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Economic analysis of transmission line operation

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***Abstract*—as a result of deregulation and privatization in the electric power industry, the estimation of the economic efficiency of projects in the electric power system is becoming a strategic issue. A strategic issue in the electric power industry is to consider the technical and economic parameters of power transmission lines. At the same time, this article discusses the problem of the economy of power transmission lines and their technical parameters. The article illustrates the influence of the pricing of the electric energy on the unit costs of the power transmission line during its operation. The economic power of transmission line can be defined with the minimal value of unit costs. Such as the unit costs as well as the economic power of the power transmission line depend on the specific characteristics of the electric power system and also on the different economic conditions during its operation. The results of the sensitivity analysis show the effect of possible changes of some economic parameters on the economic efficiency of the power transmission line. This article describe a comprehensive approach to the power transmission lines as one the most important part of the electric power system.**

Keywords—annual costs; economy; electric energy; electric power industry; unit costs; transmission line;

I. Introduction

One of the key issues of energy technology is the issue of transmission, transmission losses and economy of transmission lines, where due to the technical parameters of the current transmission high-voltage lines, significant losses occur for longer distances [1] [2].

The economic efficiency of transport of the electric energy depends on investment costs of the transmission lines and transmission losses [3]. For investments in lines is necessary to know all the input that have the influence the economic efficiency of electric energy transmission and thereby increase the accuracy of calculation of the annual costs and likewise the specific costs [4] [5]. The design and cost optimization of transmission lines is a complex aspect as various simultaneously interacting parameters are involved. When on the transmission line is a higher voltage, then transferred current decreases, as well as Joule losses that are proportional to the square of the current [6] [7]. A higher voltage increases the cost of isolation of the transmission line. In the case of external lines, there are necessary larger distances between the wires, grounded pole and ground. This leads to the requirement for larger pole dimensions, so the cost of the building of the poles increases and there is an increase in investment costs for the transmission line. If for transmission line are used higher the cross-section of the wires, eventually there are used the bundle wires with a higher number of wires, then decrease Joule losses and also similarly the operating temperature of the wire. Increasing the cross-section of wire or increasing the number of wires in the bundle wires decreases Joule losses but increases the cost of the wire and thus increases the investment costs of the transmission line. The mass of these wires increases the weight on poles and at the same time, there is necessary to take into account the icing class. At the same time, increasing the distance between neighboring poles also has a significant impact on the increasing the weight on single pole. On the other hand, increasing the distance between neighboring poles decreases the total number of poles required for the total length of the transmission line. The resulting increased weight on poles requires more expensive poles and this phenomena leads to an increase of investment costs of the transmission line [8] [9] [10].

II. The Equations for the Calculation of Economic Efficiency of the Transmission Line

The energy A is defined by equation

$$A = P_m \, \tau \tag{1}$$

Where P_m is a power of the transmission line and τ is a time of using the maximum. The specific costs c_1 and c_2 for power losses of the transmission line can be defined with the bicomponent expression, where c_{fi} is a fixed component of the price and c_{va} is a variable component of the price of the electric energy.

$$c_1 = \frac{c_{fi}}{T_{pr}} + c_{va} \tag{2}$$

$$c_2 = \frac{c_{fi}}{\tau_\Delta} + c_{va} \tag{3}$$

Where T_{pr} is time of operation and τ_Δ is time of full losses. The conversion constants w_1 and w_2 are defined as follows

$$w_1 = 10^3 \; kW \; MW^{-1} \tag{4}$$

$$w_2 = 10^{-3} \; W \; kW^{-1} \tag{5}$$

The time factor q can be defined with the help of the discount rate i by the next equation

$$q = i + 1 \tag{6}$$

The annual quota k can be defined by the equation

$$k = a_{lt} + k' = a_{lt} + p_{ma} + p_{wa} + p_{other} \tag{7}$$

Where a_{lt} is a relative annuity for the lifetime, k' are the relative constant operating costs, p_{ma} are the relative maintenance costs, p_{wa} are the relative wage costs, p_{other} are the relative other costs for the transmission line. The proposed equation involves the relative annuity for the lifetime a_{lt} and this value represents the annual repayment of the investment, which is calculated with the help of the time factor q and the lifetime T_{lt} by the next equation

$$a_{lt} = \frac{q^{T_{lt}} \left(q - 1\right)}{q^{T_{lt}} - 1} \tag{8}$$

The annual fixed costs N_{fi} for the transmission line can be expressed by these equations

$$N_{fi} = N_i\ k + 3\,U_f^{\,2}\ G_i\ T_{pr}\ c_1\ w_1 \tag{9}$$

$$N_{fi} = N_i\ k + 3\left(\frac{U}{\sqrt{3}}\right)^2\ G_i\ T_{pr}\ c_1\ w_1 \tag{10}$$

$$N_{fi} = N_i\ k + U^2\ G_i\ T_{pr}\ c_1\ w_1 \tag{11}$$

Where N_i represents the investment costs, G_i is conductance of isolators, U_f is voltage between phase and ground and U is voltage between phases [6] [7]. The dependency of resistance $R_{v\vartheta}$ from the operating temperature ϑ_P can be defined by the equation

$$R_{v\vartheta} = R_{v0}\ (1 + \alpha_R\ \Delta\vartheta) = R_{v0}\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0)) \tag{12}$$

Where R_{v0} is resistance of wire for reference temperature ϑ_0, $\Delta\vartheta$ is difference of the temperature of wire and α_R is temperature coefficient of resistance [11] [12]. The annual variable costs N_{va} for the transmission line can be defined by equation

$$N_{va} = 3\,\tau_\Delta\ c_2\ w_2\ I_m^{\,2}\ R_{v\vartheta} \tag{13}$$

The current I_m for the transmission line can be defined by equation

$$I_m = \frac{P_m}{\sqrt{3}\ U\cos\varphi} \tag{14}$$

Where cos φ is the power factor. In the next steps, equation for annual variable costs N_{va} can be rewritten to this form

$$N_{va} = 3\,\tau_\Delta\ c_2\ w_2\left(\frac{P_m}{\sqrt{3}\ U\cos\varphi}\right)^2 R_{v\vartheta} \tag{15}$$

$$N_{va} = \tau_\Delta\ c_2\ w_2\ \frac{P_m^{\,2}}{U^2\ \cos^2\varphi}\ R_{v\vartheta} \tag{16}$$

$$N_{va} = \frac{\tau_\Delta\ c_2\ w_2\ P_m^{\,2}\ R_{v\vartheta}}{U^2\ \cos^2\varphi} \tag{17}$$

$$N_{va} = \frac{\tau_\Delta\ c_2\ w_2\ P_m^{\,2}\ R_{v0}\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0))}{U^2\ \cos^2\varphi} \tag{18}$$

The annual costs N_{ve} for the transmission line can be calculated as follows

$$N_{ve} = N_{fi} + N_{va} \tag{19}$$

$$N_{ve} = N_i\ k + U^2\ G_i\ T_{pr}\ c_1\ w_1 + \frac{\tau_\Delta\ c_2\ w_2\ P_m^{\,2}\ R_{v0}\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0))}{U^2\ \cos^2\varphi} \tag{20}$$

With the help of the equation of the annual costs N_{ve} and the equation of an energy A we can define the equation for the unit costs of transmission line n_{ve}

$$n_{ve} = \frac{N_{ve}}{A} = \frac{N_{ve}}{P_m\ \tau} = \frac{N_{fi} + N_{va}}{P_m\ \tau} \tag{21}$$

$$n_{ve} = \frac{N_i\ k + U^2\ G_i\ T_{pr}\ c_1\ w_1}{P_m\ \tau} + \frac{\tau_\Delta\ c_2\ w_2\ P_m\ R_{v0}\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0))}{\tau\ U^2\ \cos^2\varphi} \tag{22}$$

It is necessary to take into account the length l of transmission line, then for the annual cost N_{ve} and unit costs n_{ve} can be written next equations

$$N_{ve} = {}_1N_i\ l\ k + U^2\ {}_1G_i\ l\ T_{pr}\ c_1\ w_1 + \frac{\tau_\Delta\ c_2\ w_2\ P_m^{\,2}\ {}_1R_{v0}\ l\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0))}{U^2\ \cos^2\varphi} \tag{23}$$

$$n_{ve} = \frac{{}_1N_i\ l\ k + U^2\ {}_1G_i\ l\ T_{pr}\ c_1\ w_1}{P_m\ \tau} + \frac{\tau_\Delta\ c_2\ w_2\ P_m\ {}_1R_{v0}\ l\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0))}{\tau\ U^2\ \cos^2\varphi} \tag{24}$$

Where ${}_1N_i$ represents the investment costs per unit of length, ${}_1R_{v0}$ is resistance per unit of length for reference temperature ϑ_0 and ${}_1G_i$ is conductance of isolators per unit of length. At the same time, it is necessary for the next calculations to find out all the required numerical data characterizing the technical and economic parameters of the transmission line. [6] [7]. All the required numerical data of the transmission line necessary for the calculation are shown in the following tables.

TABLE I.
THE TECHNICAL PARAMETERS OF TRANSMISSION LINE AND OF ELECTRIC POWER SYSTEM

Voltage on load	U	110 kV
Length	l	100 km
Power factor	cosφ	0,8
Operating temperature	ϑ_P	64 °C
Reference temperature	ϑ_0	20 °C
Temperature coefficient of resistance	α_R	$4{,}04.10^{-3}$ °C^{-1}
Resistance per unit of length	${}_1R_{v0}$	0,0384 Ω km^{-1}
Conductance of isolators per unit of length	${}_1G_i$	5.10^{-8} S km^{-1}
Time of operation	T_{pr}	7008 h year^{-1}
Time of using the maximum	τ	5000 h year^{-1}

TABLE II.
THE ECONOMICAL PARAMETERS OF TRANSMISSION LINE

Investment costs per unit of length	N_i	15000 € km^{-1}
Fixed value of price	c_{fi}	13,774 € kW^{-1} year^{-1}
Variable value of price	c_{va}	0,1448 € kWh^{-1}
Life time	T_{lt}	40 years
Time factor	q	1,05
Annual quota of fixed costs	k′	0,1117 year^{-1}

When the minimal value of the unit costs n_{ve} on the transmission line is achieved, the transmission line is loaded with the economic power P_e. For this issue we can determine the minimum of the unit costs n_{ve} as extreme, when the first derivative of this function will be zero and the second derivative will be negative. When we mark this solution as $P_m = P_e$, we can find the economic power P_e for the minimum of the unit costs n_{ve}, with the help of the first derivative [13] [14]. The economic power P_e can be defined by the equation

$$P_e = U\cos\varphi\sqrt{\frac{N_i\ k + U^2\ G_i\ T_{pr}\ c_1\ w_1}{\tau_\Delta\ c_2\ w_2\ R_{v0}\ (1 + \alpha_R\ (\vartheta_P - \vartheta_0))}} \tag{25}$$

We can also calculate the apparent economic power S_e

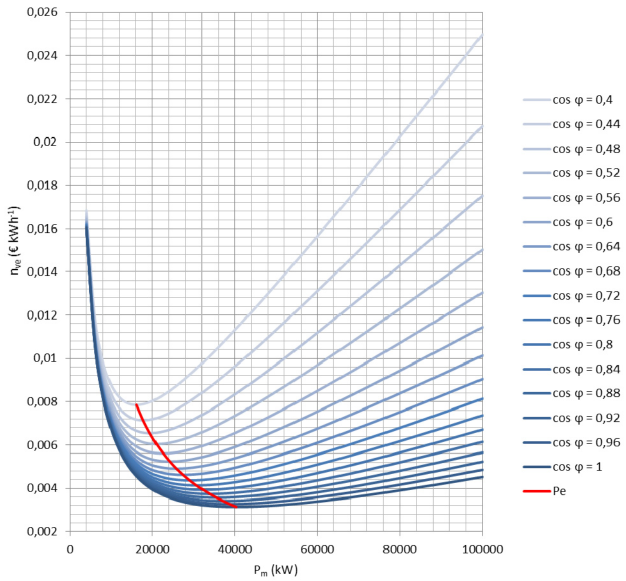
$$S_e = U \sqrt{\frac{N_i\, k + U^2\, G_i\, T_{pr}\, c_1\, w_1}{\tau_\Delta\, c_2\, w_2\, R_{v0}\, \left(1+\alpha_R\left(\vartheta_P - \vartheta_0\right)\right)}} \tag{26}$$

When we take into account the length l of transmission line, then for the economic power P_e and apparent economic power S_e can be written next equations

$$P_e = U \cos\varphi \sqrt{\frac{{}_1N_i\, k + U^2\, {}_1G_i\, T_{pr}\, c_1\, w_1}{\tau_\Delta\, c_2\, w_2\, {}_1R_{v0}\, \left(1+\alpha_R\left(\vartheta_P - \vartheta_0\right)\right)}} \tag{27}$$

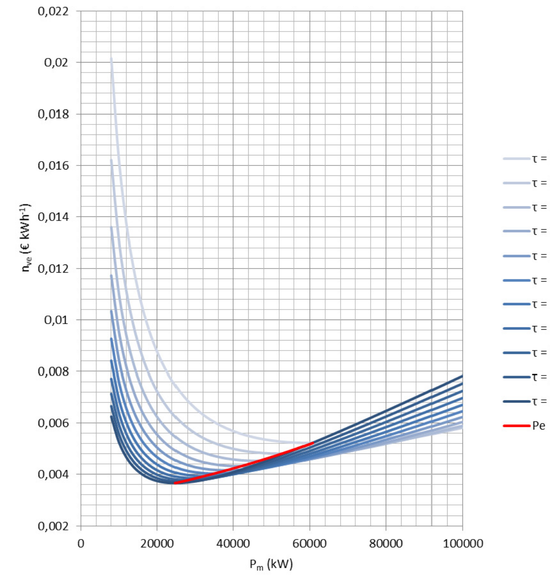
$$S_e = U \sqrt{\frac{{}_1N_i\, k + U^2\, {}_1G_i\, T_{pr}\, c_1\, w_1}{\tau_\Delta\, c_2\, w_2\, {}_1R_{v0}\, \left(1+\alpha_R\left(\vartheta_P - \vartheta_0\right)\right)}} \tag{28}$$

The Figure 1 shows calculated values of the unit costs n_{ve} in dependence of the power P_m for different values of the power factor cos φ and at the same time, the figure shows the calculated values of the economic power P_e for a comprehensive overview.



The unit costs n_{ve} in dependence of the power P_m

The increasing power factor cos φ decreases the unit costs n_{ve} and at the same time, increases the value of the maximum economic power P_e. The Figure 2 shows calculated values of the unit costs n_{ve} in dependence of the power P_m for different values of the time of using the maximum τ. If different values of the time of using the maximum τ are taken into account for transmission line in the electric power system, it is necessary to calculate with the different values of the time of full losses τ_Δ. Also the Figure 2 shows the calculated values of the economic power P_e.



The unit costs n_{ve} in dependence of the power P_m

The increase of the time of using the maximum τ causes the decrease of the unit costs n_{ve} and at the same time the decrease of the economic power P_e. The power P_m generally increases over the life of the transmission line. If the value of the power P_m is more than economic power P_e, it is necessary to consider the construction of the new transmission line in the same voltage level. Another option is to build a new transmission line at a higher voltage level, which also requires the construction of other parts of the electric power system (power plants and transformer stations) [6] [7].

III. Influence of Pricing Electric Energy to Economy of the Transmission Line

The bicomponent expression for the price of the electric energy is often used, so specific costs c_1 and c_2 are calculated according to the equation (2) and (3). As an example different values of the fixed component of the price c_{fi} and the variable component of the price c_{va} of the electric energy were chosen, which represent the impact of the price of the electric energy on the economy of the transmission line. The extent of the parameters' deviations was ± 25 % from basic value with the 5 % step. Calculated values of the specific costs c_1, c_2 and economic power P_e are in Table 3.

TABLE III.
CALCULATED VALUES OF THE SPECIFIC COSTS C_1 AND C_2 AND ECONOMIC POWER P_E

	c_{va} = 0,1448 € kWh^{-1}				c_{fi} = 13,774 € kW^{-1} year^{-1}			
d (%)	c_{fi} (€ kW^{-1} year^{-1})	c_1 (€ kWh^{-1})	c_2 (€ kWh^{-1})	P_e (kW)	c_{va} (€ kWh^{-1})	c_1 (€ kWh^{-1})	c_2 (€ kWh^{-1})	P_e (kW)
-25	10,3305	0,1462741	0,14775157	32398,9146	0,1086	0,11056547	0,11253543	36226,4458
-20	11,0192	0,14637237	0,14794834	32379,4898	0,11584	0,11780547	0,11977543	35292,5797
-15	11,7079	0,14647065	0,14814511	32360,1049	0,12308	0,12504547	0,12701543	34444,0283
-10	12,3966	0,14656892	0,14834189	32340,76	0,13032	0,13228547	0,13425543	33668,9511
-5	13,0853	0,14666719	0,14853866	32321,4547	0,13756	0,13952547	0,14149543	32957,6702
0	13,774	0,14676547	0,14873543	32302,189	0,1448	0,14676547	0,14873543	32302,189
5	14,4627	0,14686374	0,1489322	32282,9628	0,15204	0,15400547	0,15597543	31695,8354
10	15,1514	0,14696201	0,14912897	32263,7759	0,15928	0,16124547	0,16321543	31132,9929
15	15,8401	0,14706029	0,14932574	32244,6283	0,16652	0,16848547	0,17045543	30608,8965
20	16,5288	0,14715856	0,14952251	32225,5196	0,17376	0,17572547	0,17769543	30119,4734
25	17,2175	0,14725684	0,14971929	32206,4499	0,181	0,18296547	0,18493543	29661,2198

From the results in Table 3, it can be seen that the fixed component of a price c_{fi} influences the values c_1, c_2 and P_e

only to a small extent and the variable component of a price c_{va} has a significantly greater influence on the values of c_1, c_2 and P_e.
The calculated values of the unit costs n_{ve} in dependence of the power P_m for different values of the fixed component of a price c_{fi} are shown in the Table 4.

TABLE IV.
CALCULATED VALUES OF UNIT COSTS N_{VE} FOR DIFFERENT VALUES OF FIXED COMPONENT OF PRICE C_{FI} IN DEPENDENCE ON POWER P_M

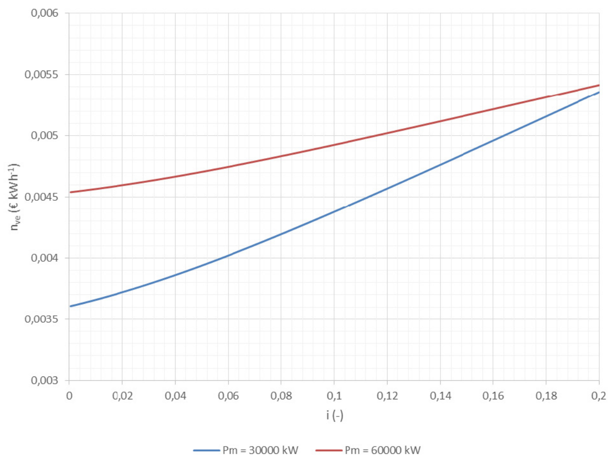
P_m (kW)		10000	20000	30000	40000	50000	60000
c_{fi} (€ kW^{-1} year^{-1})	d (%)	n_{ve} (€ kWh^{-1})					
10,3305	-25	0,0069444	0,0043782	0,0039255	0,0040012	0,0042882	0,0046809
11,0192	-20	0,006946	0,0043802	0,0039282	0,0040046	0,0042924	0,0046858
11,7079	-15	0,0069477	0,0043823	0,0039309	0,004008	0,0042966	0,0046908
12,3966	-10	0,0069493	0,0043843	0,0039336	0,0040115	0,0043007	0,0046958
13,0853	-5	0,0069509	0,0043863	0,0039363	0,0040149	0,0043049	0,0047007
13,774	0	0,0069526	0,0043884	0,003939	0,0040183	0,0043091	0,0047057
14,4627	5	0,0069542	0,0043904	0,0039417	0,0040217	0,0043133	0,0047107
15,1514	10	0,0069558	0,0043924	0,0039444	0,0040252	0,0043175	0,0047156
15,8401	15	0,0069575	0,0043944	0,003947	0,0040286	0,0043217	0,0047206
16,5288	20	0,0069591	0,0043965	0,0039497	0,004032	0,0043259	0,0047255
17,2175	25	0,0069608	0,0043985	0,0039524	0,0040354	0,0043301	0,0047305

The change of the fixed component of price c_{fi} in the range ± 25% causes a deviation of the unit costs n_{ve} of ± 0,1178 % for the power P_m = 10 MW and a deviation of the unit costs n_{ve} of ± 0,5276 % for P_m = 60 MW.
The calculated values of the unit costs n_{ve} in dependence on the power P_m for different values of the variable component of a price c_{va} are shown in the Table 5.

TABLE V.
CALCULATED VALUES OF UNIT COSTS N_{VE} FOR DIFFERENT VALUES OF VARIABLE COMPONENT OF PRICE C_{VA} IN DEPENDENCE ON POWER P_M

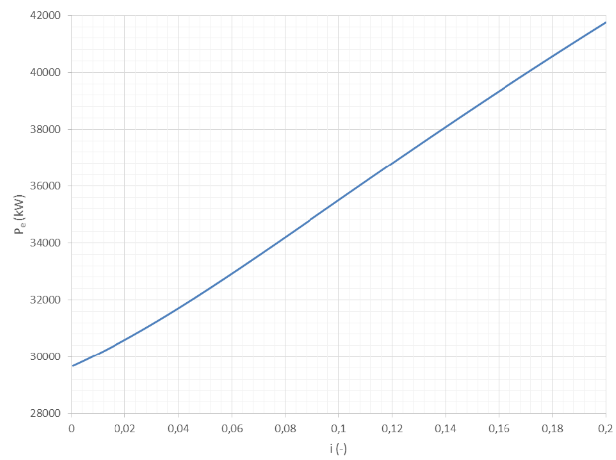
P_m (kW)		10000	20000	30000	40000	50000	60000
c_{va} (€ kWh^{-1})	d (%)	n_{ve} (€ kWh^{-1})					
0,1086	-25	0,0064976	0,0039389	0,0033927	0,0033496	0,0035078	0,0037666
0,11584	-20	0,0065886	0,0040288	0,0035019	0,0034834	0,0036681	0,0039544
0,12308	-15	0,0066796	0,0041187	0,0036112	0,0036171	0,0038283	0,0041422
0,13032	-10	0,0067706	0,0042086	0,0037205	0,0037508	0,0039886	0,00433
0,13756	-5	0,0068616	0,0042985	0,0038297	0,0038846	0,0041489	0,0045179
0,1448	0	0,0069526	0,0043884	0,003939	0,0040183	0,0043091	0,0047057
0,15204	5	0,0070436	0,0044782	0,0040482	0,004152	0,0044694	0,0048935
0,15928	10	0,0071345	0,0045681	0,0041575	0,0042858	0,0046297	0,0050813
0,16652	15	0,0072255	0,004658	0,0042667	0,0044195	0,0047899	0,0052691
0,17376	20	0,0073165	0,0047479	0,004376	0,0045533	0,0049502	0,005457
0,181	25	0,0074075	0,0048378	0,0044853	0,004687	0,0051105	0,0056448

The change of the variable component of price c_{va} in the range ± 25% causes a deviation of the unit costs n_{ve} of ± 6,5437 % for the power P_m = 10 MW and a deviation of the unit costs n_{ve} of ± 19,9566 % for P_m = 60 MW.
This bicomponent expression is often used in the pricing of the electric energy and the variable component of the price of the electric energy can change during each day.
The Figure 3 shows calculated values of the unit costs n_{ve} in dependence of the discount rate i. For a comprehensive overview these values of the unit costs n_{ve} were calculated for two different powers P_m that are 30 MW and 60 MW. The increase of the discount rate i causes the increase of the unit costs n_{ve}.



The unit costs n_{ve} in dependence of the discount rate i

Currently, the Figure 4 shows calculated values of the economic power P_e in dependence of the discount rate i. At the same time, the increase of the discount rate i causes the increase of the economic power P_e.



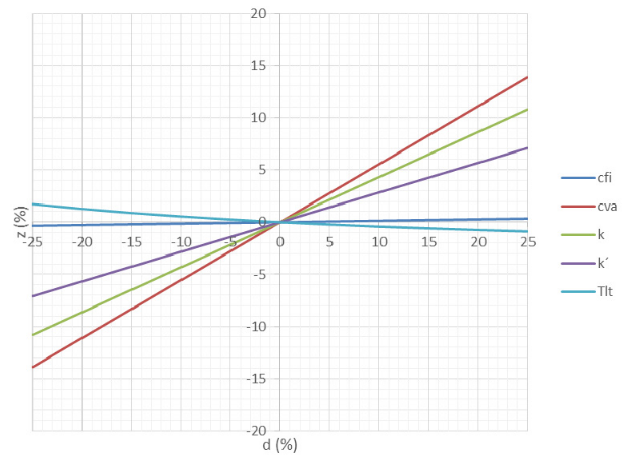
The economic power P_e in dependence of the discount rate i

IV. RESULTS OF THE SENSITIVITY ANALYSIS AND DISCUSSION

Using the sensitivity analysis, it is possible to determine how the individual input values act in order to change the resulting reference value, according to which the decision about the selection or operation of the transmission line in the electric power system is made. Factors that influence the resulting value can be sorted into significant, where the sensitivity of projects to these factors is significant and insignificant factors with the little importance. It is through the sensitivity analysis that it is possible to find which factors are significant and insignificant factors in relation to the decision making process. In this article, an assessment of the economic benefits resulting from the operation of transmission line in the electric power system is realized through the sensitivity analysis, where the influence of individual economic parameters is shown. A mathematical model can be very complicated and the result is the universal knowledge of the relationships between the input changes of considered parameters d and the observed output deviations z. For a comprehensive overview of the influences of these parameters, a sensitivity analysis of the unit costs n_{ve} was solved for different powers P_m.

The unit costs (formula 22 and formula 24) and the economic power of transmission line (formula 25 and formula 27) were selected as reference values for the purpose of this sensitivity analysis. The analysis observed the effect of these factors: the fixed component of the price of the electric energy c_{fi}, the variable component of the price of the electric energy c_{va}, the annual quota k (formula 7), the relative constant operating costs k' and the lifetime of the transmission line T_{lt}. A change of these factors was considered within ± 25% from basic value with the 5 % step.

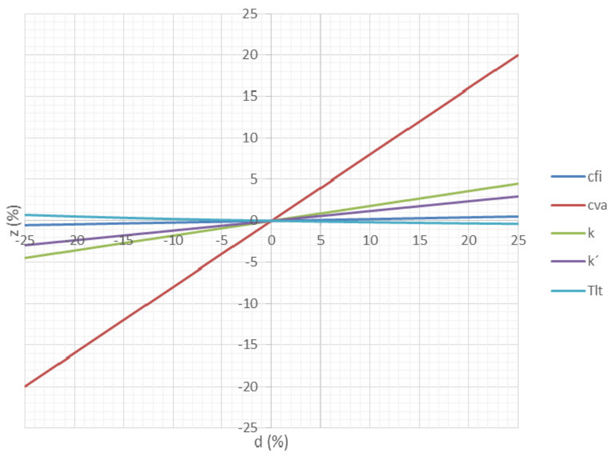
Figures 5 and 6 show the effect of selected factors on unit costs n_{ve} for two different load values of the transmission line P_m = 30 MW and 60 MW. In the Figure 5, basic value of the unit costs from which the output deviations z were observed was n_{ve} = 0,003939 €/kWh.



Sensitivity analysis of unit costs n_{ve} for the power P_m = 30 MW

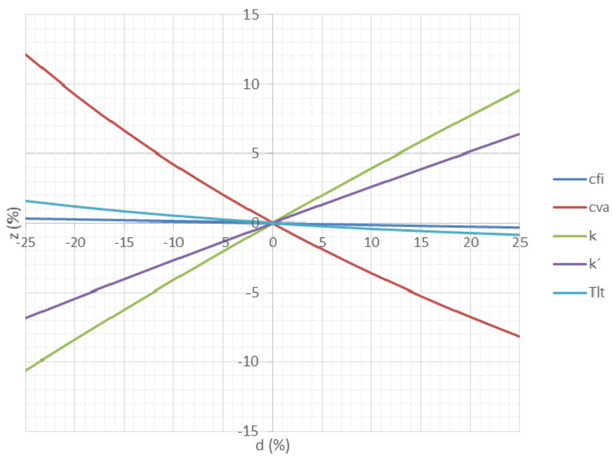
From the Figure 5 it is obvious, that the unit costs increase linearly with the increase of variable component of the price of the electric energy c_{va}, annual quota k and relative constant operating costs k´. The most significant effect has the variable component of price of the electric energy c_{va}, the impact of the fixed component of the price of the electric energy c_{fi} is unimportant. Unlike other considered parameters an increase of the transmission line lifetime T_{lt} means decrease of the unit costs n_{ve}. A simple numerical evaluation of the sensitivity analysis of the transmission line is in the Table 6.

By comparing Figures 5 and 6, it is evident that, as the transmission line power P_m increases, the unit costs n_{ve} are even more influenced than in the previous case, with the variable component of the price of the electric energy c_{va}, on the other hand, the effect of annual quota k and relative constant operating costs k´ is substantially smaller. In the Figure 6 basic value of the unit costs from which the output deviations *z* were observed was n_{ve} = 0,004706 €/kWh.



Sensitivity analysis of unit costs n_{ve} for the power P_m = 60 MW

In the Figure 7 the effect of the observed factors on the economic power of the transmission line P_e is shown. Basic value of the economic power for the sensitivity analysis is P_e = 32302 kW, from which the output deviations z were observed.



Sensitivity analysis of economic power Pe for economic parameters

This almost linear increases with the increase of annual quota k and relative constant operating costs k´. Conversely, the economic power P_e decreases with the increase of the remaining factors, fixed component of the price of the electric energy c_{fi}, variable component of the price of the electric energy c_{va} and the lifetime T_{lt}. The most significant effect in this case also has the variable component of the price of the electric energy c_{va}. A simple numerical evaluation of the sensitivity analysis is in the Table 6.

TABLE VI.
CALCULATED VALUES OF OUTPUT DEVIATION Z

Selected value	*d* (%)	c_{fi}	c_{va}	k	k'	T_{lt}
		z (%)				
n_{ve} for P_m = 30000 kW	-25	-0,3416	-13,8688	-10,7896	-7,0908	1,7196
	25	0,3416	13,8688	10,7896	7,0908	-0,8889
n_{ve} for P_m = 60000 kW	-25	-0,5276	-19,9566	-4,5158	-2,9677	0,7197
	25	0,5276	19,9566	4,5158	2,9677	-0,3720
P_e	-25	0,2994	12,1486	-10,6110	-6,8372	1,5887
	25	-0,2964	-8,1758	9,5884	6,3987	-0,8313

The proposed analysis can be easily expanded so that it takes into account different scenarios of the pricing of the electricity losses in transmission lines and various powers P_m. The analysis can be applied in a wide spectrum of transmission lines of the different voltage levels [15] [16]. This article shows the significant impact of technical and economic parameters of the transmission line on its economic efficiency as a strategic issue for the electric power industry [17].

V. Conclusion

This article also discusses the problem economic efficiency of the transmission line and its economic and technical parameters. The design and economic efficiency of transmission lines is a complex aspect and there are involved various simultaneously interacting parameters with the influence on entire electric power system. The creation of complex distribution systems, enabling transmission of electric energy trough long distances but also within the overall social structures of individual territories is effective on the one hand, because we do not need to build local energy resources, but on the other hand it contains two major problems. First, it is energy transmission losses and for the transmission of electric energy with considering to technical parameters of the actual transmission lines, more than 1 percent of the energy is lost in the high voltage transmission lines for longer distances. Second, there are a significant increase in the risk of running power systems in the face of terrorist, cyber, or hacker attacks. At the same time, transmission systems are vulnerable to extreme atmospheric phenomena. The extreme atmospheric phenomena can destabilize in the case disturbance of the electric power system and cause power failure for huge areas. Here is a presumption use of new calculations for the economy of the transmission lines. The corona and partial discharges cause additional active losses of power and therefore it is important to reduce them and at the same it is important to reduce Joule losses and similarly the operating temperature. In the further research can be considered the influence of the capacity and inductance of the transmission line. This calculations can evaluate the economic efficiency for different models of the transmission line (Γ model, T model, Π model and model described by Telegraph equations).

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