza, 2010). Figure 1 provides the graphical representation of the entire methodology based on 9 scenarios. These scenarios cover all possibilities to build ontologies based on the nature of the information available for the ontology to be developed. Indeed, the scenarios cover the possibility to build an ontology from scratch, reusing other semantic resources, extending existent ontologies, considering non-semantic resources, etc. All scenarios have in common the need for a requirements gathering phase and validation phase (bottom part of the figure).

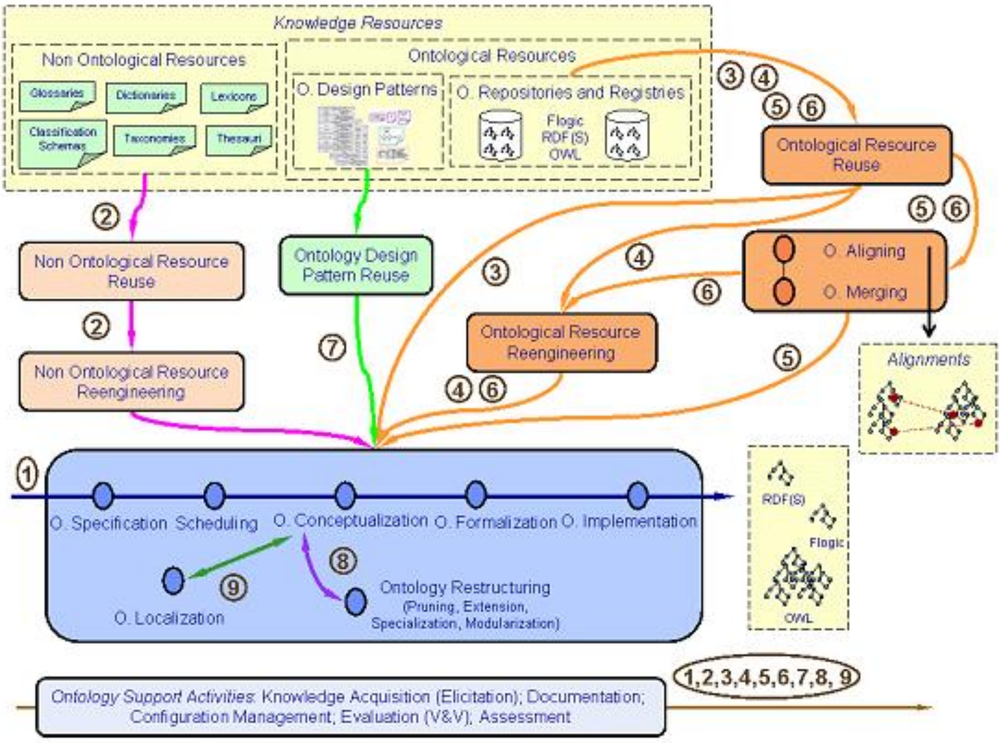


Figure 1. Scenarios defined in the NEON methodology (Baonza, 2010)

Considering this methodology, we will use 4 scenarios from the 9 possible scenarios in SIM4NEXUS. In that sense, we will apply the following scenarios:

- **SCENARIO 1. From Specification to Implementation**: This scenario will permit us to guide the ontological development in different phases that cover requirements, construction, testing and deployment of the semantic model
- **SCENARIO 2. Reusing and Re-engineering non-ontological resources**: One part of the requirements is to analyse current standards and widely adopted data exchange formats (csv, web services, databases, etc) to align the semantics with that information. Thus, this part will serve to harmonise the information and be compatible with existing non-semantic models
- **SCENARIO 3. Ontological Resource Reuse:** This part of the methodology is focused on the selection and analysis of the ontological resources.
- **SCENARIO 4. Re-engineering ontological resources**: This scenario is linked with the SCENARIO 3. In this part of the methodology, the selected ontological resources are linked and reingeniered under a newer ontology (or sub-ontology).
- **SCENARIO 5. Reusing and Merging ontological resources**: This scenario will be applied during the development. In this stage, the extension and merge of ontological and non-ontological resources will be performed

Considering these scenarios, we use them to build the SIM4NEXUS methodology for the ontology development. As represented in the Figure 2, our methodology will be composed by 3 different tasks:

- **PHASE 1: Ontology Specification & Scheduling**. This phase is aimed at identifying main requirements of the ontology including the objective, purpose and potential uses (SCENARIO 1 -requiements-).
- **PHASE 2: Ontology Conceptualization & Formalization**. This phase is devoted to the analysis of the semantic and non-semantic resources in order to build an initial vocabulary (SCENARIO 2, SCENARIO 3).

- **PHASE 3: Ontology Implementation, Evaluation and Documentation**. This phase is devoted to the contruction of the ontology in OWL file (SCENARIO 1 -implementation-, SCENARIO 4 and SCENARIO 5). Moreover, this phase also includes the validation of the ontology and the subsequent documentation and publication.

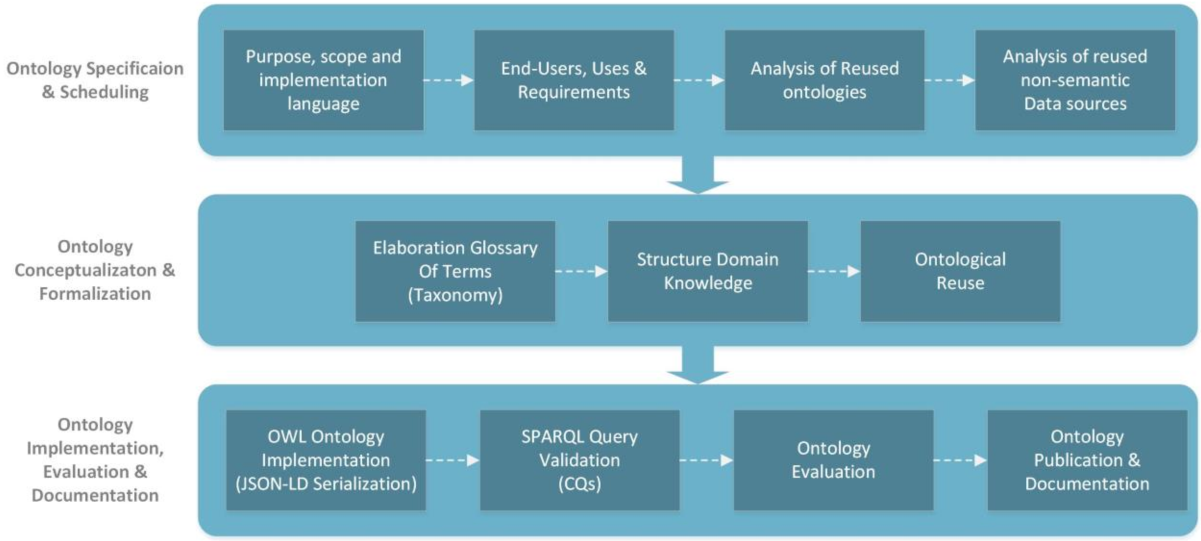


Figure 2. Adapted NEON methodology to build SIM4NEXUS ontology

During this part of the document, we will focus on the defined phases of the adapted methodology. Specifically, this part of the document will be mainly devoted to describe the PHASE 1 and PHASE 2. PHASE 3 will be detailed in the Section 3 of the document.

2.1.1. Phase1. Ontology Specification and Scheduling

The initial phase of the development is focused on establishing the bases for the ontology development. For that, the NeON methodology establishes 7 tasks to be defined. The initial task is devoted to the specification of the general purpose (objective) and scope of the ontology (Section 2.1.1.1). The ontology specification also includes the involved end users or domain experts (Section 2.1.1.2) and the different uses of the ontology inside the platform (Section 2.1.1.3). A formal specification of the requirements is devoted in Section 2.1.1.4 including functional (competency questions) and non-functional aspects that the ontology should fulfil. Section 2.1.1.5 is aimed at identifying the different ontological resources prone to be reused in our ontology. Similarly, Section 2.1.1.6 is focused on identifying the non-semantic resources needed to be present in the ontology. As a result of the process, a glossary of terms is derived from the requirements and the different analysis performed (Section 2.1.1.7). This glossary of terms will further serve to validate the ontology considering also the different competency questions defined.

2.1.1.1. Phase1.1 Identification of purpose, scope and implementation language

Purpose

The development of the SIM4NEXUS ontology is motivated by the need to integrate information from different data sources (systems, databases, thematic models, static information) referring water, energy, food, land use, under climate change scenario of different agencies and uses-cases around EU. The proposed ontology should be able to harmonise the high variability of terms referring to the same topic or domain (in ontology language called "Thing"). The ontology will provide a common data understanding of this information based on the context (their use). Moreover, semantic enriched data representation should be aligned with current standards from the integrated domains.

Considering these aspects, the SIM4NEXUS ontology main purpose is to **provide a complete ontology (or semantic model) about all knowledge and decision-making processes around water, energy, food, and land use, under climate change scenario.**

Scope

The scope of the SIM4NEXUS ontology is to **represent the information from multiple systems that are observing a heterogeneous number of water, land, energy and climate change variables**. These variables will conform some policy evaluation scenarios. The type and the number of these variables will vary from one scenario to others. So, one of the main aspects of the ontology is to make understandable the information collected from the scenarios and to harmonise it under a common model. For that, the ontology needs to follow standard definitions and terms adoptions from representative organizations (WMO, OGC, INSPIRE, W3C, etc). Moreover, the ontology needs to support the scenario definition and the human-interaction with the game in order to facilitate the evaluation of different policies and the subsequent policy recommendation as an output of the scenario simulation.

Implementation Language

The implementation language selected to **develop the ontology is OWL, the Ontology Web language**. We will combine **serialization in JSON-LD** to expose the corresponding information and variables acquired and stored in the different data sources as the semantic repository and non-structured data bases. In case of necessity, we will explore the possibility of using semantic rules to preform ontology alignments (SPIN, SWRL) and to derive policy events.

2.1.1.2. Phase1.2 Identification of End-Users

The different end-users that will consume or use information represented in the SIM4NEXUS Ontology and the Semantic repository are:

Table 2.1. Users of the SIM4NEXUS ontology and Semantic Repository

User Group	Name	Description
User Group 1	Policy Makers	This user group is focused on: (i) determining scenario variables; (ii) studying thematic and global models to derive best policies for the region; (iii) combine water, energy, food, land use, and climate change information to derive suitable governance strategies
User Group 2	Game Players (end-users)	This type of user will: (i) chose/select scenarios; (ii) change variables information; (iii) obtain results

		from the simulation model; (iv) get recommendations based on their actions over the scenarios
User Group 3	Modellers	This type of user will: (i) define scenarios; (ii) change variables information; (iii) obtain results from the simulation models; (iv) get recommendations based on their actions over the scenarios
User Group 4	Researchers	This type of user will: (i) define scenarios; (ii) change variables information; (iii) obtain results from the simulation model; (iv) get recommendations based on their actions over the scenarios

2.1.1.3. Phase1.3 Identification of the ontology uses

Considering the long-term decision-making exposed for the policy determination of the different scenarios, we consider the representation of these actions in form of requirements in the following table:

Table 2.2. Description of the different ontology uses

Uses	Concept	Description
Use 1	Integrate heterogeneous information (systems)	Pull and Push information from different data sources (Sensor-based information, BBDDs, decision-making tools, thematic/general models, etc.) coming from water infrastructure, energy infrastructure, food (economics related to agricultural data sets), land use, and climate (meteorological information)
Use 2	Standard-based serializations	Provide the information to the systems and visualization engine using standard based serializations
Use 3	Navigate through the information	Permit to navigate throughout the information in order to support semantic facet navigation
Use 4	Navigate through different scenarios	Navigate through different scenarios to represent the evolution of the scenario by applying certain policies
Use 5	Status determination for each scenario	Support the management of the stated for the indicators and the different policies applied to a scenario

2.1.1.4. Phase1.4 Identification of the Requirements

This part of the ontology development is aimed at **describing the functional and non-functional requirements that the ontology must fulfil**. The identified functional requirements are represented in form of **Competency Questions (CQs)**. These questions need to satisfy the user requirements and serve as ontology validations about the informational uses of the representative users. The non-functional requirements of the ontology describe the extra features that the semantic models need to satisfy (e.g. multi-language representation). As a result, the informational requirements of the user are identified and planned to be included in the ontology to be elaborated. This will establish the base of the entire platform and informational navigation of the semantic repository.

Functional Requirements

For the elaboration of the functional requirements, we adopted a bottom-up approach for a better understanding of the domain. Specifically, we have involved the different users and information throughout the SIM4NEXUS demo-sites in order to gather main informational interest regarding both Nexus management, policy elaboration and risk management and assessment. This interest has been translated into competency questions that includes for each of the presented questions, the feature (question) and an example of the corresponding answer from the system. The identified competency questions are:

Table 2.3. Functional requirements of the ontology in form of Competency Questions

Nº	Question	Potential Answer
CQ1	Which users are playing the game?	User 1, User 2, etc.
CQ2	Which case study is used in the "GAME-X"?	Case Study 1, Case Study 2, etc.
CQ3	Which model is included in the "Case Study 1"?	Model 1, Model 2, etc.
CQ4	Which is the game evolution for "GAME 1"?	State 1, State 2, State 3, etc.
CQ5	What are the available indicators for "State 1"?	Indicator 1, Indicator 2, etc.
CQ6	What are the agricultural indicators for "State 1"?	Indicator 2, Indicator 5, etc.
CQ7	Which Polices have been applied to "Case Study-1" in the "State-X"?	Policy 1, Policy 2, etc.
CQ8	What is the value of the indicator-1 within the year X of the game?	Value of the inicator-1
CQ9	Which are the non-satisfied KPIs at this status?	KPI 1, KPI 3, etc.
CQ10	Which indicators are affecting the Region-X?	Indicator 2, Indicator 3, etc.
CQ11	How often a policy generates an anomalous result in region X?	3 times
CQ12	Which is the impact of the application of policy X?	Indicator 1 → value 1; Indicator 2 → value 2; etc.
CQ13	Which are the goals for the "GAME-X"?	Water_Security, Ecosystem health, etc.
CQ14	Which are the corresponding indicators for the "Water-Security" goal?	Indicator 1, Indicator 2, etc.
CQ15	Which are the available policy instruments in the "Case-Study-X"?	Foster biodiversity, Prioritize demands, Moderate leakage reduction, etc.

CQ16	Which is the tree structure for the "dReservoir"?	Inflow, Evaporation, Domestic_Use, Irrigation_Use, etc.
CQ17	Which are the Inflow indicator values between 10/01/2018 and the 12/01/2018?	123L (or Time series)
CQ18	Which is the case study Nesus situation at time X?	"Rainfall": 600.0, "dReservoir": 6000.0, "Oat_area": 20000.0, "Wheat_area": 20000.0, etc.

Non-Functional Requirements

The proposed non-functional requirements are focused on determining transversal functionalities that the ontology should fulfil. In these regards, the following table represents the non-functional requirements for the presented ontology:

Table 2.4. Non-Functional Requirements of the SIM4NEXUS ontology

Nº	Non-Functional Requirement
NFR1	The ontology needs to be compatible with water standards for information exchange as WaterML2, NHD, AgroVoc or INSPIRE
NFR2	The ontological terms should have their specific definition
NFR3	The ontology must support a multilingual scenario in the following languages: English, and case studies local languages

2.1.1.5. Phase1.5 Analysis of the semantic resources

This part of the NeON methodology is devoted to analysing the existing semantic resources and select the most appropriated ones according to the elaborated competency questions. Hence, the competency questions will permit to determine an initial approach of the ontologies to be considered. Regarding these ontologies, the initial selection will cover Water domain ontologies (WatERP Ontology and Semantic Water/SWIM), agriculture (Agriculture Meteorology Sensor Network), Nexus ontology (Rahman, 2016), semantic sensor web ontologies (SSN/SOSA, SAREF, WoT), geographic ontologies (GeoSPARQL, W3CGeo) and other relevant ontologies for modelling time series (W3C Time and QUDT). The selected ontologies have been built within the last 4 years to ensure currents advancements in the semantic modelling of each of the mentioned domains. Moreover, we only have considered ontologies that follows the AAA rule (Anybody can say Anything for Any model). So, we only have included in the study those ontologies accessible to the community. This aspect is essential to analyse the axioms and expressivity of the model to evaluate if it correctly fits with our requirements.

In the following table, we have performed a primary study about the vocabulary used during the definition of the competency questions. This used vocabulary has also been used to guide the ontology selection.

Table 2.5. Selection of public ontologies to considered in SIM4NEXUS ontology

<table>
<tr><th>Conditions on the CQs of the ontology</th><th>Typical Cases</th><th>Type of general ontology to reuse</th></tr>
<tr><td rowspan="4">A reference to time appears</td><td>The word ‘period’ appears</td><td rowspan="4">Time</td></tr>
<tr><td>Some of the following adverbs appear: ‘current’, ‘currently’, ‘after’, ‘before’, ‘simultaneously’</td></tr>
<tr><td>Some of the following expressions appear: ‘how many times’, ‘how often’</td></tr>
<tr><td>Some of the following nouns appear: ‘date’, ‘hour’, ‘minute’, ‘second’, etc.</td></tr>
<tr><td rowspan="3">A reference to digital systems appears and the corresponding measurements</td><td>The word ‘sensor’, ‘device’ or ‘system’ appears</td><td rowspan="3">SSN, SAREF, WoT</td></tr>
<tr><td>Some of the following expressions appear: ‘indicators value’, ‘observations’, ‘measurements’, ‘indicators’, etc.</td></tr>
<tr><td>Some of the following nouns appear: ‘observes’, ‘observedProperty’, etc.</td></tr>
<tr><td rowspan="3">A reference to water, agriculture, land use and climate change information</td><td>The word ‘Rainfall’, ‘Inflow’, ‘Outflow’, ‘Evaporation’, ‘Evotranspiration’, etc. appears</td><td rowspan="3">WatERP Ont, SemanticWater, Agriculture Meteorology, Nexus Ont</td></tr>
<tr><td>The words ‘Fruit Area’, ‘Olives Area’, etc. appears</td></tr>
<tr><td>The words ‘Domestic_Use’, ‘Water_Use’, ‘Agriculture_Use’, ‘Industrial_Use’ appears</td></tr>
<tr><td rowspan="2">Units and geographical information</td><td>Some of the following expression appears: ‘measures located in’, ‘events in indicators/scenarios’</td><td rowspan="2">QUDT, W3CGeo, GeoSPARQL</td></tr>
<tr><td>Some of the following aspects are considered: ‘units attached measures’</td></tr>
</table>

Taking into consideration the previous table, the next step in the methodology is to select suitable candidate vocabulary based on the defined indicators in the NeON methodology. These indicators are briefly presented in the Table 2.6. The indicators will permit to quantify and rank each of the mentioned ontologies: Based on the ontology ranking by type, we can select those ones with highest ranking values. Higher values mean close alignment between terms and aspects the we are interested to represent.

Table 2.6. Heuristics needed for the ontology evaluation and selection

Criteria	Description	Value
Reuse Economic Cost	Asking the owner for an estimate	*[Unknown, Low, Medium, High]*
Reuse Time Required	Trying the connection to the server	*[Unknown, Low, Medium, High]*
Quality of the Documentation	Checking the documentation quality of the ontology	*[Unknown, Low, Medium, High]*
Availability of External knowledge Sources	Analysing if in the ontology documentation there is any reference to external sources that could be used to better understand the ontology	*[Unknown, Low, Medium, High]*

Code Clarity	Inspecting the ontology code by analysing the complexity of the definitions (and axioms) implemented the ontology	*[Unknown, Low, Medium, High]*
Adequacy of features	Counting how many features of those identified in CQs are covered by the ontology	*[Unknown, Low, Medium, High]*
Adequacy of knowledge Extraction	Analysing if the ontology is modularized, or if it can be modularized in an easier way	*[Unknown, Low, Medium, High]*
Adequacy of naming conventions	Comparing the naming conventions of both ontologies	*[Unknown, Low, Medium, High]*
Adequacy of the implementation language	Comparing the ontology language of both ontologies. If both languages are different, analysing the loss of knowledge in the translation	*[Unknown, Low, Medium, High]*
Knowledge Clash	Comparing modelling decisions and knowledge representation decision of both ontologies	*[Unknown, Low, Medium, High]*
Adaptation to the reasoner	Comparing the reasoners related to the ontology language of both ontologies	*[Unknown, Low, Medium, High]*
Necessity of bridge terms	Inspecting the ontology code	*[Unknown, Low, Medium, High]*
Availability of tests	Analysing if the ontology documentation refers to existing unit tests	*[Unknown, Low, Medium, High]*
Former Evaluation	Analysing if the ontology documentation refers to existing unit tests and the results of such tests	*[Unknown, Low, Medium, High]*
Theoretical Support	Analysing if the ontology documentation refers to the theory on which the general ontology is based	*[Unknown, Low, Medium, High]*
Development team reputation	Searching for information about the ontology development team (other ontologies developed, papers published, etc.)	*[Unknown, Low, Medium, High]*
Purpose Reliability	Analysing if the ontology documentation refers to the purpose for which the ontology was developed	*[Unknown, Low, Medium, High]*
Practical Support	Analysing if the ontology documentation refers to other ontologies and/or projects reusing the ontology	*[Unknown, Low, Medium, High]*

The evaluation of the different ontologies selected in the Table 2.5 and their corresponding evaluation criteria are described in the following table:

Table 2.7. Analysis of candidate ontologies to be reused.

Criteria	Weight		Time	SSN	SAREF	WatERP Ont	Semantic Water	IoTSchema	Agri. Meteorology	Nexus Ont	QUDT	W3CGeo	Geo SPARQL
Reuse Economic Cost	(-)	9	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*L*	*L*
Reuse Time Required	(-)	7	*M*	*M*	*M*	*H*	*M*	*L*	*L*	*H*	*M*	*L*	*L*
Quality of the Documentation	(+)	8	*H*	*L*	*H*	*L*	*M*	*M*	*H*	*H*	*L*	*M*	*H*
Availability of External knowledge Sources	(+)	7	*H*	*M*	*H*	*M*	*L*	*L*	*H*	*H*	*M*	*H*	*H*
Code Clarity	(+)	8	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*L*	*M*	*H*
Adequacy of features	(+)	10	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*M*
Adequacy of knowledge Extraction	(+)	9	*M*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*M*	*L*	*L*
Adequacy of naming Conventions	(+)	5	*M*	*L*	*M*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*
Adequacy of the implementation language	(+)	7	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*
Knowledge Clash	(-)	7	*M*	*L*	*L*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*
Adaptation to the reasoner	(+)	7	*L*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
Necessity of bridge terms	(-)	6	*H*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*M*	*L*	*L*
Availability of tests	(+)	8	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*L*	*L*	*L*
Former Evaluation	(+)	8	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*U*	*L*	*L*	*L*
Theoretical Support	(+)	9	*H*	*L*	*H*	*L*	*L*	*M*	*H*	*U*	*L*	*M*	*M*
Development team reputation	(+)	8	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*H*	*H*	*H*
Purpose Reliability	(+)	3	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*	*H*	*H*
Practical Support	(+)	7	*L*	*L*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*

In the table, the following aspects has been considered: (+) means a positive value; (-) a negative value; U corresponds with “Unknown”, L with Low, M with medium and H with High values.

Based on the evaluation performed in the Table 2.7, the following table depicts the corresponding scores and ranks as a sum of all values from previous table. For that calculus, we adopted different scores for Unknown (0), Low (1), Medium (2) and High (3) values.

Theme	Ontology	Score
Time	W3C Time Ontology	1,3
Sensor Representation	SAREF	1,44
	IoTSchema.org	1,12
	SSN	0,90
Units and Geospatial information	QUDT	1,24
	W3CGeo	0,83
	GeoSPARQL	1,46
Water Domain Ontologies	WatERP Ontology	0,90
	Semantic Web	0,88
Agriculture Domain	Agriculture Meteorology	1,60
Nexus Domain	Nexus Ontology	1,10

Considering these results, the selected ontologies have been:

- W3C Time Ontology to represent time measurements
- QUDT to represent the different measures based on the International metrics
- SAREF for representing alignment between time series and their context information
- GeoSPARQL to represent of the geo-spatial information considering the basis of the OGC standards

2.1.1.6. Phase1.6 Analysis of the non-semantic resources

This part of the document is aimed at analysing the different non-semantic resources in order to enrich the semantic vocabularies and harmonise the non-semantic resource vocabularies under a common perspective. This non-semantic resource incorporation will serve to facilitate the communication with the existent systems and files.

AgroXML Vocabulary

The AgroXML vocabulary is a structured document to facilitate data exchange between agriculture and their related sectors. This data model is implemented in XML and its structure is based on farm, plant production and livestock farming. The last version (v1.5) of the model is not updated since 2013. Considering the vocabulary, the main terms to be considered are:

Table 2.8. Terms from AgroXML Vocabulary

Term	Description
Cultivation	Describes the condition of a field in relation to the product produced on it
PrimaryCrop	Primary crops are those which come directly from the land and without having undergone any real processing, apart from cleaning. They maintain all the biological qualities they had when they were still on the plants

Water Management Vocabulary (HY_FEATURES & WaterML2)

To derive water management terms, we have considered WaterML2.0 and HY_FEATURES data exchange standards. Both standards have been created by the OGC. These models constitute common data exchange structures that are compatible with geospatial and hydrological models coming from EU and EEUU (INSPIRE, NHD and NHD+). In the one hand, WaterML2 is more focused on the description of the observation and measurement of the hydrological systems. On the other hand, HY_FEATURES is more focused on representing the hydro-physical characteristics of the catchments and other representative water bodies (rivers and lagoons). As a major consequence, the elaborated standards generate several overheads, generating an increment of the response time in situations where high volume of information needs to be exposed. The complexity of these data models also causes difficulties on automatically extract the information due to the high variability (openness of the model).

Taking into consideration the main benefits and difficulties on using these data models, the following list of terms are presented. These terms are highly linked with the Observation and Measurement model elaborated by the OGC and subsequently, linked with the SSN ontology presented in the previous section:

Table 2.9. Terms from HY_FEATURES

Term	Description
Coverage	Feature that acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain
Discharge	In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean
Feature	Abstraction of real-world phenomena
Observation	Act of observing a property
Observation Procedure	Method, algorithm or instrument, or system which may be used in making an observation
Property	Facet or attribute of an object referenced by a name
Domain Feature	Feature of a type defined within a particular application domain
Sampling Feature	Feature, such as a station, transect, section or specimen, which is involved in making observations concerning a domain feature
Sampling Point	A specialized Sampling Feature (ISO19156) where the geometry of the feature is a point. In the context of this profile this is the point at which a sample is made and is analogous to site, location, measuring point. See Monitoring Point definition for further information
Sensor	Type of observation procedure that provides the estimated value of an observed property at its output

Boundary	Geometric representation of a (catchment) boundary, usually a geometric composite curve
Catchment	A physiographic unit where hydrologic processes take place. This class denotes a physiographic unit, which is defined by a hydrologically determined outlet to which all waters flow. While a catchment exists, it may or may not be clearly identified for repeated study
Catchment Area	Two-dimensional (areal) hydrology-specific realization of the holistic catchment. Topologically, the catchment area can be understood as a face bounded by catchment divide and flow path edges. The concept of a face bounded by edges is described in detail in the ISO topology model [ISO19107]. The catchment area is usually represented as a geometric surface, and the measure of the catchment area may be denoted as surface area
Catchment Divide	One-dimensional (linear) feature that is a hydrology-specific realization of the holistic catchment. Topologically, catchment divide can be understood as an edge bounded by inflow and outflow nodes. The concept of an edge bounded by nodes is described in detail in the ISO topology model [ISO19107]. The catchment divide is usually represented as a geometric curve, or as a polygon ring feature
Catchment Topology	Edge-node topology pattern of a set of catchments connected by their hydro nexuses. The topology pattern is derived from flow paths, but ultimately reflects the inferred hydrologic connectivity between catchments and their hydro nexuses whether or not corroborated by geometric representations
Channel	Natural or artificial waterway, clearly distinguished, which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water
Channel Network	Connected set of depressions and channels that continuously or periodically contain water
Cross-Section	Section of a stream at right angles to the main (average) direction of flow.
Data	Documented value of some characteristics of a real-world phenomenon (property)
Dataset	Data compiled and arranged into a set. Used in its concatenated form to indicate a specific dataset, or as data set, for non-specific sets of data.
Data Product	Data set compiled for a specific purpose, e.g. for global dissemination using Web services
Dendritic Catchment	Catchment in which all waters flow to a single common outlet. A dendritic catchment is permanently connected to others in a dendritic (tree) network, the most common drainage pattern of streams ultimately flowing into the ocean after joining together at confluences into larger and larger streams

Depression	Landform lower than the surrounding land and partially or completely closed that is able to, but does not necessarily, contain water
Flow path	One-dimensional (linear) feature that is a hydrology-specific realization of the holistic catchment. Topologically, flow path can be understood to be an edge bounded by inflow and outflow nodes and associated with left-bank and right-bank sub-catchment faces. The concept of an edge bounded by nodes is described in detail in the ISO topology model. The flow path is usually represented as a geometric curve
Flow Line	Geometric property of a flow path, usually a geometric curve
Hydrographic Network	Aggregate of rivers and other permanent or temporary watercourses, and also lakes and reservoirs
Hydrologic Feature	Feature of a type defined in the hydrology domain, whose identity can be maintained and tracked through a processing chain from measurement to distribution of hydrologic information
Hydrologic Complex	Collection of distinct hydrologic features forming a hydrologically connected system where the union of one or more catchments and a common hydro nexus is realized by multiple complexes of hydrology-specific topological elements. For example, a single catchment may be hydrologically realized as a face-edge complex of subcatchment areas and divides, or an edge-node network of flow paths and hydro nexus nodes, and also as a dendritic edge-node network of either waterbodies or containing channels
Hydrologic Location	Any location of hydrologic significance located "on" a hydrologic network that is a hydrology-specific realization of a hydrologic nexus. In a given dataset, hydro locations may or may not have an associated hydrologic nexus and associated catchment features. In such cases, hydro locations would typically be linearly referenced to a defined set of catchments' flow paths. Topologically, a hydro-location can be understood as an inlet or outlet node located at the end of a flow path edge. The hydrologic location is usually represented as a geometric point
Hydrologic Nexus	Conceptual outlet for water contained by a catchment. The hydro nexus concept represents the place where a catchment interacts with another catchment. Every catchment flows to a hydro nexus, conversely every location in a hydrologic system can be thought of as a hydro nexus that drains some catchment. Similar to catchments, hydro nexuses can be realized in several hydrology-specific ways
Hydrologic Realization	A hydrologic feature type that reflects a distinct hydrology-specific perspective of the catchment or hydro nexus feature types. Shares identity and catchment-nexus relationships with the catchment or nexus it realizes but has hydrologically determined topological properties that express unique ways of perceiving catchments and hydrologic nexuses. Distinct from representation in that it is a

	refinement of the holistic catchment, allowing for multiple geometric representations of each hydrologic realization
Hydrology	Science that deals with the waters above and below the land surfaces of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical and physical properties, their reaction with their environment, including their relation to living beings
Hydrometric Feature	Feature of a type which denotes a physical structure intended to observe properties of a hydrologic feature
Hydrometric Network	Aggregate of hydrologically connected monitoring stations situated on and used for hydrologic observation of a feature such as a catchment or hydrographic network. This definition references the definition of a synonymous hydrological network consisting of hydrological stations and observing posts situated within a catchment in such a way as to provide the means of studying its hydrological regime
Hydrometry	Science of the measurement and analysis of water including methods, techniques and instrumentation used in hydrology
Named Feature	Feature identified by a name. Hydrologic features may have multiple names depending on the cultural, political or historical context
Storage	Impounding of water in surface or underground reservoirs, for future use
Stream	Water, generally flowing in a natural surface channel, or in an open or closed conduit, a jet of water issuing from an orifice, or a body of flowing groundwater
Waterbody	Mass of water distinct from other masses of water
Watercourse	Natural or man-made channel through or along which water may flow, including large interstices in the ground, such as cave, cavern or a group of these in karst terrain

Thematic Models

The following list of terms has to be present in the collection of variable names from thematic models across all 12 Case Studies. The list of presented list of variables corresponds to specific snapshot when started the development of the ontology. Currently, this list contains 11.000 different variables available through the naming convention tool:

Table 2.10. Terms from the Thematic Models

Term	Description
Agriculture	Set of agriculture indicators.
Agricultural Production	Vegetable and animal production that is made available for human consumption and animal feed, also including production from arable crops (e.g. wheat, potatoes, sugarbeet, etc.)
Energy Crop	Agricultural crops that are suitable for bioenergy production. These include food crops from starch crops such as maize, sugar-based crops such as sugar cane and oil seed crops such as

	soybean. Non-food crops exclusively grown for bioenergy production are also included in this category, e.g. be grass and woody crops
Crop Production	Total production for food, non-food and feed products (crops)
Livestock	The term "LIVESTOCK" is used in a broad sense to cover all grown animals regardless of age, location or purpose of breeding. Non-domesticated animals are excluded under this definition unless they are kept or raised in captivity. Domestic animals included are large and small quadrupeds, poultry, insects (bees) and larvae of insects (silkworms)
Emission	The production and discharge of something, especially gas or radiation
CH_4	Methane (CH_4), is a gas produced by a group of colonic anaerobes, absorbed from the colon and excreted in expired air
CO_2-AFOLU	CO_2 Emissions related to the Agriculture, Forestry and Other Land use
CO_2-Energy	CO_2 emissions from energy use on supply and demand side
CO_2-Industrial Process	CO_2 emissions in industrial processes
NO_2	Nitrogen Dioxide Emissions
N_2O	Nitrous Oxide Emissions: greenhouse gas emissions from land
Food Demand	All food demand in calories
Crop Food Demand	Crop Food Demand in calories
Livestock Food Demand	Livestock related food demand in calories
GDP	Gross domestic product
MER	Maximizing Economic Recovery
Population	Total Population
Land Cover	The type of surface layer of the specific land area, including vegetation, barren land, open water bodies and artificial surfaces that can be observed in the field and recorded by aerial or satellite remote sensing
Cropland	Total arable land
Energy-Crops Cropland	Cropland dedicated to energy crops
Land Cover Forest	Managed and unmanaged forest area
Land Cover Pasture	Pasture Land
Land Cover Other Land	Other land cover that do not fit in the other categories
Agriculture Price Index	Weighted average price index of non-energy crops and livestock products
Primary Energy Consumption	Total primary energy consumption
Primary Energy Consumption for Biomass	Primary energy consumption of purpose-grown bioenergy crops, crop and forestry residue bioenergy, municipal solid waste bioenergy, traditional biomass

Primary Energy Consumption Coal	Coal primary energy consumption
Primary Energy Consumption Gas	Gas primary energy consumption
Primary Energy Consumption Hydro	Total hydro primary energy consumption
Primary Energy Consumption Nuclear	Nuclear primary energy consumption (direct equivalent, includes electricity, heat and hydrogen production from nuclear energy)
Primary Energy Consumption Oil	Total oil primary energy consumption
Primary Energy Consumption Solar	Total solar primary energy consumption
Primary Energy Consumption Wind	Total wind primary energy consumption
Water Withdrawal	Total Water Withdrawal

SDM Informational Model

This data model is the standard (ISO/TS 17369:2005 - Statistical data and metadata exchange (SDMX), s.f.) used by the ECB to exchange statistical data and metadata with its partners in the European System of Central Banks (ESCB) and other organisations world-wide. It was a key element in the statistical preparations for Monetary Union and has proved both efficient and effective in meeting the ESCB's rapidly evolving statistical requirements. SDMX-ML is now progressively used also in data and metadata exchange.

Considering the glossary provided by the SDMX community (ISO/TS 17369:2005 - Statistical data and metadata exchange (SDMX), s.f.), we consider interesting to include the following terms:

Table 2.11. Terms from SDMX-ML

Term	Description
Accuracy	Closeness of computations or estimates to the unknown exact or true values that the statistics were intended to measure
Age	Length of time that an entity has lived or existed
Component	Structural artefact used to define the structure of a data or metadata set
Concept	Unit of thought created by a unique combination of characteristics
Dataset	Organised collection of data defined by a Data Structure Definition (DSD)
Policy	Policy aimed at ensuring the transparency of disseminated data, whereby preliminary data are compiled that are later revised
Economic Activity	Combination of actions that result in the production, distribution and consumption of goods or services
Institutional Mandate	Set of rules or other formal set of instructions assigning responsibility as well as the authority to an organisation for the collection, processing, and dissemination of statistics

Price Adjustment	Statistical technique used to remove the effects of price influences operating on a data series
SDMX-EDI	UN/EDIFACT format for exchange of SDMX-structured data and metadata for time series
SDMX_IM	Conceptual model for defining and describing the classes, attributes, and relationships of the SDMX standard

SIM4NEXUS initial data model

The SIM4NEXUS Datamodel corresponds to a powerBI deployment used in the Athens demo-site to collect and serve the information to the data models. The terms here presented do not corresponds with any standard vocabulary. However, the defined variables are the ones collected from the thematic models and being available through the naming convention tool. This system is dealing with the following terms:

Table 2.12. SIM4NEXUS initial data model

Term	Description
Agriculture	Includes all variables related to agriculture data models. This entity of the data model covers (model scenario relationship, total demand/production, applied region, product, objective and applied models). The model scenario is represented by a set of variables from the thematic model
Energy	The energy entity includes models and model scenarios related to energy. In this case, main variables refer to consumption, generation capacity, levelized costs, price of energy, primary production, secondary production and the corresponding supply investments
Model scenario	The model scenario is defined by the corresponding data source, the file name, validity of the data set and transaction time
Production	Similarly as previous entities, these entities cover the model scenario and the involved models. In relation to the variables, it covers the product, Price and volume
Trade	This entity refers to the trade information of the regions. It includes the product, the region, the models, exports, imports and the corresponding scenarios

2.1.1.7. Phase1.7 Initial Glossary of Terms

With regards the Glossary of Terms, we are intended to incorporate information form the semantic models and the non-semantic models. With regards the semantic models, the tentative vocabulary to incorporate refers to the following ontologies:

- **WatERP Ontology**: To represent the water domain indicators
- **Agriculture meteorology**: To represent Agriculture, land and climate change indicators
- **Nexus Ontology**: To represent or extend the different domain models to be elaborated
- **GeoSPARQL:** To represent of the geo-spatial information considering the basis of the OGC standards

- **SSN ontology:** To organise the different observations and measurements of the indicators provided by different data sources

For the case of Time and QUDT ontologies we will try to incorporate only minor axioms due to not increment the semantic complexity and representation of the information

In reference to the non-semantic resources, we are going to include the following information:

- **Thematic Models variables:** These variables should be modelled due to they will define how the different nexus components are evolving throughout the game
- **DataSetrvice Information:** Just to make all the vocabulary compatible with this service in order to consume information easily and with minor transformations
- **SDMX Information Model:** In order to model the information regarding the EDI and Thematic models

In parallel, we drafted an initial ontology to represent the different game interactions (Figure 3). Under this initial ontology (data model), the game refers to certain goals to achieve within several case studies. Each of the case studies uses its own SDM, which feeds from Thematic Models, to calculate the corresponding indicators (for policies and related to the state of the different scenarios). The indicators should correspond with the established SIM4NEXUS variables that observes certain region(s). It is also important to note the necessity of tracking each of the state evolution inside each of the scenarios.

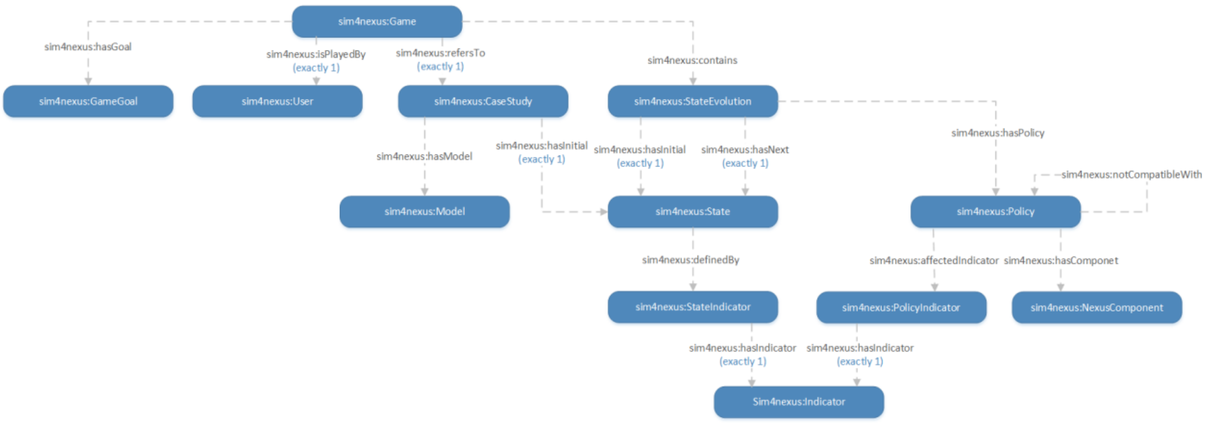


Figure 3. Initial SIM4Nexus Ontology for Game Interaction

The next step in the ontology development is to consider this glossary of terms and advancements in the game interaction in order to elaborate an initial complete version of the ontology. In order to build the semantic repository, we also need to know and detail the requirements coming from the Knowledge Elicitation Engine (KEE), aspect that we will detail during the next section.

2.2. Information Requirements from KEE

This part of the document is mainly focused on describing the requirements derived from the interaction between the Knowledge Elicitation Engine (KEE) and the Semantic Repository. Concerning this aspect, we will explain main informational needs of the KEE in terms of policies and policy cards in order to obtain information to derive the proper recommendation to the Game User Interface (Game UI). This informational needs also requires for the case-studies context information known as Case Studies metadata (location, population, regions of the case study, etc). Indeed, this information required by the KEE will be also used for the Game UI in order to maximise the user experience and make the game more realistic. Based on that, we will proceed describing the Game User Interface and the KEE in order to derive such informational needs.

Before starting a Game session, a global and interactive map (Figure 4) is presented to the Player to allow the possibility of case-study selection, where the game will focus on. Through this map, the Player can visualize and navigate throughout the different CS to inspect their context information and main characteristics. In this regards, main information displayed are:

Table 2.13. General Information to be displayed at the initialization of the Game UI

Nº	Variable	Description
1	Name	Name of the CS
2	Description	Description of the CS
3	Geolocation	GeoJSON related with each CS
4	Game Goals	Main game goals to achieve to win the game
5	Learning Goals	Main goals to be learnt while playing the game

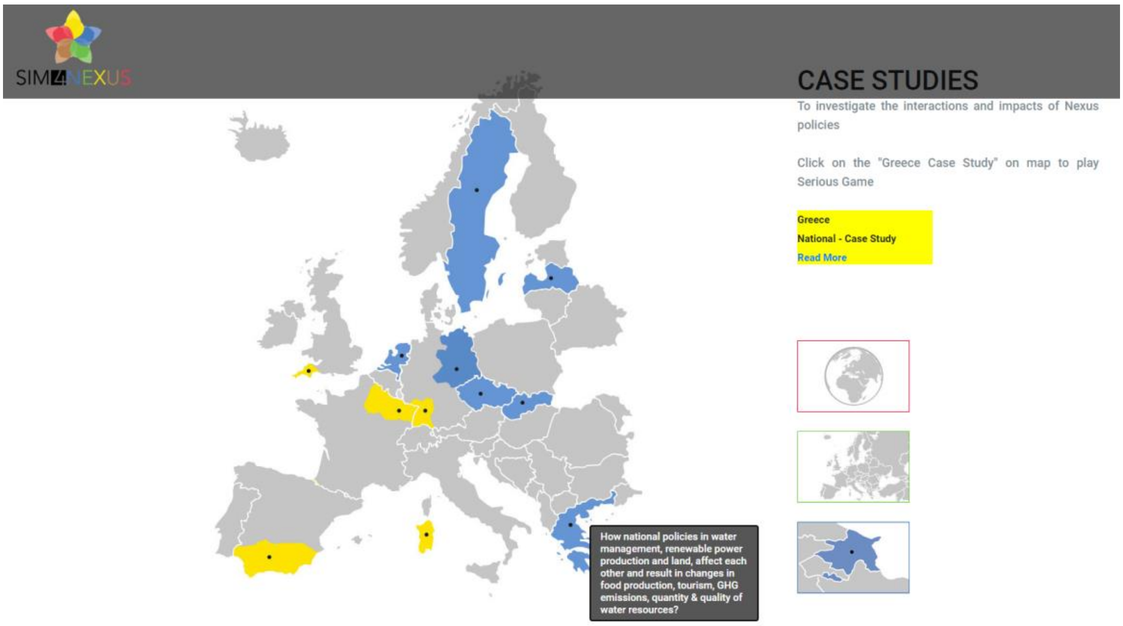


Figure 4. UI Main Map prototype

Once the Case-Study is selected, the game begins at the selected region. At this moment, the information exchanged between the UI and the KEE is the required to initialize a session. In detail, the Game UI requests the KEE all information related to a specific case-study:

Table 2.14. Game information by each Case-Study

Nº	Variable	Description
1	Policy Goals	Information regarding the thresholds, description, name, etc.
2	Policy Objectives	Information related to the policy objectives consecution in terms of weights

3	Policy Cards or Instruments	Information related to the instruments available to reach the policy objectives categorized by Nexus and including the cost of implementation and the percentages of improvement in the Nexus

This information presented in Table 2.14 represents the core of the SIM4NEXUS Game Logic in order to define the game scenarios and timeline of the actions implemented when a user interacts with the scenarios by means of implementing instruments (e.g. installation of smart pumps to improve efficiency in irrigation) in the presented case-studies. In the middle of the user interaction with the game, the SDMs and the Thematic models are used to simulate the impacts and evolution (game steps) of the scenarios considering the implemented policy instruments. This evolution simulates the different years and the policy cards represent the user decision-making to solve a game scenario challenges by means of modifying the Nexus status to achieve the policy objectives and goals.

In this regard, the entire game logic is described in the Figure 5. In this picture, an instrument or policy card (details of the policy card are present in the Section 9 -Annex 1) can contribute to a set of specific policy objectives in or across sectors (water, agriculture, industry, etc). Subsequently, the policy objectives can contribute to one or more policy goals in a different level. This level of contribution is expressed by a specific coefficient between 0 and 1 described upon the arrows in the picture. This coefficient is determined as a part of the game definition. As a result, we obtain a policy indicator as the sum of the weighted policy objectives and calculated between the KEE and the models (SDMs and thematic models) when the user interacts with the different presented scenarios.

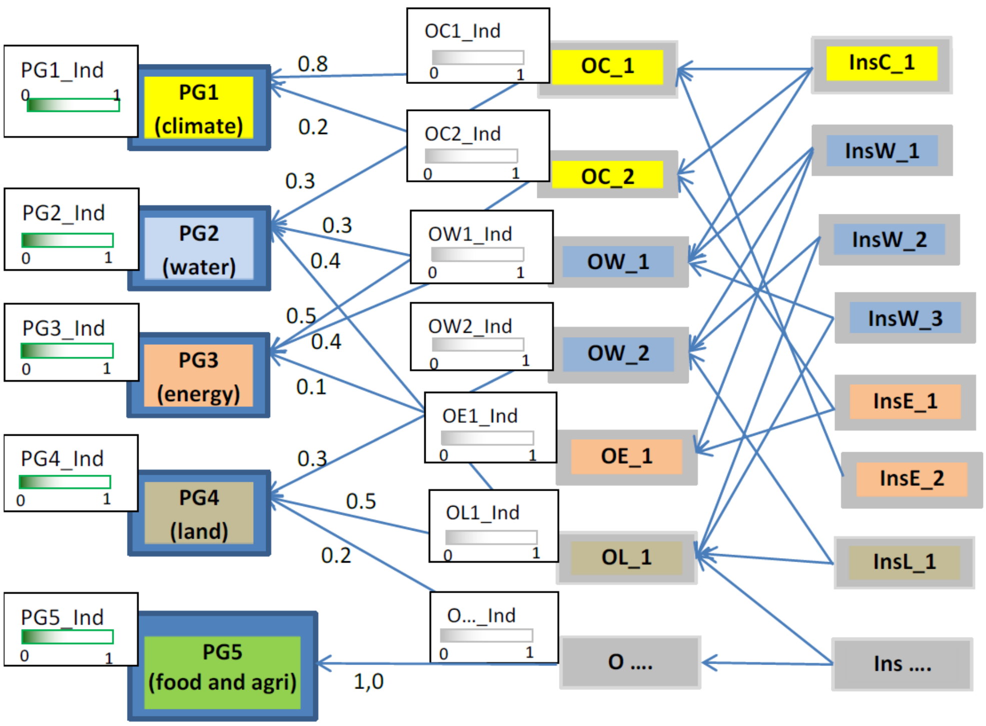


Figure 5. Policy Goals, Policy Objectives and Policy Cards logic

During the interaction and calculation of the mentioned indicators, the corresponding SDMs requires the initial information of the CSs to start with the corresponding simulations. The simulations are dependent from the game evolution and the user interaction when playing the game. During the initial and the subsequent simulations, the policies activated during the time periods are the ones considered for the simulation and calculation of the next game scenario. In this procedure, the SR should provide the information to both, the KEE and the Game UI in order to perform the simulations and also, to display the required information.

In detail, the SR should provide the information about the policies cards and policy goals. In terms of the policy cards, Figure 6 represents the interface used in the game that should be filled with the following information:

Table 2.15. Overall information about the policy cards

Nº	Variable	Description
1	Name	Name of the policy cards
2	Description	Description of the policy card
3	Policy Duration	Duration of the policy
4	Activation Time	Time required to implement a policy
5	Social Acceptance	Represent the amount of social acceptance required in order to implement a policy from the player's perspective
6	Token Capital	Represent some virtual amount of money required in order to implement a policy from the player's perspective

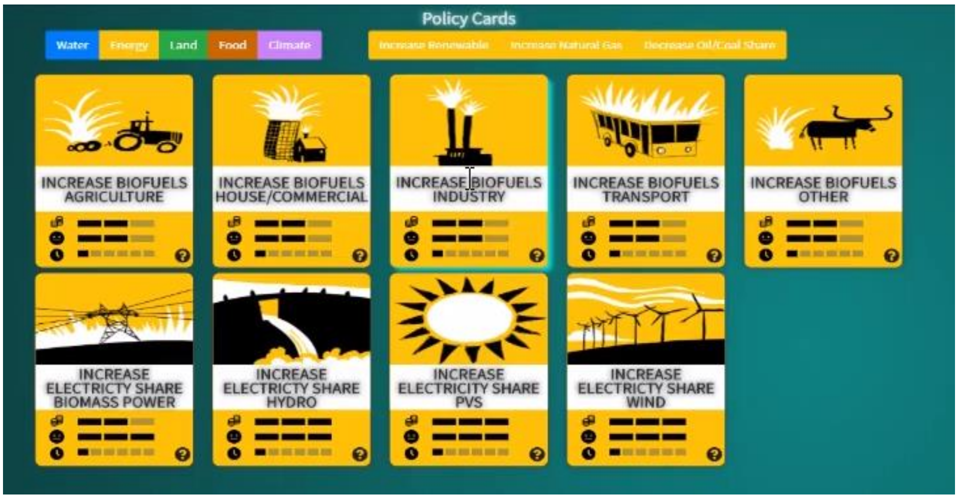


Figure 6. Policy Cards prototype interface

Similarly, Policy Goals and Policy Objectives are shown in a specific visualization screen in the Game UI (Figure 7). Under this visualization, the main information to be displayed corresponds to the different scores by nexus category including a description, image and score indicator.

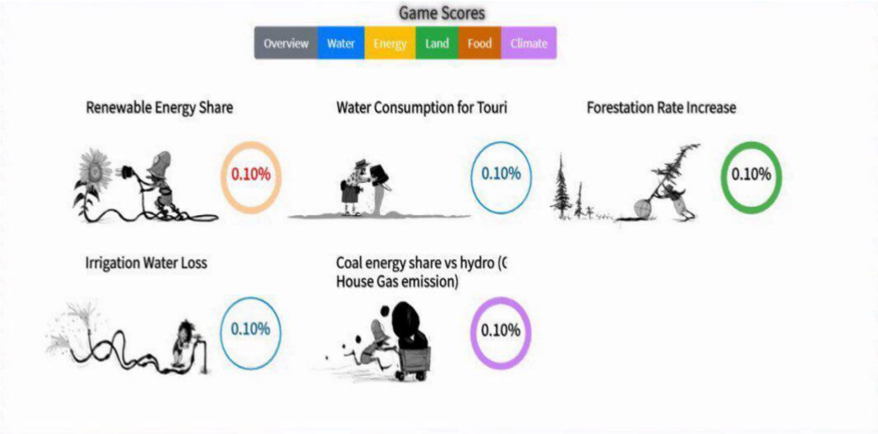


Figure 7 Policy Goals and Policy Objectives prototype interface

Considering the information shown, the required information needs to represent the policies goals are:

Table 2.16. Informational representation of the policy goals

Nº	Variable	Description
1	Name	Name of the policy card
2	Description	Description of the policy card
3	Nexus Category	Category(ies) of the Nexus associated to the goal
4	Indicators	Variables that represent the scores of the game scenario

As a conclusion, all information represented in the interaction between the KEE and the Game UI should be feed by the semantic repository. Thus, the ontology has to model such information in the data model. Subsequently, the semantic repository tool has to populate the ontology with the corresponding information.

2.3. Case-Studies Requirements

In this section, we will discuss the informational requirements coming from the representation of the variables and information of each of the case studies. The information we describe here is used by the SDMs and the Thematic Models to perform the simulation, the KEE to collect and calculate the gaming scenarios and the Game UI to visualise variables and evolution of the indicators during the game session.

As it is already known, the SIM4NEXUS project is implemented in 12 case studies (Table 2.17) that represent various Nexus components contrasting attributes such as biophysical, socio-economic and policy ones. At the end of the 2nd year of the Project (Month 24 - May 2018) data was collected for all the case studies and the process of publishing that information comprises the setup and population of the semantic repository. An analytical **Catalogue** of all the datasets collected/generated along with their metadata, was collected and presented.

However, we noticed there exist lack of data and naming convention harmonization for the variables involved in each of the demo-sites. For this reason, we decided to analyse the provided data and variables in order to build a tool capable of harmonising data variable names and then, facilitate the development of the different models. For this main reason, here we present data requirements from the demo sites as twofold objectives: (i) identify the requirements for the elaboration of the naming convention tool; and (ii) populate the semantic repository tool.

Table 2.17 . SIM4NEXUS Case studies

#	LEVEL	CASE STUDY
1	*REGIONAL*	Region of Andalusia
2		Island of Sardinia
3		SouthWest of the UK
4	*NATIONAL*	The Netherlands
5		Sweden
6		Greece
7		Latvia
8		Azerbaijan
9	*TRANSBOUNDARY*	France-Germany
10		Eastern part of Germany, Czech Republic and Slovakia
11	*HIGHER*	Europe
12		Global

2.3.1. Sardinia Climate Data

Table 2.18 summarizes the monthly climate data (historical or scenarios) that are collected for various time ranges and from various model resources (**Data Provider**: *PIK*, **data format**: *.dat).*

Table 2.18. Climate Data collected/generated for Sardinia case study

<table>
<tr><th>Climate Data</th><th colspan="2">Time Range</th><th>Scenario Models</th></tr>
<tr><td>Daily and monthly precipitation (mm/d)</td><td rowspan="4">1961-2004

2005-2099</td><td rowspan="4">Historical

RCP2P6
RCP4P5
RCP6P0
RCP8P5</td><td rowspan="4">GFDL-ESM2M
IPSL-CM5A-LR
HadGEM2-ES
MIROC-ESM-CHEM
NorESM1-M</td></tr>
<tr><td>Daily and monthly relative humidity (%), 2m above ground</td></tr>
<tr><td>Daily and monthly long-wave downward solar radiation at the ground (W/m²)</td></tr>
<tr><td>Daily and monthly short-wave downward solar radiation at the ground (W/m²)</td></tr>
</table>

Daily and monthly average air temperature 2m above ground (°*C*)			
Daily and monthly maximum air temperature (°*C*)			
Daily and monthly minimum air temperature (°*C*)			
Daily and monthly wind speed at 10m height (*m/s*)			

2.3.2. CAPRI MODEL – Data Categories

Data **Categories** obtained from CAPRI for Baseline 2010 and 2030 (RCP 8.5) are summarized in the following tables (Table 2.19 & Table 2.20):

Table 2.19. Data categories in CAPRI, Baseline 2010

Baseline 2010
Water Supply Details: Area, Yield
Biofuel Markets: Biodiesel, Bio-Ethanol
Producer Price /Product
Prices Market: Producer Price (€/Tonne) – Consumer Price (€/Tonne)

Table 2.20. Data Categories in CAPRI, 2030 - RCP 8.5

Baseline 2030 – RCP 8.5
Water Supply Details: Area, Yield
Irrigation Water Use: Total Land, Irrigated Land, Irrigation Water Use (ha, tonne)
Water Supply Details (aggregate): Area, Yield
Biofuel Markets: Bio-Diesel, Bio-Ethanol
Producer Price /Product
Prices Market: Producer Price (€/Tonne) – Consumer Price (€/Tonne)

The data produced by CAPRI for Water Supply Details (baseline 2010, 2030-RCP8.5) are listed in Table 2.21.

Table 2.21. Water Supply Details (area & yield)

WATER SUPPLY DETAILS (Hectares/herd size[ha/hds], Yield [kg, Const EU or 1/1000 head/ha], Supply - [1000 tonnes, 1000 ha or Mio Const EU)		
Utilized agricultural area	Tobacco	Dairy Cows high yield
Cereals	Other industrial crops	Dairy Cows low yield
Oilseeds	Other crops	Other Cows
Other arable crops	Vegetables and Permanent crops	Heifers breeding
Vegetables and Permanent crops	Tomatoes	Heifers fattening high weight
Fodder activities	Other Vegetables	Heifers fattening low weight
Set aside and fallow land	Apples Pears and Peaches	Male adult cattle high weight
All cattle activities	Other Fruits	Male adult cattle low weight
Beef meat activities	Citrus Fruits	Raising male calves
Other animals	Table Grapes	Raising female Calves
Utilized agricultural area	Olives for oil	Fattening male calves
Cereals	Table Olives	Fattening female calves
Soft wheat	Wine	Beef meat activities
Durum wheat	Nurseries	Other Cows
Rye and Meslin	Flowers	Heifers fattening high weight
Barley	Fodder activities	Heifers fattening low weight
Oats	Fodder maize	Male adult cattle high weight
Grain Maize	Fodder root crops	Male adult cattle low weight
Other cereals	Fodder other on arable land	Other animals
Paddy rice	Gras and grazing extensive	Pig fattening
Oilseeds	Gras and grazing intensive	Pig Breeding
Rape	Abandoned grass lands	Milk Ewes and Goat
Sunflower	Set aside and fallow land	Sheep and Goat fattening
Soya	Set-aside obligatory, idling	Laying hens
Other oils	Set-aside obligatory, used as grass land	Poultry fattening
Other arable crops	Set-aside obligatory, tree cover	Other animals
Pulses	Set-aside voluntary	Pasture
Potatoes	Fallow land	Arable land
Sugar Beet	Abandoned arable land	All agricultural activities
Flax and hemp	All cattle activities	

The data produced by CAPRI for Irrigation Water Use (baseline 2010, 2030-RCP8.5) are listed in Table 2.22.

Table 2.22. Irrigation Water Use (area, volume)

IRRIGATION WATER USE Hectares/herd size[ha/hds], Yield [kg, Const EU or 1/1000 head/ha], Supply - [1000 tonnes, 1000 ha or Mio Const EU			
soft wheat	paddy rice	sugar beet	apples pears and peaches
durum wheat	rape	flax and hemp	other fruits

Rye and Meslin	sunflower	tobacco	citrus fruits
barley	soya	other industrial crops	table grapes
oats	other oils	other crops	olives for oil
grain maize	pulses	tomatoes	table olives
other cereals	potatoes	other vegetables	wine

The data produced by CAPRI for Biofuel Markets (baseline 2010, 2030-RCP8.5) are listed in Table 2.23.

Table 2.23. Biofuel Markets

BIOFUEL MARKETS	
Total Biofuel production - [1000 tonnes]	Energy share in total fuel use - [%]
First Generation Biofuels (from Agriculture) - [1000 tonnes]	Energy share in total fuel use of Quota obligation - [%]
Second Generation Biofuels - [1000 tonnes]	Imports - [1000 tonnes]
Biofuels from non-agricultural sources - [1000 tonnes]	Exports - [1000 tonnes]
Biofuel-use by transport sector - [1000 tonnes]	consumer prices - [Euro/tonne]
Biofuel-use by industry - [1000 tonnes]	consumer taxes - [Euro/Tonne]

The data produced by CAPRI for Producer Price (€/tonne) (baseline 2010, 2030-RCP8.5) are listed in Table 2.24.

Table 2.24. Producer Prices

PRODUCER PRICE (€/TONNE)			
All primary agricultural output	Apples pears and peaches	Young heifer output	Heating
Cereals	Table grapes	Young male calf output	Lubricants
Oilseeds	Citrus fruits	Young female calf output	Water
Other arable field crops	Other fruits	Young piglet output	Agricultural Services input
Vegetables and Permanent crops	Olive for oil	Young lamb output	Other input
Coffee, Teas and Cocoa	Table olives	Young chicken output	Dairy products
All other crops	Wine	Manure output	Butter
Fodder	Coffee, Teas and Cocoa	Manure nitrate	Skimmed milk powder
Meat	Coffee	Manure phosphate	Cheese
Other Animal products	Tea	Manure potassium	Fresh milk products
Fish and other aquatic products	Cocoa	Fertiliser	Cream
Young animals	All other crops	Nitrate (N)	Concentrated milk
Manure output	Other oil	Potassium (K2O)	Whole milk powder
Fertiliser	Flax and hemp	Calcium fertiliser	Casein
Feedingstuff	Tobacco	Feedingstuff	Whey powder
Remonte	Other industrial crops	Feed cereals	Oils
Other inputs	Nurseries	Feed rich protein	Rape seed oil
Dairy products	Flowers	Feed rich energy	Sunflower seed oil
Oils	Other crops	Feed from milk product	Soya oil
Oil cakes	Fodder	Feed other	Olive oil

Secondary products	Fodder maize	Fodder maize	Palm oil
All products	Fodder root crops	Fodder root crops	Other oil
All primary agricultural output	Other fodder from arable land	Fodder other on arable land	Oil cakes
Cereals	Straw	Gras	Rape seed cake
Soft wheat	Meat		Sunflowe seed cake
Durum wheat	Beef	Milk for feeding	Soya cake
Rye and meslin	Pork meat	Sheep and Goat Milk for feeding	Olive cakes
Barley	Sheep and goat meat	Remonte	Other cakes
Oats	Poultry meat	Young cow input	Secondary products
Grain maize	Other Animal products	Young bull input	Rice milled
Other cereals	Cow and buffalo milk	Young heifer input	Molasse
Paddy rice	Sheep and goat milk	Young male calf input	Starch
Oilseeds	Raw milk	Young female calf input	Sugar
Rape seed	Eggs	Young piglet input	Bio diesel
Sunflower seed	Milk for feeding	Young lamb input	Bio ethanol
Soya seed	Other animal output	Young chicken input	Distilled dried grains from bio-ethanol processing
Other arable field crops	Fish and other aquatic products	Other inputs	Protein rich by products
Pulses	Fresh water fish	Seed	Energy rich by products
Potatoes	Saltwater fish	Plant protection	Total diesel
Sugar beet	Other aquatic	Pharma. inputs	Agricultural land
Yams, Manioc, Cassava and Other Roots and Tubers	Young animals	Maintenance machinery	Feed energy input
Vegetables and Permanent crops	Young cow output	Maintenance buildings	Total gasoline
Tomatoes	Young bull output	Electricity	Land
Other vegetables	Phosphate (P2O5)	Fuel	

The data produced by CAPRI for Market Prices (€/tonne) (baseline 2010, 2030-RCP8.5) are listed in Table 2.25.

Table 2.25. Market Prices

MARKET PRICE (€/TONNE)			
Cereals	Soya seed	Sheep and goat meat	Palm oil
Oilseeds	Other arable field crops	Poultry meat	Oil cakes
Other arable field crops	Pulses	Other Animal products	Rape seed cake
Vegetables and Permanent crops	Potatoes	Raw milk	Sunflowe seed cake
Coffee, Teas and Cocoa	Yams, Manioc, Cassava and Other Roots and Tubers	Eggs	Soya cake

All other crops	Vegetables and Permanent crops	Fish and other aquatic products	Secondary products
Meat	Tomatoes	Fresh water fish	Rice milled
Other Animal products	Other vegetables	Saltwater fish	Sugar
Fish and other aquatic products	Apples pears and peaches	Other aquatic	Bio diesel
Dairy products	Table grapes	Dairy products	Bio ethanol
Oils	Citrus fruits	Butter	Distilled dried grains from bio-ethanol processing
Oil cakes	Other fruits	Skimmed milk powder	Protein rich by products
Secondary products	Table olives	Cheese	Energy rich by products
All primary agricultural output	Wine	Fresh milk products	Total diesel
Cereals	Coffee, Teas and Cocoa	Cream	Agricultural land
Wheat	Coffee	Concentrated milk	Feed energy input
Rye and meslin	Tea	Whole milk powder	Total gasoline
Barley	Cocoa	Casein	Fat content
Oats	All other crops	Whey powder	Protein content
Grain maize	Flax and hemp	Oils	All non-agricultural goods
Other cereals	Tobacco	Rape seed oil	Sum
Oilseeds	Meat	Sunflower seed oil	
Rape seed	Beef	Soya oil	
Sunflower seed	Pork meat	Olive oil	

2.3.3. E3ME Model – Data Categories

Data Categories along with the pertinent data generated by E3ME are presented in Table 2.26 to Table 2.28:

Table 2.26. Output & Employment by sector. Available for years 2010-2030

OUTPUT BY SECTOR (M €) - EMPLOYMENT BY SECTOR (1K PERSONS)			
1 Crop production	19 Electronics	37 Warehousing	55 Employment activities
2 Forestry	20 Electrical equipment	38 Postal & courier act.	56 Travel agency
3 Fishing	21 Machinery	39 Hotels & catering	57 Security & admin.
4 Coal	22 Motor vehicles	40 Publishing activities	58 Public admin. & def.
5 Oil and Gas	23 Oth. transport equip.	41 Broadcasting & movies	59 Education
6 Other mining	24 Manufacturing nes	42 Telecommunications	60 Human health activ.
7 Food	25 Repair & installation	43 Computer services	61 Residential care
8 Textiles & leather	26 Electricity	44 Financial services	62 Arts & ent activ.
9 Wood & wood prods	27 Gas	45 Insurance	63 Sports activities
10 Paper & paper prods	28 Water supply	46 Auxiliary to finance	64 Membership orgs.
11 Printing	29 Sewerage & waste	47 Real estate	65 Repair hold goods

12 Manufactured fuels	30 Construction	48 Imputed rents	66 Other personal serv.
13 Chemicals nes	31 Sale of cars	49 Legal	67 Households employers
14 Pharmaceuticals	32 Other wholesale	50 Architect & engineer	68 Extraterritorial org.
15 Rubber & plastic	33 Other retail	51 R&D activities	69 Unallocated/Dwellings
16 Non-Met. Min. prods.	34 Land transport	52 Advertising	70 Hydrogen Supply
17 Basic metals	35 Water transport	53 Other professional	
18 Metal products	36 Air transport	54 Rental & leasing	

Table 2.27. CO2 emissions by sector

CO2 EMISSIONS BY SECTOR (THTC)			
1 Power own use & trans.	7 Non-metallics nes	13 Other industry	19 Households
2 O. energy own use & tra	8 Ore-extra. (non-energy)	14 Construction	20 Agriculture
3 Hydrogen production	9 Food	15 Rail transport	21 Fishing
4 Iron & steel	10 Tex.	16 Road transport	22 Other final use
5 Non-ferrous metals	11 Paper & pulp	17 Air transport	23 Non-energy use
6 Chemicals	12 Engineering etc	18 Other transp. serv.	

Table 2.28. Per Sector Energy demand for coal – oil – gas – electricity – heat – biomass - combustible waste

ENERGY DEMAND FOR COAL – OIL – GAS – ELECTRICITY – HEAT – BIOMASS - COMBUSTIBLE WASTE, BY SECTOR (TH TOE)			
1 Power own use & trans.	7 Non-metallics nes	13 Other industry	19 Households
2 O. energy own use & tra	8 Ore-extra. (non-energy)	14 Construction	20 Agriculture
3 Hydrogen production	9 Food	15 Rail transport	21 Fishing
4 Iron & steel	10 Tex.	16 Road transport	22 Other final use
5 Non-ferrous metals	11 Paper & pulp	17 Air transport	23 Non-energy use
6 Chemicals	12 Engineering etc	18 Other transp. serv.	

3. Nexus Ontology: Development and Deployment

This section of the document is mainly devoted to the development and deployment of the SIM4NEXUS ontology. The work that comprise the development of the ontology focuses on the design of the ontology and the subsequent implementation in OWL format (Section 3.1). Complementing the development, we also deployed the ontology for further reuse of the community. The deployment comprises the ontology documentation and publication under the SIM4NEXUS repositories (Section 3.2).

3.1. Ontology Design and Development

Considering the main requirements widely covered in the Section 2, we analysed such information in order to build a common ontology to represent all involved information like policy cards, policy objectives, case-study context information, involved variables in the models, game interaction information, etc. The main advancement and innovation of the ontology relies on the linkage between the nexus variables and instruments with specific policies and goals. The elaborated ontology supposes an advancement in **the interrelation of the nexus variables under a common instrument (policy) that affects case-study variables with a corresponding impact (indicator). This interrelation between cross-domain variables serves to demonstrate the affection of nexus in policy at long-term situations**.

Focusing on the development, the ontology has been codified in OWL format. The development covered the definition of classes, properties and constraints. In detail, the classes correspond to main entities of our data model (ex. CaseStudies, Policy, etc). The properties refer to the main features of the entities (e.g. name, id, description) or even interrelation between entities (e.g. 'contributesTo', 'indicators', etc.).
The constraints serve to categorise automatically information inside the semantic repository using the reasoner engine. A simple example is the categorization as a Policy of all "Things" that contains as a property "contributesTo" a certain policy objective. Considering this simple example, the constraint permits us to have a robust data model during time.

Technically, the ontology is presented in the Figure 11. This model has been used in the documentation (Section 3.2) in order to graphically understand the model and the interrelation between the defined nexus variables and instruments. The main part of the ontology is focused on the interrelation of the case-studies with the policies, policy goals, and policy objectives (Figure 8). With this regard, the case studies are formed by several regions where the actions are performed. Each of the case studies have defined learning goals, that means, the envisioned aspects to be learnt while playing the game. Moreover, the case studies also contain policies goals defined as the main states to be reached at the end of the game (e.g. Demand reduction in X%). To achieve these objectives, there are defined several policy objectives (e.g. Water Saving in households) that impacts positively or negatively in the consecution of the policy goals. The policy objectives are related to cross-domain indicators. To reach those policy objectives, instruments are implemented in the case studies, like for example "installation of next generation of smart meters".

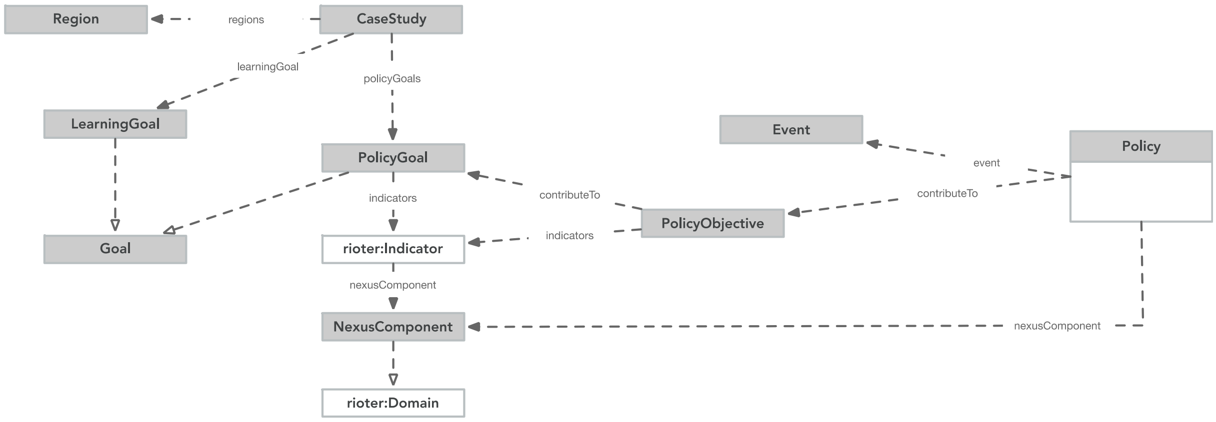


Figure 8. Case Study interrelation with the policies

Moreover, the ontology also has the capability to represent the variables (indicators) involved in the policy-making actions (Figure 9). For the representation of indicators and variables (measurements), we extended SAREF ontology with the corresponding dimension of the variables through indexes. The indexes represent temporal, spatial and other relevant categories defined for the case-studies variables. The representation of the measurements follows up the “Observation and Measurement” pattern (Cox, 2013) in which a measurement is contextualized through the phenomena observed and the element in charge of the measure and the corresponding place in which this variable is obtained.

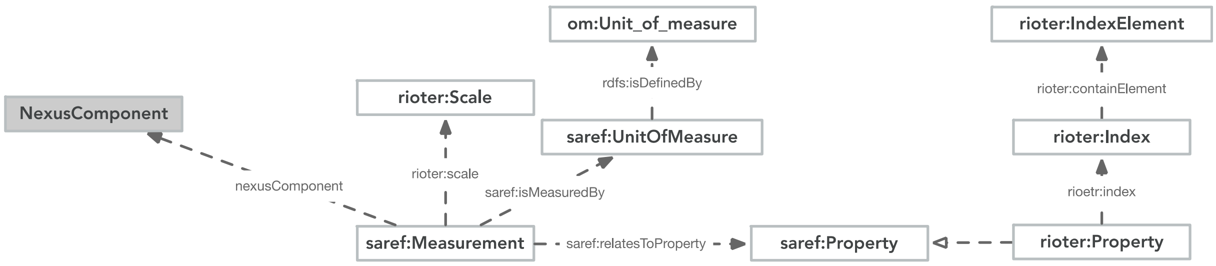


Figure 9. Indicators and Measurements representation in the ontology

Another relevant aspect of the ontology is the alignment of the models (SDM and Thematic Models) with the case-studies (Figure 10). This aspect permits the SIM4NEXUS game to understand which models are involved in each demo-case, the interrelation between the models and also the inputs and outputs corresponding with each model.

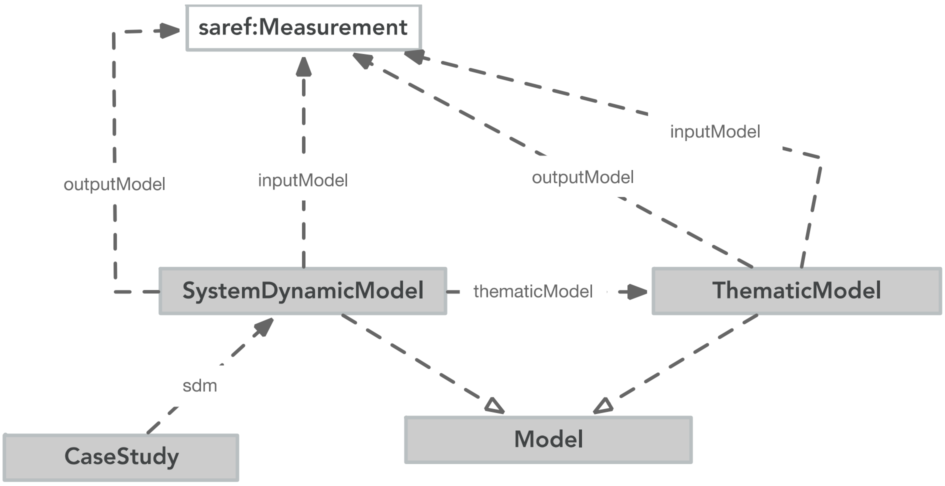


Figure 10. Case-Study models and their relationship with measurements

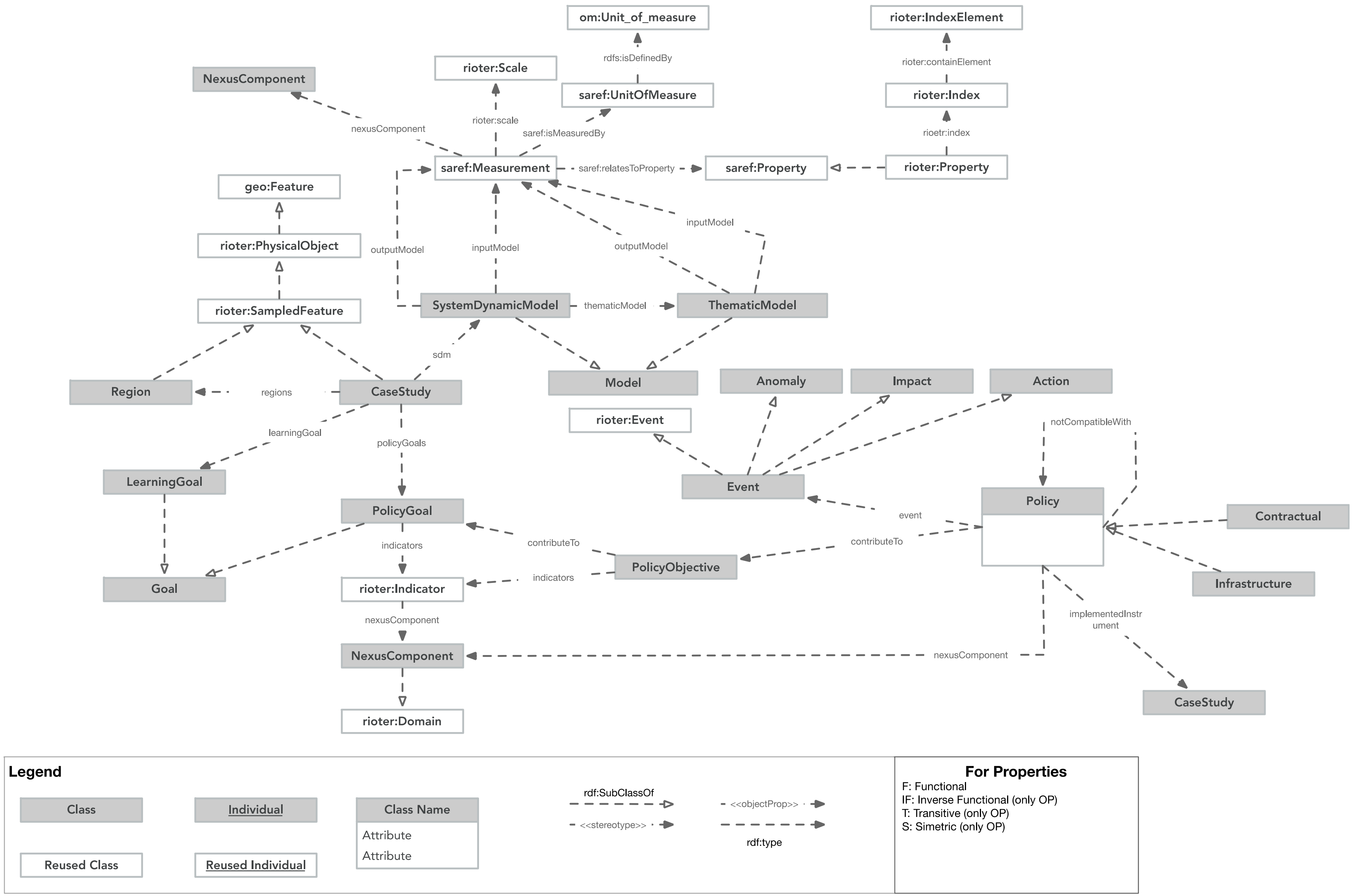


Figure 11. SIM4NEXUS ontology

3.2. Ontology Deployment and Publication

Once the ontology has been developed, the next step is focused on documenting and publishing the ontology for its reuse by the community. The final version and documentation of the ontology can be found in the following link:

http://seriousgame.sim4nexus.eu/ontology

The documentation of the ontology has been performed by using an external tool called WIDOCO[6]. This tool permits to generate automatically the documentation of the ontology based on the labels defined in the semantic model (Figure 12), hence, during ontology development.

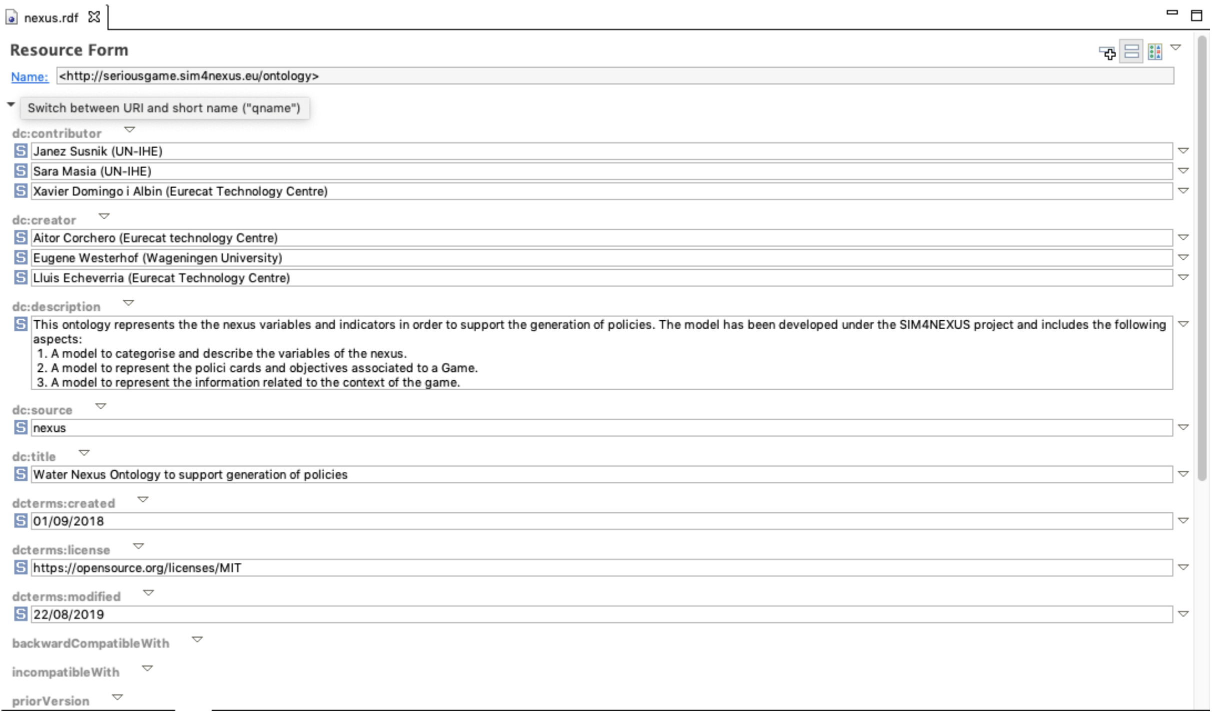


Figure 12. Annotation performed in the SIM4NEXUS ontology

Considering this aspect, the main annotations used in the ontology development for documentation purposes are:

Table 3.1. Description of the used annotations

Annotation	Description
Dc:contributor	Definition of the contributors of the ontology
Dc: creator	Definition of the creators of the ontology
Dc: description	Description of the ontology (indicating main purpose)
Dc:source	Tags of the ontology
Dc:title	Title of the ontology

[6] WiDOCO webpage: https://zenodo.org/record/2576182#.XV6ORy2B1TY

Dc:created	Date of creation
Dcterms:license	Licence determined for the ontology
Dcterms:modified	Date of the last modification
versionInfo	Version of the ontology
Comment	Description of the main entities and classes
label	Human readable label for the classes and the properties (optional)

Once the ontology annotated, the second step has been to launch the tool and use the ontology as a template for generate the documentation. This task is quite simple due to is mainly focused on following up a wizard offered by WIDOCO (Figure 13).

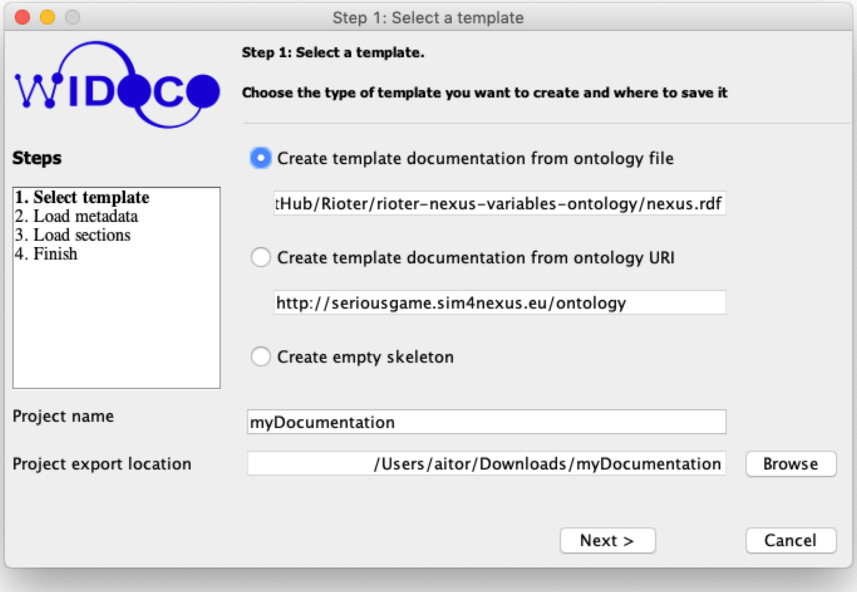


Figure 13. Widoco tool for documenting SIM4NEXUS ontology

At the end of this process, we have the ontology developed using a W3C template as main structure of the document (Figure 14). Under this generated documentation, we filled the introduction section in order to make a full description of the purpose of the ontology. Moreover, we also defined the header and footer of the webpage in order to accomplish with the EU dissemination rules of the H2020 projects and also the introduction of the SIM4NEXUS logo in the header of the documentation.

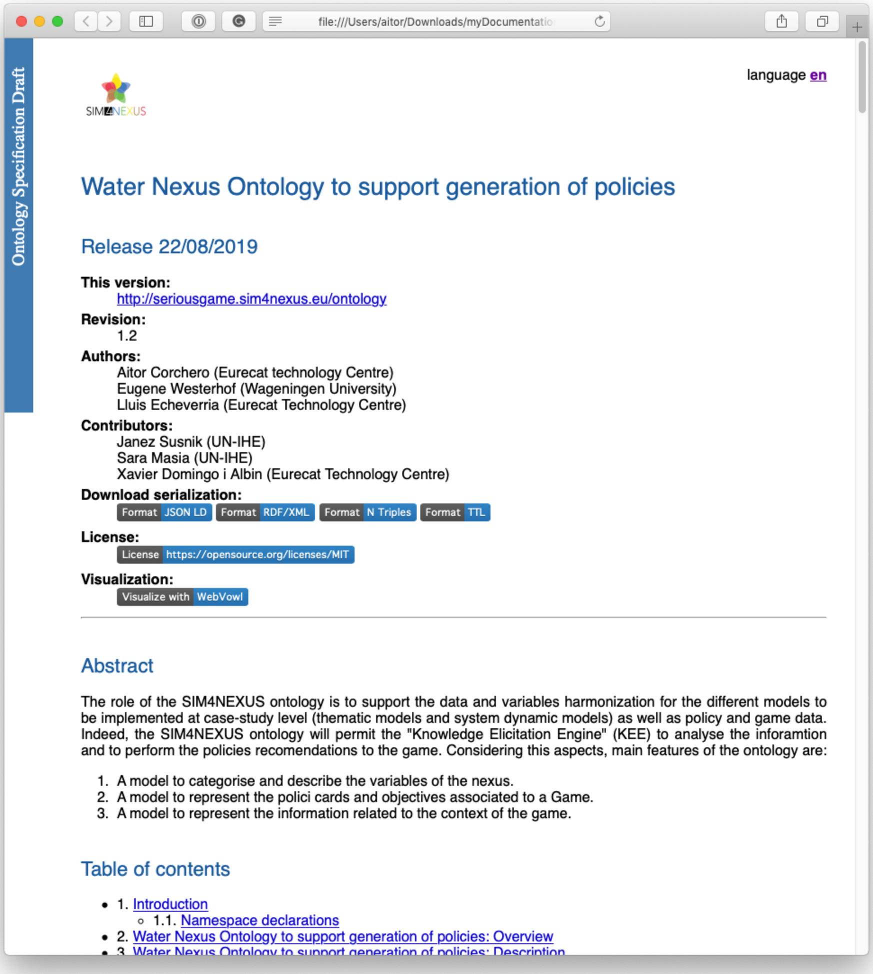


Figure 14. Documentation of the SIM4NEXUS Ontology

As a conclusion of this section, we have accomplished all ontology lifecycle from the inception of the ontology towards their publication for further reuse. At this point it is important to mention that the ontology will be evolved and slightly modified according to the KEE and Game UI requirements that could appear from now until the end of the project.

4. Naming Convention Tool

The initial part of the document has been devoted to the design and development of the SIM4NEXUS ontology. This insight permits us to model all information around the nexus variables and their corresponding ecosystem. Considering the ontology as a base for representing the information, this section is aimed at describing the implementation of the **Naming Convention Tool**.

The naming convention tool has been constructed to **manage and homogenise the case-study variables used for the system dynamic models and the thematic models**. During the collection of the variables for each case-study, we noticed that all variables were named differently in some case-studies even if their meaning was the same. On the other way around, we also noticed variables with the same name but with different meaning. As an example, we noticed "agricultural production" were expressed in physical terms (e.g. tonnes) and in monetary terms (e.g. euro). These aspects hinders the elaboration of the models at cross-case-study due to the complexity and efforts required for the mapping between models' variables and the case studies' variables. This aspect also highlighted the complexity about determining the missing information to build reliable system dynamic models for all case studies.

Based on that, we decided to build a web-based tool to harmonise the name of the variables. For that, we have created a catalogue of variables and a data exploration tool to make easier a common vision about the available variables and their associated meaning at both sides, the system dynamic and thematic models and the case-study variables.

The presented web-based tool is in continuous use and the subsequent information is continuously updated with the nexus variables used in the game. The tool and the subsequent information are publicly available at the following link:

http://seriousgame.sim4nexus.eu/namingConvention

During this section, we are going to detail the implementation and features of the naming convention tool. Thus, the Section 4.1 will provide an overall overview of the architecture. Moreover, implementation details about the Naming Convention Tool can be found in the Section 4.2.

4.1. Architecture

The naming convention tool is the part of the sematic repository focused on representing the different variables to be considered in the thematic and case study models (Figure 15). As shown in the image, the naming convention tool is mainly formed by three components: (i) the front-end or visualization engine; (ii) the backend or REST service API; and (iii) the data lake or set of databases to store the relevant information.

The interaction with the naming convention tool is made through the frontend and specifically with the **visualization environment** (HTTP visualization). This part of the tool permits to navigate through the different variables and nexus categories. During such navigation, the visualization environment deal with the **visualization routes** module in order to display the different pages requested by the user. Indeed, the visualization routes module ask for information to the **Service Manager** that subsequently request this information to the backend module. At this point, the backend intercepts the request through the REST API and communicates to the **REST controller** the petitions. The REST controller performs the petitions and translate them into JavaScript queries (MongoDB Wrapper) or SPARQL (SPARQLWrapper) depending if the information queried, generated, modified or removed is located in the semantic database (Jena) or the non-structured database (MongoDB). Once the information is collected by the corresponding wrapper, the information flow returns to the visualization environment in the other way around until displayed in the HTML.

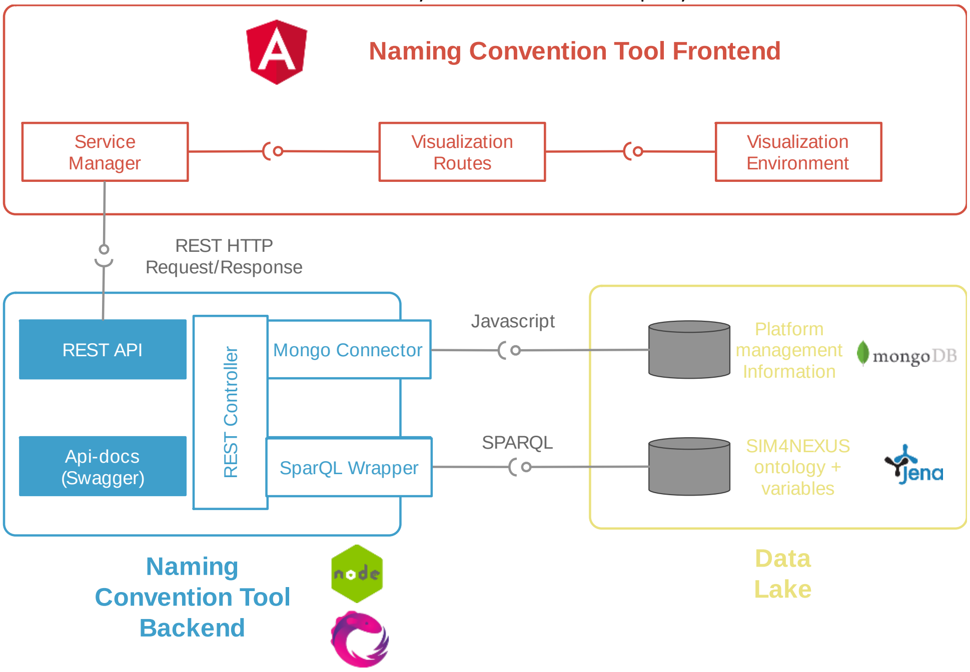


Figure 15. Naming Convention Tool Architecture

Technically, the **front-end component** (http://seriousgame.sim4nexus.eu/namingConvention) corresponds to a visualization and data exploration component. This front-end has been built on Angular, combining HTML5, JavaScript and CSS3, using responsive design. Therefore, this front-end component enables a visualization for both, desktop and mobile devices. It will actuate as a variable catalogue to find variables considering their nexus component. This front-end is composed by a public and private part. The public part mainly enables to show variables information and filtering. Moreover, this public part also permits to visualise the variables according to their name, description, concept, symbol, unit and different indexes that uniquely represents the variable. All variables are attached to their creator in order to easy maintain and create a live community to update these variables. On the other hand, the private part is aimed at creating and managing such variables inside the platform. This private part is only for administration purposes and restricted to invited users that in SIM4NEXUS corresponds with the creators of the platform and the responsible for analysing case-studies variables.

The **backend component** is a REST API that permits to manage the variables information to the database (https://seriousgame.sim4nexus.eu/BNamingConvention/semrepo/api). The main aim of this API is to create a community to maintain the variables of the SIM4NEXUS. This backend component has been constructed under Node-Express environment using Rx.js to manage the data streams inside the server. This open API has been finally documented using SWAGGER to enable other systems to consume and push up information.

This environment is complemented by the **data lake component** that corresponds to a MongoDB and Fuseki databases. The MongoDB database is used to store platforms administrative information such as users, user roles in the platform and profiles. Complementing this data store, the Fuseki Datastore is aimed at storing semantically the information in JSON-LinkedData (JSON-LD) format using the directives established in the SIM4NEXUS ontology.

Considering this architecture, we have collected and published nexus variables coming from excel files that contain 11,000 different variables considering all their indexes. To upload all this information into the repository we created a python script to read from the excel files the different variables and indexes, compute the combination of variables with indexes to derive final usable variables and, at the end, upload this information into the repository.

4.2. Implementation

Considering the main architecture described under the Section 4.1, this part of the document is aimed at describing the implementation and demonstration of the Naming Convention Tool. For that, we separated the description between the Backend (Section 4.2.1) and the Frontend (Section 4.2.2).

4.2.1. Backend Implementation of the Naming Convention Tool

As mentioned, the backend server has been implemented in Node.js environment using Express and Rx.js Library for the elaboration of the Open REST API. To facilitate the implementation of this module, we have configured a Typescript environment for the development. Typescript permits us to create efficient JavaScript code at deployment time facilitating also the reduction of undesirable errors. Moreover, we selected mongoose library as ORM for dealing with MongoDB and a custom SPARQLWrapper elaborated in SIM4NEXUS to deal with semantic data stores using HTTP requests and responses. To facilitate the use of the elaborated Open REST API, we introduced Swagger in order to document the API (Figure 16). The purpose of introducing swagger is twofold: (i) to test the API during the development without needing external tools as Postman; and (ii) document the API without requiring extra efforts during the development.

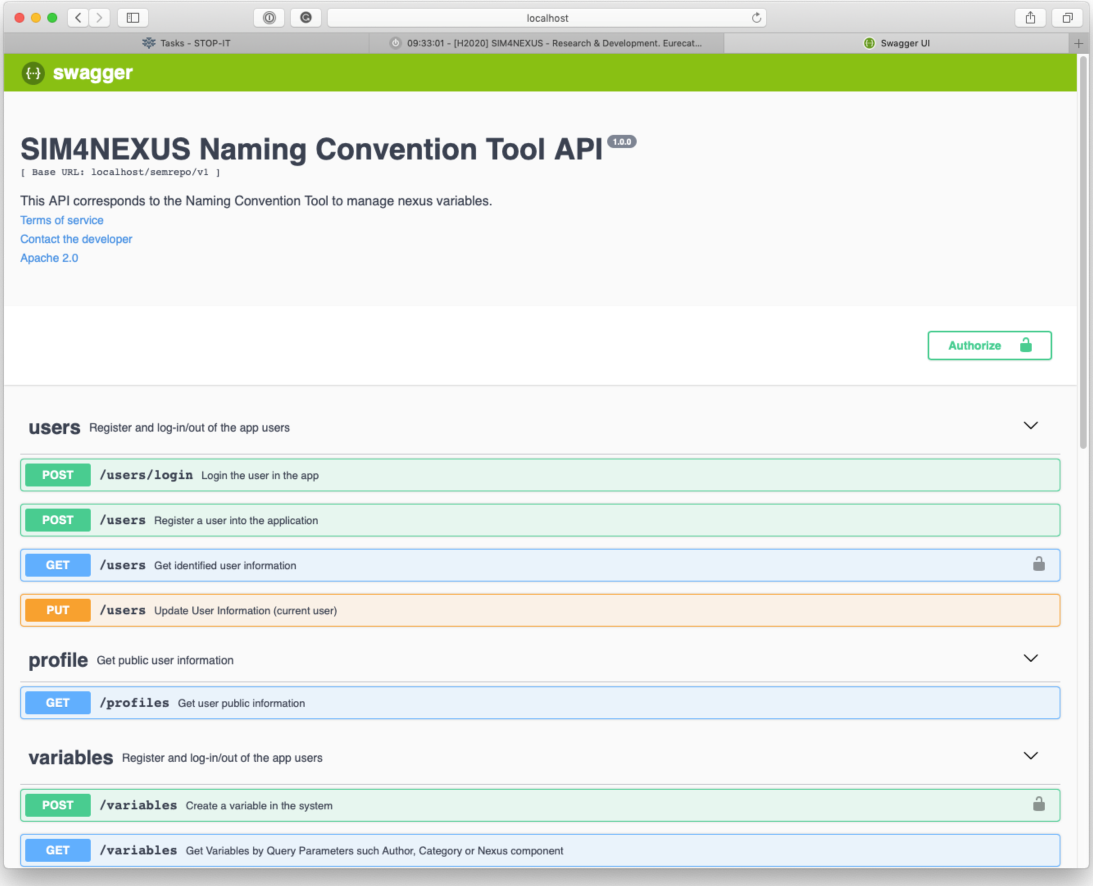


Figure 16. SIM4NEXUS Naming Convention Tool Swagger API

Under this development environment, the Table 4.1 represents the different operations implemented in the backend.

Table 4.1. Operations of the naming Convention Tool backend

Http Route	Operation	Description	Request	Response	Errors
/users/login	POST	Login a user in the platform to get the Token to perform the restricted operations if granted.	UserLogin	User	200, 402
/users	POST	Register a user in the application	UserRegister	User	200
/users	GET	Get information about the logged user in the platform.	--	User	200, 401

/users	PUT	Modify user information in the platform.	User	User	200, 401
/users/{userId}	DELETE	Delete a user from the platform.	--	--	204, 403
/profile/{userId}	GET	Get public information from a user	--	User	200, 401
/variables	POST	Create a variable in the system	Variable	Variable	200, 401
/variable	GET	Get a list of variables depending the query parameters	Author, Nexus Component, Category	Variable []	200, 401
/variable/{varId}	GET	Get a variable by Id	--	Variable	200, 401
/variables/{varId}	PUT	Update the information of a specific variable	Variable	Variable	200, 401
/variables/{varId}	DELETE	Delete a variable using their Id.	--	--	204, 403
/categories	GET	Get all categories attached to the variables	--	Categories[]	200
/nexus	GET	Get all nexus components from the variables	--	NexusComponent []	200

In the application, as we a dealing with personal information, we apply security methods to store and non-disclosure this information. Moreover, we also restricted the sign-in into the platform to an administrator user in charge of providing a fully account (username and password). Thus, we comply with the current legislation in data protection[7].

Considering these main operations, Table 4.2 to Table 4.7 represent the data models used to perform the corresponding queries and responses.

[7] https://edps.europa.eu/sites/edp/files/publication/16-03-21_guidance_isrm_en.pdf

Table 4.2. User Login Data Model

User Login Data Model		
Variable Name	Type	Description
username	String	Username used in the platform
password	string	Selected password

Table 4.3. User Register Data Model

User Register Data Model		
Variable Name	Type	Description
username	String	Username used in the platform
password	string	Selected password
Email	string	Email for the registration

Table 4.4. User Data Model

User Data Model		
Variable Name	Type	Description
name	String	Name of the user
email	string	Email of the user
bio	string	Brief summary of the user
Image	URL	image
token	string	Token used to access the API services

Table 4.5. Variable Data Model

Variable Data Model		
Variable Name	Type	Description
name	String	Name of the user
Description	String	Description of the variable
Category	String[]	Category of the variable
waternexusComponent	String[]	Nexus component associated to the variable
unit	String	Unit of measure of the variable
scale	String	Dimension of the variable
user	String	Author of the variable

Table 4.6. Categories Data Model

Categories Data Model		
Variable Name	Type	Description
categories	String []	List of categories in variables

Table 4.7. Water Nexus Component Data Model

WaternexusComponent Data Model

Variable Name	Type	Description
waternexusComponent	String []	List of nexus component in variables

Similarly, as the data models, the following error codes have been used in the REST API as showed in Table 4.8.

Table 4.8. Error Codes used in the API

REST API Error Codes		
Error Code	Name	Description
200	OK	The request has succeeded. The information returned is the expected ones according to the API.
204	No Content	The server has fulfilled the request but does not need to return an entity-body.
401	Unauthorised	The request requires user authentication.
403	Forbidden	The request was a legal request, but the server is refusing to respond to it.

4.2.2. Frontend Implementation of the Naming Convention Tool

The frontend application of the naming convention tool is the user interface to explore and navigate through the variables. The frontend application is available in the following link:
http://seriousgame.sim4nexus.eu/namingConvention

The main page when visiting the link (Figure 17) corresponds to the visualization of all variables currently available in the application. In detail, this page displays a menu on the top to navigate through the tool. The available options are:

- **Home**. To explore and navigate through the nexus variables.
- **Naming**. To see the naming convention rules established in SIM4NEXUS.

The body of the page is made up by the list of mentioned available variables and the filters that could be applied to search the different variables.

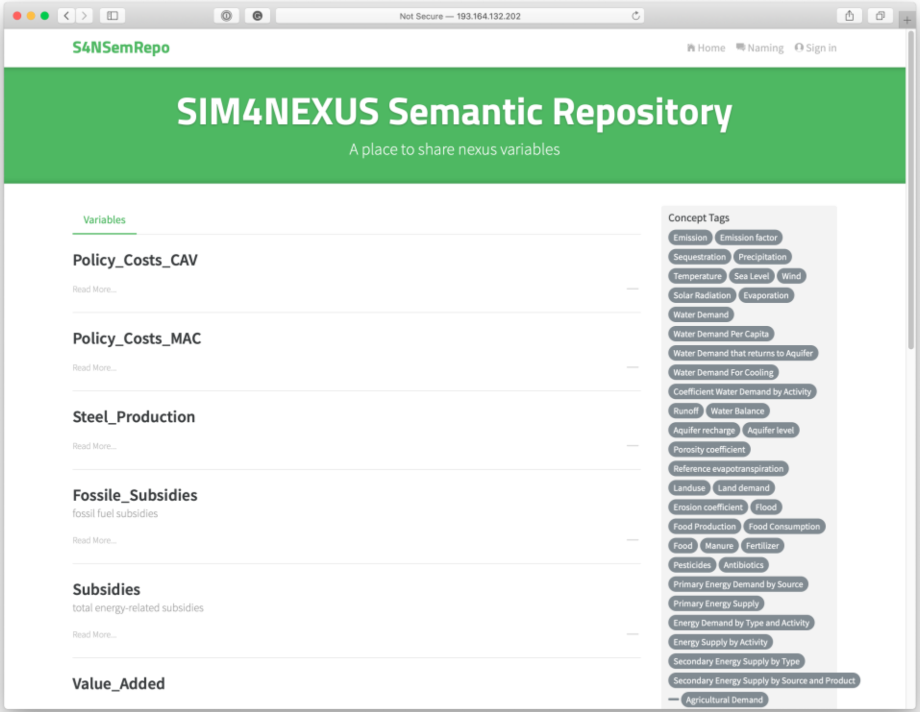


Figure 17. Naming Convention Tool main page

In this main page, the variables can be filtered by <u>*concept type or category of the variable*</u> (e.g. emission, temperature, solar radiation, etc) and water nexus component (e.g. Climate, Water, Land, Food, Energy, etc.). The application of the filters (Figure 18) generates a new tab in the variable list visualization indicating which filter is applied.

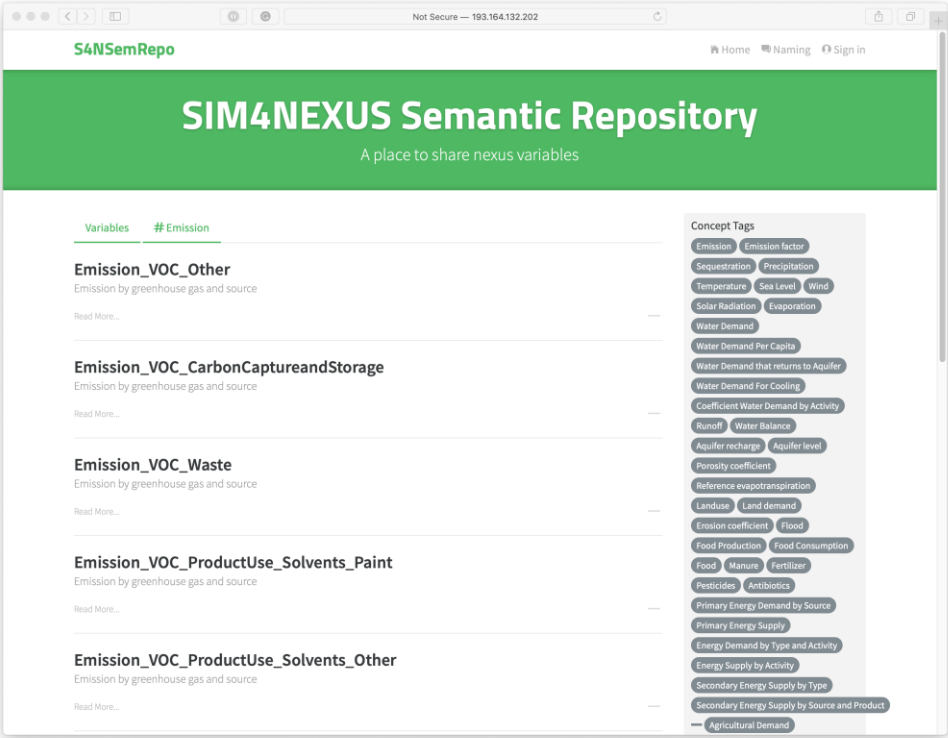


Figure 18. Application of filters inside the variable lists

When a user clicks on a variable, the application redirects us to the variable detail visualization (Figure 19). Under this visualization, the user can see the name of the variable and author on the top part of the page. In the main part of the page, the user can observe the details of the variable that includes the following information:

- Long Name of the variable. Long name of the variable if available
- Description. Description of the variable
- Concept. Main concept associated to the variable
- Symbol. Symbol of the variable used for the models
- Variable Notation. Notation of the variable (aligned also with the mathematical notation of the variables)
- Unit. Units of measure of the variable
- Type of variable. Variable type or category
- Indexes. Associated indexes and scales to the variable
- Nexus. Associated nexus component to the variable

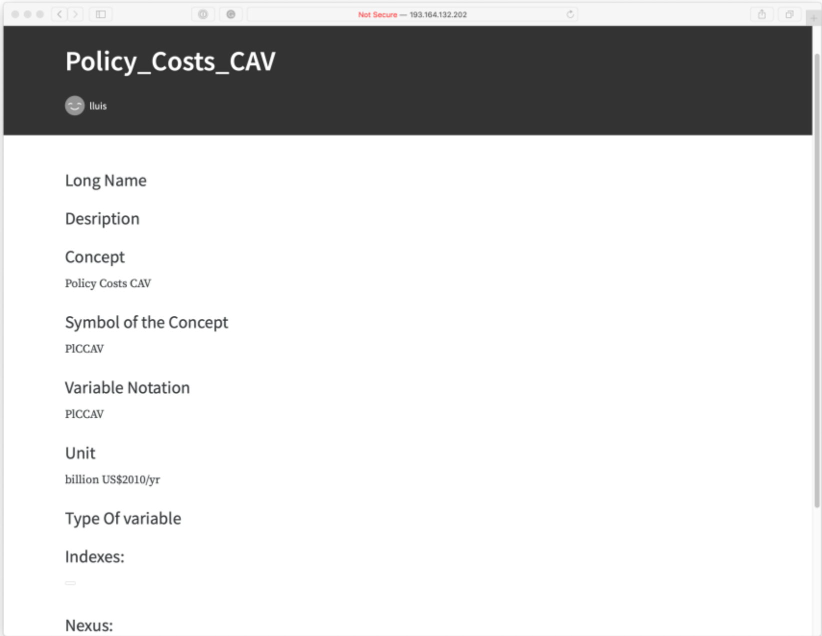


Figure 19. Visualization of the variables detail

The second main part of the visualization environment of the naming convention tool corresponds to the Naming Convention inside SIM4Nexus (Figure 20). This page corresponds to a static HTML page that describes the main variable notation (camel case notation to write variable names) and also includes the correct rules to name the variables. In our case, the only rule is to use a descriptive and understandable variable name according to this syntaxis:

Scale of the variable_Domain of the variable_Property of the variable

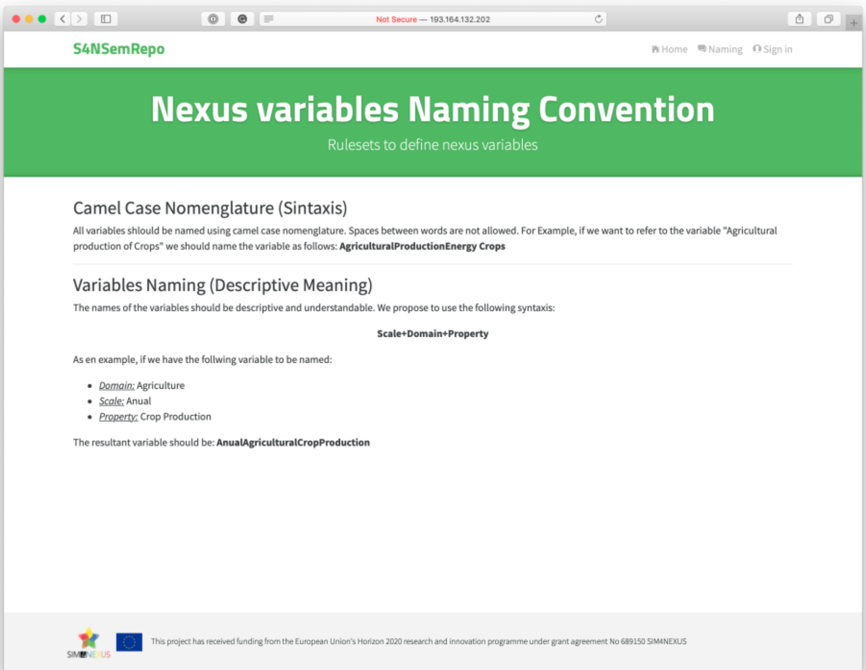


Figure 20. Nexus Variables Naming Convention

5.Semantic Repository

This part of the document is devoted to the Semantic Repository Tool for providing needed mechanism to provide enriched information to the KEE and Game UI. In parallel, the semantic repository tool also actuates as a data exploration of SIM4NEXUS using their semantics to navigate through the information (facet visualization).

The construction of the semantic repository started on M7 with the main purpose of providing the rest of SIM4NEXUS modules with required information using linked data. The semantic repository provides data homogenization and link of the case-studies information. Similarly, as occur with the naming convention, the semantic repository is a web-based tool that permits to explore all information of SIM4NEXUS. At domain level, the semantic repository represents an advance through the publication of an **open catalogue of Nexus information and their linkage with policy**. We mean, the semantic repository offers the community the possibility to **analyse openly the implications of a policy in certain topics (policy objectives) considering the Nexus**. At technology level, main innovation with the semantic repository relies on the data navigation using facets. That means, this tool provides a **navigation through the information using the properties of the defined entities (navigation using the semantics of the information)**.

The presented semantic repository tool is in continuous use and evolvement. The tool and the subsequent information are publicly available at the following link:

http://seriousgame.sim4nexus.eu/semanticRepository

During this section, we are going to detail the architectural stack and implementation details of the semantic repository tool. Thus, the Section 5.1 will provide an overall overview of the architecture. Moreover, implementation details about the Semantic Repository tool can be found in the Section 5.2.

5.1. Architecture

The semantic repository is aimed at providing semantic-enriched and homogenised information to the rest of SIM4NEXUS digital modules like the KEE and the GameUI (Figure 21). The architecture selected for the semantic repository corresponds to a REST architecture composed by: (i) the front-end or visualization engine; (ii) the backend or REST service API; and (iii) semantic data store.

The interaction with the semantic repository tool is similar to the explained for the naming convention tool in Section 5.1. The main difference with the naming convention tool is the introduction of the facet navigator as a module in the front end. The facet navigator permits us to navigate through the ontology using the URIs defined for each entity and property of the ontology and the subsequent instances. Therefore, we get a more natural navigation using JSON-LD serialization of the information. Moreover, in this tool, we only use a semantic data store inside the data lake.

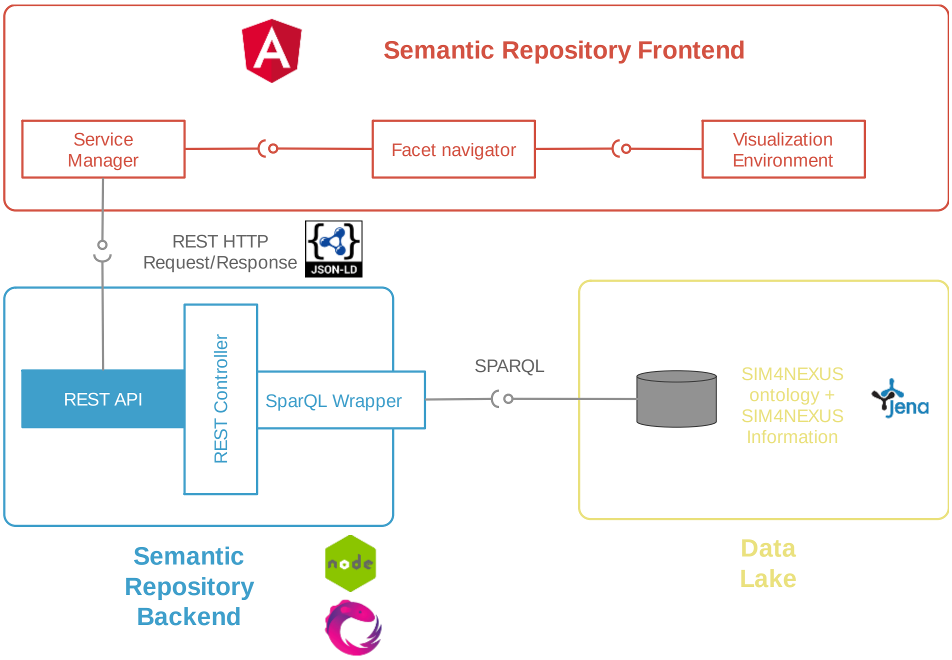


Figure 21. Architecture of the Semantic Repository

Technically, the **front-end component** (http://seriousgame.sim4nexus.eu/semanticRepository) corresponds to the data exploration and navigation tool as a user interface. The front end has been built in Angular framework combining HTML5, JavaScript and CSS3, using responsive design. For the style of the page, we used the Bootstrap library. Taking advantage of the implemented responsive design directives, the application is suitable for being displayed in desktop and mobile devices. This frontend is only composed by a public part that serves to navigate intuitively trough all concepts and information defined in SIM4NEXUS using the URIs of the information as route.

The **backend component** (https://seriousgame.sim4nexus.eu/semanticRepositoryB/s4n) is a REST API that permits to navigate and explore all information defined in SIM4NEXUS. This backend component has been constructed under Node-Express environment using Rx.js to manage the data streams inside the server. Moreover, the backend also uses RDFLib.js library and JSON-LD.js libraries to semantically enrich the information and serialise it in a linked data format.

This environment is complemented by the **data lake component** that corresponds to the Fuseki semantic data store. Fuseki is aimed at storing semantically the information in JSON-LinkedData (JSON-LD) format using the directives established in the SIM4NEXUS ontology. This data store has been selected over other existent link GraphDB or Stardog due to it is fully open source software and do not suppose any conflict of interest neither any impede to exploit in future the generated tool. Moreover, Fuseki do not pose any limitation in the data store in relation to the triples nor the inferences to be generated as GraphDB or Stardog free editions do.

Considering the architecture of the semantic repository, we have populated the semantic repository with the information of all case-studies. The navigation through the subsequent information is dynamic and adequate to the user interface standard response time (load page in less than 2000ms).

5.2. Implementation

Considering the main architecture described under the Section 5.2.1, this part of the document is aimed at describing the implementation and demonstration of the Semantic Repository. For that, we separated the description between the Backend (Section 5.2.1) and the Frontend (Section 5.2.2).

5.2.1. Backend Implementation of the Semantic Repository

As mentioned, the backend server has been implemented in Node.js environment using Express and Rx.js Library for the elaboration of the Open REST API. To facilitate the implementation of this module, we have configured a Typescript environment for the development. Typescript permit us to create efficient JavaScript code at deployment time facilitating also the reduction of undesirable errors. Moreover, we have installed RDFLib.js and JSON-LD libraries to deal with linked data generated by the SPARQL wrapper. As commented in the naming convention tool, this wrapper corresponds to an elaborated library inside SIM4NEXUS to deal with semantic data stores. This library uses HTTP request to encapsulate SPARQL queries (Select, Describe, Construct and Ask) and it gather semantic enriched information using JSON-LD for Describe, Construct queries and json for select queries.

Considering this development environment and architectural stack for the backend, the Table 5.1 represents the different operations implemented in the REST API.

Table 5.1. Semantic Repository backend API

Http Route	Operation	Description	Request	Response	Errors
/{:entity}	GET	Obtain all information regarding an entity	--	JSONLD	200, 401
/	POST	Create an entity into the semantic repository	JSONLD	JSONLD	200, 401
/{:entity}	PUT	Update the information of certain entity in the semantic repository	JSONLD	--	200, 401
/{:entity}	DELETE	Remove an entity for the semantic repository backend.	--	--	204, 403
/class/all	GET	Get all classes from the semantic Repository	--	JSONLD	200, 401
/class/facet	GET	Get all facets from the repository	--	JSONLD	200, 401
/class/{:class}	GET	Get all instances for a certain class	--	JSONLD	200, 401

/class/facet/{:facet}	GET	Get the instances list of a given facet (property)	--	JSONLD	200, 401
/class/{:class}/{:facet}	GET	Get all facets from the instances of a class	--	JSONLD	200, 401

In reference to the data model user to represent the information, the instances have an open data model and for this reason, the REST API cannot bind the information to a specific data model. In case of the ontology classes and facets, the followed data model is the represented in the following tables.

Table 5.2. Ontology Class Data Model

Ontology Class Data Model		
Variable Name	Type	Description
Id	String	Id of the entity that could correspond to an URI or curie
Uri	String	Uri of the entity
Label	String	Specific name of the class
instancesCount	Integer	Number of instances the class have
curie	string	Curie of the entity

Table 5.3.Ontology Facets Data Model

Ontology Class Data Model		
Variable Name	Type	Description
Id	String	Id of the property that could correspond to an URI or curie
Uri	String	URI of the property
Label	String	Name of the property
Range	String	Range values of the property that could be object (if corresponds to an object property) or data type (if corresponds to a data property)
Context	String	Context of the property (URI root)
instances	Integer	Number of instances that uses the property
Timeused	Integer	Number of uses of the property

Similarly, as the data models, the following error codes has been used in the REST API as showed in Table 4.8.

Table 5.4. Error codes used in the Semantic Repository

REST API Error Codes		
Error Code	Name	Description
200	OK	The request has succeeded. The information returned is the expected ones according to the API.

204	No Content	The server has fulfilled the request but does not need to return an entity-body.
401	Unauthorised	The request requires user authentication.
403	Forbidden	The request was a legal request, but the server is refusing to respond to it.

As a conclusion of this section, the elaborated Open API can be used in any semantic repository without changes the front-end neither the backend operations. We only need to configure the newer semantic repository data access (URL of the database). This aspect is an advance in order to enable in the future the access to other linked data repositories related to nexus. Indeed, this tool could integrate several data repositories easily and being a platform to navigate through nexus information.

5.2.2. Frontend Implementation of the Semantic Repository

The frontend application of the semantic repository corresponds to a data exploration tool to navigate through the SIM4NEXUS information. This front-end tool can actuate as an integrator of all Nexus information under a common visual platform. The frontend application is available in the following link:

http://seriousgame.sim4nexus.eu/semanticRepository

The main page visualised when a user enters in the semantic repository corresponds to a list of entities defined in the semantic repository (Figure 22). On the right part of this page is displayed the different facets to filter and navigate through the information.

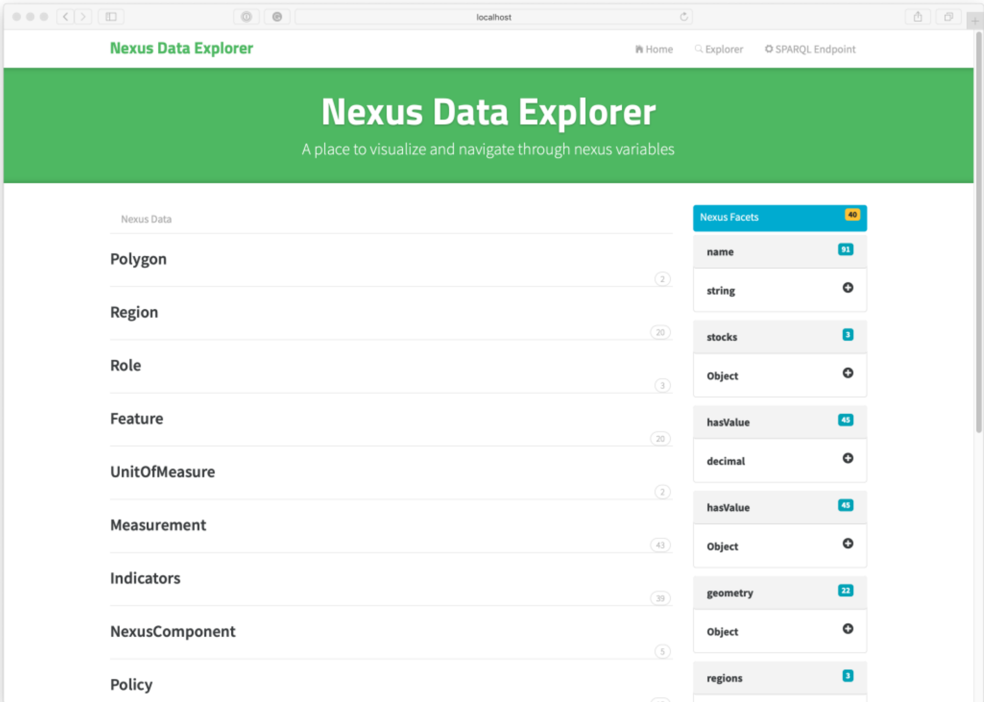


Figure 22. Main page of the semantic repository

Considering the entity list, we can see the name of the different classes (concepts) and the attached number of instances (specific information) that exist for each class. Considering the facets (right part of the screen), the information displayed corresponds to the total number of facets available for the navigation. At page loading time, only 10 most used facets are visualized in order to speed up the page load. For each of the facets, it is shown the name of the facet and the specific type of the property (string, number, object, etc). If the user clicks on the facets, the most used instances are shown (Figure 23).

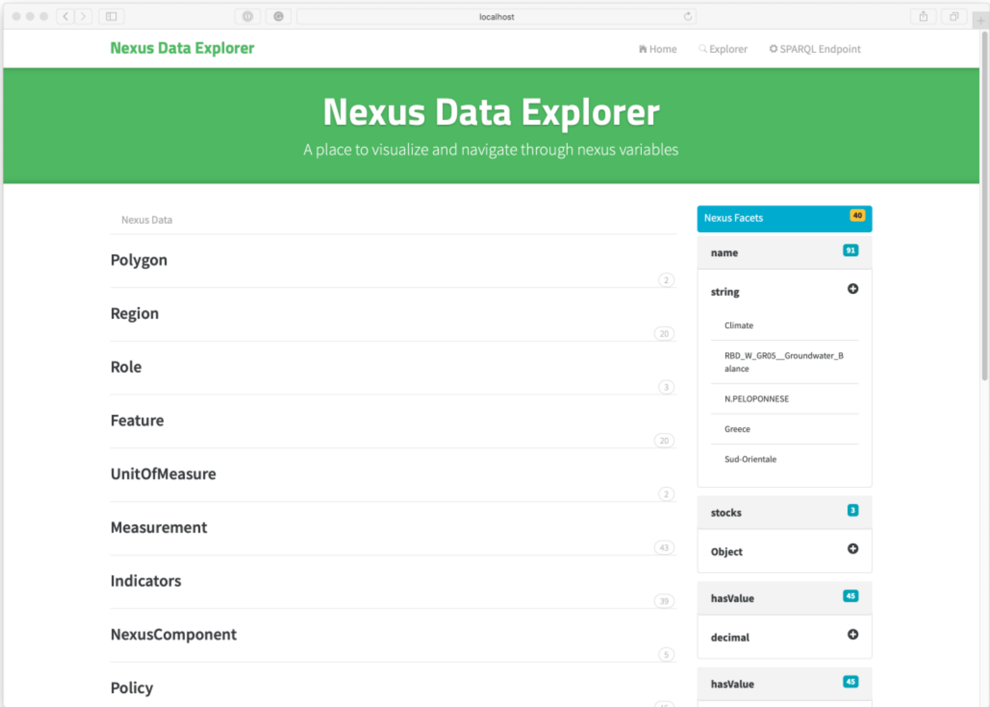


Figure 23. Instance visualization for the facets

If we click on the facets, the classes are filtered considering the information of the facets (restriction over the information using the SPARQL queries) (Figure 24). It is important to mention that the filters (restrictions) actuates as AND clauses for the information due to the front-end and backend service constructs an SPARQL query dynamically with the user interaction.

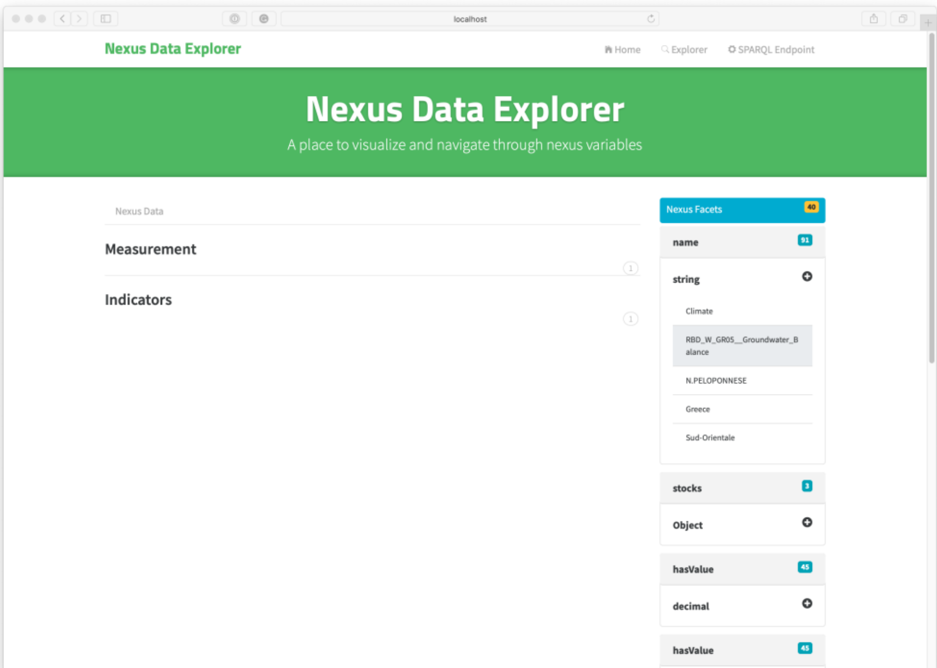


Figure 24. Facet filtering in the sematic repository

When the user clicks on a specific class, the different class instances are displayed on a new visualization screen (Figure 25). Under this new window, all instances are displayed dynamically though navigating into the different properties and corresponding values. Similarly, as the main window, we can filter and navigate through the instances and classes using the different facets.

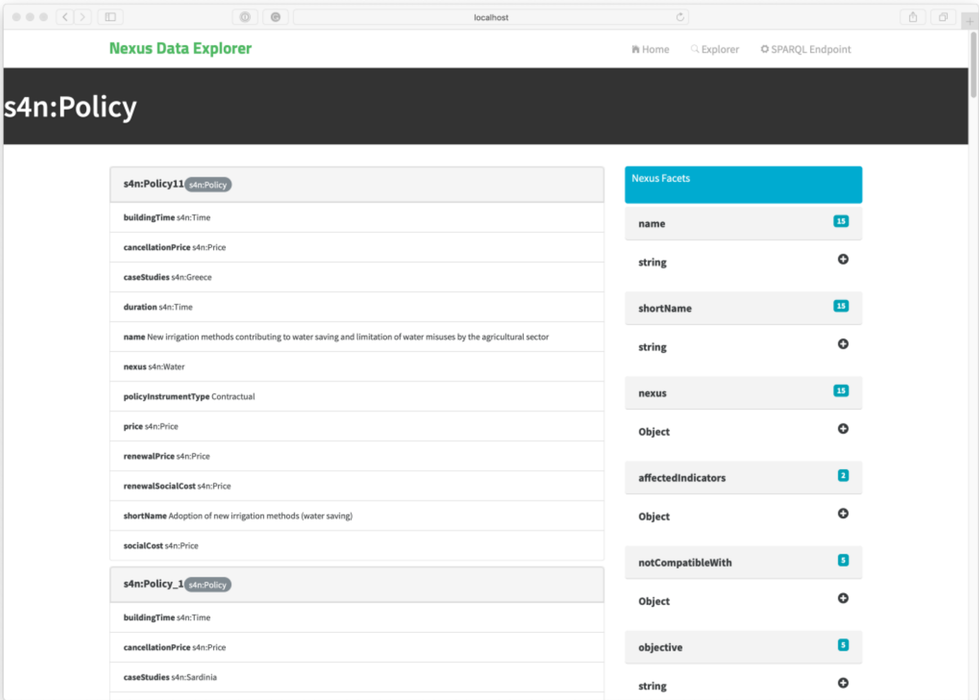


Figure 25. Instances detail for the Policy entity

As a conclusion of this section and similarly as the backend, the elaborated visualization environment permits us to explore the information dynamically and without restricting to any data model. So, this part of the semantic repository could accept the integration of different nexus catalogues without requiring so much effort.

6.Third party's connection and data exchange

The Semantic Repository is available to any software module able to deal with its API. However, in SIM4NEXUS Serios Game, this task is exclusive for the Knowledge Elicitation Engine, which acts as information bus between de Semantic Repository and the other modules.

6.1. Knowledge Elicitation Engine

The Knowledge Elicitation Engine (KEE) implements all the Game logic and persists all the decisions taken by the Players. It is being developed under "Task 4.4 Knowledge Elicitation Engine", in "WP4 Serious Game development and testing". The KEE (Figure 5) includes the Web Service API, the Coordination Module, the Data Access Module, the Game Decision Support System (DSS), the Inference Engine (IE), the analytical engine and the Agent-Based Modelling (ABM). A first version of the Knowledge Elicitation Engine is ready and integrated to the Serious Game. As proof, the Serious Game and the underlying connected KEE, is available and free to play at this URL: http://seriousgame.sim4nexus.eu/.

The main responsibilities for the KEE are:

- Provide the knowledge stored in the Semantic Repository to the Serious Game user interface (scenario setups, available policies, restrictions, etc.)
- Embed, deploy and run the SDM models coming from WP3 considering the current game status and adapting the different parameters accordingly
- Decide when a game is finished (goals accomplishment)
- Provide the contents to be displayed to the user in the Serious Game user interface
- Collect user actions and reactions while facing different scenarios and situations in the game
- Learn from these actions to provide advice also considering knowledge in the Semantic Repository
- Provide virtual players based in agents (ABM)

The current version of the Knowledge Elicitation Engine is connected to the Semantic Repository, and can run SDM models, provide feedback and contents to the graphical user interface, collects user actions and reactions, and provides very simplistic Agent-Based intelligence to simulate virtual players.

6.1.1. Overall Architecture

The Web Service API provides the communication between the SG UI and the KEE, dealing with all the requests and responses. In the following layer, the Coordination Module (KEE core) implements all the Game logic, monitors all the infrastructure status, manages the different modules and load and persist the SG data through the Data Access Module, which defines the communication between the databases and the KEE. The S4N database is composed by a relational database and the Semantic Repository, and it works as a knowledge base, where the CS and generated data is stored following the defined ontology, allowing the Analytical Engine to be able to learn from these data through machine learning algorithms.

The Decision Support System provides recommendations and feedback to users in each step of the SG. And, finally, the Agent-Based Modelling implements intelligent software agents, based on the acquired knowledge.

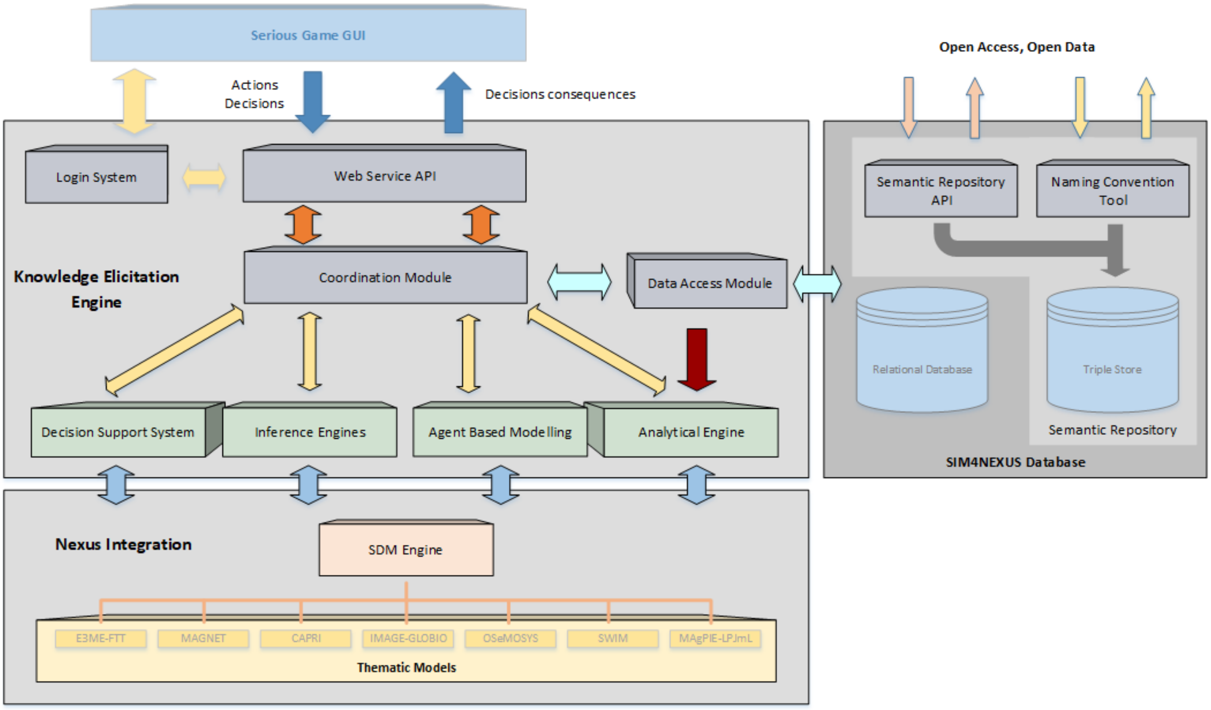


Figure 26. Knowledge Elicitation Engine Architecture

The main modules which have been implemented during this period are the Web Service, the Coordination Module, the Data Access Module, the Semantic Repository (T 4.3.), the Analytical Engine (connected with the SDM Engine) and, in parallel, the Login System, which has not been yet included in the platform.

6.1.2. Data Exchange with the Semantic Repository

The corresponding data exchange between the KEE and the semantic repository is performed through the Data Access Module (KEE) and the implemented Open API (semantic repository) described in the Section 5.2.1. In this section we will explain with example the different operations using Postman in order to demonstrate such integration between systems.

6.1.2.1. Creation of a new Entity in the semantic repository

The creation of a new entity is performed through a POST operation to the "/s4n/" URL. In the body, it is necessary to include a valid JSON-LD with the corresponding information. In our case, we will create several policies into the system as shown in the Figure 27.

none form-data x-www-form-urlencoded raw binary GraphQL BETA JSON (application/json) Beautify


```
{
    "@graph":[
        {
            "@id": "s4n:Policy_1",
            "@type": "s4n:Policy",
            "name": "Foster biodiversity",
            "shortName": "Foster biodiversity",
            "description": "Foster biodiversity conservation and wetland productivity (fisheries)",
            "policyInstrumentType": "Contractual",
            "objective": "Ensure sufficient environmental flow for sustainable environment",
            "nexus": {"@id":"s4n:Water"},
            "notCompatibleWith": [
                {"@id": "s4n:Policy_2"}
            ],
            "contributesTo": [
                {"@id": "s4n:Policy_Obj_1"},
                {"@id": "s4n:Policy_Obj_2"},
                {"@id": "s4n:Policy_Obj_3"}

            ],
            "caseStudies": [
                {"@id": "s4n:Sardinia"}
            ],
            "price": {
                "@id": "s4n:Price",
                "@type": "s4n:Measurement",
                "value": 0,
                "isMeasuredBy": {
                    "@id": "s4n:Euro",
                    "@type": "saref:UnitOfMeasure",
                    "name": "Euro"
                }
            },
            "renewalPrice": {
                "@id": "s4n:Price",
                "@type": "s4n:Measurement",
                "value": 0,
                "isMeasuredBy": {
```


Figure 27. Example of insert Policies in the semantic repository

As a result of the operation, the semantic repository backend returns us the inserted variables into the sematic store (Figure 28).

Pretty Raw Preview JSON


```
{
    "@graph": [
        {
            "@id": "s4n:Policy_1",
            "@type": "s4n:Policy",
            "name": "Foster biodiversity",
            "shortName": "Foster biodiversity",
            "description": "Foster biodiversity conservation and wetland productivity (fisheries)",
            "policyInstrumentType": "Contractual",
            "objective": "Ensure sufficient environmental flow for sustainable environment",
            "nexus": {
                "@id": "s4n:Water"
            },
            "notCompatibleWith": [
                {
                    "@id": "s4n:Policy_2"
                }
            ],
            "contributesTo": [
                {
                    "@id": "s4n:Policy_Obj_1"
                },
                {
                    "@id": "s4n:Policy_Obj_2"
                },
                {
                    "@id": "s4n:Policy_Obj_3"
                }
            ],
            "caseStudies": [
                {
                    "@id": "s4n:Sardinia"
                }
            ],
            "price": {
                "@id": "s4n:Price",
                "@type": "s4n:Measurement",
                "value": 0,
                "isMeasuredBy": {
```


Figure 28. Response of the generation of new Policies in the semantic repository

6.1.2.2. GET Information from a specific Entity

To obtain information from a specific entity, we need to create a GET HTTP method to the "/s4n/{:entity}" route of the semantic repository. As an example, to get the information from the "Policy_1" we need to make the following call:

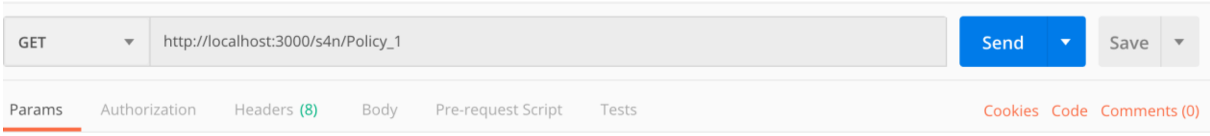


Figure 29. API call to retrieve information about an Entity

As a result, we will obtain all information about the entity in JSON-LD format (Figure 30).

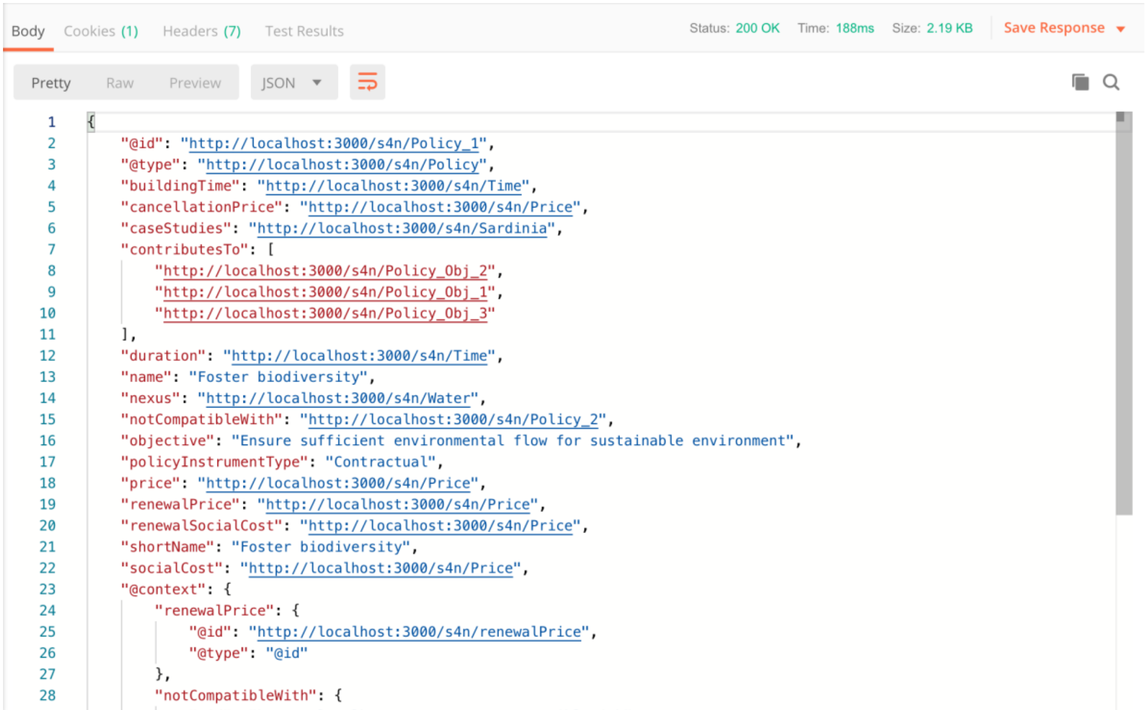


Figure 30. "Policy_1" information retrieved from the semantic repository

6.1.2.3. Update information from a specific entity

To update information from a specific entity, we need to make a PUT operation using the "/s4n/{:entity}". As an example, to modify the "Policy_1" information by adding a description we need to define the REST call:

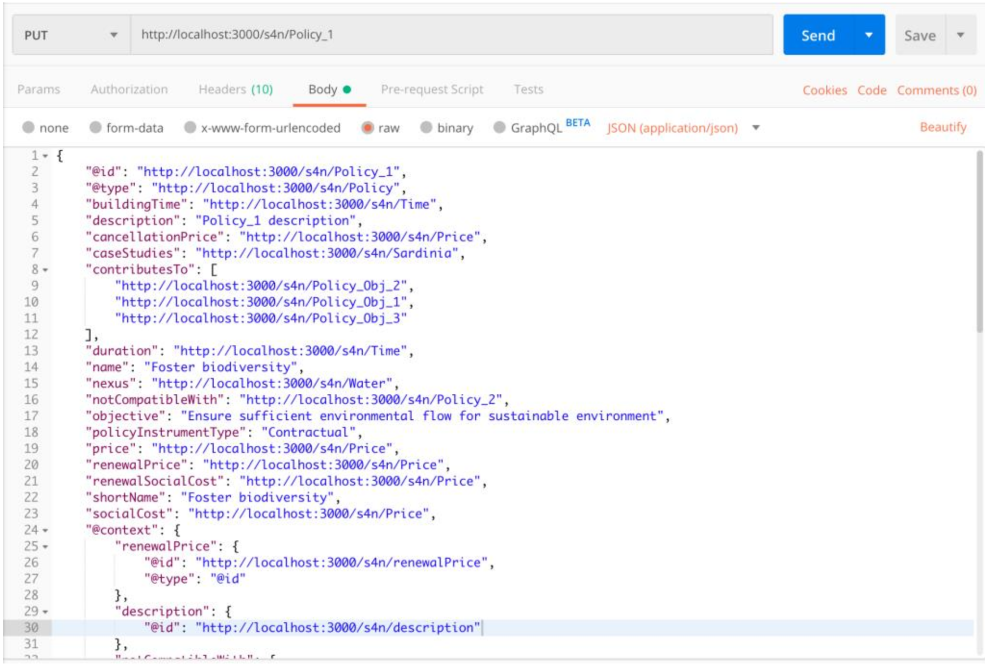


Figure 31. POST Operation over an Entity

As a result, we get if the operation is successful or not. But if we perform the GET operation over the entity, we can get the newer information in which the description is added:

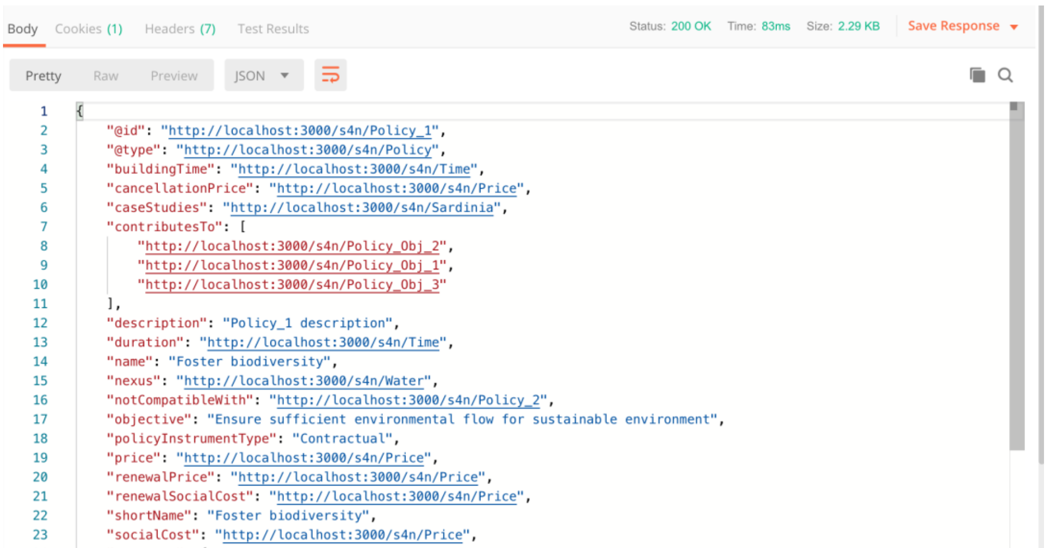


Figure 32. Result of the Update of Policy information

6.1.2.4. Delete specific Entity

This example comprises the removal of an entity for the semantic repository. With that purpose, we need to implement a DELETE operation over '/s4n/{:entity}'. For example, if we want to remove 'Policy_1' from the semantic repository, we need to implement the following operation:

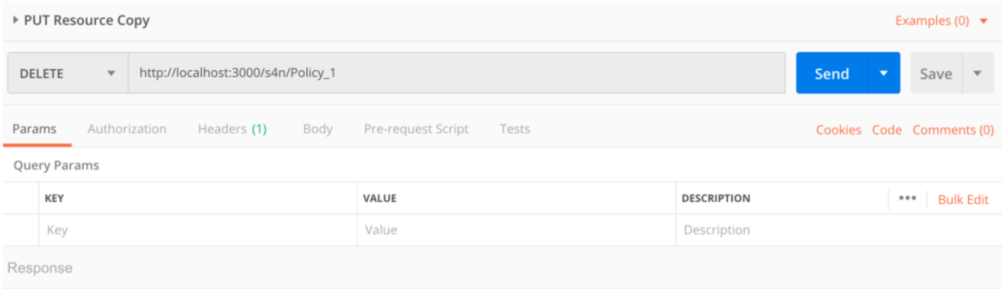


Figure 33. Delete operation for the 'Policy_1'

If everything runs fine, the response from the server is a 204. And if we make a GET over the entity, we should receive an empty object:

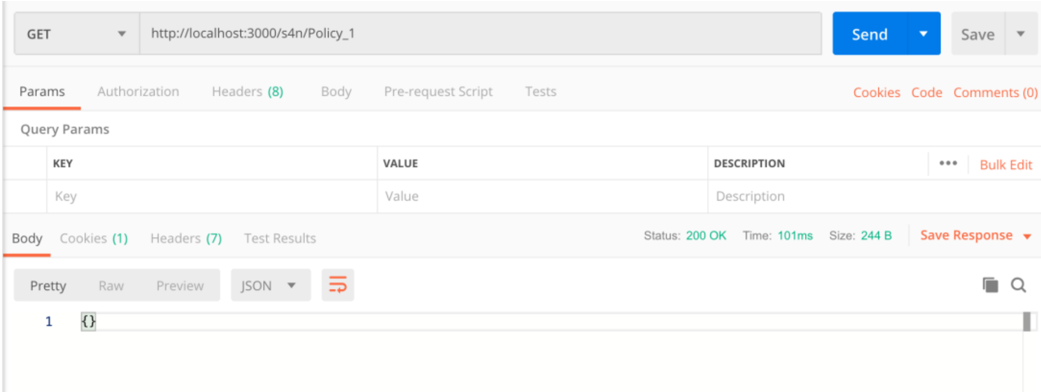


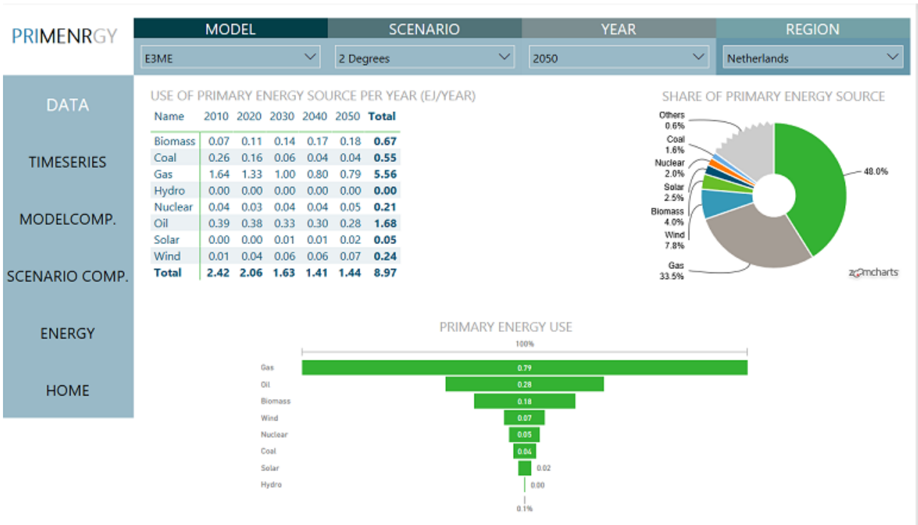
Figure 34. Check the correctness of the deletion

As a conclusion, the CRUD example over the entities of the semantic repository demonstrates how any digital system can interact with the semantic repository. In the specific case of the KEE, we used Urllib library to perform the different REST HTTP request and body-parse in order to serve the semantic repository information to the GameUI.

6.2. Data Navigation Tool

The data navigation tool streamlines the exchange of information between the Thematic Models (and other relevant sources) and the Case Studies. It is built upon a harmonized dimensional data model representing the output of the thematic models as defined in Deliverable D5.2 and serves as a central window point for the case studies to locate, query, and export all data.

The tool offers the user easy navigation through the complex data sets that the thematic models deliver during the project without having to implement their own logic and processes to make the data useful. It is implemented using Power BI desktop on top of data(warehouse) management solution that keeps data history and also performs data quality checks.



Currently it counts with the latest version of baseline and 2-degree scenario data for the Global and European, as well as a subset of the data for the Dutch, Swedish and Latvian case studies loaded in the underlying data store. The tool is on-line for SIM4NEXUS partners. Additional navigational structure has also been provided, together with an Excel power pivot interface to the thematic model data available.

7.Conclusions and Future Work

This section of the deliverable tries to summarize the conclusions and results (Section 7.1) obtained from the work developed under the “Task 4.3 - Setting-up the project database and metadata ontology“. This task finished with the present deliverable. Despite of this, the ontology and the semantic repository will be refined (if needed) according to the GameUI and KEE, and in the improvement in the case studies in general, until the end of the project. Therefore, the future work (Section 7.2) related to this document is focused on the evolution and adaptation of the ontology, naming convention and semantic repository tool to newer requirements and bugs corrections that could occur until the end of the project.

7.1. Conclusions

The present deliverable has depicted the advancements of SIM4NEXUS in the elaboration of a semantic repository tool to (i) provide nexus information about the case-studies and their impact on the policies; and (ii) data exploration and navigation tool in order to provide the community with a catalogue of policies, goals and objectives that could contribute to improve the nexus understanding at long term.

In the way of the implementation of the semantic repository tool, we elaborated a common vocabulary (ontology) in order to harmonise the representation and link of the nexus variables and metadata. This ontology goes beyond the state of the art in the **elaboration of a data model to link cross-domain (Nexus variables) with the policy (instruments) that helps to improve environment impacts at long-term**.

This ontology model has been complemented with the specific data from different case-studies in order to provide a **database of evidence about policies (instruments) and measures to improve environment impacts and goals**. This database is based on open source software and also is publicly available for query and improvement through an Open API.

Moreover, we also have implemented a naming convention tool in order to harmonise data variable names and establish a common methodology to name the different variables related to the nexus.

As a conclusion, the “Task 4.3” has generated three main outcomes in form of open tools to support the understanding of the nexus and also, to support the knowledge management of the SIM4NEXUS gaming tool.

7.2. Future Work

As mentioned, the Task 4.3 has finalised with the present deliverable. Despite of this, we envision the following future task about the mentioned tools until the end of the project (Table 7.1. Future Tasks to be accomplished). This task will be reported in the periodic reports or other deliverables of the WP4.

Table 7.1. Future Tasks to be accomplished

Component	Task	Description
Sim4nexus Ontology	Maintenance & Adaptation	In case of need, adapt the ontology model to future needs could appear during the development of the KEE and game UI
	Glossary of Terms	Adapt the ontology according to a estable version of the glossary of terms (Annex 3).
Naming Tool	Maintenance	Correct all bug could appear during the interaction with the tool
Semantic Repository	Maintenance & Adaptation	In case of need, adapt REST calls to future requirements could appear

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9. Annex 1. Detail of the Policy Goals and Policy Cards by Case-study

9.1. Introduction

This annex contains the latest version of the contents of policy goals and cards collection sent to each Case Study, and feed into the Semantic Repository. Please, consider these files' contents may be updated till the end of the project. Moreover, some of the tables have extensive contents, thus, it is highly recommended to check the Excel files for more information.

Any updates on the policy goals/policy cards will be reported in the Final Technical Report and/or D4.5 – Serious Game Tool Final Version. In any case the updates will be visible in the Final Version of the Serious Game, released in www.seriousgame.sim4nexus.eu.

9.2. Regional Case Study: Andalusia (Spain)

9.2.1. Policy Goals Tables

Table 9.1. Policy goals table for Andalusia

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Sustainable water management	Ensuring sustainable water management in agriculture to protect water resources	PG1-W
Energy efficiency and promotion of renewable energies	Promoting the introduction of renewables energies in agriculture, as well as improving energy efficiency	PG2-E
Resource efficient food production	Sustainable food production and consumption and resource use efficiency	PG3-F
Climate change mitigation and adaptation	Addressing climate change through the implementation of mitigation and adaptation measures in the agricultural sector	PG4-C
Fight against soil erosion and desertification	Reducing soil erosion and desertification by enhancing environmental measures in agriculture	PG5-L

Table 9.2. Policy goals score indicator thresholds for Andalusia

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,2
PG1-W	medium	0,4
PG1-W	high	0,6
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-E	low	0,2

PG2-E	medium	0,5
PG2-E	high	0,8
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-F	low	0,2
PG3-F	medium	0,5
PG3-F	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG4-C	low	0,2
PG4-C	medium	0,5
PG4-C	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG5-L	low	0,2
PG5-L	medium	0,5
PG5-L	high	0,7

Table 9.3. Policy objectives table for Andalusia

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-W	Improving water availability	O1	0,2
PG1-W	Improving water use efficiency	O2	0,4
PG1-W	Enhancing the good environmental status of water resources	O3	0,4
PG2-E	Increasing energy consumption from renewable sources	O4	0,5
PG2-E	Reducing energy consumption	O5	0,5
PG3-F	Sustainable food production	O6	0,6
PG3-F	Sustainable food consumption patterns	O7	0,4
PG4-C	Reduction of GHG emissions from agriculture	O8	0,7
PG4-C	Enhancing carbon sink capacity	O9	0,3
PG5-L	Promoting soil conservation	O10	1

Table 9.4. Policy objective performance indicators formulas table for Andalusia

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	Water reuse/Total water use in agriculture	Amount of water reuse in the agricultural sector
O2	Total agricultural income/Total water use in irrigation	Agricultural water productivity
O3	Total water use in irrigation/Total water availability	Water exploitation index in agriculture
O4	Renewable energy consumption/Total energy consumption	Renewable energy consumption in agriculture compared to total energy consumption
O5	Total energy consumption in agriculture/Total agricultural income	Energy intensity indicator
O6	Premiums/Total agricultural income	Ratio CAP premiums to total agricultural income

O7	Livestock food demand/Total food demand	Livestock related food demand
O8	GHG emissions from agriculture/Total GHG emissions	GHG emissions from agriculture
O9	Surface of protected areas/Total land use	Surface of protected areas
O10	Surface of ecological focus areas/Total utilised agricultural area	Surface of ecological focus areas

Table 9.5. Policy cards table for Andalusia

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes e.g. same effect for each new run, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Water	Small water reservoirs	Small water reservoirs	Economic support to construct small water reservoirs on farms to enhance resilience to extreme weather events (e.g. droughts)	1	Yes	Once	0%	0%	0%	5	5	High	High	High	High positive	no	Increase in available water for irrigation	

2	Water	Water reuse in the agricultural sector	Water reuse	Incentives to enhance water reuse in the agricultural sector	1	No	Multiple	-10%	0%	0%	5	5	High	High	Medium	High positive	no	Share of water reuse in agricultur e	
3	Water	Water price in irrigation	Water price	Water price per m3 in the agricultural sector to promote water use efficiency	1	No	Multiple	-5%	-5%	-5%	0	5	Low	Low	Low	Low negative	CAPRI	Additiona l price per m3 of irrigation water	
4	Water	Water-efficient technologi es in agriculture	Water-efficient technologi es	Promoting water-efficient technologies in agriculture	1	No	Multiple	-5%	-5%	-5%	0	5	Medium	High	Medium	Medium positive	CAPRI	Increase in irrigation efficiency	
5	Water, Food	Efficient use of fertilisers	Efficient use of fertilisers	Implementati on of technological solutions to reduce nitrates pollution	1	No	Multiple	-5%	-5%	-5%	0	5	Low	Medium	Low	Low positive	no	Fertiliser use reduction	
6	Energy, Climate	Boosting biomass production	Boosting biomass production	Support biomass production in the region to promote circular bioeconomy	1	No	Multiple	-10%	0%	0%	5	5	High	High	High	High positive	no	Share of biomass productio n	
7	Energy, Climate	Renewable energies promotion	Renewable energies promotion	Incentives to introduce renewable energies in agriculture	1	No	Multiple	-10%	0%	0%	5	5	Medium	Medium	Medium	Medium positive	no	Share of renewabl e energies consumpt ion in agricultur e	

8	Energy, Climate	Energy efficiency improvement	Energy efficiency improvement	Subsidies to improve energy efficiency in agriculture	1	No	Multiple	-10%	-5%	-5%	0	5	Medium	High	Medium	Medium positive	no	Reduction in energy use	
9	Food	CAP direct payments reduction	Direct payments reduction	CAP direct payments reduction to enhance market-oriented agricultural production and promote generational renewal	1	No	Multiple	-5%	-5%	-5%	0	5	Medium	Medium	Low	Low negative	CAPRI	Reduction in direct payments	
10	Food, Climate	Changing diets	Changing diets	Changing food consumption towards less meat-based diets	1	No	Multiple	-5%	0%	0%	5	5	Low	Low	Low	Low positive	CAPRI	Decline in livestock food demand	
11	Climate	Mitigation technologies	Mitigation technologies	Implementation of mitigation technologies in the agricultural sector to reduce GHG emissions	1	No	Multiple	-10%	-5%	-5%	0	5	Medium	Medium	Medium	Low positive	no	GHG emissions reduction	
12	Climate, Land	Preserving natural vegetation	Preserving natural vegetation	Preserving natural vegetation to increase carbon sink capacity	1	No	Multiple	-5%	-5%	-5%	0	5	Medium	Low	Low	Low positive	no	Area of protected natural spaces	

13	Land, Climate	Ecological focus areas	Ecological focus areas	Promote ecological focus areas to face soil erosion	1	No	Multiple	-5%	0%	-5%	0	5	Medium	Low	Low	Low positive	CAPRI	Ecological focus areas (EFAs) under the CAP green payment	
14	Land, Climate	Agri-environmental measures	Agri-environmental measures	Strengthening agro-enviromental measures within the CAP to enhance soil conservation	1	No	Multiple	-5%	-5%	-5%	0	5	Medium	Medium	Medium	Low positive	CAPRI	Agri-environmental payments within CAP pillar II	

9.3. Regional Case Study: Sardinia (Italy)

Table 9.6. Policy goals table for Sardinia

Policy Goal (PG) – Name	*Policy Goal (PG) – Description*	*Policy Goal id*
Improve water use efficiency in agriculture	The policy aims at reducing the water scarcity issues while increasing food production	PG1-W
Sustainable simple management	The policy aims at managing supply and demand form multiple sectors without implementing economic activities of the following years nor implementing status of ecosystems	PG2-W
Zero net emissions by 2050	The policy aims at implementing multiple measures in order to reach zero net emissions by 2050	PG3-C
Increase RES share in the energy mix	The policy aims at further increasing the energy production from RES by increasing RES power plants as well as accumulators	PG4-E
Reduce costs for energy	Energy costs pose a major limit the economic development in the region, the goal is to reduce their costs	PG5-E
Promote market of agricultural products	Agricultural products are weakly exported also in the production of specific products is limited, the goal is to increase the crop production	PG6-F
Protection of ecosystems	The policy aims at increasing the protected areas in the region	PG7-L
Regulate coastal landscape	The policies aim at minimizing the land use change in the coastal areas	PG8-L

Table 9.7. Policy goals score indicator thresholds for Sardinia

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,1

PG1-W	medium	0,25
PG1-W	high	0,5
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-W	low	0,1
PG2-W	medium	0,4
PG2-W	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-C	low	0,2
PG3-C	medium	0,5
PG3-C	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG4-E	low	0,3
PG4-E	medium	0,5
PG4-E	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG5-E	low	0,01
PG5-E	medium	0,1
PG5-E	high	0,2
Policy Goal id	*Policy Goal Indicator thresholds*	
PG6-F	low	0,1
PG6-F	medium	0,3
PG6-F	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG7-L	low	0
PG7-L	medium	0,2
PG7-L	high	0,5
Policy Goal id	*Policy Goal Indicator thresholds*	
PG8-L	low	0
PG8-L	medium	0,2
PG8-L	high	0,5

Table 9.8. Policy objectives table for Sardinia

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-W	Efficient irrigation system	O1	0,2
PG1-W	IoT service for irrigation	O2	0,2
PG1-W	Leak reduction in conveyance system for agriculture	O3	0,5
PG1-W	Improve water productivity	O4	0,1
PG2-W	Guarantee Minimum Environmental flows	O5	0,3

PG2-W	Increase resilience of water supply	O6	0,7
PG3-C	Increase energy efficiency of households	O7	0,6
PG3-C	Increase energy efficiency of public buildings	O8	0,4
PG4-E	Increase energy production from Solar and Wind	O9	0,4
PG4-E	Increase energy production from Hydropower	O10	0,2
PG4-E	Implement smart grid and accumulator systems	O11	0,3
PG5-E	Import Methane for heating and electricity production	O12	1
PG6-F	Increase production of fruits	O13	0,2
PG6-F	Increase production of vegetables	O14	0,2
PG6-F	Increase production of crop feed	O15	0,2
PG6-F	Increase production of grape	O16	0,2
PG6-F	Increase irrigated area	O17	0,2
PG7-L	Increase extension and number of protected areas (Natura 2000, parks)	O18	0,4
PG7-L	Decrease number and extension of wildfires	O19	0,6
PG8-L	moderately increase number of hosting facilities	O20	0,7
PG8-L	increase new hosting facilities	O21	0,3

Table 9.9. Policy objective performance indicators formulas table for Sardinia

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	Applied water for irrigation/Water demand for irrigation	The water demand for irrigation compared to water demand under optimal irrigation practice
O2	Applied water for irrigation/Water demand for irrigation	The water demand for irrigation compared to water demand under optimal irrigation practice
O3	Applied water for irrigation/Water demand for irrigation	The water demand for irrigation compared to water demand under optimal irrigation practice
O4	Agriculture income/water demand for irrigation	Amount of water used per euro of income
O5	Environmental flows/Minimum environmental flows	Environmental flows are satisfied
O6	Total water supply/Total water demand	quantifies water deficits
O7	total energy demand for heating/energy demand for heating in year 2010	describes change in energy for heating
O8	total energy demand for heating/energy demand for heating in year 2011	describes change in energy for heating
O9	Energy production from solar and wind/total energy production	quantifies the contribution of solar and wind to total energy production
O10	Energy production from hydropower/total energy production	quantifies the contribution of hydropower to total energy production
O11	energy production from RES/Total energy production	quantifies the contribution of all RES to total energy production
O12	(energy cost in year 2010-Cost for energy)/energy cost in year 2010	quantifies the change in energy costs
O13	(fruit production+fruit production in 2010)/fruit production in 2010	quantifies the change in fruit production compared to initial value
O14	(vegetables production+vegetables production in 2010)/vegetables production in 2010	quantifies the change in fruit production compared to initial value

O15	(crop feed production+crop feed production in 2010)/crop feed production in 2010	quantifies the change in fruit production compared to initial value
O16	(grape production+grape production in 2010)/grape production in 2010	quantifies the change in fruit production compared to initial value
O17	(Irrigated area+irrigated area in 2010)/irrigated area in 2010	quantifies the change in irrigated area compared to initial value
O18	Total protected area/protected area in 2010	quantifies the change in protected area
O19	forest area burnt/forest area burnt between 2005-2010	quantifies the reduction of burnt forests
O20	tourist flows/tourist flows in 2010	quantifies the gain in tourist flows
O21	tourist flows/tourist flows in 2011	quantifies the gain in tourist flows

Table 9.10. Policy cards table for Sardinia

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time)	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/ implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention / measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Water			Adoption of new (alternative) irrigation methods (change of irrigation systems).	1	Yes	Multiple	-5%	yes (-5% efficiency)	yes (-5% efficiency)	Medium	5	High	Medium	+High	Medium			
O1	Water	Efficient irrigation system		Adoption of new (alternative) irrigation methods (change of irrigation systems).	1	yes	Multiple	-5%	yes (-5% efficiency)	yes (-5% efficiency)	0	5	medium	medium	low	medium	no	Change of cropland areas irrigated by new technologies	

O2	Water	IoT service for irrigation		Implementation of IoT services for optimal irrigation	1	no	Multiple	-10%	no	no	0	10	medium	high	medium	high	no	irrigation efficiency
O3	Water	Leak reduction in conveyance system for agriculture		Renewal of conveyance system	1	yes	multiple	0%	no	no	5	5	high	high	low	medium	no	Change in coefficient of water losses in conveyance system
O4	Water	Improve water productivity		Renewal of conveyance system	1	yes	multiple	0%	no	yes (-10% efficiency)	0	5	low	medium	medium	medium	CAPRI	Change in coefficient of water losses in conveyance system
O5	Water	Guarantee Minimum Environmental flows		Water management accounts for fully satisfying minimum environmental flows even in case of short water supplies	1	no	multiple	0%	no	no	0	5	low	medium	medium	medium	no	Fixed rates of reservoir discharge
O6	Water	Increase resilience of water supply		Water management accounts for predicted water demand of the following year and ensures water supplies for the following year	1	no	multiple	-10%	no	yes (-10% efficiency)	5	5	medium	high	medium	high	no	reservoir stored volume
O7	Climate	Increase energy efficiency of households		Incentives to improve isolation of households	1	yes	multiple	-10%	yes (-10% efficiency)	yes (-5% efficiency)	0	5	medium	medium	medium	medium	no	Distribution of energy efficiency classes
O8	Climate	Increase energy efficiency of public buildings		Investments improve isolation of public buildings	1	yes	multiple	-10%	yes (-10% efficiency)	yes (-5% efficiency)	0	5	medium	medium	medium	high	no	distribution of energy efficiency classes
O9	Energy	Increase energy production from Solar and Wind			1	yes	multiple	-15%	yes (-5% efficiency)	yes (-10% efficiency)	5	5	medium	medium	medium	high	no	installed power for solar and wind
O10	Energy	Increase energy production from Hydropower			1	no	multiple	-15%	no	no	0	5	medium	medium	low	medium	no	water discharges for hydropower
O11	Energy	Implement smart grid and accumulator systems			1	yes	multiple	-5%	no	no	10	10	high	high	medium	high	no	decrease of electricity production from conventional sources proportional to energy accumulated

O12	Energy	Import Methane for heating and electricity production			1	yes	Once		no	yes (-20% efficiency)	0	15	high	high	medium	medium	E3ME	demand for methane	
O13	Food	Increase production of fruits			1	no	Multiple	-10%	no	no	0	5	low	medium	low	low	no	tree crop area	
O14	Food	Increase production of vegetables			1	no	Multiple	-10%	no	no	0	5	low	medium	low	low	no	crop area	
O15	Food	Increase production of crop feed			1	no	Multiple	-10%	no	no	0	5	low	medium	low	low	no	pasture area	
O16	Food	Increase production of grape			1	no	Multiple	-10%	no	no	0	5	low	high	low	medium	no	vineyard area	
O17	Food	Increase irrigated area			1	no	Multiple	-10%	no	no	0	5	medium	medium	low	medium	no	irrigated area	
O18	Land	Increase extension and number of protected areas (Natura 2000, parks)			1	no	Multiple	-10%	no	yes (-10% efficiency)	0	20	low	low	medium	medium	no	increase in protected area	
O19	Land	Decrease number and extension of wildfires			1	no	Multiple	0%	yes (-10% efficiency)	yes (-10% efficiency)	0	5	medium	medium	medium	high	no	annual burnt area	
O20	Land	moderately increase number of hosting facilities			1	yes	Multiple	-5%	yes (-5% efficiency)	yes (-10% efficiency)	0	5	low	medium	medium	high	no	tourist flows	
O21	Land	increase new hosting facilities			1	yes	Multiple	-10%	yes (-10% efficiency)	yes (-20% efficiency)	0	5	medium	high	low	low	no	tourist flows	

9.4. Regional Case Study: Southwest (United Kingdom)

Table 9.11. Policy goals table for Southwest UK

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Demand reduction	Reducing the demand for drinking water arising from society, thus offsetting the need for expanded capacity	PG1-W
Flexibility and Security	Enabling the drinking water and wastewater supply chain to respond to external shocks and pressures, while maintaining service.	PG2-W
Waste reduction	minimising the production of waste products requiring disposal to land	PG3-W
protection of human health and environment	ensuring that the local environment and human health is protected	PG4-W
Demand reduction	Reducing the demand for energy arising from society, thus offsetting the need for expanded capacity	PG1-E
Flexibility and Security	Enabling the energy supply chain to respond to external shocks and pressures, while maintaining service.	PG2-E
Decarbonisation of Energy Supply	reducing the carbon emissions associated with the generation and supply of energy	PG3-E
Environmental sustainability	Ensuring that the local environment and human health is protected	PG1-L
Minimisation of waste to landfill	reducing the total volume of waste disposed to landfill	PG2-L
Improvement of the Urban environment	Improving the urban environment to provide greater public amenity	PG3-L
Environmental sustainability	minimise negative impacts to the local environment and improve biodiversity	PG1-F
Reduce surface run-off	minimise the volume and contaminant loading of run-off water arising from agricultural	PG2-F

Table 9.12. Policy goals score indicator thresholds for Southwest UK

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,2
PG1-W	medium	0,6
PG1-W	high	0,8
PG2-W	low	0,3
PG2-W	medium	0,5
PG2-W	high	0,9
PG3-W	low	0,3
PG3-W	medium	0,6

PG3-W	high	0,9
PG4-W	low	0,3
PG4-W	medium	0,6
PG4-W	high	0,9
PG1-E	low	0,3
PG1-E	medium	0,6
PG1-E	high	0,9
PG2-E	low	0,3
PG2-E	medium	0,6
PG2-E	high	0,9
PG3-E	low	0,1
PG3-E	medium	0,2
PG3-E	high	0,3
PG1-L	low	0,1
PG1-L	medium	0,3
PG1-L	high	0,5
PG2-L	low	0,1
PG2-L	medium	0,3
PG2-L	high	0,5
PG2-L	low	0,2
PG2-L	medium	0,4
PG2-L	high	0,8
PG3-L	low	0,3
PG3-L	medium	0,6
PG3-L	high	0,9
PG1-F	low	0,2
PG1-F	medium	0,4
PG1-F	high	0,6
PG2-F	low	0,2
PG2-F	medium	0,4
PG2-F	high	0,6

Table 9.13. Policy objectives table for Southwest UK

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-W	Water saving in households	O1	0,7
PG1-W	Reducing losses of drinking water within the supply chain	O2	0,3
PG2-W	Ensure adequate water resources to meet drinking water demand	O3	0,4
PG2-W	reduce dependence on external energy supply	O4	0,2

PG2-W	ensure adequate capacity within the urban water cycle to meet demand	O5	0,4
PG3-W	minimise the production of waste requiring disposal to land, thus protecting the land bank resource	O6	1
PG4-W	improve drinking water quality	O7	0,6
PG4-W	improve wastewater effluent quality	O8	0,4
PG1-E	Improving the efficiency of energy use in households	O9	0,65
PG1-E	increasing the use of renewable energy in households	O10	0,35
PG2-E	ensure adequate capacity within the energy supply chain to meet demand	O11	0,6
PG2-E	Improve the management flexibility of the energy distribution system to meet demand	O12	0,4
PG3-E	Increasing the proportion of low carbon energy with the supply	O13	1
PG1-L	Creation forests and woodlands	O14	0,3
PG1-L	Creation of wetland environments	O15	0,3
PG1-L	Creation of natural habitats	O16	0,2
PG1-L	Creation of space for wildlife	O17	0,2
PG2-L	Waste recycling	O17	0,4
PG2-L	food waste Composting	O18	0,3
PG2-L	Waste to energy	O19	0,3
PG3-L	Increasing access to green spaces	O20	0,3
PG3-L	Providing sufficient housing to meet demand	O21	0,7
PG1-F	Improve biodiversity	O22	0,6
PG1-F	reduce agri chemical demand	O23	0,4
PG2-F	reduce agricultural run-off	O24	1

Table 9.14. Policy objective performance indicators formulas table for Southwest UK

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	if =>1 then 1, if =<0 then 0 1-((current percapita demand-target percapita demand)/(Initial percapita demand-target percapita demand))	the objective is to reduce the water consumption of households at the point of use, several policies can influence this, behaviour and water efficiency devices being the main ones. The metric used considers the percapita demand at the start of the project, and the progress towards a target percapita consumption rate. potentially the target could be visible to the player, but it should be a fixed value determined within the SDM approx. 100 litres per person per day.

O2	if =>1 then 1, if =<0 then 0 1-((1-(actual consumption/actual abstraction))/(1-(initial consumption/initial abstraction)))	the objective is to reduce the total volume of water abstracted, while maintaining adequate supply to meet demand. Several polies influence this, leakage, process losses are the primary ones. The metric is a ratio of the water consumed/water abstracted and considers the initial situation at the start of the project with the current situation. a ratio is used because an absolute value would not work, as demand will inevitably rise with population growth.
O3	1-((1-(actual distribution demand/actual Avalible resource))/(1-(initial distribution demand/initial Avalible resource)))	the objective is to ensure supply headroom which matches or exceeds demand. This metric is very similar to the previous one as it considers the total volume of water supplied / available resources. Again, the metric considers the current situation relative to the initial position to show progress
O4	if =>1 then 1, if =<0 then 0 1-((1-(actual self-supply of electricity/actual gross demand of electricity))/(1-(initial self-supply of electricity/initial gross demand of electricity)))	the objective is to reduce the volume of electricity imported and increase the proportion of energy generated on site. The metric considers the volume of self-generated electricity / the gross demand for electricity. Like the previous objectives in considers the initial and current situation to show improvement
O5	if =>1 then 1, if =<0 then 0 1-((1-(actual demand/actual capacity))/(1-(initial demand/initial capacity)))	the objective is to ensure that all of the components of the urban water cycle have capacity enough to maintain supply. The metric considers demand/capacity for the current situation relative to the initial situation
O6	if =>1 then 1, if =<0 then 0 1-(((actual sludge disposed to land/actual sludge produced))/((initial disposed to land/initial sludge produced)))	the objective is to reduce sludge disposed to land as this has significant cost and environmental implications. The metric considers the volume of sludge disposed to land / the volume of sludge produced.
O7	if =>1 then 1, if =<0 then 0 1-((actual DW quality-target DW quality)/(Initial DW quality-target DW quality))	the objective is to improve or maintain drinking water quality with respect to a target, the target should be hidden from the player.
O8	if =>1 then 1, if =<0 then 0 1-((actual WW quality-target WW quality)/(Initial WW quality-target WW quality))	the objective is to improve or maintain wastewater effluent quality with respect to a target, the target should be hidden from the player.
O9	if =>1 then 1, if =<0 then 0 1-((current percapita demand-target percapita demand)/(Initial percapita demand-target percapita demand))	the objective is to reduce percapita energy demand with respect to a target in the same way as O1
O10	if =>1 then 1, if =<0 then 0 1-((current percentage of domestic Re-target percentage of domestic Re)/(Initial percentage of domestic Re-target percentage of domestic Re))	the objective is to increase the self-supply of renewable energy on homes, thereby reducing demand for imported electricity. The metric considers the percentage of homes with Renewable energy installed against a target. This could be visible to the player.
O11	if =>1 then 1, if =<0 then 0 1-((1-(actual demand/actual capacity))/(1-(initial demand/initial capacity)))	the object is to ensure the energy supply chain has sufficient headroom of capacity to meet demand. And follows the same structure as its counterpart in water O5
O12	(energy storage capacity/network capacity)*DSO*percentage customers with smart meters*percentage commercial load on DSM	the objective is to deploy measures to enhance the flexibility of the energy supply chain, to enable to it to dynamically balance supply and demand. The metric considers the deployment of all enabling policies, but is most heavily influenced by the Distribution System Operator (DSO) policy having been enabled, as this is a binary 1 or 0.

O13	if =>1 then 1, if =<0 then 0 1-(((actual RE into supply/actual total electricity consumed))/((initial RE into supply/initial total electricity consumed)))	the objective is to increase the volume of renewable energy entering supply, thereby off-setting fossil fuels. The metric is a simple ratio between renewable energy generated and the total volume of electricity consumed. In the extremely unlikely event supply exceeds demand the excess would be exported out of the region.
O14	if =>1 then 1, if =<0 then 0 1-(((actual forest area/actual total land resource))/((initial forest area/initial total land resource)))	the objective is to protect the existing forestry stock and where possible expand it by taking land resource from agriculture or converting other natural habitat. The metric follows the same methodology as others by considers forest area / total land, with respect to the initial situation.
O15	if =>1 then 1, if =<0 then 0 1-(((actual Wetland area/actual total land resource))/((initial Wetland area/initial total land resource)))	the objective is to protect the existing wetland stock and where possible expand it by taking land resource from agriculture or converting other natural habitat. The metric follows the same methodology as others by considers forest area / total land, with respect to the initial situation.
O16	if =>1 then 1, if =<0 then 0 1-(((actual Natural habitat area/actual total land resource))/((initial Natural habitat area/initial total land resource)))	the objective is to protect the existing natural habitat stock and where possible expand it by taking land resource from agriculture or converting other natural habitat. The metric follows the same methodology as others by considers forest area / total land, with respect to the initial situation.
O17	if =>1 then 1, if =<0 then 0 1-(((actual sum of natural habitats/actual total land resource))/((initial sum of natural habitats/initial total land resource)))	the objective is to increase the total area of natural habitat irrespective of type. the metric follows the same methodology as others by considers sum of all-natural habitats / total land, with respect to the initial situation.
O18	if =>1 then 1, if =<0 then 0 1-(((actual volume of recycled waste/actual total MSW))/((initial volume of recycled waste/initial total MSW)))	the objective is to increase the volume of municipal waste that is recycled, by increasing the capacity of recycling facilities. the metric follows the same methodology as others by considering volume of recycled waste / total waste produced, with respect to the initial situation.
O19	if =>1 then 1, if =<0 then 0 1-(((actual volume of composted waste/actual total MSW))/((initial volume of composted waste/initial total MSW)))	the objective is to increase the volume of municipal waste that is composted by increasing the capacity of composting facilities. the metric follows the same methodology as others by considering volume of composted waste / total waste produced, with respect to the initial situation.
O20	if =>1 then 1, if =<0 then 0 1-(((actual volume of EfW waste/actual total MSW))/((initial volume of EfW waste/initial total MSW)))	the objective is to increase the volume of municipal waste that is used for Energy from waste fuel by increasing the capacity of EfW facilities. the metric follows the same methodology as others by considering volume of EfW waste / total waste produced, with respect to the initial situation.
O21	if =>1 then 1, if =<0 then 0 1-(((actual greenspace area/total residential area))/((initial greenspace area/initial total residential area)))	the objective is to increase the access of residents to greenspaces within the urban environment, by increasing the area of parks and other amenity spaces. the metric follows the same methodology as others by considering area of greenspace / residential area, with respect to the initial situation.
O22	if =>1 then 1, if =<0 then 0 housing supply / housing demand	the objective is to ensure supply of new housing meets demand. The metric is a simple ration between supply and demand.

O22	if =>1 then 1, if =<0 then 0 1-((1-((actual area low intensity+area organic+buffer area)/actual utilized agri area))/(1-((initial area low intensity+area organic+buffer area)/initial utilized agri area)))	the objective is to support biodiversity with agriculture through the creation of pockets of natural habitat or by reducing the intensity of farming practices. The metric considers the sum of area that is more supporting to biodiversity / total agri area, with respect to the initial situation.
O23	if =>1 then 1, if =<0 then 0 1-((1-(actual chemical demand/actual utilized agri area))/(1-(initial chemical demand/initial utilized agri area)))	the objective is to reduce chemical use in agriculture, by deintensification and organic practices. The metric considers chemical demand / total agri area.
O24	if =>1 then 1, if =<0 then 0 1-((current agri run-off volume-target agri run-off volume/(Initial agri run-off volume-target agri run-off volume))	the objective is to minimise the flow of run-off water arising in agriculture by increasing deintensification, organic farming, land buffers, improved drainage. The metric follows the methodology of previous examples

Table 9.15. Policy cards table for Southwest UK

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time)	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments

E1	Energy	Next generation smart metering	Smart metering	Smart metering designed to give the householder more detailed information on their energy use and technically compatible with upcoming household energy technology	0	Yes	Multiple	same effect	0%	0%	5	5	Low	High	Low	High+	E3ME	increases the "Percentage of dwellings with smart meter" and is an enabler to the DSO	
E2	Energy	Low carbon homes	efficient homes	Legislating for new homes to be low carbon, energy and water efficient and climate resilient. Closing the performance gap between stated design standard and actual performance	0	Yes	Once	na	0%	0%	5	5	Low	High	Low	High+	E3ME	increases the "Percentage of dwellings conforming to low carbon standard" thus reducing average percapita demand	
E3	Energy	Behavioural change programmes to encourage demand reduction	Behavioural change	Encouraging new practices through legislation, information, and behavioural economics	0	No	Multiple	same effect	0%	0%	5	5	Low	Low	Low	High+	E3ME	increases the "Percentage of population practicing low energy lifestyle", thus reducing percapita demand	
E4	Energy	Domestic scale self-supply of renewable energy	Domestic Renewable energy	The use domestic scale renewable energy on homes	0	yes	Multiple	same effect	0%	0%	5	5	Medium	low	medium	High+	E3ME	increases the "Percentage of dwellings with renewable energy" thus reducing average percapita demand	
E5	Energy	Distributed Electricity Storage	Electricity Storage	Removing barriers to deployment for battery technologies and assisting innovation around storage	0	No	Multiple	same effect	0%	0%	5	5	Low	High	Low	Low+	E3ME	increases "energy storage" which increases "effective network capacity" and is an enabler to the DSO	

E6	Energy	Electricity Network capacity reinforcement	Network capacity	Substantial investment in network capacity to better deal with the two-way flow of electricity	0	Yes	Multiple	same effect	0%	0%	5	5	Medium	high	low	medium+	no	directly increases the: Distribution Network capacity Transmission Network Capacity both of which enable increased electricity transfer	the sooner that the grid is updated, the easier and less costly it will be to create a truly flexible energy system…it will be cheaper and more renewables and storage/dsr will be possible with early implementation of this policy card
E7	Energy	Transition of Distribution Network Operator to Distribution System Operators	DNO to DSO	A DSO model will allow greater management of the generation and consumption of energy across the network	0	yes	once	na	0%	0%	5	5	low	medium	low	low+	no	the "distribution system operator" will enable improved management of the distribution network, which will increase the "effective network capacity" thus enabling more electricity to be transferred	substantial grid balancing will not be possible until DSOs can run a flexible grid and allow for an increase in two-way flow (only becomes possible if E1, E5, E8 have been at least partially enabled)
E8	Energy	Support for greater Demand Side Management	DSM	Implementing standards for smart appliances and mandating suppliers to offer time varying tariffs and DNOs to accommodate for DSR in network planning	0	no	multiple	same effect	0%	0%	5	0	low	low	low	low+	no	percentage of commercial and industrial customers whose demand is suitable for DSM, this will increase the "effective network capacity" and is an enabler to the DSO	DSR enables the grid to balance supply and demand without the need for additional generation. So, energy health will be improved without as much renewables on the system as would otherwise be required

E9	Energy	Greater deployment of commercial scale onshore Wind Energy	Onshore Wind	Strong policy and financial support for lowest cost, least risk renewables	0	yes	Multiple	same effect	0%	0%	5	5	mediu m	high	medium	low-	E3ME	increases the installed capacity of "Onshore wind"	Again, greater impact with engagement policy card
E10		Greater deployment of commercial scale Biomass fuelled Electricity Generation	Biomass Electricity	Strong policy and financial support for lowest cost, least risk renewables	0	yes	Multiple	same effect	0%	0%	5	5	mediu m		low	low+	E3ME	increases the installed capacity of "Biomass Electricity capacity"	
E11		Greater deployment of commercial scale Solar PV	Solar Farms	Strong policy and financial support for lowest cost, least risk renewables	0	yes	Multiple	same effect	0%	0%	5	5	mediu m		medium	Low-	E3ME	increases the installed capacity of "Solar PV capacity"	
E12	Energy	Developme nt of Hinkley Point Nuclear Energy site	Nuclear Energy	Financial support and government backing new nuclear power stations	0	Yes	Once	na	0%	0%	5	10	High	medium	high	low-	no	"Hinkley point operational" reduces the "effective network capacity"	New nuclear undermines the development of a smart flexible energy system and stalls investment in renewables so playing this card will have implications on the storage, dsr and renewables cards. It is also particularly unpopular and so would greatly impact on social capital levels

L1	Land	creation of new woodlands and forests	Reforestation	implementing woodland creation grants to plant trees, build 'leaky dams' and restore heather moorland	0	Yes	multiple	same effect	0%	0%	5	5	low	high	low	high+	no	"Rate of forestation", land transitioning to forestry stock.	as well as reducing flood risk, reforestation can also improve water quality, prevent erosion and store carbon so positive nexus spillover. at the same time, there is the opportunity to increase production of sustainable low-grade biomass to meet between 5% and 10% of UK energy demands in 2050. There will also be other natural capital benefits such as cleaner air, increased recreation and amenity space and positive impacts on biodiversity and conservation.
l2	Land	Creation of wetlands or re-wetting	Wetland creation	Agri-environment schemes to encourage wetland creation by land management changes that can result in increased temporary storage	0	no	multiple	same effect	0%	0%	5	5	low	medium	low	medium+	no	"Rate of rewetting" , land transitioning to wetland stock.	conversion of existing natural habitats or fallow agricultural land into wetland, or re wetted Moorland
L3	Land	Protecting existing natural habitats	Habitat protection	Increased designation of protected natural habitats to avoid loss from changing farming practices, expansion of transport networks, urban development and mining and quarrying	0	No	multiple	same effect	0%	0%	5	5	low	low	low	Low+	no	"Rate of natural habitats", land transitioning to natural habitats stock.	

L4	Land	Landfill reduction and waste Recycling	Recycling	Increase recycling efforts, update and increase the UKs recycling infrastructure and legislate against the use of non-recyclable items	0	no	multiple	same effect	0%	0%	5	5	low	low	low	Medium+	no	the capacity of recycling facilities in tonnes per unit period	
L5	Land	Increase Energy from waste	EfW	planning for and approving a further number of incinerators with which to deal with increasing amounts of waste	1	Yes	multiple	same effect	0%	0%	5	5	medium	low	medium	Medium-	no	increases installed capacity EfW, this enables more waste to be diverted from land fill and generates more energy	increasing incineration will lead to an increase in air pollution and increase levels of carbon dioxide contributing to climate change. implementing this policy will also decrease the efficiency of recycling policy (32) as councils are forced to supply enough waste to new incinerators. Energy from waste, in the form of electricity and heat can be generated from incineration
L6	Land	Food and Garden waste composting	Composting	implement drivers to encourage local authorities to invest in increased garden waste collection where it does not already happen	1	No	multiple	same effect	0%	0%	5	5	low	low	low	Low+	no	increases composting capacity in tonnes per unit period	
L7	Land	Food waste anaerobic digestion	AD	encourage local authorities to collect food waste for anaerobic digestion	1	No	Multiple	same effect	0%	0%	5	5	medium	medium	low	Medium+	no	increases installed capacity AD	

L8	Land	Demolition of Existing housing stock	Housing Demolition	The rate at which the existing housing stock is demolished ready for redevelopment	1	No	Multiple	same effect	0%	0%	5	5	low	medium	low	low+	no	increases "Rate of Demolition", which transfers land resource from the "residential area" stock to the "brown field" stock	Demolition of the existing housing stock is the primary means by which the housing stock can be renewed or modified.
L9	Land	Decommissioning of current commercial and industrial premises	Industrial decommissioning	The rate at which the existing commercial and industrial premises are demolished ready for redevelopment	1	No	Multiple	same effect	0%	0%	5	5	low	medium	low	low+	no	increases "Rate of decommissioning" which transfers land resource from the "commercial and industrial area" stock to the "brown field" stock	
L10	Land	Development on Green field land	Green Field development	The transition of undeveloped greenfield land to developed land	1	No	Multiple	same effect	0%	0%	5	5	low	medium	medium	medium-	no	increases the "Rate of green field development" which transfers land from forestry, agriculture and natural habitat to either "residential area" or "commercial and industrial area"	Use of green field land for development is highly contentious, however without readjustment of housing density is often the only option to increase housing stock
L11	Land	Commercial stimulation	commercial stimulation	stimulation to the economy driven by tax breaks or incentives, enabling accelerated development	0	No	Multiple	same effect	0%	0%	5	5	Medium	medium	medium	low+	no	increases "Commercial activity", drives the expansion of commercial and industrial land use	

L12	Land	Design housing density	housing density	The number of dwellings per hectare of residential area	1	No	Multiple	same effect	0%	0%	5	5	low	medium	medium	low-	no	increases or decreases "housing density", which determines "housing demand"	housing density is a highly contentious issue which has complex socioeconomic interactions
L13	Land	Creation of urban green spaces	Green space	The percentage of the urban and residential area used for open green spaces such as parks	1	No	Multiple	same effect	0%	0%	5	5	low	low	low	medium+	no	increases the percentage of urban and residential area used as "Greenspace" effectively as a percentage	access to greenspace within urban areas increases public well being
F1	Food	Improved biodiversity through agricultural deintensification	agricultural deintensification	Reducing the density of crops and livestock	1	No	Multiple	same effect	0%	0%	5	5	low	low	low	low+	no	increases the percentage agricultural land operating at "low density" this has impacts to yield, run-off, chemical demand.	reduces yields of crops and livestock per area of land, but increases biodiversity and minimises environmental impacts
F2	Food	Increase proportion of Organic farming practices	Organic farming	stimulate demand for organic produce through public procurement in the health sector and schools and promote community supported agriculture schemes that provide open access and exposure	1	no	multiple	same effect	0%	0%	5	5	low	medium	low	high+	no	increases the percentage of utilised agricultural land under "organic farming", this has impacts to yield, run-off, chemical demand.	A highly regulated and proscribed set of farming practices which improve perceived value of products while reducing yields but protecting the environment

F3	Food	Advance catchment sensitive farming projects	catchment sensitive farming	Work with farmers to introduce careful nutrient and pesticide planning	1	no	multiple	same effect	0%	0%	5	5	low	medium	low	high+	no	Increases the percentage of "catchment sensitive farming", this has impacts to yield, run-off, chemical demand.	this should save farms money, reduce soil loss and deliver environmental benefits such as reducing water pollution, cleaner drinking water, safer bathing water, healthier fisheries, increased wildlife and lower flood risk for local communities
F4	Food	cultivation of dedicated energy crops	Energy crops	Transition of agricultural land to dedicated energy crop cultivation	1	no	Multiple	same effect	0%	0%	5	5	low	low	low	low+	no	increases or decreases the percentage of arable land used for "dedicated energy crops"	cultivation of dedicated energy crops takes land out of food production
F5	Food	Improve natural drainage on agricultural land	Natural Drainage	Incentives for the establishment of hedgerows, the creation of natural buffer zones and overland flow ponds	0	no	multiple	same effect	0%	0%	5	5	medium	high	low	Medium+	no	Increases the percentage of "conventional agriculture with improved drainage", this has impacts to yield, run-off, chemical demand.	
F6	Food	Enclosed animal pens with drainage control	Drainage control	Introduce mandatory requirements that ensure all pens and drains do not result in contaminants entering natural watercourses	1	no	multiple	same effect	0%	0%	5	5	low	medium	low	low+	no	Increases the percentage of "livestock with drainage control", this has impacts to yield, run-off, chemical demand.	

F7	Food	Implement green belt or land buffers	Land buffers	Install more measures to protect waterways from pollution by the installation of natural buffer zones	1	No	multiple	same effect	0%	0%	5	5	low	low	low	medium	no	increases the percentage of agricultural land with land buffering, impacts to yield, run-off, chemical demand.	
W1	Water	Next generation smart metering	Smart metering	Smart metering designed to give the householder more detailed information on their water use.	1	yes	once	same effect	0%	0%	5	5	low	low	low	medium	no	increases the percentage of dwellings with smart meter, which reduces percapita demand.	
W2	Water	Water efficient devices in homes	Water efficiency	The deployment of water efficient devices in the home to reduce domestic water consumption	1	yes	once	same effect	0%	0%	5	5	low	low	low	medium	no	increases the Percentage of dwellings with water efficient devices, which reduces percapita demand.	
W3	Water	Domestic Grey water reuse and rainwater harvesting	water reuse	The deployment of grey water recycling devices and rainwater harvesting in the home to reduce domestic water consumption	1	yes	multiple	same effect	0%	0%	5	5	medium	low	low	medium	no	increases the Percentage of dwellings with water harvesting devices, which reduces percapita demand.	
W4	Water	Education and behavioural change programmes to reduce water consumption	behavioural change	Encouraging new practices through legislation, information, and behavioural economics	1	no	multiple	same effect	0%	0%	5	5	low	low	low	medium	no	increases the Percentage of population practicing low carbon lifestyle as a result of educations/awareness, which reduces percapita demand.	

W5	Water	reduction in treatment losses	treatment losses	A reduction of drinking water used during the treatment process	1	no	multiple	same effect	0%	0%	5	5	low	low	low	low	no	reduces the "treatment losses rate" from drinking water treatment. This improves overall process efficiency and helps to ensure supply demand balance	
W6	Water	Reduction of leakage from the drinking water distribution network	leakage reduction	Reducing leakage within the drinking water distribution network	1	yes	multiple	same effect	0%	0%	5	5	Medium	low	low	medium	no	reduces the "Leakage rate" from the water distribution network, thus reducing the need for additional drinking water treatment	
W7	Water	Improve drinking water and wastewater network capacity to meet growing demand	network capacity	Increase the capacity of the water distribution network to ensure continual supply	1	yes	multiple	same effect	0%	0%	5	Permanent	High	low	medium	medium	no	increases the distribution and drainage network capacities	
W8	Water	Separation of foul water and rainwater drainage systems	Dual Drainage	separation of the drainage network into storm water and foul water flows to improve operational efficiency	1	yes	multiple	same effect	0%	0%	5	5	Medium	medium	low	low	no	increases percentage of wastewater network with surface water separation, thus reducing flow to wastewater treatment	

W9	Water	use of Sustainable Urban Drainage systems	SUDS	deployment of Sustainable urban drainage technologies	1	yes	multiple	same effect	0%	0%	5	5	low	medium	low	medium	no	increases percentage of wastewater network with SUDS, thus reducing flow to wastewater treatment	
W10	Water	improve Drinking water and wastewater treatment capacity to meet growing demand	Treatment capacity	Increasing the capacity of drinking water and wastewater treatment	1	yes	multiple	same effect	0%	0%	5	5	high	low	medium	low	no	increases the "drinking water treatment capacity" thus enabling supply demand balance	
W11	Water	interregional connection of drinking water resources	Water Trading	import and export of raw water resources into the region	1	yes	once	same effect	0%	0%	5	5	low	medium	low	low	no	increases the import/export capacity enabling raw water to be imported or exported to and from the region.	
W12	Water	Sea water Desalination for drinking water	Desalination	Use of desalination plant as alternative raw water source	1	no	multiple	same effect	0%	0%	15	5	high	low	high	low	no	increases the capacity of desalination plant to provide additional water resources "Desalination capacity". Has high capital cost and energy demand, but unlimited raw water supply.	

W13	Water	sustainable Surface water abstraction for drinking water	sustainable abstraction	Limitations to the abstraction of surface water to ensure protection of the aquatic environment	1	no	multiple	same effect	0%	0%	5	5	low	low	low	low	no	increases or decreases the "raw water river abstraction limit", which maintains levels of flow in the river to support aquatic environment, and enable access to raw water resource	
W14	Water	Use of boreholes and ground water resources for drinking water	Ground water abstraction	Increased use of ground water sources	1	no	multiple	same effect	0%	0%	5	5	low	low	low	low	no	"borehole abstraction limit", increase the rate of borehole abstraction, providing more raw water resource, but high energy demand	
W15	Water	Building new raw water reservoir storage	Reservoir expansion	building new reservoirs to store raw water	1	yes	once	same effect	0%	0%	15	Permanent	high	low	high	high	no	"Reservoir capacity" expand the major raw water storage capacity in the region, long lead time, high capital cost	
W16	Water	Increase use of self-generated renewable energy Hydro and CHP	onsite renewables	Increase the proportion of electricity generated on site using renewable energy technologies	1	Yes	multiple	same effect	0%	0%	5	Permanent	Medium	medium	low	low	no	increases both "Hydro capacity" and "AD Capacity" which enable increased generation of renewable energy. Limited resources however.	

W17	Water	Energy efficiency of drinking and wastewater treatment and transmission.	Energy efficiency	Increase the efficiency of treatment technologies for both drinking water and wastewater.	1	yes	multiple	same effect	0%	0%	0	Permanent	Medium	medium	low	low	no	reduces the energy demand per unit flow of water through the treatment processes "wastewater treatment energy demand coefficient", "Drinking water treatment energy demand coefficient",	
W18	Water	Sewage sludge Incineration	Sludge incineration	disposal of Sewage sludge via incineration	1	no	multiple	same effect	0%	0%	5	5	medium	low	low	low	no	increases the "Sludge incineration capacity", enabling sludge to be disposed to incineration rather than land. Capital cost,	
W19	Water	Sewage sludge liming to Land remediation	Sludge to land	disposal of Sewage sludge to agricultural land	1	no	multiple	same effect	0%	0%	5	5	low	low	low	low	no	increases the "Sludge composting capacity" enabling more sludge to be disposed to land, low cost, low energy	
W20	Water	Sewage Sludge Pyrolysis	Sludge Pyrolysis	Conversion of sewage sludge into biochar fertiliser	1	yes	multiple	same effect	0%	0%	5	5	medium	high	low	medium	no	increases the "Sludge Pyrolysis capacity" enabling sludge to be converted to biochar fertiliser, reducing operational cost, co2 emissions and disposal to land	

W21	Water	Increase wastewater final effluent standards	Effluent standards	Increasing the quality of wastewater effluent discharge to the environment	1	no	multiple	same effect	0%	0%	5	5	medium	low	low	high	no	increase or decrease the "Final Effluent quality" from wastewater treatment, impact to river water quality, and energy demand	
W22	Water	Increase drinking water quality	Drinking water quality	Improving drinking water quality	1	no	multiple	same effect	0%	0%	5	5	medium	low	low	high	no	increase or decrease the "Drinking Water quality", impact to energy and chemical demand	

9.5. National Case Study: Azerbaijan

Table 9.16. Policy goals table for Azerbaijan

Policy Goal (PG) - Name	Policy Goal (PG) - Description	Policy Goal id
Water supply measures	The country applies a series of measures in order to decrease water consumption.	PG1-W
Water savings	The country applies a series of measures in order to increase water availability.	PG2-W
Food security	The country aims at increasing their security by increasing production.	PG3-F
Energy efficiency	The country aims at reducing electricity consumption through energy efficiency measures and by raising public awareness.	PG4-E
Renewable energy target	The country aims at increasing their renewable energy share in the electricity generation.	PG5-E
Reforestation	The country aims at increasing the share of forest areas in the total land.	PG6-L
Decarbonisation	The country aims at reducing their GHG emissions.	PG7-C

Table 9.17. Policy goals score indicator thresholds for Azerbaijan

Policy Goal id	Policy Goal Score Indicator thresholds	
PG1-W	low	0,33
PG1-W	medium	0,65
PG1-W	high	0,8

Policy Goal id	Policy Goal Indicator thresholds	
PG2-W	low	0,3
PG2-W	medium	0,6
PG2-W	high	0,75
Policy Goal id	Policy Goal Indicator thresholds	
PG3-F	low	0,25
PG3-F	medium	0,4
PG3-F	high	0,75
Policy Goal id	Policy Goal Indicator thresholds	
PG4-E	low	0,3
PG4-E	medium	0,5
PG4-E	high	0,8
Policy Goal id	Policy Goal Indicator thresholds	
PG5-E	low	0,05
PG5-E	medium	0,15
PG5-E	high	0,3
Policy Goal id	Policy Goal Indicator thresholds	
PG6-L	medium	0,08
PG6-L	high	0,12
Policy Goal id	Policy Goal Indicator thresholds	
PG7-C	low	0,5
PG7-C	medium	0,6
PG7-C	medium	0,75

Table 9.18. Policy objectives table for Azerbaijan

Policy Goal id	Policy Objective (O)	Policy objective id	Weight of the Objective in contributing to the achievement of the overall policy aim
PG1-W	Management of existing resources	O1	0,8
PG1-W	Desalination of the Caspian Sea	O2	0,2
PG2-W	Innovative irrigation systems	O3	0,65
PG2-W	Behavioural change	O4	0,35
PG3-F	Optimal use of resources	O5	0,5
PG3-F	Best practices in agriculture	O6	0,5
PG4-E	Interventions that reduce energy consumption	O7	1
PG5-E	Renewable energy target	O8	1
PG6-L	Reforestation	O9	1
PG7-C	Best practices in food production that reduce carbon footprint	O10	1

Table 9.19. Policy objective performance indicators formulas table for Azerbaijan

Policy Goal id	Policy Objective (O)	Policy objective id	Weight of the Objective in contributing to the achievement of the overall policy aim
PG1-W	Management of existing resources	O1	0,8
PG1-W	Desalination of the Caspian Sea	O2	0,2
PG2-W	Innovative irrigation systems	O3	0,65
PG2-W	Behavioural change	O4	0,35
PG3-F	Optimal use of resources	O5	0,5
PG3-F	Best practices in agriculture	O6	0,5
PG4-E	Interventions that reduce energy consumption	O7	1
PG5-E	Renewable energy target	O8	1
PG6-L	Reforestation	O9	1
PG7-C	Best practices in food production that reduce carbon footprint	O10	1

Table 9.20. Policy cards table for Azerbaijan

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?		Comments

1	Water	Water collection systems	Water collection systems	Development of new water collection systems	0	Yes	Multiple		no	no	1	1	Medium	Medium	Low	Medium			Water collection systems	Increase Surface_water
2	Water	Management of reservoirs	Management of reservoirs	Improved management of reservoirs	0	No	Multiple	5%	no	no	1	1	Low	Medium	Low	Medium			Recycling	Increase recycling
3	Water	Water recycling	Water recycling	Expansion of water recycling projects	0	No	Multiple	5%	no	no	1	1	Low	Medium	Low	Medium			Management of reservoirs	Increase Surface_water
4	Water	Flood management	Flood management	Development of flood management projects	0	Yes	Multiple		no	no	1	1	Medium	Medium	Low	Medium			Flood management	Increase Surface_water
5	Water	Desalination of Caspian Sea water	Desalination of Caspian Sea water	Development of projects for the desalination of the Caspian Sea	0	Yes	Multiple	10%	no	no	1	1	High	High	Low	High			Desalination of Caspian Sea water	Increase Surface_water
6	Water	Innovative irrigation systems	Innovative irrigation systems	Development of innovative irrigation systems	0	Yes	Multiple		no	no	1	1	Low	Medium	Low	Medium			Innovative irrigation systems	Decrease Irrigation_
7	Water	Raising awareness for water savings	Raising awareness for water savings	Training programs to raise awareness for water savings	0	Yes	Multiple	10%	no	no	1	1	Low	Medium	Low	Medium			Raising awareness for water savings	Decrease W_Demand (all segments)
8	Food	Optimal use of fertilisers	Optimal use of fertilisers	Campaigns for optimal use of fertilisers	0	Yes	Multiple	10%	no	no	1	1	Low	Low	Low	Low			Optimal use of fertilisers	Increase food production (all segments)
9	Food	Optimal use of pesticides	Optimal use of pesticides	Campaigns for optimal use of pesticides	0	Yes	Multiple	10%	no	no	1	1	Low	Low	Low	Low			Optimal use of pesticides	Increase food production (all segments)
10	Food	Optimal irrigation	Optimal irrigation	Campaigns for optimal use of water resources in agriculture	0	Yes	Multiple	10%	no	no	1	1	Low	Low	Low	Low			Optimal irrigation	Increase food production (all segments)
11	Food	Selection of the most suitable seeds	Selection of the most suitable seeds	Campaigns for selection of the most suitable seeds	0	Yes	Multiple	10%	no	no	1	1	Low	Low	Low	Low			Selection of the most suitable seeds	Increase food production (all segments)
12	Food	Soil tests	Soil tests	Campaigns for crop rotation	0	Yes	Multiple	10%	no	no	1	1	Low	Low	Low	Low			Soil tests	Increase food production (all segments)
13	Food	Crop rotation	Crop rotation	Campaigns for soil tests	0	Yes	Multiple	10%	no	no	1	1	Low	Low	Low	Low			Crop rotation	Increase food production (all segments)

14	Energy	Raising awareness for energy efficiency	Raising awareness for energy efficiency	Training programs to raise awareness for energy savings	0	Yes	Multiple	10%	no	no	1	1	Low	Medium	Low	Medium			Raising awareness for energy efficiency	Decrease energy demand (all segments)
15	Energy	Subsidies for renewables	Subsidies for renewables	Adoption of subsidies for renewables	0	No	Multiple		no	no	1	1	Medium	Medium	Low	Medium			Subsidies for renewables	Increase share of renewable electricity (an equal split of the various sources) at the expense of fossil fuel generated electricity (also equal split)
16	Energy	Direct investments in renewables	Direct investments in renewables	Direct investments in renewables by the government	0	Yes	Multiple		no	no	1	1	High	High	Low	High			Direct investments in renewables	Increase share of renewable electricity (an equal split of the various sources) at the expense of fossil fuel generated electricity (also equal split)
17	Forest	National reforestation program	National reforestation program	National reforestation program	0	Yes	Multiple		no	no	1	1	High	Low	Low	High			National reforestation program	Increase Forest LU at the expense of Fallow
18	Forest	Voluntary reforestation	Voluntary reforestation	Voluntary reforestation	0	Yes	Multiple		no	no	1	1	Zero	Low	High	Medium			Voluntary reforestation	Increase Forest LU at the expense of Fallow
19	Climate	Reducing carbon footprint in food production	Campaigns for reducing carbon footprint in food production	Reducing carbon footprint in food production	0	Yes	Multiple		no	no	1	1	Low	Medium	Low	Medium			Reducing carbon footprint in food production	Reduce carbon emission coefficient in all foods

9.6. National Case Study: Greece

Table 9.21. Policy goals table for Greece

Policy Goal (PG) - Name	Policy Goal (PG) - Description	Policy Goal id
Sustainable management of water resources	This goal focuses on the protection of water resources' quality and quantity based on the priorities having been set by the WFD 2000/60/EC	PG1-W
Reduction of GHG emissions by 2020	This goal focuses on the reduction of GHG emissions by the year 2020 according to the goals having been set by the EU (Climate and Energy Package)	PG1-C
Reduction of GHG emissions by 2030	This goal focuses on the reduction of GHG emissions by the year 2030 according to the goals having been set by the EU (Climate and Energy Framework)	PG2-C
Reduction of GHG emissions by 2050	This goal focuses on the reduction of GHG emissions by the year 2050 according to the goals having been set by the EU (long-term strategy)	PG3-C

Zero GHG emissions by 2050	This is a goal included in the last IPCC report for limiting global warming to 1.5^{0}C	PG4-C
Contribution of the LULUCF sector to the reduction of CO2 emissions	This goal focuses on the contribution of cropland, grassland and forests to the reduction of CO2 emissions	PG5-C
Increase RES share in the national energy mix by 2020	This goal focuses on the promotion of RES (national energy market) for energy production until 2020 (fully harmonised with the EU Climate and Energy Package). It aims at the increase of RES share in the national energy mix and the simultaneous reduction of fossil fuels and coal	PG1-E
Increase RES share in the national energy mix by 2030	This goal focuses on the promotion of RES (national energy market) for energy production until 2030 (fully harmonised with the EU Climate and Energy Framework). It aims at the increase of RES share in the national energy mix and the simultaneous reduction of fossil fuels and coal	PG2-E
Increase of natural gas share in national energy mix	This goal focuses on the promotion and further use of natural gas in order to replace oil	PG3-E
Decrease of oil share in the national energy mix	This goal focuses on the use of other energy sources (RES, natural gas, etc.) in order to decrease the use of oil for energy production	PG4-E
Increase RES share in the national energy mix by 2050	This goal focuses on the promotion of RES (national energy market) for energy production until 2050 (fully harmonised with the EU Climate and Energy long-term strategy). It aims at the increase of RES share in the national energy mix and the simultaneous reduction of fossil fuels and coal	PG5-E
Decrease of coal share in the national energy mix by 2050	This goal focuses on the use of other energy sources (RES, natural gas, etc.) in order to decrease the use of coal for energy production	PG6-E
Production of sufficient agricultural products	This goal focuses on the production of sufficient agricultural products in order to cover food needs	PG1-F
Production of sufficient livestock products	This goal focuses on the production of sufficient livestock products in order to cover food needs	PG2-F
Land availability for the development of agricultural and livestock activities	This goal focuses on the protection of agricultural land and the further promotion and development of agricultural and livestock sectors	PG1-L
Protection of forests, wetlands and grasslands	This goal focuses on the sustainable management of forests, wetlands and grasslands in order to protect biodiversity and natural environment	PG2-L

Table 9.22. Policy goals score indicator thresholds for Greece

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,33
PG1-W	medium	0,66
PG1-W	high	
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-W	low	0,33
PG2-W	medium	0,66
PG2-W	high	
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-W	low	0,33
PG3-W	medium	0,66

Table 9.23. Policy objectives table for Greece

Policy Goal id	Policy Objective (O)	Policy objective id	Weight of the Objective in contributing to the achievement of the overall policy aim
PG1-W	Water saving in agricultural sector	O1	0,7
PG1-W	Water saving in households	O2	0,15
PG1-W	Water saving in the industrial sector	O3	0,15
PG1-C	Effort sharing decision for Greece/Non-ETS emission reduction target by 2020: -4% compared to 2005	O4	0,7
PG1-C	ETS emission reduction target by 2020: 1,74% per year compared to 2005 emissions	O5	0,3
PG2-C	Effort sharing decision for Greece / Non-ETS emission reduction target by 2030: -16% compared to 2005 emissions	O6	0,7
PG2-C	Effort sharing decision for Greece / ETS emission reduction target by 2030: -2.2 % compared to 2005 emissions	O7	0,3
PG3-C	Effort sharing decision for Greece / Non-ETS emission reduction target by 2050: -60% compared to 2005 emissions	O8	1
PG4-C	Emission reduction target for non-ETS sectors: 0 emissions by 2050	O9	0,7
PG4-C	Emission reduction target for ETS sectors: 0 emissions by 2050	O10	0,3
PG5-C	Mitigation of climate change impacts through activities in the LULUCF sector	O11	1
PG1-E	Increase RES share in the gross final energy consumption by 20% until 2020	O12	1
PG2-E	Increase RES share in the gross final energy consumption by 32% until 2030	O13	1
PG3-E	Use of natural gas for electricity generation	O14	1
PG4-E	Decrease of oil for energy production in the several economic sectors	O15	1
PG5-E	Total penetration of RES in gross final energy generation by 2050 at a rate of 60%-70%	O16	1
PG6-E	Decrease of coal for electricity production	O17	1
PG1-F	Cover of food needs, fodder needs and needs related to industrial crops	O18	1
PG2-F	Cover of food needs from the sector of livestock (livestock products)	O19	1
PG1-L	Protection of agricultural land and land occupied by livestock	O20	1
PG2-L	Sustainable management of forest land, wetland and grassland	O21	1

Table 9.24. Policy objective performance indicators formulas table for Greece

Policy Objective id	policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1	Description of policy objective indicator

O1	First, we calculate the sum "Demand_SW+Demand_GW" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_W_GRXX.Demand_SW[1]...[12]+RBD_W_GRXX.Demand_GW[1]...[12]". The final value will be the 2015 sum, namely "RBD_W_GRXX.Demand_SW[61]...[72]+RBD_W_GRXX.Demand_GW[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial)/0.1". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_Demand_SW.Total_Demand_SW[61]...[72]+National_Demand_GW.Total_Demand_GW[61]...[72]"	1. Change of irrigated crop area (m2) 2. Change of water losses (m3) through different irrigation methods (drip, sprinkler, furrow). This indicator can only be used if we Implement interactive policy cards. Without interactive policy cards, it will give erroneous results.
O2	First, we calculate the sum "Demand_SW+Demand_GW" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_W_GRXX.Demand_SW[1]...[12]+RBD_W_GRXX.Demand_GW[1]...[12]". The final value will be the 2015 sum, namely "RBD_W_GRXX.Demand_SW[61]...[72]+RBD_W_GRXX.Demand_GW[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial)/0.1". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_Demand_SW.Total_Demand_SW[61]...[72]+National_Demand_GW.Total_Demand_GW[61]...[72]"	1. Change of household water consumption (m3)
O3	First, we calculate the sum "Demand_SW+Demand_GW" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_W_GRXX.Demand_SW[1]...[12]+RBD_W_GRXX.Demand_GW[1]...[12]". The final value will be the 2015 sum, namely "RBD_W_GRXX.Demand_SW[61]...[72]+RBD_W_GRXX.Demand_GW[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial)/0.1". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_Demand_SW.Total_Demand_SW[61]...[72]+National_Demand_GW.Total_Demand_GW[61]...[72]"	1. Change of industrial water demand by adopting water reuse practices (m3)
O4	First, we calculate "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX[1]...[12]". The final value will be the 2015 sum, namely "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial/0.04)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_GHG_Emissions.National_non-ETS_Emissions[61]...[72]	1. Change of GHG emissions derived from all non-ETS sectors (kg of CO2 equivalents) 2. Change of GHG emissions derived from the agricultural sector (kg of CO2 equivalents) 3. Change of GHG emissions derived from the non-ETS industrial sector (kg of CO2 equivalents) 4. Change of GHG emissions derived from the non-ETS transportation sector (kg of CO2 equivalents) 5. Change of GHG emissions derived from the construction sector (non-ETS) (kg of CO2 equivalents) 6. Change of GHG emissions derived from the household/commercial sector (non-ETS) (kg of CO2 equivalents) 7. Change of GHG emissions derived from other non-ETS sectors (kg of CO2 equivalents)

O5	First, we calculate "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX[1]...[12]". The final value will be the 2015 sum, namely "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial/0.087)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_GHG_Emissions.National_ETS_Emissions[61]...[72]	1. Change of GHG emissions derived from all ETS sectors (kg of CO2 equivalents) 2. Change of GHG emissions derived from the ETS industrial sector (kg of CO2 equivalents) 3. Change of GHG emissions derived from the ETS transportation sector (kg of CO2 equivalents) 4. Change of GHG emissions derived from the power generation sector (ETS) (kg of CO2 equivalents)
O6	First, we calculate "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX[1]...[12]". The final value will be the 2015 sum, namely "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial/0.04)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_GHG_Emissions.National_non-ETS_Emissions[61]...[72]	Same as the previous indicators for non-ETS sectors
O7	First, we calculate "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX[1]...[12]". The final value will be the 2015 sum, namely "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial/0.0055)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_GHG_Emissions.National_ETS_Emissions[61]...[72]	Same as the previous indicators for ETS sectors
O8	First, we calculate "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX[1]...[12]". The final value will be the 2015 sum, namely "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial/0.04)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_GHG_Emissions.National_non-ETS_Emissions[61]...[72]	Same as the previous indicators for non-ETS sectors
O9	For this, IF "RBD_Cl_GRXX.Total_non-ETS_Emissions_GRXX">0, THEN 0, ELSE 1. Same for the National Case, "National_GHG_Emissions.National_non-ETS_Emissions">0, THEN 0, ELSE 1.	Same as the previous indicators for non-ETS sectors
O10	For this, IF "RBD_Cl_GRXX.Total_ETS_Emissions_GRXX">0, THEN 0, ELSE 1. Same for the National Case, "National_GHG_Emissions.National_ETS_Emissions">0, THEN 0, ELSE 1	Same as the previous indicators for ETS sectors

O11	First, we calculate "LULUCF_GRXX.Total_Emissions" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "LULUCF_GRXX.Total_Emissions[1]...[12]". The final value will be the 2015 sum, namely "LULUCF_GRXX.Total_Emissions[61]...[72]". The performance indicator will be: "(0.5+(Initial-Final)/Initial)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_GHG_Emissions.National_LULUCF_Emissions[61]...[72]	1. Change of CO2 sequestration for Cropland (kg of CO2 equivalents) 2. Change of CO2 sequestration for Grassland (kg of CO2 equivalents) 3. Change of CO2 sequestration for Forest (kg of CO2 equivalents)
O12	First, we calculate the following: "(RBD_En_GRXX.Total_Power_Generation_Dem_GRXX/RBD_EN_GRXX.Total_Energy_Demand_GRXX)*RBD_En_GRXX.RES_Share + (1-RBD_En_GRXX.Total_Power_Generation_Dem_GRXX/RBD_EN_GRXX.Total_Energy_Demand_GRXX)*RBD_En_GRXX.Biomass_Demand_GRXX/(RBD_EN_GRXX.Total_Energy_Demand_GRXX-RBD_En_GRXX.Total_Power_Generation_Dem_GRXX)" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up for all variables except the RBD_En_GRXX.RES_Share. Here, we can use the first value of Month 1, since it stays constant during the year. So, for RES_Share, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the first value of the times series, namely "RBD_En_GRXX.RES_Share[1]". For all other variables, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_En_GRXX.Total_Power_Generation_Dem_GRXX[1]...[12]" etc. The final value will be the 2015 sum, namely "RBD_En_GRXX.Total_Power_Generation_Dem_GRXX[61]...[72]". The performance indicator will be: "((Final-Initial)/Initial)/0.2". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "(Power_Generation_Demand_National.Total[61]...[72]/ENERGY.Energy_Demand_National[61]...[72])*National_Electricity_Generated.RES_Share_National[61] + (1-Power_Generation_Demand_National.Total[61]...[72]/ENERGY.Energy_Demand_National[61]...[72])*Biomass_Demand_National.Biomass_Demand_Total/(ENERGY.Energy_Demand_National[61]...[72]-Power_Generation_Demand_National.Total[61]...[72])"	1. Biofuels (biomass) used in the transportation sector in relation to other fuels (Joules) 2. Biomass used in the industrial sector in relation to other fuels (Joules) 3. Biomass used in the household/commercial sector in relation to other fuels (Joules) 4. Biomass used in the agricultural sector in relation to other fuels (Joules) 5. Biomass used in other sectors in relation to other fuels (Joules) 6. Share of electricity generated from PVs in the gross final electricity generation (GWh) 7. Share of electricity generated from wind parks in the gross final electricity generation (GWh) 8. Share of electricity generated from hydropower plants in the gross final electricity generation (GWh) 9. Share of electricity generated from biomass in the gross final electricity generation (GWh)

O13	First, we calculate the following: "(RBD_En_GRXX.Total_Power_Generation_Dem_GRXX/RBD_EN_GRXX.Total_Energy_Demand_GRXX)*RBD_En_GRXX.RES_Share + (1-RBD_En_GRXX.Total_Power_Generation_Dem_GRXX/RBD_EN_GRXX.Total_Energy_Demand_GRXX)*RBD_En_GRXX.Biomass_Demand_GRXX/(RBD_EN_GRXX.Total_Energy_Demand_GRXX-RBD_En_GRXX.Total_Power_Generation_Dem_GRXX)" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up for all variables except the RBD_En_GRXX.RES_Share. Here, we can use the first value of Month 1, since it stays constant during the year. So, for RES_Share, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the first value of the times series, namely "RBD_En_GRXX.RES_Share[1]". For all other variables, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_En_GRXX.Total_Power_Generation_Dem_GRXX[1]...[12]" etc. The final value will be the 2015 sum, namely "RBD_En_GRXX.Total_Power_Generation_Dem_GRXX[61]...[72]". The performance indicator will be: "((Final-Initial)/Initial)/0.32". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "(Power_Generation_Demand_National.Total[61]...[72]/ENERGY.Energy_Demand_National[61]...[72])*National_Electricity_Generated.RES_Share_National[61] + (1-Power_Generation_Demand_National.Total[61]...[72]/ENERGY.Energy_Demand_National[61]...[72])*Biomass_Demand_National.Biomass_Demand_Total/(ENERGY.Energy_Demand_National[61]...[72]-Power_Generation_Demand_National.Total[61]...[72])"	Same with O12
O14	First, we calculate "RBD_En_GRXX.Power_Generation_GD" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_En_GRXX.Power_Generation_GD[1]...[12]". The final value will be the 2015 sum, namely "RBD_En_GRXX.Power_Generation_GD[61]...[72]". The performance indicator will be: "((Final-Initial)/Initial)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "Power_Generation_GD_National.Power_Generation_GD_Total[61]...[72]"	1. Share of natural gas used for electricity generation (GWh)
O15	First, we calculate "RBD_En_GRXX.Oil_Demand_GRXX" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_En_GRXX.Oil_Demand_GRXX[1]...[12]". The final value will be the 2015 sum, namely "RBD_En_GRXX.Oil_Demand_GRXX[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "Oil_Demand_National.Oil_Demand_Total[61]...[72]"	1. Change of oil demand by the industrial sector (Joules) 2. Change of oil demand by the household/commercial sector (Joules) 3. Change of oil demand by the agricultural sector (Joules) 4. Change of oil demand for power generation (Joules) 5. Change of oil demand by the transportation sector (Joules) 6. Change of oil demand by the construction sector (Joules) 7. Change of oil demand by other sectors (Joules) 8. Change of oil demand for electricity generation (Joules)

O16	First, we calculate "RBD_En_GRXX.RES_Share" for the starting year that the policy card is applied (this is the initial value). Here, we can use the first value of Month 1, since it stays constant during the year. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the first value of the times series, namely "RBD_En_GRXX.RES_Share[1]". The final value will be the 2015 value, namely "RBD_En_GRXX.RES_Share[61]". The performance indicator will be: "((Final-Initial)/Initial)/0.7". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 ANDIF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_Electricity_Generated.RES_Share_National[61]"	1. Share of electricity generated from Biomass in the gross final electricity generation (GWh) 2. Share of electricity generated from Hydropower in the gross final electricity generation (GWh) 3. Share of electricity generated from Wind in the gross final electricity generation (GWh) 4. Share of electricity generated from Solar in the gross final electricity generation (GWh)
O17	First, we calculate "RBD_En_GRXX.Power_Generation_CD" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_En_GRXX.Power_Generation_CD[1]...[12]". The final value will be the 2015 sum, namely "RBD_En_GRXX.Power_Generation_CD[61]...[72]". The performance indicator will be: "((Initial-Final)/Initial)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "Power_Generation_CD_National.Power_Generation_CD_Total[61]...[72]"	1. Share of coal used for electricity production (GWh)
O18	First, we calculate "RBD_F_GRXX.Crop_Value" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_F_GRXX.Crop_Value[1]...[12]". The final value will be the 2015 sum, namely "RBD_F_GRXX.Crop_Value[61]...[72]". The performance indicator will be: "((Final-Initial)/Initial)/0.2". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_Crop_Value.National_Crop_Value[61]...[72]	1. Crop food value (euros) 2. Crop feed value (euros) 3. Crop industrial value (euros)
O19	First, we calculate "RBD_F_GRXX.Livestock_Value" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So, if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_F_GRXX.Livestock_Value[1]...[12]". The final value will be the 2015 sum, namely "RBD_F_GRXX.Livestock_Value[61]...[72]". The performance indicator will be: "((Final-Initial)/Initial)/0.2". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_Livestock_Value.National_Livestock_Value[61]...[72]	1. Meat value (euros) 2. Milk value (euros) 3. Eggs value (euros) 4. Honey value (euros)
O20	First, we calculate "RBD_LU_GRXX.Total_Agri_Area" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_LU_GRXX.Total_Agri_Area[1]...[12]". The final value will be the 2015 sum, namely "RBD_LU_GRXX.Total_Agri_Area[61]...[72]". The performance indicator will be: "0.5+((Final-Initial)/Initial)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_AgriA.National_Agri_Area[61]...[72]	1. Change of land occupied by agricultural crops (m2) 2. Change of land occupied by livestock (m2)

O21	First, we calculate "RBD_LU_GRXX.Forest+RBD_LU_GRXX.Wetland+RBD_LU_GRXX.Grassland" for the starting year that the policy card is applied (this is the initial value). Note that we need to calculate yearly values, which means that the 12 months of each year need to be summed up. So if the policy card is applied from 2010 to 2015, the initial 2010 value will be the sum "RBD_LU_GRXX.Forest[1]...[12]+RBD_LU_GRXX.Wetland[1]...[12]+RBD_LU_GRXX.Grassland[1]...[12]". The final value will be the 2015 sum, namely "RBD_LU_GRXX.Forest[61]...[72]+RBD_LU_GRXX.Wetland[61]...[72]+RBD_LU_GRXX.Grassland[61]...[72]". The performance indicator will be: "0.5+((Final-Initial)/Initial)". For this indicator, IF INDICATOR >1, THEN INDICATOR=1 AND IF INDICATOR<0, THEN INDICATOR=0. For the National Case, the name of the corresponding variables for 2015 is "National_FA.National_Forest _Area[61]...[72]+National_WA.National_Wetland_Area[61]...[72]+National_GA.National_Grassland_Area[61]...[72]	1. Change of forest land (m2) 2. Change of wetland (m2) 3. Change of grassland (m2)

Table 9.25. Policy cards table for Greece

Policyl d	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments

1	Water	Irrigation technologies for agricultural water savings	Irrigation technologies	Adoption of new (alternative) irrigation methods (change of irrigation systems)	0	Yes	Multiple	0%	0%	10%	5	30	Medium	High	Medium	High positive	No	Change of cropland irrigated by different technologies (furrow, sprinkler, drip)	1. This card can only be played if we switch to interactive cards 2. Column H: From 2020 - Until 2050
2	Water	Agricultural water savings through changing crop type	Crop types	Diversification of crops or cultivation of crops that are resilient to drought (less water demanding crops)	0	Yes	Multiple	0%	0%	10%	5	35	Medium	High	Medium	Medium positive	No	Replace high water consuming crops with other, less water demanding crops OR replace irrigated crops with non-irrigated ones	Column H: From 2020 - Until 2050
3	Water	Water savings in the household/ commercial sites/tourist establishments	Water savings at homes/hotels	Water saving in households by establishing water saving equipment, (e.g. smart taps) changing consumption behaviour, etc.	0	Yes	Multiple	0%	0%	0%	5	30	Medium	Medium	Medium	Medium positive	No	Decrease of water demand by the household/commercial sector	Column H: From 2020 - Until 2050
4	Water	Water reuse in the industrial sector	Reuse in Industry	Reuse of water in the industrial sector (recycled water)	0	Yes	Multiple	0%	0%	0%	5	30	Medium	Medium	Medium	Medium positive	No	Establish water reuse practices or increase water reuse in industry	Column H: From 2020 - Until 2050
5	Climate	Reduction of non-ETS GHG emissions until 2020	Non-ETS emissions reduction (2020)	Reduction of GHG emissions derived from the non-ETS sectors (agriculture, non-ETS industry, etc.) through the adoption of relative technologies (e.g. technologies that reduce CO_2 emissions)	0	No	Multiple	0%	40%	60%	5	5	High	High	Medium	High positive	No	GHG emissions derived from the non-ETS sectors	Column H: Until 2020
6	Climate	Reduction of ETS GHG emissions until 2020	ETS emissions reduction (2020)	Reduction of GHG emissions derived from ETS sectors (e.g. power generation sector)	0	No	Multiple	0%	40%	60%	5	5	High	High	Medium	High positive	No	GHG emissions derived from ETS sectors	Column H: Until 2020

7	Climate	Reduction of non-ETS GHG emissions until 2030	Non-ETS emissions reduction (2030)	Reduction of GHG emissions derived from the non-ETS sectors (agriculture, non-ETS industry, etc.) through the adoption of relative technologies (e.g. technologies that reduce CO2 emissions)	0	No	Multiple	0%	0%	0%	5	10	High	High	Medium	High positive	No	GHG emissions derived from the non-ETS sectors	Column H: From 2021 - Until 2030
8	Climate	Reduction of ETS GHG emissions until 2030	ETS emissions reduction (2030)	Reduction of GHG emissions derived from ETS sectors (e.g. power generation sector)	0	No	Multiple	0%	0%	0%	5	10	High	High	Medium	High positive	No	GHG emissions derived from the ETS sectors	Column H: From 2021 - Until 2030
9	Climate	Reduction of non-ETS GHG emissions until 2050	Non-ETS emissions reduction (2050)	Reduction of GHG emissions derived from non-ETS sectors (e.g. agriculture, non-ETS industry) through the adoption of relative technologies (e.g. technologies that reduce CO2 emissions)	0	No	Multiple	0%	0%	0%	5	20	High	High	Medium	High positive	No	GHG emissions derived from the non-ETS sectors	Column H: From 2031 - Until 2050
10	Climate	Zero non-ETS GHG emissions until 2050	Zero non-ETS emissions (2050)	Reduction of GHG emissions derived from non-ETS sectors (e.g. agriculture) in order to achieve 0 emissions through the adoption of relative technologies (e.g. technologies that reduce CO2 emissions)	0	No	Multiple	0%	0%	0%	10	20	High	High	Medium	High positive	No	GHG emissions derived from the non-ETS sectors	Column H: From 2031 - Until 2050
11	Climate	Zero ETS GHG emissions until 2050	Zero ETS emissions (2050)	Reduction of GHG emissions derived from ETS sectors (e.g. power generation sector) in order to achieve 0 emissions	0	No	Multiple	0%	0%	0%	10	20	High	High	Medium	High positive	No	Assumptions about GHG emissions (CO2) derived from ETS sectors	Column H: From 2031 - Until 2050
12	Climate	Sustainable management of the LULUCF sector	LULUCF sector	Protection of forest land, wetland, grassland and crop land (e.g. land use regulations, effective confrontation of forest fires)	0	Yes	Multiple	0%	0%	0%	5	30	Medium	Medium	High	High positive	No	Assumptions about the area covered by forest land, grassland and crop land	Column H: From 2021 - Until 2050
13	Energy	Increase of RES use in the transportation sector	RES - Transportation	RES share in the transportation sector by 10% until 2020: use of biofuels (biomass)	0	No	Multiple	0%	40%	60%	5	10	Medium	Medium	Medium	Medium positive	E3ME	Share of biofuels in the transportation sector	Column H: From 2010 - Until 2020

14	Energy	Increase of RES use in the industrial sector	RES - Industry	Promotion / Use of biomass in the industrial sector	0	Yes	Multiple	0%	40%	60%	5	10 (2010-2020), 30 (2020-2050)	Medium	Medium	Medium	Medium positive	E3ME	Share of biomass in the industrial sector	Column H: From 2010 - Until 2020 / Same policy card for 2020-2050
15	Energy	Increase of RES use in the household/commercial sector	RES - Household/Commercial	Promotion / Use of biomass in the household/commercial sector	0	Yes	Multiple	0%	40%	60%	10	10 (2010-2020), 30 (2020-2050)	Medium	Medium	Medium	Medium positive	E3ME	Share of biomass in the household/commercial sector	Column H: From 2010 - Until 2020 - Same policy card for 2020-2050
16	Energy	Increase of RES use in the agricultural sector	RES - Agriculture	Promotion / Use of biomass in the agricultural sector	0	Yes	Multiple	0%	40%	60%	5	10 (2010-2020), 30 (2020-2050)	Medium	Medium	Medium	Medium positive	E3ME	Share of biomass in the agricultural sector	Column H: From 2010 - Until 2020 - Same policy card for 2020-2050
17	Energy	Increase of RES use in other sectors	RES - Other sectors	Promotion / Use of biomass in other sectors	0	Yes	Multiple	0%	40%	60%	5	10 (2010-2020), 30 (2020-2050)	Medium	Medium	Medium	Medium positive	E3ME	Share of biomass in other sectors	Column H: From 2010 - Until 2020 - Same policy card for 2020-2050
18	Energy	Contribution of PVs to electricity generation	PVs - Electricity	Electricity generation from PVs up to 2500 MW until 2020	0	No	Multiple	0%	40%	60%	5	10	High	High	High	High positive	No	Share of PVs in electricity generation	Column H: From 2010 - Until 2020
19	Energy	Contribution of wind parks to electricity generation	Wind - Electricity	Electricity generation from wind up to 7500 MW until 2020	0	No	Multiple	0%	40%	60%	5	10	High	High	High	High positive	No	Share of wind parks in electricity generation	Column H: From 2010 - Until 2020
20	Energy	Contribution of hydro-power plants to electricity generation	Hydro - Electricity	Electricity generation from hydro-power plants up to 3000 MW until 2020	0	No	Multiple	0%	40%	60%	5	10	High	High	High	High positive	No	Share of hydro-power plants in electricity generation	Column H: From 2010 - Until 2020

21	Energy	Contribution of biomass to electricity generation	Biomass - Electricity	Electricity generation from biomass power plants	0	Yes	Multiple	0%	0%	0%	5	30	Medium	High	High	High positive	No	Share of biomass power plants in electricity generation	Column H: From 2020 - Until 2050
22	Energy	Contribution of RES to electricity generation	RES - Electricity (2030)	Further promotion / use of RES for electricity generation	0	No	Multiple	0%	0%	0%	5	10	High	High	High	High positive	No	the same with 6, 7, 8, 9 sections of O1	Column H: From 2020-2030
23	Energy	Contribution of natural gas to energy generation	Natural gas - Energy	Promotion / Use of natural gas in the electricity generation plants, industrial, household/commercial, transportation and other sectors	0	Yes	Multiple	0%	40%	60%	5	10 (2010-2020), 30 (2020-2050)	High	Medium	High	High positive	No	Demand of natural gas by the electricity generation sector, industrial, household/commercial, transportation and other sectors	Column H: From 2010 - Until 2020 - Same policy card for 2020-2050
24	Energy	Replace of oil with other sources for energy production	Oil reduction	Reduction of oil and use of other resources (e.g. natural gas) for energy production in the industrial, household/commercial, electricity generation, transportation, construction and other sectors	0	Yes	Multiple	0%	40%	60%	5	10 (2010-2020), 30 (2020-2050)	High	High	Medium	High positive	No	Demand of oil by the industrial, household/commercial, agricultural, electricity generation, transportation, construction and other sector	Column H: From 2010 - Until 2020 - Same policy card for 2020-2050
25	Energy	Total electricity generated from RES (2050)	RES - Electricity (2050)	85%-100% electricity generation from RES using all commercially mature technologies	0	Yes	Multiple	0%	0%	0%	5	30 (2020-2050)	High	High	High	High positive	E3ME	Increase of RES share in electricity generation. Electricity generation plants that exploit RES to produce electricity	Column H: From 2020 - Until 2050

26	Energy	Replace of coal with other sources for electricity production	Coal reduction	Reduction of coal and use of other energy sources (e.g. RES) for electricity production	0	Yes	Multiple	0%	0%	0%	10	30 (2020-2050)	High	High	High	High positive	No	Reduction of coal demand by the industrial and electricity generation sectors. Electricity produced from coal	Column H: From 2020 - Until 2050
27	Food	Cover of food / fodder needs and needs of agri-industrial products	Agricultural production	Implementation of measures (e.g. subsidies) that reinforce agricultural production in order to cover food and fodder needs as well as needs related to agri-industrial products	0	Yes	Multiple	0%	0%	0%	5	30 (2020-2050)	Medium	Medium	Medium	High positive	No	Area of crops producing food, feed and industrial products	Column H: From 2020 - Until 2050
28	Food	Cover of food needs from the sector of livestock	Livestock production	Implementation of measures (e.g. subsidies) that reinforce livestock production in order to cover food needs	0	Yes	Multiple	0%	0%	0%	5	30 (2020-2050)	Low	Medium	Medium	High positive	No	Number of animal heads or beehives	Column H: From 2020 - Until 2050
29	Land	Protection of agricultural land and pastures	Land use regulations	Land use regulations aiming at the protection of agricultural land and livestock areas – Elimination of land use conflicts	0	Yes	Multiple	0%	40%	60%	5	5 (2015-2020) and 30 (2020-2050)	Medium	Medium	Medium	High positive	No	Area occupied by crops and livestock	Column H: From 2014 - Until 2020 and from 2020-2050
30	Land	Protection of biodiversity and LULUCF	Biodiversity/LULUCF	Organization of reforestation actions in the national, regional and municipality level in order to restore biodiversity, forest land wetlands and grasslands (often destroyed by forest fires) – Management of land use conflicts with the agricultural and livestock sectors	0	Yes	Multiple	0%	0%	50%	5	10 (2015-2025) and 25 (2025-2050)	High	Medium	High	High positive	No	Availability of forest land, wetland and grassland	Column H: From 2015 - Until 2025 and from 2025-2050

9.7. National Case Study: Latvia

Table 9.26. Policy goals table for Latvia

Policy Goal (PG) - Name	Policy Goal (PG) - Description	Policy Goal id

Water Quality	Reduction of nitrogen leakage in surface waters	PG1-W
Energy efficiency	Improving energy efficiency [in 2030 final energy consumption 3.57 Mtoe; decrease of energy demand of 41% by 2050 as compared to 2005/2006]	PG2-E
Electricity production by RES	Increase the share of electricity produced by RES in total electricity production (up to 100% of RES in 2050)	PG3-E
Decarbonisation of transport	Replacement of fossil fuels in transport [7.7 PJ of fossil fuels are replaced in 2030; share of advanced biofuels in gross final energy consumption in transport 3.5% in 2030; A biofuel mandate is set to cover remaining liquid fuels, reaching 18% of total fuel consumption by 2050.]	PG4-E
Sustainable food	Food security and sustainable food production [SDG 2]	PG5-F
Dietary patterns	Sustainable consumption and production patterns [Changing dietary (meat) patterns, SDG 12]	PG6-F
Sustainable agricultural land use	Sustainable land use (arable land and grassland) taking into account farm welfare	PG7-L
Sustainable agricultural activities	Sustainable agricultural activities on arable land taking into account farm welfare	PG8-L
GHG emissions	Reduction of GHG emissions (-55% by 2030 compared to 1990; -80% by 2050 compared to 1990)	PG9-C
CO2 sequestration	Increase CO2 sequestration (accounted GHG emissions do not exceed accounted GHG removals by 2030 - summing up all land categories)	PG10-C

Table 9.27. Policy goals score indicator thresholds for Latvia

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,1
PG1-W	medium	0,2
PG1-W	high	0,3
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-E	low	0,1
PG2-E	medium	0,2
PG2-E	high	0,4
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-E	low	0,4
PG3-E	medium	0,45
PG3-E	high	0,6
Policy Goal id	*Policy Goal Indicator thresholds*	
PG4-E	low	0,1
PG4-E	medium	0,3
PG4-E	high	0,5
Policy Goal id	*Policy Goal Indicator thresholds*	
PG5-F	low	0,2
PG5-F	medium	0,4
PG5-F	high	0,6
Policy Goal id	*Policy Goal Indicator thresholds*	
PG6-F	low	0,4
PG6-F	medium	0,7

PG6-F	high	1
Policy Goal id	*Policy Goal Indicator thresholds*	
PG7-L	low	0,4
PG7-L	medium	0,45
PG7-L	high	0,5
Policy Goal id	*Policy Goal Indicator thresholds*	
PG8-L	low	0,2
PG8-L	medium	0,5
PG8-L	high	0,8
Policy Goal id	*Policy Goal Indicator thresholds*	
PG9-C	low	0,4
PG9-C	medium	0,6
PG9-C	high	0,8
Policy Goal id	*Policy Goal Indicator thresholds*	
PG10-C	low	0,1
PG10-C	medium	0,3
PG10-C	high	0,5

Table 9.28. Policy objectives table for Latvia

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-W	Increase use of precise technologies	O1	0,3
PG1-W	Increase biological farming	O2	0,4
PG1-W	Increase N accumulation in soil	O3	0,3
PG2-E	Increase energy efficiency in industry (by insulation of buildings)	O4	0,1
PG2-E	Decrease heat consumption in households by 30% (by insulation of buildings)	O5	0,4
PG2-E	Decrease heat consumption in tertiary sector (by increasing energy efficiency in buildings of services, public buildings)	O6	0,3
PG2-E	More efficient use of biomass as a resource for heat energy production	O7	0,2
PG3-E	Application of new technologies for electricity production from biomass	O8	0,6
PG3-E	Increase electricity production from wind energy	O9	0,4
PG4-E	Increase of electric vehicles	O10	0,3
PG4-E	Increase the use of biofuels in transport	O11	0,7
PG5-F	Increase production of organic cereals	O12	0,3
PG5-F	Increase export of cereals	O13	0,3
PG5-F	More productive cultivars of cereals	O14	0,4
PG6-F	Balance diets to reduce meat consumption	O15	0,5
PG6-F	Balance meat production to ensure self-supply	O16	0,5
PG7-L	Increase arable land	O17	0,33

PG7-L	Increase perennial grassland	O18	0,33
PG7-L	Balance arable land and perennial grassland	O19	0,34
PG8-L	Increase land for rape	O20	0,7
PG8-L	increase land for legumes in crop rotation	O21	0,3
PG9-C	Reduce GHG emissions by biogas production from manure	O22	0,6
PG9-C	Reduce GHG emissions by improved feed	O23	0,2
PG9-C	Reduce GHG emissions by fertilisation planning	O24	0,2
PG10-C	Young forest maintenance	O25	0,5
PG10-C	Increase afforestation	O26	0,5

Table 9.29. Policy objective performance indicators formulas table for Latvia

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	(Share of area where the technology is applied * Share of reduction 0.08*fraction of N loss)+ (1-(Mineral fertilisers - 12.3)/mineral fertilisers kg/ha)* Share of area where the technology is applied *fraction of N loss)	Share of reduced nitrogen leakage
O2	Share of biological farming*fraction of N loss	Share of reduced nitrogen leakage
O3	Share of area for green cover* Share 0.1*fraction of N loss	Share of reduced nitrogen leakage
O4	Share of reduced energy [heat & electricity] consumption * Share of industry enterprises using subsidies / energy [heat & electricity] consumption in industry	Share of reduced energy (Heat & electricity) consumption
O5	(Share of reduced heat consumption 0.3* Share of population using subsidies in first go 0.4*Heat consumption in households) + (1- Share of population using subsidies in first go)*Heat consumption in households)/Heat consumption in households	Share of reduced heat energy consumption
O6	(Share of reduced heat consumption 0.3* Share of tertiary sector using subsidies in first go 0.2*Heat consumption in tertiary sector) + (1- Share of tertiary sector using subsidies in first go)*Heat consumption in tertiary sector)/Heat consumption in tertiary sector	Share of reduced heat energy consumption
O7	(1-(lower conversion factor cf1/higher conversion factor cf2))* Share of heat energy produced with efficient technology	Share of increased heat energy production from biomass (due to more efficient conversion factor)
O8	Electricity production from biomass/total electricity produced	Share of electricity produced by biomass energy in the total energy production
O9	Electricity production from wind/total electricity produced	Share of electricity produced by wind energy in the total energy production
O10	Share of reduced fossil fuel (oil) in transport	Share of reduced fossil fuel consumption in transport by electric vehicles
O11	Consumed energy from biofuels in transport/Total fossil (oil) consumption in transport	Share of reduced fossil fuel consumption in transport by biofuels
O12	Cereals produced in biological farms / Total amount of cereals produced	Share of organic cereals produced
O13	Cereals exported/ Total amount of cereals produced	Share of cereals export
O14	(Yield from more productive cultivars*share of area of more productive cultivars) + (Yield of conventional cultivars* share of area of conventional cultivars) / Total amount of cereals produced by conventional cultivars	Share of cereals produced from more productive cultivars

O15	(Reduced meat consumption*Share of population) + (Conventional meat consumption*Share of population)/ Conventional meat consumption	Share of meat self-supply
O16	Per capita meat consumption/(Fixed share of produced meat to meat cattle heads *meat cattle heads)/population	Share of meat self-supply
O17	(Share of arable land 0.7*Income cereals [from CAPRI] + share of grasslands 0.3* Income grass and grazing extensive)/Income utilised agricultural area	Welfare fraction of land use
O18	Share of arable land 0.3*Income cereals [from CAPRI] + share of grasslands 0.7* Income grass and grazing extensive)/Income utilised agricultural area	Welfare fraction of land use
O19	Share of arable land 0.5*Income cereals [from CAPRI] + share of grasslands 0.5* Income grass and grazing extensive)/Income utilised agricultural area	Welfare fraction of land use
O20	Share of rape on arable land 0.25*Income rape [from CAPRI] + share of cereals 0.75* Income cereals)/Income arable land	Welfare fraction of agricultural activities
O21	((1- Share of rape)* Share of cereals* Income cereals [from CAPRI] + (1-Share of rape) * Share of legumes 0.25* Income legumes + Share of rape * Income rape))/Income arable land	Welfare fraction of agricultural activities
O22	Share of dairy cows for manure for biogas production 0.5*0.1	Share of reduced GHG emissions from agriculture
O23	Share of dairy cows for improved feed 0.5*0.1*0.14	Share of reduced GHG emissions from agriculture
O24	Fertilisation planning 0.27*0.46	Share of reduced GHG emissions from agriculture
O25	Share of increase of young forest maintenance with subsidies 0.4	Share of increased CO2 sequestration in young forests
O26	Share of increased forest regeneration 0.2	Share of increased CO2 sequestration by regenerated forests

Table 9.30. Policy cards table for Latvia

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Water/ Climate	Application of precise technologies for fertilisation	Precise fertilisation	Precise technologies for application of fertilisers (reduction of N consumption 8%), subsidies for purchase of technology [reduction share of 0.08 of mineral N fertilisers]	0	Yes	Multiple	0%	5%	10%	0	5	High	Medium	Low	Low positive	No	Water: Reduction of N leakage from reduced amount of used fertilisers Climate: Reduction of N2O emissions from reducing the use of nitrogen fertilisers	[active until 2030]

2	Water/ Climate	Increase application of modern slurry application technologies	Direct slurry injection	Direct injection of organic slurry into the soil, subsidies for purchase of technologies [reduction of nitrogen fertilisers by 12.3 kg N per ha].	0	Yes	Multiple	0%	0%	5%	0	5	High	Medium	Low	Low positive	No	Water: Reduction of N leakage from reduced amount of used fertilisers	[active until 2030]
3	Water	Increase of biological farming	Biological farming	Application of mineral fertilisers is not allowed in biological farming; rural support payments for growing of cereals by biological farming [reduction share of 1 for mineral fertiliser on share of land for biological cereals]	0	No	Multiple	0%	0%	5%	0	5	Low	Low	Low	Medium positive	No	Water: Reduction of N leakage from reduced amount of used fertilisers	
4	Water	Application of green cover before next spring crops	Green cover	Establishment of green cover before next spring crops, mandatory for receiving rural support payments [reduction share of 0.1 of mineral N fertilisers]	0	No	Multiple	0%	0%	0%	5	5	Low	Medium	Low	Medium positive	No	Water: Reduction of N leakage from reduced amount of used fertilisers	
5	Energy	Increase energy efficiency in industry	Energy efficiency in industry	Improvements to energy efficiency in industry , subsidies for investments in new more efficient technologies in production processes as well as for insulation of industrial buildings, [reduction of energy consumption in industry]	0	yes	Multiple	-10%	5%	5%	5	5	High	Medium	Low	Low positive	E3ME (2-degree scenario)	Energy: Reduction in final energy demand	[active until 2030]

6	Energy	Increase energy efficiency in households	Energy efficiency in households	Improvements to energy efficiency in households (subsidies for investments in insulation of buildings) [reduction of heat energy consumption in households]	0	yes	Multiple	-10%	5%	5%	0	5	Medium	High	Medium	High positive	E3ME (2-degree scenario)	Energy: Reduction in final energy demand	[active until 2030]
7	Energy	Increase energy efficiency in tertiary sector	Energy efficiency in tertiary sector	Improvements to energy efficiency in tertiary sector (subsidies for investments in insulation of public buildings) [reduction of heat energy consumption in tertiary sector]	0	yes	Multiple	-20%	5%	10%	0	5	Medium	High	Low	Medium positive	E3ME (2-degree scenario)	Energy: Reduction in final energy demand	[active until 2030]
8	Energy	More efficient use of biomass resource	Energy from biomass	Replacement of old technologies for use of biomass in combustion plants installed in district heating and local heating (subsidies) [Coefficient on efficiency of biomass combustion technologies, result in resource savings]	0	yes	Multiple	0%	0%	0%	5	10	High	Medium	Low	Low positive	No	Energy: reduced biomass consumption (resource efficiency)	[implemented after 2025]
9	Energy	Application of new technologies for electricity production from biomass	New RE technologies	Application of new and more efficient technologies for electricity production from biomass e.g., gasification, pyrolysis, subsidies for production units [replacement of natural gas]	0	yes	Once	0%	0%	0%	5	10	High	High	Medium	Medium positive	No	Energy: Increase use of biomass	[implemented after 2030]

10	Energy	Increase wind energy production	Wind energy	Support for broader application of wind energy technologies (feed in tariffs and subsidies)	0	no	Multiple	-5%	5%	5%	0	5	Medium	Medium	High	Low positive	E3ME	Energy: Increased energy production from wind	[active until 2025]
11	Energy	Increase number of electric vehicles	Electric vehicles	Encouraging uptake of electric cars (subsidies for purchasing of ELVs) [reduction of consumption of fossil fuels in transport]	0	no	Multiple	10%	0%	0%	0	5	Medium	Medium	Medium	Low positive	E3ME	Energy: Reduction of fossil fuel consumption in transport	(only during the period of subsidies) [implemented after 2030]
12	Energy	Increase share of biofuels in transport	Use of biofuels	Mandate for the use of biofuels in transport (mandatory requirement). [Biofuels shall reach 18% of the total fuel consumption by 2050]	0	Yes	Once	0%	5%	5%	5	10	Medium	Low	High	Low positive	CAPRI, E3ME	Energy: share of biofuels in total fuel consumption in transport	
13	Food	Increase production of organic cereals in biological farming	Organic cereals	Support to biological cereals in food production (thsd.tonnes), rural support payments to organic farmers [share of cereals 3% of total production in 2017]	0	No	Multiple	5%	5%	10%	0	5	Low	Low	Low	Medium positive	No	Food: share of organic cereals	
14	Food	Increase export of cereals - wheat	Cereals export	Promotion of export of cereals (mainly wheat) at the same time ensuring domestic demand by self-supply, communication measure [increased share of export]	0	No	Multiple	0%	5%	5%	0	5	Low	Medium	Low	Low positive	CAPRI	Food: share of cereals export	

15	Food	Productive cultivars of cereals	Productive cereals	Promotion of more productive cultivars of cereals, subsidies to farmers [increased yields, not increased use of fertilizers]	0	No	Multiple	0%	0%	0%	0	5	Low	Medium	Low	Low positive	No	Food: increased yield of production	[implemented after 2025]
16	Food	Reduction of meat consumption	Reduced meat consumption	Promotion of reduction of meat consumption (kg/capita), communication measure [meat consumption reduces for 1/2, share of population implementing this; meat calories are replaced by cereals], [calculation from kcal intake from meat and cereals]	0	Yes	Multiple	0%	0%	0%	5	5	Low	Low	Medium	Medium positive	CAPRI	Food: reduced meat consumption, increased cereals consumption (kcal)	
17	Food	Balance meat production to self-supply	Meat production	Increased share of meat cattle (decrease of milk cattle), rural support payments to farmers [share of meat to dairy cattle, total number of cattle remains]	0	Yes	Multiple	0%	5%	5%	0	5	Medium	Medium	Low	Low positive	No	Food: increased number/share of meat cattle and reduced dairy cattle	
18	Land	Increase arable land	Increase arable land	Increase of arable land (max. up to 70% of used agricultural land), rural support payments, [resulting in reduction of grasslands]	0	No	Multiple	5%	5%	5%	0	5	Low	Medium	Low	Low negative	No	Land: increased arable land	[share calculated on regional level]

19	Land	Ratio-based perennial grasslands on agricultural area	Grasslands on agricultural area	Maintaining/establishing the share of perennial grasslands on arable land (up to 70% of used agricultural land), rural support payments for grasslands [reduction of sown area, reduction of total amount of mineral fertilisers applied]	0	No	Multiple	0%	0%	5%	0	5	Low	Low	Low	Low positive	No	Land: reduction of area for cereals	[share calculated on regional level]
20	Land	Balanced perennial grasslands and arable land	Balanced grasslands and arable land	Maintaining/establishing the share of perennial grasslands (50%) and arable land (50%), rural support payments for grasslands	0	No	Multiple	0%	0%	5%	0	5	Low	Low	Low	Low positive	No	Land: balanced arable land and perennial grasslands	[share calculated on regional level]
21	Land	Increase growing of energy crop - rape	Growing of energy crop - rape	Increase of land for energy crops - rape up to 25% arable area - rural support payments [baseline data show 13-15% from total arable land] [resulting in reduction of area for cereals]	0	No	Multiple	-10%	10%	20%	0	5	Low	Medium	Low	Low negative	No	Land: increased land for rape	

22	Land	Legumes in crop rotation	Legumes in crop rotation	Cultivation of legumes in crop rotation, rural support payment, (result in reduction of area for cereals, increase in nitrogen sequestration and carbon accumulation) [Up to 25% of arable land for cereals][Reduction of GHG (N20) emissions from reducing the use of nitrogen fertilisers (-62.4 kg N t/ha), increase of carbon accumulation in soil by7t/ha)]	0	No	Multiple	0%	0%	0%	0	5	Low	Low	Low	Low positive	CAPRI	Land: reduction of area for cereals Climate: increase of carbon accumulation in soil, reduction of N2O emissions	
23	Climate	Increase production of biogas from manure	Production of biogas	Promotion of production of biogas from manure (subsidies for investments); resulting in reduction of CH4 and N2O emissions from the manure management [lowest threshold for support is 80 heads of cattle; 50% from dairy cattle qualifies for receiving of subsidies]	0	Yes	Multiple	-10%	5%	5%	5	5	Medium	Medium	Medium	Low positive	No	Climate: Reduction of GHG (CH4 and N20) emissions from the manure management in agriculture	

24	Climate	Improvement of feed quality	Feed quality	Subsidies for improvement of feed quality (resulting in reduction of CH4 emissions from enteric fermentation because of food digestibility improvements from 66 to 67%) [Applied to 50% of dairy cows; reduction of CH4 emissions for 14%]	0	No	Multiple	5%	0%	0%	0	5	Low	Low	Low	Low positive	No	Climate: Reduction of GHG (CH4) emissions from cows as a result of food digestibility improvement	
25	Climate	Support to fertilization planning	Fertilization planning	Fertilization planning to reduction of GHG emissions, rural support payments [apply to 27% from 46.2% of utilized agricultural area, reduction of N2O emissions, reducing the use of nitrogen fertilizers by 27%]	0	No	Multiple	5%	5%	10%	0	5	Low	Low	Low	Low positive	No	Climate: Reduction of N2O emissions from agriculture	
26	Climate	Support to young forest maintenance	Young forest maintenance	Support to young forest maintenance [share of managed forest], subsidies for forest maintenance, increased carbon sequestration 21 tCO2/ha in 10 years]	0	No	Multiple	10%	5%	10%	0	5	Low	Medium	Low	Medium positive	No	Climate: increased carbon accumulation	

27	Climate	Increase afforestation	Increase afforestation	Support to forest cultivation (afforestation, resulted in increase of forest area, increased carbon accumulation in afforested lands), subsidies for afforestation activities [share of forest area, increase on land for meadows and pastures] [a total of 10 000 ha increased by 2030]	0	No	Multiple	0%	5%	10%	0	5	Medium	Medium	Low	Medium positive	No	Climate: Increased carbon accumulation in afforested land	[active until 2030]

9.8. National Case Study: Netherlands

Table 9.31. Policy goals table for Netherlands

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Water resources	Good water quality and supply of surface and ground water	PG1-Wa
Biomass/energy	Sustainable increase in biomass supply	PG2-B
Agriculture	Sustainable and viable agricultural sector	PG3-A
Food Policy	Food security and good quality food	PG4-F
Nature Policy	Sustainable chains (for biomass in NL)	PG5-N
Spatial Planning/Land use	Increase competitiveness of the Netherlands with respect to spatial economic structure	PG6-L
Waste policies	Optimal utilization of resources: circular economy	PG7-W
Climate policy	Low carbon economy	PG8-C

Table 9.32. Policy goals score indicator thresholds for Netherlands

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-Wa	low	0,33
PG1-Wa	medium	0,5
PG1-Wa	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-B	low	0,33
PG2-B	medium	0,5

PG2-B	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-A	low	0,33
PG3-A	medium	0,5
PG3-A	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG4-F	low	0,33
PG4-F	medium	0,5
PG4-F	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG5-N	low	0,33
PG5-N	medium	0,5
PG5-N	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG6-L	low	0,33
PG6-L	medium	0,5
PG6-L	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG7-W	low	0,33
PG7-W	medium	0,5
PG7-W	high	0,66
Policy Goal id	*Policy Goal Indicator thresholds*	
PG8-C	low	0,5
PG8-C	medium	0,8
PG8-C	high	0,95

Table 9.33. Policy objectives table for Netherlands

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-Wa	Good water quality	O1	0,5
PG1-Wa	Sufficient water supply	O2	0,5
PG2-B	Sustainable increase in biomass supply	O3	1
PG3-A	Improving competitiveness	O4	0,3
PG3-A	Improving sustainability	O5	0,7
PG4-F	Sustainable food chains	O6	0,6
PG4-F	Alternative protein for the Netherlands	O7	0,3
PG5-N	Sustainable chains (for biomass in NL)	O8	0,2
PG5-N	Closed loops and higher value for resources (biomass)	O9	0,5

PG5-N	Restoring degraded ecosystems (on land)	O10	0,3
P96-L	Space for the main network of (sustainable) energy supply and energy transition	O11	0,4
PG6-L	Sustainable, safe and efficient use of the soil	O12	0,6
PG7-W	Optimal utilization of resources: circular economy	O13	1
PG8-C	Low carbon economy non-agriculture	O14	0,94
PG8-C	Low carbon economy agriculture	O15	0,06

Table 9.34. Policy objective performance indicators formulas table for Netherlands

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	(variable1 + variable2 + variable3)/3	Nutrient emissions from agriculture to water
O2	(variable1 + variable2 + variable3)/3	Water use for irrigation
O3	(variable1 + variable2 + variable3)/3	Use of biomass of different sources
O4	(variable1 + variable2 + variable3)/3	Crops of high value production
O5	(variable1 + variable2 + variable3)/3	Combination of environmental impact variables
O6	(variable1 + variable2 + variable3)/3	National biomass consumption
O7	(variable1 + variable2 + variable3)/3	Composition of human diet
O8	(variable1 + variable2 + variable3)/3	National biomass consumptions
O9	(variable1 + variable2 + variable3)/3	Biomass consumption = biomass production
O10	(variable1 + variable2 + variable3)/3	Natural areas in the Netherlands
O11	(variable1 + variable2 + variable3)/3	Sustainable energy production in NL
O12	(variable1 + variable2 + variable3)/3	Non-intensive arable production,
O13	(variable1 + variable2 + variable3)/3	National production = national consumption
O14	(variable1 + variable2 + variable3)/3	Reduction of GHG
O15	(variable1 + variable2 + variable3)/3	Reduction of GHG

Table 9.35. Policy cards table for Netherlands

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Agriculture	Reform CAP; income support to climate measures	Income support	Payment per ha through European agricultural policy to reduce greenhouse gas emissions by 10% for 5 years	1	No	Multiple	-8%	0	0	5	5	Medium	Medium	Medium	+Medium	No	Lower GHG emission factors per unit of agricultural value added	
2	Agriculture	Reform CAP; support innovation	Innovation support	Revised CAP: per-hectare payment for biomass leading to 25,000 ha of biomass at the expense of 25,000 ha of extensive arable crops for 5 years	1	No	Multiple	-10%	0	0	5	5	Medium	high	Low	+High	No	Increase/higher share of land for biomass	

3	Agriculture	Levy on Non-ETS greenhouse gases	Levy Non-ETS	Taxation of Non-ETS greenhouse gases in agriculture leading to a 10% Lower yield per ha.	1	No	Multiple	0%	0	0	5	5	Low	Medium	high	-Medium	No	Decrease volume of agriculture production (land, herd size)	
4	Agriculture	Subsidy sustainable farming aimed at reducing greenhouse gas emissions	Subsidy sustainable farming	Stimulating production systems that save greenhouse gases by 10%.	1	No	Multiple	-30%	0	0	10	5	High	high	Low	+Medium	CAPRI	Lower GHG and other emissions per unit production	
5	Agriculture	Restriction herd size to reduce greenhouse gas emissions	Reduction herd size	Reduce the herd by 10%.	1	Yes	Multiple	0%	0	0	0	40	High	Low	high	-Medium	No	Decrease the herd size of livestock	
6	Agriculture	Investment water storage peat land (higher water tables)	Investment water storage peat land	The groundwater level in the peat meadows is raised to 10 cm below ground level. This leads to a Lower yield in grassland. (and a reduction in the number of livestock).	1	Yes	Multiple	0%	0	0	0	40	High	high	Low	+High	No	Lower yield coefficient grassland peatland	

7	Energy	Stimulating investment in CCS	Stimulating CCS	Stimulation of CCS leading to 25% more CCS	1	Yes	Once	-10%	0	0	10	5	High	high	high	-Low	E#ME	Higher prices of fossil energy production	
8	House hold	Incorporating environmental and climate costs into food prices	To include climate cost in food prices	Internalisation of environmental and climate costs leads to 20% higher food costs and a decrease in per capita demand for food.	1	No	Once	-20%	0	0	0	5	High	Medium	high	-Low	MAGNET	Lower demand for food	
9	House hold	Ban on wood-burning stoves, unless they have more than 90% efficiency	Ban on wood stoves	A ban on wood-burning stoves will lead to a 1% reduction in total greenhouse gas emissions.	1	No	Once	0%	0	0	5	40	Medium	Low	high	-High	No	A reduction in energy production and a Lower GHG emission	
10	Industry	Accelerated Lowering of the emission ceiling	Emission ceiling	A 25% reduction of the EU ETS emissions cap in industry leads to a price increase of Non-renewable energy.	1	No	Multiple	0%	0	0	5	5	High	Low	high	-Low	MAGNET	Lower demand for NRE and high demand for RE	
11	Industry	Stimulating CCS investment	CCS investment	The price of fossil energy will be increased by 10%.	1	No	Multiple	-10%	0	0	10	40	High	high	Medium	+Low	E3ME	Higher prices of fossil energy production	

12	Industry	Levy on Non-ETS greenhouse gases, industry	Levy carbon industry	A 10% levy on Non-ETS greenhouse gases (waste)	1	No	Multiple	-10%	0	0	5	5	Low	Low	Medium	-Medium	No	Decrease volume of agriculture production (land, herd size)	
13	Other	Levy on Non-ETS greenhouse gases, Non industry	Levy carbon Non-industry	A 10% levy on Non-ETS greenhouse gases from buildings	1	No	Multiple	-10%	0	0	5	5	Low	ow	Medium	-Medium	No	Decrease volume of agriculture production (land, herd size)	
14	Transportation	Levy on Non-ETS greenhouse gases, transport	levy carbon transport	A levy of 10% on Non-ETS greenhouse gas transport	1	No	Multiple	-10%	0	0	5	5	Low	Low	high	-Medium	No	Decrease volume of agriculture production (land, herd size)	
15	Transportation	Switching from diesel cars to Low-carbon cars (electric or hydrogen)	Low carbon cars	A ban on diesel cars will be introduced in 5 years' time and will lead to Lower emissions.	1	No	Once	-10%	0	0	10	5	High	Low	high	-Medium	No	Lower GHG emissions of fuel use (transportation)	
16	Agriculture	Green deal high quality biomass experimenting	Biomass experimenting	A green deal on better use of biomass for energy leads to a 10% increase in energy per tonne of dry matter.	1	Yes	Once	-20%	0	0	5	5	Low	high	Low	+High	No	Higher energy efficiency indicators biomass	

17	Agriculture	Pricing for the use of fossil carbon as a raw material for production	Pricing fossil resources	Higher energy prices (+20%). The result is a higher demand for renewable energy.	1	No	Multiple	-5%	0	0	0	5	Medium	Low	high	-Medium	No	Changes in prices, higher demand for RE in sector	
18	Agriculture	Financial support for more sustainable biomass production	Financial support biomass production	Through the Rural Development Programme, an area payment of 400 euros will be made for the production of biomass.	1	No	Multiple	0%	0	0	0	5	Medium	high	Low	+High	No	Larger share of land for biomass for energy (energy crops)	
19	Agriculture	Stimulating field margins for biodiversity and biomass	Field margins for biomass	The Rural Development Programme provides an area payment for field margins.	1	No	Multiple	0%	0	0	0	5	Medium	Medium	Low	+Medium	No	Lower productivity of land, Lower emissions from agriculture	
20	Agriculture	Water storage for irrigation of energy crops production	Water storage	Water storage for irrigation in dry periods	1	yes	Once	-20%	0	0	5	40	High	high	Medium	+High	No	Higher yields energy crops	
21	All	Carbon tax on fossil energy	Carbon tax	A 25% tax on fossil energy	1	No	Multiple	0%	0	0	0	40	Medium	Low	high	-Low	E3ME	Price level of Renewable Energy compared to fossil fuels	

22	All	Investing in the energy efficiency of existing techniques	Investment energy efficiency	Improving the energy efficiency of existing techniques	0	yes	Once	-20%	0	0	5	40	High	high	Medium	+Low	E3ME	Higher energy yields per unit of primary energy	
23	Energy	Strategic partnerships with key biomass supplying countries	Partnership biomass producing countries	Through strategic cooperation with other countries, biomass imports can be increased by 25%.	1	No	Multiple	0%	0	0	5	5	Low	high	Low	+Medium	No	Increase capacity of large-scale biomass	
24	Energy	Further tightening of sustainability requirements for biofuels, biomass and biogas	More strict sustainability criteria	The sustainability requirements for biofuels, biogas and biomass will be tightened up by banning ILUC and phasing out 1st generation biofuels.	1	yes	Once	0%	0	0	10	40	High	Medium	high	-Low	No	Decrease of biomass capacity	
25	Energy	Closure of coal-fired power stations	Closure coal power plant	The coal-fired power stations will be closed over the next five years.	1	yes	Once	0%	0	0	15	40	High	Low	Medium	+High	No	Decrease coal power production	

26	All	Limitation of use of cooling water	To limit use cooling water	Restricting the use of cooling and process water in electricity generation, agriculture and industry	1	yes	Once	0%	0	0	0	40	High	Low	Low	-Low	No	Lower energy production	
27	House hold	Information campaign on different types of biomass	Stimulate behavioural change consumption biomass	Information campaigns will bring about a change in behaviour which will lead to a 10% increase in the consumption of sustainable biomass.	1	No	Multiple	-5%	0	0	0	40	Low	high	high	+Low	No	Higher demand for RE	
28	House hold	One clear sustainability label for consumer products	Sustainability label consumer products	The introduction of a sustainability label for energy and raw materials leads to consumption of sustainable biomass	1	No	Multiple	-5%	0	0	5	5	Low	Medium	high	+High	No	Lower GHG emissions from demand	
29	House hold	Stimulating energy savings in households	Energy saving households	Subsidies stimulate energy saving volunteering	1	Yes	Multiple	-5%	0	0	0	40	Medium	high	high	+Medium	E3ME	Lower energy demand per capita	
30	House hold	Producing biogas from human manure	Biogas human manure	Energy is produced from human biomass at the sewage treatment plant.	1	Yes	Once	0%	0	0	10	40	High	Medium	high	+Low	No	Lower energy demand consumers	

31	House hold	Energy saving househo lds subsidie s	Subsidy energy saving	Subsidies on energy saving by households	1	Yes	Multip le	-10%	0	0	0	5	High	high	Low	+High	No	Higher energy efficiency households	
32	Industr y	Adapting laws and regulatio ns use biomass	Change of law use of biomass	The law and regulations are adapted so that more waste can be used as a raw material.	1	yes	Once	0%	0	0	5	40	Low	Low	Low	+High	No	Higher energy efficiency indicators biomass	
33	Industr y	Pricing for the use of fossil carbon as a raw material for producti on	Pricing carbon resource s	Taxing fossil fuels in order to stimulate renewable energy in industry through the use of revenues	1	No	Multip le	-10%	0	0	0	5	Mediu m	Low	Mediu m	-High	No	Changes in prices, higher demand for RE in sector	
34	Industr y	Extend SDE+ subsidy to Carbon Capture and Storage (CCS), CCU and other methods	SOE+ for CCS and CCU	The SDE+ subsidy which is widened to include Carbon Capture and Storage (CCS), CCU and other methods.	1	yes	Multip le	-10%	0	0	0	5	High	high	Mediu m	+High	E3ME	Increase capacity of large-scale biomass	

35	Other	Pricing for the use of fossil carbon as a raw material for production	Taxing fossil fuels	Taxing fossil fuels to promote renewable energy in industry in sectors other than industry and transport.	1	yes	Once	0%	0	0	0	5	Medium	Low	high	-High	No	Changes in prices, higher demand for RE in sector	
36	Other	Stimulate energy savings in offices	Energy saving offices	By stimulating subspecies energy saving in offices	1	yes	Once	0%	0	0	5	40	Medium	Medium	Low	+Medium	E3ME	Lower energy demand per capita	
37	Other	Producing biogas with human manure (offices)	Biogas from human manure from offices	The production of biogas from human manure from offices via the sewage treatment plant	1	yes	Once	0%	0	0	10	5	High	Medium	high	+Low	No	Lower energy demand per capita	
38	Transportation	Pricing for the use of fossil carbon as a raw material for production, transport	Pricing carbon raw materials, transport	Taxing fossil fuels in order to promote renewable energy in the transport sector through revenues	1	No	Multiple	-10%	0	0	0	5	Medium	Medium	high	-Medium	No	Changes in prices, higher demand for RE in sector	
39	Transportation	Investing in energy-efficient car engines.	Energy saving cars	Investing in energy-efficient engines and cars that reduce energy demand	1	yes	Multiple	-10%	0	0	10	40	High	Medium	Medium	+Low	No	Less energy demand per unit of Value added	

40	Transportation	More efficient transportation (carpooling etc.)	Carpooling	More efficient transport by stimulating carpooling (70% less cars (4 persons per car) leading to 3,1 kiloton CO2 reduction)	1	yes	Multiple	-10%	0	0	0	5	Medium	Medium	high	-High	No	Less energy demand transportation	
41	Transportation	Switching from diesel cars to Low-carbon cars	Low carbon cars	The transition from diesel cars to Low-carbon cars will be mandatory for the next 5 years.	1	yes	Once	0%	0	0	20	40	High	high	high	-Low	No	Less energy demand per unit of Value added	
42	Agriculture	Use irrigation only for high-quality food crops	Irrigation for high value crops	Available water should only be used for high added value crops. Prohibitions on irrigation of other crops will be introduced.	1	No	Multiple	0%	0	0	0	40	Medium	high	Low	+High	No	Production level high value crops maintains and production level other crops decreases	
43	Agriculture	Water storage for irrigation of food production	Water storage and irrigation food crops	Storage is realised to have water available in times of drought.	1	yes	Once	0%	0	0	5	40	High	high	Low	+Medium	No	Higher yields food crops	

44	Household	Change of diet, less meat and more plants	Change of diet consumer	Through public campaigns by the government, people are encouraged to consume less meat and more vegetable products.	1	yes	Multiple	-5%	0	0	15	40	High	Medium	high	-Low	No	Lower caloric per capita	
45	Household	Stimulate healthy and sustainable consumption	Healthy and sustainable consumption	Through public campaigns by the government, people are encouraged to consume less meat and more vegetable products.	1	yes	Multiple	-5%	0	0	10	40	Low	high	high	+High	No	Lower caloric per capita	
46	Industry	Eco-design directive also focus on circular economy	Circular economy	The eco-directive also focuses on circular economy and circular design. This means No pollution at the source	1	yes	Once	0%	0	0	5	5	Medium	high	high	+Low	No	Higher energy efficiency indicators biomass	
47	Industry	SDE+plus for circular raw materials	SDE+ plus circular materials	The subsidy similar to SDE+ will also be available for circular raw materials.	1	No	Multiple	-10%	0	0	5	5	Medium	high	Low	+Low	No	Higher energy efficiency indicators biomass, lower availability of biomass for energy	

48	Agriculture	Funding initiatives that promote nature, water management, climate adaptation and combine biomass production	Subsidy NEXUS initiatives	The subsidy similar to SDE+ will also be available for combinations of nature, water management, climate adaptation, biomass production, etc.	1	No	Multiple	-10%	0	0	10	40	Medium	high	Low	+Medium	No	Increase biomass productivity	
49	Agriculture	Mandatory share of land for biomass for energy	Mandatory biomass production	10% of the cereals are used for biomass for energy	1	No	Multiple	0%	0	0	0	5	High	Low	high	-Medium	No	Land associated with biomass production is set at a minimum	

50	Agriculture	Mandatory land abandonment and abandonment (sequestration and retention of carbon in the soil). Catch crops and green manure seem logical	Mandatory land abandonment	Every farmer is obliged to use cuttings and green manure.	1	No	Multiple	0%	0	0	5	5	High	Low	high	-Medium	No	Lower productivity for agricultural or energy production	
51	Energy	Subsidy scheme for increasing the area under forests and sustainably increasing timber production per ha	Subsidy for additional production on forests	It will expand the forest area with 100.000 ha. This costs 50,000 ha of arable land and 50,000 ha of grassland.	1	yes	Once	0%	0	0	10	40	Medium	Medium	high	+Medium	No	increase capacity of small-scale biomass	

52	Agriculture	Common agricultural policy: a reward for closing loops of circular economy (N, P and organic matter in the soil)	CAP subsidy circularity	Nutrient cycles are closed so that emission N decreases	1	yes	Multiple	-10%	0	0	5	5	Medium	high	Low	+Low	No	Lower N+P emission factors per unit of agricultural value added	
53	Household	Incorporating environmental and climate costs into food prices+C3	Climate costing	The internalisation of climate costs leads to a 10% reduction in the demand for food (calories).	1	No	Multiple	0%	0	0	0	5	High	Medium	high	+Low	Yes, MAGNET	Lower demand for food	
54	Agriculture	Funding initiatives that prioritize biomass application for soil improvement	Biomass for soil improvement	A subsidy on application of biomass for soil improvement in arable farming	1	No	Multiple	-10%	0	0	0	40	Medium	high	Low	+Medium	No	Reduce biomass available for energy	

55	Agriculture	No biofuels from first generation (food crops grown on arable land)	No biofuels from food crops	A ban on consumption first generation biofuels	0	permanent	once	0%	0	0	0	40	High	Low	Medium	+Low	No	No biofuels from food crops allowed	

9.9. National Case Study: Sweden

Table 9.36. Policy goals table for Sweden

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Reduced greenhouse gas emissions and climate impacts	Limiting the rise in the global average temperature by reducing emissions	PG1-C
Increase of renewable energy sources	Increasing of renewable energy sources to limit emissions from fossil fuels use	PG2-E
Sustainable use and management of water resources	Improving management of water resources to increase water quality and decrease water use	PG3-W
Food security	Increasing food production to increase food security	PG4-F
A Rich Diversity of Plant and Animal Life	Improvements in land use to foster higher biodiversity	PG5-L

Table 9.37. Policy goals score indicator thresholds for Sweden

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-C	low	0,7
PG1-C	medium	0,5
PG1-C	high	0,3
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-E	low	0,1
PG2-E	medium	0,3
PG2-E	high	0,5
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-W	low	0,1
PG3-W	medium	0,2
PG3-W	high	0,3

Policy Goal id	Policy Goal Indicator thresholds	
PG4-F	low	0,05
PG4-F	medium	0,1
PG4-F	high	0,2
Policy Goal id	*Policy Goal Indicator thresholds*	
PG5-L	low	0,1
PG5-L	medium	0,4
PG5-L	high	0,6

Table 9.38. Policy objectives table for Sweden

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-C	Reduce greenhouse gas emissions from transport sector	O1	0,6
PG1-C	Reduce greenhouse gas emissions from drained peatlands	O2	0,4
PG2-E	Increase the production of solar electricity	O3	0,33
PG2-E	Increase the use of biomass from energy crops	O4	0,33
PG2-E	Increase the use of biomass from forests	O5	0,33
PG3-W	Increase Surface Water/Groundwater Quality	O6	0,7
PG3-W	Water saving in households	O7	0,3
PG4-F	Increase the agricultural yield	O8	0,5
PG4-F	Increase the available agricultural land	O9	0,5
PG5-L	Increase average forest age	O10	0,4
PG5-L	Increase areas of protected forest	O11	0,6

Table 9.39. Policy objective performance indicators formulas table for Sweden

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	(emissions from transport sector 2050)/(emission from transport sector 2017)	Relation between emissions from transport sector in 2050 and 2017
O1	(emissions from forest 2050)/(emissions from forest 2017)	Relation between emissions from forest in 2050 and 2017
O2	solar electricity production in 2017/solar electricity production in 2050	Relation between solar electricity production in 2050 and 2017
O3	(agr. area used for energy crops 2050 - agr. area used for energy crops 2017)/ (agr. area used for energy crops 2017)	Relation between agr. area used for energy crops in 2050 - agr. area used for energy crops 2019 and 2017
O4	biomass used for energy production 2050 /biomass used for energy production 2017	Relation between biomass used for energy production in 2050 and 2017
O5	fertilizer use 2050 / fertilizer use 2017	Relation between fertilizer use in 2050 and 2017
O6	domestic water use 2050 / domestic water use 2017	Relation between domestic water use in 2050 and 2017
O7	fertilizer use 2050 / fertilizer use 2017	Relation between fertilizer use in 2050 and 2017
O7	(area of agricultural land 2050)/(area of agricultural land 2017)	Relation between area of agricultural land in 2050 and 2017
O8	average forest age 2050/ average forest age 2017	Relation between average forest age in 2050 and 2017

O8	area of non-productive forest land 2050 / area of non-productive forest land 2017	Relation between non-productive forest land in 2050 and 2017

Table 9.40. Policy cards table for Sweden

Policy Id	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Climate	Increase the share of environmentally friendly heavy trucks (>3.5 tonne) on the road to 20% though subsidies (low level)	Subsidies on environmentally friendly trucks (low level)	Subsidies for environmentally friendly trucks are introduced to foster their market share to 20%. This low support leads to slightly more biofuel used in transport sector and to 3% less emissions from domestic transport.	0	No	Multiple	0	0	0	10	5	Medium	Low	Low	Positive Medium	no	decrease of emissions in transport sector	
2	Climate	Increase the share of environmentally friendly heavy trucks (>3.5 tonne) on the road to 40% though subsidies (medium level)	Subsidies on environmentally friendly trucks (medium level)	Subsidies for environmentally friendly trucks are introduced to foster their market share to 40%. This medium support leads to slightly more biofuel used in transport sector and to 6% reduced emissions from domestic transport.	0	No	Multiple	0	0	0	10	5	Medium	Low	Low	Positive Medium	no	decrease of emissions in transport sector	

3	Climate	Increase the share of environmentally friendly heavy trucks (>3.5 tonne) on the road to 60% though subsidies (high level)	Subsidies on environmentally friendly trucks (high level)	Subsidies for environmentally friendly trucks are introduced to foster their market share to 60%. This relatively high support for sun panels leads to 8.5% less emissions from fossil fuel use and therefore to reduced climate impacts.	0	No	Multiple	0	0	0	10	5	High	Low	Low	Positive Medium	no	decrease of emissions in transport sector	
4	Climate	Increase the share of environmentally friendly heavy trucks (>3.5 tonne) on the road to 80% though subsidies (high level)	Subsidies on environmentally friendly trucks (high level)	Subsidies for environmentally friendly trucks are introduced to foster their market share to 80%. This high support for sun panels leads to 11% less emissions from fossil fuel use and therefore to largely reduced climate impacts.	0	No	Multiple	0	0	0	10	5	High	Low	Low	Positive Medium	no	decrease of emissions in transport sector	
5	Climate	Re-wetting 10% (i.e. 154,580 ha) of drained peatland (formerly ditched and drained to create productive land) to reduce GHG emissions	Re-wetting of peatlands (low level)	18% of all peatland in Sweden have been ditched long ago (to create productive land) and now these areas release a lot of GHG. Through government support (compensation schemes), 154,580 ha of forest land will be re-wetted, which leads to 309,160 kg less CO2 emissions (-0.7%).	0	Yes	Multiple	0	0	0	10	5	Low	Low	Low	Positive Low	no	decrease in total emissions	
6	Climate	Re-wetting 20% (i.e. 309,160 ha) of drained peatland (formerly ditched and drained to create productive land) to reduce GHG emissions	Re-wetting of peatlands (medium level)	18% of all peatland in Sweden have been ditched long ago (to create productive land) and now these areas release a lot of GHG. Through government support (compensation schemes), 309,160 ha of forest land will be re-wetted, which leads to 618,320 kg less CO2 emissions (-1.4%).	0	Yes	Multiple	0	0	0	10	5	Medium	Low	Low	Positive Low	no	decrease in total emissions	
7	Climate	Re-wetting 30% (i.e. 463,740 ha) of drained peatland (formerly ditched and drained to create productive land) to reduce GHG emissions	Re-wetting of peatlands (high level)	18% of all peatland in Sweden have been ditched long ago (to create productive land) and now these areas release a lot of GHG. Through government support (compensation schemes), 463,740 ha of forest land will be re-wetted, which leads to 972,480 kg less CO2 emissions (-2.1%).	0	Yes	Multiple	0	0	0	15	5	High	Low	Low	Positive Low	no	decrease in total emissions	
8	Climate	Re-wetting 40% (i.e. 618,320 ha) of drained peatland (formerly ditched and drained to create productive land) to reduce GHG emissions	Re-wetting of peatlands (high level)	18% of all peatland in Sweden have been ditched long ago (to create productive land) and now these areas release a lot of GHG. Through government support (compensation schemes), 618,320 ha of forest land will be re-wetted, which leads to 1,236,640 kg less CO2 emissions (-2.8%).	0	Yes	Multiple	0	0	0	15	5	High	Low	Low	Positive Low	no	decrease in total emissions	

9	Energy	Increase the share of solar electricity production to 2.5% (of total electricity production) through subsidies (low level: 10% of installation costs) for solar panels	Subsidies on solar panels (low level)	Subsidies for solar panels are introduced to foster their installation and the production of solar energy. This low support for sun panels leads to slightly reduced emissions from fossil fuel use and therefore to reduced climate impacts.	0	Yes	Multiple	0	0	0	5	5	Low	Low	Low	Positive Medium	no	increase of solar electricity production and decrease in fossil fuel electricity production	
10	Energy	Increase the share of solar electricity production to 5% (of total electricity production) through subsidies (medium level: 30% of installation costs) for solar panels	Subsidies on solar panels (medium level)	Subsidies for solar panels are introduced to foster their installation and the production of solar energy. This medium support for sun panels leads to somewhat reduced emissions from fossil fuel use and therefore to reduced climate impacts.	0	Yes	Multiple	0	0	0	5	5	Low	Low	Low	Positive Medium	no	increase of solar electricity production and decrease in fossil fuel electricity production	
11	Energy	Increase the share of solar electricity production to 7.5% (of total electricity production) through subsidies (high level: 50% of installation costs) for solar panels	Subsidies on solar panels (high level)	Subsidies for solar panels are introduced to foster their installation and the production of solar energy. This relatively high support for sun panels leads to reduced emissions from fossil fuel use and therefore to reduced climate impacts.	0	Yes	Multiple	0	0	0	5	5	Medium	Low	Low	Positive Medium	no	increase of solar electricity production and decrease in fossil fuel electricity production	
12	Energy	Increase the share of solar electricity production to 10% (of total electricity production) through subsidies (high level: 70% of installation costs) for solar panels	Subsidies on solar panels (high level)	Subsidies for solar panels are introduced to foster their installation and the production of solar energy. This high support for sun panels leads to reduced emissions from fossil fuel use and therefore to reduced climate impacts.	0	Yes	Multiple	0	0	0	5	5	Medium	Low	Low	Positive Medium	no	increase of solar electricity production and decrease in fossil fuel electricity production	
13	Energy	Increase the amount of arable land used for growing energy crops ("energy forest") by 5% through start-up grants (low level) for Salix plantations	Start-up grants for Salix (willow) plantations (low level)	Energy crops (more specifically Salix/willow) are slightly promoted to produce more biomass for energy production	0	No	Multiple	0	0	0	5	5	Low	Low	Low	Positive Low	no	increase in energy crops area, decrease in arable land for food production; increase in biomass energy production, decrease in fossil fuel production	

14	Energy	Increase the amount of arable land used for growing energy crops ("energy forest") by 10% through start-up grants (medium level) for Salix plantations	Start-up grants for Salix (willow) plantations (medium level)	Energy crops (more specifically Salix/willow) are somewhat promoted to produce more biomass for energy production	0	No	Multiple	0	0	0	5	5	Low	Low	Low	Positive Low	no	increase in energy crops area, decrease in arable land for food production; increase in biomass energy production, decrease in fossil fuel production	
15	Energy	Increase the amount of arable land used for growing energy crops ("energy forest") by 15% through start-up grants (high level) for Salix plantations	Start-up grants for Salix (willow) plantations (high level)	Energy crops (more specifically Salix/willow) are largely promoted to produce more biomass for energy production	0	No	Multiple	0	0	0	5	5	Medium	Low	Low	Positive Low	no	increase in energy crops area, decrease in arable land for food production; increase in biomass energy production, decrease in fossil fuel production	
16	Energy	Increase the amount of arable land used for growing energy crops ("energy forest") by 20% through start-up grants (high level) for Salix plantations	Start-up grants for Salix (willow) plantations (high level)	Energy crops (more specifically Salix/willow) are very strongly promoted to produce more biomass for energy production	0	No	Multiple	0	0	0	5	5	Medium	Low	Low	Positive Low	no	increase in energy crops area, decrease in arable land for food production; increase in biomass energy production, decrease in fossil fuel production	
17	Energy	Increase the amount of biomass produced by forests by 25% through tax reliefs (low level) on forest biomass	Tax reliefs (low level) on forest biomass	Tax reliefs (low level) on forest biomass will lead to slightly more renewable energy production (e.g. biofuels from forest biomass, wood pellets for heating).	0	No	Multiple	0	0	0	5	5	Low	Medium	Low	Positive Medium	no	Increase in biomass energy production, decrease in fossil fuel production	
18	Energy	Increase the amount of biomass produced by forests by 50% through tax reliefs (medium level) on forest biomass	Tax reliefs (medium level) on forest biomass	Tax reliefs (medium level) on forest biomass will lead to somewhat more renewable energy production (e.g. biofuels from forest biomass, wood pellets for heating).	0	No	Multiple	0	0	0	5	5	Medium	Medium	Low	Positive Medium	no	Increase in biomass energy production, decrease in fossil fuel production	
19	Energy	Increase the amount of biomass produced by forests by 75% through tax reliefs (high level) on forest biomass	Tax reliefs (high level) on forest biomass	Tax reliefs (high level) on forest biomass will lead to more renewable energy production (e.g. biofuels from forest biomass, wood pellets for heating).	0	No	Multiple	0	0	0	5	5	High	Medium	Low	Positive Medium	no	Increase in biomass energy production, decrease in fossil fuel production	
20	Energy	Increase the amount of biomass produced by forests by 100% through tax reliefs (high level) on forest biomass	Tax reliefs (high level) on forest biomass	Tax reliefs (high level) on forest biomass will lead to much more renewable energy production (e.g. biofuels from forest biomass, wood pellets for heating).	0	No	Multiple	0	0	0	5	5	High	Medium	Low	Positive Medium	no	Increase in biomass energy production, decrease in fossil fuel production	

21	Water	Reduce the use of fertilizer by 10% and thereby the leakage of nitrogen and phosphorus from agricultural land by introducing a fertilizer tax (low level).	Tax on fertilizer (low level)	A tax on fertilizer (low level) leads to slightly less fertilizer use in land sector and thus less leakage of nitrogen and phosphorus into water resources. This in turn will increase water quality. It also is positive for ecological production, but has a negative effect on food security.	0	No	Multiple	0	0	0	10	5	Low	Medium	Medium	Neutral	no	Reduction of fertiliser and P concentrations in the water; decrease in food production	
22	Water	Reduce the use of fertilizer by 20% and thereby the leakage of nitrogen and phosphorus from agricultural land by introducing a fertilizer tax (medium level).	Tax on fertilizer (medium level)	A tax on fertilizer (medium level) leads to somewhat less fertilizer use in land sector and thus less leakage of nitrogen and phosphorus into water resources. This in turn will increase water quality. It also is positive for ecological production, but has a negative effect on food security.	0	No	Multiple	0	0	0	10	5	Low	Medium	Medium	Neutral	no	Reduction of fertiliser and P concentrations in the water; decrease in food production	
23	Water	Reduce the use of fertilizer by 30% and thereby the leakage of nitrogen and phosphorus from agricultural land by introducing a fertilizer tax (high level).	Tax on fertilizer (high level)	A tax on fertilizer (high level) leads to significantly less fertilizer use in land sector and thus less leakage of nitrogen and phosphorus into water resources. This in turn will increase water quality. It also is positive for ecological production, but has a negative effect on food security.	0	No	Multiple	0	0	0	10	5	Low	High	Medium	Neutral	no	Reduction of fertiliser and P concentrations in the water; decrease in food production	
24	Water	Reduce the use of fertilizer by 40% and thereby the leakage of nitrogen and phosphorus from agricultural land by introducing a fertilizer tax (high level).	Tax on fertilizer (high level)	A tax on fertilizer (high level) leads to significantly less fertilizer use in land sector and thus less leakage of nitrogen and phosphorus into water resources. This in turn will increase water quality. It also is positive for ecological production, but has a negative effect on food security.	0	No	Multiple	0	0	0	10	5	Low	High	Medium	Neutral	no	Reduction of fertiliser and P concentrations in the water; decrease in food production	
25	Water	Reduce the domestic water use by 5% through the increase of higher water fees (low level)	Increase water fees for property owners (low level)	Water fees (low level) to be paid by property owners for public drinking water supply and the removal of waste water will be increased to slightly promote water saving.	0	Yes	Multiple	0	0	0	5	10	Low	Medium	Medium	Neutral	no	Reduction of water use in domestic and service water use; slight decrease in water losses	
26	Water	Reduce the domestic water use by 10% through the increase of higher water fees (medium level)	Increase water fees for property owners (medium level)	Water fees (medium level) to be paid by property owners for public drinking water supply and the removal of waste water will be increased to somewhat promote water saving.	0	Yes	Multiple	0	0	0	5	10	Low	Medium	Medium	Neutral	no	Reduction of water use in domestic and service water use; slight decrease in water losses	
27	Water	Reduce the domestic water use by 15% through the increase of higher water fees (high level)	Increase water fees for property owners (high level)	Water fees (high level) to be paid by property owners for public drinking water supply and the removal of waste water will be increased to strongly promote water saving.	0	Yes	Multiple	0	0	0	5	10	Low	High	High	Neutral	no	Reduction of water use in domestic and service water use; slight decrease in water losses	

28	Water	Reduce the domestic water use by 20% through the increase of higher water fees (high level)	Increase water fees for property owners (high level)	Water fees (high level) to be paid by property owners for public drinking water supply and the removal of waste water will be increased to heavily promote water saving.	0	Yes	Multiple	0	0	0	5	10	Low	High	High	Neutral	no	Reduction of water use in domestic and service water use; slight decrease in water losses	
29	Food	Increase the use of fertilizer by 10% and thereby the food production by introducing a fertilizer subsidy (low level).	Subsidy on fertilizer (low level)	Subsidies on fertilizer (low level) lead to slightly more fertilizer use in land sector and thus more production of food and consequently food security. But the use of fertilizer causes more leakage of nitrogen and phosphorus into water resources. This in turn will decrease water quality.	0	No	Multiple	0	0	0	5	5	Low	Low	Low	Positive Medium	no	Increase in fertiliser, decrease in water quality; increase in food production	
30	Food	Increase the use of fertilizer by 20% and thereby the food production by introducing a fertilizer subsidy (medium level).	Subsidy on fertilizer (medium level)	Subsidies on fertilizer (medium level) lead to somewhat more fertilizer use in land sector and thus more production of food and consequently food security. But the use of fertilizer causes more leakage of nitrogen and phosphorus into water resources. This in turn will decrease water quality.	0	No	Multiple	0	0	0	5	5	Medium	Low	Low	Positive Medium	no	Increase in fertiliser, decrease in water quality; increase in food production	
31	Food	Increase the use of fertilizer by 30% and thereby the food production by introducing a fertilizer subsidy (high level).	Subsidy on fertilizer (high level)	Subsidies on fertilizer (high level) lead to much more fertilizer use in land sector and thus more production of food and consequently food security. But the use of fertilizer causes more leakage of nitrogen and phosphorus into water resources. This in turn will decrease water quality.	0	No	Multiple	0	0	0	5	5	High	Medium	Low	Positive Medium	no	Increase in fertiliser, decrease in water quality; increase in food production	
32	Food	Increase the use of fertilizer by 40% and thereby the food production by introducing a fertilizer subsidy (very high level).	Subsidy on fertilizer (high level)	Subsidies on fertilizer (high level) lead to significantly more fertilizer use in land sector and thus more production of food and consequently food security. But the use of fertilizer causes more leakage of nitrogen and phosphorus into water resources. This in turn will decrease water quality.	0	No	Multiple	0	0	0	5	5	High	Medium	Low	Positive Medium	no	Increase in fertiliser, decrease in water quality; increase in food production	
33	Food	Increase the total arable land by 2.5% through subsidies (low level) on agricultural area	Subsidy on arable land (low level)	Subsidy on arable land (low level) will lead to a slight increase in agricultural area where crops are produced, which will lead to slightly more food production and security.	0	No	Multiple	0	0	0	5	5	Low	Low	Low	Positive Medium	no	Increase in arable land, decrease in forest land; increase of food production; increased use of water in agriculture	

34	Food	Increase the total arable land by 5% through subsidies (medium level) on agricultural area	Subsidy on arable land (medium level)	Subsidy on arable land (medium level) will lead to an increase in agricultural area where crops are produced, which will lead to more food production and security.	0	No	Multiple	0	0	0	5	5	Low	Low	Low	Positive Medium	no	Increase in arable land, decrease in forest land; increase of food production; increased use of water in agriculture	
35	Food	Increase the total arable land by 7.5% through subsidies (high level) on agricultural area	Subsidy on arable land (high level)	Subsidy on arable land (high level) will lead to a strong increase in agricultural area where crops are produced, which will lead to much more food production and security.	0	No	Multiple	0	0	0	5	5	Medium	Medium	Low	Positive Medium	no	Increase in arable land, decrease in forest land; increase of food production; increased use of water in agriculture	
36	Food	Increase the total arable land by 10% through subsidies (high level) on agricultural area	Subsidy on arable land (high level)	Subsidy on arable land (high level) will lead to a heavy increase in agricultural area where crops are produced, which will lead to much more food production and security.	0	No	Multiple	0	0	0	5	5	High	Medium	Low	Positive Medium	no	Increase in arable land, decrease in forest land; increase of food production; increased use of water in agriculture	
37	Land	Increase the average stand age of spruce and pine by 5 years through legislation (low level) regulating the rotation age	Legislation (low level) to increase the rotation age of spruce and pine	A new legislation (low level) increases the minimum rotation age slightly for spruce and pine. This will lead to slightly increased average stand age that will in turn lead to better conditions for forest biodiversity	0	No	Multiple	0	0	0	10	10	Low	Low	Medium	Neutral	no	Increase in average age; indicator of biodiversity; decrease in bioenergy production from the forest	
38	Land	Increase the average stand age of spruce and pine by 10 years through legislation (medium level) regulating the rotation age	Legislation (medium level) to increase the rotation age of spruce and pine	A new legislation (medium level) increases the minimum rotation age somewhat for spruce and pine. This will lead to somewhat increased average stand age that will in turn lead to better conditions for forest biodiversity	0	No	Multiple	0	0	0	20	10	Low	Low	Medium	Neutral	no	Increase in average age; indicator of biodiversity; decrease in bioenergy production from the forest	
39	Land	Increase the average stand age of spruce and pine by 15 years through legislation (high level) regulating the rotation age	Legislation (high level) to increase the rotation age of spruce and pine	A new legislation (high level) increases the minimum rotation age strongly for spruce and pine. This will lead to strongly increased average stand age that will in turn lead to better conditions for forest biodiversity	0	No	Multiple	0	0	0	30	10	Low	Low	High	Neutral	no	Increase in average age; indicator of biodiversity; decrease in bioenergy production from the forest	

40	Land	Increase the average stand age of spruce and pine by 20 years through legislation (high level) regulating the rotation age	Legislation (high level) to increase the rotation age of spruce and pine	A new legislation (high level) increases the minimum rotation age heavily for spruce and pine. This will lead to heavily increased average stand age that will in turn lead to better conditions for forest biodiversity	0	No	Multiple	0	0	0	40	10	Low	Low	High	Neutral	no	Increase in average age; indicator of biodiversity; decrease in bioenergy production from the forest	
41	Land	Increase the area of non-productive (protected) forest by 25 % through financial compensation (low level) for protecting forests	Compensation (low level) for forest protection	Financial compensation (low level) given to forest owners for lost production will lead to slightly more protected forest areas and thus less productive forest.	0	Yes	Multiple	0	0	0	5	5	Low	Low	Low	Positive Low	no	Increase in non-productive forest land; indicator of biodiversity; decrease in productive forest land; decrease in bioenergy production from the forest	
42	Land	Increase the area of non-productive (protected) forest by 50 % through financial compensation (medium level) for protecting forests	Compensation (medium level) for forest protection	Financial compensation (medium level) given to forest owners for lost production will lead to more protected forest areas and thus less productive forest.	0	Yes	Multiple	0	0	0	10	5	Low	Low	Low	Positive Low	no	Increase in non-productive forest land; indicator of biodiversity; decrease in productive forest land; decrease in bioenergy production from the forest	
43	Land	Increase the area of non-productive (protected) forest by 75 % through financial compensation (high level) for protecting forests	Compensation (high level) for forest protection	Financial compensation (high level) given to forest owners for lost production will lead to much more protected forest areas and thus less productive forest.	0	Yes	Multiple	0	0	0	15	5	Medium	Low	Low	Positive Low	no	Increase in non-productive forest land; indicator of biodiversity; decrease in productive forest land; decrease in bioenergy production from the forest	

44	Land	Increase the area of non-productive (protected) forest by 100 % through financial compensation (high level) for protecting forests	Compensation (high level) for forest protection	Financial compensation (high level) given to forest owners for lost production will lead to much more protected forest areas and thus less productive forest.	0	Yes	Multiple	0	0	0	20	5	Medium	Low	Low	Positive Low	no	Increase in non-productive forest land; indicator of biodiversity; decrease in productive forest land; decrease in bioenergy production from the forest	

9.10. Transboundary Case Study: Eastern (Germany, Czech Republic and Slovakia)

Table 9.41. Policy goals table for Eastern

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Abundance of water resources	Achieving high water availability and high landscape water contents in all areas	PG1-W
Good ecological status of water bodies	Good ecological status of all water bodies as defined by the EU WFD	PG2-W
Decarbonisation	Decarbonisation of the energy sector	PG1-E
Power grid stability	Maintaining power grid stability under intermittent supply from renewables	PG2-E
Public health and safety	Public health and safety must not be impaired by the energy sector.	PG3-E
Elevate food production	Achieving higher quantities of food production	PG1-F
Small environmental footprint	Minimizing the environmental footprint of the food sector	PG2-F
Healthy soils	Protecting naturally grown soils and maintaining their ecosystem services	PG1-L
Landscape heterogeneity	Increasing the heterogeneity and diversity of cultural landscapes	PG2-L
Flood protection	Protecting societies from flood events	PG3-L
Good regional climate	Mitigating large-scale climate change by optimising regional climate effects	PG1-C

Table 9.42. Policy goals score indicator thresholds for Eastern

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,2
PG1-W	medium	0,4
PG1-W	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-W	low	0,2
PG2-W	medium	0,4
PG2-W	high	0,7

Policy Goal id	*Policy Goal Indicator thresholds*	
PG1-E	low	0,2
PG1-E	medium	0,4
PG1-E	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-E	low	0,2
PG2-E	medium	0,4
PG2-E	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-E	low	0,2
PG3-E	medium	0,4
PG3-E	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG1-F	low	0,2
PG1-F	medium	0,4
PG1-F	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-F	low	0,2
PG2-F	medium	0,4
PG2-F	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG1-L	low	0,2
PG1-L	medium	0,4
PG1-L	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-L	low	0,2
PG2-L	medium	0,4
PG2-L	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-L	low	0,2
PG3-L	medium	0,4
PG3-L	high	0,7
Policy Goal id	*Policy Goal Indicator thresholds*	
PG1-C	low	0,2
PG1-C	medium	0,4
PG1-C	high	0,7

Table 9.43. Policy objectives table for Eastern

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-W	Increase water retention	O1	0,8
PG1-W	Decentralise the water sector	O2	0,2
PG2-W	Decrease surface runoff	O1	0,4
PG2-W	Increase ecosystem services of water bodies	O2	0,6
PG1-E	Decrease energy demand of housing	O1	0,3
PG1-E	Elevate biofuel production	O2	0,1
PG1-E	Decarbonise the energy sector directly	O3	0,6
PG2-E	Implement electricity storage technologies	O1	0,7
PG2-E	Build additional high-voltage power lines between regions	O2	0,3
PG3-E	Decrease number of nuclear power plants	O1	1
PG1-F	Increase food crop productivity	O1	0,8
PG1-F	Increase agricultural areas	O2	0,2
PG2-F	Change dietary preferences (less meat)	O1	0,8
PG2-F	Reduce food waste	O2	0,2
PG1-L	Increase soil organic carbon content	O1	0,4
PG1-L	Decrease soil compaction	O2	0,2
PG1-L	Decrease soil erosion	O3	0,4
PG2-L	Enhance biodiversity, erosion protection, and water retention	O1	1
PG3-L	Preserve land from being flooded	O1	0,3
PG3-L	Preserve people and goods from flood risks	O2	0,7
PG1-C	Decrease surface temperature of agricultural areas	O1	1

Table 9.44. Policy objective performance indicators formulas table for Eastern

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	(volume of water retention measures)/(maximally achievable volume)	The "volume of water retention measures" in m³ represents enhancements to the original storage capacity of the landscape. It is a summation of volumes individually calculated for the different land uses (forest, urban, agriculture, etc.).
O2	-- not in SDM due to insufficient capabilities of the underlying models	The idea behind is the transformation towards decentralized wells and WWTPs directly owned by water users to foster individual responsibility. Missing from the SDM, this objective should simply be linearly approached with every policy card played out in favour of it.
O1	max{0;1 - runDirect/aa}	A totally removed direct (i.e. surface) runoff would yield an indicator of 1. Although this runoff is modelled, effects from associated measures (complex land consolidation) cannot be represented by the underlying models and hence not in the SDM.
O2	-- not in SDM due to insufficient capabilities of the underlying models	Among the targeted ecosystem services are inland fishing and bathing opportunities with high water quality. Indicators could be length ("naturalness") of river systems or nutrient concentrations. Unfortunately, none of these are modelled.
O1	max{0;1 - bb(((ED heat)+(ED electricity))/cc)}	Reduction in energy demands (ED) for heating and cooling
O2	max{0;min{1;dd((Tot crop-biofuel)-ee)}}	Increase in production of biofuels (Tot crop-biofuel) relative to baseline (ee)

O3	max{0;1 - (Electricity generation from FF)/(ff(min{2049;current year} - 2050)}	A total shutdown of fossil fuel-based electricity generation would yield an indicator of 1. For obtaining an indicator higher than zero, increasing decarbonisation shares are needed over time.
O1	-- not in SDM due to insufficient capabilities of the underlying models	The stability of the electrical power supply is threatened by the high volatility of renewable energy inputs. There should be some kind of stability indicator added depending on installed storage and transmission capacities.
O2	-- not in SDM due to insufficient capabilities of the underlying models	The stability of the electrical power supply is threatened by the high volatility of renewable energy inputs. There should be some kind of stability indicator added depending on installed storage and transmission capacities.
O1	-- nuclear electricity generation seems to be missing in the SDM	Germany decided to shut down their nuclear plants in 2021. In the Czech Republic and Slovakia, 6114 MW gross electrical capacity are operational and further 942 MW are under construction. The indicator should increase for any of these capacities dropped.
O1	max{0;min{1;gg(((Food crops production.tot)/(TOT lu crop food))/hh - 1)}}	Whenever the average yield (food production divided by agricultural area used for production) exceeds a certain threshold, the indicator rises above zero, but cannot become larger than one (i.e. a second threshold about the maximally achievable yield).
O2	max{0;min{1;ii((TOT lu crop food)/jj - 1)}}	Whenever the area used for food production exceeds a certain threshold, the indicator rises above zero, but cannot become larger than one (i.e. a second threshold about a realistically set maximum area).
O1	max{0;1 - ((Feed demand)/(human food demand))/kk}	Meat consumption is not explicitly contained in the SDM, the ratio of animal fodder to human food however allows for deriving the indicator.
O2	-- not in SDM due to insufficient capabilities of the underlying models	Wasted food is a societal problem but does not seem to appear in CAPRI's balances based on the efficient market hypothesis. Hence this objective should simply be linearly approached with every policy card played out in favour of it.
O1	max{0;min{1;mm((Pasture)+(lu tot wetland,meadow)+(lu Tot forest)-(lu Urban)-nn)/(TOT lu)}}	As soil organic carbon content is not explicitly modelled, it could be approximated by land uses. But are these really dynamically modelled? And are the effects of the associated measures - here: greening within (!) agricultural areas - implemented accordingly?
O2	-- not in SDM due to insufficient capabilities of the underlying models	By furthering light machinery, soil fertility will increase (leading to higher yields) together with soil organic matter (thus soil carbon) contents. Both could be assumed to reach about +5% with a decade's time-lag after the light-machinery policy has been played out.
O3	Water erosion (erosion_w) is in the SWIM model, but invariant regarding the intended policies.	Missing from adequate modelling, this objective should simply be linearly approached with every policy card played out in favour of it.
O1	-- complex metric, not in the SDM.	Could be average of PG2-W-O2, PG1-F-O1, and PG1-L-O1 indicators.
O1	-- not in SDM due to insufficient capabilities of the underlying models	The indicator would be tied to the area of land protected against floods by technical measures. However, it would not only have to consider nominally protected areas but also dike heights in relation to flood height probabilities or the impaired safety of aged dikes.
O2	-- not in SDM due to insufficient capabilities of the underlying models	The indicator would be tied to the natural area affected by flood events that has been cleared from human settlements and infrastructure susceptible to flood effects.
O1	max{0;min{1;pp(Decrease of local temperature during heat days (°C) Crop)}}	Landscape temperature decreases are directly calculated in the SDM, also for other land use classes than cropping areas.

Table 9.45. Policy cards table for Eastern

PolicyId	Nexus Sector(s)	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/ implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/ measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/ measure translate into model input?	Comments
1	Water	New reservoirs	New reservoirs	Building of new reservoirs, enhanced by respective subsidies for land owners	1	Yes	Multiple	-50 %	No	No	1	10	High	Medium	High	Low, positive	No	--	Targets policy objective PG1-W-O1
2	Water	Biological wetlands	Bio-wetlands	Construction of biological wetlands	1	Yes	Multiple	-33 %	No	No	1	10	High	Low	Medium	Low, negative	No	--	Targets policy objectives PG1-W-O1 and PG2-W-O2, people won't appreciate surface-greedy WWTP in their neighbourhoods
3	Water	Water retention in forests	Forest water	Improving water retention in forested areas through small dams made from locally available materials (e.g. dead wood)	1	Yes	Multiple	-33 %	Yes	No	1	10	Medium	Medium	Medium	High, positive	No	--	Targets policy objective PG1-W-O1, pre-game application only in SDM 15

4	Water	Decentralisation of the water sector	Local wells	Decentralise water supplies and sewer systems: Build local wells and WWTPs owned by single users or small communities	0	Yes	Once		No	No	3	20	High	Low	High	Low, positive	No	--	Targets policy objective PG1-W-O2, the price for supply independency is high: People must regularly check and maintain their installations
5	Water, Land	Complex land consolidation	Small fields	Return from huge field blocks (monocultures) to small usage structures. Can be based on ownership of underlying land parcels.	0	Yes	Once		No	No	2	20	Medium	Low	Medium	Low, positive	No	--	Targets policy objectives PG2-W-O1 and PG1-L-O3
6	Water	River restoration	Natural rivers	Increase length of water courses through river restorations towards original flow paths	1	Yes	Multiple	-33 %	Yes	No	1	999	Medium	Low	Low	Medium, positive	No	--	Targets policy objective PG2-W-O2, pre-game application only selectively in SDMs 01–05 (Eastern DE)
7	Water, Land	Wetland restoration	Natural wetlands	Restore natural wetlands	1	Yes	Multiple	-33 %	No	No	2	10	Medium	Low	Medium	Low, positive	No	--	Targets policy objectives PG2-W-O2 and PG2-L-O1
8	Energy	New buildings with eco-technology	New eco-tech	Mandatory photovoltaics, heat pump systems, and water-based cooling for all new buildings	0	Yes	Once		No	No	1	4	Low	Medium	High	Medium, positive	E3ME: energy demand for housing	?	Targets policy objective PG1-E-O1, only for newly erected buildings
9	Energy	Eco-technology for existing buildings	Added eco-tech	Subsidies for fitting existing buildings with photovoltaics, heat pump and water-based cooling systems	1	No	Multiple	-10 %	No	No	1	4	High	Medium	High	Medium, positive	E3ME: energy demand for housing	?	Targets policy objective PG1-E-O1

10	Energy, Land	Subsidies for energy plants	Money for rape	Making energy plant production (especially rape) financially more attractive for farmers	0	No	Multiple	0 %	No	No	1	1	Medium	Low	Low	Low, negative	(E3ME)	Demand for biofuels	Targets policy objective PG1-E-O2
11	Energy, Land	Turning agriculture into energy forests	Fields to forest	Let some agricultural areas grow into fuel woods. This might be implemented by a combination of subsidies and, for major landowners, enforcement laws.	0	Yes	Once		No	No	4	10	Medium	Low	Medium	Low, positive	(E3ME)	Demand for biofuels	Targets policy objective PG1-E-O2, but opposes intervention #22
12	Energy, Land	Shutdown of lignite mining	Stop lignite	The remaining open-cast lignite mining pits must be disused within five years.	0	Yes	Once		No	No	1	999	Low	Low	Medium	Medium, positive	E3ME	?	Targets policy objective PG1-E-O2
13	Energy	Shutdown of fossil fuel driven power plants	Stop coal power	All coal, oil, or gas fired electrical power plants must be phased out within five years.	0	Yes	Once		No	No	1	999	Low	Low	Low	Medium, positive	E3ME	?	Targets policy objective PG1-E-O3, Highly negative social capital if blackouts happen due to deteriorated grid stability
14	Energy	Carbon tax, mild variant	Soft carbon tax	CO2 emissions are taxed by 20€/t in the first year, and this is successively raised to 200€/t over the following decade.	0	Yes	Once		No	No	2	10	Medium	Low	Medium	Low, positive	E3ME	?	Targets policy objective PG1-E-O3, may be repealed later on
15	Energy	Carbon tax, strict variant	Hard carbon tax	CO2 emissions are taxed by 100€/t in the first two years after implementation, by 180€/t in years 3–4, and by 250€/t thereafter.	0	Yes	Once		No	No	1	10	High	Medium	High	Low, positive	E3ME	?	Targets policy objective PG1-E-O3, may be repealed later on

16	Energy	Deployment of electricity storage systems	Electricity storage	As potentials for pump storage power stations are mostly tapped and do not exist at all in lowlands, this might be the joker card for the implementation of yet-to-be-invented super batteries stabilising the power grid.	1	Yes	Once		No	No	2	20	High	High	Medium	High, positive	No	--	Targets policy objective PG2-E-O1, low social capital if there were no blackouts to be avoided
17	Energy	Building more high-voltage power lines	Power lines	This needs big investments but is the currently available means for enhancing grid stability by making it easier to trade electricity across borders as needed.	0	Yes	Multiple	-50 %	No	No	3	10	Medium	Medium	High	High, positive	No	--	Targets policy objective PG2-E-O2, low social capital if there were no blackouts to be avoided
18	Energy	Shutdown of nuclear power plants	Stop nuclear	Already fixed for Germany until the end of 2021. This measure phases out the Czech and Slovak capacities (currently 6114 MW gross) linearly within 5 years.	0	Yes	Once		No	Yes	1	999	Medium	Low	Low	High, positive	E3ME	Number of nuclear power plants	Targets policy objective PG3-E-O1, note the legislative shutdown for Germany until 2021; Social capital highly negative if blackouts happening after shutdown
19	Food	Subsidies for agricultural irrigation systems	Irrigation	Farmers can obtain funding for installing highly efficient irrigation systems (e.g. demand-controlled drip irrigation).	1	No	Multiple	-10 %	No	No	1	3	Medium	Low	Medium	Medium, positive	CAPRI	Increase in irrigation efficiency, investment not covered	Targets policy objective PG1-F-O1

20	Food	Technical innovations for small farms	Tech 4 Farms	Small farms can obtain funding to be equipped with up-to-date technical goods and services, e.g. for precision farming or robotic harvesting	1	No	Multiple	-10 %	No	No	1	3	Medium	Low	Low	Medium, positive	No	--	Targets policy objective PG1-F-O1, may be joined with #27
21	Food, Land	Planting of shelterbelts	Shelter belts	Farmers are forced to plant regular strips of trees and bushes between field blocks on 5% of their land. The distance between these strips must not exceed 200 m. Subsequent agricultural yield increases usually overcompensate the loss of agricultural areas.	1	Yes	Once		No	No	4	20	Low	Low	Mediu m	Medium, positive	No	--	Targets policy objectives PG1-F-O1 and PG2-L-O1
22	Food, Land	Turning forests into agriculture	Forests to fields	Turn some forested areas into agricultural fields. This can be implemented by state purchases of forest areas, commissioned wood-harvesting, and resale of the parcels to farmers.	0	Yes	Once		No	No	2	20	Medium	Medium	High	Medium, negative	No	--	Targets policy objective PG1-F-O2, but opposes intervention #11
23	Food, Energy	Limiting energy plants	Fields for food	Reduce the cultivation of energy plants (especially rape) in favour of food crops by both a percentage and a farm-based absolute production limit.	1	No	Multiple	0 %	Yes	No	1	1	Low	Low	Low	Low, positive	(E3ME)	Deman d for biofuels	Targets policy objective PG1-F-O2, pre-game application at least in Germany (SDMs 01–05)

24	Food	Introduction of EU meat tax	Meat tax	Increase the V.A.T. on meat products by 20–30% to further dietary changes in all EU countries	0	No	Multiple	25 %	No	No	1	10	Low	Low	High	Medium, positive	CAPRI	Meat tax as such	Targets policy objective PG2-F-O1, efficiency will increase with second application, but social capital will become highly negative with the third (rebellion)
25	Food	Re-allow animal feeding by food residues	Less waste, more fodder	Relieve the EU ban on using leftovers from restaurants and canteens for animal feeding	0	No	Once		No	No	1	10	Low	Low	Low	Low, positive	No	--	Targets policy objective PG2-F-O2
26	Land	Greening in agriculture	Greeni ng	Legislative and financial incentives for maintaining green vegetation covers on agricultural areas all-year round, e.g. by intercropping.	1	No	Multiple	0 %	No	No	1	1	Medium	Low	Low	Medium, positive	No	--	Targets policy objectives PG1-L-O1 and PG2-L-O1
27	Land, Food	Investments in lighter machinery	Light machin ery	Especially small farms cannot afford modern, soil protecting light machinery. This card releases subsidies for respective modernisations.	1	No	Multiple	-10 %	No	No	1	3	Medium	Low	Low	Medium, positive	No	--	Targets policy objective PG1-L-O2, may be joined with #20
28	Land	Subsidies for organic farming	Organic farming	Organic farming is promoted by financial incentives.	1	No	Multiple	0 %	No	No	1	10	High	Medium	Low	High, positive	No	--	Targets policy objective PG1-L-O3
29	Land	Building and restoring dikes	Dike buildin g	A programme for active flood protection measures, including the building of new dikes and the restoration and raising of old ones	1	Yes	Multiple	-50 %	No	No	2	10	Medium	Low	Mediu m	Low, positive	No	--	Targets policy objective PG3-L-O1

30	Land	Relocations for flood safety	Relocations	Forced relocation of people's homes and infrastructure away from flood prone areas	0	Yes	Once		No	No	2	999	High	Low	High	Low, positive	No	--	Targets policy objective PG3-L-O2, social capital generated is net balance of highly positive environmental effects and highly negative relocation experiences.
31	Land	Removal and cutting of dikes	Dike demolition	Removal and/or cutting of dikes in order to restore riparian zones and natural flooding space	1	Yes	Multiple	-50 %	Yes	Yes	2	999	Low	Low	Low	Medium, positive	No	--	Targets policy objective PG3-L-O2, pre-game applications in SDM 03, further restorations of riparian zones planned
32	Climate	Technical measures to cool the agricultural landscape	Technical agri-cooling	Local geoengineering measures, e.g. distribution of white pigments over soil surfaces	1	No	Multiple	0 %	No	No	1	1	Medium	Low	High	Low, positive	No	--	Targets policy objective PG1-C-O1
33	Climate	Natural measures to cool the agricultural landscape	Natural agri-cooling	Developing integrated agro-forestry systems: First movers can obtain project funding	1	Yes	Multiple	0 %	No	No	4	10	High	Low	Medium	Medium, positive	No	--	Targets policy objective PG1-C-O1

9.11. Transboundary Case Study: France-Germany

Table 9.46. Policy goals table for France-Germany

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Reduction in GHG emissions	Reach the commitments made under the Paris Agreement to reduce GHG emissions	PG1
Balanced used of water resource	Ensure the balanced use of surface and groundwater resources	PG2
Resilience	Increase the resilience of the territory by ensuring food security, energy security and resilience to flood risk	PG3
Functional ecosystems	Restore and maintain forests, wetlands and water ecosystems	PG4

Table 9.47. Policy goals score indicator thresholds for France-Germany

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-W	low	0,5
PG1-W	medium	0,75
PG1-W	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-W	low	0,5
PG2-W	medium	0,75
PG2-W	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-W	low	0,5
PG3-W	medium	0,75
PG3-W	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG4-W	low	0,5
PG4-W	medium	0,75
PG4-W	high	0,9

Table 9.48. Policy objectives table for France-Germany

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim France*	*Weight of the Objective in contributing to the achievement of the overall policy aim Germany*
PG1	Decrease energy consumption	O1	0,2	0,142857143
PG1	Support the development of renewables	O2	0,2	0,142857143
PG1	Reduce primary consumption of fossil fuels	O3	0,2	0,142857143
PG1	Increase carbon storage	O4	0,2	0,142857143
PG1	Decrease emissions from food consumption	O5	0,2	0,142857143
PG1	Increase the share of electricity consumption generated by renewables	O6	0	0,142857143
PG1	Decrease electricity consumption	O7	0	0,142857143
PG2	Ensure balanced use of groundwater resources	O8	0,5	0,5
PG2	Ensure balanced use of surface water resources	O9	0,5	0,5
PG3	Increase resilience to flood risk	O10	0,25	0,25
PG3	Increase resilience to nuclear risk	O11	0,25	0,25

PG3	Ensure food security	O12	0,25	0,25
PG3	Ensure energy security	O13	0,25	0,25
PG4	Respect minimum ecological flows of surface waterways	O14	0,25	0,25
PG4	Ensure balanced use of groundwater resources	O15	0,25	0,25
PG4	Restore quality of water bodies	O16	0,25	0,25
PG4	Protect natural areas	O17	0,25	0,25

Table 9.49. Policy objective performance indicators formulas table for France-Germany

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	(1-(energy_cons/energy_cons_baseline))/(reduction_rate_energy_cons_objective)	Degree of achievement of the ultimate goal of emissions reduction
O2	((share_renewables/share_renewables_baseline)-1)/(increase_rate_share_renew_objective)	Degree of achievement of the ultimate goal in terms of share of renewables in the energy mix
O3	(1-(FF_cons/FF_cons_baseline))/(reduction_rate_FF_cons_objective)	Degree of achievement of the ultimate goal of reducing the consumption of fossil fuels
O4	total_annual_carbon_storage_capacity/maximum_possible_carbon_storage_capacity	Degree of achievement of maximum carbon storage capacity
O5	emissions_from_food_consumption/emission_from_100%_vegetarian_food_consumption	Degree of achievement minimum emissions from food consumption
O6	((share_elec_cons_renewables/share_elec_cons_renewables_baseline)-1)/(increase_rate_share_elec_cons_renew_objective)	Degree of achievement of the ultimate goal in terms of share of electricity consumption from renewables
O7	(1-(elec_cons/elec_cons_baseline))/(reduction_rate_elec_cons_objective)	Degree of achievement of the ultimate goal of reducing electricity consumption
O8	1-(1-(Raw_GW_use/(aquifer_recharge-GW_discharge_SW+GW_recharge_SW)); performance indicator = 1 if ratio Raw_GW_use/(aquifer_recharge-GW_discharge_SW+GW_recharge_SW) <1	Degree of achievement of balanced GW use : Water consumption from GW is balanced if not more than the net GW recharge is used
O9	1-(1-(Raw_SW_use/(SW_inflow+GW_discharge_SW-ET_losses-GW_recharge_SW)); performance indicator = 1 if ratio (Raw_SW_use/(SW_inflow+GW_discharge_SW-ET_losses-GW_recharge_SW) <1	Degree of achievement of balanced SW use : Water consumption from SW is balanced if not more than the net SW recharge is used
O10	(1-(decrease_in_wetlands) + (1-increase in waterproof urban areas))/2	Degree of achievement : resilience to floods is increased if there is no nett loss in wetlands and no net increase in waterproof urban areas
O11	(1-(share_nuclear/share_nuclear_baseline))/(reduction_rate_share_nuclear_objective)	Degree of achievement of the ultimate goal in terms of reducing the share of electricity produced based on nuclear power
O12	share (in %) of food consumption being locally produced	Degree of achievement of food self-sufficiency
O13	share (in %) of energy consumption being locally produced	Degree of achievement of energy self-sufficiency
O14	(total_runoff/ minimum ecological flows for main waterways); equal to 1 if the latter ratio greater than 1	Degree minimum achievement minimum ecological flows for main waterways
O15	1-(1-(Raw_SW_use/(0,75*(SW_inflow+GW_discharge_SW-ET_losses-GW_recharge_SW))); performance indicator = 1 if ratio (Raw_SW_use/(0,75*(SW_inflow+GW_discharge_SW-ET_losses-GW_recharge_SW)) <1	Degree of achievement of balanced GW use : Water consumption from GW is balanced if not more than 75% of the net GW recharge is used
O16	(1-(agri_input_use/agri_input_use_baseline))/(reduction_rate_agri_input_use_objective)	Degree of achievement of the ultimate goal of reducing the use of agricultural inputs

O17	(1-(decrease_in_wetlands) + (1-decrease in forest areas))/2	Degree of achievement : objective reached if there is no loss in forest areas and wetlands

Table 9.50. Policy cards table for France-Germany

Policyld	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level : National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Energy	Improve energy efficiency of 5% of dwelling places through a subsidy	EE - Subsidy 5	Subsidy to landlords carrying out energy renovation work ; the aim here is to reduce energy consumption from households	0	Yes	Multiple	0%	0%	0%	5	5	Low	Low	Low	Low positive	E3ME	Exogenous reduction in energy consumption. Increase in expenditure on energy efficiency goods.	
2	Energy	Improve energy efficiency of 10% of dwelling places through a subsidy	EE - Subsidy 10	Subsidy to landlords carrying out energy renovation work ; the aim here is to reduce energy consumption from households	0	Yes	Multiple	0%	0%	0%	5	5	Low	Medium	Medium	Medium positive	E3ME	Exogenous reduction in energy consumption. Increase in expenditure on energy efficiency goods.	

3	Energy	Improve energy efficiency of 20% of dwelling places through a subsidy	EE - Subsidy 20	Subsidy to landlords carrying out energy renovation work ; the aim here is to reduce energy consumption from households	0	Yes	Multiple	0%	0%	0%	5	5	Medium	Medium	Medium	Medium positive	E3ME	Exogenous reduction in energy consumption. Increase in expenditure on energy efficiency goods.	
4	Energy	Next generation smart metering energy	Smart-meters	Smart metering designed to give the householder more detailed information on their energy use a	0	Yes	Once	0%	0%	0%	5	5	Low	Low	Medium	Low positive	No		
5	Energy	Increase the share of private electric vehicles	E-Car	Rebate for the purchase of an electric vehicle aiming at decarbonizing the French fleet	0	No	Multiple	0%	0%	0%	0	5	Medium	Low	Low	Low positive	E3ME	Amount by which cost of car is reduced.	
6	Energy	Support the deployment of wind-energy	Support-Wind	Strong policy and financial support for wind energy	0	No	Multiple	0%	0%	0%	0	5	Medium	High	Medium	Low positive	E3ME	Subsidy, feed in tariff or direct regulation on wind.	
7	Energy	Support the deployment of PV	Support-Solar	Strong policy and financial support for solar energy	0	No	Multiple	0%	0%	0%	0	5	Medium	High	Low	Low positive	E3ME	Subsidy, feed in tariff or direct regulation on solar.	
8	Energy	Support the development of electricity generation from biogas	Support-Biogas	Strong policy and financial support for electricity cogenerated by mechanisation plants to ensure economic viability and foster the development of this technology	0	No	Multiple	0%	0%	0%	0	5	Low	Medium	Low	Low positive	E3ME	Subsidy, feed in tariff or direct regulation on biogas.	
9	Energy	Support heat production from renewables	Heat-R	Strong policy and financial support for heat production from renewables	0	No	Multiple	0%	0%	0%	0	5	Low	Low	Low	Low positive	No		

10	Land	Increase forest area by 2%	FOR 2	Increase in forest area allowing to increase carbon storage and wood production	0-1	No	Multiple	0%	0%	0%	30	30	Low	Low	Low	Medium positive	work in progress		
11	Land	Increase forest area by 5%	FOR 5	Increase in forest area allowing to increase carbon storage and wood production	0-1	No	Multiple	0%	0%	0%	30	30	Low	Low	Low	Medium positive	work in progress		
12	Land	Increase wetlands area by 1%	WET 1	Increase in wetlands area allowing to increase carbon sequestration and water storage (protection against floods)	0-1	No	Multiple	0%	0%	0%	0	5	Low	Low	Low	Low positive	work in progress		
13	Land	Increase wetlands area by 2%	WET 2	Increase in wetlands area allowing to increase carbon sequestration and water storage (protection against floods)	0-1	No	Multiple	0%	0%	0%	0	5	Low	Low	Low	Low positive	work in progress		
14	Land	Increase wetlands area by 5%	WET 5	Increase in wetlands area allowing to increase carbon sequestration and water storage (protection against floods)	0-1	No	Multiple	0%	0%	0%	0	5	Low	Low	Low	Medium positive	work in progress		
15	Energy	Command 20% of biofuels in total energy use in the transport sector	BioTransport 20	Increase the use of biofuels in the transport sector to decarbonize the latter	1	Yes	Once	0%	0%	0%	5	5	Low	Medium	Low	Low positive	E3ME	biofuel mandates/ other regulation.	

16	Energy	Command 50% of biofuels in total energy use in the transport sector	BioTransport 50	Increase the use of biofuels in the transport sector to decarbonize the latter	1	Yes	Once	0%	0%	0%	10	10	Medium	Medium	Low	Low positive	E3ME	biofuel mandates/ other regulation.	
17	Energy	Ban on fossil fuels for electricity generation	No FF	Decarbonization of the energy sector	0	Yes	Once	0%	0%	0%	30	50	Low	Medium	Low	Medium positive	E3ME	Regulation to phase out fossil fuel.	
18	Food	Decrease the share of animal products in food consumption by 10%	ToVeg 10	Reduce consumption of animal product in order to decrease GHG emissions from food consumption	0-1	No	Multiple	0%	0%	0%	0	5	Low	Low	Low	Medium positive	work in progress		
19	Food	Decrease the share of animal products in food consumption by 25%	ToVeg 25	Reduce consumption of animal product in order to decrease GHG emissions from food consumption	0-1	No	Multiple	0,00%	0,00%	0,00%	5	5	Low	Low	Medium	Low positive	work in progress		
20	Food	Decrease the share of animal products in food consumption by 50%	ToVeg 50	Reduce consumption of animal product in order to decrease GHG emissions from food consumption	0-1	No	Multiple	0,00%	0,00%	0,00%	10	10	Low	Low	High	Low negative	work in progress		
21	Food	Command 50% of total food consumption from local production	Local food 50	Increase food security by commanding 50% of total food consumption from local production	1	Yes	Once	0,00%	0,00%	0,00%	5	5	Low	Low	Medium	Medium positive	work in progress		
22	Food	Command 100% of total food consumption from local production	Local food 100	Ensure food security by commanding 100% of total food consumption from local production	1	Yes	Once	0,00%	0,00%	0,00%	5	5	Low	High	High	High positive	work in progress		

23	Energy	Energy efficiency standards	EE standards	Legislating for new homes to be low carbon, energy and water efficient and climate resilient	0	Yes	Once	0,00%	0,00%	0,00%	0	5	Low	Medium	Low	Low positive	No		
24	Climate	Implement soil conservation measures in agriculture through PES/AES schemes : 20% of agricultural areas	AGR-Soil 20	Increase carbon storage capacity of agricultural soils	0-1	No	Multiple	0,00%	0,00%	0,00%	5	10	Low	Low	Low	High positive	work in progress		
25	Climate	Implement soil conservation measures in agriculture through PES/AES schemes : 30% of agricultural areas	AGR-Soil 30	Increase carbon storage capacity of agricultural soils	0-1	No	Multiple	0,00%	0,00%	0,00%	5	10	Low	Medium	Medium	High positive	work in progress		
26	Climate	Implement soil conservation measures in agriculture through PES/AES schemes : 50% of agricultural areas	AGR-Soil 50	Increase carbon storage capacity of agricultural soils	0-1	No	Multiple	0,00%	0,00%	0,00%	5	10	Low	Medium	High	High positive	work in progress		
27	Climate	Implement soil conservation measures in forestry PES/AES schemes :50% of forest areas	FOR-Soil 50	Increase carbon storage capacity of forest soils	0-1	No	Multiple	0,00%	0,00%	0,00%	5	10	Low	Low	Medium	High positive	work in progress		

28	Climate	Implement soil conservation measures in forestry PES/AES schemes : 100% of forest areas	FOR-Soil 100	Increase carbon storage capacity of forest soils	0-1	No	Multiple	0,00%	0,00%	0,00%	5	10	Low	Medium	High	High positive	work in progress		
29	Water	Improve the efficiency of water distribution networks in urban areas	W-Net urban	Reducing leakage within the drinking water distribution network	1	Yes	Once	0,00%	0,00%	0,00%	10	10	Low	Low	Low	Low positive	work in progress		
30	Water	Improve the efficiency of water distribution networks in rural areas	W-Net rural	Reducing leakage within the drinking water distribution network	1	Yes	Once	0,00%	0,00%	0,00%	10	10	Medium	Medium	Low	Low positive	work in progress		
31	Water	Improve the efficiency of irrigation systems for 50% of irrigated cropland areas	EE-Irri 50	Decrease water consumption from irrigation by investing in more efficient irrigation techniques	1	Yes	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Medium	Medium positive	work in progress		
32	Water	Improve the efficiency of irrigation systems maize for 100% of irrigated cropland areas	EE-Irri 100	Decrease water consumption from irrigation by investing in more efficient irrigation techniques	1	Yes	Once	0,00%	0,00%	0,00%	0	5	Low	Low	High	High positive	work in progress		
33	Water	Next generation smart metering water	Smart-Water	Smart metering designed to give the householder more detailed information on their water use	0	Yes	Once	0,00%	0,00%	0,00%	5	5	Low	Low	Medium	Low positive	work in progress		

34	Energ y	Decrease the share of nuclear in the energy mix by 50%	D-Nucle ar 50	Diversification of the energy generation portfolio in order to decrease reliance on nuclear energy and exposure to nuclear risk	0	Yes	Multipl e	0,00%	0,00%	0,00%	15	15	High	Medium	Medium	Medium positive	E3ME	Regulation. Setting electricity capacity to certain maximum in a certain year.	
35	Energ y	Decrease the share of nuclear in the energy mix by 25%	D-Nucle ar 25	Diversification of the energy generation portfolio in order to decrease reliance on nuclear energy and exposure to nuclear risk	0	Yes	Multipl e	0,00%	0,00%	0,00%	10	10	Medium	Low	Medium	Medium positive	E3ME	Regulation. Setting electricity capacity to certain maximum in a certain year.	
36	Energ y	Decrease the share of nuclear in the energy mix by 10%	D-Nucle ar 10	Diversification of the energy generation portfolio in order to decrease reliance on nuclear energy and exposure to nuclear risk	0	Yes	Multipl e	0,00%	0,00%	0,00%	5	5	Medium	Low	Low	Low positive	E3ME	Regulation. Setting electricity capacity to certain maximum in a certain year.	
37	Water	Irrigation cap	Irriga tion cap - 10	10% maximum irrigated crops areas	1	No	Multipl e	0,00%	0,00%	0,00%	0	5	Low	Low	High	Low negative	work in progress		
38	Water	Irrigation cap	Irriga tion cap - 5	5% maximum irrigated crops areas	1	No	Multipl e	0,00%	0,00%	0,00%	0	5	Medium	Low	High	Low negative	work in progress		
39	Water	Irrigation cap	Irriga tion cap - 2	2% maximum irrigated crops areas	1	No	Multipl e	0,00%	0,00%	0,00%	0	5	Medium	Medium	High	Medium negative	work in progress		

40	Water	Domestic water reuse (grey water)	Water reuse	Deployment of grey water recycling devices in the home to reduce domestic water consumption	1	Yes	Once	0,00%	0,00%	0,00%	5	5	Low	Medium	Medium	Medium positive	work in progress		
41	Energy	Ban on nuclear power	Ban nuclear	No nuclear production in this region (but imported electricity can still be made from nuclear power plants) ; the aim here is to reduce exposure to nuclear risk	0	Yes	Once	0,00%	0,00%	0,00%	30	20	High	Low	Low	Medium positive	E3ME	Regulation. Setting electricity capacity to zero in a certain year.	
42	Land	100% Compensation of destroyed forest areas and wetland	PRC principle	Prevent - Reduce - Compensate principle : 100% compensation of destroyed natural land	0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Medium	Medium	Medium positive	work in progress		
43	Land	Ban on decrease in agricultural areas	Preserve agri	Prevent the decrease in agricultural land to secure food production	0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Low	Medium positive	work in progress		
44	Energy	Command 100% of total primary energy consumption from local production	E-Self-sufficiency	Ensure energy security by commanding 100% of total primary energy consumption from local energy production	0-1	Yes	Once	0,00%	0,00%	0,00%	10	10	Medium	Medium	Medium	High positive	No		
45	Land	Upper limit on areas for energy crops : 5% of total utilized agricultural area	Energy crops 5	5% maximum of utilized agricultural area dedicated to energy production	0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Low	Low positive	work in progress		

46	Land	Upper limit on areas for energy crops : 10% of total utilized agricultural area	Energy crops 10	10% maximum of utilized agricultural area dedicated to energy production	0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Low	Low positive	work in progress		
47	Land	Increase green urban areas by 5%	Green-urban 5	Increase in green urban areas to increase water infiltration and improve resilience to flood risk	1	No	Multiple	0,00%	0,00%	0,00%	0	10	Low	Low	Low	Low positive	work in progress		
48	Land	Increase green urban areas by 10%	Green-urban 10	Increase in green urban areas to increase water infiltration and improve resilience to flood risk	1	No	Multiple	0,00%	0,00%	0,00%	0	10	Low	Medium	Low	Medium positive	work in progress		
49	Land	Increase green urban areas by 15%	Green-urban 15	Increase in green urban areas to increase water infiltration and improve resilience to flood risk	1	No	Multiple	0,00%	0,00%	0,00%	0	10	Medium	Medium	Low	High positive	work in progress		
50	Land	Ban on land-use change	No LUC	Ban on land use change to maintain functioning ecosystems	0-1	No	Multiple	0,00%	0,00%	0,00%	0	10	Low	Low	High	Low negative	work in progress		
51	Land	Decrease the use of agricultural inputs by 25%	Less-input 25	Decrease in the use of pesticides/agricultural inputs in order to increase water quality and restore ecosystems	0	No	Multiple	0,00%	0,00%	0,00%	5	5	Low	Low	Medium	Medium positive	work in progress		

52	Land	Decrease the use of agricultural inputs by 50%	Less input 50	Decrease in the use of pesticides/agricultural inputs in order to increase water quality and restore ecosystems	0	No	Multiple	0,00%	0,00%	0,00%	10	10	Medium	Medium	High	Low positive	work in progress		
53	Energy	5% Increase price of electricity	P-Elec 5		0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Low	Low positive	E3ME	Increase domestic tax rates.	
54	Energy	10% Increase price of electricity	P-Elec 10		0	No	Multiple	0,00%	0,00%	0,00%	0	5	Medium	Low	Medium	Low negative	E3ME	Increase domestic tax rates.	
55	Energy	5% increase in price of natural gas	P-Gas 5		0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Low	Low positive	E3ME	Increase domestic tax rates.	
56	Energy	10% increase in price of natural gas	P-Gas 10		0	No	Multiple	0,00%	0,00%	0,00%	0	5	Medium	Low	Medium	Low negative	E3ME	Increase domestic tax rates. Or. Change in prices at global level	
57	Energy	5% tax on fossil fuels	FF tax 5	Implementation of a 5% tax on all fossil fuels	0	No	Multiple	0,00%	0,00%	0,00%	0	5	Low	Low	Medium	Low negative	E3ME	Energy or carbon tax on top of ETS. Need Value of tax and sectors covered.	
58	Energy	10 tax on fossil fuels	FF tax 10	Implementation of a 10% tax on all fossil fuels	0	No	Multiple	0,00%	0,00%	0,00%	0	5	Medium	Low	Medium	Low negative	E3ME	Energy or carbon tax on top of ETS. Need Value of tax and sectors covered.	

9.12. Continental Case Study: Europe

Table 9.51. Policy goals table for Europe

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Low Carbon Economy	Reduce Greenhouse Gas Emissions in Europe Consistent with at least an RCP2.6 deg pathway	PG1-EM
Nexus Health	Achieve good health status for the remaining 4 Nexus elements (Food, Energy, Land and Water)	PG2-NX

Table 9.52. Policy goals score indicator thresholds for Europe

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-EM	low	0,5
PG1-EM	medium	0,8

PG1-EM	high	0,95
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-NX	low	0,2
PG2-NX	medium	0,6
PG2-NX	high	0,9

Table 9.53. Policy objectives table for Europe

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-EM	Reduce Greenhouse Gas Emissions in Europe Consistent with RCP2.6 pathway	O1_EM	1
PG2-NX	Sustainable water withdrawals	O2_NXW	0,15
PG2-NX	Energy Security: Supply, A large portion of energy used in Europe should be created in Europe	O3_NXEa	0,1
PG2-NX	Energy Security: Access, maintain low energy prices	O4_NXEb	0,25
PG2-NX	Food Security: Supply, A large portion of food consumed in Europe should be grown in Europe	O5_NXFa	0,1
PG2-NX	Food Security: Access, maintain low food prices	O6_NXFb	0,25
PG2-NX	Protect land for Nature	O7_NXFb	0,15

Table 9.54. Policy objective performance indicators formulas table for Europe

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1_EM	Remaining GHG emissions allowed	Difference between total Greenhouse Gas Emissions and total allowable greenhouse gas emissions. Calculated in SDM and scaled to between zero and 1
O2_NXW	Remaining Sustainable Water Withdrawals	Difference between irrigation water withdrawals and sustainable water withdrawals. Calculated in SDM and scaled to between zero and 1
O3_NXEa	Energy Supply Security	Share energy (primary and secondary) used in Europe that is produced in Europe. (Calculated in SDM and scaled to meet realistic target).
O4_NXEb	Average Energy Price	Weighted average energy price of final energy consumed. Calculated in SDM and scaled to between zero and 1
O5_NXFa	Food Supply Security	Share of food consumed in Europe that is grown in Europe. (Calculated in SDM and scaled to meet realistic target).
O6_NXFb	Average Food Price	Price of Food consumed in Europe. Calculated in SDM and scaled to between zero and 1
O7_NXFb	Target available land for Nature	Area of land for Nature. Calculated in SDM and scaled to between zero and 1

Table 9.55. Policy cards table for Europe

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National (0), Regional (1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Water	Restrict Irrigation Areas	Restrict Irrigation Areas	Fix or limit growth of irrigated areas with respect to the previous period.	1	No	Multiple	0%	100%	100%	5	5	Low	Low	Low	Zero	CAPRI	Directly affects the variable (Land cover | Cropland | Irrigated)	
2	Water	Increase irrigation efficiency.	Increase irrigation efficiency.	Decrease the amount of water withdrawals needed to achieve irrigated crop yields.	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	CAPRI	Directly affects the variable (Water Withdrawal | Irrigation)	
3	Land	Increase Protected Nature areas	Protect area for Nature	Increase land cover of protected nature areas and decrease the growth potential of agricultural areas.	1	No	Multiple	0%	100%	100%	5	5	Low	Low	Low	Low positive	CAPRI, MAGNET	Directly effects the variables: (Land cover | Cropland) and (Land cover | Pasture)	

4	Energy	Increase energy efficiency in Transport	Energy efficiency , transport	Reduce the amount of energy needed in Transport	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Liquids Consumption | Transport) , (Primary Energy Coal Consumption | Transport) and (Primary Energy Gas Consumption | Transport)	Policy could also be implemented Europe wide not just regional
5	Energy	Increase energy efficiency in Industry	Energy efficiency , Industry	Reduce the amount of energy needed in Industry	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Liquids Consumption | Industry) , (Primary Energy Coal Consumption | Industry) and (Primary Energy Gas Consumption | Industry, (Electricity Consumption | Industry)	Policy could also be implemented Europe wide not just regional
6	Energy	Increase energy efficiency in Industry	Energy efficiency , Industry	Reduce the amount of energy needed in Industry	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Liquids Consumption | Industry) , (Primary Energy Coal Consumption | Industry) and (Primary Energy Gas Consumption | Industry, (Electricity Consumption | Industry)	Policy could also be implemented Europe wide not just regional

7	Energy	Increase energy efficiency in Agriculture	Energy efficiency , Agricultur e	Reduce the amount of energy needed in Agriculture	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Liquids Consumption | Agriculture) , (Primary Energy Coal Consumption | Agriculture) and (Primary Energy Gas Consumption | Agriculture), (Electricity Consumption | Agriculture)	Policy could also be implement ed Europe wide not just regional
8	Energy	Increase energy efficiency in Services	Energy efficiency , Services	Reduce the amount of energy needed in Services	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Liquids Consumption | Services) , (Primary Energy Coal Consumption | Services) and (Primary Energy Gas Consumption | Services), (Electricity Consumption | Services)	Policy could also be implement ed Europe wide not just regional
9	Energy	Increase energy efficiency in Households	Energy efficiency , Domestic	Reduce the amount of energy needed in Households	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Liquids Consumption | Domestic) , (Primary Energy Coal Consumption | Domestic) and (Primary Energy Gas Consumption | Domestic), (Electricity Consumption | Domestic)	Policy could also be implement ed Europe wide not just regional

10	Energy	Increase energy efficiency in Electricity Production	Energy efficiency , Electricity	Reduce the amount of primary energy needed in electricity production	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Electricity | Coal) , (Secondary Energy Electricity | Gas) , (Secondary Energy Electricity | Biomass), (Secondary Energy Electricity | Solar and Wind) , (Secondary Energy Electricity | Nuclear)	Policy could also be implemented Europe wide not just regional
11	Energy	Increase energy efficiency in Fuel Production	Energy efficiency , Fuel	Reduce the amount of primary energy needed in Fuel production	1	Yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Fossil Fuel | Oil) , (Secondary Biofuel |Biomass)	Policy could also be implemented Europe wide not just regional
12	Energy	Renewable Electricity Mandate	Renewable Electricity Mandate	Increase share of renewables in electricity generation	1	No	Multiple	0%	100%	100%	5	10	Medium	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Electricity | Coal) , (Secondary Energy Electricity | Gas) , (Secondary Energy Electricity | Biomass), (Secondary Energy Electricity | Solar and Wind) , (Secondary Energy Electricity | Nuclear)	Policy could also be implemented Europe wide not just regional
13	Energy	Increase Electricity Production from Solar and Wind	Increase Solar and Wind	Increase Electricity Production of Solar and Wind	1	No	Multiple	0%	100%	100%	5	10	Medium	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Electricity | Solar and Wind)	
14	Energy	Increase Electricity Production from Biomass	Increase Bioelectricity	Increase Electricity Production from Biomass	1	No	Multiple	0%	100%	100%	5	10	Medium	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Electricity | Biomass)	

15	Energy	Increase Electricity Production from Hydropower	Increase Hydroelectricity	Increase Electricity Production from Hydropower	1	Yes	Multiple	0%	100%	100%	5	40	Medium	Low	Medium	Zero	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Electricity | Hydro)	Policy can be applied limited times and in limited regions
16	Energy	Change Biofuel Mandates	Biofuel Mandates	Increase (or decrease) Biofuel mandate	1	No	Multiple	0%	100%	100%	5	5	Medium	Low	Medium	Zero	E3ME, MAGNET	(Secondary Energy Fossil Fuel | Oil) , (Secondary Biofuel |Biomass)	Policy could also be implemented Europe wide not just regional
17	Food	Increase irrigated areas	Increase irrigated areas	Increase growth of irrigated areas with respect to the previous period.	1	No	Multiple	0%	100%	100%	5	5	Low	Low	Low	Zero	CAPRI, MAGNET	Directly affects the variable (Land cover | Cropland | Irrigated)	
18	Food	Increase investments in crop yields	Increase crop yields	Increase crop production per hectare or land	1	yes	Multiple	-20%	100%	100%	5	40	Low	Low	Low	Zero	CAPRI, MAGNET	Directly affects the variable (Yield)	
19	Food	Stimulate a shift in diets, less meat consumption	Diet shift	Households reduce share of meat in total calorie consumption	1	Yes	Once	0%	100%	100%	10	40	Medium	Low	Medium	Low positive	CAPRI, MAGNET	Directly affects the variables (Food Demand | Crops) and (Food Demand | Livestock)	Policy could also be implemented Europe wide not just regional
20	Climate	Carbon price on all GHG emissions	Carbon Price All	Increase the cost of a polluting activity (e.g. electricity from coal, livestock production etc...) and therefore reduce that activity.	1	No	Multiple	0%	0%	0%	5	5	Medium	Low	High	Low positive	CAPRI, E3ME, MAGNET	Directly affects the greenhouse gas emissions from all sources (Energy and Food System) as well as the price and production of the GHG emitting activities	Policy could also be implemented Europe wide not just regional

21	Climate	Carbon price on ETS sectors	Carbon Price ETS	Increase the cost of a polluting activity in the ETS sectors	1	No	Multiple	0%	0%	0%	5	5	Medium	Low	Medium	Low positive	E3ME, MAGNET	Directly affects the greenhouse gas emissions from ETS sectors (Energy, Transport and Industry) as well as the price and production of the these GHG emitting activities	Policy could also be implemented Europe wide not just regional
22	Climate	Carbon price on Agriculture	Carbon Price Agriculture	Increase the cost of a polluting activity in the Agriculture	1	No	Multiple	0%	0%	0%	5	5	Low	Low	High	Low positive	CAPRI, MAGNET	Directly affects the greenhouse gas emissions from agricultural activities well as their price and production	Policy could also be implemented Europe wide not just regional
23	Climate	Investments in GHG emission abatement in Agriculture	Emission abatement in Agriculture	Reduce emission coefficient in agriculture	1	Yes	Multiple	-50%	0%	0%	5	40	Low	Low	Low	Zero	CAPRI, MAGNET	Directly affects the emissions coefficient of crops and Livestock	Policy could also be implemented Europe wide not just regional
24	Climate	Investments in CCS GHG emission abatement in Electricity production	CCS	Investments in Carbon Capture and Storage (CCS) to reduce the GHG emission coefficient in Electricity production (Negative for Bioelectricity)	1	Yes	Multiple	-50%	0%	0%	5	40	Medium	Low	Low	Zero	E3ME, MAGNET	Directly effects the variables: (Secondary Energy Electricity | Coal) , (Secondary Energy Electricity | Gas) , (Secondary Energy Electricity | Biomass)	Policy could also be implemented Europe wide not just regional
25	Climate	Increase electrification in road vehicles	Promote electric vehicles	Increase electricity demand and reduce petrol demand in transport.	1	Yes	Multiple	-30%	0%	0%	5	40	Low	Low	Low	Low positive	E3ME, MAGNET	Directly effects the variables: (Secondary Energy | Electricity Consumption| Transport) , (Secondary Energy Liquids Consumption| Transport)	Policy could also be implemented Europe wide not just regional

9.13. Global Case Study

Table 9.56. Policy goals table for Global

Policy Goal (PG) - Name	*Policy Goal (PG) - Description*	*Policy Goal id*
Climate and energy	Limit climate change to 2 degrees above pre-industrial temperatures	PG1-CE
Land and biodiversity	Prevent biodiversity loss	PG2-LB
Food	Achieve healthy and sufficient diets for all	PG3-F
Water	Reduce water use and improve water quality	PG4-W

Table 9.57. Policy goals score indicator thresholds for Global

Policy Goal id	*Policy Goal Score Indicator thresholds*	
PG1-CE	low	0,3
PG1-CE	medium	0,6
PG1-CE	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG2-LB	low	0,3
PG2-LB	medium	0,6
PG2-LB	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG3-F	low	0,3
PG3-F	medium	0,6
PG3-F	high	0,9
Policy Goal id	*Policy Goal Indicator thresholds*	
PG4-W	low	0,3
PG4-W	medium	0,6
PG4-W	high	0,9

Table 9.58. Policy objectives table for Global

Policy Goal id	*Policy Objective (O)*	*Policy objective id*	*Weight of the Objective in contributing to the achievement of the overall policy aim*
PG1-CE	Limit climate change to 2 degrees above pre-industrial temperatures	O1	1
PG2-LB	Prevent biodiversity loss	O2	1
PG3-F	Achieve healthy and sufficient diets for all	O3	1
PG4-W	Reduce water use and improve water quality	O4	1

Table 9.59. Policy objective performance indicators formulas table for Global

Policy Objective id	*policy objective performance indicator formula (based on SDM variables) - score must be between 0 and 1*	*Description of policy objective indicator*
O1	1	temperature
O2	1	forest area
O3	1	food price
O4	1	(water use + nutrient loading)/2

Table 9.60. Policy cards table for Global

PolicyId	Nexus Sector	Name	Very short policy card name	Description of intervention as captured by the policy card	Level: National(0), Regional(1)	Permanent? (if Permanent: effects persist until the end of the Game. Otherwise effect persists only during Policy implementation time	Can this policy be applied only once, or can it be applied multiple time (Once/Multiple)	If the policy can be applied multiple time, does it always effects the same changes, or does its effectiveness gradually loses effectiveness	Is this policy applied pre-game from 2010 to 2015 (as a % of policy efficiency)?	Is this policy applied pre-game from 2015 to 2020 (as a % of policy efficiency)?	Building/implementation time (years, multiple of 5)	Active time (years, multiple of 5)	Costs associated to the intervention/measure per turn (5 years): Order of Magnitude High, Medium, Low	Economic Value generated by the intervention/measure per playround: Order of Magnitude High, Medium, Low	Social capital required to implement the policy intervention: Order of Magnitude High, Medium, Low	Social Capital generated by the intervention/measure per turn: High, medium, low, positive or negative	Is the intervention/measure included in any of the thematic models? If yes, which one?	How does this intervention/measure translate into model input?	Comments
1	Climate, energy	Climate and energy	Climate &Energy	Climate policy to achieve 2-degree target	0	Yes	Once		0	0	5	35	High	Medium	High	Medium	yes, IMAGE	integrated in model	
1	Land, biodiversity	Land and biodiversity	Land&Biodiv	Land protection for biodiversity	0	Yes	Once		0	0	5	35	Medium	Low	Medium	Low	yes, IMAGE	integrated in model	
1	Food security	Food security	Food	Healthy diets and agricultural intensification	0	Yes	Once		0	0	5	35	Medium	Medium	High	Medium	yes, IMAGE	integrated in model	

1	Water	Water	Water	Water saving and improved quality	0	Yes	Once		0	0	5	35	High	Low	Low	High	yes, IMAGE	integrated in model	

10. Annex 2. Glossary of Terms under development in SIM4NEXUS

Glossary term	Definition	Example
A		
adaptation	The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as the adjustment in natural or human systems in the response to expected or actual climatic changes in order to take the appropriate actions to prevent, or minimize, damage or taking advantage of the opportunities emerging. In contrast to "mitigation", adaptation refers to adapting to the climate change effects that are already unavoidable.	Develop drought-tolerant crops Set aside land corridors in order to help species migrate
C		
circular economy	"Reduce, re-use, recycle". A system in which resources that are being used are minimized and when a product reaches the end of its life, it will be recycled to create further value. Thus, waste becomes a resource in the beginning of the loop. Opposite to linear economy that adopts a "take, make, dispose" chain	Recycling of plastic bags (minimizing waste, and re-using material)
climate change	Change in the statistical distribution of weather patterns, given that the change has lasted over an extended period of time. The change can either occur in the average climate conditions, or the time variation of that climatic region.	Change in intensity or duration of precipitation Alteration in extreme climatic events such as storms
Complexity science conceptual model	Conceptual (sometimes also known as a 'mind map') representation of the key interactions between and within nexus systems in the form of a qualitative diagram. The conceptual design of how nexus domains interact in a case study will serve as the basis for the development of the quantitative System Dynamics Model (SDM). The conceptual model is an abstraction of reality, usually with both a	Flow chart of energy system to reflect the actual flow of energy in a region

	physical and social meaning, and aims at providing a representation of the main complex relations between the sub-systems under investigation.	
D		
determining agent	An element or factor that determines the nature or outcome of something.	A greenhouse gases (GHG) emission reduction target determines how the energy system is transformed.
E		
energy efficiency	Reducing the amount of energy that is required in services or products, which is done by using more efficient technologies or processes to, among others, reduce energy losses.	Insulation of buildings. Electric vehicles.
G		
goal	Understood as a preferred future (Bishop et al, 2007). That results from analysing a combination of outcomes and performance metrics to see whether one have reached their objective (could be indicators).	Sustainable Development Goals (SDGs)
I		
indicator	Metric used to express, in quantitative terms, the status of important elements within each nexus domain. They serve to evaluate the performance of an action, measure or change of status (climate), infer on its potential impact and/or implication, either directly or indirectly (proxy indicator). Further, indicators are often directly related to goals.	Energy: Carbon intensity of electricity generation - CO2/kWh; Water: annual water consumption per capita (m3 PC)
indicator, success	A success indicator provides a quantitative reference /benchmark of the desired performance of a sector or system. It is derived based on the policy targets defined for that sector or system.	European Union Intended Nationally Determined Contribution (INDC) target - minimum of 40% domestic reduction

		in GHG emissions by 2030, in comparison to 1990 levels
impact	The change in status a policy mechanism and/or a technology innovation (or shift) may exert. Impacts can also be cross-sectoral if an action in a sector has an effect on another.	Change in river morphology from damming a river (water system domain). Using the example above, a cross-sectoral impact could be alteration of riverine habitats.
implication	The effect, consequence or repercussion that an action will have on something in the future. While impacts are direct effects, implications are possible consequences that are not always obvious and clear.	Increased demand due to electrification of residential heating or transport.
influencing determinant	An element or factor that influences the nature or outcome of something.	Oil price influences oil exports.
innovation	Can be divided into technical, institutional and social innovation. Technical innovations refers to the introduction of new technologies, methodologies and/or approaches to tackle challenges solve problems or simply change something established following a less conventional approach, method, idea, etc. Institutional innovations refers to introduction of policies and governance structure to improve, for instance, the performance of a sector. Social innovations refers to strategies, ideas or concepts that meets social needs, for instance working conditions or health service, with the aim to strengthen civil society	Technical: Moisture sensing technology included in irrigation systems. Institutional: Subvention of solar PV installment in rural areas. Social: Fair trade in coffee sector to improve and sustain the life and livelihood of coffee farmers
interaction	A mutual or reciprocal action, effect, or influence between two or more entities (agents, sectors, systems, elements in a system, etc.). Does not exclusively represent a co-dependence between the actors.	Water consumption in agriculture for irrigation - interaction between the water system (water availability, irrigation technology and infrastructure) and agriculture (food production).

		Energy policy may be determined by an interaction between Ministry of Finance and Ministry of Energy Resources
K		
key performance indicators (KPIs)	enable to assess the extent objectives and expected impacts of a projected are reached	Number of deliverables published according to work plan of SIM4NEXUS
M		
mitigation	IPCC defines mitigation as the anthropogenic intervention done in order to reduce other human induced actions on the climate system, for instance through greenhouse gases emissions. In contrast to “adaptation”, mitigation means reducing or stabilizing the greenhouse gases in the atmosphere that may yield effect on climate	Switching to low-carbon energy sources Preserving, or expanding, the forest to serve as a carbon sink
N		
narrative	(Concise/short) Qualitative description of the relationships among different trends and socio-economic developments assumed in a scenario. Narratives can be used with quantitative information to infer more detailed representation of local and regional conditions while maintaining consistency with trends at the scale of the globe or large regions (IPCC website). Storylines that convey the overall logic underlying the related quantitative descriptions of future economic, demographic, technology, and emissions trends. Narratives facilitate extrapolation of scenarios for other research (Van Vuuren, 2012).	Shared Socioeconomic Pathways (SSPs) narratives
nexus	Interaction and interdependency between selected resource sectors/system domains in terms adopted to understand trade-offs and synergies	Water-Energy-Food nexus: understanding trade-offs or synergies when expanding irrigation schemes

	Etude des intéractions et interdépendances entre différentes ressources ou politiques sectorielles pour en comprendre les incompatibilités ou synergies.	(water) for agricultural production (food) while in parallel expanding the hydropower system (energy)
nexus approach (D2.1)	A systematic process of inquiry that explicitly accounts for water, land use, energy, food and climate interactions in both quantitative and qualitative terms with the aim of better understanding their relationships and providing more integrated knowledge for planning and decision making in these domains.	Water-Energy-Food nexus (developed by United Nations Food and Agriculture Organization (FAO))
nexus challenge	Complex task or combination of factors that requires a solution which is not always straightforward and thus requires a “nexus approach”. In a nexus context, the problem could be derived from one nexus domain and be reflected in several others and/or could be linked to feedback mechanisms.	Cross-sectoral water allocation: safeguard water availability for agriculture, food production, domestic consumption, industry, energy.
nexus compliant practices	Such practices cope with (e.g. mitigate) trade-offs between the Nexus sectors and build synergies.	A water-efficient bio-based economy.
nexus interlinkage	A factor, connection, relation or association that connects or ties one thing to another (the condition of being linked) - in a nexus perspective it corresponds to interconnected elements within the same or between different nexus domains. A “linkage” is frequently used to convey a physical link or assemblies between parts of a mechanical device. A nexus challenge is derived from a nexus interlinkages but the latter does not necessarily imply the former.	Water is required for food crop development (water-food linkage) Land is used for cattle raising (land use - food production linkage). Electricity is used to power water systems and water is needed for cooling systems in thermal generation (water-energy interlinkage).
nexus performance indicator (NPI)	Indicators linking at least two Nexus dimensions and quantifying their co-dependence, thus identifying possible vulnerabilities of one nexus dimension compared to another one. More advanced Nexus indicators will link three or four Nexus dimensions, e.g. the amount of water and energy required for the production of a	Energy required for the production of water through desalination. A high value for this indicator will mean that the production of desalinated water is

	unit of food and the amount of CO_2 produced (climate).	highly dependent on the availability of energy.
nexus dimension / domain	Refers to a specific sphere of activity or action related to or characterized by specific features or elements. SIM4NEXUS focuses on the nexus domains of water, food, land, energy and climate.	Water nexus domain includes resources and their natural availability and dynamics (surface water river networks, aquifers, etc.); and activities for the production and/or use of water (water supply infrastructure, wastewater disposal and treatment, irrigation system, desalination, etc.).
nexus sector	A distinct part or division of a regional, national, continental or global economy. Does not represent the natural availability of nexus resources (e.g. the water cycle is not an element in of the water sector; climate is not a sector). Nexus sectors commonly exist within nexus domains, with the exception of the climate domain.	Energy sector (all activities and actors from fuels availability, transport, conversion, distribution to the final users)
nexus system	An assemblage or combination of parts or elements forming a complex or unitary whole. The parts can result from a set of interdependent elements that have a specific role, purpose or function within the complex whole; for instance, nexus sector within the nexus system. I.e. the sector is an entity within the system and thus a system can include more than one sector.	Energy system (which may involve interactions between several sectors such as water, land, energy and food).
P		
parameter	A factor that represents input data that feed into models.	Current installed generation capacity of photovoltaics (PV).
pathway	Represents a particular course of action or route to reach or achieve specific result(s)/outcome(s). It is defined by a collective action process, which is retrieved from the analysis of the outcomes of scenarios that can secure the transformation or transition envisioned.	“A climate-resilient pathway for development is a continuing process for managing changes in the climate and other driving forces affecting

		development, combining flexibility, innovativeness, and participative problem solving with effectiveness in mitigating and adapting to climate change.” [(IPCC, WGII AR5, Chapter 20)]()
policy	Guidelines of paths of actions to achieve goals and objectives. Policies are more specific than strategies. They narrow down the set of principles and rules that define how the goals and objectives will be achieved.	Agriculture Sector Policy
policy coherence	Reinforcement of policies across government departments in order to create synergies between agree objectives and to avoid, or minimize, negative effects into other policy areas.	Policies across agriculture, fisheries, energy and trade in order to strengthen policy coherence for food security
policy goal (D2.1)	Policy goals are the basic aims and expectations that governments have when deciding to pursue some course of actions. They can range from abstract general goals (e.g. attaining sustainable development) to a set of less abstract objectives (e.g. increase energy efficiency) which may then be concretized in a set of specific targets and measures (e.g. achieve 10% renewable energy share).	Increase energy efficiency; SDGs.
policy means (D2.1)	Policy means are the techniques/mechanisms/tools that governments use to attain policy goals. Similarly to goals, means range from highly abstract preferences for specific forms of policy implementation (e.g. preference for the use of market instruments to attain policy goals); to more concrete governing tools (e.g. regulation, information campaigns, subsidies); to specific decisions/measures about how those tools should be calibrated in practice to achieve	Government sponsored grants for the installation of rooftop photovoltaics at households.

	policy targets (e.g. a specific level of subsidy in the renewable energy sector).	
policy target	Policy goal expressed in a quantifiable manner. See policy goal. It informs on the success of achieving a policy.	Achieve 10% renewable energy share in a given year.
R		
resilience	The ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration or improvement of its essential basic structures and functions (IPCC).	Infrastructure works to protect a urban area from a flash floods event
resource use efficiency	Efficiency is the maximisation of outputs for a fixed input amount. Since our natural resources are limited, efficiency refers to the best use we can make from them.	Producing more food using more efficient irrigation methods, and thus using less water.
S		
scenario	It represents/illustrates a potential way, outcome, vision in which a situation may or may not develop - a possible future. It results from a planned definition of possibilities for one or more selected determinants that are relevant for the hypothetical future. Scenarios provide a context for the analysis and result from the description of drivers, implications and outcomes.	Climate change mitigation scenario.
scenario - baseline	Scenario that aims at representing the current trends of the systems being modelled. It does not include future policies, but only the ones under implementation up to the base year of the analysis.	Energy demand assumed to follow the same annual growth rate of the average annual growth rate of the last 5 years.
scenario - reference	The reference scenario develops from the baseline, but incorporates the near-term policies or policies that are certain to be implemented in the sectors under analysis.	Transposition to national policies of EU policies up to 2020 or 2030.
strategy	Policy strategies define major courses of action or patterns of successful action, usually in the format of a plan, to achieve organizational goals and objectives.	Development strategy for the energy sector

sustainable development	Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland report)	
synergy	The interaction of two or more elements or agents that when combined produce a total effect that is greater than the sum of the individual effects or contributions. It can also result from the cooperative interaction between groups and sectors, which result in an enhanced combined impact of coordinated actions or efforts.	Multi-purpose reservoir (hydropower, irrigation, tourism). Resource efficient farming practices could offer high crop output per unit of water used.
system dynamics model (SDM)	Quantitative representation of the interactions and feedback loops within and between processes in a complex system (in the case of SIM4NEXUS, the main system structure is identified in the conceptual models). Relationships can often be non-linear and may include delay mechanisms. In SIM4NEXUS, the structure of the complex system developed for the SDM will be case study-specific (i.e. is developed in the form of the conceptual model with close cooperation with case study lead partners and stakeholders) and integrates elements from the five nexus domains in which the project focuses on. SDM is a modelling approach/philosophy, for which there are many software tools and graphic environments to develop quantitative models. SIM4NEXUS uses STELLA as the modelling software to develop the SDMs for each case study.	The interactions between water, land, energy food and climate
T		
target	A measure of the degree of one's success. Can be an indicator that is established to determine how successfully you have achieved a goal.	Decrease in CO_2 emissions of 10% in a specific year, in comparison to the CO_2 emissions in a reference year.
thematic model	A mathematical model which covers one, or several, specific topics that relate to the nexus dimensions under investigation in the SIM4NEXUS project. Quantitative analysis	Models used in SIM4NEXUS: CAPRI, e3ME, IMAGE-GLOBIO, MAGNET,

	of the nexus in the case studies results from the combination and/or use of more than one thematic model. These are chosen based on the nexus challenges that are identified in each case study. Thematic models can differ on the system(s) they cover, type of modelling tool, and level of detail of representation, which then translates into a different set of input and output data.	MagPIE, OSeMOSYS and SWIM
trade-off	An exchange of one thing in return for another, especially relinquishment of one benefit or advantage for another regarded as more desirable. Loss in quality or quantity of a resource when the quality of quantity of another resource increases.	Decrease in forest area due to increase of biomass extraction for energy production.
V		
variable	Outputs / results obtained and/or derived from models.	Wind power generation capacity in 2050.
variant	Elements in the modelling exercises (e.g. parameters, variables) that can be manipulated to structure/define a specific scenario or a scenario family.	Electricity demand, water use factors, emission limits, etc.
vulnerability (to climate change)	IPCC defines it to the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change	Agricultural land flooding