13 OPERATION – TR10

13.1 Introduction, definitions and workflow overview

Based on the "Erneuerbare-Energien-Gesetz 2017" ("**EEG 2017**"), 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 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**), which is the detailed methodology description introduced in the EEG 2017, Annex 2.

The "Quality factor calculation (TR10)" sub-module includes the **full implementation of the TR10**, rev. 2. In order to use it, a separate license of this tool as well as a license for PERFORMANCE CHECK are required. Besides these, the license for the module BASIS is required. Additionally, the module METEO is recommended, as the TR10 stipulates the use of mesoscale and / or reanalysis data and such data (e.g. EmdWrf Europe+, ERA5, MERRA2, etc.) can be downloaded with this module.

13.1.1 Basic concept

The concept of the TR10 tool fully follows the TR10 guideline, rev. 2. The analyzed WTG(s) are represented in windPRO by "Existing WTG objects" ✳. The data import and the data analysis to Existing WTG objects is done in the TR10 tool, which is a sub-module of the module PERFORMANCE CHECK. The basic concept of the TR10 guideline, as well as of the TR10 tool, is as follows:

1) Assignment of status codes to categories (sorted from the highest to the lowest priority)
    a. Category 2: Constraint or not available due to other matters[1]
    b. Category 4: Constraint due to optimized selling
    c. Category 3: Constraint due to feed-in management[2]
    d. Category 1: Constraint due to permit matters
    e. Category 0: Normal operation
2) Assignment of the 10-minute time stamps to the categories using the status codes and 1)
3) Calculation of the availability
    a. ≥ 98% Simplified method 1
    b. < 98%; ≥ 97% Simplified method 2
    c. < 97% Detailed method
4) Should the availability be below 97%, electricity not produced due to unavailability (category 2) must be calculated.
    a. Calculation of correlations between wind speed time series
    b. Creating consistent wind time series
    c. Creating moving power curves
5) Generating results

13.1.2 Workflow overview

The evaluation described in this manual requires the licensed modules BASIS, PERFORMANCE CHECK, TR10 and optionally METEO.

The workflow is as follows:

- Create new "Existing WTG" objects.
- Download meso- and / or reanalysis data using METEO object(s) (optional).
- Start PERFORMANCE CHECK from the modules menu or use the shortcut in the toolbar.
- Select "Quality factor calculation (TR10)" on the tab "Concept choice".

[1] Technically not available

[2] Einspeisemanagement

- Import 10-minute SCADA data with production, wind speed, wind direction, accumulated power production and other required signals and load this data into the “Existing WTG” objects using the “Paid and load” button.
- Import and merge status codes from turbine log files to 10-minute production data using the “Setup categories” button.
- Import the “Sold electricity”, the electricity sold under optimized marketing (if any) and electricity not produced due to the constraints from the grid operator – EinsMan[3] (if any).
- Evaluate the plausibility of the imported data and calculate the availability.
- For the WTG(s) with availability equal or higher than 97%, the simplified methods as per chapters 6.1 and 6.2 in the TR10 are applicable; proceed to the tab results.
- For the WTG(s) with 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”.
- Go to “Site yield → Results” and use the buttons “Calculate production” and “Calculate site yield” to get the results.
- Go to the tab “Quality factor”. Entering the Referenzertrag[4] to the WTG(s) finishes the calculation of 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.

13.2 Data format and project preparation

13.2.1 Format of the SCADA data

The TR10 guideline stipulates that the raw SCADA data is used for the analysis. This assumes that the format exported by the SCADA software is in a format that windPRO is capable to read. Standard export features of a SCADA system typically contain an option to export the data in e.g. *.csv or *.txt files. These formats are supported by windPRO.

There are two main data sources from the SCADA systems – the 10-minute production data and the status logs. Both use separate import mechanisms within the TR10 tool, as the structure of these sources is different.

13.2.1.1 10-minute SCADA data

The imported 10-minute production data must be in a “matrix” form with header in the first line, with the time stamp in the first column and with the data in the following columns. Besides this, the 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.

[3] Einspeisemanagement. Measure used by the TSOs in Germany in order to stabilize the electrical grid by reducing the actual power generation in case of overproduction.

[4] Reference production defined for each WTG type and hub height according to the EEG.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Anlage	Seriennr.	Zeit	Wind min. [	Wind Ø [m/s	Wind max. [	Drehzahl mi	Drehzahl Ø [	Drehzahl ma	Leistung mir	Leistung Ø [	Leistung ma	Blindl. min.
2	1	101	01.01.2014 00:00	8.7	10.3	11.5	15.41	15.97	16.29	1295	1787	2089	-517
3	1	101	01.01.2014 00:10	9.1	10.1	11.5	15.65	15.94	16.19	1489	1752	2003	-498
4	1	101	01.01.2014 00:20	8.9	10.2	11.7	15.49	15.88	16.32	1346	1705	2102	-537
5	1	101	01.01.2014 00:30	8.6	9.7	11.2	15.5	15.8	16.16	1367	1631	1958	-496
6	1	101	01.01.2014 00:40	8.4	9.6	11.4	15.35	15.8	16.25	1250	1627	2083	-526
7	1	101	01.01.2014 00:50	8.5	10	11.6	15.57	15.99	16.44	1425	1809	2260	-571
8	1	101	01.01.2014 01:00	9.1	9.9	11.2	15.66	15.94	16.21	1518	1758	2028	-517
9	1	101	01.01.2014 01:10	8.7	9.9	11.5	15.59	15.89	16.17	1448	1713	1966	-503
10	1	101	01.01.2014 01:20	9	9.9	11.4	15.52	15.88	16.27	1379	1705	2062	-526
11	1	101	01.01.2014 01:30	8.8	9.8	10.8	15.41	15.83	16.07	1293	1653	1880	-479
12	1	101	01.01.2014 01:40	8.8	9.8	11.3	15.59	15.88	16.18	1438	1703	1998	-508
13	1	101	01.01.2014 01:50	9	10	11.7	15.71	15.98	16.23	1546	1793	2058	-522
14	1	101	01.01.2014 02:00	9.1	10.1	11.2	15.64	15.92	16.16	1490	1736	1963	-503
15	1	101	01.01.2014 02:10	9.3	10.2	11.6	15.68	15.98	16.24	1509	1794	2059	-521
16	1	101	01.01.2014 02:20	9	10	11	15.6	15.91	16.13	1455	1733	1936	-495
17	1	101	01.01.2014 02:30	8.9	10	11.2	15.74	15.92	16.11	1570	1735	1908	-491
18	1	101	01.01.2014 02:40	9.3	10.4	11.8	15.8	16.05	16.36	1615	1864	2160	-554
19	1	101	01.01.2014 02:50	9.6	10.6	11.9	15.89	16.13	16.45	1724	1943	2245	-576
20	1	101	01.01.2014 03:00	9.5	10.7	12.1	15.75	16.12	16.42	1596	1935	2249	-572

Figure 1 Example of SCADA data opened in MS Excel

It is important to have an identifier (ID) of the turbine in the file headers, in a column or in the file names (if one file per turbine). Later this ID will be used to pair the SCADA data with an Existing WTG object. It is useful to name the existing WTG(s) with the identical names that the SCADA system uses, as windPRO can then pair the existing WTG objects with the corresponding SCADA data automatically. For the purpose of the TR10 it can be also practical to use the EEG-Anlagenschlüssel[5] as WTG ID. More details regarding the WTG IDs can be found in chapters 13.3.1 and 13.3.2.

13.2.1.2 Status logs

The preferred formats of the status logs are *.csv or *.txt, too. The status logs are typically exported in a format with the beginning and the end (or duration) of an event. The events are then described with status codes, potentially followed by sub-codes. These are often followed by a description. The irregular structure in the status logs is going to be transformed into a regular 10-minute structure by windPRO including the assignment of the 10-minute time stamp to exactly one TR10 category according to TR10 requirements.

	A	B	C	D	E	F	G	H	I	J	K	L
1	WTG	Seriennr.	Datum	Time	Main code	Sub-Code	Status Text		T	Duration	Error	Wind speed
2	1	101	01.01.2014	10:47:26	0	2	Anlage bereit		1	00:02:23	False	11
3	1	101	01.01.2014	10:49:49	0	1	Anlage startet		1	00:01:06	False	10.8
4	1	101	01.01.2014	10:50:55	0	0	Anlage in Betrieb		1	23:40:27	False	10.7
5	1	101	02.01.2014	11:08:05	0	2	Anlage bereit		1	00:02:22	False	6.1
6	1	101	02.01.2014	11:10:27	0	1	Anlage startet		1	00:00:47	False	13.3
7	1	101	02.01.2014	11:11:14	0	0	Anlage in Betrieb		1	23:19:52	False	12.5
8	1	101	04.01.2014	11:10:05	0	2	Anlage bereit		1	00:02:26	False	7
9	1	101	04.01.2014	11:12:31	0	1	Anlage startet		1	00:00:34	False	3.2
10	1	101	04.01.2014	11:13:05	0	5	Abgleich Load-Control		1	00:00:43	False	8.5
11	1	101	04.01.2014	11:13:48	0	1	Anlage startet		1	00:00:36	False	6.2
12	1	101	04.01.2014	11:14:24	0	0	Anlage in Betrieb		1	23:17:41	False	9.7
13	1	101	07.01.2014	11:10:05	0	2	Anlage bereit		1	00:02:29	False	2.9
14	1	101	07.01.2014	11:12:34	0	1	Anlage startet		1	00:00:34	False	3.6
15	1	101	07.01.2014	11:13:08	0	5	Abgleich Load-Control		1	00:01:11	False	7.7
16	1	101	07.01.2014	11:14:19	0	1	Anlage startet		1	00:00:40	False	5.4
17	1	101	07.01.2014	11:14:59	0	0	Anlage in Betrieb		1	14:31:10	False	8.8

Figure 2 Status logs example

Some of the SCADA systems can deliver the 10-minute production time series including the already assigned status code. The signals name can be named e.g. “First alarm in the 10-minute interval” or similar. The use of such signal is not in compliance with the TR10. The assignment of the status codes to 10-minute time stamps

[5] WTG specific ID used e.g. by invoicing. Consists of 33 symbols and begins with an “E”.

was done by the SCADA system itself, but it is required that this is done by an independent tool. Although the use of such signal is not compliant with the TR10 text, the TR10 tool allows its use for testing purposes and internal calculations. This triggers a deviation-warning and is reported in the pdf report “Deviations from TR10”. The import of the status codes is described in chapter 13.3.3.

13.2.2 Format of external data

On the top of the SCADA data, some external data is needed to finalize the analysis according to the TR10.

13.2.2.1 EinsMan and optimized marketing start & end times

It can be the case that EinsMan events (category 3) or optimized selling events (category 4) do not have explicit status codes in the WTG SCADA. If so, the beginnings and the ends of these events must be imported from an external source. The format of the imported data can be again either a *.csv or *.txt file.

	A	B	C
1	EinsMan Nr.	EinsMan Start	EinsMan End
2	52221	10.01.2014 01:44	12.01.2014 10:14
3	52361	13.01.2014 06:27	13.01.2014 09:39
4	52718	15.01.2014 20:09	15.01.2014 22:23
5	53276	26.01.2014 16:55	26.01.2014 19:10
6	54892	28.02.2014 20:40	01.03.2014 00:11
7	55226	04.03.2014 12:48	04.03.2014 13:25
8	55293	04.03.2014 20:25	04.03.2014 21:06
9	56305	21.03.2014 16:13	21.03.2014 21:22
10	56684	29.03.2014 21:02	30.03.2014 12:27

Figure 3 EinsMan and optimized selling example

The EinsMan Nr. in the screenshot above is just for instance; the only two necessary columns are the ones with the start and end (resp. with the duration). The import of the EinsMan & Optimized selling data is described in chapter 13.3.3.3.

13.2.2.2 Status codes library

According to the TR10, the events logged in the status log shall be assigned to TR10 categories and then to the regular 10-minute time series. The assignment of the WTG-type specific status codes to the TR10 categories shall be done by an independent body that has proven to the FGW the necessary prerequisites and qualifications of the authorised persons. The approval of the authorised person is granted by the responsible FGW advisory board "EEG-Kategorisierung".

The final structure of the certified list is still a subject of discussions. The current implementation in the TR10 assumes the use of a list in a form of *.csv or *.txt file with a header in the first line and the list of the status codes with a main code, optionally secondary code, text description and corresponding TR10 category for each of the status codes in the lines below the header.

	A	B	C	D	E
1	Error id	Primary code	Secondary co	TR10 Category	Name
2	6670	0	0	0	Anlage in Betrieb
3	6671	0	1	0	Anlage startet
4	6672	0	2	0	Anlage bereit
5	6673	0	3	0	Startvorbereitung
6	6674	0	5	0	Abgleich Load-Control
7	6675	0	8	0	Anlage waehrend Wartung in Betrieb
8	6678	1	1	2	Anlage gestoppt - Steuerschrank
9	6680	1	2	2	Anlage gestoppt - Kundenschnittstelle
10	6682	1	3	2	Anlage gestoppt - Parkrechner (ENERCON)
11	6684	1	4	2	Anlage gestoppt - Gondel
12	6686	1	5	1	Anlage gestoppt - Aussentemperatur
13	6688	1	6	2	Anlage gestoppt - Parksteuerung
14	6690	1	7	2	Anlage gestoppt - Parkrechner (Betreiber)
15	6692	1	8	2	Anlage gestoppt - Ferndisplay
16	6694	1	9	0	Anlage gestoppt - Zeit
17	6696	1	10	2	Anlage gestoppt - Kunden-Interface (Normalstop)
18	6698	1	11	2	Anlage gestoppt - Kunden-Interface (Schnellstop)
19	6701	1	13	2	Anlage gestoppt - Parkrechner (Schnellstopp)
20	11423	1	14	0	Anlage gestoppt - Leistungsgradient
21	11424	1	15	0	Anlage gestoppt - Extern

Figure 4 Status list example

A detailed description can be found in chapter 13.3.3.5.

13.2.2.3 Sold electricity, electricity not produced due to EinsMan and electricity produced under optimized marketing

These three data sources shall be compiled in one file. They all represent the SOLD electricity (MWh). In other words – the invoiced electricity. The electricity produced and sold under “normal” conditions to the grid, the electricity produced and sold under special conditions (optimized marketing) and the electricity not produced due to the feed-in management (EinsMan).

The not produced electricity due to EinsMan events is not calculated within the TR10 analysis. The methods for the calculations are described in a separate guideline[6].

The foreseen format is the produced (resp. compensated) MWh with the resolution of one month that the owner of the WTG(s) got paid for. E.g. the values from the invoices sent to the TSO. These need to be converted into the matrix format with header in the first line and the time series (in a 1-month resolution) in the first column.

	A	B	C	D
1	Month	Sold	EinsMan	Opt. marketing
2	01.01.2014	6347.383	265.027	
3	01.02.2014	4330.018	37.758	
4	01.03.2014	4861.339	262.36	
5	01.04.2014	2818.886	61.292	
6	01.05.2014	3887.73	211.617	
7	01.06.2014	2630.089	43.071	
8	01.07.2014	3246.964	297.227	
9	01.08.2014	2385.18	31.073	
10	01.09.2014	3460.457	162.9635	
11	01.10.2014	2284.303	0	

Figure 5 "Sold" example

More details can be found in chapter 13.5.

13.2.3 Create Existing WTG objects

Either manually by inserting an Existing WTG object, copy-paste the coordinates from a spread sheet or download turbine positions directly through the Online WTG Data tool. Alternatively, you can convert New WTG objects into Existing WTG objects by copy-pasting and using the paste option “Edit object(s) before pasting”. Remember to assign an ID to the WTG object to either Description or User label. It is practical to use the WTG ID from the SCADA system as “Description” and the Anlagenschlüssel as “User label”:

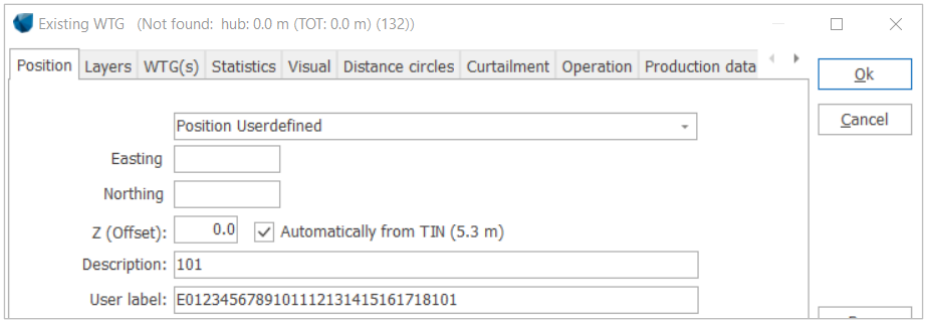


Figure 6 Existing WTG object

13.2.4 Create a new PERFORMANCE CHECK session

Start PERFORMANCE CHECK module using “Quality factor calculation” from the tab “Loads & Operation“:

[6] Leitfaden zum Einspeisemanagement

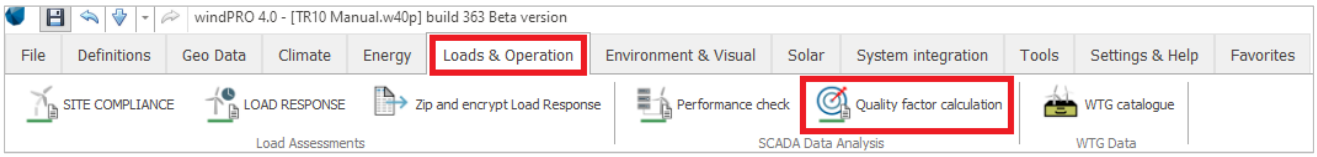


Figure 7 Starting the module from Loads & Operation tab

Create a new session and name it. As soon as done, confirm with Ok and enter the session by double clicking it in the list of the sessions.

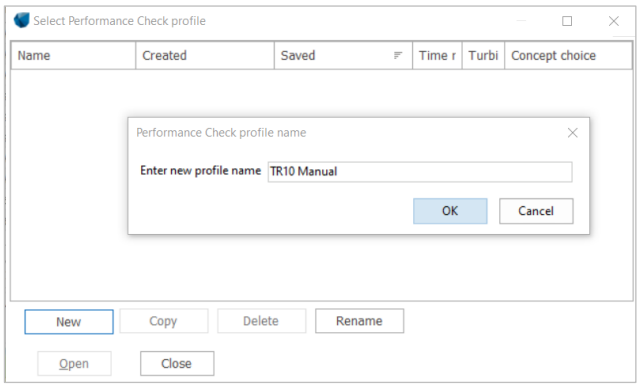


Figure 8 Create a new TR10 session

Currently, the PERFORMANCE CHECK module supports three different concept choices:

- Model validation / calibration / performance check
- Post construction evaluation following IEC 61400-26-1 and 61400-26-2
- **Quality factor calculation (TR10)**

In order to proceed with the TR10 analysis, please select the TR10 concept and confirm with Ok. As always, windPRO is recommending the next move by coloring with green color. In order to proceed with another kind of analysis, please follow the dedicated manuals.

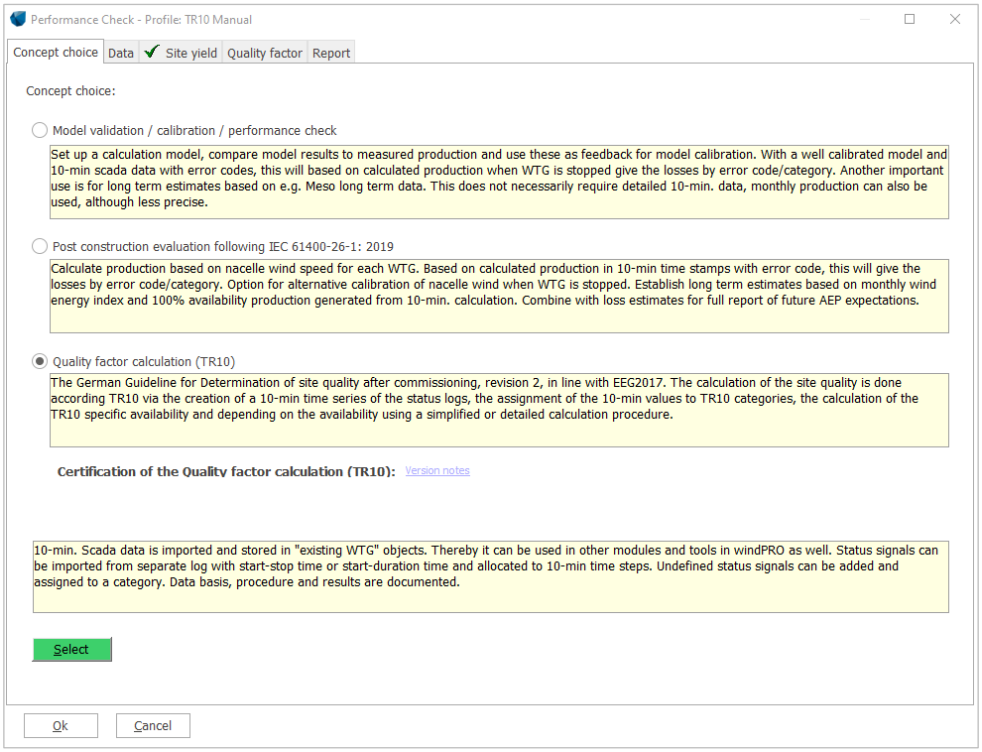


Figure 9 PERFORMANCE CHECK - Concept choice

13.3 Data: Import SCADA

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

- Prepare / export the SCADA data as *.csv or *.txt files from the SCADA system.
- Create Existing WTG objects (including IDs).
- Start PERFORMANCE CHECK and load the data.
- Setup the import filter (Auto detect).
- Pair and load.
- Merge the status logs with the 10-minute-based time series.

13.3.1 Import 10-minute data

The structure of the import filter in the module PERFORMANCE CHECK (no matter on the concept choice) is similar to the METEO object.

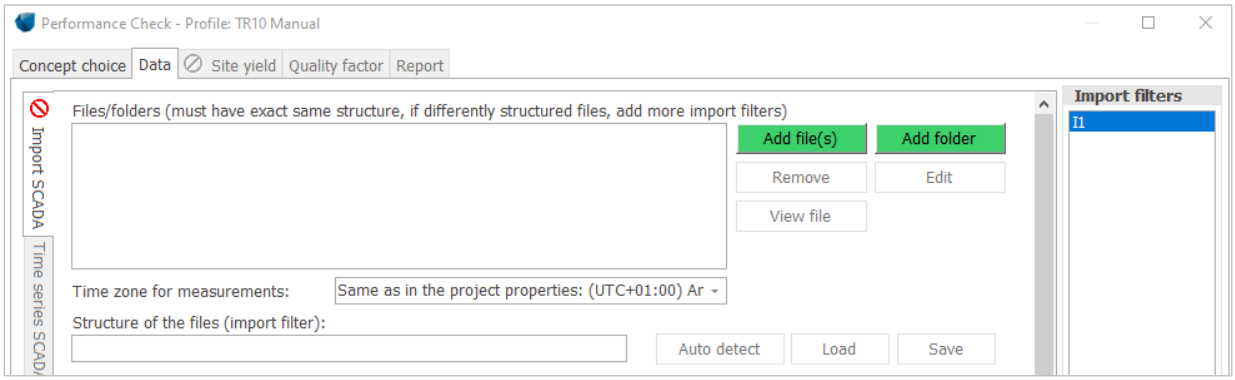


Figure 10 Add files

The first step is to import the 10-minute SCADA data from the WTG(s). windPRO is advising the next logical step of yours and proposes it by green coloring. Use the button “Add file(s)” (or “Add folder”) and select the files (or folder with files).

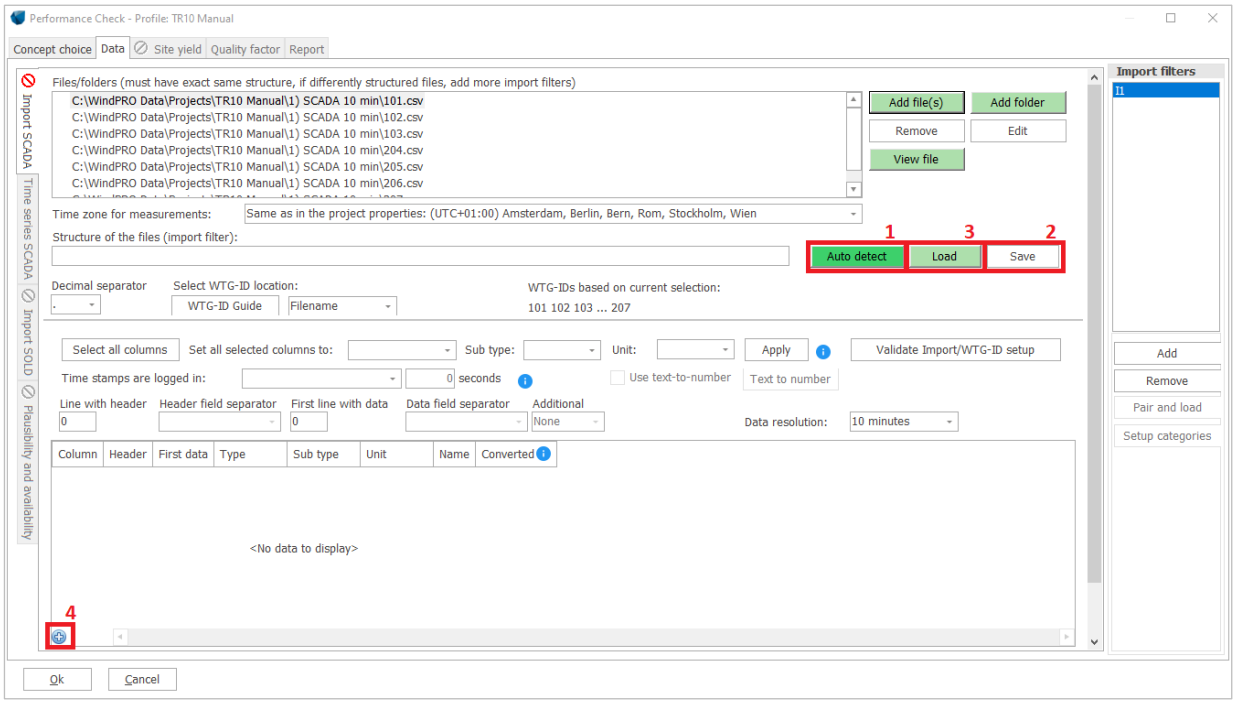


Figure 11 Define signals (1)

During the very first import of 10-minute data, the autodetect function (1) is typically very helpful. With this, windPRO tries to identify the signals in the headers of the 10-minute files. The user has the option to modify the suggested structure and specify the line with the header, the first line with data and field separators. At any step, the user can preview the file structure (using the button “View file”) and adjust file formats if required.

When the setup of the import filter is finished, it can be saved with “Save” (2) in *.pci format and re-used, e.g. when the user does an analysis of the same project once again from scratch or when preparing an analysis of the WTG type with the same or similar structure of the SCADA data. In such case, the *.pci file can be simply loaded with the “Load” button (3). The small “+” button in the left bottom corner (4) allows the user to add lines (signals) manually.

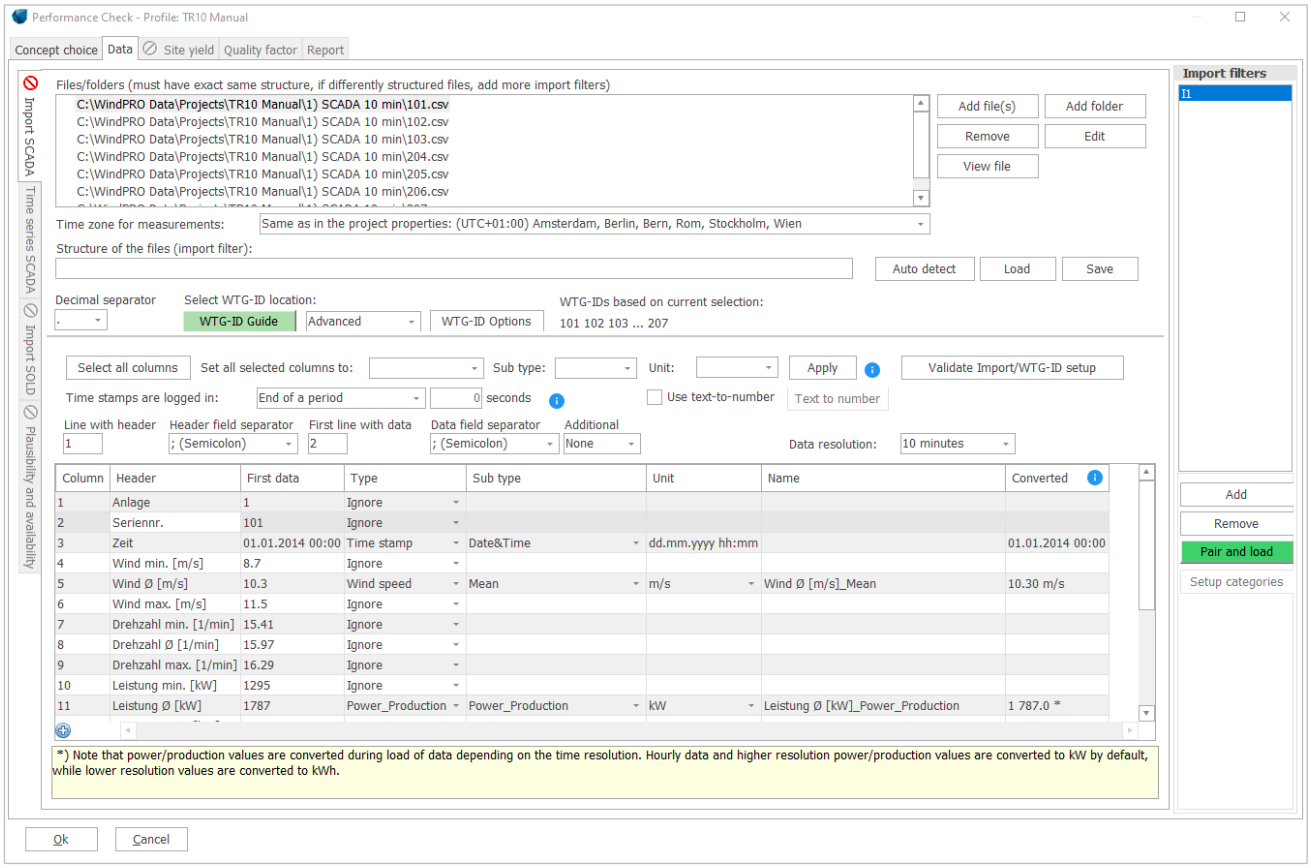
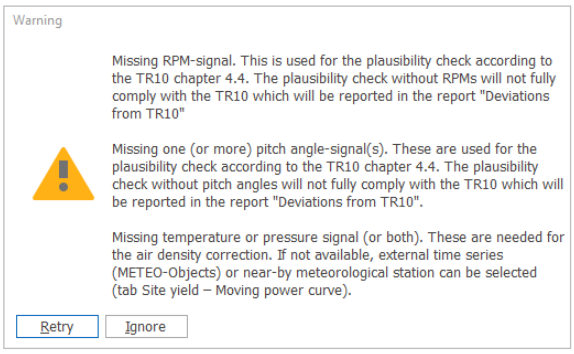


Figure 12 Define signals (2)

Following signals are necessary / recommended for a TR10 analysis:

- Date/Time (mandatory)
- Wind speed (mandatory)
- Wind direction, resp. nacelle position (mandatory)
- Production (mandatory)
- Cumulative production (not-presence triggers a deviation to TR10)
- Round per minute (not-presence triggers a deviation to TR10)
- Pitch angle (not-presence triggers a deviation to TR10)
- Ambient temperature (not-presence triggers a deviation to TR10)
- Air pressure (recommended)
- Error code (if available in the 10-minute time series. Optional, but not in compliance with TR10).

In case of missing signals that are relevant for the plausibility check according to the TR10 chapter 6.3.1, following warning appears after moving to “Pair and load”:



The user can decide to ignore it, which causes that the plausibility check will be performed using only the available signals. Such incompliance with the TR10 is documented in the report.

For some signals it is necessary to define the sub-type: Is the wind speed signal representing the mean, max, min or std? Is the production signal accumulated? Once the sub-type is defined, and the units are set, the data is converted and appears in the rightmost column. Please note that you also must specify the unit for the time stamp. Specific care must be taken in setting the unit of the power signal correctly. It is, however, at any time possible to return and change the unit. In such case, the data must be re-loaded using “Pair and load”.

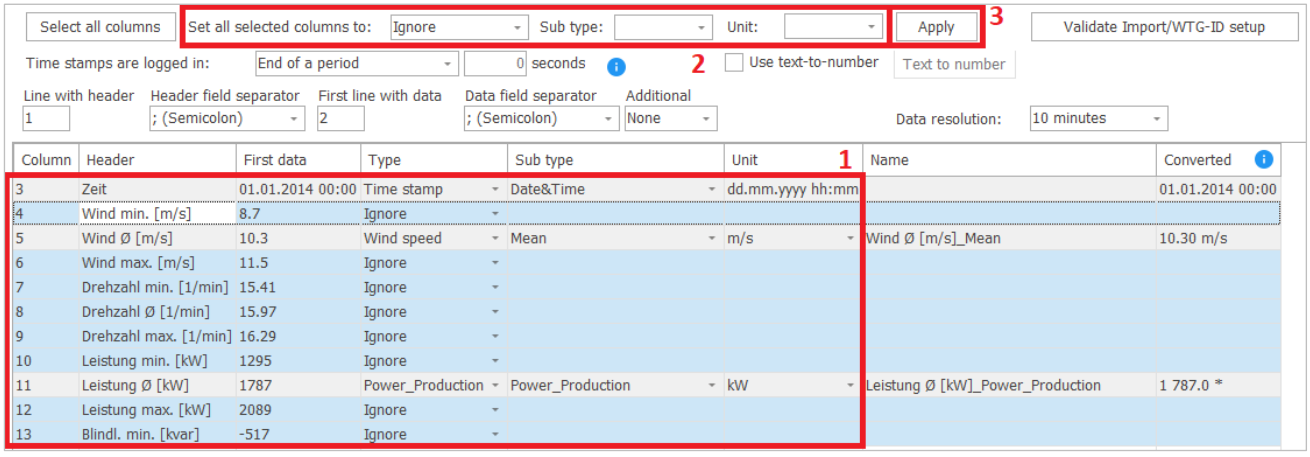


Figure 13 Signals multi-edit

Multi-editing of the signal is possible by marking the signals you want, dragging the mouse or by “Shift-click” (1), specify the type, sub-type and the unit (2) and finally pressing “Apply” (3).

Sometimes, it is necessary to change text to numbers. E.g. if your date stamp contains text like “DEC” you can translate this into “12”. Or if invalid data is marked “NAN” you can change it to “-999”.

A very important step is the setup of the time stamp, resp. whether the SCADA data represents the beginning of the period or the end of the period. This selection is in default setup empty and the user is not allowed to continue in the analysis until either the end of the beginning of a period is selected.

For example, does the time stamp “02.10.2018 10:00” represent the interval “09:50 – 10:00” or “10:00 – 10:10”? Typically, the manufacturers are using the format “End of a period”, but there can be exceptions. If you are not sure, please clarify with the WTG manufacturer.

In the next step of the process, it is necessary to assign the production data to a specific WTG. There are several options how to define the WTG ID setup. The WTG ID can be located either in a file(s) with the SCADA data or in the name(s) of the file(s). In case you know where to find the WTG-ID, you can directly set it up (1). If you do not know, where to find it, a “WTG-ID Guide” will help you with the necessary specifications (2).

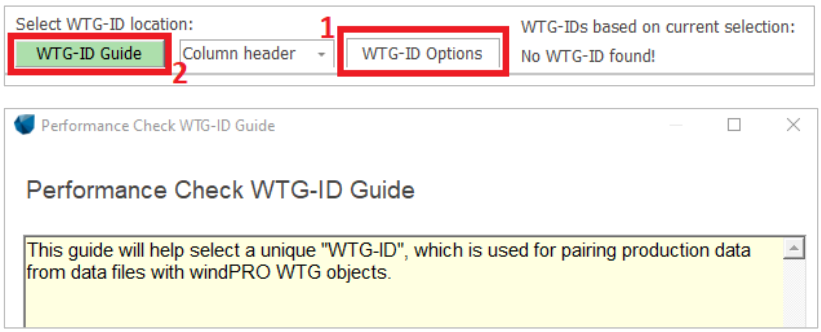


Figure 14 WTG ID setup using the guide

For example, the advanced setup can be helpful when importing data from more files, where the WTG ID is a part of the file name. You can define the symbol before and after the WTG ID string. E.g., if the names of the IDs of the WTG(s) are the same as the names of the files, the determiner behind the WTG ID string is the symbol ".":

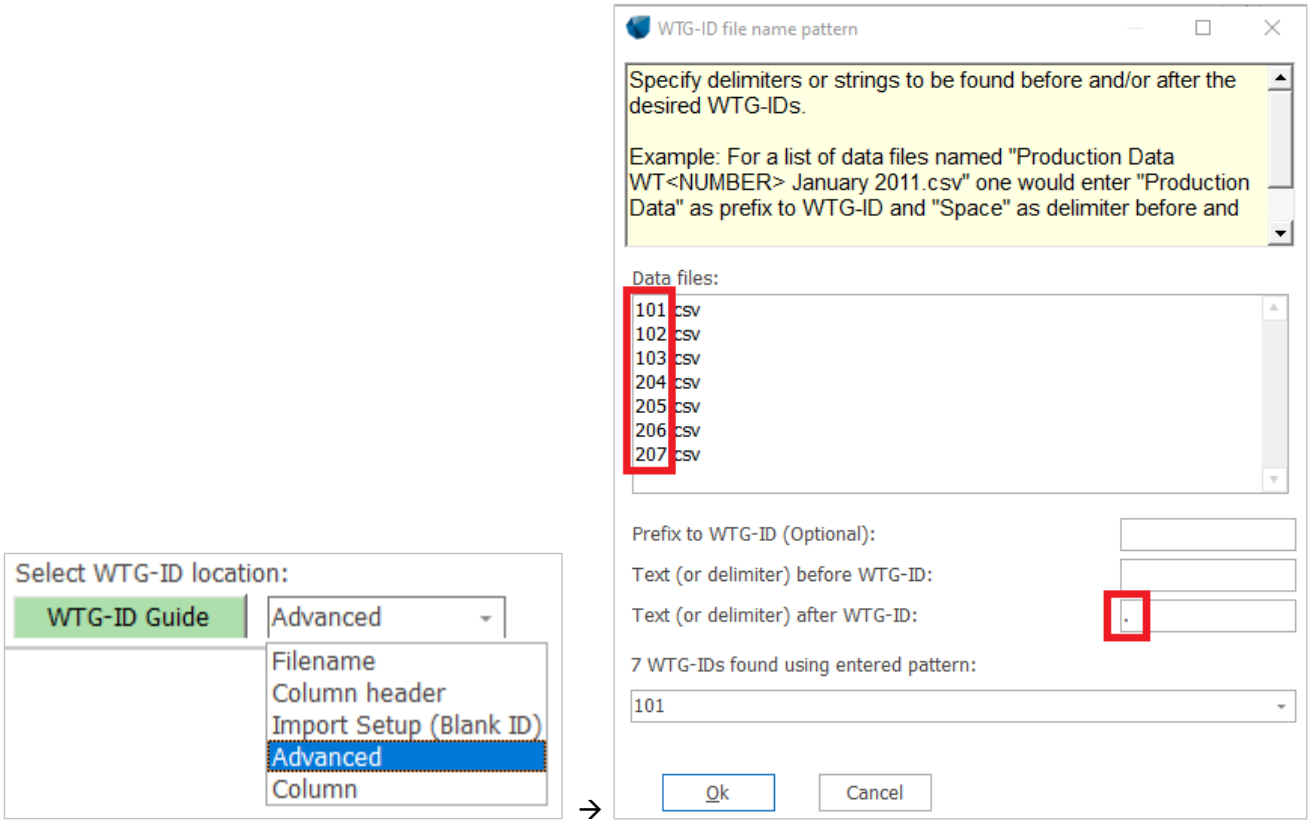


Figure 15 Advanced WTG ID setup

Another option is to have the WTG ID in the header directly next to the names of each of the signals. If this is your case, mark the position (click on it with the mouse…), where the ID of the first WTG can be found (red marked), then do the same for the second WTG (green marked) and optionally for the last WTG (violet).

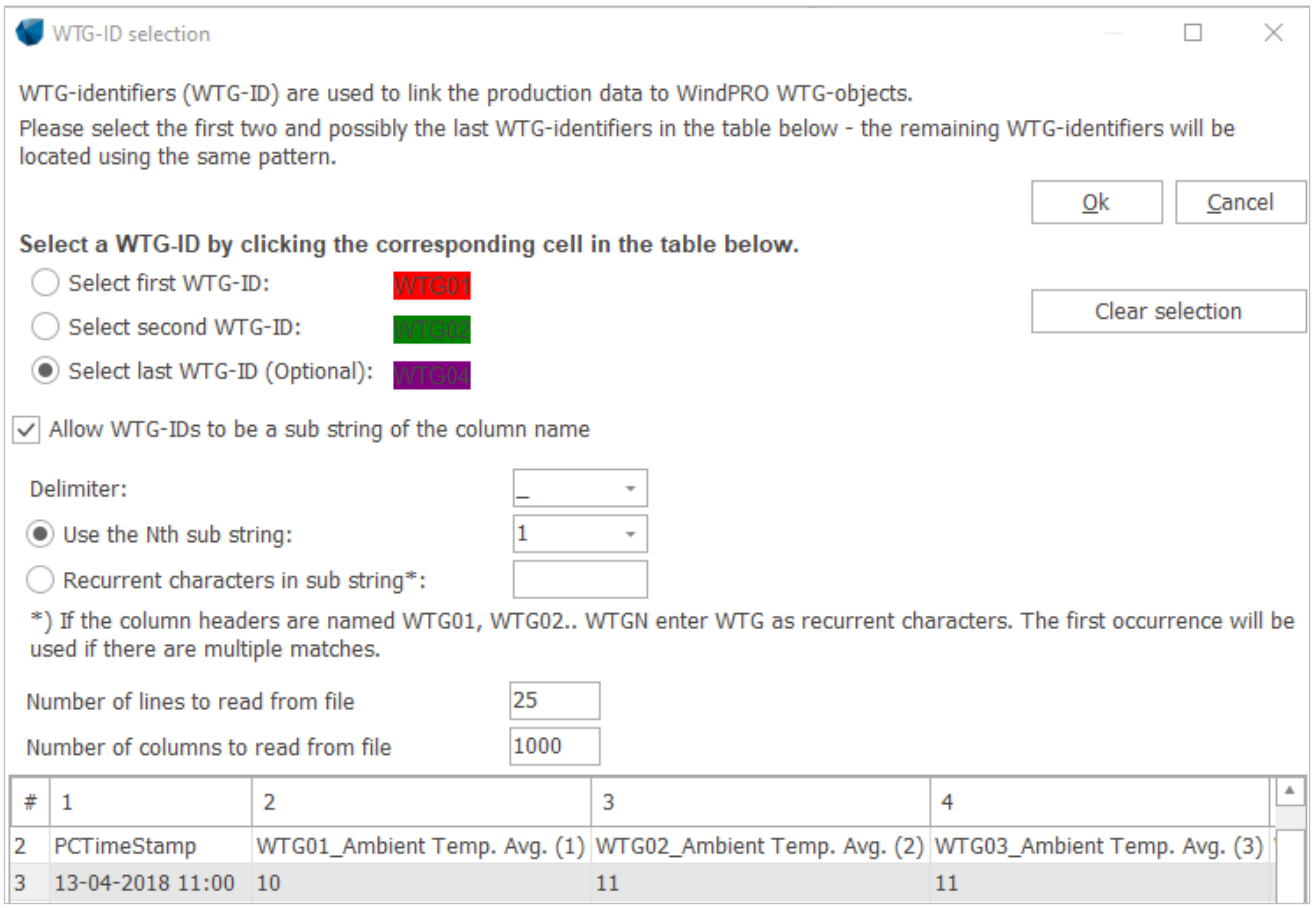


Figure 16 WTG ID setup using ID in Header

If the setup of the WTG ID has been successful, they will now show up:

Figure 17 WTG ID check

13.3.2 Pair and load

When the Import filter is done, you can proceed with the loading of the data using the “Pair and load” button. Should windPRO detect that some signals essential for the TR10 analysis are missing, you might be warned. Use the green “Add” button to add the “Existing WTG objects” representing the WTGs that are going to be the subject of the assessment.

Then the “Select WTG(s)” window appears. Activate the layer with the existing WTG objects that are the subject of the analysis. This is done by checking the checkbox by one (or more) layers in the upper part of the window.

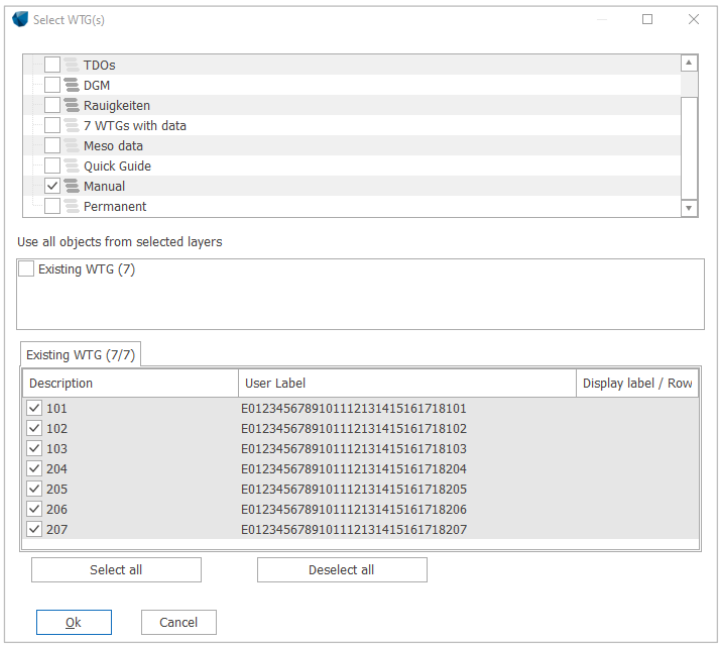


Figure 18 Select existing WTG objects

When done, select the existing WTG object(s) by checking their checkboxes in the lower part of the window. When all WTGs are selected, confirm with Ok.

In case the naming convention of the existing WTG objects is identical to the WTG ID used in the files with the SCADA data, windPRO will automatically pair the objects with the production data using the button “Auto pair”. If the automatic pairing is not possible, the user can pair them manually using the drop-down selection menu that is available in each line, resp. by each of the WTGs – see column “WTG ID from import”.

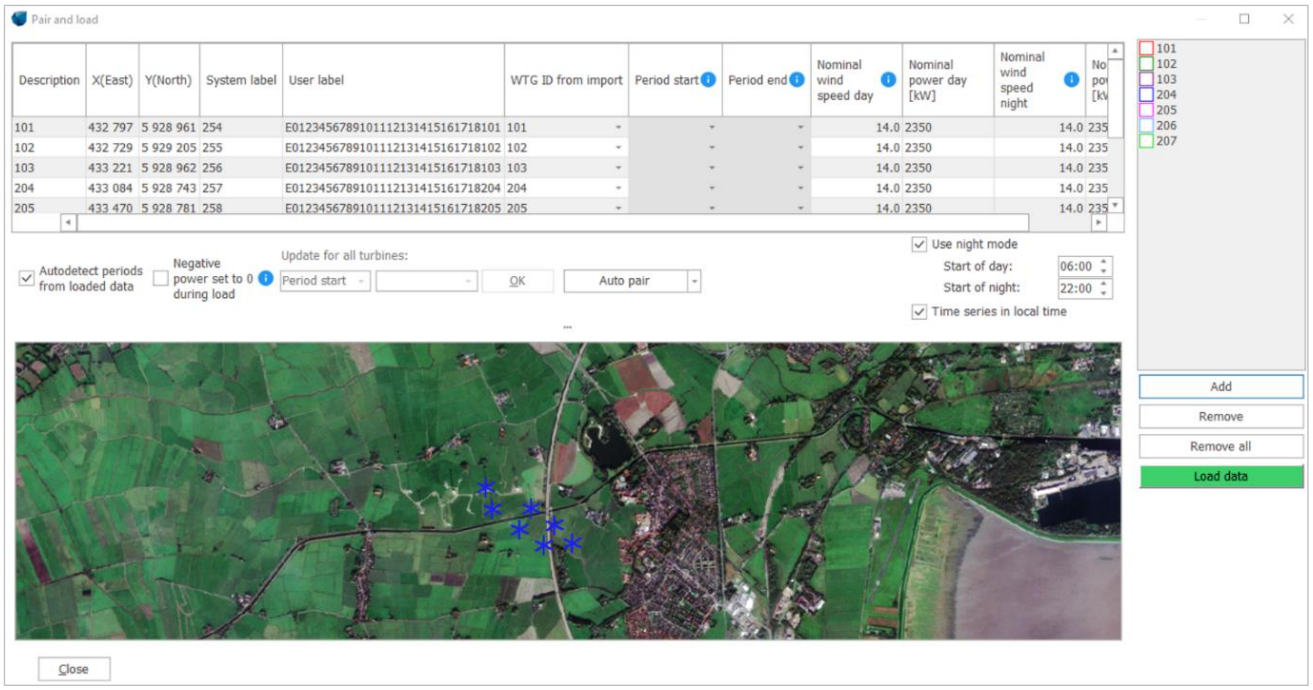
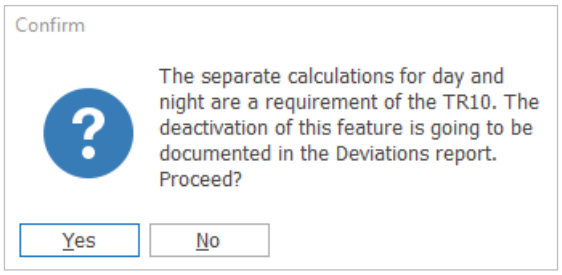


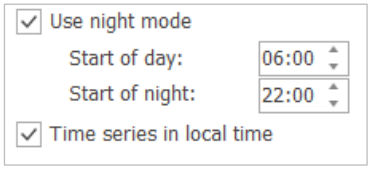
Figure 19 Load SCADA data into the existing WTG objects

Before loading the data with the green button “Load data” and leaving the “Pair and load” window, **double check and potentially correct the nominal wind speed(s) and nominal power output(s) by the day and night** modes. These are used for the calculation of the moving power curves according to chapter 6.3.4 in the TR10.

“Use night mode” is activated in default to fulfill the requirement of 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. Any change or deactivation of this feature is reported in the pdf report “Deviations from TR10”, which the user is notified about.



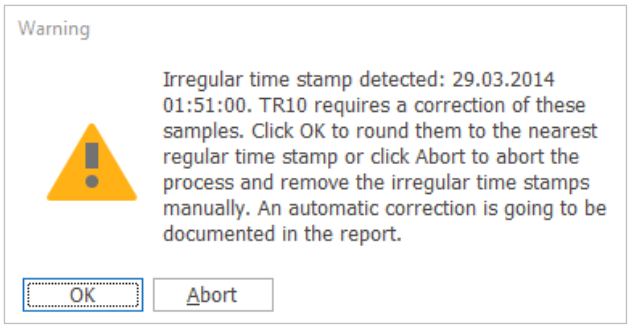
Besides that, please pay attention to the checkbox “Time series in local time”.



This checkbox is activated in the default setup. It means it is assumed that the imported time series includes already the switching between summer and winter time. If the imported time series does not have switching between summer and winter time, the checkbox needs to be deactivated. This causes that the nighttime in winter is still considered as 22-6h, but the nighttime in summer is shifted to 21-5h.

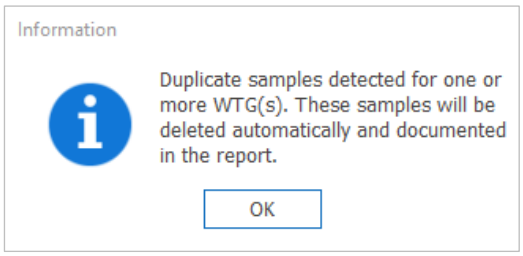
When the setup is finished, click “Load data”, so the time series are imported into the “Existing WTG objects”.

During the import of the time series, windPRO checks their consistency. Should there be a time stamp that is not in the regular 10-minute format, 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. This means that windPRO firstly checks, whether the closest regular time stamp is missing. If so, windPRO assigns the irregular one to the nearest missing one. Is the nearest time stamp not missing, windPRO checks whether the second nearest time stamp is missing. If so, windPRO will use the irregular one on the position of the second closes time stamp. If neither the closest nor the second closest regular time stamps are missing, windPRO marks the irregular time stamp as duplicate. “Abort” will abort the import and no import of the data is going to be done. The reason is that the inconsistent time stamps must be handled before the analysis proceeds to the import of the status codes, as the presence of the irregular time stamps in the time series could fully spoil the conversion of the status logs into the 10-minute time series. If needed, the user can therefore abort the import here and double check the SCADA data, potentially export the SCADA data once again from the SCADA tool.

It can also happen that there are some duplicates found in the time series, e.g., due to the assignment of the irregular time stamps as per above or due to the switching between summertime and wintertime, which are not clearly specified by the TR10. When there are some duplicates found, the user is notified:



All duplicates are deleted automatically and documented in the pdf report. Please select Ok, leave the “Pair and load” window using “Close” and move directly to the assignment of the status codes to the TR10 categories using the button “Setup categories”. It is marked with the green color again and you can find it just below the “Pair and load” button.

13.3.3 Setup categories

13.3.3.1 Basic description

The “Setup categories”-feature (tab “Import SCADA”) helps the user to import the status logs into the TR10 tool and to merge the status codes in the form “beginning – end”, resp. “beginning + duration” with the production data in a regular 10-minute format.

13.3.3.2 Concept choice

The user can select from two concept choices when entering the “Setup categories”:

Figure 20 Setup categories - Concept choice

Status signals and/or categories in time series

As already mentioned in chapter 13.2.1, some SCADA systems are capable to export the 10-minute time series incl. the status codes. Typically, the code represents the first code activated in the 10-minute time series. This approach is not in compliance with the TR10, as the SCADA system cannot be considered as independent tool. But on the other hand, it might be the case that the user decides to make the assignment of the status codes and TR10 categories into the 10-minute time series outside of windPRO in an inhouse tool. In such case this feature will help. As windPRO cannot guarantee that the assignment of the TR10 categories into the 10-minute time series was done correctly, the selection of this option will trigger a deviation to the TR10, and it will be documented in the “Deviations from TR10” pdf report.

In case this option was selected, the only relevant tab from the “Manage categories” setup is the tab “Manage status signals” – skip to chapter 13.3.3.5.

Separate status signals

This is the foreseen way of a TR10 compliant evaluation and therefore this option is always pre-selected. The user will import step by step the necessary data. By this, the status logs in the format “beginning – end” and the status log library can be merged as well as overlapping states can be evaluated and are prioritized. This results in a regular time series in 10-minute resolution where each of the time stamp is assigned to exactly one TR10 category.

The status logs are separate files logging all operational states of a WTG. The main difference in comparison to the production data is the format. The production data are in a regular 10-minute format; the status logs are saved in the format “from – to” or “from + duration”.

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. The first step is to import the file with the status logs (1). When imported, the import filter must be defined. windPRO needs to understand, in which column to search each of the signals (2). The next step is to define the format of the date and time. This is not recognized from windPRO automatically but must be typed manually (3). The symbols for “day – month – year” are “d.m.y”, the symbols for “hour – minute – second” are “h:m:s”. The WTG ID must be defined here too (4). This is identical to the definition of the WTG ID during the import of 10-minute SCADA data described in chapter 13.3.1. The option to save / load the import filter in the *.pci format that was introduced in chapter 13.3.1. is available here, too (5).

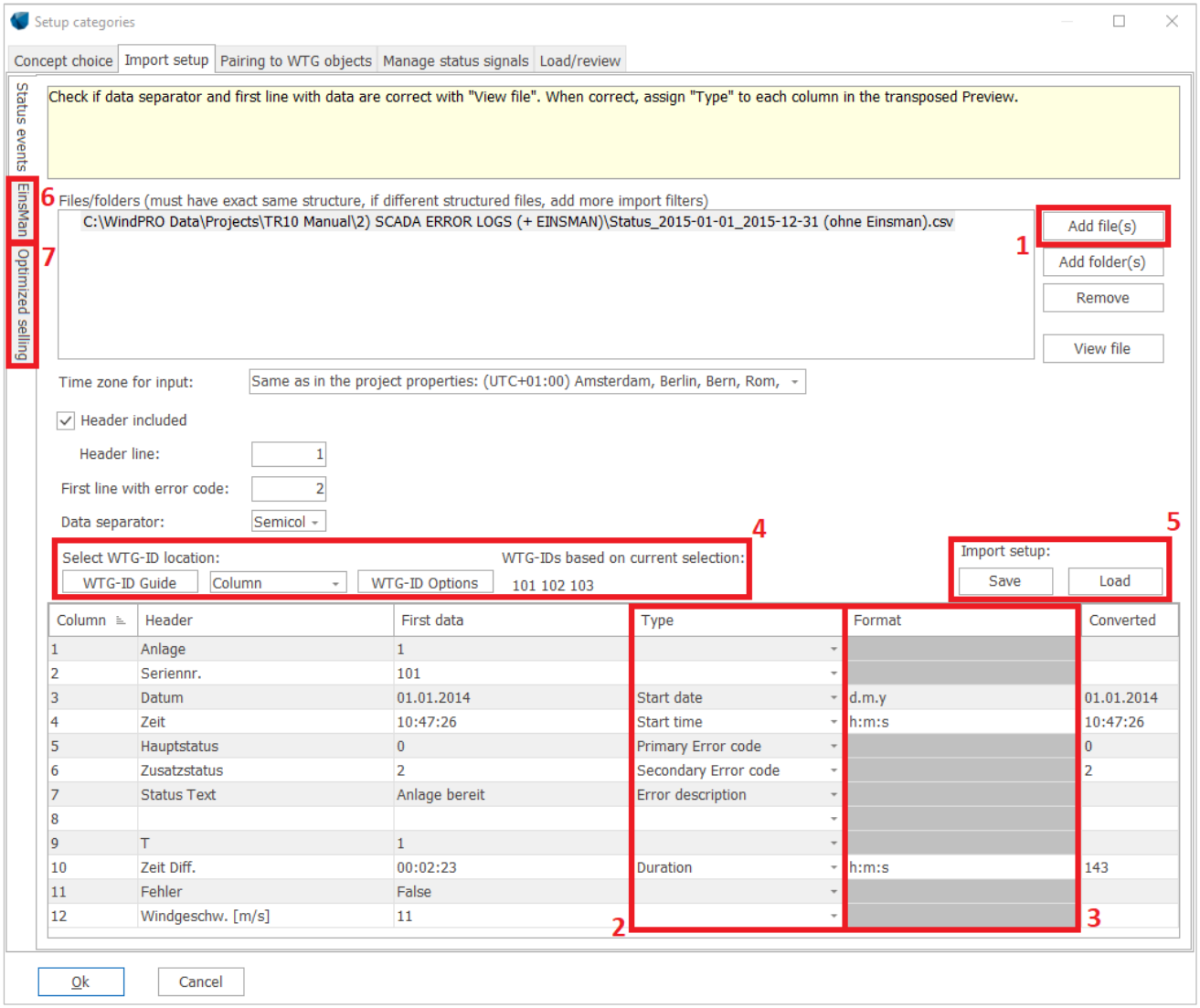


Figure 21 Import status logs

As soon as you are done with the import of the status codes, it might be the case that you need to import some external data that are not part of the SCADA status logs mentioned already in chapter 13.2.2, point 1.

Some of the SCADA systems have an explicite status code for EinsMan and Optimized marketing, some don’t. If there are such signals available in your analysis, you can fully ignore the tabs EinsMan (6) and Optimized selling (7); they are deactivated in the default setup. If such explicite status codes are not available, you can import them from an external source in the format described in chapter 13.2.2.

13.3.3.3 „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.

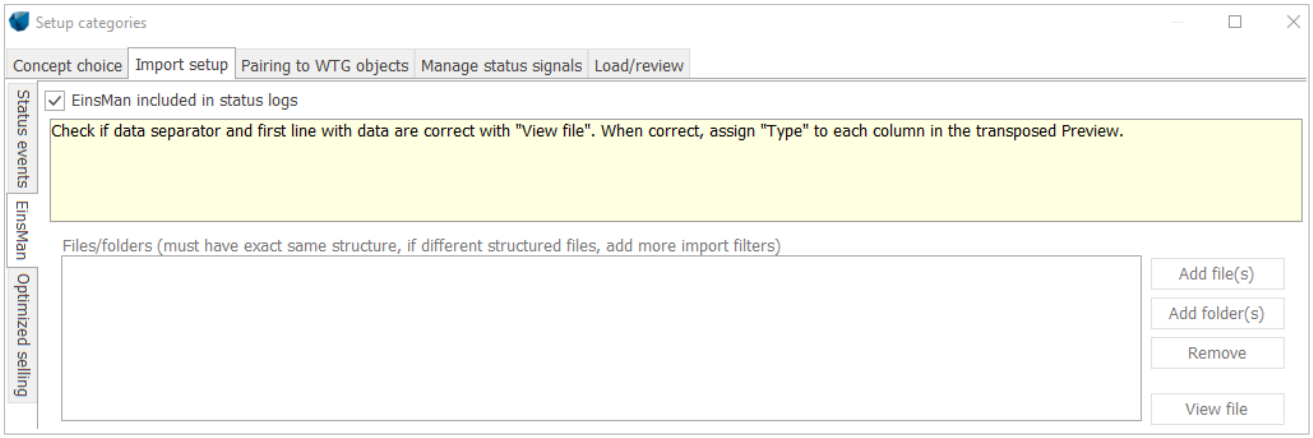


Figure 22 Import Einspeisemanagement and / or Optimized selling

The expected format of the data is: “Start date and time → End date and time” and the import filter logics are identical to the ones of the status logs. The only difference is that the feature must be activated by unchecking the checkbox “EinsMan (resp. Optimized selling) included in the status logs”.

Some more information about the formats of imported external (= non-SCADA) data are in chapter 13.2.2.

The data imported here are valid for all WTGs and therefore there is no setup of the WTG ID here. As the result, windPRO will combine the times from the status logs and the times from external sources representing the optimized selling. All situations imported using the “EinsMan” tab will be asigned to the TR10 category 3 for all WTGs. And similar for the optimized selling – these situations will be asigned to category 4 for all WTGs.

13.3.3.4 Pairing to the WTG objects

The way how to use the “Pair and load” feature here is identical to the way of use during the import of the 10-minute SCADA data described in chapter 13.3.2. If the IDs of the existing WTG objects in windPRO and the IDs used within the status logs are identical, the “Auto pair” will automatically assign them. If this is not the case, you can assign manually by using the drop-down menus in the rightmost column by each of the WTG.

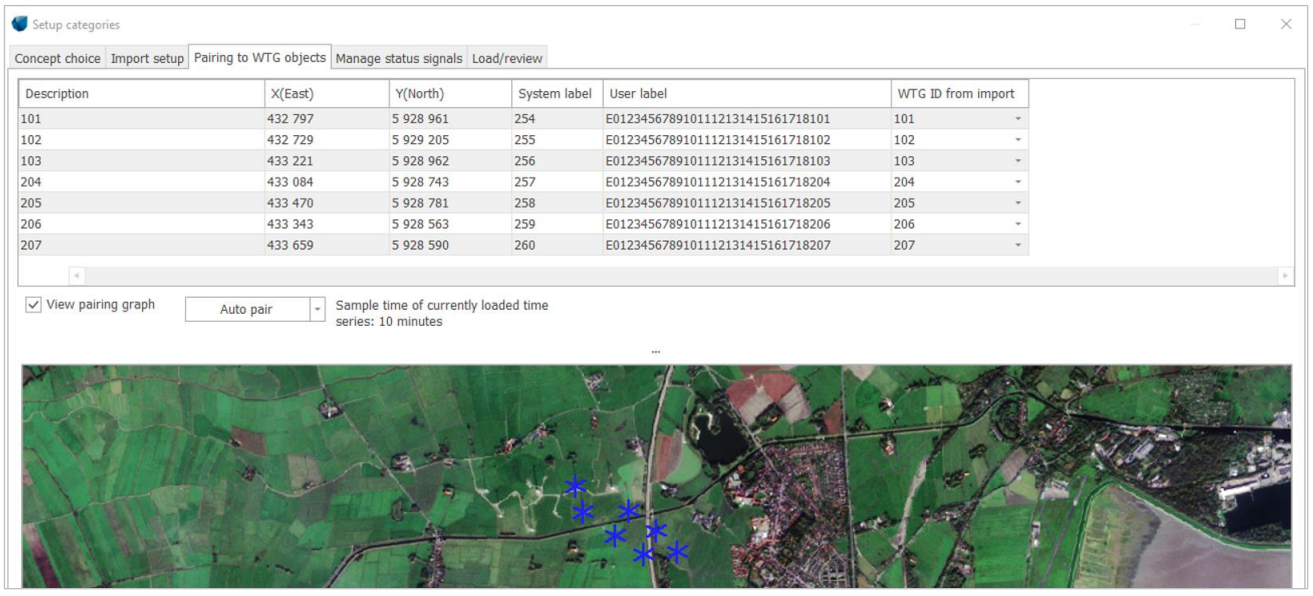


Figure 23 Merge Status logs with existing WTG objects

13.3.3.5 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 to exactly one TR10 category by an independent body that has proven to the FGW the necessary prerequisites and qualifications of the authorised persons.

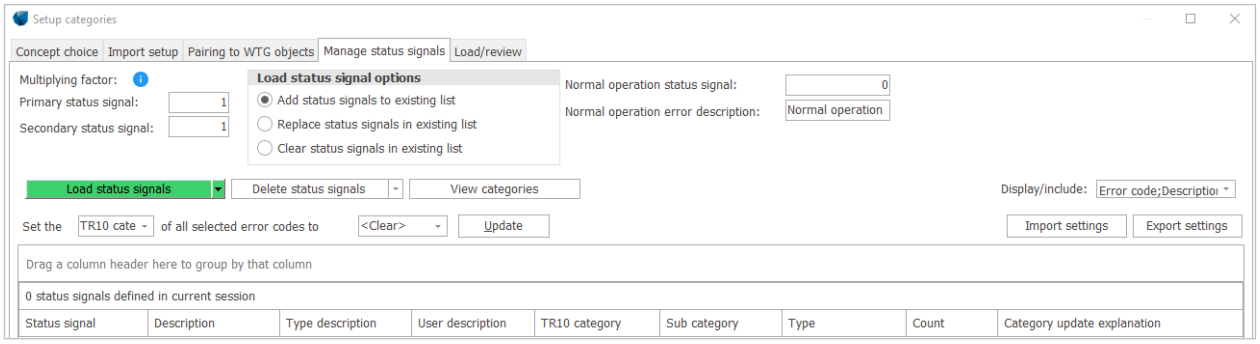
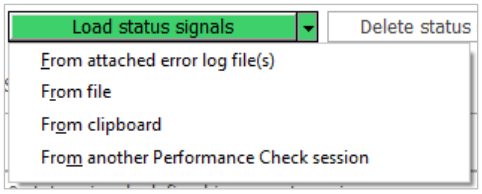


Figure 24 Manage status signals

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 the existing status codes (for the particular WTG type) are assigned to exactly one TR10 category. The data can be either uploaded from the clipboard (using copy-paste e.g. from a spread sheet) or imported from an external file (in *.csv or *.txt format). Another option is to use the status signals directly from the status logs, if they were recorded and saved directly by the SCADA system.



The imports from a file and from the clipboard are very similar to each other and very similar to the import of the status codes. The first steps are the import of the data itself (1) and the setup of the data types (2).

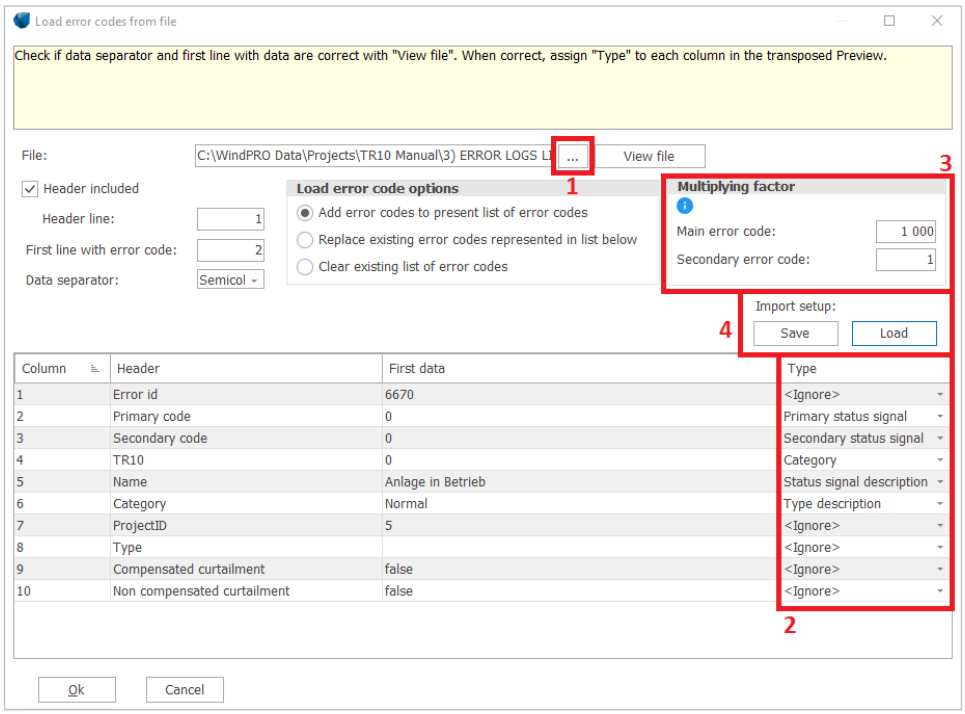
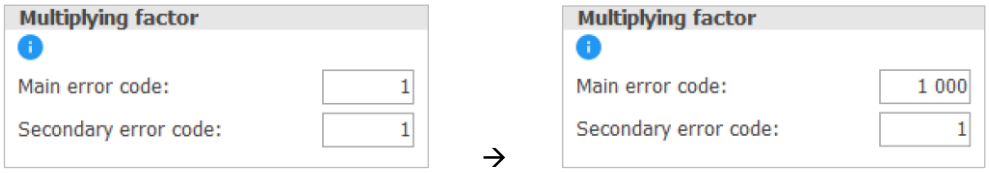
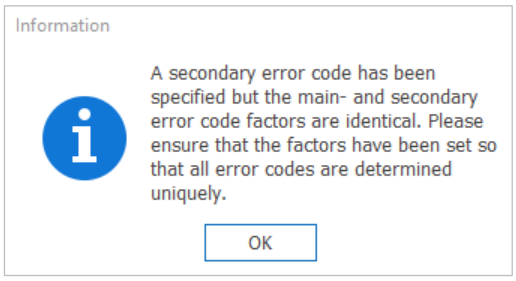


Figure 25 Import status list from file (or from clipboard)

It might be necessary to apply the “Multiplying factor” (3):

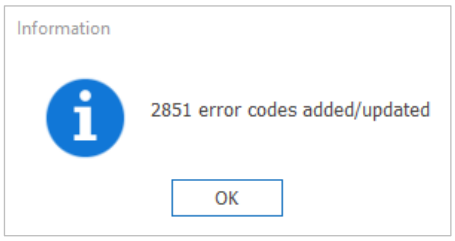


Some manufacturers use the so called “Primary and Secondary status signals”. Unfortunately, windPRO cannot handle such data structure in its native form, as it only can work with single and unique status codes. Therefore, the “Multiplying factor” was introduced. The idea is to multiply the primary error 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. for a primary status code 12 and secondary status code 2 the result will be 12002, which represents a unique status code for the further process of the analysis. As soon as you defined explicitly a primary and secondary code (2), the import setup will not allow you to leave until the multiplier is defined:



When the setup is finished, you can save it in the *.pci format, so you can use it in the future (4).

As soon as everything is settled, confirm the setup with Ok and leave the window. windPRO will inform you about the amount of the identified status codes in the library:



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

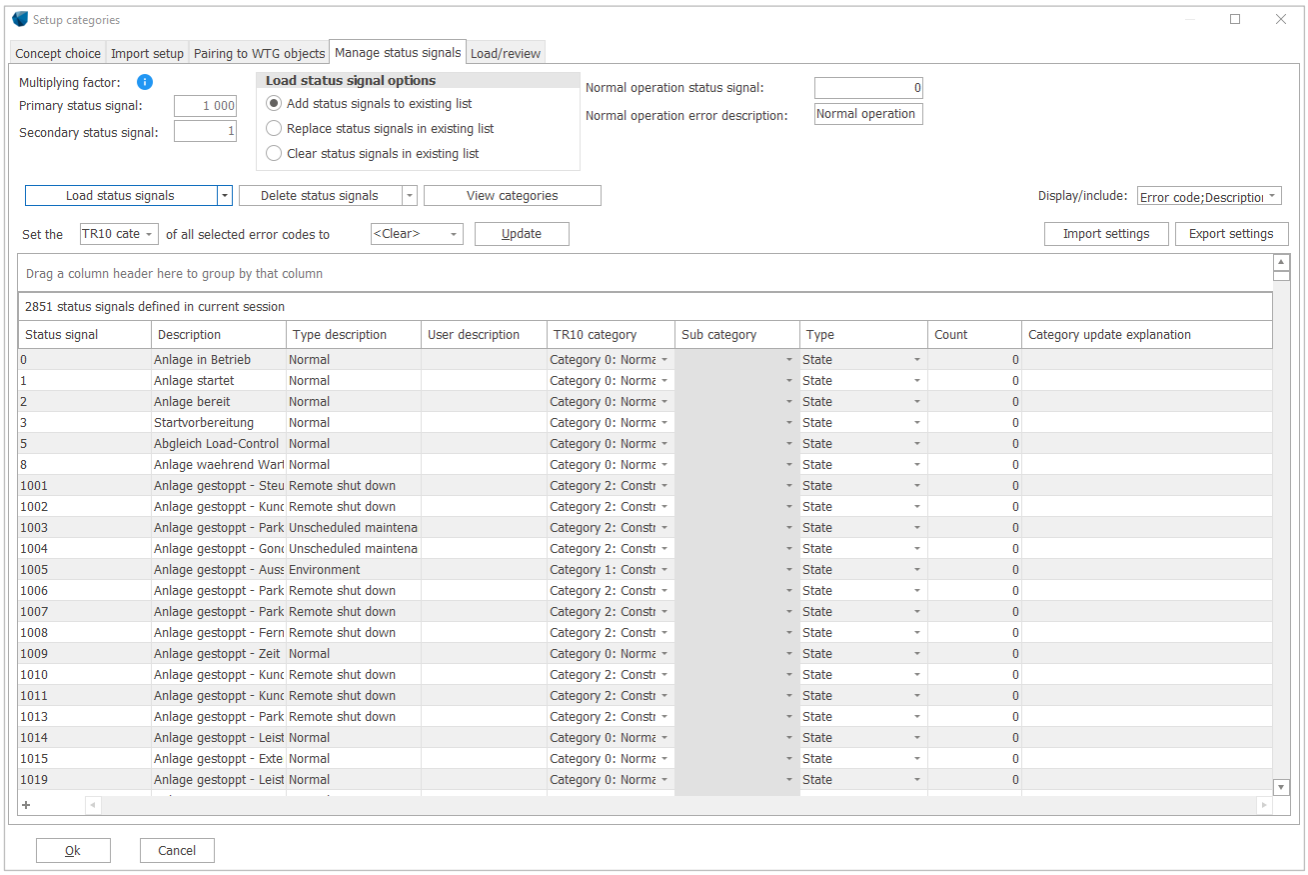


Figure 26 Imported status list

This list contains all status codes found in the library, where all of them are assigned to exactly one category. You have the option to change the category of any of the status codes here, but be aware that if you do so, the category update explanation will be requested, and the change will be documented in the pdf report "Deviations from TR10".

It is necessary that all status codes that were recorded during the operation via the status logs find their equivalent (assigned to the TR10 category) in the overall list that you imported in this step. If this is not the case, which means if there was an event during the operation with a code that is not present on the list, windPRO will notify you and will create the respective status code in the list automatically. Such a code will be marked with "[AUTO]" and will be automatically assigned to the category 2, which means "WTG technically not available". The issue will be documented in the pdf report "Deviations from TR10".

Using the Import / Export buttons you can always save or load saved setups. Similar to import filters for the 10-minute SCADA data or for the status logs.

13.3.3.6 Load/review

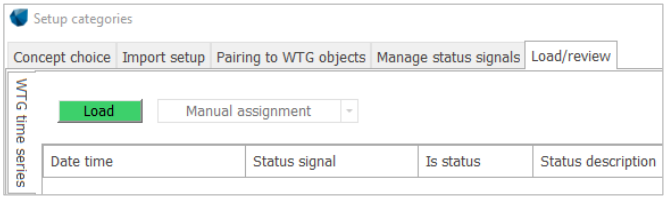


Figure 27 Use "Load" to merge Status logs with time series

windPRO is again suggesting the next step with green, which is also the only possible step at this point – to load the imported data into the time series with the button "Load". When done, all status signals from the status log in the format "from – to" or "from + duration" format are assigned to the regular 10-minute time series and each of the 10-minute time stamp is assigned to one of the categories according to the TR10.

As soon as the upload is done, you can review all 10-minute time stamps and the status signals assigned to these time stamps. In the lower part of the window, the overlapping status signals are displayed (if any):

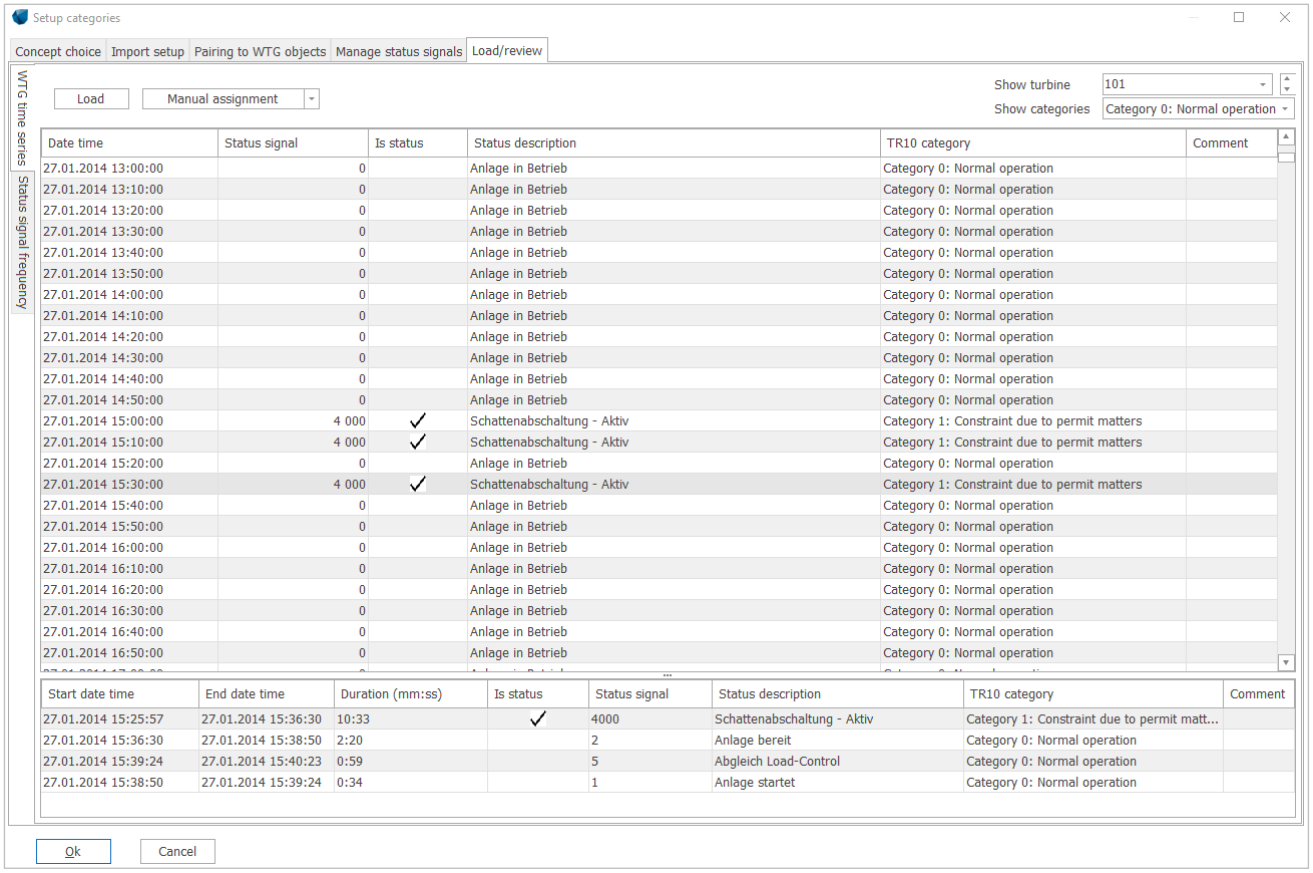
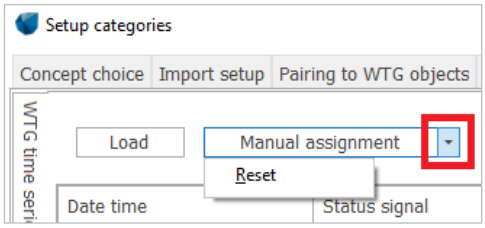


Figure 28 Final time series with status codes and TR10 categories assigned to each 10-min. time stamp

The time frames with potentially overlapping events are handled in compliance with the TR10. The longer one has a priority and at identical length of two or more events, the event belonging to category 2 has the priority, followed by 4, 3, 1 and 0.

Manual assignment

The button Manual assignment allows two options. Via “Reset”:



an already executed import of the status signals into the 10-minute time series can be deleted from the tab Time series SCADA. The second option (by simply clicking at the button, not the arrow on its right side) is the manual assignment of one or several status signals relevant for one 10-minute time stamp. This can be relevant for faulty assigned status signals. A manual assignment needs to be documented in the appearing text field and is documented in the pdf report “Deviations from TR10”.

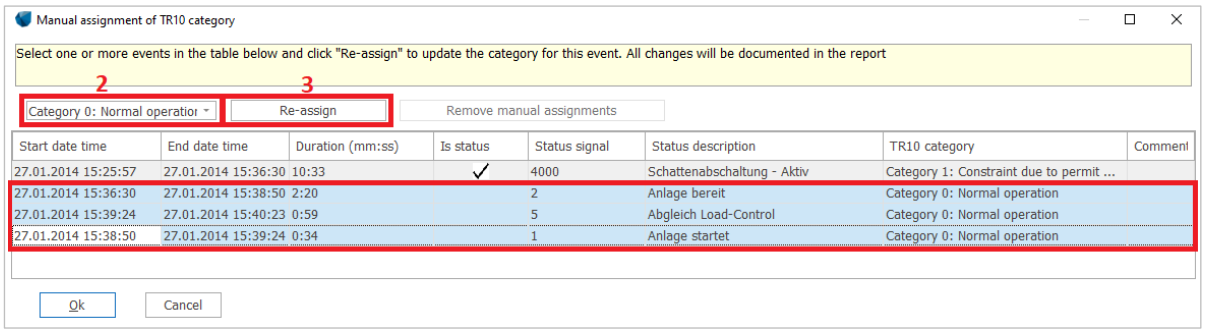
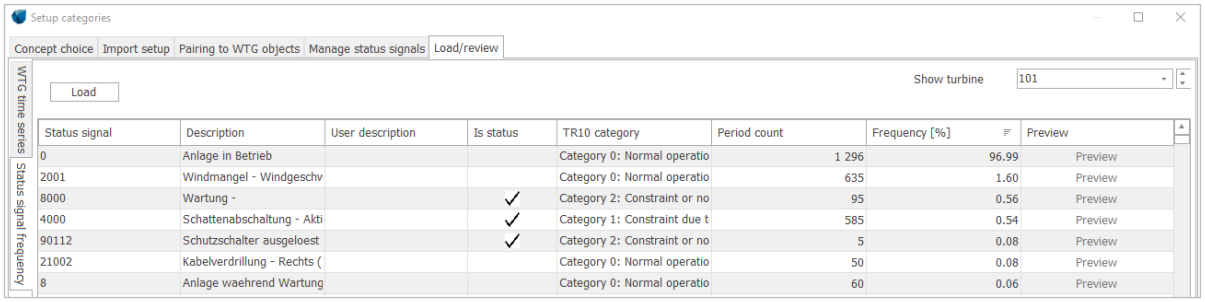


Figure 29 Manual re-assignment

Status signal frequency

This tab gives the user an overview of the frequencies of the particular status codes. Such overview / analysis is not required by the TR10 and has therefore just informational value here.



The buttons “Preview” on the right side of the recorded status signal allows you to display the relationship of each of the particular status signals to the power curve:

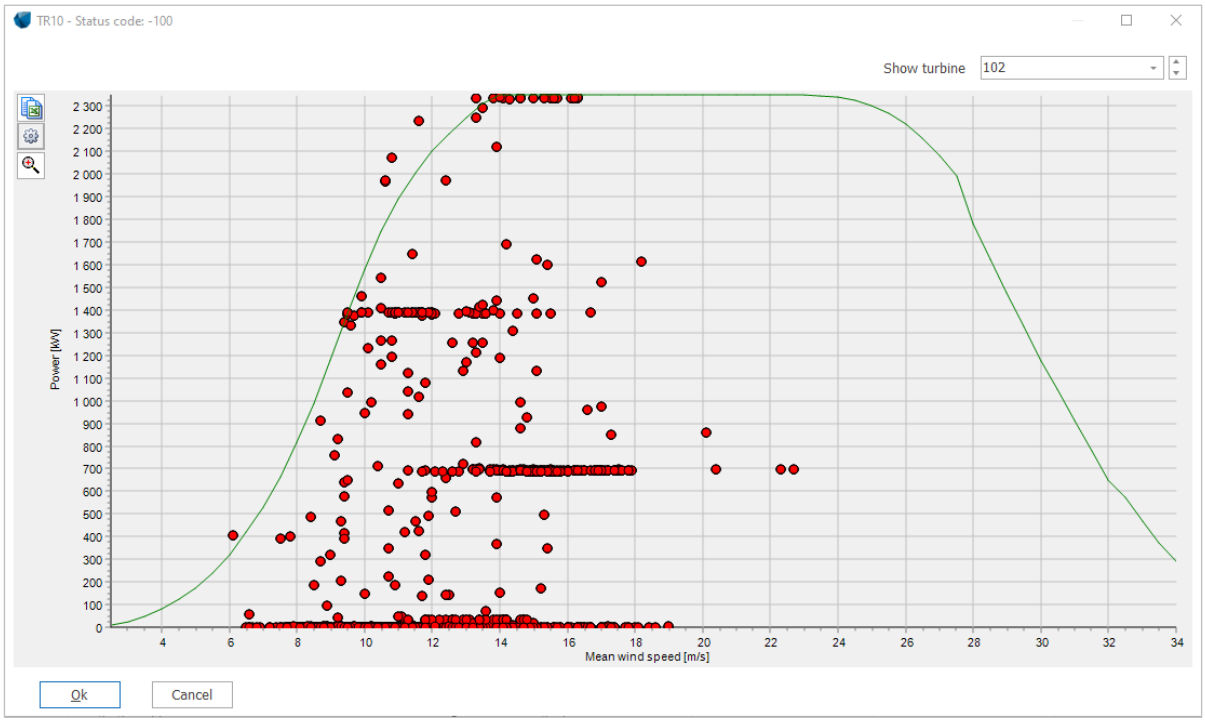


Figure 30 Example of a particular status code vs. contractual power curve

Go back to the Load/review tab and when ready, click Ok and all data in the changed structure, which means in the 10-minute format, will be saved into the “Existing WTG objects”.

13.4 Data: Time series SCADA

There is no setup option available at this tab at this stage. The imported time series can be checked on this tab, before proceeding further in the analysis. Typical indicator, that something could have gone wrong during the import, is a high number of “Out of range” values. Sometimes the reason is an incorrect setup of the import filter for the import of 10-minute data. E.g. an incorrect unit or decimal separator.

The data can be marked, copied to the clipboard (the use of the button “Copy” is recommended) and pasted into an external tool, e.g. MS Excel.

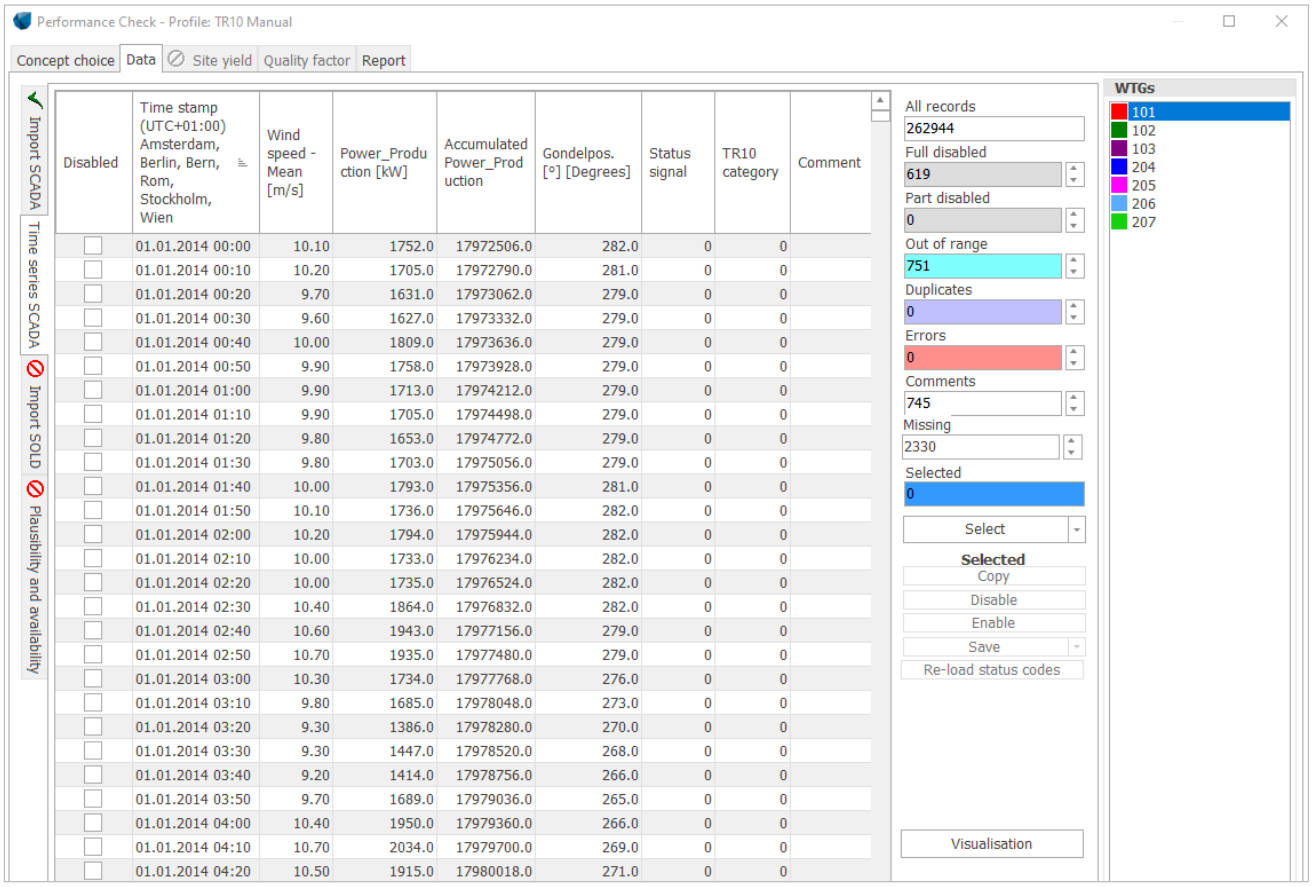


Figure 31 Time series with assigned codes and TR10 categories after plausibility checks and processing of gaps

The button “Visualisation” in the right bottom corner leads the user to the time series in a graphical form:

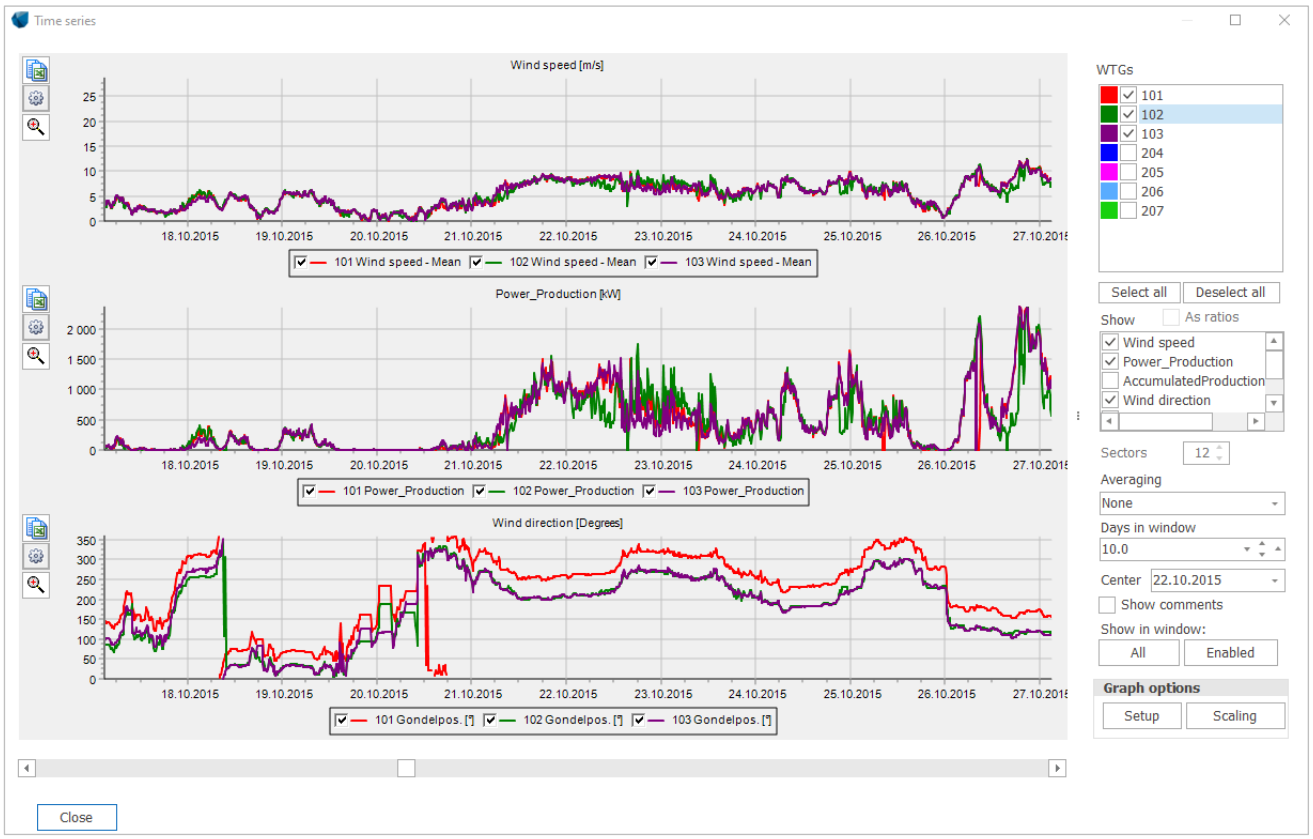


Figure 32 All signals can be visualized like in a METEO object

13.5 Data: 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[7]), as this would not be in compliance with TR10.

The first step is to create a new grid connection point:

As soon as created, a new line and the “Load data” button appears in the right window.

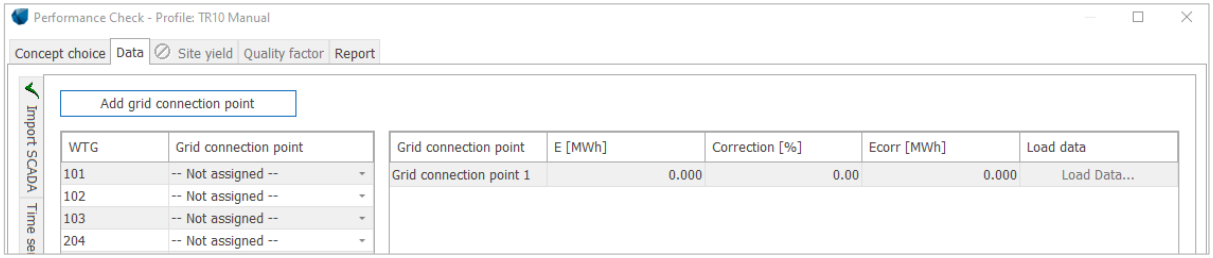


Figure 33 Mask for import of sold electricity

The “Load data” button brings the user to a table that is expecting the import of monthly data: monthly produced energy, compensated energy due to EinsMan and energy sold via optimized marketing. All are in MWh. You can either manually type the values into the table or use the button “Load data from file or clipboard”.

[7] A time series with production measured at the grid connection point. Normally in 15-minute resolution.

For importing the data from the clipboard or from a file, there is an import mask similar to one used for the import of the status codes:

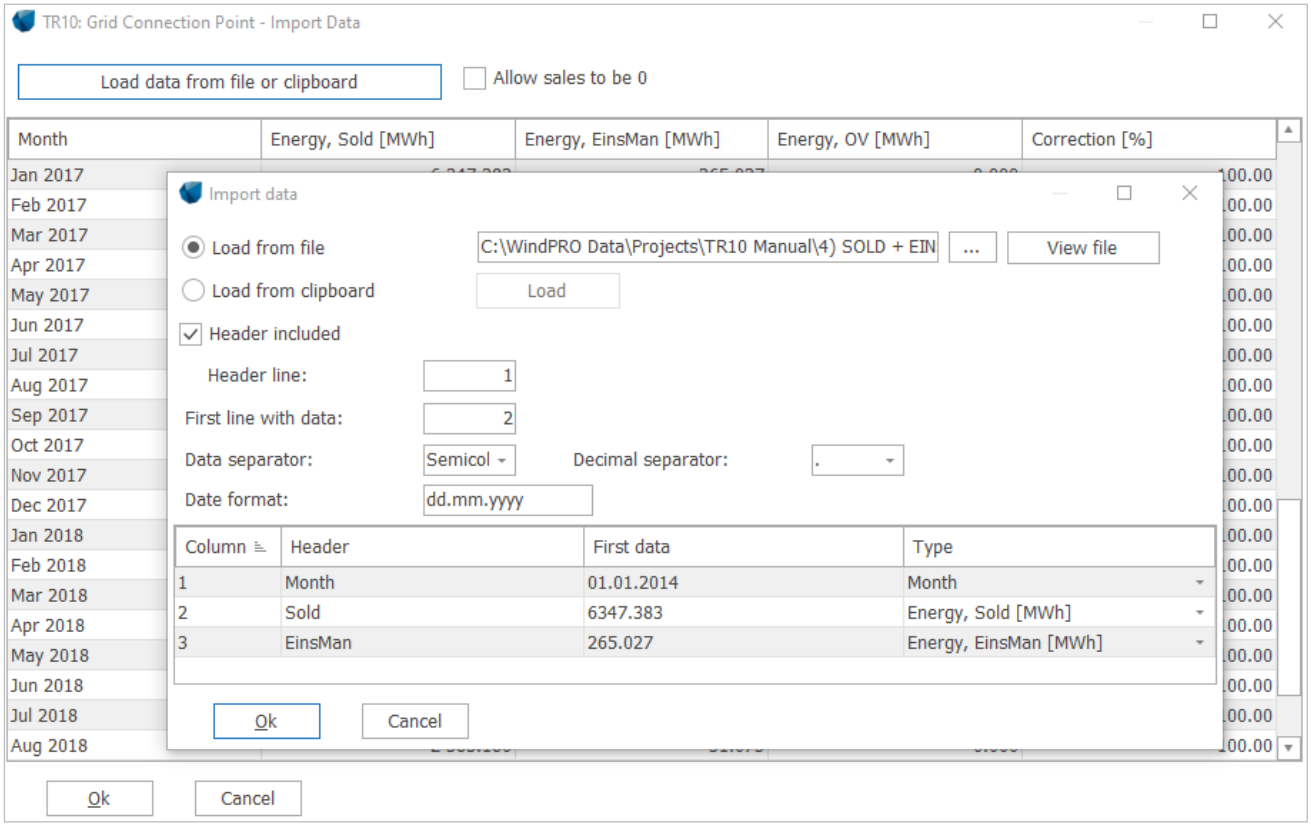
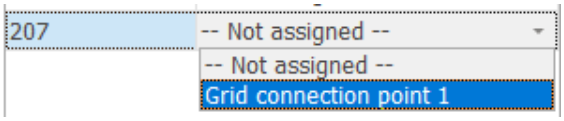


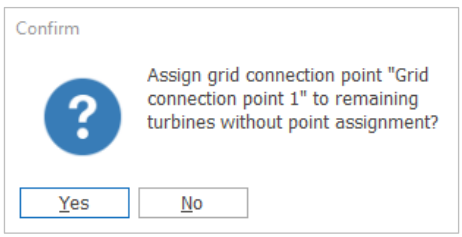
Figure 34 Import sold electricity (and eventually EinsMan and Optimized selling)

The assumption is that the source is a table with the relevant columns and monthly resolution. Month & year, Produced electricity, EinsMan, Optimized selling. See more details about the expected data format in chapter 13.2.2.

It is possible to create more grid connection points when there is more than one grid connection point. The assignment is then done by the drop-down menus of the WTGs:



As soon as the first grid connection point is selected for one of the WTGs, windPRO offers the option to assign all WTGs to the same grid connection point automatically:



13.6 Data: Plausibility and Availability

Before any calculation is available here, all checkboxes need to be checked and necessary descriptions need to be filled. These declarations are formal requirements defined in the TR10.

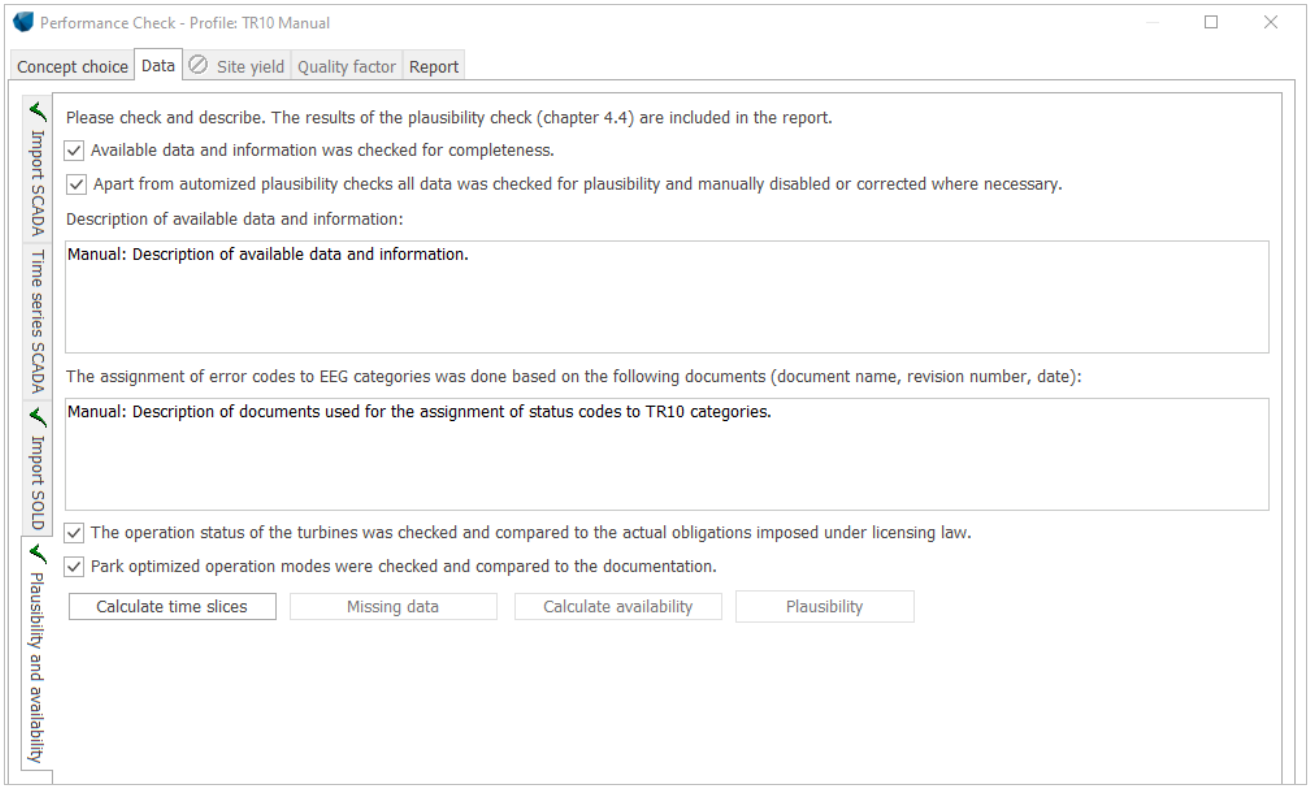
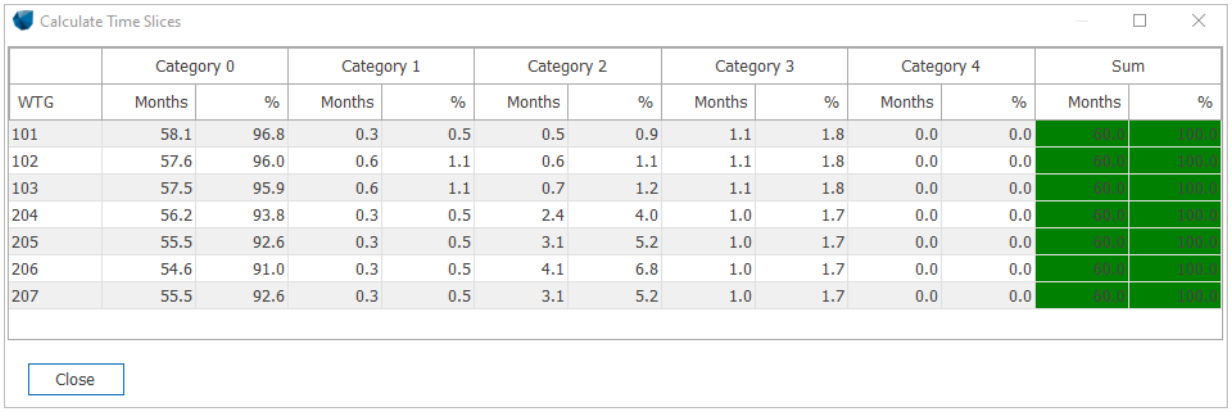


Figure 35 Plausibility checks

When this step is finished, please proceed with the button “Calculate time slices”. This calculates the total portions of each of the EEG 2017 categories during the analyzed time frame. Based on this result, the calculation of the TR10 availability can be done.



	Category 0		Category 1		Category 2		Category 3		Category 4		Sum	
WTG	Months	%	Months	%	Months	%	Months	%	Months	%	Months	%
101	58.1	96.8	0.3	0.5	0.5	0.9	1.1	1.8	0.0	0.0	60.0	100.0
102	57.6	96.0	0.6	1.1	0.6	1.1	1.1	1.8	0.0	0.0	60.0	100.0
103	57.5	95.9	0.6	1.1	0.7	1.2	1.1	1.8	0.0	0.0	60.0	100.0
204	56.2	93.8	0.3	0.5	2.4	4.0	1.0	1.7	0.0	0.0	60.0	100.0
205	55.5	92.6	0.3	0.5	3.1	5.2	1.0	1.7	0.0	0.0	60.0	100.0
206	54.6	91.0	0.3	0.5	4.1	6.8	1.0	1.7	0.0	0.0	60.0	100.0
207	55.5	92.6	0.3	0.5	3.1	5.2	1.0	1.7	0.0	0.0	60.0	100.0

Figure 36 Calculate time slices

When done, the buttons “Missing data” and “Calculate availability” become available. The “Missing data” is not necessary to use. It gives an overview of missing data:

	Missing data		Disabled data		No production and wi...		No production		No wind speed		Total	
WTG	Months	%	Months	%	Months	%	Months	%	Months	%	Months	%
101	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5
102	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5
103	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5
204	0.0	0.0	1.4	2.3	0.0	0.0	0.0	0.0	1.4	2.3	2.8	4.6
205	0.0	0.0	2.1	3.6	0.0	0.0	0.0	0.0	2.1	3.5	4.3	7.1
206	0.0	0.0	3.2	5.3	0.0	0.0	0.0	0.0	3.1	5.2	6.3	10.5
207	0.0	0.0	2.2	3.6	1.0	1.7	0.0	0.0	1.1	1.9	4.4	7.3

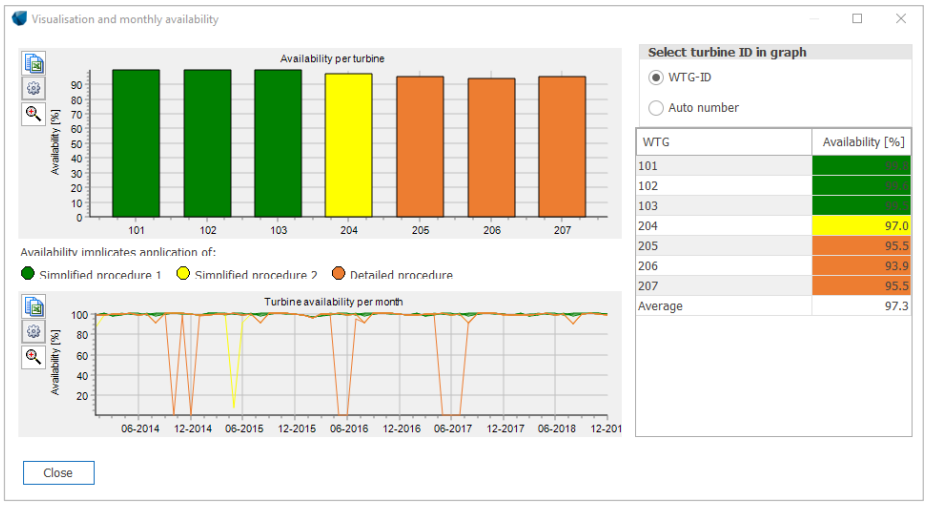
Figure 37 Calculate missing data

Proceed with the “Calculate availability” button:

WTG	Availability [%]	Procedure
101	98.8	Simplified procedure 1
102	98.8	Simplified procedure 1
103	98.8	Simplified procedure 1
204	97.0	Simplified procedure 2
205	95.5	Detailed procedure
206	93.9	Detailed procedure
207	95.5	Detailed procedure
Average	97.3	

Figure 38 TR10 conform availability

The TR10 availability can be displayed on monthly basis too:



WTG	Availability [%]
101	98.8
102	98.8
103	98.8
204	97.0
205	95.5
206	93.9
207	95.5
Average	97.3

Figure 39 Monthly availability

This has just informational value, as the TR10 does not require monthly availabilities.

The resulting availability for each turbine decides whether the calculation of the Site Yield and Quality Factor will be finalized using the simplified method 1 (green), simplified method 2 (yellow) or using the detailed method (orange), as described in chapter 13.1.1.

After this step is done, a plausibility check needs to be done. The plausibility check in the TR10 tool fulfills the check defined in chapter 5.2. It defines, how the so-called SF_{Park}[8] shall be calculated, so the electrical losses can be removed from the 10-minute time series, as described in chapter 5.3. The SF_{Park} needs to be calculated on a monthly basis and is considered as plausible, when being in the range $87\% \leq SF_{Park} \leq 109\%$.

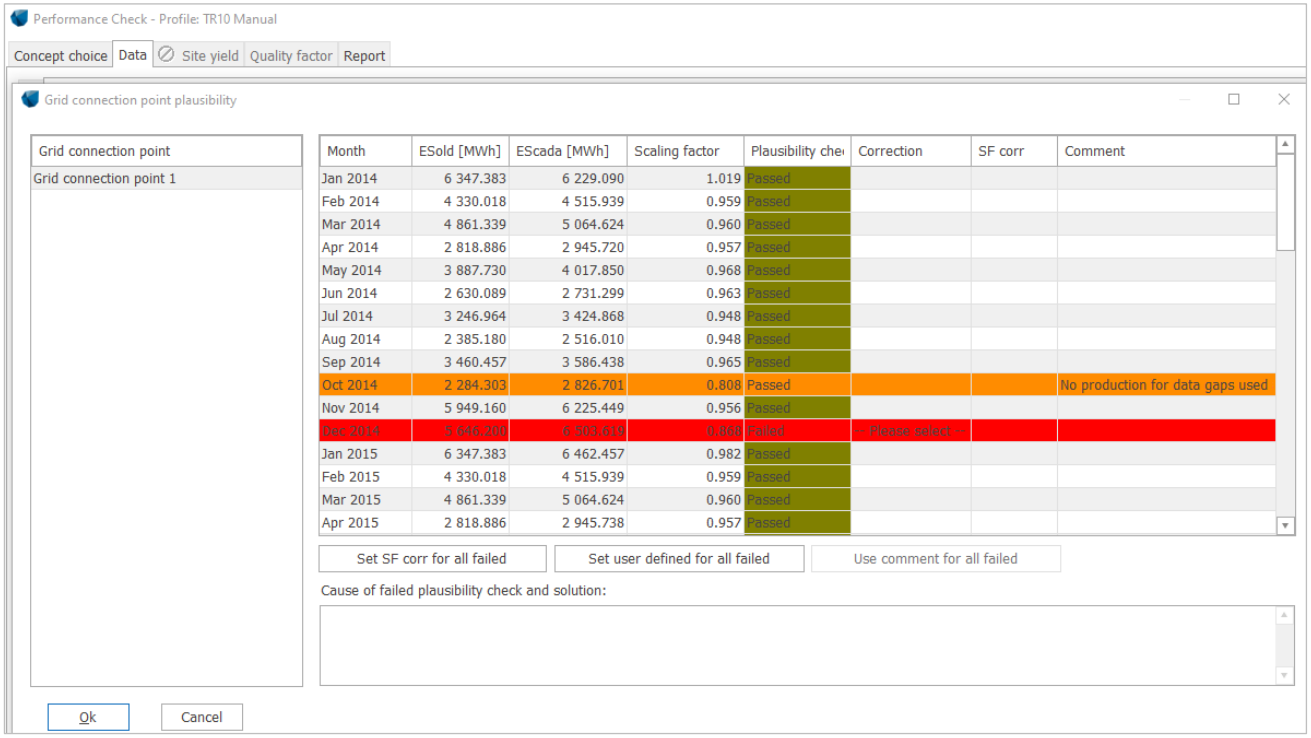
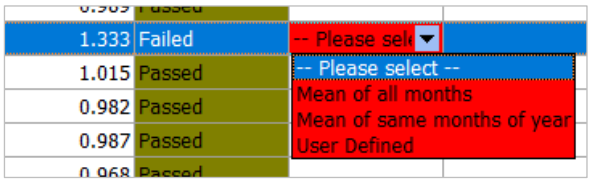


Figure 40 Plausibility check of production time series from SCADA vs. sold electricity

Each SF_{Park} in this range is marked as “Passed” in the tool and no further action is needed. The SF_{Park} -factors outside the specified range are marked as “failed” and need to be handled.



The user has three options how to handle the failed plausibility checks month by month. No matter which of the options has been selected, a description describing the reasons for the failed check is required before the user is allowed to leave the plausibility check window. A failed plausibility check and the respective correction are documented in the report.

If all WTGs have reached an availability of 97% or higher, the TR10 tool guides you directly to the sub-tab “Results” on the tab “Site yield”. Should one or more WTGs be below this limit, you need to perform the detailed analysis, which means to calculate the fictitious electricity that would have been produced during category 2 events. The theory behind the calculation of the Site Yield depending on the availability are described in the TR10 chapters 6.1, 6.2 and 6.3.

[8] Scaling factor

13.7 Site yield: Wind speed correlation

When the availability of one or more WTGs drops below 97%, the tab “Wind speed correlation” becomes available.

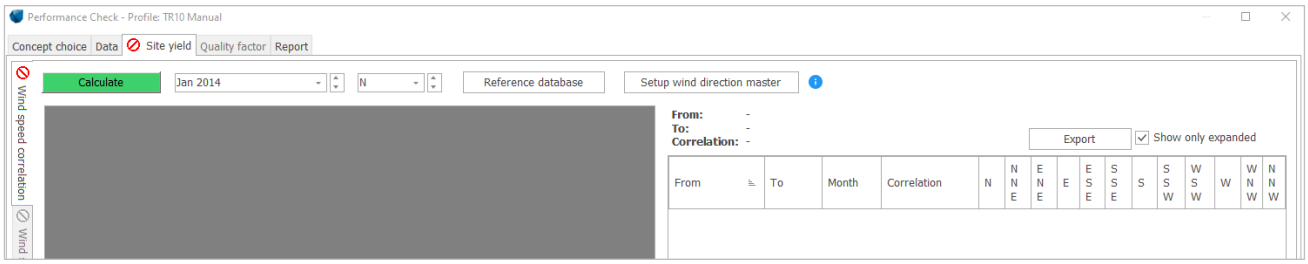


Figure 41 Correlation calculation

The TR10 presumes 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. This is done by the replacement of all wind speeds of a turbine during category 2 events with a source with the best correlation under normal operation.

Use the button “Calculate” to calculate the correlation of the available sources of wind data among each other under normal operation (Category 0). The correlation calculation is performed on a monthly basis and sector wise (with north sector defined as ≥345° - <15°) and are always done using 3-months windows. This means that the month, that the correlation is calculated for, uses the data from that month + the data from the months before and after this month. E.g. the correlations for July are based on June, July and August. The minimal amount of samples in a 3-month slot is 8640. If this cannot be achieved in a correlation calculation in a month, the month selection must be extended by one month before and one month after the currently selected time frame. The named example time frame would be then extended by May and September. In case the total amount of the 8640 samples is achieved, but the amount of the samples in one of the sectors does not reach 12, then the time frame is to be extended in the similar logic (= plus one month before and after) just for that particular sector.

Before proceeding with the calculation of the correlation, please note the two setup-buttons on the right side.

Reference database

The TR10 allows to use external sources to create the so-called consistent wind time series. Besides the nacelle wind speeds from the nearby WTGs, it is allowed to use e.g. data from nearby met masts as well as reanalysis and / or mesoscale models, too. In windPRO, these are represented via METEO objects. They can be activated by simply activating the corresponding checkbox of the selected source, resp. by the selected heights:

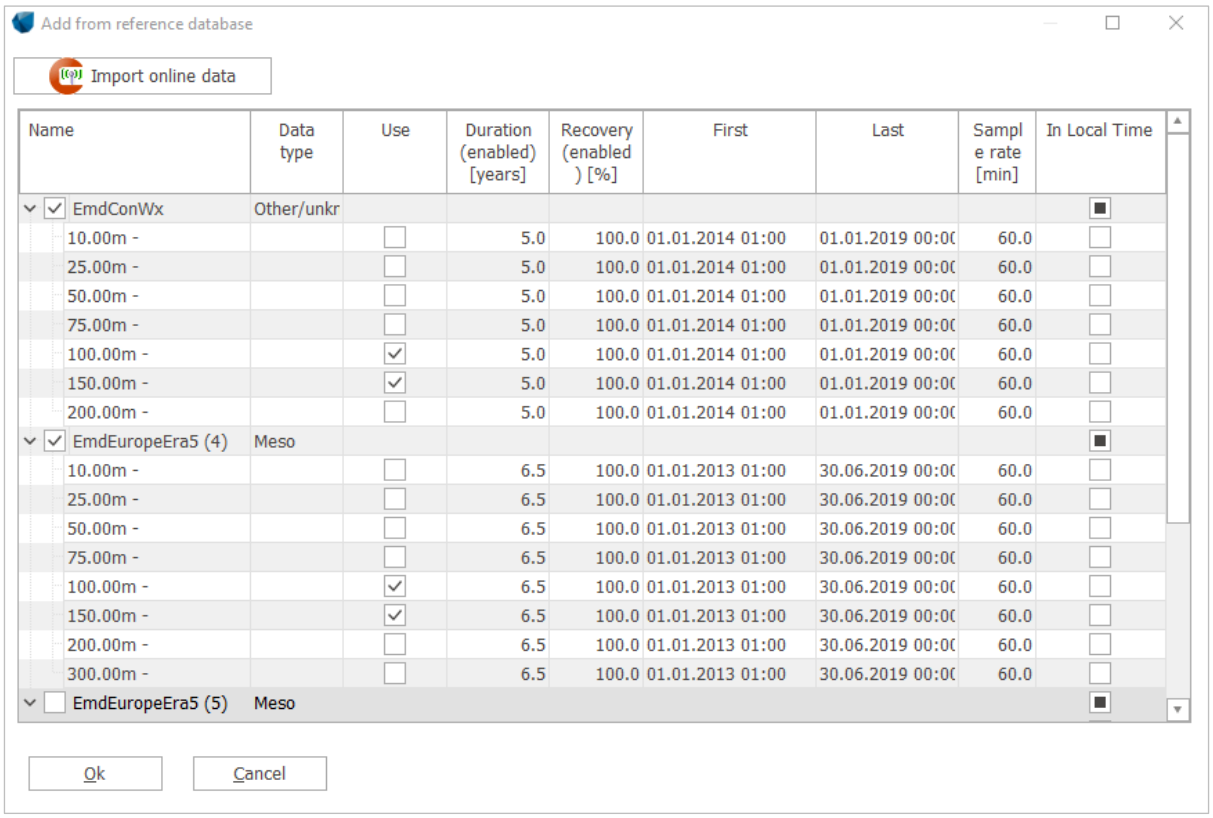


Figure 42 External meteorological time series

Using the button “Import online data”, it is possible to create new METEO objects from online sources available at the EMD server.

Setup wind direction master

The WTGs within a wind farm typically show some deviations in the wind direction measurement, resp. in the nacelle positions. Although the nacelle is correctly positioned towards the wind, the recorded wind direction might be incorrect. In case the differences in wind directions within the WTGs are too high, it is recommended not to use them directly and to define a wind direction master manually. It is possible to select either one of the WTGs or a METEO object.

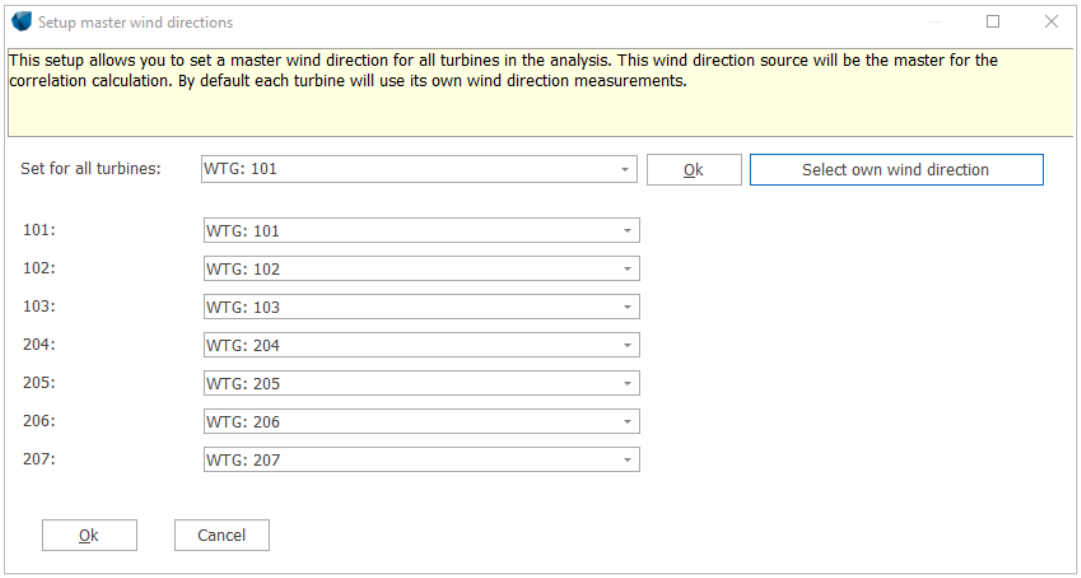


Figure 43 Selection of wind direction master

After the reference METEO objects were added (if necessary) and as soon as the wind direction master was defined (if necessary), the only way how to proceed is to use the button “Calculate”.

When the calculation is finished, you will see a graphical overview in the left side of the window (1). This part represents a matrix of turbine and reference data, where correlations of all inputs for selected months and sectors are compared. When you move with the mouse pointer within this area, you will see some details in (2). This represents the correlation calculated from a source to another source. The grey part of the left window represents the WTGs with the availability above 97%; they are available as sources for the correlations, but the correlations are not calculated for them from the other sources, as it is not necessary, because the detailed calculation is done only for WTGs with availability below 97%.

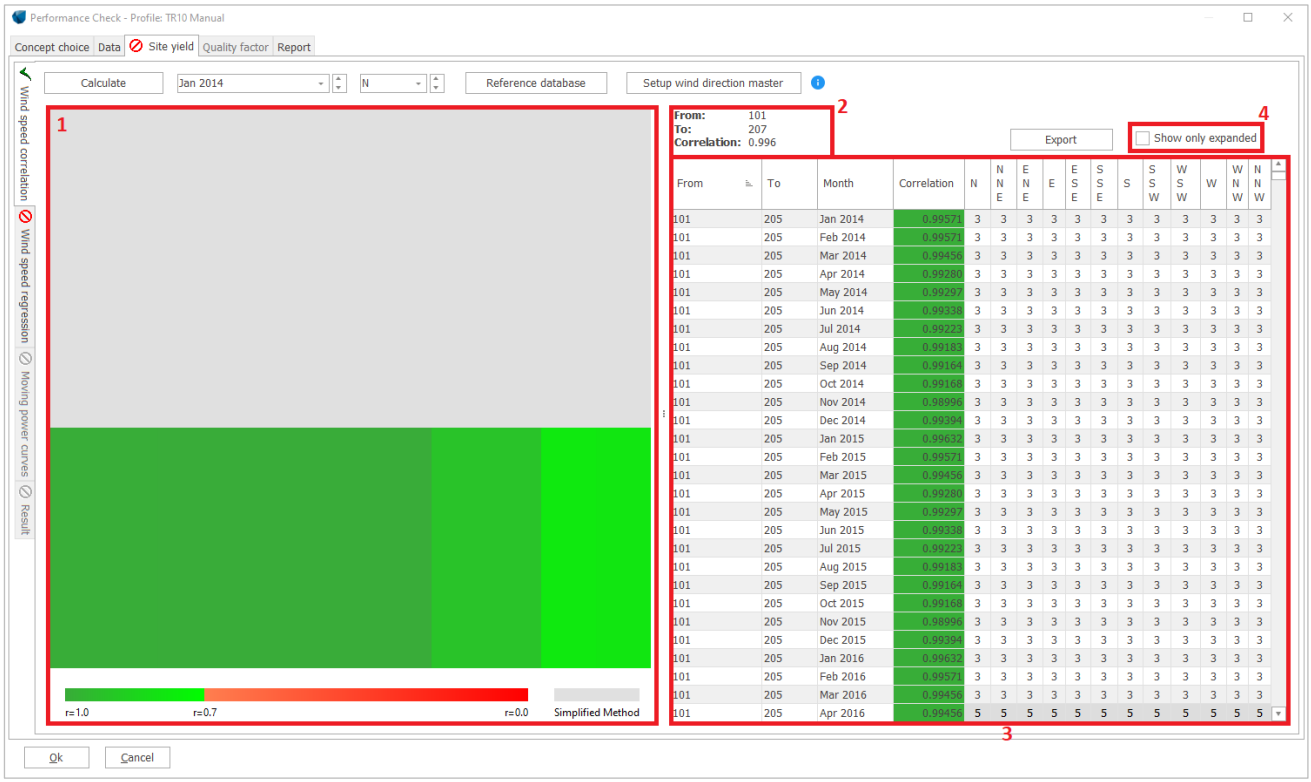


Figure 44 Calculated correlations overview

The monthly correlations are displayed in the right part of the window (3). The numbers in the directional sector columns represent the amount of the months that were used for the calculation of the correlation. 3 months is the minimum period which has to be applied. This overview might be a bit extensive and therefore there is the checkbox “Show only expanded” (4). This checkbox is in the default setup activated and assures that all months with enough data within the standard time-range (8640 samples within 3 months) are not visible. The whole table can be exported into the clipboard using the button “Export”.

13.8 Site yield: Wind speed regression

After the wind speed correlations calculated for the normal operation (category 0) were calculated on the 3-month basis and sector wise, the next step is to use the best correlating sources to replace the wind speeds of all time stamps belonging to category 2 at all WTGs with an availability below 97%. In other words – all wind speeds of the WTGs with availability below 97% will be replaced by wind speeds of the best correlating source. The best correlating source always bases minimum on a 3-month period. The whole method is described in the TR10, chapter 6.3.1.

After clicking at “Wind speed correction”, windPRO will start replacing wind speeds of time stamps belonging to category 2; no matter whether due to unavailability or due to data gaps. As soon as the process is done, the results in form of a small table (1) and a “DNA graph” (2) are shown. The table refers to the average wind

speed of the original wind speed time series, to the average wind speed of the new (consistent) wind speed time series, difference (in %) between the original and the consistent average wind speed and in the last column about the amount of replaced samples (in %). There is a small legend in the right corner (3), explaining the different colors in the “DNA graph”. The grey color by the first 3 WTGs means that there was no calculation of the consistent wind time series necessary, as the availability of these WTGs was not below 97%.

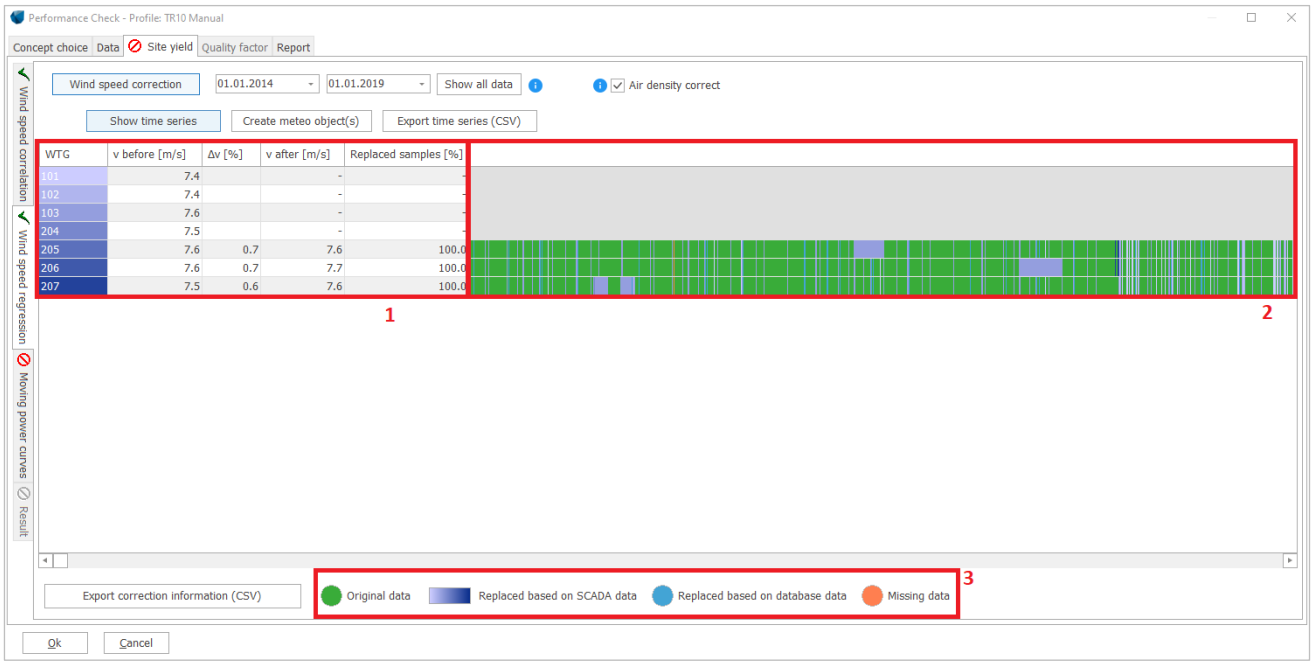
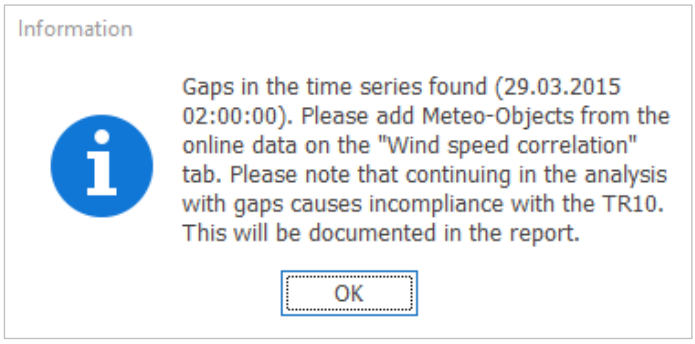


Figure 45 Calculation of consistent wind time series

Notice the orange color in the graph, which is used for missing data. The presence of the orange color in the graph means that not all wind speeds of time stamps belonging to category 2 could have been replaced, as there was no source found to replace from. E.g. during an overall data outage, when all analyzed WTGs have no data and there is no external source to get the data from (reanalysis, mesoscale model). Such situation is not in compliance with the TR10 and although the user is allowed to continue and to finish the analysis, an incompliance warning is triggered, and the incompliance is documented in the pdf report “Deviations from TR10”.



In order to solve this problem, the simplest solution is to go one step back to the “Wind speed correlations” tab and to download some online data (reanalysis, mesoscale) from the EMD server. The correlations with these sources are typically not perfect but is still better than an incompliance due to missing data.

There are some visualizing and export features available on the tab “Wind speed regression”:

- Show time series – Visualization of the time series in a graphical form similar to the point 13.4.
- Create METEO object(s) – Creates new METEO object(s) with the consistent wind speed time series.
- Export time series (CSV) – Exports the consistent wind speed time series into a *.csv file.
  Export correction information (CSV) – Exports the details about the replacements that have been done in the time series.

13.9 Site yield: Moving power curves

As the real-life power curve typically differs from the expected / guaranteed and can change in time, the TR10 defines that 3-month moving power curves need to be derived from the SCADA data in order to determine the not produced electricity for the WTGs with an availability of 97% or lower. Moving power curves base on all time stamps belonging to the categories 0 and 1 and are to be used for the calculation of the not produced electricity due to category 2 events. The tab “Moving power curves” contains two functionalities – the button “Calculate” and the check “Air density correct”. As soon as the button is used, the moving power curves for each of the 3-month slots are calculated. “Air density correct” is checked in default which means the air density correction is done according to the TR10 chapter 6.3.2. Unchecking will provoke a deviation from TR10 which will be documented in the pdf report “Deviations from TR10”.

The power curves are calculated separately for day and night mode, as required in the TR10. The day and night setup is used from the data entered during the “Pair and load” step – see chapter 13.3.2.

The power curves are calculated for 1m/s wind speeds bins: 0,5m/s ≤ v < 1,5m/s; 1,5 m/s ≤ v < 2,5m/s; etc. There are some criteria that need to be fulfilled in terms of the amount of available samples. The minimal total amount of available samples (= categories 0 and 1) is 8.640 (60 days). In case one of the wind speed bins has less than 6 samples, the power curve shall be interpolated for that particular bin using the bins below and above the missing one. Please see the TR10, chapter 6.3.2 for more details regarding this topic.

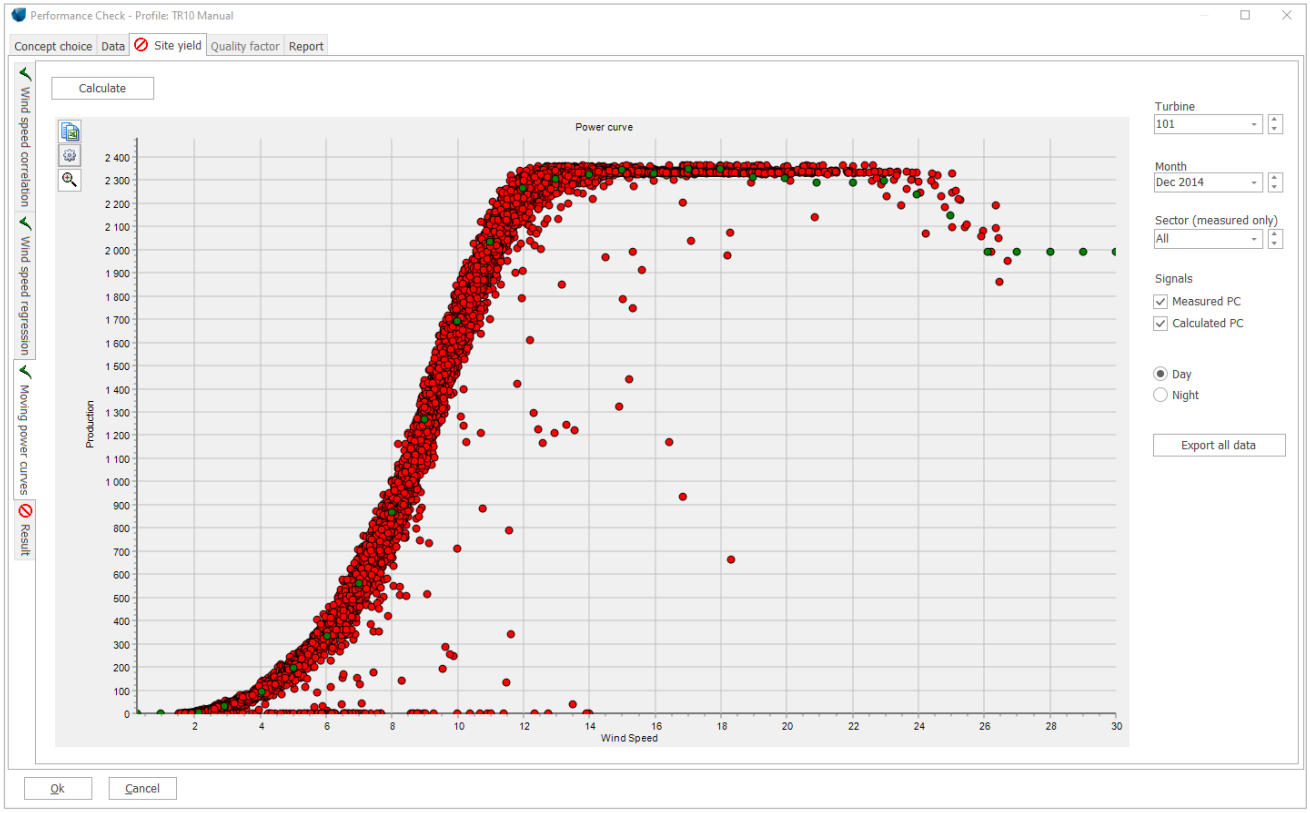
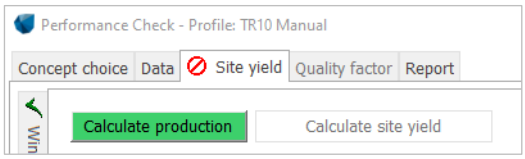


Figure 46 Calculated power curve(s)

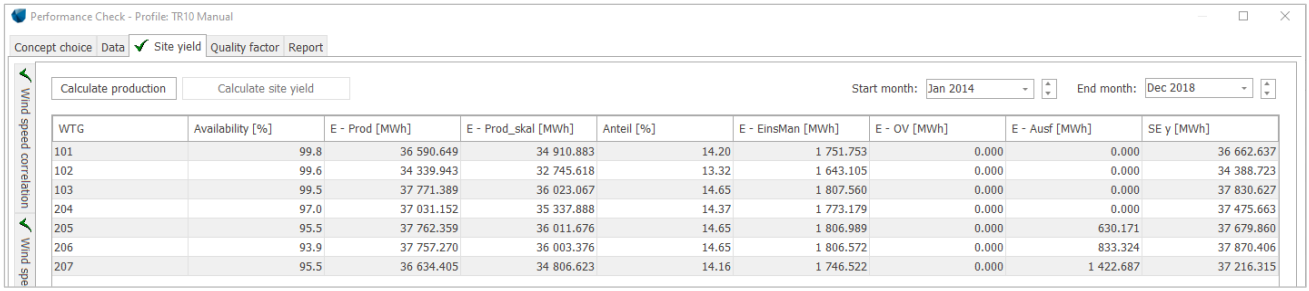
There are some view-setup options on the right side of the tab. None of the changes here has any effect to the calculation, but only on what is being displayed. The user can select, whether the day or night power curve should be displayed, etc.

13.10 Result

This tab gives an overview of the results so far. Click “Calculate production”. This step will sum up all 10-minute production values that has been imported from the SCADA system (E_{Prod}).



After E_{Prod} has been calculated and the plausibility check has been done, the button “Calculate site yield” becomes available. As soon as this one is used, you will see further results required by the TR10.



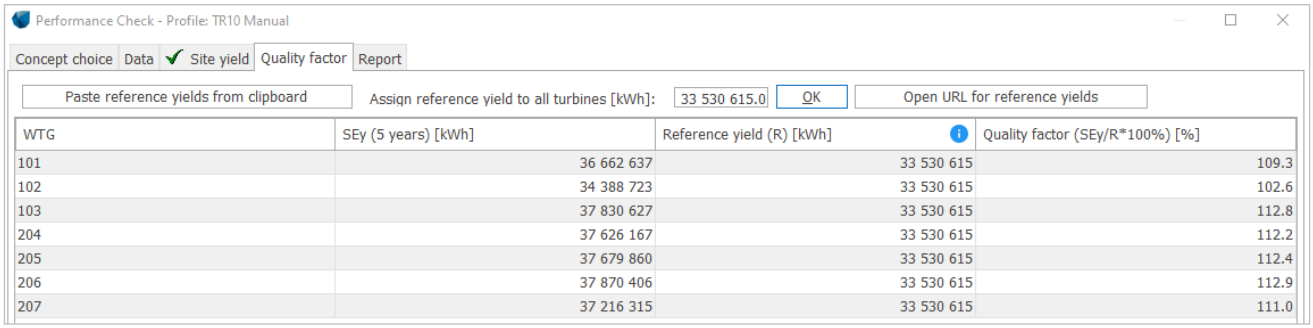
WTG	Availability [%]	E - Prod [MWh]	E - Prod_skal [MWh]	Anteil [%]	E - EinsMan [MWh]	E - OV [MWh]	E - Ausf [MWh]	SE y [MWh]
101	99.8	36 590.649	34 910.883	14.20	1 751.753	0.000	0.000	36 662.637
102	99.6	34 339.943	32 745.618	13.32	1 643.105	0.000	0.000	34 388.723
103	99.5	37 771.389	36 023.067	14.65	1 807.560	0.000	0.000	37 830.627
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

Figure 47 Results (not scaled to 5 years)

- $E_{Prod\_skal.}$ is the scaled production, resp. the production cleaned by electrical losses (TR10 chapter 5.3.).
- $E_{EinsMan}$ is the 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} is the electricity produced under optimized marketing.
- E_{Ausf} is then the fictitious electricity not produced due to the TR10 availability below or equal to 97% according to the TR10 chapter 6.3.
- SE_Y is the Site Yield and it is:
  - $\boldsymbol{SE_{y,WTGi} = E_{Prod\_skal.,WTG_i} + E_{EinsMan,WTG_i} + E_{OV,WTG_i}}$
    - for WTGs with availability 98% or higher.
  - $\boldsymbol{SE_{y,WTGi} = \frac{98\%}{V_{t,WTG_i}} * E_{Prod\_skal.,WTG_i} + E_{EinsMan,WTG_i} + E_{OV,WTG_i}}$
    - for WTGs with availability between 97% and 98%, where the "V_{WTG_i}" is the availability of the WTG “ *i* ”.
  - $\boldsymbol{SE_{y,WTGi} = \left(E_{Ausf,WTG_i} + E_{Prod\_skal.,WTG_i} + E_{EinsMan,WTG_i} + E_{OV,WTG_i}\right) * 98\%}$
    - for WTGs with availability below 97%.

13.11 Quality factor

For the calculation of the final result of the TR10, the quality factor, the WTG-specific Reference yield needs to be inserted. This can be done either step by step for each of the WTGs separately or in one step, if the Reference yield of all WTGs is identical.



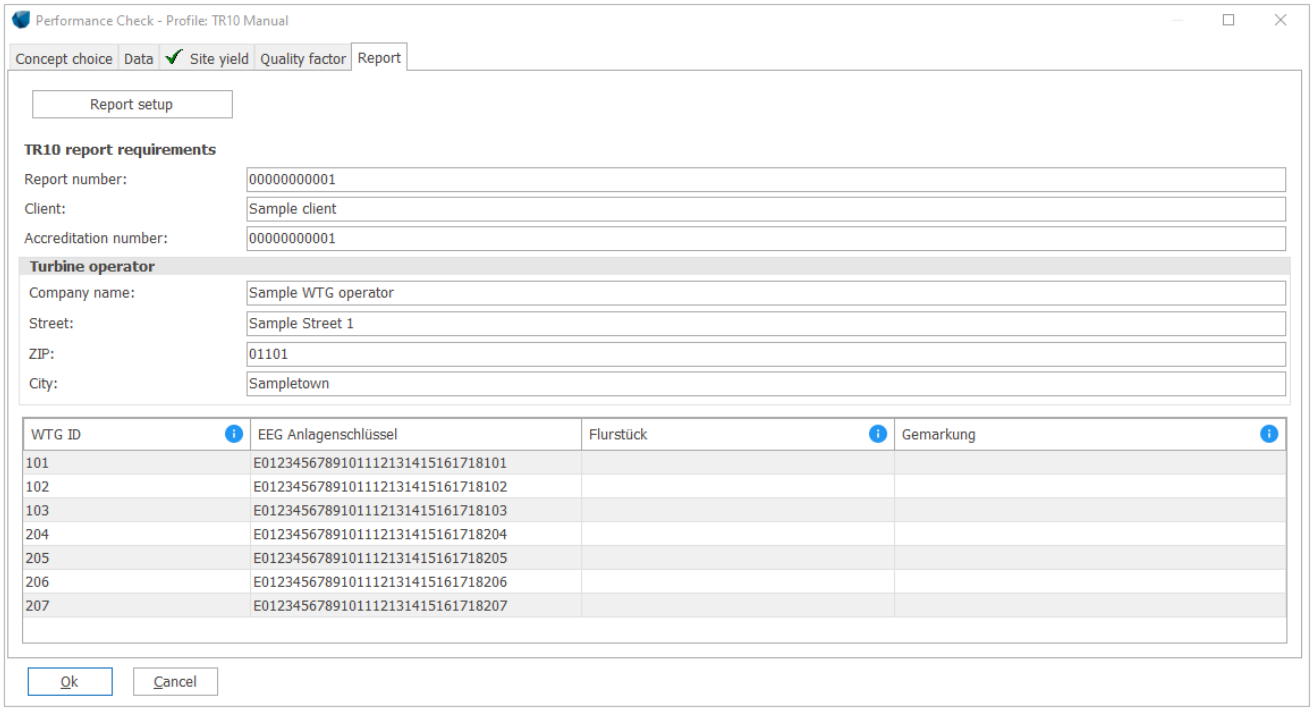
WTG	SEy (5 years) [kWh]	Reference yield (R) [kWh]	Quality factor (SEy/R*100%) [%]
101	36 662 637	33 530 615	109.3
102	34 388 723	33 530 615	102.6
103	37 830 627	33 530 615	112.8
204	37 626 167	33 530 615	112.2
205	37 679 860	33 530 615	112.4
206	37 870 406	33 530 615	112.9
207	37 216 315	33 530 615	111.0

Figure 48 Results (scaled to 5 years)

The Reference yields can be found on the FGW[9] homepage, which can be accessed directly from windPRO using the button “Open URL for reference yields”.

13.12 Report

The final results and formal TR10 requirements, can be exported into pdf reports at the end of the analysis from the tab “Report”. Besides the TR10 requirements the report additionally aims at documenting the data basis, data processing, partial results resulting from the analysis procedure and deviations from the required procedure.



WTG ID	EEG Anlagenschlüssel	Flurstück	Gemarkung
101	E012345678910111213141516171810 1		
102	E012345678910111213141516171810 2		
103	E012345678910111213141516171810 3		
204	E012345678910111213141516171820 4		
205	E012345678910111213141516171820 5		
206	E012345678910111213141516171820 6		
207	E012345678910111213141516171820 7		

Figure 49 Reports tab

[9] Fördergesellschaft Windenergie

The format of the report, resp. the formal requirements of the report, are defined in the TR10 in chapter 8. The button “Report setup” leads to the list of available reports.

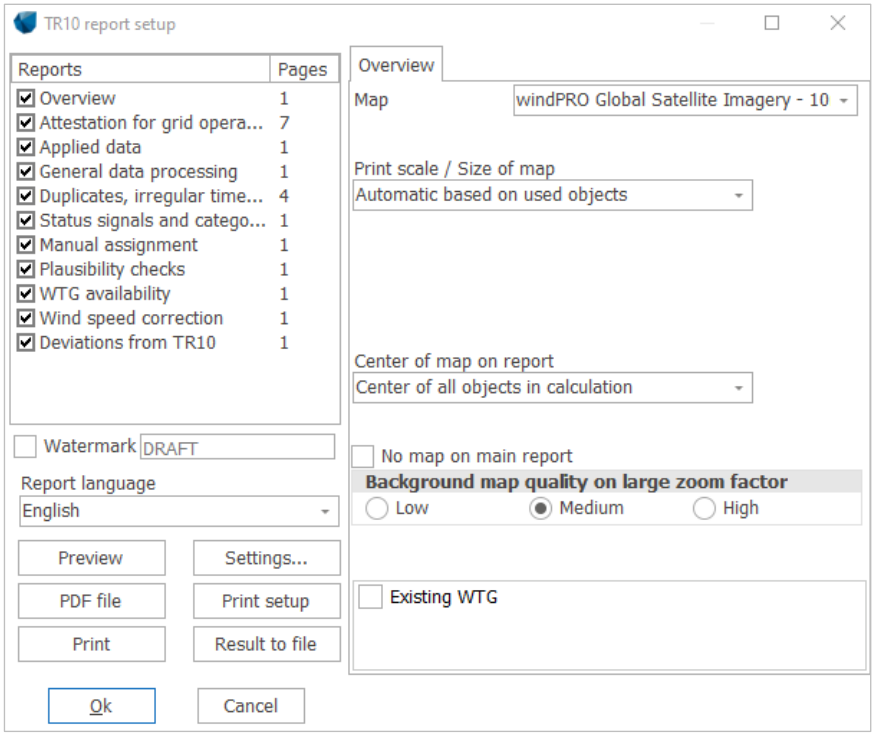
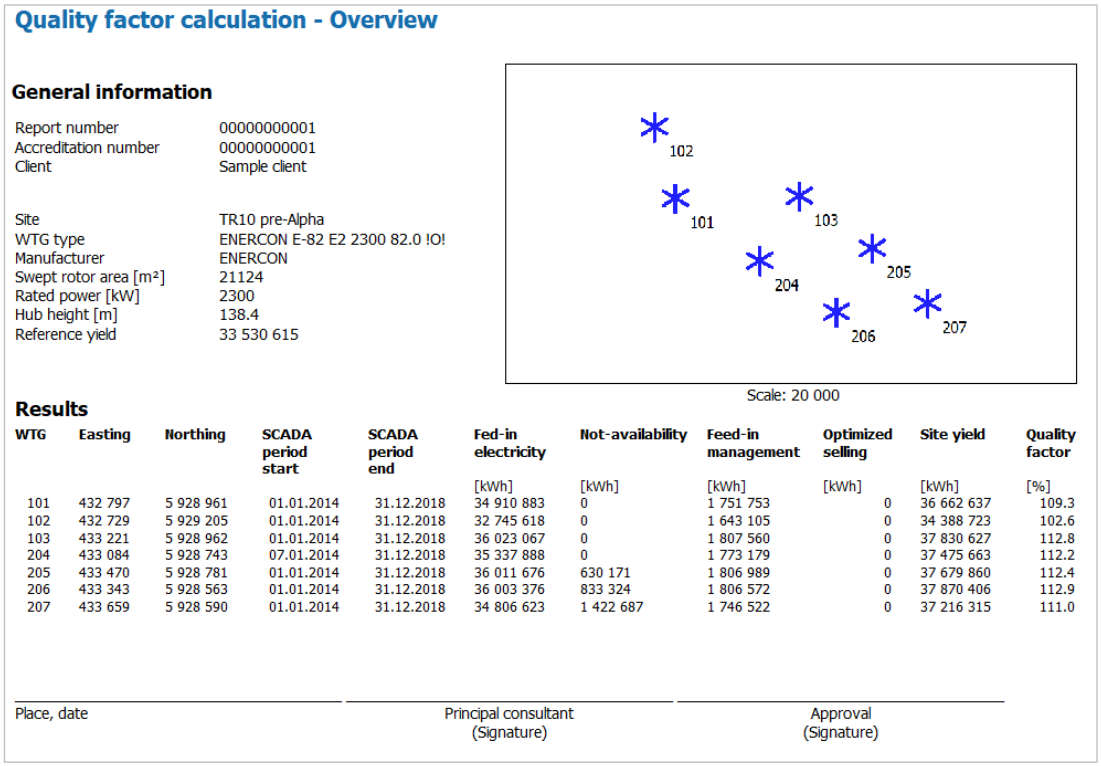


Figure 50 Reports setup

The TR10 tool in windPRO follows these requirements and extends it by some extra reports. For example, all time stamps that were marked as duplicates and / or irregular time stamps and removed are listed in the report “Duplicates, irregular time stamps and manually disabled data list”. In case of incompliance with the TR10 during the analysis, this will be reported in the report “Deviations from TR10”.



Quality factor calculation - Overview

General information

Report number	00000000001
Accreditation number	00000000001
Client	Sample client
Site	TR10 pre-Alpha
WTG type	ENERCON E-82 E2 2300 82.0 !O!
Manufacturer	ENERCON
Swept rotor area [m²]	21124
Rated power [kW]	2300
Hub height [m]	138.4
Reference yield	33 530 615

Scale: 20 000

Results

WTG	Easting	Northing	SCADA period start	SCADA period end	Fed-in electricity [kWh]	Not-availability [kWh]	Feed-in management [kWh]	Optimized selling [kWh]	Site yield [kWh]	Quality factor [%]
101	432 797	5 928 961	01.01.2014	31.12.2018	34 910 883	0	1 751 753	0	36 662 637	109.3
102	432 729	5 929 205	01.01.2014	31.12.2018	32 745 618	0	1 643 105	0	34 388 723	102.6
103	433 221	5 928 962	01.01.2014	31.12.2018	36 023 067	0	1 807 560	0	37 830 627	112.8
204	433 084	5 928 743	07.01.2014	31.12.2018	35 337 888	0	1 773 179	0	37 475 663	112.2
205	433 470	5 928 781	01.01.2014	31.12.2018	36 011 676	630 171	1 806 989	0	37 679 860	112.4
206	433 343	5 928 563	01.01.2014	31.12.2018	36 003 376	833 324	1 806 572	0	37 870 406	112.9
207	433 659	5 928 590	01.01.2014	31.12.2018	34 806 623	1 422 687	1 746 522	0	37 216 315	111.0

Place, date | Principal consultant (Signature) | Approval (Signature)

Figure 51 Main report example