Memo to:
Netbeheer Nederland

Memo Nr.: 10132353-PSP 22-1024
From: Energy Systems
Date: 29-6-2022
By: Wim Kuijpers

Explanation standard report format BLOR for load flow results Type B PGM complex parks

1 INTRODUCTION

In the Netbeheer Nederland document "Power-Generating Modules compliance verification" (hereafter referred to as NBNL CVD) for Type B, C and D, a simulation is prescribed to show that the Dutch grid code (Netcode) requirements for reactive power capability are met. For basic Type B parks, parks with radial network and single type inverter and transformer, the BLOS type **B LO** flow **S**imulation) tool can be used to perform and report the load flow simulations. For complex parks, for which the BLOS tool cannot be used, for instance with meshed network or more type of inverters or transformers, there is a request for a standard format for reporting the results of the load flow simulations. The simulations themselves are to be performed using dedicated load flow programs.

This standard report format BLOR (type **B LO**ad flow **R**eport) is based on similar inputs and presentation of results as the BLOS tool, however the results from the load flow simulations have to be entered manually. The Excel format produces graphs and warnings for exceeding limits of the power generating units automatically, supporting the PPM owner/developer and the grid operator to assess whether the requirements of Netcode are met.

Note: The PPM owner/developer remains responsible for demonstrating Compliance of the RfG requirements to the network operator and cannot derive any rights or rely on the application or outcomes of this tool. DNV is not liable for any direct or indirect consequences when using this standard report format, DNV wants to facilitate involved parties with some efficiency tooling. The end user is responsible for their input and outcomes.

2 BLOR STANDARD REPORT FOR COMPLEX PARK PPM TYPE B

In this standard report the data of the grid connection and generating units (wind turbines or PV-inverters) are entered. Up to 3 different types of generating units can be entered. The results from the prescribed 13 cases for load flow simulations (NBNL CVD chapter 4.2.8) shall be entered in the sheet in the columns referring to the load flow case. Besides the mentioned 13 cases an extra load flow case “Qc=0” is added for rated active power at the connection point with no reactive power exchange and rated voltage at the connection point. This case represents the maximum active power from the PPM at the connection point, without exchanging reactive power: “Pmax at Qc=0”.

3 SHEETS IN BLOR STANDARD REPORT

3.1 LF minimum input sheet

In the BLOR a sheet named LF minimum input sheet is available. In the sheet the blank, not colored cells have to be filled in with:

- Characteristics of the PPM (cells in columns C, D, E, F):
  - Declared voltage at the Connection Point
  - Maximum active power at rated voltage at no reactive power exchange at the Connection point
  - Connection capacity as per connection agreement (for information)
  - Data of the generating units
- Results from the load flow simulations (cells in columns I-V):
  - Active and reactive power at the connection point
  - Maximum apparent power of the generating units (unit with maximum apparent power)
  - Maximum and minimum voltage of the generating units at their terminals (unit with maximum and unit with minimum voltage)

For the generating units of the PPM enter values according to manufacturer's information. For maximum and minimum voltage, take into account the actual settings of the over and under voltage protection. In the figure below an example of a part of the input sheet is shown

Name PGM	Name as per PGMD			
Grid	Declared voltage connection point Uc (kV):	10.50		
	Maximum active power PGM Pmax at Qc=0 (MW)	10.013		
	Connection capacity grid connection point (MVA)	10.000		
Unit 1 type:	wind turbine or PV-inverter			
Unit 2 type:	wind turbine or PV-inverter			
Unit 3 type	wind turbine or PV-inverter			
	Unit type	1	2	3
Unit data	Total number	50	0	0
	Apparent power Snom (kVA)	215	0	0
	Active power Pnom (kW)	200	0	0
	Maximum reactive power supply +Qnom (kVAr)	100	0	0
	Maximum reactive power absorption -Qnom (kVAr)	-100	0	0
	Nominal voltage Unom (V)	800	0	0
	Maximum current Imax (A)	155	0	0
	Maximum voltage Umax (V)	880	0	0
	Minimum voltage Umin (V)	680	0	0

Figure 1: Part of the LF minimum input sheet

Based on the entered input data the tool calculates, the per unit values are calculated automatically and are compared with maximum limits for apparent power and current and maximum and minimum voltages of the generating units. The cell will color red if generating units are exceeding limits, if not the cell color will be green. The blue colored cells are automatically calculated values based on the entered input data. The values of the grid voltage U_c are fixed, according to the requirements for the load flow calculations given in the CVD. In figure 2 the results part of the input sheet is shown.

Results loadflow	Load flow results for scenarios 0 - 13													
Cases Q-U resp. Q-P (NBNL RFG CVD v1.3	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13
Uc grid voltage (p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.10	1.05	0.95	0.90	0.90	0.95	0.85
Active power connection point Pc (MW)	39.50	39.50	39.50	8.00	8.00	-0.15	39.50	39.50	39.50	39.50	39.50	39.50	39.50	35.00
Reactive power connection point Qc (Mvar)	0.00	-21.00	21.00	-21.00	21.00	0.00	-21.00	0.00	21.00	21.00	14.00	0.00	-21.00	19.89
Active power connection point Pc (p.u)	1.00	1.00	1.00	0.20	0.20	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.89
Reactive power connection point Qc (p.u.)	0.00	-0.53	0.53	-0.53	0.53	0.00	-0.53	0.00	0.53	0.53	0.35	0.00	-0.53	0.50
Apparent power connection point (MVA)	39.50	44.74	44.74	22.47	22.47	0.15	44.74	39.50	44.74	44.74	41.91	39.50	44.74	40.26
Unit type 1	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13
Maximum apparent power unit (kVA)	4003	4148	4272	1484	1484	15	4148	4005	4272	4272	4052	4003	4148	4025
Maximum voltage unit (V)	670	657	670	651	680	663	724	738	720	656	613	606	624	595
Minimum voltage unit (V)	668	655	664	650	677	663	722	734	713	649	607	602	622	587
Maximum current unit (A)	3460	3657	3715	1318	1266	13	3317	3150	3459	3800	3855	3839	3851	3959
Maximum apparent power unit (p.u.)	0.93	0.96	0.99	0.35	0.35	0.00	0.96	0.93	0.99	0.99	0.94	0.93	0.96	0.94
Maximum voltage unit (p.u.)	1.02	1.00	1.02	0.99	1.03	1.00	1.10	1.12	1.09	0.99	0.93	0.92	0.95	0.90
Minimum voltage unit (p.u.)	1.01	0.99	1.01	0.98	1.03	1.00	1.09	1.11	1.08	0.98	0.92	0.91	0.94	0.89
Maximum current unit (p.u.)	0.91	0.96	0.98	0.35	0.33	0.00	0.87	0.83	0.91	1.00	1.01	1.01	1.01	1.04
Maximum voltage limit unit (p.u.)	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Minimum voltage limit unit (p.u.)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Unit type 2	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13
Maximum apparent power unit (kVA)	250	251	252	25	25	0	251	250	252	252	257	250	251	200
Maximum voltage unit (V)	803	799	808	796	805	800	879	882	848	769	736	726	759	684
Minimum voltage unit (V)	803	798	806	795	804	800	878	882	846	767	732	724	758	683
Maximum current unit (A)	180	181	180	18	18	0	165	164	172	190	203	200	191	169
Maximum apparent power unit (p.u.)	0.93	0.93	0.93	0.09	0.09	0.00	0.93	0.93	0.93	0.93	0.95	0.93	0.93	0.74
Maximum voltage unit (p.u.)	1.00	1.00	1.01	1.00	1.01	1.00	1.10	1.10	1.06	0.96	0.92	0.91	0.95	0.86
Minimum voltage unit (p.u.)	1.00	1.00	1.01	0.99	1.01	1.00	1.10	1.10	1.06	0.96	0.92	0.91	0.95	0.85
Maximum current unit (p.u.)	0.92	0.93	0.93	0.09	0.09	0.00	0.85	0.84	0.88	0.97	1.04	1.02	0.98	0.87
Maximum voltage limit unit (p.u.)	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Minimum voltage limit unit (p.u.)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Unit type 3	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13
Maximum apparent power unit (kVA)	2500	2508	2518	250	250	0	2508	2500	2518	2518	2571	2504	2508	2000
Maximum voltage unit (V)	803	799	808	796	805	800	879	882	848	769	736	726	759	684
Minimum voltage unit (V)	803	798	806	795	804	800	878	882	846	767	732	724	758	683
Maximum current unit (A)	1798	1815	1804	182	180	0	1649	1636	1718	1895	2028	1997	1910	1691
Maximum apparent power unit (p.u.)	0.93	0.93	0.93	0.09	0.09	0.00	0.93	0.93	0.93	0.93	0.95	0.93	0.93	0.74
Maximum voltage unit (p.u.)	1.00	1.00	1.01	1.00	1.01	1.00	1.10	1.10	1.06	0.96	0.92	0.91	0.95	0.86
Minimum voltage unit (p.u.)	1.00	1.00	1.01	0.99	1.01	1.00	1.10	1.10	1.06	0.96	0.92	0.91	0.95	0.85
Maximum current unit (p.u.)	1.00	1.01	1.00	0.10	0.10	0.00	0.92	0.91	0.95	1.05	1.13	1.11	1.06	0.94
Maximum voltage limit unit (p.u.)	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Minimum voltage limit unit (p.u.)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85

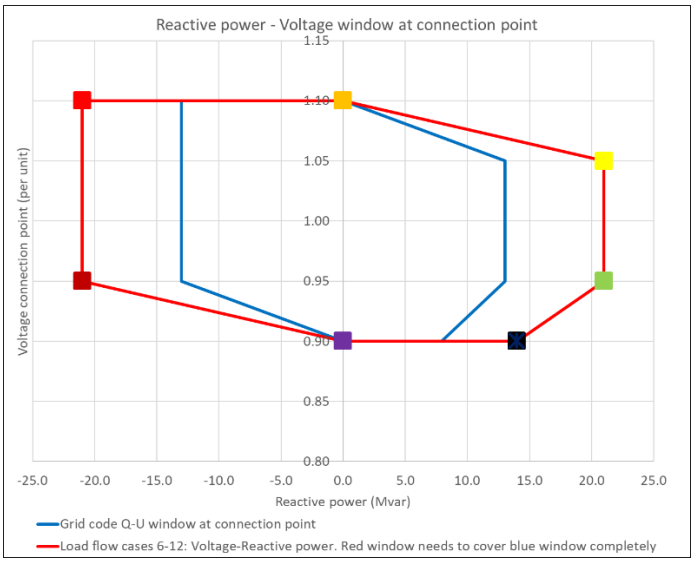
Figure 2: Results of the various load flow scenario's according to the NBNL CVD

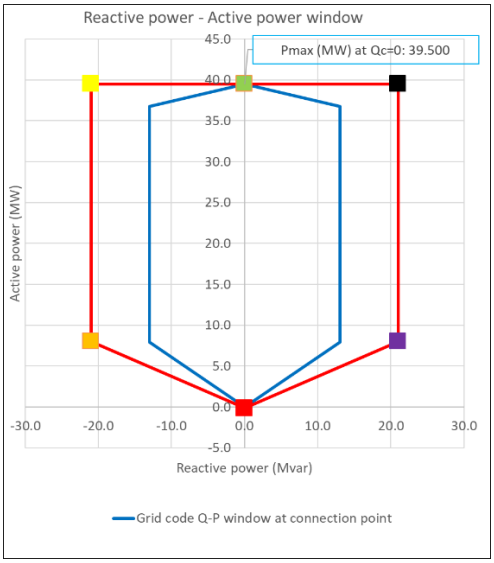
3.2 Sheet Q-U and Q-P window

In the Dutch grid code the requirements of reactive power are given in Q-U and Q-P windows. These windows are incorporated in the BLOR in the Q-U and Q-P window sheet. It is necessary to check in the sheet "Q-U en Q-P windows" whether the calculated Q-U window of the park (red window) completely encloses the window with grid code requirements (blue). If not, the requirements of the grid code are not met.

The blue window corresponds to the minimum requirements of the grid code. The red window is created from the results of the load flow cases, which are entered in the input sheet.

The colored values below the graphs represent the corner points, which are marked with a colored square in the graphs.





Load flow cases 6-12: Voltage-Reactive power. Red window needs to cover blue window completely								
Uc grid voltage (p.u.)	1.10	1.10	1.05	0.95	0.90	0.90	**0.95**	1.10
Active power connection point Pc (MW)	39.50	39.50	39.50	39.50	39.50	39.50	**39.50**	39.50
Reactive power connection point Qc (Mvar)	-21.00	0.00	21.00	21.00	14.00	0.00	**-21.00**	-21.00

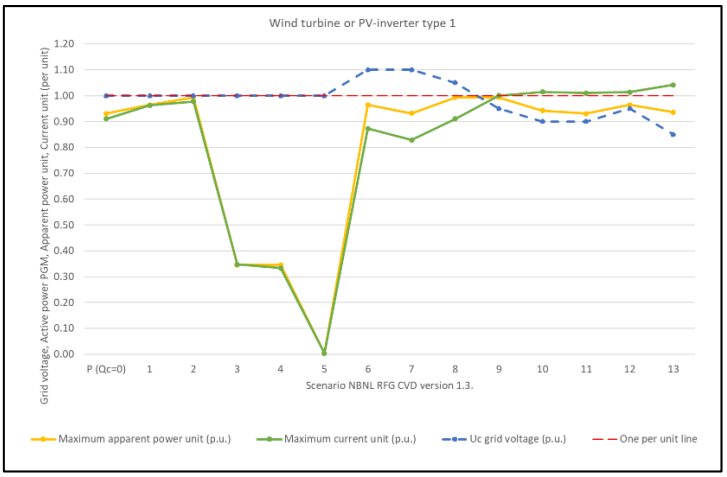
Load Flow cases 0-5: Reactive - Active power. Red window needs to cover blue window completely							
Uc grid voltage (p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Active power connection point Pc (MW)	-0.15	8.00	39.50	39.50	39.50	8.00	-0.15
Reactive power connection point Qc (Mvar)	0.00	-21.00	-21.00	0.00	21.00	21.00	0.00

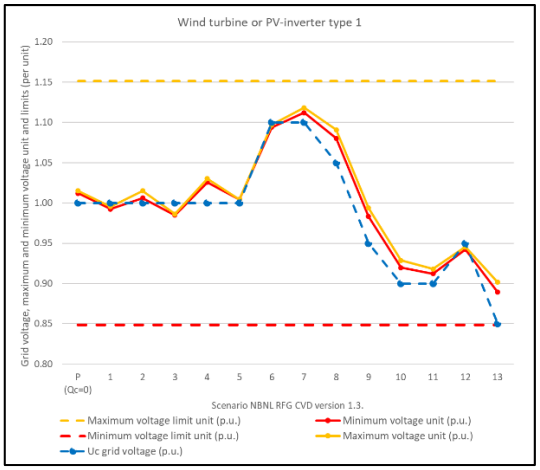
3.3 Sheet Review unit type

The results in the BLOR are given at the sheets named Sheet Review unit type. The number of sheets depends on the number of unit types considered in the BLOR with a maximum of three. Per sheet two graphs are presented which present per type of generating unit a graphical overview of the main results, more specifically if limits are exceeded at generating unit level. The grid voltage is included as reference (blue dotted curve).

The left graph presents the maximum apparent power and maximum current of the generating unit in per unit value for all 14 (13 of NBNL CVD + “Pmax at Qc=0”) cases. The studied cases are numbered on the x-axis while the results of the apparent power and current are plotted on the y-axis. Both curves should not exceed the 1 per unit reference line (red dotted line). If exceeding, the generating unit is supplying power or current above its rating, which is not acceptable.

The right graph presents the maximum and the minimum voltage at the terminals of the generating unit in per unit value. Both curves should be between the maximum and minimum voltage limit lines (orange resp. red dotted line). If exceeding, the generating unit is operating outside its voltage limits for continuous operation, which is not acceptable.





Load Flow Case	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13
Uc grid voltage (p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.10	1.05	0.95	0.90	0.90	0.95	0.85
Maximum apparent power unit (p.u.)	0.93	0.96	0.99	0.35	0.35	0.00	0.96	0.93	0.99	0.99	0.94	0.93	0.96	0.94
Maximum voltage unit (p.u.)	1.02	1.00	1.02	0.99	1.03	1.00	1.10	1.12	1.09	0.99	0.93	0.92	0.95	0.90
Minimum voltage unit (p.u.)	1.01	0.99	1.01	0.98	1.03	1.00	1.09	1.11	1.08	0.98	0.92	0.91	0.94	0.89
Maximum current unit (p.u.)	0.91	0.96	0.98	0.35	0.33	0.00	0.87	0.83	0.91	1.00	1.01	1.01	1.01	1.04