EnergyScope Pathway: Extension of EnergyScope TD [1] to a pathway version accounting for investment from 2015 to 2050 Documentation

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Contents

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Introduction

This documentation is complementary to the PhD thesis of Gauthier Limpens [2]. In the latter, the full mathematical formulation of the problems, its description, the data used, the sources, etc. are described in Chapter 2-4 and Appendix B. This documentation proposes a *User manual* to understand the repository structure and how to use the code **??**. Please visit the repository to verify for updated[1].

1 User manual

The code, its documentation and the case study are gathered on a GitHub repository**??**. A `README.md` files summarises how to launch the energy model in four steps. Here below, we propose an extensive explanation including how to compute the typical days and manage data. The data are managed through excel files which are related ones to each others. The models are coded in AMPL, using the solver CPLEX. However, the STEP 1 proposed can be run using the open-source GLPK and the GLPSOL solver. The STEP 2 relies on command requiring AMPL. In addition, the computational time of this step is longer (50 000 to 150 000 seconds), thus GLPK appears as not usable as it has performances 30 times worse than AMPL on this type of problem.

1.1 Files structure and download

EnergyScope Pathway (EnergyScope Pathway) is structured as shown in Figure **??**. A main folder contains three sub-folders, first one is dedicated to data management. Second, for the files related to typical days selection (STEP 1). Third and last branch regroups the files related to the energy model (STEP 2). Table **??** describes each files.

By ensuring that the download files respect the structure, the links between files should be respected and User could use the quick start procedure to launch the code.

1.2 Quick start

Figure **??** represents how data are managed between files listed in Figure **??** and how they are related to each others. in the following section, we will describe how to change the inputs data in `DATA.xlsx`, how to select typical days (STEP 1) and how to launch the energy system (STEP 2).

Each step is not mandatory, as User can skip a step and use the, already implemented, case which has all the input data to represent the Swiss energy system. Hence, Users who directly download the energy model and run it, will obtain the results presented in the paper.

1.2.1 Data

The `DATA.xlsx` file regroups all the required input data. An extensive description of these are given in Appendix B of [2]. In the `DATA.xlsx` file, user can change each data, such as the cost of a technology, time series, the availability of resources or the maximum amount of wind turbines. The updated output files will be automatically generated, and user will just need to copy paste them as described in Figure **??**.

[1] Repository: `https://github.com/energyscope/EnergyScope_pathway`

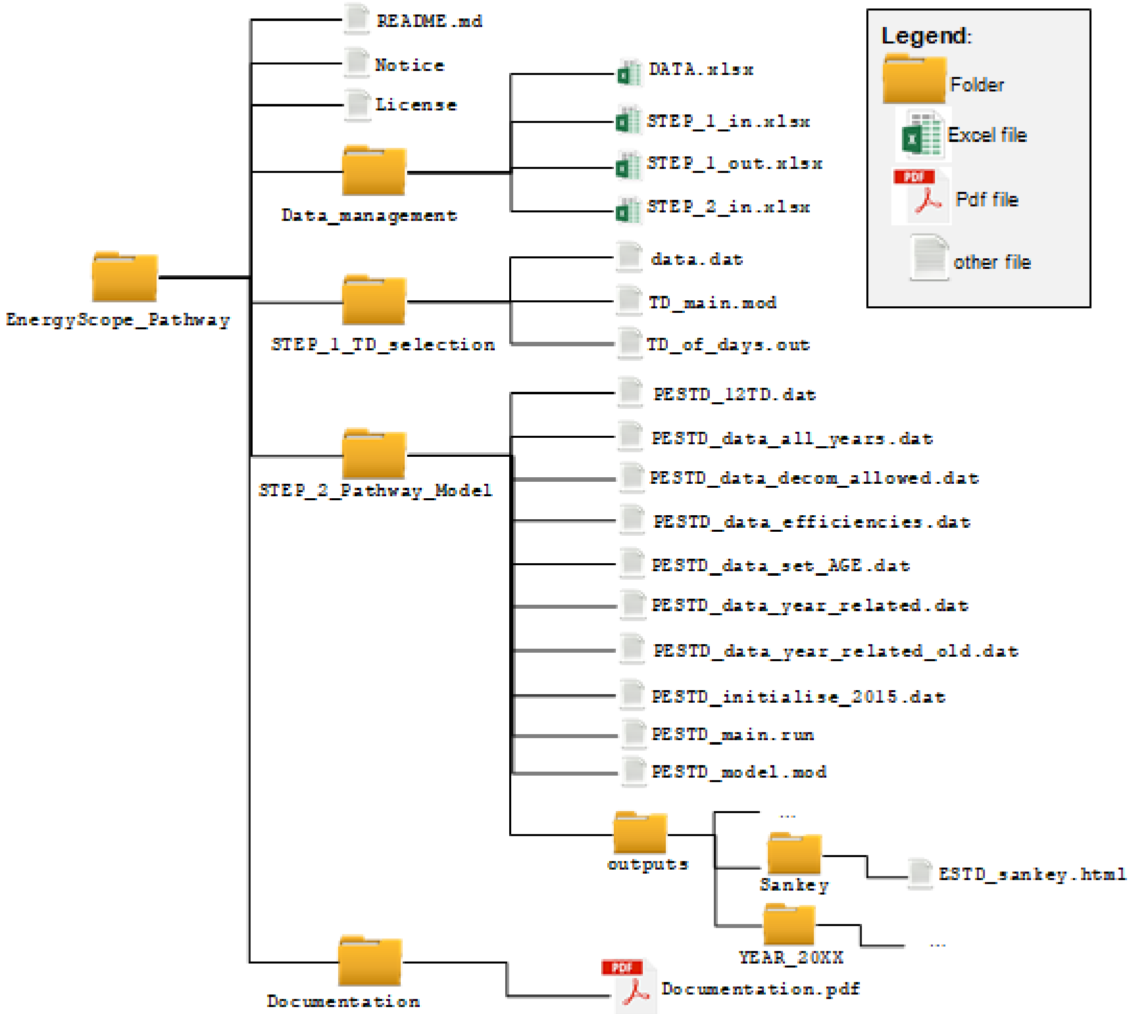

Figure 1: Files and folder structure

Table 1: Description of the files in Figure ??.

Folder	File name	Description
EnergyScope TD	`README.md`	Read me file
	`Notice`	List of contributions and references
	`License`	License file
Data	`DATA.xlsx`	All the input data
	`STEP_1_in.xlsx`	Prepare data for step 1
	`STEP_1_out.xlsx`	Process data from step 1
	`STEP_2_in.xlsx`	Prepare data for step 2
STEP1	`data.dat`	Data file for MILP problem
	`TD_main.mod`	MILP problem
	`TD_of_days.out`	Output of MILP problem: sequence of days.
STEP2	`PESTD_12TD.dat`	Data file related to time series and sequence of days for 12 TDs for all representative
	`PESTD_data_all_years.dat`	Data file defining parameters used for all representative years
	`PESTD_data_decom_allowed.dat`	Data file defining the parameter *decom_allowed*
	`PESTD_data_efficiencies.dat`	Data file defining efficiencies for each of the representative years
	`PESTD_data_decom_allowed.dat`	Data file defining the SET AGE
	`PESTD_data_year_related.dat`	Data file defining parameters for each of the representative years
	`PESTD_initialie_2015.mod`	Additional constraints for 2015
	`PESTD_main.run`	Main file which compiles all the others
	`PESTD_model.mod`	LP problem
Documentation	`Documentation`	User guide manual

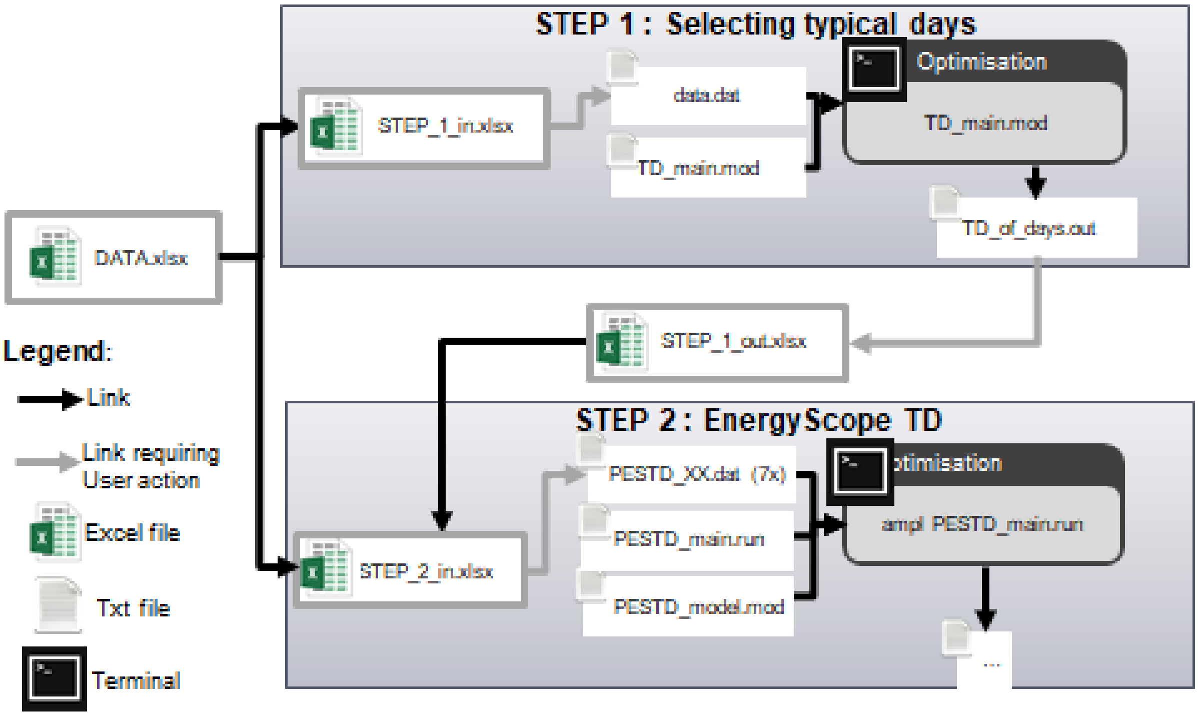

Figure 2: Management of files. Black arrows represent automatic actions instead of grey arrows which require User action. Example, from the `DATA.xlsx` file, the input for the first step (`STEP_1_in.xlsx`) are automaticaly loaded (black arrow). The file computes the loaded information to generate the data required for the MILP problem. These data must be copy-paste on the `data.dat` file (grey arrow).

1.2.2 Step 1: selecting typical days

Input

File `STEP_1_in.xlsx` loads the required data from the `DATA.xlsx` file, such as time series or number of typical days. The data required for STEP 1 mixed-integer linear programming (MILP) are generated in the `.dat` tab. User might copy-paste the tab in the `data.dat` file.

Run

Navigate to the subfolder `.\STEP_1_TD_selection` folder via terminal/cmd prompt and execute (check glpsol documentation for more options):

- Linux: `glpsol -m TD_main.mod -d data.dat`
- Mac OS X: `glpsol -m TD_main.mod -d data.dat`
- Windows: `glpsol.exe -m TD_main.mod -d data.dat`

Output

Results of the computation are recorded in `TD_of_days.out`. It contains the sequence of TDs over the year. This data must be copied-pasted in file `STEP_1_out.xlsx`.

1.2.3 Step 2: Energy model

Input

File `STEP_2_in.xlsx` loads the required data from the `DATA.xlsx` and `STEP_1_out.xlsx` files. Then, required data are generated and must be copied-pasted in seven different data files. There are many different data files in order to regroup data with the same characteristics and avoiding to have files too heavy. As an example, all the efficiencies for each technologies for the different representative years is accounted in one data file (`PESTD_data_efficiencies`). Copy-paste these data file from the tabs to the files, respectively.

Run

Navigate to the subfolder `.\STEP_2_Pathway_Model` via terminal/cmd prompt, verify that the ampl command is available, and then, execute the code:

- `ampl PESTD_main.run`

Warning: the computational time of this model is long, between 5 to 30 hours.

Output

Output files are generated automatically in folder `./output`. You can execute the `Sankey_ESTD.html` and upload the `input2sankey.csv` file to have a Sankey diagram of the energy system.

References

[1] G. Limpens et al. “EnergyScope TD: A novel open-source model for regional energy systems”. In: *Applied Energy* 255 (2019), p. 113729.

[2] Gauthier Limpens. “Optimisation of energy transition pathways - application to the case of Belgium”. PhD Thesis. UCLouvain, 2021.