Memo to:
Netbeheer Nederland

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From: Energy Systems
Date: 6-7-2024
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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 for load flow simulations (NBNL CVD chapter 4.2.8) from the prescribed 13 cases (table page 82) and 2 points (points 3&4 table page 79) 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 “Pmax - 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 target values of the cases, points at the connection point and maximum limits for apparent power and current and maximum and minimum voltages of the generating units. The cell will color red when target values of the cases/points at the connection point are not met or if generating units are exceeding limits, if not the cell color will be green. 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	Pmax	Cases 1 - 13													Points 3-4	
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	3	4
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	0.95	0.90	0.90	0.85	1.00	1.00
Active power connection point Pc (MW)	10.01	9.93	9.85	2.00	2.00	-0.01	9.97	9.98	9.86	9.35	9.15	9.35	9.35	8.30	4.96	4.92
Reactive power connection point Qc (Mvar)	0.00	-3.30	3.31	-3.29	3.31	0.00	-3.34	0.00	3.32	3.31	-3.31	2.50	0.00	3.11	-3.30	3.31
Active power connection point Pc (p.u)	1.00	0.99	0.98	0.20	0.20	0.00	1.00	1.00	0.99	0.93	0.91	0.93	0.93	0.83	0.50	0.49
Reactive power connection point Qc (p.u.)	0.00	-0.33	0.33	-0.33	0.33	0.00	-0.33	0.00	0.33	0.33	-0.33	0.25	0.00	0.31	-0.33	0.33
Apparent power connection point (MVA)	10.01	10.46	10.39	3.85	3.87	0.01	10.52	9.98	10.41	9.92	9.73	9.68	9.35	8.87	5.96	5.93
Unit type 1	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13	3	4
Maximum apparent power unit (kVA)	203	209	215	76	79	0	210	202	215	206	193	190	197	185	209	215
Maximum voltage unit (V)	798	782	814	769	801	782	860	874	852	776	731	722	742	698	782	814
Minimum voltage unit (V)	790	774	803	768	798	782	853	866	842	765	721	711	735	688	774	803
Maximum current unit (A)	148	156	155	57	57	0	142	135	147	156	155	154	155	155	156	155
Maximum apparent power unit (p.u.)	0.94	0.97	1.00	0.35	0.37	0.00	0.98	0.94	1.00	0.96	0.90	0.88	0.92	0.86	0.97	1.00
Maximum voltage unit (p.u.)	1.00	0.98	1.02	0.96	1.00	0.98	1.08	1.09	1.07	0.97	0.91	0.90	0.93	0.87	0.98	1.02
Minimum voltage unit (p.u.)	0.99	0.97	1.00	0.96	1.00	0.98	1.07	1.08	1.05	0.96	0.90	0.89	0.92	0.86	0.97	1.00
Maximum current unit (p.u.)	0.96	1.00	1.00	0.37	0.37	0.00	0.92	0.87	0.95	1.00	1.00	0.99	1.00	1.00	1.00	1.00
Maximum voltage limit unit (p.u.)	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
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	0.85	0.85
Unit type 2	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13	3	4
Maximum apparent power unit (kVA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum voltage unit (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minimum voltage unit (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum current unit (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum apparent power unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum voltage unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum voltage unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum current unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum voltage limit unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum voltage limit unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unit type 3	P (Qc=0)	1	2	3	4	5	6	7	8	9	10	11	12	13	3	4
Maximum apparent power unit (kVA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum voltage unit (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minimum voltage unit (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum current unit (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum apparent power unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum voltage unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum voltage unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum current unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum voltage limit unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum voltage limit unit (p.u.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cell Color identification		Cells for input data and results load flow calculations
		Reminder: calculated value exceeds connection capacity
		Calculated values, parameter within targets, capability, not exceeding limits
		Calculated values, parameter outside targets, capability, exceeding limits
		Calculated or copied values for information

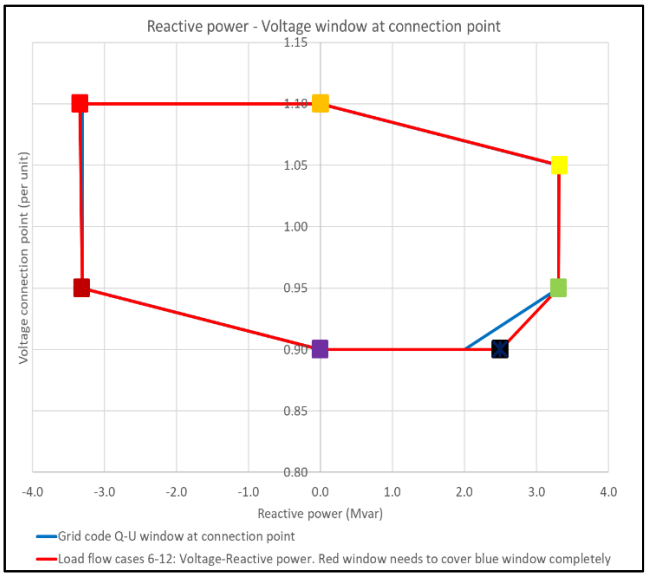
Figure 2: Results of the various load flow scenario's according to the NBNL CVD

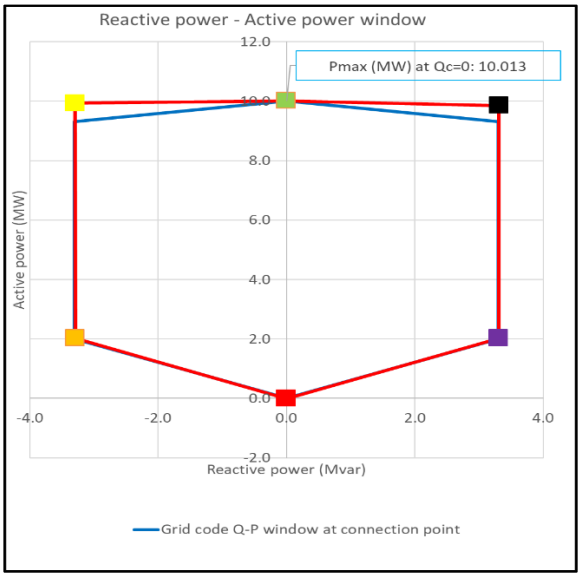
3.2 Sheet Q-U and Q-P window

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)	9.97	9.98	9.86	9.35	9.35	9.35	**9.15**	9.97
Reactive power connection point Qc (Mvar	-3.34	0.00	3.32	3.31	2.50	0.00	**-3.31**	-3.34

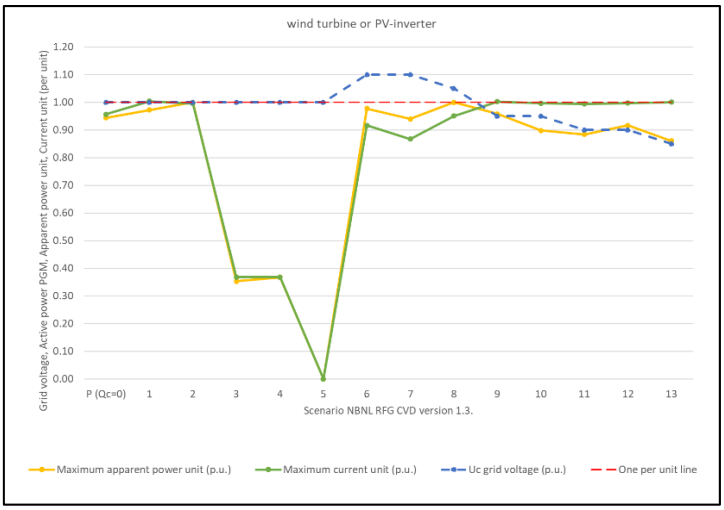
Load Flow cases 0-5: Reactive - Active power. Red window needs to cover blue window completely							
Uc grid voltage (p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Active power connection point Pc (MW)	-0.01	2.02	9.93	10.01	9.85	2.02	-0.01
Reactive power connection point Qc (Mvar)	0.00	-3.29	-3.30	0.00	3.31	3.31	0.00

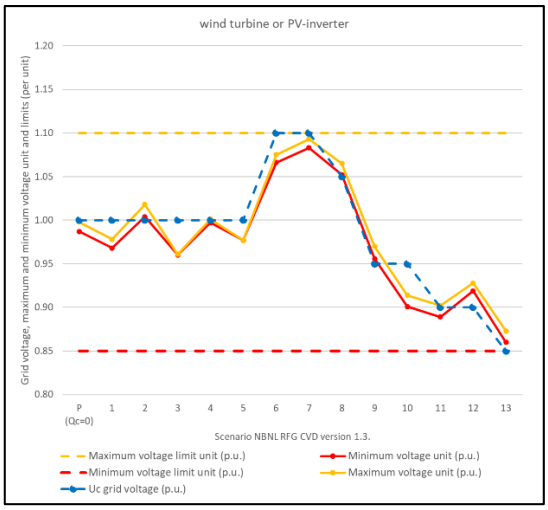
3.3 Sheet Review unit type

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	0.95	0.90	0.90	0.85
Maximum apparent power unit (p.u.)	0.94	0.97	1.00	0.35	0.37	0.00	0.98	0.94	1.00	0.96	0.90	0.88	0.92	0.86
Maximum voltage unit (p.u.)	1.00	0.98	1.02	0.96	1.00	0.98	1.08	1.09	1.07	0.97	0.91	0.90	0.93	0.87
Minimum voltage unit (p.u.)	0.99	0.97	1.00	0.96	1.00	0.98	1.07	1.08	1.05	0.96	0.90	0.89	0.92	0.86
Maximum current unit (p.u.)	0.96	1.00	1.00	0.37	0.37	0.00	0.92	0.87	0.95	1.00	1.00	0.99	1.00	1.00