10.2478/v10144-009-0017-z

SCIENTIFIC PROCEEDINGS OF RIGA TECHNICAL UNIVERSITY
THE 50TH INTERNATIONAL SCIENTIFIC CONFERENCE „POWER AND ELECTRICAL ENGINEERING," OCTOBER 2009

Load forecasting till 2020 of existing and perspective transformer substations in Riga

Svetlana Guseva, Olegs Borscevskis, Nataly Skobeleva, Nikolajs Breners
Riga Technical University (Riga, Latvia)
guseva@eef.rtu.lv, olegs.borscevskis@latvenergo.lv, nataly_skobeleva@olimps.lv, nbreners@latvenergo.lv

***Abstract* -The forecast of load till 2020 of existing and perspective transformer substations and common load of Riga is given in this paper.**

I. INTRODUCTION

Due to continuous growth of existing loads and appearance of new load centers the 110 kV substations shall be constructed in the future in order to ensure Riga city power supplies. The corresponding land plots shall be reserved in advance for these substations. All perspective transformer substations (TS) should be switched to the common energy supply of the city. For the purpose of increasing of city overall power supply safety a construction of ring of 330 kV lines around Riga shall be created. The 330 kV ring is planned to be installed with the use of 330 kV cable lines crossing the Daugava River in the route together with the planned Riga northern route for road transport [2].

For the development of 110 kV supply networks and the above-mentioned the connection of the planned 110 kV substations will be ensured by constructing less disturbing, but more expensive, cable lines instead of air supply lines [1].

II. COMMON APPROACH TO TRANSFORMER SUBSTATIONS` LOAD FORECASTING

The total electrical load of the city forms different consumer groups.

For perspective forecasting the following must be taken into account:

- consumers load growing with years;
- marketable power of new objects;
- technical possibility to cover collateral powers and another conditions [4].

The total electrical load of the city influences a lot the total collateral power of consumers, which have accidental characteristic and indefinite information about largeness and connection terms.

All results of the calculation and data have a permissive character, because this forecasting was made in indecisiveness conditions of information. Then the load elaboration also should be forecasted correctly.

A 110 kV transformer substation mounted power with reserve will be enough to guarantee normal quality for energy supply to consumers. The total electrical load of the city can be found like:

$$S_{pils} = k_{o,TA} \cdot \sum_{i=1}^{n_{TA}} S_{TA,i} = k_{o,TA} \cdot \sum_{i=1}^{n_{TA}} n_i \beta_i S_{nom,i} \quad (1)$$

where S_{pils} - the total electrical load of the city in the appointed year;
$S_{TA,i}$ - *i*-transformer substation load in the appointed year, MVA;
$k_{o,TA}$ - the simultaneity coefficient of transformers' load maximum, depends of 110kV TS quantity;
n_i - transformers' quantity in *i*-transformer substation;
β_i - each transformer load coefficient of *i*-transformer substation;
$S_{nom,i}$ - transformer's mounted rated power of *i*-transformer substation, MVA;
n_{TA} - transformer substations` quantity in the city area.

The forecasting of Riga electrical load is fulfilled for the period from 2008 till 2020. Graphical forecasting can be seen in Fig. 1. The different variants of forecasting are taken for:

- 3% and 1.9%-percent year load growing, beginning from 2008 till 2020 in favourable scenario of the economic development (till beginning of crisis of the economics);
- 3%, 1.9% and 1.5%-percent year load growing in disadvantaged scenario of the economic development (the period of recession from 2008 till 2012 without load growing) with improvement of situation since 2012.

The initial calculation's data are active loads P_{2008}, density of load σ_{2008} in supplying zone Π_r of existing transformer substations in 2008 and the common load of Riga $S_{pils,2008} = 480 MW$.

Considering produced theoretical forecasting, the existing and perspective transformer substations' loads from 2008 till 2020 are calculated in Table I, as an example of load growing.

In Table II the correction of results are demonstrated after reconstruction of existing transformer substations by substitution of transformer on largest power once or transformer's increase in TS.

TABLE I

THE LOAD'S FORECAST TILL 2020 FOR EXISTING (11-1144) AND PERSPECTIVE (1100-1177)TRANSFORMER SUBSTATIONS IN RIGA FOR DISADVANTAGED SCENARIO OF ECONOMIC DEVELOPMENT (1.5 % LOAD GROWING FROM 2012)

TS Nr.	S_{TN}, MVA			$\beta_{perm.}$	Π_r	P_{2008}	$\sigma_{2008.g.}$	β_{2008}	$P_{p.}$	P_{2020}	$S_{max, 2020.g.}$	β_{2020} *
	1	2	3		km^2	MW	MVA/km^2		MW	MW	MVA	
11	40	40		0.5	2.56	22.91	9.95	0.32	10.57	31.73	35.26	0.44
16	40	40		0.5	7.68	35.64	5.16	0.50	10.92	46.27	51.41	0.64
118	40	40		0.5	17.6	20.37	1.29	0.28	14.12	30.85	34.28	0.43
1101	25	25		0.5	1.27	13.14	11.50	0.29	17.05	24.35	27.06	0.54
1105	40	40		0.5	3	43.00	15.93	0.60	10.92	54.56	60.62	0.76
1110	31.5	40	40	0.64	9.12	37.00	4.51	0.37	9.83	47.18	52.43	0.47
1111	40	63		0.39	2.22	39.55	19.80	0.43	22.34	57.07	63.41	0.62
1112	15	20	25	0.58	8.96	16.40	2.03	0.30	9.03	23.53	26.15	0.44
1113	25	25		0.5	1.83	11.45	6.95	0.25	11.83	19.52	21.69	0.43
1114	40	40		0.5	3.9	40.08	11.42	0.56	13.59	52.76	58.62	0.73
1115	40	40		0.5	10.26	27.71	3.00	0.38	15.25	39.76	44.17	0.55
1116	25	25		0.5	0.94	15.47	18.29	0.34	26.97	32.53	36.14	0.72
1117	25	25		0.5	17.1	20.21	1.31	0.45		22.77	25.30	0.51
1119	25	25		0.5	0.9	32.71	40.38	0.73	7.08	40.81	45.34	0.91
1123	25	25		0.5	4.4	16.33	4.12	0.36	1.13	19.03	21.15	0.42
1130	25	25		0.5	12.89	27.75	2.39	0.62	14.16	39.19	43.54	0.87
1131	40	40		0.5	6.8	36.21	5.92	0.50	10.03	46.41	51.56	0.64
1132	10	10		0.5	1	0.47	0.52	0.03	0.12	0.59	0.66	0.03
1133	16	16		0.5	3.36	6.97	2.30	0.24	4.30	10.26	11.40	0.36
1136	25	25		0.5	2.5	25.84	11.48	0.57	10.48	34.98	38.86	0.78
1137	32	32		0.5		0.50		0.01	24.08	14.05	15.61	0.24
1140	25	25		0.5	7.8	31.86	4.54	0.71	4.66	38.50	42.78	0.86
1141	25	25		0.5	3.9	20.57	5.86	0.46	4.96	25.95	28.83	0.58
1142	25	25	25	0.67	14.4	42.36	3.27	0.63	25.00	61.72	68.58	0.91
1144	25	25		0.5	4.1	15.75	4.27	0.35	24.63	31.53	35.04	0.70
1100	40	40		0.5					8.14	4.56	5.06	
1104	25	25		0.5					24.34	13.63	15.14	
1106	32	32		0.5					22.97	12.86	14.29	
1107	40	40		0.5					0.31	0.17	0.19	
115	32	32		0.5					8.72	4.88	5.43	
1118	32	32		0.5							0.00	
1139	25	25		0.5					19.01	10.65	11.83	
1148	32	32		0.5					21.36	11.96	13.29	
1172	25	25		0.5					3.88	2.17	2.41	
1178	25	25		0.5					15.76	8.83	9.81	
1147	40	40		0.5								
1138	40	40	40	0.67								
1149	40	40		0.5								
1108	32	32		0.5								
1180	25	25		0.5								
1181	40	40		0.5								
1182	40	40		0.5								
1173	25	25		0.5								
1143	32	32		0.5								
1102	16	16		0.5								
1170	40	40		0.5								
119	25	25		0.5								
1187	16	16		0.5								
1171	40	40		0.5								
1128	25	25		0.5								
1174	25	25		0.5								
1177	25	25		0.5								
					148.49	600.25			360	915.60	1017.3	
						480.2032	3.23		201.6	732.483	813.87	

* - the overloaded transformer substations are allocated

TABLE II
THE CORRECTION OF LOAD'S FORECAST TILL 2020 OF TRANSFORMER SUBSTATIONS IN RIGA INCLUDING RECONSTRUCTION AND LOAD'S REDISTRIBUTION OF EXISTING TRANSFORMER SUBSTATIONS

TS Nr.	TS reconstruction	β_{2020}	TS load`s redistribution	P_{2020m}	β_{2020}*	$S_{max, 2020.g.}$	$\sigma_{2020.g.}$	S_{TN2020}, MVA			β_{pierm}
				MW		MVA	MVA/km^2				
11	(2x40 —> 2x32)	0.55		31.73	0.55	35.26	13.77	32	32		0.5
16			35 % load —> 1118	30.07	0.42	33.41	6.69	40	40		0.5
118				30.85	0.43	34.28	1.95	40	40		0.5
1101	(2x25 —> 2x32)	0.42		24.35	0.42	27.06	21.31	32	32		0.5
1105	(2x40 —> 2x63)	0.48		54.56	0.48	60.62	20.21	63	63		0.5
1110	(31.5+2x40 —> 3x40)	0.48		47.18	0.48	52.43	5.75	40	40	40	0.67
1111	(40,63 —> 2x63)	0.50	10 % load —> 1106	51.36	0.45	57.07	28.56	63	63		0.5
1112	(15,20,25 —> 3x25)	0.35		23.53	0.35	26.15	2.92	25	25	25	0.67
1113				19.52	0.43	21.69	11.85	25	25		0.5
1114	(2x40 —> 3x40)	0.49		52.76	0.49	58.62	15.03	40	40	40	0.67
1115	(2x40 —> 2x63)	0.35		39.76	0.35	44.17	4.31	63	63		0.5
1116	(2x25 —> 2x32)	0.56	15 % load —>1106	27.65	0.48	30.72	38.45	32	32		0.5
1117				22.77	0.51	25.30	1.48	25	25		0.5
1119	(2x25 —> 2x40)	0.57	15% load —> 1106	34.69	0.48	38.54	50.38	40	40		0.5
1123				19.03	0.42	21.15	4.81	25	25		0.5
1130	(2x25 —> 2x40)	0.54	20 % load —> 1139	31.35	0.44	34.83	3.38	40	40		0.5
1131			30 % load —> 1137	32.48	0.45	36.09	7.58	40	40		0.5
1132				0.59	0.03	0.66	0.66	10	10		0.5
1133			from 1136 load 10%	13.76	0.48	15.28	4.23	16	16		0.5
1136		0.61	10 % load —> 1133	31.48	0.70	34.98	15.54	25	25		0.5
1137			from 1131 load 30%	27.97	0.49	31.08	15.23	32	32		0.5
1140	(2x25 —> 2x63)	0.34	from 1141 load 20%	43.69	0.39	48.55	5.66	63	63		0.5
1141			20 % load —> 1140	20.76	0.46	23.06	7.39	25	25		0.5
1142	(3x25 —> 2x25+1x63)	0.61	(2x25+1x63—>3x63)	61.72	0.36	68.58	4.76	63	63	63	0.67
1144	(2x25 —> 2x40)	0.44		31.53	0.44	35.04	8.55	40	40		0.5
1100			100% load —> 1118								
1104				13.63	0.30	15.14	6.00	25	25		0.5
1106			10% from 1111; 115% -- 1116, 1119	29.67	0.52	32.97	9.00	32	32		0.5
1107			100% load —> 1118								
115				27.38	0.48	30.43	6.00	32	32		0.5
1118			35% from 16+100% - 1100+100% - 1107+100% -1172	23.10	0.40	25.66	5.00	32	32		0.5
1139			20% 1130	18.49	0.41	20.54	7.00	25	25		0.5
1148				11.96	0.21	13.29	7.00	32	32		0.5
1172			100% load —> 1118								
				8.83	0.20	9.81	8.00	25	25		0.5
				938.20		1042.45					
				750.56		833.96	5.05				

* - the overloaded transformer substations are allocated

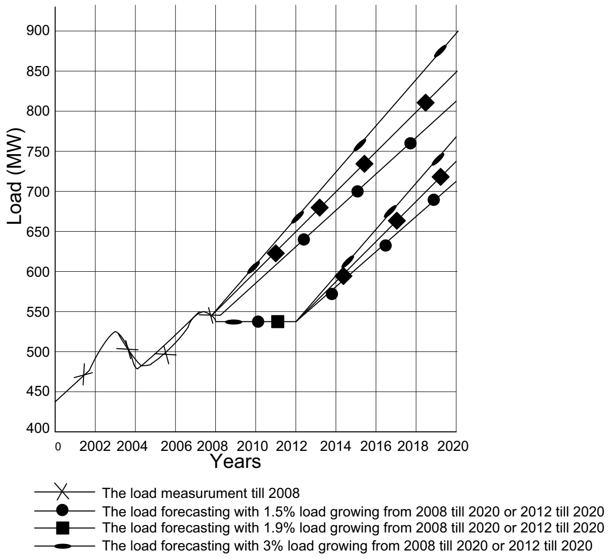

Fig. 1. The real load of Riga from 2000 till 2008 and forecast of maximal common load from 2008 till 2020

Forecasting is made for 25 existing and 28 virtual perspective 110 kV transformer substations. The perspective transformer substations can appear with irregular growing of load in different districts of city or if the load of existing transformer substations is not enough due to big load compactness in these districts. For each possible transformer substation place in the territory of Riga city and in the developed power supply system must be reserved [3].

THE CALCULATION OF LOADS FOR PERSPECTIVE TRANSFORMER SUBSTATIONS

The maximal active electrical load of existing transformer substations can be found with the help of expression [5]:

$$P_{2020} = P_{2008} \cdot \left(1 + \frac{i}{100}\right)^{t_2 - t_1} + k_1 \cdot k_2 \cdot P_p \qquad (2)$$

where i - the medium grow of consumers' load per year;
t_2 -the final year of calculation period (t_2=2020);
t_1 - the beginning year of load growing (t_1=2008 or t_1=2012 in accordance with accepted calculation variant);
Pp - the marketable power of consumer;
k_1 - the simultaneity coefficient of load maximum (k_1=0.8);
k_2 - the correction coefficient, which depends on marketable power of consumer and on uncertainty of connection term (k_2 = 0.7).

The load of perspective transformer substations consists of marketable power Pp and load's redistribution from overloaded existing transformer substations.

As an example, the calculation of perspective transformer substations` loads in disadvantaged scenario of the economics' development: the period of recession without load growing from 2008 till 2012 and with 1.5 %-percent per year load growing by improvement of situation from 2012 till 2020. Calculation's results are in Table I and Table II.

For each transformer substation calculations for all scenarios can be realized.

Considering the loads of separate transformer substations the common perspective load of Riga in 2020 is determined. The calculation's data are given in Table III and in Table IV.

TABLE III
THE STABLE VARIANT OF ECONOMIC`S DEVELOPMENT

The load`s growing, %	P_{2020}, MW	S_{2020}, MVA
3%	896	996
1,9%	844	938

TABLE IV
THE DISADVANTAGED VARIANT OF ECONOMIC`S DEVELOPMENT

The load`s growing, %	P_{2020}, MW	S_{2020}, MVA
3%	818	909
1,9%	770	853
1,5%	751	834

CONCLUSION

1. In the paper the load theoretical forecasting till 2020 of existing and perspective transformer substations in Riga for different scenarios of the economic development is realized.
2. The common perspective load of Riga in 2020 is determined for all scenarios.
3. The practical calculations of existing and perspective transformer substations are realized considering the marketable power of consumer till 2020.
4. The forecasting was made in considerations of information uncertainty: precarious information about consumers' marketable loads, loads' connection terms, perspective transformer substations' construction terms and placement, transformers' marketable powers and tendencies of economic development in state.
5. All the obtained results and data of forecasting must be correct after perspective transformer substations' construction and marketable power's switching on common electricity net of Riga.

REFERENCES

[1] Справочник по проектированию электроэнергетических сетей. /Под ред. Файбисовича Д. Л. – Москва: НЦ ЭНАС, 2006.
[2] Rīgas attīstības plāns 2006.-2018. gadam (RD, 2005.g.). http://www.rdpad.lv
[3] A/S "LATVENERGO" attīstības programma līdz 2016 gadam.
[4] E.Lakervi, E. J. Holmes. Electricity distribution network design. – London: Peter Peregrinus, 1996.
[5] Гусева С.А. Математические модели схем электроснабжения районов жилой застройки городов. – Известия АН Латв. ССР. Серия физ. и техн. наук, № 6, 1988, с.110-113