VERIFICATION OF THE REQUIREMENTS OF THE ENTSO-E "NC RFG" – REDUCING THE WORKLOAD ON TSO AND DSO BY INDEPENDENT CERTIFICATION

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ABSTRACT

The integration of renewables as well as changing requirements on the electricity networks worldwide lead to increasingly complex grid codes. As a result of this, ensuring the conformity of power generating facilities with the network codes becomes a more and more challenging and time consuming task for grid operators. In particular smaller DSOs are often confronted with a huge workload from the many small distributed power generating facilities within their grids such as wind farms, solar parks and combined heat- and power plants. This paper presents a viable – as tested – way of reducing the workload on grid operators by third party certification considering requirements of the NC RfG by ENTSO-E.

INTRODUCTION

The current draft of the "Network Code on Requirements for Grid Connection Applicable to all Generators" (NC RfG, [1]) by the "European Network of Transmission System Operators for Electricity" (ENTSO-E) provides a common framework of requirements for power generating facilities. The network code demands a "Power Generating Module Document" (PGMD) including a "Statement of Compliance" (SoC) to be supplied. The SoC has to give details on the compliance of the facility itemised for each relevant element of the NC RfG and must be accepted by the network operator prior to issuing the "Final Operational Notification". Considering that more than 50 different requirements are included in the NC RfG this will lead to an increased workload on most TSOs and DSOs.

Verifying that requirements of grid codes are obeyed by generating facilities has been done successfully via independent third party certification in Germany for several years now. In this case an accredited certification body checks the compliance of the park with the requirements of the grid code and – if compliance has been established – supplies a certificate to the grid operator summarising the results in a concise form as well as providing further details in a separate report. Through the certificate the certification body assumes partial liability and has the duty to follow up any incidents that might affect the certified properties during the validity of the certificate.

Introducing independent third parties in the certification process has helped to reduce the number of conflicts between park owners, planners and system operators. At the same time the grid connection procedure has been sped up through additionally available resources and the grid operators have been relieved in terms of workload as well as responsibility. Added sustainability can be achieved by further monitoring duties of the certification body for the certified wind and solar parks.

The paper suggests a way of verifying the requirements of the NC RfG through third party certification while providing examples from the certification in Germany.

CERTIFICATION IN GERMANY

In 2009 the German government introduced the "Ordinance on System Services by Wind Energy Plants" (System Service Ordinance – SDLWindV, [2]) which defines requirements on wind power plants and the need for an independent confirmation that those requirements are met by the wind park. This confirmation has to be provided by certification bodies that are accredited according to DIN EN 45011:1998 (and in future accredited according to EN ISO/IEC 17065:2012). The appropriate level of expertise of the certification body is regularly assessed by the German member of the "European co-operation for Accreditation". The results of the examination are published on the website of the accreditation body to ensure an open and transparent manner.

Concerning the technical requirements the SDLWindV refers for wind farms connected to the medium voltage grid to the BDEW guideline "Generating Plants Connected to the Medium-Voltage Network" (BDEW MVG, [3]) and its 3rd supplement [4]. For wind parks that are connected to the high voltage grid the SDLWindV demands that the requirements of the TransmissionCode 2007 (TC 2007, [5]) have to be met while some details of the TC 2007 are adjusted in the SDLWindV.

In order to provide common ground concerning the interpretation and requirements of the guidelines between manufacturers, system operators, testing institutes and certification bodies, a coordinated framework for the corresponding inspection and certification procedures has been established in the "Technical Guidelines 8 for Power Generating Units" [6] published by the FGW. The general process of the certification in Germany is shown in Figure 1.

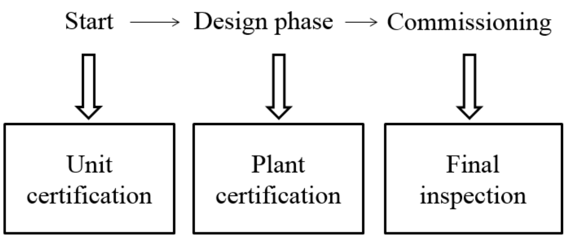

Figure 1: Three steps of the certification process in Germany (unit certification, plant certification and check of conformity)

The certification in Germany is performed by about 20 certification bodies with a total of roughly 250 experts. These authorities ensure independent assessment on power generating units (PGUs) and power generating facilities (PGFs) as well as secrecy on confidential data from manufactures and grid operators.

In Europe approximately 2600[1] DSOs and 41[2] TSOs are responsible for the network stability. According to the draft of the NC RfG they will have the duty to verify the compliance of the power generation facility with the requirements of the network code. This task can pose a significant additional workload which can be alleviated by independent certification.

POWER GENERATING UNITS

Generating units such as solar inverters, wind turbines and combustion engines contain up to 50,000 unit-specific parameters, of which many have an influence on the grid. Profound expert knowledge about different PGUs as well as control systems, de-coupling units and settings is necessary to assess the grid impact. Furthermore essential on-going developments of units, emerging technologies and software updates occur – sometimes several times each year – which lead to time consuming work in order to keep up with technical innovations as well as their conformity to the latest requirements. Certification bodies can guarantee the technical know-how on generating units and assessment of measurements of the unit-specific parameters and the grid impact.

In Germany many wind turbines and solar inverters of leading manufacturers are already certified for high system performance. The certification provides details on the operational ranges of the PGU and usually includes the validation of a simulation model of the generating unit which describes its electrical behaviour during grid faults.

The table below provides an impression of the number of certified power generating units that are currently available worldwide.

Type of PGU		Different types[3,4]	Certified[5]	Ratio
Wind turbines	Old types	401	16	~4%
	Under produc-tion	441	72	~16%
Solar inverter	Old types	~2800	-	~0%
	Under produc-tion	~4500	448	~10%

Table 1: Ratio of certified units

The NC RfG has taken these advantages on and allows for the use of unit certificates as the following definition shows:

"Equipment Certificate – is a document issued by an Authorised Certifier for equipment used in Power Generating Modules confirming performance in respect of the requirements of this Network Code. In relation to those parameters, for which this Network Code defines ranges rather than definite values, the Equipment Certificate shall define the extent of its validity. This will identify its validity at a national or other level at which a specific value is selected from the range allowed at a European level. The Equipment Certificate can additionally include models confirmed against test results for the purpose of replacing specific parts of the compliance process for Type B, C and D Power Generating Modules. The Equipment Certificate will have a unique number allowing simple reference to it in the Installation Document or the Power Generating Module Document."

POWER GENERATING FACILITIES

Although the title of the NC RfG contains "[…] Requirements for Generators" it defines (according to its Article 1) requirements for the complete "Power Generating Facility", i.e. the wind farm or solar park. Some of these requirements concern

- active power provision
- reactive power provision and
- dynamic grid support.

These aspects are considered further in the following sections and possible ways of verification are given.

[1]Number of DSOs from http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Cross-Sectoral/Tab/C12-UR-47-03_DSO-Unbundling_Status%20Review_Public.pdf [18.12.2014]

[2]Number of TSOs from https://www.entsoe.eu/about-entso-e/inside-entso-e/member-companies/Pages/default.aspx [13.01.2015]

[3]Numbers of wind turbines taken from http://www.thewindpower.net/actor_content_en.php?id_type=4 [18.12.2014]

[4]Numbers of solar inverters according to a validation of PHOTON publishing GmbH [09.10.2013]

[5]Numbers of certified PGUs taken from http://www.wind-fgw.de/pdf/Zertifikate_Neuanlagen.pdf [18.12.2014]

However, the NC RfG does only specify about a dozen requirements completely. For the majority of the requirements possible ranges are provided and the details have to be specified at national level. Furthermore, the NC RfG distinguishes between four types, type A to D, which depend on the voltage level as well as on the capacity of the plant and the requirements increase with each type.

Active power provision

An important aspect concerning the grid stability is the adjustment of active power provision due to frequency changes. Depending on the type of the power generating facility, different active power frequency responses have to be implemented. Figure 2 shows the required behaviour in the so called “Frequency Sensitive Mode” (FSM) for type C facilities according to the NC RfG.

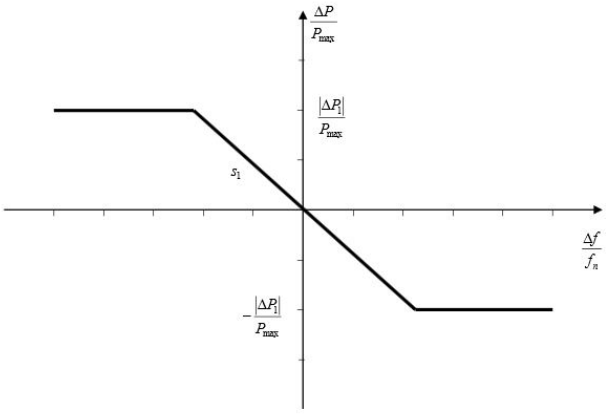

Figure 2: FSM requirement according to the NC RfG

The verification that the requirement is satisfied can be done in two steps: Firstly, the equipment certificates of the PGUs in the system need to contain the confirmation that the generating units generally allow the demanded settings and meet the requirements on a type tested basis. Then secondly, the correct settings of the generating units in the field need to be checked. This can be done via inspections in the park or through remote access on the generating units.

In a similar way other active power frequency responses like the LFSM-U and the LFSM-O, which even power generating facilities of type A must be capable of, can be verified. Further details can be found in [7].

Reactive power provision

In order to control the voltage in the grid, sufficient reactive power needs to be available for the grid operator. The NC RfG provides boundaries as well as maximal ranges for the reactive power that can be demanded at the grid connection point. Figure 3 shows the differences between the requirements from the German TC 2007 and the maximum range that the grid operator can request for power generating facilities of type C and D in Continental Europe according to the NC RfG. The outer red envelope of the NC RfG is fixed while the inner dashed blue envelope defines the maximum range for the reactive power provision and can be moved anywhere within the outer envelope.

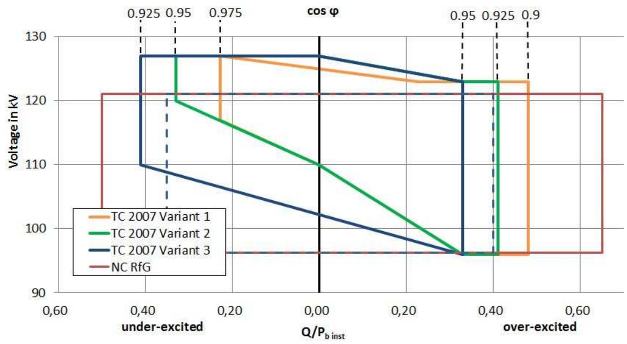

Figure 3: Comparison of the existing three variants 1-3 of the TC 2007 [5] with the envelopes for the reactive power provision in [1]

The following figure illustrates an example of the calculated reactive power supply within a German wind farm compared to the required static provision of reactive power depending on the level of active power. The computations are done using a simulation software in which the power generating facility with all generating units, cables, transformers, the park controller and further relevant electrical equipment is set up.

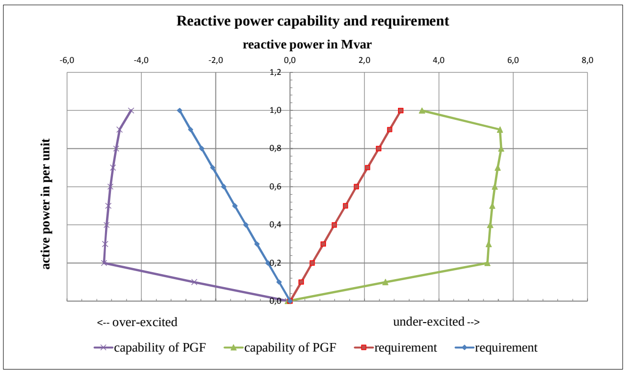

Figure 4: Comparison of the reactive power capability with the requirements

If the simulation results do not lie within the required ranges, measures have to be taken to guarantee sufficient reactive power supply. In case that the shortage is realised when the PGF is already in operation, this can be done by retrofitting the units, reducing the active power or installing compensation systems within the park. Performing the external check of the planning materials of the power generating facility already during the planning phase, can avoid cost-intensive retrofitting and accelerates the grid connection process.

Dynamic grid support

The validated PGU models from the unit certificate allow the certification bodies to perform dynamic simulations of the power generating facility. These simulations are helpful to illustrate and evaluate the behaviour of the PGFs during possible grid faults.

In the event of voltage drops power generating facilities need to support the network in order to avoid unintentional disconnections of large feed-in units. This is achieved by appropriate fault ride through (FRT) behaviour which consists of the ability of the power generating facility to remain connected to the grid during faults and to support the voltage by feeding in reactive current.

Figure 5 gives an example on the required fault-ride-through profile which describes the voltage level as a function of time during and after the fault up to which the unit must stay connected to the grid.

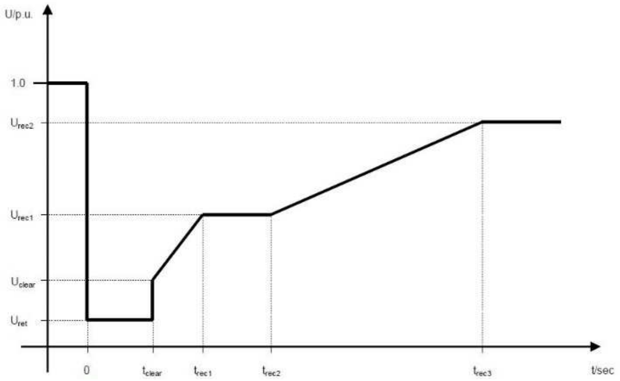

Figure 5: FRT curve from the NC RfG

The NC RfG has two levels of requirements concerning the fault-ride-through capability according to the size of the power plant (either type B/C or type D) in combination with the voltage level (below 110 kV and from 110 kV upwards). For ease of comparison here the requirements for a medium-voltage power generating facility of type B in the NC RfG and the BDEW MVG will be considered. As the precise settings are to be specified by the system operator, for the comparison here the "best" case (minimal requirements according to [1], green curve in Figure 6) and the "worst" case scenario (maximal requirements according to [1], red curve) are compared to the FRT curve for a type-2-generating unit of the BDEW MVG.

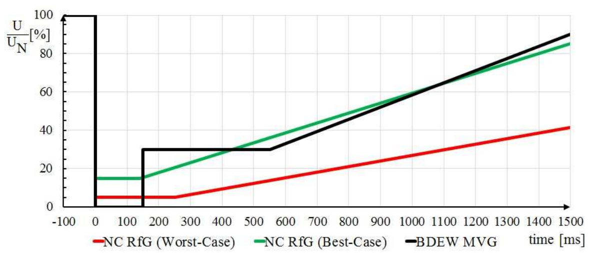

Figure 6: Comparison of the FRT profile in [1] and [3]

The result shows that in the first 150 ms the requirements from the BDEW MVG are sharper than those from the NC RfG. However, after this initial time the requirements that are possible according to the NC RfG are in the best case almost equal to the BDEW requirements but can also be considerably more challenging if the grid operator chooses the worst case requirements.

Finally, a comparison of the requirements between a PGF of type D from the NC RfG and a generating facility using renewable energy sources of type 2 from the TC 2007 is given in Figure 7.

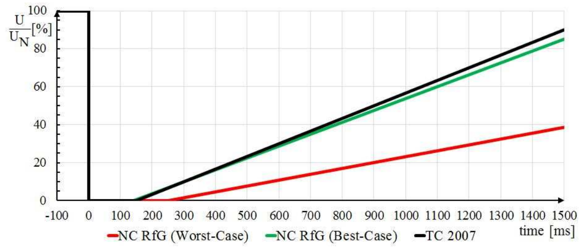

Figure 7: Comparison of the FRT profile in [1] and [5]

Again, the best case example is almost in line with the current requirements in Germany while the NC RfG allows voltage profiles that are more challenging.

The verification of the correct dynamic behaviour has been done successfully in Germany for some years. Figure 8 illustrates example results that are obtained from a dynamic simulation for a symmetrical fault. Presented are the voltage curve and the behaviour of active and reactive current at the grid connection point before, during and after the fault.

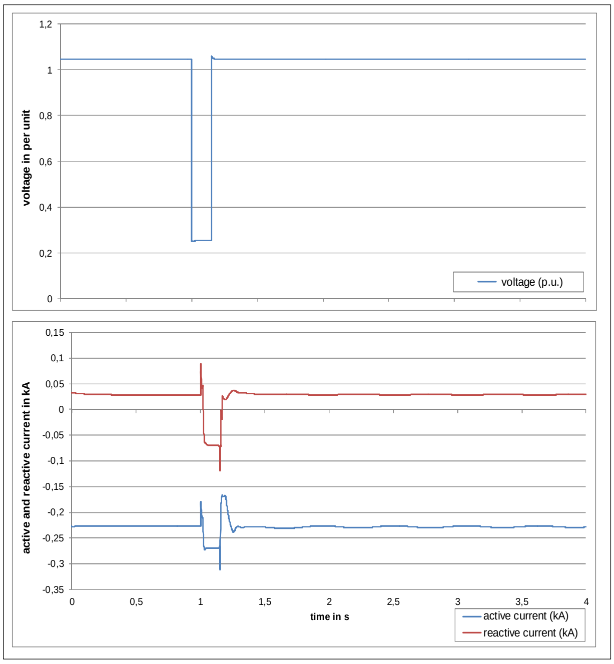

Figure 8: Example of dynamic simulation results for a symmetrical fault

Simulations for different levels of voltage drops and different fault durations can be performed for symmetrical and unsymmetrical events providing insight into the behaviour of the park during grid disturbances.

Furthermore, the NC RfG allows grid operators to request static and dynamic simulation models of power generating facilities of type C and D which shall be used for the verification of the requirements of the network code. The certification body can either provide these models using their own park setup or perform the check and validation of the park models as an independent third party. This can reduce the control work on TSOs and DSOs and improve the quality of the models which shall also be used according to the NC RfG "in studies for continuous evaluation in system planning and operation".

EXPERIENCES FROM GERMANY

Tests performed by a large DSO in Germany have shown that two thirds of the wind farms that were connected to the DSO's grid in the years 2004 to 2009 (prior to the requirement for certification) have not been able to meet the requirements. The problems concerned in particular – but not exclusively – the dynamic and static grid support. Since introducing the certification this ratio has been reduced to 5% of the connected parks. This result could be validated by M.O.E. during the retrofit program of the existing turbines (installation period from 2002 to 2008).
The significant improvement is due to the certification process as the results from an investigation of the certified projects in 2013 from six certification bodies with a total of 3.5 GW installed power has shown: In more than 80% of the projects the provided documents and settings had to be improved in order to obtain a certificate. These numbers show the large impact of the certification on the quality of the connected renewable energies and in turn on the performance, stability and safety of the grid.
In addition conflicts between park developers, park owners and grid operators have been reduced. Since the certification obligation had entered into force in Germany there have been rarely any litigations that certification bodies have been involved in.

CONCLUSION

This paper considered requirements from the draft of the ENTSO-E NC RfG and discussed how TSOs and DSOs can be relieved of some of the new control burden through independent third party certification. Examples of the practice in Germany have been described and experiences given, showing that certification is a good option for the verification of grid code compliance.

REFERENCES

[1] ENTSO-E - European Network of Transmission System Operators for Electricity, *"ENTSO-E Network Code for Requirements for Grid Connection Applicable to all Generators"*, Brussels, Draft from 08/03/2013

[2] *"Ordinance on System Services by Wind Energy Plants (System Service Ordinance – SDLWindV)"*, 03/09/2009, last amended 21/07/2014.

[3] Bundesverband der Energie- und Wasserwirtschaft e.V., *"Generating Plants Connected to the Medium-Voltage Network - Guideline for Generating Plants' Connection to and Parallel Operation with the Medium-Voltage Network"*, Berlin, June 2008

[4] Bundesverband der Energie- und Wasserwirtschaft e.V, BDEW MSR 3rd supplement *"Rules and transitional periods for specific requirements complementary to the technical guideline: Generating Plants Connected to the Medium-Voltage Network - Guideline for Generating Plants' Connection to and Parallel Operation with the Medium-Voltage Network"*, Berlin, 15/02/2011

[5] Verband der Netzbetreiber - VDN – e.V. beim VDEW, *"TransmissionCode 2007 - Network and System Rules of the German Transmission System Operators"*, Berlin, August 2007

[6] Fördergesellschaft Windenergie und andere Erneuerbare Energien e.V., *"Certification of the Electrical Characteristics of Power Generating Units and Systems in the Medium-, High- and Highest-voltage Grids"*, Revision 06.

[7] F. Scheben, J. Moeller, 2013, "Recent and Planned Changes in the Standards and Network Codes for the Grid Connection of Wind Power in Germany", *Proceedings of the 12th International Workshop on Large-scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants*, vol.1, 152-157