

An Intro to  
**EnergyPLAN** modeling





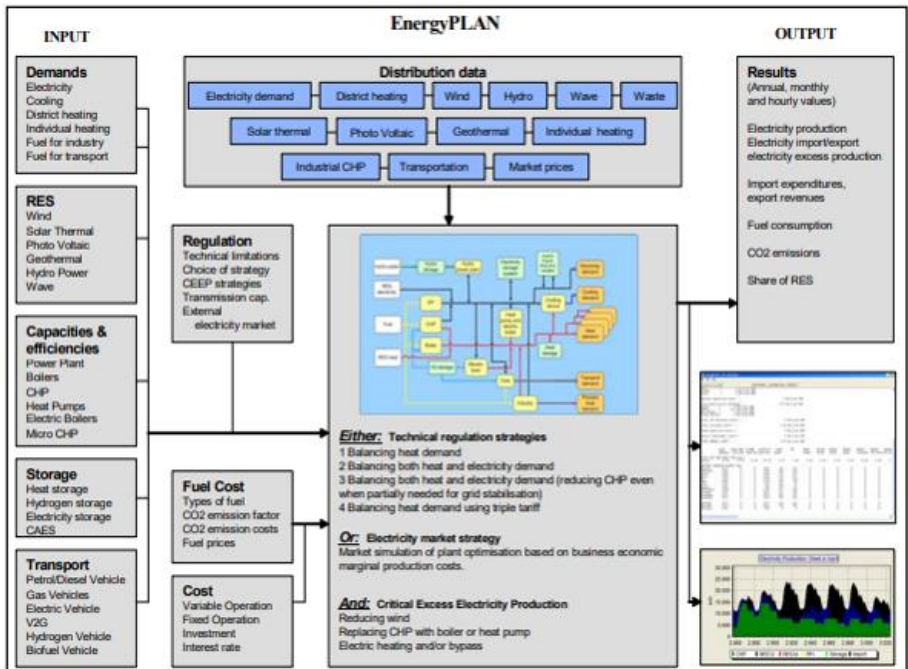
Postgraduate Programme Renewable Energy – PPRE

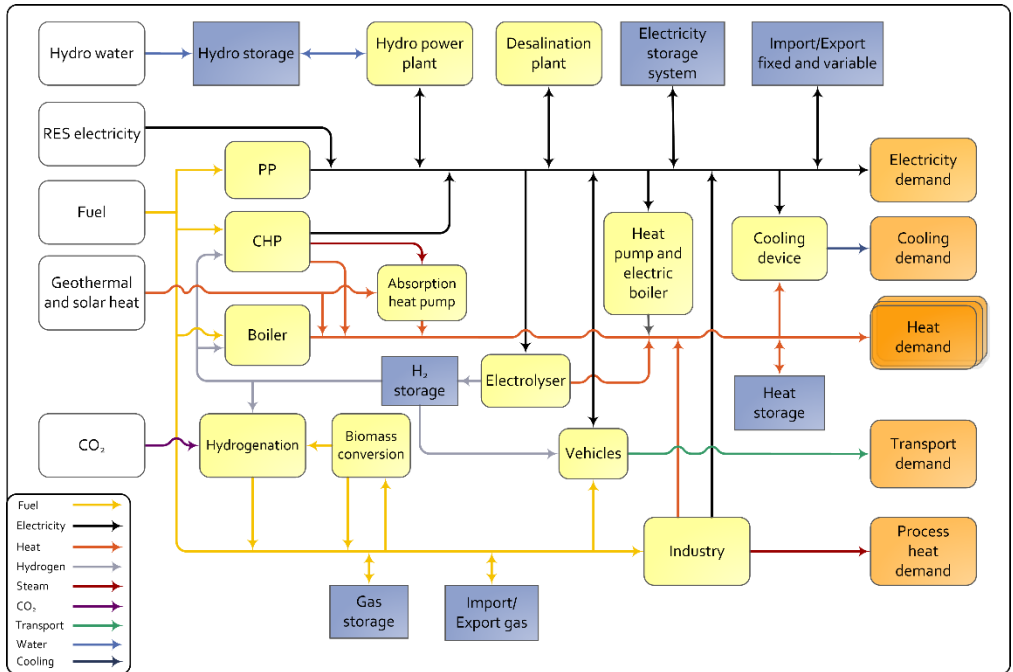
Booklet made for the course: Sustainability of Renewable Energy

Edition: SS 2020

# What is the EnergyPLAN Software ?

**EnergyPLAN** is an open source software that allows you to simulate energy systems in the framework of **Renewable Energy**.

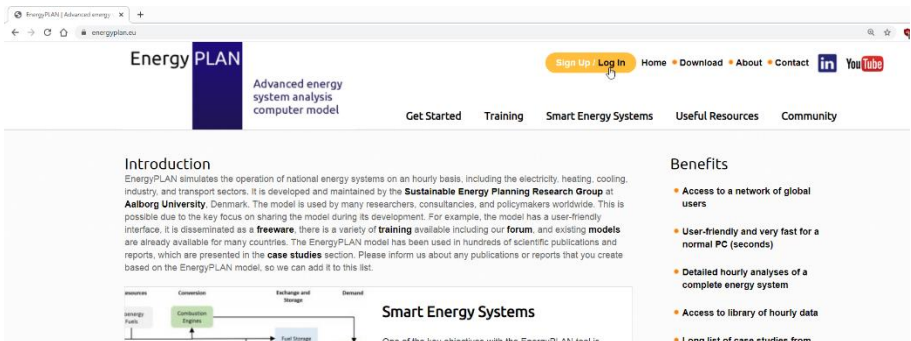




With **EnergyPLAN** is possible to represent a national energy system in hourly basis, including the **electricity, heating, cooling, industry, and transport sectors.**

# Downloading the EnergyPLAN software

## 1. Go to the official website [energyplan.eu](http://energyplan.eu) and create an account



The screenshot shows the EnergyPLAN website homepage. The header includes the logo, navigation links (Sign Up, Log In, Home, Download, About, Contact), and social media icons. The main content area features an introduction to the software, a diagram of the energy system components (Renewables, Conversion, Exchange and Storage, Demand), and a list of benefits. The diagram shows a flow from Renewables to Conversion, then to Exchange and Storage, and finally to Demand. A 'Fuel Storage' box is also shown below the main flow.

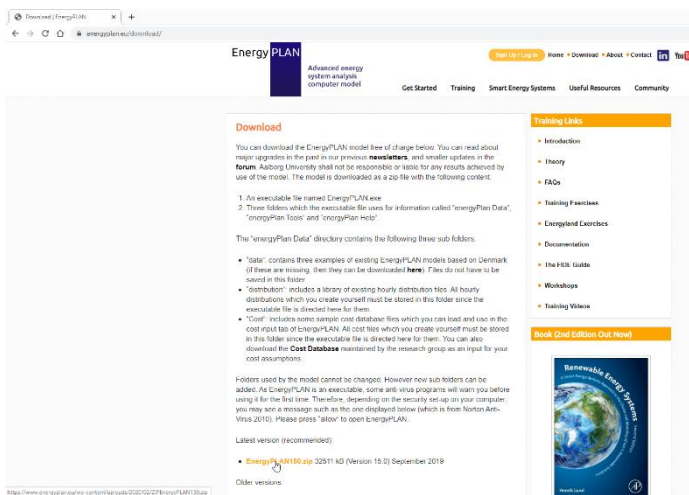
**Introduction**  
EnergyPLAN simulates the operation of national energy systems on an hourly basis, including the electricity, heating, cooling, industry, and transport sectors. It is developed and maintained by the **Sustainable Energy Planning Research Group** at **Aalborg University**, Denmark. The model is used by many researchers, consultants, and policymakers worldwide. This is possible due to the key focus on sharing the model during its development. For example, the model has a user-friendly interface, it is disseminated as a **freeware**, there is a variety of **training** available including our **forum**, and existing **models** are already available for many countries. The EnergyPLAN model has been used in hundreds of scientific publications and reports, which are presented in the **case studies** section. Please inform us about any publications or reports that you create based on the EnergyPLAN model, so we can add it to this list.

**Smart Energy Systems**  
One of the key objectives with the EnergyPLAN tool is

**Benefits**

- Access to a network of global users
- User-friendly and very fast for a normal PC (seconds)
- Detailed hourly analyses of a complete energy system
- Access to library of hourly data
- Long list of case studies from

## 2. Download the last version



The screenshot shows the EnergyPLAN download page. The page title is "Download" and it provides instructions on how to download the software. It lists the contents of the download package and provides links to the "energyPlan Data" directory. The page also includes a "Training Links" section and a "Book (2nd Edition Out Now)" section.

**Download**

You can download the EnergyPLAN model free of charge below. You can read about major updates in the past in our previous **newsletters**, and smaller updates in the **forum**. Aalborg University shall not be responsible or liable for any results achieved by use of the model. The model is downloaded as a zip-file with the following content:

1. An executable file named EnergyPLAN.exe
2. Three folders which the executable file uses for information called "EnergyPlan Data", "energyPlan Data", and "energyPlan Data".

The "energyPlan Data" directory contains the following three sub-folders:

- "data" contains three examples of existing EnergyPLAN models based on Denmark (if these are missing, then they can be downloaded **here**). Files do not have to be saved in this folder.
- "distribution" includes a library of existing hourly distribution files. All hourly distributions which you create yourself must be stored in the folder since the executable file is directed here for them.
- "cost" includes some sample cost databases (files which you can load and use in the cost input tab of EnergyPLAN. All cost files which you create yourself must be stored in this folder since the executable file is directed here for them. You can also download the **Cost Database** maintained by the research group as an input for your cost assumptions.

Folders used by the model cannot be changed. However new sub folders can be added. As EnergyPLAN is an executable, some anti-virus programs will warn you before using it for the first time. Therefore, depending on the security set-up on your computer, you may see a message such as the one displayed below (extract is from Norton Anti-Virus 2010). Please press "allow" to open EnergyPLAN.

Latest version (recommended):

- [EnergyPLAN100.zip](#) 32511 KB (Version 15.0) September 2019


Older versions:

<https://www.energyplan.eu/en/verken/updates/2020-02-27/EnergyPLAN100.zip>

**Training Links**

- Introduction
- Theory
- FAQs
- Training Exercises
- EnergyPlan Courses
- Documentation
- The HDS Guide
- Workshops
- Training Videos

**Book (2nd Edition Out Now)**



### 3. Watch the video available in the EnergyPLAN Website

**EnergyPLAN**  
Advanced energy system analysis computer model

Home Download About Contact LinkedIn YouTube

Get Started Training Smart Energy Systems Useful Resources Community

#### Introduction

EnergyPLAN simulates the operation of national energy systems on an hourly basis, including the electricity, heating, cooling, industry, and transport sectors. It is developed and maintained by the **Sustainable Energy Planning Research Group** at **Aalborg University**, Denmark. The model is used by many researchers, consultants, and policymakers worldwide. This is possible due to the key focus on sharing the model during its development. For example, the model has a user-friendly interface. It is disseminated as a **freeware**, there is a variety of **training** available including our **Forum**, and existing **models** are already available for many countries. The EnergyPLAN model has been used in hundreds of scientific publications and reports, which are presented in the **case studies** section. Please inform us about any publications or reports that you create based on the EnergyPLAN model, so we can add it to the list.

#### Smart Energy Systems

One of the key objectives with the EnergyPLAN tool is to aid in the design of 100% renewable energy systems. Since the development of EnergyPLAN began back in the year 2000, the concept of a 100% renewable energy system has evolved significantly. View ...

#### Book

#### Latest News

#### Benefits

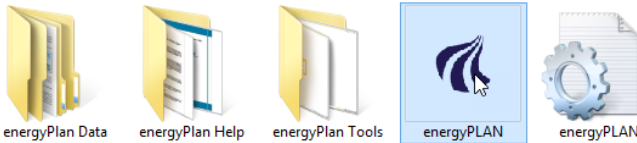
- Access to a network of global users
- User friendly and very fast for a normal PC (seconds)
- Detailed hourly analyses of a complete energy system
- Access to library of hourly data
- Long list of case studies from various countries
- Free of charge
- Free online training, guides, workshops, and documentation
- Facilitates third-party developments by allowing add-on help tools

**Download Model**

Download the latest version now and get started right away.

There you will find general and detail information of the site. Where to find data, the existing energy models that you can use as template and also, where to look for research studies that have used **EnergyPLAN.**

# Structure of the EnergyPLAN tool



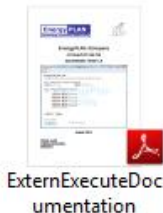
**Executable file.**  
No need of additional software installation

## Help files:

Nombre	Fecha de modifica...	Tipo	Tamaño
energyPlan Data	28/10/2018 19:33	Carpeta de archivos	
energyPlan Help	28/10/2018 19:33	Carpeta de archivos	
energyPlan Tools	28/10/2018 19:33	Carpeta de archivos	
energyPLAN	17/06/2018 17:57	Aplicación	8.193 KB
energyPLAN	13/11/2018 13:34	Opciones de confi...	2 KB



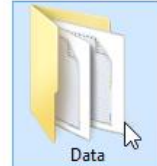
Description and understanding of calculations



Where to find energy system's data and how to entry it in the software

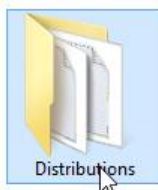
# Data folders:

## Data files



Nombre	Fecha de modifica...	Tipo	Tamaño
Denmark100%RES	17/06/2018 17:57	Documento de tex...	40 KB
Denmark2030Alternative	17/06/2018 17:57	Documento de tex...	40 KB
Denmark2030Reference	17/06/2018 17:57	Documento de tex...	40 KB
Germany2017_2SEV	23/06/2018 23:38	Documento de tex...	53 KB
Germany2017_50EV	23/06/2018 23:36	Documento de tex...	53 KB
Germany2017_7SEV	23/06/2018 23:32	Documento de tex...	53 KB
Germany2017_100EV	23/06/2018 23:28	Documento de tex...	53 KB
Germany2017BAU	23/06/2018 23:27	Documento de tex...	53 KB
Germany2027_2SEV	23/06/2018 23:49	Documento de tex...	53 KB
Germany2027_50EV	23/06/2018 20:59	Documento de tex...	53 KB
Germany2027_7SEV	23/06/2018 21:03	Documento de tex...	53 KB
Germany2027_100EV	23/06/2018 23:46	Documento de tex...	53 KB
Germany2027BAU	23/06/2018 20:56	Documento de tex...	53 KB
Germany2037_2SEV	23/06/2018 21:12	Documento de tex...	53 KB
Germany2037_50EV	23/06/2018 23:57	Documento de tex...	53 KB
Germany2037_7SEV	23/06/2018 23:56	Documento de tex...	53 KB
Germany2037_100EV	23/06/2018 23:54	Documento de tex...	53 KB
Germany2037BAU	23/06/2018 21:10	Documento de tex...	53 KB
initialize	17/06/2018 20:17	Documento de tex...	52 KB
Paper model Germany 2015	20/06/2018 14:25	Documento de tex...	54 KB

Three **default models** that can serve you as reference for starting.



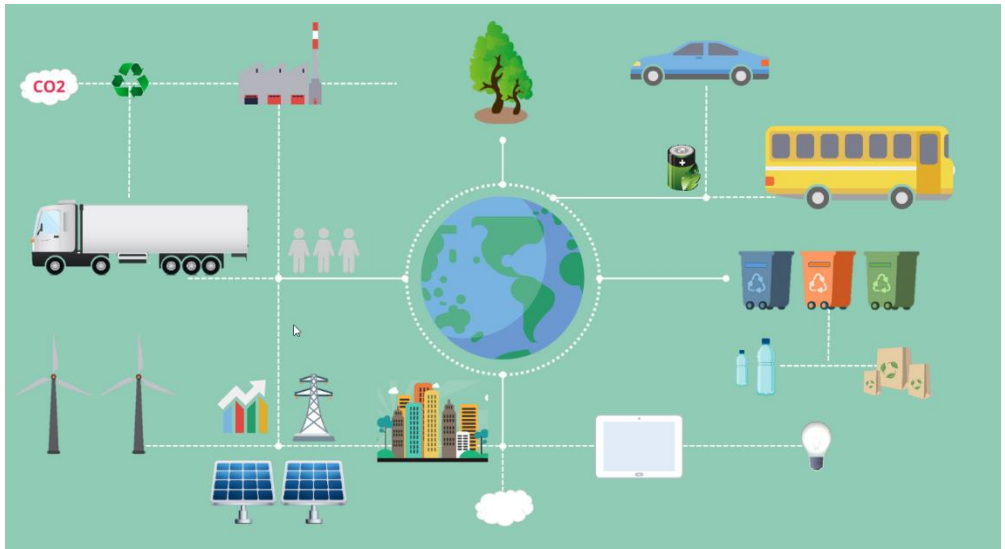
## Distributions files

Where you will store the **hourly data** for every sector of your **Energy Model**

Nombre	Fecha de modifica...	Tipo	Tamaño
2_HP-PASHigh_4C	17/06/2018 17:57	Documento de tex...	19 KB
2H_HP_ECON_OPEN_2008var	17/06/2018 17:57	Documento de tex...	19 KB
2017_TransportP2	23/06/2018 13:12	Documento de tex...	30 KB
2017Demand100EV_P2	23/06/2018 12:53	Documento de tex...	78 KB
2017ElecDemand_100EV	23/06/2018 12:40	Documento de tex...	78 KB
2017GeothermalGermany	21/06/2018 17:45	Documento de tex...	61 KB
2017GermanyDemand_withoutImport...	21/06/2018 16:14	Documento de tex...	80 KB
2017GermanyHour_transport	22/06/2018 11:26	Documento de tex...	78 KB
2017HydroGermany	21/06/2018 17:54	Documento de tex...	70 KB
2017NuclearGermany	21/06/2018 17:02	Documento de tex...	72 KB
2017OffshoreGermany	21/06/2018 17:03	Documento de tex...	111 KB
2017OtherREGermany	21/06/2018 17:05	Documento de tex...	105 KB
2017RiverHydroGermany	21/06/2018 17:04	Documento de tex...	111 KB
2017SolarPVGermany	21/06/2018 17:04	Documento de tex...	74 KB
2017WasteGermany	21/06/2018 17:05	Documento de tex...	111 KB
2017WindGermany	21/06/2018 17:03	Documento de tex...	111 KB
AAAPV	17/06/2018 17:57	Documento de tex...	71 KB
AAAWind	17/06/2018 17:57	Documento de tex...	95 KB
Aalborg Affald Årstidsvariation	17/06/2018 17:57	Documento de tex...	61 KB
Aalborg EI 2007	17/06/2018 17:57	Documento de tex...	75 KB
Aalborg Fjernvarme 25% besparelser	17/06/2018 17:57	Documento de tex...	40 KB
Aalborg Fjernvarme 75% besparelser	17/06/2018 17:57	Documento de tex...	35 KB
Aalborg Fjernvarme 2007	17/06/2018 17:57	Documento de tex...	57 KB
Aalborg Fjernvarme 2050	17/06/2018 17:57	Documento de tex...	37 KB
Aalborg Portland Fjernvarme 2007	17/06/2018 17:57	Documento de tex...	50 KB



# Keys when modeling an Energy System



You want to create models that are **simple** but, at the same time they make an **accurate** representation of the energy system.

Therefore in the design of **energy scenarios**, you need to make some simplifications and defined **General** and **Specific assumptions** for the model.

For knowing how realistic are the simplifications and assumptions you have defined, you firstly need to run a simulation using the present state scenario (Business As Usual, BAU).



Check the results of the BAU scenario with the actual state of the energy system and tune the parameters that give you deviations.

Once you know the BAU scenario is a good representation of the energy system, then you can start disturbing the model according to your research question and run further simulations.



# How EnergyPLAN works ?

This is how the software looks when you activate the **Tabs** view...

The screenshot shows the EnergyPLAN 13.2: Startdata software interface. The 'Output' tab is active, displaying various energy system components and their associated variables. The interface includes a menu bar, a toolbar, and a main workspace. The workspace is divided into several sections:

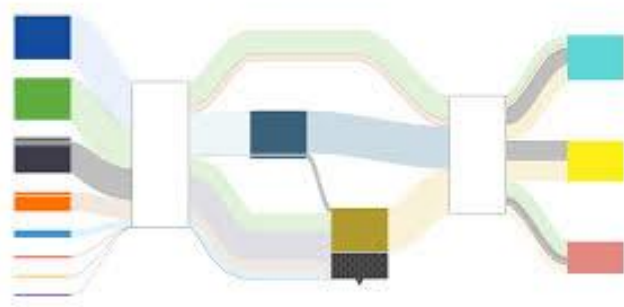
- Actors in the energy model:** This section includes tabs for Demand, Supply, Balancing and Storage, Cost, Simulation, and Output. The 'Output' tab is currently selected.
- Sectors belonging to the actors:** This section includes tabs for Electricity, Heating, Cooling, Industry and Fuel, Transport, and Water. The 'Heating' tab is currently selected.
- Individual Heating:** This section contains a table with columns for Fuel Input, Efficiency Thermal, Heat Demand, Efficiency Electric, Capacity Limit, Estimated Electricity Production, Heat Storage, Share, Solar Input, Output, and Resulting Fuel Consumption. The table lists various heating systems such as Coal boiler, Oil boiler, Ngas boiler, Biomass boiler, H2 micro CHP, Ngas micro CHP, Biomass micro CHP, Heat Pump, and Electric heating.
- District Heating:** This section contains a table with columns for Group 1, Group 2, Group 3, Total, and Distribution. It lists Production, Network Losses, and Heat Demand for different groups.
- Flow Diagram:** A flow diagram on the right side of the interface shows the energy flow between different components. It includes boxes for Oil, Ngas, Biomass, Solar, CHP, Boiler, Heat storage, and Heat demand, connected by arrows indicating the direction of energy flow.

Red arrows point from the text labels to the corresponding elements in the software interface:

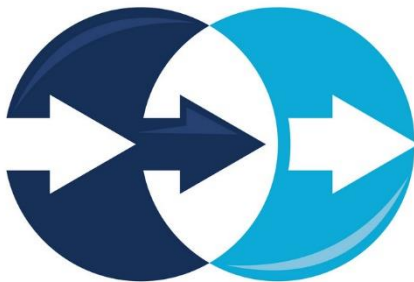
- Actors in the energy model points to the 'Output' tab.
- Sectors belonging to the actors points to the 'Heating' tab.
- Variables belonging to each sector points to the 'Output' tab.

Depending on the energy system and the **focus** of your scenario you will probably not need to define all actors and sectors.

Therefore, a lot of variables will simply **remain empty**.



The **EnergyPLAN** software is based in an input-output model. It calculates an **energy balance for every hour during ONE year** between energy demand and energy production



For the analysis of different years you need to run several simulations and probably, you will use the results of your first simulation as your input for the second simulation, and so on.

# Data Collection

Before the run of any scenario your starting point is the **hourly data** of all important sectors in the energy system you are modeling.

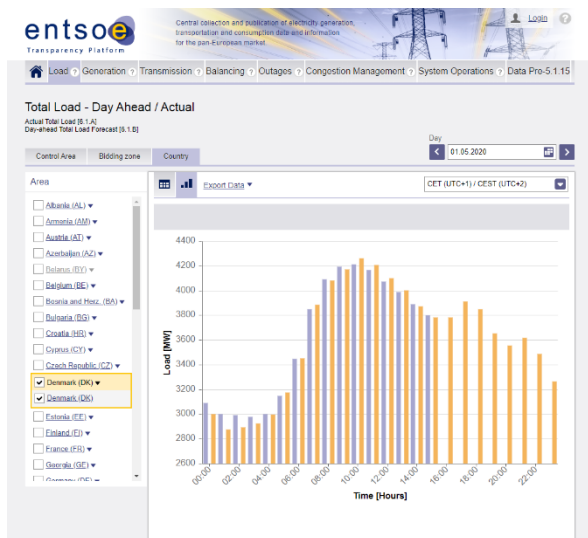


Take a look to your assumptions and from them identify the information you need to search for.

For instance, data of **demand, imports and exports** and **energy generation** will be required.

For example, at the **Entsoe portal** you can find and download data of generation and consumption for every nation in the European Union.

There you can even find generation data per technology which is very useful for modeling with EnergyPLAN.



Once you download the energy system data, you need to **organize** it in the proper way before you include it in the folder **Data/Distributions**.

You have to be sure the data is in **hourly resolution** and saved as **.txt file**. The file should include only **one column** with the data of a **complete year (+1 day)** and without the use of **any headers**.



**EnergyPLAN** includes an extra day, meaning **366 days** of data.

For this last day you can either take the data of the first day of next year or repeat the last day data of the current year.

**Be Aware of UNITS!**

# Definition of sectors in EnergyPLAN

For the configuration of every tab in the **EnergyPLAN** software, you need to entry the **total values** together with the **hourly distributions**, meaning the text files.

In the **Demand** tab, the total value is introduced in TWh/a.

The corresponding hourly data in GW for the electricity demand is also introduced.

Parameter	Value	Unit	File
Electricity demand*	433.3	TWh/year	2017GermanyDemand_withoutImportExports.txt
Electric heating (IF included)	0	TWh/year	Subtract electric heating using distribution from 'individual' window
Electric cooling (IF included)	0	TWh/year	Subtract electric cooling using distribution from 'cooling' window
Elec. for Biomass Conversion	0.00	TWh/year	(Transferred from Biomass Conversion TabSheet)
Elec. for Transportation	0.19	TWh/year	(Transferred from Transport TabSheet)
Sum (excluding electric heating and cooling)	433.49	TWh/year	
Electric heating (individual)	0.00	TWh/year	
Electricity for heat pumps (individual)	0.00	TWh/year	
Electric cooling	0.00	TWh/year	
Flexible demand (1 day)	0	TWh/year	Max-effect 1000 MW
Flexible demand (1 week)	0	TWh/year	Max-effect 1000 MW
Flexible demand (4 weeks)	0	TWh/year	Max-effect 1000 MW
Fixed Import/Export	60.13	TWh/year	Germany2017BAU_ImportExports.txt
Total electricity demand*	553.62	TWh/year	

```
graph LR; A[Import/Export fixed and variable] --> B[Electricity demand];
```

Similarly for the **Supply** tab, you introduced the **total installed capacity** with its corresponding **hourly distribution file**.

The screenshot shows the EnergyPLAN 12.5 software interface. The 'Supply' tab is active, displaying various energy generation and storage options. The 'Central Power Plants' table lists different power sources with their capacities and efficiency. The 'Intermittent Renewable Electricity' table lists renewable sources like Wind, Solar, and Hydro with their capacities and correction factors. A diagram on the right illustrates the energy flow between different technologies, including Hydro water, Hydro storage, Hydro PP, RES electricity, and Geothermal power. A text box on the right states: 'Correction factors need to be adjusted in the BAU model in order to obtain the annual energy generation per technology'.

Central Power Plants	Capacity MW-e	Efficiency	Correction Factor Percent	Annual production MWh/year	Distributions
PP1 (CHP3 Condensing Mode)*	86867.00			n/a*	
Condensing PP2	2.50	0.35		n/a*	
Nuclear	10.93	0.3	0.9555	72.22	Change 2017NuclearGermany.txt
Nuclear partload	1	Share of capacity - has to be activated in Region Strategy Tabsheet			
Geothermal	40	0.15	0.15	0.03	Change 2017GeothermalGermany.txt
Dammed Hydro Water supply*				6.87	Change 2017HydroGermany.txt
Dammed Hydro Power	8733	0.97		6.66 (Estimated)*	

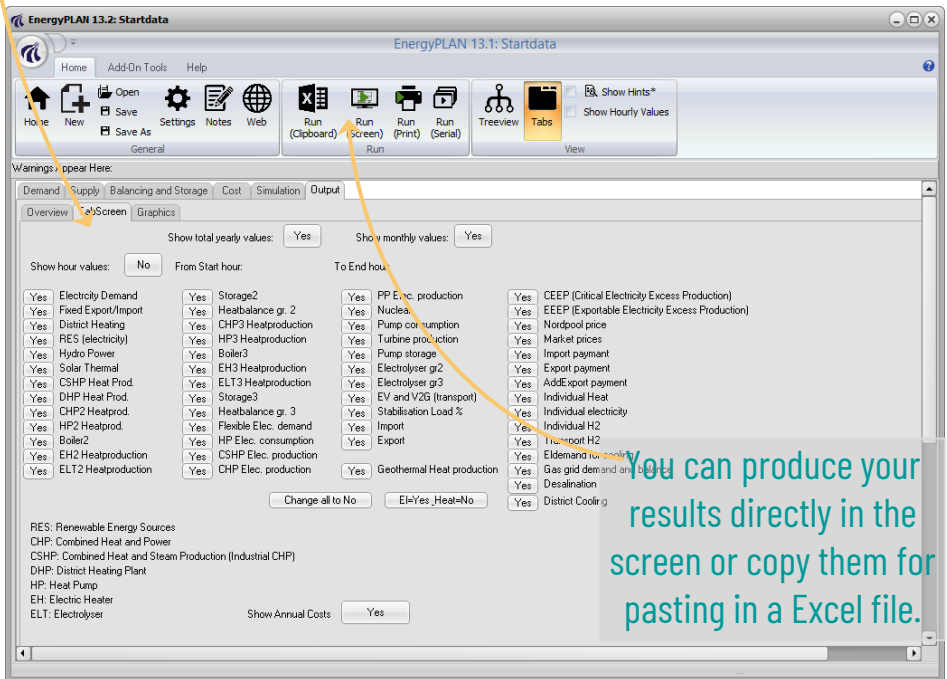
Intermittent Renewable Electricity	Capacity MW	Stabilisation share	Distribution profile	Estimated Production TWh/year	Correction factor	Post Correction production	Estimated capacity factor
Wind	45747	0	Change 2017WindGermany.txt	109.94	-0.553	85.24	0.21
Offshore Wind	4131	0	Change 2017OffshoreGermany.txt	15.45	0.284	17.41	0.48
Photo Voltaic	40417	0	Change 2017SolarPVGermany.txt	52.53	-0.002	35.88	0.10
River Hydro	3329	0	Change 2017RiverHydroGermany.txt	26.72	-4.83	14.97	0.43
Tidal	496	0	Change 2017OtherREGGermany.txt	3.82	-28.5	1.24	0.28
Wave Power	0	0	Change Hour_solar_prod1	0.00	0	0.00	0.00
CSP Solar Power	0	0	Change Hour_solar_prod1	0.00	0	0.00	0.00

Be sure that energy demand, generation, exports and imports are balanced!



# Model results from EnergyPLAN

After all **required sectors** have been configured, you can decide which variables you want to print on your results.



The screenshot shows the EnergyPLAN 13.2: Startdata software interface. The 'Output' tab is selected, displaying a grid of variables to be printed. The variables are organized into four columns. The first column includes 'Electricity Demand', 'Fixed Export/Import', 'District Heating', 'RES (electricity)', 'Hydro Power', 'Solar Thermal', 'CSHP Heat Prod.', 'DHP Heat Prod.', 'CHP2 Heatprod.', 'HP2 Heatprod.', 'Boiler2', 'EH2 Heatproduction', and 'ELT2 Heatproduction'. The second column includes 'Storage2', 'Heatbalance gr. 2', 'CHP3 Heatproduction', 'Boiler3', 'EH3 Heatproduction', 'ELT3 Heatproduction', 'Storage3', 'Heatbalance gr. 3', 'Flexible Elec. demand', 'HP Elec. consumption', 'CSHP Elec. production', and 'CHP Elec. production'. The third column includes 'PP Elec. production', 'Nuclear', 'Pump consumption', 'Turbine production', 'Pump storage', 'Electrolyser gr2', 'Electrolyser gr3', 'EV and V2G (transport)', 'Stabilisation Load %', 'Import', 'Export', and 'Geothermal Heat production'. The fourth column includes 'CEEP (Critical Electricity Excess Production)', 'EEEP (Exportable Electricity Excess Production)', 'Nordpool price', 'Market prices', 'Import payment', 'Export payment', 'AddExport payment', 'Individual Heat', 'Individual electricity', 'Individual H2', 'Transport H2', 'Eldemand (wood)', 'Gas grid demand and storage', 'Desalination', and 'District Cooling'. The interface also features a toolbar with 'Run' buttons for Clipboard, Screen, Print, and Serial, and a 'Warnings' section at the top.

RES: Renewable Energy Sources  
CHP: Combined Heat and Power  
CSHP: Combined Heat and Steam Production (Industrial CHP)  
DHP: District Heating Plant  
HP: Heat Pump  
EH: Electric Heater  
ELT: Electrolyser

Change all to No    El=Yes; Heat-No    Show Annual Costs    Yes

You can produce your results directly in the screen or copy them for pasting in a Excel file.



Have Fun!

