**Plan4eu linkage to OpenENTRANCE platform**

# Workflow

The workflow for the plan4eu model consists in:

* Uploading plan4eu inputs to platform. For this we have implemented a script that converts plan4eu inputs into IAMC format
* Downloading data from platform and creating a plan4eu input dataset. For this we have implemented scripts that download the relevant data and convert them to plan4eu input format
* Running the model. For this another step is necessary which consists in creating, from the plan4eu input format dataset (excel file plus a set of csv file), a netcdf file which is the interface with the model. This is done using a (open source) tool named ‘plan4res formatting tool’
* Uploading plan4eu results to the platform. For this a script that converts the plan4eu outputs to the IAMC format has been implemented.

# Upload plan4res reference data to platform

(we are not uploading the time series as it seems that no-one needs them and the volume is very high, but we can upload them if required)

This dataset, focused on electricity includes:

* Yearly demands per country
* Installed capacity and technical parameters of power plants per country

**Script:** CreatePlan4EUInputIAMC.py

This scripts converts a given plan4res format input file of the plan4eu model, excluding timeseries (note: another script exists that is able to convert timeseries).

Outputs: 1 CSV file in IAMC format. The list of variables it contains is described in settingsCreatePlan4euInputIAMC.yml

It uses the setting file: settingsCreatePlan4euInputIAMC.yml which contains:

* The name of the model and scenario used
* The location and name of the inputfile: Inpufile.xlsx is the input data of plan4eu in plan4res format. The format is described in <https://zenodo.org/record/3785010#.X6_Ok8hKi70>
* The location of the created outputfile.
* The definition of plan4eu region names which are not part of the nomenclature
* The list of variables of plan4eu input dataset which are not used (mainly data that are not usefull for linkages purposes and not defined in nomenclature)
* The list of technologies used in the plan4eu dataset and for each technology the correspondence between plan4eu variable names and openentrance nomenclature variable names, as well as the units of each variable
* The correspondence between the technology names in plan4eu dataset and in openentrance nomenclature

# Download relevant data from platform

## Download Scenario data from Genesys-Mod (all scenarios) :

* 1. Variables needed to compute technologies MaxPower: Capacity|Electricity|<fuel> (unit GW, converted to MW)
  2. Variables needed to compute electricity demand: Final Energy|Electricity, Final Energy|Electricity|Heat, Final Energy|Electricity|Transportation, (not yet available) (unit: PJ, converted to MWh) (note that Final Energy|Electricity|Cooling is needed but will not be available, then we use the value from plan4res reference data)
  3. for computing investment costs : Capital Cost|Electricity|<fuel> (not yet available) (unit: US$2010/kW, converted to €/MW)
  4. for computing operations costs: Variable Cost|Electricity|<fuel> and Fixed Cost|Electricity|<fuel> (unit: US$2010/MWh, converted to €/MWh)
  5. for computing emissions per technologies : CO2 Emmissions|Electricity|<fuel> (not yet available) (unit: tons) and Final Energy|Electricity|<fuel> (unit GW) will be used to compute the emissions in tons per MW for all electricity generation technologies
  6. Maximum Storage|Electricity|<fuel> (GWh, converted in MWh). Note : available only for pumped storage and batteries; for reservoirs, volumes from p4r database will be used.

**Script:** DownloadScenarioData.py

This script downloads the relevant variables from the openENTRANCE scenarios.

It uses the setting file: settingsDownloadScenarioData.yml which contains:

* The user and password for accessing openentrance database
* The path of the output file
* The name of the model (which generated the scenarios)
* The list of selected years for download
* The list of scenarios to be downloaded
* The list of variables to be downloaded
* The list of regions which exist in the database, to be downloaded
* The definition of plan4eu aggregated regions (this could be done with the nomenclature but the aggregated regions are defined as a list of NUTS regions and here it is much more simple to have them as a list of countries)
* The list of regions which should be included in the final output

Modelname\_\_date.csv is the IAMC format csv file created with the uploaded data.

## Download plan4res reference data

**Script:** included in DownloadCreatePlan4euData.py

## Download Additionnal relevant data depending on case studies

* 1. From PEAKApp (CS1)- not done yet
  2. From Friggs (CS7) – not done yet
  3. From SCOPE – not done yet

Will be implemented when outputs from models are available

# Convert data to plan4eu excel+csv input format

**Script:** DownloadCreatePlan4euData.py

This script downloads the relevant variables from the platform (including Genesys data and plan4eu data), and creates the excel plan4eu input file (The format is described in <https://zenodo.org/record/3785010#.X6_Ok8hKi70> )

It uses the setting file: settingsDownloadCreatePlan4euDataset.yml which contains:

* The user and password for accessing openentrance database
* The path and name of the plan4eu excel input and output file (the input file is only used for getting some parameters )
* The source of data : platform or excel file
* The list of technologies and regions which should be included in the final output
* For each group of data to be downloaded:
  + The name of the model which generated the scenarios
  + The list of scenarios to be downloaded
  + The list of variables to be downloaded from the scenarios
* The definition of plan4eu aggregated regions (this could be done with the nomenclature but the aggregated regions are defined as a list of NUTS regions and here it is much more simple to have them as a list of countries)
* For all technologies, default values to be used if data are not available

It also uses 2 dictionnary files:

* OpenEntrance\_plan4eu\_VariablesDict.yml which gives the correspondence between plan4re variables and openentrance variables
* plan4euDictTimeSeries.yml which gives the names of CSV files to use for each time serie.

### How the plan4eu dataset is built

Variables from scenario are in red, variables from own plan4eu dataset are in blue, variables from other models are in green

#### ZP\_ZonePartition sheet

The sheet ZP\_ZonePartition describes the different partitions that are used for dealing with different coupling constraints. The mapping between the coupling constraints and the partitions is defined in the first block of the sheet parameter. In practice for a typical European dataset at the level of countries, the first column will list the countries (or aggregated regions) for which an equilibrium (generation=demand and available frequency regulation services >= need) is reached, and the second column will list the aggregated regions for inertia (usually continental Europe, UK)

#### ZV\_ZoneValues

This sheet contains the values of all coupling constraints, as well as the costs associated (imbalance costs).

It is filled using the following variables from Genesys-mod Final Energy|Electricity, 'Final Energy|Electricity|Heat', 'Final Energy|Electricity|Transportation', ‘Network|Electricity|Import’, converted from PJ to MWh, completed by data from plan4res for 'Final Energy|Electricity|Cooling’, 'Network|Electricity|Demand|Inertia', 'Network|Electricity|Demand|Reserve|Automatic Frequency Restoration', 'Network|Electricity|Demand|Reserve|Frequency Containment' , as they will not be available in Scenarios)

Those values are used to compute the yearly demand per uses.

#### IN\_Interconnections

This describes the parameter of the interconnections between regions (max and min flow, impedance). Only data from plan4res are used here.

#### TU\_ThermalUnits

This sheet describes the thermal generation mix. Capacities, emission rates and costs are taken from genesis-mod, while technical parameters (size of plants, ramping constraints…..) come from plan4res

#### SS\_SeasonalStorage

This sheet describes the part of the hydro generation mix which is composed of big size reservoir plants. Capacities are taken from genesis-mod, while volumes and inflows come from plan4res. technical parameters (reserve…..) come from plan4res

#### STS\_ShortTermStorage

This sheet describes the storages, both Pumped Hydro and batteries. Capacities and volumes are taken from Genesys-mod. technical parameters (reserve…..) come from plan4res

#### RES\_RenewableUnits

This sheet describes the renewable generation: PV, windpower, run of river, geothermal, ocean….,. Capacities are taken from Genesys-mod. Technical parameters (reserve…..) as well as hourly profiles come from plan4res

# Run plan4eu

1. ***Convert plan4eu excel+csv input format to plan4eu NetCdF format*** using plan4res own conversion tool (C++ opensource formatting tool)
2. ***Run plan4eu***

# Convert plan4eu csv outputs to iamc outputs and upload to platform

**Script**: UploadPlan4euOutputs.py.py

This script is used to convert the plan4res output files (composed of a serie of CSV files) to the IAMC format.

It uses the config file settingsUploadOutputsPlan4eu.yml which contains the start and end date of the results, name of model and scenario used, and the list of plan4res output files, associated to openentrance variables. It also contains the number of scenarios in the outputs and a parameter ‘aggregate scenarios’ (yes means that only one aggregated scenario should be computed, no means that all scenarios will be uploaded)

The variables created are:

* 'Active Power|Electricity|'
* 'Reserve|Electricity|Frequency Containment|'
* 'Reserve|Electricity|Automatic Frequency Restoration|'
* 'Storage|Electricity|'
* 'Marginal Cost|Final Energy|Electricity'
* 'Marginal Cost|Network|Electricity|Demand|Reserve|Frequency Containment'
* 'Marginal Cost|Network|Electricity|Demand|Reserve|Automatic Frequency Restoration'
* 'Marginal Cost|Network|Electricity|Demand|Inertia'
* 'Active Power Flow|Electricity|Grid'

In the case of scenarised output data (when plan4eu was used in a multiscenario mode and produced a serie of scenarios for the results), the script computes the mean of each variable, and only uploads one scenario per variable