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ASPECTS REGARDING THE POWER QUALITY IN ELECTRIC ENERGY REPARTITION AND DISTRIBUTION SYSTEMS

BY

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Abstract. The voltage level in public repartition systems nodes requires, first of all, the control of reactive power flow both in transmission and distribution systems. Presently, due to top technological achievements in electronics area, our country has also resorted to implementation of automatic data acquisition systems in repartition networks, and active/reactive loads up to the level of the MV bars of step-down stations can undergo an on-going monitoring. At same time, spectacular evolution of automatic calculus systems during last decades, achieving remarkable performances especially regarding the memory and data storage capacity, as well as an ever increasing calculus speed, has influenced directly the perfecting of mathematical models, algorithms and was stimulated complex processes implementation in real time that occur in repartition and distribution public systems. Taking into account these aspects, the aim of this paper is to propose a voltage level analysis methodology in repartition system nodes by performing some repeated steady-state computation corresponding to each level from the active/reactive load curves.

Key words: voltage level; steady-state functioning regime; load curves.

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1. Introduction

Electric energy repartition public systems from our country are made up of overhead and cable lines with 110 kV nominal voltages, 110 kV/MV stations and 110 kV or MV switching substations intended for electricity territorial repartition. The public distribution systems or networks are made up of a set of medium (MV) and low voltage (LV) overhead and cable lines, MV/LV and MV/MV substations intended for electric energy supply of household, social-cultural consumers, administrative, their assembly representing tertiary consumption, including those industrial consumers with small power, within the limits of a certain geographical area and that require electric energy supply conditions similar to tertiary consumption (Georgescu, 2007; Ionescu *et al.*, 1998).

The profound changes that have occurred during the last decades on world and our country level, in power system area, the appearance, respectively the more and more efficient operating of energy markets and, at the same time, the considerable shifting of electric energy consumption from high voltage (HV) to MV and LV has required a special attention of the specialists from this area paid to complex designing, reconstruction, and rational operation, from the technical and economical point of view of the national energy system (NES) and the electric energy repartition and distribution systems (ERDS). Regarding the policy of power quality supplied to consumers and the related management methods, they represent the priorities of each territorial or zonal company, respectively the *Electric Energy Distribution and Supply Branches (EEDSB)* (Georgescu *et al.*, 2006). The above-mentioned priorities together with company general development strategy must be harmonized with integrated management system *Quality – Environment – Health,* and *Operational Safety*, respectively (Ionescu, 1994).

Moreover, as a result of number of non-linear and/or non-symmetrical consumer's diversification and increase, the quality parameters maintenance related to the contracted electric energy delivered to the users has become a real problem. For this reason, according to the present organization from our country, the *Energetic Distribution Dispatch* (*EDD*) has given important tasks regarding the power quality maintenance, in its double role, as *merchandise* and *service* (Neagu *et al.*, 2012). Regarding the EDD, one of its important tasks consists in maintaining admissible limits of power supply amplitude on all ERDS levels. At the same time, it can contribute to number and duration limiting, both of voltage drops and internal over-voltages (Eremia *et al.*, 2006). It must be mentioned that in order to maintain power quality, on all levels, to reduce the active power and energy losses, and reactive power compensation level, the EDD permanently contributes through its performed actions, which can be direct or indirect, according to *Technical Code of Distribution Electric Networks* (Georgescu *et al.*, 1997; Georgescu, 2008; Ionescu *et al.*, 1994).

2. Power Quality Parameters, Admissible Limits and Reactive Power Sources Management in ERDS

The electric energy supplied in three-phase power network point (node) is characterized by two categories of quality indicators, namely: *primary indicators* that depend especially on the electricity supplier/distributor, respectively *secondary indicators* that are especially determined by disturbing consumers supplied with electric energy. The primary quality indicators of electric energy are: *frequency of supply voltage, amplitude of supply voltage, temporary/transient over-voltages and voltage drops,* and the secondary indicators refer to *harmonics*, *inter-harmonics, voltage fluctuations (flicker effect) and non-symmetries.*

The voltage levels maintenance in accepted limits, in all ERDS nodes and on all voltage levels, requires the rational repartition of the loads among the electric energy sources (system and local power plants), as well as the control of reactive powers flows, both in transmission systems and ERDS. Moreover, an inadequate structure and management of reactive power sources can lead to an irrational reactive power flow, to major difficulties in optimal voltage level providing in all system nodes to an overloading of different components (lines and transformers), to additional technical losses in operation process, etc.

Also, ensuring the reactive power sources, corroborated with the adjustment of the reactive power delivered, represents a fundamental condition for obtaining the operating safety and the power system stability in each EEDSB responsibility area. Simultaneously, special problems may appear in current operating of electric energy repartition and distribution systems if the hours and days during a year at empty load, the existent reactive power sources remain connected, thus determining an excess of reactive power that will be injected upstream, in NES, respectively (Allera *et al.*, 1998; Alexandrescu, 1997; Georgescu, 2008).

It must be mentioned that power quality supplied to users closely related to ERDS systems or networks, more precisely, through the *voltage*, *frequency* and *supply continuity* quality which make up *service quality* concept. The consequence of not-complying with these quality aspects or conditions is the inadequate electric energy receivers operating which leads to useless expenses borne by the consumer, either as additional costs or investments for reducing the unwanted consequences in the damage case of some electric receivers.

Taking into account the above-mentioned issues, the global optimal determination regarding the power networks design and operation can be done by considering the *service quality* as an optimal criterion. For attaining this desideratum, the used optimization mathematical models must include the previously mentioned aspects, either through the value expression of economic aspects or some technical restrictions that must be observed.

Regarding the electric energy supply continuity, it is necessary to know social impact in occurrence case of some supply interruptions and to determine undelivered electric energy cost, the damages caused to consumers, thus allowing adoption of some rational decisions related to *quality–cost* compromise. The electric energy supply interruptions must occur as rare as possible and the long lasting or the ones that affect the consumers from extended areas must be avoided, no matter of the involved costs. In electric energy supply domain, no one can guarantee that supply interruption of consumers will not occur. The supply continuity globally depends on all components availability from NES (power plants, transformers, lines, switches, automation and protection devices, etc.), on the one hand, and the random overlapping of some individual consumptions, the influence of climate and seasonal factors, etc., on the other hand.

Another aspect of service quality is related to voltage maintenance and voltage variations, respectively, as well as the frequency within acceptable limits at user's terminals. Regarding the voltage and frequency level that must be provided at the user's terminals, there are, usually, regulations on central level or legislations that establish rules for the electric energy distribution companies and electric devices producers. Actually, these rules define the acceptable tolerances for discrepancies or deviations from nominal voltage and frequency. Thus, according to the SR EN 50160/2007 norm, a synthesis of the acceptable limits regarding the power quality parameters is indicated in Table 1.

Table 1
Acceptable Limits, According to SR EN 50160/2007 Norms, for Power Quality Parameters

No.	Name of the Parameter	Limit acceptable levels
1	Frequency	50 Hz ± 1% during 95% of the week. 50 Hz ± 4%…6% during 100% of the week.
2	Voltage amplitude	For low voltage networks: ±10% U_n (nominal voltage) during 95% of the week. ±10% U_c (contractual voltage) during 95% of the week.
3	Rapid variations (sudden)	Generally limited to 4% U_c, in exceptional case 6%.
4	Rapid variations (Flicker)	$P_{lt} \leq$ 1% of 95% during a week.
5	Voltage drops	No limits are provided. For information purposes, the duration of most of the voltage drops is less than 1 s with an amplitude below 60% of U_n.
6	Short term interruptions	No limits are provided. For information purposes, from some tens to several hundreds of interruptions per year, the duration of 70% of the interruptions is less than 1 s.
7	Long term interruptions	No limits are provided. For information purposes, from 10 to 50 long term interruptions per year.
8	Temporary over-voltages	1.7 U_c.
9	Transient over-voltages	No limits are provided; only their occurrence is indicated.
10	Unbalance	Coefficient of negative (opposite) voltage non-symmetry 2% during 95% of a week.
11	Harmonics	Limits for harmonics till the rank 25. Total distortion coefficient THD = 8% during 95% of a week.
12	Inter-harmonics	The establishing of the acceptable limits is studied.
13	Remote control signals	Limited according to Meister curve, 99% of the day.

Regarding the frequency, distribution companies and suppliers cannot intervene directly in it nominal value maintaining, depending on the whole power system operation. The voltage level maintaining in power networks nodes, knowing their structures and connection diagrams and consumers behaviour, mainly characterized through their active and reactive load curves, the distribution companies can establish during operation process the variants or practical manners of voltage regulating by adequately using the load regulators, of power transformers plots, of reactive power sources steady state, set up in the networks, etc., as well as voltage drops that are going to be used during design stage as technical restrictions for optimization of analysed solutions or variants.

3. Voltage Level Assessment in Repartition Public Systems Nodes through Steady-State Computation

Usually, 110 kV repartition public networks from our country operate in complex loop configuration at steady-state to ensure the power supply safety to consumers from large urban agglomerations. The voltage level in different repartition networks nodes depends on the power plants operating conditions, their loading with active and reactive power, the active and reactive power flows through the transmission, repartition and distribution networks elements, and also the regulation means of the available voltage in power transmission, repartition and distribution systems (autotransformers and transformers with control plots under load or, in the load absence, synchronous compensators, capacitor banks and reactance coils). The voltage variation in addition or in minus has negative consequences both on the normal operating of consumers and on the power network. For this reason, basically, the purpose of voltage regulation in power networks consists in maintaining the voltage variations between certain limits imposed by the actual norms.

For the power repartition system analysis is essential that, starting from a certain structure and system loading conditions, all characteristic parameters can be determined that define the operating state, that is: nodal voltages level, active and reactive power flows, active and reactive power losses, etc. The solving of such problem is known in the specialized literature under the name of *steady-state computation of the systems*.

Due to the fact that steady-state mathematical models are nonlinear, for the power networks steady-state analysis, two categories of numerical methods are used: *direct* and *iterative*. The *iterative methods* allow the obtaining of solutions after performing undetermined operations number though successive steps (iterations) that bring results near to the final value. *Seidel-Gauss*, *Newton-Raphson* and *hybrid* methods fall into this category. These methods allow the use of the operating eqs. under the form of powers and the memory occupied in automatic computation systems is small as compared to the *direct methods*, being proportional to analysed power network sizes. Practically, taking into account the presented advantages, all commercial computation application for the steady-state computation are based on one of these methods. The disadvantages of iterative methods are generally related to convergence issues and steps number for solution obtaining (Eremia *et al*., 1985; Georgescu, 2007).

Generally, the steady-state computation algorithm for power networks from ERDS include a sequence of stages, such as: *steady-state mathematical model, numerical solving method, possibilities of computer*, etc.

Therefore, the general stages of the ERDS steady-state computation algorithm are presented in Fig. 1.

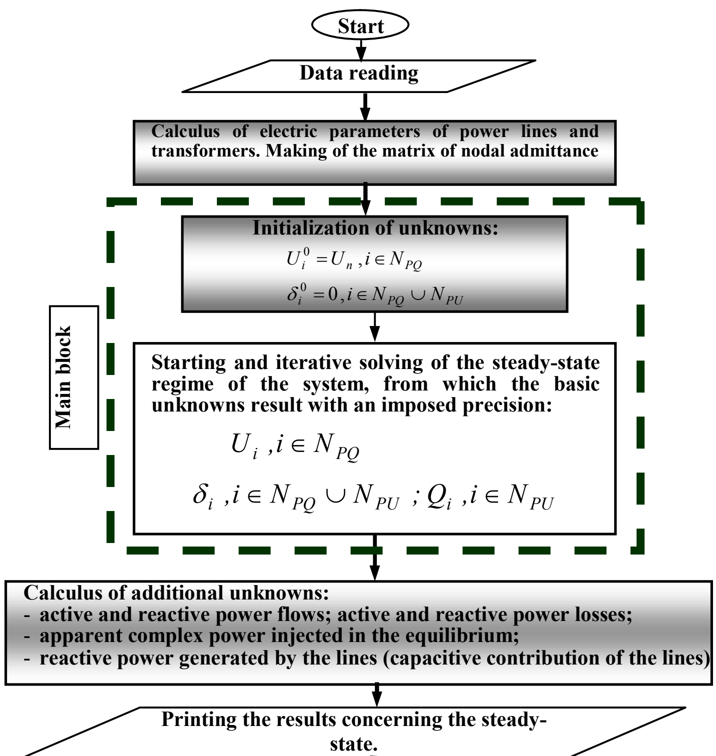

Fig. 1 – The steady-state computation diagram for an ERDS.

According to the above-mentioned facts, if the active/reactive loads absorbed by consumers from the system on the MV station bars level are continuously monitored and they are available under the form of active/reactive load curves, a quite precise voltage level assessment from HV and MV repartition systems nodes can be obtained directly following some repeated steady-state computations for a necessary and sufficient levels number for a characterization as complete as possible of the respective system operation, taking into account both the variation of consumption through load curves and the power sources that inject active/reactive power in the power system.

For an electric network with a given configuration that includes *PQ, PU* nodes and one slack node, following the steady-state computation, were obtained nodal voltages, power flows and losses on all network edges. The mathematical model that is utilized at the basis of a complex loop network steady-state leads to solving of nonlinear algebraic eqs., such as

$$\begin{cases} P_i = G_{ii}U_i^2 + \sum_{\substack{k=1 \\ k\neq i}}^{n} U_i U_k \left[G_{ik}\cos(\delta_i - \delta_k) + B_{ik}\sin(\delta_i - \delta_k) \right], \\ Q_i = -B_{ii}U_i^2 - \sum_{\substack{k=1 \\ k\neq i}}^{n} U_i U_k \left[B_{ik}\cos(\delta_i - \delta_k) - G_{ik}\sin(\delta_i - \delta_k) \right], \end{cases} \quad (i = \overline{1,n},\ i \neq e) \tag{1}$$

where: P_i , Q_i are active and reactive powers injected in the i network node; G_{ii}, G_{ik}, B_{ii}, B_{ik} – real and imaginary parts of the nodal admittance matrix corresponding to the analysed network; U_i, U_k, δ_i, δ_k – modules and arguments of the voltages in i and k nodes of analysed network.

Because eqs. (1) represent a nonlinear and usually extended system, its solving can be performed by using some iterative numerical methods. There are several numerical methods for solving such a system that are mentioned in literature, one of the most efficient and frequently used being the *Newton-Raphson method*, together with the simplified variants of this method, that is: *decoupled Newton-Raphson* and *fast decoupled Newton-Raphson* method. In literature, by using these mathematical models and some specific algorithms, a wide variety of specialized applications are mentioned, intended for steady-state analysis of power networks with complex loop configuration (Eremia *et al*., 1985; Georgescu, 2007).

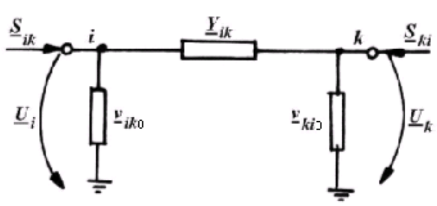

Fig. 2 – Equivalent four-pole for an overhead or cable power line.

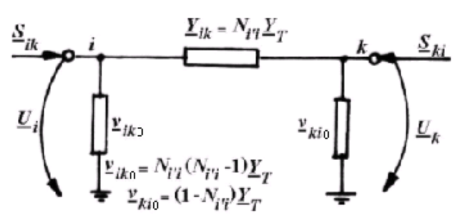

Fig. 3 – Equivalent four-pole for a power transformer with real transformation ratio ($N_{i'i}$).

Following steady-state computation using one of mentioned methods, and one of specialized computation applications, respectively, were obtained voltage level (module) and argument in all analysed system nodes, namely power flows on network elements, determined by relations such as

a) For overhead or cable power lines

$$\begin{cases} \underline{S}_{ik} = P_{ik} + \mathrm{j}Q_{ik} = U_i^2 \underline{y}_{ik0}^* + \underline{U}_{ki}\left(\underline{U}_i - \underline{U}_k\right)^* \underline{Y}_{ik}^*, \\ \underline{S}_{ki} = P_{ki} + \mathrm{j}\underline{Q}_{ki} = U_k^2 \underline{y}_{ki0}^* + \underline{U}_k\left(\underline{U}_k - \underline{U}_i\right)^* \underline{Y}_{ik}^*. \end{cases} \tag{2}$$

b) For transformers with real transformation ratio

$$\begin{cases} \underline{S}_{ik} = P_{ik} + \mathrm{j}Q_{ik} = \underline{U}_i\left(\underline{U}_k + N_{i'i}\underline{U}_i\right)^* \underline{Y}_{ik}^*, \\ \underline{S}_{ki} = P_{ki} + \mathrm{j}Q_{ki} = \underline{U}_k\left(\underline{U}_i + \underline{U}_k / N_{i'i}\right)^* \underline{Y}_{ik}^*. \end{cases} \tag{3}$$

Regarding the values significations from (2) and (3), they are indicated in the Figs. 2 and 3, where the equivalent four-poles for a power line and a power transformer with real transformation ratio are represented.

3. Case Example

For performing such analyses regarding the voltage level determination in HV and MV nodes, using the methodology presented in the previous section,

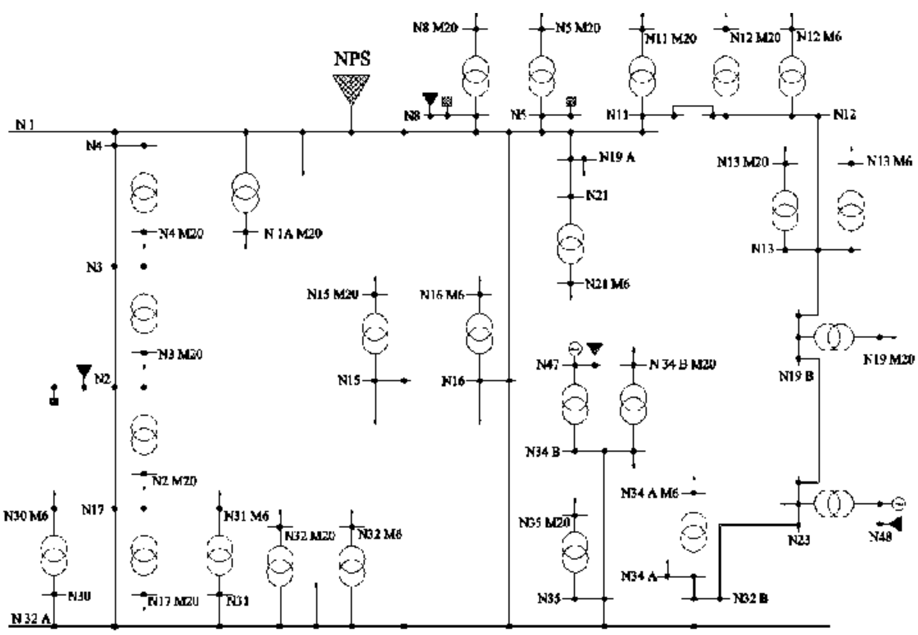

Fig. 4 – Single-line diagram of the 110 kV repartition network.

it was considered an existent and extended 110 kV public repartition system, owned by distribution operator from Moldavian area. The single-line diagram of

Table 2
Active and Reactive Power Flows through the Power Transformers of 110 kV/MV and the Voltage Level in the Nodes of the Analysed Network for the Load Level Corresponding to 19^{00} o'Clock

Node name	Element type	Cold winter regime					Hot summer regime				
		P MW	*Q* Mvar	*U* kV	*u* %	*u* rad	*P* MW	*Q* Mvar	*U* kV	*u* %	*u* rad
N 01	Transf.	5.518	3.548	118	100	0	6.782	4.728	118	100	0
N 01A M20	Transf.	–5.483	–3.035	20.78	98.95	–2.2	–6.737	–4.042	26,601	98.1	–2.7
N 02	Transf.	6.47	2.045	118.233	100.2	–0.8	4.849	2.222	118,755	100.64	0
N 02 M20	Transf.	–6.434	–1.508	21.045	100.22	–3.4	–4.819	–1.807	21,116	100.55	–1.9
N 03	Transf.	6.79	2.623	117.761	99.8	–0.9	2.99	1.696	118,349	100.30	–0.2
N 03 M20	Transf.	–6.743	–1.926	20.604	98.11	–5.6	–2.969	–1.484	20,94	99.71	–2.2
N 04	Transf.	2.219	0.728	117.809	99.84	–0.7	1.163	0.829	118,266	100.23	–0.2
N 04 M20	Transf.	–2.198	–0.468	21.18	100.86	–1.6	–1.143	–0.592	21,255	101.22	–0.6
N 05	Transf.	4.281	1.685	118.011	100.01	0.1	4.452	1.753	118,021	100.02	0.1
N 05 M20	Transf.	–4.257	–1.52	21.141	100.67	–1.1	–4.426	–1.58	21,135	100.64	–1.1
N 08	Transf.	4.538	1.586	117.745	99.78	0.3	2.618	1.889	117,725	99.77	0.2
N 08 M20	Transf.	–4.51	–1.203	21.024	100.11	–1.5	–2.596	–1.597	20,983	99.92	–0.8
N 11	Transf.	9.581	2.908	117.496	99.57	–0.6	8.090	2.587	117,69	99.74	–0.6
N 11 M20	Transf.	–9.537	–2.285	20.933	99.68	–3	–8.052	–2.088	21,000	100.00	–2.7
N 12	Transf.	7.974	2.685	117.343	99.44	–0.9	8.311	2.998	117,645	99.70	–1.0
N 12 M20	Transf.	–7.937	–2.183	20.923	99.63	–3	–8.271	–2.462	20,944	99.73	–3.1
N 12 M6	Transf.	–7.4	–2.8	6.26	99.37	–3.5	–4.400	–2.100	6,317	100.26	–2.5
N 13	Transf.	3.026	1.842	117.357	99.46	–1	6.034	2.727	117,683	99.73	–1.0
N 13 M20	Transf.	–3.003	–1.602	21.018	100.09	–1.8	–2.500	–1.200	21,120	100.57	–1.7
N 13 M6	Transf.	–7.9	–2.5	6.049	96.01	–3.9	–6,000	–2.200	6,087	96.61	–3.2
N 15	Transf.	2.764	0.889	117.822	99.85	0.4	1.330	1.046	117,846	99.87	0.2
N 15 M20	Transf.	–2.742	–0.609	21.155	100.74	–0.7	–1.310	–0.806	21,145	100.69	–0.3
N 16 M6	Transf.	–4.72	–1.73	6.12	97.14	–2	–2.700	–0.800	6,169	97.92	–1.0
N 17	Transf.	4.972	2.763	117.935	99.95	–1	3.845	1.697	118,526	100.45	–0.2
N 17 M20	Transf.	–4.942	–2.471	20.868	99.37	–3	–3.821	–1.508	21,139	100.66	–1.7
N 19 M20	Transf.	–7.32	–1.604	21.041	100.19	–3.1	–5.570	–1.591	21,128	100.61	–2.8
N 19A	Transf.	7.354	2.054	117.929	99.94	–0.1	5.598	1.934	117,916	99.93	0
N 21	Transf.	10.246	1.968	117.897	99.91	–0.1	6.634	3.339	118,067	100.06	–1.3
N 21 M6	Transf.	–10.2	–1.1	6.137	97.42	–3.7	–6.600	–2.800	6,083	96.55	–2.4
N 23	Transf.	–18.882	–22.963	118.008	100.01	–1.3	0.038	0.268	118,484	100.41	–1.5
N 30	Transf.	6.132	2.169	117.655	99.71	–0.9	3.926	1.721	117,85	99.87	–0.1
N 30 M6	Transf.	–6.1	–1.7	6.113	97.04	–3.1	–3.900	–1.400	6,141	97.48	–1.5
N 31	Transf.	0.522	0.414	117.705	99.75	–0.9	1.523	0.726	117,879	99.90	–0.1
N 31 M6	Transf.	–0.5	–0.2	6.187	98.21	–1.1	–1.500	–0.500	6,183	98.15	–0.6
N 32 A	Transf.	9.592	3.609	117.709	99.75	–0.9	3.666	2.119	117,889	99.91	–0.1
N 32 M20	Transf.	–9.532	–2.626	20.694	98.54	–5	–3.641	–1.771	20,961	99.81	–1.6
N 32 M6	Transf.	–0.8	–0.1	6.189	98.24	–1.2	–0.900	–0.400	6,186	98.19	–0.4
N 32 B	Transf.	7.728	2.069	117.921	99.93	–1.3	4.475	1.968	118,464	100.39	–1.5
N 34 B	Transf.	–5.202	–11.127	117.833	99.86	–1	–16.886	–5.592	117,958	99.96	0
N 34A	Transf.	15.382	5.51	117.816	99.84	–1.4	7.837	2.081	118,435	100.37	–1.5
N 34A M6	Transf.	–15.3	–4.2	6.058	96.15	–5.1	–7.800	–1.600	6,180	98.09	–3.3
N 34B M20	Transf.	–7.685	–1.397	20.962	99.82	–4.1	–4.447	–1.581	21,002	100.01	–1.8
N 35	Transf.	4.56	1.39	117.771	99.81	–1	5.272	3.104	117,909	99.92	0
N 35 M20	Transf.	–4.532	–1.007	21.058	100.27	–2.8	–5.239	–2.620	20,811	99.10	–2.2
N 47	Transf.	5.272	12.196	6.3	100	0	17,00	7.424	6,149	97.60	4.3
N 48	Transf.	19	25	10.191	97.05	0.7	0	0	10,219	97.32	–1.6
N16	Transf.	4.748	2.142	117.775	99.81	–0.4	2.722	1.104	117,908	99.92	–0.1

the analysed system is presented in Fig. 4 and it comprises 39 overhead lines with 110 kV nominal voltage, simple or double circuit, with 150, 185, 300 mm^2 OL-Al cross sections and 26 power transformers with 110 (123) kV/MV, and 16, 25 and 80 MVA apparent nominal powers, that equip the HV/MV stations. The repartition network operates in normal steady-state on complex loop configuration and it is supplied both from the power system and the two local heating power plants.

In order to carry out this study, was necessary to know the active/reactive load curves in all repartition network consuming nodes (station MV bars), and the operating state of the local power plants that inject power in respective network. These daily load curves, for the 2012 cold winter and hot summer state, have been continuously registered with SCADA system.

Following the analysis of these records during the cold season, was established that the most active standard working day (Tuesday-Wednesday-Thursday) is January 12, 2012 and for the hot season, July 11, 2012. For these two standard days was assessed both the voltage level in all network nodes, and active and reactive power flows in all repartition network elements, taking into account the active/reactive load curves on substation MV bars under 24 hourly levels.

Under these conditions, with the help of NEPLAN application that uses Newton-Raphson method for steady-state computation of power networks, 24 different steady-states, corresponding to the load curves level from analysed standard days, were computed.

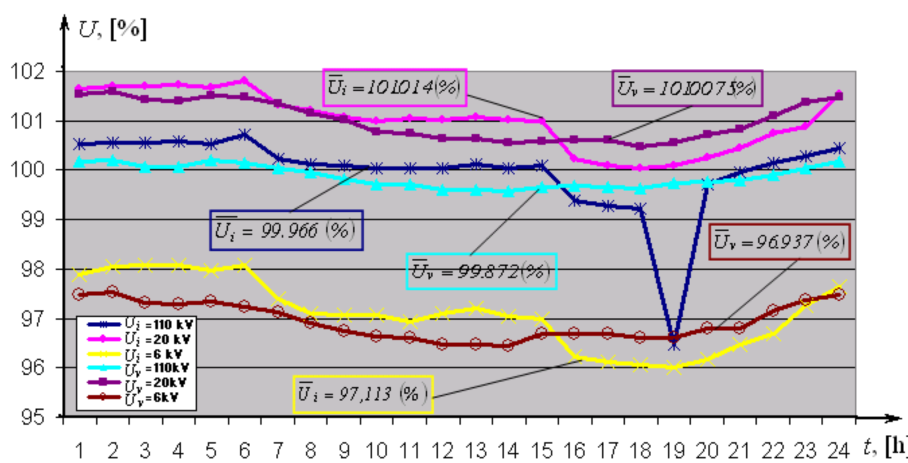

Fig. 5 – The voltage level variation, in percentages, during some working days from the cold winter and hot summer state from the analysed repartition system nodes: N13 – with 110 kV nominal voltage, N13-M20 – with 20 kV nominal voltage and N13-M6– with 6 kV nominal voltage.

Therefore, for exemplification purposes, are presented the obtained results for the standard day from cold regime corresponding to the hour (level)

19^{00} o'clock and for hot regime, the results also corresponding to 19^{00} o'clock. The previously mentioned results are presented in Table 2 comprising the active/reactive power flows through the 110 kV/MV power transformers, the voltage level in analysed system nodes, in absolute values (kV) and percentages (%) from nominal voltage, and nodal voltages arguments in radians. Also, for exemplification, Figs. 5 and 6 present voltage level percentage variation for the studied repartition system nodes, for the two analysed standard days corresponding to cold winter and hot summer state. The average daily values of the voltage are also indicated for each daily variation curve.

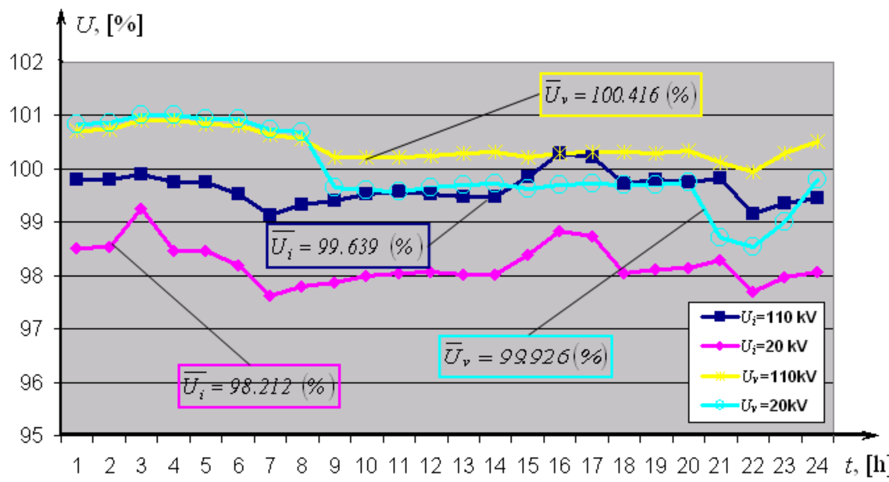

Fig. 6 – The voltage level variation, in percentages, during some working days from the cold winter and hot summer state from the analysed repartition system nodes: N03 – with 110 kV nominal voltage, N03-M20 – with 20 kV nominal voltage.

4. Conclusions

On the basis of the performed analysis in the paper regarding the voltage level variation in HV nodes (110 kV) and MV nodes (6 kV and 20 kV) of a power repartition public system, for two standard working days (winter and summer season), the most loaded from January and July 2012, the following observations and conclusions result:

a) The voltage levels from all public repartition system nodes, both for HV and MV, are accordingly to the maximum accepted deviations criterion of 106...123 kV, 20...22 kV, respectively 6...6.6 kV, during the standard days from the cold winter and cold summer state. This is possible due to the fact that, on the one hand, the analysed public repartition network operate in normal steady-state in complex-loop configuration and, on the other hand, power (energy) is injected in respective network, both from the power system and from the two local heating plants. It is possible to attain the proposed desideratum regarding the maintaining of the voltage level in all repartition network nodes, taking also into account network configuration, through the injected powers optimization by the power sources (NES and the two local power plants), depending on the loads required by consumers supplied with electric energy from different 110 kV/MV step-down stations, that belong to ERDS. Thus, at peak load state, in order to reduce the active and reactive power injected from NES, the two local plants are loaded close to nominal powers and, moreover, they supply a good part of the reactive power necessary for maintaining the voltage level. At the same time, the power transformers plots from the 110 kV/MV stations are used and changed in a rational manner, through the adequate modification of transformation ratios depending on the real operating conditions of the analysed repartition network.

b) In order to decrease the acceptable limits of voltage variations from the HV and MV repartition network nodes and the observance of the favourable bands (115...120 kV, 20.5...21.5 kV and 6.3...6.5 kV), with the purpose of damages reduction caused to users due to inadequate quality of supply voltage, and for power and active energy losses reduction from all ERDS elements, the optimal placement of some reactive power sources is recommended, that is, adjustable capacitor banks, on the MV bars of 110 kV/MV step-down stations, as well as some fixed capacitor banks on the LV bars of MV/0.4 kV substations. Moreover, the presence of these reactive power sources (shunt capacitor banks) in power repartition and distribution public system is also imposed by the fact that existent capacitor banks had to be removed and disconnected, due to the fact that, according to EU recommendations and present regulations from our country (Environment protection law *137*/2000), they contained polychlorinated biphenyls (PCB), polychlorinated threephenyls (PCT), polychlorinated naphthalene (PCN), biphenyl polybromides (PBB), etc., that are dangerous for the human and animal health, and to the environment, respectively. The reactive power sources, more precisely the capacitor banks, must be replaced by newer generation equipment that observes both the decision adopted in our country and the EU recommendations.

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ASPECTE PRIVIND CALITATEA ENERGIEI ELECTRICE ÎN SISTEMELE PUBLICE DE REPARTIȚIE ŞI DISTRIBUȚIE A ENERGIEI ELECTRICE

(Rezumat)

Nivelul tensiunilor în nodurile sistemelor publice de repartiție necesită, în primul rând, controlul circulației puterilor reactive vehiculate atât în sistemele de transport, cât şi în sistemele de repartiție şi distribuție a energiei electrice. La ora actuală, datorită realizării tehnologiilor de vârf din domeniul electronicii, s-a trecut şi în țara noastră la implementarea sistemelor automate de achiziție a datelor în sistemele publice de repartiție, putându-se astfel monitoriza, în mod continuu, sarcinile active/reactive până la nivelul barelor de MT ale ST coborâtoare. Totodată, evoluția spectaculoasă a sistemelor de calcul automat, privind capacitatea de memorie şi de stocare a datelor, precum şi o viteză de calcul din ce în ce mai mare, au influențat în mod direct perfecționarea modelelor matematice, a algoritmilor de calcul şi au impulsionat implementarea conducerii în timp real a proceselor complexe care apar în sistemele publice de repartiție şi distribuție. Având în vedere aspectele menționate, în lucrare se propune o metodologie de analiză a nivelului de tensiune în nodurile sistemelor de repartiție prin efectuarea unor calcule repetate de regim permanent, corespunzătoare fiecărui palier din curbele de sarcină activă/reactivă.