Input Data

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This document describes what are the input data of plan4res, for running the different modules (SSV: computation of strategies for the management of seasonal storages, SIM: simulation on a selected year of the operation of the power system, CEM: capacity expansion)

The correspondence of each input data with the IAMC nomenclature is provided in purple.

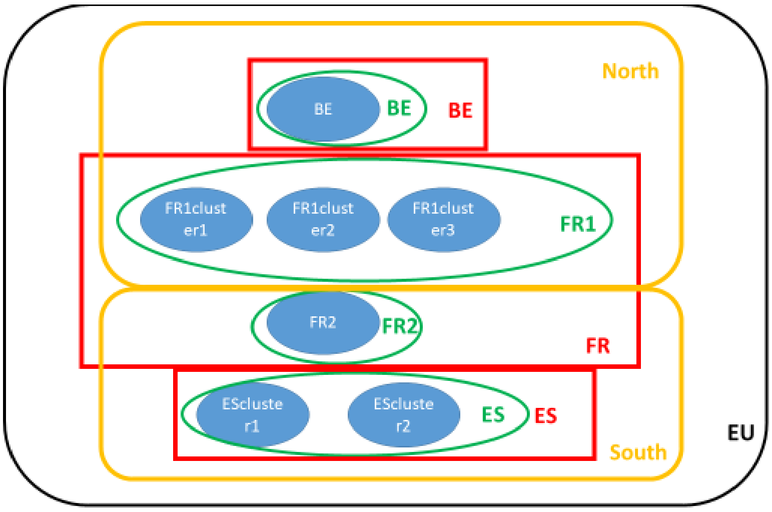
Data which can be calculated out of the inputs/outputs of GENeSYS-MOD are also identified in **green**. Data which are required but must be added compared to the inputs/ouputs of GENeSYS-MOD are identified in **red.** Other optional data are in blue.

1 Geography

Each dataset is linked to a geographical area that may be partitioned. Different partitions may be used for dealing with different levels of constraints or computations. The constraints related to the power demand (which must be equal to the power generation) are applied at the lowest level of the partition, which is called Nodes. It can correspond to countries, or to sub-country regions. Some constraints (namely system services constraints) may apply to different partitions (e.g. to group of countries).

The **Erreur ! Source du renvoi introuvable.** below illustrates this:

- In blue: the lowest level of partitions (level1), ie the Nodes; In this case there are 7 nodes in level1.
- In green: a second level of partition (level2), with 4 clusters of nodes (named here BE, FR1, FR2 and ES). Note that each level1 node belongs to a unique level2 cluster.
- In red and orange, there are 2 different partitions for the third level , grouping together clusters of level2. The orange partition is composed of 2 clusters (North and South), themselves composed of green clusters defined at level 2. The red partition is composed of 3 clusters (BE, FR, ES), themselves composed of green clusters defined at level 2.
- In black, the biggest partition has a unique cluster.



- Figure 1: geographical partitions

2 Time horizon and granularity

2.1 Time horizon

The time horizon needs to be specified. It usually is one year, but for computing the strategies for management of seasonal storages it is recommended to run the SSV module on a longer horizon, namely 18 months. There is no restriction to using longer horizons, but it may lead to very long computation times.

The user will then provide the following data (which may be different for the different modules, providing that consistency is ensured):

- Date/time of the first hour and last hour of the dataset
- Date/time of the first hour and last hour with timeseries available

Note that it is possible to provide the input timeseries on a single year. The CREATE and FORMAT modules will extend / duplicate the timeseries to adapt to the requested period if the time series are not available on the full period. As an example, we may have timeseries available for the year 2018 only, and wish to run a study from Jan 1 2022 to June 30 2023. In that case the 2018 time series will be used 'as if' they were representing 2023, and the first months will be duplicated at the end of the year.

2.2 Time granularity

Figure 2 shows how time is discretised in plan4res. There are 2 levels of discretization:

- the SSV timesteps, which are usually weeks (could be months or days). They represent the horizon for the management of short term storages. During the simulations (in SIM but also conducted while solving SSV and CEM), a unit commitment problem will be solved for each scenario and each SSV timestep.
- The timesteps, which are usually 1 hour and are the lowest granularity in plan4res. All timeseries should be provided at this granularity, but if data are not available, plan4res CREATE and FORMAT modules will be able to adapt to higher or lower granularities.

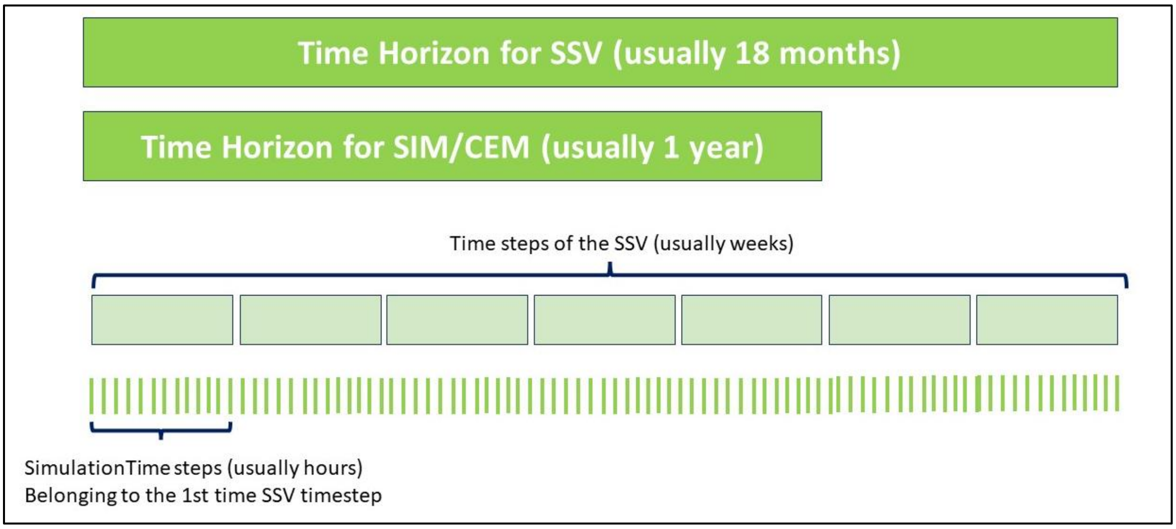


Figure 2: Time representation

3 Plan4res input data

The input data are composed of the following groups of data:

- Description of the power system:
    - Interconnections between nodes
    - Generation and storage assets
- Demands:
    - Power demand
    - (optional) System services demands (Primary, Secondary, Inertia)
- (optional) Pollutant limits

3.1 List of regions

The list of regions related to each constraint level has to be provided:

- List of nodes (e.g. countries); the power demand constraint will be given per node.
- List of regions for each other coupling constraint (if included), and for each region, list of nodes composing it.
    - Reserves can be separated in Secondary and Primary in plan4res.
    - Inertia
    - Pollutant limits.

3.2 Data for the power system

3.2.1 Interconnections

The list of interconnections between nodes, with for each interconnection:

- **The node where the interconnection starts**
- **The node where the interconnection ends**
- **The maximum power flow in MW** (Network|Electricity|Maximum Flow)
- **The minimum power flow in MW**
- (optional) the impedance of the line

- (optional) the cost of using the line (in €/MWh)
- (optional) **the investment cost (in €/MW)** (Network|Electricity|Expansion Cost)

3.2.2 Generation

3.2.2.1 Thermal generation

Thermal generation includes all kinds of generation units which can be modelled as a Thermal Unit in plan4res. In particular it includes all traditional generation units running on fossil fuels (coal, gaz, oil), but also biomass units, nuclear units as well as geothermal units.

The generation mix can be described either unit per unit, or technology per technology. The following data are necessary for each unit / technology

- **Capacity (MW) of the technology (if provided per technology, this needs to be given for each node). Can be provided as a deterministic timeseries if depending on time.** (Capacity|Electricity|)
- (optional) Maximum Power of the unit, or of an individual unit if provided per technology (MW) ; Can be provided as a deterministic timeseries if depending on time.
- **Variable Cost (including fuel cost) (€/MWh); Can be provided as a deterministic timeseries if depending on time.** (Variable Cost (incl. Fuel Cost)|Electricity|)
- (optional) **Fixed Cost (€) ; Can be provided as a deterministic timeseries if depending on time.** (Fixed Cost|Electricity|)
- (optional) Quadratic cost (€/Mwh^2); Can be provided as a deterministic timeseries if depending on time.
- **Investment Cost (€/MW); Can be provided as a deterministic timeseries if depending on time.** (Capital Cost|Electricity|)
- (optional) Minimum Power of the unit (MW) (or of an individual unit if provided per technology, or for the whole aggregated technology); Can be provided as a deterministic timeseries if depending on time.
- (optional) Auxiliary power, ie consumption when started but producing 0 (MW)
- (optional) Start up cost (€) for starting the unit after a shut-down.
- (optional) Minimum time down (hours)
- (optional) Minimum time up (hours)
- (optional) Ramping up and down, ie maximum gradients for power increase/decrease (MW per hour)
- (optional) Inertia that the unit can provide in MWs/MWA
- (optional) Share of the maximum power that can be devoted to the FCR
- (optional) Share of the maximum power that can be devoted to the AFRR
- (optional) Forced outage rate
- (optional) Planned outage rate (or schedules for planned outages)
- (optional) Mean outage duration (hours)
- (optional) **CO2 emissions (tons per MWh)** (Emission Rate|CO2|Electricity|)
- (optional) other pollutant emissions

It is possible to account for scenarios of available power for the thermal units. These must then be provided as stochastic timeseries per unit (or per technology) and node.

3.2.2.2 Hydro power

3 categories of Hydro Power can be represented in plan4res:

- Seasonal storage, corresponding to the hydro power with large reservoirs, which are operated over the year
- Pumped Hydro, corresponding to hydro power with pumping capacity, and medium size storages, operated on short term periods
- Run of river, corresponding to hydro power without reservoirs.

3.2.2.2.1 Seasonal storage

Seasonal storage is usually described as an aggregated unit per node. It can be disaggregated but this may increase a lot the computation time. The following data are necessary for each unit:

- **Capacity (MW) of the technology.** Can be provided as a deterministic timeseries if depending on time. (Capacity|Electricity|Reservoir)
- (optional) if disaggregated, Maximum Power in MW or Maximum Flow (in MW) of each unit
- **Maximum volume of the storage in MWh.** Can be provided as a deterministic timeseries if depending on time. (Maximum Storage|Electricity|Reservoir)
- (optional) As the seasonal storages are managed in MWh, it is assumed that the Minimum Volume is 0, but this data can also be provided as a number or a timeseries.
- (optional) Inertia that the unit can provide in MWs/MWA
- (optional) Share of the maximum power that can be devoted to the FCR
- (optional) Share of the maximum power that can be devoted to the AFRR
- **Inflows to the reservoir in MWh. This must be provided as timeseries, if possible stochastic timeseries (ie a number of scenarios). The time granularity may be hourly or bigger. The timeseries can be profiles which will be used to distribute the yearly inflows in MWh over the period. These profiles must have the following characteristics: the expectancy on all scenarios of the sum of the values over one year is equal to 1. If we know the expected volume of inflows in MWh on the given year, we can then use those profiles to compute representative inflows scenarios by multipliying the profiles by the total inflows. The energy produced by reservoir hydro** Secondary Energy|Electricity|Reservoir **in the GENeSYS-MOD scenario is a good approximation of the total Inflows.**
- (optional) Efficiency: this coefficient will be applied to the flow from the reservoir to compute the power generation. If not present it will be assumed to be 1.
- If the seasonal storage has some pumping capacity, there also need to be provided the Minimum Flow or minimum power (which is negative), as well as the pumping efficiency (which should be lower than 1)
- (optional) Ramping up and down, ie maximum gradients for power increase/decrease (MW per hour)
- (optional) Inertia that the unit can provide in MWs/MWA
- (optional) Share of the maximum power that can be devoted to the FCR
- (optional) Share of the maximum power that can be devoted to the AFRR
- **Volume in the reservoir at the beginning of the study in MWh**

3.2.2.2.2 Pumped Hydro

Pumped hydro is usually described as an aggregated unit per node. It can also be disaggregated:

- **Capacity in MW.** Can be provided as a deterministic timeseries if depending on time. (Capacity|Electricity|Pumped Storage)
- (optional) if disaggregated, Maximum Power in MW or Maximum Flow (in MW) of each unit

- **(optional) Minimum power or Minimum Flow in MW (=maximum pumping).** Can be provided as a deterministic timeseries if depending on time. If not provided, assumed to be equal to Capacity * pumping efficiency
- **Maximum volume of the storage in MWh.** Can be provided as a deterministic timeseries if depending on time. (Maximum Storage|Electricity|Pumped Storage)
- (optional) As the pumped storages are managed in MWh, it is assumed that the Minimum Volume is 0, but this data can also be provided as a number or a timeseries.
- **Efficiency when turbining.** Can be provided as a deterministic timeseries if depending on time. (Pumping Efficiency|Electricity|Pumped Storage)
- **Pumping efficiency.** Can be provided as a deterministic timeseries if depending on time. (Charging Efficiency|Electricity|Pumped Storage)
- **Investment Cost (€/MW); Can be provided as a deterministic timeseries if depending on time.** (Capital Cost|Electricity|Pumped Storage)
- (optional) Inertia that the unit can provide in MWs/MWA
- (optional) Share of the maximum power that can be devoted to the FCR
- (optional) Share of the maximum power that can be devoted to the AFRR
- (optional) Inflows to the reservoir in MWh. This can be provided as number in MWh (which will be linearly distributed to the timesteps) or as a deterministic timeseries.
- (optional) Ramping up and down, ie maximum gradients for power increase/decrease (MW per hour)
- (optional) Cost in €/MWh
- (optional) Volume level target at the end of the SSV time step (in that case, it will be ensured that at the end of each SSV timestep, the reservoir reaches this target.
- **Volume in the reservoir at the beginning of the study in MWh**

3.2.2.2.3 Run of river

Run of river is usually described as an aggregated unit per node. It can also be disaggregated, but the results will be similar (with longer computation times)

- **Capacity in MW.** (Capacity|Electricity|Run of River)
- **Investment Cost (€/MW); Can be provided as a deterministic timeseries if depending on time.** (Capital Cost|Electricity| Run of River)
- Power profiles. This must be provided as timeseries, if possible stochastic. These profiles will be multiplied by the Capacity to create Maximum Power timeseries. If stochastic profiles are used they must comply to the rule all values must be between 0 and 1, and the average of all values is the load factor of the technology.
- (optional) Minimum power in MW (=maximum pumping). Can be provided as a deterministic timeseries if depending on time. If not provided, assumed to be equal to 0
- (optional) Inertia that the unit can provide in MWs/MWA
- (optional) Share of the maximum power that can be devoted to the FCR and the AFRR

3.2.2.3 Variable renewable

Variable renewable includes Solar Power and Wind Power. They must be described per technology when the technologies have different characteristics.

Each technology is usually described as an aggregated unit per node. It can also be disaggregated, but the results will be similar (with longer computation times)

- **Capacity in MW.** (Capacity|Electricity|)

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- **Investment Cost (€/MW); Can be provided as a deterministic timeseries if depending on time.** (Capital Cost|Electricity|)
- Power profiles. This must be provided as timeseries, if possible stochastic. These profiles will be multiplied by the Capacity to create Maximum Power timeseries. If stochastic profiles are used they must comply to the rule all values must be between 0 and 1, and the average of all values is the load factor of the technology.
- (optional) Minimum power in MW (=maximum pumping). Can be provided as a deterministic timeseries if depending on time. If not provided, assumed to be equal to 0
- (optional) Share of the maximum power that can be devoted to the FCR and the AFRR

3.2.2.4 Short term storage (excluding hydro)

This category is mostly used for describing the different battery technologies, but may be used for any kind of electricity storage. This technology should be disaggregated as much as possible in order not to over estimate the flexibility that it provides.

- **Capacity in MW.** Can be provided as a deterministic timeseries if depending on time. (Capacity|Electricity|)
- (optional) if disaggregated, Maximum Power in MW or Maximum Flow (in MW) of each unit
- **Investment Cost (€/MW); Can be provided as a deterministic timeseries if depending on time.** (Capital Cost|Electricity|)
- **(optional) Minimum power or Minimum Flow in MW (=maximum pumping).** Can be provided as a deterministic timeseries if depending on time. If not provided, assumed to be equal to Capacity * pumping efficiency
- **Maximum volume of the storage in MWh.** Can be provided as a deterministic timeseries if depending on time. (Maximum Storage|Electricity|)
- (optional) As the pumped storages are managed in MWh, it is assumed that the Minimum Volume is 0, but this data can also be provided as a number or a timeseries.
- **Efficiency when charging/discharging.** Can be provided as a deterministic timeseries if depending on time. (Charging Efficiency|Electricity|) (Discharging Efficiency|Electricity|)
- (optional) Inertia that the unit can provide in MWs/MWA
- (optional) Share of the maximum power that can be devoted to the FCR
- (optional) Share of the maximum power that can be devoted to the AFRR
- (optional) Inflows to the storage in MWh or Demands from that storage (negative values). This can be used to represent e.g. the consumption of electric vehicles if modelling their batteries as a storage. This can be provided as number in MWh (which will be linearly distributed to the timesteps) or as a deterministic timeseries.
- (optional) Ramping up and down, ie maximum gradients for power increase/decrease (MW per hour)
- (optional) Cost in €/MWh
- (optional) Storage level target at the end of the SSV time step (in that case, it will be ensured that at the end of each SSV timestep, the reservoir reaches this target.
- **(optional) Volume in the reservoir at the beginning of the study in MWh**

3.2.3 Other flexibilities

Flexibilities such as load shifting can be represented as short term storages. The periods on which some demand can be shifted can be managed via the Minimum Storage and Maximum Storage data.

3.3 Demands

3.3.1 Power demand

The power demand must be given for each node. As much as possible it is better to provide it as stochastic timeseries, and if possible to disaggregate it per uses. The following data are necessary:

- Demand per uses
    - Demand for electric heating:
        - **Demand in MWh over the whole year** (Final Energy|Electricity|Heating)
        - **Time series , if possible stochastic. The time granularity should be hourly. The timeseries should be profiles which will be used to distribute the yearly demand in MWh over the period. These profiles must have the following characteristics: the expectancy on all scenarios of the sum of the values over one year is equal to 1. If we know the expected demand in MWh on the given year, we can then use those profiles to compute representative demand scenarios by multipliying the profiles by the total demand.**
    - Demand for cooling
        - **Demand in MWh over the whole year** (Final Energy|Electricity|Cooling)
        - **Time series, if possible stochastic. (same characteristics as for electric heating)**
    - Demand for electric transport
        - **Demand in MWh over the whole year** (Final Energy|Electricity|Transportation)
        - **Time series, usually deterministic but can be stochastic. (same characteristics as for electric heating). Timeseries over 1 day could be sufficient if there is no seasonality.**
    - Demand for electric cooking
        - **Demand in MWh over the whole year** (Final Energy|Electricity|Cooking)
        - **Time series, usually deterministic but can be stochastic. (same characteristics as for electric heating). Timeseries over 1 day could be sufficient if there is no seasonality.**
    - Demand for other uses of electricity
        - **Demand in MWh over the whole year** (Final Energy|Electricity|Other (excl. …)
        - **Time series, usually deterministic but can be stochastic. (same characteristics as for electric heating). Timeseries over 1 day could be sufficient if there is no seasonality.**
- Or if the demand per uses is not available, total demand:
    - **Demand in MWh over the whole year** (Final Energy|Electricity)
    - **Time series, if possible stochastic. (same characteristics as for electric heating)**

3.3.2 (optional) Reserves

(optional) The requested level of reserves (FCR, AFFR or aggregated) per region (which could be groups of nodes) or per node, either in share of the power demand, or in MWh, as a timeseries.

3.4 (optional) Pollutant limits

(optional) timeseries with the maximum emissions in tons of CO_2 (or other pollutant) at each timestep

3.5 Input data for the capacity expansion

For running the capacity expansion model, we need:

- The list of technologies that could be invested
- For each technology that could be invested, the maximum potential of the technology, ie the maximum possible added capacity per node.

This includes the generation technologies, but also the storages (except seasonal storages) and the interconnections (if they can be invested, for each interconnection, what is the maximum additional capacity)