open$_{e}GoDocumentation$

Release V0.3.0dev

open$_{e}Go - Team$

Aug 29, 2018

Contents

1 Getting Started **3**
1.1 Overview . . . 3
1.1.1 Installation . . . 3
1.2 On Windows . . . 3
1.2.1 Run . . . 3

2 Open_eGo the project **5**
2.1 Open Electricity Grid Optimization . . . 5
2.1.1 ego.io . . . 5
2.1.2 Ding0 . . . 5
2.1.3 eDisGo . . . 6
2.1.4 eTraGo . . . 6
2.1.5 eGo . . . 6

3 Data processing scripts **7**
3.1 Data processing . . . 7
3.1.1 SQL-Scripts . . . 7
3.1.1.1 Data Processing SQL-Scripts . . . 7
3.1.1.1.1 Overview of scripts . . . 7
3.1.1.1.1.1 dataprocessing/sql_snippets/ scripts . . . 7
3.1.1.1.1.2 ego_dp_loadarea_census.sql . . . 7
3.1.1.1.1.3 ego_dp_loadarea_consumption.sql . . . 7
3.1.1.1.1.4 ego_dp_loadarea_griddistrict_results.sql . . . 8
3.1.1.1.1.5 ego_dp_loadarea_industry_consumer.sql . . . 8
3.1.1.1.1.6 ego_dp_loadarea_landuse.sql . . . 8
3.1.1.1.1.7 ego_dp_loadarea_loadcut_griddistrict.sql . . . 8
3.1.1.1.1.8 ego_dp_loadarea_loadcut_voronoi.sql . . . 9
3.1.1.1.1.9 ego_dp_loadarea_loadmelt.sql . . . 9
3.1.1.1.1.10 ego_dp_loadarea_loads.sql . . . 9
3.1.1.1.1.11 ego_dp_loadarea_peakload.sql . . . 9
3.1.1.1.1.12 ego_dp_loadarea_statistic.sql . . . 9
3.1.1.1.1.13 ego_dp_lv_consumption_peakload.sql . . . 10
3.1.1.1.1.14 ego_dp_lv_griddistrict.sql . . . 10
3.1.1.1.1.15 ego_dp_lv_substation.sql . . . 10
3.1.1.1.1.16 ego_dp_lv_substation_voronoi.sql . . . 10
3.1.1.1.1.17 ego_dp_mv_griddistrict.sql . . . 11
3.1.1.1.1.18 ego_dp_powerflow_assignment_generator.sql . . . 11

3.1.1.1.1.19 ego_dp_powerflow_assignment_load.sql 11
3.1.1.1.1.20 ego_dp_powerflow_assignment_otgid.sql 11
3.1.1.1.1.21 ego_dp_powerflow_assignment_storage.sql 12
3.1.1.1.1.22 ego_dp_powerflow_assignment_unid.sql 12
3.1.1.1.1.23 ego_dp_powerflow_create_pp_mview.sql 12
3.1.1.1.1.24 ego_dp_powerflow_electrical_neighbour.sql 12
3.1.1.1.1.25 ego_dp_powerflow_grid_future_scenarios.sql 13
3.1.1.1.1.26 ego_dp_powerflow_hv_setup.sql 13
3.1.1.1.1.27 ego_dp_powerflow_lopf_data.sql 13
3.1.1.1.1.28 ego_dp_powerflow_osmtgmod_to_pypsa.sql 14
3.1.1.1.1.29 ego_dp_powerflow_timeseries_demand.sql 14
3.1.1.1.1.30 ego_dp_powerflow_voronoi_weatherpoint.sql 14
3.1.1.1.1.31 ego_dp_structure_input_verification.sql 14
3.1.1.1.1.32 ego_dp_substation_ehv.sql 14
3.1.1.1.1.33 ego_dp_substation_ehv_voronoi.sql 15
3.1.1.1.1.34 ego_dp_substation_hvmv.sql 15
3.1.1.1.1.35 ego_dp_substation_hvmv_voronoi.sql 15
3.1.1.1.1.36 ego_dp_substation_id_to_generator.sql 15
3.1.1.1.1.37 ego_dp_substation_otg.sql 16
3.1.1.1.1.38 ego_dp_versioning.sql 16
3.1.1.1.1.39 ego_dp_versioning_mviews.sql 16
3.1.1.1.1.40 ego_dp_versioning_overview.sql 16
3.1.1.1.1.41 dataprocessing/sql_snippets/functions scripts 16
3.1.1.1.1.42 function_query_metadata.sql 16
3.1.1.1.1.43 dataprocessing/sql_snippets/rea scripts 17
3.1.1.1.1.44 ego_dp_conv.sql 17
3.1.1.1.1.45 ego_dp_lattice_500m.sql 17
3.1.1.1.1.46 ego_dp_lattice_50m.sql 17
3.1.1.1.1.47 ego_dp_rea_lattice_per_area_500m.sql 17
3.1.1.1.1.48 ego_dp_rea_lattice_per_area_50m.sql 18
3.1.1.1.1.49 ego_dp_rea_m1.sql 18
3.1.1.1.1.50 ego_dp_rea_m2.sql 18
3.1.1.1.1.51 ego_dp_rea_m3.sql 18
3.1.1.1.1.52 ego_dp_rea_m4.sql 18
3.1.1.1.1.53 ego_dp_rea_m5.sql 19
3.1.1.1.1.54 ego_dp_rea_results.sql 19
3.1.1.1.1.55 ego_dp_rea_setup.sql 19
3.1.1.1.1.56 ego_dp_rea_wpa_per_mvgd.sql 19
3.1.1.1.1.57 ego_dp_wpa.sql 20
3.1.2 Python-Scripts 20
3.2 Preprocessing 20
3.2.1 SQL-Scripts 20
3.2.1.1 Preprocessing SQL-Scripts 20
3.2.1.1.1 Overview of scripts 20
3.2.1.1.1.1 preprocessing/sql_snippets/ scripts 20
3.2.1.1.1.2 ego_dp_res_rea_by_scenario.sql 20
3.2.1.1.1.3 Part I 20
3.2.1.1.1.4 Part II 20
3.2.1.1.1.5 Methodology 21
3.2.1.1.1.6 ego_dp_structure_boundaries_vg250.sql 21
3.2.1.1.1.7 ego_dp_structure_census.sql 21
3.2.1.1.1.8 ego_dp_structure_osm_landuse.sql 21
3.2.1.1.1.9 ego_dp_structure_scenariolog.sql 21
3.2.1.1.1.10 ego_dp_structure_versioning.sql 22

3.2.1.1.1.11 ego_nep_2015_scenario_capacities.sql 22
3.2.1.1.1.12 ego_pre_slp_parameters.sql 22
3.2.1.1.1.13 ego_pre_voltage_level.sql 22
3.2.1.1.1.14 oedb_setup_schema_structure.sql 23
3.2.1.1.1.15 preprocessing/sql_snippets/boundaries scripts 23
3.2.1.1.1.16 ego_pp_gn250_metadata.sql 23
3.2.1.1.1.17 ego_pp_vg250_metadata.sql 23
3.2.1.1.1.18 preprocessing/sql_snippets/openstreetmap scripts 23
3.2.1.1.1.19 ego_pp_osm_line_street_mview.sql 23
3.2.1.1.1.20 preprocessing/sql_snippets/society scripts 23
3.2.1.1.1.21 ego_pp_destatis_zensus_import.sql 23
3.2.1.1.1.22 ego_pp_destatis_zensus_metadata.sql 24
3.2.2 Python-Scripts 24

4 Scenario framework 25
4.1 open_eGo Scenarios 25
4.1.1 open_eGo Scenarios 26
4.1.1.1 Status Quo 26
4.1.1.2 NEP 2035 26
4.1.1.2.1 Scenario definition of renpassG!S 26
4.1.1.3 eGo 100 26
4.1.1.4 References 26
4.2 Methodology 26
4.2.1 Methodologies 26
4.2.1.1 Methodologies of Renewable Energy Plants 27
4.2.1.1.1 Renewable allocation 27
4.2.1.1.1.1 Expansion of power plants by technology 27
4.2.1.1.1.2 Wind onshore 27
4.2.1.1.1.3 Wind offshore 27
4.2.1.1.1.4 Solar 27
4.2.1.1.1.5 Hydro Power 27
4.2.1.1.1.6 Pumped Storage 27
4.2.1.1.1.7 Biomass 27
4.2.1.1.1.8 geothermal 27
4.2.1.2 Load 28
4.3 References 28
4.4 Footnotes 28

5 What's New 29
5.1 Release v0.3.0 (December 18, 2017) 29
5.1.1 Added features 29
5.1.2 Bug fixes 29
5.1.3 Other changes 29
5.2 Release v0.3.1 (April XX, 2018) 30
5.2.1 Added features 30
5.2.2 Bug fixes 30
5.2.3 Other changes 30

6 Data References 31

7 LICENSE 33

8 Indices and tables 35

Bibliography 37

[Add text here]

CHAPTER 1

Getting Started

1.1 Overview

- How to install
- How to run the dataprocessing package

1.1.1 Installation

Installation of latest release

` (sudo) pip3 install dataprocessing `

Installation (of developer version) via pip on linux systems as follows

` sudo pip3 install -e <path-to-data_processing-repo> `

Troubleshooting

1.2 On Windows

1. __Problem__: Installation of required package shapely fails. __Solution__: Install pre-build wheel from [here](http://www.lfd.uci.edu/~gohlke/pythonlibs/#shapely)

1.2.1 Run

You can run data processing by calling command-line script

` ~$ ego_data_processing `

CHAPTER 2

Open_eGo the project

2.1 Open Electricity Grid Optimization

The project open_eGo aims to develop a transparent, inter-grid-level operating grid planning tool to investigate economic viable grid expansion scenarios considering alternative flexibility options such as storages or redispatch.

Uniform grid planning is required for a successful energy transition. This involves the management of the German electricity grid with more than 800 different network operators and the resulting wide range of interests that sometimes stand at odds with the national economic objectives of the energy transition. However, there is currently no suitable grid planning tool that is able to consider optimum national economic use of the various flexibility options at the different levels. The current challenges of planning for grid expansion associated with the energy transition are answered by open_eGo.

In energy system analysis, models and input data are often handled restrictively. Such a lack of transparency impedes reproducibility and consequently also a proper interpretation of the results. Thus, in open_eGo we publish all our code on github under the Affero General Public License Version 3. The data we use as input, but also all our results will be published on the OpenEnergy Platform, in most cases under an Open Database License Version 1.

For the open_eGo project several python packages are developt which are feeded by the input data of the data processing.

2.1.1 ego.io

SQLAlchemy Interface to the OpenEnergy database (oedb).OEDB table ORM objects are defined here and small helpers for io tasks are contained. Learn more here.

2.1.2 Ding0

The DIstribution Network GeneratOr (Ding0) is a tool to generate synthetic medium and low voltage power distribution grids based on open (or at least accessible) data. Learn more here.

2.1.3 eDisGo

The python package eDisGo provides a toolbox for analysis and optimization of distribution grids. Learn more here.

2.1.4 eTraGo

The python package eTraGo provides a toolbox for Optimization of flexibility options for transmission grids based on PyPSA. Learn more here.

2.1.5 eGo

The python package eGo is a toolbox and application which connects and integrates the tools eTraGo and eDisGo in order to calcualte the overall economic optimum. Learn more here.

CHAPTER 3

Data processing scripts

3.1 Data processing

3.1.1 SQL-Scripts

3.1.1.1 Data Processing SQL-Scripts

3.1.1.1.1 Overview of scripts

3.1.1.1.1.1 dataprocessing/sql_snippets/ scripts

3.1.1.1.1.2 ego_dp_loadarea_census.sql

Loads from Census 2011 Include Census 2011 population per ha. Identify population in OSM loads.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.3 ego_dp_loadarea_consumption.sql

Allocate consumption to Loadareas

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu, Ludee

3.1.1.1.1.4 ego_dp_loadarea_griddistrict_results.sql

Results for MV Griddistrict After finishing the Loadareas we can aggregate the results for the MV Griddistricts: Area of MV Griddistrict. Municipality (Gemeinden). Municipality parts (Gemeinde-Einzelteile). Municipality types. Population results. Loadarea results (Area, Free area, Share). Consumption results.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.5 ego_dp_loadarea_industry_consumer.sql

OSM Industry consumer Calculate specific electricity consumption per million Euro GVA for each federal state. Calculate the electricity consumption for each industry polygon. Identify corresponding bus for large scale consumer (lsc) with the help of ehv-voronoi.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu, Ludee

3.1.1.1.1.6 ego_dp_loadarea_landuse.sql

OSM landuse sectors Extract landuse areas from OpenStreetMap. Cut the landuse with German boders (vg250) and make valid geometries. Divide into 4 landuse sectors: 1. Residential 2. Retail 3. Industrial 4. Agricultural

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.7 ego_dp_loadarea_loadcut_griddistrict.sql

Cut Loadarea with MV Griddistrict Identify and exclude Loadarea smaller than 100m^2. Generate Centre of Load-areas with Centroid and PointOnSurface. Calculate population from Census 2011. Cut all 4 OSM sectors with MV Griddistricts. Calculate statistics like NUTS and AGS code. Check for Loadareas without AGS code.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.8 ego_dp_loadarea_loadcut_voronoi.sql

Cut Loadarea with MV Voronoi cells Identify and exclude Loadarea smaller than 100m^2. Generate Centre of Loadareas with Centroid and PointOnSurface. Calculate population from Census 2011. Cut all 4 OSM sectors with MV Griddistricts. Calculate statistics like NUTS and AGS code. Check for Loadareas without AGS code.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.9 ego_dp_loadarea_loadmelt.sql

Melt loads from OSM landuse and Census 2011 Collect loads from both sources. Buffer collected loads with with 100m. Unbuffer the collection with 100m. Validate the melted geometries. Fix geometries with error. Check again for errors.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.10 ego_dp_loadarea_loads.sql

OSM Loads from landuse Excludes large scale consumer. Buffer OSM urban sectors with 100m Unbuffer buffer with -100m

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.11 ego_dp_loadarea_peakload.sql

Peak loads per Loadarea Uses SLP parameters per sectors.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author gplssm, Ludee

3.1.1.1.1.12 ego_dp_loadarea_statistic.sql

Results and statistics for eGoDP data Substation, Loadarea, MV Griddistricts and Consumption. MV Griddistrict types. Municipality (Gemeinden). Calculate statistics for BKG vg250.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.13 ego_dp_lv_consumption_peakload.sql

LV Consumption and Peakload Update LV Griddistrict table by a. sectoral consumption in each LV Griddistrict b. sectoral peak load in each LV Griddistrict

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author gplssm

3.1.1.1.1.14 ego_dp_lv_griddistrict.sql

LV Griddistrict Create LV Griddistrict from MVLV Substation. Generate OSM landuse per sectors.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee, jong42

3.1.1.1.1.15 ego_dp_lv_substation.sql

MVLV Substation (ONT) Create a lattice (regular fishnet grid) with 360m. Create MVLV Substation from lattice centroid.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee, jong42

3.1.1.1.1.16 ego_dp_lv_substation_voronoi.sql

MVLV Substation Voronoi Voronoi polygons with Eucldean distance (manhattan distance would be better but not available in sql).

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee, jong42

3.1.1.1.1.17 ego_dp_mv_griddistrict.sql

MV GridDistricts Generate MV GridDistricts from municipalities and Voronoi cells. Each HVMV Substation receives one catchment area. Detailed description can be found in Hülk et. al. 2017.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.18 ego_dp_powerflow_assignment_generator.sql

Generators which were assigned to a specific substation prior to this script need to be transformed to a data structure suitable for powerflow calculation with tool developed and used in the open_eGo project. The following script transforms data from the powerplant mviews and adds some parameters according to the characteristics of the generators. To reduce the data volumn in the final table structure (see ego_dp_powerflow_hv_setup.sql) the generators are clustered according to their source, installed capacity, weather point and substation they are assigned to. Here a new and unique aggregate-ID (aggr_id) is assigned. In an interims stage all generators are converted to a format suitable for powerflow flow calculation seperately. This data can be accessed in table model_draft.ego_supply_pf_generator_single.

Information on generators which are assigned to a specific substation are transformed to a data structure which is suitable for PyPSA. This script creates the scenarios 'Status Quo', 'NEP 2035' and 'eGo 100' in the hv powerflow schema.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu, Ludee

3.1.1.1.1.19 ego_dp_powerflow_assignment_load.sql

Similar to generators in the previous script the data on loads are converted and clustered to fit the data structure needed for powerflow calculations. The electricity demand of small scale consumer and industrial large scale consumer is considered.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.1.1.1.1.20 ego_dp_powerflow_assignment_otgid.sql

This scripts updates tables containing renewable power plants and conventional power plants with information on the otg_id of substations which the generator is assigned to. The otg_id and subst_id of the substations are matched in tables containing information on HV/MV substations and EHV substations.

Additionally the otg_id of offshore wind turbines is updated manually. The geometry of offshore wind power plants is matched with polygons representing a catchment area per relevant offshore grid connection point.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.1.1.1.1.21 ego_dp_powerflow_assignment_storage.sql

Equivalent to the assignment of generators in this script storages are converted and clustered for all three scenarios considered in open_eGo.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu", "lukasol

3.1.1.1.1.22 ego_dp_powerflow_assignment_unid.sql

All generators from the conventional and renewable power plant list are brought together in a central generator list. A unified id (un_id) is assigned to those generators listed. Information on the un_id is then added to the conventional and renewable power plant lists.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.1.1.1.1.23 ego_dp_powerflow_create_pp_mview.sql

This script creates discrete materialized views (mview) for conventional and renewable power plants per scenario, resulting in six different mviews for the three main scenarios considered in open_eGo.

copyright Europa-Universität Flensburg - ZNES

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author wolfbunke

3.1.1.1.1.24 ego_dp_powerflow_electrical_neighbour.sql

The electricity grid model extracted from osmTGmod is limited to the German territory. This script adds border crossing lines and corresponding buses and transformers to all neighbouring countries which have a direct electrical connection to the German grid.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.1.1.1.1.25 ego_dp_powerflow_grid_future_scenarios.sql

The grid model which is used as an input for powerflow calculations and optimization in open_eGo is the same in all three scenarios 'SQ', 'NEP 2035' and 'eGo100'. In the following script the grid model created for the 'SQ' scenario in the previous scripts is duplicated for the remaining two future scenarios

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.1.1.1.1.26 ego_dp_powerflow_hv_setup.sql

This script creates all tables which are needed for hv-powerflow calculations. The characteristics of those tables follow the structure of PyPSA's input data.

The following tables are created: model_draft.ego_grid_pf_hv_scenario_settings model_draft.ego_grid_pf_hv_source model_draft.ego_grid_pf_hv_bus model_draft.ego_grid_pf_hv_busmap model_draft.ego_grid_pf_hv_generator model_draft.ego_grid_pf_hv_line model_draft.ego_grid_pf_hv_load model_draft.ego_grid_pf_hv_storage model_draft.ego_grid_pf_hv_temp_resolution model_draft.ego_grid_pf_hv_transformer model_draft.ego_grid_pf_hv_bus_v_mag_set model_draft.ego_grid_pf_hv_generator_pq_set model_draft.ego_grid_pf_hv_load_pq_set model_draft.ego_grid_pf_hv_storage_pq_set

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author mariusves, IlkaCu, ulfmueller, Ludee, s3pp

3.1.1.1.1.27 ego_dp_powerflow_lopf_data.sql

Missing parameters necessary for calculating a linear optimal power flow (LOPF) are added to the existing data. This includes marginal costs per technology, which is composed of specific operating cost, fuel costs and CO2 costs according to renpass_gis, NEP 2014 scenario. In addition p_max_pu is set for all generators with variable dispatch based on p_max_pu = p_set / p_nom.

A further section of the script is used to insert extendable battery and hydrogen storages to all substations in the grid model. These have a initial installed capacity p_nom=0, which can be extended when executing an optimization (by calculating a LOPF).

copyright Europa-Universität Flensburg, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author wolfbunke, lukasol

3.1.1.1.1.28 ego_dp_powerflow_osmtgmod_to_pypsa.sql

osmTGmod provides a model of the German EHV and HV grid based on OpenStreetMap. This script extracts bus and branch data provided by osmTGmod and inserts the grid model into the corresponding powerflow tables. Additionally some (electrical) properties for transformers are adjusted or added.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author ulfmueller, IlkaCu, mariusves

3.1.1.1.1.29 ego_dp_powerflow_timeseries_demand.sql

Aggregated load time series for neighbouring countries are based on rennpassG!S results and are added to the corresponding powerflow table. The load is equivalent in all three scenarios.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author ulfmueller, wolfbunke

3.1.1.1.1.30 ego_dp_powerflow_voronoi_weatherpoint.sql

voronoi with climatepoints

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu, Ludee

3.1.1.1.1.31 ego_dp_structure_input_verification.sql

Input verification (eGoPP) Check the necessary input tables from eGo PreProcessing. Return version of input tables.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.32 ego_dp_substation_ehv.sql

EHV Substation Abstract EHV Substations of the extra high voltage level from OSM. This script abstracts substations of the extra high voltage level from openstreetmap data.

copyright DLR Institute for Networked Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author lukasol, C. Matke, Ludee

3.1.1.1.1.33 ego_dp_substation_ehv_voronoi.sql

EHV Substation Voronoi Voronoi polygons with eucldean distance on EHV Substation. Manhattan distance would be better but not available in sql.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu, Ludee

3.1.1.1.1.34 ego_dp_substation_hvmv.sql

HVMV Substation Abstract HVMV Substations of the high voltage level from OSM. This script abstracts substations of the high voltage level from openstreetmap data. All substations that are relevant transition points between the transmission and distribution grid are identified, irrelevant ones are disregarded.

copyright DLR Institute for Networked Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author lukasol, C. Matke, Ludee

3.1.1.1.1.35 ego_dp_substation_hvmv_voronoi.sql

HVMV Substation Voronoi Voronoi polygons with eucldean distance on HVMV Substation. Manhattan distance would be better but not available in sql.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.36 ego_dp_substation_id_to_generator.sql

Substation ID to Generator All powerplants (Conventional and Renewable) receive the corresponding Substation ID. Either the HVMV Substation ID (= MV Griddistrict ID) or the EHV Substaion ID. Identify corresponding subst_id for all power plants according to their voltage_level and geometry.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.1.1.1.1.37 ego_dp_substation_otg.sql

Substation OTG-ID Script to assign osmTGmod-id (OTG) to substation.

copyright DLR Institute for Networked Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author lukasol, C. Matke

3.1.1.1.1.38 ego_dp_versioning.sql

eGo Data Processing result data versioning Copy a version from model_draft to OEP schema

copyright © Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.39 ego_dp_versioning_mviews.sql

eGo Data Processing result data versioning Copy a version of mvies from model_draft to OEP schema

copyright Europa-Universität Flensburg

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author wolfbunke

3.1.1.1.1.40 ego_dp_versioning_overview.sql

eGo Data Processing overview Check all versioned tables

copyright © Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.41 dataprocessing/sql_snippets/functions scripts

3.1.1.1.1.42 function_query_metadata.sql

Function select important parameters of a table and it's metadata

NOT WORKING

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.43 dataprocessing/sql_snippets/rea scripts

3.1.1.1.1.44 ego_dp_conv.sql

Skript to allocate conventional power plants to loadareas

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.45 ego_dp_lattice_500m.sql

Lattice (regular point grid) with 500m Lattice on bounding box of Germany.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.46 ego_dp_lattice_50m.sql

Lattice (regular point grid) with 50m Lattice on bounding box of Germany.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.47 ego_dp_rea_lattice_per_area_500m.sql

Prepare 500m lattice Lattice on bounding box of Germany with 500m per area: wpa - points inside wind potential area la - points inside loadarea x - points inside wind potential area and loadarea out - points outside area

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.48 ego_dp_rea_lattice_per_area_50m.sql

Prepare 500m lattice Lattice on bounding box of Germany with 50m per area: la - points inside loadarea

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.49 ego_dp_rea_m1.sql

M1 biomass and solar to OSM agricultural Allocates "biomass" & (renewable) "gas" to OSM agricultural areas. The rest could not be allocated, consider in M4.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.50 ego_dp_rea_m2.sql

M2 wind farms Allocates "wind" turbines with voltage level 4 to WPA as wind farms. The rest could not be allocated, consider in M3.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.51 ego_dp_rea_m3.sql

M3 wind turbines to WPA Allocates "wind" turbines with voltage levels "5" & "6" to WPA. Also considers rest of M2. The rest could not be allocated, consider in M4.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.52 ego_dp_rea_m4.sql

M4 other and rest Allocates "wind" with voltage levels "5" & "6" to WPA. "solar ground" & "wind" ohne voltage & Rest M1-1 & Rest M1-2 & Rest M3. Also considers rest of M1-1, M1-2 and M3. There should be no rest!

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.53 ego_dp_rea_m5.sql

M5 LV to Loadarea Allocate "solar" with voltage levels "6" & "7" to Loadarea. There should be no rest!

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.54 ego_dp_rea_results.sql

Results and statistics for REA

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.55 ego_dp_rea_setup.sql

Setup tables for REA Skript to allocate decentralized renewable power plants (dea). Methods base on technology and voltage level. Allocate DEA outside of Germany to next HVMV Substation. Generate OSM farmyards.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.56 ego_dp_rea_wpa_per_mvgd.sql

Wind potential area (WPA) per MV-Griddistrict Cut WPA with MV-Griddistrict and make valid geometries.

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.1.1.1.57 ego_dp_wpa.sql

Skript to allocate decentralized renewable power plants (dea) Methods base on technology and voltage level Uses different lattice from setup_ego_wpa_per_grid_district.sql

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.1.2 Python-Scripts

[use sphinx doc strings]

3.2 Preprocessing

3.2.1 SQL-Scripts

3.2.1.1 Preprocessing SQL-Scripts

3.2.1.1.1 Overview of scripts

3.2.1.1.1.1 preprocessing/sql_snippets/ scripts

3.2.1.1.1.2 ego_dp_res_rea_by_scenario.sql

SQL Script that prepare and insert single renewable power plant data by a given scenario in order to create a high resulution allocation renewable energy expansion.

For the project open_eGo and the tools eTraGo, eDisGo and eGo the scenarios are named 'Status Quo' (2015), 'NEP 2035', 'eGo 100'. Learn more about the scenario here scenarios here.

This script is divided into two parts:

3.2.1.1.1.3 Part I

- Development of new renewable power plants by NEP 2035 scenario data

3.2.1.1.1.4 Part II

- Development of new renewable power plants by ego 100% scenario data

3.2.1.1.1.5 Methodology

Both parts of the script work more or less with the same Methodology of an expansion and allocation of renewable energy plants. A full documentation of the used Methodology of the Renewable allocation can be found here.

copyright Europa-Universität Flensburg, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author wolfbunke

3.2.1.1.1.6 ego_dp_structure_boundaries_vg250.sql

Setup borders Inputs are german administrative borders (boundaries.bkg_vg250) Create mviews with transformed CRS (EPSG:3035) and corrected geometries Municipalities / Gemeinden are fragmented and cleaned from ringholes (bkg_vg250_6_gem_clean)

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.7 ego_dp_structure_census.sql

Result tables for eGoDP

WARNING: It drops the table and deletes old entries when executed!

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee, IlkaCu

3.2.1.1.1.8 ego_dp_structure_osm_landuse.sql

analyse OSM landuse data

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.9 ego_dp_structure_scenariolog.sql

Setup scenario log table Creates a table to get inserts from other processed tables

WARNING: It drops the table and deletes old entries when executed!

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.10 ego_dp_structure_versioning.sql

Result tables for eGoDP

WARNING: It drops the table and deletes old entries when executed!

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee, IlkaCu

3.2.1.1.1.11 ego_nep_2015_scenario_capacities.sql

Create and setup the table model_draft.ego_nep_2015_scenario_capacities for electrical scenario capacities of the Netzentwicklungsplan 2015, erster Entwurf per federal state in Germany.

copyright Europa-Universität Flensburg, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author wolfbunke

3.2.1.1.1.12 ego_pre_slp_parameters.sql

Create table with assumptions and parameters on standard load profiles (SLP)

WARNING: It drops the table and deletes old entries when executed!

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author gplssm

3.2.1.1.1.13 ego_pre_voltage_level.sql

Set or adjust voltage_level according to installed capacity and technology of power plants.

copyright Flensburg University of Applied Sciences, Centre for Sustainable Energy Systems

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author IlkaCu

3.2.1.1.1.14 oedb_setup_schema_structure.sql

Setup the OpenEnergy Database (oedb) schema structure

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.15 preprocessing/sql_snippets/boundaries scripts

3.2.1.1.1.16 ego_pp_gn250_metadata.sql

Metadata for gn250 tables Geographische Namen 1:250 000 - GN250

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.17 ego_pp_vg250_metadata.sql

Metadata for vg250 tables

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.18 preprocessing/sql_snippets/openstreetmap scripts

3.2.1.1.1.19 ego_pp_osm_line_street_mview.sql

Extracted OSM streets from line

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author jong42, Ludee

3.2.1.1.1.20 preprocessing/sql_snippets/society scripts

3.2.1.1.1.21 ego_pp_destatis_zensus_import.sql

Import DESTATIS zensus 2011 table

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.1.1.1.22 ego_pp_destatis_zensus_metadata.sql

Import DESTATIS zensus 2011 table

copyright Reiner Lemoine Institut

license GNU Affero General Public License Version 3 (AGPL-3.0)

url https://github.com/openego/data_processing/blob/master/LICENSE

author Ludee

3.2.2 Python-Scripts

[use sphinx doc strings]

CHAPTER 4

Scenario framework

4.1 open_eGo Scenarios

Three scenarios were defined and used for the intended power flow simulations. Apart from one status quo scenario representing the German electrical energy system in 2015, two future scenarios were defined employing exogenous assumptions. For Germany, the installed generation capacities of the status quo scenario were taken from the power plant list of the Open Power System Data project *[opsd-conv]*, *[opsd-res]* (State: 01-01-2016). Whereas the 2035 scenario is based on publicly available information and methods of the *Netzentwicklungsplan (NEP) Strom 2025, erster Entwurf [NEP2015]* . Out of several NEP scenarios, the so-called "B1-2035" was chosen; it is characterized by a high renewable energy expansion and an increased share of natural gas *[NEP2015]*. The third scenario pictures a future electrical energy system powered to 100% from renewable energy and is mainly based on the *100% RES* scenario of the *e-Highway2050 - Modular Development Plan of the Pan-European Transmission System 2050 [ehighway2050]*. In order to build a 100% energy system in Germany 13,GW of gas fired power plants were removed (see: *[christ2017]* and *[FlEnS]*).

Table *Characterization of scenarios by key parameters* shows the scenario specifications and significant characteristics of all three scenarios.

Table 4.1: Characterization of scenarios by key parameters

	Status Quo	NEP 2035	eGo 100%
Share of RES in installed capacity	46,46%	70,02%	100,00%
Net electricity consumption (Twh)	506	506	506
Annual peak load (GW)	87,01	87,01	87,01
Share of renewable energy in el. Consumption	27,31%	65,80%	100,00%

For the calculation of the *Share of renewable energy in el. consumption* the *assumption-a* where used.

Table *Installed generation capacities in GW for Germany and marginal costs for conventional generation in 2014€/MWh , divided by scenario and technology/fuel* displays the resulting installed electrical capacities in Germany and marginal cost assumptions for each scenario divided by the different technologies and fuels.

Table 4.2: Installed generation capacities

Technology		status quo		NEP 2035		eGo 100	
	GW	EUR/MWh	GW	EUR/MWh	GW	EUR/MWh	
Nuclear energy	12	4,68	0	5,48	0	–	
Lignite	23,3	10,78	9,1	17,64	0	–	
Hard coal	31,5	14,95	11	24,79	0	–	
Natural gas	27,9	32,3	33,5	41,93	0	56,05	
Oil	4,5	41,02	0,5	68,86	0	–	
Waste	1,7	31,65	0	39,93	0	–	
CHP $<$ 10 MW	0	23,96	8,2	31,11	0	31,63	
Other conventional generation (mixed fuels)	2,6	31,65	2,4	39,93	0	–	
Total conventional generation	103,5		64,7		0		
Wind onshore		41,3		88,8		98,4	
Wind offshore		5,6		18,5		27	
Photovoltaic		38,5		59,9		97,8	
Biomass		7,2		8,4		27,8	
Hydro power		3,9		4,2		4,3	
Other renewable generation		1,4		1,2		2,2	
Total renewable generation		97,9		181		257,5	
Pump storage	9,3		12,7		12,8		
Total generation	210,7		258,4		270,3		

The table

4.1.1 open_eGo Scenarios

For the project open_eGo been three scenarios choosen in order to

4.1.1.1 Status Quo

4.1.1.2 NEP 2035

[NEP2015]

4.1.1.2.1 Scenario definition of renpassG!S

4.1.1.3 eGo 100

4.1.1.4 References

4.2 Methodology

4.2.1 Methodologies

[Intro]

4.2.1.1 Methodologies of Renewable Energy Plants

[Intro]

4.2.1.1.1 Renewable allocation

The Methodology of the expansion and allocation of renewable energy plants is done in two parts. The first part is the developent and expansion of renewable power palnts by a scenario input of installed capacities. The allocation based on the spacial level of municipalities. The second part allocated the surplus of power plants power plants on a high spacial resultion by white areas and other Polygon objects (see XXX).

4.2.1.1.1.1 Expansion of power plants by technology

4.2.1.1.1.2 Wind onshore

Text

4.2.1.1.1.3 Wind offshore

text

4.2.1.1.1.4 Solar

text

4.2.1.1.1.5 Hydro Power

run of river and reservoir

4.2.1.1.1.6 Pumped Storage

4.2.1.1.1.7 Biomass

text

4.2.1.1.1.8 geothermal

text

4.2.1.2 Load

4.3 References

4.4 Footnotes

CHAPTER 5

What's New

See what's new as per release!

Releases

- *Release v0.3.0 (December 18, 2017)*
- *Release v0.3.1 (April XX, 2018)*

5.1 Release v0.3.0 (December 18, 2017)

[Description]

5.1.1 Added features

-

5.1.2 Bug fixes

-

5.1.3 Other changes

-

5.2 Release v0.3.1 (April XX, 2018)

[Description]

5.2.1 Added features

-

5.2.2 Bug fixes

-

5.2.3 Other changes

- change use of geom (original) to rea_geom_new
- …

CHAPTER 6

Data References

CHAPTER 7

LICENSE

CHAPTER 8

Indices and tables

- genindex
- modindex
- search

Bibliography

[NEP2015] Übertragungsnetzbetreiber Deutschland, Netzentwicklungsplan Strom 2025, Version 2015, 1. Entwurf, 2015. https://www.netzentwicklungsplan.de/sites/default/files/paragraphs-files/NEP_2025_1_Entwurf_Teil1_0_0.pdf

[coastdat-2] coastDat-2 Hindcast model http://www.coastdat.de/data/index.php.en

[FlEnS] Wolf-Dieter Bunke Martin Söthe Marion Christ Cord Kaldemeyer *(Fl)ensburg (En)ergy (S)cenarios - open_eGo Scenarios for 2014/2035/2050*.

https://osf.io/bpf36/

[NEP2015] Übertragungsnetzbetreiber Deutschland. (2015).: *Netzentwicklungsplan Strom 2025*, Version 2015, 1. Entwurf, 2015. https://www.netzentwicklungsplan.de/sites/default/files/paragraphs-files/NEP_2025_1_Entwurf_Teil1_0_0.pdf

[coastdat-2] coastDat-2 (2017).: Hindcast model http://www.coastdat.de/data/index.php.en

[FlEnS] Bunke, Wolf-Dieter, Martin Söthe, Marion Wingenbach, and Cord Kaldemeyer. 2018.: *"(Fl)ensburg (En)ergy (S)cenarios - open_eGo Scenarios for 2014/2035/2050."* Open Science Framework. June 13. doi:10.17605/OSF.IO/BPF36.

[opsd-conv] Open Power System Data. 2016.: Data provided by Open Power System Data - Data Package Conventional power plants, version 2016-10-27. Primary data from BNetzA Kraftwerksliste, Umweltbundesamt Datenbank Kraftwerke in Deutschland.

[opsd-res] Open Power System Data. 2017.: Data provided by Open Power System Data - Data Package Renewable power plants, early version 2016-02-10. Primary data from BNetzA, BNetzA_PV, TransnetBW, TenneT, Amprion, 50Hertz, Netztransparenz.de, Postleitzahlen Deutschland, Energinet.dk, Energistyrelsen, GeoNames, French Ministery of the Environment, Energy and the Sea, OpenDataSoft, Urzad Regulacji Energetyki (URE)

[ehighway2050] e-Highway2050. (2015).: e-HIGHWAY 2050 Modular Development Plan of the Pan-European Transmission System 2050 - database per country. Retrieved from http://www.e-highway2050.eu/fileadmin/documents/Results/e-Highway_database_per_country-08022016.xlsx

[christ2017] Christ, M. (2017).: Integration sozial-ökologischer Faktoren in die Energiesystemmodellierung am Beispiel von Entwicklungspfaden für den Windenergieausbau in Deutschland (PhD Thesis). Europa-Universität Flensburg.

[BMWi] text . . .

[BKG2016] Bundesamt für Kartographie und Geodäsie (BKG): *Verwaltungsgebiete 1:250.000 Staat - (STA)* (VG250), 2016, Geodatenzugangsgesetz (GeoZG), <http://www.geodatenzentrum.de>

[BKG2016] Bundesamt für Kartographie und Geodäsie (BKG): *Verwaltungsgebiete 1:250.000 Kreise - (KRS)* (VG250), 2016, Geodatenzugangsgesetz (GeoZG), <http://www.geodatenzentrum.de>

[BKG2016] Bundesamt für Kartographie und Geodäsie (BKG): *Verwaltungsgebiete 1:250.000 Gemeinden - (GEM)* (VG250), 2016, Geodatenzugangsgesetz (GeoZG), <http://www.geodatenzentrum.de>

[RLI2016] Reiner Lemoine Institut gGmbH: *eGo dataprocessing - Loadarea*, 2016, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/demand/ego_dp_loadarea>

[RLI2016] Reiner Lemoine Institut gGmbH: *eGo dataprocessing - LV Distribution grid area*, 2016, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/grid/ego_dp_lv_griddistrict>

[RLI2016] Reiner Lemoine Institut gGmbH: *eGo dataprocessing - MV Grid district*, 2016, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/grid/ego_dp_mv_griddistrict>

[RLI2016] Reiner Lemoine Institut gGmbH: *eGo dataprocessing - HVMV Substation*, 2016, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/grid/ego_dp_mvlv_substation>

[RLI] Reiner Lemoine Institut gGmbH: *eGo hv powerflow - loads*, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/grid/ego_pf_hv_load_pq_set>

[RLI] Reiner Lemoine Institut: *eGo dataprocessing - SLP parameters*, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/scenario/ego_slp_parameters>

[Europa-University] Europa-Universität Flensburg: *eGo renewable power classes of wind*, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/supply/ego_power_class>

[Europa-University] Europa-Universität Flensburg: *Renewable feedin time series for eGo*, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/supply/ego_renewable_feedin>

[VerNetzen2015] Europa-University VerNetzen: *VerNetzen - Wind potential Area*, 2015, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/supply/vernetzen_wind_potential_areat>

[VerNetzen2015] Europa-University VerNetzen: *VerNetzen - Wind potential Area*, 2015, Open Data Commons Open Database License 1.0 (ODbL-1.0), <http://openenergy-platform.org/dataedit/view/supply/vernetzen_wind_potential_areat>