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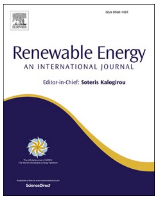

Analysis of urban network operation in presence of renewable sources for decarbonization of energy system

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ABSTRACT

In order to decarbonize the energy system, it is necessary to change all aspects of the production, transport and consumption of electricity chain. The European Union (EU) aims to become the first climate-neutral continent by 2050. To deliver on this ambition, decarbonising the energy sector is crucial because the production and use of energy accounts for more than 75 % of the EU's greenhouse gas emissions (EEA, 2021).

The connection of renewable sources near the places of consumption can lead to flexibility in changing the operating diagram, the operator having the possibility to keep certain distribution cables disconnected, which diminishes the reactive power circulating through the distribution network. The article analyzed two types of distribution areas that show that in the area where consumption is high, it is easier to implement measures to transform the area into positive energy. The concept The concept of Ecs ("energy communities") provides a great boost for overcoming resistance to infrastructure development, increasing acceptance and penetration of distributed energy resources (DERs), encouraging private investments, and establishing public-private partnerships.

1. Introduction

The European Commission has highlighted the need to move from the production of electrical energy in large fossil fuel power plants to the decentralized production of electricity from renewable sources [1]. Through European Directive 2018/2001/EU, the European Union introduced in its legislation the concept of "energy communities" (EC) as a fundamental step for a clean energy transition within the general clean energy policy for all Europeans.

Some countries of the world are planning to complete transition to the electricity supply of consumers from renewable energy generation, for example, in Sweden by 2040 [2], in Canada by 2050 [3].

Wind energy is one of the important sources of renewable energy. However, it exhibits challenges in the form of stability and control when integrating with the conventional grid [4].

The dynamic stability operation challenges facing modern power systems with extremely high VRE generation in discussed in Ref. [5], which focused on two challenges: power system stability with high inverter-based resources, and potential mitigation measures from various enabling technologies.

More than 50 % of the world's population lives in the urban environment and they consume about 60–80 % of the total energy production [6]. Electricity production is responsible for two thirds of total Greenhouse Gas (GHG) emissions [7] and urban areas are the ones that emit 75 % of the total CO_2 emissions [8]. Only 20 % of the total GHG emissions can be attributed to the industry sector. As seen in the United Nations projections for up to 2050, if the current urban population growth trend continues, global urbanization will represent 67 % of the total population [9], and cities will demand a more significant amount of energy.

The users play a key role in achieving the flexibility needed to adapt the electricity system to the variable and distributed production of electricity from renewable sources. Generating electricity for the local self-consumption is more cost effective than selling the generated electricity to the grid [10].

Community Renewable Energy (RE) initiatives offer multitudes of benefits— they democratize the energy transition [11,12], maximize the consumption of locally produced clean energy at lower prices, and can reduce grid stress by aggregating the potential of individuals to offer demand side management.

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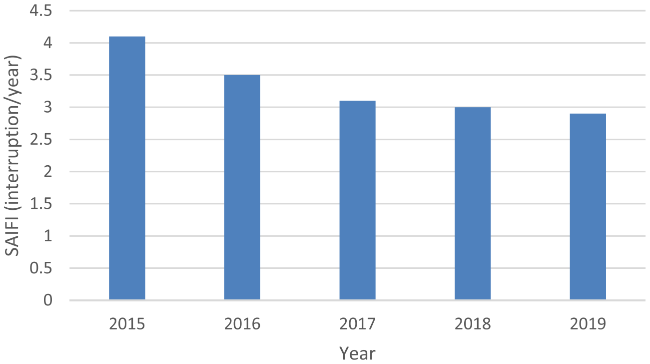

Fig. 1. Unplanned SAIFI (interruption/year).

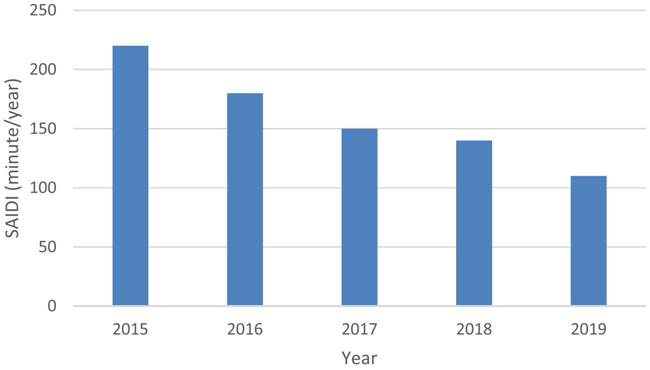

Fig. 2. Unplanned SAIDI (minute/year).

Table 1
Main sources of power in the Bucharest city area.

Power Plant	Number of groups	$P_{installed}$ [MW]	$P_{available}$ [MW]
Bucharest South	3	2 × 100 1 × 125	2 × 100 1 × 115
Bucharest West CHP	2	195	195
Grozavesti	2	2 × 50	2 × 48

The decarbonization of the energy sector, regulatory supported through Clean Energy Package, provides a favorable legislative framework for integration of renewable energy sources and the creation of local energy communities. The transition of the energy sector will require concrete measures to implement the new facilities for citizens and communities regarding electricity market and renewable energy sources. The local energy projects can develop rapidly based on renewable energy support schemes (which provide incentives), but also due to increased energy awareness. New business models, social awareness of energy efficiency and affordability, will be created based on innovative financing and remuneration schemes, smart technologies, social acceptance and citizen inclusive participation.

A significant challenge is the development of positive energy communities in crowded areas where consumption is substantial and the space needed to install renewable sources is limited.

In this paper an extended network area analysis is carried out considering the existing situation and the possibility of implementing solutions for improving the operation with benefits for both end-users and network operators in the area of interest.

2. Analysis of a metropolitan area

The Bucharest metropolitan area is a deficient area where local consumption largely exceeds local production capacity. This leads to the fact that the power supply is carried out through the transmission substations located on the outskirts of the metropolitan area.

In the urban area in Romania, E-Distribuţie Muntenia has the largest number of users (1,052,285) and in the rural area has the lowest number of users (250,301) [13].

Taking into account forecasts for the increase of consumption in the period 2020–2029, considering an average annual demand growth rate of approx. 3 %, the Bucharest Metropolitan area will reach a consumption of up to 2000 MW in 2029.

The indices characterizing the continuity of supply in power systems, worldwide monitored and used, are SAIFI (system average interruption frequency index), SAIDI (system average interruption duration index), MAIFI (momentary average interruption frequency index).

The variations of the unplanned SAIFI and SAIDI for the period 2015–2019 are shown in Fig. 1, respectively in Fig. 2.

The specific aspects of the area are represented by:

- high concentration of consumption;
- difficulty in obtaining land for development works and extremely high prices for land acquisition;
- consumers sensitive to power outages;
- a high number of km of high voltage and medium voltage cables, which determine the need to compensate for a high value of reactive power;
- many generating groups in Bucharest are scheduled for cassation;
- the fact that many renewable sources are connected in the Dobrogea area leads to the increase of power flows to the Bucharest area.

Table 1 reports the main sources of power in the Bucharest city area [14].

In 2023 it was withdraw from operation the 2 groups from Grozavesti station. Within the Municipality of Bucharest, the distribution network is made almost entirely of underground lines.

3. Analysis of voltage levels and network load

The main aspects that are monitored in the electricity networks [15] to ensure the required quality of electricity supplied to end-users are:

- the direction of power flow in the electrical distribution and transmission networks;
- the voltage level in all nodes of the electrical network (in classical systems it is sufficient to monitor the voltages in the representative nodes);
- the value of the power factor for all users of the electricity network;
- unbalance of the system (especially in low voltage networks) and neutral conductor charging;
- the level of distortion of voltage curves in all nodes of the electrical network (in classical systems it is sufficient to monitor the common point of coupling of users);

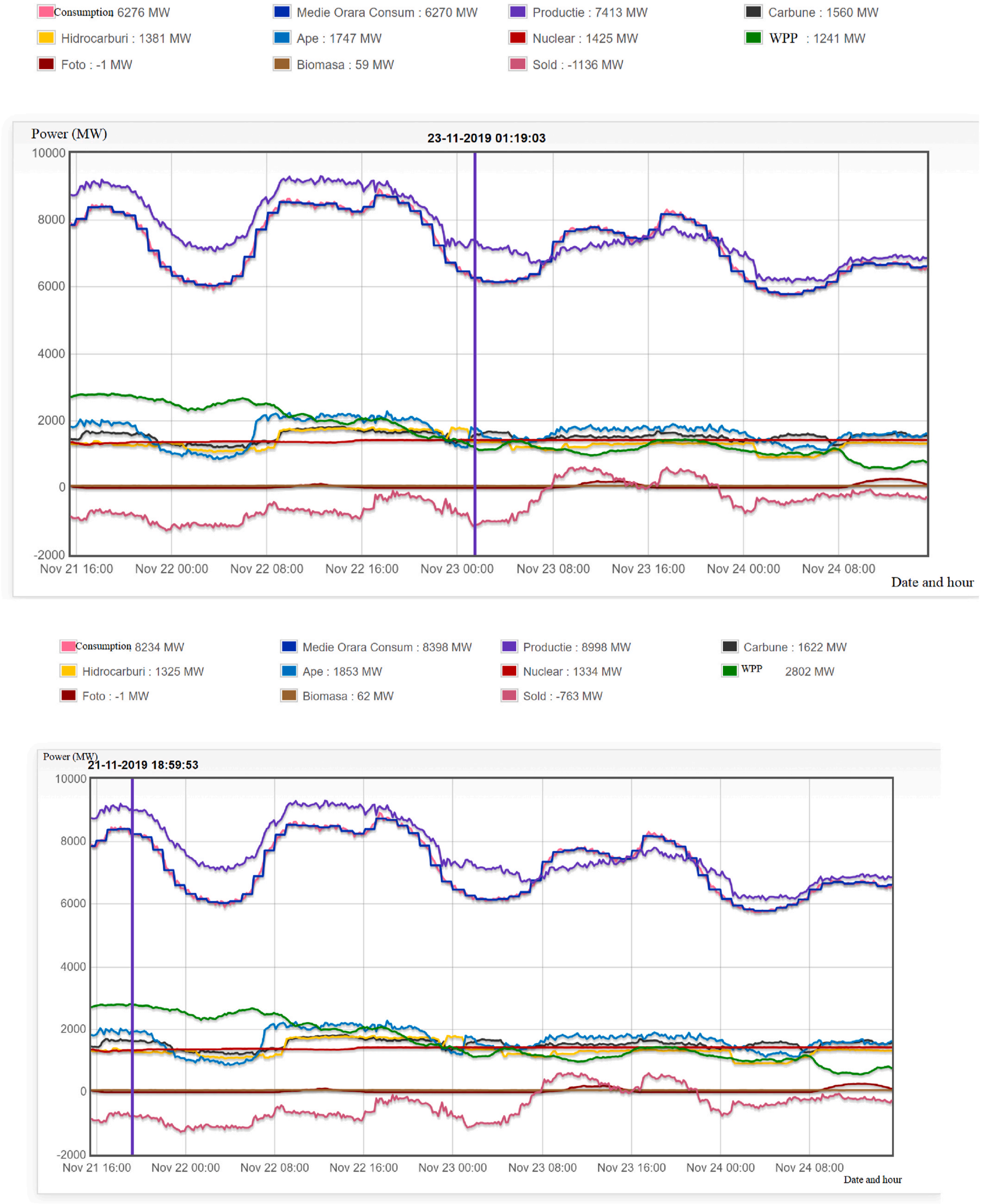

Fig. 3. Power System status in real time – example 1 with WPP (Wind Power Plant) records greater than 90 % of installed power.

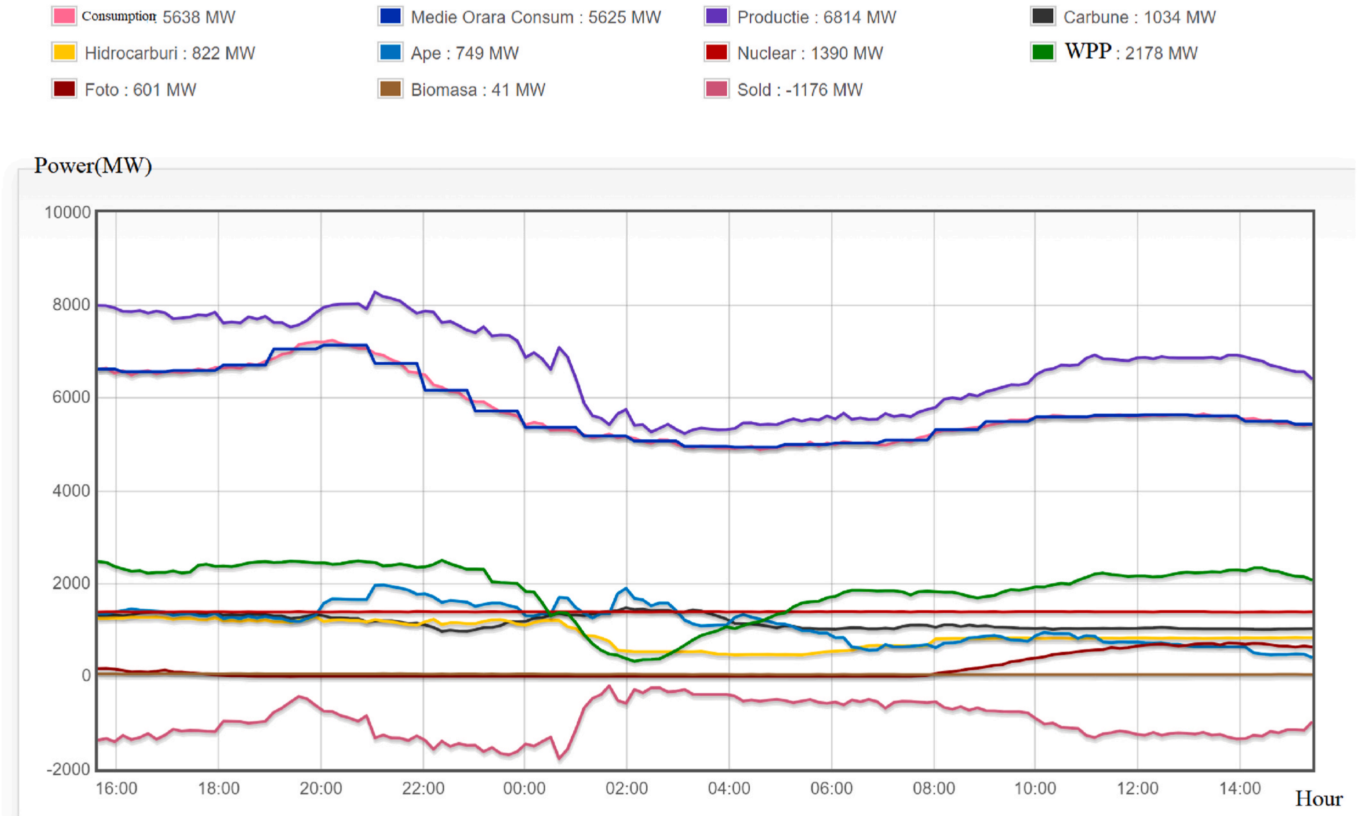

Fig. 4. System status in real time – example 2 the decrease in the power produced by WPP at 02:00 a.m.

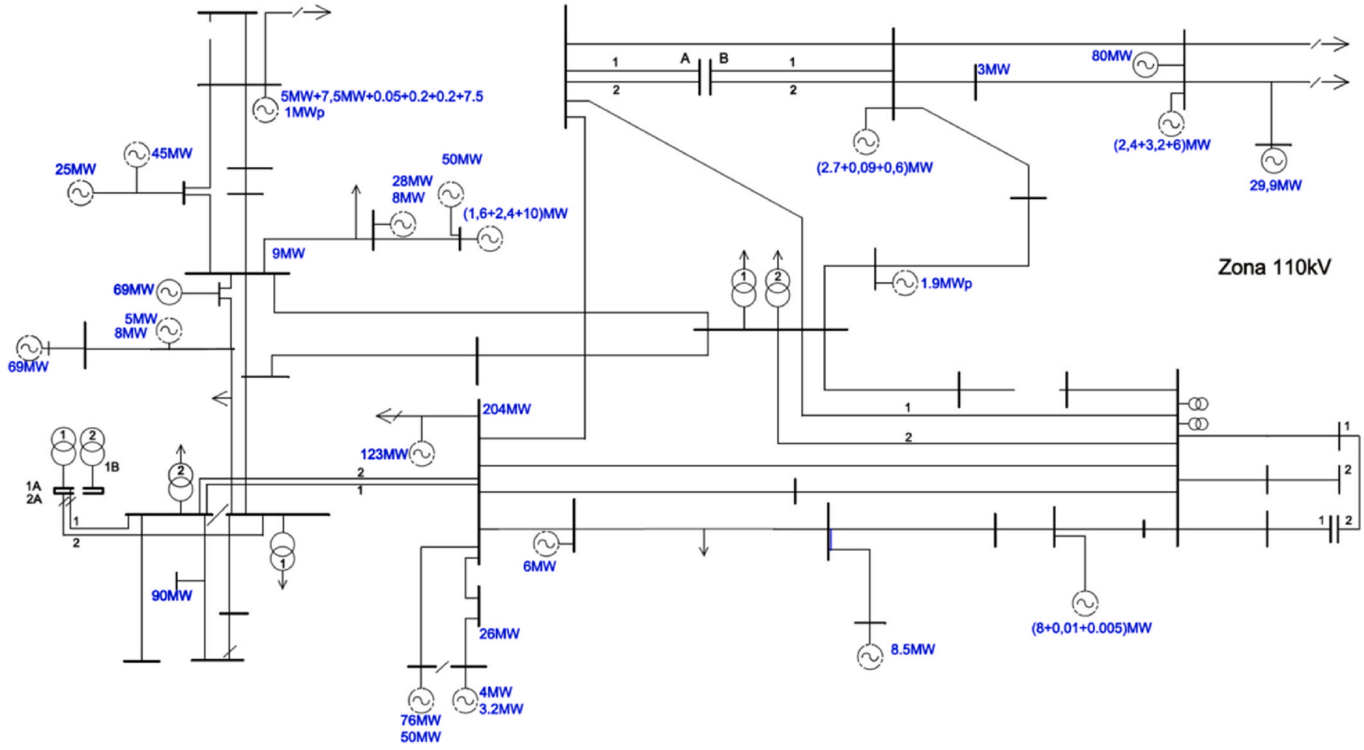

Fig. 5. Diagram of the analyzed area.

Table 2
Installed and evacuated power of WPP.

Connecting station	Installed power (MW)	Evacuated power 70 % (MW)
OHL 110 kV	69	48.3
ST 110 kV	2.4 + 10+1.6 + 4.8+50	48.16
ST 110 kV	69	48.3
OHL 110 kV	90	63
OHL 110 kV	25 + 45	49
ST 110 kV	5 + 8	9.1
ST 110 kV	7.5 + 0.05	5.285
ST 110 kV	8 + 10	12.6
OHL 110 kV	26	18.2

- the situation of islanding of microgrids.

3.1. *Analysis of an area with important wind resources*

In Romania, the wind sources are concentrated in the south-eastern area, which has a low consumption of about 350 MW. This leads to significant power flows on the lines and on the transformers, with the consequence of possible exceedances of the capacity of the existing network to evacuate the power from the production area.

In Fig. 3, 2-day intervals were taken as examples from Transelectrica's records, in which the production of power from wind sources reached 90 % of the installed power. The wind power plants are located in geographical areas where the wind speed has high values (south-eastern part of Romania).

The variability of these types of sources leads to situations described in Fig. 4, in which within 3 h the power produced by this type of source decreased from 2500 MW to approximate 380 MW. In these cases, the power system must have sources that start quickly in order to realize the production-consumption equilibrium. In the analyzed area, the wind power plants are into operation since 2010.

Fig. 5 shows a diagram of the 110 kV network in which you can identify the power lines, the power stations (busbar), the powers installed in the WPP (with blue color).

WPP into operation in the distribution area is exceeding 500 MW. In this area appears necessary connecting the second 400/110 kV transformer in the substation (who reserve the one existing).

Table 2 specifies the connection points of the WPP to the network, the installed powers that appear in Fig. 5 and the evacuated power that will be used in the regimes calculations.

Fig. 6 shows a distribution area in operation with *N* elements in

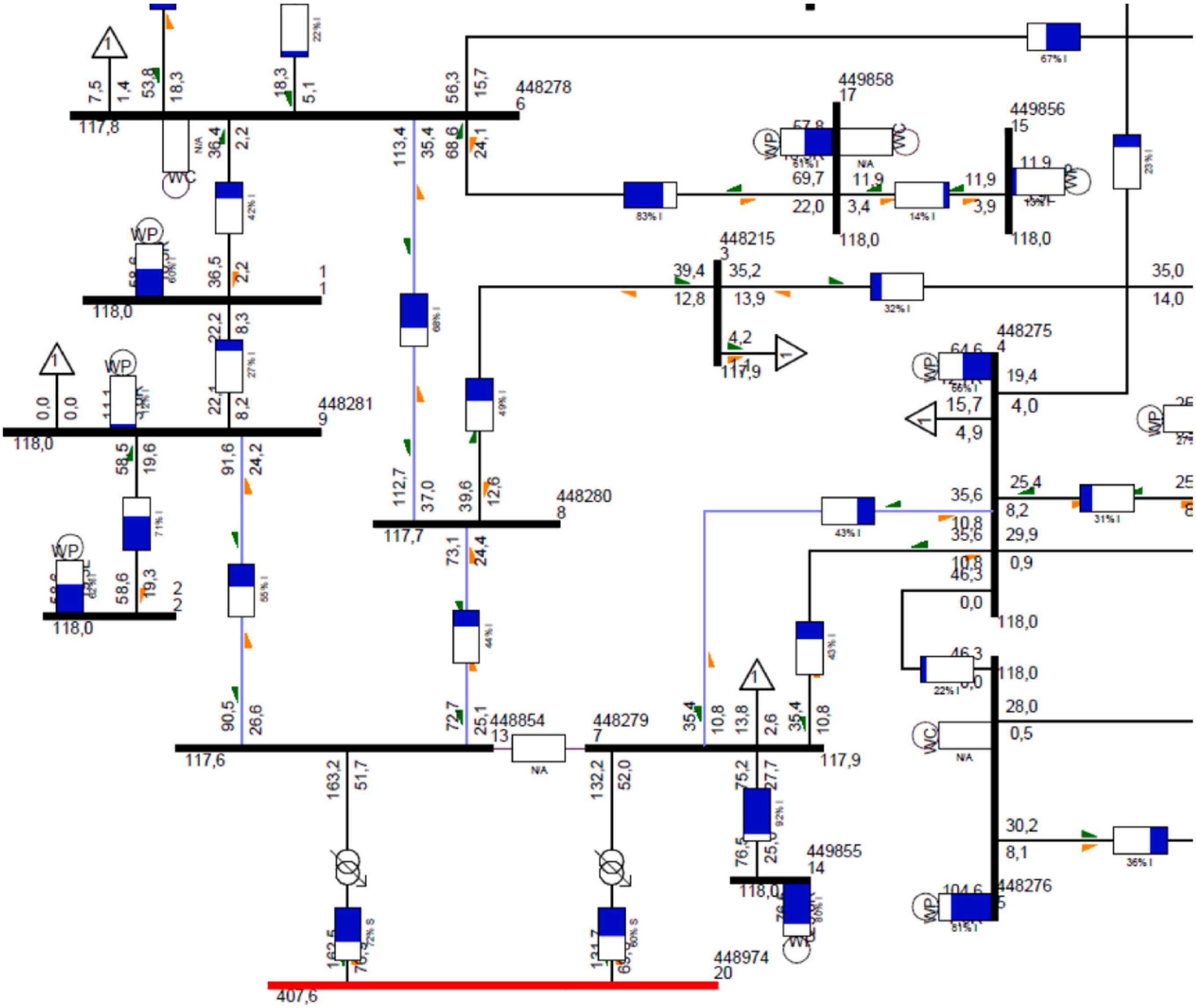

Fig. 6. The diagram of the analyzed electrical distribution network modeled in PSSe.

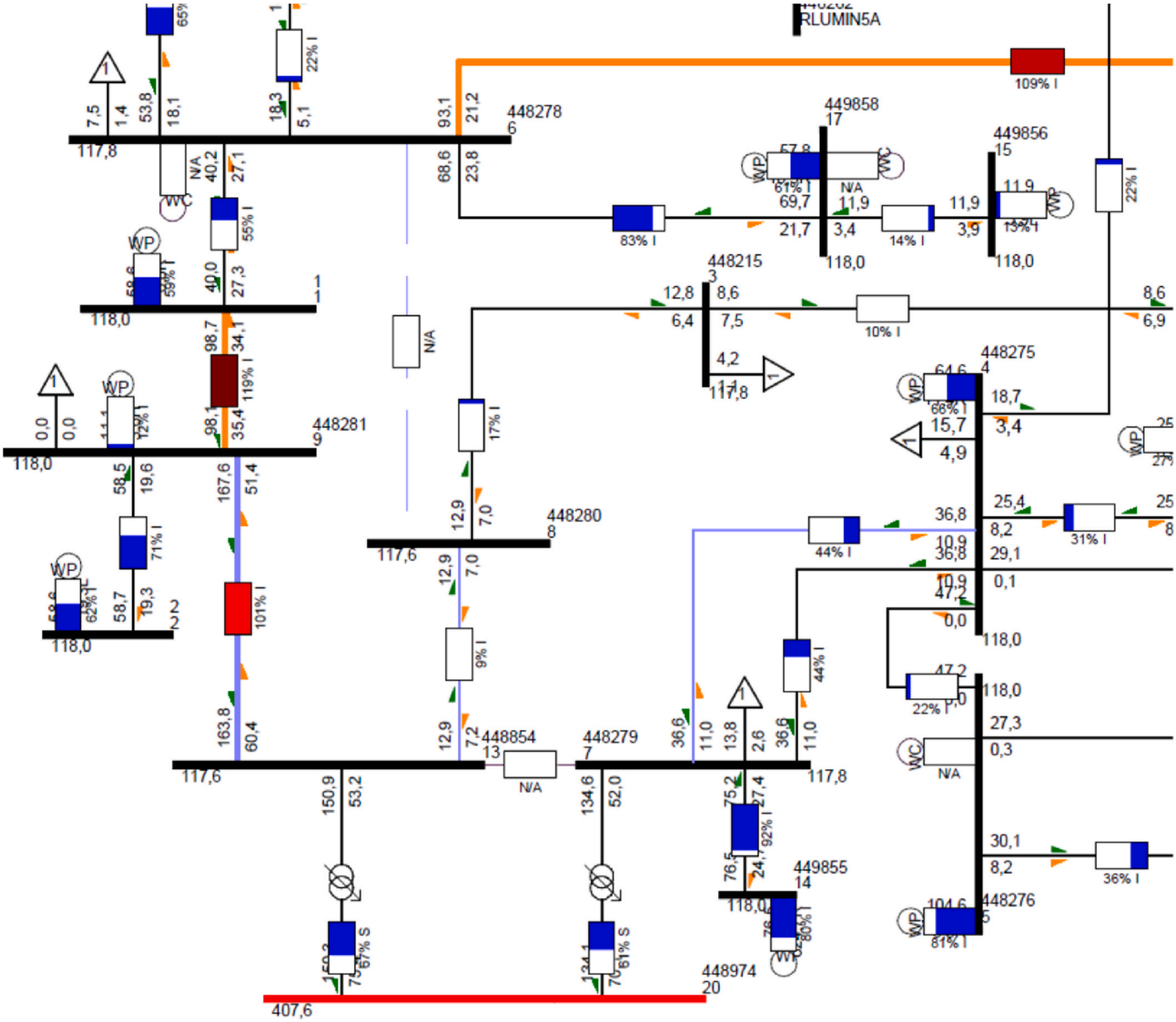

Fig. 7. Failure regime of a 110 kV line (line 6–8).

Table 3
Simulation in 110 kV area.

Network element disconnected	Network element overload	Loading percentage
OHL 110 kV 6-8	OHL 110 kV 9-13	101 %
	OHL 110 kV 1-9	119 %
	OHL 110 kV 6-30	109 %
TR 400/110 kV 13-20	OHL 110 kV 3-8	147 %
	OHL 110 kV 3-31	103 %
	OHL 110 kV 6-30	162 %
OHL 110 kV 7-20	OHL 110 kV 13-20	113,4 %
OHL 110 kV 8-13	OHL 110 kV 1-9	131,3 %
	OHL 110 kV 7-20	102,9 %
	OHL 110 kV 9-13	106,1 %
OHL 110 kV 9-13	OHL 110 kV 1-6	147 %
	OHL 110 kV 6-8	133,8 %
	OHL 110 kV 7-20	100.8 %
	OHL 110 kV 8-13	116,9 %
OHL 110 kV 13-20	OHL 110 kV 3-30	111,8 %
	OHL 110 kV 3-8	159,3 %
	OHL 110 kV 6-30	176,1 %
	OHL 110 kV 7-20	122,1 %
OHL 110 kV 6-8	OHL 110 kV 9-13	101 %
	OHL 110 kV 1-9	119 %
	OHL 110 kV 6-30	109 %
TR 400/110 kV 13-20	OHL 110 kV 3-8	147 %
	OHL 110 kV 3-31	103 %
	OHL 110 kV 6-30	162 %
OHL 110 kV 7-20	OHL 110 kV 13-20	113,4 %

operation. This section of the area includes two 400/110 kV 250MVA transformers connecting the distribution network and the transmission network. Initially, it was considered that renewable sources (wind or photovoltaic) are installed in the main 110 kV nodes.

From Fig. 6, it can be seen that from the regime with N elements in operation the two transformers are charged to 60 % Snom (TR1) respectively 72 % Snom (TR2).

The operation with unequal loads of the two transformers is given by the operation with the 110 kV disconnected coupling.

The 110 kV lines in the analyzed area have mainly 185 mm^2 sections (80MVA-420A capacity). Three 110 kV lines were reconducted with a 585 mm^2 (850A) conductor.

The simulation was performed by disconnecting each network element in the area, and examples were carried on when the failure of a network element leads to overloads in the network.

Fig. 5, illustrating the 110 kV diagram, shows that in the area there are two 69 MW wind power plants connected in two 110 kV lines.

If a 110 kV line is unavailable (line 6–8), it can be seen from Fig. 7 and Table 3 that the remaining 110 kV lines are overloaded (line 9–13, line 1–9). Given that the consumption in the area is low, the two overloaded 110 kV lines are at 120 % of their normal operation. This overload is dangerous in the operation of 110 kV lines and it is possible to disconnect several elements in the 110 kV network in a chain, leading to loads disconnection which should be avoided in the smart cities.

The failure of a transformer unit, Fig. 8, can lead to very large overloads on the 110 kV lines up to 160 % of their normal operation. If no line investments are made in 110 kV, then it is necessary to have backup transformers in the stations, in case a transformer is unavailable.

If the WPP does not produce power then the direction of power flow on the 400/110 kV transformers is reversed, and the 110 kV network receives power from 400 kV to supply the consumption of the 110 kV area.

To avoid these important power flows on the 400/110 kV transformers, in the 110 kV or 20 kV area, storage sources can be connected to be charged when there is a significant surplus produced by renewable sources.

Fig. 9 shows the voltage level (p.u. – per unit of the nominal voltage of 110 kV) at the buses where renewable sources are connected, with&without considering the consumption (Table 4) of these buses. As can be seen, the decrease in consumption to zero does not significantly influence the voltage level in the EDN, given that renewable power sources have a reactive power corresponding to a power factor of 0.95 leading to 0.95 lagging, and controlling reactive power maintains the voltage level in the analyzed buses.

In comparison, if consumption is considered constant and sources produce power between 0 % and 85 % of the installed power, the voltage level has significant changes.

Fig. 10 shows that the WPP's unpredictability may have significant effects on the voltage level in a EDN area. If the WPP drops to 0 MW within a few hours (common case), then the voltage level can rise from an admissible level (0.9 p.u.-1.1 p.u.) at voltages exceeding the limit of 1.1 p.u. in certain nodes.

From the point of view of the dynamic analyze, a short circuit on a 110 kV line is affecting by the generators in the area, both in terms of voltage level and power produced by the source.

Figs. 11 and 12 illustrate that the power of the generator on the bus bar on which the fault occurs passes through zero during the fault period from 0.2 s to 0.5 s. According to the requirements of a generator connected to the network, it must have the ability to overcome the fault, that is to return the active power after the fault has been removed to the pre-fault value.

For the generator that is further away from the short circuit site it is observed that the power variation is much smaller.

After fault clearing, the voltage at the bus where the short circuit occurs rerutn to the value before the fault, as shown in (Fig. 13). Maintaining the stable operation of the generator at any point in the active power-reactive power capability diagram shall be done by varying the reactive power so to maintsin constant the voltage level.

In terms of frequency variation, the disconnection of a group has a minor influence on the frequency, taking into account the fact that the Romanian electricity system operates in synchronism with the neighbouring electrical energy systems.

3.2. Analysis of a large consumption area that does not have renewable sources connected

In an area with large consumption, the active power flow is from the voltage level 220 kV and 400 kV (ETN- Electric Transport Network) to 110 kV (EDN- Electric Distribution Network), as shown in Fig. 14. Fig. 15 shows a substation in the Bucharest area that operates disconnected from the other areas and for which the criterion N-1 elements in operation is not met. Fig. 16 shows the 110 kV loads of the 400/110 kV Domnesti transformers. The three 400/110 kV transformers supply consumption of approx. 600 MW. In Fig. 17 is shown the operation of the power system with a transformer unit from the 400/110 kV Domnesti substation out of service (448010–449560), leading to overloads on the remaining transformer units and some 110 kV cables. Given the fact that in this area 110 kV the network has a radial configuration, no calculations were made with N-1 elements in operation on 110 kV cables because this regime involves no-power supply to consumers.

The off-peak load regime is analyzed to highlight the problem of high voltage levels in the event of low consumption in a network with a considerable cable length of 110 kV.

To maintain the voltages at the admissible level, it is necessary to install some compensation coils, in addition to those currently installed in the Fundeni 110 kV and Bucharest Sud 400 kV stations, for example:

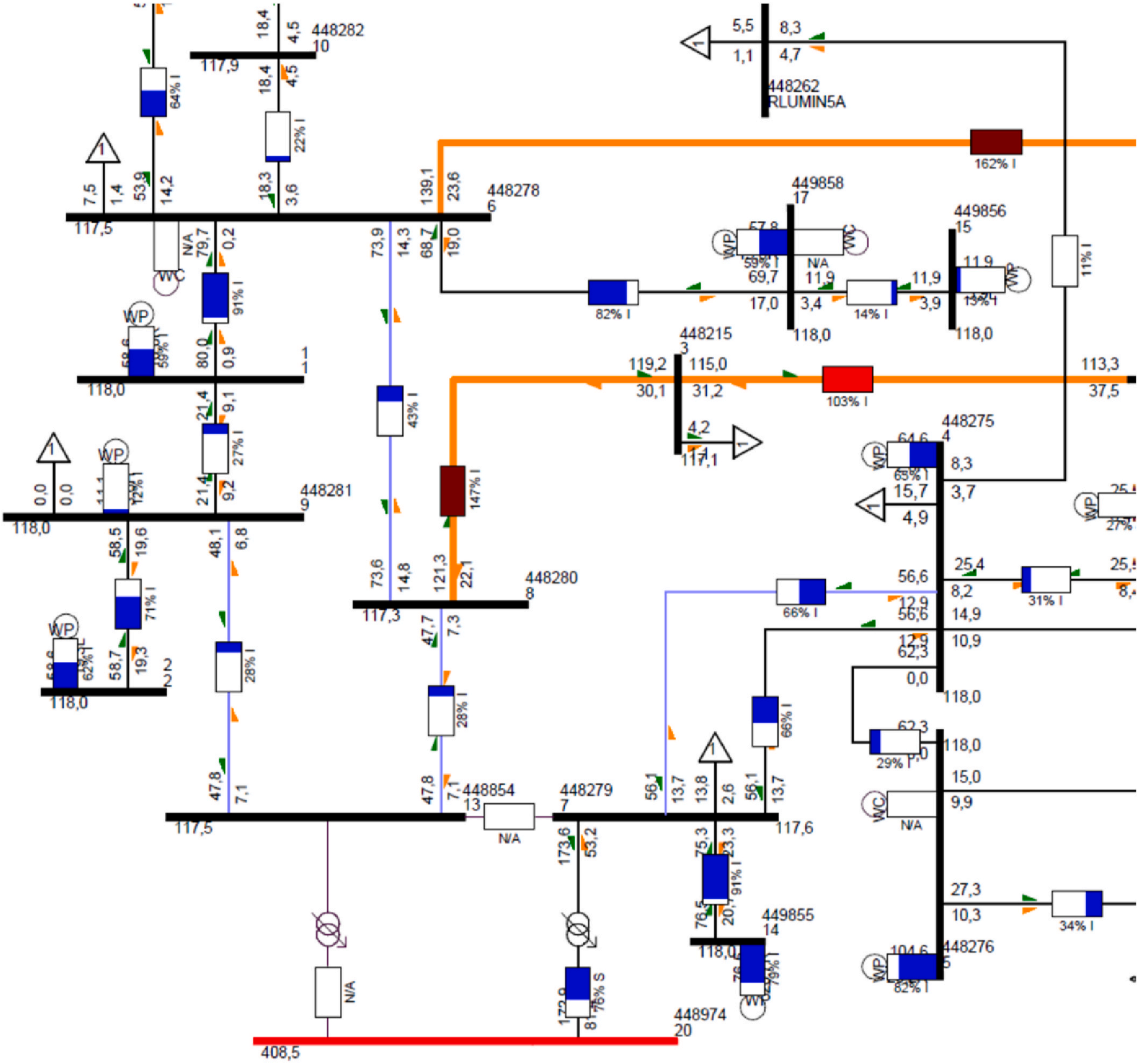

Fig. 8. Failure of the transformer unit (13–20).

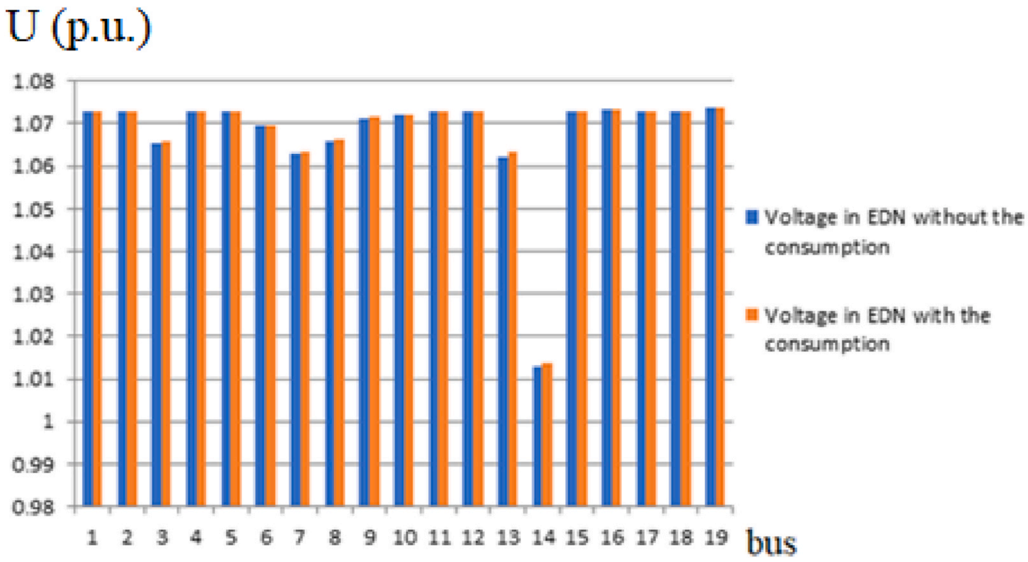

Fig. 9. Analysis of the voltage level in the EDN (Electrical Distribution Network) area when the consumption is varied.

Table 4
Consumption in 110 kV bus.

Consumption on the 110 kV busbar of the stations
4.21
15.702
7.509
13.84
0.031
1.138
4.21
46.64

- installation of a coil in a 110 kV substation belonging to Enel from the Bucharest South area (for example ENEL Faur substation min. 30MVAr); if this coil is installed, maximum voltages of 120.2 kV are obtained in the Progresu substation and minimum voltage of 119.2 kV in the Faur substation; since it operates at 110 kV, the voltage remains within the same limits in the other areas;

  OR

- installation of an additional coil in the 110 kV Bucharest South substation - busbar A of min. 30MVAr; if this coil is installed, maximum voltages of 120.4 kV are obtained in the Faur substation and minimum voltage of 119.5 kV in the Bucharest Sud substation; since it operates at 110 kV, the voltage remains within the same limits in the other areas;

If no additional compensation sources are installed the tap changer position of both Bucharest South 220/110 kV transformers can be changed. If it is changed from position 13 - nominally to position 14, a maximum voltage of 120.9 kV is obtained in the Faur substation (the maximum voltage in the 110 kV network being 121 kV).

The data reported in Table 5 reveals that:

- in the Domnesti area the reactive exchange between distribution and transmisison networks is close to zero, the power factor being higher than 0.99;
- Fundeni area has a power factor of 0.91–0.92 even if it has a 100MVAr coil installed in the 110 kV bar; this area has a minimum voltage of 115.5 kV and the installation of an additional coil or the change of the operating plots of the two 220/110 kV autotransformers can lead to an operation with voltages below this value in certain nodes in this zone; the direction of active and reactive powers is from 220 kV to 110 kV;
- Bucharest South area has a power factor of approx. 0.6 and has voltages above the allowable limit; if an additional coil (min. 30MVAr) is installed in Bucharest South or an Enel station then the power factor increases up to a maximum of 0.85;

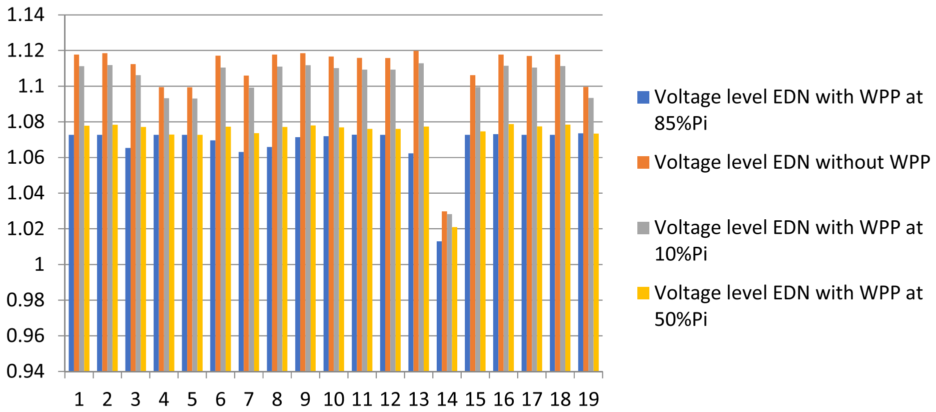

Fig. 10. Analysis of the voltage level (pu) in the EDN area at the change of the installed power in WPP.

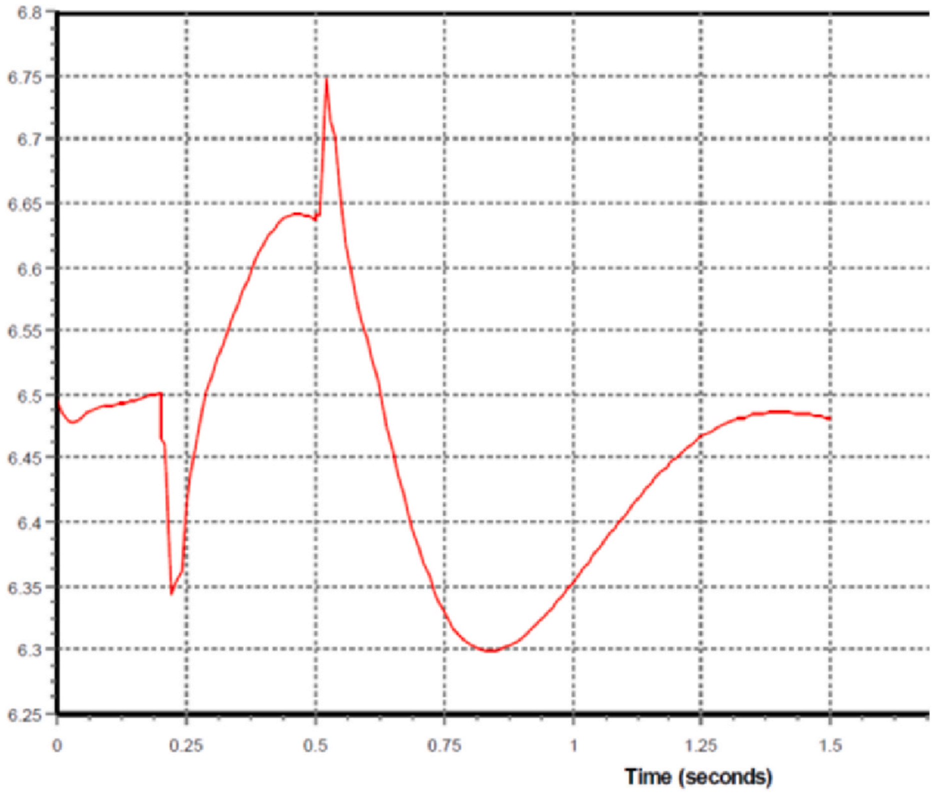

Fig. 11. The variation of the active power (MW) of a generator during a short circuit.

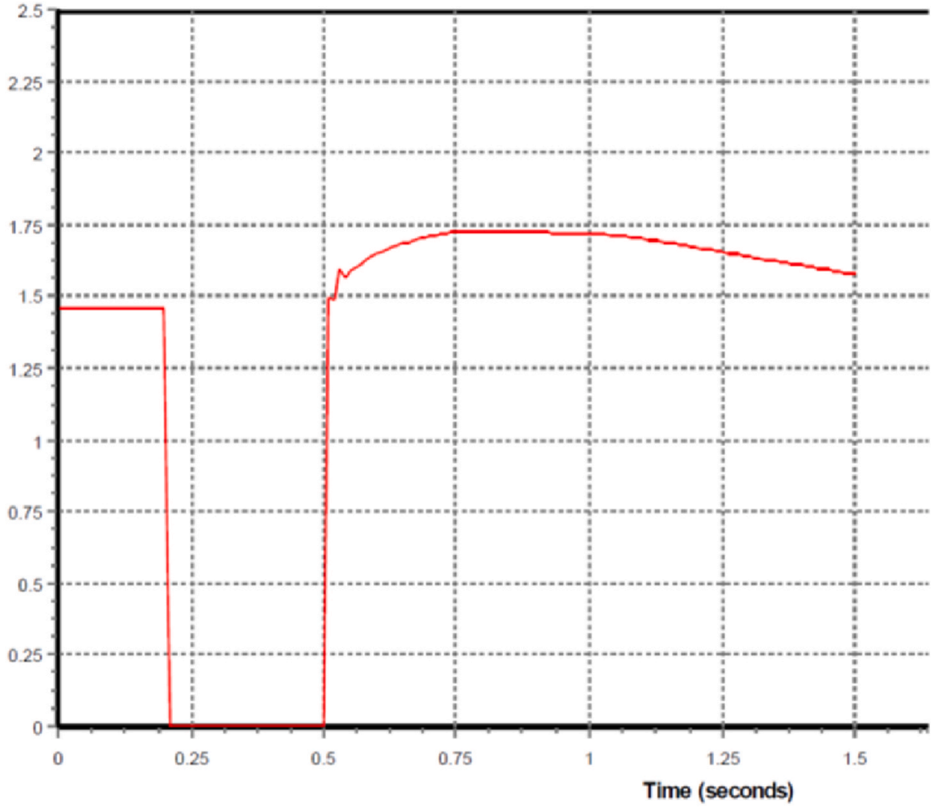

Fig. 12. The variation of the active power (MW) of a generator during a short circuit that occurs at the busbar to which the generator is connected.

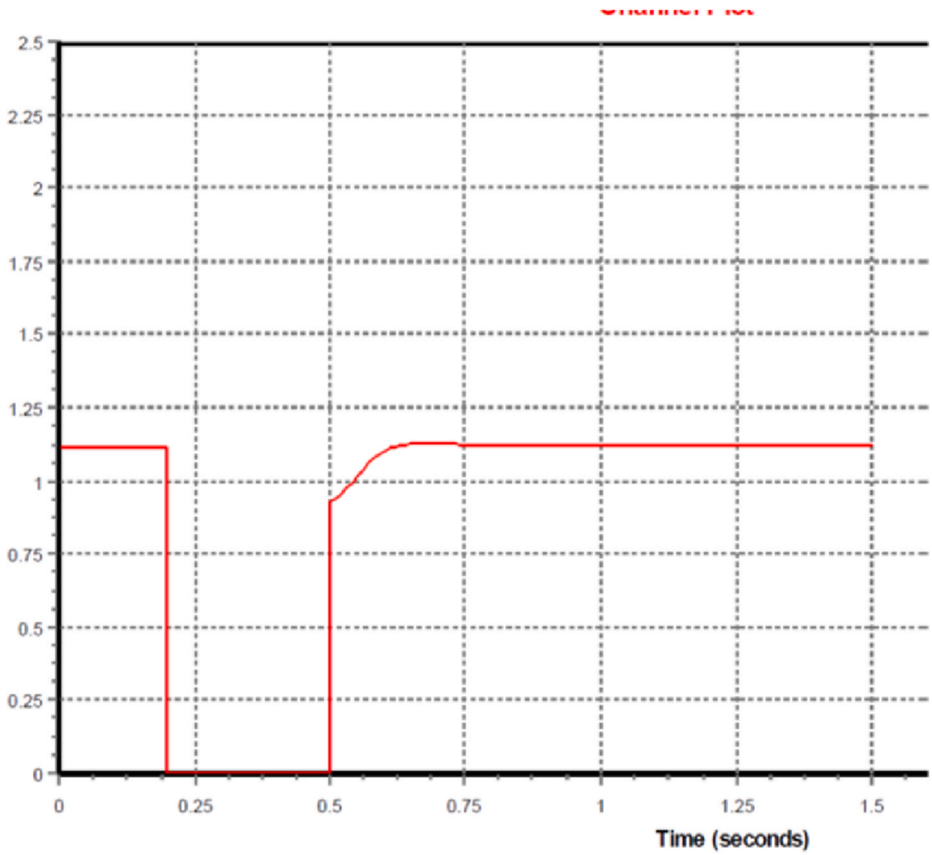

Fig. 13. The variation of the voltage (pu) on the bar on which a short circuit occurs.

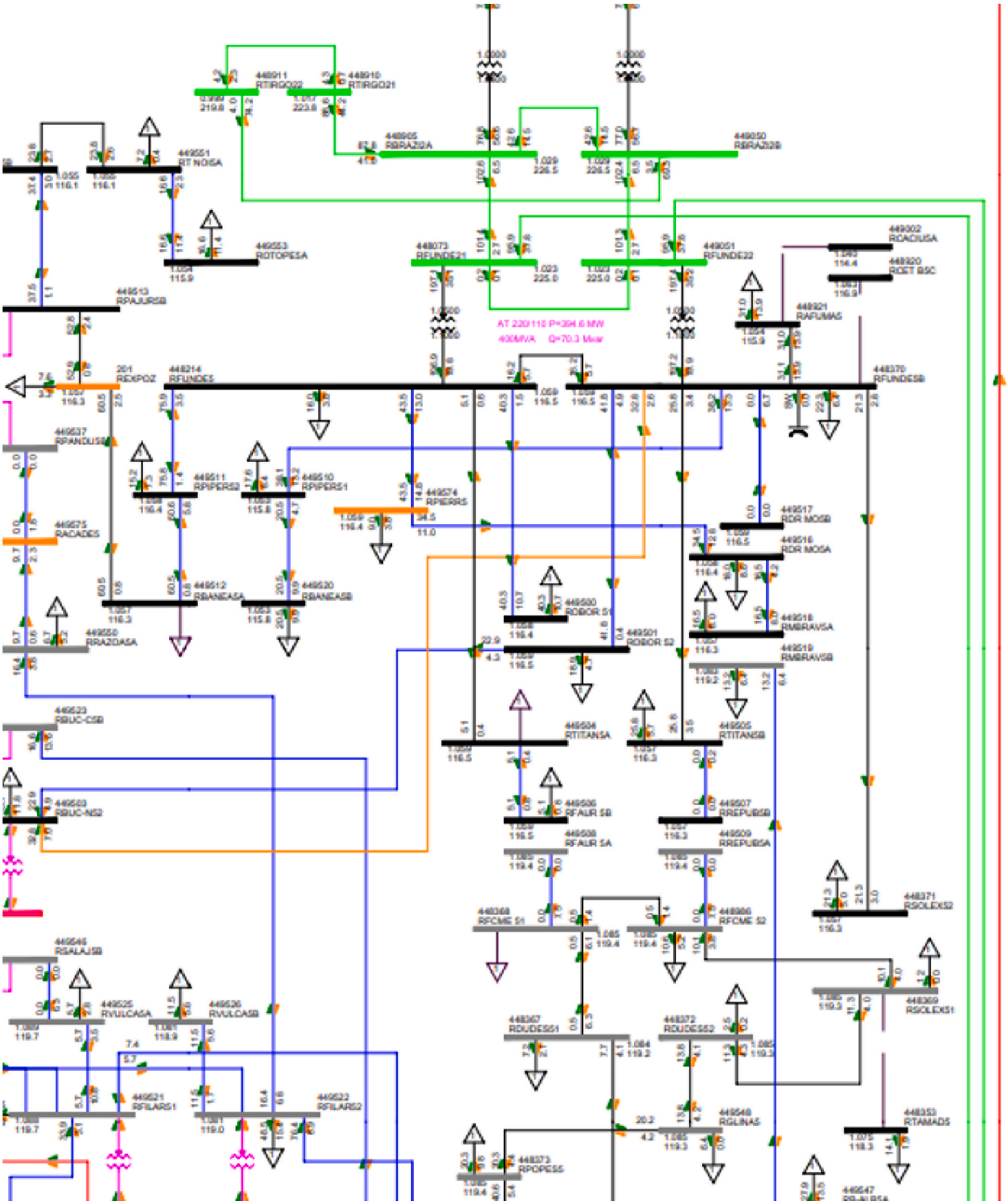

Fig. 14. The diagram of Fundeni 110 kV area (220 kV, 110 kV, OHL, grounded cable).

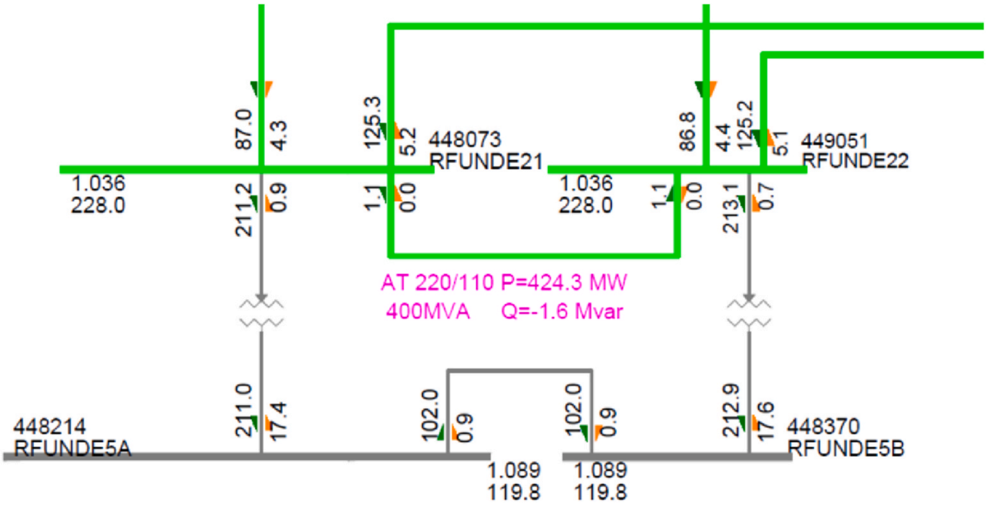

Fig. 15. Winter peak, station Fundeni.

- if the coil installed in the Bucharest South area would be 65MVAr then the reactive power circulation through the 220/110 kV transformation units would be close to zero and the minimum voltage reaches 115.8 kV.

4. Analysis of the area in terms of fault ride through

Low Voltage Ride Through (LVRT) is an important indicator of grid-connected performance. The grid requirements from Order of Regulatory Authority for Energy no. 72 of August 02, 2017 sets out the minimum technical requirements for connecting synchronous power-generating modules to public electrical grids and shall apply to new synchronous power-generating modules, according to the category to which they belong [16]. Other orders and laws may apply, eg. Order of Regulatory Authority for Energy no. 51/2019 for the approval of the procedure of notification for connection of generating units and the certification of the technical compliance of generating units with the technical requirements regarding the connection of the generating units to the electrical networks of public interest (Modified by Order of Regulatory Authority for Energy no. 184/2017).

The relevant system operator shall provide the pre-fault and post-fault conditions (as relevant values resulted from typical cases) to be considered for fault-ride-through capability as an outcome of the calculations at the connection/interface point, as the case may be:

- the pre-fault minimum short-circuit power at every connection/interface point, as the case may be, expressed in MVA;
- the pre-fault operating point of the synchronous power-generating module, expressed in active power, reactive power and voltage at the connection/interface point, as the case may be; and
- the post-fault minimum short-circuit power at the connection/interface point, as the case may be, expressed in MVA.

The diagram shown in Fig. 18 represents the lower limit of a voltage-against-time profile of the voltage at the connection/interface point. As the case may be, expressed in relative units as the ratio of its actual value and its reference value before, during and after a fault. U_{ret} is the retained voltage during a fault at the connection/interface point, as the case may be, and t_{clear} is the instant when the fault has been cleared. U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3} represent certain points of lower limits of retained voltage after fault clearance. The parameters related to the fault-ride-through are provided in Table 6.

Type D power-generating module = Connection point voltage U (U ≥ 110 kV) and installed power P (P ≥ 20 MW) of the generating unit/power plant.

The synchronous power-generating module shall remain connected to the network and shall continue to operate stably during a symmetrical fault, given the conditions existing pre-fault and post-fault provide by the relevant system operator. The synchronous power-generating module owner establishes the undervoltage protection (either the fault-ride-through capability, or the minimum voltage defined at the connection/interface point, as the case may be) according to the maximum voltage range corresponding to the synchronous power-generating module, except if the relevant system operator requires a narrower range.

Synchronous power-generating modules shall be capable of remaining connected to the network without reducing power, so long the frequency and voltage fall within the limits provided in Table 6, namely ±10 % U_n.

Synchronous power-generating modules shall be capable of remaining connected to the network during single-phase or three-phase reclosing on the lines of the loop network to which they are connected. The specific technical details shall be subject to coordination and instructions on protection schemes and settings agreed upon with the relevant system operator.

The simulations are performed with PowerFactory Version 2022. The model that is adopted for the calculations basically consists of four parts:

- Grid equivalent
- Unit transformers
- Generators
- Equivalent auxiliary load

These elements are shown in Fig. 19.

The fault-ride-through profile for the synchronous generators is shown in Fig. 20. For each of the three operating points, five different

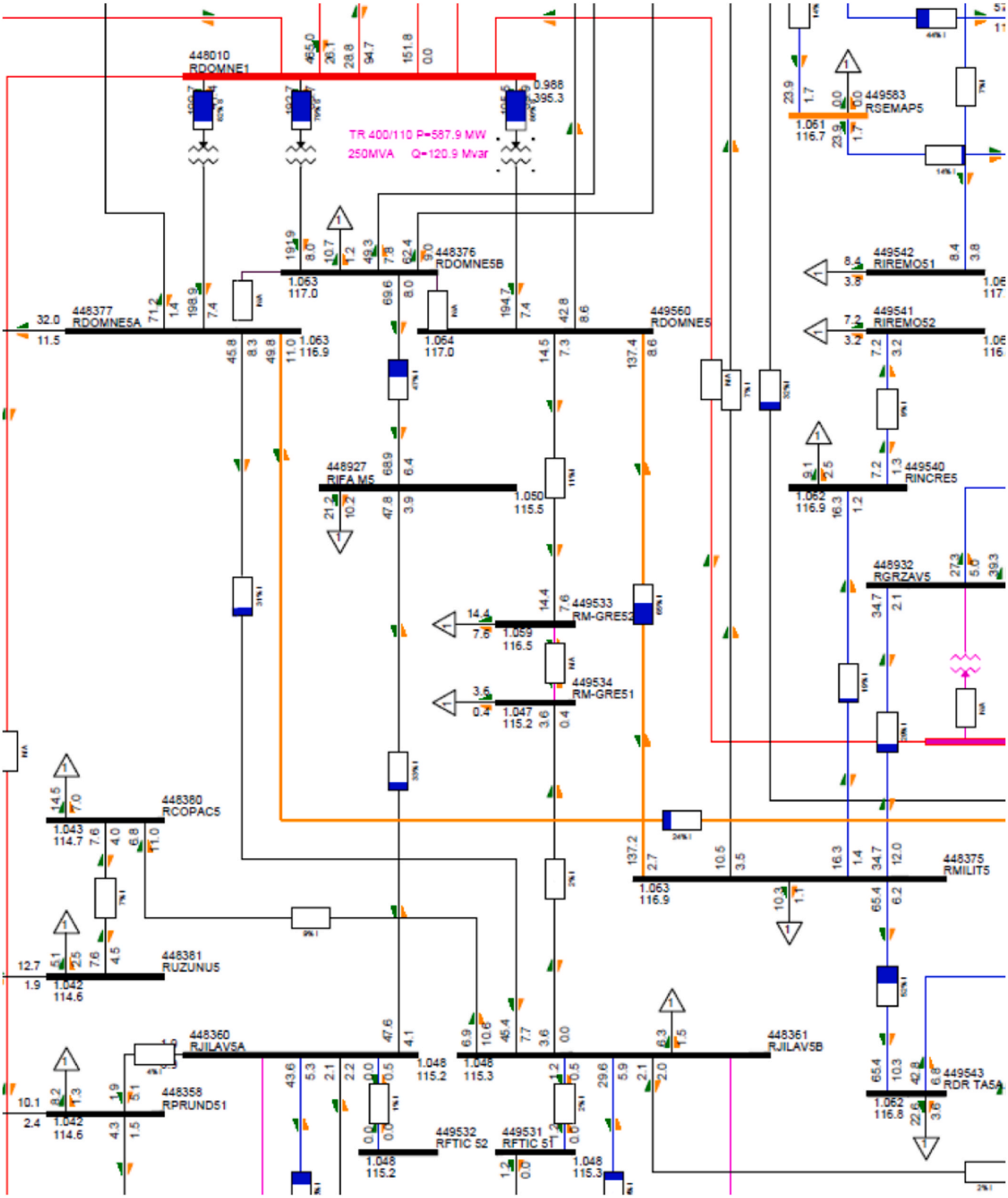

Fig. 16. Station 400/110 kV Domnesti.

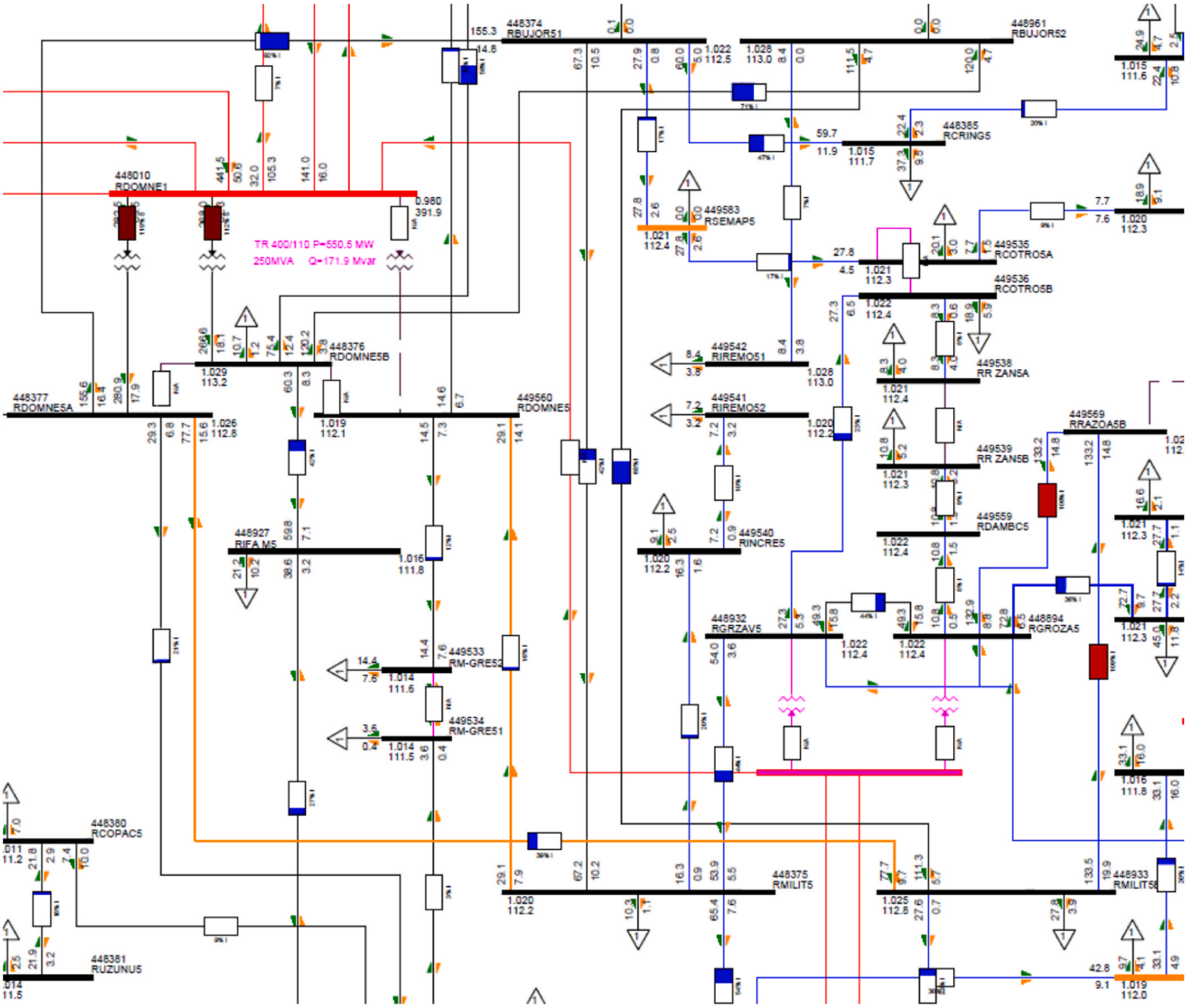

Fig. 17. Regime with N-1 elements in operation.

Table 5
The reactive power flows between EDN and ETN.

The analyzed element	P + jQ	Power factor
Reference analysis		
TR1 400/110 kV Domnesti	−40,7 + j3,8	0,9957
TR2 400/110 kV Domnesti	−39,1 + j4,2	0,9943
TR5 400/110 kV Domnesti	−41 + j5,3	0,9917
AT1 220/110 kV Bucharest South	35,7 + j49	0,5889
AT2 220/110 kV Bucharest South	31,8 + j45,2	0,5754
AT1 220/110 kV Fundeni	−86-j37,9	0,9151
AT2 220/110 kV Fundeni	−86,3-j39,1	0,9109
Analysis with a coil in the station 110 kV Bucharest South		
TR1 400/110 kV Domnesti	−40,8 + j2,6	0,9980
TR2 400/110 kV Domnesti	−39,1 + j3,1	0,9969
TR5 400/110 kV Domnesti	−41,1 + j4	0,9953
AT1 220/110 kV Bucharest South	36,6 + j23,2	0,8446
AT2 220/110 kV Bucharest South	30,9 + j30,3	0,7140
AT1 220/110 kV Fundeni	−86-j37,6	0,9163
AT2 220/110 kV Fundeni	−86,3-j38,9	0,9117
Analysis with a coil in the station 110 kV Faur		
TR1 400/110 kV Domnesti	−40,8 + j2,6	0,9980
TR2 400/110 kV Domnesti	−39,1 + j3,1	0,9969
TR5 400/110 kV Domnesti	−41,1 + j4	0,9953
AT1 220/110 kV Bucharest South	34,9 + j29,9	0,7594
AT2 220/110 kV Bucharest South	32,5 + j23,4	0,8115
AT1 220/110 kV Fundeni	−86-j37,6	0,9163
AT2 220/110 kV Fundeni	−86,3-j38,9	0,9117

short-circuit configurations (SC1 – SC5) regarding the fault clearing time t and the residual fault voltage U at the fault location are analyzed. A solid three-phase fault is applied for the shown fault clearing times and residual fault voltages at the point of connection (220-kV-side of unit transformers). This is performed without the power system stabilizer (PSS). The power system stabilizer has no significant influence on the critical fault clearing time.

Voltage parameters [p.u.]		Time parameters [seconds]	
U_{ret}	0	t_{clear}	0.25
U_{clear}	0.25	t_{rec1}	0.45
U_{rec1}	0.7	t_{rec2}	0.7
U_{rec2}	0.85	t_{rec3}	1.5

The results show that grid code compliance can be attained in all three investigated operating points with a short-circuit power of 3569 MVA. The required fault clearing time of 250 ms can be achieved.

5. Conclusions

The decarbonization of the energy sector through decentralized and renewable energy projects leads to sustainable energy production and flexible consumption practices (an important role for social innovation as they reflect a fundamental change in consumer behavior). The technical challenges on distribution network imposed by integration of renewable energy systems, due to their variability, can be overcome

Table 6
Parameters related to the fault-ride-through capability of type D synchronous power-generating modules.

Voltage parameters [p.u.]		Time parameters [seconds]	
U_{ret}	0	t_{clear}	0.25
U_{clear}	0.25	t_{rec1}	0.45
U_{rec1}	0.7	t_{rec2}	0.7
U_{rec2}	0.85	t_{rec3}	1.5

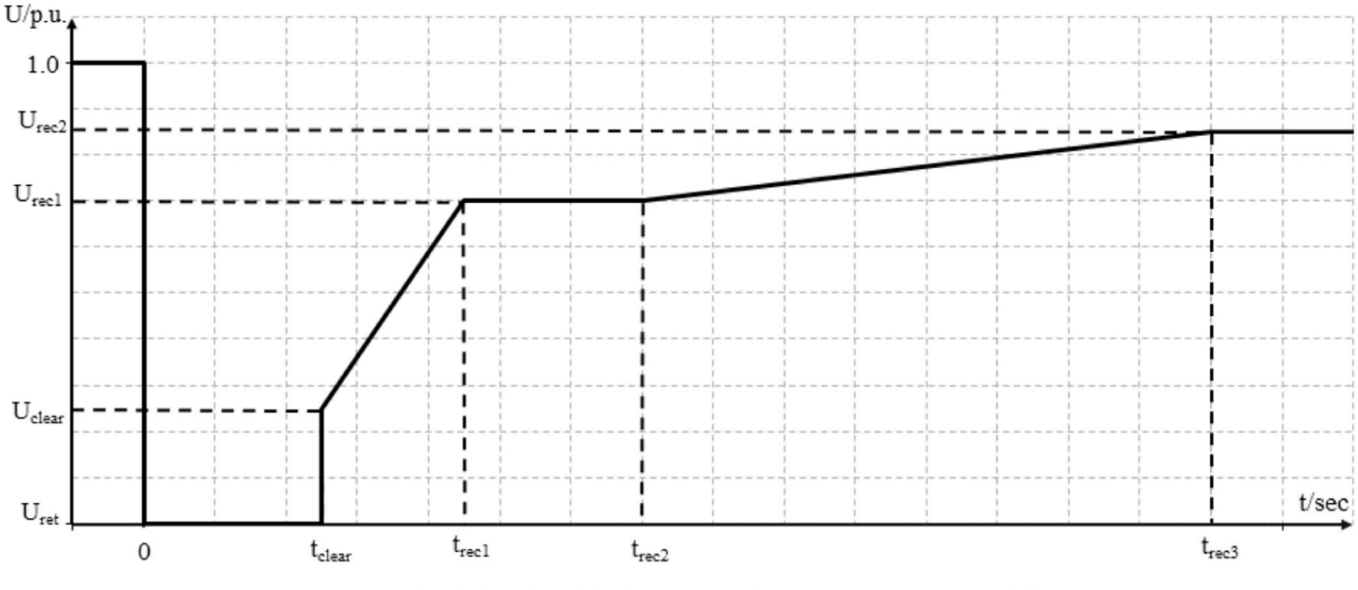

Fig. 18. Fault-ride-through profile of a type D synchronous power-generating module.

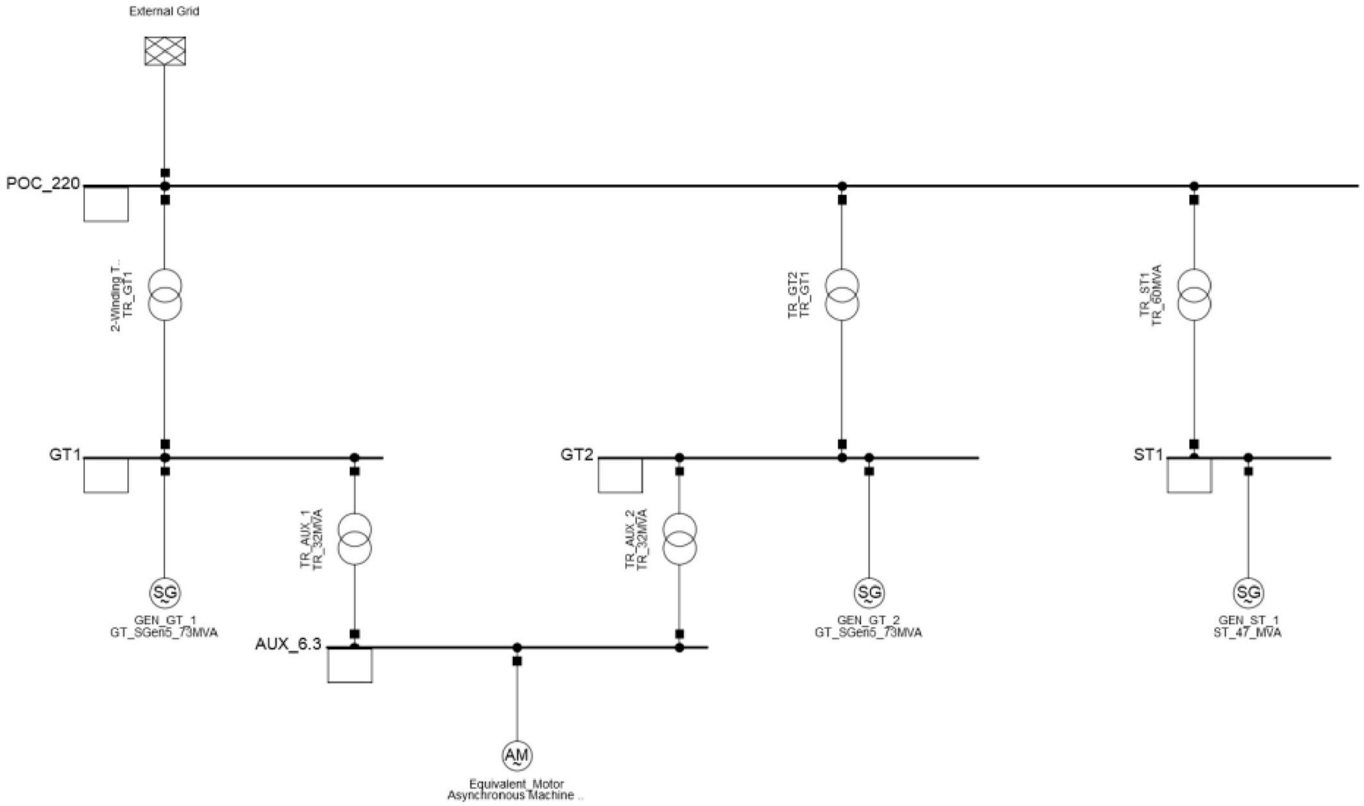

Fig. 19. General overview of the simulation model.

with adequate grid development in expansion cities, integration of distributed storage systems, better grid management algorithms and increased citizen participation. To achieve decarbonization of energy sector in the analyzed area, it is necessary to install photovoltaic panels on buildings, on warehouses of materials and goods, and to build charging stations for electric cars in more and more points, for a balanced distribution of consumption. The charging stations of electric buses in the city will be an important consumer that can be powered by installing renewable sources in the depots where these cars park.

The connection of renewable sources near the places of consumption can lead to flexibility in changing the operating diagram, the operator having the possibility to keep certain 110 kV cables disconnected, which diminishes the reactive power circulating through the distribution network.

The analysis of the two types of distribution areas shows that in the area where consumption is high, it is easier to implement measures to transform the area into positive energy community.

Decarbonization of the energy system will require a massive transformation in the way energy is provided, transported and used.

Launched in April 2022, the objective of the Energy Communities Repository is to assist local actors and citizens willing to set up a Citizens Energy Community or a Renewable Energy Community in urban areas through technical and administrative advice and encourage their development [17].

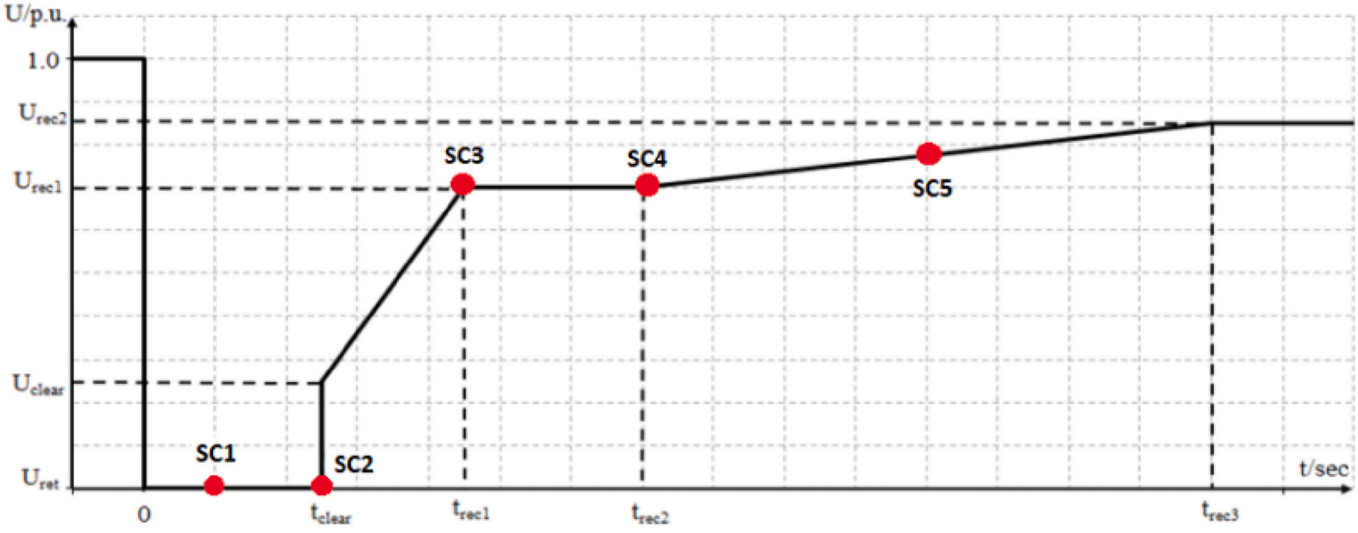

Fig. 20. The fault-ride-through profile.

CRediT authorship contribution statement

Georgiana Balaban: Writing – original draft, Validation, Methodology. **Virgil Dumbrava:** Validation, Supervision. **Alexandra Catalina Lazaroiu:** Resources, Project administration, Investigation. **Soteris Kalogirou:** Validation, Supervision, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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