MODERN TECHNIQUES OF CLIMATIC LOADS ASSESSMENT FOR THE DESIGN OF OVERHEAD TRANSMISSION LINES

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Wind, ice and combined ice-wind loads must be assessed during design and/or reconstruction of Overhead Transmission Lines (OHL). According to Russian standards, climatic loads must be assessed using climatic regional maps. Such maps are based on huge massive of meteorological observation data. Design climatic loads are calculated depending on desired reliability level of OHL. This article shows Russsian approach for design loads assessment.

Keywords: databases, wind loads during ice storms, ice loads, climatic loads, climate conditions, climatic regions, coefficient of variation, reliability, unfactored loads, factored loads.

Transmission tower that had collapsed due to glaze ice near Vostryakovsky Lane, south of Moscow

INTRODUCTION

According to Russian standards, during design and/or reconstruction of OHL climatic conditions must be assessed including wind pressure on towers and conductors, weight and size of icing, and wind pressure on iced conductor. Based on climatic conditions are assessed climatic loads – wind, ice and combined ice-wind load.

According to and SNiP (CONSTRUCTION NORMS AND REGULATIONS) 2.01.07-85* [1] and GOST (Russian State Standart) 27751-88 [2], building constructions must be designed on reliability (which means – ability to maintain its working conditions during it's lifetime) considering the degree of it's responsibility.

Modern regional climatic maps created by JSC "R&D Center @ FGC" according to FGC corporate standard "Guidelines for climatic loads assessment according to PUE-7 (Russian State Rules for Electrical Installation) [3] and climatic regional maps creating" giving possibility to assess climatic loads with any desired reliability.

According to IEC [6] climatic loads must be assessed depending on desired OHL reliability.

ASSESSMENT OF CLIMATIC LOADS ACCORDING TO PUE-7

NORMATIVE CLIMATIC LOADS

According to current Russian standard design loads are obtained on the base of normative climatic conditions. Normative climatic conditions are calculated using regional climatic maps on wind pressure, equivalent radial ice thickness and ice-wind load or calculated by using measurements for a long period made on meteorological stations.

As normative climatic load it is used the value having return period of 25-years on the conductor with a diameter of 10 mm that is suspended 10 m above the ground. Normative climatic conditions are ranged by normative climatic regions [3]. Normative wind pressure vary from 400 Pa (25 m/s) in the 1st normative region to 1500 Pa (49 m/s) in the 7th normative region. It is called "special region" if wind pressure exceeds 1500 Pa. Normative ice thickness vary from 10 mm in the 1st normative region to 40 mm in the 7th normative region. It is called "special region" if ice thickness exceeds 40 mm. Normative ice-wind load vary from 3 N/m in the 1st normative region to 28 N/m in the 8th normative region. It is called "special region" if ice-wind load exceeds 28 N/m.

Normative climatic loads are calculated on the base of normative climatic conditions considering conductor diameter, it's suspention height, center of mass of conductors and ground wires and midpoints of OHL towers.

Normative wind pressure (Pa) is calculated based on wind speed (m/s). Normative ice load (N/m) is calculated based on ice thickness (mm). Combined normative ice-wind load is calculated based on ice thickness (mm) and wind speed (m/s) during icing events having return period of 25 years.

DESIGN CLIMATIC LOADS

Design climatic loads are calculated on the base of normative climatic loads (wind load, ice load, ice-wind load) by applying coefficients of:

- responsibility (γ_{nw}),
- reliability (γ_f),
- operating conditions (γ_p)
- regional (γ_d).

INFORMATION

GREAT ICE STORM OF 1998 IN THE UNITED STATES

It is an event that took place in January 1998 in the area from eastern Ontario to southern Quebec to Nova Scotia in Canada, and from northern New York to central Maine in the United States.

The ice storm caused severe damage to the electrical infrastructure causing long-lasting disturbances in the electric supply. Around 1,000 steel transmission towers and 35,000 wooden pylons fell or were crushed by the immense mass of the ice, many high-voltage power lines were torn apart.

Millions of people were left without light for weeks. More than 40 people died, and in large cities like Montreal and Ottawa all business activity froze. Unprecedented effort and resources were spent on reconstructing the electric-power system.

The damaged caused to the electric-power system was so large that it required a major reconstruction of the power grids. The total damage to all the regions amounted close to $6 bln.

RELIABILITY AND RISK LEVEL OF TAKEN DESIGN LOADS

Return period T, years	Probability (p)	OHL lifetime			
		40 years		50 years	
		Load reliability (P)	Risk level (R)	Load reliability (P)	Risk level (R)
10	0.9	0.01	0.99	0.01	0.99
25	0.96	0.20	0.80	0.13	0.87
50	0.98	0.45	0.55	0.36	0.64
100	0.99	0.67	0.33	0.61	0.39
150	0.993	0.77	0.23	0.72	0.28
500	0.998	0.92	0.08	0.90	0.10

Table 1

These coefficients have the following values: responsibility (from 1,0 to 1,3), reliability (1,1; 1,3; 1,6), operating conditions (0,5; 1,0) and regional (from 1,0 to 1,5). Regional coefficient is defined according to standard of organisation "Guidelines for regional coefficients selection during climatic loads assessment". This value is specified by customer in the technical specification during designing of OHL.

After applying above mentioned coefficients return period of resulting load will increase. As a fact, design load will have not a return period of 25 years (as a normative load) but k=γ_{nw}, γ_f, γ_d, γ_p times less.

So, all existing OHL even have been designed for the normative climatic conditions having the same return period because of mentioned coefficients in different geographical conditions will have design loads having different return period. This leads to different reliability of the OHL in relation to different climatic loads (ice, wind and combined ice-wind load).

RELIABILITY AND RISK LEVELS OF DESIGN LOADS

It is valuable to design OHL on climatic loads (ice, wind, combined ice-wind) having the same return period. Transmission lines should be designed with sufficient reliability depending on the degree of importance of the line.

Design value of climatic load could be exceeded at any year during OHL lifetime. Probabilities of design values exceeding for the selected period are assessed with known correlations from probability theory.

Probability (p) that during a year a load would not exceed design value is [8]:

$$p=1-\varphi= 1-1/T,$$

where T – repetition period of design load; $1/T$ – probability that during a year a load will exceed design value at least 1 time per year, where the numerator of "1" is 1 year, and the denominator T – return period (calculated) loads, respectively, j – year risk level (year failure probability), probability that during a year a load will exceed design value.

Reliability of design loads (P) – probability that within a period of n years (OHL lifetime) load will not exceed specified value, shall be

$$P = p^n = \left(1 - \frac{1}{T}\right)^n.$$

Risk level of taken design loads (R) - probability that load will exceed specified value at least once in n years, is assesses as

$$R=1-P=1-(1-1/T)^n.$$

For OHL at lifetime n = 40 and 50 years, degree of risk (R) and reliability (P) of taken design loads for the required probability (p), return period (T) are shown in table 1.

Thus, with increasing return period of design climatic loads, probability of loads exceeding specified values reduces, i.e. degree of risk reduces.

For example let's assess reliability and risk level of design ice loads taken according to PUE-7. Average return period of design ice loads assessed according to PUE-7 (with all above mentioned coefficients) is equal to 77 years. Reliability of design ice loads for the OHL lifetime equal to 40 years will be 0.59 with risk level – 0.41. So in another word during 40-years OHL life cycle theoretical failure probability is 41%.

INTERNATIONAL STANDARDS (IEC, CIGRE)

According to IEC and CIGRE standards and recommendations it is suggested

to assess design climatic loads considering OHL voltage, its responsibility and owners demands taking the following reliability levels:

- for OHL 220 kV and less – 0.98 (return period 50 years);
- for OHL 330 kV and above – 0.993 and 0.998 (return period 150 and 500 years);
- in some cases for OHL 110, 220 kV and above – 0.993 and 0.998 (return period 150 and 500 years);
- for long lines to reduce possible risk should be selected the higher level of reliability.

According to IEC and CIGRE documents for approximation of statistical arrays should be used Gumbel distribution law.

HARMONIZATION OF RUSSIAN AND INTERNATIONAL STANDARDS

In order to harmonize Russian and International standards JSC "R&D Center @FGC" has developed corresponding documents:

"Guidelines for assessment of climatic conditions and loads with different reliability level depending on responsibility of OHL" (project), 2004.

In the document is shown method of climatic parameters assessment. It allows obtaining climatic loads depending on chosen reliability level from 0.96 to 0.998 depending on responsibility of OHL.

This method has been developed based on IEC and CIGRE recommendations. In the guidelines are used all modern concepts of climatic conditions and climatic loads assessment and OHL field experience.

Guidelines give possibility to get climatic loads with different reliability level depending on voltage of OHL, its responsibility and owners demands based on value with reliability of 0.96.

"Guidelines for assessment of climatic loads according to PUE-7 and regional climatic maps creation", 2010.

This document is the actualisation of previous guidelines developed in 1990. Actualisation was performed basing on "Guidelines for assessment of climatic conditions and loads with different reliability level depending on responsibility of OHL" and demands of chapter 2.5 of PUE-7.

Based on guidelines, meteorological observation data and OHL field experience climatic conditions having reliability 0.96 could be calculated and regional climatic maps could be produced for the selected territory for wind, ice and combined ice-wind load.

"Guidelines for assessment of climatic loads depending on line length", 2010.

Climatic conditions and loads, calculated according to the methods above-mentioned, are valid for every point of the territory or OHL. When designing OHL, it is usually assumed that these conditions are valid for the entire line. But the overhead transmission line is an object extended in space, and climatic conditions change along its extension and in time. So, return period and quantity of cases of overloading will differ for the entire line from that one of a single point. This is why the above-mentioned assumption leads to the underestimation for the entire OHL of the probability of occurrence of the climatic load exceeding design load. This is particularly true for the transmission lines with a length of more than 100 km.

For transmission lines having length more than 100 km, it have been developed "Guidelines for assessment

INFORMATION

GLAZE-ICE AND RIME DEPOSITIONS

Occurs on overhead lines wires and steel ropes with air temperature around -5°C and wind velocity 5 – 10 m/s.

Based on the ice sheet thickness (b) with occurrence of 1 every 25 years, Russia is divided into 8 disctircs:
I disctrict b=10 mm;
II disctrict b=15 mm;
III disctrict b=20 mm;
IV disctrict b=25 mm;
V disctrict b=30 mm;
VI disctrict b=35 mm;
VII disctrict b=40 mm;
special b>45 mm.

Standard zonation maps of Russia are provided in the ICI Electrical Installations Code.

Significant ice loads may lead to tearing of wires, steel ropes, destruction of accessories, insulators an even the support structures. The distribution of ice coating on phase conductors is quite irregular. The overhead line sags with and without the ice may differ by a few meters. This kind of misalignment and the falling of the melting ice, which causes individual wires to bounce, may lead to flashovers and to destruction of insulation.

CLIMATOLOGY DATABASE SCHEME

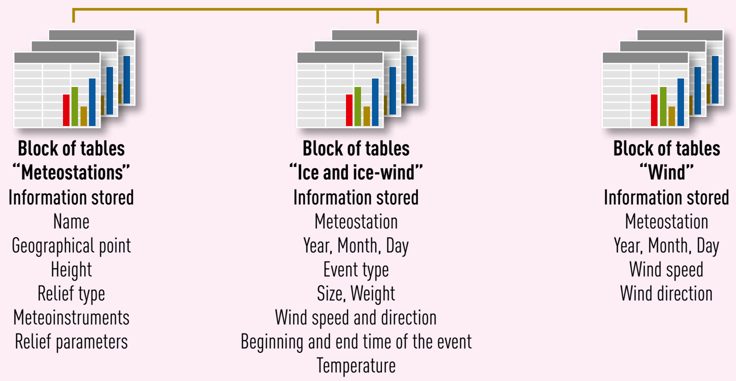

Fig. 1

of climatic loads depending on line length" that takes into account characteristics of atmospheric processes of the considered territory.

Using these guidelines it is possible to obtain the reliability for the entire line based on the exclusion probability for the single point of the line. And vice versa, if specifying desired reliability for the entire line it is then possible to calculate necessary reliability for every point of the OHL.

"Guidelines for regional coeffitients selection during climatic loads assessment", 2010.

According to PUE-7, during design loads assessment is used regional coefficient that should be specified by customer in the technical specification. But there are no concrete values defined in PUE-7. These guidelines give methods for regional coefficients selection based on OHL field operation experience and meteorological stations' observation data.

REGIONAL CLIMATIC MAPS. MODERN TECHNICS OF MAPS DEVELOPMENT AND USING

Vast territory, different geographical and orographical conditions of Russian Federation along with the lack of meteorogical stations on some territories make it difficult to assess climatic loads based only on meteorological stations' observations. There are other possibilities that could be used to assess climatic loads.

One of the possible ways for climatic conditions caracterisation and visual representation of their distribution over the territory is to use regional climatic maps. As a form for climatic loads detalisation over territory is used a break down of the territory on climatic regions.

The main purpose of the regional climatic map is to give possibility to get climatic load (climatic region) for any territory (any point of the territory). Depending of the territory size regional climatic maps could be created in scales 1:500 000 or 1:1 000 000.

Creating regional maps with higher resolution have no sense with current quantity of meteorological stations and their distribution over the territory of the country, because there is no possibility to create accurate dependency between distribution of climatic conditions over the territory and geographical characteristics of the landscape.

Regional climatic maps must be created based on meteorological stations' observation data for the period not less than 30 years taking into ac-

FRAGMENTS OF REGIONAL WIND-LOADS MAP FOR THE TERRITORY OF TUAPSE REGION

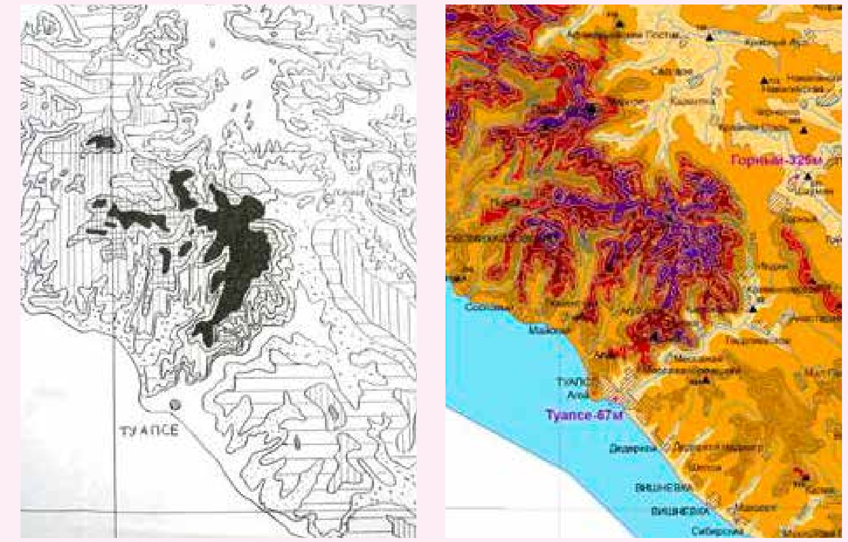

Fig. 2

count also OHL field experience data. For the purposes of regional climatic maps creation are used guidelines abovementioned.

Regional climatic maps give reliable information about climatic condition at given territory and make OHL design more fast and cost effective.

The making of regional maps is a complex work that involves a series of factors: the reckoning of meteostations observation data and past experience data with existing transmission lines, the creation of statistical arrays and their statistical processing, the analysis of physical-geographical conditions and of local relief characteristics, the analysis of terrain conditions in which the meteorological station is located, the relevance of observed data and the analysis of synoptical processes. In order to perform efficiently the above-mentioned works, it is necessary to use modern computing techniques, having the target of ultimately automatize the reckoning process and the making of regional maps.

Starting 2010, JSC "R&D Center @ FGC" is working to rise level of automatisation during works of regional climatic maps creation and design climatic loads defining. These works include automatisation of all steps prior to regional climatic map creation and design loads defining.

Today we have introduced semi-automatic processing for collection, storage and managing of observations data gathered from the meteorological station network. Furthermore, this system helps creating statistical arrays, assessment of statistical parameters and parameters of climatic characteristic having a given return period, and it provides processed data for the making of regional maps.

In order to obtain processed climatic data, we have created a specialized information system for climate conditions.

SIZE-REDUCED ICE-WIND LOADS MAP FOR THE TERRITORY OF VORONEZH REGION

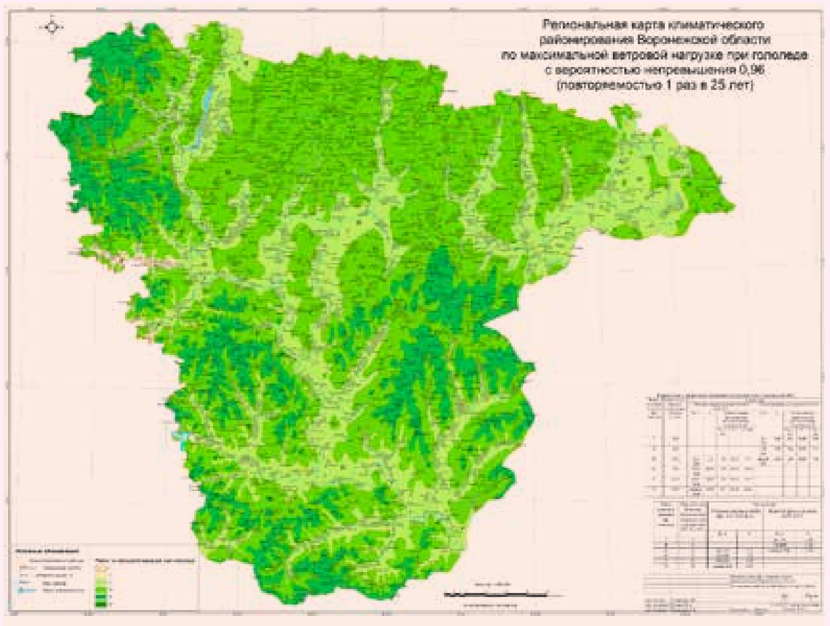

Fig. 3

SIZE-REDUCED ICE LOADS MAP FOR THE TERRITORY OF VORONEZH REGION

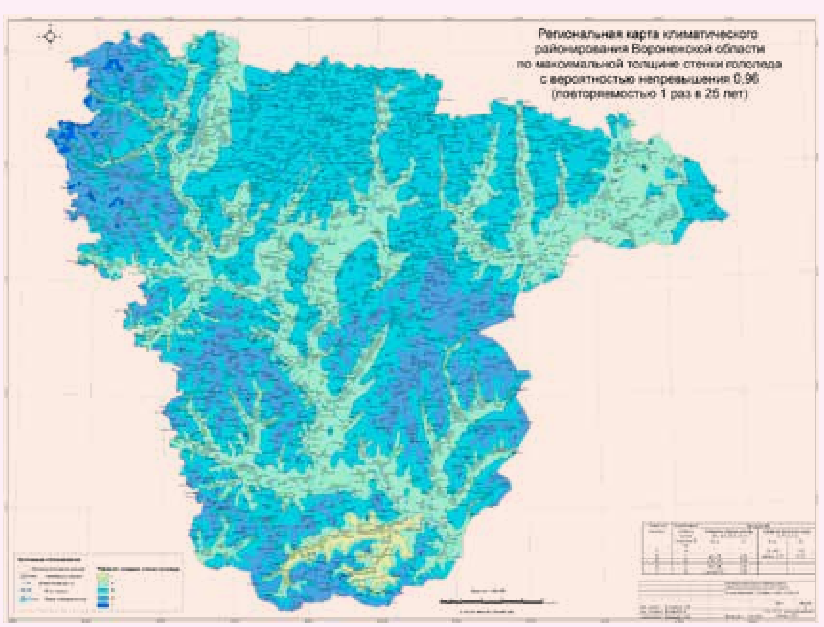

Fig. 4

The information system consists of a database of climate conditions (DB) and of a specific program.

Thanks to long-term observations done in the meteostation network (1,860 wind observation meteostations and 1,254 ice observation meteostations) in Russia, the DB contains the following information about icing events:

- date of observation;
- maximum wind speed and direction;
- icing type;
- icing size and weight;
- speed and direction of the wind at the beginning of the icing event;
- maximum wind speed during the icing event.

For every meteorological station the DB stores the following information:

- its name;
- administrative belonging;
- height above the sea level;
- technical characteristics, such as height of weather-vane and height of wind meter.

On fig. 1 it is represented the logical scheme of the database for climate conditions with main characteristics description.

The program allows DB data process-ing which includees:

- automatic data update in the DB in an electronic format;
- data handling, their processing in order to get uniform data;
- statistical arrays creation;
- statistical approximation (with different statistical distribution) and statistical parameters definition;
- creation and printing of the final report for the selected meteostation.

The program also allows describing the arrays with different statistical distributions, obtaining climatic

RECALCULATION COEFFICIENTS KV FROM NORMATIVE WIND PRESSURE TO THE WIND PRESSURE WITH DIFFERENT RELIABILITY LEVEL

Variation coefficient of the wind speed, c_v	Recalculation coefficients k_v to desired reliability				
	0.96	0.98	0.99	0.993	0.998
0.05	1.0	1.06	1.10	1.14	1.25
0.1	1.0	1.10	1.21	1.28	1.46
0.2	1.0	1.17	1.37	1.46	1.85
0.3	1.0	1.23	1.49	1.64	2.13
0.4	1.0	1.28	1.56	1.77	2.40
0.6	1.0	1.32	1.72	1.93	2.76
0.8	1.0	1.37	1.80	2.07	3.03
1.0	1.0	1.39	1.88	2.16	3.20

Table 2.
Note. The coefficient of variation for the year's maximum wind speeds is determined through the use of region's zonation maps or by analyzing years' worth of meteorological data.

RECALCULATION COEFFICIENTS FROM NORMATIVE ICE THICKNESS AND NORMATIVE ICE-WIND LOAD TO THE VALUES WITH DIFFERENT RELIABILITY LEVEL

Variation coefficient, c_v	Recalculation coefficients to desired reliability				
	0.96	0.98	0.99	0.993	0.998
0.3	1.0	1.11	1.22	1.28	1.46
0.4	1.0	1.13	1.25	1.33	1.55
0.6	1.0	1.15	1.31	1.39	1.66
0.8	1.0	1.17	1.34	1.44	1.74
1.0	1.0	1.18	1.37	1.47	1.79
1.2	1.0	1.20	1.39	1.50	1.84
1.4	1.0	1.20	1.40	1.52	1.87
1.6	1.0	1.21	1.42	1.54	1.90
1.8	1.0	1.21	1.43	1.55	1.92
2.0	1.0	1.22	1.44	1.56	1.93
2.2	1.0	1.22	1.44	1.57	1.95

Table 3.
Note. The coefficient of variation for the glaze-ice thickness as well as the wind loads during ice storms is determined through the use of region's zonation maps of by analyzing years' worth of meteorological data.

INFORMATION

DECEMBER 25, 2010. ICE STORM IN MOSCOW

In the last decades, gust-and-glaze loading has led to a number of major incidents in the Russian power lines. According to the Firm ORGRES, JSC, between 1971 and 2001 incidents in 44 power grids took place, while 21 of them happened in the period between 1991 and 2000.

On December 25, 2010, Moscow Region as well as some neighboring regions have experienced an ice storm. A 20mm thick icy coating (in some places – up to 50 mm) covered roads, sidewalks, trees, overhead power lines and so on. In the following days the situation was aggravated as wet snow stuck to the ice-covered surfaces, creating so called «сложные отложения».

Trees that fell under the weight of the ice damaged and tore overhead power lines. Emergency power cutoffs have occurred in 26 municipal and urban districts. The total loss by MOESK, OJSC due to the ice storm amounted to almost 1.3 billion rubles.

characteristics having different return period.

For the making of regional icing maps are used maps of types and subtypes of large-scale relief, along with a graph of functional dependence of climatic characteristic from the height above sea level. For types and subtypes of large-scale relief we build a graph of functional dependence of climatic characteristic (equivalent radial ice-thickness, ice-wind load, maximum wind speed for icing event) from the height above sea level. The dependence is $x=f(H)$ (where x – value of climatic characteristic, H - height above sea level) and is built considering local small-scale relief. This step is performed by climatologist by hand. In the future we plan to develop some instrumetns in help during this step.

Dependences $x=f(H)$ are used for regional climatic maps creation. In Russia for the break down of territory we use climatic characteristics having a return period of 25 years.

In order to create regional maps of the territory of the Russian Federation we use a geo-information system. This Geographical Information System (GIS) is a system for the management of geographical information, their analysis and representation [5]. Geographical information is given as a series of selected geographical data, which model the geographical environment with simple, summarised and structured data. GIS includes a set of modern and powerful instrumental means to work with geographical data.

The usage of GIS allows the making of regional maps with an elevate degree of detailed elaboration of the icing regions that takes into account local relief. Furthermore, the use of GIS improves significantly the effectiveness and quality of executed work.

On fig. 2 are shown two fragments of the map for the same territory – one made by hand and another using GIS technologies.

From fig. 2 it is possible to see, that the use of GIS allows getting detailed information about climatic regions and their borders in relation to general geographic reference points like for e.g. cities, rivers, coastlines, local altitude marks, etc.

On fig. 3 and 4 are shown size-reduced maps of ice-wind loads and ice loads having reliability 0.96 (return period 25 years) for the territory of Voronezh region. Maps are created at scale 1:500 000 and have the size of 80x59cm, that could give the idea about high detalisation level of the territory by mentioned climatic loads.

All maps are containing all necessary information for the location reference which includes: terrain heights, settlements, administrative borders, hydrographic network (rivers, lakes, etc.). Following the customer demands it could be shown on the map also the following additional information: roads and railroads, meteorological stations, existing substations and OHL's and etc.

On the maps are shown additional technical information necessary during OHL design and operation, such as climatic regions and their normative values, parameters giving possibility to obtain climatic loads with any desired reliability.

Today JSC "R&D Center @FGC" are finished works on regional climatic maps creation for all of the 79 federal subjects of the Russian Federation. For each region it was developed a set of 4 climatic regional maps (wind load map, ice load map, combined ice-wind load map, lightning activity map) in scales 1:500 000 or 1:1 000 000.

On the maps for every climatic region beside normative values and region borders' absolute heghts are shown variation coefficients which give possi-

RECOMENDED OHL RELIABILITY LEVELS

OHL voltage, kV	OHL length less than, km	Recommended reliability level	Reliability of design load, p	Return period, T, years
35	30	II	0.98	50
110	100	III	0.99	100
220	300			
330	300	IV	0.993	150
500	1,000			
750	2,000	V	0.998	500

Table 4

DESIGN WIND LOADS HAVING DIFFERENT RELIABILITIES TO DESIGN WIND LOADS DEFINED ACCORDING TO PUE-7 RATIOS

Variation coefficient	Reliability			
	0.98	0.99*	0.993*	0.998*
0.05	0.82	0.85	0.80	0.87
0.10	0.85	0.93	0.90	1.02
0.20	0.90	1.05	1.02	1.29
0.30	0.95	1.15	1.15	1.49

Table 5
* Excluding first wind region

DESIGN ICE LOADS ON CONDUCTOR HAVING DIFFERENT RELIABILITIES TO DESIGN ICE LOADS DEFINED ACCORDING TO PUE-7 RATIOS

Variation coefficient	Reliability															
	0.98				0.99				0.993				0.998			
	Ice region				Ice region				Ice region				Ice region			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
0.4	0.90	0.91	0.75	0.75	1.04	1.06	0.87	0.88	0.75	0.85	0.74	0.75	0.93	1.12	0.94	0.96
0.6	0.93	0.94	0.77	0.78	1.10	1.13	0.94	0.95	0.80	0.95	0.79	0.81	1.02	1.24	1.05	1.08
0.8	0.95	0.96	0.79	0.80	1.14	1.17	0.97	0.99	0.87	1.00	0.84	0.85	1.10	1.34	1.13	1.16
1.0	0.96	0.97	0.80	0.81	1.17	1.21	1.01	1.02	0.86	1.03	0.86	0.88	1.14	1.40	1.18	1.22

Table 6

INFORMATION

GLAZE ICE

Glaze ice is an ice coating occurring on ground, trees, transmission towers, power line cables and any other hard surface. Glaze ice occurs as a result of precipitation (such as rain, mist, hoarfrost, wet snow or ice storm) hitting cold surface which does not get sufficiently warmed up in time by the warm air masses passing by.

The ice usually builds up within a period of a few (1 and up to 12) hours. Live power lines tend to generate almost 30% more ice as compared to those that do not carry any voltage. The ice tends to build up more strongly in the direction perpendicular to that in which air masses are moving. If the weather front is moving from the west, the wires directed north-south will have up to 3 times thicker ice coating and vice versa: if the air masses move east-west, the wires parallel to the latitude lines will have a thicker ice coating built up.

bility to obtain climatic loads with any desired reliability.

Design climatic loads are calculated on the base of normative climatic conditions found on the map by applying recalculation coefficients.

Based on FGC stadard 56947007-29.240.057-2010 in tables 2 and 3 are shown recalculation coefficients from normative values to values having a certain reliability level depending on variation coefficient.

In table 2 are shown recalculation coefficients ***kv*** from normative wind pressure to the wind pressure with different reliability level.

In table 3 are shown recalculation coefficients from normative ice thickness and normative ice-wind load to the values with different reliability level.

According to international recommendations [6] and national standards OHL [4] with different voltage classes could be designed with different reliability levels. In table 4 are shown recomended OHL reliability levels of design climatic loads according to desired reliability (***p***) and return period (***T***).

Reliability level is defined by selected return period of design climatic loads or selected reliability of design climatic loads. OHL can be designed for any reliability level by choosing a specific return period (***T***).

Reliability level of OHL having length more than shown in table 4 or multiple circuit OHL or OHL that is unique supplying source must be selected one-two levels higher.

Design climatic loads (ice, wind and ice-wind) are defined based on normative climatic parameters using recalculation coefficients to selected reliability level.

Design climatic loads corresponding to different reliability levels are comparable to those defined by PUE-7.

In table 5 are shown wind load recalculation coefficients for reliabilities 0.98; 0.99; 0.993; 0.998 to design wind load on conductors taken by tower according to PUE-7 for variation coefficients 0.05; 0.10; 0.20; 0.30.

In table 6 are shown ice load recalculation coefficients (on 20 mm diameter conductor) for reliabilities 0.98; 0.99; 0.993; 0.998 to design ice load on conductors taken by tower according to PUE-7 for variation coefficients 0.4; 0.6; 0.8; 1.0.

CONCLUSION

It is appropriate to use modern computer tecnologies, including specific softwares, climatic data databases and Geographical Information Systems (GIS), during design climatic loads assessment for OHL.

In order to increase the reliability of customers power supply, it is apropriate to use regional climatic maps allowing defining climatic loads when designing and upgrading OHL.

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