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D3.1 – Open accessible representation of historical data

Lead Beneficiary: DECHEMA

Key authors (alphabetical): Kaitlyn Carter, Eva Kolle-Görgen, Mariia Merko, Frank Mintus, Dinh Du Tran

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Deliverable Contributors				
	Name	Organisation	Role/ Title	**E-mail**
Deliverable leader	Dinh Du Tran	DECHEMA	Expertise lead - data	dinhdu.tran@dechema.de
Contributing Author(s)	Kaitlyn Carter, Eva Kolle-Görgen, Mariia Merko	DECHEMA		
	Frank Mintus,	BFI		
Reviewer(s)	Anne Weiler	ERS		
	Andrea Rusman	TNO		
	Paul Stegman	TNO		
	Joel Neave	**Deloitte**		

Acknowledgements	**Organisation**
Andrea Rusman, Paul Stegmann, Paul Schouten, Noah van de Bunt,	TNO
Lisah Ligono	IIASA
Rocío García	SIE

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AMIGDALA Project Summary

Achieving climate neutrality by 2050, as envisioned in the European Green Deal, poses a multi-faceted challenge. Europe must foster a sustainable process industry that is not only climate-neutral but also globally competitive and resilient. This transformation requires strategic foresight to navigate the complex interplay of demand, global trade, and industrial production.

Decision-makers face critical choices, from crafting policies and regulations to investing in advanced technologies for public infrastructure and industrial assets. Supporting these decisions with actionable insights is essential to steering the evolution of the basic industry within the European Union.

The EU-funded project AMIGDALA – short for Alliance for Modelling Industries towards the Green Deal's objectives And circuLArity – aims to provide public and private decision-makers with insights from scenario analysis. The analysis is augmented by computer models to project transformation pathways towards climate neutral destinations. AMIGDALA is building a powerful set of tools that can simulate possible futures for Europe's industrial sector. These tools connect different types of models from global, EU and local scale - covering the economy, energy use, materials, and climate - with real-world scenarios and input from stakeholders. The goal is to turn data and models into practical advice for the people making key decisions on various pathways toward a climate neutral process industry.

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Public Summary

Historical data in the Data Explorer has been compiled and structured according to the needs of the modelling. These data sets are made publicly accessible via the Data Explorer to inform on the data and allow for outside scrutiny and review. This deliverable provides an overview of the interaction between the Data Explorer and the AMIGDALA Framework, available historical data in the Data Explorer, how to access and use the data and next steps for development.

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Acronyms and Abbreviations

AMIGDALA	Horizon Europe project Alliance for Modelling Industries towards the Green Deal's objectives And circuLArity
API	Application Programming Interface
EC	European Commission
EU	European Union
GDP	Gross Domestic Product
KPI	Key Performance Indicator
MS	Member States
PoC	Proof-of-concept
WP	Work Package

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1 Introduction

1.1 The AMIGDALA Project

The Alliance for Modelling Industries towards the Green Deal's objectives And CircuLArity (AMIGDALA) supports the transformation of European energy-intensive industries towards climate neutrality by providing insights into possible industrial transformation pathways. The project addresses the challenge of reducing emissions and resource use while maintaining a competitive and resilient European industry.

This transformation to industrial decarbonisation involves interacting developments in industrial production, energy systems, materials, circularity, feedstock, demand and global trade. It is also shaped by technological uncertainty, changing market conditions and policy decisions. AMIGDALA therefore aims to support decision-makers by combining scenario analysis with integrated modelling, analysing how different policy measures, technological developments and investment decisions may influence pathways towards climate-neutral industrial production.

A particular focus of AMIGDALA is the development and use of consistent data across these different domains. The project brings together historical data, model inputs, scenario parameters and model outputs in order to support the analysis of the five dimensions of climate neutrality identified for industry: 1) energy demand and use, 2) emissions, 3) raw materials and other resources, 4) production, and 5) the replacement of fossil carbon in materials by more sustainable streams.

The AMIGDALA Data Explorer contributes to this objective by making selected data accessible beyond the modelling teams. It provides external stakeholders with an opportunity to inspect the data underlying the project's analysis and results and is one module of the AMIGDALA Framework.

1.2 The AMIGDALA Framework

The AMIGDALA Framework brings together four complementary elements: decision analysis, scenario building, integrated modelling and data management (Wubbolts et al., 2024). These functions are implemented through a set of nine interacting modules that exchange data and provide inputs or services to one another, and which comprise

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the four main expertise areas of AMIGDALA: decision analysis, scenario building, integrated modelling and data management (Figure 1).

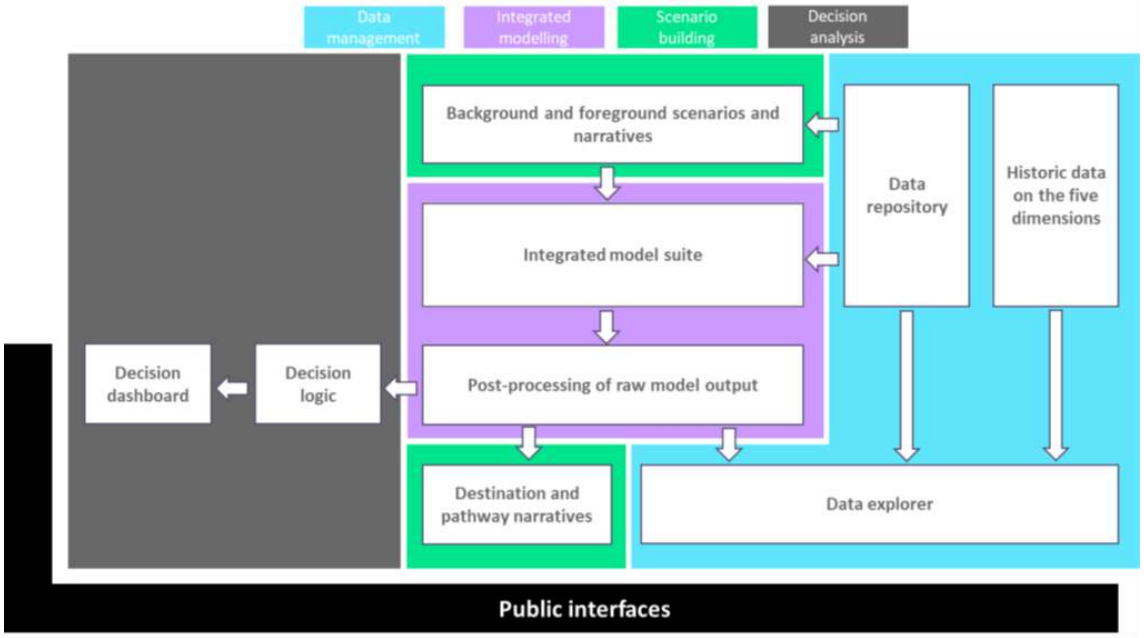


Figure 1 Modules in the AMIGDALA framework with arrows indicating the flow of information. The Data Explorer, narratives of destination and pathways, as well as the Decision Dashboard are interfaces with the public.

Decision analysis: Decision analysis serves to reflect and align the model inputs and outputs with the interaction of public and private decision-makers. A key aspect here is the relation between economic indicators and the decision options used by governments or industrial businesses. The main module is the Decision Dashboard, through which decision-makers can access the underlying integrated models to select preferred scenarios.

Scenario building: Scenario building develops scenarios and control levers on a global, EU and local level. Control levers include the options that decision-makers have to influence the achievement of the Green Deal (i.e. subsidies, pricing, investments). The scenarios are therefore centred on economic indicators and the decision options employed by decision-makers.

Integrated modelling: Integrated modelling links models with different research domains to create projections of EU industry's transformation pathways. The integrated model suite runs the scenarios expressed via control levers and reflects the effect on the uptake of transformative solutions and products.

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Data management: Data management supports the overall Framework by collecting, harmonising, validating and storing the data used and generated by the models. It includes the historical data module, the Data Repository and the Data Explorer. The Data Repository provides the underlying storage and data management function, while the Data Explorer provides an interface through which users can access and visualise selected data.

At the stage covered by this deliverable, the AMIGDALA Framework has progressed from its initial architectural design to the proof-of-concept (PoC) and development of its public interfaces. The Data Explorer is therefore presented as the access point to the historical data layer of the AMIGDALA Framework. In the coming months, all results produced from the integrated model suite will also be made available via the Data Explorer and thus accessible to the general public.

1.3 Deliverable Objectives and Structure

This deliverable demonstrates the public instance of the AMIGDALA Data Explorer as an online and accessible data deliverable. It explains the purpose of the Data Explorer, describes how users can interact with it and summarises the data made available through the interface. **Chapter 2** describes the Data Explorer in more detail, explaining its interaction with the data repository, scenarios, integrated model suite and Decision Dashboard (Section 2.1); its target audiences and intended uses (Section 2.2); and its structure and accessibility (Section 2.3). **Chapter 3** summarizes the available historical data, including data sources, selected variables and any processing of the raw data. It is organized by sector (steel, chemical, plastic, cement, glass, pulp and paper and non-ferrous metals). **Chapter 4** outlines next steps for the Data Explorer, including post-project continuity and hosting.

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2 Understanding and Using the Data Explorer

This chapter describes the function, content and use of the Data Explorer. Chapter 2.1 describes its function within the AMIGDALA Framework, while Chapter 2.2 identifies the main target audiences and anticipated uses. Chapter 2.3 describes how the available data are organised and documented, including the structure of individual entries, definitions and supporting resources. Chapter 2.4 explains how users can access the public instance and select variables, regions and scenarios to display the resulting data. Finally, Chapter 2.5 describes how the Data Explorer supports the FAIR principles.

2.1 Role of Data Explorer within AMIGDALA Framework

The Data Explorer provides public access to selected datasets used and generated within the AMIGDALA Framework. Its main function is allowing users to search, filter and visualise data through a web-based interface. At the time of writing, the Data Explorer contains historical data for the eight sectors described in Chapter 3: steel, chemicals, plastics, cement, glass, pulp and paper, aluminium and copper. The integration of model outputs and scenario data is planned as the AMIGDALA Framework develops.

The Data Explorer is connected to the AMIGDALA Data Repository, which stores data used and generated by the Framework (Figure 2). This includes historical data, scenario parameters, model inputs, model outputs and derived indicators. The Data Repository provides the underlying data-management function, while the Data Explorer makes selected and validated datasets available to users in a form that can be searched, filtered and displayed in tables or graphs. The Data Explorer is therefore not intended to contain every dataset used within AMIGDALA. Other data, such as scenario assumptions, and most of the techno-economic and process-relevant data will be made available through the Documentation section or via annexes.

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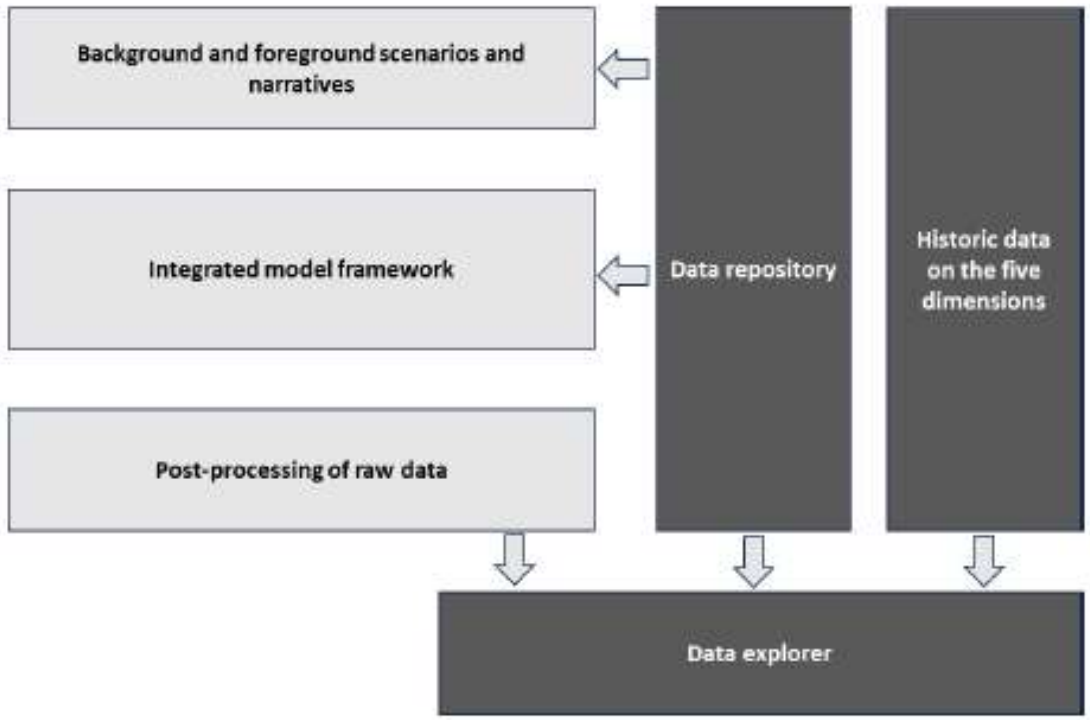


Figure 2 Interaction of the data management modules (dark grey) with the other modules.

The Data Explorer supports the data flow between the main AMIGDALA Framework components. Historical data are uploaded to support the examination of past trends. In the future, scenario parameters and other input data will be provided to the Integrated Model Suite, which generates model outputs. These outputs can then be processed into indicators within the Decision Dashboard.

The Data Explorer does not generate model predictions itself, which is the function of the Integrated Model Suite. Instead, the Data Explorer provides access to both the underlying data used to run the models and to the model outputs they generate. The Data Explorer therefore complements the Decision Dashboard. The Decision Dashboard presents interpreted results and enables users to compare different pathways, while the Data Explorer enables users to examine the underlying data in greater detail.

In this way, the Data Explorer contributes to transparency, accessibility and reuse of AMIGDALA data. Its role within the Framework is to provide a practical link between the project's data infrastructure, its modelling results and external users. The interaction between the Data Explorer and the wider AMIGDALA Framework is described in greater detail in AMIGDALA deliverables D1.1 and D2.1 (Nijs et al., 2025; Wubbolts et al., 2024).

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2.2 Target Audiences & Anticipated Uses

Researchers, modellers and other technically oriented users are expected to be the primary external users of the Data Explorer. They may use it to examine variable definitions, historical values, sources, units and trends, and to investigate the data underlying AMIGDALA's indicators and model results.

The European Commission (EC) is another important target audience for the Data Explorer. It provides an accessible overview of the data collected and generated within AMIGDALA, which the EC can use to assess AMIGDALA's data-related outputs in terms of availability, transparency and accessibility (for more information on adherence to FAIR principles, see Chapter 2.5).

2.3 Data Structure & Documentation

The Data Explorer is designed to accommodate data from different industrial sectors, models, scenarios and sources within a common structure. At the time of writing, the Data Explorer contains historical data from eight different industrial sectors described in Chapter 3. The following sections describe the structure of the uploaded data and the additional definitions and documentation available through the Data Explorer.

2.3.1 Structure of Uploaded Data

When data are uploaded to the AMIGDALA Data Explorer, each entry is organised using a defined set of fields, which provide information needed to identify the variable, interpret the recorded value and associate it with the relevant model or dataset. This structure is designed to support the future integration of model results and scenario data while maintaining a consistent basis for searching and visualising information. The main fields are:

- **Variable name and description:** The variable name identifies what is being measured. Each variable is accompanied by a description explaining its meaning and scope. The current set of variables regarding the historical data are grouped into seven thematic categories:
  - Consumption
  - In-Use Stock
  - Material Flows
  - Production
  - Production Value

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- Trade
- Waste

As model results are integrated into the Data Explorer, the thematic categories will be expanded to provide an organized overview of the variables.

- **Year:** Specifies the year to which the observation relates.
- **Unit:** Specifies how the variable is measured and provides the basis for interpreting the numerical value.
- **Value:** Contains the numerical observation for the selected variable and year.
- **Region:** Identifies the country or aggregated geographical area to which the observation relates. The available regions depend on the dataset or model.
- **Model:** Identifies the model or dataset associated with the observation. In the current public instance, the historical datasets are identified under the model label *Historical Data*.
- **Scenario:** Usually refers to the scenario for which the model was run. In case of the historical data, it refers to the sector for which the variables were collected.

The data are therefore stored as entries in which each value is linked to a defined variable, year, unit and model. This structure allows data from different sectors and sources to be stored and displayed consistently, while also identifying datasets from different models or model runs, which will be included as the AMIGDALA Framework develops.

2.3.2 Definitions & Documentation

Apart from the historical data on the various sectors covered by the AMIGDALA project, the Data Explorer also contains other information: "**Definitions**", "**Documentation**" and **"Resources"**. These sections provide context for the data and support their interpretation and reuse.

The "**Definitions**" section[1] provides information on four fields: models, scenarios, regions and variables. These fields correspond to the main dimensions used to display data in the Data Explorer. At present, the "Models" section contains the pseudo-model "Historical Data". At a later point in the project, all the other nine models, which are part of the integrated model suite, will be included. Under "Scenarios", the eight sectors and sub-sectors described above are listed. In the future, the

[1] https://amigdala.apps.ece.iiasa.ac.at/definition

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scenarios under which an integrated model run has been carried out will be visible with a short description. Within “Regions”, all countries as well as the aggregated regions for each model will be listed. Lastly, the “Variables” section contains all variables which are available in the Data Explorer together with a short description. These variables are grouped into different categories, which need to be clicked upon to show all underlying sub-categories or variables. The numbers on the right depict the number of variables that are part of each respective category (Figure 3). The description of an individual variable provides information on what it represents and, where available, its unit, data source, assumptions and references. The Definitions page therefore supports the interpretation and reuse of the data without requiring users to inspect the underlying upload files.

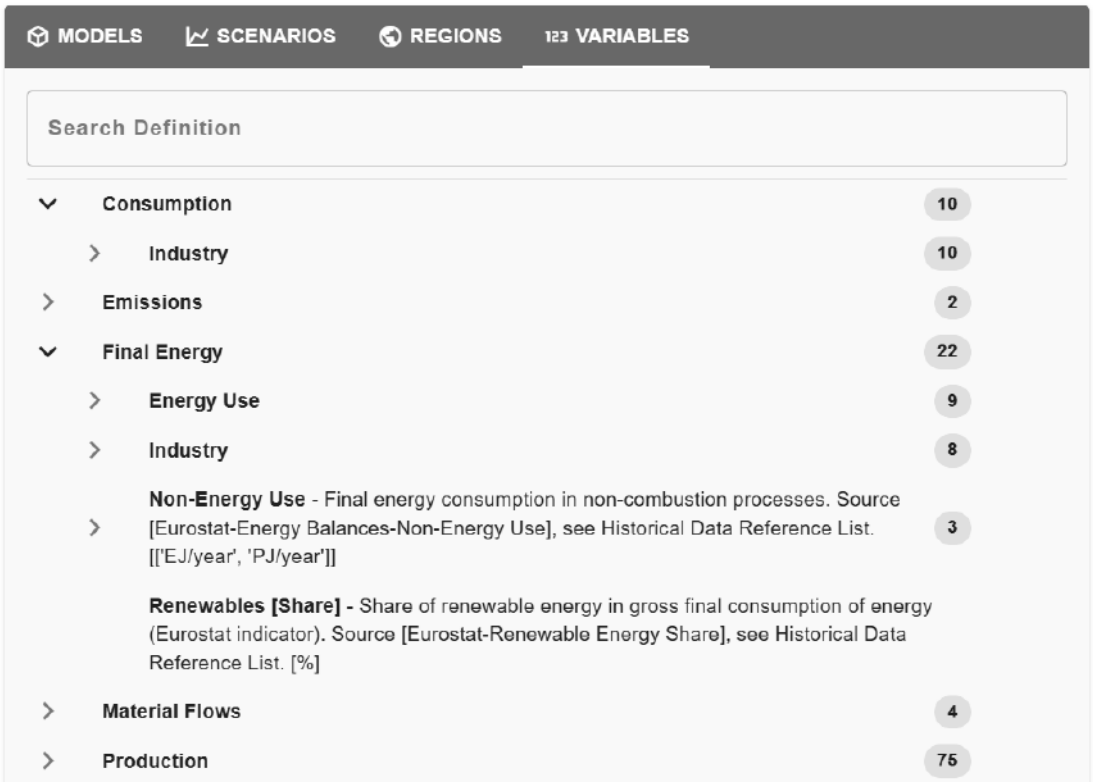


Figure 3 Screenshot of the “Definition” section of the Data explorer, in which the variables are shown.

The **“Documentation”** section is currently a placeholder, under which the consortium will be able to upload additional documents, e.g. information on the scenarios run in the integrated model runs, technical data used by models, or others. The information can be either made available directly via downloading the file or a link to a Zenodo repository, for example.

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The "**Resources**" section provides links to additional information on all used sources ("Reference List"), the application programming interface ("Data Access API"), the license as well as some general information on the Data Explorer ("About"). The "Reference list" contains the publicly available information which were used to collect the historical data. The API section provides a brief explanation on how to access the data without directly using the Data Explorer, e.g. via a python pipeline or R. The Data Explorer is licensed under CC BY 4.0, which is also described in "License". Other information, such as the partners which were responsible for collecting the information or hosting the explorer, or links to other tools of the project can be found under "About".

2.4 Accessing and Using the Data Explorer

This section explains how users can access the public instance of the Data Explorer and how they can select and visualise data. The public instance provides two complementary interfaces for data visualization: the **Data Explorer**, which presents data in charts, and the **Map Explorer**, which presents selected data geographically.

2.4.1 Public Access, Hosting and Platform Overview

The public instance of the Data Explorer is available at: https://amigdala.apps.ece.iiasa.ac.at/.

The Data Explorer is hosted through IIASA's Scenario Services infrastructure (Figure 4). The URL opens the wider IIASA scenario explorer environment, which includes the Data Explorer as well as Definitions, a link to the upcoming Decision Dashboard and information about the project. In this deliverable, the term *Data Explorer* refers primarily to the AMIGDALA data interface, while the term *scenario explorer* refers to the wider web platform in which it is hosted.

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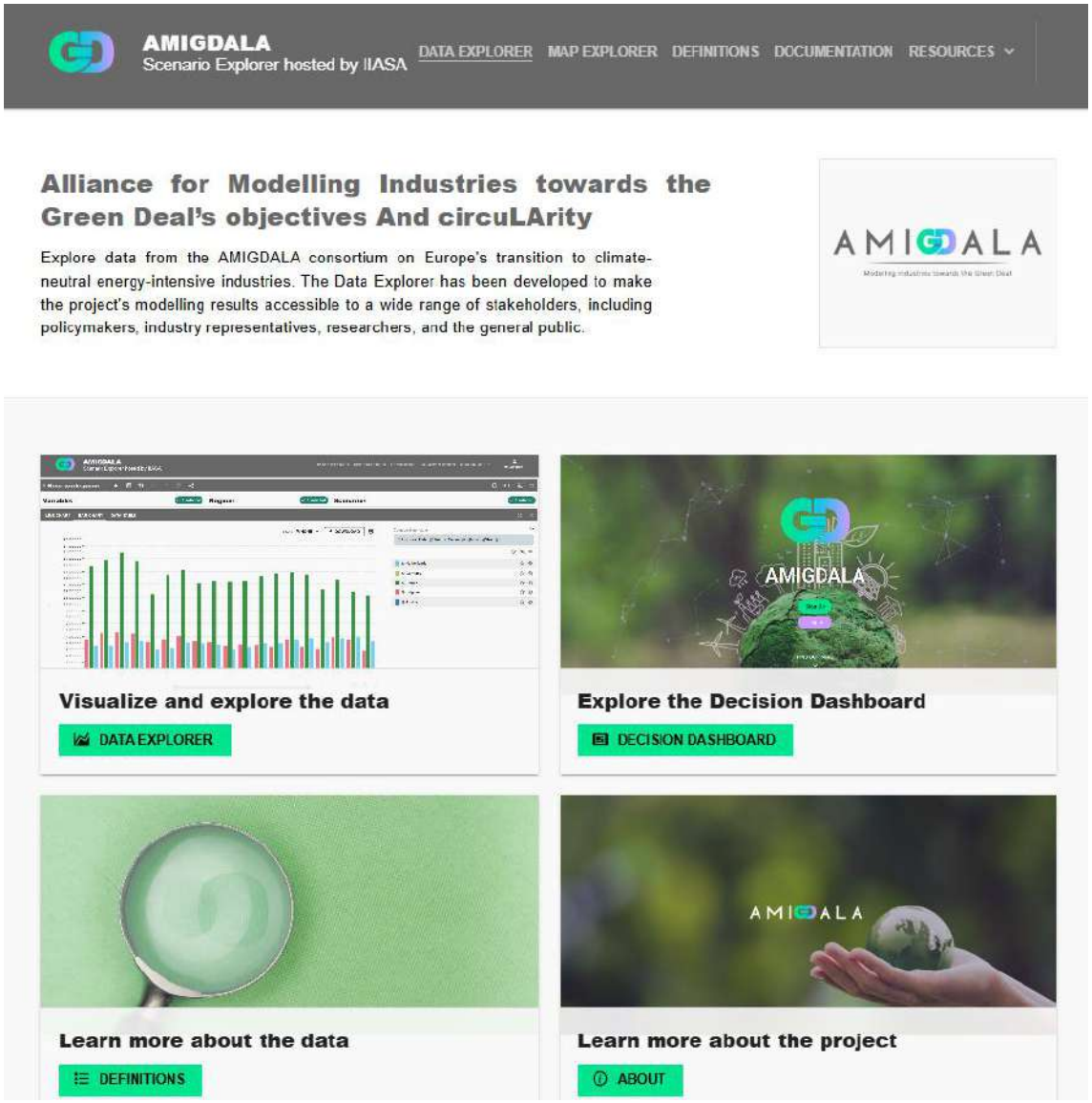


Figure 4. Scenario explorer web platform of AMIGDALA partner IIASA, which hosts the Data Explorer.

The Data Explorer will be made visible through various AMIGDALA communication channels. A link will be provided on the AMIGDALA project website[2] and shared through the project's LinkedIn channel[3] and newsletter. The Data Explorer will also be linked from the AMIGDALA Decision Dashboard, allowing users to move from the interpreted results and indicators to the underlying data. The backlink will be implemented by the AMIGDALA partner Green Decision.[4]

[2] https://amigdalaproject.eu/data-explorer/
[3] https://www.linkedin.com/company/amigdala-project/posts/?feedView=all
[4] https://amigdala.gdapps.eu/

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Information on the long-term hosting and maintenance of the Data Explorer is provided in Chapter 4.

2.4.2 Selecting and Visualising Data

The data in the AMIGDALA Data Explorer are organised according to several dimensions that allow users to identify and display a specific subset of the available datasets. The main selection areas on the Data Explorer homepage are **Variables**, **Regions** and **Scenarios** (Figure 5). At least one selection in each selection area is required to visualize the data.

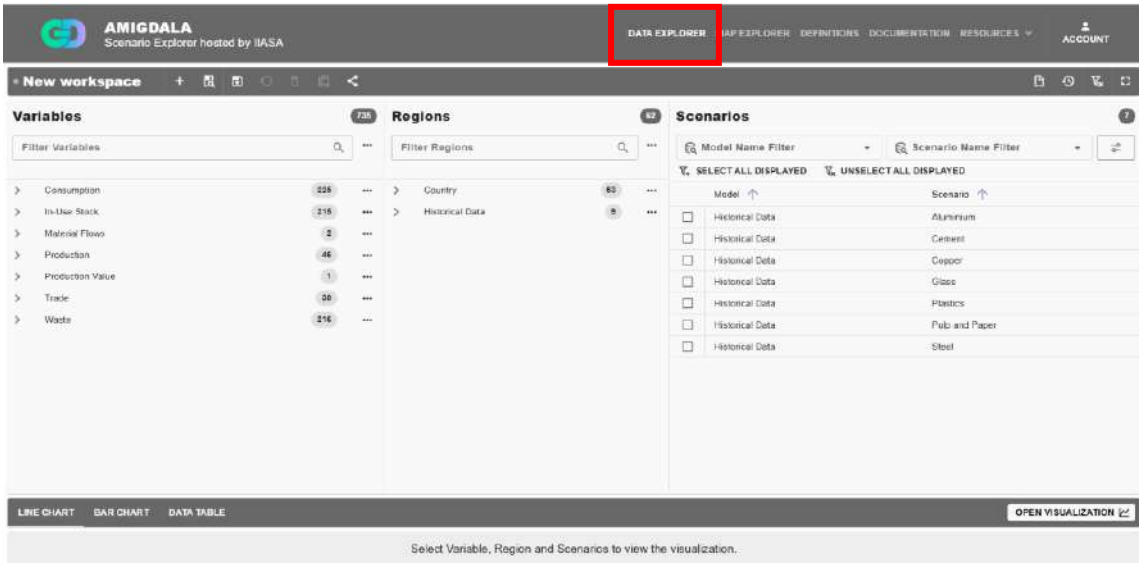


Figure 5 The Data Explorer comprises three selection areas: The variables (left), regions (centre) and a combination of model and scenario data (right). At least one selection in each section is required to display data.

Users do not necessarily need to move from left to right in selecting the data to visualize but can start with any of the three selection areas, depending on what the desired focus is. A typical selection process is as follows:

1. Select one or more variables or variable categories
2. Select one or more regions or geographical groupings
3. Select the relevant model and scenario
4. Open the visualisation as a line chart, bar chart or data table
5. Adjust the visualisation, where required, using the available display options

Once data points in each selection area are selected, users can open the data visualization (Figure 6). Figure 6 shows historical consumption data from the cement industry for 27 countries, available for years 2014-

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2021 for most countries and 2014-2022 for Germany. The plots support customizable legends, stacking, highlighting, and an improved mouseover display for information (Figure 7).



Figure 6 Historical data of industrial cement consumption is available for 27 countries. Here, the historical data is visualized by region.



Figure 7 Using the mouse roll-over function, users can view the historical cement consumption data by country. Here, the 2021 data for Poland and Portugal are shown.

To enable easier sharing and collaboration, users can save a specific data selection as a “Workspace”, by clicking on the “+” symbol (Figure

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8). This improves access to data and allows users to share their workspace with others.

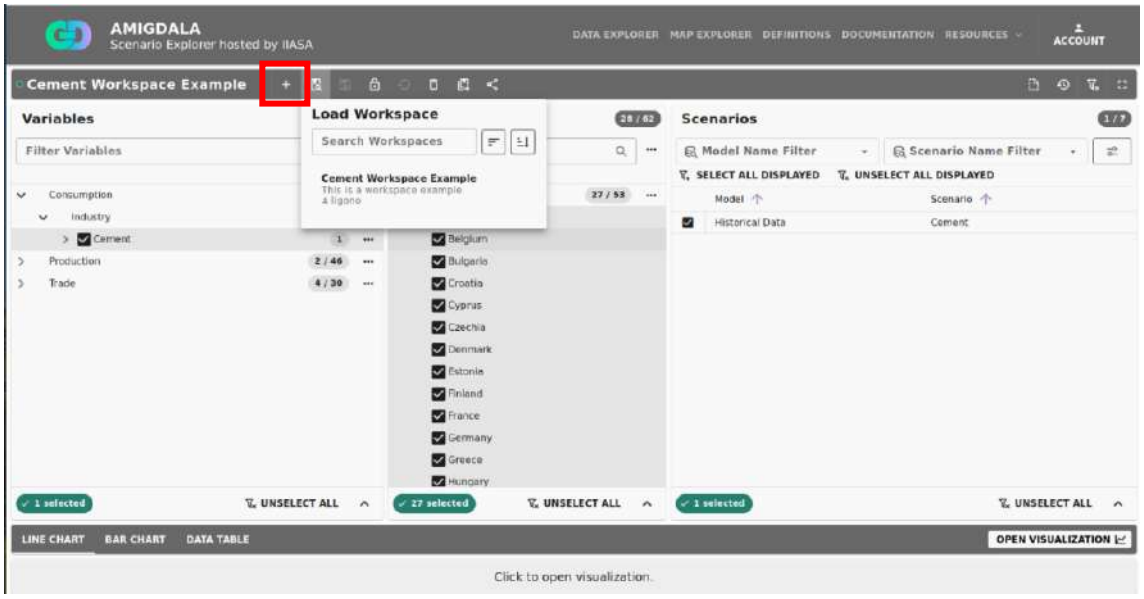


Figure 8 A specific data selection can be saved as a "Workspace" by clicking on the plus symbol, marked in the figure with a red box. Workspaces can be shared with others.

2.4.3 Map Explorer

The Map Explorer provides a complementary way of visualising selected data. It uses similar selection options to the Data Explorer and allows users to view historical data at a country-level and, where available, in the native model regions. The two figures below show an example of cement for the historical data model at the country-level hierarchy (Figure 9, Figure 10).

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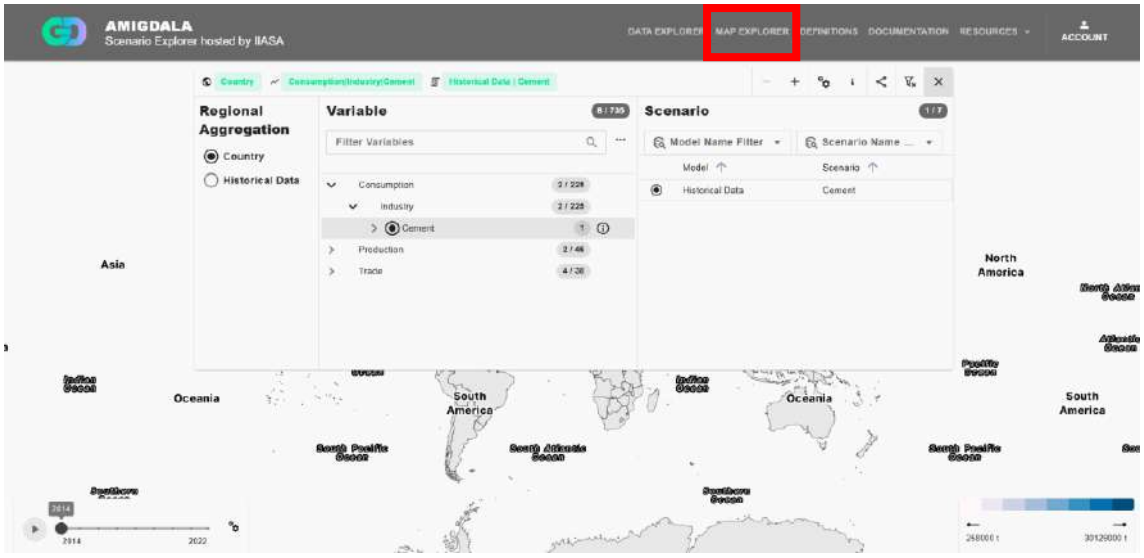


Figure 9 In the Map Explorer, users can visualize industry variables and historical data in map form. The data selection options are the same as those available in the Data Explorer.

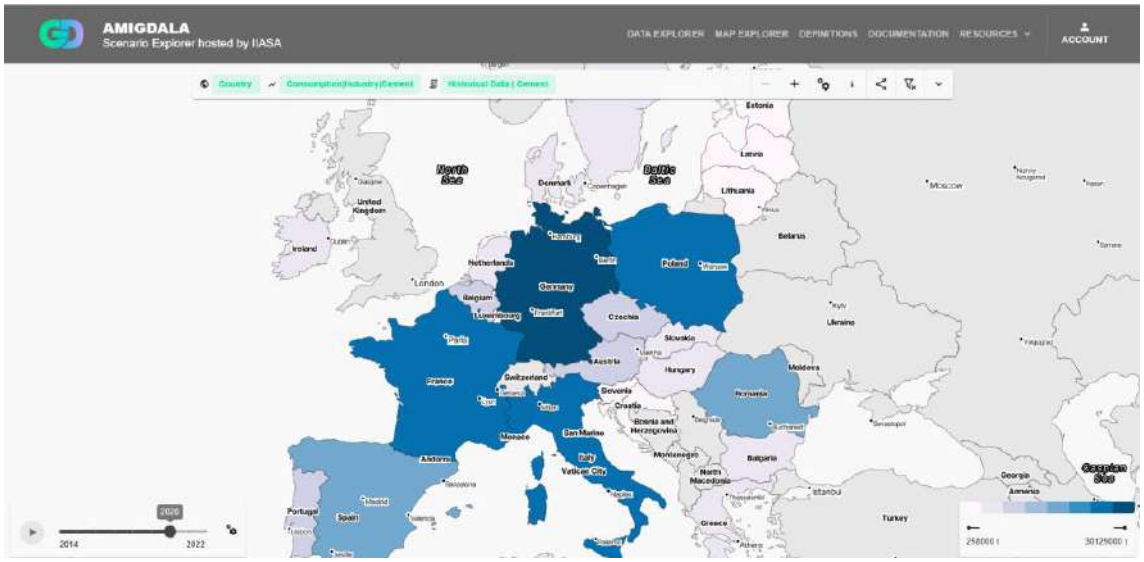


Figure 10 Historical cement consumption data for 27 EU countries. Users can click on a specific country to view all country-specific data in a line graph format.

2.5 Adherence to FAIR Principles

The Data Explorer adheres to **FAIR** principles for data management: findable, accessible, interoperable and reusable. Data are made **findable** through the public web interface, structured variable categories, and the Definitions and Documentation pages. These pages provide information on variables, models, scenarios and regions, including descriptions, units, sources and references where available. It is **accessible** through a standard web browser at the abovementioned

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URL, which is provided on the project website and will be backlinked from the Decision Dashboard. **Interoperability** is supported by the structured organisation of the data and the consistent use of fields such as variable, year, unit, value and model. **Reusability** is supported through variable definitions, source information and documentation of assumptions or processing steps.

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3 Summary of Available Data

The following chapter is divided into seven sub-chapters, each of which gives a brief explanation on the historical data collected for the different industrial sectors covered in the AMIGDALA project. Each sub-chapter describes the variables for which historical data were collected, the categories in which they are divided as well as the corresponding sources.

3.1 Historical Data on Steel

The main categories of collected historical steel data pertain to "**Production**", "**Consumption**" and "**Trade**". The data was collected for European countries as well as various country aggregations, such as the EU. Some of the production data are available on a country level, others are only available on an EU27 level.

Production data are subclassified in terms of the production route (blast furnace (BF) route and electric arc furnace (EAF) route), steel quality (stainless steel, non-alloyed and low-alloyed carbon steel) and products (long and flat products each with several subcategories and forged products). Trade data are subclassified into EU imports and exports from and to different countries. Steel consumption was collected only as an overall consumption for several European and non-European countries.

Table 1 gives an overview of the variables for historical steel data. Most of the data are public data from the World Steel Association [1], EUROFER [2] and the German Wirtschaftsvereinigung Stahl [4]. However, some of the data were not directly available, so that values were estimated based on EUROFER data or on an analysis of data from [5].

Table 1 Overview of variables for historical data on steel.

Variable name	Unit	Source
Production|Industry|Steel	t	[1]
Production|Industry|Steel|Blast Furnace	t	[1]
Production|Industry|Steel|Electric Arc Furnace	t	[1]
Production|Industry|Steel|Carbon Steel|Non-alloy	t	[2]
Production|Industry|Steel|Carbon Steel|Other alloy	t	[2]
Production|Industry|Steel|Stainless Steel	t	[2]
Production|Industry|Steel|Carbon steel|Non-alloy|Blast furnace|Share	t	[3]

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Variable name	Unit	Source
Production|Industry|Steel|Carbon steel|Low alloy|Blast furnace|Share	t	[3]
Production|Industry|Steel|Carbon steel|Non-alloy|Blast furnace	t	[3]
Production|Industry|Steel|Carbon steel|Low alloy|Blast furnace	t	[3]
Production|Industry|Steel|Electric arc furnace|Low-alloy	t	[3]
Production|Industry|Steel|Electric arc furnace|Non-alloy	t	[3]
Production|Industry|Steel|Hot rolled products|Total	t	[2]
Production|Industry|Steel|Hot rolled products|Flat|Total	t	[2]
Production|Industry|Steel|Hot rolled products|Flat|Quarto plate	t	[2]
Production|Industry|Steel|Hot rolled products|Flat|Hot rolled wide strip	t	[2]
Production|Industry|Steel|Hot rolled products|Flat|Other	t	[2]
Production|Industry|Steel|Hot rolled products|Flat|Total	t	[4]
Production|Industry|Steel|Hot rolled products|Long|Total	t	[2]
Production|Industry|Steel|Hot rolled products|Long|Wire rod	t	[2]
Production|Industry|Steel|Hot rolled products|Long|Rebars	t	[2]
Production|Industry|Steel|Hot rolled products|Long|Merchant bars	t	[2]
Production|Industry|Steel|Hot rolled products|Long|Heavy sections	t	[2]
Production|Industry|Steel|Hot rolled products|Long|Other	t	[2]
Production|Industry|Steel|Hot rolled products|Long|Total	t	[4]
Production|Industry|Steel|Cold rolled products|Flat|Total	t	[2]
Production|Industry|Steel|Cold rolled products|Flat|Hot dipped metal coated	t	[2]
Production|Industry|Steel|Cold rolled products|Flat|Organic coated	t	[2]
Production|Industry|Steel|Seamless tubes	t	[1]
Production|Industry|Steel|Forged products	t	[5]
Consumption|Industry|Steel	t	[1]
Trade|Import|Industry|Steel|EU27	t	[2]
Trade|Export|Industry|Steel|EU27	t	[2]
Trade|Import|Industry|Steel|EU27|Turkey	t	[2]
Trade|Import|Industry|Steel|EU27|Korea	t	[2]
Trade|Import|Industry|Steel|EU27|India	t	[2]
Trade|Import|Industry|Steel|EU27|China	t	[2]
Trade|Import|Industry|Steel|EU27|Ukraine	t	[2]

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Variable name	Unit	Source
Trade|Import|Industry|Steel|EU27|Vietnam	t	[2]
Trade|Import|Industry|Steel|EU27|Taiwan	t	[2]
Trade|Import|Industry|Steel|EU27|Japan	t	[2]
Trade|Export|Industry|Steel|EU27|USA	t	[2]
Trade|Export|Industry|Steel|EU27|Turkey	t	[2]
Trade|Export|Industry|Steel|EU27|Switzerland	t	[2]
Trade|Export|Industry|Steel|EU27|Mexico	t	[2]
Trade|Export|Industry|Steel|EU27|Canada	t	[2]
Trade|Export|Industry|Steel|EU27|Egypt	t	[2]
Trade|Export|Industry|Steel|EU27|China	t	[2]
Trade|Export|Industry|Steel|EU27|Morocco	t	[2]

References

[1] World Steel Association (Steel Statistical Yearbooks, https://worldsteel.org/media/publications/)

[2] EUROFER (European Steel in Figures 2025, https://www.eurofer.eu/publications/brochures-booklets-and-factsheets/european-steel-in-figures-2025)

[3] Own estimation of production volumes based on [2]

[4] Wirtschaftsvereinigung Stahl (Statistisches Jahrbuch der Stahlindustrie 2024/2025, https://www.wvstahl.de/)

[5] Own estimation based on an analysis by VDEh-Betriebsforschungsinstitut of data from the German research project "TransHyDE-Project System Analysis" (GA-No. 03HY201U). The analysis showed that it can be assumed that the difference between total steel production and rolled steel products represents steel processed into forged products.

3.2 Historical Data on Chemicals

Regarding the chemical sector, the collected historical data were grouped into "**Emissions**", "**Final Energy**" and "**Production**". The data were collected for European countries, as well as for various country aggregations, such as the EU.

For "Emissions", the CO_2-eq associated with petrochemicals are included. Under "Final Energy", data on the energy consumption of different energy carriers were collected, while for "Production", the Data Explorer displays the production volumes of various chemicals. All data were obtained either from Eurostat or petrochemistry.eu. Table 2 gives

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an overview on the variables listed in the Data Explorer, together with their corresponding units and sources.

Table 2 Overview of variables for historical data on chemicals.

Variable name	*Unit*	*Source*
Production|Industry|Chemicals|Ammonia (anhydrous)	t	[1]
Production|Industry|Chemicals|Chlorine	t	[1]
Production|Industry|Chemicals|Methanol	t	[1]
Production|Industry|Chemicals|Propylene (from steam cracking)	t	[2]
Production|Industry|Chemicals|Propylene (from other processes)	t	[2]
Production|Industry|Chemicals|Propylene	t	[3]
Production|Industry|Chemicals|Ethylene (from steam cracking)	t	[2]
Production|Industry|Chemicals|Ethylene	t	[4]
Production|Industry|Chemicals|Benzene (from steam cracking)	t	[2]
Production|Industry|Chemicals|Benzene (from reformate refining)	t	[2]
Production|Industry|Chemicals|Benzene	t	[4]
Production|Industry|Chemicals|Polyvinyl chloride	t	[5]
Final Energy|Industry|Chemicals	EJ/year	
Final Energy|Industry|Chemicals|Fossil Solids	EJ/year	[6]
Final Energy|Industry|Chemicals|Fossil Gases	EJ/year	[7]
Final Energy|Industry|Chemicals|Fossil Liquids	EJ/year	[8]
Final Energy|Industry|Chemicals|Renewables and Biofuels	EJ/year	[9]
Final Energy|Industry|Chemicals|Non-Renewable Waste	EJ/year	[10]
Final Energy|Industry|Chemicals|Electricity	EJ/year	[11]
Final Energy|Industry|Chemicals|Heat	EJ/year	[12]

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Emissions|Kyoto Gases|Industrial Processes|Chemicals	kt CO2eq	[13]
Emissions|Kyoto Gases|Industrial Processes|Chemicals|Petrochemicals	kt CO2eq	[14]

References

[1] https://ec.europa.eu/eurostat/databrowser/view/ds-059359__custom_19351091/default/table

[2] https://www.petrochemistry.eu/about-petrochemistry/petrochemicals-facts-and-figures/european-market-overview/

[3] https://ec.europa.eu/eurostat/databrowser/view/ds-059359__custom_19982620/default/table

[4] https://ec.europa.eu/eurostat/databrowser/view/ds-059359__custom_19982671/default/table

[5] https://ec.europa.eu/eurostat/databrowser/view/ds-059359__custom_19982475/default/table

[6] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_sff__custom_22463600/default/table

[7] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_gas__custom_22463699/default/table

[8] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_oil__custom_22463746/default/table

[9] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_rw__custom_22463763/default/table

[10] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_rw__custom_22463812/default/table

[11] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_e__custom_22463832/default/table

[12] https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_h__custom_22463867/default/table

[13] https://ec.europa.eu/eurostat/databrowser/view/env_air_gge__custom_22463060/default/table

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[14] https://ec.europa.eu/eurostat/databrowser/view/env_air_gge__custom_22470882/default/table

3.3 Historical Data on Plastics

Usually, plastics are considered part of the chemical sector. Within the AMIGDALA project, however, plastics are treated separately for two reasons. First, for the proof-of-concept (PoC) of the integrated model run, the consortium agreed that it would be more feasible to focus on a specific part of the rather large and complex chemical sector, particularly as the most impactful circular strategies in the chemical sector relate to plastics specifically. Second, some models focus explicitly on plastics (CITS, PRISM), which required treating them separately from other outputs of the chemical sector. Therefore, it was decided that the plastics industry be selected as a PoC for the integration of model results.

For the plastic industry variables listed in Table 3, historical data were collected and made available via the Data Explorer. These variables can be divided into two groups: "**Material Flows**" and "**Production Value**". Compared with the other industries, the plastics dataset contains fewer variables. However, in consultation with the modellers and their requirements, these data are considered sufficient to compare historical trends with future projections. All the data were obtained from Eurostat.

Table 3 Overview of variables for historical data on plastics.

Variable name	Unit	Source
Material Flows|Material Use|Fossil		[1]
Material Flows|Circularity [Rate]	%	[2]
Material Flows|Circularity|Fossil [Rate]	%	[3]
Material Flows|Recycling|Fossil		[4]
Production Value|Plastic and Rubber Products	million EUR	[5]

References

[1] https://ec.europa.eu/eurostat/databrowser/view/env_ac_sd__custom_22534346

[2] https://ec.europa.eu/eurostat/databrowser/view/env_ac_cur/default/table?lang=en&category=env.env_mrp

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[3] https://ec.europa.eu/eurostat/databrowser/view/env_ac_curm/default/table?lang=en&category=env.env_mrp

[4] https://ec.europa.eu/eurostat/databrowser/view/env_wassd__custom_15472290/

[5] https://ec.europa.eu/eurostat/databrowser/view/sbs_na_ind_r2__custom_22470721/

3.4 Historical Data on Cement

Collected historical data on cement were grouped into "**Production**", "**Consumption**" and "**Trade**", covering both cement and cement clinker. All data were collected on the country level as well as on the EU27 level.

Most of the data are public data from JRC-IDEES [1]; Eurostat [2], [11]; Reportlinker [3]; Cement Europe [6]; the German VDZ [7], [8] and literature [4]. However, some of the data were not directly available. In these cases, values were estimated based on the EU clinker ratio [5] or calculated based on differences between production, imports and exports [9], [10]. Table 4 provides an overview of all historical data collected for this sector.

Table 4 Overview of variables for historical data on cement.

Variable name	Unit	Source
Production|Industry|Cement	t	[1]
Production|Industry|Cement|Clinker	t	[2], [3], [4], [5]
Consumption|Industry|Cement	t	[6], [7], [8], [9]
Consumption|Industry|Cement|Clinker	t	[10]
Trade|Export|Industry|Cement	t	[11]
Trade|Import|Industry|Cement	t	[11]
Trade|Export|Industry|Cement|Clinker	t	[11]
Trade|Import|Industry|Cement|Clinker	t	[11]

References

[1] JRC-IDEES-2021 - Integrated Database of the European Energy System, May 2024, v2021-1.00, https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/JRC-IDEES/JRC-IDEES-2021_v1/

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[2] Eurostat: Total production [ds-059359__custom_21565663], https://ec.europa.eu/eurostat/databrowser/view/ds-059359__custom_21565663/default/table

[3] https://www.reportlinker.com/dataset/985ecd95876c122e9768e1e5d97b103fafd7ce24

[4] Schäppi et al.: Development of the cement clinker production under the EU ETS Overview and country level analysis from 2005 to 2017, German Environment Agency, Project No. (FKZ) 3719 42 505 0, 11/2024, https://doi.org/10.60810/

[5] Own estimations based on the EU clinker ratio (clinker ratio assumed with 73,7 %)

[6] https://cementeurope.eu/about-us/key-facts-figures/

[7] https://www.vdz-online.de/wissensportal/publikationen/zementindustrie-im-ueberblick-2023-2024

[8] https://www.vdz-online.de/wissensportal/publikationen/zementindustrie-im-ueberblick-2021-2022

[9] Own estimation based on the cement production + imports - exports

[10] Own estimation based on the cement clinker production + imports - exports

[11] Eurostat: Sold production, exports and imports [ds-059358__custom_20162835], https://ec.europa.eu/eurostat/databrowser/view/ds-059358__custom_20162835/default/table

3.5 Historical Data on Glass

Data on glass "**Production**" and "**Consumption**" were collected for both container glass and flat glass. While data for overall glass production were available from the JRC-IDEES [1], most of the other data were estimated. The estimates were based mainly on shares of production at the country level compared to EU27 production, and on the shares of consumption versus production. Table 5 provides an overview of all historical data collected for this sector.

Table 5 Overview of variables for historical data on glass.

Variable name	Unit	Source
Production|Industry|Glass	t	[1]
Production|Industry|Glass|Container	t	[2],[3]
Production|Industry|Glass|Flat	t	[3],[4],[5],[6]
Production|Industry|Glass|Flat [Share]	%	[3],[4]

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Consumption|Industry|Glass|Container	t	[2],[7]
Consumption|Industry|Glass|Flat	t	[8]

References

[1] https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/JRC-IDEES/JRC-IDEES-2021_v1/

[2] Close the Glass Loop: https://closetheglassloop.eu/publications-overview/, Glass collection for recycling in Europe statistics for 2021, 2022, 2023

[3] JRC Reference Report: Best Available Techniques (BAT) Reference Document for the Manufacture of Glass, 2013

[4] Centre for European Policy Studies: FRAMEWORK CONTRACT NO ENTR/2008/006 LOT 4 FOR THE PROCUREMENT OF STUDIES AND OTHER SUPPORTING SERVICES ON COMMISSION IMPACT ASSESSMENTS AND EVALUATION, FINAL REPORT, FOR A STUDY ON COMPOSITION AND DRIVERS OF ENERGY PRICES AND COSTS IN ENERGY INTENSIVE INDUSTRIES: THE CASE OF THE FLAT GLASS INDUSTRY, January 2014, https://op.europa.eu/en/publication-detail/-/publication/b43ca37c-ae26-49f3-9341-7558a75d52da)

[5] Glass Alliance Europe: Statistical Report 2024 - 2025, May 2026

[10] Own estimation based on shares of countries [3], [4] of the total flat glass production of EU27 [3], [5]

[7] Assumption that container glass placed on the market [2] is equal to container glass consumption

[8] Own estimation (rough) based on share of Packaging Glass consumption versus production

[9] Own estimation based on shares of countries [2] and on total container glass production of EU27 [3]

3.6 Historical Data on Pulp and Paper

For the pulp and paper sector, historical data were collected for four different categories of variables: "**Consumption**", "**Production**", "**Trade**" and "**Waste Stream**". As with the other sectors, data were mainly collected for European countries, as well as for an aggregated EU-level region.

For "Consumption", data on the overall net consumption of each country are available. For "Production", national production volumes for different types of paper (in tonnes or Megatons) were collected. Data on paper and cardboard packaging, however, are included in the "Waste

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Stream" category. Under "Trade", the imports and exports of pulp and paper for each country are shown.

Table 6 provides an overview of all historical data collected for this sector. The data were obtained from Eurostat or a publicly available website containing various information on paper.

Table 6 Overview of variables for historical data on pulp and paper.

Variable Name	Unit	Source
Consumption|Industry|Pulp and Paper|Net Consumption	Mt	[5]
Production|Industry|Pulp and Paper|Corrugated/Packaging	Mt	[5]
Production|Industry|Pulp and Paper|Graphic Paper	Mt	[5]
Production|Industry|Pulp and Paper|Newsprint	Mt	[5]
Production|Industry|Pulp and Paper|Others	Mt	[5]
Production|Industry|Pulp and Paper|Paper	t	[2]
Production|Industry|Pulp and Paper|Printing and Media Reproduction	t	[3]
Production|Industry|Pulp and Paper|Pulp	t	[1]
Trade|Export|Industry|Pulp and Paper	Mt	[5]
Trade|Import|Industry|Pulp and Paper	Mt	[5]
Waste Stream|Packaging waste|Paper and Cardboard packaging	t	[4]

References

[1] https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/JRC-IDEES/JRC-IDEES-2021_v1/

[2] https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/JRC-IDEES/JRC-IDEES-2021_v1/

[3] https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/JRC-IDEES/JRC-IDEES-2021_v1/

[4] https://doi.org/10.2908/ENV_WASPAC

[5] www.paperonweb.com (e.g. www.paperonweb.com/Belgium.htm)

3.7 Historical Data on Non-Ferrous Metals

Aluminium and copper were considered for the non-ferrous metals sectors. Aluminium was chosen since it is one of the most relevant non-ferrous metals in terms of energy consumption in the EU due to its high production and consumption volumes and energy-intensive production processes. Copper was chosen because it is expected to be

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highly relevant to the industrial transformation, especially regarding the electrification of industrial processes.

3.7.1 Aluminium

Collected historical data on aluminium were grouped into "**Production**", "**Consumption**" and "**Trade**". The data cover primary aluminium, secondary aluminium and alumina. All data were collected at the country level as well as at the EU27 level.

Most of the data were obtained from public sources like JRC-IDEES. However, the consumption of primary aluminium had to be estimated based on primary aluminium production and the difference between production and demand. Alumina consumption was estimated from the difference between production, imports and exports. Table 7 provides an overview of all historical data collected for this sector.

Table 7 Overview of variables for historical data on aluminium.

Variable name	Unit	Source
Production|Industry|Aluminium|Primary	t	[1]
Consumption|Industry|Aluminium|Primary	t	[2]
Production|Industry|Aluminium|Alumina	t	[3]
Production|Industry|Aluminium|Secondary	t	[3]
Consumption|Industry|Aluminium	t	[4], [5]
Consumption|Industry|Aluminium|Alumina	t	[6]
Trade|Export|Industry|Aluminium|Alumina	t	[7]
Trade|Import|Industry|Aluminium|Alumina	t	[7]
Trade|Import|Industry|Aluminium	t	[8]
Trade|Export|Industry|Aluminium|Scrap	t	[9]

References

[1] FEDERATION OF ALUMINIUM CONSUMERS IN EUROPE: THE EU ALUMINIUM INDUSTRY IN A WORLD IN UPHEAVAL: KEY RISKS AND OPPORTUNITIES, December 2024

[2] Own estimation based on the primary aluminium production and the deficit between production and demand [1]

[3] JRC-IDEES (https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/JRC-IDEES/JRC-IDEES-2021_v1/)

[4] SCRREEN2 - Factsheets Aluminium, 2023, GA-No. 958211;

[5] CRU International Ltd: Opportunities for aluminium in a post-Covid economy, 28.01.2022

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[6] Own estimation based on the alumina production + import - export

[7] https://ec.europa.eu/eurostat/databrowser/view/ds-059358__custom_20257268/default/table

[8] https://www.reportlinker.com/dataset/dacd86d592d0ecd9c7e27f7a3b08f3dafb7b84b2

[8] European Aluminium: A STRATEGY FOR THE LONG-TERM AVAILABILITY AND QUALITY OF ALUMINIUM SCRAP IN EUROPE, Position Paper, March 2

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3.7.2 Copper

Collected historical data on copper pertain to "**Production**", "**Consumption**" and "**Trade**". The data cover primary copper, refined copper and scrap. They were obtained from publicly available sources and collected at the country level as well as the EU27 level. Table 8 provides an overview of all historical data collected for this sector.

Table 8 Overview of variables for historical data on copper.

Variable name	Unit	Source
Production|Industry|Copper|Primary	t	[1],[2]
Production|Industry|Copper|Refined	t	[1],[2]
Consumption|Industry|Copper|Primary	t	[1],[2]
Consumption|Industry|Copper|Refined	t	[1]
Trade|Import|Industry|Copper|Scrap	t	[3]
Trade|Export|Industry|Copper|Scrap	t	[3]

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4 Next Steps for the Data Explorer

The public release of the historical data collected for AMIGDALA is the first milestone. By the project's completion, two major steps will be carried out: the addition of model results from various integrated model runs with different scenario parameters, as well as the connection of the Data Explorer to the Decision Dashboard. The Decision Dashboard will calculate key performance indicators in order to allow stakeholders to explore different outcomes based on their priorities.

The model results will first be uploaded to the project-internal version of the Data Explorer described in this document. This will either be done by the modellers themselves or by the data management team. It is expected that several thousand variables and regions will be available alongside the historical data. This will allow users of the Data Explorer to compare historical trends with future projections for the same or similar datasets.

The API will be used to feed the relevant data to the Decision Dashboard by the project partners currently developing it. Due to the vast amount of data, which is expected to be stored in the Data Explorer, various rounds of API testing will be required to optimize the user experience on both sides of the project's web tools.

Since the Data Explorer is one of the public-facing outputs of the project, long-term hosting and maintenance needs to be upheld not only during the project but afterwards as well. As with the project's website, the Data Explorer will be hosted for at least three years beyond the end of the project by IIASA. IIASA will also be responsible for any updates or upgrades to the backend infrastructure. No further updates to the data itself are expected after the project's end, as the data will have been validated during the processing and uploading stages.

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