Calculation of energetic loss of operating wind farms based on SCADA – Data

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Abstract

The German Renewable Act 2017 (EEG) [1] requires from all turbines erected under that act an assessment of the feed-in energy but as well energy which could have been potentially produced after 5, 10 and 15 years of operation. Having some criteria in the renewable act defined the whole process how to calculate energetic losses to fulfil the requirements was not described so far.

The Technical Guideline 10 published beginning of 2018 by the FGW e.V. [2] describes the way how energetic loss is calculated by using 10 Minutes data in connection with Status codes of the turbine. The detailed description how Status codes are summarized and which 10 Minutes data are used to create a representative power curve to calculate the energetic losses will show how finally the energetic availability is derived.

One the one hand the defined process is related to the German renewable act but on the other hand the Technical Guideline 10 (TR 10) [2] is the first guideline describing how to calculate energetic losses based on SCADA data.

In regards to the amount of data based on 5 years SCADA Data an automated approach is necessary. The presented big data approach could be easily adopted to each wind turbine in operation everywhere in the world to define an independent and standardized assessment of the energetic loss in operation creating the base fur further performance assessment.

Introduction

As it is defined in the German Renewable Act 2017 (EEG) [1] for receiving further feed-in tariffs the energetic loss based on the last 5 years of operation has to be determined if the time based availability is below 98%. In this context availability in accordance to the EEG has a partly different definition as it is described e.g. in IEC TS 61400-26-1 [3].

As the EEG refers to turbine specific data it is necessary to rely on the SCADA data of the respective turbines for the energetic loss calculation.

The recently published Technical Guideline 10 (TR 10) by FGW e.V. [2] provides guidance on these questions and thus defines the calculation method for compliance with the EEG.

Status Codes Categories

For the calculation of energetic loss it is necessary to categorize the events which are defined as available or non-available.

Based on the requirements of the EEG, 5 categories for classifying the various status codes have been defined in the TR 10. It is the intention of the TR 10 that the manufacturers classify the turbine type related status codes in these 5 categories and get the classification certified by a third party. The following categories have been defined.

0	1	2	3	4
Intentional operation according specification	Reduced mode or shut-down based on permission related restrictions	Reduced mode or shut-down due to other reasons - non availability	Reduced mode or shut-down based on grid curtailment (compensated)	Reduced / optimized mode or shut-down based on trading outside EEG

For further processing it is necessary to connect one of these categories to each 10 minute time step of the SCADA data from the Event/Status Log file. The classification of operational modes in these categories is described in detail in the TR 10 [2].

The resulting definition of availability or non-availability based on this categorization is partly not matching with the definition given in the IEC TS 61400-26-1 [3] or in contracts with manufacturers.

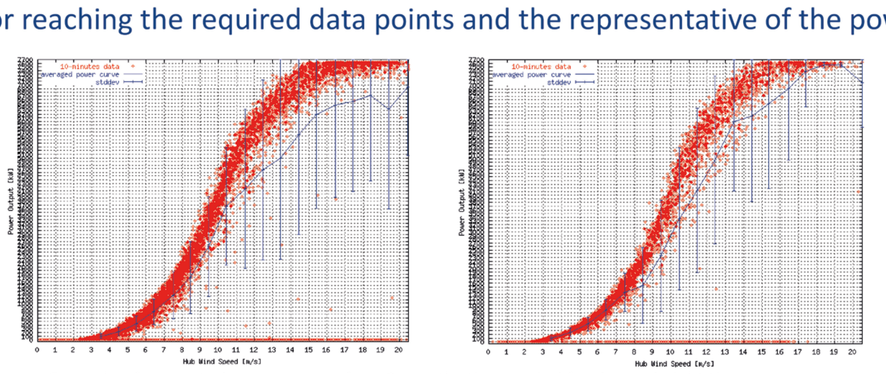
The categories 0 and 1 are defined as available and category 2 as non-available. The categories 3 and 4 are handled separately according EEG.

References

1. Gesetz für den Ausbau erneuerbarer Energien (Erneuerbare-Energien-Gesetz-EEG 2017), BGBL Teil I Seite 1629, Bonn, 2016
2. FGW e.V. – Fördergesellschaft Windenergie und andere Dezentrale Energien, Technische Richtlinien für Windenergieanlagen, Teil 10, “Bestimmung der Standortgüte nach Inbetriebnahme” Revision 0, Berlin 2018
3. International Electrotechnical Commission (IEC), IEC TS 61400-26-1:2011 Wind turbines- Part 26-1: Time based availability for wind turbine generating systems, Geneva, 2011

Power Curve Creation

For assessing the energetic loss turbine specific power curves have to be generated which are applicable for the periods where non-availability occurred to calculate the possible production. For creating these power curves all events falling under category 0 and 1 are used. As different factors influence a power curve over time it is important to use a power curve which is representative for the time of the non-availability event. The TR 10 recommends the use of a moving 3 month period power curve differentiated in day and night time to cover possible reduced mode during night. Several criteria are described in the TR 10 for reaching the required data points and the representative of the power curve.



Example of generated power curves for a 3 months time period for day and night time

Correlation Assessment

As it is known in periods of non-operation the nacelle anemometer is mostly not showing appropriate wind speed values due to different reasons. The use of the recorded wind speeds would lead to non-accurate production values when filling the gaps with a derived power curve. For that reason it is necessary to correct wind speed values in time steps marked as non available. The correction factor can be determined by linear regression with the data of nearby wind turbines or other meteorological data sources. In that process it is defined in TR 10 to focus on 30° sectors and 3 month time periods for calculating the correlation (R^2). The highest correlation per sector and reference is the selection criteria for correcting the original values. Accordingly to the generation of power curves a differentiation between day and night is necessary.

	345°-15°	15°-45°	45°-75°	75°-105°	105°-135°	135°-165°	165°-195°	195°-225°	225°-255°	255°-285°	285°-315°	315°-345°
WT1-WT2	0.874	0.771	0.799	0.735	0.733	0.825	0.826	0.812	0.925	0.935	0.903	0.911
WT1-WT3	0.8	0.666	0.819	0.663	0.665	0.626	0.537	0.702	0.898	0.907	0.871	0.843
WT1-WT4	0.312	0.408	0.577	0.82	0.84	0.849	0.832	0.785	0.883	0.903	0.85	0.763
WT1-WT5	0.805	0.596	0.524	0.402	0.5	0.711	0.765	0.774	0.802	0.805	0.772	0.729
WT-MetData	0.437	0.132	0.362	0.566	0.46	0.443	0.595	0.509	0.641	0.638	0.542	0.527

Example of R^2 for a 3 months time period for nearby Wind turbines and Meteorological Data for day time in the defined sectors

WT1-WT2	0.874	0.771	0.799	0.735	0.733	0.825	0.826	0.812	0.925	0.935	0.903	0.911
WT1-WT3	0.774	0.753	0.831	0.788	0.808	0.677	0.685	0.906	0.941	0.942	0.894	0.834
WT1-WT4	0.248	0.548	0.738	0.722	0.829	0.923	0.891	0.927	0.929	0.928	0.876	0.777
WT1-WT5	0.808	0.739	0.739	0.762	0.732	0.828	0.874	0.907	0.859	0.817	0.777	0.738
WT-MetData	0.362	0.235	0.419	0.561	0.513	0.494	0.561	0.661	0.676	0.629	0.489	0.5

Example of R^2 for a 3 months time period for nearby Wind turbines and Meteorological Data for night time in the defined sectors

Based on the described process a new timeline based on corrected wind speed values is generated for further processing.

Energetic Loss

The possible production of each non-availability event (category 2) will be assessed based on the corrected wind speed value and the respective power curve for the period of the event. The sum of the calculated production is the energetic loss for the regarded 5 year period.

Conclusion and Outlook

While the process and requirements described are somehow specific to German market requirements the TR 10 could be stated as the first guideline describing a frame and a way to calculate energetic losses and a first step of a harmonization of energetic loss calculation.

In regards of the amount of at least 5 years of 10 minutes data and the requirements of the TR 10 a specific approach is necessary to handle the huge amount of data.

UL developed several automated processes to fulfil the criteria of the EEG and the TR 10 to assess the energetic losses which are part of the mandatory Site Quality Assessment in Germany after 5, 10 and 15 years of operation.

Furthermore these processes can be easily adopted for any wind farm in the world for different periods of time or other definitions of availability and could be the base for further performance assessments.