Construction of Pan-European Zonal Market Model Based on Public Information

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ABSTRACT

Market simulations are essential to analyse the potential impact of the pan-European market development on the Italian system adequacy and to provide input data for subsequent detailed grid analyses. In this regard, continuous adjustment of the scenario datasets is of crucial importance. The objective of the research activity was to construct a comprehensive scenario of the pan-European power system zonal market for performing analyses with the sMTSIM model developed by RSE, utilizing publicly available information. The outcomes of the simulations have the capacity to play a crucial role in various market and network studies, particularly focusing on the Italian power system. Specifically, the import-export data generated from these simulations can contribute to subsequent research activity aimed at the construction of the nodal network of the Italian power system.

ENTSO-E public data was used as the primary information source, with a focus on the NT scenario for 2030. Three climatic years 1995, 2008, 2009 were considered consistently with ENTSO-E data. Adjustments were made for bidding zones in the southern region of Italy. Modelling of North Africa (Morocco, Algeria and Tunisia) was undertaken, transfer capacities were updated, and new connections were added based on TYNDP 2022 data.

Specific modelling techniques were developed to adapt the available data to sMTSIM modeling requirements. Various datasets were processed and converted into sMTSIM format for Load, Hydro, RES technologies, and installed capacities for thermal power plants, which are the main data for scenario construction. The thermal plant properties, net transfer capacities, commodity prices, and emission factors were also considered. The document provides insights into the differences between two ENTSO-E data sources relevant to the same scenario, namely NT 2030 of TYNDP 2022 and NT 2030 of ERAA 2022, particularly in thermal and RES capacities. Additionally, modelling of Luxembourg, Kriegers Flak, and Italy underwent specific adjustments for accurate representation in sMTSIM.

The testing of the first test case (NT 2030, climate year 1995) has been successfully completed, the undertaken activity ensures a robust modelling process, and the results contribute to enhancing the accuracy of the sMTSIM pan-European zonal model.

Keywords: sMTSIM, pan-European zonal model.

1 - INTRODUCTION

Wide area electricity market model analysis is crucial for several reasons, especially in the context of electricity markets and energy systems:

- Market analysis helps in understanding how resources like electricity generation are allocated in the market. This allows the identification of development strategies of neighbouring systems and helps to find the best allocation of resources, leading to improved overall efficiency in the energy system.
- Analysing market prices helps stakeholders, including consumers and producers, to make informed decisions about energy consumption, investment, and production. Policymakers can assess the impact of regulatory measures on market outcomes and other relevant factors, helping to refine and improve energy policies.
- Market model analysis becomes essential for understanding the renewable energy sources (RES) integration challenges. It helps in assessing the impact of renewables, managing intermittency, and designing market structures that support a sustainable energy transition.
- Market models contribute to the planning and operation of the electrical grid. They provide insights into the behaviour of market participants, electricity flows, and grid congestion.

This information is vital for ensuring grid reliability and stability.

The objective of the present research is to construct a comprehensive pan-European scenario utilizing publicly available information. The outcomes of the simulations have the capacity to play a crucial role in various market and network studies, particularly focusing on the Italian power system. Specifically, the import-export data generated from these simulations can contribute to a subsequent research activity aimed at the construction of the nodal network of the Italian power system, conducted within the research framework of the RdS project "Evoluzione, pianificazione, programmazione ed esercizio delle reti elettriche", WP2 LA 2.05, as detailed in report [1]. The objectives of this research initiative include the development of a nodal dataset specific to the Italian electrical system to support the grid planning process.
This document serves as an example, guiding users on how to utilize publicly available information to construct a scenario that aligns with the sMTSIM model. It can be considered as a practical addition to the sMTSIM user manual [2].

In the next sections, the activities carried out to build the pan-European scenario are described. These include assessing publicly available information, determining the focus of our work, explaining modelling techniques that align available information with the requirements of the sMTSIM model, and testing the new scenario. Then the initial results are presented as well to provide an overview of the model's performance.

1.1 Evaluations of the available information

Due to the confidential nature of the data needed for modelling and considering the area to be covered, the best available, trustworthy, and consistent information can be considered the ENTSO-E datasets. They not only present proven official information based on common EU policies but also provide all kinds of methodologies, reports, as well as protocols from meetings with stakeholders and other helpful information that aid in the common understanding of the data and the process in general.

There are two distinct activities of ENTSO-E involved in data collection:

- Ten-Year Network Development Plan (TYNDP)
- European Resource Adequacy Assessment (ERAA).

The primary goals of TYNDP include the identification and planning of new electricity infrastructure, including high-voltage transmission lines and interconnections between countries. It aims to ensure adequacy and security, integrate renewable energy sources (RES), promote market integration, and align network development plans with EU energy and climate policies. TYNDP is a comprehensive, pan-European plan that addresses the long-term network development needs of the entire ENTSO-E region.

Resource adequacy assessments typically focus on ensuring a power system has a sufficient and reliable electricity supply to meet demand. Key objectives of ERAA include evaluating generation capacity to meet peak electricity demand, maintaining a balance between electricity supply and demand, considering the integration of renewable energy sources, and assessing the adequacy of transmission and grid infrastructure.

Despite the shared objectives and analytical approaches, differences exist in the datasets used for analysis. TYNDP data includes generation data for 59 Bidding Zones (BZ), including as well countries outside EU like north African countries and Ukraine; in contrast ERAA presents data just for 53 European BZs. However, ERAA data provides separate information for each technology and split data of some big countries (Italy) into subzones, whereas TYNDP data presents aggregated data for coal and lignite and provides total generation capacity per country. The primary data source used was data concerning the National Trends (NT) 2030 scenario from TYNDP 2022 for the following reasons:

- The availability of North African data aligns with one of the modelling goals.
- The climate database of TYNDP provides data for all BZ except North Africa, but including Ukraine, whereas the ERAA 2022 climate dataset turns out to be empty.
- ERAA is mainly used for the seasonal adequacy assessments, with a short time horizon, such as the Winter or Summer Outlook, while TYNDP looks forward for 20 years ahead.
- European network development plans align more closely with grid research interests.

Because sMTSIM requires more details about all available generation capacities (technologies) as well as data for subzones, both datasets were used. The missing information of the first dataset was supplemented by the second (Table 1.1).

Table 1.1 – The difference in ERAA and TYNDP datasets.

Differences	ERAA	TYNDP
Amount of the BZ Italy	53 7	61 1
Technology	Technologies are given per fuel type	Some technologies are given aggregated (coal + lignite)
Climate dataset	Same as TYNDP	RES, Hydro, Demand A set of hourly time series of climate variables for multiple years
Thermal Properties	Yes	Not
Fuel prices, CO2	Same as TYNDP	Yes
Net Transfer capacities	Yes	Yes
Net Installed capacities	Yes	Yes

1.2 The scope of the work

To ensure a robust representation of potential future changes and a more accurate reflection of national interests, the National Trend (NT) scenario is selected as the reference for the core pan-European zonal market model, with a focus on the year 2030. The primary objectives of this initiative include:

1. Construction of a NT 2030 scenario for sMTSIM simulation:
   develop a new NT 2030 scenario for the sMTSIM simulation, based on the ENTSO-E TYNDP 2022 NT scenario for 2030. The simulation will utilize climatic year data from 1995, 2008, and 2009.

2. Bidding Zone (BZ) division in southern Italy:
   divide the southern region of Italy into two bidding zones CA (Calabria) and SU (South). Apply necessary adjustments to all bidding zones by transferring production and load data between zones, in alignment with ENTSO-E scenario data.

3. Expansion of the modelling area to include North Africa (Morocco, Algeria and Tunisia).

4. Update of Net Transfer Capacities (NTC) and addition of new connections:
   update the NTC and incorporate new connections based on the TYNDP 2022 data source.

5. Test the model in the GAMS environment.

Below, Table 1.2 includes the list of sMTSIM model sheets to be processed for scenario construction, along with the source of the information.

Table 1.2 – Minimum needed information for the new scenario.

Name of sMTSIM sheet	Sources of the data
Parameter	General information
FuelCO2	TYNDP 2022 NT 2030
FuelCost	TYNDP 2022 NT 2030, ERAA NT 2030
Load	TYNDP 2022 NT 2030: 1995,2008, 2009
Tpp	TYNDP 2022 NT 2030, ERAA NT 2030
Transits	Transfer Capacities, ERAA 2022 NT 2030
Flex	To test
Maint	To take from old model
Hydro	TYNDP 2022 NT 2030
InFlows	TYNDP 2022 NT 2030: 1995,2008, 2009
Qinject	TYNDP 2022 NT 2030: 1995,2008, 2009

The complete content description of the relevant sheets is given in the sMTSIM manual [2].

2 - MODELLING TECHNIQUE

2.1 Modelling area

The new constructed model consists of 58 bidding zones, where Italy is represented by seven BZ: Central-North (CN), Central-South (CS), North (ND), Sardinia (SA), Sicily (SC), Calabria (CA), South (SU). The modelled area is illustrated in Figure 2.1 below. Notably, Ukraine (UA) has been incorporated into the model, focusing on its western region.

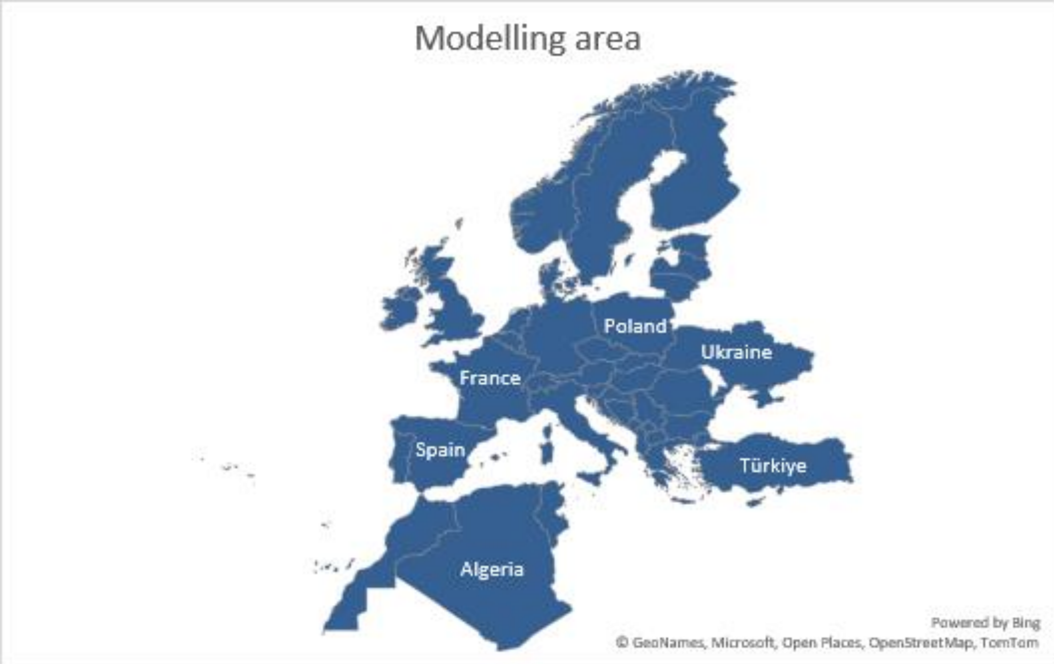

Figure 2.1 – Modelled areas in the pan-European scenario.

2.2 Commodity prices and emission factors

The data for CO2, emission factors for fuels [3], commodity prices were sourced from the Scenario Building guideline of TYNDP 2022 for NT 2030 scenario, which can be found from [4]. The main prices for the NT 2030 scenario are presented in Table 2.1 below. The same prices were applied across all bidding zones.

Table 2.1 – Commodity prices of TYNDP 2022, NT2030 scenario.

[Euro/GJ]	TYNDP 2022, NT 2030
Nuclear	0.47
Biomethane	20.74
Shale oil	1.86
Lignite	1.10
Natural Gas	6.23
Hard coal	2.48
Light oil	13.78
CO2 [€/ton]	70

2.3 Hydro

The hydro dataset was obtained from the 'PEMMDB_Country_Hydro Inflow_2030' file, which can be downloaded from the Climate Database (CD) [4]. It contains hydro data which were utilised as input data for the Hydro sheet:

- Run-of-River (RoR) and pondage
  - Reference Total turbining capacity, MW
  - Run of River Hydro Generation in GWh per day
- Reservoir:
  - Reference Total turbining capacity, MW
  - Cumulated inflow into reservoirs per week in GWh
  - Reservoir capacity, GWh
- Pumped storage - Open Loop
  - Reference Total turbining capacity, MW
  - Cumulated NATURAL inflow into the pumped-storage reservoirs per week in GWh/week, 36 years
  - Reservoir capacity, GWh
- Pumped Storage - Closed Loop
  - Reference Total turbining capacity, MW
  - Reservoir capacity, GWh

Additionally, some (but not all) countries have weekly data available:

- Minimum Generated energy, GWh per week
- Maximum Generated energy, GWh per week
- Minimum Pumped energy, GWh per week
- Maximum Pumped energy, GWh per week
- Minimum Power generated, MW
- Maximum Power generated, MW

Thus, the available information was converted into the sMTSIM format according to Table 2.2.

Table 2.2 – Approach to converting data into the required sMTSIM format.

sMTSIM input sheet	Unit of measure	RoR	Reservoir	Hydro Pumped Storage Open Loop	Hydro Pumped Storage Closed Loop
Hpp Pmin	[MW]	0	Negative value of Minimum Generation MW/week or 0	Negative value of Total pumping capacity	Negative value of Total pumping capacity
Hpp Pmax	[MW]	Total turbining capacity (TTC)	TTC or Maximum Generation/week	TTC/ MW or Maximum Generation/week /MW	TTC/MW or Maximum Generation/week /MW
Unavailability	[p.u.]	0	$1 - (\frac{\max(MaxGen/Week)}{TTC})$ or =0 (1)	$1 - (\frac{\max(MaxGen/Week)}{TTC})$ or =0	$1 - (\frac{\max(MaxGen/Week)}{TTC})$ or =0
Initial Volume	[GWh]	0	50% of HppVmax	50% of HppVmax	50% of HppVmax
Final Volume	[GWh]	0	50% of HppVmax	50% of HppVmax	50% of HppVmax
HppVmin	[GWh]	0	0	0	0
HppVmax	[GWh]	0	Reservoir capacity	Cumulated (upper or head) reservoir capacity	Cumulated (upper or head) reservoir capacity

2.4 Inflows

The hydro dataset as input data for the Inflows sheet was obtained from CD [3] [4].

- The hydro generation data for RoR was utilized in the form of GWh per day for all 365/366 days of the year. The data was converted into monthly values, starting from the daily production, and the average hourly production per each month was calculated for each bidding zone (BZ) in units of MWh/h/month/BZ. For the sMTSIM scenario, we proposed using a 'normal year' consisting of 365 days.
- The cumulated inflow into reservoirs per week in GWh was utilized per reservoir. Initially, this data (GWh) was recalculated per day (energy of the week divided by 7). Subsequently, the average hourly production per month was calculated for each bidding zone (BZ) in units of MWh/h/month/BZ.
- The cumulated NATURAL inflow into the pumped-storage reservoirs per week in GWh was utilized per Pumped storage - Open Loop. Initially, this data (GWh/week) was recalculated per day (energy of the week divided by 7). Subsequently, the average hourly production per month was calculated for each bidding zone (BZ) in units of MWh/h/month/BZ.
- Pumped Storage - Closed Loop, for the CL all values are equal to zero.

All inflows were calculated for three climatic years: 1995, 2008, 2009.

2.5 Power injections

The RES (Photovoltaic - PV, onshore wind, offshore wind, concentrated solar power - CSP) time-series as input data for the Qinject sheet was obtained from CD [4]. ENTSO-E has developed the pan-European Climate Database (PECD) in collaboration with Copernicus Climate Change Service. The PECD relies on historical reanalysis data where possible operational conditions are

[1] *Taken from the form of Climate Datasets. If data was presented, we used the equation, if not we set unavailability = 0.*

derived from past weather conditions. The data includes RES time-series based on 38 climate years for the following technologies:

- Onshore wind: 147 sub-zones, 38 years,
- Offshore wind: 155 sub-zones, 38 years,
- Solar (PV): 147 sub-zones, 38 years,
- CSP: 147 sub-zones, 38 years,
- Hydro: 47 BZ, 36 years:
    - RoR
    - HPS open loop
    - HPS close loop

The modification described in the following has been applied to the generation data.

Initially, time-series data for Solar, Onshore and Offshore wind were gathered for each sub-zone within the specific market node (zone) for the years 1995, 2008, 2009 from the CD. Subsequently, the mean time-series values were computed for every market zone. Then, hourly production data was generated using the installed capacities of TYNDP 2022 data for all market zones and each relevant year.

Additionally, concerning the RES technologies, the Qinject data sheet includes the following two technologies:

- Other RES, which are biomass, geothermal, marine (i.e., tidal and wave), waste, not defined / not known (this is for renewable output that does not fit in any of the above categories or that is of unknown origin).
- Other non-RES, which are non-renewable combined heat and power - CHP, waste, non-dispatchable thermal generation, any other thermal generation not represented elsewhere in the data.

ENTSO-E presented data for two technologies categorized as "Other RES" and "Other non-RES" in a combined format, without further subdivision into specific technologies. "Since Other non-RES generation sources tend to be many and varied, it does not make sense to gather information on individual units", thus as well for sMTSIM, data was similarly presented in this consolidated manner. Due to the absence of time-series for other RES and other non-RES technologies a constant production was used, which could be derated by the selected capacity factor, for instance some average value between different technologies (see Table 2.3). Thus, in addition to the wind and solar production, Qinject has two separate aggregated categories, i.e. Other RES and Other non-RES.

For the correlation (deration) of the hourly production the following formula was used:

$$AEO = MPEO \times CF \qquad (2.1)$$

where MPEO is the Maximum Possible Energy Output, that can be calculated assuming the plant has been operating at full load, AEO is the Actual Energy Output and CF is the Capacity Factor.

The average capacity factors are reported in Table 2.3.

Table 2.3 – Thermal technologies average capacity factors.

Technology	Capacity factor[2] %
Other RES	
CHP biomass (total of electricity and heat, small to big size)	60%
Geothermal	90-95%
Tidal and Wave	20-35%
Waste	80-90%
Lignite to biofuel	30-60%
Light oil biofuel	40-70%
Hard Coal to biofuel	40-60%
Gas biofuel	50-80%
Other non-RES	
CHP waste	70-90%
CHP gas	60-90%

2.6 Load

For the construction of hourly load profiles for most of the European countries, ENTSO-E uses a temperature regression and load projection model that incorporates an uncertainty analysis under various climate conditions; more information about the methodology can be found in the published ENTSO-E documentation [4].

The load dataset was obtained from the 'Demand_TimeSeries_2030_NationalTrends _without_bat.xlsx' file, which can be downloaded from [4]. It contains load statistics for 35 different climatic years across 61 bidding zones used by ENTSOE in its pan-European analysis. The data represents hourly consumption profiles in MW/hour for all 8760 hours of the year. The profiles should assume that January 1st is a Monday.

The actions undertaken were:

- Hourly consumption profiles were extracted for all bidding zones for the years 1995, 2008, and 2009. These profiles were then processed and converted into the sMTSIM input data format.

2.7 Thermal power plants

2.7.1 Installed capacities

ENTSO-E data from '220310_Updated_Electricity_Modelling_Results.xlsx' file and 'ERAA 2022 PEMMDB National Estimates.xlsx' [3] [4] were utilized for the installed capacities for the thermal power plants (Tpp) and Qinject sheets of sMTSIM.

There were significant differences between ENTSO-E data, when comparing the two above mentioned sources of the same scenario -National Trend- and the same target year 2030. The differences of thermal and RES capacities in GW are shown in Figure 2.2 and Figure 2.3.

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[2] *The capacity factor is the annual production divided by the maximum potential annual production. The maximum potential annual production is calculated assuming the plant has been operating at full load for the entire year, i.e. 8760 hours /year.Data sourse is [6] [3] and RSE assumption.*

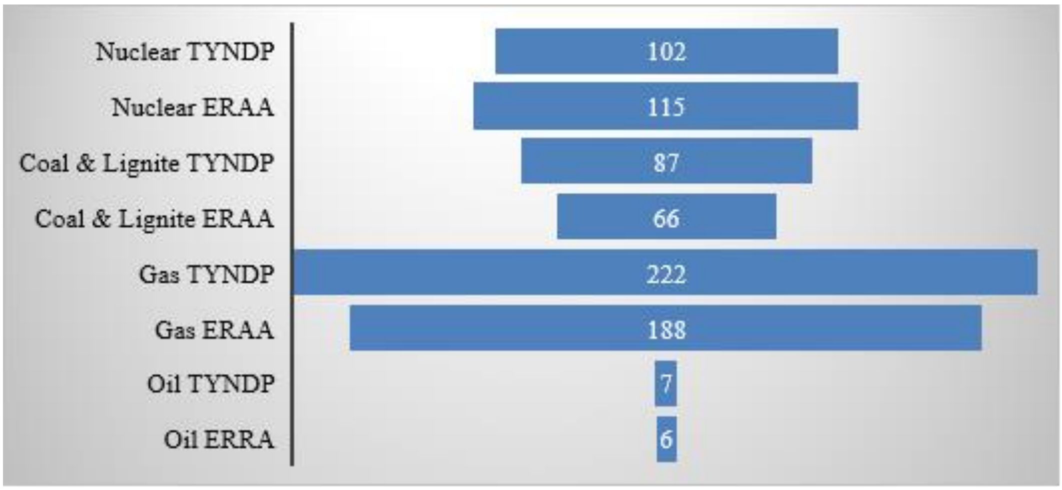

Figure 2.2 – Thermal capacities in GW in the two ENTSO-E data sources, EU only.

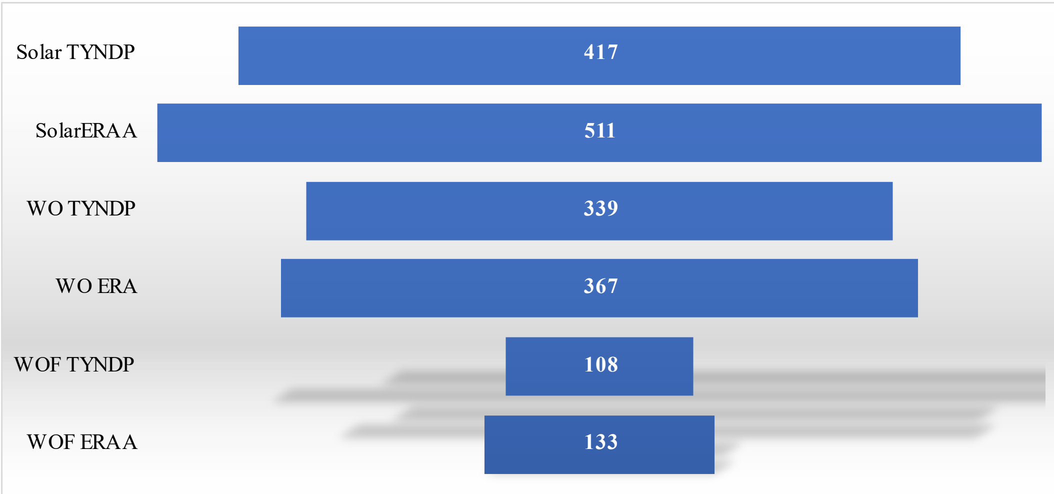

Figure 2.3 – RES capacities in GW in the two ENTSO-E data sources, EU only.

As it was mentioned before, the primary data source used was the TYNDP 2022 NT 2030 scenario, however as sMTSIM requires more details about all available generation capacities (technologies) as well as data for sub-zones, both datasets were used. The missing information of the first dataset was supplemented by the second. Thus, to distribute the gas quantity specified for Italy in TYNDP among the Italian sub-zones, a proportional split was performed using ERAA data, as illustrated in Figure 2.4.

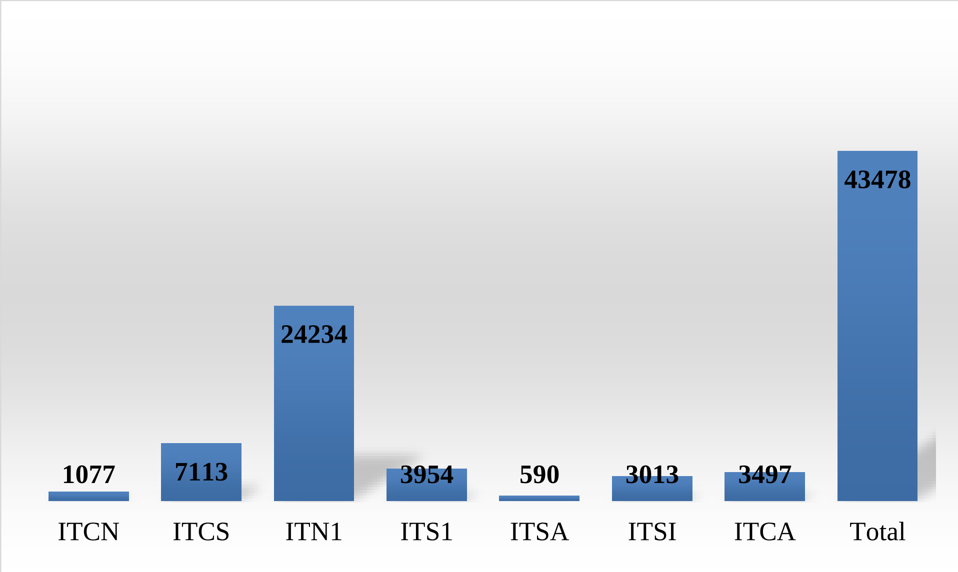

Figure 2.4 – The share of gas capacities in MW for Italian BZ.

The Annex (Section 7) provides a general overview of the thermal capacities used for the modelled bidding zones.

2.7.2 Thermal Plants Properties

In addition to the installed capacity of power plants, the Table 2.4 below represents other minimum required data that sMTSIM needs for thermal generation. This table shows an adaptation of ENTSO-E data taken from [4] for sMTSIM.

Table 2.4 – Thermal Properties.

sMTSIM	Efficiency [%]	Operation & Maintenance (O&M) [€/MWh]	B1(1) [GJ/MWh]	Forced unavailability [p.u.]	Scheduled Unavailability [day/year]
Nuclear	30% - 35%	9	10.91	0.05	54
Hard coal	44% - 46%	3.3	7.83	0.1	27
Lignite	44% - 46%	3.3	7.83	0.075 – 0.1	27
Gas	39%- 60%	1.6	6 - 8.78	0.05-0.08	13 - 27
Oil	32% - 38%	1.1	10.29	0.08 - 0.1	13 - 27

Tpp B1(1) coefficient of the linear term of the consumption curve for the primary fuel was calculated in the following way:

$$B1 = \frac{1}{Start\ Up\ Fuel\ Consumption\ (warm\ start)} \times 3.6 \qquad 2.2$$

2.8 Transits

ENTSO-E data from ‘Transfer Capacities ERAA 2022 TY2030.xlsx’ [3] was utilized for the Transits data sheet. This dataset represents a matrix of all BZ and the net transfer capacity - NTC (MW) between them. Additionally, available information was utilized for modelling North Africa. Mainly the public information of [5] were used. See Annex 7 for more information about the modelled bidding zones.

Below some details are given.

2.8.1 Luxembourg

Luxembourg (LU, L1 and L2 in figure) is connected to Germany (DE, D1 in figure) through two double interconnections 2 x 200 kV AC lines and to Belgium (BE) through one 200 kV AC line. In ENTSO-E data, LU is represented with four different zones: LUG1, LUV1, LUB1, LUF1. Among these zones the load and generation are connected only to LUG1, LUV1. To simulate the transit flows through LU, we have added the zones LUV1 (L2 in figure) and LUG1 (L1 in figure), as it is shown in Figure 2.5:

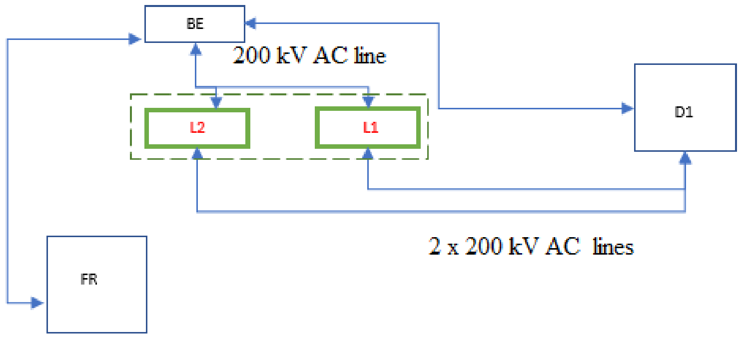

Figure 2.5 – Luxembourg BZ.

2.8.2 Kriegers Flak

The Kriegers Flak (KF) offshore wind park is located approximately 15 km east of the Danish coast in the southern part of the Baltic Sea. ENTSO-E data represents KF by two nodes: DEKF for connection with Germany (DE, D1 in figure) and DKKF for connection with Denmark (DK, DW and DO in figure). Notably, ENTSO-E KF has been modelled via AC connections. The total offshore capacity is 600 MW (DK) and 288 MW (DE). For sMTSIM, KF was modelled as a single node named DF as it is shown in Figure 2.6 below.

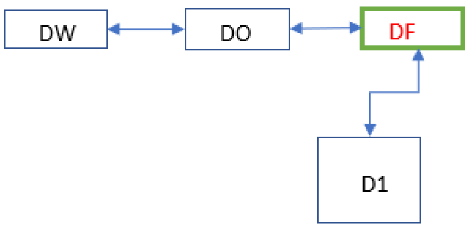

Figure 2.6 – Kriegers Flak offshore park (DF) modellization.

2.8.3 Italy

Italy has connections with several European countries, including France (FR), Switzerland (CH), Austria (AT), Slovenia (SI), Montenegro (ME), Greece (GR), and Malta (MT) and is represented by 7 bidding zones aligned with ENTSO-E data. In the figure below Figure 2.7, the primary AC and DC connections are depicted. Existing connections are represented by solid lines, while the dotted lines indicate the status of the interconnections: a blue dotted line denotes approved projects modelled in the pan-European scenario (Sacoi 3, Tyrrhenian link, Italy-Tunisia link), and a violet dotted line represents projects that are currently under consideration (Hyper Grid (HG), Sapei 2, Italy-Slovenia) but have not been modelled. All generation, load and NTC data have been directly sourced from [3].

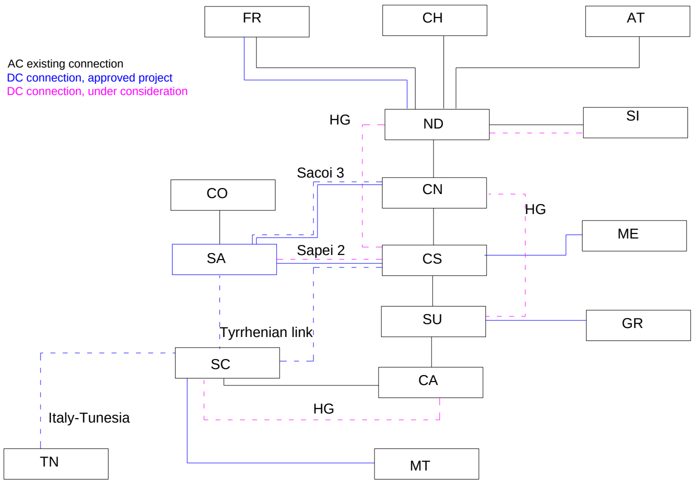

Figure 2.7 – Italian bidding zones and interconnections.

2.8.3.1 North Africa

As previously mentioned, the modelling area was expanded to include three African countries (Morocco - MA, Algeria - DZ, Tunisia - TN). The primary source of information for this extension was obtained from Med-TSO, the Association of the Mediterranean Transmission System Operators (TSOs) [5]: please see Annex 7 for more details.

2.9 Results

It is important to note that the results herein presented are preliminary. It is also worth mentioning that the main objectives were to update the dataset and construct the new pan-European scenario for future analyses. Thus, a working testcase is a noteworthy achievement and can be the starting point for further tuning of the input dataset. Therefore, the results of the simulation presented below are general ones without specific analyses on any topic of interest.

Here below the main outcomes of the NT scenario for 2030 with the 1995 Climatic Year are shown Figure 2.8, Figure 2.9, Figure 2.10 .

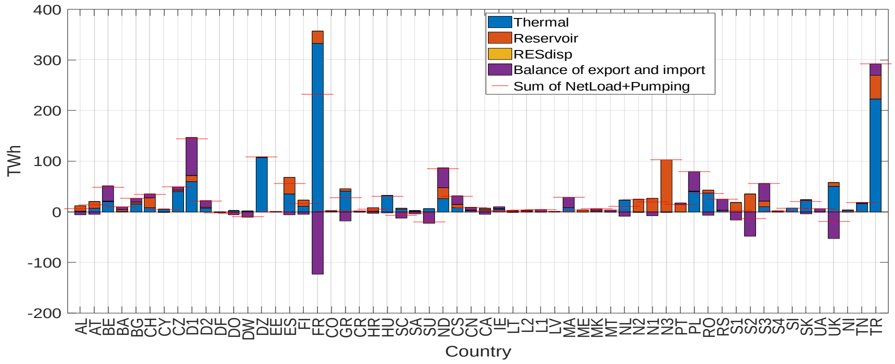

Figure 2.8 – System balance across the modelled areas.

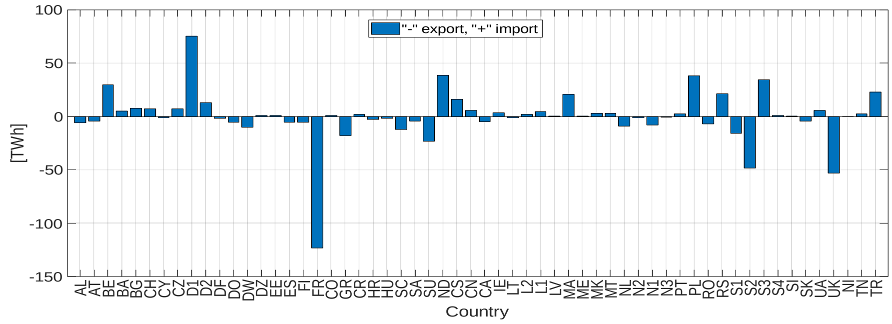

Figure 2.9 – Balance of import-export across the modelled areas.

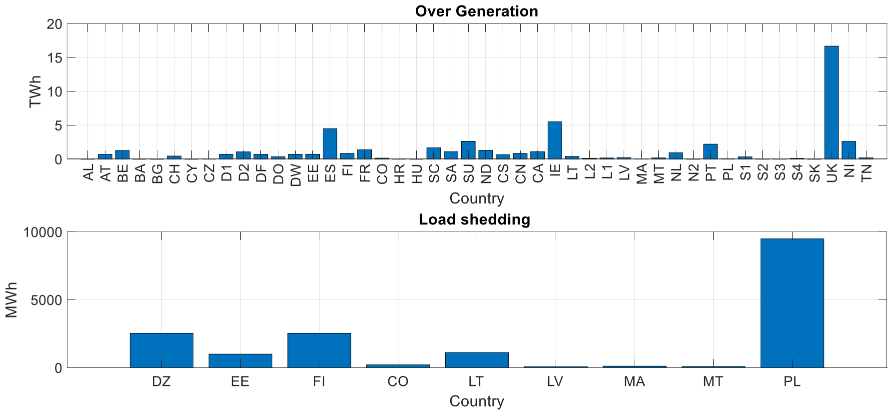

Figure 2.10 – Overgeneration and load shedding across the modelled areas.

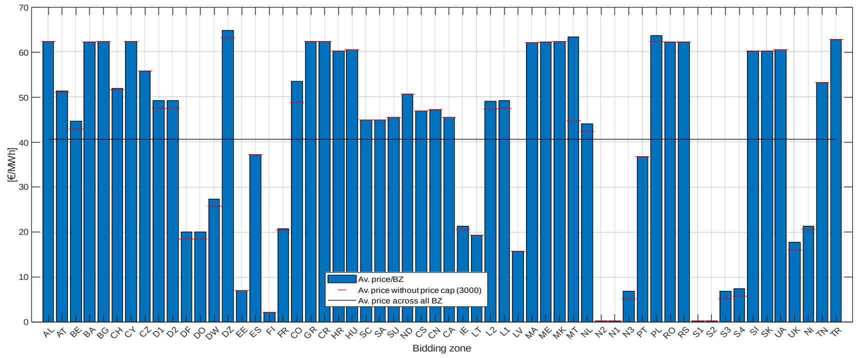

Figure 2.11 – Average zonal prices with and without price cap 3000 [€/MWh].

sMTSIM allows adjusting the production of thermal power plants, considering some of their technological limitations through Unit Commitment (UC). The following parameters can be set:

- *Emin*, Minimum production in terms of equivalent hours of production at maximum power.
- *Minimum duration ON*, the minimum number of hours the unit must remain in the ON (active) state.
- *Minimum duration OFF*, the minimum number of hours the unit must remain in the OFF (inactive) state.

It is particularly important to consider these parameters for nuclear, lignite and coal power plants, as their flexibility is limited due to technological restrictions. Below are some examples of nuclear production in United Kingdom (UK), Figure 2.12, and lignite in Poland (PL), Figure 2.13. The production of these power plants can be further adjusted through the mentioned parameters, however it may also lead to more hours of overgeneration. Refer to [2] for more details on the UC. Gas power plants are considered very flexible and can be switched on and off according to the system's needs, as shown in Figure 2.14.

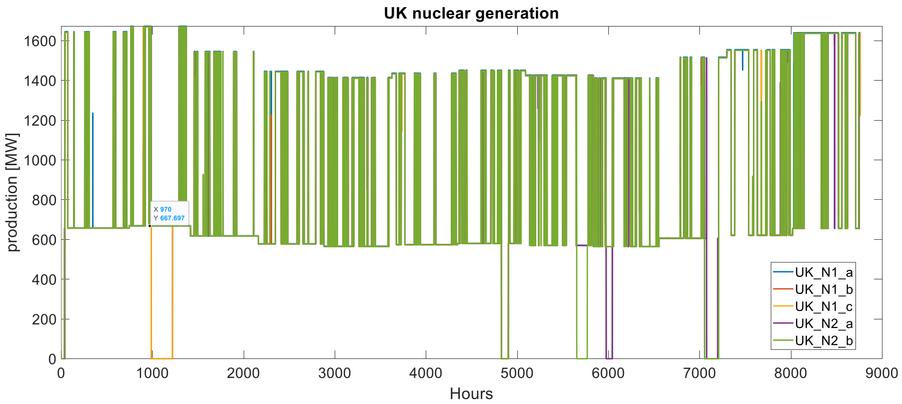

Figure 2.12 – Nuclear power plant generation in UK.

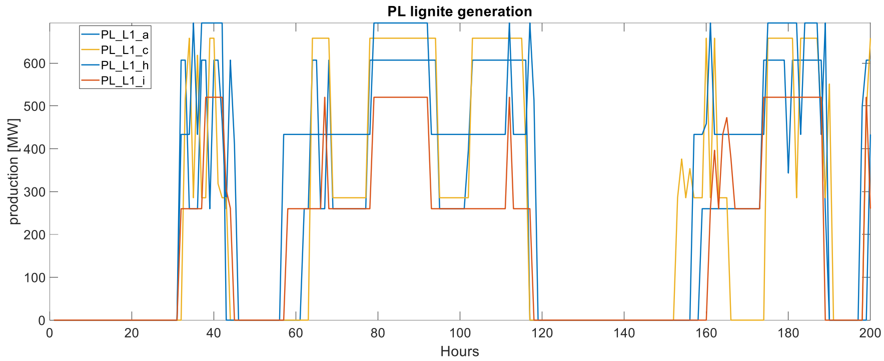

Figure 2.13 – Lignite power plants generation in Poland.

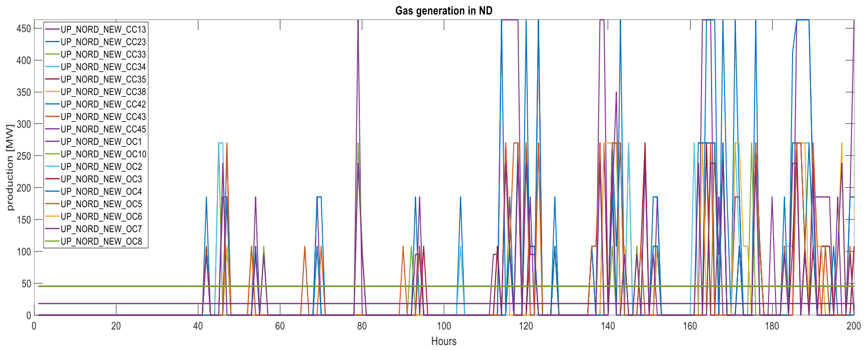

Figure 2.14 – Gas power plant generation in the Nord zone, Italy.

Energy not provided (ENP) and overgeneration are crucial indicators of energy imbalance during specific periods. Below an example of ENP is given for Poland in Figure 2.15 and Figure 2.16, where the insufficient energy supply leads to load shedding causing prices to reach their maximum level of 3000 €/MWh. Figure 2.17 shows overgeneration, resulting in zero prices for the corresponding periods.

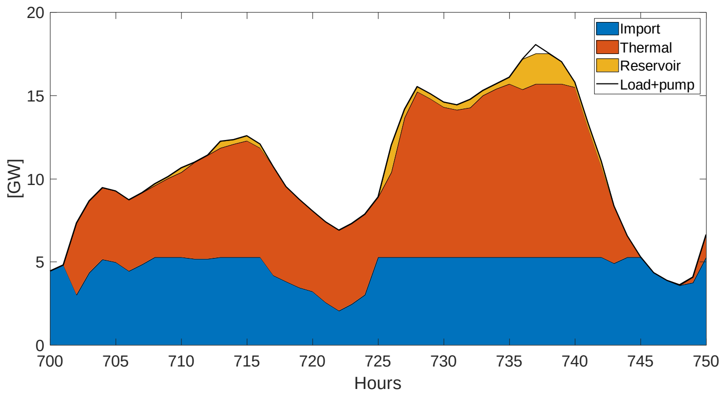

Figure 2.15 – Country balance for hours: 700 - 750, Poland.

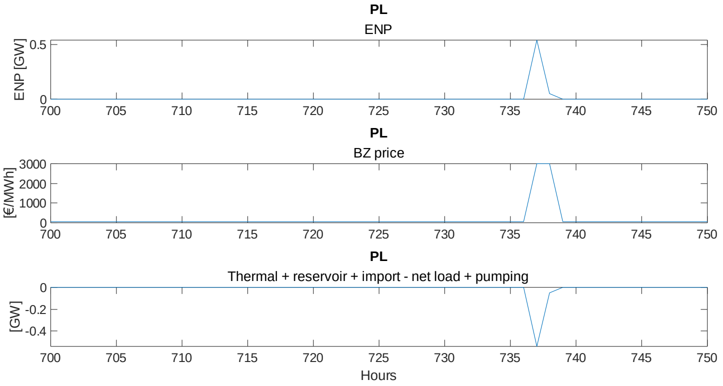

Figure 2.16 – ENP, average price and balance for hours: 70 - 100, Poland.

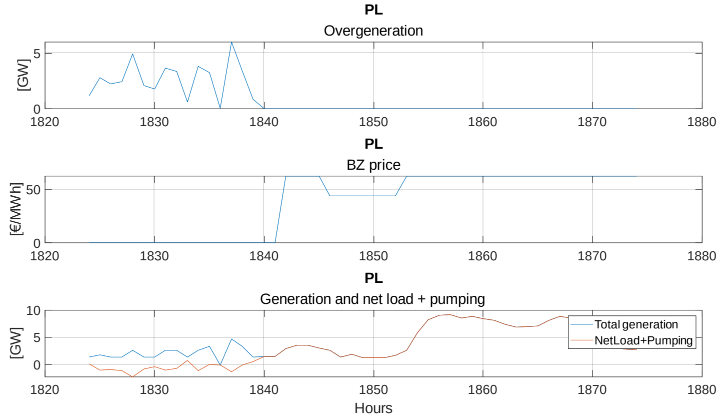

Figure 2.17 – Overgeneration, average price and balance for hours 1820 - 1880, Poland.

3 - CONCLUSIONS

Updating and expanding the modelling scenario are essential for market modelling, providing greater opportunities for a comprehensive analysis of perspectives. This not only enhances accuracy but also improves the model's applicability to diverse scenarios.

Based on the public information, it is possible to construct a pan-European scenario for various analyses. The main outcome of the current work is the updated NT scenario for 2030, relying on the last available information. The bidding zones in Italy were aligned with the ENTSO-E modelling approach, and the modelling area was expanded to now include North Africa (Morocco, Algeria and Tunisia). All transfer capacities were updated, and the model underwent testing in a new GAMS environment.

The import-export data generated from these results can contribute to a subsequent research activity aimed at the construction of the nodal network of the Italian power system, conducted within the research framework of WP2 LA 2.05 of the project, as detailed in report [1].

It can be concluded that the results obtained meet a sufficient level of quality to enable market analysis performed by sMTISM.

4 - BIBLIOGRAPHY

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5 - ANNEX: ADDITIONAL INFORMATION ON MODELLING DETAILS

The following Figure 5.1 and Figure 5.2 respectively report an overview of the installed generation capacity per technology and per country in the considered scenario, and a scheme of the interconnections between bidding zones in the European model.

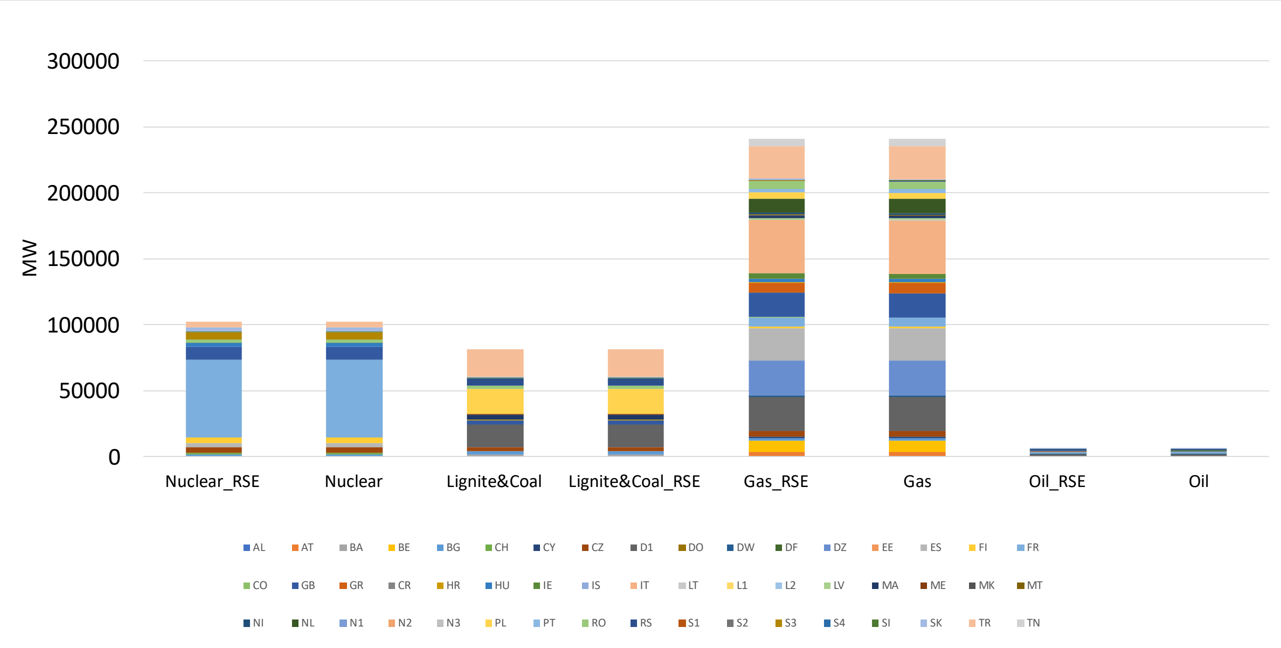

Figure 5.1 – Installed Generation Capacity, NT 2030 scenario. Comparison of RSE and ENTSO-E scenario data.

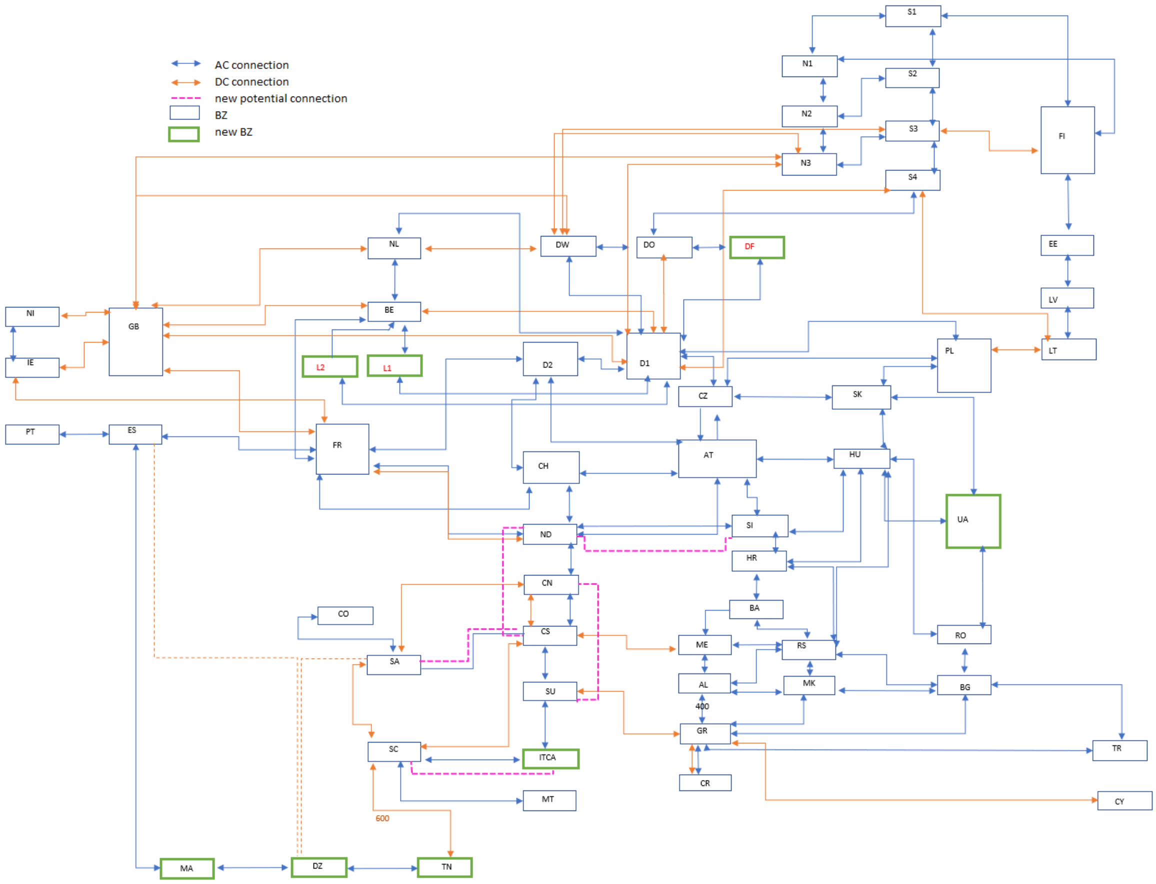

Figure 5.2 – Interconnections between Bidding Zones in the sMTSIM pan-European Zonal Model.

6 - LIST OF ABBREVIATIONS

Acronym	Description
BZ	Bidding Zones
CD	Climate Database
CHP	Combined Heat and Power
CSP	Concentrated Solar Power
CY	Climate Year
ENTSO-E	European Network of Transmission System Operators for Electricity
ERAA	European Resource Adequacy Assessment
GAMS	General Algebraic Modeling System
NT	National Trend
NTC	Net Transfer Capacity
RdS	Ricerca di Sistema
RES	Renewable Energy Sources
RoR	Run of River
RSE	Ricerca Sistema Energetico
sMTSIM	stochastic Medium Term SIMulator
Tpp	Thermal power plants
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
UC	Unit Commitment