DEKSOFT®

PHOTOVOLTAICS

User's Manual

Version 1.2.6

CONTENTS

1. APPLICATION VERSION HISTORY

Version	Date of issue	Significant changes
1.2.6	30.6.2017	Possibility for power consumption monitoring for battery systems adjusted Free battery capacity is also included in the monitored consumption
1.2.5	14.6.2017	Possibility to limit photovoltaic plant production if there is insufficient power consumption
1.2.4	28.3.2017	Possibility to view a warning and error message file for all calculations Improved 3D model auto-correction system when using 3D Editor input
1.2.3	14.3.2017	Possibility to enter the profile of electricity and hot water consumption using a file in CSV format
1.2.2	1.3.2017	Problem with activating the pre-heater tank from a high-volume photovoltaic plant fixed
1.2.1	21.10.2016	Adjusted way to enter rated power with emphasis on greater clarity
1.2.0	11.10.2016	Shading specification using program 3D Editor
1.1.2	3.10.2016	Input of Ohmic loss in the distribution system added
1.1.1	26.8.2016	Catalogue of power and hot water consumption profiles Possibility to save to catalogues directly from the input
1.1.0	18.8.2016	Reference climate data of Czech Hydrometeorogical Institue for regional cities added Calculation of accumulation of produced electricity to hot water (possibility to accumulate only surplus or all photovoltaic plant production)
1.0.1	28.6.2016	Calculation of temperature coefficients added
1.0.0	31.5.2016	The first version of the Photovoltaics using the EnergyPlus version 8.5 computing kernel was released

2. STARTING PROGRAM

There are two ways to run the program.

a) Via the website www.deksoft.eu
b) Via another program.

All programs run directly in the browser window, no installation is needed.

3. ONE FILE PRINCIPLE

All computing programs share one file. There is no need to create a separate file for each of the programs to work within a single project (building). For example, if you already have a file in Energetics or Thermal Analysis 1D, you do not need to create a new file in Photovoltaics, but just open an existing file.

4. WORK IN MORE WINDOWS

Within one computer, it is possible to run multiple windows with programs from www.deksoft.eu. This allows multiple input files to be opened at the same time. **CAUTION: When you open the same file in multiple windows, the synchronization feature is restricted and changes may not be synchronised correctly.**

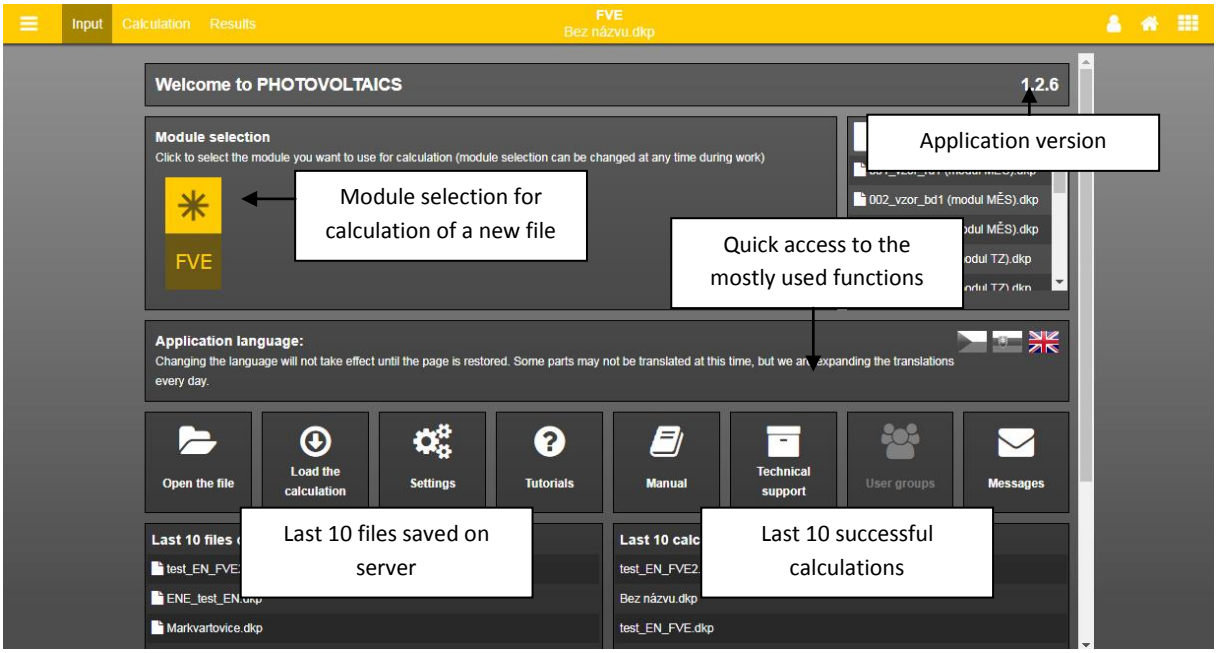
5. INTRODUCTION SCREEN

When you start the application or when you open a new file, you will see an introduction screen that provides quick access to the mostly used features and a clear choice of computing module.

At present following module is available:

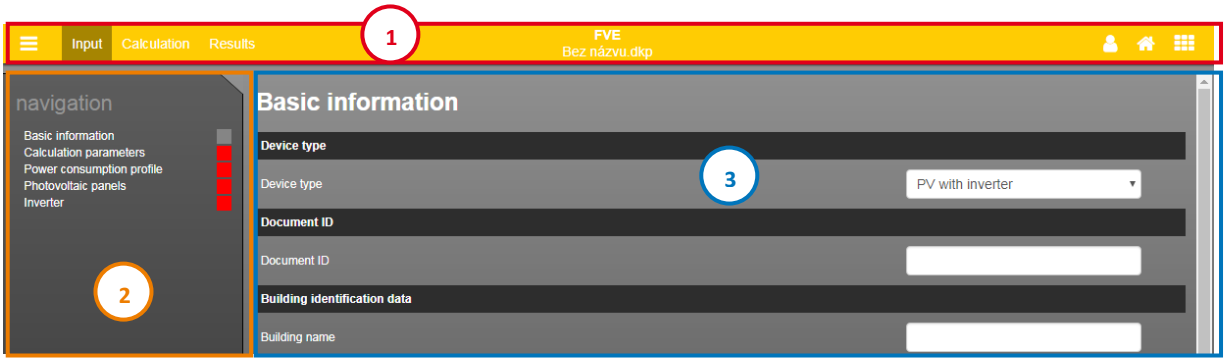
a) FVE

In case you do not have a license for one of the modules, a symbol 🔒 and restricted access information will be displayed above the module selection icon. In restricted access, you have the chance to try out the program free of charge, but you will not be able to see the results of the calculation.



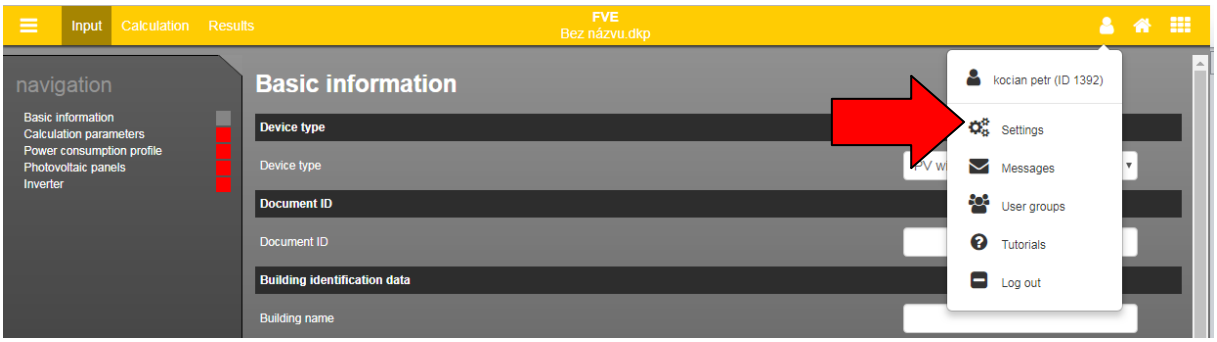
6. WINDOW ARRANGEMENT

1. Top bar / **2. Navigation in program** / **3. Window for drawing or showing results**



7. USER ACCOUNT SETTINGS

You can access the user profile settings by going to the user menu in the top bar and selecting the Settings option.



7.1. HELP SETTINGS

This option allows you to enable and disable the help system in DEKSOFT programs.

7.2. AUTHOR SIGNATURE

All programs allow you to use the function of automatically fill in identification data of the author that is filled in this section.

7.3. SEND TO CALCULATION

This option allows you to set the behaviour of the programs when you send the file to the calculation. It allows you to change the following parameters:

a) File saving when sending to calculation
b) Number of displayed files sent for calculation in the top menu
c) Behaviour when overwriting unsaved data

7.4. DEFAULT CATALOGUES

In this section you can choose which catalogues will be displayed as default after the catalogue is opened in the Photovoltaics. So you can set up the catalogue you most often use to speed up the overall work in the application.

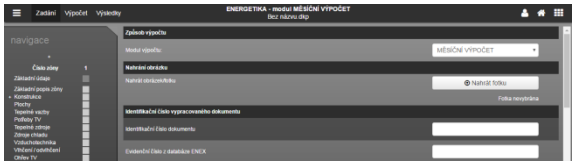
7.5. OTHER SETTINGS

In this section, you can set the auto save interval or completely disable auto-save (value set to 0). **CAUTION: auto save function only works for files stored on the server.**

You can also change the default language setting. **CAUTION: Translations are only available in some applications (see www.deksoft.eu for more information). To fully reflect your language change, you need to refresh the page.**

In the other settings section, you can also choose an alternative look of the application. In the current version, the following features are available. **CAUTION: Bright looks only apply during text input. Drawing detail window is always with a dark background.**

Default



Default, dark top bar

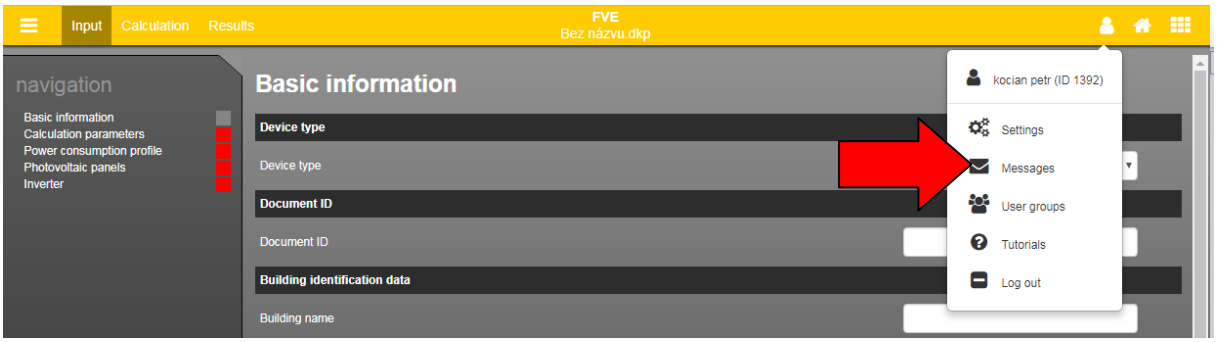
Grey

Blue

Purple

8. MESSAGES

Messages can alert you for the news in building physics applications. You can invoke the modal message window by going to the user menu and clicking Messages. The red number highlights the number of new messages.



8.1. INCOMING MESSAGES

This section is automatically opened when you click Messages. Received messages that have not been removed are displayed. Unread messages are bold. Clicking on the appropriate line will open the message.

8.2. BIN

Deleted messages are displayed in the bin. Messages from the bin are automatically completely erased after 30 days.

9. USER GROUPS

User groups allow users to share catalogues. For more information about working with user groups, see the separate manual.

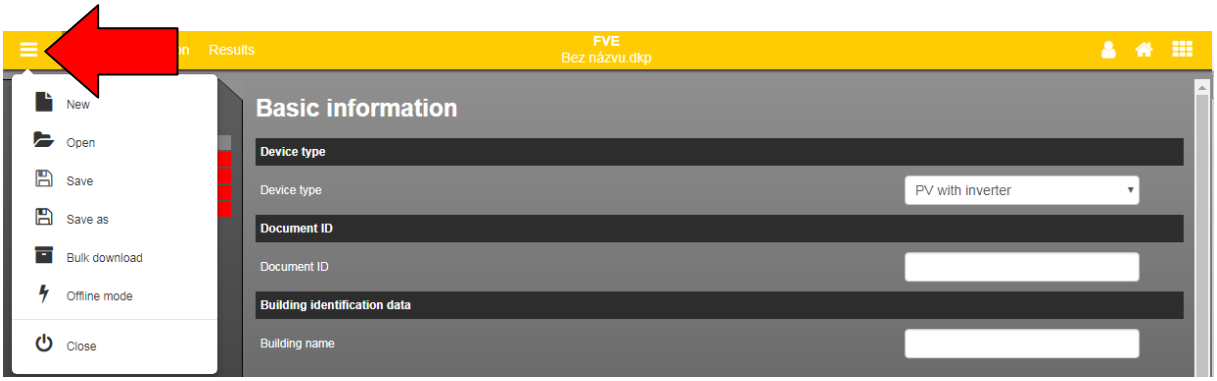
10. TUTORIALS

For a quick introduction to the new features in our applications, we have prepared a series of video tutorials and presentations. New tutorials will automatically appear after the first start of the application. You can close the tutorial at any time by using the button Ukončit. To move between the different parts of the tutorial, use the buttons and .

If you want to play one of the older tutorials, you can run it from the **User menu** under **Tutorials**.

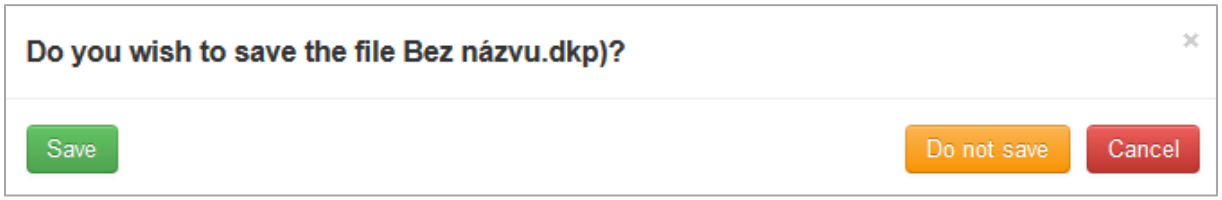
11. WORK WITH THE FILE SYSTEM

To work with the file system, use the menu ☰ in the top bar. You will be informed of all events by using the notification information in the lower right corner.



11.1. FILE – NEW

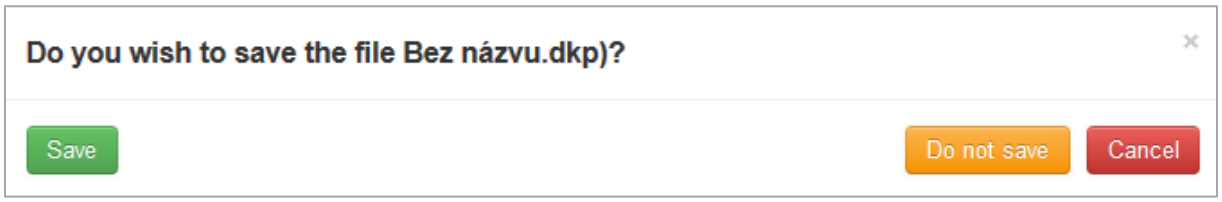
Creates a new file for work with programs. While working in the program, you may first be asked if you want to save the currently used file. In this case, the new file will only be created after saving an existing file or choosing the **Do not save** option.



CAUTION: We recommend that you save the new (created) file as soon as possible to the server to use the AutoSave feature.

11.2. FILE – OPEN

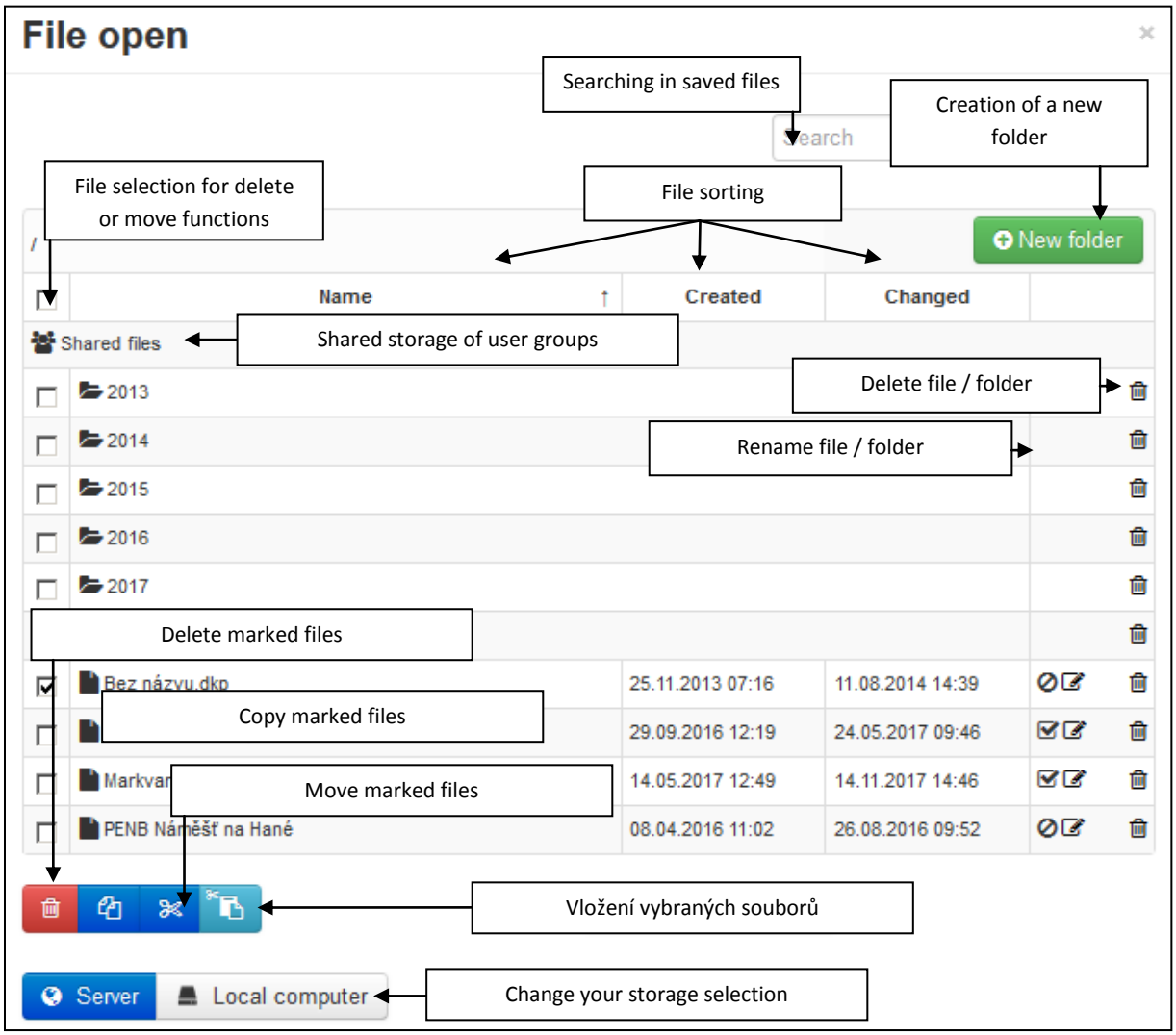
This item is used to open an existing file. While working in the program, you may first be asked if you want to save the currently used file. In this case, the new file will only be created after saving an existing file or choosing the **Do not save** option.



In the next step, you can choose whether to open a file from a server or from a local computer. By choosing **Local computer**, a system explorer will appear in which you can search for the file you want. Selecting **Server** displays the structure of your files and directories from which you can select the file you want.

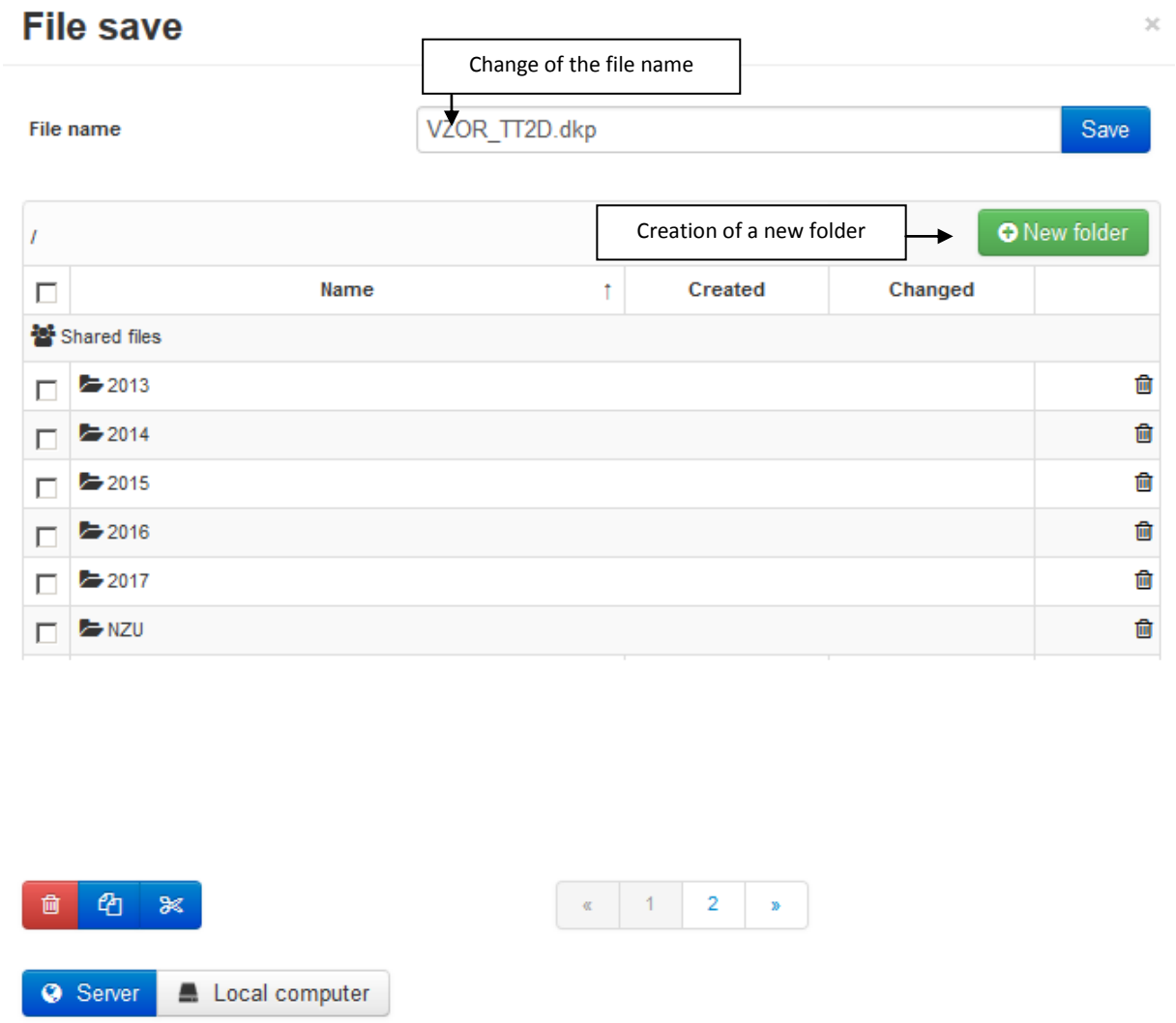
TIP: In the modal window File open, you can click the table header to sort the file by name or date.

CAUTION: Opening files from a local computer is only allowed to users with a valid license.



11.3. FILE – SAVE

If the file was previously saved, the current version of the input will be saved. During first attempt of saving the file, the selection window will appear where you want to save the file (**Server** or **Local computer**). When selecting **Local computer**, the file is downloaded according to the settings of a default Internet browser (most often automatically downloaded to the Downloads folder). When selecting **Server**, a modal window opens, where you can create folders or rename the file. Save the file with the **Save** button.



11.4. File – Save as

This option allows you to save a copy of the file. The **Save as** window is the same as the **Save** window.

CAUTION: In case of saving to server, the newly saved file will be opened after the saving is finished. When saving to a local hard drive (Local computer), the original file remains open.

11.5. File – Close

This command closes the currently used program. Before closing, you may be asked if you want to save the currently used file.

12. Recommended input procedure

The program is designed for input from the top of the page to the bottom (both in the sections and in navigation).

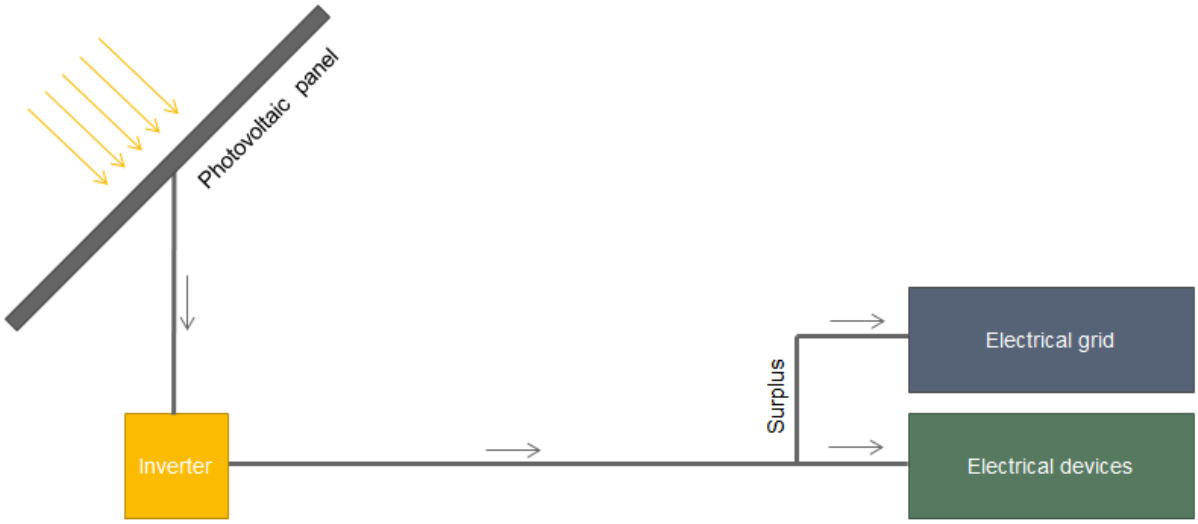
Video

At https://deksoft.eu/en/programy/photovoltaics you will find a sample video with the input procedure of the Photovoltaics.

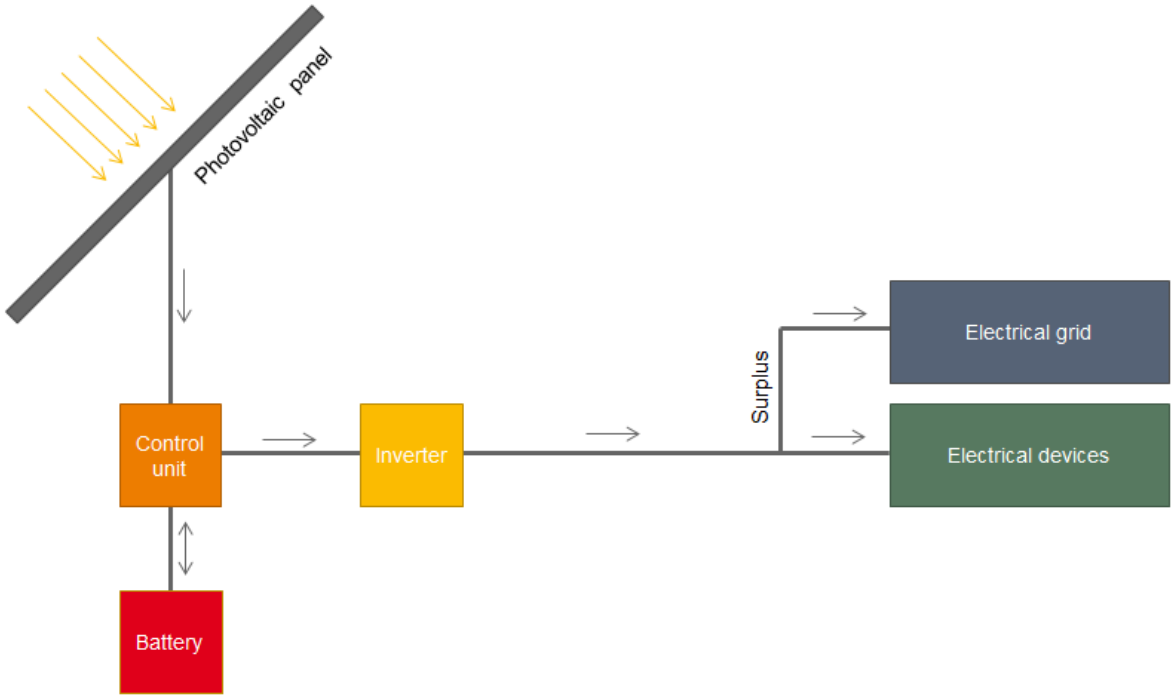
13. BASIC INFORMATION

Device type - defines the elements that the photovoltaic system contains. In the current version, following options are available:

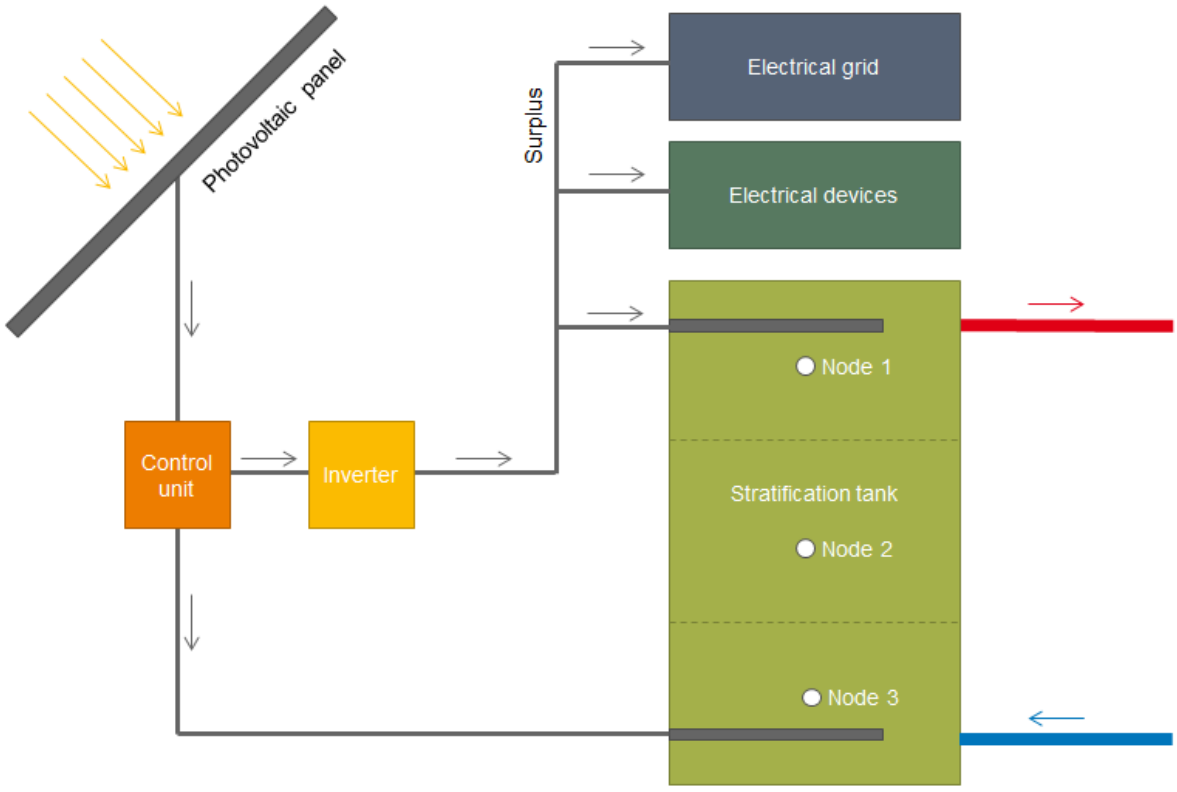
a) PV with inverter
b) PV with inverter and batteries
c) PV with inverter and accumulation of surplus to hot water with:
    1. bivalent stratification tank
    2. two separate tanks
d) PV only for heating the domestic hot water. **If you are evaluating NZÚ (Czech grant program), this calculation can only be used for orientations and inclinations that are not listed in the calculation assistant issued by the SFŽP (State Environmental Fund of the Czech Republic).**



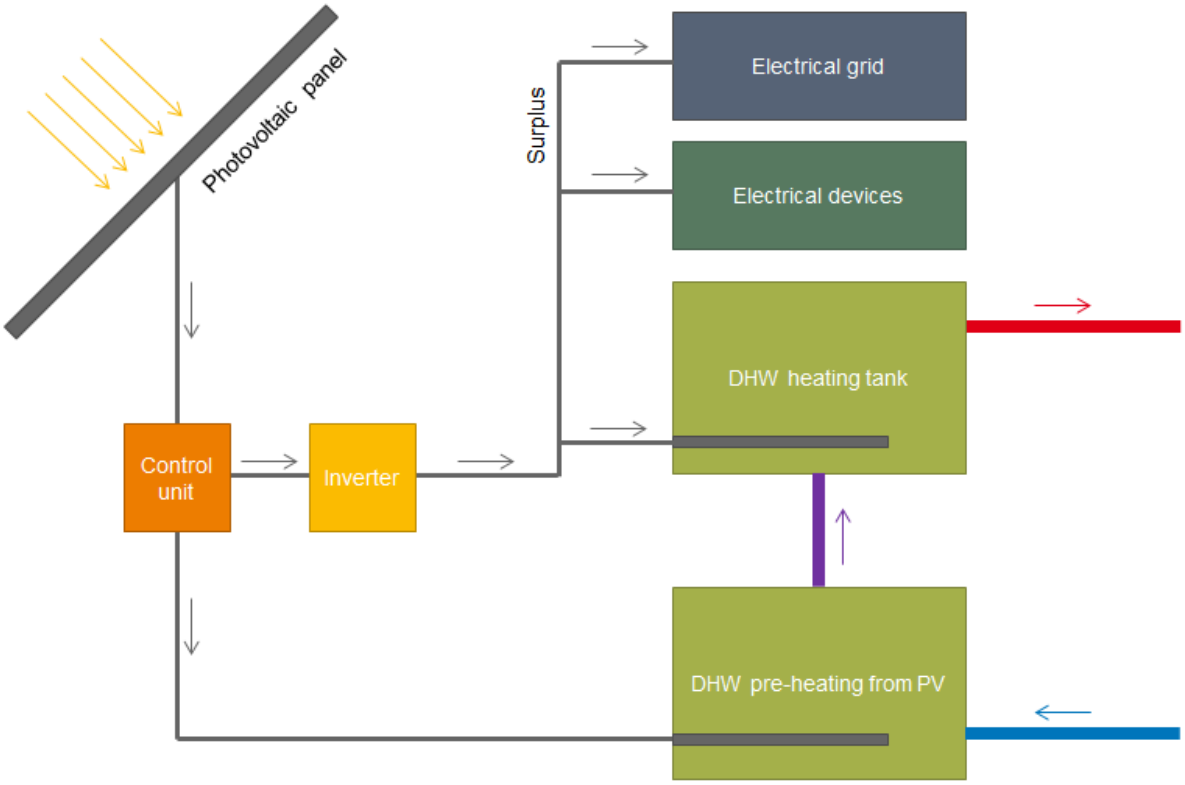
Schematics of the PV with inverter



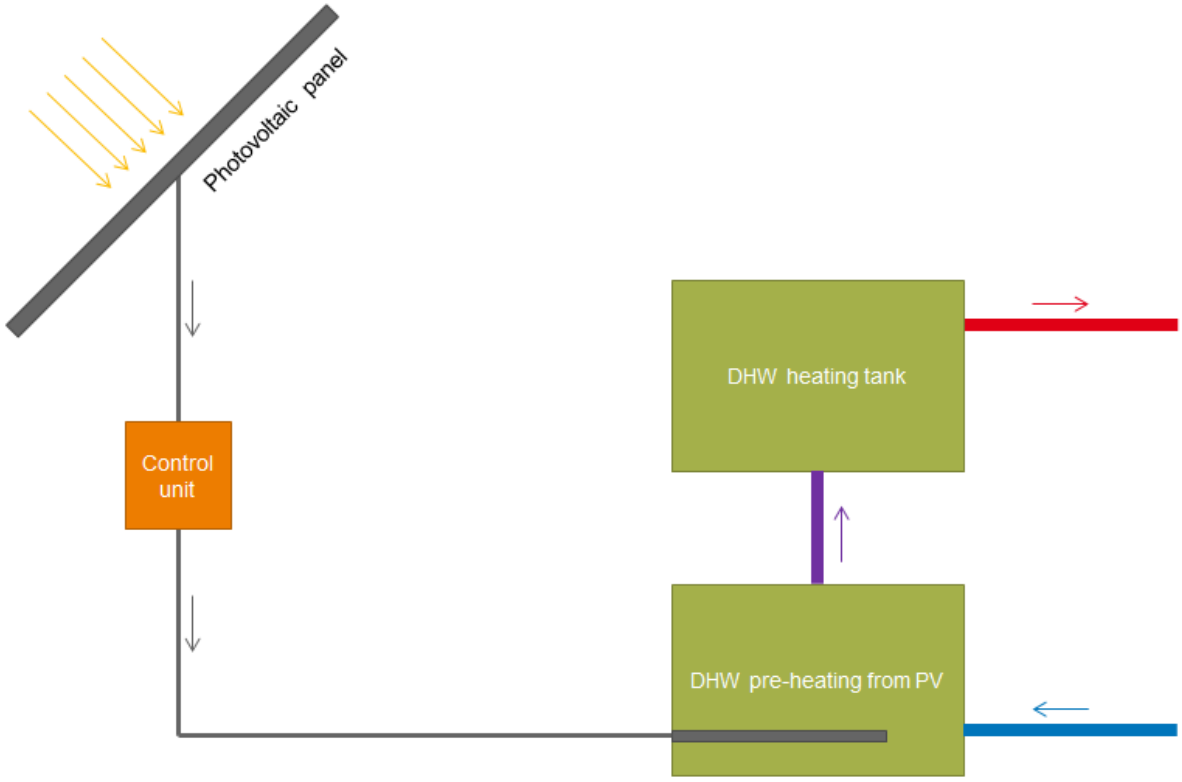
Schematics of the PV with inverter and batteries



Schematics of the PV with inverter and accumulation of surplus to hot water with bivalent stratification tank



Schematics of the PV with inverter and accumulation of surplus to hot water with two separate tanks



Schematics of the PV only for heating the domestic hot water

In the **Basic information** section, you can also fill in the information about the evaluated building and the calculation author.

Identification data is shared between applications, so it is possible to enter them in one application only and the information will appear in the other applications.

14. CALCULATION PARAMETERS

In the Calculation parameters section, basic data about the calculation interval and climatic data is entered. The calculation is always done with a 10 minute calculation step.

The **Calculation** is a choice between Whole year and Part of the year. The program allows you to perform a calculation for the selected period of the year without the need to make a whole year calculation. When selecting "Part of the year", you can enter the month and day of the beginning and end of the calculation in the following fields. **If you are evaluating the NZÚ (Czech grant program), you need to choose Whole year.**

The option **Years of calculation** makes it possible to calculate for several consecutive years (eg when modelling battery life) when choosing the yearly calculation. **If you are evaluating the NZÚ (Czech grant program), you need to enter a value of 1.**

Ohmic loss in the distribution system allows entering the loss of electricity due to the ohmic loss of the distributions in percentage.

Climate data for calculation is the option in the menu of climate data in the Czech Republic and the Slovak Republic. In the current version, two data sources are available:

a) IWEC database (International Weather for Energy Calculations). This is an hourly set of statistical data based on long-term measurements.
b) Reference climate year according to ČHMI (Czech Hydrometeorological Institute).

Alternatively, you can upload your own climate data in the .epw format. Details of the .epw format are listed on energyplus.net. For more information about building your own climate data, see "For advanced users: Entering user specific climate data" below.

The **Method of geometry entry** is a choice between simplified input and input using 3D EDITOR.

a) Simplified - the input takes place numerically directly in the program Photovoltaics. It is not possible to take into account the shading of the photovoltaic panels.
b) 3D EDITOR - the input is performed in 3D EDITOR by loading the 3D geometry of the building and the surrounding area. Panels shading during the year is automatically counted during the calculation.

Video

At https://deksoft.eu/en/programy/editor3d see a sample video with program 3D Editor.

Generate detailed hourly data. If YES is selected, the detailed outputs (.eso file) will display detailed results in one hour interval. If NO is selected, only monthly summaries will be displayed in the detailed outputs (.eso file).

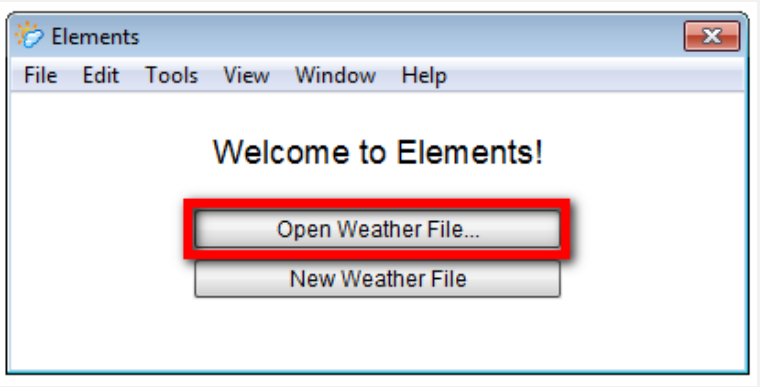
Method of photovoltaic energy production control. In case of *Maximum production*, the plant will be at each calculation step controlled to achieve its maximum output. In the case of *Power monitoring*, the photovoltaic fields will be switched on and off during the calculation so as to minimize the overflow into the distribution system. **CAUTION: In case of choosing *Power monitoring*, it is necessary to enter each switchable section as a separate photovoltaic field.**

For advanced users: Entering user specific climate data

To create and enter specific climate data, we recommend using software Elements, which is available for free download here: http://bigladdersoftware.com/projects/elements/. The advantage of Elements is that it automatically monitors the physical relationship between the values. The procedure for modifying the climate data is shown below.

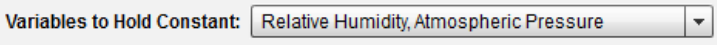
A. Open an existing .epw climate data file

We always recommend that you build your own data from existing ones to check for data completeness. Available climate data can be downloaded here: https://energyplus.net/weather-region/europe_wmo_region_6/CZE%20%20. Opening the file is possible with a button „Open Weather File..“



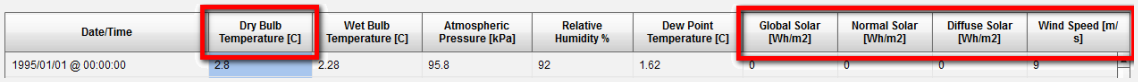
B. Inserting your own climate data

You can paste your own climate data via a clipboard from programs such as MS Excel or a similar program. Alternatively, you can fill in the required values manually directly in Elements. When inserting data, it is necessary to pay special attention to the option "Variables to Hold Constant", which, if the input variable affects some of the other values, allows to choose which values to be preserved (the remaining values will be recalculated based on the inserted data).



The basic parameters influencing the calculation in the Photovoltaics are:

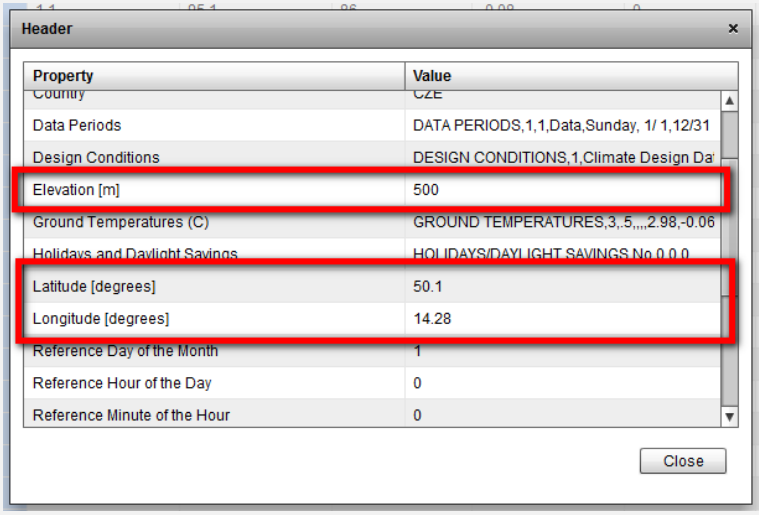
- Dry Bulb Temperature (°C)
- Global Solar (Wh/m2)
- Normal Solar (Wh/m2)
- Diffuse Solar (Wh/m2)
- Wind Speed (m/s)



Date/Time	Dry Bulb Temperature [C]	Wet Bulb Temperature [C]	Atmospheric Pressure [kPa]	Relative Humidity %	Dew Point Temperature [C]	Global Solar [Wh/m2]	Normal Solar [Wh/m2]	Diffuse Solar [Wh/m2]	Wind Speed [m/s]
1995/01/01 @ 00:00:00	2.8	2.28	95.8	92	1.62	0	0	0	9

Additionally, you need to edit the selected parameters in the location information by using the View> Header command:

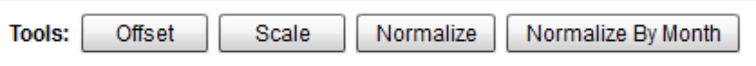
- Elevation (m.n.m.)
- Latitude (°)
- Longitude (°)



C. Editing existing climate data

Program Elements allows mass editing of entered data. The following tools are available:

- Offset > Move of all values by the specified value
- Scale > Multiply all values by the entered value
- Normalize > Adjust values to the specified average
- Normalize By Month > Adjust the values to the specified average values in each month



D. Saving the edited climate data

Edited data can be saved using the command File > Save as > EnergyPlus (.epw).

E. Entering of the data to Photovoltaics

Custom climate data can be entered in the "Calculation parameters" section using the "Climate data for calculation"> "User set of climate data" option. Then use the "Select" button to insert the appropriate .epw file.

15. POWER CONSUMPTION PROFILE

The Power consumption profile section is used to enter the power consumption profile of the evaluated building in hourly step. A profile catalogue is available, which can be opened up with the button . You can use the button to save the current input into the catalogue.

Maximum power consumption in W is the basic choice for determining power consumption. Whenever a 100% value is used in the profiles, the power take-off will be equal to the maximum hourly take-off. For values less than 100%, the take-off will be based on the specified percentages.

CAUTION: For systems with accumulated heat water, the maximum power consumption of the electric power consumption does not include the energy for the preparation of the TV, which is determined automatically during the calculation based on the hot water consumption profile.

Method of determining the electrical energy profile determines the method of determining the power take-off profile. The following options are available:

a) Constant consumption - for all hours of the year, hourly consumption is equal to the maximum hourly consumption.
b) Typical day (one in a year) - allows you to enter an hourly profile for a typical day of the year.
c) Typical day (one in a month) - allows you to enter an hourly profile for one day each month.
d) Typical working / weekend day - allows you to enter an hourly profile for working days and weekends..
e) Specific - allows you to define your own usage profile.
f) CSV file – using CSV file format.

For advanced users: How to write your own use profile

The custom use profile must cover every day and every hour (ie 8760 hours) in a year. The rows must end with a comma. The last line must end with a semicolon.

The profile entry consists of blocks, which must always contain the following parts in the exact order:

Through:

Determination of the period from 1 January or the end of the preceding period specified by the "Through" command to the specified date for which the following data is to be used. The date is to be written in the format month (MM) / day (DD). The record must cover 365 days a year, so the period must have the format "Through: 12/31,"

For:

Determination of the type of day for which the hourly profile will be used. You can use the following items: Weekdays, Weekends, Holidays, Alldays, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, AllOtherDays. For one "Through" stretch, multiple "For" commands can be used.

We always recommend that you include the AllOtherDays category (if the AllDays category is not used) for the proper operation of your own profile.

Until:

Specify the time from 00:00 or the end of the previous section "Until" for which the value will be used. Time is required in HH: MM format and for each "For" section you need to enter values for 24 hours, so the last line must be in the format "Until: 24:00, X".

X

The portion of the maximum hourly subscription. When writing, you need to use a decimal point to write numeric values. Values are allowed in the interval <0; 1>.

Example of profile record with constant consumption throughout the year

```
Through: 12/31,    !-boundary period from 1. 1. until 31. 12.
For: AllDays,      !-data for all days
Until: 24:00,      !-for time interval from 00:00 until 24:00
1;                 !-value 100% of the hourly maximum is used
```

Example of profile record with building operation only until 31. 5.:

```
Through: 05/31,    !-boundary period from 1. 1. until 31. 5.
For: Weekdays,     !-data for operational days
Until: 07:00,      !-for time interval from 00:00 until 07:00
0.05,              !-value 5% of the hourly maximum is used
Until: 12:00,      !-for time interval from 07:00 until 12:00
1,                 !- value 100% of the hourly maximum is used
Until: 24:00,      !-for time interval from 12:00 until 24:00
0.5,               !-value 50% of the hourly maximum is used
For: Weekends,     !-data for weekend days and for other
Until: 09:00,
0.1,
Until: 22:00,
0.75,
Until: 24:00,
0.2,
For: AllOtherDays, !-data for other days
Until: 24:00,
0,
Through: 12/31,    !- boundary period from 31. 5. until 31. 12.
For: AllOtherDays,
Until: 24:00,
0;
```

For advanced users: Profile input using CSV file

The program allows you to enter your own power consumption profile using a CSV file. The maximum interval of records must be 1 hour and cover 8760 hours per year (only part of the year can not be entered). The minimum interval of records is 1 minute. Values in the CSV file must be in the interval <0; 1>, where the value 1 corresponds to the maximum power output and the value 0 is of the time without power output.

The following section should provide an idea of how to set the calculation parameters so that the CSV file is read correctly.

Sample CSV file with record of power consumption in ¼ hour interval:

```
Date Time,Electricity consumption,Hot water consumption
1.1. 00:00 - 00:15,0.00,0.10
1.1. 00:15 - 00:30,0.50,0.10
1.1. 00:30 - 00:45,0.75,0.20
1.1. 00:45 - 01:00,0.00,0.25
```

Sample CSV file converted to a table:

	Column 1	Column 2	Column 3
Line 1	Date Time	Electricity consumption	Hot water consumption
Line 2	1.1. 00:00 - 00:15	0.00	0.10
Line 3	1.1. 00:15 - 00:30	0.50	0.10
Line 4	1.1. 00:30 - 00:45	0.75	0.20
Line 5	1.1. 00:45 - 01:00	0.00	0.25

Column number containing consumption profile:

Enter the number of the column to be used in the profile. If the specified column does not contain the required values, zero will be considered in the calculation. If we want to enter the power consumption profile from the CSV file in the sample, choose column number 2.

Number of rows that contain a header:

The CSV file may contain one or more lines that make up the head for the values. In the sample CSV file, the header is a single line, so we select number 1.

Separator:

Select a character to separate columns in the CSV file. A comma is used in the sample CSV file.

Interpolate to the computational step:

This option affects the way of the access to values that do not match with the length of the computation step (in the program Photovoltaics 10-minutes). If YES is specified, values are averaged between the computational steps. If NO is selected, the value from the CSV file is always taken.

The interval of values in the sample CSV file is 15 minutes, so it is different from the calculation step. If YES is selected, then 0.00 will be used at 10 minutes, 0.25 will be used within 20 minutes. If NO is selected, 0.00 will be used at 10 minutes and 0.50 will be used for 20 minutes.

Recording Interval:

Enter the number of minutes between the items in the CSV file. The value must be less than or equal to 60 minutes, and the result of dividing the number 60 by the number entered here must be no more than the remainder.

16. DOMESTIC HOT WATER CONSUMPTION PROFILE

The Domestic hot water consumption profile section is used to enter the hot water consumption profile. A profile catalogue is available, which can be opened up with the button . You can use the button to save the current entry into the catalogue.

Maximum hourly consumption of domestic hot water in liters is the basic choice for determining hot water consumption. Whenever a 100% value is used in the profiles, the domestic hot water consumption will be equal to the maximum hourly consumption. For values less than 100%, the consumption will be based on the specified percentages.

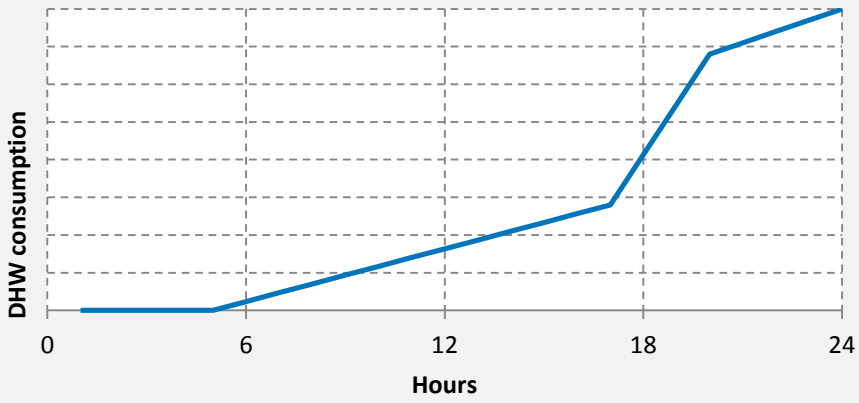
Desired domestic hot water temperature from the tap in ° C is the water temperature required at the tap. Decree No. 194/2007 Coll. prescribes the required temperature in the range 45-60 ° C.

Method of determining domestic hot water consumption profile determines how to determine the electrical energy profile. The following options are available:

a) Constant consumption - for all hours of the year, hourly consumption is equal to the maximum hourly consumption.
b) Typical day (one in a year) - allows you to enter an hourly profile for a typical day of the year.
c) Typical day (one in a month) - allows you to enter an hourly profile for one day each month.
d) Typical working / weekend day - allows you to enter an hourly profile for working days and weekends.
e) Specific - allows you to define your own use profile.
f) CSV file - using a CSV file.

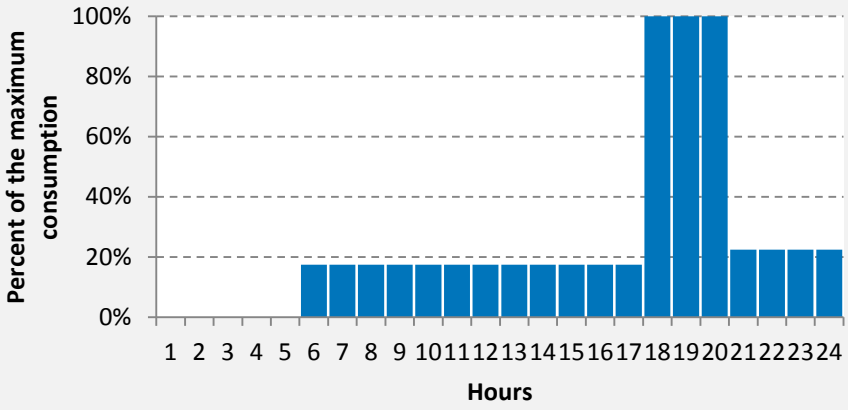
For advanced users: Domwstic hot water consumption curve according to ČSN 06 0320

If you want to use the consumption curves for residential buildings according to ČSN 06 0320 (see figure below)



For the appropriate shape of the consumption curve, the following values must be entered in the program Photovoltaics..

0 - 5 > **0 %**; 5 - 17 > **17,5 %**; 17 - 20 > **100 %**; 20 - 24 > **22,5 %**



The maximum hourly hot water consumption is 1/6 of the total daily hot water consumption when using the profile.

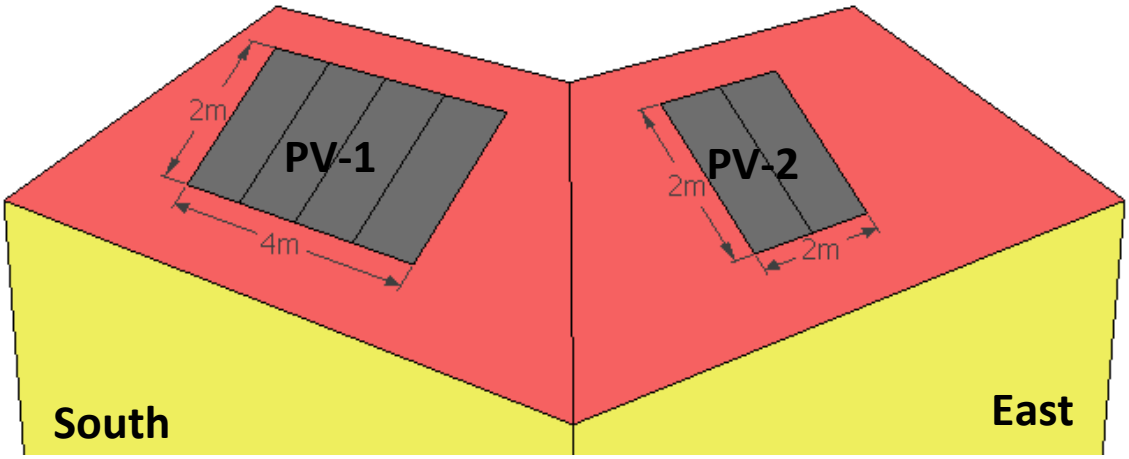
Considering the consumption of hot water 40 l / (person.day) it is 6.67 l / person.

17. PHOTOVOLTAIC PANELS

The Photovoltaic panels section is used to specify fields of PV panels. There is a catalogue of products that can be opened up with the button . You can use the button to save the current entry into the catalogue. A separate field is required for panels with different properties, orientations, or inclinations.

17.1. SIMPLE GEOMETRY INPUT

The following figure shows two PV fields on which the input method will be demonstrated for the purpose of this manual.



Orientation Specify the orientation of the photovoltaic panels in the interval <0; 360°> from the North clockwise
(N = 0°, E = 90°, S = 180°, W = 270°). For instance PV-1 = 180°, for PV-2 = 90°.

Inclination is measured from the horizontal plane and is entered in degrees. For instance 45°.

Length is the total length of the photovoltaic array (ie all panels). This is not the length of one module. For instance PV-1 = 4 m, PV-2 = 2 m.

Height is the total height of the photovoltaic array (ie all panels). This is not the height of one module. For instance PV-1 = 2, PV-2 = 2m.

17.2. INPUT OF GEOMETRY USING THE PROGRAM 3D EDITOR

When selecting an input using **3D EDITOR**, it is necessary only to select the name of the photovoltaic field that was specified in the editor. The input procedure in **3D EDITOR** is listed in a separate manual for this program.

The number of modules in parallel connection is the number of parallel lines (strings) for the photovoltaic array. For instance PV-1 = 1, PV-2 = 1.

The number of modules in serial connection per row is the number of modules connected in one string. For instance 1 = 4, FVE-2 = 2.

Total number of modules is the product of the number of modules connected in parallel and the number of serially connected modules in one row.

The method of determining the panel efficiency is Simple / Detailed. The description of the entry for each option is given in the following chapters. **If you are evaluating the NZÚ (Czech grant program), you need to use a detailed input.**

17.3. SIMPLE INPUT

Percentage of the area of the active cells from the panel area is the percentage of the photovoltaic array, which consists of the active parts of the panels.

Efficiency of photovoltaic panels is average yearly panel's efficiency.

Rated power is the nominal output of the specified photovoltaic field. This is the power of all panels in this field.

17.4. DETAILED INPUT

Cells type is a choice between Amorphous silicon cells and Crystalline silicon cells.

The number of serially connected cells in one module is the number of individual cells that are part of one module. The normal value ranges from 36 to 80 pieces.

Area of active cells in one module.

Thermal Absorptance Product is a function of the permeability of the cover material (τ), the absorbance absorption (α) and the reflection of the inside of the cover material (ρ_d). The value can be determined using the following formula. The common value is 0.9.

$$(\tau\alpha) = \frac{\tau \cdot \alpha}{1 - (1 - \alpha) \cdot \rho_d}$$

Semiconductor Bandgap. The default value for silicon is 1,12 eV.

Parallel Parasitic Resistance (Shunt Resistance). For panels made of crystalline silicon it is infinite (1 000 000 can be used), for thin-film exotic metal panels, this is the final value and need to be stated in the technical documentation of the manufacturer.

Short-circuit current of the module under standard conditions. This is a value that should be stated in the manufacturer's technical documentation.

Open Circuit Voltage (No-load voltage under standard conditions). This is a value that should be stated in the manufacturer's technical documentation.

Reference Temperature (Standard temperature). The common value is 25° C.

Reference Insolation (Standard sunshine). The common value is 1000 W/m2.

Module Current at Maximum Power. This is a value that should be stated in the manufacturer's technical documentation.

Module Voltage at Maximum Power. This is a value that should be stated in the manufacturer's technical documentation.

Temperature Coefficient of Short Circuit Current. This is a value that should be stated in the manufacturer's technical documentation. Calculation assisstant is available if the manufacturer gives values in %.

Temperature Coefficient of Open Circuit Voltage. This is a value that should be stated in the manufacturer's technical documentation. Calculation assisstant is available if the manufacturer gives values in %.

Nominal Operating Cell Temperature Test Ambient Temperature. The common value is 20°C.

Nominal Operating Cell Temperature Test Cell Temperature. The common value is 45°C.

Nominal Operating Cell Temperature Test Insolation. The common value is 800 W/m2.

Module Heat Loss Coefficient. The common value is 30 W/(m2.K).

Total Heat Capacity. The common value is 50 000 J/(m2.K)

Rated Electric Power Output is the rated power of the specified photovoltaic field. This is the power of all panels in this field.

18. INVERTER

The section Inverte describes the Inverter's performance and efficiency. There is a catalogue of products that can be opened up with the button . You can use the button to save the current entry into the catalogue.

The input method could be Simple/Detailed. The description of the entry for each option is given in the following chapters. **If you are evaluating NZÚ (Czech grant program), you can choose both simple and detailed input.** If the necessary data is available, we recommend that you use the detailed input.

18.1. SIMPLE INPUT

Inverter efficiency is average yearly inverter efficiency.

18.2. DETAILED INPUT

Rated Maximum Continuous Output Power. This is a value that should be stated in the manufacturer's technical documentation.

Night Tare Loss Power. This is the power consumption of the inverter during standby mode.

Nominal Voltage Input. This is a value that should be stated in the manufacturer's technical documentation.

Efficiency at a partial Power. This is a value that should be stated in the manufacturer's technical documentation.

19. BATTERY

The Batteries section describes battery properties and performance.

There is a catalogue of products that can be opened up with the button . You can use the button to save the current entry into the catalogue. The input method could be Simple/Detailed. The description of the entry for each option is given in the following chapters.

19.1. SIMPLE INPUT

Nominal Energetic Efficiency for Charging. Nominal Energetic Efficiency for Charging of the battery when storing electricity. A value of 100% means that there are no losses during charging. Typical values according to battery technology are listed in the table below.

Technology	Efficiency[%]
Li-ion	85 - 95
NaS	75 - 83
PbA	70 - 84
NiCd	65 - 85
NiMH	65 - 85
VRB	60 - 80
ZnBr	60 - 65
PSB	92 - 94
Zdroj: Carl Johan Rydh, Björn A. Sandén, Energy analysis of batteries in photovoltaic systems. Part I: Performance and energy requirements, Energy Conversion and Management, Volume 46, Issues 11–12, July 2005, Pages 1957-1979, ISSN 0196-8904.	

Nominal Discharging Energetic Efficiency. Nominal Discharging Energetic Efficiency of the battery when delivering electric power. A value of 100% means that there are no losses during discharge. Typical values according to battery technology are listed in the table below.

Technology	Efficiency[%]
Li-ion	85 - 95
NaS	75 - 83
PbA	70 - 84
NiCd	65 - 85
NiMH	65 - 85
VRB	60 - 80
ZnBr	60 - 65
PSB	92 - 94
Zdroj: Carl Johan Rydh, Björn A. Sandén, Energy analysis of batteries in photovoltaic systems. Part I: Performance and energy requirements, Energy Conversion and Management, Volume 46, Issues 11–12, July 2005, Pages 1957-1979, ISSN 0196-8904.	

Maximum Storage Capacity - energy that can be stored in the device. Once the maximum capacity is reached, no extra energy can be stored. Once the maximum capacity is reached, no extra energy can be stored. Calculation assistant is available.

Maximum Allowable Depth of Discharge. The maximum allowable discharge depth depends on the selected battery technology. For PbA battery it is about 50%, for LiFePo battery about 80%.

Maximum Power for Discharging. Calculation assistant is available.

Maximum Power for Charging. Calculation assistant is available.

Initial State of Charge. The default amount of energy that is stored in the batteries at the beginning of the calculation period. Calculation assistant is available.

19.2. DETAILED INPUT

Number of battery modules in parallel connection.

Number of battery modules in serial connection.

Total number of battery modules. This is the product of the number of battery modules connected in parallel and serial connection.

Maximum capacity of one module. This is the characteristic of one battery module. The parameter is rated by the total ampere-hour (Amp Hour) available when the battery is discharged to infinitely small current. Maximum capacity can be obtained from the manufacturer's technical data or test results.

Initial Fractional State of Charge. This field describes the initial amount of energy that is stored in the batteries at the beginning of the calculation period as a percentage of the maximum capacity.

Fraction of Available Charge Capacity. The kinetic model of the battery, on which the calculation is based, assumes that the battery is made up of two "reservoirs." The "available" tank can be discharged or charged immediately while the "bound" tank can only be charged and discharged through an "available" tank. The ratio between the available capacity and the total capacity is usually derived from test data by curve fitting.

Charge Rate from Bound Charge to Available Charge. This field specifies the rate at which the charge flows between the available tank and the bound tank. It is a parameter used to calculate the conversion between available charge and chemically bound charge when charging and discharging the battery. This parameter is usually derived from test data by curve fitting.

Fully Charged Module Open Circuit Voltage. This is a value that should be stated in the manufacturer's technical documentation.

Fully Discharged Module Open Circuit Voltage. This is a value that should be stated in the manufacturer's technical documentation.

Charging characteristics curve. The curve determines the change in open-circuit voltage (ΔE) as the function of charging state during charging (X). The value X is the amount of charged energy divided by the maximum capacity of the current. Open-circuit voltage change is relative to the fully discharged battery.

$$\Delta E = \frac{(C_1 \cdot X)}{(C_2 \cdot X)} + C_3 \cdot X$$

If more detailed information is not known, you can use the following values: C_1 = -0,2765; C_2 = -93,27, C_3 = 0,0068.

Discharging characteristics curve. The curve determines the change in open-circuit voltage (ΔE) as the function of charging state during discharging (X). The value X is the amount of discharged energy divided by the maximum capacity of the current. Open-circuit voltage change is relative to the fully discharged battery.

$$\Delta E = \frac{(C_1 \cdot X)}{(C_2 \cdot X)} + C_3 \cdot X$$

If more detailed information is not known, you can use the following values: C_1 = 0,0899; C_2 = -98,24, C_3 = -0,0082.

Internal electrical resistance of a module. This is the value of only one battery module, which should be stated in the manufacturer's technical data sheets.

Maximum Module Discharging Current. The maximum current of a battery module under which the battery can be discharged continuously. The limit is normally determined by the battery manufacturer as protection against damage.

Module Cut-off Voltage. The minimum allowed voltage under which the battery is generally considered to be discharged. The value is set by the battery manufacturer and is a value for one battery module.

Module Charge Rate Limit. This field specifies the limit for charging current due to the remaining battery capacity. This limit makes it possible to take into account the common practice where the charging rate decreases with increasing charge levels.

Cattery life cycle calculation. It is Yes / No. Battery life will normally be reflected in a longer timeframe than one year. The calculation does not take into account the influence of temperature and the influence of spontaneous battery discharge. You do not need to perform a life cycle calculation if you are evaluating NZÚ (Czech grant program).

Number of Cycle Bins. This field specifies the number of stacks (evenly spaced) in the battery life cycle calculation. If the value is 10, the cycling range will include 10%, 20%, ..., 100%.

Battery Life Curve Name. The curve determines the relationship between cycles after which the battery fails (C_F) and the partial discharge depth (R).

$$C_F = C_1 + C_2 \cdot e^{C_3 \cdot R} + C_4 \cdot e^{C_5 \cdot R}$$

If more detailed information is not known, you can use the following values: C_1 = 1380; C_2 = 6834; C_3 = -8,75, C_4 = 6747, C_5 = -6,22.

20. ACCUMULATION TO DOMESTIC HOT WATER

The section Accumulation of energy to domestic hot water system is used to specify accumulation tank parameters. There is a catalogue of products that can be opened up with the button . You can use the button to save the current entry into the catalogue. For the grid connected system, two ways of accumulation are available.

a) Bivalent stratification tank
b) Two separate tanks

For the system exclusively intended for DHW heating, only an option with two tanks is available.

Type of accumulation is a choice between Bivalent stratification tank and Two separate tanks. Only two separate tanks opion is available for PV only for DHW heating. The schematics of the systems are shown in the figures above.

20.1. BIVALENT STRATIFICATION TANK

The calculation model of the stratification tank divides its volume evenly into three nodes that are interconnected.

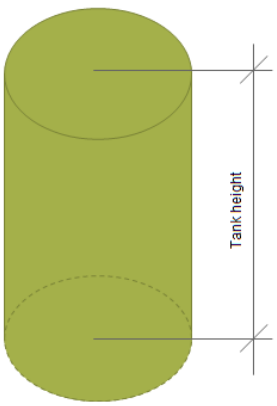
Ambient temperature near accumulation tank, is the ambient temperature in which the tank will be installed to determine heat losses.

Required minimum tank temperature in °C, is the temperature of water inside the tank to be permanently maintained to provide hot water delivery even when no photovoltaic power is available. Typically, the temperature is about 45 °C.

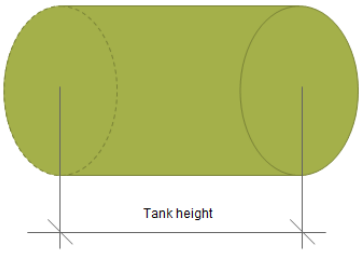
Maximum permissible tank temperature in °C is maximum permitted water temperature according to the tank technical data sheet. When this temperature is reached, no more power will be supplied to the tank even if it is available from the PV plant.

Water capacity of the tank in l is the actual volume of water in the tank. Typically, this value is not directly equal to the nominal volume stated in the data sheets. The actual volume is about 5 - 10% less than the nominal value.

Tank height in m is always measured in the direction of the tank axis (even for horizontal orientation). See the picture below.



Vertical tank

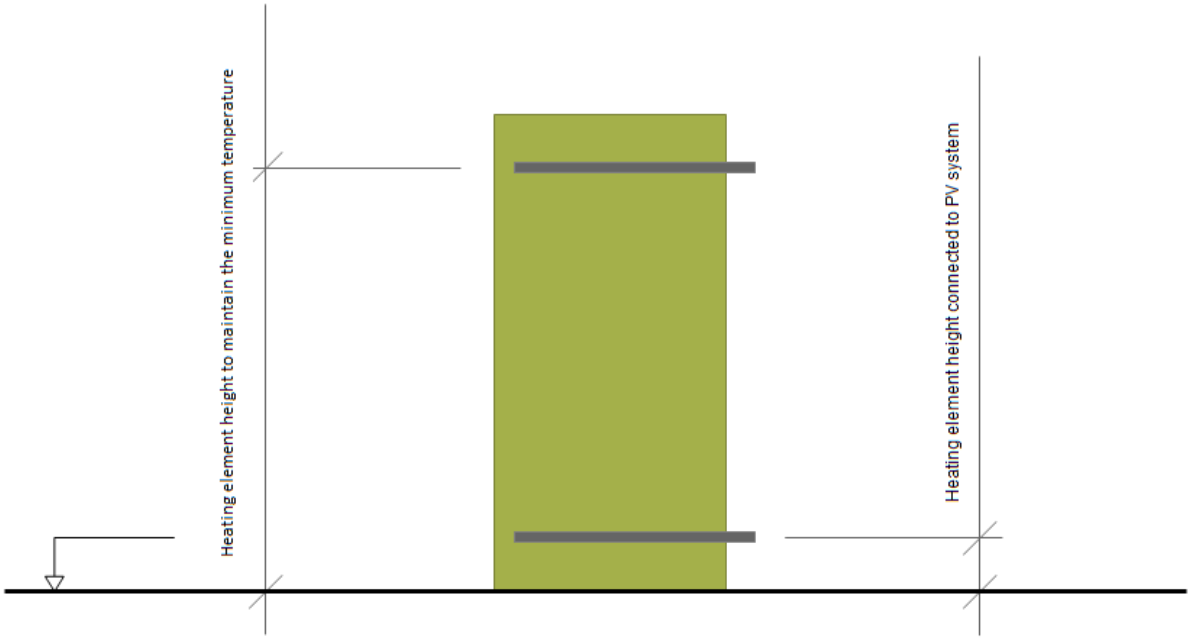


Horizontal tank

Tank shell U-value in W/(m^2.K) is the value stated in the tank manufacturer technical data sheets.

Tank orientation is chosen depending on how the tank is mounted - horizontal / vertical.

Heating element height to maintain the minimum temperature in m is shown in the picture below. Typically, this heating element is located in the upper third of the tank height.



Heating element height

Heating element power input to maintain the minimum temperature in W. The value stated in the technical data sheets of the tank. Power input is typically 2 000 - 4 500 W.

Height of the heating element connected to the photovoltaic system in metres is showed on the picture above. Typically, this heating element is located at the lower third of the tank height.

Power input of the heating element connected to the photovoltaic system. The value stated in the technical data sheets of the tank. Typically 2,000 - 4,500 W.

20.2. TWO SEPARATE TANKS

The calculation model presumes an existence of two separate tanks, in which the water is mixed in a perfect way.

20.2.1. PRE-HEATING TANK FROM PHOTOVOLTAIC SYSTEM

Ambient temperature near accumulation tank in °C is the ambient temperature in which the tank will be installed to determine heat losses.

Maximum permitted water temperature in °C in maximum tank temperature according to the tank technical data sheet. When this temperature is reached, no more power will be supplied to the tank even if it is available from the PV plant.

Water capacity of the tank in litres is actual volume of water in the tank. Typically, this value is not directly equal to the nominal volume stated in the data sheets. The actual volume is about 5 - 10% less than the nominal value.

Heating element power input in Watts is a value stated in the technical data sheets of the tank. Typically 2,000 - 4,500 W.

Tank heat loss in Watts per Kelvin is a value stated in the tank manufacturer technical data sheets.

20.2.2. DOMESTIC HOT WATER HEATING TANK

Ambient temperature near accumulation tank in °C is the ambient temperature in which the tank will be installed.

Required minimum tank temperature in °C is a water temperature inside the tank to be permanently maintained to provide hot water delivery.

Maximum permitted water temperature in °C in maximum tank temperature according to the tank technical data sheet.

Water capacity of the tank in litres is actual volume of water in the tank. Typically, this value is not directly equal to the nominal volume stated in the data sheets. The actual volume is about 5 - 10% less than the nominal value.

Heating element power input in Watts is a value stated in the technical data sheets of the tank.

Heat source fuel type could be Electricity or Others. When selecting Electricity, it is possible to cover the electricity consumption from photovoltaic plant.

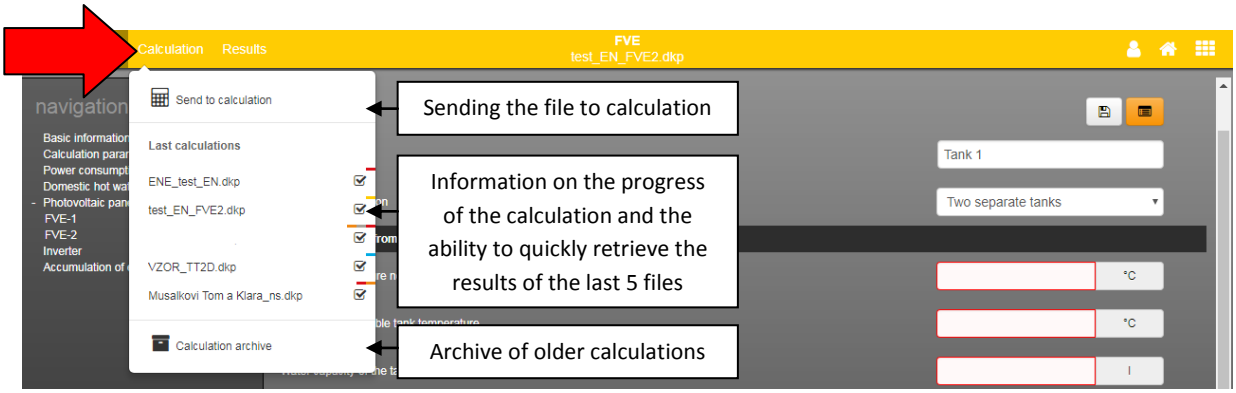
Heat source efficiency in % related to fuel efficiency. Indicative values according to TNI 73 0331 (Czech technical information) are given in the table below. **If you are processing an NZÚ (Czech grant program) rating for a hot water only system, enter 100%. The NZÚ grant program evaluates the energy demand for hot water heating for this option.**

Source type	Approximate efficiency [%]
Gas boiler up to 35 kW - standard - single stage burner	74
Gas boiler up to 35 kW - standard - modulated burner	77
Gas boiler up to 35 kW - low temperature	85
Gas boiler up to 35 kW - condensing	94
Solid fuel boilers with manual fuelling - Class I	56
Solid fuel boilers with manual fuelling - Class II	66
Solid fuel boilers with manual fuelling - Class III	76
Solid fuel boilers with automatic fuelling - Class II	79
Electric boilers	94
Building heat transfer station	98

Tank heat loss in Watts per Kelvin is a value stated in the tank manufacturer technical data sheets.

21. CALCULATION

You can view the options for working with the calculation by moving the mouse or by clicking at Calculation in the top bar.



21.1. CALCULATION START

Calculation is started by using the option Send to calculation. After submitting the calculation file, a file name appears in the Last 5 Calculations section, an icon appears on the right-hand side indicating that the file is pending or the calculation is in progress. When the calculation is complete, the status icon changes to . If an error has occurred during the calculation, the icon will appear.

CAUTION: Once you have made a change in the input, it is always necessary to recalculate the file!

In case of larger calculations, the progress bar is active (both for files and the total under section **Calculation** in the top bar). The program, for which the current calculation is performed, is indicated by a coloured rectangle next to the file name. The colour of the rectangle corresponds to the colour of the program.

21.2. INPUT CONTROL

The program Photovoltaics integrates an automatic control of completeness. During navigation, the navigation fields are colored by the amount of data filled in. The colors you might encounter in navigation are as follows:

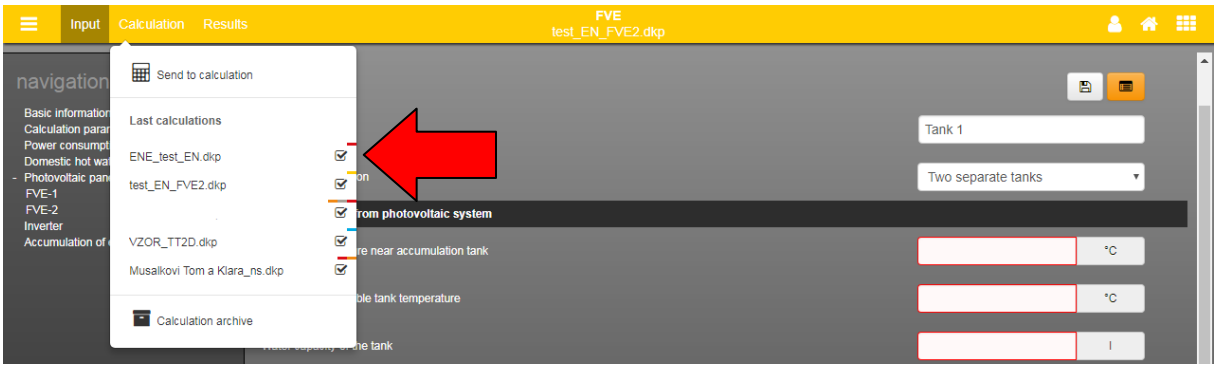
a) grey - part of the input not yet filled in
b) red - part of the input, which is incomplete
c) green - part of the input that is fully entered
d) orange - part of an input with an atypical value

In addition to navigation, the fields that are not specified are marked with a red border. You can simply find the missing parts in the input that you need to add in order for the calculation to succeed.

If there are fields marked red in the input, a modal alert window is displayed when the file is sent to calculation. You can always choose whether you want to send the file to calculation, despite the missing data, or you want to return to the input and add the necessary data.

21.3. LOADING RESULTS

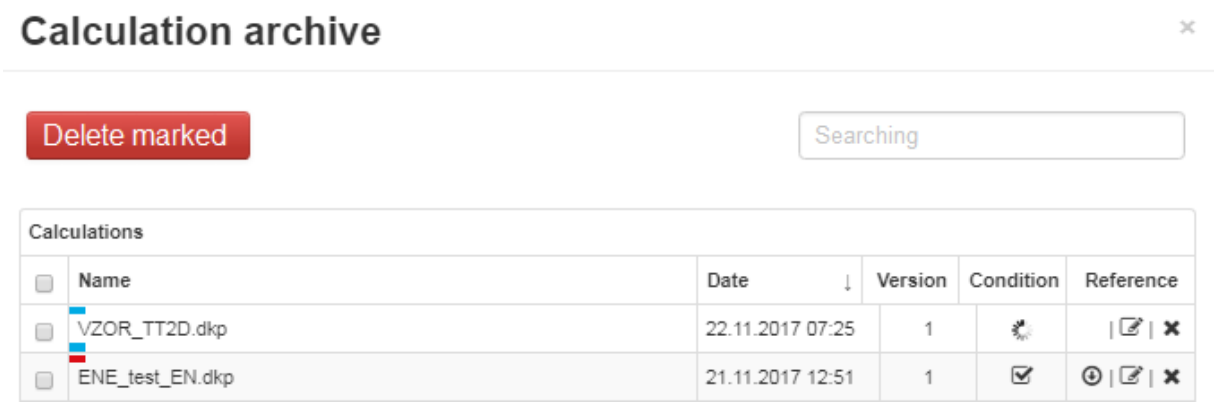
Once the calculation has been completed successfully, it is necessary to load the calculated calculation to display the results. **Loading the calculation is done by clicking the file name** in the **Last 5 calculations** section. To load the results of older calculations, you can use the **Calculation archive** option. Calculations that can be loaded for the file in DEKSOFT programs are indicated by a coloured rectangle on the right side. The rectangle colour matches the colour of the program icon.



Alternatively, the results can be loaded by using the button in the information panel in the bottom right corner.

21.4. CALCULATIN ARCHIVE

The **Calculation archive** allows you to access all calculated files in a separate modal window. You can load the calculation using the button ⓘ or by clicking on the calculation name. Use the icon ✎ to attach a note to a specific version of the calculation. The button ✖ deletes the results.



TIP: In the results modal window, you can sort the calculations by name or date by clicking on the table header.

When you load the calculation, the specific entry for which the calculation was performed is always opened. The calculations that can be loaded for each file in each application are marked with a colour rectangle next to the file name. The rectangle colour matches the application icon colour.

22. RESULTS

There are three main types of outputs available:

a) Protocol
b) ESO file
c) ERR file

To display the results, switch to the **Results** section using the top bar. If you load the results from the Calculation menu, it will be automatically switched.

22.1. PROTOCOL

In the left navigation bar, the **Protocol** button is displayed and export to PDF icon . When you click on the icon, the protocol is downloaded according to the settings of your internet browser

22.2. ESO FILE

Clicking the button will download the results file in the .eso format that is generated by the EnergyPlus computing engine. To view the calculations, you need to have the DesignBuilder Result Viewer installed, which is available for free and can be downloaded here: https://deksoft.eu/en/programy/photovoltaics.

Video

At https://deksoft.eu/en/programy/photovoltaics see a sample video with detailed results view in DesignBuilder Results Viewer.

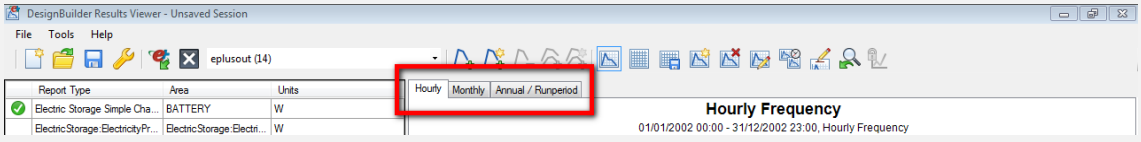
For advanced users: DesignBuilder Results Viewer

Program DesignBuilder Results Viewer is available for free and it enables to view the results in the format .eso. It can be downloaded here: https://deksoft.eu/en/programy/photovoltaics. See the following paragraphs for more information about the program.

A. Selection of time interval for results

Selecting the time interval for the results that you want to display is provided using the tabs at the top of the window. The calculation is always done in a 10-minute step. Depending on the results interval, the sum/average of the values in each calculation step is performed. With three data results options enabled, three output timeouts are available:

- Hourly > hourly data
- Monthly > monthly data
- Annual / Runperiod > data for the set time range of the calculation



B. Display of selected data in graph

The selection of the data you want to view is done in the parameter list in the right part of the page (you can select multiple parameters using the Ctrl key). The display of selected values in the graph is provided by the command „Add selected variables to new graph" .

C. Adding values to a graph / adding a new graph

You can add a new parameter to an existing graph by selecting the variable and selecting "Add selected variables to current graph" . For multiple graphs, you can select the graph you want to paste the variable in by clicking on the graph. You can add a variable to a new graph using the command "Add selected variables to new graph" .

D. Remove the variable from the graph / remove the entire graph

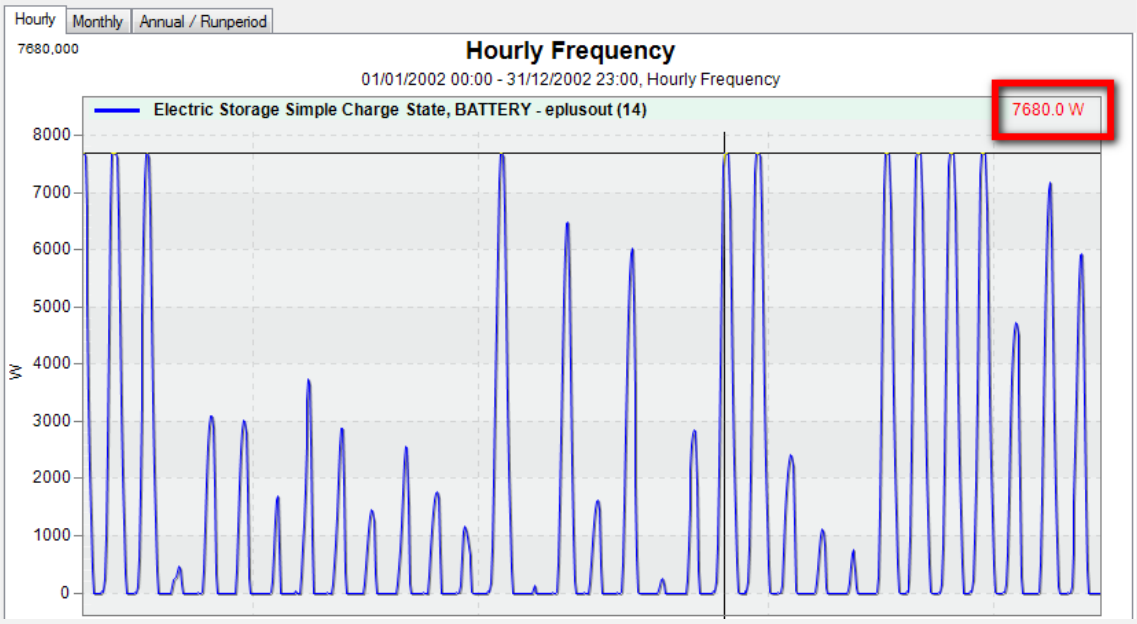
You can remove the variable from the graph by selecting in the left-hand list the command "Delete selected variables from current graph" . You can remove the entire graph using the command "Delete selected graph" .

E. Zooming the selected section in the graph

You can zoom in on the selected section of the graph by clicking and dragging the mouse over the desired section. To return to the default view, you can use the command „Undo Zoom" .

F. Display numerical values / export to csv

Numerical values can be displayed by clicking on a particular point in the graph. The value appears in the right part of the legend.



It is also possible to display values in spreadsheets using the "Display Grid" command . Alternatively, export the values to a .csv file using the „Save Grid to CSV file" command . The graph display can be reactivated using the "Display Graph" command .

22.3. ERR FILE

The .err file contains information about the warnings and errors that occurred during the calculations using the EnergyPlus computational kernel. This is a feature for advanced users, it is not necessary to download the ERR file for routine work in Photovoltaics. If you have any doubts about the information displayed in this file, you can contact Technical Support at info@deksoft.eu.

23. PROGRAM UPDATES

Program update process is a great benefit of web application format. You enter the program using a web browser and the program itself runs on high-performance servers. You are always sure to use the latest version of the application without the need for any installation, or to watch the release date of the new version.

24. TROUBLESHOOTING

The program Photovoltaics has been extensively tested. There should be no more serious problems when working with the program. If problems still occur, we recommend following the below mentioned points.

a) Do you use a supported web browser?

Supported browsers include: Mozilla Firefox, Google Chrome, Apple Safari and Opera

b) Have you tried to close and reopen the web browser?
c) Have you tried to restart your computer?
d) Have you tried to clear the browser cache?

- For Google Chrome use Ctrl + Shift + Del and *Empty Cache*
- For Mozilla Firefox using Ctrl + Shift + Del and *Cache*
- For Opera, use Ctrl + Shift + Del and *Delete cache*

If all questions are answered yes and the problem persists, please send a short description with your file to info@deksoft.eu. We will try to find the cause of the problem as quickly as possible and remove it.

You can always find the latest version of the documents at www.deksoft.eu.

If you did not find the necessary information in the document, please contact us at info@deksoft.eu.