THE EFFICIENCY OF ELECTRIC DISTRIBUTION NETWORKS OPERATING IN DISTORTION AND NON-SYMMETRICAL REGIME

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Abstract — The paper is structured in five parts. In the first part is presented the actual state of preoccupations, principles and hypothesis applied by the authors, to evaluate the electric distribution networks efficiency (EDN). In the second part is presented the mathematical model for evaluation of the distortion and non-symmetrical regime (DNSR) its impact on the energetic performances of the electric transformer – that is the main equipment of EDN. The measurement in EDN and DNSR, viewing the affects of the power performances, makes the third part of the paper. There are denoted the mathematical absolute and relative values, of EDN efficiency in DNSR toward the reference regime (RR). In the fourth part are presented the results of the researches as well as the conclusions.

Key words: electric networks, pollution mode, indices of efficiency

1. INTRODUCTION

The problem of analytical evaluations and of experimental registration viewing the extension and the consequences of the distortional and nonsymmetrical regime (DNSR) on the network elements and of the receivers connected to electric network has a very great actuality [1÷5; 11÷24].

The increasingly number of DNSR sources, perceiving ill-fated effects, has induced reactions from specialists, professional organizations and implicated economic entities. Foreign and Romanian publications with high prestige and scientific manifestations [1÷27] have great attention to analytical and experimental evaluation of the DNSR as well as its compensation, thus the standard requirements is satisfied [28, 29, and 30] that reflects the average utility of the compensations.

The presence of DNSR at an electric power system, respectively by a consumer, produces [2, 3, and 12]: supplementary losses, perturbation of the transmitted signals through the network, or through the neighbourhood networks, over voltages, secondary effects of thermal and reliability nature. The distortional regime (DR), effects and solutions for its compensation, presents the most important direction of preoccupation, concerning the electrical energy quality, components of electrical energy supplying service quality [3,7,8,18,20,24,25].

In spirit of actual tendencies, the paper uses and develops the results of the authors aiming the comparative evaluation of electric distribution networks efficiency (EDN) in DNSR, contrary with the reference regime (RR) symmetrical sinusoidal regime. By managing and analyzing the EDN performances is specified the contour (C) that limited them. As an example, in fig. 1 is given the scheme of a hypothetical EDN.

The energetic performances of an EDN are influenced by transformers and lines, where takes place significant power losses. There is noted:

P_{1i} – absorbed active power in EDN;

P_{2j} – delivered active power from EDN;

For EDN from fig. 1, may be expressed the total active input and debited power:

$$\begin{cases} P_1 = \sum_{i=1}^{4} P_{1\cdot i} \\ P_2 = \sum_{j=1}^{6} P_{2\cdot j} \end{cases} \quad (1)$$

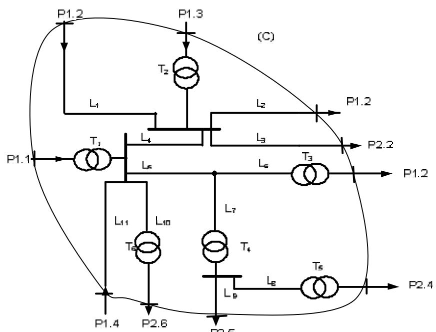

Fig.1 – Electric scheme of a hypothetical EDN

The active power loss at a "t" moment for the ensemble of EDN elements – fig.1 – is expressed with the relation:

$$\Delta P = \Delta P_T + \Delta P_L = \sum_{\rho=1}^{6} \Delta P_{T\cdot\rho} + \sum_{\varepsilon=1}^{11} \Delta P_{L\cdot\varepsilon} \quad (2)$$

$\left(\Delta P_{T\cdot\rho}; \Delta P_{L\cdot\varepsilon}\right)$ - active power losses(APL) for transformer "ρ" and "ε" line.

Generally, an EDN, with an arbitrary configuration, with "n" inputs and "m" outputs, will be evaluated:

- At "t" moment:
  - Active powers and active power losses are:

$$\begin{cases} P_1 = \sum_{i=1}^{n} P_{1\cdot i} \\ P_2 = \sum_{j=1}^{m} P_{2\cdot j} \\ \Delta P = \sum_{\rho \in C} \Delta P_{T\cdot\rho} + \sum_{\varepsilon \in C} \Delta P_{L\cdot\varepsilon} \end{cases} \quad (3)$$

Similar relations may be written for reactive powers and active powers too. In electric lines the reactive power losses are negligible. For a more exact and operative evaluation the active power losses in reference with the transformers, will equalize the reactive power losses too, that are implied by the proper reactive power consume of the transformer, using the average value of the reactive power energetic equivalent (ξ):

$$\Delta P_{T\cdot\rho} = \Delta P^{I}_{T\cdot\rho} + \xi \Delta Q_{T\cdot\rho} \quad (4)$$

- Efficiency:

$$\eta = \frac{P_2}{P_1} = \frac{P_1 - \Delta P}{P_1} = \frac{P_2}{P_2 + \Delta P} \quad (5)$$

- For a (T_A) interval of magnitudes, ($\Delta P, P_1, P_2$) are variables in function with each input and output. For evaluating the energy performances of EDN for (T_A) interval is determinate
  - Energies and energy losses:

$$\begin{cases} W_1 = \sum_{i=1}^{n} W_{1\cdot i} = \sum_{i=1}^{n} \int_0^{T_A} P_{1\cdot i} dt \\ W_2 = \sum_{j=1}^{m} W_{2\cdot j} = \sum_{j=1}^{m} \int_0^{T_A} P_{2\cdot j} dt \\ \Delta W = \sum_{\rho \in C} \int_0^{T_A} \Delta P_{T\cdot\rho} dt + \sum_{\varepsilon \in C} \int_0^{T_A} \Delta P_{L\cdot\varepsilon} dt \end{cases} \quad (6)$$

  - Energies efficiency of EDN:

$$e = \frac{W_2}{W_1} = \frac{W_1 - \Delta W}{W_1} = \frac{W_2}{W_2 + \Delta W} \quad (7)$$

2. Impact of DNSR on enwergy performance of power transformer

The power transformer (PT) is the most affected part of the EDN by DNSR. Generally, by PT the active and reactive power losses are in the: magnetic circuit, in wires of conductor and dielectric. As the PT from EDN operates until 110 kV, the losses in the dielectric may be neglected. In [9,10,12], are justified and expressed the power losses in components of PT that operates in DNSR

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2.1. Power losses in PT that operates in DR

In concordance with the effectuated evaluations in [4] there are obtained:

$$\begin{cases} \Delta P^{I}_{TD} = \left(1 + k^2_{DI}\right)\beta^2 \Delta P_{wn} + \left(1 + k_{DF}\right)\Delta P_{Fn} \\ \Delta Q_{TD} = \left(1 + k_{DQO}\right)\Delta Q_{On} + \left(1 + k_{DQk}\right)\beta^2 \Delta Qkn \end{cases} \quad (8)$$

where:
(ΔP_{wn}, ΔP_{Fn}) – nominal APL in wired and magnetic circuit;
ΔQ_{0n} – magnetizing nominal reactive power of "T";
ΔQ_{kn} – nominal reactive power losses (RPL) by dispersion;
$\left(k^2_{DI}, k_{DF}, k_{DQ0}, k_{DQk}\right)$ - supplementary coefficients of power losses in DR in comparison with RR.

In [10,12] are deduced the expressions of the supplementary coefficients in function with the (ν) harmonic grade and the effective values of the voltages and currents on harmonics (U_ν, I_ν) and on fundamental (U_1, I_1). The expressions of the four coefficients are:

$$\begin{cases} k_{DI} = \frac{\sqrt{\sum_{\nu \ge 2} I^2_\nu}}{I}; \quad k_{DF} = \sum_{\nu \ge 2} \left(\frac{U_\nu}{U_1}\right)^2 \left(\frac{1}{\nu}\right)^2 \\ k_{DQO} = \sum_{\nu \ge 2} \frac{1}{\nu} \frac{U_\nu}{U_1}; \quad k_{DQk} = \sum_{\nu \ge 2} \nu \left(\frac{I_\nu}{I_1}\right)^2 \end{cases} \quad (9)$$

2.2. Power losses in PT that are operating in NSR

$$\begin{cases} \Delta P^{I}_{TN} = K_{NI}\beta^2_e \Delta P_{wn} + K_{NF}\Delta P_{FN} \\ \Delta Q_{TN} = K_{NQO}\Delta Q_{On} + K_{NI}\beta^2_e \Delta Q_{kn} \end{cases} \quad (10)$$

The expressions of the amplification coefficients (K_{NI}, K_{NF}, K_{NQO}), are [10,12]:

$$\begin{cases} K_{NI} = 1 + \frac{2}{9\beta^2_e}\left[\beta_1(\beta_1 - \beta_2) + \beta_2(\beta_2 - \beta_3) + \beta_3(\beta_3 - \beta_1)\right] \\ K_{NF} = \sum_{k=1}^{3} \frac{\left(\alpha^2_{1k} + \alpha^2_{2k}\right)}{6} + 0{,}05\left[1 + \left(\frac{U_h}{U_{1n}}\right)^2\right] \\ K_{NQO} = \sum_{k=1}^{3} \frac{\left(\alpha_{1k} + \alpha_{2k}\right)}{6} \end{cases} \quad (11)$$

where:
β_e – equivalent loading factor of "T" in RR;
β_k– loading factor in NSR, on "k" phase $\left(k=\overline{1,3}\right)$;
(α_{1k}, α_{2k}) – primary relative voltages (α_{1k}) and secondary of "T" (α_{2k}), on "k" phase $\left(k=\overline{1,3}\right)$
U_h – displacing voltage of neutral point due the homopolar current on the primary of "T";
U_{1n} – primary nominal voltage of "T".

2.3. Power losses in EDN. Optimal of conjuncture

Allowing the overlapping effects, the total losses are expressed in a T that is operating in DNSR.

$$\begin{cases}\Delta P_T^I=\Delta P_{TD}^I\oplus\Delta P_{TN}^I=\left(K_{DI}^2+K_{NI}\right)\beta_e^2\Delta P_{wn}+\left(K_{DF}+K_{NF}\right)\Delta P_{Fn}\\ \Delta Q_T=\Delta Q_{TD}\oplus\Delta Q_{TN}=\left(K_{DQO}^2+K_{NQO}\right)\Delta Q_{On}+\left(K_{DQK}+K_{NI}\right)\beta_e^2\end{cases} \tag{12}$$

By modifying of the values of the components of power losses, released in T, in case of operation in DNSR, in function with RR, is modified the value of the load at which the operating efficiency is maximum (optimal load).

- The general expression of optimal loading factor (β_m) is:

$$\beta_m=\sqrt{\frac{\Delta P_{TI}}{\Delta P_{T\beta}}}=\sqrt{\frac{\Delta P_F+\xi\Delta Q_O}{\Delta P_w+\xi\Delta Q_k}} \tag{13}$$

(ΔP_{TI}, $\Delta P_{T\beta}$) – independent power losses (ΔP_{TI}) and loading depended ($\Delta P_{T\beta}$).

- In NR the expression of β_m factor became:

$$\beta_{mD}=\sqrt{\frac{\left(1+K_{DF}\right)\Delta P_{FN}+\xi\left(1+K_{DQO}\right)\Delta Q_{On}}{\left(1+K_{DI}^2\right)\Delta P_{wn}+\xi\left(1+K_{DQK}\right)\Delta Q_{Kn}}} \tag{14}$$

- In NR, β_m factor is expressed as follows:

$$\beta_{mN}=\sqrt{\frac{K_{NF}\,\Delta P_{Fn}+\xi K_{NQO}\Delta Q_{On}}{K_{NI}\left(\Delta P_{wn}+\xi\Delta Q_{Kn}\right)}} \tag{15}$$

3. POWER LOSSES IN ELECTRIC LINES THAT ARE OPERATING IN DNSR

In case of power losses evaluation in the electric lines (L) that is operates in DNSR, are allowed simplifying hypothesis, as [2]:

- The parameters of the circuit elements aren't variable with the time and neither aren't function with the current and voltage;
- The line isn't a source of harmonic.

For L from DNSR, the power losses are composed from active power losses of conductors, reactive power losses and the losses in the dielectric are negligible. Consequently, the total power loss in "L" [12] that operates in DNSR is expressed as:

$$\begin{cases}\Delta P_L=\left(K_{DI}^2+K_{NC}\right)\Delta P_{CN}\\ K_{NC}=\frac{1}{3}\left(\beta_1^2+\beta_2^2+\beta_3^2\right)\end{cases} \tag{16}$$

where:
ΔP_{Cn} – nominal APL in the analyzed "L" conductor;
K_{NC} – amplifying factor of APL in "L" conductor that operates in NSR, accordingly with RR.

4. GRADE OF AFFECTING OF THE ENERGY PERFORMANCES OF EDN IN DNSR

Evidencing the effecting grade of energy performances of EDN in DNSR, may be done by comparative evaluation of active power losses, of efficiency and energy efficiency, or / and the deviation of this magnitudes in DNSR, in function with RR at a given value of the outputs (P_2, W_2).

The above presented expressions of calculation are available in RR and in DNSR.

Furthermore, there will be given the absolute and relative deviations of the magnitudes that reflect the affecting grade of energy performances of EDN in DNSR against RR. In this sense, the DNSR characteristic magnitudes will be marked with NSR, as the conversely for RR with R indices.

- The supplementary losses of afferent active power EDN at "t" moment is:

$$\begin{aligned}\delta(\Delta P)&=\delta(\Delta P_T)+\delta(\Delta P_L)=\Delta P_{DN}-\Delta P_R=\\ &=\sum_{\rho\in C}\Big\{\Big[\left(K_{D\rho}^2+K_{N\rho}-1\right)\beta_{e\rho}^2\Delta P_{wn\rho}+\left(K_{DF\rho}+K_{NF\rho}\right)\Delta P_{Fn\rho}\Big]+\\ &+\xi\Big[\left(K_{DQ0\rho}\right)+K_{NQ0\rho}-1\Big]\Delta Q_{On\rho}+\left(K_{DQK\rho}+K_{N\rho}\right)\beta_{e\rho}^2\cdot\Delta Q_{Kn\rho}\Big]\Big\}+\sum_{\varepsilon\in C}\left(K_{D\varepsilon}^2+K_{NC\varepsilon}-1\right)\Delta P_{Cn\varepsilon}\end{aligned}$$

- The supplementary power losses in EDN in the period of the analyze:

$$\delta(\Delta W)=\Delta W_{DN}-\Delta W_R=\int_0^{T_A}\delta(\Delta P)\cdot dt \tag{18}$$

- Reducing the EDN efficiency for the conversely regime of "t" moment:

$$\Delta\eta=\eta_R-\eta_{DN}=\frac{P_2}{P_2+\Delta P_R}-\frac{P_2}{P_2+\Delta P_{DN}}=\eta_R\frac{\delta(\Delta P)}{P_2+\Delta P_{DN}} \tag{19}$$

- Relative reducing of EDN efficiency

$$\delta\eta=\frac{\Delta\eta}{\eta_R}=\frac{\delta(\Delta P)}{P_2+\Delta P_{DN}} \tag{20}$$

Reducing the energy efficiency of EDN for the period of analyzes (T_A):

$$\Delta e = e_R - e_{DN} = \frac{W_2}{W_2+\Delta W_R} - \frac{W_2}{W_2+\Delta W_{DN}} = e_R \frac{\delta(\Delta W)}{W_2+\Delta W_{DN}} \quad (21)$$

- Relative reducing of RED efficiency in RDN, in function with RR:

$$\delta_e = \frac{\Delta e}{e_R} = \frac{\delta(\Delta W)}{W_2 + \Delta W_{DN}} \quad (21)$$

Basing on the above expressions, by particularization are obtained, the expressions of the indices that gives the affecting grade of energetic performances of EDN in DNSR, respectively of NSR in function with RR.

5. A CASE STUDY

The elaborated and presented calculation methodology was applied referring on a part of EDN that is managed by Urban Power Distribution Network Oradea (fig.2). The points from EDN where the measurements were made and the equipment are necessary where the DNSR level has certain significance. The measure points and the implied elements characteristics in evaluation are in table 1.

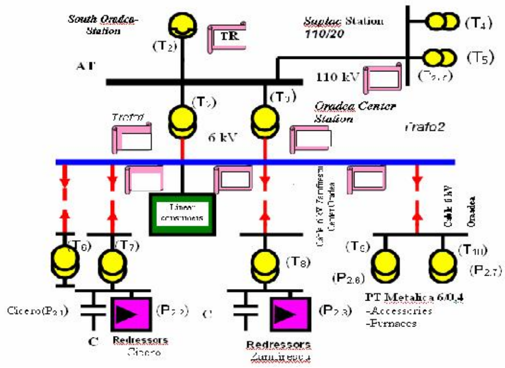

Fig 2 – Analyzed scheme EDN

Table 1. Measure points and the characteristics of the network's element

MN o.	Name of measuring point	Principle characteristics of transformer	Principle characteristics of electric cables
0	**1**	**2**	**3**
1.	Electric station ORADEA CENTRU 110/6 kV		
	- cell 6 kV Transformer 1	S_n= 25 MVA ; 110/6 kV	LEC 10 kV ; ACYABY 3x120mmp,l=100
	- cell 6 kV Transformer 2	S_n= 25 MVA; 110/35/6 kV	LEC 20 kV ; NA2Y(F) 3x150 mmp,l=100
	- cell 6 kV Cicero (blocks)	S_n= 1000 kVA ; 6/0.4 kV	LEC 10 kV ; ACYABY 3x120 mmp, l=250
	- cell 6 kV Zamfirescu (OTL)	S_n= 1000 kVA ; 6/0.4 kN	LEC 10 kV ; ACYABY3x120mmp,l=3000
	- cell 6 kV Redresori (OTL)	S_n= 1000 kVA ; 6/0.4 kV	LEC 10 kV ; ACYABY 3x120 mmp, l=250
		Electric station SUPLAC 110/6 kV	
2	- cell 6 kV Transformer 3 (SRA)	S_n= 25 MVA ; 110/6 kV	Al bars (80x10)x2 phase, l=37100m
	- cell 6 kV Transformer 6 (SRA)	S_n= 25 MVA ; 110/6 kV	Al bars (100x10)x4 phase, l=37100m
3.		Electric station South ORADEA	
	- cell 110 kV, AT	S_n= 200 MVA ; 220/110 kV	LEA 2x450/75 mmp, l=2520m
4.		PT Accesories (Metalica)	
	- cell Transformer	S_n= 1000 kVA; 20/0.4 kV	LEC 20 kV ; AOSB 3x150 mmp, l=400m
5.		Substation furnace (Metalica)	
	- cell Transformer	S_n= 1600 kVA; 20/0.4 kV	LEC 20 kV ; AOSB 3x150 mmp, l=400m

The measurements were made with "TRINET" network analyser connected to the measuring points on the scheme of "TR" In the measuring points: Suplac Station, South Oradea Station accessories PT, PT of furnace, the measurements were made in morning peak (m.p.) , while the other were made at the evening peak (e.p.). For each regime were made 5 measurements.

The made registrations in 10 points of analyzed

EDN put in evidence the maximum values of the distortion coefficients in voltage and current (δ_U, δ_I) and of total non symmetry coefficients of voltage and current (k_{nsU}, k_{nsI}), respectively the apparition probability of these values (p) indicated in table 2.

Table 2. Values of the distortions and non symmetry coefficients

Points of measuring	Distortion				Non-symmetry			
	δ_U [%]	p	δ_I [%]	p	K_{nsU} [%]	p	K_{nsI} [%]	p
Center-Oradea Cicero	2,24	0,16	4,46	0,33	2,2	0,66	12	0,50
Center-Oradea, Redressors	1,96	0,40	20,64	0,80	2,1	0,20	49	0,20
Center-Oradea, Zamfirescu	2,23	0,50	24,57	0,83	2,2	0,33	8,2	0,83
Center-Oradea, Trafo 1	2,84	0,55	3,75	0,33	3	0,66	1,4	0,88
Center-Oradea, Trafo. 2	2,3	0,57	2,58	0,85	2	0,85	1,2	0,57
Points of measuring	**Distortion**				**Non-symmetry**			
	δ_U [%]	p	δ_I [%]	p	K_{nsU} [%]	p	K_{nsI} [%]	p
Suplac, Trafo 3	2,57	0,50	3,6	0,50	1	0,50	5,6	0,50
Suplac, Trafo. 6	2,35	0,50	1,27	0,50	0,95	0,50	1,8	0,50
South Oradea	1,61	0,50	6,52	0,50	1,6	0,50	6,7	0,50
PT. Accessories	1,17	0,66	12,46	0,66	0,82	0,66	6,6	0.66
PT Furnaces	1,62	0,50	5,34	0,50	0,79	0,50	4,9	0.50

For example, we give the average effective values registered for T_1 from "Center Oradea electric station":

- Characteristic magnitudes DR;

$$\begin{cases} v = \{3; \quad 5; \quad 7; \quad 9\} \\ U_\nu = \{0.18; 0.11; 0.1; 0.08\} U_1 \\ I_\nu = \{0.18; 0.11; 0.1; 0.06\} I_1 \end{cases}$$

- The characteristic magnitudes SR:
  - For currents

$$\begin{cases} I_{21} = 810A; \quad I_{22} = 1015A; \ I_{23} = 790A; \ I_{2n} = 1400A \\ I_{21} = 468A; \ I_{22} = 586A; \ I_{23} = 456A; \ I_{2n} = 808A; \end{cases}$$

Voltage on lines

$$\begin{cases} U_{11} = 116.270V; \quad U_{12} = 113.850V \\ U_{13} = 115.500V - \text{primary} \\ U_{21} = 6.186V; \quad U_{22} = 6.234V; \quad U_{23} = 6.252V - \text{secundary} \\ U_H = 11.254V - \text{homopolar voltage in primar} \end{cases}$$

The supplementary power and energy losses may be expressed direct, in function with the supplementary factors or through the decreasing of the total losses corresponding to reference regime. The obtained results referring on the analyzed network are synthesized in tables 3 and 4.

Table 3. Energy losses provoked by transformer operating in EDN analyzed in DNSR

Station/trafo	S_n [kVA]	S_{med} [kVA]	β_{med}	ΔW_{DN} [kWh/day]	$\delta(\Delta W)_D$ [kWh/day]	$\delta(\Delta W)_N$ [kWh/day]	$\delta(\Delta W)$ [kWh/day]
Electric Station Oradea Center Cicero (T6)	1000	770	0.77	59.48	0.34	3.53	3.87
Electric station Oradea Redressors, (T_7)	1000	530	0.53	163	6.16	1.99	8.15
Electric station Oradea Center Zamfirescu, (T_8)	1000	410	0.41	147.82	3.84	2.81	6.65
Electric station Oradea Center Trafo 1 (T_2)	25000	8800	0.352	765.77	2.71	31.75	34.46
Electric station Oradea Center, Trafo 2 (T_3)	25000	9400	0.37	1210.32	2.04	52.43	54.47
Suplac - Trafo 3 (T_4)	25000	7300	0.292	481.28	2.88	16.37	19.25
Suplac - Trafo 6 (T_5)	25000	7300	0.29	417.85	1.59	15.16	16.75
Electric station Oradea CenterMetalica Accesories (T_9)	1000	360	0.36	43.05	0.75	1.18	1.93
Electric station Oradea Center, Metalica furnaces (T_{10})	1600	970	0.60	42.94	0.68	1.68	2.36
Electric station South Oradea - Autotransformer (T)	200000	91000	0.45	5462.05	64.86	208.15	273.01

Table 4. Energy losses provoked by operating electric lines of EDN analyzed in DNSR

Destination of electric lines	Transmitted power (S_{medl}) [kWA]	ΔW_{DN} [kWh/day]	$\delta(\Delta W)_D$ [kWh/day]	$\delta(\Delta W)_N$ [kWh/day]	$\delta(\Delta W)$ [kWh/day]
0	1	2	3	4	5
Electric Station Oradea Center Cicero	770	1376.07	25.21	129.23	154.44
Electric Station Oradea Center – Repressors	530	9703	478.83	6.32	485.15
Destination of electric lines	Transmitted power (Smedl) [kWA]	ΔWDN [kWh/day]	δ(ΔW)D [kWh/day]	δ(ΔW)N [kWh/day]	δ(ΔW) [kWh/day]
Electric Station Oradea Center - Zamfirescu	410	8111.12	356.56	8.48	365.4
Electric Station Oradea Center Trafo 1	8800	10390.77	385.59	82.01	467.6
Electric Station Oradea Center.Trafo 2	9400	5236.2	192.06	43.57	235.63
Suplac - Trafo 3	7300	4741.75	99.79	89.87	189.66
Suplac - Trafo 6	7300	756.2	12.57	17.68	30.25
Sl.Ord.Cenler, Metalica	360	159,28	6,03	1.14	7,17
Electric Station Oradea Center,	970	234.91	9.5	3.42	12.92
Electric station South Oradea -	91000	72710	2047.85	1587.67	3635.52

The average value of the absorbed energy in the 7 consumer points was calculated allowing $\cos\varphi_{med} = 0{,}92$. The evaluation of the total losses of energy and supplementary energy for duration of the analysed period (T_A = 24 hours), were made basing on the partial values (tables, 3 and 4), taking into account the weighting of the power in 7 points of consume in the ensemble of loading of the transformers from Oradea Center station (16.7%) and South Oradea station (19.4%).

The obtained results are:

$W_2 = 389.491{,}2$ kWh/day

$\Delta W_{DN} = 45.542{,}85$ kWh/day

$\delta(\Delta W) = 2194{,}11$ kWh/ day

$\Delta W_R = 43.348{,}74$ kWh/day

$$e_R = \frac{389.491{,}2}{389.491{,}2 + 43348{,}74} = 0{,}8998 \quad (89{,}98\%)$$

$$\Delta e = \frac{0{,}8998 \cdot 2194{,}11}{389.491{,}2 + 45.542{,}85} = 0{,}0045 \quad (0{,}45\%)$$

$$\delta e = \frac{0{,}0045}{0{,}8998} = 0{,}005 \quad (0{,}5\%)$$

6. CONCLUSIONS

From the pallet of the phenomenon's that characterizes the quality of electric energy, a special attention is given to distortional and non-symmetrical regime, justified by the phenomenon's complexity, by analytical and experimental researching possibilities. The operating of EDN with DNSR, leads to the decreasing of power and economic performances, to appearance of some special consequence risks. The power and energy supplementary losses provoked by operation of EDN in DNSR are consumed in power transformers and electric lines from the structure of DNSR. The operation of the power transformers in DNSR provokes supplementary active and reactive power losses in magnetic circuits and in the windings, as the electric lines operation in DNSR provokes supplementary power losses in its conductors. The appreciating of the affected grade of the energetic performances of EDN is made by evaluating of some moments in integrated indexes:

- Supplementary power and energy losses in EDN;
- Efficiency of EDN;
- Energy efficiency of EDN;
- Absolute and relative reducing of the power efficiency in EDN.

Referring on the results of the made study there is established the followings:

- The distortion and non symmetrical degree of the voltage waves is framed in standard limits;
- The energy efficiency of analyzed EDN is significant affected by, DNSR of nonlinear and nonsymmetrical consumers.
- The supplementary power losses provoked by DNSR in analyzed EDN, engraves the yearly budget of the branch with appreciatively 68.4 thousand EURO.

To correct this state are possible three direction of action:

- Reducing the DNSR by obligation of the consumers to assembly harmonic compensators, and to symmetries the consumes;
- The delivery note to the consumers of the value of the provoked failures by DNSR that generates it;
- Common actions of type of DSM – Demand Side Management -, of the supplier in collaboration with the consumers of energy to correct the quality

indexes of electric energy.

Actuating of some actions to improve the quality of electric energy conditioned by effectuating of a certain technical - economical analyse that stabilizes if actions like this, are opportune or not.

To compensate the DR, is recommended the use some filtration systems, with active or resonant filter, dimensioning by applying of multi-objective model financed by the entities that generates DR (often the electrical energy consumer).

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