



QUICK GUIDE – TR10 IN PERFORMANCE CHECK

Purpose:

In Germany, the “Erneuerbare-Energien-Gesetz 2017” (“**EEG 2017**”) came into force. Based on this law, the owners of German wind farms commissioned after 1st of January 2018 are obliged to report the produced electricity after 5, 10 and 15 years of operation. If the availability of a WTG drops below 97%, the electricity not produced due to the technical unavailability needs to be calculated. This and the complete calculation of the **Site yield** and **Quality factor** are described in the Technical Guideline No. 10 (hereinafter **TR10**).

The Quality factor calculation is a sub-module of the PERFORMANCE CHECK module in windPRO 4.0 and includes the **full implementation of the TR10, rev.2**. This quick guide shall guide the user through the process of the analysis.

Outline of Guide:

1. **Workflow**
2. **Data Import**
 - Production data from SCADA
 - Status logs from SCADA
 - Import Sold
3. **Plausibility and Availability**
4. **Site Yield**
5. **Quality Factor and Reports**

1. WORKFLOW

The process explained in this quick guide requires windPRO 4.0 with licensed modules BASIS, METEO, PERFORMANCE CHECK and TR10.

The workflow of this quick guide is as follows:

- Create new “Existing WTG” objects.

- Download some Meso- and / or Reanalysis data in METEO-Object(s) (optional, but recommended).
- Start PERFORMANCE CHECK from the modules menu or use the shortcut in the toolbar.
- Select “Quality factor calculation (TR10)” on the tab “Concept choice”.
- Import SCADA data with production, wind speed, wind direction and load this data into the “Existing WTG” objects.
- Import and merge status codes from turbine log files to 10 min. production data.
- Import the sold electricity, the electricity sold under optimized selling (if any) and electricity not produced due to the constraints from the grid operator – EinsMan¹ (if any).
- Evaluate the plausibility of the imported data and calculate the TR10 availability of the WTG(s).
- For the WTG(s) with a TR10 availability equal or higher than 97%, the simplified methods as per chapters 6.1 and 6.2 in the TR10 are applicable.
 - Go to “Site yield → Results” and use the buttons “Calculate production” and “Calculate site yield” to get the results.
- For the WTG(s) with TR10 availability below 97%, the detailed procedure as per chapter 6.3 in the TR10 is applicable.
 - Create “Consistent wind speed time series” according to the TR10 chapter 6.3.1 using the tabs “Wind speed correlation” and “Wind speed regression”.
 - Create “Applicable power curves” according to the TR10 chapter 6.3.2 using the tab “Moving power curves”.

¹ Einspeisemanagement

Quick Guide – TR10 in PERFORMANCE CHECK

- Go to “Site yield → Results” and use the buttons “Calculate production” and “Calculate site yield” to get the results.

WTG	Availability [%]	E - Prod [MWh]	E - Prod_kstl [MWh]	Anteil [%]	E - EinsMan [MWh]	E - OV [MW]	E - Ausf [Mh]	SE y [MWh]
101	99.8	36 590.649	34 910.883	14.20	1 751.753	0.000	0.000	36 662.637
102	99.6	34 339.943	32 745.618	13.32	1 643.105	0.000	0.000	34 388.723
103	99.5	37 771.389	36 023.067	14.65	1 807.560	0.000	0.000	37 836.627
204	97.0	37 031.152	35 337.888	14.37	1 773.179	0.000	0.000	37 475.663
205	95.5	37 762.359	36 011.676	14.65	1 806.989	0.000	630.171	37 679.860
206	93.9	37 757.270	36 003.376	14.65	1 806.572	0.000	833.324	37 870.406
207	95.5	36 634.405	34 806.623	14.16	1 746.522	0.000	1 422.687	37 216.315

- Go to the tab “Quality factor”, enter the Referenzertrag² to the WTG(s). As soon as done, windPRO will calculate the “Quality factor”, which is the final result of the whole calculation process.
- Go to the Tab “Report” and generate the report(s) for the grid operator.

2. DATA IMPORT

To run the TR10 analysis (and any PERFORMANCE CHECK analysis in general), you need to import SCADA data, through the following process:

- Prepare the SCADA data as *.csv or *.txt files.
- Create Existing WTG objects (including IDs).
- Start PERFORMANCE CHECK.
- Setup the import filter (Auto detect).
- Pair and load.
- Merge the status logs with the 10 min. based time series.
- Import EinsMan and Optimized selling data if necessary.



Prepare the SCADA data as text files

SCADA data must be in a text file as 10 min. values. If your data is in e.g. Excel, the file(s) must be saved as *.txt (TAB separated preferable) or *.csv. The PERFORMANCE CHECK data importer is quite flexible and can handle data in single or multiple files, e.g. one turbine per file; all turbines in one file; one turbine per day, per month etc. in one file.

It is important to have an identifier (ID) of the turbine in the file headers or in a column or in the file names (if one file per turbine). Later this ID will be used to automatically pair the SCADA data with an Existing WTG object.

² Reference production defined for each WTG type and hub height according to the EEG.

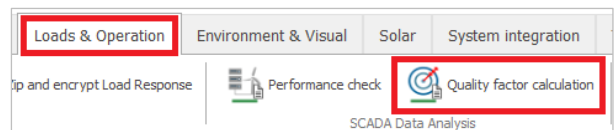
Create Existing WTG objects (including ID)

Either manually insert an Existing WTG object , copy-paste the position from a spread sheet or download turbine positions directly through the Online WTG Data tool . Alternatively, convert New WTG(s) into Existing WTG(s) by using the paste option “Edit object(s) before pasting”.

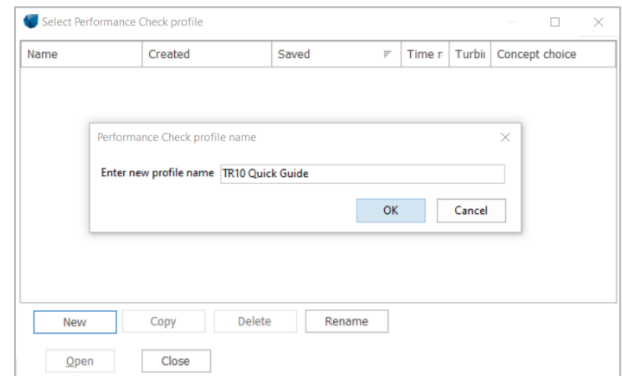
Remember to assign an ID to the WTG object as either Description or User label. It is convenient to name the WTG(s) using the same WTG IDs as the SCADA system uses, so the “Auto pair” function can be used later on.

Import from data files

Start PERFORMANCE CHECK using “Quality Factor calculation” from the tab “Load & Operation”.



As soon as started, create a new session, name it and enter it.



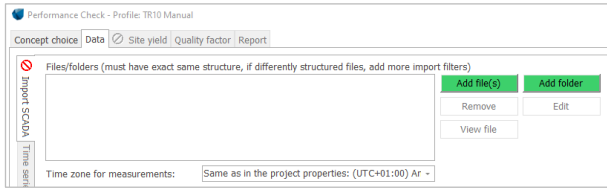
Inside the session, please select the concept “Quality factor calculation (TR10)” and proceed to the tab “Data”.

Import production data from SCADA

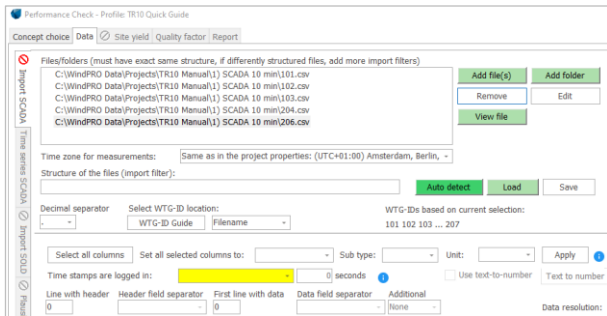
The structure of the import filter in the module PERFORMANCE CHECK (no matter on the concept choice) is similar to the METEO-Object. Tip: windPRO is advising

Quick Guide – TR10 in PERFORMANCE CHECK

the next logical step of yours and proposes it by green coloring.

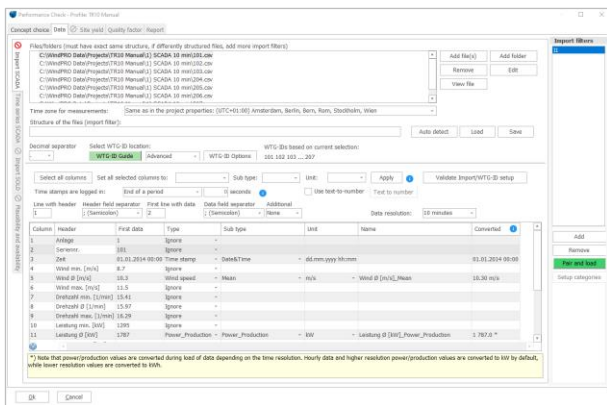


Select “Add file(s)” or “Add folder”, select the files (or folder with files) and confirm the selection with “OK”.



The “Auto detect” option is typically used, when importing the data for the first time. As soon as the import filter is finalized (see next step), it is practical to save it using the “Save” button. By this, the created import filter setup in the “.pci” format can be used to setup the import filter e.g. in another session very fast.

With no “.pci” file available, the import setup needs to be finalized manually:



In the example above, 7 files (each contains SCADA-Data of one turbine) are added to the import setup with following data fields:

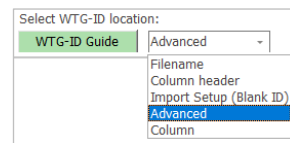
- Column 3: Date/Time (mandatory)
- Column 5: Wind speed (mandatory)
- Column 11: Production (mandatory)

- Column 19: Wind direction, resp. nacelle position (mandatory)

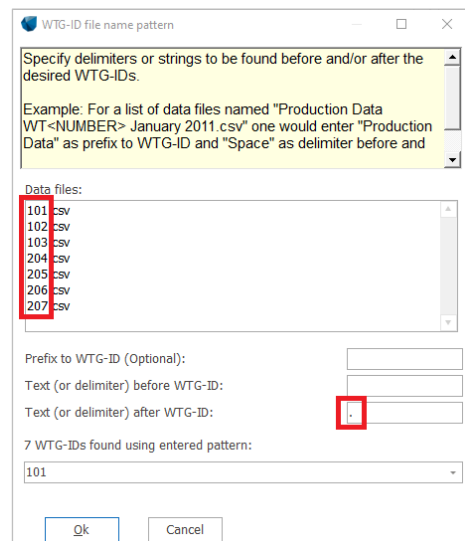
Following signals are not mandatory for the finalization of an analysis, but not using them causes a deviation to the TR10 and will be documented in the report “Deviations to TR10”.

- Cumulative production (see Column 16)
- Temperature
- Air pressure
- RPMs
- Pitch angle

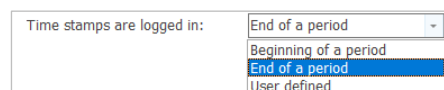
Besides the definition of the signals “inside the files” as per step above, it is also necessary to define where windPRO can find the data for each of the WTG(s), resp. how the WTG ID handling is done. There are several options:



In this example, the “Advanced” was used, which allows the user to select e.g. a string from the file name:



In compliance with the requirements defined in the TR10 chapter 4.1, the user must decide, whether the SCADA data represents the beginning of the period or the end of the period.

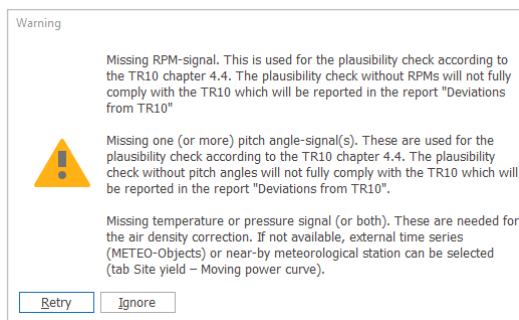


Quick Guide – TR10 in PERFORMANCE CHECK

For example, does the time stamp “02.10.2018 10:00” represent the interval “09:50 – 10:00” or “10:00 – 10:10”.

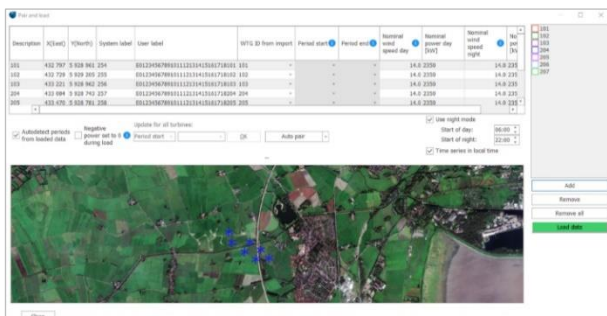
If you are not sure, please clarify with the WTG manufacturer. If the “End of a period” was selected, the loaded time series are shifted by 10 minutes, so the status logs and the 10 min. time stamps are in line.

As soon as the setup of the import filter has been finished, the “Pair and load” button Pair and load becomes green, which again indicates that the user should proceed this way. When moving “Pair and load”, windPRO always notifies the user, if one or more TR10-relevant signals are missing:



These signals are necessary for the plausibility check according to the chapter 6.3.1. The assessment can proceed without them too, but their unavailability will be documented in the report.

Use the green Add button to add the “Existing WTG objects” representing the WTG(s) that are going to be the subject of the assessment. In case that the user did a proper setup of the WTG ID, the “Auto pair” button should link exactly one source of the SCADA data (e.g. one file or one column) with exactly one “Existing WTG object” – see in the next figure. In this case, the User labels of each of the “Existing WTG objects” finds exactly one file with the SCADA data with the same name as this “User label” is. The button “Load data” is now available. Use it to import the 10-min SCADA data into the WTG objects.



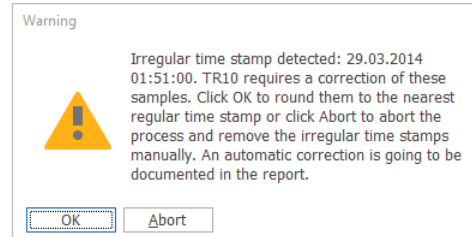
Before leaving the “Pair and load” window, double check and potentially correct the nominal wind speeds and nominal power outputs for day and night modes. These are used for the calculation of the moving power curves according to chapter 6.3.2 in the TR10.

The “Use night mode” is activated in default to fulfill the requirement of the chapter 6.3.2 to calculate the moving power curves for day and night separately. The correct nominal wind speed and nominal power output of the day / night mode should be defined here manually by the user. The default time for night in Germany is 10PM – 6AM.

The import-concept foresees that the imported time series is in local time with DST (summer- / wintertime) changing. Shouldn’t this be the case, please deactivate the checkbox “Time series in local time”.

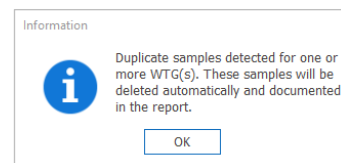
When ready with the setup, click “Load data”, so the data are imported into the “Existing WTG objects”.

During the import of the data, windPRO checks its consistency. Should there be time stamp that is not in the regular 10 min. form, windPRO will notify the user and request a corrective measure:



When confirming with “Ok”, windPRO will assign this irregular time stamp to the nearest regular one.

It can also happen that there are some duplicates found in the time series, e.g. due to the assignment of the irregular time stamp as per above, when there is already some other data with this regular time stamp. As soon as some duplicates are found, the user is notified:



The TR10 currently defines that the chronologically first occurrence shall be deleted (unless the second occurrence fails the plausibility checks).

Quick Guide – TR10 in PERFORMANCE CHECK

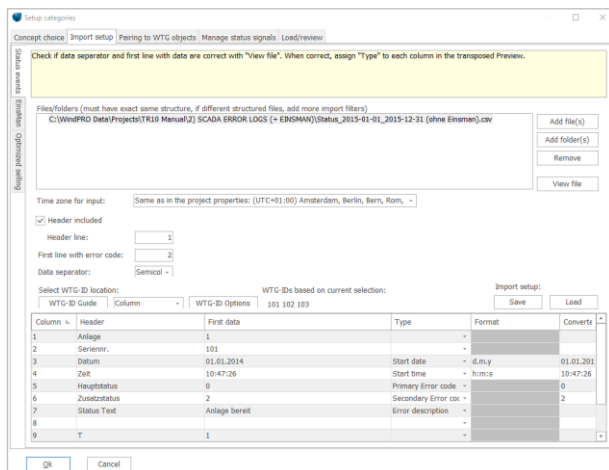
As soon as the “Pair and load” process is done, the button to the next step, which is the upload of the status logs, becomes green: **Setup categories**

Import status logs from SCADA

The status logs are separate files logging all specific operational states of a WTG. The main and the most complicated difference in comparison to the production data is the format. The production data are in regular 10 min. format; the status logs are saved in the format “from – to” or “from + duration”. Please note that although some SCADA systems do have a feature to export the production data in 10 min. format including status codes by each of the 10 min. time stamp, the TR10 defines that the raw status logs in the form as per above must be used for the analysis.

The way how to import the status logs in windPRO is similar to the process of the import of the production data described in previous steps. Which means:

- Upload the status logs as well as EinsMan and optimized selling information.
- Define the import filter.
- Pair the data with the “Existing WTG(s)”.
- Import the list with assignment of all WTGs and project specific status codes to the TR10 categories.
- Load the data.



Unlike the import of the production data in 10 min. format, there is no “Auto detect” button available here. The signals must be defined manually using the drop down menu in each line. The format of the defined signals needs to be defined manually, too. “d.m.y” is used for the definition of the date, month and year, “h:m:s” for hour, minute and second. The order of the

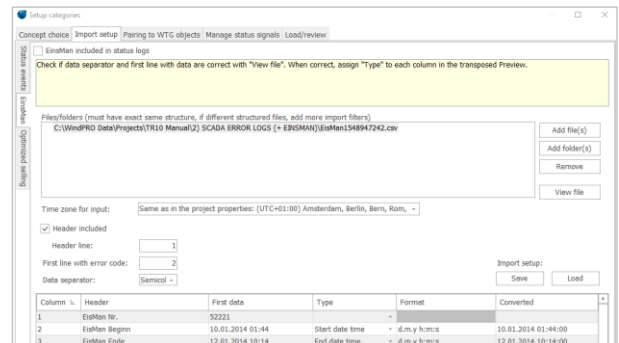
symbols can be changed, if the format of the data and time in the status logs is different. Similar to the import filter of the production data, the import setup can be saved in a separate “.pci” file for a later use. Last step at this tab is to setup the WTG ID location:



The purpose of the next tab, “Pairing to WTG objects”, is again similar to the pairing to the WTG objects by the import of the production data in 10 min. format. windPRO uses the WTG-ID setup to merge the status logs and the “Existing WTG objects”.

„Einspeisemanagement and Optimized selling“:

The default setup is “EinsMan (resp. Optimized selling) included in the status logs”. This means that the events that belong to these categories have an explicit status code directly in the SCADA system. Shouldn’t this be the case, you can deactivate the checkbox and upload the data manually from an external source.



The foreseen format of the data is: “Start date and time → End date and time” and can be entered either from a *.csv file (or similar) or from a spread sheet via clipboard. The information about EinsMan events is publicly available on the internet on the pages of the Transmission operators (TSO).

Manage status signals

The idea of TR10 is that there is going to be a list of all available status codes for each particular WTG and that each of the status codes is going to be assigned (ideally by an independent external advisor / accredited advisor) to one of the TR10 categories.

Quick Guide – TR10 in PERFORMANCE CHECK

The aim of the step in this tab is to merge the status logs uploaded in the previous steps with the library/ list (ideally certified), where all of them are assigned to a certain TR10 category. The data can be either uploaded from clipboard (using copy-paste e.g. from a spreadsheet) or imported from an external file (in *.csv or *.txt format). Another option is to use the categories directly from the status logs, if they were recorded & saved directly by the SCADA system.

An important thing to apply is the “Multiplying factor”:

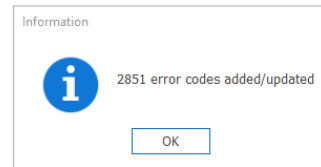
Some manufacturers use the so called “Primary and Secondary status signals”. Unfortunately, windPRO cannot handle such data structure in its native form, as it only can work with single and unique status codes. Therefore, the “Multiplying factor” was introduced. The idea is to multiply the primary error code with some big value, e.g. 1000. windPRO multiplies then each primary status code by 1000 and adds the secondary status code to this number. E.g. a primary status code of 12 and a secondary status code of 2 result in the value 12002, which represents a unique status code for the further process of the analysis.

Import the library with status codes either from the clipboard or directly from a *.csv or *.txt file.

Column	Header	First data	Type
1	Error id	6670	<Ignore>
2	Primary code	0	Primary status signal
3	Secondary code	0	Secondary status signal
4	TR10	0	Category
5	Name	Anlage in Betrieb	Status signal description
6	Category	Normal	Type description
7	ProjectID	5	<Ignore>
8	Type		<Ignore>
9	Compensated curtailment	false	<Ignore>
10	Non compensated curtailment	false	<Ignore>

The columns in the file need to be defined in a similar way as for the import of the production data or the status logs. The used import filter can be saved as *.pci file.

After the import, windPRO informs you about the amount of identified status codes:



Confirming this notification with Ok will close the import of the status codes library and will show you the list of imported status codes:

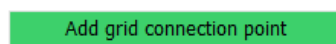
Status signal	Description	Type description	TR10 category	Sub category	Type	Count	Category update explanation
0	Anlage in Betrieb	Normal	Category 0: Normal	-	State	0	-
1	Anlage start	Normal	Category 0: Normal	-	State	0	-
2	Anlage bereit	Normal	Category 0: Normal	-	State	0	-
3	Startüberholung	Normal	Category 0: Normal	-	State	0	-
4	Anlagen-Last-Control	Normal	Category 0: Normal	-	State	0	-
5	Anlage nachverdonk	Normal	Category 0: Normal	-	State	0	-
1001	Anlage gestoppt - Clay Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1002	Anlage gestoppt - Kevlar Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1003	Anlage gestoppt - Park Unavailable maintenance	Category 2: Control	Category 2: Control	-	State	0	-
1004	Anlage gestoppt - Gain Unavailable maintenance	Category 2: Control	Category 2: Control	-	State	0	-
1005	Anlage gestoppt - Axle Displacement	Category 2: Control	Category 2: Control	-	State	0	-
1006	Anlage gestoppt - Park Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1007	Anlage gestoppt - Park Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1008	Anlage gestoppt - Fern Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1009	Anlage gestoppt - Clut. Normal	Category 2: Control	Category 2: Control	-	State	0	-
1010	Anlage gestoppt - Kevlar Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1011	Anlage gestoppt - Kevlar Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1012	Anlage gestoppt - Park Remover shut down	Category 2: Control	Category 2: Control	-	State	0	-
1014	Anlage gestoppt - Load Normal	Category 0: Normal	Category 0: Normal	-	State	0	-
1015	Anlage gestoppt - Load Normal	Category 0: Normal	Category 0: Normal	-	State	0	-
1016	Anlage gestoppt - Load Normal	Category 0: Normal	Category 0: Normal	-	State	0	-

In the example, the list contains 2854 status codes. Only around 100 were activated during the operation of the WTG(s), which is typical. Move to the tab “Load/review” and use the “Load” button. When done, close the “Setup categories” with Ok and move to the next vertical tab.

Date time	Status signal	Is status	Status description
-----------	---------------	-----------	--------------------

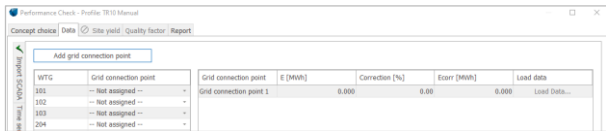
Import SOLD

The sold data are imported as monthly production data. The current windPRO version does not support the import of a time series (e.g. Lastgänge) as this would not be in compliance with TR10. The first step is to create a new grid connection point:



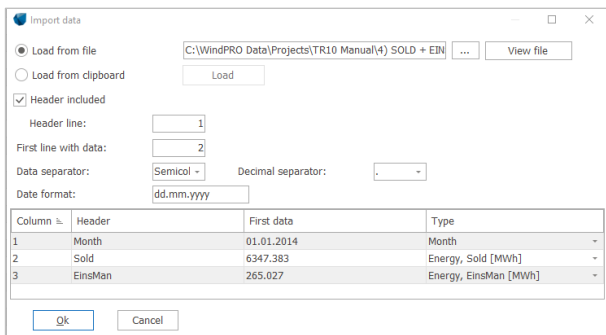
Quick Guide – TR10 in PERFORMANCE CHECK

When created, a new line and the “Load Data” button appear in the right window.



Use the “Load Data” button. This will bring you to a table that is expecting the import of monthly data: monthly produced energy, compensated energy due to EinsMan and energy sold via optimized selling. All are in MWh. You can either manually type the values into the table or use the button “Load data from file or clipboard”.

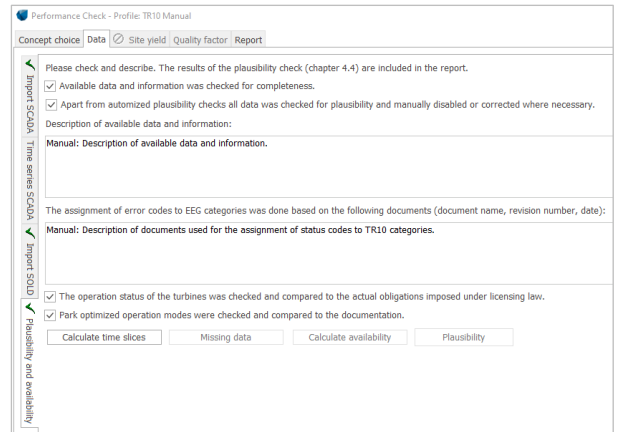
For importing the data from the clipboard or from a file, there is another import mask:



The assumption is that the source is a table with just few columns. Month & year, Produced electricity, EinsMan, Optimized selling.

3. PLAUSIBILITY AND AVAILABILITY

Before it is possible to calculate the time slices and availability, you need to check all of the checkboxes and add a description of the available data and information and a description of the source of the assignment of the status signals to the EEG 2017 categories. The checkboxes are declarations of yours in terms that the data was checked for its completeness etc. This is required in the TR10 and will be documented in the report.



After this step is finished, please proceed with the button “Calculate time slices”. This calculates the total times of each of the EEG 2017 categories, which is a pre-step for the calculation of the TR10 availability.

In the next step, you can check the missing data using the button “Missing data”. An overview appears. Please proceed with the button “Calculate availability”.



The TR10 availability can be displayed on a monthly basis too, but this is just informative. In case it is necessary to analyze all WTGs using the detailed method, please check the checkbox “Use detailed procedure for all”. This is not in compliance with the TR10 and is documented in the report “Deviations to the TR10”.

Last button at this tab is the “Plausibility”. It is not possible to proceed in the analysis until the plausibility of the produced (E_Scada) and sold (E_Sold) yield is verified. The ratio between these must be within the range $\geq 87\%$ and $\leq 109\%$ (see TR10, chapter 5.2).

Quick Guide – TR10 in PERFORMANCE CHECK

Month	ESold [MWh]	EScads [MWh]	Scaling factor	Plausibility che	Correction	SF corr	Comment
Jan 2014	6 347.383	6 229.090	1.019	passed			
Feb 2014	4 230.018	4 515.939	0.939	passed			
Mar 2014	4 861.339	5 064.624	0.960	passed			
Apr 2014	2 818.886	2 945.720	0.957	passed			
May 2014	3 887.730	4 017.850	0.968	passed			
Jun 2014	2 430.089	2 731.299	0.963	passed			
Jul 2014	3 246.964	3 424.868	0.948	passed			
Aug 2014	2 385.180	2 516.010	0.948	passed			
Sep 2014	3 460.457	3 584.438	0.965	passed			
Oct 2014	2 294.303	2 929.701	0.789	failed			no production for data gaps used
Nov 2014	5 949.166	6 225.449	0.956	passed			
Dec 2014	6 347.383	6 462.457	0.982	passed			
Jan 2015	4 230.018	4 515.939	0.939	passed			
Feb 2015	4 861.339	5 064.624	0.960	passed			
Mar 2015	2 818.886	2 945.720	0.957	passed			
Apr 2015	3 887.730	4 017.850	0.968	passed			

If one or more months fail this test, the user must decide, which corrective measure shall be applied and comment the reasons for the failure / correction. All these steps are documented in the report.

4. SITE YIELD

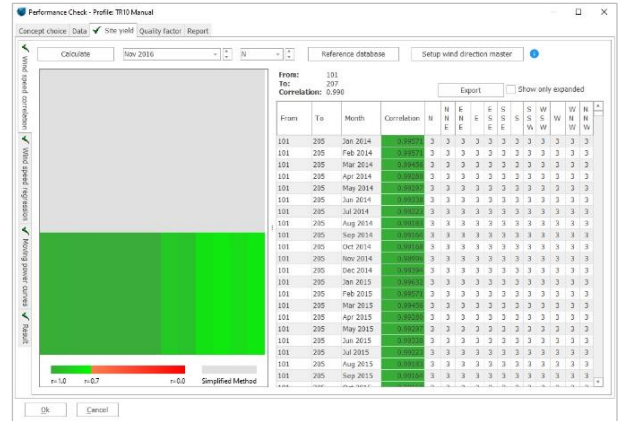
If all WTGs have reached an availability of 97% or higher, you can go directly to the tab “Results”. Should one or more WTG(s) be below this limit, you need to perform the detailed analysis, which means to calculate the fictitious electricity that would have been produced if the availability of the WTG would have been 98%.

Wind speed correlation

The TR10 assumes that as soon as the WTG is not producing, the wind measured by the nacelle anemometer is not reliable anymore, as the nacelle transfer function (NTF) is only valid for normal operation. Therefore, it is necessary to correct wind speeds in non-normal conditions and fill gaps in the wind speed time series in order to generate a consistent wind speed time series.

Use the button “Calculate” to calculate the correlation of the available sources of wind data with each other. The correlation calculation is performed on a monthly basis like required in TR10.

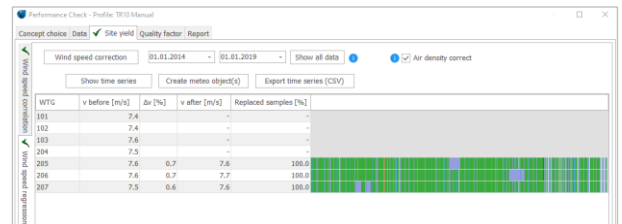
An overview is then shown as the result. There is a graphical overview in the left side of the window, showing a matrix of the correlations of all signals with each other. The green colors are used for the correlations above 0.7, the red colors for the correlation below this value. The grey color is used for data that are used as data source, but nothing is replaced in them, as their availability was above 97%.



Using the button “Reference database” you can add wind data from met masts or online sources, re-analysis or mesoscale data. They have typically the worst correlations but can still be helpful in situations, where no other data sources are available. Proceed to the next vertical tab.

Wind speed regression

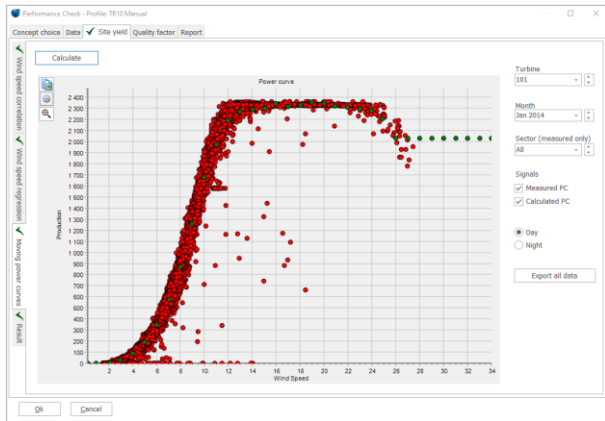
As soon as the best correlations were calculated, they need to be applied for the time stamps assigned to category 2 in order to create a consistent wind speed time series according to TR10 chapter 6.3.1.



Moving power curves

The real-life power curves and the theoretical pre-assessment power curve are different, and the powers curve can change in time. Use the button “Calculate” to obtain moving power curves for all WTGs with the availability below 97%.

Quick Guide – TR10 in PERFORMANCE CHECK



Proceed to the next vertical tab.

Result

This tab gives you an overview of the results so far. Click “Calculate production”. This step will sum all production produced by the WTG(s) (E_Prod). After this step is done, the button “Calculate site yield” becomes green. As soon as this one is used, you will see further results required by the TR10:

- **E_Prod_skal**: the scaled production, resp. the production of the WTG(s) cleaned by electrical losses as per TR10 chapter 5.3,
- **E_EinsMan**: electricity not produced due to the constrains by the TSO, where this not produced electricity is compensated. “Anteil” is a factor used for this calculation described in the TR10 chapter 5.4 (as well as E_Einsman),
- **E_OV**: electricity not produced due to optimized selling,
- **E_Ausf**: fictitious electricity not produced due to the TR10 availability below or equal to 97% according to the TR10 chapter 6.3,
- **SE_y**: sum of E_Prod_skal, E_EinsMan, E_OV and E_Ausf depending on the TR10 availability and the applied method respectively.

5. QUALITY FACTOR AND REPORTS

For the calculation of the final result of the TR10, the quality factor, you have to insert the reference yield of the turbine/s calculated after the new reference site specified in EEG 2017. Some are published here: <https://wind-fgw.de/themen/referenztraege/>. You can do this manually or by copy paste.

The final results but also many results of the calculation steps as well as the data basis and processing are documented in a pdf report. You can create this report via the tab Report where you only have to fill some informative text fields. The report fulfills all documentation requirements of the TR10 chapter 8 and the annex including the attestation for the grid operator.