Deliverable 3.2.B
“Periodic Adequacy Report”

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“Med-TSO—Mediterranean Project II”

Task 3.2 “Risk preparedness: Winter Outlook or/and Summer Outlook ”

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1. EXECUTIVE SUMMARY

Considering the overall priority of any Transmission System operator (TSO) is to secure the operation of its electrical system efficiently and in an optimized way, it is necessary to provide a variety of activities related to the balance management of the system in a real time framework and this, in cooperation with other interconnected power systems. System adequacy the ability of the electricity system to supply the load in all situations which the system is expected to face in standard conditions.

This document summarizes what the association have done in preparation for a first roll of a seasonal adequacy study.

In the framework of the Mediterranean Project II conducted by Med-TSO, the association decided to pave the way for a rolling seasonal outlook as new challenging and promising activity in order to assess system adequacy in an extended geographical perimeter covering all the members of Med-TSO.

The main principles applicable for carrying out this activity were established and published by Med-TSO at the beginning of 2020 in the report "Del 3.2.A Guidelines and Methodology for Periodic Adequacy report"[1].

In this document, the basic guidelines are presented, followed by the main methodology principles used to produce the seasonal outlook of the Mediterranean countries, according to the Med-TSO context.

In particular, this initial work concluded that the seasonal outlook study shall be deployed by using as much as possible software and databases already deployed for Med-TSO activities for the load forecasts and for the assessment of the variability of wind farm and photovoltaic plant production, assuming for its step-by-step implementation the relevance of adopting a gradual approach (in terms of perimeter and methodology), with the aim of laying the foundations in terms of organization, while simultaneously seeking practical efficiency.

Among all the parameters that condition this type of study, two crucial parameters must be perfectly mastered for carrying out adequacy studies, modeling the production of variable renewable energies, wind and solar, and forecasting short-term electricity consumption. In the step-by-step implementation that has been adopted, these two questions require complex technical means, which include establishing the collection of detailed assumptions, the calibration of simulation models, the adaptation of already existing software already used within Med-TSO, and their experimentation in real situations in several test countries.

It is this process that is described precisely in this document, which was built on three main pillars.

The first chapter was dedicated to a general description of what is expected from Mediterranean seasonal outlook and adequacy assessment on a relatively short time horizon. Two main geographical areas were identified as zones where the study has the most expected added value

The second chapter named Seasonal Outlook Requirements is a description of the data set needed to perform the seasonal adequacy outlooks with a focus on the preparatory effort made by Med-TSO association in order to make this kind of studies possible. A brief description of the available tools and the climatic database adaptations is given.

[1] https://www.med-tso.com/publications/Deliverable_3.2.A_Guidelines_and_Methodology_for_Periodic_Adequacy_report.pdf

The last chapter represents a first exercise performed for a pre-selected area in the Mediterranean, the so-called Test Zone, where we highlight the main outcomes of the different activities that need to be assessed for a future wider and more general roll of the seasonal adequacy outlook.

Across this study we faced several challenging issues related to the amount of data to be prepared and calculations to be performed. It is thanks to deep and strong relation that Med-TSO and ENTSO-e have established that the concretization of this study has been possible. The work that was done in order to fine tune the renewables hourly production curves, the exchanges of the Pan European Climate Database (PECD) and the improvements of the TRAPUNTA software, together with the coordinated training sessions between Med-TSO and ENTSO-e have made the deployment of this study possible.

Signed in October 2017, the cooperation agreement between Med-TSO and ENTSO-e allowed, during Mediterranean Project 2 (2018-2020), the implementation of numerous cooperation initiatives, whether through exchanges of data (Power system model, RES generation data base) or tools. But beyond that, cooperation also focused on the knowledge and experience sharing, for example through common training sessions on the consumption forecasting tool TRAPUNTA, and the pooling of technical specifications to evolve this software.

In this context, the report describes how the two crucial activities relying on PECD and TRAPUNTA have been successfully developed within Med-TSO, respectively with the sharing of detailed data of Mediterranean countries (PECD) and specifications then functional validations for TRAPUNTA which confirms the relevance of this tool for performing demand forecasts in the specific context of Mediterranean countries.

In the future, this study will be rolled every year and for this reason, close cooperation need to stay strong and efforts need to be increased.

2. PURPOSE OF THE MEDITERRANEAN SEASONAL OUTLOOKS

Unlike long-term Mediterranean scenarios and Master plan activities (several years ahead), the Mediterranean seasonal adequacy assessment has the purpose of identifying potential adequacy issues in short timeframes (season ahead).

2.1. General objectives of Med Seasonal Outlook

Med seasonal adequacy assessments intends to ensure risk awareness for all the involved TSO's and support system operation by answering the following questions:

- Is the electrical system adequate through the season (summer or winter)?
- Is the system able to deal with historical extreme weather conditions or would its adequacy be threatened?
- What are the adequacy risks? In which circumstances do we face such risks?
- What are the best means to mitigate those risks?

There is no doubt that, individually, every TSO keeps asking and answering these questions before every season. Historically, adequacy studies focus on the moment with the highest load in order to know whether one system is adequate enough to cope with load increase on a basis of a worst-case scenario. However, due to the recent trends in the energy generation mix, with a remarkable increase of the share of intermittent renewables, this rule may no longer be sufficient and the analysis should be pushed further in order to cover all possible situations that may occur in a system. In fact, comfort loads on one side and the introduction of increasingly important shares of weather-dependent renewable electricity generation on the other, all contribute to an increasing demand for skillful and reliable seasonal forecasting services, namely through customized requirements of users in the energy sector and probabilistic approaches that allow to incorporate the volatility associated to the input variables.

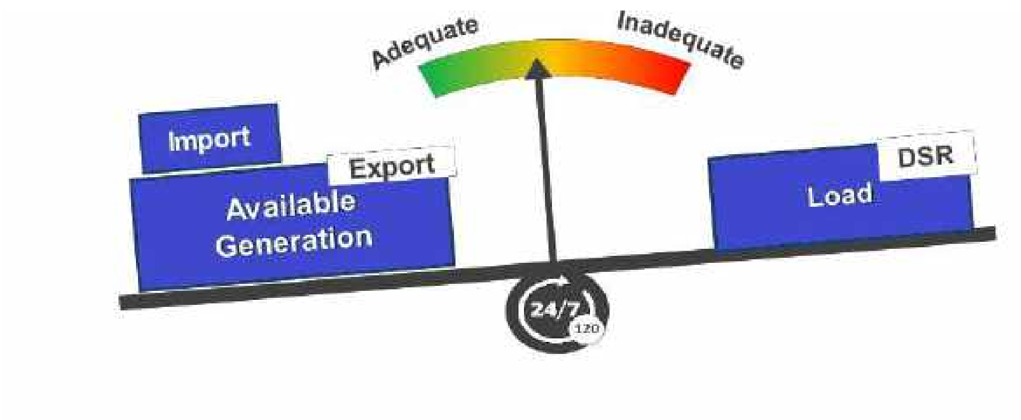


Figure 1 : Seasonal Adequacy Principle (4 months basis)[i]

Adequacy issues may be addressed in a common regional approach, as it is the case for ENTSO-e. However, this is regional approach is more likely to be complementary to the individual national assessments of security of supply and adequacy. A regional approach to these issues is usually reliant on a properly functioning regional electricity market, where every market bidder knows exactly how he is expected to perform in order to fulfill his responsibilities in complying with the schedule that resulted from the market bidding, and thus contributing to the security of supply.

On the other hand, many of Med-TSO countries (mainly the southern coast of the Mediterranean) are not operating in regional electricity markets. Adequacy issues are addressed for the isolated

system and in case of non-adequacy, gaps are usually filled by load shedding or, when possible, by pre-defined agreements of commercial flows with neighboring TSO's.
Raising this matter at Med-TSO level could provide an early warning when available resources are expected to fail in keeping the pace with demand growth. It will also help TSOs to address the weather condition scenarios in a common regional approach.
In addition, Med-TSO seasonal outlook may address some key messages when focusing on images of solidarity between the members in terms of boosting energy exchanges in order to cover the potential gaps.

2.2. Areas with great potential

It is well known that the situation of the Mediterranean power systems is not homogeneous and it presents wide differences in what concerns availability of resources and existence of transparent regulated market zones. Nevertheless, even when such regulated markets are nonexistent (south and eastern coasts), countries still aim to use their interconnections in a way that improves the security of supply and bilateral or multilateral agreements are being established in order to guaranty enough support from neighboring countries when needed.
We can easily identify two big zones where the interest in performing seasonal outlooks is high since interconnections are already implemented and there is an unexploited potential of exchange between the countries.

2.2.1. South-western Mediterranean area (Maghreb)

In the Maghreb area, Algerian, Tunisian and Libyan TSO's discuss the possibility to enhance exchanges between the three North African countries in order to cover a part of Libya's shortage of production and difficulties to cope with the increasing demand.

In the Electricity Committee of Maghreb, COMELEC, a dedicated sub-committee called CIM (Interconnections Committee of Maghreb) discuss continuously from a technical point of view the possibility of reviewing and increasing thresholds of the security settings for the interconnections between the countries.

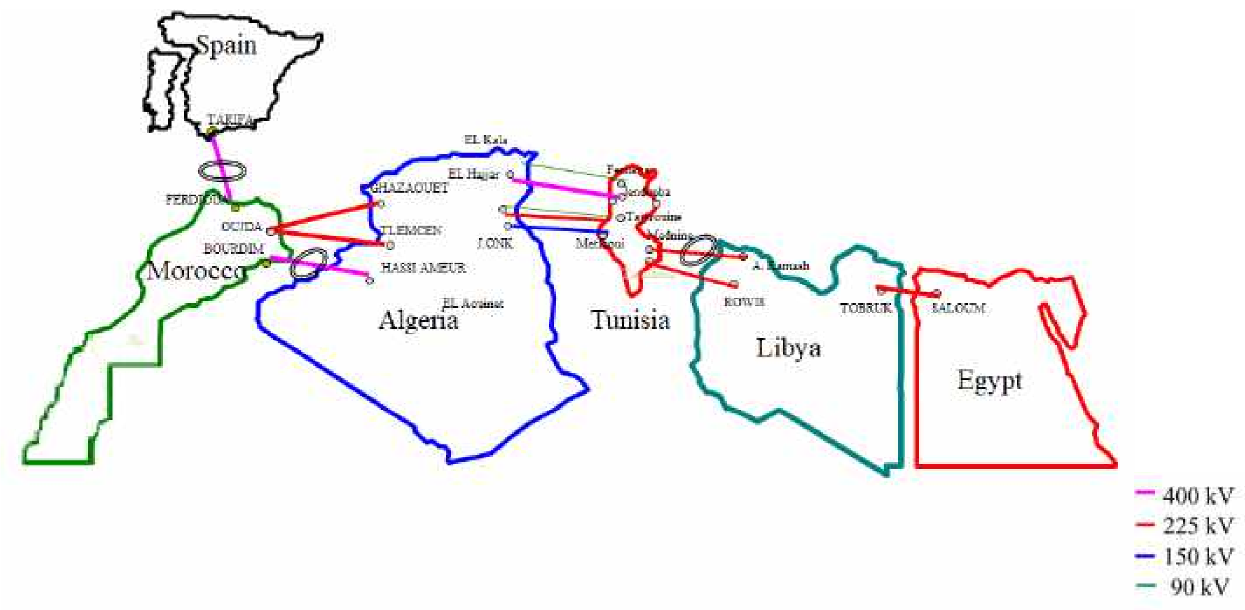


Figure 2: Existent interconnections in the Maghreb area

Since 2018, exchanges between Algeria, Tunisia and Libya were enhanced even if the balance is still low. For example, the balance between Algeria and Tunisia showed that commercial flows did not exceed 11 GWh, but the total exchanged energy between the two countries was about 717 GWh. In the same year, Libya bought around 139 GWh from Tunisia in order to reduce load shedding mainly during the summer period.[ii]

Every year, an increasing trend in these figures is observed, despite the inexistence of a regulated electricity market in the area.

2.2.2. Eastern Mediterranean Region

With the existence of The Eight Country Interconnection Project (named EIJLLPST) involving Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria, and Turkey, a regional adequacy assessment will have multiple advantages, starting from sharing the auxiliary services and the need for flexibility in order to allow higher shares of renewable into the whole generation mix. It may also reduce the overall unserved energy mainly in Lebanon, Syria and Palestine.

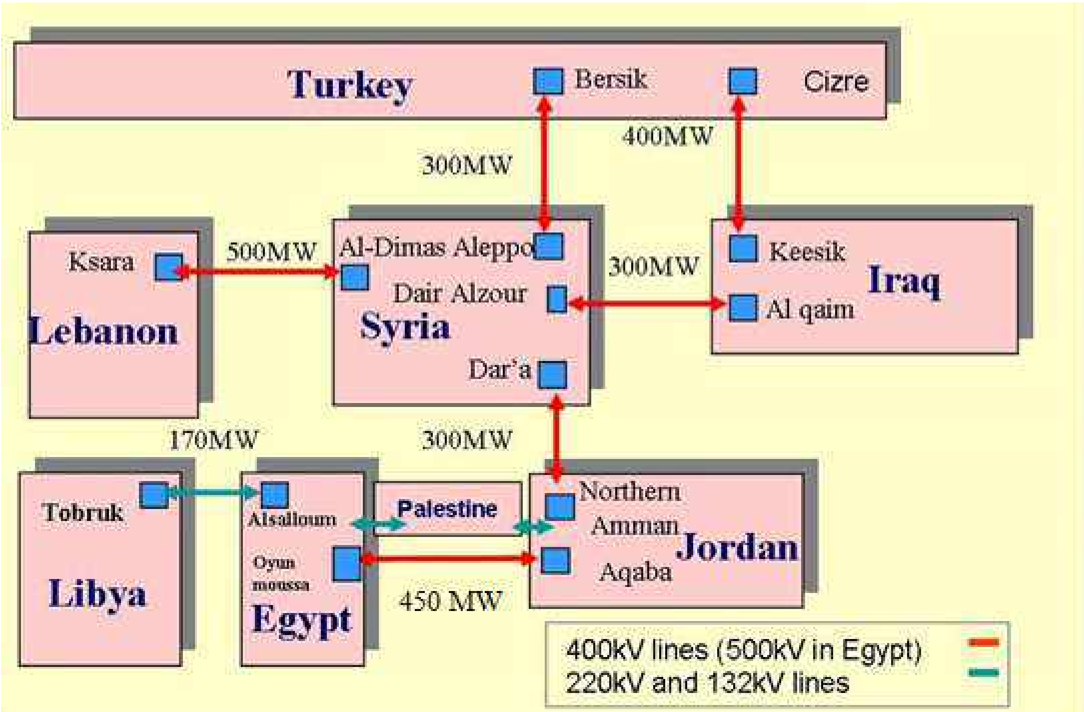


Figure 3 : The Eight Countries Interconnection Project[iii]

The statistical data collected in the framework of the actual Mediterranean project showed that many of the existing interconnection lines have been used in order to avoid load shedding in some countries when the load increases (mainly in summer period) and along the years some of the electricity exchange contracts have been activated. For example, Egypt exported almost 327 GWh to Libya and 234 GWh to Jordan during 2019. Additionally, and despite the two grids being interconnected at medium voltage level, Jordan is constantly trying to contribute to cover part of Palestine's demand (in 2019, the total exchanged energy was about 88 GWh).

3. SEASONAL OUTLOOK REQUIREMENTS

System adequacy is determined by measuring the ability of the electricity system to supply the load in all situations which the system is expected to face in standard conditions, including expected load, generation, network configuration, technological limitations, etc.

Adequacy models are built using three major pillars; supply and accurate grid representation connecting demand and supply in a pre-defined perimeter.

Following the Guidelines and Methodology elaborated and published by Med-TSO in the framework of the Mediterranean Project II, periodic Adequacy studies are to be addressed considering the inclusion of climatic conditions affecting the operation of the system.

3.1. Energy and power demand forecast

Electricity usage is highly volatile, depending on the weather conditions, as changes that may occur in temperature and humidity affect the electricity demand for heating and cooling. For this reason, and in order to cover all the possible near future needs for electricity, many TSOs started to switch to probabilistic methods of forecast taking into account the historical load together with the recorded climatic situations along the years.

On the other hand, and knowing that joint studies require unified tools, Med-TSO took an early decision, before even the contractual start of its Mediterranean Project II: to improve the cooperation with its historical partner ENTSO-E. In this framework, ENTSO-E offered Med-TSO members access to its new software application developed by an external provider and called TRAPUNTA.

TRAPUNTA employs a new methodology for the electric load prediction analyses. Thus, it can create a model (the forecast model) starting from historical weather database (e.g. population weighted temperature, city temperature, irradiance, wind speed, humidity) and the electric load time series of a given market node. The forecast model can then be used for load prediction based on: i) climatic variables provided by the user for the forecast year; or ii) a previously calculated normalized year. In addition, the forecast model can be provided with load tunings to take into account the main parameters distressing the market evolution (heat pumps, electric vehicles, temperature-dependent load growth, etc). The methodology proposed by TRAPUNTA for demand forecasting is described below.

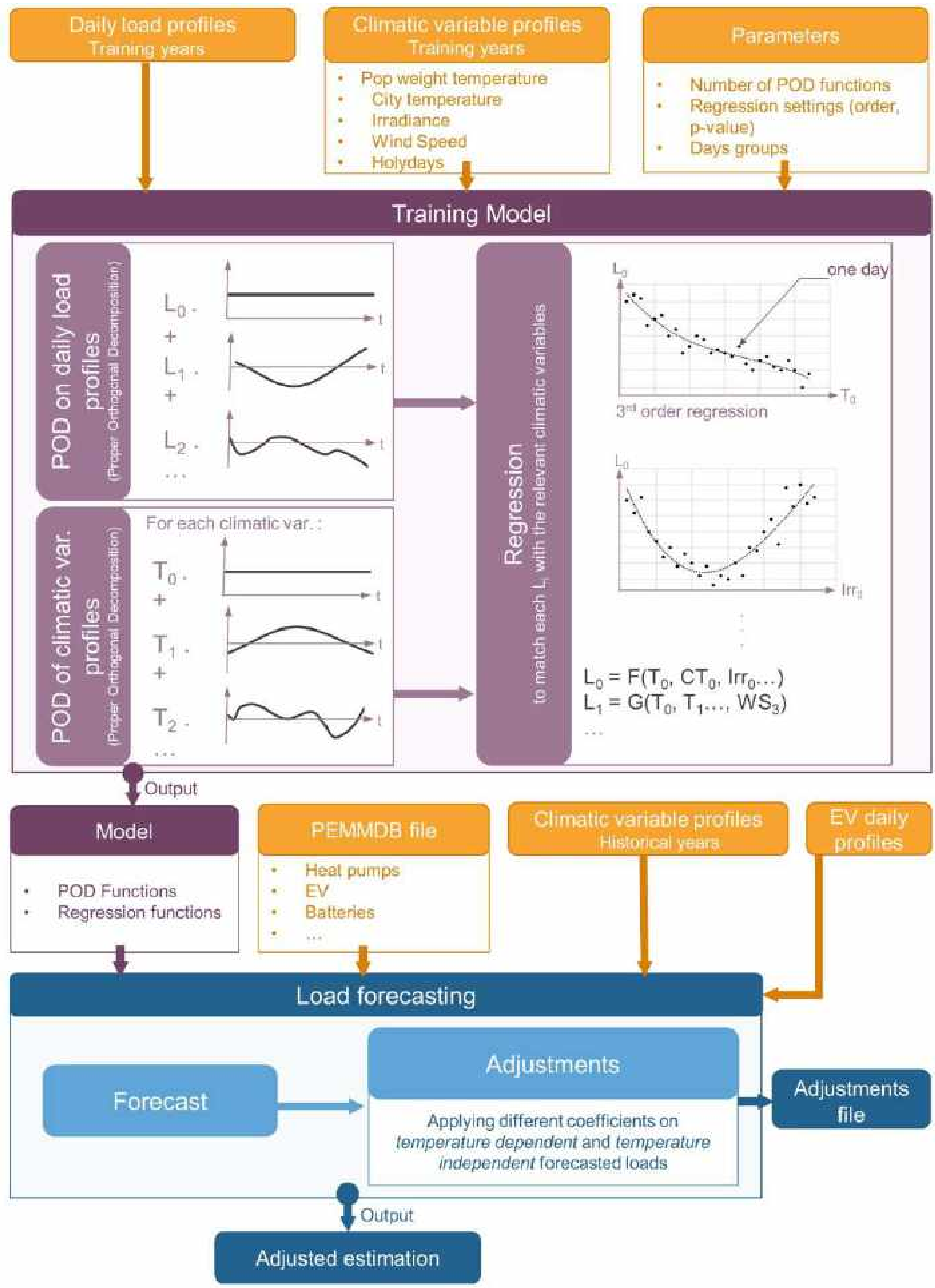


Figure 4 : Demand forecasting methodology [iv]

The expected advantages for using this software include, but are not limited to, the following:

- Multiple historical climate and load time series are used to derive forecasted load profiles for each market node;
- Automatic identification of different climate variables needed for the forecasting process (temperature, irradiance, wind speed, etc.);
- Adequate treatment of historical profiles used in the forecasting process (correction of holiday periods, exceptional events, etc.);
- The load forecast is broken down into temperature-dependent and temperature-independent components. This way, the final load profiles are adjusted taking into account added consumption from heat pumps and electric vehicle charging. Consequently, the forecasts also consider the interdependencies of historical temperatures of each climate year and historical load patterns.

Med-TSO members have shown a strong interest in the tool: its possibility to model the load increase associated with fast-growing economies, coupled with a reliable model for weather dependency. Being already tested and validated for all ENTSO-E countries, TRAPUNTA results reveal to be reassuring for North-African countries such as Morocco, Algeria, and Tunisia. Interest was shown also from the Southeastern coast countries of the Mediterranean.

Consequently, the weather data base was extended to the full Mediterranean perimeter, covering all Med-TSO members. The period covered begins in January 2000 and the database is completed each year (currently until the end of 2019) in order to be able to update the forecasts with the latest data available. It is important to note that the years prior to 2000 were deliberately excluded from the database, due to the particularly sensitive climate change in the Mediterranean. In fact, the security of supply in this region is particularly sensitive in summer due to the massive use of air conditioning. This implies a good accuracy of peak consumption forecasts in summer under exceptional climatic conditions, which therefore requires not taking into account previous climatic years which reflect a climate which is no longer the one that the region now experiences.

The first use of the software by Med-TSO was for the target year 2030 - demand forecast needed for the Mediterranean Master Plan. Although TRAPUNTA's use was globally positive, it also showed some specific difficulties related to the high growth of consumption in some of the Mediterranean countries and mainly developing countries, where demand growth rate is expected to reach 4% per year. For this reason, it was important to consider a multi-year de-trending correction aimed to solve faced training and forecast issues related to the steep change in energy usage habits. Several new functions are also needed in order to provide a user-friendly environment for performing long-term and seasonal outlook activities. Med-TSO hired the tool developer to perform the above-mentioned changes, in order to update TRAPUNTA and enabling it to cope with the specific needs of the members, such as: the trend correction factor; the normal year historical load analysis and the historical load reanalysis that would evaluate and separate the weather-dependent and weather-independent components of the electric load usage evolution. Those functionalities are crucial both for the short-term adequacy studies and for the seasonal outlooks.

In the beginning of 2020, the software developer released a new version integrating all the updates requested by Med-TSO. Furthermore, the developer was invited to present the new functionalities and to train the members of both Med-TSO and TRAPUNTA TF of ENTSO-e on the use of the new version.

3.2. The Mediterranean generation landscape[v]

According to the Mediterranean statistical report for the year 2018, the Mediterranean power system presents a very wide generation landscape with more than 600 GW of installed capacity, considering all technologies combined.

Gas and Renewable are the most dominant sources of electricity with over 230 GW of installed capacity each.

Investments in conventional gas production units are expected to rise with the great potential already existing in the area and the new offshore discoveries in the Mediterranean pool. Moreover, most of the Mediterranean countries have shown a remarkable involvement in the energy transition and shares of renewable generation are escalating significantly from year to year, following the trend in cost reduction of these technologies and the announced ambitious targets.

The table below describes the Mediterranean installed capacity landscape for the year 2018.

Table 1 : Mediterranean installed capacity landscape- 2018

Mediterranean Installed capacity [MW]	
Nuclear	70943
Coal	33619
Lignite	24182
Gas	231669
Oil	28049
Others non-renewable	4270
Hydro	112260
Wind	67381
Solar	47707
Others renewable	5354

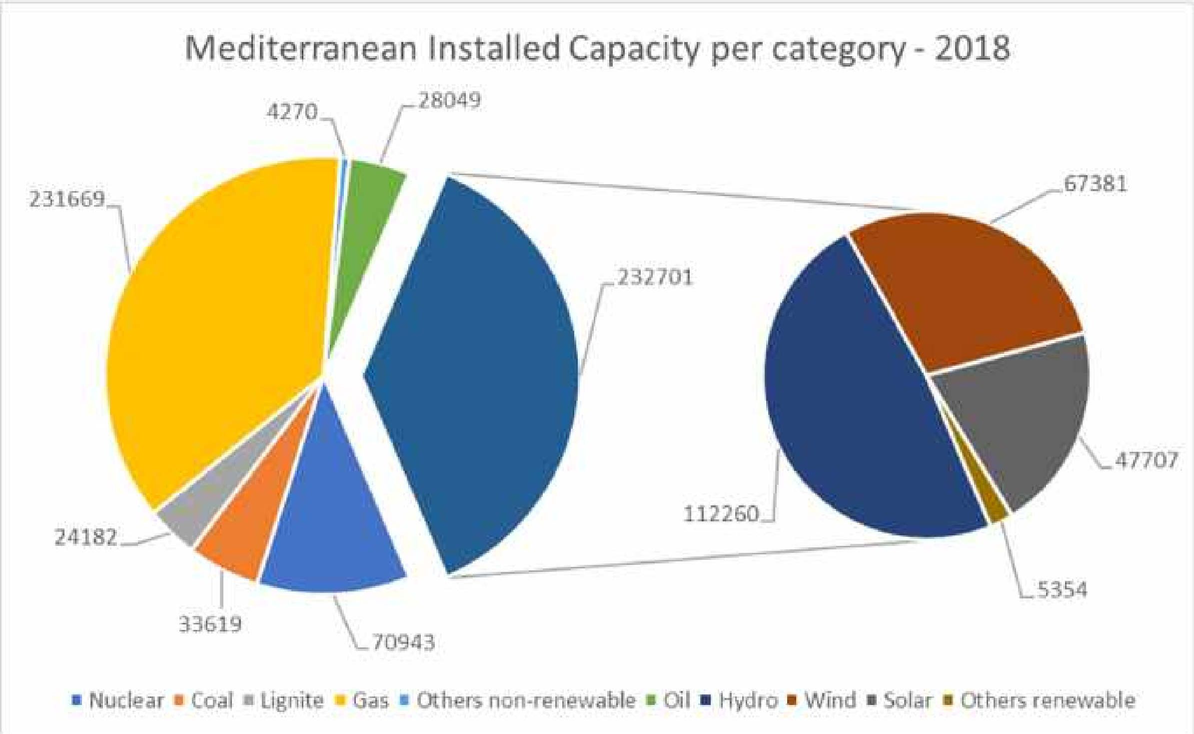


Figure 5 : Installed capacity Mix – 2018 – Unit is MW

From the graph above, it is obvious that the portion of renewables is already high (one third of the installed capacity) with a fast-growing share of wind and solar new installations. This fact was one of the main drivers that motivated Med-TSO to design a methodology for adequacy studies that covers different kinds of uncertainty that may occur in the Mediterranean electric system.
Availability of the generation is one of the most important identified pillars that may present a high uncertainty reflected through the consideration of different wind, solar and hydro generation outputs for N different scenarios, each of them linked to a climate year.
During the last few years, the Pan-European Climate Database (PECD) has always been used by ENTSO-E as the basis input for solar and wind generation and to account for the load-temperature sensitivities. The PECD dataset has been provided to ENTSO-E by the Technical University of Denmark (DTU) under a project meant to evaluate photovoltaic and wind hourly production on regional scale in the whole Europe.

In the framework of its close cooperation with ENTSO-E, Med-TSO succeeded to extend the perimeter covered by the PECD to integrate all Med-TSO members and datasets have been prepared for all of the southern members of the association.

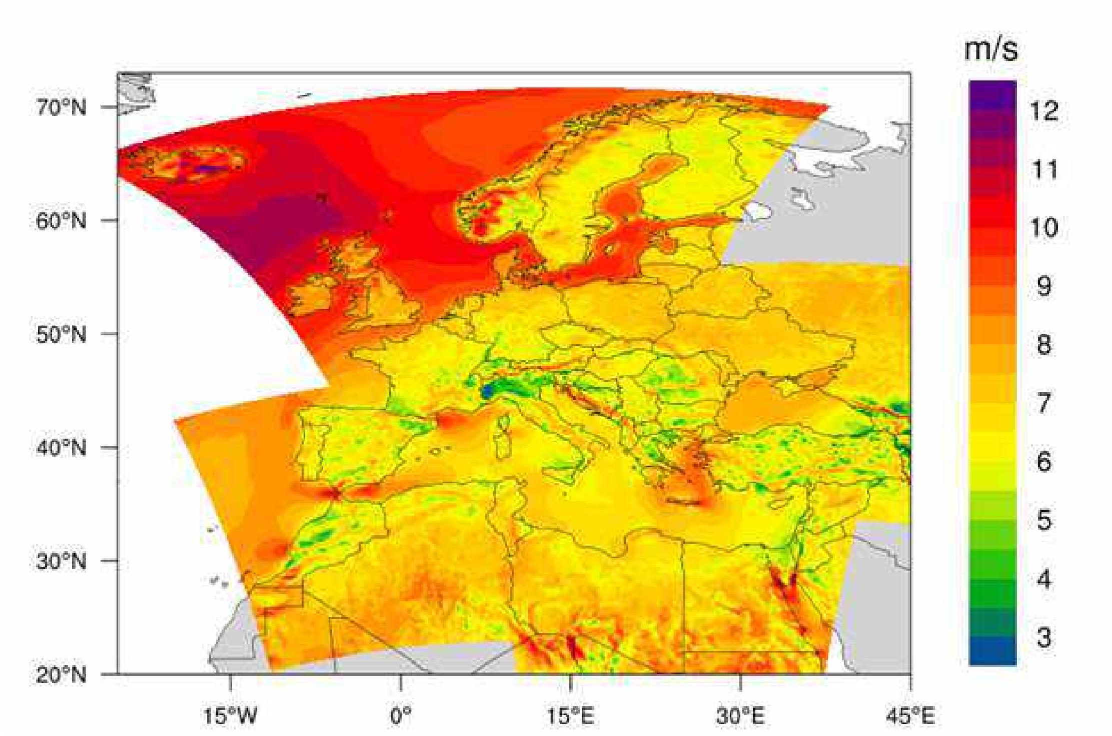


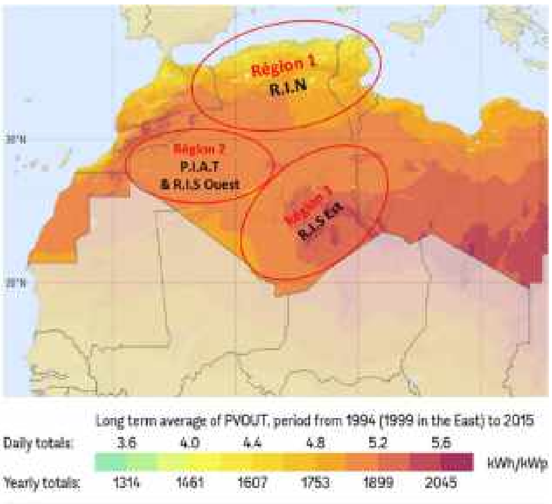
Figure 6 : Weather Research and Forecasting (WRF) results for wind speed[vi]

Interested members furnished a detailed subdivision of their covered territories based on the availability and potentiality of their wind and solar resources. The provided geographical distribution as defined by the TSOs are as follows:

- For Morocco six zones where identified for both wind and solar generation

Figure 7 : Geographical distribution for both solar and wind production - MA

- For Algeria, and based on the types of networks, the subdivision considered three areas for solar and the same for wind generation.



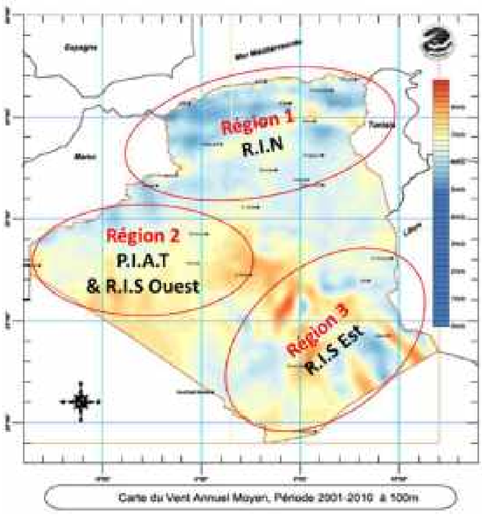


Figure 8 : Geographical distribution for solar - DZ

Figure 9 : Geographical distribution for wind - DZ

- For Tunisia, the subdivision considered eight zones for both solar and wind generation.

Figure 10 : Geographical distribution for both solar and wind production - TN

- Libya considered the subdivision considered three zones for both solar and wind generation.
  Note: Wind and PV plant location showed on this map are provisional information, not planned, and shall be confirmed or changed later.

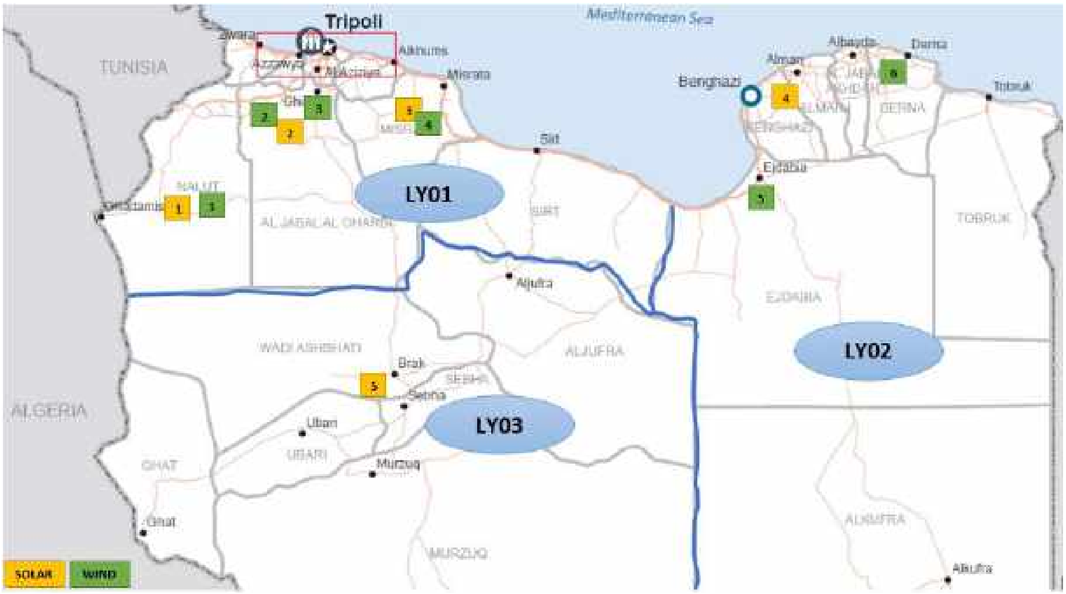


Figure 11 : Geographical distribution for both solar and wind production - LY

- For what concerns Turkey, fifteen zones were defined for both wind onshore and solar, other five zones for zones, which present a potential of wind offshore.

Figure 12 : Geographical distribution for both solar and wind onshore – TR

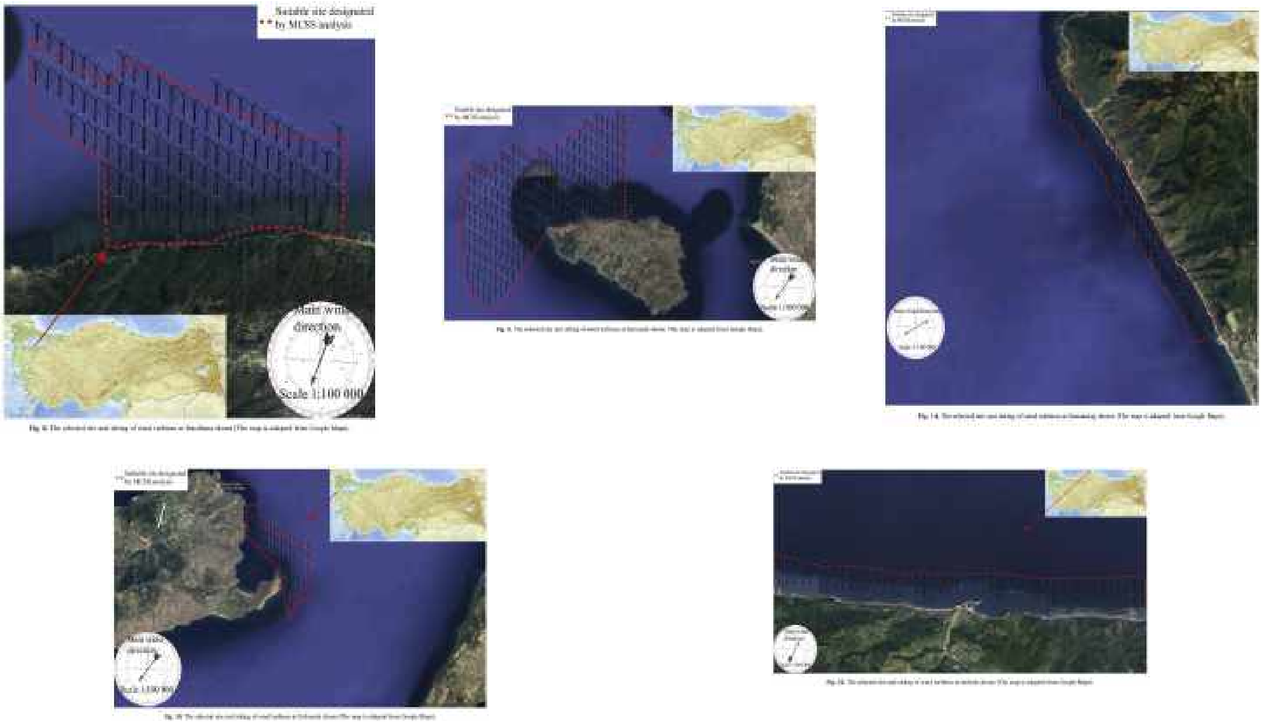


Figure 13 : Geographical distribution for wind offshore – TR

Appendix 1 contains the detailed list of existing and planned renewable projects and assumptions related to the concerned Med-TSO countries that have been considered by DTU in order to prepare the hourly generation profile for both wind and solar.

3.3. The Mediterranean interconnections

The Euro-Mediterranean Transmission grid presents more than 400 000 km of length and numerous voltage levels. As mentioned in chapter 2 of this report, in some areas, interconnections are still under-used due to the absence of a fully integrated electricity market.

As given in the following Map, it is easy to distinguish three major areas different from each other in terms of interconnections utilization, operation and market integration:

i. ENTSO-E's synchronous Continental Europe zone,
ii. South Western Mediterranean Block, which is synchronous with the ENTSO-E's synchronous Continental Europe zone;
iii. South Eastern Mediterranean Block

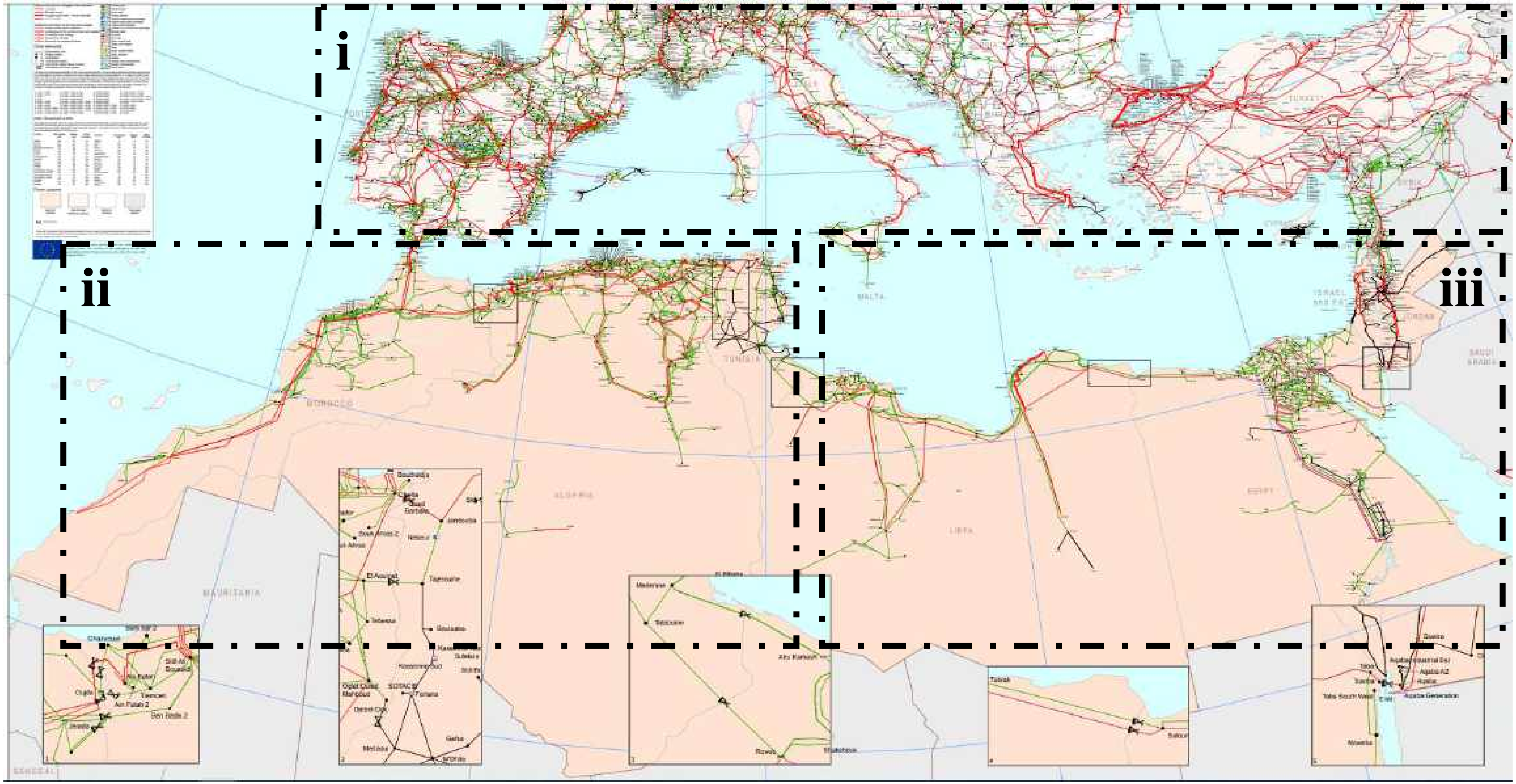


Figure 14 : Map of the interconnected electricity transmission networks[vii]

4. SUMMER OUTLOOK 2020 – ROLLING THE EXERCISE ON A PRESELECTED AREA

4.1. Perimeter definition

The implementation of adequacy studies and their publication by Med-TSO is a very ambitious goal, given the challenges it implies, not only in technical terms, but also in accessing data and transparency requirements, together with other practical terms related to the availability of the contributing members. This is why a gradual approach (in terms of perimeter and methodology) will be adopted, with the aim of laying the foundations in terms of organization, while simultaneously seeking practical feasibility and efficiency. The first phase of the gradual approach can be implemented by a Pilot (or test) Zone.

The test zone includes both Algeria (SONELGAZ) and Tunisia (STEG) and the objective was to roll the load forecast activity and compare results to the already addressed forecasts for the year 2020. As we all know, the COVID19 pandemic enormously impacted the electricity consumption in all the countries, with the industrial activity quasi-shut down and the reduction or even closure of the tourism and services facilities (restaurants, hotels, clubs, etc.) for at least one month. All the countries are expected to be far from their targets in relation with electricity consumption and all the forecasts were reviewed downwards. For this reason, all comparisons will be made with the pre-COVID 19 forecasts for the year 2020.

Although not included in the test zone, it was considered of interest to complete the TRAPUNTA experiment with the case of Turkey (TEİAŞ). In fact, the consumption of this country has characteristics that make the demand modeling particularly complex: dynamic annual growth although irregular in recent years, high climate sensitivity, both in winter with electric heating and in summer with a massive development of air conditioning. As for Tunisia and Algeria, the reference period for Turkey is prior to the start of the crisis induced by CODIV 19. However, the year chosen for the forecast is 2021.

4.2. Input data description

Data inputs used for the model fitting phase are as described below:

• Model parameters – a set of parameters that determine, for example, the number of basis function number used in the SVD (Singular Value Decomposition) of time series, number of (virtual) cities considered, number of day groups considered (holidays/ special days), regression order, p-value (threshold for elimination of regressors) among others.

• Pan-European Climate Data Base (PECD) consisting of time series for N climate years on temperature, irradiance, humidity, wind speed, among others. From this database, the demand forecasting methodology principally relies on historical load, humidity, wind speed, irradiance and temperature time series that are used to establish a link between load and the remaining variables.

• Holiday/special days are days that are characterized by different electrical load behavior, related to the load pattern deviations experienced during holiday days or special days (Ramadan, national and religious holidays). Currently, the software allows users to cluster special days into several groups that are separately treated during the forecasting process.

Both STEG and Sonelgaz prepared their set of historical input data related to the period 2012-2019, only those referring to the period 2015-2019 were used. Data prepared for Turkey covers the 2015-2019 period. Some checks have been performed in order to be sure that the datasets are consistent and reliable. Holiday files referring to the same period were prepared as well.

The next graphs show the evolution of the energy consumption for the three countries for the period of the study.

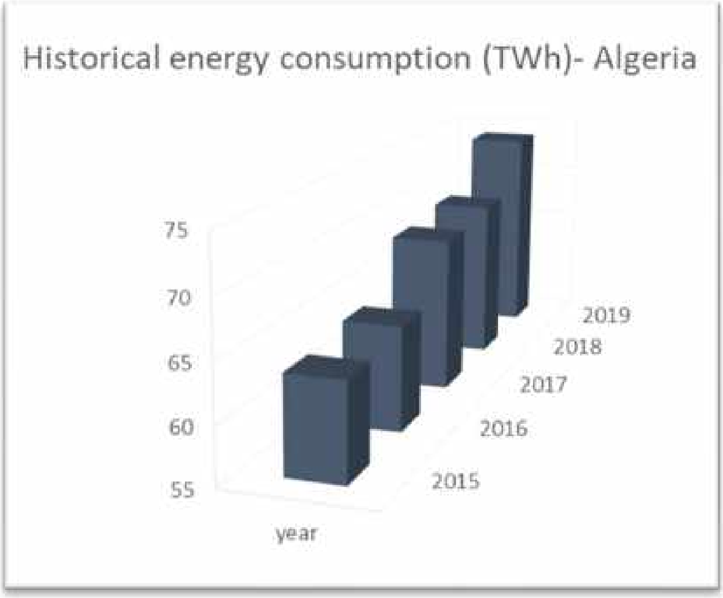


Figure 15 : Algerian Electricity consumption trend 2015-2019

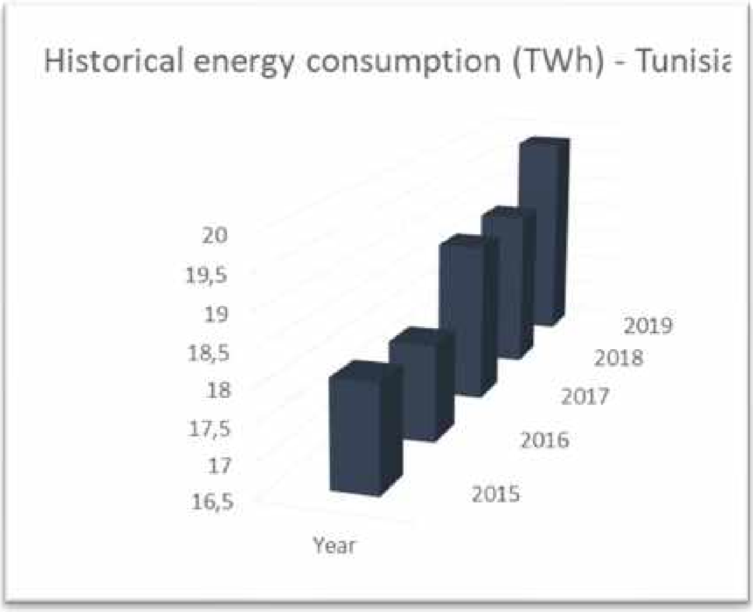


Figure 16 : Tunisian Electricity consumption trend 2015-2019

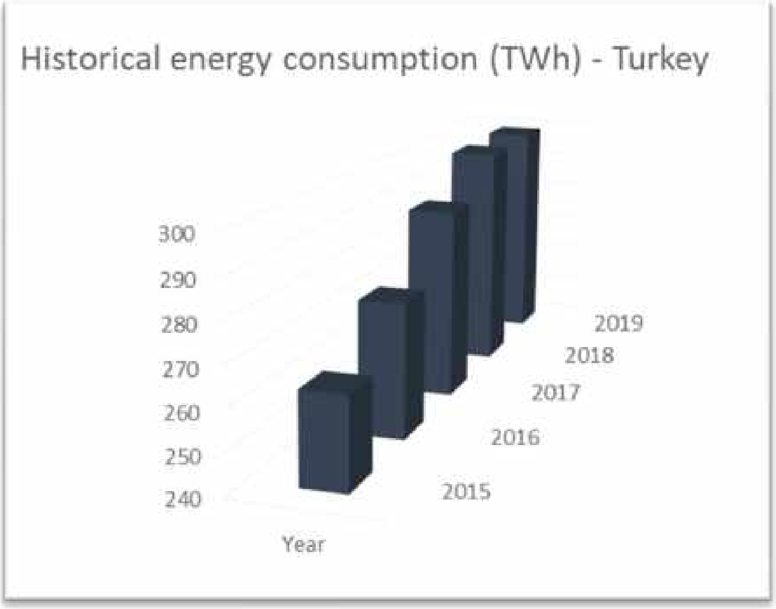


Figure 17 : Turkish Electricity consumption trend 2015-2019

The historical hourly load analysis with focus on peak power demand for both countries led to the following summary table.

Table 2 : Historical peak load 2015-2019

Year	Peak load (MW)		Date of occurrence		Hour (UTC)	
Country	**DZ**	**TN**	**DZ**	**TN**	**DZ**	**TN**
2015	12380	3599	Wednesday05-08	Thursday 30-07	15h	12h
2016	12839	3400	Monday 01-08	Monday 01/08	15h	12h
2017	14182	4025	Monday 31-07	Tuesday 08-08	15h	13h
2018	13676	3887	Thursday 19-07	Friday 13-07	15h	13h
2019	15656	4224	Wednesday 07-08	Tuesday 09-07	15h	12h

According to the table n°2, it is obvious that there is an interesting time shift between peak load in terms of days and hours of occurrence. Knowing that for the both countries, summer peak loads are related to an intense heat wave during the working days, we may conclude that even if heat waves appear in the same time in both the two neighboring countries, peak loads are usually shifted thanks to the difference in working days (Sunday – Thursday in Algeria vs Monday – Friday in Tunisia).

The following figure shows the electric load in Turkey during the full year of 2019.

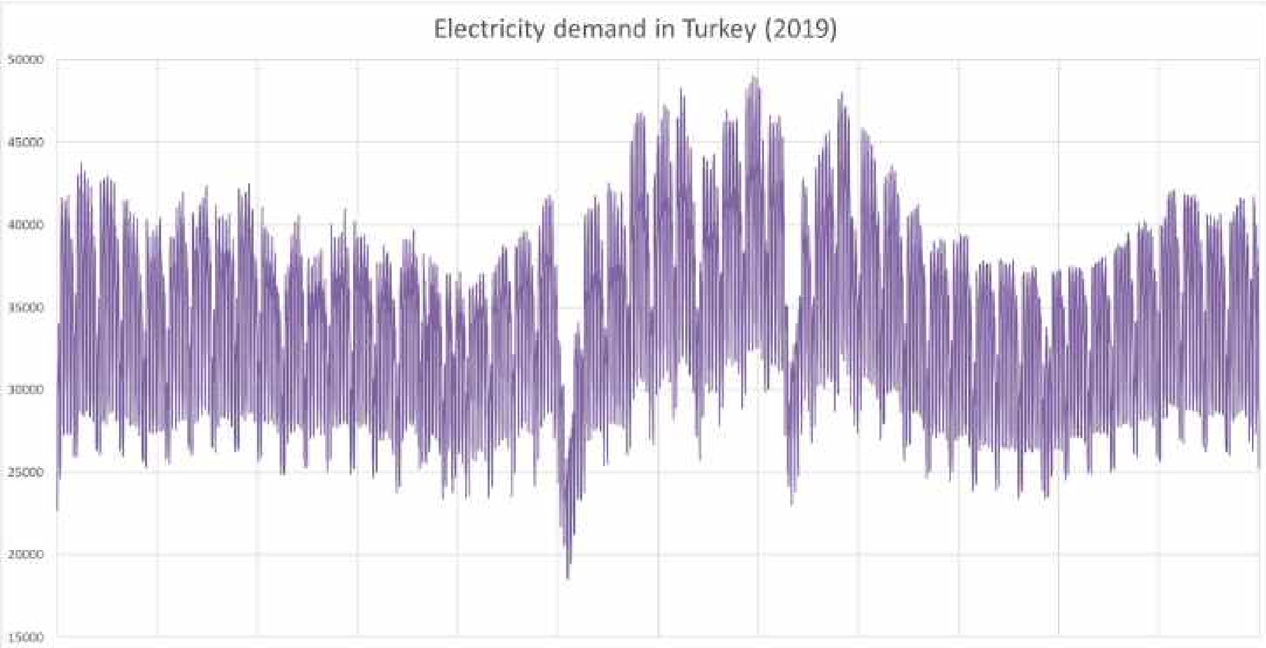


Figure 18 : Turkish Electricity consumption in 2019

There are several elements to note: first of all, demand is highly seasonal, with two periods of high consumption in summer and in winter linked to temperature-sensitive uses of electricity. These two periods are not only marked by high consumption, but also by strong inter-weekly variability directly dependent on weather variations. While the daily peak consumption in April and October (neutral period for temperature-sensitive uses of electricity) is close to 37 GW, we can see that the excess consumption linked to air conditioning during the hottest weeks of the summer 2019 is around 12 GW. More modest but nevertheless significant, the excess consumption linked to heating in winter represented up to 6-7 GW in January 2019.
It should also be noted two periods of very low consumption in early June and mid-August 2019, which correspond to Muslim religious holidays (Ramazan Bayrami and Kurban Bayrami). On the one hand, they constitute an important stake because they are simultaneously the lowest point of consumption of the year and very hard to model. Indeed, being linked to the date of Ramadan, the date advances by 10 days each year, which represents from the point of view of modeling a major difficulty.

4.3. Training activity

4.3.1. Set of regression parameters and reconstruction of historical load

This is the first step of the methodology for the electric load prediction. It consists in creating a regression model able to explain the correlations between the electrical load and the climatic variables presents in the PECD (Pan-European Climate Database) info (e.g., population weighted temperature, city temperature, irradiance, wind speed, humidity). The model is based on a training set of information, i.e., the electrical load and climatic variables time series. Since the regression is created on these data, it is necessary to provide:

- ✓ electric load data of the selected period;
- ✓ holiday/special days file (divided in type from A to G) of the selected period;

- ✓ climatic variable data of the selected period;
- ✓ the options for the data loading;
- ✓ the options and the parameters for the specific reduced order modelling methodology,
- ✓ employed by TRAPUNTA (Proper Orthogonal Decomposition, see the Theory Manual for further details);
- ✓ the options and the parameters for the regression analysis.

Thanks to the work done by the association during the Mediterranean Project II, and the strict collaboration with ENTSO-e, PECD was made available for all southern countries in addition to European countries already included by ENTSO-e.
PECD covers a period of 20 years (from 2000 to 2019), test zone countries have prepared both historical load dataset (2012-2019) and Holidays file (2012-2019).

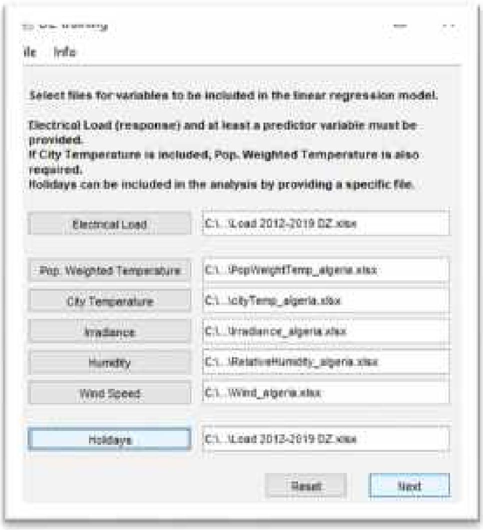


Figure 19 : Input data for training activity

For each of the countries included in the test zone, the training was performed in the same way, both a year per year training and all years together using the new functionality De-Trend.
The difference was in Days aggregation in groups. In fact, there is no trivial way to make the Day Group segregation since it depends on the grouping defined in the Holidays excel sheet.
The tool, in its new version, allows to display regressors vs load plots highlighting the different groups, from now on it is possible to;

- easily identify meaningful day groups;
- visualize third-order data fits to assess the grouping sanity;
- recognize anomalous days;
- reveal ill-posed special days;
- visualize the real data vs the fitted one (only after the training);
- identify out-of-scope forecast grouping.

On the other hand, knowing that the counties involved in the test zone are characterized by a strong annual growth, we choose to add a linear regressor able to catch and describe this growth. There are three couples of options to set (see the figure below):

- Granularity:
    1. Uniform base load: the correction is applied on the average load;
    2. Hourly load profiles: the correction is applied both on the average load and on the basis function/profiles of the hourly load.

- Days grouping:
  1. All group days: the same correction is applied on all group days;
  2. Group-by-group: each group is corrected separately.
- Electricity usage splitting:
  1. Temperature independent: the correction is applied only on the load not depending on temperature;
  2. Full load: the correction is applied on the full load (temperature dependent and independent).

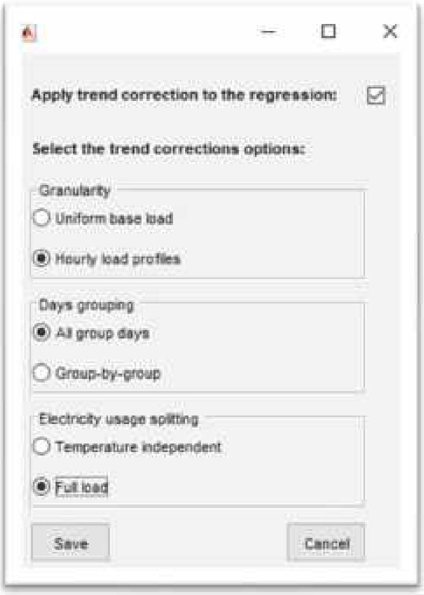


Figure 20 : Selection of trend correction settings

Herein after the Days grouping for Algeria, Tunisia and Turkey are given:

4.3.1.1. Algeria – all years using De-Trend function

Figure 21 :All year training - Algeria

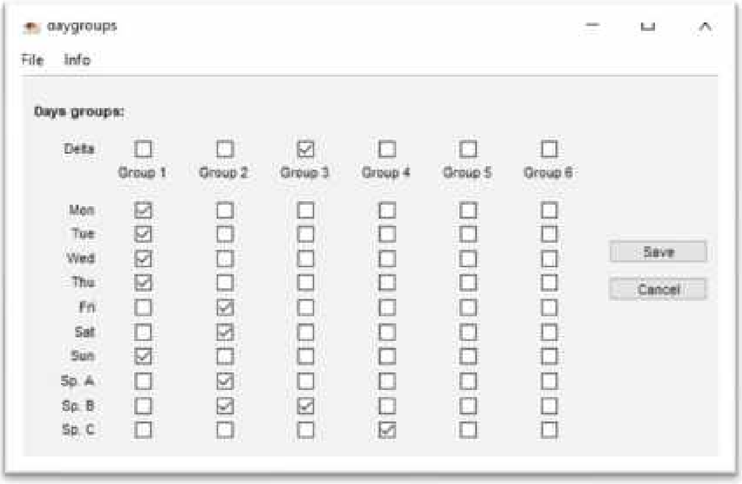


Figure 22 : Day-Grouping definition - Algeria

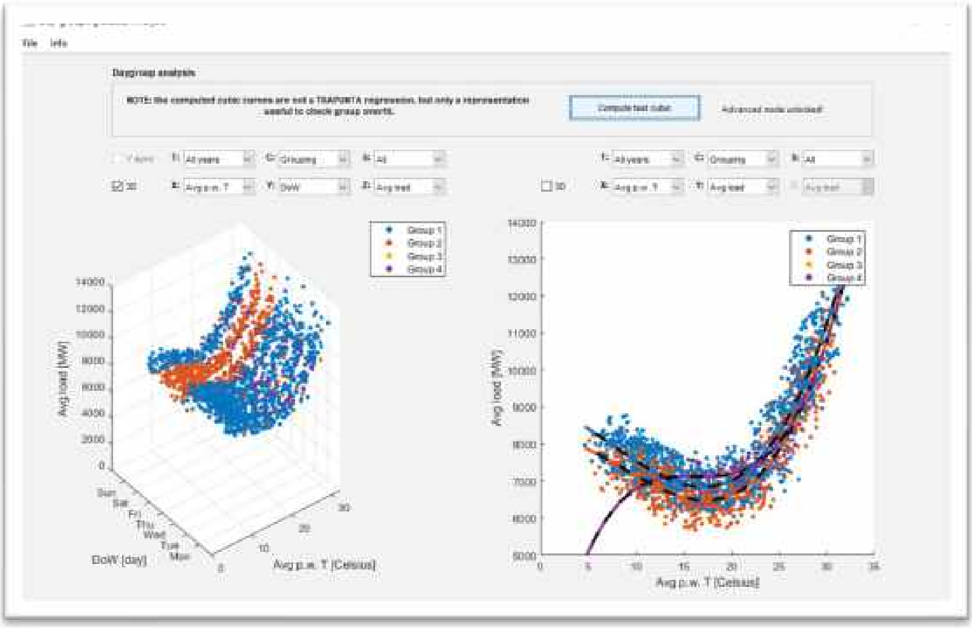


Figure 23 : Day Grouping - Scatter Analysis for Algeria

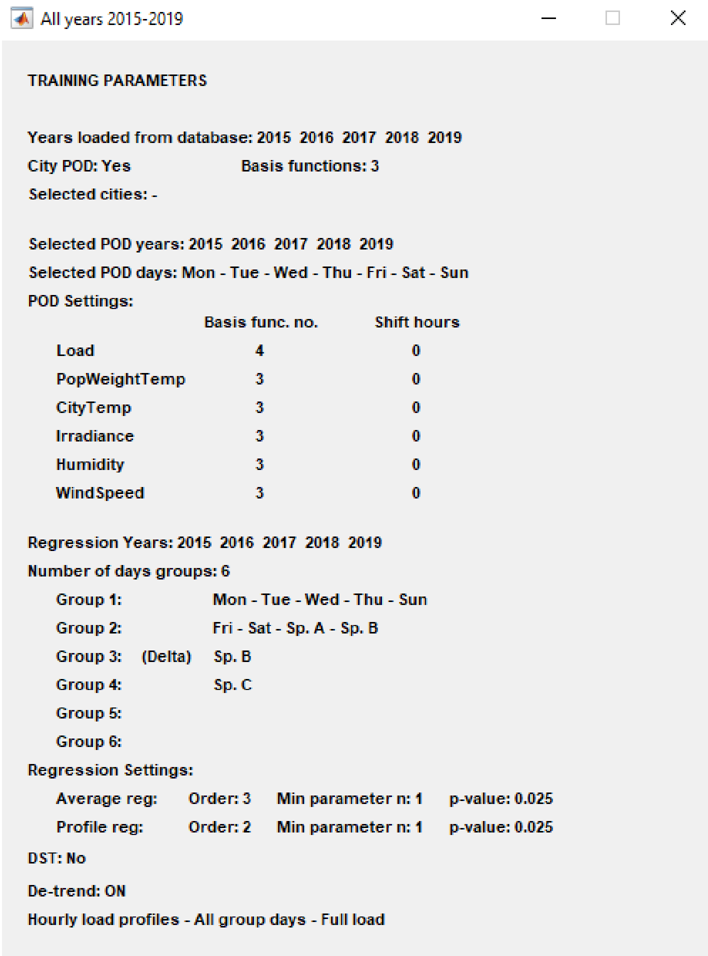


Figure 24 : Training Parameters synthesis - Algeria

4.3.1.2. Tunisia – all years using De-Trend function

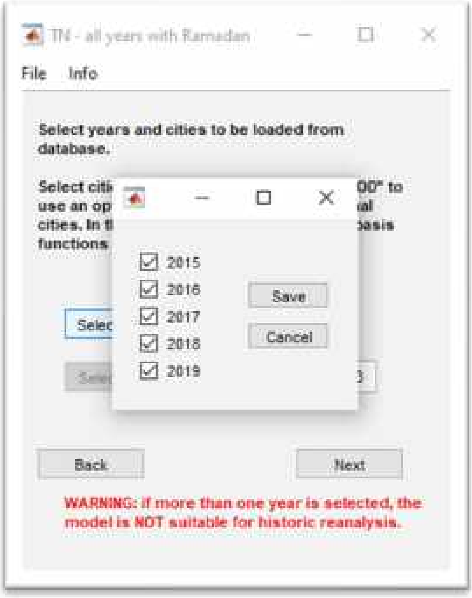


Figure 25 :All year training - Tunisia

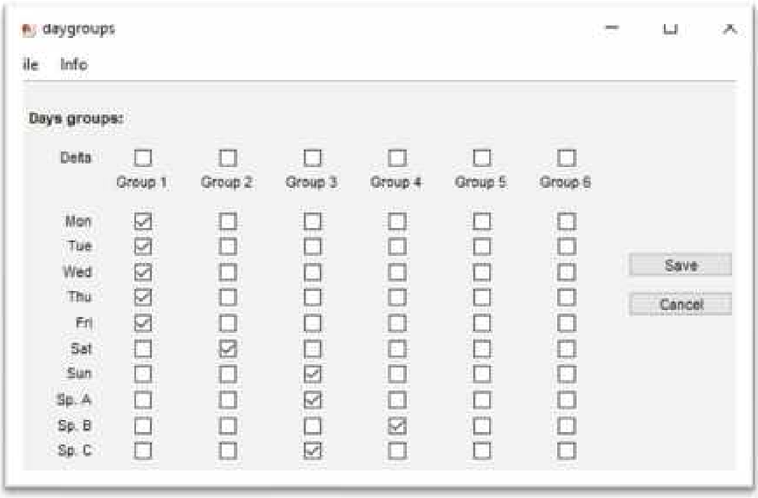


Figure 26 : Day-Grouping definition - Tunisia

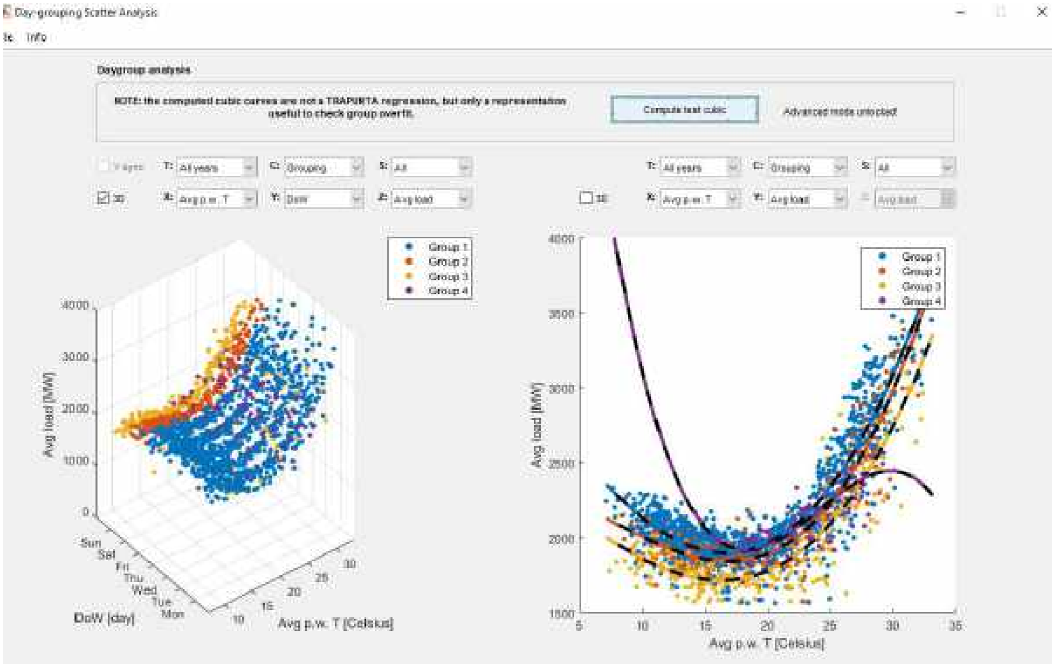


Figure 27 : Day Grouping - Scatter Analysis for Tunisia

TN - all years with Ramadan

TRAINING PARAMETERS

Years loaded from database: 2015 2016 2017 2018 2019
City POD: Yes   Basis functions: 3
Selected cities: -

Selected POD years: 2015 2016 2017 2018 2019
Selected POD days: Mon - Tue - Wed - Thu - Fri - Sat - Sun
POD Settings:

	Basis func. no.	Shift hours
Load	4	0
PopWeightTemp	3	0
CityTemp	3	0
Irradiance	3	0
Humidity	3	0
WindSpeed	3	0

Regression Years: 2015 2016 2017 2018 2019
Number of days groups: 6

Group 1:	Mon - Tue - Wed - Thu - Fri
Group 2:	Sat
Group 3:	Sun - Sp. A - Sp. C
Group 4:	Sp. B
Group 5:	
Group 6:	

Regression Settings:

Average reg:	Order: 3	Min parameter n: 1	p-value: 0.025
Profile reg:	Order: 2	Min parameter n: 1	p-value: 0.025

DST: No
De-trend: ON
Hourly load profiles - All group days - Full load

Figure 28 : Training Parameters synthesis - Tunisia

4.3.1.3. Turkey – all years using De-Trend function

The training phase of TRAPUNTA is performed for Turkey by considering six different types of Special days:

- Special A Monday (and similar days, for example first day after holiday)
- Special B Saturday (and similar days, for example bridge days)
- Special C Sunday (and similar days, for example National Day)
- Special D Ramazan Bayrami & Kurban Bayrami (lower days)
- Special E Ramazan Bayrami & Kurban Bayrami (intermediate lower days)
- Special F Other holidays and untypical days (to be discarded in forecast and replaced by similar special day)

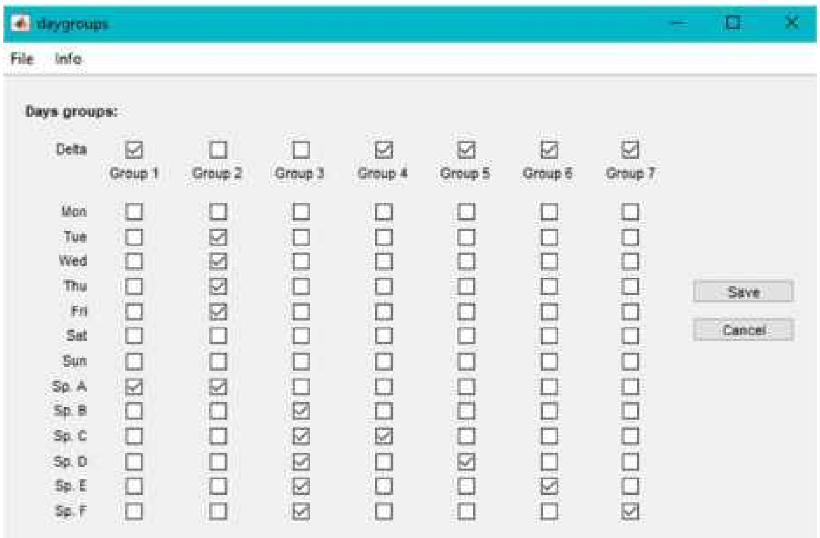


Figure 29 : Day-Grouping definition - Turkey

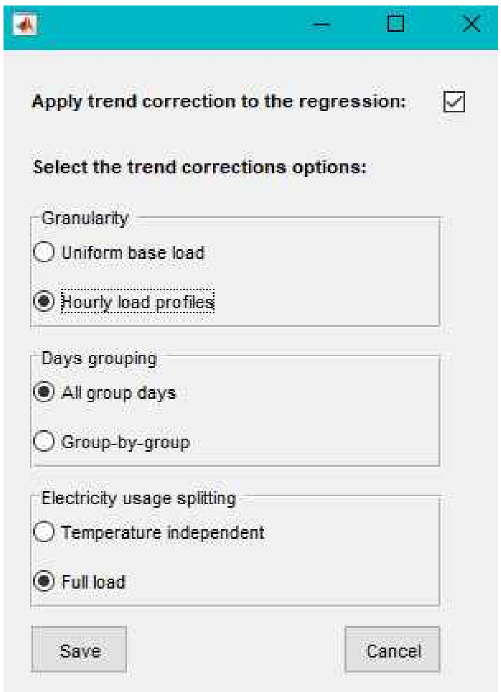


Figure 30 : De-Trend parameters - Turkey

4.3.2. Training results

Once the regression is finished, TRAPUNTA allows to save the forecast model as a mat file (standard output file of Matlab), which in turn allows to reuse this forecast model without having each time to recalculate it.

In the first tab of results window, the real load profile and the reconstructed profile can be visually compared by selecting specific days in the training set. Reconstructed and predicted results are also available as daily, monthly and yearly profiles. The tool will show the prediction interval with the 95% confidence.

The second tab of the window reports:

- the regressors selected by the automatic procedure for the average load and for the basis functions for the load profile (the variables in the forecast model);
- some figures of merit for assessing the regression, for example the R^2 adjusted, RMSE (Root Mean Square Error) of the daily average, minimum and maximum electrical load, L^2 RMSE (Root Mean Square Error in L2 norm) of the electrical load profile.

The following graphs illustrate the main training results for both Algeria and Tunisia.

4.3.2.1. Algeria – all years Training results

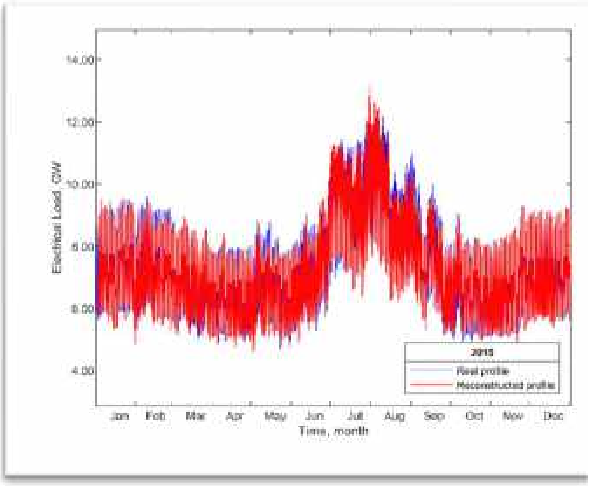


Figure 31 : DZ - reconstructed load profile vs real load profile - 2015

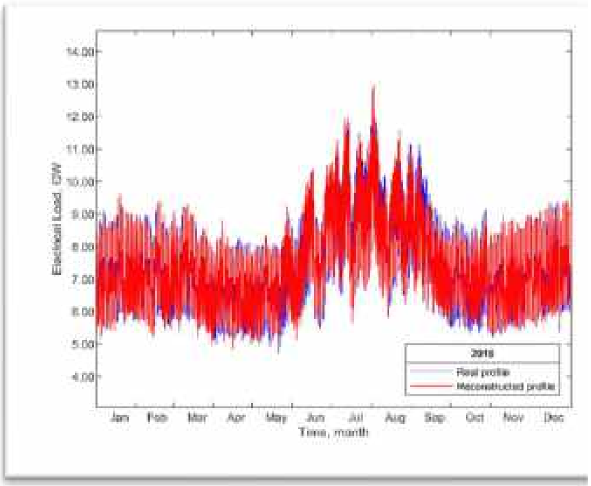


Figure 32: DZ - reconstructed load profile vs real load profile - 2016

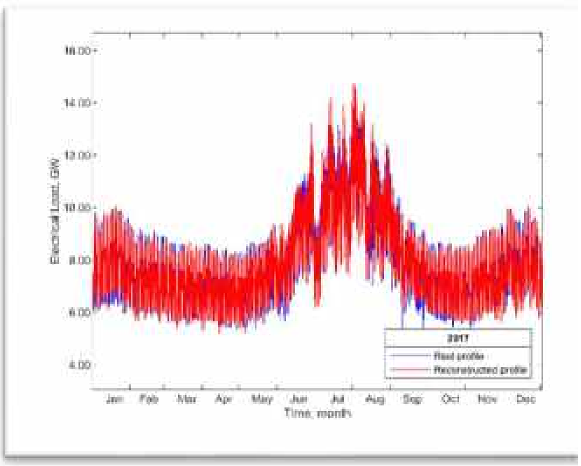


Figure 33 : DZ - reconstructed load profile vs real load profile - 2017

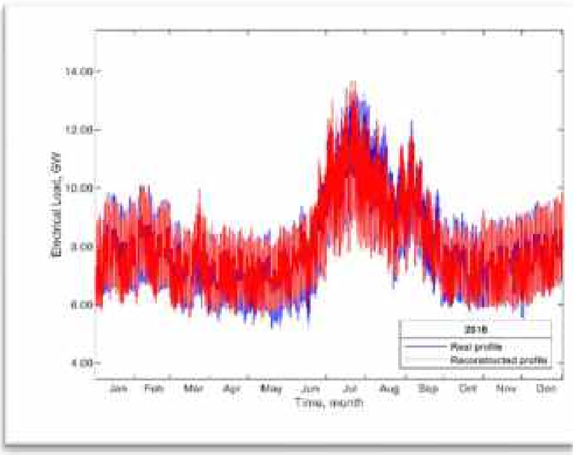


Figure 34 : DZ - reconstructed load profile vs real load profile - 2018

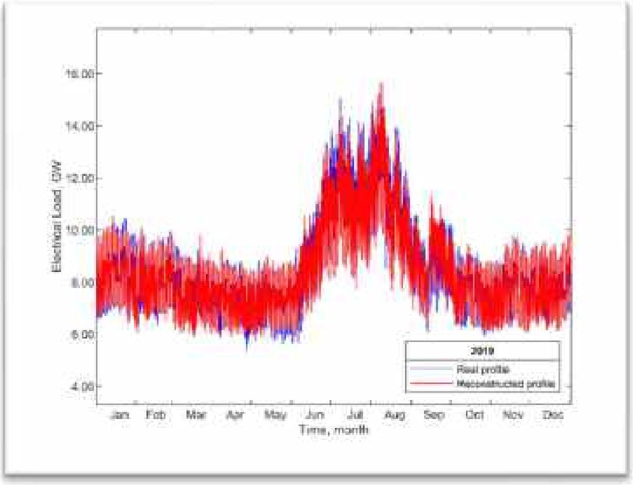


Figure 35 : DZ - reconstructed load profile vs real load profile - 2019

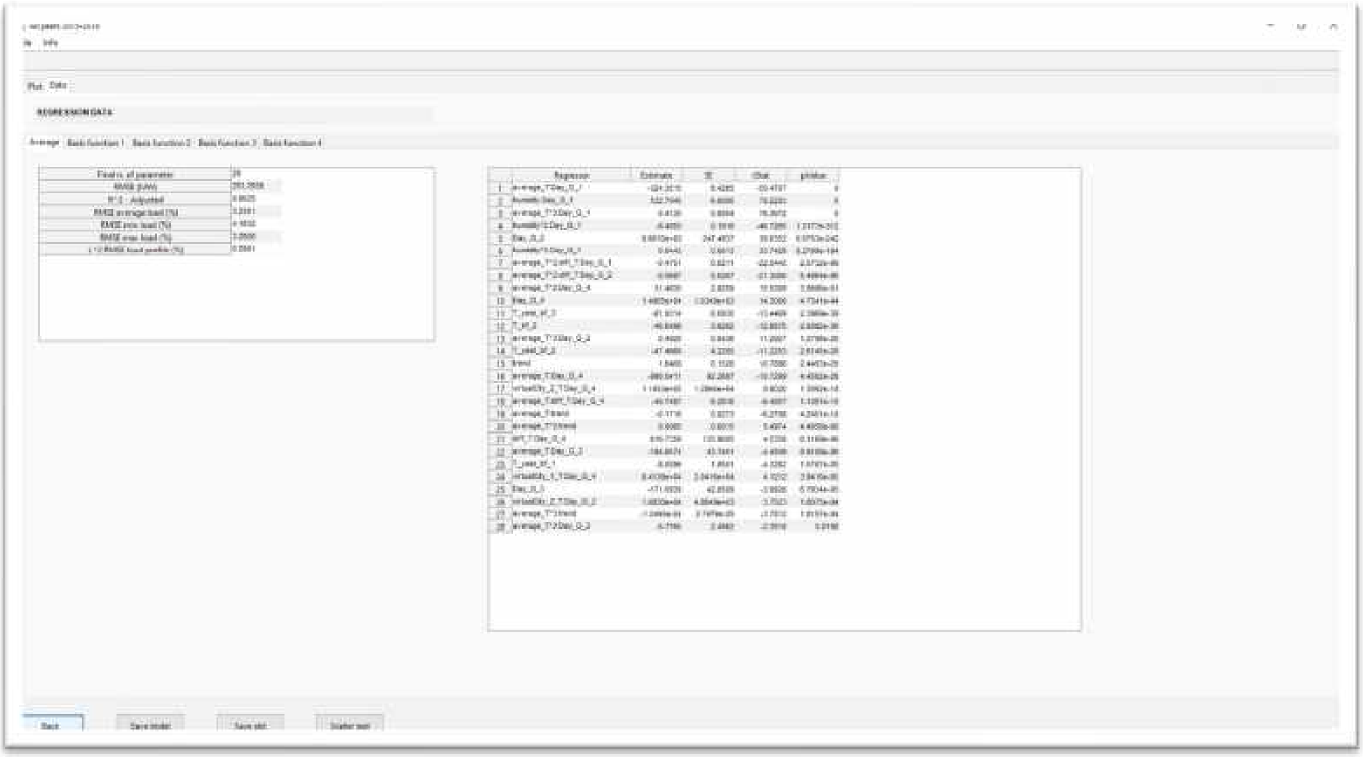


Figure 36 : DZ – Results window – Data Tab

From the graphs we can notice the almost perfect superposition between the blue curve (historical consumption profile) and the red curve (reconstructed consumption profile), and this for all the years from 2015 to 2019.

Figure 36 give us a detailed comparison between the two profiles where the Root Mean Square deviation (RMSE) did not exceed 3.5%.

4.3.2.2. Tunisia – all years Training results

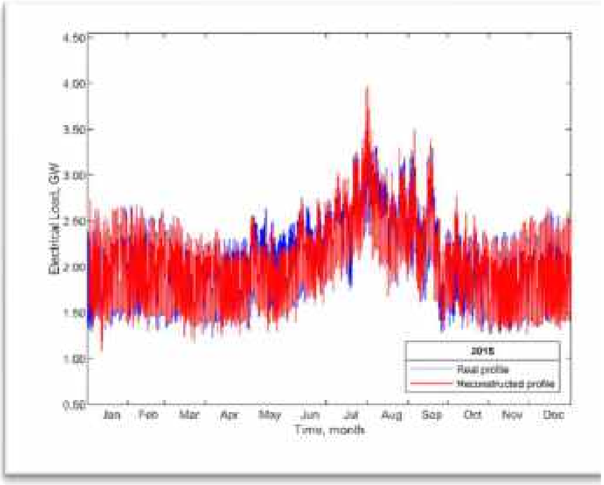


Figure 37 : TN - reconstructed load profile vs real load profile - 2015

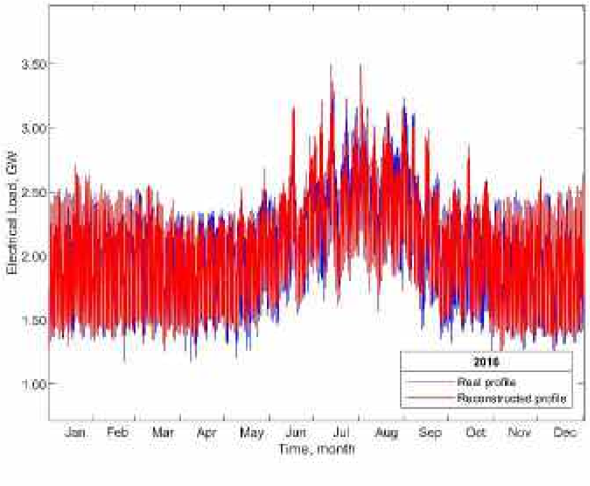


Figure 38: TN - reconstructed load profile vs real load profile - 2016

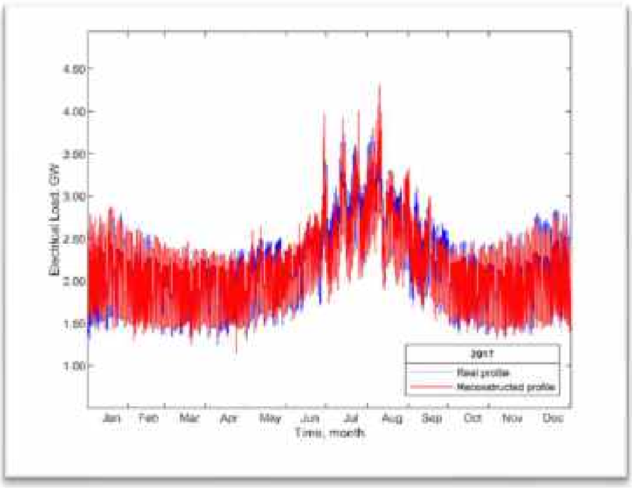


Figure 39 : TN - reconstructed load profile vs real load profile - 2017

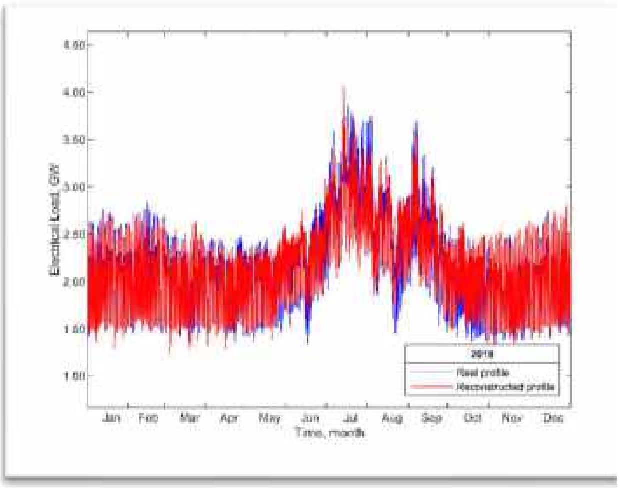


Figure 40 : TN - reconstructed load profile vs real load profile - 2018

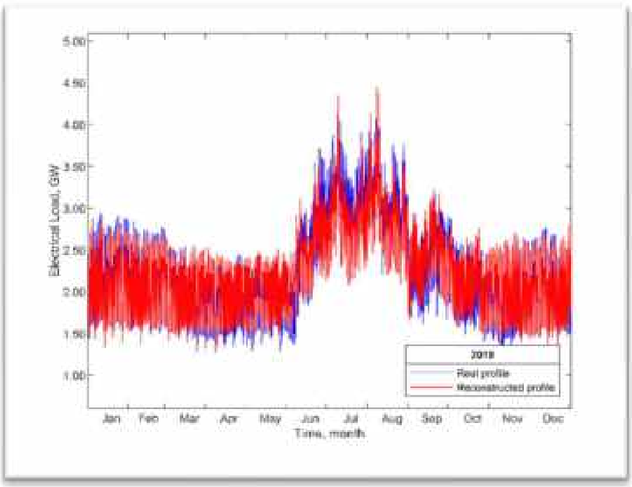


Figure 41 : TN - reconstructed load profile vs real load profile - 2019

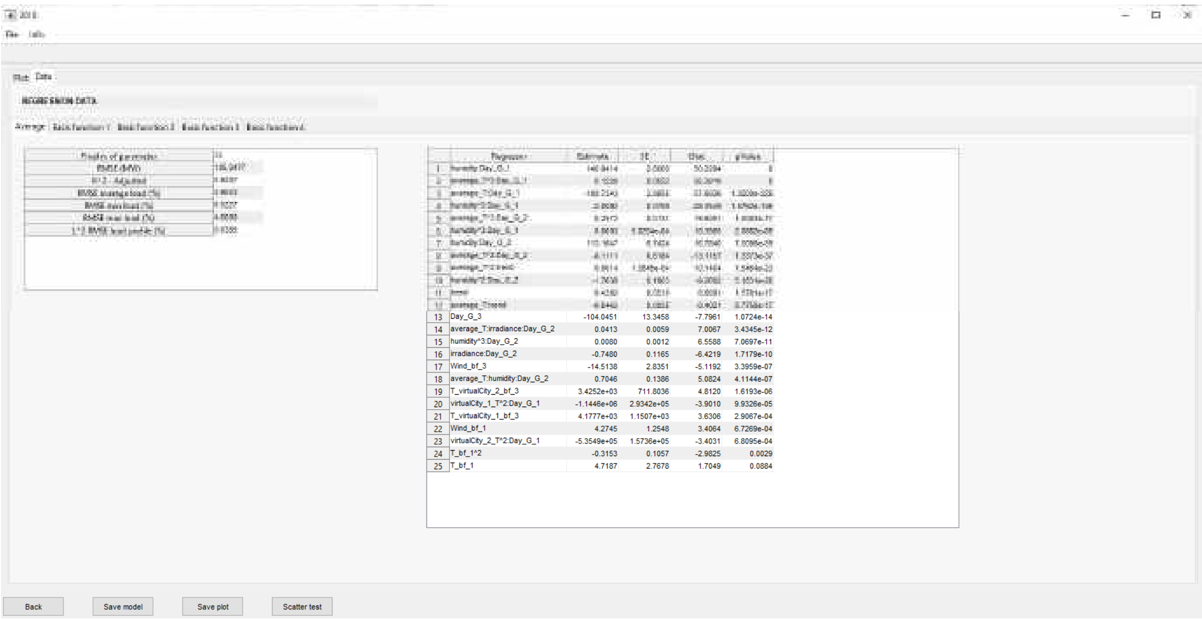


Figure 42 : TN – Results window – Data Tab

From the graphs we can notice the almost perfect superposition between the blue curve (historical consumption profile) and the red curve (reconstructed consumption profile), and this for all the years.

Figure 42 give us a detailed comparison between the two profiles where RMSE was still around 4% for all the years.

4.3.2.3. Turkey – all years Training results

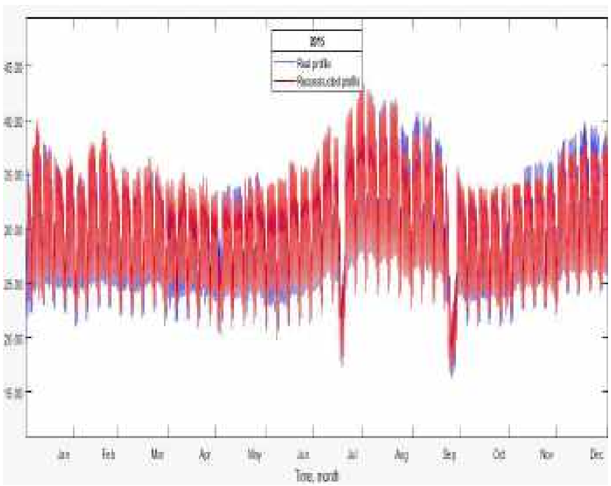


Figure 44 : Turkey - reconstructed load profile vs real load profile - 2015

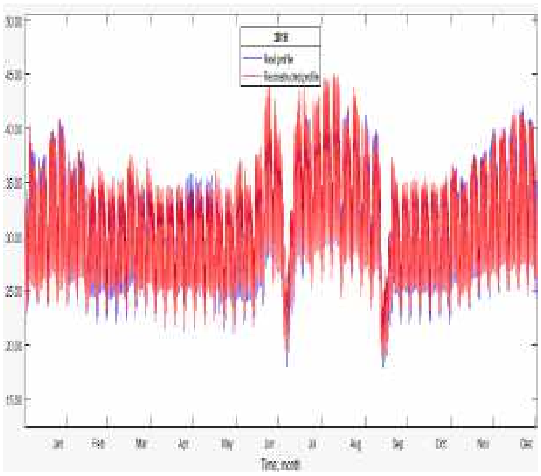


Figure 43 : Turkey - reconstructed load profile vs real load profile - 2016

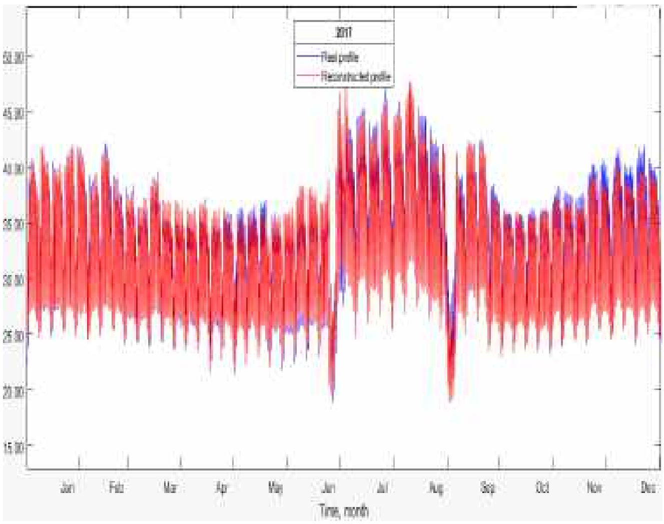


Figure 46 : Turkey - reconstructed load profile vs real load profile - 2017

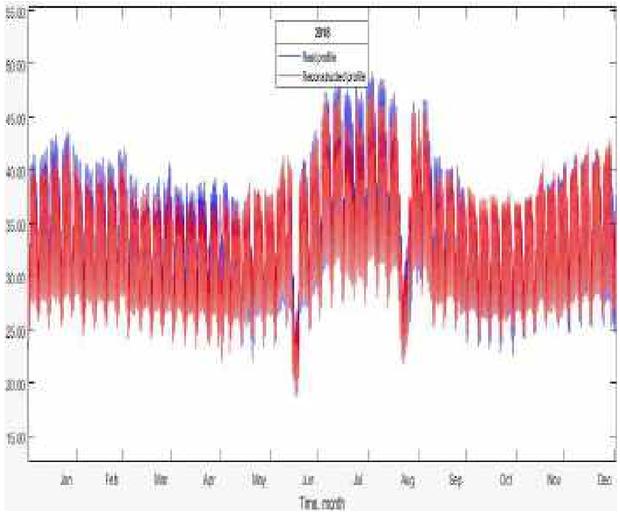


Figure 45 : Turkey - reconstructed load profile vs real load profile - 2018

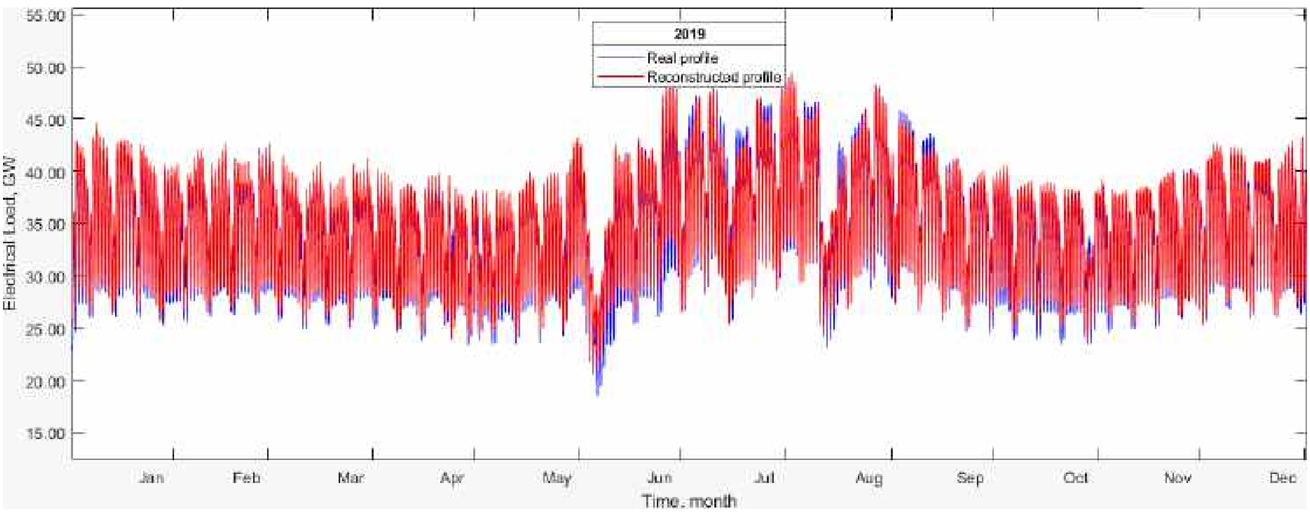


Figure 47 : Turkey - reconstructed load profile vs real load profile - 2019

REGRESSION DATA

Average | Basis function 1 | Basis function 2 | Basis function 3 | Basis function 4

Final n. of parameter	28
RMSE (MW)	876.2991
R^2 - Adjusted	0.9388
RMSE average load (%)	2.6602
RMSE min load (%)	3.7405
RMSE max load (%)	2.8155
L^2 RMSE load profile (%)	0.1627

Figure 48 : Turkey – Regression Performance indicators

From the graphs we can notice the almost perfect superposition between the blue curve (historical consumption profile) and the red curve (reconstructed consumption profile), and this for the years 2015, 2016, 2017 and 2019. The year 2018 modelling presents that shows the De-Trend function doesn't perfectly manage the annual growth for this year. The possible explanation is that the demand growth in Turkey was not linear at the end of the period considered for training.
However, it is expected this issue would not affect the performance of forecasting.

Figure 48 give us a detailed comparison between the two profiles where RMSE is around 2.6% of the average load.

4.4. Historical electrical load analysis

In order to realize a good forecast on a short-term horizon, it is necessary to perform a precise analysis of the consumptions over a recent history and covering several years.
The historical reanalysis module gives the possibility to compare the historical load with the load calculated with normalized climatic variables, for each year of the reanalysis.
For this purpose, we firstly need to create a normalized year profile for all the climatic variable, which is possible in TRAPUNTA thanks to the functionality Normalized year that will create an average climatic year based on the data time series of the PECD.

Figure 49: TRAPUNTA interface - Normalized year

At the end of this process, the normalized year divided in the different climatic variables (normalized population weighted temperature, normalized city temperature, normalized irradiance, etc.) and can be used in the application of the forecast model to predict the electric load.

4.4.1. Historical analysis – Algeria

In the following sections we will present an example of the graphs obtained for the year 2019 in what concerns reconstructed load (real conditions) compared to the normalized load (normalized conditions or average of climate variable of all climatic years), and its decomposition on cooling and heating electricity usage.

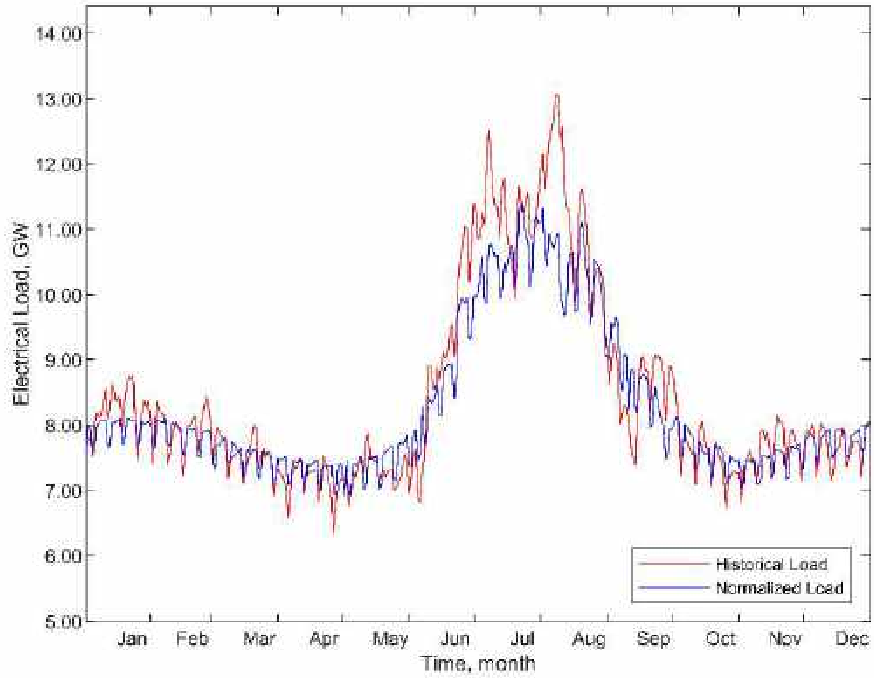


Figure 50 : Full load Reconstructed profile vs Normalized year profile - DZ

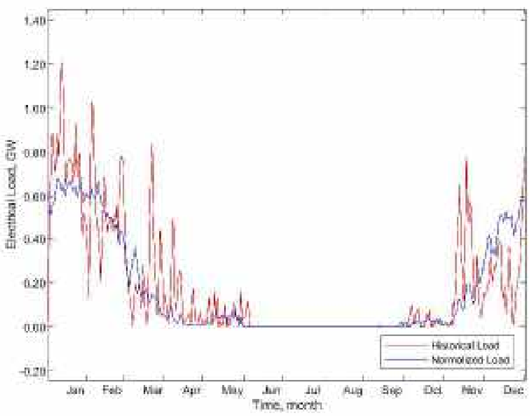


Figure 51 : Heating load Reconstructed profile vs Normalized year profile - DZ

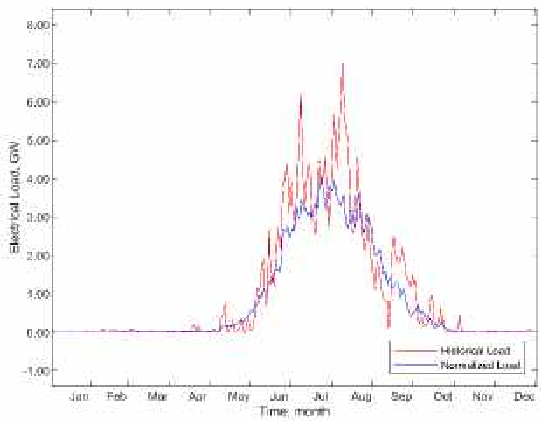


Figure 52 : : Cooling load Reconstructed profile vs Normalized year profile - DZ

4.4.2. Historical analysis – Tunisia

The same comparison is made for Tunisia and the same example of 2019 is given here in after.

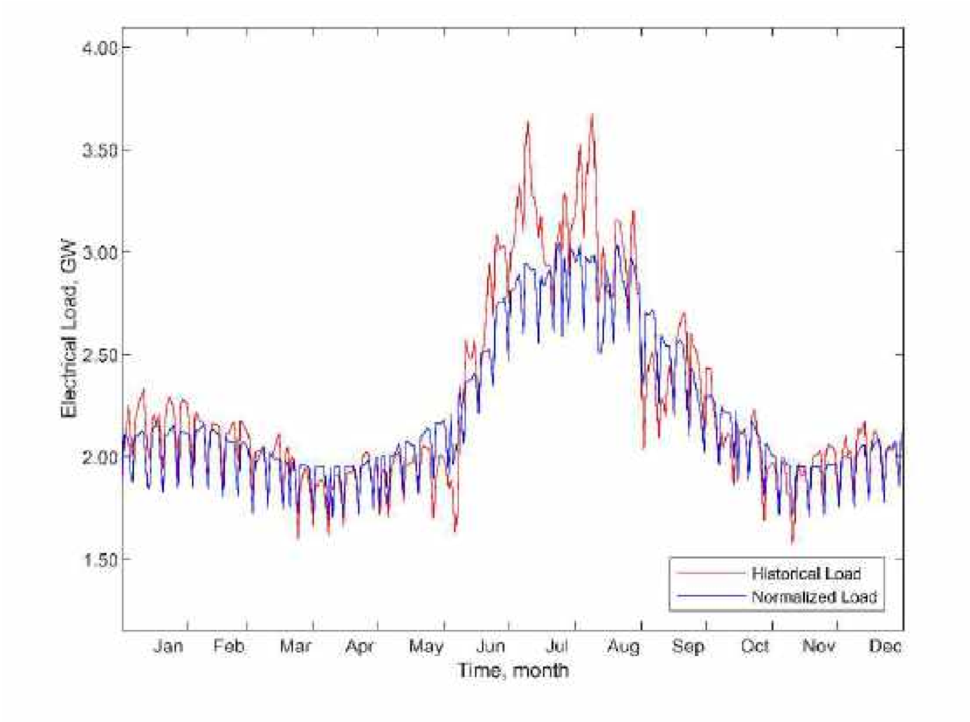


Figure 53 : Full load Reconstructed profile vs Normalized year profile – TN

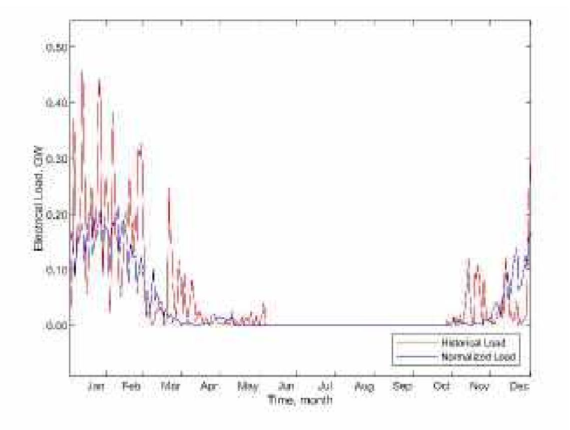


Figure 54 : Heating load Reconstructed profile vs Normalized year profile - TN

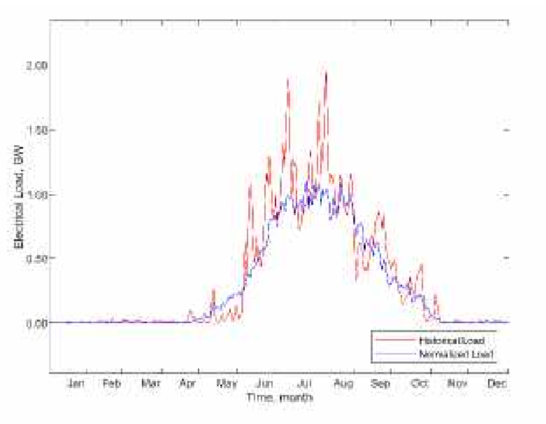


Figure 55 : Cooling load Reconstructed profile vs Normalized year profile - TN

4.4.3. Historical analysis – Turkey

The same comparison is made for Turkey and the same example of 2019 is given herein after.

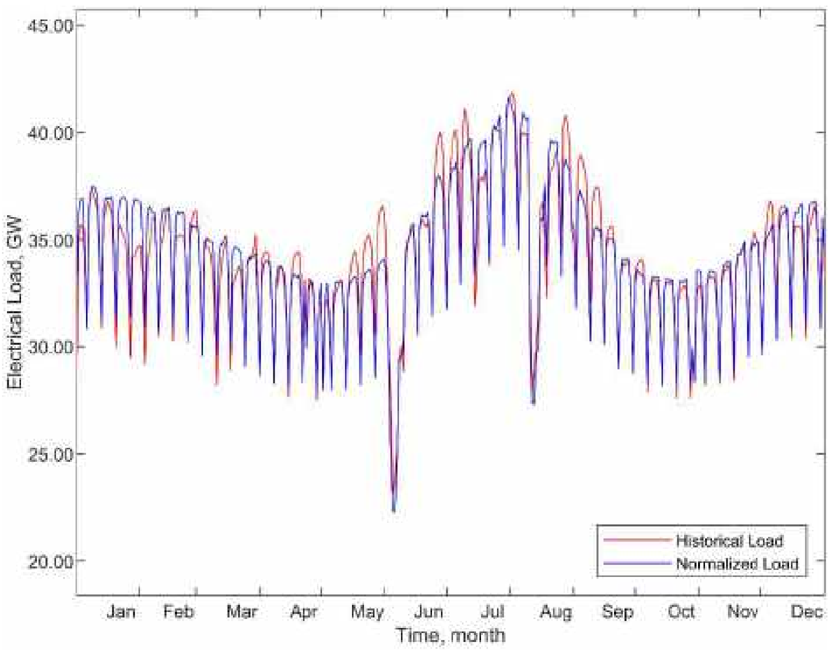


Figure 56 : Full load Reconstructed profile vs Normalized year profile - Turkey

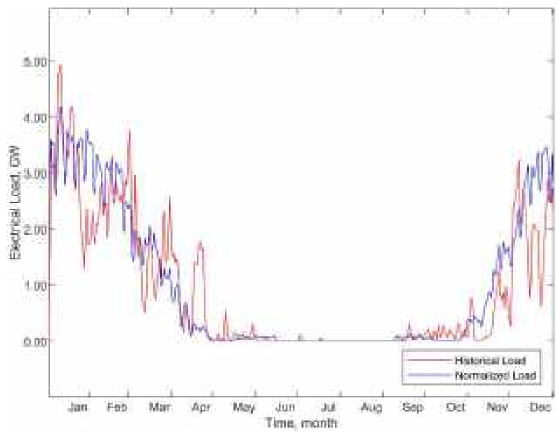


Figure 57 : Heating load Reconstructed profile vs Normalized year profile - Turkey

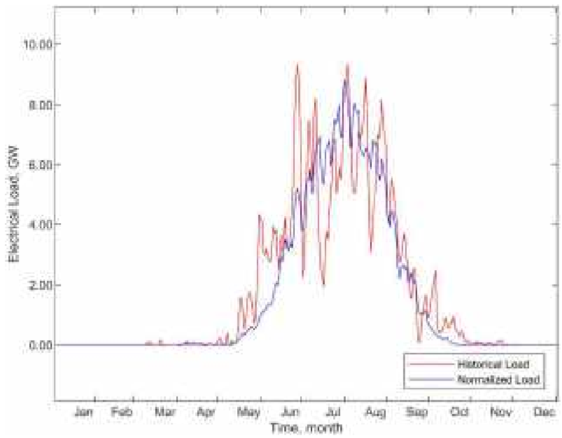


Figure 58 : Cooling load Reconstructed profile vs Normalized year profile - Turkey

4.4.4. Summary table

Table 3 : Historical analysis summary table - Algeria

Data		Year_2015	Year_2016	Year_2017	Year_2018	Year_2019	CAGR (%)
Total Load in real conditions (TWh)		*63,5*	*64,3*	*68,6*	*69,2*	*73,8*	*3,9 %*
From which electric heating (Winter period)		*2,0*	*1,0*	*1,4*	*1,5*	*1,6*	*-5,1 %*
From which air conditioning (Summer period)		*7,4*	*6,7*	*8,4*	*7,6*	*8,7*	*3,9 %*
Total T dependent load (TWh)		*9,4*	*7,7*	*9,8*	*9,1*	*10,3*	*2,2 %*
Share of T dependent load		*14,8 %*	*11,9 %*	*14,3 %*	*13,2 %*	*13,9 %*	
Share of T independent load		*85,2 %*	*88,1 %*	*85,7 %*	*86,8 %*	*86,1 %*	
annual load growth (%)	**Algeria**		*+ 1,4 %*	*+ 6,7 %*	*+ 0,9 %*	*+ 6,6 %*	
Peak load in real conditions (GW)		*12,4*	*12,8*	*14,2*	*13,7*	*15,7*	*6,05*
Total load in normalized conditions (TWh)		*62,1*	*64,2*	*66,7*	*69,2*	*72,2*	*3,8 %*
From which electric heating (Winter period)		*1,7*	*1,1*	*1,3*	*1,4*	*1,4*	*-4,2 %*
From which air conditioning (Summer period)		*6,4*	*6,5*	*6,7*	*7,7*	*7,1*	*2,9 %*
Annual load growth (%)			*+ 3,4 %*	*+ 3,9 %*	*+ 3,6 %*	*+ 4,3 %*	
Peak load in normalized conditions (GW)		*10,6*	*11,6*	*11,7*	*13,7*	*14,3*	*7,7 %*

- The electricity demand for heating (winter period) represents 1,4 TWh per year in 2019 in normal weather conditions. This figure is equal to 7,1 TWh for cooling (summer period).
- The temperature-dependent electricity usages show an increase around 2,9 % per year, that is lower than the growth of the full load contrary to Tunisia and Turkey. Consequently, the peak load in normal weather conditions increased 7,7% by year in average over the 5-year period when the energy demand increased 3,8 % by year.

Table 4 : Historical analysis summary table - Tunisia

Data		Year_2015	Year_2016	Year_2017	Year_2018	Year_2019	CAGR (%)
Total Load in real conditions (TWh)	Tunisia	18,0	17,9	18,9	18,9	19,8	2,3 %
From which electric heating (Winter period)		0,3	0,2	0,3	0,3	0,4	6 %
From which air conditioning (Summer period)		2,1	1,6	2,3	2,1	2,9	8,5 %
Total T dependent load (TWh)		2,4	1,8	2,6	2,4	3,3	8,1 %
Share of T dependent load		13,3 %	10 %	14,0 %	12,7 %	16,5 %	
Share of T independent load		86,8 %	90 %	86,0 %	87,3 %	83,5 %	
annual load growth (%)			-0,8	4,4	0,2	4,7	
Peak load in real conditions (GW)		3,6	3,4	4	3,9	4,2	4,1 %
Total load in normalized conditions (TWh)		17,7	18	18,6	18,9	19,3	2,2 %
From which electric heating (Winter period)		0,2	0,2	0,2	0,3	0,3	6,4 %
From which air conditioning (Summer period)		1,8	1,6	2,1	2,1	2,5	8 %
annual load growth (%)			+ 1,6 %	+ 2,9 %	+ 1,4 %	+ 2,3 %	
Peak load in normalized conditions (GW)		3,1	3,4	3,3	3,9	4	5,9 %

- The electricity demand for heating (winter period) represents 0,3 TWh per year in 2019 in normal weather conditions which is relatively neglected comparing to that for cooling (summer period) which is equal to 2,5 TWh.
- The temperature-dependent electricity usages show an increase of around 6,4 % per year, that is bigger than two times the growth of the full load.

Table 5 : Historical analysis summary table - Turkey

Data		Year_2015	Year_2016	Year_2017	Year_2018	Year_2019	CAGR (%)
Total Load in real conditions (TWh)		263,7	274,9	290,0	299,2	299,6	*3,2%*
From which electric heating (Winter period)		*6,9*	*7,6*	*7,0*	*8,8*	*7,7*	*2,8 %*
From which air conditioning (Summer period)		*11,8*	*11,9*	*13,2*	*13,2*	*14,9*	*6,0 %*
Total T dependent load (TWh)		*18,7*	*19,5*	*20,2*	*22,1*	*22,6*	*4,8 %*
Share of T dependent load		*7,1 %*	*7,1 %*	*7,0 %*	*7,4 %*	*7,5 %*	
Share of T independent load		*92,9 %*	*92,9 %*	*93,0 %*	*92,6 %*	*92,5 %*	
annual load growth (%)	**Turkey**		*+ 4,3 %*	*+ 5,5 %*	*+3,2 %*	*+0,1 %*	
Peak load in real conditions (GW)		42,5	44,3	47,1	49,3	49,0	*3,6 %*
Total load in normalized conditions (TWh)		262,2	272,9	287,6	298,6	299,4	*3,4 %*
From which electric heating (Winter period)		*6,8*	*7,7*	*6,3*	*9,0*	*8,7*	*6,4 %*
From which air conditioning (Summer period)		*10,5*	*9,9*	*11,5*	*12,4*	*13,7*	*7,0 %*
annual load growth (%)			*+ 4,1 %*	*+ 5,4 %*	*+ 3,8 %*	*+ 0,3 %*	
Peak load in normalized conditions (GW)		40,2	41,9	44,3	48,0	48,0	*4,5 %*

- In four years from 2015 to 2019, the electricity demand corrected from weather hazard in Turkey increased by 3.4% per year (in average). The growth was higher during the two first years, and lower during the two latest years.
- The electricity demand for heating (winter period) represents 8-9 TWh per year in 2019 in normal weather conditions. This figure is equal to 13-14 TWh for cooling (summer period).
- The temperature-dependent electricity usages show an increase around 6-7 % per year, that is two times the growth of the full load. It does mean the Power system becomes increasingly weather-dependent. Consequently, the peak load in normal weather conditions increased 4,5% by year in average over the 5-year period when the energy demand increased 3,4 % by year.

From the previous tables, it is obvious that the impact of the climatic and weather variables is high on the maximum peak load value, while its impact on the annual energy consumption is less remarkable. For example, average Algerian real load is 1,4% higher than Algerian normal load, whereas average Algerian real peak load is 11,4% higher than Algerian peak load in normal conditions.
On the other hand, and while comparing the evolution from one year to the other, we can notice, both for Algeria and Tunisia, that the weather conditions 2018 are very close to the normalized year weather condition, with this fact explaining why we faced a reduction in the peak load value in comparison to 2017 with a lower trend of energy increase.

4.5. Electrical load Forecast

Once the forecast model is created, it can be used for electric load prediction. This prediction can be done in TRAPUNTA based on a pre-selected set of climatic data/variables. The tool also allows the creation of a typical choice for these climatic data so-called normalized year, which consists on a year featuring climatic data that are the average over the available set of yearly climatic data.

4.5.1. Forecast adjustments

During the training phase described in §4.3 of this report, we noticed that regressions performed using the trend correction functionality are accurate compared with the old training method. In fact, it allows a better representation from the tool to the special days such as normal holidays, religious holidays and Ramadan. This is due to the fact that when using several years for the training, the tool has a sufficient number of days per each defined category, which is better for the regression. This was the reason why, when performing the forecast, we used the 5 years training models.
When performing the forecast for a future time horizon (2020 for this exercise), the tool makes a prediction based on the introduced climatic variables and calendar variables.

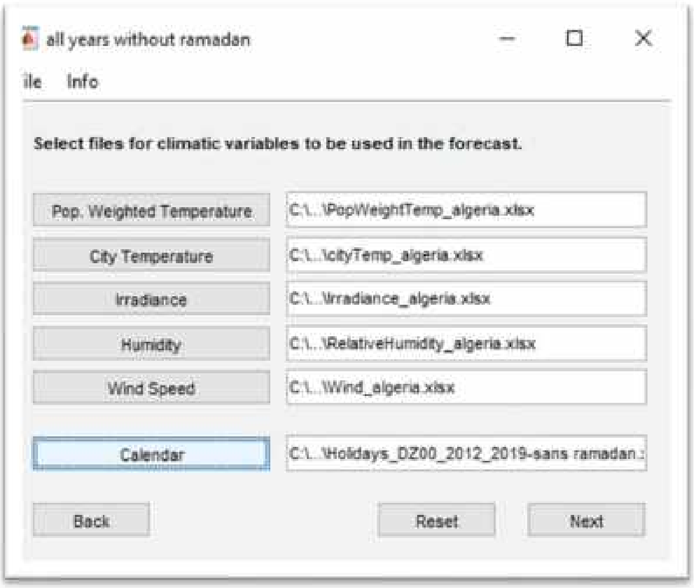


Figure 59 : Input definition for forecast

It is also necessary to correct the prediction based on information and estimates about other load components. In particular, it is possible to include predictions on:

- ✓ electric vehicles,
- ✓ sanitary water,
- ✓ air conditioning fraction,
- ✓ air conditioning load,
- ✓ heating heat pumps fraction,
- ✓ heating heat pumps load,
- ✓ batteries impact,
- ✓ additional base loads,
- ✓ energy demand increase.

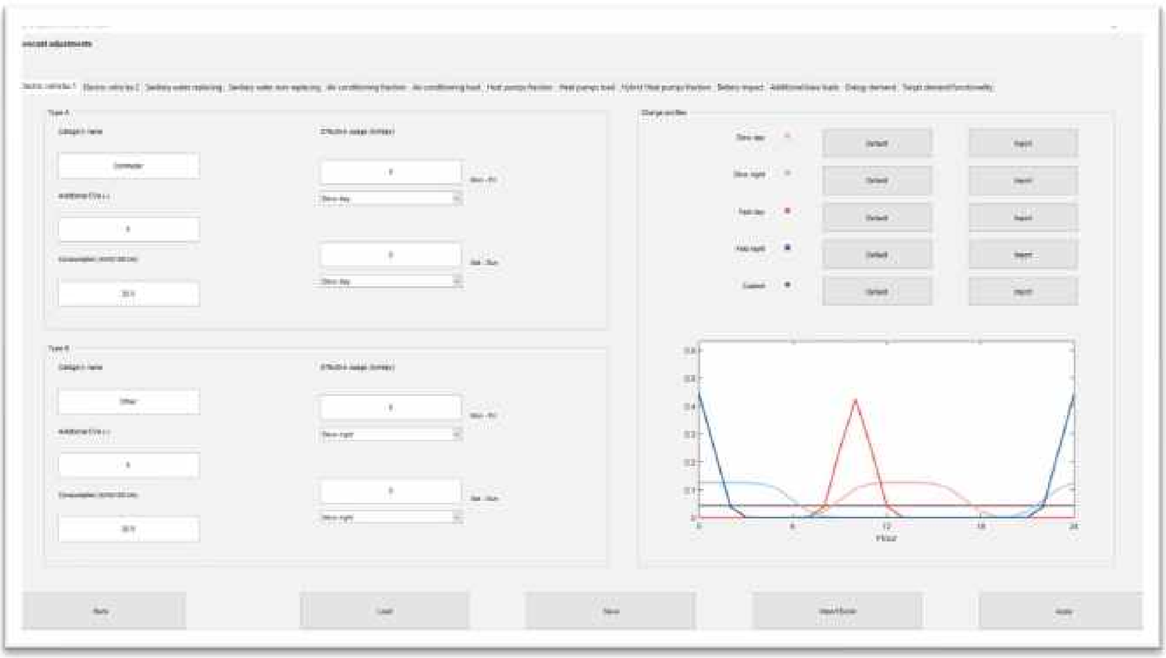


Figure 60 : Forecast adjustments interface

For the test zone countries, the forecast was performed using the trend or Compound Annual Growth Rate (CAGR) identified for all the countries in §4.4.
The following table shows the parameters introduced into the forecast adjustments table for both countries.

Table 6 : Set of parameters introduced to the forecast adjustments model

		total CAGR (%)	Share in the total load (%)	CAGR decomposition (%)
Algeria	T-dependent	3,86	13,62	0,53
	T-independent		86,38	3,33
Tunisia	T-dependent	2,34	13,3	0,312
	T-independent		86,7	2,03

4.5.2. Main results

The main results obtained for the forecast related to the year 2020 with reference to 20 climatic years from 2000 to 2019 is presented with a focus on the maximum and minimum load, their day and hour of appearance together with the predicted energy consumption.
The following tables and graphs summarize those aspects for what concerns Algeria, Tunisia and Turkey.

4.5.2.1. Algeria forecast results

Table 7 : DZ - 2020 Load forecast among 20 climatic years

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Energy (TWh)		74,3	75,0	73,3	76,4	74,4	75,3	75,1	74,4	75,1	75,6	74,0	75,0	77,1	73,8	74,7	75,8	74,5	76,5	74,4	75,7
Peak load	**Value (MW)**	14689	15112	14541	15966	15156	15058	14131	14121	14952	16744	15710	15852	15902	15139	14617	15743	14236	16173	14950	15640
	Date hour	02/07 15h	30/07 15h	22/07 15h	22/07 15h	24/08 15h	16/07 15h	28/07 15h	26/08 15h	13/08 15h	23/07 15h	23/07 15h	12/07 15h	14/07 15h	27/07 15h	11/08 15h	30/07 15h	30/07 15h	02/08 15h	20/07 15h	09/08 15h
Mini-mum load	**Value (MW)**	5719	5832	5975	5949	5947	5917	5972	5970	5843	5969	5735	5594	5988	5845	6012	5972	5867	5966	6015	5923
	Date hour	25/04 7h	24/04 7h	25/05 7h	25/04 7h	02/05 7h	08/05 7h	05/06 7h	09/05 7h	07/04 7h	08/05 7h	09/05 7h	02/05 5h	09/05 7h	24/05 7h	24/05 7h	01/05 7h	30/03 4h	01/05 7h	23/05 7h	15/05 7h

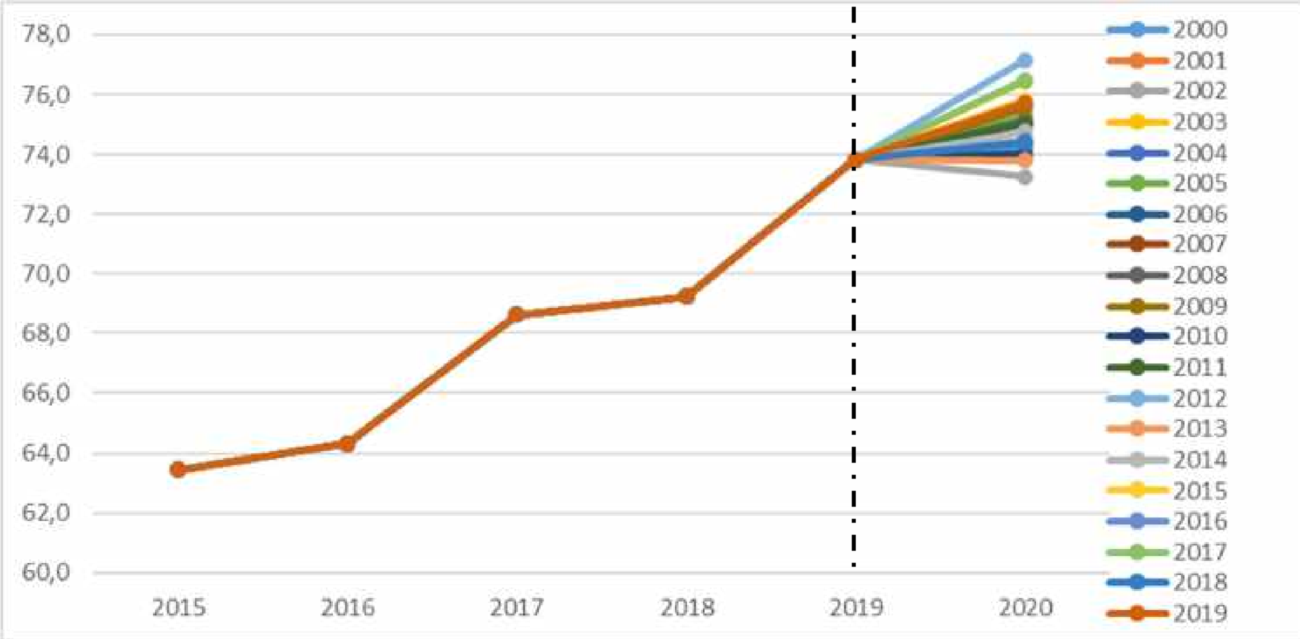


Figure 61 : DZ – Energy (TWh) among the years with 20 possible forecasts for 2020

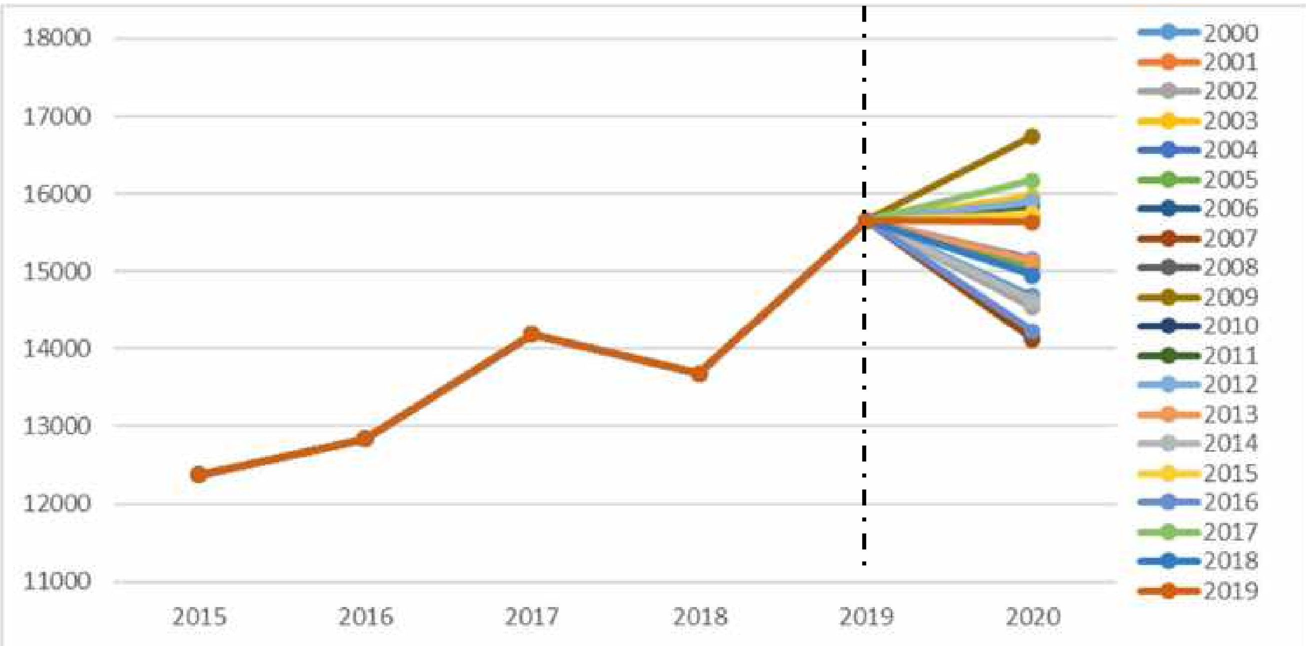


Figure 62 : DZ – Peak load (MW) among the years with 20 possible forecasts for 2020

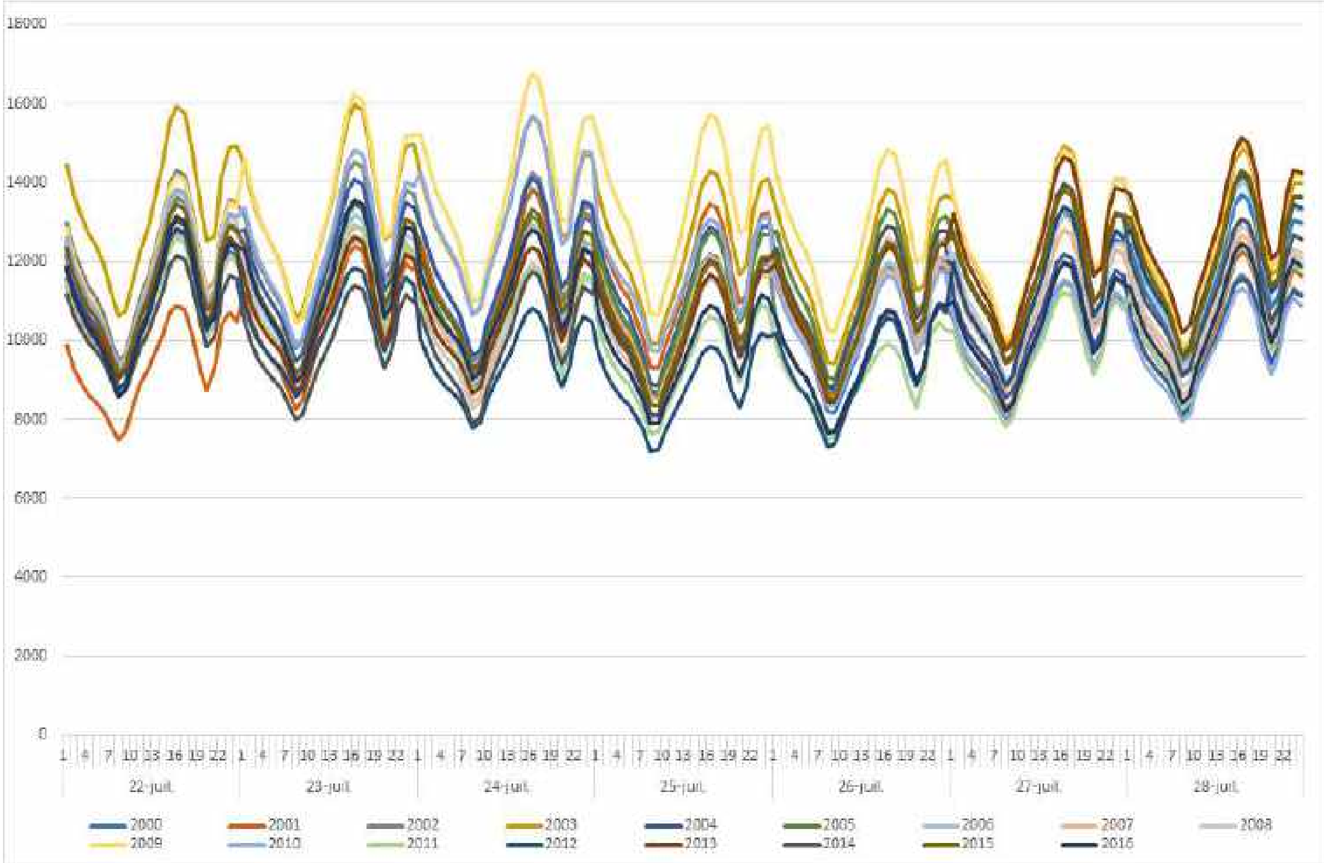


Figure 63 : DZ - Predicted load curve shape during a week in summer (MW)

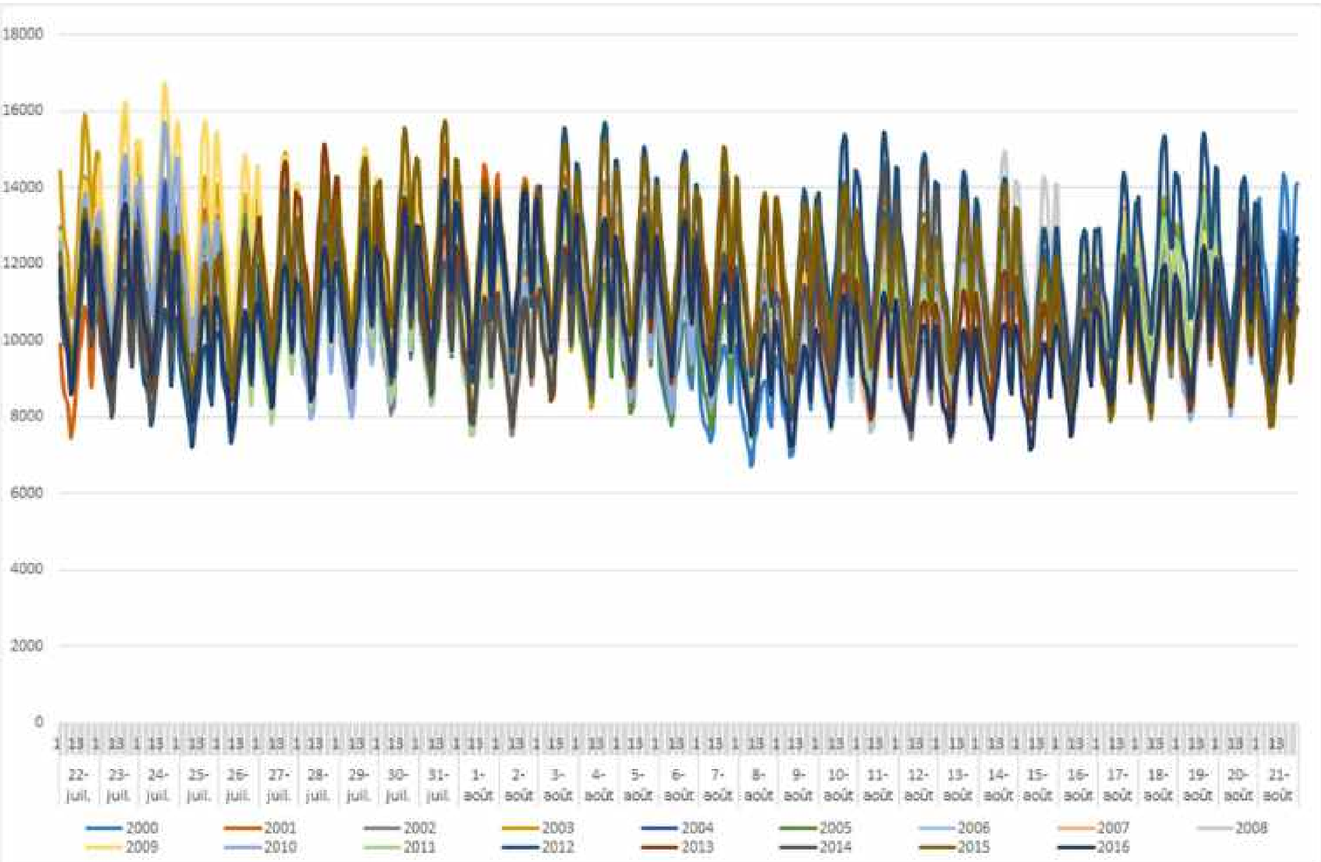


Figure 64 : DZ - Predicted load curve shape during a month in summer (MW)

4.5.2.2. Tunisia forecast results

Table 8 : TN - 2020 Load forecast among 20 climatic years

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Energy (TWh)		19,80	19,87	19,70	20,62	19,75	20,01	20,01	19,82	20,02	19,99	19,75	19,78	20,61	19,84	20,02	20,18	19,71	20,10	19,77	20,20
Peak load	**Value (MW)**	4119	3877	4214	4595	4246	4083	3997	4267	3996	4087	4372	4138	4404	3715	3771	4330	3723	4418	4199	4487
	Date hour	31/08 13h	19/08 13h	06/08 13h	30/06 13h	10/08 13h	10/08 13h	19/08 13h	25/06 13h	07/07 13h	25/08 13h	23/07 13h	02/09 13h	05/08 13h	07/08 13h	21/09 13h	30/07 13h	10/07 13h	23/07 13h	13/07 13h	07/08 13h
Mini-mum load	**Value (MW)**	1321	1307	1160	1372	1368	1356	1373	1322	1336	1368	1306	1340	1382	1318	1325	1363	1320	1347	1250	1269
	Date hour	01/03 2h	23/02 02h	01/03 3h	19/04 3h	12/01 2h	29/11 1h	01/03 2h	09/02 2h	29/11 2h	01/05 3h	01/01 2h	22/11 2h	15/10 3h	22/11 2h	19/04 3h	22/03 3h	12/04 4h	20/03 3h	29/10 23h	25/04 4h

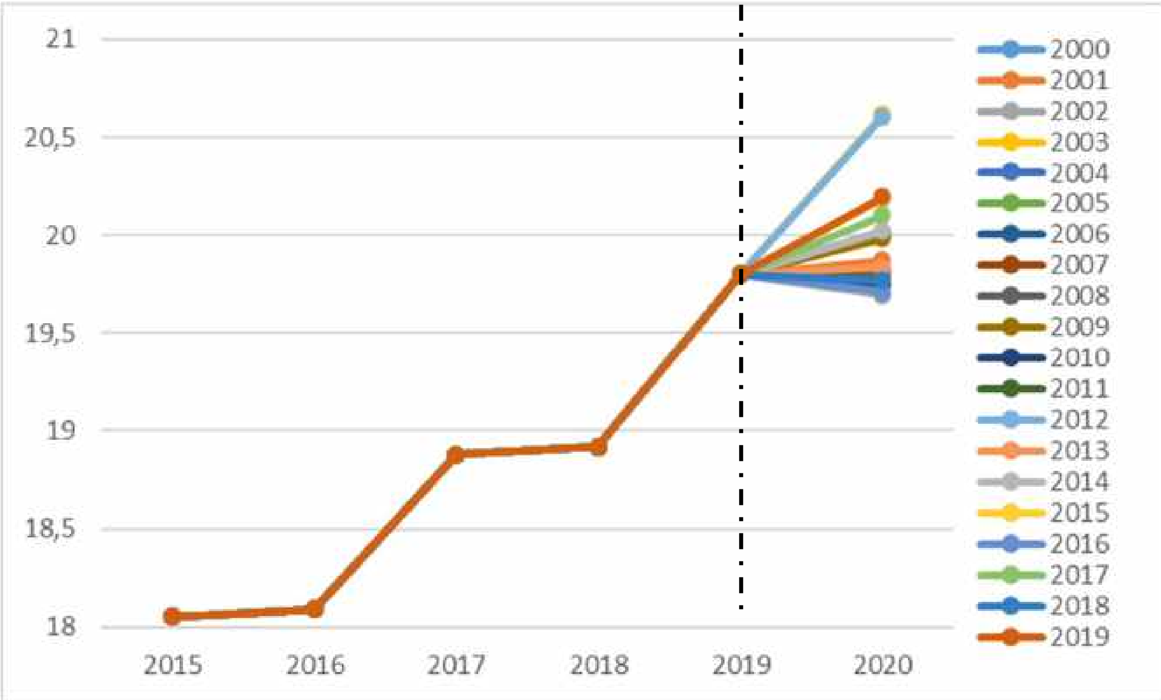


Figure 65: TN – Energy (TWh) among the years with 20 possible forecasts for 2020

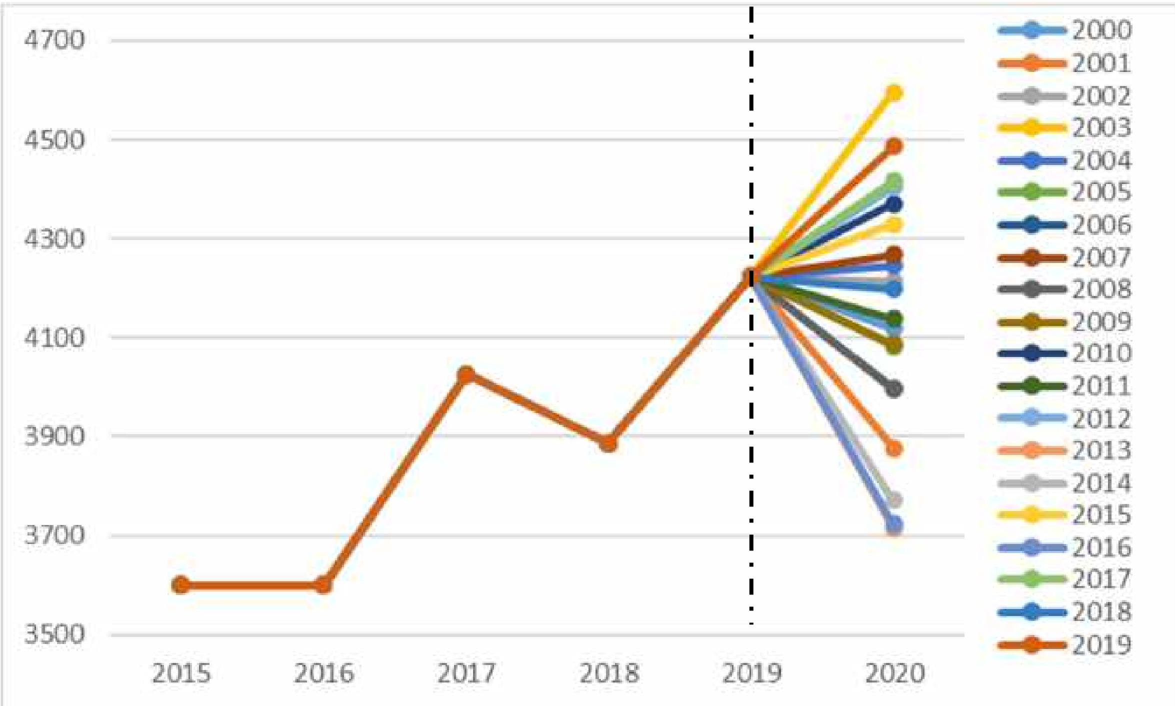


Figure 66 : TN – Peak load (MW) among the years with 20 possible forecasts for 2020

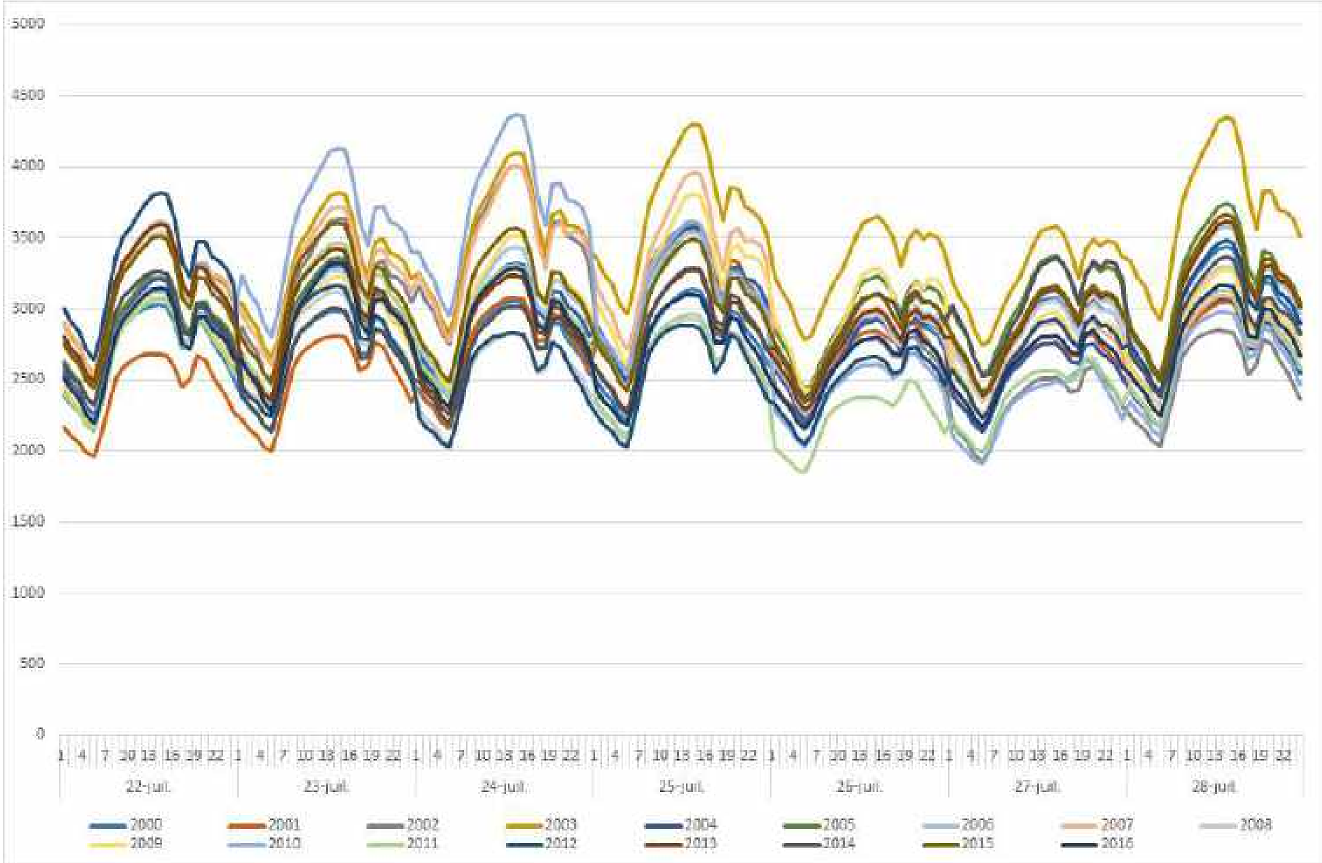


Figure 67 : TN - Predicted load curve shape during a week in summer (MW)

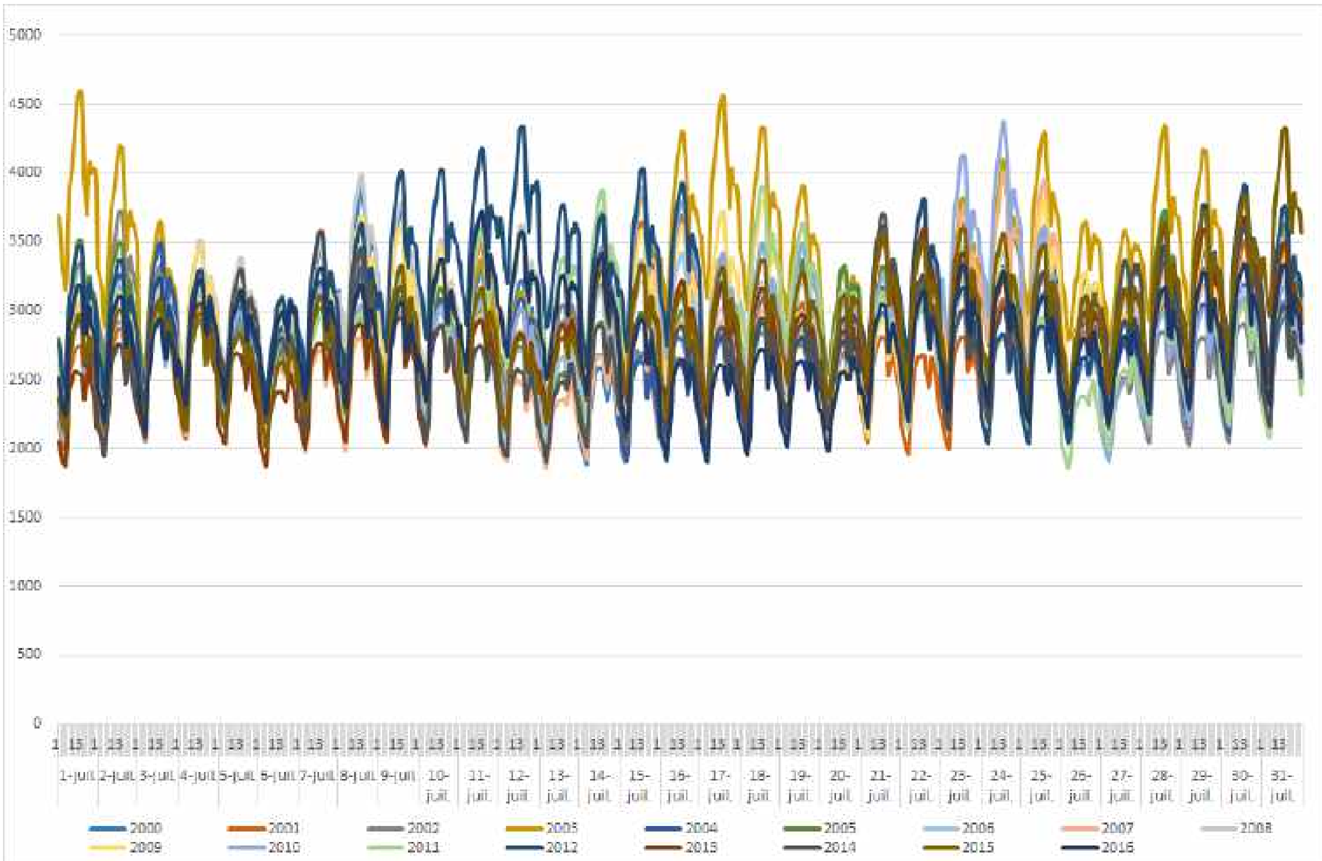


Figure 68 : TN - Predicted load curve shape during a month in summer (MW)

From the previous tables and graphs, it seems obvious that forecasts cover a wide range of possibilities for both energy consumption and maximum load evolution, which allows us to decide on the ability of electrical systems to meet the demand.

4.5.2.3. Turkey forecast results

For Turkey, the forecast generated using TRAPUNTA is determined from an annual energy target of 315.8 TWh for the year 2021.
From this hypothesis provided by TEIAS, the following results are obtained. Min and Max values, respectively 312 TWh and 320 TWh, illustrate the variability due to weather conditions.

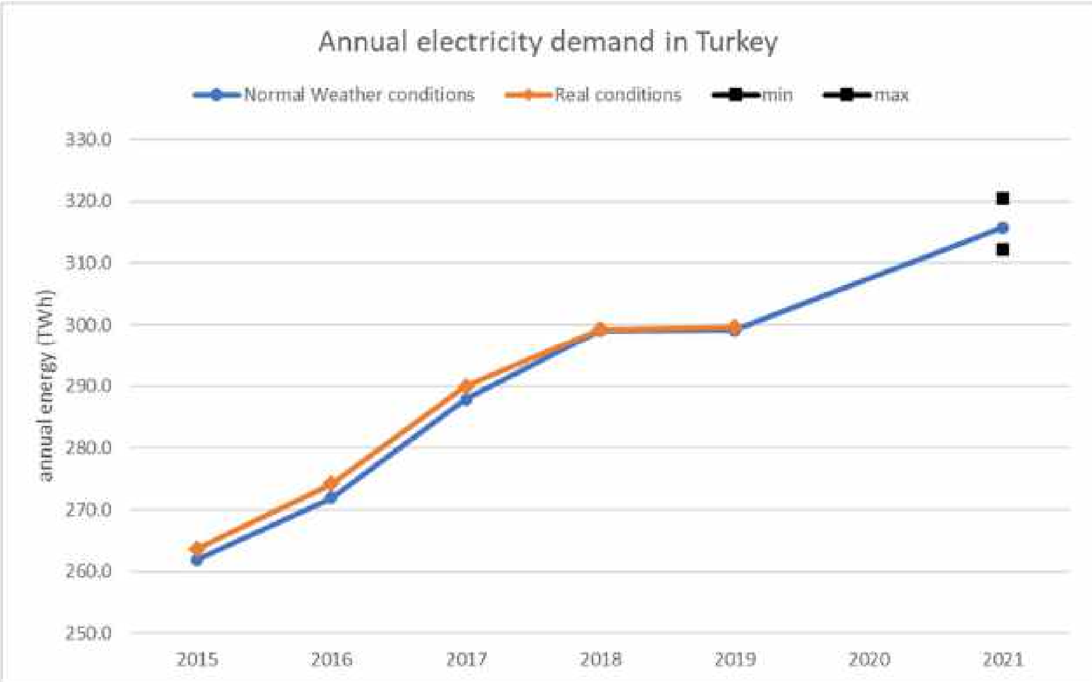


Figure 69: Turkey – annual energy (TWh) trajectory 2015-2021

While it has been shown in the previous paragraphs the strong impact of weather conditions on summer and winter consumption in Turkey, the following table illustrates for the year 2021 the amplitude of the uncertainty linked only to the weather.

2021 - Turkey	Normal weather conditions	Lowest value	Highest value	Mean value
Annual energy (TWh)	315,8	312,1	320,5	315,8
Annual peak load (GW)	48,4	47,0	55,9	51,5
Winter peak (GW)	45,1	45,1	48,2	47,0
Summer peak (GW)	48,4	46,7	55,9	51,4

Table 9: Turkey – detailed demand forecast for 2021

As a preamble, it should be noted that, for Turkey, the climatic database is made up of all the years between 1979 and 2019. Thus, the columns 'Lowest value' and 'Highest value' are respectively the minimum and maximum values observed among the 41 climatic years used to generate the consumption forecast for 2021. The 'Mean value' column presents the average of the values obtained over the 41 years, and can be regarded as the statistical expected value.

We can reasonably consider that this dataset is representative of the meteorological diversity that could potentially affect electricity consumption in Turkey in 2021, with a caveat, however, linked to the reality of global warming.

The first observation is that the annual consumption under normal climatic conditions is equal to the average consumption (mean value) obtained for all the 41 climatic years. The reason is that each climatic year can potentially present at one time or another of winter and summer a cold or hot wave respectively, and that the excess energy is compensated by an under-consumption at any other times of the year. For the same reason, the variability around the normal year is relatively low (312-320 TWh), i.e. an amplitude which corresponds to less than 3% of the expected value.

On the other hand, the examination of the Peak demand shows a very different behavior. Whether for summer or winter, the peak reached under normal climatic conditions is significantly lower than the average peak observed over each of the 41 climatic years. This is easily explained by the fact that the average climatic year does not include any particular event whereas each real year will present at one time or another a particular event of cold or heat respectively in winter or in summer.

This table indicates more precisely that the peak demand in winter exceeds by 2 GW on average the value expected under normal climatic conditions, and that this same difference is 3 GW for the peak in summer.

To conclude, while it has been shown previously that all thermosensitive uses of electricity do not exceed 8% of total consumption in Turkey, this table shows that the impact of these same uses, and in particular air conditioning in summer, is the major determinant of peak consumption. For the year 2021, the simulation results indicate that, depending on climatic conditions, and more particularly on the occurrence or not of a heat wave event, the consumption peak can be between 47 GW (-9%) and 56 GW (+ 9%) around an expected value of 51.5 GW.

This amplitude is several times greater than the uncertainty which affects the annual energy forecast.

This result confirms the importance for seasonal outlook studies of perfectly mastering these phenomena for the consumption forecast phase. The use of TRAPUNTA in the case of Turkey and for this study seems to reach a satisfactory level of performance.

The following illustrate the variability of the demand in summer (example: three first week of August 2021).

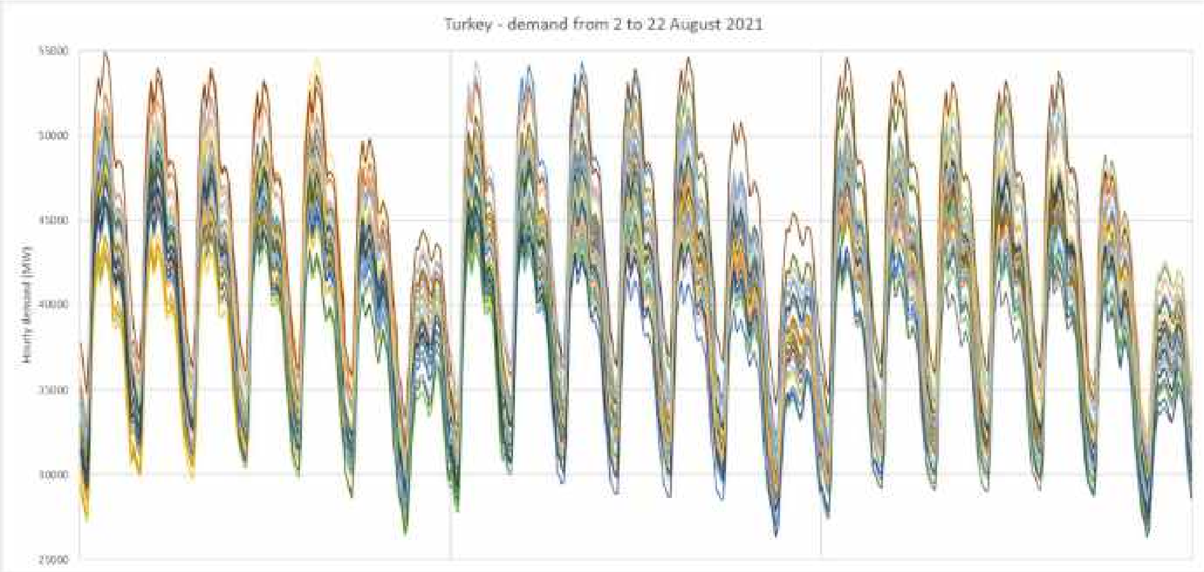


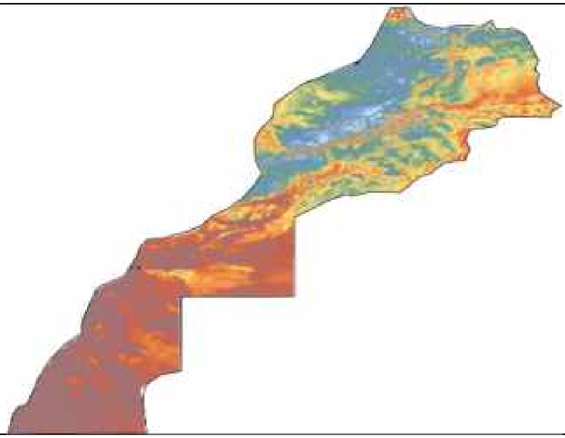
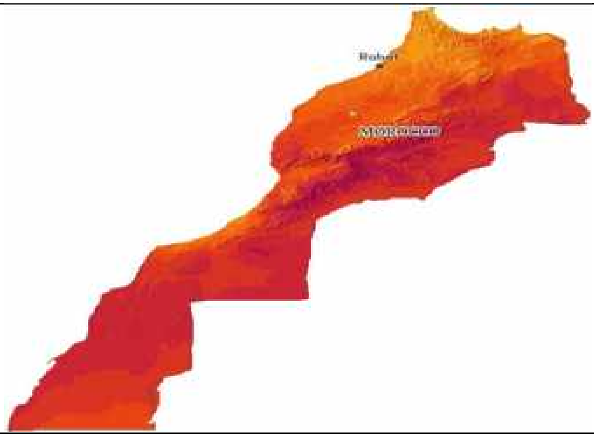
Figure 70: Turkey - Predicted load curve shape during a month in summer 2021

APPENDICES

APPENDIX 1: PECD GRAPHS AND GEOGRAPHICAL DISTRIBUTION OF THE PROJECTS

Morocco

Table 9 : Renewable Projects geographical location vs Solar and wind Atlas

Wind Atlas	Wind Projects
	
Solar Atlas	**Solar Projects**
	

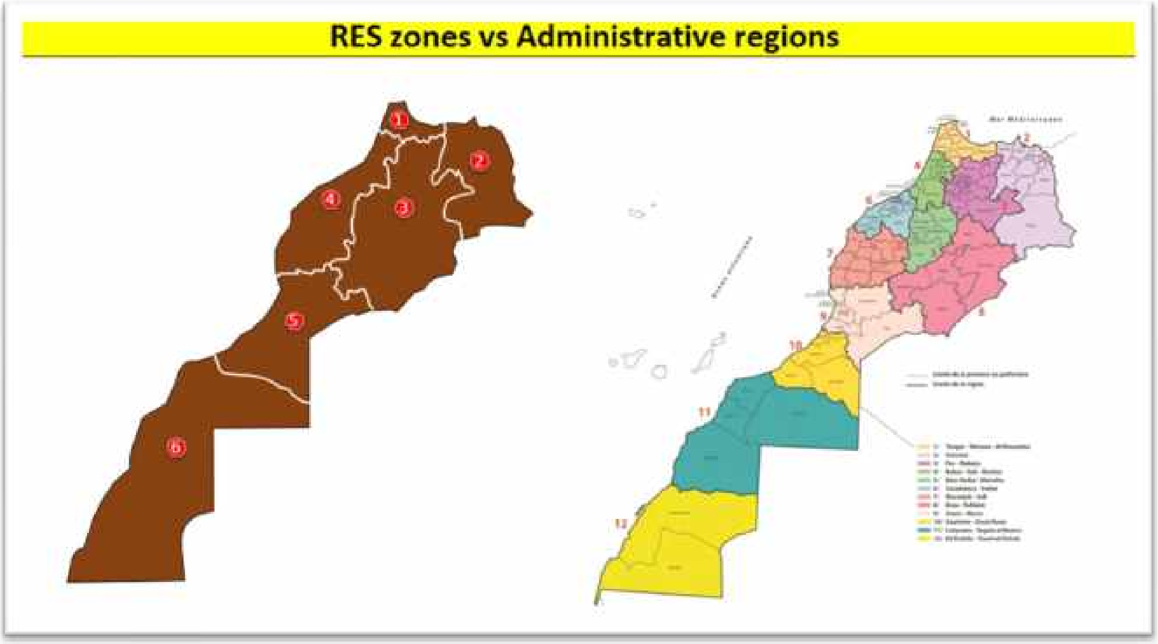


Figure 69 : Morocco zones definition

Table 10 : zones definition among administrative regions in Morocco

RES zone n°	Administrative regions n°
1	1
2	2
3	3-5-8
4	4-6-7
5	9-10
6	11-12

Table 11 : Actual and planned Renewable projects in Morocco

		Present Capacity MW	Capacity by 2030 MW
Zone 1	Wind	450	790
	Solar	0	694
Zone 2	Wind	0	0
	Solar	20	714
Zone 3	Wind		360
	Solar	582	1827
Zone 4	Wind	61	297
	Solar	0	925
Zone 5	Wind	0	0
	Solar	0	925
Zone 6	Wind	705	4105
	Solar	105	568

Algeria

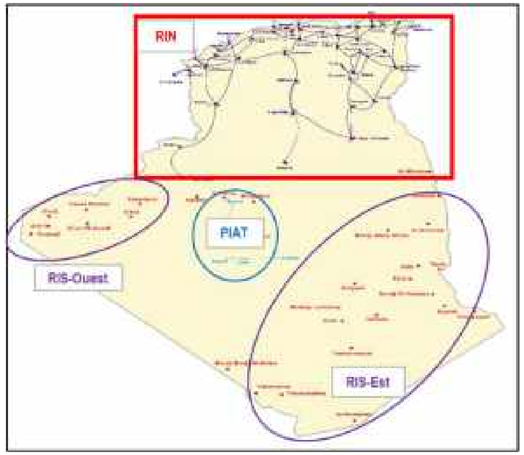


Figure 70 : Algerian Electrical Network

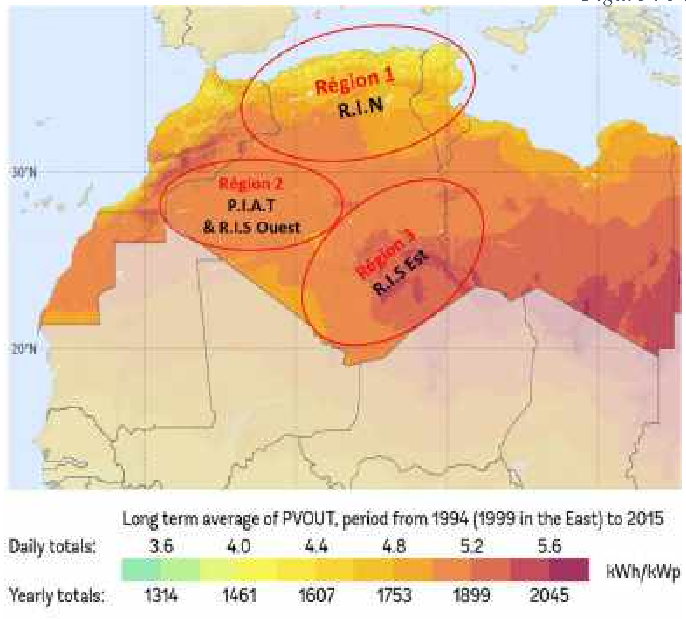


Figure 71 : Solar Geographical zones in Algeria

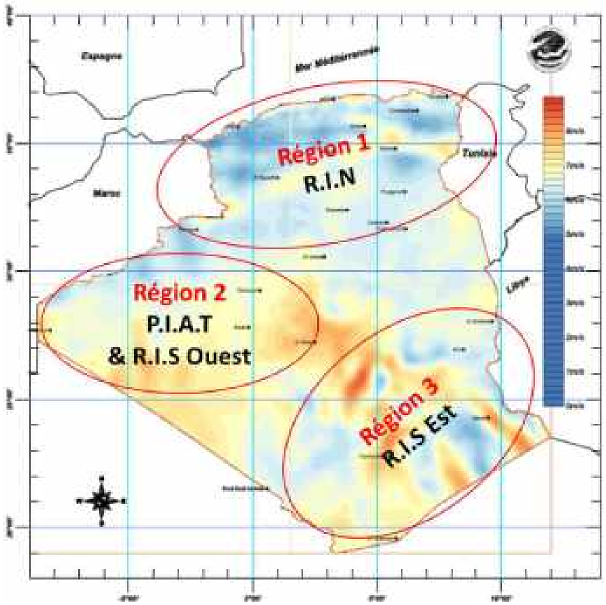


Figure 72 : Wind Geographical zones in Algeria

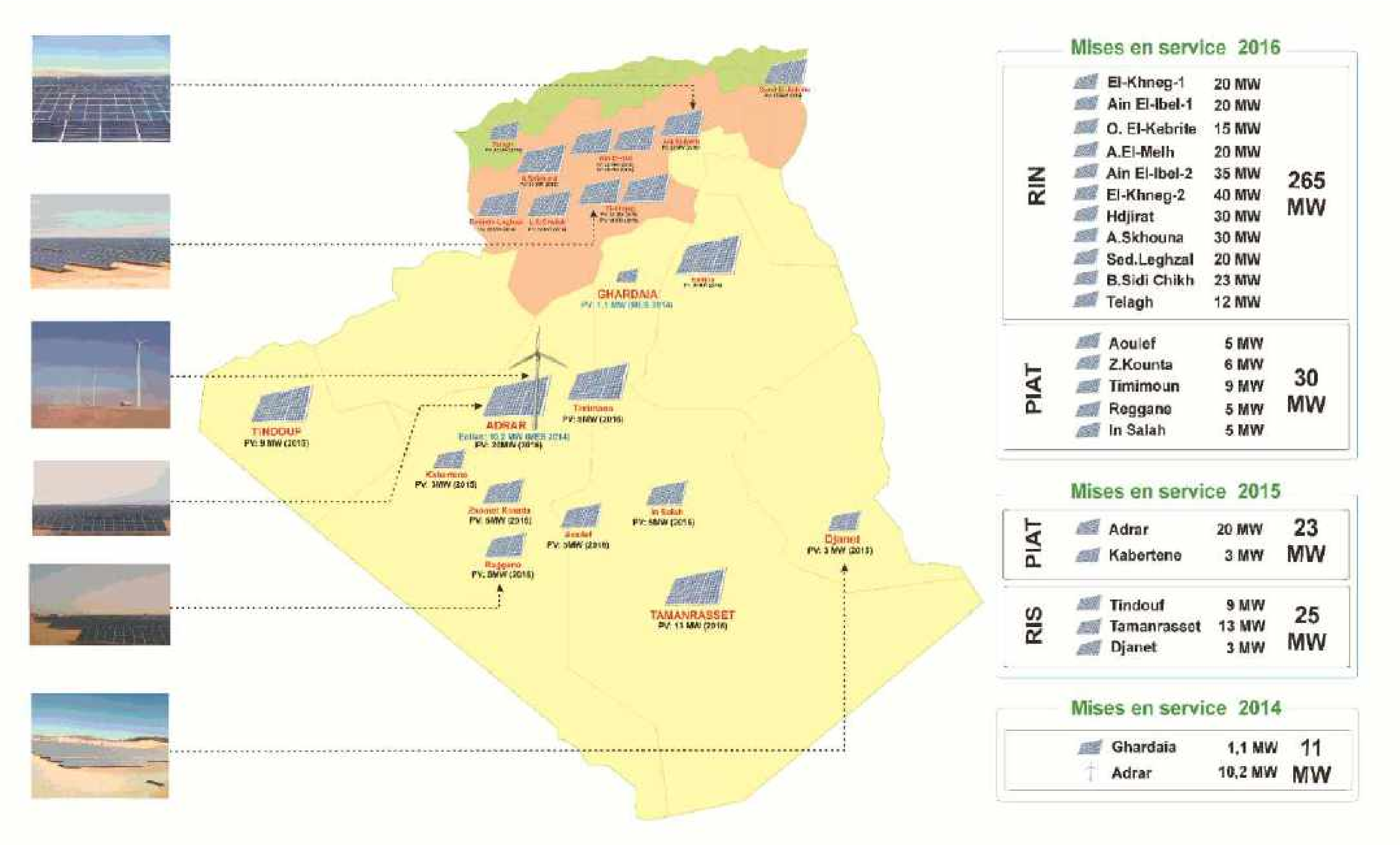


Figure 73 : Existing Solar and Wind projects in Algeria

Table 12 : Future Solar PV projects in Algeria

PV Plant	Installed Capacity (MW)	Commissioning year	Approximate location
Project 150 MW (15*10 MW)	150	2020	Several sites are prospected
Hassi Bahbah	50	2020 - 2030	Djelfa
El Oued	50	2020 - 2030	El Oued
Guerrara	50	2020 - 2030	Ghardaia
M'Ghaier	470	2020 - 2030	El Oued
Benaceur	450	2020 - 2030	Ouargla
El Foulia	360	2020 - 2030	El Oued
Bellil	310	2020 - 2030	Laghouat
M'Sila	300	2020 - 2030	M'Sila
Erekassa	300	2020 - 2030	Bechar
Laghrouss	300	2020 - 2030	Biskra
Ain Rougha	250	2020 - 2030	Biskra
Irara	250	2020 - 2030	Hassi Messaoud
Bamendil	250	2020 - 2030	Laghouat
Knadsa	240	2020 - 2030	Bechar
El Ateuf	130	2020 - 2030	Laghouat
Bahrara	60	2020 - 2030	Djelfa
Khenguet Sid Naji	120	2020 - 2030	Laghouat
Ain Ouessra	50	2020 - 2030	Djelfa
Tendla	60	2020 - 2030	El Oued
Total	**4200**		

Table 13 : Future Wind projects in Algeria

Wind farm	Installed Capacity (MW)	Commissioning year	Approximate location
Gdyel	100	2020 - 2030	Oran
Tiaret	100	2020 - 2030	Tiaret
E Bayadh	100	2020 - 2030	El Bayadh
Béchar	100	2020 - 2030	Béchar
Aflou	100	2020 - 2030	Laghouat
Hassi Bahbah	200	2020 - 2030	Djelfa
Laghouat	200	2020 - 2030	Laghouat
Hassi R'Mel	200	2020 - 2030	Laghouat
Ghardaia	200	2020 - 2030	Ghardaia
Bourdj Bouarriridj	100	2020 - 2030	Bourdj Bouarriridj
Bousaada	100	2020 - 2030	M'Sila
Merouana	100	2020 - 2030	Batna
Tazoult	100	2020 - 2030	Batna
Kais	100	2020 - 2030	Khenchla
Biskra	200	2020 - 2030	Biskra
Total	**2000**		

Tunisia

Figure 74 : Geographical zones definition in Tunisia vs administrative zones

Table 14 : Zones definition - Tunisia

Zone	Governorates of Tunisia
	Ariana, Manouba
	Béja
	Bizerte
	Jendouba
	Kef
	Siliana
TN01	Tunis
	Nabeul, Zaghouan
TN02	Ben Arous
	Kairouan
	Kasserine
TN03	Sidi Bouzid
	Mahdia
	Monastir
TN04	Sousse
	Gafsa
	Kebili
TN05	Tozeur
	Gabès
TN06	Sfax
TN07	Medenine
TN08	Tataouine

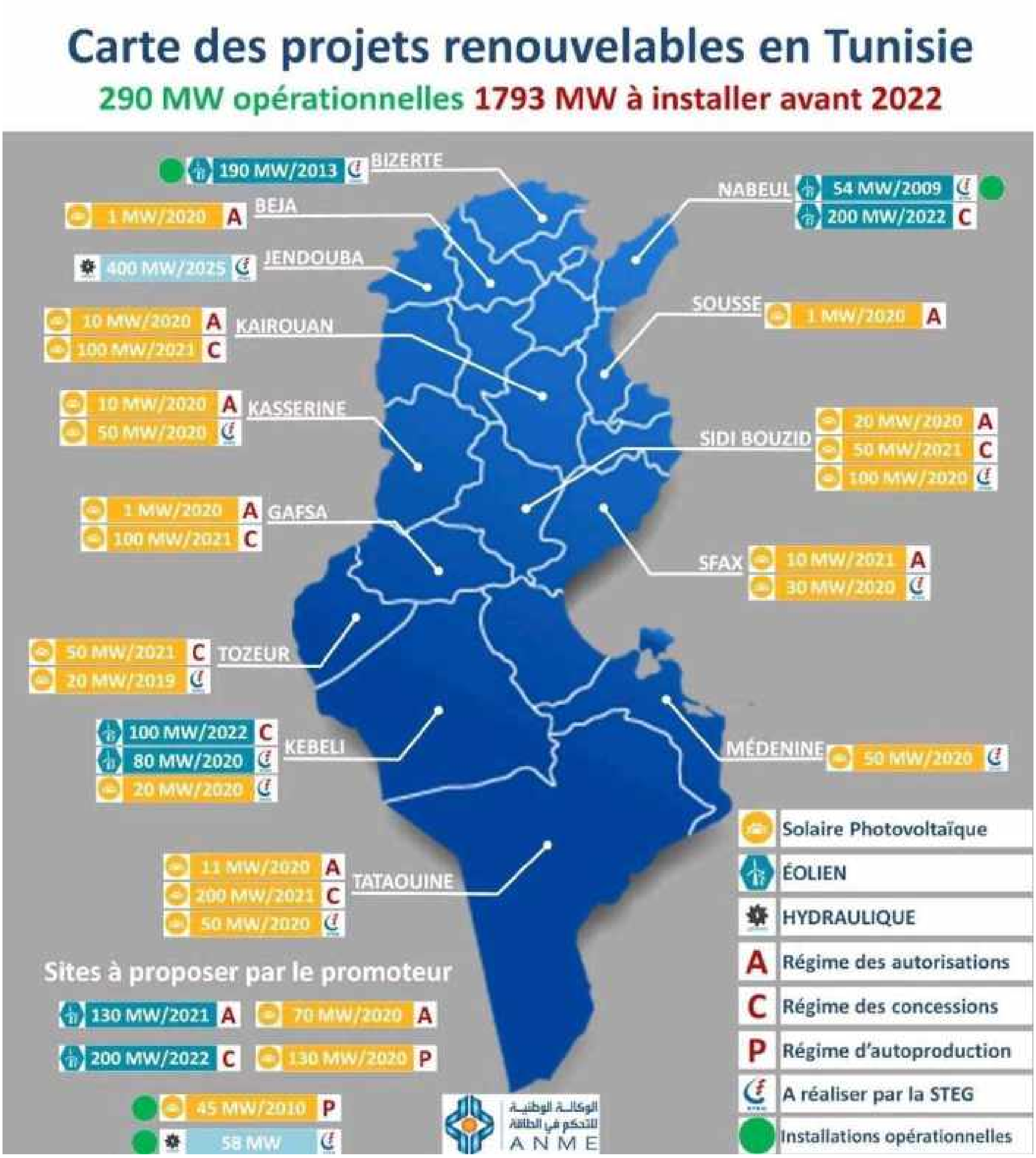


Figure 75 :Project situation Map – Tunisia

Libya

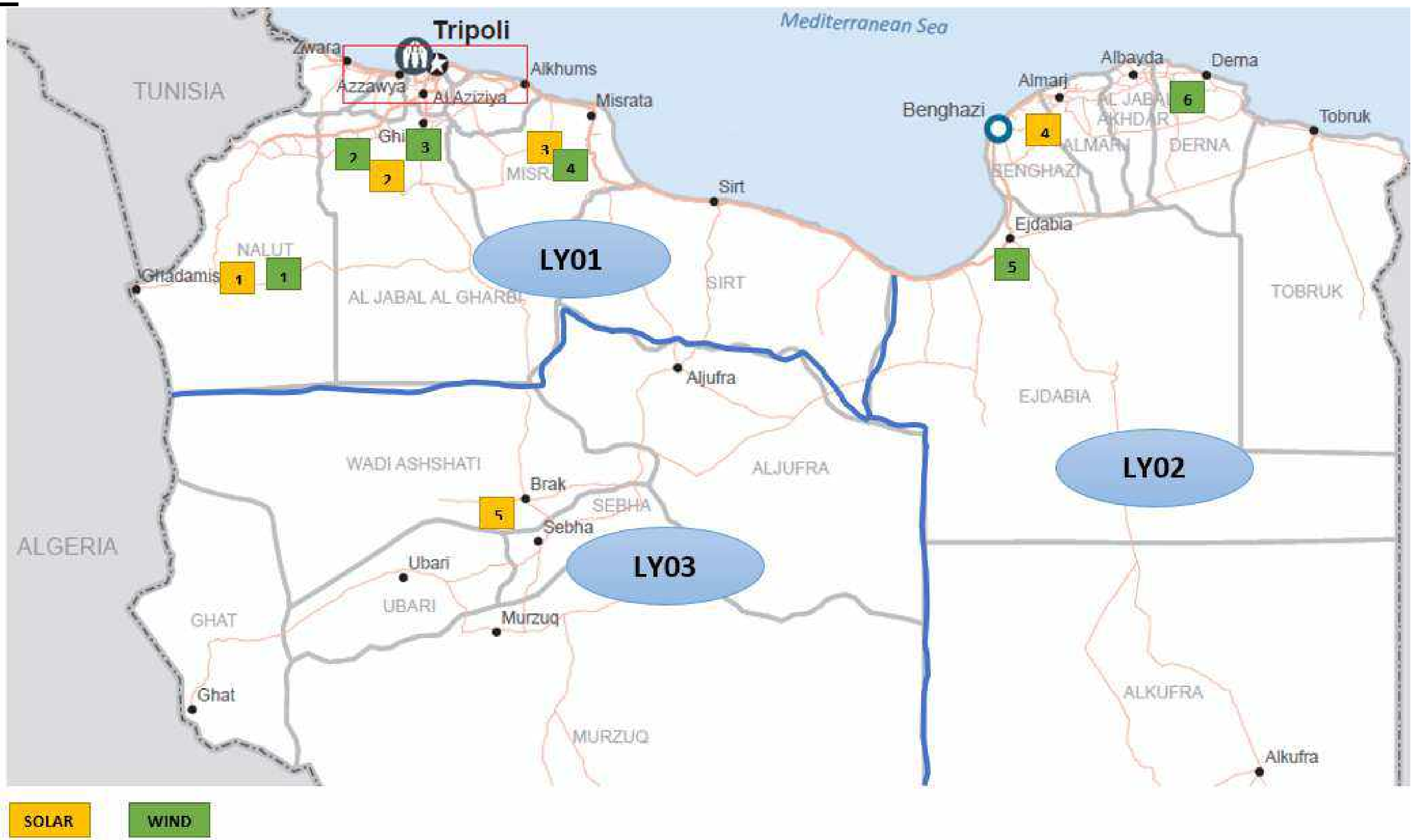


Figure 76 : Geographical zones definition – Libya

Note: Wind and PV assumptions for 2025 and for 2030 time horizon are provisional information, not planned, and shall be confirmed or changed later.

Table 15 : Actual and planned renewables projects details - Libya

REGION	PLANT (PV or WIND)	LATI-TUDE	LONGI-TUDE	Today Capacity	2025 Capacity	2030 Capacity
LY01	PV#1	30.2	10.4	100 MW	200 MW	400 MW
LY01	PV#2	32.0	11.95		200 MW	400 MW
LY01	PV#3	32.0	14.65		200 MW	400 MW
LY02	PV#4	31.9	20.65		200 MW	400 MW
LY03	PV#5	27.65	14.20		200 MW	400 MW
	TOTAL PV			100 MW	1000 MW	2000 MW
LY01	WIND#1	30.2	10.6	50 MW	100 MW	200 MW
LY01	WIND#2	31.85	12.0	50 MW	100 MW	200 MW
LY01	WIND#3	31.9	12.8			100 MW
LY01	WIND#4	31.65	15.0			100 MW
LY02	WIND#5	30.65	20.25	50 MW	100 MW	200 MW
LY02	WIND#6	32.65	22.4	50 MW	100 MW	200 MW
	TOTAL WIND			200 MW	400 MW	1000 MW

Turkey

CITY	REGION
Edirne	Region 1
Istanbul	Region 1
Kirklareli	Region 1
Tekirdag	Region 1
Balikesir	Region 2
Bursa	Region 2
Çanakkale	Region 2
Yalova	Region 2
Bilecik	Region 3
Kocaeli	Region 3
Aydın	Region 4
Izmir	Region 4
Manisa	Region 4
Mugla	Region 4
Afyon	Region 5
Denizli	Region 5
Isparta	Region 5
Usak	Region 5
Amasya	Region 7
Kirsehir	Region 7
Konya	Region 8
Kayseri	Region 9
Hatay	Region 10
K.maras	Region 10
Mersin	Region 10
Osmaniye	Region 10
Sivas	Region 11
Tokat	Region 11
Adıyaman	Region 12
Malatya	Region 12
Gaziantep	Region 13

Figure 77 : Geographical zones definition - Turkey

Table 16 : Wind onshore generation capacity in Turkey (MW)

REGION	Today Installed Capacity	Additional capacity* Today-> 2025	2025 Installed Capacity	Additional capacity** 2025-> 2030	2030 Capacity
Region #1	698	1002	1700	700	2400
Region #2	1701	1299	3000	1000	4000
Region #3	50	850	900	600	1500
Region #4	2510	1490	4000	1000	5000
Region #5	384	516	900	500	1400
Region #6		150	150	150	300
Region #7	300	150	450	150	600
Region #8	139	62	200	100	300
Region #9	265	135	400	100	500
Region #10	935	465	1400	400	1800
Region #11	296	204	500	100	600
Region #12	28	173	200	100	300
Region #13	66	134	200	100	300
Region #14		0	0	0	
Region #15		0	0	0	
TOTAL	7369		14000		19000

* adopting Today technology

** adopting 2025 technology

Table 17 : Wind off shore generation capacity in Turkey (MW)

REGION	Today Installed Capacity	Additional capacity Today-> 2025	2025 Installed Capacity	Additional capacity 2025-> 2030	2030 Capacity
Region #1	0		0		0
Region #2	0	Bozcaada = 700 MW	700	Bandirma = 300 MW Gokceada = 200 MW	1200
Region #3	0		0		0
Region #4	0		0		0
Region #5	0		0		0
Region #6	0		0		0
Region #7	0		0	Inebolu = 300 MW	300
Region #8	0		0		0
Region #9	0		0		0
Region #10	0		0	Samanda = 200 MW	200
Region #11	0		0		0
Region #12	0		0		0
Region #13	0		0		0
Region #14	0		0		0
Region #15	0		0		0
TOTAL	0		700		1700

Table 18 : Solar PV generation capacity in Turkey (MW)

REGION	Today Installed Capacity	Additional capacity* Today-> 2025	2025 Installed Capacity	Additional capacity** 2025-> 2030	2030 Capacity
Region #1	14	161	175	53	228
Region #2	145	317	462	140	601
Region #3	596	497	1093	331	1424
Region #4	674	490	1164	352	1516
Region #5	814	696	1510	457	1967
Region #6	140	254	394	119	514
Region #7	390	422	812	246	1058
Region #8	640	1996	2636	798	3434
Region #9	652	497	1149	348	1497
Region #10	552	558	1110	336	1446
Region #11	267	429	696	211	907
Region #12	401	368	769	233	1002
Region #13	504	510	1014	307	1321
Region #14	118	374	492	149	641
Region #15	80	318	398	120	518
TOTAL	5987	7887	13874	4200	18074

* adopting Today technology

** adopting 2025 technology

APPENDIX 2: GLOSSARY

TSO: Transmission System Operator
COMELEC: Electrical Comity for Maghreb
CIM: Interconnection Comity for Maghreb
TRAPUNTA: Temperature Regression and LoAd Projection with UncerTainty Analysis
PECD: Pan European Climate Data Base
WRF: Weather Research and Forecasting
RMSE: Root mean square deviation
SVD: Singular Value Decomposition

APPENDIX 3: REFERENCES

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[iv] ENTSO-E : "Demand forecasting methodology" prepared by TF TRAPUNTA and published in August 2019 : https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/sdc-documents/MAF/2019/Demand%20forecasting%20methodology.pdf

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[vii] Med-TSO map of the interconnected electricity transmission networks https://med-tso.com/map.aspx?f=

[ix] TRAPUNTA User Manual

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