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

Version 0.9

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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.

JRC-PPDB-OPEN can be accessed here: http://data.europa.eu/89h/9810feeb-f062-49cd-8e76-8d8cfd488a05.

[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.

JRC_OPEN_UNITS		
Field	**SQL Type**	**Description**
eic_p	varchar(20)	EIC (Energy Identification Code[6]) for the producing unit
eic_g	varchar(20)	EIC (Energy Identification Code) for the generation unit
name_p	text	Production unit name
name_g	text	Generating unit name
capacity_p	float	Production unit capacity, net (MW)
capacity_g	float	Generating unit capacity, net (MW)
type_g	text	ENTSO-E classification for the generation unit[7]
lat	float	Latitude (WGS84)
lon	float	Longitude in the range -180, 180 (WGS84)
country	Varchar(40)	Name of the country
NUTS2	text	NUTS2 code according to the NUTS 2016 definition[8]
status_g	text	Status of the generating unit[9]
year_commissioned	int	Year of commissioning
year_decommissioned	int	Year of decommissioning

[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, MOTHBALLED and CONSTRUCTION

Table 2. Fields in the Linkages table.

JRC_OPEN_LINKAGES		
Field	**SQL Type**	**Description**
eic_p	varchar(20)	EIC (Energy Identification Code) for the producing unit
eic_g	varchar(20)	EIC (Energy Identification Code) for the generation unit
eprtr_facilityID	varchar(10)	Facility ID in E-PRTR
WRI_id	varchar(20)	ID in WRI Power Watch
GEO_id	varchar(20)	ID in Global Energy Observatory
fresna_id	int	ID in FIAS Renewable Energy Systems & Network Analysis

Table 3. Fields in the Performance table.

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

Table 4. Fields in the Temporal table.

JRC_OPEN_TEMPORAL		
Field	**SQL Type**	**Description**
eic_p	varchar(20)	EIC (Energy Identification Code) for the producing unit
eic_g	varchar(20)	EIC (Energy Identification Code) for the generation unit
cyear	Int	Year that the record refers to
production	float	Sum of reported generation in the time series in MWh
cf	float	Capacity factor of plant operation in the published record set
time_coverage	float	Fraction of the total hours in a year covered
co2emitted	float	Kg of CO_2 emitted/year based on the reported annual emissions

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[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.

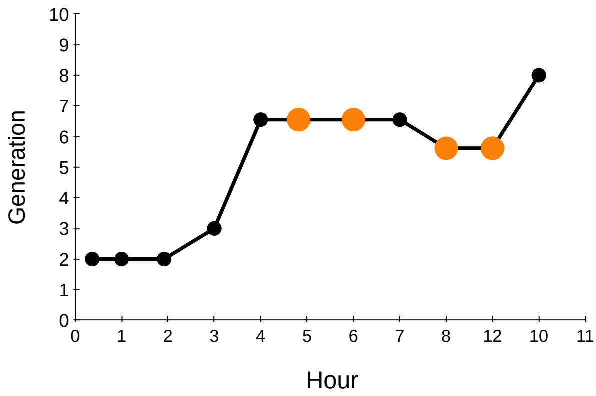
3.1 Time series analysis

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.

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.



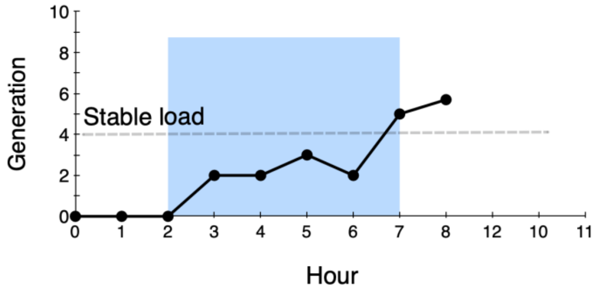
Following the simple conditions described above, a collection of stable values is then defined. Then the stable load for the time-series is defined as the first percentile of this distribution.

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] 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

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.

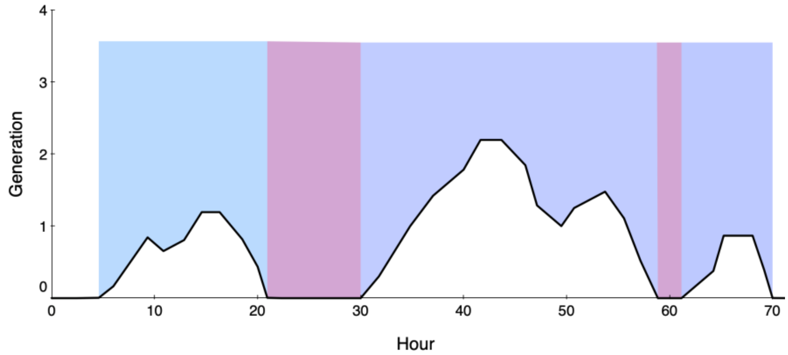


Once obtained a distribution of all the intervals for a time series, the estimated time to stable load can be obtained by specifying a percentile of this distribution.

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.

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.



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_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.

$$eff = \frac{\text{generation} * 3.6}{\frac{\text{CO2emissions}_{\text{excl}_{\text{biomass}}}}{\text{Intensity}_{\text{fuel}}} + \frac{\text{CO2emissions} - \text{CO2emissions}_{\text{excl}_{\text{biomass}}}}{\text{Intensity}_{\text{biomass}}}}$$

Where :

$\text{Intensity}_{\text{fuel}}$: The CO_2 content per calorific energy in the fuel expressed in tonnes CO_2 per TJ[11]

Generation : annual net generation of the power plant in MWh

CO2emissions : Annual emissions in kg

[11] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/submissions/national-inventory-submissions-2017

References

1. K. Kanellopoulos, I. Hidalgo, H. Medarac, A. Zucker, The Joint Research Centre Power Plant Database (JRC-PPDB) - A European Power Plant Database for energy modelling, EUR 28549 EN, doi:10.2760/329310

List of abbreviations and definitions

CCGT	Combined Cycle Gas Turbine
EIC	Energy identification code
ENTSO-E	European Network of Transmission System Operators for Electricity
JRC	Joint Research Centre
JRC-PPDB	The JRC Power Plant Database
TSO	Transmission System Operator
OCGT	Open Cycle Gas Turbine
OEM	Original equipment manufacturer

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