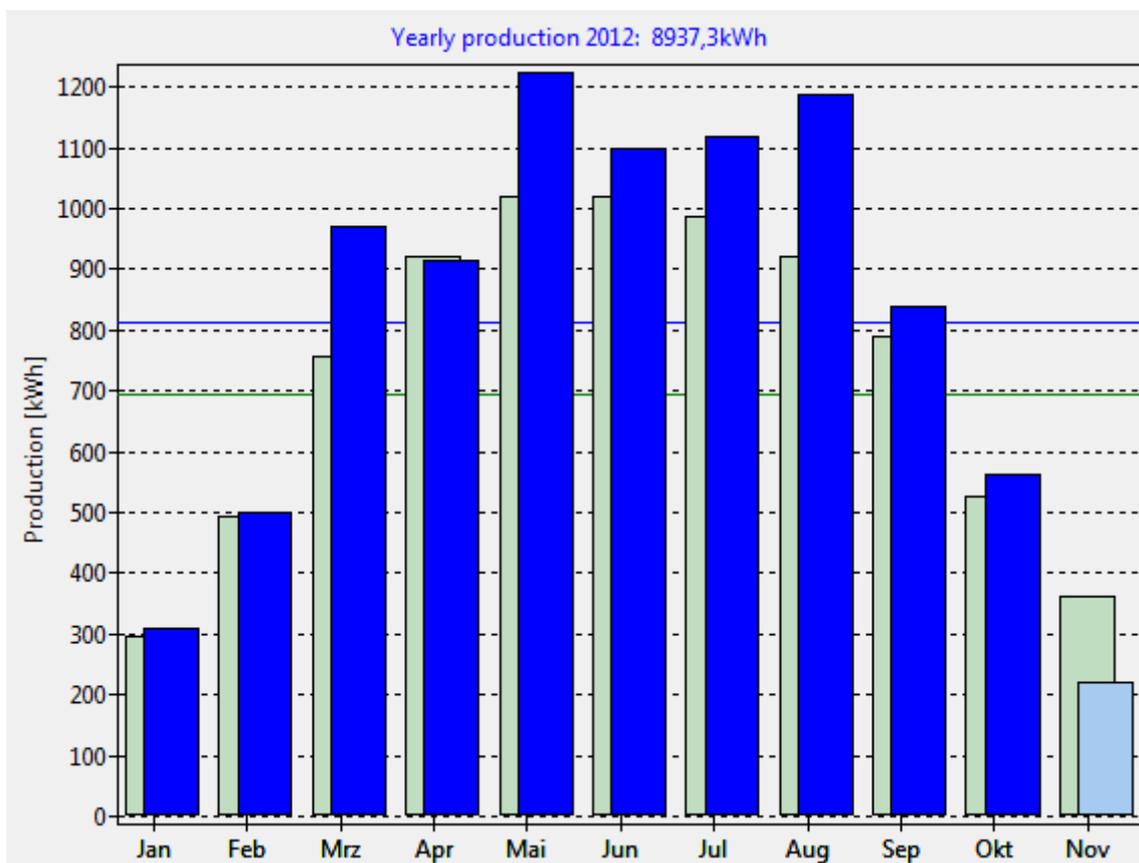


PV_Ausw User Manual

Processing of photovoltaic system performance data from inverters (Danfoss, IBC, Kaco, SMA)



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Table of contents

Table of contents.....	2
1. Overview	3
1.1 Optional start parameter:.....	4
2. Data analysis with charts	5
2.1 Analysis per day.....	5
2.2 Analysis per month.....	7
2.3 Analysis per year	8
2.4 Statistics.....	9
3. Installation/commissioning of the program.....	10
3.1 Basic data.....	10
3.2 Program options	12
3.3 FTP client and FTP access data.....	13
3.4 FTP connection log	15
4. Additional program features	15
4.1 HTML protocol function and data export.....	15
4.2 Demo function.....	16
4.3 Backup and restore.....	16
4.4 Archiving of daily data.....	17
4.5 Simulation power limitation of the inverter	17
4.6 Additional analysis at "Playground".....	18
5. Data format	20
5.1 Data format of CSV file for Demo and Backup (Field delimiter: Semicolon).....	20
5.2 Data format of archive file (Field delimiter: Semicolon)	20
6. LINUX.....	21
7. Configuration and information flow	22
7.1 System configuration (local server for FTP and HTTP):.....	22
7.2 System configuration (FTP and HTTP server located in internet):.....	22
8. Contact.....	22

1. Overview

TripleLynx Pro inverters from *Danfoss®* or *IBC Solar AG®* (FLX Pro, TLX Pro and TLX Pro +) records the energy production of your photovoltaic system (PV system) and presents it by FTP-Push to a so called „Datawarehouse“. The file name starts with FTP user account name and contains date/time as trailing number.

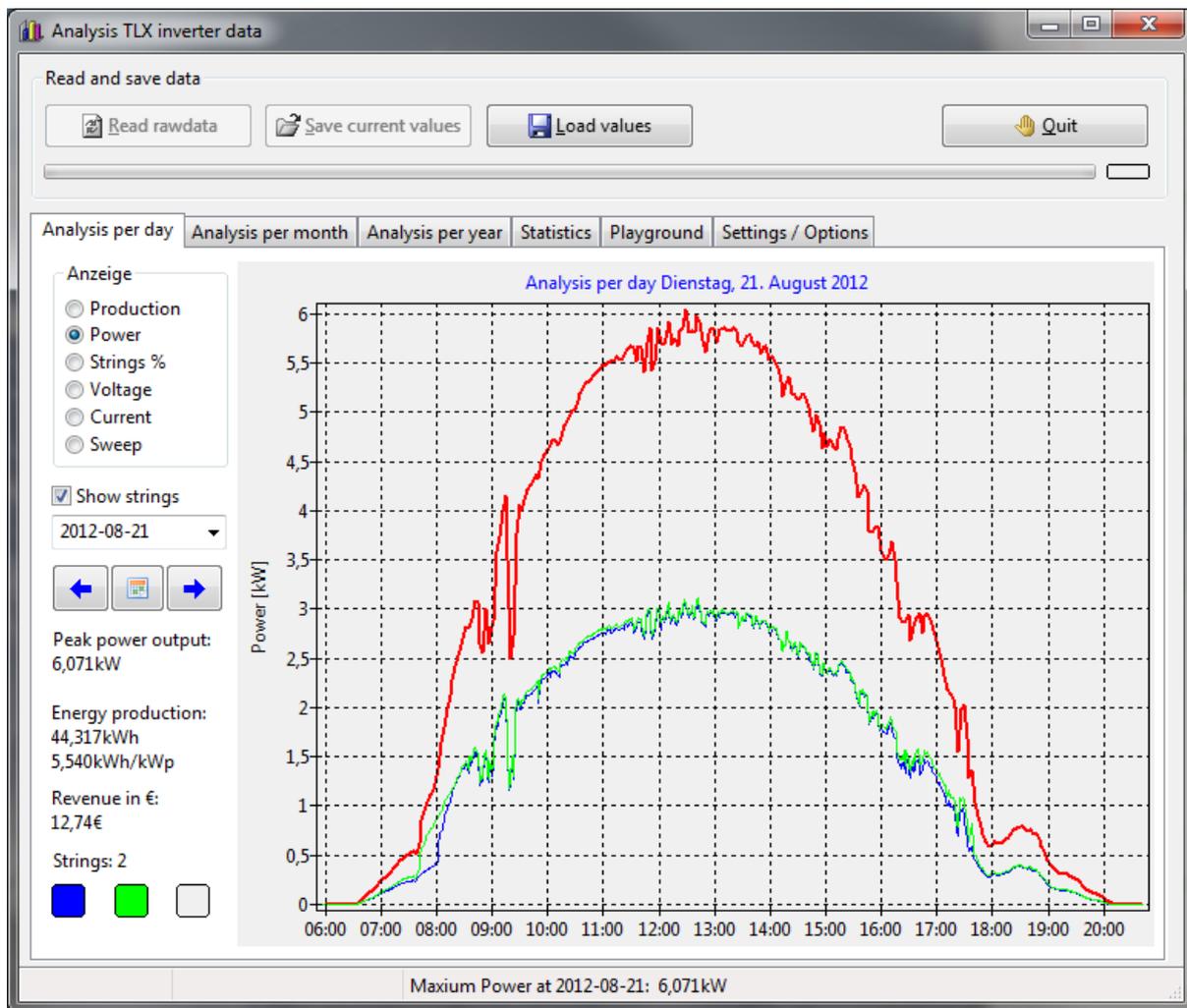
Please check your user manual of the inverter and its web-site for more details. Manuals, Updates and new firmware you can find online at download area of **SMA**.

It is also possible to evaluate the CSV data files from inverter *Powador TL3-Serie* with new firmware (from v1.16 on) by *Kaco new energy GmbH®*. There are some limitations:

- At Kaco frequency is not available → is fix set to 50,00Hz,
- Leakage resistance is not available → set to zero although there is a (unknown) resistance,
- at Kaco detailed production is not available but will be computed and later corrected to the value taken from monthly files,
- at SMA the inverter temperature is not available → will be set to fix 18°C,
- DC power is available but will be ignored from raw data due to backwards compatibility, DC power will be computed from DC voltage and DC current,
- Recovery of a daily file from backup is not possible.



The program „**PV_Ausw**“ was made to evaluate those files, create charts like web-interface of TLX inverter does and some more features. The evaluation is available **for one inverter (=Master) only**. This should be the usual use case for small PV systems.



For documentation or print-out charts can be copied or saved as pictures: Right mouse button > context menu „Save as picture...“.

1.1 Optional start parameter:

- | | | |
|----|-----------|---|
| -s | --stop | Program will be automatically closed after processing |
| -n | --noftp | Program processing without FTP access |
| -o | --options | Program comes up with tab-sheet Settings/Options |
| -m | --month | Program comes up with tab-sheet Analysis per month |
| -a | --sendall | Sends all not archived daily production data in file "days_hist.js" instead only the last 31 days |

Remark: All data are measurement data of the inverter and are not relevant for invoice. The program was made only for private evaluation.

2. Data analysis with charts

2.1 Analysis per day

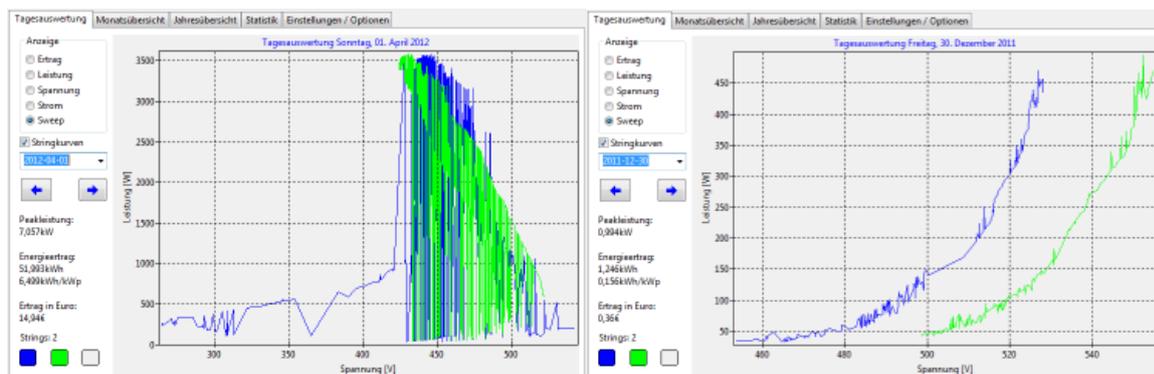
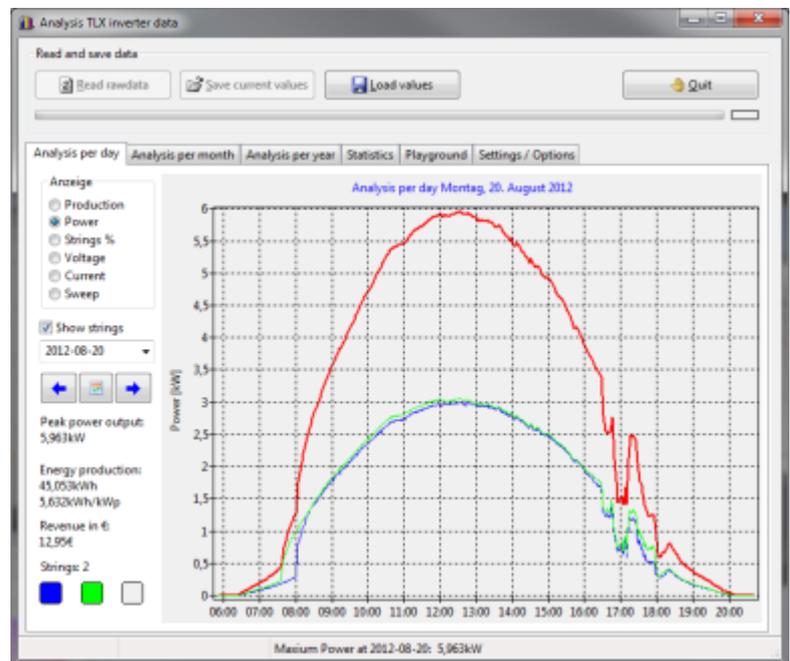
Charts for energy production and power will be created. This can be done only for total output or, if „Show strings“ was set, for total output and for DC input per PV-array (string). So it is possible to monitor the behavior of the different strings (shadowing effects, snow, aging, defects, etc...). Beside of that the power output of the strings can be displayed in percent from planned Peak power (Strings %). This was done to compare strings with different peak power or with different direction (east- / west roof).

Select the day in the list box or scroll through by arrow buttons or by calendar.

The following values will be displayed on the left side:

- Peak power output on this day in kW.
- Production absolute in kWh.
- Production normalized kWh/kWp (just to compare different PV systems).
- Revenue in currency for the case that all production will be sold.
- Number and color code of PV arrays (strings).

Additionally it's possible to show the DC voltage or DC current per string (PV array 1 to PV array 3). To see how "PV sweep" feature is working the relation power to voltage per string will be displayed. For this only those data will be used where the power is greater than the power threshold (see settings).



Color code for chart lines:

red	Total production or total power
blue	PV-Array 1 (String 1)
green	PV-Array 2 (String 2)
magenta	PV-Array 3 (String 3)

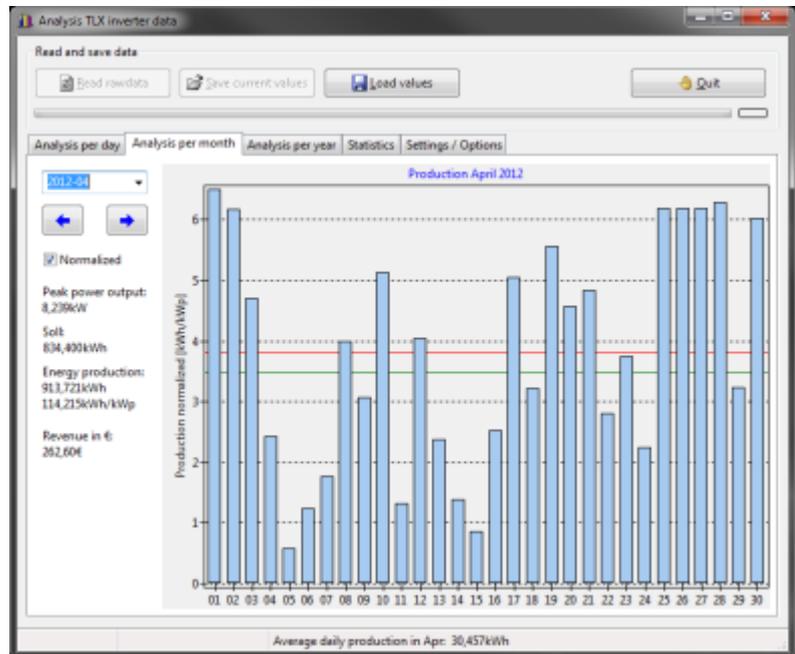
To see more it is possible to zoom into the graphs. To zoom-in move mouse from left to right with pressed left mouse key. To zoom-out click or move mouse from right to left.

In the context menu (right mouse click) there is also the possibility to switch on/off the crosshair tool to inspect data-points. Values for selected data-point will be displayed in the status bar.

2.2 Analysis per month

The chart shows the daily production as 2D-columns for the selected month in kWh. The month can be directly selected by list box (format yyyy-mm) or you can scroll through by arrow buttons. The following values will be displayed on the left side:

- Peak power output for the selected month in kW.
- Production absolute in kWh.
- Production normalized in kWh/kWp (just to compare different PV systems).
- Revenue in currency for the case that all production will be sold.



The horizontal red line is the arithmetic mean of daily production for the selected month. This line turns to green if the production is over target. The green line is the target daily production of the selected month.

To jump direct to related Analysis per day click on a bar.

To switch on/off labels for the columns do double click on the chart. The chart can also be displayed in normalized mode to compare different PV systems.

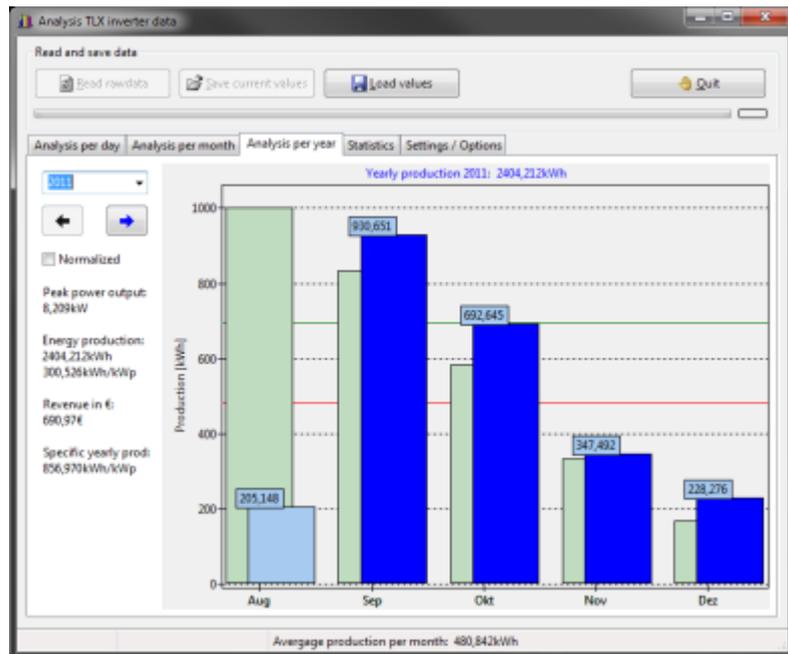
2.3 Analysis per year

The chart shows the monthly production as 2D-columns for the selected year in kWh. Additionally there is a light green set of columns that represent the target production per month.

The year can be directly selected by list box or you can scroll through by arrow buttons.

The following values will be displayed on the left side:

- Peak power output in the year in kW.
- Production absolute in kWh.
- Production normalized in kWh/kWp (just to compare different PV systems).
- Revenue in currency for the case that all production will be sold.
- Specific yearly production.



The horizontal red line is the arithmetic mean of monthly production for the selected year. This line turns to green if the production is over target. The green line is the target monthly production of the selected year.

In the first quarter of a year the last three month of the last year will be displayed too to have a nicer chart.

The monthly production target will be computed from planned specific yearly production and a correction value that can be maintained on basic data page (Distribution of target production to month).

To jump direct to related Analysis per month click on a bar.

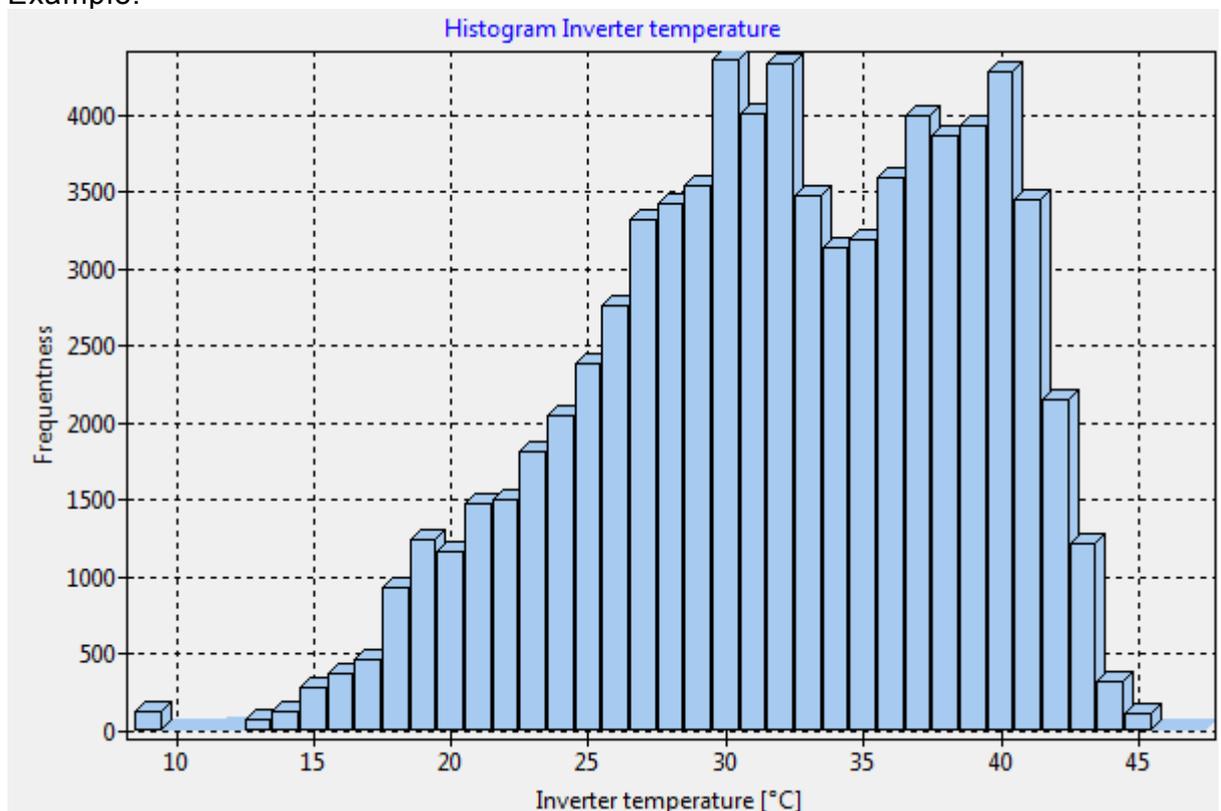
To switch on/off labels for the columns do double click on the chart. The chart can also be displayed in normalized mode to compare different PV systems.

2.4 Statistics

Some statistics for deeper analysis of the PV system:

- Statistic daily peak power output. The red line is the arithmetic mean of the daily peak power output. The green line is the planned Peak power output of the PV system.
- Begin and end timestamps taken at power threshold (Start: green; End: red). Breaks in the line due to change from/to Daylight Saving Time (DST) can be removed by checking “No DST” at tab sheet “Playground”.
- Daily production time interval computed by end time minus begin time taken at power threshold.
- Statistic daily power production. The red line is the arithmetic mean of the daily production.
- Statistic Specific yearly production (Specific YP): This was made to observe production for a long term comparison.
- Histogram (graphical representation of the distribution of data) showing the relative daily production in relation to the target production in percent (Specific yearly production*Peak power output/365=100%).
- Histogram AC voltage.
- Frequency spectrum (Frequentness of measured AC frequency) to check frequency of power supply system. The value should be 50Hz for most of the energy provider in Europe.
- Histogram of inverter temperature.

Example:



3. Installation/commissioning of the program

Download latest version of *PV_Ausw* by menu item „Downloads“ at <http://h-elsner.mooco.com/>. The program is available for Windows (2000, XP, Vista, Win7) or LINUX (with GTK2).

Simply unzip the zip-file (Windows version) or tar.gz-file (LINUX version) and copy it to directory where you have write access. This can also be a memory stick or something like that. You only need write access to it because the environment data will be stored in a XML-file, no other changes in the system.

Program options, basic data and FTP settings will be saved in file 'PV_Ausw.xml' in program directory. In LINUX this file is located in users home directory as '.PV_Ausw.xml'.

3.1 Basic data

After first start all basic environment data must be set up for proper work.

The screenshot shows the 'Settings / Options' window of the PV_Ausw software. The 'Basic data' tab is selected, and the 'Read or write data files' section is expanded. The 'Local data directory (Copy of datawarehouse)' is set to 'D:\temp'. The 'Inverter data type' is set to 'Danfoss TLX Pro'. The 'Project data of your PV system' section shows the following values: Peak power output [W] is 8000, Specific yearly production [kWh/kWp] is 1043,000, Peak power per string [W] for String 1 is 4000, for String 2 is 4000, and for String 3 is 0. The Revenue [€/kWh] is 0,2874 and the Currency string is €.

- Local data directory (Copy of Datawarehouse):
This is the working directory of the program on the local disc. This local directory is always necessary to have it for proper work, also if FTP is used.

It should be used only for this purpose. Backup files will be stored into this directory too.

- File filter:
File filter with FTP account and wildcard *. This filter is necessary to detect the valid data files from the inverter. For danfoss/IBC it is usually the FTP `username-*`, for Kaco it should be `20*.CSV` (this should be good for the next 80 years...).
- Location and file name of HTML file:
Directory and file name of the HTML protocol file on the local harddisc where the table with selected results from PV system will be written into. This file will be downloaded from remote FTP server if not exists. You must have write access to this location. The file name should not have white spaces.
- Inverter data type:
Select the inverter type that sends out the data. For SMA use the selection depending on the tool that sends the data.
- Line number in HTML file:
Line number from where on the HTML code for the table with selected results from the PV system will be inserted. Please insert enough empty lines (>30) that can be overwritten by the HTML code for the table. Too much empty lines are no problem for the browser. Default=0 (HTML protocol disabled).
- Create import files for sonnenertrag.eu:
The 3 *.js files for a portal like www.sonnenertrag.eu will be created in the same directory as the HTML protocol is located if this check box is checked.
- Automatic reload:
Files from data warehouse will be downloaded and evaluated automatically every hour as long as the program is running.
- Peak power [W]:
Planned peak power output of your PV system in Wp. This should be part of your project specification.
- Specific yearly production [kWh/kWp]:
Planned specific yearly production by your PV system from project specification.
- Peak power per string [W]:
Planned peak power output of each string (PV array) of PV system in Wp. This should be part of your project specification. For SMA the 'string' stands for MPP tracker.
- Revenue [Currency/kWh]:
This is the compensation for energy production from your provider in currency per kWh. Compensation for own consumption will not be supported.
- Currency string:
In Euro zone this can be € or Euro. But also other currency are possible depending on your local currency.

3.2 Program options

Program options are made to tune the behavior of the program for your own needs. However you can keep the defaults if you do not know what to do with it. Remark: The naming of the month is depending on the locale settings of your computer.

Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez
9	15	23	28	31	31	30	28	24	16	11	8

- Power threshold [W]:
Default 100W, but you can play with this value a little bit. If you set this threshold to zero then all data records greater than zero will be taken into account.
- Histogram generation:
To speed up the generation of histograms the amount of data will be reduced by factor 2 to 10. Value 1 means: no data reduction and is the slowest. Then more data will be reduced the faster the chart will be displayed.
- Distribution target production per month:
The monthly target is a result of the planned specific yearly production and a monthly correction factor that can be adjusted here. Please enter in the table the relation of the target per month in **integer values**. The absolute values are not important but only the relation between it.
- Archiving:
Set up how many days will be kept when archiving.
- Smoothing:
A factor to reduce data in power chart in Analysis per day. Aim is to get a smoother line in power chart.

- Correction:
- Edit correction value for production in plus/minus percent of production measured by inverter in comparison to official counter values. If correction value is zero then there are no changes, production measured by inverter will be used. there are no changes, production measured by inverter will be used.
Example: Inverter shows 1223 kWh for the month, but counter has only 1202 kWh. Correction value is in this case -1,72% (21 kWh from 1223 kWh).
- Power limitation:
Select the power limitation for the inverter that shall be simulated.

Besides this you can find here some tools (Backup / Restore, Archiving, Simulation power limit → see chapter 4), links to program update repository and the well-known about box (button Info).

3.3 FTP client and FTP access data

There is a build-in FTP client that can access two different FTP server. Datawarehouse to download missing data files from Danfoss datawarehouse and Homepage / Webspace to upload either HTML protocol to homepage or import files to a web portal.

- Datawarehouse, the location where the inverter stores its data files.
- Homepage / Webspace is for data exchange with homepage or web portal like www.sonnenertrag.eu.

Status of FTP connection will be shown in a small field above right:

black	Test FTP connection
green	Download
blue	Upload
red	Error
w/o color	Inactiv/Logout

If FTP download is activated **PV_Ausw** will check if FTP server contains new data files and will download those files to the local working directory (local copy of datawarehouse).

Results will be uploaded if no download is running and upload to homepage or web-space is activated (see FTP settings). File names for FTP should not have white spaces. Default is active FTP mode but in case of connections problems via router or firewall you can force passive FTP.

If FTP access to Datawarehouse and/or to Homepage is necessary then FTP access data is mandatory. FTP port is set fix to 21. File name HTML file was taken from Basic data. It cannot be changed here, this is only for information. FTP access data you should got from provider of the FTP server. In case of access problem please read the help files from the provider of the FTP service. It is possible to force passive FTP. This may help in case of router/firewall

problems.

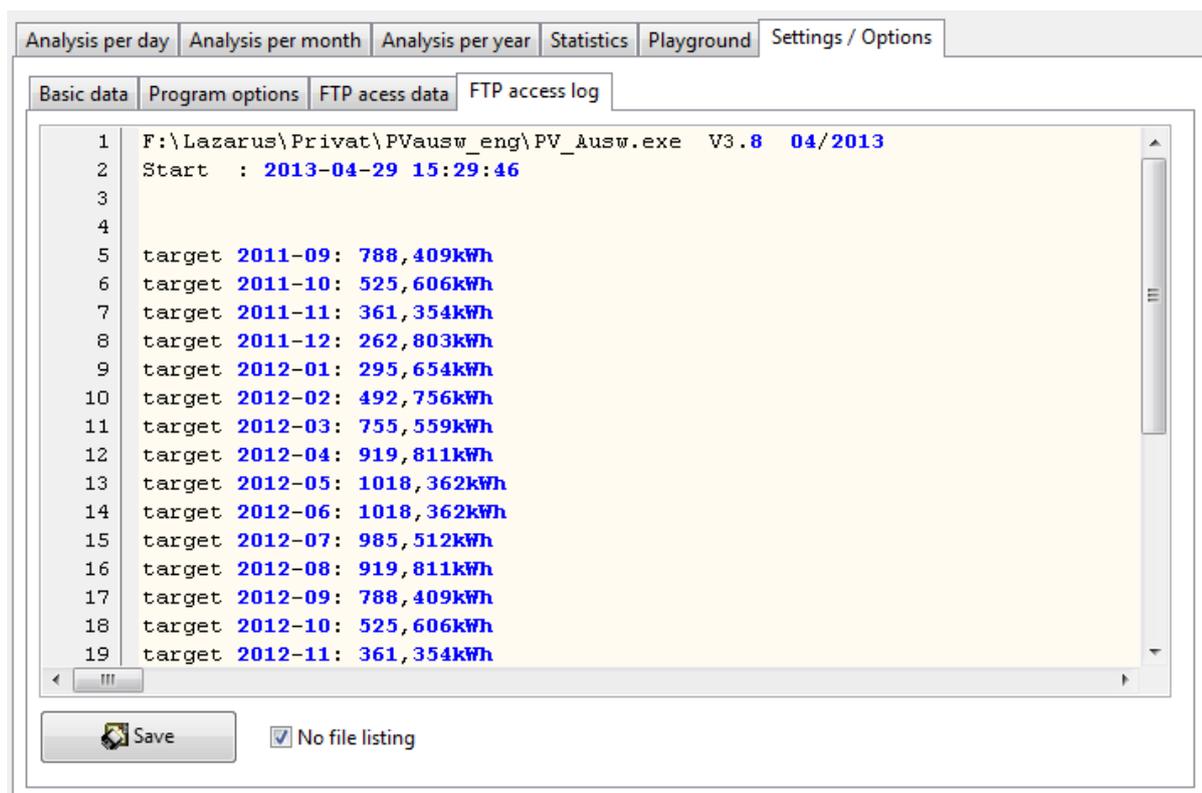
FTP features are only enabled if „FTP activated“ is checked.

The screenshot shows a software interface with a top navigation bar containing 'Analysis per day', 'Analysis per month', 'Analysis per year', 'Statistics', and 'Settings / Options'. The 'Settings / Options' window is open, showing two tabs: 'FTP access data' and 'FTP access log'. The 'FTP access data' tab is active, displaying two sections: 'WR-Datwarehouse' and 'Webspace/Homepage'. Each section contains input fields for 'Host / server name', 'Account name', and 'remote directory on FTP server'. The 'WR-Datwarehouse' section also includes a 'Password' field and a 'Passive FTP' checkbox. The 'Webspace/Homepage' section includes a 'File name HTML file' field. Both sections have 'FTP activated' and 'Show Password' checkboxes, and 'Test' buttons ('Test DW-FTP' and 'Test HP-FTP').

With Test buttons on the right side you can check the FTP connection to the FTP server. If connection is OK then in the status bar the remote directory will be displayed else you will see an error message. In this case check the FTP log for more information. Check host name, account name and password or try passive FTP mode.

3.4 FTP connection log

In case of problems with FTP the FTP connection log may be helpful. The log can be saved to a text file. This file you can send to me if you need help (mail address, see 9. contact). This helps me to understand what's happen and where the program stops working. The log file contains account names but no passwords at all. To avoid too long output it is possible to suppress file name listing in FTP access log (set "No file listing").



4. Additional program features

4.1 HTML protocol function and data export

The HTML protocol is a table with some selected values that will be embedded into a HTML file selected by settings. This table will be written into the file by overwriting the line and next 30 lines that is set in the field "Line number in HTML file". So it is possible to keep the layout of your homepage untouched but have the table with actual values somewhere in. To deactivate this feature set zero set in the field "Line number in HTML file".

Data export means to create import files for web portals like www.sonnenertrag.eu (according SolarLog-standard).

To enable this feature set check box „Create import files for sonnenertrag.eu“. Following files will be created:

- base_vars.js PV system description
- days_hist.js Daily production
- min_days.js Interval data of current day
- months.js Monthly production

Those files can be uploaded to any portal that supports SolarLog-standard. Please check description of the web-portal you want to use.

More info regarding this format is here (in German):

http://photonensammler.homedns.org/wiki/doku.php?id=solarlog_datensformat

Same functionality is available as command line program (LINUX or Windows) „cpvausw“ that can be automatically started by cron-job.

Example for the table that will be embedded into a HTML file:

Inverter	018202G221
Planned Peak power output:	8,000 kWp
Current Peak power output:	8,209 kWp
Planned Specific yearly production:	1043,000 kWh/kWp
Current Specific yearly production:	913,948 kWh/kWp
Total production:	2303,650 kWh
Production last month:	347,492 kWh
Highest Daily production:	48,436 kWh
Average Daily production:	20,032 kWh
Daily production 18.12.2011 (14.35h):	7,027 kWh

Red values are below target / average, green values means on or above target / average.

4.2 Demo function

With "Save current values" and "Load rawdata" it is possible to use all functions of the program without having access to copy of datawarehouse. This makes sense in case you want to show your systems behavior offline to others (Demo).

With button " Save current values " all relevant data will be saved to a file 'rawdata.csv' located in program directory. So it is possible to save the program itself, the settings (the xml file) and the rawdata to a memory stick and take it away.

4.3 Backup and restore

The same file format for raw data will be used for backup files. Go to "Program options" and hit button „Backup“. Then a backupfile with time stamp will be created at the local datawarehouse directory. This should be done at least once a year. You should save those backups on another medium (i.e. a CD).

In case a file in datawarehouse was lost or destroyed it is possible to recreate it from the backup file (only those data that are in the backup file, but enough for further evaluations):

1. Program options > Tools > button „Restore day“.
2. Select backup file. This file will be loaded and the program jumps to Analysis per day.
3. Select missing or destroyed day → the chart will be displayed and the file will be recreated. You can select another day and repeat restoring as long as the day field is orange which indicates the restore function is active.
4. The restore function will be stopped by „Read rawdata“ or hit button “Restore day“ again.

4.4 Archiving of daily data

To reduce the amount of files and data to process the program gives the possibility to archive old data. Program will react faster if the not so much days with detailed data will be kept. The evaluation of monthly or yearly data will be untouched by archiving, only the daily analysis will be lost if the data of the day was archived. In Program options you can define, how many day back you want to keep untouched. Older files with detailed data per day will be renamed on local directory as well as in remote directory on FTP server (if available). So file filter can filter out those data, but it is not lost forever. Results per day will be stored in a very small file "*arch_days_hist.csv*". This file will also be saved in case of backup. Archiving will not be done automatically but only by manual command

Start archiving: Settings/Options > Program options > Tools > Button „Archive data“.

4.5 Simulation power limitation of the inverter

„Simulation power limit“ (70% may be Germany specific only!) compares the production with and without a power limitation of the inverter. Of course this is only possible if power limitation is not set at the inverter. It is a What-If-Analysis with real values to help making decisions if 70% rule should be implemented on command of the legislative authority (German law). The reduction of energy production will be computed on monthly base and stored in a CSV file.

Example:

Analysis 70% rule

- Power limited to 5,600kW

05.06.2012

Month	Production [kWh]	Production 70% [kWh]	Loss [%]
Aug 2011	206,762	200,44	3,06
Sep 2011	930,324	908,437	2,35
Okt 2011	658,93	640,982	2,72
Nov 2011	347,172	346,506	0,19
Dez 2012	228,091	227,894	0,09
Jan 2012	307,543	305,922	0,53
Feb 2012	500,39	486,488	2,78
Mrz 2012	968,961	925,476	4,49
Apr 2012	913,253	863,538	5,44
Mai 2012	1222,962	1161,227	5,05
Jun 2012	30,768	28,488	7,41
Total	6315,157	6095,396	3,48

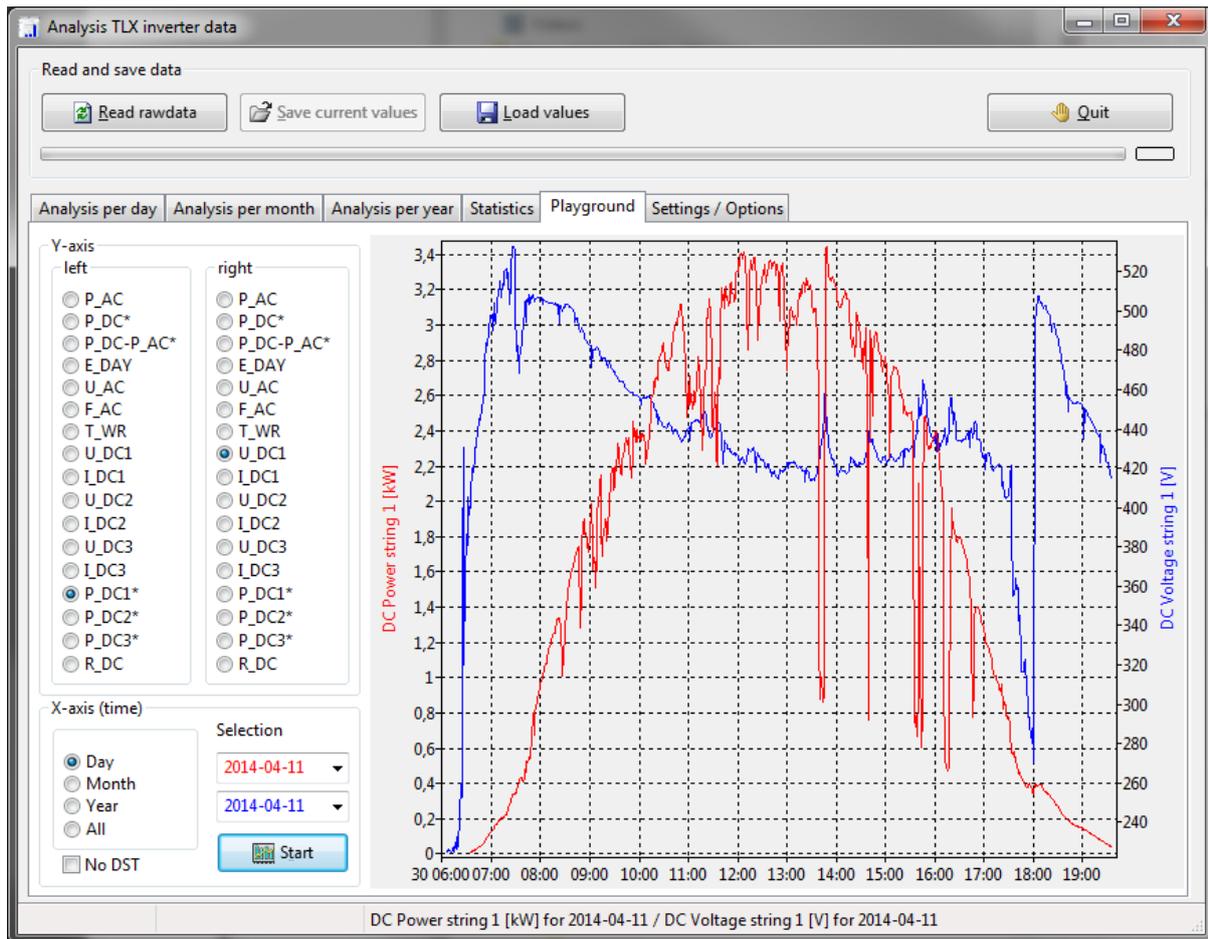
To start analysis: Settings/Options > Program options > Tools > Button „Simulation power limit“.

For other cases it is possible to simulate a limitation to 60%. Select Power Limitation = 60%.

4.6 Additional analysis at "Playground"

This chart was made to combine two different values on a time base. Time base can be day, month, year or all. Not every combination makes sense but this is up to you. Voltage and current of a single string may be very useful. For X-axis selection 'Day' it is possible to compare data from two different days. Normally the two days are synchronized but it is possible to select another day in the second selection field. In this case the evaluation will be done immediately.

To compare results from days that have different status regarding Daylight Saving Time (DST) the Daylight Saving Time can be removed by checking option "No DST".



Right mouse click opens a context menu to save the chart.

To go more in detail it is possible to zoom into the graphs. To zoom-in move mouse from left to right with pressed left mouse key. To zoom-out click or move mouse from right to left.

In the context menu there is also the possibility to switch on/off the crosshair tool to inspect data-points. Values for selected data-point will be displayed in the status bar.

Two of the following values can be combined in a chart:

P_AC	Output power inverter [kW]
P_DC*	Input power, computed by sum of voltage * current of the three strings [kW]
P_DC-P_AC*	Delta between input and output power of the inverter [W]
E_DAY	Production per day [kWh]
U_AC	AC voltage [V]
F_AC	AC frequency [Hz]
T_WR	Inverter temperature [°C]
U_DC1	Voltage string 1 [V]
I_DC1	Current string 1 [A]
U_DC2	Voltage string 2 [V]
I_DC2	Current string 2 [A]
U_DC3	Voltage string 3 [V]
I_DC3	Current string 3 [A]

P_DC1*	Input power, computed by voltage * current of the strings 1 [kW]
P_DC2*	Input power, computed by voltage * current of the strings 2 [kW]
P_DC3*	Input power, computed by voltage * current of the strings 3 [kW]
R_DC	Leakage resistance [kOhm]

Values with star (*) are computed, other values are coming directly from raw data of the inverter. Data are only available from non-archived days.

5. Data format

5.1 Data format of CSV file for Demo and Backup (Field delimiter: Semicolon)

Field	meaning	PV-Array	from Danfoss	unit
0	Date		TIMESTAMP	[JJJJ-MM-TT]
1	Time		TIMESTAMP	[hh:mm]
2	Power		P_AC	[W]
3	Production		E_DAY	[Wh]
4	Temperature inverter		T_WR	[°C]
5	DC voltage	1	U_DC_1	[/10 V]
6	DC current	1	I_DC_1	[mA]
7	DC voltage	2	U_DC_2	[/10 V]
8	DC current	2	I_DC_2	[mA]
9	DC voltage	3	U_DC_3	[/10 V]
10	DC current	3	I_DC_3	[mA]
11	AC voltage		U_AC	[V]
12	AC frequency		F_AC	[/100 Hz]
13	Record interval		INTERVAL	[sec]
14	Leakage Resistance		R_DC	[kOhm]

File name: *rawdata.csv* (as backup file with time stamp in file name)

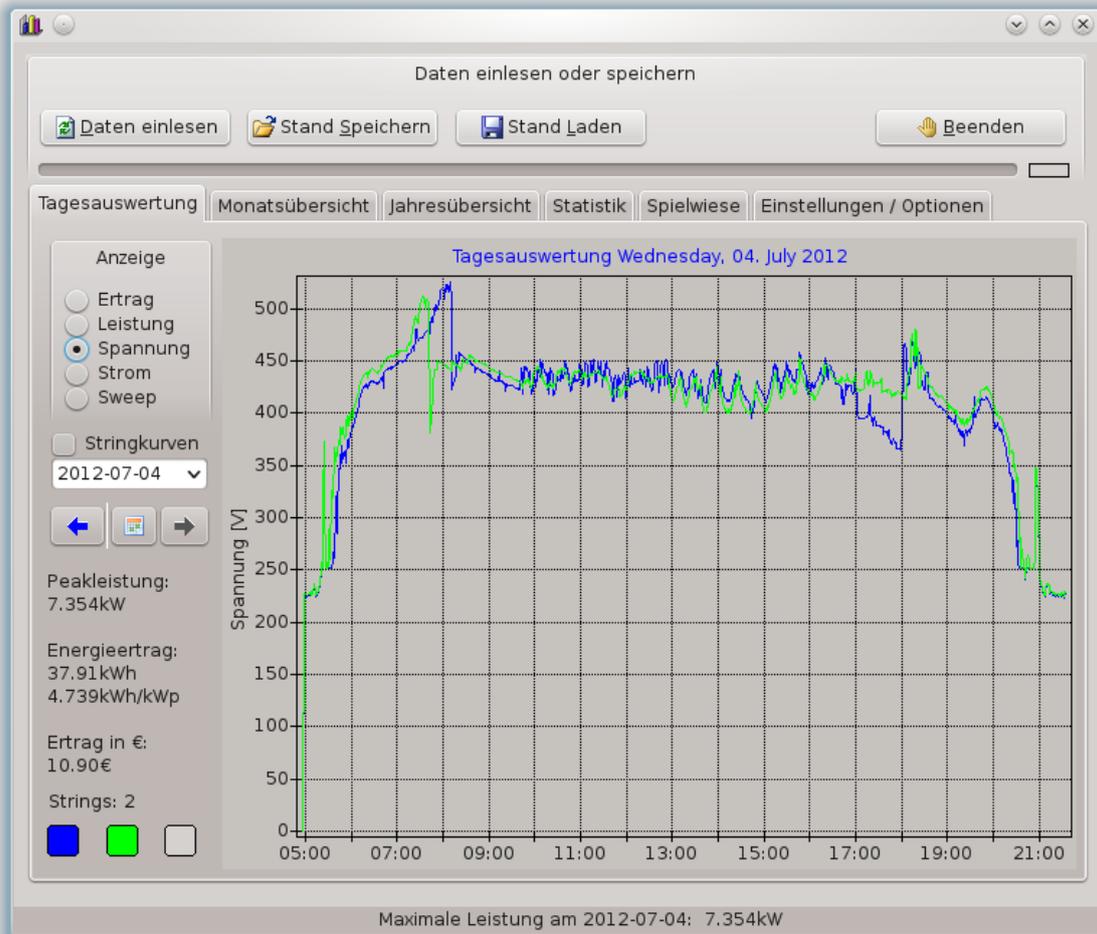
5.2 Data format of archive file (Field delimiter: Semicolon)

Feld	Inhalt	Maßeinheit
0	Date	[JJJJ-MM-TT]
1	Daily peak power	[W]
2	Daily production	[Wh]
3	Begin production	[hh:mm]
4	End production	[hh:mm]

File name: *arch_days_hist.csv*

6. LINUX

The program is also available for LINUX (gtk, gtk2 or qt4). Tested with OpenSuse and KDE. LINUX user have the same features, look and feel like Windows user. Please take care of location settings at your system (floating point numbers may have comma instead of point as decimal separator).

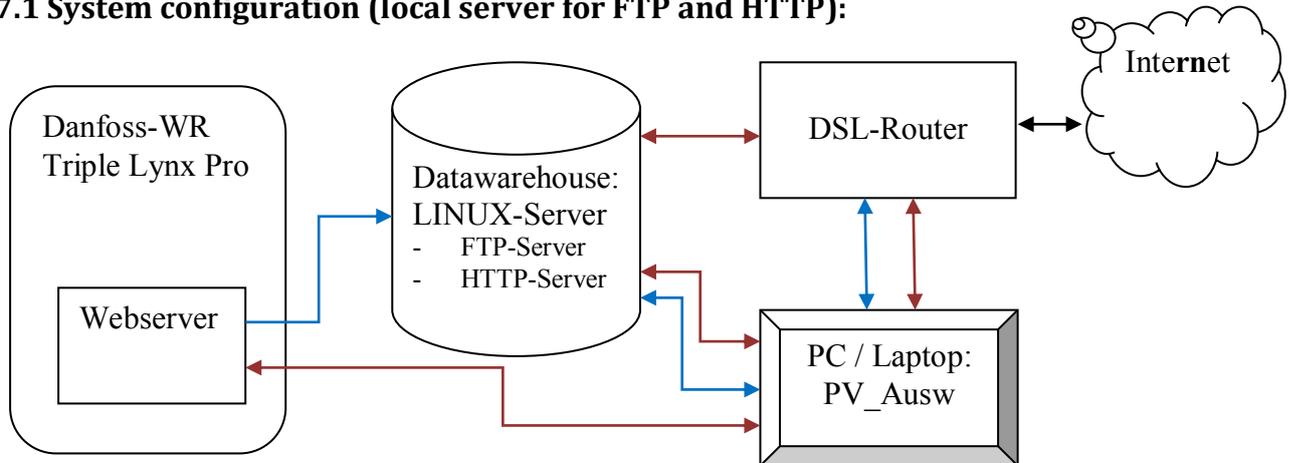


The screenshot from a LINUX system shows the typically voltage per day from two PV arrays.

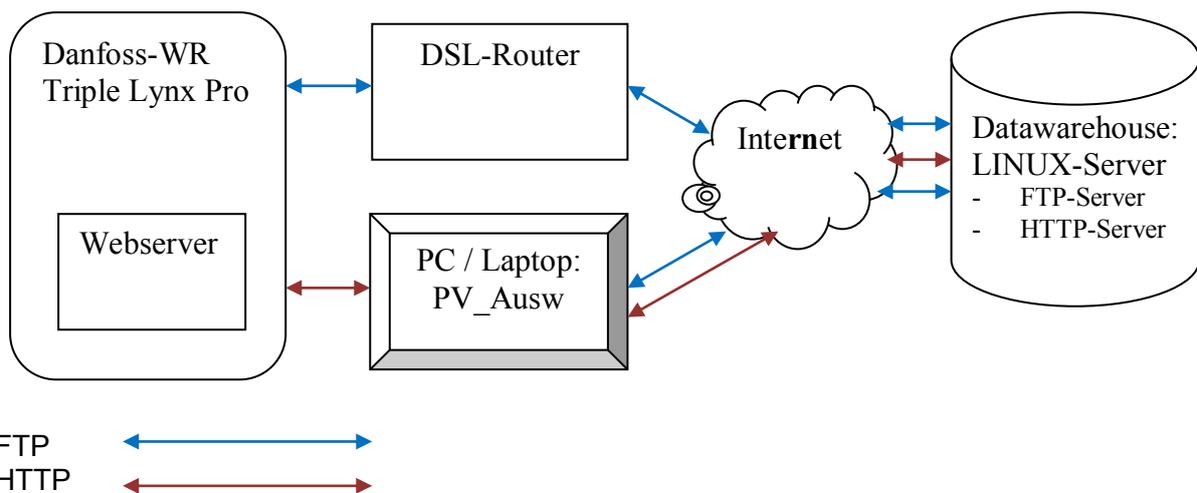
It is possible to get the HTML protocol feature and/or the files for *sonnenertrag.eu* without GUI by a command line tool called "cpvsausw". This can be started by *cron-job* after upload of raw data files by the *Danfoss inverter*. So it is possible to get the embedded table with PV production results for your homepage and/or input files for *sonnenertrag.eu*.

7. Configuration and information flow

7.1 System configuration (local server for FTP and HTTP):



7.2 System configuration (FTP and HTTP server located in internet):



8. Contact

Regarding questions, bugs and hints please feel free to mail me at helmut.elsner@live.com with subject „PV_Ausw“. Mails without Subject will be probably filtered out by spam filter. Another communication channel is this [Thread](#) at [Photovoltaikforum](#) (in German) or [this on](#) at [photovoltaicboard.com](#) (in English).