Guidelines on verification report

Technical regulation 3.2.2
for PV power plants with a power output above 11 kW

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Reading instructions

The present guidelines describe how to prepare a verification report to demonstrate that a *PV power plant* complies with the technical, functional and documentation requirements which all *plants* with a *rated power* of 50 kW must comply with in order to be connected to the grid in Denmark.

The guidelines are published by Energinet.dk and can be downloaded from www.energinet.dk.

1. Terminology and definitions

The general terms and definitions stated in TR 3.2.2, section 1, are used in this document.

Specific terms or definitions used in the verification report must be stated in this section.

2. Requirements for verification test

2.1 Introduction

Brief introduction to the verification test, specifying the technical and temporal scope of the test.

Technically, the following must be verified:

- Tolerance of frequency and voltage deviations
- Power quality
- Control and regulation
- Protection
- Data communication and exchange of signals
- Signal list.

The exact environmental and other relevant conditions for each test must be specified, including temperature, irradiation, cloudiness, grid voltage and grid frequency etc.

The duration of each test must be specified.

2.2 Test set-up

This section must include all verification set-ups, including an outline of the relationship between all major system components together with associated programs and tools.

In this section, the versions of all components, programs and tools of any kind which form part of the verification must also be indicated.

2.3 Scope of test

The scope of each verification test must be specified – for instance, the test or sub-test selected for verification of a requirement.

If sub-tests are mutually dependent, it must be explained how possible impacts from previous tests have been minimised or clarified in the test results.

2.4 Test conditions

All test conditions applying to each test must be specified – both internal and external. Internal test conditions include *plant* configurations, grid configuration, primary and secondary grid set-ups and state of maintenance etc.

All external conditions relevant to the specific test must be indicated, for instance irradiation, cloudiness, temperature, grid voltage, grid frequency etc.

2.5 Reference documents

This section must include all documents which form the basis of the test, or which are used during the test.

3. Verification of requirements for control and regulation

R5.1	If a *plant* has been disconnected due to a failure in the *public electricity supply grid*, the *plant* must at the earliest connect automatically three minutes after the voltage and frequency once again lie within the *normal production* area.	Verify that the *plant* connects as specified.
R5.2	A *plant* which has been disconnected by an external signal prior to a failure occurring in the *public electricity supply grid* must not be connected until the external signal has been eliminated, and the voltage and frequency once again lie within the *normal production* area.	Verify that the *plant* connects as specified.
R5.3	All set point changes and orders must be registered together with an identification of the operator.	Verify that all recordings are performed as specified.
R5.4	All set point changes or orders for production changes must be time stamped.	Verify that all recordings are performed as specified.

3.1 Active power control functions

R5.5	In case of frequency deviations in the *public electricity supply grid*, the *plant* must be able to provide *frequency control* in order to stabilise the grid frequency (50.00 Hz).	Demonstrate that the *plant* is capable of meeting the frequency stability requirements.
R5.6	All frequency point settings must be indicated with a minimum resolution.	Demonstrate that the *plant* is capable of meeting the resolution requirements.
R5.7	Accuracy of grid frequency measurements.	Demonstrate that the *plant* is capable of meeting the requirements for frequency measurement accuracy.
R5.8	It must be possible to set the *frequency control* function for all frequency points as specified.	Demonstrate that the *plant* is capable of meeting the set-up requirements.
R5.9	In case of grid frequencies above f_5, upward regulation must not be commenced until the grid frequency is lower than f_7.	Demonstrate that the *plant* is capable of meeting the control requirements.
R5.10	P_{Delta} is the set point by which the current active power has been reduced to provide frequency stabilisation (upward regulation) in case of falling grid frequency.	Demonstrate that the *plant* is capable of meeting the frequency stability requirements.
R5.11	It must be possible to enable the *frequency control* function in the f_{min} to f_{max} range.	Demonstrate that the *plant* is capable of meeting the requirements for dynamic range.
R5.12	The *plant* must be capable of continuously regulating the active power to a random value in the interval from 100% to 0% of the *rated power*.	Demonstrate that the *plant* is capable of meeting the function requirements.

R5.13	An absolute production constraint is used to constrain the active power from a *plant* to a predefined power limit in the *point of connection*.	Demonstrate that the *plant* is capable of meeting the requirements for the control constraint function.
R5.14	A delta production constraint is used to constrain the active power from a *plant* to a required constant value in proportion to the possible active power.	Demonstrate that the *plant* is capable of meeting the requirements for the control constraint function.
R5.15	A power gradient constraint is used to limit the maximum speed by which the active power changes in the event of changes in irradiation or changes in the set points for the *plant*.	Demonstrate that the *plant* is capable of meeting the requirements for the control constraint function.

3.2 Reactive power control functions

R5.16	The reactive power control functions are mutually exclusive, which means that only one of the three functions can be activated at a time.	Demonstrate that the *plant* is capable of meeting the requirements for reactive control functions.
R5.17	*Q control* is a control function ensuring that reactive power is supplied continuously and independently of the active power in the *point of connection*. It must be possible to change the *Q control* by means of set points with a resolution of 1 kvar.	Demonstrate that the *plant* is capable of meeting the *Q control* requirements.
R5.18	*Power factor control* is a control function that ensures variable reactive power in proportion to the active power in the *point of connection*. It must be possible to change the *power factor* by means of set points with a resolution of 0.01.	Demonstrate that the *plant* is capable of meeting the requirements for *power factor control*.
R5.19	*Automatic power factor control* is a control function whereby the *power factor* changes depending on the active power production.	Demonstrate that the *plant* is capable of meeting the requirements for *automatic power factor control*.
R5.20	*Voltage control* is a control function that stabilises the voltage in the *voltage reference point*. *Voltage control* must have a setting range for minimum to maximum voltage, as indicated, with a resolution of 1 kV.	Demonstrate that the *plant* is capable of meeting the *voltage control* requirements.
R5.21	It must be possible to set the *droop* of the *voltage control* within the 2-8% range with a resolution of 1% and an accuracy of ±0.2%.	Demonstrate that the *plant* is capable of meeting the *voltage control* requirements.
R5.22	When the *voltage control* is adjusted to the *plant's* dynamic planning limits, the control function must await possible overall control from the tap changer or other *voltage control* functions.	Demonstrate that the *plant* is capable of meeting the *voltage control* requirements.

3.3 System protection

R5.23	A *plant* must be equipped with system protection – a control function which must be capable of automatically downward regulating the active power supplied by a *plant* to one or more predefined set points. The number and value of the set points are determined by the *grid company* upon commissioning.	Demonstrate that the *plant* is capable of meeting the function requirements.
R5.24	Control following activation must be commenced as quickly as technically possible.	Demonstrate that the *plant* is capable of meeting the function requirements.

4. Verification of protection requirements

R6.1	Protective functions with associated operating settings and trip time must be as indicated in the relevant sections in TR 3.2.2.	Relay set-ups at the time of commissioning must be stated in the documentation.

5. Verification of data communication requirements

R7.1	The *plant* must be prepared for receiving an external start signal (released) and an external stop signal. The signals must be accessible via commands in accordance with the specifications.	Demonstrate that the *plant* is capable of meeting the function requirements.
R7.2	It must be possible to obtain correct measurements and maintain data communication in all situations, including when *plants* are shut down and the grid is dead. Local back-up supply must as a minimum ensure the logging of relevant measurements and data and ensure the controlled shut-down of the *plant's* control and monitoring system.	Demonstrate that the *plant* is capable of meeting the function requirements.
R7.3	All measurements and data relevant to recording and analysis must be logged with a time stamp and an accuracy ensuring that such measurements and data can be correlated with each other and with similar recordings in the *public electricity supply grid*.	Demonstrate that the *plant* is capable of meeting the requirements.
R7.4	For a *plant*, the information exchange must as a minimum be implemented using a protocol stack in accordance with IEC 6161850 with mapping to IEC-60870-5-104. The protocol stack must be implemented with support for two masters as a minimum.	Demonstrate that the *plant* is capable of meeting the requirements.
R7.5	The specific requirements for information and signals must be documented in the *PCOM* interface.	Demonstrate that the *plant* is capable of meeting the requirements. A complete signal list may be enclosed.