International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:6, No:1, 2012

Detecting the Capacity Reserve in an Overhead Line

S. Berjozkina, A. Sauhats, V. Bargels, E. Vanzovichs

***Abstract*—**There are various solutions for improving existing overhead line systems with the general purpose of increasing their limited capacity. The capacity reserve of the existing overhead lines is an important problem that must be considered from different aspects. The paper contains a comparative analysis of the mechanical and thermal limitations of an existing overhead line based on certain calculation conditions characterizing the examined variants. The methodology of the proposed estimation of the permissible conductor temperature and maximum load current is described in detail. The transmission line model consists of specific information of an existing overhead line of the Latvian power network. The main purpose of the simulation tasks is to find an additional capacity reserve by using accurate mathematical models. The results of the obtained data are presented.

***Keywords*—**capacity of an overhead line, mechanical conditions, permissible conductor temperature, thermal conditions.

I. Introduction

A high percentage of all the transmission lines that are in service today have been built with traditional type conductors, like aluminum conductor steel reinforced (ACSR) conductors. This conductor type was designed for a service life of 40 years with the required durability and minimum maintenance, yet most of these products are still in service today and may be as old as 40…60 years [1].

Due to the great impact of renewable energy sources, which are expected to dominate Europe's energy supply in a sustainable future energy system, as well as the large number of new power plants – like wind power plants – an increase in electricity network expansion will be required both from a national and an international perspective [2]. Due to these reasons, one of the possible options for improving the power system would ideally be the installation of new overhead lines. However, erecting a new transmission line is more complicated than it seems at first sight. There are different aspects to be considered, for example, the high population density, the intensive use of land, and the environmental protection laws that have undergone frequent changes over the recent time period, the small amount of space available and, of course, economic issues. Therefore, the limited capacity increase using the existing infrastructure to maximum possible extent has led to the accommodation of new technologies into the existing overhead power line systems.

There are different suggestions for increasing the capacity of the existing lines, usually involving methods such as re-tensioning and re-conductoring [3]. Several solutions can be mentioned, for example, replacement of the traditional power conductor (ACSR) by the High-Temperature Low Sag (HTLS) conductor [4], [5], [6]; replacement of the existing conductors by ones with a larger cross-section; modification of the design of the existing towers or increasing their height [7]; rebuilding of the overhead line for a higher voltage; using the installation of series and shunt compensations [8]; increasing the permissible load current.

Sources [9], [10] review in detail the methodology for calculating line ampacity, which is based on the steady state heat balance concept implying that heat gain is equal to heat loss. Both methods take into account weather conditions like wind speed, wind direction and turbulence, ambient temperature and solar radiation. Besides, there are differences between the presented calculation methods [11]. In this case, the maximum conductor temperature is assumed to be known. Based on this, the permissible load current is calculated. In addition, this study takes into consideration the dependence of the permissible conductor temperature on the thermal and mechanical characteristics of the overhead line, taking account of the weather conditions.

The paper deals with the impact of the thermal and mechanical limitations in the load current of an existing overhead line with the purpose of finding the hidden capacity in the examined power line. That is, the impact of conductor temperature on the permissible load current of the conductor will be considered, taking into account the clearance to the ground. The presented calculation method helps to assess the possible additional clearance of a particular power line in order to determine the hidden capacity reserve; at the same time, it improves the accuracy of maximum load current determination. All the conductor thermal rating simulations were based on an existing Latvian power line with its defined information.

II. The Selected Transmission Line Model

A. The Existing Overhead Line Route

For simulation purposes, an existing overhead line route in the eastern part of the Latvian network was chosen. The examined 330 kV overhead line, named "Pleskava–Rezekne" or LN-309 (see Fig. 1), is taken as the basis for the

S. Beryozkina is with the Faculty of Power and Electrical Engineering, Riga Technical University, Riga, LV-1010 Latvia (e-mail: svetlana.berjozkina@rtu.lv).

A. Sauhats is with the Faculty of Power and Electrical Engineering, Riga Technical University, Riga, LV-1010 Latvia. He is now the Director of the Power Engineering Institute of Riga Technical University (e-mail: sauhatas@eef.rtu.lv).

E. Vanzovichs is with the Faculty of Power and Electrical Engineering, Riga Technical University, Riga, LV-1010 Latvia (e-mail: vanzovic@eef.rtu.lv).

V. Bargels is with joint stock Company Siltumelektroprojekts, Riga, LV-1001 Latvia (e-mail: bargel@sep.lv).

International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:6, No:1, 2012

implementation of the presented calculation method. The line was built in 1985 with the main aim of increasing the throughput capacity of an 330 kV intersystem transit between Latvia and Estonia (international perspective) as well as increasing the reliability of power supply and improving power supply in the south-eastern part of the country (national perspective).

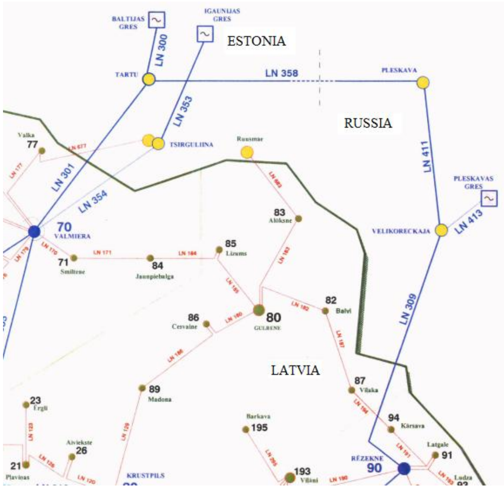


Fig. 1 Part of the electrical diagram of the Latvian power network indicating the location of the existing line “Pleskava-Rezekne”

B. The Initial Data of the Existing Supports

The examined part of the existing overhead line LN-309 was selected for examination due to a problem, namely, undesirable sag between support No. 419 and tension support No. 420 that results in the permissible clearance to the ground being exceeded. Support No. 419 is an intermediate support of the type PB 330-3 (see Fig. 2) and support No. 420 is a unified tension support of the type U 330-3 (see Fig. 3). These supports are used with two conductors per phase. The initial conditions for the evaluation of the existing supports are presented in Table I.

TABLE I
THE INITIAL CONDITIONS FOR THE CALCULATION OF THE EXISTING SUPPORTS

Symbol	Quantity	Unit	PB 330-3	U 330-3
C	wind region I – ice thickness	mm	10	10
Q	wind region III – wind pressure	kg/mm^2	50	40
h	height of string hanging at the lower cross-arm	m	22.9	19.3
λ	length of hanging string	m	3.2	0
h_s	support height	m	27	19.3
L_{cr}	middle cross-arm projection	m	8,3	
M	mass of support with zinc	kg	6392	6134
σ_{max}	permissible conductor stress conductor at maximum load	kg/mm^2	11.3	13.2
σ_{-}	permissible conductor stress at minimum load	kg/mm^2	10.0	10.8
σ_{op}	permissible conductor stress at average operating conditions	kg/mm^2	8.1	8.4
Ccl	standard clearance to the ground	m	7.5	7.5

Fig. 2 The support PB 330-3

Fig. 3 The support U 330-3

C. The Initial Data of the Existing Conductor

Aluminum Conductor Steel Reinforced (ACSR) is the most popular type of conductor that is widely used in the field of overhead transmission lines because of its high strength, reliability and relatively low amount of investment required.

ACSR is composed of aluminum wire (the electric part) and steel wire (reinforcement). Its structure consists of one or more layers of hard-drawn EC grade aluminum wires over a high tensile strength steel core. The steel core may be a galvanized, aluminum-coated single steel wire or a stranded multi-wire core, depending on the size. Because of the numerous aluminum and steel wire stranding patterns that may be used, it is possible to vary the aluminum and steel portions so as to obtain the most suitable relation between current-carrying capacity and mechanical strength for each application. There are anti-corrosion type ACSR conductors, which can be used in high-corrosion areas like coastal areas or industrial zones. This ACSR is filled with anti-corrosive grease applied on the gaps between the stranded wires and on their external surfaces [12], [13]. A cross-section of the ACSR conductor is shown in Fig. 4.

Here, the interest is in the thermal rating of a particular line; the margin conditions of conductor capacity including maximum permissible conductor temperature have been defined according to the existing standards. As a result, 70°C has been assumed as a standard limit of permissible ACSR conductor temperature in view of its thermal and mechanical limitations [14]. Yet in some other countries, the maximum permissible conductor temperature for the same type of conductor is set at a higher value; for example, in USA and Japan it is 90°C, in France – 85°C, in Indonesia – 75°C [15].

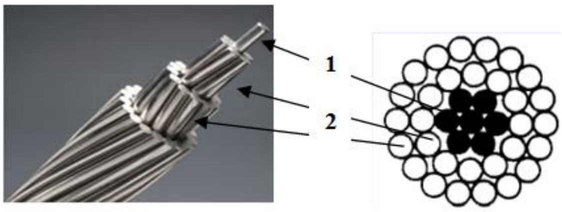


Fig. 4 The cross-section of an ACSR conductor:
1 – steel core; 2 – round aluminum conductor wire

The technical parameters for the calculation of an existing conductor (ACSR) are shown in Table II.

TABLE II
THE INITIAL CONDITIONS OF THE CALCULATION OF THE EXISTING CONDUCTOR

Symbol	Quantity	Unit	AC-240/32
d	conductor diameter	mm	21.6
S	conductor cross-section	mm^2	275.7
E	conductor modulus of elasticity	kg/mm^2	7700
α	coefficient of linear expansion	1/°C	$19.8\cdot10^{-6}$
p_1	conductor linear load	kg/m	0.921
γ_1	conductor specific load	kg/m· mm^2	$3.34\cdot10^{3}$
p_4	linear load of maximum wind	kg/m	0.808
p_3	linear load of conductor weight and ice weight	kg/m	1.82
σ_d	destructive stress	kg/mm^2	28
N	number of conductors per phase	pcs	2

Based on the presented existing line model that was described in detail, several simulation tasks were performed in order to identify the point of view of the proposed methodology by using mathematic formulation.

III. The Mathematical Formulation of the Methodology

As is known, the thermal limitation of the maximum load current of a transmission line is restricted by two general conditions:

1) The "clearing distance" between the conductor and the ground or between the conductor and the crossed objects has to be maintained;

2) The permissible conductor temperature must not be exceeded in view of its mechanical and thermal characteristics.

The strongly advisable boundaries of mechanical and thermal limitations are reduced to define the maximum conductor temperature.

As far as the permissible conductor temperature is considered, some aspects have to be noted: firstly, the thermal limitation takes into account the physical characteristics of the conductor with the determination of the actual conductor temperature under specific climate conditions; secondly, the mechanical limitation takes into account conductor sag and the "clearing distance" between the conductor and the ground. In this case, the clearance between the conductor and the crossed objects was not determined.

Based on the well-known concept of the heat balance equation, implying a balance between absorbed and dissipated heat, the following expressions (1) – (5) were adapted for evaluating the permissible conductor temperature under specified overhead line conditions [16].

In this study, we need to find the temperature of the conductor that is permissible according to the condition of retaining the distance (H_{norm} – $H_{allow\ g}$) between wire and ground at the lowest point of mid-span; the temperature is as follows:

$$t_{allow} = t_c + \frac{\Delta H}{\alpha}\left[\frac{\gamma_1 l^4}{8Ef\left[f(l^2-4a^2)+l^2\Delta H\right]} + \frac{8}{3}\cdot\frac{2(l^2-4a^2)f+l^2\Delta H}{(l^2-4a^2)^2}\cos\psi\right], \tag{1}$$

where $$\Delta H = H-(H_{norm} - \Delta H_{allow\ g}). \tag{2}$$

Here, we are dealing with a sloping span; it means that the conductor hanging points are not at an equal height, besides, the line span is limited with tension and intermediate supports. The above formulas contain variable conventional designations that are presented in Table III.

TABLE III
THE PARAMETERS OF CONDUCTOR TEMPERATURE ESTIMATION

Symbol	Quantity	Unit
t_c	conductor temperature	°C
l	length of span	m
E	conductor modulus of elasticity	kg/mm^2
α	coefficient of linear expansion	1/°C
γ_1	conductor specific load	kg/m· mm^2
a	distance between mid-span and the lowest point of sag of conductor	m
f	measured mid-span sag	m
Ψ	an inclination angle of straight, which connects hanging points of conductor	°
ΔH	the difference between the measured and predetermined dimensions, distance, respecting the permissible reduction of $\Delta H_{allow\ g}$	m
H	the vertical distance between the wire and the ground in the middle of span, which is measured at the temperature tc	m
H_{norm}	the permissible distance between the conductor and the ground	m
$H_{allow\ g}$	the permissible reduction in the distance between the wires and the ground	m

In addition, the permissible reduction in the distance between the conductor and the ground, – $\Delta H_{allow\ g}$, is taken as follows:

- for a 110–150 kV overhead line, – $\Delta H_{allow\ g} = 0.5$ m;
- for a 220–330 kV overhead line, – $\Delta H_{allow\ g} = 1.0$ m.

Of course, there are other expressions, which show how to define the temperature of the conductor that is permissible according to the condition of retaining the distance ($H_{norm} - H_{allow\ g}$) between conductor and ground at mid-span depending on the type of the supports limiting the span under consideration; a different approach describes how to determine the temperature of the conductor that is permissible according to the condition of retaining the distance ($H_{norm} - H_{allow\ o}$) between conductor and crossed objects at any point of span, also depending on the type of the supports; in all these cases there is an equivalent span – the hanging points of conductor are at an equal height and have been described in [17], [5].

When the permissible conductor temperature has been determined, the next step is the determination of the maximum conductor temperature.

A simplified determination of the permissible load current takes into consideration certain meteorological conditions, like ambient temperature, wind speed, wind direction, solar radiation; then, the thermal limitation, which in this case is represented by the maximum conductor temperature; finally, the mechanical limitations, like the clearance between the conductor and the ground, the conductor sag, and is defined by the following formula:

$$I = \sqrt{\frac{(\lambda_s + \lambda_c) \cdot \Delta t}{R_t}}, \quad (3)$$

where λs is the coefficient of heat exchange by way of radiation, λc is the coefficient of heat exchange by way of convection, Δt is the temperature rise, Rt is the resistance of the conductor at temperature t and I is the current rating of the temperature rise (Δt).

As can be seen, expression (3) does not provide for the impact of solar radiation; thus, it can be concluded that the effect of solar radiation should be considered in the calculation of permissible load current if there are extreme weather conditions like sunny, cloudless, an air temperature of above +35°C, no wind, a line with old type wires (a solar absorption coefficient higher than 0.6), then the load current can be found in the following way:

$$I = \sqrt{\frac{(\lambda_s + \lambda_c) \cdot \Delta t - Qr}{R_t}}, \quad (4)$$

where Qr is the solar radiation absorption power of the conductor (W/m):

$$Q_r = 100 \cdot \xi \cdot d \cdot q_S, \quad (5)$$

where q_s – total solar radiation intensity, W/cm²;

d – conductor diameter, cm;

ξ – solar absorption coefficient.

This study takes into account only formula (3) because of the specific climate conditions in Latvia; of course, sometimes the ambient temperature increases up to +38°C in summer; this has to be considered as well.

The maximum conductor temperature and load current simulation tasks were adopted according to the mathematical principles of the proposed methodology, which were described previously.

IV. Allowable Conductor Temperature Simulation Results

There is an existing overhead line LN-309, which will be examined, with all its technical and electrical data taken as the initial information for calculation.

The conductor temperature can be found in two different ways: first, it can be measured by using special thermovision equipment as in [17] or temperature sensors that are basically used in dynamic rating monitoring systems [18]; the second and most commonly used method is mathematic calculation. In this paper, the conductor was evaluated at four different conditions based on the heat balance equation concept:

A. The conductor temperature is in the position “balance”, which means that the amount of absorbed heat in the conductor is equal to the amount of dissipated heat in the conductor;

B. The conductor temperature is in the position “overheating by three degrees” as compared to the ambient temperature;

C. The conductor temperature is in the position “overheating by six degrees” as compared to the ambient temperature;

D. The conductor temperature is in the position “overheating by nine degrees” as compared to the ambient temperature.

Therefore, the simulation is based on four conditions (A, B, C, D); the conductor temperature (t_c) for calculating the permissible conductor temperature is assumed as follows:

A. 17.1 °C at a measured ambient temperature of 17°C;
B. 20.0 °C at a measured ambient temperature of 17°C;
C. 23.0 °C at a measured ambient temperature of 17°C;
D. 26.1 °C at a measured ambient temperature of 17°C.

The conductor has forced convective cooling: the wind speed is 2 m/s and it is directed perpendicular to the conductor axis.

Since the aim of the study is to find the capacity reserve of a particular overhead line (the span between supports No. 419 and No. 420), two variants will be discussed. The first variant presents the actual situation before the reconstruction of the existing tension support, and the second variant considers the situation after upgrading.

The first variant entails a problem; there is a mechanical limitation, namely, the small clearance between the conductor and the ground – only 8.0 m –, which is very close to the permissible standard clearance. That is why, for solving the problem under consideration, it was decided to increase the height of the tension support.

The second variant shows the result after the reconstruction: the applied performance increases the clearance between the conductor and the ground, which now becomes 9.3 m at the lowest point of the span.

The simulation of the permissible conductor temperature based on two variants at the conditions A, B, C and D is presented in graphic form (see Fig. 5).

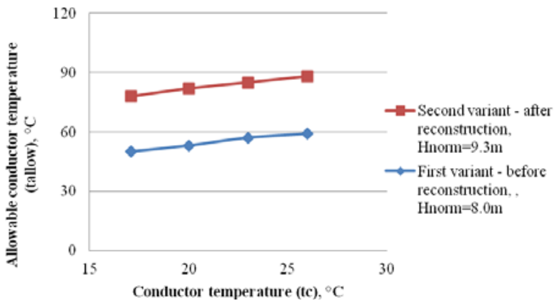


Fig. 5 Dependence of the allowable conductor temperature on the thermal limitation (conductor temperature) and the mechanical limitation (ground clearance)

The diagram shows that for both variants, the permissible conductor temperature has a rise tendency as the conductor temperature increases. Moreover, the first variant, which is the worst, is characterized by smaller permissible conductor temperature values than the second variant, which is to be considered favorable, because of larger clearance to the ground. As a result, the impact of the mechanical limitation is less in the second case. Besides, the permissible conductor temperature ranges from 50°C to 88°C, which means that 70°C (the temperature that is laid down in the standard) is not the thermal limit for the examined conductor.

V. Conductor Maximum Load Current Simulation Results

Once the permissible conductor temperature has been determined, the next step is to define the capacity reserve, which includes the difference between the two examined variants; in this case, it is the mechanical limitation, namely, the clearance to the ground.

The results of the first variant are presented in Fig. 6, which shows the dependence of the maximum load current on the thermal limitation (conductor temperature, permissible conductor temperature), the mechanical limitation and the climate conditions (wind speed, wind direction, ambient temperature, solar radiation (the solar radiation absorption coefficient is taken as 0.6)).

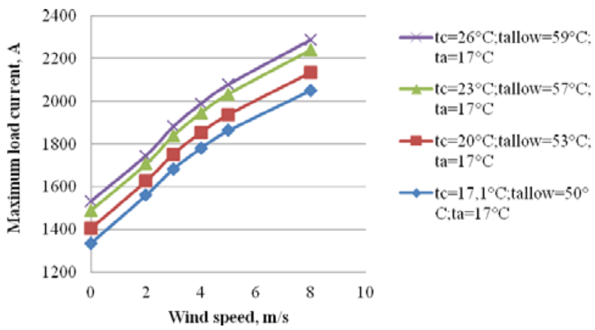


Fig. 6 Maximum load current for the first variant of the examined conditions

The results of the second variant are presented in Fig. 7, which, similarly to the first variant, shows the dependence of the maximum load current on the above-mentioned, both the thermal and mechanical limitations and the climate conditions, but with a higher clearance between wire and ground, namely, 1.3 m. This clearance reserve allows increasing the maximum load current of the overhead line, taking into account the thermal limitation and certain meteorological conditions. Indeed, the capacity reserve of the power line has increased, as has the clearance to the ground (see Fig. 8).

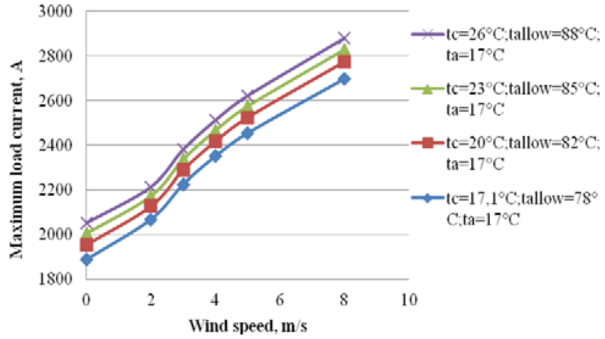
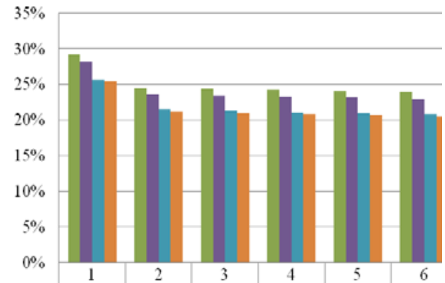


Fig. 7 Maximum load current for the second variant of examined conditions

The difference of the maximum load current between the variants before and after the reconstruction of the examined overhead line is expressed in percentage in Fig. 8.

The ambient temperature in all the cases is 17°C; the wind speed is 0, 2, 3, 4, 5, 8 m/s for columns 1 to 6 respectively.



	1	2	3	4	5	6
ΔImax for "A" term, %	29%	25%	24%	24%	24%	24%
ΔImax for "B" term, %	28%	24%	23%	23%	23%	23%
ΔImax for "C" term, %	26%	21%	21%	21%	21%	21%
ΔImax for "D" term, %	25%	21%	21%	21%	21%	21%

Fig. 8 The difference of maximum load current in percentage form

On analyzing the presented difference of the maximum conductor temperature, it can be concluded that the second variant shows a capacity reserve of the specific transmission line based on four examined conditions and in consideration of several climate factors, which makes it possible to utilize by about 30% more capacity, without deterioration of the electrical parameters of the observed power line.

VI. Conclusions

The implementation of the proposed approach of permissible conductor temperature and maximum load current determination improves one of the possible solutions for detecting the capacity reserve in an existing transmission line, taking into account thermal and mechanical limitations as well as environmental conditions. As a result, the gap or additional reserve was determined in the increase of the clearance between wire and ground, which allows finding additional throughput capacity for existing transmission lines or transmission lines under design. Therefore, the maximum load current of an overhead line is significantly increased by accurate determination of the permissible conductor temperature.

The proposed method provides new opportunities for the integration of the smart grid. Simulations confirm the efficiency of the above-described mathematical formulation of the problem implying the reduction of the total investments in the upgrading of transmission lines, which presents itself as an economically justified opportunity.

Acknowledgment

This work has been supported by the European Social Fund within the project «Support for the implementation of doctoral studies at Riga Technical University».

References

[1] Dale A. Douglass, *Practical application of High-Temperature Low-Sag (HTLS) Transmission Conductors.* New Haven, Connecticut: 2004, p. 53.

[2] Ozge Ozdemir, Karina C. Veum, Jeroen de Joode, Gianluigi Migliavacca, Andrea Grassi, Alessandro Zani, “The impact of Large-scale Renewable Integration on Europe’s Energy corridors”, in *Proc. of IEEE PowerTech Confrence,* Trondheim, 2011, pp. 1-8.

[3] K. Kopsidas, S. M. Rowland, M. N. R. Baharom, and I. Cotton, “Power transfer capacity improvements of existing overhead line systems”, in *Proc. of Electrical Insulation (ISEI), Conference Record of the 2010 IEEE International Symposium on,* San Diego, 2010, pp. 1-5.

[4] Svetlana Berjozkina, Vladimirs Bargels, Antans Sauhats, Edvins Vanzovichs, “A Comparative assessment of Conductors with Composite Core”, in *Proc. of 52nd Annual International conference of RTU,* Riga, 2011, pp. 1-6.

[5] S. Berjozkina, A. Sauhats, E. Vanzovichs, “Modeling of the Load Current of the Transmission Line”, in *Proc. of 10th International Conference on Environment and Electrical Engineering Conference*, Roma, 2011, pp. 911-914.

[6] Santiago Cascante Nogales, José Antonio Lama Miñana, Adrián Alonso, M. Paz Comech, Miguel García-Gracia, Eduardo Martín, "HTLS and HVDC solutions for overhead lines uprating", *in Proc.of the 11th Spanish Portuguese Conference on Electrical Engineering,* 2009, pp.1-5.

[7] Dan Lawry & Bernie Fitzgerald, “Finding Hidden Capacity in Transmission Lines”, *North American Windpower,* April 2007 issue, pp. 1-4.

[8] E. Rosolowski, J. Izykowski, P. Pierz, M. M. Saha, P. Balcerek, M. Fulczyk, “Optimization of distance protection algorithm for series-compensated transmission line”, in *Proc. of IEEE PowerTech Confrence,* Trondheim, 2011, pp. 1-7.

[9] Mathematical Model for evaluation of Conductor Temperature in the Steady (or Quasi-Steady) State (Normal Operation), CIGRE, ELECTRA No. 144, Oct. 1992, pp. 109-115.

[10] IEEE standard for Calculation the Current-Temperature Relationship of Bare Overhead Conductors, IEEE Std. 738-2006 (revision of IEEE Std 738-1993).

[11] L. Staszewiski, W. Rebizant, “The Differences between IEEE and CIGRE Heat Balance Concepts for Line Ampacity Considerations”, in *Proc. of the International Symposium of Modern Electric Power Systems (MEPS),* Wroclaw, 2010, pp. 1-4.

[12] TAIHAN, Electric Wire Co. Ltd, *“Overhead electrical aluminum conductors”*, catalogue, online available at: www.taihan.com/customer/pdf_down.asp?file=0902.pdf.

[13] LS VINA Cable, *“Bare conductor for overhead lines”*, catalogue, online available: http://www.lsvinacable.com.vn/Desktop.aspx/Bare-Conductors/Bare-Conductors-for-Overhead lines/Bare_Conductor_for_Overhead_Lines/.

[14] Electrical Code. Moscow: Gosenergonadzor, 2000, pp.213-281 [in Russian language].

[15] LIJIA REN, XIUCHEN JIANG, GEHAO SHENG, WU BO, “Design and calculation method for Dynamic Increasing Transmission Line Capacity”, *WSEAS Transactions on Circuits and Systems*, vol. 7, issue 5, May 2008, pp. 348-357.

[16] The method of calculation of limit loads for current conditions of the heating wires to the existing power lines. MT 34-70-037-87. Moscow: Soyuztehenergo, 1987, pp. 3-35 [in Russian].

[17] Svetlana Beryozkina, Antans Sauhats, Edvins Vanzovichs, “Climate Conditions Impact on the Permissible Load Current of the Transmission Line”, in *Proc. of IEEE PowerTech Confrence,* Trondheim, 2011, pp. 1-6.

[18] I. Albizu, E. Fernandez, A. J. Mazon, J. Bengoechea, and E. Torres, “Hardware and software architecture for overhead line rating”, in *Proc. of IEEE PowerTech Confrence,* Trondheim, 2011, pp. 1-6.

Svetlana Berjozkina received B.Sc., M.Sc. in Power Engineering from Riga Technical University, Riga, Latvia in 2008 and 2010 respectively. Now she continues studying as PhD student at RTU and works as an engineer at joint-stock company „Siltumelektroprojekts”. Her research interests include power supply, transmission lines state evaluation, analysis of power systems as well as their mathematical modeling.

Antans Sauhats received Dipl. Eng., Cand.Techn.Sc., and Dr.hab.sc.eng. degrees from Riga Technical University (former Riga Polytechnic Institute) in 1970, 1976, and 1991 respectively. Since 1991 he is Professor at Electric Power Systems. Since 1996 he is the Director of the Power Engineering Institute of Riga Technical University. President of joint stock company “Siltumelektroprojekts”.

Vladimirs Bargels received Dipl.Eng. Degree from Riga Technical University (former Riga Polytechnic Institute) in 1974. Since 1998 he works as a leading specialist at joint-stock company „Siltumelektroprojekts”. His work includes the designing of the overhead transmission line system.

Edvins Vanzovichs received diploma engineer degree from Riga Technical University in 1969, PhD degree from Belarus University of Technology in 1987, Dr.Sc.Ing. degree from Riga Technical University in 1992. Professor of Department of Energy Supply at Riga Technical University, Faculty of Power and Electrical Engineering. Main scientific interests are in the fields of power supply, relay protection, automation and optimum development of electrical power networks, as well as the influence of lighting on these networks.