The Joint Research Centre Power Plant Database (JRC-PPDB)

Version 0.9

Kanellopoulos K., De Felice M., Hidalgo I., Bocin A., Uihlein A

2019
This publication is a Scientific Information Systems and Databases report by the Joint Research Centre (JRC), the European Commission’s science and knowledge service. It aims to provide evidence-based scientific support to the European policymaking process. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication.

Contact information
Name: Kostis Kanellopoulos
Email: Konstantinos.kanellopoulos@ec.europa.eu

EU Science Hub
https://ec.europa.eu/jrc

JRC117303

EUR 29806 EN


Luxembourg: Publications Office of the European Union, 2019
© European Union, 2019

The reuse policy of the European Commission is implemented by Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Reuse is authorised, provided the source of the document is acknowledged and its original meaning or message is not distorted. The European Commission shall not be liable for any consequence stemming from the reuse. For any use or reproduction of photos or other material that is not owned by the EU, permission must be sought directly from the copyright holders.

All content © European Union, 2019

# Contents

Abstract ................................................................................................................................. 1  
1 Introduction .......................................................................................................................... 2  
2 Tables and fields .................................................................................................................. 3  
3 Performance data methodology ......................................................................................... 6  
  3.1 Time series analysis ....................................................................................................... 6  
      3.1.1 Stable load ........................................................................................................... 6  
      3.1.2 Time to stable load .......................................................................................... 6  
      3.1.3 Minimum on-off/off-on .................................................................................... 7  
      3.1.4 Maximum and minimum ramping rates ............................................................ 7  
  3.2 Class transient performance indicators ........................................................................ 7  
  3.3 Thermal efficiency ......................................................................................................... 8  
      3.3.1 Emissions derived efficiency ............................................................................. 8  
References .............................................................................................................................. 9  
List of abbreviations and definitions ....................................................................................... 10  
List of figures .......................................................................................................................... 11  
List of tables ........................................................................................................................... 12
Abstract

This report is a description of the European Commission's Joint Research Centre's open power plant database (JRC-PPDB-OPEN), its structure and the information it contains. JRC-PPDB-OPEN is mainly based on information from ENTSO-E's lists of installed capacity in Europe, extended through information contained in other open datasets, as well as own analysis of historical hourly generation time series data.
1 Introduction

In 2017 the Joint Research Centre developed a Power Plant Database [1] for energy systems modelling (JRC-PPDB) in order to support the unit activities in energy systems modelling and knowledge management.

As demand for open data is increasingly sought after, an open version (JRC-PPDB-OPEN), based on exclusively open data was designed. The JRC-PPDB-OPEN is primarily based on a collection of all the information published by ENTSO-E\(^1\) on the European power plants at unit level. This information was extended, improved, and where possible corrected using information contained in open datasets published by WRI Powerwatch\(^2\), Global energy observatory\(^3\), FRESNA\(^4\) and the EEA\(^5\).

The JRC-PPDB-OPEN database is a first attempt towards a more detailed and coherent, albeit still incomplete, dataset of European power plants. Further work to expand and improve the information contained therein is called for. To this extend, and in order to facilitate the future involvement of third parties in such efforts, the associations between records in the different datasets (linkage) are included.


---

\(^1\) https://transparency.entsoe.eu/
\(^2\) http://datasets.wri.org/dataset/globalpowerplantdatabase
\(^3\) http://globalenergyobservatory.org/
\(^4\) https://github.com/FRESNA/powerplantmatching
\(^5\) https://prtr.eea.europa.eu/#/home
2 Tables and fields

The JRC-PPDB-OPEN dataset contains four tables:

1. Unit table: characteristics of the individual power plant units
2. Linkage table: mapping of the keys and id codes for several datasets
3. Performance table: indicators (see Section 3) for a subset of units
4. Temporal table: yearly statistics for a subset of units

Table 1. Fields in the Unit table.

<table>
<thead>
<tr>
<th>Field</th>
<th>SQL Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eic_p</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the producing unit</td>
</tr>
<tr>
<td>eic_g</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the generation unit</td>
</tr>
<tr>
<td>name_p</td>
<td>text</td>
<td>Production unit name</td>
</tr>
<tr>
<td>name_g</td>
<td>text</td>
<td>Generating unit name</td>
</tr>
<tr>
<td>capacity_p</td>
<td>float</td>
<td>Production unit capacity, net (MW)</td>
</tr>
<tr>
<td>capacity_g</td>
<td>float</td>
<td>Generating unit capacity, net (MW)</td>
</tr>
<tr>
<td>type_g</td>
<td>text</td>
<td>ENTSO-E classification for the generation unit</td>
</tr>
<tr>
<td>lat</td>
<td>float</td>
<td>Latitude (WGS84)</td>
</tr>
<tr>
<td>lon</td>
<td>float</td>
<td>Longitude in the range -180, 180 (WGS84)</td>
</tr>
<tr>
<td>country</td>
<td>varchar(40)</td>
<td>Name of the country</td>
</tr>
<tr>
<td>NUTS2</td>
<td>text</td>
<td>NUTS2 code according to the NUTS 2016 definition</td>
</tr>
<tr>
<td>status_g</td>
<td>text</td>
<td>Status of the generating unit</td>
</tr>
<tr>
<td>year_commissioned</td>
<td>int</td>
<td>Year of commissioning</td>
</tr>
<tr>
<td>year_decommissioned</td>
<td>int</td>
<td>Year of decommissioning</td>
</tr>
</tbody>
</table>

6 https://www.entsoe.eu/data/energy-identification-codes-eic/
7 The ENTSO-E production types are the following: Fossil Peat, Nuclear, Fossil Hard coal, Wind Onshore, Fossil Brown coal/Lignite, Geothermal, Hydro Run-of-river and poundage, Hydro Water Reservoir, Wind Offshore, Hydro Pumped Storage, Other renewable, Solar, Fossil Oil shale, Waste, Fossil Gas, Fossil Coal-derived gas, Fossil Oil, Marine, Other, Biomass
8 https://ec.europa.eu/eurostat/web/nuts/history
9 COMMISSIONED, RESERVE, DECOMMISSIONED, MOTHBALED and CONSTRUCTION
Table 2. Fields in the Linkages table.

<table>
<thead>
<tr>
<th>Field</th>
<th>SQL Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eic_p</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the producing unit</td>
</tr>
<tr>
<td>eic_g</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the generation unit</td>
</tr>
<tr>
<td>eptrr_facilityID</td>
<td>varchar(10)</td>
<td>Facility ID in E-PRTR</td>
</tr>
<tr>
<td>WRI_id</td>
<td>varchar(20)</td>
<td>ID in WRI Power Watch</td>
</tr>
<tr>
<td>GEO_id</td>
<td>varchar(20)</td>
<td>ID in Global Energy Observatory</td>
</tr>
<tr>
<td>fresna_id</td>
<td>int</td>
<td>ID in FIAS Renewable Energy Systems &amp; Network Analysis</td>
</tr>
</tbody>
</table>

Table 3. Fields in the Performance table.

<table>
<thead>
<tr>
<th>Field</th>
<th>SQL Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eic_p</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the producing unit</td>
</tr>
<tr>
<td>eic_g</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the generation unit</td>
</tr>
<tr>
<td>min_load</td>
<td>float</td>
<td>Stable load, % of installed net capacity</td>
</tr>
<tr>
<td>ramp_up</td>
<td>float</td>
<td>Ramp-up capability, % of installed net capacity per minute</td>
</tr>
<tr>
<td>ramp_down</td>
<td>float</td>
<td>Ramp-down capability, % of installed net capacity per minute</td>
</tr>
<tr>
<td>minimum_up_time</td>
<td>float</td>
<td>Minimum time the unit was in operation during cycling (minute)</td>
</tr>
<tr>
<td>minimum_down_time</td>
<td>float</td>
<td>Minimum time the unit was shut down during cycling (minute)</td>
</tr>
<tr>
<td>eff</td>
<td>float</td>
<td>Net electrical efficiency of thermal power plants</td>
</tr>
<tr>
<td>best_source</td>
<td>text</td>
<td>Source of efficiency estimate</td>
</tr>
</tbody>
</table>
**Table 4.** Fields in the Temporal table.

<table>
<thead>
<tr>
<th>Field</th>
<th>SQL Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eic_p</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the producing unit</td>
</tr>
<tr>
<td>eic_g</td>
<td>varchar(20)</td>
<td>EIC (Energy Identification Code) for the generation unit</td>
</tr>
<tr>
<td>cyear</td>
<td>Int</td>
<td>Year that the record refers to</td>
</tr>
<tr>
<td>production</td>
<td>float</td>
<td>Sum of reported generation in the time series in MWh</td>
</tr>
<tr>
<td>cf</td>
<td>float</td>
<td>Capacity factor of plant operation in the published record set</td>
</tr>
<tr>
<td>time_coverage</td>
<td>float</td>
<td>Fraction of the total hours in a year covered</td>
</tr>
<tr>
<td>co2emitted</td>
<td>float</td>
<td>Kg of CO₂ emitted/year based on the reported annual emissions</td>
</tr>
</tbody>
</table>
3 Performance data methodology

The linkage of available open sources (ENTSO-E, E-PRTR and other power plant databases) enabled the estimation of several performance parameters for a large part of the listed power plants. These are provided in the Performance table and it is based on analysis of the generation time series provide in ENTSO-E’s Transparency Platform\(^\text{10}\), the CO\(_2\) emissions published by the European Environmental Agency’s E-PRTR database, as well as the country specific carbon intensity of fuels in each country, published by the UNFCCC.

3.1 Time series analysis

The set of metrics computed on hourly power plant generation time-series is summarised in the following paragraphs. In the cases when sub-hourly data are available in the original time series, an aggregation by averaging is carried out.

3.1.1 Stable load

The stable load value for an electricity generation time series is estimated from the distribution of all the “stable values”. A stable value is a generation data point which is not greater (i.e. equal or less) than the values before and after, in mathematical terms a point \(x_t\) is a stable value if \(x_t \leq x_{t-1}\) and \(x_t \leq x_{t+1}\). Furthermore, the generation must be also above a specific threshold, here defined as the 5% of the plant power peak. Figure 1 shows an example, with the yellow point indicating the stable values.

\[\begin{align*}
\text{Figure 1: Example figure for the stable load metric. In yellow the points labelled as ‘stable values’. The dashed line represents a minimum threshold for the stable values.}
\end{align*}\]

Following the simple conditions described above, a collection of stable values is then defined. Then the stable load for the time-series is defined as the first percentile of this distribution.

3.1.2 Time to stable load

This metric describes the time needed for a power plant to reach the stable load (defined above). As for the stable load, this metric is estimated from a distribution of values, each of them indicating the time interval for the generation to reach the stable load. This interval is defined as a period that starts when the generation goes from zero to a positive value and ends when the generation goes from a value less than the stable load to a value greater. Figure 2 provides an example, highlighting in blue the interval to reach the stable load.

\[^{10}\text{See the section: Actual Generation Output per Generation Unit [16.1.A] accessible at the following URL: https://transparency.entsoe.eu/generation/r2/actualGenerationPerGenerationUnit/show}\]
Once obtained a distribution of all the intervals for a time series, the estimated time to stable load can be obtained by specifying a percentile of this distribution.

### 3.1.3 Minimum on-off/off-on

This metric defines the interval between the switching on of a power plant (i.e. the moment when the generation becomes positive) and the switching off (i.e. the time step when the generation goes to zero). Figure 3 illustrates the periods on-off and off-on measured in this metric.

After the computation of all the intervals for the two categories (off-on and off-on), a single value is estimated by considering the minimum or a specific percentile.

### 3.1.4 Maximum and minimum ramping rates

This metric estimates the maximum/minimum rate of ramping up and down of a power plant time-series. For each two consecutive data points, the difference in generation is computed (i.e. $x_t - x_{t-1}$) and then for all the points, grouped by their sign (thus separating positive from negative ramping rates) the maximum (for the positive) and the minimum (for the negative) are calculated.

### 3.2 Class transient performance indicators

The analysis of the generation time series described in the preceding paragraph provided the indicators of the transient performance characteristics for the power plants, as manifested in their averaged within one hour operation. These indicators were subsequently used to calculate class-average transient performance indicators for 60 classes based on the fuel, technology and size of plant, which were then assigned to the individual power plant codes in the JRC_OPEN_PERFORMANCE table.
3.3 Thermal efficiency

The thermal efficiency of the individual power plants was estimated based on the available information in the linked datasets. This enabled the estimation of the efficiency values by applying three different methods with declining accuracy level, denoting the order of preference:

1. Original equipment manufacturer (OEM) derived efficiency for gas turbine-based power plants where the turbine model is known. This allowed the use of OEM information on plant efficiencies for CCGTs and OCGTs.
2. Emission derived efficiency for power plants with production and emission data for 2015 or 2016.
3. Class derived efficiency for the rest of the units based on available information on the installed capacity, the age and type of power plant.

3.3.1 Emissions derived efficiency

The CO\textsubscript{2} emissions of a power plant are proportionally related to the type of fuel used, the amount of fuel consumed during the year, and therefore the generated electricity and the efficiency. The following formula relates the efficiency to the above mentioned values.

\[ \text{eff} = \frac{\text{generation} \times 3.6}{\frac{\text{CO}_2\text{emissions} - \text{CO}_2\text{emissions}_{\text{excl biomass}}}{\text{Intensity}_{\text{fuel}}} + \frac{\text{CO}_2\text{emissions}_{\text{excl biomass}}}{\text{Intensity}_{\text{biomass}}}} \]

Where:

- Intensity\textsubscript{fuel} : The CO\textsubscript{2} content per calorific energy in the fuel expressed in tonnes CO\textsubscript{2} per TJ\textsuperscript{11}
- Generation : annual net generation of the power plant in MWh
- CO\textsubscript{2}emissions : Annual emissions in kg

References

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCGT</td>
<td>Combined Cycle Gas Turbine</td>
</tr>
<tr>
<td>EIC</td>
<td>Energy identification code</td>
</tr>
<tr>
<td>ENTSO-E</td>
<td>European Network of Transmission System Operators for Electricity</td>
</tr>
<tr>
<td>JRC</td>
<td>Joint Research Centre</td>
</tr>
<tr>
<td>JRC-PPDB</td>
<td>The JRC Power Plant Database</td>
</tr>
<tr>
<td>TSO</td>
<td>Transmission System Operator</td>
</tr>
<tr>
<td>OCGT</td>
<td>Open Cycle Gas Turbine</td>
</tr>
<tr>
<td>OEM</td>
<td>Original equipment manufacturer</td>
</tr>
</tbody>
</table>
List of figures

Figure 1: Example figure for the stable load metric. In yellow the points labelled as “stable values”. The dashed line represents a minimum threshold for the stable values. .......................................................... 6

Figure 2: Example for the estimation for the time to stable load. The filled blue area shows the interval to the reach the stable load, indicated by a dashed line. .......................................................... 7

Figure 3: Example for the minimum on-off/off-on metric. The blue interval represents the period off-on (from the switching on to the switching off). Vice versa, the light red area shows the interval for the on-off. ........ 7
List of tables

Table 1. Fields in the Unit table. ............................................................................................................. 3
Table 2. Fields in the Linkages table......................................................................................................... 4
Table 3. Fields in the Performance table. ............................................................................................... 4
Table 4. Fields in the Temporal table. ..................................................................................................... 5
GETTING IN TOUCH WITH THE EU

In person
All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email
Europe Direct is a service that answers your questions about the European Union. You can contact this service:
- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696, or
- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online
Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications
You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).
The European Commission’s science and knowledge service
Joint Research Centre

JRC Mission
As the science and knowledge service of the European Commission, the Joint Research Centre’s mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
europa.eu/jrc

EU Science Hub - Joint Research Centre
EU Science, Research and Innovation
EU Science Hub