Memo to:
Netbeheer Nederland

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From: Energy Systems
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Explanation BLOS load flow tool Type B PGM revision 01-06-2024

1 INTRODUCTION

In the Netbeheer Nederland document "Power-Generating Modules compliance verification" for Type B, C and D, a simulation is prescribed to show that the Netcode requirements for reactive power capability are met. This BLOS tool (type **B LO**ad flow **S**imulation) has been developed as a tool in the Compliance process for Type B Power Park Modules. This can be used for this purpose if it concerns a "Basic Park Type B" (definition see below). Based on the rated capacities of the inverters (PV inverter, wind turbine), transformers and cables to be filled in, the tool calculates the active and reactive power (MW, Mvar) at the connection point and shows the results in table and graph form. This assesses whether the requirements of Netcode are met.

Note: The PPM owner/developer remains responsible for demonstrating Compliance 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 tool. It is not permitted to use this tool for purposes other than as a tool for Type B compliance activities, to copy and/or share with parties other than the network operator.

2 BLOS LOAD FLOW TOOL FOR BASIC PARK PPM TYPE B

In this tool a simple park grid configuration can be modeled if this grid meets the principles of a basic park, see chapter 3: Connection point - MV connection - MV installation - MV connection - MV/LV transformer – LV connection – inverters. An MV or LV connection consists of one or more parallel three-phase cables or, in the case of single-core cables, one or more parallel three-phase circuits. A MS connection between the Connection point and the central medium voltage distribution station on the park is modelled separately. Furthermore, the average length of the MV and LV connections to the transformers in the park is to be determined. You specify the number of parallel cables between transformers and central MV park installation in the model per transformer. The same applies to the LV connection, which connects the transformer to the inverters/wind turbine.

You specify the number of transformers. In the base park we assume identical transformers that are connected to an equal number of parallel MS cables to the central MV distribution station and an equal number of parallel LV cables to the inverters. Short LV cables from the individual inverter to a collection cabinet are neglected.

The total number of inverters to be specified is the total number in the entire PV park, not per transformer. The number of inverters per transformer is therefore determined by a calculation. Again, for the model, we assume that the number of inverters per transformer is the same. The rated data of the inverter to be filled in must come from inverter certificates/data sheets.

The transformers are usually equipped with tapping selector switch. We assume a switch with 5 positions with a voltage change on the medium voltage side of 2.5% per step. The position must correspond to the actual position in the installation. If no switch is present, select position 0. Position adjustment gives a change of 2.5% per step in the primary voltage and results in a shift of the Q-U window. This may be necessary to demonstrate compliance.

3 STARTING POINTS FOR USE

3.1 Basic park

Starting points for using this simple BLOS load flow tool and basic park configuration shown schematically in (top scheme) are:

- Inverters of one type
- Connection inverters to MS/LS transformers via LS cable (one or more parallel) (LS cables). Maximum length of LS cables: 500 meters
- One or more MS/LS transformers of one type, equipped with a tapping selector switch. If no switch is installed, select position 0
- Equal distribution of inverters over MS/LS transformers. A difference in distribution of up to 2 inverters per transformer is acceptable
- Connection of individual MS/LS transformers via MS cable (MS-TR) to a central MS distribution station (MS). One or more cables in parallel. Length MS cable up to 2 km
- Connection Central MS distribution station (MS) via MS cables (OP-MS) to the connection point (OP). One or more cables in parallel. Length MS cable up to 10 km
- Grid operator MS station (“inkoopstation”/överdrachtspunt”/connection point) (OP)
- Radial cable network, not meshed, no crossings
- No reactive power compensation

3.2 Sub parks and shared MS connection

It might be the case that a park configuration does not meet the starting points, but consists of sections ("sub parks") that do comply. In that case, a BLOS model can be used per sub park. If all sub parks comply, the entire park will also comply. The BLOS tool for all sub parks must then be submitted to the grid operator.

Exceptionally, the BLOS tool can also be used for a park, where the transformers are connected to the connection point by a common medium voltage connection (shared MS connection). This is shown in the lower diagram in for the connections MS cable #1-2/#2-3/#3-4. However, the total length of the connection between 1st transformer (MS#1) and last transformer (MS#4) shall not exceed 2000 meters. When entering cable connection OP-MS, the cable type connected to the connection point (purchasing station) must be chosen with a length from the grid operator station to the first transformer station (MS#1) plus half of the total length of the connection from the transformer station MS#1 to MS#4 (maximum 1000 meters). Set the MS-TR cable to 0 meters in this case.

If the PV/wind turbine park does not meet these principles, you must use a dedicated load flow simulation package.

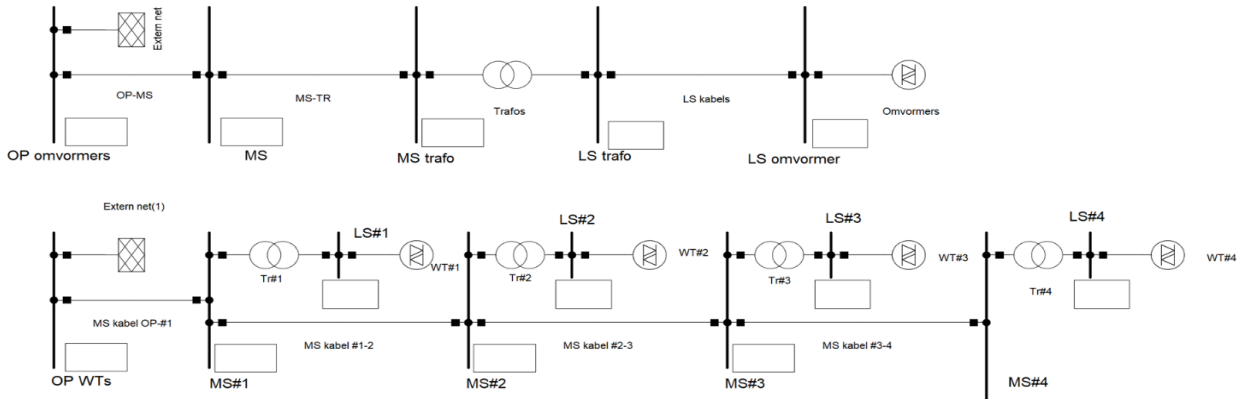


Figure 1 Schematic representation of the base parks

4 SHEETS IN BLOS TOOL

4.1 Input and Results sheet (“Invoer en resultaten”)

4.1.1 Input data

In the "Invoer en resultaten" sheet, the data of the park must be entered: inverters/wind turbines, low and medium voltage cables and transformers. The input cells are shown in . There is an internal library with cables and transformers, from which you can choose. In addition, it is possible to add medium voltage cables (2 types), low-voltage cables (1 type) and transformer (1 type) with corresponding parameters yourself. The white colored fields are to be used to enter the corresponding data yourselves.

The block OP-MS cables concerns the cables from the connection point to the central MS park installation. The block MS-TR cables concerns the cables from the central MS park installation to the transformer(s). If the connection point is located on the central MS park installation, fill in a length of 0 meters for the OP-MS cables, but choose a (random) type.

Fill in the rated primary and secondary voltage at the transformer. A tap selector switch with 5 positions (respectively +2, +1, 0, -1, -2) has been assumed. The selected position must correspond to the actual position in the installation. Position adjustment gives a change of 2.5% per step in the primary voltage and results in a shift of the Q-U window. This may be necessary to achieve compliance.

Each input field is accompanied by a note with a brief explanation. The text becomes visible when the cell is clicked.

Details:

- For inverters and wind turbines, enter values according to manufacturer’s information. At maximum and minimum voltage, take into account the actual settings over and under voltage protection
- MS-TR cables and LS cables to transformers can have different lengths. Assume the average length of the cables
- If there is no OP-MS cable, because there is a connection point at the central MS installation of the park, to which the transformers are also connected, then choose a type for OP-MS cable but fill in length of 0 meters.
- If no tap selection switch is installed, select position

Invoergegevens		
Naam PGM	Demo park	
Type omvormers	Fabricaat/type	
Omvormers	Totaal aantal omvormers	50
	Schijnbaar vermogen omvormer Snom (kVA)	250
	Werkzaam vermogen omvormer Pnom (kW)	250
	Maximaal blindvermogen levering omvormer (kvar)	250
	Maximaal blindvermogen opname omvormer (kvar)	-250
	Nominale spanning Unom (V)	550
	Maximale stroom I max (A)	262
	Maximale spanning Umax (V)	630
	Minimale spanning Umin (V)	480
	Maximale kortsluitstroom (A)	270
LS kabels Omvormers naar transformatoren	aantal (driefasen)kabels parallel per transformator	10
	Lengte per kabel (km)	0.20
	Doorsnede geleider kabel (mm2)	240 Al
MS trafos Transformatoren	aantal transformatoren	5
	Schijnbaar vermogen S (kVA)	2500
	Nominale spanning primair Ums (kV)	10.50
	Nominale spanning secundair Uls (kV)	0.55
	Positie aftakschakelaar (0=nom. overzetverhouding)	+1
MS TR kabel Transformatoren naar MS verzamelstation	Aantal (driefasen)kabels parallel per transformator	1
	Lengte per kabel (km)	0.50
	Doorsnede geleider kabel (mm2)	95 Al
OP-MS kabels MS verzamelstation naar overdrachtspunt	Aantal (driefasen)kabels parallel naar overdrachtspunt	1
	Lengte per kabel (km)	5.00
	Doorsnede geleider kabel (mm2)	800 Al
NET	Toegekende netspanning Uc (kV):	10.50

BLOS Excel load flow tool Type B PGM revisie per 01-06-2024

Alleen voor eenvoudige basisparken/ only for simple basic parks

Rechts kunnen 2 eigen typen MS-kabels ingevoerd worden	Ruimte voor 2 typen eigen MS kabels				
	Geleider (mm2)	Weerstand R (Ω/km)	Reactantie X (Ω/km)	Capaciteit C (µF/km)	Belastbaar-heid (A)
	830test	0.053	0.106	0.470	580
	95test	0.322	0.110	0.230	245

Rechts kan 1 eigen type LS-kabel ingevoerd worden	Ruimte voor 1 type eigen LS kabel			
	Geleider (mm2)	Weerstand R (Ω/km)	Reactantie X (Ω/km)	Belastbaar-heid (A)
	95test	0.322	0.069	230

Rechts kan 1 eigen type transformator ingevoerd worden	Ruimte voor 1 type eigen Transformator			
	Vermo-gen (kVA)	Nullast-verlies (kW)	Kortsluit-verlies (kW)	Kortsluit-spanning (%)
	5200test	4.00	42.50	10.00

Figure 2 Overview of the input sheet of the BLOS tool

4.1.2 Results load flow calculations

On the right side of the sheet "Invoer en resultaten" the results of the load flow calculation are shown, see Figure 3. These include:

- the results of the 13 load flow cases from the "Netbeheer Nederland RfG compliance verification Power generating modules type B, C and D, version 2.0", page 82
- Pmax case. The starting point here is the maximum active power that the PPM can deliver at 95% voltage and power factor 1 at the connection point.
- Load flow cases 0.4P/+Qm and 0.4Pm/-Qm representing points 3 and 4 of the PPM simulations on page 79 (30-50% Pmax, maximum lagging/leading). Points 1, 2, 5, 6 from this table are covered with cases 1 to 4.

The following are shown per case:

- the calculated and target value per unit at the connection point of the voltage, active and reactive power
- the calculated value in per unit at the inverter terminals of apparent, active and reactive power, voltage and current

The target values are colored blue. The calculated values are coloured green if the calculation criteria are met and the limit values of the inverter are not exceeded. **If starting points are not met or limit values are exceeded, the colour of the cell in question changes to red. In that case, the requirements have not been met. Depending on the deviation, an adjustment must be made to the input data. Please note that this adjustment may have consequences for the maximum permissible operating power of the inverter, the position of the transformer's tap changer, or increasing the capacity/rating of cables or transformers.**

In the lower part, the calculated values of the power at connection point and total of the inverters in MW and Mvar are shown. Underneath is an indication of the loading of the cables and transformer. If the load is higher than 100% (1 per unit), the cell will turn orange. This is for information purposes only and does not constitute a violation of an assessment criterion.

Load Flow Case NBNL CVD	Pmax	1	2	3	4	5	6	7	8	9	10	11	12	13	0.4Pm/+Qm	0.4Pm/-Qm
	Evaluatie resultaten en criteria load flow cases															
Netspanning (p.u.)	0.95	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
Netspanning doelwaarde NBNL CVD (p.u.)	0.95	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
Werkzaam vermogen overdrachtspunt (P/Pmax)	1.00	1.00	0.93	0.20	0.20	-0.02	1.00	1.02	0.94	0.92	0.94	0.93	0.95	0.88	0.40	0.40
Werkzaam vermogen doelwaarde NBNL CVD (p.u.)	1.00	≥0.93	≥0.93	0.20	0.20	0.00	≥0.93	1.00	≥0.93	≥0.93	≥0.93	none	none	≥0.80	≥0.93	≥0.93
Blindvermogen overdrachtspunt (Q/Pmax)	0.00	-0.33	0.33	-0.33	0.33	0.00	-0.33	0.00	0.33	0.33	-0.33	0.20	0.00	0.19	0.33	-0.33
Blindvermogen doelwaarde NBNL CVD (p.u.)	0.00	-0.33	0.33	-0.33	0.33	0.00	-0.33	0.00	0.33	0.33	-0.33	≥0.20	0.00	geen	0.33	-0.33
Schijnbaar vermogen omvormer (p.u.)	0.99	1.00	1.00	0.35	0.37	0.01	1.00	1.00	1.00	1.00	0.95	0.97	0.95	0.92	0.50	0.48
Werkzaam vermogen omvormer (p.u.)	0.99	0.98	0.91	0.19	0.19	0.00	0.98	1.00	0.92	0.91	0.93	0.92	0.94	0.87	0.39	0.39
Blindvermogen omvormer (p.u.)	0.12	0.18	0.41	0.29	0.31	0.01	0.21	0.09	0.40	0.42	0.18	0.31	0.12	0.30	0.33	0.28
Klempanning omvormer (p.u.)	1.00	1.00	1.07	0.95	1.03	0.97	1.10	1.13	1.12	1.03	0.95	0.97	0.95	0.92	1.04	0.96
Stroom omvormer(p.u.)	1.00	1.00	0.93	0.37	0.36	0.01	0.91	0.88	0.90	0.97	1.00	1.00	1.00	1.00	0.49	0.50
	Belangrijke parameters load flow cases															
Werkzaam vermogen overdrachtspunt (MW)	11.50	11.44	10.67	2.29	2.30	-0.02	11.52	11.77	10.78	10.55	10.81	10.66	10.89	10.08	4.60	4.60
Blindvermogen overdrachtspunt(Mvar)	0.00	-3.79	3.79	-3.80	3.79	0.00	-3.79	0.00	3.79	3.79	-3.80	2.30	0.00	2.17	3.79	-3.80
Werkzaam vermogen omvormers totaal (MW)	12.34	12.29	11.41	2.43	2.43	0.00	12.23	12.45	11.47	11.36	11.65	11.51	11.74	10.92	4.82	4.82
Blindvermogen omvormers totaal (Mvar)	1.52	-2.29	5.09	-3.67	3.90	-0.10	-2.57	1.14	4.97	5.22	-2.28	3.83	1.53	3.71	4.07	-3.50
Belasting kabel naar overdrachtspunt (p.u.)	1.14	1.14	1.07	0.43	0.41	0.01	1.05	1.01	1.03	1.11	1.14	1.14	1.14	1.15	0.56	0.57
Belasting MS kabel transformator (p.u.)	0.58	0.58	0.54	0.22	0.21	0.00	0.53	0.51	0.52	0.56	0.58	0.58	0.58	0.58	0.28	0.29
Belasting transformator (p.u.)	1.00	1.00	0.93	0.37	0.36	0.01	0.91	0.88	0.90	0.97	1.00	1.00	1.00	1.00	0.49	0.50
Belasting LS kabel omvormer (p.u.)	0.55	0.55	0.52	0.21	0.20	0.00	0.51	0.49	0.50	0.54	0.55	0.55	0.55	0.55	0.27	0.28

Kleurcodering	
	Geen overschrijding van de grenzen van de omvormers
	Bedrijfspunt boven grenswaarde van de omvormer
	Overschrijding van de grenzen transformatoren of kabels

Figure 3 Results load flow calculations

4.2 Sheet Criteria windows

In addition to the table of calculation results (see 4.1.2), the sheet "Criteria windows" also contains a graphical presentation of the results.

Figure 4 shows at a glance whether the maximum values for apparent, active and reactive power and current of the wind turbine or PV inverter has been exceeded (greater than 1.0 per unit).

Figure 5 makes it easy to see whether the calculated voltages on the terminals of the wind turbine or PV inverter remain within the permissible limit values.

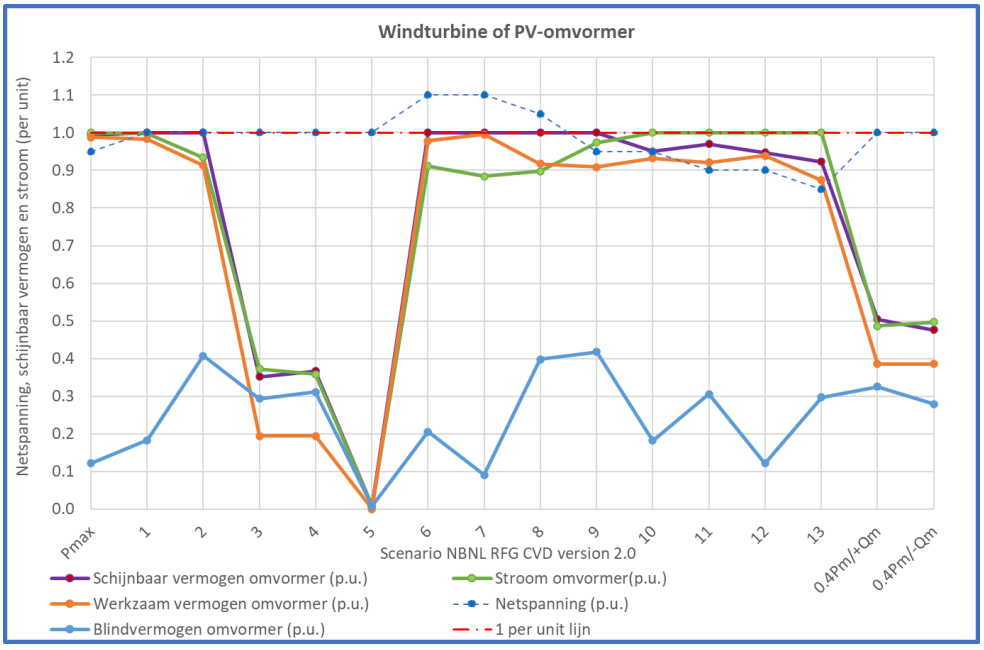


Figure 4 Grid voltage and calculated powers and current wind turbine or PV-inverter

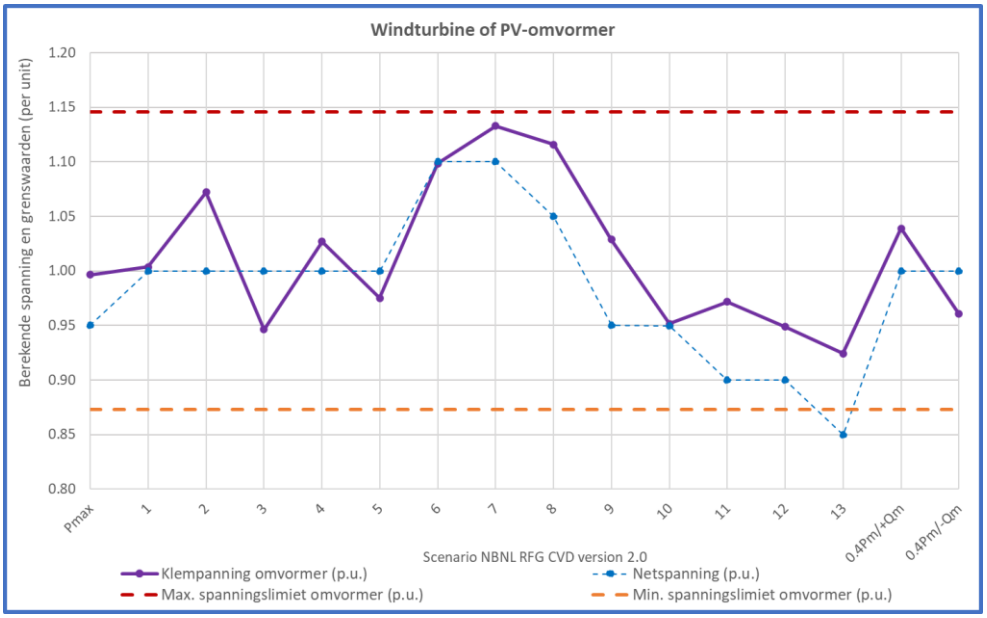
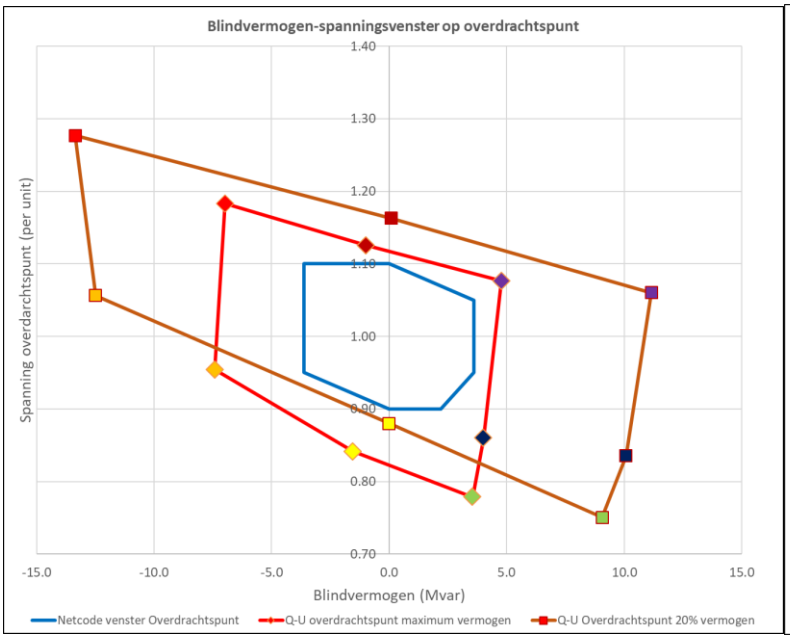


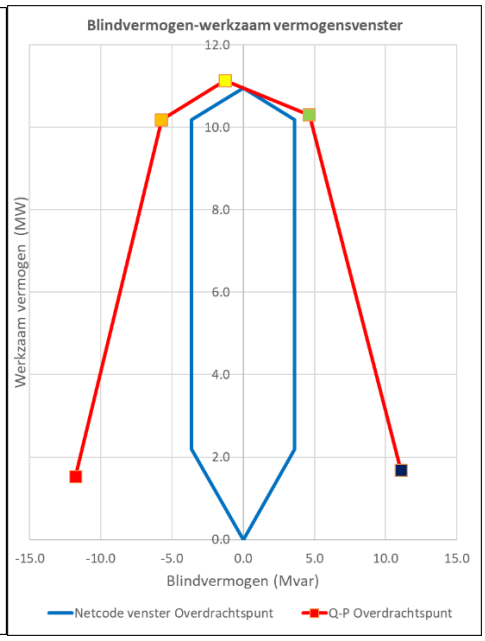
Figure 5 Calculated and limit values voltage at wind turbine or PV-inverter terminals

4.3 Sheet Q-you and Q-P window

The sheet "Q-U en Q-P vensters" show, as indication, the reactive power range of the PPM at te connection point, see **Figure 6**.

The blue window corresponds to the minimum requirements of the grid code. The red and brown window are calculated values of the park at the connection point, based on the data entered, at maximum and at 20% of the maximum active power of the park. The red and brown window in the “Blindvermogen-spanningsvenster op overdrachtspunt” shall completely cover the blue window. If not, the requirements of the grid code are not met.





In blindvermogen-spanningsdiagram dienen rode en bruine venster het blauwe venster geheel af te dekken															Blindvermogen-werkzaamvermogen				
Uc netspanning (p.u.)	1.18	0.95	0.84	0.78	0.86	1.08	1.13	1.28	1.06	0.88	0.75	0.84	1.06	1.16	1.00	0.97	1.01	1.01	1.02
Pc overdrachtspunt (MW)	10.36	8.72	10.05	8.78	9.63	10.37	11.26	1.70	1.53	2.32	1.52	1.52	1.71	2.32	1.54	10.18	11.13	10.30	1.68
Qc overdrachtspunt (Mvar)	-6.99	-7.41	-1.54	3.55	4.02	4.78	-0.98	-13.37	-12.49	0.00	9.06	10.07	11.16	0.09	-11.77	-5.74	-1.27	4.64	11.08
Uomv (p.u.)	1.15	0.90	0.87	0.87	0.95	1.15	1.15	1.15	0.90	0.87	0.87	0.95	1.15	1.15	0.84	0.95	1.03	1.09	1.11
Pomv omvormers totaal (MW	11.03	9.56	10.89	9.62	10.47	11.03	11.86	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	11.03	11.86	11.03	2.37
Qomv omvormers totaal (Mva	-5.89	-5.89	0.00	5.10	5.55	5.89	0.00	-12.27	-10.98	0.00	10.63	11.62	12.27	0.00	-10.26	-4.22	0.00	5.89	12.27
Uc (p.u.)	1.18	0.95	0.84	0.78	0.86	1.08	1.13	1.28	1.06	0.88	0.75	0.84	1.06	1.16	1.00	0.97	1.01	1.01	1.02
Pc/Pmax (p.u.)	0.94	0.79	0.91	0.80	0.87	0.94	1.02	0.15	0.14	0.21	0.14	0.14	0.16	0.21	0.14	0.92	1.01	0.94	0.15
Qc/Pmax(p.u.)	-0.63	-0.67	-0.14	0.32	0.37	0.43	-0.09	-1.21	-1.13	0.00	0.82	0.91	1.01	0.01	-1.07	-0.52	-0.11	0.42	1.01

Figure 6 Calculated Q-U and Q-P windows

4.4 Sheet LF-model CVD 2.0 cases

This sheet contains the calculations and formulas of the 15 load flow cases in accordance with NBNL RFG CVD 2.0 and Pmax case. The voltage at the connection point and the requirements for active and reactive power at the connection point are taken into account. Voltages, currents and powers for inverters, cables and transformers are calculated. The power losses in cables and transformers have also been calculated. Because the wind turbine or PV inverter is used as the source, several iterations per load flow case are necessary to calculate the required voltages and powers at the connection point. The last column per case is the final result of that case and it is incorporated into the results in the "Invoer en resultaten" and "Criteria vensters" sheet.

An example of the presentation of the calculation results is shown in Figure 7. The main results of the calculations in the columns L to AC in sheet "LF model Q-U en Q-P windows" are automatically provided with a cell color. The meaning of this is explained below the table. In the case of an orange colour, the operating point of the inverters is exactly at the limit or the limit is active. For cables and transformer, an orange color is an indication of possible overload. If a cell is coloured red, an adjustment must be made by, for example, installing more inverters, cables or transformers, reducing the maximum active power per inverter, adjusting the tap changer.

The 1st block, with indices "c" represents the calculated values at the connection point.

The 2nd block, with indices "ms-op" concerns the kW and kvar losses in the cables from the transfer point to the MV park installation. The relative loading of the cables is also indicated. The transformers are connected to the MS-park installation via MV-TR cables (3rd block, indices ms-tr). The kW and kvar losses and the relative loading of the cables were also calculated. The kvar losses can be negative: in that case, the MV cable generates more reactive power than it consumes.

The 4th block, with indices "tr", concerns kW and kvar losses and the relative loading of the transformers. The relative voltage on the MV or LV side of the transformers is shown in the row above (Ums) and below (Uls) this block.

The 5th block, with indices "ls", concerns kW and kvar losses and the relative load of the cables between transformers and inverters/wind turbines.

The 6th and 7th blocks, with indices "omv", represent the generated active, reactive and apparent power of all inverters/wind turbines together (6th block) or of the individual inverter/wind turbine (7th block). Below this are the absolute (Uomv (V)) and relative (Uomv (p.u.) voltage and the relative current (Iomv (p.u.)) of the inverter/wind turbine.

Resultaten loadflow		9		9	11			11	10			10	12			12	6			6	7			7	8			8
Uc netspanning (p.u.)	0.871	0.949	0.951	0.950	0.906	0.900	0.900	0.900	0.988	0.917	0.944	0.949	0.850	0.902	0.900	0.900	1.101	1.103	1.100	1.100	1.113	1.102	1.100	1.100	1.065	1.048	1.050	1.050
Pc overdrachtspunt (MW)	10.86	10.50	10.55	10.55	10.72	10.66	10.66	10.66	9.80	10.22	10.72	10.81	10.28	10.92	10.89	10.89	11.58	11.53	11.52	11.52	11.75	11.78	11.78	11.77	10.81	10.79	10.78	10.76
Qc overdrachtspunt (p.u.)	0.21	0.34	0.33	0.33	0.21	0.20	0.20	0.20	-0.59	-0.36	-0.33	-0.33	0.00	0.00	0.00	0.00	-0.30	-0.33	-0.33	-0.33	0.04	0.00	0.00	0.00	0.33	0.33	0.33	0.33
Qc overdrachtspunt (Mvar)	2.41	3.90	3.81	3.79	2.40	2.31	2.30	2.30	-6.74	-4.19	-3.84	-3.80	-0.02	0.01	0.00	0.00	-3.49	-3.76	-3.80	-3.79	0.42	0.02	0.00	0.00	3.78	3.76	3.79	3.79
Sc overdrachtspunt (MVA)	11.13	11.20	11.21	11.21	10.98	10.91	10.91	10.91	11.89	11.05	11.39	11.46	10.28	10.92	10.89	10.89	12.10	12.12	12.13	12.13	11.76	11.78	11.78	11.77	11.45	11.42	11.42	11.42
Ic overdrachtspunt (A)	702	649	648	649	666	666	666	666	662	663	663	664	666	665	665	665	604	605	606	606	581	587	589	589	592	599	598	598
Pms-op (kW)	389.7	331.8	331.4	331.9	350.5	350.6	350.6	350.6	350.1	349.6	350.2	350.3	350.8	350.6	350.6	350.6	290.5	290.9	292.4	292.5	266.7	273.1	274.2	274.2	275.5	282.7	281.8	281.8
Qms-op (kVAr)	711.0	582.7	581.6	582.8	627.6	628.7	628.8	628.8	621.9	629.7	626.2	625.4	638.3	630.1	630.4	630.4	480.1	480.7	484.1	484.4	427.0	442.1	444.6	444.7	451.0	468.3	466.2	466.1
Ims-op kabelstroom (p.u.)	1.21	1.11	1.11	1.11	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.15	1.14	1.14	1.14	1.04	1.04	1.05	1.05	1.00	1.01	1.01	1.01	1.01	1.03	1.03	1.03
Pms-tr (kW)	61.1	51.9	51.8	51.9	54.9	54.9	54.9	54.9	54.7	54.7	54.8	54.8	55.0	54.9	54.9	54.9	45.4	45.5	45.7	45.7	41.6	42.7	42.8	42.8	43.0	44.1	44.0	44.0
Qms-tr (kVar)	5.2	-0.9	-1.0	-0.9	1.9	2.1	2.1	2.2	0.7	2.8	1.7	1.5	4.3	2.5	2.5	2.5	-7.8	-7.9	-7.7	-7.6	-10.4	-9.5	-9.4	-9.4	-8.4	-7.4	-7.5	-7.5
Ims-tr kabelstroom (p.u.)	0.61	0.56	0.56	0.56	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.53	0.53	0.53	0.53	0.51	0.51	0.51	0.51	0.51	0.52	0.52	0.52
Ums (p.u.)	0.917	0.998	0.999	0.998	0.950	0.944	0.943	0.943	0.982	0.925	0.955	0.961	0.882	0.934	0.932	0.932	1.114	1.115	1.112	1.112	1.144	1.131	1.129	1.129	1.108	1.093	1.094	1.094
Ptr (kW)	120.7	108.9	108.8	108.9	111.6	111.3	111.3	111.3	110.9	109.2	110.5	110.7	108.6	110.5	110.4	110.4	101.3	101.3	101.6	101.6	97.3	98.3	98.5	98.5	98.8	100.0	99.8	99.8
Qtr (kVAr)	831.0	708.6	707.6	708.7	747.5	747.5	747.5	747.5	748.0	747.8	747.8	747.8	747.6	747.6	747.6	747.6	617.5	618.1	621.2	621.5	568.5	582.0	584.3	584.3	588.7	604.1	602.3	602.2
Itransformer (p.u.)	1.05	0.97	0.97	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	0.91	0.91	0.91	0.87	0.88	0.88	0.88	0.89	0.90	0.90	0.90
Uls (p.u.)	0.920	1.001	1.001	1.000	0.950	0.943	0.943	0.943	0.931	0.889	0.922	0.928	0.872	0.923	0.921	0.921	1.081	1.080	1.078	1.077	1.124	1.111	1.109	1.109	1.103	1.088	1.090	1.090
Pls (kW)	366.9	312.9	312.4	312.9	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	272.6	272.9	274.2	274.4	251.0	257.0	258.0	258.0	259.9	266.8	265.9	265.9
Qls (kVAr)	164.8	140.5	140.4	140.6	148.3	148.3	148.3	148.3	148.3	148.3	148.3	148.3	148.3	148.3	148.3	148.3	122.4	122.6	123.2	123.3	112.8	115.4	115.9	115.9	116.8	119.8	119.5	119.4
Ils-kabelstroom (p.u.)	0.58	0.54	0.54	0.54	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.50	0.50	0.50	0.51	0.48	0.49	0.49	0.49	0.49	0.50	0.50	0.50
Pomv omvormers totaal (MW)	11.80	11.31	11.35	11.36	11.57	11.51	11.51	11.51	10.64	11.07	11.57	11.65	11.13	11.76	11.74	11.74	12.29	12.24	12.23	12.23	12.41	12.45	12.45	12.45	11.49	11.48	11.47	11.47
Qomv omvormers totaal (Mvar)	4.13	5.33	5.24	5.22	3.92	3.84	3.83	3.83	-5.22	-2.66	-2.32	-2.28	1.52	1.54	1.53	1.53	-2.28	-2.54	-2.58	-2.57	1.52	1.15	1.13	1.14	4.93	4.94	4.97	4.97
Somv omvormers totaal (MVA)	12.50	12.50	12.50	12.50	12.21	12.13	12.13	12.13	11.86	11.38	11.80	11.87	11.23	11.86	11.84	11.84	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Pomv omvormer (kW)	236	226	227	227	231	230	230	230	213	221	231	233	223	235	235	235	246	245	245	245	248	249	249	249	230	230	229	229
Qomv omvormer (kVar)	83	107	105	104	78	77	77	77	-104	-53	-46	-46	30	31	31	31	-46	-51	-52	-51	30	23	23	23	99	99	99	99
Somv omvormer (kVA)	250	250	250	250	244	243	243	243	237	228	236	237	225	237	237	237	250	250	250	250	250	250	250	250	250	250	250	250
Uomv (V)	523	566	566	566	538	535	535	534	523	502	520	523	495	523	522	522	606	606	604	604	632	624	623	623	621	613	614	614
Uomv (p.u.)	0.950	1.029	1.030	1.029	0.979	0.972	0.972	0.972	0.950	0.912	0.945	0.951	0.900	0.950	0.949	0.949	1.102	1.102	1.099	1.099	1.149	1.135	1.133	1.133	1.129	1.114	1.116	1.116
Iomv (p.u.)	1.05	0.97	0.97	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	0.91	0.91	0.91	0.87	0.88	0.88	0.88	0.89	0.90	0.90	0.90
Kortsluitbijdrage overdrachtspunt (A)	690																											

Resultaten loadflow	13			13	1			1	2			2	3			3	4			4	5			5
Uc netspanning (p.u.)	0.848	0.850	0.850	0.850	0.998	1.000	1.000	1.000	1.006	1.001	1.000	1.000	1.040	1.016	1.001	1.000	1.049	0.996	1.000	1.000	1.052	1.000	1.000	1.000
Pc overdrachtspunt (MW)	10.05	10.08	10.07	10.08	11.45	11.45	11.44	11.44	10.58	10.68	10.67	10.67	2.42	2.26	2.29	2.30	2.38	2.30	2.30	2.30	-0.02	-0.02	-0.02	-0.02
Qc overdrachtspunt (p.u.)	0.19	0.19	0.19	0.19	-0.33	-0.33	-0.33	-0.33	0.35	0.33	0.33	0.33	-0.20	-0.32	-0.33	-0.33	0.33	0.33	0.33	0.33	0.01	0.00	0.00	0.00
Qc overdrachtspunt (Mvar)	2.17	2.17	2.17	2.17	-3.77	-3.78	-3.79	-3.79	4.02	3.78	3.79	3.79	-2.30	-3.69	-3.80	-3.80	3.84	3.78	3.79	3.79	0.11	0.00	0.00	0.00
Sc overdrachtspunt (MVA)	10.28	10.31	10.31	10.31	12.05	12.06	12.06	12.06	11.32	11.33	11.32	11.32	3.34	4.33	4.44	4.44	4.52	4.42	4.43	4.44	0.11	0.02	0.02	0.02
Ic overdrachtspunt (A)	667	667	667	667	664	663	663	663	619	622	623	623	176	234	244	244	237	244	244	244	6	1	1	1
Pms-op (kW)	351.2	351.2	351.2	351.2	350.4	349.3	349.5	349.5	301.6	305.0	305.6	305.4	25.6	45.0	48.6	48.8	42.9	45.6	45.6	45.7	0.0	0.0	0.0	0.0
Qms-op (kVAr)	637.9	637.5	637.5	637.5	617.7	615.0	615.4	615.6	513.2	520.7	522.1	521.8	-36.1	8.0	17.8	18.2	-7.8	6.5	5.8	5.9	-90.1	-81.3	-81.3	-81.3
Ims-op kabelstroom (p.u.)	1.15	1.15	1.15	1.15	1.14	1.14	1.14	1.14	1.06	1.07	1.07	1.07	0.31	0.41	0.43	0.43	0.40	0.41	0.41	0.41	0.00	0.01	0.01	0.01
Pms-tr (kW)	55.0	55.0	55.0	55.0	54.8	54.6	54.7	54.7	47.1	47.6	47.7	47.7	4.0	7.0	7.6	7.6	6.6	7.0	7.0	7.0	0.0	0.0	0.0	0.0
Qms-tr (kVar)	4.0	3.9	3.9	3.9	-0.4	-0.5	-0.5	-0.5	-4.7	-4.3	-4.2	-4.2	-19.0	-16.7	-16.0	-15.9	-19.6	-17.4	-17.5	-17.5	-21.1	-19.0	-19.0	-19.0
Ims-tr kabelstroom (p.u.)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.54	0.54	0.54	0.54	0.16	0.21	0.22	0.22	0.20	0.21	0.21	0.21	0.00	0.00	0.00	0.00
Ums (p.u.)	0.891	0.893	0.893	0.893	1.011	1.013	1.013	1.013	1.053	1.047	1.046	1.046	1.036	1.004	0.989	0.987	1.073	1.021	1.025	1.024	1.053	1.000	1.000	1.000
Ptr (kW)	109.4	109.4	109.4	109.4	112.7	112.5	112.5	112.5	103.3	103.9	104.0	104.0	28.3	31.7	32.0	32.0	35.5	34.0	34.1	34.1	22.7	20.4	20.4	20.4
Qtr (kVAr)	747.5	747.5	747.5	747.5	746.9	744.3	744.7	744.9	644.6	651.6	652.8	652.5	54.7	95.9	103.7	103.9	90.3	96.0	95.9	96.0	0.0	0.0	0.1	0.1
Itransformer (p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.93	0.93	0.93	0.27	0.36	0.37	0.37	0.35	0.36	0.36	0.36	0.00	0.01	0.01	0.01
Uls (p.u.)	0.893	0.896	0.895	0.895	0.978	0.980	0.980	0.980	1.052	1.046	1.045	1.045	1.000	0.962	0.946	0.945	1.064	1.015	1.018	1.018	1.027	0.975	0.975	0.975
Pls (kW)	330.1	330.1	330.1	330.1	329.7	328.6	328.8	328.8	284.6	287.7	288.3	288.1	24.2	42.3	45.8	45.9	39.9	42.4	42.3	42.4	0.0	0.0	0.0	0.0
Qls (kVAr)	148.3	148.3	148.3	148.3	148.1	147.6	147.7	147.7	127.8	129.2	129.5	129.4	10.9	19.0	20.6	20.6	17.9	19.0	19.0	19.0	0.0	0.0	0.0	0.0
Ils-kabelstroom (p.u.)	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.51	0.52	0.52	0.52	0.15	0.20	0.21	0.21	0.19	0.20	0.20	0.20	0.00	0.00	0.00	0.00
Pomv omvormers totaal (MW)	10.89	10.92	10.92	10.92	12.29	12.29	12.29	12.29	11.32	11.42	11.42	11.41	2.50	2.38	2.43	2.43	2.50	2.42	2.43	2.43	0.00	0.00	0.00	0.00
Qomv omvormers totaal (Mvar)	3.71	3.71	3.71	3.71	-2.26	-2.28	-2.29	-2.29	5.30	5.07	5.09	5.09	-2.29	-3.59	-3.67	-3.67	3.92	3.88	3.90	3.90	0.00	-0.10	-0.10	-0.10
Somv omvormers totaal (MVA)	11.51	11.54	11.53	11.53	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	3.39	4.31	4.40	4.40	4.65	4.58	4.59	4.59	0.00	0.10	0.10	0.10
Pomv omvormer (kW)	218	218	218	218	246	246	246	246	226	228	228	228	50	48	49	49	50	48	49	49	0	0	0	0
Qomv omvormer (kVar)	74	74	74	74	-45	-46	-46	-46	106	101	102	102	-46	-72	-73	-73	78	78	78	78	0	-2	-2	-2
Somv omvormer (kVA)	230	231	231	231	250	250	250	250	250	250	250	250	68	86	88	88	93	92	92	92	0	2	2	2
Uomv (V)	507	508	508	508	551	552	552	552	593	590	590	590	552	530	521	520	590	563	565	565	565	536	536	536
Uomv (p.u.)	0.922	0.924	0.924	0.924	1.002	1.004	1.004	1.004	1.079	1.073	1.072	1.072	1.004	0.964	0.948	0.946	1.072	1.023	1.027	1.027	1.027	0.975	0.975	0.975
Iomv (p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.93	0.93	0.93	0.27	0.36	0.37	0.37	0.35	0.36	0.36	0.36	0.00	0.01	0.01	0.01

Resultaten loadflow	Pmax			Pmax	40%Pmax/+Qmax			40%Pmax/+Qmax	40%Pmax/-Qmax			40%Pmax/-Qmax
Uc netspanning (p.u.)	0.899	0.954	0.950	0.950	0.988	1.000	1.000	1.000	0.974	1.011	1.001	1.000
Pc overdrachtspunt (MW)	10.89	11.54	11.50	11.50	4.64	4.60	4.60	4.60	4.67	4.58	4.59	4.60
Qc overdrachtspunt (p.u.)	0.02	0.00	0.00	0.00	0.31	0.33	0.33	0.33	-0.24	-0.32	-0.33	-0.33
Qc overdrachtspunt (Mvar)	0.18	0.03	0.00	0.00	3.62	3.77	3.79	3.79	-2.78	-3.69	-3.80	-3.80
Sc overdrachtspunt (MVA)	10.89	11.54	11.50	11.50	5.88	5.95	5.96	5.96	5.44	5.88	5.96	5.96
Ic overdrachtspunt (A)	666	665	665	665	327	327	328	328	307	320	327	328
Pms-op (kW)	350.6	350.4	350.4	350.4	83.4	83.3	83.5	83.6	75.8	82.6	86.4	86.8
Qms-op (kVAr)	630.4	621.7	622.3	622.4	82.5	80.1	80.7	80.8	74.5	83.1	92.3	93.2
Ims-op kabelstroom (p.u.)	1.14	1.14	1.14	1.14	0.56	0.56	0.56	0.56	0.53	0.56	0.57	0.57
Pms-tr (kW)	54.9	54.9	54.9	54.9	12.9	12.9	13.0	13.0	11.8	12.9	13.5	13.5
Qms-tr (kVar)	2.5	0.6	0.7	0.7	-15.2	-15.7	-15.7	-15.7	-13.9	-14.8	-14.2	-14.1
Ims-tr kabelstroom (p.u.)	0.58	0.58	0.58	0.58	0.28	0.28	0.28	0.28	0.27	0.28	0.29	0.29
Ums (p.u.)	0.933	0.986	0.983	0.982	1.018	1.030	1.030	1.031	0.973	1.005	0.995	0.994
Ptr (kW)	110.5	112.6	112.4	112.4	43.8	44.3	44.4	44.4	38.8	41.7	42.3	42.3
Qtr (kVAr)	747.6	747.6	747.6	747.6	176.5	176.2	176.8	176.9	161.3	175.8	183.9	184.6
Itransformer (p.u.)	1.00	1.00	1.00	1.00	0.49	0.48	0.49	0.49	0.46	0.48	0.50	0.50
Uls (p.u.)	0.922	0.973	0.969	0.969	1.013	1.025	1.025	1.025	0.938	0.965	0.954	0.953
Pls (kW)	330.1	330.1	330.1	330.1	77.9	77.8	78.1	78.1	71.2	77.6	81.2	81.5
Qls (kVAr)	148.3	148.3	148.3	148.3	35.0	34.9	35.1	35.1	32.0	34.9	36.5	36.6
Ils-kabelstroom (p.u.)	0.55	0.55	0.55	0.55	0.27	0.27	0.27	0.27	0.26	0.27	0.27	0.28
Pomv omvormers totaal (MW)	11.73	12.39	12.35	12.34	4.86	4.82	4.82	4.82	4.87	4.80	4.81	4.82
Qomv omvormers totaal (Mvar)	1.71	1.54	1.52	1.52	3.90	4.05	4.07	4.07	-2.53	-3.41	-3.50	-3.50
Somv omvormers totaal (MVA)	11.86	12.49	12.44	12.44	6.23	6.29	6.30	6.31	5.48	5.88	5.95	5.96
Pomv omvormer (kW)	235	248	247	247	97	96	96	96	97	96	96	96
Qomv omvormer (kVar)	34	31	30	30	78	81	81	81	-51	-68	-70	-70
Somv omvormer (kVA)	237	250	249	249	125	126	126	126	110	118	119	119
Uomv (V)	523	550	548	548	565	571	571	571	520	535	529	528
Uomv (p.u.)	0.950	1.001	0.997	0.997	1.027	1.039	1.039	1.039	0.946	0.972	0.962	0.960
Iomv (p.u.)	1.00	1.00	1.00	1.00		0.49	0.49	0.49		0.48	0.50	0.50

Kleurcodering	
	Geen overschrijding van de grenzen van de omvormers, transformatoren of kabels
	Bedrijfspunt op nominale of grenswaarde van de omvormer of overschrijding belastbaarheid transformator of kabel
	Overschrijding van de grenzen van de omvormers
	Berekend blindvermogen, werkzaam vermogen en relatieve spanning op het overdrachtspunt

Figure 7 Calculations load flow cases NBNL CVD 2.0 and Pmax

4.5 Sheet LF model Q-U and Q-P vensters

This sheet includes the calculations and formulas. Taking the limits of the wind turbine or PV-inverter as a starting point, the voltages, currents and power are calculated for the turbine//inverter, cables and transformers. An example of the presentation of the calculation results is shown in Figure 4. The main results of the calculations in columns L to AC in sheet "LF model" are automatically provided with a cell color. Its meaning is explained below the table. With an orange color, the operating point of the inverters is exactly on the limit or the limiter is active. If a cell is coloured red, the inverters, transformer or cable are overloaded. In this case, the component in question must be adjusted by installing more inverters, cables or transformers or a substantiated explanation must be given as to why the calculated overload will not be problematic. The calculations are based on interpretation of the requirements in Netcode.

The 1st block, with indices "c", refers to the calculated values at the connection point.

The 2nd block with indices "ms-op" concerns the kW and kvar losses in the cables from the connection point to the MS park installation. The relative load of the cables is also indicated. The transformers are connected to the MS park installation via MS-TR cables (3rd block, indices ms-tr). Of these, the kW and kvar losses and the relative load of the cables are also calculated. The kvar figure can be negative: in that case, the MS cable generates more reactive power than it consumes.

The 4th block with indices "tr", concerns kW and kvar losses and the relative load of the transformers. The relative voltage on MS resp. LS side of the transformers is presented above (Ums) resp. below (Uls) this block.

The 5th block, with indices "ls", concerns kW and kvar losses and the relative load of the cables between transformers and inverters/wind turbines.

The 6th and 7th block, with indices "omv", concern the generated active, reactive and apparent capacities of all inverters/wind turbines together resp. of the individual inverter/wind turbine. Below this are presented the absolute (Uomv (V)) and relative (Uomv (p.u.) voltage and the relative current (Iomv (p.u.)) of the inverter/wind turbine.

Finally, the calculated contribution to the short circuit current at the connection point. This is determined by dividing the specified maximum short circuit current of the joint inverters/wind turbines on the low voltage side by the transfer ratio of the transformers.

The calculations have also been carried out for 20% of the maximum active power. These results are also presented in the BLOS tool. An example of this presentation is shown in Figure 8.

Resultaten loadflow	Load flow bij maximaal werkzaam vermogen											
Uc netspanning (p.u.)	0.919	1.183	0.954	0.841	0.779	0.860	1.077	1.126	1.183	0.970	1.005	1.014
Pc overdrachtspunt (MW)	11.01	10.36	8.72	10.05	8.78	9.63	10.37	11.26	10.36	10.18	11.13	10.30
Pc overdrachtspunt (p.u.)	1.00	0.94	0.79	0.91	0.80	0.87	0.94	1.02	0.94	0.92	1.01	0.94
Qc overdrachtspunt (p.u.)	-0.14	-0.63	-0.67	-0.14	0.32	0.37	0.43	-0.09	-0.63	-0.52	-0.11	0.42
Qc overdrachtspunt (Mvar)	-1.53	-6.99	-7.41	-1.54	3.55	4.02	4.78	-0.98	-6.99	-5.74	-1.27	4.64
Sc overdrachtspunt (MVA)	11.11	12.50	11.45	10.17	9.47	10.43	11.42	11.30	12.50	11.69	11.20	11.30
Ic overdrachtspunt (A)	665	581	660	664	668	667	583	552	581	662	613	613
Pms-op (kW)	350.4	270.4	348.5	350.1	353.0	351.2	267.3	241.7	270.4	350.1	297.8	295.2
Qms-op (kVAr)	628.4	427.8	625.0	639.4	650.1	634.8	431.9	376.0	427.8	623.6	509.4	498.5
Ims-op kabelstroom (p.u.)	1.14	1.01	1.14	1.14	1.15	1.15	1.00	0.95	1.01	1.14	1.06	1.05
Pms-tr (kW)	54.9	42.2	54.5	54.9	55.3	55.0	41.7	37.7	42.2	54.7	46.6	46.1
Qms-tr (kVar)	2.1	-11.7	2.1	4.8	6.2	3.3	-9.5	-12.0	-11.7	1.1	-4.0	-5.5
Ims-tr kabelstroom (p.u.)	0.58	0.51	0.58	0.58	0.58	0.58	0.51	0.48	0.51	0.58	0.53	0.53
Ums (p.u.)	0.944	1.178	0.941	0.865	0.829	0.911	1.123	1.149	1.178	0.970	1.029	1.063
Ptr (kW)	110.5	98.0	109.1	107.6	107.5	110.4	97.5	90.6	98.0	110.7	100.0	102.2
Qtr (kVAr)	747.7	571.8	748.1	747.7	747.5	747.5	571.6	514.2	571.8	747.9	634.3	631.1
Itransformer (p.u.)	1.00	0.87	1.00	1.00	1.00	1.00	0.87	0.83	0.87	1.00	0.92	0.92
Uls (p.u.)	0.924	1.130	0.884	0.846	0.844	0.921	1.120	1.124	1.130	0.926	1.007	1.064
Pls (kW)	330.1	252.4	330.1	330.1	330.1	330.1	252.4	227.0	252.4	330.1	280.0	278.6
Qls (kVAr)	148.3	113.4	148.3	148.3	148.3	148.3	113.4	102.0	113.4	148.3	125.8	125.2
Ils-kabelstroom (p.u.)	0.55	0.48	0.55	0.55	0.55	0.55	0.48	0.46	0.48	0.55	0.51	0.51
Pomv omvormers totaal (MW)	11.86	11.03	9.56	10.89	9.62	10.47	11.03	11.86	11.03	11.03	11.86	11.03
Qomv omvormers totaal (Mvar)	0.00	-5.89	-5.89	0.00	5.10	5.55	5.89	0.00	-5.89	-4.22	0.00	5.89
Somv omvormers totaal (MVA)	11.86	12.50	11.23	10.89	10.89	11.86	12.50	11.86	12.50	11.81	11.86	12.50
Pomv omvormer (kW)	237	221	191	218	192	209	221	237	221	221	237	221
Qomv omvormer (kVar)	0	-118	-118	0	102	111	118	0	-118	-84	0	118
Somv omvormer (kVA)	237	250	225	218	218	237	250	237	250	236	237	250
Uomv (V)	523	630	495	480	480	523	630	630	630	520	567	600
Uomv (p.u.)	0.95	1.15	0.90	0.87	0.87	0.95	1.15	1.15	1.15	0.95	1.03	1.09
Iomv (p.u.)	1.00	0.87	1.00	1.00	1.00	1.00	0.87	0.83	0.87	1.00	0.92	0.92
Kortsluitbijdrage overdrachtspunt (A)	690											

Resultaten loadflow	Load flow bij 20% van maximaal werkzaam vermogen										
Uc netspanning (p.u.)	1.277	1.056	0.880	0.751	0.835	1.060	1.163	1.277	1.002	1.005	1.025
Pc overdrachtspunt (MW)	1.70	1.53	2.32	1.52	1.52	1.71	2.32	1.70	1.54	2.32	1.68
Pc overdrachtspunt (p.u.)	0.15	0.14	0.21	0.14	0.14	0.16	0.21	0.15	0.14	0.21	0.15
Qc overdrachtspunt (p.u.)	-1.21	-1.13	0.00	0.82	0.91	1.01	0.01	-1.21	-1.07	0.00	1.01
Qc overdrachtspunt (Mvar)	-13.37	-12.49	0.00	9.06	10.07	11.16	0.09	-13.37	-11.77	0.04	11.08
Sc overdrachtspunt (MVA)	13.48	12.58	2.32	9.19	10.19	11.29	2.32	13.48	11.87	2.32	11.21
Ic overdrachtspunt (A)	580	655	145	673	670	586	110	580	651	127	602
Pms-op (kW)	273.5	348.2	16.6	358.6	354.7	268.0	9.6	273.5	344.2	12.8	283.2
Qms-op (kVAr)	424.5	615.2	-30.8	663.7	644.1	435.0	-92.0	424.5	615.6	-57.6	471.6
Ims-op kabelstroom (p.u.)	1.01	1.14	0.25	1.16	1.15	1.00	0.19	1.01	1.13	0.22	1.03
Pms-tr (kW)	42.6	54.1	2.6	55.8	55.1	41.5	1.5	42.6	53.4	2.0	43.9
Qms-tr (kVar)	-13.9	-0.2	-14.1	6.9	3.9	-9.2	-25.5	-13.9	1.6	-18.8	-6.9
Ims-tr kabelstroom (p.u.)	0.51	0.58	0.13	0.59	0.58	0.50	0.10	0.51	0.57	0.11	0.52
Ums (p.u.)	1.227	0.999	0.887	0.811	0.896	1.114	1.169	1.227	0.945	1.011	1.080
Ptr (kW)	99.0	109.9	20.5	108.0	111.0	98.0	30.5	99.0	107.8	24.4	100.5
Qtr (kVAr)	571.9	748.3	35.4	748.1	748.0	571.8	20.6	571.9	748.4	27.4	603.9
Itransformer (p.u.)	0.87	1.00	0.22	1.00	1.00	0.87	0.17	0.87	1.00	0.19	0.90
Uls (p.u.)	1.151	0.906	0.867	0.855	0.933	1.131	1.141	1.151	0.849	0.988	1.100
Pls (kW)	252.4	330.1	15.6	330.1	330.1	252.4	9.1	252.4	330.1	12.1	266.5
Qls (kVAr)	113.4	148.3	7.0	148.3	148.3	113.4	4.1	113.4	148.3	5.4	119.7
Ils-kabelstroom (p.u.)	0.48	0.55	0.12	0.55	0.55	0.48	0.09	0.48	0.55	0.11	0.50
Pomv omvormers totaal (MW)	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Qomv omvormers totaal (Mvar)	-12.27	-10.98	0.00	10.63	11.62	12.27	0.00	-12.27	-10.26	0.00	12.27
Somv omvormers totaal (MVA)	12.50	11.23	2.37	10.89	11.86	12.50	2.37	12.50	10.53	2.37	12.50
Pomv omvormer (kW)	47	47	47	47	47	47	47	47	47	47	47
Qomv omvormer (kVar)	-245	-220	0	213	232	245	0	-245	-205	0	245
Somv omvormer (kVA)	250	225	47	218	237	250	47	250	211	47	250
Uomv (V)	630	495	480	480	523	630	630	630	464	546	613
Uomv (p.u.)	1.15	0.90	0.87	0.87	0.95	1.15	1.15	1.15	0.84	0.99	1.11
Iomv (p.u.)	0.87	1.00	0.22	1.00	1.00	0.87	0.17	0.87	1.00	0.19	0.90

Kleurcodering	
	Geen overschrijding van de grenzen van de omvormers, transformatoren of kabels
	Bedrijfspunt op nominale of grenswaarde van de omvormer of overschrijding belastbaarheid transformator of kabel
	Overschrijding van de grenzen van de omvormers
	Berekend blindvermogen, werkzaam vermogen en relatieve spanning op het overdrachtspunt

Figure 8 Presentation of the calculation results at a maximum and 20% of maximum active power