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THE POWER INDUSTRY OF THE KALININGRAD REGION: AN ANALYSIS OF THE CURRENT STATE, FUTURE DEVELOPMENT, AND COOPERATION WITH THE ENERGY SYSTEMS OF THE BALTIC REGION STATES

This article analyses the current state of the power system of the Kaliningrad region and gives recommendations regarding the increase in energy efficiency. The author considers the prospects of its development taking into account the possible accession of the Baltic States to the UCTE.

Key words: energy system, electrical energy, power, electric loss, AC and DC transmission lines, power plant, the Kaliningrad region.

In the year 2008, the internal resources of the Kaliningrad region, mainly the Kaliningrad CHPP-2, accounted for 73% of the regional power demand. Table 1 shows the 2008 electricity balances of the Kaliningrad region and OAO Yantarenergo.

Table 1

The electricity balance of the Kaliningrad region in 2008 [9; 13]

Energy amount	Power generation			OAO Yantargenergo		
	Total	Local	Imported	Received from power systems	Supplied to consumers	Losses
kW · h, bln	3.97	2.83	1.14	3.74	3.05	0.68
%	100	73	27	100	71.7	18.3

Today, Japan and Germany spend 7 and 3-4 times, respectively, less power per product unit than Russia, which is explained by the high efficiency of manufacturing sectors in these countries. The data presented in Table 2 prove this statement. As a result, over the last years, the production growth in developed countries has not been followed by the increase in power demand.

Table 2

The key energy characteristics of the leading primary energy consumers (2003) [10]

Country	Population, mln people.	GDP, $/person.	Primary energy, EJ/a		Power plant output, GW	GDP, $ · 10^9/ GW
			Demand	Generation		
USA	290.8	37 840	98.16	70.16	953.2	11.6
China	1284.0	960	43.60	40.97	356.6	3.45

Russia	143.7	3030	28.23	47.00	216.1	2.01
Japan	127.3	29 770	22.97	4.11	266.1	14.3
India	1042.0	440	16.59	16.59	108.0	4.25

Thus, the low efficiency of all spheres of Russian national economy resulted in unreasonably high power demand. Experts believe that at least a twofold increase in efficiency can enable OAO Yantarenergo to reduce consumer supply from 3.05 bln kW · h in 2008 to 1.5 bln kW · hour, while the output of the existing generation facilities will surpass the regional demand by 2010.

An important factor of increasing the efficiency of the electrical networks that provide for the transmission and distribution of power is the reduction of expenditure related to the mentioned process. According to international experts, a relative power loss in the course of transmission and distribution in most countries can be assessed as satisfactory if it does not exceed 4-5%. 10% losses are considered maximum permissible in the framework of transmission physics [11]. Thus, one of the criteria used to assess the efficiency of electrical networks and systems is the level of energy loss.

Let us consider the power losses in OAO Yantarenergo networks, which amounted in 2008 to 0.68 bln kW · hour, or 18.3 % of power supplied to the network from the power system (table 1). One should mention that the standard practice is to assess the losses of effective supply, therefore, the losses in the power network of OAO Yantarenergo amounts to 22.3%.

Table 3 shows the structure of power losses during the transmission from sources to consumers.

Table 3

The structure of power losses by the elements of power system of the Russian Federation, %

Transmission lines	Transformers	Reactors, synchronous compensators, power condensers, meters, current and voltage measuring transformers	Substation auxiliaries
≈ 65 (5 – through corona discharge)	≈ 30 (a half accounts for losses in steel)	3	2

Most power losses in electric networks occur in transmission lines. The methods to reduce these losses are well-known [7; 11; 12]. First of all, it is the increase in voltage during power transmission. So, power transmission at a voltage of 10 kV instead of 0.4 kV, given the same length and section of wires, reduces losses 625 times.

$$\Delta P = 3I^2 \cdot \Sigma r = \frac{P^2 + Q^2}{U^2} \Sigma r.$$

Another method is the reduction in current density in transmission lines, reactive power compensation, etc.

The next important group of losses is those in power transformers. The use of energy-efficient transformers, especially in distribution networks may lead to 2-5 times reduction in power losses depending on the type of transformer load [3].

The energy security of the Kaliningrad region, owing to its geographical position, greatly depends on the supply of energy resources from abroad and the steps taken by the Baltic States and the EU in the framework of the integration of the Baltic electricity market into Europe. Today, the power system of the Kaliningrad region is connected to that of mainland Russia through the electric networks of the Baltic States and Belarus (fig. 1). However, this link of a voltage of 330 kV is not reliable enough, since it is carried through only one substation in the town of Sovetsk.

There are four other lines linking the Lithuanian and Kaliningrad power systems at a voltage of 110 kW, but they are rather weak (table 4) and are not designed for large capacities (figure 1 does not show the 110 kW lines).

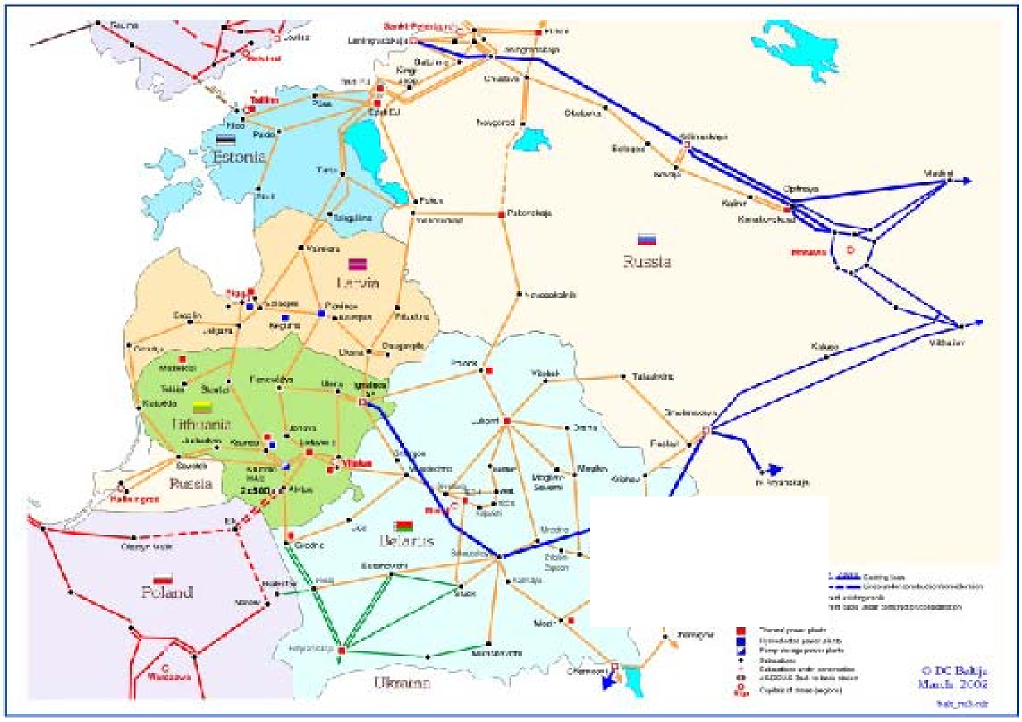

Fig. 1. The main networks of the Baltic States, Belarus, the North-west of the RF, and the Kaliningrad region

Table 4

The transmission capacity and range of AC voltage lines (110—750 kV)

Transmission line voltage, kV	Wire section, mm^2	Transmission capacity, MW		Transmission line length, km	
		Natural	At a current density of 1.1A/mm^2	Maximum (efficiency= 0,9)	Average (of two neighbouring substations)
110	70—240	30	13—45	80	25
220	240—400	135	90—150	400	100
330	2 · 240—2 · 400	360	270—450	700	130
400	3 · 300—2 · 400	500	620—820	1000	180
750	5 · 300—5 · 400	2100	1500—2000	2200	300

The EU and the Baltic States declared the integration of electricity market of the Baltic States into Europe to be a priority in the field of energy. The final stage of the integration is the secession of the Baltic States from the IPS/UPS + Baltic States systems and subsequent parallel operation with UCTE. Figure 2 shows European transmission system operator associations, table 4 offers the characteristics of three of them.

Table5

The characteristics of three European transmission system operator associations [1]

Energy Union	NORDEL	UCTE	IPS/UPS + Baltic States
Member states	4	23	14
Regional population, million people	25	450	280
Installed capacity, GW	90	600	315
Annual consumption, GW · h/a	401,5	2323	1237
Maximum consumption, GW	65	384	197

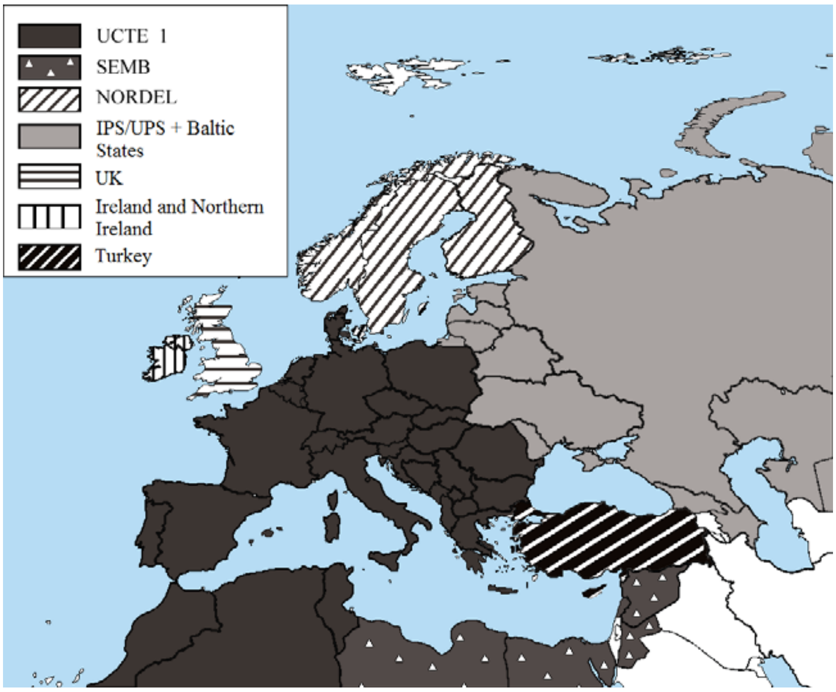

Fig. 2. Transmission system operator associations

It is important to mention that, until recently, such secession was impossible, since the power systems of the Baltic States did not have electrical links with UCTE, while the power systems of Russia and Belarus had 11 links with the Baltic States at a 330 and 750 kV voltage (see fig. 1).

All further steps of the Baltic States speak of the implementation of formulated plans. As Figure 1 shows, the power systems of the Baltic States are linked by an electric network, which enables power transmission. In the end of 2006, Estonia and Finland set in operation a 350 MW DC line (fig. 3, DCL 8).

In April 2009, it was decided to construct an up to 1000 MW power bridge on the basis of a DC line between the power systems of Sweden and Lithuania (fig. 3, DCL 4). The termination of the project is scheduled for 2016. The Baltic States, owing to the closure of the Ignalina NPP (fig. 3, INPP) on December 31, 2009, attach not only commercial but also strategic importance to the implementation of this project. An agreement on the integration of Lithuanian and Polish power systems was signed in Vilnius in 2006. The 'power bridge' is designed as a 400 kV transmission line running from the Kruonis pumped storage plant (Alytus) through the border with Poland to the Polish city of Ełk (fig. 3).

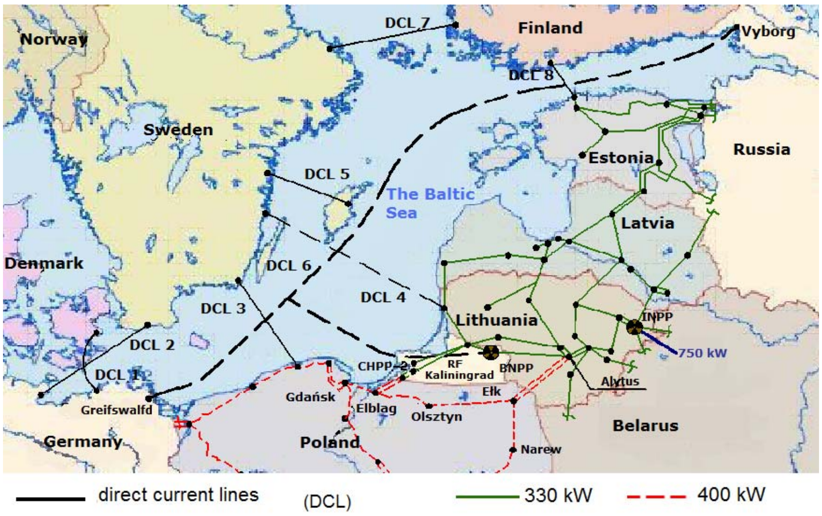

Fig. 3. Main networks of the Kaliningrad region, the Baltic States, and Poland

The completion of the power bridge' construction is planned for 2011. On June 17, 2009, the Baltic States signed in Brussels a policy statement on the integration of power market as to the power systems of Lithuania, Latvia, and Estonia [6]. The European commission offered Russia to connect the Kaliningrad region to UCTE after the accession of the Baltic States ("The EU and Kaliningrad" communication from the Commission to the Council, 2001). Today, the backbone network of the Kaliningrad power system is based on a 110 kV voltage. The scheduled construction of the 330 kV second level of the main network is of great importance, since it will significantly increase the capacity of the region's power system (table 3). Regarding the connection of the power system of the Baltic States and the Kaliningrad region to UCTE, it seems sensible to supplement the Kruonis (Lithuania) – Ełk (Poland) connection with a 400 kV double-circuit line linking the 330 kV substation in Kaliningrad and the substation in the vicinity of Elblag (Poland) (fig. 3). The Kaliningrad-Elbalg connection will allow the Baltic region to solve a number of crucial problems: 1) the increase in stability and reliability; 2) 1640 MW capacity transmission in both directions along the Baltic Sea coast; 3) the reception of power from offshore wind power plants, which are to be constructed in the Baltic Sea [4; 6]. Thus, the integration of the power systems of the Baltic States in the synchronous operation of UCTE and secession from IPS/UPS seems feasible in 2011-2016. In view of the provision of backup power and the requirements of stability and reliability, the operation of the Kaliningrad power system is possible only in the framework of a large power system, such as IPS/UPS + Baltic States, the Kaliningrad system is included in today, or UCTE (fig. 3).

The expected power demand in the Kaliningrad region for the for the period until 2015, according to the experts of OAO System Operator of the

United Energy System and the administration of the Kaliningrad region is shown in figure 4 [9].

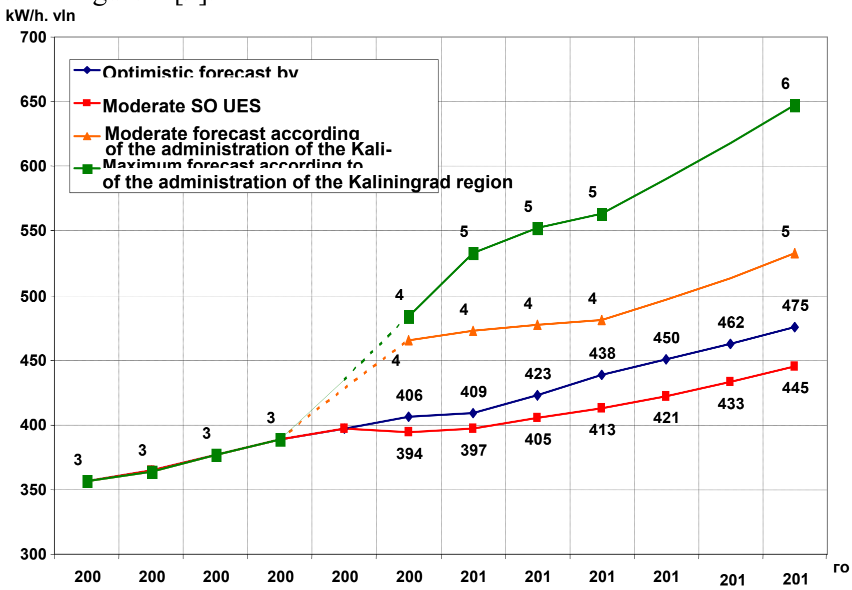

Fig. 4. Expected electricity demand in the Kaliningrad region for the period until 2015

Taking into account the circumstances mentioned above as well as the expected increase in electricity demand, the regional authorities consider the provision of energy security in the Kaliningrad region while developing local generation capacities. In June 2009, the following scenario of generation capacity development was adopted at the meeting on the development of energy in the Kaliningrad region chaired by the minister of energy of the Russian Federation, S.I. Shmatko:

1) The start up of the second 450 MW power unit at the Kaliningrad CHPP-2 in 2010;

2) The start up of the first 1150 MW power unit of the Yantar NPP in 2016;

3) The start up of the second 1150 MW power unit of the Yantar NPP in 2018.

The development plan also includes the construction of several CHPPs fuelled by coal and local peat of a total capacity of 800 MW in the cities and towns possessing a developed heat supply system.

In our opinion, the Kaliningrad region does need large energy facilities – the Kaliningrad CHPP-2 and the Yantar NPP. As to the construction of coal and peat-burning CHPPs, most attention should be drawn to the building of generation facilities on the basis of renewable energy sources: wind power, biomass, water resources, etc. [2; 5].

As the construction of the first NPP unit is completed in 2016, the Kaliningrad power system will exceed local demand creating conditions for the export of a significant part of generated power. Having entered the European electricity market, the Kaliningrad CHPP-2 and Yantar NPP will be able to sell generated power to consumers beyond the Kaliningrad region only through intermediaries, i.e. Lithuanian and Polish distribution companies, which cannot be always favourable for the region. The technical aspects of the backbone networks of the Baltic states, their capacities as to the transmission of electricity from the Kaliningrad region to European consumers, the prospect of the development of networks and generation facilities, the condition of the operation of the Kaliningrad regional power system within UTCE have not been studied in detail yet. Future situation can be aggravated by the completion of the construction of an up to 3400 MW NPP (Ignalina-2) scheduled by the Baltic States and Poland for 2018. It can result in zero demand for the surplus power generated in the Kaliningrad region.

One of the solutions to these problems is the construction, alongside the "Nord stream" gas pipeline, of an electric bridge on the basis of a DC line between mainland Russian, the Kaliningrad region and Germany on the floor of the Baltic Sea (fig. 3, DCL 6). The bridge is a direct current line consisting of three converter substation and power cables running across the floor of the Baltic Sea. Such bridge will ensure the direct transmission of the power generated in the Kaliningrad region to Germany and mainland Russia bypassing intermediaries, i.e. Poland, Lithuania, and Belarus, regardless whether the Kaliningrad region remains in IPS/UPS or accedes to UCTE. It will significantly increase the level of energy security, reliability and financial independence of the Kaliningrad power system. The cost estimation and location of the connection to German electricity networks was conducted under the supervision of a Professor of the Technical University of Stralsund (Germany), Edgar Harzfeld. According to interim calculation, given a capacity of 2000 MW, the cost of the bridge will amount to 3 billion Euros [8]. To date, six successfully operating DC bridges have been constructed on the floor of the Baltic Sea (see fig. 3). The DC connection of the Yantar NPP does not exclude a 330 kV connection, which is a priority for the Kruonis pumped storage plant (fig. 3, Alytus) and other power plants during the construction of the second level of the main 330 kV network in the Kaliningrad region.

Bibliography

1. *Аюев Б.* В едином ритме с Европой // Мировая энергетика. 2007. № 6. С. 66—69.
2. *Белей В. Ф.* Возобновляемые источники энергии и перспективы их использования в Калининградской области // Известия КГТУ. 2006. № 11. С. 20—30.
3. *Белей В. Ф.* Оценка роли трансформаторов в системах энергообеспечения с позиций энергосбережения и повышения качества электроэнергии // Промышленная энергетика. 2002. № 5. С. 36—42.

4. *Белей В. Ф.* Перспективы соединения системообразующих сетей Польши, Калининградской области и Литвы между собой и оценка возможностей подключения к ним потенциальных ветропарков // Международная конференция «Комплексное управление, индикаторы развития, пространственное планирование и мониторинг прибрежных районов Юго-Восточной Балтики» (г. Калининград, 26—30 марта 2008 г.): избр. тр. Ученые записки Русского географического общества (Калининградское отделение). Т. 1, ч. 1 (спец. выпуск). 2008. № 1—7.

5. *Белей В. Ф.* Современное состояние и мировые проблемы развития ветроэнергетики // Энергетик. 2007. № 12. С. 21—25.

6. *Белей В. Ф.* Электроэнергетика Калининградской области и стран Балтии: проблемы и анализ некоторых вариантов их развития // Электрика. 2009. № 12. С. 3—8.

7. *Белей В. Ф., Свердлин Ф. С.* Сельские электрические сети: проблемы и некоторые пути их решения // Эксплуатационная эффективность технических систем: тр. V междунар. сем. 29—30 апреля 1999 г. Ольштын, 1999. С. 41—46.

8. *Белей В. Ф., Харцфельд Э.* Создание электрического моста при строительстве газопровода «Северный поток» // 7-я международная научная конференция «Инновации в науке и образовании — 2009» (г. Калининград, 30—22 октября 2008 г.): сб. науч. тр. Калининград, 2009. С. 86—89.

9. *Белей В. Ф., Паршина В. Ф., Жуков Д. А.* Состояние энергетического комплекса и энергетическая политика в Калининградской области // Там же. С. 93—95.

10. *Велихов Е. П., Гагабульский А. Ю., Субботин С. А., Цибульский В. Ф.* Человечество и энергия // Энергия: экономика, техника, экология. 2007. № 8. С. 3—6.

11. *Воротницкий В. Э., Калинкина М. А.* Расчет, нормирование и снижение потерь электроэнергии в электрических сетях. М., 2000.

12. *Железко Ю. С.* Стратегия снижения потерь и повышения качества электроэнергии в электрических сетях // Электричество. 1992. № 5. С. 6—12.

13. **Обзоры компаний электроэнергетики (МРСК). Холдинг МРСК. Итоги деятельности компаний. URL: http://www.openutilities.ru (дата обращения: 17.11.2009).**