

TYNDP 2018

Data and expertise as key ingredients

Final version after public consultation and ACER opinion - October 2019

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Contents

1	SHARING DATA AND KNOWLEDGE	1
2	MARKET DATA	2
3	MARKET SIMULATION TOOLS	3
4	GRID DATA	5
5	CLIMATE DATABASE	7
6	GRID DATA EXCHANGE AND INTEROPERABILITY	9
7	FURTHER IMPROVEMENTS OF AVAILABLE DATA	10
8	Annex I	11

ENTSO-E Reports 2018

As an improvement to the TYNDP 2018 package, the Insight Reports have been categorised in order to help readers navigate through the document and focus on what readers might find of interest. The category of reports are:

- Executive Report – Contains the key insights of the whole TYNDP package through its two-year cycle.
- Regional Reports – Based on the four projects of common interest (PCI) regions, the reports focus on the regional challenges of the energy transition.
- Communication – These reports communicate how we have interacted with our stakeholders and improved the TYNDP package from 2016 to 2018.
- Technical – These reports give a deeper insight into the technical subjects, including how we use our data, and the technical challenges of energy transition.

We hope this guide is of benefit to all stakeholders.

Main Report

Regional Reports

- North-South Interconnections East
- North-South Interconnections West
- Northern Seas Offshore Grid
- Nordic & Baltics

Communication

- Stakeholder Engagement
- Improvements to TYNDP 2018

Technical

- Data and Expertise
- Technologies for Transmission
- Viability of the Energy Mix
- CBA Technical

Adequacy

- Mid-Term Adequacy Forecast

Section 1

Sharing data and knowledge

This report gives an overview of the data, formats, and tools applied by ENTSO-E's experts in delivering the TYNDP. It aims at raising the public's awareness to the fact that a lot of TYNDP underlying data and maps is made freely available by ENTSO-E.

ENTSO-E believes that all institutional and non-institutional stakeholders should be able to access the TYNDP data. It improves the understanding of the TYNDP's results and recommendations, fuels in discussions for future TYNDP studies and can support additional research related to grid development.

The main gateway to access ENTSO-E's data is the transparency platform, which can be accessed through the following url <https://transparency.entsoe.eu/>.

The platform required under Regulation (EU) No 543/2013 of 14 June 2013, offers close to real time data on generation, electricity cross-border exchanges and consumption for the whole ENTSO-E area. The data is collected from transmission system operators (TSOs) but includes also power exchanges and data from other market players.

Prior to the platform, ENTSO-E published key figures through its data portal. Data from pre-ENTSO-E associations are still available through the ENTSO-E website.

In line with this long tradition of allowing public access to fundamental data on the EU power system, ENTSO-E is also publishing the TYNDP datasets. There are some exceptions to the general transparency rule when the data fall under some national confidentiality legal obligation or their access is contractually limited to ENTSO-E. These exceptions are regularly reviewed with the aim of moving towards more and more openness. Should you have any suggestions or recommendations, we invite you to share them with ENTSO-E.

Section 2

Market data

A basic element in any long-term grid development study is the set of scenarios applied.

Each TYNDP 2018 scenario sketches a possible future for the European power system in 2020, 2025, 2030 and 2040. Each contains the following elements:

- installed generation capacities per technology and country;
- consumption profiles;
- border reference capacities;
- key assumptions for generator efficiencies, fuel prices and CO2 prices.

Some of the scenarios are based on collections of national data, others show the changes to be expected if in the future there will be a different balance in the development of technologies at Pan-European level (with impacts in the location of renewable energy sources (RES), the sizing of thermal generation and adoption of load profiles) .

A fully detailed overview of the TYNDP2018 scenarios can be found in the Scenario Development Report which was widely consulted in various steps of the TYNDP process.

Most data used for the TYNDP scenarios can freely be accessed from Maps and Data site. Detailed elements such as efficiency assumptions per generator, operational restrictions and maintenance profiles, smaller market node data, and climatological data for hydro, wind and solar are not included in this set due to data confidentiality reasons with the data provider.

Section 3

Market simulation tools

The TSOs' experts, collaborating on the TYNDP studies, use a variety of market simulation tools to design the scenarios, conduct planning studies, and perform calculations for the cost benefit analysis (CBA) of projects.

The tools used in TYNDP 2018 studies are among others:

- BID
- Antares
- JMM
- Pymas
- Plexos
- PowerSym
- PROMED.

It is important to understand that the number of tools does not give a biased outcome to particular studies or regions. On the contrary, the common exchange of results, questions and experts' suggestions stimulates a better understanding of the results provided by the different commercial tools together with a better understanding of the tools functioning. This approach ensures various input assumptions can be cross-checked. Furthermore, it gives more insight in the inherent uncertainty ranges due to treatment of data and mathematical approximations that each tool must make for modelling such a complex system and that should be attributed to TYNDP results.

The TYNDP experts use the same standards for data input and exchange. They use a common reference dataset. This reference dataset is in line with the CBA methodology and respectful of additional ENTSO-E guidelines in terms of IT applications for TSO use. All market studies, with whatever simulation tool, are done for the whole ENTSO-E perimeter and they are all performed based on a full-year 8760-hour dispatch optimisation.

For particular infrastructure projects, more detailed modelling assumptions were tested, such as climatic conditions, multiple market nodes, redispatch optimisations, hydro constraints, etc. Where relevant this is indicated in the TYNDP project sheets to explain the CBA assessment results.

All TYNDP market studies were directed by a central coordination group to ensure all regional groups and TSOs performed detailed high-quality studies, reviewed with regional colleagues, in an overall consistent manner.

Section 4

Grid data

Pan-European grid data is often perceived as complex and of a critical nature, and a significant amount of data is already available through ENTSO-E's website.

The actual TYNDP grid data are prepared by a dedicated expert team to get one converging model per synchronous area, continental Europe being the main piece. The models include:

- Substations with distinct code names, formulated as single nodes, and with indication of the voltage level;
- Active and reactive power of each node in the model (physical injection or aggregation point), for the given planning case;
- Impedance and reactance of every line and transformer;
- Transmission capacities per line and transformer.

The planning case to which each model is applied is a snapshot of a TYNDP scenario. In other words, it represents only a specific time-frame (usually a hour) of the whole year market results of a certain scenario. Combined with the full TYNDP scenario data sets, these models allow for many insightful load flow studies to be tested. In fact, the TYNDP models are amongst the largest and closest-to-reality models available for research purposes worldwide.

Grid data is already available <https://www.entsoe.eu/publications/statistics-and-data/#entso-e-on-line-application-portal-for-network-datasets> for the TYNDP 2016 studies and will be made available for the TYNDP 2018.

For anyone interested in testing more dynamic phenomena, ENTSO-E has made available a simplified dynamic model <https://docstore.entsoe.eu/publications/system-operations-reports/continental-europe/Initial-Dynamic-Model/Pages/default.aspx> for the Continental Europe area. The dynamic model is simplified due to the commercial sensitive data it contains. The model is able to represent the main frequency response of the system as well as the main inter-area oscillation modes. The TYNDP 2016 grid data are available at the ENTSO-E On-Line Application Portal for Network Datasets.

Although simplified and partially anonymized in terms of data content, this dynamic model has been tuned to provide comparable results as the full model. At present the TYNDP planning studies and the project assessments focus on market integration studies and static load flow analyses. Nonetheless, there is a move towards using dynamic planning studies more centrally for future TYNDPs as the network itself becomes more exposed to dynamic phenomena.

Section 5

Climate database

ENTSOE has been working with the DTU university in Denmark to develop a Pan-European Climate Database (PECD).

In the 2016 edition of the TYNDP, the PECD only contained 14 historical years. One key improvement to this database was an increase to 34 climate years (1982 to 2014). The weather years are then re-analysed and projected into the future to give wind and PV load factors. These projections are based on the expected developments of technologies e.g. increased height of wind turbines and size of turbine blades.

In 2016, the analysis for the TYNDP was done on one climate year (2011). This year the TYNDP has endeavoured to increase the amount of climate years used in the studies running 3 climate years selected as reported in Annex I. These have been sourced and selected as the most representative years from the 34 years available to show the wider impact of changes in climatic years.

In order to select a limited number of climate conditions to be used in the analysis the “k-means clustering” analysis has been applied.

“k-means clustering” is a method of vector quantization, originally from signal processing that aims to partition n observations (living in an m -dimensional space) into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster.

Additional countries were added to the PECD including Albania, Malta, Turkey, the Ukraine (Burshtyn Island), Morocco, Tunis, and Algeria.

Additional data items were included, these being:

- Concentrated Solar Power load factors (weather based data considering typical daily patterns)
- City temperatures and population weighted temperatures
- Weather data for wind and PV power generation modelling to be used with transfer functions

Calibration of model parameters has been done using recently available datasets (e.g. Transparency Platform operated by ENTSO-E) and considering latest developments.

The configuration of wind turbines and solar panels should represent the existing generation capacity. For countries with no or negligible generation an estimate was requested based on the preferable location for wind or solar energy and hence siting of these technologies, and the technology that is currently available.

Section 6

Grid data exchange and interoperability

For both market and grid studies, TSOs across Europe apply a variety of tools. For grid analysis the need for and focus on common exchange formats is even higher given the number of data points and their complexity.

ENTSO-E is undertaking significant investigation into translating the IEC common information model (CIM) for use by the whole TSO community. ENTSO-E's Common Grid Model Exchange Standard (CGMES) is a superset of the IEC CIM standard.

This CGMES standard is a must in the seamless exchange of national/regional grid models for TYNDP studies. All TYNDP project CBA grid analyses have been performed by various TSO study groups, based on various tools, but all based on the same central CGMES-compliant data set.

The CGMES once finalised will be applied by power system data management tools and tools supporting the following analyses:

- load flow and contingency analyses,
- short circuit calculations,
- market information and transparency,
- capacity calculation for capacity allocation and congestion management,
- dynamic security assessment.

The development of the CGMES is a collaborative effort between ENTSO-E, the TSOs, software vendors, the IEC CIM User Group and the IEC TC57/WG13. ENTSO-E will continue improving the CGMES to cover additional requirements defined in the European network codes and/or by TSO needs.

As with market studies, network study experts coordinated via a central expert group overseeing all CBA application issues and questions to ensure all studies were executed with a consistent approach.

Section 7

Further improvements of available data

ENTSO-E hopes that all interested parties will easily find their way to the TYNDP public datasets and see value in applying these in their own studies and analyses.

You can expect further improvement in the way in which relevant data is shared in future. ENTSO-E is committed to ensuring that the relevant data is made available to suit its stakeholders. We welcome your feedback or suggestions on what you need and how you would like it to be shared at info@entsoe.eu.

Section 8

Annex I

<http://tyndp.entsoe.eu/maps-data/>

8.1 Choice of climate years

The CBA analysis performed in TYNDP 2018 have been developed in three different climate conditions selected in a climatic database of 34 different time series (Pan European Climate Database - PECD) provided with the cooperation of Météo-France and Technical University of Denmark.

The time series available for the years between 1984 and 2014, are related to:

- precipitation;
- wind;
- temperature;
- sun exposition.

In order to select a limited number of climate conditions to be used in the analysis¹ the “k-means clustering” analysis has been applied.

“k-means clustering” is a method of vector quantization, originally from signal processing that aims to partition n observations (living in an m-dimensional space) into

k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster.

The method is based on an iterative algorithm that divides the data into k groups so that observation within a group are similar whilst observations between groups are different. After each iteration a parameter, R2, is evaluated to indicate the proportion of the variance in the dependent variable that is predictable from the independent variable. The closer R2 is to 1, the more representative it is the clustering.

The main advantage is that it will yield k climate years that represent best all the 34 climate years available in PECD.

In the specific framework of TYNDP 2018 the algorithm has been performed on 4 dimensions (load, wind, solar and hydro inflow) and considering different zones aggregation as reported in the following table:

Table 8.1: Zone aggregations

Macro Region	Zones										
Scandinavia	DKe	DKKf	DKw	FI	NOM	NOm	NOs	SE1	SE2	SE3	SE4
Baltic Countries	LV	EE	LT								
Central West 1 FR-BE-NL	BE	FR	NL								
Central West 2 DE-CH-AT-LU	DE	DEKf	AT	CH	LUB	LUF	LUg	LUv			
South West	ES	PT									
Central East	CZ	SK	HU	PL	RO						
GB+IE	GB	IE	NI								
South East	GR	CY	BG	MK	ME	MT	HR	SI	RS	AL	BA
South Central	ITcn	ITcs	ITn	ITs	ITsar	ITsic					

¹ The need to limit the number of climate conditions was to guarantee the feasibility of the overall TYNDP 2018 process workplan

In addition:

- n = number of climate years (34 in this case);
- k = target number of climate years.

The input data are, for each year, and for each region: the difference between the value and the average of all years.

According to the data available and the feasibility of the workpan 3 clusters (see Figure 8.1) have been considered at the end as reported in the following

figure ($R^2 = 0,55$). A weighting has been also allocated to each cluster, based on the number of years included in the same cluster.

Inside the clusters the different years can be considered with the same representativity, therefore, the reference year has been selected considering the most recent year, the improvement of the technology, the quality of climatic surveys.

Figure 8.1: Clusters definition





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