EU–CHINA
BRIDGE

Building Roadmaps to Industrial Decarbonisation and Green Economy through EU-China Cooperation

D7.6 – Data Management Plan V1

WP7 – Open & FAIR science, mutual learning. Communication. Dissemination, and Exploitation

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EC Summary Requirements

1. Changes with respect to the Description of the Action (DoA)

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

2. Dissemination and uptake

This report shall serve as a guide for all consortium partners on how to handle project datasets. It can also be used by external users to understand how data in the EU-CHINA BRIDGE project is collected, processed, and disseminated.

3. Short summary of results (<250 words)

This deliverable revolves around the development of the Open Data Management Plan (DMP) for EU-CHINA BRIDGE. It presents the data that will be used and created during the project, along with strategies to ensure that this data is findable, accessible, interoperable, and reusable (FAIR). The report also outlines issues related to resource allocation, data security, and ethical considerations. In addition to this report, the project will use the ARGOS service from OpenAIRE and EUDAT to create a machine-actionable data management plan (maDMP). This will be an online living document that is continuously updated with links and metadata for datasets generated by project activities. The DMP report will be further refined and updated twice throughout the project: Version 2 (D7.7) and Version 3 (D7.8).

4. Evidence of accomplishment

This report.

Preface

EU-CHINA BRIDGE will support the transition to a climate-neutral and resilient society in both Europe and China by jointly advancing knowledge on technology innovations and roadmaps for decarbonising energy intensive industries, co-creating innovative modelling by combining cutting-edge bottom-up and integrated assessment modelling to quantify net-zero sustainable pathways, and developing the most updated and comprehensive emissions data. It will intensively engage relevant stakeholders from both regions, enhancing dialogues, and fostering mutual learning among policymakers, industries, and experts. It will deliver two open-source EU-China joint technology inventories of promising net-zero emission technology options for the iron & steel and chemical industries, two co-implemented demonstrations of promising technologies in China, and co-created scale-up paths and roadmaps of the selected industrial technologies in both regions. It will also develop the most up-to-date, high-resolution, multi-sectoral, national and regional GHG and short-lived climate pollutant emission inventories as well as dynamic monitoring of key emission sources at high spatiotemporal granularity. A state-of-the-art modelling framework will be developed, exploiting and advancing cutting-edge and established modelling tools for EU and China, using the latest emissions data, representing technology and policy options, enabling assessment of socioeconomic impacts, covering multiple economic sectors and regions, and offering high spatial and technology detail. The enhanced models will be used to co-produce net-zero pathways for the EU and China, explicitly assessing co-benefits and trade-offs of climate policies with other societal goals while exploring cooperation policies and governance to drive the global transformation and assessing the distributional and global-level implications of the two regions' decarbonisation. The pathways will be documented in new workspaces in the I^{2}AM PARIS platform.

WI – Wuppertal Institut Für Klima, Umwelt, Energie gGmbH	DE
E3M – E3-Modelling AE	GR
IIASA – Internationales Institut Für Angewandte Systemanalyse	AT
UoB – The University of Birmingham	UK
ICCS – Institute of Communication and Computer Systems	GR
HOL – HOLISTIC IKE	GR
ITE – University of Kassel	DE
THU-SA – Tsinghua University	CN
THU-CE – Department of Chemical Engineering, Tsinghua University	CN
THU-DESS – Department of Earth System Science, Tsinghua University	CN
RUC – Renmin University of China	CN
SDU – Shandong University	CN
CHINACOAL – China National Coal Group Corporation	CN
BITARIM – Advanced Research Institute of Multidisciplinary Sciences, Beijing Institute of Technology	CN
FULONG – Inner Mongolia Fulong Heating Engineering Technology Co., LTD	CN
BIT-ME – School of Mechanical Engineering, Beijing Institute of Technology	CN

Executive Summary

The EU-CHINA BRIDGE project includes a variety of data-intensive research activities, including new model development by combining bottom-up and integrated assessment models, extensive scenario modelling, decarbonisation roadmaps for industry, and a comprehensive emissions stocktaking. This report presents the project's Open Data Management Plan, outlining the data that are used as inputs to project activities as well as all resulting datasets. The plan details how the data will be made findable, accessible, interoperable, and reusable (FAIR), and addresses their resource allocation, data security, and ethical considerations. The DMP will be updated in two subsequent versions: Version 2 (D7.7) and Version 3 (D7.8).

EU-CHINA BRIDGE will also leverage the ARGOS service from OpenAIRE and EUDAT to develop a machine-actionable version of the data management plan (maDMP), containing metadata and links for datasets developed throughout the project. The maDMP will be continuously updated, allowing for revisions whenever new data or significant changes occur.

Section 1 begins with an introduction to the scope of the DMP for EU-CHINA BRIDGE and to the terminology used (such as machine-actionability). Following this, Section 2 presents the project's objectives and main activities and, accordingly, the purpose of data collection and generation in the context of the project. The Section also provides details on data formats, origin, use, and utility. Section 3 outlines different strategies to ensure that the data generated by the project adheres to FAIR principles, i.e., that it is Findable, Accessible, Interoperable, and Reusable. Then, Section 4 discusses the allocation of resources necessary to support FAIR data, Section 5 covers aspects of data security, recovery, and storage, and Section 6 addresses ethical aspects related to the data handling activities that are envisioned in the project. Lastly, Section 7 presents the ARGOS service, describes how new datasets will be incorporated into the maDMP, and provides an outlook on its further updates.

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1 Introduction

This report marks the first version of the open data management plan (DMP) for the Horizon Europe EU-CHINA BRIDGE project. It outlines the protocols and guidelines for managing research data, detailing the processes involved in the collection, generation, processing, and dissemination of data throughout the project's lifecycle. The report also presents a transparent strategy for ensuring that data is managed according to FAIR principles—Findable, Accessible, Interoperable, and Reusable—facilitating effective knowledge and data exchange.

A DMP is a structured document that outlines the procedures for managing research data, encompassing the entire data lifecycle from creation to preservation and beyond the project's duration. It details the necessary steps and strategies to maintain data quality, safety, sustainability, and, where possible, its accessibility and reusability.

In addition to this report, we will develop a machine-actionable Data Management Plan (maDMP) as soon as we have the first dataset resulting from the project. Machine-actionability refers to the ability of DMPs to be understood, processed, and executed by computational systems without human intervention. This concept is promoted by the Research Data Alliance (RDA), which highlights the importance of maDMPs in facilitating the automatic exchange, integration, and validation of information between systems involved in the research lifecycle. This capability allows DMPs to become "active" documents that can be updated as the project progresses.

Our maDMP will be developed using the ARGOS[1] service provided by OpenAIRE and EUDAT. ARGOS is an online tool designed to streamline the management, validation, and monitoring of a maDMP throughout its lifecycle. Users begin by creating a new maDMP and linking it with the datasets produced or used in the project. The datasets are categorised by type or scientific discipline, ensuring organised information and easy access to relevant data activities. Once finalised, DMPs can be validated, made public, and shared via Public Dashboards. Additionally, ARGOS integrates with Zenodo[2], allowing users to publish their DMPs directly from the platform.

[1] https://argos.openaire.eu/splash/
[2] https://zenodo.org/

2 Data summary

2.1 Project objectives and implications for data collection and generation

The EU-CHINA BRIDGE project aims to facilitate the transition to a climate-neutral and resilient society in both Europe and China by focusing on technological innovation and roadmaps for decarbonising energy-intensive industries (EIIs). Specific technologies in the steel, chemical, and industrial waste heat utilisation (IWHU) sectors will be assessed. The project will develop and scale up these technologies through detailed modelling and policy analysis, co-creating technology roadmaps and decarbonisation strategies with stakeholders. EU-CHINA BRIDGE will also create net-zero emission pathways for the EU and China, considering technological and policy factors. Additionally, it will analyse the global implications of EU and China decarbonisation efforts, including impacts on trade and climate action, and explore possible coordination between the two regions. All data, models, and findings will be documented and made available through open-access platforms, databases, and publications.

An advanced modelling framework, already integrated into EU and Chinese decision-making processes, will be further enhanced to cover a broad range of sectors, technologies, and geographic areas. For steel industry, the WISEE Energy Demand Model Global Steel (EDM-GS) will be expanded to increase detail for China and the EU, updating regional cost data and enhancing project-specific modelling capabilities. For the chemical sector in the EU, modelling is divided into three modules, EDM-s, EDM-i, and EDM-d, which will be soft-linked to create a robust and credible net-zero technology roadmap by calculating polymer demand, resource consumption, technology investment, and energy use. In China, the CIEEM model will analyse energy flows and emissions, particularly in EIIs. Additionally, for industrial waste heat utilisation (IWHU) in district heating, CIEEM will be used alongside the China Building Energy and Emission Model (CBEEM) to analyse energy and emission trajectories in buildings, considering various technologies. The aforementioned sectoral models in the EU-CHINA BRIDGE project will be integrated with large-scale energy system models, such as PRIMES for the EU and PROMETHEUS in global scope.

For the EU's national and sub-national modelling EU-CHINA BRIDGE employs a suite of EU models (PRIMES, GLOBIOM, GAINS, GEM-E3) to quantify mitigation pathways at national and sub-national levels across various sectors. Each model focuses on a specific area: PRIMES for energy system mitigation options, GLOBIOM for land-use and biodiversity impacts, GAINS for non-CO2 greenhouse gases and air quality, and GEM-E3 for socio-economic impacts. These models are integrated to capture the complex interactions necessary for developing credible, holistic net-zero transition pathways. They will also explore the milestones and conditions required by 2030 and 2040 to achieve long-term net-zero goals. As for China's national and sub-national modelling, the AGHG-INV model will be utilised to develop emissions reduction pathways for China's agricultural sector, focusing on promoting healthy and sustainable diets. Additionally, the RE3M computational general equilibrium (CGE) model will be used by Chinese partners to analyse the socio-economic challenges and opportunities of transitioning to climate neutrality. This analysis will cover areas such as labour market transformation, economic growth, health and welfare, industrial competitiveness, trade, and the distributional impacts across different sectors, social groups, and regions in China.

Moreover EU-CHINA BRIDGE uses global Integrated Assessment Models (IAMs) like PROMETHEUS and GEM-E3-World to assess the worldwide implications of EU and China's decarbonisation efforts on trade, commodity markets and climate action in other regions. These models are holistic, covering all sectors and the connections between energy, land systems, the environment, and the economy, while maintaining consistency with national and regional models through data exchange. The framework integrates various models: PRIMES for

EU biomass demand, PROMETHEUS for global energy system development, GLOBIOM for land use, and GAINS for non-CO_2 gases. The GEM-E3-World model evaluates global socio-economic impacts of these pathways. Similarly, China's RE3M-Global model assesses global decarbonisation pathways, focusing on the socio-economic, industrial, trade, and distributional effects along the global supply chain, in line with Paris Agreement goals. The integration of such a diverse set of complementary modelling, enables detailed analysis with high granularity. Thud three global IAMs (PROMETHEUS, GEM-E3-World, RE3M-Global) will be used to compare EU and China mitigation pathways and their global interactions, addressing uncertainties and providing robust recommendations.

EU-CHINA BRIDGE will also create a comprehensive and up-to-date greenhouse gas (GHG) and short-lived climate pollutants emission dataset (GSLEDs) for over 100 countries, focusing on major emitters like the EU, China, and emerging economies. The dataset will include emissions of CO_2, CH_4, N_2O, HFCs, PFCs, SF6, and black carbon, using state-of-the-art methods aligned with IPCC guidelines. Emissions will be calculated based on activity data (e.g., energy use, industrial production) and sector-specific emission factors, with sub-national or high-resolution estimates generated through machine learning. The project will expand existing CO_2 and non-CO_2 emission datasets and develop a new bottom-up inventory for these emissions, covering 100+ countries and 47 economic sectors, with data gridded to a 10x10 km resolution. A near-real-time data platform will also be created, offering global daily emissions data for highly polluting industries with high temporal, sectoral, and spatial resolution. The resulting datasets will be integrated with the project's modelling tools to support detailed sectoral and regional analyses.

The project will update models with state-of-the-art GHG emission data, integrate advanced technology insights, and utilise open data sharing between the EU and China for near-real-time calibration. Emphasising the importance of transparency and openness we will ensure that the data used and produced by the models adhere to the FAIR principle and model capabilities and specifications are documented for expert and non-expert audiences, through refinement and improvement of the open-access knowledge exchange platform I^2AM PARIS[3] which will support data assimilation and provide a user-friendly, web-based visualisation of pathways, facilitating dissemination and stakeholder engagement. Additionally, the project seeks to foster mutual learning on decarbonisation technologies, net-zero pathways, and their broader societal impacts by enhancing capacities of researchers in the EU and China and mutual learning on data and modelling tools through hands-on training workshops, which will also be supported by the refined I^2AM PARIS platform. Finally, the project is committed to promoting the widespread adoption of its findings by policymakers, stakeholders, the scientific community, and the public, while advancing the understanding of decarbonisation opportunities and their socio-economic implications.

EU-CHINA BRIDGE will prioritise open science and rigorous data management by enhancing the I^2AM PARIS platform, which supports transparent data management, model harmonisation, and coordination between European and Chinese consortium members. This platform, linked with the project's website, will provide stakeholders with accessible information on modelling capabilities and results, serving as a database for open-source models, emissions inventories, and technology roadmaps. To ensure scientific transparency and trust, the project will offer detailed documentation and open-access resources in both English and Chinese. A comprehensive Data Management Plan (DMP) will be developed to guide data generation and adherence to FAIR (Findable, Accessible, Interoperable, Reusable) principles. The DMP, coordinated between European and

[3] https://www.i2am-paris.eu/

Chinese members, will include strategies for managing Intellectual Property rights. The project will use the OpenAIRE ARGOS service to automate data management, ensuring compliance with FAIR principles. All research outputs will be publicly available, with a preference for open-access journals, and hosted on platforms like Zenodo with Creative Commons licensing. Each publication and dataset will have a unique DOI for easy access, and interactive visualisations will be provided to enhance interoperability. The platform will cater to both expert users, offering detailed modelling information, and non-experts, providing accessible explanations to engage a wider audience.

2.2 Types and formats of data

Achieving the objectives outlined in Section 2.1 necessitates the generation and collection of various data types. Table 1 provides a representative, though not exhaustive, list of the data types and formats that will be utilised across different project activities. Modelling inputs will primarily consist of quantitative data, typically in spreadsheet formats like xlsx or csv, or in prebuilt data formats such as Rda, commonly used in the R programming language. New model code will be available in the programming languages used to develop the models. For example, the EDM-S model within the WISEE-EDM suite, which is a detailed Material Flow Analysis (MFA) model tracking materials from production through to recycling, is coded in Python, and thus its code will be available in Python file format. Additionally, qualitative insights drawn from existing research and stakeholder co-creation activities, such as interviews and surveys, will contribute to the modelling process. Similar to the data inputs, the outputs from the scenario analysis conducted within the EU-CHINA BRIDGE project will also be quantitative, provided in spreadsheet formats or easily convertible formats, and will be accessible on the I²AM PARIS platform. These datasets will support the project's scientific and policy publications, which will be available in pdf format.

Table 1. Data types and formats per project activity

Project activity	Data collected and generated	Data formats
Develop and improve models	**Collect:** Code from previous versions of models, feedback from project stakeholders and communities of practice for the different models	File formats related to the programming language of each model (e.g., py, R, h, cpp, GAMS), reports documenting the model and stakeholder feedback in pdf
	Generate: New model code and documentation	
Compile the input data for new models	**Collect:** National and sectoral statistics on socioeconomic parameters, macroeconomic indicators, energy use and supply, industrial indicators, physical demand for products, policy options; technological cost and innovation data; investment costs; global material demands, supply; global material demands and other modelling inputs	Spreadsheet-like formats, e.g., xlsx and csv, as well as other formats such as txt, json, SQLite databases, etc.
	Generate: Curate the raw data into a format and data structure that is usable by project models	

Create a comprehensive and up-to-date dataset of GHG and short-lived climate pollutants emissions	**Collect:** Activity data and sector-specific emissions factors by fuel for each country. Estimate sub-national or high-resolution emission data using machine learning techniques integrated with the standard IPCC approach, expanding CO_2 emission data from CEADs, MEIC and near-real-time emission dataset Carbon Monitor	Spreadsheet-like formats, e.g., xlsx and csv, as well as other formats such as txt, mat, json, SQLite databases, etc.
	Generate: Curate the raw data into a consistent format and data structure that is usable by the project's models and can be easily understood by external users. Both databases will be accessible through online interactive interfaces in I^2AM PARIS.	
Technology inventories for EIIs	**Collect**: Technology-specific technoeconomic data (CAPEX, OPEX, lifetime, specific energy and feedstock demand, emissions, etc.), as well as qualitative challenges and requirements.	Spreadsheet-like formats, e.g., xlsx and csv
	Generate: Curate the raw data into a consistent format and data structure that can be easily understood by external users.	
Policy inventories for EIIs	**Collect**: policy data (policy objectives, types, design features, etc.).	Spreadsheet-like formats, e.g., xlsx
	Generate: Curate the raw data into a consistent format and data structure that can be easily understood by external users.	
Scenario analysis using new models	**Collect:** Scenario definitions based on the stakeholder engagement activities of the project	Reports documenting results and stakeholder feedback in pdf; results in xlsx, csv, txt, json. Scenario results will be also uploaded to the I^2AM PARIS platform as interactive tables.
	Generate: GHG emissions, material imports, sufficiency, future energy demand, fuel mix, jobs creation, resilience to shocks	

2.2.1 Data processing tools

Modelling tools will serve as the primary data processing instruments for the project. Table 2 lists all the models that are being expanded and enhanced within the EU-CHINA BRIDGE project to evaluate and develop net-zero emission pathways. These models are well-established and will undergo further development and integration (WP5). Already aligned with EU and Chinese policy processes, these models will be improved by incorporating stakeholder feedback and the latest greenhouse gas (GHG) inventory data (WP2), as well as insights from technology roadmaps for energy-intensive industries (WP3). Additionally, an open-access, web-based visualisation interface will be made available to assist stakeholders and policymakers in linking long-term climate objectives with the necessary short-term measures.

Table 2. Models used in EU-CHINA BRIDGE

Models	Scope of models	Responsible partner(s)
WISEE EDM-GS[4]	EU & China steel industry	WI, BITARIM
WISEE EDM-s, EDM-i, EDM-d[5]	EU Chemical sector	WI
CIEEM	China Chemical sector and IWHU	THU-CE
CBEEM	China IWHU	THU-CE
PRIMES[6]	EU Energy system	E3M
GLOBIOM[7]	EU Land use	IIASA
GEM-E3[8]	EU Socioeconomics	E3M
GAINS[9]	EU non-CO2 GHG, human health & ecosystems	IIASA
AGHG-INV	China agricultural sector	
RE3M	China Socioeconomics	
PROMETHEUS[10]	Global Energy system	E3M
GEM-E3-World[11]	Global Socioeconomics	E3M
RE3M-Global	Global Socioeconomics & Industrial	

Beyond the models, the project will also employ various data processing tools, including (but not limited to) Microsoft Excel for managing and editing xlsx and csv files, Microsoft Word for drafting reports and manuscripts based on project findings, and Adobe Reader/Acrobat for creating publications in pdf format. Additionally, tools and scripting languages like Python (e.g., in WISEE EDM-S) and R will be utilised for data processing and curation tasks.

[4] https://www.i2am-paris.eu/detailed_model_doc/wisee-edm
[5] https://www.i2am-paris.eu/detailed_model_doc/wisee-edm
[6] https://e3modelling.com/modelling-tools/primes/
[7] https://iiasa.ac.at/models-tools-data/globiom
[8] https://e3modelling.com/modelling-tools/gem-e3/
[9] https://gains.iiasa.ac.at/models/
[10] https://e3modelling.com/modelling-tools/prometheus/
[11] https://e3modelling.com/modelling-tools/gem-e3/

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2.2.2 Data inputs and outputs for models

For data inputs in EU-CHINA BRIDGE, we will prioritise using fully open datasets whenever possible, while also providing flexible options that allow users to choose between open or proprietary datasets for simulations. Data outputs will be made fully open access, adhering to the FAIR data guidelines outlined in this report and its updates (Section 3). These guidelines will also be incorporated into the maDMP to support the uptake and reuse of outputs through automatic metadata parsing. Insights from scenario modelling will be made publicly available on Zenodo in the form of scientific papers for academics, and policy briefs for policymakers and other stakeholders. Datasets will be presented through interactive visualisations on I^2AM PARIS, featuring customised interfaces for various audiences and offering key insights and clarifications relevant to policy and industry. All publications and datasets will be openly accessible via our Zenodo community (and in respective repositories, such as the GHG and SLCF emissions dataset onto CEADs), and all new project code will be available as open source on GitHub[12]. Publications and associated datasets will be shared promptly upon publication, utilising Creative Commons licenses for reusability and DOIs for findability. Table 3 provides an indicative list of data inputs and outputs for the models.

Table 3. Indicative input and output data for project models (Giarola et al., 2021; Pauliuk et al., 2017)

Data type	Category	Input/output
Population	Socioeconomic	Input
GDP	Socioeconomic	Input & output
Employment	Socioeconomic	Input & output
Total gross/real disposable income	Socioeconomic	Input & output
Interest rates and exchange rates	Socioeconomic	Input
Labour participation and productivity	Socioeconomic	Input
Household size and space	Socioeconomic	Input
Physical activity data	Socioeconomic	Input
Macroeconomic and sectoral activity data	Socioeconomic	Input & output
GHG emissions (CO_2, methane, others)	Emissions	Input & output
CO_2 emission factors	Emissions	Input
Abatement curves	Emissions	Input

[12] This mandate concerns European partners; partners in China shall consider releasing code as open source but are not mandated by their funding agency.

Water availability	Impacts	Input
Water withdrawal/consumption	Impacts	Output
Air quality (e.g., PM2.5)	Impacts	Output
Installed capacity for different energy technologies and for storage	Energy	Input & output
Electricity and heat production mix	Energy	Input & output
Specifications of energy technologies and availability	Energy	Input
Potential of renewable energy sources	Energy	Input
Network infrastructure specifications	Energy	Input
Conversion technology characteristics	Energy	Input
Sectoral energy intensities	Energy	Input & output
Energy/electricity trade	Energy	Input & output
Food/agricultural demand	AFOLU	Input & output
Land uses, types, and potential as emissions sinks	AFOLU	Input
Energy performance of buildings (HVAC, envelope, appliances)	Buildings	Input
Energy efficiency improvements rates	Buildings/Industry	Input
Industrial technologies - specifications and availability	Industry	Input
Sectoral productivity and growth	Industry	Input & output
Material stocks and flows	Industry	Input & output
Vehicle fleet and structure	Transport	Input & output
Technological characteristics of vehicles	Transport	Input
Fuel efficiency	Transport	Input
Mobility characteristics and modal shifts	Transport	Input & output
Energy prices	Prices/costs	Input & output
Energy and power technology costs	Prices/costs	Input & output

Technology costs (capital, operating and maintenance)	Prices/costs	Input & output
Fossil fuel prices	Prices/costs	Input & output

2.2.3 Data used in scenario analysis

In addition to the data inputs shown in the previous section, EU-CHINA BRIDGE models may need inputs related to specific scenarios to explore. For most of these inputs, the consortium will build on existing datasets tailored to the models used. However, technoeconomic assumptions will be updated and extended during the project. Scenario-specific assumptions will be developed among the interdisciplinary consortium and in the co-creation processes with stakeholders.

Table 4. Input data used in scenario analysis in WP3

Industrial sector	Input data
Petrochemical industry	Plastics demand in Europe
	Assumptions about mechanical recycling rates for plastics
	European biomass potentials usable for chemical feedstock
	Existing refineries and petrochemical capacities per site in Europe
	Technoeconomic assumptions on technologies (TRL, specific inputs/outputs, costs)
	Prices for energy carriers per EU Member State
	World market prices for chemical feedstock
Steel industry	Assumptions on energy carrier prices and raw material prices (region-specific)
	Existing steelmaking capacities
	Transformation pathway for a given scenario (crude steel production per route until 2050)
	Technoeconomic assumptions on technologies (TRL, energy demand per carrier, iron ore requirements, scrap shares, costs)
	Prices for energy carriers and feedstocks

2.3 Origin, expected size, and utility of data

2.3.1 Origin

As previously discussed, the EU-CHINA BRIDGE project will focus on further developing, improving, and soft-linking existing, well-established modelling frameworks. This means that the extended models will build on existing code, and their inputs will be derived from current data sources. These inputs will be significantly enhanced through insights and datasets gathered from stakeholder engagement.

A key objective of the project is to make both any *new* modelling code and input data openly accessible. This may require adapting or finding alternatives to any existing model code that cannot be made open source, so as to ensure that the new model code is *as open as possible*. Additionally, all data inputs will need to be open access, which presents a major challenge given that many critical data sources for modelling are proprietary or not publicly available. To address this, the project will develop strategies on a case-by-case basis to replace proprietary datasets with equivalent open-source data. If this substitution is not feasible, an alternative solution could involve converting input data into a prebuilt, binary format that can only be read by the models and potentially shared openly. Table 5 provides an indicative list of publicly available data inputs used in the existing models that can be directly utilised by the enhanced models of EU-CHINA BRIDGE.

Table 5. Open-access data from the base models that can be re-used by the models

Topic	Variable	Context	Indicative data origin	Data format
Socioeconomics	**Population**	EU27+Norway	Population data from Eurostat: Historical statistics through 2018 (Eurostat, 2023); EUROPOP2019 projections from 2019 through 2100 (Eurostat, 2022a, 2022b)	csv
		OECD+7 except EU27/Norway	Population data from OECD Economic Outlook 109 Long-term baseline projections (available for 1990 through 2060), to ensure consistency with GDP projections (OECD, 2021). Extend with growth rates from UN WPP2022 after 2060 if necessary (see below).	csv
		Rest of World	UN World Population Prospects 2022 figures for all years (available from 1960 through 2100, with historical data until 2022) (United Nations, 2022)	csv
	GDP	All regions, through 2028	GDP from IMF World Economic Outlook (IMF, 2023) in constant 2017 international dollars unless otherwise indicated by the research question	csv

		EU27+Norway, from 2029	Extend IMF forecast with linearly interpolated real GDP growth rates from the 2021 Ageing Report (European Commission, 2021b, 2021a)	csv
		OECD+ except EU27/Norway, from 2029	Extend IMF forecast with real GDP growth rates from the OECD Economic Outlook 109 long-term baseline	csv
		Rest of World	Extend IMF forecast with GDP growth rates per working age capita from Shared Socioeconomic Pathway 2 (must be calculated using the projected population figures) multiplied by population growth rate from the harmonised population time series	csv
Techno-economics	**Technology costs (for reference scenarios)**	EU27 and comparable countries	The EU Reference Scenario 2020 (European Commission, 2021c; European Commission et al., 2021d)	csv
		Other regions, power-sector technologies	Most suitable option are cost assumptions from IEA's World Energy Outlook 2022 (International Energy Agency, 2022)	csv
		Other regions, non-power technologies	Options include adapting costs from the EUR Reference Scenario 2020	csv
	Fossil fuel prices	Historical prices	Regional prices from IEA datasets (International Energy Agency, 2023a). If participating modellers do not have access to proprietary IEA data, data for some years and regions can be extracted from the freely available World Energy Outlook 2022 report (International Energy Agency, 2022), or if global benchmarks are sufficient, some of these are available for free from the World Bank "pink sheet" (World Bank, 2023)	csv

		Price projections	Regional price forecasts from the World Energy Outlook 2022 extended dataset (International Energy Agency, 2023), requires subscription. Participating modellers who do not have a license can extract some prices visually from charts in the World Energy Outlook 2022 report (International Energy Agency, 2022). For long-term EU- specific exercises that do not need short-term trends, price projections from the EU Reference Scenario 2020 may be used (European Commission, 2021d)	csv
Energy	**Energy production and consumption**	Historical data	IEA World Energy Balances (International Energy Agency, 2023c)	csv
Emissions	**Energy-related CO_2, CH_4, N_2O**	Historical data	IEA Greenhouse Gas Emissions from Energy dataset (International Energy Agency, 2023b), if modellers have or can acquire access. Alternatively use EDGAR v7.0 (Branco et al., 2022) which is consistent with IEA but with less detailed breakdowns. Emissions can also be calculated from energy consumption data using default Tier 1 emission factors from the 2006 IPCC guidelines for GHG inventories, which are consistent with IEA emission factors.	csv
	IPPU CO_2 from cement	Historical data	Production data and emission factors from (R. Andrew, 2018). Updated data available on Zenodo (R. Andrew, 2023)	csv
	F-gases and non-energy CO_2, CH_4, N_2O	Historical data	EDGAR v7.0 (Branco et al., 2022)	csv
	Other emissions	Historical data	CEDS (O'Rourke et al., 2021)	csv

2.3.2 Size

Drawing from experience with previous modelling-based projects like PARIS REINFORCE[13], it is expected that the total data collected, processed, and produced in the context of EU-CHINA BRIDGE will amount to approximately 500GB. The bulk of this data will likely come from the inputs used in the models and more significantly from the large volumes of data outputs that will be generated. Other data types that may contribute substantially to the total size include audio and video recordings of consortium and stakeholder meetings, which are expected to be several hundred megabytes per meeting, multiplied by the dozens of meetings planned. In contrast, the minutes from these meetings will be compiled into a limited number of reports, each only a few megabytes in size. Similarly, model publications, consisting of around 70 PDF documents, are expected to occupy minimal space. More precise estimates will become available as the project progresses and will be reflected in the next versions of the DMP.

2.3.3 Utility

The data outputs generated by EU-CHINA BRIDGE are anticipated to be highly valuable across all targeted audiences of the project. The extended and enhanced models and the GSLED datasets will be directly beneficial to climate-economy modelers and researchers focused on related fields. Additionally, the scenario results data can provide actionable insights and short-to-medium term recommendations for sustainable pathways, informing sectoral strategies and policies for both the EU and China. That is why we will place particular emphasis on disseminating project data to key stakeholders, including the European Commission, EU agencies, national and local governments, businesses, industrial actors (especially in energy-intensive sectors), financial institutions, and researchers working in the broader climate- and energy-economy modelling domains. Our goal is to ensure that these data outputs not only advance academic and industrial research but also contribute to informed decision-making and strategic planning across multiple sectors.

[13] https://paris-reinforce.eu/

3 FAIR data

As open data becomes increasingly important, a consortium of stakeholders from academia, industry, and government came together to establish the FAIR Principles. These principles serve as a standard for evaluating the extent to which scientific data is Findable, Accessible, Interoperable, and Reusable (Wilkinson et al., 2016). By adopting the FAIR principles, researchers are better equipped to build upon existing knowledge, driving new discoveries and technological innovations. Rather than imposing specific technical requirements, these principles provide a flexible framework that enhances reusability across a wide range of implementations.

In the context of EU-CHINA BRIDGE, we will implement open science principles by establishing a transparent pipeline for model development, effectively opening the 'black box' of scientific assumptions, processes, and results. This approach will ensure full access to newly developed modules and models, including code[12], interfaces, and data. The data used and produced will adhere to FAIR principles, fostering a vibrant community of practice focused on industry-academia collaboration for knowledge valorisation, benefiting both creators and users (Mons et al., 2017). Additionally, this will enable the documentation of new modelling capabilities for both expert and non-expert audiences. The FAIRness of research data will be assessed by evaluating various aspects of the data's characteristics and infrastructure.

The key guidelines for assessing the FAIRness of research data are outlined below.

1. **Findability**: Ensuring data is easily located and accessed by interested parties is crucial. To achieve findability, data must be assigned a unique and permanent identifier, known as a Persistent Identifier (PID). PIDs offer stable references to digital objects and remain linked to the data even if its location or access method changes over time. They are a key element of findability, allowing anyone with the identifier to discover and access the data, regardless of its storage location. In addition to PIDs, comprehensive machine-readable metadata is essential for the automated discovery of relevant datasets and services. These metadata must explicitly include the identifier of the data they describe and should be registered or indexed in a searchable resource, forming a critical part of the FAIRification process (Jacobsen et al., 2020).

2. **Accessibility**: Accessibility ensures that data is readily available and usable by both humans and machines. Metadata and data should remain accessible, even if the data itself is no longer available. They should be retrievable by their identifier using a standardised communications protocol that is open, free, universally implementable, and supports an authentication and authorisation procedure, when necessary. Accessibility does not necessarily imply openness; rather, it means data is "accessible under well-defined conditions," which may include protecting personal privacy, national security, and ensuring proper data protection (Mons et al., 2017).

3. **Interoperability**: Ensuring interoperability is essential for the seamless integration and analysis of scientific data across various systems and tools. This requires structuring scientific data in open and standardised formats that are easily understandable and usable by different software and applications. Such an approach facilitates data sharing and reuse across multiple disciplines and domains, thereby promoting collaboration and interdisciplinary research. By using standardised formats and protocols, data can be integrated into analysis workflows, allowing researchers to extract insights and knowledge from diverse datasets (Ravi et al., 2022). This is achieved through the exchange of data and metadata among different software packages via application programming interfaces (APIs), adhering to relevant community standards, and including references to other objects. Consequently, metadata should employ vocabularies that follow FAIR principles and include qualified references to other (meta)data (Calamai & Frontini, 2018). When used effectively, metadata enables research data to

function as "mobile" objects (Latour, 1987), meaning they can transition between different production contexts while maintaining their evidential value (Pasquetto et al., 2019).

4. **Re-usability**: For data to be effectively reused for various purposes, it must be meticulously structured and thoroughly documented. This includes providing comprehensive details about the data's provenance, quality, and usage rights, and adhering to standardised formats and structures. By enhancing reusability, the value and impact of scientific data are maximised, as well-documented, structured, and metadata-annotated data become more comprehensible and usable (da Silva Santos et al., 2023). This process involves detailing the origin, quality, and accessibility of the data, while adopting transparent and widely recognised standardised data formats and structures. Ensuring the long-term reusability of data allows researchers to build on existing knowledge, accelerate the generation of results, and foster connections across different researchers and scientific disciplines.

3.1 Making Data Findable

We will ensure that all EU-CHINA BRIDGE outputs are easily discoverable by assigning Persistent Identifiers (PIDs), providing detailed metadata, and using relevant keywords to facilitate document retrieval through search engines. All deliverables, policy briefs, and business guides will be uploaded to the project's Zenodo community and will receive Digital Object Identifiers (DOIs). For scientific publications, a DOI will be assigned by the publishing journal; however, we will also upload the publications, accepted manuscripts, or preprints to Zenodo to maintain a comprehensive archive of our work. Zenodo's versioning system will be used to track different versions of documents, with each version receiving a separate DOI, while a top-level DOI will link to the latest version.

We will also establish a consistent naming convention for each type of output:

- **Scientific publications**: "{author(s)}_{year}" (e.g., Smith_et_al_2023.pdf)
- **Policy/Business briefs**: "EU_CHINA_BRIDGE _{title}" (e.g. EU_CHINA_BRIDGE _Policy_Brief_on_Collaborations_between_EN_and_China.pdf)
- **Deliverables**: "EU_CHINA_BRIDGE _DX.X_{title}" (e.g. EU_CHINA_BRIDGE_D7.6_Open_Data_Management_Plan.pdf)
- **Datasets**: "{author(s)}*{year}*{dataset_name}" (e.g., Smith_et_al_2024_Cost_Assumptions.csv)

All datasets generated during the project will also be archived in Zenodo and assigned a DOI. After uploading a dataset to Zenodo, we will link it to the machine-actionable Data Management Plan (maDMP) in ARGOS, providing rich metadata and keywords according to the Horizon Europe template in ARGOS (see Chapter 7). Additionally, all final model code will be publicly stored on GitHub[12], linked to Zenodo, and integrated into the maDMP.

Model documentation, inputs, and outputs will also be published on the I^{2}AM PARIS modelling platform to further promote them within the climate-economy modelling community that has been using the platform since its inception in 2020. Each dataset will include links to all related project publications to enhance findability. Lastly, both the platform and the project website will feature adequate content and an optimised sitemap to ensure visibility in search engines like Google and Bing.

3.2 Making Data Accessible

We will apply Creative Commons licenses to all deliverables, policy briefs, business guides, and datasets produced in the EU-CHINA BRIDGE project. Most outputs will be published under the highly permissive CC BY license (version 4.0). In certain cases, we may opt for less permissive licenses, such as CC BY-SA, to ensure that derivative works remain available under the same open license. This approach is particularly useful for model code developed in EU-CHINA BRIDGE as it ensures that any derivative software remains open and free, supporting the transition to a climate-neutral and resilient society in both Europe and China.

Scientific publications will be published in journals offering open-access options, in compliance with Horizon Europe rules. Whenever possible, we will choose fully open-access journals, including the Open Research Europe publishing platform. If fully open-access options do not align with the publication's scope, we will select a journal offering a gold open-access option, prioritising those with which the project partners' organisations have publishing agreements.

All new models used in the context of EU-CHINA BRIDGE will be released under open-source licenses[12]. We will explore various licensing options for each module in collaboration with the respective model development teams. It is important to note that different licenses may be used for model code and input data. If some input data within a module is not open access, we will suggest alternative datasets that can be used in their place.

In terms of file formats, we will prioritise well-known formats that are accessible via freeware software, such as pdf, csv, txt, mp3, and mp4 files. When this is not feasible (for example, when publishing an Excel spreadsheet with multiple tabs), we will provide links to compatible freeware software, such as the Open Office suite, alongside the proprietary files.

We are committed to ensuring that all open project outputs remain accessible for as long as possible. All project publications and datasets will be stored in established online repositories like Zenodo and GitHub, where they are expected to remain available for many years. The project website will also be maintained for at least three years after the project's conclusion to support the dissemination and discoverability of project outcomes. Additionally, ICCS and HOLISTIC will ensure the I²AM PARIS platform's longevity after the project ends, extending its availability until around 2032.

3.3 Making Data Interoperable

We will ensure high interoperability of project data by utilising appropriate data formats and providing detailed metadata. As outlined in Section 3.2, all project datasets and reports will be shared in widely used formats such as pdf, csv, and txt, with an emphasis on avoiding proprietary formats whenever possible. Documentation for all new modules, as well as the results of scenario analyses, will be formatted according to the IPCC AR6/AR7 reporting templates. This approach will make the data accessible to the broader climate-economy modelling community and ensure compatibility with other relevant software, such as the pyam Python package. Additionally, we will explore formats commonly used in industrial ecology.

Metadata for all project datasets will be incorporated into EU-CHINA BRIDGE maDMP in ARGOS, following the Horizon Europe format template. Since all information in ARGOS is machine-actionable, this metadata can be converted to other format templates if needed, further enhancing the interoperability of project datasets.

3.4 Making Data Reusable

As mentioned in the previous section on open access, by releasing all deliverables and datasets of EU-CHINA BRIDGE under a CC BY license, we will facilitate their use by a broad range of interested parties. Similarly, all scientific papers will be published under open-access licenses and made available to the research community immediately after journal acceptance. To ensure the reusability of datasets, we will utilise the Horizon Europe metadata scheme within the project's maDMP. This scheme will include a brief description of each dataset, links to related publications and datasets, and specific guidelines addressing FAIR practices, resource allocation, and security and ethical considerations. While similar in structure to this report, the scheme will provide more detailed information tailored to each dataset. Additionally, all modelling documentation and results will be formatted using the IPCC AR6 reporting templates, and potentially relevant templates from industrial ecology research, to ensure their reusability by the broader modelling community.

4 Allocation of resources

Most of the FAIR practices outlined in Section 3 do not incur any costs for the EU-CHINA BRIDGE project. All deliverables and datasets will be uploaded to Zenodo, which is free to use, and we will utilise the free version of GitHub for storing new project code[12]. Similarly, documenting datasets in the maDMP via ARGOS is also free of charge. However, additional activities related to implementing our open data management plan that require resources have been accounted for in the project's Grant Agreement. The expansion and hosting of I²AM PARIS and the development and maintenance of the project website are budgeted under WP7. There also exist provisions in terms of budget, for publishing in open access journals. Suggested options for publishing in open-access journals are provided in Table 6.

Table 6. Suggested options for open-access scientific publishing in EU-CHINA BRIDGE

Access type	Funder	Fees	License
Publish in a fully Open Access journal	EU-CHINA BRIDGE Grant	Article Processing Charges; ranging between ~200€ (e.g. Elsevier Societal Impacts[14]) to over 10,000€ (e.g. Nature[15])	CC BY 4.0 CC BY-NC-ND 4.0
Publish in a journal that has the option of Gold Open Access	Publishing agreements between the organisations of project partners and the publisher		

Regarding data curation, storage, and preservation, the project coordinator and quality manager will oversee data management and quality control and ICCS will prepare and regularly update this DMP report—with the support of WI and HOLISTIC.

Each project partner will be responsible for proper data handling and curation according to the DMP guidelines. As mentioned earlier, HOLISTIC will be in charge of maintaining the website, ensuring that all related project data remains accessible for at least three years after the project's conclusion. Additionally, both ICCS and HOLISTIC are exploring options to further extend the I²AM PARIS platform's longevity.

[14] https://www.elsevier.com/about/policies-and-standards/pricing
[15] https://www.nature.com/nature/for-authors/publishing-options

Funded by the European Union

Funded by the Ministry of Science and Technology of P.R. China

5 Data security

Data assets collected, processed, or stored during the research project, as outlined in Section 2, are classified according to their sensitivity and importance, necessitating varying levels of protection. To ensure the security of all project data, robust storage solutions and secure platforms for communication and data exchange have been implemented.

WI has established a dedicated workspace within its enterprise version of Google Drive to facilitate internal communication, including video calls and chats among project partners using Zoom. Access to the Google Drive platform is restricted to authorised users (consortium members) thereby ensuring confidentiality.[16] The parent company of Google Drive is certified under the EU-US Data Privacy Framework (DPF). The management and security of these systems are overseen by WI administrators and their Data Protection Officer (DPO), with servers located within the EU to ensure compliance with GDPR and relevant EU regulations. This adherence to GDPR standards is crucial, particularly as Google Drive will also store the contact details of project stakeholders, requiring strong security measures. Similarly, the personal data of newsletter subscribers will be securely stored in HOLISTIC's GDPR-compliant MailerLite account.

In addition to Google Drive, the project also utilises the databases of the project website and the I^{2}AM PARIS platform for data storage. HOLISTIC and ICCS have implemented disaster recovery and backup policies for both databases, ensuring data protection against loss due to critical system failures, fire, theft, or natural disasters. A similar process is in place for the Google Drive system, which also features a versioning system to protect users from accidentally deleting or modifying data.

The project's communities on Zenodo and GitHub will be used to store data during the project and, importantly, to preserve all created datasets and publications after the project concludes. For each dataset, only the minimum amount of data necessary to achieve its intended purpose will be released. The risk of data loss in these repositories is minimal, as all files and documents are stored across multiple online servers to ensure redundancy. Additionally, the likelihood of these repositories ceasing operations is extremely low. However, in the unlikely event that this occurs, contingency plans are in place to migrate all content to appropriate archives, such as those managed by the Software Heritage Foundation and Internet Archive.

[16] This does not apply to Chinese partners, as access to Google services is restricted in P.R. China; however, WI actively seeks alternatives to enable smooth exchange of information among all project partners.

6 Ethical aspects

All data collection and management activities within EU-CHINA BRIDGE will comply with the EU GDPR regulations and the national privacy and data protection laws of each partner country. This includes implementing appropriate measures to protect the privacy and confidentiality of personal data collected or processed during the research, obtaining consent for data processing where necessary, and ensuring secure data storage and handling. While ethical and legal considerations are minimal for most activities related to model development—mainly focusing on respecting the licenses of databases used as sources for modelling inputs—ethical considerations are paramount in all co-creation activities of the project. These activities involve gathering diverse perspectives from project stakeholders through workshops, interviews, and surveys.

During workshops, the Chatham House Rule (Chatham House, 2024) will be applied to ensure the anonymity of speakers and participants. Workshop minutes will strictly adhere to this rule, avoiding any direct association between individuals and specific statements. Similar procedures will be followed for documenting interviews, while surveys will collect only the personal details necessary for research purposes, such as academic or policymaking affiliation. Clear and explicit informed consent will be obtained from all participants in engagement activities, with details on ethical aspects.

As detailed in Section 5, all contact details and feedback from project stakeholders will be securely stored within the project's Google Drive instance, while newsletter subscriber contact details will be maintained in HOLISTIC's MailerLite account. Both platforms are hosted within the EU and are GDPR compliant. Measures will be implemented to prevent the bulk exchange of contact details through insecure channels like email. No transfer of personal data will occur between EU and non-EU countries. The only information collected will be lists of research questions raised by project stakeholders, ensuring anonymity is maintained. In cases where information of stakeholders is collected (e.g., institutions, positions), this information will be anonymised prior to any processing or transferred.

Finally, EU-CHINA BRIDGE will consider the broader societal implications of our research and strive to maximise its positive impact on society. This involves engaging with stakeholders to ensure that research outcomes are socially beneficial and address pressing societal challenges.

7 maDMP in ARGOS

Data Management Plans are essential tools that help researchers manage their data effectively, ensuring their quality, accessibility, and reusability long after the project concludes. To continue being a valuable resource for researchers and other stakeholders, the DMP must be regularly updated to reflect the methods used and the data generated. While it is crucial to maintain a human-readable narrative, there is increasing recognition of the benefits of enhancing the DMP with thematic, machine-actionable details to add further value for all stakeholders (Michener, 2015).

To this end, the EU-CHINA BRIDGE maDMP in ARGOS will provide a comprehensive overview of all datasets generated, curated, or managed during the project. The maDMP will be updated whenever a project dataset is created or modified, with a summary of its contents included in the updates of this report (D7.7 & D7.8). Personnel from ICCS will be responsible for entering new datasets into the maDMP, while all project partners will ensure the metadata provided for their datasets in the maDMP is accurate. The complete DMP lifecycle in ARGOS is illustrated in Figure 1. The maDMP of EU-CHINA BRIDGE has been already created as a draft in ARGOS and will become publicly available when the first dataset from the project is added there.

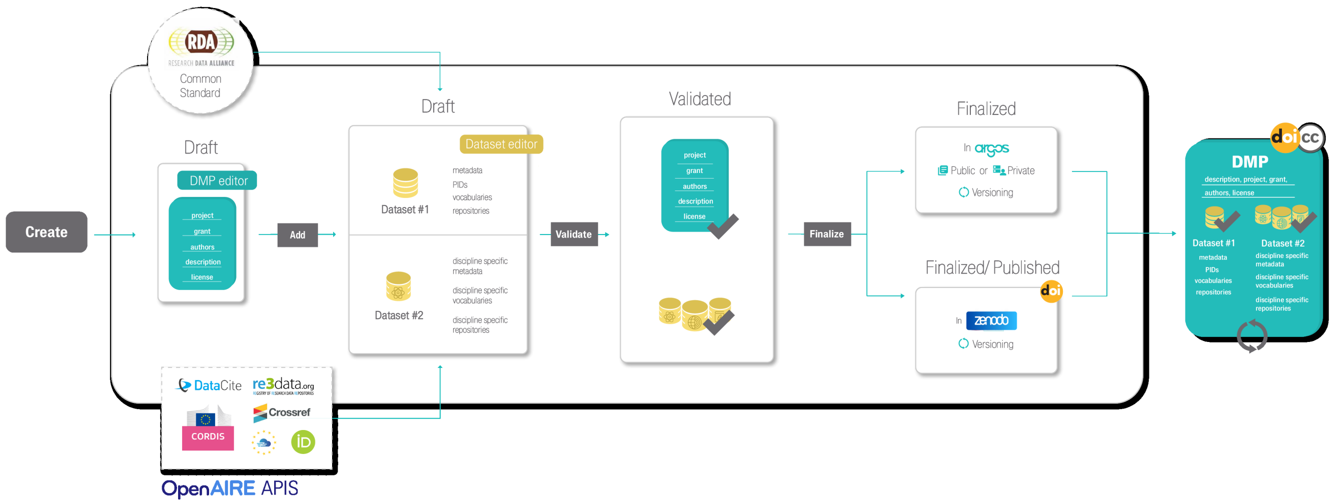

Figure 1: DMP publication lifecycle (OpenAIRE, 2024)

The following process will be followed for creating a new dataset in the maDMP of EU-CHINA BRIDGE:

1. The project partner(s) responsible for creating the dataset (referred to as "data creators") will share it with ICCS (referred to as "data managers").
2. The data managers will then upload the dataset to Zenodo.
3. The data managers will create a new dataset entry in the maDMP, pre-filling it by searching for the dataset's name using the ARGOS search engine.
4. The data managers will complete the dataset's metadata according to the guidelines provided in this report and its updates, linking the dataset to relevant deliverables or scientific publications.
5. The data creators will be invited to review the metadata and ensure its accuracy.
6. Finally, the data managers will update the maDMP with the newly created dataset.

A similar process will be followed for new model code, where links will be established between the model repositories in GitHub and Zenodo to ensure that the code base of the models receives a unique DOI[12]. This Zenodo entry will then be linked to the maDMP and documented with the appropriate metadata, as described earlier. These processes will be continually evaluated based on the experiences of the data managers and creators and may be adapted and optimised as the project progresses.

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