openENTRANCE

Platform Innovation Recommendation

DELIVERABLE NO. 4.5

Version 1.0 - April 2023

Deliverable No.	D4.5	Work Package No. 4	WP4
Work Package Titel	Open modelling platform		
Status	Work in progress		
Dissemination level		PU	
Due date deliverable	2022.4.30	Submission date	
Deliverable version	Initial internal draft version		

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History of Change

Release	Date	Reason for Change	Status
Version 0.1	2023.03.31	Internal draft	
Verison 1.0	2023.04.28	Submitted version	

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Preamble

The project 'Open ENergy TRansition ANalyses for a low-carbon Economy' – Open ENTRANCE develops an open, transparent and integrated modelling platform for assessing low-carbon transition pathways. The platform gathers a suite of state-of-the-art modelling tools and data for covering the multiple dimensions of a green and clean energy transition.

Open ENTRANCE is a project funded by the European Commission under the Horizon 2020 framework and implemented by a consortium of 12 leading European research institutions and universities in addition to one industrial company.

Section 1 provides an overview of new developments implemented in the modeling platform over the course of the project. Section 2 collects ideas and feature requests that arose over the course of the Open ENTRANCE project but which could not be implemented within this project. This document can therefore serve as input to other, ongoing Horizon projects like the European Climate and Energy Modeling Forum (ECEMF, www.ecemf.eu) or PRISMA (www.prisma-horizon.eu).

The ideas and feature requests presented in this document were collected throughout the project. In addition, a dedicated workshop session was held at the final consortium meeting, which took place in Trondheim on March 23, 2023.

1. Platform development in the project

This section presents key developments related to the components of the open modelling platform over the course of the Open ENTRANCE project.

New features for the pyam package

The **pyam** package is an open-source community Python package that combines numerous features for scenario processing, analysis and data visualization. The package simplifies and streamlines many common operations required for energy systems modelling. Read the docs at https://pyam-iamc.readthedocs.io.

In the Open ENTRANCE project, several new features were implemented to streamline scenario processing and validation. For example, the feature for aggregation of timeseries data along the variable tree was extended to provide for recursive aggregation (see IAMconsortium/pyam: #405).

Another important contribution from work within the Open ENTRANCE project is the direct implementation of a Sankey diagram feature in the pyam plotting library. See this example in the plotting gallery. This feature simplifies the visualization and analysis of scenario results.

A common data format

The Open ENTRANCE project extended the widely used IAMC timeseries tabular data format to support sub-annual resolution like representative time-slices (e.g., "summer-year") or continuous time formats (e.g., hourly data). The data format proved very useful to facilitate model linkage and scenario analysis in the project.

The data format and the naming conventions adopted in the Open ENTRANCE project is described in detail at https://github.com/OpenENTRANCE/OpenENTRANCE.

Harmonization and clarifications of definitions and terms

The most important prerequisite for model comparison projects and scenario analysis is an agreed, standardized set of definitions and terms of reference. In the Open ENTRANCE project, we developed a "variable template" and list of regions to be used for the comparison.

The definitions and lists of regions, including the mappings from model-native regions to common "aggregate-regions", are managed via a GitHub repository under an open-source license that permits reuse in other projects. See https://github.com/OpenENTRANCE/OpenENTRANCE for details.

Scenario processing using the nomenclature package

Validation and automated processing are an essential aspect of the integrated modeling platform developed in the Open ENTRANCE project. To streamline validation of scenario results, we first developed prototype Python scripts and workflows. These scripts were then released as a stand-alone, open-source Python package. Read the docs at https://nomenclature-iamc.readthedocs.io.

The **nomenclature** package is now also used to run the scenario validation in several other projects, including the Horizon 2020 projects ECEMF and ENGAGE.

Model linkage scripts

The Open ENTRANCE project developed linkages between various models to implement the case studies and develop European decarbonization scenarios. The scripts are available on GitHub under an open-source license that permits reuse in other projects. See https://github.com/OpenENTRANCE/linkages for further information.

A website to access all tools in the open platform

To simplify access, visibility and reusability of all open model and tools used in the Open ENTRANCE project, the consortium launched a new website to serve as a simple, intuitive entrypoint. This website is available at https://openenergymodels.net.

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2.Ideas for future platform innovation

This section collects various ideas from users on (possible) future improvements and extensions to the different components of the open platform.

A general recommendation across all components is to improve and extend tutorials and guidance for new users. The pyam package and the Scenario Explorer already have dedicated websites for this purpose (see https://pyam-iamc.readthedocs.io/ and http://software.ece.iiasa.ac.at/ixmp-server/tutorials.html), but a regular revision of existing training material is critical to ensure that all available material remains relevant and useful.

IIASA Scenario Explorer

- The Scenario Explorer presents a simple way to display timeseries data. The options to select scenario data and filter variables/regions are not very intuitive. A revision of the web user interface should include advise from interface usability experts. Also, there should be a "quick view" feature that does not require creating a workspace and panel.
- The Scenario Explorer should provide better overview features to understand the types of models and scenarios, for example integrating a data summary, meta indicators and the documentation This information is currently available via different sub-pages of a Scenario Explorer instance, but a unified interface could improve usability and intelligibility of the available scenario data.
- The Scenario Explorer already has a feature to select scenarios according to qualitative and quantitative meta indicators, such as cumulative GHG emissions over the century or the categorization of scenarios by warming categories. However, this feature is not used in many projects (including Open ENTRANCE). Improvements to the user interface should also discuss a more user-friendly selection of scenarios using these meta indicators.
- Visualization options of timeseries data are currently limited to data tables and standard plots like line charts or bar charts. Showing key results using maps would greatly improve the usability and relevance of the Scenario Explorer for many different user groups.
- The IIASA Scenario currently offers three solutions to download scenario timeseries data: download of pre-generated Excel spreadsheets, download of data shown in a workspace panel, or direct database access using the RestAPI or the pyam package. Several users suggested a web interface to generate Excel spreadsheets "on the fly" for easier download.
- The IIASA Scenario Explorer currently supports sub-annual time resolution, but the selection of hourly timeseries data is quite cumbersome and the visualizations options do not support a continuous time axis. The usability of data selection at sub-annual temporal resolution should be improved.

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- Upon submission of scenario data (i.e., data upload), the log file is available only in a sub-menu of the job list. The status and any error messages should be easier to find for the users.

Database infrastructure, scenario classification and API

- The current database infrastructure (see https://github.com/iiasa/ixmp) was not designed for large scenario datasets, for example scenarios with an hourly temporal resolution. A re-implementation must ensure acceptable performance for large datasets like those used in the case studies with high temporal or spatial resolution.
- The current RestAPI of the database does not support querying the index dimensions of (filtered) timeseries data. This requires inefficient roundtrips during data queries. A revised API should support more flexible, customizable filters and index query endpoints.

The pyam package

- The pyam package currently supports the file types xlsx and csv as well as the frictionless datapackage format (https://framework.frictionlessdata.io/) for data input and output ("i/o"). However, these file types are not well suited for large scenario datasets. Implementing data i/o support for the NetCDF/HDF5 file format could be very beneficial for use cases with large scenario ensembles or data with high spatial/temporal resolution.

Model linkage scripts

- The model linkage scripts are useful to connect specific models in the suite of tools used by the Open ENTRANCE project, but the (re-)usability and usefulness could be improved by further standardization and better documentation of the model linkage scripts.
- The scripts for connecting models in Open ENTRANCE uses a so-called "soft-linking approach", where models are solved iteratively and selected results are passed back and forth until convergence is reached. Future work on model linkage building on the suite of Open ENTRANCE models should investigate options for developing integrated modelling frameworks (aka "hard-linking of models").

A website to access all tools in the open platform

The recommendations and suggestions refer to the page https://openenergymodels.net.

- The intended audience of the "open platform" website is not sufficiently clear. More guidance should be added to ensure that any user finds the most relevant information for their needs.
- The list of models should be extended to include direct links to publications, the repository with the source code, and a contact person or website, respectively.

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