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## LIST OF ABBREVIATIONS

<b>ATB</b>	Main Busbar
<b>FRT</b>	Fault Ride Through (Contribution of Wind Power Generation Facilities to the System After a Fault)
<b>Hz</b>	Hertz
<b>kA</b>	Kiloampere
<b>kV</b>	Kilovolt
<b>kVA</b>	Kilovolt-ampere
<b>kW</b>	Kilowatt
<b>LVRT</b>	Low Voltage Ride Through
<b>MVAR</b>	Mega Volt-Ampere Reactive
<b>MW</b>	Megawatt
<b>MV</b>	Medium Voltage
<b>P</b>	Active Power
<b>PF</b>	Power Factor
<b>pu</b>	per unit
<b>Q</b>	Reactive Power
<b>R</b>	Resistance
<b>RES</b>	Wind Power Plant
<b>RMU</b>	Ring Main Unit
<b>rpm</b>	Revolutions Per Minute
<b>s</b>	Second
<b>TM</b>	Substation
<b>V</b>	Volt
<b>WTG</b>	Wind Turbine
<b>X</b>	Reactance
<b>HV</b>	High Voltage

## INTRODUCTION

The purpose of this report is to analyze the compliance of Gogni Wind Company LLC (Licensee)'s 187.5 MW Gogni Wind Power Plant (WPP), located in the Imereti region of Georgia, with the criteria specified in the "General Grid requirements - GSE.pdf" document.

For the analysis, a simulation model of the Gogni WPP's medium-voltage (MV) grid was created in a grid analysis software. Since the regulatory requirements apply to grid connection point 1, the high-voltage (HV) grid was modeled in a simplified manner but was not subject to a specific analysis.

The dynamic turbine and main controller mathematical models required for the analysis were provided by MingYang Electric in encrypted form.

The studies cover the following topics.

- Power Flow Analyses
- Reactive Power Capacity,
- Provision of Reactive Power Support
- Grid-Connected Transformer for Wind Power Generation Facilities,

The analyses in this study were performed based on a steady-state condition.

# 1 GOGNI WIND POWER PLANT MODEL

This section describes the dynamic grid model created for the Gogni Wind Power Plant.

## 1.1 LOCATION

The Gogni Wind Power Plant is located on a ridge line stretching between the villages of Gogni and Mukhura, within the administrative boundaries of the Terjola and Tkibuli municipalities in the Imereti region of Georgia. Figure 1 shows the locations of the turbines at the wind power plant on a geographic map.

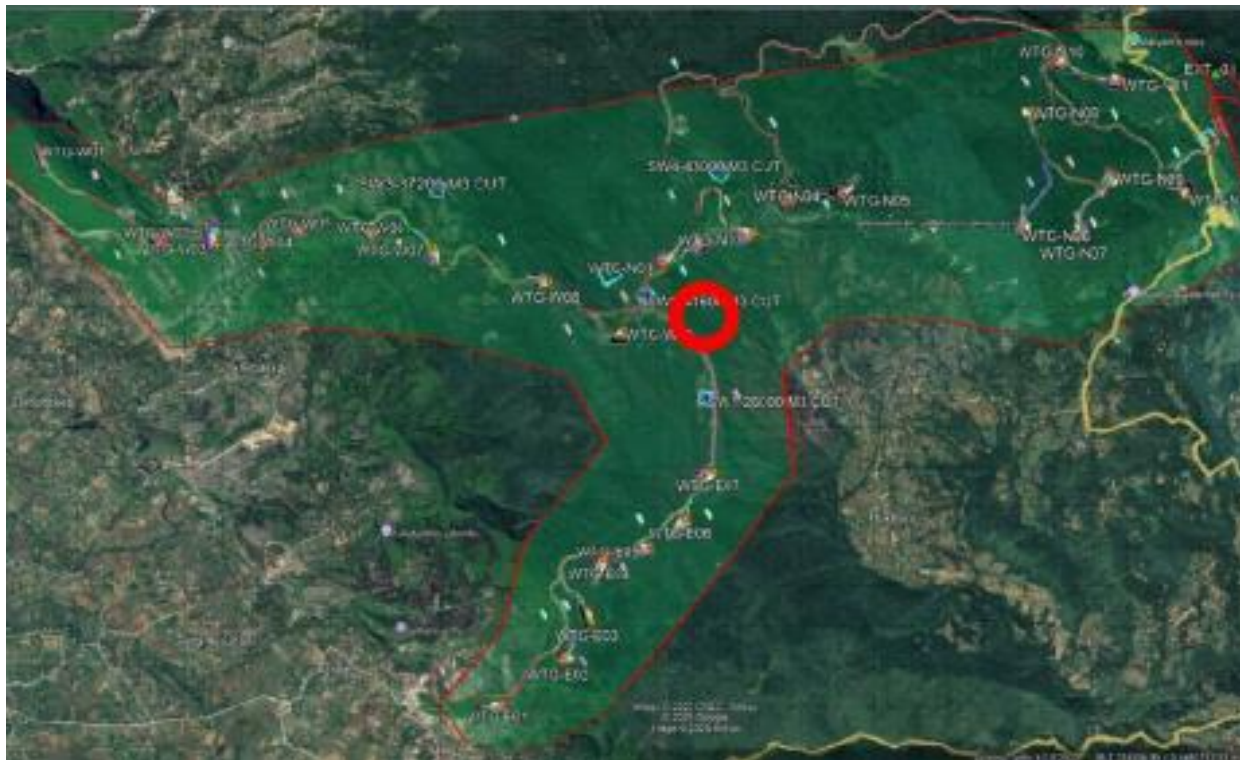


Figure 1 . Gogni Wind Farm Geographic Map i

## 1.2 WIND TURBINE GENERATORS

Analysis studies at Gogni RES were conducted only for the turbine generators listed below:

- **MingYang** MY7500KDF : 7.5 MW, WEC Type, 25 Units

Table 1 lists the turbine parameters used in the grid model.

Table 1 . MingYang MY7500KDF Turbine Parameters

Parameter	Unit	MY7500KDF
Rated Voltage	V	1140
Rated Power	kW	7,500

### 1.2.1 LOAD CURVES

Figure2 shows the load curve of the MY7500KDF 7.5MW turbine model, created based on data provided by MingYang.

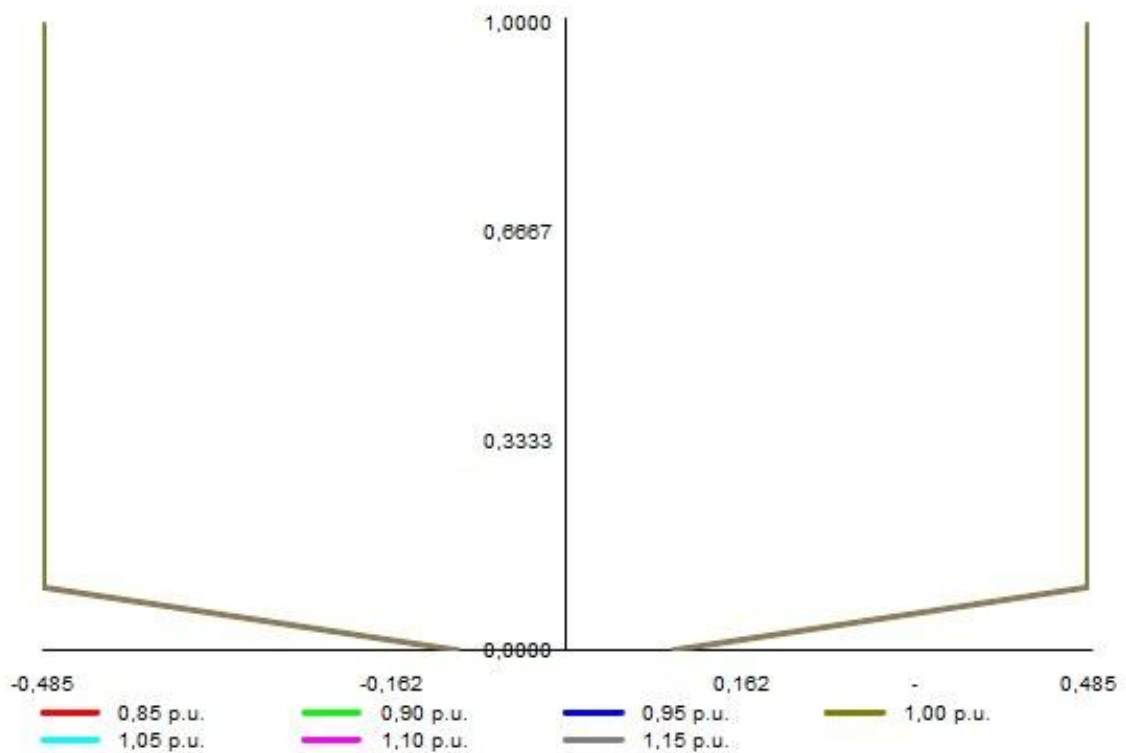


Figure2 . MingYang MY7500KDF /7.5MW

The values of the curve are provided in the table below.

Table2 . MingYang MY7500KDF /7.5MW P-Q Values (When Voltage is 1 p.u.)

P (p.u.)	-Q (MVAr)	+Q (MVAr)
0,	0,	0,
0.1	-3.64	3.64
1	-3.64	3.64

### 1.3 TURBINE TRANSFORMERS

The parameters for the turbine transformer model created based on the data provided by MingYang are listed in the table below.

**Table3 . MY7500KDF Turbine Transformer Parameters**

Parameter	Unit	MY7500KDF
Rated Power	MVA	7.5
Rated Frequency	Hz	50
Low-Voltage Side	kV	1.14
High-Voltage Side	kV	34.5
Connection Type	-	Dyn11
Short-Circuit Impedance ( $u_k$ )	%	9.0
Copper Loss	kW	45
Tap Changer (HV, Open)	-	$\pm 2 \times 2.5\%$

### 1.4 POWER PLANT MV GRID

The Gogni RES MV grid connects the wind turbines to two main busbars (ATB-01 and ATB-02) located within the power plant site. As part of the power plant configuration, each main busbar is connected to the grid connection point via its own HV/MV step-up power transformer. The grid connection point is connected to the national transmission system via a high-voltage line. The parameters of these power transformers used in the model are provided in the table below.

**Table4 . HV/MV Transformer Parameters**

Parameter	Unit	Value
Rated Power	MVA	120
Nominal Frequency	Hz	50
Low-Voltage Side	kV	34.5
High-Voltage Side	kV	220
Connection Type	-	YnD11
Short-Circuit Impedance ( $u_k$ )	%	11.0
Copper Loss	kW	400
No-Load Losses	kW	85
Voltage Regulator (HV)	-	$\pm 9 \times 1.78\%$

The MV network model was created based on the document “1.1 Gogni Single Line Diagram 17.04.2026.dwg” submitted by the investor company. Cable types and lengths were also obtained from the same document.

The table below lists the cross-sections, rated currents, and positive-sequence parameters of the cables used in the MV network.

**Table5 . Underground Cables**

Cross-Section (mm <sup>2</sup> )	Voltage (kV)	Material	Rated Current (A)	R ( $\Omega$ /km)	X ( $\Omega$ /km)
1x150	34.5	Aluminum	355	0.209	0.126
1x240	34.5	Aluminum	460	0.129	0.116
1x400	34.5	Aluminum	640	0.066	0.104

The single-line diagram of the Gogni RES OG grid, created in the simulation software, is shown below.

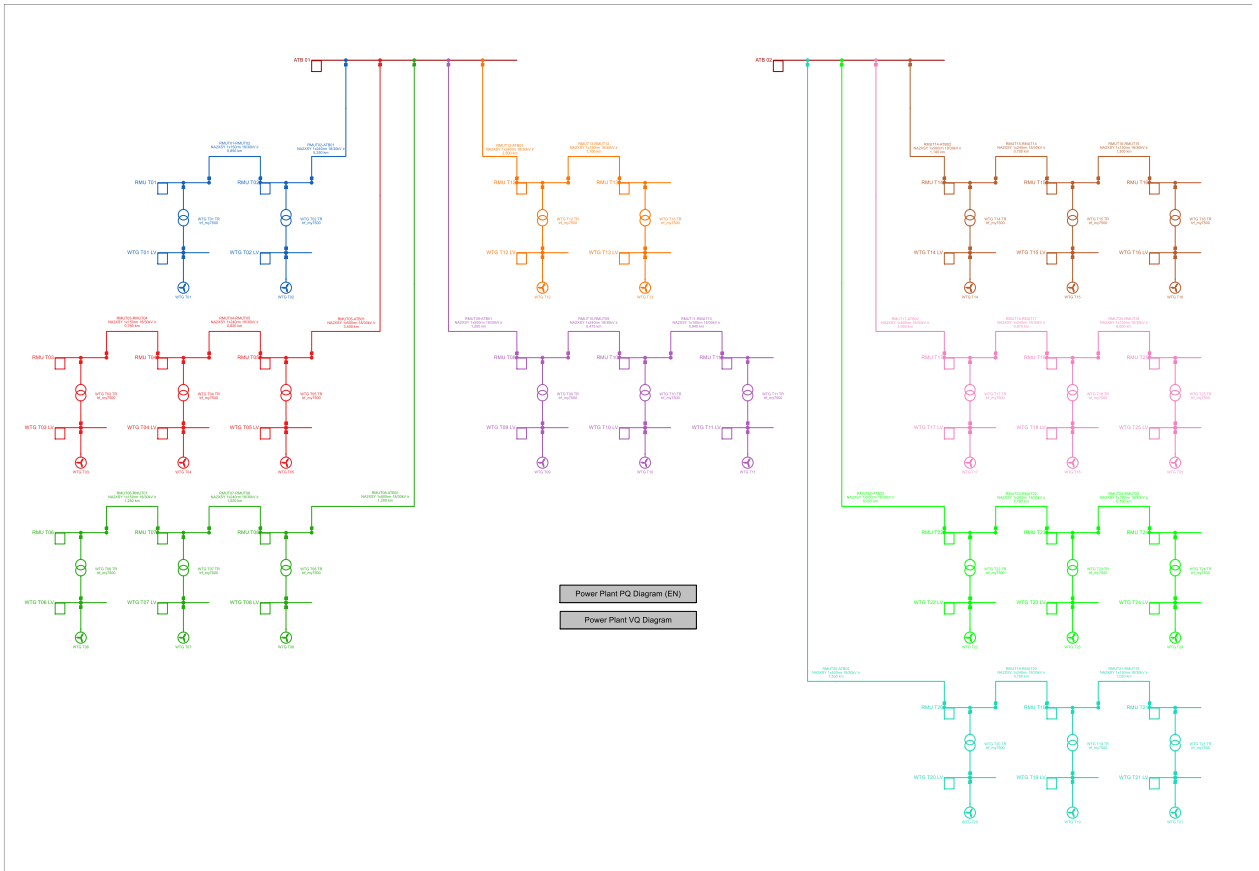


Figure3 . Gogni RES OG Network

Table6 lists the parameters of the cables used in the connections between the RMUs and the ATB, as generated in the network model.

Table6 . Locations of Cables in the OG Network

From	To	Cross-Section (mm <sup>2</sup> /Material)	Length (km)
RMU T06	RMU T07	150/Aluminum	1,250
RMU T07	RMU T08	240/Aluminum	1,020
RMU T08	ATB 01	500/Aluminum	1,200
RMU T03	RMU T04	150/Aluminum	0,780
RMU T04	RMU T05	240/Aluminum	0,820
RMU T05	ATB 01	500/Aluminum	3,400
RMU T01	RMU T02	150/Aluminum	0,850
RMU T02	ATB 01	240/Aluminum	5,250
RMU T11	RMU T10	150/Aluminum	0,940
RMU T10	RMU T09	240/Aluminum	0,475
RMU T09	ATB 01	500/Aluminum	1,200
RMU T13	RMU T12	150/Aluminum	1,100
RMU T12	ATB 01	240/Aluminum	2,500

From	To	Cross-Section (mm <sup>2</sup> /Material)	Length (km)
RMU T21	RMU T19	150/Aluminum	1,020
RMU T19	RMU T20	240/Aluminum	0.700
RMU T20	ATB 02	500/Aluminum	7,500
RMU T24	RMU T23	150/Aluminum	0.790
RMU T23	RMU T22	240/Aluminum	1.780
RMU T22	ATB 02	500/Aluminum	8,000
RMU T25	RMU T18	150/Aluminum	6,650
RMU T18	RMU T17	240/Aluminum	0.875
RMU T17	ATB 02	500/Aluminum	5,000
RMU T16	RMU T15	150/Aluminum	1,300
RMU T15	RMU T14	240/Aluminum	0.700
RMU T14	ATB 02	500/Aluminum	1.140

## 1.5 GOGNI RES HIGH-VOLTAGE NETWORK

Gogni RES is connected to the Zabvis TM via a 2x1272 MCM cross-section overhead line approximately 2 km in length.

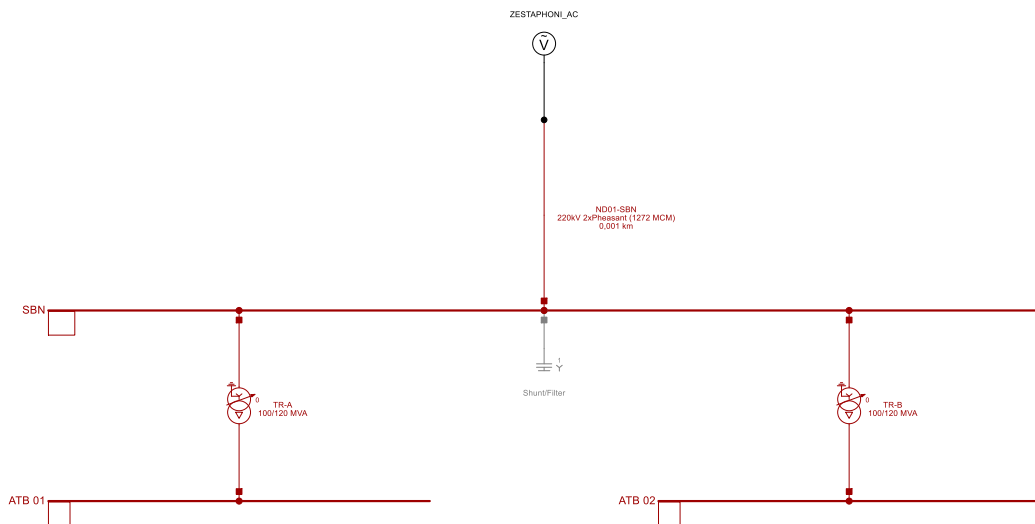


Figure4 . Simulation Model of the Gogni RES Power Transmission Line

## 2 GRID COMPATIBILITY ANALYSES

All requirements specified in the regulation apply to the Grid Connection Point.

The Grid Connection Point is defined as follows in the “General Grid requirements - GSE.pdf” file.

**Connection Point:** The final pole following the point where the switchyards of transmission facilities and generation and consumption facilities connected at the distribution voltage level end, and the building entry point of consumers connected at the low-voltage level.

Accordingly, the ND-1 grid connection point located at the Gogni RES output has been accepted.

## 2.1 LOAD FLOW ANALYSES

Load flow analyses comprising four scenarios were conducted as part of the Gogni RES connection analysis studies. All analyses were performed using the Newton–Raphson iteration method based on power balance equations. The four scenarios used in the load flow simulations are briefly summarized below.

- Case 1: Turbines operating at 25% load
- Case 2: Turbines operating at 50% load
- Case 3: Turbines operating at 75% load
- Case 4: Turbines operating at 100% load

### 2.1.1 CASE 1

In this scenario, a load flow simulation was performed for the Gogni RES turbines operating at 25% load. The simulation results shown in the figure are displayed on the single-line diagram generated by the grid analysis software.

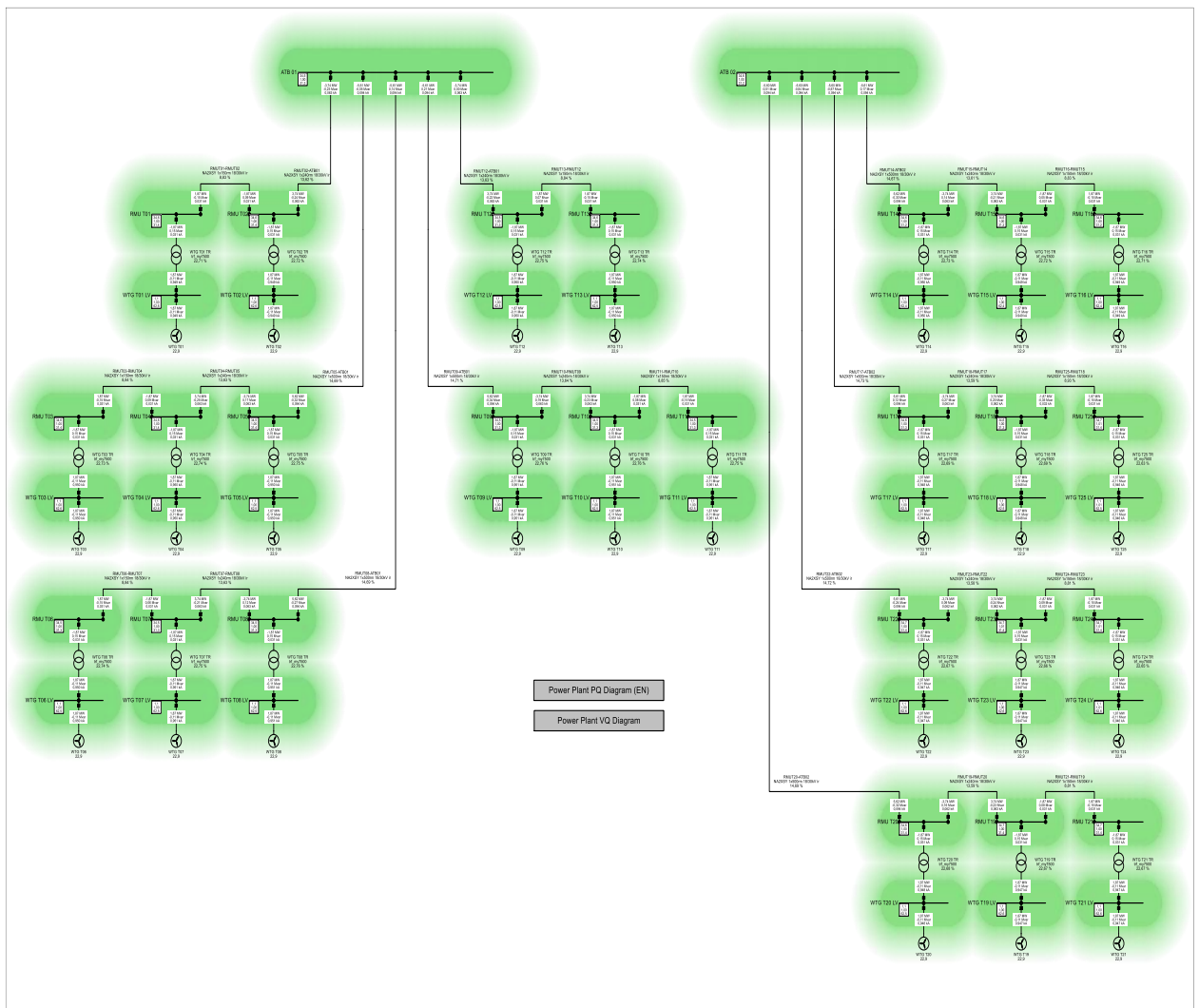


Figure5 . Gogni RES, Power Flow Simulation Results, Case 1

2.1.2 CASE 2

In this scenario, a load flow simulation was performed with the Gogni RES turbines operating at 50% load. The simulation results shown in the figure are displayed on the single-line diagram generated by the grid analysis software.

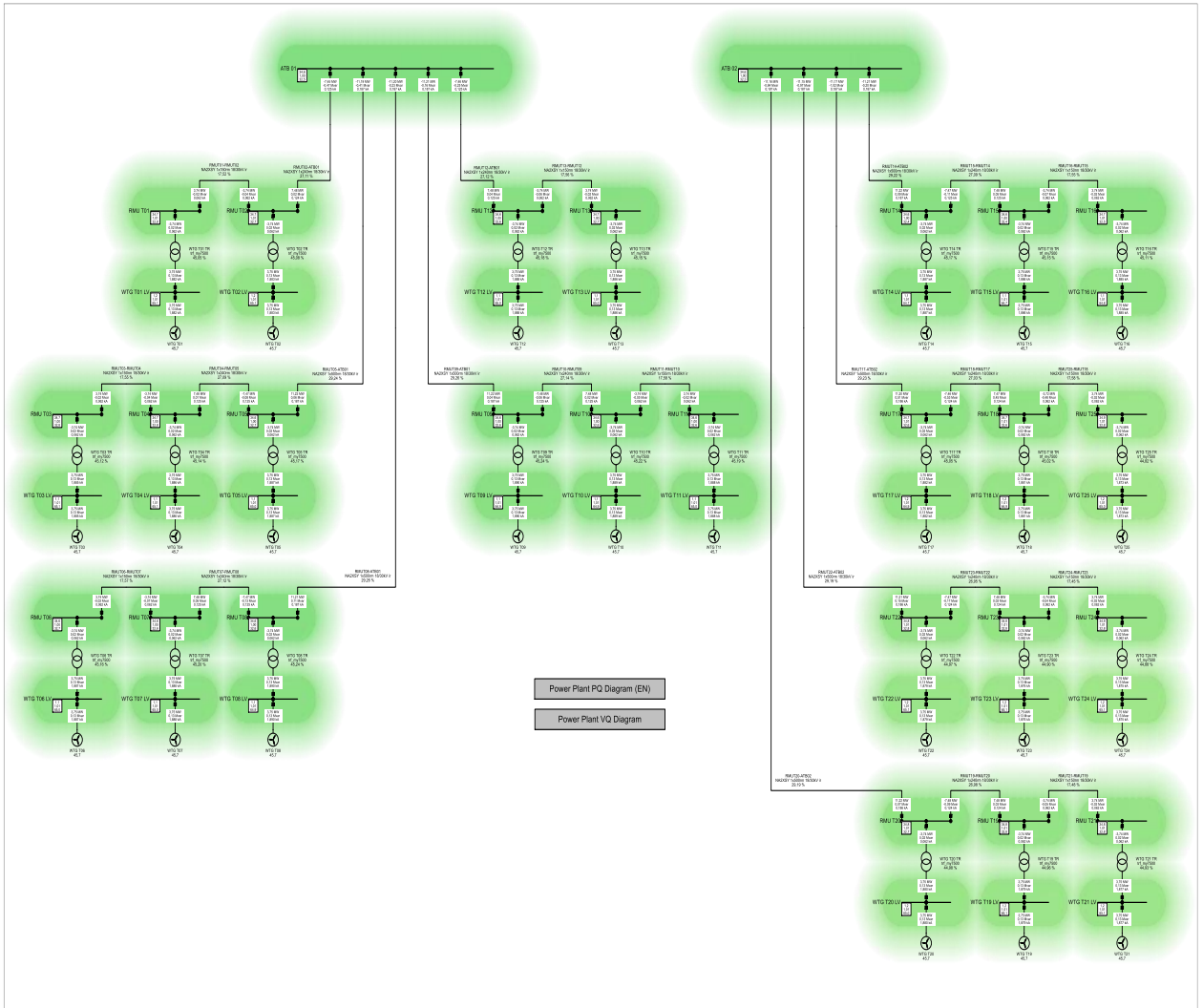


Figure6. Gogni RES, Load Flow Simulation Results, Case 2

2.1.3 CASE 3

In this scenario, a load flow simulation was performed with the Gogni RES turbines operating at 75% load. The simulation results shown in the figure are displayed on the single-line diagram generated by the network analysis software.

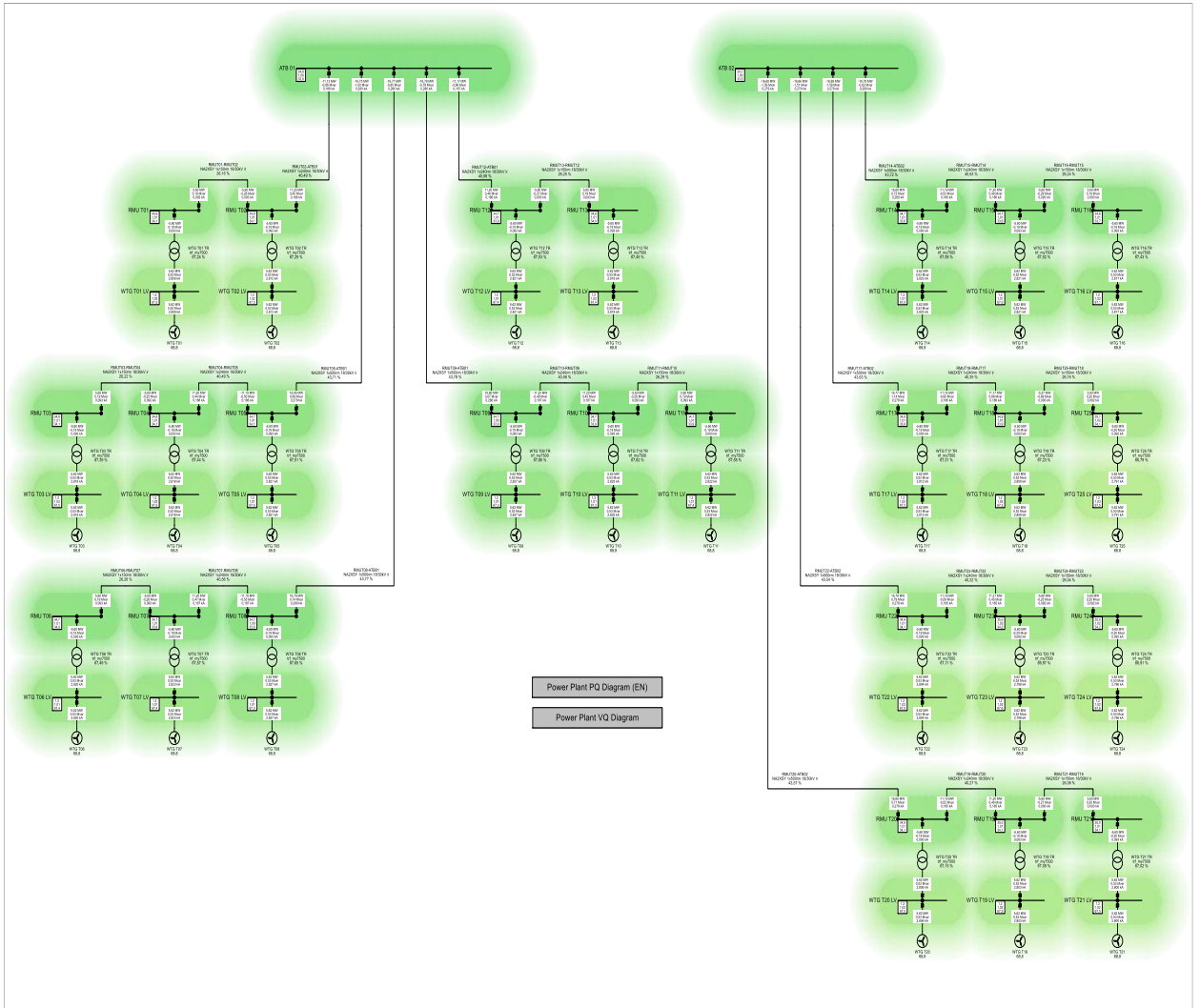


Figure7. Gogni RES, Load Flow Simulation Results, Case 3

2.1.4 CASE 4

In this scenario, a load flow simulation was performed with the Gogni RES turbines operating at 100% capacity. The simulation results shown in the figure are displayed on the single-line diagram generated by the network analysis software.

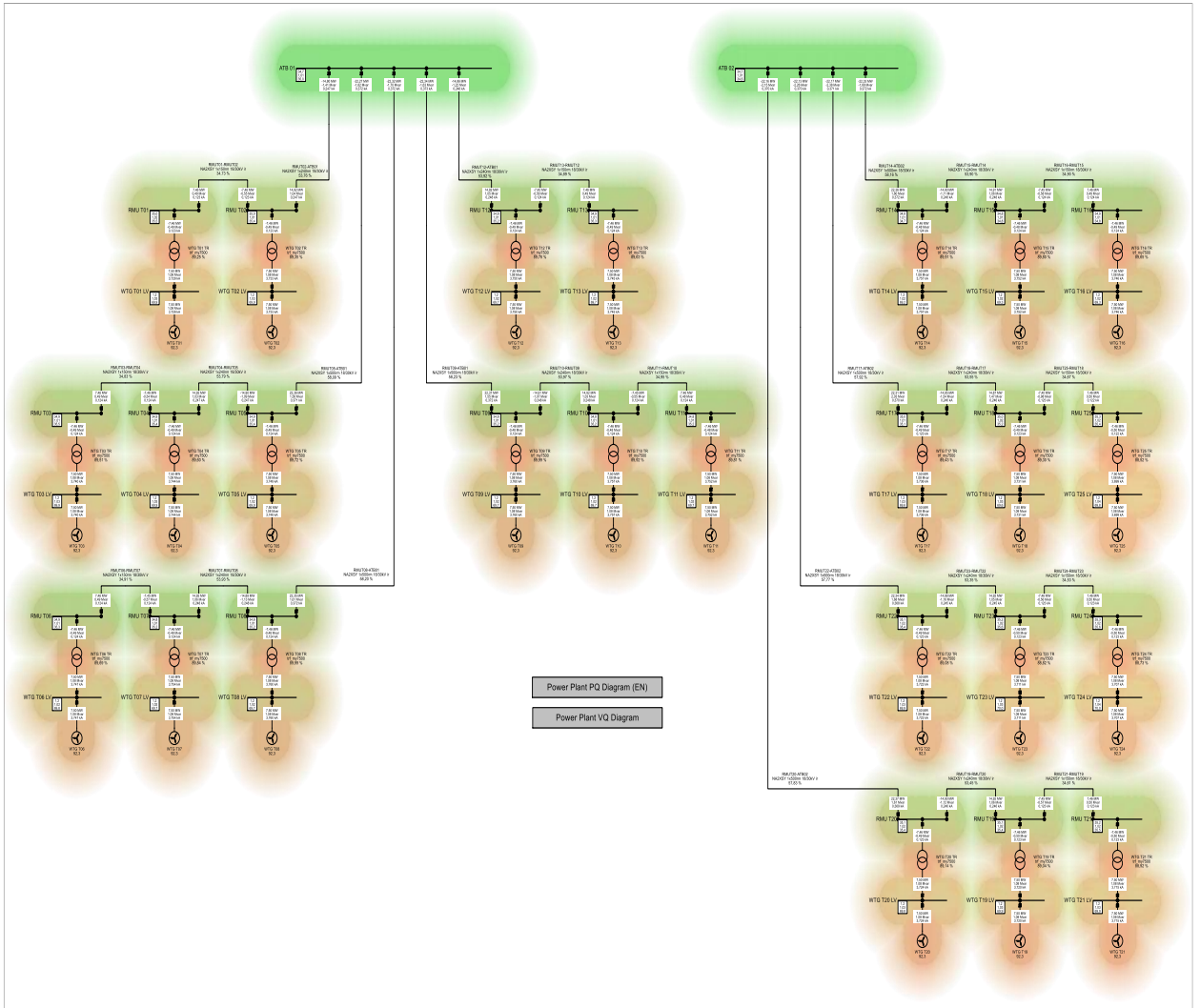


Figure8. Gogni RES, Load Flow Simulation Results, Case 4

## 2.2 REACTIVE POWER CAPACITY

In the figure below, the reactive power capacity of the Gogni RES is compared with the requirements specified in the Regulation, without considering losses that will occur in the power plant's OG grid and transformers.

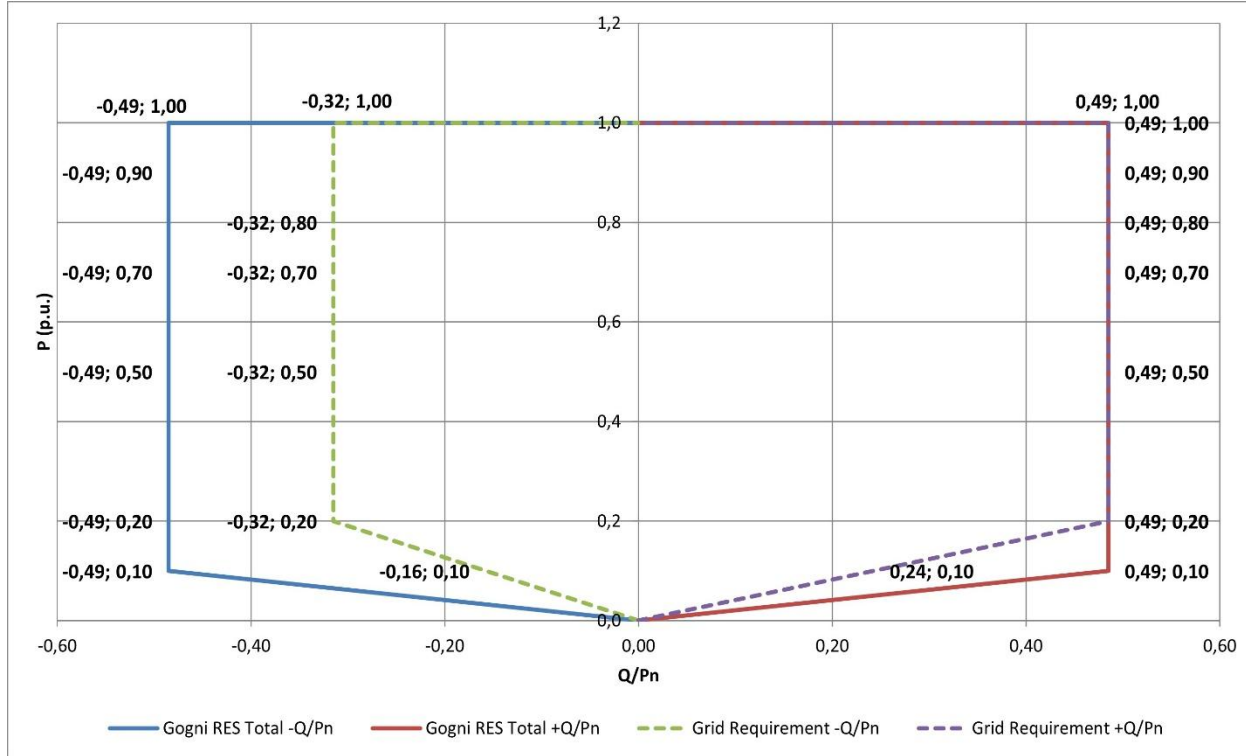


Figure9 . Gogni RES Total Reactive Power Capacity

The values shown in the figure are provided in the table below.

Table7 . Gogni RES Reactive Power Capacity

Active Power		Regulation Reactive Power Capacity				Gogni RES Total Reactive Power Capacity			
		Inductive		Capacitive		Inductive		Capacitive	
MW	MW (p.u.)	+ Q (MVA <sub>r</sub> )	+Q/P <sub>n</sub> (p.u.)	-Q (MVA <sub>r</sub> )	-Q/P <sub>n</sub> (p.u.)	+ Q (MVA <sub>r</sub> )	+Q/P <sub>n</sub> (p.u.)	-Q (MVA <sub>r</sub> )	-Q/P <sub>n</sub> (p.u.)
0	0.0	0	0	0	0	0.00	0.00	0.00	0.00
18.75	0.1	45.47	0.24	-29.53	-0.16	90.94	0.49	-90.94	-0.49
37.5	0.2	90.94	0.49	-59.06	-0.32	90.94	0.49	-90.94	-0.49
93.75	0.5	90.94	0.49	-59.06	-0.32	90.94	0.49	-90.94	-0.49
131.25	0.7	90.94	0.49	-59.06	-0.32	90.94	0.49	-90.94	-0.49
168.75	0.9	90.94	0.49	-59.06	-0.32	90.94	0.49	-90.94	-0.49
187.5	1.0	90.94	0.49	-59.06	-0.32	90.94	0.49	-90.94	-0.49

As can be seen from the table, the reactive power capacity of the Gogni Wind Farm is in compliance with the Regulation’s requirements, however; since the reactive power capacity specified in the Regulation is for the grid connection point, the reactive power capacity of the Gogni RES at the grid connection point—which includes reactive power losses occurring in cables and transformers as a result of the load flow analyses—is provided in Figure 10.

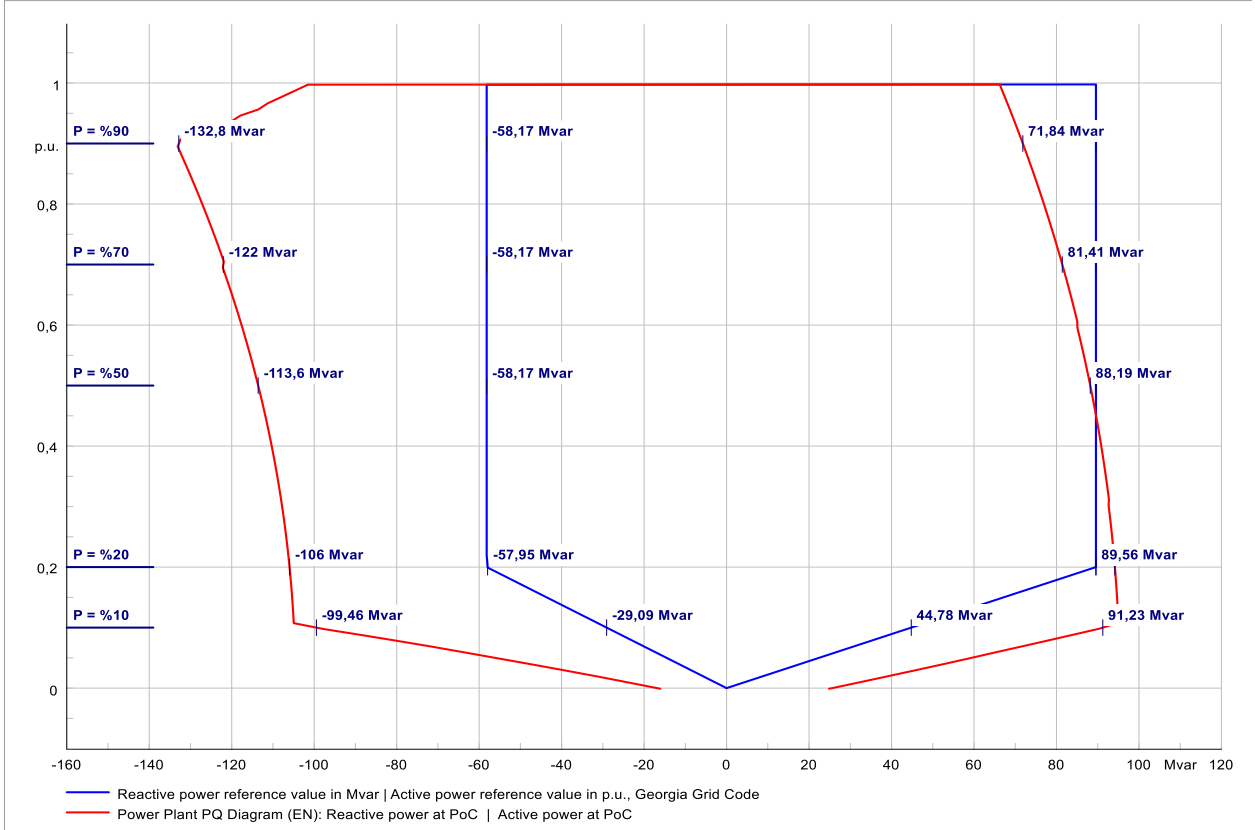


Figure 10 . Total Reactive Power Capacity of the Gogni RES at the Grid Connection Point

The results obtained from the simulation are summarized in the table below.

Table 8 . Reactive Power Capacity of the Gogni RES at the Grid Connection Point

Active Power		Regulatory Reactive Power Capacity				Gogni RES Total Reactive Power Capacity			
MW	MW (p.u.)	Inductive		Capacitive		Inductive		Capacitive	
		+ Q (MVar)	+Q/Pn (p.u.)	-Q (MVar)	-Q/Pn (p.u.)	+ Q (MVar)	+Q/Pn (p.u.)	-Q (MVar)	-Q/Pn (p.u.)
0	0.0	0	0	0	0	0	0.00	0	0.00
18,467	0.1	44.78	0.24	-29.09	-0.16	91.23	0.49	-99.46	-0.54
36,934	0.2	89.56	0.49	-58.17	-0.32	94.16	0.51	-106.00	-0.57
92,335	0.5	89.56	0.49	-58.17	-0.32	88.19	0.48	-113.60	-0.62
129,269	0.7	89.56	0.49	-58.17	-0.32	81.41	0.44	-122.00	-0.66
166,203	0.9	89.56	0.49	-58.17	-0.32	71.84	0.39	-132.80	-0.72
184,67	1.0	89.56	0.49	-58.17	-0.32	66.23	0.36	-101.50	-0.55

Figure10 , the Gogni RES can meet the reactive power requirement specified in the Regulation in the capacitive direction; however, in the inductive direction, the capacity falls short by approximately 23.34 MVAR at 100% active power level.

Limit values reached during the simulation:

- Maximum Cable Loading Ratio: 64.517%
- Maximum Transformer Load Factor: 99.987%
- Maximum Voltage in the Power Plant MV Grid: 1.069 p.u. (36.88 kV)
- Minimum Voltage in the Power Plant MV Network: 0.939 p.u. (32.40 kV)
- Maximum Voltage at Turbine Terminals: 1.069 p.u. (1.22 kV)
- Minimum Voltage at Turbine Terminals: 0.939 p.u. (1.07 kV)

The requirement in the Regulation regarding *the "Variation of Mandatory Reactive Power Values Depending on the Connection Point Voltage"* has been compared for the Gogni RES grid connection point as shown below.

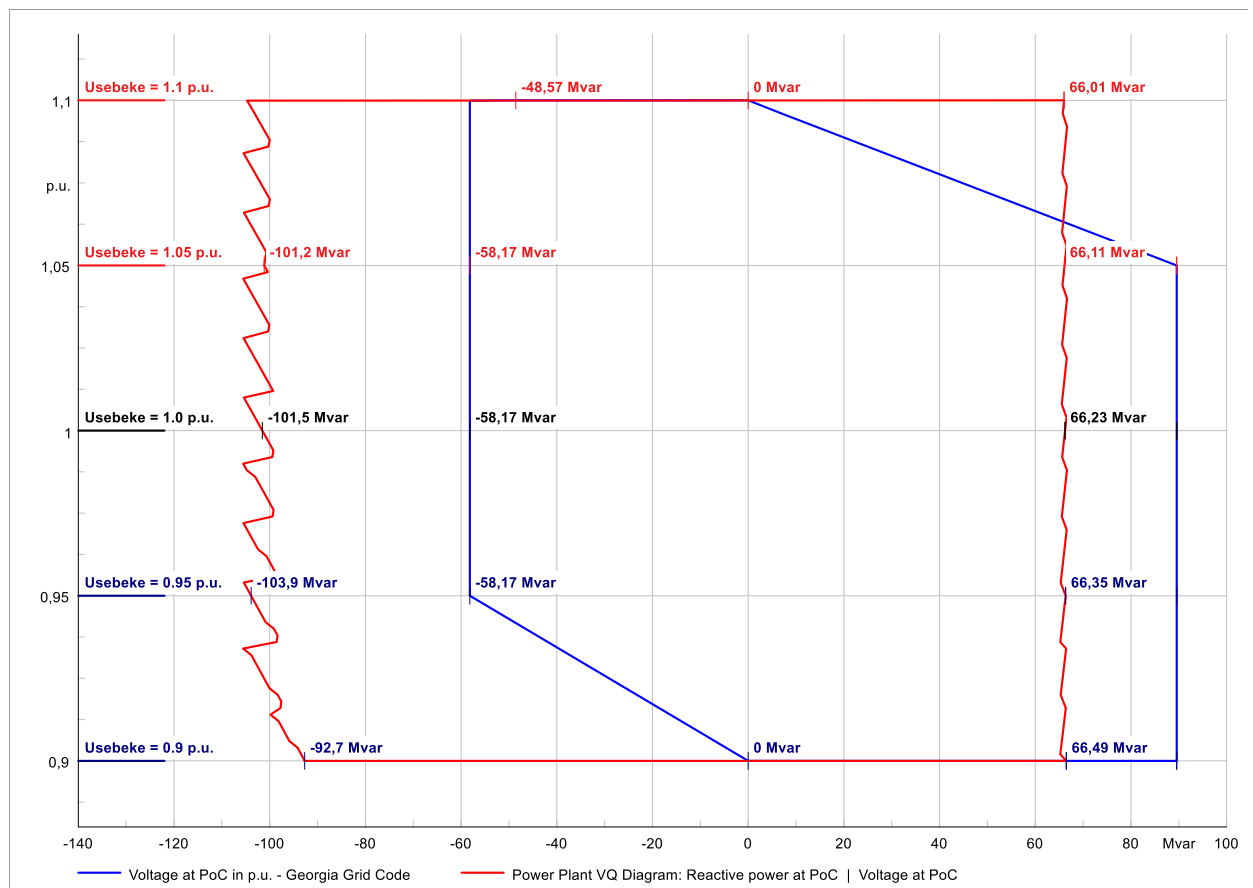


Figure11 . Variation of Mandatory Reactive Power Values at the Gogni RES Connection Point Based on Voltage

The values indicated in the figure are provided in the table below.

**Table9 . Variation of Mandatory Reactive Power Values at the Gogni RES Connection Point as a Function of Voltage**

Grid Voltage (p.u.)	Regulation Reactive Power Capacity				Gogni RES Total Reactive			
	+Q (MVA <sub>r</sub> )	-Q (MVA <sub>r</sub> )	+Q/P <sub>n</sub> (p.u.)	-Q/P <sub>n</sub> (p.u.)	+Q (MVA <sub>r</sub> )	-Q (MVA <sub>r</sub> )	+Q/P <sub>n</sub> (p.u.)	-Q/P <sub>n</sub> (p.u.)
1.1	0.00	-58.17	0.00	-0.32	66.01	-104.70	0.36	-0.57
1.05	89.56	-58.17	0.49	-0.32	66.11	-101.20	0.36	-0.55
1	89.56	-58.17	0.49	-0.32	66.23	-101.50	0.36	-0.55
0.95	89.56	-58.17	0.49	-0.32	66.35	-103.90	0.36	-0.56
0.9	89.56	0.00	0.49	0.00	66.49	-92.70	0.36	-0.50

Figure11 , when the voltage at the Gogni RES grid connection point increases, the system can meet the reactive power requirement specified in the Regulation in the capacitive direction; however, in the inductive direction, the reactive capacity supplied by the turbines falls short by up to 24.34 MVA<sub>r</sub>.

Limit values reached during the simulation:

- Maximum Cable Loading Ratio: 64.738%
- Maximum Transformer Load Factor: 99.995%
- Maximum Voltage in the Power Plant MV Grid: 1.100 p.u. (37.95 kV)
- Minimum Voltage in the Power Plant MV Network: 0.900 p.u. (31.05 kV)
- Maximum Voltage at Turbine Terminals: 1.076 p.u. (1.23 kV)
- Minimum Voltage at Turbine Terminals: 0.961 p.u. (1.10 kV)

## 2.3 PROVISION OF REACTIVE POWER SUPPORT

This article of the regulation can be divided into two groups: “Static Droop” and “Response Time.”

### Static Droop

$\frac{\Delta U}{\Delta Q}$  The static droop value calculated from the equation represents the wind turbine’s response to changes in grid voltage—whether positive or negative—by adjusting its reactive power output. For example, at a 2% droop value, in response to a ±2% change in grid voltage, the wind power plant must provide the full reactive power capacity (±60.7 MVar for Gogni RES) that it is obligated to supply, whether in an over-excited or under-excited state. As specified in the regulation, the droop value is a figure between 2% and 12%, to be determined by the system operator.

The figure below shows the reactive power capacity provided by the Gogni RES to the system in response to voltage changes at the grid connection point for droop values of 2%, 4%, 7%, and 12%.

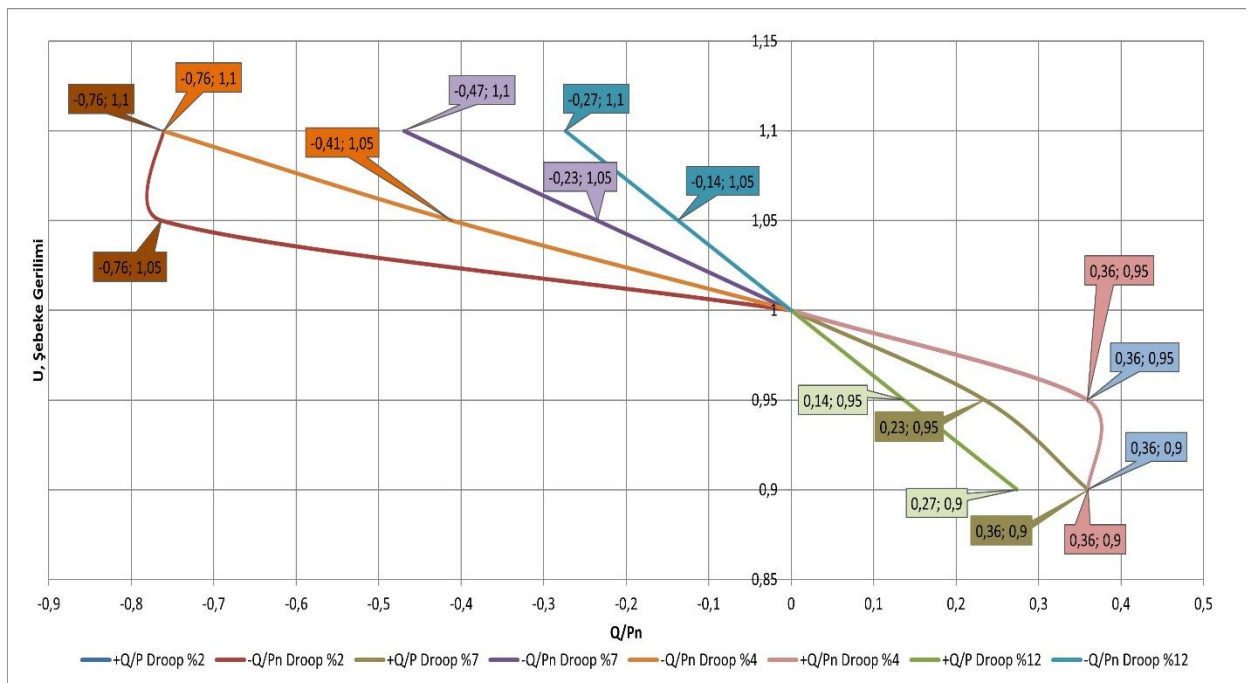


Figure12 . Reactive Power Support Curve to Be Provided to the System by Wind Power Plants, Comparison

The values shown in the figure are summarized in the table below.

Table10 . Reactive Power Support

U, Grid	Droop=2%		Droop=4%		Droop=7%		12% Droop	
	+Q/Pn	-Q/Pn	+ Q/Pn	- Q/Pn	+ Q/Pn	-Q/Pn	±Q/Pn	-Q/Pn
1.10		-0.76		-0.76		-0.47		-0.27
1.05		-0.76		-0.41		-0.23		-0.14
0.95	0.36		0.36		0.23		0.14	
0.90	0.36		0.36		0.36		0.27	

## 2.4 GRID-CONNECTED TRANSFORMERS FOR WIND POWER GENERATION FACILITIES

The document provided by the manufacturer states that the grid connection transformers used at Gogni RES are equipped with an automatic tap changer under load.

Technical Specification				
No	Name	Unit	Parameter	
14	220/35kV Voltage Three Phase Power Transformer	Comp.	2	
1	Manufacturer & Type			
2	Minimum temperature	°C	-25	
3	Maximum temperature	°C	+40	
4	Altitude above sea level	M	<1000	
5	Standard		IEC 60076	
6	Setup Type		Outdoor Setup	
7	Rated Power	MVA	120/100	
8	Type of cooling		(ONAF) and (ONAN)	
9	Nominal Frequency	Hz	50	
	Nominal voltages without load			
10	High Voltage Side	kv	220	
11	Low Voltage Side	kv	35	
12	Oil Protection		Membrane	
13	Winding Connection Scheme and Group		Ynd11	
14	Permissible Temperatures			
15	Oil	°C	±55	
16	Scroll	°C	±60	
17	Relay Protection Supply Voltage	F	220 DC	
18	Gas Relay		Yes	
19	Inkjet Relay for RPN Tank		Yes	
20	Oil Level Control		Yes	
21	Tank Protection in the Event of Overpressure		Yes	
22	Oil Temperature Indicator		Yes	
23	Scroll Temperature Indicator		Yes	
24	Number of adjustment steps on the high voltage side		±9 x 1.78%	
25	Voltage Switch Type High Voltage Side		Under Load Switch	

Figure13 . Gogni RES, Grid Connection Transformer with Automatic Tap Changer

### 3 CONCLUSION

The following results were obtained from the Electrical Grid Compliance analyses performed on the Gogni RES mathematical grid model.

#### **E.18.5 Reactive Power Capacity**

The power plant can meet the reactive power requirement specified in the Regulation in the capacitive direction; however, in the inductive direction, the capacity falls short by approximately 23.34 MVAR at 100% active power level.

If the voltage at the power plant's grid connection point increases, the plant can meet the reactive power requirement specified in the Regulation in the capacitive direction; however, in the inductive direction, the reactive capacity provided by the turbines falls short by up to 24.34 MVAR at various voltage levels.

#### **E.18.6 Provision of Reactive Power Support**

The reactive power support to be provided by the plant to the system has been statically verified at droop values of 2%, 4%, 7%, and 12%. A dynamic analysis must be performed to verify compliance with the Regulation's requirements.

#### **E.18.6 Grid Connection Transformer for Wind Power Generation Facility**

The documentation provided by the manufacturer states that the grid connection transformers used at the Gogni RES are equipped with an automatic tap changer under load.